Appendix 4-A

Soils

Appendix 4-A

SOILS

CONTENTS

TABLES

1. General

The present study on soil and land resources were conducted on the basis of the soil survey carried out from October to December, 1989 by the CV SECON, the local consultant in Bandung. The said survey was done inaccordance with the technical specification which the JICA team submitted to DGWRD and under the supervision of the JICA team.

The objective area of the survey was about 45,000 ha including the whole project area. The field survey was performed by auger boring and profile observatin of typical soils. The intensity of auger survey was one per 200 ha by the grid method in principle and profile observation was done at 35 sites. Laboratory analysis was made on 180 samples taken from typical profiles. The items of analysis include; pH, EC, soil particle distribution, cation exchange capacity, major exchangeable cations and potential soil acidity.

In the survey, the soil and land suitability classifications were made in accordance with the systems commonly adopted in Indonesia. The soil map and land suitability map were prepared on a scale of 1/50,000, based on the results of the survey.

On the basis of the soil map prepared by the local consultant, further study on soil distribution and characteristics in the project area (14,300 ha) were made using mosaic map of 1/20,000 scale by the JICA team and slight modification to the original soil map was made. According to the results of the same, soil classification of the project area was carried out basically in accordance with the system currently adopted by the Soil Research Center, in which soil classification based on land systems are employed. Morphlogical characteristics (wetness of soils, etc.), parent materials and other major characteristics of soils are also considered as well. On the results of the same, land suitability classification for irrigation development was studied. Soil and and classification map was prepared on a base topographic map of 1/50,000 scale and reduced to 1/100,000.

2. Land Systems in the Project Area

The physiographical features of the project area are classified into the following four land systems.

- Tidal flat above storm level,
- Tidal flat above storm level, peat deposit
- Alluvial plains
- Flat plains & fans of Toba tuff

The tidal flat land externsively occupies the lowlying areas of the project area and the alluvial plains are developed along the Silau river. The flat plains & fans of Toba tuff represent the upland area in the project area.

3. Soil and Land Classification

The soils in the project area are classified into six (6) soil units in accordance with soil and land characteristics. The soil units are further subclassified into ten (10) subunits on the basis of surface texture, effective soil depth and drainage conditions. The subunits are employed as soil mapping unit and land unit for land classification. The distribution of soils in the project area is indicated in Table A-1 and the soil map is presented in Fig. 3-1. Physio-chemical properties of the soils are presented in Table A-2. The characteristics of soil unit/subunit and profile descriptions of typical profiles of the soils are indicated in Tables A-4 to A-13.

The potential land classification of the soils in the project area for both irrigated paddy and upland crops are examined principally in accordance with "A Framework for Land Evaluation, FAO". The classification criteria is prepared based on the criteria defined by the Soil Research Center with some modification made taking into consideration of the proposed irrigation and drainage development and the envisaged intensive farming under the present project, as indicated in Table A-3. Accordingly, the soils in the project area are classified

into four classes both for paddy and upland crops as; S1 (suitable), S2 (moderately suitable), S3 (marginally suitable) and N (non suitable). The results of the land classification are presented in Table A-1.

Table A-1 SOIL AND LAND CLASSIFICATION OF THE PROJECT AREA

Soil Unit	Soil Submit	No. of Subunit	Land System	Potential Land Suitability Classes 1/ Paddy	Upland crops	Distribution Area (ha)	Proportion (%)	Classification by Indonesian System 2/	USDA system
Partly ripened poorly drained low land soils	Fine textured, deep, poorly drained	I-1	Tidal flat above storm level	S2	S3	1,650	11.5	Gleisol hidrik	Tropaquepts
Partly ripened very poorly drained low land soils	Fine textured, deep, very poorly drained	II-1	Tidal flat above storm level	S2	S3	2,310	16.2	Gleisol hidrik	Hydraquepts
	Sapric, fine textured, deep, very poorly drained	II-2		S3	S3	320	2.2	Gleisol humic	
Medium textured alluvial soils	Coarse to medium textured, moderate to deep, moderately drained	III-1	Alluvial plains	S2	S2	1,230	8.6	Aluvial gleik	Tropaquents
	Medium textured, deep, poorly drained	III-2		S2	S2	480	3.4	Aluvial gleik	
Flat volcanic tuff soils	Fine to medium textured, deep, poorly drained	IV-1	Flat plains and fans of Toba tuff	S1	S2	750	5.2	Andosol gleik	Tropaquepts/ Dystropepts
	Fine to medium textured, deep, moderately drained	IV-2		S2	S2	370	2.6	Andosol gleik	
	Medium textured, moderate moderately drained	IV-3		S2	S2	5,430	38.0	Regosol gleik	
Coarse textured volcanic tuff soils	Coarse textured, shallow, well drained	V-1	Flat plains and fans of Toba tuff	S3	S3	1,240	8.7	Regosol gleik	Dystrandepts
Moderately deep organic soils	Sapric, very poorly drained, moderate depth 0.5-1 m	VI-1	Tidal flat above storm level, peat deposit	S3	S3	360	2.5	Organasol hemist	Troposaprists
River and riverbed				NR	NR	160	1.1		
Total						14,300	100.0		

1/: S1 - Suitable, S2 - Moderately suitable, S3 - Marginally suitable
N - Not suitable, NR - Not relevant for classification
2/: Indonesian classification system employed by the local consultant.

Table A-2 PHYSIO-CHEMICAL PROPERTIES OF SOILS

No. of Soil Subunit	Soil Depth	Texture(%) S	L	C	Texture	pH H2O	KCl	EC ms/cm	CEC meq/100g	Ex. Cation(meq./100g) K	Na	Ca	Mg
I-1	0 - 8	18	28	54	C	6.0	5.2	0.40	-	0.38	0.80	0.80	0.76
	8 - 26	14	24	62	C	6.4	5.5	0.37	32	1.00	2.07	4.35	2.83
	26 - 105	12	28	60	C	6.7	5.5	0.32	33	0.65	2.10	4.08	2.93
	105 - 125	18	28	54	C	6.9	5.8	0.38	31	0.37	1.62	4.71	2.81
II-1	0 - 16	16	30	54	C	5.2	4.0	0.02	32	0.65	1.12	3.44	2.54
	16 - 40	12	40	48	C	5.6	4.6	0.25	25	0.26	2.12	4.08	2.69
	40 - 105	12	48	40	SiC	6.0	4.8	0.26	25	0.29	2.58	4.67	2.89
II-2	0 - 25	18	24	58	C	6.1	5.1	0.13	28	0.73	0.81	5.23	2.69
	25 - 105	16	24	60	C	6.5	5.3	0.16	30	0.81	1.17	5.23	2.66
	105 - 140	16	26	58	C	6.9	5.9	0.00	33	2.00	2.43	6.03	2.72
III-1	0 - 36	68	20	12	SL	5.0	4.2	0.03	17	0.18	0.06	0.21	0.05
	36 - 94	84	10	6	LS	5.5	4.5	0.01	9	0.07	0.10	0.21	0.16
	94 - 140	48	32	20	L	5.4	4.1	0.02	13	0.02	0.18	0.40	0.56
III-2	0 - 10	20	52	28	CL	5.8	4.4	0.04	45	0.55	0.36	0.48	2.85
	10 - 26	20	56	24	SiL	5.7	4.2	0.01	23	0.24	0.08	0.37	0.15
	26 - 52	32	62	6	SiL	5.2	4.1	0.00	11	0.23	0.06	0.40	0.09
	52 - 120	20	60	20	SiL	5.4	4.3	0.03	9	0.36	0.13	0.75	0.12
IV-1	0 - 13	20	40	40	CL	5.3	4.2	0.05	32	0.33	0.32	0.83	0.56
	13 - 23	18	40	42	SiCL	5.5	4.2	0.05	24	0.47	0.79	0.96	0.66
	23 - 70	26	36	38	Cl	6.6	5.2	0.05	23	0.86	1.39	0.64	1.18
	70 - 120	86	6	12	LS	6.8	5.2	0.04	6	0.37	0.72	0.37	0.90
IV-2	0 - 27	26	36	38	CL	4.6	4.0	0.02	11	0.21	0.03	0.53	0.17
	27 - 47	24	34	42	CL	4.8	3.9	0.02	12	0.15	0.05	0.37	0.19
	47 - 110	44	22	34	CL	5.2	4.2	0.04	28	0.25	0.63	2.56	1.49
IV-3	0 - 17	42	28	30	CL	5.3	4.4	0.15	11	0.30	0.26	0.59	0.46
	17 - 34	46	26	28	SCL	5.9	5.2	0.04	10	0.09	0.41	0.64	0.67
	34 - 61	60	34	6	SL	6.5	5.2	0.01	6	0.17	0.30	0.53	0.73
	61 - 94	16	66	20	SiL	5.7	4.1	0.01	10	0.31	0.50	0.21	0.50
	94 - 125	14	54	32	SiCL	5.3	4.1	0.04	22	0.43	0.71	0.11	0.78
V-1	0 - 14	84	10	6	LS	6.0	5.2	0.01	-	0.12	0.01	0.61	0.10
	14 - 28	82	12	6	LS	6.0	4.8	0.01	3	0.17	0.01	0.21	0.10
	28 - 120	86	8	6	S	5.9	4.8	0.00	2	0.13	0.05	0.24	0.08

Note: pH & EC - 1 : 2.5 suspension

Table A-3 CRITERIA FOR POTENTIAL LAND SUITABILITY CLASSIFICATION

il & Land racteristics	Land Classes							
	Irrigated Paddy 1/				Upland Crop 1/			
	Class 1 (S1)	Class 2 (S2)	Class 3 (S3)	N	Class 1 (S1)	Class 2 (S2)	Class 3 (S3)	N
Effective soil depth(cm)	>75	50-75	20-50	<20	>100	50-100	25-50	<25
Texture	fine-medium	fine-very fine medium-coarse	coarse	stony	medium-fine	fine	coarse	stony
Cosrse fragments/ surface soil	none	slight-moderate	moderate-stony	stony	none	slight-moderate	moderate-stony	stony
Permeability	-	-	-	-	high	moderate	low	-
Moisture holding capacity	-	-	-	-	high	moderate	low	very low
CEC/surface soil (meq/100g soil)	>25	10- 25	3- 10	<3	>25	10- 25	3- 10	<3
Soil fertility (ex-K, Ca & Mg)	high-moderate	moderate-low	-	-	high-moderate	moderate-low	-	-
EC (ms, 1:2.5 suspension)	<1.5	1.5-2.5	2.5-4.0	>4.0	<1.5	1.5-2.5	2.5-4.0	>4.0
Soil reaction (pH)/ surface soil	5.0-7.5	4.5-5.0	4.0-4.5	<4.0	5.5-7.0	5.0-5.5	4.0-5.0	<4.0
Terminal acidity (pH)	>4.5	3.5-4.5	<3.5	-	>5.0	4.5-5.0	3.5-4.5	<3.5
Peat thickness (cm) & degree of decomposition 2/	sapric: <30	sapric: 30-50 fibric:<30 hemic: <30	sapric: 100 fibric: 30-100 hemic: 30-100	fibric:>100 hemic: >100	sapric: <50	sapric: 50 fibric:<50 hemic: <50	- fibric: 50-200 hemic: 50-200	fibric:>200 hemic: >200
Drainability	poor-moderate	poor-very poor moderate-well	well-excessive	excessive	good	moderate	poor	very poor
Slope (%)	<0.5	0.5-2	2-5	>5	<3	3-8	8-15	>15
Erosion hazard	-	-	-	-	insignificant	slight	moderate	severe

1/: S1 - Suitable, S2 - Moderately suitable, S3 - Marginally suitable, N - Not suitable
2/: For organic soils only

Table A-4 CHARACTERISTICS AND PROFILE DESCRIPTION -1

Soil unit : I: Partly ripened, poorly drained low land soils
Subunit : I-1: Fine textured, deep, poorly drained soils
Area : 1,650 ha(11.5%)
Land class : Paddy S2; Upland crops S3 1/

Major Characteristics:

The soils derive from marine deposits and are distributed in the flat to swampy lowlying area in the project area. The soils are fine textured, poorly drained soils with deep effective soil depth and soil reaction is acid to slightly acid and CEC is high. The surface layer of the soils are generally abundant with reddish yellow mottlings and seasonal drying of surface soil is identified through morphological observation, though the saturated misture regime prevails most of a year due to rice cultivation and seasonal inundation. The unit is usually used for paddy field and partly for coconut field. Considerably high productivity of rice cultivation is expected under proper irrigation.

Typical Profile

Location : Ujung Kubu
Topography : flat
Drainage : poor

Land use: Mix of coconut & paddy
Depth of inundation: +15cm

Soil depth (cm)	
0 - 8	Yellowish gray (2.5Y 5/1), clay, no mottling, sticky and plastic, organic matter content high, pH 6.0
8 - 26	Dark grayish yellow (2.5Y 5/2) + orange (7.5YR 6/8, mottling), clay, sticky and plastic, pH 6.4
26 - 105	Gray (5Y 5/1) + orange(7.5YR 6/8, mottling), clay, very sticky and very plastic, pH 6.7
105 - 125	Gray (5Y 6/1), clay, no mttling, sticky to very sticky and plastic to very plastic, pH 6.9

1/: Potential land suitability class

Table A-5 CHARACTERISTICS AND PROFILE DESCRIPTION -2

Soil unit : II: Partly ripened,very poorly drained low land soils
Subunit : II-1: Fine textured, deep, very poorly drained soils
Area : 2,310 ha (16.2%)
Land class : Paddy S2: Upland crops S3 1/

Major Characteristics:

The soils are developed from marine deposits and are distributed in the flat to swampy lowlying area in the project area. The soils are fine textured, very poorly drained soils with deep effective soil depth and soil reaction is acid to slightly acid and CEC is considerably high. The profile shows greyish color with or without mottlings, indicating continuous moisture saturation or inundation of soils almost throughout a year. The unit is exclusively used for the cultivation of local variety of paddy. Poor drainability is the primary constraint in the unit and drainage improvement is pre-requisite for successful irrigation farming.

Typical Profile

Location : Sei Mentaram
Topography : flat — Land use: Rainfed paddy
Drainage : very poor — Depth of inundation: +20cm

Soil depth (cm)	
0 - 16	Olive black(5Y 3/2), clay, no mottling, sticky and plastic, high in organic matter, pH 5.2
16 - 40	Dark olive(5Y 4/3) + orange(7.5YR 6/8, mottling), clay, sticky and plastic, pH 5.6
40 - 105	Light yellow(2.5Y 7/4) + orange(7.5YR 6/8), silty clay, very sticky and very plastic, pH 6.0

1/: Potential land suitability class

Table A-6 CHARACTERISTICS AND PROFILE DESCRIPTION -3

Soil unit : II: Partly ripened, very poorly drained low land soils: II: Partly ripened, ve
Subunit : II-2: Sapric, fine textured, deep, very poorly drained soils
Area : 320 ha (2.2%)
Land class : Paddy S3: Upland crops S3 1/

Major Characteristics:

The soils are found in an limited area in lowlying area close to the Bunut river. The surface layer is covered with well decomposed organic materials and the bearing capacity of the soils is extremely low. The soils are fine textured and very poorly darined. The effective soil depth is deep. The soil reaction is slightly acid and CEC is considerably high. The area distributed with the soils is inundated throughout a year and used for paddy field. Drainage improvement is essential for the introduction of the intensive farming in the area.

Typical Profile

Location : Silo Bonto
Topography : flat — Land use: Rainfed paddy
Drainage : very poor — Depth of inundation: +30cm

Soil depth (cm)	
0 - 25	Gray(5Y 6/1)+dull brown(7.5YR 5/4, mottling), clay, sticky and plastic, rich in well decomposed organic materials, pH 6.1 surface layer covered with sapric material
25 - 105	Light gray(5Y 7/2) + bright brown(7.5YR 5/6), clay, very sticky and very plastic, pH 6.5
105 - 140	Litght gray(5Y 7/1),clay, no mottling, sticky and plastic, pH 6.9

1/: Potential land suitability class

Table A-7 CHARACTERISTICS AND PROFILE DESCRIPTION -4

Soil unit : III: Medium textured alluvial soils
Subunit : III-1: Coarse to medium textured, moderate to deep, moderately drained soils
Area : 1,230 ha(8.6%)
Land class : Paddy S2; Upland crops S2 1/

Major Characteristics:

The soils are formed from the alluvial deposits of the Silau river and distribute along the both sides of the Silau river. Due to the stratification of materials different in texture, texture and effective soil depth varies within the unit. However, majority are medium textured and moderate to deep. Soil reaction is slightly acid to acid and CEC is low to medium. Drainability is moderate, in general. The area distributed with the soils is mainly used for paddy field with the exception of limited area for coconut field. The potential for irrigated rice farming is considered to be high when the area is freed from seasonal flooding occurring frequently at present.

Typical Profile

Location : Sei Lama
Topography : flat — Land use: Rainfed paddy
Drainage : moderate — Depth of inundation: +18cm

Soil depth (cm)	
0 - 36	Yellowish brown(2.5Y 5/4), sandy loam, no mottling, slightly sticky and slightly plastic, pH 5.0
36 - 94	Dull yellow(2.5Y 6/4), loamy sand, non sticky and non plastic, pH 5.5
94 - 140	Brownish gray(5YR 5/1) + bright brown(7.5YR 5/8 mottling), loam, slightly sticky and slightly plastic, pH 5.4

1/: Potential land suitability class

Table A-8 CHARACTERISTICS AND PROFILE DESCRIPTION -5

Soil unit : III: Medium textured alluvial soils
Subunit : III-2: Medium textured, deep, poorly drained
Area : 480 ha(3.4%)
Land class : Paddy S2; Upland crops S2 1/

Major Characteristics:

The soils are found at the right bank side of Silau river in limited area and considered to be formed from medium textured alluvial deposits of the river. The effective soil depth is generally deep with some exception of moderate depth. Drainage condition of the soils is poor and soil reaction is slightly acid and CEC is medium to low. The soils are predominantly used for paddy cultivation. Considerably high productivity of rice farming in the area is expected under proper irrigation.

Typical Profile

Location : Lubuk Sirambe
Topograhy : flat — Land use: Irrigated paddy
Drainage : poor — Depth of inundation: +10cm

Soil depth (cm)	
0 - 10	Grayish olive(5Y 5/3) + brown(10YR 4/6, mottling), clay loam, sticky and plastic, pH 5.8
10 - 26	Grayish olive(5Y 6/2) + bright reddish brown(2.5YR 5/6, mottling), silty loam, sticky and plastic, pH 5.7
26 - 52	Dark grayish yellow(2.5Y 4/2), silty loam, no mottling, slightly sticky and slightly plastic, pH 5.2
52 - 120	Gray(5Y 5/1), silty loam, no mottling, sticky and plastic, pH 5.4

1/: Potential land suitability class

Table A-9 CHARACTERISTICS AND PROFILE DESCRIPTION -6

Soil unit : IV: Flat volcanic tuff soils
Subunit : IV-1: Fine to medium textured, deep, poorly drained
Area : 750 ha(5.2%)
Land class : Paddy S1; Upland crops: S2 1/

Major Characteristics:

The soils are derived from fine to medium textured volcanic tuff deposits and distributed in limited extent in the fringe of flat fans of Toba tuff. The surface soil texture is fine to medium and effective soil depth is deep. Soil reaction is slightly acid and CEC is considerably high. Drainage condition is poor due to texture and phsiographical conditions The unit is used for paddy and coconut field. High productivity of irrigated paddy is anticipated when the seasonal inundation is successfully prevented through drainage improvement.

Typical Profile

Location : Binjai Sebangan
Topography : flat — Land use: Irrigated paddy
Drainage : poor — Depth of inundation: +13cm

Soil depth (cm)	
0 - 13	Grayish olive(5Y 5/2), clay loam, no mottling, sticky and slightly plastic, organic matter content medium, pH 5.3
13 - 23	Dull yellow(2.5Y 6/4) + orange(7.5YR 6/8, mottling), silty clay loam, sticky and slightly plastic, ph 5.5
23 - 70	Light gray(2.5Y 7/1) + bright brown(7.5YR 5/8, mottling), clay loam, slightly sticky and slightly plastic, pH 6.6
70 - 120	Yellowish gray(2.5Y 6/1), loamy sand, no mottling, non sticky and non plastic, pH 6.8

1/: Potential land suitability class

Table A-10 CHARACTERISTICS AND PROFILE DESCRIPTION -7

Soil unit : IV: Flat volcanic tuff soils
Subunit : IV-2: Fine to medium textured, deep, moderately drained
Area : 370 ha(2.6%)
Land class : Paddy S2; Upland crops S2 1/

Major Characteristics:

The soils are developed from volcanic tuff deposits of fine to medium and cover a small part of the project area. The effective soil depth is deep and drainability is moderate. The soil reaction is acid to slightly acid and CEC is medium. The unit is used for paddy field at present and potential for irrigated irce farming is high.

Typical Profile

Location : Sei Balai
Topography : flat — Land use: Oil palm estate
Drainage : moderate — Groundwater depth: 39cm

Soil depth (cm)	
0 - 27	Dull yellowish brown(10YR 5/3), clay loam, no mottling, sticky and plastic, organic matter content low, pH 4.6
27 - 47	Light gray(10YR 8/1) + orange(7.5YR 6/8, mottling), clay loam, sticky and plastic, pH 4.8
47 - 110	Light gray(10YR 8/1) + orange(7.5YR 6/8, mottling), clay loam, slightly sticky and slightly plastic, pH 5.2

1/: Potential land suitability class

Table A-11 CHARACTERISTICS AND PROFILE DESCRIPTION -8

Soil unit : IV: Flat volcanic tuff soils
Subunit : IV-3: Medium textured, moderate, moderately drained
Area : 5,430 ha(38.0%)
Land class : Paddy S2; Upland crops S2 1/

Major Characteristics:

The soils are derived from medium textured volcanic tuff deposits and occupy the majority of upland area in the project area. Surface soil texture is medium and effective soil depth is moderate underlain with coarse volcanic glasses. The depth to the coarse layer differs on locations, generally deeper than 70cm. While, the soils are sometimes interbedded with coarser materials. The drainability of the soils is moderate due to coarse fraguments. The soil reaction is slightly acid to acid and CEC is moderate. The area covered with the unit is extensively used for paddy field and partly for coconut field. High productivity of rice under intensive irrigation farming is expected because of preferable internal drainability.

Typical Profile

Location : Pasar Lembu
Topograhy : flat — Land use: Rainfed paddy
Drainage : moderate — Depth of inundation: +10cm

Soil depth (cm)	
0 - 17	Gray(5Y 6/1), no mottling, clay loam, sticky and plastic, organic matter content moderate, pH 5.3
17 - 34	Gray(5Y 6/1) + yellowish brown(10YR 5/8, mottling), sandy clay loam, slightly sticky and slightly plastic, pH 5.9
34 - 61	Light gray(2.5Y 7/1) + yellowish brown(10YR 5/8, mottling) sandy loam, slightly sticky and slightly plastic, pH 6.5
61 - 94	Grayish olive(5Y 4/2) + yellowish brown (10YR 5/8, mottling), silty loam, slightly sticky and slightly plastic, pH 5.7
94 - 125	Gray(5Y 4/1), no mottling, silty clay loam, sticky and plastic, pH 5.3

1/: Potential land suitability class

Table A-12 CHARACTERISTICS AND PROFILE DESCRIPTION -9

Soil unit : V: Coarse textured volcanic tuff soils
Subunit : V-1: Coarse textured, shallow, well drained
Area : 1,240 ha(8.7%)
Land class : Paddy S3; Upland crops S3 1/

Major Characteristics:

The soils are derived from coarse to medium textured volcanic tuff deposits and distributed in and around the village yard in the upland area of the project area. The surface layer of the soils is coarse textured rich in volcanic glasses and usually underlain with layers of finer texture. The effective soil depth, therefore, shallow and drainability is good. The soil reaction is slightly acid anc CEC of surface soil is low. The soils are utilized for paddy field and village yard. The percolation loss of irrigation water, however, is not so large due to high ground water table at present. In order to improve the productivity of paddy, management of soil fertility and careful application of fertilizer for minimizing percolation losses is essential in the area.

Typical Profile

Location : Meranti
Topography : flat — Land use: Coconut field
Drainage : good — Groundwater depth: 79cm

Soil depth (cm)	
0 - 14	Dark reddish brown(5YR 3/2), loamy sand, nonsticky and non plastic, organic matter content low to medium, pH 6.0
14 - 28	Brown(7.5YR 4/4), loamy sand, non sticky and non plastic, pH 6.0
28 - 120	Grayish brown(7.5YR 4/2), sand, non sticky and non plastic, pH 5.9

1/: Potential land suitability class

Table A-13 CHARACTERISTICS AND PROFILE DESCRIPTION -10

Soil unit : VI: Moderately deep organic soils
Subunit : VI-1: Sapric, very poorly drained, moderate depth 0.5 - 1m
Area : 360 ha(2.5%)
Land class : Paddy S3; Upland crops S3 1/

Major Characteristics:

The soils are organic soils covered with well decomposed organic materials of moderate depth, 50 - 100cm. The distribution is limited and found in the lower reach of the Bunut river in the project area. The drainage condition is very poor and bearing capacity is low. The soil reaction is acid. Drainage development is prerequisite for successful irrigation farming.

Typical Profile

Location : Air Hitam
Topography : flat
Drainage : very poor

Land use: Rainfed paddy
Depth of inundation: +25cm

Soil depth (cm)	
0 -30	Brownish black(10YR 3/2), well decomposed organic layer, non sticky and non plastic
30-60	Brownish brown(10YR 3/2), fairly decomposed organic layer, deribs of tree and leaves identified
60-90	Glei layer, dull yellow(2.5Y 6/3), heavy clay, no mottlings, sticky to very sticky and plastic to very plastic
90-110	Glei layer, olive gray(5Gy 6/1), heavy clay, no mottling, sticky to very sticky and plastic to very plastic

1/: Potential land suitability class

Appendix 4-B

Climate and Hydrology

Appendix 4-B

CLIMATE AND HYDROLOGY

CONTENTS

3.2 Low-flow Analysis by the Tank Model Method

3.3 Estimated Monthly Average Discharge

2.4 Basic Year for Water Resource

4. Tidal Influence in the Low-Lying Area

Table B-1 SUMMARY OF CLIMATIC CONDITIONS

(Station: Sei-Dadop)

Item	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	Annual
Mean Temperatur (degree C.)													
Sei Dadap ('66-'88)	25.7	26.0	26.3	26.6	26.7	26.6	26.4	26.3	26.2	26.2	26.2	25.9	26.3
Daily-Max Temperature (degree C.)													
Sei Dadap ('66-'82)	31.5	32.0	32.4	32.7	32.9	32.9	32.6	32.4	32.1	31.8	31.4	31.3	32.2
Daily-Min Temperature (degree C.)													
Sei Dadap ('69-'82)	21.8	21.5	21.9	22.7	22.7	22.5	22.3	22.2	22.5	22.6	22.5	22.2	22.3
Absolute-Max Temperature (degree C.)													
Sei Dadap ('66-'82)	34.5	35.0	35.0	35.5	36.0	36.0	35.5	35.5	35.5	35.0	33.5	35.0	36.0
Absolute-Min Temperature (degree C.)													
Sei Dadap ('69-'82)	16.8	17.0	18.6	18.7	20.0	13.5	18.2	16.5	19.5	19.0	20.0	18.6	13.5
Relative Humidity (%)													
Sei Dadap ('66-'88)	88.7	87.6	88.2	88.4	87.9	86.8	87.0	88.3	88.5	89.4	89.7	89.3	88.3
Wind Velocity (m/s)													
Sei Dadap ('79-'88)	0.19	0.24	0.25	0.23	0.24	0.25	0.25	0.23	0.28	0.22	0.21	0.21	0.23
Sunshine Duration (%)													
Sei Dadap	-	-	-	-	-	-	-	-	-	-	-	-	-
Aek Loba ('70-'88)	57.5	65.2	54.0	54.2	57.8	59.5	62.1	59.9	52.2	59.1	57.0	50.2	57.4
Evaporation (mm)													
Sei Dadap ('79-'88)	93.5	104.8	111.5	112.5	111.9	108.3	112.4	114.8	106.0	105.5	87.9	91.9	1261.0
Rainfall (mm)													
Sei Dadap ('58-'88)	102	78	99	106	131	119	143	151	230	242	164	137	1,702.0

Source; Bandan Meteorologi dan Geofisika (BMG),Balai Wilayah I,Sampali

Table B-2 AVERAGE ANNUAL RAINFALL AND TOTAL RAINFALL FROM JANUARY TO AUGUST IN AND AROUND PROJECT AREA

Unit: mm

Code No.	Station Name	Ave. Annual Rainfall		Ave. Total Rainfall from Jan. to Aug.	
5.04	Lidah Tanah	1,594	(1,392)	840	(726)
6.06	Bunut	1,948	(1,878)	1,053	(1,022)
147/6.10	Hessa	1,689	(1,682)	883	(906)
6.18	Sei Baleh	1,537	(1,550)	792	(805)
145B/6.19	Sei Dadap	1,702	(1,782)	929	(975)
6.22	Serbangan	1,823	(1,681)	913	(866)
6.28	Sibogat	1,846	(1,846)	1,002	(1,002)
145	Kisaran	2,290	(2,290)	1,208	(1,208)
Average		1,734	(1,687)	916	(900)

Note: 1) Locations of the rainfall stations are presented in Fig. B-1.

2) ( ) indicates the calculated value using the data of range from 1986 to 1988.

3) Average values indicate the calculated values excluding Kisaran.

4) Monthly average rainfalls at the stations in and around Project area are presented in Table B-3.

Table B-3 MONTHLY AVERAGE RAINFALL IN AND AROUND PROJECT AREA

Unit: mm

Code No.	Station Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Jan.-Aug. Total
5.04	Lidah Tanah	83.4	78.6	67.6	89.2	107.7	89.7	93.2	116.5	180.1	211.5	157.8	116.5	1,391.8	725.9
6.06	Bunut	109.4	98.9	99.3	124.9	122.7	128.7	151.1	186.9	255.1	250.9	181.5	168.1	1,877.5	1,021.9
147/6.10	Hessa	103.1	71.7	78.1	109.0	132.9	116.5	149.1	145.8	215.6	228.5	171.4	160.2	1,681.9	906.2
6.18	Sei Baleh	70.4	89.0	69.6	77.2	111.8	103.7	128.1	155.3	211.4	228.2	167.9	138.1	1,550.7	805.1
145B/6.19	Sei Dadap	115.5	75.1	104.6	123.7	149.0	137.1	140.7	129.2	256.1	235.9	162.1	152.7	1,781.7	974.9
6.22	Serbangan	98.9	66.0	92.6	96.3	115.4	99.1	139.1	158.8	193.3	264.8	172.2	184.5	1,681.0	866.2
6.28	Sibgat	92.9	100.0	86.6	108.6	111.6	151.3	160.4	190.8	237.5	232.5	179.0	194.7	1,845.9	1,002.2
145	Kisaran	134.9	120.8	98.2	175.4	121.1	146.3	181.8	229.9	290.0	342.5	228.4	220.9	2,290.2	1,208.4
Average		96.2	82.8	85.5	104.1	121.6	118.0	137.4	154.8	221.3	236.0	170.3	159.3	1,687.2	900.3

Note: 1) Locations of the rainfall stations are presented in Fig. B-1.
2) The caluculation period is in the range from 1968 to 1988.

Table B-4 CORRELATION COEFFICIENT OF MOTHLY RAINFALL

Code No.	5.04	6.18	6.22	6.28	6.06	6.27	6.21	6.11	6.12	6.14	6.02	6.15	145	6.19	6.10	6.23	6.26
5.04																	
6.18	0.69																
6.22	0.73	0.59															
6.28	0.80	0.62	0.90														
6.06	0.69	0.61	0.78	0.87													
6.27	0.56	0.49	0.72	0.81	0.79												
6.21	0.58	0.61	0.60	0.50	0.59	0.53											
6.11	0.54	0.49	0.57	0.74	0.63	0.65	0.59										
6.12	0.57	0.54	0.60	0.68	0.66	0.67	0.72	0.64									
6.14	0.43	0.56	0.49	0.59	0.57	0.66	0.52	0.62	0.71								
6.02	0.37	0.46	0.42	0.48	0.39	0.37	0.51	0.52	0.47	0.59							
6.15	0.61	0.51	0.66	0.64	0.66	0.63	0.58	0.66	0.66	0.72	0.39						
145	0.47	0.55	0.56	0.76	0.66	0.55	0.52	0.47	0.63	0.44	0.11	0.42					
6.19	0.56	0.56	0.71	0.74	0.70	0.71	0.58	0.55	0.65	0.62	0.32	0.66	0.59				
6.10	0.62	0.61	0.75	0.78	0.72	0.77	0.67	0.57	0.72	0.60	0.30	0.60	0.63	0.72			
6.23	0.52	0.35	0.55	0.05	0.32	0.13	0.33	0.33	0.29	0.31	0.22	0.37	0.35	0.23	0.35		
6.26	0.63	0.60	0.71	0.65	0.70	0.64	0.51	0.57	0.66	0.69	0.34	0.67	0.56	0.73	0.77	0.14	

Note: 1) Locations of the rainfall stations are presented in Fig. B-1.

2) Correlation coefficients of monthly rainfall between Sibogat (6.28) and the other stations, between Bunut (6.06) and the other stations, and between Hessa (6.10) and the other stations are relatively higher than those of others.

Table B-5 REPRESENTATIVE MONTHLY RAINFALL FOR IRRIGATION PLAN (STATION; HESSA (6.10))

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Jan-Aug Total
1968	155	10	74	123	74	94	175	142	252	249	126	155	1,629	847
1969	76	80	84	7	184	144	103	146	269	229	284	124	1,730	824
1970	100	39	74	161	138	174	99	127	260	353	145	150	1,820	912
1971	193	89	105	63	63	154	105	197	184	243	94	271	1,761	969
1972	51	12	17	135	41	48	141	46	226	189	260	130	1,296	491
1973	175	43	118	128	100	87	85	145	194	183	109	304	1,671	881
1974	26	238	5	170	33	279	107	98	189	177	72	8	1,402	956
1975	97	16	125	109	184	164	130	239	246	206	93	67	1,676	1,064
1976	102	172	36	65	233	73	339	98	183	78	120	82	1,581	1,118
1977	53	211	33	94	74	133	102	181	234	447	331	204	2,097	881
1978	52	60	94	160	185	163	122	135	217	231	123	145	1,687	971
1979	49	73	53	118	93	171	246	56	225	80	248	43	1,455	859
1980	87	79	22	160	47	91	154	250	212	277	142	365	1,886	890
1981	72	153	80	162	118	111	159	154	308	283	182	45	1,827	1,009
1982	86	104	58	118	99	100	331	197	84	145	261	90	1,673	1,093
1983	90	2	94	7	255	106	76	118	126	121	95	147	1,237	748
1984	145	130	64	99	109	207	66	35	207	99	64	56	1,281	855
1985	43	102	178	86	140	16	165	125	211	225	271	122	1,684	855
1986	241	32	168	148	267	169	146	151	147	220	43	234	1,966	1,322
1987	111	30	92	113	81	56	69	357	352	310	266	192	2,029	909
Ave.	100.2	83.8	78.7	111.3	125.9	127.0	146.0	149.9	216.3	217.3	166.5	146.7	1,669.4	922.7

Note:
1) The values presented above include supplemented values for lacking data period.
2) Hessa rainfall station is selected as the representative station of the aerial rainfall of the project area. The selection criteria applied to are as fllows:
   - the station has long term (more than 20 years) record
   - the record is available in series
   - average annual and monthly rainfall is similar to that of stations in the area (See Table B-2 and Fig.B-2)
   - correlation coefficient between representative station and the other stations is relatively higher than that of others (See Table B-4)
3) According to the design standard of DGWRD, the design year is selected based on the rainfall having 80% dependability. As seen in Table B-14, the year of 1979 is selected as the design year for the irrigation plan based on the analysis of annual rainfall and total rainfall from January to August.

