REPORT
ON
DETAILED DESIGN WORKS
FOR
MODEL INFRASTRUCTURE IMPROVEMENTS
OF
THE INSTITUTE OF POSTGRADUATE STUDIES
IN AGRICULTURE
IN
BANGLADESH

APRIL 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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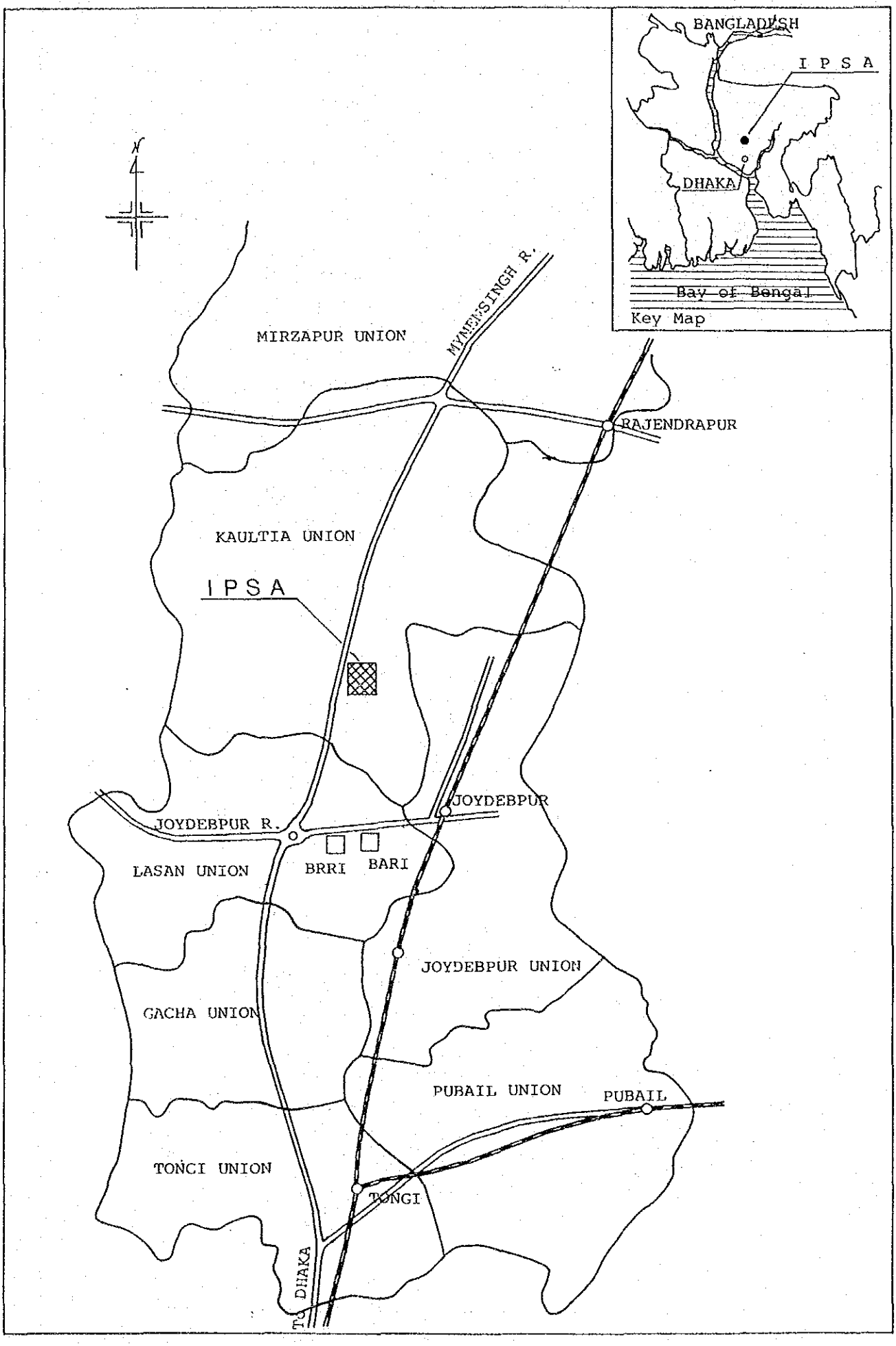
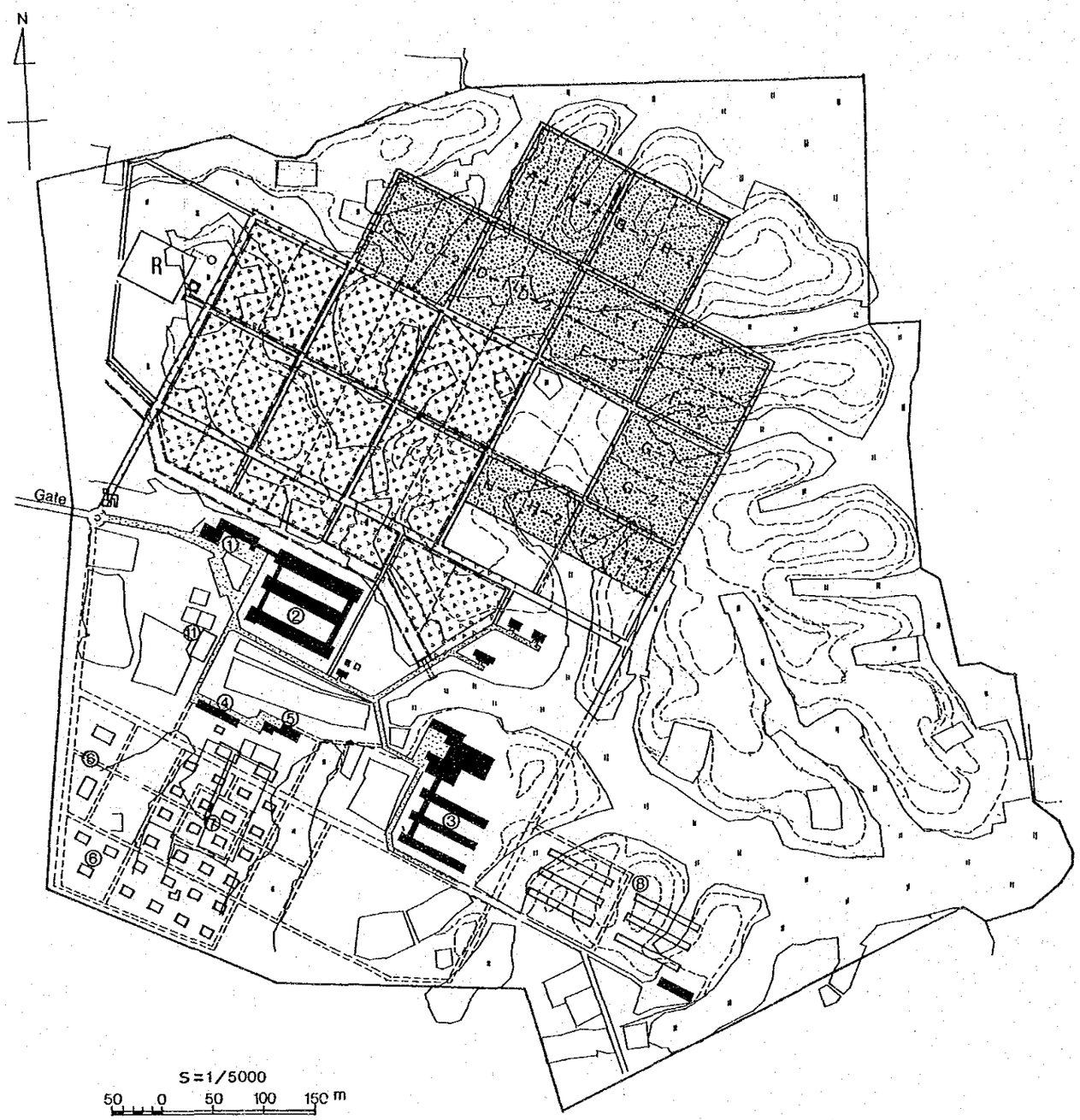
LOCATION MAP



INSTITUTE OF POST-GRADUATE STUDIES IN AGRICULTURE

GENERAL PLAN



LEGEND

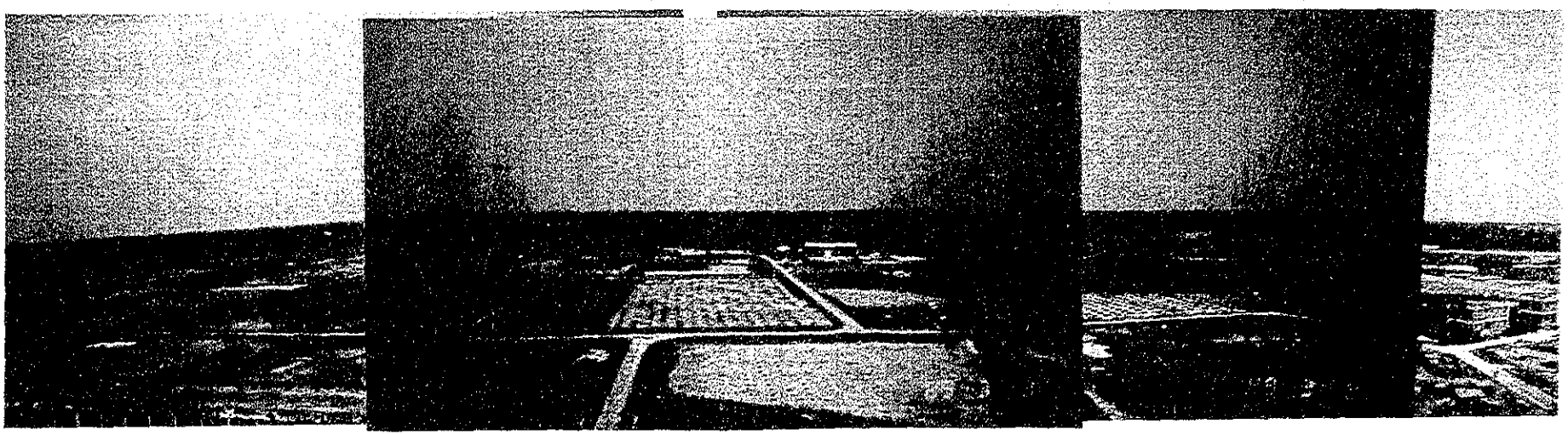
Experimental Field
- U-Upland Field
- O-Orchard Field
- P-Paddy Field

Buildings
- ■ Existing Bldg
- □ Proposed Bldg
- ① Functional Bldg
- ② College Bldg
- ③ Hostel Bldg
- ④ Workshop
- ⑤ Comunity Facilities
- ⑥ Residential Bldg (Officer)
- ⑦ Residential Bldg (Staff)
- ⑧ Residential Bldg (Labor)
- ⑨ Farm Machinery Center
- ⑩ Green House
- ⑪ Library

Irrigation and Drainage Facilities
- ○ Deep Weel Pump
- ⊠ Irrigation Pump
- [R] Reservoir
- ---- Irrigation Pipeline
- ---- Farm Drain
- ⊏⊐ Box Culvert
- ⊏⊐ Pipe Culvert

Road
- ═ Main Road
- ═ Secondary Road

- Existing Area
- Proposed Area to be constructed



1. Proposed experimental farm (8.0 hectares)

2. Discrission with Bangladesh staffs

3. Existing experimental farm

4. Survey the proposed experimental farm

5. Soil profile

ABBREVIATIONS

MAF	Ministry of Agriculture and Forestry
MP	Ministry of Planning
BARI	Bangladesh Agricultural Research Institute
BRRI	Bangladesh Rice Research Institute
BJRI	Bangladesh Jute Research Institute
BTRI	Bangladesh Tea Research Institute
FRI	Forest Research Institute
INA	Institute of Nuclear Agriculture
BARC	Bangladesh Agricultural Research Council
CERDI	Central Extension Resources Development Institute
BADC	Bangladesh Agricultural Development Corporation
SCCA	Seeds Certification Center of Agriculture
BAU	Bangladesh Agricultural University
BAC	Bangladesh Agricultural Institute
IPSA	Institute of Post-graduate Studies in Agriculture
BCAS	Bangladesh College of Agricultural Sciences
USAID	United States Agency for International Development
ADC	Agricultural Development Council
ERD	External Resource Department
PC	Planning Commission
PIET	Project Implementation Evaluation Team
CASR	Committee of Advance Studies and Researches

DG	Director General
DC	Deputy Commissioner
Sec.	Secretary
Add. Sec.	Additional Secretary
Jot. Sec.	Joint Secretary
Dep. Sec.	Deputy Secretary
CSO	Chief Scientific Officer
PSO	Principal Scientific Officer
SSO	Senior Scientific Officer
SO	Scientific Officer
Prof.	Professor
Assoc. Prof.	Associate Professor
Asstt. Prof	Assistant Professor
Res. Assoc.	Research Associate
D/D	Detailed Design
R/D	Records of Discussion
T/R	Terms of Reference
PPP	Preliminary Project Proforma
GAPP	Grant Assistance Project Proposal
TAPP	Technical Assistance Project Proposal

CONTENTS

Chapter 1 Survey Objectives

Chapter 1 Survey Objectives

1-1 Survey Objectives

The technical cooperation in model infrastructure improvement for the Institute of Postgraduate Studies in Agriculture (IPSA) started from 1985 with the cooperation of JICA. In July 1986, the experimental farm of 7.8 hectares was completed in IPSA. In accordance with the expansion of experimental activities and organization in IPSA, a demand for increasing the experimental farm is considered. In the dry season of 1988/1989, an experimental farm of 15.8 hectares will be needed. As consequent, 8.0 hectares of experimental farm will be a newly constructed.

The objectives of this survey are firstly to select a suitable site for the new experimental farm, and to conduct site survey, data collection and detailed design of the Model Infrastructure together with preparation of contract documents for the implementation of construction works.

1-2 Member List and Progress of the Survey

Member list of the survey team and progress of the survey are shown in Appendix-1, 2.

1-3 Major Persons Involved

Major persons involved in the survey are shown in Appendix-3.

Chapter 2 Present Conditions

Chapter 2 Present Conditions

2-1 Climate

Meteorological data listed below at Dhaka and Joydebpur are collected, which results are shown in Table 2-1.

Dhaka : Average monthly temperature, Relative humidity, Rainfall, Sunny days, Sunshine hours, Wind velocity and Maximum daily rainfall.

Joydebpur (BARI) : Average monthly rainfall, Maximum daily rainfall, Rainfall days, Temperature, Relative humidity and Pan evaporation.

2-2 Topography

The proposed location of the new experimental farm is at the north-eastern part of the existing experimental farm completed in July 1986. Its topographical feature is hilly and undulating, and the slope is descending to the north and the east with a difference of 3.0 to 4.0 meters at an incline of 1/200 degrees. Most of hilly parts are not used but low lands are almost used as paddy fields with rainwater.

2-3 Soil

Soil profiles of 8 open pits as shown in Fig. 2-1 have been observed and these resutls are summarized in Table 2-2. In general, no important differences among them and existing farms could be recognized. The surface soil is silty clay loam to clay in texture and the subsoil is clay or clay with strong plasticity.

2-4 Land Use

The present land use of the campus is detected in the following table:

Present Land Use

Item	Area in ha (percentage)	
Building area	6	(7%)
Experimental farm	9	(11%)
Paddy field	22	(28%)
Others	43	(54%)
Total	80	(100%)

2-5 Drainage

Drainage network in and around the campus is shown in Fig. 2-2. There exist two water routes flowing from the west through the western border of the campus to the east, into a natural stream started from the eastern corner.

