STUDY TO IMPROVE OPERATION AND MAINTENANCE OF NAM HUAM IRRIGATION SYSTEM IN LAO PDR

A DISSERTATION

submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF ENGINEERING
in
IRRIGATION WATER MANAGEMENT

By

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CANDIDATE'S DECLARATION

I hereby declare that work which is presented in this Dissertation entitled, **"STUDY TO IMPROVE OPERATION AND MAINTENANCE OF NAM HUAM IRRIGATION SYSTEM IN LAO PDR"**, in partial fulfilment of the requirement for the award of the degree of MASTER OF ENGINEERING IN IRRIGATION WATER MANAGEMENT, submitted in Water Resources Development Training Centre, Indian Institute of Technology, Roorkee, is a record of my own work carried out during the period from July 16th, 2001 to December 8th, 2001 under the supervision of **Prof. Raj Pal Singh**, Emeritus Fellow, WRDTC, and **Dr. M.L. Kansal**, Associate Professor, WRDTC, Indian Institute of Technology, Roorkee (India).

The matter embodied in this dissertation has not been submitted by me for the award of any other degree or diploma.

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Rainfall Data

Northern Part	Total precipitation in millimeters												Total
Station /month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Phongsaly	(1988-99)	13.1	22.6	51.9	79.6	173.7	228.2	368.3	272.7	140.3	76.0	28.0	30.9	1485.2
L. Namtha	(1994-99)	10.5	7.2	47.1	87.9	176.8	182.3	270.3	308.1	184.5	81.2	57.6	35.4	1448.7
Bokeo	(1996-99)	15.5	25.6	24.5	118.0	219.5	262.6	339.8	500.5	292.5	111.1	59.1	8.5	1977.4
Oudomsay	(1990-99)	6.7	21.4	47.3	90.7	154.4	201.5	246.0	310.6	194.1	67.6	32.4	20.3	1390.9
Viengsay	(1982-99)	12.5	19.4	47.9	104.9	201.2	249.2	259.4	277.2	214.2	85.8	27.2	15.4	1514.3
Vieng Khuang	(1985-99)	7.6	14.2	57.9	147.7	183.3	195.5	253.2	309.2	141.4	66.0	117.6	6.4	1399.9
L. Phabang	(1950-99)	12.1	18.1	34.4	95.3	146.8	179.5	225.2	266.3	163.1	95.6	29.8	12.2	1278.2
Sayabouly	(1969-99)	11.0	14.1	43.4	117.3	167.0	172.1	207.4	239.4	209.6	90.0	25.7	9.8	1306.2

Central Part	Total precipitation in millimeters												Total
Station /month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Phonettong	(1971-99)	7.1	18.2	36.3	99.6	316.0	370.7	453.0	462.7	336.8	119.7	19.5	2.3	2241.8
Vientiane	(1951-99)	7.7	13.0	34.0	83.5	246.5	278.5	273.6	336.6	298.3	78.4	11.4	2.5	1663.9
Paksane	(1987-99)	2.5	31.3	60.0	120.1	370.3	705.0	747.3	626.2	396.6	98.4	24.8	2.6	3184.5
Thakhek	(1988-99)	1.9	31.8	70.9	76.0	275.0	380.5	497.3	536.1	287.8	94.0	8.8	9.2	3279.3
Savankhet	(1971-99)	3.9	17.5	32.8	85.3	160.4	264.6	220.5	347.5	217.3	88.6	7.1	2.5	1441.1

Southern Part	Total precipitation in millimeters												Total
Station /month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sasavane	(1981-99)	4.3	19.3	41.0	74.5	216.9	304.5	428.2	376.7	361.5	102.2	27.8	1.5	1958.3
Pakse	(1950-99)	1.8	11.4	22.3	66.3	212	364.2	361.2	488.5	312.9	96.7	21.3	2.4	1961.1
Sekong	(1994-99)	0.2	11.7	26.5	98.7	220.8	162.6	345.3	206.4	265	104.7	40.1	8.4	1490.3
Attapeu	(1989-99)	6.0	22.9	54.0	91.5	234.1	285.2	477.4	472.7	462.7	130.3	30.3	7.0	2274.1

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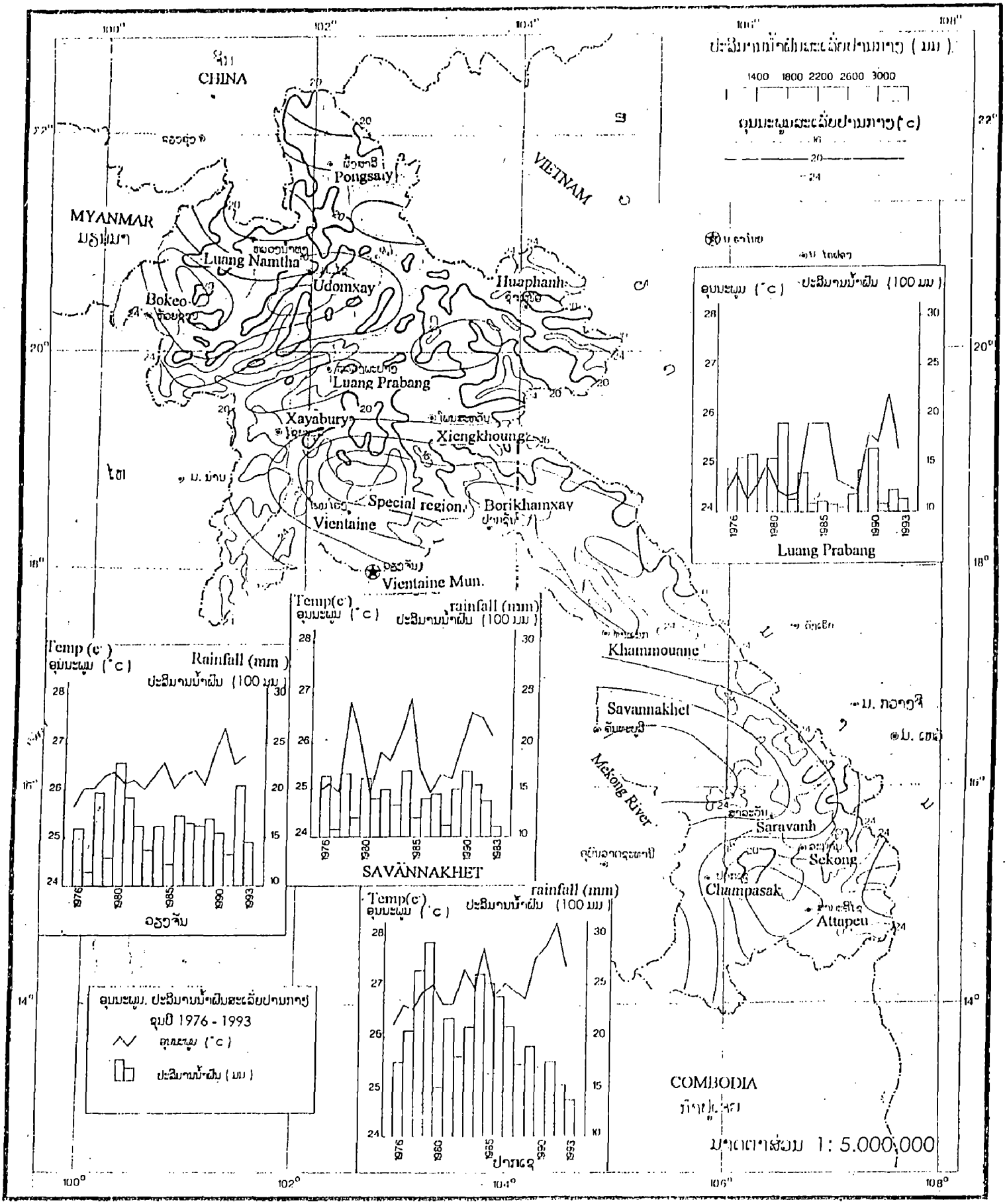

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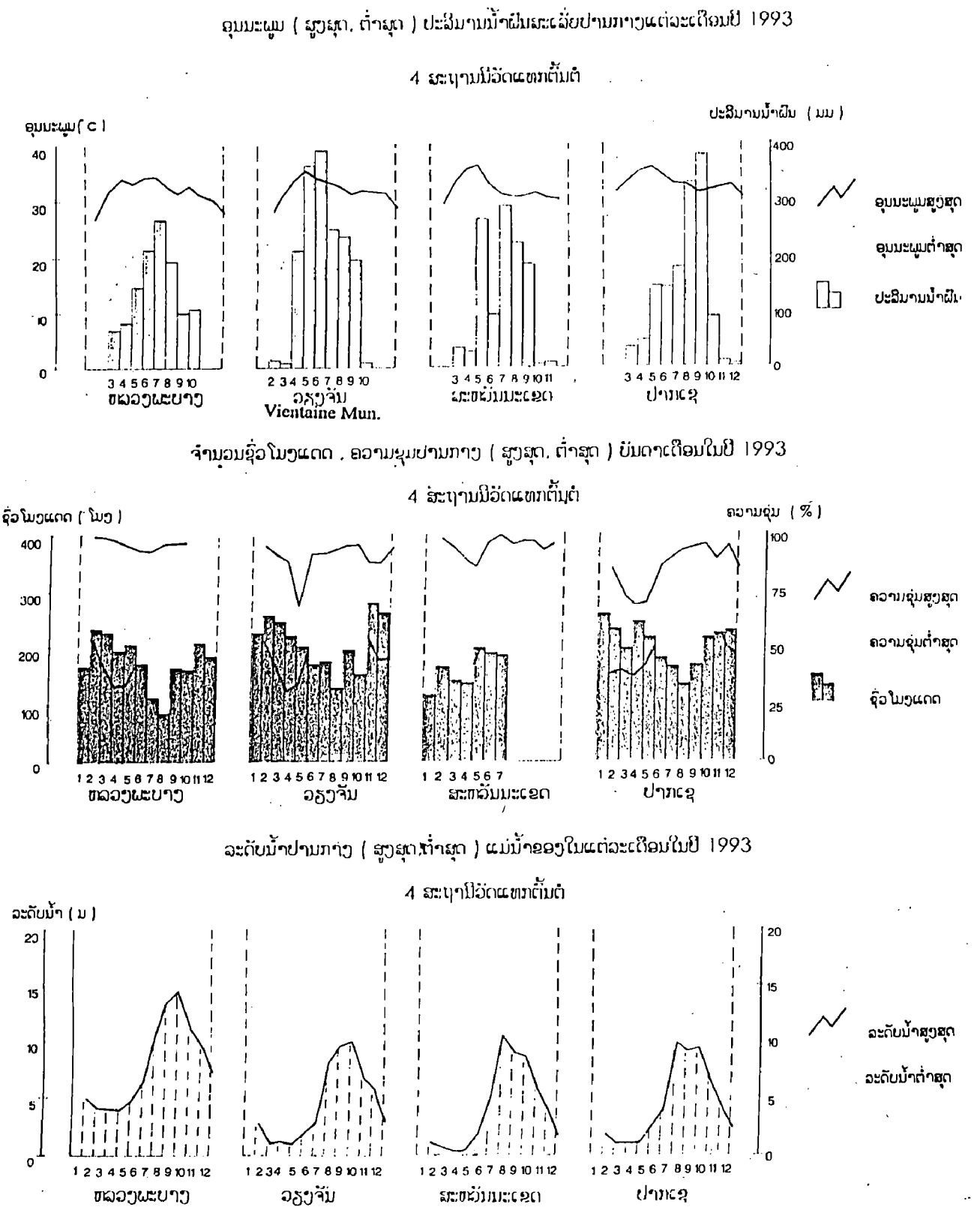
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Fig. 2

SYNOPSIS

The Namhuam irrigation system is proposed be used to meet out the rising food demand for continuing increasing population growth. Namhuam irrigation area with 1500 ha, located at Nasaythong District may be developed with basic principle "Low cost and simple technology concept".

In agricultural area, proper water management is a key factor for optimal crop production. The success of water management depends on the efficient operation of the infrastructure and also the economical maintenance of the system in order to maintain the capabilities in a good order.

Operation activity should be closely supervised and well coordinated in order that the available water may be properly utilised to meet the needs of the water users.

Maintenance objective are:

1. To keep the system in top operating condition at all times through proper maintenance.
2. To obtain the longest life and greater use of the system's facilities by providing adequate maintenance and replacements and also to ensure safety of the works.
3. To achieve the above two objectives at the lowest possible cost.

In this dissertation, the study would cover both operation and maintenance of the infrastructure created for Namhuam irrigation system. It is hoped that this dissertation study will help in achieving better understanding of Namhuam irrigation system and may suggest some appropriate measures and guide lines for adaptable strategies for optimal operation and maintenance. This would ensure better equity in distribution of water and also achieve high production levels.

INTRODUCTION

1.1 IRRIGATION TRADITIONS IN LAO PDR

Irrigation in Lao PDR has a long tradition and is deep-rooted in Laotian society. For many centuries, farmers have practiced irrigation by diverting water from the river streams to their rice fields. The farming community mostly builds the traditional irrigation systems. Construction of weirs and canals is done with materials that are ready available, using traditional building techniques. Also the delivery of water and maintenance of the irrigation system is managed by the water users themselves.

A large scale system serves many villages and may contain several agencies or even cross provincial boundaries. These agencies carry out the operation and maintenance of irrigation works. It is only at the level of the tertiary units that the farmers themselves are responsible for water distribution. Although, the size of tertiary unit is comparable to that of a traditional irrigation scheme, the design and construction of these units is in most cases carried out by Government so as to ensure a lay-out that permits efficient water use and equitable water distribution among the users.

The investments and high operational cost of the irrigation system finally need to be recovered through a higher production in the project area. Therefore, a major effort is required from the water users and the agencies supplying agricultural services to the farmers so as to ensure that the improved water supply does lead to a substantial increase in agricultural production.

1.2 GEOGRAPHICAL FEATURES:

The Lao People's Democratic Republic (Lao PDR) is land locked country with an area of 236,800 square kilometers stretching more than 1,700 km, in

North-South direction and between 100 to 400 km from East to West. The country is bordered by Vietnam in East (1,957 km), Cambodia (492 km) in South, Thailand in the West (1,700 km), Myanmar (230 km) and China (416 km) in the North. Fig. 1 shows the location map of LAO PDR.

Geographically, the Lao PDR is dominated by two features, i.e., the mountains of North and East, and the Mekong river and its East-bank tributaries. Extensive mountain ranges with an average height of 1,200 meters cover an area of 70% of the territory and along fertile flood plains embrace 30% of the territory, stretching along the left bank of the Mekong river. Forests (highest forest coverage ratio in Asia) cover more than 40% of the land. It is estimated that the total cultivated area for agricultural purposes is 7,10,000 ha. The country experiences a tropical monsoon climate with alternating wet and dry season.

Typically, the wet season extends from April to October and it dominated by a South-West monsoon with high rainfall, temperature, and humidity. The distribution within this season is nevertheless uneven, varying with respect to location, topography and other factors. The annual rainfall ranges from less than 1,300 mm / year in the Northern valleys to over 3,700 mm / year in South. The heaviest annual rainfall is in August. The dry season extends from November to March, a period that typically includes both coolest month (January) and warmest month (March). Average maximum and minimum temperatures vary between 16.4 to 30 degrees Celsius.

1.3 CLIMATIC CONDITION IN NAMHUAM BASIN:

The climate of the Namhuam basin is moderate throughout the year. The year may be divided into two distinct seasons. These are monsoon and non-monsoon, the monsoon season starts from June to October, whereas, the non-monsoon season starts from November to May.

There is no Meteorology Department observatory located in the Namhuam basin. The meteorological data of the Phonhon station, which is situated near to the Namhuam basin boundary, is assumed to be the same for Namhuam basin

and is considered in this project study. Fig. 1.1 shows the location of this observatory.

1.3.1 Temperature

The temperature in the Namhuam basin is generally moderate without much variation. The mean daily maximum temperature in the month of April is 30°C and mean minimum temperature in January is 16.4°C recorded in the Watthai Meteorology Department.

1.3.2 Wind Velocity

Winds are generally moderate with some strengthening in force in the South-West monsoon seasons. During the period from May to September, winds are mostly Westerly or South Westerly. North-easterly and Easterly appear in October and these become more predominant in next four months. In the March and April winds are mainly South-Westerly or Westerly in the morning, while in the afternoon they blow from directions between North and East.

Maximum wind speed is of the order of 8 – 10 km/h and is experienced during monsoon. During non-monsoon period, wind speed may be upto 12 km/h.

1.4 RAINFALL PATTERN:

There are Vientiane rain gauge stations within the Namhuam basin. Generally the pattern of rainfall in the Namhuam basin is tropical rainfall as mentioned above. Average monthly and annual rainfall are shown in the Table 1.1. The monsoon period is considered from 1st June to 30th November for the purpose of hydrological study. During monsoon period the average rainfall is 350 mm and during non-monsoon period the average rainfall is 220 mm.

