CHAPTER VI. PROJECT IMPLEMENTATION AND OPERATION

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6.1. Project Implementation

6.1.1. Executing Agency of the Project

The executing agency of the project will be a governmental agency in the joint of such organizations as ICTA, WAPDA, SDO, CDA, PHED, NARC and MFA which has a sufficient capability and deep experience in carrying out the detailed design, construction control of civil works, and operation and maintenance of the completed facilities of the project. And the agency shall be referred to hereinafter as Project Agency.

The Project Agency executes the detailed design for the major project facilities in recruiting a consulting firm, the construction contracting with a competent contractors, and the operation and maintenance guidance of the Water Users' Association. The organization of the Project Agency is shown in Figure 6-1.

6.1.2. Financing

The foreign currency portion of the project cost will be financed by the international financing institution while the local currency portion will be provided by the Pakistani Government.

6.1.3. Construction Mode

A qualified contractors for the civil works of the project will be selected by the international competitive bidding. The construction of the on-farm facilities will be made under the control of the Project Agency in close collaboration with farmers' association such as the Agricultural Cooperatives and the Water

Users' Association to be newly established in the Area in taking into account complicated topography under the Barani area.

According to the information obtained from SDO dealing with small scale irrigation projects, the construction cost of the on-farm facilities is shared with the farmers in the following two ways;

i) - All of the materials are firstly supplied by the Government,

- Five percent of the material costs will be paid by farmers in installment of seven years, and

- All of the labour charges will be borne by the farmers.

ii) - All of the expenses including material and labour will be firstly paid by the Government, and

- 20 percent of the total expenses will be paid by farmers in installment of over seven years.

The operation and maintenance (O/M) works of the project facilities except on-farm facilities will be made directly by the O/M staff of the Project Agency. The Project Agency will provide necessary equipment for O/M prior to completion of the construction works. The O/M works of the on-farm facilities will be basically undertaken by Water Users' Association to be established.

6.1.4. Pre-Engineering Works

The preparatory works are composed of survey and investigation works for the detailed design stage.

Though the topographic maps with a scale of 1:1,000 covering the proposed damsite area and the geological map at the damsite, which were obtained during the Feasibility Study stage, will be useful, topographic map with a scale of about 1:5,000 covering the

whole Project Area should be inevitably prepared for commencement of detailed design works. The items of the additional survey and investigation works necessary for the detailed design are given in Table J-7.

6.1.5. Consulting Services

The engineering staff of the Project Agency will have a capability to carry out the detailed design and construction control for the ordinary structure of the proposed project facilities. However, the consulting services will be required for the specific items to assist the above mentioned staff.

The total man-month of consulting staff to be assigned to the detailed design and construction supervision are estimated on the assistant basis of the engineering staff and are shown in Table J-17, and summarized as follows;

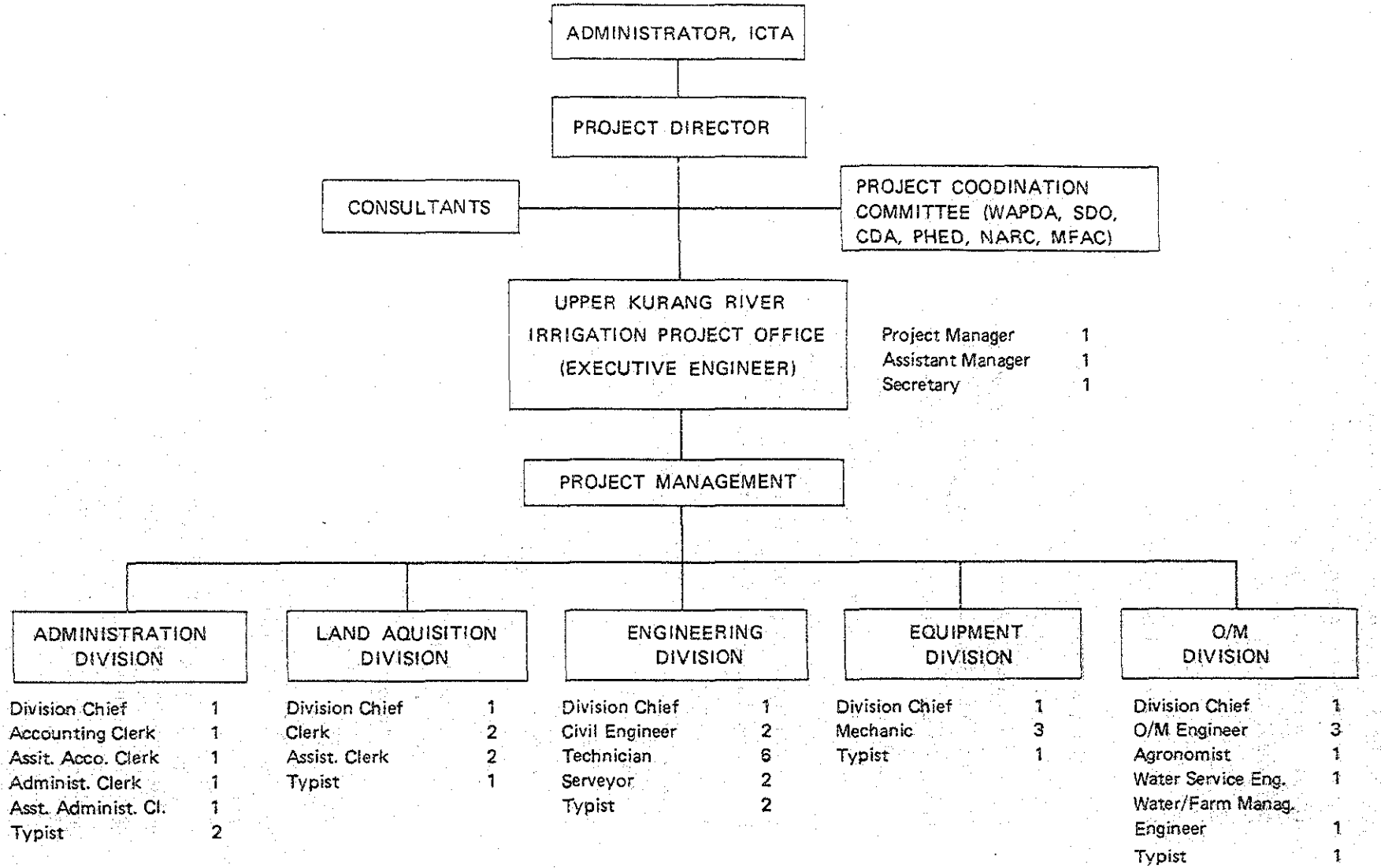
Man-Month of Consultants

Item	Detailed Design Stage (man-month)	Construction Supervision Stage (man-month)	Supporting Service and Management Stage (man-month)	Total (man-month)
Consultant				
- Foreign Expert	82.0	124.0	34.0	240.0
- Local Expert	27.0	78.0	12.0	117.0
Total	109.0	202.0	46.0	357.0

6.1.6. Land Acquisition and Compensation

Land acquisition in the reservoir area and along the canal alignment will be undertaken by Project Agency before starting of construction works. The details of land acquisition and compensation are shown in Table J-14.

FIGURE 6–1. PROPOSED ORGANIZATION CHART FOR PROJECT IMPLEMENTATION



6.2. Construction Plan

6.2.1. Dam Works

1) Work Volume

The work volume for construction of the K-2 Dam is as follows;

- Diversion Tunnel : 9 m dia. circular shaped tunnel, length L = 435 m
- Dam Embankment : Main dam 1,870,000 cu.m
  Saddle dam 190,000 cu.m
- Grouting : Length of drilling 20,000 m
- Spillway Excavation: 1,640,000 cu.m
- Spillway Concrete : 65,000 cu.m
- Irrigation Outlet Works: Concrete encased pressure pipe conduit, 1.5 m dia, length L = 95 m
- River Outlet Works : Tunnel with steel liner pipe (1.0 m dia.) length L = 340 m

2) Diversion Tunnel

The upper half portion is excavated prior to the lower portion, and then, the center part of the lower portion is excavated. The remaining parts at the both sides are removed finally.

The steel support is erected at proper time at 1 to 1.5 m interval on an average to prevent the excavated parts from collapses. The excavation is carried out from downstream of the tunnel towards upstream.

The fresh concrete is batched and mixed at the central batching plant, and transported by agitator car to the placing site. The concrete is placed by a concrete placer.

3) Dam

Dam Embankment

The embankment works followed by the stripping, excavation and required foundation treatment, are carried out at those zones of core, filter, random and rock by proper equipment with adequate method.

The embankment quantities of both the dams are as follows;

(unit: cu.m)

Embankment Zone	Main Dam	Saddle Dam	Total
Core	380,000	150,000	530,000
Filter	116,000	21,000	137,000
Rock & Riprap	212,000	17,000	229,000
Random	1,160,000	-	1,160,000
Total	1,868,000	188,000	2,056,000

There are no materials suitable for the filter zone and bedding for the riprap around the damsite. And these materials shall be provided by the Contractors. Other embankment materials will be obtained from borrow areas and both excavations on the spillway and dam. The materials distribution chart for the K-2 Dam is shown in Figure 6-2.

In the Feasibility Study stage, the compaction manner of embankment materials is planned as shown below; however, the decisive selection of the compaction method should be made after performing the test embankment.

Compaction Manners

Embankment Zone	Thickness		No. of Pass	Compaction Machinery
	Spread (cm)	Finished (cm)		
Core	20	15	8	Tamping roller 12-20
Filter	30	25	5	Vibrating roller 8-10
Rock	100	80	5	"
Random	60	50	5	"

Grouting

Grouting for the main dam will be made in curtain grouting along the foundation of the core zone and blanket grouting under the core zone at the river bed. The curtain grouting is carried out by stage grouting.

4) Excavation Works

Soils and soft rocks are excavated by bulldozers (32 ton capacity) with ripper, and hard rocks are drilled by crawler drills and blasted by bench cut method (bench height: 5 m).

The machinery used mainly for earth works is as follows;

Excavation	:	Bulldozers, 32 ton
Loading	:	Wheel loaders, 3.2 cu.m
Hauling	:	Dump trucks, 11 ton

5) Concrete Works

Fresh concrete is batched and mixed at batching plant installing two mixers with capacity of 0.75 cu.m. The capacity of the plant is planned to be 26 cu.m/hr (1.5 cu.m x 20 batches x 85%).

In order to prevent the massive concrete from cracking caused by hydration heat when hardened, the special admixtures are used to reduce water/cement ratio without lowering workability together with adopting the proper curing method.

6.2.2. Canal Works

Excavation is carried out by backhoes (0.6 cu.m bucket) and the excavated materials are transported by dump trucks (11 tons) to the canal and road construction sites where fill materials are required.

The distance of transportation is planned to be 500 m in maximum. The development of the ways to borrow pits is not required except for temporary access roads to reach filling site.

For high quality concrete placing with small amount of cement to considerably wide sites, several number of median size concrete mixers shall be prepared so as to be moved from site to site according to the progress of work schedule.

6.2.3. On-Farm Development Works

The main works of the on-farm development are earth moving works for excavation of drainage canals and embankment of Katcha and roads.

The soils excavated at drainage canal sites shall be hauled and used as the fill materials of Katcha and roads. The development of borrow pits may not be required.

6.2.4. Construction schedule of Civil Works

The construction schedule of civil works in the Project is determined in taking into account the work volume and workable days in a year.

Figure 6-3 shows the proposed construction schedule of the Project.

FIGURE 6–2. MATERIALS DISTRIBUTION CHART FOR K–2 DAM

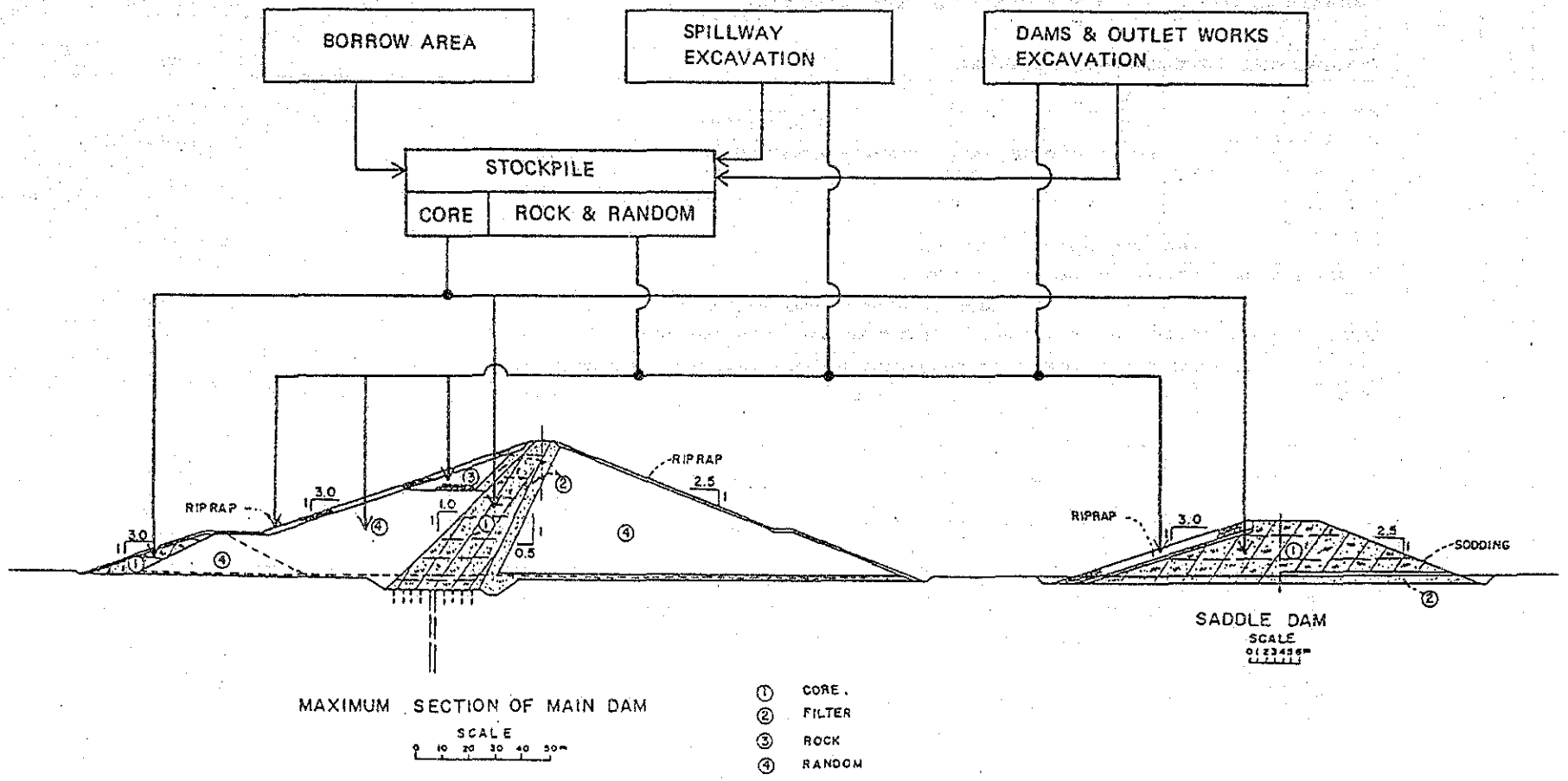
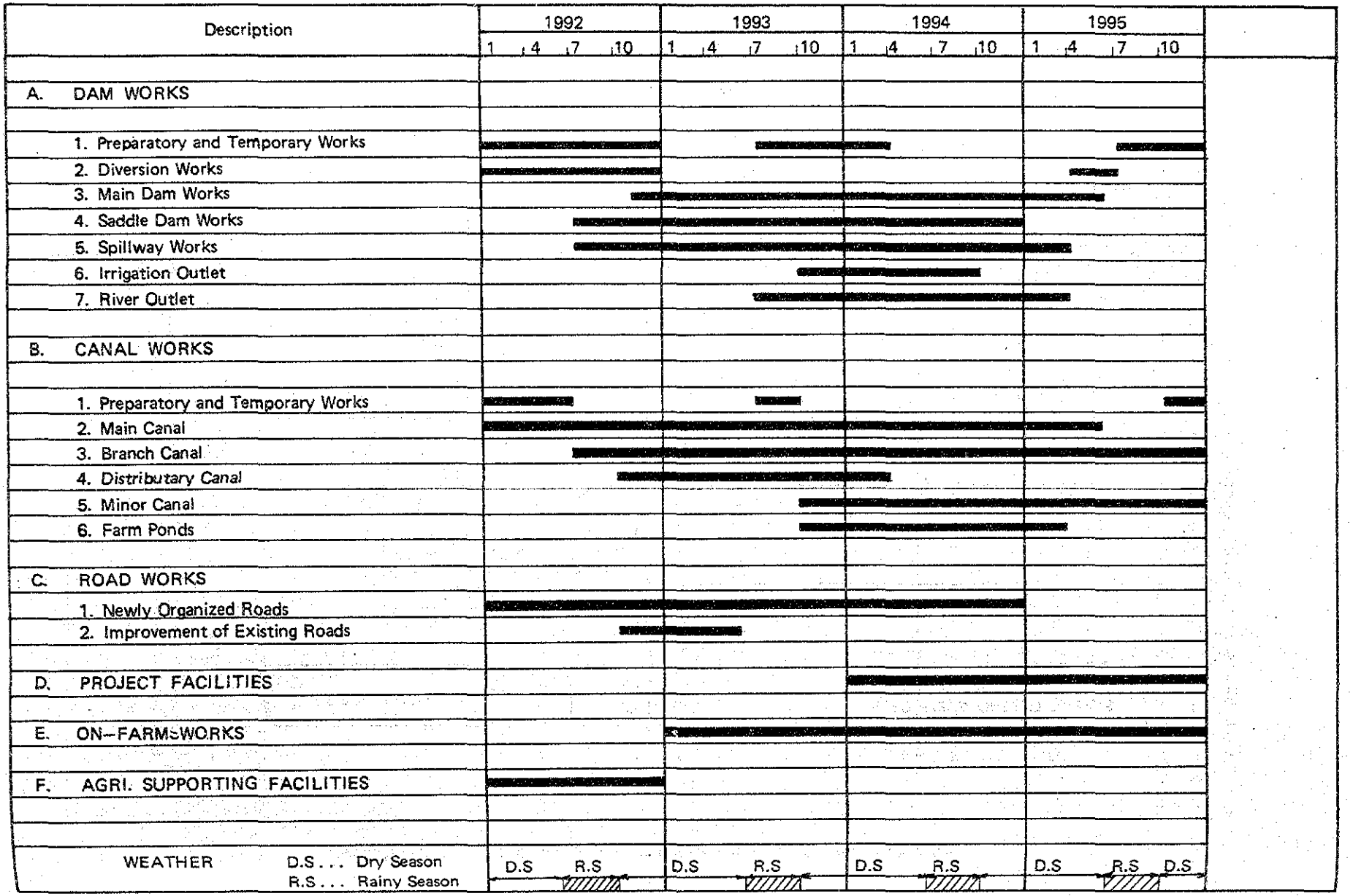


FIGURE 6–3. CONSTRUCTION SCHEDULE

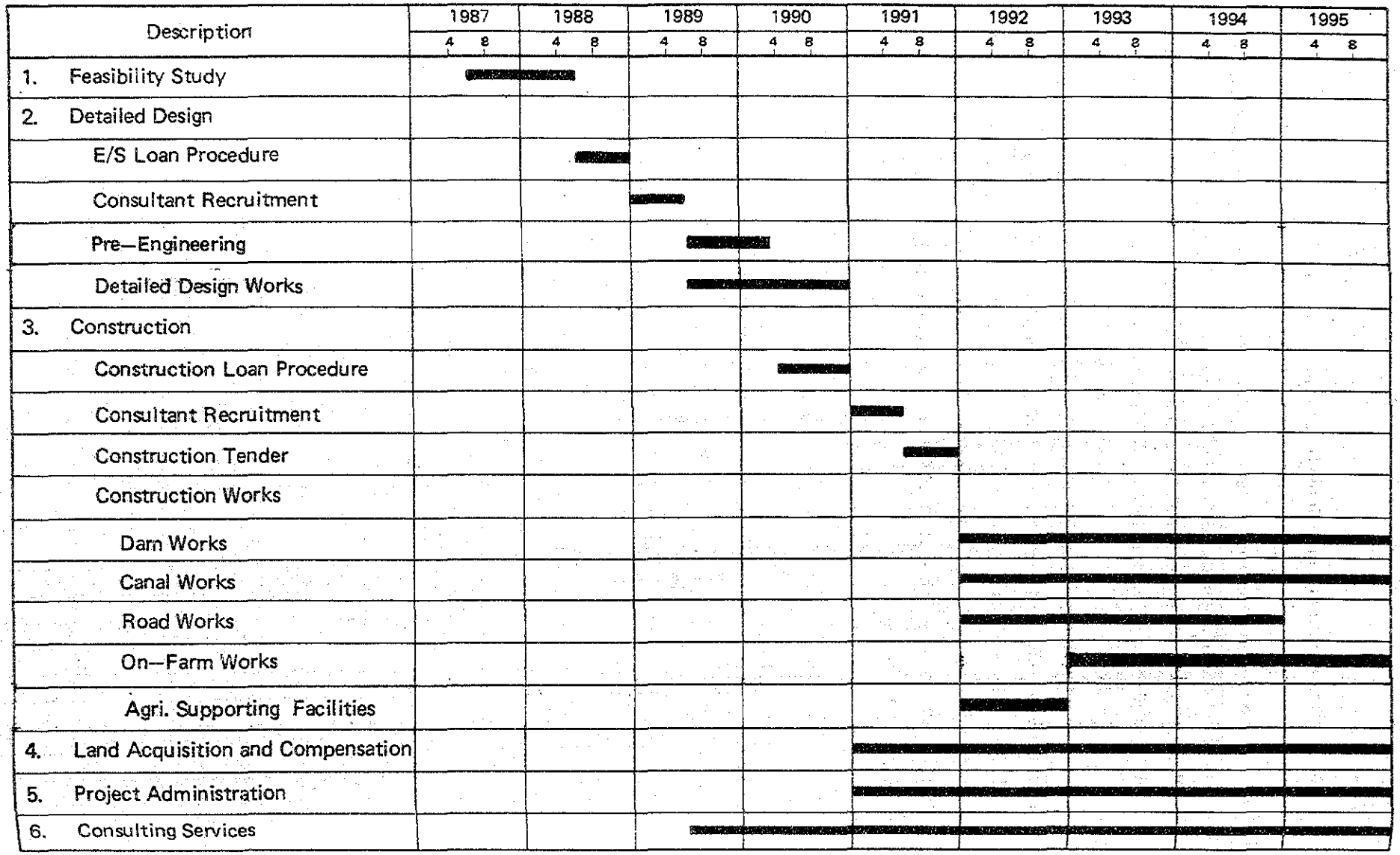


6.3. Implementation Schedule of the Project

The construction of the project facilities is planned to be started within three and a half years after completion of the Feasibility Study taking into consideration of the loan procedures, detailed design and bidding for contract.