Table 2-1 Meteorological Data (1/4)

Item Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Temperature (°C)	18.6	20.7	25.7	29.3	29.6	28.8	28.4	28.6	31.0	27.3	23.1	19.5	25.9
Relative Humidity (%)	76	68	65	72	84	87	88	88	87	84	79	81	80
Rainfall (mm)	18.8	31.2	58.2	102.66	194.3	321.8	436.9	304.8	235.7	168.6	25.4	2.3	1900.6
Sunny Days (day)	18.4	15.3	10.9	3.6	1.8	0.2	0.0	0.0	0.1	4.2	11.5	15.8	81.8
Sunshine hour (hr/day)	6.85	7.37	7.37	7.30	7.02	5.24	4.20	5.05	4.15	6.15	–	7.47	68.17
Wind Velocity (m/sec)	1.4	1.6	2.6	3.7	4.4	3.8	3.9	3.3	3.4	2.5	1.4	1.5	2.8

Data : Bangladesh Meteorological Department
Station : Dhaka

Table 2-1 Meteorological Data (2/4)

Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	1981	3.3	51.3	61.2	314.7	–	–	307.5	434.0	190.7	14.0	10.0	26.7
	1982	0.0	5.0	160.0	222.0	194.1	515.6	155.3	275.1	150.9	31.0	28.4	0.0
Monthly	1983	–	–	129.0	167.2	312.3	313.1	216.1	445.8	407.7	393.5	0.0	21.2
Rainfall	1984	1.8	0.0	0.0	99.4	595.5	516.6	571.6	389.0	427.2	217.0	0.0	0.0
(mm/month)	1985	2.5	–	67.0	96.5	274.0	403.8	210.7	227.5	254.3	30.5	0.0	5.5
	1986	6.0	10.5	33.8	172.0	260.5	355.5	271.7	280.2	517.0	446.3	139.5	1.0
	1987	0.0	0.0	51.0	182.0	143.5	328.5	664.5	481.0	378.8	95.5	25.5	29.8
	1988	0.0	71.5	47.5	143.9	695.7	435.0	485.2	261.4	202.2	300.8	175.5	1.0
	Ave.	1.9	23.1	68.7	174.7	353.7	409.7	360.3	349.3	316.1	191.1	47.4	10.7
	1981	–	20.8	20.0	92.2	–	–	54.5	118.5	40.5	14.0	10.0	24.4
Maximum	1982	0.0	5.0	59.0	74.3	100.4	119.5	46.0	57.5	68.0	25.0	21.5	0.0
Daily	1983	–	–	60.0	66.0	64.2	111.0	51.0	112.0	109.0	147.5	0.0	19.2
Rainfall	1984	1.8	0.0	0.0	43.0	129.0	133.4	150.0	101.0	135.0	40.0	0.0	0.0
(mm/day)	1985	–	–	38.5	21.8	–	70.0	43.5	57.0	50.0	22.0	–	5.5
	1986	6.0	6.5	21.5	51.3	111.5	125.0	75.0	44.0	122.0	227.0	110.0	1.0
	1987	–	–	30.0	46.0	39.0	101.0	175.0	108.5	93.5	56.5	25.5	16.5
	1988	0.0	40.0	17.5	32.0	89.5	56.5	70.0	64.0	30.0	131.5	115.5	2.1
	1981	2	5	10	14	–	–	18	22	13	1	4	2
	1982	0	2	5	12	10	13	14	14	10	2	2	0
Rainfall	1983	–	–	5	9	13	12	9	19	20	9	0	2
days per	1984	1	0	0	6	14	16	19	20	13	9	0	0
month	1985	–	–	6	11	–	25	24	21	22	3	–	1
	1986	1	2	3	14	14	15	18	19	21	8	5	1
	1987	–	–	5	10	7	14	22	19	18	2	1	2
	1988	0	3	5	6	19	18	21	20	12	7	3	1
	Ave.	1	2	5	10	13	16	18	19	16	5	2	1

Table 2-1 Meteorological Data (3/4)

Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature (°C)	1981	19.8	21.6	25.2	27.4	–	–	29.0	29.4	29.0	28.7	24.4	20.8
	1982	21.0	22.1	26.6	29.0	30.9	29.6	30.3	29.5	30.1	28.7	23.4	20.9
	1983	–	–	28.8	28.7	29.7	30.5	30.7	29.7	29.6	28.9	25.3	19.8
	1984	19.5	21.8	28.0	29.5	28.1	28.8	28.5	28.9	28.3	29.0	24.4	20.6
	1985	19.1	21.1	27.5	28.6	28.1	29.0	28.5	29.2	28.7	27.4	23.5	20.5
	1986	19.0	21.1	26.4	27.1	28.1	29.4	28.6	29.3	27.9	27.3	24.4	20.6
	1987	18.6	22.4	25.4	27.6	29.1	29.9	29.0	28.6	29.3	28.0	23.5	20.0
	1988	18.2	21.0	24.3	27.8	28.4	27.5	27.9	27.8	28.0	26.5	22.9	19.7
	Ave.	19.3	21.6	26.5	28.2	28.9	29.2	29.1	29.1	28.9	28.1	24.0	20.4
Relative Humidity (%)	1981	68.6	65.9	63.6	71.6	–	–	78.9	75.4	70.7	61.6	60.8	59.1
	1982	–	63.1	69.3	71.0	71.7	83.2	81.8	80.3	76.9	70.7	67.2	66.3
	1983	–	–	70.1	70.0	76.1	78.6	80.6	80.6	80.6	76.5	66.8	65.4
	1984	65.6	63.0	66.4	74.1	82.8	83.6	86.9	85.5	84.2	81.9	77.9	75.2
	1985	70.5	63.5	69.0	74.5	79.0	83.5	85.0	81.5	81.0	70.0	65.5	63.5
	1986	65.0	52.5	69.0	70.0	69.0	74.0	81.5	80.0	82.0	76.0	71.5	68.0
	1987	65.0	62.5	61.0	71.0	68.0	79.0	83.0	82.5	80.5	71.0	70.5	68.5
	1988	66.4	65.9	66.3	68.8	76.7	79.4	79.4	80.1	76.1	71.8	69.0	69.0
	Ave.	66.9	62.3	66.8	71.4	74.8	80.2	82.1	80.7	79.0	72.4	68.7	66.9
Pan Evaporation per day (mm/day)	1981	3.0	4.1	7.3	8.7	–	–	3.5	3.2	4.4	3.2	3.0	2.4
	1982	2.4	3.4	4.4	7.8	–	–	–	–	–	–	–	–
	1983	2.5	3.8	5.0	5.9	5.6	4.4	6.2	6.0	3.6	3.7	2.8	2.0
	1984	1.2	1.9	1.3	1.6	2.1	–	–	–	–	–	–	–
	1985	1.2	1.9	1.3	1.6	2.1	–	–	–	–	–	–	–
	1986	–	4.8	5.5	6.3	5.8	5.0	4.4	5.5	4.0	5.3	3.9	3.5
	1987	2.6	3.3	4.5	5.2	5.9	5.0	5.3	4.1	4.5	3.6	2.8	1.9
	1988	2.0	2.0	3.3	3.8	3.1	3.8	4.1	3.5	3.7	3.6	2.8	3.0
	Ave.	2.1	3.2	4.1	5.1	4.1	4.6	4.7	4.5	4.0	3.9	3.1	2.6

Table 2-1 Meteorological Data (4/4)

Year	Month	Date	Maximum Daily Rainfall	Remarks
1953	7	5	90	
1954	6	24	147	
1955	6	14	115	
1956	7	14	326	
1957	7	1	73	
1958	8	5	137	
1959	9	12	125	
1960	5	23	141	
1961	6	21	185	
1962	9	9	116	
1963	6	19	189	
1964	7	17	114	
1965	5	12	177	
1966	9	16	257	Design Rainfall
1967	4	20	125	
1968	6	15	145	
1969	8	19	86	
1970	7	13	152	
1971	7	22	251	
1972	5	25	231	
1973	9	18	168	
1974	–	–	–	
1975	9	17	143	
1976	6	8	163	
1977	10	4	100	
1978	6	26	128	
1979	10	7	108	
1980	10	18	91	
1981	6	8	83	
1982	6	30	105	
1983	8	3	128	
1984	7	15	151	
1985	6	1	70	
1986	11	8	227	
1987	7	31	175	
1988	10	19	132	

Data : Bangladesh Meteorological Department
Station : Dhaka, 1953 - 1988

Table 2-2 Soil Profile (1/2)

Depth (cm)	A	B	C	D
No.	A	B	C	D
Land Use	Cutover	Cutover	Cutover	Cutover
Topography	Terrace almost level	Terrace less than 5°	Terrace almost level	Terrace almost level
0	1. dry yellow orange 30~31	1. dry bright yellowish brown 33~35	1. dry pale yellow 33~35	1. dry bright yellowish brown 34~35
	2. half dry bright yellowish brown 25~28	2. half dry bright yellowish brown 27	2. half dry bright yellowish brown 31~33	2. half dry bright yellowish brown 30~31
			3. wet bright yellowish brown 24~28	
50	3. wet bright yellowish brown 25~28	3. wet yellow organge 25	4. wet yellowish brown 23~24	3. wet yellowish brown 26~28
	4. wet grayish yellow brown 20~22	4. wet yellowish brown 24~26	5. wet yellowish brown 21~23	4. wet yellowish brown 25~27
		5. wet yellowish brown 24~25		
100				

Note) Figures indicate the hardness of soil with YAMANAKA durometer

Table 2-2 Soil Profile (2/2)

No.	E	F	G	I
Land Use	Paddy field	Cutover	Upland field	Upland field
Topography	Terrace level	Terrace almost level	Terrace less than 5°	Terrace almost level
Depth (cm) 0	1. dry pale yellow 31~33	1. dry bright yellowish brown 30~32	1. dry pale yellow 33~34	1. dry pale yellow 34~35
	2. half dry bright yellowish brown 26~30	2. dry bright yellowish brown 30~31	2. half dry bright yellowish brown 27~29	2. half dry bright yellowish brown 27~30
	3. wet bright yellowish brown 21~23	3. half dry bright yellowish brown 30	3. wet bright yellowish brown light gray 24~26	3. wet bright yellowish brown 26~27
50	4. wet bright yellowish brown 19~21	4. wet bright yellowish brown 28~30 light gray		4. wet bright yellowish brown 22~25
	5. wet bright yellowish brown brownish gray 21~25	5. wet bright yellowish brown 25~26 light gray	4. wet bright yellowish brown light gray 22~23	
100				

Note) Figures indicate the hardness of soil with YAMANAKA durometer

Fig. 2－1 Point of Soil Sampling

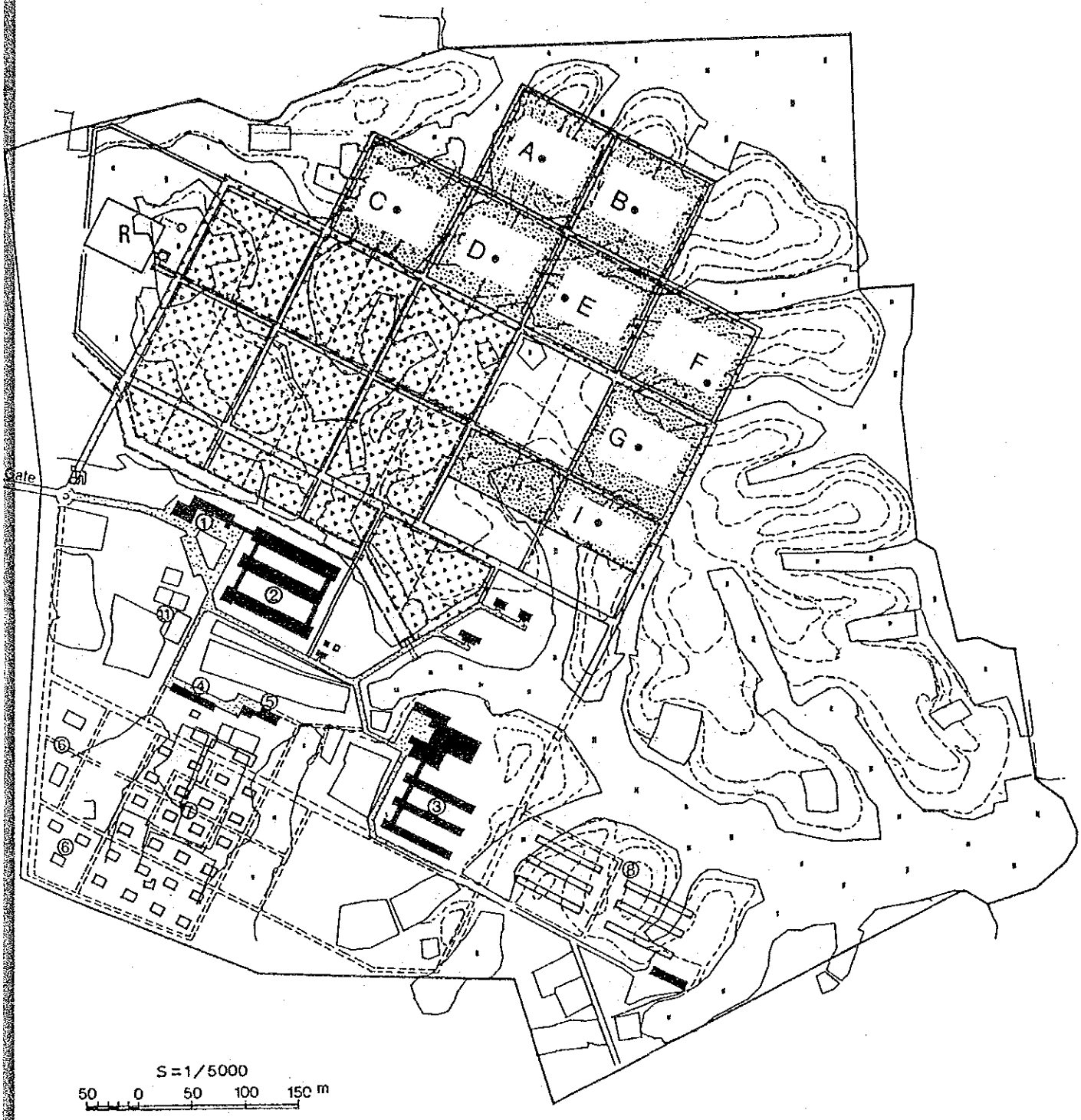
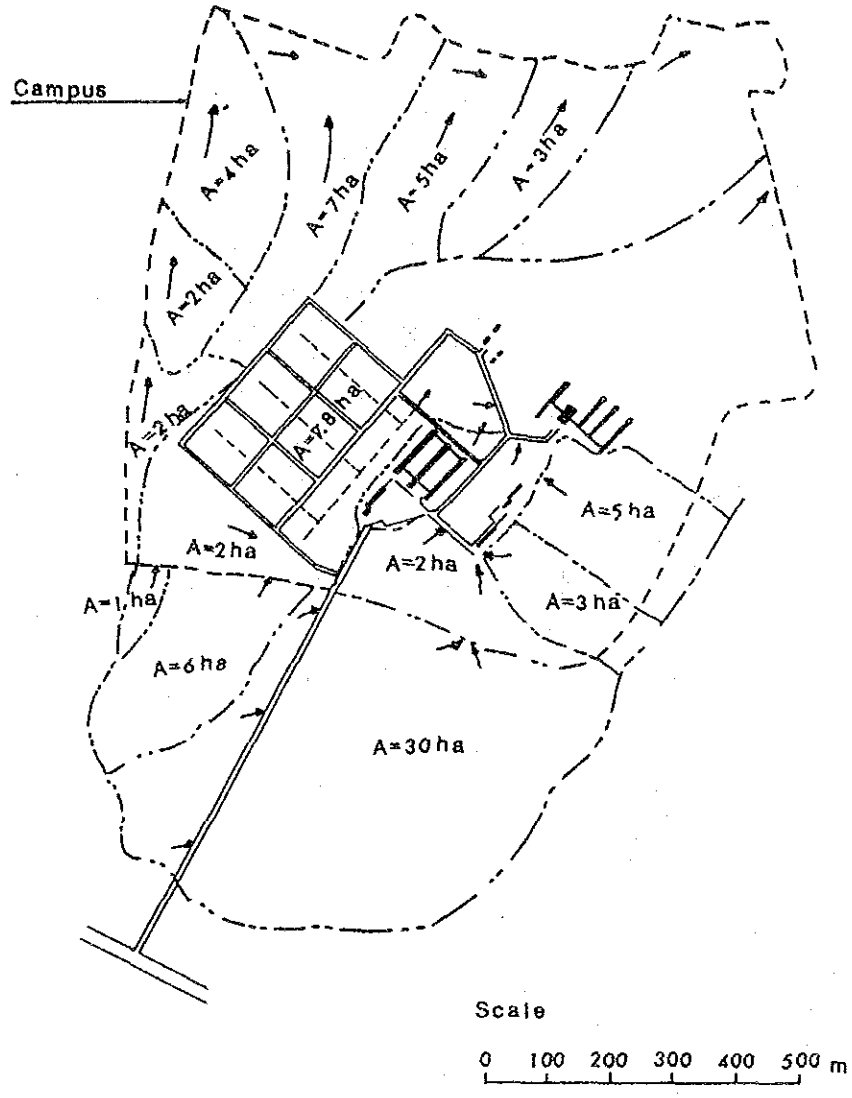


Fig. 2-2 Drainage Wter Shed Around the Campus



Chapter 3 Design Principles

Chapter 3 Design Principles

3-1 Background

The technical cooperation in the Institute of Postgraduate Studies in Agriculture (IPSA) has been conducted since 1985 with the cooperation of JICA. In July 1986, the experimental farm of 7.8 hectares was completed in IPSA. In accordance with the expansion of experimental activities and organization in IPSA, a demand for increasing the experimental farm is considered accordingly. In the dry season of 1988/1989, an experimental farm of 15.8 hectares would be needed. As per consequent, 8.0 hectares of experimental farm will be subjected to a new construction.

