No. 08

THE PEOPLE'S REPUBLIC OF BANGLADESH

BASIC DESIGN REPORT

ON

TERMINAL IRRIGATION FACILITIES

IN

NARAYANGANJ-NARSINGDI IRRIGATION PROJECT AREA

(N-N Demonstration Project)

December 1981

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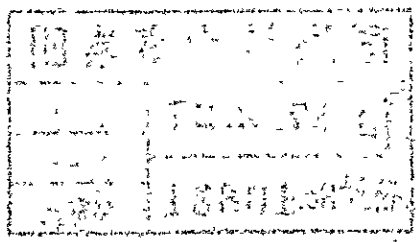

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Preface

It is with great pleasure that I present this Basic Design Report on Terminal Irrigation Facilities in Narayanganj-Narsingdi Irrigation Project Area in the People's Republic of Bangladesh.

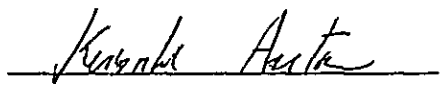
This Report embodies the result of a basic design survey, with principal terms of reference to work out detailed cost estimates for the proposed Project.

To this end and at the request of the Government of Bangladesh, a Japanese Survey Team commissioned by Japan International Cooperation Agency was fielded from July 8 to 29, 1981. This occasion provided the opportunity to carry out a series of discussions with the concerned officials of the Government and conduct a comprehensive survey and subsequent data analysis on which the present Report is based.

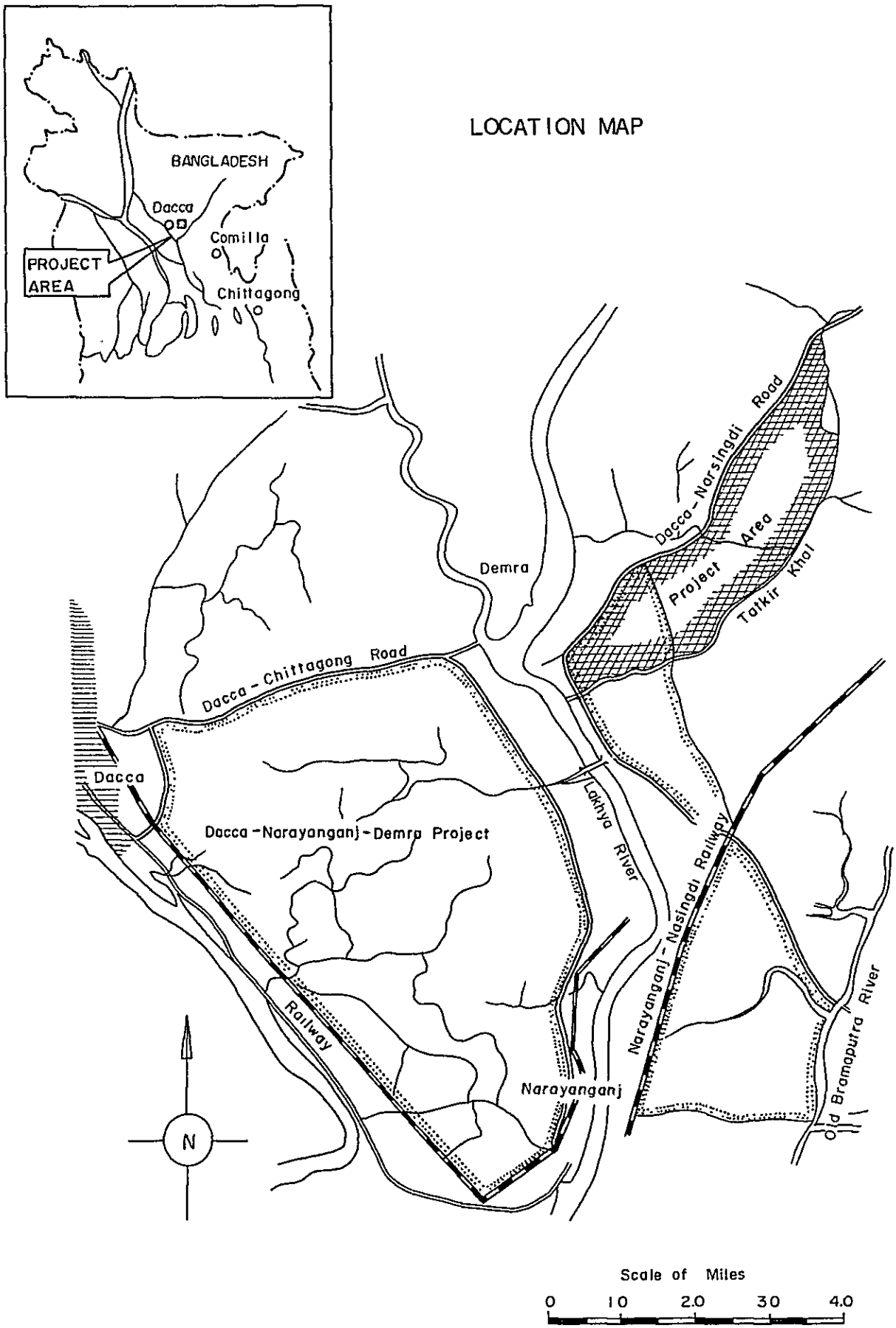
It is sincerely hoped that this Report will be helpful as a basic reference for the development of the Project.

Finally, I wish to take this opportunity to express my deep appreciation to the concerned officials of the Bangladesh Government for their whole-hearted cooperation and support extended to the Team during its stay in Bangladesh.

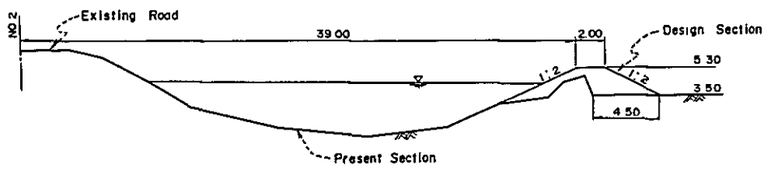
November, 1981



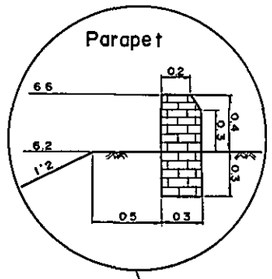
Keisuke Arita
President
Japan International
Cooperation Agency


LOCATION MAP
BANGLADESH
Dacca
Comilla
Chittagong
PROJECT AREA
Dacca - Narsingdi Road
Project Area
Talkir Khal
Demra
Dacca - Chittagong Road
Dacca
Dacca - Narayanganj - Demra Project
Lakhya River
Narayanganj - Nasingdi Railway
Railway
Narayanganj
Old Bramaputra River
N
Scale of Miles
0 1.0 2.0 3.0 4.0

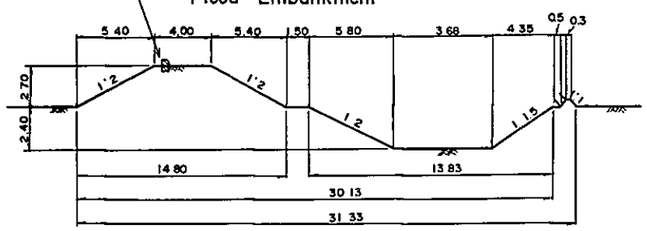
Main Canal

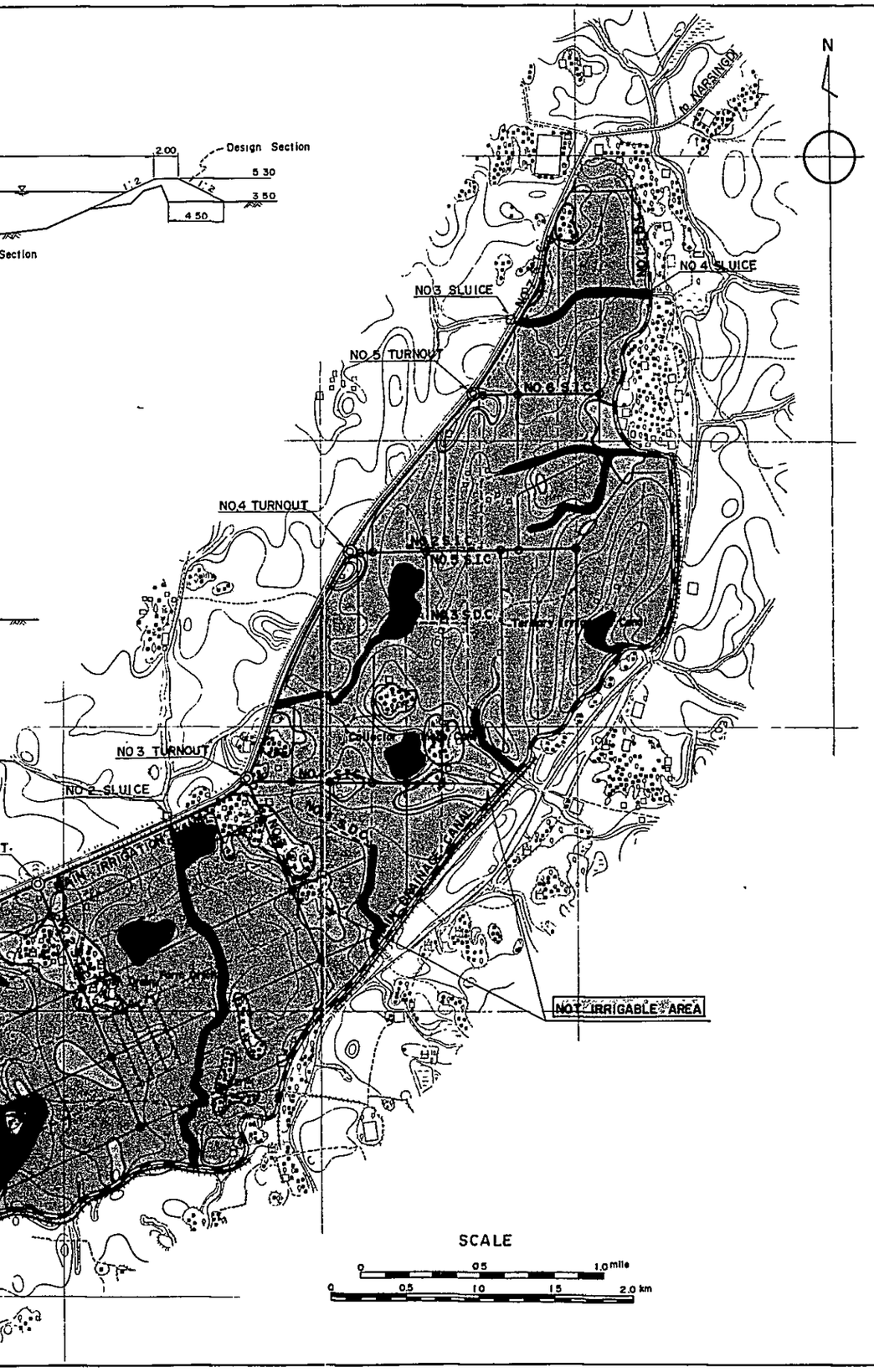


Parapet



Flood Embankment





SCALE

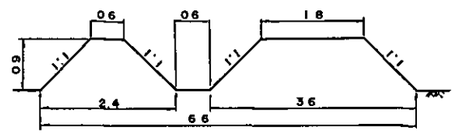
0 0.5 1.0 mile

0 0.5 1.0 1.5 2.0 km

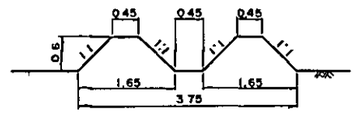
TYPICAL CANAL SECTION

Scale = 1 : 100

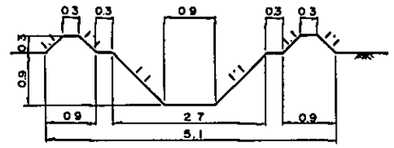
Secondary Irrigation Canal (S.I.C.)



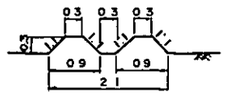
Tertiary Irrigation Canal



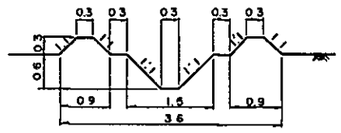
Collector Drainage Canal



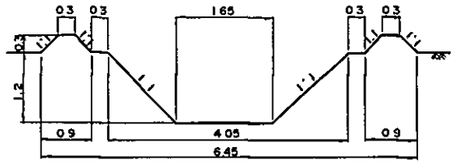
Farm Ditch



Farm Drain



Secondary Drainage Canal (S.D.C.)



NARAYANGANJ-NARSINGDI IRRIGATION PROJECT
BANGLADESH WATER DEVELOPMENT BOARD

GENERAL LAYOUT

DATE AUG. 1981 | DWG. NO

JAPAN INTERNATIONAL COOPERATION AGENCY

CONTENTS

Appendixes, Tables, Figures, Photographs, Collected Data

I

Purpose and Background of Survey

FIGURE AND BACKGROUND OF SPACE

I. PURPOSE AND BACKGROUND OF SURVEY

1-1 Survey Objective

The Survey Team was dispatched by JICA at the request of the Government of Bangladesh to conduct a basic design survey for the construction of terminal irrigation structures and facilities in an approximately 1,000 ha portion of the proposed Narayanganj-Narsingdi Irrigation Project (N-N Project) area located near Dacca. A feasibility study for the N-N Project was undertaken by JICA in 1977, and served as a reference for the subject survey.

1-2 Background of Survey

The aim of the First Five Year Plan (1973 - 77) of Bangladesh was to improve the severe economic situation of the country. The primary objectives of the plan were;

i) equal distribution of income;
ii) active government guidance in the production and distribution sectors; and
iii) prioritized investment in the agriculture and water resources sectors.

While 24% of total government budget of the Plan was allocated to the water resources sector, developmental targets were only partially achieved. Moreover, the food grain production outlook has remained clouded despite continuous efforts into the Second Five Year Plan (1978 - 82).

Between 1973 - 79 the World Bank and the Asian Development Bank have extended as many as 14 loans to the Government of Bangladesh to improve the low per capita income, approximately US$100, by expediting the development of a sound economic structure in the water resource sector. The total value of these loans is over US$279 million, on both hard and soft financial terms (APPENDIX II).

Bilateral financial assistance from foreign governments (US$74.5 million) for large scale water resource scheme have also been extended but limited to only a few Western countries. Some factors for the hesitancy exhibited by foreign governments are as follows:

i) substancial capital investment is necessary due to the natural conditions of the delta region of the Ganges and Brahmaputra rivers;
ii) cultivation of floating rice has not contributed satisfactorily towards achieving the national goal of self-sufficiency in food grain production, and significant difficulties in the introduction of alternative cash crops continue;
iii) funds for local cost financing continue to be inadequate; and
iv) reliable economic benefits from large scale projects evolve only after an extended period, while total recovery of investment is extremely difficult.

The N-N Project represents the first intensive Japanese Government involvement on a large scale irrigation and drainage project in Bangladesh, the feasibility study being completed in 1977. The project entails the construction of a ring embankment to enclose an estimated area of 35,000 ha (86,484 ac) of which 22,500 ha (55,597 ac) is to be developed during the first phase, and the remaining 12,500 ha (30,887 ac) during the second phase.

An examination of large scale agricultural development projects in Bangladesh indicates that preparation of terminal irrigation and drainage facilities often lag well behind the construction of main structures. Such delay has typically prolonged materialization of project benefits for as much as 10 - 15 years. Also, general failure to construct terminal facilities in a technologically sound fashion has further reduced the efficiency of on-farm irrigation water supply.

In light of the above, the Government of Bangladesh announced the intention to commission an international institution to carry out a survey of basic design criteria for construction of terminal irrigation and drainage facilities on a Demonstration Unit within the N-N Project area. To this end, the Japanese Government in early 1981 was requested to execute a design survey grant. Through subsequent meetings with concerned officials, this request has been agreed to in principal. As the first step, a Basic Design Survey Team was organized by the Japan International Cooperation Agency and fielded between July 8 - 29, 1981. Subsequent to the field survey a Basic Design Report is to be submitted by the end of September.

1-3 Scope of Work

In close consultation with concerned agencies of the Government of Bangladesh, the survey team selected the location for the Demonstration Unit, determined the extent of required structures and facilities (pump station, flood embankment, canals, etc.), formulated the basic design and construction cost estimates thereof; and undertook to evaluate the effects of implementation of the Demonstration Unit.

1-4 Survey Team Members

Position	Name	Organization
Mission Leader	Mitsuru Naito	MFA
Deputy Mission Leader	Tohru Mase	MAFF
Project Coordinator	Shozo Matsuura	JICA
Agriculture Specialist	Mitsuo Yoshimeki	Chuo Kaihatsu Corp.
Irrigation/ Drainage Engineer	Takafumi Suzuki	"
Soil Analysis Engineer	Hisao Ando	"
Structure/Facility Design Engineer	Akira Kojima	Nippon Koei Co., Ltd.

1-5 Survey Team Itinerary

8 July 1981	Depart Narita, arrive Bangkok
9 "	Depart Bangkok, arrive Dacca
10 "	Preliminary field inspection of candidate sites for Demonstration Unit; courtesy calls to Japanese Embassy and JICA Dacca Office.
11 "	Courtesy calls to heads of concerned Bangladesh government agencies; project study.
12 "	Detail inspection of candidate sites for Demonstration Unit.
13 "	Selection of location for Demonstration Unit.
14 "	Signed Mission "minutes"
15-27 July 1981	Team members gather data relevant to their special areas of responsibility; field survey of proposed area for Demonstration Unit; correlate and analyze observations and data.
28 July 1981	Courtesy calls to heads of concerned Bangladesh government agencies, Japanese Embassy, and JICA Dacca Office; depart Dacca, arrive Bangkok.
29 "	Depart Bangkok, arrive Narita

1-6 Concerned Personnel

Bangladesh Government

Mr. A. Hannan, Division Chief, Planning Commission

Mr. M. Moniruzzaman, Additional Secretary, MPWRFC

Mr. M. Rahman, Chairman, WDB

Mr. G.R. Chowdhury, Member, Implementation, WDB

Mr. E. Ali, Member, Planning, WDB

Mr. A. Islam, Chief Engineer, Planning (F/S), WDB

Mr. P.N. Bhakat, Deputy Director, Planning (F/S), WDB

Mr. A.N. Wahid, Deputy Director, Planning (F/S), WDB

Counterpart

Mr. A.Ali, Deputy Director, Planning (F/S), WDB

Mr. M. Zzaman, Deputy Director, Design Engineer, WDB

Mr. A. Mannan, Senior Agricultural Planning Officer, WDB

Mr. H.S.M. Faruque, Assistant Engineer, WDB

Japanese Government

Mr. T. Iwanami, Counsellor, Embassy of Japan

Mr. K. Niino, First Secretary, Embassy of Japan

Mr. T. Murakoshi, Resident Representative, JICA Dacca Office

II

Outline of the Project

II. OUTLINE OF THE PROJECT

2-1 Background of the Project

The national economy of Bangladesh is wholly dependent on agriculture, lacking few other natural resources. By 1978 the annual rate of population had increased to 2.9% on the one hand, while agricultural yields were adversely affected by habitual flooding and drought on the other hand. It is reasoned that chronic food shortages will become more critical unless remedial measures are taken. To improve agricultural production, some selected areas have been cultivated introducing, in particular appropriate technology, and irrigation, drainage, and flood control facilities (Table 1). As a result, increased productions have been clearly obtained (Table 2).

The proposed Demonstration Unit (Unit) for construction of terminal irrigation facilities is located in Rupganj Thana on the left bank of Lakhya River approximately 12 km (7.5 miles) east of Dacca. The Unit consists of about 1,000 ha (2,470 ac) of low land circumscribed by existing road embankments (Dacca-Narsingdi Road) and the Tatkir Khal.

The area is inundated by the middle of May as the level of Lakhya, Meghna, and old Brahmaputra rivers rise, reaching the maximum depth of 1.5 - 3 m by August/September, while receding rapidly by the end of November.

The major crops of the area are deep water Aman rice and white jute (Corchorus capsularis) occupying approximately 45% and 20% of the area, respectively. In the dry season, however, lack of irrigation water forces area farmers to leave fallow even potentially cultivable land.

Rice yields are low under present agricultural conditions mainly due to excessive deep water during the wet season, as well as a shortage in irrigation water in the dry season, preventing successfull cultivation of higher yielding rice varieties (Table 3). Under such conditions, lower quantity/quality jute varieties are cultivated. Total flood/drought damage is rare, but partial crop damages are recorded every year (Table 4).

It is planned that the proposed Unit be protected from flooding by utilizing existing road embankments and constructing flood protection embankments along the existing Tatkir Khal which surround the area. Irrigation/drainage will then be carried out by a dual purpose pump. Agricultural production in the area will be therefore, increased by constructing a ring embankment with a pumping station for drainage during the monsoon season and irrigation during the dry season. As a result, conditions within the unit shall become favourable for annual double/triple cropping. In addition, conditions for the cultivation of pulses, vegetables and rape/mustard shall also be improved.

Taking into consideration the good transportation linkage to Dacca, Comilla, and Chittagong, the proposed area is an ideal location to serve as a demonstration for not only modern irrigation/drainage agriculture but also technology for rapidly constructible embankment and terminal irrigation facilities. Thereby, government officials, engineers, researchers, students, farmers, and others who are interested in personal observation of an agricultural project can easily visit the area.

2-2 Significance and Impact of the Project

The greater portion of cultivable land in Bangladesh lies in the wide alluvial plain formed from deposits borne by the Gauges, Pubna, and Meghna river systems. In order to improve the agricultural productivity of the plain, it is necessary to both implement flood control measures for the rainy season crop as well as guarantee a stable supply of irrigation water for the dry season crop. In view of these imperatives, the Government of Bangladesh has concentrated its agricultural development efforts on the implementation of numerous irrigation projects in the plain. Unfortunately, steps to introduce appropriate cultivation technology for irrigated agriculture at the farmers' level have not kept pace with construction of major irrigation facilities, and thus many of these projects have not generated results on a level with expections.

Although the benefit area is a relatively small 1,000 ha, effective implementation through the introduction of farming technology and construction of irrigation structures and facilities appropriate to existing levels of agricultural development in the area will not only serve as a powerful model on methodology for improving agricultural productivity, but also fits comfortably into the one-year completion requirement to qualify for grant assistance from the Japanese Government. As such, the completed project will also function as an effective demonstration of the technology for rapid construction of embankments, pump stations, canals, and other irrigation structures and facilities, the completion of which in the past has often tended to fall behind schedule.

Avoiding the mistakes of past experience whereby projects have directly introducted inappropriately advanced farming practices into areas not yet prepared to effectively absorb such, only that technology applicable to agricultural levels in the demonstration area will be incorporated in the project. The cropping pattern to be adopted will emphasize a long term agricultural outlook, allowing an ample fallow period between major crop seasons to prevent depletion of soil nutrients and to inhibit the propagation of crop pests and disease.

Although the subsequent economic internal rate of return (EIRR) for the project is relatively low, it represents a rational approach to a steady, long term increase in the agricultural productivity of the area, while avoiding the pitfall of striving for overly ambitious improvements in crop yield which often lies at the root of unsatisfactory project performances in the past.

2-3 Main Features of the Project

Net Irrigable Area	1,000 ha	2,470 ac
Flood Protection Embankment	6.6 km	4.1 mile
Pumping Station (ø700 x 3 Nos.)		
Electro-mechanical equipment	1 lot	1 lot
Civil work	1 lot	1 lot
Irrigation Canal		
Main canal	7.8 km	4.8 mile
Secondary canal	7.8 km	4.8 mile
Tertiary canal	30.0 km	18.6 mile
Turnout (main - secondary)	5 nos.	5 nos.
" (secondary - tertiary)	40 nos.	40 nos.
Diversion box	200 nos.	200 nos.
Drainage Canal		
Main canal	8.6 km	5.3 mile
Secondary canal	15.6 km	9.7 mile
Tertiary canal	20.7 km	12.9 mile
Sluice	4 nos.	4 nos.
On Farm Facilities		
Farm ditch	70.0 km	43.5 mile
Farm drain	70.0 km	43.5 mile
Related structure	1 lot	1 lot
Farm Facilities		
Miscellaneous equipment	1 lot	1 lot
Project Facilities		
Offices and houses	1 lot	1 lot
Transmission Line		
Transmission line	200 m	656 ft
Sub station	1 unit	1 unit
Construction Machinery	1 lot	1 lot
Land Acquisition		
Flood embankment	26 ha	64 ac
Canal	30 ha	74 ac
Pumping station	2 ha	5 ac

III

Basic Design

Microfilmed at the National Archives

III. BASIC DESIGN

3-1. Basic Survey

3-1-1 Meteorological survey

As part of the sub-continent of India, the climate of the area is classified as a typical monsoon zone. It has four different seasons; a wet season, a dry season and two intervening transitional seasons.

