8.5 SELECTION OF PRIORITY SCHEMES

Alternatives for engineering intervention measures for Sacobia-Bamban River were formulated under the assumption that the San Francisco Bridge is newly in service in 1997. Of the alternatives, the Alternative 2 for short and medium term plan was selected for the priority scheme proceeded to the Feasibility Study as a result of discussion in the Steering Committee Meeting held on March 25, 1995. The combination of structures adopted in the Feasibility Study are enumerated below:

SHORT TERM PLAN :

a) Reinforcement of Sand Pocket Structures
   - Reinforcement of existing dike
   - Lateral dike

b) River improvement of the Sapang Balen River

c) Road dike on Route 329

MEDIUM TERM PLAN :

a) Training Works of the Sacobia River
   - Consolidation dam
   - River Channeling Work

b) River Improvement of the Bamban River

c) River Improvement of the Sapang Cauayan River

d) Restoration of Route 3

The overall plan is shown in Figure 8.14.

8.6 STRUCTURAL DESIGN FOR SHORT TERM PLAN

8.6.1 SAND POCKET STRUCTURE

(1) Flood/Mudflow Control Effect by Sand Pocket

The expected functions of the sand pocket are protection from remobilization of sediment deposits, retention of sediment inflow and prevention of dispersing sediment in the low-lying area. The effects of flood/mudflow control structures in sand pocket were examined under 1994 topographic conditions against a 20-year flood. As the control structures, Malonzo-San Pedro Hill Dike and the Parua River Dike between Sacobia and Bamban rivers, lateral dikes in lower end of sand pocket, sump, elevated Route 329 and collector channels were considered. According to the observation in 1995 rainy season, the flood flows in sand pocket were well drained into the Sapang Balen River and sediment materials were trapped at the lower lateral dike and sump. Most of sediment deposits were in upper part of the sand pocket. It means that sediment materials will not only be transported downstream by a single flood event but also be gradually transported by normal flows.

Because of the siltation of collect channels and sump located downstream end of sand pocket, overflow of the collector channel/river channel occurred in the Sapang Balen River in 1995. The sediment deposit was obvious in the upper half of the sand pocket as well as north east corner of the sand pocket. According to this long term changes and flow conditions due to the probable floods, major flood flow in the sand pocket would run along the Malonzo-San Pedro Hill Dike and the Parua River Dike between the sand pocket and the Bamban River. Reinforcement of the dikes along the possible water way should be considered as well as the flood control works in the downstream reaches of the sand pocket.

(2) Existing Structures in Sand Pocket Area

In 1995, the sand pocket area of around 23 km^2 is closed off by the Malonzo-San Pedro Hill Dike and the Parua River Dike on the northern boundary, by the San Nicolas Balas Ring Dike and Route 329 on the eastern boundary, and by the Mabalacat-Magalang-San Francisco Bridge Dike on the southern boundary. These closing dike system and lateral dike which was considerably damaged after flood on October 1, 1995 are major structural components in the sand pocket area.

Most of these dikes were built by lahar material without any slope protection works so that they deteriorated due to bank erosion by surface water and gully erosion by heavy rain drops. Although the lateral dike was restored using gabions and sandbags in the early September, 1995, some portions were washed away by rapid current during the flood on October 1, and a remarkable volume of sediment, which was contained during previous floods and lahar events in the sand pocket, was eroded and spread out over the downstream areas of Barangays San Bartolome and San Isidro.

In order to prevent heavy siltation in the low-lying areas downstream of the sand pocket, it is necessary to implement some countermeasures to stabilize the sediment deposits and to trap the sediment transported from the upstream reaches of the Sacobia River.

(3) Concept on Structural Measure

To stabilize the sediment deposits and trap the sediment newly coming from the upstream reaches, the construction of lateral dike system is a likely measure based on the field observation. Sump is also one of the alternatives to attain those purposes, however, the sump which was constructed immediately upstream of Route 329 before the onset of the 1995 rainy season was completely buried by a few small-scale floods in the early 1995 rainy season. After this event the sump could not function any more. On the contrary, after the flood on October 1, 1995 a considerable volume of sediment was found in the stilled flow area created by the lateral dike, even though its construction material, such as sandbags, was of poor endurability against flood water.

The expected functions and required structural elements for the lateral dike system are (i) to stabilize the sediment deposits, it has to cross over the sand pocket area with firm foundation against pressure of flood water, (ii) to trap the sediment transported from the upstream reaches, it has to have an appropriate height of its body for sediment retention, (iii) to avoid the sediment re-entrainment by scouring on the downstream side of the structures, the height of spillway or overflow section should be designed as lower as possible with an appropriate energy dissipating structures, (iv) to reduce the sediment transport capacity of the active channels, the spillway or overflow section has to disperse flood water with shallow flow depth.

The gabion lateral dike is determined from taking into account the above-mentioned functions and provisional use of the sand pocket until the training works of the Sacobia River will be completed to discharge out its surface water into the Bamban River. In order to attain sediment containment of about 1 million m^3 per year in addition to the natural containment function of the sand pocket, one row of the lateral dike has to be built year by year from the downstream end toward the upstream. According to the construction plan, the Sacobia River channel will be diverted in the dry season of 1998/1999. Thus three rows of the lateral dike in total will be built during the coming three dry seasons of 1995/1996, 1996/1997, and 1997/1998.

However, the dimension and structural design of lateral dike is preferable to be re-examined on the basis of the sediment accumulation due to lateral dike of downstream end. In case that the small volume of sediment accumulation occurred due to lateral dike of downstream end, the second and third rows of lateral dike may be changed to simple structures such as a series of pile to reduce the flow velocity.

Regarding the closing dike system of the sand pocket, slope protection work of the sand pocket side should be considered on the whole stretch of the target dike system in order to protect against bank erosion and scouring by braided flood water.

(4) Structural Design

(a) Lateral Dike

Non-overflow section of the lateral dike of 1 m high is necessary to contain about 1.0 million m^3 of sediment in each storage area. The body of 3.0 m thick with three gabions (2.0 m x 1.0 m x 1.0 m) and the foundation of 1.0 m deep, which is the same scale as the body height, are designed to sustain the pressure of flood water and contained sediment. Flood water of the Sacobia River is flowing down forming two or three main streams of 100 to 200 m in each width on the sand pocket area based on the ocular investigation. These braided streams are sometimes shifting over the sand pocket area following its micro-topography. Thus several overflow sections should be designed along the lateral dike to discharge out flood water safely as shown in Figure 8.15.

A 2-year flood of 175 m^3/s is adopted as a design discharge for the lateral dike, since the sand pocket is planned as a temporary measures for the coming three rainy seasons, 1996 to 1998. Overflow sections of 150 m wide and 0.5 m high without freeboard are designed to enable to release 2-year flood from at least two overflow sections simultaneously.Front apron of two layers with height difference of 0.5 m is designed for dessipating energy of overflowing flood water so as to avoid the occurrence of heavy scouring around the front side of the lateral dike. The structural design of the lateral dike is shown in Figure 8.16.

The lateral dike is organized into three rows with gabion structures. However, in case that the downstream end row of lateral dike, which is scheduled definitely to be constructed in one year advance, will not be buried completely with sediment deposition, the structures in second and third rows may be changed from gabion to a series of piles taking into account the future land use for irrigation development.

(b) San Nicolas Balas Ring Dike

Proposed road dike of Route 329 will be elevated up to 3 m above the present ground level. The San Nicolas Balas Ring Dike should be at least higher than the road dike, since this dike directly protects Barangay San Nicolas Balas from flooding. Thus height of this dike is set at 3.5 m, and its height should transition to 3.0 m near the junction with the Parua River Dike because the design height of the Parua River Dike is 3.0 m.

The sand pocket area will be expected to be raised to 1.0 - 1.5 m higher than the present elevation by sediment confinement of the lateral dike. Slope protection work should be made up to 2 m from the present ground with freeboard of 0.5 - 1.0 m on the sand pocket side, in order to prevent bank erosion by erosive flood water. Furthermore, top of foundation shall be buried 1 m deep under the ground so as to avoid the anticipated collapse of slope protection due to local scouring also by local current of erosive flood water.

The others of elements are referred to the existing structures done by DPWH. The structural design of the San Nicolas Balas Ring Dike is presented in Figure 8.17.

(c) Parua River Dike

The target of the Parua River Dike for reinforcement of the sand pocket is a stretch from the junction with the San Nicolas Balas Dike to the downstream end of the Malonzo-San Pedro Hill Dike, since the effect of sediment confinement by third-row lateral dike would reach to the downstream end of the Malonzo-San Pedro Hill Dike.

Slope protection work on the sand pocket side shall be made in the same manner as the San Nicolas Balas Ring Dike. According to the Bamban River improvement plan, Parua River Dike is designed of 3 m high and with slope protection. Thus dike design on the Bamban River side is followed to its improvement plan. The structural design of the Parua River Dike is shown in Figure 8.17.

(d) Mabalacat-Magalang-San Francisco Bridge Dike

The target of the Mabalacat-Magalang-San Francisco Bridge Dike for reinforcement of the sand pocket is a stretch from the downstream end of open levee to about 3 km upstream point, since effect of sediment confinement by third-row lateral dike would reach to this point.

At present the Mabalacat-Magalang-San Francisco Bridge Dike is composed of open levee system in this stretch, and on the opposite side of the sand pocket the dike is suffered from the overbanked flood water of the Sapang Balen River. Thus the existing dike system should be closed to attain sediment confinement, and then be raised with slope protection on both side.

The expected function of this dike is to confine sediment safely on the sand pocket side, and to prevent bank erosion and dike breach by the Sapang Balen flood on the other side. Therefore dike height of 2 m is determined from the viewpoint of minimum requirement for flowing Sapang Balen floods, and the others of design elements are in the same manner as another closing dike systems. The structural design of the Mabalacat-Magalang-San Francisco Bridge Dike is shown in Figure 8.17.

(5) Construction Schedule

Construction of closing dike system should proceed in parallel with progress of construction of the lateral dike so as to create a well-functioning circumstances for sediment confinement. The construction schedule until the 1997/1998 dry season is as follows;

(a) 1995/1996 Dry Season

. Construction of the front-row lateral dike (Length = 1,110 m)
. Raising and slope protection of the San Nicolas Balas Ring Dike (Length = 2,100 m)
. Raising and closing of the open levee (the Mabalacat-Magalang-San Francisco Bridge Dike) and slope protection (Length = 1,000 m)

(b) 1996/1997 Dry Season

. Construction of the second-row lateral dike (Length = 2,130 m)
. Raising and slope protection of the Parua River Dike (Length = 1,000 m)
. Raising and closing of the open levee (the Mabalacat-Magalang-San Francisco Bridge Dike) and slope protection (Length = 1,000 m)

(c) 1997/1998 Dry Season

- Construction of the third-row lateral dike (Length = 2,720 m)
- Raising and slope protection of the Parua River Dike (Length = 1,090 m)
- Raising and closing of the open levee (the Mabalacat-Magalang-San Francisco Bridge Dike) and slope protection (Length = 1,050 m)

8.6.2 *RIVER CHANNEL IMPROVEMENT OF SAPANG BALEN RIVER*

(1) River Improvement executed in 1995

In 1995, one of the most critical condition in the Sacobia-Bamban river basin was the maintenance work of the design cross section of the Sapang Balen River. In spite of the river improvement works for widening by 60 m and deepening by 1.5 m of the Sapang Balen River downstream from Route 329 for 13 km long in order to ensure the flow capacity for a 5-year probable flood peak discharge of 380 m^3/sec, the river channel was silted with finer sediment particles.

