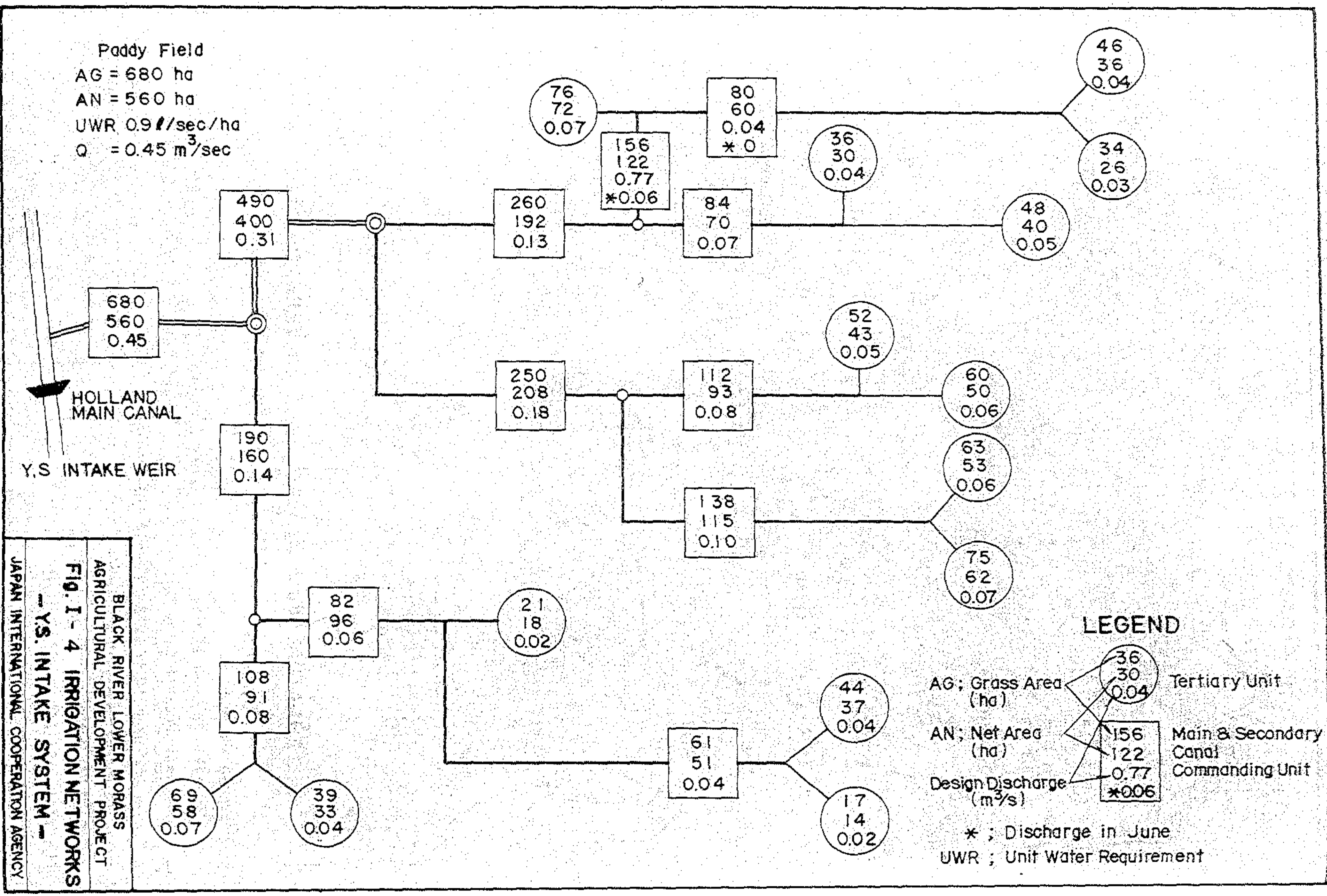
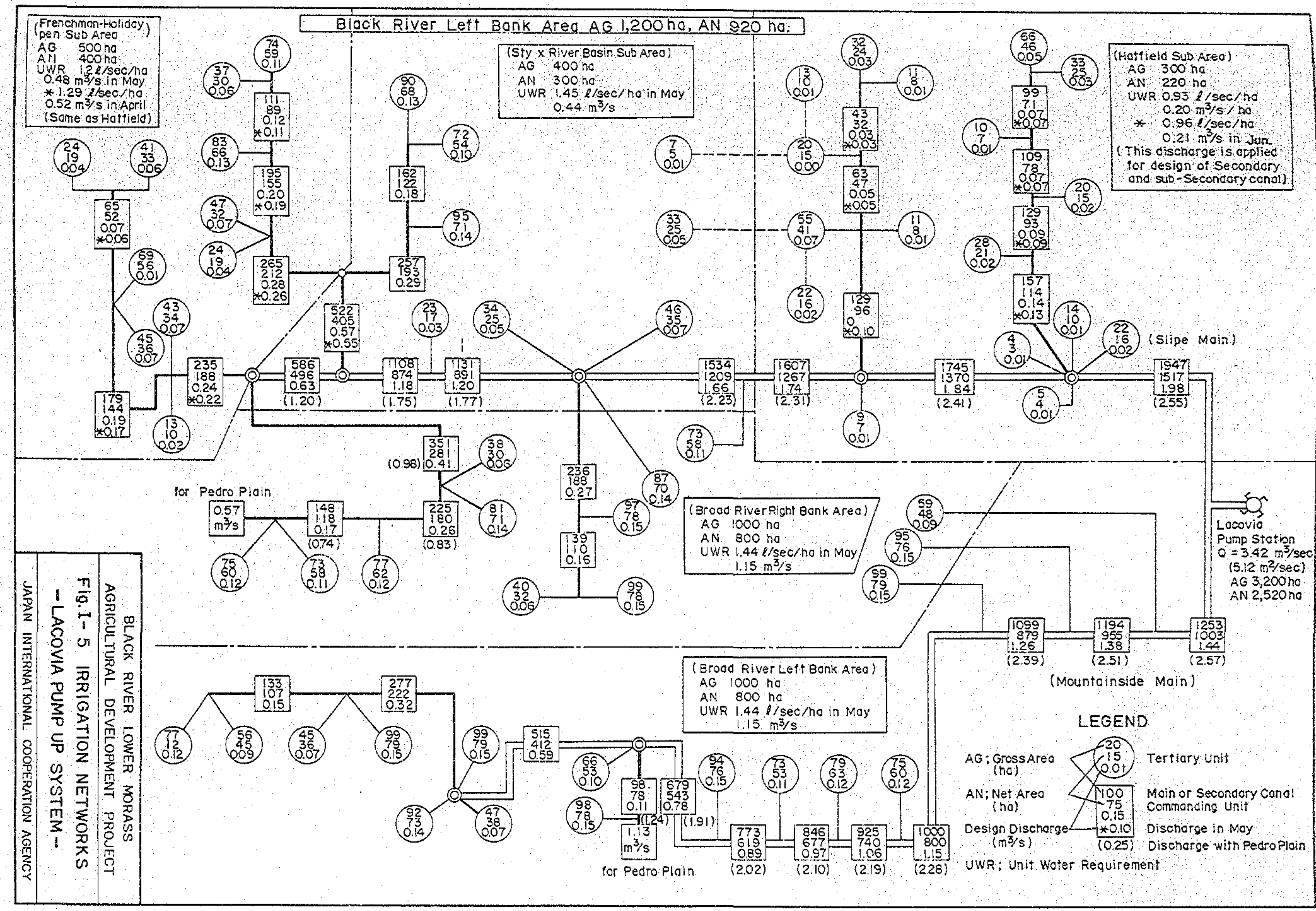


BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. I - 4 IRRIGATION NETWORKS

- Y.S. INTAKE SYSTEM -

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. I- 5 IRRIGATION NETWORKS
– LACOVIA PUMP UP SYSTEM –

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX J

PRELIMINARY DESIGN

ANNEX J

PRELIMINARY DESIGN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX J

PRELIMINARY DESIGN

1. DRAINAGE FACILITIES

1.1 Drainage Pump Station

1) Design discharge

Design discharge was determined based on the drainage requirement estimated in Annex H, as follows:

Pump Station	Design Discharge
Holland	4.5 m^3/s
Black River Left	7.5 m^3/s
Broad River Right	6.0 m^3/s
Broad River Left	4.5 m^3/s

2) Diameter and number of pumps

As shown in Table J-1, economic comparisons of alternative plans were made for most suitable diameter and number of pumps. As a result, the following numbers and diameter of drainage pumps are proposed:

Pump Station	Diameter (m/m)	Number (set)
Holland	800	3
Black River Left	800	5
Broad River Right	800	4
Broad River Left	800	3

3) Pump head

a) Actual pump head

For design of the actual pump head, differences of inside and outside water levels at each pump station were used. The inside water level was given by the rating curve for the low water discharge shown in Fig. H-6, in the main drainage canals. On the other hand, the outside water level was determined based on the fifty year probable flood stages. The actual pump head estimated is given below:

b) Total pump head

Total pump head including loss of head "HL" was estimated by the following equation.

$$HL = hf + hi + ho + hbe$$

where, HL: Loss of head

hf: Friction loss of head

hi: Loss of head by inflow

ho: Loss of head by outflow

hbe: Loss of head by pipe bend

Total pump head of each pump station is as follows:

(Unit: m)

Pump Station	Actual Head	Loss of Head	Total Head
Holland	2.70	1.10	3.80
Black River Left	2.30	1.10	3.40
Broad River Right	2.10	1.10	3.20
Broad River Left	2.00	1.10	3.10

4) Pump type

As shown above, drainage pumps require a low head, so an axial flow pump is employed for the drainage pump. Topographic conditions of all drainage pump stations proposed are similar to Lacovia Irrigation Pump Station. Accordingly, an incline axial flow pump is selected.

5) Prime mover equipment

a) Selection of prime mover equipment

Diesel engines are adopted for prime mover equipment taking the following factors into consideration;

- drainage pumps should only be operated when floods occur so that operation hours are short and not continuous all year round,
- construction cost is more economical advantages than electric motor drive.

6) Required capacity of engine

Based on the design conditions and pump specification, power requirement is estimated as follows:

$$P = C \cdot \frac{0.222 \cdot \gamma \cdot Q \cdot H}{\eta p \cdot \eta t} \text{ (PS)}$$

where, P: Power required for the prime mover

C: Excess (Engine = 1.2)

γ: Specific weight of pumped liquid (kg/ℓ)
(Water = 1.0)

Q: Capacity (m^3/min)
(Q = 90 m^3/min)

H: Total pump head (m)

ηp: Pump efficiency (ηp = 0.78)

ηt: Transmission efficiency (ηt = 0.96)

Power requirement of each pump station per unit is as follows:

Pump Station	P (P.S)
Holland	125
Black River Left	110
Broad River Right	105
Broad River Left	100

A preliminary design of each pumping station is shown in Drawings No. 5-1 to 5-4.

1.2 Dikes

Based on the flood discharge and flood level of the respective rivers, the soil characteristics of embankment materials as well as usage as road, proposed dikes are designed as shown below:

River	Dike	B (m)	H (m)	m	fb (m)	L (km)
Black River	Right Dike	8.0	-*	1.5	0.5	2.1
Black River	Left Dike	8.0	-*	2.0 (1.5)	0.5	8.0
Black River	Holland East Dike	8.0	-*	1.5	0.5	2.9
Y.S. River	Holland West Dike	6.0	0.8	2.0	0.3	2.4
Y.S. River	Y.S. Dike Improvement	6.0	0.5	1.5	0.3	1.6
Broad River	Right Dike	8.0	0.8	2.0	0.3	5.7
Broad River	Left Dike	8.0	0.8	2.0	0.3	5.7

where, B: Width of dikes crest

H: Height of dike

m: Side slope
for clay/clayey soil area - 1:1.5
for peat area - 1:2.0

Fb: Freeboard

L: Length of dikes

Remarks: * Height of dike is not fixed because the ground surface is undulated.