3-2 Design Principles

Design principles of experimental farm are as follows. (Appendix 8-4).

(1) Location of the experimental farm

Location of the proposed experimental farm is to be made in the eastern and northern parts of the existing experimental farm.

(2) Scale of the experimental farm

The area of the new experimental farm will be 8.0 hectares consisted of 6.0 hectares for rice and/or upland crops and 2.0 hectares for orchard field.

(3) Design principles

a) Farm block and land consolidation work

The farm block will be designed as one hectare (100m×100m). As for land leveling, the surface of the field block surrounding roads and drainage canals will be evenly leveled. Soil dressing work with sand will be planned for the whole new experimental field.

b) Road plan

Main road with 7.0 m width and secondary road with 4.0 m width will be planned. The pavement of the main and secondary roads will not be planned in this work.

c) Drainage plan

Drainage canal for the internal surface water will be planned in the center of the farm block. The pipe culverts will be designed to cross the road. Pipe drainage system will be planned in G-2 plot (0.5 ha) as a demonstration.

d) Irrigation plan

Irrigation water for the new experimental farm will be intaken from the existing deep well and the reservoir by utilizing the existing deep well pump and booster pump. Pipeline system to supply irrigation water to the field will be adopted for the proposed new experimental farm. Sprinkler irrigation system will be proposed for the new experimental farm and this system will be also utilized for flood irrigation.

Chapter 4 Detailed Design of the Experimental Farm

Chapter 4 Detailed Design of the Experimental Farm

4-1 Location of the Experimental Farm

The experimental farm of about 8.0 hectares will be developed in this stage. However, IPSA will have the total experimental farm of more than 21.0 hectares in the future. As a matter of fact, there is a necessity for considering the whole development plan of the experimental farm.

About thirty (30) hectares already purchased by IPSA in the eastern and northern parts of the existing experimental farm could be considered for the new experimental farm.

Eight (8.0) hectares for the new experimental farm are, therefore, to be made in the eastern and northern parts of the existing experimental farm as shown in Fig. 4-1 based on following considerations:

i) The farm machinery center was constructed in the eastern and northern parts of the existing experimental farm, and these farm machinery center will be planned as the center of the whole experimental farm.

ii) Existing irrigation facilities such as deep well pump, reservoir and booster pump will be used also for the new experimental farm.

4-2 Land Consolidation Work

1. Farm Block

As per standard, the size of field plot will be designed at 0.5 ha with length of 100 m and width of 50 m. The designed farm plot will be consisted of two field plots. The field drain canal will be planned in the center of the farm plot. Criteria are considered as follows.

i) Criteria for the existing experimental farm will be used also for the new experimental farm.

ii) Most of experimental studies are conducted in small scale plots in BARI, BRRI, BAU and IPSA.

Fig. 4－1 Location of Experimental Field

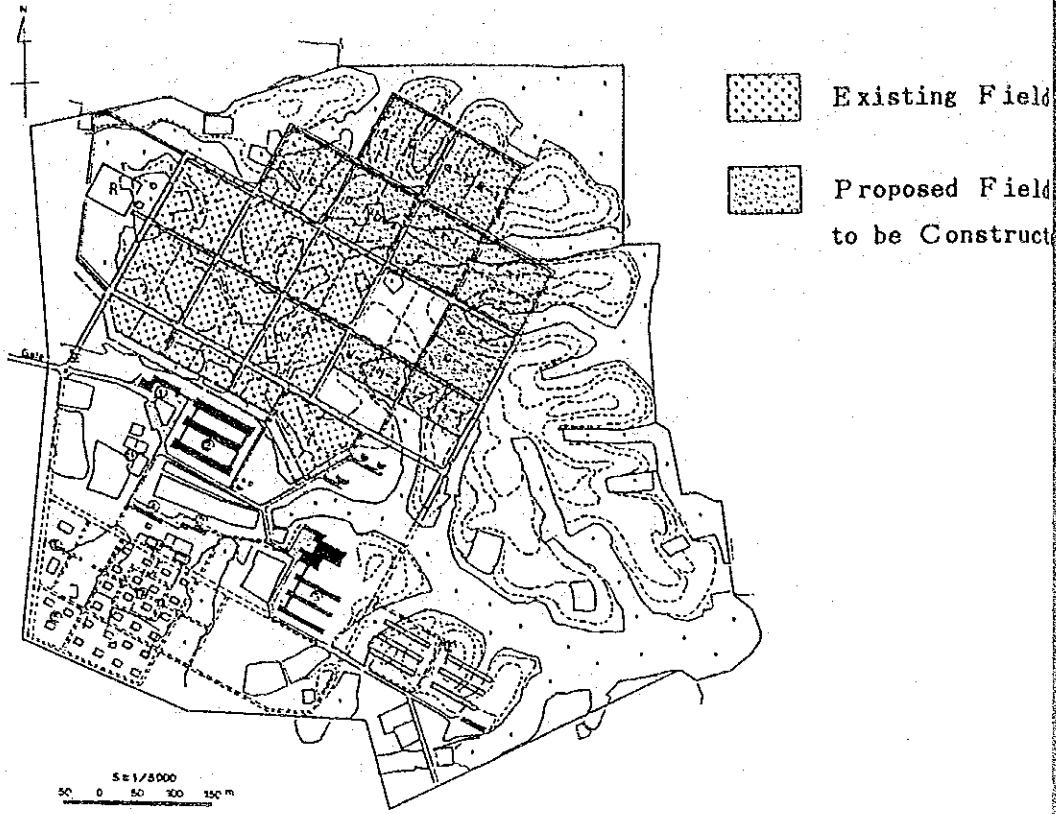
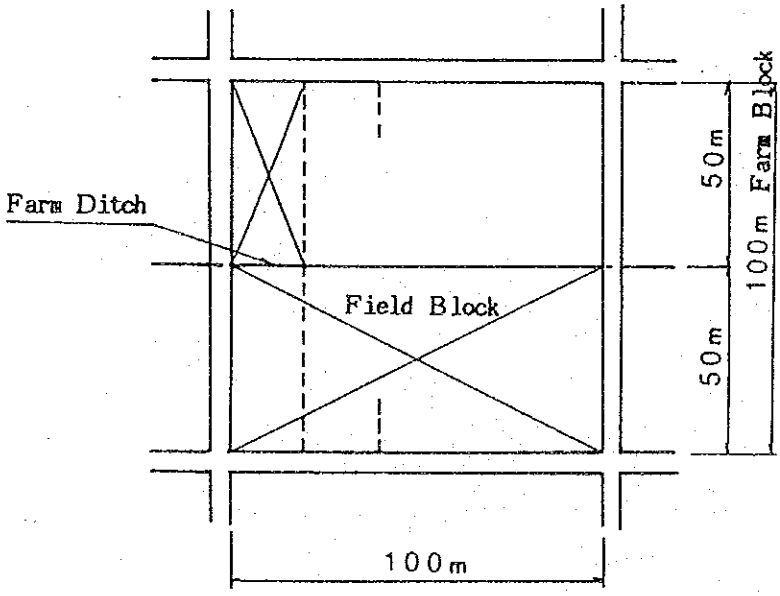


Fig. 4－2 Standard Farm Block



iii) Most of machines such as tractor and plow used in the field are of medium-size.

iv) Irrigation method for the experimental farm will be planned as sprinkling system with portable pipes.

2. Land consolidation Work

As for land leveling, the surface of the field block surrounding roads and drainage canals will be evenly leveled in order to avoid soil erosion.

Surface soil handling is not necessarily applied to the whole area due to its poor content of hums, according to the result of field survey.

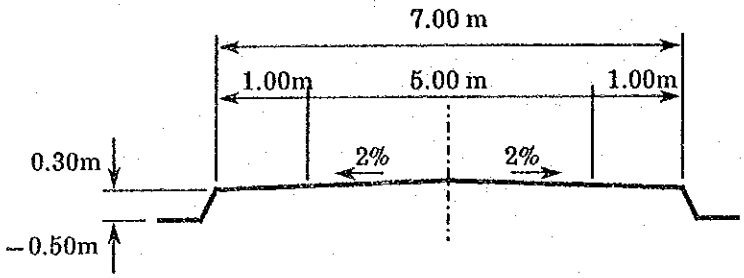
Soil dressing work with sand will be planned for the whole new experimental field in order to uniform the soil condition after land consolidation. As with the land leveling of the field block, its surface soil such as silty clay loam to clay will be mixed with the subsoil such as clay or clay with strong plasticity.

4-3 Road Plan

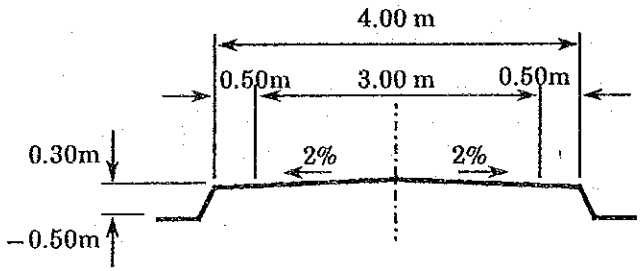
Main and secondary roads will be planned and connected with existing main and secondary roads. The interval of secondary roads will be made at 100 meters, and perpendicularly connected to the main road. The effective width is 5.0 meters for the main road and 3.0 meters for secondary roads as shown in Fig. 4-3. The elevation of road surface for the main road and secondary roads shall be 50 cm and 30 cm above the field surface, respectively. The banking slope shall be at the ratio of 1:1.5 with sodding.

Fig. 4-3 Standard Section of Road

Main Road



Secondary Road



4-4 Irrigation Plan

1. Water requirement

(1) Irrigable area

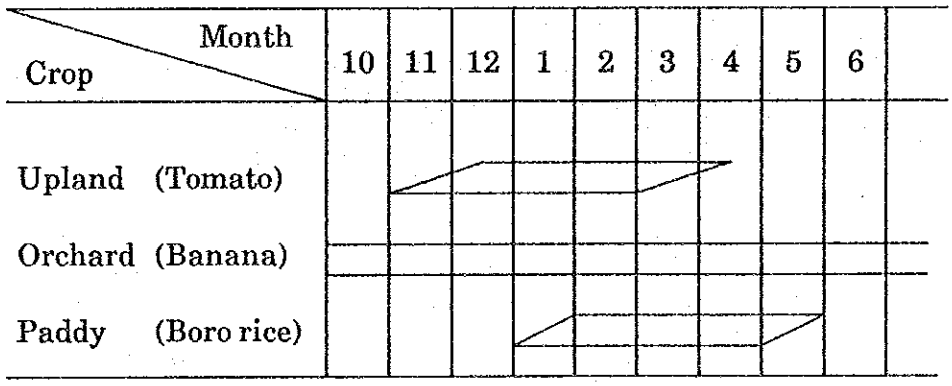
The total farm area to be constructed as the experimental farm amounts to 15.8 hectares composing of an upland field of 11.8 hectares, an orchard field of 2.0 hectares and a paddy field of 2.0 hectares.

Irrigable area for the experimental farm including the existing experimental farm is shown below:

Field	Existing Experimental Field	New Experimental Field	Total
Upland field	6.8 ha	5.0 ha	11.8 ha
Orchard field	–	2.0	2.0
Paddy field	1.0	1.0	2.0
Total	7.8	8.0	15.8

As crop varieties, cropped areas and cropping seasons are subjected to experimental purposes, the water requirement for experimental fields is not constant. For this reason, the most water consumed crops in each field are employed as indication crops for safety calculation, tomato for upland field, banana for orchard field and boro rice for paddy field. The water requirement is computed in conditions of the dry season. The cropping season for each farm land category is shown as follows.

Cropping Season



(2) Irrigation methods

There are three irrigation systems, surface (furrow and basin), sprinkling and dripping. Among these, sprinkling is suitable for keeping equal watering condition. Here, sprinkling is proposed for the upland field and surface irrigation (basin) for the orchard field based on the following conditions.

i) Sprinkling system is suitable for upland field in order to supply irrigation water uniformly.

ii) As irrigation water will be supplied through the deep well, high irrigation efficiency will be required.

iii) Installation cost for sprinkling system is cheaper than dripping system.

iv) Irrigation canal will be planned as pipeline system because of the condition of field.

v) Surface irrigation system is suitable for the orchard field. Since proposed crop for the orchard field will be banana, mango and pineapple, most of these crop will be grown up accordingly.

Portable pipe for sprinkling system will be applied based on its installation cost.

(3) Irrigation hour

At present, the working time on the field is 11 hours from 6 a.m. to 5 p.m. During this span of time, 10 hours are supposed to devote to irrigation. The operation hours of the well pump will be 20 hours at the peak demand.

(4) Water requirement

Water requirement will be computed based on the evapotranspiration (ETo), the irrigation efficiency and the effective rainfall. Evapotranspiration (ETo) by Penman method, Blaney-Criddle method and Radiation method are indicated in Table 4-1 to Table 4-3 and summarized as follows:

ETo

unit: mm/day

Method \ Month	11	12	1	2	3	4	5
Penman	3.8	3.3	3.2	4.3	5.7	6.6	6.9
Blaney-Criddle	2.8	3.4	2.8	3.0	4.9	4.2	4.6
Radiation	3.5	3.2	3.1	3.8	5.3	5.2	5.3

Consequently, evapotranspiration by Penman method will be adopted for this water requirement in irrigation.