The transition from northeastern monsoon to southwestern monsoon occurs around early April while the rainy season comes suddenly towards the end of May. The transitional period is characterized by a sudden climatic change bringing stormy weather, occasionally accompanied with hailstorms. Tropical depressions and cyclones strike the area frequently.

Starting in June, the southwest monsoon brings about a rainy, high-temperature, humid season which continues till the end of September. During this time, the precipitation reaches 65% of the total annual precipitation. In October and November, the southwest monsoon gradually regresses while the northeast monsoon returns. Precipitation declines, tropical depressions, and cyclons entering from the Bay of Bengal cause considerable damage in the area.

From December to March, the northeast monsoon prevails and brings the dry season. Then fair weather continues with only occasional rainfall and very low humidity.

The general agricultural weather data at Dacca Meteorological Station whereat reliable long-term records are available is shown in Table 5.

3-1-2 River survey

Six water level gauging stations are located on the periphery of the N-N Project at Ghrosal, Demra, and Narayangandi along the Lakhya River and at Narsingdi, Baidya Barzar and Meghna Ferry Ghat along the Meghna River.

Since the Unit is located across from Demra on the Lakhya River, irrigation facilities therefor are planned on the basis of water levels measured at the Demra gauging station.

Probable maximum and minimum water levels observed at the Demra gauging station are shown in Fig. 1 and 2, respectively. The maximum water level pattern during the flood season of 1974, when the maximum flood level recorded over the past 13 years occured, is given in Fig. 3.

3-1-3 Current land utilization

According to the Statistical Yearbook of Bangladesh, while cultivatable waste (cultivatable area lying fallow for a year or so), has reduced, current fallow has expanded during the period 1964-1977. Subsequently, the cropped area has decreased.

As is shown clearly in Table 6, the unarable area is extremely limited and forest/wood area and cultivable waste/current fallow lands are non-existent within the Unit. Therefore, the majority (95%) of the total land is cultivated. While double/triple cropping is favorable (87.4%) to Bangladesh at large, such cropping patterns are limited in the Dacca District and the Unit area, with present percentages at only 39.0% and 15.6% respectively due to excessive deep water during the wet season and lack of irrigation water during the dry season. In other words, single cropping (Aus/Aman) is broadcasted in 79.8% of the arable land under the deep water condition with extremely limited planting during the arable dry season due to insufficient irrigation water.

Results of an interview analysis shows that the farmers of the Unit area are forced to cultivate broadcasted Aman/high yielding Boro and Jute. Mustard and pulses are moderately favored, and wheat, chili, onion, cauliflower and tobacco leaves are cultivated to some extent (Table 7).

However, Boro rice is planted in 74.9% of the arable land in Dacca District under irrigation followed by 15.9% potato, 3.5% wheat and 2.6% Aus rice (Table 8). As is shown in Table 7, while local Boro rice has

advantages of yield against the local Aman/Aus. Boro HYV, in particular, produces extremely high yields. Research in cultivating rice under tropical conditions has shown that rice cultivated during the dry season under irrigated conditions produces a higher yield than that during the wet season under rain-fed and/or irrigated conditions. HYV's produce undoubtedly higher yield than local varieties, if sufficient irrigation water is available. Accordingly, the completion of the present Unit will contribute to better rice production under year-round irrigable conditions. In addition, the farmers shall be able to cultivate other favourable crops, such as Rabi vegetables, wheat and mustard, as desired (Table 7).

3-1-4 Soil mechanical survey

The proposed Unit is part of the flood plain of the Meghna, Lakhya, and old Brahmaputra rivers, being raised annually by freshly deposited silt carried by these rivers during the flood season.

The characteristics of the soil in the Unit area are clay and silt subjected to the seasonal flooding with a trace of organic matter but lacking sandy and gravelly soil. As the permeability of the soil is very low, it remains moist and/or saturated for a long time, even well into the dry season.

Based on precise examination of the soil properties in the Unit area, two soil model profiles, A and B, were derived. Subsequently, the embankment and pump station have been designed according to their respective models. These soil properties are charted as on the subsequent page.

1) Model A (embankment)

Depth (m)	Soil Type	Penetration	Properties
	Clayey silt	n = 5	c = 2 t/m^2 ϕ = 10° rt = 1.85 t/m^3
4			
	Clayey silt	n = 10	c = 2.5 t/m^2 ϕ = 10° rt = 1.85 t/m^3
8			
	Silty clay	n = 20	c = 3.5 t/m^2 ϕ = 10° rt = 1.90 t/m^3
11			
	Sandy clayey silt	n = 30	c = 5 t/m^2 ϕ = 20° rt = 1.95 t/m^3

1) Model B (pump station)

Depth (m)	Soil Type	Penetration	Properties
	Silt tr. peat	n = 1	c = 1.0 t/m^2 ϕ = 10° rt = 1.8 t/m^3
4			
	Clay tr. sand	n = 3	c = 2.0 t/m^2 ϕ = 15° rt = 1.85 t/m^3
8			
	Clay tr. sand	n = 5	c = 3.0 t/m^2 ϕ = 20° rt = 1.90 t/m^3
11			
	Silt tr. sand	n = 20	c = 4.0 t/m^2 ϕ = 20° rt = 1.95 t/m^3

A sedimentation analysis was made by utilizing the equation:

$$S = H \frac{eo - e}{1 + eo}$$

As a result, sedimentation of the embankment was estimated as 22.5 mm, and in general is thus accordingly within the margin of safety.

3-1-5 Current farm practices

Floating rice and white jute (Corchorus capsularis) are principal crops in the area. If tubewell water is available, Rabi crops are also cultivated during the dry season.

The interview survey evidenced that 79.8% of the arable land in the Unit is single cropped with rice and/or jute, 15.6% is double cropped with rice, and 4.6% is mixed planted with Rabi crops. The percentages of total farmers utilizing country plough, low-lift pump, and tubewell equipment are 90%, 28% and 2%, respectively. There is no evidence of the use of shallow tubewells, treshers, power tillers or handhoes. While, 100% and 72% of farmers use manure/fertilizers and pesticides, respectively, 62% of the farmers have used improved seeds. It is estimated that the potential for improved farming techniques can be represented as power tiller (96%), sprayer (86%), thresher (60%), hand-rake (40%), hand-hoe (32%), low-lift pump (16%), seed-driller (4%), and manure/fertilizer (2%) (Table 9).

Crop yields correlate to the degree of production technology of the farmer. Table 10 shows the yields of selected agricultural crops in Bangladesh compared to other Asian developing countries and the world average.

Furthermore, the table indicates that crop yields (kg/ha) of Bangladesh have increased during the past decade with some exceptions. It is also observed that production practices for jute, sweet potato, pulses, ground nuts, sesame, linseed, cauliflower, sugar cane, and tabacco leaf yield somewhat moderately high output, while the introduction of high yielding agricultural practices required for rice, barley, maize, pumpkin/squash, cucumber, onion, and garlic seem insufficient.

However, it is evident from Table 11 that an increase in production can be achieved if HYVs of rice and wheat are cultivated. Since the production problem in Bangladesh and/or the Unit area depends upon control of annual inundation and/or irrigation water management, the present project will contribute to the improvement in crop yields, with minimal scientific alteration of current agronomic and soil conditions.

3-1-6 Socio-economic survey

In 1978 the annual population growth rate in Bangladesh was 2.9%, and thus the national population in 1981 is estimated to be 90 million. The 1978 census assessed that 67,417,000 (79.6%) of the population was temporarily engaged in agriculture, and 23,064,000 (27.3%) was actively engaged in agriculture. Within the Unit, age distribution groups are: under 15, 16-30, 31-50, and over 50, representing 42.8%, 25.9%, 17.5%, and 13.8% of the population respectively. On the other hand, 59.4% of the population in the Unit area is engaged in agriculture. Therefore, active population in agriculture in the Unit area can be estimated as 25.8% ([25.9% + 17.5%] x 59.4%).

Educational levels of the inhabitants of the Unit area are: illiterate, primary school, secondary school, and college or above at 57.4%, 34.7%, 7.3%, and 0.6%, respectively. Located in close proximity to Dacca, the educational facilities in the Unit area are moderately accomodated. Moreover, it is anticipated that primary/secondary school levels will improve in the near future.

Occupational patterns extended to farming, services, business (cottage industries), and others are respectively 59.4%, 26.6%, 12.6%, and 1.4% of Unit inhabitants.

Sources of farmers income are 98% rice, 68% services (boat and labour wages), 62% jute, 48% Rabi crops (mustard and wheat), 34% poultry, and 30% business (cottage industries), with a few farmers engaged in the sale of milk, goat/sheep, and fish (Table 12).

A survey of agricultural commodities sold in the local market within the Unit indicates that all the farmers market rice, and more than half market poultry (62%), jute (58%), and vegetables (54%), and approximately one-third market goat/sheep (36%), Rabi crops (32%) and fish (24%). Among Rabi crops, vegetables (32%), pulses (24%), and wheat (18%) are apparently favored, while mustard (8%), oilseed (4%), potato (2%) and millets (2%) hold only a limited share of the market (Table 13).

In conclusion, the farmers within the Unit are then mainly dependent on rice cultivation, boat and labour wages, and Rabi crop (mustard and wheat) cultivation for cash.

3-1-7 Irrigation design survey

Water level in the area was approximately 16ft public works datam (PWD) during the survey period in July. Due to the relatively high water level, the area was submerged to a depth of from 3-7 feet. Accordingly, the Mission reviewed reports on similar development schemes, such as the DND Project, and collected and analyzed other existing data.

A site survey was also conducted whereby the Mission identified the location and elevation of existing canals, roads, etc. However, survey accuracy was hindered by the fact that bench marks scattered throughout the Unit area were submerged, and as a result observations were based on water levels presumed through existing data. Accordingly, a measurement survey will have to be performed during the subsequent detail design stage.

Planning for irrigation facilities will stress simplicity of design and maximum utilization of local materials to ensure smooth project implementation, and to facilitate future operation and maintenance.

3-1-8 Basic design criteria

In light of the agreement between the Bangladesh Water Development Board and the Basic Design Survey Mission, the basic design criteria can be enumerated as set out on the subsequent page.

i) The proposed Unit area should be approximately 1,000 ha (2,471 ac) and constitute one portion of the N-N Project.

ii) Irrigation shall be the main feature of the Unit. However, to achieve maximum benefit, flood protection and pump irrigation/drainage are essential components.

iii) To limit excavation and embankment construction, and to minimize the cost of land acquisition for the embankment, borrow pits and main canals, for construction of the pump station, embankment, and irrigation and drainage canals, the maximum utilization of existing roads, their borrow pits and Tatkir Khal embankment shall be made.

iv) Upon completion of the Unit, double/triple cropping per year shall be carried out.

v) The Unit's long term objective is water management.

vi) The Unit shall also be developed to demonstrate applicable intensive agricultural techniques and to stimulate farmers involved in similar irrigation development schemes throughout Bangladesh.

3-1-9 Identification of subject area

Precise investigations were made on three respective candidate locations for the Demonstration Unit in light of the criteria of 3-1-8 above, and in close collaboration with counterpart personnel of the executive agencies (Bangladesh Water Development Board and Basic Design Survey Mission). Carefull considerations resulted in the following conclusion.

The most promising site among those investigated is located in Rupganj Thana, Dacca District. This area is enclosed with the existing road embankment, (Dacca-Narsingdi Road) which runs along the respective westside and southside of the area, while Tatkir Khal runs along the eastside (Location Map). The gross and net acreage are about 1,300 ha (3,212 ac) and 1,000 ha (2,471 ac), respectively.

Detailed land use plan of the proposed Unit area is shown in Table 14.

Advantages for the selected location are set out below:

i) To enclose the Unit, the existing road embankment can be fully utilized.
ii) A new embankment is required only along 6.6 km (4.1 miles) of Tatkir Khal which is presently contained by only a minor dike structure.
iii) The borrow pits of the existing road and Tatkir Khal can be further utilized for construction/reinforcement of the embankment to minimize construction cost and land acquisition.
iv) The Unit would be appropriate for a Japanese Government Grant as construction can be completed within a very short time with minimal capital investment.
v) Provision of an additional embankment will not hamper the existing main Khal's drainage capability.
vi) The Unit will not adversely affect the N-N Project plan.

3-1-10 Identification of pump site

Careful hydrological/topographical studies of data including maps, and field surveys of the Unit area have been carried out, during the Basic Design Survey period.

In view of the Unit's objective, provision of year round irrigation water will be the major goal. However, it is essential that flood protection should be provided for the monsoon season in order to materialize maximum agricultural production.

It is provisionally planned that the Unit area will be protected from flooding by a ring embankment. Irrigation water will subsequently be pumped from Lakhya River through Tatkir Khal. Drainage of excess water in the wet season will be performed by the same pump, and lifted into Lakhya River through Tatkir Khal.

The location of proposed pump site is at Jatramura, situated on the existing Dacca - Narsingdi Road (D-N Road) at the southern end of the Unit area where Tatkir Khal runs southwards. The nature of the soil around the proposed pump site is stable enough to support the pumping plant.

Closures will be made on other existing drainage Khals with sluice gates at appropriate crossings to excellerate drainage of excess water from outside the Unit area by Unit area pumps during the post-monsoon period.

The pump station is designed to accomodate three axial flow type vertical shaft pumps energized by electric motors. Each pump is rated at 37.5 cusces. For irrigation purpose, two pumps are estimated as sufficient to deliver normal demand, while the remaining one pump will be maintained as a standby for maximum demand.

3-1-11 Determination of main canal alignment

It is essential that costs of land acquisition for the proposed embankment including borrow pit area and pump station site should be minimal. In this regard, maximum utilization of existing structures is required.

The borrow pit which is located on the inside toe of the D-N Road has been selected as the main irrigation canal of the Unit, since it runs along almost the entire southwest portion of the Unit and has sufficient hydraulic section. This canal will also be effectively utilized throughout the entire N-N Project. The proposed new embankment and it's borrow pit will be aligned parallel to the inerside of the Tatkil Khal on the eastern periphery of the Unit. Upon completion of the Unit, this latter borrow pit will serve as the main drainage canal. Lakhya River will serve as the source of irrigation water as well as the dispository of drainage, while Tatkil Khal will be utilized as the diversion irrigation cum drainage channel. However, dreadging will be required.

Alignment of the secondary canals shall be designed taking into careful consideration landownership.

Tertiary canals will be provided for approximately every 50 ha (124 ac). Additional necessary tertiary canals and terminal feeder canals shall be constructed by the farmers.

Slide gate turnouts for water control will also be provided under the Unit.

As the Unit area is generally flat, only minor levelling will be required. Where necessary, this work shall be carried out by the farmers. The limited swampy area can be utilized as a fish pond.

At present, there are 6 bridge openings provided originally for drainage of the small Khals within the area. These Khals drain into Tatkil Khal passing through the area. Since these opening will be closed upon completion of construction works, drainage gates shall be provided taking into consideration the above matter.

The density of the canals in the Unit are as follows:

Irrigation (main to tertiary)	45.6 m/ha
Drainage (" ")	44.9 "
Rehabilitated	(15.6) "
Newly constructed	(29.3) "

Since density of the canals are expected to be about 115 m/ha including farm ditches (70 m/ha) and drains (70 m/ha), which are to be constructed by the farmer, rotational irrigation at the farm ditch level would be applied in the Unit.

3-1-12 Borrow pit area and embankment

The Unit plan envisages the construction of a ring embankment made up of a 10.7 km (6.7 miles) long existing road embankment and a 6.6 km (4.1 miles) long newly proposed embankment.

Since borrow pits are to be utilized for the main drainage canals, said pits are to be located on the inside of the flood embankment.

The soil of the area is an alluvial clay composed of a mixture of non-calcareous dark-grey sand and silt which is very characteristic of the estuary flood plains of old Brahmaputra, Karatoya, Bangali and Meghna rivers. Erosion is evident accordingly, and that of the embankment will likely occur, and as such due consideration thereof has been given to preliminary design of the Unit.

The surface layer of silt soil can be used as material for construction of the flood embankment. However, removal of the silty fine sand soil under the silt soil layer would cause piping and thus threaten the stability of the embankment in due course. Therefore, the depth of the borrow pit will be limited.

In Bangladesh, crest elevation of flood embankments are usually determined by the highest water level which has occured during the last 20-25 years plus freeboard. However, for the Unit, factors such as the height of the existing road and the economics of such an approach were also seriously taken into consideration.

The design crest width of the newly proposed embankment is rather narrow since it is planned to function only as a foot path. Accordingly, the borrow pit area can be considerably reduced, further alleviating the problem of land acquisition.

Compaction of the flood embankment and major irrigation canal dike is essential. If compaction is inadequate, these structures will be subjected to piping leading to possible collapse.

As the cost of mechanical compaction is considerable, mechanical compaction will be carried out only below the flooded water level, while manual compaction shall be undertaken for the remaining portion.

3-2 Proposed Cropping Pattern

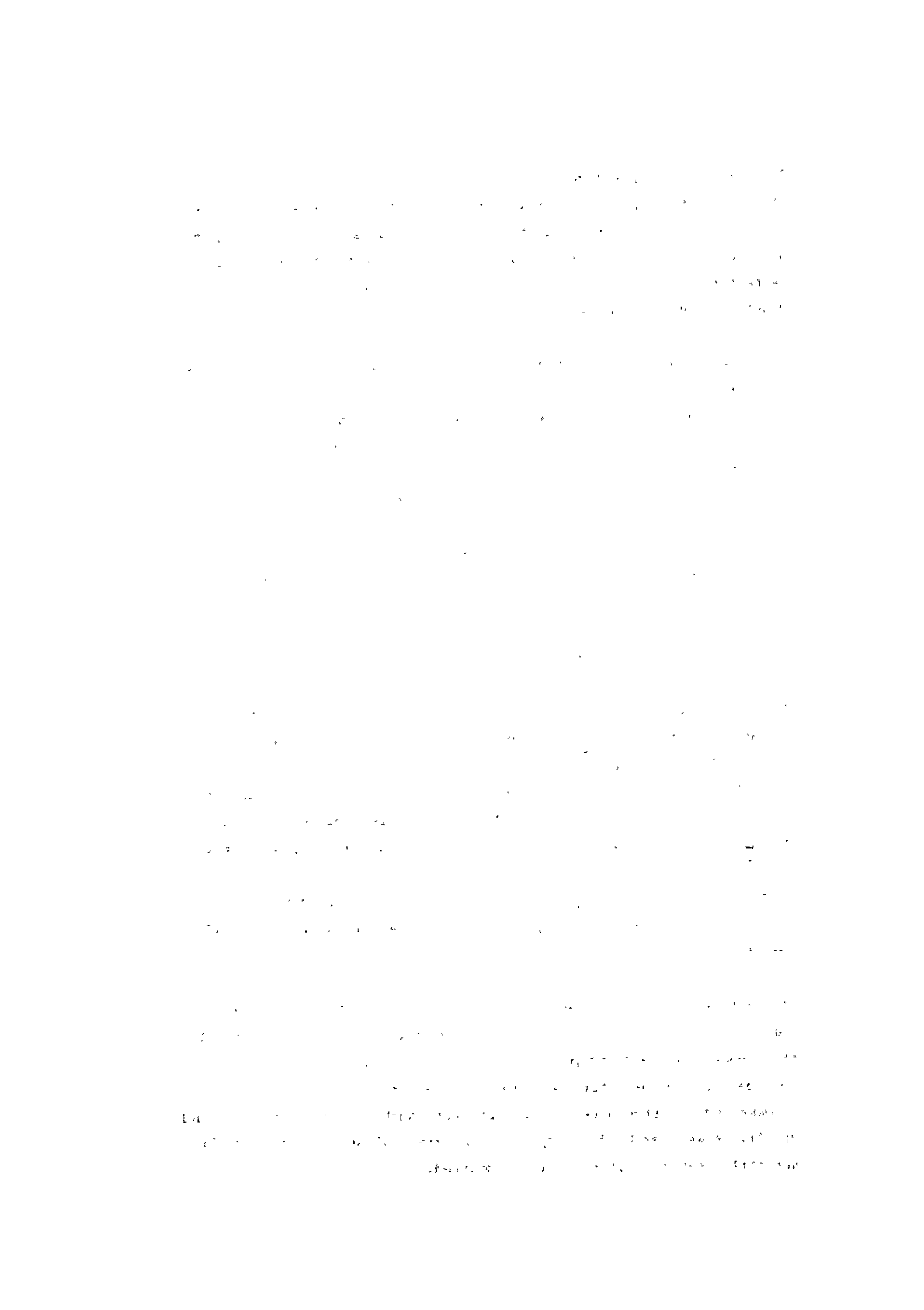
The proposed cropping pattern was prepared with reference to proposed and on-going case examples of the Meghna-Dhonagoda Irrigation Project and the Dacca-Narayanganji-Derma Irrigation Project (DND Project), respectively. Accordingly, the following items were taken into consideration when preparing the cropping pattern.

i) To simplify the cropping pattern as much as possible so as to be most appropriate at the farm level.
ii) To utilize irrigation water properly and economically.
iii) To prevent wasting of soil fertility by the introduction of inappropriate cropping patterns.
iv) To introduce green manures in the fallow for soil conservation, if possible.
v) To prepare fallow between the two major crop seasons to reduce insect pest and decrease the diseases of major crops for the purpose of intergrated pest management.
vi) To determine appropriate crops and growing seasons.
vii) To stabilize farm management and improve farm life.

By Table 15 and 16 it can be observed that rice, wheat, jute and mustard are economically very important crops in the international market. Therefore, priority has been given to these crops. In the case of rice, however, not only better yields but also better quality is required. Thus, IRRI-rice and Paijam rice are proposed for high yielding and higher yielding with good cooking quality, respectively.

Tossa jute (Corchorus olitorius) is recommended as a cropping pattern since its quality and quantity is better than white jute, a low land variety.

In the proposed cropping pattern (Table 17), both international and domestic requirements of agricultural commodities were considered. In this regard, mustard and potato for the Rabi crop, and pulses, cucumber, and pumpkin for the Bhadoi crop are respectively recommended. Furthermore, other Rabi crops such as tomato, pumpkin and chilli, as well as Bhadoi crops such as okra, oil seeds, onion, garlic, and chilli can be cultivated if so desired.



3-3 Plan and Design

3-3-1 Drainage plan

Point Rainfall Analysis, as described in "Hydrologic and Hydraulic Design Procedures for Drainage Structures (BWDB)", is generally utilized for hydrological studies on irrigation projects in Bangladesh.

For the overall N-N Project area, total drainage volume is calculated at 2.4 l/sec/ha. In the planning of drainage facilities for the Unit, the Mission applied Point Rainfall Analysis. By deriving the rainfall for a 5 day storm from the 4 months rainfall index, and computing the water balance for a drainage capacity of 2.4 l/sec/ha, the inundated area with a depth of 30 cm or more for a greater than 6 day period was calculated at 230 ha. In such case, according to the cropping pattern shown in Table 17, HYV cultivation will be affected by flooding. However, since the area affected represents only 23% of the total, a unit drainage capacity of 2.4 l/sec/ha is considered appropriate, and the drainage plan will be formulated accordingly.

A block diagram of the proposed drainage canal system is shown in Fig. 4, with water balance calculation procedures in Tables 18, 19, 20 and Fig. 5 and 6.

3-3-2 Irrigation plan

The irrigation water requirements for recent projects undertaken in Bangladesh have for the most part been calculated according to the modified Penman method, and such is the case for this Unit.

Meteorological data at the Hydraulic Laboratory in Dacca represents the most abundant and reliable source of information on weather conditions affecting the area, and as such has been utilized for this project. Crop coefficients were adopted from those given in the World Bank report "Bangladesh Land and Water Resources Sector Study, Volume VII, 1972".

Computation results based on the proposed cropping pattern, and the effective rainfall occuring during a drought year with a 10 year return period are given in Tables 17, 21 and 22. From these results, the maximum irrigation water requirement was calculated and used as a basis for determining the irrigation plan and necessary facilities.

