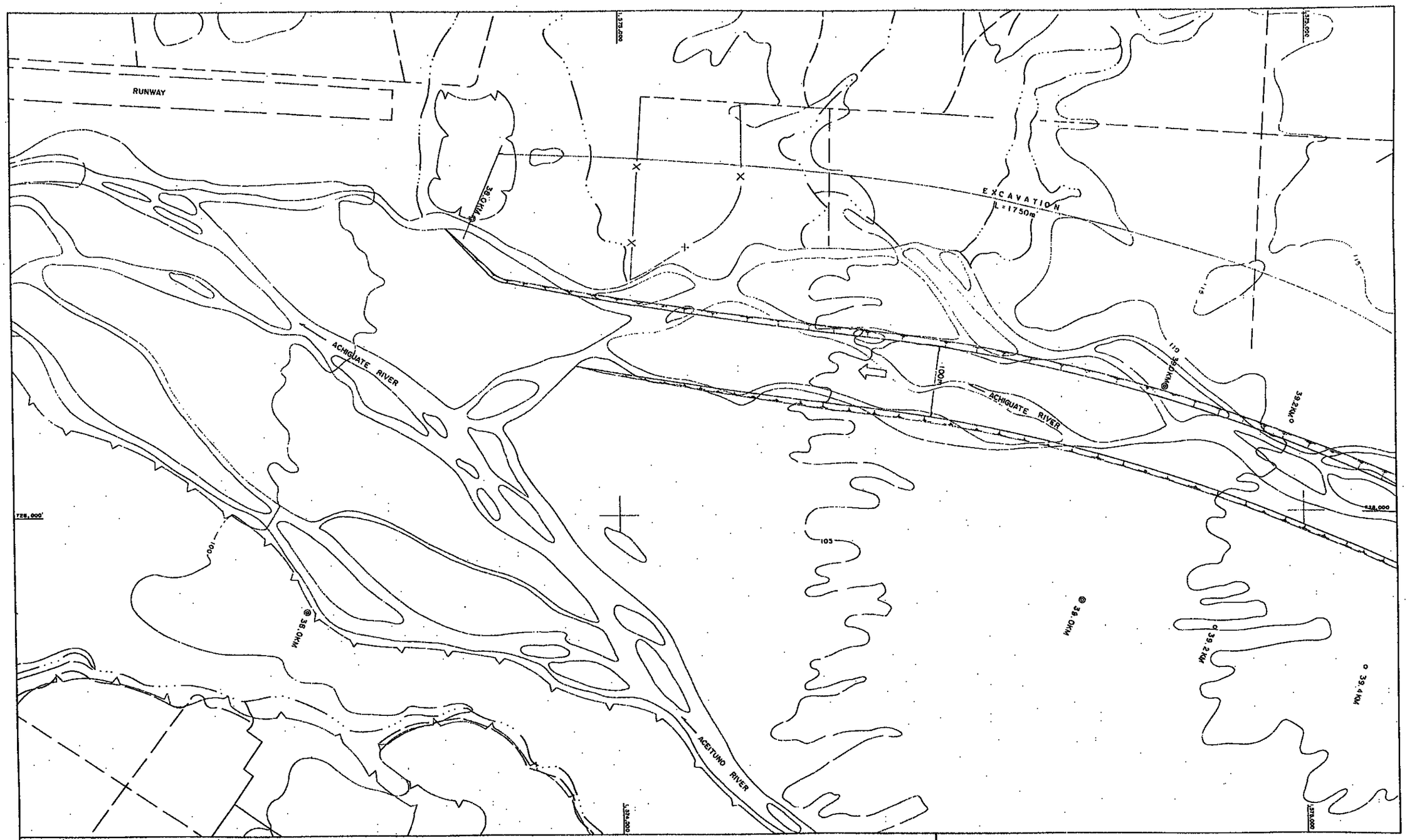


Fig. 4-27 (1/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (ACHIGUATE RIVER)

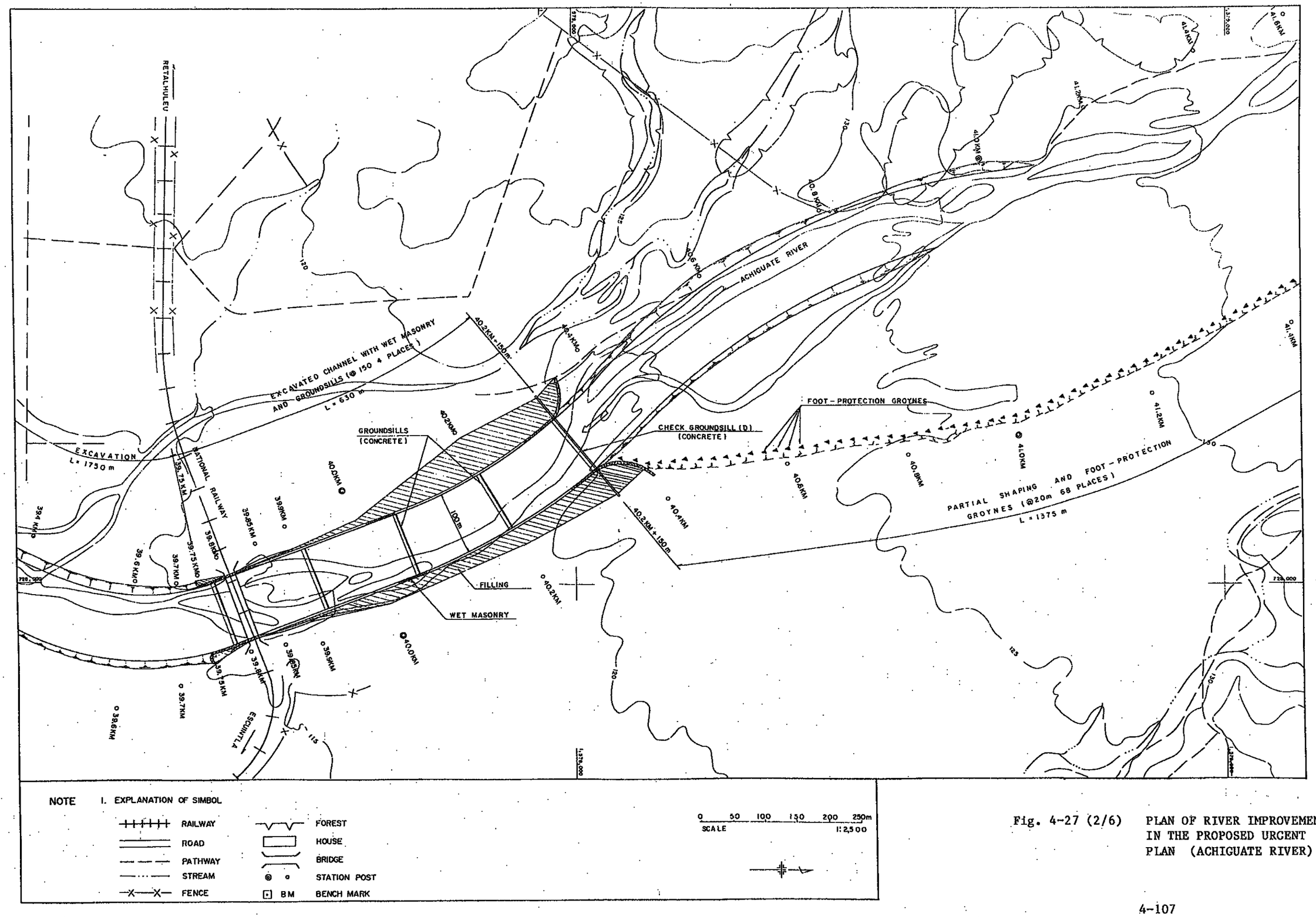


Fig. 4-27 (2/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (ACHIGUATE RIVER)

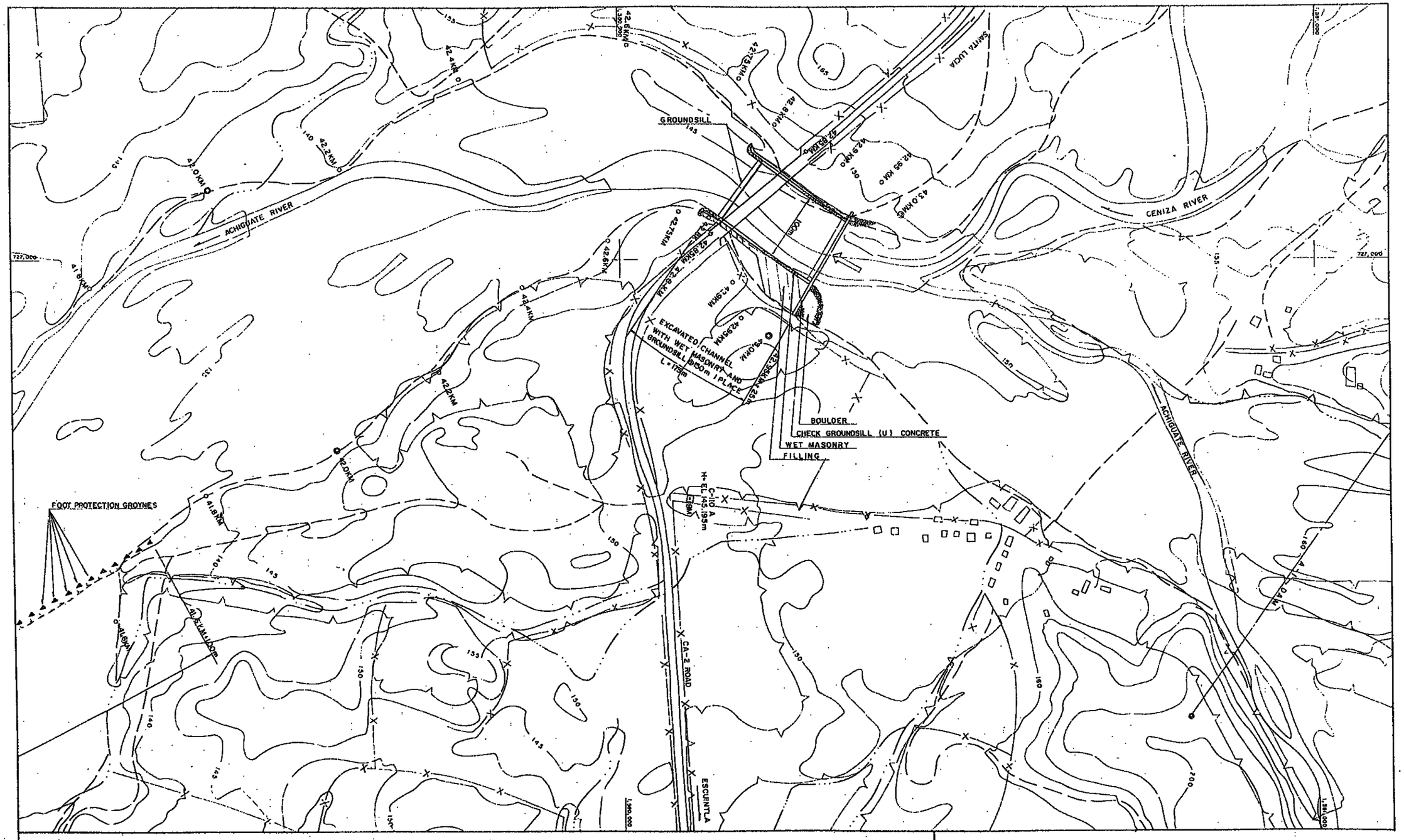


Fig. 4-27 (3/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (ACHIGUATE RIVER)

Fig. 4-27 (4/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (PANTALEON RIVER)

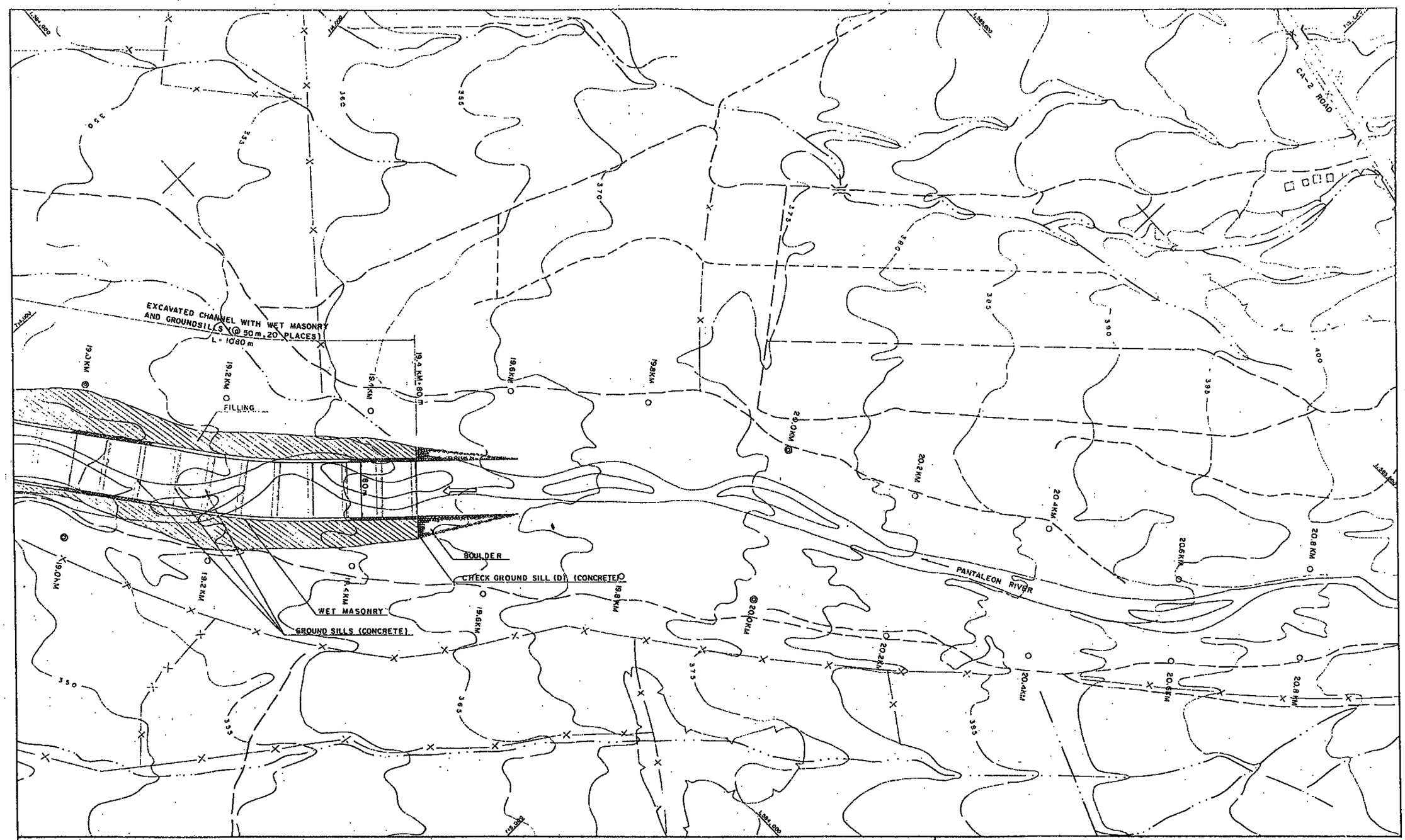


Fig. 4-27 (5/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (PANTALEON RIVER)