Profile, plan and cross section of dikes are shown in Drawings No. 7-1 to 7-4.

1.3 Catch Drain

1) Design discharge

The design discharge is determined at 6.7 ℓ/s/ha as a peak runoff from the hinter land, of which runoff coefficient is estimated at 0.5, based on the 10-year probable daily rainfall (115 mm) using Rational Formula. The maximum design discharge of each catch drain is as follows:

(Unit: m^3/s)

Catch Drain	Maximum Design Discharge
Santa Cruz - North -	5.1
Santa Cruz - South -	9.6
Arlington	18.6

2) Hydraulic gradient

Considering the maximum velocity and natural gradient of ground surface, hydraulic gradient is designed to be with the range of 1/2,000 to 1/4,000.

3) Canal section

Cross sections of the catch drain were determined with the following criteria:

- Type : Trapezoidal earth canal
- Permissible maximum velocity: 0.7 m/s
- Roughness coefficient : 0.03 for Manning formula
- Size slope
  - Inside slope : 1:1.0
  - Outside slope : 1:2.0
- Minimum bottom width : 1.0 m

Designed canal section of each catch drain is shown in Drawings No. 7-5, and summarized below:

(Unit: m)

Catch Drain	Bottom Width	Canal Height
Santa Cruz (North)	2.0	1.5
Santa Cruz (South)	1.0 - 2.0	1.0 - 1.5
Arlington	1.0 - 2.0	1.0 - 4.0

1.4 Drainage Canals

1) Design discharge

The maximum design discharge of each main drainage canal is taken to be the same as the drainage pump station mentioned in 1.1.1., and is as follows:

Canal		Water-shed Area (ha)	Maximum Design Discharge (m^3/s)
Holland Main Drainage Canal		990	5.2
Black River L/B	"	1,680	8.7
Broad River R/B	"	1,180	6.7
Broad River L/B	"	1,080	5.0

Normal design discharge is described in Annex H and shown in Fig. H-6.

The design discharge of a lateral drain (one for 0.5 ha) is planned to be 0.19 m^3/s based on design rainfall as described in Annex H.

2) Hydraulic gradient

In main drainage canal, considering the maximum velocity and natural gradient of the ground surface, hydraulic gradient is designed to be with the range of 1/10,000 to 1/1,500. Lateral and farm drains are designed 1/2,000. Based on these design conditions, each main drainage canal is designed as shown in Drawings No. 6-1 to 6-5. The low water level is designed based on normal discharge, same as the above canal section.

Typical cross sections of lateral and farm drain is shown in Drawings No. 8-1.

3) Canal section

The drainage canal sections were determined with the following conditions:

- Type : Trapezoidal earth canal
- Permissible maximum velocity : 0.7 m/s
- Roughness coefficient : 0.03 for Manning formula

- Minimum freeboard : 0.3 m
- Minimum bottom width

  Main drain : 0.5 m
  Lateral drain : 0.3 m
- Inside slope

  Main drain : 1:2.0
  Lateral drain : 1:1.0

Designed canal section of each main drainage canal is shown in Drawings No. 6-1 to 6-5, and summarized below:

(Unit: m)

	Bottom Width	Canal Height
Holland	0.5 - 4.0	1.4 - 2.1
Black River Left Bank	0.5 - 8.0	2.1 - 3.1
Broad River Right Bank	0.5 - 6.0	2.4 - 2.6
Broad River Left Bank	0.5 - 5.0	2.0 - 2.6

4) Related structures

a) Drainage culvert

A drainage culvert is proposed to the place where main drain crosses under the road. This is constructed as pre-cast concrete pipe culvert due to its flexibility against foundation shrinkage in the peat area. Foundation method is adopted as wooden ladder with marl.

b) Drain check

A drain check is planned at the outlet from the paddy field area to the main drainage canal in order to control and to separate the water level in the lateral drain by the gate from that in the main drainage canal. A gate is installed together with a stoplog.

2. IRRIGATION FACILITIES

2.1 Y.S. Intake Weir

2.1.1 Design condition

1) Design discharge

As described in Annex I, the design discharge to be taken from Y.S. River to Holland area is determined at 0.45 m^3/sec.

2) Flood water level

Flood discharge of the river is referred in Annex B as 55 m^3/s with a recurrence interval of 50 years. Flood water level (F.W.L.) computed by the perfect overflow formula as follows:

$$Q = kbh^{3/2}$$

where, Q: Overflow discharge of weir (55 m^3/sec)

K: Coefficient for discharge (2.0)

b: Width of weir (14 m)

h: Overflow depth (m)

$$h = (Q/kb)^{2/3} = 1.57 \text{ m}$$

Therefore,

F.W.L. = 10.1 (Top elevation of weir) + 1.57 = 11.7 m

3) Low water level

Low water level of the river is designed at the same level as the top of the weir structure at 10.1 m.

2.1.2 Gate

Submerged-orifice gate type is proposed for the intake in consideration of its moderate charge of intake discharge against the change of water depth in front of the orifice. Dimension and design intake discharges are computed as follows:

$$Q = C \cdot a \cdot \sqrt{2g\ (H + hv)}$$

where,
- Q: Intake discharge (m^3/sec)
- C: Coefficient ($\fallingdotseq 0.5$)
- a: Area ($b \times d = 0.7\ m \times 0.5\ m = 0.35\ m^2$)
- g: Acceleration of gravity ($9.8\ m/sec^2$)
- H: Differential of water level (m)
- hv: Velocity head ($\fallingdotseq 0$)

(in low water level)

$$Q\ell = 0.60 > 0.45\ m^3/sec$$

(in F.W.L.)

$$Qh = 1.15\ m^3/sec$$

$$Qo = 1.15 - 0.45 = 0.7\ m^3/sec \text{ (to spillway)}$$

2.1.3 Spillway

Normally, the gate would be controlled by manual. Unexpected flood caused by heavy rainfall in the upperstream would damage the main irrigation canal. Therefore, a 0.7 m^3/sec capacity of spillway is proposed to be constructed at the intake weir with the overflow water running to the Y.S. river again. Based on above condition, Y.S. intake weir is designed as shown in Drawings No. 3-1.

2.2 Lacovia Irrigation Pump Station

2.2.1 Design condition

1) Design discharge

The peak water requirement is estimated at 3.42 m^3/s, which is adopted to the design of pump station.

2) Pump head

The low water level on the Black River at 1.7 km downstream from the Lacovia bridge is estimated at 0.00 meter from mean sea level, of which minimum flow of 2.07 m^3/s was recorded in March, 1977. The high water level of the Black River is estimated to be about 3.8 meters from the mean sea level based on the 50 year return period probable flood discharge.

Taking into considerations required water levels of the Mountainside Main Canal and Slipe Main Canal, and distribution losses, the discharge water level is taken to be 5.45 meters from mean sea level. Accordingly, actual pump head is estimated to be 5.45 m based on above.

Calculation of the total pump head is calculated by the following equation:

$$H = Ha + hf + hi + ho + hbe$$

where,
- Ha: Actual pump head
- hf: Loss of head by friction $= \lambda \cdot \frac{L}{D} \cdot hv$
- hi: Loss of head by suction $= fi \cdot hv$
- ho: Loss of head by discharge $= Fo \cdot hv$
- hbe: Loss of head by bend $= fbe \cdot hv$
- hv: Loss of head by velocity
- λ: 0.031
- fi: 0.5
- fo: 1.0
- fbe: 0.34

therefore, H = 7.00 m.

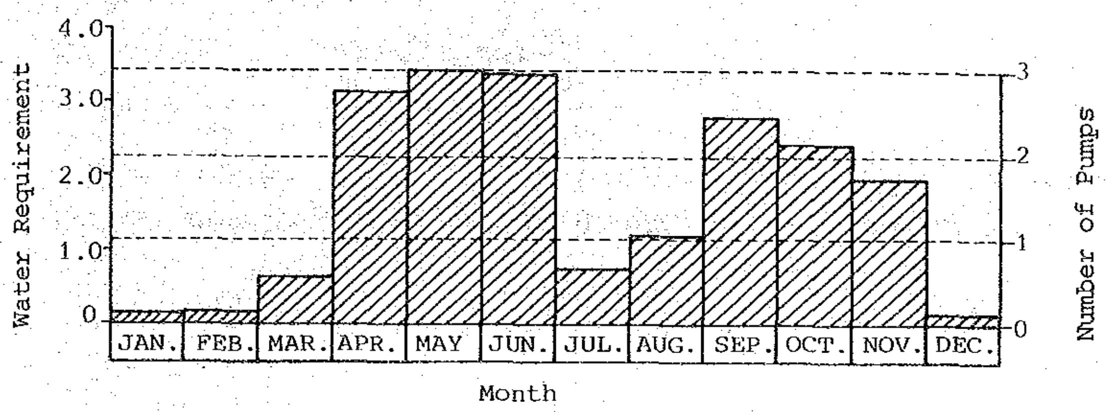
3) Selection of number of pumps, diameter of bore and type of flow

Number of pumps and diameter of bore are determined to 3 sets and 700 mm in this project by the following reason.

The pump equipment should be designed to have the highest efficiency and good economy taking into fluctuation of the irrigation water requirement, occurrence of the natural and artificial calamities. The following graph shows the fluctuation of the monthly water requirement to be pumped up in a year. In this condition, it is most advantageous to install four pumps including one stand-by pump.

Based on maximum head and minimum head, mixed flow pump is adopted.

NUMBER OF PUMPS



When the total capacity and number of pumps are determined, the capacity of each pump can be calculated as follows:

Water requirement : W = 3.42 m^3/sec

Number of sets : N = 3 sets

Pump capacity : Q = W/N x 60 sec·m^3/min/set

therefore, Q = 68.4 m^3/min/set.

The bore of the pump has been determined based on the flow rate. Fig. J-1 shows the relation between the flow rate and the bore of the pumps for general purposes from which a 700 millimeter diameter mixed flow pump can be adopted.

2.2.2 Alternative study of pump type

From the above-mentioned design conditions, a low lift range application pump can be proposed as follows:

- Vertical Mixed Flow Pump (see Fig. J-2)
- Inclined Mixed Flow Pump (see Fig. J-3)

The above two types of pump were compared from a viewpoint of easiness of construction works and cost.

a) Economical comparison

Construction Costs

(Unit: US$)

Item	Pump Type	
	Vertical Mixed Flow	Inclined Mixed Flow
Design Condition	ø700 mm, 485 rpm 90 kW, 3 sets	ø700 mm, 485 rpm 90 kW, 3 sets
Pump, Motor	210,650	245,000
Pump Accessories	419,500	358,250
Cost, Insurance, Freight (C.I.F.)	40,500	35,420
Installation Cost	119,250	116,670
Sub-total	789,900	755,340
Construction Cost of Pump House	93,330	25,210
Total	883,230	780,550

b) Availability of construction works

Item	Pump Type	
	Vertical Mixed Flow	Inclined Mixed Flow
Civil works	The works are difficult and construction period long.	Simple
Architectural works	Demand Pump House L= 8m, B= 14m, H= 11m The works are difficult and costs high.	Demand Operation House L= 85m, B= 10m, H= 4m
Installation works	The works are complicated.	Simple
Operation & maintenance	Ordinary	Ordinary
Additional work (Pedro Plain)	Civil work & pump house	Civil work

From the viewpoint of cost and simplicity of construction works as mentioned above, the inclined pump is adopted for the project.

2.2.3 Prime mover equipment

1) Selection of prime mover equipment

Electric motors are recommended taking the following factors into consideration.

- electric power is easily supplied from Lacovia village, and
- the pump is easily operated all year round and especialy continious 24 hours operation in the peak season. (Apr., May, Jun.)

