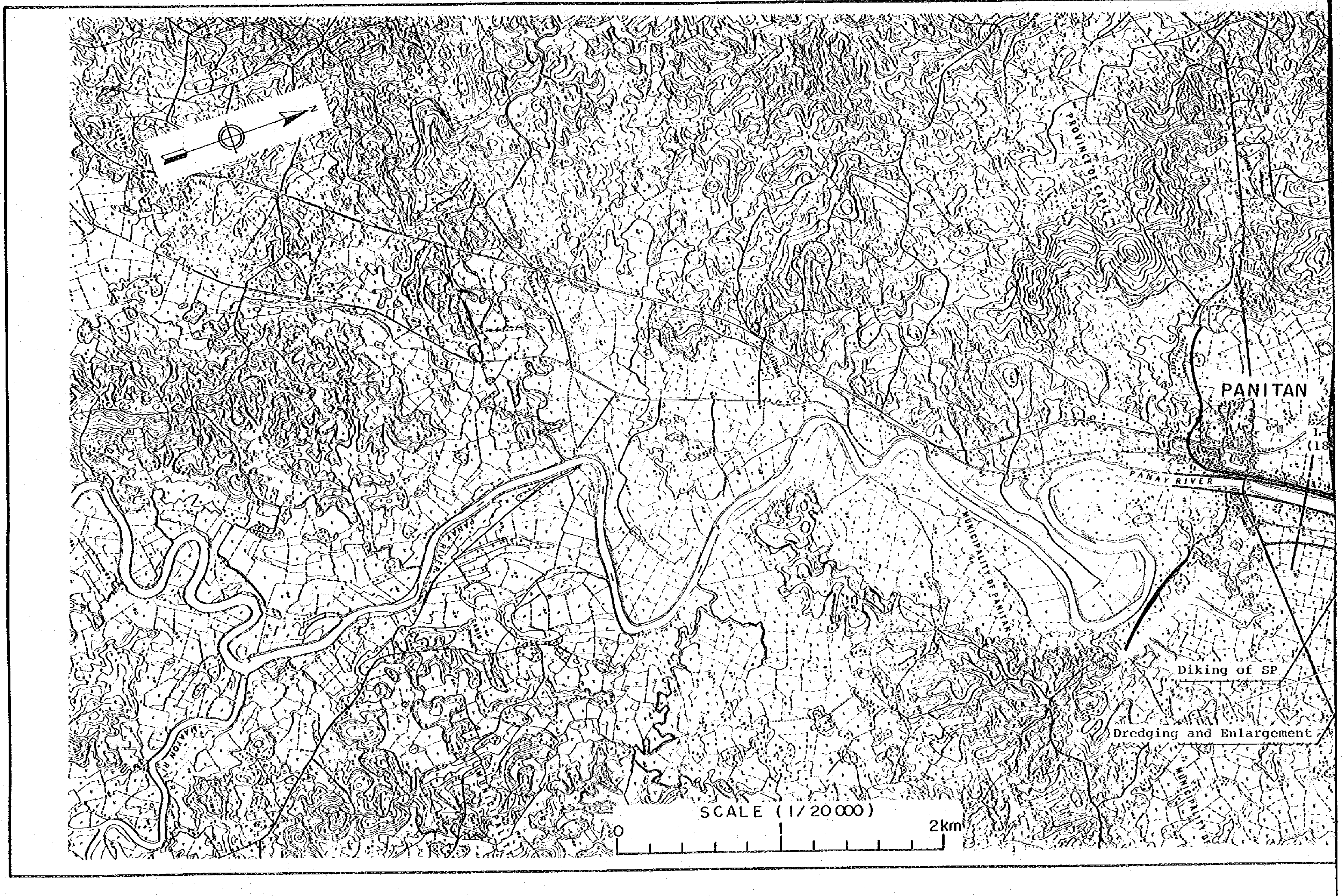
N
PROVINCE OF CAPIZ
PANITAN
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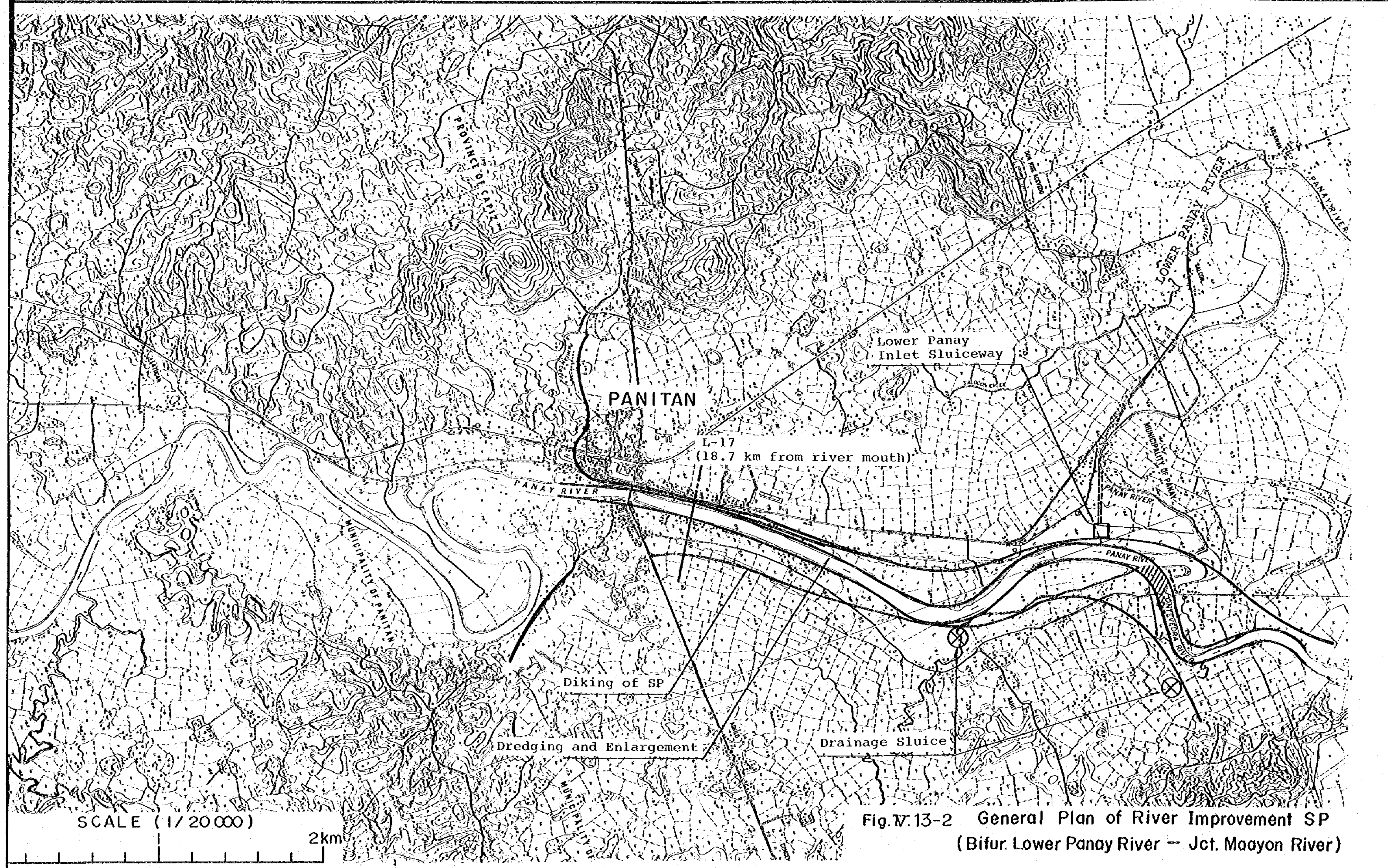
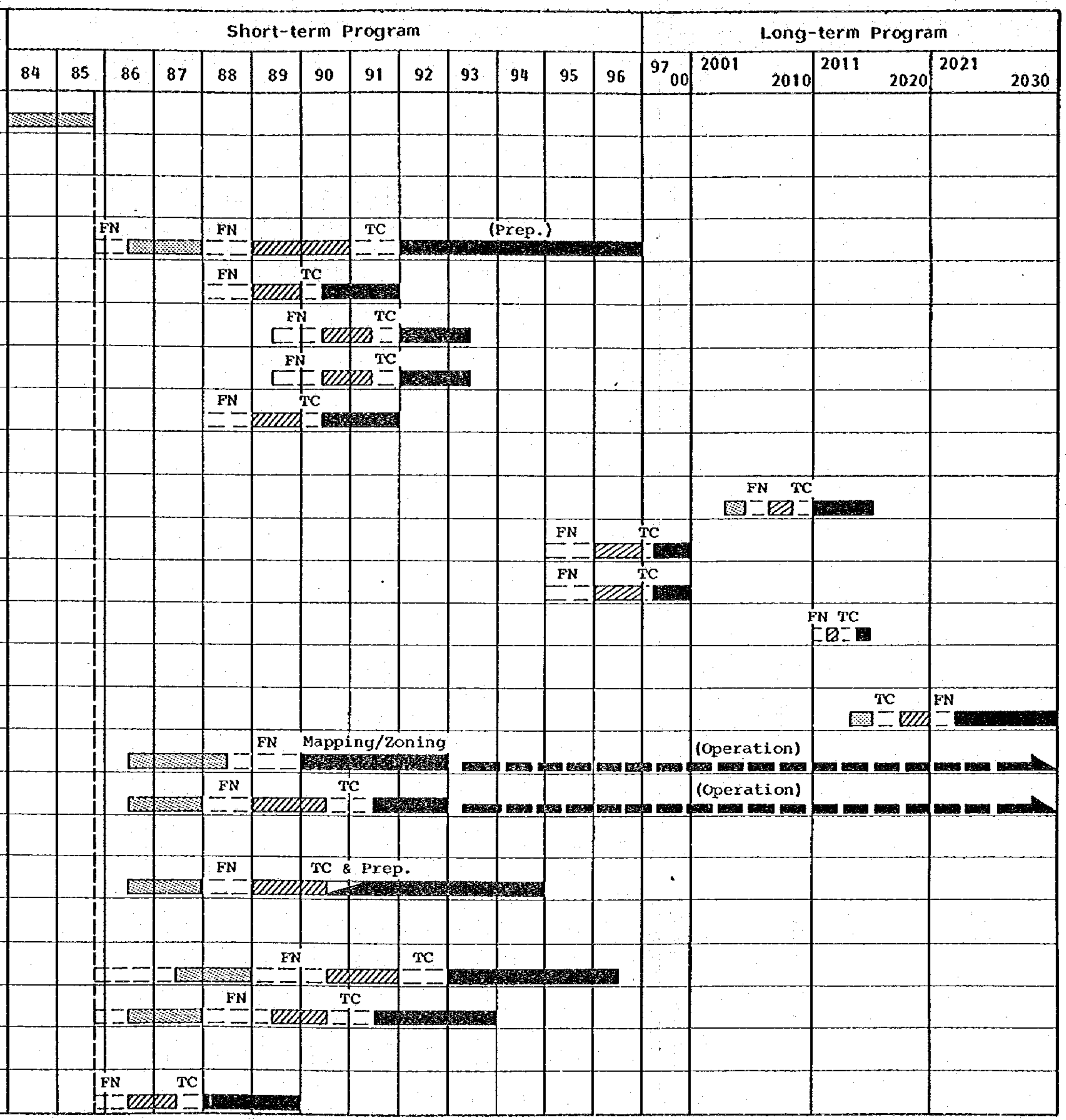


Fig.Ⅳ.13-2 General Plan of River Improvement SP
(Bifur. Lower Panay River — Jct. Maayon River)

Fig. IV.14-1 IMPLEMENTATION OF PROPOSED PROJECTS MASTER SCHEDULE

PROJECT	CONST. △ COST (₱ x 10^6)
BASIN-WIDE FLOOD CONTROL STUDY	
FLOOD CONTROL PROJECT	
First Stage Project	
- River improvement work (I)	589
- Polder - Dao	55
- Polder - Cuartero	59
- Polder - Sigma	42
- Polder - Mambusao	78
Second Stage Project	
- River improvement work (II)	440
- Polder - Maayon	49
- Polder - Jamindan	39
- Polder - Dumarao	58
Third Stage Project	
- River improvement work (III)	3,486
Non-structural Measures	51
Flood Forecasting and Warning System	84
MULTIPURPOSE DAM PROJECT	
Panay B Dam	471
IRRIGATION PROJECT	
Panitan - Panay Scheme	183
Mambusao Scheme	79
WATER SUPPLY PROJECT	
Roxas-WD Water Supply Project	56



Notes; Feasibility study   Detailed design   Construction

FN: Financing   TC: Tender and Contract   Prep.: Preparatory works incl. land acquisition

△ 1984 base price

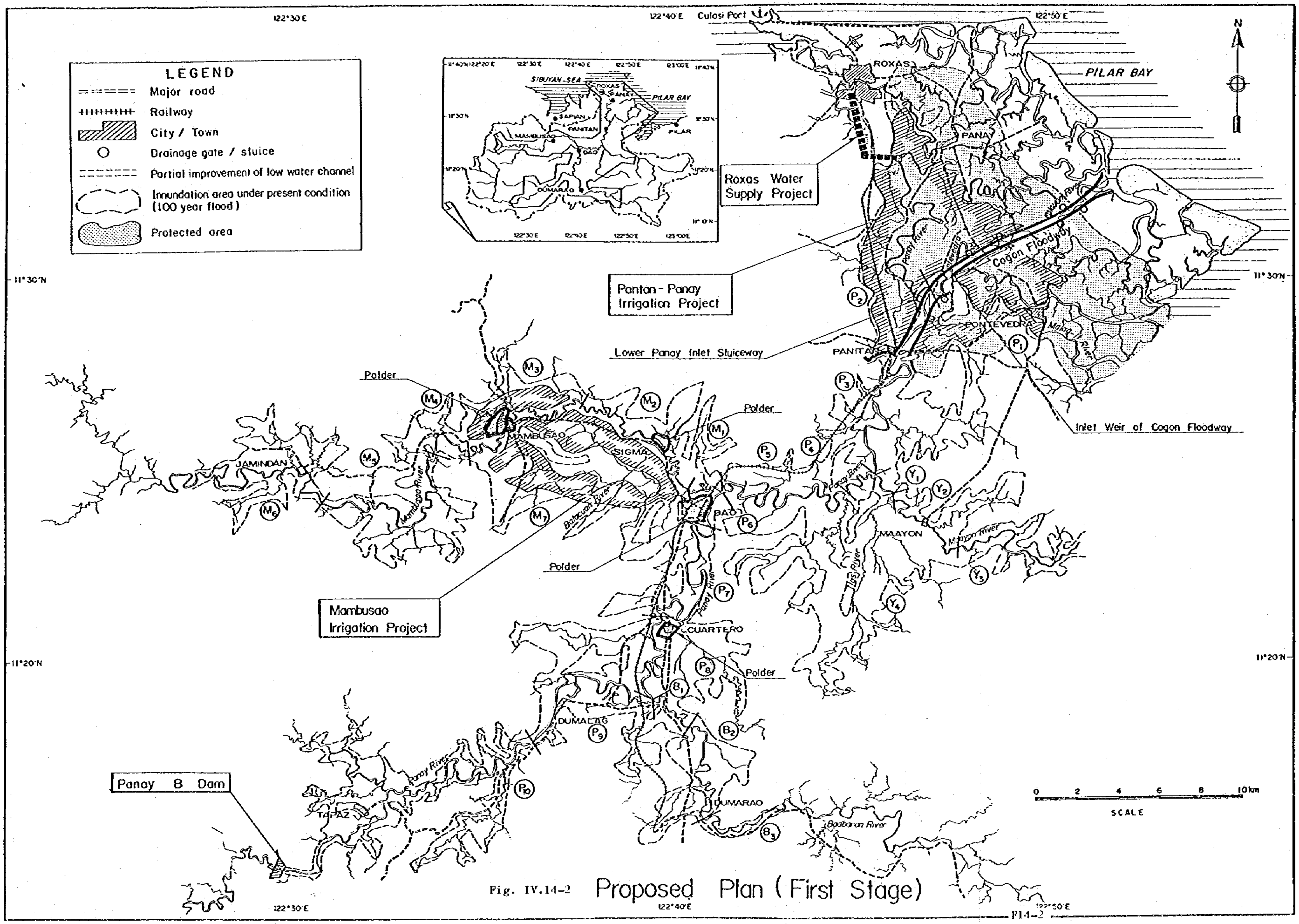


Fig. IV.14-2 Proposed Plan (First Stage)

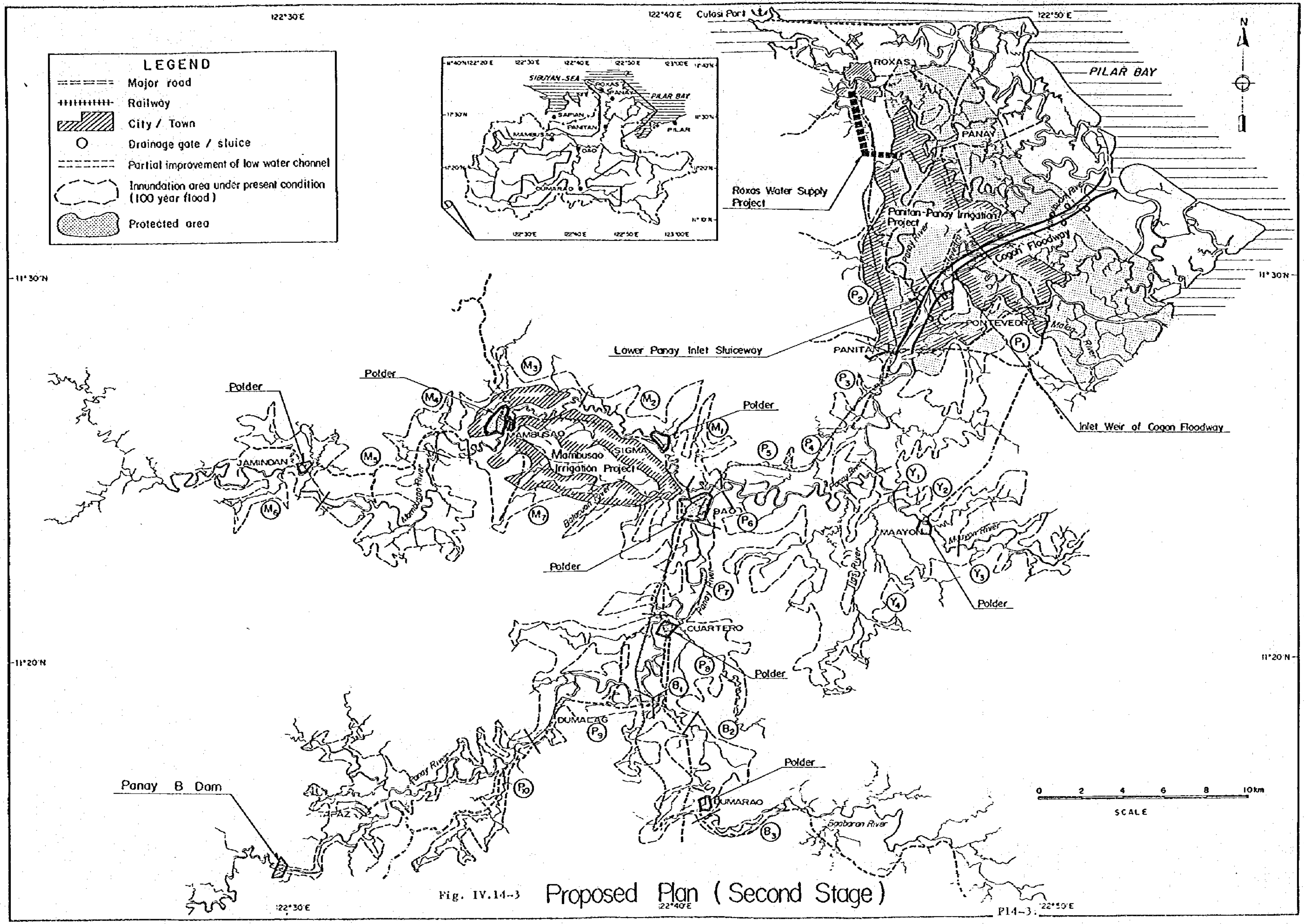


Fig. IV.14-3 Proposed Plan (Second Stage)