The construction of the major works will be completed for the period of about four years, from the beginning of 1992 to the end of 1995. The on-farm works will also be constructed together with the major works to supply irrigation water after completion of the project facilities. The relevant implementation programme is shown in Figure 6-4.

FIGURE 6-4. IMPLEMENTATION PROGRAM FOR THE PROJECT



6.4. Operation and Maintenance Plan

6.4.1. Operation and Maintenance Organization

1) Organization of Government O/M Office

Since the Upper Kurang River Irrigation Project Area belongs to the Islamabad Capital Territory area, the operation and maintenance (O/M) works of the project facilities after completion will be supervised by Project Director of Upper Kurang River Irrigation Project Office. The operation and maintenance works are carried out by the Upper Kurang River Irrigation Project O/M Office, which will be newly established in the Project Area in the operation and maintenance stage.

The proposed organization chart for the O/M Office is shown in Figure 6-5. The O/M Office headed by an Irrigation Superintendent consists of two sections; Operation and Maintenance Section and Administrative Section. Operation and Maintenance Section is responsible for engineering matters of the irrigation system, major repairs of facilities and supervising of operation and maintenance through Zone Offices. Administrative section serves personnel and records management, collection services and others.

Two Zone Offices will be assigned for operation and maintenance of two irrigation systems divided largely into two areas. One is Zone-I Office for upstream area and the other is Zone-II Office for downstream area respectively. Each zone area will be divided into Operation Divisions to be directed by Water Masters. Each Operation Division will be furthermore divided into Operation Sections to be directed by the Supervision of Service Engineers.

With regard to the proposed operation system mentioned above, Zone-I and II will be divided into five Operation Divisions in

total covering about 1,200 to 1,400 ha (2,964 to 3,458 acre) on an average (see Figure 6-5). Each Operation Division will be divided into six to seven Operation Sections covering a commanded area of about 200 to 300 ha (494 to 741 acres) on an average. An average terminal rotation area, so-called Chak, can be estimated at about 40 to 50 ha (99 to 124 acres). Accordingly, each Service Engineer will work for five to six rotation areas and each Water Master will be responsible for about 30 to 40 rotation areas.

At the early stage of management for irrigation system, the Zone Office will be responsible for operation and maintenance of the whole systems including on-farm facilities. However, operation and maintenance for the on-farm facilities will be transferred to the Water Users' Association step by step.

2) Organization of Farmers

At the early stage of project implementation, beneficial farmers by the project should be organized into Water Users' Association with the initiatives and assistance by Local Government and Rural Development (LGRD), ICTA, which will be main executing agencies of the project.

The Farmers' Groups will be organized on the basis of Nucca covering the area of 40 to 50 ha (99 to 124 acres) by the outlet level. And the groups will be integrated into the Water Users' Association on each Operation Division level.

The Farmers' Groups will be responsible for operation and maintenance of the on-farm facilities. Possibly close cooperation between Farmers' Groups and Project O/M Office is quite essential for successful day-to-day water management. Furthermore, the Farmers' Groups shall provide the groups to correspond to the Operation Section of the Project Office. Such groups shall be called Water Management Groups.

Federation of Water Users' Association will be formed in uniting all Water Users' Associations in the Project Area, in order to make one representative of the Associations in their dealing with the Project O/M Office. Figure 6-6 shows the proposed organization of Water Users' Association.

6.4.2. Operation and Maintenance Plan

1) Proposed Irrigation Systems

The irrigation facilities in the Project Area can be largely classified into two categories; one is the K-2 Dam to store irrigation water for the resources and the other is the irrigation canals systems to convey irrigation water to the objective area. The irrigation canal systems are divided into five Divisions by the proposed irrigation networks as shown in Figure 6-7.

2) Operation and Maintenance Structure

Operation and maintenance of the project facilities is planned to be undertaken by two Zone Offices headed by Sub-Executive Engineer in accordance with the operation rule which will be prepared by the Project Office in the implementation stage.

The operation and maintenance works will be divided into two phases; one is for the major irrigation facilities of the reservoir, main and branch canals and is undertaken by two Zone Offices and the other is for distributary canals and is made by five Operation Divisions. Accordingly, the formation and roles of water management personnel of the projected irrigation system in accordance with the phased works is proposed as follows;

- Water management for the major irrigation facilities such as dam, main and branch canals will be carried out by gate keepers manned at Zone Offices under the direction of Sub-Executive Engineer.

- Water management for distributary canal in each Operation Division is practised by gate keepers under the direction of Water Master.

- Service Engineers principally work for supervision and management for their section through Water Management Group.

Operation and maintenance works of the on-farm facilities by the outlet level are practised under the responsibility of Farmers' Groups. The Project O/M Office provides them with necessary technical assistance, heavy equipment and materials for repair and maintenance works. The Farmers' Groups are responsible for providing man-power requirement for operation and maintenance of the on-farm facilities.

3) Water Management

a) Planning of Seasonal Water Supply

The Project O/M Office will prepare the water supply plan for each cropping season along with the proposed operation rule. When sufficient water is available at the beginning of cropping season, water supply is planned to meet full irrigation requirement for the proposed cropping pattern.

On the contrary, when water source is insufficient for proposed cropping pattern at the beginning of cropping season, the water supply plan is arranged to supply water evenly by the discounted rate for all the rotation areas by magnitude of proposed deficit water.

b) Water Management of Major Irrigation Facilities

For the water management of the major irrigation facilities, three groups of gate keepers are assigned to the K-2 Dam and two irrigation systems of upstream and downstream. They are cooperative each other for successful systematic water supply and water control

in the reservoir and main and branch canals by direction of operation staff of Zone Offices.

Water release from K-2 Dam to Rawal Dam should be conducted according to the systematic reservoir operation rule proposed in the project implementation stage.

c) Water Management at Distributary and Minor Canals

The water management of the distributary canals is practised by each Operation Division by direction of a Water Master who will conduct day-to-day water management of distributary canals. A gate keeper and a canal supervisor will be assigned to each Operation Division for operation and maintenance of the distributary canals.

The Gate Keeper in the Operation Division will distribute water to each turn-out by direction of Water Master along with water distribution plan. All the turnouts should be operated systematically by Gate Keepers for even distribution.

Furthermore, water management at the minor canals connected to the farm ponds which will be provided at the beginning point of the minor canals as shown in Figure 6-8 will be done by Gate Keepers by direction of Service Engineer in Section Office. The farm ponds function to regulate irrigation water to meet water supply at the on-farm level.

Efficient feed-back system of information from each Operation Division to Zone Office should be established to minimize waste water in the total system. To this end, each Water Master should transmit practical information on irrigation requirements to Zone Office so as to revise water distribution plan.

The management to supply and distribute irrigation water from K-2 Dam to distributary canals will be carried out under the

responsibility of Project O/M Office and the water supply by these canal systems is planned for 24 hours.

d) Water Management at On-Farm Level

The water management at the on-farm level covering an area of about 40 - 50 ha (99 to 124 acres) on an average will be practised under the responsibility of Farmers' Groups with the assistance of Section Offices. Irrigation water will be conveyed to individual farmers' lots through water course in rotation system (Wara Bandi) within the area of 40 - 50 ha covered by outlet set by land holding size of each farmer.

Irrigation water supply at the minor canals and water courses is planned for 12 hours, which will be enabled by the provision of farm pond.

4) Maintenance of Irrigation Facilities

Periodical cleaning and maintenance works of all the irrigation facilities should be ruled in order to keep the facilities in good conditions for keeping their life long. It is assumed that regular maintenance works for the facilities are implemented in participation of members of Water Users' Association or Water Management Group in depending on the scale and extent of maintenance work.

5) Take-Over of Operation and Maintenance Works

The responsibility for operation and maintenance of such irrigation facilities in the downstream area of the farm ponds such as farm ponds, minor canals, outlets and water courses will be finally taken over to the Water Management Groups, which will be correspondent with about one village unit. To this end, an appropriate training and instructions for leaders and the Group

Members should be given by Zone Office, and personnel to be assigned to each Section Office should be selected from the residents well-qualified as Water Management Group Members.

6.4.3. Operation and Maintenance Cost

Operation and maintenance cost was estimated at about 4.40 million Rupees per annum, and is summarized as follows:

Annual Operation and Maintenance Cost

(unit: 1,000 Rupees)

Description	Cost
Salary and Wages	1,477
Administration and General Expenditure Cost	175
Equipment Operation Cost	2,039
Office Maintenance Cost	409
Total	4,370

Note: Details are given in Table J-19.

FIGURE 6-5. PROPOSED ORGANIZATION CHART OF OPERATION AND MAINTENANCE

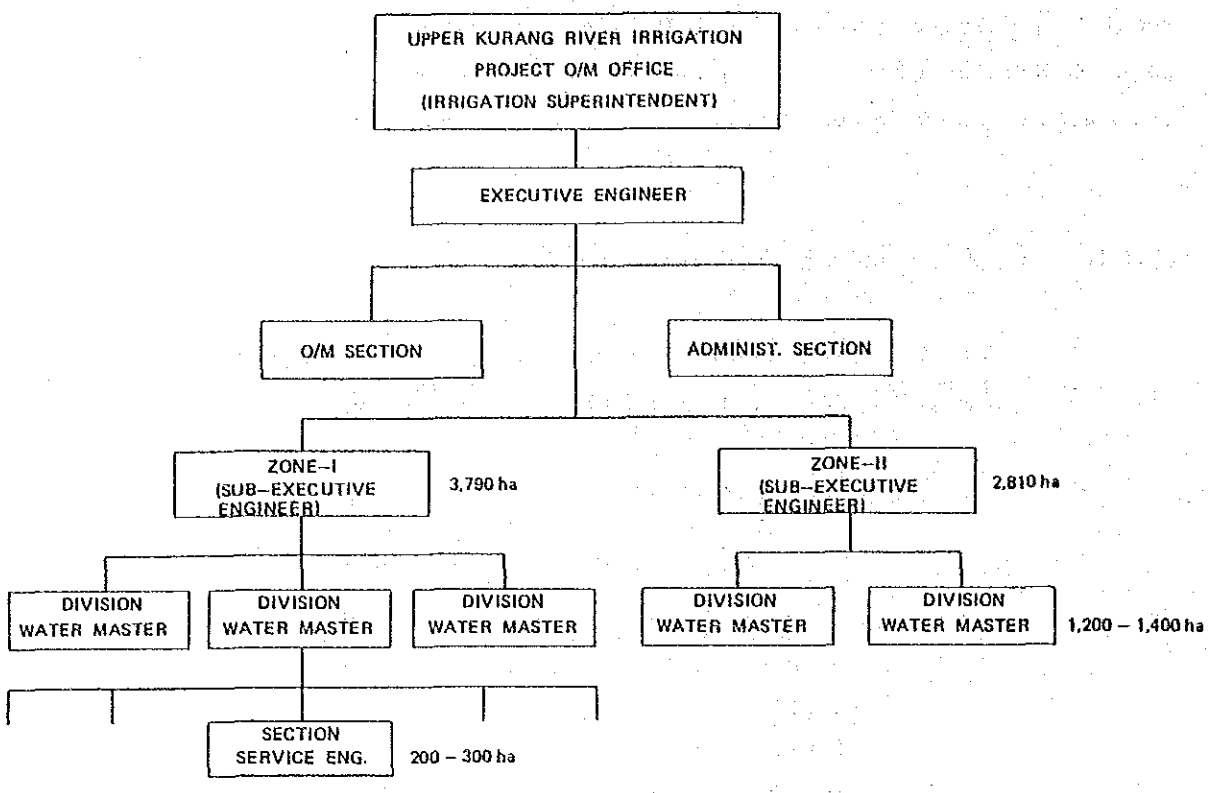


FIGURE 6-6. PROPOSED ORGANIZATION CHART OF WATER USERS' ASSOCIATION

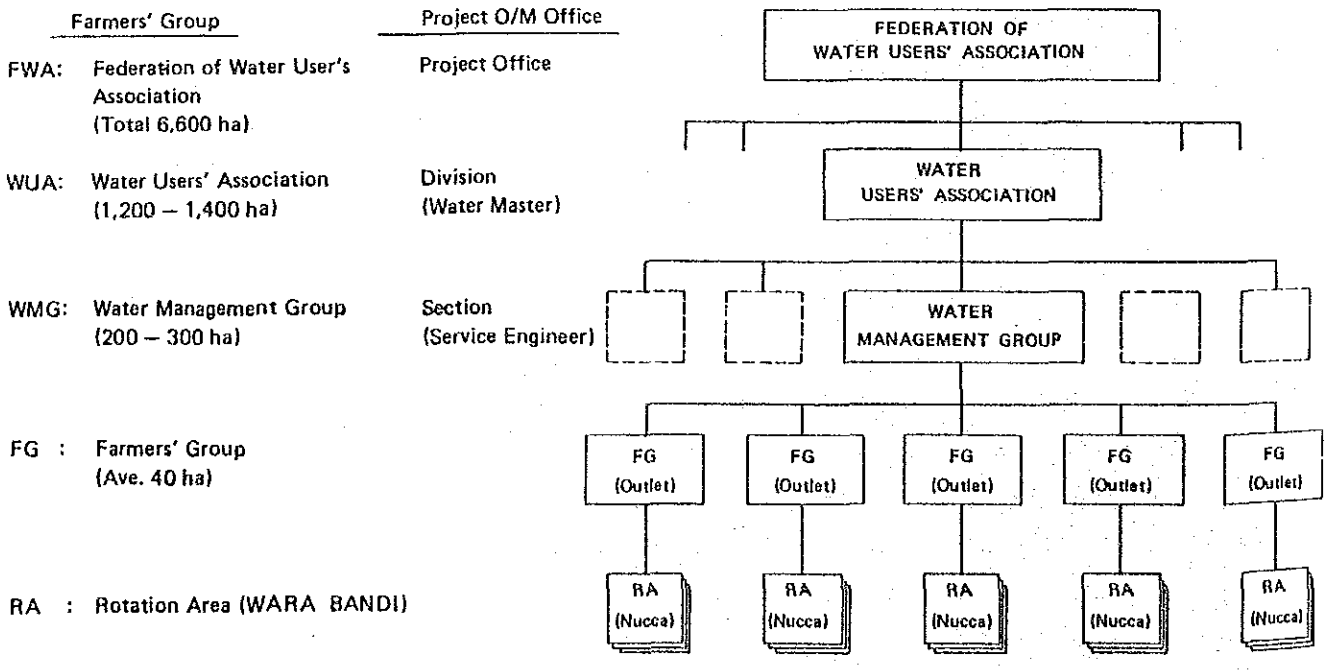


FIGURE 6-7. LOCATION OF OPERATION AND MAINTENANCE DIVISION

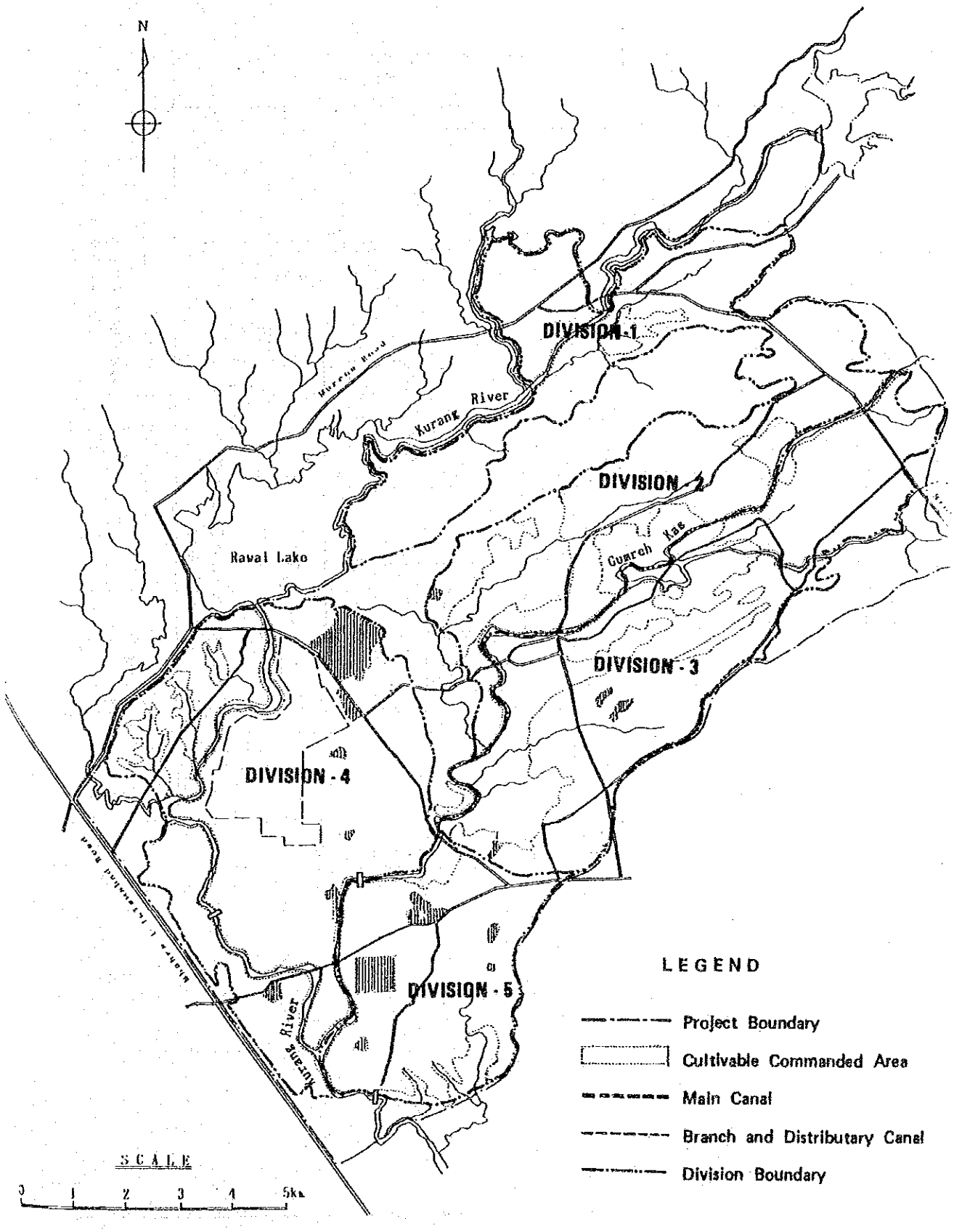


FIGURE 6–8. ILLUSTRATION FOR ESTABLISHMENT OF WATER USERS' ASSOCIATION AT IRRIGATION CANAL SYSTEM LEVEL

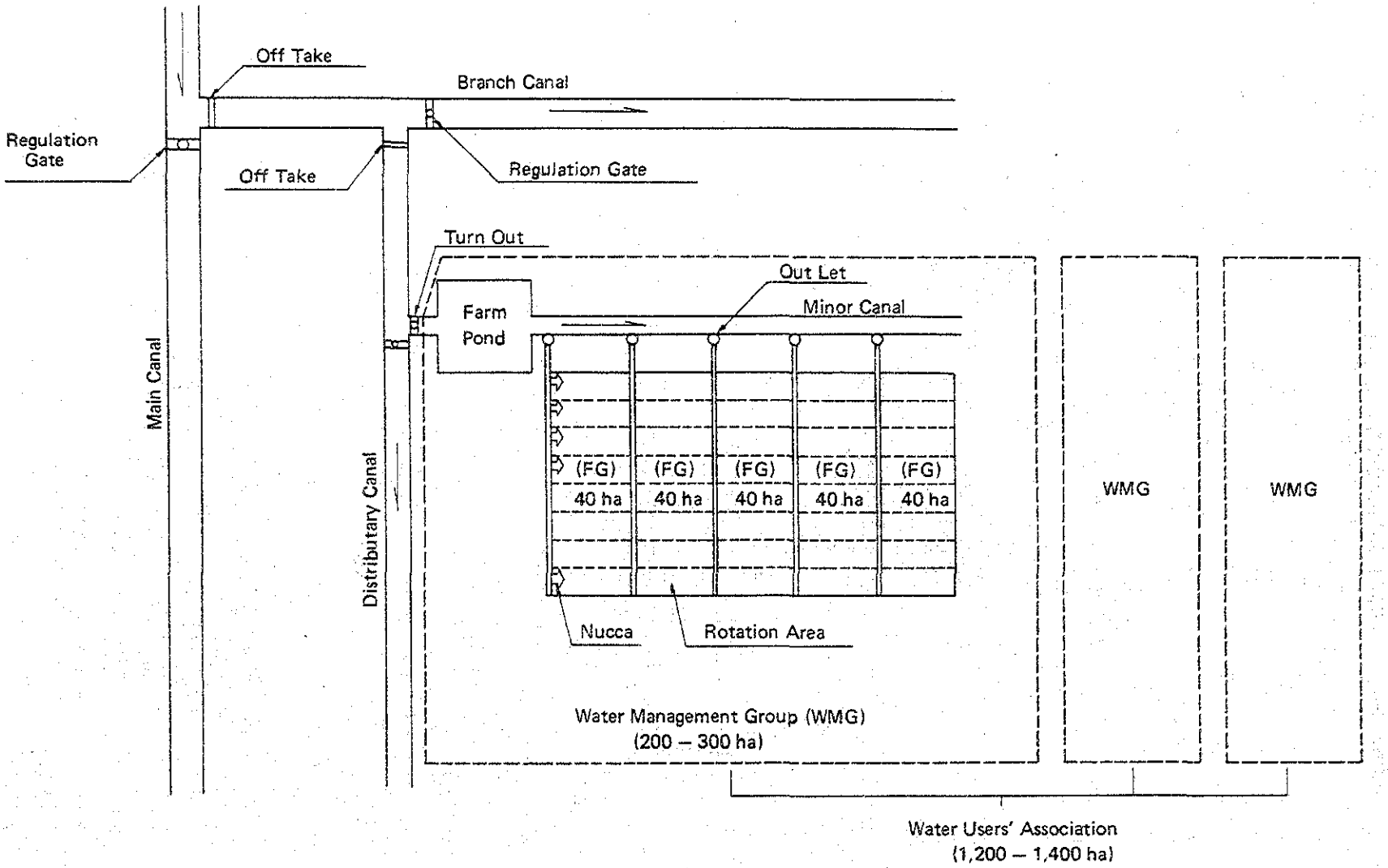
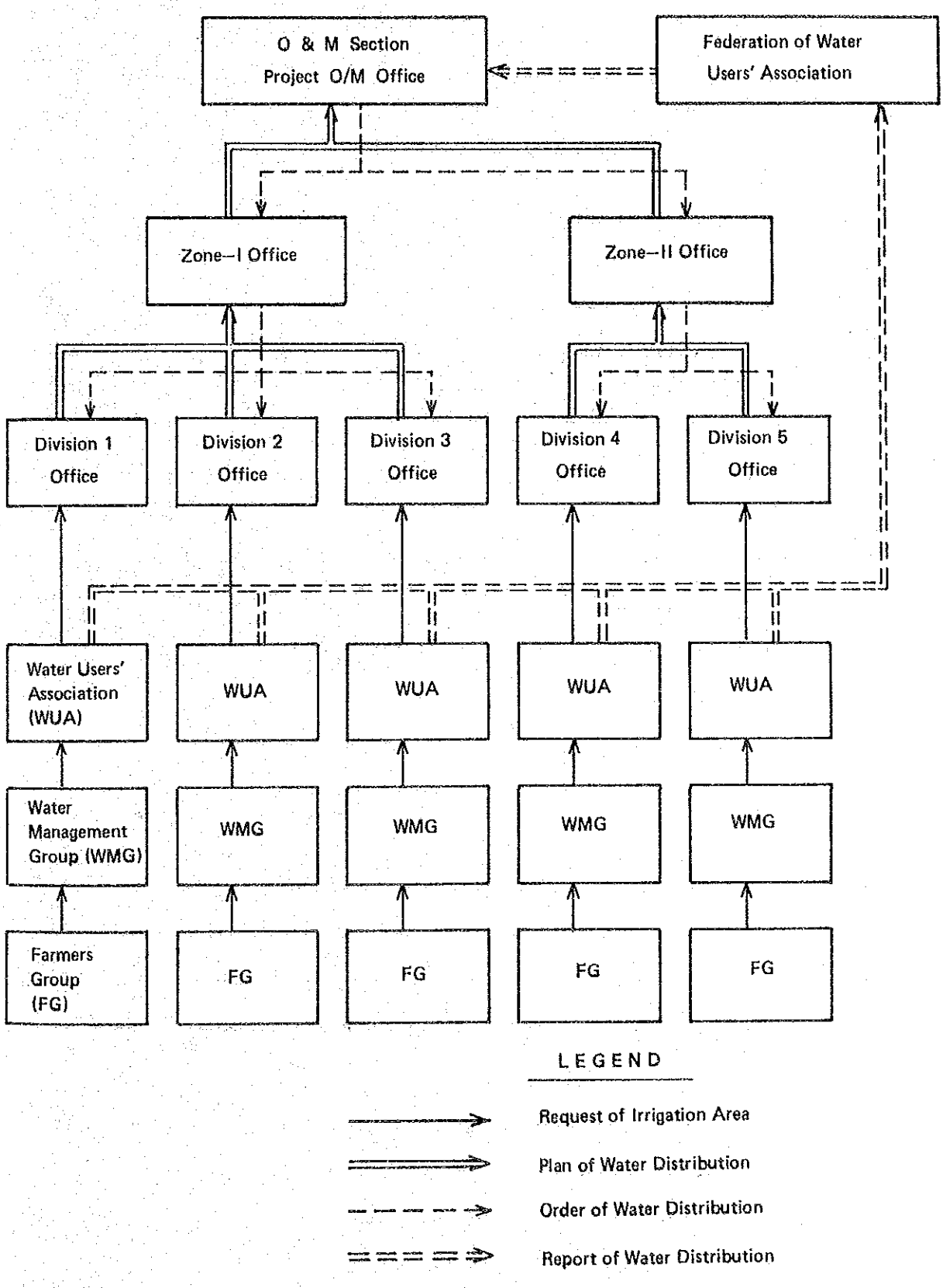


