

REPUBLIC OF GUATEMALA

FLOOD CONTROL PROJECT

EXECUTIVE SUMMARY

JANUARY 1985

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(ACHIGUATE AND PANTALEON RIVERS)

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JAPAN INTERNATIONAL COOPERATION AGENCY

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国際協力事業団	
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PREFACE

In response to the request of the Government of the Republic of Guatemala, the Government of Japan decided to conduct a study on Flood Control Project in the Achiguat and Pantaleon River Basins and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Guatemala a team headed by Mr. Mitsuo Igarashi of the CTI Engineering Co., Ltd. from August, 1983 to March, 1984 and from June to November, 1984.

The team had discussions on the Project with the officials concerned of the Government of Guatemala and conducted a field survey in the Achiguat and Pantaleon River Basins in the Department of Escuintla. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Guatemala for their close cooperation extended to the team.

January, 1985

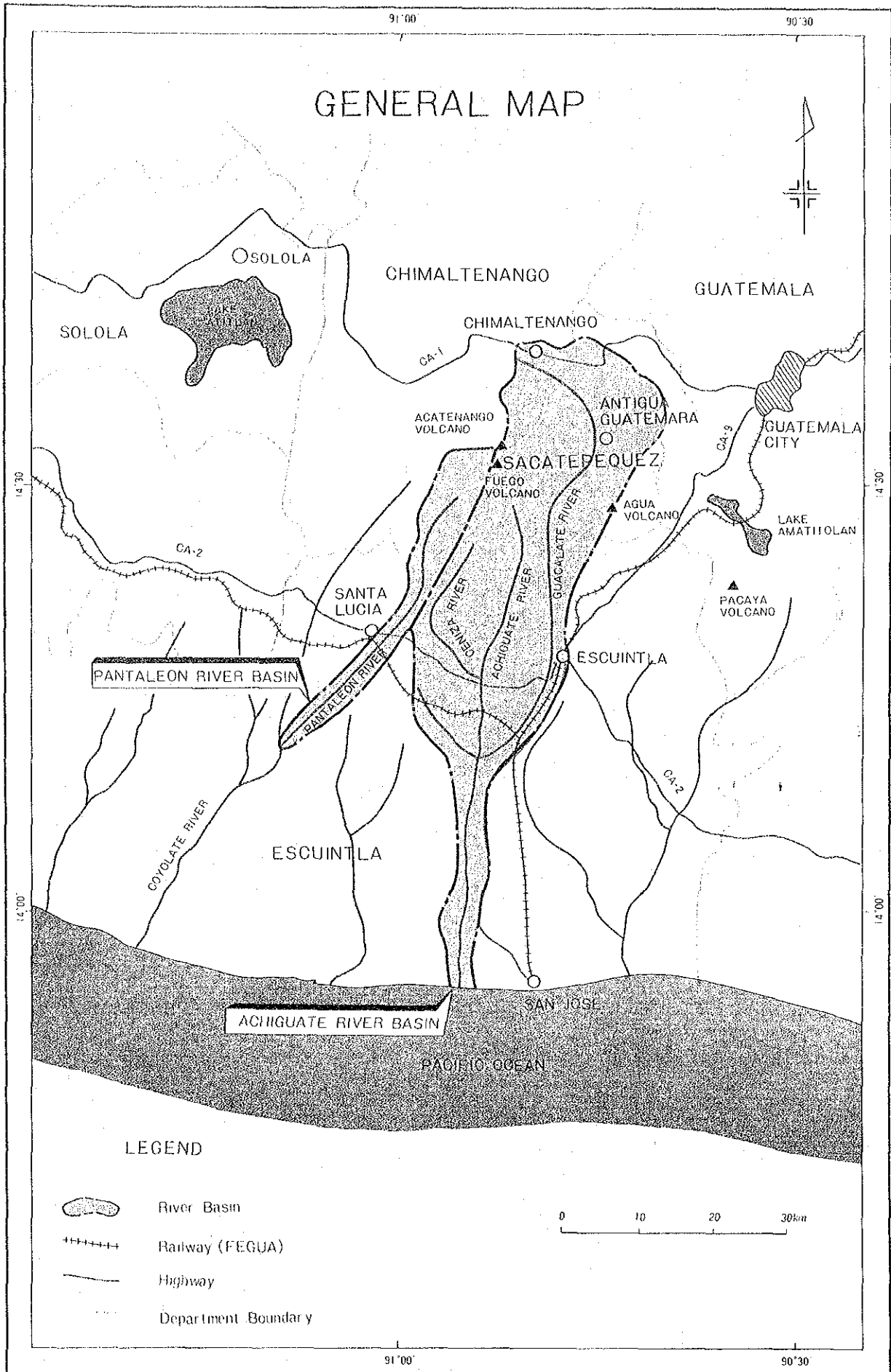
A handwritten signature in black ink, reading "Keisuke Arita", is written over a horizontal line.

Keisuke Arita

President

Japan International Cooperation Agency

GENERAL MAP



LEGEND





-  River Basin
-  Railway (FEGUA)
-  Highway
-  Department Boundary





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1. General

A chain of volcanoes running in parallel to the Pacific Coast from Mexico to El Salvador and forming the southern range of the Sierra Madre exists in Guatemala. Some of these volcanoes, such as the Santiaguito, Fuego and Pacaya, are in constant activity, inflicting tremendous sediment and flood damages which are compounded by the tropical cyclones that frequently hit the country.

Some rivers arise from these volcanoes, and the areas along the Achiguate and Pantaleon rivers have long been suffering from serious sediment and flood damage.

The Achiguate and the Pantaleon river basins have an agricultural land better developed than the other areas, and they are especially noted for the production of sugarcane, cotton and cattle, which are ranked first in the whole country. Along the Achiguate river course, some densely populated villages such as Finca La Trinidad and La Barrita are located.

The central american road of CA-2 and the national railway going in parallel with the road, run through these two river basins and connect Guatemala City, the capital of the country, to the agricultural production area. Interruption of these transportation lines have serious adverse effects on not only regional but also national economic activities.

The foregoing situation prompted the Government of Guatemala to undertake a study on the feasibility of a sediment and flood control project through the technical cooperation and assistance from the Government of Japan.

2. Objectives of the Study

The study has two objectives; namely,

- (1) to formulate a long-term comprehensive flood control project in the Study Area; and
- (2) to conduct a feasibility study with respect to the identified and priority works to be formulated through the above-mentioned study as an urgent flood control project for immediate implementation.

3. Study Area

Achiguate River Basin

Achiguate River originates in the active Fuego Volcano and has a total catchment area of 1,080 km², including those of the tributaries such as the Guacalate, the Ceniza and the Mazate. The main stream of Achiguate River, however, has a catchment area of only 216 km² with a river length of 55 km.

The river flows down on the steep slope of the mountainous area with the gradient of 1:10 and after joining some tributaries, pours into the North Pacific Ocean through the fan area with the gradient of 1:400.

The average annual rainfall amounts to 3,500 mm in the upstream area and 2,300 mm in the entire river basin.

Most of the alluvial fan area in the lower reaches are utilized for livestock farming and cultivation of sugarcane, maize and cotton.

Pantaleon River Basin

Pantaleon River, the tributary of Cristobal River which joins Coyolate River, also originates in Fuego Volcano, and the catchment area and river length are 150 km² and 40 km, respectively. It runs down at some distance in the mountain-side with the gradient of 1:10 and then joins Cristobal River, passing through the alluvial fan area in the stretch of 20 km with the gradient of 1:100. The average annual rainfall in the basin reaches to 3,300 mm.

The upper reaches is covered with volcanic debris and assorted trees, and the lower reaches have also been relatively developed for the cultivation of sugarcane, maize and cotton. Only a small area is utilized for livestock farming.

4. Long-Term Plan

The design scale for the long-term sediment and flood control plan was decided from the viewpoint of social requirements to be equivalent to the recorded biggest flood that corresponds to a 30-year return period. A comparative study on three alternative plans of 1) Channel improvement of the entire river improvement, 2) Partial river improvement (case I) and 3) Partial river improvement (case II) have been carried out and verified that the partial river improvement (case II) is the optimum plan from both social and economical viewpoints.

The target assets to be protected by the plan are the CA-2 road bridge and the national railway bridge across the Achiguate and the Pantaleon rivers and the urban areas in Finca La Trinidad and Finca La Barrita along the Achiguate river course. (Refer to Fig. 1.) The value of assets to be benefitted has been estimated on the basis of the future situation of assets in the year 2010.

Sediment Control Works

The design sediment discharge of 30-year return period, which has been calculated from the sediment volume that had accumulated immediately after the eruption of Fuego Volcano in September 1971 because it is the largest one experienced in the recent past, is $1,940 \times 10^3 \text{ m}^3$ in the Achiguate river basin and $3,246 \times 10^3 \text{ m}^3$ in the Pantaleon river basin.

The sediment control plan is made up of sediment control dams of cobble stone concrete type. It is proposed that three (3) dams for the Achiguate river basin and five (5) dams for the Pantaleon river basin be constructed to fully regulate the design sediment discharge. (Refer to Fig. 2.)

Flood Control Works

The design flood discharges are $1,200 \text{ m}^3/\text{s}$ and $1,150 \text{ m}^3/\text{s}$ for Achiguate River and Pantaleon River, respectively.

To protect the target assets from flood damage, partial river improvement works are employed for the project. For Achiguate River, the flood control works consist of river channel improvement in two stretches for the CA-2 road bridge and the railway bridge and for the urban area in Finca La Trinidad, respectively, and a ring levee around the urban area in Finca La Barrita. For Pantaleon River, river channel improvement will be undertaken for the protection of the CA-2 road bridge and the national railway bridge. (Refer to Fig. 2.)

The total lengths of river improvement are 11.0 km and 3.4 km in the Achiguate and the Pantaleon rivers, respectively. The ring levee is constructed over 5.0 km around Finca La Barrita. Riparian facilities such as revetment, ground sill, etc., will be installed to maintain the function of the proposed improvement works.

Construction Schedule and Cost

The construction period is projected at seven (7) years, including the detailed design of two (2) years (refer to Fig. 3).

The total financial construction cost is estimated at US\$63.2 million, comprising US\$36.2 million of foreign currency and US\$27.0 million of local currency. The operation, maintenance and replacement cost (OMR cost) is estimated at US\$560 thousand a year. (Refer to Tables 2 and 3.)

5. **Urgent Plan**

From the economic point of view, the sediment and flood control works under the urgent plan are proposed in such a scale that they can control a flood of 10-year return period or smaller (refer to Table 1). If assessed from the view of social requirement, the project of this scale can satisfy the national average of attainment in flood control.

The target assets for this plan are narrowed down to only the CA-2 road bridge and the national railway bridge spanning the Achiguat and the Pantaleon rivers as shown in Fig. 1.

This urgent plan has been evaluated on the basis of the existing assets.

Proposed Plan

The Proposed Plan was formulated based on the precept that economic viability of the project may be maximized in due consideration of the social requirement in the area.

(1) Sediment Control Works

The design sediment discharges of 10-year return periods are estimated at $710 \times 10^3 \text{ m}^3$ and $1,206 \times 10^3 \text{ m}^3$ on the basis of sediment deposits existing in the upper river basins as of 1983 for the Achiguate and the Pantaleon rivers, respectively.

Sediment control can be accomplished at a limited number of sites by high dams which have the highest sediment regulation effect.