2) Decision of power required for pump

Power required for the prime mover is calculated by the following equation.

$$P = C \frac{0.163 \cdot r \cdot Q \cdot H}{\eta p \cdot \eta t} \quad (kW)$$

where, P: Power required for the prime mover

c: Excess (motor = 1.5)

r: Specific weight of pumped liquid (kg/ℓ) (water = 1)

Q: Capacity (m^3/min) (Q = 68.4 m^3/min)

H: Total pump head (m) (H = 7.00 m)

ηp: Pump efficiency (ηp = 0.79)

ηt: Transmission efficiency (ηt = 0.96 - As reduction gear box with horizontal spur gears)

therefore, P = 120 kW.

2.2.4 Design of bifurcation work

Irrigation water from the Lacovia pump station will be diverted into the Mountainside Main Canal and the Slipe Main Canal. The canal discharges are 1.44 m^3/s for the former, 1.98 m^3/s for the latter. Consequently a bifurcation needs to be constructed. A longitudinal bifurcation work with an overflow weir is employed from the viewpoint of accuracy of diverted water volume and easy operation. The weir width is divided into two parts in proportion to the ratio of the discharge to be diverted.

Since the width of the discharge pond is decided at 10.40 meters due to the disposition of the pumps, the weir width is determined at 8.60 meters exclusive of the width of the partition walls which is calculated to be 1.8 m (0.30 m x 6 walls). Hence, in proportion to the flow ratio, the weir width for the Mountainside Irrigation Canal and Slipe Irrigation Canal, can be determined as 3.62 m and 4.98 m respectively.

On the other hand, the overflow depth can be determined as follows:

$Q = C \cdot B \cdot h^{3/2}$ $\quad h = (Q/(C \cdot B))^{2/3}$

where, Q: Discharge (m^3/s)

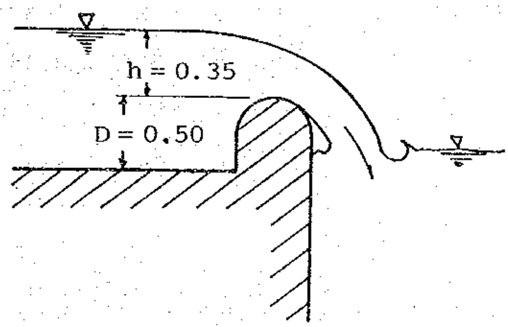
C: Coefficient of capacity (1.96)

$(C = 1.785 + (\frac{0.00295}{h} + 0.237\frac{h}{D}))$

B: Width of weir (8.60 m)

h: Height of weir (0.35 m)

D: Height of weir edge relative to bottom of weir (D = 0.50 m)



A preliminary design of Lacovia Pump Station is made as shown in Drawings No. 2-1.

2.2.5 Operation house

As an operation house will be built for the purpose of operation and maintenance of the pumps it includes; an office, power room and operation room. Dimensions of the operation house can be determined from the office space and the equipment to be installed as follows:

Item	Dimensions B	L	H	Number
Feeder panel	1,000 x	2,000 x	2,350	1
Receiving panel	800 x	2,000 x	2,350	1
High-tension motor panels	900 x	2,000 x	2,350	3
Low-tension panel	800 x	2,000 x	2,350	1
Three-phase transformer	800 x	2,000 x	2,350	1
On-the-spot control panels	1,890 x	550 x	2,350	3
Relay panel	800 x	550 x	2,350	1
DC power supply unit	1,000 x	800 x	1,900	1

Therefore, the dimensions of the operation house are 10.00 m length, 8.5 m width and 4.00 m height. (See Fig. J-4)

2.3 Irrigation Canals

1) Design discharge

The design discharge for irrigation canals is based on the peak monthly requirement in respective sub-areas described in Annex I (3.2.7) and shown in Figures I-4 and I-5. The design discharge for each main canal is summarized below:

Canal	Area (ha)	Design Discharge (m^3/sec)
Holland Main Canal	560	0.45
Slipe Main Canal	1,520	1.98 (2.55)
Mountainside Main Canal	1,000	1.44 (2.57)

Remarks: Design discharge in ( ) shows that with Pedro Plain

2) Canal lining

To minimize operation and maintenance costs in particular for the weed protection, main, secondary and sub-secondary canals will be lined with plain concrete, and thus, lesser canal section and lesser head of pump will be applicable than that of earth canal. Tertiary canals and farm ditches will be lined with soil cement, of which details are described in Section 3.2.

3) Hydraulic gradient

Considering the allowable water velocity and natural gradient of the ground surface, hydraulic gradient of main and secondary canals is designed to be with the range of 1/8,000 to 1/300.

4) Canal section

Cross sections, the irrigation canals were determined based on the hydraulic calculation using Manning formula with the following criteria.

- Permissible velocity

Type of Canals	Maximum Velocity	Minimum Velocity
Concrete lined canal	1.5 m/s	0.3 m/s
Soil cement lined canal	1.0 m/s	0.3 m/s

- Roughness coefficient for Manning formula

Concrete lined canal : 0.015

Soil cement lined canal : 0.020

- Minimum freeboard

$Fb = 0.05d + hv + 0.15$

where, Fb: Freeboard (m)

d: Water depth (m)

hv: Head of velocity (m)

- Side slope

Type of Canals	Inside Slope	Outside Slope
Concrete lined canal	1:1.25 (1:1.0 in embankment)	1:1.5
Soil cement lined canal	1:1.25	1:2.0

- Bottom width (B) and water depth (D)

Canal bottom width and water depth are decided based on most effective cross-section and B/D ratio. In principle the ratio is used 1.0 to 1.5 in the design.

Designed canal section of each main canal is shown in Drawings No. 4-1 to 4-3, and summarized below:

(Unit: m)

	Bottom Width	Canal Height
Holland Main Canal	0.4 - 0.5	0.8
Slipe Main Canal	0.8 - 1.5	1.0 - 1.5
Mountainside Main Canal	0.8 - 1.2	1.0 - 1.2

5) Related structures

A number of structures such as turnouts, checkgates, culverts, cross drains, drop and spillways are required in conjunction with the irrigation canals. These structures are shown in Drawings No. 9-1 to 9-5 in Volume III. The number of structures required is shown in Table J-2, and summarized below:

( ): with Pedro Plain

Canal	Turnout	Checkgate	Culvert	Cross Drain	Drop	Spill-way
Main canal	32 (34)	14	19	5	1	9
Secondary canal	48 (50)	23 (24)	58	0	8	12 (13)
Total	80 (84)	37 (38)	77	5	9	21 (22)

a) Turnout

A turnout is constructed to distribute water from a parent canal to a lower grade canal, and a Parshall flume is constructed in a lower grade canal to measure the diverted water discharge. The turnouts are classified into the following three types;

Type	Q_1 (m^3/s)	Q_2 (m^3/s)
I	$1.0 \leq Q_1 \leq 2.0$	$0.2 < Q_2$
II	$1.0 \leq Q_1 \leq 2.0$	$Q_2 \leq 0.2$
III	$Q_1 < 1.0$	$Q_2 \leq 0.2$

where, Q_1: Discharge of a parent canal in upstream

Q_2: Discharge of a lower grade canal at the beginning point

b) Check gate

A check gate is proposed to maintain the required water level for diversion of irrigation water. The design of the facilities generally depends on the gradient of canals and the seasonal fluctuation of water requirement. Two types of check gate are proposed as follows:

Type I : for Slipe and Mountainside Main Canal

Type II: for Holland Main Canal and Secondary Canals

c) Culvert

A concrete pipe culvert is provided for road cross over the canal. The velocity in the conduit which is less than 1.0 m/s is adopted. Two types of culvert is proposed as follows:

Type	Pipe Diameter
I	1,200 mm
II	600 mm

d) Cross drain

A cross drain for the stream and catch drain is planned to be constructed to cross under the main canal into the river or lateral drains. Two types of cross drain are designed as follows:

Type	Design Discharge	Pipe Diameter
I	more than 10 m^3/s	1,500 mm
II	less than 10 m^3/s	600 mm

e) Drop

A drop is required where topography along the canal has a steeper slope than that of designed hydraylic gradient in the canal, i.e. has the function to dissipate excess hydraulic energy. Two types of drop are proposed as follows:

Type	Drop Height
I	1.0 m
II	0.5 m

f) Spillway

A spillway is designed in the canal system for two purposes. One is to empty the canal for emergency or clearing to repair the canal, the other is to spill out an excess flow in the canals. A spillway is generally provided at the end of main and secondary canal and the site where a secondary canal is branched off from a main canal. All spillways are connected to the nearby drainage canals.

3. ON-FARM DEVELOPMENT

3.1 Farm Plot

The size of each field plot was determined at 50 m x 100 m (= 0.5 ha) in both the peat and mineral soil areas in Annex H.

Typical on-farm system is proposed taking into consideration the co-relation between irrigation, drainage facilities and farm roads network as shown in Fig. J-5.

3.2 On-farm Irrigation Facilities

1) Tertiary irrigation canal and farm ditch

a) Design discharge

Unit water requirement for tertiary unit is calculated by the following equation on the assumption that there would be no effective rainfall during one rotation interval.

UWR = (CU. + Pr.)/Ei

where, UWR: Unit Water Requirement
CU.: Consumptive Use of Water (average in spring crop)
Pr.: Percolation (average in spring crop)
Ei: Irrigation Efficiency

Design discharge of tertiary canals and firm ditches is estimated as product of UWR and area of irrigation rotation block (20 ha). Tertiary unit means an organization of one or more and at most 5 irrigation rotation blocks. UWR and design discharge are shown in the following table.

Descriptions	In Mineral Soil Area	In Peaty Soil Area
CU.+Pr. (mm/day)	7.0	11.4
CU.+Pr.(ℓ/sec/ha)	0.81	1.32
Ei	0.72	0.72
(CU.+Pr.)/Ei(ℓ/sec/ha)	1.13	1.83
Design discharge (ℓ/sec)		
Irrigation rotation unit (20 ha)	22.6 say 30	36.6 say 40
Tertiary unit (100 ha)	113 say 120	183 say 200

b) Canal type

The canal lining for tertiary irrigation canals and farm ditches is proposed to be soil cement lining based on the alternative case study shown in Table J-3. In this study, corrugated steel pipe canal, soil cement lined canal and clayey earth canal are carefully compared. Corrugated steel pipe canal is light resulting in less sinkage of canal bodies even on the peat soil foundation, but it is very expensive. Soil cement lined canal and clayey earth canal can be constructed by local-made material but the former has an economical advantage in consideration of maintenance cost. Canal type is, therefore, proposed as soil cement lined canal for tertiary canal and farm ditch in not only the peat soil area but also the mineral soil area as well.

2) Division box and field outlet

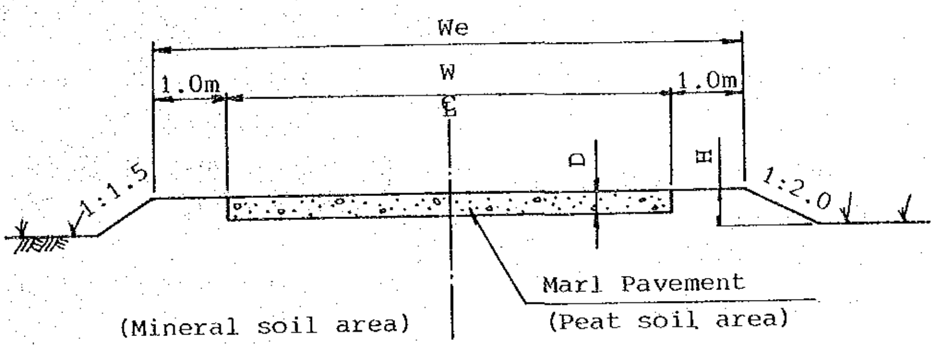
Rotational irrigation method does not necessitate the division box for each field plot (0.5 ha). One division box and two field outlets on both sides of the farm ditch are sufficient for one rotational irrigation block (4.0 ha). Foundation of these concrete structures is designed as wooden ladder with marl for the peat soil area. A division box and a field outlet is to be made by precast concrete.

