THE PEOPLE'S REPUBLIC OF BANGLADESH

BANGLADESH WATER DEVELOPMENT BOARD

FEASIBILITY STUDY ON THE NORTH RAJSHAHI IRRIGATION PROJECT

VOLUME 3 APPENDICES VI-XII

AUGUST 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF REPORTS

THE PEOPLE'S REPUBLIC OF BANGLADESH

BANGLADESH WATER DEVELOPMENT BOARD

FEASIBILITY STUDY ON THE NORTH RAJSHAHI IRRIGATION PROJECT

VOLUME 3
APPENDICES VI-XII

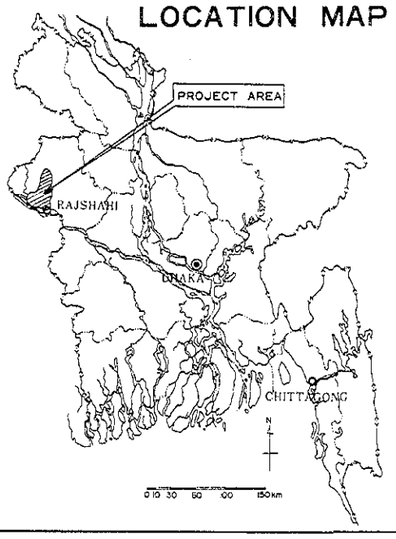
AUGUST 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

NORTH RAJSHAHI IRRIGATION PROJECT

PROJECT MAP

LOCATION MAP



LEGEND

	Boundary of Study Area
	Boundary of Project Area
	Boundary of Upazila
O	Upazila Head Quarter
	Project Area (Barind Area)
	Project Area (Paba Flood Plain Area)
P	Pumping Station
	Delivery Pipe & Pond
	Main Irrigation Canal
	Secondary Irrigation Canal
	River and Water Body
	Regulator
	Proposed Drainage Improvement Works

NIAMATPUR
MANDA
ATRAI RIVER
NACHOLE
SIB RIVER
BARIND AREA
OPEN POLDER (D)
CHALAN BEEL PROJECT (POLDER (D) AREA)
EMBANKMENT
AMNURA
TANOR
CHAPAI NAWABGANJ
MOHADEVPUR
MAHANANDA RIVER
SULTANGANJ
GODAGARI
BARAIPARA PUMPING STATION
PABA FLOOD PLAIN AREA
NAWHATA
BARNAI PROJECT AREA
PABA
RAJSHAHI
GANGES RIVER
KASBA PUMPING STATION

N

0 5 10km

SCALE 1 : 200,000

APPENDIX VI

PROJECT DEVELOPMENT PLAN

APPENDIX VI

PROJECT DEVELOPMENT PLAN

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. BASIC DEVELOPMENT CONCEPTS

The proposed Project aims to expand agricultural production and thereby increase income of residents in the area through the introduction of modern agricultural technology and stable year-round irrigation water supply by surface water. Furthermore, the Project is intended to promote the living standards of local residents by introducing rural development such as road network, fisheries and village water supply. The project will also create new employment opportunities in the area not only during the implementation period of the Project but also by stimulating private sectors of post harvest system and marketing activities.

In order to achieve the above objectives, the main component of the development plan is to provide irrigation facilities in agricultural land for mainly rice. For water resources development to supply irrigation water it will be necessary to lift up water from the Ganges or Mahananda rivers by pumps. In addition, supplementary components related to the irrigation development, such as road network development, and fish pond culture development are incorporated into the Project.

A development plan and appropriate scale for each component was determined in accordance with the alternative studies.

(1) Project Area

The Project area can be categorized into two distinct area from the view point of topography, soil condition, cropping pattern and flood effect.

The lower flat area of about 13,000 ha is located in the Paba Upazila and belongs to flood plain area. This area will be called "Flood Plain Area" or "Paba Area" in the report.

Another area which is flood free is located in high and undulated area, called Barind Tract. This area will be called "Barind Area" in the report.

Since characteristics of both areas are so different that it will be better to consider the development plans separately.

(2) Project Components

The following three components were selected as tangible and studied for economic feasibility :

a) Establishment of an agricultural development plan based upon providing irrigation and drainage facilities ;
b) Development of a road network in the area, through effective utilization of the operation and maintenance road for irrigation facilities ; and,
c) Inland fisheries development in existing ponds or tanks and beels along the Sib river utilizing irrigation water and the return flow.

(3) Study Approach

An overall development plan for the whole proposed area will be initially formulated. Based on this plan, a stage-development plan will also be studied as practical method of implementation.

1) Overall Development Plan

Taking into account the present natural, social and economic conditions,the proposed land use and farming types for the project area will be studied.

The proposed project aims to promote rural development by increasing productivity, farm income, and employment opotunities through irrigation development.

As for the irrigation development, several alternative studies will be performed to optimize the development size (especially irrigation acreage) and capacity of major irrigation facilities. The optimization of the irrigation facilities will be considered together with the capacities of pump stations on the Ganges and Mahananda river.

2) Stage Development Plan

To attain more productivity and expected benefit from the overall development plan, new technology of farming practice, and social infrastructures such as supply system for the necessary farm input, provision of post-harvest facilities and marketing facilities are inevitable.

Therefore, in order to develop the whole Project area, it is necessary to provide not only the irrigation facilities but also all the relevant social infrastructures at the same time.

However, taking into consideration the economic and social conditions of the country, a step-by-step development method (so-called stage-development) will be more practicable and realizable method of implementation. The stage-development plan will be studied within the framework of the overall development plan.

2. FACTORS OF THE DEVELOPMENT PLAN

2-1. Topographical conditions

The Barind tract forms an undulating area like a terrace landscape ranging from 15 to 45 m (50 to 150 feet) in elevation with average slope of 1 to 500 to 1,000. In the southern and western areas, the tract is hilly and dissected by narrow (usually streamless) valleys.

In the northern and eastern parts, the tract becomes rather flat with an average slope of 1 to 1,000.

In the south-west area along the Ganges river, the elevation of the land near the river is 15 to 20 m (60 to 70 feet). With about 3 to 4 km from the river to the inland, the elevation rises up to about 30 to 33 m (100 to 110 feet). The hill covers over 20 km. The lowest elevation of the ridge is about 24 m (80 feet), and this makes it difficult to irrigate the Barind tract.

In order to irrigate the Barind tract, it is necessary to install pumping stations along the Ganges river.

According to records of river bank shifting of the Ganges river, Baraipara is the most stable bank in the past several decades. Along the Mahananda river, Sultanganj is also a stable site for pumping station. Accordingly, Baraipara and Sultanganj are proposed for the pumping station sites.

Taking into consideration the high ridge along the Ganges river near the Godagari and Sultanganj, it will be required to lift the river water to a rather high elevation to go over to the ridge to irrigate the Barind tract.

To irrigate the Barind tract from the Baraipara and Sultanganj, the high lifting of Ganges river water by pumping stations can irrigate more areas. In order to irrigate more areas, high cost of pump equipment as well as electric charges will be required and vice-versa.

Compromise should be made to find the optimal point of elevation to be irrigated. Then alternative studies are required.

Due to the high ridge along the Ganges river, it will be rather difficult to irrigate the flood plain area that belongs to Paba upazila from the proposed pumping station at Baraipara, because there will be very

few irrigable areas along the Ganges river from Baraipara to the western side of Rajshahi. The proposed pumping station should be located near the Rajshahi for flood plain area. Therefore, the irrigation areas will be necessary to be divided into two areas of Paba flood plain area and highly elevated Barind area.

In order to utilize the return-flow and effective use of the pumped irrigation water, the route and layout of the irrigation canal will be carefully selected.

There are many farm ponds and small-scale impoundings in the Project area for the agricultural, aquaculture and village water uses. Supplemental water supply to these existing impoundings can be considered by connecting them with the proposed irrigation canal.

2-2. Availability of the Water Resources

As for the ground water, deep tube-well project is on-going in the Barind tract in the Project area. There is not enough ground water resource to irrigate about 20,000 to 40,000 ha of land; accordingly, no groundwater utilization for the Project has been considered.

As for the surface water resources, there are four major rivers in and near the Project area for irrigation use. The most reliable source of water is the Ganges river which flows into the southern boundary of the Project area. The available discharge in the Mahananda river is about 7 to 8 m^3/sec in the driest months of April and May, which can be used only for supplemental water resources.

Along the eastern boundary of the Project area, the Sib river flows from north to south and confluenced to the Barnai river at Nawhata. But the river water will be dried up during dry season, except in the depressions (so-called Beel in Bangladesh) along the Sib river.

The Atrai river flows in the northern part of the Project area from north to south and confluenced at Manda to the Sib river. But the confluence point had been closed by an embankment by the local people. The discharge of the Atrai river is very small during the dry season.

Accordingly, only the Ganges river has enough water for dry season irrigation. However, irrigation water can be supplemented during pre-monsoon or post-monsoon from the Mahananda, Sib and Atrai rivers.

In the Mahananda river, supplemental irrigation water is also expected even during the dry season although the capacity will not be enough for a large area.

Consequently, the main water resources during the dry season for irrigation water is the Ganges river and for the supplemental irrigation water is Mahananda river.

3. ALTERNATIVE PLANS FOR IRRIGATION SYSTEM

3-1. Alternative Plans for Barind Area

The Project area consists of two areas; namely, the Paba flood plain area and the high elevated Barind area. From economic, and operation and maintenance points of view, it would be better to separate the irrigation systems into two areas.

At first, the boundary of the Flood Plain area should be delimited on the basis of the irrigation networks. The alternative plans will be studied within the Barind tract.

There is a highly elevated area near Sultanganj at an elevation of 36.6 meters for about 1.6 km from the Mahananda river to the point, where a delivery point can be proposed. It has not enough water to irrigate the whole area from the proposed Sultanganj pumping station in the Mahananda river due to the limitation of available river flow during the dry season.

There is enough river flow at Baraipara in the Ganges river. However, the distance from the Baraipara to the highest point (proposed delivery pond site) is rather far, about 6 km.

There is a long depressed area like a river along the Ganges river from Godagari to Sultanganj which can be utilized for a leading canal to convey the pumped water at Baraipara pumping station to the Sultanganj. A socondary pump equipment will be necessary to lift the Ganges river water to the proposed delivery pond site (EL. 36.6 meters) together with the water from the Mahananda river at Sultanganj.

3-1-1. Alternative plans for Barind Tract

In order to find the most optimal elevation of the pumping-up point for the irrigation system for the Barind tract, the following three alternative plans have been proposed :

Alternative Plan 1: Pumping-up point EL 36.6 m (120 feet)
Alternative Plan 2: Pumping-up point EL 30.5 m (100 feet)
Alternative Plan 3: Pumping-up point EL 24.4 m (80 feet)

The layout of the major irrigation facilities for alternative plans 1, 2 and 3 are shown in VI-3-1, VI-3-2 and VI-3-3 espectively.

3-1-2. Sib river reservoir plan (Alternative 4)

In the Barind tract, northern area from the road between Tanore and Mandamara is less undulated than the southern area in the same elevation of the pumping-up point. In order to irrigate more area around the pumping-up point with the same energy for pumping, the irrigation system for Alternative Plan 4 has been considered to propose a pumping station in the northern portion near Niamatpur. The elevation of delivery point of the pump station is proposed at 27.4 m (90') considering the topography. The route of the main canal has been selected to irrigate from north to south.

In order to convey the irrigation water pumped up from the Ganges river, the Sib river can be utilized as a main canal during the dry season.

The Sib river flows from north to south and the Joakhali river surrounding the Karnahar Barabila Polder flows to the south near the Ganges river. Therefore, a pumping station is proposed at Kasba village in the Ganges river to lift the Ganges water and to connect to the Joakhali river, in order that the water be supplied to the Sib river. To limit the water supply area in the Sib river, a regulator will be provided at Nawhata. The top of the regulator can be used as wider road than the existing bridge at Nawhata. The layout of the major facilities are shown in FIG: VI-3-4.

Under this Plan, the following advantage and disadvantages are expected:

Advantages

- One more regulator can be proposed at the confluence of the Sib river and the Atrai river near Manda to intake irrigation water during pre and post-monsoon period from the Sib river by gravity.

- The water level can be maintained at around EL. 45 feet controlling the two regulators at Manda and Nawhata and operating the proposed pumping station at Kasba village.
- Along the Sib river, there are big depressed areas to store the water for irrigation and fishery development. The Sib river can be used as a reservoir, of which capacity will be about 57 MCM at the level of 45 feet, as shown in FIG VI-3-4.
- To irrigate the Barind tract, a pumping station is proposed near Niamatpur to lift the water at EL. 27.4 m (90')
- The river flows from the Atrai river and the tributaries in the Barind tract during pre and post-monsoon can be effectively utilized for irrigation by gravity. So, the operation cost of the Ganges pumping station will be less.
- The return-flow from the irrigation water supply to the Barind tract will flow into the Sib river and could re-use for irrigation.
- During flood season the proposed regulator at Nawhata should be opened so as to maintain the conditions same as the present.

Disadvantages

- It will be required to dredge the Sib river from north to south in order to make the flow from south to north.
- The water loss causes by evaporation from the water surface area in the Sib river and leakage from the existing regulators will make the embankment rather high.
- The water in the Sib river during dry season can be used by local people along the river. So, the beneficial area of the water supply will be quite difficult to be fixed.
- Effect of the siltation in the Sib river from the Barind tract will be difficult to estimate.
- The submerged area can not be planted by Boro even during the dry season.
- Land acquisition cost for the submerged area will be very high.