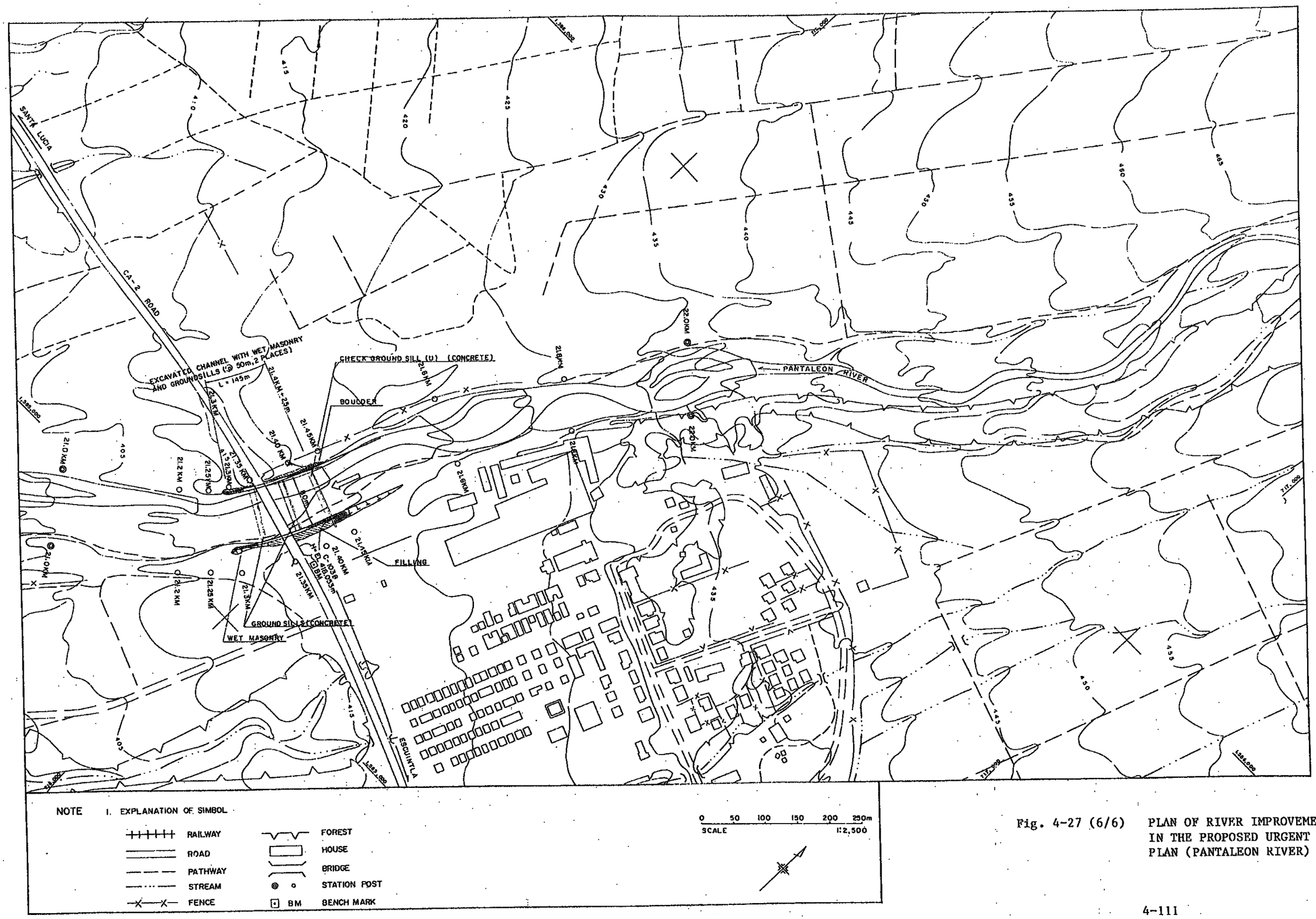
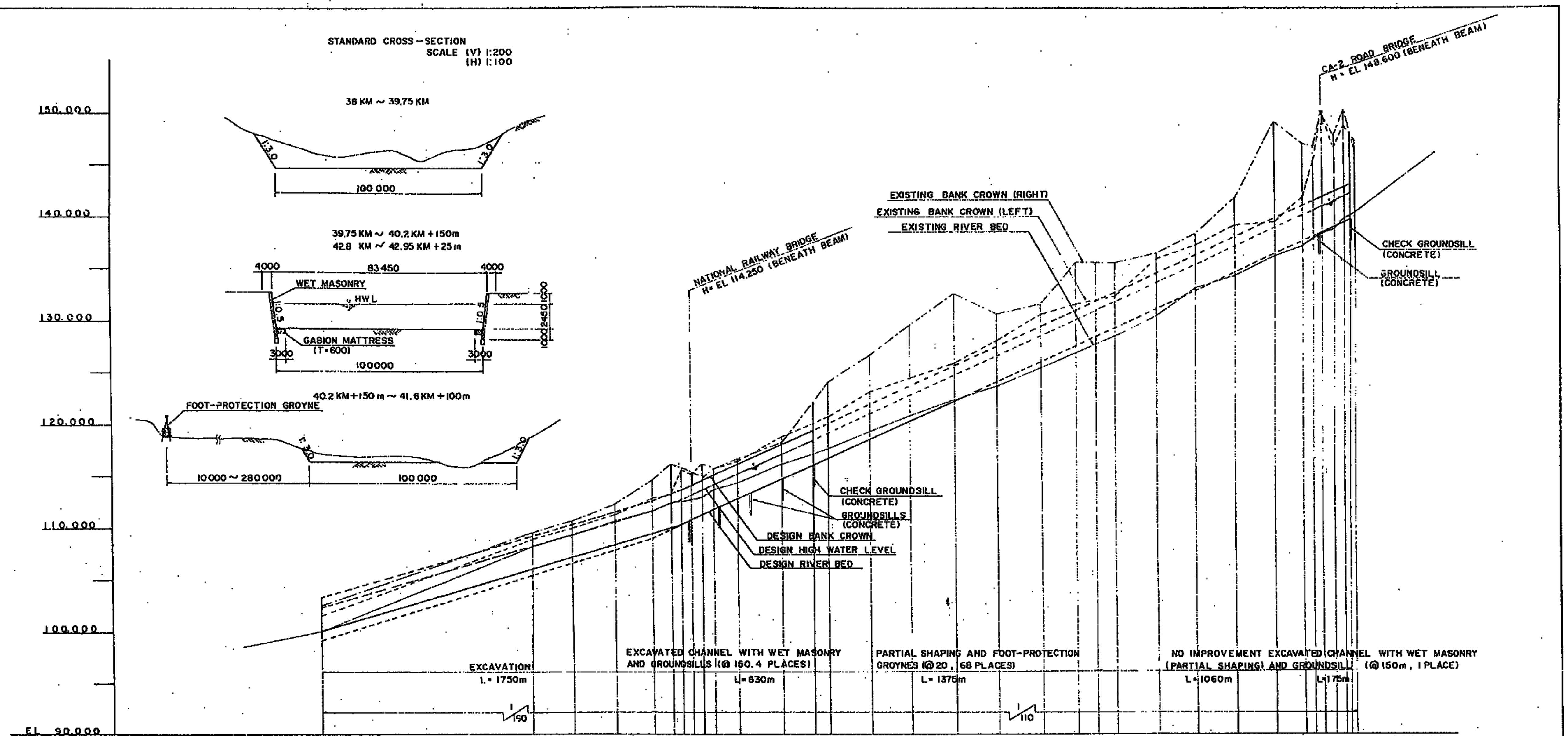


Fig. 4-27 (6/6) PLAN OF RIVER IMPROVEMENT IN THE PROPOSED URGENT PLAN (PANTALEON RIVER)



STATION No. (KM)	DISTANCE (m)	ACCUMULATIVE DISTANCE (m)	DESIGN ELEVATION EL (m): BANK CROWN	HIGH WATER LEVEL	RIVER BED
38.0	0	38000	(103.25)	(102.25)	100.00 (99.00)
39.0	1025	39025	(109.16)	(108.16)	106.03 (105.41)
39.2	195	39220	(110.38)	(109.38)	107.18 (106.63)
39.4	205	39425	(111.66)	(110.66)	108.39 (107.91)
39.6	180	39605	(112.75)	(111.75)	109.45 (109.00)
39.7	95	39700	(113.31)	(112.31)	110.01 (109.86)
39.75	50	39750	113.75	112.75	110.30
39.8	50	39800	114.20	113.20	110.75
39.85	55	39855	114.70	113.70	111.25
39.9	55	39910	115.20	114.20	111.75
40.0	110	40020	116.20	115.20	112.75
40.2	210	40230	118.11	117.11	114.66
	150	40380	119.57	118.57	116.03
40.4	75	40455	120.16	119.16	116.71
40.6	205	40660	(122.02)	(121.02)	118.57
40.8	195	40855	(123.80)	(122.80)	(120.35)
41.0	215	41070	(125.75)	(124.75)	122.30
41.2	200	41270	(127.57)	(126.57)	124.12
41.4	215	41485	(129.52)	(128.52)	(126.07)
41.6	170	41655	(131.07)	(130.07)	(127.62)
	100	41755			
41.8	95	41850	(132.84)	(131.84)	(129.39)
42.0	205	42055	(134.70)	(133.70)	(131.25)
42.2	185	42240	(136.39)	(135.39)	(132.94)
42.4	195	42435	(138.16)	(137.16)	(134.71)
42.6	195	42630	(139.93)	(138.93)	(136.48)
42.75	135	42765	(141.16)	(140.16)	(137.70)
42.8	50	42815	141.61	140.61	138.16
42.85	40	42855	141.98	140.98	138.53
42.9	60	42915	142.52	141.52	139.07
42.95	50	42965	142.98	141.98	139.53
	25	42990	143.20	142.20	139.75
43.0	25	43015			(139.98)

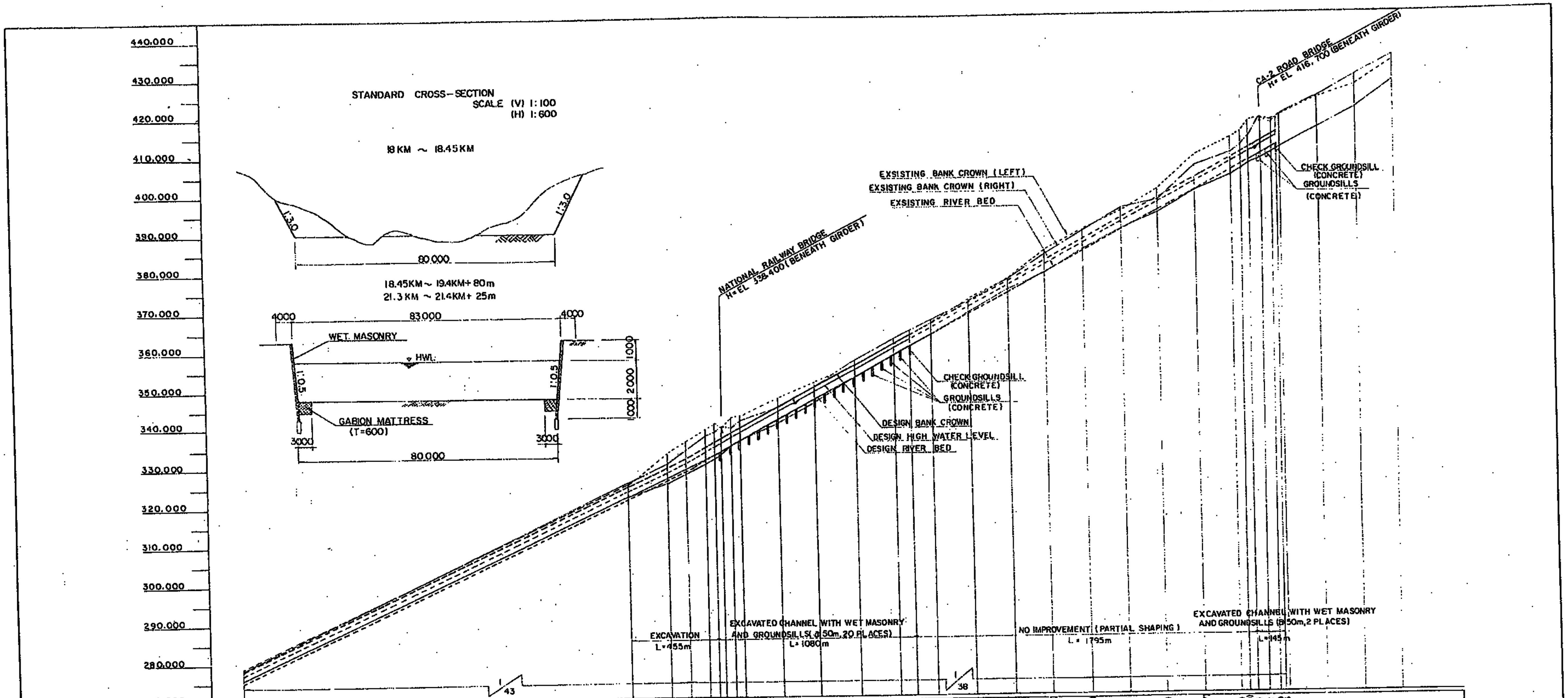
NOTE

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.

VERTICAL
0 5 10 15 20m
SCALE 1:200

HORIZONTAL
0 200 400 600 800 1000m
SCALE 1:10,000
0 20 40 60 80 100m
SCALE 1:100

Fig. 4-28 (1/2) DESIGN PROFILE OF RIVER CHANNEL IN THE PROPOSED URGENT PLAN (ACHIGUATE RIVER)



DESIGN ELEVATION EL (m)	BANK CROWN	(278.08)	(324.67)	(329.33)	(331.97)	(334.36)	336.00	336.92	338.37	339.68	344.95
	HIGH WATER LEVEL	(277.08)	(323.67)	(328.33)	(330.97)	(333.36)	335.00	335.92	337.37	338.68	343.95
	RIVER BED	(274.88)	322.00 (321.82)	326.65 (326.28)	328.92 (328.60)	331.68 (331.36)	333.00	333.92	335.37	336.68	341.95
ACCUMULATIVE DISTANCE (m)		16000	18010	18210	18310	18415	18465	18500	18555	18605	18805
DISTANCE (m)		0	2010	200	100	105	50	35	55	50	200
STATION No. (KM)		16.0	18.0	18.2		18.4	18.45	18.5	18.55	18.6	18.8

DESIGN ELEVATION EL (m)	BANK CROWN	350.08	355.47	361.00	363.11	(366.13)	(371.53)	(376.92)	(382.05)	(387.45)	(392.71)	(397.71)
	HIGH WATER LEVEL	349.08	354.47	360.00	362.11	(365.13)	(370.53)	(375.92)	(381.05)	(386.45)	(391.71)	(396.71)
	RIVER BED	347.08	352.47	358.00	360.11	(363.13)	(368.53)	(373.92)	(379.05)	(384.45)	(389.71)	(394.71)
ACCUMULATIVE DISTANCE (m)		19000	19205	19415	19495	19610	19815	20020	20215	20420	20620	20810
DISTANCE (m)		195	205	210	80	115	205	205	195	205	200	190
STATION No. (KM)		19.0	19.2	19.4		19.6	19.8	20.0	20.2	20.4	20.6	20.8

DESIGN ELEVATION EL (m)	BANK CROWN	(402.97)	(407.97)	(409.29)	410.34	411.92	413.30	414.16				
	HIGH WATER LEVEL	(401.97)	(406.97)	(408.29)	409.34	410.92	412.50	413.16				
	RIVER BED	(399.97)	(404.97)	(406.29)	407.34	408.92	410.50	411.16				
ACCUMULATIVE DISTANCE (m)		21010	21200	21250	21290	21350	21410	21435	21460	21655	21850	22045
DISTANCE (m)		200	190	50	40	60	60	25	25	195	195	195
STATION No. (KM)		21.0	21.2	21.25	21.3	21.35	21.4		21.45	21.6	21.8	22.0

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.

VERTICAL

0 10 20 30 40 50m SCALE 1:500

0 2 4 6 8 10m SCALE 1:100

HORIZONTAL

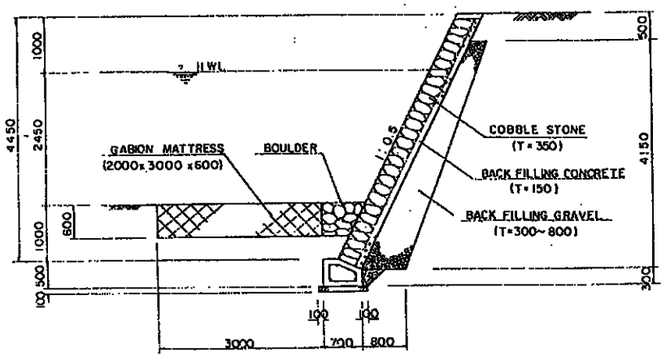
0 200 400 600 800 1000m SCALE 1:10,000

0 10 20 30 40 50 60m SCALE 1:600

Fig. 4-28 (2/2) DESIGN PROFILE OF RIVER CHANNEL IN THE PROPOSED URGENT PLAN (PANTALEON RIVER)

REVETMENT

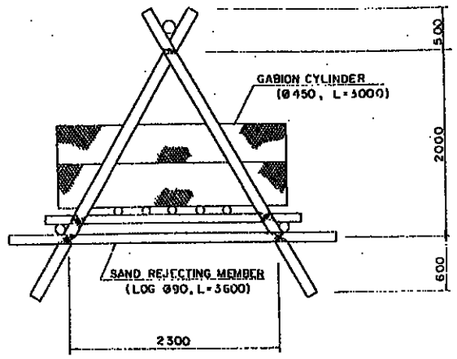
SCALE 1:50



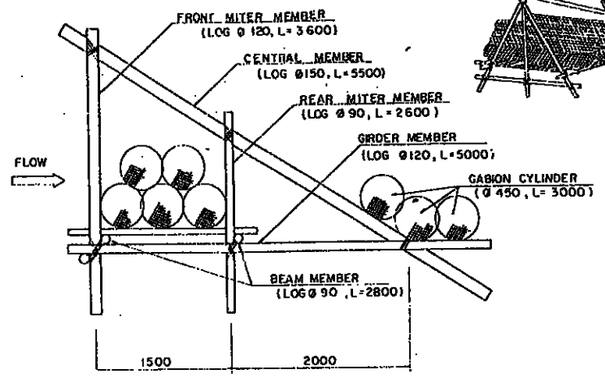
FOOT-PROTECTION GROYNE (CRIB)

SCALE 1:30

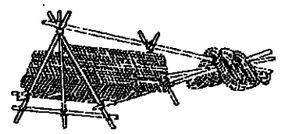
ELEVATION



SECTION



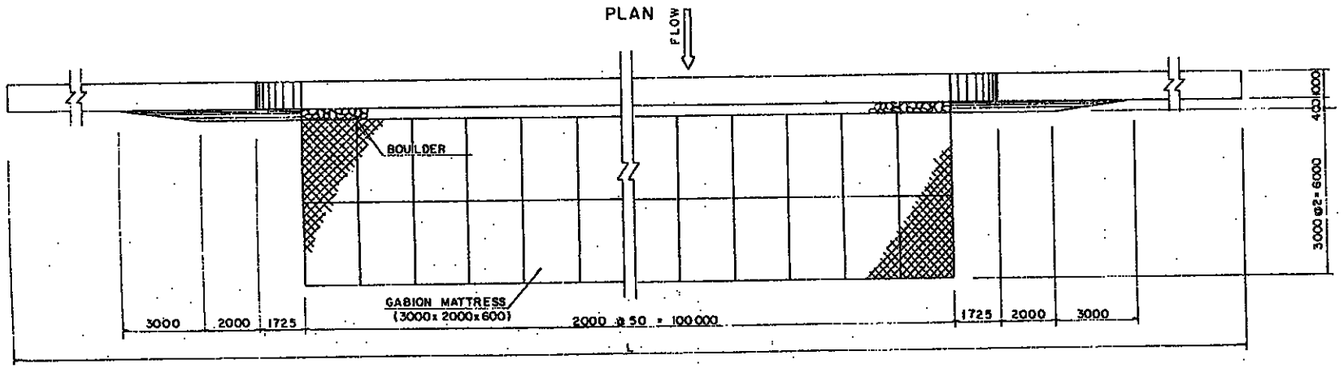
SKETCH



GROUNDSILL

SCALE 1:100

PLAN



ELEVATION

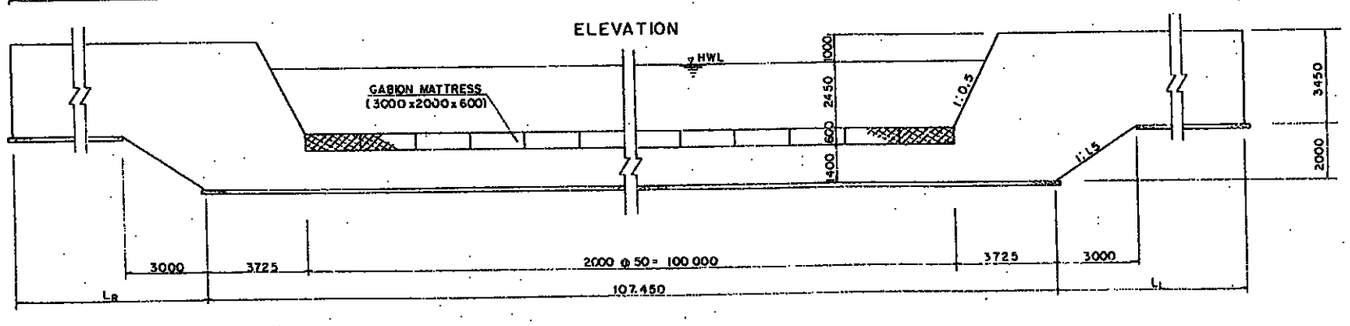
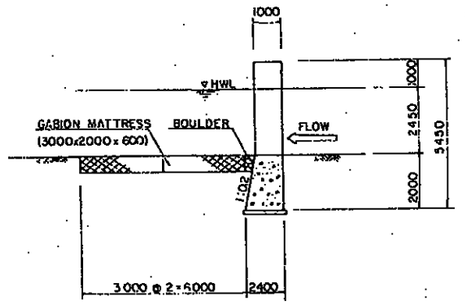