1.5 AGRICULTURAL PRACTICES

The total population in Lao PDR is 5 million and about 85% are engaged in Agriculture. The major crop in Kharif is rice as majority of people take rice in lunch as well as in dinner. However, sugarcane is now becoming the main crop in kharif as the farmers have adopted it recently. Further, in rabi season the farmers prefer cultivation of safron in unirrigated areas because of tradition and being popular for growing safron crop. Since very early times, safron is grown in this valley. However, before provision of irrigation facilities, the cropping pattern was different. In kharif, the farmers had been growing oil seeds and maize. Because of limitation on irrigation facilities, the small and marginal farmers are the great sufferers as they have no alternative except to follow the same traditional cropping pattern because of food habits, old tradition and higher yielding under the prevailing circumstances in the command area. Because of limited resources, farmers were hesitant to adopt the improved varieties and irrigation facilities. Most of the times, they remain indebted and were not having even surplus product to sell. With the provision of irrigation facilities and improved varieties, the farmers can improve yield and get more benefits.

1.6 OBJECTIVES OF THE PRESENT STUDY

The objectives of the present study are :

(i) To discuss the salient features, i.e., the geographical, soil, climatic, etc. of the Namhuam Irrigation project located in LAO PDR.

(ii) To discuss critically the present irrigation practices, agricultural practices, and the operational & maintenance practices adopted in the project area.

(iii) To study the operation and maintenance practices adopted elsewhere in other countries.

(iv) To study measures for improving the operation and maintenance practices that can be adopted in the Namhuam irrigation project so that the productivity can be increased.

DETAILS OF CASE STUDY

2.1 NAMHUAM IRRIGATION SYSTEM DESCRIPTION

In 1978 Japanese Government supported aid for construction of the "Namhuam River integrated Development Project". This project is located at the Nasaythong district, which is about 30 kilometers North of Vientiane municipality. The primary purpose of this project is the irrigation and agricultural development of about 1500 ha of land for growing rice, so that the rice production can be improved from 3 ton/ha to 4.5 ton/ha.

The Namhuam Irrigation system is one of the irrigation systems within the Namhuam river basin integrated development project. It is a small irrigation system, which has area of 1500 ha of paddy field, derives a portion of its water from the earth dam across the Namhuam River.

The canal is located in Nasaythong district residency involving the Nasythong and Houmbang at Northern part of Vientiane municipality. In these areas more than 85 percent of the people cultivate land for agriculture.

The project includes:

(1) Headwork in terms of an earthen dam that is 22 meters high and 770 meters long.

(2) Main canal of 12 kilometers length for Nasaythong District.

(3) Branch canal of 22 kilometers length for Houmbang.

2.2 WATER AVAILABILITY:

Namhuam River is a major border River of Nasaythong and Houmbang. It carries discharge varying from 70 m^3/sec to 120 m^3/sec (measured flow in 1980). Water for the Namhuam Irrigation project is supplied from the Earth Dam on the

Namhuam side of the border under bilateral agreement (dates back to 1980) as follows :

(a) From 15th March to 15th November, a minimum supply of 6.7 m^3/sec and is provided a surplus if available upto 8 m^3/sec.

(b) From 16th November to 15th March, a supply of 4.25 m^3/sec. The agreement further stipulates that from 16th November to 15th March the supply canal to Nasaythong would be alternately closed and opened for 10 days at a time and could run at 6.5 m^3/sec capacity whenever the canal is opened. These stipulated quantities are only minor portion of the flows in the Namhuam River and Nasaythong would have no difficulties in providing these flows.

2.3 SOIL CONDITIONS

The result of various tests conducted on soil samples from various reaches indicate soil properties as follows:

- Bulk density = 1.31 g/cm^3
- Field capacity = 23% by weight
- Permanent wilting point = 10% by weight
- Water holding = 13% by weight.
- Capacity = 170 mm/m soil dept.

(i) Medium textured soil (silty sandy loam) : There are dark brown to deep brown coloured soil. Vertical cracks are found when dry and hard. This soil is located at the western and of the project area and along the Namhuam River.

(ii) Find textured soil (silty clay Loams, clay loams) : Soils are dark brown to dark grey coloured soils. These soils are well suited to rice, which located at the Eastern of the project area.

2.4 CROPPING PATTERN

There are two cropping seasons in the project area,i.e., (i) Wet season from April to October, and (ii) a dry season from November to March. Main crops of the two seasons are rice and sugarcane. Rice is the principal crops grown on about 90 percent of the areas. The area planted to sugarcane has increased over the last few years. This is mostly located at the western end of the project area and along the bank of the Namhuam river. Table 2.2. shows the irrigated area between 1980 and 1984 in the Namhuam Irrigation system.

Table 2.2 : Irrigated Area in Namhuam Project (1980 – 1984)

Area of Crop	1980		1981		1982		1983		1984	
	Dry	Wet	Dry	West	Dry	Wet	Dry	Wet	Dry	Wet
Area under rice (ha)	750	1200	800	1300	1000	1600	1500	1900	1500	1900
Area under sugarcane ha)	100	120	115	130	140	166	150	185	150	185

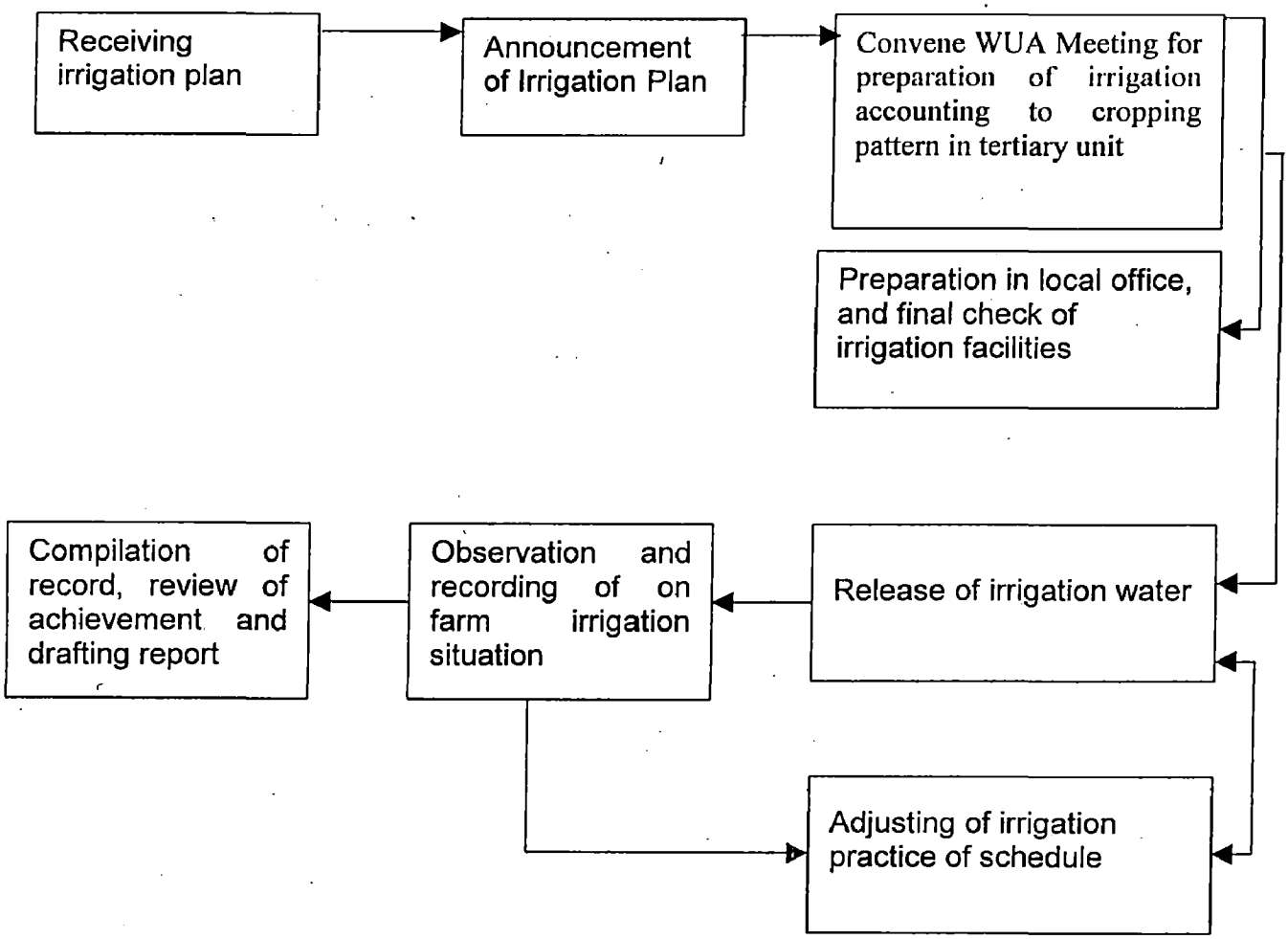
2.5 IRRIGATION INTENSITY:

Irrigation development started a few hundred years ago in the North part of the country. There were a number of traditional irrigation schemes, in which the water level was raised by small dams made of logs, earth and stone, thus enabling the irrigation of about 30 ha, during the wet season. In 1960, with collaboration of foreign assistance the improvement of irrigation accelerated. Small concrete dams and water distribution systems were built in several provinces. However, these were inadequate to provide both necessary irrigation and water supply for the villagers. The major irrigation development began in 1980. The department of irrigation now provides central planning and coordination of irrigation development throughout the country. It also offers advice to provincial administration on matters concerning irrigation services. The irrigation schemes are classified in three categories such as small scale ranging

from 1 to 100 ha, medium scale from 101 to 500 ha, and large scale schemes above 500 ha.

2.6 WATER DISTRIBUTION OF IRRIGATION

Once the irrigation supervisor receives the irrigation plan from relevant section, he initiates to implement the same. The process of implementing the irrigation plan is illustrated as follows :



Execution Irrigation Plan:

1. After receiving the approved irrigation plan announcement of the plan should be made by Irrigation Supervisor (Namhuam) Office to inform the Water User's Organization, as well as the relevant agencies of the irrigation plan, and to solicit their coordination, support, and assistance.

2. Meeting with Water User Association.

The main topics to be explained and discussed in the meeting are:

a) Explanation by Irrigation Inspector or Irrigation Supervisor of detailed irrigation plan as well as the rotational group system.

b) Briefing by the water master of WUA and special points of the irrigation practices prepared to implement the irrigation plan, i.e. condition of continuous or rotational irrigation method to be adopted, organization of group for rotational irrigation, order of rotation, etc.

c) Determination on the ways and means of repairing tertiary and quaternary canals and farm drains before irrigation begins, and also the ways and means of maintaining such ditches the application of irrigation.

d) Arrangement of the agricultural cooperative groups. The peak demand for manpower and farm implements, during the land preparation, transplanting and harvesting periods.

2.7 WATER MANAGEMENT SYSTEM

The present system of water management does not provide for collective efforts in self-governance by the users. The result is that there is no effect on the part of the farmers to maintain the watercourses in their fields, nor the sense of economical use of water amongst the users. Necessity of involving farmers in the management and maintenance arises, as accurate information is now available about the soil and plant-water relationship, particularly about the time when to irrigate, how much to irrigate, and how to irrigate for better water use and application efficiency.

The necessity of involving farmers in water management is considered on the assumption that water distribution costs would get reduced, the maintenance of the irrigation systems at micro level would be achieved, the beneficiaries would have sense of owning the system which would motivate economic use of the water. The effectiveness of the system would improve, reliability of assured water supply made known to the beneficiaries would also motivate them to go for appropriate inputs leading to higher productivity. The distribution of water will be

equitable and schedules of supply could be more effective. It is therefore, felt that farmers participation would ultimately give stability to the operation and maintenance of irrigation system.

2.8 GENERAL MAINTENANCE PRACTICES

Maintenance activities for an irrigation scheme fall into three categories:

1. **Routine maintenance:**

Routine maintenance activities have to be repeated throughout the life time of an irrigation scheme to keep it functioning. Some of these activities are daily routines, which do not require special skills:

- Greasing of gates;
- Removing vegetation from embankments, canals and drains.
- Removing silt from canals, drains and structures.

Whenever possible, these daily routines should be done by the water users themselves, otherwise by operational field staff.

Other routine maintenance activities require skilled persons, such as a mechanic, a mason, a carpenter and a painter. They may be needed to do routine maintenance work such as:

- Repair of gates and measuring structures;
- Repainting of steel structures;
- Installation of water level gauges;
- Maintenance and small repairs of pumps and engines.

Larger routine maintenance jobs are usually done between irrigation seasons, when the canals are dry. These include:

- Major repair or replacement of gates, pumps and engines.
- Large – scale silt clearance from canals and drains;
- Large-scale maintenance of roads and embankments.

In the off-season, when both farmers and operators are not using irrigation facilities, can be engaged in maintenance work. Sometimes, for very large or difficult jobs, it may be necessary to hire a contractor.

2. **Emergency works:**

Emergency works require immediate and joint action by irrigation staff and farmers, to prevent or reduce the effects of unexpected events such as:

- Beach or overtopping of canal embankment or river dike, causing flooding.
- Critical failure of pumps or head-works, causing interruption of irrigation water supplies.
- Natural disasters such as floods, earthquakes or typhoons.

3. **Scheme Improvement:**

The routine maintenance and emergency repairs described above are aimed at keeping or restoring the technical infrastructure in the condition equivalent to that when it was newly built. There are a number of reasons, however, not just to maintain the scheme in its original condition, but to gradually improve it.

The main reasons are :

- A newly constructed scheme is hardly ever perfect. Some alterations are usually necessary to make it fully operational.
- It is sometimes better to construct a scheme at minimum capacity, with low cost structures. Then, if the scheme proves to be a success, it can be gradually expanded and the structures replaced with more permanent ones.
- Conditions change, both inside and outside the scheme. Improvements are necessary to ensure that the scheme continues to deliver services that correspond with farmers' needs.

2.9 PERFORMANCE OF WUA IN THE NAMHUAM IRRIGATION SYSTEM:

The performance of the water users association in Namhuam Project has not progressed as smoothly as was thought in the beginning because of the following reasons:

a) The farmer's traditional behavior, education, way of thinking and believe are still strong.

b) Enforcement of WUA rules is a problem as members themselves are the user farmers who are reluctant to report violators.

c) The traditional water distribution system of the village managed by village under the direction of the head of village, often continues to run in parallel with WUA, which can result in conflicting practices.

d) In some villages, the establishment of the WUA is not based on bottom up system, but top down system.

e) The faulty design and construction of the irrigation system that does allow the water to reach the tail end.

f) Farmers claim for changing the lay out of the tertiary networks after construction, while they are already agreed before construction.

g) Farmers expect to receive water supplies without having to pay tax (50 kg paddy / ha / season), and tend to wait for government funds to initiate any maintenance or rehabilitation of the tertiary.

h) Interagency working relationship between local Government, Agricultural, Extension, Services and Irrigation Services are not so smooth.

THE ORGANIZATION FOR MANAGEMENT OF THE NAMHUAM IRRIGATION SYSTEM

3.1 OPERATION AND MAINTENANCE ORGANIZATION

This project has a new organization to carry out efficient operation and maintenance of irrigation scheme that has been set up in North of Vientiane. Fig.3.1 depicts a line staff structure upto level of tertiary "Houmbang".

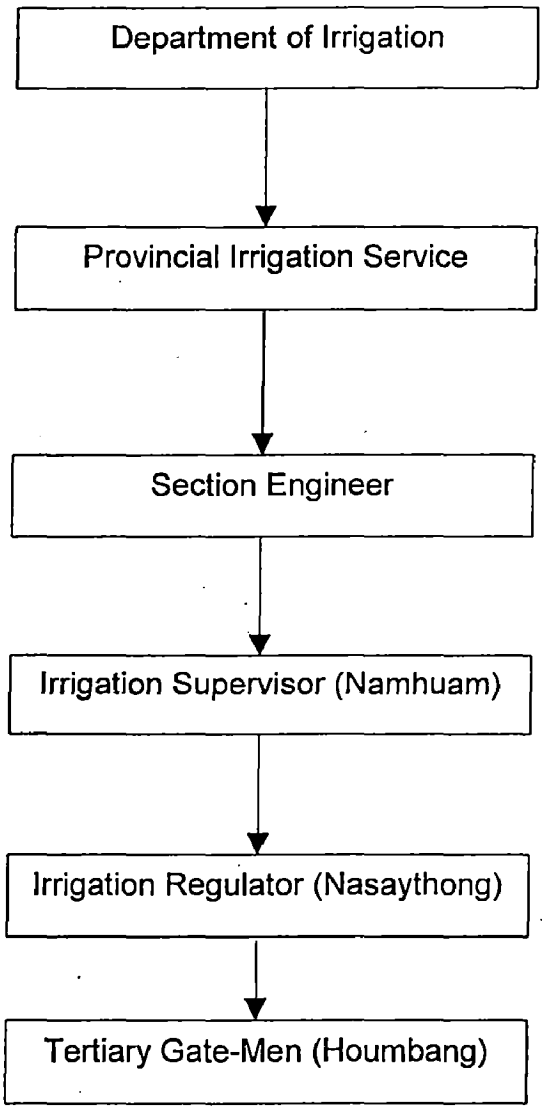


Figure 3.1 OPERATION AND MAINTENANCE ORGANIZATION

Management of an operation and maintenance organization includes anticipation of problems, planning, taking action for effective operation and maintenance of completed works, and efficient utilization of budget, man-power and materials. The organization provides important service by taking care of the irrigation schemes and supplying water to farmers on time and according to needs for maximum rice production.