The relationship of the elevation of water surface in the Sib river, submerged area and the irrigable are are shown in FIG VI-3-5.

FIGURE VI-3-1

ALTERNATIVE PLAN I

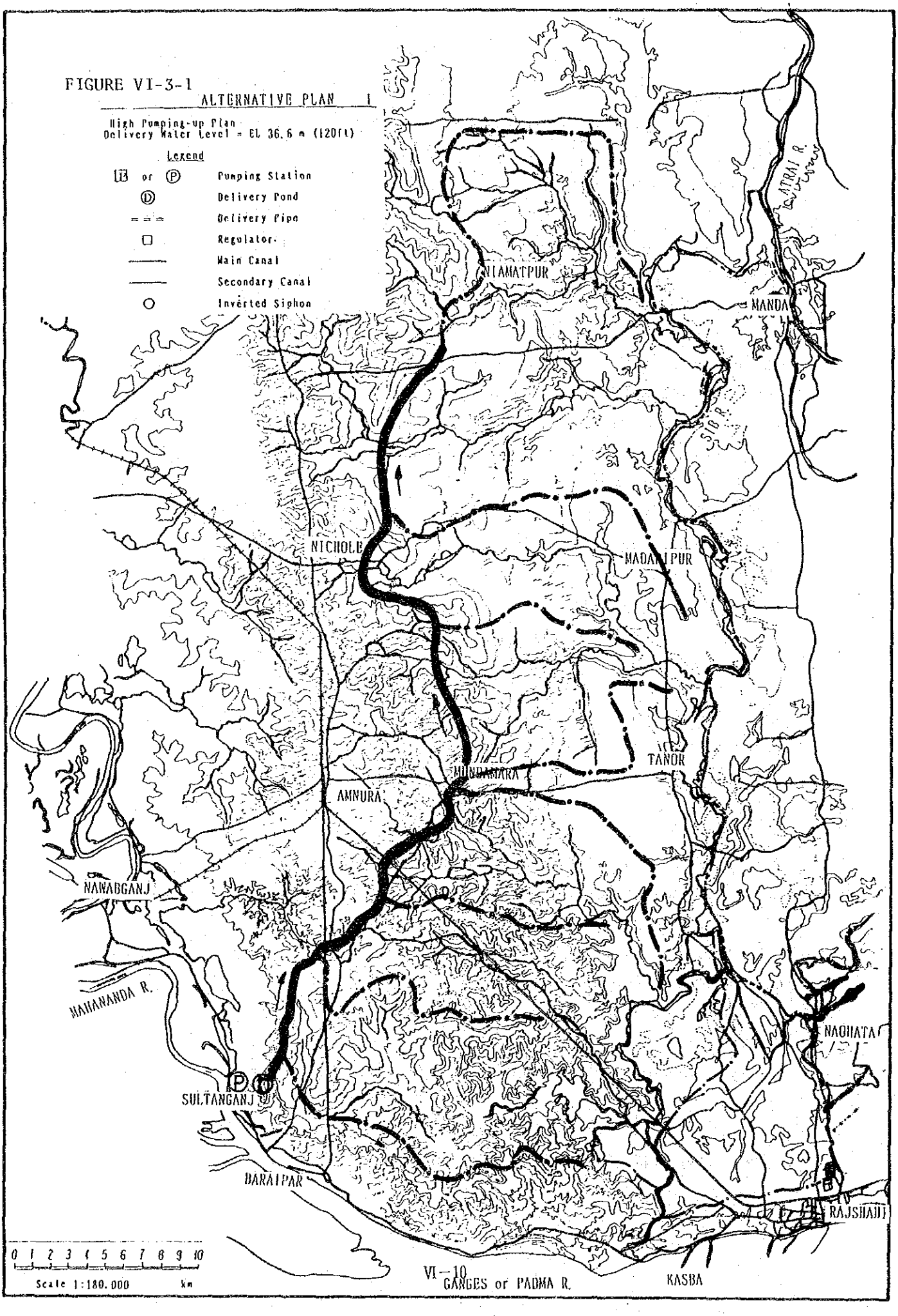


FIGURE VI-3-2
ALTERNATIVE PLAN II

Medium Pumping-up Plan
Delivery Water Level = EL 30.5 m (100ft)

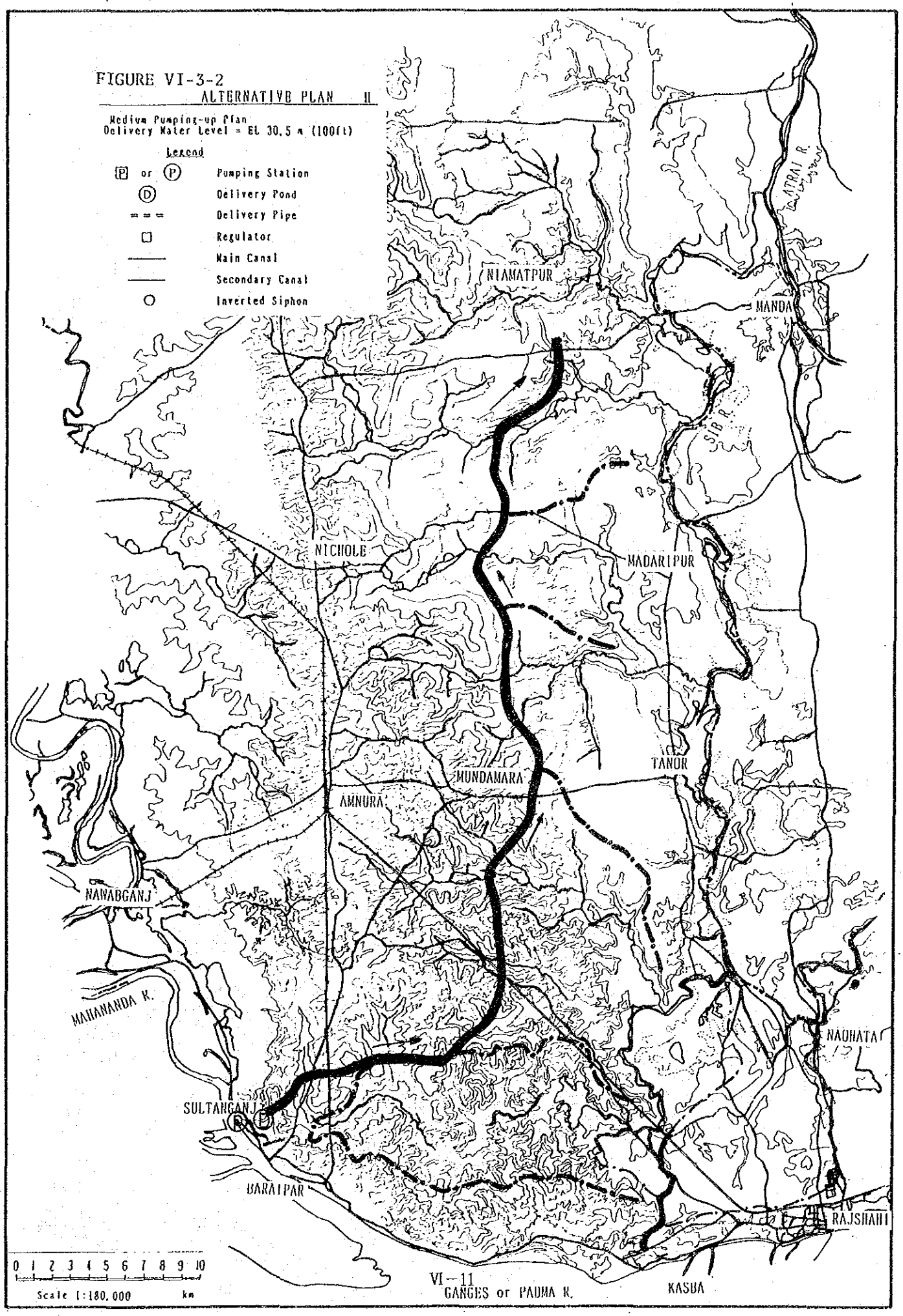


FIGURE VI-3-3

ALTERNATIVE PLAN III

Low Pumping-up Plan
Delivery Water Level = EL 24.4 m (80ft)

Legend

- [P] or (P) Pumping Station
- (D) Delivery Pond
- Delivery Pipe
- Regulator
- Main Canal
- Secondary Canal
- Inverted Siphon

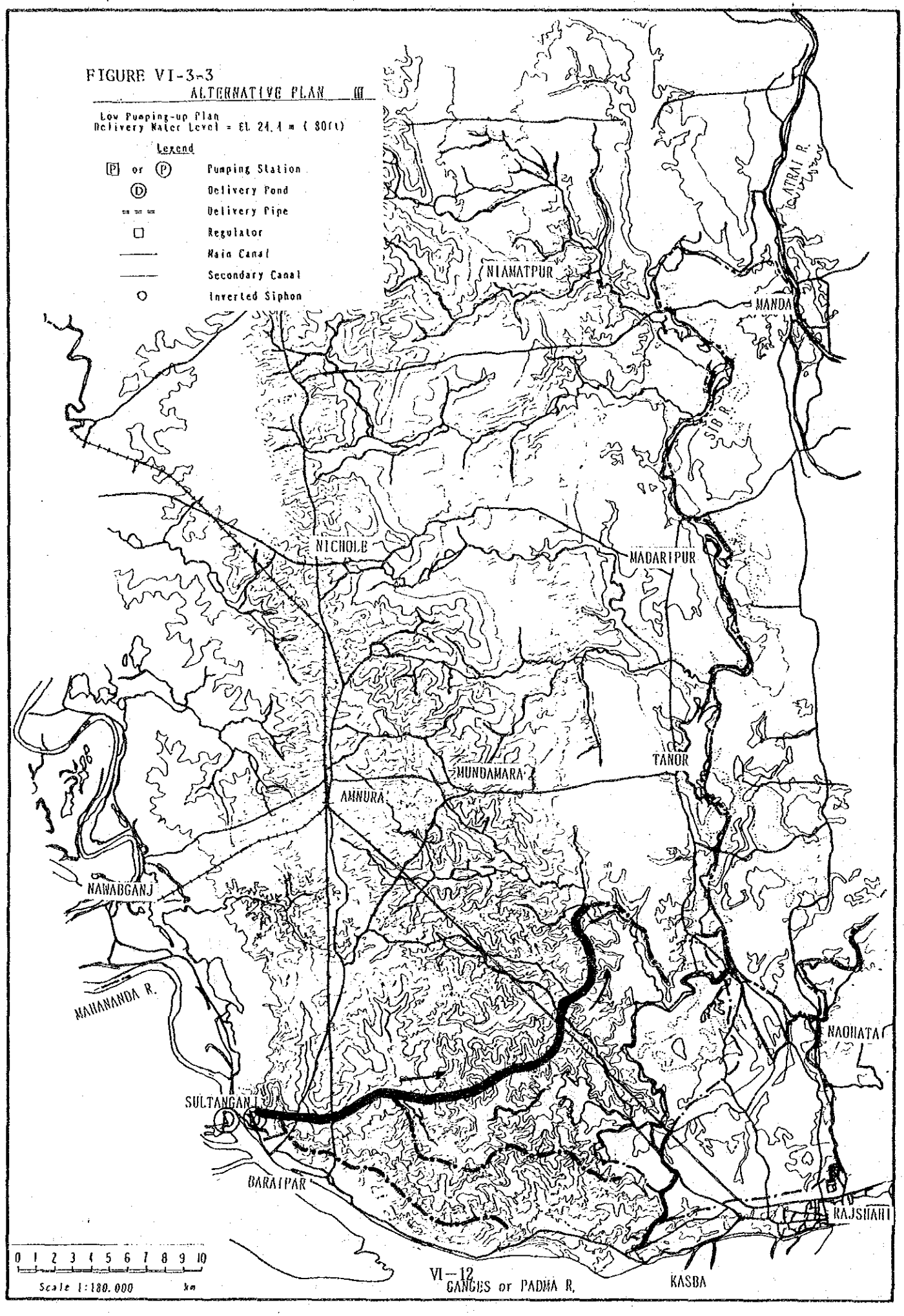


FIGURE VI-3-4

ALTERNATIVE PLAN IV

Sivu River Plan
Delivery Water Level = EL 21.3 m (70ft)

