Table G-15 LABOUR REQUIREMENT OF SOYA BEAN ON MINERAL SOILS

Dates after Planting	Labour Operation	hrs/ha	MD/ha
	Tillage (disc harrow)	(3.0)1/	-
	Pulverizing (rotary harrow)	(1.5)	-
	Ridging (ridger)	(1.5)	-
4 week	Molding (cultivator)	(2.0)	-
13 week	Harvesting (combine)	(2.0)	-
	Fertilization	8.0	1.0
	Planting (manual seeder)	8.0	1.0
Immediately	Applying pre-emergence herbicide	4 x 3 2/	1.5
5 week	Applying herbicide	4 x 3	1.5
6 week	Applying pesticide	4 x 2	1.0
8 week	Applying pesticide	4 x 2	1.0
10 week	Applying pesticide	4 x 2	1.0
	Irrigation (10 time)	64.0	8.0
	Transportation	(1.0)	-
	Total Manual (Mechanical)	128.0 hrs (9.5 hrs)	16.0 MD

Remarks: 1/: Figures in parentheses represent mechanical operation in hours.

2/: Operating hours x operating personnel required.

Table G-16 LABOUR REQUIREMENT OF RICE ON PEAT SOIL

Dates after Planting	Labour Operation	Spring Rice		Fall Rice	
		hrs/ha	MD/ha	hrs/ha	MD/ha
	Tillage (disc harrow)	(3.0) 1/	-	(3.0)	-
	Pulverizing or puddling (rotary harrow)	(2.0)	-	(3.0)	-
	Levelling (land leveller)	(2.0)	-	-	-
	Harvesting (combine)	(3.2)	-	(2.6)	-
	Basal fertilization	8.0	1.0	8.0	1.0
	Pre-germinating seed	-	-	4.0	0.5
	Planting (drill seeder or broadcasting)	8.0	1.0	8.0	1.0
1 week	Applying herbicide (1st)	4x3 2/	1.5	4x3	1.5
2 week	Supplementary transplanting	8.0	1.0	8.0	1.0
5 week	Applying herbicide (2nd)	4x3	1.5	4x3	1.5
6 week	Applying pesticide (dithane)	4x2	1.0	4x2	1.0
10 week	Applying pesticide (sumition, dithane)	4x2	1.0	4x2	1.0
	Irrigation and drainage	36.0	4.5	40.0	5.0
	Transportation	(1.6)	-	(1.3)	-
	Total Manual	100.0 hr	12.5 MD	108.0 hr	13.5 MD
	Mechanical	(11.8 hr)		(9.9 hr)	

Remarks: 1/: Figures in parentheses represent mechanical operation in hours.

2/: Operating hours x operating personnel required.

Table G-17 YIELD OF MAIN VARIETIES OF RICE IN JAMAICA AND U.S.A.

(Unit: t/ha)

Varieties	Jamaica Mineral	Jamaica Peat	Florida Peat	Arkansas Mineral
Newbonnet	5.2	-	5.3	6.5
Lamont	5.5	-	4.4	-
Bond	4.6	-	4.6	6.3
Starbonnet	4.8	2.1	7.4 - 7.9	-
Lebonnet	1.6	3.0	4.0 - 6.7	-
Labelle	1.7	2.2 - 3.2	4.1 - 6.1	-

Remarks: Cited from BRUMDEC Annual Agricultural Report, 1983, and "Suggested Guidelines for Rice Production in Everglades Area of Florida (Kenneth D. Shuler et al)".

Table G-18 ANTICIPATED YIELD OF RICE AND SOYA BEAN

(Unit: ton/ha)

	Year 1st	2nd	3rd	4th	5th	6th	7th
(Paddy)							
Mineral soil	3.4	3.6	4.2	4.6	5.0	5.3	5.5
Peat soil	2.0	2.2	2.4	2.8	3.6	4.2	4.5
(Soya Bean)							
Mineral soil	1.7	2.2	2.5	2.5	2.5	2.5	2.5

Annual production at full development stage:

Paddy (Mineral soil)	5.5 t x (720 ha x 2 crops/year + 60 ha)	8,250 ton
Paddy (Peat soil)	4.5 t x 2,300 ha x 2 crops/year	20,700 ton
Total		28,950 ton
Soya bean (Mineral soil	2.5 t x 780 ha	1,950 ton

Table G-19 SELECTION OF FARM OPERATING METHODS AND THEIR EFFICIENCY FOR TRIPLE CROPPING

(Unit: hr/ha)

Crop	Implement	Operation and Field Condition	Operating Efficiency
<u>Land Preparation</u>			
Spring Rice:			
(Rainy Season 2°)	Disc harrow (16" x 16)	Tilling (after soya bean) on dry field, 2 way	2.0
	Rotary harrow (2.2 m width)	Pulverizing on dry field, 1 way	3.0
	Land leveller	Levelling on dry field	2.0
Fall Rice:			
(Rainy Season 1°)	Disc harrow (16" x 16)	Tilling (after spring rice) on wet field, 2 way	3.0
	Rotary harrow (2.2 m width)	Puddling/levelling under water, 1 way	3.0
Soya Bean:			
(Dry Season 1°)	Disc harrow (16" x 16)	Tilling (after fall rice) on dry field, 2 way	2.0
	Rotary harrow (2.2 m width)	Pulverizing/levelling on dry field, 1 way	1.5
	Ridger (2 row)	Making ridge on dry field, 1 way	1.5
	Cultivator (3 row)	Molding on dry field	2.0
<u>Harvesting</u>			
Spring Rice:			
(Dry Season 2°) (Rainy Season 1°)	Combine harvester (2.5 m width)	Reaping, threshing on wet field	3.2
Fall Rice:			
(Dry Season 1°)	Combine harvester (2.5 m width)	Reaping, threshing on dry field	2.6
Soya Bean:			
(Dry Season 1°)	Combine harvester (2.5 m width)	Reaping, threshing on dry field)	2.0

Table G-20 SELECTION OF FARM OPERATING METHODS AND THEIR EFFICIENCY FOR DOUBLE CROPPING

(Unit: ha)

Crop	Implement	Operation and Field Condition	Operating Efficiency
Land Preparation			
Spring Rice			
(Dry Season 1°)	Disc harrow (16" x 16)	Tilling on dry field, 2 way	3.0
(Rainy Season 2°)	Rotary harrow (2.2 m width)	Pulverizing on dry field, 1 way	2.0
	Land leveller (1.8 m width)	Levelling on dry field, 1 way	2.0
Fall Rice			
(Rainy Season 1°)	Disc harrow (16" x 16)	Tilling, on wet field, 2 way	3.0
	Rotary harrow (2.2 m width)	Puddling/levelling under water, 1 way	2.0
Harvesting			
Spring Rice			
(Rainy Season 1°)	Combine harvester (2.5 m width)	Reaping, threshing on wet field	3.2
Fall Rice			
(Dry Season 1°)	Combine harvester (2.5 m width)	Reaping, threshing on dry field	2.6

Table G-21 WORKABLE DAYS AND HOURS OF MACHINERY FOR TRIPLE CROPPING

	Land Preparation				Harvesting			
	1° Dry Season	2° Rainy Season	2° Dry Season	1° Rainy Season	2° Dry Season	1° Rainy Season	1° Dry Season	2° Rainy Season
Rate of Workable days (%)	85	65	75	70	85	85	85	85
Hours of Duty per Day (hrs)	10	12	12	12	12	12	10	12
Rate of Workable Hours per Day (%)	80	80	80	80	65	55	70	60
Effective Working Hours (hrs)	8	9.6	9.6	9.6	7.8	6.6	7.0	7.2
Day Length (hrs)	11.0-12.5	12.5-13.0	12.7-13.0	12.0-12.7	12.7-13.0	12.0-12.7	11.0-12.5	12.5-13.0

Table G-22 CALCULATION OF REQUIRED NUMBERS OF MACHINERY FOR TRIPLE CROPPING

		Duration of Working Days (days)	Rate of Workable Days (%)	Workable Days (days)	Hours of Duty per Day (hrs)	Rate of Operating Hours per Day (%)	Operating Hours per Day (hrs)	Total Operating Hours (hrs)	Operating Hours per Hectare (hrs/ha)	Operating Area within Duration (ha)
Spring Rice										
Disc harrow	Mar. 1-31	31	85	26.4	10	80	8.0	210.8		
	Apr. 1- 9	9	65	5.8	12	80	9.6	55.7) 266.5	3.0	88.8
Rotary harrow	Apr.10-May 19	40	65	26.0	12	80	9.6	249.6	3.0	83.2
Land leveller	Apr.10-May 19	40	65	26.0	12	80	9.6	249.6	2.0	124.8
Combine	Jul.19-31	13	85	11.0	12	65	7.8	85.8		
	Aug. 1-27	27	85	22.9	12	55	6.6	151.1) 236.9	3.2	74.0
Fall Rice										
Disc harrow	Aug.11-Sep.19	40	70	28.0	12	80	9.6	268.8	3.0	89.6
Rotary harrow	Aug.11-Sep.19	40	70	28.0	12	80	9.6	268.8	3.0	89.6
Combine	Nov.18-Dec.27	40	85	34.0	10	80	8.0	272.0	2.6	104.6
Soya Bean										
Disc harrow	Dec. 2-Jan.10	40	85	34.0	10	80	8.0	272.0	3.0	90.7
Rotary harrow & ridger	Dec. 2-Jan.10	40	85	34.0	10	80	8.0	272.0	3.0	90.7
Cultivator	Dec.23-Jan.31	40	85	34.0	10	80	8.0	272.0	2.0	136.0
Combine	Feb.29-Mar.31	32	85	27.2	10	70	7.0	190.4		
	Apr. 1- 8	8	85	6.8	12	60	7.2	49.0) 239.4	2.0	119.7
Power sprayer		40	80	32.0			8.0	256	4.0	64.0
Manual seeder (Soya bean)		40	80	32.0			8.0	256	8.0	32.0