3.2 RESPONSIBILITIES AND DUTIES OF STAFF IN NAMHUAM IRRIGATION SYSTEM

O & M Engineer (Head Office) implement and manage the entire O & M works in the province and is directly responsible to the head of the provincial irrigation service. His responsibilities include:

1. Manpower selection for the O & M organization.
2. Preparation of the annual budget for the entire O & M work.
3. Periodically reviewing the O & M programme with the section engineer to see that all the policies are properly implemented.
4. To review the plans and estimates for major repair works requested by the section offices and to prepare contract documents for these repair for approval and award of the contract by the head of irrigation service.
5. Review and approve the request for equipment, material, and additional personnel for initiating and continuing O & M programme.
6. Collection of the summaries of the O & M data from section offices on a regular basis and to use the same for planning future O & M programme.
7. Inspecting each section office and the project works on a regular/periodic basis to ensure that the works are functioning properly according to programme and to review recommendations for improving the systems and the O & M programme.
8. To prepare design for major repair or replacement work for which assistance may also be available.

9. Approval of any work or extension to a scheme if requested by the section Engineer.

3.3 RESPONSIBILITIES AND DUTIES OF SECTION ENGINEER

He shall be responsible to the O & M Engineer for all technical matter. His many responsibilities shall consist of:

(1) Administration and supervision of all the O & M works and staff.

(2) Planning and programming of the operation schedules and cropping for irrigation schemes in consultation with the irrigation Supervisor (Namhuam), and monitoring their progress.

(3) Close supervision of maintenance repairs and costs on each scheme to ensure that the schemes are kept in good operating condition, control on budgets provisions an enforced and emergency requirements for repairs are attached in time.

(4) Approval of hired daily labour for periodic maintenance and emergency repairs requested by Irrigation Supervisor.

(5) Visit to irrigation area atleast once in a month to ensure that the correct O&M procedures are in use, and to familiarize himself about the problems and accomplishment during and irrigation season.

(6) Authorization of the dry-season rice cropping and any restriction to irrigation supplies during periods of low flows. He shall keep the District Irrigation committee informed of these.

(7) Recommending the head quarters about new outlets improvements to or construction of new structures, tertiary improvements and extension of irrigated areas on any scheme if requested by the farmers or found necessary in the interest of work.

(8) Membership of the District Irrigation Committee.

(9) Periodic communication with the O & M Engineer to report progress and any request for additional staff, extension of O & M programme, materials and equipment.

(10) Preparation of annual report summarizing the accomplishment, special problems faced and suggested remedial measures, and actual expenditure incurred on the O & M works.

3.4 RESPONSIBILITIES AND DUTIES OF IRRIGATION SUPERVISOR

He is responsible to Section Engineer and supervises several irrigation regulator (Nasaythong) in his jurisdiction. His duties include:

1. To follow and carry out instruction and programme for operation and maintenance in his jurisdiction, as directed by Section Engineer.
2. To direct water distribution and to quantity of irrigation water every month during the irrigation season after the cropping an irrigation schedule are agreed with the Section Engineer.
3. Collection of all the field operation data from schemes on 10 days basis and the analysis of the data. Preparation of monthly data on flows, crops, crops damages and maintenance cost and their transmittal to the section office.
4. To put forward recommendations to the Section Engineer concerning the requests for dry season rice irrigation. To keep the section office informed of any serious water shortages developing on a scheme.
5. To report on any natural disasters occurring in his jurisdiction e.g. flood damage, land slides.
6. Regulate visits at least once in a fortnight to scheme to ensure adequate supervision of the O & M programme, O & M contract in progress, and adherence of the correct rules and procedures. The accomplishments and problems on scheme will thus be known to him.
7. Accompanying the Section Engineer on annual inspection an also to perform inspection of secondary system and territories on each scheme twice a year.
8. Keeping the Section Office informed of the requirement of major repairs and rehabilitation.

9. To ensure that each scheme is adequately maintained by the field staff and remains in good operating condition during an irrigation season. Control on the movement and performance of Irrigation Supervisor group. Subject to approval from Section Engineer, additional labour to be fired fair repairs.
10. To report on offences or criminal acts such as authorized use water and damages inflicted to irrigation structures.
11. To authorize, with the approval of Section Engineer, canal closures for maintenance repairs.
12. To forward recommendations to the Section Engineers concerning construction of additional structures, new outlets or extension to the system is requested by the formers of found necessary in the interest of works.
13. To organize survey in the project area for correct determination of common area.
14. To give instruction and guidance through delegated irrigation regulator, to village operated irrigation scheme.

3.5 RESPONSIBILITIES AND DUTIES OF IRRIGATION REGULATOR

The Irrigation Regulator in charge of scheme will performed by his function with the assistance from the field staff comprising gatemen and labourers. The Irrigation Regulator will be responsible to the Irrigation Supervisor. His duties will include:

1. To follow instruction and programme, set up by the Irrigation Supervisor, on a scheme according to the rules contained in this meeting.
2. Day to day operation of gates on regulators on the headwork and primary canals according to plan agreed with Irrigation Supervisor.

3. Distribution of water through tertiary outlet gates and maintenance of canal level in the secondary canals such that the available water is distributed evenly and unhindered throughout the system.
4. To maintain regular contact (at least once in 10 days) with "Houmbang" or the farmers to provide details about the irrigation action, period of low irrigation supplies, and to receive complaints regarding water shortage by the farmers, or field drainage problems.
5. Responsibility for routine maintenance on a scheme so that the systems are well maintained during an irrigation season with least disturbance in water supply to the farmer.
6. To report promptly to the Irrigation Supervisor about natural disasters and emergency repairs and to organize the remedial measures as directed by the Irrigation Supervisor.
7. To supervise on field the minor repairs under Irrigation Supervisor groups as programmed by Irrigation Supervisor and also to supervise major repair (O&M) contract as authorize by provincial irrigation.
8. To observe regularly the condition of canals, structures and measuring devices, and report any undesirable condition that need immediate corrective measures.
9. To record regularly the gauge, crop and maintenance data and their periodic transmittal to the Irrigation Supervisor according to the procedures.
10. Any other field duties and surveys on the scheme as assigned by the Irrigation Supervisor.

3.6 RESPONSIBILITIES AND DUTIES OF TERTIARY GATE MEN

1. To distribute water among the "Thongna" a tertiary unit.
2. To organize the farmer to maintain and clean the tertiary and quaternary channels within a tertiary block.

3. To follow and implement rotation on farmers as directed by the irrigation regulator. Such instructions may be given on 10 day contacts between Houmbang and Irrigation regulator.
4. To report to irrigation regulator about crop damages, area cropped and fields irrigation problems on a regular basis.
5. To assist the irrigation regulator on sampling and measurement of yield from plots.
6. To attend any meeting held by irrigation regulator on matters relating to irrigation on a scheme.

OPERATION AND MAINTENANCE OF THE NAMHUAM IRRIGATION SYSTEM

4.1 OPERATION AND MAINTENANCE RESPONSIBILITIES:

Responsibilities for operation and maintenance start from the head works on the Namhuam River through to the primary and secondary canal system and end at tertiary head gates. The operation and maintenance staff is to ensure that these works are operated and maintained efficiently without interrupting the supplies to any area during the irrigation season. At the same time irrigation water is to be distributed among tertiary channels as equitably as possible.

The responsibility for water distribution on farms and maintenance of on farm irrigation system lies with the village. The technical advice and direction on water distribution and use to farmer is, however, to be given by the operation and maintenance staff. It is expected that the farmers on each tertiary unit will organize the Water User Association (Water User Association) and appoint "Houmbang" for necessary communication with the operation and maintenance staff. All the efforts must be made to make operation and maintenance successful as execution of operation and maintenance by farmer is a decisive factor in the success or failure of agriculture production. Although, the operation and maintenance at primary and secondary system are good but if operation and maintenance at tertiary system get failure, the end results are not achieved. Then primary and secondary system may also be said to be failed.

Also, the people who understand about irrigation science, hydraulic science, construction science etc execute operation and maintenance at primary and secondary system, but the farmers do not understand the same. Therefore, project staff have to make the efforts so that the farmers can use tertiary system as maximum as possible with higher efficiency for longer duration.

So at Namhuam project problems which are handled by project staff not only construction problem but also farmer creation problem.

4.2 MAINTENANCE OBJECTIVE:

The objective of maintenance programme shall be:

a) To keep the system in good operating condition at all times through proper routine maintenance.

b) To obtain the longest life and greatest use of the system facilities by providing timely action of rehabilitation.

c) To achieve the foregoing objectives at the lowest possible costs.

4.3 DAMAGE INCIDENTS:

1. Constant vigilance by field staff is necessary to correct potentially unsafe or unsatisfactory condition as they develop. Seepage below structures, damage to masonry, serious erosion below structures, and settlement of embankment etc. may result in major failure problems. The growth of weeds, erosion of banks, seepage of water through bank and bottom, and silting or scouring of canal beds, etc may not be of such serious nature. But they must be given due attention as these are more time consuming and costly over years.

2. Routine problems, e.g., silting of canal, weed infestation, canal bank maintenance, minor seepage and erosion, minor cracks to masonry or joints and lubrication of gates etc. shall be attended frequently as part of the O & M duty of the field staff.

   The more serious changes occurring to the system facilities shall be reported promptly to the Irrigation Regulator (Nasaythong) by the gatemen or labourer observing the damage.

3. On receipt of the report of the damage, the Irrigation Regulator shall go immediately to the scene of incident and determine all facts possible concerning the situation. If the damage can be handled easily by the field staff supplemented by locally hired or voluntary labour, it should be done so. Other matters needing repair from Irrigation Supervisor maintenance

group should be brought to the notice of the Irrigation Supervisor who can then schedule this work in the maintenance group's programme.

4. Emergency repairs or conditions which can not be handled by the Irrigation Supervisor staff should be reported by the quickest means possible to the Section Engineer. Section Engineer shall investigate the facts of the damage for presenting the details to the O & M Engineer while making request for special funds or contracts to correct the damage.

5. The aim should be to defer, if possible, the major repairs to dry season when canals can be closed and the repair is carried out. But the cases of damages or obstructions covering reduction or stoppage of flow in the system during an irrigation season must be corrected without delay so that irrigation of crops can be continued.

4.4 MAINTENANCE SCHEDULING:

The maintenance works is divided into four broad categories, which are as follows:

a) Routing maintenance
b) Periodic repairs
c) Emergency repairs
d) Major repairs

The maintenance responsibility of the system from the headwork to tertiary outlets lies with the Irrigation Staff but maintenance of tertiary system is the responsibility of the water user association.

4.4.1 Routine Maintenance:

In order to keep the entire Irrigation System in good state of operation and maintenance and to reduce the possibility of recurrent rehabilitation work in future, some system of regular maintenance is necessary. Any damage occurring in canals and structures which may eventually lead to serious failures have to be noted as part of the routine maintenance and corrected as part of periodic repairs.

The routine maintenance shall essentially include the following elements:

1. Patrolling of canals banks and routine bank repairs to stop seepage and to maintain safe free board 40 cm to 50 cm above Full Supply Level (FSL). For the banks seepage holes should be blocked to prevent erosion and possible failure of the bank. It is important that all soil placed for bank repairs are of right quality and well compacted. Trees and deep-rooted bushes must not be allowed to grow on the banks and are to be cleaned at the earliest.
2. Observation of the canal lining and reporting cracked or damaged masonry lining. Canal bank above the top of lining can cause cavities behind the lining and damage the masonry. Most soil in such cavities shall be replaced with coarse material.
3. Silt clearance in canals and upstream of distribution and measuring structures to ensure unhindered passage of water throughout the system in irrigation season. Despite routine silt clearance, sediments may still deposit in the bed and sides of canal. Such deposits shall be cleaned seasonally during canal closure periods, and classified as periodic repair. Frequency of silt clearance during an irrigation season will depend on silt intake of canals.
4. Floating weeds and fixed weeds above water line in canals should be controlled as part of the routine maintenance. The submerged weed in the canal beds shall be cleaned in the dry condition when canals are closed. This work shall be considered part of the periodic repairs.
5. Lubrication and maintenance of gates and all other structures so that they operate easily during the irrigation season and flows are not unduly restricted. The need of timber stop-logs and check-plants can be easily met during day to day work.
6. Routine observation of masonry work. The condition of structures and erosion below them must be watched during daily patrols. Minor damages such as cracked masonry, poor masonry joints, cracked concrete, masonry damage and dislodged stone protection (rip-rap) should be

reported immediately to the Irrigation Regulator. These minor damages should be repaired promptly by calling the Irrigation Supervisor maintenance group as if neglected these minor damages may lead to serious and costly damage in future. Serious damages shall be observed and included in the next periodic repair programme.

7. The gauges and measuring structures should be watched regularly. Any sediment or debris accumulation around them and damaged crest of the weirs must be corrected at once. The dislodged or broken gauges must be replaced or fixed.

8. Keeping open the paths along canal banks so as to maintain good access conditions. Routine silt and weed clearance of project drains where such are in existence.

The aforesaid duties should be performed by the irrigation regulator and maintenance labour on a scheme. On small schemes no maintenance labour can be posted for reason of economy. Routine maintenance such as weed clearance above water lines, clearance of silt or debris for unhindered flow of water in irrigation season, lubrication of gates, cleaning around gauges and measuring devices, and routine reporting of masonry damages shall then be carried out by the tertiary gatemen.

On such schemes, most of the silt and weed clearance and repairs of masonry works shall be performed once or twice a year using locally hired labour and or Irrigation Supervisor maintenance group. The work programme and extent of hired labour shall be authorized by the Irrigation Supervisor for each season. Such repairs should preferably be done in the long closing season i.e. August and September.

4.4.2 Periodic Repairs:

These comprises of periodic work such as canal normalization or masonry repairs or repair and painting of gates or grading of access road etc. These works are carried out during an irrigation season or dry period depending upon

circumstances or urgency of the situation. The periodic repairs shall include the following works:

1. Repairing of gates: The gates are extremely important for control and operation of an irrigation system. They should always be in good state and must be able to get closed and opened easily. The gate surface, groves and lifting gears should be well treated and protective coating applied to the metal work and woodwork. While the lubrication and grading of gate appurtenances help in keeping them in good shape, damages to stem, leaf or gears may occur that need repair. Also, the gates are desired to be painted periodically.
2. Fabrication, repairs of stop-logs, check-plants, and carpentry works should be performed according to seasonal requirements.
3. Repairs to measuring structures should be done as follows:
   a) Repairs and replacing weir crest plates.
   b) Repairing broken or damaged head measuring gauges.
   c) Repairing masonry including upstream and downstream lining at measuring structures.
4. Repair to masonry work:: Timely repair to masonry is important to keep the structures in good condition. The small damages such as cracked masonry or dislodged rip-rap or localised structural damage above water line should be repaired as early as possible. Undermined structures or broken structural elements should be repaired. Such work will be easier to undertake in the dry season. Repairs to weir and control structures shall have main priorities and the repair of canal lining have low priority.
5. Normalization of canal: Despite routine maintenance, some canals may develop serious silt and weed accumulation in the bed and on side of canals below water line after one or two season of irrigation. During the non-irrigation season, between the wet and dry season crop or the longer closure period in August and September, the canals should be cleaned properly upto the formation levels.

6. Repair to across road and buildings: Approach or access roads, wherever existing, should be graded and repaired at least one a year. Small repairs can be carried out using manual labour. The requirements for the periodic repair on each scheme shall be communicate to the Irrigation Supervisor by the irrigation regulator in advance for each season or for any emergency need. The programme and work order for deployment of the maintenance group among different schemes shall be pre-planned by the Irrigation Supervisor according to the needs and priorities.

4.4.3 Emergency Repairs:

Unforeseen damages can occur, during an irrigation season. These may be of nature to stop or grossly reduce the system supplies because of breached canal banks, breakdown of structures, blocking of canal due to land slides or by large rocks or trees entrapped in canal and flood damages to head works or cross drainage works etc. The causes could be many such as floods, mis-operation of canal, land slide, earthquake, undermining of control structures and broken or struck gates. The O & M staff must always be alert and vigilant of such emergency situations. Repairs to such damages must be performed with least delay, as otherwise the standing crop on the scheme could be completely lost thus causing serious financial loss to farmers.

The emergency disasters must be reported immediately to the Irrigation Supervisor. In many cases the repairs or temporary relief measures can be easily handled on site by mobilising extra labour and by enlisting voluntary labour from farmers.

Emergency bank repairs, closing of breaches and removal of debris, rock and trees from blocked canal etc. must be attended to at the earliest opportunity.

There may be rare instances of major disasters resulting in outflanking of diversion dams, loss of gation weir, complete collapse of a major control structure and long breach in canals or banks which may take substantial time to repair such incidents must be inspected by the Irrigation Supervisor and Section Engineer who shall evaluate the extent of the disaster and submit report to O &

M Engineer Vientiane providing photographs and facts of the damage and proposing plans and cost estimates of undertaking the repairs. In such unforeseen cases the canal way by out of use for long time and crop damages may occurs.

