3. FLOOD CONTROL PLAN FOR UPPER AGNO RIVER

3. FLOOD CONTROL PLAN FOR UPPER AGNO RIVER

3.1 River Improvement Plan

3.1.1 Basic Concept for Plan Formulation

(1) Outline of Priority Project

The Framework Plan for the Agno River was formulated for the flood control target of 100-year probable flood with the combination of river improvements, the Poponto natural retarding basin, and the Moriones-O'Donnel dam. The San Roque dam and the Balog-Balog dam are assumed to be existing. The general layout of the Framework Plan and the design flood discharge distribution are shown in Figure 3.1.1 and Figure 2.4.3 respectively.

The river improvements for the stretch between the Wawa bridge and the San Roque bridge in the upper Agno River, which has a total river length of about 69 km, was selected as the Priority Flood Control Project to be implemented urgently with the minimum flood protection level of a 10-year design flood in conforminity with the Master Plan.

These river improvements aim to restore and reinforce the diking system of the Asingan-San Manuel stretch on the right bank where flooding penetrates habitually into the Allied River basin area through the existing breaches. These works, however, confine the flood flow inside the river area and induce a significant increase of flood run-off in the downstream reaches (refer to Section 3.2). In this respect, these improvements should be implemented together with reinforcement of the Alcala-Asingan and Bayambang-Alcala stretches, and construction of the new Poponto floodway and natural retarding basin. The Poponto floodway and natural retarding basin aim to regulate the confined flood discharge in the lower Agno River stretch within an allowable level.

(2) Plan Formulation Criteria

The priority river improvement plan was formulated from the following criteria:

a) The 10-year design flood discharge distribution shown in Figure 2.4.5 is adopted.

b) The present condition for the basis of the plan formulation is the one after completion of the DPWH's earthquake damage rehabilitation program.

c) Flood control measures in the Study area consist of river improvement, the Poponto natural retarding basin, and the San Roqe dam. River improvement works in the upper reaches would cause a significant increase of flood runoff in the lower reach. In this respect, the river improvement in the upper Agno should be implemented together with construction of the Poponto floodway and the natural retarding basin which regulates the flood discharge in the lower reach within an allowable level.

d) An earth embankment is adopted in principle in case of no special restriction of land use for dike construction. Existing concrete dikes are to be maintained as they are, or to be heightened in urban areas where the river channel is adjacent to a densely built-up area. The dike crown elevation is set at the H.W.L. elevation plus a freeboard as shown below.

Design discharge (m^3/s)	Freeboard (m)
less than 200	0.60
200 to 500	0.80
500 to 2,000	1.00
2,000 to 5,000	1.20
5,000 to 10,000	1.50

e) Existing bridges which have insufficient dimensions to meet the design elevation of dike crown and/or design river width, are to be improved with the 100-year design flood in principle. If the 10-year flood can be flowed with required freeboard by extension works of existing bridge length, those bridges are to be improved with the 10-year design flood.

Further details of the plan formulation criteria is presented in the Supporting Report, River Improvement Plan.

3.1.2 River Improvement Plan

The proposed river improvement plan for the upper Agno River is composed of the following three major works in view of the river regime and channel conditions:

1) Bayambang - Alcala stretch (AG181-AG321 : 22.55 km)
2) Alcala - Asingan stretch (AG321-AG414 : 30.85 km)
3) Asingan - San Manuel stretch (AG414-AG473 : 15.66 km)

(1) Alcala - Bayambang Stretch

The river improvement works in the Alcala - Bayambang stretch consist of following three components:

a) Construction of a new dike downstream of the Calvo bridge
b) Demolition of the existing Poponto inlet weir and construction of the new Poponto floodway together with channel improvement thereof
c) Construction of a new diversion channel at the bifurcation point of the floodway leading to the Bayambang stretch

The layout of the plan and typical cross-sections are illustrated in Figure 3.1.2 (1/5). Longitudinal profiles thereof are shown in Figure 3.1.3 (1/2)-(2/2). The river width and dike height are summarized in Table 3.1.1.

Diversion and Distribution Facilities

For preventing the Bayambang stretch from overtopping, the design flood discharge for the Bayambang stretch and the floodway are planned to be controlled with the following distribution:

Flood control Plan	Design flood (m^3/sec)	Diverted flood (m^3/sec)	
		Bayambang Stretch	Poponto Floodway
Framework (100-year flood)	9,200	1,000	8,200
Priority project (10-year flood)	4,000	500	3,500

Non-gated diversion channel is adopted in order to ease operation and maintenance. Fixed-weir types (Figure 3.1.20) and diversion channel types (Figure 3.1.15) were compared, and a diversion channel type was consequently adopted.

With this diversion and distribution facilities about 15% (5.0 m^3/s) of the monthly average (33 m^3/s) of the dry season river flow can be distributed to the Bayambang stretch, which fulfills the existing irrigation water use of about 2 m^3/s.

Floodway

The 1,200 m wide floodway is planned by providing a new setback levee on the right bank outside the existing 850 m wide floodway and one in the downstream part on the left bank. Widening of the floodway is required to ease fluctuation of the river bed due to scoring and to mitigate dynamic hydraulic forces acting on the right bank which might loose the stability of the guide wall structure of the right bank.

(2) Carmen Stretch in Alcala - Asingan Stretch

This stretch forms a bottleneck near the Carmen bridge with the minimum river width of 650 m in the 30.85 km long Alcala - Asingan stretch. The river improvement works consist of:

a) Enlargement of the existing low water channel; the design bed width of 150 m
b) Construction of a new setback levee which is 0.3 m higher than the existing dike height on the right bank, and to enlarge the existing minimum river width to 900 m; stretch length of 2.8 km.

c) Heightening of the existing dike

. 0.6 m for the existing 3.6 km long concrete dike on the left bank

In the Framework Plan it is a prerequisite to widen the existing river width to 900 m because of significant degradation of the river bed (about 2 m in case of 100-year flood; refer to the river fluctuation analysis in Section 2.6.4). The new setback levee on the right bank is proposed to be implemented as a part of the Priority Project because the resettlement issues after completion of the project are expected to be much more critical.

The design cross-section of the concrete dike heightening (refer to Figure 3.1.8) is adopted after comparative study with an earthdike heightening plan which involves land compensation and evacuation of the residents along the left bank. The layout of the plan and the typical cross-sections are illustrated in Figure 3.1.2 (2/5)-(3/5). The longitudinal profile is shown in Figure 3.1.3. The river width and dike height are summarized in Table 3.1.1.

(3) Asingan - San Manuel Stretch

The river improvement works in the Asingan - San Manuel stretch consist of:

a) Construction of a new setback levee on the right bank; stretch length of 7 km
b) Heightening of existing dikes
c) Improvement of the existing low water channel; downstream from AG416 at the junction of the Viray-Dipalo River

The general layout of the plan and the typical cross-sections are shown in Figure 3.1.2 (4/5)-(5/5). The longitudinal profile is shown in Figure 3.1.3. The river width and dike height are summarized in Table 3.1.1.

The new setback levee on the right bank is aligned over the paddy land aside the old river channel area in the stretch between the stretch AG470 downstream of the ARIS intake dam and the stretch AG453 at the junction of the Ambayoan River in consideration to the following technical aspects:

a) Flow velocity in this stretch is around 3.6 m/sec - 5.5 m/s for the 10-year probable flood because of its steep river gradient of about 1/200. Scouring on the toe and slope of the dikes is destructive.

b) This stretch forms braided channels which are composed of interconnected channels separated at random by sandy gravel dunes. Thus, flood flow readily spreads wide together with heavy sediment loads. In this respect, dikes and banks are exposed to severe erosion due to the water colliding.

c) Foundation of the old river areas along the existing breaches (AG421 - AG470) on the right bank is highly permeable due to sand and gravel formation therein.

The existing damaged diking system is planned to be maintained as a guide wall to prevent flood flow from colliding directly against the new setback levees.

Since the sandy gravels are heavily deposited in the upstream stretch of the junction with the Viray-Dipalo River located at the tip of the alluvial fan, maintenance works to the low water channel would not overcome the supply of heavy sediment conveyed from the upstream basin. Its improvement and training works of the low water channel is recommended to be followed after the completion of the San Roque dam which traps the majority of sediment supply inside its reservoir.

3.1.3 Principal Design Features

(1) Design Channel Features of the River Improvement Plan

Principal features of the design channel are shown in Table 3.1.1 and are summarized below:

Stretches	Bayambang - Alcala	Floodway	Alcala -Asingan	Asingan -San Manuel
Design discharge(m^3/s)	500	3,500	4,000-3,500	3,500-2,400
River width(m)	1,300-250	1,200	3,000- 900	3,000- 300
Gradient of channel bed	1/1,850	1/1,600	1/1,600-665	1/665- 230
Channel bed width(m)	100	150	150	Existing
Design water depth(m)	7.85-3.79	8.78-5.85	5.85	5.85-3.30

The typical cross-sections are illustrated in Figure 3.1.4 (1/3)-(3/3) respectively.

The items of river improvement works in the Priority Project area are summarized as follows:

- New dike construction	:	46.00 km earthdike and 7.70 km setback levee
- Heightening of dike	:	29.50 km earthdike and 2.50 km concrete dike
- Counterweight earthdike	:	42.00 km
- Channel improvement	:	48.20 km
- Revetment	:	23.20 km for low-water channel 37.30 km for earthdike
- Groins	:	10.55 km
- Drainage facilities	:	18 sluiceways
- Diversion structures	:	Bayambang diversion channel
- Irrigation facilities	:	2 box culverts with gates of the LAIS
- Bridges	:	3 road bridges (Calvo/Floodway/Plaridel) and 2 railway bridges demolished

The quantities of dikes and channel improvement, and drainage facilities are listed in Table 3.1.2 and Table 3.1.3 respectively.

The standard design features of dikes, revetment, sluice, and other related structures adopted for the Upper Agno River Improvement Works are shown in the figures listed in Table 3.1.4. The work quantities are summarized in Table 7.3.1.

(2) Alternative Alignment of Alcala Closing Dike

In order to distribute the design flood discharge of 4,000 m^3/sec to the Bayambang stretch (500 m^3/sec) and the Poponto Floodway (3,500 m^3/sec) a closing dike is to be provided across the Alcala stretch near the bifurcation point. Among the following two alternative alignments, Alignment-1 is proposed to be adopted:

Alignment-1; A bended closure dike is provided as an extension of the right bank of the Poponto floodway. With this closure dike the majority (3,500 m^3/sec) of the flood runoff of the Agno River can be directly diverted to the Poponto floodway (refer to Figure 3.1.2 (1/5)).

Alignment-2; A closure dike is provided perpendicular to the Agno main stream at about 3.0 km downstream of the existing bifurcation point. With this closure dike kinematic energy of the flood runoff from upstream can be dissipated in dead water between the closure dike and the bifurcation point, before diverting to the Poponto floodway (refer to Figure 3.1.21).

Advantages and disadvantages of the two alignments are summarized below.

Technical Points	Alignment-1 (upstream)	Alignment-2 (downstream)
a. River Hydraulics	. direct flow pressure on the closure dike . smooth flow into the floodway	. indirect flow pressure on the closure dike . turbulent and eddy flow due to dead water
b. Stability of Closure Dike	. water pressure on the closure dike . heavy scouring on the slope and toe of the closure dike . deep sand foundation requires seepage and bearing treatment	. partial deep sand foundation
c. Maintenance of the Low Water Channel Leading to Bayambang	. minor dredging/excavation of expected sediment . partial structural reinforcement	. periodical dredging/excavation of expected sediment . structural reinforcement to maintain channel stability

Main construction costs and design features of the two alternatives are summarized below.

Particulars	Alignment-1 (upstream)	Alignment-2 (downstream)
a) Main Construction Cost	₱167.2 millions	₱211.5 millions
b) Design Features		
. Closing dike length including protection works	3,370 m	1,100 m
. Low water channel excavation length	1,700 m	2,200 m
. Revetment for low water channel	2,700 m	7,700 m
. Revetment for high water channel	-	2,800 m
. Groyne	400 m	400 m
. Heightening of the existing dike (m)	-	6,800 m

Though the Alternative-1 is adopted in this stage, it is recommended to execute a laboratory hydraulic model test for finalizing the alignment and dimensions in the detailed design stage.

(3) Alternative Alignment in Carmen Stretch

Among the following two alternatives, Alternative-1, a new setback levee is proposed to be retained:

Alternative-1; A new setback levee alignment on the right bank (refer to Figure 3.1.2 (2/5)).

Alternative-2; Improvement of the existing dike (refer to Figure 3.1.22).

Advantages and disadvantages of the two alternatives are summarized below.

Technical Points	Alternative-1: New Setback Levee	Alternative-2: Existing Dike
a. River Hydraulics	. more stable hydraulic condition . water level lowered by 0.5 m under a 100-year flood . flow velocity of less than 2.0 m^3/sec	. hydraulic bottleneck . significant river bed degradation, and local scouring around piers and revetment toes, particularly under 100-year flood
b. Dike stability	. better foundation and less scouring	
c. Social Impact	. land acquisition and house evacuation in the commercial area in Villasis	. no right-of-way issues in the Priority Project but very serious impact in implementing the Framework Plan

Main construction and compensation costs, and design features of the two alternatives are summarized below.

Particulars	Alternative-1: New Setback Levee	Alternative-2: Existing Dike
a) Project Cost		
Framework Plan (100-year flood)		
. Main Construction cost	₱481.8 millions	₱579.8 millions
. Compensation cost	₱ 85.1 millions	-
	₱566.9 millions	₱579.8 millions
Priority Project (10-year flood)		
. Main Construction cost	₱ 65.2 millions	₱137.4 millions
. Compensation cost	₱ 85.1 millions	-
total	₱150.3 millions	₱137.4 millions
b) Social Impact		
. Land acquisition	0.556 km^2	-
. Resettlement of buildings	184	-
. Extension of bridge	250 m	-
c) Design Features for 10-year Design flood		
. Setback embankment	2,800 m	-
. Heightening of dikes	-	2,800 m
. Revetment for low water channel	2,300 m	-
. Revetment for dikes	3,400 m	3,400 m
. Steel sheet piling for dikes	-	1,000 m
. Groyne	300 m	600 m
. Protection works for low water channel	-	2,300 m
. Gabion mattress for high water channel	-	$1{,}000^m \times 20^m$
. River bed protection works around the bridge piers	-	$150^m \times 50^m$
. Ground sill	-	1
d) River Bed Fluctuation in 100-year Design Flood		
. Average degradation	80 cm	160 cm

(4) Alternative Alignment in San Manuel Stretch

Among the following two alternatives, Alternative-1, a new setback levee is proposed to be adopted:

Alternative-1; A new setback levee is provided alongside the traces of old river courses where impervious top soils exist (refer to Figure 3.1.2 (4/5 - (5/5)). The existing dike will be utilized as a guide wall to prevent flood flow from directly striking against the new setback levee.

Alternative-2; The existing dike is reinforced and new dikes on the alignment of the breached stretches are provided (refer to Figure 3.1.23).

Advantages and disadvantages of the alternatives are summarized below.

Technical Points	Alternative-1: New Alignment	Alternative-2: Existing Alignment
a. River Hydraulics	. weakened scouring and colliding hydraulic forces	. scouring and colliding hydraulic forces (flow velocity 4 m^3/sec) directly imposed on the dike slope and toe
b. Dike Stability	. higher structural stability because of better foundation conditions and less hydraulic forces	. heavy foundation treatment against seepage . heavy revetment and toe protection against scouring
c. Social Impact	. land acquisition of 600 ha and evacuation of 710 houses	. no right-of-way issues

Main construction and compensation costs, and design features of the two alternatives are summarized below.

Particulars	Alternative-1: New Alignment	Alternative-2: Existing Alignment
a) Main Construction Cost	₱171.7 millions	₱311.1 millions
Compensation Cost	₱ 46.8 millions	-
total	₱218.5 millions	₱311.1 millions
b) Social Impact		
. Land acquisition	6 km^2	-
. Resettlement of houses	712	-
c) Design Features		
. Setback embankment	7,600 m	-
. Embankment	-	5,600 m
. Dike protection works		
Type I	3,700 m	-
Type II	1,800 m	3,300 m
Type III	1,500 m	-
Type V	-	5,200 m
. Channel protection works, type D	-	2,100 m

(5) Inner-Water Drainage in Alcala Area

With provision of the Poponto floodway right dike and the Bayambang left dike, inner-water in the Alcala area is confined inside a drainage area of about 12 km^2.

The present land use in this area is classified as mostly paddy field and residential land. The former is in the area around the ground elevation from 13.0 m to 17.0 m, the latter has the ground elevation from 15.5 m to 16.0 m (M.S.L.). On the other hand the water levels of 5-year and 10-year probable floods in the Poponto natural retarding basin are 14.1 m and 15.6 m respectively.

The inner-water drainage system with 4 drainage gates and the mound construction with a 15 m top elevation are proposed to mitigate submergence damages.

3.2 Poponto Retarding Basin Plan

3.2.1 Retarding Basin Plan

(1) Definition of Retarding Basin Plan

The Poponto retarding basin naturally regulates the flood inflows from the upper Agno and Tarlac Rivers without specific flood control facilities other than the construction of the dikes on both abutments of the Wawa bridge. The works involve protection and evacuation measures for the residents and heightening and renovation of the existing roads and bridges in the affected Poponto swamp area due to raising of the flood water level from the existing condition.

The maximum high water level of the existing Poponto swamp is simulated to be around El. 14.50 m for the 10-year design flood case. This water level is expected to be raised up to the design high water level of El. 16.00 m in the case with the river improvement works of the upper Agno because all the flood runoff in the upstream is confined inside the new dike system as illustrated in Figure 3.2.1. The inundation area will increase from 124 km^2 to 203 km^2. The affected number of buildings and houses will increase from 4,420 to 11,390 including the public facilities while the affected population will increase from 26,000 to 68,000. Agricultural land and swamp area, and residential and commercial area amounts to 97% and 3% of the inundation area respectively.

Of the affected population of 68,000, 44,000 residents (65%) are planned to be protected by ring levees. The remaining 35% are planned to be resettled to either planned mounds, to the areas inside the ring levee, or to the areas outside the retarding basin. The general plan of these measures is presented in Figure 3.2.2. The mobilization plan of resettlement is illustrated in Figure 3.2.3.

(2) Design High Water Level and Freeboard of Retarding Basin

The design high water level, H.W.L 16.00 m is adopted for the Poponto retarding basin under the following conditions:

. The 10-year design flood (at the Wawa base point)

- The flood runoff from the upper Agno River is discharged into the swamp through the new floodway and no overtopping from the existing dike system is allowed at the Bayambang stretch.
- The existing river channel below the Wawa bridge is kept open but the road across the Agno River is heightened to El. 16.60 m.
- The Balog-Balog and San Roque dams are assumed to be existing.
- Horizontal sediment volume of 50 years (261 x 10^6 m^3) is assumed as the dead storage.

The crest elevation of the ring levee is set at El. 17.20 m with a 1.2 m freeboard over the H.W.L 16.00 m while the top elevation of the mound for resettlement is set at El. 16.60 m with a 0.6 m freeboard against wind waves over the H.W.L 16.00 m.

3.2.2 Land Use, Resettlement and Compensation

The affected land use, population, and infrastructures in the expected inundation area of the Poponto retarding basin are roughly estimated for the high water level of El. 16.00 m as summarized below:

a) Affected Residents

Municipality	Inundation Area (km^2)	Number of Houses	Population
Moncada	104.1	5,530	33,180
Bautista	39.3	780	4,680
Paniqui	32.4	4,260	25,740
Camiling	21.7	440	2,640
Bayambang	2.5	370	2,220
Alcala	1.7	10	60
Anao	1.3	0	0
Total	203.0	11,390	68,340

b) Affected Infrastructures

Road	National	9.0 km
	Provincial	7.5 km
	Municipal	10.5 km
	Barangay	24.5 km

Bridge	San Isidro (length 62.4 m, width 6.9 m)	
	Camangahan (box curvert)	
	Morong (length 30.0 1m, width 6.9 m)	
Rail Road	(non-operational)	23.3 km

c) <u>Affected Land</u>

Agriculture	Irrigated Paddy	8.7 km^2
	Rainfed Paddy	122.0 km^2
	Sugar Cane	7.5 km^2
	Corn	25.8 km^2
	Tobacco, root crops	
	Lagume	32.7 km^2
Fish pond		0.8 km^2
Residential/Commercial		5.5 km^2

The high water level of the existing retarding basin without the project is estimated to be around El. 14.50 m for the 10-year design flood. The corresponding inundation area and affected quantities of houses, residents, and infrastructures are roughly estimated in Table 3.2.1 for comparison.

3.2.3 Protection Measures and Resettlement

The residents inside the retarding basin are planned to be protected by either ring levees or resettlement as summarized below.