Crop evapotranspiration (ET crop) will be computed based on evapotranspiration (ETo) and crop coefficient shown in Table 4-4. Regarding the paddy field, puddling water and field percolation are considered. The computed result of crop evapotranspiration is shown in Table 4-5. Net and gross water requirements are calculated as shown in Table 4-6 considered with effective rainfall, cropping season and irrigation efficiency. The average water requirement at the peak demand is 5.6 mm per day. In case of 10 hours in irrigation at peak demand the unit water requirement is computed as follows:

Upland field $q = 166.7 \times \frac{1 \times 5.1}{10 \times 60} = 1.42$ ℓ/sec/ha

Orchard field $q = 166.7 \times \frac{1 \times 4.0}{10 \times 60} = 1.11$ ℓ/sec/ha

Paddy field $q = 166.7 \times \frac{1 \times 10.5}{10 \times 60} = 2.92$ ℓ/sec/ha

Average $q = 166.7 \times \frac{1 \times 5.6}{10 \times 60} = 1.56$ ℓ/sec/ha

Table 4-1 Calculation of ETo by PENMAN METHOD

Function Items	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
U' (Km/day)	121	130	121	138	225	320	380
U (Km/day)	113	121	113	128	209	298	353
Temperature: T mean (°C)	24.0	20.4	19.3	21.6	26.5	28.2	28.9
Humidity: RH mean (%)	68.7	66.9	66.9	62.3	68.8	71.4	74.8
ea (mbar)	29.8	24.0	22.4	25.8	34.7	38.3	39.9
ed: ea ×RH mean/100 (mbar)	20.5	16.1	15.0	16.1	23.2	27.3	29.8
ea-ed	9.3	7.9	7.4	9.7	11.5	11.0	10.1
$f(u)=0.27(1+U/100)$	0.58	0.60	0.58	0.62	0.83	1.07	1.22
$(1-W)$	0.27	0.31	0.33	0.30	0.25	0.23	0.23
W	0.73	0.69	0.67	0.70	0.75	0.77	0.77
Ra (mm/day)	10.7	9.7	10.2	11.9	13.9	15.4	16.4
n (hr)	7.3	7.5	6.9	7.4	7.4	7.3	7.0
N (hr)	10.9	10.6	10.7	11.3	12.0	12.7	13.3
n/N (mm/day)	0.67	0.71	0.64	0.65	0.62	0.57	0.53
$RS=(0.25+0.50\ n/N)\ Ra$	6.3	5.9	5.8	6.8	7.8	8.2	8.4
$Rns=(1-\alpha)\ RS$	4.7	4.4	4.3	5.1	5.8	6.1	6.3
f(T)	15.4	14.7	14.5	14.9	16.0	16.3	16.5
f(ed)	0.14	0.16	0.17	0.16	0.13	0.11	0.10
f(n/N)	0.70	0.74	0.68	0.69	0.66	0.61	0.58
RnI	1.5	1.7	1.7	1.6	1.4	1.1	1.0
Rn=Rns−RnI	3.2	2.7	2.6	3.5	4.4	5.0	5.3
c	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$ETo=c\{W.Rn+(1-W)\cdot f(u)\cdot(ea-ed)\}$ (mm/day)	3.8	3.3	3.2	4.3	5.7	6.6	6.9

(1) *Calculation Formula*

$$ETo = c\{W.Rn + (1-W)\cdot f(u)\cdot(ea-ed)\}$$

radiation term | aerodynamic term

Where: ETo = reference crop evapotranspiration in mm/day
W = temperature-related weighting factor
Rn = net radiation in equivalent evaporation in mm/day
f(u) = wind-related function
(ea-ed) = difference between the saturation vapor pressure at mean air temperature and the mean actual vapor pressure of the air, both in mbar
c = adjustment factor to compensate for the effect of day and night weather conditions

(2) Date : BARI (Lat. 24° N, Alt. = 20 m)

Table 4-2 Calculation of ETo by BLANEY-CRIDDLE METHOD

Function Items	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Temperature: T mean (°C)	24.0	20.4	19.3	21.6	26.5	28.2	28.9
P	0.25	0.24	0.24	0.26	0.27	0.29	0.30
P (0.46T + 8) = f	4.8	4.2	4.1	4.7	5.5	6.1	6.4
Humidity: RH min. (%)	53 H	48 M	45 M	38 M	46 M	61 H	64 H
Wind Spped: U day (m/sec)	1.3	1.4	1.3	1.5	2.4	3.4	4.1
n/N (%)	0.7 M-L	0.7 M-L	0.6 L	0.65 L	0.6 L	0.6 L	0.5 L
ETo = c {P (0.46T + 8)} (mm/day)	2.8	3.4	2.8	3.0	4.9	4.2	4.6

Calculation Formula

ETo = c {P (0.46T + 8)} (mm/day)

Where: ETo = reference crop evapotranspiration in mm/day for the month considered

T = mena daily temperature in °C over the month

P = mena daily percentage of total annual daytime hours obtained from Table 1 for a given month and latitude

c = adjustment factor which depends on minimum relative humidity, sunshine hours and daytime wind estimates

Table 4-3 Calculation of ETo by RADIATION METHOD

Function Items	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Temperature: T mean (°C)	24.0	20.4	19.3	21.6	26.5	28.2	28.9
Humidity: RH mean (%) (min)	69 M-H	67 M-H	67 M-H	62 M-H	67 M-H	71 H	75 H
U'	1.3	1.4	1.3	1.5	2.4	3.4	4.1
Ra. (mm/day)	10.7	9.7	10.2	11.9	13.9	15.4	16.4
n (hr)	7.3	7.5	6.9	7.4	7.4	7.3	7.0
N (hr)	10.9	10.6	10.7	11.3	12.0	12.7	13.3
n/N	0.67	0.71	0.64	0.65	0.62	0.57	0.53
Rs = (0.25 + 0.5 n/N) Ra	6.3	5.9	5.8	6.8	7.8	8.2	8.4
W	0.73	0.69	0.67	0.70	0.75	0.77	0.77
WRs (mm/day)	4.6	4.1	3.9	4.8	5.9	6.3	6.5
ETo = c (WRs) (mm/day)	3.5	3.2	3.1	3.8	5.3	5.2	5.3

Calculation Formula

ETo = c (WRs) mm/day

Where: ETo = reference crop evapotranspiration in mm/day for the periods considered

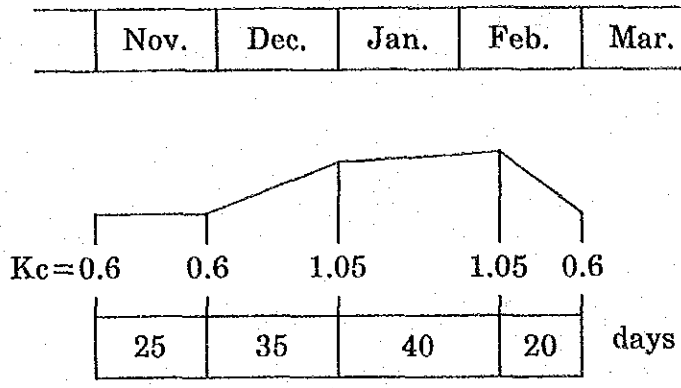
Rs = solar radiation in equivalent evaporation in mm/day

W = weighting factor which depends on temperature and altitude

c = adjustment factor which depends on mean humidity and daytime wind conditions

Table 4-4 Crop Coefficient (1/2)

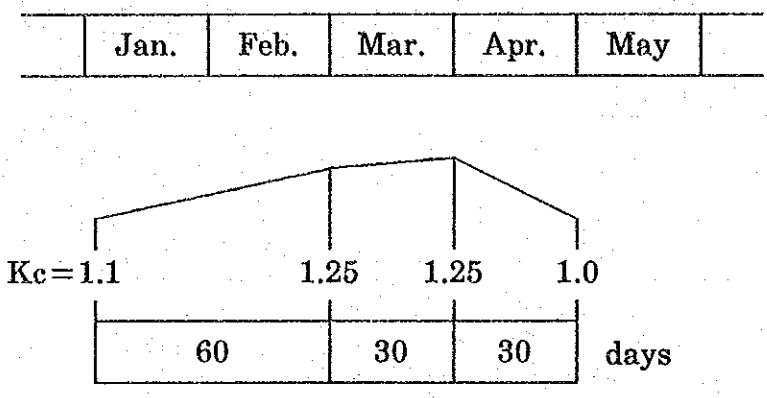
(1) Kc of Upland Crop (Tomato)



Month		Kc					(Ave.)
Nov.	1	0.60					
	2	0.60	0.60				
	3	0.62	0.60	0.60			0.22
Dec.	1	0.73	0.62	0.60	0.60		
	2	0.86	0.73	0.62	0.60	0.60	
	3	0.99	0.86	0.73	0.62	0.60	0.70
Jan.	1	1.05	0.99	0.86	0.73	0.62	
	2	1.05	1.05	0.99	0.86	0.73	
	3	1.05	1.05	1.05	0.99	0.86	0.93
Feb.	1	0.98	1.05	1.05	1.05	0.99	
	2	0.83	0.98	1.05	1.05	1.05	
	3	0.68	0.83	0.98	1.05	1.05	0.98
Mar.	1		0.68	0.83	0.98	1.05	
	2			0.68	0.83	0.98	
	3				0.68	0.83	0.50
Apr.	1					0.68	
	2						
	3						0.05

Table 4-4 Crop Coefficient (2/2)

(2) Kc of Rice Crop



Month		Kc			(Ave.)
Jan.	1	1.12			
	2	1.14	1.12		
	3	1.17	1.14	1.12	0.75
Feb.	1	1.19	1.17	1.14	
	2	1.22	1.19	1.17	
	3	1.24	1.22	1.19	1.19
Mar.	1	1.25	1.24	1.22	
	2	1.25	1.25	1.24	
	3	1.25	1.25	1.25	1.25
Apr.	1	1.21	1.25	1.25	
	2	1.13	1.21	1.25	
	3	1.04	1.13	1.21	1.19
May	1		1.04	1.13	
	2			1.04	
	3				0.36

(3) Kc of Fruit (Bananas)

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Kc	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Data : FAO Irrigation and Drainage Paper No.24.

Table 4-5 Crop Evapotranspiration (ET crop)

Function Items		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
ETo	(mm/day)	3.8	3.3	3.2	4.3	5.7	6.6	6.9
Kc	Upland crop	0.22	0.70	0.93	0.98	0.50	0.05	–
	Fruit	1.0	1.0	1.0	0.8	0.75	0.7	0.7
	Paddy	–	–	0.75	1.19	1.25	1.19	0.36
ET	crop							
	Upland crop	0.8	2.3	3.0	4.2	2.9	0.3	–
	Fruit	3.8	3.3	3.2	3.4	4.3	4.6	4.8
	Paddy	–	–	3.2	5.1	7.1	7.9	2.5
	Paddy 1/	–	–	9.2	7.1	9.1	9.9	4.5

Note : ETo : Evapotranspiration by Penman Method
Kc : Crop Coefficient
ET crop : Crop Evapotranspiration (= ETo × Kc)
1/ : with in 150 mm/30 days of puddling water and 2.0 mm/day of field percolation

Table 4-6 Water Requirement

(Unit: mm/day)

Function Items		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Rainfall		1.6	0.3	0	0.8	2.2	5.8	11.4
Effective Rainfall 1/		1.0	0.2	0	0.5	1.3	3.5	6.8
Net W.R.	Upland Crop	0	2.1	3.0	3.7	1.6	0	0
	Fruit	2.8	3.1	3.2	2.9	3.6	1.1	0
	Paddy	–	–	9.2	6.6	7.8	6.4	0
Gross W.R. 2/								
	Upland Crop	0	2.9	4.2	5.1	2.2	0	0
	Fruit	3.9	4.3	4.4	4.0	5.0	1.5	0
	Paddy	–	–	14.6	10.5	12.4	10.2	0
	Average 3/	0.5	2.7	5.5	5.6	3.8	1.5	0

Note 1/ : Rainfall × 0.6
Note 2/ : Net W.R./Irrigation efficiency

Irrigation Efficiency	Sprinkler Irrigation	Surface Irrigation
Conveyance Efficiency	0.9	0.9
Application Efficiency	0.8	0.7
Irrigation Efficiency	0.72	0.63

Note 3/ : Irrigation Area (ha)

Upland Crop	Fruit	Paddy
11.8 ha	2.0 ha	2.0 ha

2. Water Sources

There are two available water sources for irrigation, stored water and ground water. At the existing experimental farm, ground water had been used for irrigation. Consequently, groundwater will be used for the new experimental farm which will be constructed in this time.

3. Water Distribution system

(1) Reservoir

Water pumped up from the deep well is once stored in the regulating pond of capacity of 1,500 m^3. This is to make the well pump operate more constant and at the save time to reserve a volume of water for flexible irrigation at time intervals on the fields.

The capacity of reservoir has about 1.7 days of gross water requirement needed for the whole experimental farm of 15.8 hectares.

(2) Booster pump

Since the irrigation method for the existing experimental farm has applied the sprinkling system with booster pump located at the reservoir, the same irrigation system will be designed for the new experimental farm by using the existing facilities such as deep well pump and booster pump.

(3) Pipeline

Pipeline system to supply irrigation water to the field will be adopted for the proposed new experimental farm as with the existing system. The diameter of pipeline is proposed at 75 mm to 150 mm and P.V.C. pipe is selected as its material under the consideration of the pipe laying easiness.

(4) On-Farm Irrigation Plan

The on-farm irrigation plan for the upland field will be designed at the peak demand as follows:

Net water requirement (at peak)	3.7 mm/day
Gross water requirement (at on-farm)	4.6 mm/day
Irrigation interval	4 days
Working hours per day	10 hours
Removal times per day	3 times
Irrigation hours per 1 time	3.3 hours
Irrigation water per 1 time	18.4 mm
Irrigation intensity	5.6 mm/hr
Interval of sprinkler	18×12 m
Sprinkler discharge	20.2 ℓ/min
Pressure	2.5 kg/cm^2

Rotation block for irrigation will be 0.5 to 1.0 hectare and eight sprinklers will be used at one time irrigation.

5. Irrigation Facilities

(1) Deep well and deep well pump

Deep well and deep well pump constructed in 1986 will be available for the proposed experimental farm. The capacity of deep well pump is shown as follows:

Type of pump	:	Submersible motor pump
Diameter	:	100 mm
Discharge	:	19.6 ℓ/sec = 1.18 m^3/min
Total head	:	H=75 m
Output	:	30 Kw

In case of irrigation for the whole experimental farm of 15.8 hectares with existing facilities, operation hours of the deep well pump will be estimated at about 12.5 hours.

$$\text{Operation hours of deep well pump} = 166.7 \times \frac{A \times E}{Q \times 60}$$

$$= 166.7 \times \frac{15.8\ \text{ha} \times 5.6\ \text{mm/day}}{19.6\ \ell/\text{sec} \times 60} = 12.5\ \text{hr}$$

where A : whole irrigation area = 15.8 ha
E : Average gross water requirement = 5.6 mm/day
Q : Discharge of pump = 19.6 ℓ/sec

Groundwater level has been measured in November 1988 which is at the end of wet season and in March 1989 which is in the middle of dry season with continuous operation in 24 hours. The result of measurements after 24 hours of continuous operation shows the groundwater level is 20.45 meters at the end of wet season and 26.0 meters in the middle of dry season from the ground level as shown in Table 4-7. These results show that it is possible to irrigate the whole experimental farm of 15.8 ha by using the existing deep well pump.

(2) Reservoir

The reservoir constructed in 1986 at the north-west side of the campus has a capacity of 1,500 m^3. As the capacity of reservoir can supply 1.7 days of gross water requirement needed for the whole experimental farm, this existing reservoir will be used for the proposed experimental farm.

(3) Booster pump

Specifications of the booster pump located near the reservoir constructed in 1986 are as follows:

Type of pump : Single suction volute pump
Diameter : 125×100 mm

Table 4-7 Result of groundwater level measurement

End of wet season 17th~18th Nov. 1988		Middle of dry season 11th~12th Mar. 1989		Remarks
hour	Depth from ground level	hour	Depth from ground level	
11:30 Am	7.95 m	10:30 Am	14.10 m	
11:30 Am	7.95	10:40 Am	26.05	
12:00 Am	20.40	10:50 Am	26.07	
12:30 Am	20.40	11:00 Am	26.10	
1:30 Pm	20.40	11:30 Am	26.11	
2:30 Pm	20.45	12:30 Am	26.15	
3:30 Pm	20.45	1:30 Pm	26.15	
4:30 Pm	20.45	1:47 Pm	14.52	Power Stoppage
5:30 Pm	20.45	5:00 Pm	14.28	Start
6:30 Pm	20.45	5:10 Pm	25.95	
7:30 Pm	20.45	5:20 Pm	26.00	
8:30 Pm	20.45	5:30 Pm	26.00	
9:30 Pm	20.45	6:00 Pm	26.00	
10:30 Pm	20.45	7:00 Pm	26.00	
11:30 Pm	20.45	8:00 Pm	26.00	
12:30 Pm	20.45	9:00 Pm	26.00	
1:30 Am	20.45	10:00 Pm	26.00	
2:30 Am	20.45	10:07 Pm	14.52	Power Stoppage
3:30 Am	20.45	10:15 Pm	14.52	
4:30 Am	20.45	10:20 Pm	25.90	
5:30 Am	20.45	10:30 Pm	26.00	
6:30 Am	20.45	11:00 Pm	26.00	
7:30 Am	20.45	11:02 Pm	14.52	Power Stoppage
		11:10 Pm	25.90	
		11:20 Pm	26.00	
		11:30 Pm	26.00	
		12:00 Pm	26.00	
		1:00 Pm	26.00	
		2:00 Pm	26.00	
		3:00 Pm	26.00	
		4:00 Pm	26.00	
		5:00 Pm	26.00	
		6:00 Pm	26.00	

Discharge	:	23.7 ℓ/sec = 1.42 m^3/min
Total head	:	35 m
Out put	:	15 Kw
Unit	:	1

In case of irrigation for the whole experimental farm by using above the existing booster pump, the operation hours of booster pump will be estimated at about 10.4 hours.

$$\text{Operation hours of booster pump} = 166.7 \times \frac{A \times E}{Q \times 60}$$

$$= 166.7 \times \frac{15.8\ \text{ha} \times 5.6\ \text{mm/day}}{23.7\ \ell/\text{sec} \times 60} = 10.4\ \text{hr}$$

where A : whole irrigation area = 15.8 ha
E : Average gross water requirement = 5.6 mm/day
Q : Discharge of pump = 23.7 ℓ/sec

One set of booster pump was installed in 1986, and the capacity of this existing booster pump can cover the existing and proposed experimental farm. In case of expansion of the experimental farm in the future, additional booster pump will be needed because of lack of capacity.