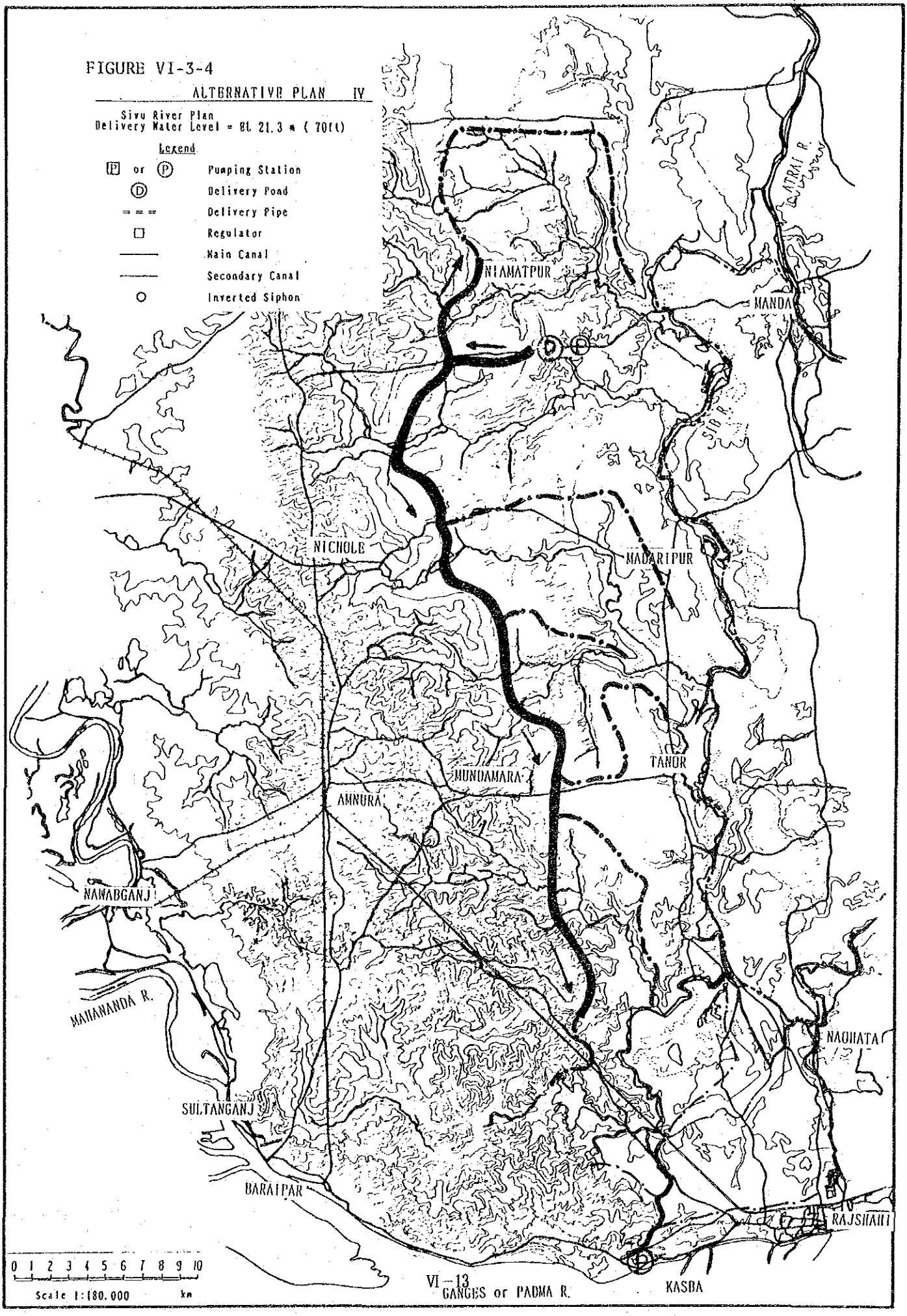
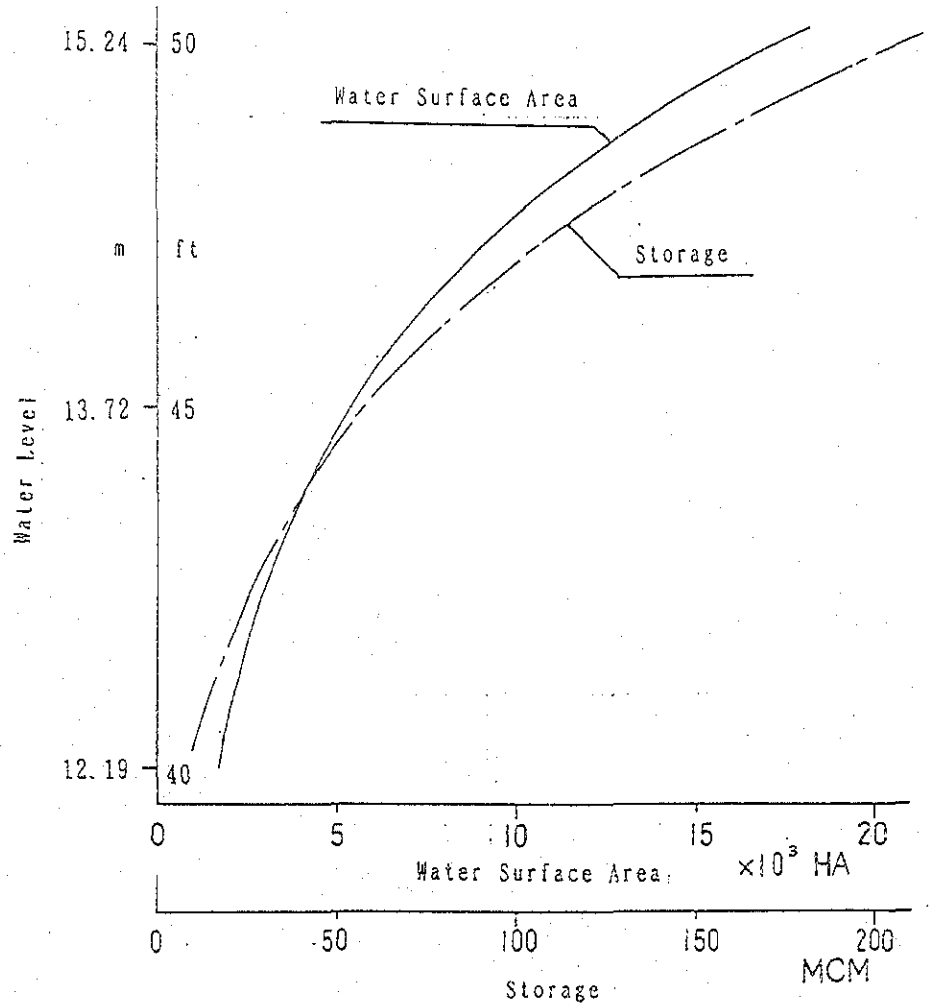


FIGURE VI-3-5 Water Surface Elevation to Area and Capacity of Sib River



Elevation		Water Surface Area	Average	Storage	Accumulated Capacity
m	ft	ha	ha	MCM	MCM
10.67	35.0	0			
12.19	40.0	1,680	×1/3 560	850	8.50
12.50	41.0	2,110	1,895	580	14.30
12.80	42.0	2,670	2,390	730	21.60
13.11	43.0	3,360	3,015	920	30.80
13.41	44.0	4,240	3,800	1,160	42.40
13.72	45.0	5,350	4,795	1,460	57.00
14.02	46.0	6,750	6,050	1,800	75.00
14.33	47.0	8,520	7,640	2,330	98.30
14.63	48.0	10,740	9,630	2,940	127.70
14.94	49.0	13,550	12,145	3,700	164.70
15.24	50.0	17,100	15,330	4,670	211.40

FIGURE VI-3-6 Relationship of Water Level in the Sib River , Irrigation Area and Proposed Pump Capacity for Alternative Plan 4.

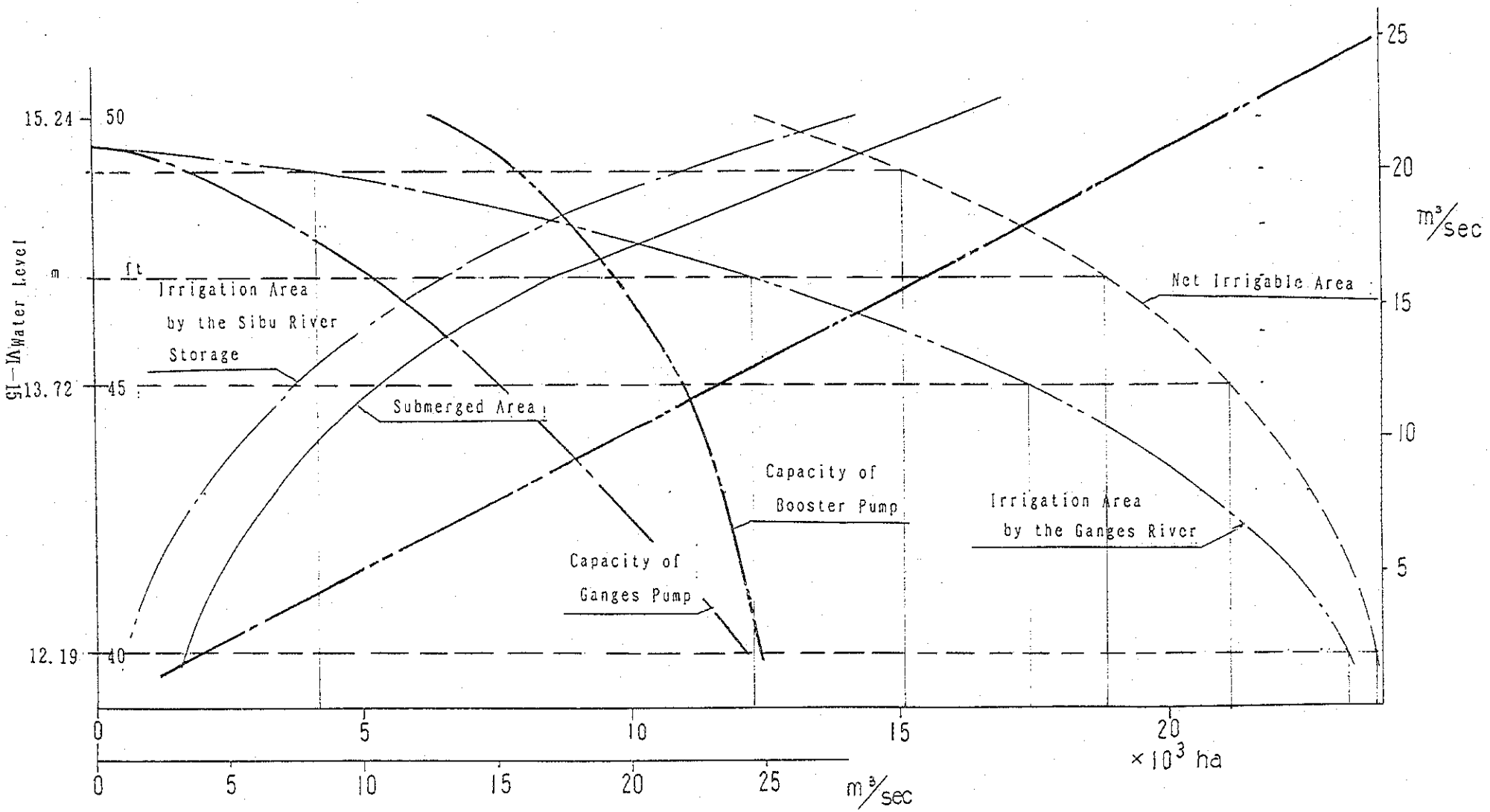


TABLE VI-3-1 COMPARATIVE TABLE FOR THE SIB RIVER RESERVOIR

Water level of the estimated reservoir of Sib River	EC. 12.2 m 40 feet	EC. 13.7 m 45 feet	EC. 14.3 m 47 feet	EC. 14.9 m 49 feet
1. Basic data				
Net irrigation area (ha)	23,880	21,630	18,830	15,110
Submerged area (ha)	1,680	5,350	8,520	13,550
Booster at Namkura (m^3/s)	24.9	22.5	19.6	15.7
Pumping Station of the Ganges River	24.2	15.0	10.7	3.6
2. Construction cost (1,000 TK)				
1) Pumping Stations	1,879,300	1,430,500	1,234,300	999,300
2) Canals	119,800	108,500	94,400	75,800
3) Terminal facility	42,000	38,100	33,100	26,600
4) Regulators	90,000	90,000	90,000	90,000
5) Contingency (about 10%)	213,000	166,700	142,200	119,100
Sub-total	2,344,100	1,833,800	1,605,000	1,310,9800
Compensation cost for submerged area	99,300	316,200	503,600	800,900
Total project cost	2,443,400	2,150,000	2,108,600	2,111,700
3. O & M Cost	83,600	65,000	53,000	38,000
4. Benefit (1,000 TK)				
1) NPV with project	635,700	575,800	501,200	402,200
2) NPV without project	156,600	141,300	123,000	98,700
3) Net benefit	479,600	434,400	378,200	303,500
5. Financial IRR	10.3%	11.1%	10.1%	8.6%

3-2. JUSTIFICATION OF ALTERNATIVE PLANS

The results acquired through layout of irrigation facilities for each plan on 1/50,000 topographic map, are shown in the following TABLE VI-3-2.

TABLE VI-3-2 BENEFICIAL AREAS FOR EACH PLAN

Area	The Barind Tract			
	Alternative Plan			
	Plan-1	Plan-2	Plan-3	Plan-4
Study Area	138,500	138,500	138,500	138,500
Excluded Area	37,000	70,400	119,000	98,000
Project Area	100,800	68,100	19,500	40,500
Unirrigable Area	12,700	13,800	8,800	11,200
Gross Beneficial Area	88,100	54,300	10,700	29,300
Homestead and Others	15,800	9,800	1,900	5,270
Cultivated Area	72,300	44,500	8,800	24,030
Net Beneficial Area	65,050	40,060	7,920	21,630

With this map, net beneficial area of each plan has been studied. The study area is 151,800 ha; within this area, the irrigable area of the low flat Paba, EL 15.24 (50') (by means of pumping station at Kasba) have been separated. Therefore, the study area of the Barind tract is 138,500 ha. Within the boundary of the study area, the layout of main canals have been designed. The area surrounded by those main canals and Polder D have been confirmed as the project area.