In August 1995, the river was connected with the Bamban River at 3 km upstream from the confluence with the Rio Chico River, where there was no difference in riverbed elevation between Sapang Balen and Bamban/Parua rivers.

As for the alignment of the river, straight alignment of river channel was firstly proposed in 1994 taking into account advantages from the hydraulic viewpoint. However, the plan encountered a plenty of opponents because of the right-of-way problem. The alignment was then changed from straight line to meandering one which followed the pre-eruption condition having several/meandering portions. After the flood on October 1, 1995, which is equivalent to the magnitude of a 20-year probable flood peak discharge, the embankment was collapsed at several portions along the Sapang Balen River. The straightening of river channel has just started in October 1995 after reconciliation between the DPWH and tillers.

(2) Proposed Reinforcement Plan of Sapang Balen River

Shown in Figure 8.18 is the proposed alignment of the Sapang Balen River. The plan includes the following work items:

1) To straighten six (6) meandering portions to avoid another breach of dike as much as possible,

2) To provide slope protection works with rubble concrete revetment at the locations; two (2) confluence with collector channels, the confluence with the Bamban River and the stretches around sand pocket, and

3) To provide an additional bridge span of 30 m long to the existing San Antonio Bridge between Barangays San Antonio and San Bartolome, which is located at 3.5 km downstream from Route 329.

(3) Future Operation and Maintenence

The maintenance work to settle the riverbed elevation of the Sapang Balen River is one of the most important works to release safely the flood from the Sacobia River until the Sacobia River joins into the Bamban River after a few years. Careful monitoring of riverbed aggradation is required to prevent barangays from flooding. While, at the confluence between the Sapang Balen and Bamban/Parua rivers, the riverbed elevation of the Bamban/Parua River tends to aggradate continuously because of the supply of sediment transported from upstream reach. The dredging/excavation works of riverbed materials is required in the Bamban/Parua River.

8.6.3 ROAD DIKE ON ROUTE 329

(1) Present Condition

In the Master Plan Study, the road dike is designed for 4.5 km long with 5 m high between San Roque Creek and San Francisco Bridge on the conservative assumption that the aggradation of ground surface would be 3.0 m in 1995. However, according to the monitoring in 1995, the ground surface elevation immediately upstream of Route 329 was stable although siltation of sump and river channel of the Sapang Balen River has occurred.

(2) Basic Design Concept and Future Prospect

The elevating of Route 329 was designed under the following considerations:

1) Surface elevation of sediment deposits was stable at immediately upstream of Route 329 in 1995.

2) Lateral dike system proposed in the Short Term Plan would accelerate to diminish the sediment transportation to the downstream reach. The ground level at immediately upstream of Route 329 may be stable until the Sacobia River joins into the Bamban River as far as the lateral dike system functions, although some finer particles may silt up in the channel of the Sapang Balen River.

3) Therefore, the safety against flood is the most important matters in the downstream end of sand pocket area. The reinforcement of San Nicolas Balas Dike in the north, the elevating Road dike on Route 329 in the east and reinforcement of right dike along Sapang Balen River in the south are required to function properly as flood control structures.

4) In case that an excessive volume of sediment occurs in the sand pocket and the upstream storage by lateral dike is buried with sediment fully, the storage between lateral dike and road dike is available for sediment deposits. In such a case, the excess sediment will deposit between lateral dike and Route 329 with a volume of 60,000 m^3. However, the crest elevation of Road 329 is higher than that of lateral dike as shown in Figure 8.19.

5) The volume of sediment from the Sacobia River is diminishing drastically in 1995 and the training work of the Sacobia River could be scheduled to be advanced in 2 years. Route 329 would be safe against sediment deposition to be raised by 2.5 m from the viewpoint sediment balance.

(3) Alignment

A part of Barangay San Nicolas Balas, which is located at north east part of sand pocket upstream of Route 329, would be safe against flooding as far as the San Nicolas Balas Dike is rehabilitated and is assured for the safety against flood. Consequently, the elevating of Route 329 is subject to the segment between the Sapang Balen River and San Nicolas Balas of 1.65 km long. The new alignment is delineated at 30 m upstream of the existing Route 329 under the following reasons:

1) The construction works of the new San Francisco Bridge has just started in October 1995 at 30 m upstream of existing bridge as shown in Figure 8.20. It is expected to connect between San Francisco Bridge and new Route 329 as a straight alignment when the traffic volume is increased in the future.

2) The flood diverting facilities of new Route 329 would be malfunctioned because of the blockage/damage by the materials of existing road, bridges and box culverts

along Route 329 in case that the new road is aligned at downstream of existing one.

3) The construction works will not disturb the traffic flow along Route 329.

The general plan of the alignment of new Route 329 is shown in Figure 8.21.

(4) Flood Control Structures along New Route 329

The height of embankment is designed to release safely a flood water with 5-year probable flood, while the Sapang Balen Bridge is for 50-year probable flood as the permanent structures. The distribution of design flood is illustrated in Figure 8.22.

1) Case-1 : Before the training works for the Sacobia River

Design flood of 5-year probability was adopted to the design of flood control works along Route 329 taking into account the construction period of training works of the Sacobia River in 1997/1998.

The flood control works along Route 329 are organized into three (3) structures; namely, Sapang Balen Bridge, Baidbid box culvert and San Nicolas Balas box culvert. Firstly, the Sapang Balen Bridge is designed as a permanent structure to ensure the flowing capacity of 50-year probable flood peak discharge of Sapang Balen River, while a series of box culverts is designed for releasing the remaining flood peak discharge by subtracting a 50-year probable flood peak discharge of Sapang Balen River from a 5-year probable flood of both Sacobia and Sapang Balen rivers . The flood discharge bifurcates into three (3) channels to keep the upstream flood water level of Route 329 without any hydraulic gradient among the upstream sides of flood control structures.

2) Case-2 : After the training works for the Sacobia River

Design flood of 50-year probability is adopted for flood control structures as a permanent use of structures after training works of the Sacobia River. The 50-year probable flood peak discharge of the Sapang Balen River is released through the Sapang Balen Bridge to the downstream reach, while the flood peak discharge in the area where is used as sand pocket at present is estimated at 68 m^3/sec with 25-year probability in accordance with the design criteria established by the DPWH. The Baidbid box culvert will be a main drainage as a permanent structures to release the flood peak discharge.

Design flood water level of EL.39.7 m and the bottom of girder of EL.40.7 m are determined under the following conditions:

Design discharge	:	170 m^3/sec (50-year return period)
Riverbed elevation	:	EL.35.84 m (for Sapang Balen River)
Riverbed gradient	:	1/440 (for Sapang Balen River)
Freeboard	:	1.0 m (Design Criteria by DPWH)
Roughness coeff.	:	0.035 (for Sapang Balen River)

While, the flow width of the box culverts is equivalent to that of the Sapang Balen River and the invert elevation was determined to ensure the flow capacity under the assumption that the upstream water level of Route 329 coincides with the design flood water level of Sapang Balen River. Consequently, the opening sizes of box culvert were determined under the following condition:

Design discharge	:	160 m^3/sec (5-year return period)

		in which, 330 m^3/sec (a 5-year return period from Sacobia and Sapang Balen rivers and) - 170 m^3/sec (a 50-year flood from Sapang Balen River)
Invert elevation	:	EL.37.1 m
Riverbed gradient	:	1/440 (for Sapang Balen River)
Freeboard	:	80 % inner height corresponds to design high W.L.
Roughness coeff.	:	0.025 (for concrete structure)

(5) Sapang Balen Bridge

A pre-stressed concrete (PC) girder with single span are shown in Figure 8.23 is adopted to the Sapang Balen Bridge to release a flood discharge smoothly into downstream reach of the Sapang Balen River under the following reason:

1) PC girder type is not only standardized by the DPWH but also the most popular type in the Philippines.
2) Material for steel bridge is not domestic products of the Philippines
3) Maintenance works after completion would be difficult because that few Filipino contractors have experienced to construct a steel bridge.

(6) Box Culvert and Pipe Culvert

Box culverts are designed as 9-barrel for San Nicolas Balas and 4-barrel for Baidbid Bridge to ensure the flow capacity of design discharge. Dimension of each barrel of 3 m x 3 m was adopted in the design. The height of barrel was designed that the design flood water level was set at 80 % height of barrel as shown in Figure 8.24.

As for a pipe culvert, flush flood may occur in the upstream of the Route 329 in the north east part of sand pocket area where is confined by the San Nicolas Balas Dike and Route 329. A couple of pipe culvert is required to release the flood water across the Route 329. The flood peak discharge was estimated at 2.53 m^3/sec by the equation:

$$Q = C\,I\,A / 3.6$$

where, Q : peak discharge (m^3/sec)
C : runoff coefficient (= 0.3)
I : design rainfall intensity (= 93.3 mm/hr: 10-year return period)
A : catchment area (=23 km^2)

The profile of pipe culvert is also shown in Figure 8.24.

(7) Height of Embankment of Road Dike

The height of embankment of road dike was determined to coincide with the surface elevation of the Sapang Balen Bridge. The dimension of road dike was determines as follows:

Location	:	Route 329 (Magalang-Concepcion Road) between the Sapang Balen River and San Nicolas Balas
Length	:	1,650 m
Embankment height	:	2.65 m above the surface elevation of existing Route 329
Slope of Embankment	:	1:2.0 with wet stone masonry with 0.3 m thick
Road width	:	2-lane traveled way of 6.1 m wide and shoulder of 2.5 m wide
Embankment Volume	:	76,500 m^3 with lahar material

General plan, profile and typical section are shown in Figure 8.25.