Protection Measures	Number of Houses	Number of Residents	Share (%)
1) Ring levees	7,430	44,580	65
2) Resettlement			
a) Resettlement to the planned mounds	640	3,840	6
b) Resettlement to the areas inside the ring levees	2,120	12,720	19
c) Resettlement to the areas outside the retarding basin	1,200	7,200	10
Total	11,390	68,340	100

Heightening of roads and improvement of bridges are planned. The rail road is kept untouched because of no concrete operation plans at present.

(1) Ring Levees

Ring levees are provided for Bautista, Moncada, and Paniqui municipalities as set out below. The locations and alignment are illustrated in Figure 3.2.2.

Municipality	Municipality Barangay	Protected Area (Km^2)	Levee Length (Km)	Protected Houses (Nos.)
Bautista	Poponto	0.11	1.49	240
Moncada	Moncada	5.07	9.76	3,530
	Tubectubang	0.12	1.40	240
	San Julian	0.69	4.20	430
Paniqui	Paniqui	2.09	3.78	360
	Ines	0.14	1.92	250
	Pance	0.10	1.98	550
	Salomague	0.39	3.70	500
	Baladang	0.20	1.70	450
	Ventemilla	3.17	6.78	880
Total		12.08	36.71	7,430

The design features of the ring levee are

- . Crest elevation El. 17.20 m
- . Crest width 6.0 m
- . Slope 1:3.0
- . Freeboard against wind, etc. 120 cm
- . Sod facing
- . Gravity type inland drainage facility 5-year design flood

The work quantities of the ring levee plan are shown in Table 3.2.2.

(2) Resettlement Program

Resettlement program is prepared for the residents who can not be protected by ring levees. The inundation area, other than those protected by the ring levee plan, is divided into 14 blocks (from A to N). The appropriate resettlement program is formulated for each block from the three types. The mobilization flow of the resettlement is illustrated in Figure 3.2.2.

(3) Mounds for Resettlement

Mound construction is planned for the residents of Barangay Spang and San Isidro as set out below.

The locations and alignment are illustrated in Figure 3.2.2.

Municipality	Barangay	Acreage of Mound (m^2)	Resettled Houses (Nos.)
Moncada	Spang	111,000	480
Paniqui	San Isidro	40,000	160
Total		151,000	640

The design features of the mound are

- . Crest elevation El. 16.00 m
- . Slope 1: 3.0
- . Freeboard 60 cm
- . Sod facing

The work quantities of the Mound construction plan are shown in Table 3.2.3.

(4) Road Heightening

Heightening is planned for the selected major road systems as setout below. The subject parts are illustrated in Figure 3.2.2.

Road Class	Route	Length (km)	Width (m)	Type of Pavement	Maximum Heightening (m)
National	Moncada-Paniqui	5.3	7.3	Asphalt	1.40
Provincial	Babilang-Paniqui	4.4	6.1	Concrete	1.45
	Aman Casiling -San Vicente	1.6	7.3	Asphalt	3.60
Municipal	Sapang-Moncada	6.9	5.5	Gravel	2.60

The crest elevation of the road is set at El. 16.60 m with a freeboard of 60 cm. The work quantities of the road heightening are shown in Table 3.2.4.

(5) Bridge Improvement

Improvement works of the three affected bridges are planned as setout below. Their locations are illustrated in Figure 3.2.2.

Bridge	Existing condition	Plan
Extension of San Isidro Bridge	Top elevation El. 16.5 m Length 35.0 m	Top elevation El. 16.5 m Extension length 22.0 m
Replacement of Camangahan Bridge with New one	Top elevation El. 15.4 m Box culvert 4.00m x 2.20m x 1	Top elevation El.16.6 m New bridge length 21.0 m
Replacement of Morong Bridge with a new dike	Top elevation El. 16.3 m Length 30.1 m	Top elevation El. 16.6 m Box culvert 4.0 x 20 x 2

The bottom elevation of the Wawa bridge girder is El. 17.85 m, which provides 1.85 m clearance to the H.W.L 16.00 m, and thus replacement of the bridge will not be required unless the Framework Plan is implemented.

Table 3.1.1 CHANNEL DESIGN FEATURES OF UPPER AGNO RIVER

River:Agno River
Design Flood: 10-yr

Item	Unit	Retarding AG.181- FW.314	Floodway FW.314- FW.320B	Bayambang AG.282B -AG.307	Agno R. FW.320B -AG.351
Discharge	m3/s	-	3500	500	4000
Length of Stretch	m	7100	3800	9640	15930
Gradient of Channel Bed	-	1/1600	1/1600	1/1850	1/1600
River width	m	-	1200	250-1300	900-1900
Width of Channel Bed	m	150	150	80-100	150
Gradient of H.W.L	-	Level	1/1600	1/1680	1/1600
Dike Height (Ave.)	m	4.00	3.05	2.05	3.05
Water Depth	m	8.78-5.85	5.85	5.85	5.85
Low Channel Depth (Ave.)	m	4.00	4.00	5.00	4.00

Item	Unit	Agno R. AG.351- AG.367	 AG.367- AG.414	 AG.414- AG-453	 AG.453- AG.460
Discharge	m3/s	3500	3500	3500	2400
Length of Stretch	m	8170	8150	5330	3120
Gradient of Channel Bed	-	1/1300	1/665	1/440	1/280
River Width	m	1250-3000	3000-2000	2000-1200	1500-3000
Width of Channel Bed	m	150	150	100/Exist.	Existing
Gradient of H.W.L	-	1/1300	1/665	1/440	1/280
Dike Height (Ave.)	m	2.80	2.50	2.20	1.50
Water Depth	m	5.85-430	4.30	4.00	3.30
Low Channel Depth (Ave.)	m	3.50	3.00	3.00	3.00

Item	Unit	Agno R. AG.460- AG.464	 AG.464- AG.469	 AG.469- AG.474
Discharge	m3/s	2400	2400	2400
Length of Stretch	m	1990	2420	2800
Gradient of Channel Bed	-	1/230	1/230	1/230
River Width	m	3000-2200	2200-1100	1100-300
Width of Channel Bed	m	Existing	Existing	Existing
Gradient of H.W.L	-	1/230	1/180	1/230
Dike Height (Ave.)	m	1.50	1.70	1.20
Water Depth	m	3.30	3.30-4.70	4.70-5.30
Low Channel Depth (Ave.)	m	3.00	3.50	5.00

Table 3.1.2 SUMMARY OF DIKE CONSTRUCTION AND LOW-WATER CHANNEL IMPROVEMENT WORKS IN UPPER AGNO RIVER

(Unit : km)

Stretch	Bayambang-Alcala		Alcala-Asingan	Asingan-San Manuel	Whole
	Bayambang (L=9.64)	Floodway (L=12.30)	AG321 - AG414 (L=30.85)	AG414 - AG474 (L=20.26)	(L=68.45)
DIKE CONSTRUCTION					
(Right Dike)					
New Dike	4.80	9.50 (SB=2.4)	10.45 (SB=2.8)	9.05	38.80
Heightening	0.00	2.40	10.00	3.55	15.95
Existing	7.45	0.65	10.90	2.85	21.85
No Diking Sys.	0.00	0.00	0.00	0.00	0.00
(Left Dike)					
New Dike	4.90	2.50 (SB=2.5)	12.50 <1	0.00	19.90
Heightening	0.00	0.00	16.05	0.00	16.05
Existing	4.00	3.00	13.40	0.00	20.40
No Diking Sys.	0.00	0.00	0.00	14.31	14.31
(Total)					
New Dike	9.70	12.00 (SB=4.9)	22.95	9.05	58.70
Heightening	0.00	2.40	26.05	3.55	32.00
Existing	11.45	3.65	24.30	2.85	42.25
No Diking Sys.	0.00	0.00	0.00	14.31	14.31
LOW-WATER CHANNEL IMPROVEMENT					
New Channel	2.50	5.50	0.00	0.00	8.00
Enlargement	1.20	6.80	30.40	0.00	38.40
Cut off	0.00	0.00	1.80	0.00	1.80
Existing	5.94	0.00	0.00	14.31	20.25

Note : SB : Set Back LEVEE
<1 : Including Back water Dike of Tributaries (L=9.50)

Table 3.1.3 LIST OF NEW DRAINAGE FACILITIES IN UPPER AGNO RIVER

Stretch	Location (Sta.)		Drainage Area (km2)	Facility	
				type	B x H x Pcs.
Bayambang	AG.180	(R)	5.0	Sluice way	2.0 x 2.0 x 2
	AG.282A +300 m	(L)	4.8	Sluice way	2.0 x 2.0 x 2
	AG.290	(L)	0.6	Sluice way	D = 0.8
	AG.293 + 100 m	(R)	1.3	Sluice way	1.5 x 1.5 x 1
	AG.298	(L)	1.8	Sluice way	2.0 x 2.0 x 1
	AG.299	(R)	3.3	Sluice way	2.0 x 2.0 x 2
Floodway	AG.286 +1200 m	(R)	9.2	Sluice way	2.0 x 2.0 x 4
	FW.314	(R)	2.7	Sluice way	2.0 x 2.0 x 2
Floodway-Asingan	AG.321	(L)	0.7	Sluice way	1.5 x 1.5 x 1
	AG.325 + 350 m	(L)	1.4	Sluice way	1.5 x 1.5 x 1
	AG.336 + 300 m	(L)	0.4	Sluice way	D = 0.8
	AG.352	(L)	2.0	Sluice way	2.0 x 2.0 x 1
	AG.359 + 200 m	(L)	0.8	Sluice way	1.5 x 1.5 x 1
	AG.368 + 200 m	(L)	3.4	Sluice way	2.0 x 2.0 x 2
	AG.368 + 400 m	(R)	0.3	Sluice way	D = 0.8
	Banila R.	(R)	0.5	Sluice way	D = 0.8
	Banila R.	(R)	0.3	Sluice way	D = 0.8
Asigan-San Manuel	AG.409	(R)	3.8	Sluice way	2.0 x 2.0 x 2

Note; B: Width (m), H: Heigh (m), D: Diameter (m)

Table 3.1.4 DESIGN FEATURES OF FLOOD CONTROL FACILITIES FOR UPPER AGNO RIVER (1/2)

Classification	Title	Description	Figure No.
Dike	- STANDARD DESIGN SECTION OF AGNO RIVER EARTH DIKE	- Standard sections applied to newly constructed dikes and those that require raising.	3.1.5
	- STANDARD DESIGN OF COUNTERWEIGHT FILL AGAINST LIQUEFACTION	- Determined by the slip circular stability and liquefaction analysis. Horizontal seismic coefficient 0.15.	3.1.6
	- STANDARD DESIGN SECTION OF BAYAMBANG CLOSING DIKE	- Section features and protection works	3.1.7
	- DESIGN SECTION OF CONCRETE FLOODWALL DIKE	- Heightening of the existing concrete gravity dike in the Carmen stretch.	3.1.8
Revetment and Foot Protection Groin	- PROTECTION WORKS FOR RIVER DIKE (I)	- {Type-I} For the set back levee in AGR 472 to AGR 456 {Type-II} AGR 456 to AGR 369 {Type-IV} Existing Dikes in AGR 470 to AGR 466 {Type-III} All other stretches	3.1.9
Revetment and Spur Dike	- PROTECTION WORKS FOR RIVER DIKE (II)	- Protection for the existing dikes in AGR 470 to AGR 466	3.1.10
	- PROTECTION WORKS FOR RIVER DIKE (III)	- Spur dikes provided for eroded dikes in the lower reaches from the Carmen bridge.	3.1.11

Table 3.1.4 DESIGN FEATURES OF FLOOD CONTROL FACILITIES FOR UPPER AGNO RIVER (2/2)

Classification	Title	Description	Figure No.
Revetment	- PROTECTION WORKS FOR LOW-WATER CHANNEL BANK (I)	- Wet stone masonry type for the channel bank close to the dike & Gabion cylinder type for the low water channel.	3.1.12
	- PROTECTION WORKS FOR LOW WATER CHANNEL BANK (II)	- Provided in the San Manuel stretch against extraordinarily high scouring.	3.1.13
Groyne	- STANDARD DESIGN OF GROYNE (PILE TYPE)	- Pile type groynes for the bank protection and flow control structures in the low water channel except the Asingan-San-Manuel stretch.	3.1.14
Diversion Channel	- BAYAMBANG DIVERSION CHANNEL	- The distribution channel across the closing dike.	3.1.15
Sluice	- STANDARD DESIGN OF SLUICE (AGNO RIVER TYPE C2 AND D)	- Drainage and intake sluices were classified into 7 types; A, B, C1, C-2, C-3, C-4, and E depending on discharge capacity.	3.1.16
	- STANDARD DESIGN OF SLUICE WAY IN AGNO RIVER AND POPONTO SWAMP (TYPE-A)	- (Planned number of sluice way); Agno River - 18 Poponto swamp - 10	3.1.17
Box Culvert	- STANDARD DESIGN OF BOX CULVERT	- 10 box culverts to be reconstructed for the road raising around the Poponto swamp	3.1.18
Road	- ROAD RAISING DESIGN AND PAVEMENT	- The same design features of the existing roads are adopted.	3.1.19

Table 3.2.1 POPULATION AND PROPERTIES IN THE EXPECTED INUNDATION AREA OF THE POPONTO SWAMP

	PRESENT CONDITION	PRIORITY PLAN
Probable Flood	10-year	10-year
H.W.L.	El. 14.5 m	El. 16.0 m
Inundation Area (km2)	124.0	203.0
Number of House	4,420	11,390
Population	26,520	68,340
National Road (km)	0	9.0
Provincial Road (km)	0	7.5
Municipality Road (km)	8.5	10.5
Railroad (km)	0.5	23.3
Agricultural Land (km2)	117.3	196.7
Fish Pond (km2)	0.4	0.8

Table 3.2.2 WORK QUANTITIES OF RING LEVEE

Name of Municipality	Location	Catchment Area (km²)	Length (km)	Height (m)	Embankment (m³)	Riverwall (m³)	Turf (m²)	Gutter (km)	Drainage facility	Land (m²)
BAUTISTA	POPONTO	0.11	1.49	2.3	44,200	-	21,700	1.49	. 800x2 . 800x1	29,500
MONCADA	MONCADA	5.07	9.76	1.3-2.3	281,500	-	143,800	9.76	.20x20x2 .20x20x1	203,200
	TUBECTUBANG	0.12	1.40	2.3-2.8	44,300	-	21,200	1.40	. 800x2 . 800x1	28,500
	SAN JULIAN	0.69	4.20	1.8	86,200	-	47,800	4.20	.1.5x1.5x1 .1.5x1.5x1 . 800x1	70,600
PANIQUI	PANIQUI	2.09	3.78	0 - 1.8	64,200	-	36,800	3.78	.2.0x2.0x1 .2.0x2.0x1	57,600
	INES	0.14	1.92	2.3	57,000	1,200	27,000	1.92	. 800X2	38,000
	PANCE	0.10	1.98	1.8	40,600	3,000	22,500	1.98	. 800x2	33,300
	SALOMAGUE	0.39	3.70	1.8	75,900	-	42,100	3.70	. 800x1 . 800x1 . 800x2	62,200
	BALAOANG	0.20	1.70	2.3	50,400	750	24,700	1.70	. 800x1 . 800x2	33,700
	VENTEMILLA	3.17	6.78	1.3-3.3	196,100	-	92,800	6.78	.2.0x2.0x2	128,700
TOTAL		12.08	36.71		940,400	4,950	481,300	36.71	-	685,300

Table 3.2.3 WORK QUANTITIES OF MOUNDS CONSTRUCTION

Name of Municipality	Location	Area of mound (m²)	Height (m)	Embankment (m³)	Turf (m²)	Land (m²)
MONCADA	SAPANG	111,000	3.60	429,000	17,200	127,800
PANIQUI	SAN ISIDRO	40,000	1.60	67,000	3,100	43,000
TOTAL				469,000	20,300	170,800

Table 3.2.4 WORK QUANTITIES OF ROAD HEIGHTENING

Class	Section	Length (km)	Type	Width (m)	Embankment (m³)	Pavement area (m²)	Land (m²)	Box culvert
National road	Moncada-Paniqui	5.3	Asphalt	7.3	124,000	38,690	17,300	4.5mx2.2m - 12 2.4mx1.8m - 4
Provincial road	Babilang-Paniqui	4.4	Concrete	6.1	38,000	26,840	2,400	-
	Amancacilling -San Vicente	1.6	Asphalt	7.3	121,000	11,680	16,500	-
Municipal road	Sapang-Moncada	6.0	Gravel	5.5	227,000	37,950	53,000	4.5mx2.2m - 2