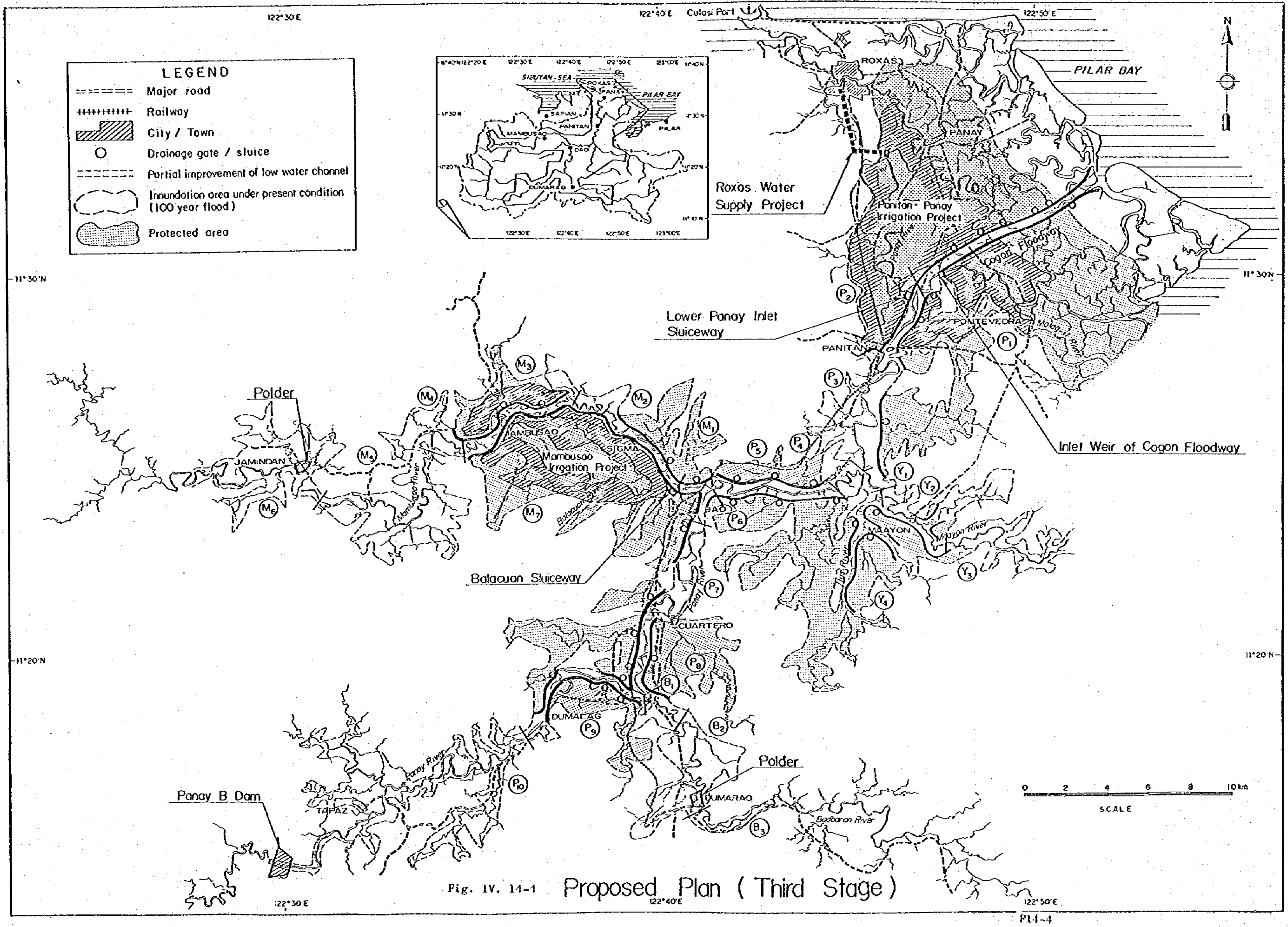


Fig. IV. 14-4 Proposed Plan (Third Stage)

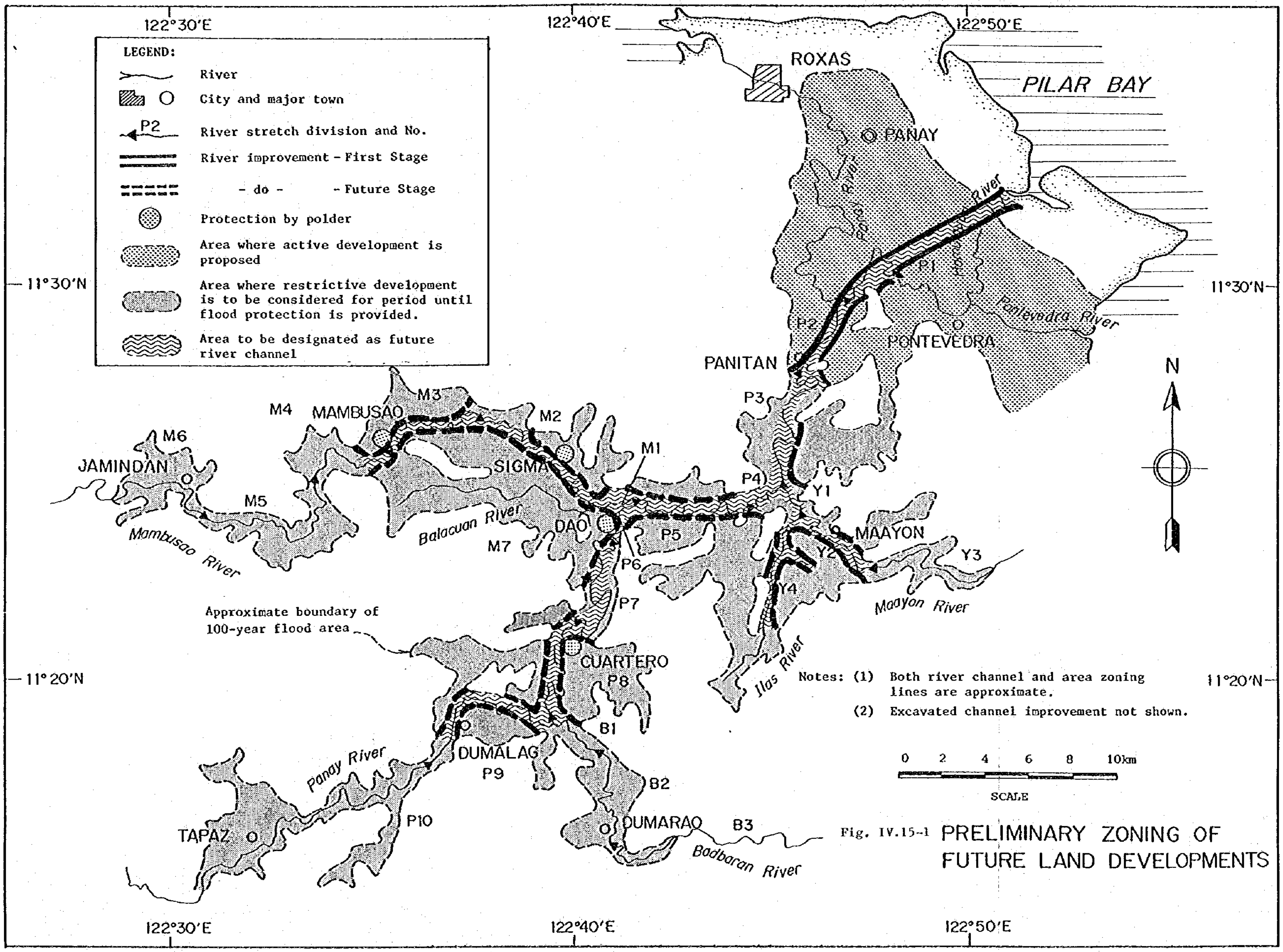


Fig. IV.15-1 PRELIMINARY ZONING OF FUTURE LAND DEVELOPMENTS

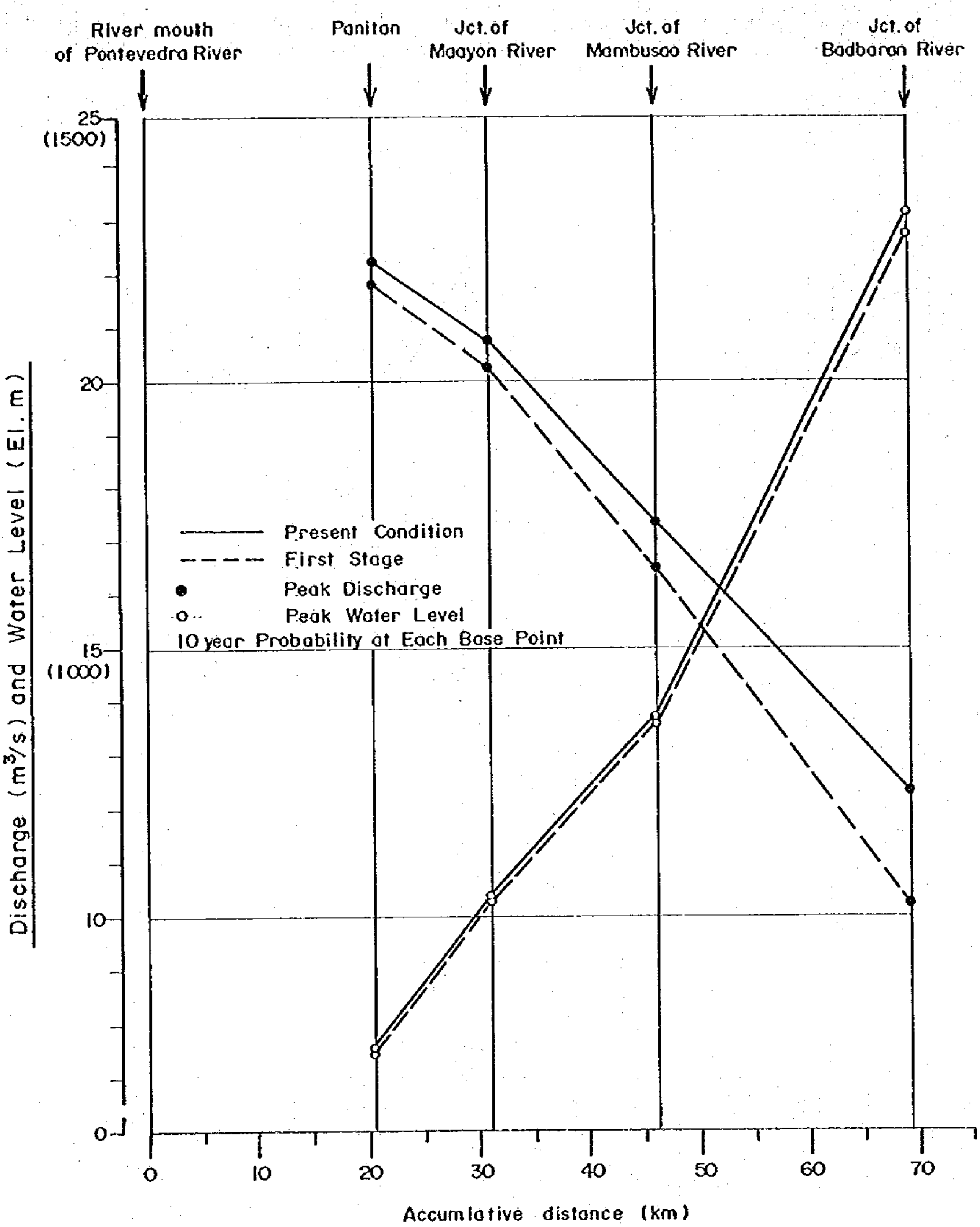


Fig. IV, 15-2 EFFECT OF FIRST STAGE FLOOD CONTROL PLAN ON DISCHARGE AND WATER LEVEL (10yr Flood)

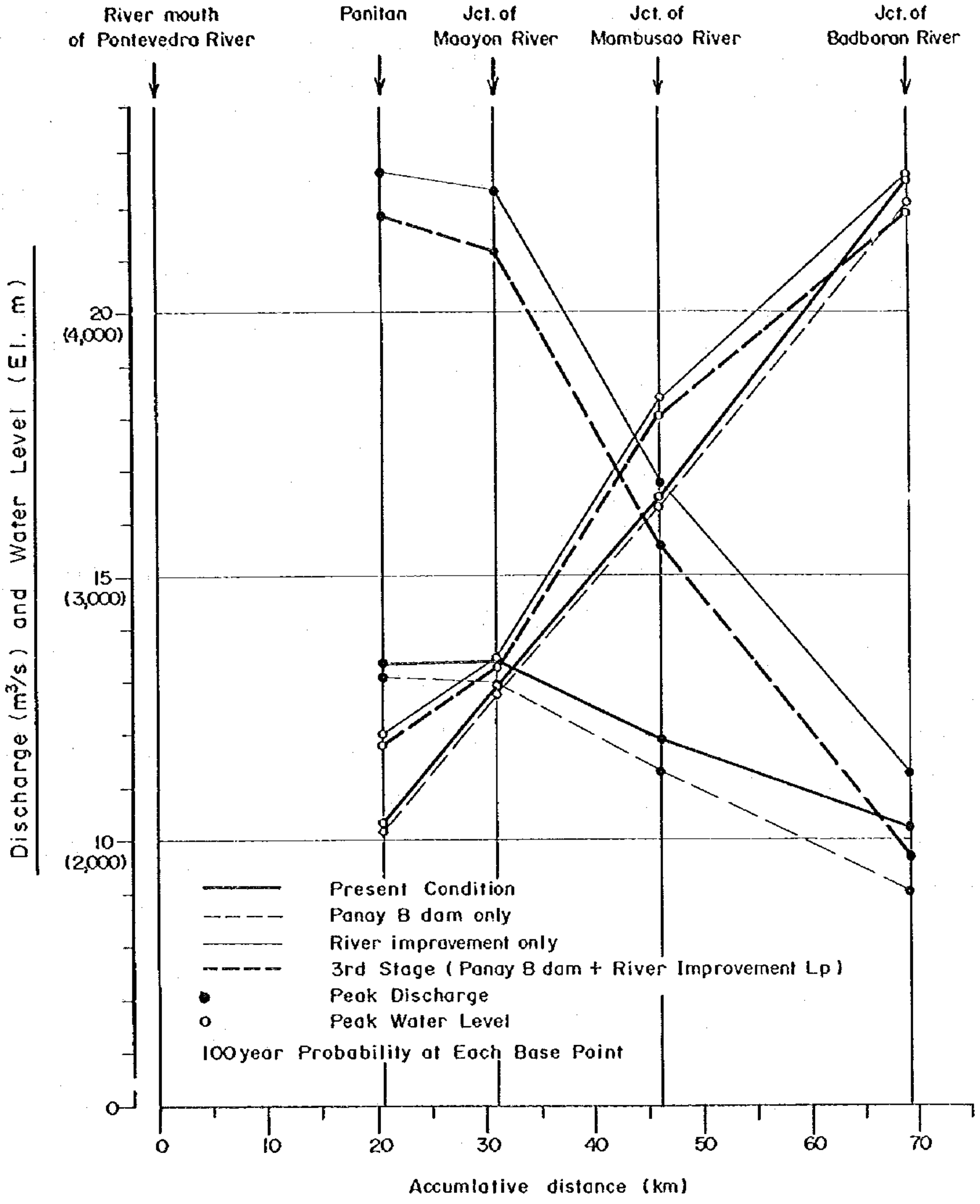


Fig. IV, 15-3 EFFECT OF THIRD STAGE FLOOD CONTROL PLAN ON DISCHARGE AND WATER LEVEL (100yr Flood)

APPENDIX V

MULTI-PURPOSE DAM PLAN

FOR

FINAL REPORT

ON

THE PANAY RIVER BASIN-WIDE

FLOOD CONTROL STUDY

APPENDIX V MULTI-PURPOSE DAM PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

The objective of the present study (the Panay River Basin-wide Flood Control Study) is to formulate an integrated water resources development plan for the Panay river basin placing a particular emphasis on flood control.

The study includes, in its scope of works, the multi-purpose dam plan. Purposes of multi-purpose dams generally include irrigation water supply, municipal and industrial water supply, flood control and hydropower generation as the main purposes. However, the multi-purpose dams planned in the Study are proposed for limited purposes of flood control and hydropower generation.

As stated in Chapter 6 - Water Budget of the Appendix I Meteorological and Hydrological Study, one of the outstanding characteristics of the river is that water supply capacity of the river is abundant compared with water demand even under natural condition and that even at the end of the study horizon of 50 years, the river water without regulation will be able to meet the expected water demand at any site along the river.

The study in this appendix includes i) identification of prospective dam sites, ii) preliminary selection of dam sites, iii) geological and hydrological condition, iv) alternative plans, v) optimization of dam plan and vi) conclusion.

2. Identification of Prospective Dam Sites

The following eight dam sites were identified, through desk study on 1 : 50,000 topographic maps, referring to previous study results. The location of dams is shown in Figure V.2-1.

- Panay A site, Panay B site, Panay C site (Upper Panay river)
- Badbaran A site, Badbaran B site (Badbaran river)
- Mambusao A site, Mambusao B site (Mambusao river)
- Maayon site (Maayon river)

Among the above dam sites, the Panay A site had been identified in the Feasibility Study of Jalaur River Multi-purpose Project by NIA, and Panay C, Badbaran B, Mambusao B and Maayon sites had been identified in the previous study of "Nation-wide Flood Control Plan" by MPWH. Other sites, i.e., Panay B, Badbaran A and Mambusao A sites were identified in this Study.

3. Preliminary Selection

Reconnaissances and surface geological investigations were carried out at these dam sites, and preliminary planning of dams and hydropower generation was made on the basis of 1 : 10,000 topographic maps, using estimated runoff data for each dam site.

The results of the investigation and studies are summarized in Table V.3-1. Based on the above information, the following four sites were ruled out from further study.

Panay A site	:	Though the results of the preliminary planning on maps is prospective, the geology of the dam site is not favourable; the site consists of less-consolidated conglomerates while extra-ordinary water leakage was recorded in past drillings.
Badbaran B site	:	The site is situated in a limestone zone. The rock shows cavernous appearance and springs were found near the site. (N.B.: Badbaran A dam site in an upstream reach was found to be outside the limestone zone.)
Mambusao A site	:	The catchment area is small (73 km^2) and geology at the dam site is not favourable. Moreover, cost index value per storage (dam construction cost/total storage) is low.
Maayon site	:	The catchment area is relatively small (140 km^2). The cost index value is not good, either.

Hence Panay B site, Panay C site, Badbaran A site and Mambusao B site were selected for further study. The locations of dams including the preliminarily selected four dams are shown in Figure V.2-1.

4. Geological Condition at Preliminarily Selected Dam Sites

4.1 Panay B Dam Site (Refer to Fig. V.4-1)

At the dam site, many rock outcrops are observed in the lower parts of the slopes and river bed. Foundation rock is andesitic volcanic breccia which seems to be underlain by massive andesite. The foundation rocks seems to be very hard consolidated and be water-tight. Both abutment sites are covered with top soil zone of one meter thick which is underlain by intensively weathered zone of 1.0 - 1.5 m in thickness and weathered rock zone of about 5 to 7 m.

4.2 Panay C Dam Site (Refer to Fig. V.4-2)

Foundation rock seems to be almost the same as that at Panay B dam site. Massive andesite outcrops are outstanding in mountain areas on western part of the site.

On the slopes of the abutments, there are 2 to 3 m thick talus deposits which are generally composed of clayey soil with weathered andesitic gravels.

Below the talus deposits, intensively weathered bedrock is confirmed in the layer of less than 2 m in thickness.

Underlying the intensively weathered rock zone, there are weathered rock zones, which are mainly composed of oxidized weathered fragmental rocks.

The depth of river deposit seems to be 7 to 8 m in the central part of the river channel. Permeability coefficient of the foundation rock is generally 10^{-5} to 10^{-6} cm/sec, however, in some portion in the left abutment, a high permeability zone of 10^{-3} cm/sec is located.

4.3 Badbaran A Dam Site (Refer to Fig. V.4-3)

The foundation rock of the Badbaran A dam site is composed of andesite, occupying the most of the right abutment and volcanic breccia, occupying the left abutment and lower slope of the right abutment. The andesitic volcanic breccia is assumed to be underlain by the andesite. Both types of rock are in general very hard and fresh.

The both abutments are covered with talus deposits or weathered rock of about 2 to 3 m thick. Below the talus deposits, the observed are intensively weathered rock zones with a thickness of 2 to 3 m from which only fragmental weathered cores with soil materials are recovered.

In some parts below the intensively weathered rock zones, slightly weathered rock zones of about 3 m in thickness are confirmed.

River deposit materials are about 3 to 4 m thick.

Permeability of the foundation rocks ranges between the orders of 10^{-4} cm/sec and 10^{-5} cm/sec. Relatively high permeable values of 10^{-4} cm/sec are confirmed in shallow zones of the right abutment area. From these zones fractuated core samples were recovered.

4.4 Mambusao B Dam Site (Refer to Fig. V.4-4)

Upper part of the right abutment is composed of fine to medium grained sandstone. The section covering the left abutment and lower part of right abutment seems to be composed of alternation of conglomerate, siltstone and sandstone.

The ground surface is covered with talus deposits and intensively weathered bed rock zones are developed for about 5 to 10 m.

Below these zones, the weathered bed rock zones seem to be developed for about 3 to 5 m.

At the upper portion of the right abutment, weathered loose sandy soil zone is confirmed. Thickness of river deposit seems to be about 12 m.

Permeability coefficient of the foundation rock ranges between the orders of 10^{-4} and 10^{-5} cm/sec mostly. A zone with relatively high permeability of 10^{-3} cm/sec was found on the right abutment.

5. Hydrological Condition at Preliminarily Selected Dam Sites

5.1 Monthly Mean Discharge

Monthly mean discharge at each dam site were estimated from the monthly mean discharge records observed at the existing gauging stations by using correlation technique. Discharge records of 23 years (1956 - 1978) at Cuartero gauging station were used for estimating the monthly mean discharge at Panay B dam, Panay C dam and Badbaran A dam, and discharge records of 28 years (1950 - 1977) at Tumalalud gauging station near Mambusao town were used for Mambusao B dam.

The correlation factors applied to each dam site are obtained as follows,

Correlation Factors used for Estimating Dam Site Runoff

	Dam Site		Gauging Station		$K^{/1}$
	C.A.D (km^2)	R.D (mm)	C.A.G (km^2)	R.G (mm)	
Panay B	239	3,350	930	2,600	0.33
Panay C	509	3,100	930	2,600	0.65
Badbaran A	258	1,900	930	2,600	0.20
Mambusao B	217	3,250	307	3,200	0.72

Note; /1: $K = \frac{C.A.D \times R.D}{C.A.G \times R.G}$

where: K = Correlation factor

C.A.D = Catchment area at dam site

C.A.G = Catchment area at gauging station

R.D = Basin annual rainfall at dam site

R.G = Basin annual rainfall at gauging station

By using these correlation factors, monthly mean discharge at each dam site was estimated as shown in Table V.5-1 to V.5-5. Average run-off at each dam site is obtained as follows.

Average Runoff at Dam Sites

Dam Site	Average Runoff (m^3/sec)
Panay B	14.3
Panay C/1	28.3
Panay C/2	28.0
Badbaran A	8.7
Mambusao B	12.2

Notes: /1; Independent scheme
/2; Combined with Panay B dam

5.2 Flood Discharge

Probable flood runoff of different return periods was estimated from the past rainfall records. The details of the estimation are discussed in the Appendix I - "Meteorological and Hydrological Study". The results of probable flood discharge at each dam sites are shown below.

Probable Flood Discharge at Dam Sites

(Unit: m^3/sec)

	Return Period			
	200-year	100-year	25-year	10-year
Panay B	3,300	2,420	1,250	750
Panay C/1	5,580	4,120	2,120	1,260
Panay C/2	5,580	3,230	1,700	1,020
Badbaran A	2,450	1,900	1,080	700
Mambusao B	2,380	1,770	990	620

Notes: /1; Independent scheme
/2; Combined with Panay B dam

6. Alternative Plans at Each Dam Site

6.1 Methods and Conditions for Alternative Plans

The following methods and conditions were applied to the formulation of alternative plans of each dam site.