8.7 STRUCTURAL DESIGN FOR MEDIUM TERM PLAN

8.7.1 CONSOLIDATION DAM

Maskup narrow path is located at the downstream end of the sediment deposition area in the spindle-shaped valley. The river course of the Sacobia River has shifted frequently in the sediment deposition due to bank erosion and channel clogging. Under such situations, the water course is likely stabilized by installation of sediment control structures at the narrow path. Maskup consolidation dam is placed with high priority because of its suitable location for sediment retention. The restoration work of Route 3 including two bridges across Sacobia and Bamban rivers can be achieved as a permanent structure only when the Maskup consolidation dam fixes the outlet of river channel at spindle-shaped valley and river course is trained properly to the downstream of Maskup. The spillway crest is set at 3.0 m in effective height in consideration of the height of terrace and the existing right dike along Clark Field. The wing embankment on the right terrace connected with the right dike was also designed as a protective dike. Figure 8.26 shows the plan and typical sections of Maskup consolidation dam. The following gives the design discharge:

Item		Main Dam	Sub-dam
Catchment area	:	62.5 km^2 (Pre-piracy condition)	
Design discharge	:	568 m^3/s (100-year probable flood)	
Sediment Concentration	:	20 %	20 %
Mudflow discharge	:	710 m^3/sec	710 m^3/sec
Freeboard	:	1.7 m	1.0 m
Length of Apron	:	15.0 m	14.0 m

Although the main body made of concrete structure is generally preferable for the construction material of sabo dam, the foundation for Maskup consolidation damsite is very soft with loosened lahar deposit of insufficient bearing capacity for concrete and masonry structures, while the main body of embankment type is unaffordable at spillway portion because of possibility of overtopping during flooding. However, the consolidation dam with double wall structures may ensure the highest reliability for very soft foundation. It is also preferable to allow a high workability and shortest construction period among the other types. The proposed design is likely most suitable under the geomorphologic condition in 1995. In case that additional geotechnical data in the detailed design stage allow the bearing capacity for cement-mixed material in dam body, the plan as shown in Figure 8.27 will be one of the alternatives for implementation.

The principal features of consolidation dam are enumerated below:

Design Condition	Unit	Main Dam	Sub-dam	Cut-off	Wing Embankment
Construction Material		Sheet Pile	Sheet Pile	Reinf't Bar	Soil
Effective Height	m	3.3	2.0	0.0	3.5
Depth of Embedment	m	6.0	5.5	6.0	2.0
Length of Dam	m	490.0	190.0	173.0	542.0
Width of Dam	m	9.0	7.5	5.0	10.0
Width of Spillway	m	150.0	150.0	150.0	0.0

In 1994, Dolores consolidation dam was also planned for stabilizing the river course together with Maskup consolidation dam and preventing secondary erosion of sediment deposits so as to make the restoration of the Route 3 possible. The results of geotechanical survey carried out in 1995 clarified that a very weak sediment depositional layer with N-value of less than 5 interbeds at 10 m below sediment depositional surface. Therefore, a series of groundsills was adopted effective in order to ensure the stability of river channel in lieu of Dolores consolidation dam.

8.7.2 TRAINING WORKS OF SACOBIA RIVER

(1) Alternatives for Channel Alignment

Sediment in the Sacobia River is diminishing remarkably since the river piracy of the Pasig River in 1993. In 1995, a gradation of lahar deposits is now developing in sand pocket area between Routes 3 and 329 . It is expected that the Sacobia River forms a braided river system in the sand pocket area in case of no training work of the Sacobia River.

Alternatives for the alignment of the Sacobia River were elaborated in order to join into the Bamban River as shown in Figures 8.28 to 8.30. The alternatives are:

Alternative-1 : The Sacobia River is trained to follow the river channel alignment of pre-eruption period. The Sacobia River changes its flow direction to northward at Maskup and joins into the Marimla and Sapang Cauayan rivers at Bamban.

The alternative is required the least construction cost among the alternatives because that the river channel is shortest among alternatives and the Mabalacat Bridge of Route 3 across the Sacobia River is not required.

However, the center line of river channel forms right angle with the Bamban River and the maleffects would occur at the left bank of the Bamban River due to the rapid current of flood water. In case that the unexpected sediment flows down through the Sacobia channel, the sediment may block the river flow of the Sapang Cauayan and Marimla rivers.

Alternative-2 : The Sacobia River is trained to join into the Bamban River at immediately upstream of San Pedro Hills.

The Alternative-2 gives slightly shorter channel than the others. However, the dam axis of Maskup consolidation dam is required to be bent and the width of dam crest is longer than the others. Furthermore, the angle of confluence between Sacobia and Bamban rivers makes rather bigger angle comparing with that in Alternative-3

Alternative-3 : The Sacobia River is trained to join into the Bamban River where the Bamban River has the widest river channel.

The alternative ensures the straight flow direction of the Sacobia River down to the confluence with the Bamban River. The angle of confluence between the Sacobia and Bamban rivers is rather gentle, and the confluence point is located where the Bamban River has the widest river channel against flooding.

According to the results of riverbed fluctuation analysis in the upstream stretch from Barangay Bamban to San Pedro Hill of the Bamban River, the riverbed has a tendency of degradation by 10 m within a decade until the riverbed lowers to the riverbed elevation of pre-eruption. The confluence may be settled as lowerer reach as possible to avoid the riverbed degradation at confluence which results in the erosion of at downstream face of groundsill.

On the contrary, in case that the confluence point is set at upstream reach as Alternative-1, the continuous embedment of slope protection work is required corresponding to the riverbed degradation and unexpected sediment supplied from the Sacobia River may result in the riverbed aggradation in the upstream reach.

From the viewpoint of riverbed fluctuation, the location upstream of Malonzo is preferable to the confluence between the Sacobia River and the Bamban River. Thus, a stretch of 5 km of Alternative-3 was adopted as river training works between Maskup consolidation dam and the confluence.

However the riverbed fluctuation forecast contained assumptions of sediment delivery rate and uncertainty of rainfall amount. The monitoring of geomorphologic change and riverbed fluctuation should be made to clarify the appropriate alignment of training channel in the detailed design period.

(2) Design of Training Works

(a) River Channel

A 20-year return period of 470 m^3/sec including sediment concentration of 10 % is applied for design scale. Slope of 1/180 with an average water depth of 1.5 m is proposed based on the existing topographic condition surveyed in early 1994. River channel with slope protection was proposed.

Design Cross Section is enumerated below:

Design cross section shape	:	single trapezoid (1.0 V / 2.0 H)
Design discharge	:	470 m^3/sec
Design flow velocity	:	2.6 m/sec
Design depth	:	1.4 m
Freeboard	:	0.8 m
River width	:	150 m
Riverbed width	:	141.2 m
Roughness Coefficient	:	0.035

(b) Groundsill

A series of groundsill is designed as shown in Figure 8.31. Groundsill is generally effective in storing sediment in the upstream reach and maintaining riverbed elevation. In the Alternative-3, a series of groundsill was arranged to settle the riverbed gradient of 1/180 which corresponds to the present ground surface gradient of 1/110. In case that the excessive riverbed degradation occurs in the Bamban River, the additional groundsill in the downstream end would be required.

Six groundsills of 2.0 m high are proposed at an interval of 500 m. Double wall with steel sheet piles is adopted to the design of main body and cut-off, while the apron is designed as concrete structures. The depth of steel sheet pile was designed taking into account the horizontal riverbed gradient between groundsills.

8.7.3 CHANNEL IMPROVEMENT OF BAMBAN RIVER

(1) Design Condition

Design flood with a 20-year probability was applied to the river structures in the Feasibility Study, and the design discharges computed under the catchment area of pre-eruption conditions are applied.

River Stretch	Design Discharge	Freeboard
Confluence with Rio Chico River (Sta. 0+000) - Confluence with Sapang Balen River (Sta. 3+000)	1,260 m^3/s	1.0 m
Confluence with Sapang Balen River (Sta. 3+000) - Confluence with Sacobia River (Sta. 21+800)	1,040 m^3/s	1.0 m
Confluence with Sacobia River (Sta. 21+800) - Confluence with Sapang Cauayan and Marimla Rivers	580 m^3/s	1.0 m

(2) River Improvement Plan

(a) Channel Alignment

1) Lower and Middle Reaches

Alignment of lower and middle reaches of river channel from the confluence with the Rio Chico River to San Francisco Bridge follows the present one considering that parallel dikes exist in whole reaches.

2) Upper Reach

From San Francisco Bridge to Bamban town, present river channel varies its widths from 300 m to 1,100 m and spreads towards the right bank of pre-eruption period.

To realize future land use plan to restore dislocated families to their original settlements, the alignment of river channel is likely fixed at minimum width. The following two alignment alternatives are compared to determine the suitable alignment, (refer to Figure 8.32):

i) Alternative-A : River channel with specified width is aligned within the present river channel in 1995.

ii) Alternative-B : River channel with specified width is aligned within the river channel before eruption of Mt. Pinatubo.

Work Items	Alternative - A	Alternative - B
Land Acquisition	0.7 km^2	None
Channel Excavation	Minor	2 million m^3
Maintenance of Channel	Easier because of straight channel	Two curvatures to be carefully maintained

Although the Alternative-B is required an additional excavation work of 2 million m^3 to construct the channel, it is exempt from the right-of-way problem. It is preferable to adopt the Alternative-B for smooth construction works.

(b) Longitudinal Profile and Cross Section

1) Riverbed Fluctuation

The longitudinal profiles of the Bamban River was surveyed in early 1994 and early 1995. The results show that no remarkable riverbed fluctuation was identified.

2) Design Riverbed Elevation

The riverbed is preferable to be designed as lower as possible from the viewpoint of flood control. Although the riverbed elevation in 1995 is higher than inland elevation, it is proposed to adopt the present longitudinal profiles for Feasibility Design taking into account a flow capacity and a stability of existing revetments in the upper and middle reaches. While in the lower reach, river improvement works is crucial to remove sediment deposits down to design riverbed levels for 12.6 km long from Sta.0+000 to Sta.12+600 because of insufficient flow capacities.

Design riverbed profile is shown in Figure 8.33. Design riverbed gradient varies from 1/650 at lowest reach to 1/190 at uppermost reach of the Bamban River.

3) Design High Water Level

Design high water level is computed by non-uniform flow method on the following basis:

i) The construction works of the Pampanga Delta Flood Control Project has been carried out by the DPWH since 1991. Flood water level with a 20-year probability is defined as the design high water level for the above Project. Thus, the design high water level of EL.12.53 m at the confluence with the Rio Chico River was adopted to that at downstream end of the Bamban River.

ii) Roughness coefficient is estimated at 0.035

Figure 8.33 also shows design high water level profiles with design riverbed gradient from 1/1980 to 1/190.