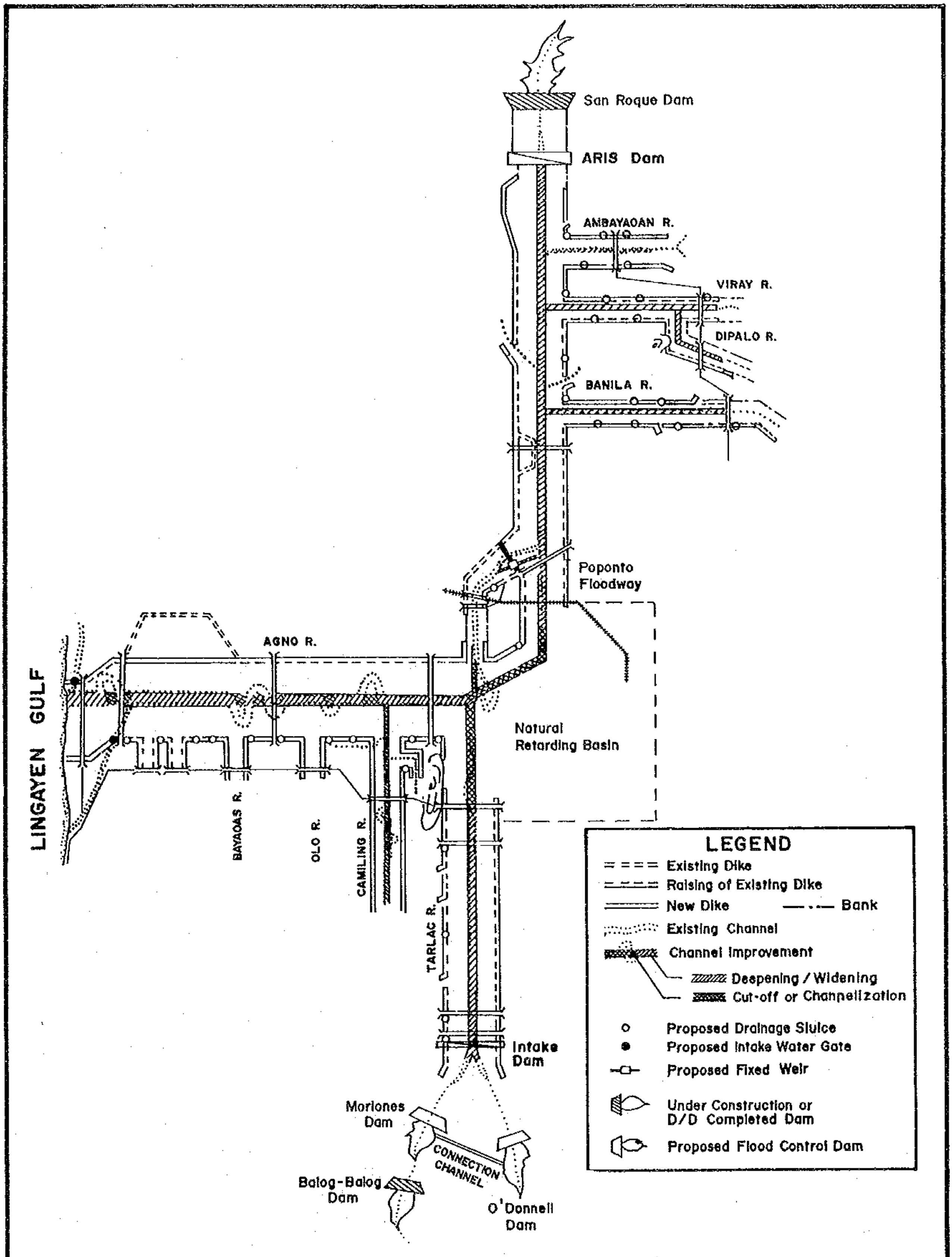


Fig. 3.1.1 GENERAL LAYOUT OF AGNO RIVER IMPROVEMENT FOR FRAMEWORK PLAN

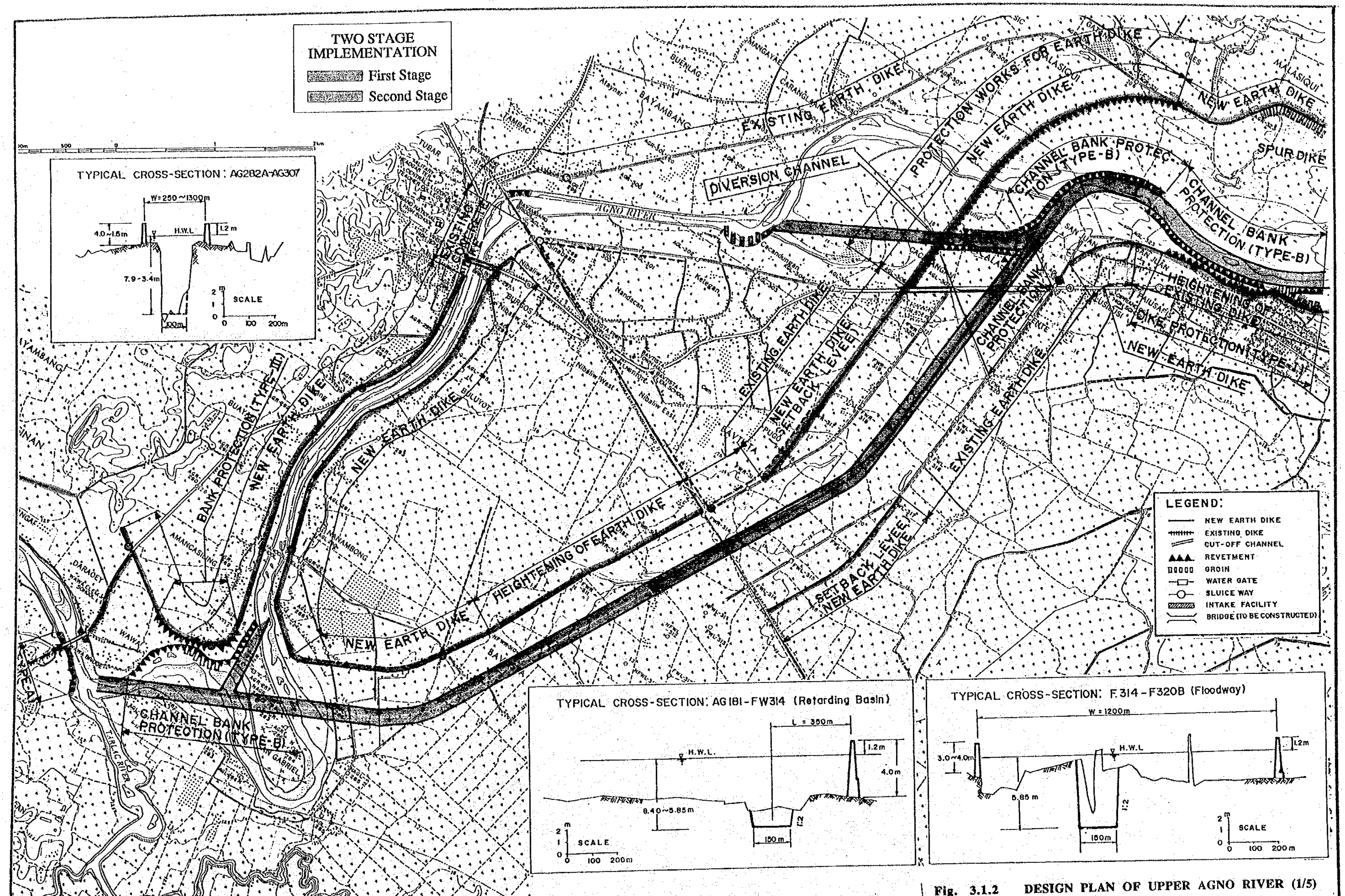


Fig. 3.1.2 DESIGN PLAN OF UPPER AGNO RIVER (1/5)

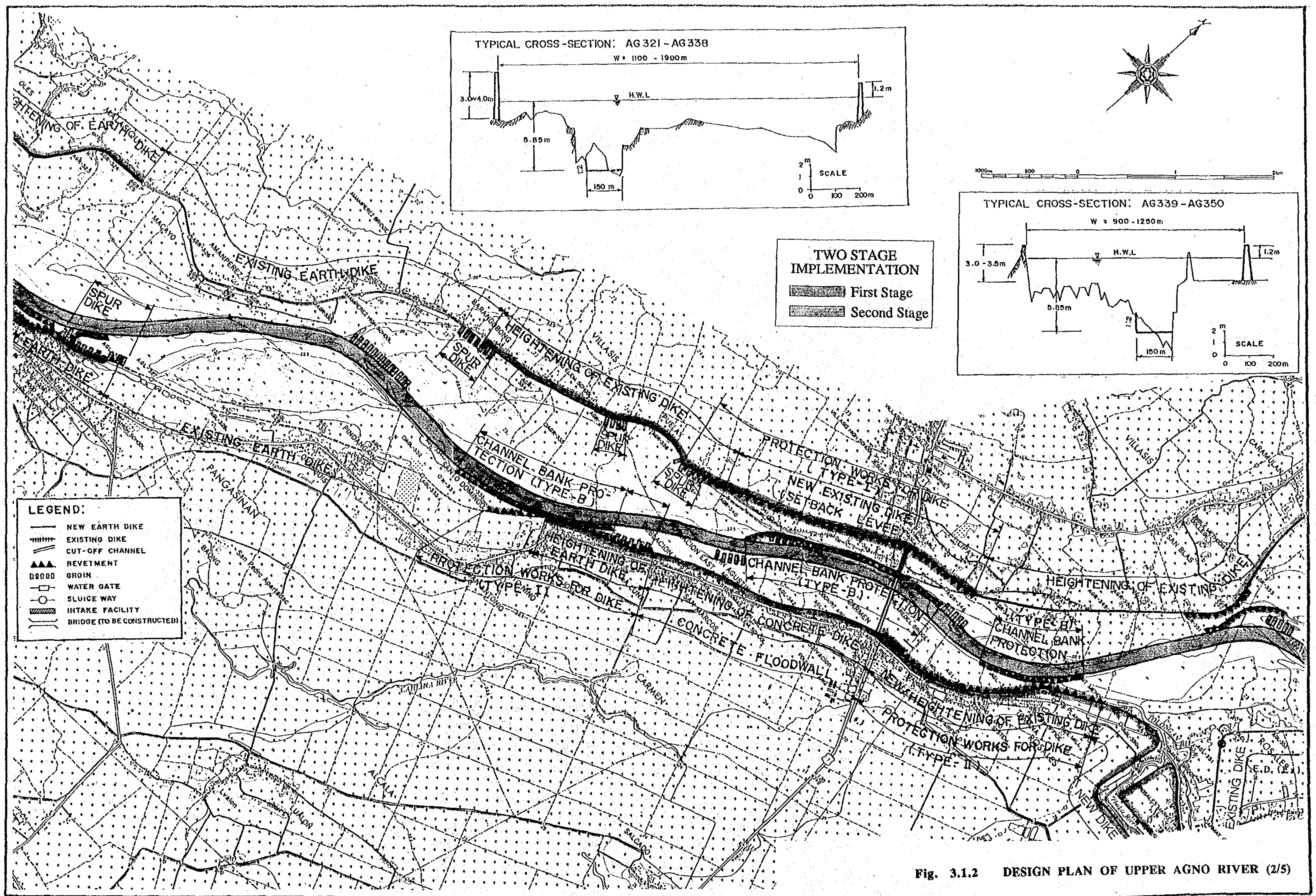


Fig. 3.1.2 DESIGN PLAN OF UPPER AGNO RIVER (2/5)

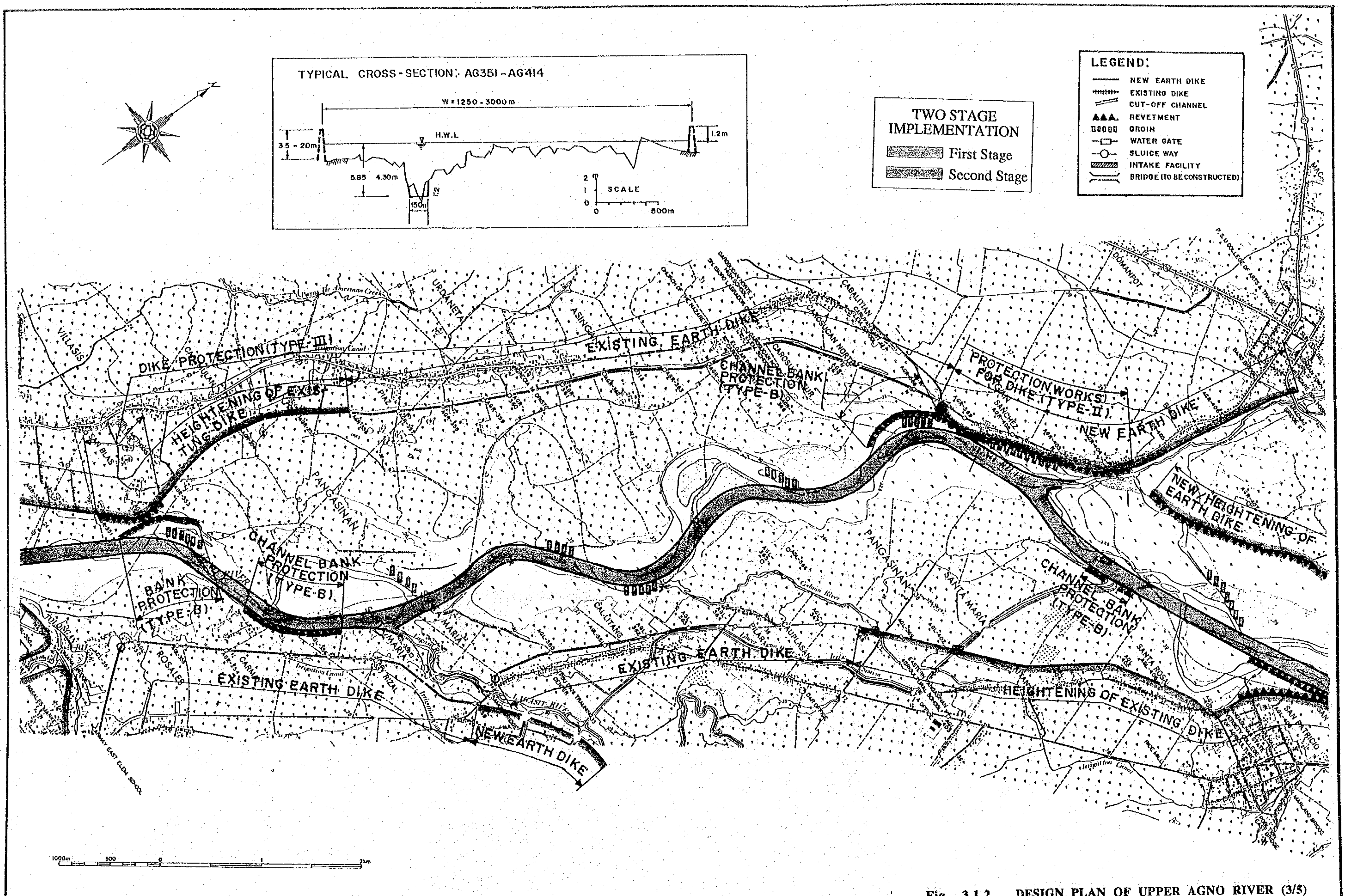


Fig. 3.1.2 DESIGN PLAN OF UPPER AGNO RIVER (3/5)

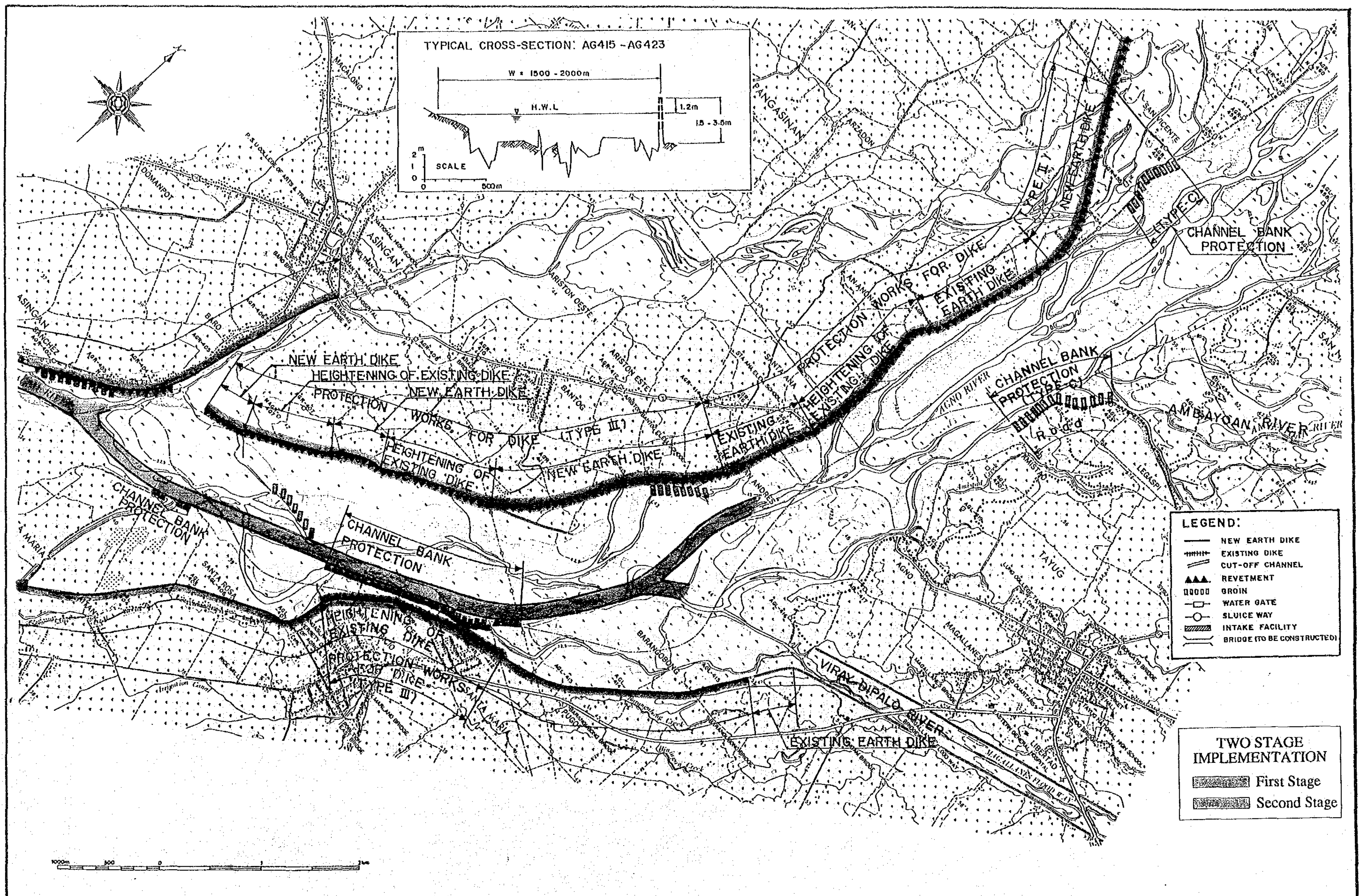


Fig. 3.1.2 DESIGN PLAN OF UPPER AGNO RIVER (4/5)

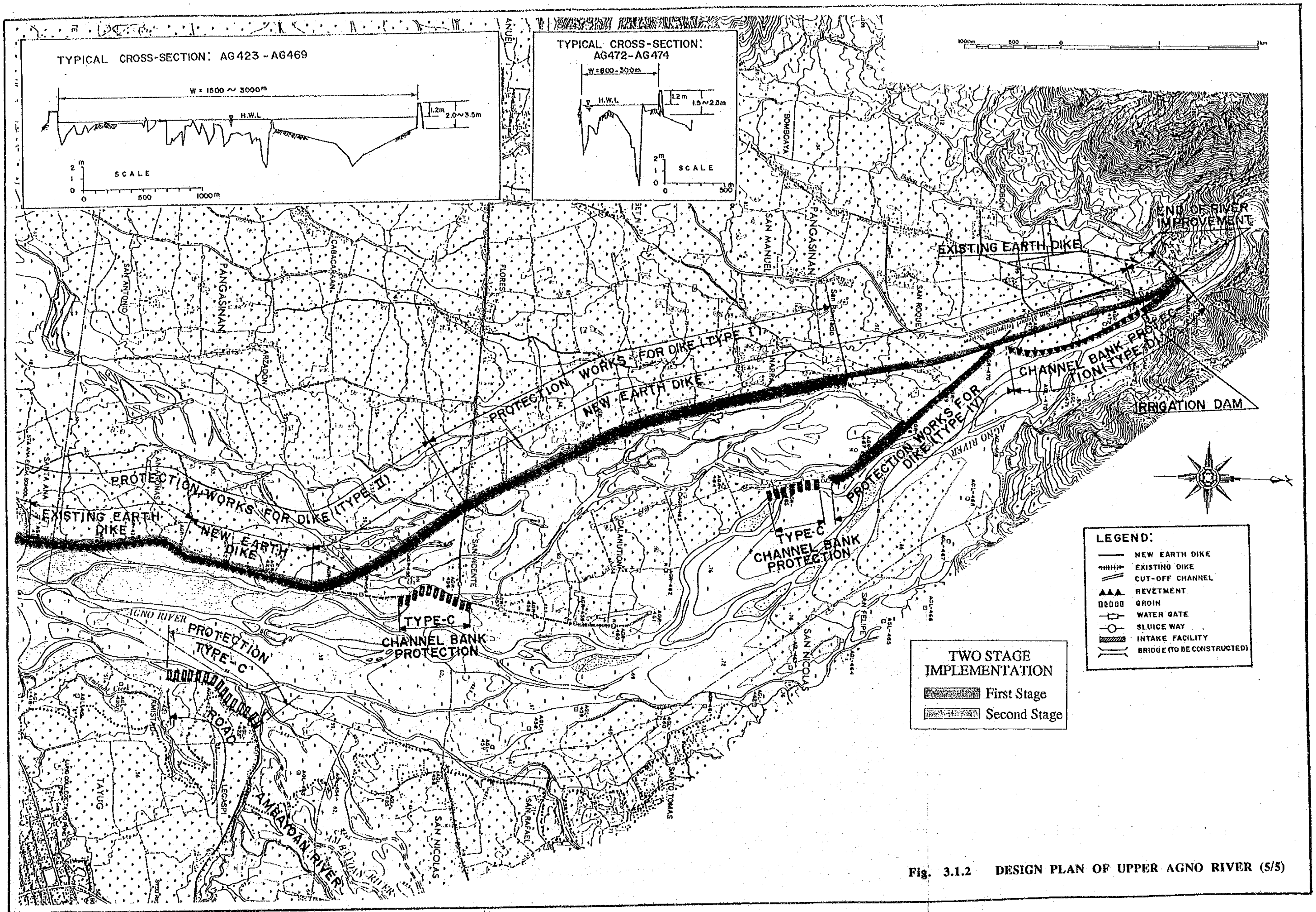
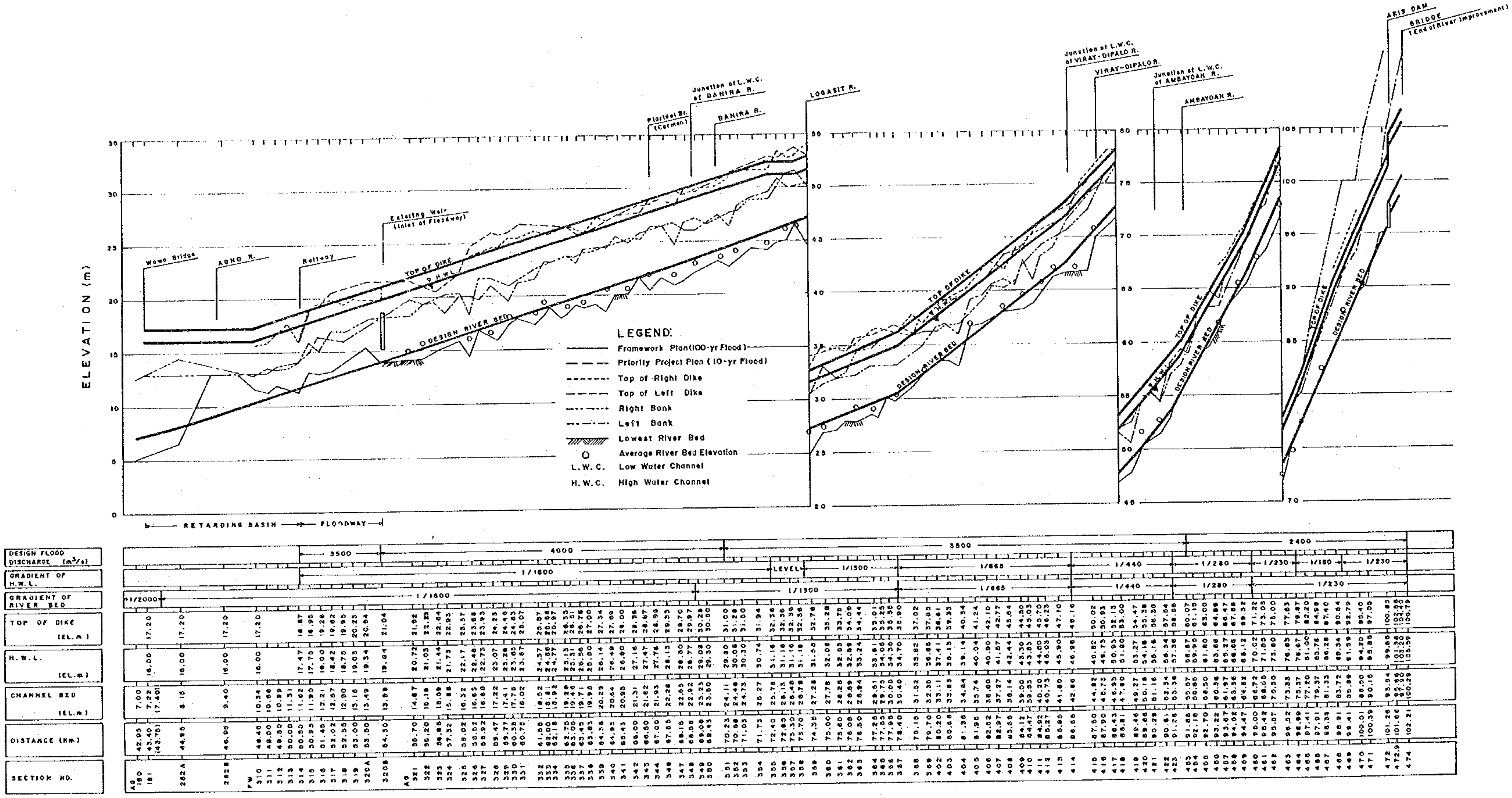
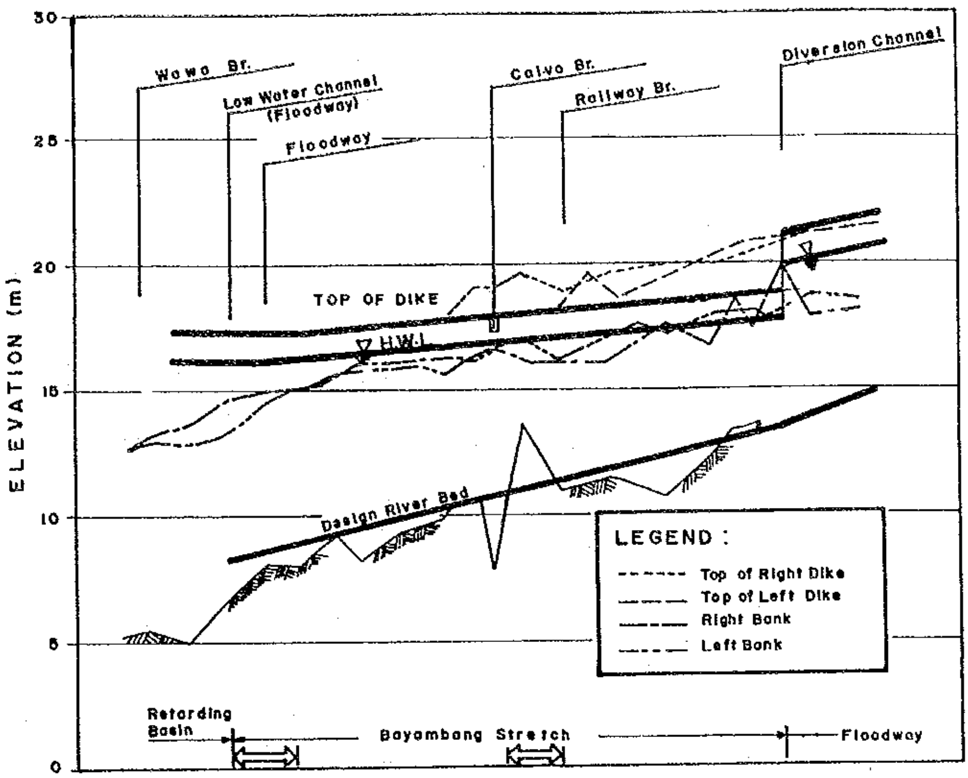