Percolation, however, has not been considered in the above irrigation planning. The reasons for this are that: i) during the rainy season the water level outside the embankment exceeds the elevation of the Unit area, thus precluding vertical percolation, and ii) an extremely thick, clayey stratum exists throughout the area.

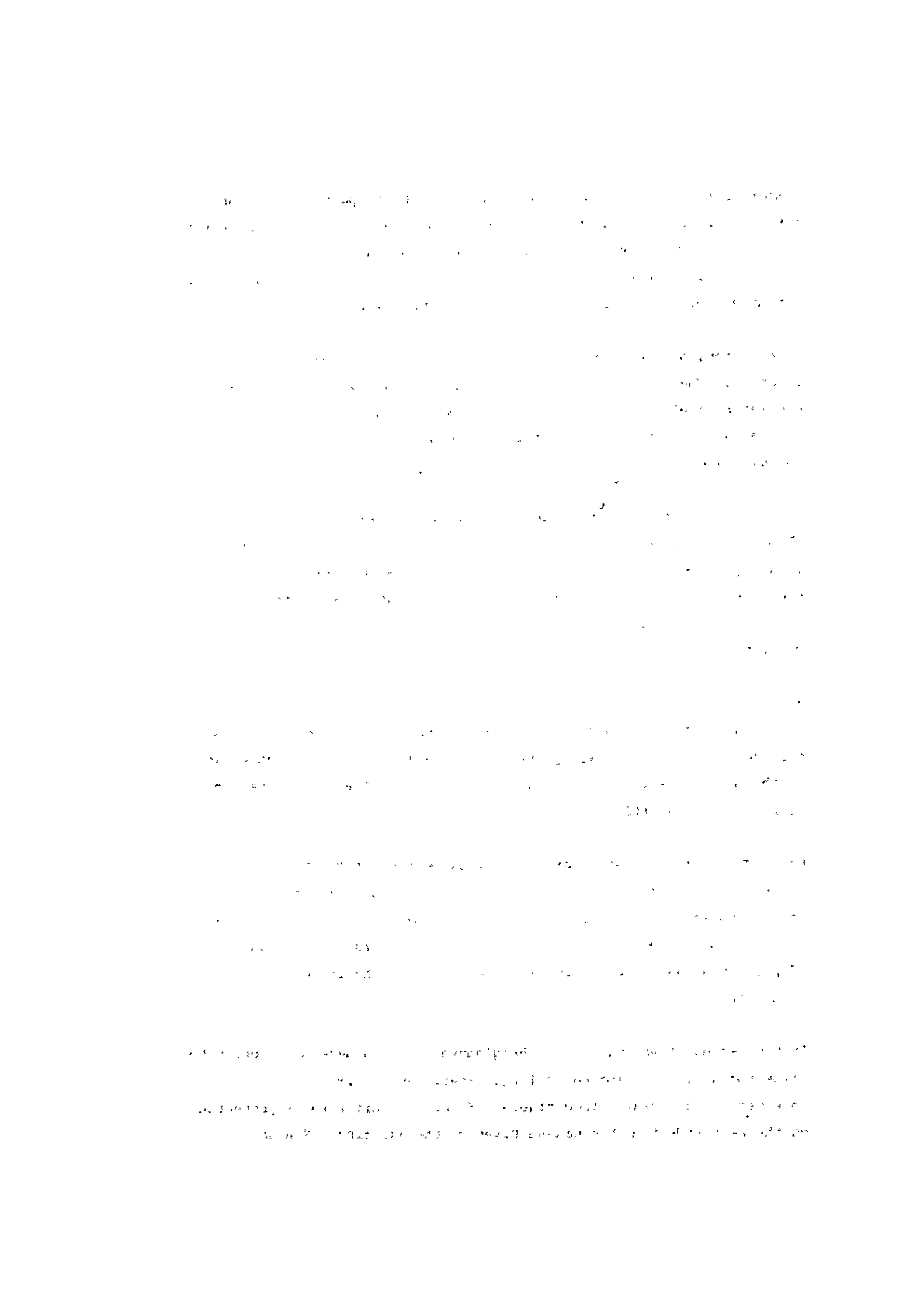
Even if, for example, the effects of percolation were to be included in planning, the peak value thereof would be 1.89 l/sec/ha. Since pump capacity is determined according to discharge amount, and ample freeboard has been incorporated into canal design to allow for rotational irrigation, problems do not arise in terms of facility capacity.

3-3-3 Flood embankment

The results of river survey in the Unit area indicate that the 6.6 m recorded at Dacca in 1974 represents the maximum water level observed in the past 13 years. The maximum water level with a 10 year return period is 6.20 m (PWD).

Bearing in mind the fact that the primary purpose of the Unit is to serve as a demonstration, minimization of land aquisition to permit early completion thereof becomes a major concern. Consequently, the maximum flood level with a return period of 10 years (6.20 m) was adopted as a basis for determining the height of the proposed embankment.

In the design of embankments in Bangladesh, it is a general practice to allow for a 1.5 m freeboard on large rivers, and a 0.9 m on intermediate and small sized rivers. Since the Unit area is protected on the west side from the Lakhya River by the existing D-N Road



embankment, a flood embankment 6.6 m is proposed to be constructed only along the east side featuring a 0.4 m high, brick parapet freeboard, protecting the area from the Meghna River. This embankment base is provisionally approximately 31 m, or roughly 2 m less than would be required if the embankment (including freeboard) were entirely constructed of earthern materials.

During flooding which occured last year in the Unit area, flood waters washed over and damaged a portion of the D-N Road, which is currently under repair. When said repairs are completed, the elevation of the road will be approximately 6.6 m, which has been determined to be a safe height against overflow, and is equivalent to the elevation of the top of the proposed brick parapet.

The safe slope for the flood embankment has been provisionally computed at 1:2, although at the implementation design stage it will be necessary to re-examine this initial calculation on the basis of soil surveys conducted in the Unit area, and adjust slope specifications as required (Fig. 7).

Preliminary flood embankment and main drainage canal designs are given in Fig. 8.

3-3-4 Pump station

As discussed earlier, the jucture of Tatkir Khal and D-N Road (Unit area side of the intersection) is the most attractive candidate site for the pump station. The primary reason for prioritizing this location is that dredging of the intake/outlet channel from Lakhya River to the pump station is minimized to a distance of approximately 700 m.

However, since said pump station location is in close proximity to the proposed primary pump station site for the overall N-N Project area, the Unit pump station must be so designed that it can continue to be effectively utilized even upon implementation of the N-N Project in its entirety.

Pump station water levels as required for the overall N-N Project, and as proposed for the unit are compared in Table 23.

In the event that the primary pump station for the overall N-N Project is constructed, irrigation pumping for the Unit will switch from the smaller, initial phase pump station to the larger station and irrigation water will be delivered by pump, the capacity of which will be determined by the projected drainage amount for the overall N-N Project. This will require some future increase in height of the main irrigation canal dike located in the demonstration Unit, which need not be constructed so high at this phase, since irrigation water will be conducted initially through the smaller pump station.

On the other hand, the proposed pump station for the Unit will continue its drainage function even upon completion of the greater N-N Project. This will ensure continued effective use and demonstrative effect of said facility.

In addition to head and discharge, pump capacity is determined on the basis of drainage. Basic specifications are as set out below:

Type:	vertical, axial flow
Diameter, no. of units:	700 mm x 3
Output:	75 kW x 3
Capacity:	63.6 m^3/min (37.5 cusec) x 3

As indicated in Table 23, the SWL (suction water level) and DWL (delivery water level) are designated as the minimum and maximum water levels respectively. The pump design point, however, was calculated as discussed hereafter.

Pumpage was designed as the maximum discharge amount of 3.18 m^3/sec. The difference between design SWL and design DWL, or net pump head, was computed at 3.85 m. Design SWL was calculated as the mean between the

maximum flood level of 3.4 m and the normal minimum water level of 1.5 m in the Unit area, and the design DWL represents the maximum delivery level of 6.30 m. Total head for a net head of 3.85 m is estimated at 4.6 m.

Nevertheless, the pump must also be capable of lifting the design irrigation requirement under conditions of 5.1 m total pump head which sometime occur during periods of irrigation.

Field survey results of the Unit area indicate that power can be readily supplied to the proposed pump station site from a 33 kV transmission line traversing the area (Fig. 9).

3-4 Cost Estimate

Work Item	Q'ty	Financing (million) Local Yen	Local (TK)	Foreign Yen
Net Irrigable Area	1,000 ha (2,740 ac)			
1. Preparatory Work	L.S.	7.5*	(0.5)	1
2. Flood Protection Embankment	6.6 km (4.1 mile)	-	-	120
3. Pumping Station (ø700 x 3 Nos.)				
Electro-mechanical equip't	L.S.	-	-	175
Civil work	L.S.	-	-	160
4. Irrigation Canal				
Main canal	7.8 km (4.8 mile)	-	-	22
Secondary canal	7.8 km (4.8 mile)	-	-	15
Tertiary canal	30.0 km (18.6 mile)	-	-	12
Related structure	L.S.	-	-	29
5. Drainage Canal				
Main canal	8.6 km (5.3 mile)	-	-	38
Secondary canal	15.6 km (9.7 mile)	-	-	17
Tertiary canal	20.7 km (12.9 mile)	-	-	15
Related structure	L.S.	-	-	51

* including land and geological surveys

Work Item	Q'ty	Financing (million) Local Yen	Local (TK)	Foreign Yen
6. On Farm Facilities				
On farm ditch, drain and related structures	1,000 ha (2,470 ac)	20	(1.6)	-
7. Farm Facilities	L.S.			20
8. Project Facilities	L.S.	20	(1.6)	20
9. Transmission Line	L.S.	27	(2.2)	-
10. Construction Machinery	L.S.	-	-	50
11. Land Acquisition	58 ha (143 ac)	108	(8.6)	-
12. Engineering & Supervision	L.S.	-	-	95
13. Contingency (15%)	L.S.	45	(3.0)	-
Total		227.5	(17.5)	840.0

Exchange Rate Tk. 1.00 = ¥12.5
Note: Local cost estimates for project operation and administration undertaken by the Bangladesh Government are not included.

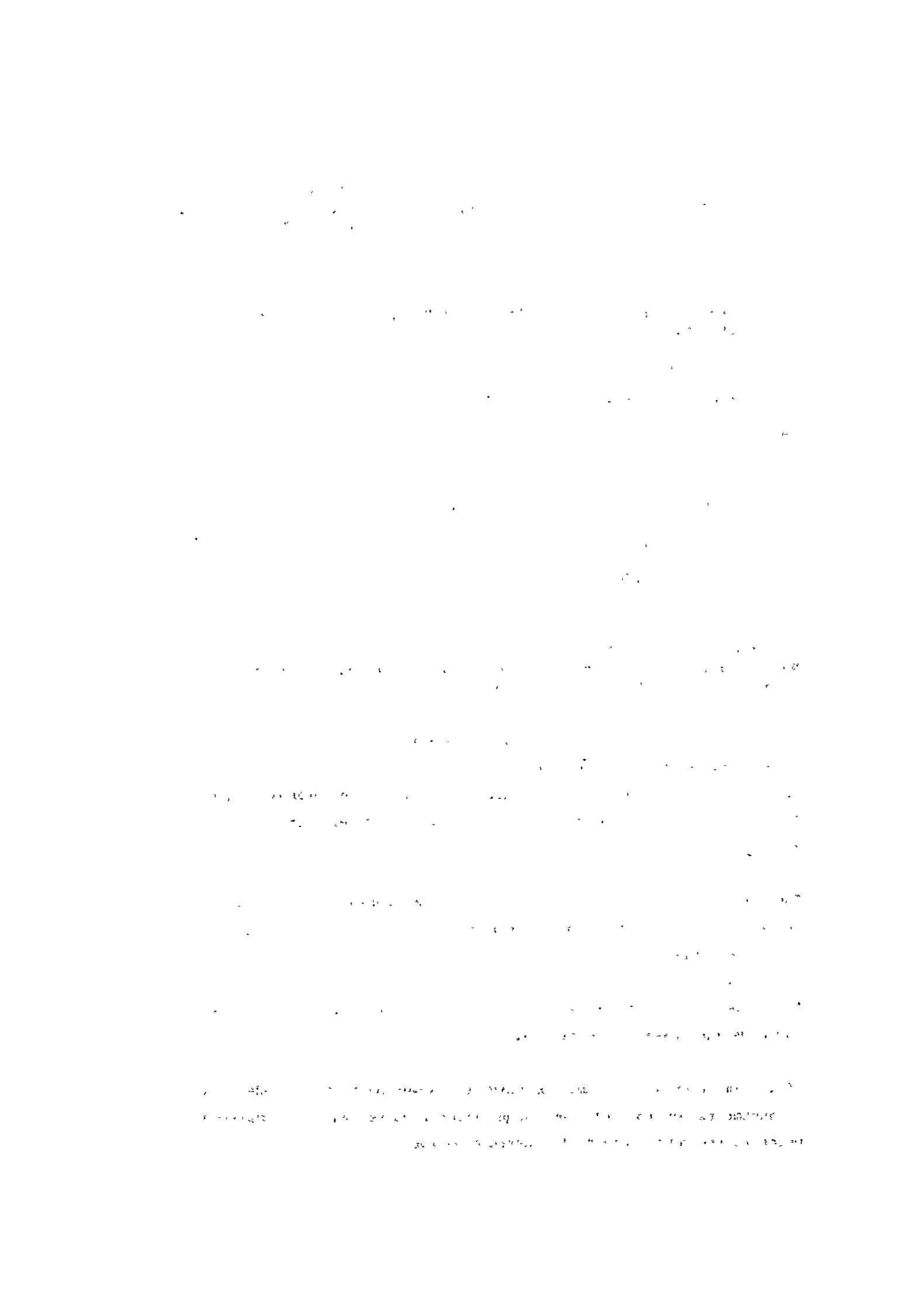
3-5 Implementation Schedule and Organization

3-5-1 Implementation schedule

Assuming that the Unit is to be implemented under the Japanese Grant Aid Program, the implementation schedule is tentatively set forth in Fig. 10.

The overall schedule is divided into: i) the present basic design stage to be undertaken through technical cooperation, and ii) detail design and construction supervision. The detail design stage, consisting of the preparation of drawings and specifications necessary for tendering procedures, will commence upon completion of the current basic design phase of the project.

Of the implementation items for which the Government of Bangladesh is to assume responsibility, land acquisition required must be completed prior to the commencement of construction work.



3-5-2 Organization structure

In the case of the DND Project, the Water Development Board (WDB) assumed both responsibility for the implementation of agricultural extension services, and operation and maintenance as well as assistance to the Board of Revenue. It is anticipated that a similar type of executing agency structure will be adopted for this project. Such an agency would assume the organizational format given in figures 11 and 12.

3-6 Operation and Maintenance

Operation and maintenance (O/M) costs are estimated on the basis of the DND Project (15,000 ac) and are briefed as set out below:

Position		Personnel
Mechanical	sub-division	14
Irrigation	" "	21
Agriculture	Extension	5
Revenue	Collection of water charges	2
		42

O/M costs in '80/81 excluding energy costs is then Tk854,000 which has been estimated proportionate to the annual O/M cost during '75/76 - '79/80 in the DND Project, including such factors as price increase in commodities.

Considering that electricity charges were increased in 1981 from Tk0.37/kWh to Tk1.05/kWh, the total O/M cost is therefore Tk1.05 million for the Unit, which is considered quite reasonable as the amount is 1.2% of the projected investment of the N-N Project.

3-7 Project Evaluation

Based on the proposed cropping pattern (Table 17) an economic benefit analysis on values of agricultural production was made at current prices. Inputs consisted of agricultural chemicals, munure, seeds, and labour wages. Based on this analysis farmer incomes are expected to increase by 388% upon full development of the project.

The socio-economic survey (Table 12) indicated that 45.5% and 12.8% of the family income are dependant upon cottage industry and boat/labour wages, respectively. However, the construction work of the Unit will offer immediate employment opportunities. Moreover, upon completion the Unit will provide continuous and stable employment in the agricultural sector by also stimulating such salient subsectors as livestock, poultry, fishery, trading and transport.

The EIRR has been calculated on the basis of the direct benefits and costs. The major assumptions for the EIRR are as follows:

i) project economic life is 50 years;
ii) complete agricultural development occurs 3 years after completion of Unit facilities; and
iii) very heavy flooding occurs every 10 years.

The EIRR is thus estimated at 11.7%.

Sensitivity tests were conducted to determine the impact of several contingencies on the economic feasibility of the Unit. The various contingencies and their relevant EIRRs are tabulated as follows:

Contingency	EIRR
Reduction in benefits by 10%	9.3%
Increase in Project costs by 10%	10.7%
Increase in production costs by 10%	11.6%
Increase in Project and production costs by 10%	10.6%
Reduction in benefits by 10% and an increase in construction and production costs by 10%	8.4%

The proposed operational program of the Unit also allows some latitude for other agricultural cropping practices as is seen in Table 17. Taking this point into consideration, and based on the other factors discussed herein, the project is economically justifiable.

IV

RECOMMENDATION

RECOMMANDÉ

IV. RECOMMENDATION

Implementation items to be funded by the Government of Bangladesh, and which require special consideration are discussed hereunder.

4-1 Land Aquisition

Of the estimated 30 ha of land necessary for canal construction, the greater portions will be utilized for irrigation canals, the maximum width of which is relatively small 6-7 m. Consequently land acquisition for canal construction is not anticipated to be a problem.

On the other hand, the land area to be acquired for the construction of the flood embankment is calculated at approximately 26 ha, with a maximum width (including borrow pit area) of about 31 m. Since the average land ownership in the Unit area is around 1.05 ha, an estimated 25-50 farmers will possibly loose their land as a result of flood embankment construction.

Consequently, it is strongly recommended that countermeasures be taken to provide alternative employment opportunities for farmers affected in the above manner. Assignment of gate keeper duties as required by the Water User's Association and/or the granting of rights to engage in pisciculture in main canals represents another possible approach.

The construction schedule as proposed is extremely tight. In order to incorporate maximum leeway into said schedule, it is highly desirable that pump station excavation and embankment of the administrative compound be completed by the end of the dry season this year. Accordingly, land acquisition procedures for these purposes must be commenced immediately.

4-2 Construction Machinery

Arrangement must be made to rent a minimum of at least the machinery listed on the sequent page from WDB.

1.	Bulldozer	(D5-D6 class)	2
2.	Backhoe	(0.6 m^3)	1
3.	Dump Truck	(10 ton)	2
4.	Other relevant machinery	-	Lot

The above machinery must be obtained prior to the end of this year's dry season when the initial phase of construction operations are scheduled to commence.

4-3 Preparatory Works and Office Construction

Preparatory works consist principally of various types of land surveys, and geological and soil surveys, the greater part of which will be commenced immediately after the end of the flood season this year.

Required office and facilities are as described below:

1.	Administrative Office Building	1 unit
2.	Warehouse Facility	1 unit
3.	Basic Repair Shop	1 unit
4.	Staff Quarters	1 unit

Using as a basis the fact that the administrative compound site for the DND Project is 2.02 ha (5 ac), it is estimated that approximately 4,000 m^2 (1 ac) is necessary for the above structures in the Unit.

4-4 Inundation During the Early Monsoon Season

Annual inundation of the estuary flood plains supplies considerable amounts of fertile alluvial substances. This makes it possible to achieve appreciable production of appropriate agricultural crops without application of additional fertilizers.

Sluice gate facilities have been proposed under the project to facilitate drainage of the Unit area. As an additional benefit to the project, these gates are recommended to be open for 15 - 20 days during the early monsoon season to inundate the area; thereby, nutrient

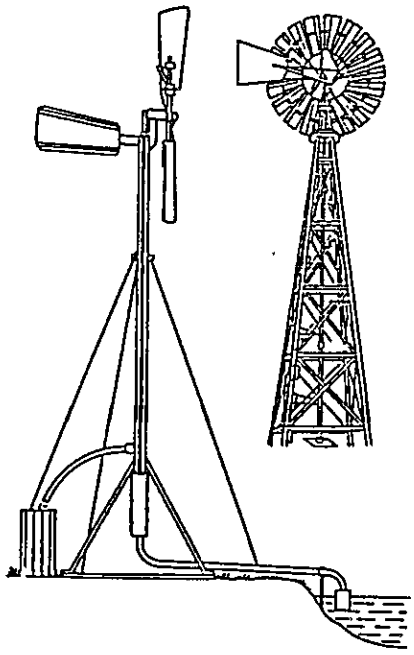
substances, weed control and reduction of pest population can continue to be provided naturally. It is anticipated that this approach would not only substantially reduce the need for agricultural chemicals, fertilizers, herbicides and pesticides, but also soften the cultivable land and facilitate puddling during land preparation. This measure would thus add considerable cost savings to the project.

4-5 Probable Windmill Pumping

The difference between the proposed arable land and high land within the Unit is about 1.5 m. Therefore, a supplementary device for low lift pumping will possible be needed on occasion.

Since the worldwide oil crisis in 1973, tremendous efforts have been given to develop and utilize the very familiar solar, wind, water, and bio gas energy sources. For the small scale dual purpose (irrigation/drainage) pump, a windmill is apparently economical and reliable.

Horizontal shaft rotating windmill pump derives water by means of a diaphragm or piston apparatus. The existing data of the multi-blade windmill pump operating under the condition of a 3 m lift, 7 m/s wind velocity, and 70% mechanical efficiency are given below.



piston-type

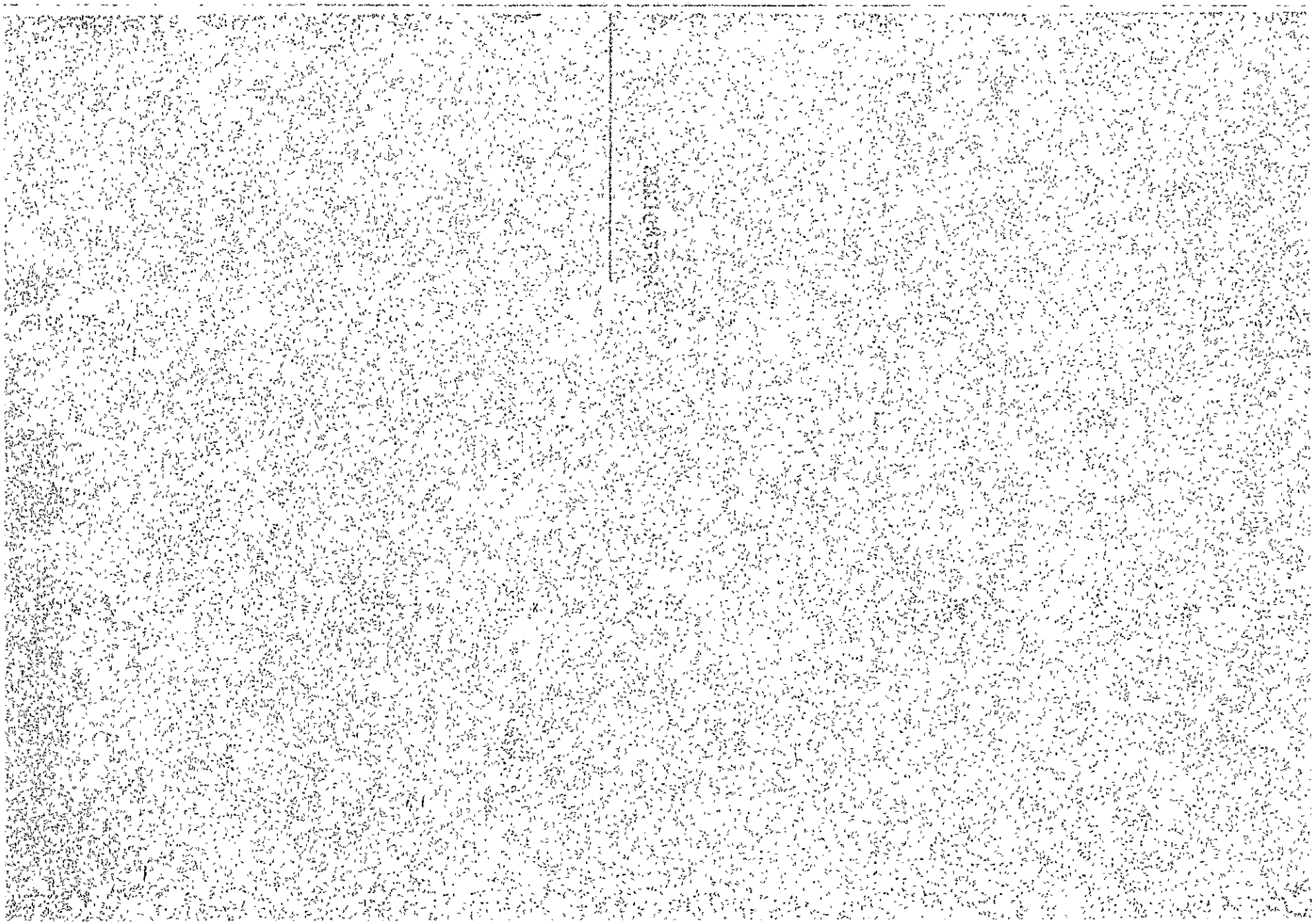
Diameter of Cylinder (mm)	Water lift capacity (m3/h) Diameter of Windmill 2m	Diameter of Windmill 4.5m
50	494	1,786
75	1,216	2,280
100	2,166	3,154
125	3,420	4,940

Maximum wind speed (km/h) by month at Dacca Meteorological Station, 1968 - 1977 is recorded as follows:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
19.6	42.5	61.3	93.9	79.6	48.5	35.0	30.2	26.1	49.6	31.7	18.5

On a prima facie basis the establishment of a windmill pump system appears provisionally appropriate. This approach to upland irrigation warrants, therefore, review during the design stage of the Unit.