Sediment control is made up of two (2) dams of cobble stone concrete type for Achiguate River and one (1) dam of the same type for Pantaleon River. (Refer to Figs. 4 and 5.)

(2) Flood Control Works

The design flood discharges are $950 \text{ m}^3/\text{s}$ and $900 \text{ m}^3/\text{s}$ for the Achiguate and the Pantaleon rivers, respectively.

Flood control can be accomplished by river improvement works. For Achiguate River, the river improvement stretch totals 5.0 km to protect the CA-2 road bridge and the railway bridge. The river improvement works are composed of channel excavation with wet masonry revetment and concrete ground sill, and construction of foot protection groyne. For Pantaleon River, river improvement stretches to 3.4 km, and river improvement works are of excavation with wet masonry revetment and concrete ground sill. (Refer to Figs. 6 and 7.)

(3) Construction Schedule and Cost

The construction works will be executed in a period of five (5) years, including the detailed design of one (1) year as shown in Fig. 8.

The total construction cost is estimated at US\$20.5 million at the price level in August 1984, comprising US\$11.5 million of foreign currency and US\$9.0 million of local currency. The operation, maintenance and replacement cost (OMR cost) is estimated at US\$300 thousand a year. (Refer to Tables 4 and 5.)

Alternative Plan

The alternative plan was formulated in consideration of (1) easier construction method, (2) possibility of stepwise construction, and (3) availability of materials in the proximity of the construction sites.

The planning conditions, such as design scale of the project, target assets, etc., are the same as those of the Proposed Plan.

(1) Sediment Control Works

Sediment control is provided by low dams at several sites on the precept that they can effectively regulate the design sediment discharge as well as the high dams which were applied in the Proposed Plan.

Totally, four (4) dams in Achiguate River and five (5) dams in Pantaleon River are planned.

(2) Flood Control Works

Flood control is accomplished by the river improvement works. The stretches of the Achiguate and the Pantaleon rivers to be provided with flood control works are the same as those of the Proposed Plan. For Achiguate River, river improvement works comprise revetment of gabion cylinder, groyne and groundsill of gabion mattress. As for Pantaleon River, the works consist of revetment and groundsill, of the same types as those employed in Achiguate River.

(3) Construction Schedule and Cost

The construction works will be executed in a period of five (5) years, same as in the Proposed Plan.

The total construction cost, which was estimated in the same manner as in the Proposed Plan, is US\$21.8 million. The operation, maintenance and replacement cost (OMR cost) is estimated at US\$640 thousand a year.

6. Project Evaluation

The annual benefits that will accrue from the sediment and flood control project under each plan are summarized as follows:

<u>Plan</u>	<u>Annual Benefit (US\$10³)</u>
Long-Term Plan	3,478
Urgent Plan	1,465

The economic internal rate of return (EIRR) was estimated as follows:

<u>Plan</u>	<u>EIRR (%)</u>
Long-Term Plan	5.1
Urgent Plan	
(1) Proposed Plan	7.3
(2) Alternative Plan	4.4

The above EIRR shows that the project under the proposed long-term plan is relatively of a low economic viability. As for the urgent project, EIRR is also not so high for either the urgent proposed and the urgent alternative plans, but EIRR for the Proposed Plan exceeds somewhat the standard rate of 6.5% which is equivalent to the average of the interest rates of project loans from financing agencies in Guatemala. The Proposed Plan has been, therefore, identified to be economically viable.

7. Recommendations

The urgent plan was verified to be technically and economically viable. In this respect, it is recommended that the urgent sediment and flood control project be carried forward to the next stage with least lapse of time in due consideration of the enhancement of the national economy by securing the transportation system.

In the event that financial constraints arise resulting in the difficulty to implement the Urgent Proposed Plan, the Urgent Alternative Plan, whose construction can be more stepwisely executed subject to the limitation of the annual appropriations for the project, may be implemented.

PRINCIPAL FEATURES OF THE PROJECT

1. Proposed Plan for the Long-Term Project

<u>Design Scale of Project</u>	30-year return period
<u>Target Assets to be Protected</u>	CA-2 road bridge and railway bridge across the Achiguate and the Pantaleon rivers; urban areas in Finca La Trinidad and Finca La Barrita

Sediment Control Works

(1) Design Sediment Discharge 1,940 x 10³ m³ at Achiguate Reference Point, 3,246 x 10³ m³ at Pantaleon Reference Point

(2) Sediment Control Dam

<u>Dam Name</u>	<u>Catchment Area (km²)</u>	<u>Dam Type</u>	<u>Effective Height (m)</u>	<u>Crest Length (m)</u>	<u>Dam Body Volume (m³)</u>	<u>Regulation Volume (10³ m³)</u>
(Achiguate River)						
A-1	92.0	Cobble Stone Concrete	8.0	460	21,000	990
A-2	39.0	-do-	18.0	135	24,000	562
C-1	112.0	-do-	7.0	455	19,000	338
(Pantaleon River)						
P-1	115.0	Cobble Stone Concrete	5.0	210	7,000	60
P-2	107.0	-do-	9.0	392	17,000	976
P-3	62.0	-do-	11.0	160	17,000	235
P-4	61.0	-do-	9.0	190	12,000	315
P-5	60.0	-do-	18.0	230	44,000	1,370

River Improvement

(1) Design Flood Discharge 1,200 m³/s at Achiguate Reference Point I and 1,150 m³/s at Pantaleon Reference Point

- (2) Stretch to be Improved 11.0 km in total along Achiguatue River; 3.4 km in total along Pantaleon River
- (3) Revetment Wet masonry, 9.2 km in total (4.6 km for Achiguatue and 4.6 km for Pantaleon)
- (4) Groundsill Concrete Type, 64 places in total (17 places for Achiguatue and 47 places for Pantaleon)

2. Proposed Plan for the Urgent Project

Design Scale of Project 10-year return period

Target Assets to be Protected CA-2 road bridge and railway bridge across the Achiguatue and the Pantaleon rivers

Sediment Control Works

- (1) Design Sediment Discharge 710 x 10³ m³ at Achiguatue Reference Point;
1,206 x 10³ m³ at Pantaleon Reference Point

- (2) Sediment Control Dam

Dam Name	Catchment Area (km ²)	Dam Type	Effective Height (m)	Crest Length (m)	Dam Body Volume (m ³)	Regulation Volume (10 ³ m ³)
(Achiguatue River)						
A-1	92.0	Cobble Stone Concrete	6.5	409	14,000	551
G-1	112.0	--do--	4.5	425	10,000	119
(Pantaleon River)						
P-2	107.0	Cobble Stone Concrete	9.0	392	17,000	976

River Improvement

- (1) Design Flood Discharge 950 m³/s at Achiguatue Reference Point I and 900 m³/s at Pantaleon Reference Point

- | | |
|----------------------------|--|
| (2) Stretch to be Improved | 5.0 km along Achiguate River;
3.4 km along Pantaleon River |
| (3) Revetment | Wet masonry, 4.0 km in total
(1.7 km for Achiguate and
2.3 km for Pantaleon) |
| (4) Groyne | Crib, 68 places for Achiguate |
| (5) Groundsill | Concrete type, 31 places in
total (7 places for Achiguate
and 24 places for Pantaleon) |

3. Alternative Plan for the Urgent Project

Design project scale, target assets to be protected, design sediment discharge, design flood discharge, and stretch to be improved are the same as those of the Proposed Plan for the Urgent Project.

Sediment Control Works

(1) Sediment Control Dam

Dam Site	Catchment Area (km ²)	Dam Type	Effective Height (m)	Crest Length (m)	Dam Body Volume (m ³)	Regulation Volume (10 ³ m ³)
(Achiguate River)						
A-1	92.0	Gabion Mattress	5.0	404	38,000	350
A-1'	87.0	-do-	3.5	401	21,000	111
A-2	39.0	-do-	5.0	101	9,000	90
C-1	112.0	-do-	4.5	424	35,000	119
(Pantaleon River)						
P-2	107.0	Gabion Mattress	5.0	276	23,000	370
P-2'	64.0	-do-	4.0	308	21,000	101
P-3	62.0	-do-	5.0	167	16,000	105
P-4	61.0	-do-	5.0	170	14,000	180
P-5	60.0	-do-	5.0	158	18,000	220

River Improvement

- | | |
|---------------|--|
| (1) Revetment | Gabion cylinder, 4.0 km in total (1.7 km for Achiguate and 2.3 km for Pantaleon) |
| (2) Groyne | Crib, 68 places for Achiguate |

(3) Groundsill

Gabion mattress, 31 places in total (7 places for Achiguata and 24 places for Pantaleon)

TABLES

Table 1 COMPARISON OF EIRR'S OF STUDY CASES IN THE LONG-TERM AND THE URGENT PLANS

Study Case	Return Period of Floods	EIRR (%)	Remarks
(Long-Term Plan)			
1. Entire River Improvement	30 years	2.2	
2. Partial River Improvement (Case I)	- ditto -	3.0	
3. Partial River Improvement (Case II)	- ditto -	5.1	Employed
(Urgent Plan)			
1. Partial River Improvement	5 years	6.1	
2. - ditto -	10 years	7.4	
2' - ditto -	10 years	7.3	Employed
3. - ditto -	30 years	5.2	

Note : In 2' of the urgent plan, revetment and groundfills are provided in the scale against 30-year return period floods to avoid double investment and duplication of construction works when the long-term plan is implemented.

Table 2 CONSTRUCTION COST FOR THE PROPOSED LONG-TERM PLAN

Works Item	Unit	Quantity			Cost (x 10 ³)		
		Achiguate River	Pantaleon River	Total	F.C. (US\$)	L.C. (Q.)	Total (US\$)
1. Sediment Control Dam							
Excavation	m ³	103,000	202,000	305,000	824	519	1,343
Back-filling	m ³	9,400	14,300	23,700	74	89	163
Main Dam	m ³	78,000	126,000	204,000	7,175	6,895	14,070
Sub Dam	m ³	10,000	11,000	21,000	743	878	1,621
Apron and Side Walls	m	69	140	209	651	579	1,230
Saddle Dam	m	170	-----	170	174	107	281
Sub-total of 1.					9,641	9,067	18,708
2. River Improvement							
Excavation	m ³	1,140,000	240,000	1,380,000	3,174	1,932	5,106
Embankment	m ³	160,000	-----	160,000	1,488	944	2,432
Sodding	m ²	79,000	7,000	86,000	-----	147	147
Drainage Ditch	m	12,000	-----	12,000	588	684	1,272
Revetment(1:0.5)	m	4,600	4,600	9,200	947	1,008	1,955
Groundsill	Unit	15	45	60	1,383	1,256	2,639
Check Groundsill	Unit	2	2	4	171	202	373
Ring Levee	m	5,000	-----	5,000	510	424	934
Drainage Facility	L/S	1	-----	1	490	130	620
Sub-total of 2.					8,751	6,787	15,478
Sub-total of 1. and 2.					18,392	15,794	34,186
3. Preparation Cost	L/S				1,839	1,579	3,418
(10% of total of 1. and 2.)							
4. Land Acquisition Cost							
Dam Construction	ha	4	-----	4	-----	3	3
River Improvement	ha	24	-----	24	-----	17	17
5. Engineering Services	L/S				5,526	1,374	6,900
6. Administration Cost	L/S				216	448	664
Sub-total of 1. to 6.					25,973	19,215	45,188
7. Physical Contingency	L/S				2,597	1,922	4,519
(10% of total of 1. to 6.)							
Grand Total of 1. to 7.					28,570	21,137	49,707