4) Design of Channel Cross Section

River channel in upper reach from the confluence with the Sacobia River is designed using the uniform flow method under the condition that design velocity should be smaller than 3.0 m/s to avoid remarkable riverbed degradation and lateral erosion:

Design discharge	: 580 m^3/s
Design longitudinal bed slope	: 1/190
Design roughness coefficient	: 0.035
Design velocity	: 2.6 m/s
Design shape of section	: Single trapezoid
Design channel top width	: 170.0 m
Design channel bed width	: 160.4 m
Design water depth	: 1.4 m
Design freeboard	: 1.0 m
Design channel side slope	: 1V : 2.0H

Figure 8.34 shows design cross sections of whole stretches.

(3) Proposed Structure

Figure 8.35 shows the proposed arrangement of the mudflow/flood control works for the Sacobia-Bamban River.

(a) Dike

At present, existing dikes are eroded by flow river water and damaged by rainwater at some portions. Moreover, dikes of lower reach should be raised because of insufficient flow capacity. Raising and repairing works should be done in accordance with the following existing dike dimensions (refer to Figure 8.36):

Top width of dike	: 7 m
Side slope	: 1H:3V (without revetment)
	: 1H:2V (with revetment)
Reinforcement of dike surface	: to be covered with mountain clayey soil
Provision of inspection road	: gravel metal on the top of dikes.

(b) Slope Protection

At present, slope protection works of about 9 km long in total have been constructed along the Bamban River. Additional provision of rubble concrete slope protection work should be required along the right dike of middle reach, right dike of middle reach, and both banks of upper reach as shown in Figure 8.35.

Figure 8.37 shows typical section of slope protection with rubble concrete organized into rubble concrete on filter clothing, concrete footing and gabion mattress. Crest elevation of rubble concrete is equivalent to the design high water level in principle. Toe is embedded with a depth of 1 m into riverbed.

(c) Spur Dike

Permeable reinforced concrete pile spur dikes, as shown in Figure 8.38, with a length of 20 m and 1 m high are proposed at the four severe curvatures of middle reach to avoid erosion of dikes and promote sedimentation. There are no rules of general applicability for determining the spacing, lengths and angle. Practically the following may be applicable based on the experiences in Japan.

Direction	:	right angle to flow,
Length	:	less than 10% of river channel width,
Spacing	:	1 to 4 times of length, and
Height	:	as low as 0.5 to 1.0 m above low water level to minimize scour around spur dikes

(4) Dredging and Spoil Bank

The river channel improvement works for the lower reach is proposed to excavate about 1.5 million m^3 on the basis of the cross sectional data in the early 1995. The excavated materials is available to reinforce the existing dike system in the lower reach , while the remains are transported to spoil bank.

The area of spoil bank of about 350 ha is required at the southwest swampy area of the confluence between Bamban and Rio Chico rivers as shown in Figure 8.35. The spoil bank is also utilized for the materials due to maintenance dredging works for 9 years.

8.7.4 RIVER IMPROVEMENT OF SAPANG CAUAYAN RIVER

(1) Treatment of Dammed Lake

A lake formed by damming Sapang Cauayan river with lahar deposit is located at 2.5 km upstream from the confluence with the Marimla and Bamban river. This lake will be reserved as it is in the Medium Term Plan.

However, the dammed lake may exist temporarily and would be smaller year by year because of the erosion of the lake outlet. To maintain the lake is one of the schemes in the Long Term Plan, a permanent structure such as consolidation weir might be required at the lake outlet in order to maintain the surface water level of lake.

The land acquisition for the land submerged into the lake where many tillers cultivated their farm land before eruption will be required when the consolidation weir is constructed as permanent structure and maintain the lake water.

(2) Bank Protection Works

At present, water from the lake flows through the channel with width of 50 to 200 m width into the Bamban river. Slope of channel is about 1/250 based on topographic maps surveyed in April, 1994 by JICA.

Banks of river are made of lahar deposit which are easily eroded by flowing/rain water. Accordingly, it is proposed to construct the bank protection from dammed lake to the confluence with the Bamban river, a total length of about 2.7 km (1.7 km for right bank and 1.0 km for left bank, refer to Figure 8.35), to ensure highway route 3 to be restored.

Figure 8.37 shows the typical section of proposed bank protection structure consisting of rubble concrete with a slope of 1V:2H and concrete footing on gabion mattress embedded in river bed with a depth of 1.0 m.

The features of proposed training works are listed below:

Design discharge	: 150 m^3/s (20-year return period)
Design longitudinal bed slope	: 1/190
Design roughness coefficient	: 0.035
Design velocity	: 2.6 m/s
Design shape of section	: Single trapezoid
Design channel top width	: 170.0 m
Design riverbed width	: 160.4 m
Design water depth	: 1.4 m
Design freeboard	: 1.0 m
Design channel side slope	: 1 V : 2.0 H

8.7.5 RECONSTRUCTION OF ROUTE 3

(1) General Description

Route 3 is one of major trunk highway system in Luzon island and connecting Manila and northern Luzon regions. It is passing through towns of San Fernando, Angeles, Mabalacat, Bamban, Capas and Tarlac in the project area.

Before the eruption of Pinatubo in 1991, it run northward from Mabalacat to Bamban along Sacobia river and crossed over the Bamban river in south of the town of Bamban. At just upstream of the bridge, the Sacobia river jointed with the Marimla river and the river downstream reaches is named as the Bamban/Parua river.

Lahar avalanches triggered by the eruption of Pinatubo and succeeding secondary explosions and heavy storms completely buried the Sacobia valley upstream of the Route 3. Then the Sacobia river shifted its direction at just upstream of the highway toward straightway crossing the highway.

The stretch between Mabalacat and Bamban of the Route 3 was completely destroyed and buried by frequent lahars and floods. DPWH have been trying to open the route by constructing a temporary road parallel to the ordinal alignment of the highway and temporary bridges across the Sacobia flood channel and the Bamban River every dry season, but the Sacobia river shifted the river channel easily at every lahar events and therefore the temporary road could not be maintained during the rainy season.

The number and magnitude of lahar events from the Sacobia river are remarkably reduced in 1994 and 1995 and it is expected that the river channel of the Sacobia River and the Bamban River would be stabilized by providing appropriate structural measures proposed in the previous sections.

According to the plan of river training works, the Sacobia river is to be diverted northeastward across the original alignment of Route 3 and connected to the Bamban river about 5 km downstream of the pervious Bamban bridge site.

The restoration works of Route 3 would be implemented when the river training works are completed and the channel is stabilized.

The volume of the traffic of Route 3 at Mabalacat before the eruption was above 9,500 vehicles per day in 1990 (Nationwide Traffic Count Program in 1990, DPWH). During the rainy season, most of the traffic have made a detour through Route 329 crossing the Bamban river at San Francisco bridge about 10 km downstream of the town of Bamban and partially through Pan-Philippines Highway (Highway Route 5).

(2) Route Selection

Following three alternative routes were examined in a comparison study of Highway Route 3 restoration ; Alternative-1 (ALT-1) ; the shortest route connecting Mabalacat and Bamban, Alternative-2 (ALT-2) : original route in pre-eruption, and Alternative-3 (ALT-3) : the shortest route from Mabalacat to Tarlac. The brief characteristics of each route are as follows:

ALT-1 : Two towns of Mabalacat and Bamban are connected by a straight alignment. The stretch of road restoration is the shortest and the construction cost is the lowest. But additional land acquisition area is larger than ALT-2.

ALT-2 : This route is planned to trace the original Route 3 before eruption. Additional land acquisition area is the smallest. But it is necessary to improve the horizontal alignment partially and bridges cross the river on the skew.

ALT-3 : This route is the shortest to Tarlac direction. The accessibility to Tarlac is better than others but additional land acquisition area is the largest and the construction cost is the highest.

The alignment of these alternatives are illustrated in Figure 8.39 and advantages and disadvantages of each alternative are summarized in the Table below.

Route	Advantage	Disadvantage	Quantities / Cost
ALT-1	1)Smooth horizontal alignment 2)The lowest construction cost 3)The shortest bridge section 4)Avoid the existing CIS area	1)Large additional land acquisition area	Road : 3.0 km Bridge(L>100m) : 360m (2nos.) Add. Land Acq : 75,000 m^2 **Cnst.Cost P177million**
ALT-2	1)Small additional land acquisition area 2)Avoid the existing CIS area	1)Partially unfavorable horizontal alignment. 2)The longest bridge section	Road : 3.1 km Bridge(L>100m) : 375m (2nos.) Add. Land Acq : 10,000 m^2 **Cnst.Cost P182million**
ALT-3	1)The best accessibility from Mabalacat to Tarlac 2)Smooth horizontal alignment	1)Large additional land acquisition area 2)The highest construction cost 3)Crossing the existing CIS area	Road : 3.9 km Bridge(L>100m) : 360m (2nos.) Add. Land Acq : 95,000 m^2 **Cnst.Cost P192million**

CIS : Communal Irrigation System in Bamban

On the basis of the above comparison, ALT-1 is recommendable because,

1) the length of ALT-1 is the shortest, namely the construction cost of ALT-1 is the lowest.

2) the horizontal alignment of access road to bridge will be rather smooth in ALT-1 . The girder plate with rectangular can be adopted, it make possible the safety of bridge piers against flood discharge by crossing the river channel with right angle.

3) additional land acquisition is one of the most serious and important matter for construction schedule and the area to be acquired for ALT-1. However, the land for old alignment of Route 3 (almost same as the alignment of ALT-2) will be bartered for the ALT-1.

(3) Road Alignment and Standard Cross Section

The proposed route alignment of ALT-2 almost traces the original one before the eruption. In order to follow the design criteria of DPWH, some modifications are made to improve the horizontal alignment and the standard cross section. The criteria adopted for the proposed ALT-2 are those for Average Daily Traffic (ADT) between 10,000 and 20,000 and rolling topographic condition as summarized below.

Design Speed	:	80 km/hr
Min. Radius of Curvature	:	220 m
Max. Grade	:	4 %
Non Passing Sight Distance	:	115 m
Passing Sight Distance	:	560 m
Lane Width	:	3.65 m
Shoulder Width	:	2.5 m

The longitudinal profile of Route 3 and typical section are shown in Figure 8.40.

(4) Bridges

Two bridges are necessary to be built on the Highway between Mabalacat and Bamban, one is crossing over the Sacobia diversion channel (Mabalacat bridge) and the other is over the Bamban River (Bamban bridge).

(a) Mabalakat Bridge

They are designed as PC girder type as shown in Figure 8.41 under the following reasons;

1) PC girder type is standardized by the DPWH and most popular in the Philippines.

2) Material of steel bridge is not domestically produced in Philippines.

3) Maintenance works of steel bridge after completion would be difficult because few Filipino contractors have experienced to construct steel bridges.

The design return period of flood is determined to be 50-year in accordance with the Design Standard of DPWH.