(1) Each Alternative plans are formulated for purposes of flood control (Basic design flood: 100-yr flood) and hydropower generation. The allocation of storage capacity is determined with placing a criterion that the flood control should be given a higher priority. Reservoir area and storage volume at each dam site are shown in Figure V.6-1.

(2) Flood flow regulation is made by a constant ratio - constant rate method basically with gate control. Varying outflow ratios, i.e. 1/5, 1/4, 1/3 and 1/2 of peak inflow discharge, were examined for comparison in evaluating the flood control functions of the alternative plans.

(3) A concept of reservoir water level lowering during flood seasons are not introduced in view that non-flood season lasts only two to three months in a year.

(4) As spillway design flood, a 200-year probable flood is applied to concrete gravity type dam, and 1.2 times the 200-year probable flood applied to rockfill type dam.

(5) Spillway should be capable of discharging the maximum peak inflow discharge determined in the above item (4), that is, no flood retardation effect in the reservoir is taken into account.

(6) Dam crest elevation is determined by adding a freeboard above the flood water level. The freeboard is 2.5 m for the concrete gravity type dam and 3.0 m for the rockfill type dam.

(7) For hydropower generation, the rated water level is fixed at a 2/3 of drawdown depth above the low water level.

(8) Maximum plant discharge is selected to be 4 times the exploitable firm discharge in this master plan study.

(9) Power output calculation is based on simulated reservoir operation study. For a uniform comparison among alternative plans, overall efficiency of generating plant is assumed as 0.84 for all the schemes.

6.2 Alternative Plans

6.2.1 Panay B Dam

Relatively low and thin ridges are developed on the left bank of the dam site. If the crest elevation of the dam should be lower than these ridges, the dam will be of 49.5 m in height at the maximum, with crest elevation of El.74.5 m. In case of building a higher dam than 50m in height,it will be necessary to construct sub-dams on these low ridges.

In regard to the dam type, a concrete gravity type is selected due to the following reasons.

(1) On the upstream right bank of dam axis, a comparatively deep valley exists. The fill type dam is not economical at this topography.

(2) As ungated type of spillway is desirable, a concrete gravity type is beneficial for taking the crest length of spillway overflow weir as long as possible.

(3) The foundation is composed of volcanic breccias which is stable enough for a concrete gravity dam of about 50 m high.

Twelve (12) alternative plans were examined as summarized below and detailed in Table V.6-1.

Alternative Plans of Panay B Dam

Case No.	Dam Crest El. (m)	Flood Outflow Ratio	SWL/1 (m)	HWL/2 (m)	Installed Power (MW)	Energy Output (GWh/y)
1.1	71.3	0.5	65.0	-	-	-
1.2	73.4	0.5	67.3	60.0	4.2	23.7
1.3	77.4	0.5	71.3	65.0	7.1	31.4
1.4	80.9	0.5	75.0	70.0	10.0	36.8
2.1	76.2	0.333	68.9	-	-	-
2.2	78.1	0.333	70.9	60.0	4.2	23.7
2.3	81.5	0.333	74.3	65.0	7.1	31.4
2.4	84.6	0.333	77.6	70.0	10.0	36.8
3.1	78.7	0.25	71.0	-	-	-
3.2	80.5	0.25	72.8	60.0	4.2	23.7
3.3	83.7	0.25	76.0	65.0	7.1	31.4
3.4	86.8	0.25	79.2	70.0	10.0	36.8

Notes: /1; SWL = Surcharge water level for flood control
/2; HWL = High water level for power generation

6.2.2 Panay C Dam

According to the result of preliminary study, hydropower generation at this dam is not so favorable, but the site is favorable in an aspect of having a large storage capacity which can be used for flood control. Therefore, the primary purpose of this dam shall be flood control.

The concrete gravity type is selected due to the following reasons.

(1) It seems that a concrete dam on the rock after excavation of gravel zone is benefitial and more reliable in comparison with a fill dam on the river bed gravel zone of about 8 m deep.

(2) The river diversion need much works in case of fill type dam.

(3) The foundation rock is composed of andestic volcanic breccias. The concrete gravity dam of 30 - 50 m high is stable enough on the foundation, though some treatment of permeable zone located on the left bank is necessary.

In order to decide the optimum dam scale, twelve alternative plans were compared as shown in Table V.6-2 and summarized below.

Alternative Plans of Panay C Dam

Case No.	Dam Crest El. (m)	Flood Outflow Ratio	SWL/1 (m)	HWL/2 (m)	Installed Power (MW)	Energy Output (GWh/y)
1.1	40.2	0.333	33.4	30.0	5.7	22.6
1.2	42.5	0.333	35.4	32.5	8.5	27.1
1.3	44.8	0.333	37.5	35.0	11.0	31.4
1.4	47.1	0.333	39.6	37.5	13.0	35.1
2.1	41.7	0.25	34.1	30.0	5.7	22.6
2.2	43.9	0.25	36.1	32.5	8.5	27.1
2.3	46.2	0.25	37.9	35.0	11.0	31.4
2.4	48.5	0.25	40.1	37.5	13.0	35.1
3.1	42.7	0.2	34.6	30.0	5.7	22.6
3.2	44.9	0.2	36.4	32.5	8.5	27.1
3.3	47.1	0.2	38.3	35.0	11.0	31.4
3.4	49.5	0.2	40.4	37.5	13.0	35.1

Notes: /1; SWL = Surcharge water level for flood control
/2; HWL = High water level for power generation

6.2.3 Badbaran A Dam

Similar to Panay B dam site, there exist relatively low ridges on the left bank. If the dam crest should be lower than this level, the maximum dam height will be 29.5 m with crest elevation of El.45.5 m. In case that a higher dam is to be constructed, it is necessary to construct a sub-dam on the ridge.

The rockfill type dam is selected due to the following reasons.

(1) The riberbed gravel zone is comparatively deep especially at the right bank side.

(2) The suitable materials for rockfill dam are available in the vicinity area.

In view of a limited storage capacity available at this dam site, no notable storage could be allocated for hydropower generation. For deciding the optimum dam scale, the following six alternative plans including flood control single purpose plans were listed for comparison. Outline of the plans are summarized below and the details shown in Table V.6-3.

Alternative Plans of Badbaran A Dam

Case No.	Dam Crest El. (m)	Flood Outflow Ratio	SWL/1 (m)	HWL/2 (m)	Installed Power (MW)	Energy Output (GWh/y)
1.1	46.9	0.5	40.2	-	-	-
1.2	47.0	0.5	40.5	37.5	1.0	6.3
2.1	49.8	0.333	41.6	-	-	-
2.2	50.0	0.333	41.8	37.5	1.0	6.3
3.1	51.4	0.25	42.4	-	-	-
3.2	51.6	0.25	42.7	37.5	1.0	6.3

Notes: /1; SWL = Surcharge water level for flood control
/2; HWL = High water level for power generation

6.2.4 Mambusao B Dam

The combined type of rockfill and concrete gravity is selected at the site of Mambusao B dam due to the following reasons.

(1) The riverbed gravel zone is as deep as 12 m and the soft conglomerate zone underlies this gravel zone. On this condition, the fill type is desirable.

(2) On the other hand, the river diversion treatment has to be done for the discharge of about 800 m^3/S diameter. However, the difficulty is expected for the excavation of tunnel, judging from the topography and geology at the damsite. Therefore, on the right bank side foundation, it is recommended to construct a concrete gravity dam and to provide the facilities of river diversion, spillway and intake of power plant on this concrete portion as the depth of riverbed gravel zone is comparatively shallow on the right bank side.

As in the case of Badbaran A dam, this dam has also a limited storage capacity and only a small portion could be allocated for hydropower generation. With a similar consideration applied to the case of Badbaran A dam, the following six alternative cases were examined, with details given in Table V.6-4.

Alternative Plans of Mambusao B Dam

Case No.	Dam Crest El. (m)	Flood Outflow Ratio	SWL/1 (m)	HWL/2 (m)	Installed Power (MW)	Energy Output (GWh/y)
1.1	44.7	0.5	36.6	-	-	-
1.2	45.2	0.5	37.6	35.0	0.8	5.1
2.1	48.7	0.333	38.0	-	-	-
2.2	49.1	0.333	38.7	35.0	0.8	5.1
3.1	50.7	0.25	38.7	-	-	-
3.2	51.2	0.25	39.4	35.0	0.8	5.1

Notes: /1; SWL = Surcharge water level for flood control

/2; HWL = High water level for power generation

6.2.5 Panay C Dam Combined with Panay B Dam

An alternative plan conceivable is the case that the Panay C dam will be constructed in combination with the Panay B dam. In this case, runoff at the Panay C dam site as well as flood inflow will be these regulated by the Panay B dam. Considering these changes in hydrological regimes by the Panay B dam, the optimum scale of the Panay C dam was evaluated.

Alternative plans of the Panay C dam, combined with Panay B dam, were formulated based on the following considerations:

(i) Flood control function of the Panay C dam is examined by comparing three different flood outflow ratios, ranging from 1/3 to 1/5 of peak inflow.

(ii) High water level (H.W.L) for hydropower generation of the Panay C dam is determined to be tailwater level (T.W.L) of the Panay B power station, i.e. EL.30.0 m.

(iii) Flood outflow ratio of the Panay B dam is assumed to be 1/2 of peak inflow discharge.

(iv) Installed capacity of the Panay B power station is assumed to be 7,100 MW, associated with the maximum plant discharge being 27.2 m^3/s.

The latter two conditions were derived from Case 1.3 of the Panay B independent dam scheme.

Selected alternative plans of the Panay C dam, combined with the Panay B dam, are summarized below and the details are shown in Table V.6-5.

Alternative Plans of Panay C Dam
(Combined with Panay B Dam)

Case No.	Dam Crest El. (m)	Flood Outflow Ratio	SWL/1 (m)	HWL/2 (m)	Installed Power (MW)	Energy Output (GWh/y)
1	39.9	0.333	33.1	30.0	6.8	22.6
2	41.4	0.25	33.8	30.0	6.8	22.6
3	42.3	0.2	34.3	30.0	6.8	22.6

Notes: /1; SWL = Surcharge water level for flood control
/2; HWL = High water level for power generation

7. Optimum Development Scale at Each Dam Site

7.1 General

The optimum development scale of each dam is deemed to be the one that yields the largest net benefit, defined as the benefit less the cost, both expressed in present worth at a discount rate of 8% p.a. The cost stream is composed of the economic costs of the dam scheme, including capital cost and operation/maintenance cost. The benefits of dam plan comprise the flood control benefit and power benefit.

7.2 Methodology and Conditions of Optimization

(1) Cost estimation and disbursement

The cost of each alternative plan was estimated on 1984 price level. Major cost items were computed based on the quantities measured on plans, whereas the minor items were estimated on lump-sum basis or by applying cost formulas. Quantities of land acquisition and resettlement in the reservoir area were derived from 1 : 10,000 map, assuming that the compensation would be effected for the area below the maximum flood water level.

Respectively, 100% and 82% of the estimated foreign and local currency costs were regarded as the economic costs.

The construction period of the dam plan was assumed to be 5 years including preparatory works. Disbursements of the construction cost would be 10% in the first year, 15% in the second year, 25% in the third year, 30% in the fourth year and 20% in the fifth year. The annual amount of the operation and maintenance cost was assumed to be 2% of the economic construction cost.

(2) Flood control benefit

The flood control benefit was assessed in the manner shown in the Appendix IV. In this optimization study, the flood control benefit is assumed to be combined with Long-term Plan of river improvement works.

(3) Power benefit

Benefit of hydropower generation in this study is regarded to be the costs of the most likely least cost thermal alternative. Diesel plant with unit capacity of 6,000 kW is considered to be the most likely alternative sources in the Panay power system.

Power benefit is assessed dividing into capacity benefit and energy benefit by applying the unit capacity value and unit energy value.

(i) Unit capacity value

Unit capacity value is assessed based on the following assumptions and procedures.

The construction cost of Diesel unit is estimated to be US$600 per kW. The annualized capital cost and annual operation and maintenance cost are calculated to be 14.7% and 4% of construction cost, respectively. Therefore, the total cost is US$112 per kW.

Adjustment factor to be applied to the above cost is assessed to take into account different performances between hydropower and diesel power and then kW value is calculated as shown below.

(Unit: %)

	Hydropower	Diesel Power
Transmission loss	0.8	0
Auxiliary power use	0.7	4.4
Forced outage	0.5	2.0
Overhaul	0.4	10.0

$$\text{Adjustment factor} = \frac{(1-0.008)(1-0.007)(1-0.005)(1-0.004)}{(1-0.044)(1-0.02)(1-0.1)}$$

$$= \frac{0.976}{0.843} = 1.16$$

Unit kW value = Total kW cost x Adjustment factor
= US$112/kW x 1.16
= US$130/kW = ₱2,340/kW

(ii) Unit energy value

Unit energy value is assessed based on the following assumption and procedure:

Fuel consumption and fuel cost are assumed to be 0.24 lit per kWh and US$42.1 per barrel, respectively. Then, fuel cost is assessed to be 63.5 mills per kWh. Lubricant cost, repair cost and other associated cost are assumed to be 4% of fuel cost (2.5 mills per kWh), 0.7 mills per kWh and 1.0 mill per kWh, respectively. Therefore, the total energy cost is calculated as 67.7 mills per kWh.

Unit kWh value is then calculated by multiplying an adjustment factor estimated as below.

$$\text{Adjustment factor} = \frac{(1-0.008)(1-0.007)}{(1-0.044)} = 1.03$$

Unit kWh value = Total energy cost x Adjustment factor
= 67.7 mills/kWh x 1.03
= 69.7 mills/kWh = ₱1.255/kWh

(4) Negative benefit

The negative benefits due to the implementation of the dam plan are those associated with the production of crops which would be foregone by impounding the reservoir.

The net production values per hectare are broken down into four categories in accordance with major crops in the reservoir area. Net production value per hectare at 1984 price level was estimated as follows.

Net Production Value per Hectare

Item	Net Production Value (₱/ha/year)
Irrigated Paddy	11,200
Rainfed Paddy	9,460
Upland Paddy	860
Sugar Cane	2,910

The area of land uses in the reservoir area was measured on 1 : 10,000 maps. The annual amount of production foregone at each dam site is estimated by elevation as summarized below.

Annual Production Foregone
1984 Price

(Unit: ₱ x 10^3)

Elevation (m)	Panay B dam	Panay C dam	Badbaran A dam	Mambusao B dam
75.0	290	-	-	-
72.5	275	-	-	-
65.0	233	-	-	-
55.0	172	-	-	-
50.0	-	15,444	-	-
45.0	-	-	9,089	-
42.5	-	-	7,325	-
40.0	-	14,745	5,488	5,739
37.5	-	-	-	5,450
35.0	-	13,640	1,586	5,038
30.0	-	11,639	703	1,079
20.0	-	1,021	-	-

In this study, production foregone in the reservoir area was assessed for areas situated below surcharge water level during inflow of 100-year flood.

7.3 Results of Optimization Study

7.3.1 Panay B Dam

Twelve alternative plans, formulated for varying flood outflow ratios and power generation capacities, were compared by the results of economic evaluation. The results are shown in Table V.7-1 and summarized below. The net present values evaluated for the alternative plans are illustrated in Figure V.7-1.

Economic Evaluation of Panay B Dam

Case No.	Dam Crest El. (m)	Present Value/1 (₱ x 10^6)			B/C	EIRR (%)
		Cost	Benefit	NPV		
1.1	71.3	157.9	106.0	-51.9	0.67	5.8
1.2	73.4	275.9	384.0	108.1	1.39	11.0
1.3	77.4	345.7	499.3	153.6*	1.44	11.4
1.4	80.9	451.0	594.4	143.4	1.32	10.6
2.1	76.2	190.2	126.4	-63.8	0.66	5.7
2.2	78.1	330.5	404.4	73.9	1.22	9.7
2.3	81.5	425.6	519.8	94.2	1.22	9.8
2.4	84.6	536.0	614.9	78.9	1.15	9.2
3.1	78.7	234.7	139.0	-95.7	0.59	5.1
3.2	80.5	384.2	417.1	32.9	1.09	8.7
3.3	83.7	501.1	532.4	31.3	1.06	8.5
3.4	86.8	610.0	627.5	17.5	1.03	8.3

Notes: /1; At discount rate of 8% p.a.
/2; * indicates the largest net benefit

The above table shows that Case 1.3 would have the largest net benefit among twelve alternative plans at the Panay B dam site. This plan will have a flood control capability of reducing the flow to a half rate (outflow ratio: 0.5) and a generating capacity of 7,100 kW.

7.3.2 Panay C Dam

Economic evaluation was carried out for twelve alternative plans. The results are shown in Table V.7-2 and summarized below. The net present value evaluated for alternative plans are illustrated in Figure V.7-1.

Economic Evaluation of Panay C Dam

Case No.	Dam Crest El. (m)	Present Value/1 (₱ x 10^6)			B/C	EIRR (%)
		Cost	Benefit	NPV		
1.1	40.2	513.1	463.0	-50.1	0.90	7.3
1.2	42.5	582.7	543.4	-39.3	0.93	7.5
1.3	44.8	644.5	618.0	-26.5	0.96	7.7
1.4	47.1	709.6	680.5	-29.1	0.96	7.7
2.1	41.7	531.0	510.7	-20.3	0.96	7.7
2.2	43.9	601.1	591.4	-9.7	0.98	7.9
2.3	46.2	671.4	667.0	-4.4	0.99	8.0
2.4	48.5	738.8	729.6	-9.2	0.99	7.9
3.1	42.7	546.8	530.2	-16.6	0.97	7.8
3.2	44.9	618.3	611.7	-6.6	0.99	7.9
3.3	47.1	687.3	687.3	0 *	1.00	8.0
3.4	49.5	760.7	750.2	-10.5	0.99	7.9

Notes: /1; At discount rate of 8% p.a.
/2; * indicates the largest net benefit

The above table shows that Case 3.3 is accorded the largest net benefit among the twelve alternative plans of the Panay C independent dam scheme. The plan contemplates to regulate the flood flow to a 1/5 rate and to have a generating capacity of 11,000 kW.

7.3.3 Badbaran A Dam

Economic evaluation was carried out for six alternative plans. The results are shown in Table V.7-3 and summarized below. The net present value of the alternative plans are illustrated in Figure V.7-1.

Economic Evaluation of Badbaran A Dam

Case No.	Dam Crest El. (m)	Present Value/1 (₱ x 10^6)			B/C	EIRR (%)
		Cost	Benefit	NPV		
1.1	46.9	212.7	74.9	-137.8*	0.35	3.3
1.2	47.0	289.3	145.1	-144.2	0.50	4.1
2.1	49.8	319.9	97.2	-222.7	0.30	2.7
2.2	50.0	403.0	167.9	-235.1	0.42	3.2
3.1	51.4	391.5	106.8	-284.7	0.27	2.2
3.2	51.6	471.7	177.0	-294.7	0.38	2.8

Notes: /1; At discount rate of 8% p.a.
/2; * indicates the largest net benefit

The above table shows that Case 1.1 is accorded the largest net benefit among the six alternative plans at the Badbaran A dam site, though the net benefit indicates a negative value. The plan represents a minimum development scale at the site, i.e. a flood control single purpose scheme with the minimum flow regulating capacity (outflow ratio 0.5)

7.3.4 Mambusao B Dam

Economic evaluation was carried out for six alternative plans. The results are shown in Table V.7-4 and summarized below. The net present value of the alternative plans are graphically shown in Figure V.7-1.

Economic Evaluation of Mambusao B Dam

Case No.	Dam Crest El. (m)	Present Value/1 (P x 10^6)			B/C	EIRR (%)
		Cost	Benefit	NPV		
1.1	44.7	290.1	15.2	-274.9*	0.05	-/2
1.2	45.2	355.3	72.2	-283.1	0.20	-
2.1	48.7	350.6	48.6	-301.9	0.14	-
2.2	49.1	419.6	106.2	-313.4	0.25	0.8
3.1	50.7	423.8	72.9	-350.9	0.17	0.3
3.2	51.2	508.7	130.4	-378.3	0.26	0.9

Notes: /1; At discount rate of 8% p.a.

/2; - indicates no EIRR value

/3; * indicates the largest net benefit

The above table shows that Case 1.1 is accorded the largest net benefit among the six alternative plans at the Mambusao B dam, though the net benefit value is negative. Being similar to the case of Badbaran A dam, the plan is formulated to be of a minimum scale, i.e. a flood control single purpose scheme with the minimum flow regulating capacity (outflow ratio: 0.5).

7.3.5 Panay C Dam Combined with Panay B Dam

Three alternative plans of varying flood outflow ratios were compared based on the results of economic evaluation. Flood control benefit accrued by the Panay C dam was regarded to be the total flood damage reduction achieved by two dams (Panay C dam and Panay B dam) less the flood damage reduction by Panay B dam alone. Commencement of the Panay C dam construction was assumed to be four years after the commencement of the Panay B dam construction. The results are shown in Table V.7-5 and summarized below. The net present value evaluated for the alternative plans are graphically shown in Figure V.7-1.

Economic Evaluation of Panay C Dam
(Combined with Panay B Dam)

Case No.	Dam Crest El. (m)	Present Value/1 (₱ x 10^6)			B/C	EIRR (%)
		Cost	Benefit	NPV		
1	39.9	508.1	392.7	-115.4	0.77	6.2
2	41.4	525.6	438.9	-86.7	0.84	6.7
3	42.3	537.8	461.7	-76.1*	0.86	6.9

Notes: /1; At discount rate of 8% p.a.
/2; * indicates the largest net benefit

The above table shows that Case 3 is accorded the largest net benefit among the three alternative plans examined, though the evaluated NPV is negative. The proposed plan contemplates to have a maximum flood control function (outflow ratio of 0.2) within the range studied and an installed capacity of 6,800 kW for hydropower generation.