Table B-6 MAXIMUM PROBABLE RAINFALL OF 1-DAY, 2 CONTINUOUS DAYS AND 3 CONSECUTIVE DAYS WITH A 5 YEAR RETURN PERIOD

Code	Station Name	Maximum Probable Rainfall		
		1-day	2 Continuous days	3 Continuous days
5.04	Lidah Tanah	98 (112)	118 (149)	130 (164)
6.06	Bunut	103 (113)	117 (143)	144 (207)
147/6.10	Hessa	102 (130)	127 (165)	147 (207)
6.18	Sei Baleh	* 127 (200)	153 (253)	* 172 (277)
145B/6.19	Sei Dadap	114 (169)	129 (170)	150 (188)
6.22	Serbangan	111 (144)	135 (176)	160 (220)
** 145	Kisaran	190 (247)	227 (299)	237 (314)

Note: 1) Locations of the rainfall stations are presented in Fig. B-1.

2) ( ) indicates the maximum observation rainfall.

3) According to the following selection criteria, Sei Balah station is selected as the representative rainfall station for drainage plan.
- Long (more than 20 years) and series rainfall record is available
- Station which indicates the maximum probable rainfall of 1-day, 2 continuous days and 3 continuous days.

The exceedance probable rainfall of 7 stations is tablated in Table presented above. In accordance with the design standard DGWRD, the design rainfall is estimated based on 3 days continuous probable rainfall with a 5 year return period.
The estimated design rainfall is 172 mm for 3 days.

4) ** The rainfall record at Kisaran is short priod of 16 years.

Table B-7 EXCEEDANCE PROBABLE RAINFALL OF 1-DAY, 2 CONTINUOUS DAYS AND 3 CONSECUTIVE DAYS

Maximum 1 day Rainfall

Unit: mm

Return Period	Lidah Tanah 5.04	Bunut 6.06	Hessa 6.10	Sei Balch 6.18	Sei Dadap 6.19	Serbangan 6.22	Kisaran 145
1/2	82	85	76	84	90	87	125
1/5	98	103	102	127	114	111	190
1/10	109	114	119	155	129	128	233
1/20	119	125	135	183	144	143	-
1/30	125	132	145	198	153	152	-
1/50	132	140	157	218	163	164	-
1/100	142	150	173	244	178	179	-

Maximum 2 continuous days Rainfall

Unit: mm

Return Period	Lidah Tanah 5.04	Bunut 6.06	Hessa 6.10	Sei Baleh 6.18	Sei Dadap 6.19	Serbangan 6.22	Kisaran 145
1/2	93	99	96	106	103	107	153
1/5	118	117	127	153	129	135	227
1/10	134	130	148	185	146	154	275
1/20	150	141	169	215	162	172	-
1/30	159	148	180	233	171	182	-
1/50	170	157	195	254	183	195	-
1/100	186	168	214	284	198	212	-

Maximum 3 continuous days Rainfall

Unit: mm

Return Period	Lidah Tanah 5.04	Bunut 6.06	Hessa 6.10	Sei Baleh 6.18	Sei Dadap 6.19	Serbangan 6.22	Kisaran 145
1/2	102	113	111	121	119	127	154
1/5	130	144	147	172	150	160	247
1/10	149	165	171	205	171	182	309
1/20	167	185	194	237	191	203	-
1/30	178	196	207	256	202	215	-
1/50	191	211	223	279	216	230	-
1/100	208	230	245	310	236	251	-

Note: 1) Locations of the rainfall stations are presented in Fig. B-1.

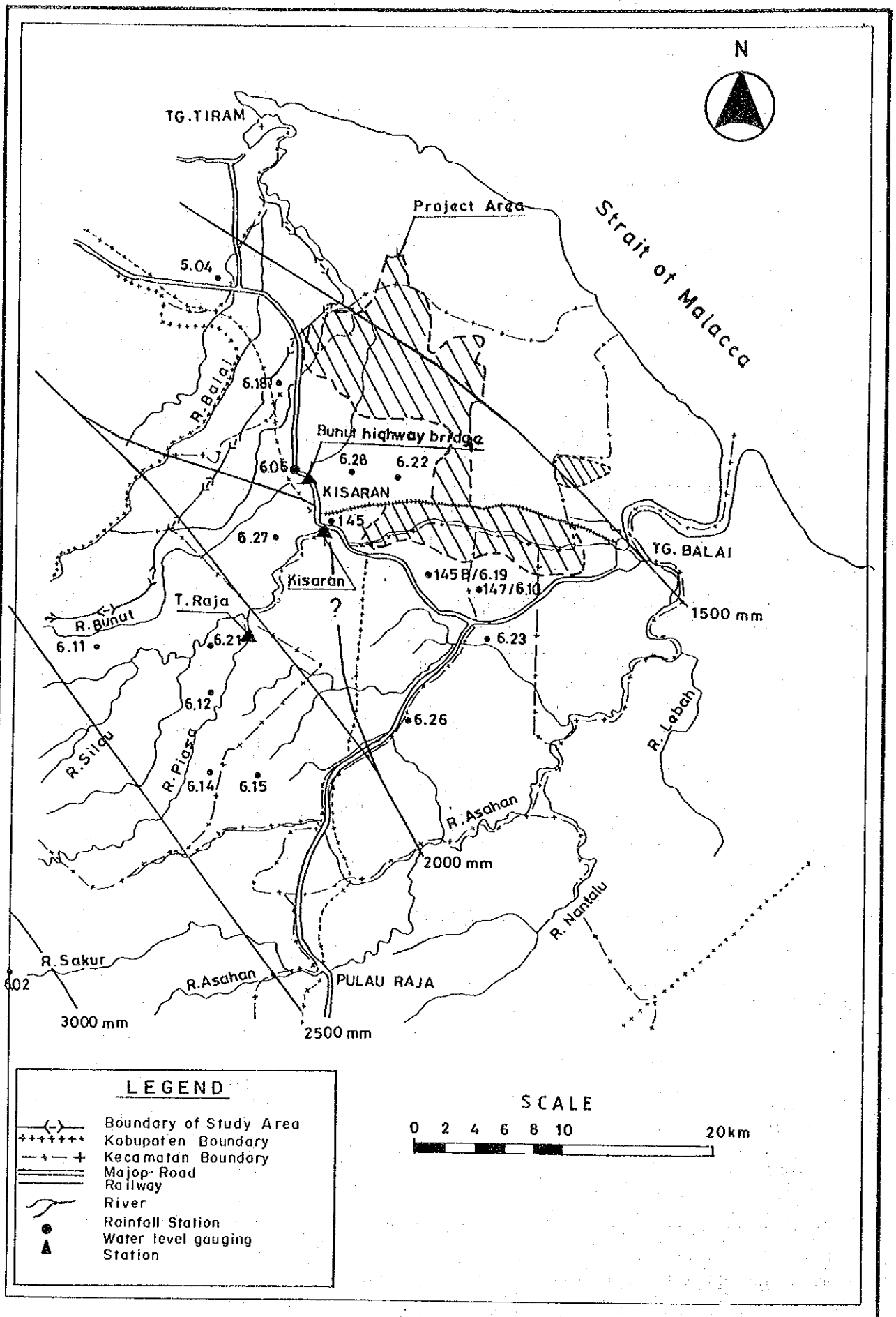

Fig. B-1 LOCATION OF RAINFALL AND WATER LEVEL GAUGING STATIONS

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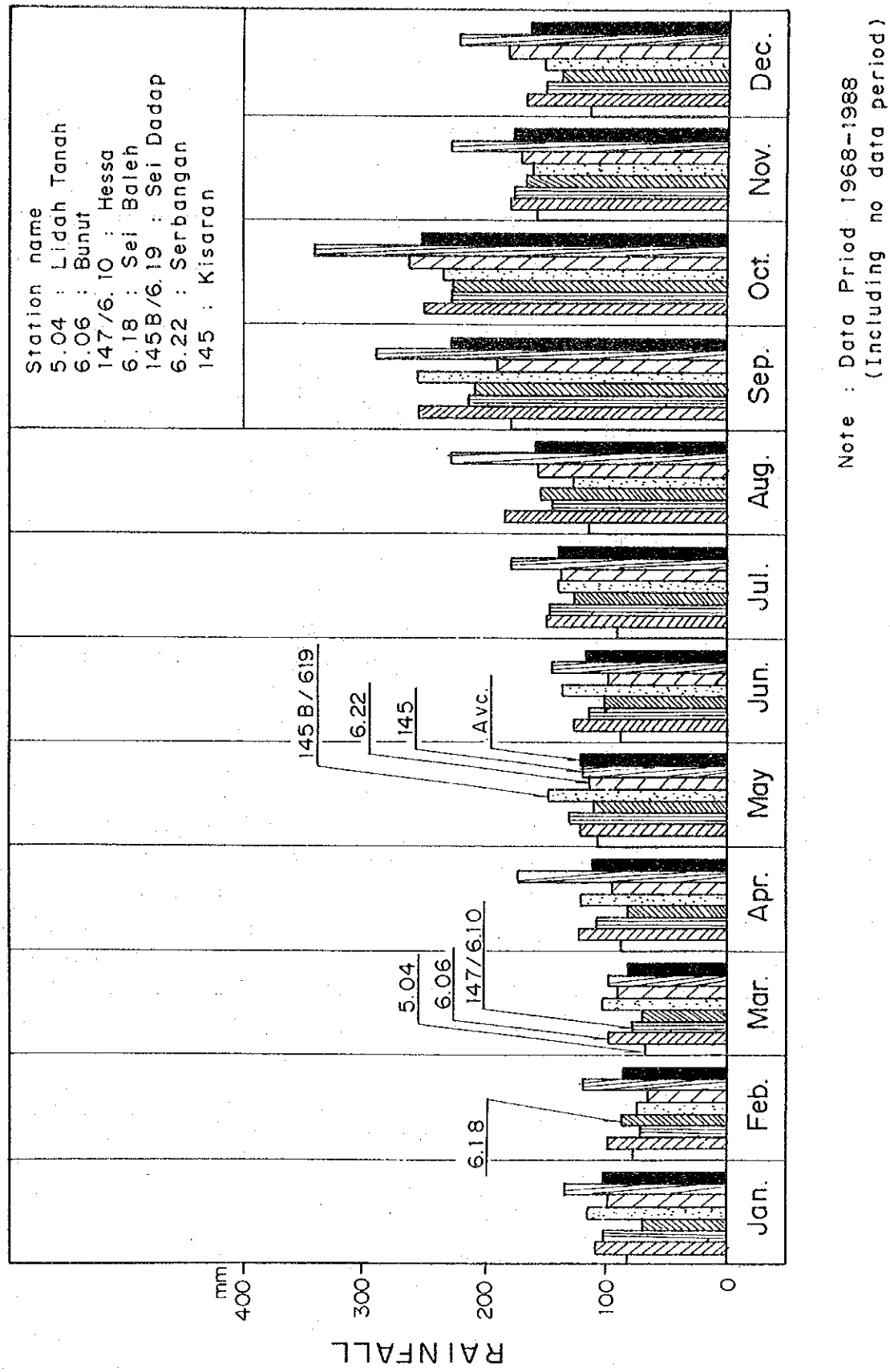

Fig. B - 2 MONTHLY AVERAGE RAINFALL IN AND AROUND PROJECT AREA

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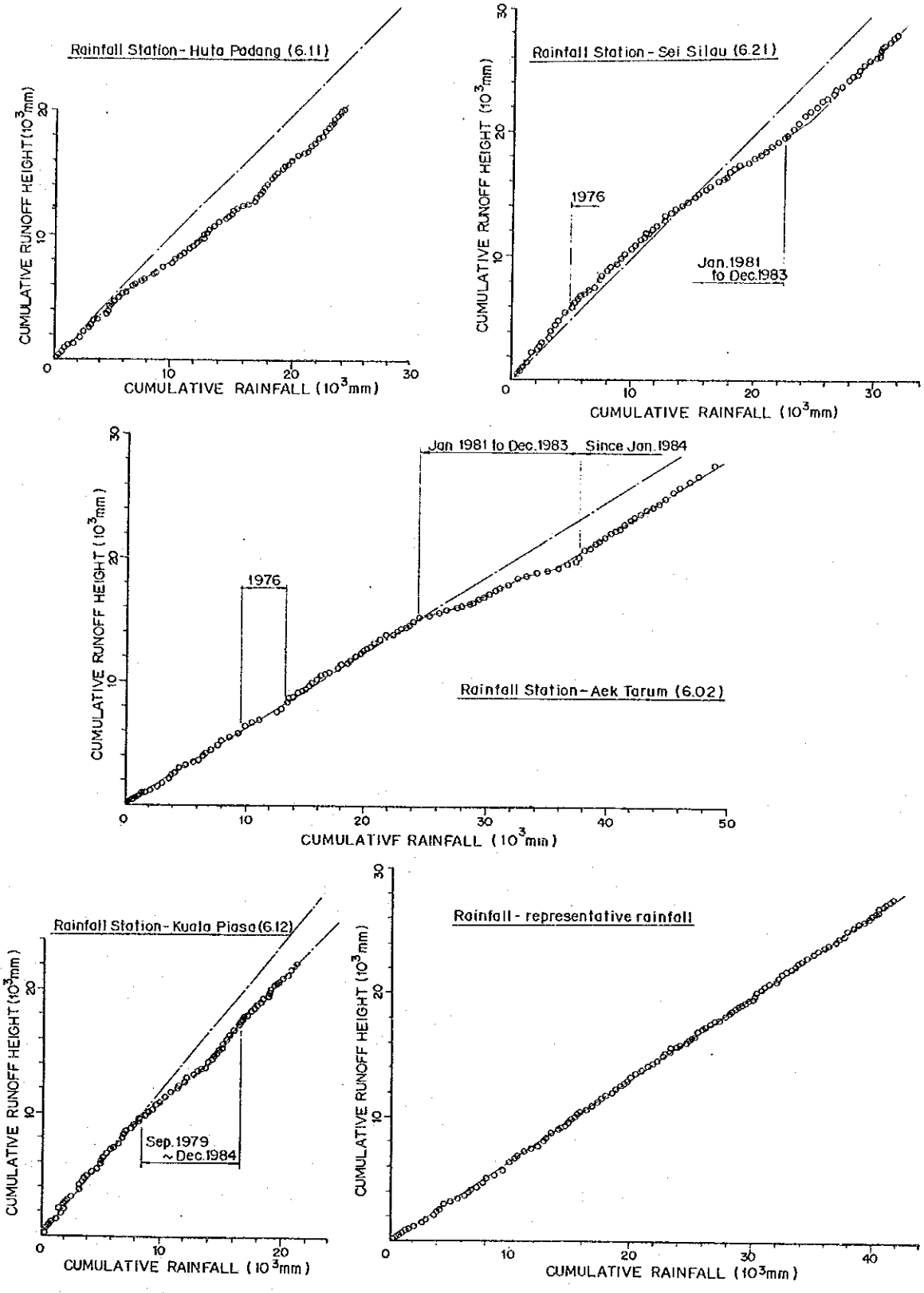
Table B-8 REPRESENTATIVE MONTHLY RAINFALL FOR LOW-FLOW ANALYSIS BY TANK MODEL METHOD

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1968	245	116	253	101	366	446	298	380	460	369	229	247	3,510
1969	219	140	85	122	250	122	184	209	289	383	600	384	2,987
1970	250	21	296	245	178	324	255	202	414	384	397	261	3,227
1971	86	374	319	42	207	207	54	300	288	172	100	328	2,477
1972	24	104	79	134	128	52	118	83	285	241	287	115	1,650
1973	142	223	296	325	147	310	267	337	411	283	325	652	3,718
1974	185	259	47	356	244	281	337	92	324	311	443	233	3,112
1975	212	112	240	293	196	177	392	177	342	361	352	98	2,952
1976	171	43	98	147	237	309	243	199	339	154	151	161	2,252
1977	110	67	111	116	299	108	137	225	288	290	201	294	2,246
1978	131	54	98	169	431	335	277	156	356	349	236	215	2,807
1979	117	157	71	340	205	251	104	28	195	293	311	158	2,230
1980	68	150	354	286	378	214	266	419	272	351	311	304	3,373
1981	111	188	67	292	361	235	151	157	513	257	228	115	2,675
1982	43	31	165	414	245	83	350	495	270	245	262	172	2,775
1983	125	32	212	16	164	207	115	224	314	329	283	141	2,162
1984	226	351	210	383	500	215	186	216	320	425	238	323	3,593
1985	293	136	220	229	297	67	341	228	242	400	572	278	3,303
1986	387	118	219	427	200	213	50	119	333	386	276	354	3,082
1987	90	38	131	300	122	102	283	294	336	482	561	151	2,890
Ave.	161.8	135.7	178.6	236.9	257.8	212.9	220.4	227.0	329.6	323.3	318.2	249.2	2,851.1

Note: The rainfalls at Aek Tarum were applied for the representative rainfalls before 1980 excluding 1976 and after 1984, and those at Sei Silau were applied for them in 1976 and from 1981 to 1983.



Note :

1) Locations of the rainfall stations are presented in Fig. B-1.

2) Sei Silau (6.21) and Aek Tarum (6.02) as the representative reinfall stations for low-flow analysis, were slected by double mass curve analysis presented above. The rainfalls at Aek Tarum were applied for the representative reinfalls before 1980 excluding 1976 and after 1984, and those at Sei Silau were applied for them in 1976 and from 1981 to 1983.

Fig. B-3 DOUBLE MASS CURVE BETWEEN RUNOFF HEIGHT AT KISARN AND RAINFALL AT THE RAINFALL STATIONS IN AND AROUND THE SILAU RIVER BASIN

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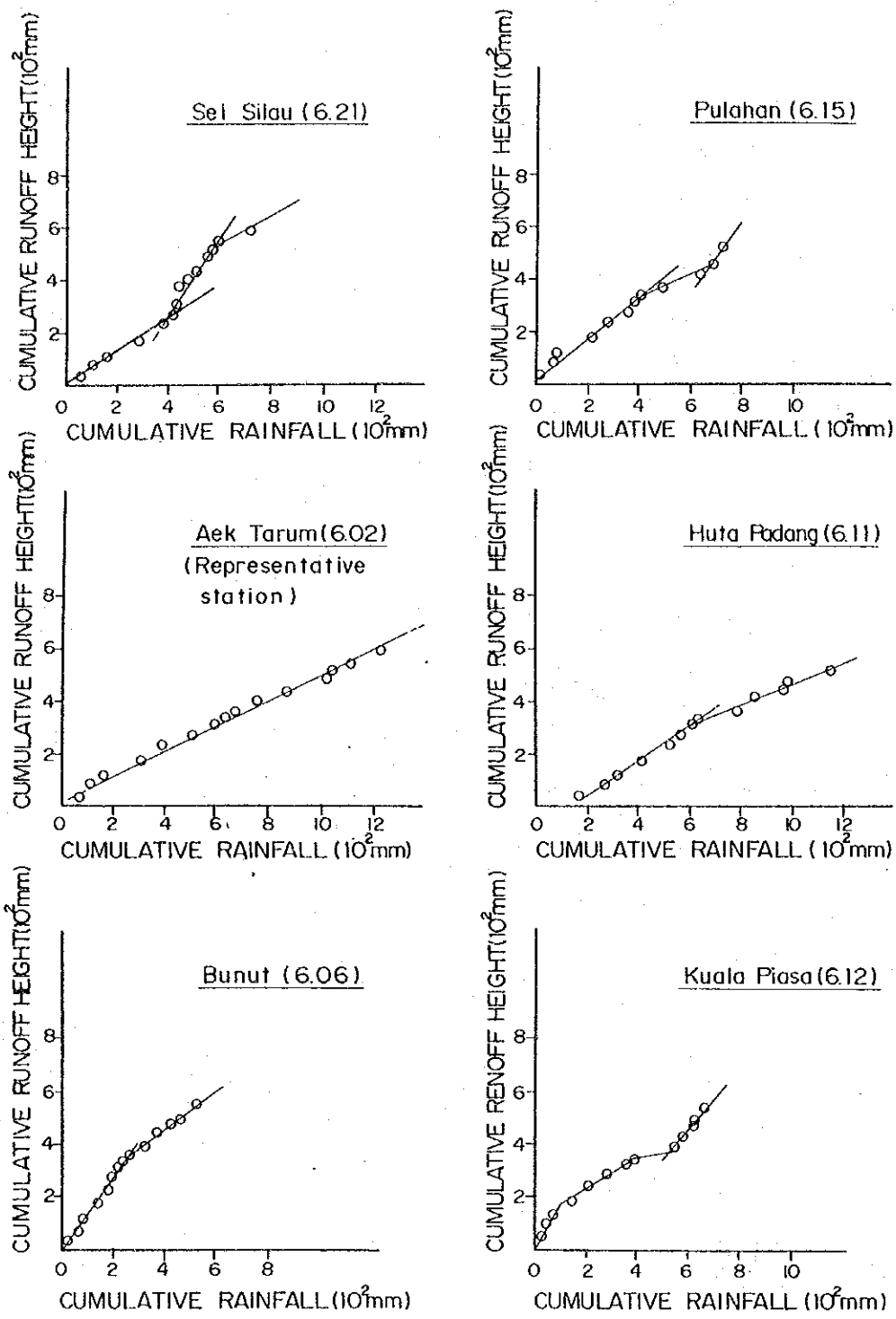

Note;

1) Locations of the rainfall stations are presented in Fig. B - 1
2) Aek Tarum (6.02) was selected as the representative rainfall station for low analysis of the Bunut river by double mass curve analysis therefore the representative rainfalls for low-flow analysis of the Silau river were applied to them for low-flow analysis of the Bunut river.

Fig. B-4 DOUBLE MASS CURVE BETWEEN RUNOFF HIGHT AT BUNUT HIGHWAY BRIDGE AND RAINFALL AT THE RAINFALL STATIONS IN AND AROUND THE BUNUT RIVER BASIN

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Table B-9 RESULTS OF LOW-FLOW RUNOFF ANALYSIS BY TANK MODEL METHOD AT KISARAN

Unit: m3/s

Year=1984	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	3,302.7	3,127.1	2,859.0	2,421.0	4,032.8	2,211.8	1,820.1	1,821.2	1,917.1	2,517.0	2,663.3	2,941.8	31,634.9
Calculated Runoff (2)	1,519.9	2,584.8	2,241.6	2,675.0	4,024.2	2,918.9	1,705.6	1,956.1	2,339.3	3,138.4	3,029.8	2,611.0	30,744.6
(2)/(1)	0.46	0.83	0.78	1.10	1.00	1.32	0.94	1.07	1.22	1.25	1.14	0.89	1.03
Year=1985	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	2,234.4	1,565.7	2,124.3	1,979.5	2,376.0	1,128.7	1,496.4	1,260.1	1,894.2	2,600.2	3,092.8	3,539.3	25,291.6
Calculated Runoff (2)	2,939.7	1,624.3	1,729.0	1,663.2	2,370.9	1,457.4	1,872.4	1,906.9	2,185.1	2,799.5	4,237.8	3,578.1	28,364.3
(2)/(1)	1.32	1.04	0.81	0.84	1.00	1.29	1.25	1.51	1.15	1.08	1.37	1.01	1.12
Year=1986	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	3,121.0	2,453.9	2,536.6	2,992.2	1,590.5	1,614.7	1,176.7	961.2	1,444.5	3,264.5	2,587.5	2,468.5	26,211.8
Calculated Runoff (2)	2,900.7	2,266.7	1,638.5	3,042.1	2,248.4	1,824.1	1,277.4	1,047.4	1,877.3	3,044.4	2,706.8	3,074.1	26,947.9
(2)/(1)	0.93	0.92	0.65	1.02	1.41	1.13	1.09	1.09	1.30	0.93	1.05	1.25	1.03
Year=1987	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	1,525.6	1,390.0	1,833.5	1,916.7	1,991.3	1,453.6	1,597.2	2,248.0	-	-	-	-	13,955.9
Calculated Runoff (2)	1,420.1	986.6	977.5	1,600.1	1,178.9	944.0	1,325.6	2,172.2	-	-	-	-	10,605.0
(2)/(1)	0.93	0.71	0.53	0.83	0.59	0.65	0.83	0.97	-	-	-	-	0.76

1.00

Table B-10 RESULTS OF LOW-FLOW RUNOFF ANALYSIS BY TANK MODEL METHOD AT PRAPAT JANJI

Unit: m3/s

Year=1985	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	-	-	-	-	-	-	827.0	671.4	993.6	1,213.7	1,483.4	1,849.7	7,038.8
Calculated Runoff (2)	-	-	-	-	-	-	847.1	850.3	1,011.7	1,348.6	2,202.6	1,762.2	8,022.5
(2)/(1)	-	-	-	-	-	-	1.02	1.27	1.02	1.11	1.48	0.95	1.14

Year=1986	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	1,666.5	1,274.2	1,466.9	1,531.1	898.9	840.6	-	-	867.9	1,760.9	1,434.7	1,225.3	12,967.0
Calculated Runoff (2)	1,434.6	1,181.4	883.9	1,519.9	1,109.5	938.1	-	-	880.1	1,496.3	1,394.9	1,613.4	12,452.1
(2)/(1)	0.86	0.93	0.60	0.99	1.23	1.12	-	-	1.01	0.85	0.97	1.32	0.96

Year=1987	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Observed Runoff (1)	863.7	895.8	879.8	1,011.1	1,063.8	858.8	951.4	1,206.7	-	-	-	-	7,731.1
Calculated Runoff (2)	855.0	695.8	628.9	810.7	689.5	619.1	672.0	1,006.9	-	-	-	-	5,977.9
(2)/(1)	0.99	0.78	0.71	0.80	0.65	0.72	0.71	0.83	-	-	-	-	1.29

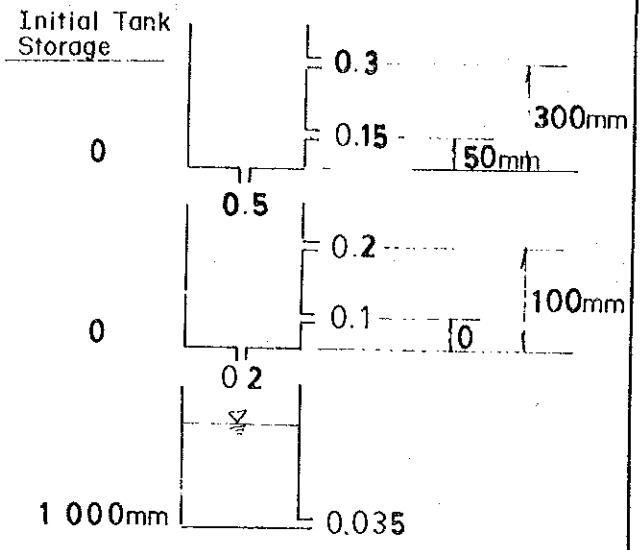
0.95

Kisaran (Silau river)

Catchment Area ; 1050 Km²

Rainfall Reduction Factor ; 1.0

Evaporation Reduction Factor ; 0.8

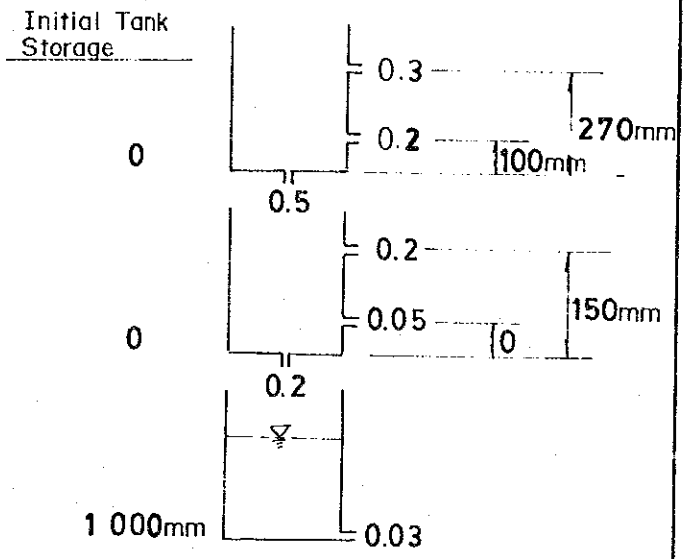


Prapat Janji (Silau river)

Catchment Area; 605 Km²

Rainfall Reduction Factor ; 0.95

Evaporation Reduction Factor ; 0.8



Bunut Highway Bridge (Bunut river)

Catchment Area ; 115 Km²

Rainfall Reduction Factor ; 0.8

Evaporation Reduction Factor ; 0.8

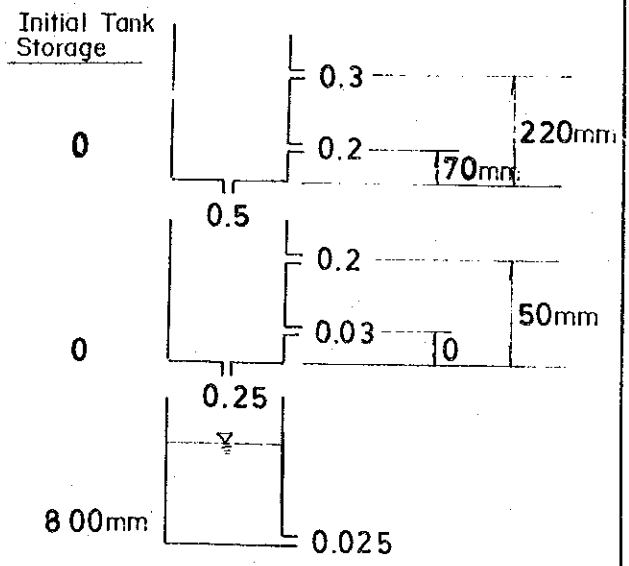


Fig. B-5 TANK MODEL DIMENSION

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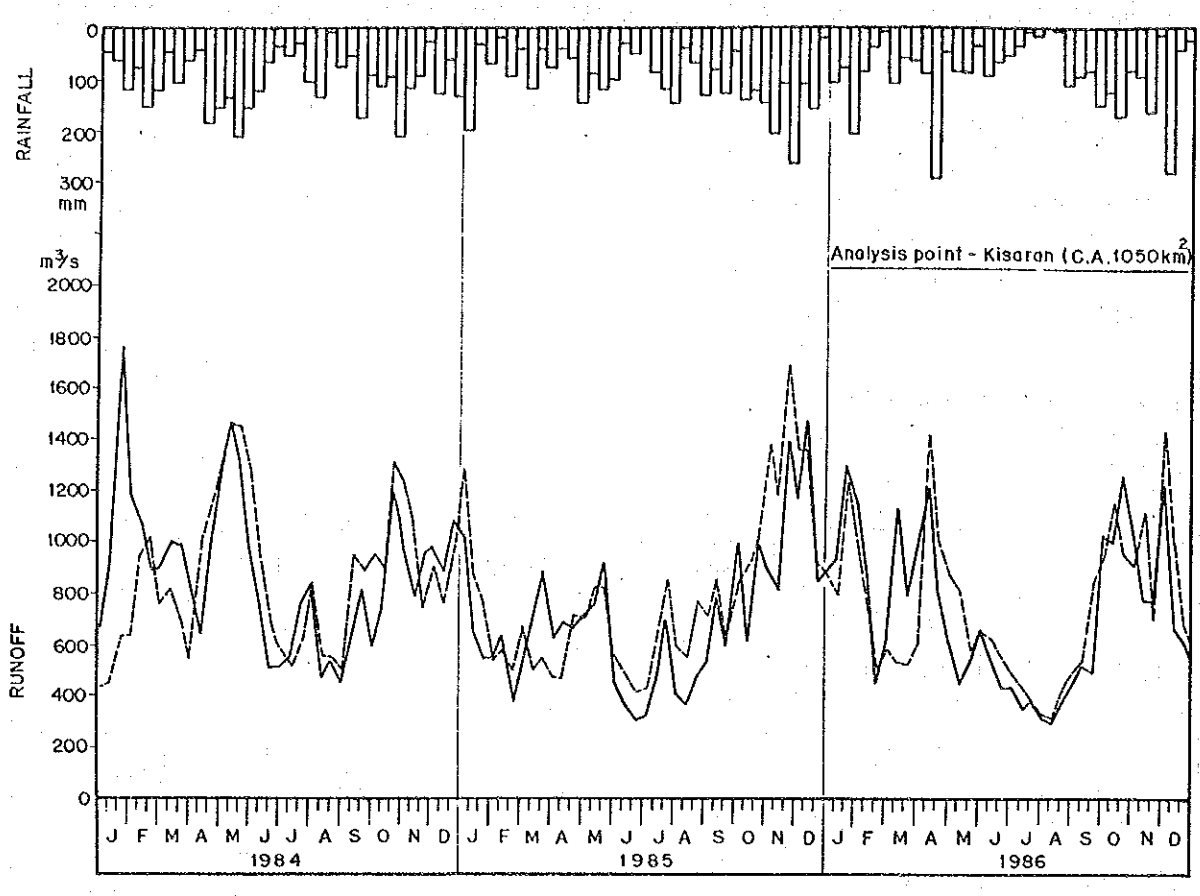

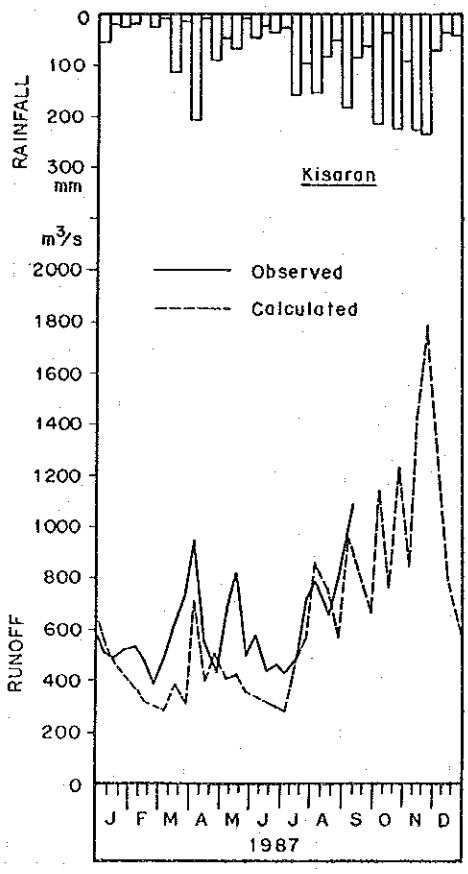

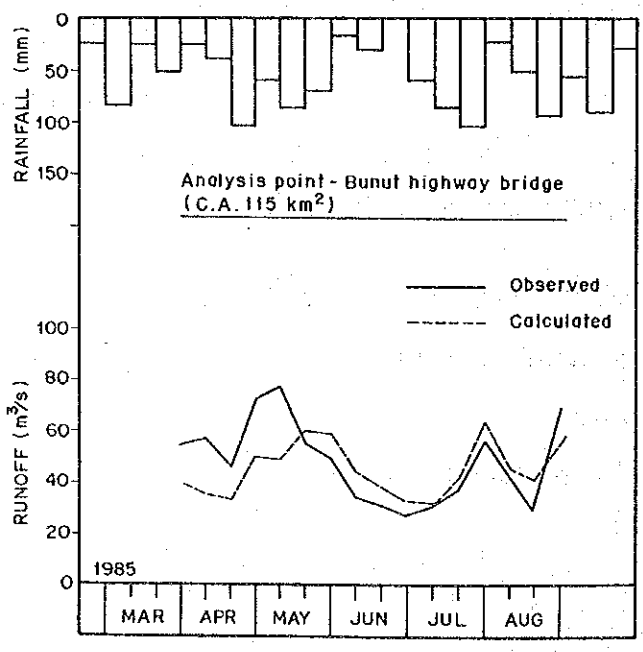

Note :
1) Runoff analysis was carried out by tank model method
2) Tank model dimension is presented in Fig. B-5.