TABLE OF DIMENSIONS

STRUCTURE	L (m)	L_R (m)	L_L (m)	LOCATION
GROUNDSILLS	107.45	0	0	39.75 KM + 30m, 39.9 KM + 20m, 40.0 KM + 80m, 40.2 KM, 42.8 KM + 25m,
CHECK GROUNDSILL (U)	172.0	15.275	49.275	42.95 KM + 25m,
CHECK GROUNDSILL (D)	201.0	43.275	50.275	40.2 KM + 150m,

SECTION



NOTE

SCALE 0 1 2 3m 1:30

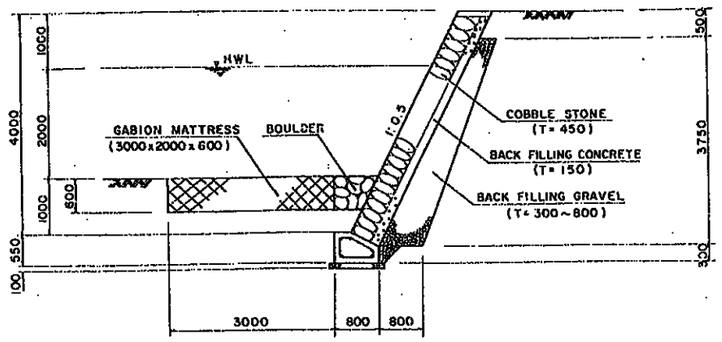
SCALE 0 1 2 3 4 5m 1:50

SCALE 0 2 4 6 8 10m 1:100

Fig. 4-29 (1/2) GENERAL STRUCTURE OF RIPARIAN STRUCTURES IN THE PROPOSED URGENT PLAN (ACHIGUATE RIVER)

REVETMENT

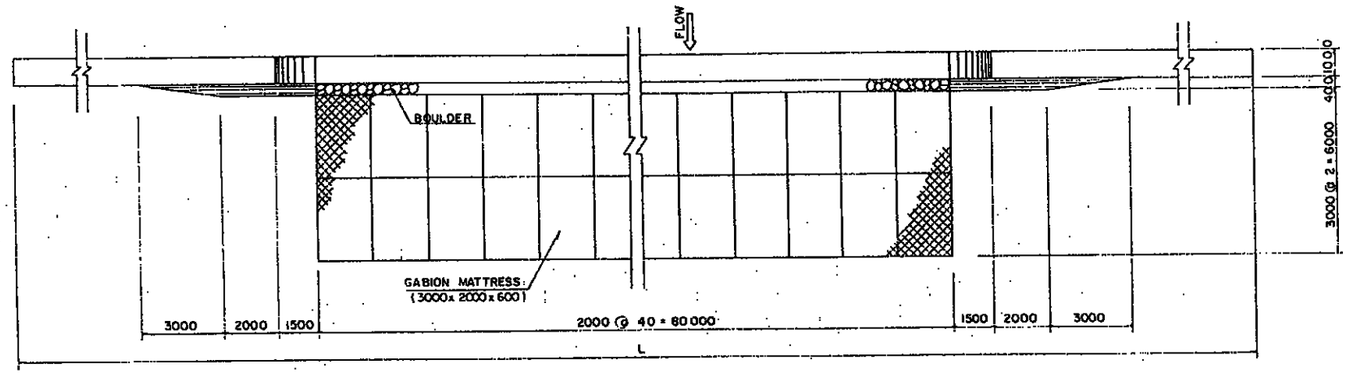
SCALE 1:50



GROUNDSILL

SCALE 1:100

PLAN



ELEVATION

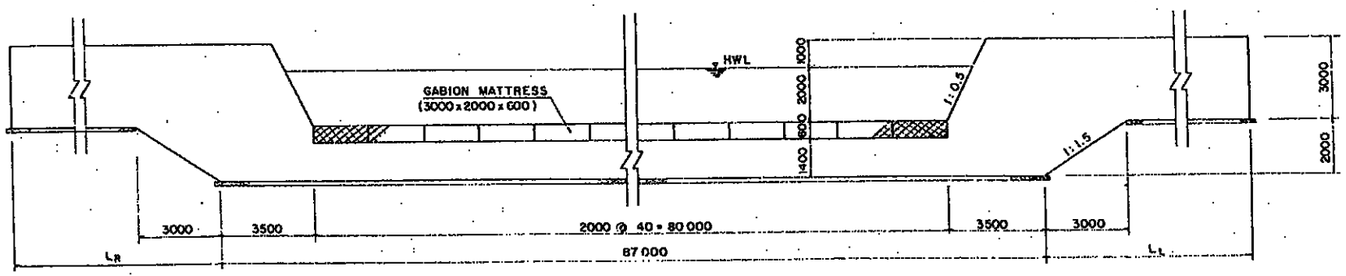
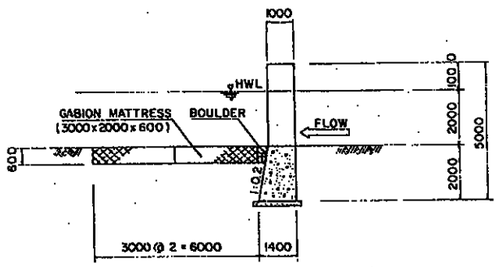


TABLE OF DIMENSIONS

STRUCTURE	L(m)	L_R(m)	L_L(m)	LOCATION
GROUNDSILLS	87.0	0	0	18.45KM+30m, +45m, 18.55KM+40m, 18.6KM+40m, +90m, +140m +190m, 18.8KM+40m, +90m, +140m, 190m, 19.0KM+45m, +95m
CHECKGROUNDSILL (U)	104.0	3.5	13.5	21.4KM+25m +145m, +195m, 19.2KM+40m, +90m, +140m, +190m
CHECKGROUNDSILL (D)	132.0	28.5	16.5	19.4KM+80m 19.4KM+30m, 21.3KM+45m, 21.35KM+35m,

SECTION



NOTE

SCALE 1:50 — 0 1 2 3 4 5m

SCALE 1:100 — 0 2 4 6 8 10m

Fig. 4-29 (2/2) GENERAL STRUCTURE OF RIPARIAN STRUCTURES IN THE PROPOSED URGENT PLAN (PANTALEON RIVER)

REVETMENT

SCALE 1:50

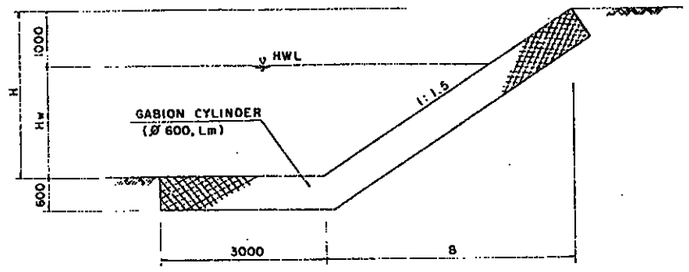


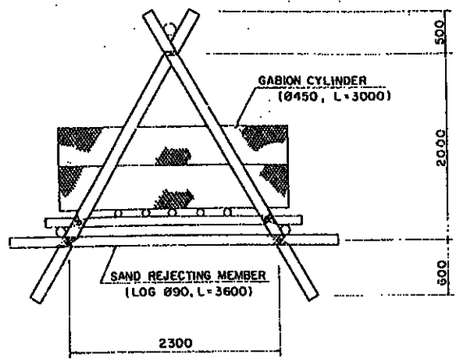
TABLE OF DIMENSIONS

RIVER	Hw(m)	H(m)	B(m)	L(m)
ACHIGUATE RIVER	2.1	3.1	4.65	8.0
PANTALEON RIVER	1.7	2.7	4.05	7.0

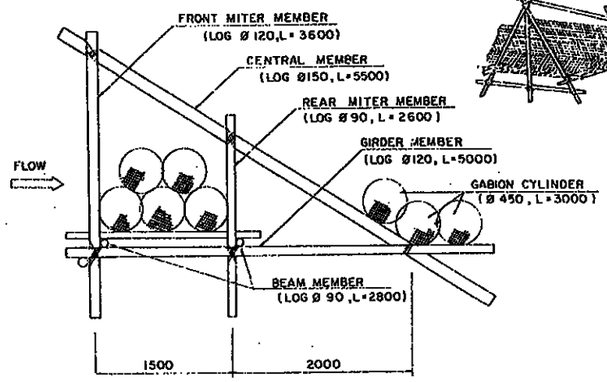
FOOT-PROTECTION GROYNE (CRIB)

SCALE 1:30

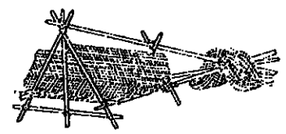
ELEVATION



SECTION



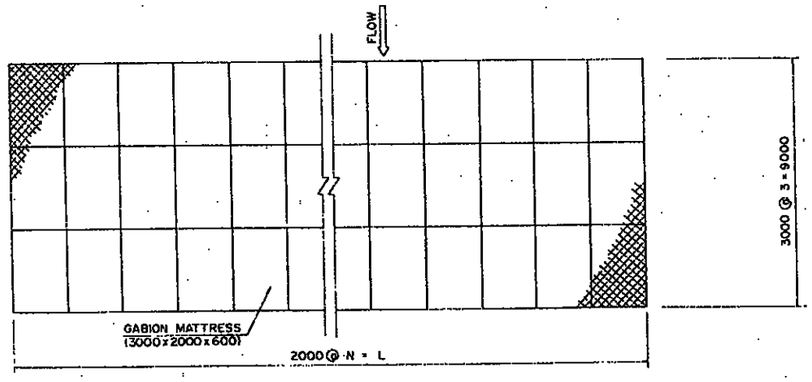
SKETCH



GROUNDSILL

SCALE 1:100

PLAN



ELEVATION

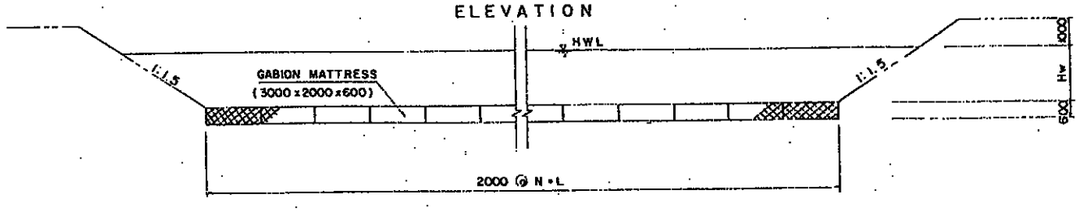
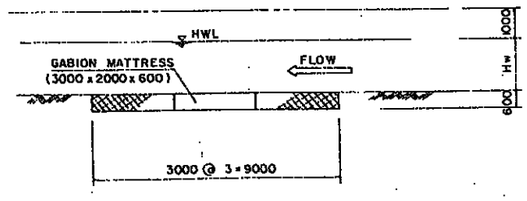


TABLE OF DIMENSIONS

RIVER	N	L(m)	Hw(m)	LOCATION
ACHIGUATE RIVER	50	100.0	2.1	18.45KM+30m, +45m, 18.55KM+40m, 18.6KM+40m, +90m, +140m, +190m, 18.8KM+40m, +90m, +140m, +190m, 19.0KM+45m, +95m, +145m, +195m, 19.2KM+40m, +90m, +140m, +190m,
PANTALEON RIVER	40	80.0	1.7	39.75KM+30m, 39.9KM+20m, 40.0KM+60m, 40.2KM 40.2KM+30m, 42.8KM+25m, 43.95KM+25m / 19.4KM+30m, +80m, 21.3KM+45m, 21.35KM+35m, 21.4KM+25m

SECTION



NOTE

0 1 2 3
SCALE 1:30

0 1 2 3 4 5
SCALE 1:50

0 2 4 6 8 10
SCALE 1:100

Fig. 4-30 GENERAL STRUCTURE OF RIPARIAN STRUCTURE IN THE ALTERNATIVE URGENT PLAN

5. CONSTRUCTION PLAN AND COST ESTIMATES

CONSTRUCTION PLAN AND COST ESTIMATES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. GENERAL

This sector of the supporting report presents the results of the construction plan and cost estimates of the three sediment and flood control plans; namely, the Proposed Long-Term Plan, the Proposed Urgent Plan and the Alternative Urgent Plan, which were selected as suitable and realizable under Sector 3, Sediment Control Plan, and Sector 4, River Improvement Plan.

2. BASIC CONDITIONS

2.1 Conditions for Construction Plan

Workable Day and Working Hour

It is advisable to execute construction works for the sediment control dams and river improvement during the dry season, or from the middle of October to the middle of May, judging from the data on monthly rainy days in Table 5-1. This is because the data indicate that rainfalls of over 10 mm/day will occur in more than half of the number of days in a rainy season; therefore, it will be difficult and risky to carry out the construction works during this period.

Workable days in a year are estimated at 165 days by excluding Sundays, national holidays and rainy days from the total number of days in the dry season.

Daily working hours have been set at eight (8) hours according to the actual circumstances in this country.

Availability of Materials and Machinery

Among the construction materials required for each plan, concrete aggregates, gravel, cobblestones, boulders, and embankment materials can be obtained from riverbeds and borrow pits in the vicinity of the construction sites. It is also easy to procure cement, wood and grass, because they are produced in this country. However, reinforcement bars, wire for gabions and other materials, and construction machinery will have to be imported.

Availability of Electricity, Water and Fuel

There exist no electric and water supply systems that can supply electricity and water in sufficient quantity for the construction works. Electricity, therefore, will be produced in the construction sites by generators, and river water near the sites will be used as construction water.

Fuel or oil is available from the vicinity of the construction sites, though it is imported.

2.2 Conditions for Cost Estimates

Project Implementation Method

Construction costs will be estimated not on the force account basis, but on the contract basis. A one-package contract system is assumed to be applied to the construction works.

Currency and Exchange Rate

Construction cost will be estimated by dividing it into a foreign currency portion and a local currency portion. The foreign currency portion is represented by the United States Dollar (US$), while the local currency portion by the Quetzal (Q).

Costs for foreign engineers, machinery, and imported construction materials mentioned in Subsection 2.1 are counted in the foreign currency portion, and those for local engineers, labor, domestic products, land acquisition, administration are basically in the local currency portion.

Exchange rate between US$ and Q is US$1.00 to Q1.00.

Price Level and Price Escalation Rate

Cost estimates will be made at the price level as of August 1984. Annual price excalation rate is assumed at 6% for both the foreign and local currency portions.