Table G-23 CALCULATION OF REQUIRED NUMBERS OF MACHINERY FOR DOUBLE CROPPING

		Duration of Working Days (days)	Rate of Workable Days (%)	Workable Days (days)	Hours of Duty per Day (hrs)	Rate of Operating Hours per Day (%)	Operating Hours per Day (hrs)	Total Operating Hours (hrs)		Operating Hours per Hectare (hrs/ha)	Operating Area within Duration (ha)
Spring Rice											
Disc harrow	Feb.29-Mar.19	20	85	17.0	10	80	8.0	136.0		3.0	45.3
Rotary harrow	Mar.20-31	12	85	10.2	10	80	8.0	81.6	256.3	2.0	128.2
	Apr. 1-28	28	65	18.2	12	80	9.6	174.7			
Land leveller	Mar.20-31	12	85	10.2	10	80	8.0	81.6	246.3	2.0	128.2
	Apr. 1-28	28	65	18.2	12	80	9.6	174.7			
Combine	Jun.28-Jul.31	34	85	28.7	12	60	7.8	225.4	259.1	3.2	80.9
	Aug. 1-6	6	85	5.1	12	55	6.6	33.7			
Fall Rice											
Disc harrow	Aug. 7-Sep.15	40	70	28.0	12	80	9.6	268.8		3.0	89.6
Rotary harrow	Aug. 7-Sep.15	40	70	28.0	12	80	9.6	268.8		3.0	89.6
Combine	Nov.14-Dec.23	40	85	34.0	10	70	7.0	238		2.6	91.5
Power sprayer		40	80	32.0			8.0	256		4.0	64.0
Manual seeder (paddy)		40	80	32.0			8.0	256		8.0	32.0

Table G-24 REQUIRED NUMBER OF MACHINERY AND EQUIPMENT

Machinery & Equipment	Specification	Holland	Hatfield Styx River	Frenchman Holiday-pen	Broad R. Righ B.	Rroad R. Left B.	Stand-by	Total
Disc harrow	16" x 16	8	11	10	19	19	2	69
Rotary harrow	2.2m width	8	7	5	10	10	2	42
Land leveller	1.8m width	5	5	4	7	7	2	30
Ridger	2 row	8	3	-	-	-	1	12
Cultivator	3 row	5	2	-	-	-	1	8
Tractor (4 DW)	32 Hp	14	13	10	19	19	3	78
Cage wheel	(pair)	-	7	10	19	19	3	58
Combine harvester	2.5m width 75 Hp	8	8	6	11	11	1	45
Power sprayer	10 - 15 lit./min	30	19	14	27	27	5	122
Manual seeder	1 row	19	11	14	27	27	5	103
Dump truck	2 ton	5	5	3	6	6	3	28

Table G-25 COST OF FARM MACHINERY AND WORKSHOP

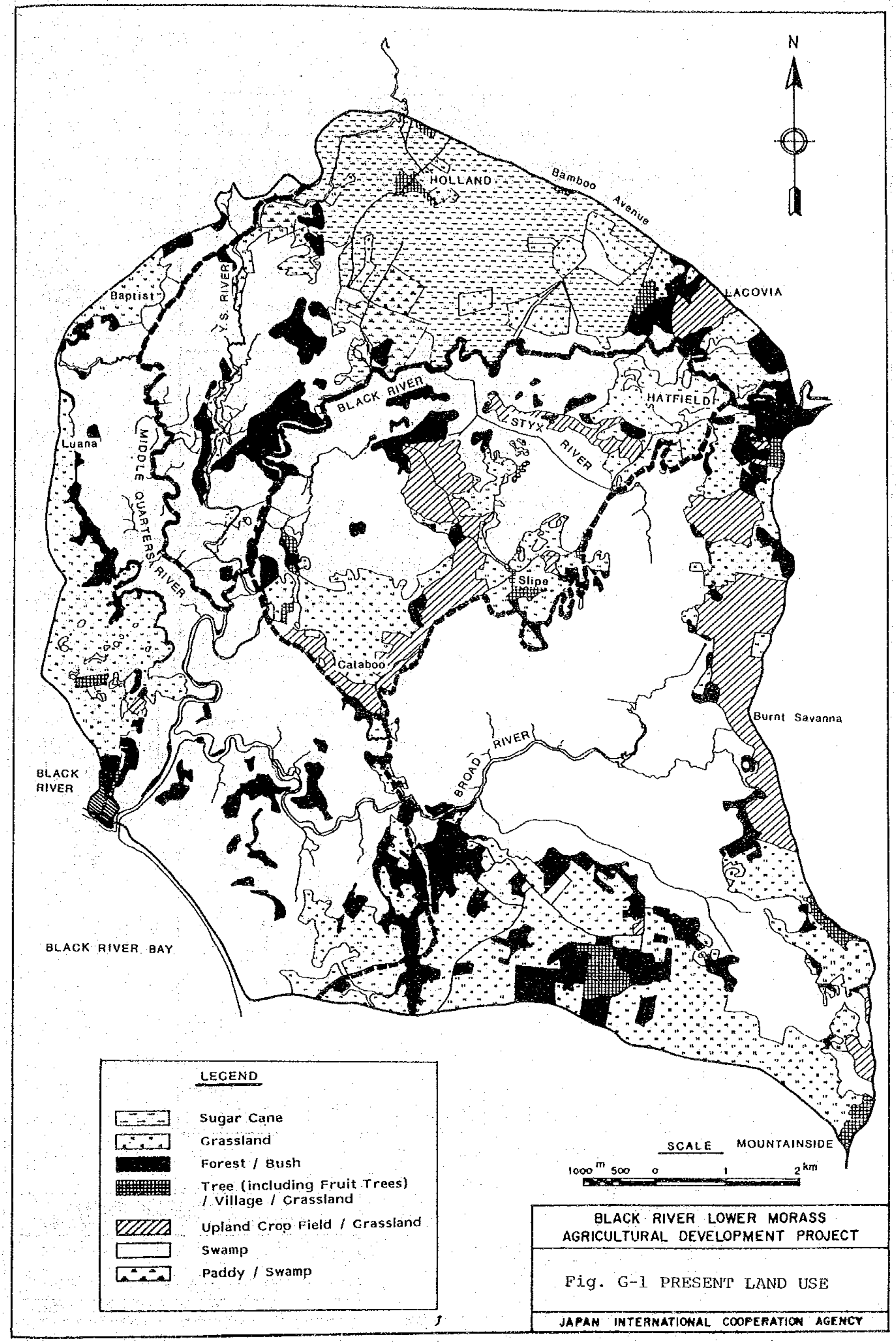
(Unit: J$10³)

		L.C	F.C	Total
I.	Procurement Cost of Farm Machinery			
	1. Farm machinery	-	14,970	14,970
	2. Attachment	-	2,570	2,570
	3. Spare parts	-	1,750	1,750
II.	Facilities			
	1. Office			
	- Main	190	250	440
	- Branch	300	460	760
	2. Workshop			
	- Building	680	820	1,500
	- Tools and equipment	-	1,750	1,750
	3. Machinery pool	50	-	50
III.	Sub-total	1,220	22,570	23,790
IV.	Contingencies			
	1. Physical contingencies	120	2,260	2,380
	2. Price contingencies	430	5,040	5,470
V.	Total (US$10³)	1,770 (442)	29,870 (7,468)	31,640 (7,910)

Table G-26 COST OF RICE PROCESSING FACILITIES AND STORAGE

(Unit: J$$10^3$)