(4) Pipeline

Pipeline network and hydraulics analysis are shown in Fig. 4-4 and Table 4-8. The total head of booster pump is calculated as 35 m based on the headloss calculation of pipeline. The diameter of main and secondary pipeline are planned as 150 mm and 75 mm and its material is selected as P.V.C. pipe under the consideration of hydrostatic pressure calculated at about 40 meters.

Pipe laying work will be planned along main and secondary roads within the field and excavation depth of pipe laying work under the consideration of plowing in the field and pipe culverts.

(5) On-farm facilities

The hydrants will be set in the intervals of 36 m so as to lay down the hand-moved aluminum pipe at intervals of 18 m and sprinkler sets with a riser of 12 m spacing.

4-5 Drainage Plan

1. Design Discharge of Surface Water

The maximum record of daily rainfall during 1953 to 1988 in Dhaka represents 326 mm and 257 mm, respectively, as shown in Table 4-8. As the result of the probability analysis by Thomas' Plot Method as shown in Fig. 4-5, the figure of 257 mm equals to the rainfall of one scene in 10 years. Design rainfall is proposed at 257 mm/day for the drainage facilities. Drainage water requirement is computed based on the principle of 4-hours-drain for 4-hours-rainfall as follows:

$$Q = (1/3.6) * \gamma * f * A \qquad (m^3/sec)$$

where, γ : rainfall intensity in mm/hr

$$\gamma = (R_{24}/24) * (24/T)^n$$

R_{24} = 257 mm/day
T = 4 hours
n = 2/3

γ = 35.4 mm/hr in T = 4 hr

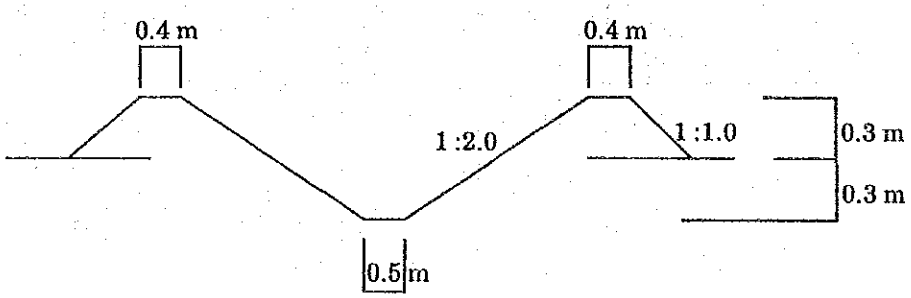
f : runoff percentage (0.75)
A : acreage of watershed in km^2

therefore, Q = 0.074 m^3/sec/ha

2. Design of Drainage Facilities

(1) Drainage canal

The drainage canal for the internal surface water will be planned in the center of the farm block and the cross section of the drainage canal with side slope of ratio at 1:2.0 is shown as follows:



Side slope of drainage canal will be covered with sod in order to protect from erosion.

(2) Pipe Culvert

The pipe culverts will be designed to cross the road. According to the result of headloss calculation for the pipe culverts as shown in Fig. 4-6 , pipe culvert of 300 mm will be used for upto 1.0 hectare of watershed and 400 mm pipe culvert for 2.0 ha to 3.0 ha of watershed and 600 mm pipe culvert for 6.0 to 7.0 ha of watershed.

(3) Pipe Drainage

The pipe drainage system will be planned in G-2 farm block as a demonstration. PVC pipe of diameter of 30 mm will be installed to drain out the underground water.

Table 4-8 Calculation of Hydraulics (1/2)
Maine Pipeline

Station	Distance	Total Distance	Ground Level	Proposed Ground Level	Discharge	Diameter	Velocity	Hydraulic Grad.	Headloss	Dynamic Water Potencial	Dynamic Water Pressure	Hydrostatic Pressur	
	m	m	m	m	l/s	mm	m/s		m	m	m	m	
0										55			
1	20	20	19.4		24.648	Ø 150	1.39	11.0	0.22	54.78	35.38		
2	100	120	19.5		14.508	〃	0.82	4.1	0.41	54.37	34.87		
3	105	225	19.8		12.792	〃	0.72	3.3	0.35	54.02	34.22		
4	105	330	19.7		9.048	〃	0.51	1.7	0.18	53.84	34.14		
5	105	435	19.2		5.148	〃	0.29	0.6	0.06	53.78	34.58		
6	100	535	18.72		2.34	〃	0.53	4.1	0.41	53.37	34.65		
7	100	635	18.27		1.56	〃	0.35	1.9	0.19	53.18	34.91		
0										55			
1	20	20	19.4		24.648	Ø 150	1.39	11.0	0.22	54.78	35.38		
8	235.1	255.1	20.4		10.14	〃	0.57	2.1	0.49	54.29	33.89		
9	190.1	445.2	20.22		9.36	〃	0.53	1.8	0.34	53.95	33.73		
10	99	544.2	20.28		7.02	〃	0.40	1.1	0.11	53.84	33.56		
11	19.1	563.3	19.12		4.68	〃	0.26	0.5	0.01	53.83	34.71		
12	72	635.3	19.12		3.90	〃	0.22	0.4	0.03	53.80	34.68		
13	99	734.3	19.12		2.34	〃	0.13	0.1	0.01	53.79	34.39		

Table 4-8 Calculation of Hydraulics (2/2)
Secondary Pipeline

Station	Distance	Total Distance	Ground Level	Proposed Ground Level	Discharge	Diameter	Velocity	Hydraulic Grad.	Headloss	Dynamic Water Potencial	Dynamic Water Pressure	Hydrostatic Pressur
	m	m	m	m	l/s	mm	m/s		m	m	m	m
Secondary 1												
9		455.2	20.22							53.95	33.73	
①	91.1	546.3	19.32		0.78	Ø 75	0.18	0.5	0.05	53.90	34.58	
Secondary 2												
9		455.2	20.22							53.95	33.73	
②	85.5	540.7	20.22		1.56	Ø 75	0.35	1.9	0.16	53.79	33.57	
Secondary 3												
10		544.2	20.28							53.84	33.56	
③	91.1	635.3	19.17		1.56	Ø 75	0.35	1.9	0.17	53.67	34.50	
Secondary 4												
10		544.2	20.28							53.84	33.56	
④	85.5	629.7	20.18		0.78	Ø 75	0.18	0.5	0.04	53.80	33.52	
Secondary 5												
12		635.3	19.12							53.80	34.68	
⑤	91.1	726.4	19.81		0.78	Ø 75	0.18	0.5	0.05	53.75	33.94	
Secondary 6												
12		635.3	19.12							53.80	34.68	
⑥	91.1	726.4	18.65		0.78	Ø 75	0.18	0.5	0.04	53.76	34.31	
Secondary 7												
13		734.3	19.43							53.79	34.39	
⑦	85.5	819.8	19.43		0.78	Ø 75	0.18	0.5	0.04	53.75	34.32	
Secondary 8												
13		734.3	19.43							53.79	34.39	
⑧	91.1	825.4	18.50		1.56	Ø 75	0.35	1.9	0.17	53.62	35.12	

Fig. 4－4 Irrigation Water System

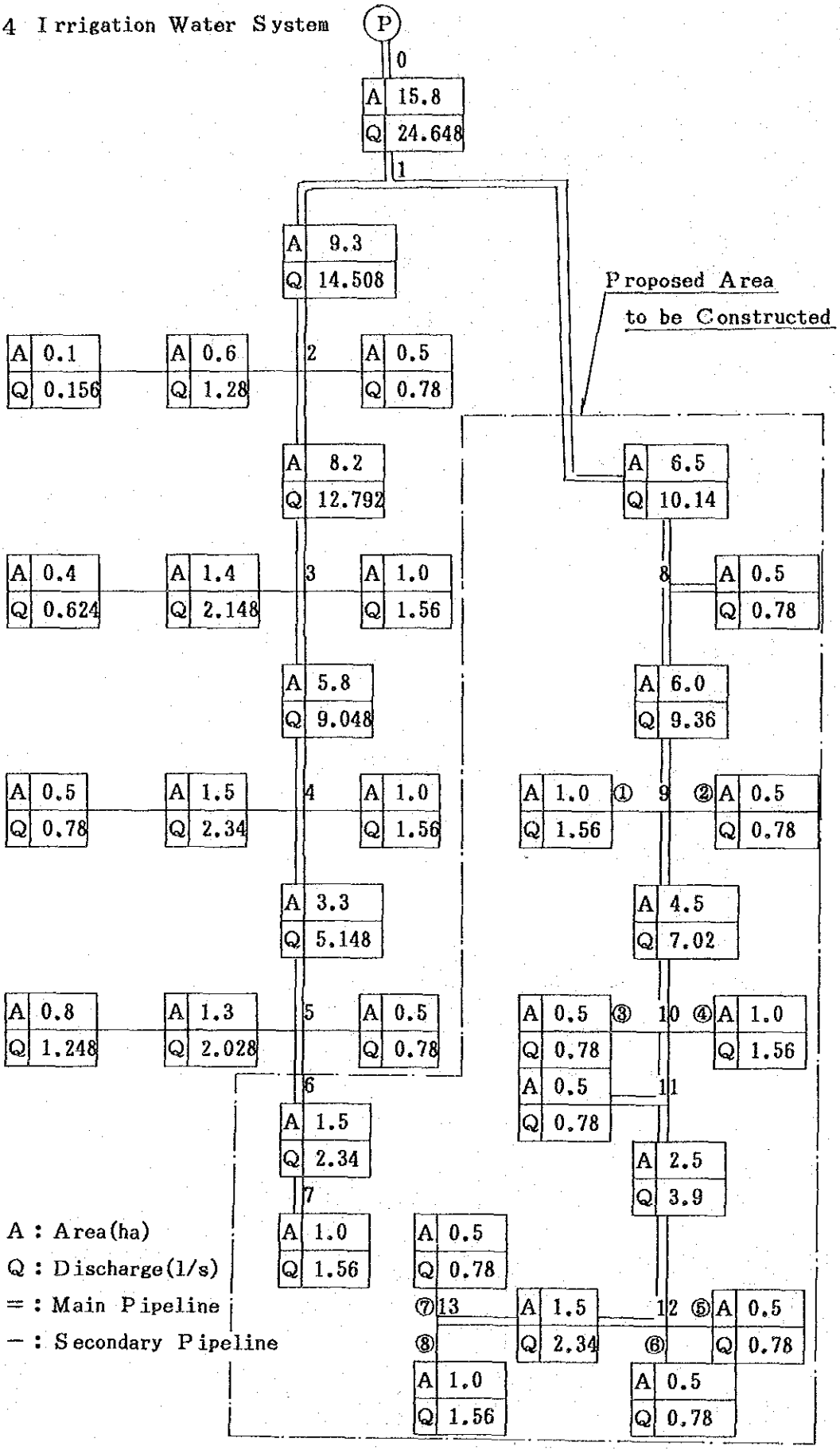


Fig. 4－5 Probability Analysis For Maximum Daily Rainfall By The Thomas' Plot

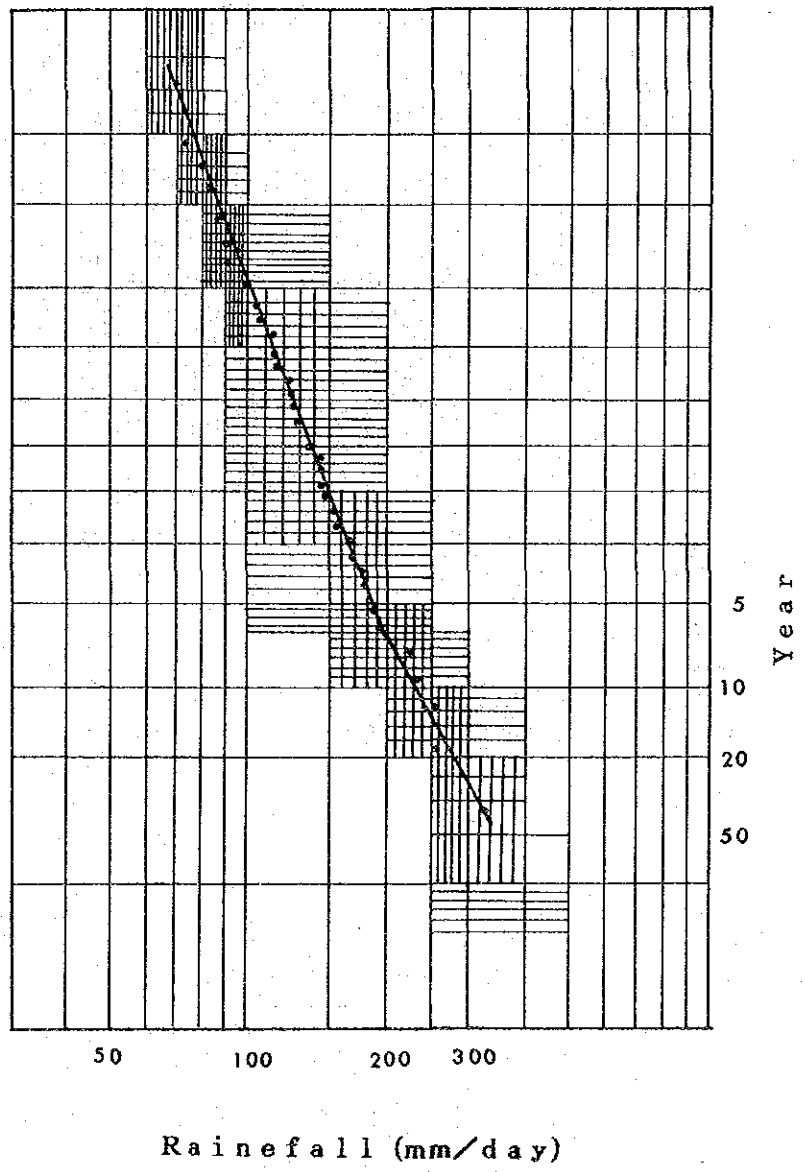
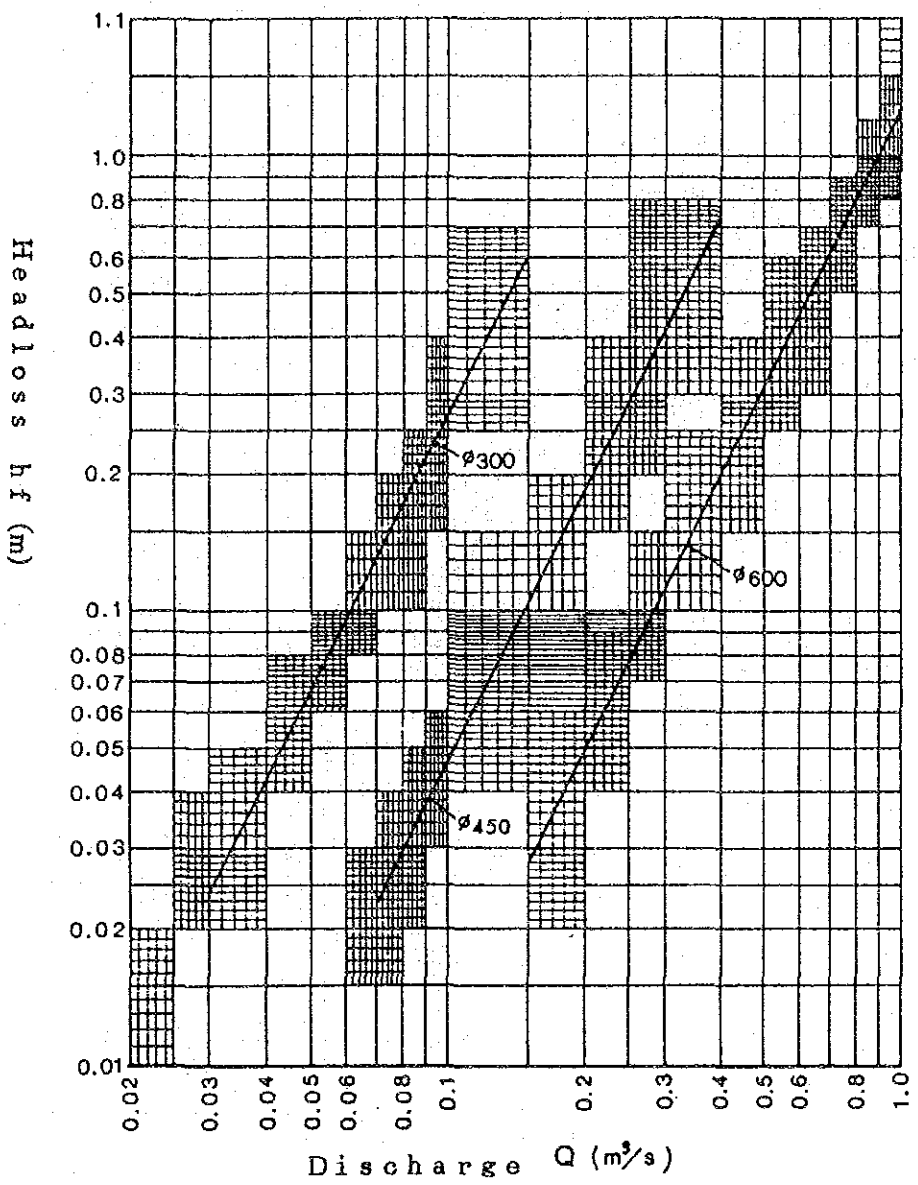
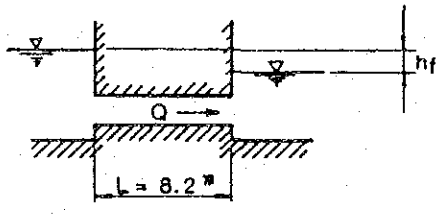