8. Conclusion

8.1 General Features and Costs of Optimum Dam Schemes

The development scale of the four dams was examined to have dual purposes of flood control and hydropower generation as described in the previous section. Among the four sites, however, Badbaran A and Mambusao B dams were finally proposed as single purpose scheme for flood control, because only a small portion of storage could be allocated for power generation, resulting the power scheme to be less attractive. The general features of the selected dam plans are shown in Table V.8-1 and summarized below.

General Features of Selected Dams

Item	Panay B	Panay C/1	Badbaran A	Mambusao B	Panay C/2
Type of Dam	Concrete gravity	Concrete gravity	Rockfill	Combined C. gravity & rockfill	Concrete gravity
Catchment Area (km^2)	239	509	258	217	509
Dam Height (m)	52.4	39.1	30.9	34.7	34.3
Storage for Flood Control ($10^6 m^3$)	33.8	144.8	38.0	31.5	130.2
Storage for Power Generation ($10^6 m^3$)	30.5	252.3	-	-	127.6
Installed Power (kW)	7,100	11,000	-	-	6,800

Notes: /1; Independent scheme
/2; Combined with Panay B dam

The allocation of storage volume for each selected dam is shown in Figure V.6-1. Flood regulating capacity of the selected dam plans are summarized in Table V.8-2. The estimated cost of the selected plans are summarized below, with breakdowns of foreign and local cost portions, and the details are shown in Table V.8-3.

Construction Cost of Each Dam Plan

(Unit: ₱ x 10^6)

Dam Plan	Construction Cost		
	Foreign Currency	Local Currency	Total
Panay B	227.24	193.96	471.2
Panay C/1	457.12	587.58	1,044.7
Badbaran A	118.00	235.20	353.2
Mambusao B	129.16	309.54	438.7
Panay C/2	345.83	488.47	834.3

Notes: /1; Independent scheme

/2; Combined with Panay B dam

The general layout of dam and power staiton for each dam plan is shown in Figure V.8-1 to V.8-4.

8.2 Flood Control Effect of Dam Plans

A flood flow analysis for downstream reaches was made taking into account flood regulation effects of each dam plan. As its outcome, flood flow discharges and flood water levels at the Panitan base point are shown in Table V.8-4, and flood peak discharges for 2-, 5-, 10-, 25- and 100-year floods at major base points along the Panay mainstream are summarized in Figure V.8-5 and flood water levels are illustrated in Figure V.8-6.

The figures suggested the following:

i) The flood control effect of the Panay C dam would be largest, followed by the Panay B dam, Badbaran A dam and Mambusao B dam among the independent dam plans. It is noteworthy that the flood control effect of the Mambusao B dam is very small; though the Mambusao B dam would cut the peak inflow flood of 1,770 m^3/sec to 885 m^3/sec in case of a 100-year flood, the flood control effect at the Panay - Mambusao junction is almost nil. Flood discharge reduction would only be 20 m^3/sec (from

2,720m^3/sec to 2,700m^3/sec), due mainly to substantial natural retardation effects in the downstream reach.

ii) The flood control effect in terms of the peak discharge reduction would gradually decrease in the downstream reaches. In case of the Panay B dam, the peak discharge reduction for a 100-year flood is 180 m^3/sec at the Badbaran junction, while it would further drop to 60 m^3/sec at Panitan. This tendency is common to all other cases.

iii) Decrease in the flood water level is not much different between the cases of small floods and large ones. In case of the Panay B dam, the decrease in the flood water level at Mambusao junction is 0.2 m, in either case of 100-year, 5-year and 2-year floods. This tendency is common to all other cases.

TABLES

FOR

APPENDIX V

Table V.3-1 Preliminary Study Results of Prospective Damsites in Panay River Basin (1)

River System	Dam-site	Type & Scale of Dam	Geological Condition at Damsite	Catch Area Km^2	Design Flood m^3/sec	Annual Run-off 10^6m ($m^3/sec\text{-}km^2$)	H.W.L El.m	Total Storage 10^6m^3	Sedim. Storage 10^6m^3	Total Effect Storage 10^6m^3	Water Utilize Storage 10^6m^3	Flood Cont. Storage 10^6m^3
Panay	A Site	Concrete gravity H=71.5m, L=110m V=145,000m^3 Spillway free over-flow type	Conglomerate, Sandstone and silt-stone which are not well con-solidated. Lot of water leakage is recorded in the part drilling	211.9	1,000 (200yr. flood)	560.5 (0.0839)	120	134	21	113	56.5	56.5
	B Site	Concrete gravity H=47m, L=130m V=92,000m^3 Spillway with gates	Andesitic volcanic breccia with many outcrop in river bed	238.8	1,120 (200yr. flood)	632.6 (0.0839)	75	73	24	49	24.5	24.5
	C Site	Concrete gravity H=26m, L=153m V=41,500m^3 Spillway with gates	Andesitic volcanic brecca with same outcrop in riverbed	509.2	2,400	1,151.3	30	229	51	178	89	89
Lacbaram	A Site		Andesite and volcanic breccia. Depth to fresh rock is about 10m	258.4	2,130 (1.2x200yr. flood)	354.3 (0.0435)	42.5	115.3	37.5	77.8	35.1	42.7
	B Site	Rockfill H=23m, L=335m V=354,000m^3 Spillway with gate	Karstic limestone much leakage expected	290.0	2,260 (1.2x200yr. flood)	431.5 (0.0472)	35	97	29	68	34	34
Mambusao	A Site	Concrete gravity H=44m, L=130m V=77,000m^3 Spillway free over-flow type	Moderately hard consolidated conglomerate, sandstone and siltstone overburden very thick	72.9	250 (200yr. flood)	136.4 (0.0593)	90	38	7	31	15.5	15.5
	B Site	Rockfill H=15m, L=280m V=148,000m^3 Spillway with gate	Sandstone, conglomerate and siltstone. Site is covered with thick overburden.	216.6	910	405.2	32	72	22	50	25	25
Maayon	Maayon	Rockfill H=30m, L=385m V=480,000m^3 Spillway with gates		140.1	910	177.5	97	50	14	36	18	18

Table V.3-1 Preliminary Study Results of Prospective Damsites in Panay River Basin (2)

River System	Damsite	Firm disch. m^3/sec	Max. disch. m^3/sec	Intake H.W.L EL.m	L.W.L EL.m	T.W.L EL.m	Total Head m	Inst. Capa. KW	Depend. Output KW	Annual Anergy 10^6KWh	Construction Cost ₱10^6 Dam	Construction Cost ₱10^6 Power S.	Construction Cost ₱10^6 Total	Dam Cost / Eff. Storage ₱/m^3	Energy Cost [1] ₱KWh
Panay	A Site	14.46	30.0	104.0	86.0	59.0	44.5 ~27.0	10,700	6,360	45.3	627.5	242.4	869.9	5.55	0.54
	B Site	12.50	25.0	68.0	61.5	39.0	29.0 ~22.5	5,700	4,400	35.5	403.7	166.3	570.0	8.24	0.47
	C Site	24.6	50.0	25.5	21.2	14.0	11.5 ~7.2	4,480	2,760	24.1	523.1	212.4	735.5	2.94	0.88
Badbaran	A Site	8.79	18.0	40.0	36.8	22.0	18.0 ~14.8	2,250	2,120	11.7	275.6	97.5	373.1	3.55	0.83
	B Site	6.5	13.0	31.5	27.5	17.0	14.5 ~10.5	1,400	990	8.7	441.7	106.1	547.8	6.50	1.21
Mambusao	A Site	3.2	6.5	83.0	73.0	35.0	28.0 ~18.0	1,440	920	6.8	297.4	63.7	361.1	9.59	0.94
	B Site	7.8	15.0	30.0	26.0	19.0	11.0 ~7.0	Head is too low. Not planned			358.4			7.17	
Maayon	Maayon	3.4	6.8	42.5	38.0	29.0	18.5 ~14.0	900	710	5.8	293.2	74.3	367.5	8.14	1.29

Remark: 1. Energy cost is tentatively calculated to be $\frac{\text{Construction Cost of Power House}}{\text{Annual energy output}}$ x annual cost factor.

Annual cost factor is taken at 0.1.

Table V.5-1 Monthly Mean Discharge at Panay B Dam

(Unit : m^3/sec)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1956	14.72	4.49	6.37	11.22	13.10	12.08	23.76	20.82	11.06	20.13	18.12	26.04	15.16
1957	39.30	8.88	4.82	9.74	4.16	7.62	19.37	17.49	12.21	16.30	11.88	6.17	13.16
1958	7.29	4.42	3.80	5.05	5.51	10.40	13.37	16.57	9.04	36.93	32.93	13.83	13.26
1959	6.04	3.76	7.16	2.74	10.16	8.58	30.43	15.38	25.51	25.84	29.04	17.79	15.20
1960	6.80	7.95	4.42	14.88	8.22	17.49	20.26	16.50	10.59	25.44	37.16	15.31	15.42
1961	10.33	6.90	4.59	3.40	7.36	11.45	15.64	12.77	15.77	24.82	17.03	9.17	11.60
1962	10.10	8.18	8.35	3.66	3.23	13.66	25.28	27.39	46.60	12.08	27.09	20.53	17.18
1963	15.97	8.68	5.02	3.60	2.87	3.10	6.73	22.54	13.50	15.71	12.24	19.67	10.80
1964	7.62	5.05	2.71	2.84	7.72	3.10	5.08	7.72	25.44	13.83	34.52	24.59	11.68
1965	21.35	8.22	12.11	6.93	4.75	13.40	16.50	22.80	13.63	16.73	7.52	22.24	13.85
1966	9.21	3.86	3.17	2.64	15.94	13.04	22.61	24.78	31.25	39.30	45.41	21.22	19.37
1967	57.12	23.17	11.35	4.36	3.80	4.98	9.41	8.09	13.00	15.15	27.19	9.67	15.61
1968	7.72	10.16	11.62	13.60	13.46	12.01	15.18	12.97	10.16	25.34	31.35	6.57	14.18
1969	2.61	2.34	1.82	1.72	2.08	7.59	25.01	11.09	14.85	12.71	14.45	36.40	11.06
1970	5.61	10.26	10.13	5.21	4.59	8.15	28.84	7.76	10.99	14.49	25.84	23.53	12.95
1971	12.61	15.25	11.48	2.51	13.30	41.65	15.02	7.36	7.16	9.24	21.85	14.88	14.36
1972	10.00	3.93	7.06	5.87	2.94	8.35	28.91	7.52	25.51	7.03	27.29	24.92	13.28
1973	10.59	8.28	5.87	4.82	3.99	2.74	4.39	8.18	28.84	19.97	106.33	56.69	21.73
1974	25.34	32.34	16.07	5.28	5.81	8.22	17.79	8.42	9.67	15.68	12.05	11.88	14.04
1975	11.68	20.00	7.82	5.05	3.17	20.30	14.49	20.99	21.58	17.26	14.49	32.31	15.76
1976	18.65	16.20	5.61	9.34	12.01	16.10	10.73	53.66	10.86	5.05	13.37	20.36	15.99
1977	10.40	6.30	8.12	5.28	7.03	15.74	14.98	12.57	13.04	12.41	16.76	11.39	11.17
1978	7.36	10.40	2.77	7.36	13.33	18.51	27.72	4.26	8.71	14.12	20.43	22.21	13.10
AVERAGE	14.28	9.96	7.05	5.96	7.33	12.10	17.89	15.98	16.91	18.07	26.28	20.32	14.34

Table V.5-2 Monthly Mean Discharge at Panay C Dam

(Unit : m^3/sec)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1956	28.99	8.84	12.55	22.10	25.81	23.79	46.80	41.02	21.78	39.65	35.69	51.29	29.86
1957	77.42	17.49	9.49	19.18	8.19	15.02	38.16	34.45	24.05	32.11	23.40	12.16	25.92
1958	14.37	8.71	7.48	9.95	10.86	20.48	26.33	32.63	17.81	72.74	64.87	27.24	26.12
1959	11.90	7.41	14.11	5.40	20.02	16.90	59.93	30.29	50.25	50.90	57.20	35.04	29.94
1960	13.39	15.67	8.71	29.32	16.19	34.45	39.91	32.50	20.87	50.12	73.19	30.16	30.37
1961	20.35	13.59	9.04	6.70	14.50	22.56	30.81	25.16	31.07	48.88	33.54	18.07	22.85
1962	19.89	16.12	16.45	7.22	6.37	26.91	49.79	53.95	91.78	23.79	53.37	40.43	33.84
1963	31.46	17.10	9.88	7.09	5.66	6.11	13.26	44.40	26.59	30.94	24.12	38.74	21.28
1964	15.02	9.95	5.33	5.59	15.21	6.11	10.01	15.21	50.12	27.24	67.99	48.43	23.02
1965	42.06	16.19	23.86	13.65	9.36	26.39	32.50	44.92	26.85	32.96	14.82	43.81	27.28
1966	18.14	7.61	6.24	5.20	31.40	25.68	44.53	48.82	61.56	77.42	89.44	41.80	38.15
1967	112.52	45.63	22.36	8.58	7.48	9.82	18.53	15.93	25.61	29.84	53.56	19.05	30.74
1968	15.21	20.02	22.88	26.78	26.52	23.66	29.90	25.55	20.02	49.92	61.75	12.94	27.93
1969	5.14	4.62	3.58	3.38	4.10	14.95	49.27	21.84	29.25	25.03	28.47	71.70	21.78
1970	11.05	20.22	19.96	10.27	9.04	16.06	56.81	15.28	21.65	28.54	50.90	46.35	25.51
1971	24.83	30.03	22.62	4.94	26.20	82.03	29.58	14.50	14.11	18.20	43.03	29.32	28.28
1972	19.70	7.74	13.91	11.57	5.79	16.45	56.94	14.82	50.25	13.85	53.76	49.08	26.15
1973	20.87	16.32	11.57	9.49	7.87	5.40	8.65	16.12	56.81	39.33	209.43	111.67	42.79
1974	49.92	63.70	31.66	10.40	11.44	16.19	35.04	16.58	19.05	30.88	23.73	23.40	27.66
1975	23.01	39.39	15.41	9.95	6.24	39.98	28.54	41.34	42.51	34.00	28.54	63.64	31.04
1976	36.73	31.92	11.05	18.40	23.66	31.72	21.13	105.69	21.39	9.95	26.33	40.11	31.50
1977	20.48	12.42	15.99	10.40	13.85	31.01	29.51	24.77	25.68	24.44	33.02	22.43	22.00
1978	14.50	20.48	5.46	14.50	26.26	36.47	54.60	8.39	17.16	27.82	40.24	43.75	25.80
AVERAGE	28.13	19.61	13.89	11.74	14.43	23.83	35.24	31.48	33.31	35.59	51.75	40.02	28.25

Table V.5-3 Monthly Mean Discharge at Panay C Dam (Combined with Panay B Dam)

(Unit : m^3/sec)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1956	28.77	11.15	12.78	18.98	25.50	23.51	46.54	40.79	21.52	39.42	35.47	51.05	29.62
1957	77.21	17.21	11.27	16.74	10.63	13.99	36.08	34.26	23.84	31.91	23.22	12.58	25.75
1958	13.67	10.89	10.28	11.50	11.94	16.68	21.26	32.36	17.57	72.51	64.64	27.01	25.86
1959	12.46	10.25	13.54	9.26	16.46	14.92	57.60	30.11	50.04	50.66	56.96	34.85	29.76
1960	13.19	15.71	10.89	26.43	15.87	34.26	39.65	32.30	20.67	49.87	73.03	29.95	30.15
1961	20.12	13.29	11.05	9.90	13.74	17.70	29.97	24.88	30.90	48.66	33.31	17.80	22.61
1962	19.69	15.84	16.20	10.15	9.74	19.85	49.51	53.76	91.58	23.61	53.17	40.20	33.61
1963	31.19	16.82	11.46	10.09	9.38	9.61	13.13	31.76	26.39	30.73	23.87	38.47	21.07
1964	14.79	11.70	9.22	9.35	14.09	9.61	10.13	14.09	38.07	27.01	67.77	48.24	22.84
1965	41.80	15.97	23.54	13.32	11.21	23.99	32.30	44.71	26.62	32.72	14.60	43.57	27.03
1966	17.93	10.34	9.67	9.16	22.06	24.14	44.32	48.63	61.30	77.21	89.23	41.58	37.96
1967	112.29	45.36	22.11	10.82	10.28	11.43	15.72	14.44	22.01	29.59	53.37	18.78	30.52
1968	14.99	20.16	22.56	26.48	26.26	23.45	29.72	25.28	19.76	49.68	61.60	12.97	27.74
1969	9.13	8.87	7.46	3.16	3.92	13.96	37.46	21.65	29.00	24.82	28.22	71.50	21.60
1970	12.04	18.65	19.62	11.66	11.05	14.50	54.07	15.02	21.46	28.35	50.66	46.12	25.27
1971	24.62	29.78	22.34	9.03	21.70	81.78	29.36	14.24	13.84	17.96	42.78	29.13	28.05
1972	19.50	10.61	13.45	12.30	9.45	14.70	50.93	14.60	50.04	13.62	53.56	48.86	25.97
1973	20.67	16.03	12.30	11.27	10.47	9.26	10.86	14.54	45.67	39.16	209.20	111.48	42.57
1974	49.68	63.46	31.38	11.72	12.23	14.57	33.65	16.36	18.88	30.70	23.48	23.22	27.44
1975	22.83	39.09	15.08	11.50	9.67	34.18	28.35	41.15	42.33	33.84	28.35	63.43	30.82
1976	36.48	32.21	12.04	16.76	23.35	31.52	20.90	105.43	21.13	11.50	24.36	39.84	31.29
1977	20.28	12.71	15.17	11.72	13.42	29.36	29.33	24.49	25.44	24.23	32.86	22.24	21.77
1978	14.24	20.28	9.29	13.74	22.33	36.25	54.38	10.73	15.05	26.90	40.01	43.54	25.56
AVERAGE	28.15	20.28	14.90	12.83	14.55	22.75	33.70	30.68	31.87	35.42	51.47	39.84	28.04

Table V.5-4 Monthly Mean Discharge at Badbaran A Dam

(Unit : m^3/sec)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1956	8.92	2.72	3.86	6.80	7.94	7.32	14.40	12.62	6.70	12.20	10.98	15.78	9.19
1957	23.82	5.38	2.92	5.90	2.52	4.62	11.74	10.60	7.40	9.88	7.20	3.74	7.98
1958	4.42	2.68	2.30	3.06	3.34	6.30	8.10	10.04	5.48	22.38	19.96	8.38	8.04
1959	3.66	2.28	4.34	1.66	6.16	5.20	18.44	9.32	15.46	15.66	17.60	10.78	9.21
1960	4.12	4.82	2.68	9.02	4.98	10.60	12.28	10.00	6.42	15.42	22.52	9.28	9.35
1961	6.26	4.18	2.78	2.06	4.46	6.94	9.48	7.74	9.56	15.04	10.32	5.56	7.03
1962	6.12	4.96	5.06	2.22	1.96	8.28	15.32	16.60	28.24	7.32	16.42	12.44	10.41
1963	9.68	5.26	3.04	2.18	1.74	1.88	4.08	13.66	8.18	9.52	7.42	11.92	6.55
1964	4.62	3.06	1.64	1.72	4.68	1.88	3.08	4.68	15.42	8.38	20.92	14.90	7.08
1965	12.94	4.98	7.34	4.20	2.88	8.12	10.00	13.82	8.26	10.14	4.56	13.48	8.39
1966	5.58	2.34	1.92	1.60	9.66	7.90	13.70	15.02	18.94	23.82	27.52	12.86	11.74
1967	34.62	14.04	6.88	2.64	2.30	3.02	5.70	4.90	7.88	9.18	16.48	5.86	9.46
1968	4.68	6.16	7.04	8.24	8.16	7.28	9.20	7.86	6.16	15.36	19.00	3.98	8.59
1969	1.58	1.42	1.10	1.04	1.26	4.60	15.16	6.72	9.00	7.70	8.76	22.06	6.70
1970	3.40	6.22	6.14	3.16	2.78	4.94	17.48	4.70	6.66	8.78	15.66	14.26	7.85
1971	7.64	9.24	6.96	1.52	8.06	25.24	9.10	4.46	4.34	5.60	13.24	9.02	8.70
1972	6.06	2.38	4.28	3.56	1.78	5.06	17.52	4.56	15.46	4.26	16.54	15.10	8.05
1973	6.42	5.02	3.56	2.92	2.42	1.66	2.66	4.96	17.48	12.10	64.44	34.36	13.17
1974	15.36	19.60	9.74	3.20	3.52	4.98	10.78	5.10	5.86	9.50	7.30	7.20	8.51
1975	7.08	12.12	4.74	3.06	1.92	12.30	8.78	12.72	13.08	10.46	8.78	19.58	9.55
1976	11.30	9.82	3.40	5.66	7.28	9.76	6.50	32.52	6.58	3.06	8.10	12.34	9.69
1977	6.30	3.82	4.92	3.20	4.26	9.54	9.08	7.62	7.90	7.52	10.16	6.90	6.77
1978	4.46	6.30	1.68	4.46	8.08	11.22	16.80	2.58	5.28	8.56	12.38	13.46	7.94
AVERAGE	8.65	6.03	4.27	3.61	4.44	7.33	10.84	9.69	10.25	10.95	15.92	12.31	8.69