Table 3 ANNUAL DISBURSEMENT FOR THE PROPOSED LONG-TERM PLAN

Unit:
 Total : US\$ x 10³
 F.C : US\$ x 10³
 L.C : Q x 10³

Item	Total	1st.		2nd.		3rd.		4th.		5th.		6th.		7th.	
		F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1. Sediment Control Dam	18,708	9,641	9,067	---	---	1,153	1,042	2,702	2,532	2,639	2,494	1,957	1,847	1,190	1,152
2. River Improvement	15,478	8,751	6,727	---	---	---	---	1,166	900	2,184	1,827	2,573	1,872	2,828	2,128
Sub total of 1. and 2.	34,186	18,392	15,794	---	---	1,153	1,042	3,868	3,432	4,823	4,321	4,530	3,719	4,018	3,280
3. Preparation Cost (10% of total of 1. and 2.)	3,418	1,839	1,579	---	---	115	104	387	343	482	432	453	372	402	328
4. Compensation	20	---	20	---	---	---	---	---	---	---	---	---	---	---	---
Sub total of 1. to 4.	37,624	20,231	17,393	---	---	1,268	1,146	4,255	3,775	5,305	4,753	4,983	4,091	4,420	3,608
5. Engineering Services	6,900	5,526	1,374	1,111	305	740	204	720	173	720	173	720	173	720	173
6. Administration Cost	664	216	448	113	53	75	35	---	72	---	72	---	72	---	72
Sub total of 1. to 6.	45,188	25,973	19,215	1,224	358	815	259	4,975	4,020	6,025	4,998	5,703	4,336	5,140	3,853
7. Physical Contingency (10% of total of 1. to 6.)	4,519	2,597	1,922	122	36	209	139	498	402	603	500	570	434	514	285
Total of 1. to 7.	49,707	28,570	21,137	1,346	394	896	285	5,473	4,422	6,628	5,498	6,273	4,770	5,654	4,238
8. Price Contingency F.C (6%) L.C (6%)	13,492	7,611	5,881	---	---	54	17	1,045	845	1,740	1,443	2,122	1,613	2,366	1,774
9. Grand total of 1. to 8.	63,199	36,181	27,018	1,346	394	950	302	6,518	5,267	8,368	6,941	8,395	6,383	8,020	6,012

Table 4 CONSTRUCTION COST FOR THE PROPOSED URGENT PLAN

Work Item	Unit	Quantity			Cost (x 10 ³)		
		Achiguata River	Pantaleon River	Total	F.C (US\$)	L.C (Q.)	Total (US\$)
1. Sediment Control Dam					(2,500)	(2,538)	(5,038)
Excavation	m ³	56,800	51,200	108,000	292	184	476
Embankment and Back-filling	m ³	28,700	5,400	34,100	106	126	232
Concrete Works	m ³	25,200	16,100	41,300	1,776	1,446	3,222
Boulder Works for Main and Sub Dams	m ³	7,600	4,500	12,100	100	64	164
Boulder Works for Apron	m ³	5,300	3,700	9,000	62	40	102
Form Works	m ²	20,100	9,200	29,300	0	557	557
Wet Masonry Works for Side Walls	m ²	520	390	910	14	29	43
Saddle Dam Works	m	150	0	150	150	92	242
2. River Improvement					(2,893)	(2,344)	(5,237)
Excavation of River Channel	m ³	552,000	163,000	715,000	1,645	1,001	2,646
Excavation and Back-filling of Trench	m ³	21,600	36,100	57,700	138	87	225
Wet Masonry Works (Type A)	m ²	8,020	0	8,020	56	144	200
Wet Masonry Works (Type B)	m ²	0	10,200	10,200	112	255	367
Base Concrete Works for Wet Masonry (Type A)	m	1,630	0	1,630	26	34	60
Base Concrete Works for Wet Masonry (Type B)	m	0	2,280	2,280	55	66	121
Gabion Mattress Works for Wet Masonry	m ³	2,450	3,420	5,870	194	23	217
Foot-protection Groyne works (Crib)	Unit	68	0	68	24	38	62
Concrete and Form Works for Groundsill	m ³	2,760	6,600	9,360	384	665	1,049
Gabion Mattress Works for Groundsill	m ³	2,100	5,760	7,860	259	31	290
Sub-total of 1. and 2.					(5,393)	(4,882)	(10,275)
3. Preparation Works (10% of Total of 1. and 2.)	L/S	-----	-----	-----	939	488	1,027
4. Engineering Services	L/S	-----	-----	-----	2,100	400	2,500
5. Land Acquisition	ha	4	0	4	0	3	3
6. Administration Cost	L/S	-----	-----	-----	0	414	414
7. Physical Contingency (10% of Total of 1. to 6.)	L/S	-----	-----	-----	803	619	1,422
Sub-total of 1. to 7.					(8,835)	(6,806)	(15,641)
8. Price Contingency (6% For P/C and L/C)	L/S	-----	-----	-----	2,677	2,140	4,817
Grand Total					11,512	8,946	20,458

Table 5. ANNUAL DISBURSEMENT FOR THE PROPOSED URGENT PLAN

Unit: x 10³ US\$

Item	1986		1987		1988		1989		1990		Total		
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	Grand
1. Sediment Control Dam	-----	-----	-----	-----	1,250	1,269	1,000	1,015	250	254	2,500	2,538	5,038
2. River Improvement	-----	-----	-----	-----	-----	-----	2,170	1,758	723	586	2,893	2,344	5,237
3. Preparation Works	-----	-----	250	254	289	234	-----	-----	-----	-----	539	468	1,027
4. Engineering Services	740	118	198	19	475	113	502	113	185	37	2,100	400	2,500
5. Land Acquisition	-----	-----	0	3	-----	-----	-----	-----	-----	-----	0	3	3
6. Administration Cost	0	83	0	83	0	83	0	83	0	82	0	414	414
7. Physical Contingency (10% of Total of 1. to 6.)	74	20	45	36	201	170	367	297	116	96	803	619	1,422
Sub-total of 1. to 7.	(814)	(221)	(493)	(395)	(2,215)	(1,869)	(4,039)	(3,266)	(1,274)	(1,055)	(8,855)	(6,806)	(15,661)
8. Price Contingency (6% for F/C and L/C)	101	27	94	75	583	492	1,365	1,104	534	442	2,677	2,140	4,817
Total	915	248	587	470	2,798	2,361	5,404	4,370	1,808	1,497	11,512	8,946	20,458