The provincial irrigation has budget to meet such unforeseen disasters. What are needed during emergencies are:

i) Prompt reporting of incident

ii) Quick inspection

iii) Planning for remedial works by the section staff and

iv) Decision by the O & M Engineer to authorize repairs in time.

4.4.4 Major Repairs:

The annual maintenance works, which cannot be handled by Irrigation Supervisor and maintenance group, major rehabilitation works and system improvement, are classified as major repairs. These should be carried out on contract approved by the provincial irrigation. Rehabilitation of systems and their improvement e.g. expansion of the scheme or construction of new major structures etc. shall be organised and controlled by either the rehabilitation section.

The Section Engineer will identify the locations and general requirements for rehabilitation and system improvement works, following the bi-annual inspections in their area.

The responsible agencies within the provincial irrigation shall evaluate design and implement the requested rehabilitation works. The programme for executing the rehabilitation work by an agency must be coordinated with the O & M section so that these are carried out in the long off-season with least disturbance to irrigated cropping. If such major works are going to delay the start of irrigation season or disturb the irrigation patterns, the effected farmers must be given advance notice of this.

The annual maintenance works of size, which are beyond the capability of the Irrigation Supervisor maintenance group e.g. works involving large quantities

of masonry, special structures and replacement or major repair of gates etc. shall have to be pre-force, executed under O & M contracts. The objective should be however, to minimize the contracts work and upgrade the task force capacity to handle most of the annual repairs. This would be economical and less delaying.

The major repairs and contract works should preferably be planned for implantation in the long - off season, July to September. These must be so arranged that the cropping season and this may have to be allowed in extreme cases of the stopped due to construction work. The farmers must be given notice of such sufficiently in advance.

SURVEY OF TECHNICAL LITERATURE OF OTHER PROJECTS / COUNTRY

5.1 USBR GUIDELINES FOR OPERATION AND MAINTENANCE OF IRRIGAITON SYSTE MS

Since the Bureau of Reclamation (USBR) is the Federal agency in the United State with the most experience in planning, designing, constructing and operating and maintaining irrigation system, the concepts and procedures developed and used by this agency will be described in this chapter. It is certainly not implied that these policies and procedures are best under all conditions but overall they have been quite successful in their implementation in the United States. The procedure described below should be adaptable to most countries and conditions.

5.2 PROJECT PLANNING:

Operational activities and procedures should be integrated into the planning process to insure their eventual implementation during project operation. Aspects such as funding, design for proper O & M, estimating O&M costs, hydrologic aspects, repayment for construction, contractual agreements, etc., should all be worked out during the planning stage. Personnel experienced in the O & M of projects should be involved in the planning process to provide practical input during this stage of project development. The following matters, among others, should receive strong emphasis.

5.2.1 Funding:

Plans must be made at an early stage of project planning to determine the O&M funding requirements including source, amount, and continuity. Many projects fail or experience rapid deterioration as a result of inadequate O & M funding, therefore, it is imperative that an O & M funding source (s) be

identified early. If multiple sources are anticipated, they should all be identified along with the facilities that each will fund. These matters should all be documented and agreements consummated among the involved parties. Assurance should also be provided that this funding will be continued on an indefinite basis.

5.2.2 O&M Cost Estimate:

During the planning stage of a proposed project, an O&M cost estimate should be made based on developed procedures and past experience. All systems should have at least a reserve fund to provide for unforeseen conditions. The O&M budget or cost estimate made prior to project operation is primarily a starting point relative to actual O&M cost needs. Obviously the best indicator of the actual needs for project operation is operational experience. Comparison to similar project and conditions is usually reliable also. After the system has been operated for one or more years, an evaluation of O&M cost and budget should be made and appropriate change made. Adjustments should be timely as there is a strong tendency to resist significant upward changes once the budget figure has been established.

5.2.3 Drainage Requirements:

For many project developed in the past and even some being presently developed, drainage needs (particularly subsurface) have not been adequately analyzed and/or handled. The deterioration and inability of projects to realize potential benefits can and are often attributed to inadequate attention to this factor.

Drainage requirements should be determined during the project-planning phase and definite funding identified and scheduled for use as needed. Costs for drainage are often significant and can have an adverse effect on project feasibility and benefit cost ratios. Because of the subtle nature of drainage problems and the fact that they are usually not apparent until after some years of operation they are often ignored. The USBR Drainage Manual ([3]) is a good

reference which describes all aspects of planning, design, construction, operation, and maintenance for a satisfactory subsurface drainage system.

5.2.4 Repayment and Contractual Agreements:

Prior to project operation, a contract is made between the Bureau and the irrigation district or other operating entity which stipulates repayment provisions, O & M requirements, and other responsibilities of each party. Irrigation districts usually repay that portion of the construction charge that is within their economic ability to repay based on project conditions. All O&M costs are paid by the district, either directly or to the Bureau for facilities that the Bureau operates.

5.3 DESIGN AND CONSTRUCTION:

Although these phases of project development are not directly related to O & M, they are a key factor in attaining future satisfactory O&M of a project. Before design starts and periodically during the design stage O&M personnel should have an opportunity to review all designs and plans to provide input from an operational viewpoint and assure that past lessons learned are used. Personnel who perform this review should be experienced in actual O&M of a project. it is also an excellent idea to provide an opportunity for design personnel to visit similar projects under operation to observe problems and conditions first-hand.

O&M personnel should also be involved in the construction phase of the project. A good process is to have operations personnel on site during construction to input into the process from an O&M viewpoint. This provides an excellent opportunity to write O&M manuals (rules, regulations and instruction), assure operational integrity, and become acquainted with all aspects of the project for future O&M. As mentioned before, it is also very advantageous for these people to have previous O&M experience. In some cases, if the O&M of project facilities is to be transferred to another operating entity such as an irrigation district, experienced O&M personnel on-site can provide a smooth

transition in this process. They can also provide valuable input, in formulating policies and procedures; organizational and O&M personnel and equipment needs; and funding requirements.

The concepts and processes described above apply to new projects as well as those being rehabilitated.

5.4 TRANSFER OF FACILITIES:

It is the general practice of the USBR to transfer most single-purpose irrigation facilities to an irrigation district for O&M. Dams which serve multiple purposes and large supply canals which serve two or more entities or purposes may or may not be retained by the USBR for O&M depending on conditions. Essentially all distribution facilities are transferred to and operated and maintained by an irrigation district.

After construction is complete and prior to transfer of project facilities to an operating district, a pre-transfer examinations held to determine the adequacy of the system for operation. A report is written on this examination describing the status of system facilities, the system's, adequacy for operation and the deficiencies identified and scheduled for correction (including responsible party). A transfer date may then be set. This formal transfer process is important so that all parties agree on and are aware of the transfer date and conditions and that all legal and practical factors are satisfied. This process is described in more detail in Appendix 1.

5.5 ORGANIZATION AND RESPONSIBILITIES:

The general organizational structure of the USBR is shown in Appendix 1. The USBR is the primary agency in the United States for planning construction, operation maintenance and overall watch and assistance to irrigation districts. The specific roles and responsibilities of the various O & M offices in the Bureau are as follows:

- Commissioner's Office (Bureau-wide)
  - (a) Formulates O & M policy for the Bureau

- Engineering and Research Center (Bureau-wide)
  - (a) Provides technical assistance to other offices
  - (b) Develops training programs an assistance in some training
  - (c) Develops technical standards
  - (d) Provides periodic review of facilities
  - (e) Reviews plan, design, reports, etc., related to O & M of facilities and infrastructure.
- Regional Offices (Region-wide)
  - (a) Direct responsibility for all O & M activities in their area of jurisdiction
  - (b) Provide technical assistance and training to project and irrigation districts personnel
  - (c) Periodic review of facilities
  - (d) Provide O&M input to regional activities
  - (e) Fulfilment of contractual obligation – efficient water use, repayment and care of facilities.
- Project Offices (Project-wide)
  - (a) Direct O&M of facilities retained for operation by Bureau
  - (b) Provide technical assistance and training to irrigation district personnel
  - (c) Periodic and annual review of facilities
  - (d) Fulfilment of contractual obligation-efficient water use, repayment and care of facilities.

Irrigation districts, are a non-profit entity organized under state laws, operate many of the facilities constructed by the USBR. The organizational structure of an irrigation district consists of a Board of Directors (3,5 or 7 members are common) who formulate policy for O&M facilities. Provides guidelines for Irrigation District directors. Each Board member is a water user and is selected by the water users, thus policy formulation is made directly by the water users. Each director serves a prescribed term at the end of which

they are re-elected or replaced. The directors are not paid a salary. Board of Directors hires a manager who is responsible for the day-to-day operation of the district and who hires most other district employees. The USBR provides and retains certain overview and review functions throughout the project life and usually retains ownership in perpetuity. This is to ensure proper and continued operation of the project to attain intended benefits and protect the Federal investment.

5.6 OPERATION:

Written instructions are essential to the effective operation of an irrigation system. Without written instructions, essential procedures are easily forgotten or never known by operational personnel, resulting in premature breakdowns, use of improper procedures, unsafe practices, and discontinuity in operations, especially during changes of personnel.

The purpose of an irrigation system is to deliver water in a specific quantity at a proper place and time for development of land resource and assure increased yields in the large command. The purpose can be accomplished by proper and timely regular measurement of water in transient through the system including farm outlets. Water measurement is more important in shortage simulation and for equitable distribution and large no. of users.

A good communication system is another very important to the efficient and safe operation of an irrigation system. Reliable and rapid communication can aid greatly in scheduling routing and handling emergency problems. This may include telephones, mobile radios and all weather roads.

The operation of an irrigation system to assure equity, adequacy and reliability in water distribution in large areas among very large no. of users is really a very complex process and need professional managers and trained staff who are very adept in managing the systems for operation use on experience and "guts". Use of computers can assist in this process through the use on more sophisticated and efficient transmittal techniques, especially in

newly planned systems. A system scheduling programme for use in routing the water through distribution system may be used in conjunction with above programme to the extent it can be used.

The installation and use of automation techniques and equipment on newly planned water system will conserve water and more effectively routing trough the system but need to be thought over on availability for skilled operational and maintenance personnel.

5.6.1 Water Measurement:

Without proper water measurement, there is inadequate control of the water in an irrigation distribution system. The purpose of an irrigation system is to deliver water in a specific quantity at the proper place and time for the development of a land resource in an area. To accomplish this purpose, water must be measured both in storage and in transit through the system, including the farm turnouts. Water measurement should receive strong emphasis for all systems particularly if there is a potential shortage and if water is used for multipurpose. Adequate water control and measurement is necessary to meet legal requirements concerning water rights, to conserve water, to ensure equitable distribution and to establish and maintain a good relationship between owners, operators and water users.

Water records should also be kept to compile a record of water deliveries, supply, wastewater, etc., for operational and / or legal purposes. These records can often be kept with the assistance of a small computer which has multiple uses in the management of an irrigation system.

There are many different devices and procedures for proper measurement of water in an irrigation distribution system.

5.6.2 Communication System:

A good communication system is very important to the efficient and safe operation of an irrigation system. Reliable and rapid communications can aid greatly in scheduling routine and emergency work and are usually a very cost-

effective item. Communication systems may include telephones, mobile radios (vehicle mounted or portable), and all-weather roads. Special efforts should be made to maintain a good and complete all-weather road system on the main parts of the project. Since modes of communication, availability and reliability of equipment, and maintenance equipment vary from place to place, it is usually a good idea to evaluate availability and obtain a system which is modern and has proven reliability for the conditions. Maintenance equipment, personnel, and costs must be considered when upgrading or obtaining a new communication system.

5.6.3 System Operation:

Determining the amount of water available and / or needed in a system at any given time and routing the water through the system for optimum use are often complex processes and do not usually happen by accident. Very often O&M personnel are very adept at managing water-based systems on experience and "gut" feelings. As the water management process becomes more complex, computers are often being utilized to assist in this process through the use of models and more sophisticated and efficient transmittal techniques. One such system has been constructed in the Yakima River Basin in Washington, which collects hydrometeorological data from the watershed and reservoirs, and stores the data for use by software programs or other uses. A large computer stores data for the entire Columbia River System of which the Yakima River is a tributary. Ultimately, releases may be made automatically from dams and canals through the use of additional programming and modeling.

A system scheduling program for use in routing the water through the distribution system may be used in conjunction with the above program. After identifying specific quantities of water needed at each turnout (by on-farm scheduling procedures), the system scheduling program assists in efficiently routing the water as needed. By integrating these needs, releases may be specifically planned and accomplished by using these programs and

techniques. On-farm irrigation scheduling can further refine these techniques and determine consumptive use needs of specific fields and schedule water needs accordingly.

Adoption of some or all of the above-described procedures and programs will often depend on water availability, crops produced, and complexity of system; however, they all will usually lead to more efficient operation. The degree of complexity or simplicity should be adapted to the system and conditions so that it can be further developed if needed in the future.

5.6.4 Automation:

The installation and use of automation techniques and equipment in a water system will conserve water, aid in more effectively routing water through the system, and provide a smoother and safer operation. Automation is sometimes a misconstrued word but its use is becoming more and more common and may consist of simple local controllers to an integrated supervisory control system. Its use should be evaluated for all water systems to determine feasibility, need, and cost effectiveness.

One factor, which sometimes discourages the use of automation techniques, is the requirement for skilled maintenance and operations personnel. As the equipment and procedures become more popular, however, O&M requirements are becoming more standard and easier to perform. The initial cost of some automation equipment has also become much less costly and more reliable as technological advances are made.

5.7 MAINTENACE:

A main objective of any irrigation system should be to attain a high level of O&M and maintain it on a sustained basis. One of the most reliable way to reach this objective is through the use of periodic review of the O&M of the system. The purpose of this review is to evaluate, discuss, and identify deficiencies in the OMM of the system. This review should be done by some

one from "outside" the project who is experienced in system O&M and evaluation. The purpose of this is to attain an unbiased evaluation of past system operation, maintenance, and management activities. Factual data should however be available to the reviewers. A report is written describing the findings of the review including deficiencies in the O&M, by priority. A schedule should be developed for correction of the problems by responsible parties.

This has been a very effective Bureau program for reviewing the condition of facilities and attaining standards for O&M. In many cases it is the only history of O&M for the system facilities and it provides excellent project continuity and credibility.

Availability and use of equipments are quite often extremely useful for timely and proper maintenance. One general rule, which appear to all conditions, however, is that the need should be assured before buying a piece of equipment. Equipments provides quick facility and quite often cost effective as well. There were well maintained unit of essential equipments normally at most of the Headworks of Canal Systems and other major structures to tame care of time bound repairs in short and limited canal closure periods. With time the practice has been faded away resulting into continuing deterioration of conditions of important structures and gross neglect of preventive and other essential repairs.

The number and type of personnel required to efficiently operate and maintain and irrigation system varies with country philosophy, crops grown and type of system. With the Development of useful equipments the strength of personnel can be controlled and substantial important requirements can be fulfilled by seasonal workers which has been the practice on all major works for regulation requirements. Maintenance of equipments and facilities is obviously one of the most important and critical aspects related to efficient delivery of water and maintenance cost may account for atleast 50 percent cost of total O&M Budget as per experience by USBR.

5.7.1 O&M Roads and Right-of Way:

An irrigation system cannot be properly operated and maintained without adequate O&M roads and Rights-of-Way. The road requirement will vary somewhat depending on the type of maintenance procedures and equipment used but in any case adequate roads must be maintained to accommodate the proper maintenance equipment and to perform surveillance and make water deliveries. If heavy mechanized equipment is used, for example, the roads must be adequate to pass that equipment. Ditches that are cleaned by manual methods would have a lesser requirement. Criteria for O&M road requirements on canals, laterals, etc.

5.7.2 Public Relations:

This is an aspect of operation that has received little emphasis in most districts in the United States until the last 10-15 years. It is now being emphasized in many districts. An irrigation district is usually a very important and integral part of the community in which it is located and it affects most people in the area. It is therefore important that the people are aware of the project purpose and how and why it is operate in certain ways. As people become more aware of safety, environmental, cultural, social, and other effects of the project, they want to know and should be made aware of and informed of what is being done to minimize harmful effects and maximize benefits. This can best be done be providing periodic on-the-spot information on project facilities, operations, unique problems, emergencies, etc., and what is being done about the conditions. Bulletins, news releases, annual reports, tours, news letters, etc., can be used to disseminate this information.

5.7.3 Written Policies and By-Laws:

In addition to written operating instructions for system facilities, a documented set of rules and regulations containing the overall policy of the operating organization should be in place and enforces. This makes the job of the directors, managers, and other personnel much easier as it leaves no question of what the rules are. If situations come up which are not covered, a

policy should be established as soon as possible for this situation and made a part of the written policy. This is especially important since it often occurs that directors must make decisions which adversely affect other users who may be friends an neighbors. Written rules make this process much easier and equitable.

In establishing a new irrigation system it is often a good idea for experienced O&M personnel to write the first set of rules and policies of the operating entity. As operations continue, the rules and policies can be modified to more closely suit the actual conditions.