The total length of Mabalacat bridge crossing Sacobia diversion channel is determined to be 198 m, consisting of 6-span of 33 m long girder because the bridge will cross over the 150 m width channel at 50 degree skew. The span length is determined to be 33 m by applying the Japanese Structural Standard given as following formula,

$$L = 30 + 0.005Q$$

where, L : span length (m)
Q : flood peak discharge of 50-year return period (500 m^3/sec)

The design flood water level is determined to be EL.92.8m under the following conditions;

Design discharge	:	Q = 500 m^3/s (a 50-year return period)
Riverbed elevation	:	H = 91.4 m (for Sacobia Diversion Channel)
Longitudinal profile	:	I = 1/180 (for Sacobia Diversion Channel)
Freeboard	:	1.0 m (Design Criteria of DPWH)
Roughness coeff.	:	0.035 (for Sacobia Diversion Channel)

(b) Bamban Bridge

The suitability of the various bridge types is governed primarily by the span length. Table 8.8 shows the applicable ranges of span length for different types of concrete and steel bridges.

The four alternative bridge types as shown in Figure 8.42 have been compared on the basis of following criteria;

1) Construction Period
2) Technical Aspect
3) Aesthetic View
4) Actual Experience of Construction
5) Construction Cost
6) Maintenance Requirement

7) Influence by the future riverbed degradation

The evaluation results are summarized in Table 8.9. The table shows that the most economical and suitable is PC girder type in case of stable rivebed elevation in the future. However, in case that the riverbed lowers year by year as given in the numerical simulation in the Master Plan, the Nielsen Bridge ensures the safety against the flood. The monitoring of riverbed fluctuation is required in order to judge either of type is applicable for the bridge.

In the Feasibility Study, Bamban bridge is designed as PC girder type tentatively as shown in Figure 8.43 under the following reasons;

1) Construction cost is the lowest and construction period is the shortest.

2) PC girder type is standardized by the DPWH and most popular in the Philippines.

3) Material for steel bridge is not domestic products of Philippines.

4) Maintenance works of steel bridge after completion would be difficult because few Filipino contractors have experienced to construct steel bridges.

The design return period of flood is determined to be 50-year in accordance with the Design Standard of DPWH. Total length of Bamban bridge crossing the Bamban river is determined to be 170 m, consisting of 5-span of 34 m long girder. The span length was determined to be 34 m based on the same Japanese Structural Standard given in the previous section where the flood peak discharge of 50-year return period is 690 m^3/sec. The design flood water level is determined to be EL.83.7m under the following conditions;

Design discharge	:	Q = 690 m^3/s (a 50-year return period)
Riverbed elevation	:	H = 82.1 m (for the Bamban River)
Longitudinal profile	:	I = 1/190 (for the Bamban River)
Freeboard	:	1.0 m (Design Criteria of DPWH)
Roughness coeff.	:	0.035 (for the Bamban River)

8.8 COST ESTIMATE

8.8.1 CONDITIONS OF COST ESTIMATE

Cost estimate for the project proposed in the Feasibility Study is based on the following criteria which were also applied for Master Plan.

1) Construction works to be executed on the contract basis.
2) Prices used for estimation on the basis of the price level as of November, 1995.
3) Exchange rates; US$1 = Peso 25.0 = Yen 100 (Peso 1.0 = Yen 4.0).
4) Unit cost base for civil works.
5) Some percentage of major cost components for costs of preparatory works, miscellaneous works, administration, physical contingency.

8.8.2 PROJECT COST

Project cost for the Project of Sacobia-Bamban river basin is estimated at 2,834 million pesos in total including physical and price contingencies. The following is a summary of estimated cost. Detailed breakdown of cost is shown in Table 8.10.

Unit: million Pesos

	Item	Foreign Currency Portion	Local Currency Portion	Total
1.	Main Construction Cost	1,184	747	1,931
1.1	Preparatory Works	52	32	84
1.2	Main Works	1,030	649	1,679
1.3	Miscellaneous Works	103	65	168
2.	Land Acquisition	0	34	34
3.	Administration Cost	0	98	98
3.	Engineering Service Cost	174	19	193
4.	Physical Contingency	134	80	216
	Total	1,494	978	2,472
4.	Price Contingency	113	249	362
	Grand Total	1,607	1,227	2,834

8.8.3 DISBURSEMENT SCHEDULE

The following is the annual disbursement schedule of Project Cost from 1996 to 1999 based on the implementation schedule indicated in Figure 8.44.

Unit: million Pesos

Year	Foreign Currency Portion	Local Currency Portion	Total
1996	196	130	326
1997	241	170	411
1998	608	464	1,072
1999	562	463	1,025
Total	1,607	1,227	2,834

Detailed Annual Disbursement Schedule is shown in Table 8.11.

8.8.4 OPERATION AND MAINTENANCE COST

Annual cost of operation and maintenance (O/M), from the year of 2000 following completion of project works, is estimated at 9.7 million pesos assuming it to be 0.5% of main construction cost.

Aside from the O/M cost above, maintenance works (desilting work of channel) should be continued for 9 years from 1996 to 2004. Annual maintenance cost for desilting work is estimated at 90 million pesos.

8.9 ECONOMIC EVALUATION

8.9.1 COST OF THE PROJECT

The investment cost was estimated on the basis of the following preconditions:

1) the base period of cost estimate was set at as of November 1994,

2) the exchange rates were assumed at US$ 1=Peso 25=¥ 100,

3) value added tax and import duties of 7% in total were estimated in the local currency portion,

4) the price contingency for the future were estimated assuming annual inflation rates of 2.5% for foreign currency and 8.7% for local currency portions respectively,

5) the administration cost was estimated in local currency portion at 5% of the total of main construction cost (including F.C. and L.C.) and land acquisition cost,

6) the engineering cost was estimated at 10% of the total main construction cost, of which 90% was assumed to be in foreign currency and 10% in local currency, and

7) the physical contingency was estimated by 10% of the total of main construction cost, land acquisition cost and engineering cost.

The cost for desilting works were treated as the maintenance cost and scheduled to be disbursed in nine (9) years for Sacobia/Bamban Rivers starting from the initial stage of the construction.

The Project cost (financial) is estimated at P 2,834 million with foreign currency (F.C.) portion of P 1,607 million and local currency (L.C.) portion of P 1,227 million at the price level as of November 1995 as shown below.

Project Cost of Flood/Mudflow Control Works for Sacobia/Bamban River Project

Unit: million Pesos

	Financial Cost			Economic Cost		
	F.C.	L.C.	Total	F.C.	L.C.	Total
1) Main Construction Cost	1,184.36	746.62	1,930.98	1,184.36	525.49	1,709.85
2) Land Acquisition Cost	0.00	34.20	34.20	0.00	0.00	0.00
3) Administration Cost	0.00	98.26	98.26	0.00	78.59	78.59
4) Engineering Cost	173.79	19.31	193.10	173.79	15.44	189.23
5) Physical Contingency	135.82	80.01	215.83	135.82	63.99	199.81
6) Price Contingency	112.65	249.11	361.76	-	-	-
7) Total	1,606.61	1,227.51	2,834.12	1,493.97	683.51	2,177.48

The operation and maintenance costs were estimated based on 0.5% of the total of the main construction cost.

The financial cost shown above was converted into the economic cost to adjust the distorted market price value. Considering the current unemployment situation, the market wage was adjusted by shadow wage rate which was assumed at 60% of the market wage rate. In order to adjust the distortion of the official exchange rate, the standard conversion factor of 0.86 was applied following the recent ADB practice. The economic cost of land acquisition was assumed to be nil based on the fact that the land required for the Project have been either a swamp area or lahar areas with no productive use.

8.9.2 BENEFIT OF THE PROJECT

(1) Criteria of Benefit

The benefit to be accrued from the implementation of the Project was defined in this Study as the reduction of the direct and indirect damages caused by flood/mudflows. The probable direct and indirect damages were estimated under the current conditions at the end of 1994. The damage under the with-project conditions was assumed to be zero under the design flood of 20 year-return period. Thus the project benefit constitutes the probable damage to be occurred by the flood of the designed scale of 20-year return period..

(2) Estimate of Direct Damage

In estimating the damageable value of all the properties in the probable inundation area, a " Barangay Data Base" was established in the GIS (Geographical Information System). All the data required for the estimate of damage including population, number of household, value of properties and areas of each barangay were input and arranged in this Data Base.

The probable inundation areas were delineated for the river basin on the basis of a hydrological simulation study for each return period of 2, 5, 10, 20, 50 and 100 years out of which those of 20- and 100-year return period floods are depicted in Figure 8.45.

Damage curves were generated for major items of properties such as residential buildings, non-residential buildings, paddy field, upland crops, and infrastructures including roads and bridges. The damage curves were generated for each hazard of flooding, sediment and lahar toward the depth and duration of each hazard. The curves are depicted in Figure 8.46. Unit values each damageable property applied in this Study are shown in Table 8.12.

The method of identifying and estimating damageable values is stated by each item hereunder:

(a) Buildings

The number of buildings locating in probable flood areas were counted on a topo map of 1:10,000 which was produced from aerial photos taken in 1994. Through superimposing the flood area map on the said topo maps, buildings to be inundated were counted for each flood return period.

The result of the population census in 1990 conducted by NSO and the population survey conducted by the JICA Study Team in August 1994 were referred to. The recent result of the Survey of Establishment conducted by NSO in 1993 was also utilized.

(b) Agricultural Crops

The land use map by each agricultural crop in the Study area as of 1994 was produced and was stored in GIS Barangay Data Base. This land use map was produced mainly based on the aerial photo map taken by the JICA Study Team in April 1994 with a scale of 1:10,000 and the land use map of Magalang, Mexico, Santa Ana and Arayat municipalities which were prepared by the JICA study of "the Mapping and Agricultural Potential Study for the Integrated Rural Development Program in Pampanga" in November 1992.

Unit prices applied were those net income values of each crop adopted in Agno Study after being adjusted for the price change between the time of the two studies. The damage of the livestock was estimated by a ratio (7%) of the agricultural crops following the Agno Study after reviewed based on recent statistics.

(c) Infrastructures

The length of roads, bridges and irrigation canals were stored in the Barangay Data Base for each barangay. The damage to these infrastructures were computed according to the probable affected area in each barangay. The data on roads and bridges were originated from a GIS map prepared by JICA study of CLDP and those on irrigation canals were originated from the recent "Irrigation Systems/Projects Survey" prepared by JICA study in October 1994.

The probable flood damage for each property and for each flood return period is summarized in Table 8.13. The average annual direct damage was obtained after aggregating each property damage and is tabulated in Table 8.14.

(3) Estimate of Indirect Damage

In this Study, the indirect damage covers such secondary damages to be stemmed from and induced by the flood/mudflow occurrences as the additional transportation cost due to forced detouring, the opportunity loss of product due to the interruption of economic activities caused by flood/mudflow, and the cost of evacuation and clean-up of buildings. The indirect damages were estimated as stated hereunder.