Table V.5-5 Monthly Mean Discharge at Mambusao B Dam

(Unit : m^3/sec)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
1950	16.70	7.56	6.05	3.89	5.62	41.83	9.29	20.59	20.38	26.21	38.38	13.39	17.49
1951	6.12	7.27	2.52	1.30	26.71	18.14	15.05	7.49	16.06	23.54	28.66	44.28	16.43
1952	11.66	2.95	2.88	1.22	8.78	10.15	21.10	30.10	42.26	51.12	48.96	22.54	21.14
1953	51.26	11.74	6.05	3.89	3.46	8.42	6.55	4.32	12.10	16.92	20.30	20.38	13.78
1954	16.70	7.56	6.70	0.36	0.36	40.68	32.47	7.49	9.86	19.08	13.03	79.13	19.45
1955	62.93	3.67	3.02	8.50	3.74	56.59	53.21	15.19	27.86	11.16	51.26	54.22	29.28
1956	12.74	14.62	11.59	13.32	21.17	12.74	21.24	19.73	10.73	25.56	21.31	19.87	17.05
1957	29.88	10.58	5.83	17.14	4.46	6.84	15.91	12.10	8.14	17.50	14.04	6.41	12.40
1958	9.22	5.76	6.55	4.46	4.39	7.78	9.00	18.50	5.04	28.22	25.70	11.81	11.37
1959	4.97	3.02	7.92	2.81	5.83	9.58	20.52	10.66	5.83	15.48	21.74	18.72	10.59
1960	8.64	6.05	4.97	12.89	6.62	15.12	20.66	6.70	12.67	24.05	31.61	13.68	13.64
1961	5.90	2.81	1.87	1.58	3.31	12.67	9.79	7.56	12.10	38.38	14.69	5.47	9.68
1962	13.10	9.14	9.43	2.88	4.39	20.16	17.71	17.14	33.55	8.06	17.78	29.74	15.26
1963	17.86	3.67	4.39	3.17	2.52	1.30	3.89	13.54	18.14	11.30	13.10	20.02	9.41
1964	5.76	5.33	3.17	4.68	6.62	8.21	4.39	6.70	16.78	18.94	41.54	13.97	11.34
1965	13.75	6.41	6.12	2.66	4.46	7.99	8.42	5.62	8.28	17.06	6.55	19.44	8.90
1966	18.14	2.88	2.52	2.30	16.13	7.63	19.87	9.22	3.31	22.18	5.47	12.96	10.22
1967	50.33	10.08	6.91	1.94	1.73	3.53	3.10	2.59	2.45	11.88	7.92	2.81	8.77
1968	2.81	2.16	1.73	1.30	1.22	3.17	3.17	6.62	2.45	5.04	20.95	2.45	4.42
1969	1.66	1.30	0.86	0.36	0.58	6.62	18.65	4.61	16.06	11.66	10.66	13.32	7.19
1970	2.66	2.23	1.87	1.30	0.94	1.73	1.15	1.94	2.02	13.03	20.81	43.42	7.76
1971	45.22	36.58	45.58	1.01	0.86	4.39	5.04	4.82	6.19	7.99	16.63	9.29	15.30
1972	10.01	3.82	3.82	1.30	1.30	4.97	9.43	9.94	9.07	6.12	23.83	21.74	8.78
1973	9.22	0.79	0.65	0.72	0.86	1.87	6.55	8.28	6.48	6.55	8.14	5.40	4.63
1974	2.59	1.22	1.73	1.08	2.02	7.20	15.55	7.34	8.42	13.68	10.51	5.40	6.40
1975	10.22	17.42	6.84	4.39	2.74	17.71	12.67	18.29	18.86	15.05	12.67	28.22	13.76
1976	16.27	14.11	4.90	8.14	10.51	13.75	13.10	4.75	1.80	3.74	10.94	30.38	11.03
1977	10.94	10.51	2.95	0.50	1.30	4.03	8.42	5.54	2.81	3.74	12.46	2.88	5.51
AVERAGE	16.69	7.54	6.05	3.90	5.45	12.67	13.78	10.26	12.13	16.90	20.35	20.40	12.18

Table V.6-1 Alternative plans of Panay B Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	100-year Flood Inflow (m^3/sec)	100-year Flood Outflow (m^3/sec)	Operation Levels (m) FWL	SWL	HWL	LWL	Storage Volume (10^6 m^3) For Flood Control	For Power Generation	Dead Water	Total	Installed Power (kW)	Energy Output (GWh/y)	Max. Discharge (m^3/sec)
1.1	71.3	0.5	2,420	1,210	68.8	65.0	-	56.7	33.8	-	31.7	65.5	-	-	-
1.2	73.4	0.5	2,420	1,210	70.9	67.3	60.0	56.7	33.8	10.7	31.7	76.2	4.2	23.7	18.0
1.3	77.4	0.5	2,420	1,210	74.9	71.3	65.0	56.7	33.8	30.5	31.7	96.0	7.1	31.4	27.2
1.4	80.9	0.5	2,420	1,210	78.4	75.0	70.0	56.7	33.8	56.2	31.7	121.7	10.0	36.8	34.9
2.1	76.2	0.333	2,420	807	73.7	68.9	-	56.7	52.8	-	31.7	84.5	-	-	-
2.2	78.1	0.333	2,420	807	75.6	70.9	60.0	56.7	52.8	10.7	31.7	95.3	4.2	23.7	18.0
2.3	81.5	0.333	2,420	807	79.0	74.3	65.0	56.7	52.8	30.5	31.7	115.0	7.1	31.4	27.2
2.4	84.6	0.333	2,420	807	82.1	77.6	70.0	56.7	52.8	56.2	31.7	140.7	10.0	36.8	34.9
3.1	78.7	0.25	2,420	605	76.2	71.0	-	56.7	63.8	-	31.7	95.5	-	-	-
3.2	80.5	0.25	2,420	605	78.0	72.8	60.0	56.7	63.8	10.7	31.7	106.2	4.2	23.7	18.0
3.3	83.7	0.25	2,420	605	81.2	76.0	65.0	56.7	63.8	30.5	31.7	126.0	7.1	31.4	27.2
3.4	86.8	0.25	2,420	605	84.3	79.2	70.0	56.7	63.8	56.2	31.7	151.7	10.0	36.8	34.9

Table V.6-2 Alternative Plans of Panay C Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	100-year Flood Inflow (m^3/sec)	100-year Flood Outflow (m^3/sec)	Operation Level (m) FWL	SWL	HWL	LWL	Storage Volume (10^6 m^3) For Flood Control	For Power Generation	Dead Water	Total	Installed Power (kW)	Energy Output (GWh/y)	Max. Discharge (m^3/sec)
1.1	40.2	0.333	4,120	1,373	37.7	33.4	30.0	25.6	103.4	95.9	68.9	268.2	5.7	22.6	62.8
1.2	42.5	0.333	4,120	1,373	40.0	35.4	32.5	25.6	103.4	167.2	68.9	339.5	8.5	27.1	81.3
1.3	44.8	0.333	4,120	1,373	42.3	37.5	35.0	25.6	103.4	252.3	68.9	424.6	11.0	31.4	93.0
1.4	47.1	0.333	4,120	1,373	44.6	39.6	37.5	25.6	103.4	355.7	68.9	528.0	13.0	35.1	98.5
2.1	41.7	0.25	4,120	1,030	39.2	34.1	30.0	25.6	125.8	95.9	68.9	290.6	5.7	22.6	62.8
2.2	43.9	0.25	4,120	1,030	41.4	36.1	32.5	25.6	125.8	167.2	68.9	361.9	8.5	27.1	81.3
2.3	46.2	0.25	4,120	1,030	43.7	37.9	35.0	25.6	125.8	252.3	68.9	447.0	11.0	31.4	93.0
2.4	48.5	0.25	4,120	1,030	46.0	40.1	37.5	25.6	125.8	355.7	68.9	550.4	13.0	35.1	98.5
3.1	42.7	0.2	4,120	824	40.2	34.6	30.0	25.6	144.8	95.9	68.9	309.3	5.7	22.6	62.8
3.2	44.9	0.2	4,120	824	42.4	36.4	32.5	25.6	144.8	167.2	68.9	380.9	8.5	27.1	81.3
3.3	47.1	0.2	4,120	824	44.6	38.3	35.0	25.6	144.8	252.3	68.9	466.0	11.0	31.4	93.0
3.4	49.5	0.2	4,120	824	47.0	40.4	37.5	25.6	144.8	355.7	68.9	569.4	13.0	35.1	98.5

Table V.6-3 Alternative Plans of Badbaran A Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	100-year Flood		Operation Levels (m)				Storage Volume (10^6 m^3)				Installed Power (kW)	Energy Output (GWh/y)	Max. Discharge (m^3/sec)
			Inflow (m^3/sec)	Outflow (m^3/sec)	FWL	SWL	HWL	LWL	For Flood Control	For Power Generation	Dead Water	Total			
1.1	46.9	0.5	1,900	950	43.9	40.2	-	36.8	38.0	-	37.5	75.5	-	-	-
1.2	47.0	0.5	1,900	950	44.0	40.5	37.5	36.8	38.0	6.3	37.5	81.8	1.0	6.3	8.2
2.1	49.8	0.333	1,900	633	46.8	41.6	-	36.8	60.0	-	37.5	97.5	-	-	-
2.2	50.0	0.333	1,900	633	47.0	41.8	37.5	36.8	60.0	6.3	37.5	103.8	1.0	6.3	8.2
3.1	51.4	0.25	1,900	475	48.4	42.4	-	36.8	76.1	-	37.5	113.6	-	-	-
3.2	51.6	0.25	1,900	475	48.6	42.7	37.5	36.8	76.1	6.3	37.5	119.9	1.0	6.3	8.2

Table V.6-4 Alternative Plans of Mambusao B Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	100-year Flood		Operation Levels (m)				Storage Volume (10^6 m^3)				Installed Power (kW)	Energy Output (GWh/y)	Max. Discharge (m^3/sec)
			Inflow (m^3/sec)	Outflow (m^3/sec)	FWL	SWL	HWL	LWL	For Flood Control	For Power Generation	Dead Water	Total			
1.1	44.7	0.5	1,770	885	41.7	36.6	-	33.6	31.5	-	28.7	60.2	-	-	-
1.2	45.2	0.5	1,770	885	42.2	37.6	35.0	33.6	31.5	12.9	28.7	73.1	0.8	5.1	7.2
2.1	48.7	0.333	1,770	590	45.7	38.0	-	33.6	50.1	-	28.7	78.8	-	-	-
2.2	49.1	0.333	1,770	590	46.1	38.7	35.0	33.6	50.1	12.9	28.7	91.7	0.8	5.1	7.2
3.1	50.7	0.25	1,770	443	47.7	38.7	-	33.6	63.0	-	28.7	91.7	-	-	-
3.2	51.2	0.25	1,770	443	48.2	39.4	35.0	33.6	63.0	12.9	28.7	104.6	0.8	5.1	7.2

Table V.6-5 Alternative Plans of Panay C Dam (Combined with Panay B Dam)

Case No.	Dam Crest El. (m)	Flood Outflow Rate	100-year Flood		Operation Levels (m)				Storage Volume (10^6 m^3)				Installed Power (kW)	Energy Output (GWh/y)	Max. Discharge (m^3/sec)
			Inflow (m^3/sec)	Outflow (m^3/sec)	FWL	SWL	HWL	LWL	For Flood Control	For Power Generation	Dead Water	Total			
1	39.9	0.333	3,230	1,077	37.4	33.1	30.0	23.5	60.2	127.6	37.2	255.0	6.8	22.6	80.0
2	41.4	0.25	3,230	808	38.9	33.8	30.0	23.5	113.2	127.6	37.2	278.0	6.8	22.6	80.0
3	42.3	0.2	3,230	646	39.8	34.3	30.0	23.5	130.2	127.6	37.2	295.0	6.8	22.6	80.0

Table V.7-1 Economic Evaluation of Each Alternative Plan for Panay B Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	Installed Power (kW)	Energy Output (GWh/y)	Economic Const. Cost (₱ x 10^6)	Present Value/1 (₱ x 10^6) Cost	Benefit Flood	Benefit Power	Benefit Energy	Benefit Negative	Benefit Total	NPV	B/C	EIRR (%)
1.1	71.3	0.5	-	-	195.9	157.9	107.9	-	-	-1.9	106.0	-51.9	0.67	5.8
1.2	73.4	0.5	4.2	23.7	342.3	275.9	107.9	69.1	209.0	-2.0	384.0	108.1	1.39	11.0
1.3	77.4	0.5	7.1	31.4	428.9	345.7	107.9	116.7	276.9	-2.2	499.3	153.6*	1.44	11.4
1.4	80.9	0.5	10.0	36.8	559.5	451.0	107.9	164.4	324.5	-2.4	594.4	143.4	1.32	10.6
2.1	76.2	0.333	-	-	235.9	190.2	128.5	-	-	-2.1	126.4	-63.8	0.66	5.7
2.2	78.1	0.333	4.2	23.7	410.0	330.5	128.5	69.1	209.0	-2.2	404.4	73.9	1.22	9.7
2.3	81.5	0.333	7.1	31.4	528.0	425.6	128.5	116.7	276.9	-2.3	519.8	94.2	1.22	9.8
2.4	84.6	0.333	10.0	36.8	664.9	536.0	128.5	164.4	324.5	-2.5	614.9	78.9	1.15	9.2
3.1	78.7	0.25	-	-	291.2	234.7	141.2	-	-	-2.2	139.0	-95.7	0.59	5.1
3.2	80.5	0.25	4.2	23.7	476.6	384.2	141.2	69.1	209.0	-2.2	417.1	32.9	1.09	8.7
3.3	83.7	0.25	7.1	31.4	621.6	501.1	141.2	116.7	276.9	-2.4	532.4	31.3	1.06	8.5
3.4	86.8	0.25	10.0	36.8	756.7	610.0	141.2	164.4	324.5	-2.6	627.5	17.5	1.03	8.3

Notes: /1 At discount rate of 8% p.a. /2 * indicates the largest net benefit

Table V.7-2 Economic Evaluation of Each Alternative Plan for Panay C Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	Installed Power (kW)	Energy Output (GWh/y)	Economic Const. Cost (₱ x 10^6)	Present Value/1 (₱ x 10^6) Cost	Benefit Flood	Benefit Power	Benefit Energy	Benefit Negative	Benefit Total	NPV	B/C	EIRR (%)
1.1	40.2	0.333	5.7	22.6	636.6	513.1	276.2	93.7	199.3	-106.2	463.0	-50.1	0.90	7.3
1.2	42.5	0.333	8.5	27.1	722.9	582.7	276.2	139.8	239.0	-111.6	543.4	-39.3	0.93	7.5
1.3	44.8	0.333	11.0	31.4	799.5	644.5	276.2	180.9	276.9	-116.0	618.0	-26.5	0.96	7.7
1.4	47.1	0.333	13.0	35.1	880.3	709.6	276.2	213.8	309.6	-119.1	680.5	-29.1	0.96	7.7
2.1	41.7	0.25	5.7	22.6	658.7	531.0	325.9	93.7	199.3	-108.2	510.7	-20.3	0.96	7.7
2.2	43.9	0.25	8.5	27.1	745.7	601.1	325.9	139.8	239.0	-113.3	591.4	-9.7	0.98	7.9
2.3	46.2	0.25	11.0	31.4	832.9	671.4	325.9	180.9	276.9	-116.7	667.0	-4.4	0.99	8.0
2.4	48.5	0.25	13.0	35.1	916.5	738.8	325.9	213.8	309.6	-119.7	729.6	-9.2	0.99	7.9
3.1	42.7	0.2	5.7	22.6	678.4	546.8	346.8	93.7	199.3	-109.6	530.2	-16.6	0.97	7.8
3.2	44.9	0.2	8.5	27.1	767.0	618.3	346.8	139.8	239.0	-113.9	611.7	-6.6	0.99	7.9
3.3	47.1	0.2	11.0	31.4	852.6	687.3	346.8	180.9	276.9	-117.3	687.3	0*	1.00	8.0
3.4	49.5	0.2	13.0	35.1	943.7	760.7	346.8	213.8	309.6	-120.0	750.2	-10.5	0.99	7.9

Notes: /1 At discount rate of 8% p.a. /2 * indicates the largest net benefit

Table V.7-3 Economic Evaluation of Each Alternative Plan for Badbaran A Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	Installed Power (kW)	Energy Output (GWh/y)	Economic Const. Cost (₱ x 10^6)	Present Value/1 (₱ x 10^6) Cost	Benefit Flood	Benefit Power	Benefit Energy	Benefit Negative	Benefit Total	NPV	B/C	EIRR (%)
1.1	46.9	0.5	-	-	263.9	212.7	120.6	-	-	-45.7	74.9	-137.8*	0.35	3.3
1.2	47.0	0.5	1.0	6.3	358.9	289.3	120.6	16.4	55.6	-47.5	145.1	-144.2	0.50	4.1
2.1	49.8	0.333	-	-	396.8	319.9	151.2	-	-	-54.0	97.2	-222.7	0.30	2.7
2.2	50.0	0.333	1.0	6.3	500.0	403.0	151.2	16.4	55.6	-55.3	167.9	-235.1	0.42	3.2
3.1	51.4	0.25	-	-	485.7	391.5	165.6	-	-	-58.8	106.8	-284.7	0.27	2.2
3.2	51.6	0.25	1.0	6.3	585.2	471.7	165.6	16.4	55.6	-60.6	177.0	-294.7	0.38	2.8

Notes: /1 At discount rate of 8% p.a. /2 * indicates the largest net benefit

Table V.7-4 Economic Evaluation of Each Alternative Plan for Mambusao B Dam

Case No.	Dam Crest El. (m)	Flood Outflow Rate	Installed Power (kW)	Energy Output (GWh/y)	Economic Const. Cost (₱ x 10^6)	Present Value/1 (₱ x 10^6) Cost	Benefit Flood	Benefit Power	Benefit Energy	Benefit Negative	Benefit Total	NPV	B/C	EIRR (%)
1.1	44.7	0.5	-	-	359.9	290.1	58.4	-	-	-43.2	15.2	-274.9*	0.05	-/3
1.2	45.2	0.5	0.8	5.1	440.8	355.3	58.4	13.2	45.0	-44.4	72.2	-283.1	0.20	-
2.1	48.7	0.333	-	-	434.9	350.6	93.4	-	-	-44.8	48.6	-301.9	0.14	-
2.2	49.1	0.333	0.8	5.1	520.6	419.6	93.4	13.2	45.0	-45.4	106.2	-313.4	0.25	0.8
3.1	50.7	0.25	-	-	525.7	423.8	118.3	-	-	-45.4	72.9	-350.9	0.17	0.3
3.2	51.2	0.25	0.8	5.1	631.1	508.7	118.3	13.2	45.0	-46.1	130.4	-378.3	0.26	0.9

Notes: /1 At discount rate of 8% p.a. /2 * indicates the largest net benefit
/3 - indicates no EIRR value

Table V.7-5 Economic Evaluation of Each Alternative Plan for Panay C Dam
(Combined with Panay B Dam)

Case No.	Dam Crest El. (m)	Flood Outflow Rate	Installed Power (kW)	Energy Output (GWh/y)	Economic Const. Cost (₱ x 10^6)	Present Value/1 (₱ x 10^6) Cost	Benefit Flood	Benefit Power	Benefit Energy	Benefit Negative	Benefit Total	NPV	B/C	EIRR (%)
1	39.9	0.333	6.8	22.6	630.3	508.1	186.8	111.8	199.3	-105.2	392.7	-115.4	0.77	6.2
2	41.4	0.25	6.8	22.6	652.1	525.6	235.1	111.8	199.3	-107.3	438.9	-86.7	0.84	6.7
3	42.3	0.2	6.8	22.6	667.2	537.8	259.3	111.8	199.3	-108.7	461.7	-76.1*	0.86	6.9

Notes: /1 At discount rate of 8% p.a. /2 * indicates the largest net benefit

Table V.8-1 General Features of Each Dam Plan

Item	Unit	Panay B	Panay C	Badbaran A	Mambusao B	Panay C (After Panay B)
Reservoir						
Total storage capacity	10^6 m^3	96.0	466.0	75.5	60.2	295.0
Sediment capacity	10^6 m^3	31.7	68.9	37.5	28.7	37.2
Effective storage capacity	10^6 m^3	64.3	397.1	38.0	31.5	257.8
(for flood control)	10^6 m^3	(33.8)	(144.8)	(38.0)	(31.5)	(130.2)
(for power generation)	10^6 m^3	(30.5)	(252.3)	(0)	(0)	(127.6)
Flood water level	El. m	74.9	44.6	43.9	41.7	39.8
Surcharge water level	El. m	71.3	38.3	40.2	36.6	34.3
High water level	El. m	65.0	35.0	-	-	30.0
Low water level	El. m	56.7	25.6	36.8	33.6	23.5
Dam						
Type		Concrete gravity dam	Concrete gravity dam	Rockfill dam	Rockfill dam	Combined dam
Crest elevation	El. m	77.4	47.1	46.9	44.7	42.3
Crest length	m	160.0	190.0	240.0	280.0	175.0
Height	m	52.4	39.1	30.9	34.7	34.3
Power Station						
Maximum discharge	m^3/sec	27.2	93.0	-	-	80.0
Rated head	m	31.7	14.4	-	-	10.3
Installed capacity	kW	7,100	11,000	-	-	6,800
Annual energy output	GWh	31.4	31.4	-	-	22.6
Tail water level	El. m	30.0	17.0	-	-	17.0

Table V.8-2 Flood Regulating Capacity of Selected Dams

(Unit: m^3/sec)

Item	Panay B Dam	Panay C Dam/1	Panay C Dam/2	Badbaran A Dam	Mambusao B Dam
100-year flood					
- peek inflow	2,420	4,120	3,230	1,900	1,770
- outflow	1,210	824	646	950	885
25-year flood					
- peak inflow	1,250	2,120	1,700	1,080	990
- outflow	625	424	340	540	495
10-year flood					
- peak inflow	750	1,260	1,020	700	620
- outflow	375	252	204	350	310

Notes; /1 Independent scheme.

/2 With Panay B dam in upper reach, in which FSL of Panay C dam is planned to be equal to TWL of Panay B dam.