FIGURES

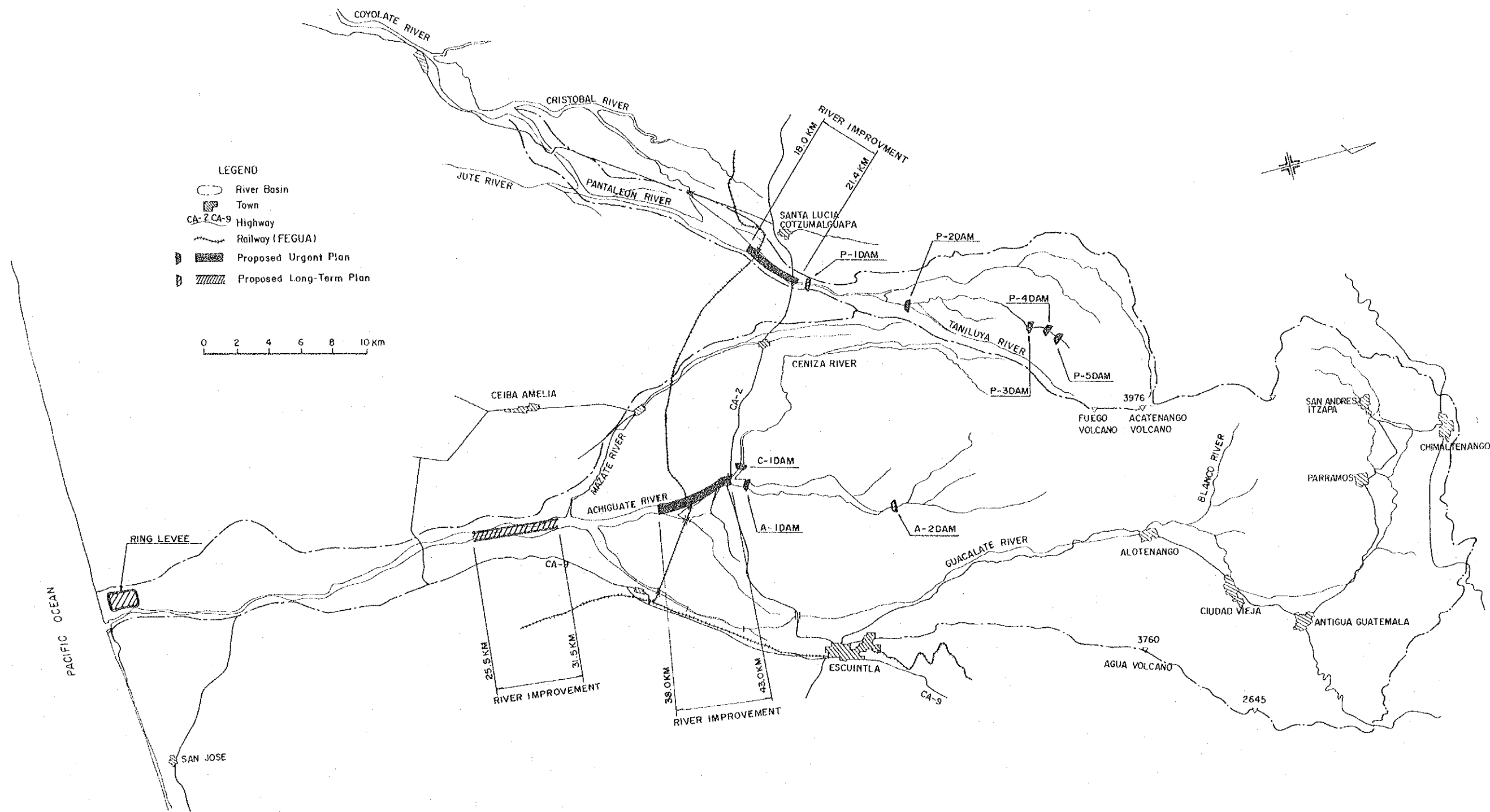
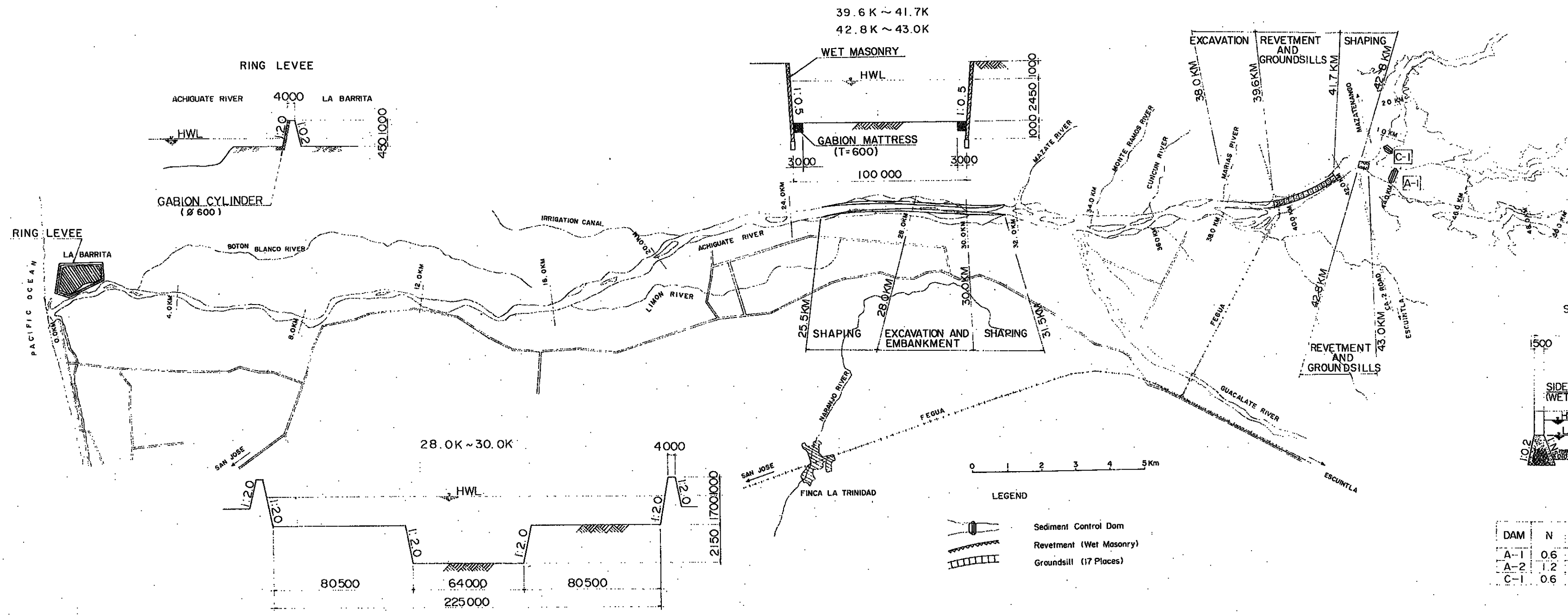
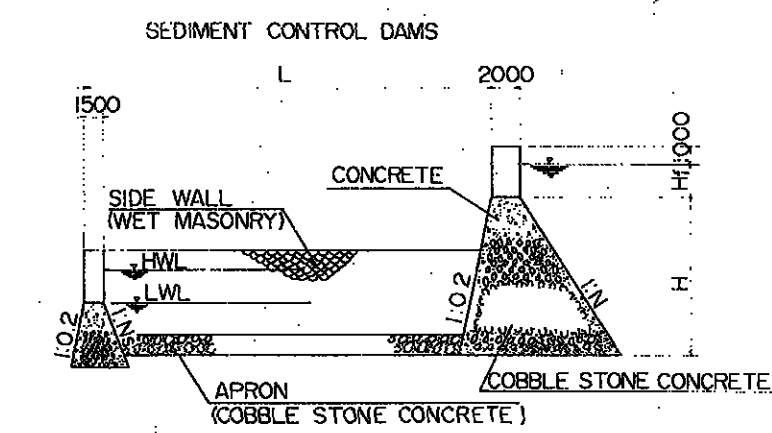
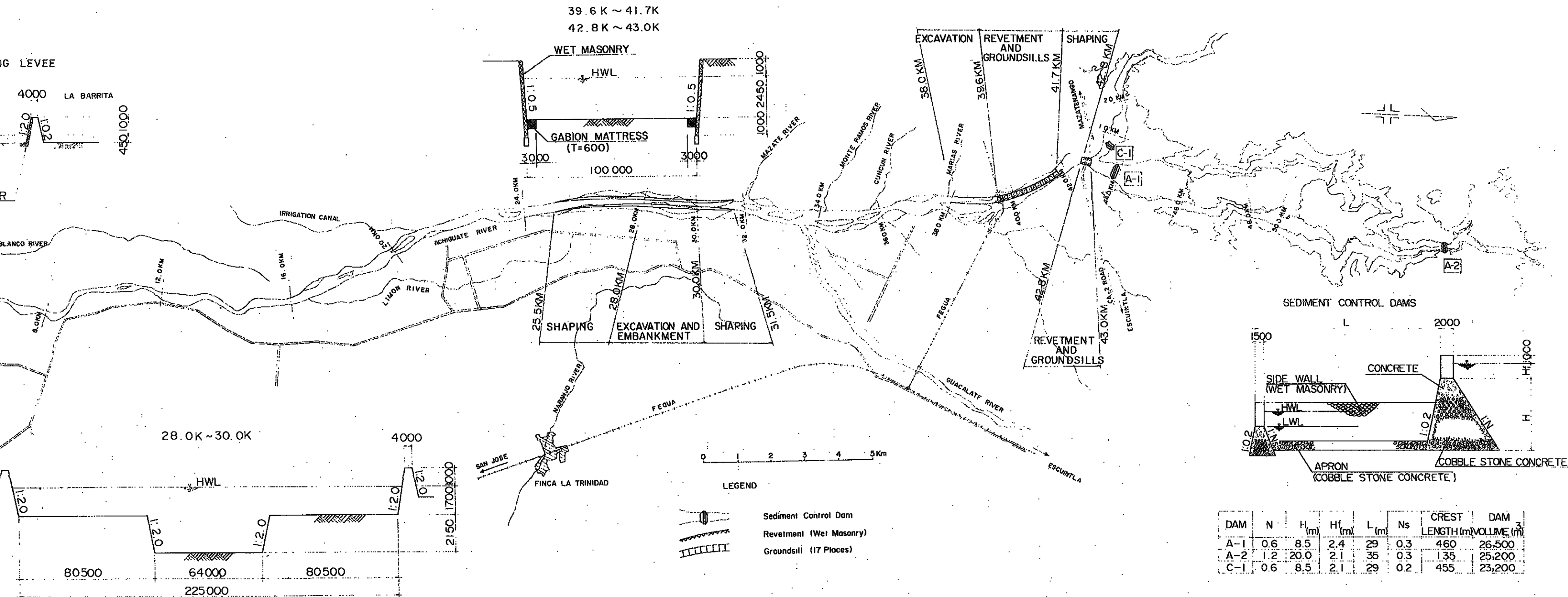


Fig. 1 PROJECT AREA



DAM	N
A-1	0.6
A-2	1.2
C-1	0.6

Fig. 2 (



DAM	N	H _i (m)	H _f (m)	L (m)	N _s	CREST LENGTH (m)	DAM VOLUME (m ³)
A-1	0.6	8.5	2.4	29	0.3	460	26,500
A-2	1.2	20.0	2.1	35	0.3	1,35	25,200
C-1	0.6	8.5	2.1	29	0.2	455	23,200

Fig. 2 (1/2) PROPOSED LONG-TERM PLAN (ACHIGUATE RIVER)

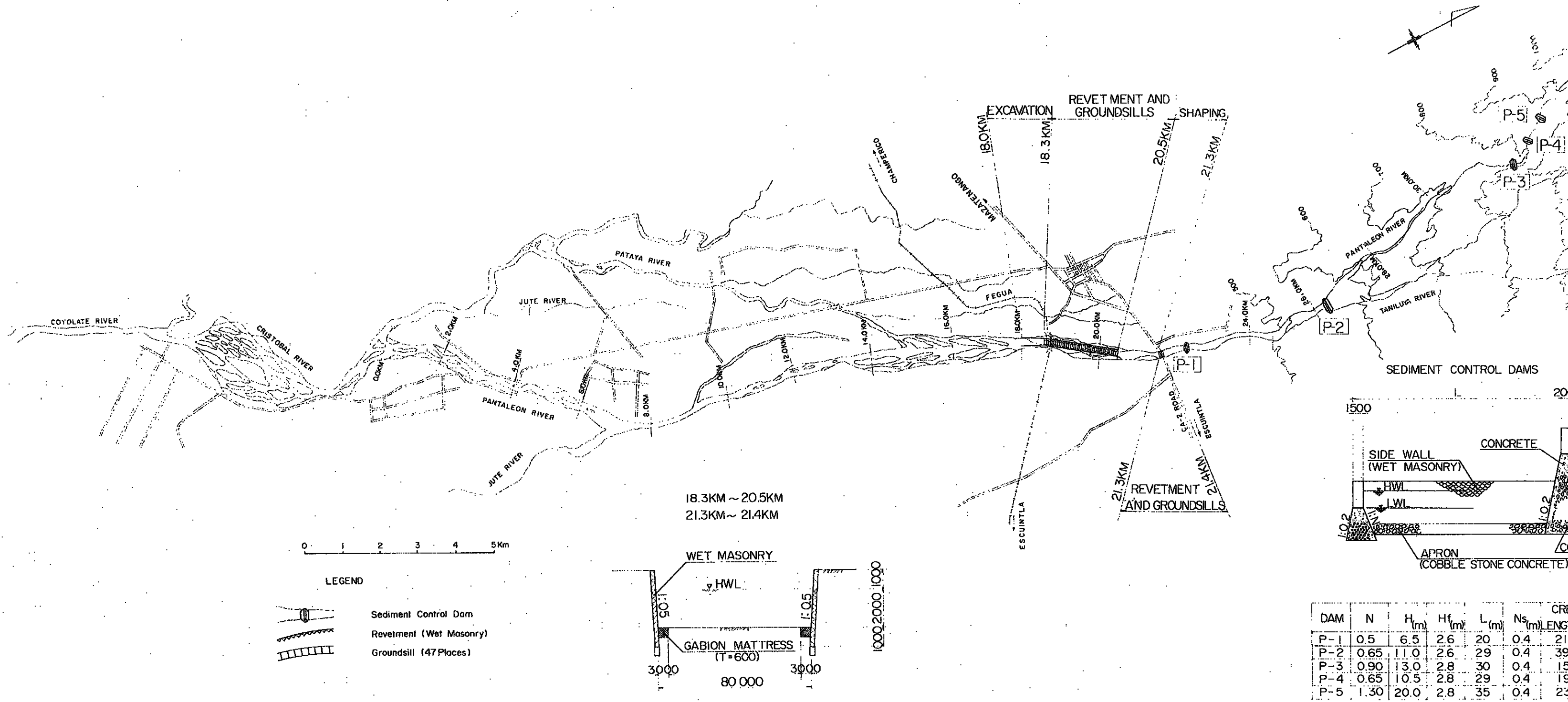


Fig. 2 (2/2) PROPOSED LONG SEDIMENT CONTROL DAM (PANTALEON RIVER)