(a) Detour Cost of Transportation

The probable additional cost of transportation due to the forced detour caused by flooding of roads and bridges was computed based on the detour distance, duration and the vehicle operation cost.

In the typhoon season, it was assumed that the San Francisco Bridge becomes impassable ten times for each three days which results 30 impassable days in a year due to flooding of access roads to the bridge. Within this period, it was assumed that all the vehicles were forced to make a long detour taking Friendship Highway via Santa Rita near Malolos without taking the shorter route via San Fernando-Gapan road to avoid the habitual flood prone area near around Mexico municipality.

For other eleven (11) months of the year, it was assumed that all the traffics except 2,500 vehicles per day which prefer to take a detour through the Friendship Highway to avoid the probable congestion caused by non-existence of Bamban Bridge would take a route via San Francisco Bridge.

The total traffic demand for crossing the Bamban River was assumed at 13,000 per day based on the recent traffic survey of JICA and PNCC. JICA Study Team made a traffic counting survey at three (3) points of roads in Mabalacat, Magalang and Capas in the period of July 16-July 23, 1995.

The detour alternative routes were assumed for each origin-destination route under the normal condition i.e. under the pre-eruption conditions which is considered as with-Project conditions and are shown in Figure 8.47. The computation formula and other data for the computation is shown in Tables 8.15 and 8.16.

The extension of North Luzon Expressway is now under planning by extending the existing route from Santa Ines terminal to Tarlac. Its completion is expected in 2010. Therefore, it was assumed in this Study that 6,000 vehicles taking the North Luzon Expressway presently would take the new route after its completion. This will lessen the benefit of the Bamban Bridge construction after 2011.

(b) Loss of Production by Interruption of Economic Activities

The loss of production due to the interruption of economic activities caused by flood/mudflows were estimated based on the per capita GRDP of non-agricultural sector (estimated at P33,550 in 1994 at 1994 price) multiplied by the duration (assumed to be ten days in a year) and the number of affected people in urban areas.

The loss of production in the agricultural sector was not considered here since it is already included in the direct flood damage of agricultural crops. The basic data for computation of the estimated loss of GRDP is shown in Table 8.17.

(c) Evacuation and Building Clean-up Costs

The evacuation cost and the clean-up cost of buildings to be occurred at the time of disasters were estimated based on the unit cost adopted from a similar study in the past and the assumed duration of the incidence. For the cost of evacuation, the duration of ten (10) weeks in a year and the unit cost of P216 per week per household were assumed for lahar incidence. For the cost of clean-up of buildings, the duration of six (6) days in a year and the unit cost of P150 per day per building were assumed for lahar. No similar costs were considered for flood incidence.

The probable costs of evacuation and building clean-up together with the estimated loss of GRDP are shown for each flood return period in Table 8.18 and their average annual costs are shown in Table 8.19.

8.9.3 COMPARISON OF COST AND BENEFIT

The comparison of cost and benefit is presented in Table 8.20.

Benefits were assumed to accrue immediately after the completion of the Project. When the expected rapid economic growth in the Central Luzon Region is considered, the value of properties in the Study Area is also expected to increase rapidly. In this Study, the flood control benefit (reduction of direct damages) was assumed to increase at the same rate as that of GRDP of the Region i.e. 8.23 % p.a.

The benefit accrued from the saving of detour costs of vehicles is also expected to increase as the traffic volume increases. In this Study, the growth rate estimated for the new North Luzon Expressway studied by JICA in the LISR Study was adopted and 1.9% p.a. growth of traffics were applied. Meanwhile, assuming the completion of the said new highway after 15 years, the transportation benefit was treated to decrease after its completion in 2010.

The estimated foregone of production caused by the flood/mudflow incidence together with costs of evacuation and building clean-up was assumed arbitrarily to increase with a rate of growth of population in Region 3 which was estimated at 2.67% per annum for the period of 1990-2010 in JICA CLDP Study.

As the result of benefit-cost comparison, EIRR of 16.4% was derived. The net present value discounted at 12%, which is in this Study considered as the opportunity cost of capital in the Philippines, was computed at P 873 million.

A sensitivity analysis was conducted by varying both the benefit and cost of the Project. The result is summarized in Table 8.21. As shown in the table, the Project cannot be justified only in the worst case where the cost is assumed to increase by 20% and the benefit is assumed to decrease by 20%.

8.9.4 IMPLICATION OF ECONOMIC EVALUATION

(1) "Present Status"

It is to be noted that the project benefit to be accrued from the saving of the probable direct damage was computed on the basis of the present (as of end 1994) conditions of the Study Area which is being covered partially by lahar deposit. Therefore, in such areas as Bamban and Mabalacat municipalities where a wide lahar deposit exists, the probable damage counted in the economic analysis is far less than that to be occurred under the pre-eruption conditions. In other words, there are less probable damage remaining in such heavily damaged areas which worked to reduce the EIRR of the Project.

(2) Evaluation of the Project

The transportation benefit i.e. savings of the detour cost of vehicles caused by the flooding of roads and bridges constitutes the biggest benefit with a share of more than 40% of the total benefit (cf. table hereunder). This shows the fact that the Study Area is situated at an important location connecting the National Capital Region and the Northern Luzon Regions.

Average Annual Damage for 20-Year Return Period (Pesos million)

Building	Crops & Livestock	Infra-structure	Evacuation Cleanup	Loss of GRDP	Detour Cost	Total
51.09	19.00	17.06	8.62	7.25	76.77	179.97
28%	11%	9%	5%	4%	43%	100%

According to the PNCC data of North Luzon Expressway in July 1995, vehicles traveling directly between Metro Manila (Balintawak) and Santa Ines, the present terminal of NLE in Mabalacat, are the majority on NLE. Out of 3,940 vehicles arriving at Santa Ines, 2.290 (58%) were those entered at Manila and out of 4,050 vehicles entered at Santa Ines, 2,450 (60%) were bound for Manila. The transportation of raw materials and final products transported into and out-of Metro Manila constitutes the major flow of the traffic in the Study Area.

Following the transportation benefit, the benefit to be accrued from the saving of probable direct damage of buildings constitutes nearly 30% of the total project benefit This is resulted from the fact that some densely populated barangays in Concepcion municipality are included in the probable inundation area.

Despite the rural characteristics of this area, the probable damage on agricultural crops is expected comparatively small with 11% of the total Project benefit. The wide farmland presently covered by lahar is attributed to the reduction of probable agricultural damage.

(3) Reclamation of Sand Pocket

The pre-eruption conditions of the current sand-pocket area is shown below:

Barangays being buried in Sand Pocket

Barangay Name	Telabanca	Malonzo	St. Rosario	Sapan Baren	Tabun
Area (sq.km)	7.7	2.4	1.7	7.9	1.7
Household (1990)	350	128	379	60	528
Population (1990)	2,249	811	2,268	347	3,001

The total area of about 22 square km land is now abandoned and utilized as the sand trap. As shown above, there existed in this area five (5) barangays before the eruption and the population was about 8,700 (1,450 households) in total of the whole barangays.

In this Study, the reclamation of the sand-pocket area was not included as a Project component. In other words, both the cost incurred and the benefit accrued from the reclamation of the sand pocket area were not considered in this Study. Because, the feasibility of the lahar cultivation was not confirmed.

Meanwhile, a study on the future perspectives of agricultural development in the lahar affected farmland was carried out and compiled in the Master Plan. This study will show one of the possible ways for farmers in the area to exploit the land resources in the long term span.

(4) Tourism Development

Apart from the structural measures to cope with possible natural disasters, the present Project will pave a way for the region to promote a possible tourism development in this area. Actually, a small natural lake has been created after the eruption in the upper stream of the Sapang Cauayan River in a walking distance from the Route No.3. When the safety of climbing the Mt.Pinatubo is assured, then a volcano tourism with a sight-seeing network linking the mountains and lakes will become popular in this area. In the CLDP Study of JICA, the development of a sort of eco-tourism is being envisaged in the Region. An amusement Park in Clark Field is also proposed in the same Study. A golf course is under operation near Dolores in Mabalacat municipality and another golf course has been newly opened in November 1995 in Clark Special Economic Zone. All these tourism development plans can be successfully operated only after the security against possible natural disasters is assured by such a structural measures proposed by the present Project.

(5) Physical Benefit

The Project benefit was estimated by the saving of probable direct and indirect damages caused by the probable flood and/or lahar with a scale of 20 year-return period. The consequent physical benefit will extend to the following :

1)	Population to be relieved from inundation	:	19,800 (21% of Study Area)
2)	Number of household to be relieved	:	3,900 (22%)
3)	Land area to be saved from inundation	:	58.2 square km (22%)
4)	Farm land to be saved	:	2,800 ha (31%)

In summing up, the Sacobia/Bamban Project will relieve 19,800 persons of 3,900 households from suffering the inundation and will also save 58 square km of land in which 2,800 ha is a farm land.

The road traffic will become possible to maintain the normal order, which is absolutely necessary for economic activities of the region and also for the daily life of an ordinary people. With a security of safety from the natural disasters, investments with a longer time span consideration would become possible. The most valuable benefit of the Project seems to be that many people can be free from the risk of losing their lives though it is not included in the benefit computation.

Table 8.1 Possible Structural Measures in Sacobia-Bamban River System

Structural Measures	Applicable Area	Purpose	Dimension/Components	Adaptability/Evaluation
Revegetation	Sediment Source Zone	- To prevent sheet and gully/rill erosion - To contribute to environmental conservation	-	Revegetation will be effective when the pyroclastic deposit field become cool.
Simple Sabo Dam		- To control sediment inflow from tributaries	-	Sediment control effect might be small compared with measures in the middle reaches.
Sabo Dam	Sediment Deposition/Secondary Erosion Zone	- To retain sediment inflow	Mactan Dam: 10 m in height, 78 m in length, 100,000 m3 in volume	Retention capacity is relatively small compared with anticipated sediment inflow, and construction cost is not economically viable.
Consolidation Dam		- To consolidate accumulated sediment and reduce sediment discharge - To control watercourse	Maskup Dam: 8m in height, 460 m in length; Dolores Dam: 7 m in height, 800 m in length; A series of dams: 8 m each in height, 8,360 m in total length (9 dams).	Consolidation dam at Maskup is preferable to stabilize accumulated sediment and control sediment discharge. Although a series of consolidation dams will firmly stabilize sediment, it is costly.
Sand Pocket		- To retain sediment inflow	- Slope protection work of closing dike - A series of lateral groundsills - A sump to trap fine particles - Channeling and excavation of Sapang Balen River	If the components of sand pocket structure are completed, sediment control effect may be enormous.
Bed Girdle		- To stabilize riverbed and reduce sediment discharge	6 rows of groundsill between Bamban and Malonzo, 400 m in length	Bed girdles in the upper reaches of Bamban River will be effective in regulating riverbed aggradation of the lower reaches.
Channel Works		- To fix watercourse and avoid lateral erosion and scouring	5 km in length between Maskup and Bamban	In the case of joining the Sacobia River with the Bamban River, channel works will be needed to avoid forming distributary channel.
Channel Excavation		- To maintain riverbed elevation or increase flow capacity		Channel excavation is necessary in the aggrading portion of the riverbed.
Dike	Sediment Conveyance Zone	- To protect land from flooding	50 km in length, 4-8 m in height	New dike system will be needed with mountain soil cover and slope protection instead of lahar dike.
Spur Dike/Groin		- To protect dike from scouring	4 meandering parts	A spur dike/groin will be placed at the meandering part to reduce the flow velocity along the dike.