Fig. 3.1.2 DESIGN PLAN OF UPPER AGNO RIVER (5/5)



NOTE: NO LOW-WATER CHANNEL IMPROVEMENT IN STRETCH FROM AG416-AG474 FOR PRIORITY PROJECT.

Fig. 3.1.3 LONGITUDINAL PROFILE OF UPPER AGNO RIVER (1/2)



DESIGN FLOOD DISCHARGE (m^3/s)	500 (Section 282A to 307)
GRADIENT OF H.W.L.	LEVEL (Section 181 to 288); 1/6000 (Section 288 to 307)
GRADIENT OF RIVER BED	1/1850 (Section 282A to 307)

SECTION NO.	DISTANCE (Km.)	CHANNEL BED (EL. m.)	H.W.L. (EL. m.)	TOP OF DIKE (EL. m.)
AG				
180	42.95	7.00		
181	43.40			
281	44.25		16.00	17.20
282A	44.95	8.15	16.00	17.20
288	45.75	8.58	16.00	17.20
289	46.32	8.89	16.15	17.20
290	46.75	9.12	16.23	17.23
291	47.10	9.31	16.29	17.29
292	47.58	9.57	16.37	17.37
293	48.23	9.92	16.42	17.42
294	48.70	10.18	16.56	17.56
295	49.17	10.43	16.63	17.63
296	49.72	10.73	16.73	17.73
297	50.07	10.92	16.78	17.78
298	50.55	11.23	16.88	17.88
299	51.25	11.56	16.98	17.98
300	51.77	11.84	17.07	18.07
301	52.22	12.08	17.14	18.14
302	52.77	12.38	17.23	18.23
303	53.29	12.66	17.32	18.32
304	54.19	13.14	17.47	18.47
305	54.57	13.40	17.55	18.55
306	54.95	13.56	17.60	18.60
307	55.60	13.91	17.70	18.70
320B +500m		14.29	20.14	21.34
321		14.87	20.72	21.92

NOTE : ⇔ : Low Water Channel Improved

BAYAMBANG STRETCH

Fig. 3.1.3 LONGITUDINAL PROFILE OF UPPER AGNO RIVER (2/2)

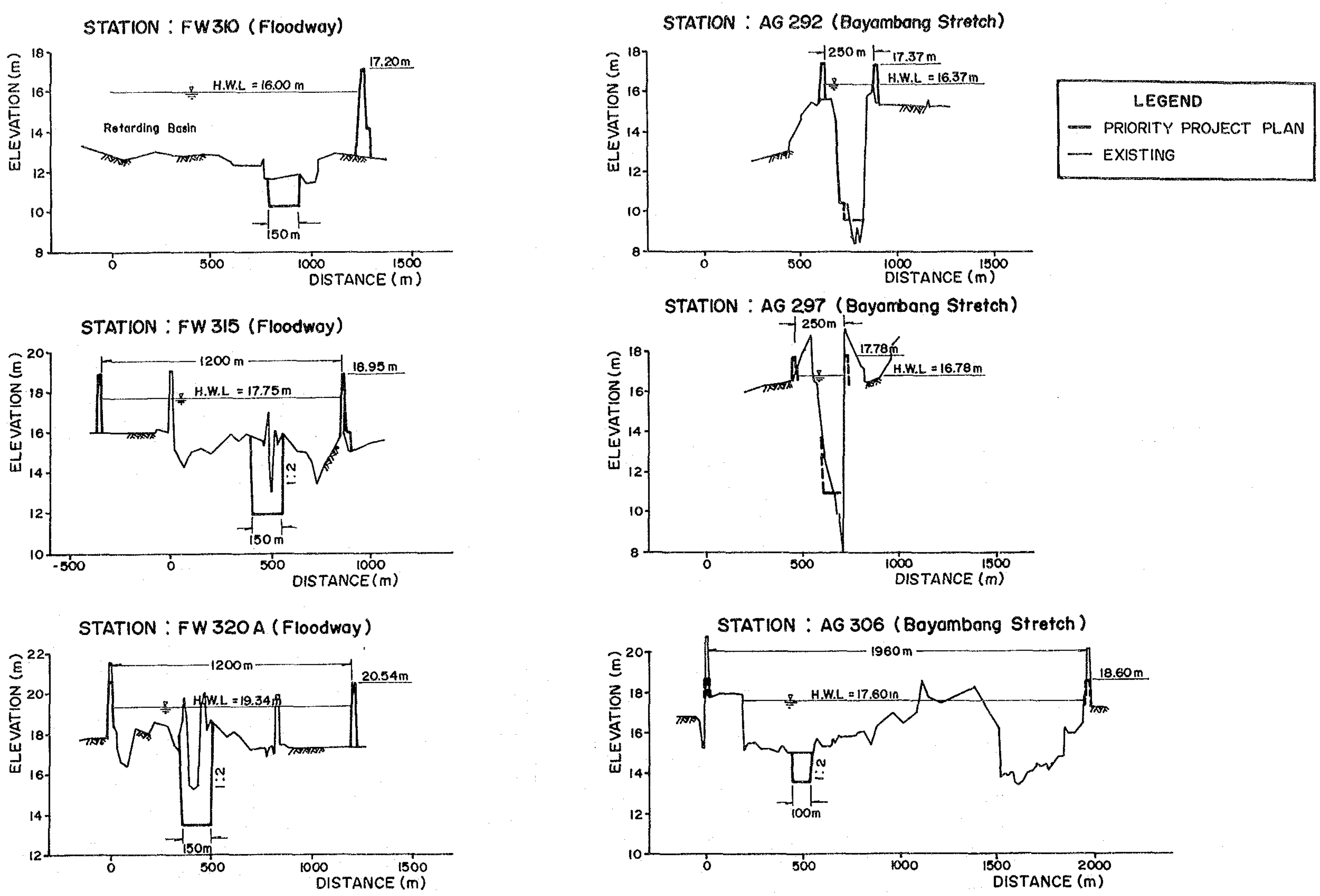


Fig. 3.1.4 TYPICAL CROSS-SECTION OF UPPER AGNO RIVER (1/3)

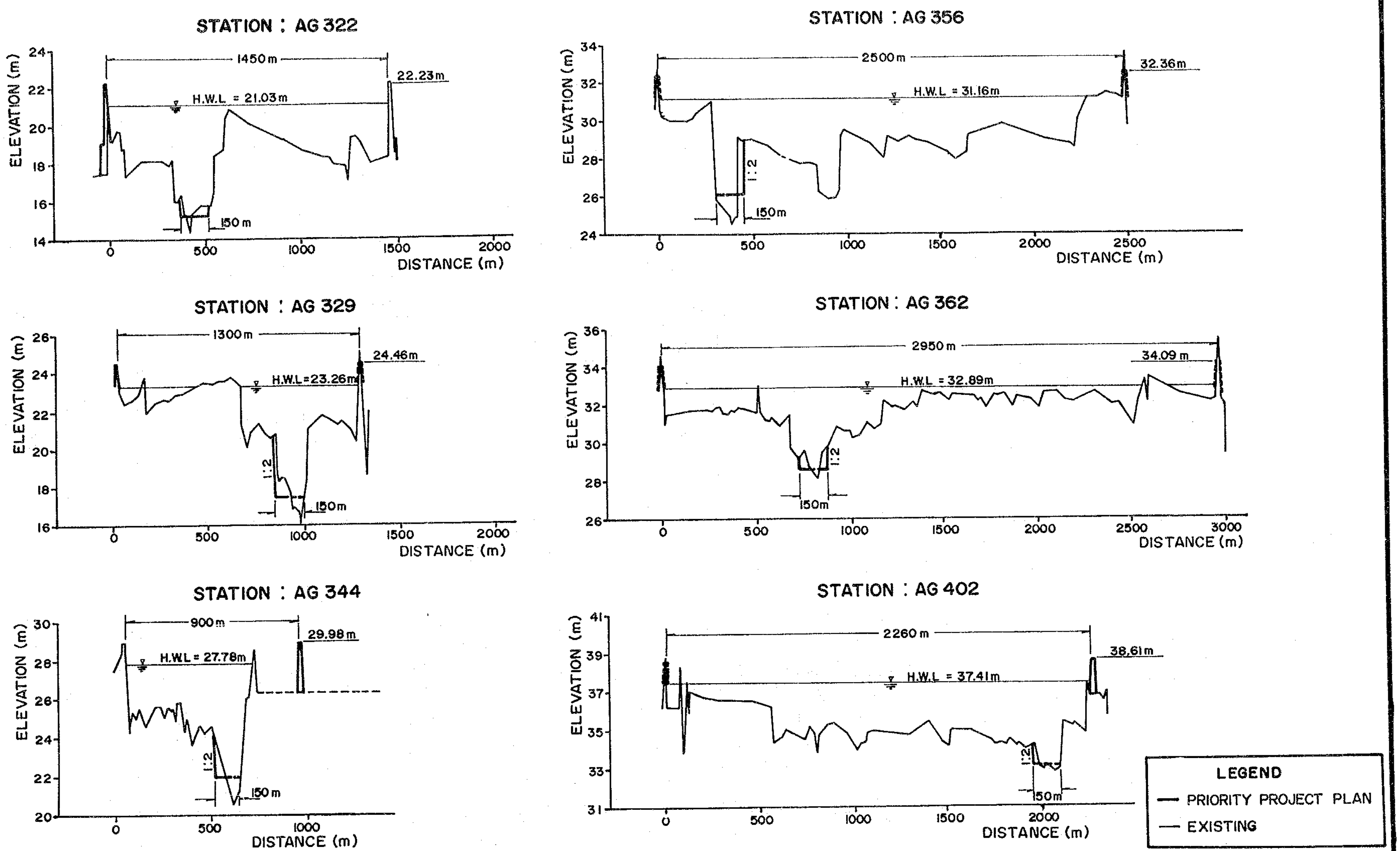


Fig. 3.1.4 TYPICAL CROSS-SECTION OF UPPER AGNO RIVER (2/3)

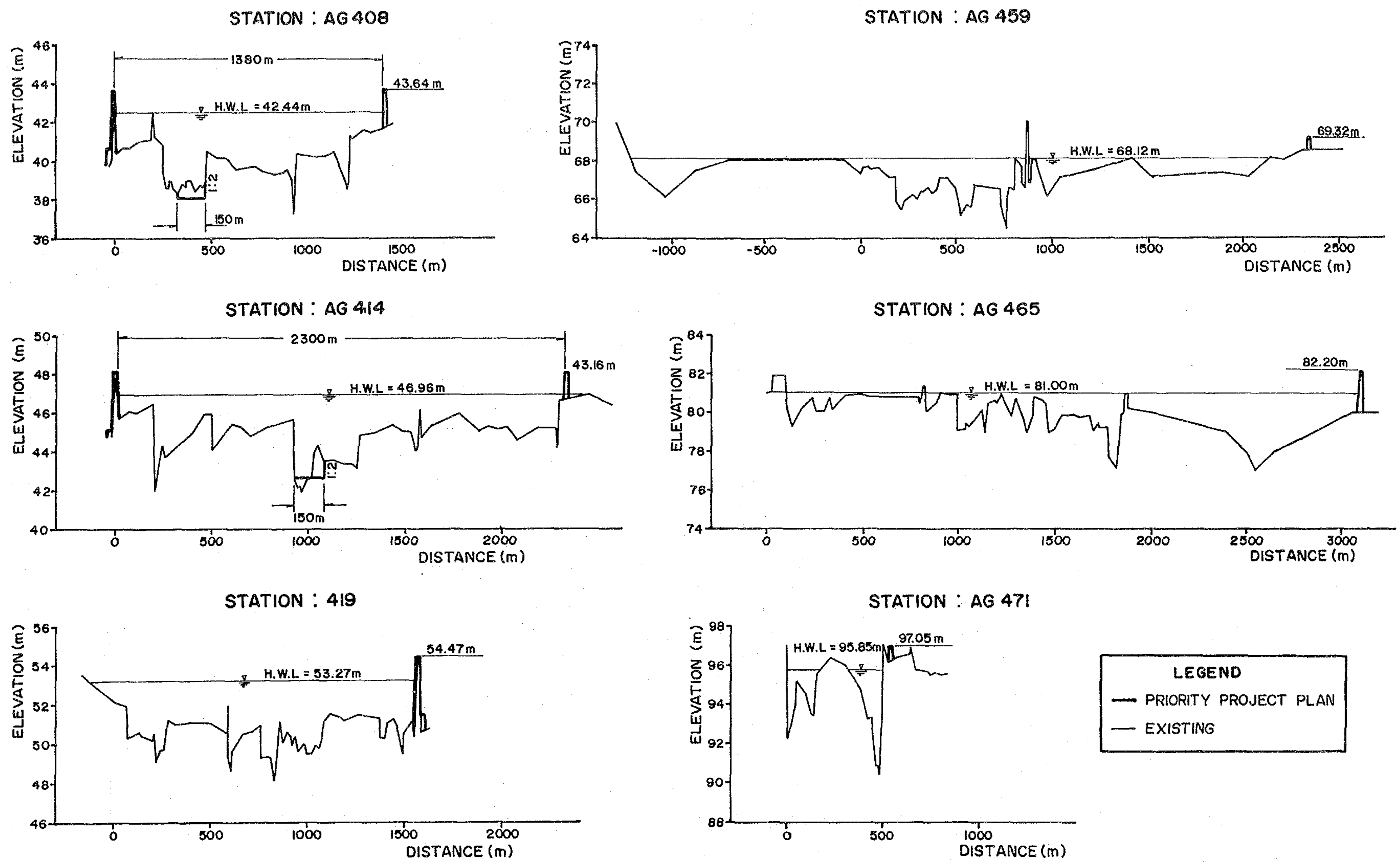


Fig. 3.1.4 TYPICAL CROSS-SECTION OF UPPER AGNO RIVER (3/3)