Fig. B-6
LOW-FIOW RUNOFF SIMULATION
(1/2)

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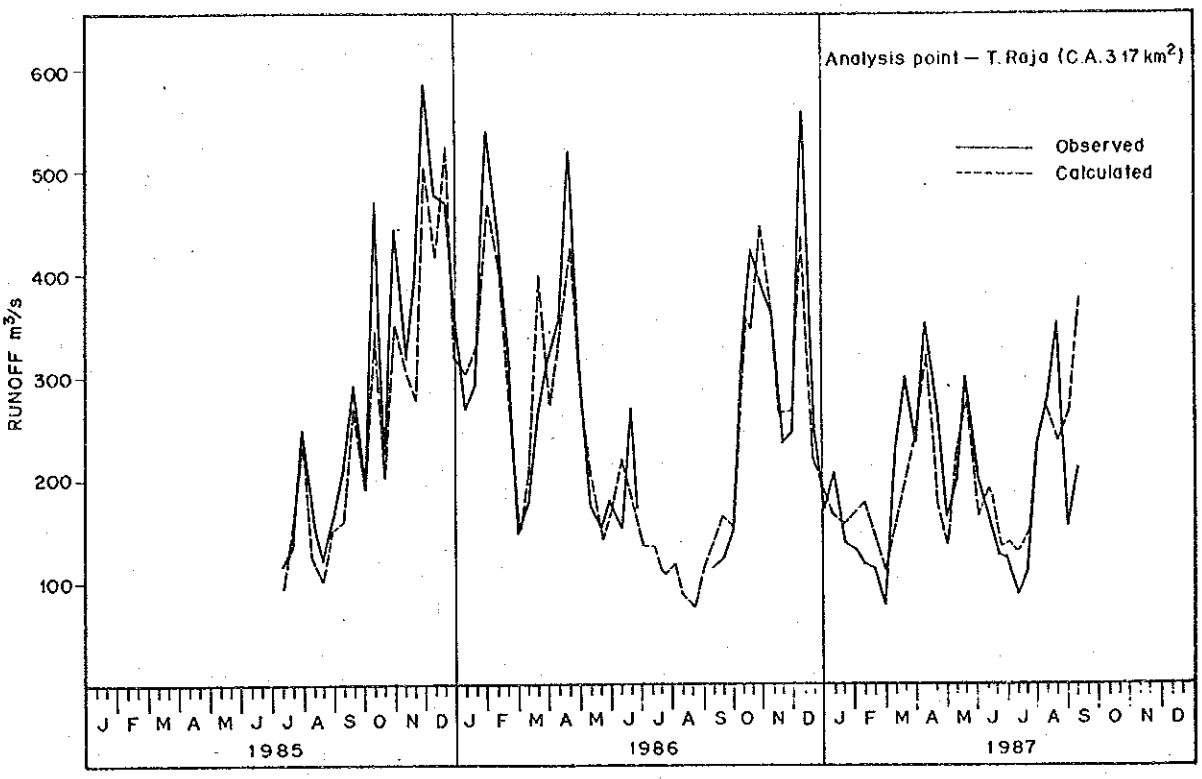
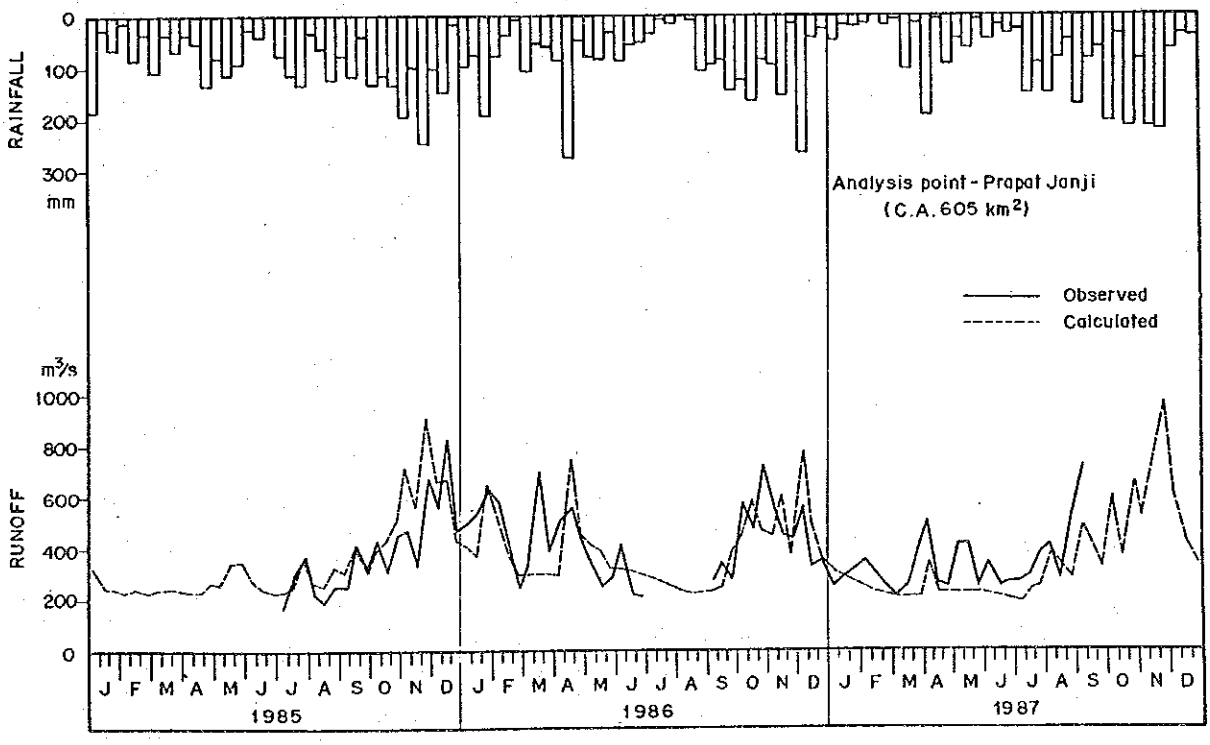


Note :

1) Runoff analysis was carried out by regression line formula made between the 10 day's discharges at Kisaran and those at T. Raja at the same period.
2) Regression line formula.
   Y = 0.38 X - 29.0 where, Y ; Estimated 10 days discharge at T. Raja (m^3/s) X ; Observed 10 day's Discharge at Kisaran (m^3/s)
3) Correlation coefficient 0.89



Note :

1) Runoff analysis was carried out by tank model method
2) Tank model dimension is presented in Fig. B-5.

Fig. B-7
LOW-FLOW RUNOFF SIMULATION
(2/2)

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Japan International Cooperation Agency

Table B-11 ESTIMATED MONTHLY AVERAGE DISCHARGE AT KISARAN

Unit: m3/s

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	52.1	54.7	51.5	55.6	66.1	109.4	100.3	85.5	143.0	98.8	91.1	72.3	81.6
1969	74.5	55.8	37.4	36.4	48.1	39.6	44.3	45.3	59.2	83.4	165.7	123.3	67.8
1970	82.8	44.7	50.1	64.4	48.3	65.0	64.7	64.9	96.2	98.4	118.0	82.9	73.5
1971	55.3	73.5	93.4	47.0	42.7	53.0	36.1	49.5	73.5	48.0	36.9	63.4	55.9
1972	37.5	31.8	24.6	22.7	23.1	20.7	16.8	17.3	36.2	41.4	56.9	39.1	30.6
1973	59.4	45.2	62.3	84.7	58.2	67.2	39.1	56.9	76.5	81.8	70.3	189.8	74.5
1974	81.5	83.5	59.6	64.6	58.3	55.0	52.7	49.0	60.6	68.9	84.6	75.9	66.1
1975	73.3	66.2	62.3	99.0	82.9	55.9	53.1	43.5	82.3	83.1	93.4	87.7	73.5
1976	82.9	67.0	51.5	77.9	63.4	61.2	58.3	58.1	57.9	77.0	100.9	82.9	69.9
1977	60.5	51.2	44.7	45.3	48.8	48.3	32.5	41.5	54.3	120.6	93.5	80.8	60.2
1978	49.2	53.0	44.7	44.0	49.4	58.3	48.2	29.9	48.1	63.3	62.8	69.2	51.7
1979	51.6	43.7	37.6	60.4	44.0	59.2	41.8	33.4	51.9	61.1	95.3	65.2	53.7
1980	51.1	44.0	74.0	49.4	70.0	42.2	34.8	73.8	52.3	61.4	91.8	67.1	59.4
1981	71.5	58.3	40.6	50.5	84.3	46.4	45.3	32.0	78.0	80.7	72.6	47.6	59.0
1982	48.1	58.2	68.4	90.6	96.8	45.1	43.1	47.5	54.1	65.2	61.2	54.9	61.1
1983	45.1	34.7	38.7	27.0	44.9	40.6	45.8	42.3	73.0	87.4	48.8	82.0	51.0
1984	106.5	107.8	92.2	80.7	130.1	73.7	58.7	58.7	63.9	81.2	88.8	94.9	86.4
1985	72.1	55.9	68.5	66.0	76.6	37.6	48.3	40.6	63.4	83.9	103.1	114.2	69.3
1986	100.7	87.6	81.8	99.7	51.3	53.8	38.0	31.0	48.2	105.3	86.3	79.6	71.8
1987	49.2	49.6	59.1	63.9	64.2	48.5	51.5	72.5	85.5	107.3	91.1	85.9	69.2
1988	77.2	95.2	80.3	55.3	62.1	72.5	70.4	62.1	121.2	70.8	99.1	91.6	79.6
Total	1,304.9	1,166.5	1,143.2	1,229.7	1,251.8	1,080.9	953.5	973.3	1,357.9	1,598.3	1,713.2	1,658.6	1,286.2
Ave.	62.1	55.5	54.4	58.6	59.6	51.5	45.4	46.3	64.7	76.1	81.6	79.0	61.2

Note: Monthly average discharges from 1973 to 1987 presented above are the observed records.

Table B-12 ESTIMATED MONTHLY AVERAVE DISCHARGE AT TINGGI RAJA

Unit: m3/s

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	17.0	17.8	16.8	18.2	22.3	38.7	35.3	29.7	51.4	34.7	31.7	24.7	28.2
1969	25.5	18.1	11.4	10.9	15.5	12.2	14.0	14.4	19.6	28.9	60.1	44.0	22.9
1970	28.7	13.9	16.2	21.6	15.6	21.8	21.8	21.9	33.7	34.6	41.9	28.7	25.1
1971	18.2	24.8	32.7	15.0	13.4	17.2	10.9	16.0	25.0	15.4	11.1	21.3	18.4
1972	11.5	9.1	6.5	5.7	6.0	5.0	3.6	3.8	10.8	12.9	18.7	12.1	8.8
1973	19.8	14.1	20.9	29.3	19.3	22.6	12.0	18.8	26.2	28.3	23.8	69.3	25.5
1974	28.2	28.6	19.8	21.7	19.3	18.0	17.2	15.8	20.1	23.4	29.2	26.0	22.2
1975	25.1	22.0	20.9	34.7	28.7	18.3	17.4	13.7	28.4	28.8	32.6	30.5	25.1
1976	28.7	22.5	16.8	26.7	21.3	20.4	19.3	19.3	19.1	26.4	35.5	28.7	23.7
1977	20.2	16.4	14.2	14.3	15.7	15.5	9.5	13.0	17.7	43.0	32.6	27.9	20.0
1978	15.9	17.0	14.2	13.8	16.0	19.3	15.5	8.5	15.4	21.3	21.0	23.5	16.8
1979	16.8	13.5	11.5	20.1	13.9	19.6	13.1	9.9	16.8	20.4	33.3	22.0	17.5
1980	16.6	13.7	25.3	15.9	23.8	13.2	10.4	25.2	17.0	20.5	32.0	22.7	19.7
1981	24.3	19.0	12.6	16.3	29.2	14.7	14.4	9.4	26.7	27.9	24.7	15.3	19.5
1982	15.5	19.0	23.2	31.5	34.0	14.2	13.6	15.2	17.6	22.0	20.4	18.1	20.4
1983	14.3	10.1	11.9	7.4	14.3	12.5	14.6	13.3	24.9	30.4	15.6	28.4	16.5
1984	37.7	38.0	32.2	27.8	46.6	25.1	19.5	19.5	21.4	28.0	30.8	33.3	30.0
1985	24.6	18.1	23.2	22.2	26.3	11.4	15.9	14.4	23.3	36.4	43.2	41.8	25.1
1986	35.5	32.5	24.5	37.9	16.2	19.9	11.6	9.0	13.1	36.5	28.3	31.7	24.6
1987	15.4	10.9	24.7	24.0	22.6	13.8	14.3	25.3	23.9	41.7	33.5	29.8	23.4
1988	27.0	35.1	28.5	16.1	19.7	24.4	23.7	20.0	39.5	19.5	30.2	34.0	26.4
Total	439.4	379.1	379.5	414.8	420.0	353.3	304.1	316.0	452.1	561.5	600.0	579.7	433.5
Ave.	20.9	18.1	18.1	19.8	20.0	16.8	14.5	15.0	21.5	26.7	28.6	27.6	20.6

Table B-13 ESTIMATED MONTHLY AVERAGE DISCHARGE AT PRAPAT JANJI

Unit: m3/s

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	29.0	30.5	28.7	30.8	36.1	58.3	53.6	46.0	75.5	52.8	49.0	39.3	44.1
1969	40.4	31.1	21.4	21.0	26.9	22.7	25.0	25.5	32.7	45.0	87.2	65.4	37.0
1970	44.7	25.4	28.0	35.4	27.0	35.6	35.4	35.5	51.6	52.7	62.8	44.7	39.9
1971	30.6	40.1	50.1	26.4	24.2	29.5	20.8	27.6	40.0	26.8	21.3	34.7	31.0
1972	21.5	18.7	14.9	14.0	14.1	13.0	10.9	11.1	20.9	23.5	31.5	22.3	18.0
1973	32.7	25.7	34.2	45.7	32.1	36.8	22.3	31.4	41.5	44.2	38.4	99.4	40.5
1974	44.0	45.3	32.8	35.5	32.1	30.5	29.3	27.4	33.4	37.6	45.7	41.1	36.1
1975	39.8	36.4	34.2	53.0	44.7	31.0	29.5	24.6	44.5	44.8	50.2	47.2	40.0
1976	44.7	36.8	28.7	42.2	34.8	33.7	32.1	32.0	32.0	41.7	54.0	44.7	38.1
1977	33.3	28.8	25.2	25.6	27.3	27.1	18.9	23.6	30.2	64.0	50.2	43.6	33.2
1978	27.5	29.7	25.2	24.9	27.6	32.2	27.0	17.6	27.0	34.7	34.5	37.7	28.8
1979	28.7	24.9	21.5	33.3	24.8	32.7	23.7	19.4	28.9	33.6	51.1	35.6	29.8
1980	28.4	25.0	40.2	27.7	38.1	24.0	20.1	40.1	29.1	33.7	49.3	36.6	32.7
1981	38.9	32.4	23.1	28.2	45.4	26.1	25.5	18.7	42.3	43.6	39.5	26.7	32.5
1982	26.9	32.3	37.3	48.7	51.8	25.5	24.4	26.6	30.0	35.7	33.7	30.4	33.6
1983	25.4	20.3	22.1	16.2	25.3	23.2	25.8	24.0	39.8	47.0	27.3	44.3	28.5
1984	56.8	57.6	49.5	43.7	68.9	40.1	32.3	32.4	35.1	43.8	47.8	50.9	46.6
1985	39.2	31.2	37.4	36.1	41.5	21.6	26.7	21.7	33.1	39.1	49.4	59.7	36.5
1986	53.8	45.5	47.3	51.0	29.0	28.0	21.7	18.2	28.9	56.8	47.8	39.5	38.9
1987	27.9	32.0	28.4	32.9	34.3	28.6	30.7	38.9	50.8	54.2	47.6	46.3	37.7
1988	41.4	49.6	42.7	32.4	35.0	39.7	38.5	34.7	67.4	42.3	56.8	47.5	43.9
Total	714.1	649.6	630.0	672.3	686.2	600.3	535.7	542.2	747.3	855.4	918.4	890.1	703.5
Ave.	34.0	30.9	30.0	32.0	32.7	28.6	25.5	25.8	35.6	40.7	43.7	42.4	33.5

Table B-14 ESTIMATED MONTHLY AVERAGE DISCHARGE AT BUNUT HIGHWAY BRIDGE

Unit: m3/s

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	3.1	3.2	3.3	3.4	4.3	7.7	6.7	6.0	10.5	7.0	6.4	5.2	5.6
1969	5.7	4.1	3.0	2.9	3.4	2.9	3.2	3.3	4.1	6.2	13.0	9.1	5.1
1970	6.3	3.6	3.9	4.6	3.8	4.9	5.0	4.6	7.3	7.4	9.0	6.3	5.6
1971	4.3	5.7	7.0	3.8	3.2	4.3	2.9	3.7	5.6	3.7	2.9	4.9	4.3
1972	3.0	2.7	2.2	2.1	1.9	1.8	1.5	1.4	2.4	2.6	4.2	2.8	2.4
1973	1.9	2.5	3.7	5.3	3.1	5.5	3.9	4.8	8.2	5.1	5.9	12.1	5.2
1974	6.5	5.6	3.5	4.5	5.7	4.8	6.5	3.8	4.5	6.0	8.6	6.1	5.5
1975	6.0	3.9	3.6	6.0	4.3	4.1	5.6	4.4	6.1	6.8	7.9	4.3	5.2
1976	4.2	3.5	2.8	2.8	5.1	7.1	6.1	5.4	7.4	5.7	4.3	4.1	4.9
1977	3.7	3.3	2.6	2.5	4.2	3.6	2.8	2.7	4.6	6.7	4.2	5.9	3.9
1978	3.1	2.8	2.3	2.1	3.5	5.5	3.6	2.7	3.2	5.2	3.6	3.2	3.4
1979	2.9	2.5	2.1	3.4	3.3	4.5	2.4	2.0	2.0	3.6	5.0	3.9	3.1
1980	2.1	2.0	3.2	2.9	5.6	3.3	2.4	4.5	3.9	4.2	5.8	3.8	3.6
1981	2.9	3.1	2.4	4.0	5.5	4.4	2.9	2.5	9.3	4.8	5.2	3.4	4.2
1982	2.5	2.4	1.9	4.5	4.9	2.8	3.9	8.4	6.2	4.0	5.3	3.9	4.2
1983	2.9	2.8	2.5	2.2	1.9	2.2	2.2	2.1	4.8	5.0	4.8	3.6	3.1
1984	2.8	5.8	4.5	6.1	9.3	6.6	3.7	4.4	5.4	7.3	7.3	6.0	5.8
1985	6.9	4.4	4.0	4.0	5.4	3.8	4.4	4.5	5.3	6.8	11.3	8.6	5.8
1986	7.1	6.2	4.1	7.8	5.4	4.6	3.4	2.9	4.9	7.6	7.0	7.8	5.7
1987	3.7	3.2	2.6	4.3	3.0	2.6	3.2	5.2	6.0	7.8	11.2	6.3	4.9
Total	81.7	73.3	65.3	79.2	86.8	87.0	76.3	79.4	111.6	113.5	132.9	111.0	91.5
Ave.	4.1	3.7	3.3	4.0	4.3	4.4	3.8	4.0	5.6	5.7	6.6	5.6	4.6

Table B-15 SELECTION OF BASIC YEAR

Year	Bunut R. Annual total Discharge (m3/s)	Bunut R. Drought Discharge (m3/s)	Bunut R. Jan-Aug total Discharge (m3/s)	Silau R. Annual total Discharge (m3/s)	Silau R. Drought Discharge (m3/s)	Silau R. Jan-Aug total Discharge (m3/s)	Representative Rainfall Annual total Rainfall (mm)	Representative Rainfall Jan-Aug total rainfall (mm)
1968	2034.2	2.51 (Mar)	1152.0	29883.8	41 (Mar)	17558.2	1629 7	847 4
1969	1849.8	2.67 (Jul)	862.0 9	24733.9	35.3 (Mar)	11579.3 6	1730	824 3
1970	2031.2	2.97 (Mar)	1119.3	26818.7	33.3 (Mar)	14780.3	1820	912
1971	1580.3 9	2.61 (Jul)	1057.6	20408.6 5	29.6 (Jul) 8	13645.5 9	1761	969
1972	874.7 1	1.27 (Aug) 1	508.0 1	11210.4 1	15.4 (Aug) 1	5919.4 1	1296 3	491 1
1973	1890.6	1.78 (Jan) 3	934.1 10	27200.8	32.6 (Jul)	14373.6	1671 8	881 8
1974	2009.9	2.84 (Mar)	1240.3	24108.4 10	39.2 (Aug)	15263.5	1402 4	956
1975	1912.3	3.07 (Mar)	1150.3	26834.4	40.1 (Jun)	16267.1	1676 10	1064
1976	1784.9 10	2.59 (Mar)	1130.6	25576.7	37.5 (Aug)	15857.5	1581 6	1118
1977	1425.0 6	2.29 (Jul) 9	769.5 4	21986.7 8	26.4 (Jul) 4	11311.9 4	2097	881 8
1978	1243.6 4	2.04 (Mar) 7	778.1 5	18854.2 3	27.2 (Aug) 5	11415.9 5	1687	971
1979	1141.6 3	1.74 (Aug) 2	700.8 3	19604.0 4	27.9 (Aug) 7	11274.2 3	1455 5	859 7
1980	1334.7 5	1.88 (Jan) 6	793.7 6	21745.0 7	30.6 (Jul) 10	13440.2 8	1886	890 10
1981	1531.7 7	2.15 (Mar) 8	846.6 8	21521.0 6	25.9 (Aug) 3	13024.3 7	1827	1009
1982	1548.9 8	1.84 (Mar) 4	959.8	22300.1 9	34 (Jan)	15118.9	1673 9	1093
1983	1125.4 2	1.85 (Jul) 5	571.8 2	18627.8 2	24.1 (Apr) 2	9723.3 2	1237 1	748 2
1984	2106.0	2.69 (Jan)	1313.5	31634.9	45.1 (Sep)	21595.7	1281 2	855 5
1985	2117.1	3.20 (Jul)	1143.7	25300.6	30.4 (Jun) 9	14165.1	1684	855 5
1986	2090.3	2.74 (Aug)	1259.2	26211.8	27.8 (Aug) 6	16446.8	1960	1322
1987	1797.4	2.37 (Jul) 10	844.2 7	25244.0	42 (Jul)	13955.9 10	2029	909
1988				29150.9	46.1 (Apr)	17507.6		
Total	33429.6	47.10	19135.1	498956.7	691.5	294224.2		
Ave.	1671.5	2.36	956.8	23759.8	32.9	14010.7	1669.4	922.7
Return Period								
1/2	1708	2.38	969	24321	33.2	14142	1680	927
1/5	1377	1.93	767	20322	26.5	11306	1469	786
1/10	1182	1.68	657	17873	23	9785	1356	711
1/20	1011	1.48	565	15661	20.2	8546	1263	652
1/30	919	1.37	519	14447	18.8	7918	1216	622
1/50	811	1.25	465	12987	17.2	7209	1162	589
1/100	675	1.11	402	11113	15.3	6374	1099	550

Note: 1) Probable calculation was carried out by Gumbel Method.

2) Drought discharges were estimated based on the minimum 10-day's discharge in every year.

3) According to the irrigation design standard of DGWRD, the basic drought year with once in five years probability is selected as basic year for water resource based on the estimated discharges.
The selection is made by paying attention not only the minimum drought discharge but to the total discharge from January to August. It is considered that the critical run-off for the irrigation development occurs during rather drought season in the above duration.
As seen in Table B-15 ,the year of 1977 is selected as the basic year for the study.

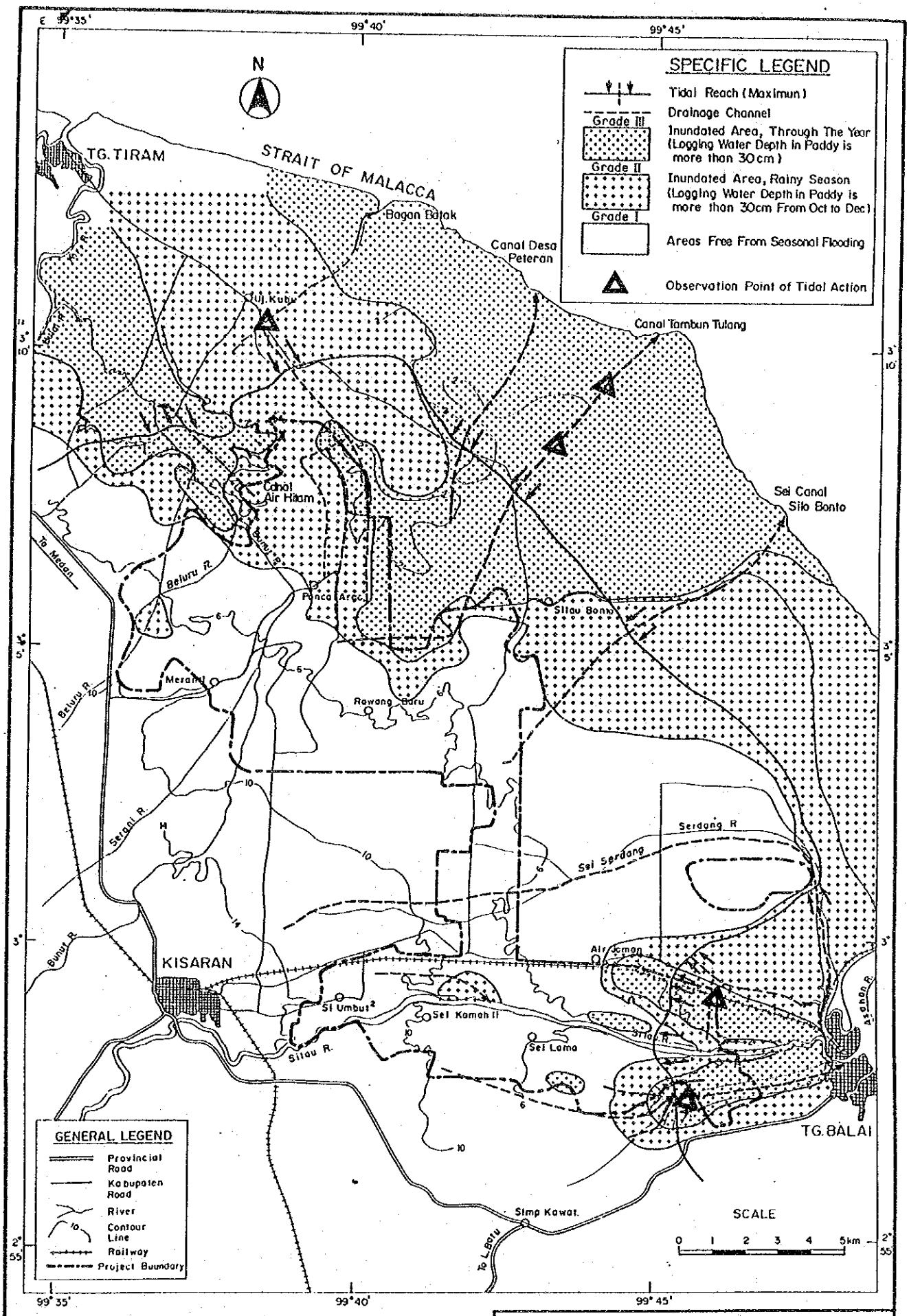

Fig. B-8 OBSERVATION POINT OF TIDAL ACTION

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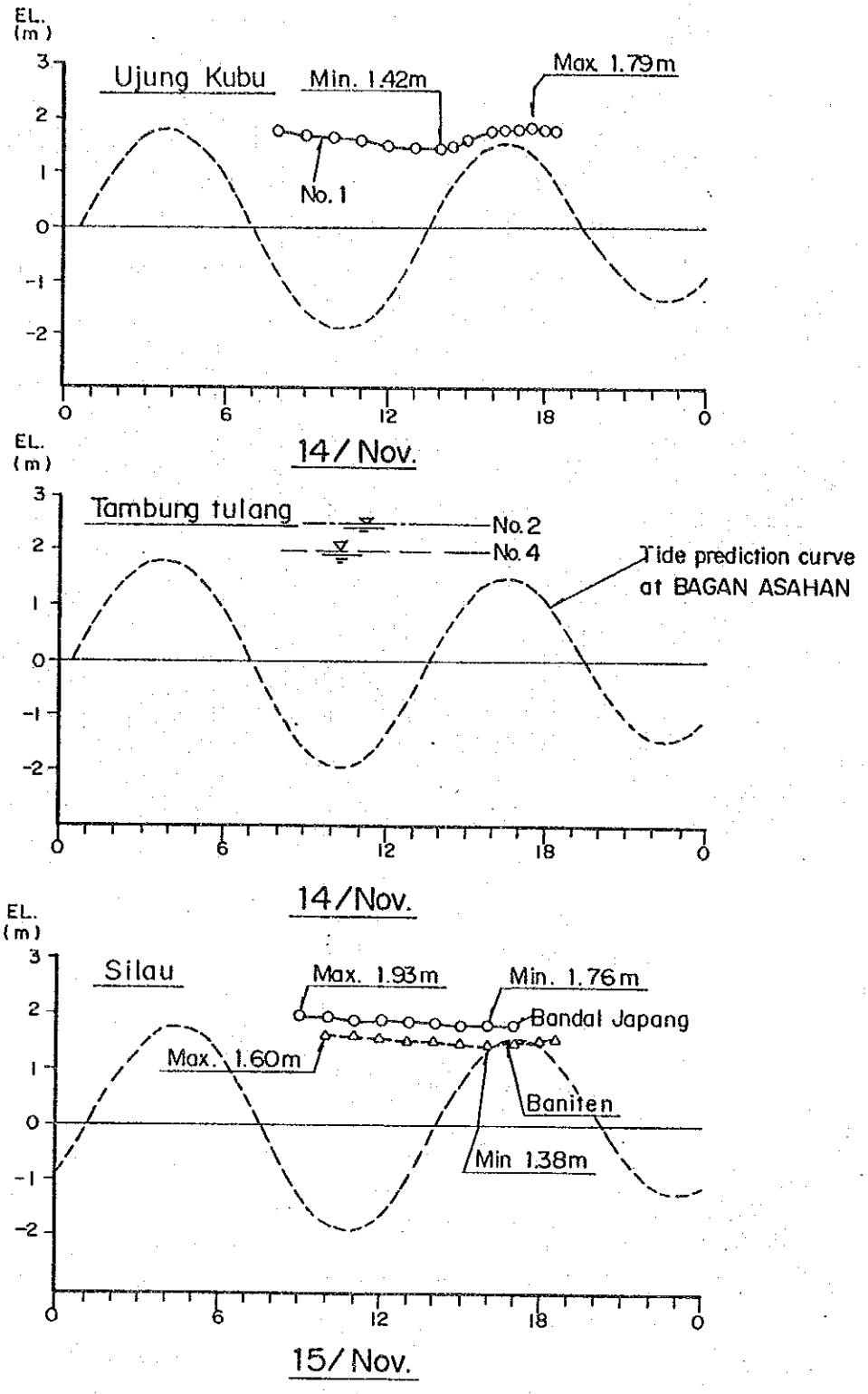

Note:

1) Observation points are presented in Fig. B - 8
2) No. means station No. in Fig. B - 10
3) Source of tide prediction curve at Bagan Asahan is Daftar Pasang Surut (Tide Tables) Tahun 1989 TNI-AL Dinas Hidro-Oseanografi

Fig. B - 9 OBSERVATION RESULTS OF TIDAL VARIATION

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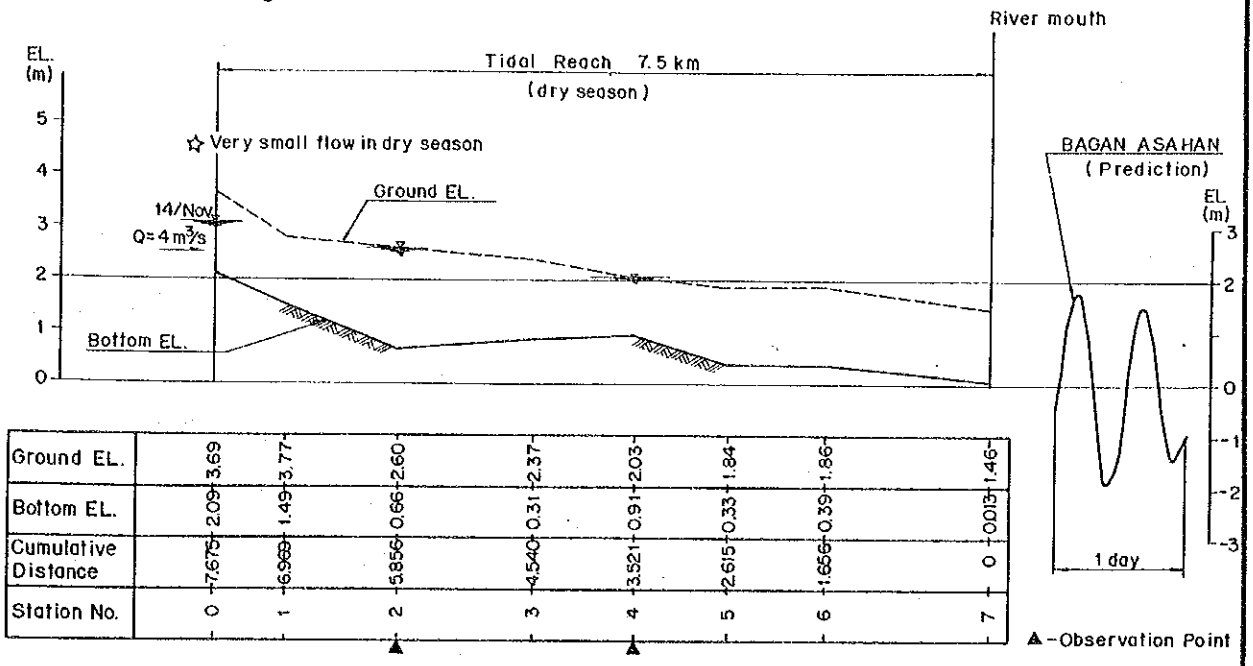
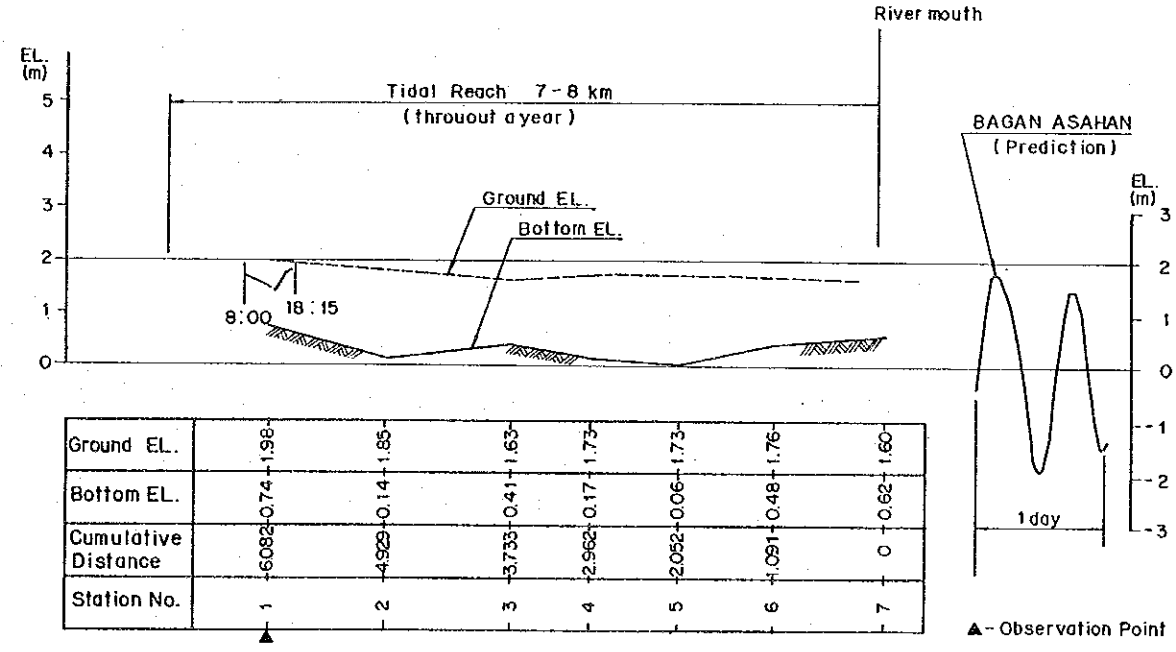
Tambung Tulang



Ground EL.	3.69	3.77	2.60	2.37	2.03	1.84	1.86	1.46
Bottom EL.	2.09	1.49	0.66	0.31	0.91	0.33	0.39	0.013
Cumulative Distance	7.675	6.969	5.856	4.540	3.521	2.615	1.656	0
Station No.	0	1	2	3	4	5	6	7

▲-Observation Point

Ujung kubu



Ground EL.	1.98	1.85	1.63	1.73	1.73	1.76	1.60
Bottom EL.	0.74	0.14	0.41	0.17	0.06	0.48	0.62
Cumulative Distance	6.082	4.929	3.733	2.962	2.052	1.091	0
Station No.	1	2	3	4	5	6	7

▲- Observation Point

Note :

1) Observation points are presented in Fig. B-8.
2) The tidal action reaches 6-8 km upstream from sea.
3) Tidal reach retreats to downstream in wet season due to much more discharge than that in dry season.