3.3 Tractor Passage

A passage from farm road into fields is proposed to facilitate a tractor coming into field. Its slope is lower than 1:4.0 (25%) and 4.0 m in width considering the size of proposed farm machineries and their implements. Differential of each field plot elevation is an important factor for the decision of tractor passage intervals. In the peat soil area one passage is practical for four field plots (2.0 ha) and it is possible to move over from one plot to another field plot even by combine. In the Hatfield sub-area one passage is designed to be attached to each field plot and in the Holland area one for two plots on an average.

4. ROADS

The road width of main and secondary roads are determined at 8.0 m (0.6 m in effective width) and 7.0 m (0.5 m) respectively taking expected traffic density into consideration and width of farm road is 6.0 m (0.4 m in effective width) taking width of farm machines to be introduced. All roads are paved by marl compaction of 0.3 m, 0.2 m, and 0.1 m in thickness, respectively. The height of main road is designed at 0.5 m from the field surface, and 0.4 m for the others based on the allowable inundation depth in the paddy field as described in Annex H. Typical cross section is shown below:



(in meters)

Roads	We	W	H (min.)	D
Main road	8.0	6.0	0.5	0.2
Secondary road	7.0	5.0	0.4	0.2
Farm road	6.0	4.0	0.4	0.1

5. PRINCIPAL FEATURES

PRINCIPAL FEATURES OF HOLLAND SYSTEM

1. Source of Irrigation Water : Y.S. River

2. Gross Irrigable Area : 680 ha

3. Net Irrigable Area : 560 ha

4. Y.S. Intake Weir
   - 4.1 Design discharge of intake : 0.45 m^3/s
   - 4.2 Intake weir : Fixed type concrete weir
     B = 14.0 m, H = 2.6 m
   - 4.3 Gate : Submerged orifice gate
     0.5 m x 0.7 m

5. Irrigation Facility
   - 5.1 Main canal
     - (1) Canal type : Trapezoidal concrete lined canal
     - (2) Design discharge : 0.45 - 0.31 m^3/s
     - (3) Canal length : 3.2 km
     - (4) Related structure :
       - Turnout : 3 nos.
       - Check gate : 2 nos.
       - Culvert : 7 nos.
       - Cross drain : 5 nos.
       - Spillway : 2 nos.
   - 5.2 Secondary & sub-secondary canal
     - (1) Canal type : Trapezoidal concrete lining canal
     - (2) Design discharge : 0.18 - 0.02 m3/s
     - (3) Canal length : 11.1 km
     - (4) Related structure
       - Turnout : 11 nos.
       - Check gate : 7 nos.
       - Culvert : 37 nos.
       - Drop : 5 nos.
       - Spillway : 4 nos.

6. Holland Drainage Pump Station

6.1	Type of pump	: Incline axial flow driven by diesel engine
6.2	Diameter	: 800 mm
6.3	Design discharge per one unit	: 90 m^3/min
6.4	Capacity of power unit	: 125 PS
6.5	Number of pump sets	: 3 sets

7. Main Drainage Canal

7.1	Canal type	: Trapezoidal earth canal
7.2	Design discharge	: 2.68 - 0.93 m^3/s
7.3	Canal length	: 8.9 km
7.4	Drainage culvert	: 7 nos.

8. Roads

8.1	Length of main road	: 9.0 km
8.2	Length of secondary road	: 19.4 km
8.3	Length of farm road	: 34.0 km

9. On-farm Development

9.1 Area of on-farm development : 560 ha

9.2 Irrigation facility

(1)	Canal type	: Trapezoidal soil cement lined canal
(2)	Length of tertiary canal	: 4.5 km
(3)	Length of farm ditch	: 28.0 km
(4)	Related structure	
	- Division box	: 140 nos.
	- Culvert of tertiary canal	: 28 nos.

9.3 Drainage facility

(1)	Canal type	: Trapezoidal earth canal
(2)	Length of lateral drainage canal	: 28.0 km
(3)	Length of farm drain	: 117.6 km
(4)	Drain check	: 28 nos.

10. Dike

10.1	Length of Black River right dike	:	1.9 km
10.2	Length of Holland east dike	:	2.9 km
10.3	Length of Holland west dike	:	2.4 km
10.4	Length of Black River short cut	:	0.5 km

11. Y.S. River Bank (Improvement) : 1.6 km

PRINCIPAL FEATURES OF LACOVIA PUMP UP SYSTEM

1. Source of Irrigation Water		:	Black River
2. Lacovia Pump Station (with Pedro plain)			
2.1	Type of pump	:	Incline mixed flow driven by not
2.2	Diameter	:	700 mm
2.3	Peak discharge per one unit	:	68 m^3/min (61 m^3/min)
2.4	Capacity of power unit	:	120 kW (110 kW)
2.5	Number	:	4 nos. (6 nos.)
3. Irrigation Facility (with Pedro Plain)			
3.1	Slipe main canal		
(1)	Canal type	:	Trapezoidal concrete lined canal
(2)	Design discharge	:	1.98 - 0.63 m^3/s (2.55 - 1.20 m^3/s)
(3)	Canal length	:	5.2 km
(4)	Related structures		
	- Turnout	:	16 nos. (18 nos.)
	- Check gate	:	6 nos.
	- Culvert	:	6 nos.
	- Spillway	:	5 nos.
	- Drop	:	1 nos.
3.2	Mountainside main canal (with Pedro Plain)		
(1)	Canal type	:	Trapezoidal concrete lined canal
(2)	Design discharge	:	1.44 - 0.59 m^3/s (5.12 - 0.59 m^3/s)
(3)	Canal length	:	8.8 km
(4)	Related structures		
	- Turnout	:	13 nos.
	- Check gate	:	6 nos.
	- Culvert	:	6 nos.
	- Spillway	:	2 nos.
	- Cross drain	:	4 nos.
4. Roads			
4.1	Length of main road	:	25.5 km
4.2	Length of secondary road	:	26.2 km
4.3	Length of farm road	:	64.0 km

(Black River Left Bank Area)

5. Gross Irrigable Area	:	1,200 ha
6. Net Irrigable Area	:	920 ha
7. Secondary Canal		
7.1 Canal type	:	Trapezoidal concrete lined canal
7.2 Design discharge	:	0.57 - 0.03 m^3/s
7.3 Canal length	:	12.3 km
7.4 Related structure		
- Turnout	:	25 nos.
- Check gate	:	13 nos
- Culvert	:	12 nos.
- Spillway	:	5 nos.
- Drop	:	3 nos.
8. Black River Left Pump Station		
8.1 Type of pump	:	Incline axial flow driven by diesel engine
8.2 Diameter	:	800 mm
8.3 Pump capacity	:	90 m^3/min
8.4 Capacity of power unit	:	110 PS
8.5 Number of pump sets	:	5 sets
9. Main Drainage Canal		
9.1 Canal type	:	Trapezoidal earth canal
9.2 Design discharge	:	8.70 - 0.62 m^3/s
9.3 Canal length	:	17.1 km
9.4 Drainage culvert	:	9 nos.
10. Length of Secondary Farm Road	:	27.3 km
11. On-farm Development		
11.1 Area of on-farm development	:	920 ha
11.2 Irrigation facility		
(1) Canal type	:	Trapezoidal soil cement lined canal
(2) Length of tertiary canal	:	7.4 km
(3) Length of farm ditch	:	46.0 km

(4) Related structure

- Division box : 230 nos.
- Culvert of tertiary canal : 46 nos.

11.3 Drainage facility

(1) Canal type : Trapezoidal earth canal

(2) Length of lateral drainage canal : 46.0 km

(3) Length of farm drain : 193.2 km

(4) Drain check : 46 nos.

12. Length of Black River Left Dike : 8.3 km

(Broad River Right Bank Area)

5. Gross Irrigable Area	:	1,000 ha
6. Net Irrigable Area	:	800 ha
7. Secondary Canal (with Pedro Plain)		
7.1 Canal type	:	Trapezoidal concrete lined canal
7.2 Design discharge	:	0.41 - 0.16 m^3/s (0.98 - 0.16 m^3/s)
7.3 Canal length	:	3.1 km (5.5 km)
7.4 Related structure		
- Turnout	:	8 nos. (9 nos.)
- Check gate	:	2 nos. (3 nos.)
- Culvert	:	4 nos. (5 nos.)
- Spillway	:	2 nos.
8. Broad River Right Pump Station		
8.1 Type of pump	:	Incline axial flow driven by diesel engine
8.2 Diameter	:	800 mm
8.3 Design discharge per one unit	:	90 m^3/min
8.4 Capacity of power unit	:	105 PS
8.5 Number of pump sets	:	4 sets
9. Main Drainage Canal		
9.1 Canal type	:	Trapezoidal earth canal
9.2 Design discharge	:	6.70 - 0.88 m^3/s
9.3 Canal length	:	7.0 km
9.4 Drainage culvert	:	2 nos.
10. Length of Secondary Farm Road (with Pedro Plain)	:	17.5 km (18.9 km)
11. On-farm Development		
11.1 Area of on-farm development	:	800 ha
11.2 Irrigation facility		
(1) Canal type	:	Trapezoidal soil cement lined canal
(2) Length of tertiary canal	:	6.4 km
(3) Length of farm ditch	:	40.0 km

(4) Related structure

- Division box : 200 nos.
- Culvert of tertiary canal : 40 nos.

11.3 Drainage facility

(1) Canal type : Trapezoidal earth canal

(2) Length of lateral drainage canal : 40.0 km

(3) Length of farm drain : 168.0 km

(4) Drain check : 40 nos.

12. Length of Broad River Right Dike : 5.7 km

13. Santa Cruz (North) Catch Drain

13.1 Catch drain length : 4.0 km

13.2 Related structure

- Culvert : 3 nos.
- Drainage culvert : 1 nos.

(Broad River Left Bank Area)

5. Gross Irrigable Area : 1,000 ha

6. Net Irrigable Area : 800 ha

7. Secondary Canal (with Pedro Plain)

   7.1 Canal type : Trapezoidal concrete lined canal

   7.2 Design discharge : 0.32 - 0.15 m^3/s

   7.3 Canal length : 5.1 km (6.6 km)

   7.4 Related structure

   - Turnout : 4 nos. (5 nos.)
   - Check gate : 1 nos. (2 nos.)
   - Culvert : 5 nos.
   - Spillway : 1 nos. (2 nos.)

8. Broad River Left Pump Station

   8.1 Type of pump : Incline axial flow driven by diesel engine

   8.2 Diameter : 800 mm

   8.3 Design discharge per one unit : 90 m^3/min

   8.4 Capacity of power unit : 100 PS

   8.5 Number of pump sets : 3 sets

9. Main Drainage Canal

   9.1 Canal type : Trapezoidal earth canal

   9.2 Design discharge : 5.00 - 0.50 m^3/s

   9.3 Canal length : 8.2 km

   9.4 Drainage culvert : 3 nos.

10. Length of Secondary Farm Road (with Pedro Plain) : 19.2 km (20.7 km)

11. On-farm Development

   11.1 Area of on-farm development : 800 ha

   11.2 Irrigation facility

   (1) Canal type : Trapezoidal soil cement lined canal

   (2) Length of tertiary canal : 6.4 km

   (3) Length of farm ditch : 40.0 km

(4) Related structure

- Division box : 200 nos.
- Culvert of tertiary canal : 40 nos.

11.3 Drainage facility

(1) Canal type : Trapezoidal earth canal

(2) Length of rateral drainage canal : 40.0 km

(3) Length of farm drain : 168.0 km

(4) Drain check : 40 nos.