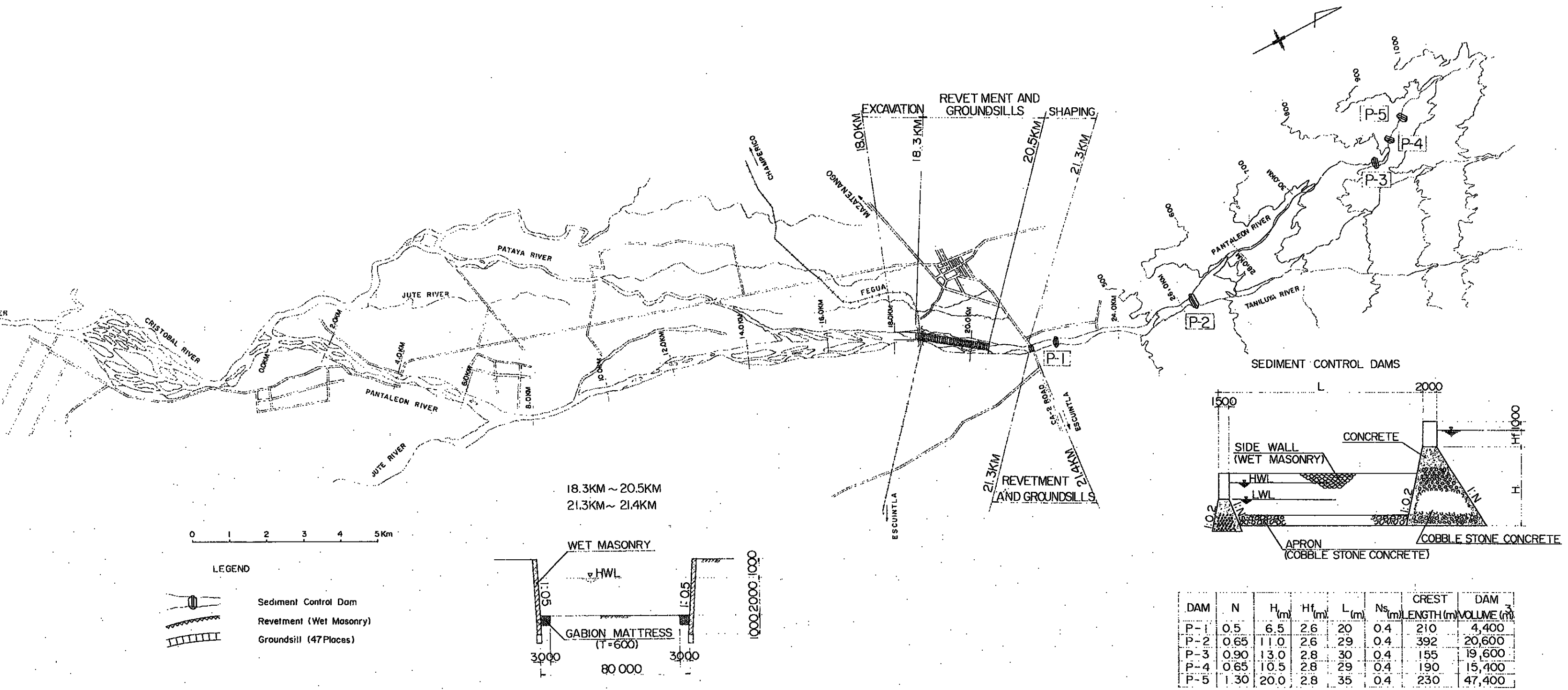


Fig. 2 (2/2) PROPOSED LONG-TERM PLAN (PANTALEON RIVER)

WORK STAGE	WORK VOLUME	1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr	6th Yr	7th Yr
ACHIGUATE	1 L/S	[Gantt chart showing construction from 1st to 2nd year]						
ACHIGUATE	1 L/S	[Gantt chart showing construction from 1st to 2nd year]						
ACHIGUATE	103 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	78 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	10 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
PANTALEON	1 L/S	[Gantt chart showing construction from 1st to 2nd year]						
PANTALEON	202 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
PANTALEON	126 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
PANTALEON	11 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	1 L/S	[Gantt chart showing construction from 1st to 2nd year]						
ACHIGUATE	140 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	160 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	4 600 m	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	17 Units	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	1 L/S	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	1 L/S	[Gantt chart showing construction from 1st to 2nd year]						
ACHIGUATE	240 000 m ³	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	4 600 m	[Gantt chart showing construction from 3rd to 5th year]						
ACHIGUATE	47 Units	[Gantt chart showing construction from 3rd to 5th year]						

Fig. 3 CONSTRUCTION SCHEDULE OF THE PROPOSED LONG-TERM PLAN

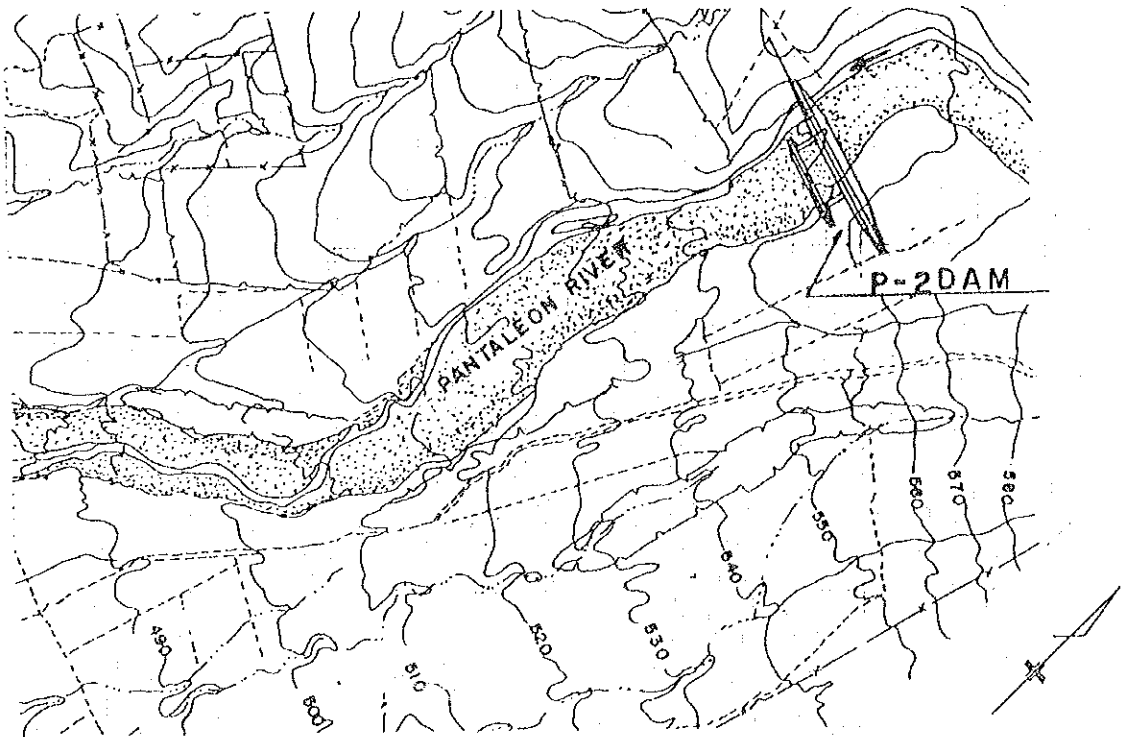
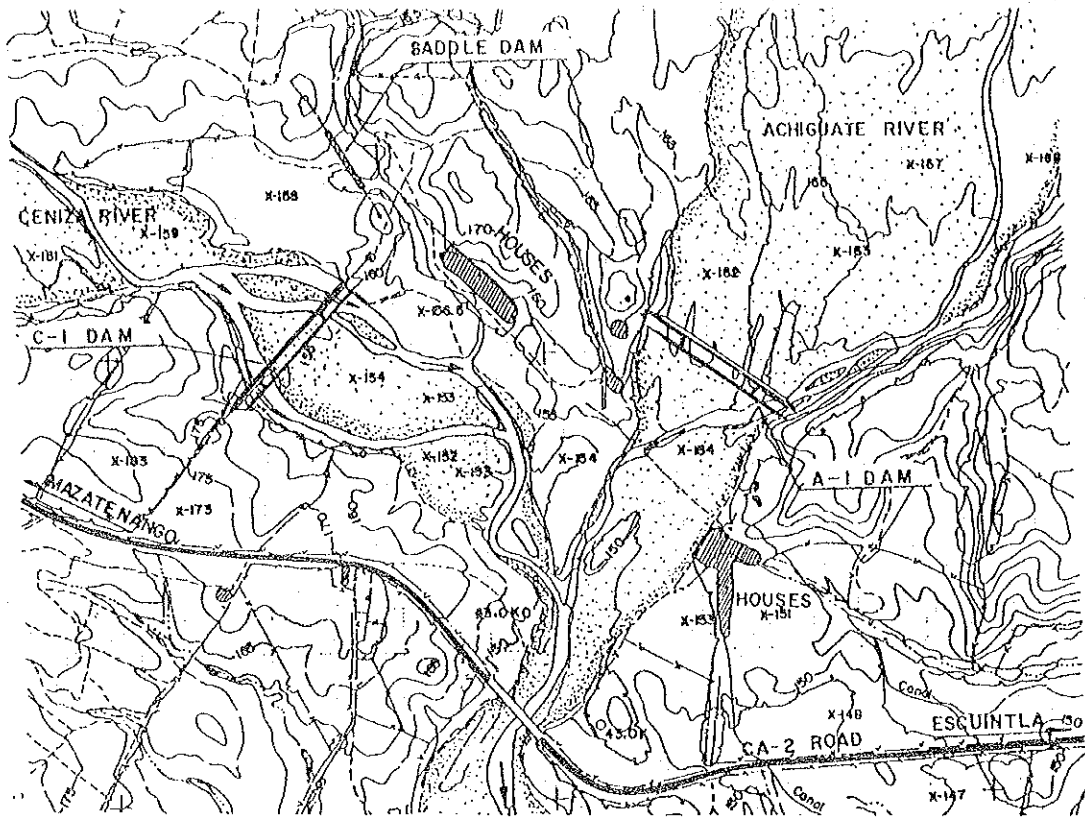
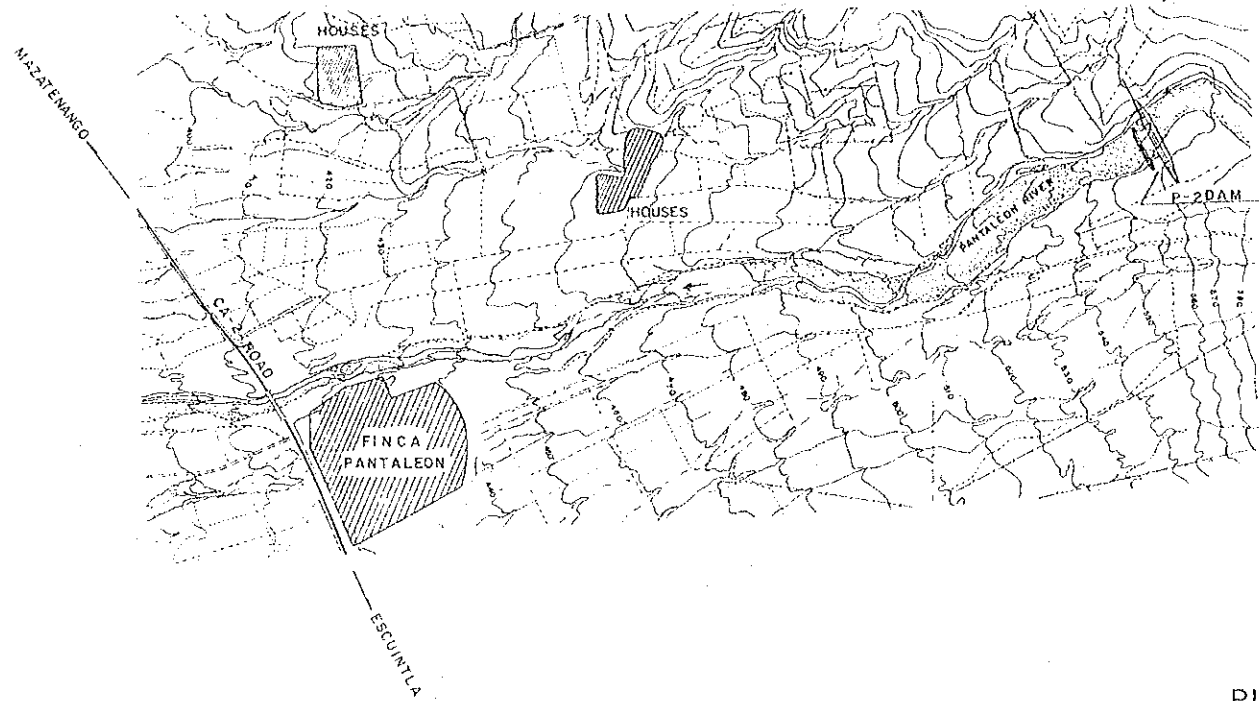