Fig. B-10

TIDAL INFLUENCE IN THE UJUNG KUBU AND TAMBUNG TULANG DRAINAGE CANAL

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Appendix 4-C

Irrigation and Drainage

Appendix 4-C
IRRIGATION AND DRAINAGE

CONTENTS

2 Irrigation and Drainage Development Plan

2.1 Irrigation and Drainage Plan

2.2 Flood Protection Plan

2.3 Operation and Maintenance Plan

3. Proposed Project Works

3.1 Water Resource Facilities

4. Cost Estimate

Tabel C-1 INVENTORY OF IRRIGATION CANALS AND RELATED STRUCTURES

	Irrigation Scheme	Nos. of canal	Canal length (m)/Condition					Related Structures (nos.)										
			A	B	C	D	Total	DW	IT	TO	CK	CV	AQ	SP	DP	BR	SW	MD	Total
I.	Silau River System																		
	1 Si Umbut-umbut	1	490	7,200	1,100	0	8,790	0	1	9	0	5	0	1	0	8	0	0	24
	2 Binjai Serbangan	1	0	150	4,650	0	4,800	0	0	1	0	1	0	2	0	1	0	0	5
	3 Tasik Malaya	2	50	5,920	1,335	120	7,425	0	1	7	0	5	0	0	0	0	0	0	13
	4 Kapias Batu VIII	1	0	10,400	2,100	0	12,500	0	0	2	0	0	0	0	0	8	0	0	10
	5 Sei Silau	3	0	11,840	1,450	0	13,290	0	1	16	0	2	3	0	0	14	0	0	36
	6 Bandar Saleh	1	290	1,120	0	0	1,410	0	0	2	0	0	3	0	0	1	0	0	6
	7 Sijambi	3	0	5,055	0	0	5,055	0	1	7	0	0	4	1	0	0	0	0	13
	Total I	12	830	41,685	10,635	120	53,270	0	4	44	0	13	10	4	0	32	0	0	107
II.	Bunut River System																		
II A.	Managed by PU																		
	1 Sei Serani	4	0	4,060	0	0	4,060	1	1	3	0	0	0	0	0	4	0	0	9
	2 Serbangan	5	0	15,155	0	0	15,155	1	1	17	15	3	2	0	2	8	0	0	49
	3 Panca Arga	5	25	1,450	2,270	1,100	4,845	1	1	6	0	1	2	0	0	2	0	0	13
	4 Sei Beluru	1	0	4,000	0	0	4,000	1	1	4	0	0	1	1	0	3	0	0	11
	5 Silo Bonto	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6 Desa Gajah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total II A	15	25	24,665	2,270	1,100	28,060	4	4	30	15	4	5	1	2	17	0	0	82
II B.	Village Irrigation																		
	1 Desa Durian	2	0	430	1,240	0	1,670	1	1	0	0	2	0	0	0	0	0	0	4
	2 Desa Gajah (left bank of Bunut river)	1	0	640	550	0	1,190	2	2	0	0	0	0	0	0	0	0	0	4
	Total II B	3	0	1,070	1,790	0	2,860	3	3	0	0	2	0	0	0	0	0	0	8
	Total II	18	25	25,735	4,060	1,100	30,920	7	7	30	15	6	5	1	2	17	0	0	90
	Total (I+II)	30	855	67,420	14,695	1,220	84,190	7	11	74	15	19	15	5	2	49	0	0	197

Note: Structures: DW; Diversion weir, IT; Intake structure, TO; Turnout, CK; Check, CV; Culvert
AQ; Aqueduct, SP; Siphon, DP; Drop, BR; Bridge, SW; Spillway/Wasteway, MD; Measuring divice

Name of canal:
- SP; Main canal
- SS; Secondary canal

Condition of canal: A; Well maintained
B; Functioning properly
C; Deteriorated/Partiary collapsed
D; Completely collapsed

Table C-2 INVENTORY OF DRAINAGE CANALS AND RELATED STRUCTURES

	Irrigation Scheme	Nos. of drain	Canal length (m)/Condition					Related Structures (nos.)			
			A	B	C	D	Total	CV	SP	BR	Total
I.	Silau River System										
1	Si Umbut-umbut	2	0	7,500	1,700	0	9,200	0	0	0	0
2	Binjai Serbangan	0	0	0	0	0	0	0	0	0	0
3	Tasik Malaya	1	0	0	0	5,430	5,430	0	0	0	0
4	Kapias Batu VIII	0	0	0	0	0	0	0	0	0	0
5	Sei Silau	4	0	0	12,600	0	12,600	4	2	6	12
6	Bandar Salch	1	0	1,500	2,100	0	3,600	0	0	0	0
7	Sijambi	4	0	13,500	0	0	13,500	0	0	0	0
	Total I	12	0	22,500	16,400	5,430	44,330	4	2	6	12
II.	Bunut River System										
1	Sei Serani	0	0	0	0	0	0	0	0	0	0
2	Serbangan	4	0	13,000	0	0	13,000	0	4	8	12
3	Panca Arga	1	0	6,000	0	0	6,000	0	0	2	2
4	Silo Bonto	1	0	13,900	0	0	13,900	0	0	1	1
5	Desa Gajah	1	0	0	3,200	0	3,200	0	0	1	1
6	Sei Beluru	1	0	900	0	0	900	0	0	1	1
7	Others	2	0	13,100	15,700	0	28,800	0	0	2	2
	Total II	10	0	46,900	18,900	0	65,800	0	4	15	19
	Total (I+II)	22	0	69,400	35,300	5,430	110,130	4	6	21	31

Note: Structures: CV; Culvert, SP; Siphon, BR; Bridge

Condition of canal: A; Well maintained
B; Functioning properly
C; Deteriorated/Partiary collapsed
D; Completely collapsed

Name of canal: SP; Main canal
SS; Secondary canal

Table C-3 DIMENSION OF EXISTING IRRIGATION CANALS

Scheme (DP)	Canal Name	Total Length (m)	Flow Capacity (m3/s) Max	Min	Gradient	Canal Bed EL (m) High	Low	Canal Dimension (m) B	H	Remark
I. SILAU RIVER SYSTEM										
1. Si Umbut umbut	SP-Si Umbut2	7,430	3.74	0.47	1/1,500 - 1/1,750	13.76	8.05	4.4 - 1.8	2.7 - 0.9	Earth Canal
2. Tasik Malaya	SP-T. Malaya	140	5.76	4.68	1/1,150	9.51	8.50	3.3 - 2.8	2.0 - 1.9	Earth Canal
	SS-T. Malaya	7,390	3.64	0.30	1/1,450	8.70	3.16	3.8 - 1.7	1.9 - 0.7	Earth Canal
3. Kapias Bt.VIII	SS-K.Batu VIII	2,620	3.27	0.40	1/1,150	8.70	4.77	3.7 - 1.6	1.7 - 0.9	Earth Canal
4. Sei Silau	SP-Sei Silau	1,635	28.15	13.76	1/1,400	11.50	11.19	7.5 - 7.4	3.2 - 2.3	Earth Canal
	SS-Silau Kn	5,670	9.20	0.97	1/1,000 - 1/1,200	11.09	4.10	4.8 - 2.2	2.2 - 0.7	Earth Canal
	SS-Silau Kr	6,465	5.60	0.56	1/1,400 - 1/1,450	11.39	3.49	4.0 - 1.8	2.0 - 0.9	Earth Canal
5. Bandar Salch	SS-B. Saleh	1,405	0.61	0.15	1/1,400	5.07	3.36	2.0 - 0.9	1.0 - 1.6	Earth Canal
II. BUNUT RIVER SYSTEM										
1. DP. Serbangan	SP-Serbangan	6,120	12.43	0.47	1/1,800	9.00	5.14	1.8 -13.0	1.0 - 3.0	Earth Canal
	SS-Rawang Lama	3,470	3.77	0.05	1/1,200	8.57	5.13	2.7 - 5.0	0.7 - 1.5	Earth Canal
	SS-Rawang Baru I	1,835	0.74	0.13	1/800	7.99	5.09	1.7 - 3.0	0.7 - 1.0	Earth Canal
	SS-Rawang Baru II	1,980	1.65	0.07	1/3,000	6.41	5.75	1.0 - 3.5	0.7 - 1.2	Earth Canal
	SS-Rawang Baru III	1,405	1.83	0.41	1/1,800	7.41	6.54	1.7 - 2.6	1.0 - 1.6	Earth Canal
2. DP. Panca Arga	SP-Panca Arga	1,525	0.73	0.26	1/800	4.67	2.83	0.8 - 1.2	0.9 - 1.1	Earth Canal
	SS-PA Kn-2	1,950	0.63	0.48	1/800	4.46	3.94	1.1	1.2 - 1.3	Earth Canal
	SS-PA Kr-1	425	0.27	0.27	1/800	5.50	4.97	0.6	1	Earth Canal
	SS-PA Kn-1	700	0.17	0.17	1/1,100	3.38	2.70	1.2	0.8	Earth Canal
3. Dp. Sei Beluru	SS-Sei Beluru	3,940	0.57	0.11	1/1,400	8.89	5.99	1.0 - 2.0	0.9 - 1.2	Earth Canal
4. DP. Sei Serani	SP-Sei Serani	935	0.94	0.06	1/3,800	7.09	7.31	1.4 - 2.1	0.7 - 1.5	Earth Canal
	SS-Sei Serani I	1,030	0.18	0.14	1/1,600	7.13	6.40	1.0 - 1.3	0.8 - 0.9	Earth Canal
	SS-Sei Serani II	1,520	0.31	0.08	1/1,000	7.27	5.33	0.9 - 1.4	0.7 - 0.9	Earth Canal
	SS-Sei Serani III	685	0.21	0.13	1/1,300	7.51	6.97	1.0 - 1.1	0.8 - 0.9	Earth Canal
5. DP. Sijambi	SP-Sijambi	2,505	1.48	0.28	1/2,100	3.00	2.34	1.0 - 2.3	1.0 - 1.5	Earth Canal
	SS-Tumpat	1,470	0.25	0.20	1/800	2.78	1.00	0.9 - 1.3	0.8 - 0.9	Earth Canal

Note: B; Canal bottom width.
H; Canal height.
SP; Main irrigation canal.
SS; Secondary irrigation canal.

Table C-4 EXISTING ROAD CONDITION

Route No.	Road Section From	To	Length (km)	Total Width (m)	Pavement Condition (km) Asphalted	Gravel M	Macadum	Earth	Bridge (nos.)	Status Good	Medium	Damaged	Remarks
(Provincial Road)													
P - 1	S. Bejangkar	Simpang Kawat	47.20	6.00	47.20	-	-	-	25	-	47.20	-	Hotmix
P - 7	Arteri	Kisaran	5.00	6.00	5.00	-	-	-	-	-	5.00	-	Hotmix
P - 10	Simpang Kawat	Teluk Nibung	18.70	6.00	18.70	-	-	-	7	-	18.70	-	Hotmix
Sub Total - P			70.90		70.90	0.00	0.00	0.00	32	0.00	70.90	0.00	
(Kabupaten Road)													
K - 01	Kisaran	Pasar V	3.00	4.50	3.00	-	-	-	3	1.00	2.00	-	
K - 02	Pasar V	Rawang	6.85	4.50	6.85	-	-	-	7	0.50	6.35	-	
K - 03	Pasar V	Pasar XI	5.45	4.50	5.45	-	-	-	3	2.00	3.45	-	
K - 04	Pasar XI	Silau Laut	13.82	4.50	-	-	13.82	-	7	12.00	11.82	-	
K - 05	Pasar XI	Air Joman	3.90	4.50	3.90	-	-	-	3	3.90	-	-	
K - 06	Air Joman	Pasar Lembu	3.65	4.50	-	-	-	3.65	-	-	3.65	-	
K - 07	Air Joman	Tanjung Balai	5.69	4.50	-	-	5.69	-	11	3.00	2.00	0.69	
K - 08	Silau Laut	Teluk Nibung	18.96	4.50	-	5.50	6.96	6.50	17	-	18.96	-	
K - 25	Sei Balai	Ujung Kubu	9.46	4.50	-	-	9.46	-	17	-	8.46	1.00	
K - 49	Rawang	Panca Arga	6.58	4.50	-	-	4.20	2.38	5	6.58	-	-	
K - 50	Panca Arga	Sei Beluru	7.95	4.50	3.35	-	4.60	-	6	5.00	2.95	-	
K - 53	Kisaran	Siumbut-umbut	4.50	4.50	4.50	-	-	-	4	-	4.50	-	
K - 54	Pasar Miring	Sei Lama	6.50	4.50	-	-	6.50	-	12	-	6.50	-	
K - 55	Ujung Kubu	Pemt. Pao	8.00	4.50	-	-	-	8.00	11	-	6.00	2.00	
K - 56	Pematang Pao	Silau Laut	6.01	4.50	-	-	-	6.01	2	-	-	6.01	
K - 67	Pekan Minggu	Silau Bonto	3.95	4.50	-	-	2.85	1.10	3	3.95	-	-	
K - 80	Sipori pori	Lubuk Palas	1.11	4.50	-	-	-	1.11	3	1.11	-	-	
K - 82	Pasar Dua	Lubuk Palas	9.25	4.50	-	-	5.75	3.50	8	5.75	3.50	-	
K - 90	Ujung Kubu	Bagan Baru	2.50	4.00	-	-	-	2.50	-	-	2.50	-	
K - 92	Kp. Durian	Meranti	5.00	4.00	-	-	2.52	2.48	5	5.00	-	-	
K - 93	Sidomukti	Pondok Bunga	4.80	3.50	-	-	1.30	3.50	3	1.30	3.50	-	
Sub Total - K			136.93		27.05	5.50	63.65	40.73	130	51.09	86.14	9.70	
Total			207.83		97.95	5.50	63.65	40.73	162	51.09	157.04	9.70	

Source: 1) Provincial Road; Daftar Jalan-jalan Dikelola, Cabang Dinas PU Bina Marga Asahan, Jun. 1989.

2) Kabupaten Road; Data-data Jalan Kabupaten Daerah Tingkat II Asahan 1988/89, Seksi Jalan dan Jembatan, PUD Asahan.

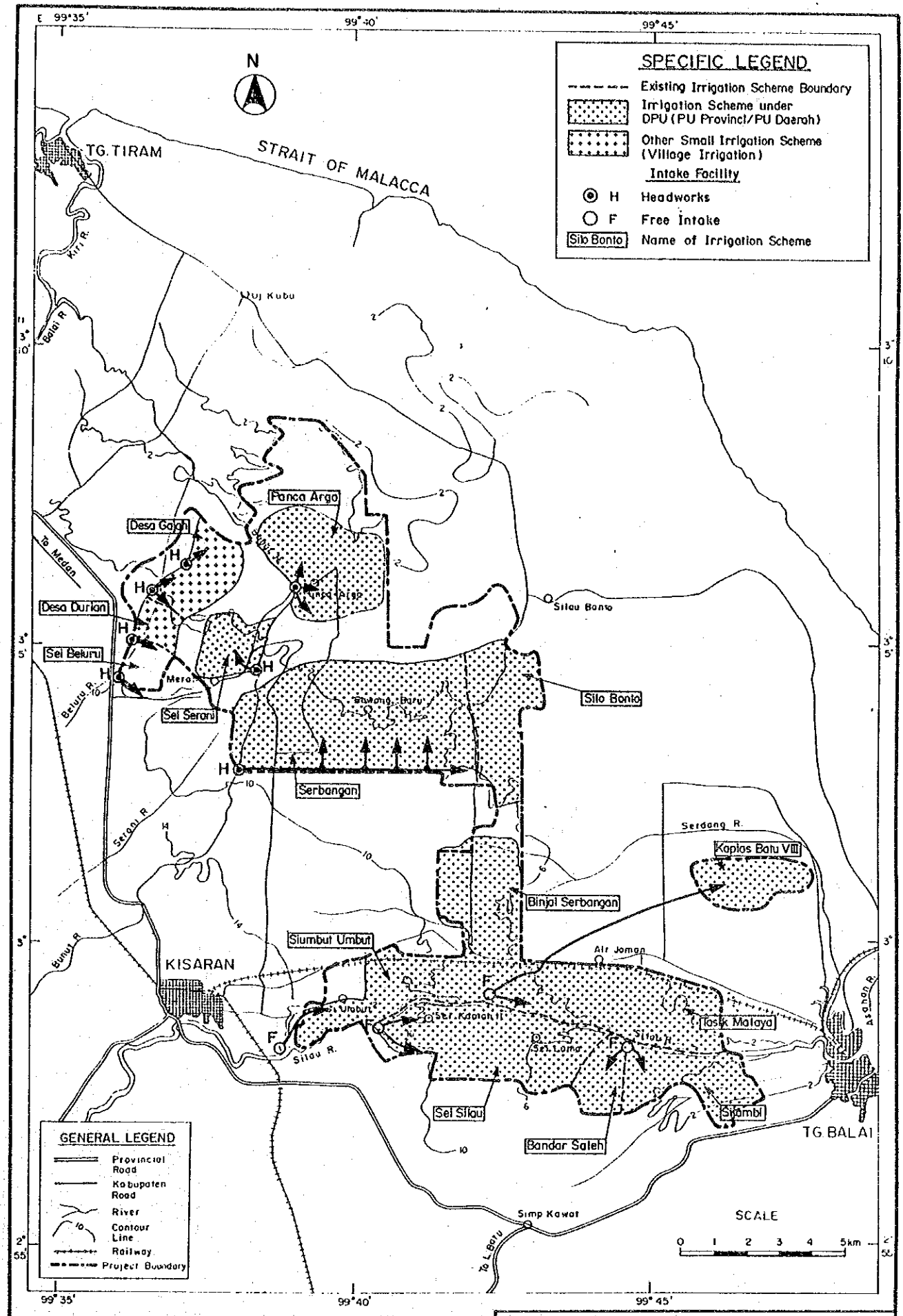

Fig. C - 1 PRESENT IRRIGATION SCHEMES

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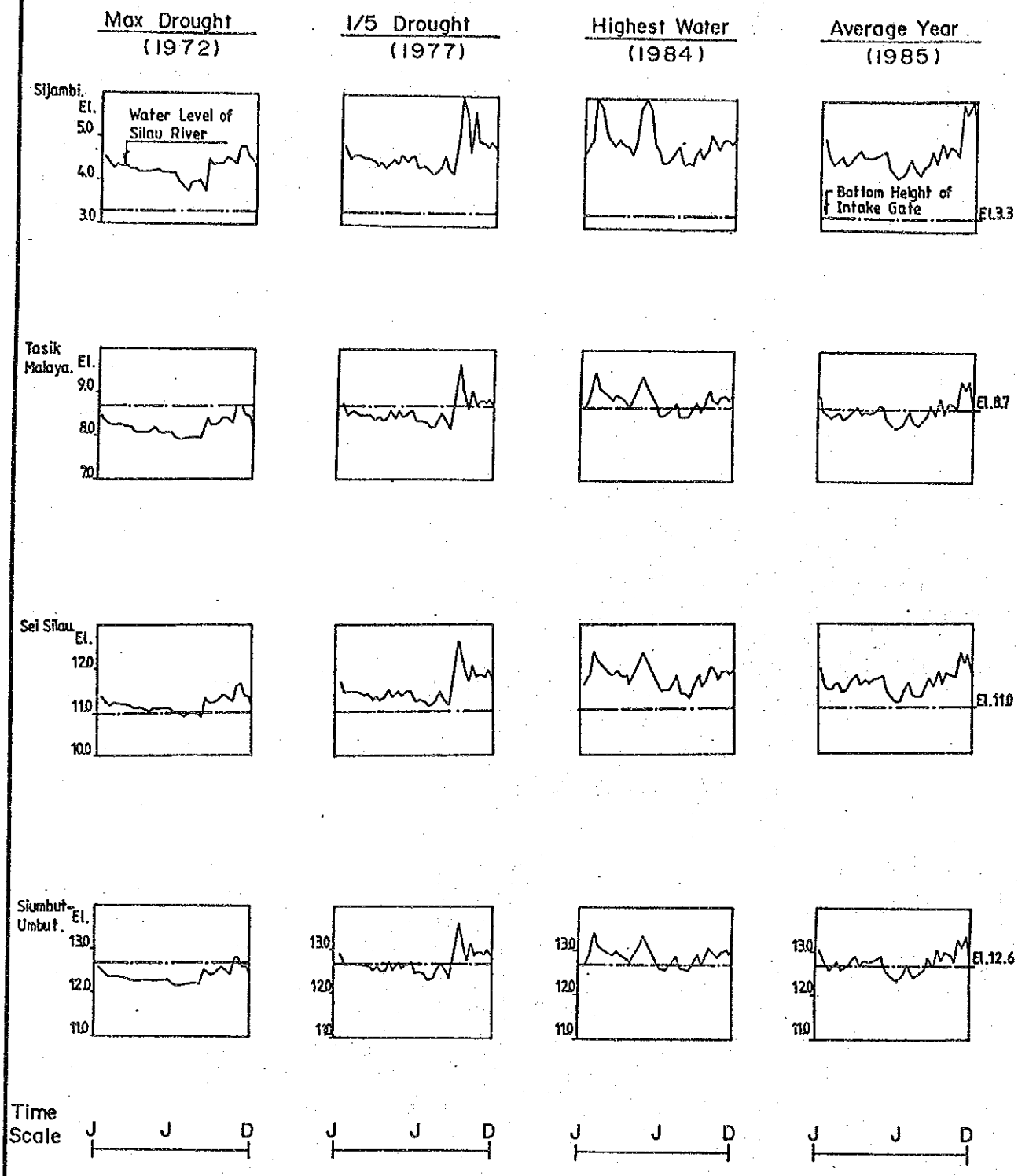

Fig. C-2 WATER LEVEL VARIATIONS AT FREE INTAKE SITES ON SILAU RIVER

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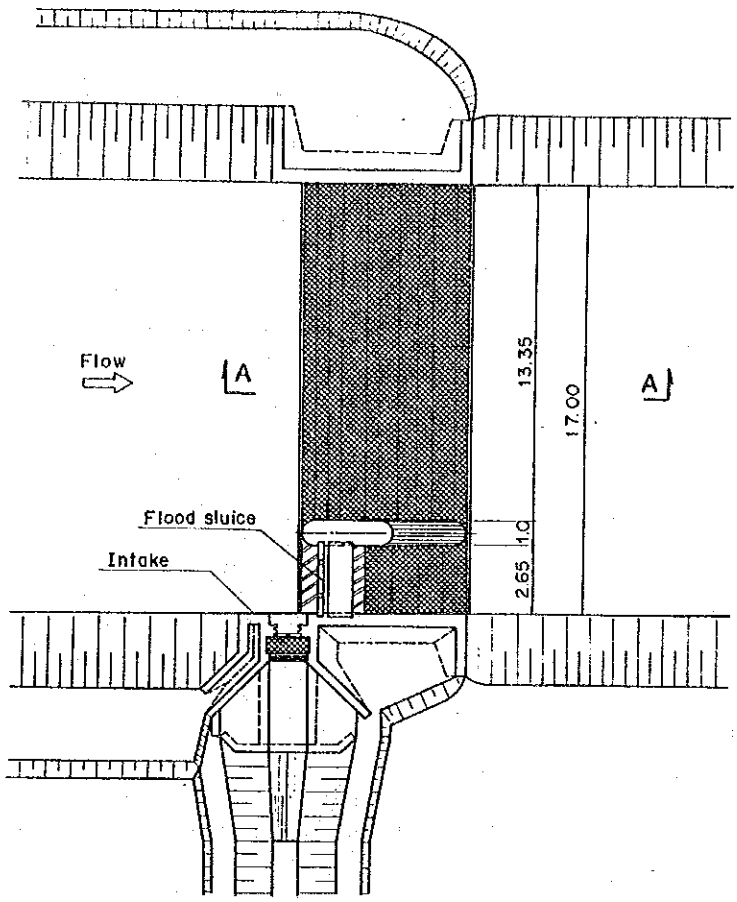

PLAN

Scale
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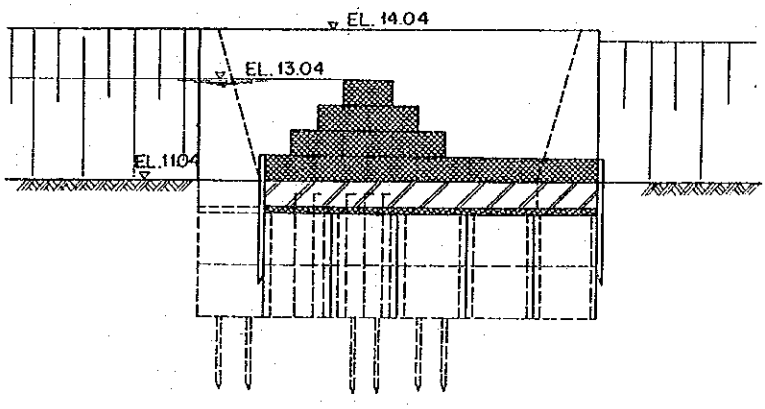

PROFILE (A-A)

Scale
0 1 2 3 4 5m

Fig. C-3 PRESENT CONDITION OF BELURU WEIR

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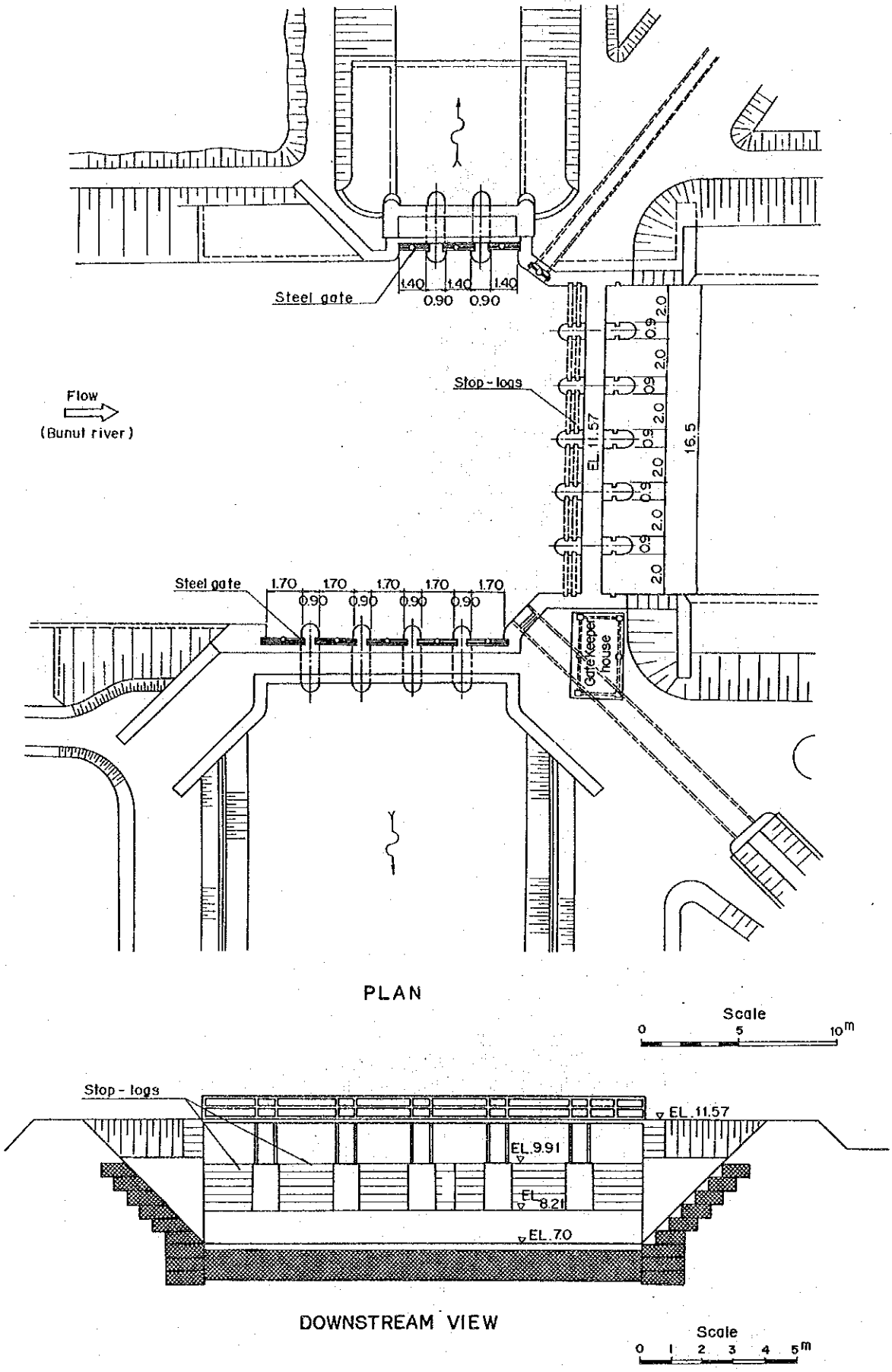

Fig. C-4 PRESENT CONDITION OF SERBANGAN WEIR

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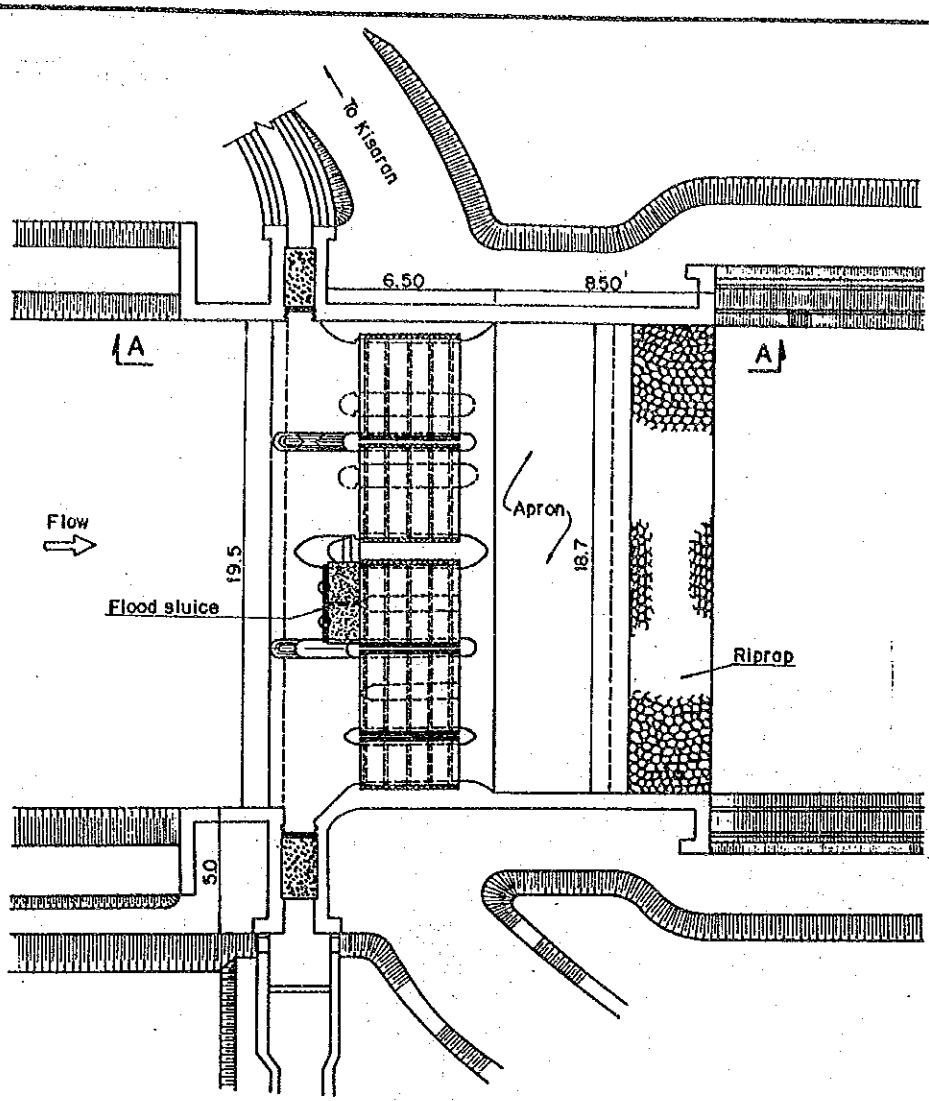
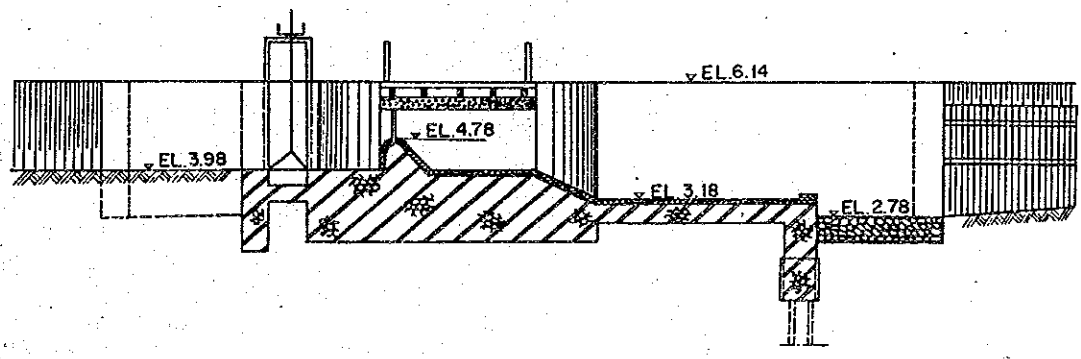


PLAN

Scale 0 5 10m



CROSS SECTION A-A

Scale 0 1 2 3 4 5m

Fig. C-5 PRESENT CONDITION OF PANCA ARGA WEIR

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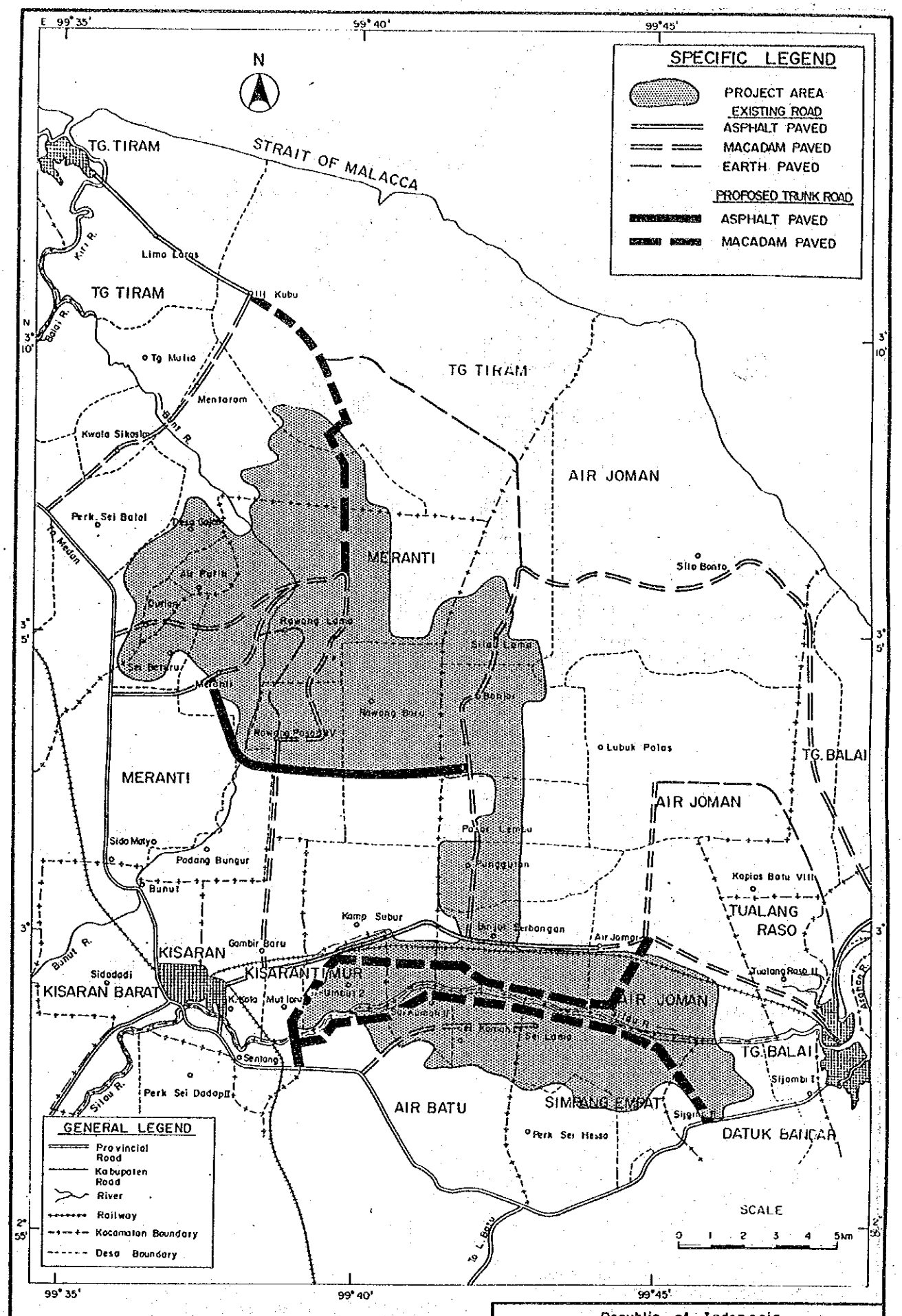