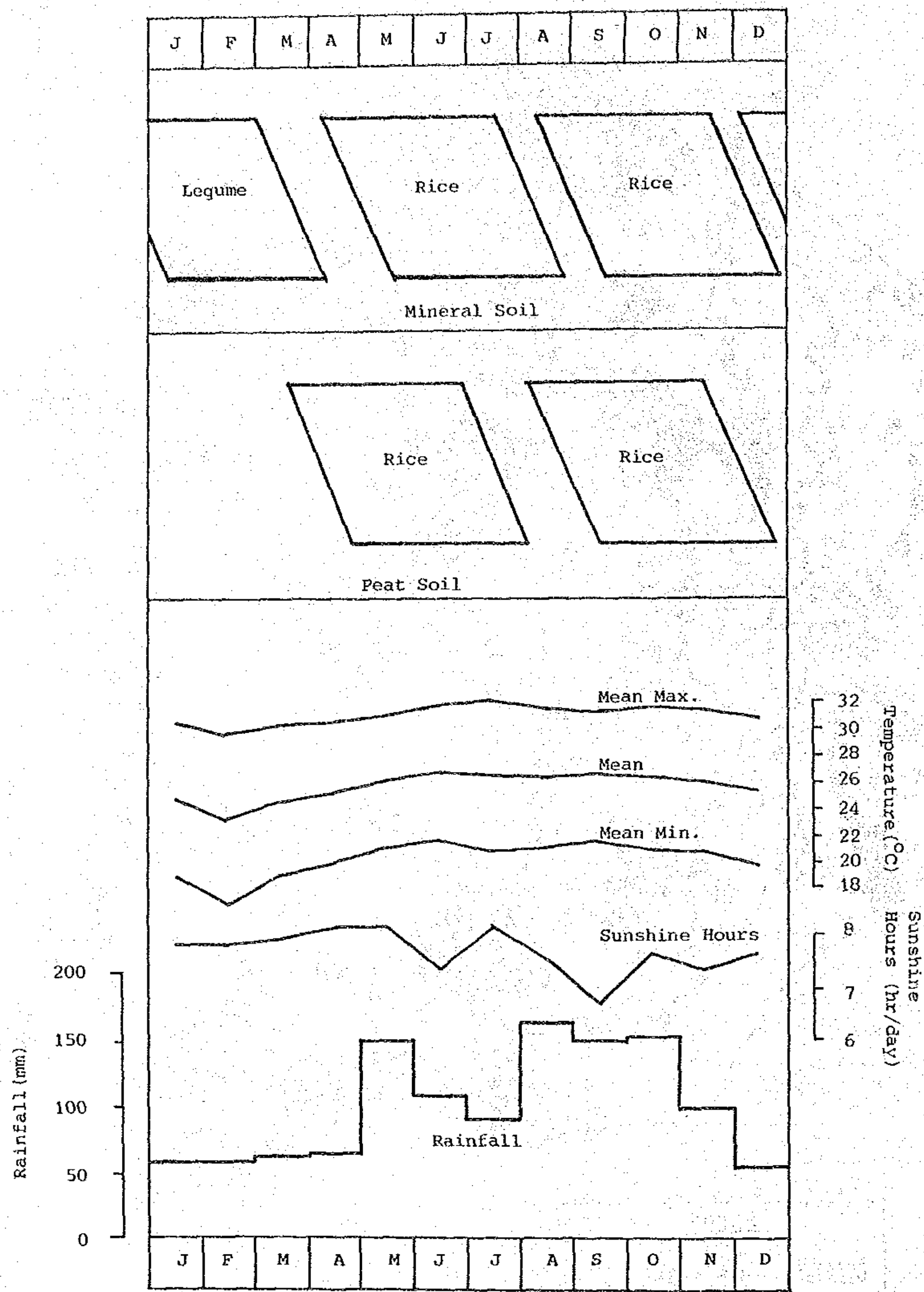
		L.C.	F.C.	Total
I.	Drying Facilities			
	1. Building	1,920	2,300	4,220
	2. Drying equipment	-	15,330	15,330
II.	Storage Facilities	-	12,520	12,520
III.	Milling Facilities			
	1. Building	480	580	1,060
	2. Mill	-	2,950	2,950
IV.	Engineering Services	-	760	760
V.	Sub-total	2,400	34,440	36,840
VI.	Contingency			
	1. Physical contingency	240	3,440	3,680
	2. Price contingency	790	5,430	6,220
VII.	Total (US$$10^3$)	3,430 (858)	43,310 (10,827)	46,740 (11,685)



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. G-1 PRESENT LAND USE

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. G-2
PROPOSED CROPPING PATTERN

JAPAN INTERNATIONAL COOPERATION AGENCY

SUPPLEMENT

TOXICITY AND SAFETY REGULATIONS IN THE USE OF PESTICIDES

1. General

Toxicity of pesticides may be divided into two type, i.e. acute and chronic toxicity. The acute toxicity denotes the character which inflicts lesion in a short time on the functions and organs of living body by its once giving. It gives a clear index of toxicity to mammals and aquatic animals in relation to pesticide quantity. Pesticides are classified by the extent of their acute toxicity and standards for safety use are instituted in this steps.

The chronic toxicity is the character which inflicts lesion in more than six months later on the functions and organs of living body by its repeated giving. As for the chronic toxicity to mammals, acceptable daily intake (ADI) of pesticides are introduced, and then tolerances for pesticide residues may be established. Based on these tolerances for residues, standard for safety application of pesticide in crop field or other place are determined.

2. Classification of mammalian toxicity

The World Health Assembly had adopted a classification system for formulated pesticide products and recommended its use for member states of the World Health Organization (WHO), as shown in Table 1. This classification method has been accepted by most member states of WHO, but not yet accpeted by Japan. Because, Japan has had already the classification of mammalian toxicity concerning all chemicals including pesticide products under the Poisonous and Deleterious Substances Control Law, as shown in Table 2.

Both classifications are based on the acute oral and dermal toxicity to the net in terms of LD_{50} (50% lethal dose) of the pesticides. WHO's criterion is indicated in formulated pesticide, while Japanese one in technical material. In Japan, chemicals are designated as poisonous or deleterious substances depending on their toxicity and extremely toxic one as specific poisonous substances. Non-designated chemicals of lower toxicity are called ordinary substances. Comparing Table 1 with Table 2, class Ia, Ib, II and III in WHO may correspond to specific poisonous, poisonous, deleterious and ordinary substances of designation in Japan, respectively. So far as the solid formulation in Table 1, no significant difference is observed between both criteria. In this project, pesticides of deleterious and ordinary substances are proposed to be used for the control of diseases, insects and weeds.

3. Classification of toxicity to aquatic animals

There is no international classification of toxicity to aquatic animals. No information in some States such as USA and UK has been obtained so far. Japanese classification of pesticide toxicity to aquatic animals and their standards for safety use have been instituted under the Agricultural Chemicals Regulation Law, and indicates the concentration (PPM) of the median tolerance limit (TLm) of pesticides for the carp 48 hours and for the daphnid (zoo - plankton) 3 hours of exposure periods, as shown in the following classification.

A Class : TLm (48 hr) for carp is over 10 ppm and TLm (3 hr) for daphnid is over 0.5 ppm.

There would be no problem in toxicity under usual method of application.

B Class : TLm (48 hr) for carp is within the range of 10 - 0.5 ppm and TLm (3 hr) for daphnid is less than 0.5 ppm despite of TLm for carp over 10 ppm.

There would be a little effect of toxicity under usual method of application, but sufficient precaution should be taken under the application covering a wide area at one time.

B-s Class: Agricultural chemicals belong to B class, allowed to use in paddy over wide area, providing one of the following three conditions.

1) TLm (48 hr) for carp is less than 2 ppm.
2) TLm (48 hr) for fishes other than carp is less than 0.5 ppm.
3) Concentration of no lethal effect for red killifish is less than 0.5 ppm. Special attention is needed in the use of B-s class.

C Class : TLm (48 hr) for carp is less than 0.5 ppm.

1) No use is allowed in the place where there is a possibility of applied chemicals scattering or flowing in rivers or lakes, and also in the other places no use is made in a wider area at one time.

2) Washed water of implement and container used for application, residue of chemicals and empty bottles or bags should be disposed at the place where no effect on aquatic animals is considered, such as burying into soils.

D Class : Substances designated as water pollutant pesticide by the Agricultural Chemicals Regulation Law.

1) Do not use at the prohibited area of application, and use in obedience to the request at the area restricted in applying condition.

2) Same as description (1) and 2)) in C class.

Since paddy is grown all over the country and much pesticides have been used in paddy cultivation in Japan, toxicity of pesticides provides for a great influence upon the living of aquatic animals as well as mammals which use the water polluted by pesticide. Japanese standards for safety use of pesticide to prevent the damage of aquatic animals are therefore very strict. In this Project area where paddy will be grown substantially and environmental pollution is to be strictly controlled from the view-point of natural conservation, it is proposed to use such chemicals under a standard of equivalent to the Standard for Safety Application of Chemicals in Japan. Pesticides proposed in this Project were selected from those of Class A and B in view of importance mentioned above.

4. Tolerances for pesticide residue

FAO/WHO codex Alimentarius Commission (Food Code Comm) established in 1962 had adopted international Codex Tolerance for pesticide residues depending on the co-work of Codex Committee on Pesticide Residues (CCPR) and Joint Meeting of the FAO Working Party of Experts and the WHO Expert Committee on Pesticide Residues (JMPR). This tolerances have been recommended for use in member states of FAO. Japan did not accept the recommendation, because original tolerances for pesticide residues has been investigated under the Food Hygiene Law in Japan. Table 3 shows the Japanese and international tolerances for several pesticide residues of main food. As shown in the table, Japanese tolerances are more strict than international one.

Tolerances for pesticide residues are determined on the basis of the acceptable daily intake (ADI) of pesticides, the average daily intake of foods in which pesticides are contained and pesticide residues in agricultural products under proper use of pesticides. International tolerances for residues of 45 pesticides in total 481 item had been adopted by FAO/WHO CAC and recommended by FAO. Japanese tolerances have been set for 26 pesticides in total 56 foods. As for the pesticides of which tolerances for residues are not yet provided because of their unseparated and unanalysable active ingradient, standards for withholding registration have been established by Environment Agency under the Agricultural Chemicals Regulation Law. Japanese tolerances for residues or standards for withholding registration of pesticide residues proposed in this plan are shown in Table 4.

5. Standards for safety use concerning pesticide residue

Standards for safety use of pesticide are set up on the basis of tolerance for pesticide residue. This standards indicate the maximum number of application and the interval between the last application and harvesting with every crop and every formulated pesticide. There is no international standards for safety use concerning pesticide residue, but each country prepared them. Japanese standards have been established on the basis of tolerance for pesticide residue and standard for withholding registration of pesticide residue under the Agricultural Chemicals Regulation Law. Table 5 shows standards for safety use of a pesticide 'carbonyl' (NAC) on rice in several countries.