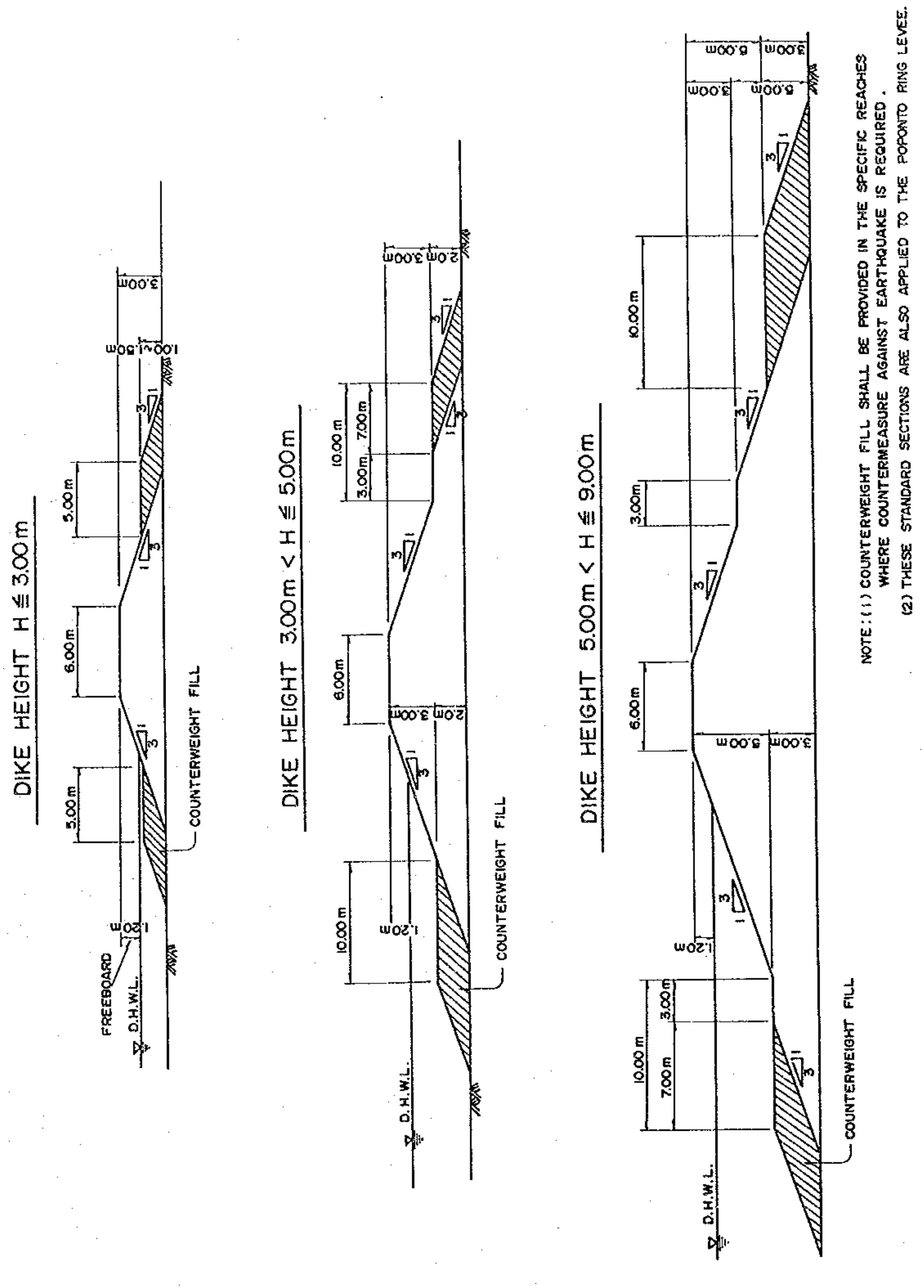


Fig. 3.1.5 STANDARD DESIGN SECTION OF AGNO RIVER EARTHDIKE

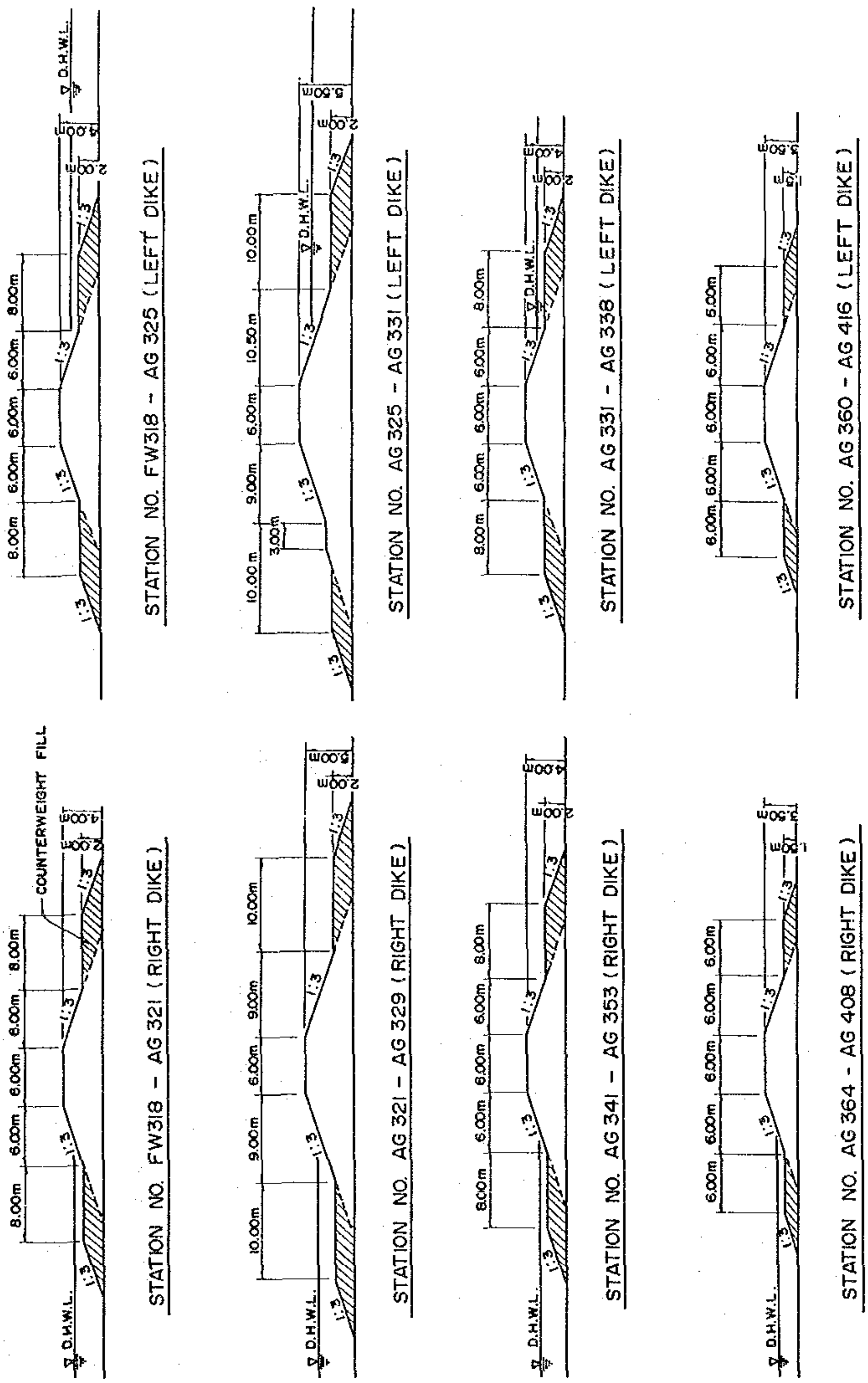


Fig. 3.1.6 STANDARD DESIGN OF COUNTERWEIGHT FILL AGAINST LIQUEFACTION (AGNO RIVER)

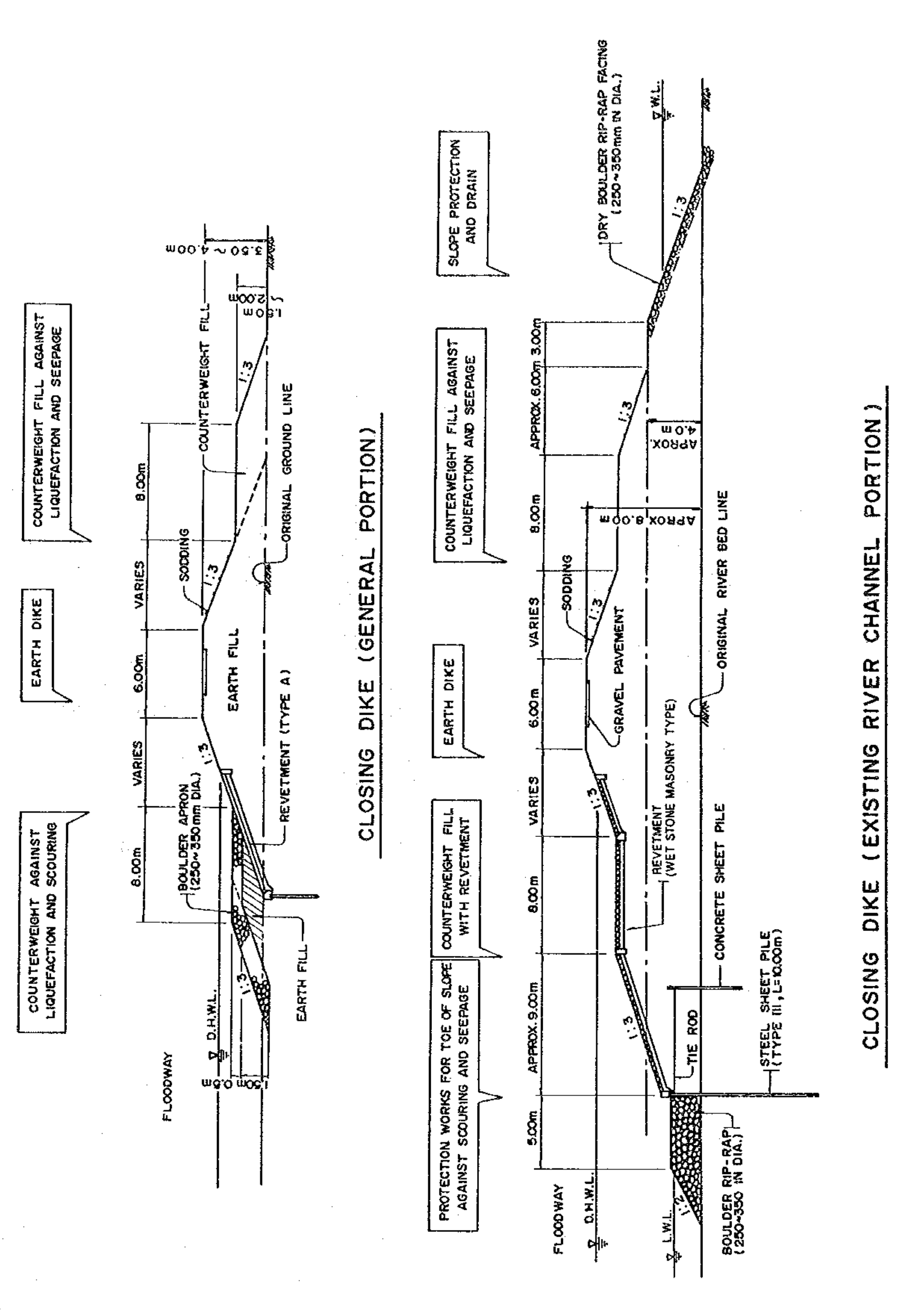


Fig. 3.1.7 STANDARD DESIGN SECTION OF BAYAMBANG CLOSING DIKE

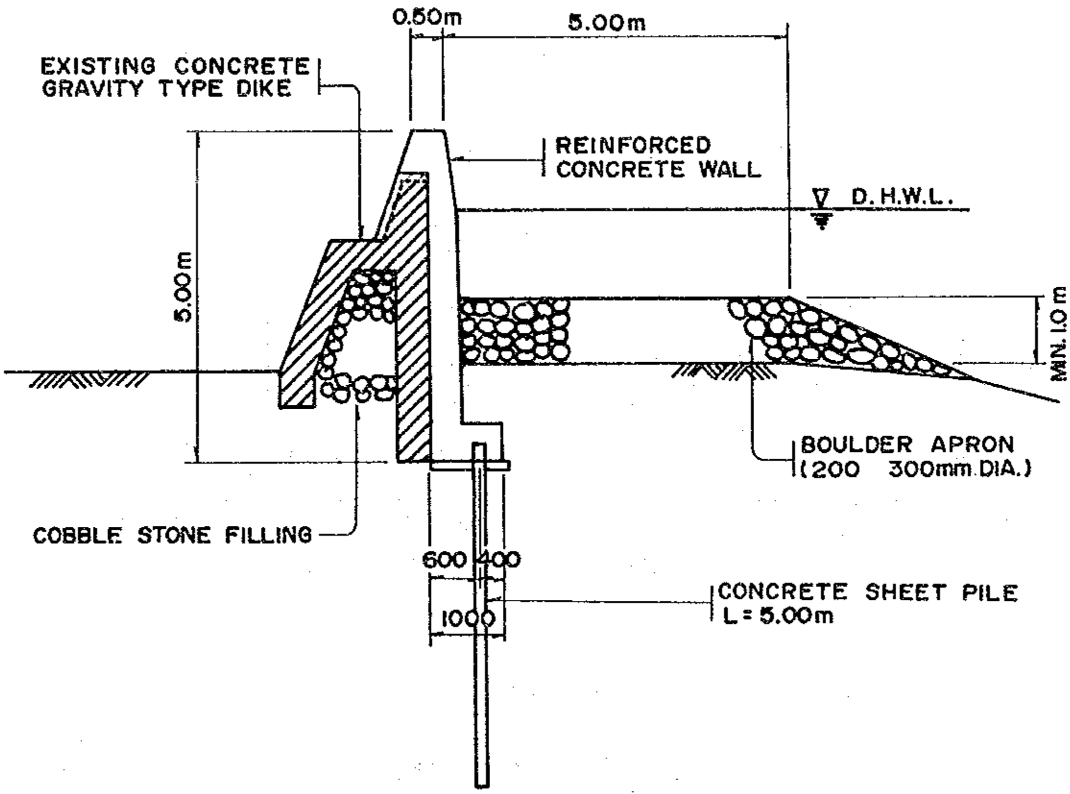
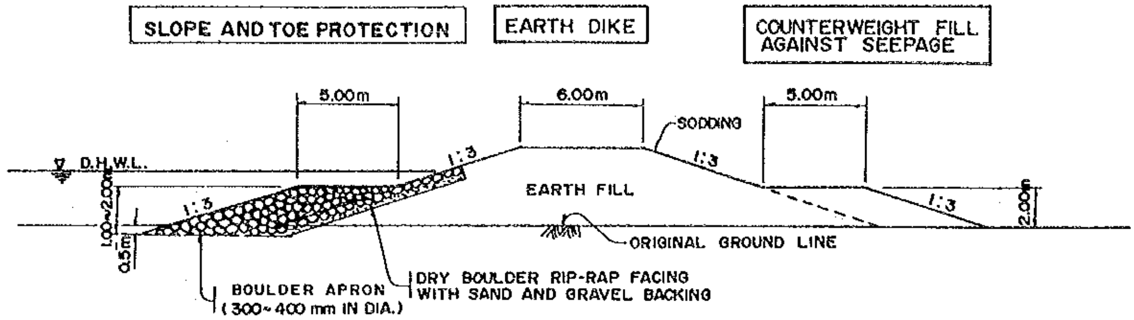
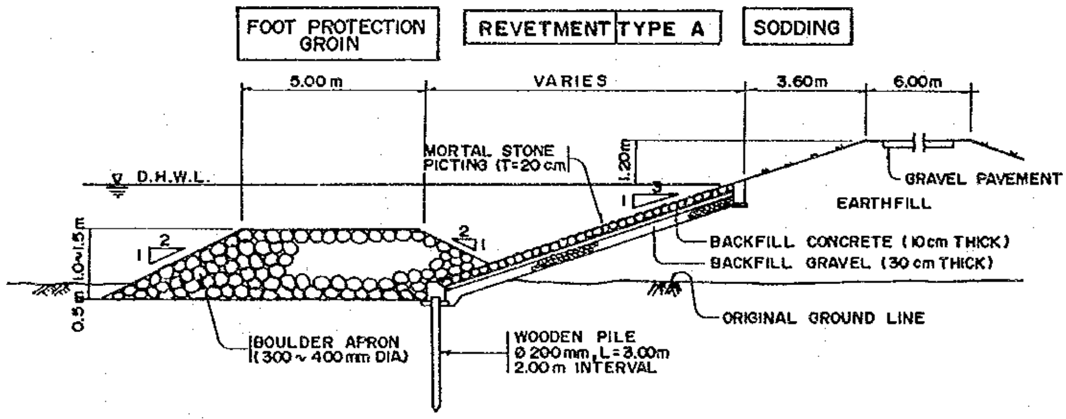


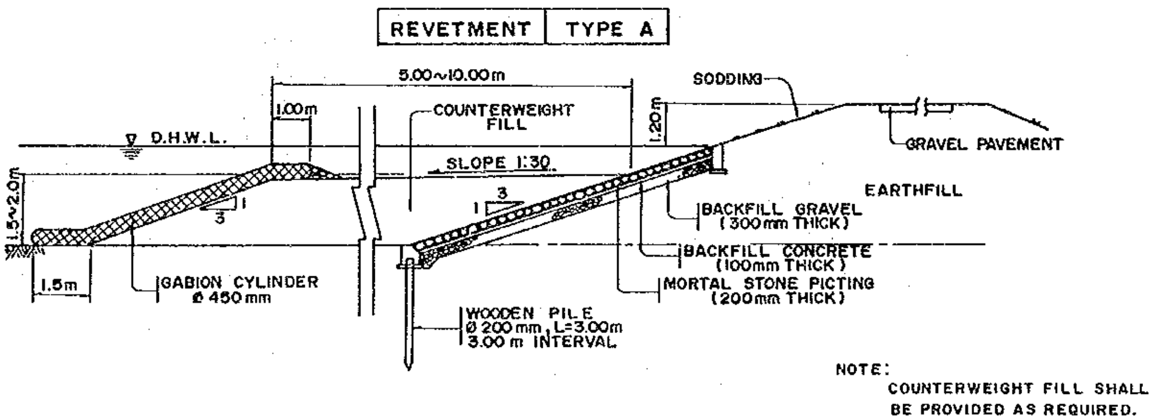
Fig. 3.1.8 DESIGN SECTION OF CONCRETE FLOODWALL DIKE



PROTECTION WORKS FOR DIKE (TYPE - I)



PROTECTION WORKS FOR DIKE (TYPE - II)



PROTECTION WORKS FOR DIKE (TYPE - III)

Fig. 3.1.9 PROTECTION WORKS FOR RIVER DIKE (I)

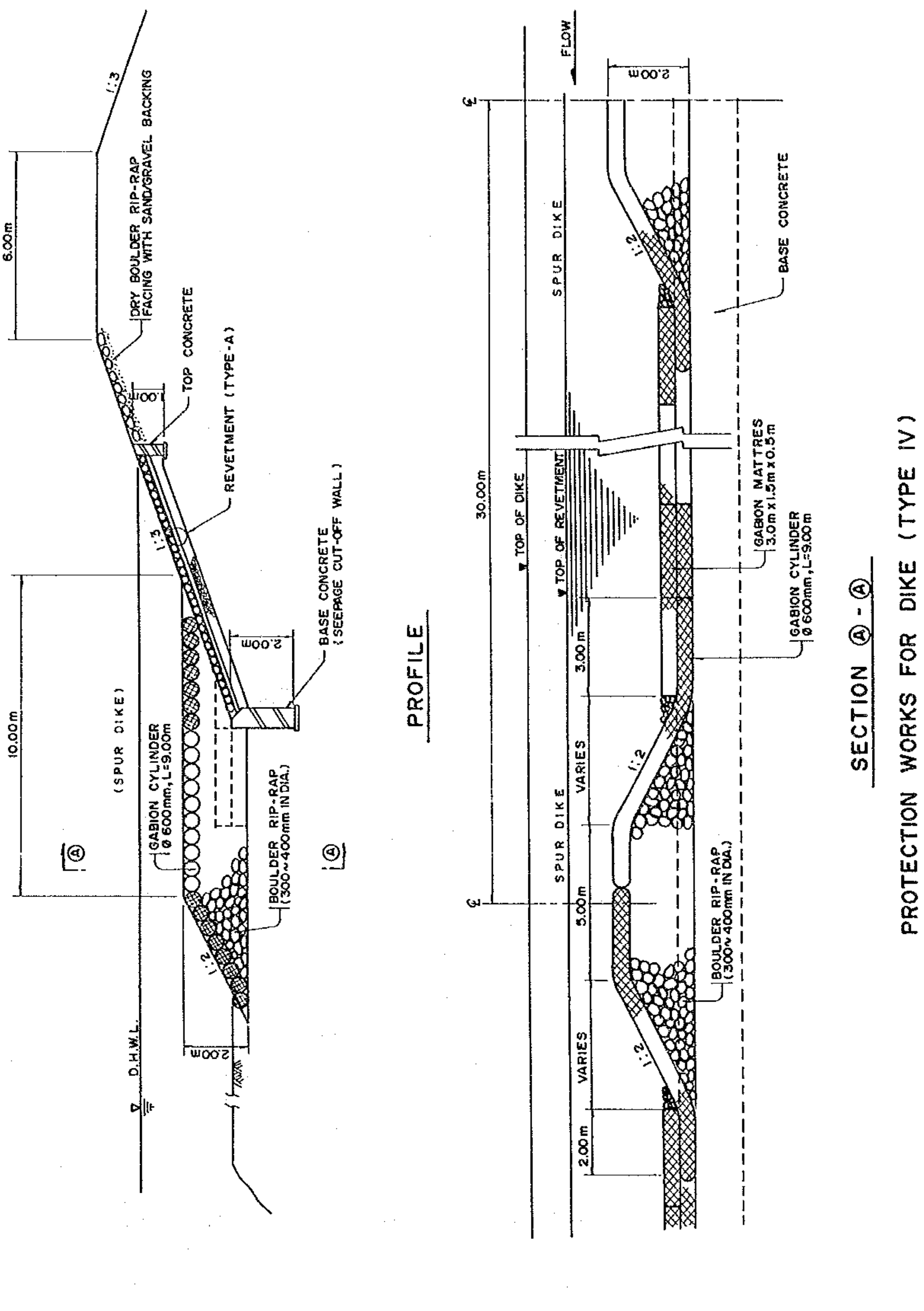


Fig. 3.1.10 PROTECTION WORKS FOR RIVER DIKE (II)