FIGURE 6-9. OPERATION SYSTEM OF WATER DISTRIBUTION



CHAPTER VII. PROJECT EVALUATION

CHAPTER VII. PROJECT EVALUATION

7.1. Introduction

The Project aims to enhance the living standards of beneficiaries in the Kurang River basin of the Islamabad rural area and to rectify income distribution between the rural area and others in Pakistan. To achieve the above two objectives, the Project places the emphasis on the development of irrigation, marketing road networks and agricultural supporting services. The Project is one of the important regional development plans deeply related to the major governmental development policies as "The development of rural areas in which the majority of the poverty problems still remain".

The Project includes the plan to make supplemental water supply to the experimental fields of NARC. It is deemed unreasonable, however, that such water supply to NARC is evaluated inclusively as part of this irrigation Project, since the purposes are different in Project from experiment. That is the reason why the cost and benefit of NARC is excluded of the Project evaluation.

In this chapter, financial and economic analysis from the standpoints of private and national economy were carried out for project cost, operation and maintenance cost and benefits. Project cost and benefits were estimated for 50 years as the project life by constant price as of 1987.

7.2. Project Cost

The total of project capital cost for 6,600 ha (16,300 acres) of the proposed irrigation area is estimated at 954.8 million Rupees (144,700 Rs/ha, 58,500 Rs/acre) in financial value, which is equivalent to 799.8 million Rupees (121,200 Rs/ha, 49,000 Rs/acre) in economic value. The project cost of financial base was converted

to the border price by applying the standard conversion factor. Based on the import and export value, trade duties and export subsidies for the last five years in Pakistan, the standard conversion factor is estimated at 0.85. The conversion factor is applied to the local portion of the cost.

The conversion factor is also applicable to the conversion for economic value of operation and maintenance cost. The operation and maintenance cost with project reaches 4.4 million Rupees per year (662 Rs/ha, 268 Rs/acre) on a financial base and 3.7 million Rupees per year (563 Rs/ha, 228 Rs/acre) on an economic base.

Cost Allocation

(unit: million Rs.)

Items	Total (6,600 ha)		Service Area (6,100 ha)		NARC Area(500 ha)	
	Financial	Economic	Financial	Economic	Financial	Economic
1. Capital Cost						
- Specific Cost	190.1	177.7	190.1	177.7	-	-
- Joint Cost	764.7	622.1	706.7	574.8	58.0	47.3
Total	954.8	799.8	896.8	752.5	58.0	47.3
2. O & M Cost	4.4	3.7	4.1	3.5	0.3	0.2

On the assumption that the Project will be started in 1989, the disbursement of project cost is tabulated as shown below;

Financial and Economic Project Cost
(Excluding NARC Area)

(unit: million Rs.)

Year	Capital Cost		O & M Cost		Total Project Cost	
	Financial	Economic	Financial	Economic	Financial	Economic
1989	5.2	5.2	-	-	5.2	5.2
1990	2.2	2.2	-	-	2.2	2.2
1991	106.0	13.5	-	-	106.0	13.5
1992	215.5	197.3	-	-	215.5	197.3
1993	220.1	202.1	-	-	220.1	202.1
1994	236.8	226.6	-	-	236.8	226.6
1995	111.0	105.6	4.1	3.4	115.1	109.0
1996	-	-	4.1	3.4	4.1	3.4
Total	896.8	752.5				

7.3. Project Benefits

From the national socio-economic point of view, various kinds of directly and indirectly associated benefits would be created from the Project. And, the project benefits consist of quantifiable and unquantifiable benefit.

7.3.1. Agricultural Production Benefit

In view of the national economy, implementation of the Project will generate a variety of benefits directly or indirectly. And the Project benefits can be specified into two, tangible benefits and intangible benefits. The crops production benefits which are tangible and expressive in monetary terms shall be applied to the comparative study with the project costs. In other words, the Project includes such components as water resources development, irrigation system development, marketing road networks development, introduction of irrigated agriculture, and improvement of agri-supporting services, and realization of the Project will ensure to give favorable effects in increase of cropping acreage together with yield and upgrading of crop quality.

The crop production in the existing farm land within proposed K-2 reservoir area shall be considered as minus benefits, and the said benefits shall be taken into consideration as plus benefits in the case of without-project, while omitted from the project benefits in the case of with-project. Besides, the land to be acquired for canals for irrigation system development and roads for marketing road networks development is considered as minus benefits in the same view as the farm land within K-2 reservoir area.

The benefit of the Project is as follows:

Crop Benefit (excluding NARC Area)

Items	Without-Project		With-Project	
1. Cultivated Area (ha)	6,930[1/]		6,100	
2. Cropping Area (ha)	7,530		10,180	
3. Cropping Intensity (%)	106		167	
4. Benefit ('000 Rs.)	(Financial)	(Economic)	(Financial)	(Economic)
- Gross Production	36.1	47.4	291.8	324.6
- Crop Production	20.0	21.6	78.5	83.4
- Net Production	16.0	25.8	213.3	241.2
- Incremental Production (= Benefit)	-	-	197.3	215.4

Note: 1/ ... 130 ha (320 acres) of K-2 dams' farm land is included

7.3.2. Other Benefits

In addition to the above-mentioned tangible benefit, the following benefits are expected to be realized with the Project.

1) Benefits at the Project Area Level

- The Project realization will improve the farmers' living standard through an increase in the farm income. The increase in the farm income from the increase of agricultural income means the increase in consumption and saving. The magnifying of the farm family economy will improve the villagers living standard in terms of quantity and quality (nutrition, education, health and others).

- With the Project, for making good use of irrigation water inside the commanded area, it will be necessary to establish the Water User's Associations by all the beneficiary farmers. These cooperative systems will certainly improve communication among farmers influencing the technical up-grading of crop cultivation and farm management of the farmers around the Project Area as well as in the Project Area.

- The Project aims to develop upland crops cultivation, particularly including vegetable cropping under careful control of irrigation water supply with proposed farm ponds constructed and managed by villages. And the new farm ponds shall have multiple functions not only for irrigation but also for miscellaneous farming works, domestic use, etc. The year-round domestic use of the water by farm ponds shall be made by not only farmers but whole villagers, and the farm ponds will play a role to develop the attractive villages to live in as well as to give a lesson on vitally important works for collective use of water resources through generation to generation.

- Many villagers will have the employment opportunity not only in the construction and O & M of the Project but in the farming works for vegetable cultivation.

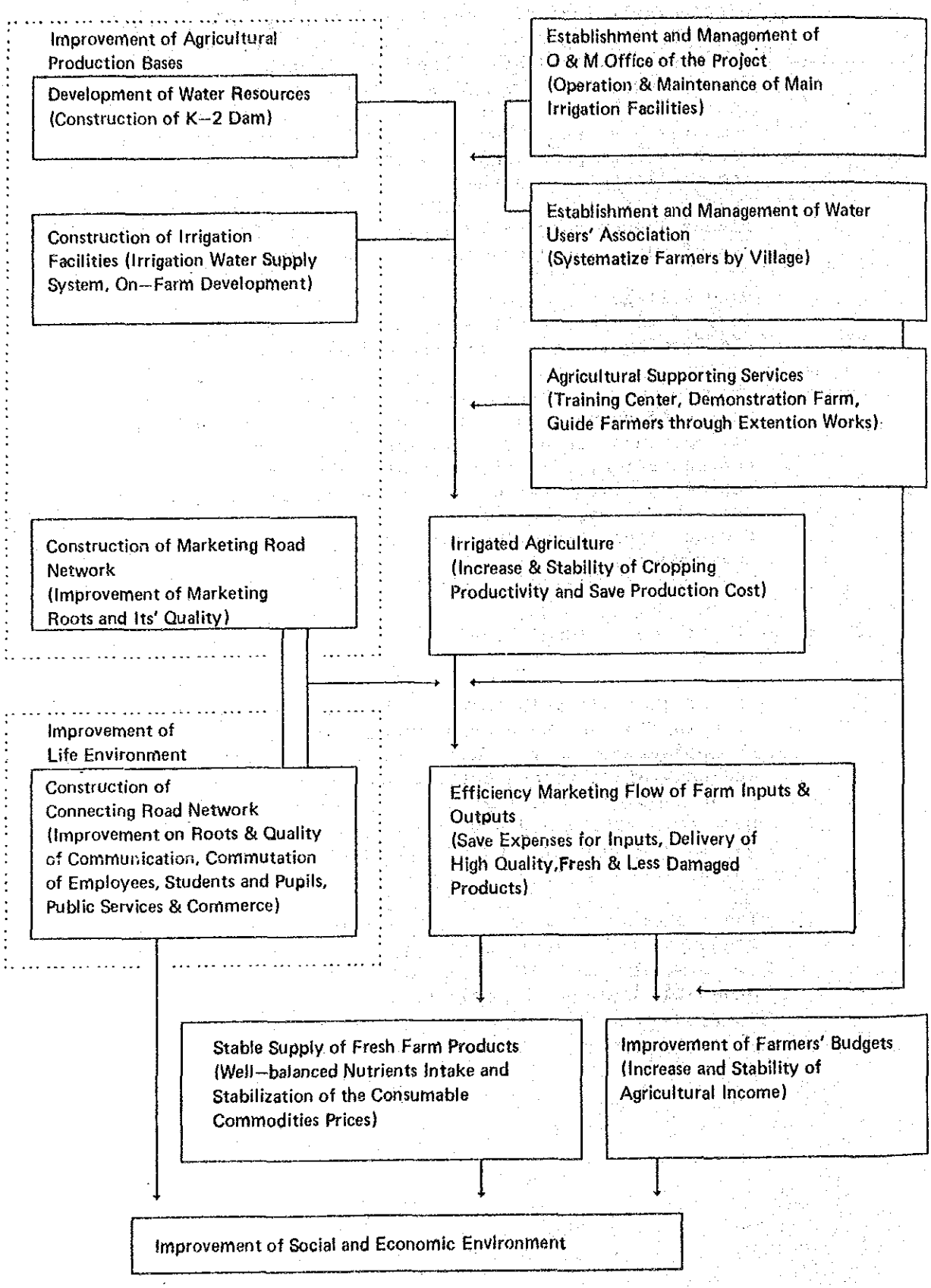
- The new improved marketing road network will function also as a connecting road network among villages and between villages and urban areas in various purposes such as communication, communication of employees, students and pupils, public services and commerce. It will benefit not only the farmers but also the whole residents of the Project Area, improving the social and economical environment.

2) Benefits at the National Level

- The Project shall introduce and encourage vegetable cropping in the whole area, and stable supply of fresh and cheap farm products to metropolitan areas like Islamabad and Rawalpindi throughout the year from the neighboring production areas will greatly contribute to well-balanced nutrients intake and also give a favorable effect on stabilization of the consumable commodities prices for the urban life.

- The implementation of the Project is of the effective socio-economic development type, not only for promoting rural welfare but also alleviating the disparity in living standards between the regions.

FIGURE 7-1. IMPACT ON SOCIO-ECONOMIC ENVIRONMENT WITH PROJECT



7.4. Economic Efficiency of the Project

7.4.1. Comparison of Cost and Benefit

1) Economic Internal Rate of Return

Economic analysis of the Project was made by employing the Internal Rate of Return (IRR) method. IRR is a rate that makes the present worth of cost and benefit for the project life equal to zero. The Economic Internal Rate of Return (EIRR) of the Project is estimated at 13 percent.

Judging from the fact that the opportunity cost of capital in Pakistan is 12 percent, EIRR of the Project is not so high as the economic index. However, agriculture is the main industry in the country in spite of low productivity industry, and the implementation of the Project will pay the effective availability of resources and an important role in correcting the differences in living standards among regions in the country.

2) Sensitivity Analysis

Analyses have been made to test the sensitivity of the rate to other parameters than those considered probable in the initial calculation. The parameters employed are reduction in benefits, delay in benefits, increase in project costs, and combinations of these parameters.

a) Reduction in Benefit

If there were no efforts in crop cultivation technique by the farmers, good cooperation among the farmers, or effective supporting to the farmers by the government through Extension Center for irrigated agriculture, it is impossible to accomplish target benefit. If benefits are reduced by 10 percent, EIRR will fall to 11.9 percent, respectively.

b) Delay in Benefit

Delay in benefit buildup may result from no effective supporting to the farmers by government through Extension Center for irrigated agriculture. If the construction of Extension Center is delayed to bring delay in benefit by five years, EIRR will fall to 11.5 percent.

Sensitivity Test

Alternative	EIRR (%)
1. Proto-type	12.7
2. 10% increase in capital cost	12.0
3. 10% reduction in benefit	11.9
4. five-years delay in benefit	11.5
5. Combination of 2. and 3.	11.2
6. Combination of 2. and 4.	10.8
7. Combination of 3. and 4.	10.7
8. Combination of 2.,3. and 4.	10.1

7.4.2. Farm Budget Analysis

1) Improvement on Farmers' Budgets

The farm budget analysis has been made for the average size (1.7 ha, 4.2 acres) of the owner farmers of vegetables, fruits and grains. It has been revealed that Rs.5,400 per year of the average farm income in the Project Area at present is lower than Rs.21,300 (1984 - 1985) of the average income of Pakistan.

However, the implementation of the Project will make it possible for those farmers to raise their lining standard above the average of the rural area of Pakistan and Punjab with the increase in cropping intensity and its yield.

Farm Income With-Project

(unit: ha, 000 Rs/year)

Items	Future Without-Project	Future With-Project			
		Average	Vegetable Farm	Fruit Farm	Grain Farm
1. Cultivated Area	1.7	1.6	1.6	1.6	1.6
2. Total Cropping Area	1.8	2.7	3.1	1.6	2.4
3. Gross Income	8.9	76.5	148.5	128.0	16.4
4. Net Agricultural Income	4.0	56.0	110.3	98.6	7.1
5. Farm Household Income 1/	6.3	64.0	123.8	109.1	10.6

Note: 1/... including production cost of family labor.

The Project gives more benefits to the large size vegetable and fruit farmers, while the small size and grain farmers without the cultivation of vegetable will not always receive the Project benefit. Therefore, it should be considered essential to give these small and grain farmers the intensive guidance about cultivation of vegetable and fruit through extension service. This extension service is important to raise the rate of cost recovery and keep it high.

2) Farm Income and Project Cost Recovery

The cost to be borne by the beneficiaries is the construction cost of the on-farm works and the operation and maintenance cost after the completion of construction.

Farmers' burden of the Project cost is estimated with the following assumption;

i. Construction cost of on-farm works
   - 20 percent of the total project cost will be paid by farmers in instalment of over seven years.

ii. Operation and maintenance cost
   - Total of the operation and maintenance cost will be paid by farmers.
   - Total of depreciation cost of the gate of dam & canal, pump, vehicles and etc. will be paid by farmers.

The result of the estimation of the farmers' burden is 1,184 Rs./ha (479 Rs./acre) of the beginning seven years of the irrigation and 939 Rs./ha (380 Rs./acre) of the after eight years, respectively. The farmers burden to the agricultural income shares only 2.7 percent in the target year, but shares high 20 to five percent after five to six years of the construction completion. Therefore, an improvement of the repayment condition and subsidy will be needed for five or six years after the start of irrigation.

Farm Income and Cost Recovery

(unit: Rs./ha)

Year	Agricultural Net Income	Farmers Burden Charge		
		Cost of On-farm Works	O & M Cost	Total
	(1)	(2)	(3)	(1)≈100
1. 1996	5,250	245	939	1,184 (22.5)
2. 1997	7,340	245	939	1,184 (16.1)
3. 1998	10,490	245	939	1,184 (11.3)
4. 1999	13,980	245	939	1,184 (8.5)
5. 2000	17,490	245	939	1,184 (6.8)
6. 2001	21,330	245	939	1,184 (5.5)
7. 2002	25,180	245	939	1,184 (4.7)
8. 2003	27,980	-	939	939 (3.4)
9. 2004	30,080	-	939	939 (3.1)
10. 2005	31,820	-	939	939 (3.0)
11. 2006	32,870	-	939	939 (2.9)
12. 2007	33,570	-	939	939 (2.8)
13. 2008	34,280	-	939	939 (2.8)
14. 2009	34,620	-	939	939 (2.7)
15. 2010 ~	34,970	-	939	939 (2.7)

Note: Annual farmers burden per hectare is estimated as follows.

	(Rs.)
1. Construction Cost of On-farm Works	
- Total	52,200,000
- Farmers burden (20%)	10,440,000
- Annual repayment (for 7 years)	1,491,400
- Annual repayment per hectare (6,100 ha)	245
2. O & M Cost	
- O & M cost (4,104,000/6,100 ha)	673
- Depreciation cost	266
Sub-total	939

CHAPTER VIII. ENVIRONMENTAL IMPACT ANALYSIS

CHAPTER VIII. ENVIRONMENTAL IMPACT ANALYSIS

As described previously, the project includes the construction of the K-2 Dam to store 29.4 MCM of river water in the Kurang River and the construction of about 130 km of irrigation canals to convey irrigation water to the area of 6,600 ha (16,300 acres). The Project implementation will bring about a variety of impacts in the Project Area and its vicinity in both the positive and negative forms in terms of the national and local socio-economic environment.

The subsequent deals with these environmental impacts brought by the project implementation.

8.1. Environmental Setting

The Study Area located on the northwestern edge of the Potwar Plateau is referred to as the rual area of Islamabad Capital Territory and lies adjacent to the urban area of Rawalpindi.

Topographically the Study Area has a gentle slope in the direction from northwest to southeast, and is covered with a vast area of reticulated gullied land. The eroded land is still expanding due to natural and weather conditions such as hot and dry summer followed by heavy rains in monsoon season, so called Barani, geological conditions as deposits of wind-laid materials and human activities such as over-grazing and destruction of vegetation. Such land erosion has caused serious soil conservation and social problems in the area.

8.1.1. Water Quality and Aquatic Life Environment

In the Study Area, there are many rivers and streams running from north or northeast to south or southwest, and all of them pour

themselves into the Soan River flowing through the Study Area. These tributaries of the Soan River run through the hilly areas or lower parts of mountains in the area, and their discharges fluctuate heavily by seasons (monsoon and dry) or by years (drought and wet).

The Kurang River is the main stream in the Project Area, which serves aquatic fresh water habitats, and in the neighboring area of the Islamabad, the Rawal Dam is provided across the Kurang River for the purposes of supplying domestic water supply to Rawalpindi. This Rawal Dam is presently producing fresh water fish such as carp. Their population is augmenting year by year.

The quality of water of the Kurang River is remarkably turbid with minor floating debris and siltation, when rainfall is observed in the catchment area. On the other hand, the quality of water in the Rawal Dam shows that i) the water sampled in normal stage is fit for human consumption, ii) some light green vegetation matter is observed and iii) a few algae-chlorination is recommended according to the chemical and micro-biological analyses. However, water sampled in severe drought month presents hygienically unfit for human consumption in rare case without providing of an adequate treatment, due to the presence of coliform bacteria.

8.1.2. Extension Environment

The catchment area of the Study Area in the Kurang River basin is about 580 sq.km (234 sq.mi) in total, and out of this area that of the proposed K-2 Dam is estimated at 137.0 sq.km (53 sq.mi). Watershed of the K-2 Dam is under thin forest by slashing and burning three, and these conditions lead to serious sediment problems in the basin. Furthermore, in the Project Area of about 12,900 ha (31,876 acres), about 3,900 ha (9,637 acres) of lands extending in the lower area of the proposed K-2 Dam is categorized to be wasted land with gullied topography, and these soil erosions also cause one of the serious problems in the area.

8.1.3. Social Environment

The proposed K-2 reservoir area is presently inhabited, and about 130 ha (321 acres) of cultivated land by 125 households will be submerged by construction of the K-2 Dam. And, other households and farm land near the submerged land will be adversely affected in either limited mobility and access from sources of human needs or abrupt change of environment. These households will be relocated to an adequate place in the Project with land compensation.

8.2. Environmental Interaction by the Project Implementation

8.2.1. Construction Phase

Geographical conditions in the Project Area will be changed distinctly especially at the K-2 damsite and cultivable commanded area where land development will be made. The major topographic changes will be a man-made reservoir of the K-2 Dam with water surface area of about 300 ha (742 acres) at maximum water level of 649.8 m above mean sea level. The reservoir is to be created by rise of dam across the Kurang River.