Fig. 4-6 Headloss of Pipe Culvert





$$h_f = (1.0 + 0.5) \cdot \frac{V^2}{2g} + \frac{124.5\ n^2}{D^{1/3}} \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

Chapter 5 Construction Cost

Chapter 5 Construction Cost

5-1 Construction Cost

The construction cost of Model Infrastructure Works in IPSA is estimated as ¥ 23,400,000 in total which is summarized as follows.

Item	TK	J¥
Land Consolidation Works	2,001,000	8,028,000
Road Works	448,000	1,797,000
Irrigation Works	1,466,000	5,883,000
Drainage Works	296,000	1,188,000
Sub-Total	4,211,000	16,897,000
Overhead Cost (20%)	842,000	3,379,000
Construction Cost	5,053,000	20,276,000
Contingencies (10%)	505,000	2,027,000
Fee (5%)	272,000	1,097,000
Total Cost	5,830,000	23,400,000

$$\frac{1\ \text{US\$}\ ¥\ 132.00}{1\ \text{US\$}\ \text{TK}32.90} = 4.012\ \text{J¥/TK}$$

The breakdown of the construction cost is shown in Table 5-1.

5-2 Unit Cost

The unit costs used for cost estimation are listed in Table 5-2 and Table 5-4. These are based on data collected in Bangladesh.

5-3 Bill of Quantities

The bill of quantities used for cost estimation are listed in Table 5-3.

Table 5-1 Breakdown of Construction Cost

J¥ 23,400,000.-

$$TK5{,}830{,}000 \times \frac{1\ US\$\ ¥\ 132.00}{1\ US\$\ TK32.90} = J¥\ 23{,}400{,}000.-$$

Item	Q'ty	Unit	Unit Price	Amount	No. of Unit Price	Remarks
			TK	TK		
1. Land Consolidation Works						
Cutting and Hauling	26,400	m^3	53	1,399,200	1	$\ell = 50$ m
Land Grading and Plowing	8.0	ha	11,476	91,808	2	
Soil Dressing Work	8.0	ha	63,750	510,000	3	
Sub-total				2,001,008		
2. Road Works						
Main Road	370	m	194	71,780	4	
Secondary Road	1,845	m	199	367,155	5	
Tractor Passage (Type I)	49	places	148	7,252	6	
Tractor Passage (Type II)	1	place	1,687	1,687	7	
Sub-total				447,874		
3. Irrigation Works						
Pipe Materials	1	LS		1,337,487	8	
Pipe Setting	1	LS		128,686	9	
Sub-total				1,466,173		

Item	Q'ty	Unit	Unit Price	Amount	No. of Unit Price	Remarks
			TK	TK		
4. Drainage Works						
Drainage Canal	1,025	m	105	1,07,625	10	
RC pipe ø450	8	pieces	1,031	8,248	11	
RC Pipe ø300	28	pieces	559	15,652	12	
Brick	36	m3	1,739	62,604	13	
Concrete	3	m3	1,830	5,490	14	
Excavation by Manpower	127	m3	20	2,540	15	
Backfilling by Manpower	89	m3	11	979	16	
Pipe Drain	0.5	ha	186,059	93,030	17	
Sub-total				296,168		
Total				4,211,223		
Over head				842,245		20%
Construction Cost				5,053,468		
Contingencies				505,347		10%
Fee				271,185		5%
Grand Total				5,830,000		

Table 5-2 Unit Price

Item	Specification	Q'ty	Unit	Unit Price	No. of Unit Price	Remarks
				TK		
Cutting and hauling	11 ton Classed Bulldozer	1	m^3	53	1	
Land Grading and Plowing	11 ton Classed Bulldozer	1	ha	11,476	2	
Soil Dressing	4 ton truck	1	ha	63,750	3	
Main Road	11 ton Classed Bulldozer. Road roller	1	m	194	4	
Secondary Road	- do -	1	m	199	5	
Tractor Passage (Type I)	11 ton Classed Bulldozer	1	place	148	6	
Tractor Passage (Type II)	11 ton Classed Bulldozer RC Pipe ø100 m/m	1	place	1,687	7	
Pipe Materials		1	LS	1,337,487	8	
Pipe Setting		1	LS	128,686	9	
Drainage Canal	by manpower	1	m	105	10	
RC Pipe ø450		1	piece	1,031	11	
RC Pipe ø300		1	piece	559	12	
Brick		1	m^3	1,739	13	
Concrete		1	m^3	1,830	14	
Excavation	by manpower	1	m^3	20	15	
Backfilling	by manpower	1	m^3	11	16	
Pipe Drain	ø30 m/m PVC pipe	1	ha	186,059	17	
Spreading	11 ton Classed Bulldozer	1	m^3	15	18	
Land Grading	11 ton Classed Bulldozer	1	ha	9,370	19	
Compaction	11 ton Classed Bulldozer	100	m^2	305	20	
Spreading and Compaction	11 ton Classed Bulldozer	1	m^3	30	21	
Plowing	Tractor and Plow	1	ha	2,106	22	
Compaction of road Surface	Road roller	100	m^2	59	23	
Embankment	by manpower	1	m^3	9	24	
Arrangement of Cutting Slope	by manpower	10	m^2	20	25	
Arrangement of Embankment Slope	by manpower	10	m^2	17	26	

Item	Specification	Q'ty	Unit	Unit Price	No. of Unit Price	Remarks
				TK		
Land Grading	by manpower	100	m^2	14	27	
Arrangement of Band		10	m	12	28	
Sodding		10	m^2	144	29	
Spreading of Sand		1	m^3	255	30	
Spreading of Gravel		1	m^3	702	31	
Concrete	1 : 2: 4	1	m^3	2,462	32	
Mortar	1 : 3	1	m^3	2,842	33	
Mortar	d = 30 m/m 1 : 3	1	m^2	134	34	
Reinforcement Bar	D10~D20	1	ton	23,634	35	
Form		1	m^2	273	36	
RC Pipe ø100		1	peice	319	37	
RC Pipe ø600		1	piece	1,473	38	
Pipe Setting	PVC ø150	1	m	51	39	
Pipe Setting	PVC ø100	1	m	43	40	
Pipe Setting	PVC ø75	1	m	40	41	
Pipe Setting	PVC ø50	1	m	37	42	
Valve Setting		1	place	671	43	

Table 5-3 Bill of Quantities

Item	Specification	Unit	Q'ty	Remarks
1. Land Consolidation Works				
Cutting and Hauling	Block A-1	m^3	2,468	A = 0.5 ha
	Block A-2	m^3	2,006	A = 0.5 ha
	Block B-1	m^3	1,156	A = 0.5 ha
	Block B-2	m^3	2,165	A = 0.5 ha
	Block C-1	m^3	1,404	A = 0.5 ha
	Block C-2	m^3	1,550	A = 0.5 ha
	Block D-1	m^3	1,359	A = 0.5 ha
	Block D-2	m^3	764	A = 0.5 ha
	Block E-1	m^3	1,675	A = 0.5 ha
	Block E-2	m^3	1,573	A = 0.5 ha
	Block F-1	m^3	1,994	A = 0.5 ha
	Block F-2	m^3	2,583	A = 0.5 ha
	Block G-1	m^3	1,827	A = 0.5 ha
	Block G-2	m^3	563	A = 0.5 ha
	Block H-1	m^3	879	A = 0.25 ha
	Block H-2	m^3	879	A = 0.25 ha
	Block I-1	m^3	795	A = 0.25 ha
	Block I-2	m^3	760	A = 0.25 ha
Total			26,400	L=50 m ΣA=8.0 ha
Land Grading and Plowing		ha	8.0	
Soil Dressing		ha	8.0	
2. Road Works				
Main Road	B = 7.0 m	m	370	Cutting and hauling works include land consolidation works
Secondary Road	B = 4.0 m	m	1,845	
Tractor Passage (Type I)		places	49	
Tractor Passage (Type II)		place	1	
3. Irrigation Works				
Main Pipeline	PVC ø150	m	1,025	
Secondary Pipeline	PVC ø75	m	887	
Sluice Valve Setting	ø150	place	2	
"	ø75	place	8	
Air Valve Setting	ø50	place	3	
Hydrant Setting	ø50	place	48	

Item	Specification	Unit	Q'ty	Remarks
4. Drainage Works				
Drainage canal		m	1,025	
Pipe Culvert	RC Pipe ø450	place	2	
Pipe Culvert	RC Pipe ø300	place	6	
Pipe Drainage	PVC Pipe ø30 m/m	ha	0.5	

Table 5-4 Breakdown of Unit Price

Cutting and Hauling — Unit Price No.1

53 TK/m3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Lease fee of Bulldozer	11 ton Bulldozer	1.0	hr	974.50	974.50	7796 TK/8 hr (including driver and fuel)
TK per 1 m^3		974.50 ÷ 18.55 = 52.53 ≒ 53 TK/m^3				
	Working capacity per 1 hour of 11 ton class Bulldozer					
	$Q = \frac{60 \times q \times E}{0.034 \cdot L + 0.25} = \frac{60 \times 1.34 \times 0.45}{0.034 \times 50 + 0.25} = 18.55$ m^3/hr					

Land Grading and Plowing — Unit Price No.2

11,476 TK/ha

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Land Grading					9,370	
Plowing					2,106	
Total					11,476	

Soil Dressing — Unit Price No.3

63,750 TK/ha — TK per ha

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Carrying sand	t = 2.5 cm	250	m^3	255	63,750	
Total					63,750	

Main Road (TK per 1 meter) — Unit Price No.4

194 TK/m — Estimate per 10 meters

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Spreading and compaction	11 ton Bulldozer	48.3	m^3	30	1,449	
"	Manpower	70	m^2	100 m^2 14	10	
Compaction	Road roller	161	m^2	100 m^2 59	95	
Arrangement of Embankment slope		23.7	m^2	100 m^2 17	40	
Sodding		23.7	m^2	100 m^2 144	341	
Total					1,935	
TK per 1 meter					194	

Secondary Road (TK per 1 meter) — Unit Price No.5

199 TK/m — Estimate per 10 meters

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Spreading and compaction	11 ton Bulldozer	45.5	m^3	30	1,365	
"	Manpower	40	m^2	100 m^2 14	6	
Compaction	Road roller	152	m^2	100 m^2 59	90	
Arrangement of Embankment Slope		32.6	m^2	100 m^2 17	55	
Sodding		32.6	m^2	100 m^2 144	465	
Total					1,985	
TK per 1 meter					199	

Tractor Passage (Type I) — Unit Price No.6

148 TK/place

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Cutting and Hauling		2.8	m^3	53	148	
Total					148	

Tractor Passage (Type II) — Unit Price No.7

1,687 TK/place

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
RC Pipe	ø100 m/m ℓ=1.8 m	3	pieces	319	957	
Brick		0.4	m^3	1,739	696	
Excavation	Manpower	0.7	m^3	20	14	
Backfilling	Manpower	0.3	m^3	11	3	
Embankment		1.9	m^3	9	17	
Total					1,687	

Pipe Setting — Unit Price No.9

TK 128,686

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Pipe Setting						
VP ø150		1,025	m	51	52,275	
VP ø75		887	m	40	35,480	
Sluice Valve Setting		10	places	671	6,710	
Air Valve Setting		3	places	671	2,013	
Hydrant Setting		48	places	671	32,208	
Total					128,686	

Pipe Materials — Unit Price No.8

TK 1,337,487

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Pipe Materials						
VP C-Class pipe	ø150	1,025	m	623.20	638,780	
"	ø75	887	m	165.64	146,923	
VP Socket	ø150	52	pieces	216.48	11,257	30%
"	ø75	45	"	55.20	2,484	30%
Tee	ø150×150	3	"	1,500.00	4,500	
"	ø150×75	11	"	422.17	4,644	
"	ø75×75	6	"	306.36	1,838	
Bend	ø150×90°	3	"	652.90	1,959	
"	ø75×90°	3	"	117.24	352	
Sluice Valve	ø150	2	"	9,630.00	19,260	
"	ø75	8	"	3,630.00	29,040	
Socket Flange	ø150	4	"	3,825.00	15,300	
"	ø75	16	"	2,040.00	32,640	
Dressor Joint	ø150	14	"	700.00	9,800	
Dressor Tee	ø150×50	10	"	1,000.00	10,000	
"	ø75×50	19	"	600.00	11,400	
Bush for steel pipe	ø50	29	"	100.00	2,900	
Reducer	ø150×75	3	"	700.00	2,100	
"	ø75×50	20	"	300.00	6,000	
Valve Socket	ø50	20	"	60.00	1,200	
Elbow	ø50	20	"	35.00	700	
Air Valve	ø50	3	"	12,500.00	37,500	
Socket for steel pipe	ø50	3	"	35.00	105	
Hydrant	ø50	48	"	4,500	216,000	
Steep Pipe	ø50	48	m	192.00	9,216	
Sub-Total					1,215,898	
Transportation					121,589	10%
Total					1,337,487	

Drainage Canal — Unit Price No.10

105 TK/m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Excavation	Manpower	0.97	m^3	20	19	
Embankment	Manpower	0.45	"	9	4	
Arrangement of cutting slope		4.98	$m^{2"}$	10 m^2 20	10	
Sodding		4.98	"	10 m^2 144	72	
Total					105	

RC Pipe Setting ø450 m/m — Unit Price No.11

1031 TK/piece

Estimate per 10 pieces

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
RC Pipe	ø450 $\ell = 1.8$	10	pieces	957	9,570	
Mortar		0.072	m^3	2,842	205	
Pipe layer		2.70	man	100	270	
Common labour		5.78	"	45	260	
Total					10,305	
TK per 1 piece					1,031	

RC Pipe Setting ø300 m/m — Unit Price No.12

559 TK/piece — Estimate per 10 pieces

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
RC Pipe	ø300 ℓ=1.8	10	pieces	510	5,100	
Mortar		0.038	m^3	2,842	108	
Pipe layer		2.43	man	100	243	
Common labour		3.02	"	45	136	
Total					5,587	
TK per 1 piece					559	