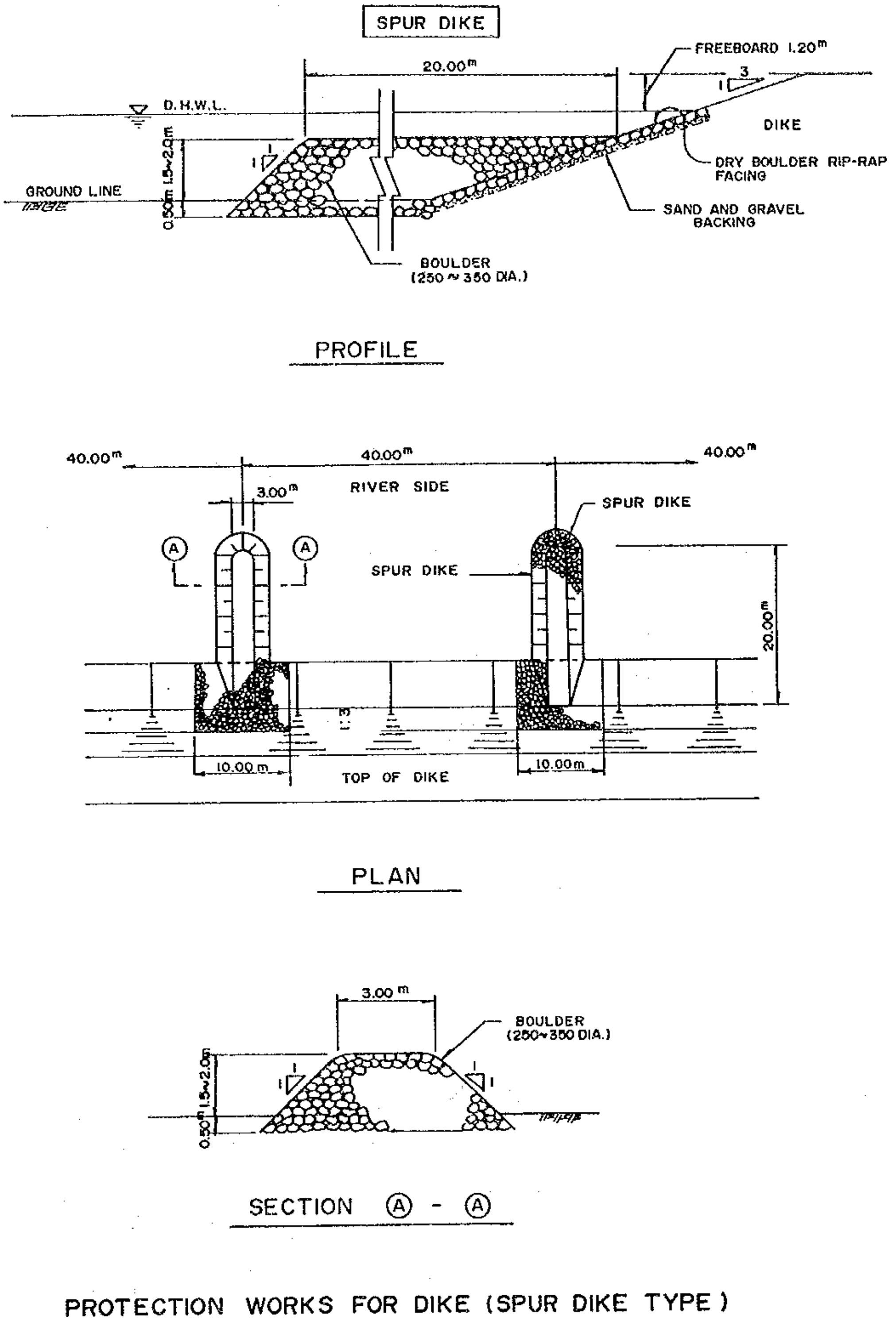
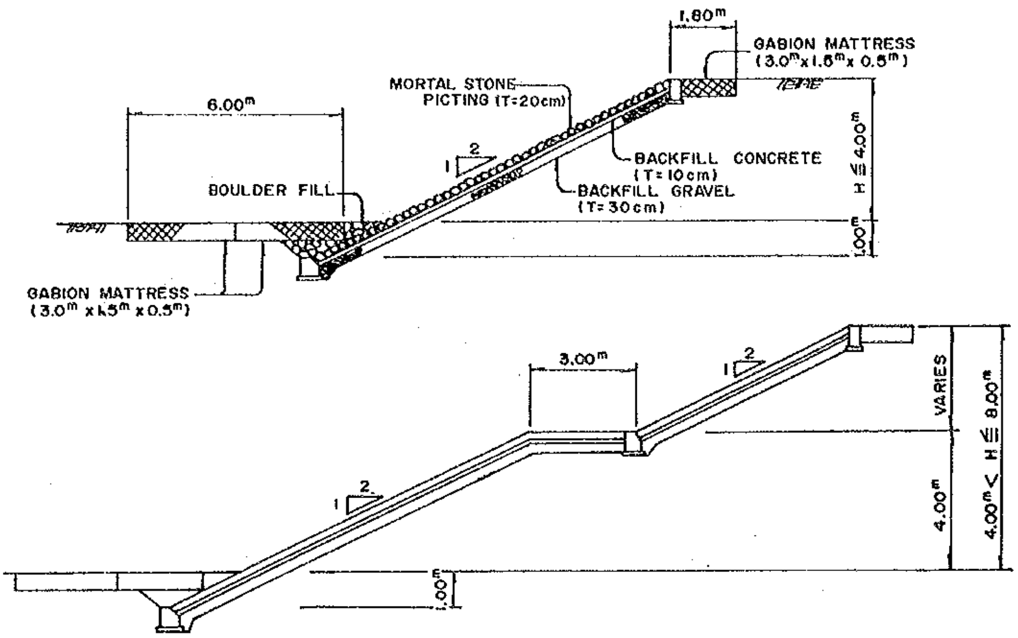
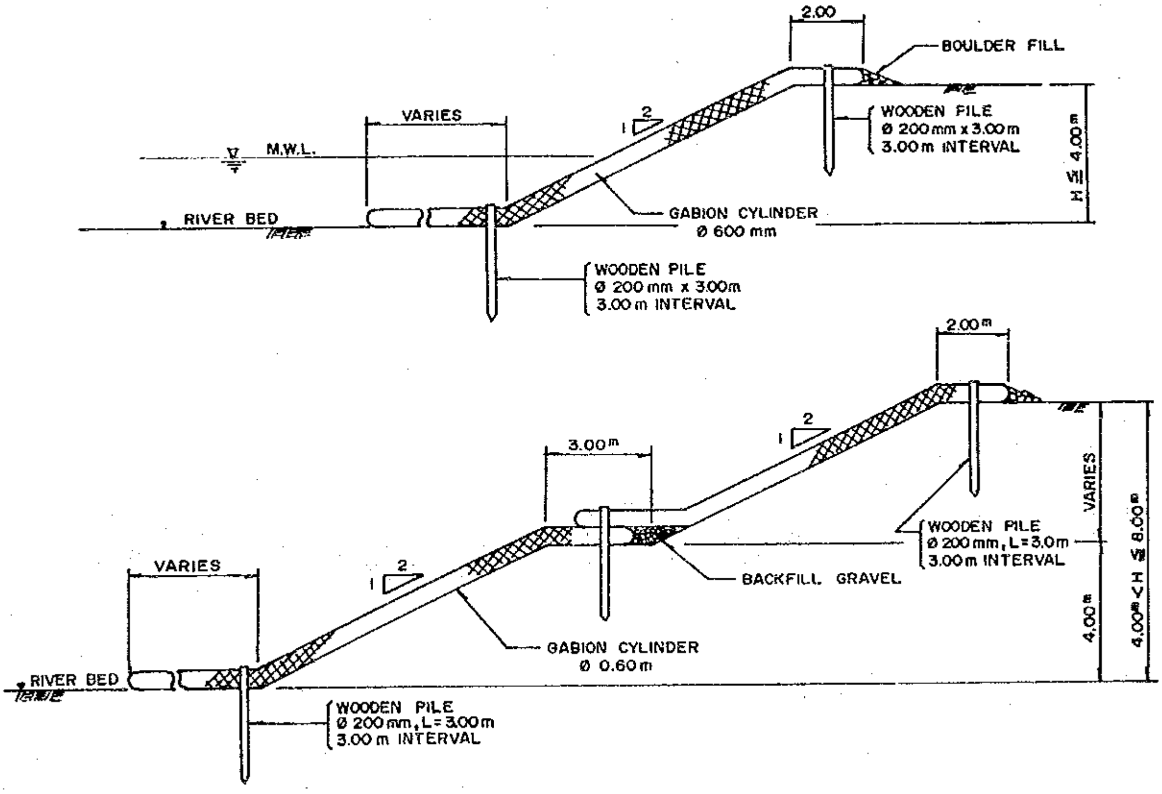


Fig. 3.1.11 PROTECTION WORKS FOR RIVER DIKE (III)

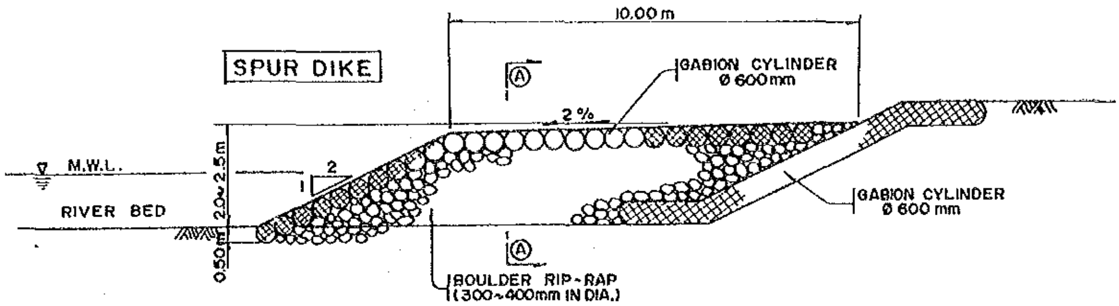


REVETMENT WORKS FOR LOW WATER CHANNEL (TYPE - A)

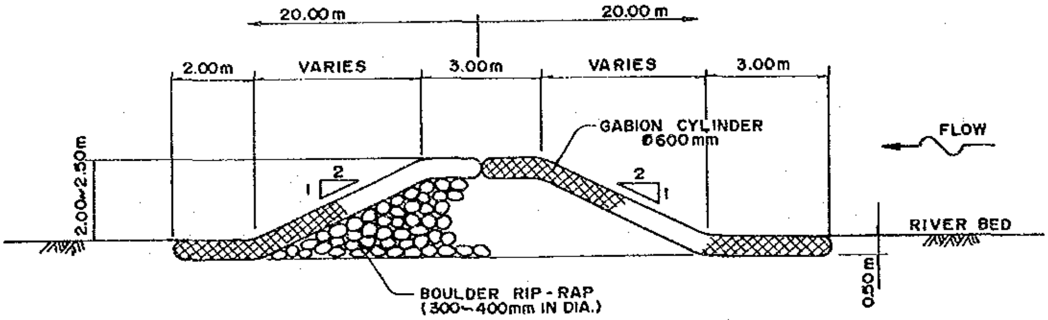


REVETMENT WORKS FOR LOW WATER CHANNEL (TYPE - B)

Fig. 3.1.12 PROTECTION WORKS FOR LOW WATER CHANNEL BANK (I)

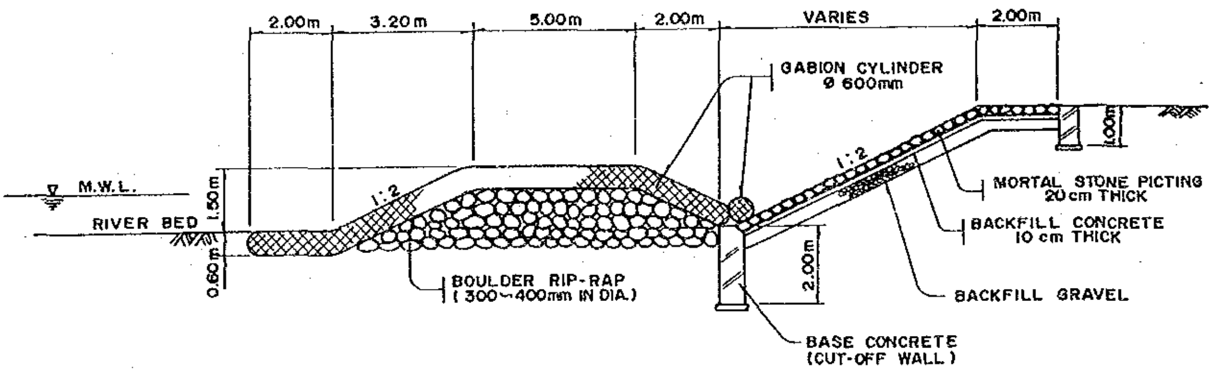


PROFILE



SECTION Ⓐ - Ⓐ

BANK PROTECTION WORKS (TYPE - C)



BANK PROTECTION WORKS (TYPE - D)

Fig. 3.1.13 PROTECTION WORKS FOR LOW WATER CHANNEL BANK (II)

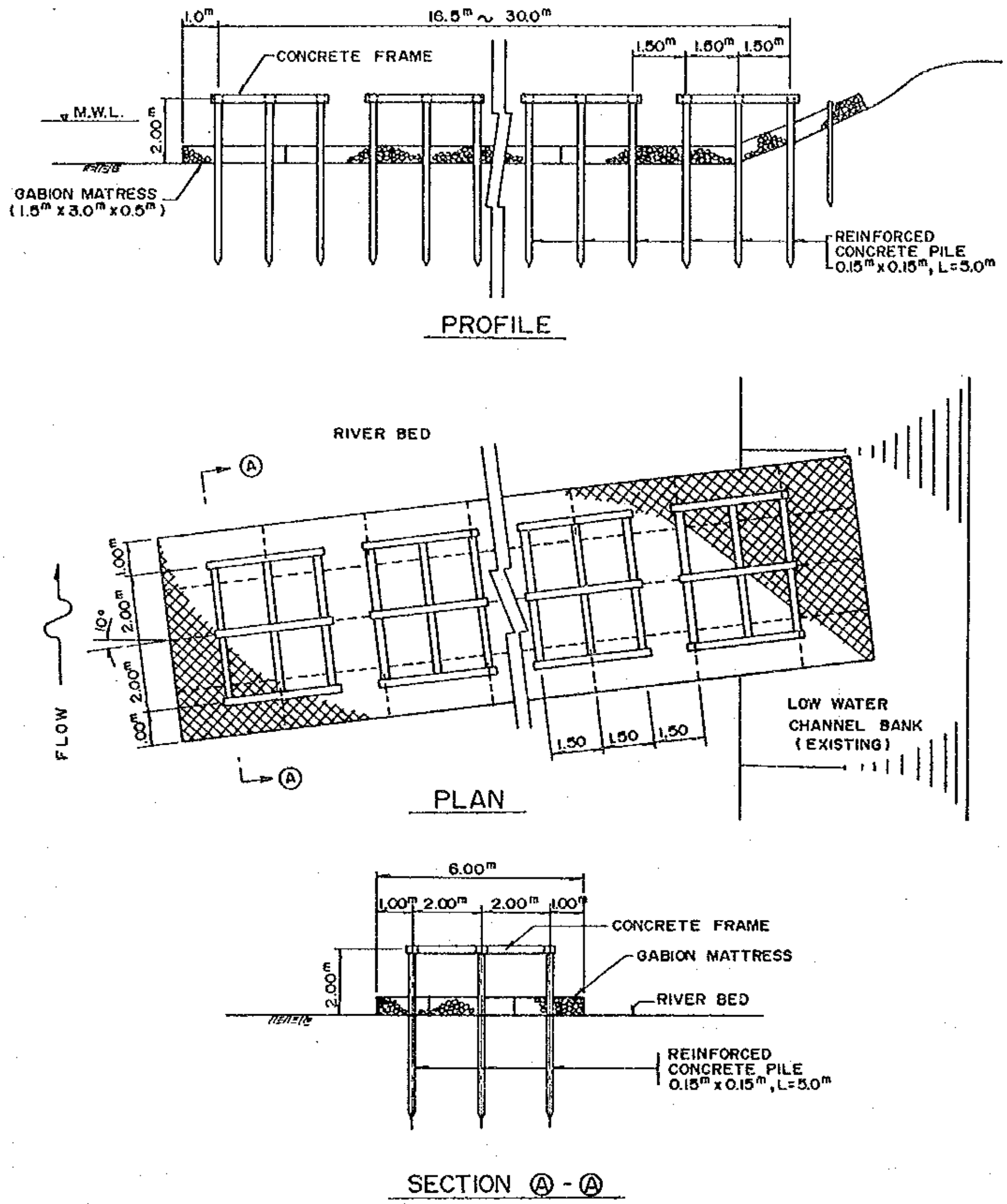


Fig. 3.1.14 STANDARD DESIGN OF GROYNE (PILE TYPE)

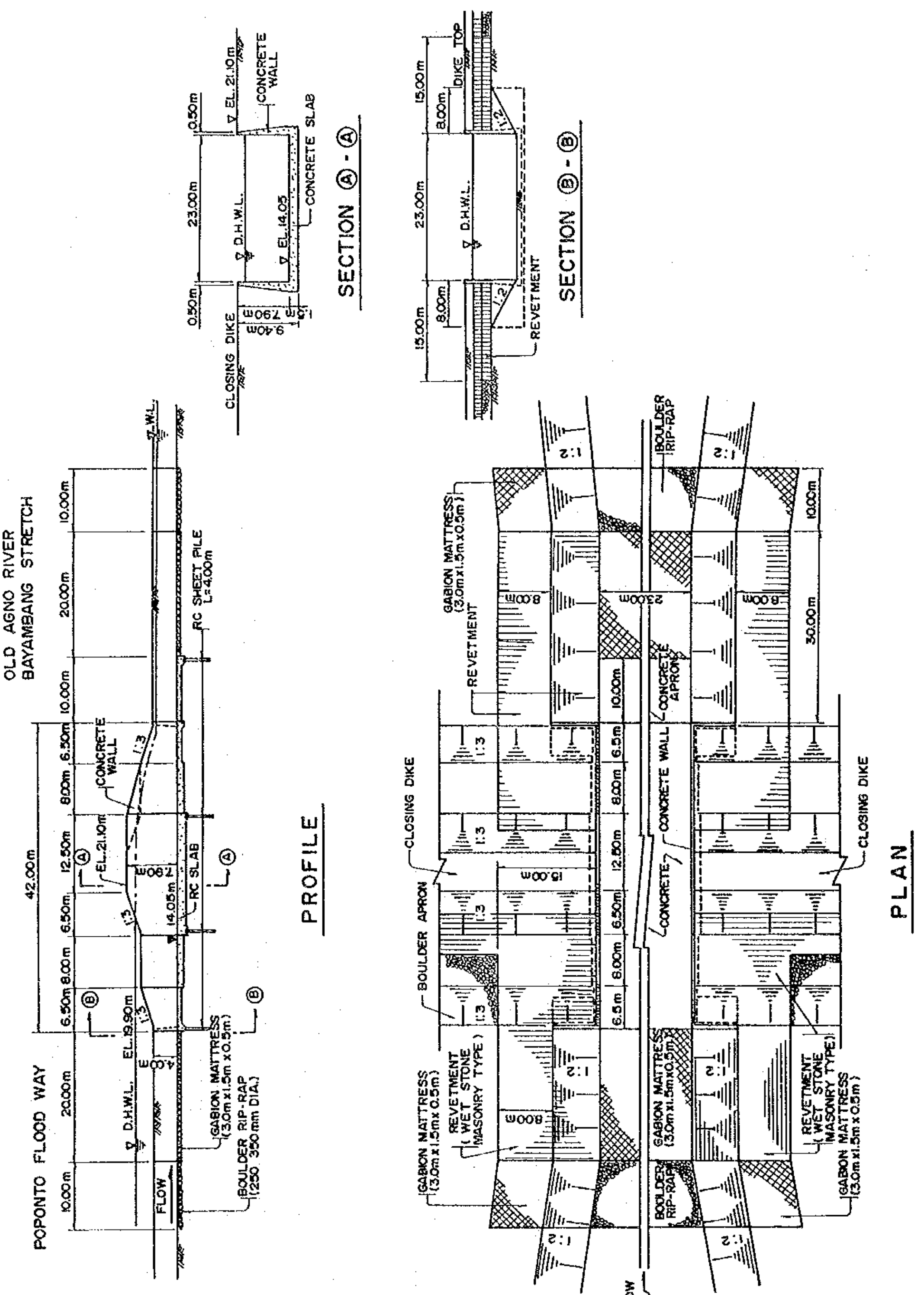


Fig. 3.1.15 BAYAMBANG DIVERSION CHANNEL

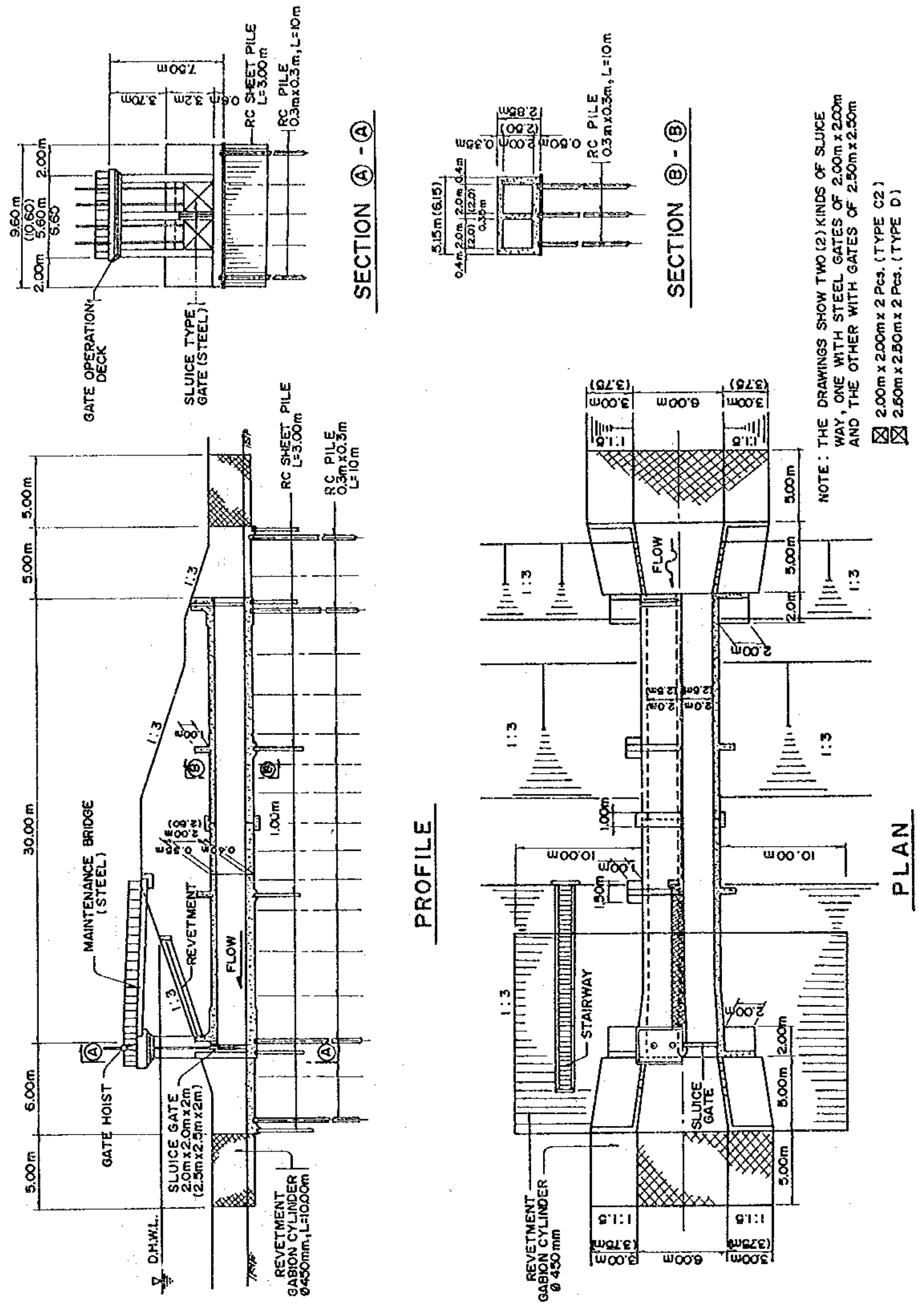


Fig. 3.1.16 STANDARD DESIGN OF SLUICE WAY (AGNO RIVER TYPE C2 AND D)