5.7.4 Training:

Training of district personnel is often one of the most important but neglected aspects of the operation of irrigation systems. Often the day-to-day work and pressures take priority over training needs and, unless it is scheduled and followed through on, it often is delayed or never takes place. Training programs for all types of personnel should be developed and implemented and documented similar to other operating instructions of the district. These programs should include specific training for certain functions, such as ditch riding, pump repair, dam tending etc., and general programs, such as workshops and seminars with other who do similar work. Seminars are a good avenue for obtaining new ideas, exchanging methods of O&M, and developing channels of communication.

1. In the USBR, workshops, seminars, water user meetings, and study tours provide training through technical sessions, exchanges of ideas, and observation and study of other systems and ideas. Some of these sessions include state water user meetings, Bureau-organized water user meetings, special sessions, Water Systems Management Workshops, dissemination of information through the Water Operation and Maintenance Bulletins and other current literature. Most of these sessions are held annually to maintain current knowledge. Appendix 1 contains general training requirements for operation and maintenance personnel.

5.8 ADAPTION TO DEVELOPING COUNTRIES:

As mentioned earlier in this discussion, the policies, procedures, and programs outline here were developed and pertain primarily to project constructed by the USBR. In general, this operational philosophy is adaptable to most irrigation projects; however, on-site local conditions must be considered and applied with flexibility. In fact, application in the United States is not uniform and varies with climate, soils, crops grown, management philosophy, O&M funding, system condition, etc. Consequently, it should be expected that application in developing countries will vary considerably since on-site conditions can be significantly different. Some examples of possible means of implementation follow:

A key element in successful irrigation district operation is direct involvement of the water users. Operation and maintenance of an irrigation project by an irrigation district as described in this chapter is one way to accomplish this purpose. However, any organizational structure, which has direct user involvement in policy decisions and in overall management of the project, will accomplish this purpose. A key element of this process is that all formulate policies rules, regulations, etc., are documented they are enforceable, if not, they cannot be enforced uniformly and they will ultimately be useless.

As mentioned earlier, the concepts and processes discussed in this chapter should generally apply to all irrigation projects. Judgement, experience, and knowledge must be exercised in applying them to on-site conditions.

5.8.1 Brief discussion

Large number of water resource systems in USA have been planned, designed and constructed from early part of 20^{th} century when level of development of engineering sciences and technology had substantially established. These systems have been very carefully and methodically operated and maintained with a clear policy of retaining ownership in perpetuity to attain intended benefits and protect Fedral investment.

In many other developing countries, many major canal systems were projected right from mid of nineteenth century, when engineering practices of design and construction were not developed for hydraulic structures. These systems though built on simple bold design and careful construction are being operated over a very long time with increased supplies and under varying adverse conditions to meet out present day requirement of intensive irrigated agriculture.

In view of above proper operation and careful maintenance with valuable input of long past professional experience is extremely necessary to achieve efficiency in operation, economy in maintenance and attain assurance for long future with dependability.

5.9 IRRIGATION MANAGEMENT IN TAIWAN, CHINA

Since 1945, the organization responsible for irrigation management has been called irrigation association, which is organized by farmers receiving irrigation benefits from the facilities operated and managed by the association. The service areas of the associations are divided according to water regions.

Usually the irrigation associations undertake the construction work of an irrigation project having a service area of less than 500 ha. All larger projects are handled by the government, with the facilities constructed to be turned over to the irrigation association for operation and maintenance after completion.

Water use and control in Taiwan are governed basically by the Water Law. The irrigation associations are organized and operated in accordance with the General Rules Governing the Organization of Irrigation Associations, and the Regulations Governing the Administration of Irrigation Undertakings in Taiwan, respectively.

The major functions of irrigation associations are:

1. Construction, improvement, operation, management and maintenance of irrigation and drainage facilities.
2. Preparation of irrigation plans and regulation of water distribution.
3. Settlement of water disputes among farmers.

4. Collection of ordinary membership fees for financial operation.
5. Collection of engineering costs for loan repayment.
6. Study of ways to expand irrigation and drainage benefits.
7. Coordination with the government in carrying out policies on land and water resources development.

5.9.1. Organizational Status

Irrigation associations underwent recoganization several times after 1945. At present, there are 17 irrigation associations, of which 15 are in Taiwan Province and 2 in Taipei City. In addition, there is a joint irrigation association for coordination of activities of all the irrigation associations. According to the size of their irrigation areas, the associations are divided into three classes: Class A (more than 50, 000 ha), Class B (50,000-20,000 ha), and Class C (less than 20,000 ha).

The chairmen of the irrigation associations are elected by the members representatives, who in turn are elected from among the members of the associations. The number of representatives for an association is determined on the basis of the size of its irrigation area (Table 1).

Table 1: Irrigation area vs. number of member's representatives

Area, ha	No. of representatives
100,000-50,000	47-41
50,000-30,000	39-33
30,000-20,000	31-29
20,000-10,000	27-25
Less than 10,000	23-15

The representatives are responsible mainly for the election and recall of chairman, screening of financial reports, discussion and approval of operational plans, determination of membership fee rates, and study of matters proposed by members. They are only paid an allowance for the time spent in the meetings.

Both the chairmen and the members' representatives are elected for a term of four years. The chairmen can serve only two terms if re-elected, while there is no such limitation for the representatives.

5.9.2. Head Office

The Chairman represents the irrigation association and is assisted by a general manager in performing the functions of the association. A chief engineer is assigned to an association of Class A, and a principal engineer assigned to an association of Class B, to take care of the technical and engineering matters of the association. For an association of Class C, the position of a chief engineer or a principal engineer is not provided.

In the head office of the association, there are two main divisions, engineering and management, which are directly concerned with irrigation. The former is in charge of planning, layout, survey, design and construction of irrigation projects, while the latter is in charge of operation, management and maintenance of the completed irrigation works. However, an association serving less than 20,000 ha (Class C) has only a management division to take care of all the technical and engineering matters.

The head office of the association also includes a finance division, an administrative division, an administrative division, an accounting office, a personnel office and a security office, which take care of matters in their respective areas.

5.9.3. Working Stations

Under the head office of the association there are working stations, which perform most of the work of the association in the field. The management division in the head office exercise direct supervision over the irrigation working stations. Each working station handles an area of 1,000-2,000 ha. For a large irrigation system, there are also water source working stations and main canal working stations, which are parallel in function to the working stations.

5.9.4 Rotational Irrigation System

Water shortage happens sometimes during dry season. For effective water distribution to minimize drought damage, a rotational irrigation practice has been adopted especially for dry seasons. The system is a method of water control through measurement devices to supply water in specific amounts to the field at scheduled times.

Generally, the entire project area is a blocked into district of about 50 ha each, which is called a "Rotation district". Each district further divided into five or six rotation units, takes water from the lateral through a turnout gate to irrigate the units inside the district one by one. Delivery structures include head-gates and turnouts. The head-gates are installed at the branch points of the main channel and the laterals,

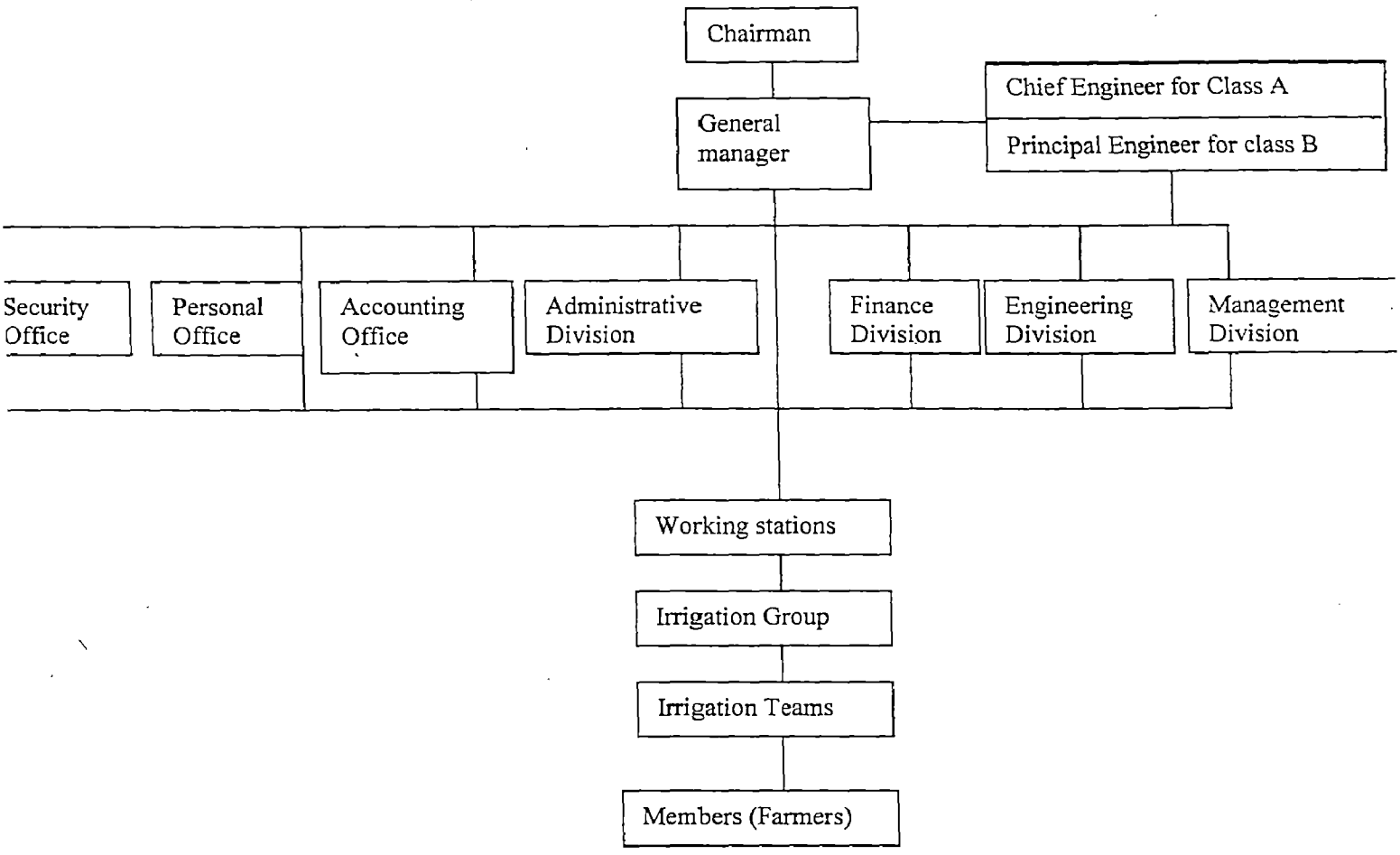


FIGURE 1: Organization chart of Irrigation Associations Class A and B

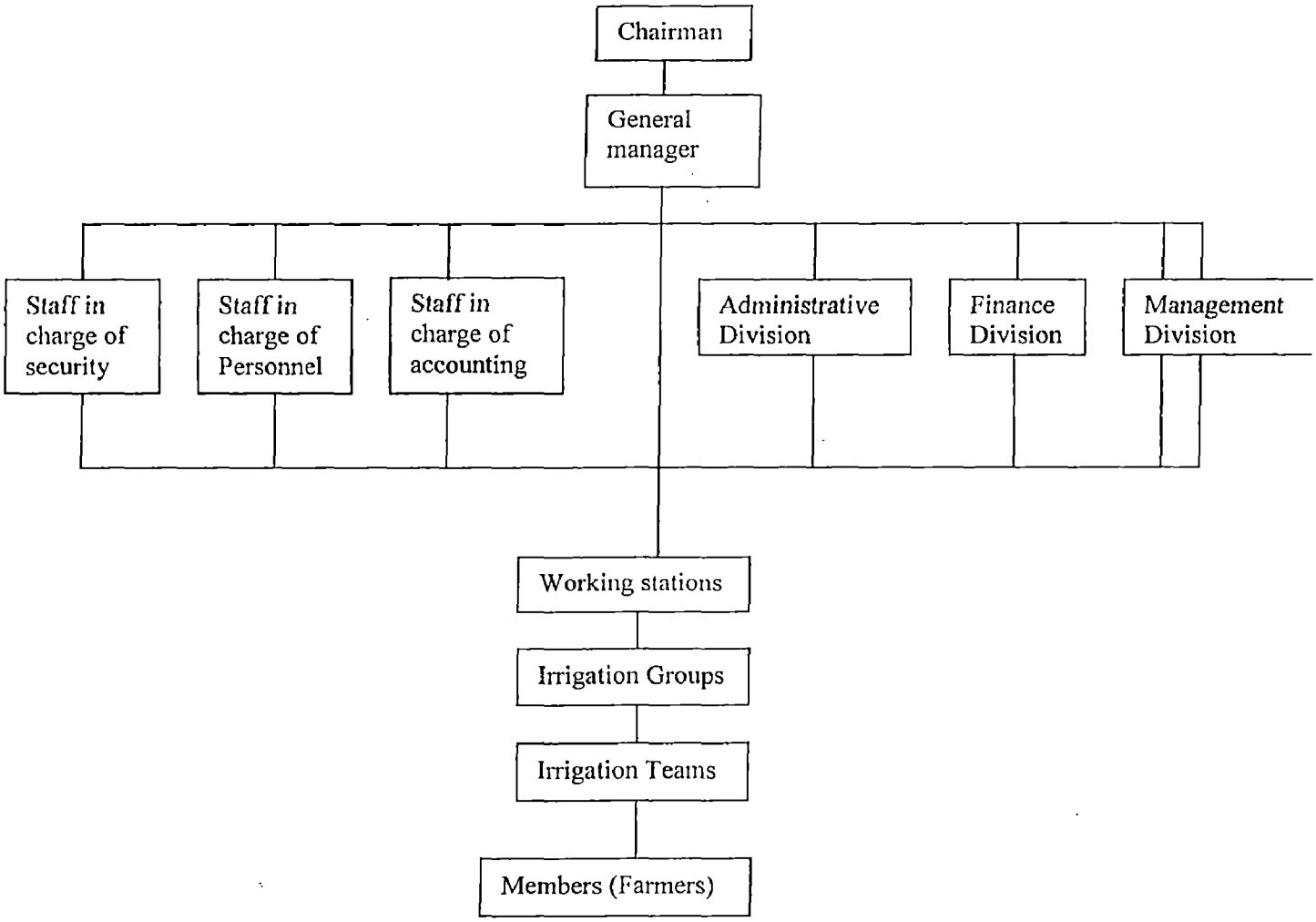


FIGURE 2: Organization Chart of Irrigation Associations Class C

While the turnouts are installed at the beginning points of the farm ditches of the rotation districts.

To avoid stealing of water, special gates of different sizes have been manufactured for water delivery. These gates are equipped with combination locks, which are specially made and can be opened only by operators in charge of them. Water measurement devices are important in water control and are installed at the water delivery points. The most commonly used measurement devices in Taiwan are parshall flumes, weirs, and constant head orifice gates.

5.9.5 IRRIAGATION OPERATION

The technical staff of the irrigation association operates and controls water delivery at main canals and laterals. From turnout gates through farm ditches to individual fields, the water is distributed by the irrigation groups under the supervision of the association staff. It is more effective for the association to undertake irrigation operation and management in farms after consolidation.

Usually, the management division in the head office of the association prepares annually an irrigation guide according to past experiences, government policy, production goals, water sources available, etc., for distribution to the local working stations. Then meetings with the irrigation groups will be called to discuss and work out detailed irrigation plans, which will be reported to the head office for approval and compilation. The irrigation plan will include the name of the canal system, number of rotation districts, names of irrigation groups, estimated amounts of water from different water sources, irrigation methods and intervals, kinds of crops and areas to be planted, conveyance losses, water requirements of seedbeds and main fields, times of irrigation, water delivery schedules, etc.

The water delivery schedule may be revised to meet actual needs when it is put into operation, by taking account of the actual water sources and amounts of effective rainfall during the irrigation period. When water shortage occurs and the available water is not sufficient for regular or normal irrigation, a strict rotational irrigation plan will be followed.

Records of the irrigation work done are prepared by the working stations and reported to the management division in the head office for checking and for reference in future irrigation planning.

5.9.6. Irrigation Maintenance

In addition to operation and management, the association is also responsible for maintenance of the irrigation and drainage facilities which should be properly maintained. The maintenance work is generally divided into three categories, namely, routine maintenance, annual repairs, and emergency repairs.

The routine maintenance is to make immediate repairs on the spot upon discovery by the patrolmen. The annual repairs are to be made during the suspension of irrigation to insure proper operation of the facilities for the next irrigation season. The emergency repairs are mainly made after flood damage. When the flood damage is heavy, financial aid and technical assistance are required from the government.

The costs of the routine maintenance and the annual repairs are usually paid out of the associations' own budget.

5.9.7. Financing

1. Financing of Irrigation Projects

Sources of financing for irrigation development and improvement project include grants from the government and loans from the Joints Irrigation Loan Fund. Loans are to be repaid with interest by the project beneficiaries, whose repayment ability is determined by the amount of the loan and the benefit to be derived from the project.

Before 1960, for new irrigation projects, the East Coast received 70 per cent and the West Coast 50 per cent of the financing in grants. For the improvement projects such as rotational irrigation, supplementary ground water irrigation and canal lining, the percentages of grants were lower and depended on the annual budget availability.