Accordingly, in order to estimate gross beneficial area, the layout of secondary canals have been designed in the project area and the unirrigable area and the water surface area of the Sib river have been excluded. The net beneficial area will be finally determined with on-farm development and land use plan studied by aerial photograph. However, at present stage, the net beneficial area is estimated from the statistical data of land use.

3-2-2. Economic Justification for Each Plan

In accordance with the layout of major irrigation facilities for each plan, the dimension of the major facilities are shown in TABLE VI-3-3. Estimated construction cost for major facilities, ten-year average operation hours of pumps and electricity rate have been calculated.

The net production value with project and without project have been initially studied, and the results are shown in TABLE VI-3-4.

TABLE VI-3-3 MAIN FEATURES OF ALTERNATIVE PLANS

	Barind Area			
	Plan 1 EL. 36.50 m	Plan 2 EL. 30.50 m	Plan 3 EL. 24.40 m	Plan 4 EL. 27.40 m
Net Irrigation Area (ha)	65,050	40,060	7,920	21,630
(%)	162.4	100	19.8	54.0
1. Pumping Station				
1) Ganges Pump				
Capacity (Max) (m^3/s)	68.2	42.0	8.3	15.0
Capacity (Design) (m^3/s)	64.5	40.0	7.8	14.0
Intake W.L (EL, m)	8.50	8.50	8.50	8.30
Delivery W.L (EL, m)	36.60	30.50	24.40	18.30
Actual Pump Head (m)	28.10	22.00	15.90	10.00
Motor Power (kw)	32,110	15,400	2,850	2,170
Operation Hour (Hr)	4,000	4,000	4,000	4,000
2) Booster Pump				
Capacity (Max) (m^3/s)	-	-	-	22.5
Capacity (Design) (m^3/s)	-	-	-	20.0
Intake WL. (EL, m)	-	-	-	12.20
Delivery WL. (EL, m)	-	-	-	27.40
Actual Pump Head (m)	-	-	-	15.2
Motor Power (kw)	-	-	-	4,840
Operation hour (hr)	-	-	-	4,000
3) Delivery Pipe (m)	1,800	1,400	1,700	1,000
2. Irrigation Facility				
1) Main Canal Length (m)	50,400	48,800	24,000	45,000
2) Secondary Canal Length	257,400	157,700	61,000	50,000
3. On-farm Facility				
Slope Area (ha)	40,790	25,120	4,790	-
Flat Area (ha)	24,260	14,940	2,950	21,630
4. Drainage				
1) Canal (m)	-	-	-	-
2) Regulators	-	-	-	-
5. Canal Related Structure				
1) Rail Road Crossing	11	7	2	4
2) Bridge	18	11	3	6
3) Gate Nawhata (w×h)	-	-	-	70m×5m
4) Gate Atrai (w×h)	-			20m×3m

TABLE VI-3-4 ECONOMIC JUSTIFICATION OF ALTERNATIVE PLANS

×1,000TK

	Barind Area			
	Plan 1 EL. 36.50 m	Plan 2 EL. 30.50 m	Plan 3 EL. 24.40 m	Plan 4 EL. 27.40 m
1. Basic data				
Net irrigable area (ha)	65,050	40,060	7,920	21,630
Delivery WL. (m)	36.60	30.50	24.40	27.40
Q max (m^3/sec)	68.2	42.0	8.3	22.5
Sediment Volume (m^3)	68,154	44,227	8,315	22,688
2. Construction Cost				
1) Pumping Station	3,417,000	1,747,000	34,000	1,430,500
2) Irrigation Canal	351,700	236,000	97,100	108,500
3) Facilities	123,700	83,000	34,100	38,100
4) Road and Bridge	280,100	173,000	34,200	93,400
5) On Farm	90,900	56,000	11,000	30,200
6) Transmission Line	113,400	58,000	11,300	37,200
7) Telephone Line	400	400	400	900
8) Construction Equipment	222,700	131,000	25,900	70,700
Sub-total	4,599,900	2,484,400	554,000	1,809,500
9) Land Acquisition	289,100	194,000	79,800	89,200
Sub-total	4,889,000	2,678,400	633,800	1,898,700
10) Contingency (15%)	733,300	401,700	95,000	284,800
Total construction Cost	5,622,300	3,080,100	728,800	2,183,500
Construction Cost /ha	86,430	76,887	92,020	100,947
3. O & M Cost				
Electric Charge	165,900	88,300	11,800	42,900
Dredging	3,800	2,400	500	1,300
Pump & Canal	36,800	22,700	4,500	12,200
Sub-total	206,500	113,400	16,800	56,400
Miscellaneous	20,600	11,300	1,600	5,600
Sub-total	227,100	124,700	18,400	62,000
Administration	4,300	4,300	4,300	4,300
Total	231,400	129,000	22,700	66,300
O & M cost per ha	3.557	3.220	2.866	3.065
4. Benefit				
With Project NPV	1,731,637	1,066,407	210,839	575,836
Without Project NPV	425,098	261,780	51,719	141,379
Net Benefit	1,306,539	804,627	159,120	434,457
5. Financial IRR	13.0%	14.7%	12.7%	11.0%

3-2-3. Selection of the Optional Scale of Development

In order to justify these alternative plans, a financial basis of justification has been adopted.

As shown in TABLE VI-3-2, the internal rate of return on the financial basis in the Alternative Plan 2 is the highest among the alternatives. Also, the construction cost per hectare in the Plan 2 shows the lowest among them.

As for the annual operation and maintenance cost per hectare among the alternatives, it is shown that the cost increases in accordance with the size of area due to the high cost of electric charge for pumping operation.

Consequently, the Alternative Plan 2, water lifting to EL. 30.5 m (100 feet), has been selected as the most optional plan to be recommended for the Project development plan.

4. DELINEATION OF THE PROJECT AREA

4-1. PROJECT AREA

4-1-1. Gross Area

In accordance with the selected alternative plan 2, the layout of the main canal and irrigable area have been re-studied in detail to finalize and fix the Project beneficial area.

Based upon the present land use map as shown in Appendix-I, the total land use area is estimated at 77,000 ha. The large residential area has been included in the area located in the Rajshahi urban area and along the national road on the Ganges river side area. These areas should be excluded from the project area.

According to the study for type and location of pumping station, the Baraipara has been selected as a proposed pumping station site for Barind area. The route of the main canal from Sultanganj in the alternative study has been shifted to Baraipara for the Barind area. The area in the Sultanganj has also been excluded from the Project area due to high elevation of topographic condition.

As the result, the gross Project area has been decided at 72,270 ha as shown in TABLE VI-4-1 in which the Paba flood plain area is 11,600 ha and the Barind area is 60,610 ha.

Along the Sib river, there are several beels such as Jaonia Beel, Manda Beel and Saila Beel etc. The water level in these beels and the Sib river during the dry season will be increased when irrigation water supply will be started in the Barind area due to the return flow of irrigation. Accordingly the lower elevation area less than EL. 13.7 m (45 feet) along the Sib river has been excluded from the farm land. Instead of the farm land the area below EL. 13.7 m for 4,800 ha has been planned to utilize as inland fisheries development area.

4-1-2. Net Irrigable Area

According to the layout of the main, secondary and sub-secondary canals in the Project area, high land and where irrigation water can not be

TABLE VI-4-1 LAND USE OF THE PROJECT AREA

Area Land Use.	Total Land Use Area.	Excluding Areas			Project Area					
		Rajshahi Urban Area	Ganges River Side	Sultanganj	Total Area		Flood Plain (Paba)		Barind Area	
					ha	%	ha	%	ha	%
Project Area	77,000	2,000	1,110	1,620	72,270	-	11,660	-	60,610	-
Below 45 feet	4,800	-	-	-	4,800	-	-	-	4,800	-
Gross Area (Over 45 feet)	72,200	2,000	1,110	1,620	67,470	100.00	11,660	100.00	55,810	100.00
Residential etc.	8,068	1,208	730	150	5,980	8.87	1,720	14.75	4,260	7.63
Rivers	392	-	-	-	392	0.58	-	-	392	0.70
Ponds	722	-	10	16	696	1.03	118	1.01	578	1.04
Water Body	320	-	15	-	305	0.45	252	2.16	53	0.09
Sub-total	9,502	1,208	755	166	7,373	10.93	2,090	17.92	5,283	9.46
Farm Land	62,698	792	355	1,454	60,097	89.07	9,570	82.08	50,527	90.54

supplied by gravity has been excluded from the irrigable area.

On the basis of the land use, the farm land area has been estimated. The net irrigation area has been estimated from the farm land subtracting the right of way area for irrigation and drainage facilities upto the on-farm level.

The results of the net irrigation area for Paba flood plain area and Barind area are shown in TABLE VI-4-2, they are 9,000 ha and 42,200 ha, respectively.

Table VI-4-2 NET IRRIGABLE AEA

	Flood Plain Area				Barind Area				Total Irrgable Area	
	Gross Aera	High Land	Irrigable Area		Gross Aera	High Land	Irrigable Area			
	ha	ha	ha	%	ha	ha	ha	%	ha	%
Gross Area	11,660	100	11,550	100.00	55,810	5,730	50,800	100.00	61,630	100.00
Residential etc.	1,720	11	1,709	14.80	4,260	437	3,823	7.63	5,532	8.98
Rivers	-	-	-	-	392	39	395	0.70	353	0.57
Ponds	118	3	115	1.00	578	59	519	1.04	297	0.48
Water Body	252	-	252	2.18	53	8	45	0.09	297	0.48
Sub-total	2,090	14	2,076	17,98	5,283	543	4,740	9.47	6,816	11.06
Farm Land	9,570	96	9,474	82.02	50,527	5,187	45,340	90.54	54,814	88.94
Right of Way	(Approx. 5%)		474	4.10	(Approx. 7%)		3,140	6.27	3,614	5.86
Net Irrigable Area			9,000	77.92			42,200	84.27	51,200	83.08
Deep Water Rice			(720)				-		(720)	

APPENDIX Ⅶ

IRRIGATION AND DRAINAGE

APPENDIX Ⅶ

IRRIGATION AND DRAINAGE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. PRESENT CONDITIONS

1-1. Projects under BWDB

In and around the Study area, several development schemes are organized under the Rajshahi Circle of BWDB. The schemes will be categorized into Completed, On-going and Proposed Schemes.

The list of completed, on-going and proposed schemes are shown in Table1-1-1 and the location of the schemes are shown in Fig. 1-1-1.

1-2. Other Related Projects

(1) Barind Integrated Area Development Project (BIADP)

a) Background

The Barind Integrated Area Development Project covers Godagari, Tanore Upazilas of Rajshahi; Bholahat, Shibganj, Gomostapur, Nachole and Mawabganj of Nawabganj; Sapahar, Porsha, Manda, Niamatpur, Mohadevpur, Dhamoirhat and Patnitala of Naogaon Districts - all belong to Rajshahi Barind. Out of total area of 12.5 lac acres, 10.25 lac acres is cultivable. the net cultivable area is 9.0 lac acres only. The present cropping intensity is about 117 percent. Of the total land area 47 percent is high farm land and 38 percent medium farm land. Only 15 percent is lowland which means that as for 85 percent of the farm land of the Project area, multiple cropping (for HYV crops) will be possible especially during the winter months on conditions that the irrigation system is facilitated. About 46 percent of the land is cultivated under owner-cum-tenant land holding system. The percentage of pure tenant holders is negligible. According to BBS during 1982-83, as total of 9.0 lac acres was brought under cereal production of which only about 12 percent of land aerea was devoted to HYV varieties.

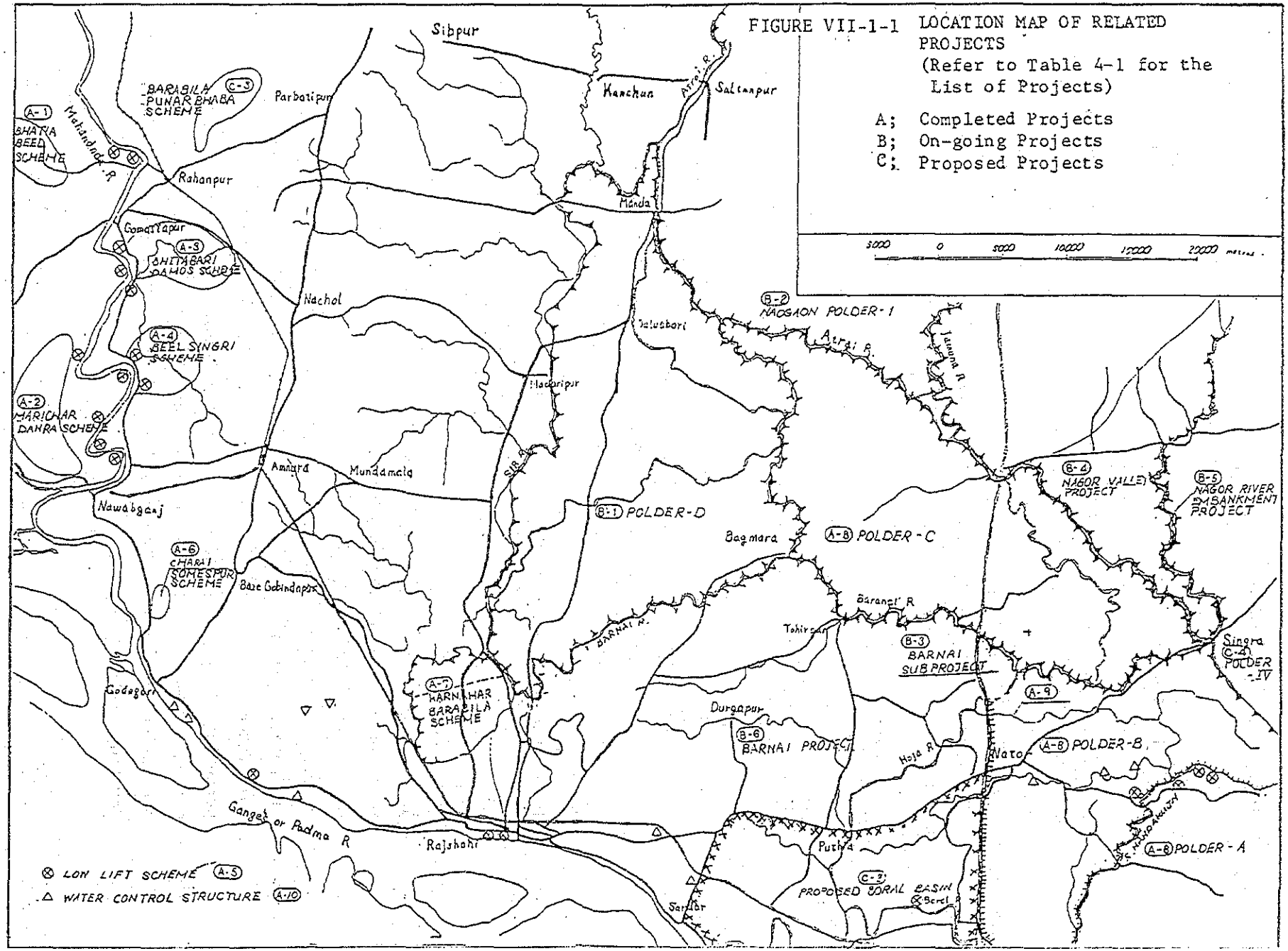


FIGURE VII-1-1 LOCATION MAP OF RELATED PROJECTS
(Refer to Table 4-1 for the List of Projects)