Vegetative covers will be submerged and affect adversely their thriving. New kinds of vegetation, however, will grow adaptive to the created habitat characterized with deep water and more humid climate. Fish raising will be productive at the early stage of storage because of increasing nutrients resulting from decayed vegetation by submergence. But, in long terms fish production will be deteriorated due to the limited source of food and eutrophication.

Erosion and dust increase in the atmosphere will occur by earth moving up to the time of vegetative recovery in dam construction site, borrow area, open excavation of canals, access roads, and the

cultivable commanded area where land development is to be made. Preventive measures have to be taken for such works since these works are only localized and carried out temporarily. Erosion will be minimized by considering and understanding the slope stability as well as soil cohesiveness. Also, dust presence in the atmosphere will be diminished to a tolerable level by spraying water at the earth-moving sites.

The household of 125 located in the reservoir area will be relocated to an adequate farmland area of about 130 ha (321 acres) in total within the cultivable commanded area in the Project Area. It is considered that the residents overwhere are willing to cooperate without any conditions, but implementation should be made carefully to avoid development of troubles and other incidents that could trigger social tension.

At the peak of construction works, when there is an influx of laborers from neighboring areas, the proponent should look into the possible migration of laborers.

8.2.2. Operation and Maintenance Phase

Usually the project proponent tries to operate and manage the project at less cost to gain substantial benefits without consideration of cost additive that is equally important for component and aspects. On the other hand, the efforts of the environmentalist are not to dissuade the proponent from pushing through the project but rather assist him in looking properly the totality of the project and its relationship between the environmental contributory to the attainment of the designed project and expected benefits.

Irrigation project should always consist of not only the dam and reservoir, irrigation facilities and on-farm facilities, but

also the watershed management. The watershed is the source of water of the river being tapped for irrigation. Several irrigation projects already implemented showed sound rivers' characteristics during the study phase related to the design of the facilities and acreage of the cultivable commanded area thereto. But during the operation and maintenance phase, the water resources could not provide the considerable water volume for the designed life span of the project. The possible causes of this tragedy is an alternation of watershed vegetation cover which is caused by excessive slashing and burning. ICTA, therefore, has to establish coordination committee together with Government agencies concerned about quality of vegetation cover for the watershed of the Kurang River, especially at the upstream of the Rawal Dam.

Water quality of the Rawal Dam, which is supplying domestic water to Rawalpindi, will be one of the serious subjects in the drought month and year after the completion of K-2 Dam in the Kurang River basin. Accordingly, the necessary countermeasures to control water quality of the Kurang River should be taken by the Government agencies concerned.

Manipulation of the environment of 6,600 ha (16,300 acres) from rainfed area to irrigated area would induce artificial manage on ecosystem, whereby vegetable, orchard, grain and feed crops are introduced. The natural ecological consequence will be the emergence of pests and diseases. But since the aim of development is for greater benefit gains, farmers will resort to use of farm chemicals to combat insects and other pests.

The applied chemicals remain either in or on crop, or in the soil and drift to nearby crop areas or flow into stream and drainages, thereby create a hazard to aquatic and terrestrial life. Therefore, information on dissemination and control of use of insecticides is necessary to minimize danger and avoid production setbacks that coved undermine development and threaten the financial viability of the project.

More distinct positive impact of the project will be manifested in increase of income, employment opportunities, improvement of nutrition mobility and lifestyle. These impacts will fee-up the introduction of fishery development, tourism and water based sports and recreation in the Project Area.

The impact identification and evaluation are shown in Table 8-1.

TABLE 8-1. IMPACT IDENTIFICATION AND EVALUATION CHECK LIST FOR RECOMMENDED SCHEME

Environmental Parameters	Impact		Magnitude of Impact					
	+	−	O	L	M	H	U	N
A. Existing Physical and Chemical Characteristics								
1. Earth:								
a. Mineral Resources			x					
b. Soils		x		x				
c. Land Forms	x			x				
d. Unique Physical Features	x		x					
2. Water:								
a. Stream, Drainage, Effluent	x				x			
b. Groundwater	x				x			
c. Quality		x		x				
d. Recharge	x				x			
3. Processes:								
a. Floods	x			x				
b. Erosion	x				x			
c. Stress–Strain (Earthquake)		x					x	
d. Downstream Sedimentation	x				x			
B. Existing Cultural Factors								
1. Land Use:								
a. Agricultural	x					x		
b. Residential		x				x		
c. Industrial			x					
d. Commerical			x					
e. Forestry			x					
f. Grazing	x				x			
g. Wetlands	x				x			
2. Infrastructures:								
a. Major Structures			x					
b. Utility Networks	x				x			
c. Transportation Networks	x				x			

Environmental Parameters	Impact		Magnitude of Impact					
	+	−	O	L	M	H	U	N
3. Aesthetic and Human Interests:								
a. Scenic Views and Vistas	x					x		
b. Parks and Reserves	x			x				
c. Rare and Unique Species			x					
d. Historical and Archeological Sites and Objects			x					
4. Cultural Status:								
a. Employment	x			x				
b. Life Styles	x			x				
c. Health and Safety		x		x				
d. Population Density	x			x				
e. Food Production	x					x		
5. Recreation:								
a. Resorts	x				x			
b. Swimming, Fishing	x					x		
C. Ecological Relationship								
1. Food Chain	x						x	
2. Water–Related Disease Vectors	x				x			
3. Insect Vectors							x	

\+ Positive Environmental Impact
− Negative Environmental Impact

O No Environmental Impact
L Minor Environmental Impact
M Moderate Environmental Impact
H High Environmental Impact
U Unknown Environmental Impact Magnitude
N Not Applicable

CHAPTER IX. RECOMMENDATIONS

CHAPTER IX. RECOMMENDATIONS

9.1. Recommendations for Project Implementation

The Upper Kurang River Irrigation Project is found technically feasible for construction of the facilities and to have 13 percent of Economic Internal Rate of Return (EIRR); the Project, therefore, can be evaluated technically viable and economically feasible. It is recommended to commence implementation of the Project at the first available opportunity. The early implementation is expected from the following view points.

- Realization of the Project will bring the agricultural production increase, which will allow to raise the living standards of the rural inhabitants of the Islamabad Capital Territory (ICT) and also to correct the income disparity among areas and classes of the people in the Country.
- The Project works include construction of the dam, main/lateral canals, roads, farm pond as well as those terminal facilities at on-farm level etc. The construction of these facilities is expected to increase the acreage of irrigated farm land, which will greatly contribute to development of the agro-economy in ICT and to absorption of the local surplus labor power.
- The Project will enable to have about 220,000 tons of agricultural products annually, which will allow the ICT local economy to be vitalized through development of the facilities in the fields of agri-processing and marketing.
- The water resource development in the Kurang River basin by construction of the K-2 Dam will permit not only the irrigation beneficial areas available by 6,600 ha (16,300 acre), but the water sources stabilized for the Rawal Dam which is supplying domestic water supply to Rawalpindi. In other respect, the K-2 Dam will be greatly helpful to extend a life span of the Rawal reservoir by curbing inflow of sediment into the reservoir.

- The terminal facilities shall be constructed by cooperative works of the Government and the local beneficiary farmers. And the terminal facilities and crop husbandry in the area will enable to prevent soil erosion as a social problems in the Barani area including the Project Area and furthermore to make soil conservation realized. In this view, the Project will be a model of soil conservation to the similar-natured hilly land of the Barani area.

9.2. Recommendations for the Detailed Design and Implementation of the Project

The current Feasibility Study has been carried out based on the topographical map with the scale at 1/21,100 together with various data/information collected during the field works. And the detailed design and implementation of the Project should be carried out with a great care to the following points.

- The executing agency of the Project is an organization to be jointly composed of the governmental agencies such as ICTA, WAPDA, SDO, CDA, PHED, NARC, and MFAC. And it is recommended to establish the organization in the closest cooperation among relevant governmental agencies so as to implement the Project works effectively and smoothly.

- The Project should be implemented with the following basic data/information to be collected and studied.

  Preparation of Topographical Maps

  ° Project Area: Topographical map to cover 12,900 ha of the area with scale at 1/5,000.

  ° K-2 Dam Site: Topographical map of cross-section and profile with scale at 1/5,000 and 1/1,000

  ° Canal Route: Topographical map and cross-section

  Geological Investigation

  ° K-2 Dam site core-boring and analysis and seismic prospecting

° Borrow pit survey

° Embankment material tests

° Geological survey for canal route

- The Feasibility Study has been made on the basis of the topographical map with scale at 1/21,100, as mentioned previously. In particular the study on the present land use and the determination of the Project Area and beneficial area could not but be made based on the said map and some supplemental field survey. Under the situation, the more detailed estimation of the Project Area and the beneficial area should be made according to the topographical map with scale at 1/5,000 which shall be prepared in the course of the detailed design works.

- A review on the discharge of the Kurang River should be made according to the hydrological and meteorological records observed with the rain gauges and level gauges which were installed by two each in the area by the Study Team during the Feasibility Study. And it is necessary to review the water balance of the Rawal Dam and the K-2 Dam according to the results of the river discharges reviewed.

- It is quite desirable to carry out the geological investigation and embankment material tests in participation of the geologist, soil expert and dam engineer in the detailed design stage, in taking into consideration the geological conditions of the dam foundation, borrowing of most of the embankment materials from spillway and dam excavation, and the embankment with mixed materials.

- The canal plan has been made according to the topographical map with the scale of 1/21,100. The re-study for the canal plan should be made on the canal alignment, layout of the related canal structure based on the topographical map with the scale of 1/5,000 to be prepared during the detailed design stage.

- A thorough study should be made on availability of the pre-cast reinforced concrete flume because this type of flume is easy in quality control and handling.

- The construction of the K-2 Dam will have to submerge about 300 ha of land (including 130 ha of farm land) and 125 houses. For land acquisition and compensation of properties of the inhabitants in the proposed reservoir area, negotiation and necessary procedures should be followed very carefully in the best understanding of the local people's wishes.

9.3. Recommendations for Raising Project Effects

During and after implementation of the Project, the following conditions should be fulfilled for raising the Project effects smoothly and steadily.

1) Provision of the Terminal Facilities

It is essentially required to provide the on-farm facilities for reaching the target of agricultural production through successful water resources utilization under effective and efficient water management.

The construction works of the proposed on-farm facilities, which should be carried out by beneficiary farmers themselves in principle, shall be implemented under the powerful support and close cooperation of the governmental organizations/agencies for smooth implementation in considerably intricated topography. Especially, those works shall be completed within the designated construction period by technical and financial assistance of the governmental organizations.

2) Operation of Rawal Dam and K-2 Dam

The proposed K-2 Dam shall be operated in the link with the existing Rawal Dam in view of the effective utilization of the Kurang River water resource, and the first priority is given to the function as stable source to supplement the water to the Rawal Dam. The operations linked with each other, therefore, shall be practised according to the detailed operation manual to be prepared during the detailed design stage together with full operation and close coordination with SDO responsible for the Rawal Dam operation.

3) Implementation of Irrigated Upland Farming

Efficient irrigated upland farming requires to carry out the following researches, studies, and analysis of the data to be collected.

- To introduce and diffuse the crops and varieties with high suitability to irrigated farming so as to ensure the early achievement of the target of the agricultural production,
- To carry out the measurement of the soil moisture contents by soil types and water requirements by crops in the Project Area and to prepare the irrigation standards covering those items of irrigation water required per one operation and number of the interval days, etc.,
- To develop a furrow irrigation method suitable to the Project Area,
- To encourage deep-plowing and to construct underdrainage in the fruit crop area,
- To formulate fertilization standards by crops,
- To research/study the crop-wise planting patterns, water management by growing stages, seedling method improvement, training method, development of new cropping patterns, plant protection methods, labor saving in farming works, etc., and to prepare the guideline for successful irrigated upland farming, to try to transfer and diffuse these latest developed knowledge and techniques, etc.,
- To establish the reasonable rotational cropping pattern with tree crops and legumes introduced,
- To make a plan for timely distribution of quality seeds, fertilizer, agri-chemicals, and other input materials required, and to organize a system to smoothly distribute these materials,
- To encourage the farmers to make records on their daily farming works, kind/amount of fertilizer and other input materials applied, and also to practise the improvement works for their individual farm management and farming works by their own diagnosis,
- To encourage the local formers to grow vegetables as much as possible and to make a plan for greenhouse farming expected in the future,

- To encourage the local farmers to produce their characteristic farm products on the village basis and to organize cooperative associations for collective works for marketing of such products,

- To give positive guidance for small scale farmers to concentrate their energy to vegetable farming and transfer to greenhouse farming smoothly in the future,

4) Agri-Supporting System

At present, the agri-supporting services in ICT have been rendered by Technical Transfer Unit (TTU) of NARC. Rainfed farming is dominantly practised in ICT, and consequently, it is necessary to establish the Extension Center of Irrigated Agriculture with TTU as a core for improving and diffusing the irrigated agriculture in the Project Area. And following appropriate measures shall be taken for agricultural production increase in the area and income raise of the local beneficial farmers.

- In the Construction Period:

  The construction works of the irrigation facilities including the dam and its related structures are scheduled to be completed for four years after commencement of construction works.

  Prior to completion of the construction works, however, the extension workers and the beneficial farmers shall raise consciousness on irrigated agriculture and be trained to learn the related technology of irrigation, since on-farm water management, as a whole, shall be carried out by beneficial farmers themselves.

  Under the circumstances, the Extension Center shall be established at the same time as the construction works of the irrigation facilities are commenced so as to render the necessary services for supporting works.

- Period of One to Seven Years after Completion of the Construction Works:

  The irrigated agriculture with stable water supply will enable to increase of agricultural production; however, steady production increase for hitting the Project target requires to make application study/research on soil

conditions, suitable crop selection, cropping/ fertilization management, rotational cropping, farm management, so as to realize the planned agricultural production, and the farmers' training for practising applied technology successfully will be necessary for the purpose as well.

- Period of Eight to Fifteen Years after Completion:

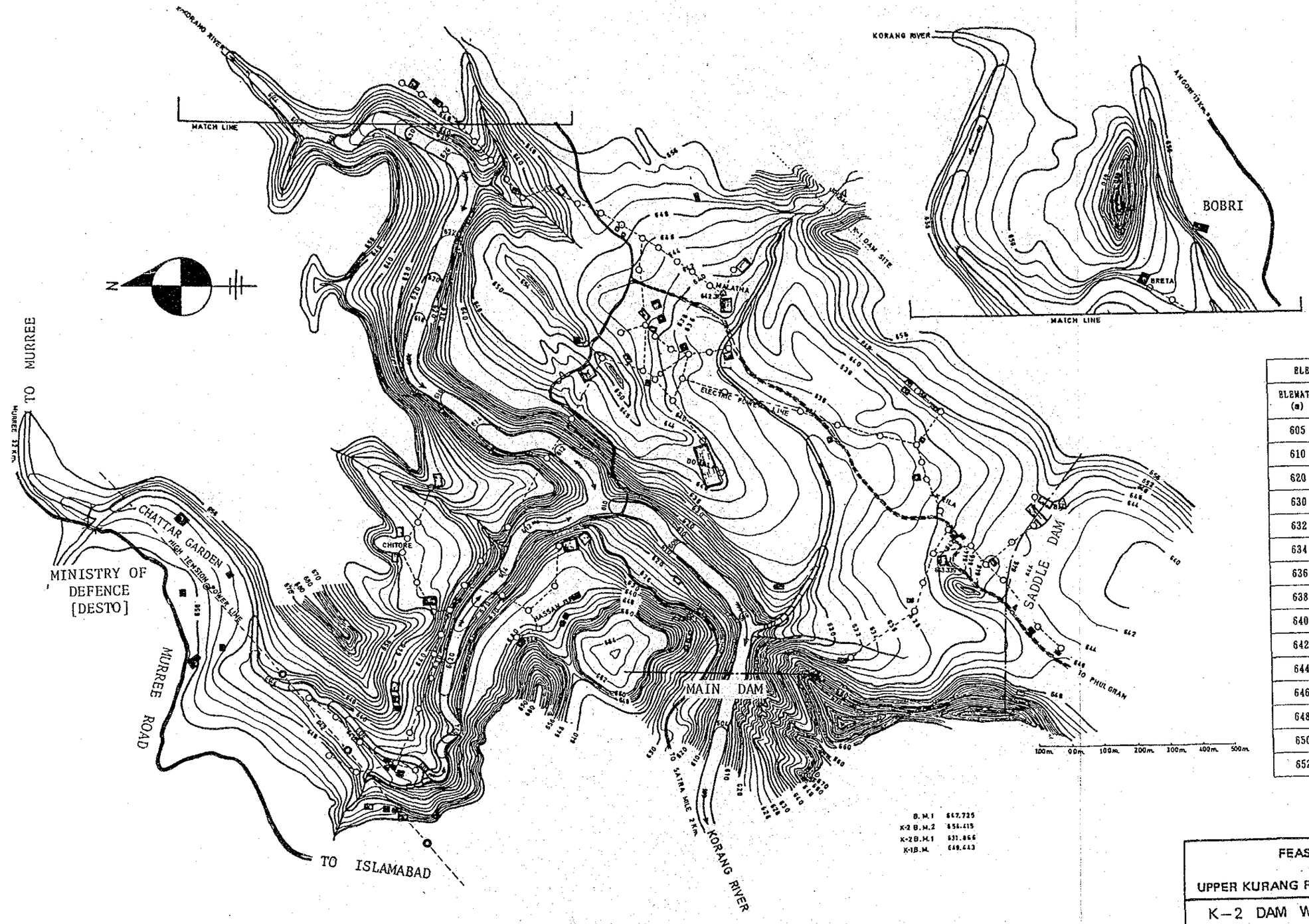
  The locally best suited cropping and farm management technology shall be firmly established to enable the Project Area to be a prosperous vegetable and fruit production area in the Country.

5) Water Pollution Control and Soil Conservation in the Project Area

According to the physio-chemical analysis and bacteriological analysis of the Kurang River water in the dry season, there have been some coliform bacteria found sometimes in the river water, and only in such case, treatment of water has been taken up as a problem. An agreement, therefore, should be concluded between Pakistani Government and the local inhabitants on water resources development by Project as well as water pollution control in the river. In other respect, excessive felling of the trees to develop new farm land in the Kurang River basin have caused such critical sand wash that ICTA as the executing agency should provide a coordination committee for soil conservation in the Kurang River basin and the like under the close cooperation with the related agencies and organization so as to execute the soil conservation in the area.

LIST OF DRAWINGS

DWG. NO.	TITLE
K – 2 Dam Works	
D – 1001	RESERVOIR AREA
D – 1002	GENERAL PLAN
D – 1003	PROFILE AND SECTIONS OF DAM
D – 1004	SPILLWAY
D – 1005	IRRIGATION OUTLET WORKS
D – 1006	RIVER OUTLET WORKS
D – 1007	DIVERSION TUNNEL
Canal Works	
C – 1001	GENERAL PLAN
C – 1002	PROFILE – MAIN & 1ST BRANCH CANALS
C – 1003	PROFILE – 2ND & 3RD BRANCH CANALS
C – 1004	PROFILE – 4TH, 5TH AND 6TH BRANCH CANALS
C – 1005	TYPICAL CANAL SECTIONS, CUT & COVER CONDUIT AND AQUEDUCT
C – 1006	KURANG RIVER SIPHON
C – 1007	DROP
C – 1008	OFF TAKE TYPE – A
C – 1009	OFF TAKE TYPE – B & FARM POND
C – 1010	WASTEWAY
On – Farm Development	
O – 1001	SAMPLE AREA – 1 (UPSTREAM AREA) GENERAL PLAN
O – 1002	SAMPLE AREA – 2 (DOWNSTREAM AREA) GENERAL PLAN
O – 1003	STRUCTURES
Road Works	
R – 1001	MARKETING ROAD



B.M.1 662.725
K-2 B.M.2 658.415
K-2 B.M.1 631.866
K-1 B.M. 649.643

ELEVATION-CAPACITY TABLE

ELEVATION (m)	AREA (1000 m²)	CAPACITY (1000 m³)
605	0	0
610	38.5	96
620	232.4	1,450
630	518.0	5,202
632	643.3	6,363
634	835.0	7,841
636	1,044.4	9,720
638	1,328.1	12,092
640	1,607.8	15,027
642	1,857.1	18,491
644	2,113.0	22,461
646	2,358.3	26,932
648	2,652.3	31,942
650	2,975.8	37,570
652	3,226.7	43,773

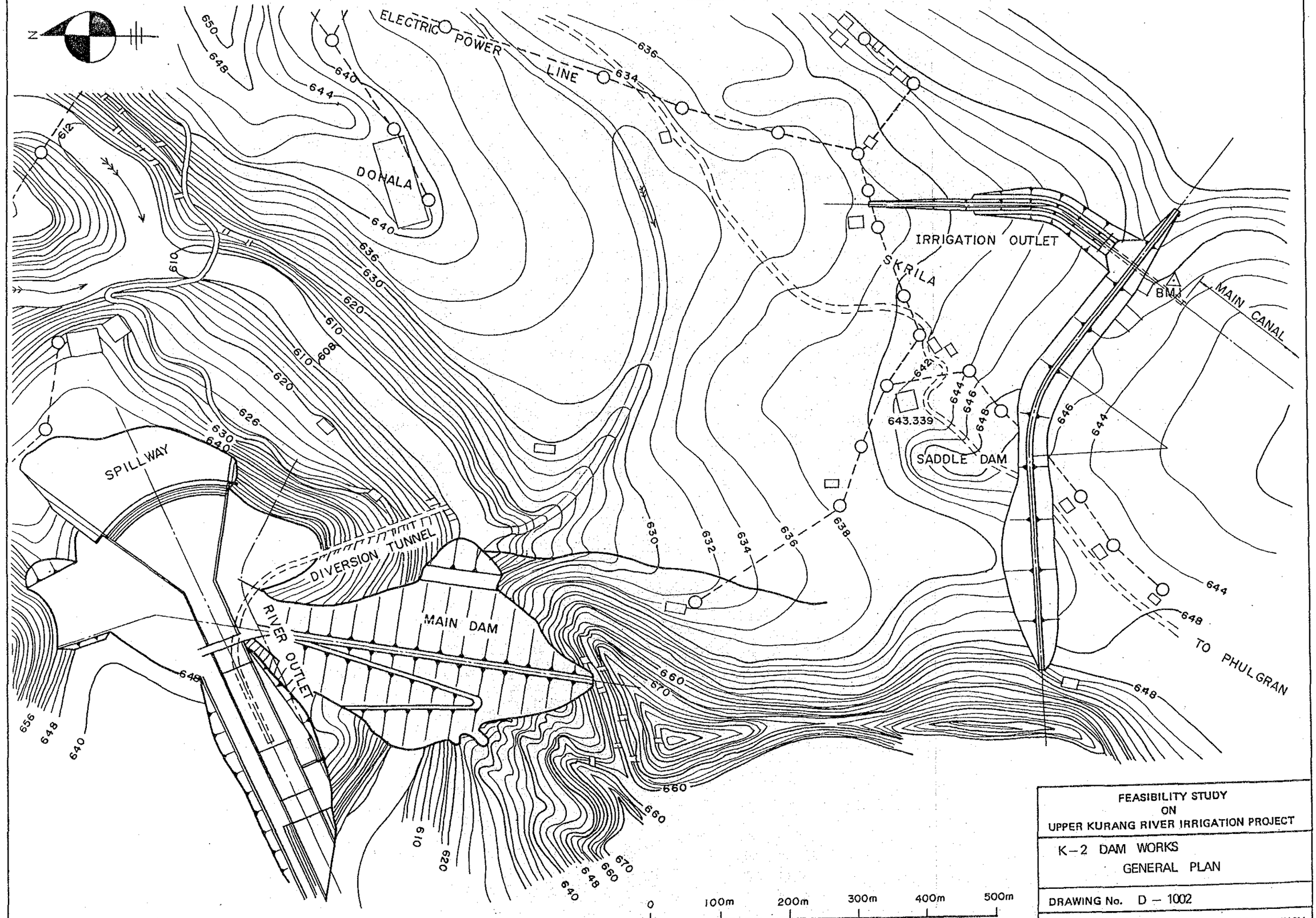
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