Fig. C - 6 EXISTING AND PROPOSED ROAD NETWORKS IN AND AROUND PROJECT AREA

Republic of Indonesia
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Japan International Cooperation Agency

Table C-5 INVENTORY OF EXISTING FLOOD CONTROL FACILITIES

Item	Unit	Quantity/ Description
1 Silau river		
(1) River dike		
1) Length	km	Left side ; 18.3, Right side ; 17.75
2) Height	m	Old dike ; 1.2, New dike ; more than 2.0
3) Crown width	m	Old dike ; 2.0, New dike ; more than 4.0
4) Side slope		Old dike ; 1:1.5, New dike ; 1: 2.0
(2) Bank protection		Wooden pile groynes or wooden piles of 17 places
(3) Structures along river		
1) Free intake	nos	5 free intakes of Pasar Baru, Sijambi, T.Malaya, S.Silau, and Si Umbut umbut
2) Pump station	nos	2 sites for city water supply and irigation
3) Drainage outlet	nos	7 sites
4) Bridge	nos	5 bridges
5) Ferry terminal	nos	2 sites
2 Bunut river		
(1) River dike		
1) Length	km	Left side ; 4.0, Right side ; 9.5
2) Height	m	1.0 -2.0
3) Crown width	m	2.0 -3.0
4) Side slope		1: 1.0 - 1: 2.0
(2) Bank protection		Non
(3) Structures along river		
1) Intake weirs	nos	2 nos. of Serbangan and Panca Arga weirs for irrigation
2) Pump station	nos	Non
3) Drainage outlet	nos	Non
4) Bridge	nos	3 bridges
5) Ferry terminal	nos	Non

Table C-6 MAIN FEATURES OF THE LOWER ASAHAN FLOOD CONTROL PROJECT BY DGWRD

No.	Item	Description	Unit	Quantity
1.	Background			
	- 1984-85	Master plan study on lower Asahan river basin development and feasibility study on urgent flood control plan by JICA		
	- 1988-89	Detailed design of Lower Asahan river flood control project		
2.	Project Works			
	(1) Asahan river			
	- Objective stretch	From Pd. Mahondang to Nantal river	km	19
	- Design flood discharge	10-year flood discharge at Pulau Raja	cum/sec	1,100
	- Major work quqntities	- Excavation and dredging (x 1,000)	cu-m	3,345
		- Dike embankment (x 1,000)	cu-m	560
	(2) Silau river			
	- Objective stretch	From railway bridge to the confluence with Asahan river	km	20
	- Design flood discharge	10-year flood discharge at Kisaran	cum/sec	600
	- Major work quqntities	- Excavation and dredging (x 1,000)	cu-m	2,220
		- Dike embankment (x 1,000)	cu-m	1,250
		- Revetment	m	4,130
		- Parapet wall	m	3,130
	(3) Lebah river			
	- Objective stretch	Prevention dike for retarding basin	km	15
	- Major work quqntities	- Excavation (x 1,000)	cu-m	220
		- Dike embankment (x 1,000)	cu-m	220
3.	Project Cost			
	- Foreign currency portion		Rp.mil.	35,020
	- Local currency portion		Rp.mil.	72,630
	- Total		Rp.mil.	107,650
4.	Economic Evaluation			
	- Economic cost		Rp.mil.	82,517
	- Economic annual benefits	Flood damage reduction and enhancement benefits	Rp.mil.	9,125
	- EIRR		%	8.5
5.	Implementation Schedule			
	(1) Executing agency	Establishing the project office under Directorate of River, DGWRD		
	(2) Construction period		years	4

Exchange rate : US$ 1.0 = ¥ 130 = Rp. 1,750

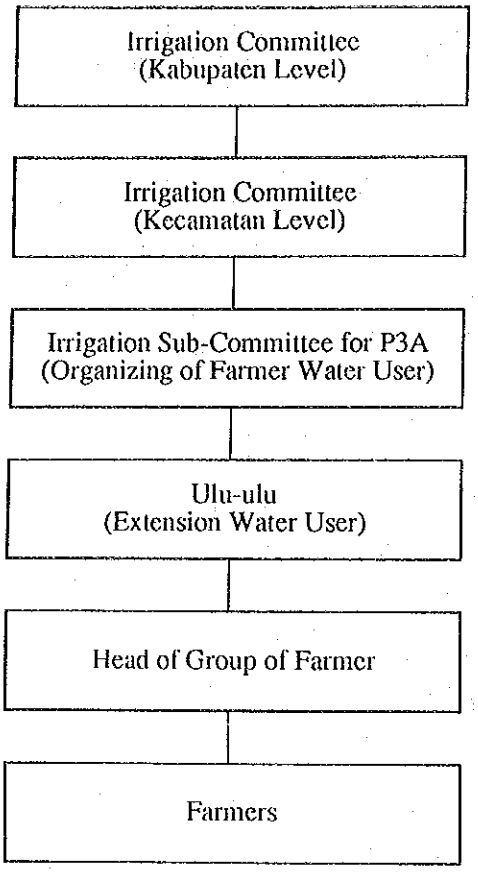
Source : Design Report on River Improvement Works for Lower Ashan River Flood Control Project, Vol. I Main Report, DGWRD, June 1989

Table C-7 ORGANIZATION OF THE IRRIGATION SERVICE BRANCH OFFICE OF DPU NORTH SUMATRA IN KABUPATEN ASAHAN AREA

(Unit: person)

Description	Management Staff	Technical Staff Office	Technical Staff Field	Admini-stration	Casual Labour
I. Management Staff					
1. Head of Branch Office	1				
2. Sub-head	1				
II. Office Staff					
3. Exploitation Section		6			
4. Maintenance Section		3			
5. Tertiary Section		3			
6. Technical Service		4			
III. Field Staff					
7. Head of Sub-branch office			4		
(1) Irrigation Inspector			8		
(2) Gate Keeper			14		
(3) Casual Labour					145
IV. Administration Staff					
8. Administration Division Chief				1	
(1) Administration Section				4	
(2) Logistic Section				5	
(3) Personnel Section				7	
(4) Budget Section				7	
Total	2	16	26	24	145

Note: 1) Total command area of the office; 28,900 ha
2) Total number of staff; 68 persons
3) Average command area per field staff; 1,100 ha/staff
4) Ration of Admi. staff (24/68=); 35%
(Nos. of admi. staff is superfluous compairing with that of technical staff.)
5) Casual labours are employed for regular maintenance work of the facilities.



Note: Irrigation Committee of Kabupaen Asahan

(1) Members :

Chairman : Bupati Kab. Asahan
Secretary : Head of Irrigation Branch Office Asahan
Member :
1. Chief of Police Resort
2. Chief of Irrigatin Section of Regional Public Works
3. Chief of Regional Agriculture Office
4. Chief of Sub-Directorate Land Use (Agraria)
5. Chief of Sub-Directorate Rural Development

(2) Interval of Meeting :

- Two times in a year at the time just before cropping season in principal
- Incidentially, irrigation problems need to meeting

(3) Activities :

No substantial activity of the Committee has been performed. The reasons of poor activities are; i) irrigation activities in Kab. Asahan are relatively not dynamic, ii) lack of information related to irrigation and drainage problems such as inundation area, pest and disease shortage of irrigation water, cropping season are not reported to the irrigation committee members.

Fig C-7 ORGANIZATION OF IRRIGATION COMMITTEE IN KABUPATEN ASAHAN

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Table C-8 ESTIMATE OF IRRIGATION WATER REQUIREMENT

Basic Meteological Data

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Air Temperature (Centigrade in degree)												
Max.	31.5	32.0	32.4	32.7	32.9	32.9	32.6	32.4	32.1	31.8	31.4	31.3
Mean	25.7	26.0	26.3	26.6	26.7	26.6	26.4	26.3	26.2	26.2	26.2	25.9
Min.	21.8	21.5	21.9	22.7	22.7	22.5	22.3	22.2	22.5	22.6	22.5	22.2
Relative Humidity (%)												
Mean	88.7	87.6	88.2	88.4	87.9	86.8	87.0	88.3	88.5	89.4	89.7	89.3
wind Velocity(m/s)												
Average	0.19	0.24	0.25	0.23	0.24	0.25	0.25	0.23	0.28	0.22	0.21	0.21
Sunshine (%)												
Average	58	65	54	54	58	60	62	60	52	59	57	50

Unit Diversion Water Requirement

Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
(day)												
1 - 10	1.48	0.28	0.00	0.89	1.26	1.57	1.21	0.18	0.00	0.67	1.48	1.27
10 - 20	0.98	0.31	0.63	1.15	1.03	0.00	0.00	0.00	0.00	0.97	0.33	0.58
21 -	0.91	0.06	0.45	1.37	1.20	1.10	0.04	0.00	0.00	1.08	0.06	1.67

Calculation Conditions;

1. All procedures follow DGWRD Irrigation Design Standards.
2. Crop water requirement is based on FAO reference evapotranspiration.
3. Nursery and preparation requirements employ pre-satulation requirement and average water depth of 75mm.
4. Pre-satulation requirement is estimated to be 75mm and another 50mm is added if dry-up peeriod is more than 2.5 months.
5. Percoration loss is estimated to be 2mm for dry season from Jan. to Aug. and 1mm for rainy season from Sep. to Dec.
6. Water layer replacement requirement of 50 mm is introduced.
7. Overall irrigation efficiency is estimated to be 60 %.
8. Cropping area factor follows the proposed cropping pattern.
9. Rainfall distribution pattern of the standard year of 1979 is used for calculation.
10. An linear regression is used for effective rainfall estimation.

Effective rainfall = 0.68 * Actual rainfall

11. Effective rainfall is based on the results of dayly water ballace simulation supposing that rainfalls less than 5mm is neglected and that maximum and minimum storage depth of paddy are 100 and 50mm respectively.
12. The calculation employs physical conditions at Kisaran and meteological conditions at Sei Dadap station(6.19).

Table C-9 ESTIMATE OF DRAINAGE WATER REQUIREMENT

Calculation Table

Case	Land Use Discription	Rainfall Data	Design Rainfall (mm/day)	Water Ballance (mm/day)	Storage (mm)	Runoff Coefficient	Drainage Depth (mm)	Drainage Modulous (l/s/ha)
1.	Paddy Field	3 day consecutive rain	172	-5	75	-	82	3.16
2.	Non Paddy Field	1 day consecutive rain	127	0	0	0.65	-	-

Equations for Drainage Requirement

1. for Paddy Field
   Design Drainage Discharge(l/s) = 1.62 * Drainage Modulous * Paddy Area(A)^ 0.92 = 5.13 A ^ 0.92

2. for Non-paddy field
   Design Drainage Discharge(l/s) = 0.116 * Design Rainfall * Runoff Coefficient * Non Paddy Area(A) ^ 0.92
   = 9.58 A ^ 0.92

Calculation Conditions

1. Design Rainfall is with 20 % probability of exceedance.
2. All calculation procedures follow DGWRD Irrigation Design Standards.
3. Water Ballance is a sum of irrigation(positive), evapotranspiration(negative) and percoration(negative).
4. Average Storage Depth is estimated based on field investigation.
5. Drainage Depth is calculated by the following equation.

   Drainage Depth = Design Rainfall + Numbers of consecutive days * Water Ballance - Average Storage Depth.

6. Drainage Modulous is an unit conversed from of Drainage Depth.
7. Runoff Coefficient is selected supposing that non-paddy area is covered by light forest.

Table C-10 WATER BALANCE CALCULATION (1/3)
SEPARATE ASSESSMENT

Month	Period (Day)	Diversion Requiremnet (l/s/ha)	Silau River System			Bunut River System		
			Design Discharge (m3/s)	Available Discharge (m3/s)	Surplus Discharge (m3/s)	Design Discharge (m3/s)	Available Discharge (m3/s)	Surplus Discharge (m3/s)
Jan.	1-10	1.48	77.06	51.06	36.37	4.39	2.59	1.83
	11-20	0.98	50.7	24.7	14.97	3.48	1.68	1.17
	21-	0.91	54.3	28.3	19.27	3.14	1.34	0.87
Feb.	1-10	0.28	54.84	28.84	26.06	3.17	1.37	1.23
	11-20	0.31	50.8	24.8	21.72	3.06	1.26	1.10
	21-	0.06	47.16	21.16	20.56	3.64	1.84	1.81
Mar.	1-10	0	49.34	23.34	23.34	2.72	0.92	0.92
	11-20	0.63	40.56	14.56	8.31	2.59	0.79	0.47
	21-	0.45	44.26	18.26	13.79	2.42	0.62	0.39
Apr.	1-10	0.89	36.55	10.55	1.72	2.61	0.81	0.35
	11-20	1.15	41.5	15.5	4.09	2.47	0.67	0.08
	21-	1.37	57.98	31.98	18.38	2.52	0.72	0.01
May	1-10	1.26	42.62	16.62	4.11	2.45	0.65	0.00
	11-20	1.03	57.55	31.55	21.33	4.48	2.68	2.15
	21-	1.2	46.52	20.52	8.61	5.64	3.84	3.22
Jun.	1-10	1.57	52.82	26.82	11.24	4.13	2.33	1.52
	11-20	0	54.95	28.95	28.95	3.84	2.04	2.04
	21-	1.1	37.14	11.14	0.22	2.89	1.09	0.52
Jul.	1-10	1.21	38.01	12.01	0.00	3.21	1.41	0.79
	11-20	0	33.64	7.64	7.64	2.82	1.02	1.02
	21-	0.04	26.43	0.43	0.03	2.29	0.49	0.47
Aug.	1-10	0.18	27.87	1.87	0.08	2.54	0.74	0.65
	11-20	0	38.47	12.47	12.47	2.65	0.85	0.85
	21-	0	56.73	30.73	30.73	2.9	1.1	1.10
Sep.	1-10	0	35.49	9.49	9.49	3.84	2.04	2.04
	11-20	0	27.65	1.65	1.65	3.69	1.89	1.89
	21-	0	99.8	73.8	73.80	6.34	4.54	4.54
Oct.	1-10	0.67	185.74	159.74	153.09	9.26	7.46	7.11
	11-20	0.97	111.05	85.05	75.42	6.98	5.18	4.68
	21-	1.08	70.02	44.02	33.30	4.23	2.43	1.87
Nov.	1-10	1.48	112.65	86.65	71.96	4.14	2.34	1.58
	11-20	0.33	82.06	56.06	52.78	4.33	2.53	2.36
	21-	0.06	85.64	59.64	59.04	4.12	2.32	2.29
Dec.	1-10	1.27	78.26	52.26	39.65	7.82	6.02	5.36
	11-20	0.58	91.84	65.84	60.08	5.21	3.41	3.11
	21-	1.67	72.98	46.98	30.40	4.7	2.9	2.04

Note; Maintenance Discharge; Monthly 10 Year Drought Discharge

Silau River	26.0	cum/sec
Bunut River	1.8	cum/sec

Available Discharge = Design Discharge - Maintenance Discharge

Maximum Irrigation Area; **Silau River System:** **9,925.62** **ha**
Bunut River System: **515.87** **ha**

Table C-10 WATER BALANCE CALCULATION (2/3)
POTENTIAL WATER SUPPLY CONDITION

Month	Period	Design Discharge		Available Discharge		Diversion	Water Balance				Diversion Plan	
							Silau River		Bunut River			
		Silau River	Bunut River	Silau River	Bunut River	Requirement	Intake	Surplus	Intake	Surplus	Silau to Bunut	Silau R. Surplus
	(Day)	(m3/s)	(m2/s)	(m3/s)	(m3/s)	(l/s/ha)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Jan.	1-10	77.1	4.4	51.1	2.6	1.48	6.3	44.8	10.1	(7.5)	7.5	37.24
	11-20	50.7	3.5	24.7	1.7	0.98	4.2	20.5	6.7	(5.0)	5.0	15.51
	21-	54.3	3.1	28.3	1.3	0.91	3.9	24.4	6.2	(4.9)	4.9	19.55
Feb.	1-10	54.8	3.2	28.8	1.4	0.28	1.2	27.6	1.9	(0.5)	0.5	27.10
	11-20	50.8	3.1	24.8	1.3	0.31	1.3	23.5	2.1	(0.9)	0.9	22.62
	21-	47.2	3.6	21.2	1.8	0.06	0.3	20.9	0.4	1.4	0.0	20.90
Mar.	1-10	49.3	2.7	23.3	0.9	0.00	0.0	23.3	0.0	0.9	0.0	23.34
	11-20	40.6	2.6	14.6	0.8	0.63	2.7	11.9	4.3	(3.5)	3.5	8.36
	21-	44.3	2.4	18.3	0.6	0.45	1.9	16.3	3.1	(2.5)	2.5	13.89
Apr.	1-10	36.6	2.6	10.5	0.8	0.89	3.8	6.8	6.1	(5.3)	5.3	1.49
	11-20	41.5	2.5	15.5	0.7	1.15	4.9	10.6	7.9	(7.2)	7.2	3.42
	21-	58.0	2.5	32.0	0.7	1.37	5.8	26.2	9.4	(8.7)	8.7	17.51
May	1-10	42.6	2.5	16.6	0.7	1.26	5.4	11.3	8.6	(8.0)	8.0	3.30
	11-20	57.6	4.5	31.6	2.7	1.03	4.4	27.2	7.0	(4.4)	4.4	22.81
	21-	46.5	5.6	20.5	3.8	1.20	5.1	15.4	8.2	(4.4)	4.4	11.05
Jun.	1-10	52.8	4.1	26.8	2.3	1.57	6.7	20.1	10.7	(8.4)	8.4	11.74
	11-20	55.0	3.8	29.0	2.0	0.00	0.0	29.0	0.0	2.0	0.0	28.95
	21-	37.1	2.9	11.1	1.1	1.10	4.7	6.5	7.5	(6.4)	6.4	0.03
Jul.	1-10	38.0	3.2	12.0	1.4	1.21	5.1	6.9	8.3	(6.9)	6.9	0.00
	11-20	33.6	2.8	7.6	1.0	0.00	0.0	7.6	0.0	1.0	0.0	7.64
	21-	26.4	2.3	0.4	0.5	0.04	0.2	0.3	0.3	0.2	0.0	0.26
Aug.	1-10	27.9	2.5	1.9	0.7	0.18	0.8	1.1	1.2	(0.5)	0.5	0.61
	11-20	38.5	2.7	12.5	0.9	0.00	0.0	12.5	0.0	0.9	0.0	12.47
	21-	56.7	2.9	30.7	1.1	0.00	0.0	30.7	0.0	1.1	0.0	30.73
Sep.	1-10	35.5	3.8	9.5	2.0	0.00	0.0	9.5	0.0	2.0	0.0	9.49
	11-20	27.7	3.7	1.6	1.9	0.00	0.0	1.6	0.0	1.9	0.0	1.65
	21-	99.8	6.3	73.8	4.5	0.00	0.0	73.8	0.0	4.5	0.0	73.80
Oct.	1-10	185.7	9.3	159.7	7.5	0.67	2.8	156.9	4.6	2.9	0.0	156.89
	11-20	111.1	7.0	85.1	5.2	0.97	4.1	80.9	6.6	(1.5)	1.5	79.47
	21-	70.0	4.2	44.0	2.4	1.08	4.6	39.4	7.4	(5.0)	5.0	34.47
Nov.	1-10	112.7	4.1	86.7	2.3	1.48	6.3	80.4	10.1	(7.8)	7.8	72.58
	11-20	82.1	4.3	56.1	2.5	0.33	1.4	54.7	2.3	0.3	0.0	54.66
	21-	85.6	4.1	59.6	2.3	0.06	0.3	59.4	0.4	1.9	0.0	59.38
Dec.	1-10	78.3	7.8	52.3	6.0	1.27	5.4	46.9	8.7	(2.7)	2.7	44.19
	11-20	91.8	5.2	65.8	3.4	0.58	2.5	63.4	4.0	(0.6)	0.6	62.82
	21-	73.0	4.7	47.0	2.9	1.67	7.1	39.9	11.4	(8.5)	8.5	31.36

Note: (7.5) = Minus Value

Maintenance Discharge; Monthly10 Year drought Discharge

Silau River	26.0	m3/s
Bunut River	1.8	m3/s

Average Discharge = Design Discharge - Maintenance Discharge

Potential Irrigable Area:

Silau River System:	**4,250.7**	**ha**
Bunut River System:	**6,840.2**	**ha**
Total Area:	**11,090.9**	**ha**

Table C-10 WATER BALANCE CALCULATION (3/3)
PROJECT CONDITION

Month	Period	Design Discharge		Available Discharge		Diversion	Water Balance				Diversion Plan	
		Silau River	Bunut River	Silau River	Bunut River	Require-ment	Silau River		Bunut River		Silau to Bunut	Silau R. Surplus
							Intake	Surplus	Intake	Surplus		
	(Day)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(l/s/ha)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)	(m3/s)
Jan.	1-10	77.1	4.4	51.1	2.6	1.48	6.3	44.8	8.8	(6.2)	6.2	38.60
	11-20	50.7	3.5	24.7	1.7	0.98	4.2	20.5	5.8	(4.1)	4.1	16.41
	21-	54.3	3.1	28.3	1.3	0.91	3.9	24.4	5.4	(4.0)	4.0	20.38
Feb.	1-10	54.8	3.2	28.8	1.4	0.28	1.2	27.6	1.7	(0.3)	0.3	27.36
	11-20	50.8	3.1	24.8	1.3	0.31	1.3	23.5	1.8	(0.6)	0.6	22.91
	21-	47.2	3.6	21.2	1.8	0.06	0.3	20.9	0.4	1.5	0.0	20.90
Mar.	1-10	49.3	2.7	23.3	0.9	0.00	0.0	23.3	0.0	0.9	0.0	23.34
	11-20	40.6	2.6	14.6	0.8	0.63	2.7	11.9	3.7	(2.9)	2.9	8.94
	21-	44.3	2.4	18.3	0.6	0.45	1.9	16.3	2.7	(2.0)	2.0	14.30
Apr.	1-10	36.6	2.6	10.5	0.8	0.89	3.8	6.8	5.3	(4.5)	4.5	2.31
	11-20	41.5	2.5	15.5	0.7	1.15	4.9	10.6	6.8	(6.1)	6.1	4.47
	21-	58.0	2.5	32.0	0.7	1.37	5.8	26.2	8.1	(7.4)	7.4	18.76
May	1-10	42.6	2.5	16.6	0.7	1.26	5.4	11.3	7.5	(6.8)	6.8	4.45
	11-20	57.6	4.5	31.6	2.7	1.03	4.4	27.2	6.1	(3.4)	3.4	23.75
	21-	46.5	5.6	20.5	3.8	1.20	5.1	15.4	7.1	(3.3)	3.3	12.15
Jun.	1-10	52.8	4.1	26.8	2.3	1.57	6.7	20.1	9.3	(7.0)	7.0	13.18
	11-20	55.0	3.8	29.0	2.0	0.00	0.0	29.0	0.0	2.0	0.0	28.95
	21-	37.1	2.9	11.1	1.1	1.10	4.7	6.5	6.5	(5.4)	5.4	1.04
Jul.	1-10	38.0	3.2	12.0	1.4	1.21	5.1	6.9	7.2	(5.8)	5.8	1.11
	11-20	33.6	2.8	7.6	1.0	0.00	0.0	7.6	0.0	1.0	0.0	7.64
	21-	26.4	2.3	0.4	0.5	0.04	0.2	0.3	0.2	0.3	0.0	0.26
Aug.	1-10	27.9	2.5	1.9	0.7	0.18	0.8	1.1	1.1	(0.3)	0.3	0.78
	11-20	38.5	2.7	12.5	0.9	0.00	0.0	12.5	0.0	0.9	0.0	12.47
	21-	56.7	2.9	30.7	1.1	0.00	0.0	30.7	0.0	1.1	0.0	30.73
Sep.	1-10	35.5	3.8	9.5	2.0	0.00	0.0	9.5	0.0	2.0	0.0	9.49
	11-20	27.7	3.7	1.6	1.9	0.00	0.0	1.6	0.0	1.9	0.0	1.65
	21-	99.8	6.3	73.8	4.5	0.00	0.0	73.8	0.0	4.5	0.0	73.80
Oct.	1-10	185.7	9.3	159.7	7.5	0.67	2.8	156.9	4.0	3.5	0.0	156.89
	11-20	111.1	7.0	85.1	5.2	0.97	4.1	80.9	5.7	(0.6)	0.6	80.36
	21-	70.0	4.2	44.0	2.4	1.08	4.6	39.4	6.4	(4.0)	4.0	35.46
Nov.	1-10	112.7	4.1	86.7	2.3	1.48	6.3	80.4	8.8	(6.4)	6.4	73.94
	11-20	82.1	4.3	56.1	2.5	0.33	1.4	54.7	2.0	0.6	0.0	54.66
	21-	85.6	4.1	59.6	2.3	0.06	0.3	59.4	0.4	2.0	0.0	59.38
Dec.	1-10	78.3	7.8	52.3	6.0	1.27	5.4	46.9	7.5	(1.5)	1.5	45.36
	11-20	91.8	5.2	65.8	3.4	0.58	2.5	63.4	3.4	0.0	0.0	63.35
	21-	73.0	4.7	47.0	2.9	1.67	7.1	39.9	9.9	(7.0)	7.0	32.89

Note: (7.5) = Minus Value

Maintenance Discharge; Monthly 10 Year drought Discharge

Silau River	26.0	m3/s
Bunut River	1.8	m3/s

Average Discharge = Design Discharge - Maintenance Discharge

Potential Irrigable Area:

Silau River System:	**4,251 ha**
Bunut River System:	**5,922 ha**
Beluru River System:	**128 ha**
Total Area:	**10,300 ha**

Table C-11 PROPOSED IRRIGATION SYSTEM

No.	Source of Water	Name of Main System	Intake Facility	Area (ha) Gross Area	Gross Sawah	Net Sawah	Peak Diversion Discharge (M3/S)
1.	Silau R.	Silau Kr.	Silau Integrated Weir	3,644.2	2,863.2	2,565.5	4.28
2.	Silau R.	Silau Kn.	Silau Integrated Weir	2,326.9	1,881.6	1,685.2	2.81
	Sub-Total- Silau R. (1-2)			5,971	4,745	4,251	7.09
3.	Bunut R.	Serbangan	Serbangan Weir	4,160.3	3,025.4	2,709.4	4.52
4.	Bunut R.	Meranti	Meranti Weir	2,184.5	1,890.4	1,692.9	2.83
5.	Bunut R.	Panca Arga	Panca Arga Weir	1,807.8	1,696.4	1,519.3	2.54
6.	Bunut R.	Beluru	Beluru Weir	175.4	142.3	127.5	0.21
	Sub-Total-Bunut Area (3-6)			8,328	6,755	6,049	10.10
	TOTAL			14,299	11,499	10,300	17.19

Table C-12 PROPOSED DRAINAGE SYSTEM

No.	Water Shed	Name of Main System	Outlet River/Canal	Project Area		External Area		Total Drainage Discharge (M3/S)
				Area (ha)	Discharge (M3/S)	Area (ha)	Discharge (M3/S)	
1.	Silau/Asahan	(1) Serdan	Serdan R.	948.8	3.04	-	-	3.04
		(2) SI Umbut2	Dp. Si Umbut2	687.7	2.28	400.0	2.40	4.68
		(3) Air Joman	Dp. Air Joman	1,331.2	4.43	1,140.0	6.22	10.65
		(4) Kapias	Kapias R.	350.0	1.12	-	-	1.12
		(5) Bandar Jepang	Dp. Bandar Jepang	2,264.4	7.37	9,700.0	44.60	51.97
		(6) Tg. Balai	Asahan R.	62.5	0.23	-	-	0.23
2.	Bunut R.	(1) Air Hitam	Dp. Air Hitam	568.4	1.86	900.0	2.68	4.54
		(2) Panca Arga	Dp. Meranti	1,521.8	4.92	-	-	4.92
		(3) Beluru	Beluru R.	511.6	1.68	400.0	2.40	4.08
		(4) Serani	Serani R.	326.5	1.05	-	-	1.05
3.	Bagan Batak	Bagan Batak	Dp. Bagan Batak	1,239.4	3.79	900.0 *	2.68	6.47
4.	Tambung Tulang	Tambung Tulang	Dp. Tambung Tulang	3,332.4	10.52	1,000.0 *	2.95	13.47
5.	Silo Bonto	Silo Bonto	Dp. Silo Bonto	1,154.4	3.74	4,100.0 *	18.32	22.06
	Total			14,299	46.03	18,540	82.25	128.28

Note: * ; Drainable area of swampy area downstream of the project area included.

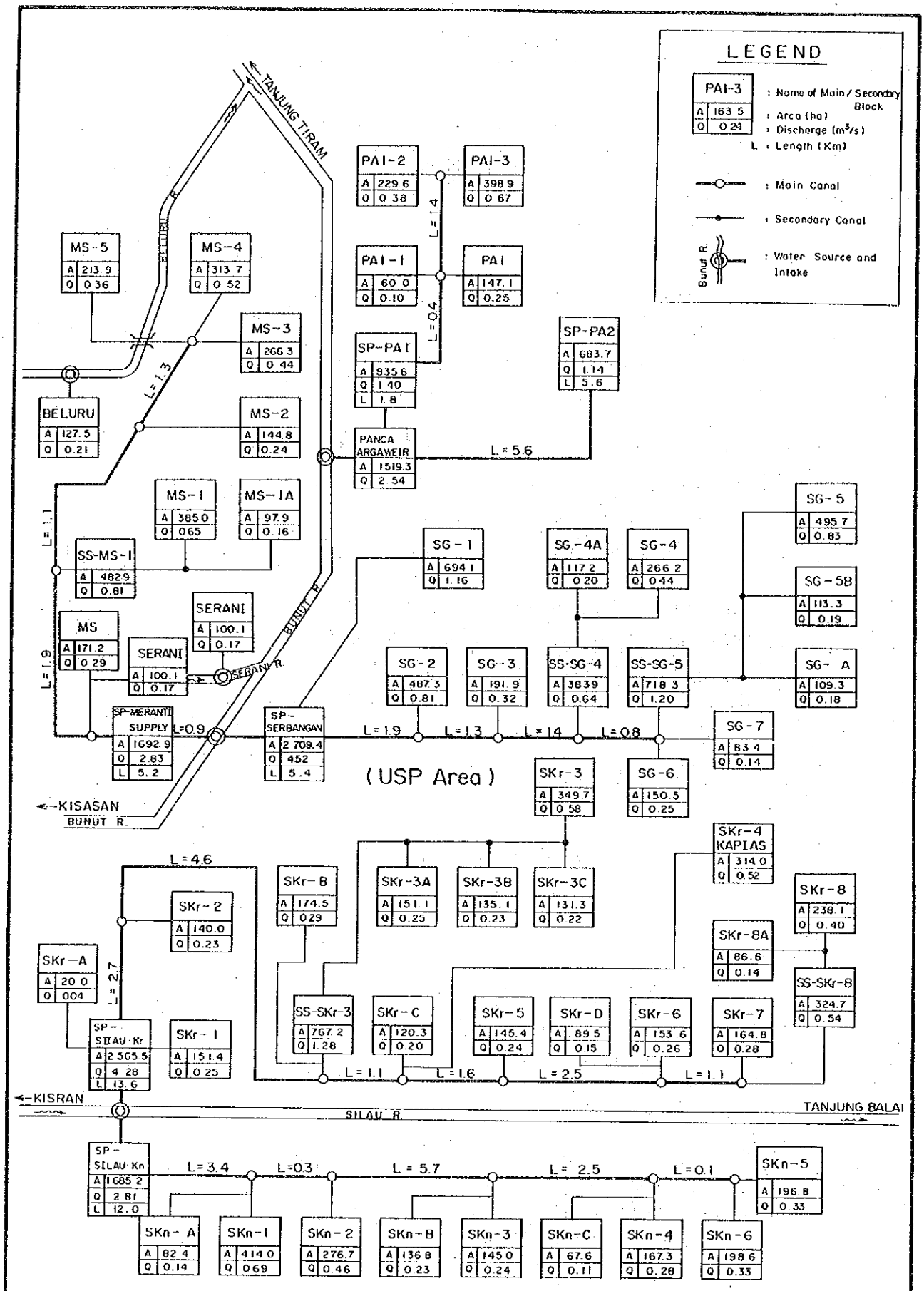

Fig. C - 8 PROPOSED IRRIGATION DIAGRAM

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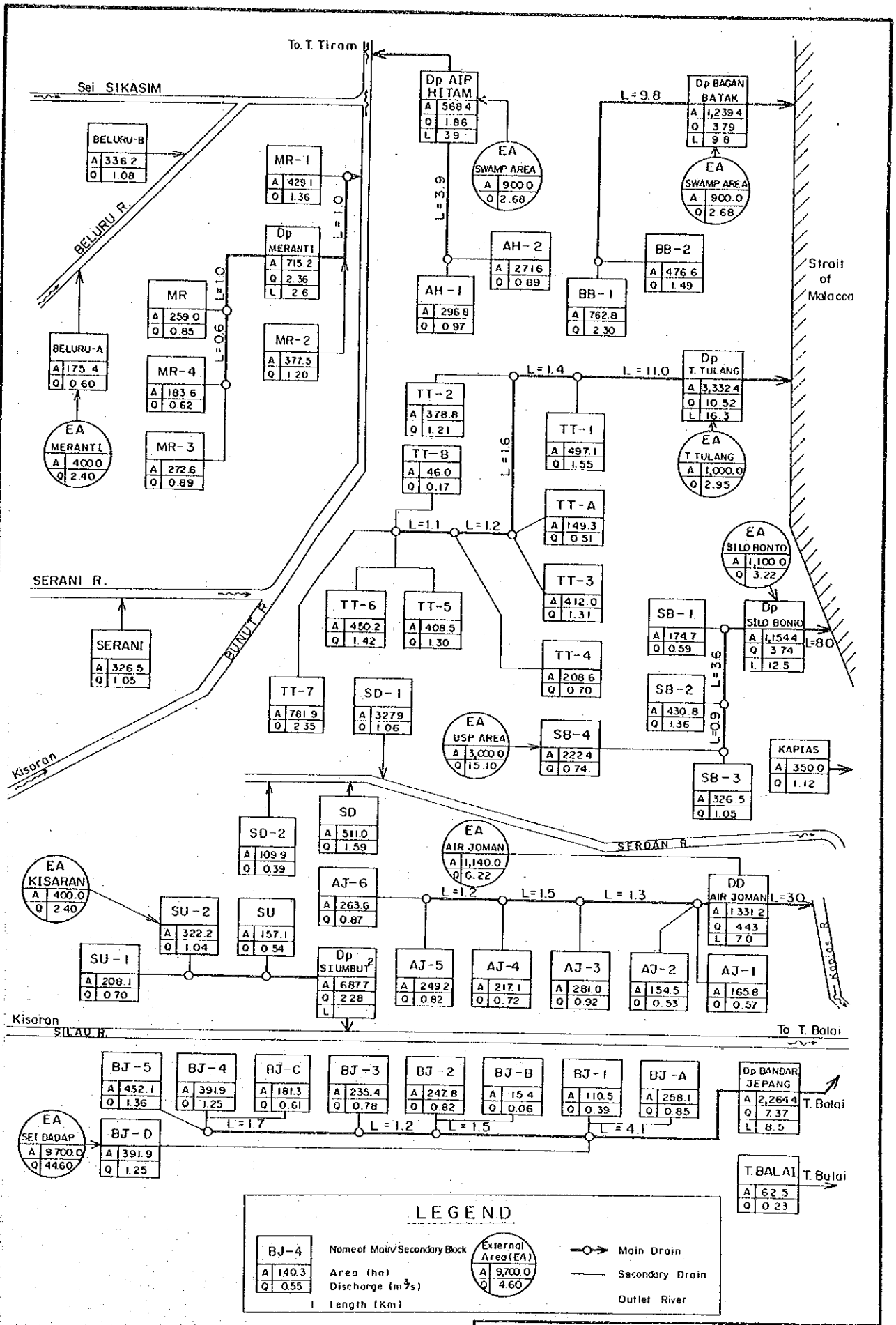

Fig. C - 9 PROPOSED DRAINAGE DIAGRAM

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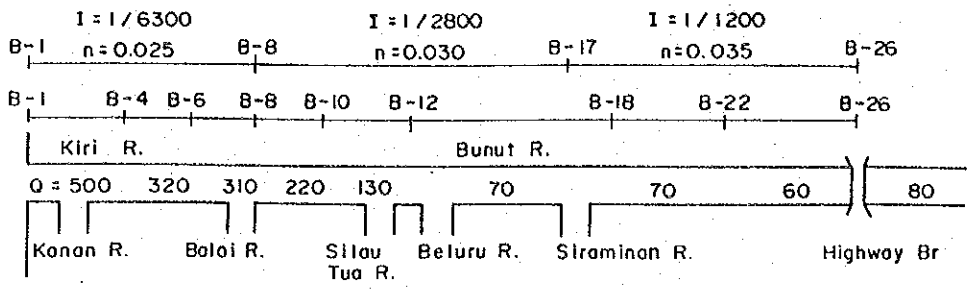
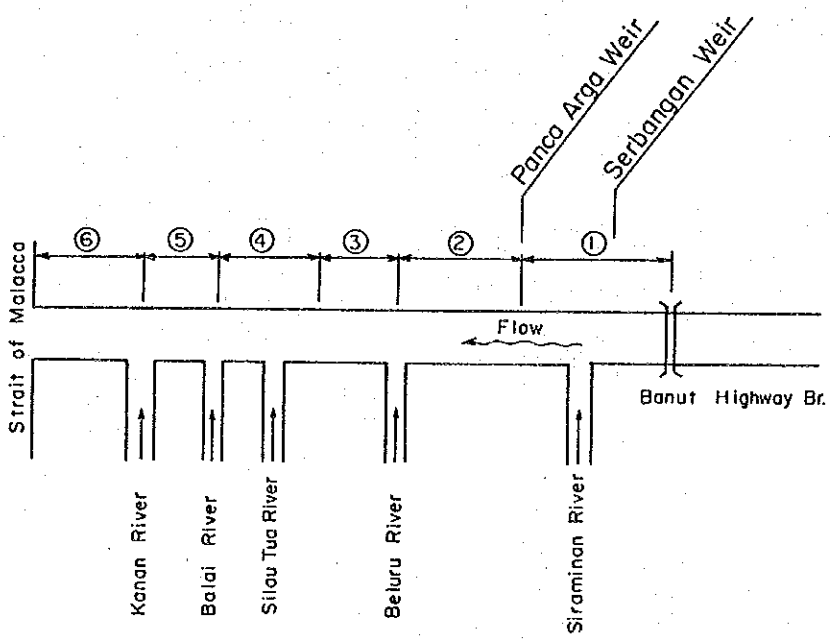
Discharge Capacity of Existing River Channel



Flood Distribution Plan



Probable Flood Discharge

(Unit : m^3/s)

Return Period / Setion	1/5	1/10*	1/30
①	65	70	80
②	120	130	150
③	170	190	210
④	240	260	290
⑤	310	340	380
⑥	340	360	390

* Applied for the Project.