Japanese standards for safety use of insecticides and fungicides proposed in this plan are shown in Table 6. Application of these pesticides in this plan is restricted within the range of the standards. Table 7 shows half-lives of the proposed pesticides in the soil within the container. Half-lives indicates the duration of reduction by half in residues or residual activity of pesticide. Half-lives of most insecticides and fungicides in the soil are within one month, but there are many herbicides which have longer half-lives. However, as they are applied at earlier stage of growth and in less number, persistence of herbicides is smaller than insecticides and fungicides. Reduction of pesticide would be far earlier in the soil of open field where decomposition by sunlight other than micro-organism, vaporization and run-off will be practiced much more.

Table 1 WHO CLASSIFICATION METHOD OF FORMULATED PESTICIDE PRODUCTS

Class		LD50 (rat) mg/kg Body Weight			
		Oral		Dermal	
		Solids	Liquids	Solids	Liquids
Ia	Extremely hazardous	5 or less	20 or less	10 or less	40 or less
Ib	Highly hazardous	5 - 50	20 - 200	10 - 100	40 - 400
II	Moderately hazardous	50 - 500	200 - 2,000	100 - 1,000	400 - 4,000
III	Slightly hazardous	over 500	over 2,000	over 1,000	over 4,000

Table 2 STANDARD FOR DESIGNATION OF MAMMALIAN TOXICITY IN JAPAN

Designation	LD50 mg/kg		LC50 1/ ppm/kg/1 hr
	Oral	Dermal	Inhalant
Poisonous Substances (PS)	less 30	less 100	less than 200
Deleterious Substance (DS)	30 - 300	100 - 1,000	200 - 2,000
Ordinary Substance (OS)	(Substances except Poisonous and Deleterious ones)		

Note: 1/: 50% lethal concentration

Table 3 COMPARISON OF INTERNATIONAL TOLERANCES FOR SOME PESTICIDES WITH JAPANESE

(Unit: PPM)

	Fenitration (MEP)		Malathion (Malathon)		Diazinon	
	FAO	Japan	FAO	Japan	FAO	Japan
Rice	-	0.2	8	0.1	0.1	0.1
Wheat	-	-	8	-	0.1	-
Potato	-	-	-	0.5	-	0.1
Apple	0.5	0.2	-	0.5	-	0.1
Grape	0.5	0.2	-	0.5	-	0.1
Citrus	-	0.2	4	0.5	0.7	0.1
Strawberry	-	0.2	1	0.5	-	0.1
Cucumber	-	0.2	-	0.5	0.5	0.1
Tomato	0.5	0.2	3	0.5	0.5	0.1
Lettuce	0.5	0.2	-	0.5	0.7	0.1
Cabbage	-	0.2	-	0.5	0.7	0.1
Carrot	-	0.2	0.5	0.5	0.5	-

Note: FAO denotes international recommended tolerances by FAO.

Table 4 JAPANESE TOLERANCES FOR PESTICIDE RESIDUES AND STANDARDS FOR WITHHOLDING REGISTRATION OF PESTICIDE

	Rice	Pea	Vegetable	Fruit	Potato
(Insecticides or Fungicides)					
Tricheorfon* (Depterex, DEP)	0.5	-	0.5	0.5	0.5
Fenitrothion (Sumithion, MEP)	0.2	0.2	0.2	0.2	-
Mancozeb* (Dithane)	-	0.1	0.4	1.0	0.2
Monocrotophos (Navacron)	-	-	-	-	-
(Herbicide)					
Bentiocarb (Saturn)	UD**	UD	UD	-	-
2.4 - PA* (2.4 - D Amin)	0.2	-	-	-	-
Propanil* (DCPA Stam)	0.1	-	0.1	-	0.1
Diphenamid (Dynid)	-	-	-	-	-
Bentazone	-	-	-	-	-

Note: *: Figure of the pesticides indicate standards for Withholding Registration

**: Undetectable, being below the detection limits

Table 5 STANDARDS FOR SAFETY USE OF PESTICIDE 'CARBORYL' (NAC) ON RICE IN SEVERAL COUNTRIES

Countries	Name of Pest	Rate (kg/ha)	Number of Application	Limited[1/] Days Before Harvest
Australia	Common armyworm (Pseudaletia convecta)	1.1	as required	3
U.S.A.	Rice stink bug (Olbatus pugnax)	1.12	1	14
Brazil	Caterpillars-lagartas (Mocis latipes)	2.4	1 - 2	14
Japan	Leafhoppers, Planthoppers (Laodelphaz striatellus) (Nephtettix cincticeps) (Nilaparvata lugens)	0.2 - 0.9	5	14 (solid) 24 (liquid)
	Rice leaf beetle (Oulema oryzae)	0.5 - 0.9	5	14 (solid) 24 (liquid)

Note: 1/: The interval between the last application and harvesting

Table 6 JAPANESE STANDARDS FOR SAFETY USE OF PESTICIDES PROPOSED IN THIS PLAN

Pesticides	Crops	Number of Application	Limited Days Before Harvest
Trichlorfon (DEP)	Rice	4	14
Fenitrothion (MEP)	Rice	7	21
Mancozeb (Dithane)	Legume	4	30
Monocrotophos (Nuvacron)	Rice	3	21

Table 7 HALF-LIVES OF THE SELECTED PESTICIDES IN THE SOILS WITHIN CONTAINER

(Unit: day)

	Soils	Half lives	
		Mineral Soil	Volcanic Soil
(Herbicides)			
Bentiocarb	Paddy	35 - 40	-
2.4 - D Amine	Paddy	1 - 2	2 - 3
Diphenamid	Upland	28 - 42	42 - 56
(Insecticides & Fungicides)			
Trichlorfon	Paddy	7 - 14	3 - 7
Fenitrothion	Paddy	7 - 14	7 - 14
Mancozeb	Upland	42 - 49	35 - 42

ANNEX H

LAND RECLAMATION AND DRAINAGE

ANNEX H

LAND RECLAMATION AND DRAINAGE

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LAND RECLAMATION AND DRAINAGE

1. LAND RECLAMATION

1.1 Field Survey

1.1.1 General

The proposed survey area comprising 11,450 ha is somewhat quadrangular in shape and is bounded on all sides by main roads. It is bounded on the north by the main road from Lacovia to Middle Quarters through Bamboo Avenue, on the west by the main road from Middle Quarters to Black River town through Luana where there is a crossing of main roads, on the south by the main road from the town of Black River to Mountainside through a seashore line, and on the east by the main road running along the mountain slope from Mountainside village to Lacovia.

This total of 11,450 ha is divided into the upland area consisting of 4,790 ha and the swamp area consisting of 6,660 ha. The proposed reclamation area was selected from this total area by means of a field survey.

The selection of the proposed upland reclamation area depends mainly upon the soil survey and the land suitability classification.

For the swamp area, the results of the soil physical survey were adopted as a first screen in order to select the proposed development area.

In this section, the field survey and its analysis based on the soil physical properties are explained. The soil physical survey in the swamp area was carried out over a period of 23 days from 7th July to 6th September, 1984.

The total number of surveyed sites was 137 and Fig. H-1 shows the location of the sites.

1.1.2 Survey items and methods

Soil physical survey was carried out mainly to clarify the trafficability of farming machinery and construction equipments in the peat area.

1) Cone penetration test

For the cone penetration test in the field a cone penetrometer with a base area of 10 m^2 was used.

This test is useful for determining the trafficability for the machinery in the field. A cone index is observed every 10 cm from the soil surface to a depth of 5 m or to a hard foundation layer with 7.0 kg/cm^2 of bearing capacity.

2) Peat soil thickness

Peat soil thickness influences the settlement of structures. For thicknesses of more than 5 m the Netherlands' Report of 1964 was referred to.

3) Moisture ratio

The moisture ratio (w) is shown by the percentage of water mass (Mw) contained in proportion to the dry soil mass (Ms), $W = 100$ Mw/Ms (%).

Moisture ratio is one of the most useful indexes in determining peat soil characteristics and is required for the design of structures.

4) Shrinkage

Shrinkage of the peat soil is used to determine the degree of surface settlement as a result of drainage. Shrinkage is shown by the percentage of the vertical shrinking of the samples.

Shrinkage is measured by using 280 × 214 × 98 mm, box containers.

1.1.3 Data analyses

1) Cone penetration test

i) Cone index (qc) is calculated by the following equation;

F = Gauge reading/1.83 (kg/cm^2)

qc = F/Sectional area of cone (kg/cm^2)

where,

F: Resistance force

qc: Cone index

Sectional area of cone: 10 cm^2

ii) Average cone index values are shown for each 0.50 m layer in Table H-2.

The stability of the layers was tested in the following manner, and the results are shown in Table H-3.

a) Whether a layer of qc > 0.5 kg/cm^2 exists within a depth of 1.0 m, or not. A layer of qc > 0.5/cm^2 within a depth of 1.0 m can be considered to play an important role in supporting farm machinery works.

b) Whether a layer of qc > 1.0 kg/cm^2 exists within a depth of 2.0 m, or not. A layer of qc > 1.0 kg/cm^2 within a depth of 2 m can be considered able to support constructional machinery, farm roads and tertiary canals.

c) Whether a layer of qc > 7.0 kg/cm^2 exists within a depth of 5.0 m, or not. A layer of qc > 7.0 kg/cm^2 within a depth of 5.0 m can be considered able to support large scale structures such as riverine dikes, pumping stations, main roads and others.

d) Frequency in Table H-3 means the number of eligible data in comparison to the number of survey data.