K-2 DAM WORKS

RESERVOIR AREA

DRAWING No. D – 1001

JAPAN INTERNATIONAL COOPERATION AGENCY

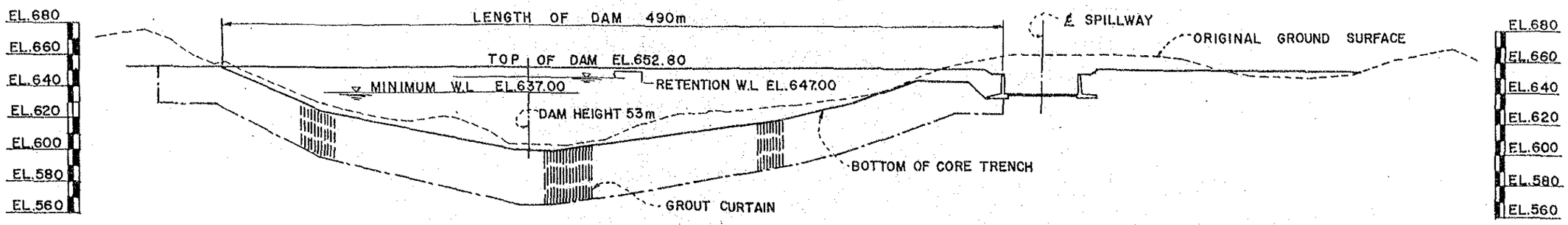


FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

K–2 DAM WORKS
GENERAL PLAN

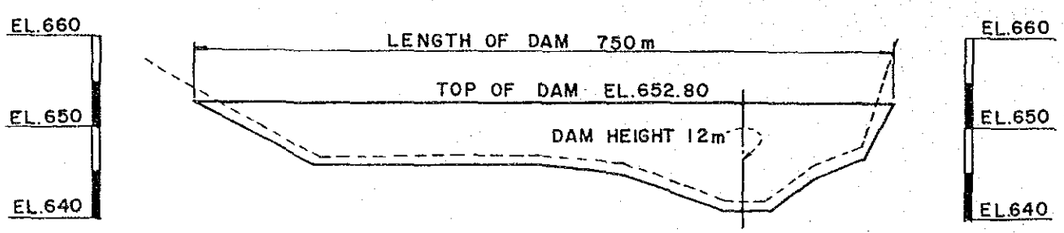
DRAWING No. D – 1002

JAPAN INTERNATIONAL COOPERATION AGENCY



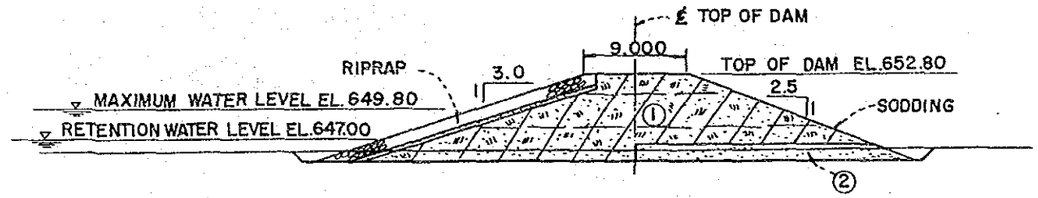
PROFILE ON ℄ TOP OF MAIN DAM

SCALE
0 50 100m



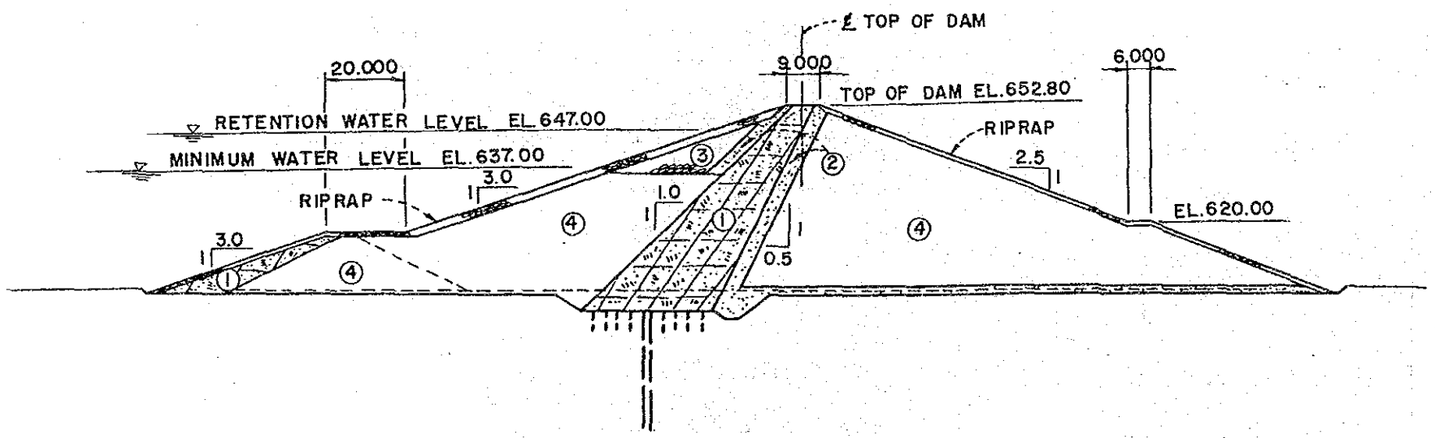
PROFILE ON ℄ TOP OF SADDLE DAM

SCALE
0 50 100 150m



SADDLE DAM

SCALE
0 1 2 3 4 5 6m



MAXIMUM SECTION OF MAIN DAM

SCALE
0 10 20 30 40 50m

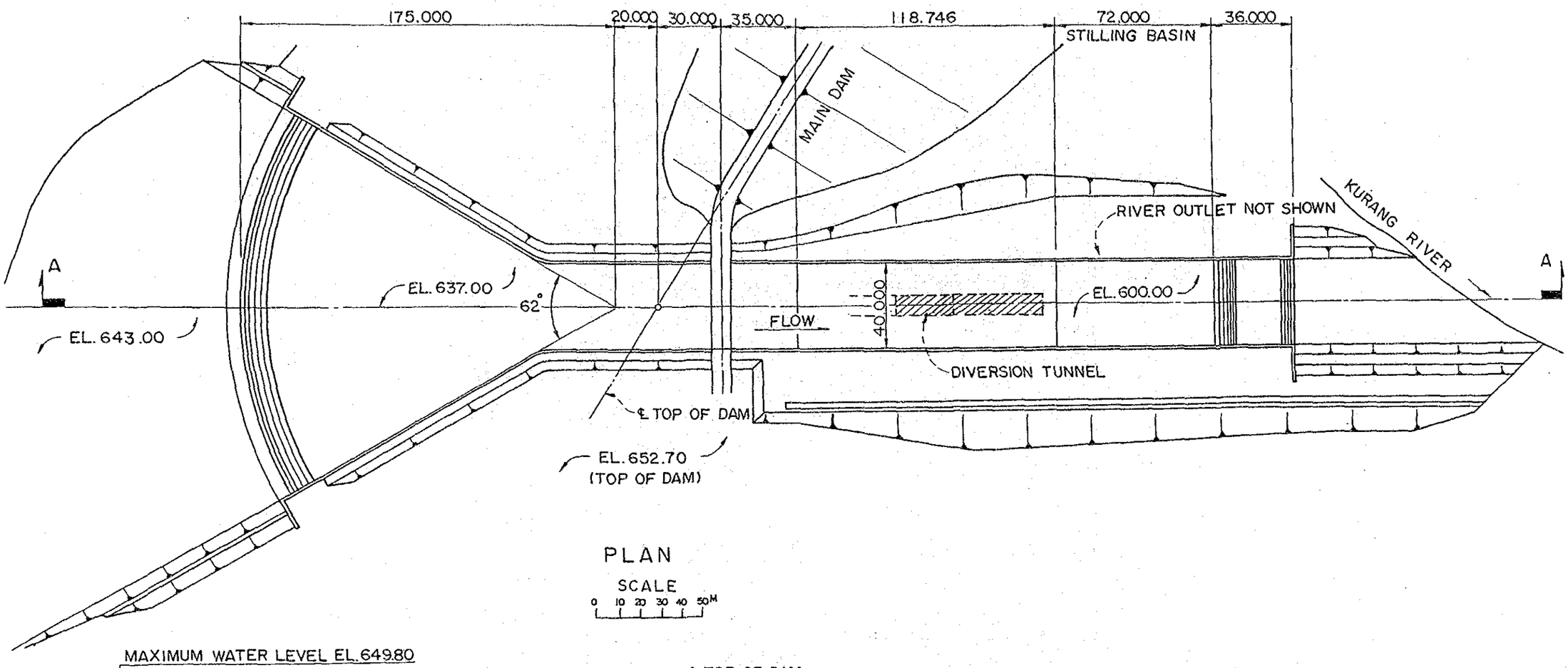
① CORE
② FILTER
③ ROCK
④ RANDOM

FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

K-2 DAM WORKS
PROFILE AND SECTIONS OF DAM

DRAWING No. D - 1003

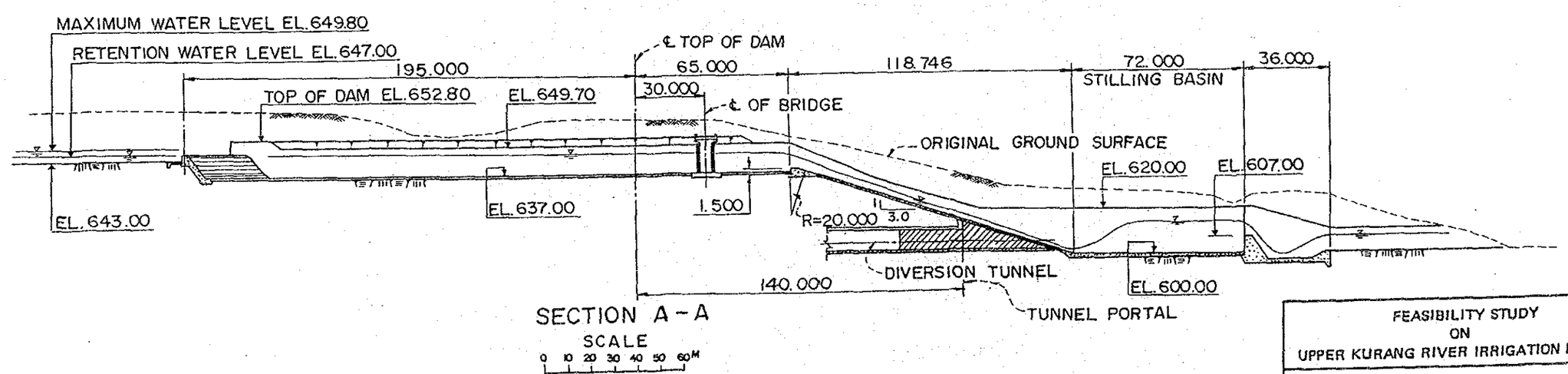
JAPAN INTERNATIONAL COOPERATION AGENCY



PLAN

SCALE

0 10 20 30 40 50M



SECTION A-A

SCALE

0 10 20 30 40 50 60M

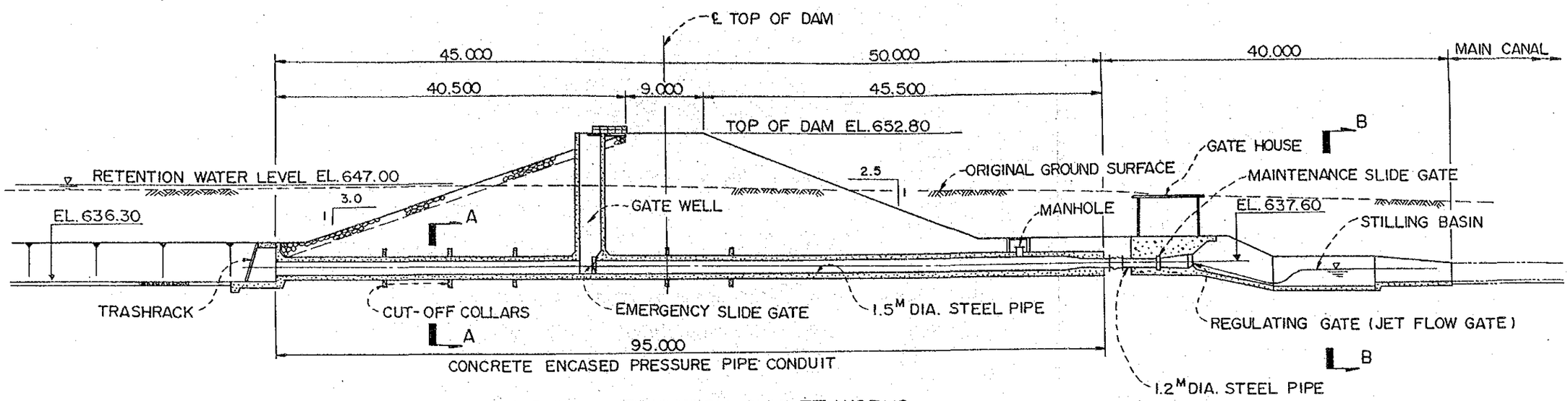
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

K-2 DAM WORKS

SPILLWAY

DRAWING No. D – 1004

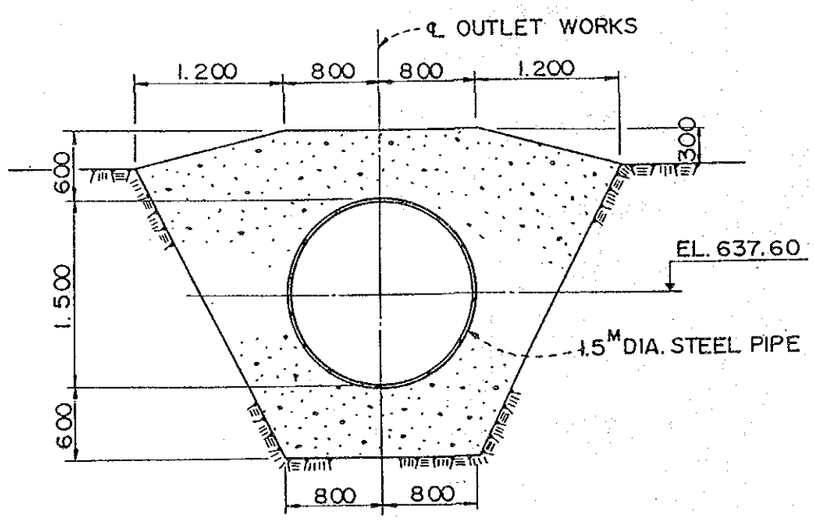
JAPAN INTERNATIONAL COOPERATION AGENCY



PROFILE ON ℄ IRRIGATION OUTLET WORKS

SCALE

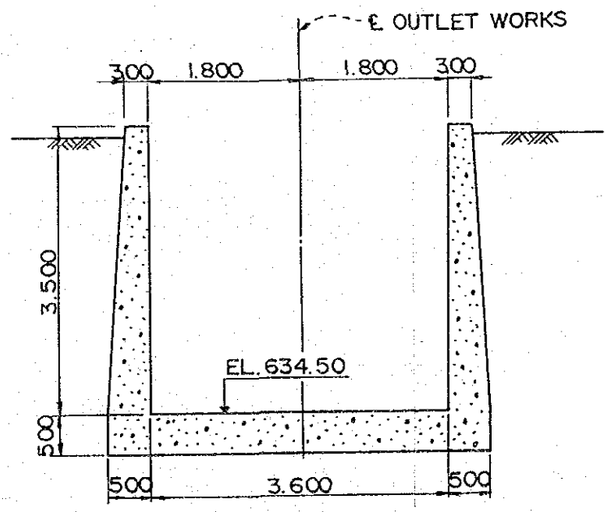
0 10 20 30 M



SECTION A-A

SCALE

0 1 2 3 M

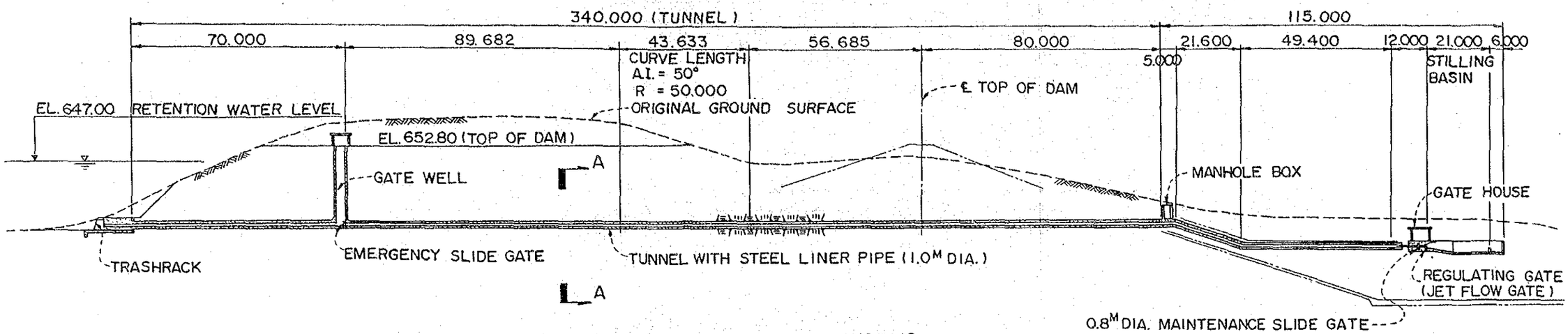


SECTION B-B

SCALE

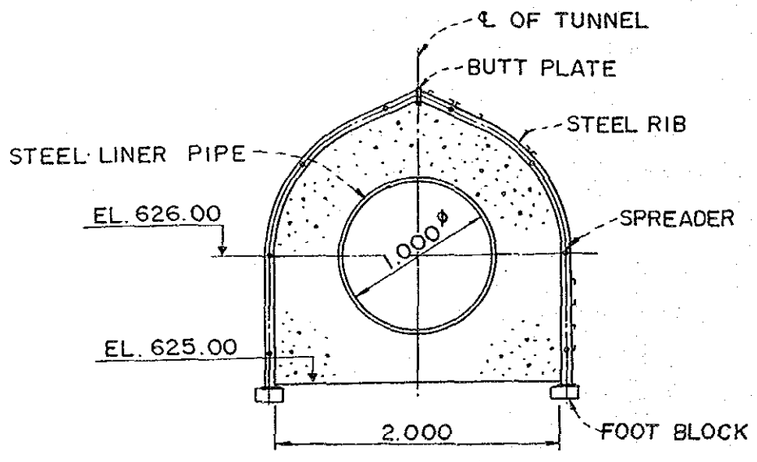
0 1 2 3 4 M

FEASIBILITY STUDY ON UPPER KURANG RIVER IRRIGATION PROJECT
K-2 DAM WORKS IRRIGATION OUTLET WORKS
DRAWING No. D – 1005
JAPAN INTERNATIONAL COOPERATION AGENCY