APPENDIXES



AGREED MINUTES OF DISCUSSION

In response to the request made by the Government of Bangladesh for the construction of Terminal Irrigation Facilities in Narayanganj-Narsingdi Irrigation Project Area (hereinafter referred to as "the Project"), the Government of Japan has sent, through the Japan International Cooperation Agency (hereinafter referred to as "JICA"), a team headed by MITSURU NAITO to conduct a basic design survey for 19 days from July 10, 1981. The team had a series of discussions and exchanged views with the authorities concerned.

Both parties have agreed to recommend to their respective Governments to examine the results of the survey attached toward the realization of the Project.

July 14, 1981

(Signed)
MITSURU NAITO
Team Leader
The Japanese Survey Team

(Signed)
M. MUNIRUZZAMAN
Additional Secretary
Ministry of Power, Water Resources and Flood Control
Government of the People's Republic of Bangladesh.

MINUTES

1. The proposed site of the Project will be the area, enclosed by Dacca-Narsingdi Road, Tatkir Khal in the District of Dacca in Bangladesh (hereinafter referred to as "the Project Site").

2. The objectives of the Project is to provide necessary Terminal Irrigation Facilities at the Project Site.

3. The Japanese Survey Team will convey the desire of the Government of Bangladesh to the Government of Japan that the latter will take necessary measures to cooperate in implementing the Project and will provide the Irrigation Facilities as listed in Annex I within the scope of Japanese economic cooperation in grant form.

4. The Government of Bangladesh will take necessary measures on condition that the grant assistance by the Government of Japan is extended to the Project:

a) to provide data and information necessary for the design and the construction

b) to secure lands necessary for the construction

c) to clear the Project Site before the start of the construction, including the removal of existing obstacles

d) to provide other items listed in Annes II.

e) to ensure prompt unloading and customs clearance in Bangladesh of imported materials and equipment necessary for the execution of the Project and also to facilitate the internal transportation of the same.

f) to exempt Japanese nationals concerned from customs duties, internal taxes and other fiscal levies which may be imposed in Bangladesh on the occasion of the supply of goods and services for construction, as admissible under the relevant rules of the Government of Bangladesh.

g) to provide and accord necessary permission, licences and other authorization required for carrying out the Project.

ANNEX I

Items requested by the Government of Bangladesh whose cost will be borne by the Government of Japan:

1. Construction of Terminal Irrigation Facilities

   * Net Irrigation Area 1,000 HA
   * Flood Protection Embankment
   * Irrigation Earth Canal (including check gate, turnout and Foot bridges)
   * Drainage Earth Channel
   * Pumping Station
   * Farm Facilities (Measuring station)

2. Equipment for the maintenance of the Terminal Irrigation Facilities

   * Construction Machinery

ANNEX II

Items whose cost will be borne by the Government of Bangladesh

1) Construction of on Farm facilities

2) Other structures except the list of Annex I

3) Transmission lines

4) Electrical power main line to the Project Site

ANNEXURE

Please indicate your opinion in respect of the following statements

1)	Do you agree that the Government should take steps to control the price of onion ?				
2)	Do you agree that the Government should take steps to control the price of potato ?				
3)	Do you agree that the Government should take steps to control the price of pulses ?				
4)	Do you agree that the Government should take steps to control the price of edible oil ?				
5)	Do you agree that the Government should take steps to control the price of petrol ?				
6)	Do you agree that the Government should take steps to control the price of diesel ?				
7)	Do you agree that the Government should take steps to control the price of kerosene ?				
8)	Do you agree that the Government should take steps to control the price of LPG ?				
9)	Do you agree that the Government should take steps to control the price of Electricity ?				
10)	Do you agree that the Government should take steps to control the price of Transportation ?				

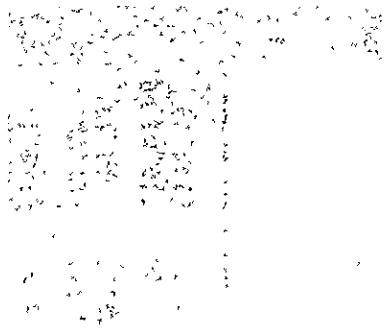
APPENDIX II

BANGLADESH: MAJOR EXTERNAL ASSISTANCE TO THE BANGLADESH WATER RESOURCES SECTOR

(1973-1979)

Source	Project Name	($)
ADB	Agricultural Credit Project (mainly shallow tubewells)	9,430,000
	Meghna-Dhonagoda Irrigation Project	24,000,000
	Serajgonj Integrated Rural Development Project (mainly irrigation and flood control)	26,000,000
	Pabna Irrigation and Rural Development	38,000,000
	Low-Lift Pump Maintenance Program	8,900,000
IDA	Chandpur Irrigation Project	13,000,000
	Northwest Region Deep Tubewell Project	14,000,000
	Muhuri Irrigation Project	30,000,000
	Barisal Irrigation Project	27,000,000
	Karnafuli Irrigation Project	22,000,000
	Shallow Tubewells Project	16,000,000
	Drainage and Flood Control Project	19,000,000
IFAD	Pabna Irrigation and Rural Development Project[a]	30,000,000
United Nations Capital Development Fund	Serajgonj Integrated Rural Development Project[a]	2,153,000
Netherlands	Dredgers, pump house	2,580,000
	Land Reclamation Project	1,800,000
	Small-Scale Flood Control and Irrigation Project	4,800,000
Sweden	Northwest Region Deep Tubewell Project	6,690,000
U.K.	Tubewell materials and equipment	32,659,055
U.S.A.	Groundwater investigation, dredger fleet and various equipment	4,961,640
	Development of small scale irrigation	14,000,000
U.S.S.R.	Dredger, drilling rigs, tools and equipment	2,162,110
West Germany	Water Resources Development at Thakurgaon	4,855,500

[a] Co-financing with ADB



TABLES

Table 1 Area (acres) Irrigated Under Different Crops and Growth Indices* in Bangladesh, 1969-70 to 1978-79

	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
Aus rice	72,710	76,990	89,710	107,560	172,300	178,020	182,117	189,060	211,030	228,371
Growth index*	(100)	(105.9)	(123.4)	(147.9)	(237.0)	(244.8)	(250.5)	(260.0)	(290.2)	(314.2)
Aman rice	394,905	323,350	243,050	254,590	294,160	275,250	208,003	208,370	208,045	241,439
Growth index	(100)	(81.9)	(61.5)	(64.5)	(74.5)	(69.7)	(52.7)	(52.8)	(52.7)	(61.1)
Boro rice	1,759,490	2,095,135	2,043,510	2,220,860	2,361,900	2,699,650	2,618,121	2,022,925	2,515,385	2,436,490
Growth index	(100)	(119.0)	(116.1)	(126.2)	(134.2)	(153.4)	(148.8)	(115.0)	(143.0)	(138.5)
Wheat	22,350	28,050	23,250	34,250	34,050	45,442	125,102	178,620	231,805	351,927
Growth index	(100)	(125.5)	(104.0)	(153.2)	(152.3)	(203.3)	(559.7)	(799.2)	(1,037.2)	(1,574.6)
Other Cereals	7,550	6,515	5,270	10,660	9,665	10,120	5,980	6,025	3,960	3,549
Growth index	(100)	(86.3)	(69.8)	(141.2)	(128.0)	(134.0)	(79.2)	(79.8)	(52.5)	(47.0)
Pulses	16,720	15,190	10,060	11,590	4,000	5,180	4,325	2,635	2,255	2,393
Growth index	(100)	(90.8)	(60.2)	(69.3)	(23.9)	(31.0)	(25.9)	(15.7)	(13.5)	(14.3)
Oilseeds	4,950	4,725	7,870	7,110	4,400	4,250	3,510	9,710	8,010	9,354
Growth index	(100)	(95.5)	(159.0)	(143.6)	(88.9)	(85.9)	(70.9)	(185.2)	(161.8)	(189.0)
Potato	79,675	99,990	94,020	100,020	102,370	123,900	133,660	139,815	153,070	164,477
Growth index	(100)	(125.5)	(118.0)	(125.5)	(128.5)	(155.5)	(167.8)	(175.5)	(192.1)	(206.4)
Vegetables	80,540	85,800	73,200	91,310	87,550	89,330	85,273	94,145	103,855	121,336
Growth index	(100)	(106.5)	(90.9)	(113.4)	(108.7	(110.9)	(105.9)	(116.9)	(128.9)	(150.7)
Sugar cane	30,525	27,150	14,800	15,520	17,280	17,170	18,958	22,315	25,135	22,753
Growth index	(100)	(88.9)	(48.5)	(50.8)	(56.6)	(56.3)	(62.1)	(73.0)	(82.3)	(74.5)
Other Food Crops	82,750	50,005	43,080	140,520	123,400	113,150	90,389	135,400	137,120	110,619
Growth index	(100)	(60.4)	(52.0)	(169.8)	(149.1)	(136.7)	(109.2)	(163.6)	(165.7)	(133.7)

* Calculated as 100 for 1969-70 acreage

Source: The Yearbook of Agricultural Statistics of Bangladesh,1979-80

Table 2 Indices* of Agricultural Production

	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
Paddy (all varieties)	100	118.1	111.8	126.5	118.0	130.1
Jute	100	92.2	53.4	60.5	74.3	82.8
Pulses	100	94.4	101.1	98.9	106.7	115.6
Cereals (minors)	100	150.0	128.9	242.1	294.7	397.4
Sugar Cane	100	119.2	124.7	110.7	112.7	128.0
Potatoes	100	94.7	112.1	117.4	100.0	113.2
Oil Seeds	100	91.9	104.1	103.4	106.8	117.6
Cotton and Sunhemp	100	100.0	80.0	80.0	80.0	80.0
Tea	100	114.1	133.3	132.3	132.3	145.5
Tobacco	100	102.9	100.0	111.8	111.8	129.4
Chilli	100	103.4	95.5	101.1	88.6	97.4
Total Agricultural Crops	100	113.9	106.4	118.3	113.6	125.3

* Calculated as 100 for 1972-73 production.

Source : Statistical Yearbook of Bangladesh, 1979

Table 3 Yield of Rice in Bangladesh, 1975-76 to 1977-78

Aman (ton/ha)

	B. Aman			L.T. Aman			HYV Aman		
	75/76	76/77	77/78	75/76	76/77	77/78	75/76	76/77	77/78
Dacca District	1.70	1.41	1.50	2.30	2.10	2.22	3.96	3.43	4.24
Bangladesh	1.62	1.49	1.66	1.98	1.98	2.10	3.55	3.47	4.00

Aus (ton/ha)

				L. Aus			HYV Aus		
				75/76	76/77	77/78	75/76	76/77	77/78
Dacca District	-	-	-	1.25	1.41	1.33	4.16	4.16	4.20
Bangladesh	-	-	-	1.54	1.25	1.29	3.96	3.72	3.72

Boro (ton/ha)

	Paijam			L. Boro			HYV Boro		
	75/76	76/77	77/78	75/76	76/77	77/78	75/76	76/77	77/78
Dacca District	-	3.03	3.46	1.73	2.06	2.40	4.58	4.14	4.16
Bangladesh	-	3.45	3.55	2.11	1.83	2.30	4.15	3.97	4.13

Keys: B : Broadcasted
L.T. : Local Variety Transplanted
HYV : High Yielding Variety (IRRI variety)
L : Local Variety
Paijam: Improved Local Variety

Source: Statistical Yearbook of Bangladesh, 1979

Table 4 Loss of Rice Crop by Flood/Drought and Potential Production in Bangladesh, 1968-69 to 1976-77

(million ton)

	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	Average
Production	11.60	11.82	10.97	9.79	9.93	11.72	11.11	12.56	11.57	11.23
Loss	1.10	0.22	1.95	0.31	0.25	0.60	1.54	0.16	0.95	0.79
Loss in %	(9.5%)	(1.8%)	(17.8%)	(3.2%)	(2.5%)	(5.2%)	(13.9%)	(1.3%)	(8.2%)	(6.4%)
Potential	12.70	12.04	12.92	10.01	10.18	12.32	12.65	12.72	12.52	12.02

Source: Statistical Yearbook of Bangladesh, 1979

Table 5 Meteorological Data in Dacca

(1967-1980. average)

Item / Month	Rainfall	Temperature of			Relative Humidity %				Evaporation	Sunshine Hr.	Wind Velocity Knots		
		Mean Max.	Mean	Mean Min.	6.00 AM	9.00 AM	6.00 PM	Mean	mm	hr.	6.00 AM	9.00 AM	6.00 PM
Jan.	2.8	77.3	65.6	53.8	90	75	58	75	59.4	8.8	0.4	1.2	0.8
Feb.	12.2	82.2	70.5	58.5	87	67	48	68	84.6	9.1	0.6	1.6	1.0
Mar.	50.1	90.3	79.3	68.3	85	66	48	67	135.6	8.8	1.5	2.5	2.3
Apr.	125.0	93.7	83.7	73.7	90	74	62	76	160.3	8.9	2.7	4.2	4.9
May	306.4	90.6	84.1	77.6	93	77	73	83	162.6	8.0	2.4	3.8	4.1
Jun.	357.3	88.7	83.5	78.3	94	85	80	87	105.9	5.2	2.7	3.9	3.7
Jul.	378.5	86.8	82.7	78.6	94	86	83	89	102.1	4.9	2.7	3.8	3.6
Aug.	331.8	88.0	83.4	78.7	94	87	82	88	94.7	6.0	2.2	3.5	3.3
Sep.	221.3	84.6	81.5	78.3	94	83	81	88	92.7	6.0	1.4	2.6	2.1
Oct.	165.5	87.6	80.9	74.1	94	79	76	85	84.8	7.6	0.6	1.8	1.1
Nov.	29.1	84.1	74.9	65.6	91	76	68	80	74.4	8.3	0.3	1.4	0.9
Dec.	10.3	78.6	67.3	55.9	90	77	65	78	58.7	8.9	0.3	1.3	0.6
Annual	1990.3								1215.9				

Table 6 Land Utilization of Bangladesh in 1978-79

	Dacca District		Bangladesh		Project Site*	
	Acreage(ac)	%	Acreage(ac)	%	Acreage(ac)	%
Total area	1,844,480	100.0	25,280,640	100.0	135.65	100.0
Unarable area	402,250	21.8	6,673,509	26.4	5.93	4.4
Forest/wood	60,000	3.3	5,422,980	21.5	0.	0.0
Culturable waste	8,810	0.5	623,745	2.5	0.	0.0
Current fallow	112,329	6.0	1,759,802	6.9	0.	0.0
Net area cropped	1,261,091	68.4	10,800,604	42.7	129.72	95.6
Single crop	770,280	(61.0)	1,364,846	(12.6)	103.53	(79.8)
Double crops	388,789	(30.8)	7,825,777	(72.5)	20.19	(15.6)
Tripple crops	102,022	(8.2)	1,609,981	(14.9)	0.00	(0.0)
Mixed crops	-	-	-	-	6.00	(4.6)

* Based on results of interview.

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1978-80

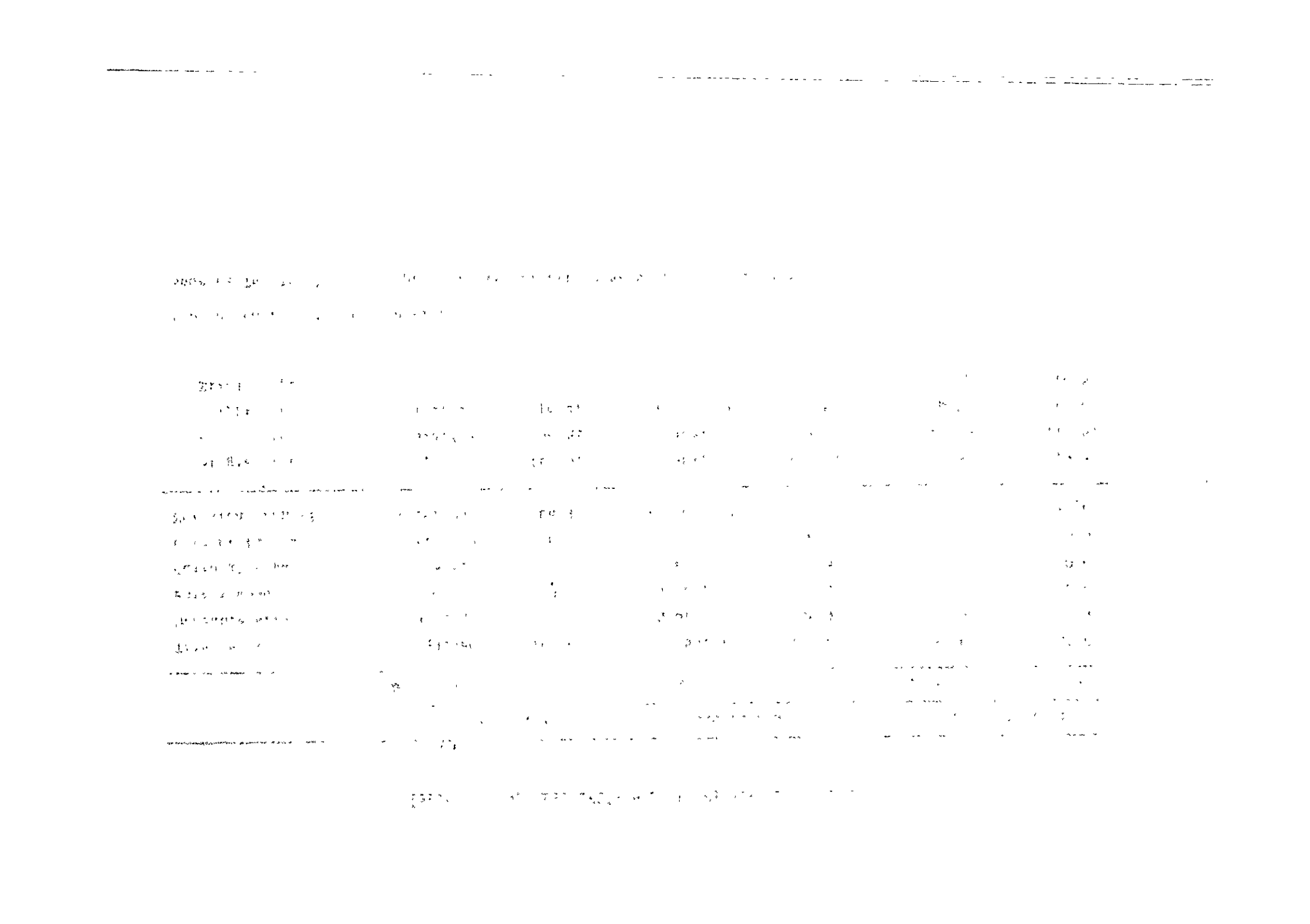


Table 7 Agricultural Commodities, Their Frequencies Acreages, and Yields in Unit Area

Agricultural commodity	Frequency (%)	Acreage (ac)	Yield	Ha Yield
L. Boro	8	2.50	37 Mand	2,231 ton/ha
Boro (HYV)	72	42.55	1,926 "	6,825 ton/ha
B. Aman	82	71.73	1,094 "	2,299 ton/ha
T. Aman	0	0.00	-	-
Aus	4	6.00	86 "	2,161 ton/ha
Jute	74	13.84	181.50 Bale	9,610 ton/ha
Mustard	52	10.64	96.75	
Pulses	32	6.00	59.00	
Vegetables (Cauliflower)	2	0.50	300.00	
Wheat	10	4.75	62.50 Mand	1,984 ton/ha
Chilli	8	0.75	5.75	
Onion	4	0.35	17.00	
Tobacco	2	0.05	0.25	

Remarks: L. Boro Boro rice with local variety
Boro (HYV) Boro rice with high yielding variety
B. Aman Aman rice broadcasted
T. Aman Aman rice transplanted
1 Mand = 37.3261 kg
1 Bale = 181.4 kg

| | | |

Table 8 - Crops in Dacca District Under Irrigated Condition, 1978-79

	Acreage (ac)	Acreage (%)
Aus paddy	7,180	2.6
Aman paddy	4,885	1.7
Boro paddy	214,670	74.9
Wheat	10,000	3.5
Oil seeds	700	0.2
Potatoes	45,600	15.9
Vegetables	2,700	0.9
Sugar cane	650	0.2
Cotton	50	0.0
Others	148	0.1
Total	286,583	100.0

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1979-80

Table 8. Crops in Dacca District Under Irrigated Condition, 1978-79

Crop	Acreage (ac)	Acreage (%)
Aus paddy	[illegible]	[illegible]
Aman paddy	[illegible]	[illegible]
Boro paddy	[illegible]	[illegible]
Wheat	[illegible]	[illegible]
Oil seeds	[illegible]	[illegible]
Potatoes	[illegible]	[illegible]
Vegetables	[illegible]	[illegible]
Sugar cane	[illegible]	[illegible]
Cotton	[illegible]	[illegible]
Others	[illegible]	[illegible]
Total	[illegible]	100.0

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1978-79

Table 9 Level of Agricultural Technology and Farming-Equipment

Facility/Equipment	Frequency at Present (%)	Frequency of Future Requirement (%)
Deep Tube Well	2	0
Shallow Tube Well	0	0
Low Lift Pump	28	16
Country-plough	90	0
Thresher	0	60
Power-tiller	0	96
Hand-hoe	0	32
Hand-raking	0	40
Seed-driller	0	4
Sprayer	0	86
Manure/Fertilizer	100	2
Pesticides	72	0
Better Seeds	62	0

Table 9. Level of Agricultural Technology and Farming-Equipment

Machinery/Equipment	Number of Users (%)	Farmers Who Need/Require (%)
Deep Tube Well	2	0
Shallow Tube Well	0	0
Low Lift Pump	85	15
Country-plough	99	0
Thresher	0	5
Insecticides	0	67
Hand-hoe	0	32
Hand-raking	0	60
Seed-drilling	0	5
Sprayer	0	30
Manure/Fertilizer	100	2
Pesticides	72	0
Tractor Stand	23	[illegible]

Table 10 Yield Comparison: Bangladesh/World

(kg/ha)

	Bangladesh		Asian average	World average
	1961-65	1977-78		
Rice	1,680	1,890	1,956	2,594
Wheat	609	1,698	1,237	1,902
Barley	549	800	997	2,078
Maize	766	960	1,396	3,082
Jute	1,475	1,478	1,175	1,568
Potato	6,591	9,586	8,534	15,026
Sweet potato	9,310	10,896	7,388	8,361
Pulses	700	720	701	748
Ground nuts	1,340	1,182	1,310	998
Sesame	474	554	480	312
Linseed	477	505	355	501
Cauliflower	5,226	6,891	6,898	6,891
Cabbage	5,957	7,967	6,422	20,186
Tomatoes	6,271	7,500	5,545	11,023
Pumpkin, Squash	5,744	7,597	5,816	9,417
Cucumbers	4,512	5,242	5,429	13,501
Onions	5,510	4,286	4,730	11,702
Garlic	3,342	3,320	4,224	6,290
Sugar cane	39,057	44,667	41,196	56,285
Tobacco leaves	680	886	712	1,292