12. Length of Broad River Left Dike : 5.7 km

13. Santa Cruz & Arlington Catch Drain

13.1 Length of catch drain : 13.0 km

13.2 Related structure

- Culvert : 9 nos.
- Drainage culvert : 1 no.

PRINCIPAL FEATURES IN ALTERNATIVE CASE STUDY

Description	Unit	Alternative Case			
		Case 1	Case 2	Case 3	Case 1-a
1. Source of Irrigation Water		Black River and Y.S. River			
2. Gross Irrigable Area	ha	3,880	2,880	1,280	
3. Net Irrigable Area	ha	3,080	2,280	1,480	
4. Y.S. Intake Weir					
4.1 Design discharge	m^3/sec	0.45	0.45	0.45	0.45
5. Lacovia Pump Station					
5.1 Design discharge	m^3/sec	3.42	2.27	1.12	5.12
5.2 Pump diameter	mm	700	700	500	700
5.3 Number of pump sets	set	4	3	3	6
6. Length of Main Irrigation Canal	km	17.2	8.4	8.4	17.2
7. Length of Secondary Irrigation Canal	km	31.6	30.1	21.4	35.5
8. Drainage Pump Station					
8.1 Number of pump station	place	4	3	2	4
8.2 Total discharge	m^3/sec	25.6	20.6	13.9	25.6
8.3 Pump diameter	mm	———	800	———	———
8.4 Number of pump sets	nos.	15	12	8	15
9. Length of Dikes	km	28.5	22.8	17.1	28.5
10. Length of Main Drain Canal	km	41.2	33.0	26.0	41.2
11. Length of Catch Drain	km	19.9	4.0	0	19.9
12. On-farm Development	ha	3,080	2,280	1,480	3,080
13. Length of Main Road	km	35.2	24.8	16.1	35.2
14. Length of Secondary Road	km	83.4	64.2	46.7	83.4

Table J-1 ALTERNATIVE CASE STUDY FOR SPECIFICATIONS OF DRAINAGE PUMPS

Pump Station	Alternative Case	Design Discharge (m^3/sec)	Inundated Duration (hours) GLa.	Wla.	Cost of Pump Facilities (US$)	Appraisal
Holland	I: ø700 mm x 3 sets	3.5	83	63	-	Not Feasible
	II: ø700 mm x 4 sets	4.7	60	44	786,000	Feasible
	III: ø800 mm x 3 sets	4.5	61	46	676,000	Practicable
Black River Left	I: ø700 mm x 5 sets	5.8	110*	64*	-	Not Feasible
	II: ø700 mm x 6 sets	7.0	96	50*	-	Not Feasible
	III: ø800 mm x 5 sets	7.5	86	45	1,047,300	Practicable
Broad River Right	I: ø700 mm x 4 sets	4.7	110*	26	-	Not Feasible
	II: ø700 mm x 5 sets	5.8	84	0	952,500	Feasible
	III: ø800 mm x 4 sets	6.0	75	0	861,700	Practicable
Broad River Left	I: ø700 mm x 3 sets	3.5	115*	28	-	Not Feasible
	II: ø700 mm x 4 sets	4.7	76	0	786,000	Feasible
	III: ø800 mm x 3 sets	4.5	81	0	676,000	Practicable

Remarks: WLa.: Inundation duration over Allowable inundation water level.
GLa.: Inundation duration over Datum ground elevation.
*: Shortage of pump capacity

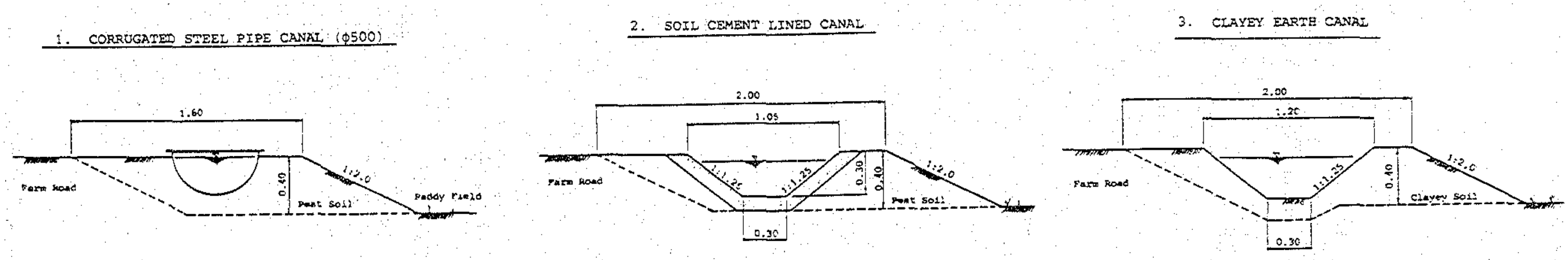
Table J-2 NUMBER OF STRUCTURES

	Turnout			Checkgate		Culvert		Cross Drain		Drop		Spillway
	I	II	III	I	II	I	II	I	II	I	II	
Holland Main Canal	-	-	3	-	2	-	7	-	5	-	-	2
Slipe Main Canal	2	12 (14)	2	6	-	6	-	-	-	1	-	5
Mountainside Main Canal	- (1)	5 (8)	8 (9)	6	-	6	-	1	3	-	-	2
Sub-total	2 (3)	17 (22)	13 (9)	12	2	12	7	1	8	1	-	9
Holland Area	-	-	11	-	7	-	37	-	-	5	-	4
Black River, Left Bank Area	-	-	25	-	13	-	12	-	-	-	3	5
Broad River, Right Bank Area	-	-	8 (9)	-	2	-	4	-	-	-	-	2
Broad River, Left Bank Area	-	- (1)	4	-	1 (2)	-	5	-	-	-	-	1 (2)
Sub-total	-	- (1)	48 (49)	-	23 (24)	-	58	-	-	5	3	12 (13)
Total	2 (3)	17 (23)	61 (58)	12	25 (26)	12	65	1	8	6	3	21 (22)

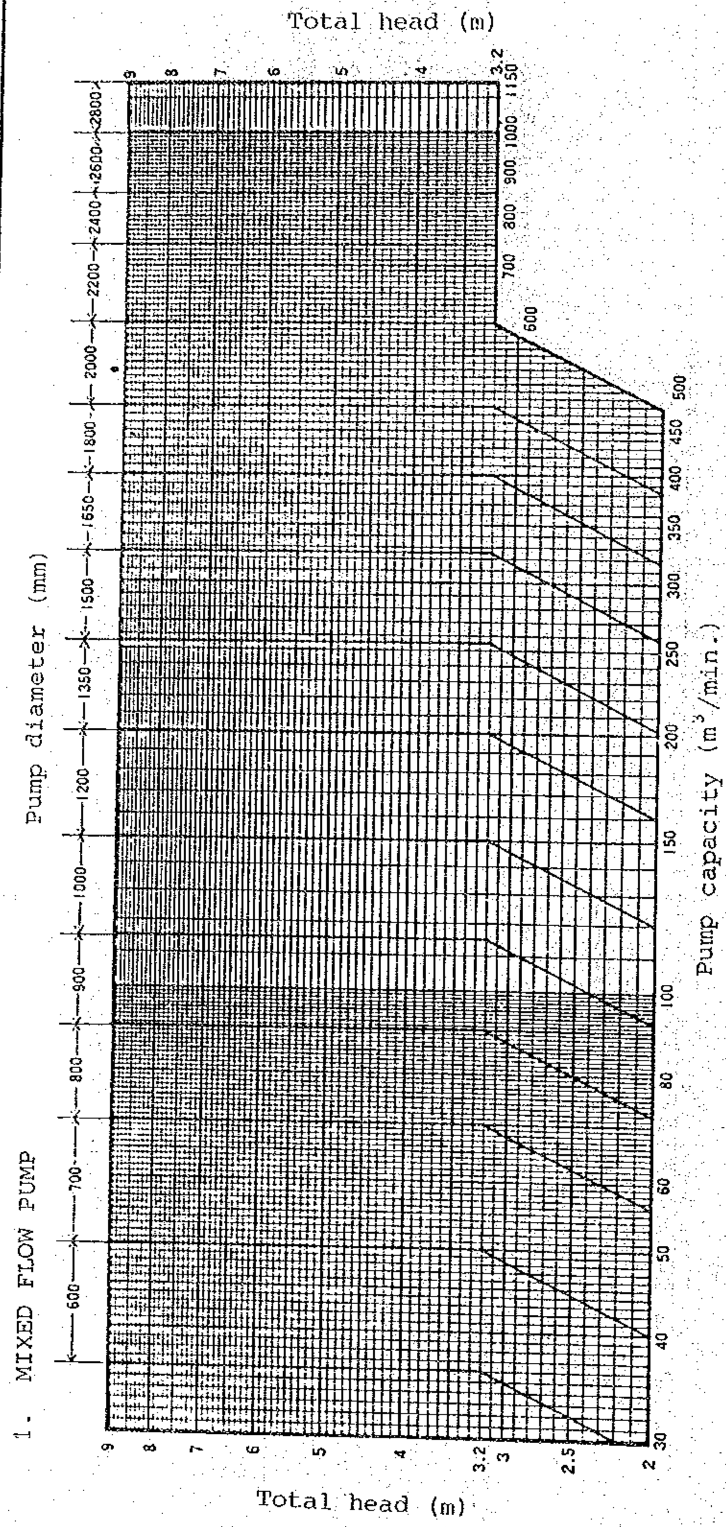
Table J-3 ALTERNATIVE CASE STUDY FOR CANAL TYPE OF FARM DITCH

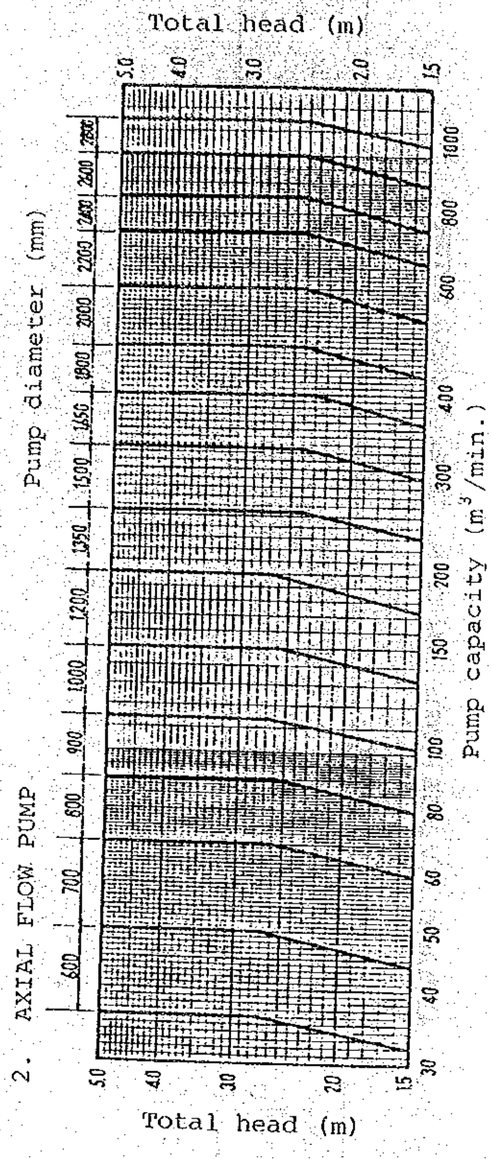
Alternative Case	Canal Type	Discharge (ℓ/sec)	n	Construction Cost (US$/10m)	O/M Cost Ratio (%)	O/M Cost Cost (US$10 years)	Total Cost (US$)	Cost Ratio (%)	Appraisal
Case 1	Corrugated Steel Pipe Canal	39	0.025	3,880	2	176	4,656	4,670	
Case 2	Soil Cement Lined Canal	39	0.020	66.5	5	33.3	99.8	100	Feasible
Case 3	Clayey Earth Canal	39	0.030	55.3	10	55.3	110.6	111	

TYPICAL CROSS SECTION



Note: Canal bed slope is designed as 1:2,000.