3. BASIC STUDY

3.1 Construction Methods for Main Works

3.1.1 Sediment Control Dams

Excavation

(1) Working Procedure and Required Machinery

Excavation for the foundations of the main dam, subdam and apron is planned to be carried out in accordance with the following procedure and by using the corresponding machinery:

(a) Coffering and dewatering
(b) Excavation by bulldozer with ripper (21T)
(c) Loading by dozer shovel (1.2m^3)
(d) Hauling to spoil bank by dump truck (8T)

(2) Capacities of Machinery

Capacities of the main machinery used for excavation were calculated as follows:

(a) Bulldozer (21T) with Ripper for ripping and Excavation

$$Q = \frac{Q1 \times Q2}{Q1 + Q2} = 62 \text{ m}^3/\text{hr}$$

$$Q1 = \frac{60 \times A \times L1 \times F1 \times E1}{Cm1} = 183 \text{ m}^3/\text{hr}$$

$$Q2 = \frac{60 \times q \times F2 \times E2}{Cm2} = 93 \text{ m}^3/\text{hr}$$

where,

Q : Hourly total capacity (m^3/hr)
Q1 : Hourly ripping capacity (m^3/hr)
A : Area of ripper (0.4 m^2)
L1 : Hauling distance (20 m)
F1 : Swell factor of soil (1.0)
E1 : Work efficiency (0.4)
Cm1: Cycle time (0.04 L1 + 0.25 = 1.05 min)
Q2 : Hourly excavation capacity (m^3/hr)
q : Blade volume (2.8 m^3)
F2 : Swell factor of soil (1.0)
E2 : Work efficiency (0.55)
Cm2: Cycle time (0.037 L2 + 0.25 = 0.99 min)
L2 : Hauling distance (20 m)

(b) Dozer Shovel (1.2 m^3) for Loading

$$Q = \frac{3600 \times q \times F \times E}{Cm} = 40 \text{ m}^3/\text{hr}$$

where,

Q : Hourly loading capacity (m^3/hr)
q : Loading volume (1.2 m^3)
F : Swell factor of soil (0.8)
E : Work efficiency (0.5)
Cm : Cycle time (43 sec)

(c) Dump Truck (8T) for Hauling

$$Q = \frac{60 \times q \times F \times E}{Cm} = 28 \text{ m}^3/\text{hr}$$

where,

Q : Hourly hauling capacity (m^3/hr)
q : Loading volume (4.4 m^3)

F : Swell factor of soil (0.8)
E : Work efficiency (0.9)
Cm : Cycle time $\left(\frac{0.5 \text{ km} \times 2}{20 \text{ km/60}} + 1.2 \times 2 + 1.5 = 6.9 \text{ min}\right)$

Embankment and Backfilling

(1) Working Procedure and Required Machinery

The following procedure and machinery will be applied to the embankment behind the side walls and backfilling in the excavated portions around the main dams and subdams after completion of their construction:

(a) Loading of soil at spoil bank by dozer shovel (1.2 m^3)
(b) Transportation of soil by dump truck (8T)
(c) Compaction of soil at construction site by bulldozer (21T)

(2) Capacities of Machinery

The capacity of the bulldozer (21T) for the compaction of soil was calculated in the following equation. The other machinery have the same capacities as those given above.

$$Q = \frac{V \times W \times D \times E}{N} = 43 \text{ m}^3/\text{hr}$$

where,

Q : Hourly campaction capacity (m^3/hr)
V : Work speed (1,600 m/hr)
W : Effective compaction width (0.9 m)
D : Thickness of compacted layer (0.3 m)
E : Work efficiency (0.5)
N : Number of compaction times (5)

Cobblestone Concreting Works

(1) Working Procedure and Required Machinery

The main dams, subdams and aprons are planned to be built of cobblestone concrete. The cobblestone concreting works will be executed according to the following procedure and by using the corresponding machinery:

(a) Gathering of boulders by bulldozer (21T)
(b) Formworks
(c) Placing of boulders by truck-mounted crane (16T) and manual labor

(d) Mixing of concrete by portable bacher (0.5 m^3), etc.
(e) Carrying of concrete by truck-mounted mixer (1.6 m^3)
(f) Placing of concrete by truck-mounted crane (16T), etc.
(g) Curing of concrete
(h) Removal of forms

(2) Capacities of Machinery

The capacities of the main machinery necessary for the cobblestone concrete works were given as below:

(a) Bulldozer (21T) for Excavation

$$Q = \frac{60 \times q \times F \times E}{Cm} = 19 \text{ real } m^3/hr$$

where,

$q = 2.8\ m^3$
$F = 0.6$
$E = 0.4$
$Cm = 0.037 \times 50 + 0.25 = 2.1$ min

(b) Truck-Mounted Crane (16T) for Boulder Placing

$$Q = \frac{60 \times q \times F \times E}{Cm} = 11 \text{ real } m^3/hr$$

where,

Q : Hourly hanging capacity (real m^3/hr)
q : Bucket volume (0.6 m^3)
F : Swell factor of soil (0.6)
E : Work efficiency (0.8)
Cm: Cycle time (1.5 min)

(c) Portable Bacher (0.5 m^3) for Concrete Mixing

$$Q = \frac{60 \times q \times E}{Cm} = 9.0\ m^3/hr$$

where,

Q : Hourly mixing capacity (m^3/hr)
q : Mixer volume (0.5 m^3)
E : Work efficiency (0.9)
Cm: Cycle time (3 min)

(d) Truck-Mounted Mixer (1.6 m^3) for Concrete Carrying

$$Q = \frac{60 \times q \times E}{Cm} = 7.7 \ m^3/hr$$

where,

Q : Hourly carrying capacity (m^3/hr)
q : Mixer volume (1.6 m^3)
E : Work efficiency (0.8)
Cm: Cycle time (0.005 L + 8.5 = 10 min)
L : Carrying distance (300 m)

(e) Truck-Mounted Crane (16T) for Concrete Placing

$$Q = \frac{60 \times q \times E}{Cm} = 8.2 \ m^3/hr$$

where,

q = 0.6 m^3
E = 0.8
Cm = 3.5 min

3.1.2 River Improvement

Excavation of River Channel

(1) Working Procedure and Required Machinery

Excavation of river channel will be carried out by the procedure and machinery mentioned below:

(a) Coffering and dewatering
(b) Excavation by bulldozer (21T)
(c) Loading by wheel loader (2.3 m^3)
(d) Hauling by dump truck (8T)

(2) Capacities of Machinery

The capacities of the bulldozer and the wheel loader were calculated by the following equation. As for the dump truck, the capacity is shown above.

(a) Bulldozer (21T) for Excavation

$$Q = \frac{60 \times q \times F \times E}{Cm} = 63 \ m^3/hr$$

where,

$q = 2.8\ m^3$
$F = 0.8$
$E = 0.55$
$Cm = 0.037 \times 25 + 0.25 = 1.18$ min

(b) Wheel Loader (2.3 m^3) for Loading

$$Q = \frac{3600 \times q \times F \times E}{Cm} = 100\ m^3/hr$$

where,

$q = 2.3\ m^3$
$F = 0.8$
$E = 0.65$
$Cm = 43$ sec

Excavation and Backfilling of Trench

(1) Working Procedure and Required Machinery

The foundations of the revetments and groundsills will be excavated by buckhoes, separate from the excavation of the river channel. The working procedure and required machinery are shown below:

(a) Excavation and loading or temporary placement of soil by buckhoe (1.2 m^3)
(b) Hauling of spoiled soil by dump truck (8T)
(c) Backfilling by bulldozer (11T)

(2) Capacities of Machinery

The capacities of the machinery were calculated as follows, except the capacity of the dump truck which is shown above.

(a) Buckhoe (1.2 m^3) for Trench Excavation

$$Q = \frac{3600 \times q \times F \times E}{Cm} = 43\ m^3/hr$$

where,

Q : Hourly capacity for excavation and loading or temporary placement of soil (m^3/hr)
q : Bucket volume (1.2 m^3)

F : Swell factor of soil (0.8)
E : Work efficiency (0.5)
Cm: Cycle time (40 sec)

(b) Bulldozer (11T) for Compaction

$$Q = \frac{V \times W \times D \times E}{N} = 86 \text{ m}^3/\text{hr}$$

where,

V = 4000 m/hr
W = 0.6 m
D = 0.3 m
E = 0.6
N = 5

Embankment

(1) Working Procedure and Required Machinery

In the proposed long-term plan, the embankment of levees is planned along the whole lower stretch of Achiguate River. The working procedure and required machinery are shown below:

(a) Excavation of embankment materials by bulldozer (21T) at borrow pit
(b) Loading by wheel loader (2.3 m^3)
(c) Hauling of embankment materials by dump truck (8T)
(d) Spreading and compaction by bulldozer (11T), etc., at construction site
(e) Sodding on levee slope
(f) Excavation of drainage ditch by buckhoe (1.2 m^3) along the landside of levee
(g) Construction of dry masonry along the levee-side slope in the drainage ditch

(2) Capacities of Machinery

The capacities of the machinery required for embankment works were calculated by the equation below, except the wheel loader and buckhoe whose capacities are mentioned above.

(a) Bulldozer (21T) for Excavation

$$Q = \frac{60 \times q \times F \times E}{Cm} = 43 \text{ m}^3/\text{hr}$$

where,

q = 2.8 m^3
F = 0.8

$E = 0.55$

$Cm = 0.037 \times 40 + 0.25 = 1.73$ min

(b) Dump Truck (8T) for Hauling

$$Q = \frac{60 \times q \times F \times E}{Cm} = 4.3 \text{ m}^3/\text{hr}$$

where,

$q = 4.4 \text{ m}^3$

$F = 0.8$

$E = 0.9$

$$Cm = \frac{10 \text{ km} \times 2}{30 \text{ km}/60} + 1.2 \times 2 + 1.5 = 43.9 \text{ min}$$

(c) Bulldozer (11T) for Spreading and Compaction

$$Q = \frac{Q1 \times Q2}{Q1 + Q2} = 36 \text{ m}^3/\text{hr}$$

$$Q1 = 10 \, E1 \, (11D + 8) = 85 \text{ m}^3/\text{hr}$$

$$Q2 = \frac{V \times W \times D \times E2}{N} = 63 \text{ m}^3/\text{hr}$$

where,

Q : Hourly total capacity (m^3/hr)
Q1: Hourly spreading capacity (m^3/hr)
E1: Work efficiency (0.75)
D : Thickness of compacted layer (0.3 m)
Q2: Hourly compaction capacity (m^3/hr)
V : Work speed (2500 m/hr)
W : Effective compaction width (0.6 m)
E2: Work efficiency (0.7)
N : Number of compaction times (5)

Revetment Works of Wet Masonry

Revetment works consisting mainly of wet masonry will be carried out in accordance with the following procedure and by manual labor without any heavy machinery:

(1) Construction of base concrete including formworks, arrangement of reinforcement bars and concreting;

(2) Wet masonry works including spreading of gravel, laying of cobblestones and concreting; and

(3) Gabion mattress works, including spreading of wire mattress, filling of boulders and sewing of wire mattress.

Groyne Works of Cribs

Groyne works of cribs comprise assembling of logs and installation of gabion cylinders. No heavy machinery is required.

Groundsill Works

Groundsill works of concrete will be carried out according to the following procedure:

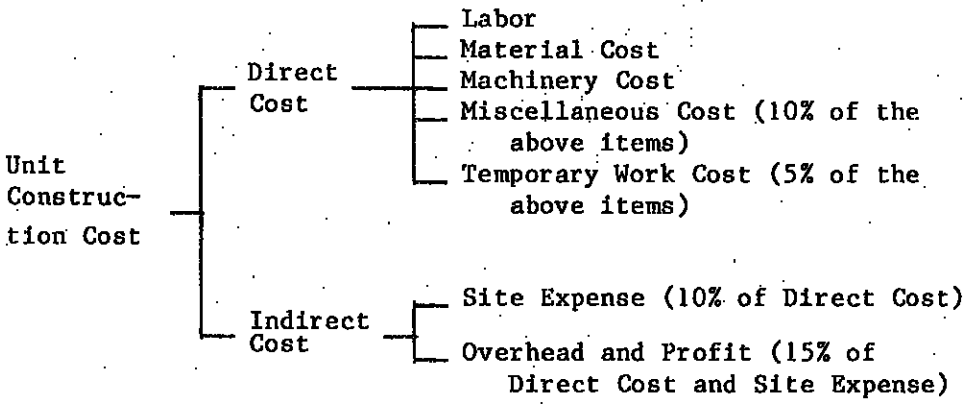
(1) Construction of main body including formworks and concreting; and

(2) Placement of gabion mattress at the downstream riverbed of main body.

The machinery used for concreting are mentioned in 3.1.1, together with their capacities.

3.2 Unit Construction Costs

Unit construction cost is composed of cost items that are schematically shown below:



The quantity of labor, materials and machinery necessary for all work items have been determined on the results of the preliminary design and on the construction methods mentioned in Subsection 3.1.

The unit cost of labor, materials and machinery in Guatemala have been basically applied to this study/1. The unit construction costs calculated on the above conditions have been

/1 Refer to "ENCVESTA BASICA DE MANUFACTURERA DE CONSTRUCTION MANO DE OBRA Y SALALIOS" published by Directrato General de Estadistica etc.

confirmed to be consistent with those used for public works in this country/1.

The unit construction costs are tabulated in Table 5-2.

4. STUDY ON EACH PLAN

4.1 Proposed Long-Term Plan

4.1.1 Construction Plan

Construction works for the sediment control dams consist of excavation, cobblestone concreting works, and so on. The river improvement works include excavations, embankment and installation of structures such as revetments, groundsills, and so on.

Basically, it is more effective to execute the works basin by basin and to start on the construction of the sediment control dams first.

The proposed period of construction works is seven (7) years, including the detailed design engineering services of two (2) years, as follows:

Work Stage	Year
(1) Detailed Design	1st to 2nd
(2) Construction Works	
(a) Sediment Control Dam construction in Achiguate	3rd to 6th
(b) Sediment Control Dam construction in Pantaleon	3rd to 7th
(c) River Improvement Works in Achiguate	4th to 7th
(d) River Improvement Works in Pantaleon	6th to 7th

The construction schedule covering all the stages of the proposed long-term plan is shown in Fig. 5-1.

4.1.2 Construction and OMR Costs

Construction Cost

The total base construction cost is estimated at US$49.7 million, consisting of US$28.6 million in foreign currency and Q.21.1 million in local currency. The breakdown of the construction cost is shown in Table 5-3.

/1 Refer to "MEMORIA 1982" published by CAMINOS.

In addition to the cost mentioned above, taking price contingency based on the annual escalation rate of 6% for both foreign and local currency portions into consideration, the total financial cost is estimated at US$63.2 million, consisting of US$36.2 million or 57% in foreign currency and Q.27.0 million or 43% in local currency. The annual disbursement of the construction cost is presented in Table 5-4.

Operation, Maintenance and Replacement Cost (OMR Cost)

Scope of works for operation, maintenance and replacement is composed of periodical patrolling, emergent observation, periodical maintenance and restoration works after floods, and replacement. The operation, maintenance and replacement cost (OMR Cost) comprise costs for personnel, machinery, fuel, materials for repairing, replacement of the drainage facility and miscellaneous items. Most of the machinery are required for the removal of sand deposited in the river channels by floods.

The annual OMR Cost is estimated at US$560 thousand on the basis of the financial cost (refer to Table 5-5).

4.2 Proposed Urgent Plan

4.2.1 Construction Plan

The construction works required for the proposed urgent plan are broadly divided into two categories; construction works of three (3) sediment control dams and improvement works on the Achiguate and the Pantaleon rivers. The river improvement works cover approximately 5.0 km and 3.5 km, respectively.

The major work items for the construction of the sediment control dams are excavation, embankment and backfilling, cobblestone concreting works, wet masonry works for the side walls, and saddle dam works at C-1 dam site. Those for river improvement are excavation of river channel, excavation and backfilling of trench, wet masonry works for revetments, foot protection groyne works of cribs and groundsill works of concrete.

The construction works will require a period of two (2) years and seven (7) months, or three (3) dry seasons, considering priority of the dam construction to avoid redeposition of sand in the improved or excavated river channels, the work volume of each work item and the site conditions. Besides, a detailed design period of one (1) year and pre-construction period of ten (10) months will be proposed prior to the construction period. Fig. 5-2 shows the construction schedule, which is briefly explained as follows:

Work Stage		Year
(1)	Detailed Design	1st (1986)
(2)	Construction Works	
	(a) Construction of A-1 Dam	2nd to 4th (1987-1990)
	(b) Construction of C-1 Dam	2nd to 4th (1987-1989)
	(c) Construction of P-2 Dam	2nd to 5th (1987-1990)
	(d) River Improvement Works in Achiguate	3rd to 5th (1988-1990)
	(e) River Improvement Works in Pantaleon	3rd to 5th (1988-1990)

The main construction machinery and their quantities given by the work volumes and construction methods (refer to Subsection 3.1) are presented in Table 5-6.

4.2.2 Construction and OMR Costs

Construction Cost

The total financial construction cost is estimated in the foreign and local currency portions on the contract basis. The price level is as of August of 1984. The quantity of works is estimated on the basis of the preliminary design which has been prepared during this study period. Unit costs required for the project implementation are in line with the recent bid prices for similar works in Guatemala. Physical contingencies of 10% have been applied to all the works. Price contingencies are also taken into account at an annual escalation rate of 6% for both the foreign and local currency portions.

The estimated financial construction cost for the proposed urgent plan is summarized hereunder, together with the percentages between the foreign and local currency portions:

Foreign Currency	US$11.5 million	(56%)
Local Currency	Q.9.0 million[1/]	(44%)
Total	US$20.5 million	

The breakdown of the construction cost is shown in Table 5-7 and its annual disbursement schedule is presented in Table 5-8.

Operation, Maintenance and Replacement Cost (OMR Cost)

The annual OMR Cost required for the proposed urgent plan is estimated at US$300 thousand on the basis of financial cost, covering personnel, machinery, fuel, materials for repairing, replacement of gabion mattresses and groynes, and miscellaneous items. The breakdown of this cost is shown in Table 5-9.

1/ : US$1.0 = Q.1.0

One bulldozer, one wheel loader, and three dump trucks will be necessary to remove the sand deposited on the existing riverbed along the immediate downstream stretches of the improved river channels in the Achiguate and the Pantaleon rivers. The number of machinery has been determined on the assumption that the deposited sand volumes after completion of this plan are about 50,000 m^3/year and 20,000 m^3/year in the Achiguate and the Pantaleon rivers, respectively. This assumption was derived from the sediment capacity balance between the improved channels and the existing channels.

4.3 Alternative Urgent Plan

4.3.1 Construction Plan

The alternative urgent plan requires construction works of nine (9) sediment control dams of gabion mattresses and improvement works in the Achiguate and the Pantaleon rivers. The improvement stretches are approximately 5.0 km and 3.5 km, respectively, same as the proposed urgent plan.

Major work items for the dam construction are excavation, backfilling, gabion mattress works, boulder works for main dams and aprons, and saddle dam works at C-1 dam site. Those for the river improvement are excavation of river channel, gabion cylinder works for revetments, foot protection groyne works of cribs and gabion mattress works for groundsills.

The construction works will be executed in a period of four (4) years and five (5) months, including the detailed design stage of one (1) year and pre-construction stage of ten (10) months. The construction schedule is shown in Fig. 5-3, which is summarized hereunder:

Work Stage	Year
(1) Detailed Design	1st (1986)
(2) Construction Works	
(a) Construction of Dams in Achiguate	2nd to 3rd (1987-1988)
(b) Construction of Dams in Pantaleon	4th to 5th (1989-1990)
(c) River Improvement Works in Achiguate	3rd to 5th (1988-1990)
(d) River Improvement Works in Pantaleon	4th to 5th (1989-1990)

Table 5-10 shows the main construction machinery and the quantity required for these construction works.

4.3.2 Construction and OMR Costs

Construction Cost

The financial construction cost required for the alternative urgent plan has been estimated, as shown on the following table, on the same premises as mentioned in 4.2.2.

Foreign Currency	US$10.7 million	(49%)
Local Currency	Q.11.1 million[1/]	(51%)
Total	US$21.8 million	

The breakdown of the financial construction cost is shown in Table 5-11 and its annual disbursement schedule is presented in Table 5-12.

Operation, Maintenance and Replacement Cost (OMR Cost)

The annual OMR Cost necessary after completion of the alternative urgent plan is estimated at US$640 thousand on the financial cost basis. The breakdown of the annual OMR Cost is presented in Table 5-13.