Source: FAO Production Yearbook, 1979

Table 10. Yield/hectare: International/Bangladesh, M.T. [illegible]

Crop	Bangladesh 1969-70	1977-78	[illegible]	[illegible]
Rice	[illegible]	[illegible]	[illegible]	[illegible]
Wheat	[illegible]	[illegible]	[illegible]	[illegible]
Barley	[illegible]	[illegible]	[illegible]	[illegible]
Maize	[illegible]	[illegible]	[illegible]	[illegible]
Jute	[illegible]	[illegible]	[illegible]	[illegible]
Potato	[illegible]	[illegible]	[illegible]	[illegible]
Sweet potato	[illegible]	[illegible]	[illegible]	[illegible]
Pulses	[illegible]	[illegible]	[illegible]	[illegible]
Ground nuts	[illegible]	[illegible]	[illegible]	[illegible]
Sesame	[illegible]	[illegible]	[illegible]	[illegible]
Linseed	[illegible]	[illegible]	[illegible]	[illegible]
Cauliflower	[illegible]	[illegible]	[illegible]	[illegible]
Cabbage	[illegible]	[illegible]	[illegible]	[illegible]
Tomatoes	[illegible]	[illegible]	[illegible]	[illegible]
Pumpkin, Squash	[illegible]	[illegible]	[illegible]	[illegible]
Green chillies	[illegible]	[illegible]	[illegible]	[illegible]
Onions	[illegible]	[illegible]	[illegible]	[illegible]
Garlic	[illegible]	[illegible]	[illegible]	[illegible]
Sugar cane	[illegible]	[illegible]	[illegible]	[illegible]
Tobacco leaves	[illegible]	[illegible]	[illegible]	[illegible]

Source: FAO Production Yearbook, 1979

Table 11 Comparison of Rice/Wheat Yield between Local and High Yielding Varieties in Bangladesh, 1975-76 to 1977-78

Rice (ton/ha)

	Local Variety			High Yielding Variety		
	75/76	76/77	77/78	75/76	76/77	77/78
Dacca District	1.66	1.54	1.62	4.4	3.97	6.02
Bangladesh	1.65	1.65	1.75	3.89	3.72	3.88

Wheat (ton/ha)

	Local Variety			High Yielding Variety		
	75/76	76/77	77/78	75/76	76/77	77/78
Dacca District	1.18	1.48	1.63	2.60	2.97	3.12
Bangladesh	1.18	1.12	1.18	3.15	3.16	3.32

Source: Statistical Yearbook of Bangladesh, 1979

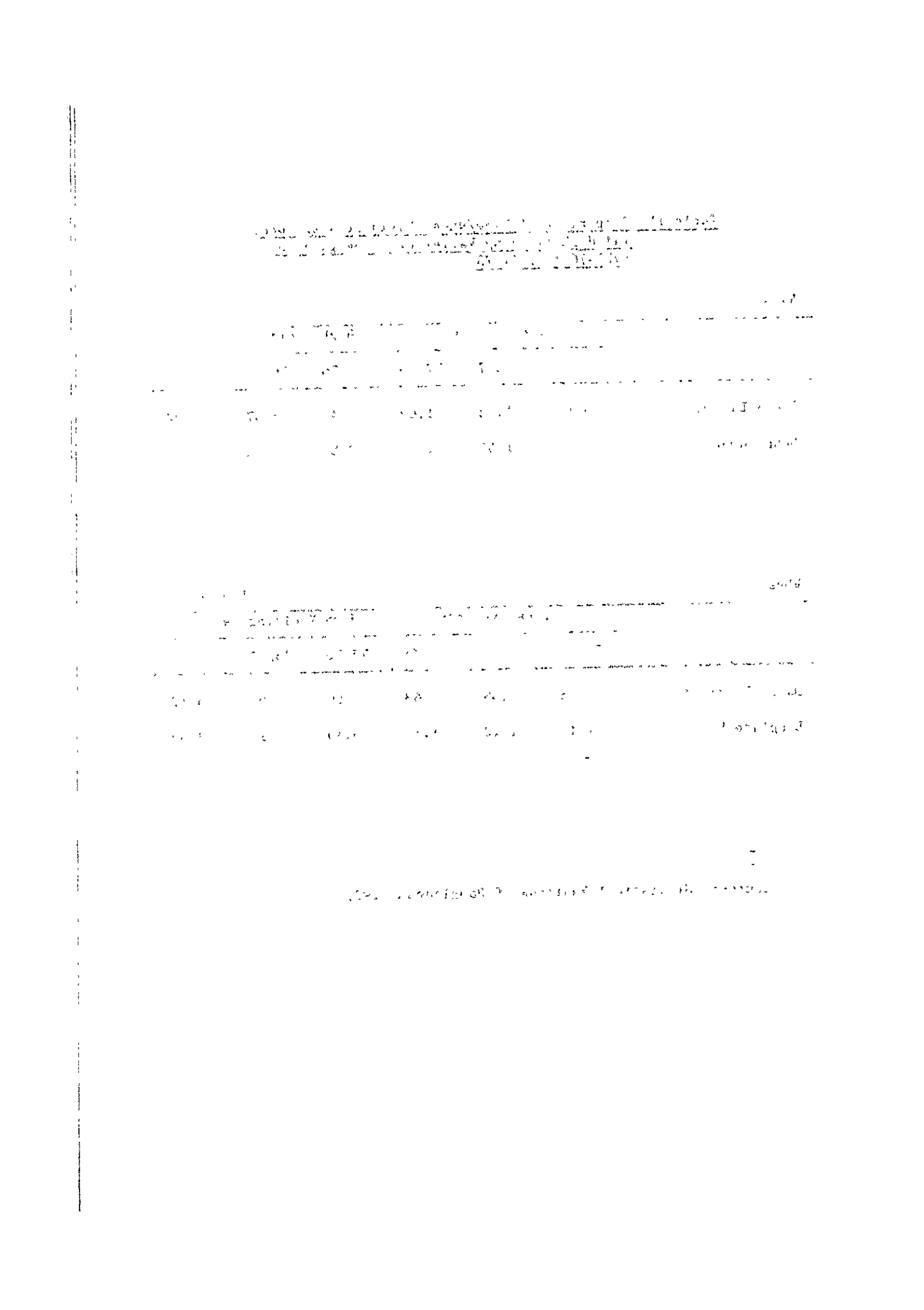


Table 12 Farmers' Income Patterns: Rupganj Thana

Source of Income	Farmers Engaged	Share of Total Income
Rice	98	47.7
Jute	62	10.4
Business (Cottage Industry, etc.)	30	12.8
Service (Boat, Labor Wage, etc.)	68	45.5
Winter Crops (Mustard, Wheat, etc.)	48	33.4
Poultry	34	5.6
Goat/Sheep	4	7.5
Milk	6	9.0
Fishing	2	5.0

[illegible]

[illegible]

Table 13 Agricultural Commodities Sold in Market

Commodity	Frequency (%)
Rice	100
Jute	58
Vegetables	54
Poultry	62
Goat/Sheep	36
Fishes	24
Rabi Crops	32
Mustard	8
Potato	2
Wheat	18
Pulses	24
Oil Seeds	4
Millet	2
Vegetables	32
Jamdarin Sari	8

Table 1[illegible]. Agricultural Commodities Sold in Market[illegible]

Commodity	Frequency (%)
Rice	[illegible]
Tuba	[illegible]
Vegetables	[illegible]
Poultry	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
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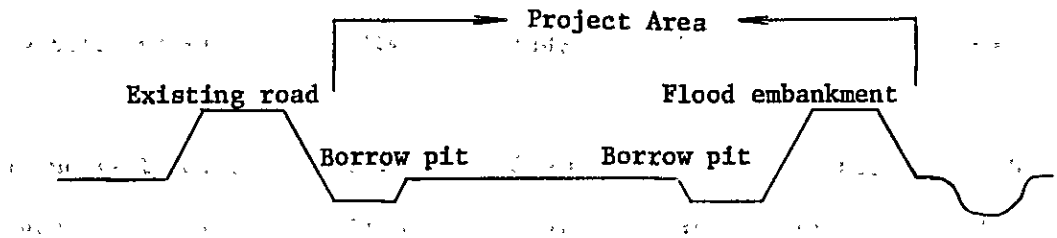
Table-14

Project Area

Gross Area 1,325 ha

Outside Toe of the Flood Embankment and Inside Toe of the Existing Road Bank



Non-cultivable Land

Homestead, Highland & Others (more than 3.81 m)	140 ha
Khals, Marshes & Low Land (less than 2.591 m)	90 ha
Roads	9 ha
Existing Borrow Pit along the Road	28 ha

Area Required for Engineering Features

Flood Embankment (including borrow pit)		26 ha
Canal & Roads		30 ha
Pump Stations		2 ha
	Sub-total	325 ha

Net Irrigable Area

1,325 ha - 325 ha = 1,000 ha

Problem 14

Project Area

Gross Area 3,375 ha

Determine Ecological Compensation and Trading Ratios
of Land Developing Plan Below

Non-Developable Land

Slopes Greater Than 25 Percent Within Project Site (Slope Value 1.25)	144 ha
Ponds & Wetlands & Fish Land (Slope Value 1.25)	50 ha
Roads	4 ha
Existing Reserve & Nature Use Area	17 ha

Area Required for Ecological Protection

Total Conservation Area (Including Buffer Area)	45 ha
Ponds & Swales	45 ha
Temp Vegetation	2 ha
Sub-Total	137 ha

Net Developable Area

$3,375 \text{ ha} - 338 \text{ ha} = 1,000 \text{ ha}$

Table 15 Quantity (MT) and Value (US$) of Jute Exported

	1974	1975	1976	1977	1978
Quantity (ton)	472,113	279,000	423,627	439,014	301,700
(growth index)*	(100)	(59)	(90)	(93)	(64)
Value (x 1,000 $)	112,471	78,000	108,380	119,621	98,170
(growth index)	(100)	(69)	(96)	(106)	(87)

* Calculated as 100 for 1974 export.

Source: FAO Production Yearbook, 1979

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.

Quisque (unde)	1,234	5,678	9,012	3,456	7,890
Ullamco laboris	(12)	(34)	(56)	(78)	(90)
Nemo enim (c. 1,000)	123,456	78,901	23,456	67,890	12,345
Excepteur sint	(111)	(222)	(333)	(444)	(555)

Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Table 16 Import Quantity (MT) and Value (US$) of Selected Agricultural Commodities of Bangladesh, 1974 to 1978

	1974	1975	1976	1977	1978
Rice					
Quantity (ton)	87	268	417	105	318
(growth index)*	(100)	(308)	(479)	(121)	(366)
Value (x 1,000$)	21	70	107	32	73
(growth index)	(100)	(333)	(509)	(152)	(348)
Wheat					
Quantity (ton)	1,615	2,080	1,173	623	2,806
(growth index)	(100)	(129)	(72)	(39)	(173)
Value (x 1,000$)	365	403	159	557	1,851
(growth index)	(100)	(110)	(44)	(153)	(507)
Rape & Mustard Seeds					
Quantity (ton)	30,200	42,900	54,208	43,678	47,877
(growth index)	(100)	(142)	(179)	(145)	(158)
Value (x 1,000$)	10,000	15,000	21,102	17,000	18,500
(growth index)	(100)	(150)	(211)	(170)	(185)
Rape & Mustard Oils					
Quantity (ton)	7,000	10,600	51,328	8,959	45,934
(growth index)	(100)	(151)	(733)	(127)	(656)
Value (x 1,000$)	4,000	5,500	41,248	6,000	33,000
(growth index)	(100)	(138)	(1,031)	(150)	(825)

* Calculated as 100 for 1974 import.

Source: FAO Production Yearbook, 1979

Table 13. Income distribution (current dollars) and poverty status of families and persons in 1974: [All races, Spanish origin, and black]

Subject	All races	Spanish origin	Black
Number of families (thousands)	51,586	2,283	4,168
Median income	$12,836	$9,551	$8,779
Mean income	$14,094	$10,284	$10,020
Percent with income of—			
Under $3,000	5.1	9.4	10.4
$3,000 to $4,999	7.4	11.4	13.2
$5,000 to $6,999	7.6	11.2	12.8
$7,000 to $9,999	12.4	16.1	17.2
$10,000 to $14,999	22.2	22.1	21.4
$15,000 to $24,999	27.2	19.0	16.0
$25,000 and over	18.1	10.8	9.0
Number of persons (thousands)	11,837	1,337	2,603
Median income	$3,670	$2,715	$2,795
Mean income	$4,902	$3,284	$3,450
Percent with income of—			
Under $1,000	10.1	15.2	15.1
$1,000 to $1,999	8.2	12.1	12.2
$2,000 to $2,999	8.1	11.2	11.4
$3,000 to $3,999	7.8	10.1	10.2
$4,000 to $4,999	7.4	9.1	9.2
$5,000 to $6,999	14.2	16.1	16.2
$7,000 to $9,999	16.2	12.1	12.2
$10,000 to $14,999	12.1	8.1	8.2
$15,000 to $24,999	5.1	3.1	3.2
$25,000 and over	2.1	1.1	1.2
Number of persons (thousands)	11,837	1,337	2,603
Median income	$3,670	$2,715	$2,795
Mean income	$4,902	$3,284	$3,450
Percent with income of—			
Under $1,000	10.1	15.2	15.1
$1,000 to $1,999	8.2	12.1	12.2
$2,000 to $2,999	8.1	11.2	11.4
$3,000 to $3,999	7.8	10.1	10.2
$4,000 to $4,999	7.4	9.1	9.2
$5,000 to $6,999	14.2	16.1	16.2
$7,000 to $9,999	16.2	12.1	12.2
$10,000 to $14,999	12.1	8.1	8.2
$15,000 to $24,999	5.1	3.1	3.2
$25,000 and over	2.1	1.1	1.2
Number of persons (thousands)	11,837	1,337	2,603
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$1,000 to $1,999	8.2	12.1	12.2
$2,000 to $2,999	8.1	11.2	11.4
$3,000 to $3,999	7.8	10.1	10.2
$4,000 to $4,999	7.4	9.1	9.2
$5,000 to $6,999	14.2	16.1	16.2
$7,000 to $9,999	16.2	12.1	12.2
$10,000 to $14,999	12.1	8.1	8.2
$15,000 to $24,999	5.1	3.1	3.2
$25,000 and over	2.1	1.1	1.2

Table 17 Cropping Pattern and Irrigation Water Requirement

(in m³/sec)

Items	Month	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
Proposed Cropping Schedule	100% / 80 / 60 / 40 / 20 / 0	Paijam rice 80% (105 days)						Fallow				Land preparation		Rice (HYV) 40% (105 days)						Fallow					
										Tossa jute 40% (120 days)						Rabi crops 40% (mustard, potato)						Land preparation			
						Bhadoi crops 20% (pulses, cucumber, pumpkin)								Other arables:- okra, oil seeds, onion/ garlic, chilli				Other arables:- tomato, pumpkin, chilli				Wheat (HYV) 20% (105 days)			
Kind of Crops	Paijam rice 800 ha	0.34	0.36	0.55	0.57	0.76	0.13															1.48		0.32	0.32
	Rice (HYV) 400 ha										0.63	–	0.05	–	–	–	–	0.21	–						
	Tossa jute 400 ha							0.05	–	0.09	0.15	–	0.03	–	0.07	–	–								
	Wheat (HYV) 200 ha	0.08	0.08	0.05																	0.02	–	0.05	0.05	0.07
	Rabi crops 400 ha															–	–	0.04	–	–	0.14	–	0.03		
	Bhadoi crops 200 ha			0.04	0.07	0.10	0.03	0.11	–	0.05	0.05	–	–	–	–	–	–	0.03	–	–	0.04	–			
Net Irrigation Water Requirement		0.42	0.44	0.64	0.64	0.86	0.16	0.16	–	0.14	0.83	–	0.08	–	0.07	–	–	0.28	–	–	0.20	–	1.56	0.37	0.39

Table - 18 Percentage of Point Rainfall

Average Distance From Storm Center (miles)	5-Day Storm Percentage of Point Rainfall (%)	Area (sq. miles)	Area Times Percentage (sq. miles)
1/4	100	0.196	0.196
1	88.0	1.727	1.520
2	81.7	2.452	2.003
3	77.5	0.881	0.683
Total		5.256	4.402

$$\text{(Percentage of Point Rainfall)} = \frac{\text{Area Times Percentage}}{\text{Area}} \times 100$$

$$\frac{4.402}{5.256} \times 100 = 84\%$$

Table - 19 Accumulative Point Rainfall

Day(s)	Combined Rainfall Index for 10-Year Storm	Accumulative Point Rainfall (inches)	Equivalent Uniform Depth	
			Accumulative Total (inches)	Daily Increments (inches)
1	0.128	7.0	5.88	5.88
2	0.192	10.6	8.90	3.02
3	0.230	12.7	10.67	1.77
4	0.257	14.1	11.84	1.17
5	0.276	15.2	12.77	0.93

(Accumulative Point Rainfall) = (4-Month Rainfall Index = 55 inches) × (Combined Rainfall Index)

(Equivalent Uniform Depth) = (Accumulative Point Rainfall) × (Percentage of Point Rainfall)

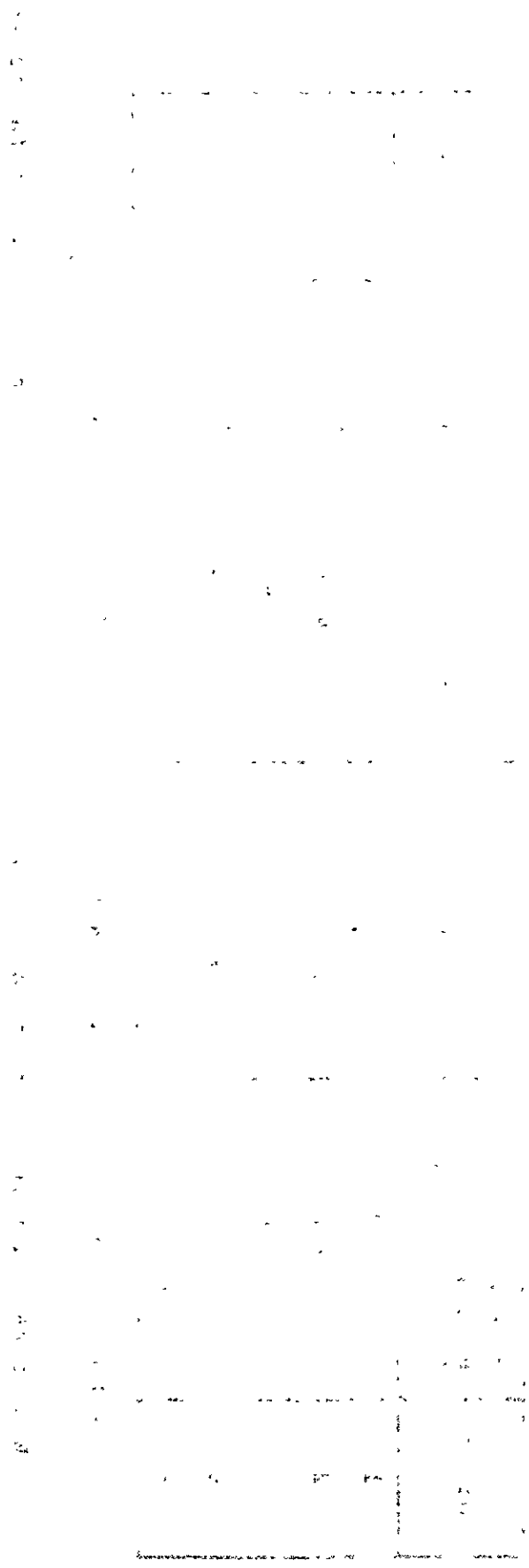

Table- 20 Calculation of Water Balance

Day	Rainfall (m)	Volume (m^3)	Drainage (3.18m^3/sec) (m^3)	Remaining Volume (m^3)	Water Level (PWD feet)	Inundated Area (ha)
1	0.045	596,250	274,752	321.498	9.1	103
2	0.077	1,020,250	274,752	1,066,996	10.1	337
3	0.149	1,974,250	274,752	2,766,494	11.2	746
4	0.030	397,500	274,752	2,889,242	11.2	746
5	0.024	318,000	274,752	2,932,490	11.3	780
6	-	-	274,752	2,657,738	11.1	711
7	-	-	274,752	2,382,986	11.0	674
8	-	-	274,752	2,108,234	10.9	634
9	-	-	274,752	1,833,482	10.7	563
10	-	-	274,752	1,558,730	10.5	491
11	-	-	274,752	1,283,978	10.3	417
12	-	-	274,752	1,009,226	10.1	337
13	-	-	274,752	734,474	9.8	236
14	-	-	274,752	459,722	9.4	147
15	-	-	274,752	184,970	8.5	40

Year	Net Income	Dividends	Retained Earnings	Total Assets	Total Liabilities	Shareholders' Equity
1	2,000	0	2,000	10,000	6,000	4,000
2	2,200	0	2,200	12,200	7,200	5,000
3	2,420	0	2,420	14,620	8,520	6,100
4	2,662	0	2,662	17,282	9,972	7,310
5	2,928	0	2,928	20,210	11,570	8,641
6	3,221	0	3,221	23,431	13,327	10,105
7	3,543	0	3,543	26,974	15,260	11,714
8	3,897	0	3,897	30,871	17,387	13,484
9	4,287	0	4,287	35,158	19,726	15,432
10	4,716	0	4,716	39,874	22,299	17,575
11	5,188	0	5,188	45,062	25,129	19,933
12	5,707	0	5,707	50,769	28,243	22,526

Table —21 Calculation of Eto

***** N-N PROJECT DACCA 1967-1976 PENMAN

MONTH	NO.	CROP EVAPO-TRANSPIRATION ETO (MM/DAY)	ADJUSTMENT FACTOR C	WEIGHTING FACTOR W	NET RADIATION RN (MM/DAY)	1-W	WIND RELATED FUNCTION F(U)	SATURATION VAPOUR PRESSURE EA (MBAR)	MEAN ACTUAL VAPOUR PRESSURE ED (MBAR)
JAN	1	2.9	1.06	0.66	3.1	0.34	0.41	20.6	15.3
FEB	2	4.2	1.10	0.70	3.9	0.30	0.46	24.9	16.7
MAR	3	5.8	1.10	0.75	4.9	0.25	0.57	33.6	22.5
APR	4	6.2	1.01	0.77	5.8	0.23	0.80	37.8	28.5
MAY	5	5.9	1.01	0.78	6.0	0.22	0.73	40.1	32.9
JUN	6	4.3	0.92	0.77	5.0	0.23	0.71	37.8	32.9
JUL	7	4.1	0.92	0.77	4.8	0.23	0.71	37.8	33.5
AUG	8	4.6	1.01	0.77	5.0	0.23	0.67	37.8	33.3
SEP	9	4.3	1.06	0.76	4.6	0.24	0.58	35.7	31.2
OCT	10	4.2	1.06	0.76	4.4	0.24	0.47	35.7	30.3
NOV	11	3.4	1.06	0.72	3.5	0.28	0.43	28.1	22.6
DEC	12	2.8	1.06	0.68	3.0	0.32	0.40	22.0	16.9