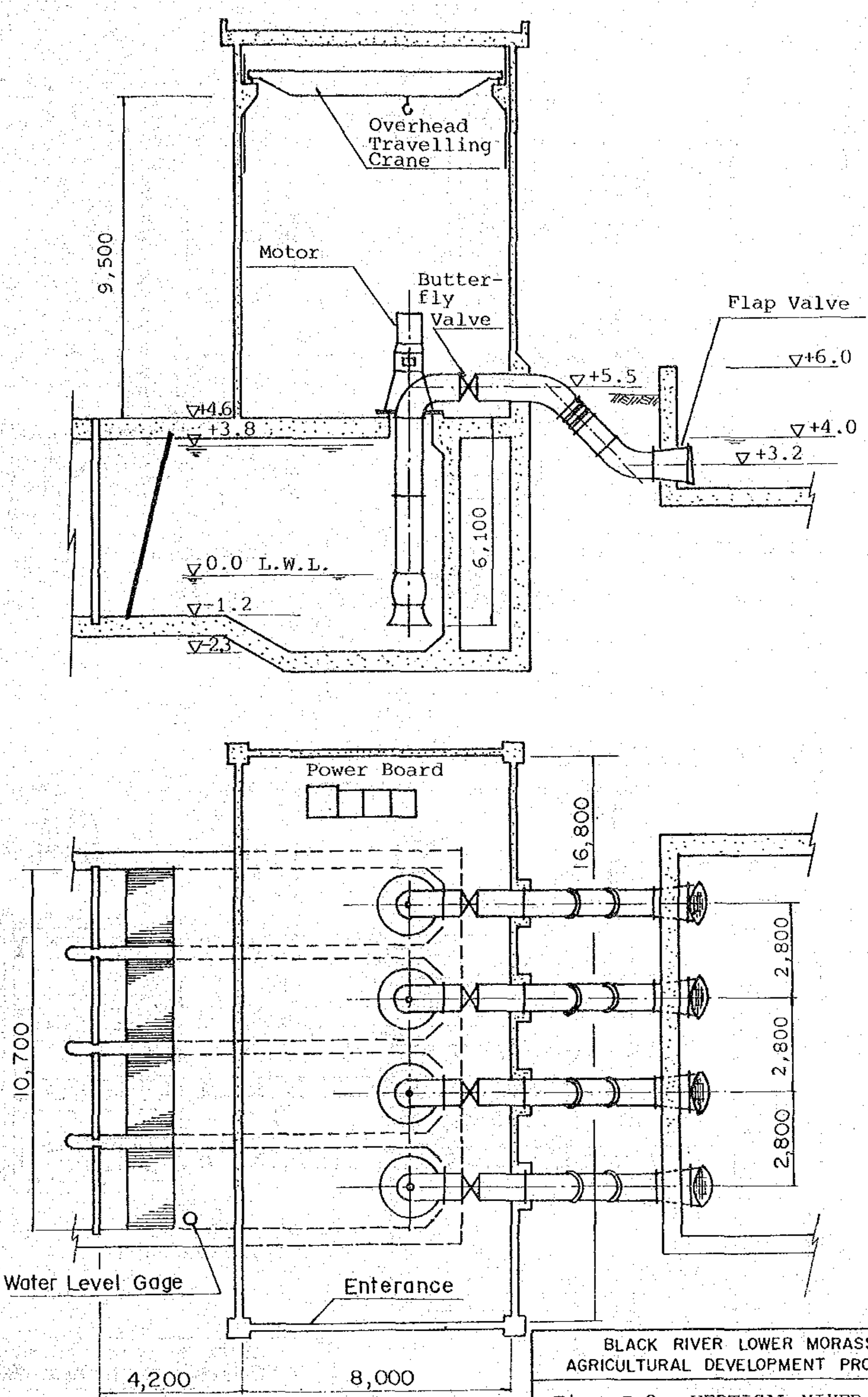




BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. J-1 SELECTION CHART OF PUMP

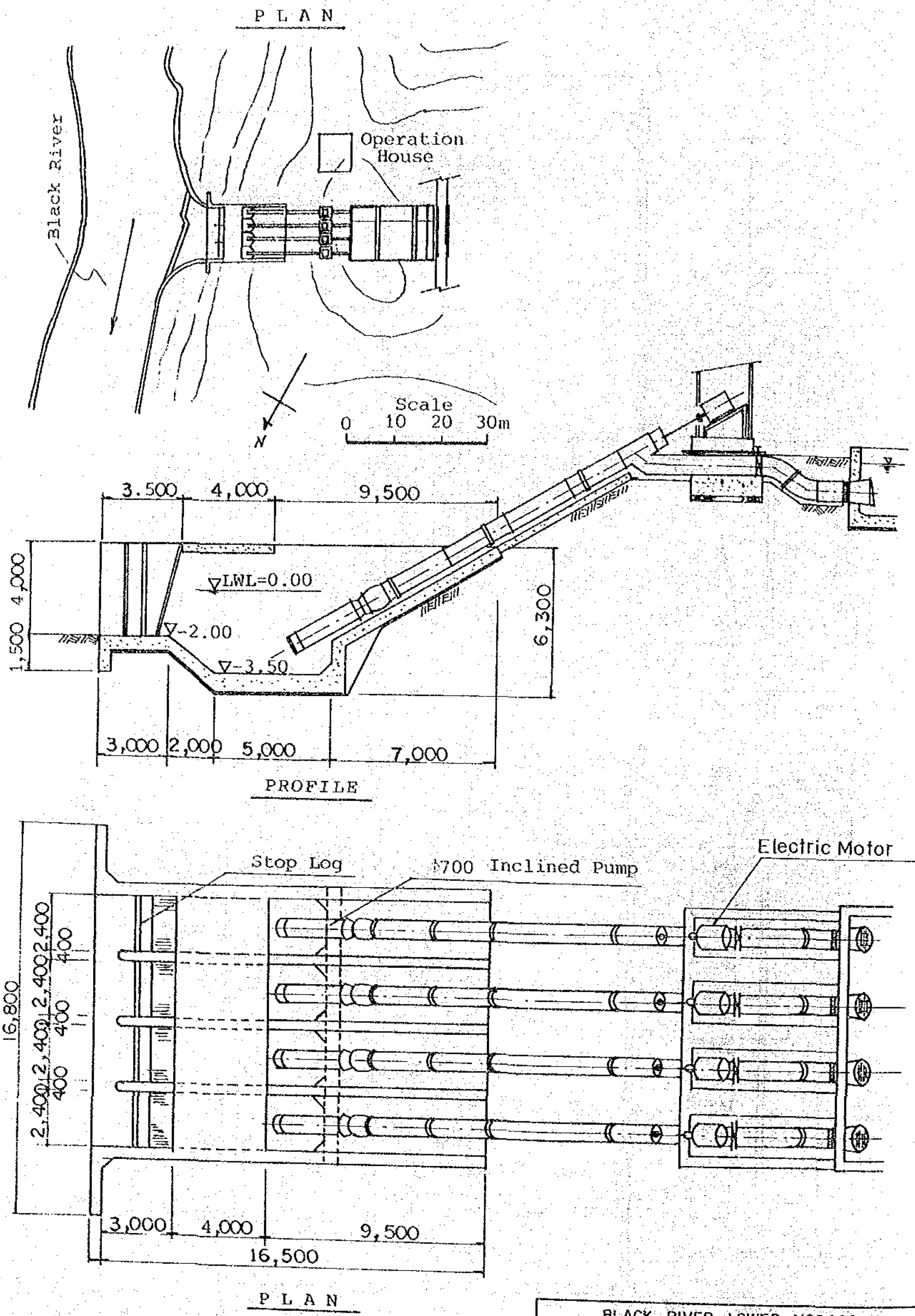
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. J-2 VERTICAL MIXED FLOW PUMP

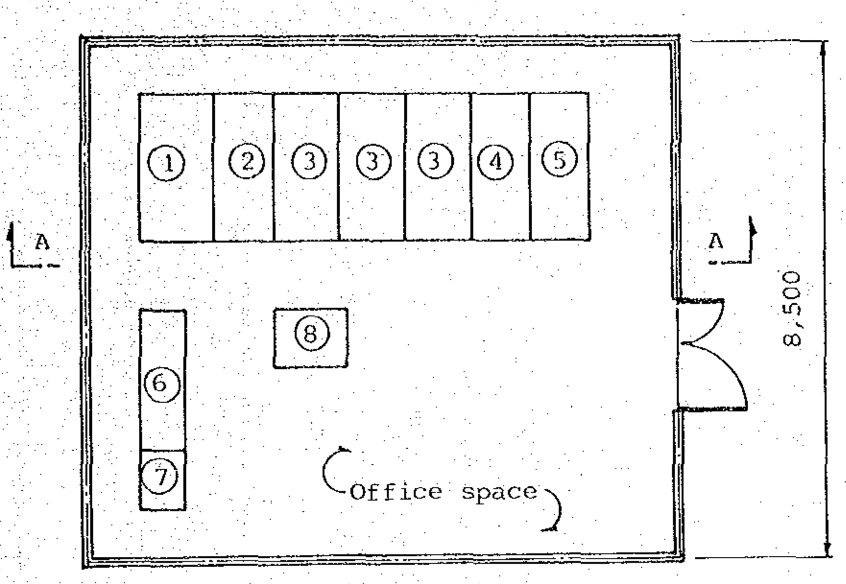
JAPAN INTERNATIONAL COOPERATION AGENCY



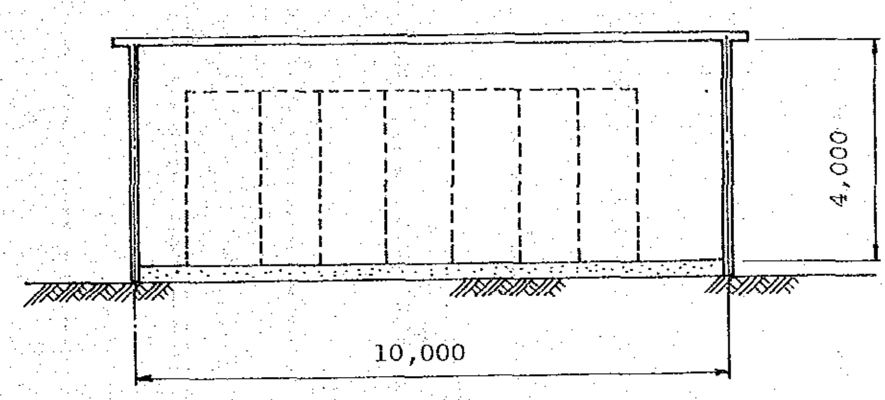
BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. J-3 INCLINED MIXED FLOW PUMP