Table 8.2 Evaluation of Alternatives

	Alternative-1	Alternative-2	Alternative-3	Alternative-4
Plan	- Permanent use of sand pocket	- Provisional use of sand pocket - Shift of Sacobia R. to Bamban R. with sediment retention structures	- Provisional use of sand pocket - Shift of Sacobia R. to Bamban R. with sediment retention structures	- Provisional use of sand pocket - Shift of Sacobia R. to Bamban R. with sediment retention structures
Major Components	- Sand pocket structure - Sapang Balen R. improvement - Bamban R. Improvement	- Sand pocket structure (temporary) - Maskup & Dolores consolidation dam - Sacobia R. training works - Bamban R. Improvement	- Sand pocket structure (temporary) - Maskup & Dolores consolidation dam - Series of consolidation dams between Mactan & Maskup - Sacobia R. training works - Bamban R. Improvement	- Sand pocket structure (temporary) - Maskup & Dolores consolidation dam - Bed girdles in upper Bamban R. - Sacobia R. training works - Bamban R. Improvement
Advantage	- Simple measures	- Possibility to restore Highway Route 3 & sand pocket area - Solution of siltation problem in low-lying area	- Possibility to restore Highway Route 3 & sand pocket area - Solution of siltation problem in low-lying area	- Possibility to restore Highway Route 3 & sand pocket area - Solution of siltation problem in low-lying area - Possibility to utilize river water of upper Bamban River
Disadvantage	- Continuous construction & maintenance work of sand pocket structure - No chance of restoration for Highway Route 3 & affected area - Continuous siltation problem in low-lying area	- Apprehension of scouring at front side of dams	- Apprehension of scouring at front side of dams - Close monitoring to scouring downstream of consolidation dams - Uncertainty of safety for long lateral structures on loose sandy base - Prolonging construction period and inevitability of structural flexibility for topographic change - Low cost benefit ratio	- Apprehension of scouring at front side of dams - Close monitoring to scouring downstream of bed girdles
Remarks	- Maintenance excavation of 1.5 million m^3/year	- Maintenance excavation of 1.5 million m^3/year - Inevitability of monitoring activity to topographic change and constructed structures	- Maintenance excavation of 1.5 million m^3/year - Inevitability of monitoring activity to topographic change and constructed structures	- Maintenance excavation of 1.0 million m^3/year - Inevitability of monitoring activity to topographic change and constructed structures

Table 8.3 *Construction Cost for Alternatives*

(Unit: 1,000 Pesos)

WORK ITEMS	Alt-1	Alt-2	Alt-3	Alt-4
1.MAIN CONSTRUCTION COST	880,440	1,534,388	3,170,148	1,681,013
1.1 Preparatory Works	38,280	66,713	137,833	73,088
1.2 Main Works	765,600	1,334,250	2,756,650	1,461,750
(1) Sand pocket	283,780	140,900	140,900	140,900
(2) Road dike of Route 329	192,100	191,100	191,100	191,100
(3) Consolidation dam		157,000	1,579,400	157,000
(4) Sacobia River training works		468,300	468,300	468,300
(5) Bamban River improvement	204,500	204,500	204,500	204,500
(6) Bank protection for S.Cauayan R.		41,200	41,200	41,200
(7) S.Balen River improvement	85,220			
(8) Restoration of Route No.3		131,250	131,250	131,250
(9) Bed girdles in Bamban River				127,500
1.3 Miscellaneous Works	76,560	133,425	275,665	146,175
2. COMPENSATION COST	9,000	9,000	9,000	9,000
2.1 Land Aquisition	7,000	7,000	7,000	7,000
2.2 House Evacuation	2,000	2,000	2,000	2,000
3. PHYSICAL CONTINGENCY AND OTHERS	222,360	385,847	794,787	422,503
GRAND TOTAL	1,111,800	1,929,234	3,973,934	2,112,516
MAINTENANCE DREDGING WORKS	810,000	810,000	810,000	630,000

Table 8.4 List of Priority CIS/CIP for Urgent Restoration Program

Name of Irrigation System	Location	Parts Damaged by Lahar	Estimated Restoration Cost (million Peso)	Potential Irrigation Area (ha)	Irrigation Area Wet Season a/ (ha)	Irrigation Area Wet Season b/ (ha)	Irrigation Area Dry Season a/ (ha)	Irrigation Area Dry Season b/ (ha)	Crop Yield in Cavans/ha Wet Season a/	Crop Yield Wet Season b/	Crop Yield Dry Season a/	Crop Yield Dry Season b/	Number of Farmer Beneficiaries
TARLAC PROVINCE													
1. Pannisan CIS *	Bamban	A. B. C.	2.522	400	300	112	200	50	80	80	85	85	60
2. Lab CIS *	Capas	A. B. C. D. E.	2.975	362	242	242	120	120	80	80	85	85	140
3. Kawili-wili CIP	Capas	A. B. C.	29.500	340	0	0	0	0	0	0	0	0	300
4. Balucuk CIS *	Concepcion	B. C. E.	0.820	119	100	100	100	100	85	85	85	85	45
5. Lucong CIS *	Concepcion	A. B. C. D. F.	30.677	2,250	1,600	1,300	1,000	900	85	85	90	90	700
6. Sta. Monica CIS *	Concepcion	A. F.	3.017	740	300	300	300	150	85	85	85	85	193
7. Sto. Rosario CIS *	Concepcion	A. F.	2.580	210	200	200	100	100	85	85	90	90	102
8. Tinang CIS	Concepcion	A. B. C.	2.980	600	190	190	40	40	80	80	85	85	170
9. Caluluan PIS	Concepcion	B. C.	0.300	114	114	114	70	50	75	75	85	85	42
		Sub-total	75.371	5,135	3,046	2,558	1,930	1,510	655	655	690	690	1,752
PAMPANGA PROVINCE													
10. Cutud CIS *	Angeles City	A. B. C.	0.821	120	27	21	14	11	50	40	40	35	16
11. Mawaque CIS *	Mabalacat	A. B. F.	0.116	80	80	80	31	25	70	55	80	70	46
12. Sapang Biabas CIS *	Mabalacat	B. C. F.	0.070	110	70	50	25	20	70	55	65	52	96
13. Sta. Maria CIS	Mabalacat	A. B. F.	6.500	113	98	75	94	75	70	50	65	51	95
14. San Agustin CIS *	Magalang	A. B. C. F.	0.120	65	65	65	63	50	70	70	65	65	22
15. Camias CIS *	Magalang	A. B. C.	0.520	58	58	48	58	48	85	85	65	65	28
16. Banquili CIS	Magalang	A. B. C. F.	0.570	13	13	13	0	0	65	65	0	0	14
17. Bitas Libutad CIS *	Arayat	A. B. F.	0.550	265	140	108	13	10	65	65	50	50	69
18. Gatiawin CIS *	Arayat	A. B. F.	0.500	62	63	63	0	0	70	70	0	0	30
19. Inumang Baca CIS *	Arayat	A. B. F.	0.950	132	110	85	0	0	60	60	0	0	55
20. San Roque Bitas CIS*	Arayat	A. B.	0.070	126	126	103	4	3	70	70	50	50	80
21. Lacmit CIS *	Arayat	A. B.	0.100	138	138	138	0	0	60	60	0	0	72
22. Panlinlang CIS *	Arayat	A. B. F.	0.250	29	29	29	13	10	30	30	50	50	15
23. Buenavista CIS *	Arayat	A. B. F.	0.405	30	30	30	0	0	60	60	0	0	15
24. Pandacaqui CIS *	Mexico	A. B. C. D. F.	1.330	180	100	77	16	12	80	80	55	55	54
25. Calulut I CIS *	San Fernando	A. B.	0.180	60	60	60	66	51	85	85	75	75	40
26. Telabastagan CIS *	San Fernando	A. B.	0.100	24	24	24	9	7	75	75	60	60	15
27. San Agustin CIS	Sta. Ana	A. B. C. F.	0.410	28	26	26	0	0	70	70	0	0	16
28. Pansinao PIS	Candaba	E.	0.200	163	120	120	120	120	85	85	95	95	93
29. Sto. Rosario PIS	Candaba	E.	0.200	280	220	220	50	50	35	35	95	95	115
30. Gulap PIS	Candaba	E.	0.200	311	40	40	320	320	70	70	110	110	136
31. San Sebastian PIS	San Luis	E.	0.200	206	206	206	120	120	45	45	100	100	176
		Sub-total	14.362	2,593	1,843	1,680	1,014	931	1,440	1,380	1,120	1,078	1,298
		Grand Total	89.733	7,728	4,889	4,238	2,944	2,441	2,095	2,035	1,810	1,768	3,050

Note : * CIS/CIP already availed of Rehabilitation of Areas Affected by Mt. Pinatubo Eruption (RAAMPE) Funds

A. Repair and desilting of dam and reservoir
B. Desilting of Irrigation Canals
C. Installation of Control Slidegates
D. Upgrading of Service Roads
E. Installation of Pumps and/or Desilting at the Intake Works
F. Canal Lining

a/ - Before Eruption

b/ - After eruption and/or after partial rehabilitation using RAAMPE Funds in 1993;
Note that after rehabilitation, some systems were again affected by lahar flow.