Fig. C-10 FLOOD DISTRIBUTION PLAN OF BUNUT RIVER

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Table C-13 LIST OF PROPOSED O&M EQUIPMENT

No.	Item	Specification	Required Nos.	Remarks
I.	Operation Equipment			
	(1) Jeep type car	4,000 cc, 4 x 4	4	
	(2) Station wagon	1,500 cc, 4 x 4	1	
	(3) Motor cycle	100 cc	25	
	(4) Wireless radio	50 km	5	
	(5) Personnal computer	16 bit w/printer	2	
II.	Maintenance Equipent			
	(1) Hydraulic backhoe	0.4 m2/swamp type	2	
	(2) Angle dozer	11 ton	2	
	(3) Wheel loader	1.0 m3	1	
	(4) Motor grader	9 ton/3.1. m	1	
	(5) Slope compactor	3 ps	4	
	(6) Concrete mixer	0.12 m2	2	
	(7) Submergible pump	50 mm dia.	2	
	(8) Portable generator	3 kVA	2	
	(9) Dump truck	6 ton	2	
	(10) Cargo truck	6 ton/crane	1	
	(11) Pick-up truck	1 ton, 4 x 4	2	
III.	Meteo-hydrological Equipment			
	(1) Rain gauge	7 days	3	
	(2) Meteo-station	standard set	2	
	(3) Water level gauge	Automatic (7 days)	5	

Note: Since no O&M equipment of the irrigation service office is available at present, a one set of the O&M equipment is proposed.

Table C-14 COMPARISON OF MOVABLE WEIR TYPE

Item	Roller gate	Flap gate	Rubber tube gate
1 Gate body			
(1) Gate type	Plate girder roller gate	Fish-belly type	Rubber tube (Air filling up type)
(2) Dimensions	20.0 m (w) x 3.0 m (h) x 8 nos.	43.5 m (w) x 2.55 m (h) x 4 nos.	40.2 m (w) x 2.55 m (h) x 4 nos.
(3) Materials	Steel	do. as left	Rubber
(4) Weight			
2 Civil works			
(1) Piers (b x l x nos)	2.0 m x 11.0 m x 9 nos.	2.0 m x 8.0 m x 5 nos.	3.5 m x 8.0 m x 5 nos.
(2) Foundation	RC pile (ø=500, l=10 m), 81 nos.	Non	Non
3 Operation			
(1) Flow control			
- Control method	Under flow (possible delicate control)	Over-flow(possible delicate control)	Overflow (On-off control only)
- Flood time	Starting generator by manually	Automatic tumbling with relation to the water level sensor	Automatic tumbling with relation to the water level sensor
(2) Flushing of silt	Partial open (jet flow flushing)	Full open of a part of gate	Full open of a part of gate
4 Maintenance			
(1) Painting	Once every 5 years required	do. as left	Not required
(2) Repair	Fulfill every portion by local technics	Fulfill by local except pressure pipe	Fulfill by local except pressure pipe and rubber body
(3) Cost	Medium	Medium	Medium
5 Durability	More than 30 years	More than 30 years	More than 30 years (Recent information shows more than 30 years)
6 Construction period	Long (2 years)	Rather short (1.5 years)	Rather short (1.5 years)
7 Construction cost (Direct cost only, Unit : Rp. million)			
(1) Gates (incl. intake gate, etc)	6,480	5,125	3,520
(2) Civil works	2,330	2,030	2,030
(3) Others	890	725	565
(4) Total	9,700	7,880	6,115
(Ratio)	(100)	(81)	(63)

Table C-15 COMPARISON OF ALTERNATIVE INTER-BASIN DIVERSION PLANS

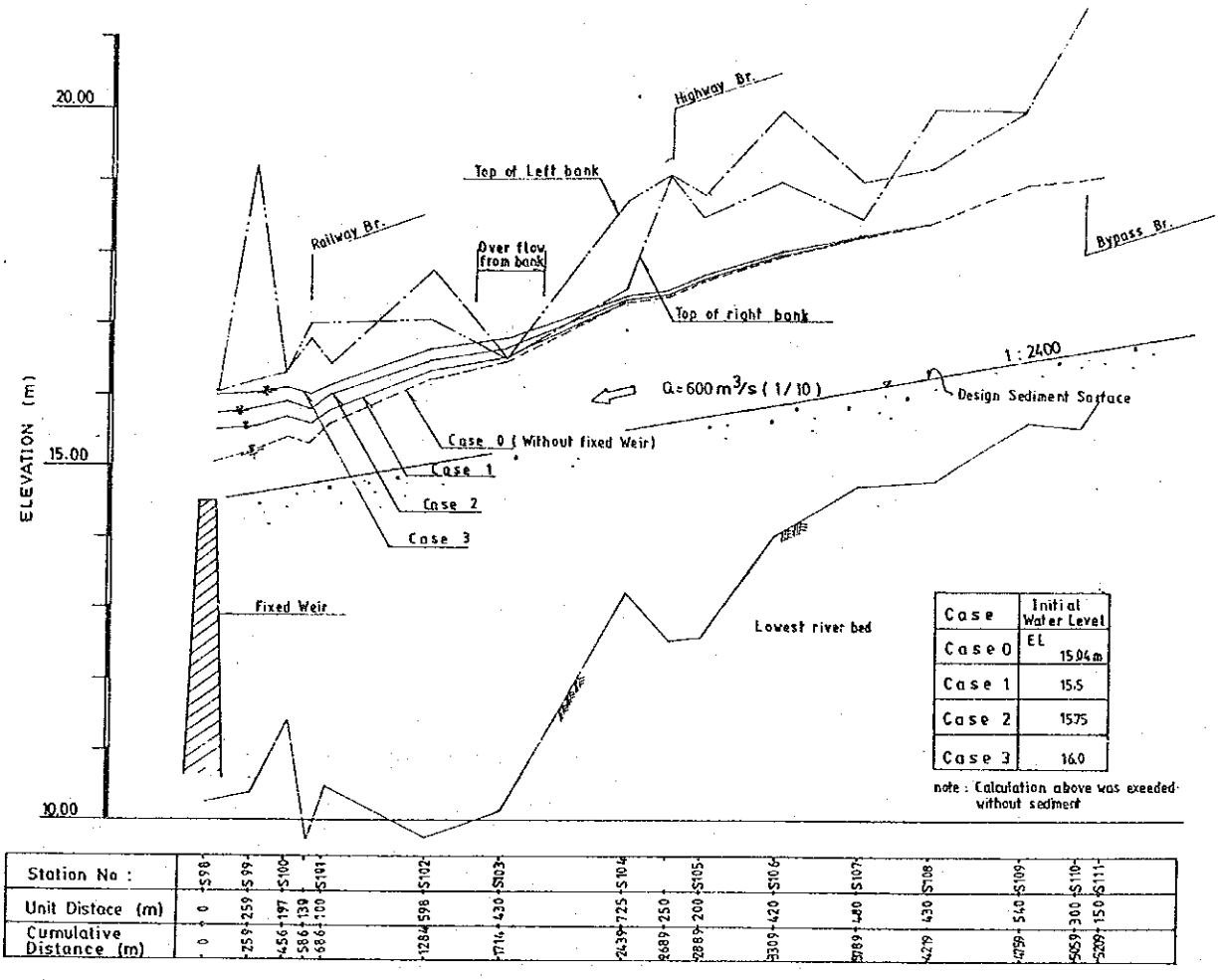
Item	Alternative 1	Alternative 2 (Proposed Plan)	Remarks
I. General			
- Diversion point on the Silau	Prapat Janji, 20 km upstream Kisaran	Siumbut Umbut, 1 km downstream Kisaran	
- Inflow point to Bunut	Sidodadi, 16 km upstream Kisaran	1.5 km upstream Serbangan Weir	
- History	Proposed by DPU in 1983 and PR-III	Alternative Plan newly proposed	PR-III:Progress report III in Oct. 1989
II. Physical Condition			
- Diversion discharge	7.8 m3/sec	7.4 m3/sec	In Alt-1, conveyance loss of 5% through the Bunut river is considered
- Intake facility	Independent side-overflow Free Intake	Conjunctive use of the Silau Integrated weir	In Alt-1, the similar Silau integrated weir is also required to supply the stable irrigation water to the Silau area
- Inter-basin canal	Enlargement of existion drain through oil palm plantation area (6.1 km)	New channel through Rubber plantation area (8.3 km)	
- River improvement	Enlargement of river cross sections of the Bunut river (15.8 km)	Not required	
- Construction Cost(Rp. mill)	3,837	3,103	
III. Operation and Maintenance			
- Daily operation and Maintenance	Difficult to communicate with the irrigation area downstream	Easy to operate in accordance with demand of the Bunut irrigation area	
- Access condition	Approx. 1 hr from Kisaran via Kabupaten road	Within 10 min. from Kisaran by asphalt paved Kabupaten road	

Table C-16 UPGRADING PLAN OF WEIRS ON THE BUNUT RIVER

Item	Serbangan weir	Panca Arga weir	Beluru weir
I CONDITIONS OF EXISTING STRUCTURES			
1 Dimension s			
(1) Construction year	1943	1974	1983
(2) Weir body			
Type	Wooden stop-log weir (Semi permanent)	Concrete fixed weir	Gabion matress fixed weir
W X H (m)	2.0(w) x1.7(h) (6 spans)	Crest width = 9.0 m	Crest width = 13.5 m
(3) Intake gate(s)	Right bank	Right bank	Right bank
W X H (m)	1.7 x 1.0 (5 nos)	1.0 x 1.0 (1 no)	1.0 x 1.0 (1 no)
	Left bank	Left bank	
	1.4 x 1.0 (3 nos)	1.0 x 1.0 (1 no)	
2 Flood flow capacity of existing weir (m3/sec)*	80 m3/s	12 m3/s	21 m3/s
3 Main constraints	- Leakage from stop-logs - Deterioration of foundation (45 years) - Wooden intake gates are deteriorated	- Flooding caused by the weir - Intake gates are not functioned well	- Leakage from weir body - Intake gates are not functioned well
II UPGRADING PLAN			
1 Conditions			
(1) Design flood discharge (30-year flood)	80 m3/s	80 m3/s	60 m3/s
(2) Irrigation command area (ha)	Right bank : 2,710 ha Left bank : 1,690 ha	Right bank : 1,520 ha	Right bank(1) : 130 ha
(3) Intake discharge (m3/s)	Right bank : 4.52 m3/s Left bank : 2.83 m3/s	Right bank : 2.54 m3/s	Right bank : 0.21 m3/s
2 Upgrading plan of diversion structure			
(1) Type	Manually-operated roller gate (Installing of steel gates)	Concrete fixed weir (Widening the weir crest)	Concrete fixed weir (Existing gabion matress is fully used)
(2) Dimensions			
Crest El.	-	El. 4.8	El. 13.0
Weir height	-	0.8	2.0
Crest length	-	25.0	13.5
Diversion gate	2.5 (w)x 2.0 (h) x 6 nos.	-	-
Sluice gate	-	2.0 (w)x 1.0 (h) x 1 no.	1.3 (w)x 2.0 (h) x 2 nos.
3 Intake structure and Related facilities			
(1) Replacement of intake gate	2.5 (w)x 2.0 (h) x 2 nos. 1.5 (w)x 2.0 (h) x 2 nos.	1.6 (w)x 1.0 (h) x 2 nos.	1.0 (w)x 1.0 (h) x 1 no.

Note: Design concept of the upgrading plan
(1) The diversion structure should pass the design flood discharge safely.
(2) Conditions of the existing structure are to be maintained as far as possible.

*: Freeboard of 60 cm is considered for estimating the flow capacity.



Station No :	S98	S99	S100	S101	S102	S103	S104	S105	S106	S107	S108	S109	S110	S111
Unit Distace (m)	0	259	197	139	598	430	725	250	200	420	480	430	540	300	150
Cumulative Distance (m)	0	259	456	586	1284	1714	2439	2689	2889	3309	3789	4219	4759	5059	5209

Fig. C-11 BACKWATER EFFECT BY FIXED WEIR

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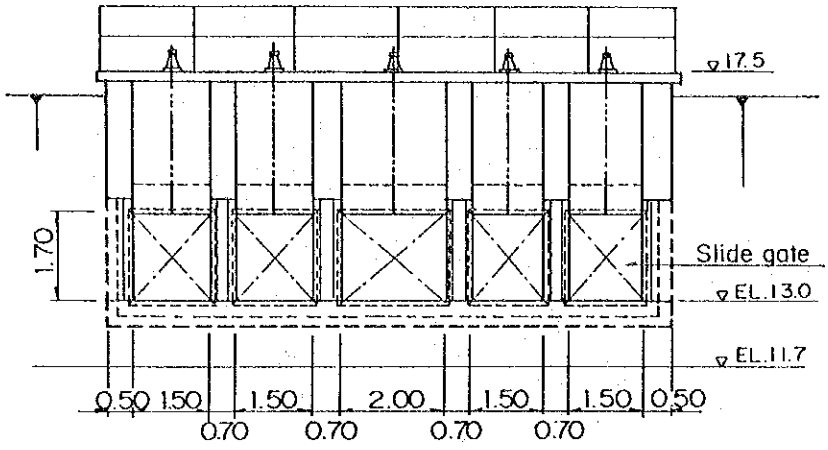
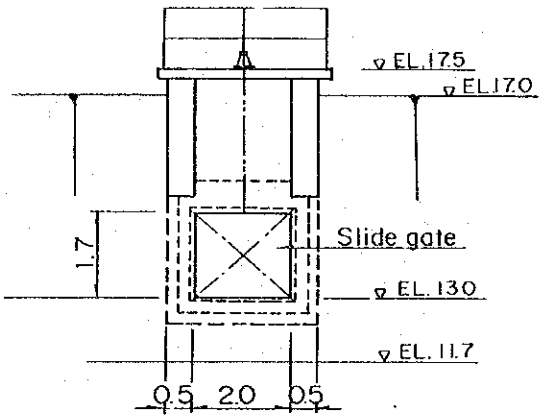
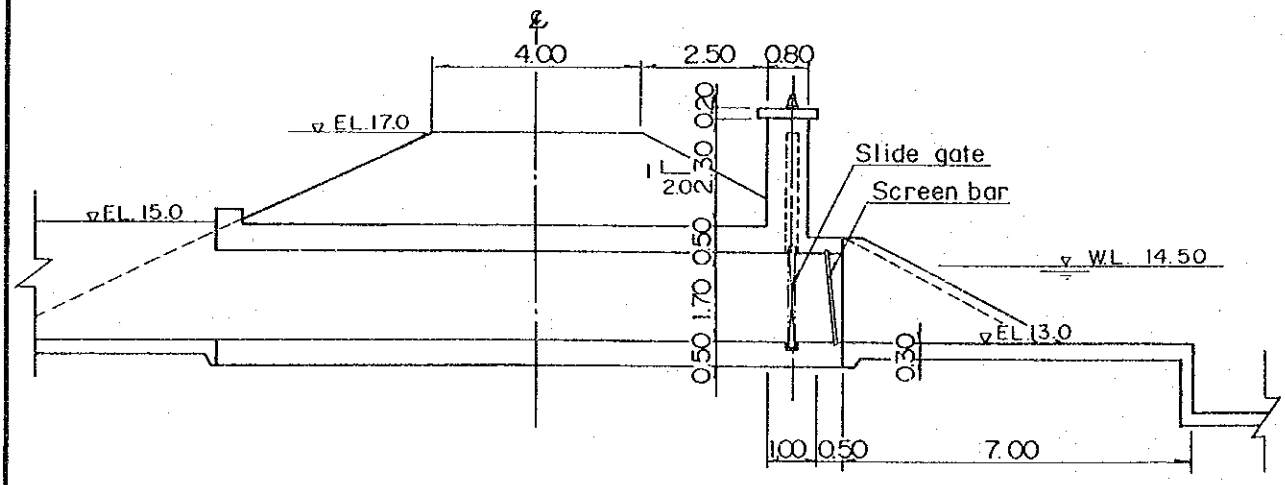


INTAKE GATE (LEFT BANK)



INTAKE GATE (RIGHT BANK)



PROFILE OF INTAKE

0 1 2 3 4 5 10m

Scale

Fig. C-12 INTAKE STRUCTURES OF PROPOSED SILAU INTEGRATED WEIR

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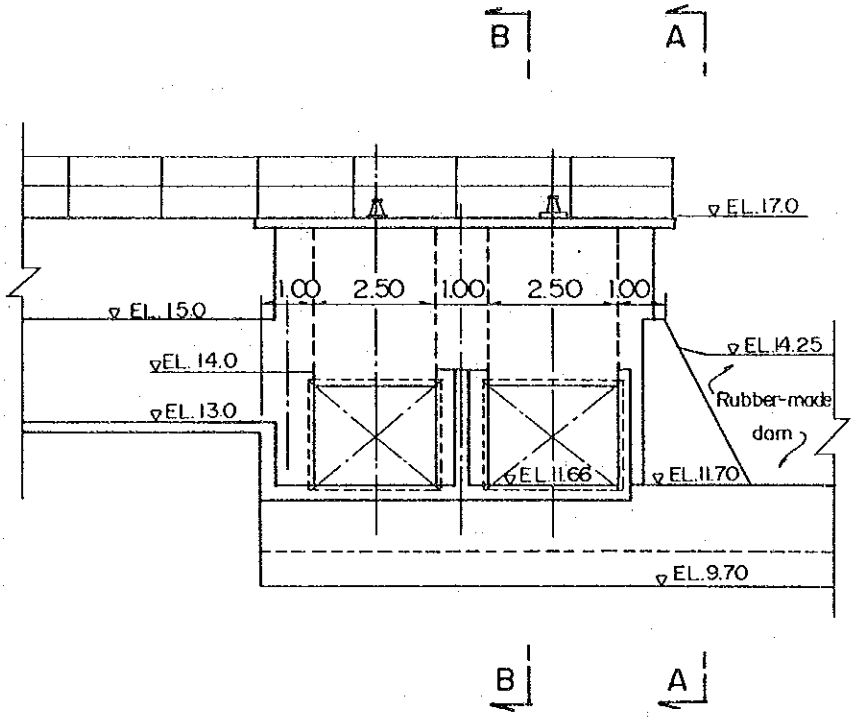
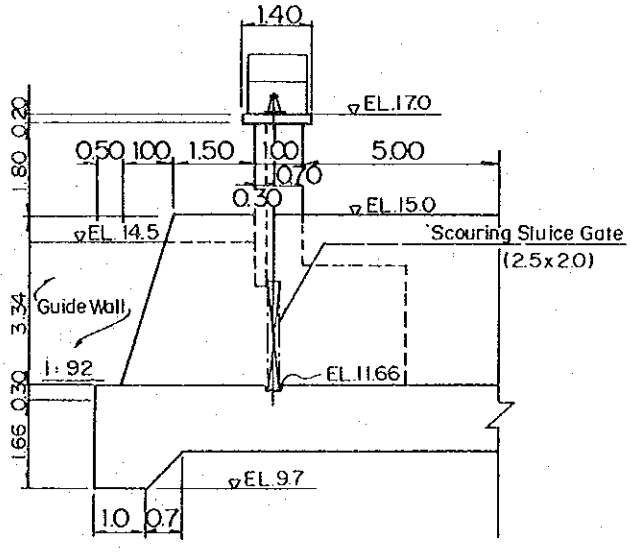
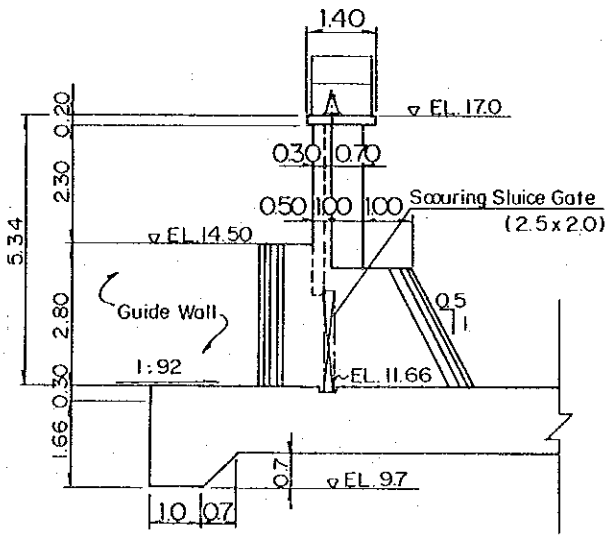


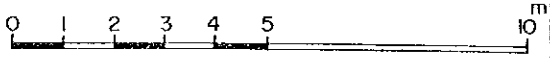
SCOURING SLUICE



CROSS SECTION A-A



CROSS SECTION B-B



Scale

Fig. C-13 SCOURING SLUICE OF PROPOSED SILAU INTEGRATED WEIR

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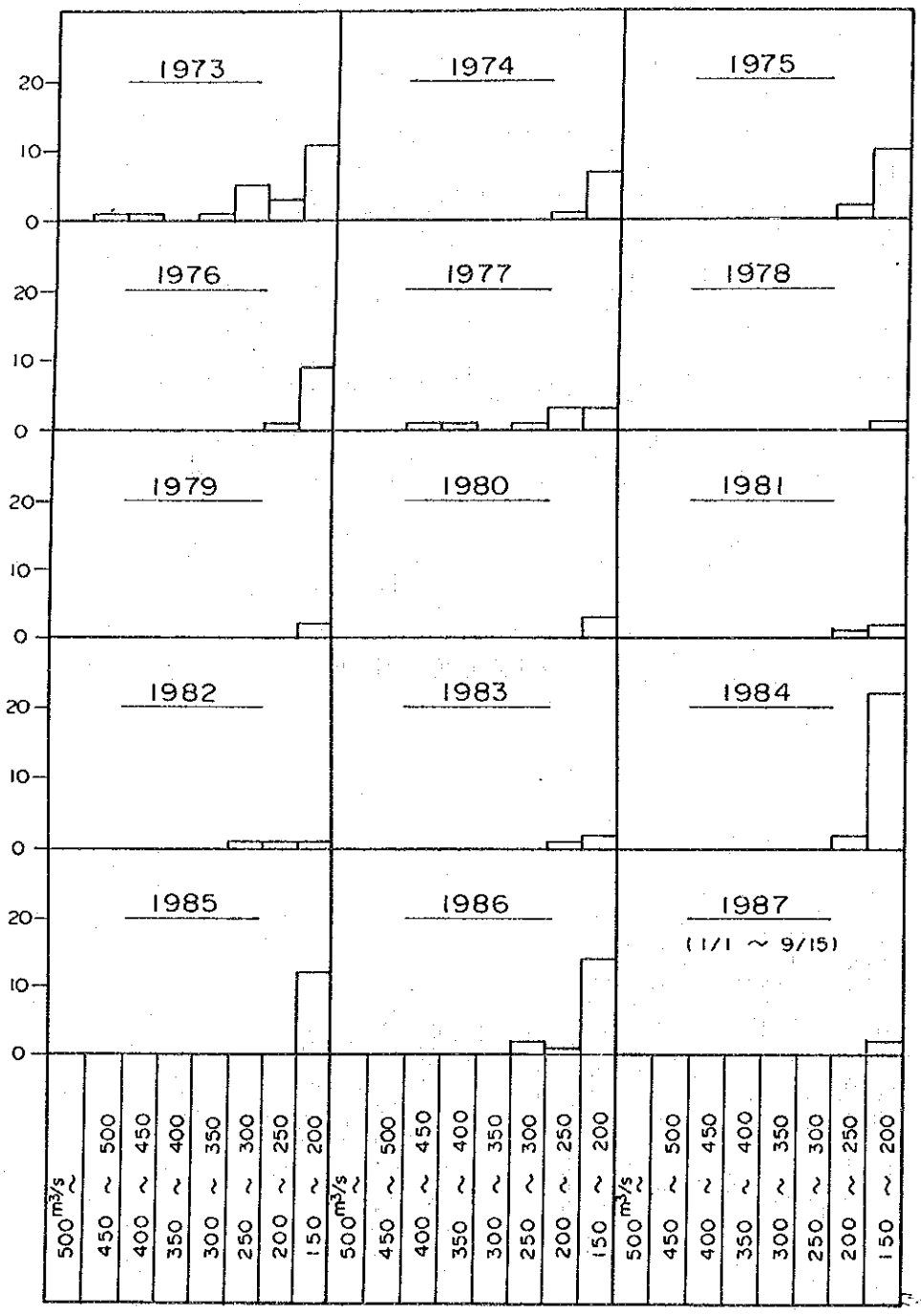

Fig. C-14 FLOOD FREQUENCY OF THE SILAU RIVER AT KISARAN

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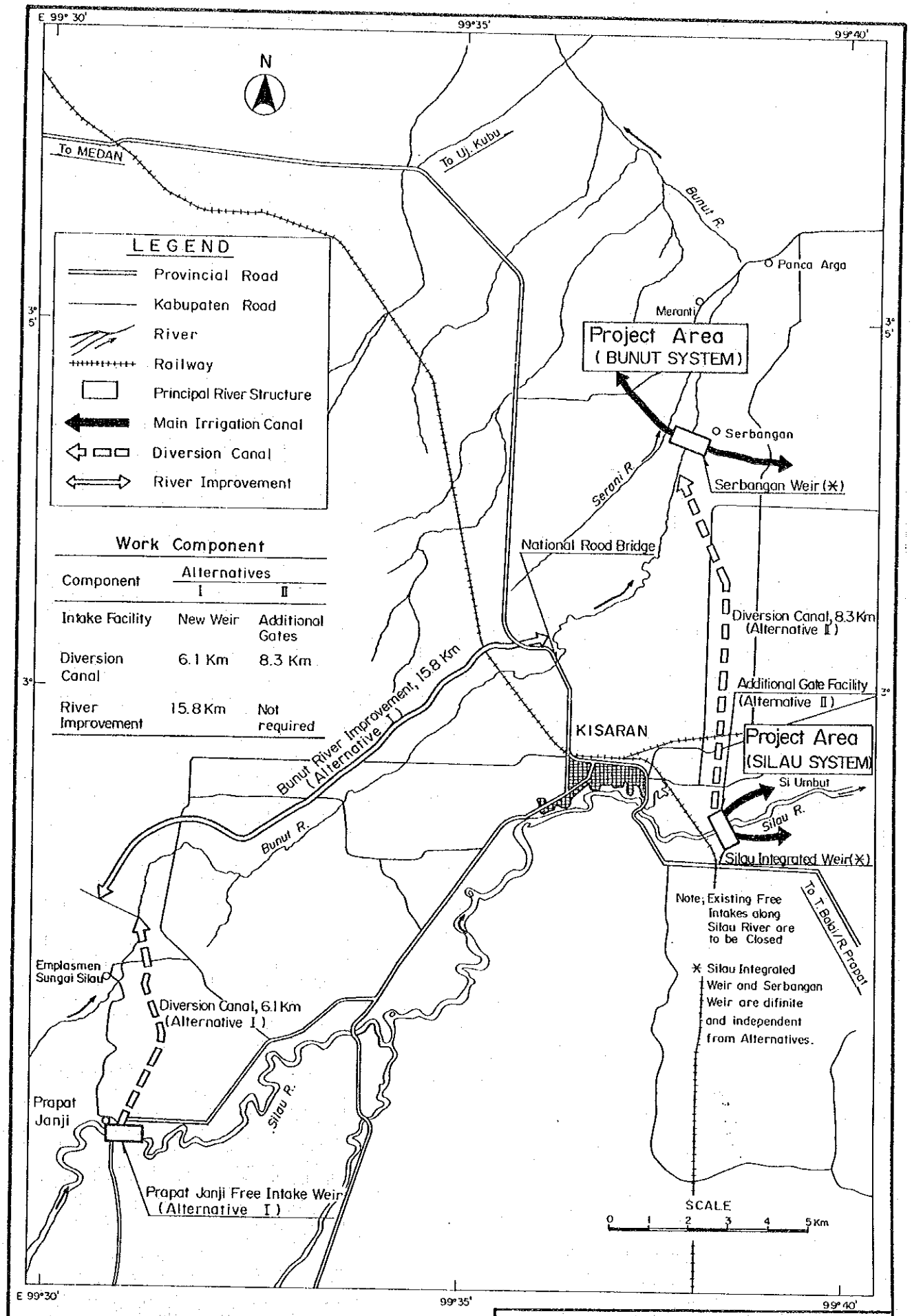

Fig.C - 15 INTER BASIN DIVERSION PLAN ALTERNATIVES

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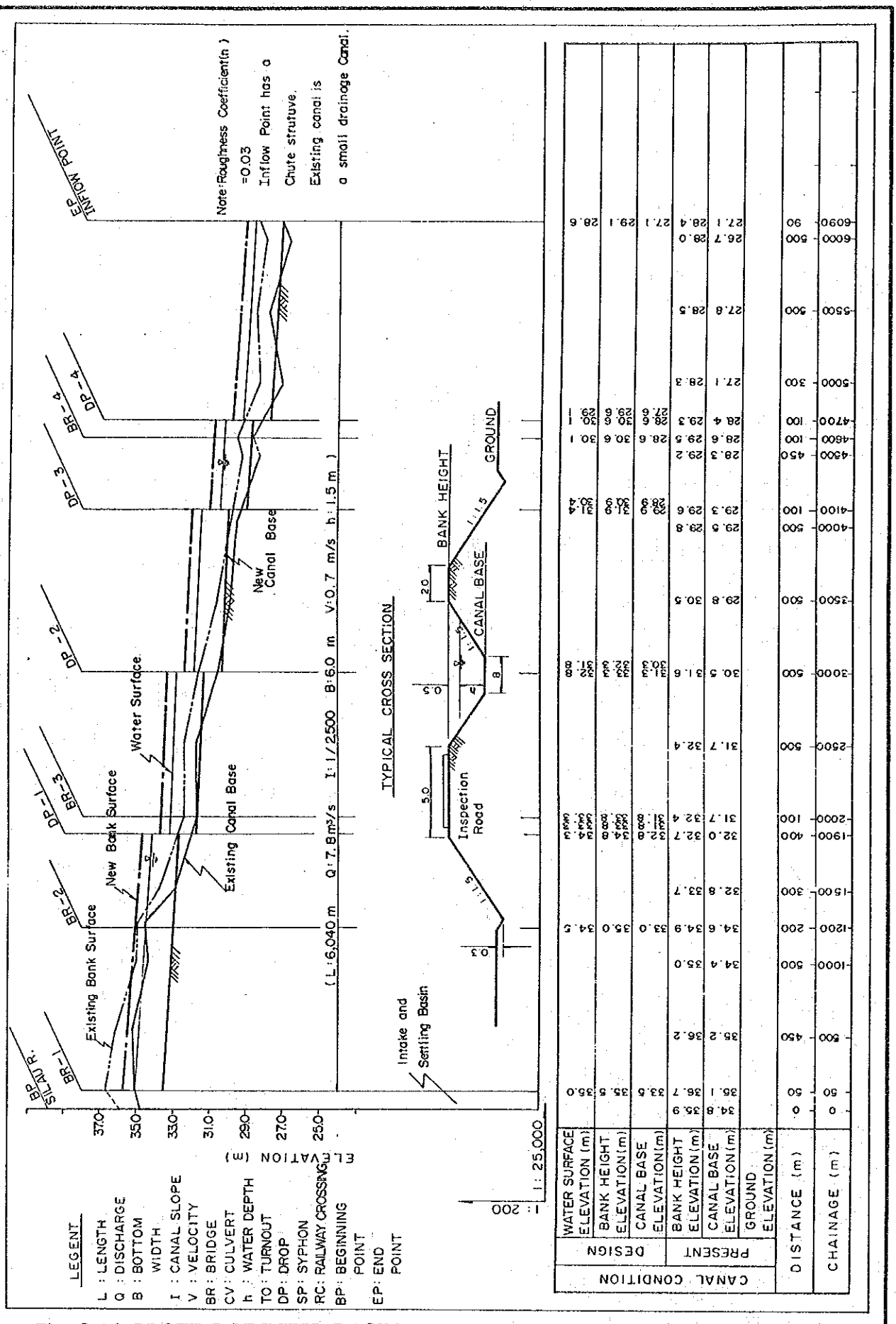

CANAL CONDITION		CHAINAGE (m)	DISTANCE (m)
PRESENT	GROUND ELEVATION (m)	0	0
	CANAL BASE ELEVATION (m)	50	50
	BANK HEIGHT ELEVATION (m)	500	450
	WATER SURFACE ELEVATION (m)	1000	500
DESIGN	CANAL BASE ELEVATION (m)	1200	200
	BANK HEIGHT ELEVATION (m)	1500	300
	WATER SURFACE ELEVATION (m)	1900	400
		2000	100
		2500	500
		3000	500
		3500	500
		4000	500
		4100	100
		4300	450
		4600	100
		4700	100
		5000	300
		5500	500
		6000	500
		6090	90