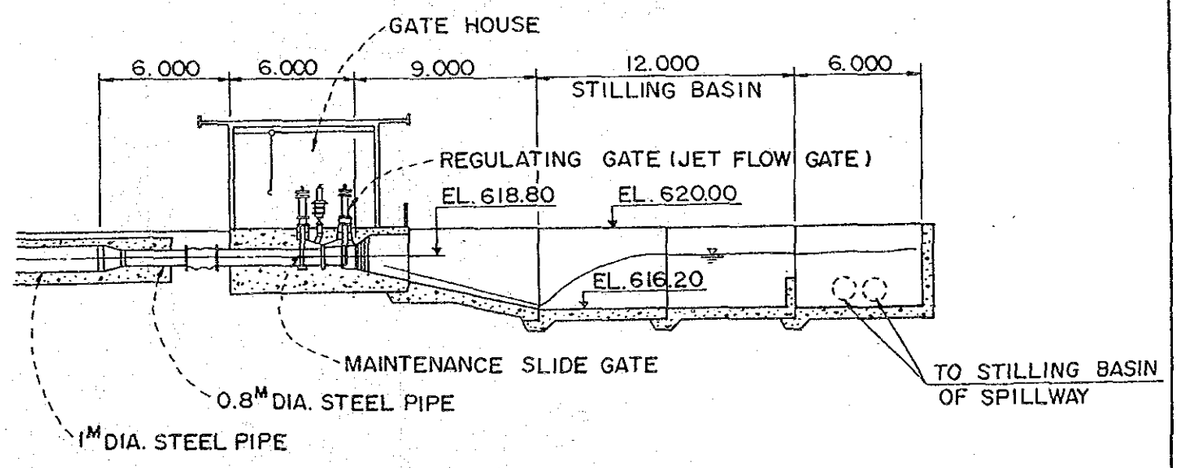


PROFILE ON ℄ RIVER OUTLET WORKS

SCALE
0 10 20 30 40M



SECTION A-A
NOT TO SCALE



DETAIL OF TERMINAL STRUCTURE

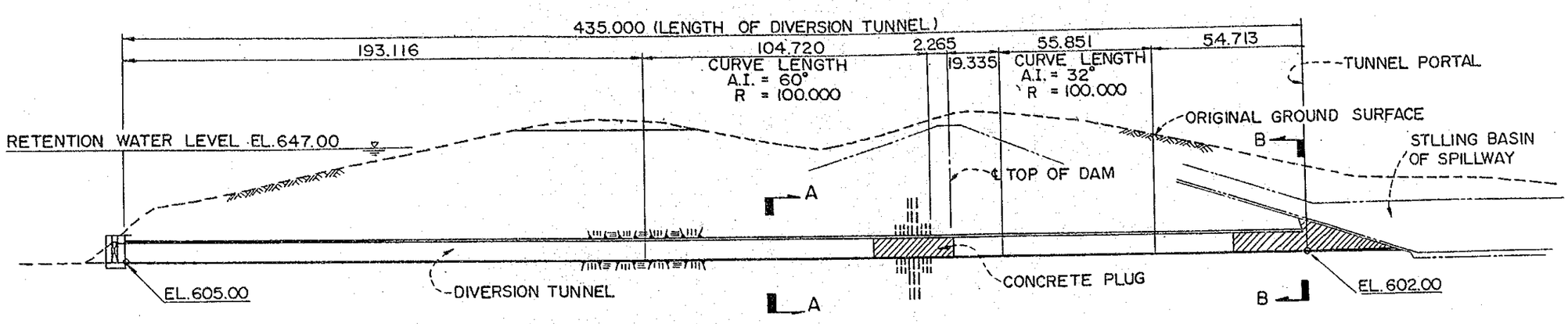
SCALE
0 1 2 4 6 8 10M

FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

K-2 DAM WORKS
RIVER OUTLET WORKS

DRAWING No. D - 1006

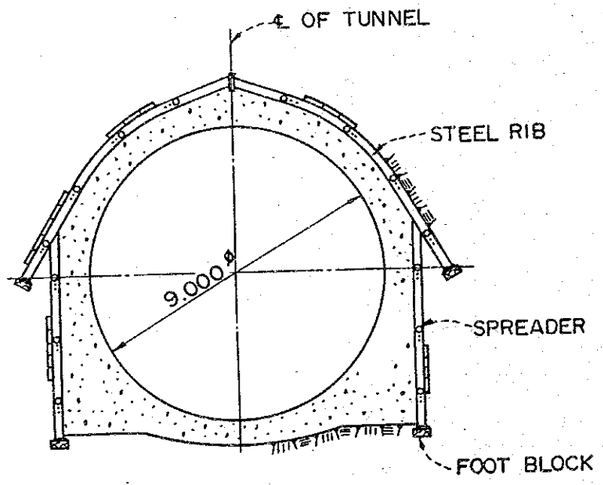
JAPAN INTERNATIONAL COOPERATION AGENCY



PROFILE ON ℄ DIVERSION TUNNEL

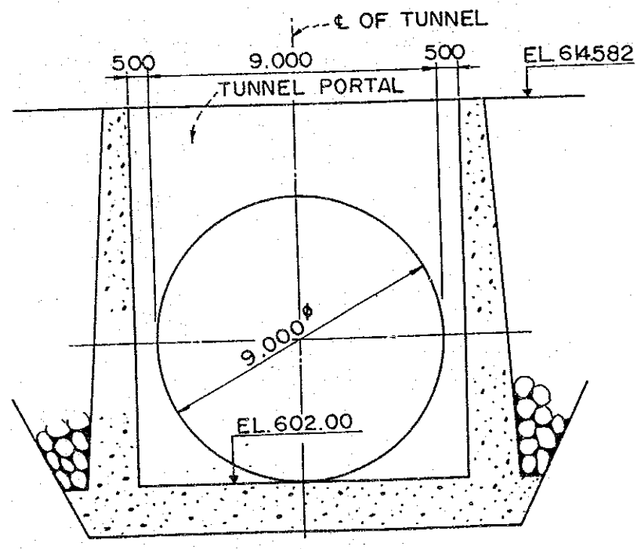
SCALE

0 10 20 30 40 50 M



SECTION A - A

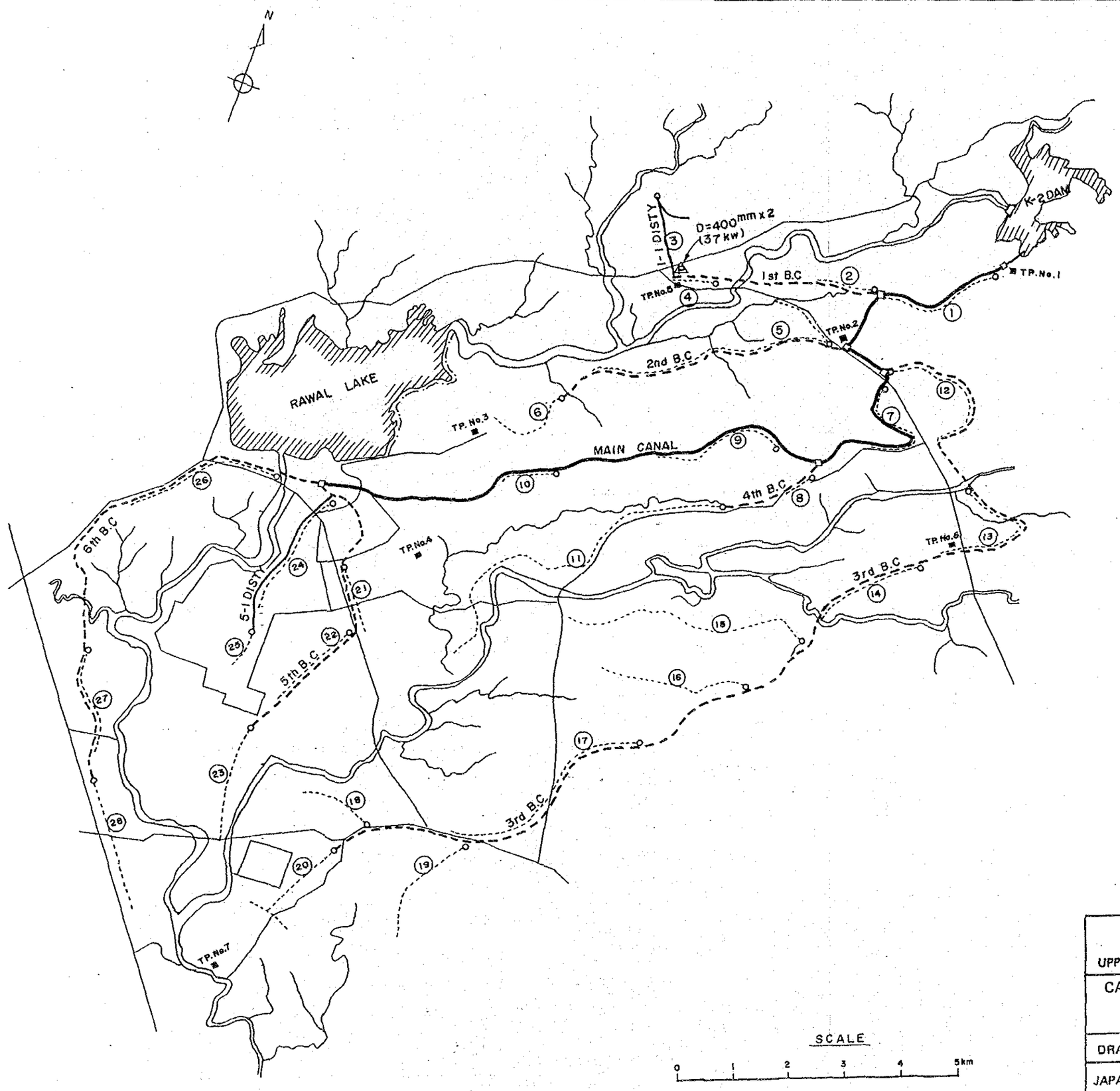
NOT TO SCALE



SECTION B - B

NOT TO SCALE

FEASIBILITY STUDY ON UPPER KURANG RIVER IRRIGATION PROJECT
K-2 DAM WORKS DIVERSION TUNNEL
DRAWING No. D - 1007
JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

- K-2 Dam
- Main Canal
- Branch Canal
- Distributary Canal (Disty)
- ② Minor Canal
- Farm Pond
- Location Of Test Pit
- Pump Station

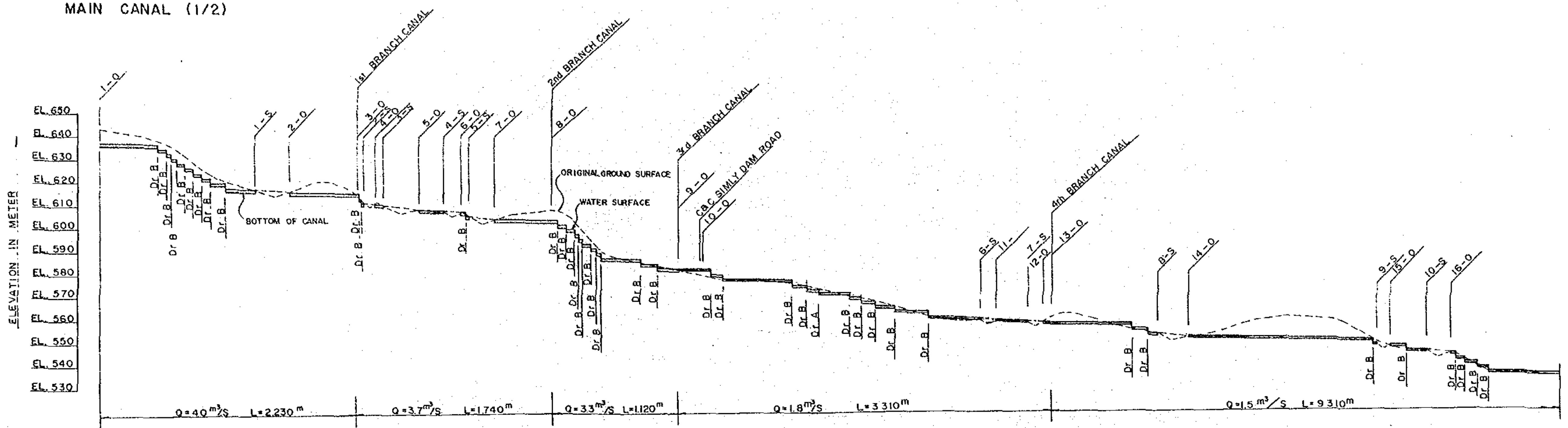
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

CANAL WORKS
GENERAL PLAN

DRAWING No. C – 1001

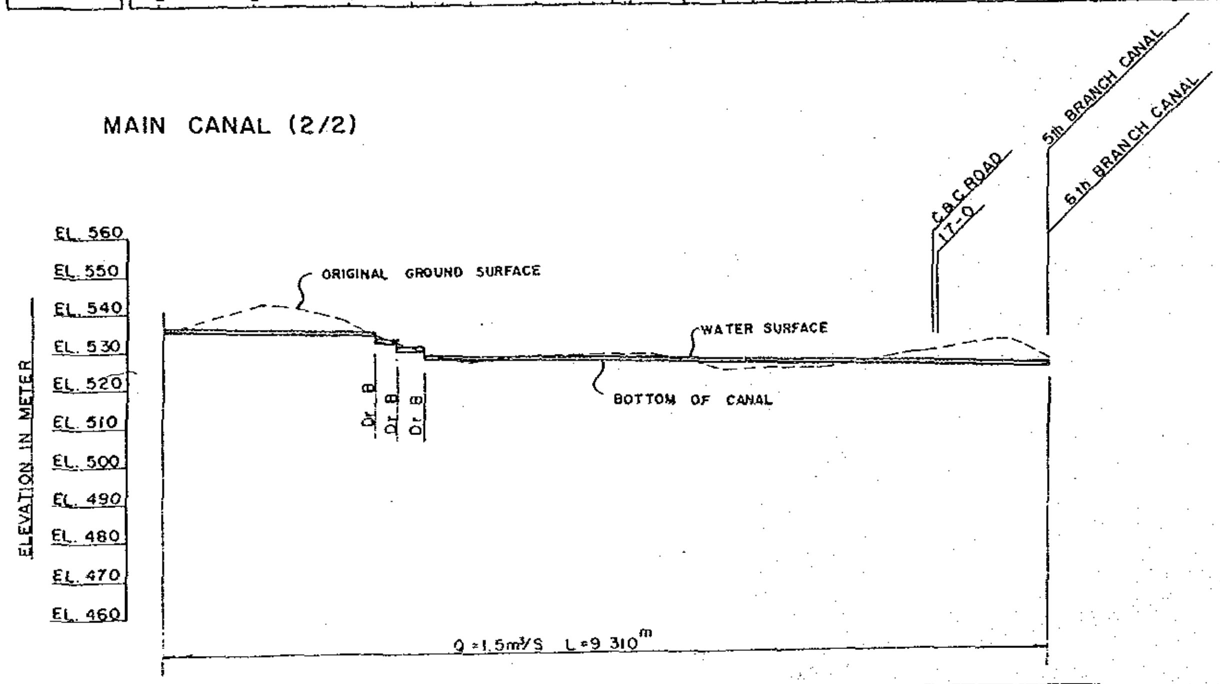
JAPAN INTERNATIONAL COOPERATION AGENCY

MAIN CANAL (1/2)



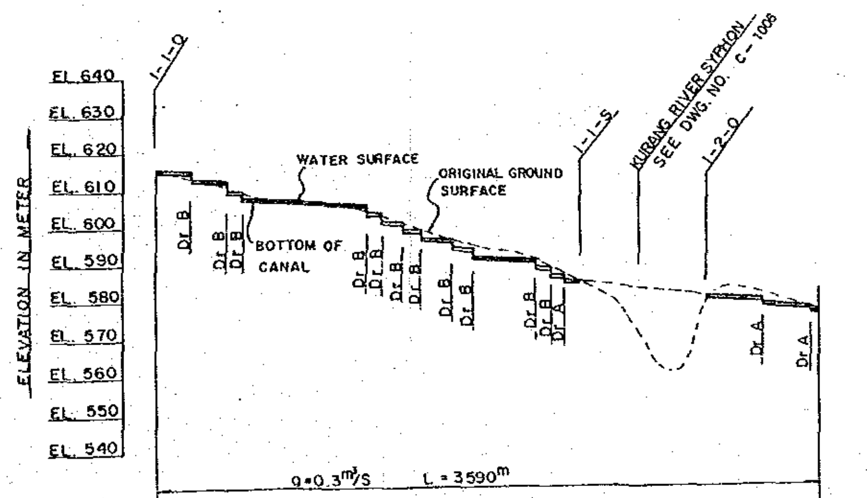
STATION	DISTANCE (m)	ORIGINAL GROUND SURFACE (m)	WATER SURFACE ELEVATION (m)	BOTTOM OF CANAL ELEVATION (m)
NO.0	0	645	637.00	635.80
NO.1	500	638	636.50	635.30
NO.2	1000	622	622.00	620.80
+340	1340	618	617.66	616.46
NO.3	1500	616	616.09	615.00
+150	1650	616	616.16	614.96
NO.4	2000	620	615.61	614.81
+230	2230	616	615.56	614.36
+300	2300	611	611.51	610.31
+410	2410	609	610.51	609.31
+480	2480	609	610.54	609.24
NO.5	2500	609	610.34	608.00
+290	2790	608	608.94	607.74
NO.6	3000	607	608.75	607.55
+160	3160	604	607.93	606.73
+230	3230	604	605.86	604.66
+450	3450	605	604.86	603.66
NO.7	3500	606	604.81	603.61
+470	3870	608	604.34	603.14
NO.8	4000	608	604.31	603.11
NO.9	4500	588	587.81	586.61
NO.10	5000	583	583.31	582.11
+90	5090	582	583.22	582.02
+290	5290	580	583.02	582.22
NO.11	5500	578	576.81	578.01
NO.12	6000	577	578.31	577.51
NO.13	6500	572	572.81	572.01
NO.14	7000	566	566.31	565.51
NO.15	7300	560	561.81	561.01
+260	7760	560	561.55	560.75
+400	7900	560	560.65	559.85
NO.16	8000	560	560.55	559.75
+180	8180	561	560.37	559.57
+310	8310	562	559.47	558.67
+400	8400	562	556.56	558.56
NO.17	8500	563	559.28	558.53
NO.18	9000	557	558.78	558.03
+360	9360	554	554.42	553.67
NO.19	9500	553	555.10	550.60
+170	9870	553	552.92	552.17
NO.20	10000	556	552.59	551.84
NO.21	10500	561	552.09	551.34
NO.22	11000	559	551.59	550.84
+320	11320	550	549.27	548.52
+470	11470	547	548.47	547.72
NO.23	11500	547	548.44	547.69
+290	11790	546	546.15	545.40
NO.24	12000	545	545.15	544.40
NO.25	12500	536	536.65	535.90
NO.26	13000	535	536.15	535.40

MAIN CANAL (2/2)



STATION	DISTANCE (m)	ORIGINAL GROUND SURFACE (m)	WATER SURFACE ELEVATION (m)	BOTTOM OF CANAL ELEVATION (m)
NO.26	13000	535	536.15	535.40
NO.27	13500	542	535.65	534.90
NO.28	14000	536	535.15	534.40
NO.29	14500	527	528.65	527.90
NO.30	15000	528	528.15	527.40
NO.31	15500	528	527.65	526.90
NO.32	16000	524	527.15	526.40
NO.33	16500	524	526.65	525.90
NO.34	17000	528	526.15	525.40
NO.35	17500	531	525.65	524.90
+210	17710	525	525.44	524.69

1st BRANCH CANAL



STATION	DISTANCE (m)	ORIGINAL GROUND SURFACE (m)	WATER SURFACE ELEVATION (m)	BOTTOM OF CANAL ELEVATION (m)
NO.0	0	615	615.30	615.18
NO.1	500	608	608.08	607.68
NO.2	1000	605	606.58	606.18
NO.3	1500	597	597.08	596.68
NO.4	2000	591	591.58	591.18
+280	2280	585	586.58	586.18
NO.5	2500	577	584.93	575.80
+270	2770	560	582.94	557.80
NO.6	3278 / 3008	382 / 382	581.45 / 581.39	581.06 / 580.97
NO.7	3500	578	578.87	578.47
+90	3590	577	577.60	577.20

LEGEND

- O : OPEN CANAL
- S : SYPHON
- C&C : CUT & COVER CONDUIT
- Dr. A : DROP H = 1.0 m
- Dr. B : DROP H = 2.0 m
- Disty : DISTRIBUTARY CANAL
- ----- : ORIGINAL GROUND SURFACE
- WATER SURFACE
- BOTTOM OF CANAL

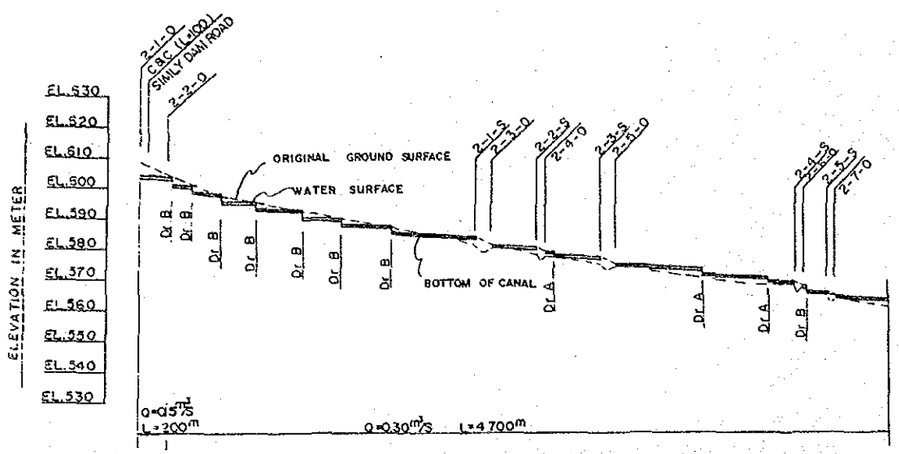
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

CANAL WORKS
PROFILE
– MAIN & 1st BRANCH CANALS

DRAWING No. C – 1002

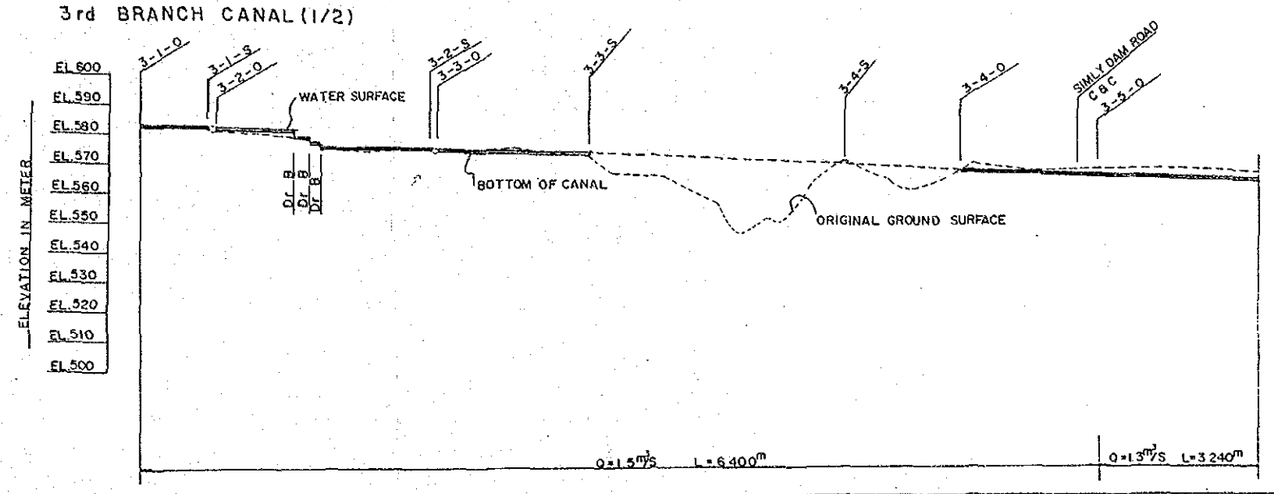
JAPAN INTERNATIONAL COOPERATION AGENCY

2nd BRANCH CANAL



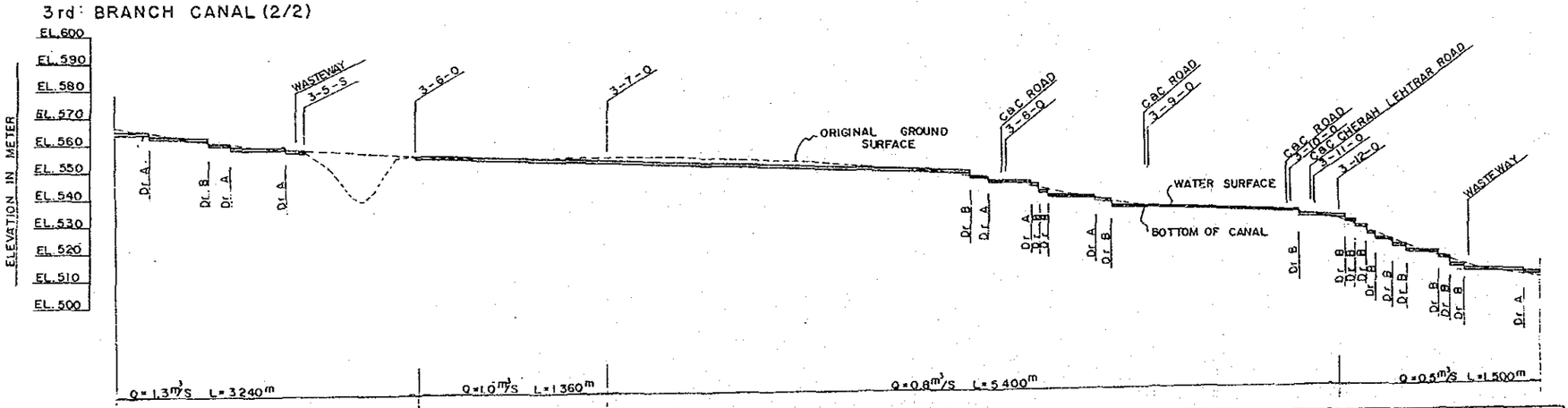
STATION	DISTANCE (m)	ORIGINAL GROUND SURFACE (m)	WATER SURFACE ELEVATION (m)	BOTTOM OF CANAL ELEVATION (m)
NO. 0	0	608	604.34	603.74
+140	140	606	604.34	603.74
+200	200	606	603.94	603.34	
NO. 1	1,000	603	603.94	603.34
NO. 2	2,000	598	598.64	598.24
NO. 3	3,300	593	593.14	592.74
NO. 4	4,000	588	587.64	587.24
NO. 5	5,000	584	584.14	583.74
+200	5,200	585	583.94	583.54
+300	5,300	581	581.54	581.14
NO. 6	6,000	579	580.94	580.54
+100	6,100	580	580.64	580.24
+150	6,150	578	578.64	578.24
NO. 7	7,000	575	577.39	577.19
+100	7,100	574	573.59	573.19
NO. 8	8,000	573	574.39	573.99
NO. 9	9,000	568	571.49	571.49
+200	9,200	569	569.99	569.59
+350	9,350	568	568.99	568.59
NO. 9	9,400	568	568.24	567.84
+50	9,450	568	565.24	565.84
+400	9,800	562	564.19	563.79