Furthermore, in 1976, the government made a special appropriation of NT$ 300 million to the irrigation associations to help them pay their outstanding debts, which had been a heavy burden to them due to improper subsidies for the projects implemented in the past.

Because land and water resources are limited, new development is no longer feasible. Since 1973, attention has been paid to the improvement, strengthening and repair of existing irrigation and drainage facilities to prolong their service life in the interest of agricultural production. At present, the above-mentioned improvements of the existing facilities are financed with government subsidies amounting to 60-90 per cent of the total cost according to the financial situation of the irrigation associations. The balance is met by matching funds provided by the associations either with loans or with their annual budgets.

2. Financial Operation of Irrigation Associations

The irrigation associations may collect fees from their members. The annual budget for financing their regular operation comes mostly from the collecttion of ordinary membership fees, for which different rates are set according to water use. In principle, the total amount of the collected membership fees must meet the annual requirements for administrative and personnel expenses as well as irrigation operation and maintenance costs.

However, the rates were already fixed 30 years ago between an upper limit of 300 kg and a lower limit of 20 kg of paddy per hectare per year, which are collected in cash according to the prevailing price: and in addition, personnel expenses, labor wages and material prices are increasing, and it has been financially difficult for the associations to fulfil their responsibility in irrigation operation and management.

The total annual collection of the ordinary membership fees from the 15 irrigation associations in the Taiwan Province and their total disbursement during the last decade. It is obvious that most of the collection of the membership fees is used for personnel expenses which amounted to 35.37 per cent in 1976 and increased to 73.95 per cent in 1985, because of the fixed membership fee scales. The highest percentage of 92.53 appeared in 1981. Accordingly, the

annual budget for the maintenance and improvement of the facilities has been reduced yearly from 33.22per cent in 1976 to 14.77 per cent in 1986.

5.9.8 Brief Discussion

Irrigation management organization has been reorganized many times according to historical and social background. Now, the organization is called irrigation association. There are 17 irrigation associations which are organized by farmers according to water regions. Most of the irrigation and drainage systems in Taiwan are operated and managed by them. In the head office of each association, there are divisions for taking care of respective fields. Among them, the management division is responsible for irrigation operation, management and maintenance of the systems. Under the head office of the association, here are local working stations to take the place of the association in carrying out most of the irrigation management work in the fields in cooperation with irrigation groups, which are organized by the members of the association as fundamental units for water distribution at the farm level.

Usually, the staff of the association operate and control water delivery at main canal and laterals. The members of the irrigation groups handle water distribution form turnout gates through farm ditches to their fields under the supervision of the staff of the association. When there is water shortage, a rotational irrigation practice should be followed according to the predetermined time schedule so as to minimize drought damage. On the other hand, operation of regulation gates is also very important during rainy season for the prevention of irrigation facilities and crops from flood damage.

5.10 USSR EXPERIENCE IN IMPROVED IRRIGATION MANAGEMENT

5.10.1 Failure of the Project

In many cases the deteriorated state of irrigation facilities as well as outdated engineering decisions and inadequate irrigation techniques are also to blame for poor efficiency of irrigated farming. Since the growth of crop yields from decade to decade is obviously due to the introduction of high-yielding varieties,

rational application of fertilizers, regular and well time field practices. So that only serious violations of irrigation rules and the advanced field practices are to blame for failures in achieving the planned indices. The typical violations as related to irrigated lands commonly manifest themselves in the following:

- Failure to observe irrigation time and rates.
- Improper condition of irrigation network, structures and irrigation facilities.
- Deterioration of topsoil.
- Under-use of organic and mineral fertilizers much below the rates envisaged for obtaining the planned crop yield.
- Non-observance of cultivation schedule and field practices.
- Deficiency in qualified personnel (operators of sprinkling and other irrigating machinery, agronomists, economists, etc.)
- Insufficient skill of or shortage in land users.
- Underestimation of secondary crops (e.g. maize or alfalfa within the cotton growing zone).

5.10.2 Improvement and Maintenance:

For long time it had been common practice in the USSR that the maintenance of large canals and drains was under taken by the maintenance bodies of the Ministry of Land Reclamation and Water Management (Minvodkhoz), budget by the government, by collective and state farms at their own expense.

The criterion for the adoption of a project, as usual, is the capital payback within the specified period in terms of the net income resulting from the planned measures. The net income from the rehabilitation is formed in the following ways:

- Increase in the productivity of irrigated lands as a response to the improved water application technique.
- Enlargement of the productive area (through the use of underground canals and drains instead of open ones).

- Rise of productivity of labour in water application.
- Enlargement of irrigated area due to the saving of water by means of canal lining, land levelling, and introduction of water-saving application techniques (drip, subsoil and mist irrigation).

1. Rehabilitation of irrigation schemes may become urgent in the case of deterioration of soil conditions, which is a typical reason for underproduction on irrigable lands. In the majority of cases soil deterioration occurs as a result of irrigation in drainless conditions. Such a situation is usually a consequence of the development of water less plains in the arid zones, formed of clayey soils with initial occurrence of ground-water table at a depth of more than 20 m below surface (sometimes 50-60 m). Usually in such cases technical reports of the proposed irrigation scheme recommend the installation of tile drainage by the time when the ground-water table reaches the elevation of 10 m below the surface. But the practice shows that such recommendations are seldom realized.
2. The drainage is started to be thought of only when the ground water nearly reaches the surface. In such a situation the drain construction cost is two to three times more as compared to that with a lower ground-water table. And if drainage construction is delayed for several years, the topsoil might become saline. If the degree of salinization is high enough to require leaching by flooding, there is a further rise in the total cost. There are also cases when irrigation had been started before the desalinization of the initially saline topsoil, and in such situations too rehabilitation may become necessary.
3. The improvement of soil conditions also includes efforts for maintaining the soil reaction close to neutral. The gypsum application may also become necessary on initially neutral soils if water for irrigation contains significant amount of sodium ions.
4. The preservation of the soil fertility must be given during the land levelling work, especially in the case of a thin topsoil layer.

5. Another kind of rehabilitation aimed at ensuring the planned yield is to minimize the water deficiency within the irrigation scheme by undertaking all possible measures to stop water losses due to mismanagement.
6. The provision of full-scale social infrastructure in the area of new irrigation development seems to be of particular importance. Such infrastructure includes well-arranged modern dwellings, roads, and cultural and service facilities. The higher the level of this activity, the greater the chance to attract more experienced and industrious labor for new irrigation schemes. The development of the desert lands of the Golodnaya Steppe in the Uzbek SSR fully proves the correctness of this approach.
7. The establishment of cooperatives (even in the case of individual implementation of the major part of the work) allows the farmer to invite skilled specialists, especially agricultural economists, whose experience and knowledge can substantially reinforce the efforts of the farmers to attain high yields.
8. Integration into cooperatives with the common brain center can also help to overcome some traditional concepts of a certain living wage level which is not considered worth while to surpass (one of the authors has met such an approach among the colonists of a new Irrigation scheme in North-East Thailand).
9. Discussing the ways of increasing the productivity of irrigated lands one should not forget that the production sphere, to take care of, it is not enough just to grow and harvest crops. Particular efforts shall be made to avoid losses in storage and during transportation of products. Motor roads for the safe transportation of crop on the irrigation land should not be less than 3-5 km per 1000 ha. Providing the sufficient number of processing factories, storehouses refrigerators (including truck-mounted, railroad cars and ship- borne ones) is a necessary pre-requisite for efficient use of irrigated lands.
10. The practice shows that in most cases the cropping pattern is formed traditionally and often does not reflect all regional possibilities.

5.10.3 Brief Discussion

Improved irrigation management is considered a top priority task in the agricultural development of the USSR. This major goal is being achieved by carrying out the following general tasks: obtaining the planned yields of irrigated crops, optimization of the cropping pattern, proper maintenance of Irrigation facilities available, along with the timely rehabilitation of outdated irrigation schemes. The authors are confident that the measures under taken in the USSR in this domain and presented in this paper could be of interest to professionals in developing countries in spite of the existing differences in socio-economic conditions.

5.11 MANAGEMENT OF WATER DISTRIBUTION BY OSRABANDI / WARBANDI IN INDIA

The distribution of water in Warbandi system is a two tier operation and each is managed by a separate agency. In the upper tier which is managed by state, all distributories and consequently watercourses are always operated with their full and not partial discharges. This reduces the runing time, and consequently the conveyance losses in distributaries to the minimum. Further, normally the distributaries are operated in eight- day periods (Haryana). The number of such eight-day periods depends upon availability and crop requirements. In the case of Bhakra project , in a normal year, it may be possible to operate them for 18 periods during Kharif and 16 periods during Rabi.

The system is tightly managed and hence is a deterrent against wastage. This model of running a distributary and its watercourses involves human control only at the distributary head leaving the watercourse head at the outlet to be automatic. To a great extent, the absence of human control at the watercourse head makes distribution foolproof. As the system minimizes the up and down running of a distribyutary or its watercourse with partial supplies, the conveyance losses in distributaries and watercourses are at their minimum.

This is one of the biggest achievements of this system. Decentralized management below the outlet minimizes the administrative costs but creates a

different type of problem. Cultivators can not afford to hire experts for giving them advice or for managing the affairs of their watercourse. They have to depend on their own experience. Their collective wisdom, sturdy commonsense ands innate ability to cooperate and unit during difficulties makes the system work fairly well, so far as the day to day administration is concerned. Each farmer contributes labour and money to the common cause of repair and maintenance of their watercourse. However, hey are not sufficiently organized for collective borrowing from any institution to improve their watercourse.

Under these circumstances sometime, the physical condition of a watercourse may be poor and its performance inefficient. Despite the success of the Warabandi system, absorption losses in watercourse below the outlet continue to be nearly 25 percent of the supply at its head. Losses are not the same for every body and they increase towards the tail reaches of a watercourse. Shareholders receive proportionate running time, but not necessarily a proportionate quantity of water. However, there is very little consciousness of this shortcoming in the distribution method and adequate measures normally should not be taken to remedy this problem. Lining of watercourses which is being undertaken in some states, will reduce the adverse effects of this shortcoming to some extent, but some absorption losses will still be there. The farmers do not maintain any record of the quantity of water received either at the watercourse head or at their fields and hence are ignorant of losses enroute.

In spite of this seeming imbalance, the two levels of administration have co-existed side by side, and the warabandi system as a whole has survived for over a century. It has come to be regarded as the only system which can ensure equitable distribution of water, even when there is a gap between supply and demand and that too in large commands will large number of users, without any administrative expenditure.

5.11.1 MANAGEMENT OF WATER AMONG USERS THROUGH OSRABANDI / WARBANDI (NORTHERN INDIA)

It is a mode of distribution of shares of water of an outlet amongst the beneficiaries cultivators, the share is basically decided in terms of time interval as a fraction total hours in a week for which an individual cultivator or a group of cultivators or a village is entitled to use. As the powerful and big cultivators started obstructing weaker section of peasontary from use of canal water, it resulted in dispute between them.

The necessary legislative to control and develop canal irrigation in Northern India. It empowered interalia, the state Government to regulate water supply from canal, to contract watercourses and field channels, to carry water from canal outlets to fields, to levy and collect water fees, to settle dispute regarding water course construction and maintenance and to distribute water among share holders on a watercourse. Executive Engineer Incharge of a canal division was the sole authority to settle disputes among farmers on sharing water on an outlet and finalise Osrbandi after receiving application from farmers.

OSRABANDI could be got prepared by Executive Engineer as his own initiatives and at Government expenses in the following cases:

(1) when the area commanded by an outlet cover more than one village.

(2) When any Government land was irrigated at the outlet.

(3) When a redistribution of outlet was carried out.

OSRABNDI was Generally not done In the following cases:

(1) When area commanded by fan outlet was very small

(2) The area was irrigated by wells.

(3) The area was situated on the far side of a drain or a low ground or lies outside the command of the outlet

5.11.2 System of Osrabandi

Three types of Osrabandi namely "thok-wise", "chak-wise" and "village-wise" can be prepared according to convenience of cultivators. At present Chak-

wise Osrabandi is in vogue in Western U.P as it is best suited to cultivators, specially after implementation of scheme of consolidation of agriculture land holdings against continuing fragmentation of available holdings.

The Osrabandi has been very well established in U.P. Punjab and Pakistan by mid of twentieth century and shall be in use successfully by farmers in Northern India.

5.11.3 Preparation of Osrabandi (Evolution of Successful Practice)

The beneficiary cultivators combine together to form a number of group Known as "thok". The share of water at different thoks is then decided on area basis. Head of the group (Thok) is known as Thokdar and distribution of water to the cultivators in a thok is done by thokdar

The Osrabandi operations are done by Ziladar under Deputy Revenue Officer or a Sub-Divisional Officer. The operations are done as speedily as possible and are required to be completed within three months normally, the various steps involved are as follows:

(i) Marking command area.

(ii) Preparing the map.

(iii) Preparing form 57-v

(iv) Preparing form 58-v

(v) Enaquiry by Deputy Revenue Officer-Sub-divisional officer.

(vi) Hearing objections on form 58-v

(vii) Preparing forms 59-v

(viii) Divisional officer (Executive Engineer) scrutiny and final sanction and distribution of final purchas $59\frac{1}{2}V$, the last final action. The necessary form used in U.P. (India) in Warbandi are appended at the end.

5.11.4 Benefits of Osrabandi

Osrabandi has become very popular on North Indian canals as well as Pakistan in water scarcity areas, due to following benefits:

1. Water is properly distributed and economically used.

2. Guls are also cleared and well maintained.
3. It has lessened conflicts between farmers.
4. Normally greater coverage of irrigated area has been observed after Osrabandi.
5. Offence of ignoring claims of individual farmers in Osrabandi are cognizable and a case could be instituted under North India canal and Drainage.

5.11.5 Brief Discussion:

To end the discussion, there is no doubt that Warabandi has very well established almost over hundred years in North India, U.P., Haryana, Punjab and the Pakistan canal systems clearly indicating self-discipline among farmers in distribution of water and also resulting into economical and better use of water by normally large number of users involved extensive command. Undoubtedly no where in the world. Such successful achievement could be cited. Where farmers without any traditionally established practices and traditional has been carrying with satisfaction the distribution of water peacefully in equitable manner, involving quite large numbers and extending over very large agricultural lands. But there is again a serious matter to examine why this well tried established system could not be expanded and used on a large scale in other parts of Indian Irrigated Agriculture. Several professionals Agronomists, Agricultural Engineers and Irrigation Engineers and the Administrators holding the key position shall have to think seriously for some Integrated approach with more commitment on this important matter of water management. Taking a lead and assisting other developing countries in the world which are keen to learn from rich experience of Irrigation system-operation and water management in India. Over almost long period of 150 years and covering very large areas and also large numbers of users.

SEARCH OF STRATEGIES TO IMPROVE O & M ON THE PROJECT

6.1 ADAPTABLE STRATEGIES FROM USBR

From USBR guidelines for operation and maintenance of irrigation systems, some strategies are studied and can be used with Namhuam Irrigation System in Lao P.D.R. as follows :

(1) Operational procedures should be integrated into planning, design and construction process. Personnel experienced in the O & M should be involved in the planning process to provide input, specially regarding O & M cost estimate, comparison to similar projects and condition is useful and reliable input. Evaluation of O & M cost budget be made with timely changes.

(2) O & M personnel should have an opportunity to review design and plans from operational view point and assure that past lessons are used.

(3) Provide an excellent opportunity to write required O & M manuals (regulation and operating orders and instructions) and also provide proper background for transfer of distribution facilities to users organization for operation and maintenance similar to irrigation districts in operation.

(4) Provide technical assistance and training to projects and irrigation districts.

(5) Irrigation districts consist of Board of Directors (3, 5 or 7 members) who formulate policy for O & M facilities, provide guidelines for Directors and each Board Member is water user and is selected by water users, thus policy formulation is controlled directly by water users.

(6) A good communication system is another very important to the efficient and safe operation of an irrigation system, reliable and rapid

communication can aid greatly in scheduling routine and handling emergency problems.

(7) Training of field personnel responsible for operation and maintenance, water users' meeting and study tours provide through technical sessions conducted by experienced and knowledgeable professionals within depth knowledge of such other systems.

6.2 ADAPTABLE STRATEGIES FROM TAIWAN IN CHINA

From the studied in the organization of irrigation management in Taiwan found that some strategies are suited and can be used in Lao P.D.R.'s irrigation management since Lao P.D.R. is developing country. Actually the service areas are scattered so that the project have been managed by farmers themselves and if the area is larger than 500 ha can be handled by the government.

The adaptable of the strategies in Taiwan in the below also may can be used in the Lao P.D.R.:

1. Construction, improvement, operation, management of irrigation and drainage facilities.
2. Preparation of irrigation plans and regulation of water distribution.
3. Settlement of water disputes among farmers.
4. Collection of ordinary membership fees for financial operation.
5. Collection of engineering costs for loan payment.
6. Study of ways to expand irrigation and drainage benefits.
7. Coordination with the government in carrying out policies on land and water resources development.