Table – 22 Semi-Monthly Water Requirement for Various Crops

Months	ET_0 (inches/day)	ET_0 (inches /0.5 month)	Effective Rainfall: Paddy (inches /0.5 month)	Effective Rainfall: Other Crops (inches /0.5 month)	Water Requirement (in inches): Paijam rice Kc	Paijam rice U_1	Paijam rice U_2	Rice(HYV) Kc	Rice(HYV) U_1	Rice(HYV) U_2	Tossa jute Kc	Tossa jute U_1	Tossa jute U_2	Wheat(HYV) Kc	Wheat(HYV) U_1	Wheat(HYV) U_2	Rabi crops Kc	Rabi crops U_1	Rabi crops U_2	Bhadoi crops Kc	Bhadoi crops U_1	Bhadoi crops U_2
Jan.	0.114	1.71	0	0	1.275	2.18	2.18	–	–	–	–	–	–	1.20	2.05	2.05	–	–	–	–	–	–
		1.82	0	0	1.35	2.46	2.46	–	–	–	–	–	–	1.125	2.05	2.05	–	–	–	–	–	–
Feb.	0.165	2.31	0	0	1.425	3.29	3.29	–	–	–	–	–	–	0.50	1.16	1.16	–	–	–	0.38	0.88	0.88
		2.31	0	0	1.475	3.41	3.41	–	–	–	–	–	–	–	–	–	–	–	–	0.76	1.76	1.76
Mar.	0.228	3.42	0	0	1.425	4.87	4.87	–	–	–	–	–	–	–	–	–	–	–	–	0.76	2.60	2.60
		3.65	1.60	2.06	0.675	2.46	0.86	–	–	–	–	–	–	–	–	–	–	–	–	0.76	2.77	0.71
Apr.	0.244	3.66	0	0	–	–	–	–	–	–	0.167	0.61	0.61	–	–	–	–	–	–	0.76	2.78	2.78
		3.66	2.44	2.89	–	–	–	–	–	–	0.383	1.40	–	–	–	–	–	–	–	0.76	2.78	–
May	0.232	3.48	1.04	1.34	–	–	–	–	–	–	0.70	2.44	1.10	–	–	–	–	–	–	0.76	2.64	1.30
		3.71	0.89	1.35	–	–	–	1.20	4.45	*2 8.56	0.917	3.40	2.05	–	–	–	–	–	–	0.76	2.82	1.47
Jun.	0.169	2.54	4.09	4.89	–	–	–	1.20	3.05	–	1.20	3.05	–	–	–	–	–	–	–	0.76	1.93	–
		2.54	2.43	3.05	–	–	–	1.225	3.11	0.68	1.35	3.43	0.38	–	–	–	–	–	–	0.76	1.93	–
Jul.	0.161	2.42	3.88	4.26	–	–	–	1.275	3.09	–	1.433	3.47	–	–	–	–	–	–	–	0.76	1.84	–
		2.58	3.51	2.67	–	–	–	1.35	3.48	–	1.40	3.61	0.94	–	–	–	–	–	–	0.76	1.96	–
Aug.	0.181	2.72	8.95	9.87	–	–	–	1.425	3.88	–	0.933	2.54	–	–	–	–	0.233	0.63	–	0.76	2.07	–
		2.90	7.92	7.62	–	–	–	1.475	4.28	–	0.467	1.35	–	–	–	–	0.467	1.35	–	0.76	2.20	–
Sep.	0.169	2.54	0.90	1.27	–	–	–	1.425	3.62	2.72	–	–	–	–	–	–	0.70	1.79	0.52	0.76	1.93	0.66
		2.54	4.74	5.34	–	–	–	0.675	1.71	–	–	–	–	–	–	–	0.70	1.79	–	0.76	1.93	–
Oct.	0.165	2.48	2.98	3.38	–	–	–	–	–	–	–	–	–	–	–	–	0.70	1.74	–	0.76	1.88	–
		2.64	0	0	–	–	–	–	–	–	–	–	–	0.25	0.66	0.66	0.70	1.85	1.85	0.38	1.00	1.00
Nov.	0.134	2.01	1.03	1.13	–	–	–	–	–	–	–	–	–	0.55	1.11	–	0.467	0.94	–	–	–	–
		2.01	0	0	1.20	2.41	*1 9.41	–	–	–	–	–	–	0.65	1.31	1.31	0.233	0.47	0.47	–	–	–
Dec.	0.110	1.65	0	0	1.225	2.02	2.02	–	–	–	–	–	–	0.85	1.40	1.40	–	–	–	–	–	–
		1.76	0	0	1.25	2.20	2.20	–	–	–	–	–	–	1.075	1.89	1.89	–	–	–	–	–	–

ET_0: Crop Evapotranspiration

Kc : Crop facter

$*_1$: Considering Required Water for land preparation (7.0 inches)

$*_2$: Considering Required Water for land preparation (5.0 inches)

$U_1 = ET_0 \times Kc$

$U_2 = U_1$ – Effective Rainfall

[illegible]

[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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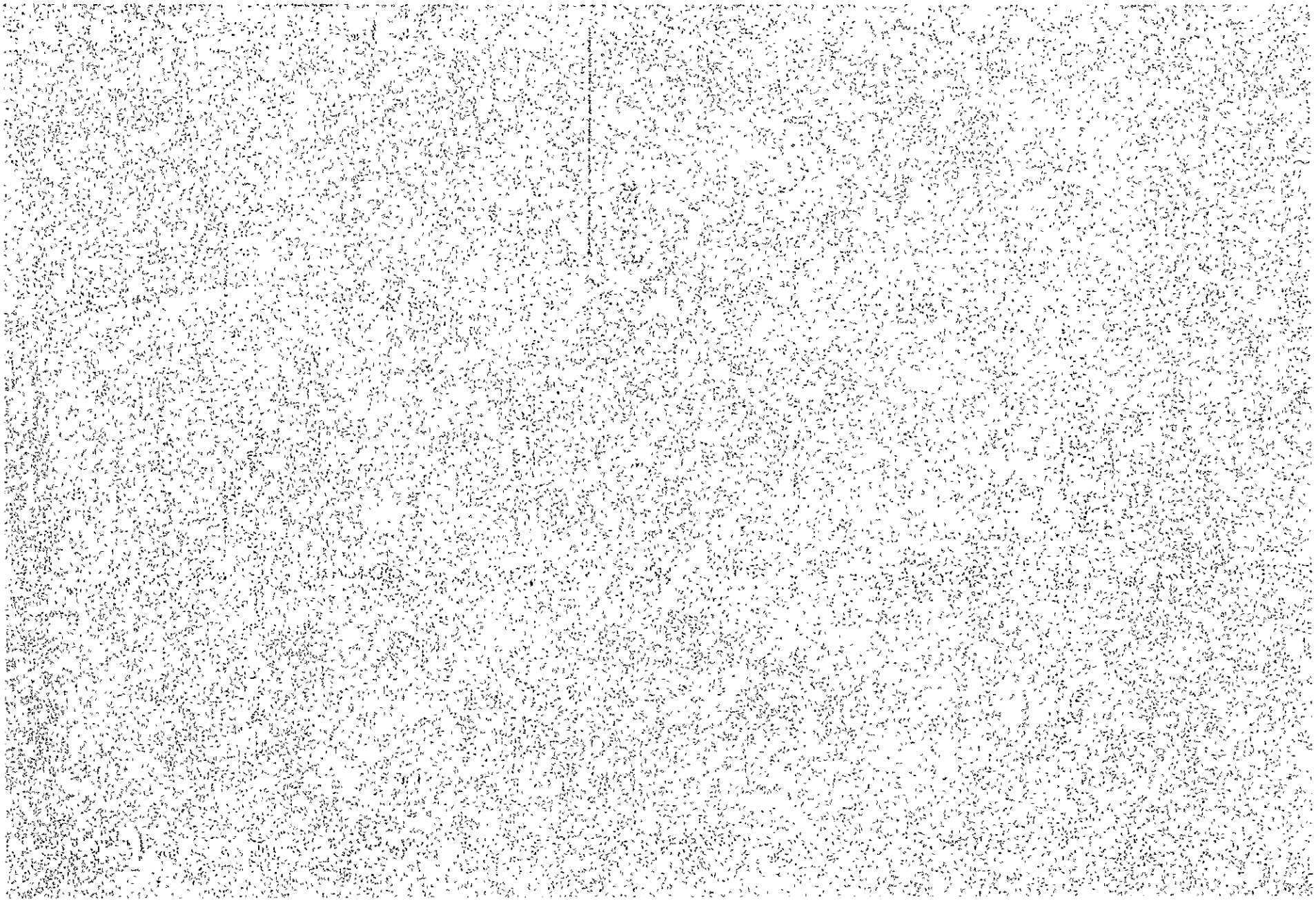
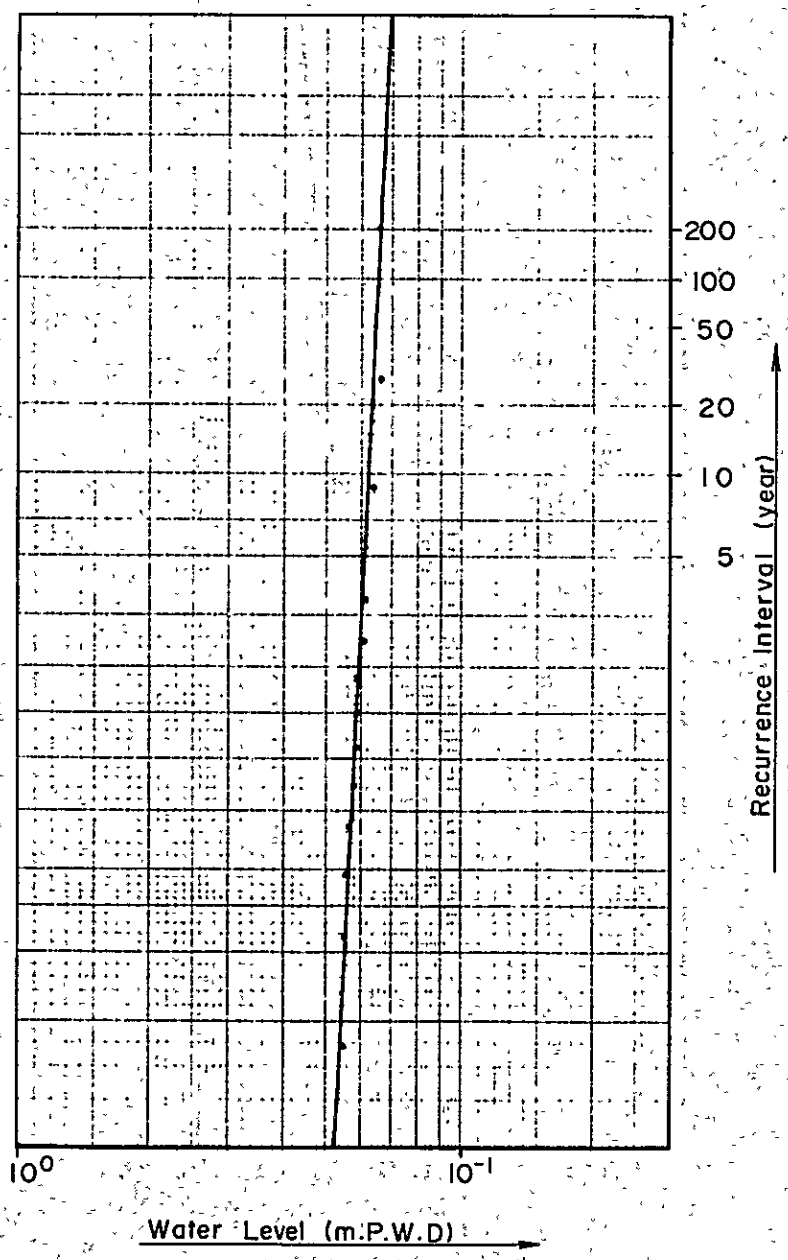
Table- 23 Water Level at Pumping Station

		No.1 Pump Stn. in N-N Entire Project		Proposed Pump Stn. in This Project (m PWD)	Design (m PWD)	
		(ft)	(m PWD)		Design	Normal
S.W.L. Suction Water Level	Drainage	2.0	0.61	1.50	2.45	1.50
	Irrigation	1.0	0.305	0.50	0.50	
D.W.L. Discharge Water Level	Drainage	22.0	6.706	6.30	6.30	6.00
	Irrigation	21.0	6.401	4.85	4.85	
Net Head	Drainage	20.0	6.10	4.35	3.85	4.50
	Irrigation	20.0	6.10	5.00	4.35	
Total Head	Drainage	23.0	7.01	-	4.60	5.20
	Irrigation	23.0	7.01	-	5.10	

FIGURES



Fig–1 Probable Maximum Water Level at DEMRA Gauging Station



Fig–2 Probable Minimum Water Level at DEMRA Gauging Station

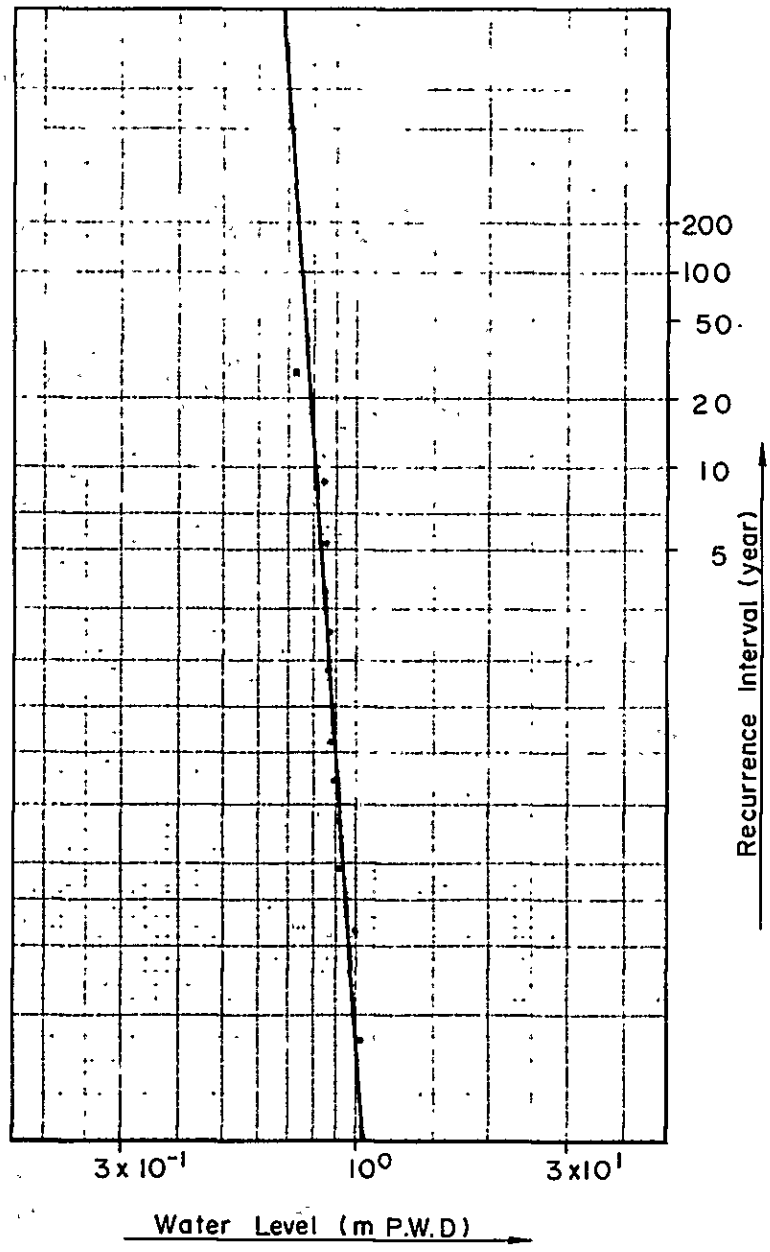


Fig-5 Maximum Water Level

Water Year 1974

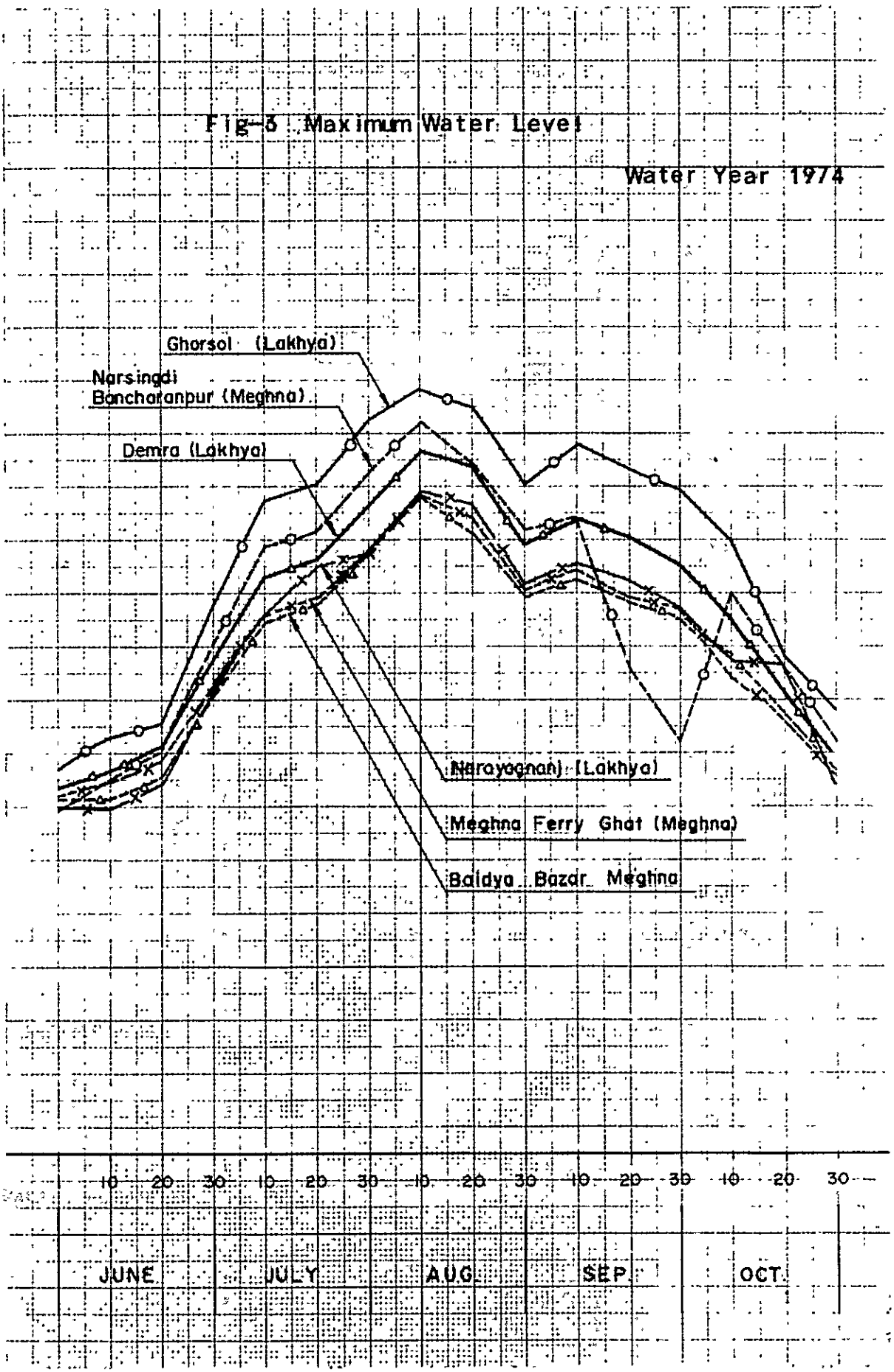
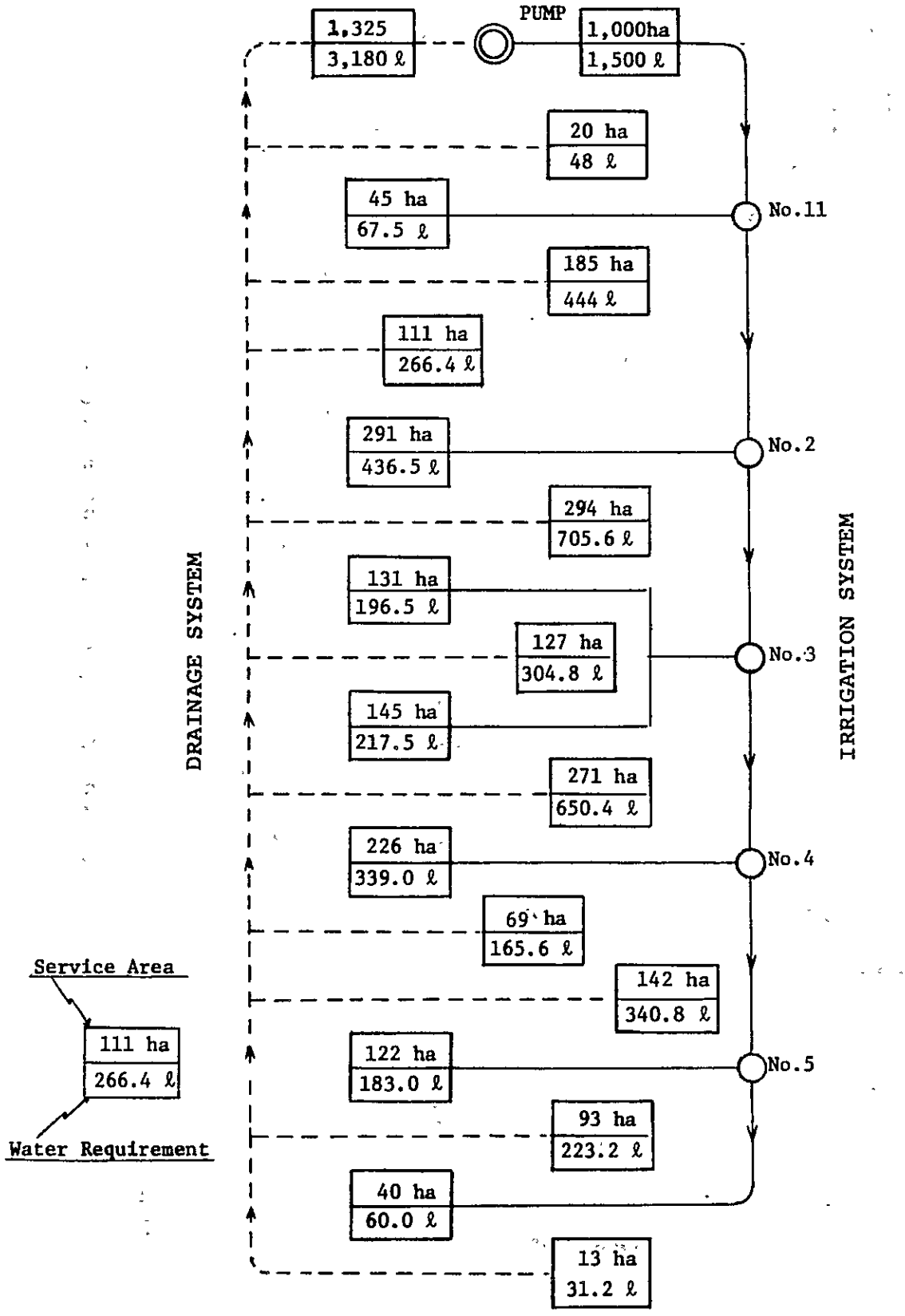


Fig-4 BLOCK DIAGRAM OF CANAL SYSTEM



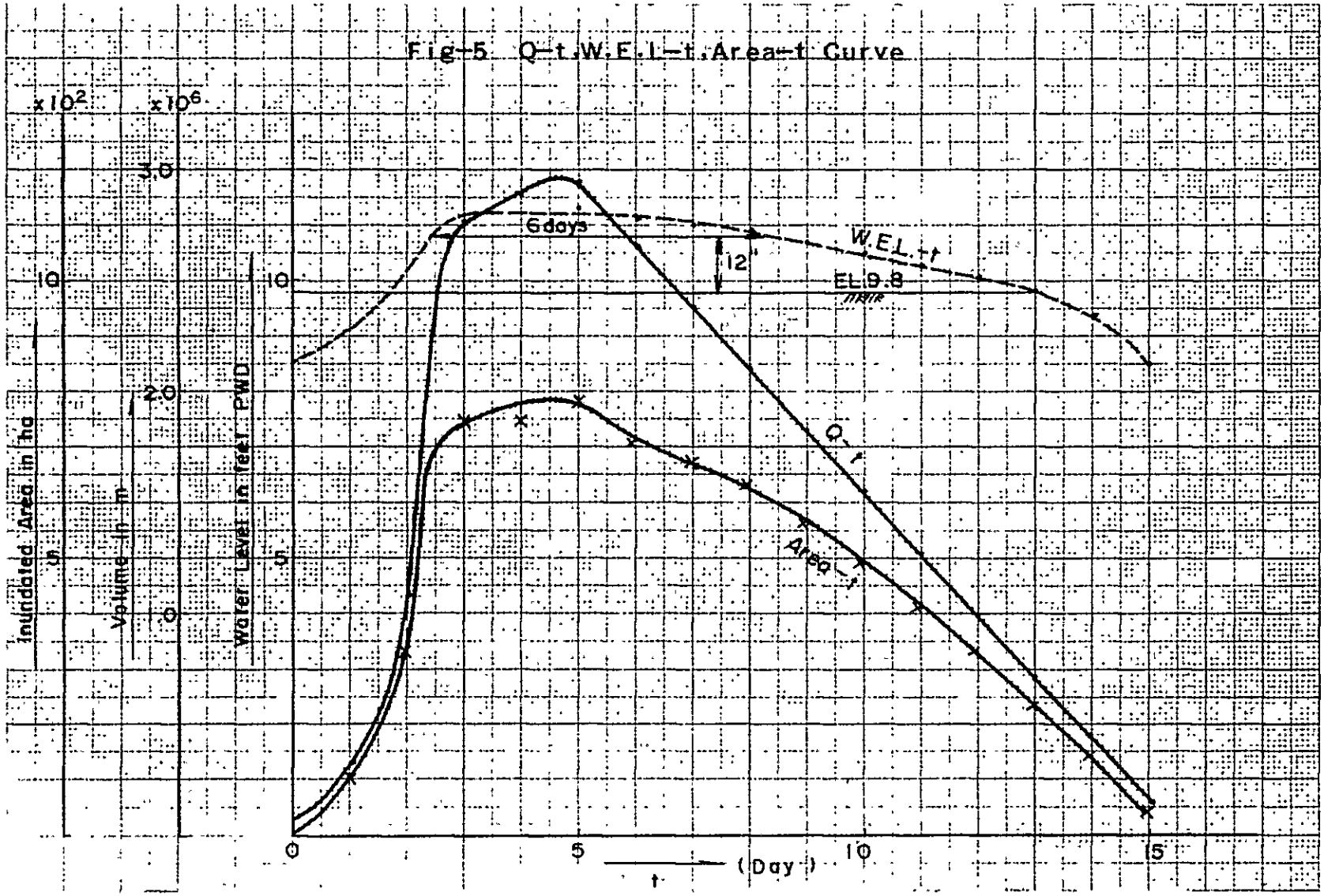


Fig-5 Q-t, W.E.L-t, Area-t Curve
x10²
x10⁶
3.0
2.0
10
0
6days
12'
W.E.L.-t
EL 9.8 m/sec
Q-t
Area-t
Inundated Area in ha
Volume in m
Water Level in feet PWD
0
5
10
15
t
(Day)