Fig. 4 LOCATION OF SEDIMENT CONTROL DAMS IN THE PROPOSED URGNET PLAN

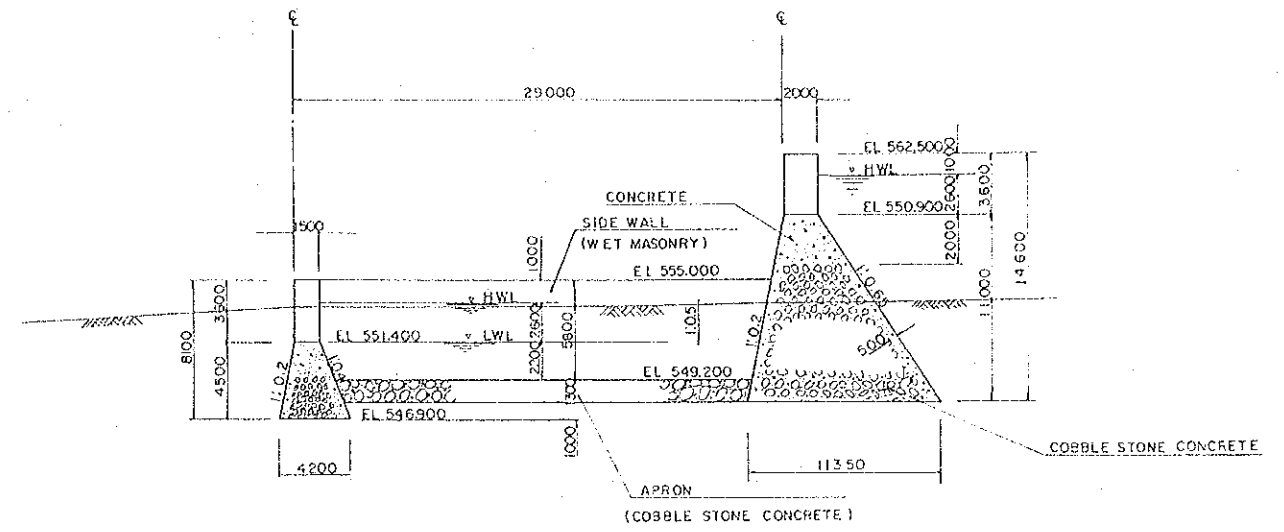
LOCATION MAP

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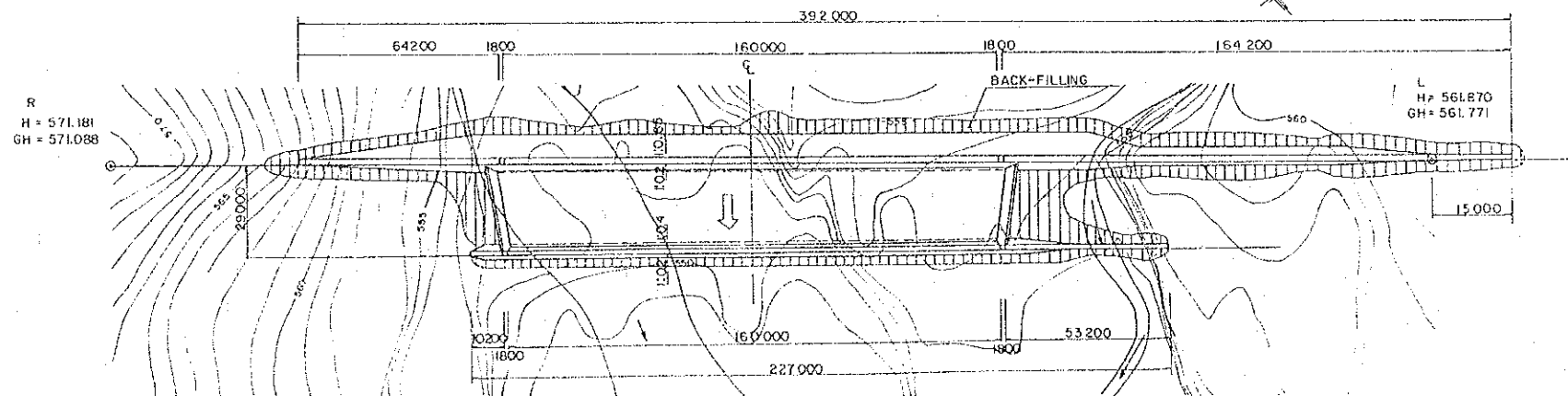
PROFILE

SCALE 1:200



PLAN

SCALE 1:1000



NOTE

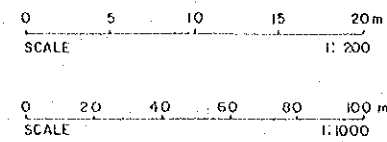


Fig. 5 GENERAL STRUCTURE OF SEDIMENT CONTROL DAM IN THE PROPOSED REGENT PLAN (P-2 DAM)



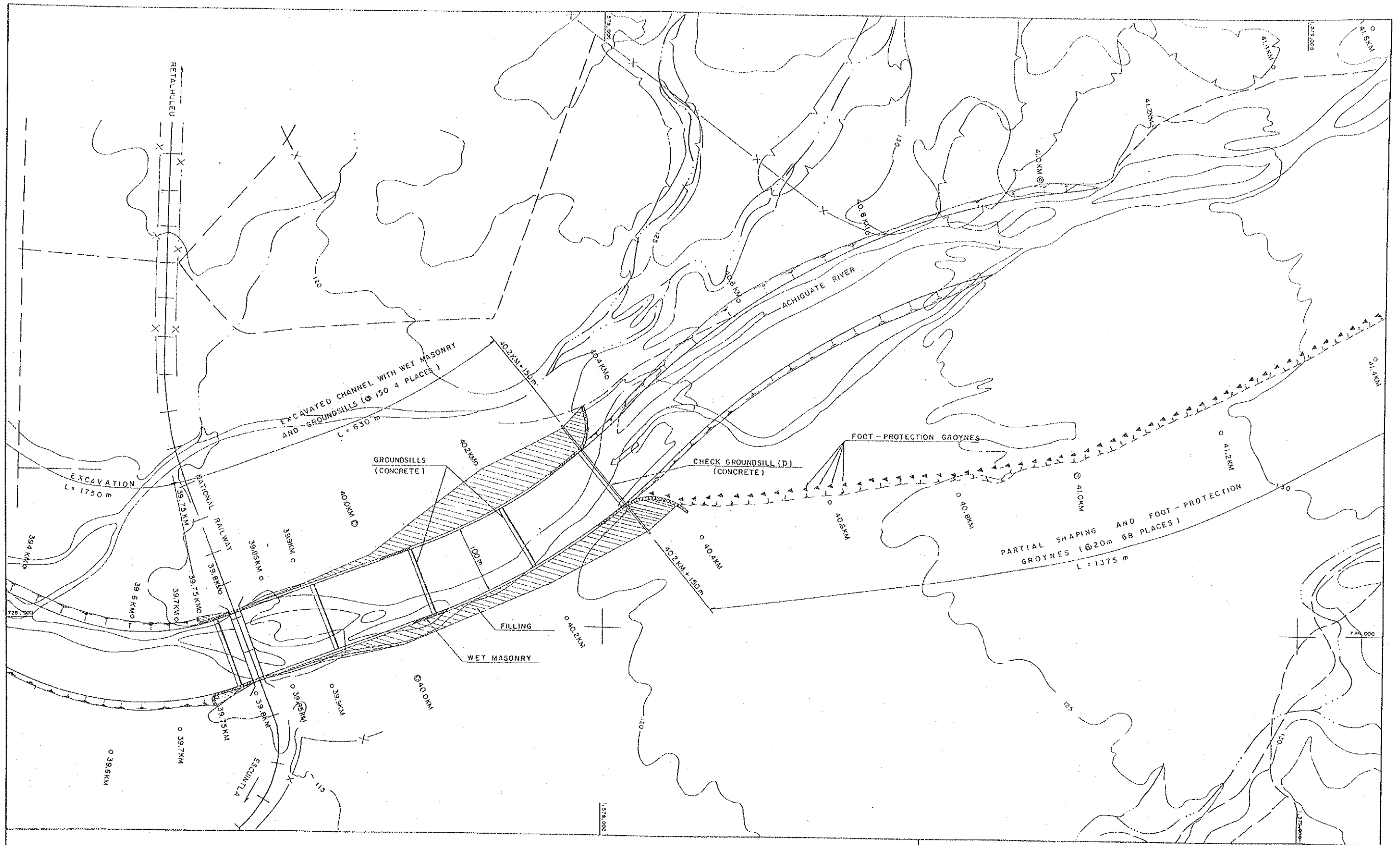
NOTE I. EXPLANATION OF SYMBOL

+++++	RAILWAY	⌒	FOREST
— — —	ROAD	□	HOUSE
- - - -	PATHWAY	⌒	BRIDGE
⋯	STREAM	⊙	STATION POST
-X-X-	FENCE	□	BM BENCH MARK

0 50 100 150 200 250m
SCALE 1:2,500



Fig. 6 (1/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (ACHIGUATO RIVER)