Fig. C-16 PROFILE OF INTER-BASIN DIVERSION CANAL ALTERNATIVE - 1

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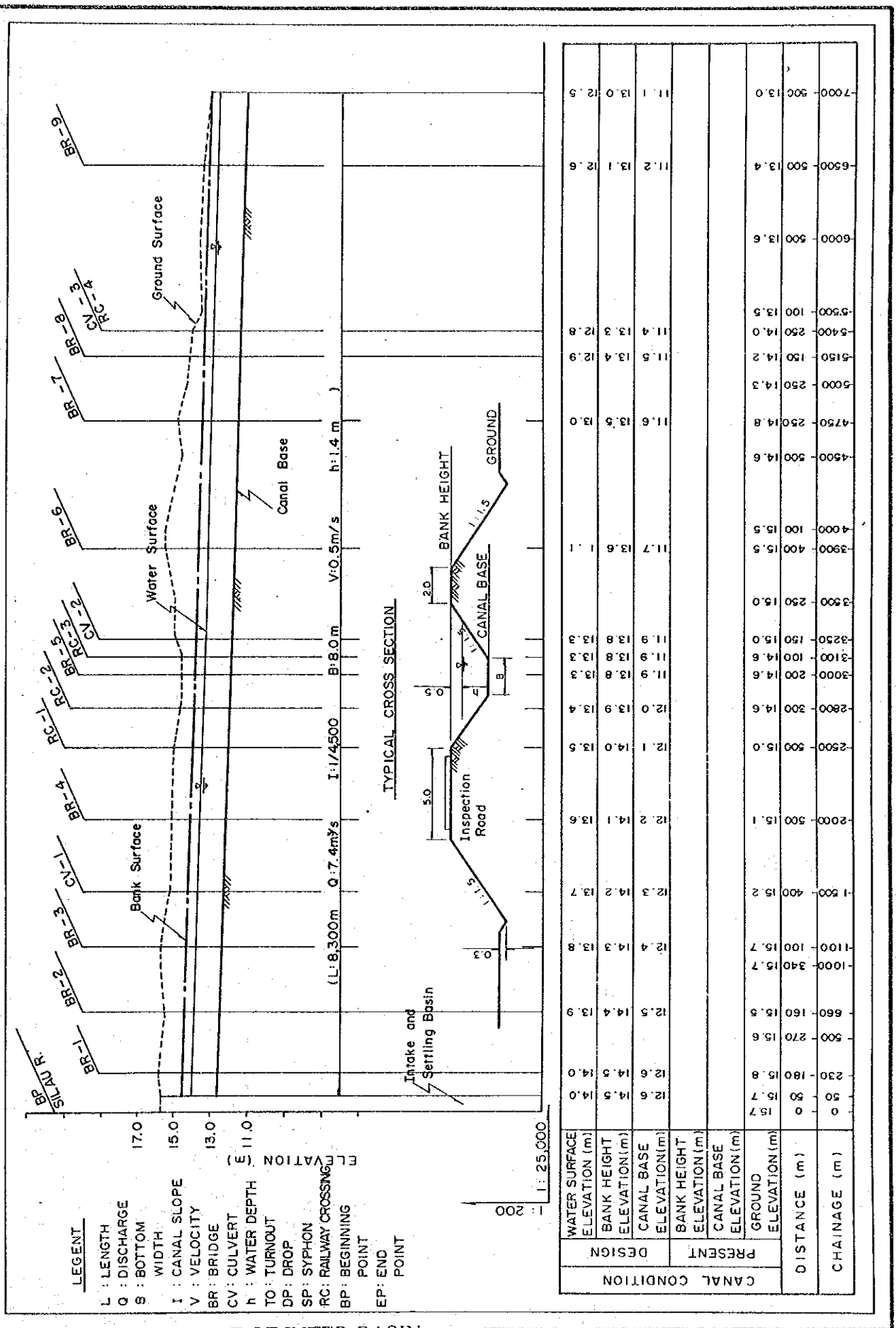

CANAL CONDITION		DISTANCE (m)	CHAINAGE (m)
DESIGN	WATER SURFACE ELEVATION (m)		
	BANK HEIGHT ELEVATION (m)		
	CANAL BASE ELEVATION (m)		
PRESENT	BANK HEIGHT ELEVATION (m)		
	CANAL BASE ELEVATION (m)		
	GROUND ELEVATION (m)		
		0	0
	15.7	50	50
14.0	14.5	14.5	12.6			180	15.8	230
						270	15.6	500
13.9	14.4	14.5	12.5			160	15.5	660
						340	15.7	1000
						100	15.7	1100
13.8	14.3	14.4	12.4			400	15.2	1500
13.7	14.2	14.3	12.3			500	15.1	2000
13.6	14.1	14.2	12.2			500	15.0	2500
13.5	14.0	14.1	12.1			300	14.6	2800
13.4	13.9	14.0	12.0			200	14.6	3000
13.3	13.8	13.9	11.9			100	14.6	3100
13.3	13.8	13.9	11.9			150	15.0	3250
13.3	13.8	13.9	11.9			250	15.0	3300
13.0	13.6	13.7	11.7			400	15.5	3900
						100	15.5	4000
12.9	13.4	13.5	11.5			300	14.6	4500
12.8	13.3	13.4	11.4			250	14.8	4750
						250	14.3	5000
12.9	13.4	13.5	11.5			150	14.2	5150
12.8	13.3	13.4	11.4			250	14.0	5400
						100	13.5	5500
12.6	13.1	13.4	11.2			500	13.4	6500
						500	13.6	6000
12.5	13.0	13.3	11.1			500	13.0	7000

Fig. C-16 PROFILE OF INTER-BASIN DIVERSION CANAL ALTERNATIVE - 2

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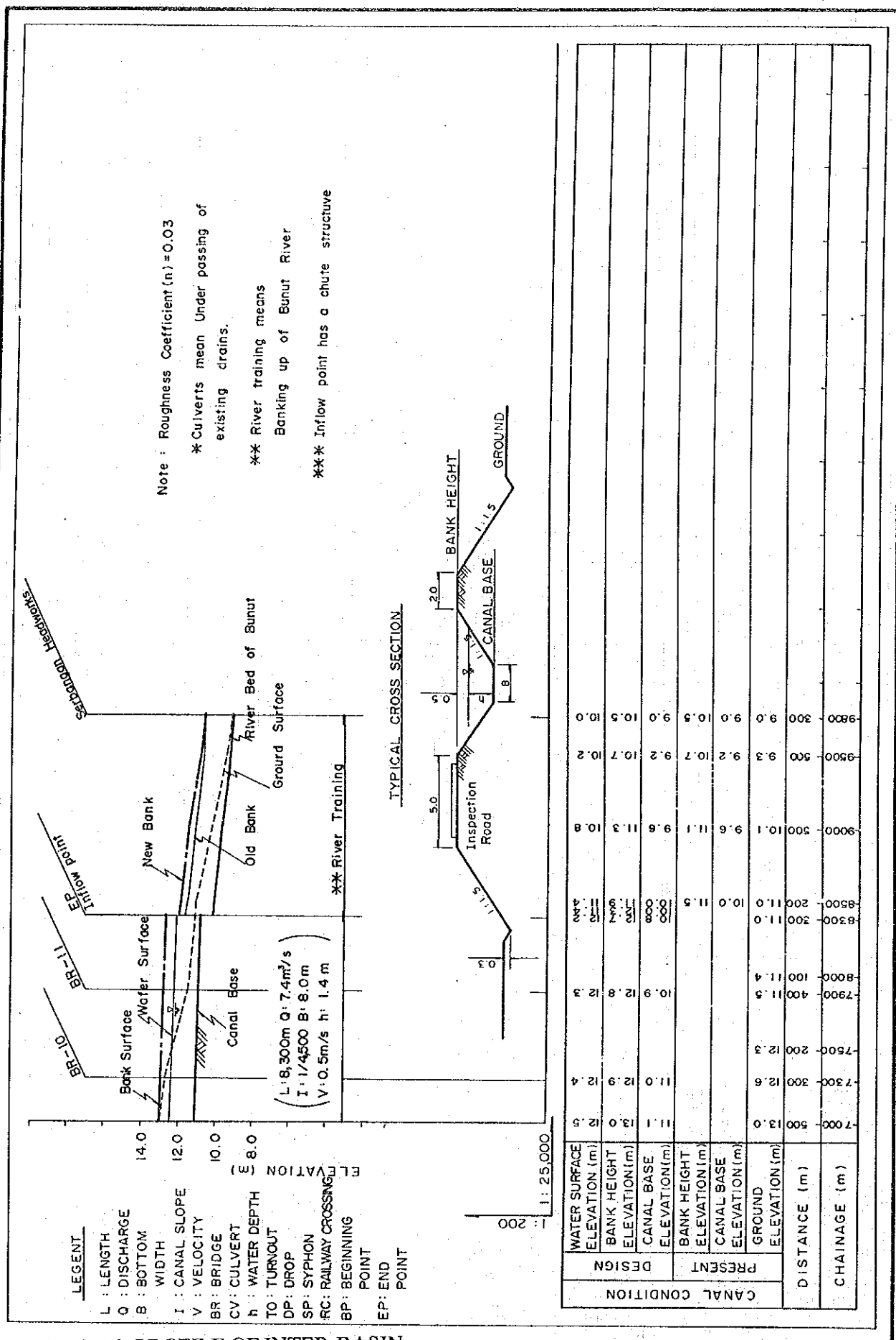

CANAL CONDITION										
DESIGN	WATER SURFACE ELEVATION (m)	12.5	12.4	12.3						
	BANK HEIGHT ELEVATION (m)	13.0	12.9	12.8						
	CANAL BASE ELEVATION (m)	11.1	11.0	10.9						
PRESENT	BANK HEIGHT ELEVATION (m)				11.5					
	CANAL BASE ELEVATION (m)					10.0				
	GROUND ELEVATION (m)	13.0	12.6	11.4	11.5	11.0	11.0	10.1	9.3	9.0
DISTANCE (m)		500	300	400	100	200	300	300	500	300
CHAINAGE (m)		7000	7300	7900	8000	8200	8300	8600	9300	9800

CANAL CONDITION										
DESIGN	WATER SURFACE ELEVATION (m)							10.8	10.2	10.0
	BANK HEIGHT ELEVATION (m)							11.3	10.7	10.5
	CANAL BASE ELEVATION (m)							9.6	9.2	9.0
PRESENT	BANK HEIGHT ELEVATION (m)							11.1	10.7	10.3
	CANAL BASE ELEVATION (m)							9.6	9.2	9.0
	GROUND ELEVATION (m)							10.1	9.3	9.0
DISTANCE (m)								300	500	300
CHAINAGE (m)								9000	9300	9800

Fig. C-16 PROFILE OF INTER-BASIN DIVERSION CANAL ALTERNATIVE - 3

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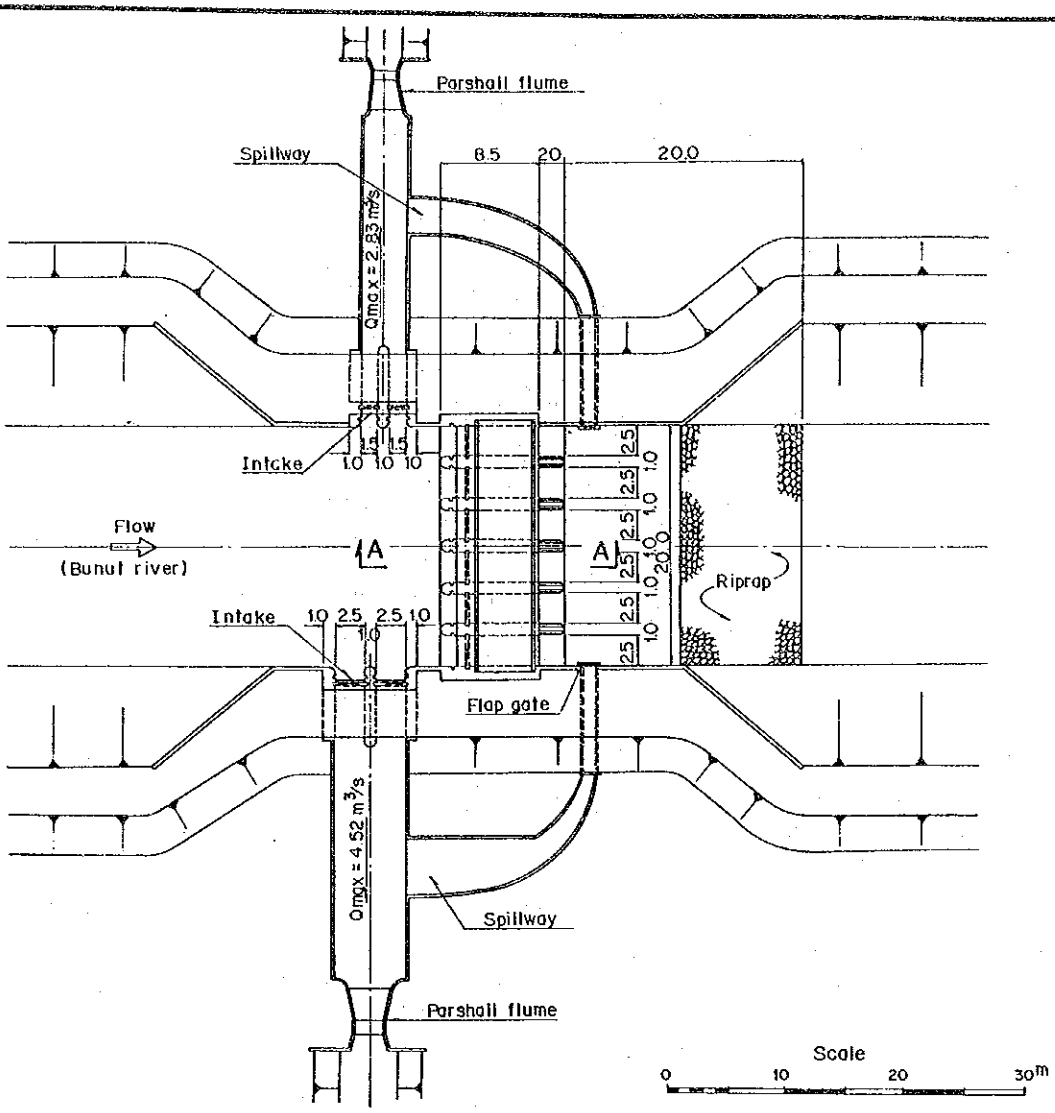
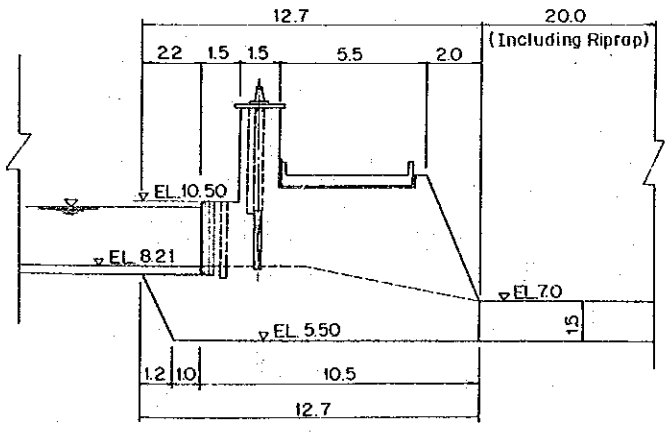


PLAN



PROFILE (A-A)

Fig. C-17 REHABILITATION PLAN OF SERBANGAN WEIR

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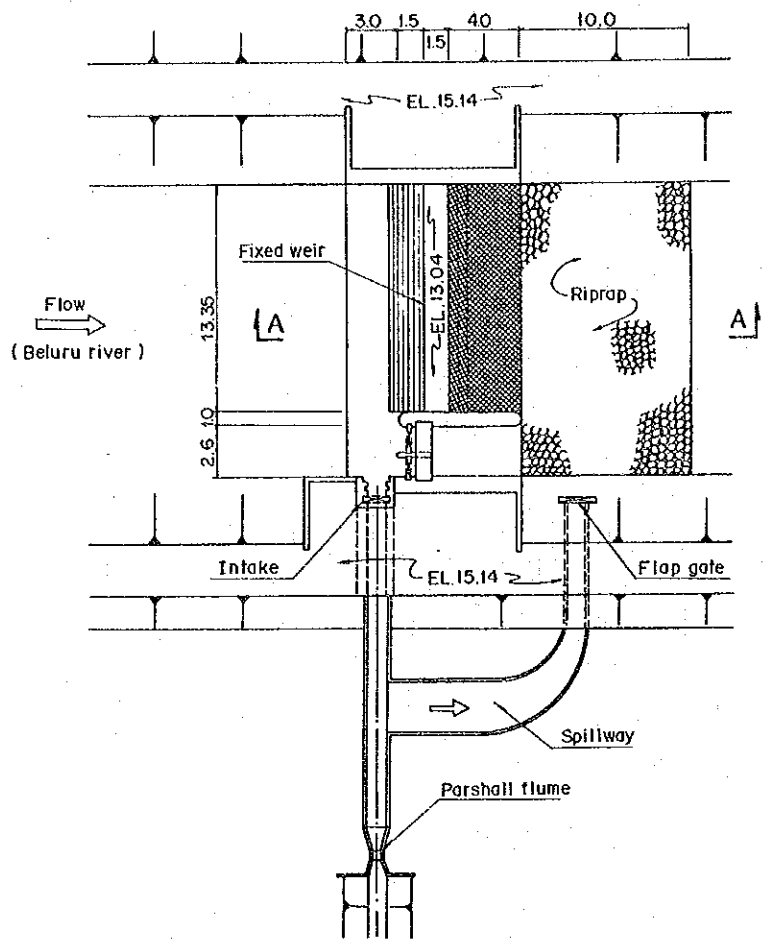
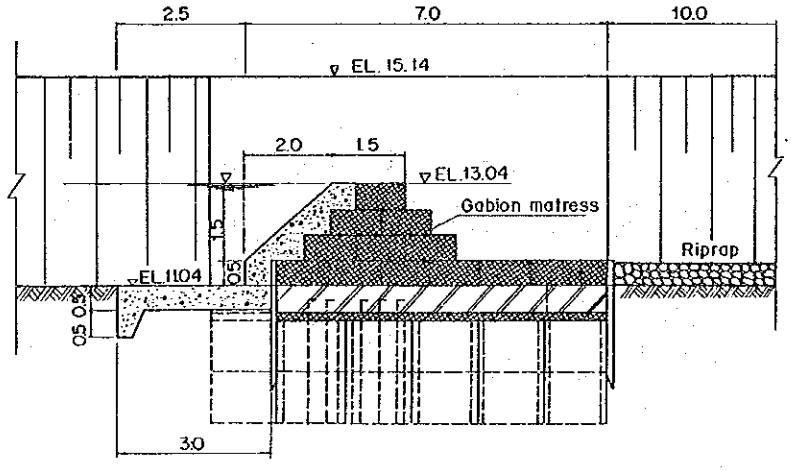


PLAN

Scale
0 10 20m



PROFILE (A-A)

Scale
0 1 2 3 4 5m

Fig. C-18 REHABILITATION PLAN OF BELURU WEIR

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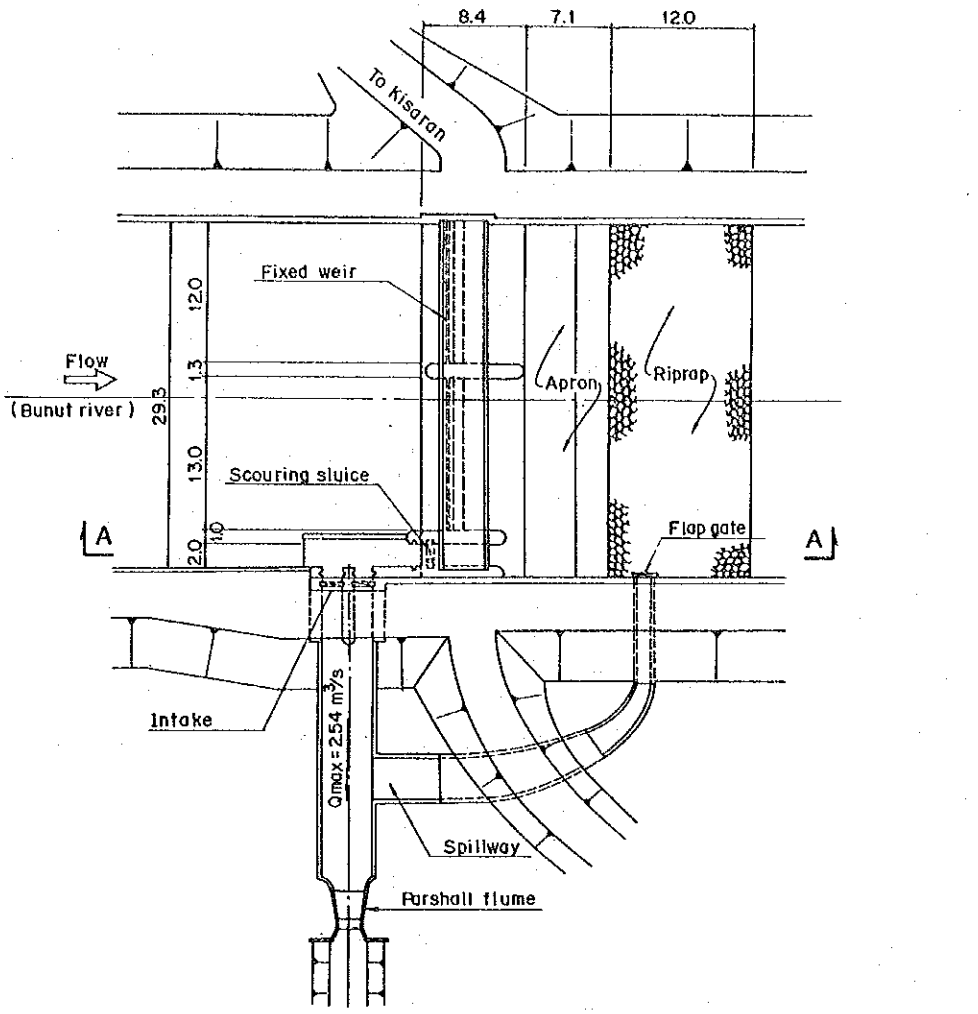
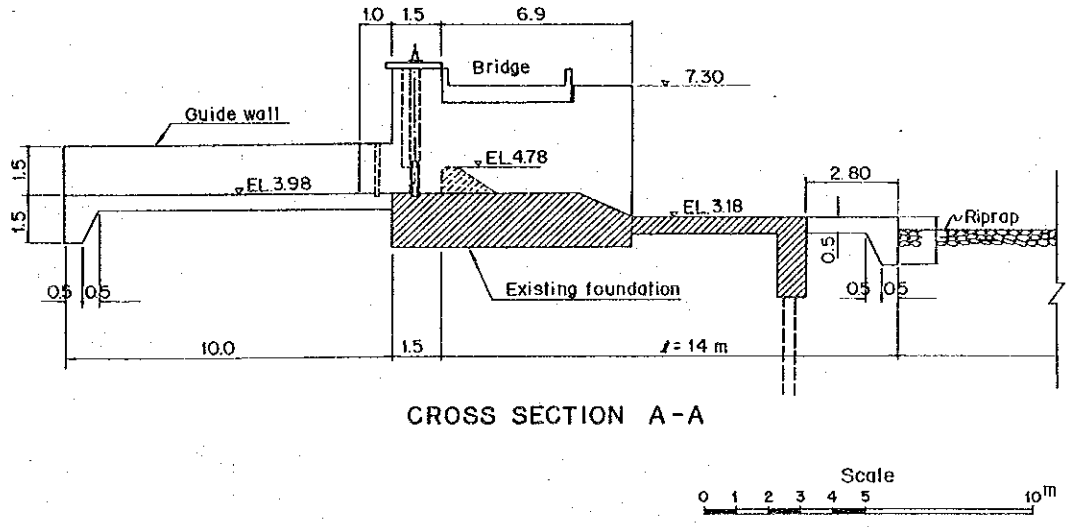


PLAN

Scale
0 10 20 30 m



CROSS SECTION A-A

Scale
0 1 2 3 4 5 10 m

Fig. C-19 REHABILITATION PLAN OF PANCA ARGA WEIR

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Table C-17 LENGTH OF MAIN AND SECONDARY IRRIGATION CANALS

No.	Name of irrigation block	Nos. of canals	Canal length (m)				
			New canal	Rehabilitation			Total
				Level I	Level II	Total	
Main Canal							
I. Silau river system							
1	Silau Kanan	1	10,000	2,000	0	2,000	12,000
2	Silau Kiri	1	5,700	5,100	2,800	7,900	13,600
	Sub-total	2	15,700	7,100	2,800	9,900	25,600
II. Bunut river system							
3	Serbangan	1	0	3,900	1,500	5,400	5,400
4	Panca Arga	2	6,800	0	600	600	7,400
5	Meranti	1	5,200	0	0	0	5,200
6	Beluru	0	0	0	0	0	0
	Sub-total	4	12,000	3,900	2,100	6,000	18,000
	Total	**6**	**27,700**	**11,000**	**4,900**	**15,900**	**43,600**
Secondary Canal							
I. Silau river system							
1	Silau Kanan	6	5,100	12,300	5,300	17,600	22,700
2	Silau Kiri	12	23,500	3,100	12,100	15,200	38,700
	Sub-total	18	28,600	15,400	17,400	32,800	61,400
II. Bunut river system		0	0	0	0	0	0
3	Serbangan	12	25,800	7,200	2,800	10,000	35,800
4	Panca Arga	5	7,700	500	0	500	8,200
5	Meranti	7	20,500	0	400	400	20,900
6	Beluru	1	0	300	0	300	300
	Sub-total	25	54,000	8,000	3,200	11,200	65,200
	Total	**43**	**82,600**	**23,400**	**20,600**	**44,000**	**126,600**
Main and Secondary Canal							
I. Silau river system							
1	Silau Kanan	7	15,100	14,300	5,300	19,600	34,700
2	Silau Kiri	13	29,200	8,200	14,900	23,100	52,300
	Sub-total	20	44,300	22,500	20,200	42,700	87,000
II. Bunut river system							
3	Serbangan	13	25,800	11,100	4,300	15,400	41,200
4	Panca Arga	7	14,500	500	600	1,100	15,600
5	Meranti	8	25,700	0	400	400	26,100
6	Beluru	1	0	300	0	300	300
	Sub-total	29	66,000	11,900	5,300	17,200	83,200
Irrigation Canal Total		**49**	**110,300**	**34,400**	**25,500**	**59,900**	**170,200**

Note; Level I: Special Maintenance or Reshaping only Level II: Flow Capacity Expansion Required
Source; Field Inventory Survey by JICA Oct. 1989

Table C-18 RELATED STRUCTURES ON IRRIGATION CANALS

No.	Structure	Nos of Structure New (nos)	Repair (nos)	Sub-Total	Nos of Structure New (nos)	Repair (nos)	Sub-Total	Nos of Structure New (nos)	Repair (nos)	Total
		Main			Secondary			Total		
I.	Silau river system									
1	Turn out/Diversion	28	0	28	58	12	70	86	12	98
2	Aquiduct	0	0	0	0	5	5	0	5	5
3	Siphon	0	0	0	2	0	2	2	0	2
4	Bridge	11	0	11	17	21	38	28	21	49
5	Culvert	0	0	0	6	6	12	6	6	12
6	Drop	7	0	7	0	1	1	7	1	8
7	Spillway	0	0	0	10	0	10	10	0	10
	Sub-total	46	0	46	93	45	138	139	45	184
II.	Bunut river system									
1	Turn out/Diversion	16	0	16	85	6	91	101	6	107
2	Aquiduct	0	0	0	3	1	4	3	1	4
3	Siphon	1	0	1	1	1	2	2	1	3
4	Bridge	8	0	8	12	14	26	20	14	34
5	Culvert	0	0	0	4	0	4	4	0	4
6	Drop	0	0	0	0	2	2	0	2	2
7	Spillway	0	0	0	5	0	5	5	0	5
	Sub-total	25	0	25	110	24	134	135	24	159
	Total	**71**	**0**	**71**	**203**	**69**	**272**	**274**	**69**	**343**

Note; Level I: Special Maintenance or Reshaping only Level II: Flow Capacity Expansion Required
Source; Field Inventory Survey by JICA Oct. 1989

Table C-20 RELATED STRUCTURES ON DRAINAGE CANALS

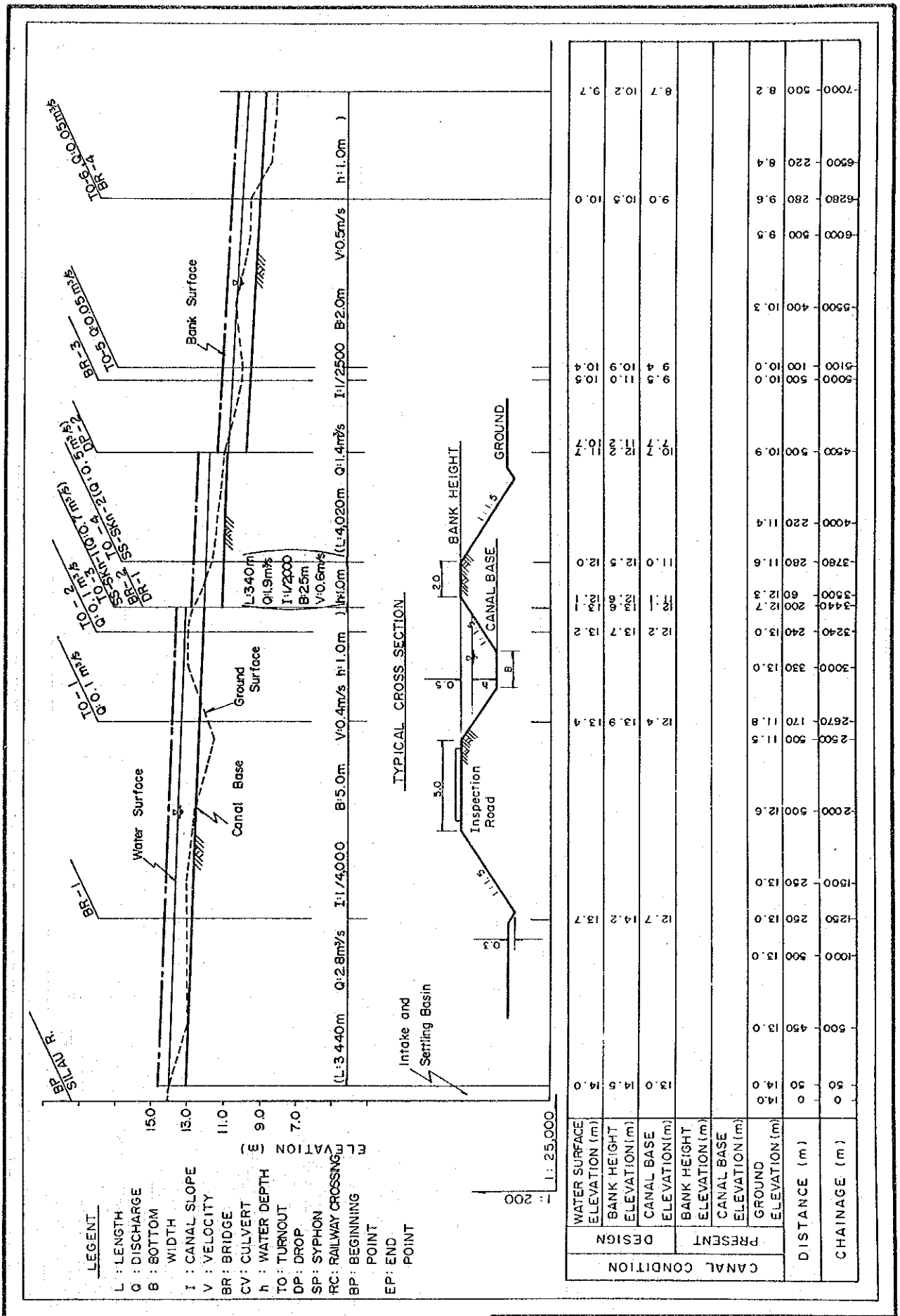
No.	Structure	Nos of Structure New (nos)	Repair (nos)	Sub-Total	Nos of Structure New (nos)	Repair (nos)	Sub-Total	Nos of Structure New (nos)	Repair (nos)	Total
		Main			Secondary			Total		
I.	Silau river system									
1	Culvert	4	0	4	4	8	12	8	8	16
2	Siphon	0	0	0	0	0	0	0	0	0
3	Bridge	1	0	1	2	3	5	3	3	6
4	Junction (w/ culvert)	7	0	7	36	0	36	43	0	43
	Sub-total	12	0	12	42	11	53	54	11	65
II.	Bunut river system									
1	Culvert	2	1	3	8	7	15	10	8	18
2	Siphon	0	0	0	1	0	1	1	0	1
3	Bridge	10	0	10	6	12	18	16	12	28
4	Junction (w/ culvert)	10	0	10	41	0	41	51	0	51
	Sub-total	22	1	23	56	19	75	78	20	98
	Total	**34**	**1**	**35**	**98**	**30**	**128**	**132**	**31**	**163**

Note; Level I: Special Maintenance or Reshaping only Level II: Flow Capacity Expansion Required
Source; Field Inventory Survey by JICA Oct. 1989

Table C-19 LENGTH OF MAIN AND SECONDARY DRAINAGE CANALS

No.	Name of irrigation block	Nos. of canals	Canal length (m)				
			New canal	Rehabilitation			Total
				Level I	Level II	Total	
Main Drain							
I. Silau river system							
1	Bandar Jepang	1	300	4,100	4,100	8,200	8,500
2	Si Umbutumbut	1	0	0	1,400	1,400	1,400
3	Sei Serdang	0	0	0	0	0	0
4	Air Joman	1	4,000	3,000	0	3,000	7,000
5	Binjai Serbangan	0	0	0	0	0	0
	Sub-total	3	4,300	7,100	5,500	12,600	16,900
II. Bunut river system							
6	Air Hitam	1	0	0	3,900	3,900	3,900
7	Silo Bonto	1	0	0	11,400	11,400	11,400
8	Tambung Tulang	1	0	0	14,100	14,100	14,100
9	Meranti	1	2,600	0	0	0	2,600
10	Beluru	0	0	0	0	0	0
11	Bagan Batak	1	0	0	9,800	9,800	9,800
	Sub-total	5	2,600	0	39,200	39,200	41,800
	Total	**8**	**6,900**	**7,100**	**44,700**	**51,800**	**58,700**
Secondary Drain							
I. Silau river system							
1	Bandar Jepang	5	9,600	0	4,200	4,200	13,800
2	Si Umbutumbut	2	3,700	0	2,200	2,200	5,900
3	Sei Serdang	2	1,300	0	0	0	1,300
4	Air Joman	6	11,600	0	0	0	11,600
5	Binjai Serbangan	1	2,000	0	0	0	2,000
	Sub-total	16	28,200	0	6,400	6,400	34,600
II. Bunut river system							
6	Air Hitam	2	0	0	5,600	5,600	5,600
7	Silo Bonto	5	24,600	0	2,500	2,500	27,100
8	Tambung Tulang	8	19,300	7,000	100	7,100	26,400
9	Meranti	6	16,200	0	0	0	16,200
10	Beluru	1	2,100	0	400	400	2,500
11	Bagan Batak	2	700	0	8,500	8,500	9,200
	Sub-total	24	62,900	7,000	17,100	24,100	87,000
	Total	**40**	**91,100**	**7,000**	**23,500**	**30,500**	**121,600**
Main and Secondary Drain							
I. Silau river system							
1	Bandar Jepang	6	9,900	4,100	8,300	12,400	22,300
2	Si Umbutumbut	3	3,700	0	3,600	3,600	7,300
3	Sei Serdang	2	1,300	0	0	0	1,300
4	Air Joman	7	15,600	3,000	0	3,000	18,600
5	Binjai Serbangan	1	2,000	0	0	0	2,000
	Sub-total	19	32,500	7,100	11,900	19,000	51,500
II. Bunut river system							
6	Air Hitam	3	0	0	9,500	9,500	9,500
7	Silo Bonto	6	24,600	0	13,900	13,900	38,500
8	Tambung Tulang	9	19,300	7,000	14,200	21,200	40,500
9	Meranti	7	18,800	0	0	0	18,800
10	Beluru	1	2,100	0	400	400	2,500
11	Bagan Batak	3	700	0	18,300	18,300	19,000
	Sub-total	29	65,500	7,000	56,300	63,300	128,800
Drainage Canal Total		**48**	**98,000**	**14,100**	**68,200**	**82,300**	**180,300**