2) Peat soil thickness

Peat soil thickness is shown in Table H-4 and Fig. H-2. These data are quoted from the Report of the Petroleum Corporation of Jamaica.

3) Moisture ratio and ignition loss

Moisture ratio and ignition loss were measured in the field office, and these are shown in Table H-5. A term, which is called natural dry, is used in ANNEX H. Natural dry means to dry soil samples for 7 days in a room at normal temperature. The moisture ratio of natural dry may be useful to estimate the natural water contents in the field after drainage.

4) Shrinkage

Shrinkage is measured 4 weeks after natural drying. Data is arranged by vertical-wise shrinkage value as shown in Table H-6.

1.2 Proposed Area

In advance of this feasibility study, a pre-feasibility study was carried out covering an area of about 11,450 ha which were divided into 17 segments, as the object of the survey (See Table H-1).

Out of the proposed survey area, 3,080 hectares were selected for the proposed reclamation area. The breakdown of the proposed area is as follows:

Block	Soil	Hectareage
Black River Right Bank	Mineral Soil	560 ha
" " Left Bank	Peat Soil	920
Broad River Right Bank	"	800
" " Left Bank	"	800
Total		3,080

These proposed areas were selected in accordance with the following criteria and characteristics.

1.3 Selection Criteria

Selection of reclaimable land was determined in accordance with each criteria for bearing capacity, land classification and consolidation settlement.

1.3.1 Land classification

Selection criteria by land classification are described in ANNEX D. SOIL AND LAND CLASSIFICATION, therefore, it is omitted in this section.

Specific degree is classified into the following 5 categories.

Category	i	very high,	suitable to develop
"	ii	high,	"
"	iii	moderately high	"
"	iv	low,	"
"	v	very low	unsuitable to develop

Therefore, a segment which was given category v was excluded from the reclaimable land.

1.3.2 Bearing capacity

Selection criteria by bearing capacity are also classified into 5 categories as follows:

Cagetory	i	eligibility	90% or more
"	ii	"	80% "
"	iii	"	70% "
"	iv	"	60% "
"	v	"	below 60%

It was decided that categories i to iv were suitable to develop and category v was unsuitable to develop.

Evaluation was carried out from 3 data: layer of 0.5 kg/cm^2; layer of 1.0 kg/cm^2; and layer of 7.0 kg/cm^2.

1.3.3 Peat thickness and settlement

Peat soil is settled by the drainage or by the construction of structures. These calculation and results are shown in detail in ANNEX D. SOIL MECHANICS.

In the case of banking of embankments by peat soil of the original peat area, the permissible thickness of the peat layer is up to 3.0 m, on condition that the banking height is less-than-2.0 m and the extra banking (settlement) is less-than-60%.

In the case of settlement by drainage, the permissible thickness of the original peat layer is up to 3.0 m, on condition that the drop in water level is 0.6 m to 1.0 m from the ground surface and the settlement is less-than-60% of the drop in water level.

In case of banking of mineral soil, transported from outside of the swamp area, the permissible thickness of the original peat layer is up to 4.0 m, on condition that the banking height is less-than-1.0 m and the extra banking (for settlement) is less-than-100%.

The period which is naturally needed for the settlement of peat soil is also a very important factor. For this factor, the number of days which is needed for 80% settlement of the initial stage is used.

The permissible thickness of the peat layer is up to 4.0 m on condition that the period is limited within one year.

Selection criteria by settlement were decided by the percentage of hectareage of the less-than-3.0 m peat layer, as follows,

Category	i	eligibility	90%	or more	suitable
"	ii	"	80%	"	"
"	iii	"	70%	"	"
"	iv	"	60%	"	"
"	v	"	below 60%		unsuitable

1.4 Reclamable Land

1.4.1 General

In accordance with the above described criteria Table H-7 is obtained. The factors of bearing capacity, soil property and settlement (peat soil thickness) are very basic conditions required to develop an agricultural farm in a peat area.

Therefore, any segment which was evaluated as unsuitable even for only one of these factors could not be selected as reclaimable land.

The Black River right bank has no problems for selection as reclaimable land because the whole area is silty or clayey soil upland.

The Black River left bank and both banks of the Styx River have conditions favouring selection.

The Y.S. River left bank has some problems in being selected. Its upper reach which has Aeric-tropaquest soil can be developed. However, the middle and lower reaches cannot be developed because the area has very thick peat layer, very weak bearing capacity, and also a wide forest area which has extremely poor soil conditions.

The Broad River right bank and left bank can be developed without problem.

The Y.S. River right bank, Middle Quarters right bank and Black River estuary cannot be developed because of their unsuitable conditions for use as agricultural land.

1.4.2 Reclaimable segments and characteristics

1) Holland estate lower area

Some parts of the lower area are used for sugar cane plantation but productivity is not high due to its poor drainage. Other parts are used for rice plantation, productivity is also not high because of lack of facilities for irrigation.

Holland Estate has a pumping station for drainage with 2 pump sets of 700 mm and 400 mm diameter for both the upper and lower areas. However, this pumping capacity is insufficient.

2) Hatfield

Hatfield is located in the northeast corner of the project area, and there are many forests or shrubs. Parts of the area are used as natural pasture, however, about 300 ha could be utilized as paddy fields after drainage.

3) Black River left bank (Holiday Pen)

Black River left bank has a comparatively shallow peat layer area. Six hundred and eight (608) ha or 80% of the total 760 ha have a peat thickness of less than 3.0 m. In this segment peat thickness of more than 6.0 m is only distributed in a narrow range of 15 ha or 2% of the area. This implies that the foundation is stable.

Stagnant water on the ground surface is 0.10 m on the average which is shallow for this segment.

The bearing capacity, which influences trafficability for machinery, in this segment is of a moderate level within the project area. Especially, the surface layer is stable, namely out of 11 survey sites 10 sites have a layer which has a bearing capacity (qc) greater than

0.5 kg/cm2 within a depth of 1.0 m, furthermore, this layer is 0.5 m thick or more.

This layer can be considered to be capable of bearing agricultural machinery.

The next layer which has a bearing capacity (qc) greater than 1.0 kg/cm2 and a thickness 0.5 m or more exists within a depth of 2.0 m at a total of seven of the survey sites or 64%. This layer can be considered suitable to bear construction machinery after completion of initial drainage and the foundation of farm roads.

The base layer which has a bearing capacity (qc) greater than 7.0 kg/cm2 exists within a depth of 5.0 m at 6 sites out of a total of 11 survey sites or 55%. This layer can be considered suitable to bear any of the project's layer scale civil works such as pumping stations, main canals, main dikes and others.

4) Styx River both banks

The Styx River basin which includes 410 ha of the total reclaimable area, is the smallest of the inundated swamp segments. Styx River is a tributary of the Black River, and is also under poor drainage condition. The average stagnant water is comparatively deep at 0.40 m.

The peat thickness is very shallow, however, namely 402 ha or 98% of the total area is less than 3.0 m deep, and the deepest is 5.0 m and only covers an area of 8 ha.

As for the bearing capacity quite satisfactory results were obtained, namely results obtained at 6 survey sites had a "qe" value greater than 0.5 kg/cm2 within a depth of 1.0 m, a "qc" value greater than 1.0 kg/cm2 within a depth of 2.0 m and a "qc" value greater than 7.0 kg/cm2 within a depth of 5.0 m.

5) Broad River right bank

The Broad River right bank is one of the better segments together with the left bank. Furthermore, the possible paddy area is the largest consisting of some 1,290 ha.

Concerning the thickness of the peat layer, 1,135 ha or 88% of the total area has a shallow peat layer less than 3.0 m, furthermore, the deepest layer in the remaining area is only 4.0 m.

Stagnant water in the major part of this area is not so deep, 0 to 0.15 m, however, some parts in the lower reaches near the Cataboo area have a 0.35 m to 0.40 m depth of water.

The bearing capacity of this segment exhibits no problems Eighty-two (82) data out of a total of 87 come up to the eligible standard.

6) Broad River left bank

The Broad River left bank consisting of 1,200 ha also has good conditions for reclamation from a view-point of trafficability of machinery.

The peat layer thickness of 1,080 ha or 90% of the total area has a shallow peat layer less than 3.0 m, and the deepest layer is only 5.0 m.

Stagnant water depth is shallow ranging from 0 to 0.2 m.

The bearing capacity, this segment also exhibits no problems. Forty-three (43) data out of a total of 45 data come up to the eligible standard.

1.5 Reclamation Plan

1.5.1 Reclamation criteria

1) Standard field lot

i) Scale of machinery system

A small scale machinery system will be introduced into the project, though a large scale machinery system is desirable from a view-point of machinery efficiency. The reason for introducing the small scale machinery system is based on the specific characteristics of peat soil.