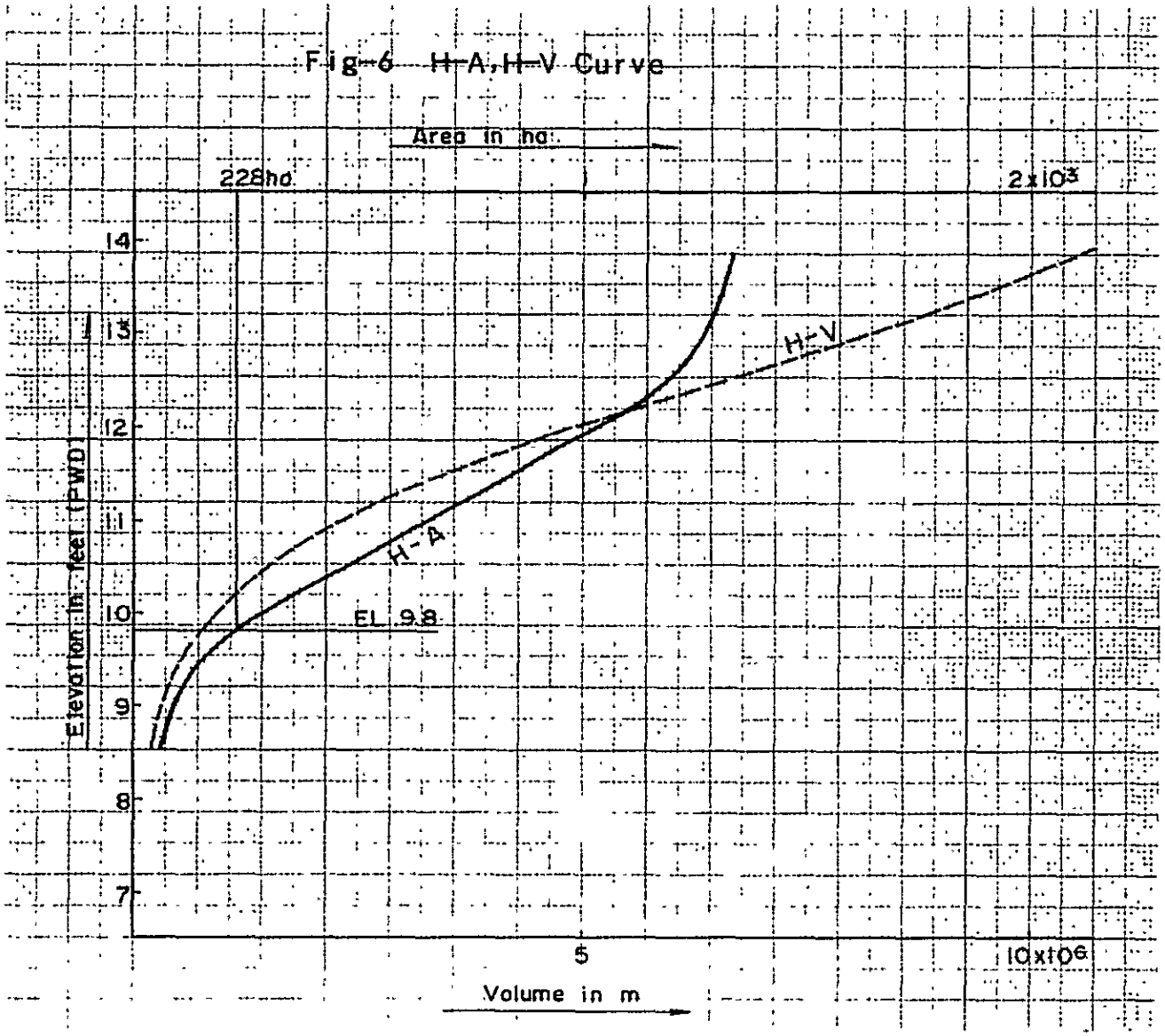


Fig-6 H-A, H-V Curve

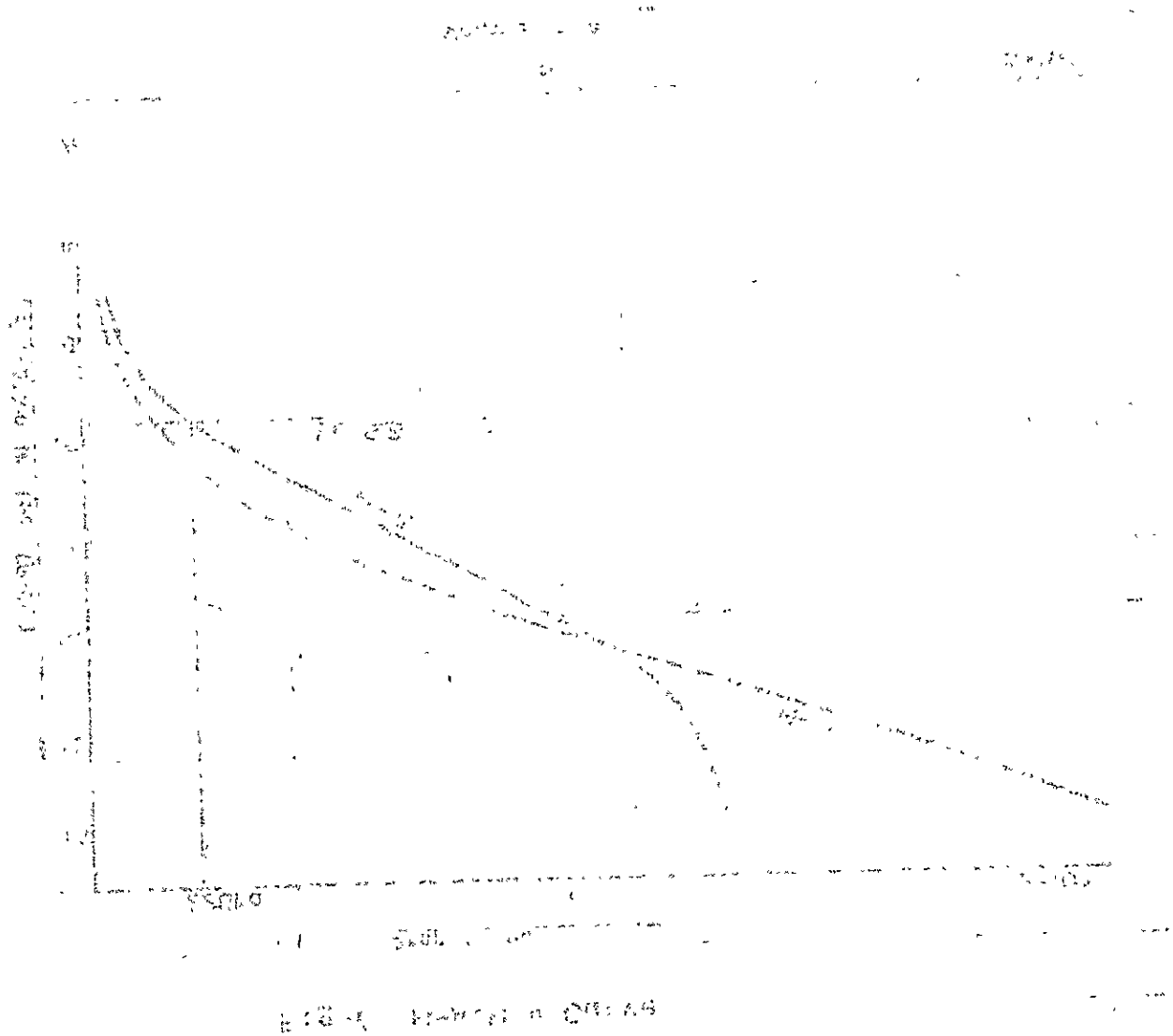


Fig.- 7 Slope Stability Analysis

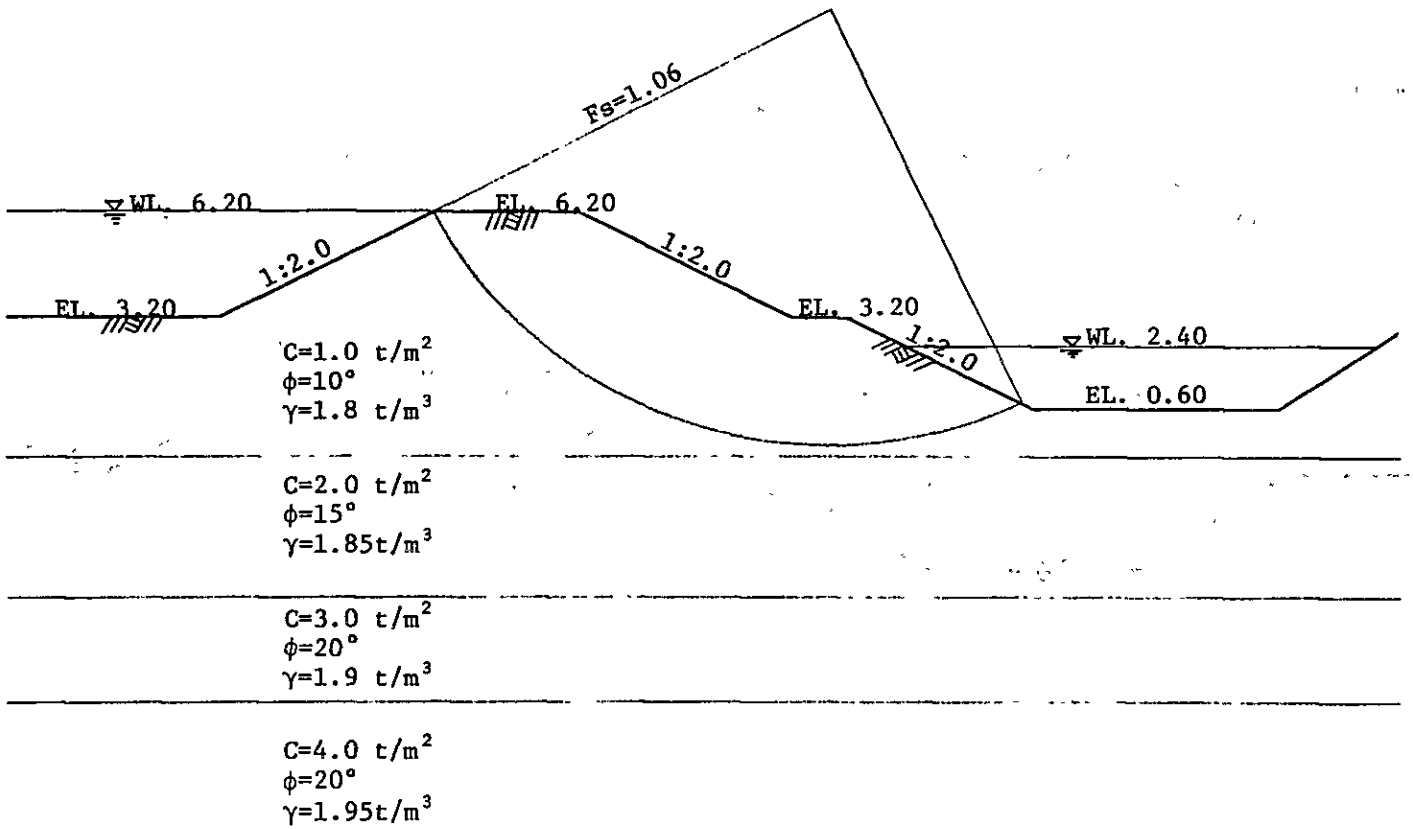


Fig -8 Flood Protection Embankment & Main Drainage Canal

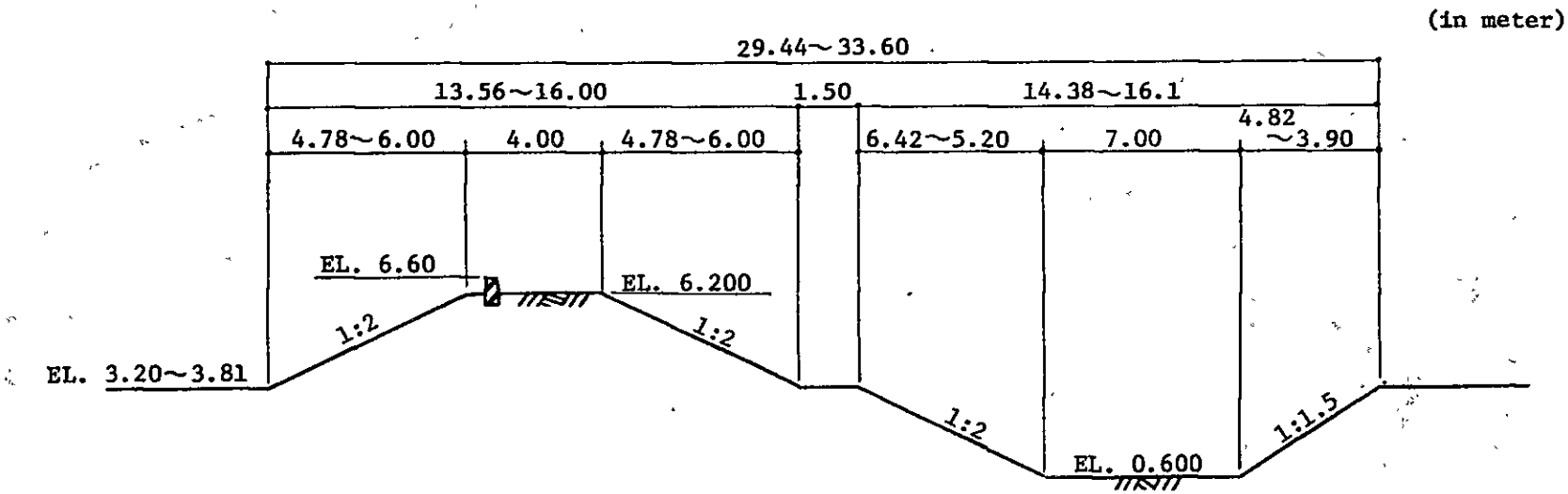


Fig – 9 Existing Power Line Grid in and Around Project Site

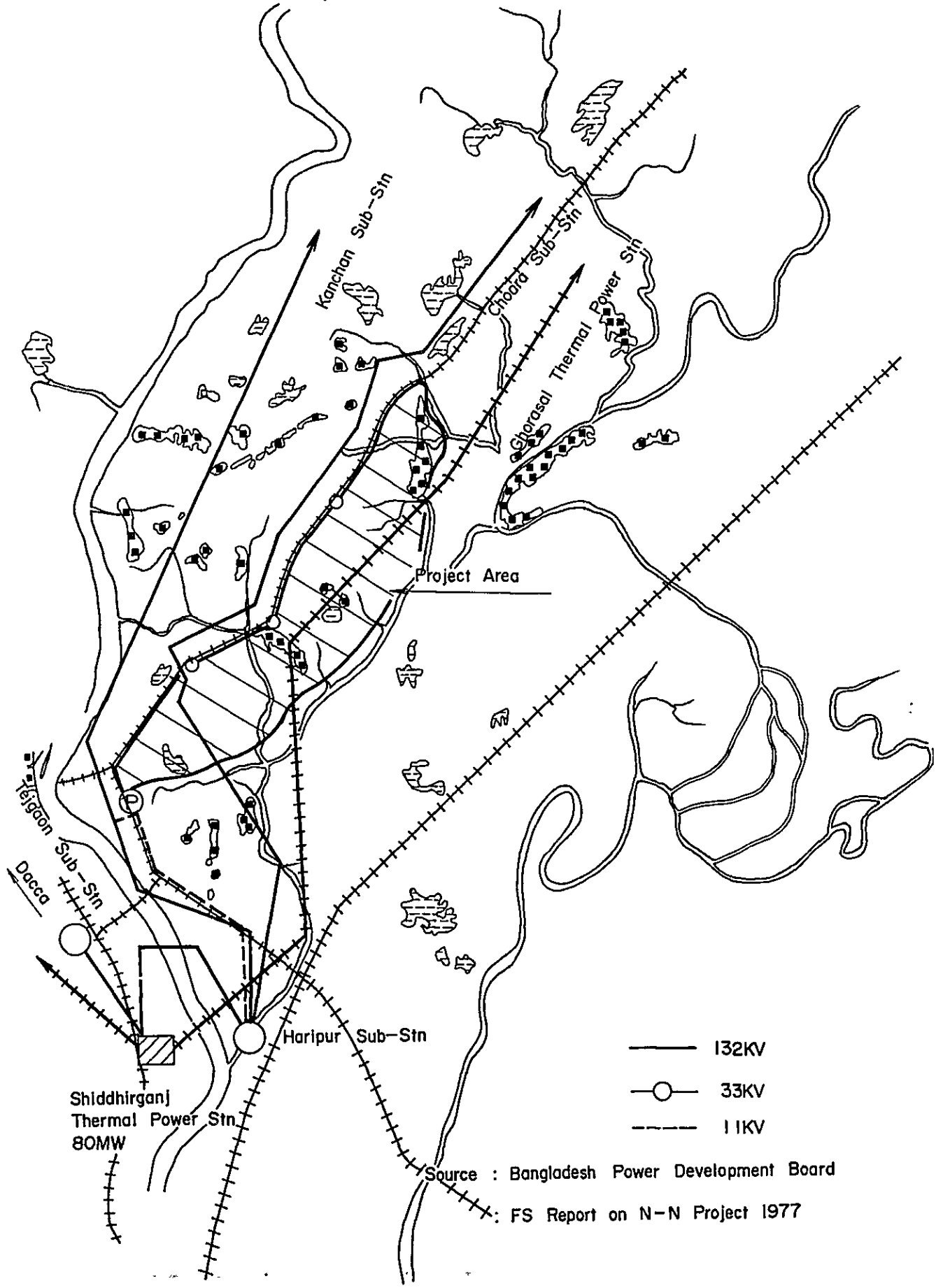


FIG-10 IMPLEMENTATION SCHEDULE

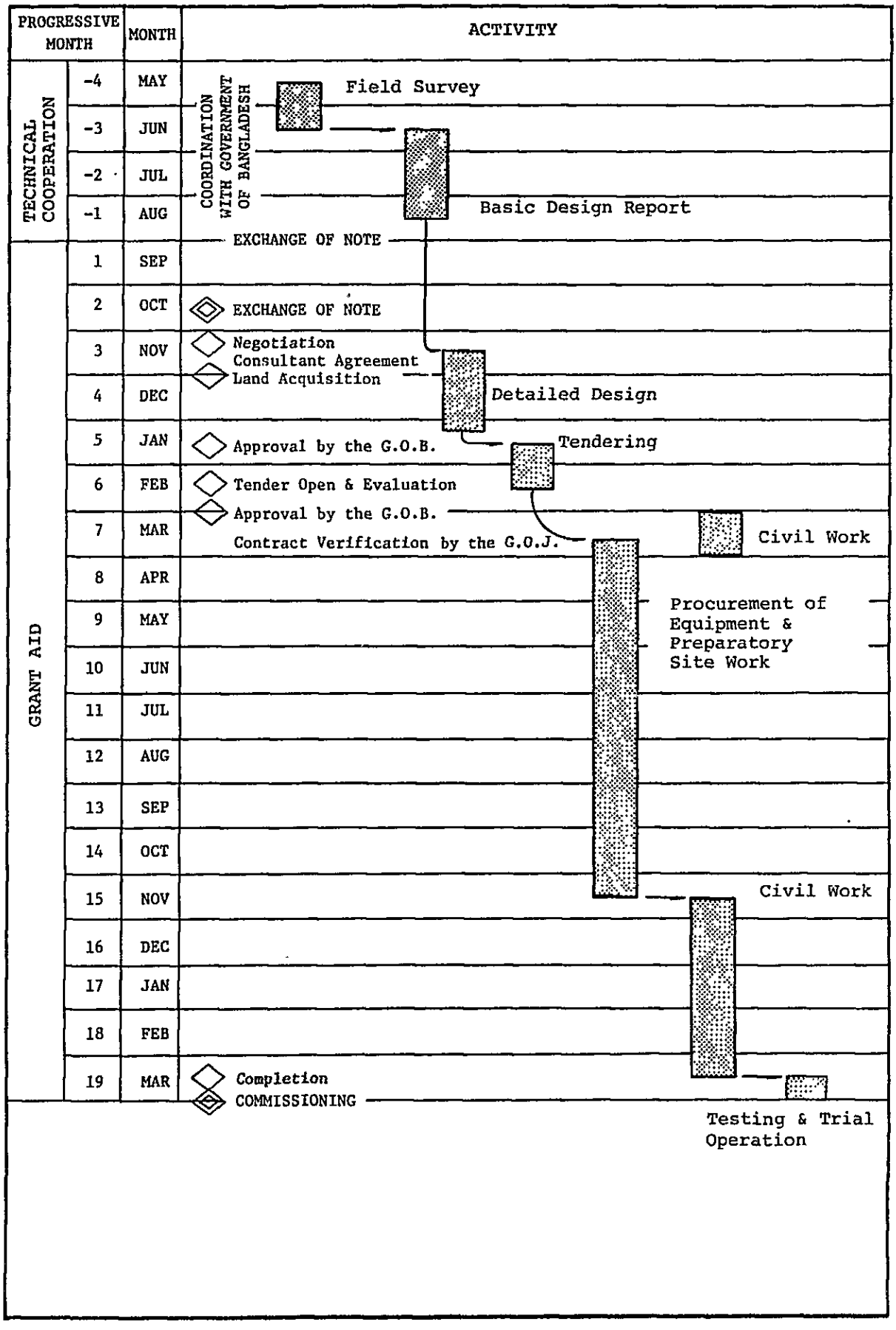


FIG-11 PROJECT ORGANIZATION CHART

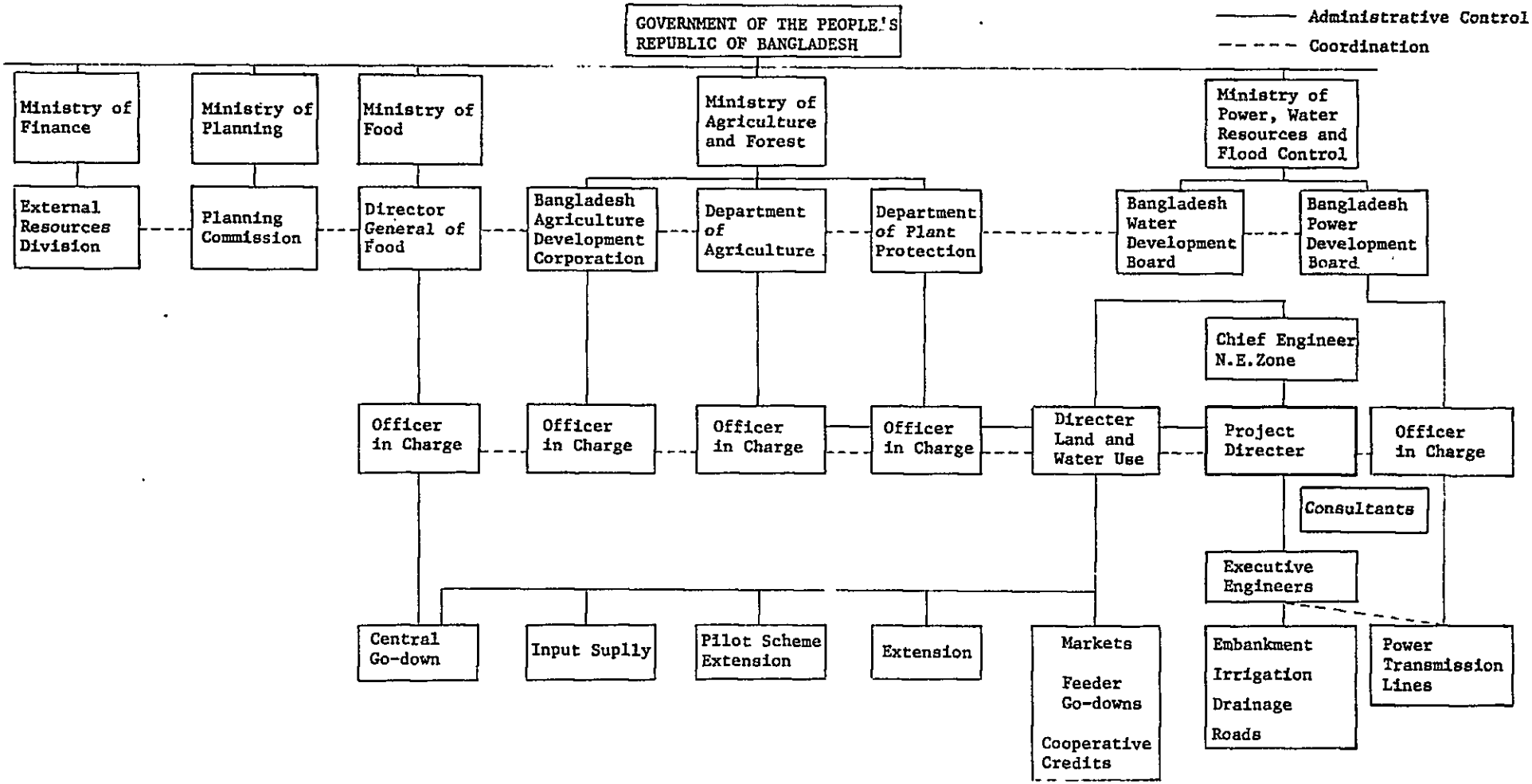
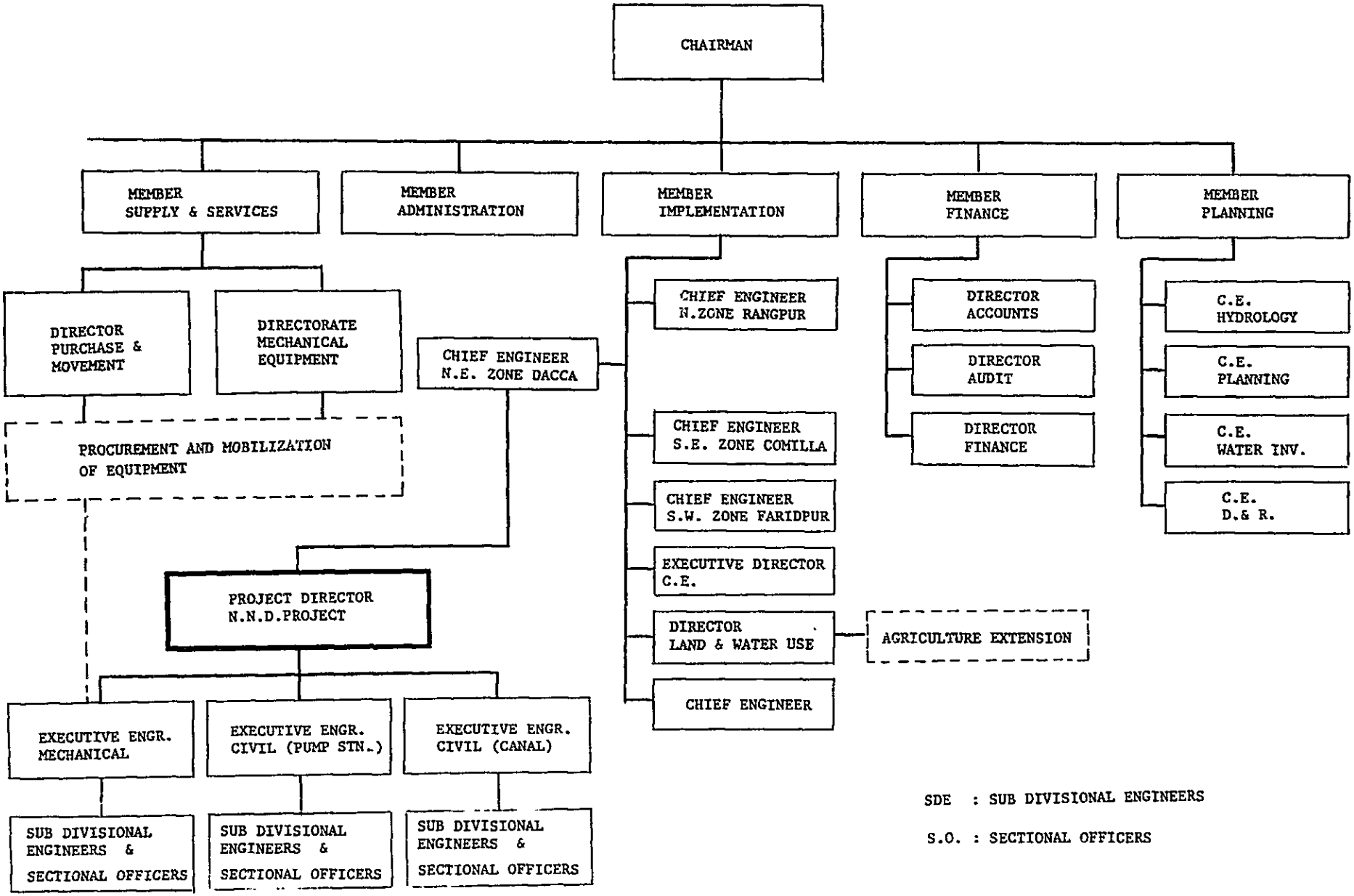


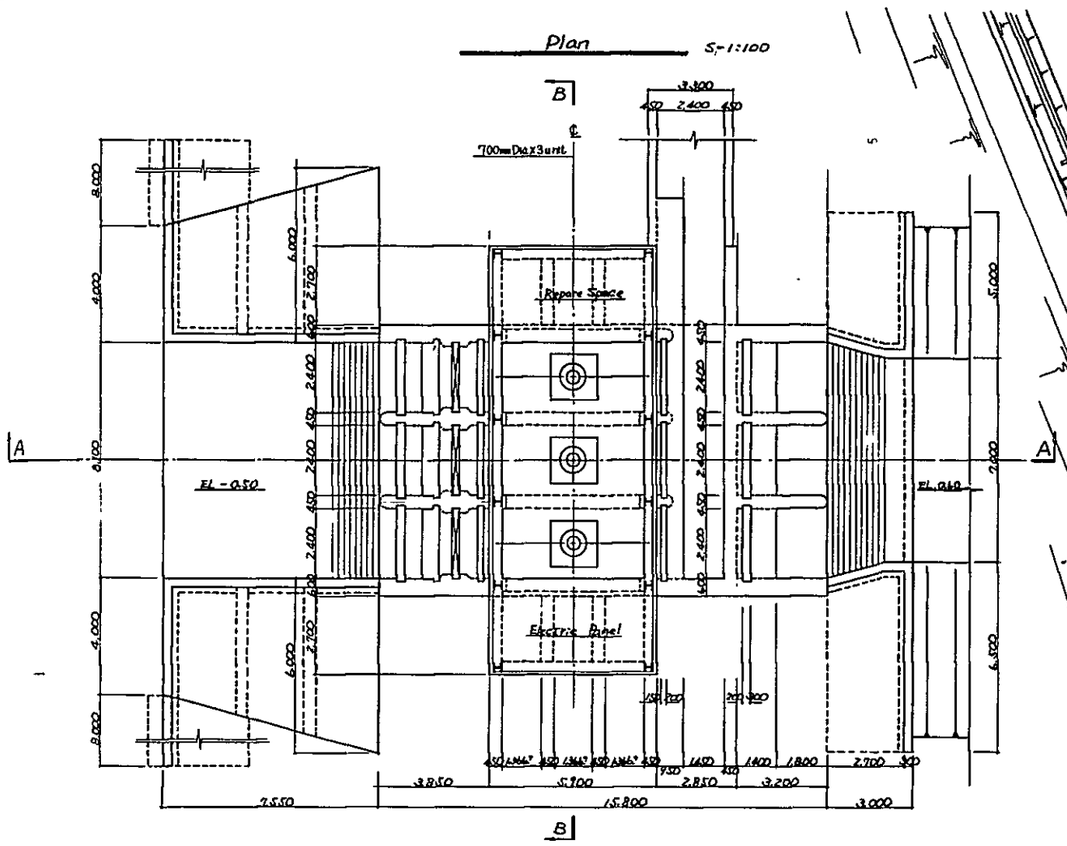
Fig-12 BANGLADESH WATER DEVELOPMENT BOARD



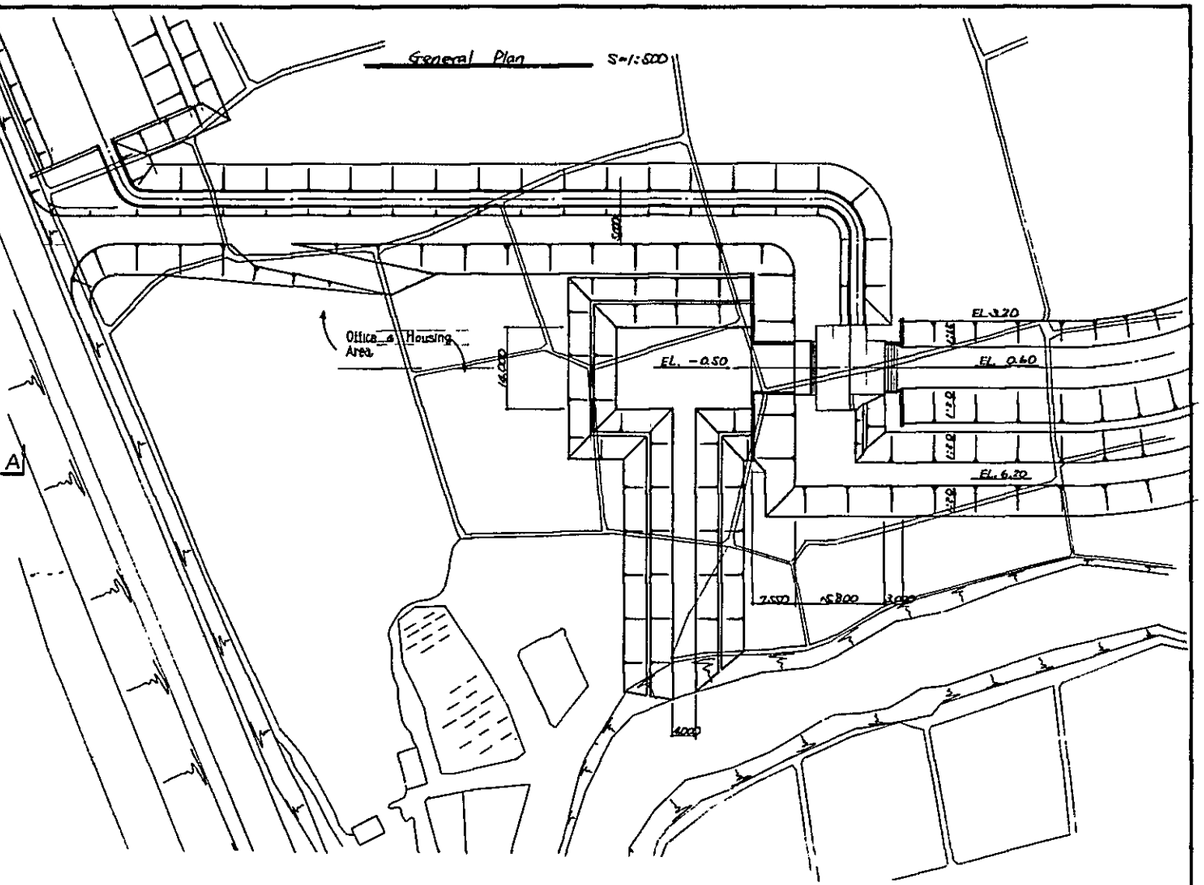
SDE : SUB DIVISIONAL ENGINEERS

S.O. : SECTIONAL OFFICERS

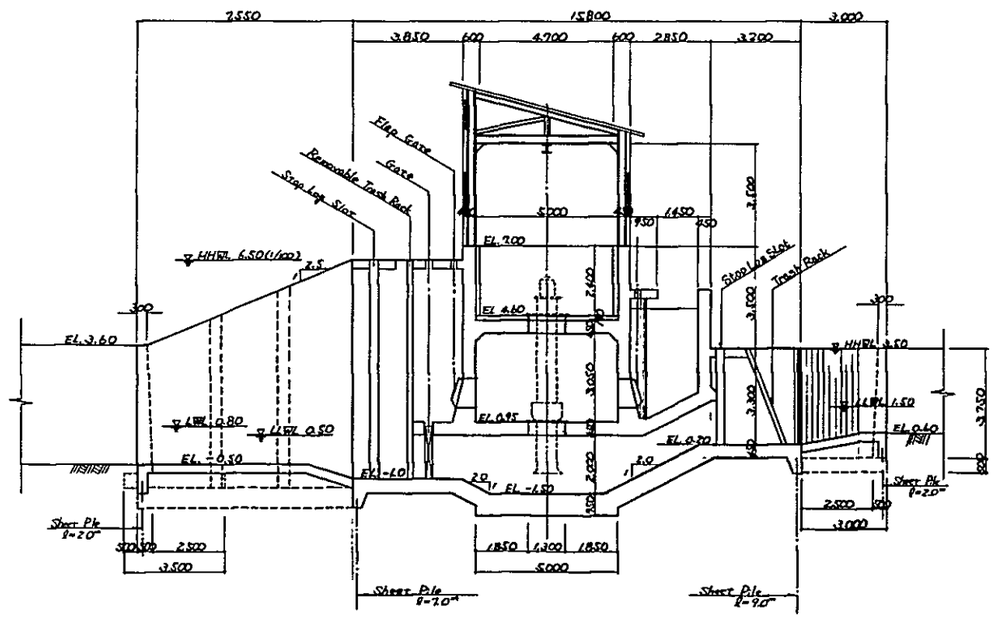
Plan S=1:100



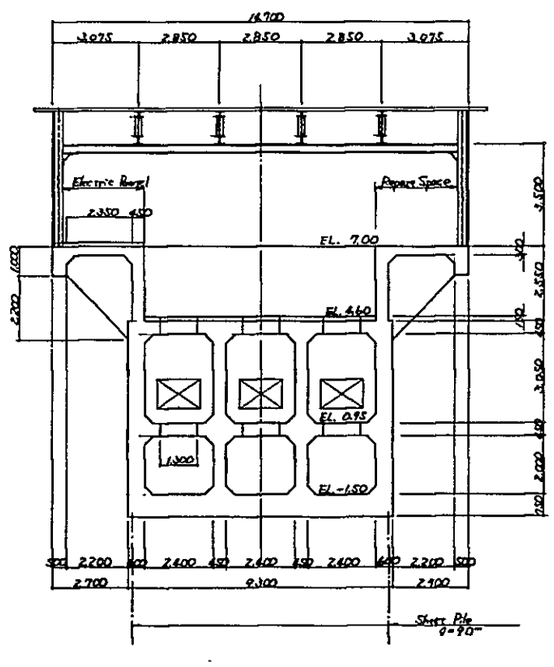
General Plan S=1:500



A-A Section S=1:100



B-B Section S=1:100



8.00"
6.00"
4.00"
2.00"
MSL 0.00"
-2.00"

NARAYANGANJ-NARSINDDI IRRIGATION PROJECT
BANGLADESH WATER DEVELOPMENT BOARD

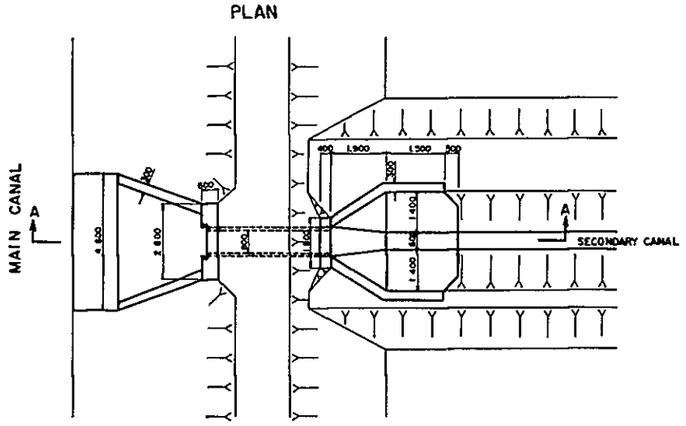
PUMPING STATION

DATE AUG. 1981 | DWG NO.

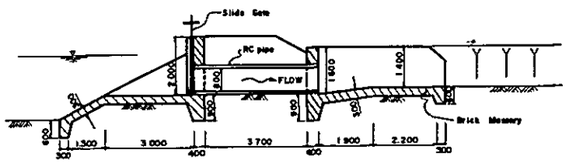
JAPAN INTERNATIONAL COOPERATION AGENCY

TYPICAL TURNOUT FOR SECONDARY CANAL

PLAN

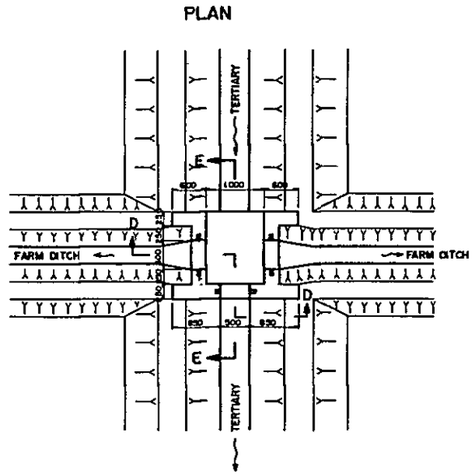


SECTION A - A

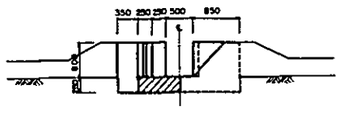


TYPICAL DIVISIONBOX FOR FARM DITCH

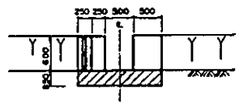
PLAN



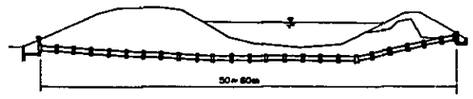
SECTION D - D



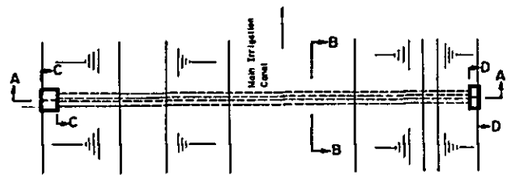
SECTION E - E



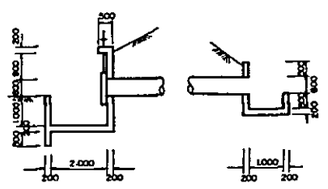
CROSS SECTION



PLAN



SECTION A - A