Table V.8-3 Construction Cost of Each Dam Plan

(Unit: ₱ x 10^6)

Work Item	Panay B			Panay C			Badbaran A			Mambusao B			Panay C (after Panay B)		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
A. Preparatory Works															
(1) Road construction	0	17.01	17.01	0	60.19	60.19	0	38.95	38.95	0	65.48	65.48	0	60.19	60.19
(2) Workshops, offices, etc. /1	8.86	6.92	15.78	15.74	10.40	26.14	5.84	5.17	11.01	6.99	4.90	11.89	11.58	7.67	19.25
Sub-total of A	8.86	23.93	32.79	15.74	70.59	86.33	5.84	44.12	49.96	6.99	70.38	77.37	11.58	67.86	79.44
B. Civil Works															
(1) River diversion works	11.56	8.78	20.34	35.05	23.38	58.43	13.18	9.13	22.31	Included in Dam and Spillway			34.24	22.84	57.08
(2) Dam and Spillway	88.04	68.89	156.93	123.84	78.77	202.61	59.85	55.46	115.31	87.32	61.25	148.57	82.28	52.25	134.53
(3) Waterway	Included in Dam and Spillway			15.21	10.67	25.88	0	0	0	0	0	0	12.60	8.86	21.46
(4) Power station	11.12	8.82	19.94	22.61	17.19	39.80	0	0	0	0	0	0	15.60	11.88	27.48
Sub-total of B	110.72	86.49	197.21	196.71	130.01	326.72	73.03	64.59	137.62	87.32	61.25	148.57	144.72	95.83	240.55
C. Metal Works	29.63	2.96	32.59	47.34	4.73	52.07	20.02	2.00	22.02	13.48	1.35	14.83	47.54	4.77	52.31
D. Electrical Works															
(1) Generating equipment	55.65	7.63	63.28	99.31	13.68	112.99	0	0	0	0	0	0	79.56	10.94	90.50
(2) Transmission line	16.93	13.85	30.78	12.42	10.15	22.57	0	0	0	0	0	0	0.76	0.61	1.37
(3) Substation	7.20	1.80	9.00	7.20	1.80	9.00	0	0	0	0	0	0	2.88	0.72	3.60
(4) Others	7.98	2.33	10.31	11.90	2.56	14.46	0	0	0	0	0	0	8.32	1.22	9.54
Sub-total of D	87.76	25.61	113.37	130.83	28.19	159.02	0	0	0	0	0	0	91.52	13.49	105.01
E. Land Acquisition and Compensation	0	14.72	14.72	0	263.16	263.16	0	90.54	90.54	0	133.92	133.92	0	233.46	233.46
F. Government Administration /2	0	18.80	18.80	0	31.21	31.21	0	10.48	10.48	0	12.04	12.04	0	23.87	23.87
G. Engineering Service /3	15.04	3.76	18.80	24.97	6.24	31.21	8.38	2.10	10.48	9.63	2.41	12.04	19.10	4.77	23.87
H. Physical Contingency /4	25.23	17.69	42.92	41.53	53.45	94.98	10.73	21.37	32.10	11.74	28.19	39.93	31.37	44.42	75.79
Grand Total	227.24	193.96	471.20	457.12	587.58	1,044.70	118.00	235.20	353.20	129.16	309.54	438.70	345.83	488.47	834.30

Notes: /1 (2) = 8% of item B
/2 F = 5% of item (A + B + C + D)
/3 G = 5% of item (A + B + C + D)
/4 H = 10% of items A to G

Table V.8-4 Flood Levels and Discharges Before and After Dam Projects (At Panitan Base Station)

Dam	Without Dam		With Dam	
	Flood Level (El. m)	Flood Discharge (m^3/sec)	Flood Level (El. m)	Flood Discharge (m^3/sec)
Panay B dam	10.30	2,670	10.19	2,610
Panay C dam/1	10.30	2,670	9.62	2,300
Panay B dam + Panay C dam/2	10.30	2,670	9.51	2,240
Badbaran A dam	10.30	2,670	10.17	2,600
Mambusao B dam	10.30	2,670	10.25	2,645

Notes: The above represents flood levels and discharges at occurrence of 100-year flood under present river channel condition.