This cost includes machinery cost required for the same purpose as mentioned in 4.2.2, and also includes replacement cost for the gabion mattresses and boulders for the dams and gabion cylinders, cribs and gabion mattresses for the rivers.

1/ : US$1.0 = Q.1.0

TABLES AND FIGURES

Table 5-1 MONTHLY RAINY DAYS / 1

Item	Daily Rainfall (mm)	Month											
		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	1-10	1	2	3	4	6	5	5	4	5	7	5	2
	10-20	0	0	1	2	3	4	6	8	6	4	2	1
Rainy	20-30	0	0	1	2	3	4	3	4	4	3	1	1
	30-40	0	0	0	1	2	3	2	3	3	3	1	0
Days	40-50	0	0	0	0	2	2	1	1	2	2	0	0
	over 50	0	0	0	1	3	5	4	3	6	3	2	0
	Total	1	2	5	10	19	23	21	23	26	22	11	4
Rate of Rainy Days	over 10	0.00	0.00	0.06	0.20	0.42	0.60	0.52	0.61	0.70	0.48	0.20	0.06
	Total	0.03	0.07	0.16	0.33	0.61	0.77	0.68	0.74	0.87	0.71	0.37	0.13

/ 1. This data was collected at Los Tarros near Santa Lucia in a period of 1974 to 1983.

Table 5-2 UNIT CONSTRUCTION COST

Work Item	Unit	Unit Construction Cost		
		F.C. (US$)	L.C. (Q.)	Total (US$)
1. Sediment Control Dam				
Excavation	m^3	2.7	1.7	4.4
Embankment and Back-filling	m^3	3.1	3.7	6.8
Concrete Works	m^3	43	35	78
Boulder Works for Main and Sub Dam	m^3	8.3	5.3	13.6
Boulder Works for Apron	m^3	6.9	4.4	11.3
Form Works	m^2	0	19	19
Wet Masonry Works for Side Walls	m^2	15	32	47
Saddle Dam Works	m	1,000	610	1,610
2. River Improvement				
Excavation of River Channel	m^3	2.3	1.4	3.7
Excavation and Back-filling of Trench	m^3	2.4	1.5	3.9
Embankment of Levee	m^3	9.3	5.9	15.2
Sodding	m^2	0	1.7	1.7
Drainage Ditch Works	m	49	57	106
Wet Masonry Works (Type A)	m^2	7	18	25
Wet Masonry Works (Type B)	m^2	11	25	36
Base Concrete Works for Wet Masonry (Type A)	m	16	21	37
Base Concrete Works for Wet Masonry (Type B)	m	24	29	53
Gabion Cylinder Works	m^3	22	13	35
Gabion Mattress Works for Wet Masonry, Groundsill and Dam	m^3	33	4	37
Foot-protection Groyne Works (Crib)	unit	360	560	920
Concrete and Form Works for Groundsill	m^3	41	71	112
Ring Levee	m	102	85	187
Drainage Facility (Pump Station)	L/S	490,000	130,000	620,000

Table 5-3 CONSTRUCTION COST FOR PROPOSED LONG-TERM PLAN

Works Item	Unit	Quantity			Cost ($\times 10^3$)		
		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 (10% of total of 1. and 2.)	L/S				1,839	1,579	3,418
4. Land Acquisition Cost							
Dam Construction	ha	4	-------	4	-------	3	3
River Improvement	ha	24	-------	24	-------	17	17
5. Engineering Service	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 (10% of total of 1. to 6.)	L/S				2,597	1,922	4,519
Grand Total of 1. to 7.					28,570	21,137	49,707

Table 5-4 ANNUAL DISBURSEMENT SCHEDULE FOR PROPOSED LONG-TERM PLAN

Unit:
Total : US$ x 10^3
F.C : US$ x 10^3
L.C : Q. x 10^3

Item	Total	F.C	L.C	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	F.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	-----	-----	-----	20	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sub total of 1. to 4.	37,624	20,231	17,393	-----	-----	-----	20	1,268	1,146	4,255	3,775	5,305	4,753	4,983	4,091	4,420	3,608
5.Engineering Service	6,900	5,526	1,374	1,111	305	740	204	795	173	720	173	720	173	720	173	720	173
6.Administration Cost	664	216	448	113	53	75	35	28	72	-----	72	-----	72	-----	72	-----	72
Sub total of 1. to 6.	45,188	25,973	19,215	1,224	358	815	259	2,091	1,391	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	81	26	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	2,300	1,530	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	284	189	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	2,584	1,719	6,518	5,267	8,368	6,941	8,395	6,383	8,020	6,012

Table 5-5 ANNUAL OMR COST FOR PROPOSED LONG-TERM PLAN

Cost Item	Unit	Unit Cost (US$)	Quantity	Cost ($\times 10^3$ US$)	Life (Year)	Annual Cost ($\times 10^3$ US$/Year)
1. Personnel Cost						(139.8)
Chief Engineer	M/M	1,000	6	----	----	6.0
Sabo Engineer	M/M	1,000	6	----	----	6.0
River Engineer	M/M	1,000	6	----	----	6.0
Mechanical and Electric Engineer	M/M	1,000	6	----	----	6.0
Supervisor	M/M	1,000	12	----	----	12.0
Secretary	M/M	500	12	----	----	6.0
Operater	M/M	500	60	----	----	30.0
Driver	M/M	350	108	----	----	37.8
Labour	M/M	250	120	----	----	30.0
2. Machinery Cost						028.2
Bulldozer (23t)	Unit	140,000	2	280	6	46.7
Wheel Loader (2.3t)	Unit	90,000	2	180	6	30.0
Dump Truck (8t)	Unit	30,000	6	180	4	45.0
Land Cruiser	Unit	13,000	2	26	4	6.5
3. Fuel Cost (15% of Sub-total of 2.)	L/S	-------	---	----	----	19.2
4. Material Cost for Repairing	L/S	-------	---	----	----	110.0
5. Replacement Cost (Drainage Facility)	L/S	-------	---	620	20	31.0
Sub-total of 1. to 5.						(428.2)
6. Miscellaneous Cost (30%)	L/S	-------	---	----	----	128.5
Grand Total						556.7

Table 5-6 MAIN CONSTRUCTION MACHINERY FOR PROPOSED URGENT PLAN

Machinery (Plant)	Capacity	Unit
Sediment Control Dam		
Bulldozer with ripper	21t	3
Bulldozer without ripper	21t	3
Dozer shovel	$1.2m^3$	3
Truck crane	16t	6
Dump truck	8t	6
Truck mixer	$1.6m^3$	4
Portable bacher	$0.5m^3$	3
Belt conveyer	-----	9
Generator	30KVA	3
Vibrator	45Ø	15
River Improvement		
Bulldozer	21t	12
Bulldozer	11t	2
Wheel loader	$2.3m^3$	8
Back hoe	$1.2m^3$	2
Dump truck	8t	27
Concrete mixer	$0.2m^3$	5
Belt conveyer	-----	5
Generator	15KVA	5
Vibrator	45Ø	10

Table 5-7 CONSTRUCTION COST FOR PROPOSED URGENT PLAN

Work Item	Unit	Quantity			Cost ($\times 10^3$)		
		Achiguate 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
Bounlder 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 Grondsill	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 Service	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 F/C and L/C)	L/S	------	------	------	2,677	2,140	4,817
Grand Total					11,512	8,946	20,458

Table 5-8 ANNUAL DISBURSEMENT SCHEDULE FOR PROPOSED URGENT PLAN

Unit; x 10^3 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	488	1,027
4. Engineering Service	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)	(8,835)	(6,806)	(15,641)
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

Table 5-9 ANNUAL OMR COST FOR PROPOSED URGENT PLAN

Cost Item	Unit	Unit Cost (US$)	Quantity	Cost ($\times 10^3$ US$)	Life (Year)	Annual Cost ($\times 10^3$ US$ /year)
1. Personnel Cost						(94.2)
Chief Engineer	M/M	1,000	6	----	----	6.0
Sabo Engineer	M/M	1,000	6	----	----	6.0
River Engineer	M/M	1,000	6	----	----	6.0
Mechanical and Electric Engineer	M/M	1,000	6	----	----	6.0
Supervisor	M/M	1,000	6	----	----	6.0
Secretary	M/M	500	12	----	----	6.0
Operater	M/M	500	36	----	----	18.0
Driver	M/M	350	72	----	----	25.2
Labour	M/M	250	60	----	----	15.0
2. Machinery Cost						(67.3)
Bulldozer (23t)	Unit	140,000	1	140	6	23.3
Wheel Loader (2.3 t)	Unit	90,000	1	90	6	15.0
Dump Truck (8 t)	Unit	30,000	3	90	4	22.5
Land Cruiser	Unit	13,000	2	26	4	6.5
3. Fuel Cost (15% of Sub-total of 2.)	L/S	------	--	----	----	10.1
4. Material Cost for Repairing	L/S	------	--	----	----	35.0
5. Replacement Cost						(23.1)
Gabion Mattress for Dam	m^3	37	0	0	10	0
Boulder for Dam	m^3	13.6	0	0	10	0
Gabion Cylinder for River	m^3	35	0	0	10	0
Groyne (Crib) for River	Unit	920	68	62	10	6.2
Gabion Mattress for River	m^3	37	4580	169	10	16.9
Sub-total of 1. to 5.						(229.7)
6. Miscellaneous Cost (30%)	L/S	------	--	----	----	68.9
Grand Total						298.6

Table 5-10 MAIN CONSTRUCTION MACHINARY FOR ALTERNATIVE URGENT PLAN

Machinery (Plant)	Capacity	Unit
Sediment Control Dam		
Bulldozer with ripper	21t	2
Bulldozer without ripper	21t	4
Dozer shovel	$1.2m^3$	2
Truck crane	16t	10
Dump truck	8t	4
River Improvement		
Bulldozer	21t	10
Bulldozer	11t	2
Wheel loader	$2.3m^3$	8
Dump truck	8t	22

Table 5-11 CONSTRUCTION COST FOR ALTERNATIVE URGENT PLAN

Work Item	Unit	Quantity			Cost ($\times 10^3$)		
		Achiguate River	Pantaleón River	Total	F.C (US$)	L.C (Q.)	Total (US$)
1. Sediment Control Dam					(3,137)	(4,760)	(7,897)
Excavation	m^3	29,400	34,200	63,600	172	108	280
Back-filling	m^3	5,600	6,600	12,200	38	45	83
Gabion Mattress Works	m^3	103,000	92,000	195,000	2,730	4,485	7,215
Boulder Works	m^3	2,600	3,100	5,700	47	30	77
Saddle Dam Works	m	150	0	150	150	92	242
2. River Improvement					(1,777)	(1,511)	(3,288)
Excavation of River Channel	m^3	505,000	146,000	651,000	1,497	911	2,408
Gabion Cylinder Works	m^3	4,960	5,980	10,940	98	284	382
Foot-protection Groyne Works (Crib)	Unit	68	0	68	17	45	62
Gabion Mattress Works for Groundsill	m^3	3,150	8,640	11,790	165	271	436
Sub-total of 1. and 2.					(4,914)	(6,271)	(11,185)
3. Preparation Works (10% of Total of 1. and 2.)	L/S	------	------	------	491	627	1,118
4. Engineering Service	L/S	------	------	------	2,100	400	2,500
5. Land Acquisition	ha	4	0	4	0	3	3
6. Administration Cost	L/S	------	------	------	0	444	444
7. Physical Contingency (10% of Total of 1. to 6.)	L/S	------	------	------	751	775	1,526
Sub-total of 1. to 7.					(8,256)	(8,520)	(16,776)
8. Price Contingency (6% for F/C and L/C)	L/S	------	------	------	2,435	2,597	5,032
Grand Total					10,691	11,117	21,808

Table 5-12 ANNUAL DISBURSEMENT SCHEDULE FOR ALTERNATIVE URGNET PLAN

Unit; x 10^3 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	-----	-----	-----	-----	1,568	2,380	1,255	1,904	314	476	3,137	4,760	7,897
2.River Improvement	-----	-----	-----	-----	-----	-----	1,333	1,133	444	378	1,777	1,511	3,288
3.Preparation Works	-----	-----	313	476	178	151	-----	-----	-----	-----	491	627	1,118
4.Engineering Service	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	89	0	89	0	89	0	89	0	88	0	444	444
7.Physical Contingency (10% of Total of 1. to 6.)	74	21	51	59	222	273	310	324	94	98	751	775	1,526
Sub-total of 1. to 7.	(814)	(228)	(562)	(646)	(2,443)	(3,006)	(3,400)	(3,563)	(1,037)	(1,077)	(8,256)	(8,520)	(16,776)
8.Price Contingency (6% for F/C and L/C)	101	28	107	123	643	791	1,149	1,204	435	451	2,435	2,597	5,032
Total	915	256	669	769	3,086	3,797	4,549	4,767	1,472	1,528	10,691	11,117	21,808

Table 5-13 ANNUAL OMR COST FOR ALTERNATIVE URGENT PLAN

Cost Item	Unit	Unit Cost (US$)	Quantity	Cost (x 10^3 US$)	Life (Year)	Annual Cost (x 10^3 US$ /year)
1. Personnel Cost						(94.2)
Chief Engineer	M/M	1,000	6	----	----	6.0
Sabo Engineer	M/M	1,000	6	----	----	6.0
River Engineer	M/M	1,000	6	----	----	6.0
Mechanical and Electric Engineer	M/M	1,000	6	----	----	6.0
Supervisor	M/M	1,000	6	----	----	6.0
Secretary	M/M	500	12	----	----	6.0
Operater	M/M	500	36	----	----	18.0
Driver	M/M	350	72	----	----	25.2
Labour	M/M	250	60	----	----	15.0
2. Machinery Cost						(67.3)
Bulldozer (23t)	Unit	140,000	1	140	6	23.3
Wheel Loader (2.3 t)	Unit	90,000	1	90	6	15.0
Dump Truck (8 t)	Unit	30,000	3	90	4	22.5
Land Cruiser	Unit	13,000	2	26	4	6.5
3. Fuel Cost (15% of Sub-total of 2.)	L/S	------	--	----	----	10.1
4. Material Cost for Repairing	L/S	------	--	----	----	40.0
5. Replacement Cost						(276.6)
Gabion Mattress for Dam	m^3	37	65,000	2,405	10	240.5
Boulder for Dam	m^3	13.6	1,900	26	10	2.6
Gabion Cylinder for River	m^3	35	3,650	128	10	12.8
Groyne (Crib) for River	Unit	920	68	62	10	6.2
Gabion Mattress for River	m^3	37	3,930	145	10	14.5
Sub-total of 1. to 5.						(488.2)
6. Miscellaneous Cost (30%)	L/S	------	--	----	----	146.5
Grand Total						634.7

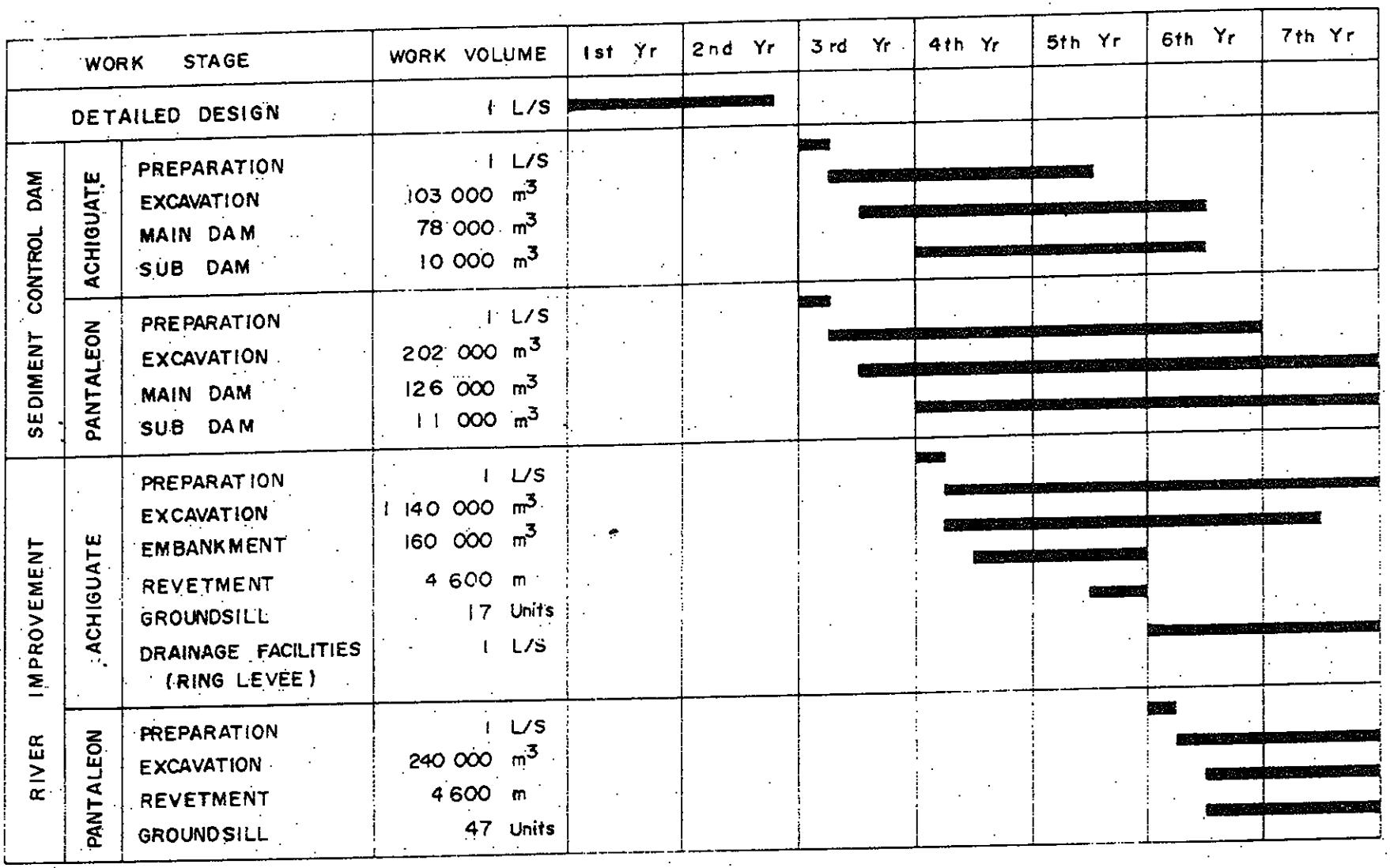


Fig. 5-1 CONSTRUCTION SCHEDULE FOR PROPOSED LONG-TERM PLAN

WORK ITEM				VOLUME	YEAR				
					1986	1987	1988	1989	1990
DETAILED DESIGN				L/S					
CONSTRUCTION WORKS	SEDIMENT CONTROL DAM	PREPARATION		L/S					
		A-1 DAM	EXCAVATION	30,800 m³					
			STONE CONCRETE WORKS	21,900 m³					
			OTHER WORKS	L/S					
		C-1 DAM	EXCAVATION	26,000 m³					
			STONE CONCRETE WORKS	16,200 m³					
			OTHER WORKS	L/S					
		P-2 DAM	EXCAVATION	51,200 m³					
			STONE CONCRETE WORKS	24,300 m³					
			OTHER WORKS	L/S					
	RIVER IMPROVEMENT	PREPARATION		L/S					
		ACHIGUATE	EXCAVATION	574,000 m³					
			REVETMENT WORKS (WET MASONRY)	8,020 m²					
			GROYNE WORKS(CRIB)	68 unit					
			GROUNDSILL WORKS(CONCRETE)	2,760 m³					
		PANTALEON	EXCAVATION	199,000 m³					
			REVETMENT WORKS(WET MASONRY)	10,200 m²					
			GROUNDSILL WORKS(CONCRETE)	6,600 m³					