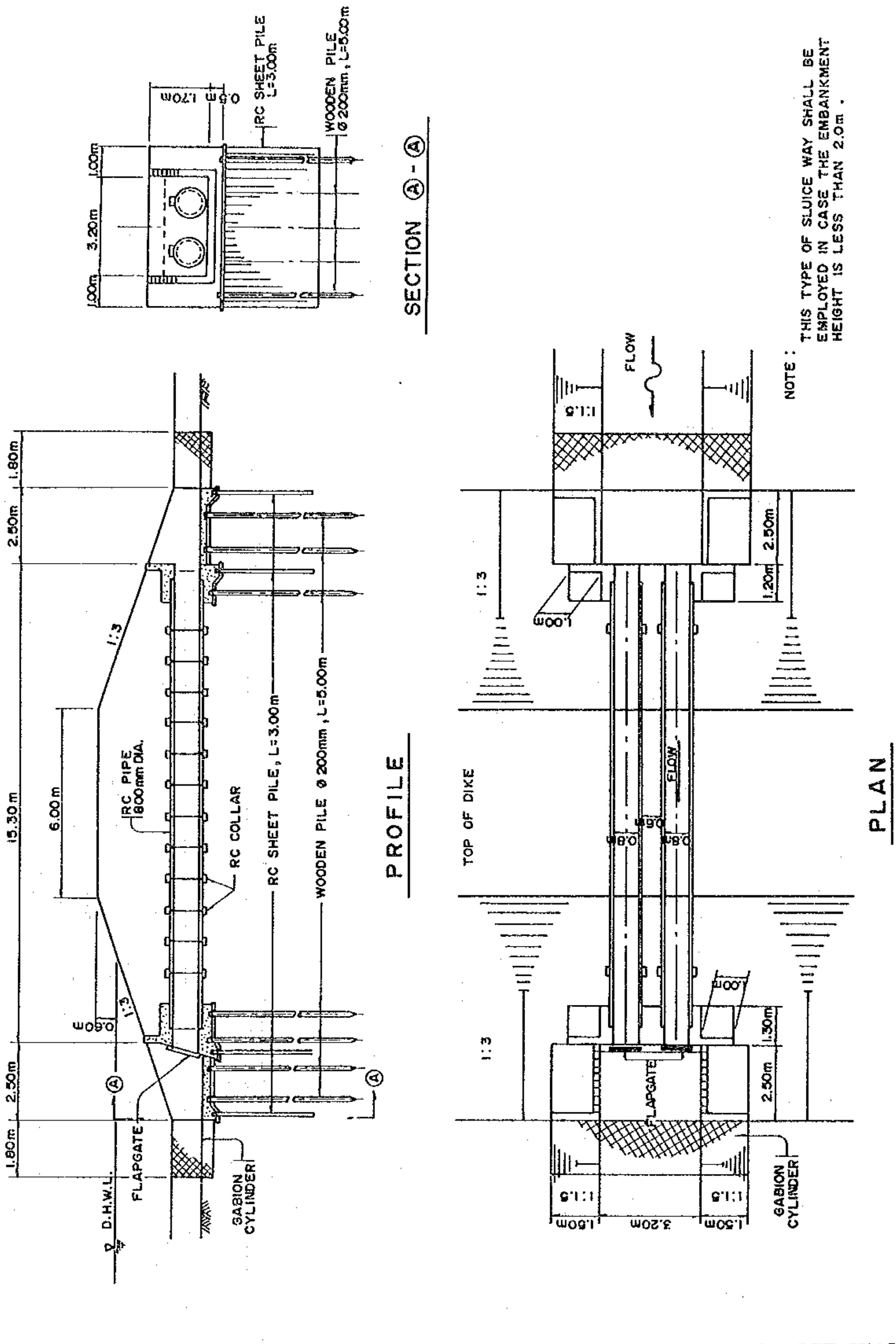


Fig. 3.1.17 STANDARD DESIGN OF SLUICE WAY IN POPONTO SWAMP (TYPE A2)

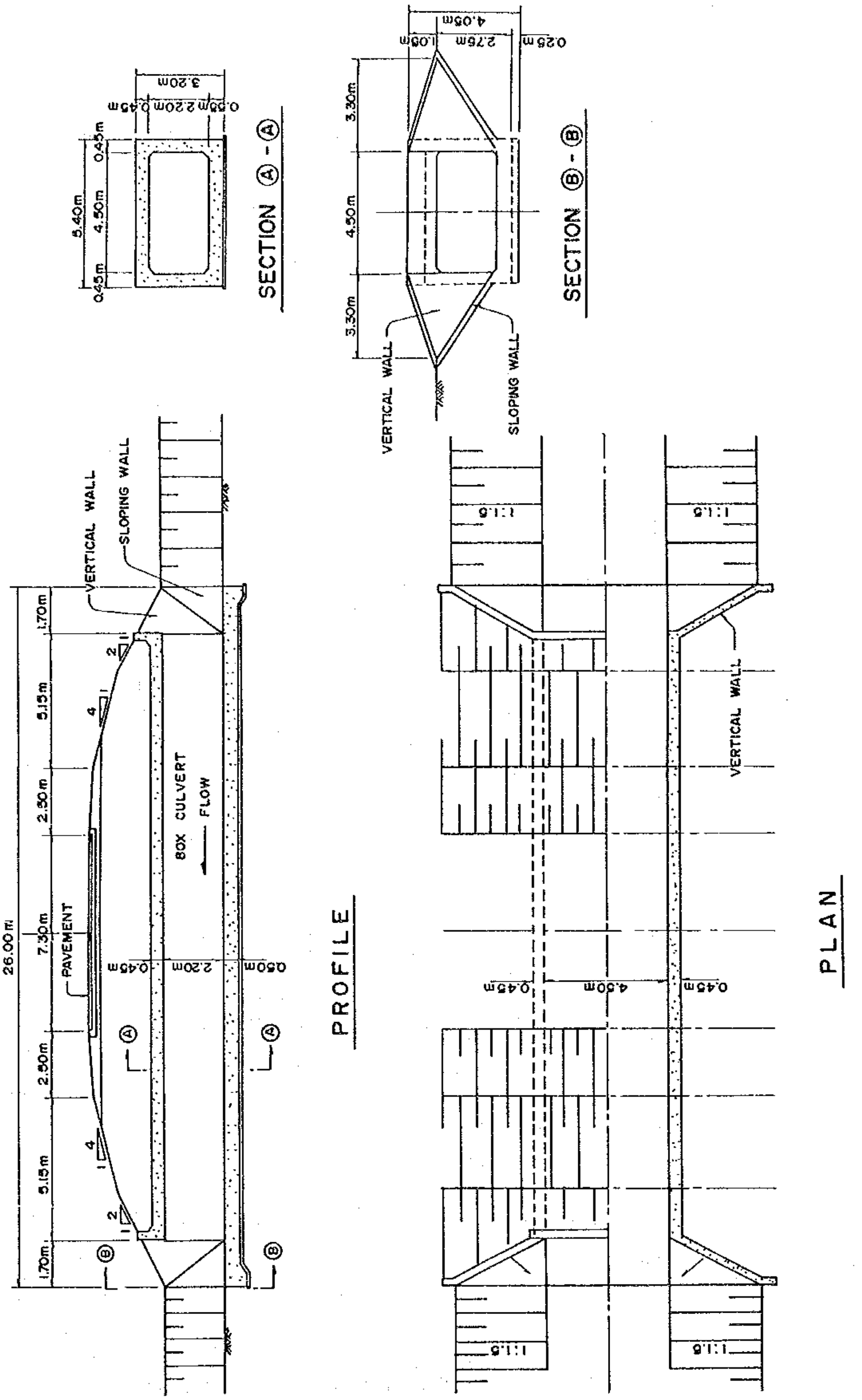
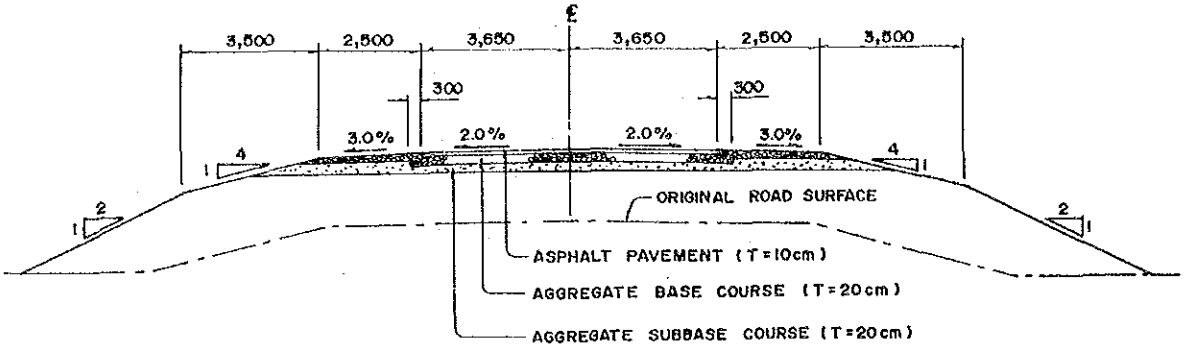
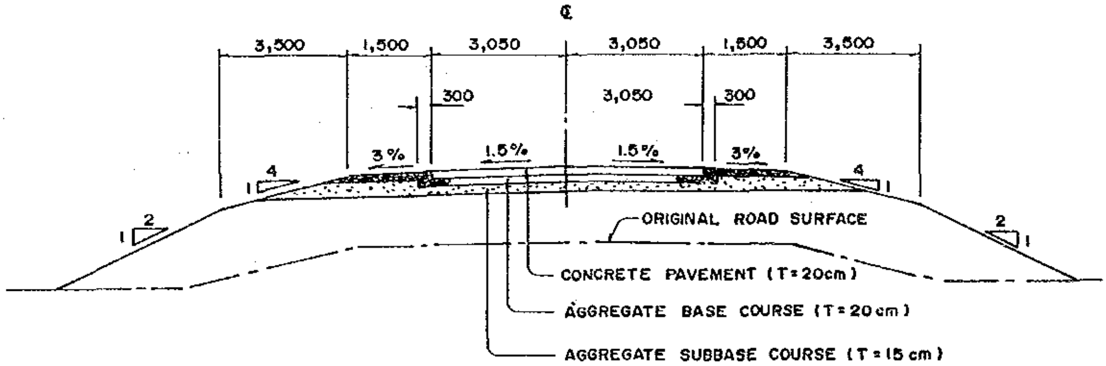


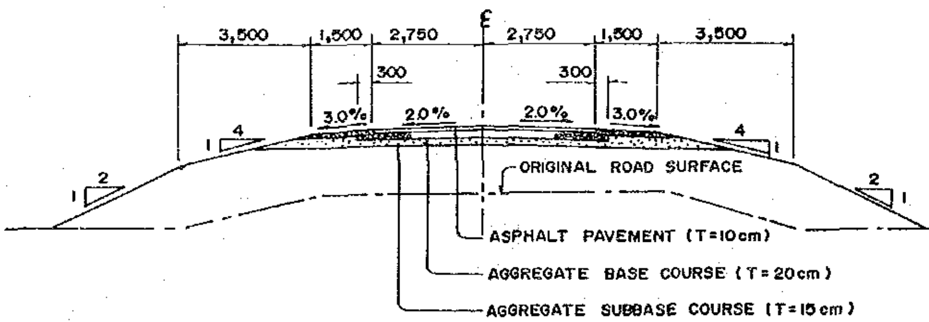
Fig. 3.1.18 STANDARD DESIGN OF BOX CULVERT



ROAD RAISING AND PAVEMENT (TYPE A)



ROAD RAISING AND PAVEMENT (TYPE B)



ROAD RAISING AND PAVEMENT (TYPE C)

NOTE : THE OTHER ROAD SUBJECT TO RAISING IS PAVED WITH GRAVEL.

Fig. 3.1.19 ROAD HEIGHTENING AND PAVEMENT

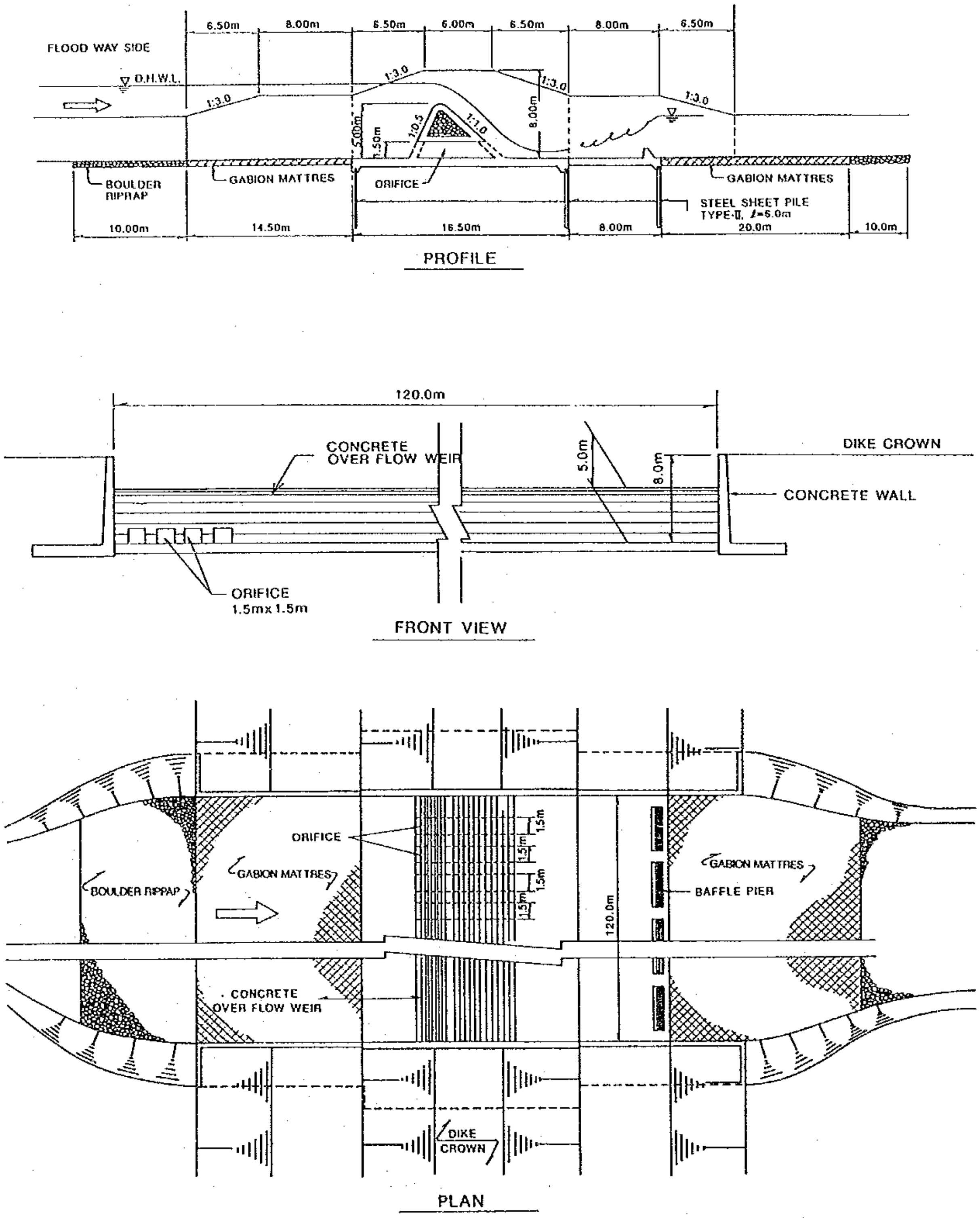


Fig. 3.1.20 ALTERNATIVE PLAN FOR DIVERSION FACILITIES (FIXED WEIR TYPE - ALTERNATIVE II)

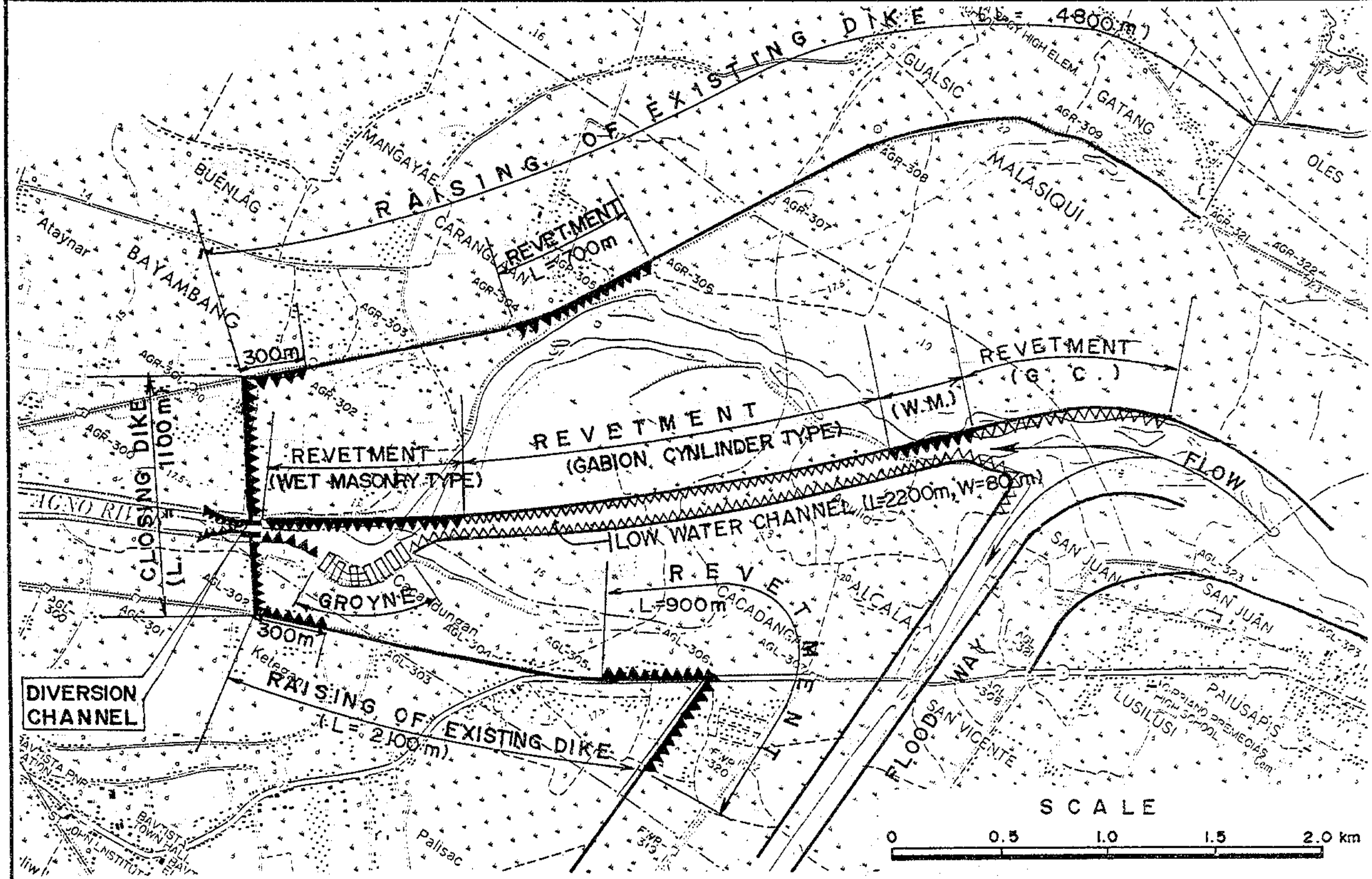


Fig. 3.1.21 BAYAMBANG CLOSING DIKE AND DIVERSION SYSTEM (ALTERNATIVE II)