A; Completed Projects
B; On-going Projects
C; Proposed Projects

TABLE 1-1-1 . STATEMENT ON THE ACTIVITIES OF WATER DEVELOPMENT BOARD IN THE GREATER RAJSHAHI DISTRICT & OTHER ADJOINING AREAS

The Overall Development activities of BWDB at Rajshahi may be classified into 3 categories, namely :-

A. Completed Schemes.

B. On-going Schemes.

C. Proposed Schemes.

A. COMPLETED SCHEMES

Under this category the following are the completed schemes which is given with their salient features :-

Sl. No.	Name of scheme with Upazila and District	Benefited area	Nature of scheme	Salient feature
1.	Bhatia Beel Drainage Scheme, Bholarhat, Dist. Nawabganj.	5,760 acres	Drainage improvement and flood control.	a) Regulator = 2 Nos. b) Improvement of drainage channel = 19 Miles
2.	Maricha Danra Scheme Nawabganj & Shibganj Dist. Nawabganj.	12,160 acres	Drainage improvement and flood control.	a) Regulator = 2 Nos. b) Improvement of drainage channel = 3.25 Miles c) Embkt. = 2.37 "
3.	Bhitabari Damos Beel drainage scheme, Gomostapur, Dist. Nawabganj.	8,960 acres	Drainage improvement and flood control.	a) Regulator = 1 No. b) Improvement of drainage channel = 10 Miles
4.	Beel Singri Scheme in Upazila Natore Dist. Natore.	6,000 acres	Drainage improvement and flood control.	a) Regulator = 1 No. b) Improvement of drainage channel = 12 Miles
5.	20 Nos. Low Lift Pump scheme 12 Nos. in district Nawabganj & 3 Nos. in District Rajshahi and 5 Nos. in District Natore.	7,439 acres	Irrigation facilities	Irrigation = 5,500 acres

Sl. No.	Name of scheme with Upazila & District.	Benefited area	Nature of scheme	Salient feature
6.	Charai Someshpur Beel drainage scheme.	19,000 acres	Drainage improvement	a) Regulator = 4 No. b) Improvement of drainage channel. = 2.85 Miles
7.	Karnahar Barabila drainage-cum-flood control scheme.	9,650 acres	Drainage improvement cum flood control	a) Regulator = 8 Nos. b) Embankment = 18.87 Miles
8.	Chalan Beel Project Phase-I, Polder-A,B,C for the district of Rajshahi, Natore and Naogaon.	2,63,280 acres	Flood control and drainage improvement	a) Embankment = 136 Miles b) Regulator = 9 Nos.
9.	Improvement of Bhedra Beel drainage scheme in Upazila Natore, Dist. Natore.	27,000 acres	Improvement of drainage channel	a) Drainage channel
10.	14 Nos. Water Control structure of different places of Rajshahi, Natore, Nawabganj & Naogaon District.	6,550 acres	Irrigation	Water retention structure = 24 Nos.

B. ON-GOING SCHEME

Sl. No.	Name of scheme with Upazila & District	Benefited area	Nature of scheme	Salient feature
1.	Chalan Beel Project Polder-D under IDA Upazila Paba, Mohanpur, Tanor, Manda, Bagmara in the Dist. of Rajshahi, Noagaon.	1,31,000 acres	Flood control and drainage improvement	a) Embankment = 83 Miles b) Regulator = 9 Nos. c) Improvement of drainage channel =120 Miles d) Improvement of Internal road = 90 Miles e) Inlet/Outlet structure = 77 Nos.
2.	Naogaon Polder-I Naogaon, Raninagar, Mohadebpur & Manda Dist. Naogaon under IDA.	1,14,000 acres	Flood control and drainage improvement.	a) Embankment b) Regulator c) Improvement of drainage channel.
3.	Barnai sub-project Na Dist. Natore under ADB.		Flood control and drainage improvement	a) Regulator = 4 Nos. b) Embankment c) Improvement of drainage channel.
4.	Nagor Valley Project in Upazila Raninagar Atrai & Adamdighi in the Dist. Naogaon and under EIP Dutch Assistance.	27,170 acres	Flood control & drainage	a) Embankment = 37.20 Mile b) Re-excavation channel = 14.70 Nos. c) Regulator = 4 Nos. d) Re-mdelling of Regulator= 2 Nos. e) Irri.& drainage scheme= 90 Nos.
5.	Nagor River Embankment Project in Natore Dist. under Dutch Assistance.	38,000 acres	Flood control & drainage	a) Regulator = 1 No. b) Re-excavation of drainage channel = 8.50 Mile c) Regulator = 1 No. d) Irri. and drainage
6.	Barnai project Upazila Paba, Bagmara, Durgapur, Puthia of Rajshahi Dist. and Natore of Natore Dist. under IDA.	1,40,000 acres	Flood control & drainage improvement.	a) Embankment = 55 Km. b) Regulator = 26 Nos. c) Improvement of drainage channel =455 Km. d) Improvement of road = 60 Km. e) Inlet/Outlet structure & cross Regu.=250 Nos.

C. PROPOSED SCHEME

Sl. No.	Name of the scheme with Upazila and District	Benefited area	Nature of scheme	Expected financial assistance
1.	North Rajshahi Irrigation Project Upazila in Rajshahi, Natore and Nawabganj Dist.	Irrigation area 1,38,500 acres	Irrigation	Japanese Assistance
2.	Boral Basin Dev. Charghat Puthia, Bagha of Rajshahi Dist. and Bagatipara, Baraigram of Natore Dist.	1,04,000 acres	Flood control drainage improvement & irrigation facilities.	CIDA
3.	Comprehensive Dev. of Mohananda & Punarbhaba river basin.			Any source/IFAT CIDA
4.	Bogra Project Polder-IV	1,86,000	Flood control drainage	IDA

Though the area is surplus in food production but the per acre yield is very poor - rice 12.8 mds. and wheat 16.0 mds - compared to potentials.

b) physical components

(i) Surface wqater augmentation: At present there is about 800 miles long perennial/seasonal canals of which 300 miles canals will be re-excavated to bring/to make water available nearer to farmers field.

(ii) Installation of 2,000 DTWs under a water grid system through underground pipe delivery to ensure proper utilization of ground water within the project area.

(iii) Re-excavation of 14,000 derelict ponds for fish culture and for water conservancy.

(iv) Large scale propagation of tree plantation and horticulture development.

(v) Improvement of communication system specially improvement of about 1,400 miles feeder roads to ensure fair farm gate prices to the farmers.

(vi) Diversification of crop production through provision of tractors and propagation of less water consumptive crops.

(vii) Establishment of project office complex and procurement of basic logistic equipment.

(viii) Procurement of vehicles for project staff.

(ix) Electrification of irrigation equipment (to be implemented by PDB/REB) and establishment of agro-based industries under private initiative.

(2) North West Rural Development Project (under ADB)

North West Rural Edvelopment Project (NWRDP) has the Agricuture Development Program in its various components. The objective of the program is to improve the Government-owned derelict pond for landless people to enterprise fish culture. The ponds are leased to landless cooperatives (BSS) or women's cooperatives (WBBS) for a period of eight year. One BSS will operate in one village where 0.4 ha (one acre) of pond will be available to a vcillage group. Fish-polyculture (mixed culture of various species) will be adopted to increase the productivity per unit water area. To increase the income, agriculture is combined with duck and banana raising on the pond dikes.

The two Fish Seed Multiplication Farms (FSMF) are selected to be upgraded out of eight existing FSMFs in the Rajshahi Region. The selected FSMF will be provided with reliable water sources and distribution system, new ponds and a hatchery equipped to increase species, and with a water testing kit and other necessary equipment.

1-3. Irrigation Conditions

Three types of irrigation methods, which are also common in other areas in Bangladesh are implemented in the Project area.

(1) Shallow Tube-Well (STW)

A Well, of which depth is within 30 meters and of which capacity is about 0.5/cusec is called Shallow Tube Well. The Irrigable area per well is about 4-5 ha.

According to 1985/86 Agro-statistics, there are about 500-600 shallow tube-wells in the Project area. However, these wells are used only as a substitute irrigation method in the rainy season, and are not available in the dry season due to the decrease of groundwater.

(2) Deep Tube-Well (DTW)

A well of which depth is above 30 meters, and of which capacity is more than 2.0/cusec is called Deep Tube-Well. The irrigable area per well is about 20-40 ha.

At present, this method is implemented under Barind Tract Tube-Well Project This type of well has been installed in about 3,000 places, of which about 200 places are included in the NRIP Project area. However, in the high elevated portion of the Barind Tract, the ground water level is low in the dry season. The ground water recharge will not be enough in the Barind tract due to its clay texture. FIGURE Ⅶ-1-2

(3) Low Lift Pump (LLP)

The water resources for LLP is surface water. Along the Ganges river (from Sultangonj to Rajshahi) in the Project Area, few LLPs are existing. However, several LLPs are provided along the Mahananda river, although the areas are outside of the Project area. About 8 to 18 hectares of area can be irrigated by one LLP.

1-4. Flood and Drainage Conditions

Along the Ganges river, flood protection dikes have been constructed, which can be said that the flood of the Ganges river has been protected. However, an abnormal flooding in August to September 1987 caused severe damages to all over the country. In the Project area, the national road in the Godagari and Nawabgonj have been over-topped by the flood and the probability of the flood was 50 to 70-year return-period.

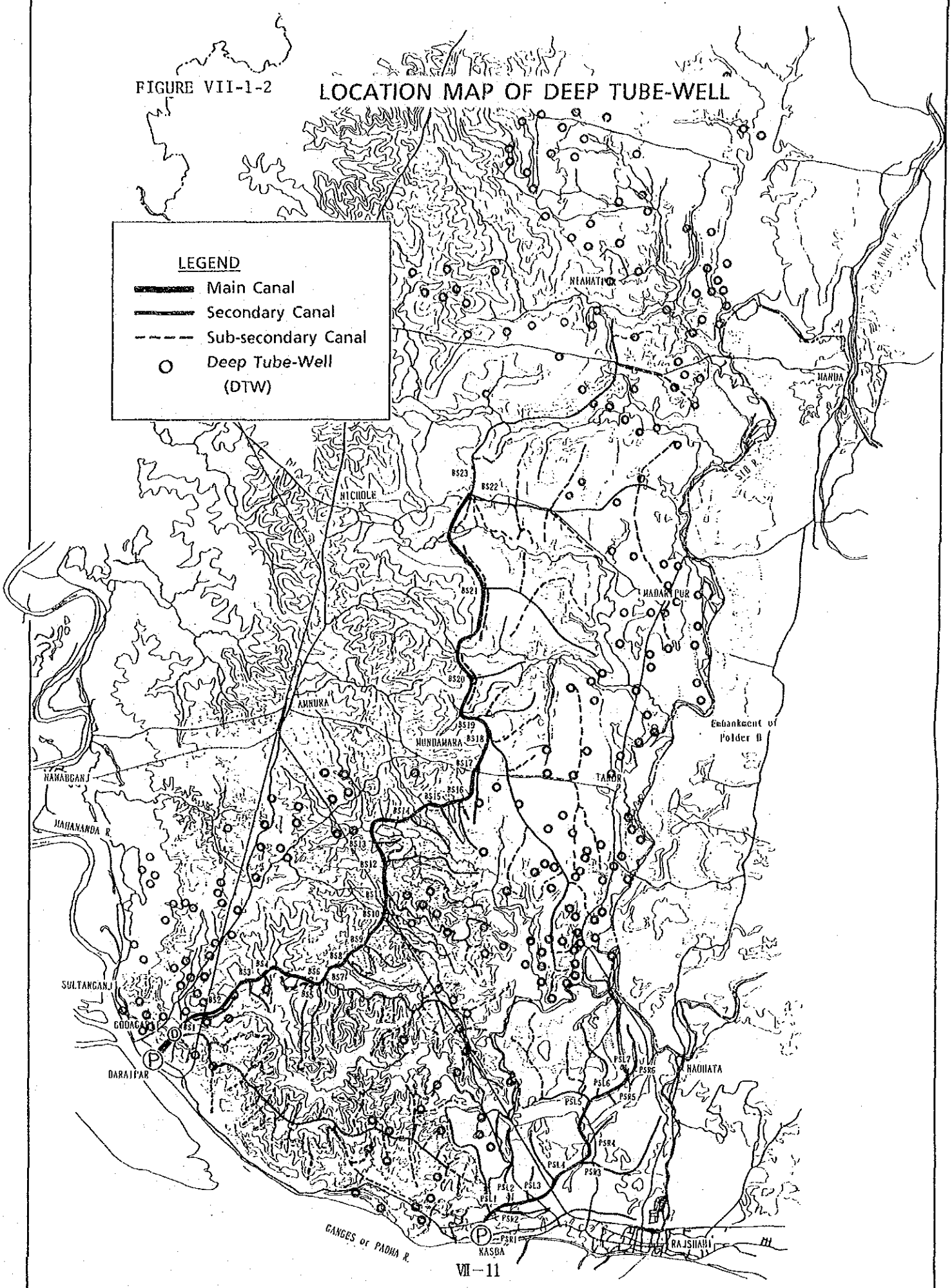
Rajshahi City protection project is under implementation to protect the city from erosion of the Ganges river. As of todate, five groins have been constructed.