Fig. 5-2 CONSTRUCTION SCHEDULE FOR PROPOSED URGENT PLAN

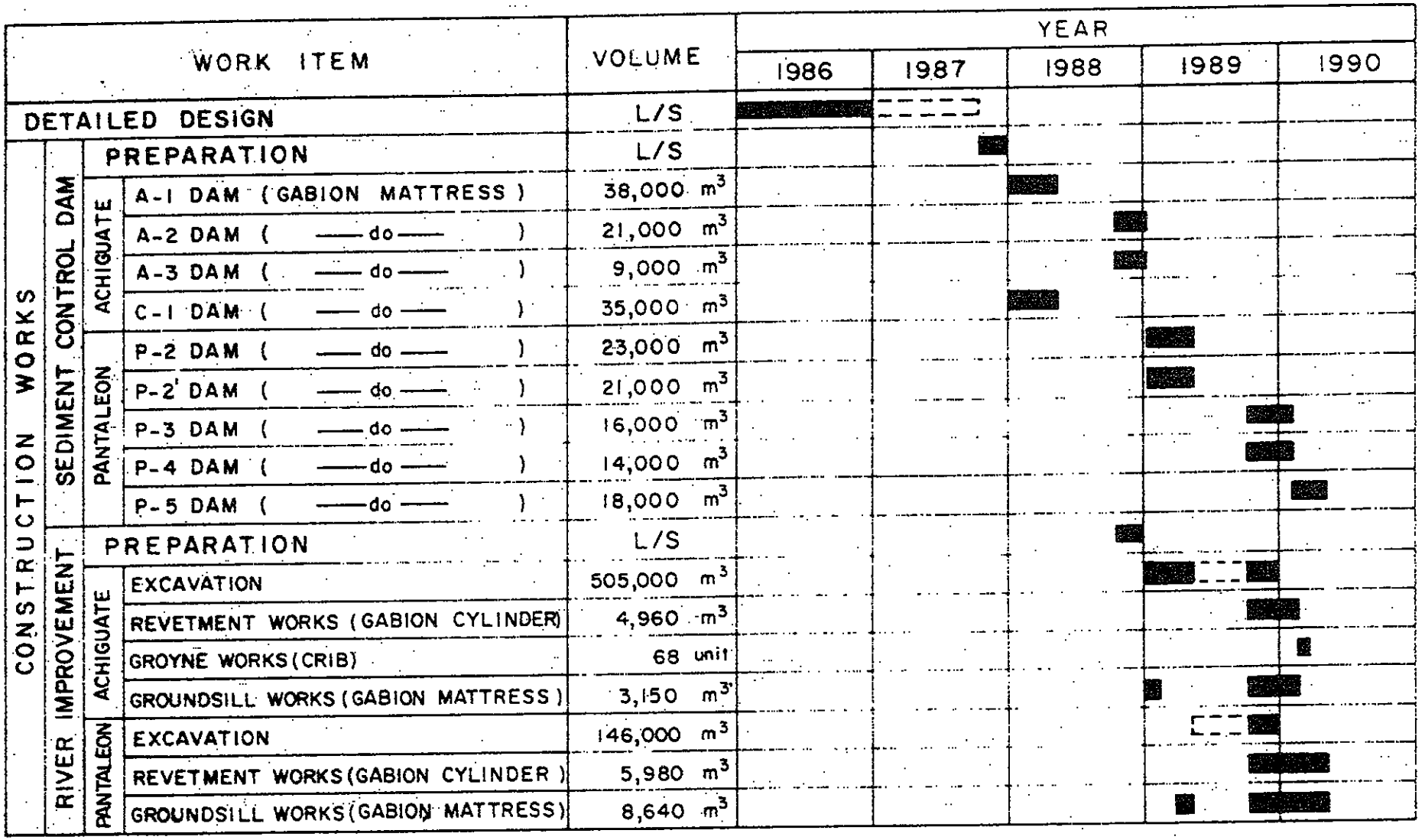


Fig. 5-3 CONSTRUCTION SCHEDULE FOR ALTERNATIVE URGENT PLAN

6. PROJECT EVALUATION

PROJECT EVALUATION

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1. GENERAL

The long-term and urgent plans have been formulated in the present study in connection with the implementation of the project. As for the long-term plan, three (3) cases have been studied; one case of improvement of the entire river course and two cases of partial river improvements, based on the clasification of assets to be protected from flood. The assets in the Study Area have been classified into four (4) categories; A, B, C and D, according to their socio-economic significance, as mentioned below:

Priority	Assets
A	Comunity in a dangerous zone
B	Major infrastructure and urban area
C	Cultivated land
D	Pasture

The assets designated as A are socially required to be protected from flood by all means. However, such assets do not exist in the Study Area under the present circumstances.

The plan for protecting the assets designated as B is evaluated from the viewpoint of both social requirement and economic viability, and in the Study Area the following assets correspond to B:

(1) Road bridges on CA-2 and railway bridges, crossing the Achiguate and Pantaleon rivers, and

(2) Urban areas of Torinidad and Barrita.

As for the assets recognized as C and D, only the economic viability is evaluated.

In the Study Area, the assets corresponding to B, C and D have been clssified and studied using land use maps with 1:50,000 scale, aerophotographics with 1:20,000 scale and having censuses in 1973 and 1981.

The assets in the flooded area are roughly classified as illustrated in Fig. 6-1. In the figure, the river stretch to be improved is classified in accordance with the most dominant asset among them to be protected in the river basin.

The maximum flooded area covers 14,300 ha, comprising pasture of 58%, cultivated land of 25% and other area of 17%. Number of houses in the flooded area is estimated at about 2,400. The breakdown is shown in Table 6-1, and further details on assets B is given in Tables 6-2 and 6-3.

At the first stage of the study, the economic viability of the Project has been roughly examined to select an optimum plan out of the above three cases. The result is summarized as follows:

Cases	Construction Cost ($US\$10^6$)	Annual Benefit ($US\$10^3$)	EIRR (%)	Assets to be Protected	Return Period (year)
Case I, Entire River Improvement	192	8.6	2	B,C,D	30
Case II, Partial River Improvement	143	8.0	3	B,C	30
Case III, Partial River Improvement	40-50	3-4	4-6	B	30

As is obvious from the above table, Cases I and II have very low economic viabilities and need enormous funds, so that it is impractical to put their plans into implementation.

As for Case III, various methods were studied from the technical aspect, and an optimum long-term plan was selected on the basis of social requirements in due consideration of the financial, economic and technical aspects, so that the transportation system by the CA-2 road and the national railway and both the urban areas in Finca La Trinidad and Finca La Barrita will be protected from flood. In this case, the design scale for flood control was determined to be equivalent to the biggest recorded flood that corresponds to a 30-year return period in both the Achiguate and the Pantaleon rivers.

On the other hand, in order to release the Study Area from sediment and flood damage as promptly as possible, an urgent plan was formulated on a practical basis by narrowing the range of assets to be protected. This is called the Proposed Plan.

Based on the above viewpoint, the assets to be protected were limited to the CA-2 road bridge and the railway bridge across the Achiguate and the Pantaleon rivers. It is expected that in such an urgent plan, the economic viability of the Project may be maximized and that the socio-economic activities in a large area may be secured. An alternative to the urgent proposed plan was also formulated based on the construction method and the construction materials to be used, and called as the Alternative Plan.

In this sector of Project Evaluation, the project will be evaluated from a purely economic standpoint with respect to the above-mentioned three (3) plans; the proposed plan for the long-term project and the proposed and alternative plans for the urgent project.

Economic evaluation will be carried out to ascertain the economic viability by comparing the economic cost to be invested for the project and the economic benefit that will accrue by implementing the project. The economic viability will be evaluated by Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C), and the sensitivity test for EIRR of the proposed urgent plan will be made with respect to variations in cost and benefit.

Projects are generally considered to be economically viable, if the estimated EIRR exceeds the opportunity cost of capital (OCC) in the country concerned. However, it is in general difficult to estimated precisely the opportunity cost or marginal productivity of capital, because the OCC may change from time to time.

In practice of the international financing agencies, the EIRR of 10 - 12% has been accepted as the cut-off point, and if it is lower, further justification is usually required, which consists of discussion of unquantified benefits.

An infrastructural project such as sediment and flood control is essential to the social stabilization, although the high prercentage of EIRR will not be generally expected.

In recent years, some infrastructural projects in Guatemala have been financed by the international and local financial agencies with the interest rates of the range from 1 to 9%, which is 6.5% on the average.

On the basis of the above-mentioned matters, in the present study such an average rate is adoped as a standard of the project evaluation for selecting the optimum plan.

The evaluation is based on the following assumptions:

(1) Economic Life

The economic life of the project is taken as 30 years after completion of the construction works.

(2) Direct Tangible Benefits

Direct tangible benefits are mainly counted in the evaluation, and indirect and/or intangible benefits are described as socio-economic impacts of the project in Section 5.

(3) Imlementation Period

The implementation period of the project is seven (7) years for the long-term plan and five (5) years for the urgent plan, including the detailed engineering service periods of two (2) years and one (1) year, respectively.

2. CONDITIONS AND METHODOLOGY FOR ESTIMATION OF ECONOMIC COST AND BENEFIT

2.1 Prices

In estimating the economic cost and benefit, the economic prices are assumed to be as follows:

(1) Foreign exchange rate is set at Q1.00 to US$1.00 on the basis of the following situations:

(a) Official exchange rate is Q1.00 to US$1.00 at present.

(b) Shadow exchange rate (SER) is nearly equal to 1.00 in recent years, as shown in Table 6-4.

(2) Economic prices of unskilled laborers hired locally are assumed to be 70% of the actual market prices in consideration of the unemployment situation in the country in recent years.

(3) As for transfer payment such as tax and duty, it is assumed that goods and services procured locally would include the transfer payment of 10% of their prices and those imported from abroad would exclude any transfer payment.

(4) The cost and benefit estimates are made on the basis of the price level in August of 1984.

2.2 Costs

The financial construction costs, as described in Sector 5, Construction Plan and Cost Estimates, consist of the following items:

(1) direct construction cost;
(2) land acquisition cost and compensation;
(3) government administration expenses;
(4) engineering service charges;
(5) physical contingencies; and
(6) price contingencies.

Among these costs, price contingencies are not included in the economic construction cost. Other costs are given as the economic cost by making adjustments on the aforementioned economic prices.

Annual operation and maintenance costs (OMR costs), including the replacement costs of pumps and other installations, are required during the economic life of the project after the construction work is completed. The OMR costs for the construction period are estimated by assuming that the costs would be increased in proportion to the progress of the construction works. The economic OMR costs are also given by making adjustments on the said economic prices.

2.3 Benefits

2.3.1 General

The direct tangible benefits of the project are given as the economic effect of reduction in sediment and flood damage to assets in and around the flooded area.

The benefits will accrue immediately after the construction works are completed. Partial benefits that will accrue during

the construction period are estimated in the same way as in the OMR costs, assuming that the benefits would be increased in proportion to the progress of the construction works.

2.3.2 Assets to be Protected from Flood

The major assets to be protected from flood of the Achiguate and the Pantaleon rivers are as follows:

(1) road and railway bridges;
(2) transportation system;
(3) houses and household effects
(4) agricultural products;
(5) business activities; and
(6) public facilities, aside from (1).

Based on collected information and results of field surveys, the assets are appraised as follows:

(1) Road and Railway Bridges

The road bridge and the railway bridge across the Achiguate and the Pantaleon rivers are appraised at the 1984 prices based on the information from CAMINOS and FEGUA, as follows:

Bridge	Appraisement (US10^3)
Achiguate Road Bridge	1,000
Pantaleon Road Bridge	750
Achiguate Railway Bridge	230
Pantaleon Railway Bridge	420

(2) Transportation System

The average daily traffic volume at Sta. 200[1/] on CA-2 is estimated at 4,500 vehicles in 1984 and 6,000 vehicles in 2010 on the basis of the traffic statistics by CAMINOS. The former is applied to the estimation of benefit for the urgent plan and the latter, for the long-term plan.

The volume of goods and number of passengers transported by railway are assumed to be 5% of those by the road, according to the information from FEGUA.

(3) Houses and Household Effects

Based on the 1981 housing census, the number of houses in the Study Area is estimated at 405 houses per km^2 in the urban area and 13 houses per km^2 in the rural area in 1984, and its average annual growth rate was 2.81% for the period from 1973 to 1981.

1/ Kilopost which is 78 km away from the Municipality of Guatemala.

By assuming that such a growth will be maintained, the number of houses in the urban and rural areas in the year 2010 is estimated to be 810 houses and 26 houses per km^2, respectively. These figures are used for the estimation of the project benefit for the long-term plan.

As for the urgent plan, it is, on the basis of the present study, estimated that 28 farmhouses in the Study Area will be submerged due to flood discharges of over 2-year return period.

The Study Area contains various types of buildings, such as residence, farmhouse, shop, factory, office, church, etc., and their appraisements are also multifarious. Since it is difficult to appraise these buildings individually, in the present study, the farmhouse, which occupies the greater part of buildings in the Study Area, is adopted as the object of asset evaluation. For convenience, all buildings are described as houses in this report.

Based on the site study, the appraisement of houses is set at Q3,750 per house on the average. The appraisement of household effects is estimated at one-third (1/3) of that of houses in conformity to the studies of similar projects in Guatemala.

(4) Agricultural Products

The unit yields of agricultural products were estimated on the basis of production and cultivated area of each crop in recent years in the Department of Escuintla. The values are used not only for the urgent plan but also for the long-term plan, because the unit yields of major crops in the Department of Escuintla remain almost unchanged since 1973. The unit yields of the major crops, together with their economic prices, are shown in Table 6-5.

2.3.3 Rates of Damage to Assets

(1) Road and Railway Bridges

It is assumed that two (2) bridges on the railway will be washed away by floods with discharges of over 2-year return period, based on the study result on the past floods. In this case, the damage is given as a loss of appraisement of the railway bridges mentioned in 2.3.2(1), and its amount is estimated at US$650,000, consisting of US$230,000 for the Achiguate railway bridge and US$420,000 for the Pantaleon railway bridge. As for the two (2) road bridges on CA-2, it is assumed that a part of the bridge structure will be damaged by floods with discharges of over 2-year return period and the damage is given as the repairing cost. Its amount is estimated at US$175,000, consisting of US$100,000 (or 10% of the appraisement) for the Achiguate road bridge and US$75,000 (or 10% of the appraisement) for the Pantaleon road bridge.

(2) Transportation System

The flood damage to the transportation system is mainly studied on the road traffic, because the transportation volume by railway is very little.

Traffic on CA-2 is assumed to be interrupted by floods with discharges of over 2-year return period, based on the study on floods of the Achiguate and the Pantaleon rivers in the past. During the period of the traffic interruption, the concern of passengers and offices will be to select from either waiting or making detours using other roads.

Based on the origin and destination survey (OD-Survey1/) on CA-2 and conditions of roads connecting to CA-2, the following things are assumed to estimate the flood damage to transportation system.

(a) About 90% of the number of vehicles running on CA-2 in the Study Area will come from or go to Guatemala City, Escuintla City or their surrounding areas (refer to Table 6-6).

(b) Due to the interruption of traffic on CA-2, the above-mentioned vehicles will select the CA-1 route through Cocales and Godinez from the economical viewpoint. In this case, the damage will be given as an increase in cost due to the extended traveling distance and time of vehicles.

(c) The rest vehicles of 10%, traveling on CA-2 in the Study Area alone, will be obliged the waiting until the restration of traffic. The damage to the waiting vehicles will be estimated as the loss due to suspension of business activities described later on.

Increase in the cost for a vehicle traveling between an arbitrary origin and distination is given by the following farmula:

$$di = (Cir + Cit)(L_1 - L_2) \quad \ldots\ldots\ldots\ldots\ldots \quad (6.1)$$

where, di : increase in cost for an i-vehicle,
i : kind of vehycle,
Cir : running cost per km for an i-vehicle,
Cit : time cost per km for an i-vehicle, and
L_1 and L_2 : travel distance in case of without and with the project, respectively.

A rate of number by kind of running vehicles has been obtained by the said OD-survey as shown in Table 6-7. Such a rate is naturally to undergoes a change by day of

1/ : OD-Survey was carried out on CA-2 close to the Achiguate and Pantaleon rivers for two days of 4th and 5th July, 1984, by the JICA Study Team in cooperation with CAMINOS.

the week and the month or the weather. In the present study, this rate is however applied to the estimation of flood damage to the transportation system, because there are no available data in Guatemala, besides the result of the above-mentioned OD-Survey.