NOTE

I. EXPLANATION OF SYMBOL

++++	RAILWAY		FOREST
====	ROAD		HOUSE
----	PATHWAY		BRIDGE
----	STREAM	⊙ ○	STATION POST
-X-X-	FENCE	□ BM	BENCH MARK

0 50 100 150 200 250m
SCALE 1:2500

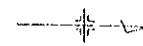
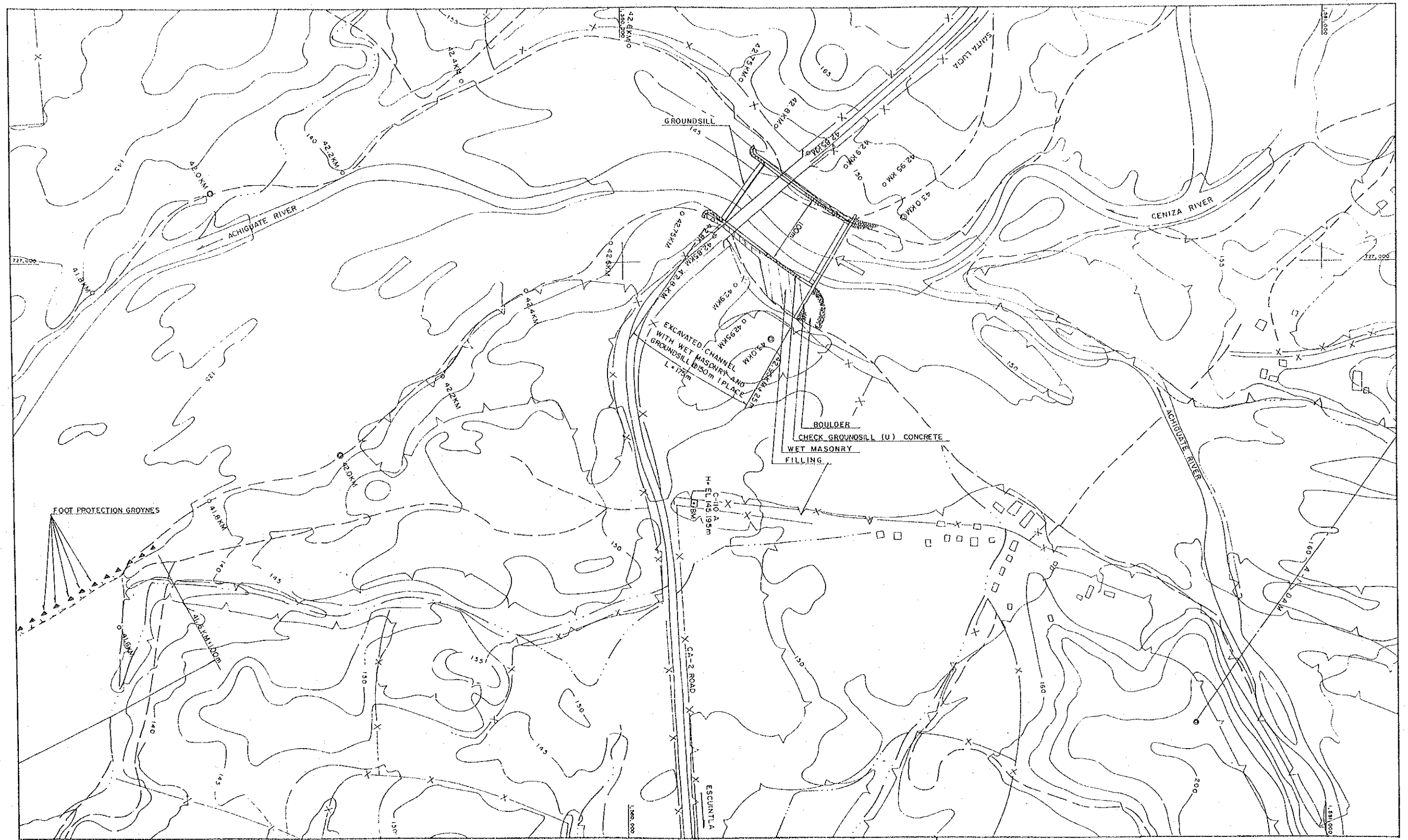


Fig. 6 (2/6) PLAN OF RIVER IMPROVEMENT
IN THE PROPOSED URGENT
PLAN (ACHIGUATE RIVER)



NOTE

I. EXPLANATION OF SYMBOL

+++++	RAILWAY		FOREST
====	ROAD		HOUSE
----	PATHWAY		BRIDGE
----	STREAM		STATION POST
-X-X-	FENCE		BENCH MARK

0 50 100 150 200 250m
SCALE 1:2,500

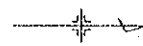


Fig. 6 (3/6) PLAN OF RIVER IMPROVEMENT
IN THE PROPOSED URGENT
PLAN (ACHIGUATE RIVER)

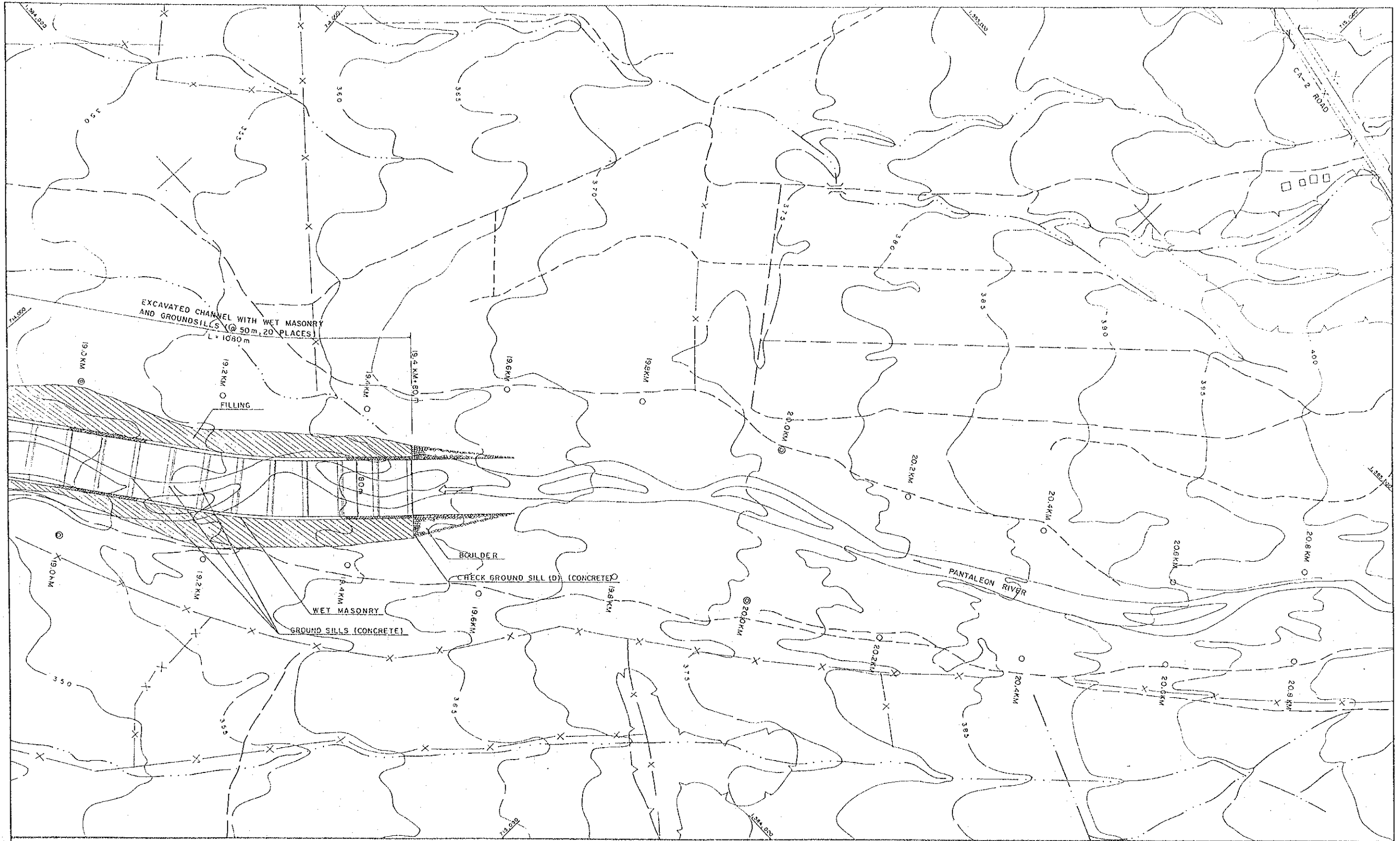


NOTE I. EXPLANATION OF SIMBOL

	RAILWAY		FOREST
	ROAD		HOUSE
	PATHWAY		BRIDGE
	STREAM		STATION POST
	FENCE		BENCH MARK

0 50 100 150 200 250m
SCALE 1:2,500

Fig. 6 (4/6) PLAN OF RIVER IMPROVEMENT
IN THE PROPOSED URGENT
PLAN (PANTALEON RIVER)



NOTE

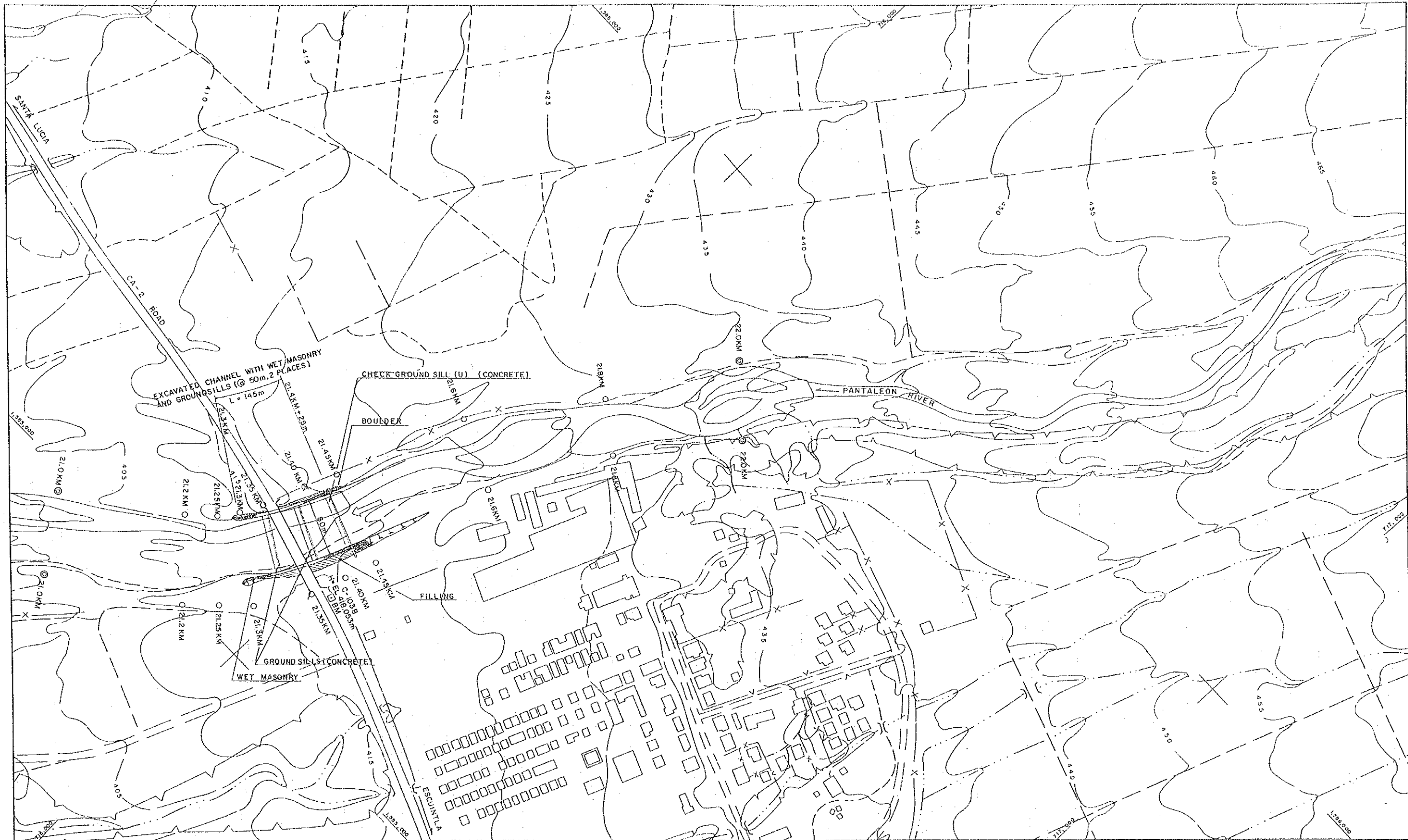
I. EXPLANATION OF SYMBOL

+++++	RAILWAY	~~~~~	FOREST
====	ROAD	□	HOUSE
----	PATHWAY		BRIDGE
----	STREAM	⊙ ○	STATION POST
-X-X-	FENCE	□	BM BENCH MARK