The Sib river flows from north to south to catch the runoff from the Barind tract, which connects to the Barnai river at Naohata, and confluences to the Atrai river, and then flows in to the Jamuna river. The elevation fo the low flat area is lower than the water level in the Ganges river during rainy season making it rather difficult to drain the land water into the Ganges river. Therefore, the inland water should be drained from west to east even though the length of the river is very long.

The left side of the Sib river has been protected by the flood protection dike of the Polder D in the Cahalan Beel Project. The right side of the Sib river which is the lower portion of the Barind tract will be affected by an inundation.

FIGURE VII-1-2

LOCATION MAP OF DEEP TUBE-WELL



2. IRRIGATION DEVELOPMENT PLAN

2-1. Basic Concept of Irrigation Development Plan

The proposed Project aims to expand agricultural production and thereby increase income of residents in the area through the introduction of modern agricultural technology and stable year-round irrigation water supply by surface water. Furthermore, the Project is intended to promote the living standards of local residents by introducing rural development such as road network, fisheries and village water supply. The project will also create new employment opportunities in the area not only during the implementation period of the Project but also by stimulating private sectors of post harvest system and marketing activities.

In order to achieve the above objectives, the main component of the development plan is to prove irrigation facilities in agricultural land for mainly rice. For water resources development to supply irrigation water, it will be necessary to lift up water from the Ganges or Mahananda rivers by pumps. In addition, supplementary components functionary related to the irrigation development, such as road network development, fish pond culture development and village water supply are incorporated into the Project.

A development plan and appropriate scale for each component was determined in accordance with the alternative studies.

2-2. Irrigable Area

The Project area can be categorized into two distinct area from the view point of topography, soil condition, cropping pattern and flood effect.

The lower flat area is located in the Paba Upazila and belongs to flood plain area of about 13,000 hectares. This area will be called "Flood Plain Area" or "Paba Area" in the report.

Another area is located in high and undulated area, called Barind

Tract which is flood free area. This area will be called "Barind Area" in the report.

Since characteristics of both areas are so different that it will be better to consider the development plans separately.

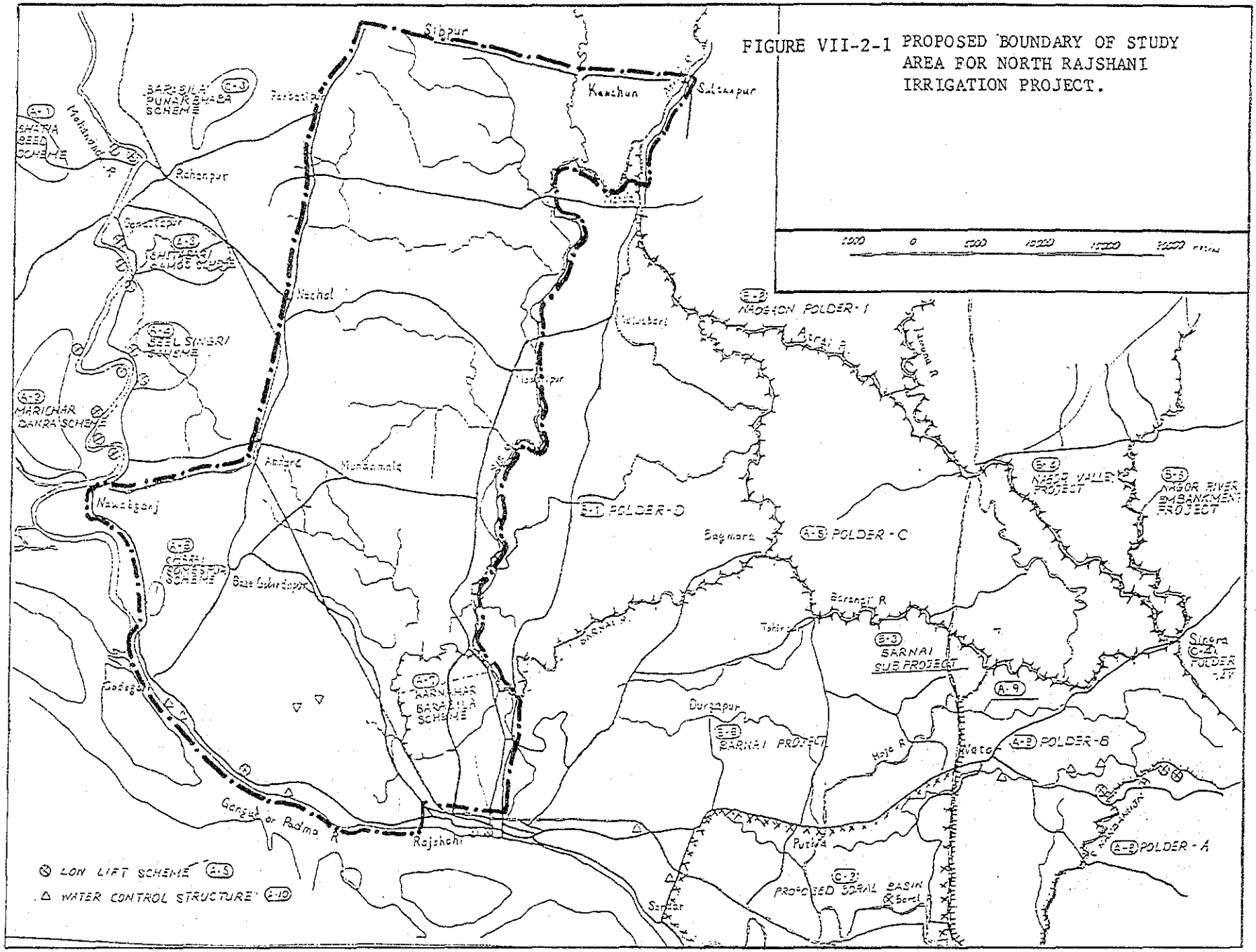


FIGURE VII-2-1 PROPOSED BOUNDARY OF STUDY AREA FOR NORTH RAJSHANI IRRIGATION PROJECT.

TABLE VII-2-1 LAND USE OF THE PROJECT AREA

Area / Land Use.	Total Land Use Area.	Rajshahi Metropolitan Area.	Project Area.		Flood Plain (Paba)		Ganges River side	Sutanganj	Barind Area	
			ha	%	ha	%	ha	ha	ha	%
Project Area	77,000	2,000	75,000	-	11,660	-	1,110	1,620	60,610	-
Below 45 feet	4,800	-	4,800	-	-		-	-	4,800	-
Over 45 feet	72,200	2,000	70,200	100.00	11,660	100.00	1,110	1,620	55,810	100.00
Residential etc.	8,068	1,208	6,860	9.77	1,720	14.75	730	150	4,260	7.63
Rivers	392	-	392	0.55	-		-	-	392	0.70
Ponds	722	-	722	1.03	118	1.01	10	16	578	1.04
Water Body	320	-	320	0.46	252	2.16	15	-	53	0.09
Sub-total	9,502	1,208	8,294	11.81	2,090	17.92	755	166	5,283	9.46
Farm Land	62,698	792	61,906	88.19	9,570	82,08	355	1,454	50,527	90.54

TABLE VII-2-2 NET IRRIGABLE AREA

	Flood Plain Area				Barind Area				Total Irrgable Area	
	Gross Area	High Land	Irrigable Area		Gross Area	High Land	Irrigable Area			
	ha	ha	ha	%	ha	ha	ha	%	ha	%
Gross Area	11,660	110	11,550	100.00	55,810	5,730	50,080	100.00	61,630	100.00
Residential etc.	1,720	11	1,709	14.80	4,260	437	3,823	7.63	5,532	8.98
Rivers	-	-	-	-	392	39	353	0.70	353	0.57
Ponds	118	3	115	1.00	578	59	519	1.04	634	1.03
Water Body	252	-	252	2.18	53	8	45	0.09	297	0.48
Sub-total	2,090	14	2,076	17.98	5,283	543	4,740	9.46	6,816	11.06
Farm Land	9,570	96	9,474	82.02	50,527	5,187	45,340	90.54	54,814	88.94
Right of Way	(Approx. 5%)		474	4.10	(Approx. 7%)		3,140	6.27	3,614	5.86
Net Irrigable Area			9,000	77.92			42,200	84.27	51,200	83.08
Deep Water Rice			(450)				-		(450)	

2-3. Irrigation Water Requirements

2-3-1 . Factors for Water Requirements

1) Consumptive use

Pan evaporation data at Rajshahi were collected. According to the pan evaporation method described in "crop water requirements" (Page-30) published by F.A.O. i.e.

$$ETo = Kp \cdot Epan$$

where, Epan = Pan evaporation in mm/day

Kp = Pan coefficient

the value of Kp was selected. In this case 0.8 which is a moderate value (table-18, Page-34 of the same ref.) was chosen.

In order to calculate the consumptive use the equation below (Page-35, same ref.) i.e.

$$ETcrop = Kc \cdot ETo$$

$$= Kc \cdot Kp \cdot Epan \text{ (Putting the value of ETo)}$$

where, Kc is a crop coefficient

was used. Selecting 1.29 as the Kc value (table-3, Page-2-7, Technical Report No.2 "Irrigation Water Requirements" Published by the Ministry of Irrigation, Water development and Flood Control, Bangladesh) and multiplying by Kp (0.8) gives a value of 1.032 which is almost unity. Therefore, from the above explanation the value of pan evaporation can be used as the value for consumptive use.

The pan evaporation data of Rajshahi for the year 1977 - 86 is presented below:

PAN EVAPORATION DATA (1977-86)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
77	83.4	113.3	231.6	184.9	153.4	122.0	121.6	145.6	130.3	126.0	91.0	82.6	1591.8
78	83.4	108.1	171.0	191.7	162.0	126.3	119.7	142.3	116.0	123.0	92.3	96.4	1532.2
79	83.9	92.4	193.0	219.6	270.7	199.3	139.9	141.7	133.7	124.4	111.1	79.9	1789.6
80	81.1	95.9	159.6	223.7	172.0	124.0	131.3	137.4	126.1	131.4	115.9	80.3	1578.7
81	75.3	92.4	143.9	158.6	165.4	142.1	130.3	135.6	118.6	136.7	110.9	85.9	1495.7
82	81.0	93.9	130.4	177.0	215.1	148.6	136.0	123.4	130.0	122.3	89.3	78.9	1525.9
83	80.1	95.6	-	-	-	-	-	-	-	99.7	104.3	83.6	463.3
84	77.3	90.0	186.3	186.6	179.1	111.6	101.9	103.4	121.7	101.1	88.0	80.0	1427.0
85	70.1	93.4	194.0	-	-	-	-	-	-	-	-	-	357.5
86	-	-	-	162.4	159.0	157.7	109.7	119.6	98.0	104.7	86.4	58.7	1056.2
AVERAGE	79.5	97.2	176.2	188.1	184.6	141.5	124.6	131.1	121.8	118.8	98.8	80.7	1563.0

2) Percolation rate

Prercolation rates were adopted as a factor of soil classification in the study area. A weighted average of the percolation rates was used for the irrigation schemes and 1.0 mm/day was decided as the percolation rate in the Project area.

3) Pre saturation requirements

The pre-saturation requirements were estimated according to the following parameters:

Pre-saturation Period: 40days

Pre-saturation Requirement:

Land Soaking	60.0mm
Standing Water	20.0mm
Total	80.0mm

4) Effective rainfall

As for effective rainfall during crop growth, daily rainfall of 5.0 mm or less is considered inefeective while rainfall exceeding 5.0 mm is considered 80% effective. When effective rainfall exceeds the daily water requirement, the surplus is stored in the paddy field and used the following day. Effective rainfall, however, is limited to 80 mm/day due to over spill.