3rd BRANCH CANAL (1/2)



STATION	DISTANCE (m)	ORIGINAL GROUND SURFACE (m)	WATER SURFACE ELEVATION (m)	BOTTOM OF CANAL ELEVATION (m)
NO. 0	0	383	382.32	382.47
+430	430	382	382.02	381.07
NO. 1	500	381	381.32	381.37
NO. 2	1,000	380	381.67	381.12
NO. 3	1,300	378	378.42	378.47
+40	1,830	377	377.01	376.26
NO. 4	2,000	377	374.31	373.76
NO. 5	2,500	375	374.06	373.31
NO. 6	3,000	372	373.61	372.86
NO. 7	3,500	369	372.16	371.41
NO. 8	4,000	368	370.70	369.95
NO. 9	4,500	362	369.23	368.50
+220	4,720	370	368.61	367.86
NO. 10	5,000	364	367.86	367.14
NO. 11	5,500	367	366.61	365.86
NO. 12	6,000	366	366.16	365.41
+400	6,400	367	366.40	365.65
NO. 13	6,500	367	365.92	364.92
NO. 14	7,000	367	364.72	364.02
NO. 15	7,600	368	363.92	363.12

3rd BRANCH CANAL (2/2)



STATION	DISTANCE (m)	ORIGINAL GROUND SURFACE (m)	WATER SURFACE ELEVATION (m)	BOTTOM OF CANAL ELEVATION (m)
NO. 15	7,500	356	363.92	363.12
NO. 16	8,000	361	361.92	361.22
NO. 17	8,500	358	359.02	357.32
+200	8,800	356	356.49	355.78
+240	8,840	356	356.41	355.71
NO. 18	9,000	350	356.01	355.31
NO. 19	9,500	353	354.76	354.06
+140	9,640	354	354.41	353.71
NO. 20	10,000	353	353.76	353.06
NO. 21	10,500	353	352.96	352.16
NO. 22	11,000	353	351.96	351.26
NO. 23	11,500	353	351.06	350.46
NO. 24	12,000	352	350.16	349.36
NO. 25	12,500	351	349.26	348.66
NO. 26	13,000	349	348.36	347.76
NO. 27	13,500	347	347.46	346.86
NO. 28	14,000	343	344.56	342.96
NO. 29	14,500	338	339.76	337.06
NO. 30	15,000	334	335.76	335.16
NO. 31	15,500	333	332.86	332.26
NO. 32	16,000	332	331.96	331.36
+400	16,400	326	329.24	328.64
NO. 33	16,500	326	329.14	328.54
NO. 34	17,000	317	315.44	314.84
+400	17,400	310	308.27	307.67
NO. 35	17,500	309	307.97	307.37
+400	17,900	306	309.77	310.17

LEGEND

O : OPEN CANAL
S : SYPHON
C&C : CUT & COVER CONDUIT
Dr A : DROP H = 1.0m
Dr B : DROP H = 2.0m
Distry : DISTRIBUTARY CANAL
-----: ORIGINAL GROUND SURFACE
: WATER SURFACE
BOTTOM OF CANAL

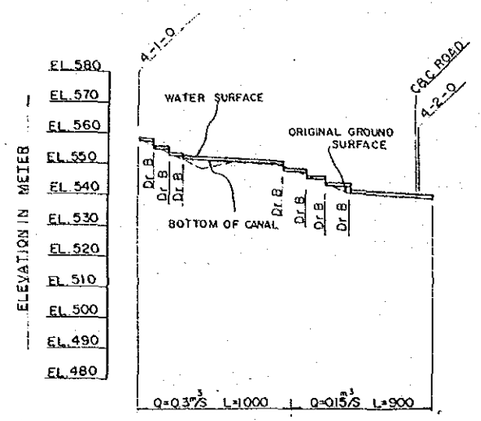
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

CANAL WORKS
PROFILE
– 2nd & 3rd BRANCH CANALS

DRAWING No. C – 1003

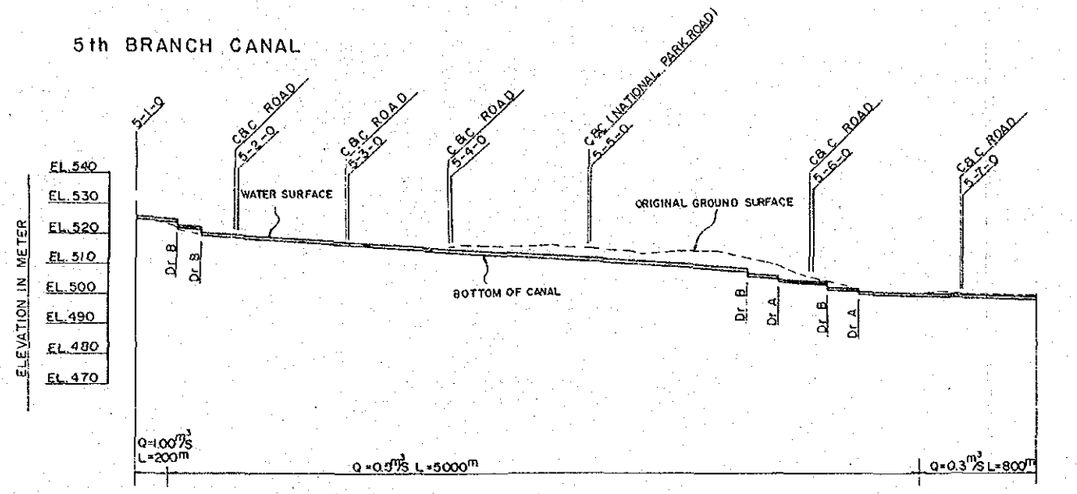
JAPAN INTERNATIONAL COOPERATION AGENCY

4th BRANCH CANAL



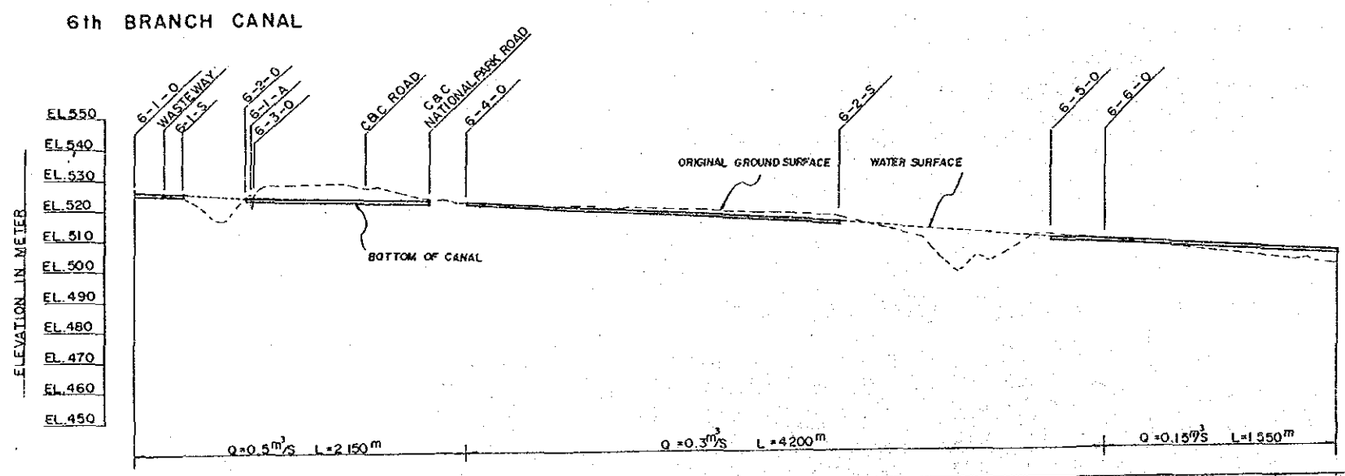
BOTTOM OF CANAL ELEVATION(m)	338.80	331.40	327.88	240.88	240.38	239.38
WATER SURFACE ELEVATION (m)	339.30	331.88	328.38	240.88	238.98	239.68
ORIGINAL GROUND SURFACE (m)	338	349	348	340	340	339
DISTANCE (m)	0	300	1000	1200	1800	1900
STATION	NO. 0	NO. 1	NO. 2	NO. 3	+300	+400

5th BRANCH CANAL



BOTTOM OF CANAL ELEVATION(m)	326.62	324.26	318.04	316.66	316.56	315.06	315.26	312.06	310.56	309.06	304.56	300.06	299.46	298.66	297.16
WATER SURFACE ELEVATION (m)	325.44	324.96	320.06	318.56	317.36	317.08	312.56	315.96	314.08	313.56	312.56	311.06	309.56	305.06	300.56	299.96	299.06	298.66	304.03
ORIGINAL GROUND SURFACE (m)	326	324	320	319	318	317	317	315	316	315	314	313	311	305	301	301	301	298
DISTANCE(m)	0	200	500	640	1000	1400	1500	2000	2100	2500	3000	3500	4000	4500	5000	5200	5500	6000
STATION	NO. 0	+200	NO. 1	+140	NO. 2	+400	NO. 3	NO. 4	+100	NO. 5	NO. 6	NO. 7	NO. 8	NO. 9	NO. 10	+200	NO. 11	NO. 12

6th BRANCH CANAL



BOTTOM OF CANAL ELEVATION(m)	324.84	325.64	324.53	314.80	322.91	322.63	322.13	321.72	321.63	321.48	320.63	318.13	317.63	316.13	314.63	314.33	308.80	300.80	309.33	308.28	307.93	306.43	304.93	303.73
WATER SURFACE ELEVATION(m)	323.44	324.24	323.13	324.37	323.51	323.23	322.73	322.32	322.23	322.08	321.03	319.53	318.03	316.53	315.03	314.73	313.30	311.32	309.73	308.68	308.23	306.73	305.23	304.03
ORIGINAL GROUND SURFACE(m)	326	325	324	317	320	320	327	325	325	322	321	320	319	318	317	316	311	303	310	308	307	304	302	300
DISTANCE (m)	0	200	310	300	720	1000	1300	1910	2000	2150	2500	3000	3500	4000	4500	4600	5000	5500	6000	6350	6500	7000	7300	7900
STATION	NO. 0	+200	+310	NO. 1	+220	NO. 2	NO. 3	+410	NO. 4	+150	NO. 5	NO. 6	NO. 7	NO. 8	NO. 9	+100	NO. 10	NO. 11	NO. 12	+350	NO. 13	NO. 14	NO. 15	+400

LEGEND

O : OPEN CANAL
S : SYPHON
C&C : CUT & COVER CONDUIT
Dr A : DROP H=1.0m
Dr B : DROP H=2.0m
A : AQUEDUCT
Disty : DISTRIBUTARY CANAL
----- : ORIGINAL GROUND SURFACE
: WATER SURFACE
BOTTOM OF CANAL

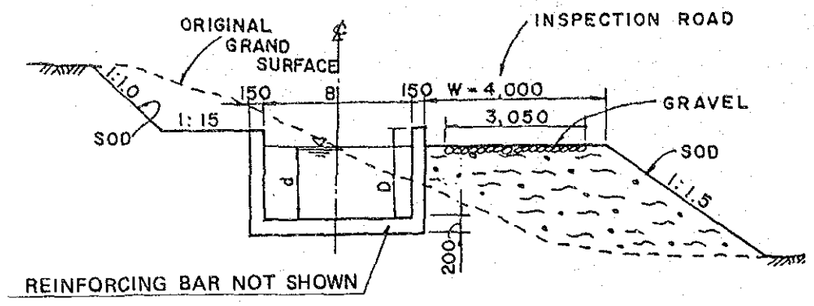
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

CANAL WORKS
PROFILE
– 4th, 5th AND 6th BRANCH CANALS

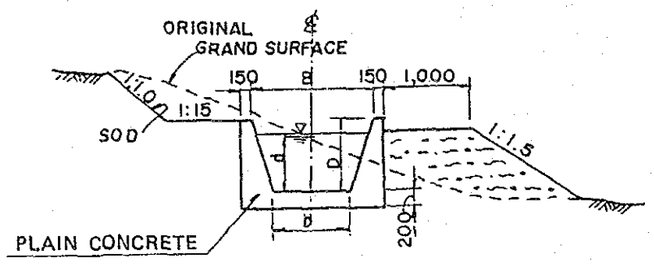
DRAWING No. C – 1004

JAPAN INTERNATIONAL COOPERATION AGENCY

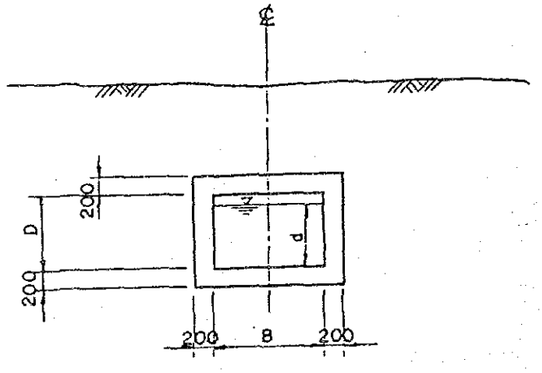
OPEN CANAL TYPE-A



OPEN CANAL TYPE-B



CUT & COVER CONDUIT



OPEN CANAL

(UNIT: mm)

TYPE	CLASS	Q(m³/s)	B	b	D	d
A	1	4.0	2400	—	1600	1200
	2	3.7	2200	—	1600	1200
	3	3.3	2000	—	1600	1200
	4	1.8	1800	—	1200	800
	5	1.5	1800	—	1100	750
	6	1.3	1800	—	1100	700
	7	1.0	1300	—	1100	700
	8	0.8	1300	—	1000	600
B	1	0.5	1120	700	700	500
	2	0.3	860	500	600	400
	3	0.15	700	400	500	300

WIDTH OF INSPECTION ROAD

(UNIT : mm)

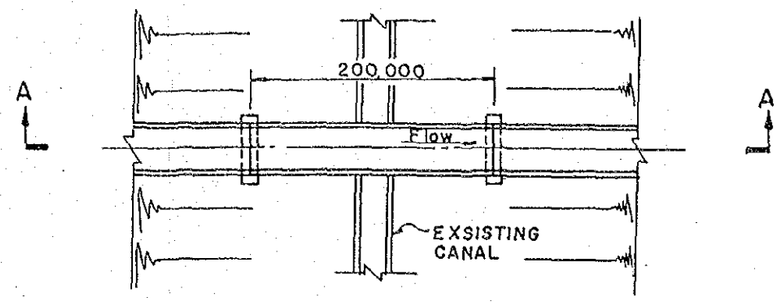
TYPE	STANDARD W	SPECIAL WIDTH	
A	4,000	1,000	M.C. No.7+470 ~ No.10+90 3rd L=1,120,000 3rd B.C. No.19+140 ~ No.30+00 L=5,340,000
B	1,000	4,000	2nd B.C. No.0+200 ~ No.9+400 L=4,350,000 3rd B.C. No.32+400 ~ No.35+400 L=1,500,000 6th B.C. No.11+00 ~ No.15+400 L=1,900,000 MINOR CANAL ⑥.⑪.⑮.⑯.⑱.⑲.㉘ L=22,460,000

CUT & COVER CONDUIT

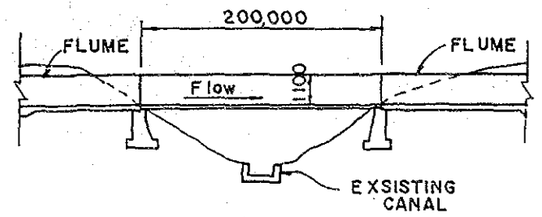
(UNIT: mm)

CLASS	Q(m³/s)	B	D	d
1	4.0	2400	1600	1200
2	3.7	2200	1600	1200
3	3.3	2000	1600	1200
4	1.8	1800	1200	800
5	1.5	1800	1100	750
6	1.3	1800	1100	700
7	1.0	1300	1100	700
8	0.8	1300	1000	600

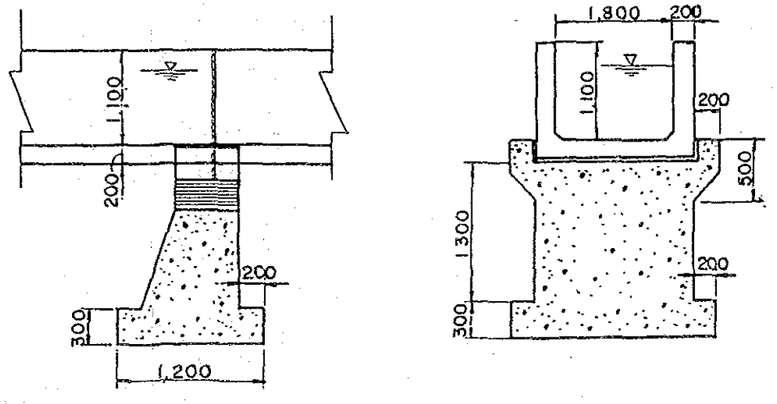
AQUEDUCT (6th BRANCH CANAL)



PLAN



SECTION A-A



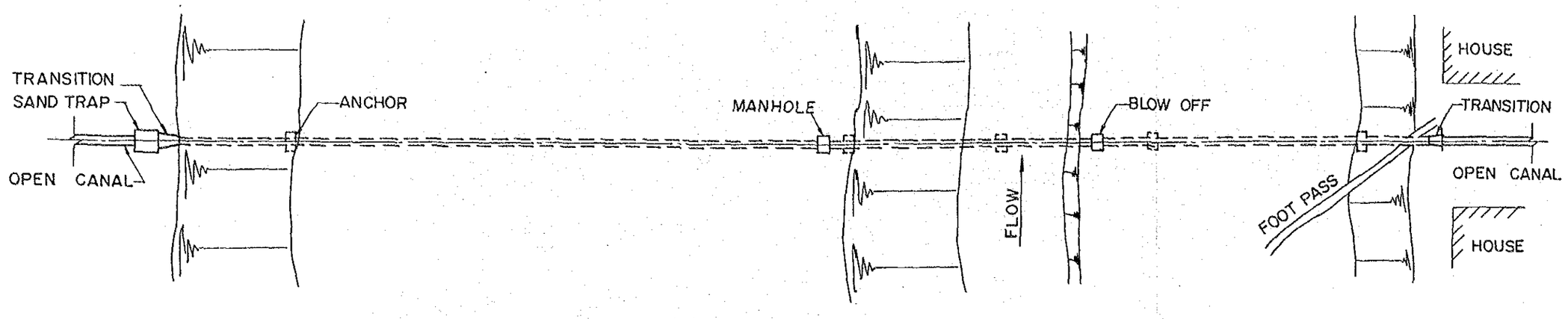
ABUTMENT

FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

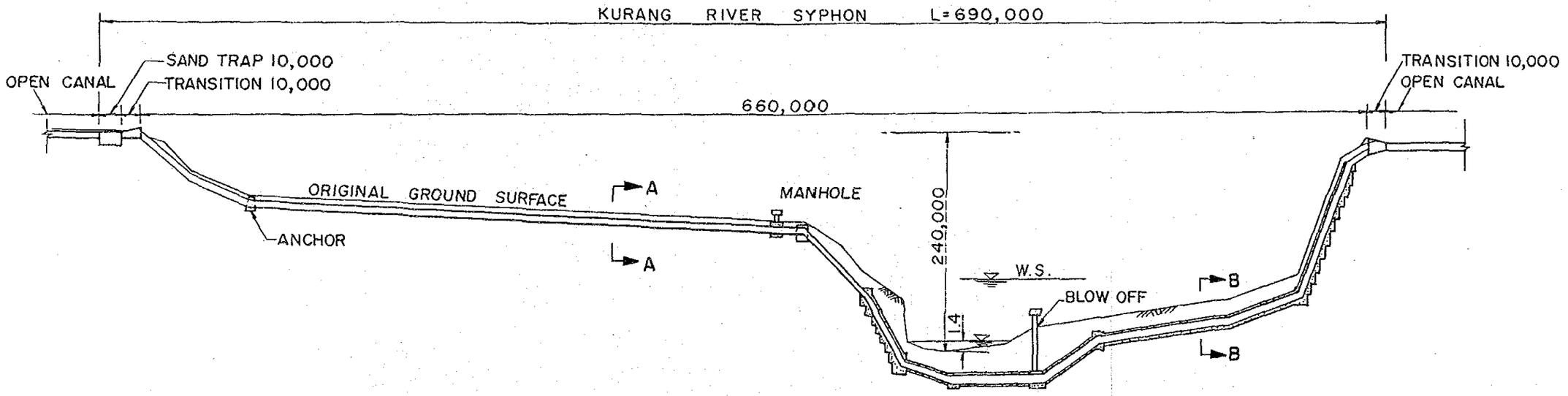
CANAL WORKS
TYPICAL CANAL SECTIONS,
CUT & COVER CONDUIT AND AQUEDUCT

DRAWING No. C – 1005

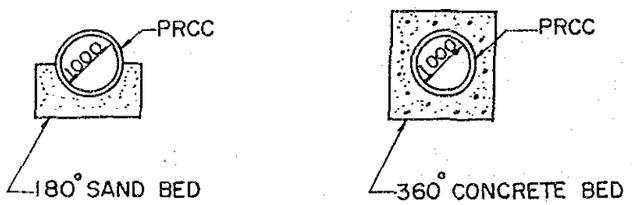
JAPAN INTERNATIONAL COOPERATION AGENCY



PLAN



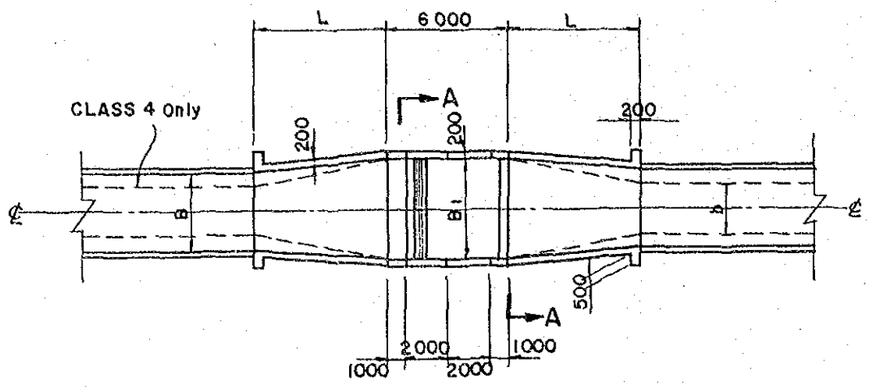
PROFILE



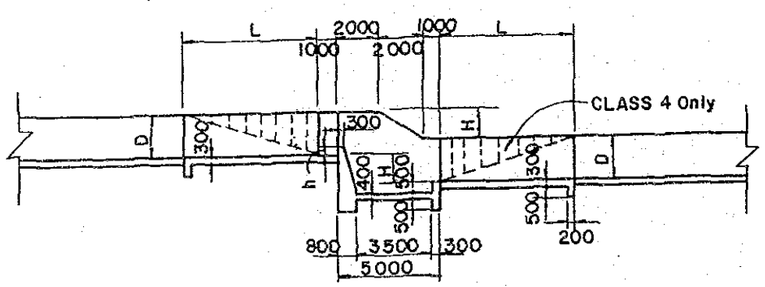
SECTION A-A

SECTION B-B

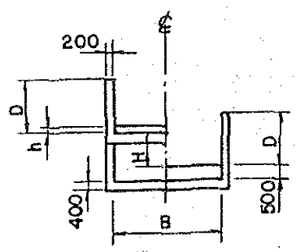
FEASIBILITY STUDY ON UPPER KURANG RIVER IRRIGATION PROJECT
CANAL WORKS KURANG RIVER SIPHON
DRAWING No. C – 1006
JAPAN INTERNATIONAL COOPERATION AGENCY