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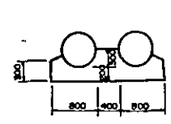
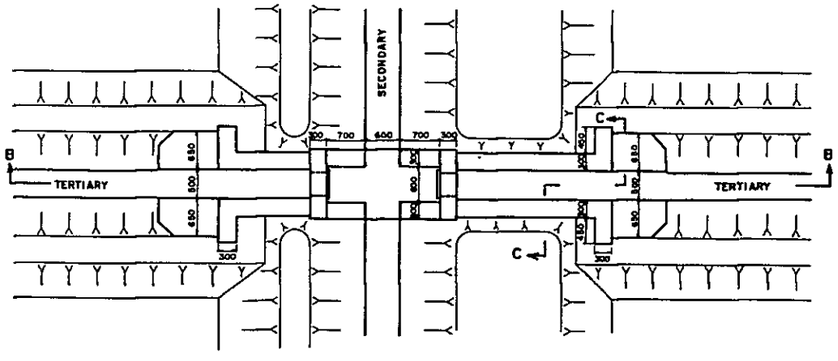


TYPICAL TURNOUT FOR TERTIARY CANAL

PLAN



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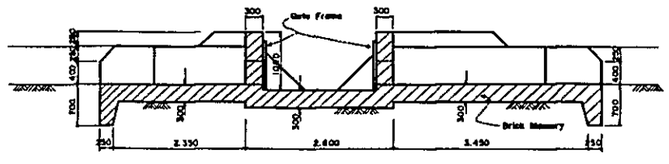

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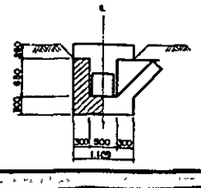

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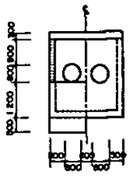

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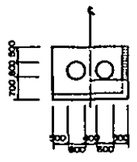


NARAYANGANJ - NARSINGDI IRRIGATION PROJECT
BANGRADESH WATER DEVELOPMENT BOARD

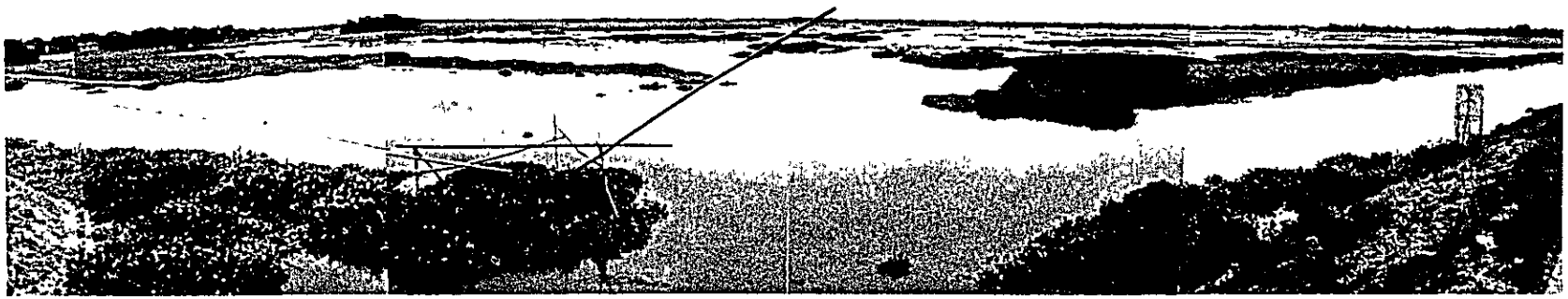
TYPICAL RELATED STRUCTURES

DATE AUG 1981 | DWG NO.

JAPAN INTERNATIONAL COOPERATION AGENCY

PHOTOGRAPHS

Proposed Pump Station Site (Jatramura, July 1981)



Panoramic View of Heart of Demonstration Unit (D-N Road near Barba, July 1981)

Collected Data

Collected Data

[1] Guideline on Agro-Economic Analysis in Project Feasibility Studies. Dacca: East Pakistan Water & Power Development Authority, 1970.

[2] Dacca-Narayanganj-Derma Irrigation Project. Dacca: East Pakistan Water & Power Development Authority, 1961.

[3] The Dacca-Narayanganj-Derma Irrigation Project Phase I; A Socio-Economic Study. Dacca: East Pakistan Water & Power Development Authority, 1966.

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[10] Materials Testing Report; Dacca-Narayanganj-Derma Irrigation Project (soil-1[62], soil-11[63], soil-17[63]). Dacca: East Pakistan Water & Power Development Authority, 1962-63.

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