JAPAN INTERNATIONAL COOPERATION AGENCY

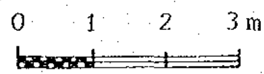


PLAN



SECTION A-A

SCALE



FACILITIES

① Feeder panel

② Receiving panel

③ High-tension motor panels

④ Low-tension panel

⑤ Three-phase transformer

⑥ On-the-spot control panels

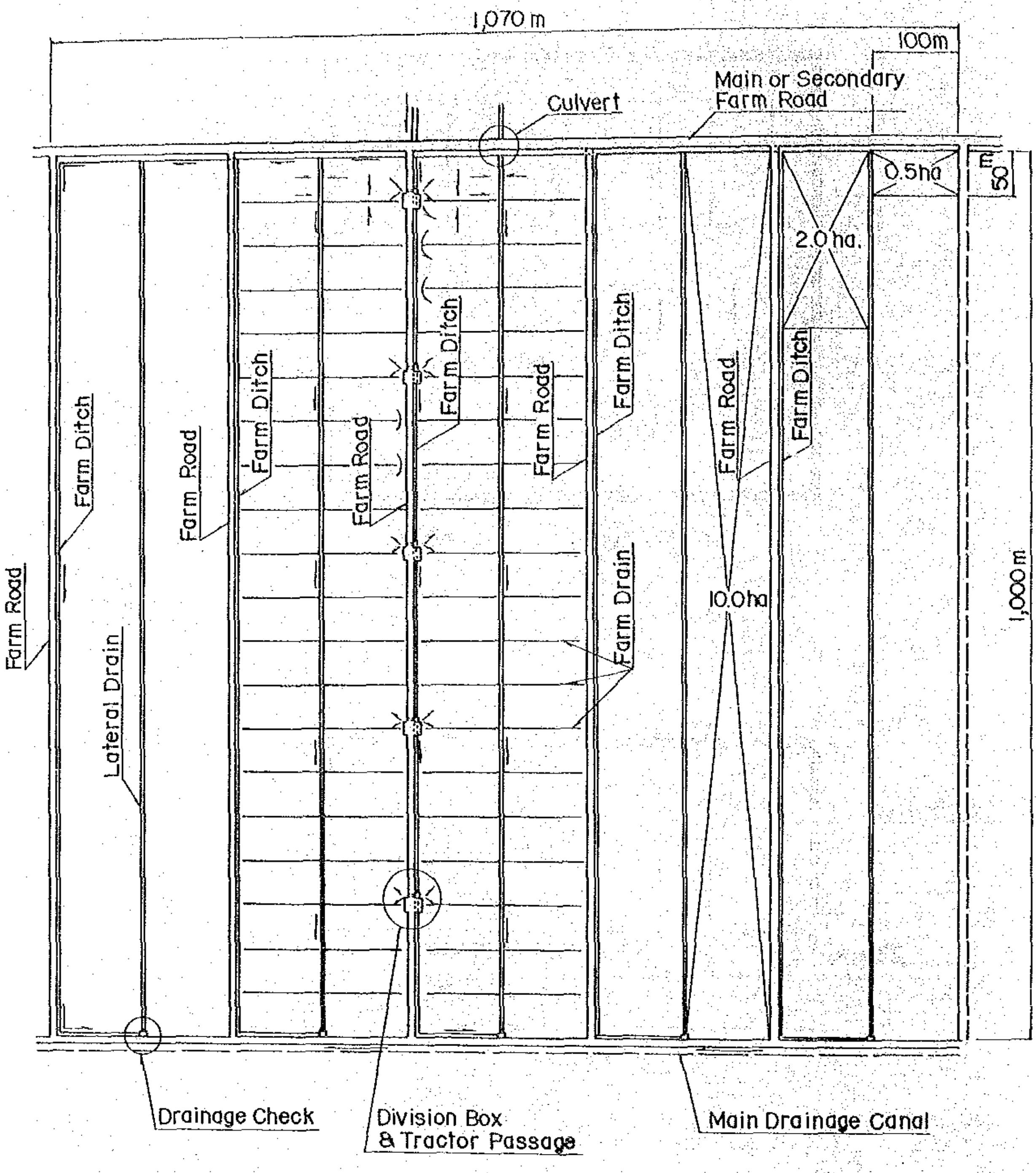
⑦ Relay panel

⑧ DC power supply unit

BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. J-4 OPERATION HOUSE

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. J-5

ON-FARM DEVELOPMENT PLAN

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX K

INLAND FISHERIES

ANNEX K

INLAND FISHERIES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX K

INLAND FISHERIES

1. INTRODUCTION

1.1 Fisheries in Jamaica

Fish has been a traditional staple in the Jamaican diet. However, production of marine fish has gradually decreased as follows:

Year	1977	1978	1979	1980	1981	1982
Production (Metric ton)	10,100	9,600	9,600	9,000	7,757	7,740

Source: FAO (1984)[1]

Thus, Jamaica has always relied on imports to supply its food demand. Fish imports exceeded the exports by J$46.2 million in 1983[2]. Moreover, recent research has shown that Jamaica's fishing grounds are at or near their optimal production level, and it is expected that marine fish landings will increase only if the fishing activity develops on distant fishing grounds in front of and managed by other countries.

Under these circumstances, Jamaica has turned to the development of aquaculture by taking advantage of the blessed natural conditions in the island. At present, the following aquaculture ventures are going on:

1. Mangrove oyster, Crassostrea rhizophorae, culture,
2. Pond culture of Tilapia nilotica, which is one of the main activities of the Inland Fisheries Unit (hereinafter called "IFU"), has been satisfactorily commercialized in the island.
3. Farming of freshwater shrimp, Macrobrachium rosenbergii.

---

1), 2) : see References

1.2 Inland Fisheries in Jamaica

The Inland Fisheries Unit (IFU) in the Ministry of Agriculture was established in 1977 to develop inland fisheries in the island. According to IFU (1983)[3), the main functions of the Aquaculture Division are:

1. Research,
2. Training of farmers and technical personnel,
3. Extension, and
4. Some fingerling production to stock and serve the new fish farmers ponds

Since natural conditions are suitable for aquaculture ventures in the island, some symposiums have been held to consider the possibility of undertaking aquaculture ventures in the island[4),5)]. The present main venture in freshwater culture in the island is the pond culture of Tilapia and Macrobrachium.

Tilapia culture has been successfully carried out by the private sector, and has been one of the main objectives of IFU activities. The present status (1982) of Tilapia farming is as follows (IFU, 1983)[3)].

	Subsistence	Commercial	Total
1. No. of farmers	102	72	174
2. Area ha (acre)	1.2 (3.0)	78.3 (193.4)	79.5 (196.4)

3), 4), 5): see References

Annual production of Tilapia in the public and private sectors is as follows:

Unit: Metric ton (10^3 lbs)

Year	Public Sector	Private Sector	Total
1980 1/	6.9 (15.2)	13.3 (29.5)	20.2 (44.7)
1981 1/	7.4 (16.3)	24.9 (55.0)	32.3 (71.3)
1982 2/	23.2 (51.2)	106.3 (234.7)	129.5 (285.9)
1983 2/	- (-)	- (-)	139.9 (308.8)

Remarks: 1/: After Cooke and Moo Young (1982)[6].
2/: After IFU (1983)[3].

Aquaculture of freshwater shrimp, Macrobrachium rosenbergii, had been started in 1970's at Ferris Cross, Westmorland, and Elim, St. Elizabeth. However, these two attempts were unsuccessful because of the pollution from the nearby factory and of the difficulty of leasing the land. (A policy for development of aquaculture in Jamaica, FAO, 1983). At present, BRUMDEC, which started commercial freshwater shrimp culture in July 1983, produced 1,812 kg (4,000 lbs) of freshwater shrimps in two months of 1984, and their goal is 4,530 kg (10,000 lbs) has been offering for sale post larvae of M. rosenbergii.

1.3 The Project Area

The project area covers about 11,450 ha gross including a swamp of approximately 6,850 ha which is the largest freshwater swamp in Jamaica representing about 56% of the total swamp rosources. Fishing activities have been developed in the project area to take advantage of swamp conditions.

---

3), 6): see References

1.4 Purpose and Scope

The present study was undertaken as an adjunct to the Agricultural Development Project on the Black River Lower Morass. The objects of the study were:

1. to appraise the impact of the agricultural development project on the inland fisheries; and

2. to formulate a potential development plan for inland fisheries in the project area.

To achieve these objectives, the study was made within the scope of the following aspects:

1. To understand the existing conditions of inland fisheries in the project area (Chapter 2);

2. To appraise the potential impacts of the agricultural development project (Chapter 3.1);

3. To appraise the potential impacts of the peat mining project (Chapter 3.2);

4. To examine the effective use of post peat mining lakes (Chapter 4.1); and

5. To discuss the prospective plan of fisheries development in the project area (Chapter 4.2).

2. EXISTING CONDITION OF INLAND FISHERIES IN THE PROJECT AREA

2.1 Socio-economic Conditions

A socio-economic survey was conducted amongst fishermen and vendors living in the project area. Shrimps are mainly of commercial importance. "Fishermen" in this section means shrimp fishermen usually and "Vendors" means shrimp vendors.

2.1.1 Fishermen

A total of 46 fishermen were interviewed with questionnaires. The interviews were carried out at 5 places in the project area (Areas A to E in Fig. K-1). The catch and income of a fisherman are summarized as follows:

	Rainy season	Dry season
1. Daily catch (kg; lbs)	(2.3; 5.1)	(0.7; 1.5)
2. Unit price (J$/kg; J$/lb)	(11.3; 5.1)	(13.0; 5.9)
3. Monthly income (J$)		
- obtained from interviews	500	258
- calculated 1/	650	220
4. Monthly catch (kg; lbs) 2/	(57.6; 128)	(17.1; 38)
5. Months 3/	4	8
6. Annual gross income (J$)	4,360	
7. Annual catch (kg; lbs)	(337; 816)	

1/ Based on items 1 and 2 for one month to be 25 days.

2/ Based on item 1 for one month to be 25 days.

3/ Refer to Annex A.

According to the interviews with fishermen, the following number of fishermen are engaged in each area:

Area	No. of Fishermen
Frenchman and Slipe	150
Cataboo	50
Middle Quarters	50
Burnt Savanna	10
Total	260

The annual gross value of shrimp catch in the project area is thus estimated to be approximately J$1.1 million and the annual catch in the project area to be about 90 tons (210,000 lbs).

There are two important fishing implements: fish traps of "pots" made of bamboo and/or wild cane, and canoes of cotton tree. The average number of pots possessed by a fisherman is 73, and the cost averages J$3.2. The useful life of a pot is one year, and a fisherman's annual expenditure is J$234. Thirty-three fishermen (72% of interviewers) possess their own canoes. The cost averages J$200, ranging from J$70 to J$500. Assuming 1.5-year of useful life for a canoe, the annual depreciation cost is about J$133.

As for fishermen with subsidiary agricultural farming, (11 in number, 24% of interviewees) their annual income derived from fishing activities averages J$3,720 which corresponds to about 80% of the total income, about J$4,700. Thus, the annual gross value of the shrimp industry in the project area is estimated to be in excess of J$1,000,000, corresponding to approximately 3.3% of the domestic product of fishing in 1983[1]. The shrimp industry in the project area is of importance not only for the socio-economic base in the area but in helping to meet the island's food requirements. Thus, it must be strictly protected from all external impacts.

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1): see Reference

2.1.2 Vendors

An interview survey was carried out in three villages, Frenchman, Cataboo and Middle Quarters. Sixteen vendors were interviewed. The parched shrimps are sold to car drivers, passers-by, visitors, etc. on the highway in and around Middle Quarters. In addition, considerable amounts of shrimps are sold to the commercial centers in the island. The following table shows the markets of vendors interviewed.

Market place	No. of vendors
Highway in Middle Quarters	5
Kingston	3
Mandeville	3
Ocho Rios	2
Montego Bay	2
Santa Cruz	1
Total	16

2.2 Biological Survey

2.2.1 Fishes

The information of fishes was collected by means of interviews with fishermen and visits to the Black River Town Fish Market and canoe bases.

Table K-1 shows the list of fishes which were recorded from the Lower Morass. About 40 species have been known to occur in the Morass. With the exception of two freshwater species, Gambusia affinis and the introduced Tilapia mossambica, all of the species found are those of marine and brackishwater.

At present, commercial fin-fish fishery is scarcely practised in the project area. Out of 46 shrimp fishermen interviewed, 6 possess 3 to 10 wire pots for harvesting fish, and sometimes small fishes such as Dormitator maculatus, gobiid fish and Tilapia mossabica are caught by shrimp pots. Fishes caught by fishermen are mostly for self-consumption. When large fishes, e.g., Magalops atlanticus, mugilid fish and snappers, are caught, they are sold in fish markets.