Brick — Unit Price No.13

1739 TK/m^3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Brick		402	pieces	2.40	965	251×124×80
Mortar		0.23	m^3	2,842	654	mortar 1 cm
Plasterer		0.3	man	100	30	
Common labour		2.0	"	45	90	
Total					1,739	

Concrete (1 : 4 : 8) Unit Price No.14

1,830 TK/m3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Cement		0.173	t	4,000	692	
Sand		0.53	m3	399	211	
Gravel		1.01	"	682	689	
Common labour		1.60	man	45	72	
Total					1,664	
					1,830	10% up

Excavation Unit Price No.15

20 TK/m3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		10 m3	man	45	198	
TK per m3		4.4			20	

Backfilling — Unit Price No.16

11 TK/m3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		10 m3	man	45	107	
TK per 1m3		4.4			11	

Pipe Drainage — Unit Price No.17

186,059 TK/ha — TK per ha

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Excavation		480	m3	20	9,600	
Sand		480	"	255	122,400	
VP pPipe ø30		1,000	m	36.08	36,080	including transportation
Valve Socket		40	piece	17.11	684	
Valve ø30		20	"	750	15,000	
Pipe VP ø100		16	m	143.42	2,295	20×0.8
Total					186,059	

Spreading — Unit Price No.18

15 TK/m³ — 11 ton Bulldozer ℓ = 20 m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Lease fee of Bulldozer		1.0	hr	974.50	974.50	7796 TK/8 hr (including driver and fuel)
TK per 1 m³		974.50 ÷ 66.3 = 14.7 TK ≒ 15 TK/m³				
	Working capacity	per 1 hour of 11 ton classed Bulldozer				
	Q =	10E (11D+8) = 66.3 m³/hr				
		D = 0.20 m	E = 0.65			

Land Grading — Unit Price No.19

9,370 TK/ha

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Lease fee of Bulldozer		1.0	hr	974.50	974.50	7796 TK/8 hr (including driver and fuel)
TK per 1 ha		974.50 ÷ 0.104 = 9,370 TK/ha				
	Working capacity	per 1 hour of 11 ton classed Bulldozer				
	A =	So×E×1/100 = 1,730 m³/hr × 0.60×1/100 =				10.4 a/hr
						= 0.104 ha/hr

Compaction — Unit Price No.20

305 TK/100 m²

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Lease fee of Bulldozer		1.0	hr	974.50	974.50	
TK per 100 m²		974.50 ÷ 3.2 = 305 TK/100 m²				

Working capacity per 1 hour of 11 ton classed Bulldozer

$$A = \frac{V \cdot W \cdot E}{100 \cdot N} = \frac{3{,}500 \times 0.7 \times 0.65}{100 \times 5} = 3.2 \text{ a/hr}$$

$$Q = \frac{V \cdot W \cdot D \cdot E}{N} = \frac{3{,}500 \times 0.7 \times 0.2 \times 0.65}{5} = 64 \text{ m}^3\text{/hr}$$

Spreading and compaction — Unit Price No.21

30 TK/m³

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Lease fee of Bulldozer		1.0	hr	974.50	974.50	
TK per 1 m³		974.50 ÷ 32.5 = 30 TK/m³				

Working capacity per 1 hour of 11 ton classed Bulldozer

$$Q = \frac{Q_1 \times Q_2}{Q_1 + Q_2} = \frac{64 \times 66}{64 + 66} = 32.5 \text{ m}^3\text{/hr}$$

Plowing — Unit Price No.22

2,106 TK/ha

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Tractor		1,417	TK/ 8 hr		177	1,417 TK/8 hr
TK per ha		177×11.9			2,106	

Working capacity per 1 hour of Tractor

$$T = T' \times E_1 \times E_2 \times E_3 \times E_4$$
$$= 10.8 \times 1.1 \times 1.0 \times 1.0 \times 1.0 = 11.9 \text{ hr/ha}$$

Compaction of Road Surface — Unit Price No.23

59 TK/100 m2

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Lease fee of Road Roller		2,035	TK/hr		254	
TK per 100 m2		(254 ÷ 432) ×100			59	

Working capacity per 1 hour of Road Roller

$$A = \frac{V \cdot W \cdot E}{N} = \frac{3{,}000 \times 1.8 \times 0.4}{5} = 432 \text{ m}^2/\text{hr} \quad d = 0.3 \text{ m}$$

Embankment — Unit Price No.24

9 TK/m^3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour TK per m^3		10 m^3 1.9	man	45	85.50 9	Spreading and compaction

Arrangement of Cutting Slope — Unit Price No.25

20 TK/10 m^2

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		10 m^2 0.45	man	45	20	

Arrangement of Embanking Slope — Unit Price No.26

17 TK/10 m^2

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		10 m^2 0.38	man	45	17	

Land Grading by Manpower — Unit Price No.27

14 TK/100 m^2

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		100 m^2 0.3	man	45	14	

Arrangement of Bank — Unit Price No.28

12 TK/10 m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		10 m 0.26	man	45	12	

Sodding — Unit Price No.29

144 TK/10 m^2

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Common labour		10 m^2 2.46	man	45	111	
Transportation		1.5	m^3	22	33	
Total					144	

Spreading of Sand — Unit Price No. 30

255 TK/m^3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Sand		1.0	m^3	240	240	
Common labour		0.34	man	45	15	
Total					255	

Spreading of Gravel — Unit Price No. 31

702 TK/m^3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Gravel		1	m^3	682	682	
Common labour		0.45	man	45	20	
Total					702	

Concrete (1:2:4) Unit Price No. 32

2,462 TK/m3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Cement		0.326	t	4,000	1,304	160 TK/bag
Sand		0.50	m3	399	200	
Gravel		0.95	m3	682	648	
Common labour		1.90	man	45	86	
Total					2,238	
					2,462	10% up

Mortar (1:3) Unit Price No. 33

2,842 TK/m3

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Cement		0.53	t	4,000	2,120	
Sand		1.05	m3	399	419	
Common labour		1.0	man	45	45	
					2,584	
Total					2,842	10% up

Mortar (d = 30m/m) Unit Price No. 34

134 TK/m²

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Cement		0.024	t	4,000	96	
sand		0.031	m³	399	12	
Plasterer		0.12	man	100	12	
Common labour		0.04	man	45	2	
Total					122	
					134	10% up

Reinforcement Bar (D10~D20) Unit Price No. 35

23,634 TK/ton

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Reinforcement Bar		1.03	t	20,117	20,721	
Union wire		5.00	kg	24	120	
Special labour		4.10	man	100	410	
common labour		5.20	man	45	234	
					21,485	
Total					23,634	10% up

Form for Concrete Work — Unit Price No. 36

273 TK/m2

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
Normal		1	m2		273	

RC Pipe Setting (ϕ100 m/m) — Unit Price No. 37

319 TK/piece — Estimate per 18m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
RC Pipe	ϕ100 ℓ=1.8	10	piece	283	2,830	
Mortar		0.02	m3	2,842	57	
Pipe layer		1.95	man	100	195	
Common labour		2.42	man	45	109	
Total					3,191	
TK per piece					319	

RC Pipe Setting (φ600 m/m) — Unit Price No. 38

1,473 TK/piece — Estimate per 18m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
RC Pipe	φ600 ℓ = 1.8 m	10	piece	1,382	13,820	
Mortar		0.08	m^3	2,842	227	
Pipe layer		2.96	man	100	296	
Common labour		8.53	man	45	384	
Total					14,727	
TK per 1 piece					1,473	

Pipe Setting (PVC φ150 m/m) — Unit Price No. 39

51 TK/m — Estimate per 60m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
PVC Pipe	φ150×6.0	10	Piece		–	
Solvent Cement		0.77	kg	650	501	
Pipe layer		0.75	man	100	75	
Common Labour		1.25	man	45	56	
Excavation		38.34	m^3	20	767	
Back filling		31.98	m^3	11	352	
Sand Bed		5.10	m^3	255	1,301	
Total					3,052	
TK per 1 meter					51	

Pipe Setting (PVCφ100m/m) — Unit Price No. 40

43 TK/m — Estimate per 60m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
PVC Pipe	φ100×6.0 m	10	piece		-	
Solvent Cement		0.36	kg	650	234	
Pipe layer		0.45	man	100	45	
Common labour		0.92	man	45	41	
Excavation		36.48	m^3	20	730	
Back filling		31.26	m^3	11	344	
Sand Bed		4.62	m^3	255	1,178	
Total					2,572	
TK per meter					43	

Pipe Setting (PVCφ75 m/m) — Unit Price No. 41

40 TK/m^3 — Estimate per 60m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
PVC Pipe	φ75×6.0 m	10	piece		-	
Solvent Cement		0.22	kg	650	143	
Pipe layer		0.45	man	100	45	
Common labour		0.77	man	45	35	
Excavation		35.55	m^3	20	711	
Back filling		30.84	m^3	11	339	
Sand Bed		4.38	m^3	255	1,117	
Total					2,390	
TK per meter					40	

Pipe Setting (PVC ϕ50) Unit Price No. 42

37 TK/m Estimate per 60m

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
PVC Pipe	ϕ50×6.0 m	10	piece		-	
Solvent cement		0.11	kg	650	72	
Pipe layer		0.30	man	100	30	
Common labour		0.60	man	45	27	
Excavation		34.56	m^3	20	691	
Back filling		30.24	m^3	11	333	
Sand Bed		4.14	m^3	255	1,056	
Total					2,209	
TK per meter					37	

Valve Setting Unit Price No. 43

671 TK/place

Item	Specification	Quantities	Unit	Unit Price	Amount	Remarks
R.C. Pipe	ϕ300×1.80 m	0.85	m		370	559/2+45×2
Concrete Hutch	Concrete	0.03	m^3	2,462	74	
Reinforcement Bar	ϕ10	1.42	kg	24	34	
	ϕ16	0.47	kg	24	11	
Mortar	1:3	0.01	m^3	2,842	28	
Gravel		0.02	m^3	702	14	
Excavation		0.69	m^3	20	14	
Backfilling		0.59	m^3	11	6	
Special labour		0.3	man	100	30	
common labour		2.0	man	45	90	
Total					671	

Labour and Material Cost — Unit Price No. 44

Item	Specification	Quantities	Unit	Unit Price	Remarks
				TK	
Common labour		1	day	45	
Driver		1	day	70	
Operater		1	day	100	
Manager		1	day	300	
Pipe layer		1	day	100	
Plasterer		1	day	100	
Special labour		1	day	100	
Fuel	Normal	1	ℓ	19.00	
Fuel	Highoctane	1	ℓ	21.10	
Fuel	Light oil	1	ℓ	8.90	
Fuel	Heavy oil	1	ℓ	5.90	
Lease fee of Truck	6 ton	1	day	2,500	
Lease fee of Truck	4 ton	1	day	2,000	
Lease fee of Truck	2 ton	1	day	1,000	
Lease fee of 11 ton class Bulldozer		1	day	7,796	
Lease fee of Road Roller		1	day	2,035	
Brick	made by manpower	1000	piece	2,400	
Brick	made by manpower	1000	piece	3,200	
Reinforcement Bar	D10~D20	1	ton	20,117	
Cement		40	kg	160	
Sand	for concrete	1	m^3	399	
Sand	for foundation	1	m^3	240	
Brick chips		1	m^3	682	
Crushed stone		1	m^3	682	
Gravel	1″	1	m^3	682	
Gravel	~4″	1	m^3	770	

Chapter 6 Construction Plan

Chapter 6 Construction Plan

6-1 Construction Schedule

1. Working days

The average monthly rainfall and rainfall days from 1981 to 1988 at Joydebpur are shown as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average Monthly Rainfall	1.9	23.1	68.7	174.7	353.7	409.7	360.3	349.3	316.1	191.1	47.4	10.7
Rainfall days	1	2	5	10	13	16	18	19	16	5	2	1
Working days	30	26	26	20	18	14	13	12	14	26	28	30

Due to difficulties for carrying out construction works in rainy days which main works for this Project are in land consolidation, working days for construction are non-rainfall days.

2. Working days for each work

The working days calculated for each work are shown in Table 6-1 based on the total quantities, the required machines and labours.

3. Construction Schedule

Construction works of this Project which main works are in land consolidation will be executed during a period of 6 months from October to March of the dry season. The land consolidation work will be carried out in the first half of construction period, while works for road, canal and relative

4. Supervision

Supervision for this construction works included tender announcement and evaluation of tenderers will be planned as six(6) months from October 1989 to March 1990.

6-2 Construction Plan

Construction plan of each work will be summarized as follows.

1. Land Consolidation Works

(1) Land Consolidation Works : A = 8.0 ha

As for the 8.0 ha experimental farm, the works will be carried out with the sequence of - excavation and soil hauling - land grading and compaction, without handling of surface soil, by using the 11 ton classed bulldozers. In this case, as the hauling distance will be 50m and the working capacity of 11 ton classed bulldozer is 130 m^3/day and the volume of earth work is 26,400 m^3, an amount of N = 26,400/130 = 204 unit/days by bulldozer work will be required. Considering the construction period is from October to March, at least two sets of bulldozer or three sets of bulldozer in case of peak demand will be required.

These bulldozers are available at Mechanical Workshop Division of P.W.D.

(2) Land Grading and Plowing Work

Land grading and plowing work will be carried out after land consolidation work. The accuracy of land grading within the field block (100m × 50m) will be made at ± 5cm.

(3) Soil Dressing

As for the 8.0 ha experimental farm, the soil dressing work and the transportation of sand by four-ton truck will be carried out in order to improve soil. Volume of sand to be carried will be planned at 250 m^3 per hectare. Soil dressing work will be carried out after land consolidation

and land grading works. The plowing work will be carried out for mixing sand with soil.

2. Road Work

The road work will be carried out roughly along with the land consolidation work, of which the subsoils could be converted to road foundation. A bulldozer will be used for land grading and compaction and a road roller for final compaction. The sodding work for side shop of the road will be done in order to protect from ellosion during rainy seasons. The construction length is shown as follows:

Main Road	ℓ=370m (with 7.0m width)
Secondary Road	ℓ=1,845m (with 4.0m width)

3. Irrigation Work

Pipeline irrigation is planned along the road. The pipe laying works will be carried out after land consolidation and road works. Excavation pipe laying and backfilling work will be carried out by manpower due to difficulties to get excavation machines.
The construction length is shown as follows:

Main pipeline	ℓ=1,025m	VPφ150mm
Secondary pipeline	ℓ=887m	VPφ75mm
Hydrant	n=48 places	φ50mm

4. Drainage Work

Drainage work will be carried out after land consolidation work. Since it is a small earth canal with difficulties to get excavation machines, drainage excavation work will be carried out by manpower. The slope of drainage canal is planned at the ratio of 1:2.0 and the sodding work for the slope will be carried out in order to protect from ellosion. The outlet work from each field is planned by brick.
The construction length is shown as follows:

Drainage canal	ℓ=1,025m	
Pipe culvert	n=2 places	RCφ450m/m
Pipe culvert	n=6 places	RCφ300m/m

(Table 6-1) Available working days

Work Item	Q'ty	Q'ty per day	Required machines or labours	days
1. Land Consolidation Work				
(1) Cutting/Houling (11ton Bulldozer)	26,400 m^3	130 m^3/day	2 units	102 days
(2) Soil Dressing (4ton truck)	2,000 m^3	12.5 m^3/day	3 units	54 days
(3) Leveling and Plowing				
i) LEveling	8.0 ha	0.73 ha/day	1 units	11 days
ii) Plowing	8.0 ha	0.60 ha/day	1 units	14 days
Sub-total of (3)				25 days
2. Road Work				
(1) Main Road (ℓ = 370m)				
i) Cutting and Compaction with 11ton Bulldozer	1,800 m^3	228 m^3/day	1 units	8 days
ii) Compaction with Road Roller	6,000 m^2	3,000 m^2/day	1 units	2 days
iii) Arrangement of slope by labours	880 m^2	26.3 m^2/day	34 labours	
iv) Sodding by labour	880 m^2	4.1 m^2/day	215 labours	
v) Transportation for sod	130 m^3	2.6 m^3/day	50 labours	
Sub-total iii) - v)	299 labours		40 labours/day	8 days
Sub-total of (1)				18 days
(2) Secondary Road (ℓ = 1,845m)				
i) Cutting and Compaction with 11ton Bulldozer	8,400 m^3	228 m^3/day	1 units	37 days
ii) Compaction with Road Roller	28,000 m^2	3,000 m^2/day	1 units	10 days
iii) Arrangement of slope by labours	6,100 m^2	26.3 m^2/day	232 labours	
iv) Sodding by labours	6,100 m^2	4.1 m^2/day	1,488labours	
v) Transportation for sod	915 m^3	2.6 m^3/day	352 labours	
Sub-total of iii) - v)	2,072labours		40 labours/day	52 days
Sub-total of (2)				99 days