As mentioned in the above, due to the project and service area in Lao P.D.R., the organization chart of irrigation chart of irrigation association class 'C' it is studied. As the operation system involved:

1. Head of office, 2. Working station
3. Irrigation group and 4. Organization chart.

According to class 'C' the Chairman represents the irrigation association and is assisted by general manager is performing the function of association. The position of the Chief Engineer or Principal Engineer is not provided.

It has only a management division to take care of all the technical and engineering matters. Under the head office of the association there are working stations which perform most of the work of the association in the field. Irrigation group are also organized by member of the association as basic units for irrigation and drainage operation and management at the farm level, each handling an area of 50 – 150 ha. However, there have been various incentive measures taken by associations under guidance of the government.

6.3 ADAPTABLE STRATEGIES FROM RUSSIA (USSR)

The adaptation of this studied to Lao P.D.R., may some things could be adopted to be used, as the practice in the country is under guidance of the government staff by contacted with the farms located in the region which the policy can also be following:

- To increase the productivity.
- Rise of the productivity of labour in water application
- Enlargement of irrigated area due to the saving of water by mean of canal, land levelling and introduction of water – saving application techniques (drip, subsoil and mist irrigation).
- The rehabilitation of the scheme due to deterioration of soil condition and other problems & constraints.
- Giving the advice of using fertilizer to the farmers .
- To design of structure should be done after observed and analysis the data in the area.
- To increase irrigation network and irrigation facilities.
- Need to maintenance of cultivation schedule and field practices.
- Mobilize the fund and develop the human quality.
- Need the staff and leader to improve the skill of land user.

- Crop estimation and type of crop should correctly with the land and climate condition.

6.4 ADAPTABLE STRATEGIES FROM OSRBANDI / WARBANDI

Osrabandi has very well established water distribution practices among the farmers who land comes under command of outlet. In this practice the one week (U.P. practice) water delivery time is allowed to farmers according to their land holding. The osrabandi is very practical, simplest way to provide equitable water distribution. Before application of osrabandi the big or powerful cultivators started obstructing weaker section of farmers from use of canal water.

The Executive Engineer incharge of a canal division is the Authorised Officer from the government to prepare osrabandi schedule according to act, when the cultivators failed to agree on mutual settlement.

These are the following condition when osrabandi could be got prepared by the Executive Engineer even without any require form cultivators:

1. When the area commanded by an outlet cover more than one village.
2. When any government land was irrigated at the outlet.
3. When a redistribution of outlet was carried out.

These are the following advantages of osrabandi.

1. Water is properly distributed and economically used.
2. Water course are well maintained
3. There is no conflicts between farmers.

Osrabandi is the well established and tested method of water distribution, with on North Indian canal systems over a period of nearly 100 years with practically number administrative cost and least problems or court cases in dispute resolutions.

This is a well listed practice for equitable distribution of water from canals specially in scarcity conditions, specially when supplies are much less than the demands.

In India, there is a nation wide derive to implement it on other canal systems through CAD Programme (GOI) or WUA by States.

CONCLUSIONS

7.1 CONCLUSIONS

The proper operation of irrigation system is very essential in order to achieve the optimum result of agriculture production. Operation activities should be closely supervised and coordinated in order that the desired issues of water to meet the needs of the water users are attained. The ultimate goal of system water management is to deliver the right amount of water at he proper tie and at the right place and the removal of excess water from the farms to promote maximum production in conjunction with other improved cultural practices.

The operation and maintenance of Namhuam irrigation system consist of two parts:

(1) The O&M of irrigation at primary and secondary system, which is managed by the Government that is provincial irrigation service.

(2) The O&M of irrigation at tertiary system which is managed by the farmer.

In addition to the provincial irrigation service the provincial agricultural service has responsibility for the establishment of the water users association, training, and supervision of the farmers, and co-ordination among association officials.

Looking into the above management set up and the problems and constraints to attain the desired benefits the following conclusions based on in-depth study of other system in other countries are recorded:

USBR (USA) Practice of Operation Maintenance and Management of Irrigation System.

1. The concepts and procedures used successfully in operating and maintaining irrigation system in USA by USBR over a long period have been critically examined and discussed with a view to be adaptable to most countries and conditions, specially developing countries including Lao PDR.
2. O & M personnel should have an opportunity to review design and plans from operational view point and assure that past lessons are used.
3. This may provide an excellent opportunity to write required O&M manuals (Regulation and operating orders and instructions).
4. The USBR provide and retain overview and review functions throughout the project life and usually retains ownership in perpetuity to attain intended, benefits and protect the investment.
5. This review should be done periodically on an interval of 4 - 5 years, by some one from outside the organization of the project and who is really experienced in such system O &M and evaluation.

Taiwan Practice of Management of Irrigation System

1. In Taiwan are 17 irrigation associations which are organized by farmers according to different water regions, most of the irrigation and drainage systems in Taiwan are operated and managed by them.
2. In the head office of each association, there are divisions for taking care of respective field, among them the management division is responsible for irrigation operation, management and maintenance of the system.
3. The members of the irrigation group handle water distribution from turnout gates through farm ditches to their fields under the supervision of the staff of the association.
4. In order to facilitate irrigation management, improvements in water distribution system at the farm level as well as farm structures have been incorporated with land consolidation.

USSR Practiced Management of Irrigation System

1. Improved irrigation management is considered a top-priority task in the agricultural development of the USSR, this major goal is being achieved by carrying out the following general tasks: obtaining the planned yields of irrigated crops optimization of the cropping pattern, proper maintenance of irrigation facilities available, along with the timely rehabilitation of outdated irrigation schemes. The need for

rehabilitation should be taken care on priority as soon as it is considered necessary.

Management of Water Distribution Among Farmers by Osrabandi on Indian Large Irrigation System

1. Osrabandi on large Indians Systems specially in northern India has been very well established and successfully used over a long period of nearly 100 years. This has also been successfully used on Pakistan Canal System. There are no administrative expenditure in the practice of water management and it is quite simple and followed by farmers without any disputes. This can be tried in other developing countries and especially Lao PDR Irrigation System.
2. In this practice farmers are motivated to make full use of their share of water and also for better use, by making all efforts to control the wastage.

REFERENCES

1. Improvement in Irrigation Management with Special Reference to Developing Countries State of the –Art Number 4. Irrigation, Drainage and Flood Control 1987 International Commission Irrigation and Drainage (ICID).
2. Organization and Procedures for Optimum Operation, Maintenance and Management of Irrigation Systems, by Jerome (Jerry) M. Schaaak in 1987.
3. Irrigation Management in Taiwan, China by Ching Ho Kuo in 1987.
4. USSR Experiences in Improved Irrigation Management and Its Applicability to Developing Countries by N. S. Grishenko and A. S. Berezner in 1987.
5. Class note of an Osrabandi in Indian Canal by Prof. R. P. Singh WRDTC University of Roorkee Semester Autumn 2000.
6. Central Board of Irrigation and Power (GOI) Publication No. 157 (April 1982). The Warbandi System and its Infrastructure.
7. Project Report at Namhuam Irrigation System by Department of Irrigation in Vientiane 1986.
8. Irrigation Water Training Manual No. 10 by W. Bart Snellen, International Institute for Land Reclamation and Improvement Rome, 1996.

APENDIX 1.

SIMPLIFIED INSTRUCTIONS FOR THE REVIEW OF OPERATION AND MAINTENANCE OF IRRIGATION PROJECT AS SUGGESTED BY USBR

The Program

The Review of Maintenance Program is an essential Bureau-wide function necessary for the fulfilment of the Bureau of Reclamation's obligation to protect the federal investment and to assist water user organizations. Such reviews are necessary to assure satisfactory operation of the systems and to provide a basis for establishment of an orderly program of maintenance. The review of Maintenance Program covers all structures and facilities for which the Bureau is responsible either directly or indirectly. It covers reserved works, works transferred to the water users and other interests for operation, and works built by other agencies but forming an integral part of the Bureau's operating plant.

While directed primarily to the condition and functioning of the facilities themselves, the review program extends to the condition of related areas and structures, such as water-logging of lands, bank erosion, channel changes, reservoir silting, interference with drainage, buildings and appurtenances, working facilities for operating employees, and equipment. Maintenance records are studies and control conditions observed, including operating instructions, guide and warning signs, and other provisions for the safety of structures, equipment, employees, and the public.

Responsibility for the Program:

Examination of the Bureau's structures and facilities is a joint responsibility which requires continuing cooperation of all segments of the organization in the operating offices, the regions, and Denver. The Regional Director is responsible for the satisfactory condition and functioning of Bureau structures and facilities under his jurisdiction, for developing a comprehensive maintenance review program, for coordinating and guiding the scheduling and execution of

examinations of completed features and facilities, and for insuring proper follow-up on recommendations resulting from the review program.

These examinations, performed as a part of the Review of Maintenance Program, are conducted by teams selected by the Denver Office and the Regional Director.

Provision is made for informing Denver of the review program schedule so that arrangements can be made for participation as appropriate. Each employee cooperated in maintaining the safety and serviceability of the Bureau's works in accordance with his assigned duties and his opportunity for observation.

Effective with the transfer from construction to operation and maintenance status, responsibility for operation and maintenance passes form the head of the construction activity to the head of the operation and maintenance activity. This does not preclude later charges to the principal obligation for completions and corrections found necessary.

TRANSFER FROM BUREAU TO WATER USER OPERATION

Reclamation law and established Bureau policy provide for the transfer of the responsibility for operation and maintenance of works to irrigation, conservancy, water supply, or similar districts or other legally authorized water users' organizations. The transfer is usually made as soon as the works are reasonably complete and stabilized, and the water users' organizations has a competent staff and is financially able to operate and maintain the works. Arrangement for transfer of works from the Bureau to water users' organization also are initiated by the Regional Director. He notifies the commissioner with a copy to the Chief, Division of Water O&M, Denver, E&R Center, of his intention to make the transfer. His letter to notification of intention includes a general description of the works to be transferred, mentions any important or unusual problems that may be involved such as contract considerations, and establishes a schedule of the steps to be taken in effecting the transfer, including the following major ones:

(a) Making a joint inspection

(b) submission of examination report to the Commissioner with request for his concurrence and copy to Chief, Division of Water O&M

(c) Clearing of transfer by the Commissioner and Denver E&R center

(d) Notifying Commissioner and Denver E&R Center of scheduled date of transfer.

TRANSFER INSPECTIONS AND REPORTS

The inspections in connection with transfers of works either from construction to operation and maintenance or from the Bureau to water user operation cover the general condition of the structures and facilities; their sufficiency, and the availability of necessary operation and maintenance facilities, equipment, and instructions including Designers' Operating Criteria and Standing Operating Procedures with supporting documents, where applicable. Preparatory to the transfer of project works to operation and maintenance status, the structures and facilities to be transferred are inspected and reported jointly, if feasible, by operation and construction personnel.

The Denver E&R Center normally is represented on transfer inspections of major structures and of some nondelegated minor facilities where special problems exist. Preparatory to the transfer of project works to water users' organizations, the structures and facilities are inspected jointly by representatives of the Bureau and the water users. In conducting examinations of carriage, distribution, and drainage systems, it is not expected that each lateral, drop, check, farm turnout, or other structure in the system will be examined. A sufficient number of these features and structures are examined, however, to assure personal knowledge of the general operating conditions of all divisions or units of each project and each type of structure.

A report is prepared of all regional reviews of maintenance. All reports include the current findings, comparisons with previous records, and summarized conclusions and recommendations. The report should be

adequately illustrated with photo-graphs and/or drawings. Available observational records pertinent to the review also should be included.

An essential feature of every report should be information on whether or not each structure and facility is fully equipped with necessary instructions for care and operation. Each report after the first one also contains a list of the items of work recommended by previous reports which have not been accomplished and a short statement as to the reasons for not complying with the previous recommendations. Reports of regional reviews of maintenance are addressed to the Regional Director and one copy each forwarded to the appropriate operating office heads and water users' organizations, and copies to the Denver E&R Center, attention Code 400.

REVIEW OF MAINTENANCE BY THE DENVER OFFICE

Every sixth year, in lieu of the regular regional review of maintenance of principal irrigation structures and facilities, representatives of the Denver E&R Center, together with regional representatives, make a review of these features to check the adequacy of the maintenance program, to verify or further investigate the findings of previous reviews, to determine the condition of principal structures and facilities, and to develop technical information bearing on design and construction practice. Such reviews may be conducted more often if the Chief, Division of Water O&M, deems it necessary or the Regional Director recommends more frequent examination of specific structures or projects.

The review of maintenance of principal structures and facilities by representatives of the Denver E&R Center include storage and diversion dams, power and pumping plant buildings. The electrical and hydraulic machinery of the power- plants and the larger pumping plants are examined annually by the Division of Power Operation and Maintenance and, to avoid duplication, are not included in the Water Review of Maintenance Program unless a specific request is made. Smaller pumping plants not examined by the Division of Power O&M are examined under the Water Review of Maintenance Program.

Such structures as tunnels, siphons, and other features of the carriage, distribution, and drainage system may be included in the irrigation facility examinations made by representatives of Denver, although structures of this type are usually covered only in regional reviews of maintenance.

The classification of a principal structure or facility does not preclude examination by representatives of Denver of any facility the Regional director or the Denver engineers wish to have considered for structural or operational reasons.

When representatives of the Denver E&R Center make the review, they prepare a report similar to that required for regional reviews addressed to the Chief, Division of Water O&M. Copies are forwarded to the responsible Regional Director in sufficient number to permit distribution to the appropriate operating office head and water users' organizations.

PROCEDURES FOR REVIEW OF MAINTENANCE

To obtain uniformity and effectiveness in the Review of Maintenance Program and to promote proper relationships and avoid unnecessary difficulties. The following procedural instructions, as applicable, are followed by personnel making reviews:

(a) Prior to commencing a review of maintenance, examine the previous report, record drawings, and other sources of information concerning the facilities to be examined.

(b) Proper scheduling of examination trips is important. It should be done with a view to allowing ample time for the examination of each structure visited without requiring the participants to work unreasonably long hours every day. Where considerable time must be spent in driving from one structure to the next, it may be desirable to use a vehicle such as a station wagon large enough to accommodate the entire team. This will permit the use of driving time to reach agreement upon recommendations to be made and their categories. Equipment such as rubber boots, lights, etc., should be carried with the team.

(c) Be sure that the responsible operating officials are fully informed of the proposed review well in advance so that the necessary local arrangements such as draining of lines, removal of manhole covers, provision of ladders, furnishing keys, etc., may be accomplished before the arrival of the examining team.

(d) Avoid developing an atmosphere of a formal inspection. Be considerate and helpful, keeping in mind that good public relations are essential to the success of the program.

(e) Where water users' organizations have major interests and responsibilities, arrange, if possible, for members of the official board and representatives from the operating group to participate in the review.

(f) Be complimentary where appropriates, recognizing improvements and good work.

(g) Prepare a preliminary draft of important recommendations and discuss these with responsible officials before leaving the project.

(h) Group recommendations into three categories as follows, according to the importance of the problem involved:

Category 1. Recommendations involving matters of great importance which must be acted upon in a prescribed period. Complete records will be kept of all pertinent correspondence and reports. The Regional Director will be required to report the action taken on a Category 1 recommendation at 6-month intervals until the recommended action has been completed, and the progress made will be reported in the annual summary report to the Commissioner.

Category 2. Recommendation covering a wide range of important problems that should be solved. These recommendations will be included in the annual summary, and records will be kept of follow-up actions.

Category 3. Recommendations in the form of suggestions, which the review team believe to be, sound and would be beneficial to the feature or

project. This category of recommendations will not be included in the annual summary.

(a) Before a report is submitted to the Regional Director for concurrence, agreement should be reached with responsible project or regional officials on all Category 1 and 2 recommendations. Review teams representing the Denver E&R Center will reach agreement on proposed recommendations with the Regional Director and his staff before completing its assignment in the field. If agreement on recommendations cannot be reached, the circumstances shall be set forth in a separate memorandum to the Regional Director; Chief Division of Water O&M; or the Commissioner as may be appropriate before approval of the report is requested.

Summary Report:

A summary report on the Review of Maintenance Program is prepared by the Division of Water O&M in the Denver E&R Center and submitted to the Commissioner annually. This report outlines the accomplishments of the program in term of reviews made and the status of actions on recommendations with particular emphasis being given to the important recommendations made and placed in Category 1 on which the Regional Director is to report at 6-month intervals until the work required has been completed. Also, the annual report calls the attention of the Commissioner to significant problems.

Corrective Action:

Responsibility for initiating corrective action with to defective structures, facilities, or operating practices lies with the officials responsible for operation and maintenance of the work; i.e. the operating office head and the Regional Director. On receipt of a review of maintenance report, the Regional Director of head of the operating office initiates any required action and programs the work for execution. Whenever the items of work recommended cannot be carried out promptly or included in the program for next year, the operating office justifies its action to the Regional Director. As necessary, the Regional Director requests

the Denver E&R Center to undertake analysis and design work and to estimate the cost of remedial measures.

Reports of reviews of maintenance continue to list the recommendations contained in previous reports and show the status of action on them until the required action has been completed and so reported. The reports are reviewed by the Denver Office to determine the adequacy of the program and follow-up Within 6 months after receipt of a report of a review of maintenance conducted by the representatives of the Denver E&R Center, the Regional Director submits to the Denver E&R Center, Code 400, a statement outlining the actions taken or under consideration on Category 1 recommendations.