That is, peat soil has small values in bearing capacity. There is a "cone index" which represents the bearing capacity of the surface soil. The average cone index of a layer of 0 to 0.5 m and a layer of 0.5 to 1.0 m in each segment are as follows,

Segment	Number of data	Cone index (kg/cm^2)		
		Below 0.49	0.5 to 1.4	Above 1.5
Black River Left	22	6	13	3
Styx River	12	3	8	1
Broad River Right	58	18	34	6
Broad River Left	30	1	27	2
Total	122	28	82	12
Percent	100	23	67	10

Out of the total of 122 data, only 12 data or 10% showed a cone index of more than 1.5 kg/cm^2. It is considered that the bearing capacity is required at a cone index of more than 2.0 kg/cm^2 or at least more than 1.5 kg/cm^2 for the large scale machinery system.

On the other hand, it is analogized that the bearing capacity of the cone index 0.5 kg/cm^2 to 1.5 kg/cm^2 will support only a small scale machinery system that has a machine weight of less than 4 to 6 tons.

ii) Spacing of drainage canals

In accordance with calculations in the section 2.2.2, Drainage Canal of Chapter 2. DRAINAGE, the permissible maximum spacing of drains in the peat area was determined to be 50 m.

The drainage of the field lot is, therefore, arranged at 50 m-intervals along the length of the field lot.

In the mineral soil area the drain of the field lot is also arranged at 50 m-intervals.

iii) Shape of field lot

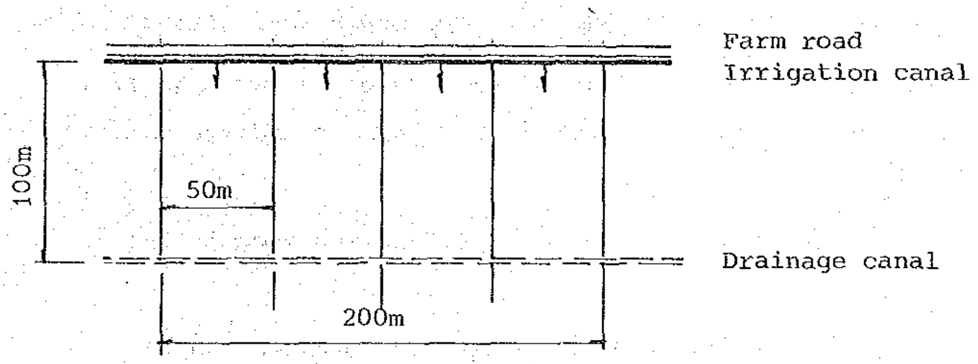
In the peat soil area some uneven settlement of the land is to be expected to extend over several years after the implementation of drainage work. Levelling work for this uneven settlement is, therefore, required during every crop season.

As much as possible field lots of a square shape are requested for easy levelling work in the peat area.

A rectagular shaped field lot is requested on sloping land to minimize the quantity of earth to be moved for levelling.

iv) Standard field lot

In accordance with the above-mentioned reasons the size of a standard field lot was determined to be 0.5 ha as shown in the figure below.



It is considered that a field lot with a hundred meter length will not deteriorate the efficiency of the small scale machinery system.

An arrangement of the standard field lot is shown in the Drawings No. 8-1.

v) Extension of area of field lot

Several years after the implementation of the drainage works land settlement is expected to be concluded.

During this time open drainage canals can be shifted to pipe drains on some farms. After that the farmers can use their farm as 1 hectare field lot, and even 2 hectare field lots at the largest. In this situation, the small scale machinery system should be kept as it is.

However, to adopt the pipe drains from the first year should be avoided in the peat area since pipe drains can lose their function of drainage because of uneven settlement.

2) Embankment

Embankments will be almost entirely constructed on peat soil, therefore, settlement of the embankment body is unavoidable. The establishment of a high embankment should therefore be avoided.

In this project the maximum height of an embankment is determined to be 2.0 m. Therefore, a satisfactory distance is placed between both river-side embankments for flood control.

3) Road

The Black River right bank area is at present being utilized for cultivation of sugar cane. Therefore, the area has a road network.

The area has 8 access roads by 400 meters on the average from Bamboo Avenue. There is also a farm road network, its average interval is about 100 to 200 m.

These access roads and farm roads are utilized even in the development plan.

In the swamp areas of the Black River left bank, Broad River right and left banks, there are no roads, therefore, a new farm road network will have to be established in the development plan. As the main road for the farm road network the existing local road from Lacovia to Salt Spring via Slipe and Cataboo which runs along the limestone upland areas would be utilized.

Farm roads would be arranged at 200 m intervals in principle and each field plot would be planned to about a road.

Consequently, the road network has been established as shown in Fig. H-3.

4) Field surface finishing

The following works will be carried out as civil works in the final stage.

Levelling by bulldozers,
Deep ploughing by bottom plows, and
Harrowing by disk harrows.

1.5.2 Proposed reclamation plan

1) Proposed reclaimable area

According to the Pre-Feasibility Study, 6 segments are clarified as suitable areas for agricultural development mainly for rice production. These 6 segments can be grouped into 4 groups by river basin. Proposed irrigable areas are shown below.

1.	Black River right bank (Holland Estate)	560 ha
2.	Black River left bank	400 ha
	Hatfield area	220 ha
	Styx River both banks	300 ha
	Total	920 ha
3.	Broad River right bank	800 ha
4.	Broad River left bank	800 ha

Therefore, in case of full development, the possible irrigable area is 3,080 ha.

2) Reclamation plan

i) Black River right bank

Almost the entire area of this group is covered by mineral soil, a field lot 100 x 50 m was adopted.

There has already been established an embankment on the right bank of the Black River. This embankment is not high enough, however, to protect the area from flood damage on the 50 year return-period scale. Therefore, this embankment should be raised up to 2.0 m.

In the Y.S. River upper area, the existing embankment is to be raised up to 1.0 m.

A new drainage pump station is proposed at the site of the existing small pump station.

As for main drainage canals, the existing drainage canal line of the Holland Estate area is traced with a view to deepen and widen it. For the Y.S. River upper area a new canal is proposed up to the pump station.

ii) Black River left bank

The major part of this area is peat soil, a field lot 100 x 50 m was adopted.

At present, on the left bank there is no embankment at all. Therefore, a new embankment of 2.0 m in height will be established from Lacovia to Cataboo.

The main drainage canal would be arranged along the proposed new embankment. The drainage canal for the Styx River basin would be arranged as a branch of the left bank main drainage canal.

The drainage pump station would be established at Cataboo upland point at the end point of the main drainage canal.

iii) Broad River right bank

The whole area of this segment was covered with peat soil, a field lot 100 x 50 m is adopted.

The embankment of the right bank, 1.0 m in height, is a new arrangement from Burnt Savannah to Salt Spring bridge.

The main drainage canal would be arranged along the embankment.

The drainage pump station would be established at the site of the Salt Spring bridge.

iv) Broad River left bank

The whole area of this segment is also peat soil, therefore, a field lot 100 x 50 m was adopted.

Embankment, main drainage canal and drainage pump station would be established in the same way as for the right bank.

1.5.3 Alternative reclamation plans

1) Number of alternative plans

The plan described in the foregoing sections is the full development plan for alternative No.1.

Alternative No.2 is almost the same as alternative No. 1 excluding group No. 4 of Broad River left bank. The reason for excluding the Broad River left bank is based on the environmental aspect namely that this area has the biggest "Blue Hole" in Broad River upper reaches. Also this alternative has a conservation role.

Alternative No.3 is a small scale plan of Black River both banks.

These 3 alternatives are studied and shown in Fig. H-4.

2) Conception of alternatives

i) Alternative No.1

a) Net irrigable area

Black River right bank	560 ha
" left bank	920 "
Broad River right bank	800 "
" left bank	800 "
Total	3,080 ha

b) Major civil works

Black River right embankment	7.70 km
" left embankment	8.30 "
Broad River right embankment	5.70 "
" left embankment	5.70 "
Drainage pumps stations	4 sites
Irrigation "	1 site
Head works	1 site

ii) Alternative No.2

a) Net irrigable area

Black River right bank	560 ha
" left bank	920 "
Broad River right bank	800 "
Total	2,280 ha

b) Major civil work

Black River right embankment	7.70 km
" left "	8.30 "
Broad River right "	5.70 "
Drainage pump stations	3 sites
Irrigation " "	1 site
Head work	1 site

iii) Alternative No.3

a) Net irrigable area

Black River right bank	560 ha
" left bank	920 "
Total	1,480 "

b) Major civil works

Black River right embankment	7.70 km
" left "	8.30 "
Drainage pump stations	2 sites
Irrigation " "	1 site
Head work	1 site

2. DRAINAGE

2.1 Existing Drainage System

2.1.1 General

The project area for the feasibility study was set at 3,080 hectares on the Black River right bank (Holland Estate), the Black River left bank, the Broad River right bank and the Broad River left bank.

Out of the total 3,080 hectares, 560 hectares of the Black River right bank are presently being utilized in the production of sugarcane by the Holland Estate.

The remaining 2,520 hectares excluding the 560 hectares of the Black River right bank are undeveloped peaty swamp area.

2.1.2 River

The Black River is the main drain for 560 hectares of the right bank area and 920 hectares of the left bank area. The Black River has a width of 15 to 20 m and a depth of 3 to 5 m.

The Broad River is the main drain for 800 hectares of the right bank area and 800 hectares of the left bank area. The Broad River has a width of 15 to 20 m and a depth of 3 to 4 m.

River depth of 3 to 5 m will be satisfactory for utilizing the river as the drainage system in the development of the peat soil area.

The elevation of the ground surface and the elevation of the water surface are almost the same level during ordinary periods, therefore, river dikes and a drainage pump station will be indispensable for the development of the peat soil area.