DrA DrB PLAN



DrA DrB PROFILE



SECTION A-A

(UNIT : mm)

CLASS	DISCHARGE (m^3/sec)	L	B	b	B1	D	H		h
							DrA	DrB	
1	4.0~3.3	6 000	2400 ~ 2000	—	3 000	1 600	1 000	2 000	200
2	1.8~1.3	5 000	2000 ~ 1800	—	2 600	1200~1100	1 000	2 000	200
3	1.0~0.8	4 000	1300	—	2 000	1100~1000	1 000	2 000	200
4	0.5~0.3	3 000	1100 ~ 700	500~300	1300~1000	500~300	1 000	2 000	100

FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

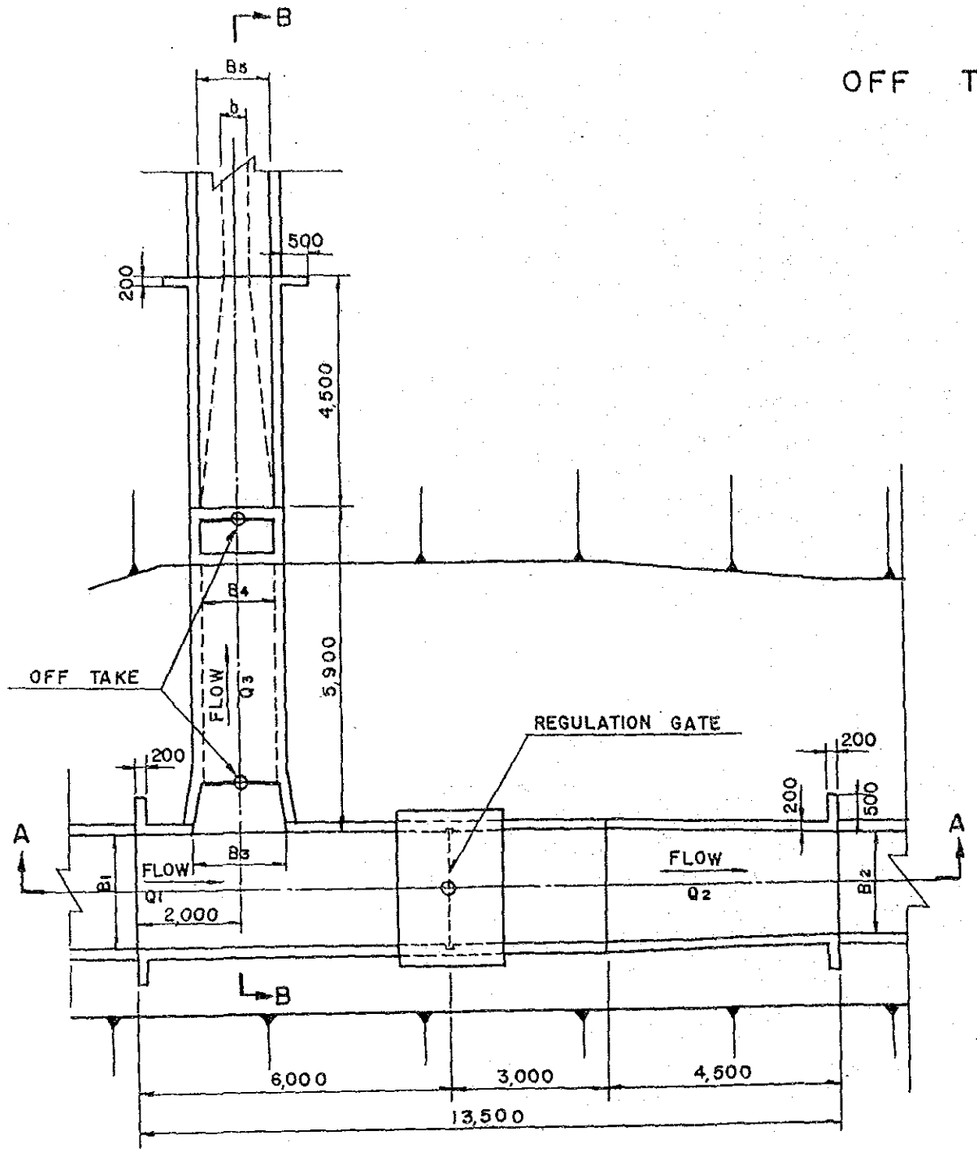
CANAL WORKS

DROP

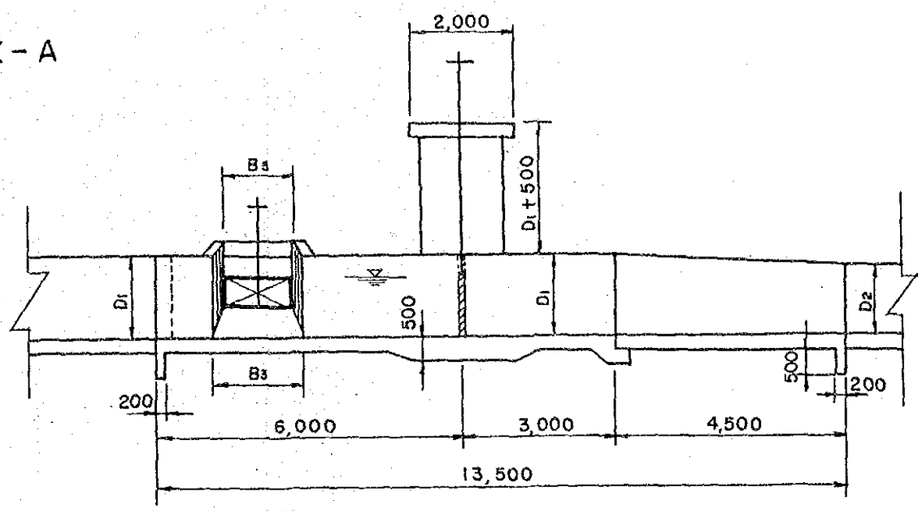
DRAWING No. C – 1007

JAPAN INTERNATIONAL COOPERATION AGENCY

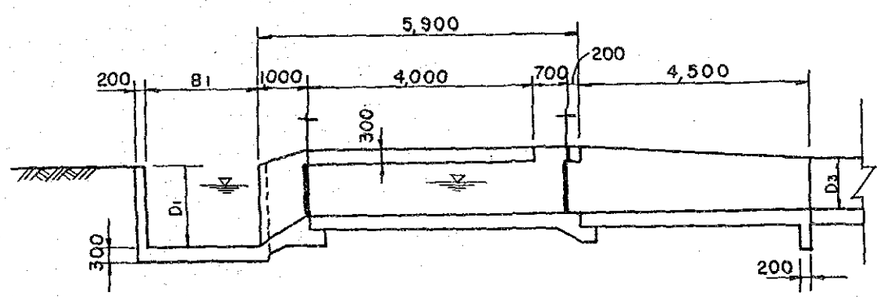
OFF TAKE TYPE-A



PLAN



SECTION A – A



SECTION B – B

(UNIT.; mm)

	DISCHARGE (m^3/s)			DIMENSIONS									REGULATION GATE	OFF TAKE
	Q_1	Q_2	Q_3	B_1	B_2	B_3	B_4	B_5	b	D_1	D_2	D_3		
1st B.C.	4.0	3.7	0.3	2,400	2,200	1,400	1,000	860	500	1,600	1,600	600	2,500 ~ 1,600	1,100 ~ 600
2nd B.C.	3.7	3.3	0.5	2,200	2,000	1,400	1,000	1,000	—	1,600	1,600	1,000	2,300 ~ 1,600	1,100 ~ 1,000
3rd B.C.	3.3	1.8	1.5	2,000	1,800	2,200	1,800	1,800	—	1,600	1,200	1,100	2,100 ~ 1,600	1,900 ~ 1,100
4th B.C.	1.8	1.5	0.3	1,800	1,800	1,400	1,000	860	500	1,200	1,100	600	1,900 ~ 1,200	1,100 ~ 600
6th B.C	1.5	1.0	0.5	1,800	1,300	1,600	1,200	1,200	—	1,100	1,100	1,000	1,900 ~ 1,100	1,300 ~ 1,000
5-1 Disty	1.0	0.5	0.5	1,300	1,300	1,400	1,000	1,000	—	1,100	1,100	1,000	1,400 ~ 1,100	1,100 ~ 1,000

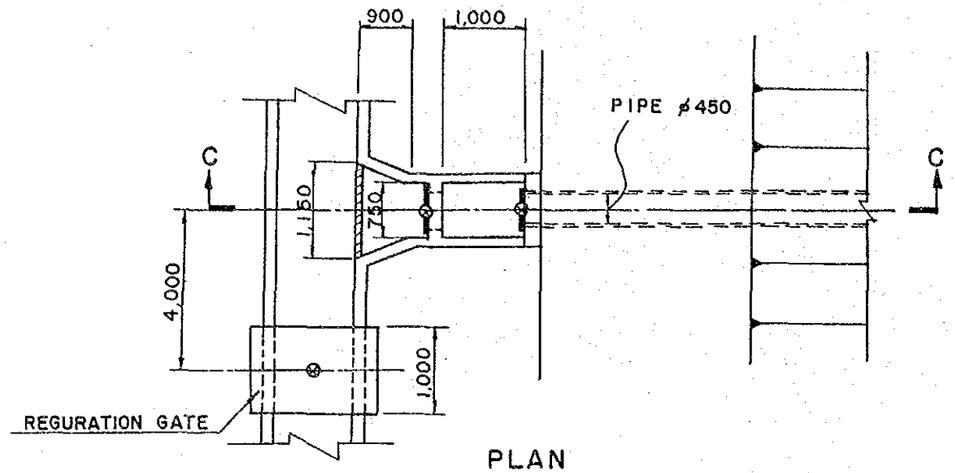
FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

CANAL WORKS
OFF TAKE TYPE – A

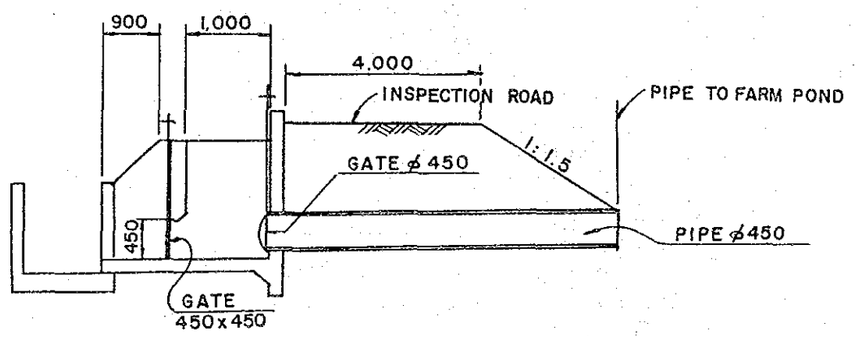
DRAWING No. C – 1008

JAPAN INTERNATIONAL COOPERATION AGENCY

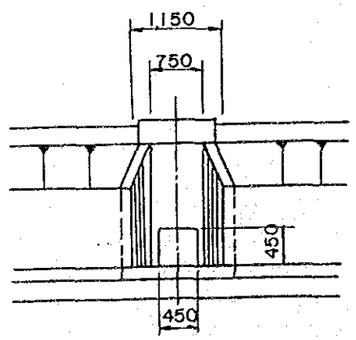
OFF TAKE TYPE-B



PLAN

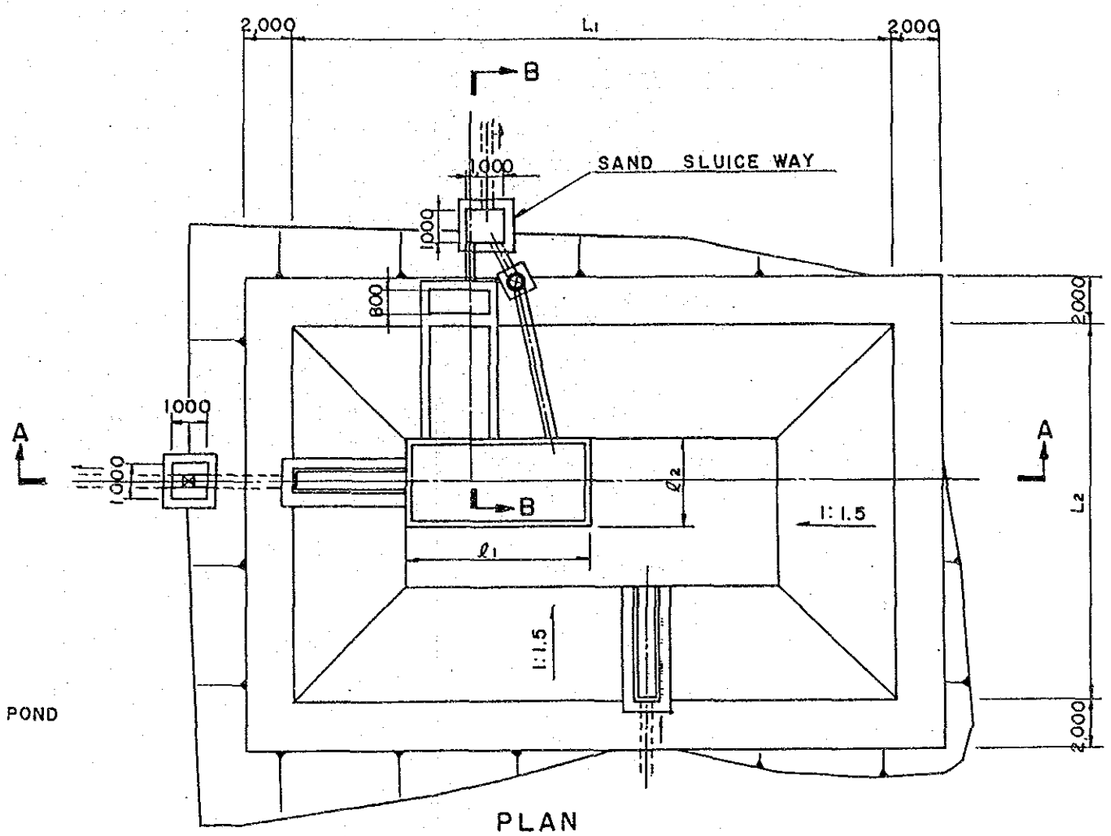


SECTION C-C

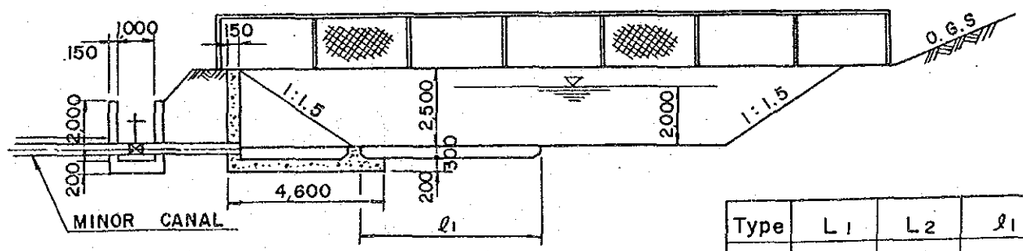


SECTION D-D

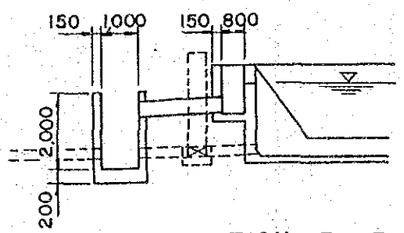
FARM POND



PLAN



SECTION A-A



SECTION B-B

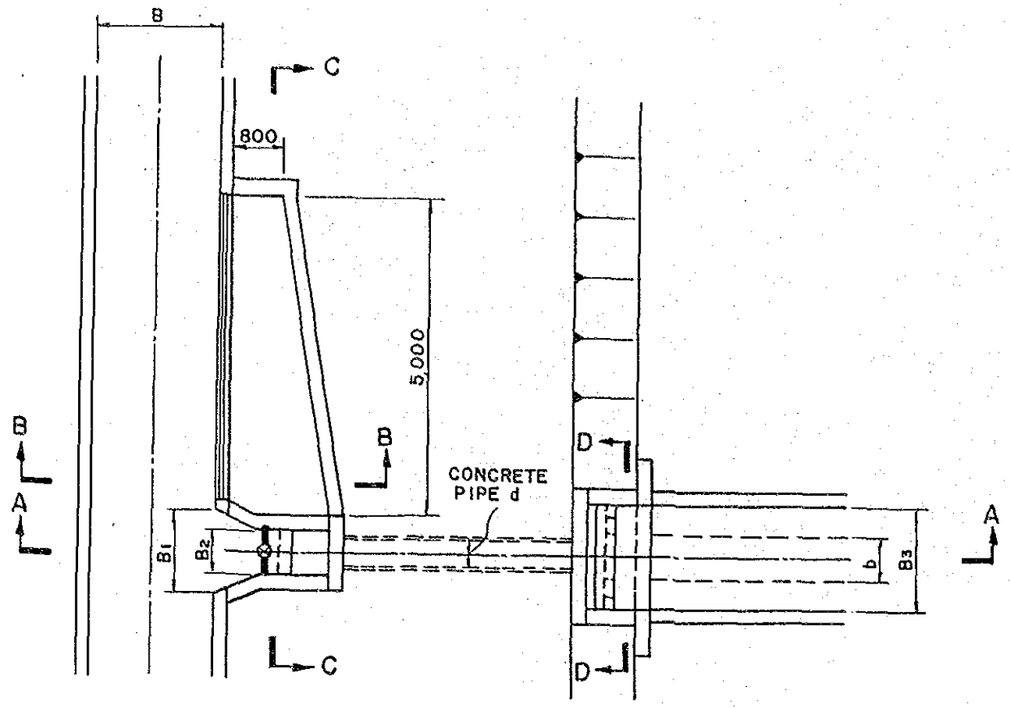
Type	L 1	L 2	ℓ 1	ℓ 2
A	70.000	45.000	30.000	20.000
B	85.000	55.000	35.000	25.000

FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

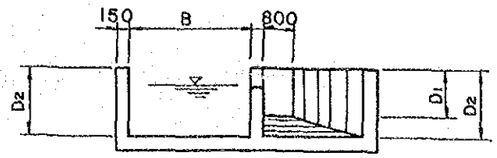
CANAL WORKS
OFF TAKE TAPE – B & FARM POND

DRAWING No. C – 1009

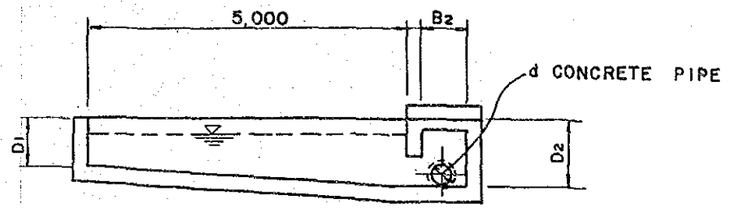
JAPAN INTERNATIONAL COOPERATION AGENCY



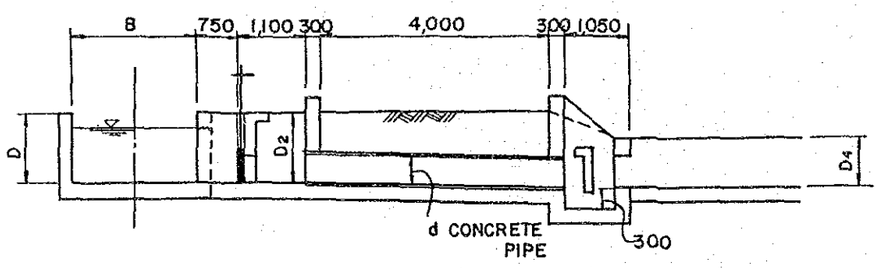
PLAN



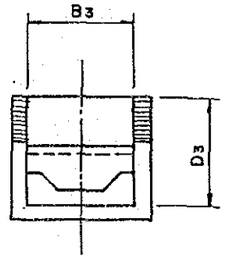
SECTION B-B



SECTION C-C



SECTION A-A



SECTION D-D

(UNIT : mm)

CANAL	STATION	Q(m^3/s)	B	B1	B2	B3	b	D	D1	D2	D3	D4	d	GATE
MAIN CANAL	NO.17 + 400	1.5	1,800	1,500	1,100	1,300	—	1,100	800	1,100	1,800	1,000	800	ø 800
3rd B.C.	NO.17 + 300	1.3	1,800	1,500	1,100	1,300	—	1,000	700	1,000	1,800	1000	800	ø 800
3rd B.C.	NO.34 + 400	0.5	1,120	1,100	700	1,120	700	700	500	700	1500	700	400	ø 400
6th B.C.	NO. 0 + 200	0..5	1,200	1,100	700	1,120	700	1,000	500	1,000	1,500	700	400	ø 400

FEASIBILITY STUDY
ON
UPPER KURANG RIVER IRRIGATION PROJECT

CANAL WORKS
WASTEWAY

DRAWING No. C – 1010

JAPAN INTERNATIONAL COOPERATION AGENCY