5) Growing stage requirements

Water requirement during crop growth has been computed as the sum of the daily soncumptive use and the percolation rate.

2-3-2. Irrigation Efficiency

The conveyance losses for the main, secondary and tertiary canals were determined at 3.0%, 4.0% and 3.0%, respectively, with an overall conveyance efficiency of 90%.

As for operation loss, overall operation efficiency can be assumed at 90% and this value is also applied to the main, secondary and tertiary canal, considering the number of gate structures along the

canal. Field efficiency was adopted at 70% during the wet season considering the effect of rainfall, and 75% during the dry season.

Accorgingly, each irrigation efficiency factor in accordance with the type of canal was decided as shown in the following table. The period from November to May is designated as the dry season and the rest as the wet season.

OVERALL IRRIGATION EFFICIENCIES

	Conveyance	Operation	Field	Total	Overall
Main	0.97	0.98	-	0.95	0.57 (0.61)
Secondary	0.96	0.97	-	0.93	0.60 (0.64)
Tertiary	0.97	0.95	-	0.92	0.64 (0.69)
SF & On-farm	-	-	0.70 (0.75)	0.70 (0.75)	0.70 (0.75)
Total	0.90	0.90	0.70 (0.75)	0.57 (0.61)	

Note: The figures in parentheses refer to the dry season.

2-3-3. Diversion Water Requirement

Since the Project area is extended for about 60 sq.km in the size and the difference of the elevation is about 30 meters. The rainfall distribution is rather different in the daily basis. The areal rainfal analysis has been made adopting Thiesen Poligon method among 5 rain gauge stations at Rajshahi (12%), Tanor (24%), Nachol (26%), Godagari (21%) and Manda (17%). The figures are the ratio of the command area.

The areal rainfall has been adopted to estimate the effective rainfall for the water requirements.

According to the proposed cropping calendar and pattern, the cropping pattern has been categorized into two patterns. The main pattern is a combination of T-aman and Boro and the other is Aus and T.Aman.

As explained in the Interim Report, simulation snalysis has been made to minimize the water requirement and peak water requirement to utilize effectively rainfall as much as possible.

In accordance with the proposed cropping calendar and above mentioned two patterns of unit water requirements, diversion water requirement for Paba Flood Plain Area and Barind Area have been computed for 10 years from 1977 to 1987.

The maximum peak diversion water requirement during 10 year period is appeared on September the 3rd-10-day in 1982 as shown in TABLE VII-2-3 and TABLE VII-2-4 for Barind and Paba areas, respectively. In the table, the pattern 1 and pattern 2 means as following cropping calendar ;

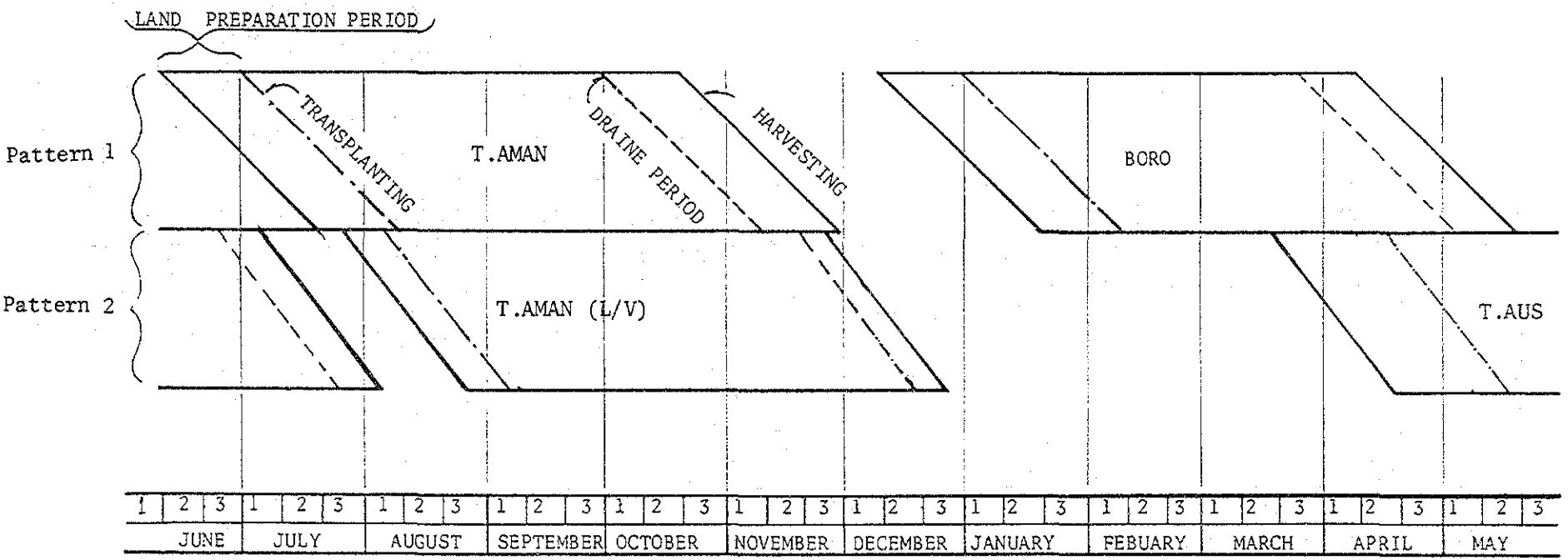
Pattern 1 : Boro - T.Aman (See FIGURE VII-2-2)

Pattern 2 : Aus - T.Aman

The annual maximum unit water requirement and diversion water requirements are shown in TABLE VII-2-7 and TABLE VII-2-8.

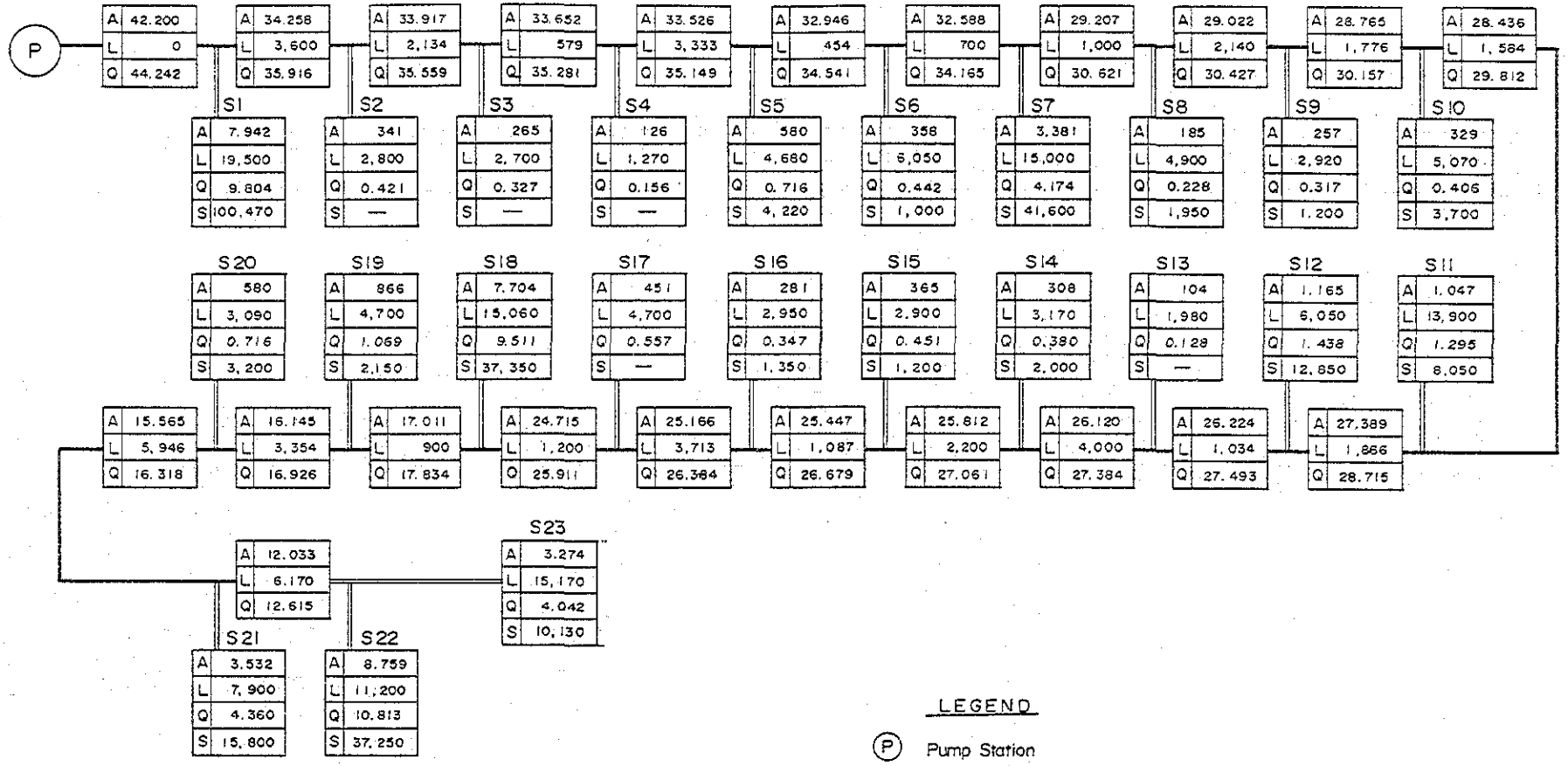
As for the percolation rate of 1.0 mm/day mentioned in the Interim Report, we are convinced that the value is quite safe as shown the laboratory analysis of percolation test which shows almost zero value.

FIGURE VII-2-2 CROPPING PATERN FOR WATER REQUIREMENT ANALYSIS



* Pattern 1 : Boro - T.Aman
Pattern 2 ; Aus - T.Aman

FIGURE VII-2-3 (1) DIAGRAM OF IRRIGATION SYSTEM NETWORKS
(BARIND AREA)



Note : The discharge has been estimated based upon the Unit Water Requirement for ;

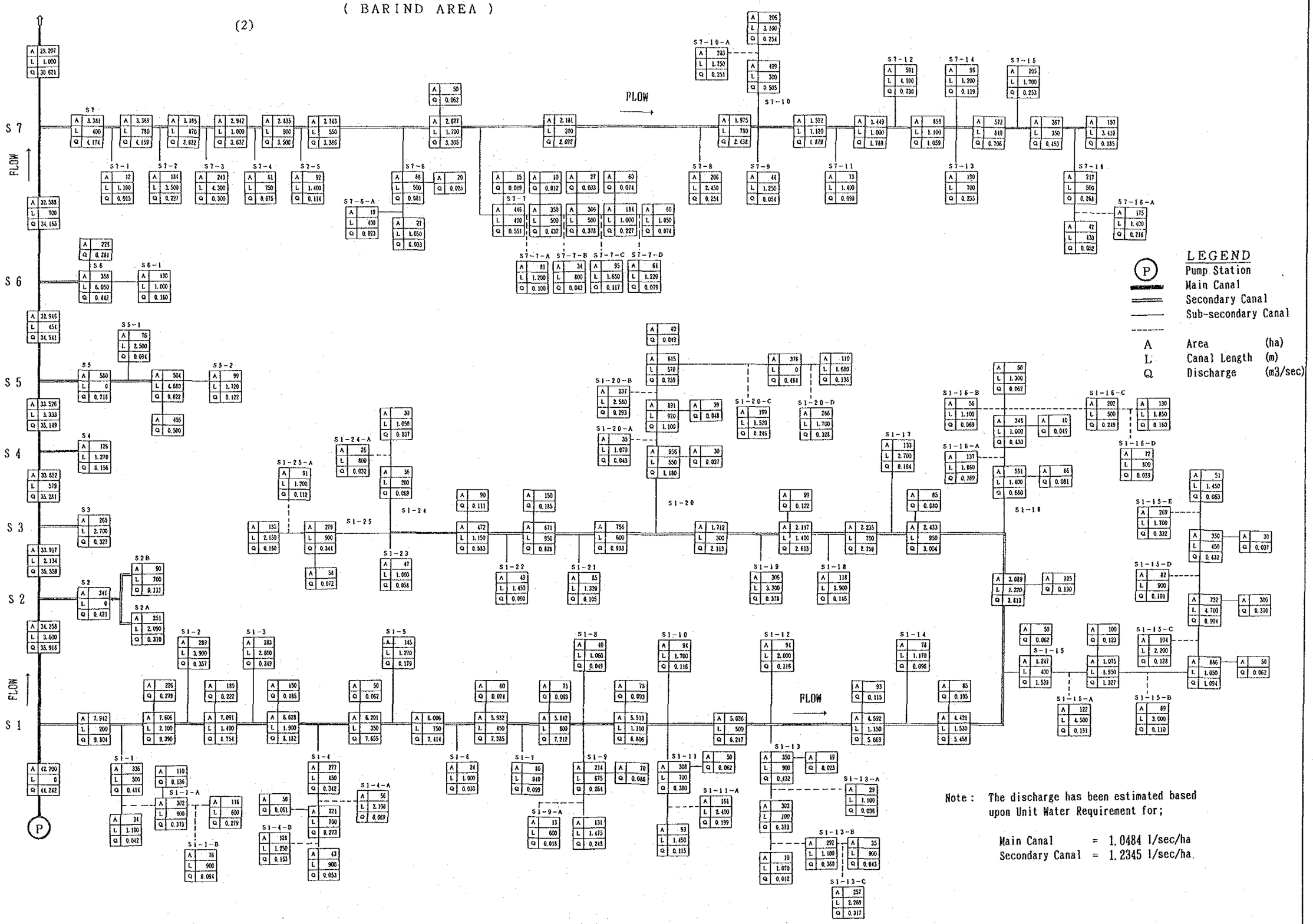
Main Canal = 1.0484 L/sec/ha
Secondary Canal = 1.2345 L/sec/ha