0 50 100 150 200 250m
SCALE 1:2,500



Fig. 6 (5/6) PLAN OF RIVER IMPROVEMENT
IN THE PROPOSED URGENT
PLAN (PANTALEON RIVER)



NOTE I. EXPLANATION OF SIMBOL

+++++	RAILWAY	~~~~~	FOREST
====	ROAD	□	HOUSE
----	PATHWAY		BRIDGE
----	STREAM	⊙ ○	STATION POST
-X-X-	FENCE	□	BM BENCH MARK

0 50 100 150 200 250m
SCALE 1:2,500

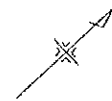
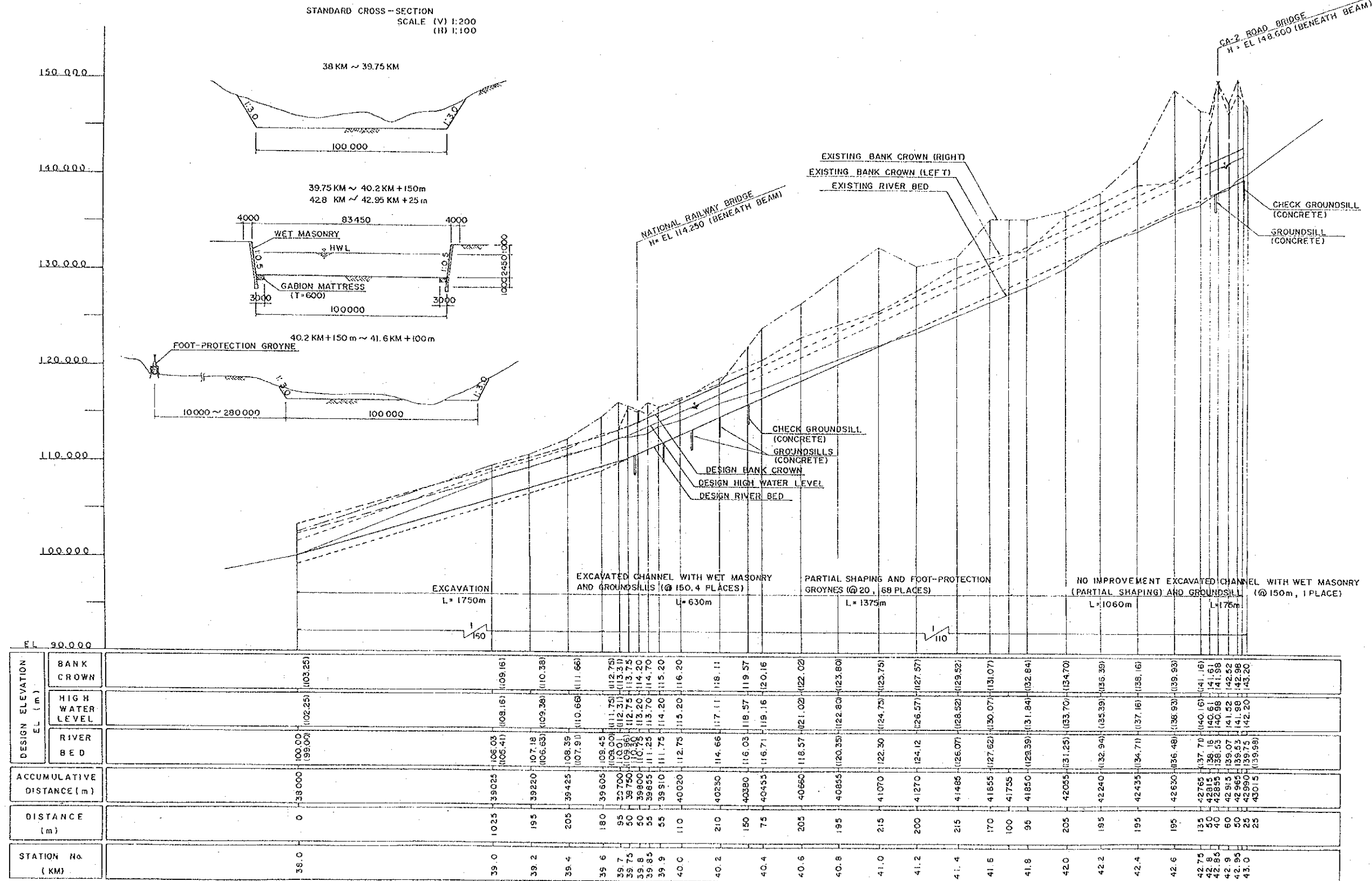


Fig. 6 (6/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (PANTALEON RIVER)



NOTE

1. The real lines and broken lines in the drawing and also the figures outside () and inside () in the columns are applied to the urgent plan and the comprehensive long-term plan, respectively.

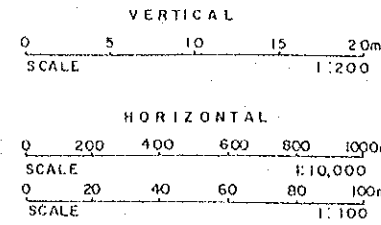
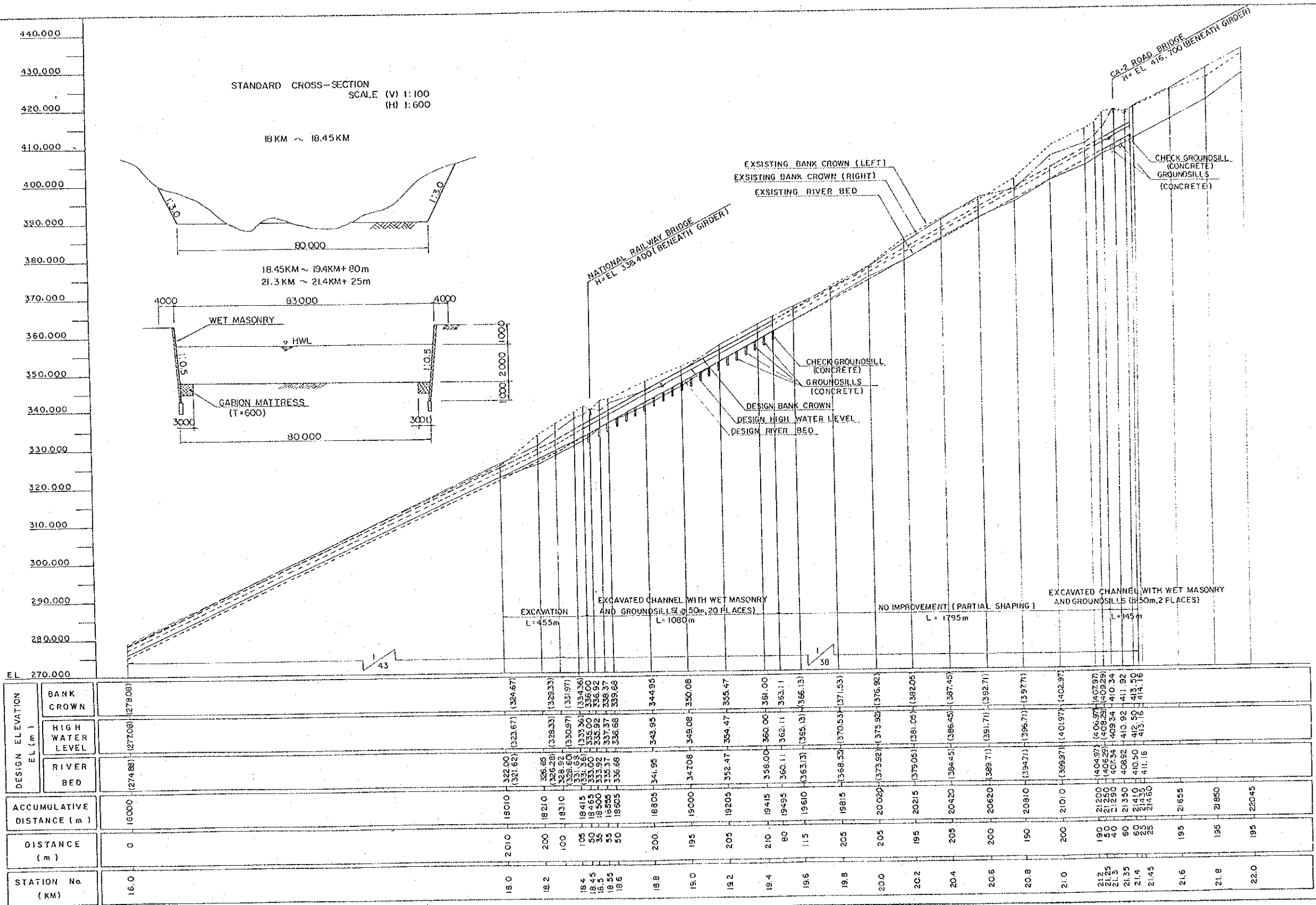


Fig. 7 (1/2) DESIGN PROFILE OF RIVER CHANNEL IN THE PROPOSED URGENT PLAN (ACHIGUATE RIVER)



NOTE

1. The real lines and broken lines in the drawing and also the figures outside () and inside () in the columns are applied to the urgent plan and the comprehensive long-term plan, respectively.

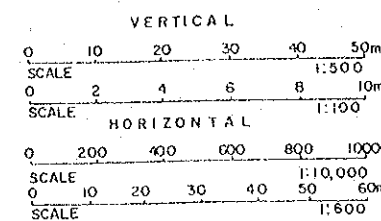


Fig. 7 (2/2) DESIGN PROFILE OF RIVER CHANNEL IN THE PROPOSED URGENT PLAN (PANTALFON RIVER)

CONSTRUCTION WORKS	WORK ITEM	VOLUME	YEAR				
			1986	1987	1988	1989	1990
SEDIMENT CONTROL DAM	DETAILED DESIGN	L/S	██████████	-----			
	PREPARATION	L/S		██████████			
	EXCAVATION	30,800 m ³			██████████		
	STONE CONCRETE WORKS	21,900 m ³		██████████	██████████		
	OTHER WORKS	L/S				██████████	
	EXCAVATION	26,000 m ³			██████████		
	STONE CONCRETE WORKS	16,200 m ³			██████████	██████████	
	OTHER WORKS	L/S					██████████
	EXCAVATION	51,200 m ³			██████████		
	STONE CONCRETE WORKS	24,300 m ³			██████████	██████████	██████████
RIVER IMPROVEMENT	OTHER WORKS	L/S					██████████
	PREPARATION	L/S				██████████	
	EXCAVATION	574,000 m ³				██████████	██████████
	REVTMENT WORKS (WET MASONRY)	8,020 m ²					██████████
	GROYNE WORKS(CRIB)	68 unit					██████████
	GROUNDSILL WORKS(CONCRETE)	2,760 m ³				██████████	██████████
	EXCAVATION	199,000 m ³				██████████	██████████
	REVTMENT WORKS(WET MASONRY)	10,200 m ²					██████████
	GROUNDSILL WORKS(CONCRETE)	6,600 m ³				██████████	██████████
							██████████

----- : Rainy season

Fig. 8 CONSTRUCTION SCHEDULE OF THE PROPOSED URGENT PLAN

JICA