2.1.3 Drainage system

Holland Estate area is now utilized for the cultivation of sugar cane which is the only segment having a drainage canal system.

This drainage canal system will be utilized when the Estate area is incorporated into the project area. The dimensions of the main drainage canal is 3 to 5 m in width and 1.0 to 1.5 m in depth on the average.

Holland Estate area also has a drainage pump station equipped with 2 pump sets 700 mm and 400 mm diameter respectively.

The Black River has an embankment of 2.14 km on its right bank.

2.2 Drainage System Plan

2.2.1 River improvement

1) General

The main rivers in case of the full development plan are the Black River and the Broad River.

These rivers are natural rivers which meander down through the peat area, therefore, they have many bends. In the development work extreme bends will be improved by the new short-cut-canal.

2) Black River

i) Short-cut-canal

In the Black River 2 short-cut-canals are planned between Lacovia and West Cataboo. Short-cut-canals will be given the same width and depth as up and down stream. Their total length will be 0.6 km.

ii) Dike

a) On the right bank there exists a dike between the crossing point of the Estate main drainage canal and the point of the Estate pump station. Length is 2.1 km. This existing dike will be raised up to 2.0 m high on the average.

b) An Estate inner dike named the Holland East dike is to be newly established along the existing Estate main drain canal. Length is 2.9 km. The height of this dike is 2.0 m in average.

c) On the Black River left bank a new 8.0 km long dike will be established between Hatfield and West Cataboo. Its average height is 2.0 m in the upper reaches with a length of 4.6 km and 1.0 m in the lower reaches with a length of 3.4 km. The reason the dike in the lower reaches is lower than that in the upper reaches is that the right bank area's water level is lower since there is no dike for retaining it.

d) To involve the upper clayey soil area of the Y.S. River into the Black River right bank area a new dike of 1.0 m height will be established along the Y.S. River left bank. Length is 1.6 km improvement and 2.4 km new line. This dike would be 1.0 m high on the average.

e) Spacing of dikes

The spacing between the right and left dikes should be 150 m at least. This spacing is determined by hydraulic calculation to give enough cross-sectional area for the flood discharge flowing away.

3) Broad River

The Broad River has the largest scale "Blue Hole" in its upper reaches, and a wide sectional area in comparison with its catchment area. To conserve the grand view the river dikes should be planned rather low and rather wide.

The height of the dike is, therefore, planned at 1.0 m above the average ground surface. The spacing between both dikes is given as 400 m at least.

The length of the dikes of both right and left banks, will be 5.7 km.

2.2.2 Drainage canal

1) General

There are 2 types of main and secondary drainage canal. The first is a drainage canal alongside a dike, and the second a drainage canal alongside a road.

The cross-sections of the two types of drainage canals will be determined according to their scale of structure. Where the canal is more significant structure its cross-section is determined by hydraulic factors. In the event where the road or dike is larger than the drainage canal the cross-section of the canal will be determined by the structure of the road or dike. The dredged earth will be used in the construction of the bank for the road or dike.

2) Proposed drainage network

The proposed drainage network should follow the existing drainage network in the Holland Area and utilize the borrow pit for the dikes as the main drainage canal route from an economical points of view. Main drainage canal follows a route along the dike up to the drainage pump station. Proposed drainage network is shown in Fig. H-5.

3) Discharge

Flood discharge in the main drainage canal will be co-related with the proposed drainage pump capacity. Design discharge is computed by the following equation:

$$Q_1 = Q_0 \times (A/A_0) \quad (m^3/sec)$$

where, Q_1: Design discharge for the main canal (m^3/sec)

Q_0: Proposed pumping drainage capacity

Q = 5.2 m^3/sec in Holland area

8.7 " in Black River Left Bank area

6.7 " in Broad River Right Bank area

5.0 " in Broad River Left Bank area

A_0: Water-shed acreage at the drainage pump station (ha)

A = 990 ha in Holland area

1,680 ha in Black River left bank area

1,180 ha in Broad River right bank area

1,080 ha in Broad River left bank area

A: Water-shed acreage at the design point of main drainage canal (ha)

Low water level in the main drain is an important factor for sub-surface water table control in the paddy fields. Low water discharge is designed taking into consideration the gross irrigation water requirement, effective rainfall, evapotranspiration and, furthermore, the increase in ground-water inflow from the outside of the water-shed into the project area.

The drainage diagram and unit drainage discharge are shown in Fig. H-6 and Table H-8.

4) Total length of drainage canal

Total length of the main and secondary drainage canal is 36.38 km, broken down as follows;

Area	Total	First Type	Second Type
Black Right	8.90	2.70	6.20
" Left	17.10	7.90	9.20
Broad Right	7.00	3.70	3.30
" Left	8.20	3.70	4.50
Total	41.20	18.00	23.20

2.2.3 Farm drains

1) General

In this section, the drainage system of the field lot level is studied. Open ditches or pipe drains are usually used for the drainage system of the field lot level.

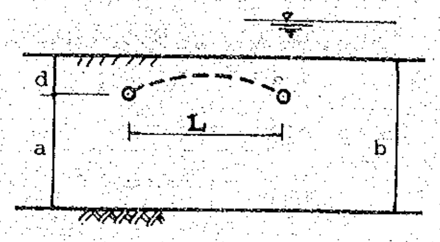
The merits of the open ditch are that the construction cost is low and maintenance is easy. On the other hand its demerits are that the non-cultivated area is increased and machinery operation is sometimes interrupted.

In case of the pipe drain, its merits and demerits are just the opposite of the open ditch. Namely, its merits are increase of cultivated area and effective machinery operation. Demerits are high construction cost and difficult maintenance.

In the peat area, the open ditch should be adopted for an initial stage of several years after development since during the initial stages uneven settlement of the land is unavoidable. After the problem of uneven settlement has been solved the open ditches can be shifted to a pipe drains. As the result the field lot can be extended two, three and even four times in width.

2) Calculation of drain spacing

Donnan's equation of pipe drain was adopted. Given condition and calculation are as follows:



$$L^2 = \frac{4k\ (b^2 - a^2)}{q}$$

Where, L: drain spacing in meter.

q: drain discharge in m/day,

5 mm/day = 0.005 m/day,

k: hydraulic conductivity in m/day

8×10^{-4} cm/sec = 0.69 m/day,

a: distance between drain and impermeable layer in meter (2.10 m),

b: distance between ground water level and impermeable layer (3.00 m)

$$L = \frac{4 \times 0.69\ (3.00^2 - 2.10^2)}{0.005} = 50.3 = 50 \text{ m}$$

The major peat area has a peat layer depth of within 3.0 m. The layer below the peat soil is hard impermeable clay.

Hydraulic conductivity of the peat soil is generally estimated in the order of 10^{-3} to 10^{-4} cm/sec. It is assumed to be 8×10^{-4} cm/sec in the project.

Therefore, the maximum spacing of drains in the peat soil area is 50 m.

2.2.4 Hydraulic calculations

1) Flood discharge

Flood discharges of the Black River and the Y.S. River were computed according to the hydrological stochastic analysis of the observational data. The detailed calculations are shown in Annex B.

Flood discharge of the Broad River were computed by daily rainfall analysis.

a) Black River

Point	Hydro-Analysis m^3/sec	Design Discharge m^3/sec
i) Lacovia Bridge	195	200
ii) Bamboo Avenue	16.1	20
iii) Confluence point of Black R. and Bamboo Ave.	211.1	220

b) Y.S. River

The discharge at the Y.S. River Bridge is 55 m^3/sec.

c) Broad River

Runoff from the west hillside of Santa Cruz Mountain will be gathered by the catch drain which is newly planned alongside the main irrigation canal. Excavated earth from the catch drain is applied to the banking of the irrigation canal. The catch drain will be connect with the upper point of the Broad River and runoff water will flow out into the river directly.

The design discharge of the catch drain is 20 m^3/sec as follows;

$$Q = \frac{R_{50}}{10^3} \times A \times 10^4 \times f \times \frac{1}{86,400}$$

$$= 19.7 = 20 \ m^3/sec$$

where, Drain rainfall of 50 year return period: R_{50} = 155 mm

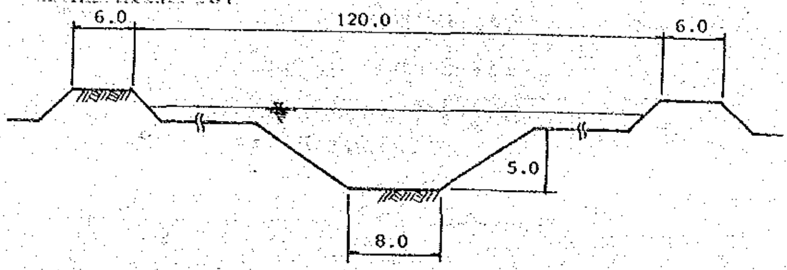
Catchment area: A = 2,200 ha

Runoff ratio: f = 0.5

2) Hydraulic calculation

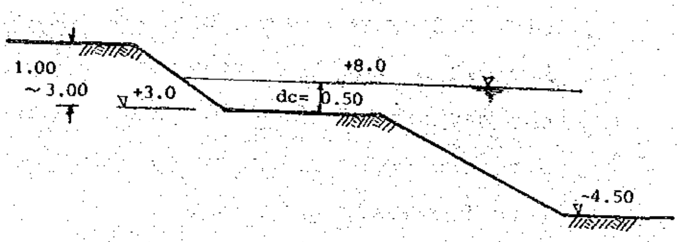
a) Black River

Hydraulic calculation of the Black River was carried out by computer applying Bernoulli's Theorem. The standard cross-section of the Black River was decided as follows.