2.2.2 Shrimps

According to Hunte (1978)[7], the distribution of fishwater shrimp is under the high and low gradient conditions of streams. The Black River Basin falls into the low-gradient stream category. In the Black River Basin at least the following 7 species of freshwater shrimps have been known to occur:

Family	Species	Common name
Palaemonidae	*Macrobrachium acanthurus*	shrimp
	M. carcinus	cray fish
	M. faustinum	crabonanny
Atyidae	*Jonga serei*	
	Potimirim mexican	
	Xiphocaris elongata	

Source : Hunte (1978)[7].

1) Distribution

The distribution of adult freshwater shrimp in the project area was confirmed by interviews with fishermen. A dip-net survey was carried out for juveniles at 5 sites along the Black River (Fig. K-1).

According to the interviews, the fishing ground is concentrated in the swamp in the western part of the project area (Fig. K-2). In the Broad River fishing activities are practiced not in the swamp but in the river.

A total of 146 juvenile shrimps were collected by a dip-net survey under the water hyacinth. As shown in Fig. K-3, various sized juvenile shrimps are distributed all over the river regardless of the upper and lower streams. This suggests that the river is an important nursery for prerecruitment shrimp. In addition, water hyacinth provides a suitable habitat for juvenile shrimps.

2) Species composition

The species composition was examined on the basis of 569 shrimps. The number of shrimps collected in each collecting station is shown by each collecting date as follows:

Collecting Station	Collecting Date Sept. 18, 1984	Oct. 16, 1984
Frenchman (A in Fig. K-1)	186	105
Cataboo (B)	96	103
Middle Quarters (C)	41	-
Farbas (E)	38	-
Subtotal	361	208
Total	569	

Three freshwater shrimp species of the genus Macrobrachium, M. acanthurus, M. carcinus and M. faustinum, were found in fishermen's catch. The biological characteristics of these three species are reviewed and summarized in Table K-2. Fig. K-4 shows the species composition examined, in which M. acanthurus is the dominant species, comprising well over 90% of the catch (93.6% in Sept. 18, 1984 and 93.8% in Oct. 16, 1984). This suggests that M. acanthurus is of the most commercial importance in the project area.

3) Size composition of Macrobrachium acanthurus

The size composition of M. acanthurus caught by fishermen is shown in Fig. K-5. The size ranges from 47 mm to 144 mm in total length (TL) in Sept. 18 and from 48 mm to 153 mm in Oct. 16. Each histogram is bimodal, which indicates the presence of a biological characteristic in the species, e.g., sexual difference of growth. The biological minimum size (BMS) of the species is confirmed to be 59 mm TL in Sept. 18 and 48 mm TL in Oct. 16. The number of individuals smaller than the BMS is 29 (8.6% of the total number) in Sept. 18, and in Oct. 16 no specimen is confirmed to be smaller than BMS (Fig. K-5). Holthuis 1980[8)]

8): see Reference

reported that the maximum total length of the species is 166 mm in the male and 110 mm in the female. The maximum total length is, as far as examined, 153 mm in the male and 100 mm in the berried female. This condition suggests that no miniaturization of body size occurs in the species (cf., Fig. K-5 and Table K-2).

In conclusion, the results of size composition studies of Macrobrachium acanthurus indicate that the species is not at present exposed to over-fishing.

2.3 Environmental Survey

2.3.1 Water resources

1) Water quantity

The Black River and aquifers provide an ample supply of water in the project area. The water in swamp in the project area is approximately 20 - 30 cm in depth in the rainy season, while less in the dry season.

2) Water quality

The water quality analysis was made at several stations in the project area (Fig. K-6). The results are summarized in Table K-3. The "water quality standard for fishery" and "water quality standard for fishery environment", both of which were established by Japan Fishery Resources Conservation Corporation in 1965 and 1972, respectively, are also tabulated in Table K-3 for comparison. The present state of water quality in the project area can be evaluated as follows:

a. COD shows the excessive value in all rivers. This indicates the rivers to be eutrophic condition.

b. DO shows a marginal level to support fisheries resources. DO is sensitive to the change of other factors, e.g., nutrients and COD. This indicates a need to monitor or totally avoid impacts which would cause any reduction in DO.

c. The value of SS is (at times) rather high in the Black River, Y.S. River and Middle Quarters River. According to EIFAC (European Inland Fisheries Advisory Commission), the effect of SS on fishing activities is expected as follows:

SS (ppm)	Effect
25	No effect on fishing activities
25 - 80	Slight effect, but no problem
80 - 400	Poor fishing activities
400	No fishing activities

The value of SS in each river is judged to be no problem for fishing.

d. Nutrients, phosphates and nitrates are relatively high in all rivers except for the Broad River, as compared with the tabulated standards. Nutrients are expected to cause eutrophic conditions, resulting in adverse impacts on the natural resources if excessive case.

e. BOD and pH are considered to be in the desirable range in all rivers.

These results indicate that the water quality in the project area is not beyond the advisable limits for fishing activities. The results of a visual survey of the transparency and colour of each river carried out at 9 stations (Fig. K-7) support this conclusion. Although the Black River was found to be the most polluted river in comparison with the others, all rivers were expected to be appropriate for fishing. Since in all cases the transparency was greater than 30 cm which is generally thought to be the desirable minimum for fishing. The results of the survey are tabulated in Table K-4.

2.3.2 Biology

The complex eco-system of the project area is described in Annex L. The following aquatic plant associations offer a good shelter, feeding grounds and habitat for fish and shrimp:

1. Water hyacinth (Eichnornia crassipes)
2. Sawgrasses (Cladium jamaicense and Rhynchospora sp.)
3. Giant grass (Typha angustifolia)
4. Swamp forest composed of many vegetations.

3. IMPACTS OF FUTURE DEVELOPMENT PLANS ON INLAND FISHERIES IN THE PROJECT AREA

3.1 Agricultural Development Project

3.1.1 Project description

Of the project area covering about 11,450 ha, the area proposed for agricultural development is a maximum of 3,880 ha gross. Artificial dikes will be constructed along both sides of the Black and Broad Rivers for protecting the area from flood. Two irrigation pump stations, Y.S. weir and four drainage pump stations are to be established for irrigation and drainage.

3.1.2 Construction phase

The probable impacts of construction phase in the project on the inland fisheries resources are summarized as follows:

- Decrease of swamps (I1 in Table K-5)
- Increase of suspended solids (I2)
- Increase of turbidity (I3)
- Increase of colour (I4)
- Increase of petroleum pollution (I5)

The proposed agricultural development project covers the eastern part of the project area (C1 in Table K-5). This suggests that there will not be any less serious impacts from the decrease of swamps on inland fishery resources, because the distribution of shrimp is concentrated on the western part of the project area and fish are distributed in the rivers (Fig. K-2). Frenchman-Holiday Pen and the Broad River areas are competitive between shrimp distribution and the proposed project. Frenchman-Holiday Pen area is not richly populated by shrimp, but there is one of the most important canoe bases (Fig. K-1). On the other hand, distribution of shrimp in the Broad River is not concentrated in the swamp but in the river. However, because the following considerations are to be taken with regard to the implementation of the project, no impact is expected to arise on these two matters:

a. Case 1: A channel (the Frenchman River) is to be retained from Frenchman canoe base to the Black River for securing the passage of canoes, and a "canoe lift" provided for lifting canoes over the dike will be provided.

Case 2: If Case 1 is not adopted, the canoe base will be established in the Black River at the junction of the Black River and the Frenchman River.

b. A reasonable distance (about 700 m) is to be kept between the dikes on both sides of the Broad River. This distance is considered to be enough to enable fishing activities in the river to be continued.

When dikes (C2 in Table K-5), roads (C3) and canals (C4) are constructed and the reclamation (C5) is carried out, the suspended solids (I2) are expected to increase, which would cause the secondary increase of turbidity (I3) and colour (I4). These operations will be accompanied by an increase in petroleum pollution (I5), resulting in adverse effects on the water quality. Because these impacts would never remain for a long time, these are not so serious. However, it is recommended that the operations must be carefully performed so that then effects may be avoided if not eliminated.

3.1.3 Operation phase

With the commencement of agricultural activities, the following matters are expected to be changed:

- Increase in outflow in rainy season (I6 in Table K-5)
- Decrease in outflow in dry season (I7)
- Intrusion of sea water (I8)

In the rainy season the increase in outflow (I6 in Table K-5) caused by the drainage (O1) is expected to result in positive beneficial effects for inland fisheries resources. In the dry season, on the other hand, a decrease of water flow (I7) is likely to arise through the irrigation activities (O2). The decrease in river flow in dry season would result in the intrusion of salt water (I8) into the river and swamp. However, the impacts of decrease of water flow and salt water intrusion would not be critical. The probable effects of the construction and operation phases of the proposed agricultural development project on fisheries resources are summarized and tabulated in Table K-5.

3.1.4 Agricultural chemicals

In the proposed agricultural project, nitrogen, phosphate and potash are applied (for detailed design, see Annex G). A little outflow of these fertilizers into the river and swamp may be unavoidable. This would increase eutrophic conditions of the river and swamp. Eutrophic conditions are favorable for inland fisheries resources from the viewpoint of the biomass production, though the excessive eutrophic condition would lead to the decrease of DO and increase of BOD and COD, which would be adverse effects on the resources. Careful management must be exercised when these chemicals are applied.

Because shrimps are considered to be more sensitive to herbicides and pesticides in comparison with fish and other aquatic animals, it is necessary to select appropriate chemicals which are free from effect on shrimp. The following table shows the ranking of agricultural chemicals and toxicity to aquatic animals as established by Japanese Ministry of Agriculture, Forestry and Fishery:

Class	Remarks and value of TLm 1/
A	No problem of toxicity under usual method of app. Carp, over 10 ppm; Zoo-plankton, over 10 ppm.
B	Little effect under usual method of app. Take special precaution in app. on a wide scale at the same time. Carp, 10-0.5 ppm. Take special care of B-s in B class.
C	Do not use where there is a possibility of applied chemicals reaching rivers and lakes. Carp, less than 0.5 ppm.
D	Do not use in prohibited areas of application. Submit request for applying within an area of limited application.

Remarks: 1/: Median tolerated limit.

As for the kinds of agricultural chemicals, it is desirable to select from the above-tabulated classes A and B.

In the proposed agricultural development project 4 kinds of herbicide and 4 kinds of pesticide are to be applied for paddy field and upland. The characteristics of these chemicals are summarized in Table K-6 concerning the impacts on the aquatic animals. All of the chemicals applied fall into the class A or B. Special care must be exercised when Bentiocarb, Trichlorphon, Fenitrothion, Mancozeb and Dimethoate, which are classified as B class, are applied. When Diazion, which is B-s class, is applied, measures must be taken to prevent it reaching rivers and swamps. Careful management is needed even in use of class A chemicals.

In conclusion, there should be no serious impact on the inland fisheries resources from use of agricultural chemicals in the proposed agricultural development project. However, careful management is needed when these chemicals are applied, and it is necessary to avoid letting these chemicals reach the river and swamp. The application of a mixture of two or more chemicals must be strictly prohibited since there may be the possibility of making a compound which would be harmful to the aquatic life.

3.2 Peat Mining Project

The most critical impact on the project would be the decrease of shallow swamp. Because most of the peat mining area being proposed is thickly inhabited by shrimp at the present, the decrease in shallow swamp would annihilate the shrimp fishery in the project area (cf., Figs. K-2 and -8). According to the predictions of NRCD and TIG[13], even if only part of the swamp is mined each year, the deterioration of the shrimp industry may be inevitable. Table K-7 shows the probable impacts of the peat mining project on wild fisheries resources. As shown in Table K-7, most of the impacts would affect the wild resources adversely. The decrease in DO would be particularly harmful even if not mortal to the resources, because the present DO in the project area is already marginal to support them.