The traveling cost (Cir and Cit) varies with kind and running speed of vehicle as shown in Table 6-8. Cir is composed of costs of materials such as fuel, oil, tire, etc., and the fuel cost accounts for 80% of the running cost. Cit is estimated on the basis of the per capite GDP of Guatemala, with reference to the time costs which are being applied in Japan and other countries.

L_2 is given as a distance on CA-2 and its connection routes, whereas L_1 is given on CA-1 and its connection routes as described in the above (b). As illustrated in Fig. 6-2, $L_1 > L_2$ obviously.

Fig. 6-2 shows the mean running speed of vehicles together with the travel distance on the related routes. Where, the mean running speed of vehicles was estimated on the basis of observation of running vehicles and running test by an experimental car.

Goods and passengers to be transported byrailway will also be to select either waiting or making the conversion from railway into road until the damaged bridges are restored.

In the present study, the flood damage to railway transportation is simply assumed to be 5% of that to road transportation, in proportion to both transportation volumes by road and railway.

(3) Houses, Household Effects and Agricultural Products

The damage rate of the assets submerged will be given as a function of the water depth and duration of submergence. However, since there are no available data in this country, the damage rate used in thetropic zone has been applied to this study.

Table 6-9 shows the damage rate of the assets, such as houses, household effects and agricultural products; where, the damage rate means the rate of reduction in appraisement of houses and household effects submerged and the rate of decrease in production of the farm crops submerged, respectively.

(4) Business Activities

Some aspects of the business activities of inhabitants and offices around and in the inundated area will be suspended during the period of inundation. Since it is, however, very difficult to clearly estimate such a loss in the present study, the loss is assumed to be 6% of the total

damage to houses and household effects, with reference to the similar projects in the tropic zone.

(5) Public Facilities

Public facilities, except bridges on CA-2 road and railway mentioned in (a) of this sub-section, such as electric power and water supply systems, agricultural facilities and roads in the Study Area will be damaged due to the ununda̲tion. However, it is also difficult to clearly estimate the damage. In the present study, the damage is therefore assumed as 60% of the total damage to houses and household effects, in the light of similar projects in the tropic zone.

2.3.4 Econimic Benefit

The sediment and flood damage is estimated for the respective probable discharges of 2-year, 5-year, 10-year and 30-year return periods.

Using this sediment and flood damage, the average annual damage is generally given by the following formula:

$$d = \int_{Qo}^{Qm} D(Q) \cdot P(Q) \cdot dQ \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (6.2)$$

where, d : average annual damage,
Q : flood discharge,
D(Q): damage caused by flood discharge Q,
P(Q): probability of occurrence of flood discharge Q,
Qm : maximum flood discharge,
Qo : innocuous discharge, and
dQ : infinitely small discharge

If the Project is executed under the design flood discharge of Qn ($\leq$ Qm), it is expected that the average annual damage will be reduced in accordance with the formula 6.2. Such a reduced damage is given an average annual benefit of the Project.

Calculation of the average annual benefit is actually made by using the following difference formula:

$$B_n = \sum_{i=1}^{n} 1/2 \, [D(Q_{i-1}) + D(Q_i)] \cdot [P(Q_{i-1}) - P(Q_i)] \quad \cdots\cdots \quad (6.3)$$

$$i = 1, 2, 3, \cdots\cdots, n-1, n$$

where, $D(Q_{i-1})$ and $D(Q_i)$ mean damages caused by (i-1)th-flood with Q_{i-1} discharge and (i)th-flood with Q_i discharge, respectively, and $P(Q_{i-1})$ and $P(Q_i)$ mean probabilities of occurrence of larger discharges than Q_{i-1} discharge and Q_i discharge, respectively. $P(Q_{i-1})-P(Q_i)$, therefore, will be a probability of occurrence of the discharges between Q_{i-1} and Q_i, namely it

will be given as a difference in reciprocals of two return periods of Q_{i-1} and Q_i.

Using the formula (6.3) mentioned above, the average annual benefit is estimated for the respective assets in the flooded area as follows:

(1) Road and Railway bridges

As described in Sub-section 2.3.3(1), the damages to the bridges on railway and CA-2 road are estimated at US$650,000 and US$175,000, respectively, due to the floods with discharges of over 2-year return period.

By applying the formula (6.3) to these damages, the average annual benefits are calculated as follows:

Unit: US$10^3

Assets	Return period (year)				
	2	5	10	30	50
Railway bridges	162	357	422	465	475
Road bridges	44	96	114	126	128

(2) Transportation System

The damage to the transportation system is estimated under the following conditions:

(a) The traffic volume damaged by floods of the Achiguate and Pantaleon rivers is estimated at 4,500 vehicles per day for the urgent plan and 6,000 vehicles per day for the long-term plan.

(b) The period of traffic interruption is estimated at 20 days in case of floods with over 2-year return period, judging from the flood damage in the past.

(c) During the above-mentioned period, the traveling cost of vehicles is increased for 90% of the traffic volume described in (a) (refer to Table 6-4).

(d) Increase in the traveling cost per vehicle is calculated using the formula (6.1) of Sub-section 2.3.3.

(e) As described in Sub-section 2.3.3, the damage to railway transportation is included in the total damage to the transportation system at the rate of 5% of that to the road transportation.

Based on the above-mentioned conditions, the damage to the transportation system is estimated to be 1,234 x 10^3 US$ for the urgent plan and 1,646 x 10^3 US$ for the long-term plan, due to floods with over 2-year return period.

Using these damages, the average annual benefits of the project on the transportation system are calculated as follows:

Unit: US$10^3

Plan	Return period (year)				
	2	5	10	30	50
Urgent plan	309	680	802	884	900
Long-term plan	412	907	1,070	1,179	1,198

(3) Houses and Household Effects

The flood damage to houses and household effects is generally calculated by the following formula:

$$D = \sum_{i=1}^{n} (A_1 R_1 + A_2 R_2)i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.4)$$

where, d : flood damage to houses and household effects submerged,

A_1 and A_2 : appraisements of a house and its household effects, respectively (refer to (3) of Subsection 2.3.2),

R_1 and R_2 : damage rates to a house and its household effects, respectively (refer to (3) of Subsection 2.3.3), and

n: number of houses submerged.

The damage to houses and household effects is actually estimated under the following conditions:

(a) Number and locations of houses to be submerged by floods can be obtained using the housing census in 1981, the land use map and the flooded area shown in Table 6-2.

(b) The water depth required to estimate the flood damage is given for the respective return periods of floods as shown in Table 4-2 in Sector 4, River Improvement Plan.

(c) The damages to business activities and public facilities, which are explained in (4) and (5) of Subsection 2.3.3, are included in the damages to houses and household effects.

Using such flood domages, the average annual benefits of the Project on houses and household effects can be estimated. The results are given in the succeeding Subsections 3.2 and 4.2.

(4) Agricultural Products

The flood damage to agricultural products is given by the following formula:

$$D = \sum_{i=1}^{n} (P \cdot Y \cdot A \cdot R)i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.5)$$

where, i : kind of agricultural products (1, 2, ..., n),
D : damage to agricultural products,
P : unit price (refer to Table 6-5),
Y : unit yield (refer to Table 6-5),
A : inundation area, and
R : rate of decrease in yield due to inundation (refer to Table 6-9).

The inundation areas for the respective agricultural products can be estimated using the land use map and the flooded area shown in Table 6-2.

Using the damages calculated under the above-mentioned conditions, the average annual benefit of the Project on the agricultural products is calculated. The results are given in the succeeding Sub-section 3.2 and 4.2.

3. EONOMIC EVALUATION FOR THE LONG-TERM PLAN

3.1 Economic Cost

The economic cost of the project is obtained by making some adjustments, as described in Sections 1 and 2, on the financial cost estimated in Sector 5, Construction Plan and Cost Estimates, of the Supporting Report.

The economic construction cost of the project under the proposed long-term plan is estimated at US$46,633 million, consisting of the foreign currency portion of US$28.570 million and the local currency portion of US$18.063 million. The annual disbursement of the economic construction cost is shown in Table 6-10.

The econimic operation, maintenance and replacement costs (OMR costs) are estimated at US$500 thousand per annum throughout the economic life of the project after the construction work is completed. The annual flow of OMR costs, including those for the construction period, is also given in Table 6-10.

3.2 Economic Benefit

The maximum area inundated due to floods of the Achiguate and the Pantaleon rivers is estimated at about 14,000 ha in total. Out of the inundated area, the area of 3,271 ha including 2,054 houses may be saved from the inundation by floods of less than 30-year return period by implementing the long-term plan. The breakdown of the inundation area is shown in Table 6-8.

The benefits that accrue by the reduction in the sediment and flood damage to assets, are estimated by the method shown in Sub-section 2.3.4. Table 6-11 shows the economic annual benefits that will accrue by protecting Assets B, for the respective flood discharges of 2-year, 5-year, 10-year, 30-year and 50-year return periods.

As is obvious from the figures in the table, the economic annual benefit for a 50-year return period is only a little higher than that for a 30-year return period. On the other hand, the basic construction costs for 5-year, 10-year, 30-year and 50-year were estimated to be approximately US$40.0 million, US$44.0 million, US$50.0 million and US$57.0 million, respectively. As a result, EIRR of the project has been roughly estimated at 5%, 6%, 5% and 4%, respectively, namely, these percentages are relatively of the low economic viability.

Therefore, in the present study the sediment and flood control plan under the 30-year return period is proposed as the optimum long-term plan on the basis of social requirements, as mentioned in Section 1.

The economic annual benefit under the proposed long-term plan that will accrue during the period of economic life of the project is estimated at US$3.478 million, consisting of the following items:

Item		Annual Benefit (US$10^3)
(1)	Railway Bridges	465
(2)	Road Bridges	126
(3)	Transportation System	1,179
(4)	Houses and Household Effects[1/]	651
(5)	Agricultural Products	1,057
	Total	3,478

The annual flow of benefit, including partial annual benefits that will accrue for the construction period is also given in Table 6-10.

3.3 Economic Evaluation

EIRR, together with B/C and NPV in cases discounted at the rates of 5% and 6%, is summarized as follows:

Item	EIRR (%)	B/C Discount Rate (5%)	B/C Discount Rate (6%)	NPV (US$10^3) Discount Rate (5%)	NPV (US$10^3) Discount Rate (6%)
Proposed Long-Term Plan	5.1	1.01	0.92	446	-3,411

1/ Includes benefits for business activities and public facilities such as electric power and water supply systems, agricultural facilities and roads in the inundation area.

The result shows that the project under the proposed long-term plan is relatively of a low economic viability. However, the percentage of EIRR is within the range of the maximum and the minimum interest rates of the financing agencies in Guatemala as described in Chapter IV of the Main Report, and it is close to the standard rate for economic evaluation defined in the same chapter.

This result gives a general evaluation from the economic viewpoint for the long-term plan. Further study on the economic evaluation will be carried out for the urgent plan, as described in the succeeding section.

4. ECONOMIC EVALUATION FOR THE URGENT PLAN

4.1 Economic Cost

The economic cost of the project under the urgent plan is estimated on two (2) cases; Proposed Plan and Alternative Plan.

The economic construction costs are summarized as follows:

Plan	Foreign Currency Portion (US$10^3)	Local Currency Portion (US$10^3)	Total (US$10^3)
Proposed Plan	8,835	5,815	14,650
Alternative Plan	8,256	7,281	15,537

The annual disbursements of the economic construction costs are shown in Tables 6-12 and 6-13.

The annual OMR Costs are estimated at US$260 thousand for the Proposed Plan and US$540 thousand for the Alternative Plan during the period of economic life of the project after the construction works are completed. The annual flows of OMR Costs, including those for the construction period, are also given in Tables 6-12 and 6-13.

4.2 Economic Benefit

The area, which may be saved from the inundation by floods of less than 10-year return period by implementing the urgent plan is estimated at 291 ha including 28 houses, as shown in Table 6-3. (Refer to Fig. 6-3.)

The benefits, which accrue by the reduction in the sediment and flood damage to assets, are estimated by the method shown in Sub-section 2.3.4. Table 6-14 shows the economic annual benefits under the respective return periods of 5-year, 10-year and 30-year. On the other hand, the basic construction costs under the above return periods are estimated at approximately US$14.0 million, US$15.5 million and US$22.0 million, respectively. EIRR of the project is roughly estimated to be 6%, 7%

and 5%, respectively, i.e., EIRR for the 10-year return period is the highest.

The economic annual benefit of the project under the urgent plan with 10-year return period is estimated at US$1.465 million for either the proposed and the alternative plans, consisting of the following items:

	Item	Annual Benefit (US$10^3)
(1)	Railway Bridges	422
(2)	Road Bridges	114
(3)	Transportation System	802
(4)	Houses and Household Effects[1/]	38
(5)	Agricultural Products	89
	Total	1,465

The benefits will accrue during the period of economic life of the project. The annual flows of benefit including partial benefit that will accrue for the construction period are shown in Tables 6-12 and 6-13.

4.3 Economic Evaluation

EIRR of the project under the urgent plan is estimated at 7.3% for the Proposed Plan and 4.4% for the Alternative Plan as shown in the following table, together with B/C and NPV in cases discounted at the rates of 6% and 7% per annum.

Plan	EIRR (%)	B/C Discount Rate (6%)	B/C Discount Rate (7%)	NPV (US$10^3) Discount Rate (6%)	NPV (US$10^3) Discount Rate (7%)
Proposed Plan	7.3	1.12	1.06	1.779	774
Alternative Plan	4.4	0.93	0.87	-1,211	-2,152

EIRR of the project is not so high for either of the two plans, but EIRR for the proposed plan exceeds somewhat the standard rate of 6.5% mentioned in Chapter IV of the Main Report; therefore, it has been identified to be economically viable.

In addition to the above, it must be emphasized that the project has the social needs more seriously, and its implementation will generate great socio-economic impacts, as described in the succeeding section.

The economic viability of the project is further discussed under the sensitivity test.

1/ Includes benefits for business activities and public facilities such as electric power and water supply systems, agricultural facilities and roads in the inundation area.

4.4 Sensitivity Test

The estimates and assumptions in the present study have been arrived at after careful study based on professional experience and expert judgment, but there always remains the question as to the degree of reliability of inputs. It is customary, therefore, to test the results of economic analysis for sensitivity to variations in certain important inputs.

In the present study, most of the important inputs have been quantified afer careful study. The sensitivity test is, therefore, carried out to only the variations in the total discounted costs and benefits, without any examination of the variations in the major inputs. The test is made for the variations in 5% and 10% of the cost and benefit with respect to EIRR of the proposed plan for the urgent project, and the results are given in Table 6-15.

For instance, in two cases such as 5% decrease in benefit and 5% increase in cost, EIRR still holds a higher rate than the standard rate of 6.5%, and it is identified to be economically viable. While, in case of 10% decrease in benefit or 10% increase in cost, it becomes slightly lower than the said standard rate.

5. Socio-Economic Impacts

Aside from the benefits discussed earlier, the following effects would be produced from the implementation and completion of the sediment and flood control works:

(1) stimulative effect for the promotion of the development of the socio-economy in the south coastal region by securing the safety of transportation on the main national road of CA-2 and the national railway;

(2) stabilization of the people's livelihood in the Study Area by the reduction in flood menace, improvement of environmental conditions and the effective use of land; and

(3) greater employment opportunities for people in and around the Department of Escuintla through the implementation of the construction works.

TABLES AND FIGURES

Table 6-1 ASSETS IN MAXIMUM FLOODED AREA IN 1984

River Basin	Dominant Assets	Number of Houses (nos.)	Maximum Flooded Area							
			Cultivated Land		Pasture		Others		Total	
			ha	%	ha	%	ha	%	ha	%
1. Achiguate	B	1,019	1,021	32	1,653	51	537	17	3,211	100
	C	382	284	14	1,209	60	527	26	2,020	100
	D	748	1,482	20	4,796	66	1,052	14	7,330	100
Sub-total		2,149	2,787	22	7,658	61	2,116	17	12,561	100
2. Pantaleon	B	8	19	32	33	55	8	13	60	100
	C	184	758	58	369	29	173	13	1,300	100
	D	66	58	15	265	70	57	15	380	100
Sub-total		258	835	48	667	38	238	14	1,740	100
3. Total	B	1,207	1,040	32	1,686	51	545	17	3,271	100
	C	566	1,042	31	1,578	48	700	21	3,320	100
	D	814	1,540	20	5,061	66	1,109	14	7,710	100
Total		2,407	3,622	25	8,325	58	2,354	17	14,301	100

Table 6-2 INUNDATION AREA TO BE PROTECTED BY PROPOSED LONG-TERM PLAN

River Basin	Number of Houses	Inundation Area (ha)								
		Urban Area	Rural Area							Total
			Sugar Cane	Maize	Cotton	Banana	Pasture	Others	Sub-total	
Achiguate	2,038	134	39	345	571	66	1,653	403	3,077	3,211
Pantaleon	16	0	19	0	0	0	33	8	60	60
Total	2,054	134	58	345	571	66	1,686	411	3,137	3,271

Table 6-3 INUNDATION AREA TO BE RPOTECTED BY URGENT PLAN

River Basin	Number of Houses	Inundation Area (ha)				
		Sugar Cane	Maize	Pasture	Others	Total
Achiguate	20	6	40	150	35	231
Pantaleon	8	19	0	33	8	60
Total	28	25	40	183	43	291

Table 6-4 SHADOW EXCHANGE RATE (SER) ESTIMATED ON THE BASIS OF AMOUNTS AND DUTIES OF IMPORT AND EXPORT, 1976 - 1980

Unit: Million Quetzales

Item	Year				
	1976	1977	1978	1979	1980
Import(CIF)					
Amount(I)	838.4	1,052.5	1,260.7	1,449.4	1,559.1
Duty(di)	48.5	77.1	82.5	83.3	81.5
I + di	886.9	1,129.6	1,343.2	1,532.7	1,640.6
Export(FOB)					
Amount(E)	760.3	1,160.2	1,111.6	1,217.1	1,472.8
Duty(de)	49.1	151.6	158.4	129.2	146.9
E - de	711.2	1,008.6	953.2	1,087.9	1,325.9
I + E	1,598.7	2,212.7	2,372.3	2,666.5	3,031.9
I+di+E-de	1,598.1	2,138.2	2,296.4	2,620.6	2,966.5
SER	1.00	0.97	0.97	0.98	0.98