Critical depth of the starting point of the hydraulic calculation is dc = 0.50 m as follows.

$$dc = (Q_1{}^2/gb^2)^{1/3}$$
$$= (129.4^2/9.8 \times 120^2)^{1/3}$$
$$= 0.49 = 0.50 \text{ m}$$



where, dc: critical depth

Q : discharge of major bed

g : gravity coefficient

b : width of major bed

b) Broad River

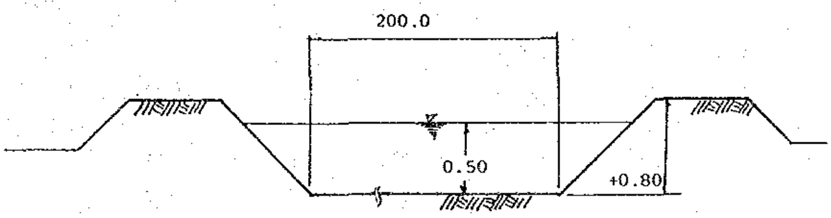
Cross sectional area of flow was calculated by applying the formula of uniform flow.

$$A = b \times d = 200 \times 0.50 = 100 \text{ m}^2$$
$$P = 200 \text{ m}$$
$$R = A/P = 100/200 = 0.50 \text{ m}$$
$$n = 0.1$$
$$I = 1/1,000$$

$$V = \frac{1}{n} R^{2/3} I^{1/2} = \frac{1}{0.1} \times 0.50^{2/3} \times (1/1,000)^{1/2}$$

$$= 0.199 \text{ m/sec}$$

$$Q = AV = 100 \times 0.199 = 19.9 > 20 \text{ m}^3\text{/sec} \quad \underline{\text{OK}}$$



c) Y.S. River

Cross sectional area of flow was calculated by applying the formula of uniform flow.

$$A = \frac{1}{2} (12 + 6) \times 3 + 0.5 \times 112 = 83 \text{ m}^2$$

$$P = 114.5 \text{ m}$$

$$R = A/P = 83/114.5 = 0.72 \text{ m}$$

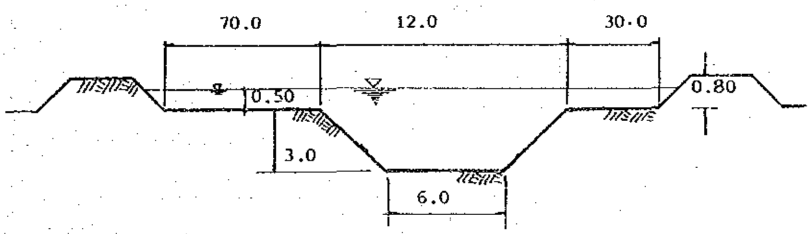
$$I = 1/1,000$$

$$n = 0.034$$

$$v = \frac{1}{n} R^{2/3} I^{1/2} = \frac{1}{0.034} \times 0.72^{2/3} \times (1/1,000)^{1/2}$$

$$= 0.74 \text{ m/sec}$$

$$Q = AV = 83 \times 0.74 = 61.4 > 55 \text{ m}^3\text{/sec} \quad \underline{\text{OK}}$$



2.2.5 Runoff analyses

1) Design rainfall

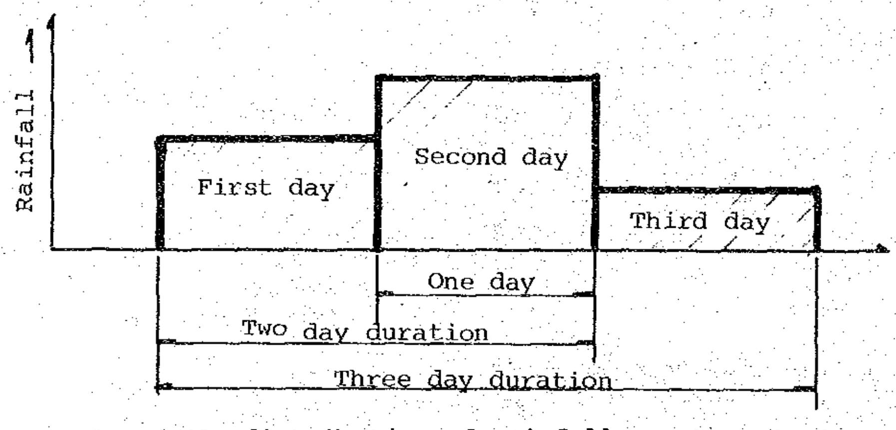
A three-day, duration probable rainfall with a 10-year return period was adopted for the design rainfall. It is shown as follows for each block:

Block	Rainfall	Station
Black River right bank	228 m	Holland
" left bank	256	Lacovia
Broad River right bank	256	"
" left bank	199	Burnt Savannah

Daily distribution of rainfall can be calculated by applying the following data which show the most frequent rainfall pattern as follows.

(mm)

Station	Total	First day	Second day	Third day
Holland	228	66	138	24
Lacovia	256	60	167	29
B. Savannah	199	60	155	24



Namely, daily distribution of rainfall can be calculated as follows.

i) First day rainfall is the value deducting one-day probable rainfall from two-day duration probable rainfall.

ii) Second day rainfall is the value of one-day probable rainfall.

iii) Third day rainfall is the value deducting two-day duration probable rainfall from three-day duration probable rainfall.

One day, two day duration and three day duration probable rainfall with a 10-year return period are given as follows;

(Unit: mm)

Station	10-year Probable Rainfall		
	One-day	Two-day Duration	Three-day Duration
Holland	138	204	228
Lacovia	167	227	256
B. Savannah	115	175	199

Hourly rainfall distribution was calculated by the following rainfall intensity formula.

$$Rt = R_T \cdot \left(\frac{t}{T}\right)^k$$

where, Rt: Maximum rainfall of t-hour duration

RT: 24-hour duration rainfall

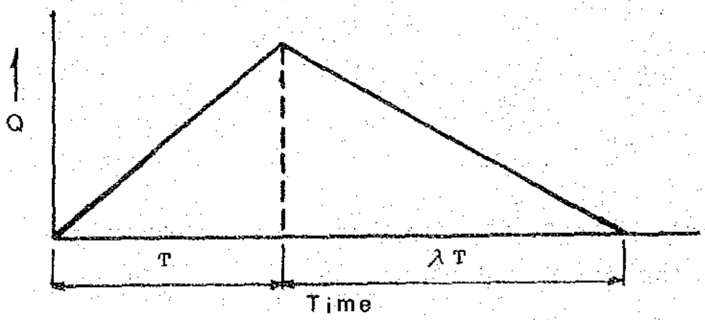
T: 24 hours

K: Coefficient, average K = 0.5

According to the above-mentioned values and methods, hourly rainfall distribution in each block is decided and shown in Tables H-9, H-10 and H-11.

2) Unit hydrograph

A unit hydrograph for each block was prepared by the simple triangle method and Rziha formula,



$$T = \frac{L}{W}$$

$$W = 72\left(\frac{H}{L}\right)^{0.6}$$

where, T : Concentrate time of flood (hr)

L : Concentrate distance (m)

H : Difference of elevation (m)

W : Velocity of flood arrival (hr)

λ : Coefficient of area (3.0)

That is, T and λ of the 4 blocks were considered to have approximately the same value. Fig. H-7 shows the unit hydrograph of each block to determine the peak discharge.

3) Runoff coefficient

Runoff coefficient for total rainfall was calculated according to the accumulative rainfall as follows,

Accumulative rainfall (mm)	Below 10	10 to 30	30 to 50	50 to 100
Runoff coefficient (%)	0	10	30	50

Accumulative rainfall (mm)	100 to 200	200 to 300	above 300
Runoff coefficient (%)	80	90	95

4) Base flow

Base flow volume gathering as ground water is composed of two factors, percolation of irrigation water and underground flow from the outside of the project area. The unit quantities of these flows are as follows:

Percolation of peat soil	7.7 mm/day
Percolation of mineral soil	3.7 "
Groundwater from hinterland	1.15 "

Black River right bank

Percolation M. $3.7 \times 500 \times \frac{1}{86,400} \times 10 = 0.214$ m^3/s

Groundwater $1.15 \times 994 \times \frac{1}{86,400} \times 10 = 0.132$

Total 0.346

Black River left bank

Percolation M. $3.7 \times 220 \times \frac{1}{86,400} \times 10 = 0.094$

" P. $7.7 \times 700 \times \frac{1}{86,400} \times 10 = 0.624$

Groundwater $1.15 \times 1,682 \times \frac{1}{86,400} \times 10 = 0.224$

Total 0.942

Broad River right bank

Percolation P. $7.7 \times 800 \times \frac{1}{86,400} \times 10 = 0.713$

Groundwater $1.15 \times 1,182 \times \frac{1}{86,400} \times 10 = 0.157$

Total 0.870

Broad River left bank

Percolation P. $7.7 \times 800 \times \frac{1}{86,400} \times 10 = 0.713$

Groundwater $1.15 \times 1,079 \times \frac{1}{86,400} \times 10 = 0.144$

Total 0.857