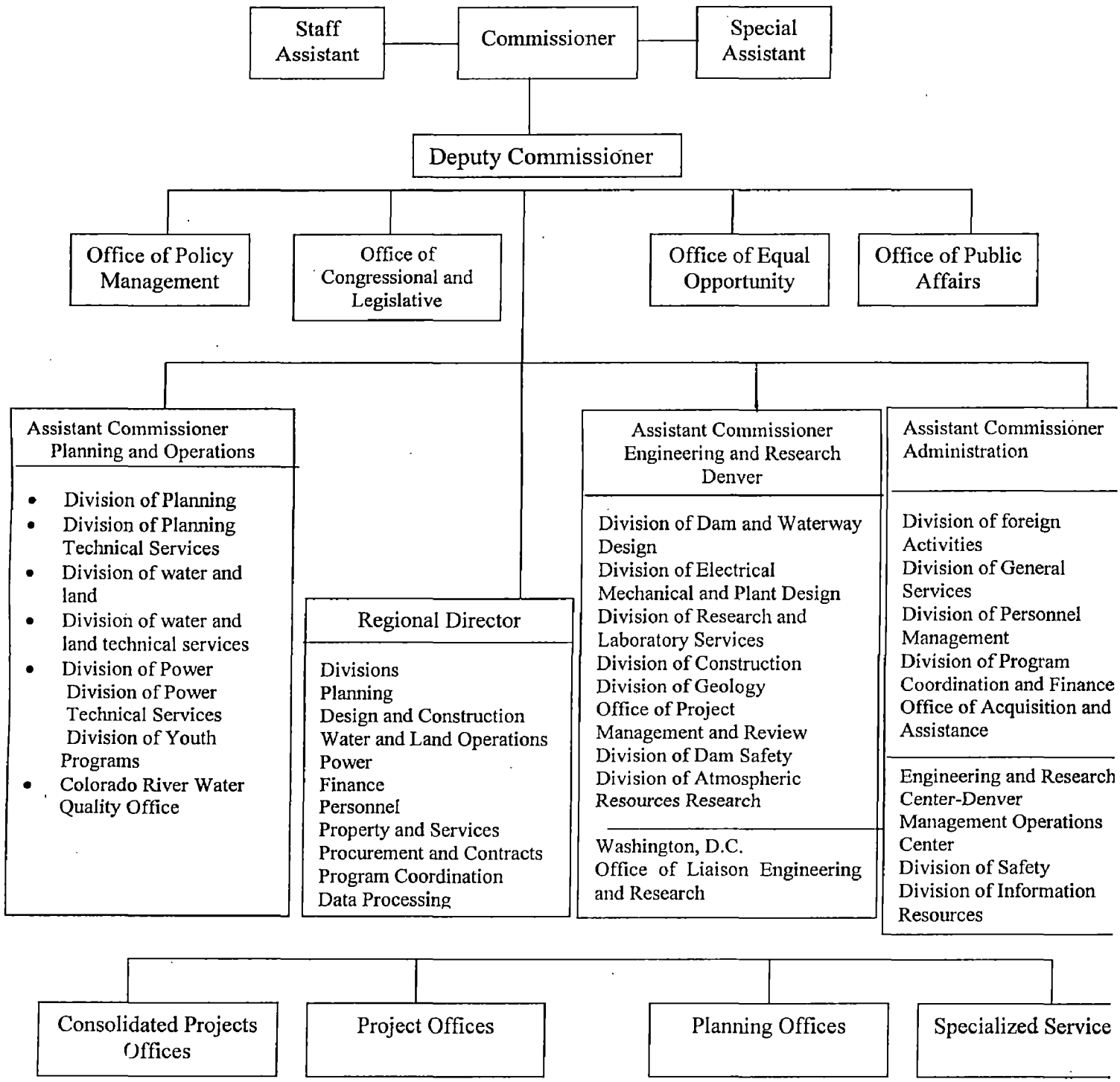
As a result of the Review of Maintenance Program, certain structures and facilities may be found to be in a state of inadequate repair or technical defects may be dis-covered which have not been correct in a reasonable time. In such an event a thorough "inspection" of the structure or facility should be made by appropriate technical personnel from the Denver Office and representatives of the Regional Director. The term "inspection" as used here means the thorough investigation into the condition of the structure or facility to be in bad order, and the development of plans for its rehabilitation.

Financing:

The examinations of facilities conducted under the Review of Maintenance Program shall be financed with funds generally identified as General Administrative Expenses and are nonreimbursable. The costs of "inspections" as defined in the preceding paragraphs, however, shall be charged to the project under the terms, if any, of the repayment contract with the irrigation district or water users' organizations. If the recovery of such costs by the Government is not covered by terms of a contract with the water users' organization, the costs shall be financed from General Investigation funds available for examination of existing projects and shall be recovered through repayment arrangements for any rehabilitation and betterment program that is undertaken.

APPENDIX-1

GENERAL ORGANIZATIONAL CHART FOR THE U.S. BUREAU OF RECLAMATION



*** Located of the Engineering and Research Centre, Denver, Colorado**

GENERAL TRAINING REQUIREMENTS FOR O&M PERSONNEL

Irrigation District Personnel

Ditchrider Training

Watermaster Training

Manager Training

Director Training

Administrative Training

Bureau Personnel

O&M Training

Technical Training

- Civil
- Mechanical
- Structural

Training for I.D (Irrigation District) personnel usually consists of in-house and out-of-house training. Specific ditchriding responsibilities, for example, may be taught by I.D. personnel but may also be combined or supplemented with workshop attendance put on by others (USBR, State, etc.) to enhance exchange of ideas and obtain a broader perspective of responsibilities. Subjects such as water measurement, general operations, and maintenance procedures are often subjects covered in outside seminars and/or workshops.

Typically, watermaster, manager, and administrative training is obtained through seminars and workshops or specific courses put on by educational organizations.

Much of the training related to the general O&M area is obtained through seminars or workshop. Those sessions consist of general topics covering all aspects of O&M and are sponsored by Federal (USBR, ARS, SCS, etc.), state, and other organizations. Some examples of this training are training are Four states Irrigation Council, North West Irrigation operators Conference, State Water User Association, consulting firms, etc.

Bureau, O&M personnel receive their O&M training through similar seminars and workshops, participation in field activities (on-the-job training), technical course related to engineering principles, and other related activities.

In general, O&M training is quite varied and often informal. Maintenance procedures of concrete repair, for example, may consist of laboratory demonstration and discussion followed by doing the active repair work in the field. The USBR has numerous manuals, which provide a good background discussion for actual performance of O&M work.

APPENDIX-2

OSRABANDI

I.D.FORM No.57-V

Details of area Osrabandi Outlet No..... Distributary/Minor Mile ..... Left/Right Bank

Ziledari ..... Division.....

Village, Pargana, District	Field no. as per Settlement	Area in Acres Flow	Area in Acres Lift	Name of Cultivators	Details of area: Included in Osrabandi	Irrigated by Canal	Irrigated by other source	Cultivated	Unculturable	Unit	Remarks
Grand Total											

I.D.FORM No. 58-V

Cultivator-wise list of area Osrabandi Outlet No.....Distributary/ Minor..... Mile .....Left/Right bank

Ziledari ..... Division.....

Name of Village	Name of Thok-Dar	Name of Cultivator	Details of Fields with area: Flow	Details of Fields with area: Lift	Cultivator-Wise Total Area: No.of Fields	Cultivator-Wise Total Area: Area	Thok-wise Total area: No. of Fields	Thok-wise Total area: Area
		Total						

APPENDIX-2

OSRABANDI

I.D.FORM No. 59-V

THOK-WISE ABSTRACT OSRABANDI OUT-LET No.....DISTRIBUTARY/
MINOR Mile..... LEFT/RIGHT BANK
ZILEDARI..... DIVISION.....

Sl.No.of Thok	Name of Thok	Name of Cultivator	Resident: Village, Pargana, District	Name of village in which irrigation has been done	T.No.of Fields	Total area in acres: Flow, Lift	Details of Osras Part A: From (Name of Day, Hours)	To (Name of Day, Hours)	Total Time (Hours, Minutes)	Details of osras Part B: From	To

FINAL PURCHA 59½ V

DIVISION.....
By the Order of Executive Engineer

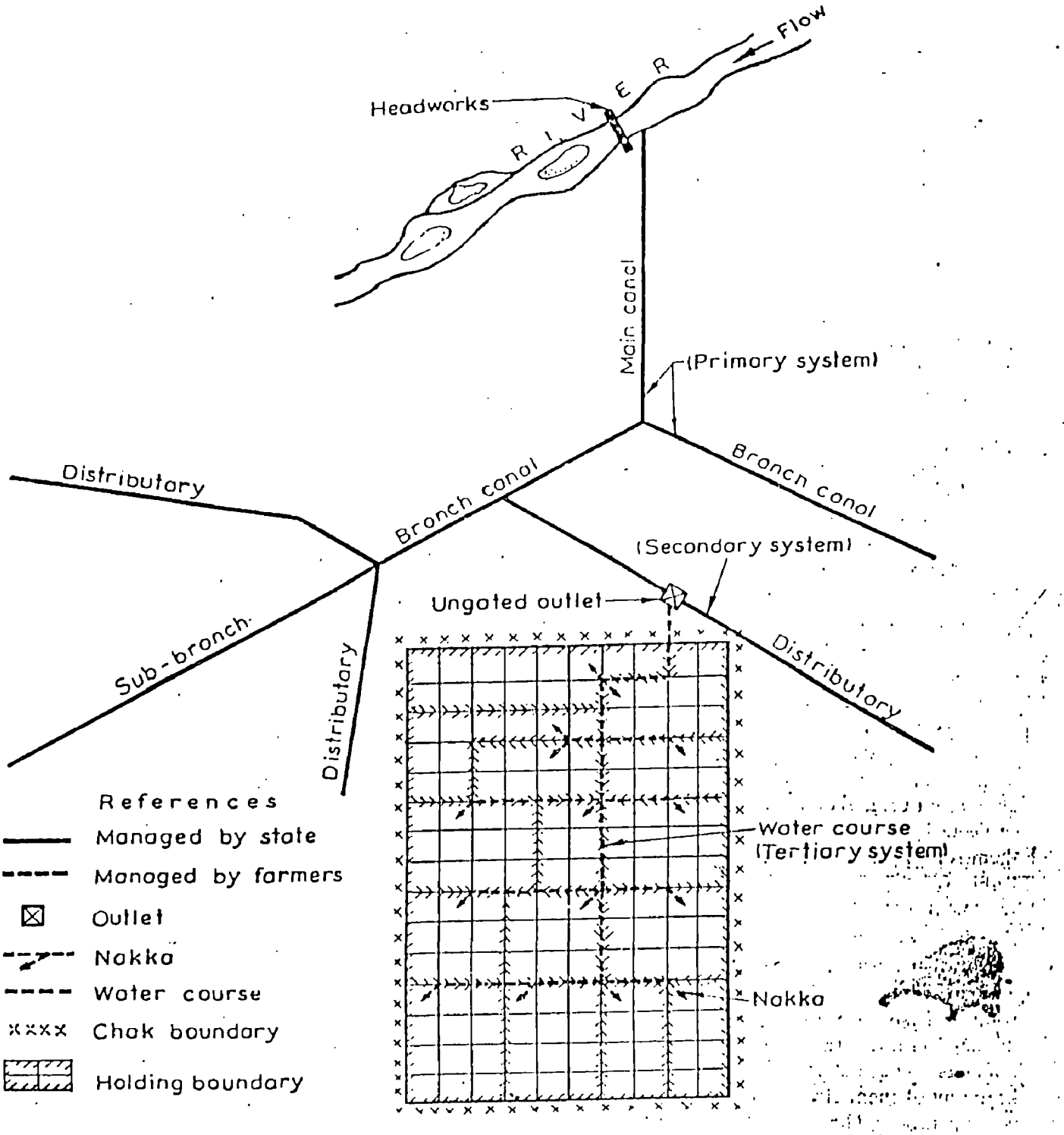
As per Osrabandi of outlet No..... Ventage..... at mile.....
Furlong....., Feet..... of ..... Minor/Distributary left/
Right bank., village....., Pargana....., District.....
.....

Name of thok..... No. of thok..... in running week of 7 days for irrigation of ..... acres area.of your thok..... hours..... minutes are being fixed. It is hereby ordered that irrigation must be done according to this osrabandi, otherwise legal action will be taken.

Details of Cultivators of Thok

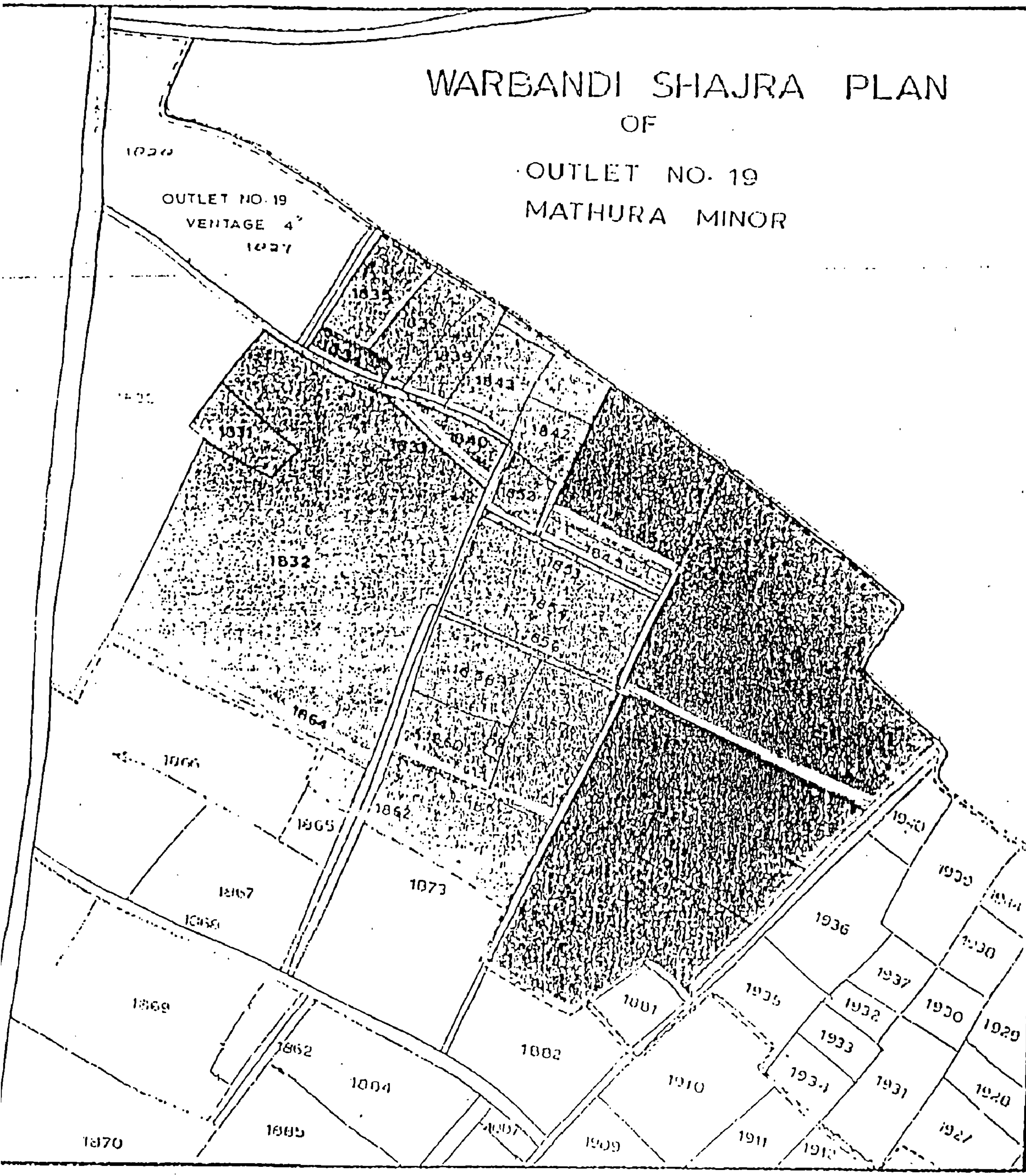
No. of Thok	Name of tenants	Area in acres	Time: hours	Time: Min.	PART 'A': From	PART 'A': To	PART 'B': From	PART 'B': To

Note:- It is to be prepared on cloth.



: Typical distribution system.

WARBANDI SHAJRA PLAN OF OUTLET NO. 19 MATHURA MINOR



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NO. OF [illegible]	NAME OF [illegible]	COLOUR	FIRST FIELD NO.	AREA IN ACRES	TIME	
					HOURS	MINUTES
1	[illegible]		[illegible]	[illegible]	34	[illegible]
2	JABAR DIN		1832	12.60	41	14
3	NASIBU		1834	16.85	55	35
4	ISMAIL		1936	10.05	35	53
	MINOR, WATER COURSE		—	—	—	—
			TOTAL	[illegible]	168	00