Note: SER = I+E/I+di+E-de

Table 6-5 UNIT YIELD AND UNIT PRICE OF AGRICULTURAL CROPS IN THE DEPARTMENT OF ESCUINTLA IN 1984

Crops	Unit Yield (kg/ha)	Unit Price (Q/kg)
Sugar	8,000	0.350
Pasture (Q/ha) /1	225	
Maize	850	0.240
Cotton	1,700	1.200
Banana	60,000	0.200
Orchard /2	60,000	0.200
Coffee	550	3.200
Upland crops /3	25,000	0.300

/1 : estimated on the basis of the production of beef and milk

/2 : orange and other tree fruits

/3 : vegetables, beans, etc., except sugar cane and maize

Table 6-6 OD-DISTRIBUTION OF VEHICLES TRAVELING ON CA-2 IN THE STUDY AREA

Unit : %

Origin (or Destination)	Destination (or Origin)	Traffic Volume
1. Guatemala City and its Surrounding Areas	Cocales and Westward	42
2. - do -	Area between Cocales and Santa Lucia	13
3. - do -	Area between Santa Lucia and Siquinala	8
4. Escuintla City and its Surrounding Areas	Cocales and Westward	12
5. - do -	Area between Cocales and Santa Lucia	8
6. - do -	Area between Santa Lucia and Siquinala	7
	Sub-total	90
7. Study Area	Study Area	
	Total	100

Table 6-7 KIND OF VEHICLES TRAVELING ON CA-2 IN THE STUDY AREA

Unit: %

Origin or Destination	Kind of Vehicles /1							Total
	P_1	P_2	B_1	B_2	T_1	T_2	T_3	
I. Guatemala City	26	4	2	15	31	18	4	100
II. Escuintla City	14	2	1	1	32	32	18	100

/1 : P_1 : Passenger car (<2,000 CC) and Jeep
P_2 : Passenger car (≥2,000 CC)
B_1 : Micro bus (<30 passengers)
B_2 : Bus (≥ 30 passengers)
T_1 : Truck (<5 tons)
T_2 : Truck (≥5 tons, <15 tons)
T_3 : Truck (≥15 tons)

Table 6-8 TRAVELING COST OF VEHICLE (PER VEHICLE-km)

Unit: US$

Item	Kind of Vehicles /1						
	P_1	P_2	B_1	B_2	T_1	T_2	T_3
(1) Speed: 45 km/h							
A. Running cost	0.0645	0.0895	0.1020	0.1480	0.1078	0.1396	0.1513
B. Time cost	0.0400	0.0554	0.1328	0.1897	0.0601	0.0759	0.1353
Total	0.1045	0.1449	0.2348	0.2377	0.1679	0.2155	0.2866
(2) Speed: 65 km/h							
A. Running cost	0.0511	0.0719	0.0816	0.1143	0.0852	0.1077	0.1157
B. Time cost	0.0277	0.0384	0.0919	0.1314	0.0416	0.0525	0.0937
Total	0.0788	0.1103	0.1735	0.2457	0.1268	0.1602	0.2094
(3) Speed: 75 km/h							
A. Running cost	0.0526	0.0746	0.0846	0.1193	0.0884	0.1125	0.1212
B. Time cost	0.0240	0.0333	0.0796	0.1138	0.0360	0.0455	0.0812
Total	0.0766	0.1079	0.1642	0.2331	0.1244	0.1580	0.2024

Note: The above costs are values for 2 - 4% or the average road longitudinal gradient.

/1 : P_1 : Passenger car (<2,000 CC) and Jeep
P_2 : Passenger car (≥2,000 CC)
B_1 : Micro bus (<30 passengers)
B_2 : Bus (≥ 30 passengers)
T_1 : Truck (<5 tons)
T_2 : Truck (≥5 tons, <15 tons)
T_3 : Truck (≥15 tons)

Table 6-9 DAMAGE RATE OF ASSETS SUBMERGED

(a) Excludes Siediment Accummulation of Earth and Sand

Assets	Inundation Depth (m)							
	0.01 to 0.25	0.25 to 0.49	0.50 to 0.74	0.75 to 0.99	1.00 to 1.24	1.25 to 1.49	1.50 to 1.99	2.00 to 2.99
1. General Assets								
House	0.078	0.151	0.192	0.226	0.258	0.292	0.341	0.439
Household Effects	0.050	0.115	0.167	0.215	0.262	0.307	0.373	0.499
2. Agricultural Crops								
Sugar Cane	0.45	0.60	0.70	0.75	0.80	0.85	0.90	1.00
Pasture	0.35	0.50	0.60	0.65	0.70	0.75	0.80	0.90
Maize	0.45	0.60	0.70	0.75	0.80	0.85	0.90	1.00
Cotton	0.40	0.60	0.70	0.80	0.90	1.00	1.00	1.00
Banana	0.10	0.25	0.40	0.50	0.60	0.70	0.80	1.00
Orchard /1	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50
Coffee	0.20	0.40	0.50	0.60	0.70	0.80	1.00	1.00
Upland Crops /2	0.55	0.70	0.80	0.85	0.90	0.95	1.00	1.00

(b) Includes Sediment Accumulation of Earth and Sand

Assets	Inundation Depth (m)							
	0.01 to 0.25	0.25 to 0.49	0.50 to 0.74	0.75 to 0.99	1.00 to 1.24	1.25 to 1.49	1.50 to 1.99	2.00 to 2.99
1. General Assets								
House	0.117	0.227	0.288	0.339	0.387	0.438	0.512	0.659
Household Effects	0.075	0.173	0.250	0.322	0.393	0.460	0.560	0.749
2. Agricultural Crops								
Sugar Cane	0.65	0.90	1.00	1.00	1.00	1.00	1.00	1.00
Pasture	0.50	0.75	0.90	1.00	1.00	1.00	1.00	1.00
Maize	0.65	0.90	1.00	1.00	1.00	1.00	1.00	1.00
Cotton	0.60	0.90	1.00	1.00	1.00	1.00	1.00	1.00
Banana	0.15	0.40	0.60	0.75	0.90	1.00	1.00	1.00
Orchard /1	0.10	0.15	0.25	0.30	0.40	0.45	0.60	0.75
Coffee	0.30	0.60	0.75	0.90	1.00	1.00	1.00	1.00
Upland Crops /2	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00

/1 : orange and other tree fruits
/2 : vegetables, beans, etc., except sugar cane and maize

Table 6-10 ANNUAL FLOW OF ECONOMIC COST AND BENEFIT AND INTERNAL RATE OF RETURN FOR PROPOSED LONG-TERM PLAN

Unit: US$10^3

Year	Economic Cost		Economic Benefit
	Construction Cost	OMR Cost /1	
1	1,683		
2	1,139		
3	3,608		
4	9,252	100	696
5	11,326	200	1,391
6	10,349	300	2,087
7	9,276	400	2,782
8		500	3,478
9		500	3,478
10		500	3,478
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
37		500	3,478
Total	46,633	16,000	11,296

EIRR = 5.1%

/1 : Operation, maintenance and replacement costs

Table 6-11 ECONOMIC ANNUAL BENEFIT WHICH ACCRUES BY PROTECTING ASSETS B

Unit: US$10^3

Assets	Return Period				
	2-year	5-year	10-year	30-year	50-year
(a) Railway bridges	162	357	422	465	475
(b) Road bridges	44	96	114	126	128
(c) Transportation system	412	907	1,070	1,179	1,198
(d) Houses and household effects /1	210	485	577	651	675
(e) Agricultural products	386	847	983	1,057	1,076
Total	1,214	2,692	3,166	3,478	3,551

/1 : Includes benefits for business activities and public facilities such as electric power and water supply systems, agricultural fcilities and roads in the inundation area

Table 6-12 ANNUAL FLOW OF ECONOMIC COST AND BENEFIT AND INTERNAL RATE OF RETURN FOR PROPOSED URGENT PLAN

Unit: US$10^3

Year	Economic Cost		Economic Benefit
	Construction Cost	OMR Cost /1	
1986	1,003		
1987	830		
1988	3,812	52	293
1989	6,830	104	586
1990	2,175	208	1,172
1991		260	1,465
1992		260	1,465
1993		260	1,465
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
2020		260	1,465
Total	14,650	8,164	46,001

EIRR = 7.3%

/1 : Operation, maintenance and replacement costs

Table 6-13 ANNUAL FLOW OF ECONOMIC COST AND BENEFIT AND INTERNAL RATE OF RETURN FOR ALTERNATIVE URGENT PLAN

Unit: US$10^3

Year	Economic Cost		Economic Benefit
	Construction Cost	OMR Cost /1	
1986	1,009		
1987	1,114		
1988	5,012	108	293
1989	6,445	216	586
1990	1,957	432	1,172
1991		540	1,465
1992		540	1,465
1993		540	1,465
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
'		'	'
2020		540	1,465
Total	15,537	16,956	46,001

EIRR = 4.4%

/1 : Operation, maintenance and replacement costs

Table 6-14 ECONOMIC ANNUAL BENEFIT WHICH ACCRUES BY PROTECTING ASSETS "RAILWAY AND ROAD BRIDGES"

Unit: US$10^3

	Assets	Return Period		
		5-year	10-year	30-year
(a)	Railway bridges	357	422	465
(b)	Road bridges	96	114	126
(c)	Transportation system	680	802	884
(d)	Houses and household effects /1	31	38	44
(e)	Agricultural products	75	89	101
	Total	1,239	1,465	1,618

/1 : Includes benefits for business activities and public facilities such as electric power and water supply systems, agricultural facilities and roads in the inundation area

Table 6-15 RESULTS OF SENSITIVITY TEST FOR PROPOSED URGENT PLAN

Case	Benefit	Cost	EIRR (%)	B/C	NPV (US$10^3)
1	10% increase	-	8.5	1.13	1,827
2	-	10% decrease	8.6	1.14	1,789
3	5% increase	-	7.9	1.08	1,103
4	-	5% decrease	7.9	1.08	1,084
5	5% decrease	-	6.7	0.98	-345
6	-	5% increase	6.8	0.98	-326
7	10% decrease	-	6.1	0.92	-1,069
8	-	10% increase	6.2	0.93	-1,032

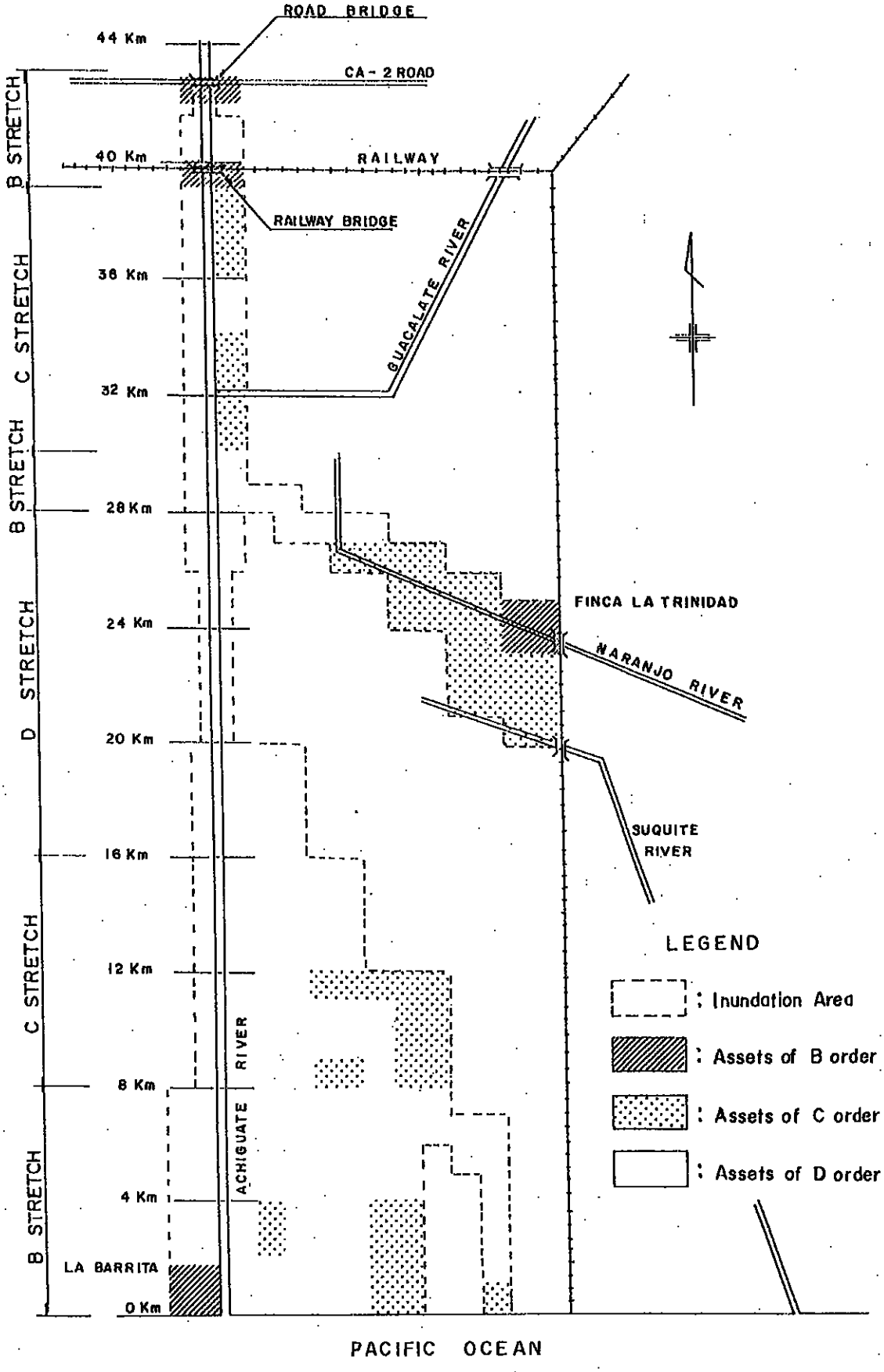

Fig. 6-1 (1/2) CLASSIFICATION OF ASSETS (ACHIGUATE RIVER BASIN)

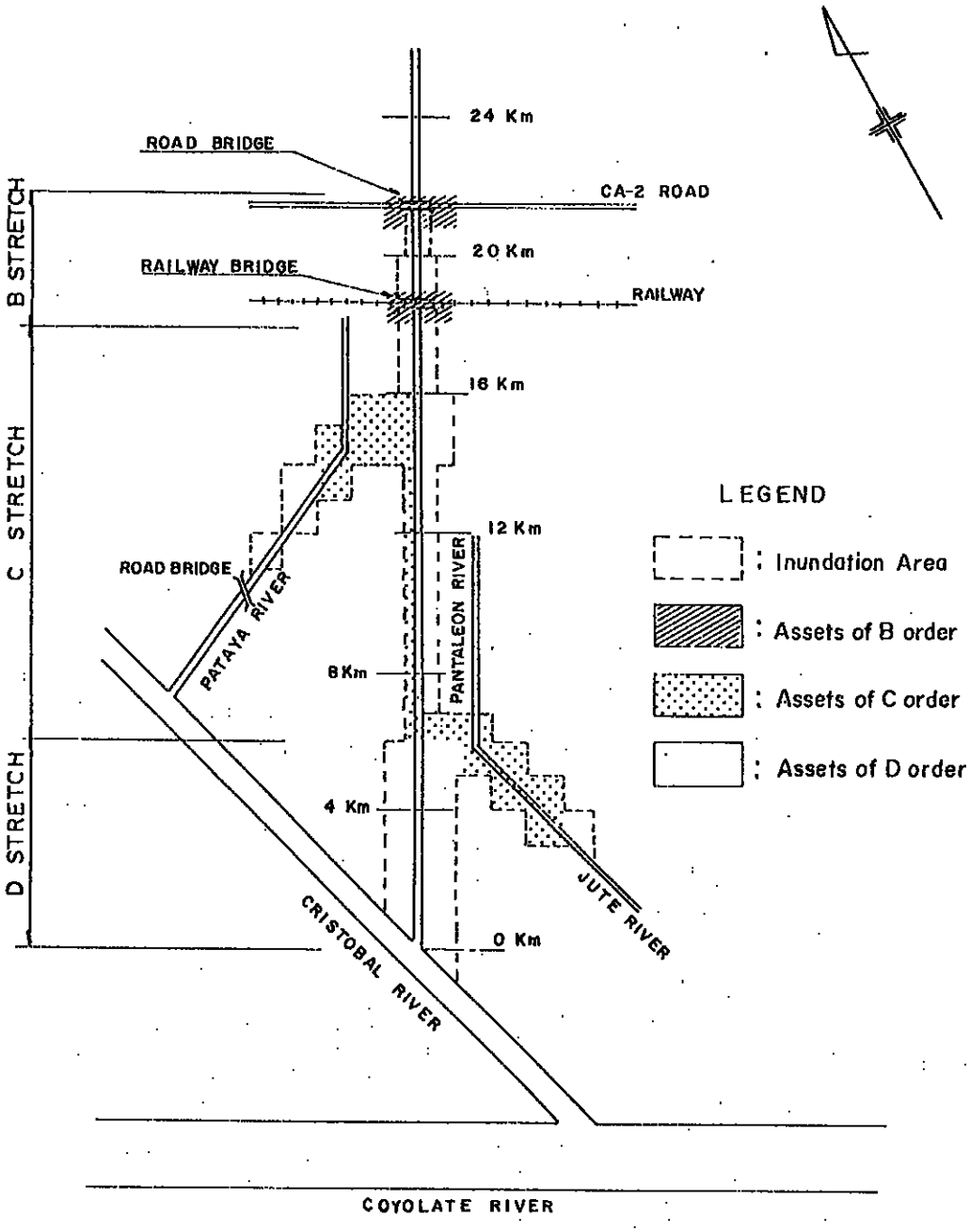

Fig. 6-1 (2/2) CLASSIFICATION OF ASSETS (PANTALEON RIVER BASIN)