Note; Level I: Special Maintenance or Reshaping only Level II: Flow Capacity Expansion Required
Source; Field Inventory Survey by JICA Oct. 1989



CANAL CONDITION		CHAINAGE (m)	DISTANCE (m)	GROUND ELEVATION (m)	CANAL BASE ELEVATION (m)	BANK HEIGHT ELEVATION (m)	WATER SURFACE ELEVATION (m)
PRESENT		0	0	14.0			14.0
		50	50	14.0			14.5
		500	450	13.0			
		1000	500	13.0			
		1250	250	13.0	12.7	14.2	13.7
		1500	250	13.0			
		2000	500	12.6			
		2500	500	11.5			
DESIGN		2670	170	11.8	12.4	13.9	13.4
		3000	330	13.0			
		3240	240	13.0	12.2	13.7	13.2
		3440	200	12.7			
		3500	60	12.3			
		3760	260	11.6	11.0	12.5	12.0
		4000	220	11.4			
		4500	500	10.9	10.7	11.2	10.7
		5000	500	10.0	9.3	11.0	10.5
		5100	100	10.0	9.4	10.9	10.4
		5500	400	10.3			
		6000	500	9.5			
		6280	280	9.6	9.0	10.3	10.0
		6500	220	8.4			
		7000	500	8.2	8.7	10.2	9.7

Fig. C-20 PROFILE OF SILAU RIGHT MAIN IRRIGATION CANAL (1/2)

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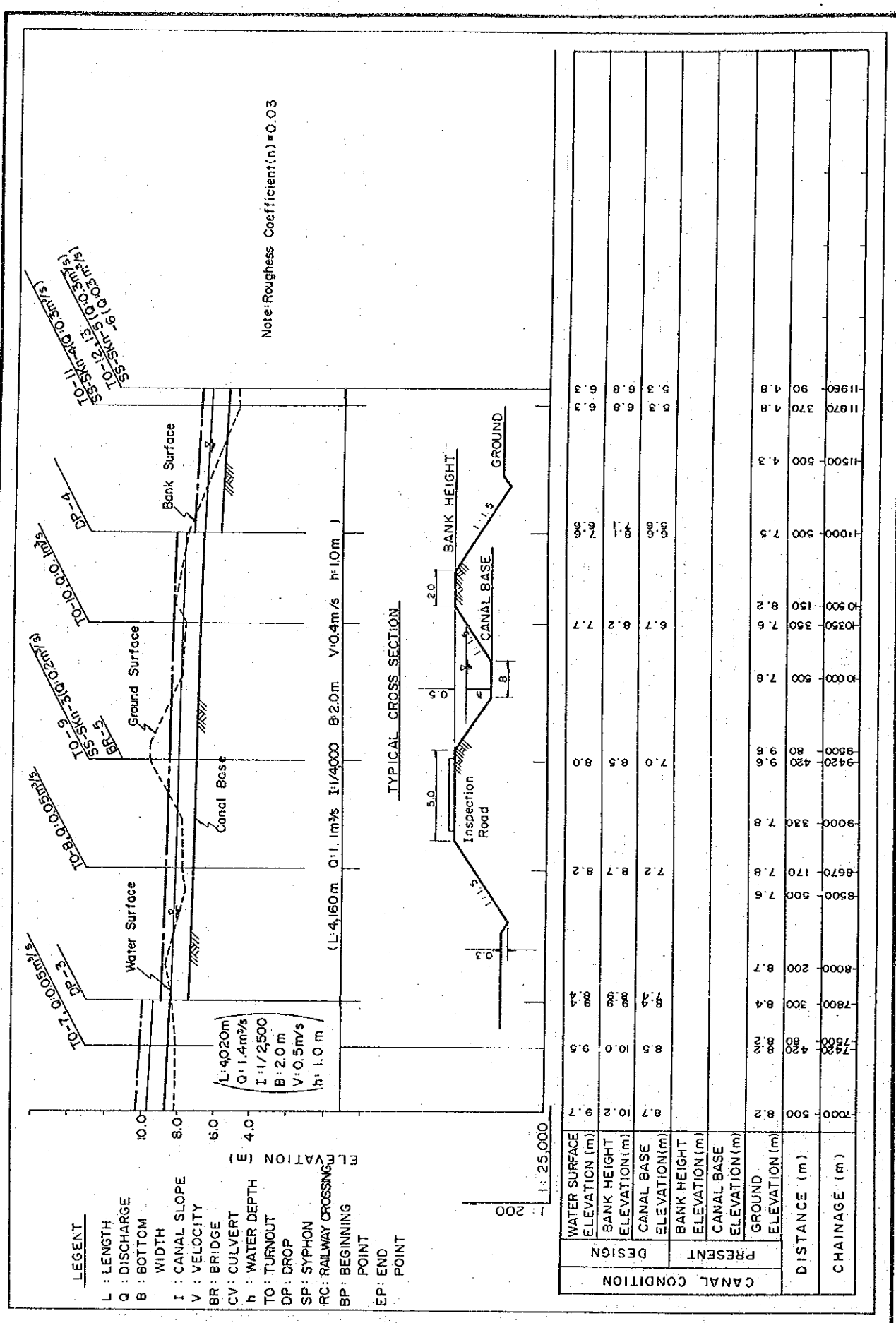

CANAL CONDITION		CHAINAGE (m)	DISTANCE (m)		
PRESENT	GROUND ELEVATION (m)	7000	500	8.2	9.7
		7420	420	8.0	9.5
		7500	80	N.G.	
		7800	300	8.4	8.4
		8000	200	8.7	
		8500	500	7.6	
		8670	170	7.8	8.2
		9000	330	7.8	
		9420	420	9.6	8.0
		9500	80	9.6	
		10000	500	7.8	
		10350	350	7.6	7.7
		10500	150	8.2	
		11000	500	7.5	7.6
		11500	500	4.3	
		11870	370	4.8	6.3
		11960	90	4.8	6.3
DESIGN	WATER SURFACE ELEVATION (m)				9.7
	BANK HEIGHT ELEVATION (m)				9.5
	CANAL BASE ELEVATION (m)				8.4
	BANK HEIGHT ELEVATION (m)				
	CANAL BASE ELEVATION (m)				

Fig. C-20 PROFILE OF SILAU RIGHT MAIN IRRIGATION CANAL (2/2)

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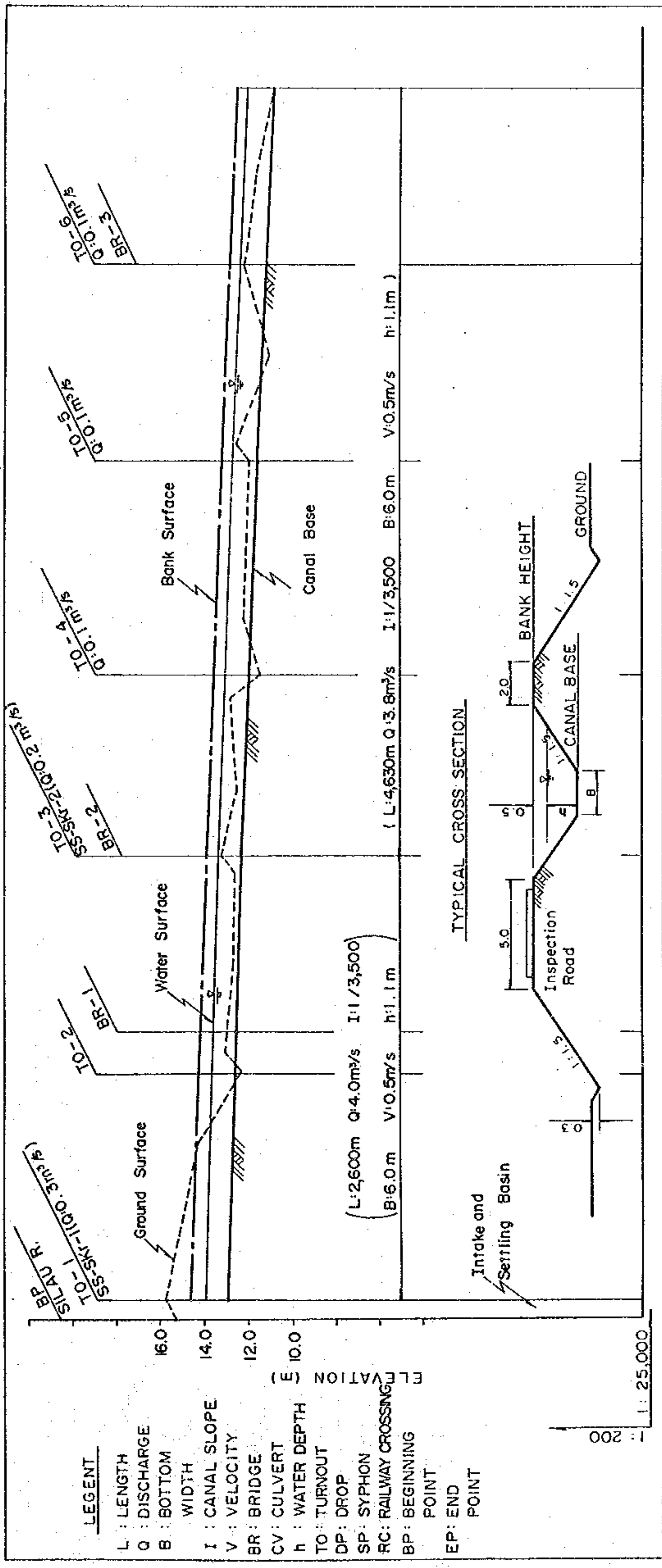

CHAINAGE (m)	DISTANCE (m)	GROUND ELEVATION (m)	PRESENT CANAL BASE ELEVATION (m)	PRESENT BANK HEIGHT ELEVATION (m)	DESIGN CANAL BASE ELEVATION (m)	DESIGN BANK HEIGHT ELEVATION (m)	DESIGN WATER SURFACE ELEVATION (m)
0	0	15.4					
50	50	15.8			12.4	14.5	14.0
500	450	15.1					
1000	500	14.3					
1400	400	12.3			12.5	14.1	13.6
1500	100	13.0					
1600	100	13.00			12.5	14.1	13.6
2000	500	12.6					
2500	500	12.6					
2650	150	13.2			12.3	13.8	13.3
3000	350	12.5					
3500	500	12.8					
3680	180	11.5			11.9	13.5	13.0
4000	320	12.2					
4500	500	12.0					
4930	430	11.8			11.5	13.1	12.6
5000	70	12.4					
5500	500	11.0					
6000	500	12.1			11.2	12.8	12.3
6500	500	11.7					
7000	500	10.9			10.9	12.5	12.0

Fig. C-21 PROFILE OF SILAU LEFT MAIN IRRIGATION CANAL (1/2)

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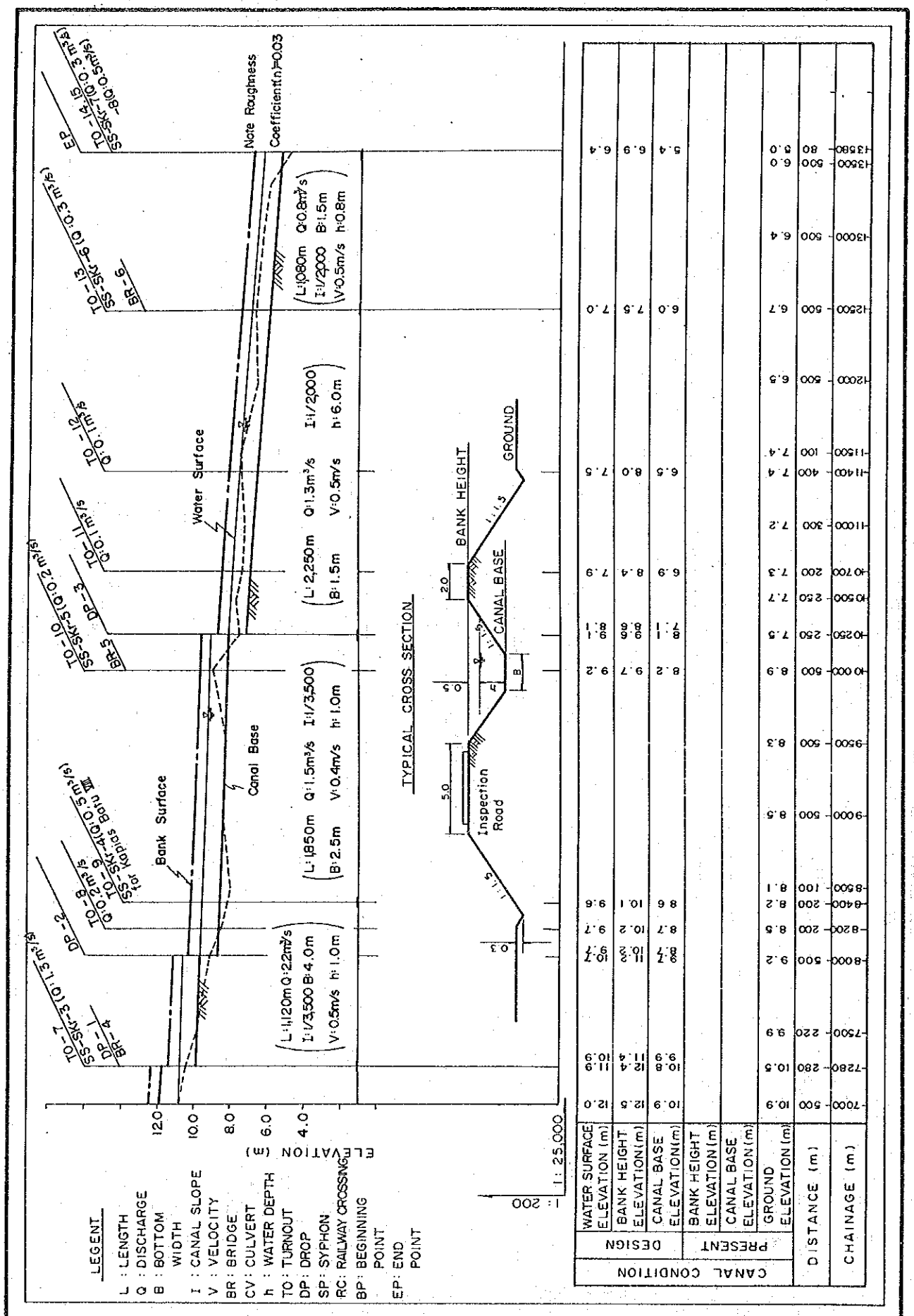

CANAL CONDITION									
DESIGN			PRESENT						
WATER SURFACE ELEVATION (m)	BANK HEIGHT ELEVATION (m)	CANAL BASE ELEVATION (m)	BANK HEIGHT ELEVATION (m)	CANAL BASE ELEVATION (m)	GROUND ELEVATION (m)	DISTANCE (m)		CHAINAGE (m)	
12.0	12.5	10.9			10.9	500	7000		
10.9	11.4	9.9			10.5	280	7280		
					9.9	220	7500		
					9.2	500	8000		
					8.5	200	8200		
9.7	10.2	8.7			8.2	200	8400		
9.6	10.1	8.6			8.1	100	8500		
					8.5	500	9000		
					8.3	500	9500		
9.2	9.7	8.2			8.9	500	10000		
					7.3	250	10250		
					7.7	250	10500		
7.9	8.4	6.9			7.3	200	10700		
					7.2	300	11000		
7.5	8.0	6.5			7.4	400	11400		
					7.4	100	11500		
					6.5	500	12000		
7.0	7.5	6.0			6.7	500	12500		
					6.4	500	13000		
6.4	6.9	5.4			5.0	80	13580		
					6.0	500	13500		

Fig. C-21 PROFILE OF SILAU LEFT MAIN IRRIGATION CANAL (2/2)

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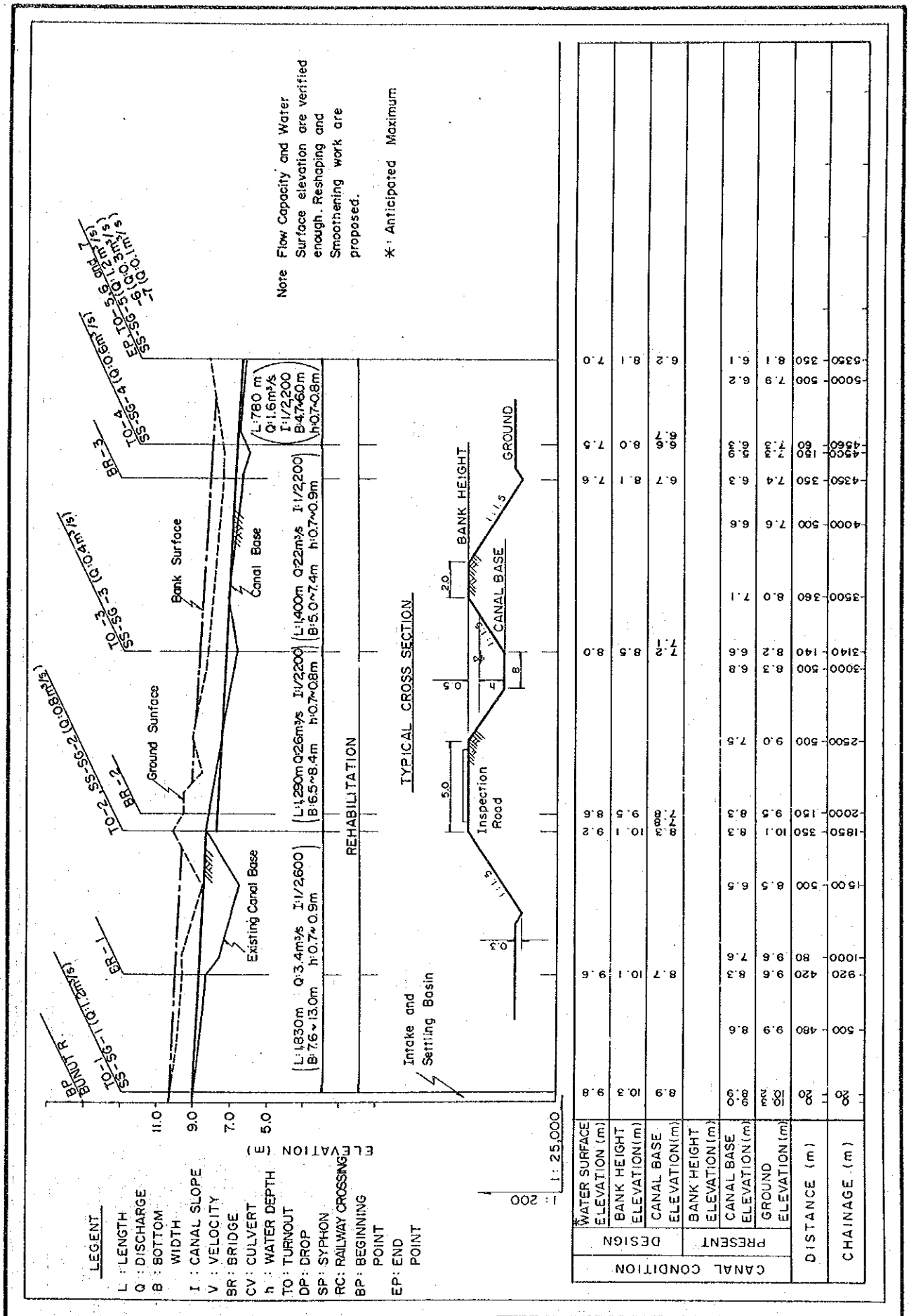

CANAL CONDITION		CHAINAGE (m)	DISTANCE (m)		0	500	920	1000	1500	1850	2000	2500	3000	3140	3500	4000	4350	4560	5000	5350
					0	480	420	80	500	350	150	500	500	140	360	500	350	150	500	350
PRESENT		GROUND ELEVATION (m)			9.9	9.6	9.6	9.6	8.5	10.1	9.3	9.0	8.3	8.2	8.0	7.6	7.4	7.4	7.9	8.1
		CANAL BASE ELEVATION (m)			8.6	7.6	8.3	7.6	6.5	8.3	8.3	7.5	6.8	6.6	7.1	6.6	6.3	6.3	6.2	6.1
		BANK HEIGHT ELEVATION (m)																		
DESIGN		CANAL BASE ELEVATION (m)			8.9		8.7			7.8	7.8			7.2				6.9	6.2	
		BANK HEIGHT ELEVATION (m)			10.3		10.1			10.1	9.5			8.5			8.1	8.0	8.1	
		WATER SURFACE ELEVATION (m)			9.8		9.6			9.2	8.6			8.0			7.6	7.5	7.0	

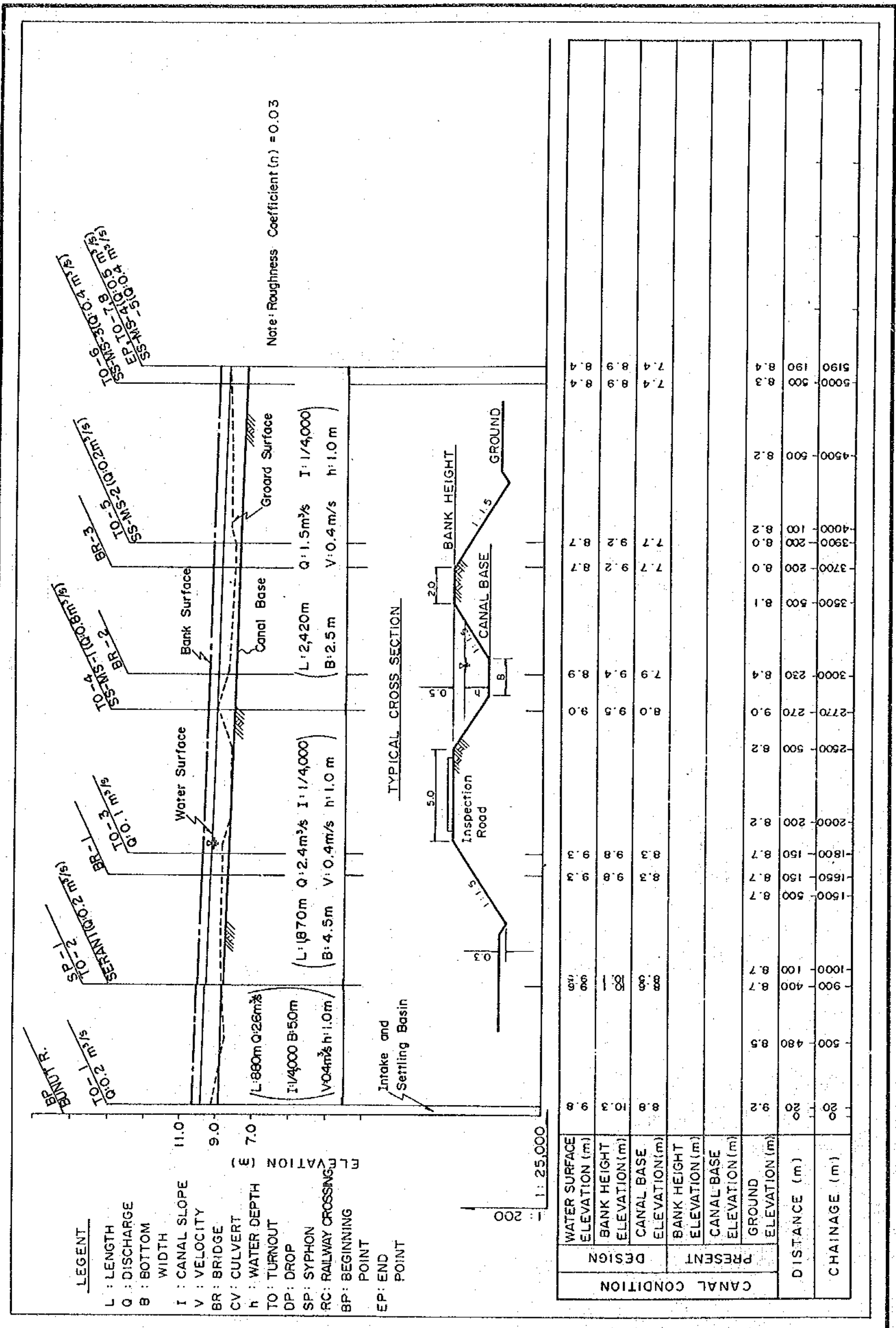

Fig. C-23 PROFILE OF MERANTI SUPPLY IRRIGATION CANAL

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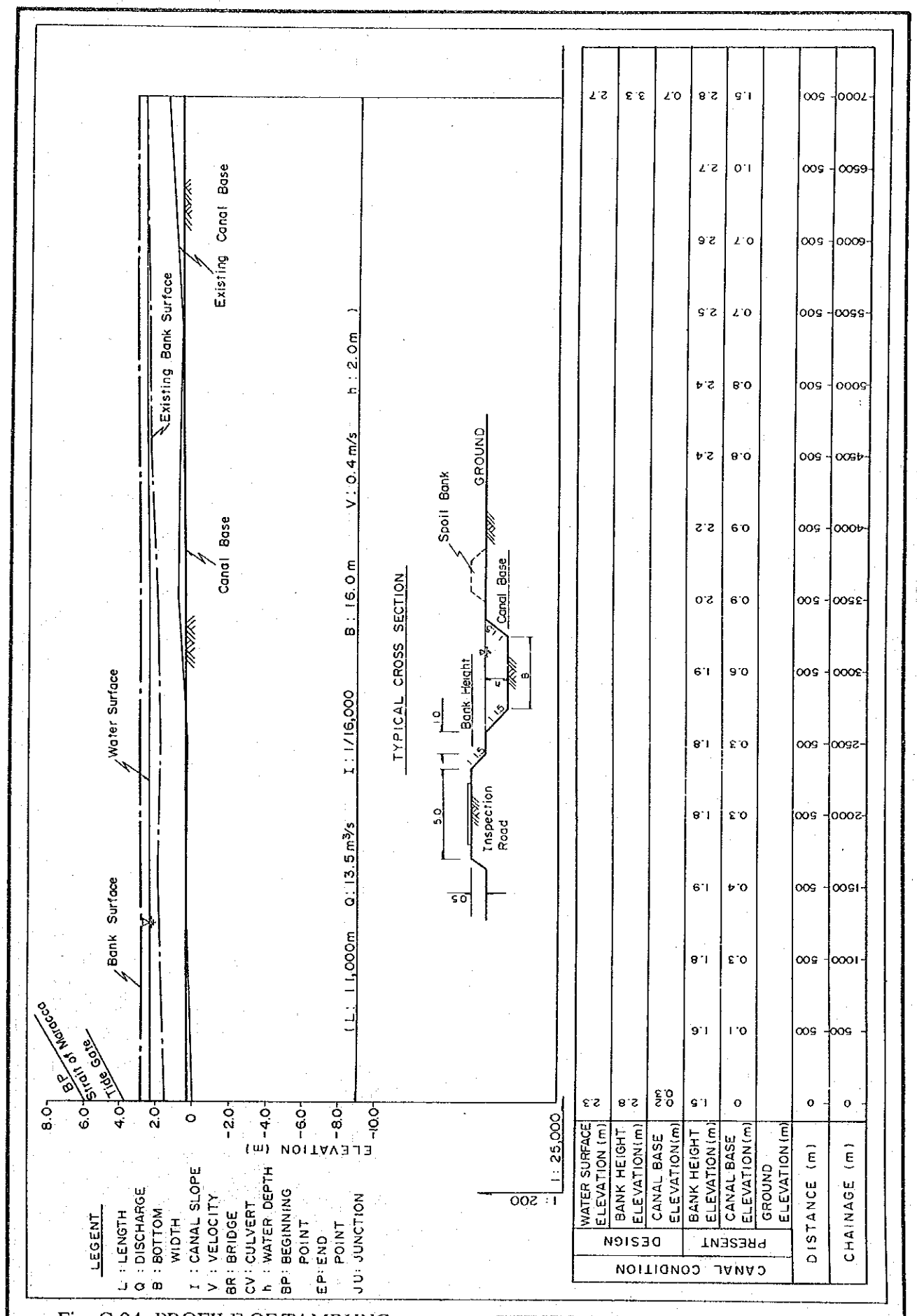

Fig. C-24 PROFILE OF TAMBUNG TULANG MAIN DRAINAGE CANAL (1/3)

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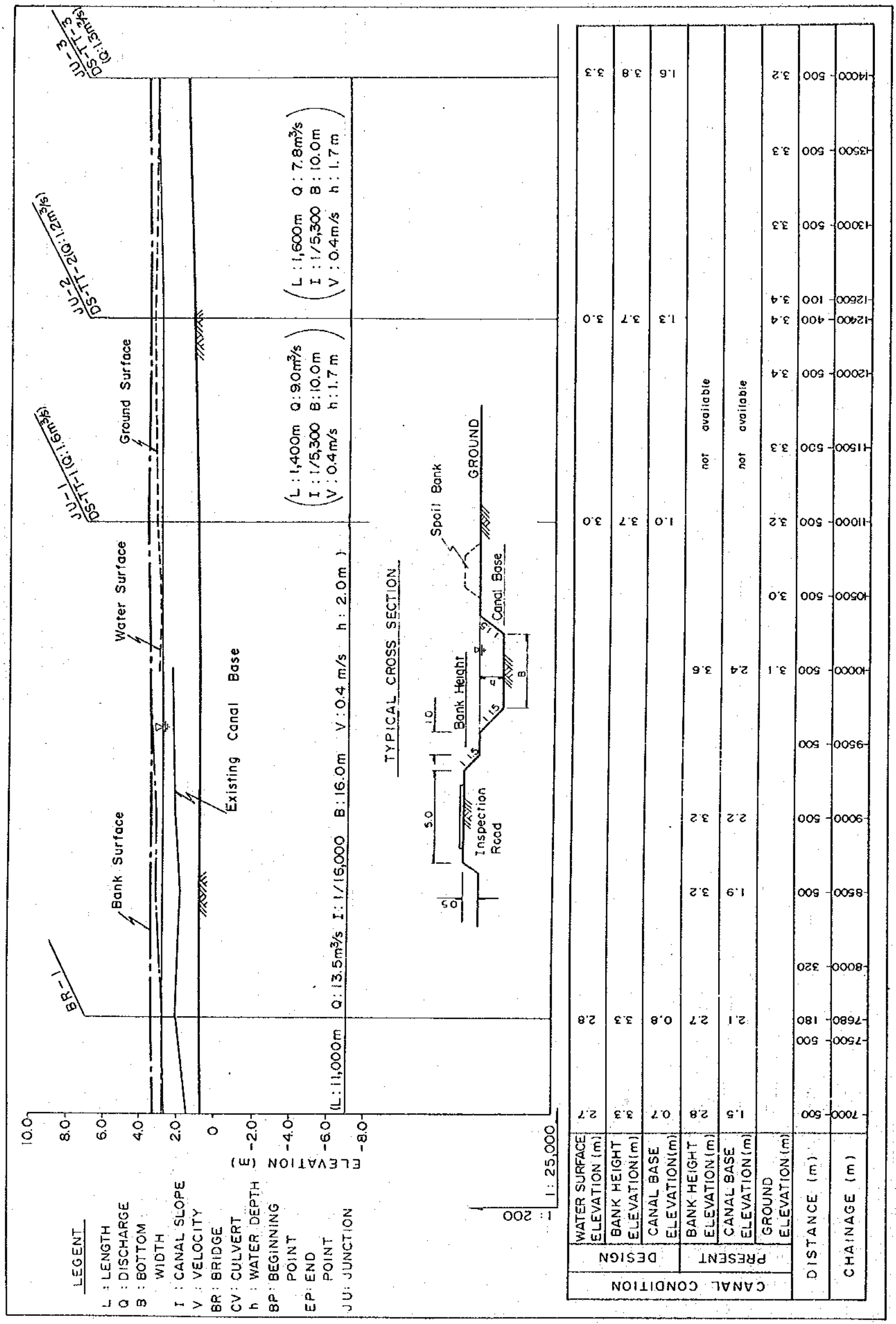

Fig. C-24 PROFILE OF TAMBUNG TULANG MAIN DRAINAGE CANAL (2/3)

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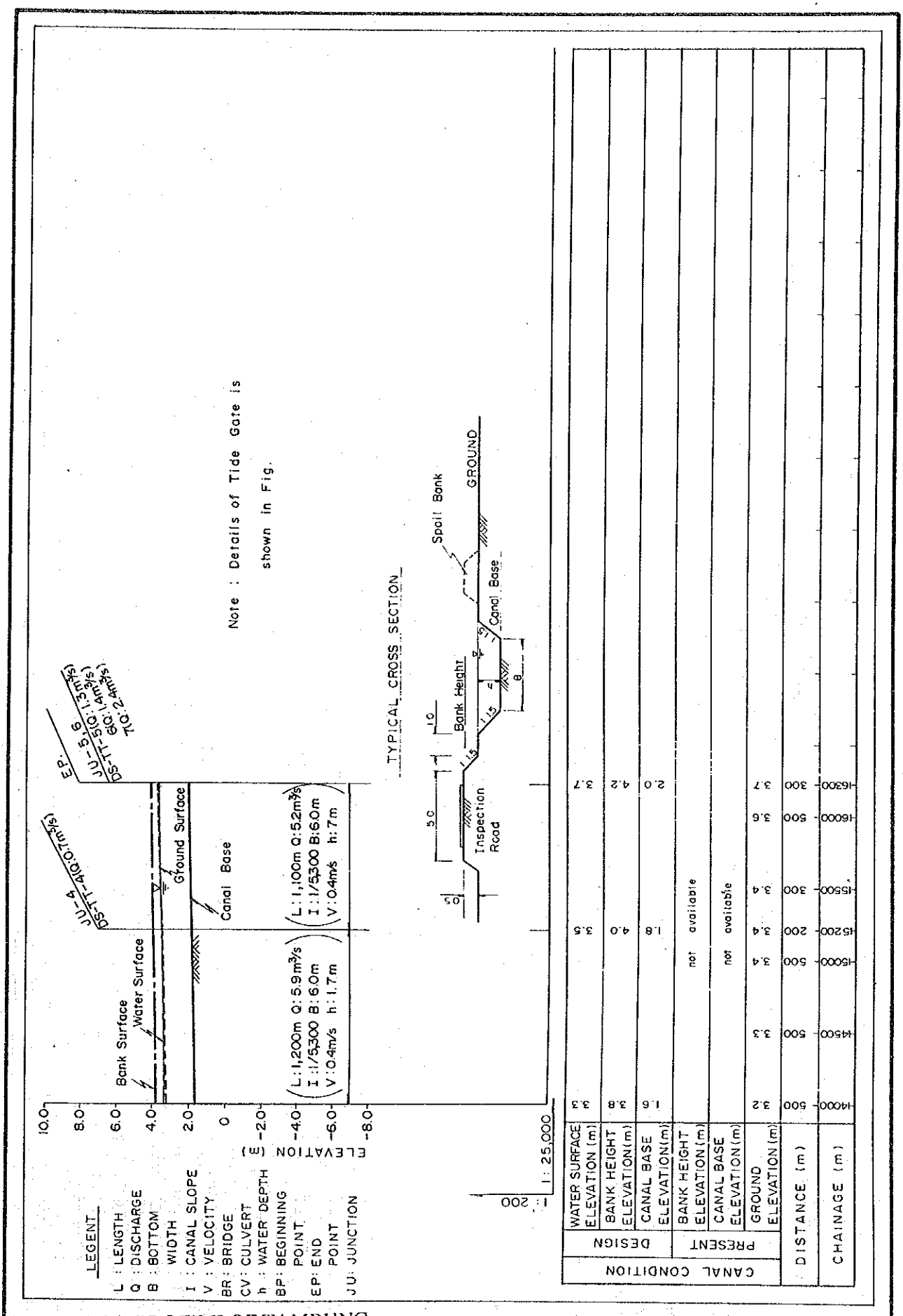

Fig. C-24 PROFILE OF TAMBUNG TULANG MAIN DRAINAGE CANAL (3/3)

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