LEGEND

- (P) Pump Station
- Main Canal
- Secondary Canal
- A Area (ha)
- L Canal Length (m)
- Q Discharge (m^3/s)
- S Sub-Secondary Length (m)

FIGURE VII-2-3 DIAGRAM OF IRRIGATION SYSTEM NETWORKS
(BARIND AREA)

(2)



LEGEND

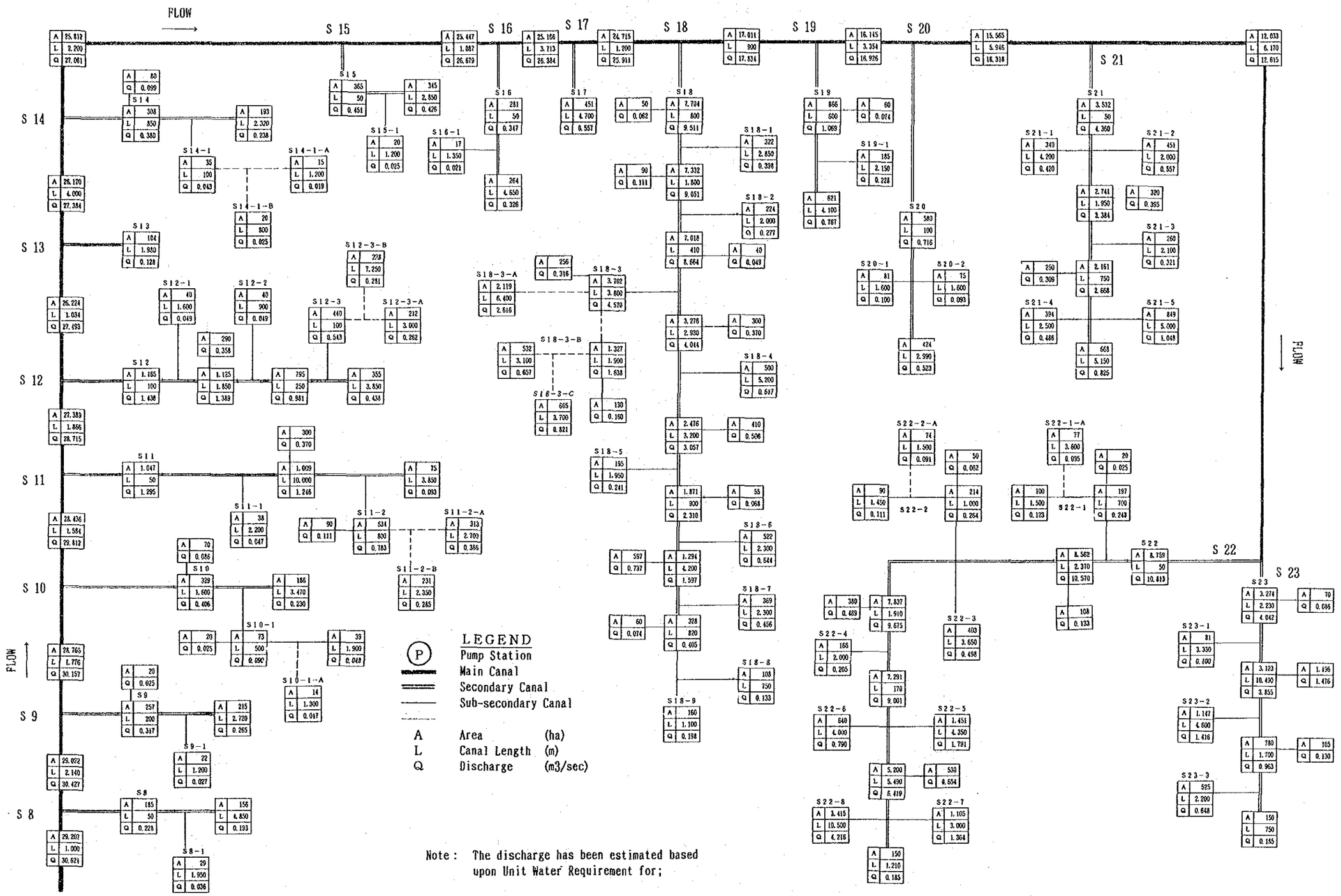
- P : Pump Station
- Main Canal
- Secondary Canal
- Sub-secondary Canal

A	Area	(ha)
L	Canal Length	(m)
Q	Discharge	(m3/sec)

Note : The discharge has been estimated based upon Unit Water Requirement for;

Main Canal = 1.0484 l/sec/ha
Secondary Canal = 1.2345 l/sec/ha.

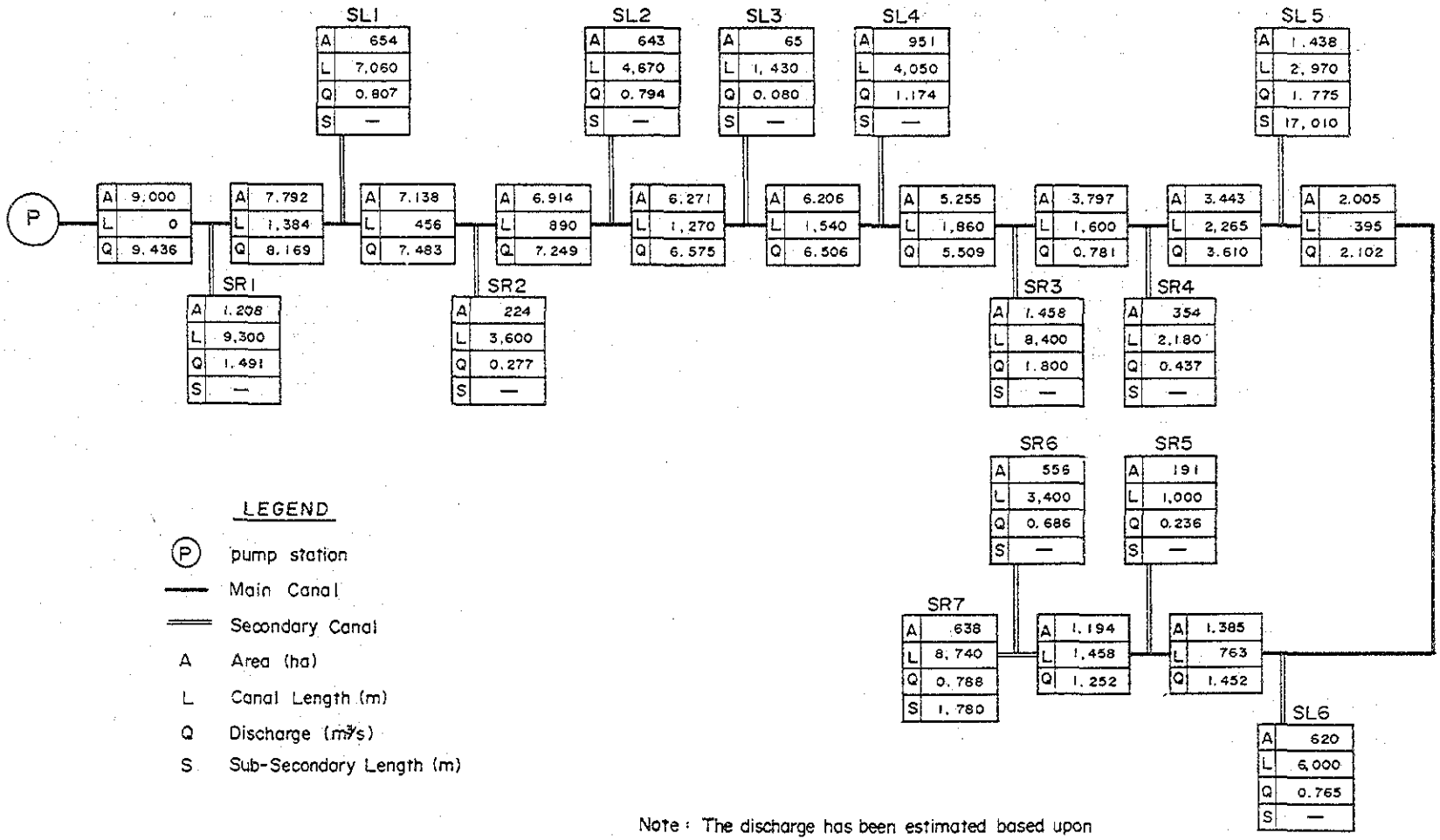
FIGURE VII-2-3 (3) DIAGRAM OF IRRIGATION SYSTEM NETWORKS
(BARIND AREA)



Note : The discharge has been estimated based upon Unit Water Requirement for;

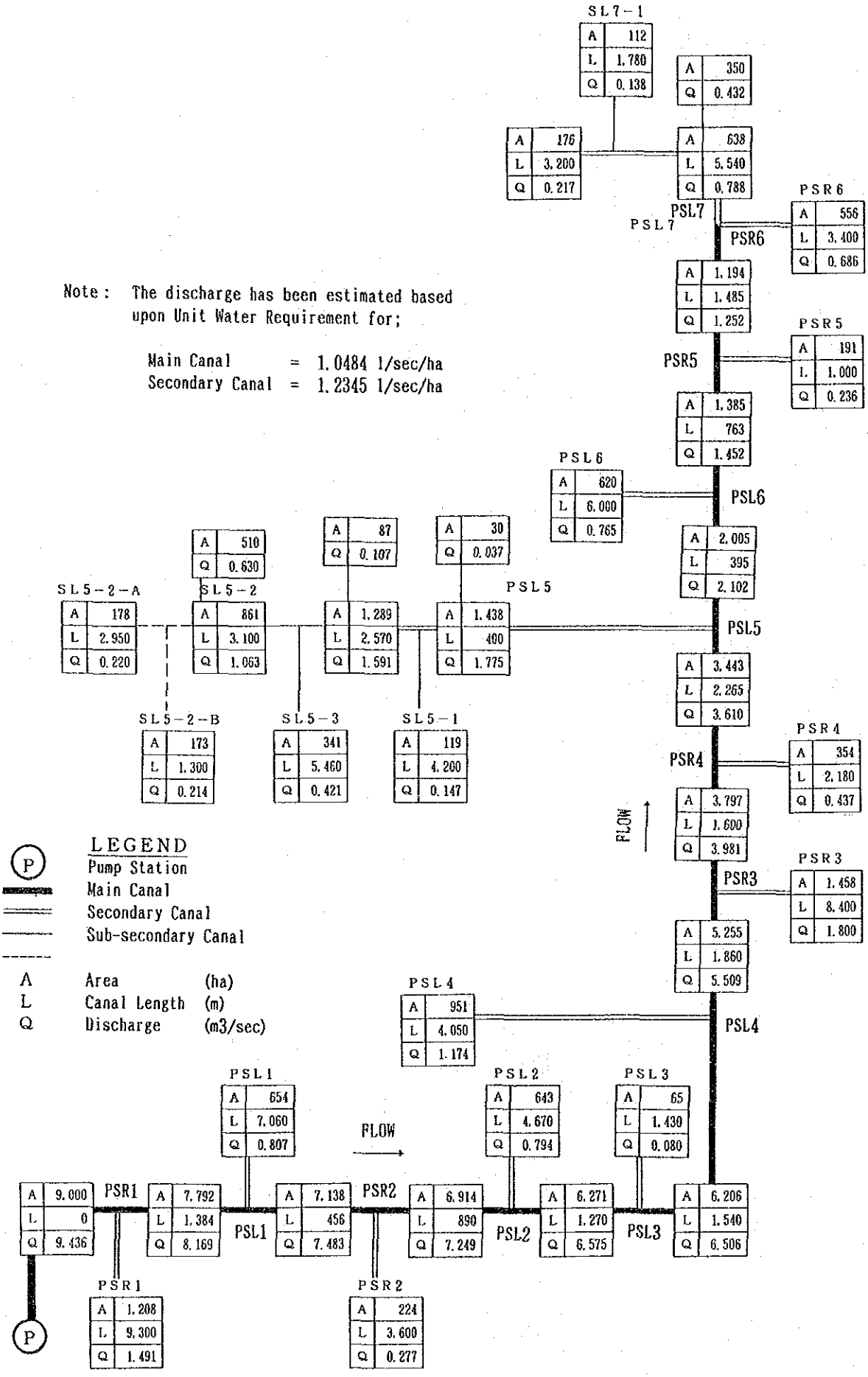
Main Canal = 1.0484 l/sec/ha
Secondary Canal = 1.2345 l/sec/ha

FIGURE VII-2-4 (1) DIAGRAM OF IRRIGATION SYSTEM NETWORKS
(FLOOD PLAIN AREA)



Note : The discharge has been estimated based upon the Unit Water Requirement for ;
Main Canal = 1.0484 L/sec/ha
Secondary Canal = 1.2345 L/sec/ha

FIGURE VII-2-4 (2) DIAGRAM OF IRRIGATION SYSTEM NETWORKS
(FLOOD PLAIN AREA)



Note : The discharge has been estimated based upon Unit Water Requirement for;

Main Canal = 1.0484 l/sec/ha
Secondary Canal = 1.2345 l/sec/ha