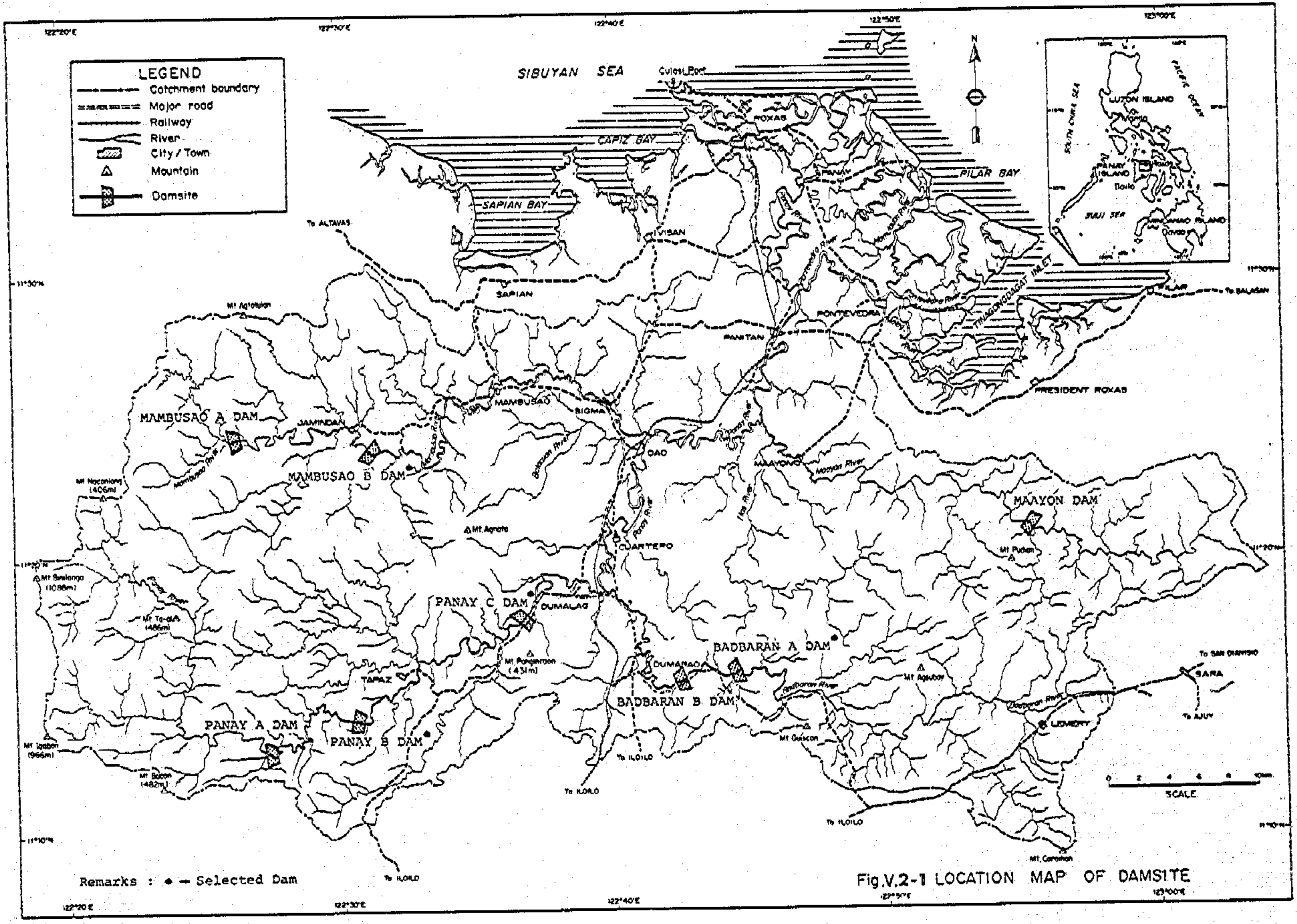
/1 Independent scheme

/2 Scheme with Panay B dam in upper reach

FIGURES

FOR

APPENDIX V



Remarks : ● — Selected Dam

Fig.V.2-1 LOCATION MAP OF DAMSITE

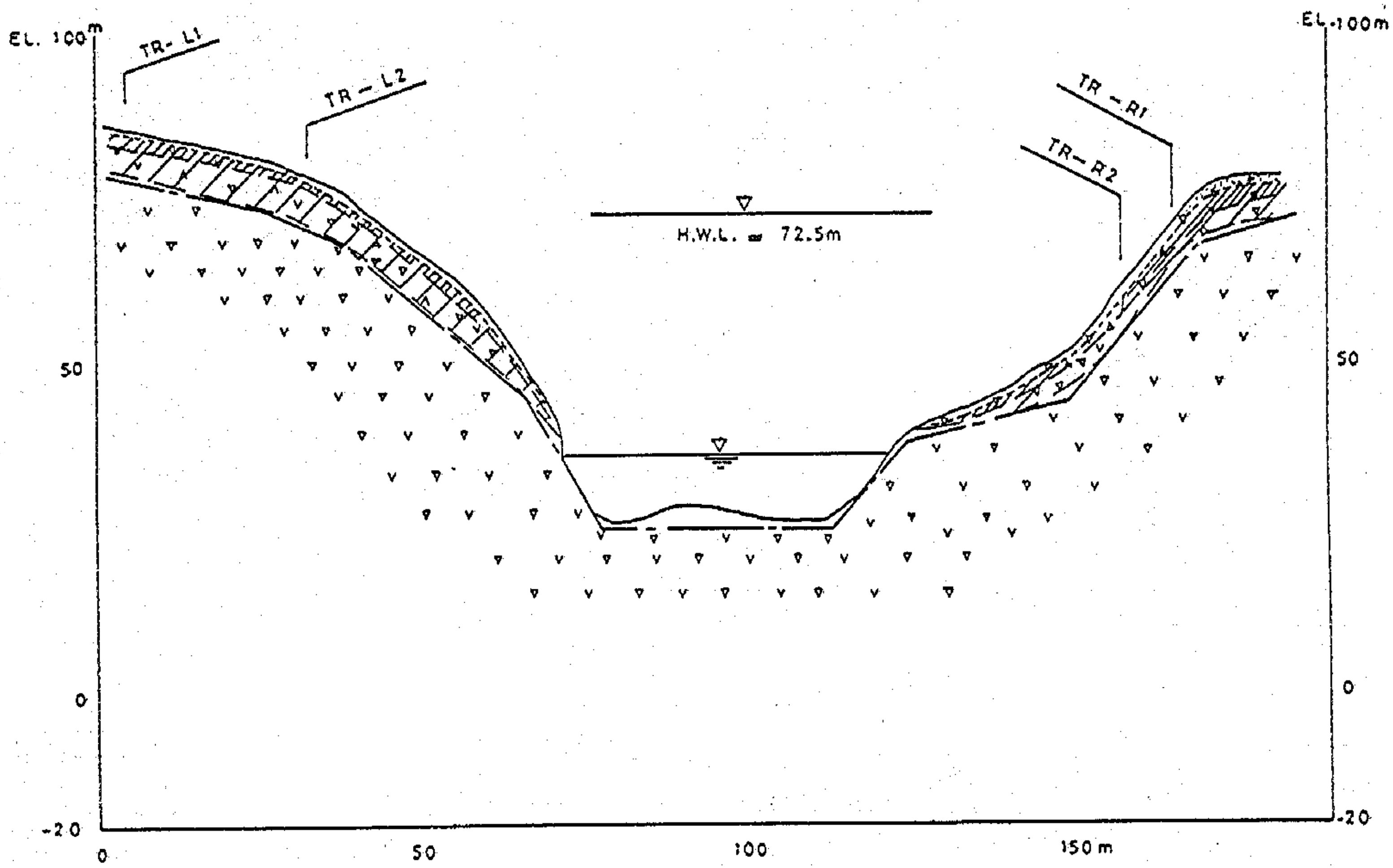


Fig.V.4-1 GEOLOGICAL PROFILE ALONG THE DAM AXIS OF PANAY B DAMSITE

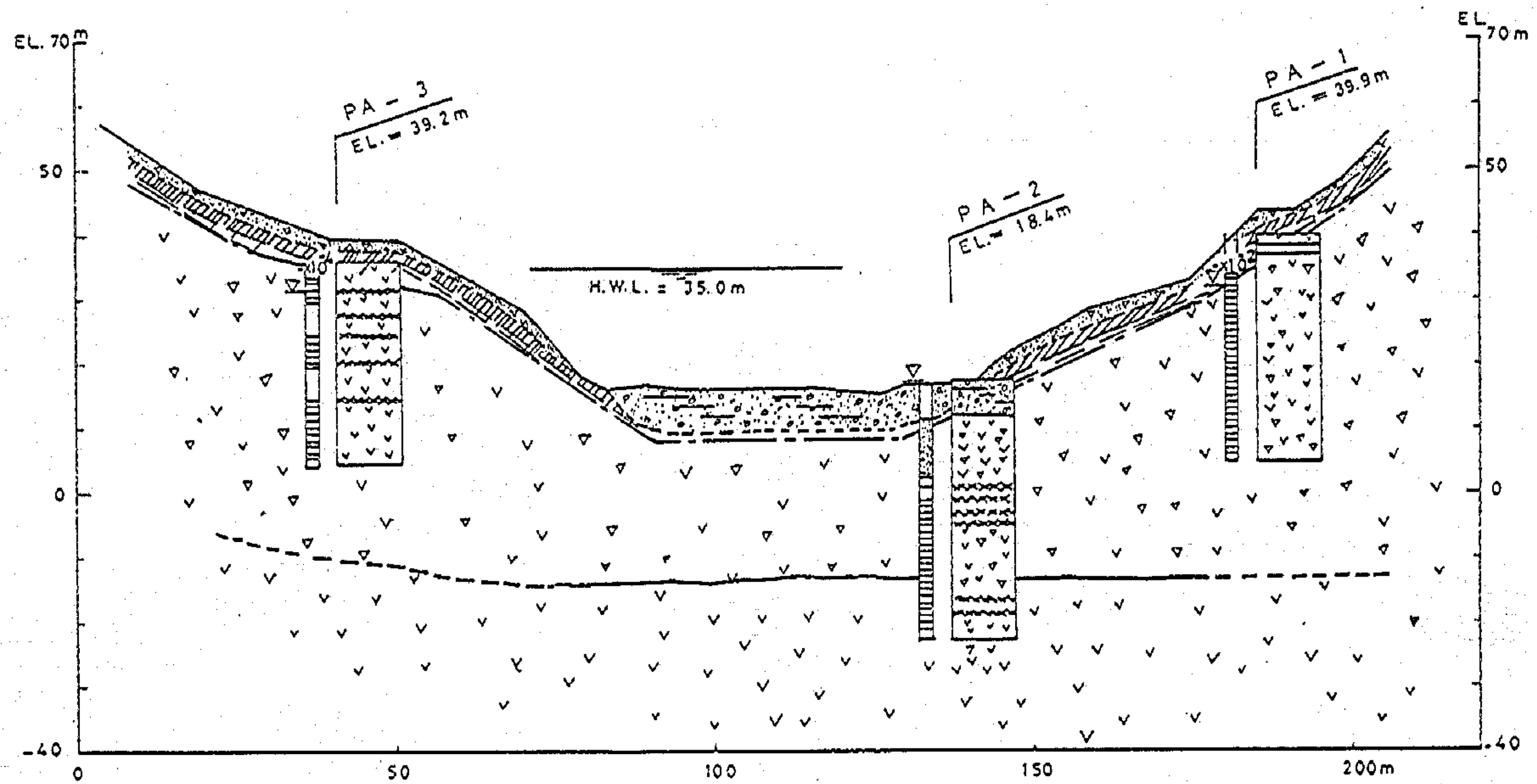


Fig.V.4-2 GEOLOGICAL PROFILE ALONG THE DAM AXIS OF PANAY C DAMSITE

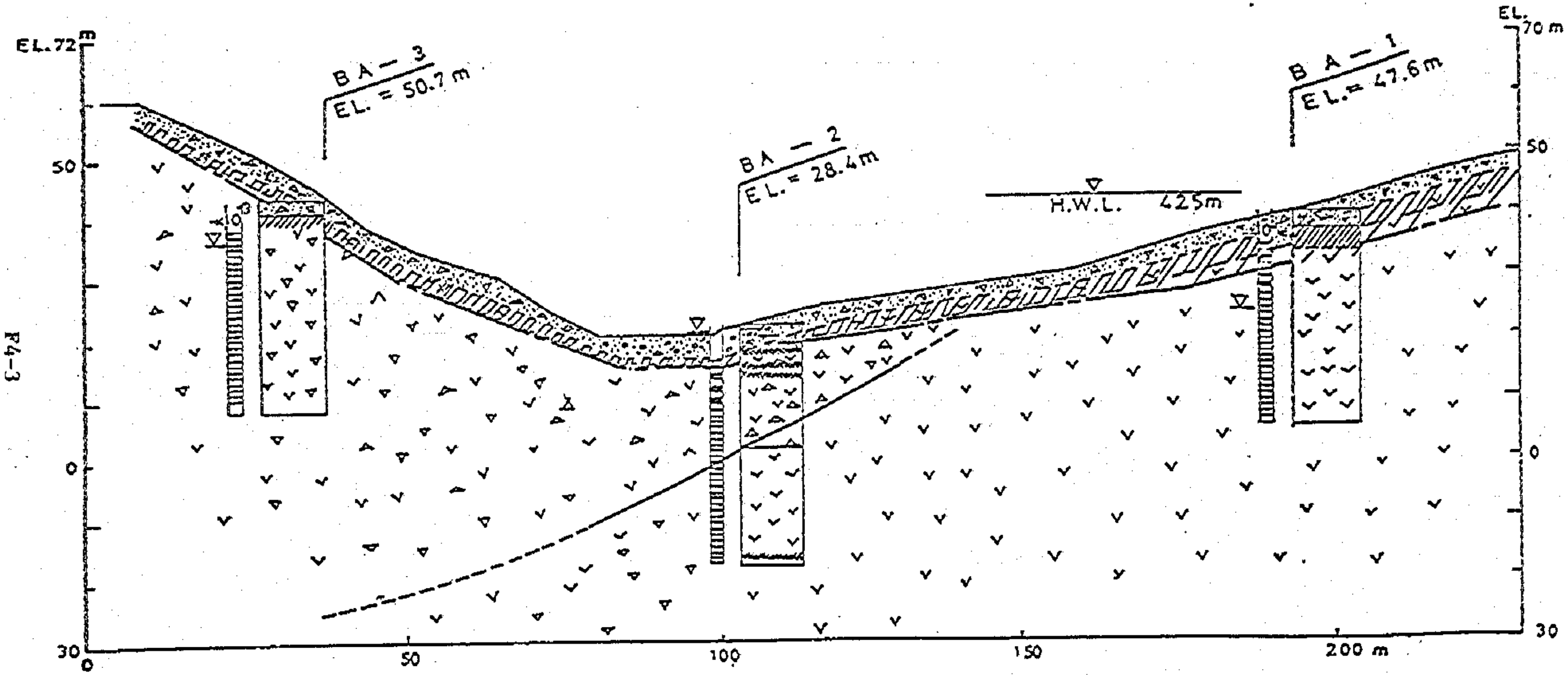


Fig.V.4-3 GEOLOGICAL PROFILE ALONG THE DAM AXIS OF BADBARAN A DAMSITE

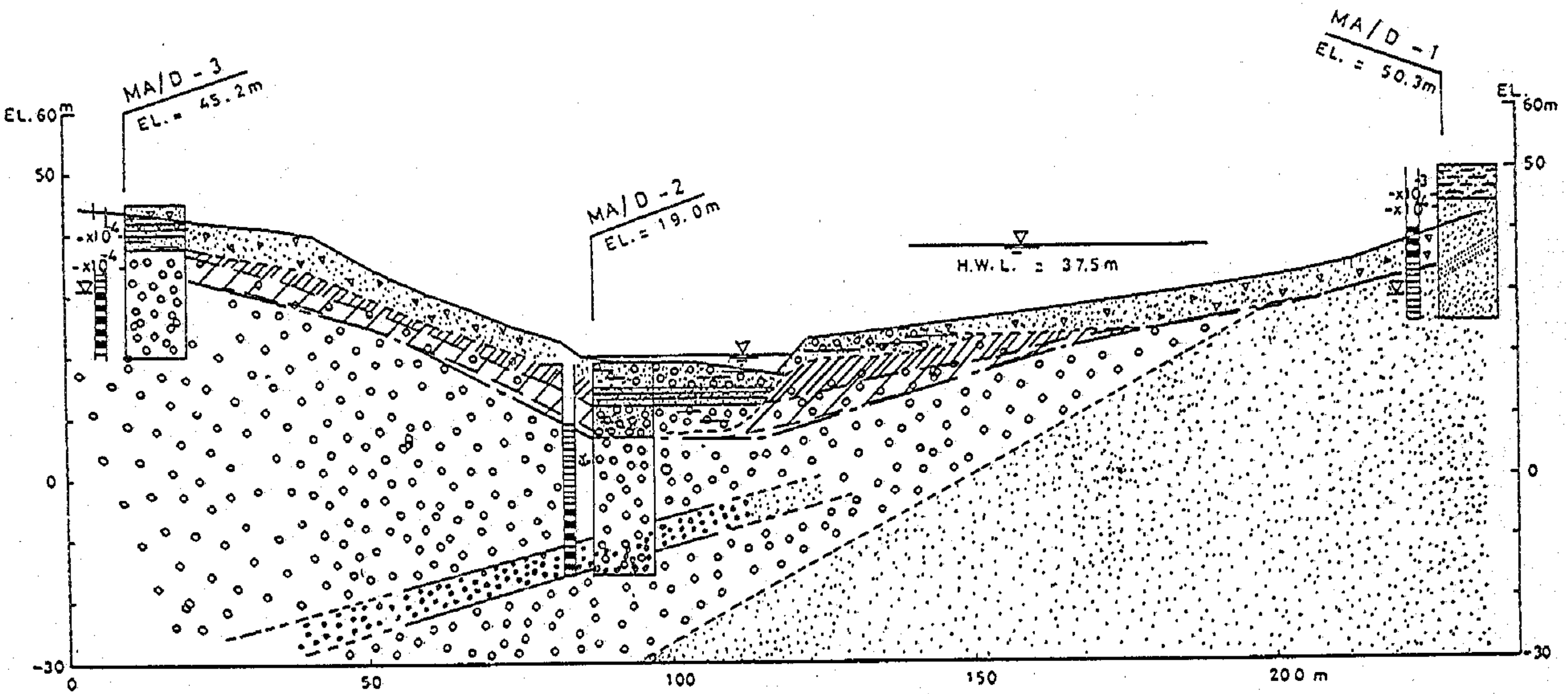
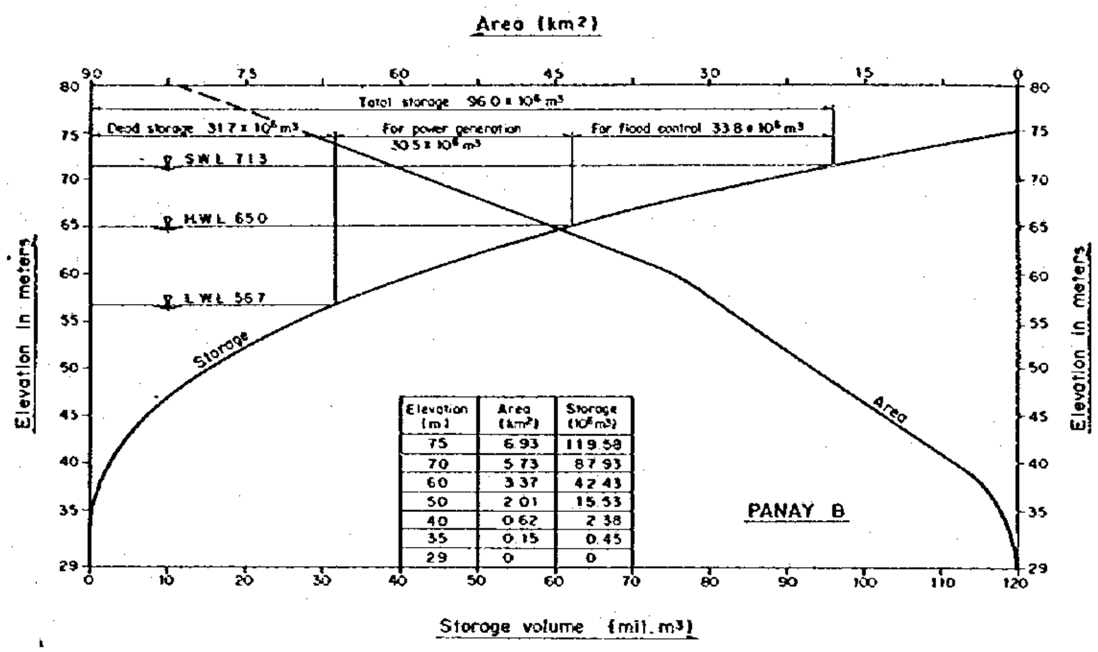
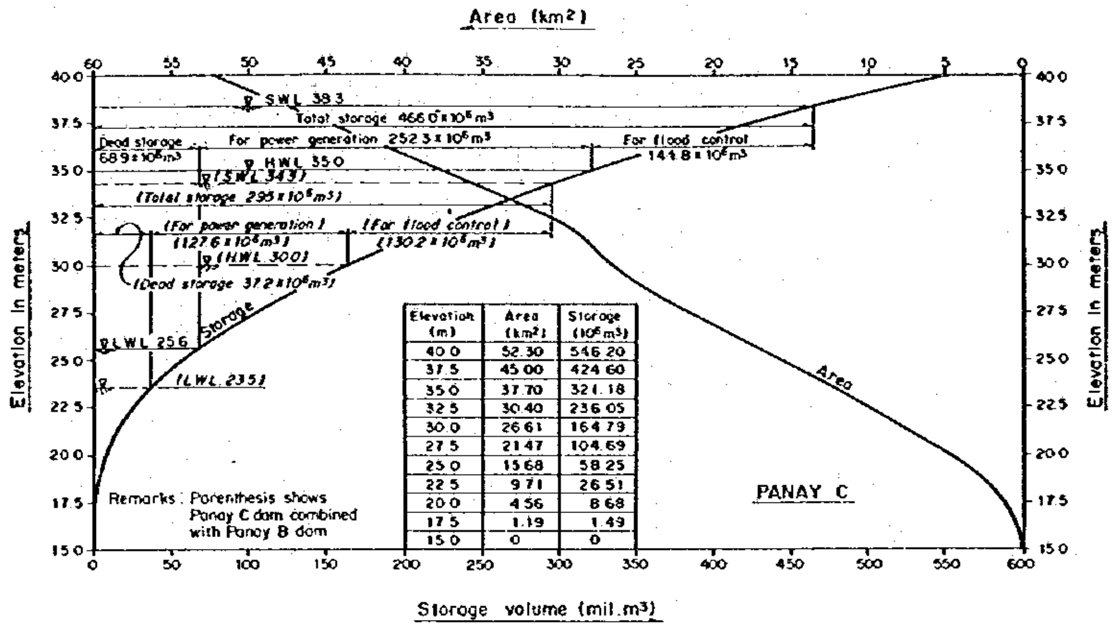


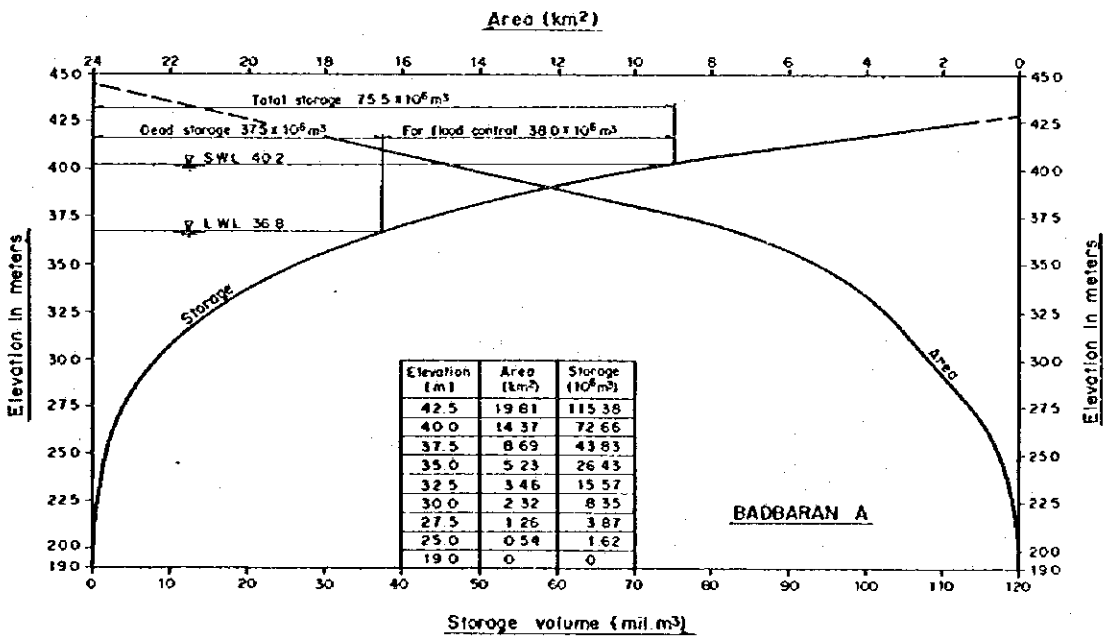
Fig.V.4-4 GEOLOGICAL PROFILE ALONG THE DAM AXIS OF MAMBUSAO B DAMSITE



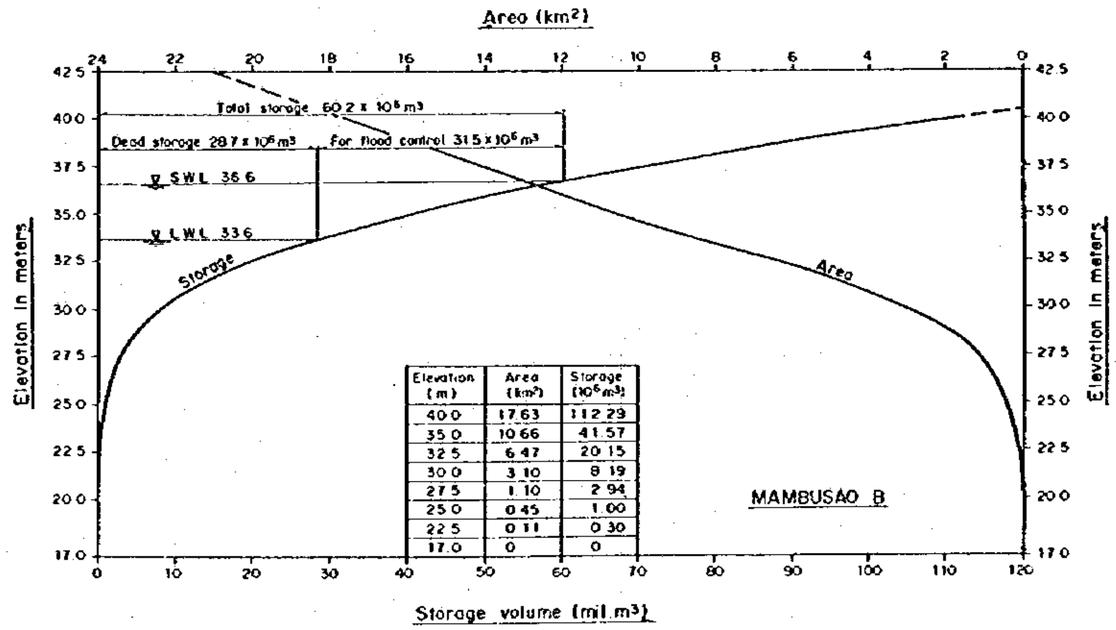
Elevation (m)	Area (km^2)	Storage ($10^6 m^3$)
75	6.93	119.58
70	5.73	87.93
60	3.37	42.43
50	2.01	15.53
40	0.62	2.38
35	0.15	0.45
29	0	0



Elevation (m)	Area (km^2)	Storage ($10^6 m^3$)
40.0	52.30	546.20
37.5	45.00	424.60
35.0	37.70	321.18
32.5	30.40	236.05
30.0	26.61	164.79
27.5	21.47	104.69
25.0	15.68	58.25
22.5	9.71	26.51
20.0	4.56	8.68
17.5	1.19	1.49
15.0	0	0



Elevation (m)	Area (km^2)	Storage ($10^6 m^3$)
42.5	19.81	115.38
40.0	14.37	72.66
37.5	8.69	43.83
35.0	5.23	26.43
32.5	3.46	15.57
30.0	2.32	8.35
27.5	1.26	3.87
25.0	0.54	1.62
19.0	0	0



Elevation (m)	Area (km^2)	Storage ($10^6 m^3$)
40.0	17.63	112.29
35.0	10.66	41.57
32.5	6.47	20.15
30.0	3.10	8.19
27.5	1.10	2.94
25.0	0.45	1.00
22.5	0.11	0.30
17.0	0	0

Fig.V.6-1 AREA AND STORAGE CURVES OF RESERVOIR

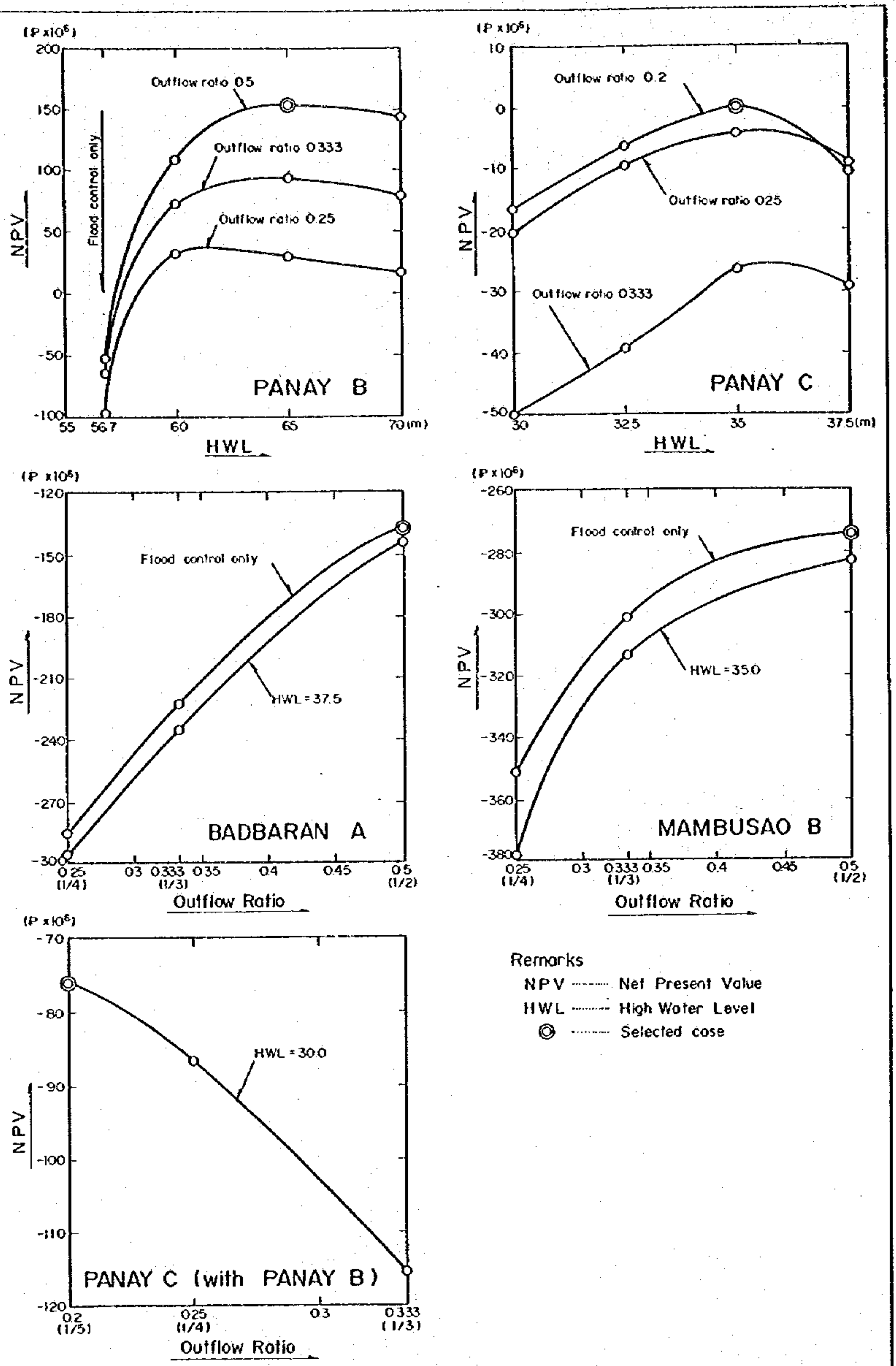


Fig. V.7-1 NET PRESENT VALUES OF EACH DAM PLAN

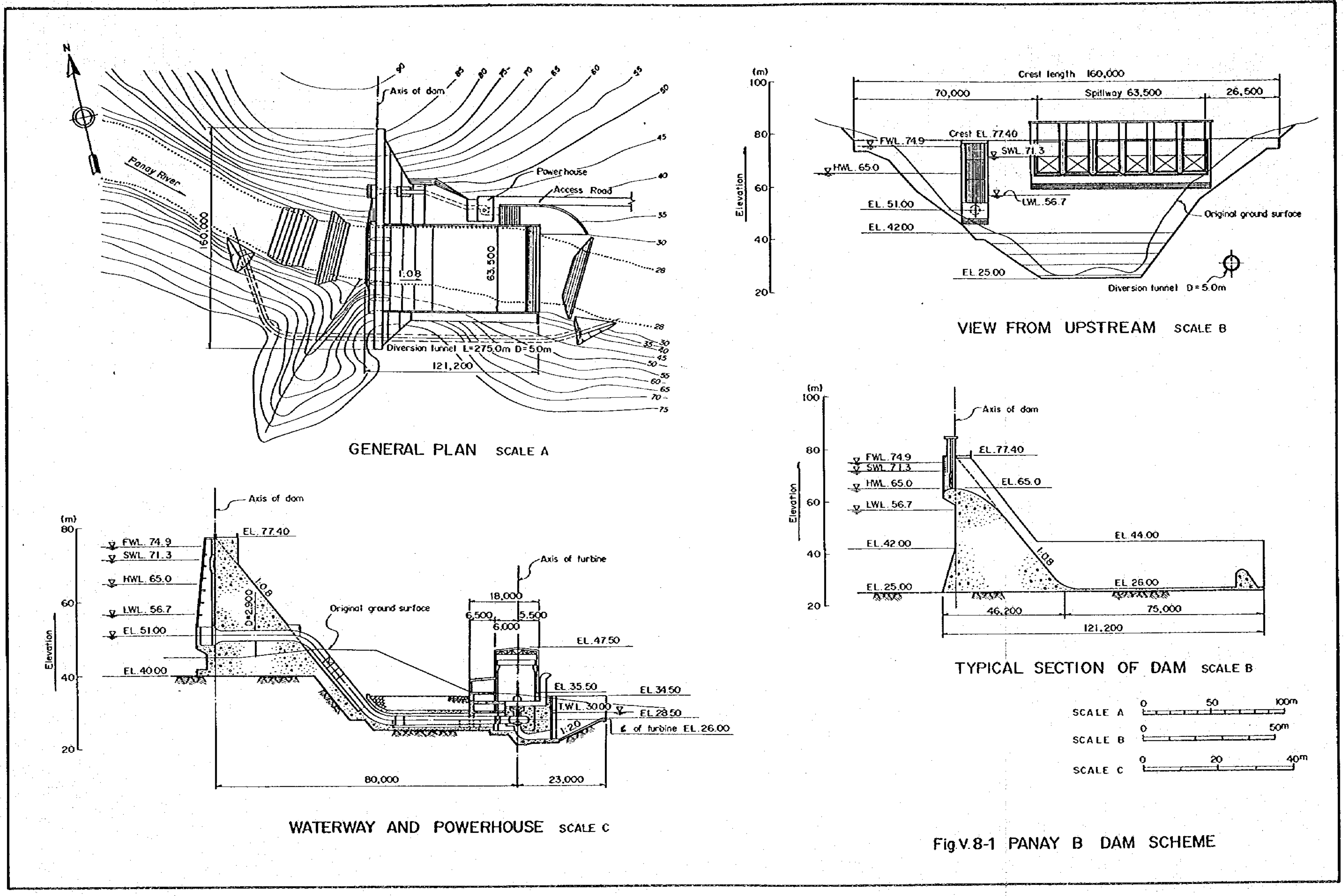
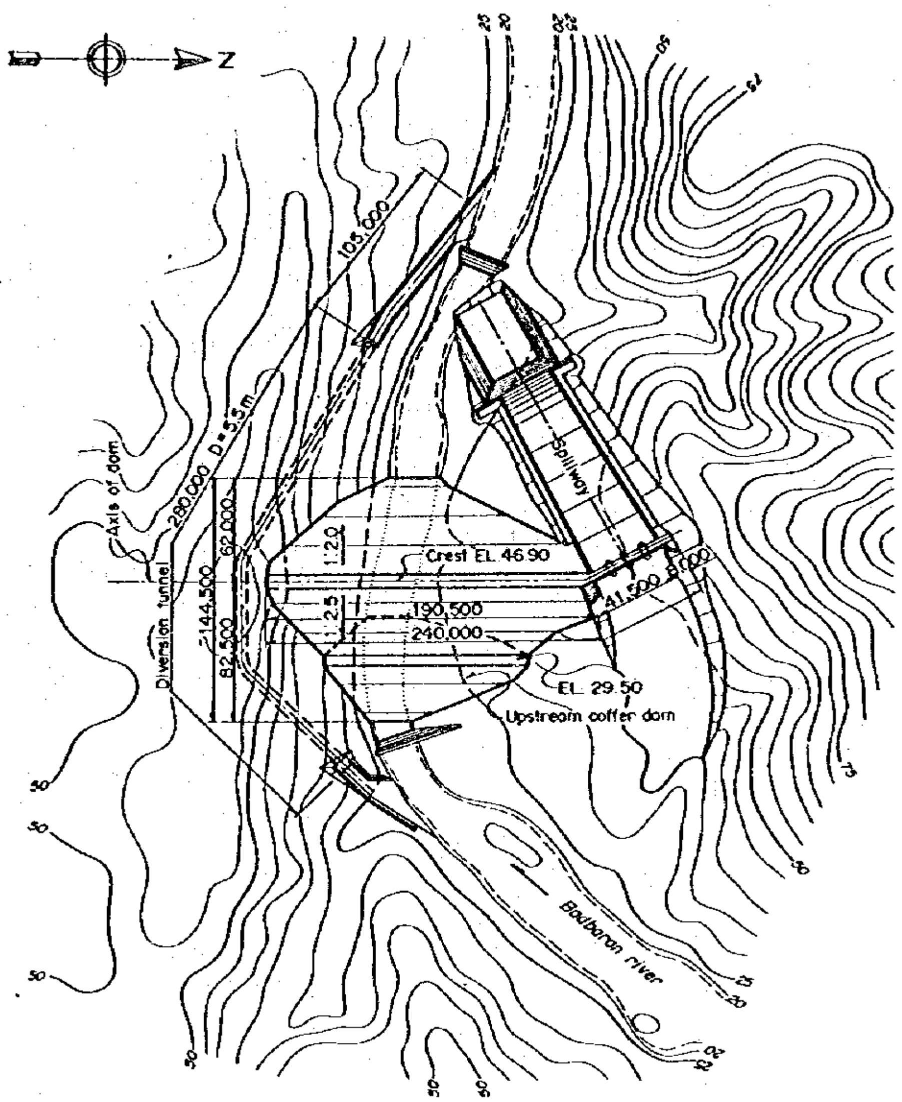
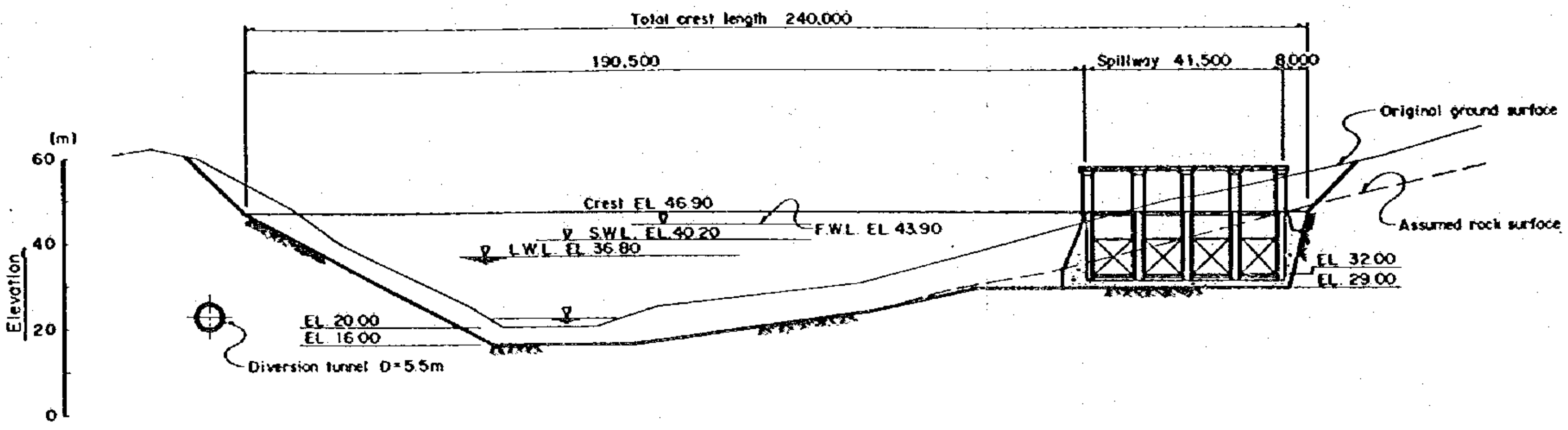