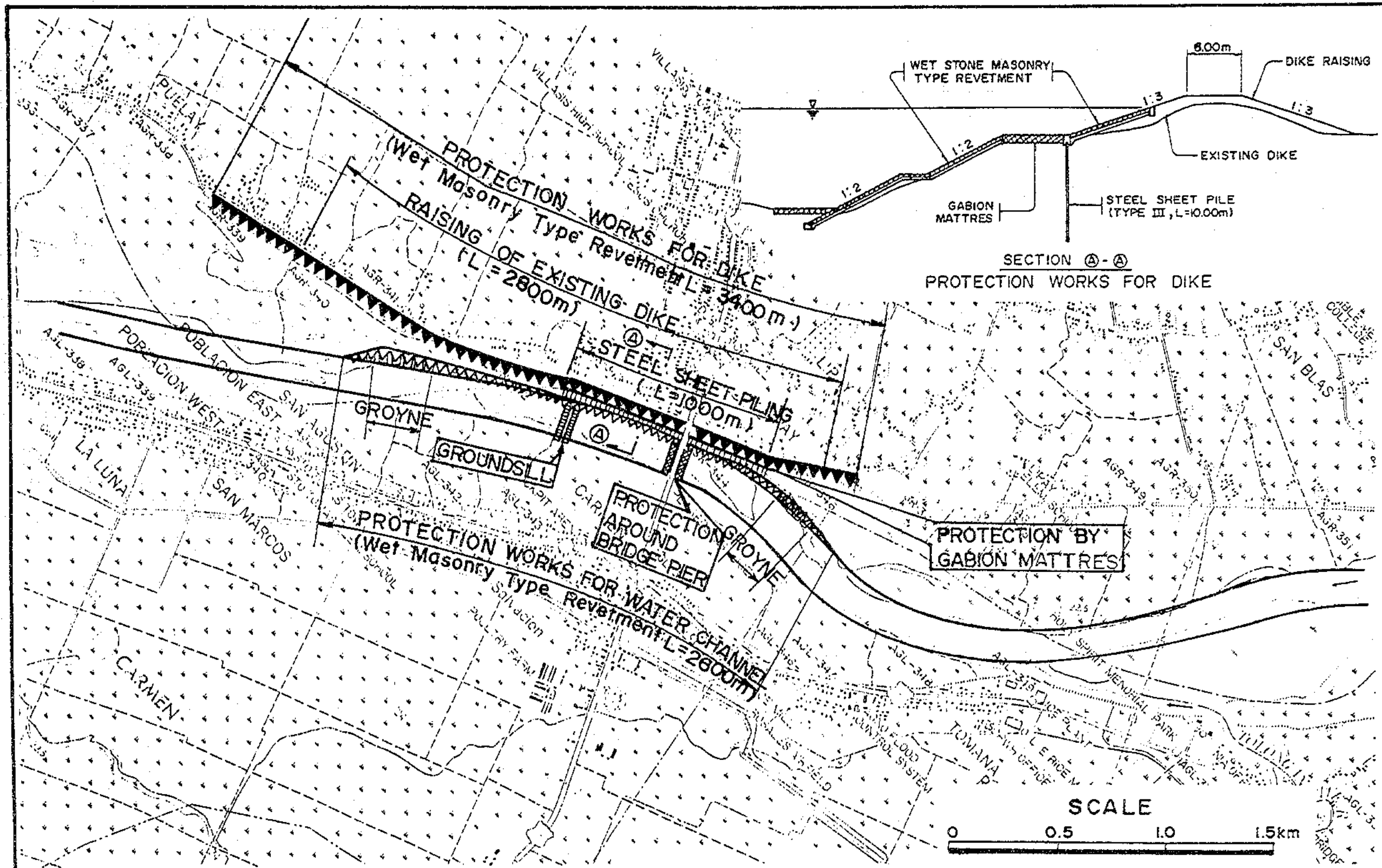


Fig. 3.1.22 DIKING SYSTEM IN CARMEN STRETCH (10-YEAR FLOOD ALTERNATIVE II)

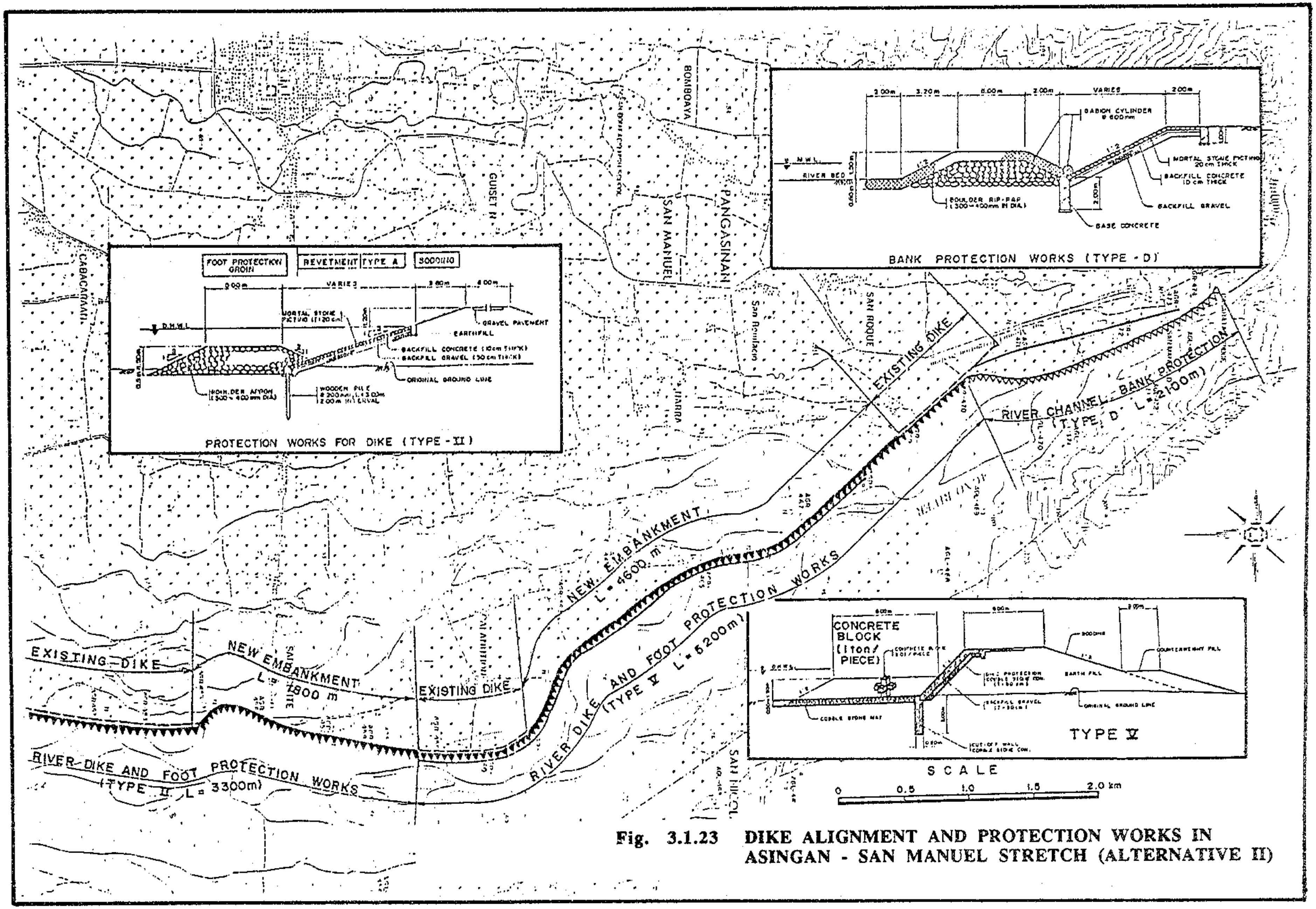
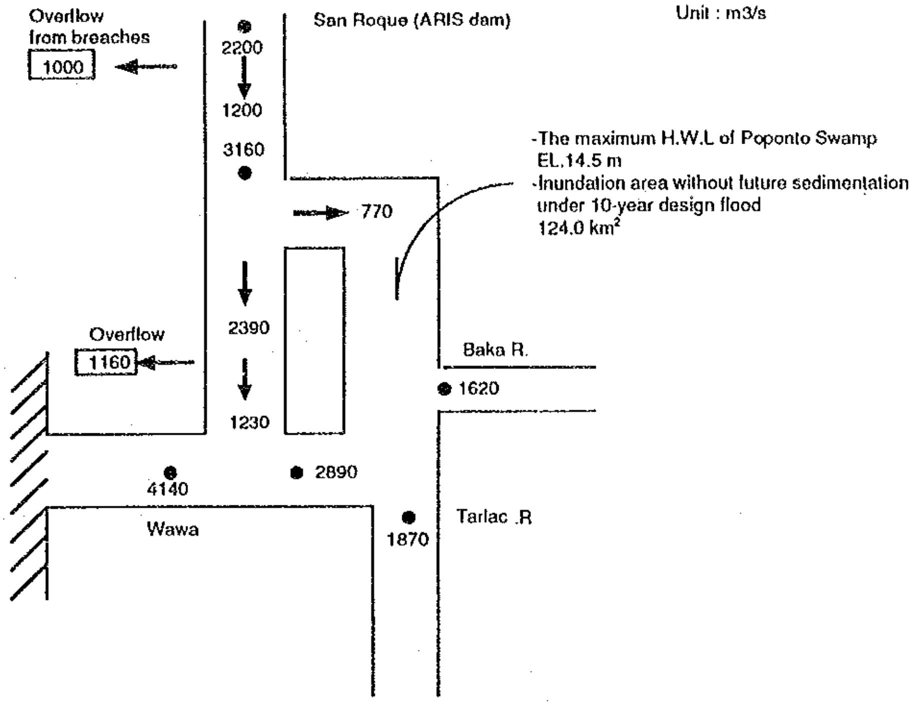
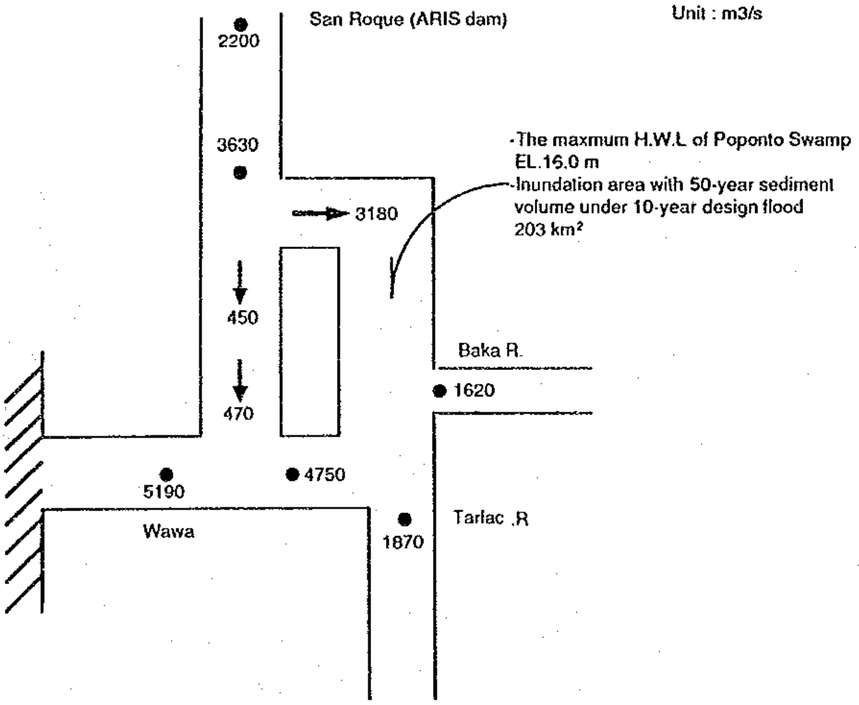


Fig. 3.1.23 DIKE ALIGNMENT AND PROTECTION WORKS IN ASINGAN - SAN MANUEL STRETCH (ALTERNATIVE II)



EXISTING POPONTO SWAMP WITHOUT PROJECT



POPONTO SWAMP WITH PROJECT

Fig. 3.2.1 SIMULATED FLOOD DISCHARGE DISTRIBUTION AND HIGH WATER LEVEL OF POPONTO SWAMP WITH AND WITHOUT PRIORITY PROJECT

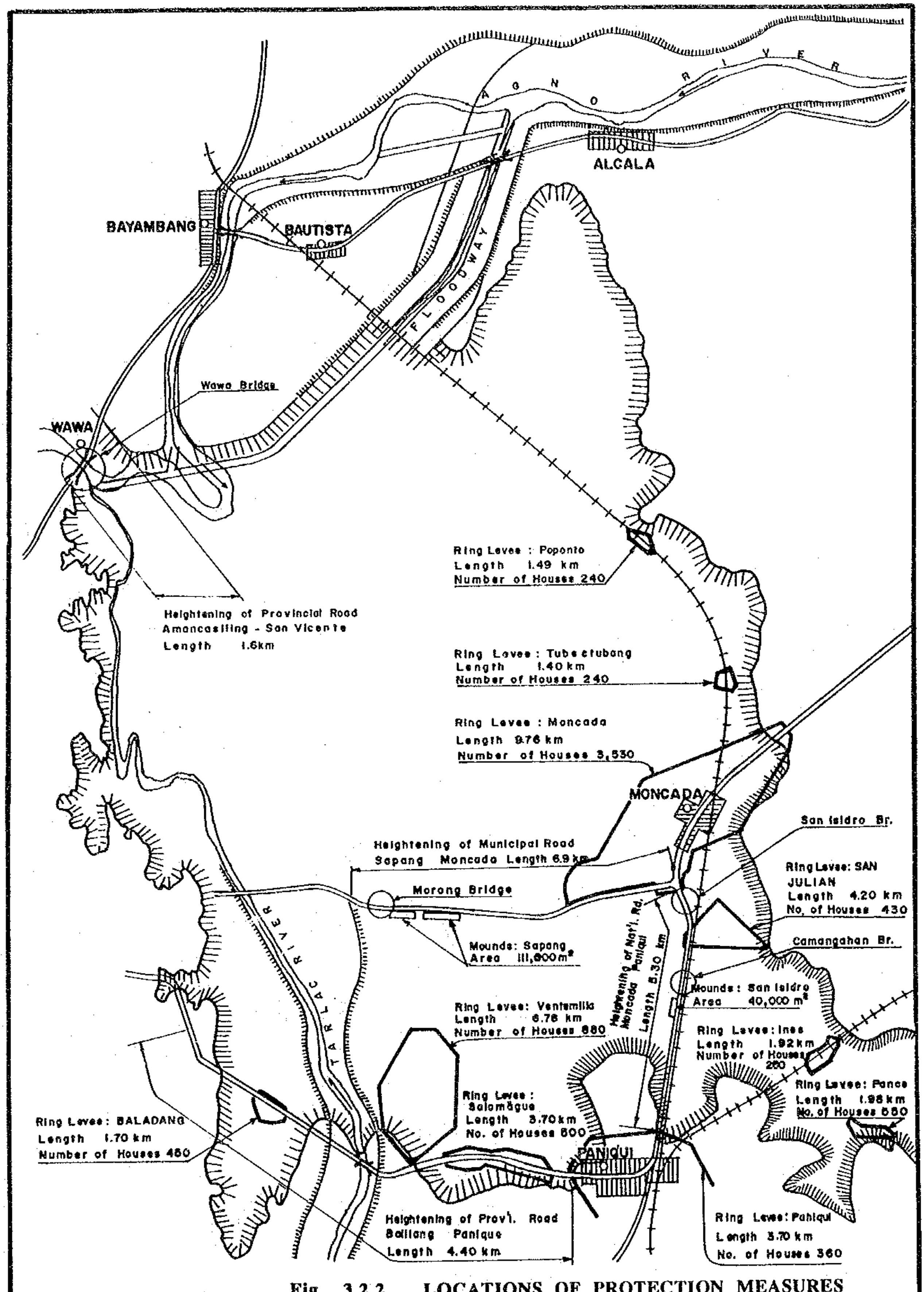
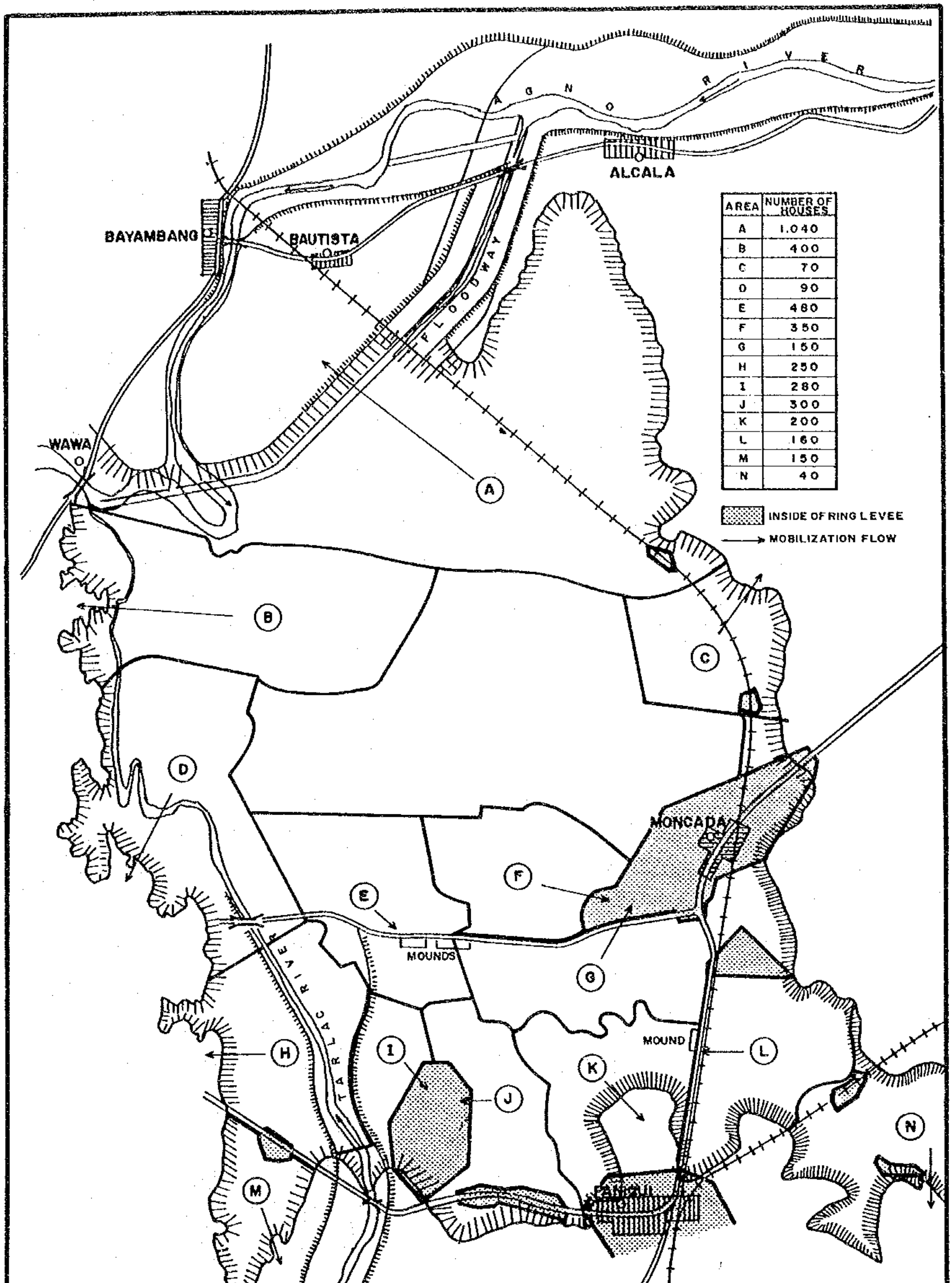


Fig. 3.2.2 LOCATIONS OF PROTECTION MEASURES



AREA	NUMBER OF HOUSES
A	1,040
B	400
C	70
D	90
E	480
F	350
G	150
H	250
I	280
J	300
K	200
L	160
M	150
N	40

Fig. 3.2.3 MOBILIZATION FLOW OF THE RESETTLEMENT