Work Item	Q'ty	Q'ty per day	Required machines or labours	days
3. Irrigation Work				
(1) Main Pipeline (ℓ = 1,025m)				
i) Excavation by labours	660 m^3	2.3 m^3/day	287 labours	
ii) Backfilling by labours	550 m^3	4.2 m^3/day	131 labours	
iii) Pipe layer	1,025 m	80 m/day	13 labours	
iv) Pipe layer by labours	1,025 m	48 m/day	22 labours	
v) Sand	87 m^3	2.9 m^3/day	30 labours	
Sub-total of i) - v)	483 labours		20 labours/day	25 days
(2) Secondary Pipeline (ℓ = 887m)				
i) Excavation by labour	530 m^3	2.3 m^3/day	231 labours	
ii) Backfilling by labours	460 m^3	4.2 m^3/day	110 labours	
iii) Pipe layer	887 m	133 m/day	7 labours	
iv) Pipe layer by labours	887 m	78 m/day	12 labours	
v) Sand	65 m^3	2.9 m^3/day	23 labours	
Sub-total of i) - v)	383 labours		20 labours/day	20 days
(3) Setting Valve and Hydrant	61 places	2 place/day		31 days
4. Drainage Work				
(1) Drainae canal (ℓ = 1,025m)				
i) Excavation by labour	1,000 m^3	2.3 m^3/day	435 labours	
ii) Banking by labours	460 m^3	5.3 m^3/day	87 labours	
iii) Arrangement of slope by labours	5,110 m^2	26.3 m^2/day	195 labours	
iv) Sodding by labours	5,110 m^2	4.1 m^2/day	1,247 labours	
v) Transportation for sod	770 m^3	2.6 m^3/day	297 labours	
Sub-total of i) - v)	2,261 labours		40 labours/day	57 days
(2) Pipe culvert	8 places	0.3 place/day		27 days

(Table 6-2) Construction Schedule

Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Rainfall days	5	2	1	1	2	5
Working days	26	28	30	30	26	26
1. Temporary works	(30 days)					
2. Land Consolidation Works			(102 days)			
i) Land leveling and plowing						(25 days)
ii) Soil dressing					(54 days)	
3. Road Works				(117 days)		
4. Irrigation Works					(76 days)	
5. Drainage Works					(84 days)	
6.Supervision					(180days)	

Chapter 7 Contract Documents

Chapter 7 Contract Documents

7-1 Contract

CONTRACT

FOR

CONSTRUCTION OF EXPERIMENTAL FARM

FOR

THE INSTITUTE OF POSTGRADUATE STUDIES

IN

AGRICULTURE

CONTRACT

For Construction of Experimental Farm

for

the Institute of Postgraduate Studies in Agriculture

This Contract is executed on this _____ day of _____, 1989 at the JICA Dhaka Office between the Japan International Cooperation Agency, Dhaka Office by Mr. _____ Title, Resident Representative as its authorised representative of the JICA Dhaka Office, hereinafter referred to as "JICA" of the one part, and _____ whose office is situated at _____ represented by _____ Nationality _____, Title _____ hereinafter referred to as the "Contractor" of the other part.

Both parties mutually agree under the terms of this Contract as follows:-

Article - 1 (a) (Purpose of Agreement)

JICA agrees to employ the Contractor and the Contractor agrees to perform the works for the construction of the experimental farm for the Institute of Postgraduate Studies in Agriculture located at Salna, Joydebpur, Gazipur, Bangladesh.

Article - 1 (b)

The following documents shall form an integral part of this Contract:-

i) Bill of quantities (itemized statement)
ii) The attached construction drawings
iii) The attached specifications

Article - 2 (Contract Sum of Construction)

The contract sum of construction shall be Taka _____ _____ and be based on the bill of quantities attached hereto.

Article - 3 (Time for Completion of Construction)

The Contractor shall start work within ten (10) days after the signing by both parties of this agreement, and complete work by the ____ of _____, _____.

Article - 4 (Delays)

In a case where it is clear that the Contractor is failing to fulfil his obligations within the period referred to in the preceeding Article, the Contractor shall inform JICA of this as soon as possible, and if JICA agrees that the delay is due to such causes as natural calamity or others for which the Contractor is not liable, a reasonable extension of time shall be approved. In this case, the sum referred to in Article 15 shall not be collected.

Article - 5 (Process of Carrying out the Work)

The Contractor shall carry out the work in accordance with the drawings and specifications referred to in Article 1 (b). And in cases where necessary works are not mentioned therein, the Contractor shall carry out the said work under the direction of JICA. In cases where the Contractor has any doubt concerning the plans of construction, the Contractor shall request JICA for the necessary directions before commencing work on the part for which there exists any doubt.

Article - 6 (Quality of Materials and Workmanship)

The Contractor shall follow the direction of JICA or the Engineer to be appointed by JICA. As to materials for construction, the Contractor shall use only those inspected and approved by JICA or the Engineer appointed by JICA. In cases where any defective work has been done as a result of such use of materials which have not been inspected by the Engineer, the Contractor shall be liable to change the materials or repair the work at his own cost. The construction shall be carried out in accordance with the proper technique and durability shall be the principal aim as regards to the construction.

Article - 7 (Workmen)

As for workmen to be hired by the Contractor for the works, the Contractor shall assume the responsibility as entrepreneur or employer as provided for by the Laws and Regulations of Bangladesh Government.

Article - 8 (Transfer of Right and Obligation)

The Contractor shall not assign or sublet to a third party the Contract or any part thereof without the prior written consent of JICA.

Article - 9 (Damages)

In cases where any damage is caused to JICA or a third party, materials or buildings, through carelessness on the part of the Contractor during the course of the works or transportation of materials, the Contractor shall be liable to repair or compensate such damage at his own expense by the date appointed by JICA or the third party.

Article - 10 (Failure to Repair or Compensate for Damages)

In cases where the Contractor fails to repair or compensate such damages referred to in the proceeding Article by the fixed date, JICA has a right to deduct from any money due to the Contractor but yet unpaid. If the total amount of the loss is larger than the money above mentioned, the Contractor agrees that JICA has a right to retain the Construction equipment, materials and supplies etc., and demand payment of the balance from such equipment etc., or proceeds of sale thereof.

Article - 11 (a) (Change in Construction Drawings and Submission of Necessary Documents)

In cases where JICA feels it is necessary to discontinue the works owing to unavoidable circumstances or to alter the plan of construction, JICA shall request the Contractor to calculate, on the basis of the unit prices as detailed in the bill of quantities referred to in Article - 2, the increase of decrease in the sum of construction costs resulting from such suspension or alteration of the works and the Contractor shall comply with the request. When JICA orders such a suspension or alteration, depending on the statement of the above

mentioned calculation, the Contractor shall submit a written consent by the date appointed by JICA.

Article - 11 (b) (Daywork Rates for Additional Works)

Where additonal works cannot be properly measured and valued on the basis of the unit price in the bill of quantities referred to in Article-2, the contractor shall be allowed to charge daywork rates in accordance with a written consent issued by JICA.

Article - 12 (Price Adjustment)

(a) In the case of the costs of materials rising sharply as a result of a fluctuation in the market prices due to an unexpected change in economic conditions, a reasonable adjustment of the above mentioned sum or the contents of the works will be made according to a mutual agreement between JICA and the Contractor.

(b) In case the Contractor incurs a loss or suffers a loss unreasonably under an item of the bill of quantities due to JICA's failure to provide the information and details referred to in Article - 5 of the particular item of work, then a reasonable adjustment of the above mentioned losses may be considered by JICA against a detailed claim submitted by the Contractor.

Article - 13 (Right to cancel Contract and Penalty)

In cases where the Contractor fails to fulfil his obligations under this contract, JICA may reserve the right to cancel the whole or any part(s) of the Contract. In such a case, JICA may collect from the Contractor a sum as a penalty of ten percent (10%) of the amount which is equivalent to the rescinded part of the Contract. In cases where the damages caused to JICA, due to failure to fulfil the contract by the Contractor, exceed the sum referred to in the preceeding paragraph, JICA may further demand the Contractor to pay the excess.

Article - 14 (Contractor's Failure to Fulfil Obligations)

In cases other than provided for in the preceeding Article where the Contractor fails to fulfil his obligations, or in cases where the fulfilment of the obligation by the Contractor is regarded to be difficult, JICA may have a third

party fulfil, at the cost of the Contractor, the whole or part(s) of the obligations of the Contractor. Even if the liability of the Contractor exceeds the contract sum referred to in Article - 2 in consequence of this, the Contractor may not raise any objection to it.

Article - 15 (Penalty for Delay)

In cases other than provided for in Article - 13, where the Contractor fails to complete the construction at his own cost, within the period referred to in Article - 3, the Contractor shall be liable, within a period fixed by JICA, to pay JICA, for every week of delay, a sum equivalent to 0.2 percent (0.2%) of the contract sum referred to in Article - 2.

Article - 16 (Damages caused by Natural Calamity etc.)

In cases where serious damages occur to the completed part(s) of the work, or the materials, tools etc., already carried into the field of construction, the contractor shall promptly inform the JICA of the circumstances. If such damages are caused by a natural calamity, an earthquake, a flood, a civil war, a war, an epidemic, or a general/trade strike, rioting or other unavoidable reasons, the occurence of which no responsibility can be attributed to either JICA or the Contractor and it is admitted that the Contractor has paid the care of good administration to avoid the occurence of such damages, JICA shall be liable for the amount of the damages which shall be fixed through negotiations between JICA and the Contractor.

Article - 17 (a) (Inspection)

The work at any stage shall be subject to inspection to be conducted by JICA or an inspector appointed by JICA, in the presence of the Contractor and necessary labour and articles required for such inspection(s) shall be provided by the Contractor.

Article - 17 (b) (Failure to Pass Inspection)

In cases where the work fails to pass the inspection referred to in the preceeding paragraph, the Contractor shall carry out necessary repairs or replacement at his own cost, under the direction of JICA.

Article - 18 (Date of Completion of Construction and Obligation thereafter)

The date of completion of construction shall be regarded as the date on which the final work, including removal of temporary constructions and cleaning, has passed the inspection referred to in Article - 17 and on that date the object of the total construction shall be handed over to JICA by the Contractor. For a period of six (6) months thereafter, any defect in the construciton, the cause of which is judged in the opinion of JICA to be attributable to faulty or inadequate techniques or materials employed by the Contractor, shall be immediately repaired or improved at the cost of the Contractor.

Article - 19 (a) (Payment and Currency)

JICA shall pay to the Contractor in Taka currency as follows:-

Payment for the part of the work already completed shall be allowed by JICA three times, every 40 days or more, during the course of construction at the request of the Contractor, provided that it has passed the inspection referred to in Article - 17.

However, the amount of the payment shall be limited to ninety percent (90%) of the work already completed. The final payment will be carried out within one month after JICA receives the request for such payment which should be submitted by the Contractor on or after the date of completion of construction referred to in the preceeding Article.

Article - 19 (b)

Ten percent (10%) of the contract price shall be paid as an advance payment for mobilization after the issuance of the order to commence the works upon production by the Contractor of a Bank Guarantee for an amount equal to the said advance payment.

Article - 19 (c)

This advance payment shall be deducted from each payment stated above 19 (a) by ten percent (10%) of that each payment.

Article - 19 (d)

The Bank Guarantee as provided in paragraph (b) shall be returned to the Contractor by JICA upon final acceptance of the works.

Article - 19 (e)

The ten percent (10%) of the contract price deducted as retention money, the progress payment as stated above in 19 (a), will be held as a guarantee through the six (6) months maintenance period described in Article 18.

Article - 20 (a) (Settlement of Dispute)

If there arises any dispute in regard to this Contract or the Construciton Drawings or Specifications referred to in Article - 1 (b), it will be settled by a mutual consultation between JICA and the Contractor.

Article - 20 (b)

Should it not be possible to reach a mutual agreement between JICA and the Contractor on such dispute, then it shall be referred to an Arbitrator or Arbitrators acceptable to both JICA and the Contractor and the decision of the Arbitrator or Arbitrators shall be binding on both JICA and Contractor.

The Conclusion of the Contract

Two copies of the Contract shall be prepared with the signature of both parties affixed to each of the copies, one copy to be held by each party.

Date:

..... JICA

Resident Representative
Japan International Cooperation Agency
Dhaka Office

..... Contractor

..... Witness

Japanese Technical Cooperation Project Team for IPSA

..... Witness

The Institute of Postgraduate Studies in Agriculture

BIL OF QUANTITIES

Item No.	Description		Unit	Q'ty	Unit Price TK	Extended Amount TK
1.	Land Leveling Works					
	1-1 Excavation and Hauling (L = 50 m)		m^3	26,400		
	1-2 Leveling / Plowing / Finishing		ha	8.0		
	1-3 Soil Dressing (Sand, d = 2.5 cm)		ha	8.0		
	Sub-total of Item 1					
2.	Road works					
	2-1 Main road	Leveling by 11 ton class Bulldozer, compaction with road roller, slop tamping and sodding for slop	m	370		
	2-2 Secondary road	- do -	m	1,845		
	2-3 Tractor Passage Type I		place	49		
	2-4 Tractor Passage Type II		place	1		
	Sub-total of Item 2					

Item No.	Description		Unit	Q'ty	Unit Price TK	Extended Amount TK
3.	Irrigation Works					
3-1	Pipe Materials (including transportation)					
(1)	VP C-class pipe	ø150	m	1,025		
(2)	"	ø75	m	887		
(3)	VP Socket	ø150	pieces	52		
(4)	"	ø75	"	45		
(5)	Tee	ø150×150	"	3		
(6)	"	ø150×75	"	11		
(7)	"	ø75×75	"	6		
(8)	Bend	ø150×90°	"	3		
(9)	"	ø75×90°	"	3		
(10)	Sluice Valve	ø150	"	2		
(11)	"	ø75	"	8		
(12)	Socket Flange	ø150	"	4		
(13)	"	ø75	"	16		
(14)	Dressor Joint	ø150	"	14		
(15)	Dressor Tee	ø150×50	"	10		
(16)	"	ø75×50	"	19		
(17)	Bush for Steel Pipe	ø50	"	29		
(18)	Reducer	ø150×75	"	3		

Item No.	Description		Unit	Q'ty	Unit Price TK	Extended Amount TK
(19)	"	ø75×50	pieces	20		
(20)	Valve Socket	ø150	"	20		
(21)	Elbow	ø50	"	20		
(22)	Air Valve	ø50	"	3		
(23)	Socket for Steel Pipe	ø50	"	3		
(24)	Hydrant	ø50	"	48		
(25)	Steel Pipe	ø50	m	48		
	Sub-total of Item 3-1					
3-2	Pipe Installation					
(1)	Piping (excluding pipes) PVC	ø150	m	1,025		
(2)	Piping (excluding pipes) PVC	ø75	m	887		
(3)	Sluice Valve Setting (excluding Valve)	ø150	pieces	2		
(4)	Sluice Valve Setting (excluding Valve)	ø75	"	8		
(5)	Air Valve Setting (excluding Valve)	ø75	"	3		
(6)	Hydrant Setting (excluding Hydrant)	ø50	"	48		

Item No.	Description	Unit	Q'ty	Unit Price TK	Extended Amount TK
	Sub-total of Item 3-2				
	Sub-total of Item 3				
4.	Drainage Works				
4-1	Farm Drain	m	1,025		
4-2	RC-pipe ø450	pieces	8		
4-3	" ø300	"	28		
4-4	Brick with mortal (1 : 3)	m^3	36		
4-5	Concrete 1 : 2 : 4	"	3		
4-6	Excavation by manpower	"	127		
4-7	Backfilling by manpower	"	89		
4-8	Pipe Drainage Works (PVC ø30 pipe and Sand)	ha	0.5		
	Sub-total of Item 4				
	Grand Total				