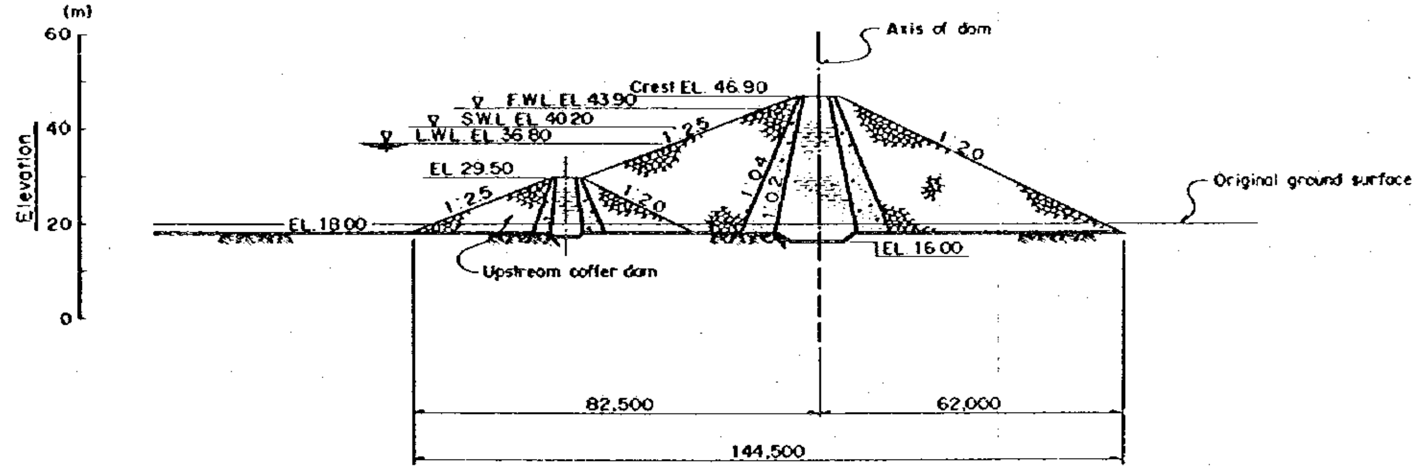
Fig.V.8-1 PANAY B DAM SCHEME



PLAN SCALE A



UPSTREAM ELEVATION SCALE B



TYPICAL CROSS SECTION SCALE B

SCALE A 0 50 100m

SCALE B 0 50m

Fig. V.8-2 BADBARAN A DAM SCHEME

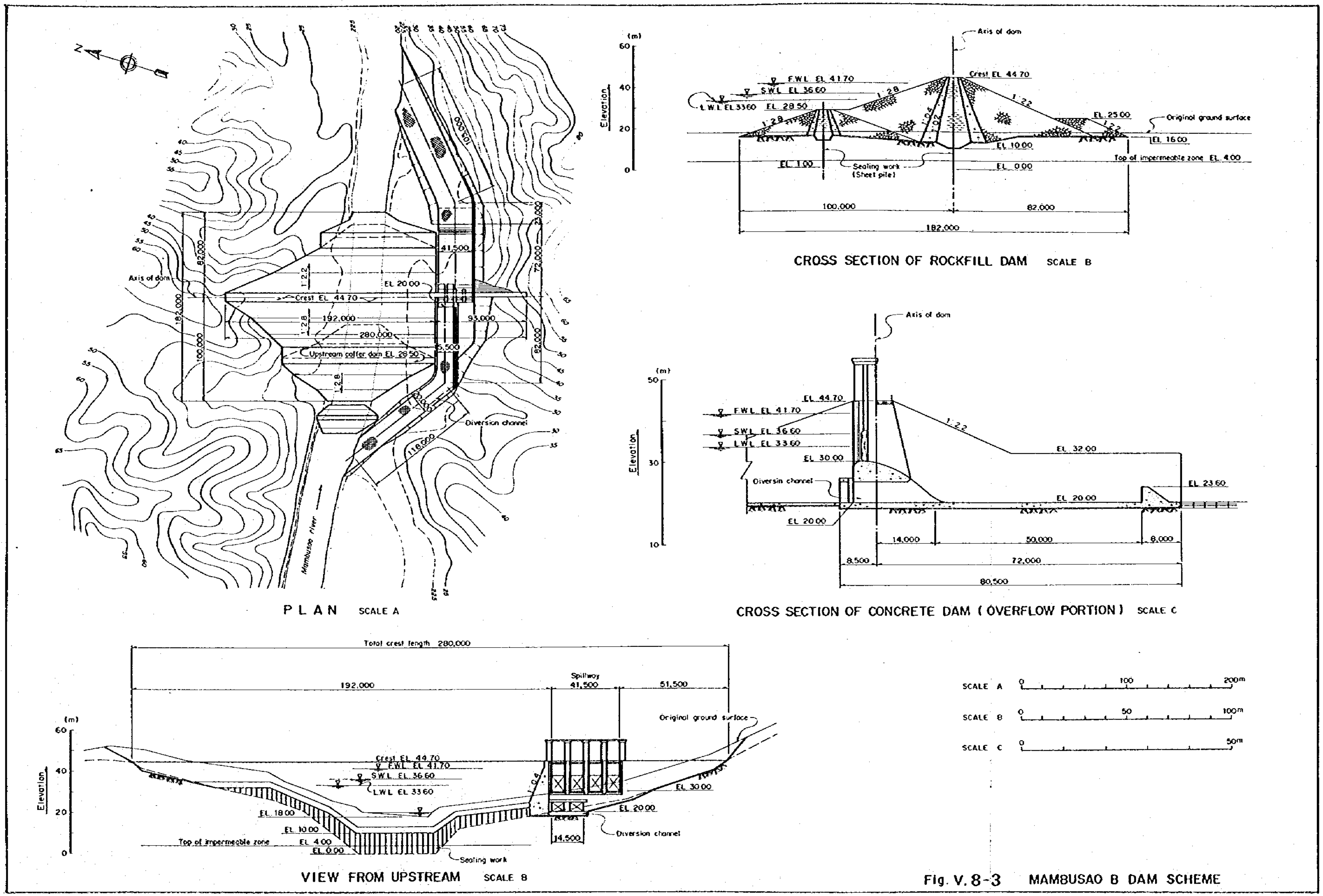


Fig. V.8-3 MAMBUSAO B DAM SCHEME

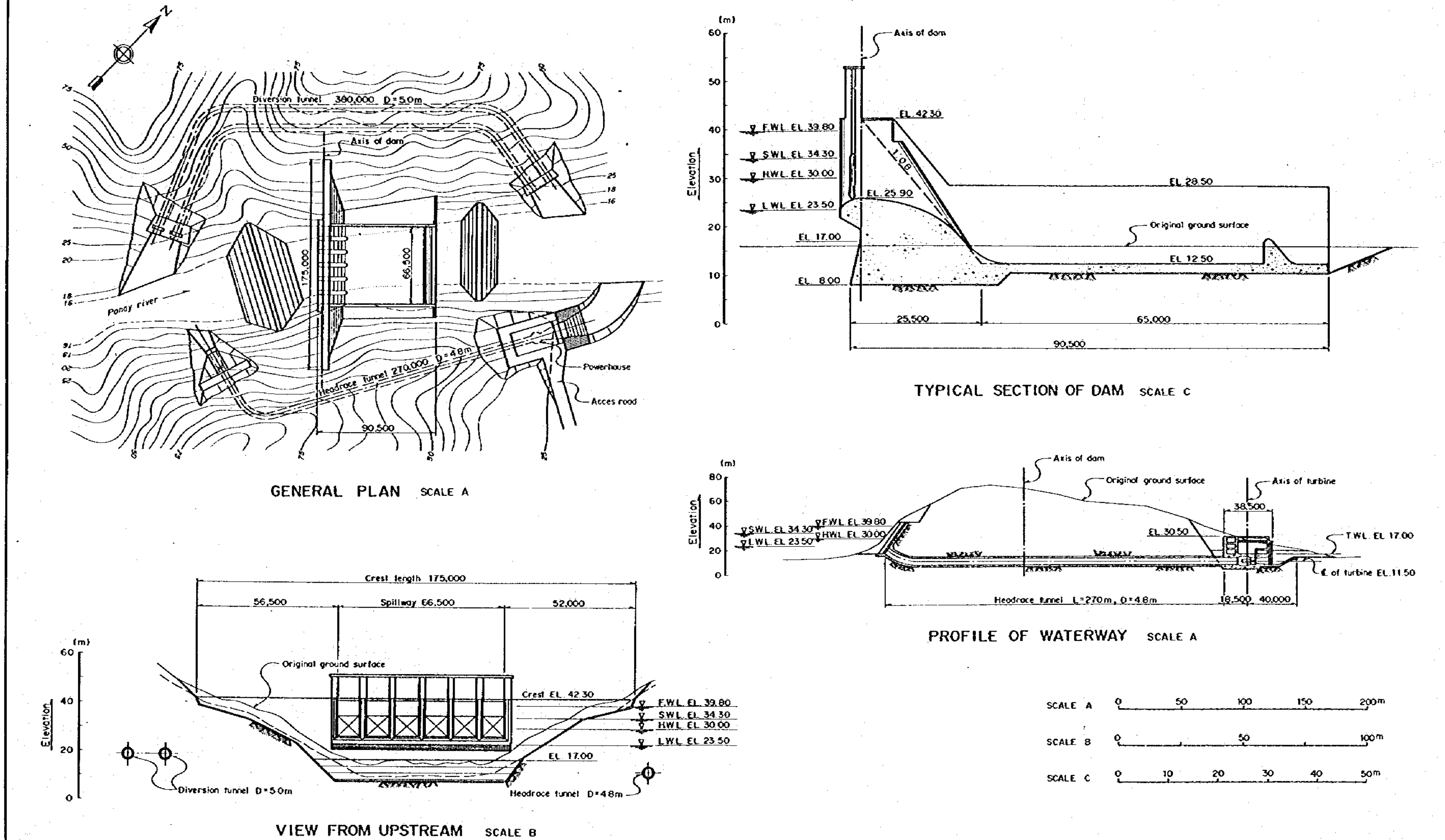
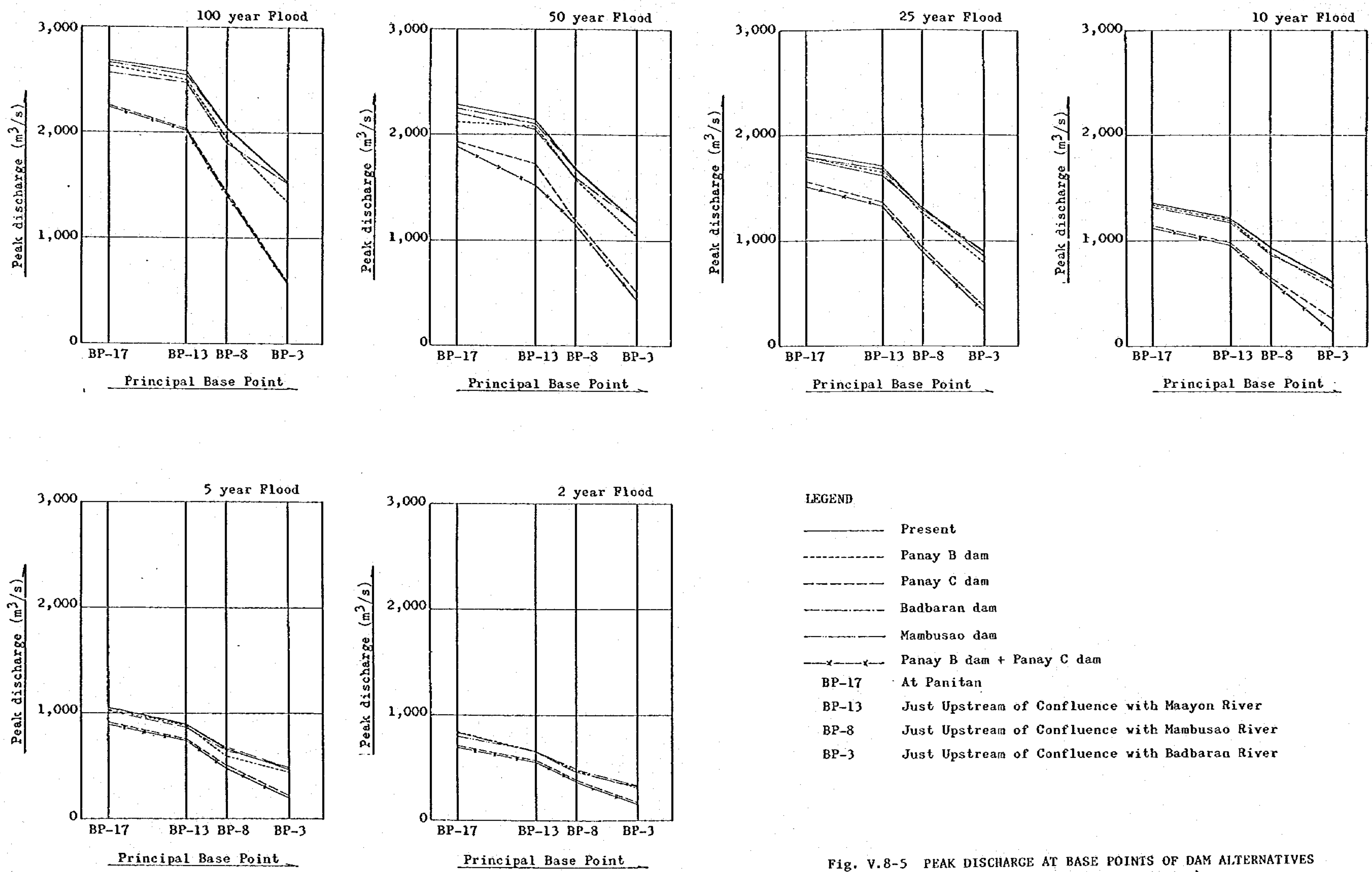


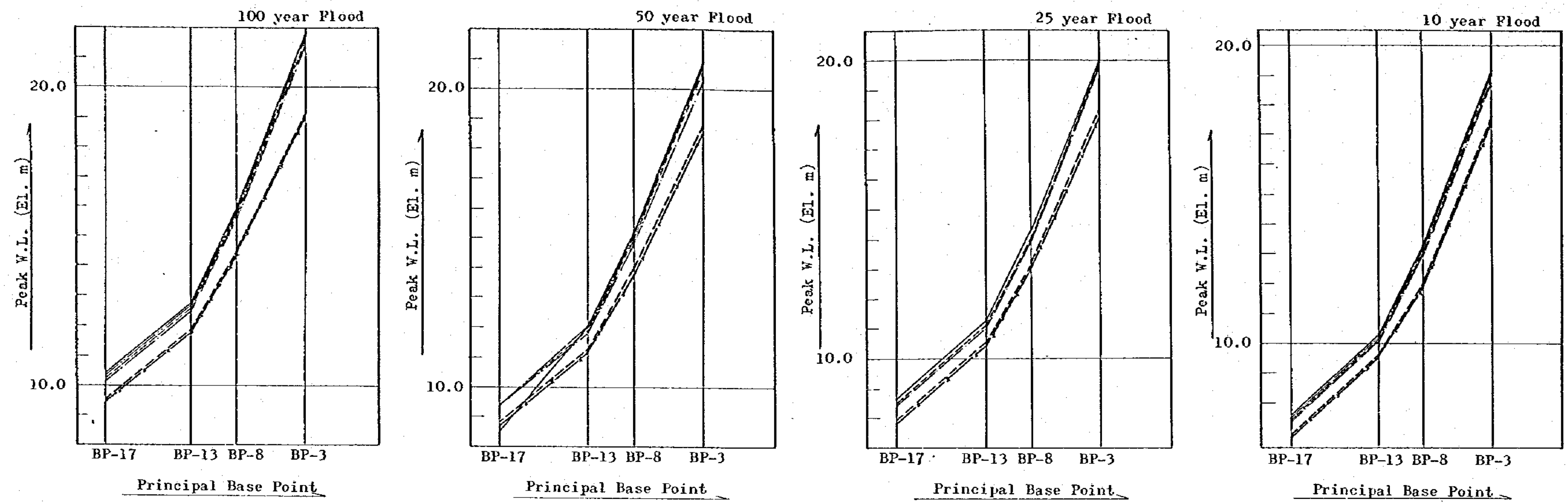
Fig. V.8-4 PANAY C (AFTER PANAY B) DAM SCHEME

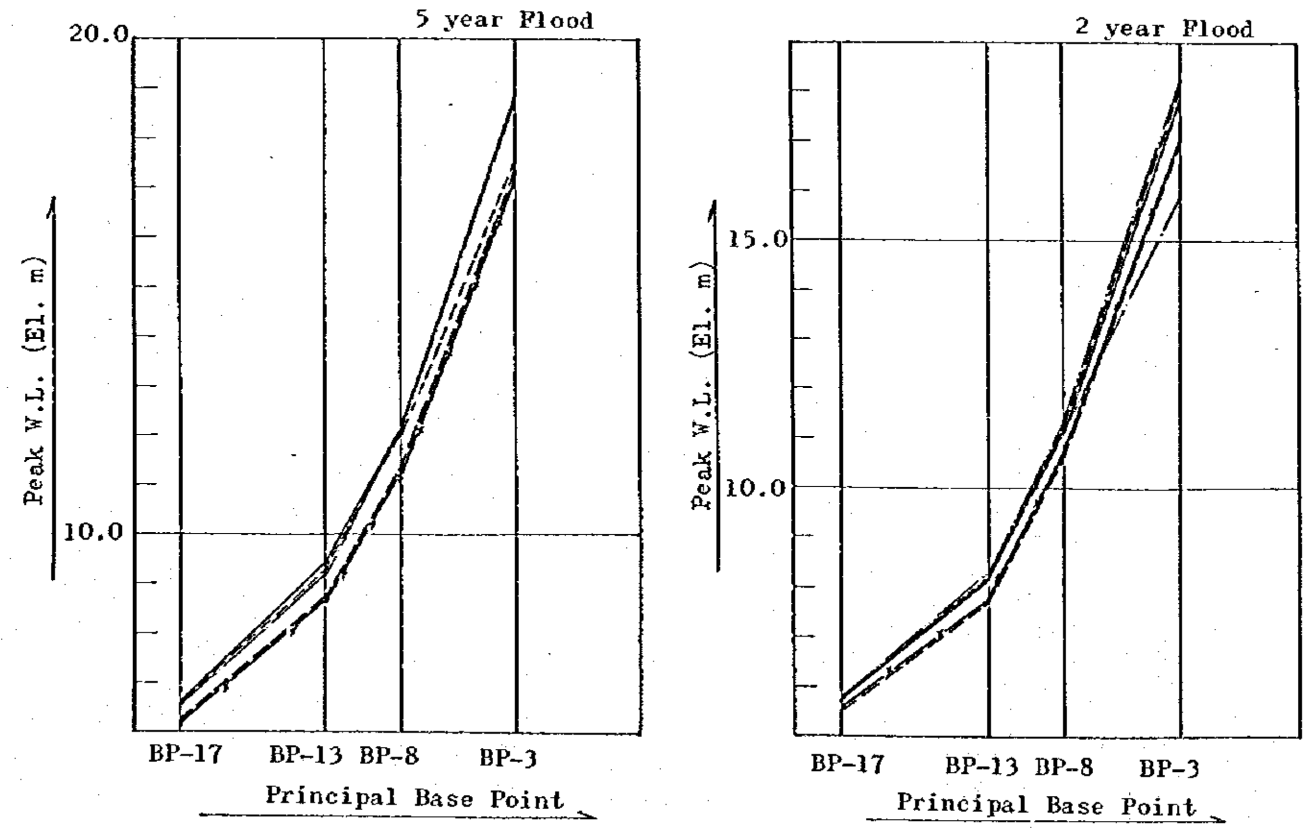


LEGEND

————————	Present
- - - - - - - - - -	Panay B dam
— — — — —	Panay C dam
—·—·—·—	Badbaran dam
—··—··—	Mambusao dam
—x——x—	Panay B dam + Panay C dam
BP-17	At Panitan
BP-13	Just Upstream of Confluence with Maayon River
BP-8	Just Upstream of Confluence with Mambusao River
BP-3	Just Upstream of Confluence with Badbaran River

Fig. V.8-5 PEAK DISCHARGE AT BASE POINTS OF DAM ALTERNATIVES
(Under the Present River Condition)





LEGEND

————————	Present
– – – – – –	Panay B dam
— — — — —	Panay C dam
——·——·——	Badbaran dam
——··——··—	Mambusao dam
——x——x——	Panay B dam + Panay C dam
BP-17	At Panitan
BP-13	Just Upstream of Confluence with Maayon River
BP-8	Just Upstream of Confluence with Mambusao River
BP-3	Just Upstream of Confluence with Badbaran River

Note; Probability at Panitan Base

Fig. V.8-6 PEAK WATER LEVELS AT BASE POINTS OF DAM ALTERNATIVES (Under the Present River Condition)