Table 8.5 Project Description of the Proposed CIS/CIP

Proposed CIS/CIP	Potential Irrigation Area				Water Source	No of Intake	Type of Diversion Dam	Length of Main Canal
	Paddy	Upland	Agro-forest.	Total				
	(ha)	(ha)	(ha)	(ha)				(km)
BAMBAN RIVER BASIN AREA								
1. Bamban C.I.S.	600	250	0	850	Bamban river	1	Ogree type	12.5
2. San Pedro C.I.S.	80	50	0	130	Banban river	same as Bamban C.I.S.		3.5
3. Bangcu C.I.S.	430	220	0	650	Bamban river	same as Bamban C.I.S.		9.6
4. Tabun C.I.P.	0	100	120	220	Marimla river	1	Ogree type	4.2
5. MASKUP C.I.P.	0	500	820	1,320	Sacobia/ Bamban rivers	2	Intake	6.7 # 9.4 26.5 #
6. Sat. Rita C.I.P.	200	120	130	450	Bamban river	1	Ogree type	5.5
7. Marita C.I.P.	210	170	170	550	Bamban river	same as Marita C.I.S.		10.7
8. Magao C.I.S.	450	120	120	690	Lucung river	2	Check-Gate	6.2
9. San Vicente C.I.P.	710	100	0	810	Bamban river	1	Ogree type	12.5
10. San Bartolome C.I.P.	560	270	0	830	Sapan Belen creek	2	Check-Gate	10.3
11. San Isidro C.I.S.	560	90	0	650	Dalandanum creek	1	Check-Gate	9.0
12. Balutu C.I.S.	90	10	0	100	Parua creek	1	Check-Gate	1.4
13. Caluis Gueco C.I.P.	240	130	0	370	Balen creek	1	Check-Gate	4.5
Total Area	4,130	2,130	1,360	7,620				
ABACAN RIVER BASIN AREA								
1. San Juan C.I.P.	360	100	0	460	Abacan river	1	Ogree type	9.4
2. San Patricio C.I.P.	250	210	0	460	Abacan river	1	Ogree type	8.6
3. San Joaquin C.I.P.	150	90	0	240	Joaquin creek	1	Check-Gate	3.4
Total Area	760	400	0	1,160				

Remarks : These figures are estimated based on 1/10,000 topographic map.
Agro-forestoration field are included fruits/ fodder trees field, fish ponds, livestock yard.
(#) ; Secondary canal

Table 8.6 Proposed Implementation Schedule for Agricultural Development Project (1/2)

Description	Potencial Service Area	Location (Munincipality)	Executing Agency	Implementation Schedule													
				1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
SHORT TERM PLAN	(ha)																
Urgent Restoration Program :																	
Tarlac Province :																	
1. Panasian CIS*	400	Bamban	LGU	●	●												
2. Lab CIS*	362	Capas	LGU	●	●												
3. Kawili-wili CIP	340	Capas	LGU		●	●	●										
4. Balucuk CIS*	119	Concepcion	LGU	●	●												
5. Lucong CIS*	2,250	Concepcion	LGU	●	●												
6. Sta. Monica CIS*	740	Concepcion	LGU	●	●												
7. Sto. Rosario CIS*	210	Concepcion	LGU	●	●												
8. Tinang CIS	600	Concepcion	LGU		●	●	●										
9. Caluluan PIS	114	Concepcion	LGU		●	●	●										
Pampanga Province :																	
10. Cutud CIS*	120	Angeles City	LGU	●	●												
11. Mawaque CIS*	80	Mabalacat	LGU	●	●												
12. Sapang Biabas CIS*	110	Mabalacat	LGU	●	●												
13. Sta. Maria CIS	113	Mabalacat	LGU		●	●	●										
14. San Agustin CIS*	65	Magalang	LGU	●	●												
15. Camias CIS*	58	Magalang	LGU	●	●												
16. Banquili CIS	13	Magalang	LGU		●	●	●										
17. Bitas Libutad CIS*	265	Arayat	LGU	●	●												
18. Gatiawin CIS*	62	Arayat	LGU	●	●												
19. Inumang Baca CIS*	132	Arayata	LGU	●	●												
20. San Roque Bitas CIS*	126	Arayat	LGU	●	●												
21. Lacmit CIS*	138	Arayat	LGU	●	●												
22. Panlinlang CIS*	29	Arayat	LGU	●	●												
23. Buenavista CIS*	30	Arayat	LGU	●	●												
24. Pandacaqui CIS*	180	Mexico	LGU	●	●												
25. Calulut CIS*	60	San Ferunando	LGU	●	●												
26. Telabastagan CIS*	24	San fernando	LGU	●	●												
27. San Agustin CIS	28	Magalang	LGU		●	●	●										
28. Pansinao PIS	163	Candaba	LGU		●	●	●										
29. Sto. Rosario PIS	280	Sto. Rosario	LGU		●	●	●										
30. Gulap PIS	311	Candaba	LGU		●	●	●										
31. San Sebastian PIS	206	San Luis	LGU		●	●	●										

Remarks : CIS ; Communal Irrigation System, CIP ; Communal Irrigation Project, PIS ; Pump Irrigation System
LGU ; Local Government Unit, NIA ; National Irrigation Administration, DA ; Department of Agriculture
DPWH ; Department of Public Works and Highways, DAR ; Department of Agrarian Reform
(*) ; CIS/CIP already availed of Rehabilitation of Areas Affected by Pinatubo Eruption (RAAMPE) Funds.

☆ ; Study
★ ; Design
● ; Construction

Table 8.6 Proposed Implementation Schedule for Agricultural Development Project (2/2)

Description	Potencial Service Area (ha)	Location (Municipality)	Executing Agency	Implementation Schedule 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
MEDIUM TERM PLAN																	
Restoration and Rehabilitation Projects																	
1. Magao CIS	690	Concepcion	LGU / NIA		★	●	●										
2. San Isidro CIS	650	Concepcion	LGU / NIA		★	●	●										
3. Balutu CIS	100	Concepcion	LGU / NIA		★	●	●										
4. Calois Gueco CIP	370	Concepcion	LGU / NIA		☆	★	●	●									
5. San Juan CIP	360	Mexico	LGU / NIA		☆	★	●	●									
6. San Patricio CIP	460	Mexico	LGU / NIA		☆	★	●	●									
7. San Joaquin CIP	140	Mexico	LGU / NIA		☆	★	●	●									
Santa Rita Pilot Demonstration Project																	
1. Santa Rita CIP	450	Concepcion															
- Land reclamation work			LGU / DPWH		☆	★		●	●	●							
- Resettlement work			LGU / DAR		☆	★		●	●	●							
- Agriculture development work			LGU/ DA/ NIA		☆		★			●	●	●					
- Crop experimental work			DA / NIA		☆		★	O	O	O	O	O	O	O	O	O	O
LONG TERM PLAN																	
Restoration and Rehabilitation Projects																	
1. Bamban CIS	850	Bamban	LGU / NIA				☆		★	●	●						
2. San Pedro CIS	130	Banban	LGU / NIA				☆		★	●	●						
3. Bangu CIS	650	Bamban / Concepcion	LGU / NIA				☆		★	●	●						
4. San Vicente CIP	810	Concepcion	LGU / NIA				☆		★	●	●						
5. San Bartolome CIP	830	Concepcion / Magalang	LGU / NIA						★	●	●						
Integrated Land and Agriculture Development Projects in Heavy Lahar Affected Area																	
1. Marita CIP	550	Concepcion															
- Land reclamation work			LGU / DPWH				☆		★	●	●	●					
- Resettlement work			LGU / DAR				☆		★		●	●					
- Agriculture development work			DA/ NIA				☆		★			●	●	●			
2. Tabun CIP	220	Mabalacat															
- Land reclamation work			LGU / DPWH				☆		★	●	●	●					
- Resettlement work			LGU / DAR				☆		★		●	●					
- Agriculture development work			DA/ NIA				☆		★			●	●	●			
3. MASKUP CIP	1,320	Bamban / Concepcion / Mabalacat															
- Land reclamation work			LGU / DPWH				☆		★	●	●	●	●	●			
- Resettlement work			LGU / DAR				☆		★			●	●	●	●		
- Agriculture development work			DA/ NIA				☆		★			●	●	●	●	●	●

Remarks: CIS ; Communal Irrigation System, CIP ; Communal Irrigation Project, PIS ; Pump Irrigation System
LGU ; Local Government Unit, NIA ; National Irrigation Administration, DA ; Department of Agriculture
DPWH ; Department of Public Works and Highways, DAR ; Department of Agrarian Reform

☆ ; Study
★ ; Design
● ; Construction
O ; Experiment & Demonstration

Table 8.7 Comparison Table for Alternative Routes of North Luzon Expressway

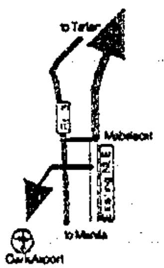
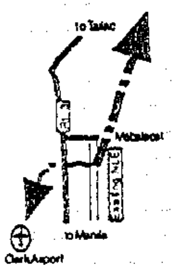
Route Name	Advantage	Disadvantage	Quantities / Cost
ALT-1 	1) Accessibility from Clark Airport to the NLE will be good 2) Additional land acquisition area and cost will be minimum for passing the Clark Area. 3) No obstruction for urban expansion of Mabalacat City 4) Cross the edge of future CIP area 5) No need of improvement of Mabalacat Interchange	1) Construction cost will be high 2) Main route will cross Route 3 twice and railway three(3) times 3) Holizontal and vertical alignments of main route will be not smooth 4) Social enviroment impactwill be high	Main Road 16.0 km Access Road 2.0 km Interchange Single Trumpet 1 no. Semi-direct Y type 1 no. Toll Gate 1 no. Bridge(L>100m) 2 nos. (700 m) Viaduct Main Road 3 nos. (1,500 m) Access Road 0 no. (0 m) Flyover Bridge 3 nos. **Construction Cost ₱ 2,287 million**
ALT-2 	1) Construction cost will be the lowest 2) Holizontal and vertical alignments of main route will be smooth 3) Social enviroment impact will be low	1) Additional land acquisition area willbe large 2) Access road will cross Route 3 once 3) Obstruction for urban expansion of Mabalacat City 4) Cross the center of future CIP area 5) Necessity to improve on Mabalacat Interchange	Main Road 10.0 km Access Road 3.0 km Interchange Semi-direct Y type 1 no. Diamond 1 no. Direct Y type 1 no. Toll Gate 1 no. Bridge(L>100m) 2 nos. (600 m) Viaduct Main Road 0 no. (0 m) Access Road 1 no. (500 m) Flyover Bridge 4 nos. **Construction Cost ₱ 1,282 million**
ALT-3 	1) Accessibility from Manila to Tarlac will be good 2) Holizontal and vertical alignments of main route will be smooth 3) Social enviroment impact will be low 4) No need of improvement of Mabalacat Interchange	1) Additional land acquisition area is large 2) Access road will cross Route 3 once 3) Obstruction for urban expansion of Mabalacat City 4) Cross the center of future CIP area	Main Road 11.3 km Access Road 3.0 km Interchange Semi-direct Y type 1 no. Direct Y type 1 no. Toll Gate 1 no. Bridge(L>100m) 1 no. (800 m) Viaduct Main Road 0 no. (0 m) Access Road 1 no. (500 m) Flyover Bridge 4 nos. **Construction Cost ₱ 1,440 million**

Table 8.8 Applicable Ranges of Span Length by Bridge Type

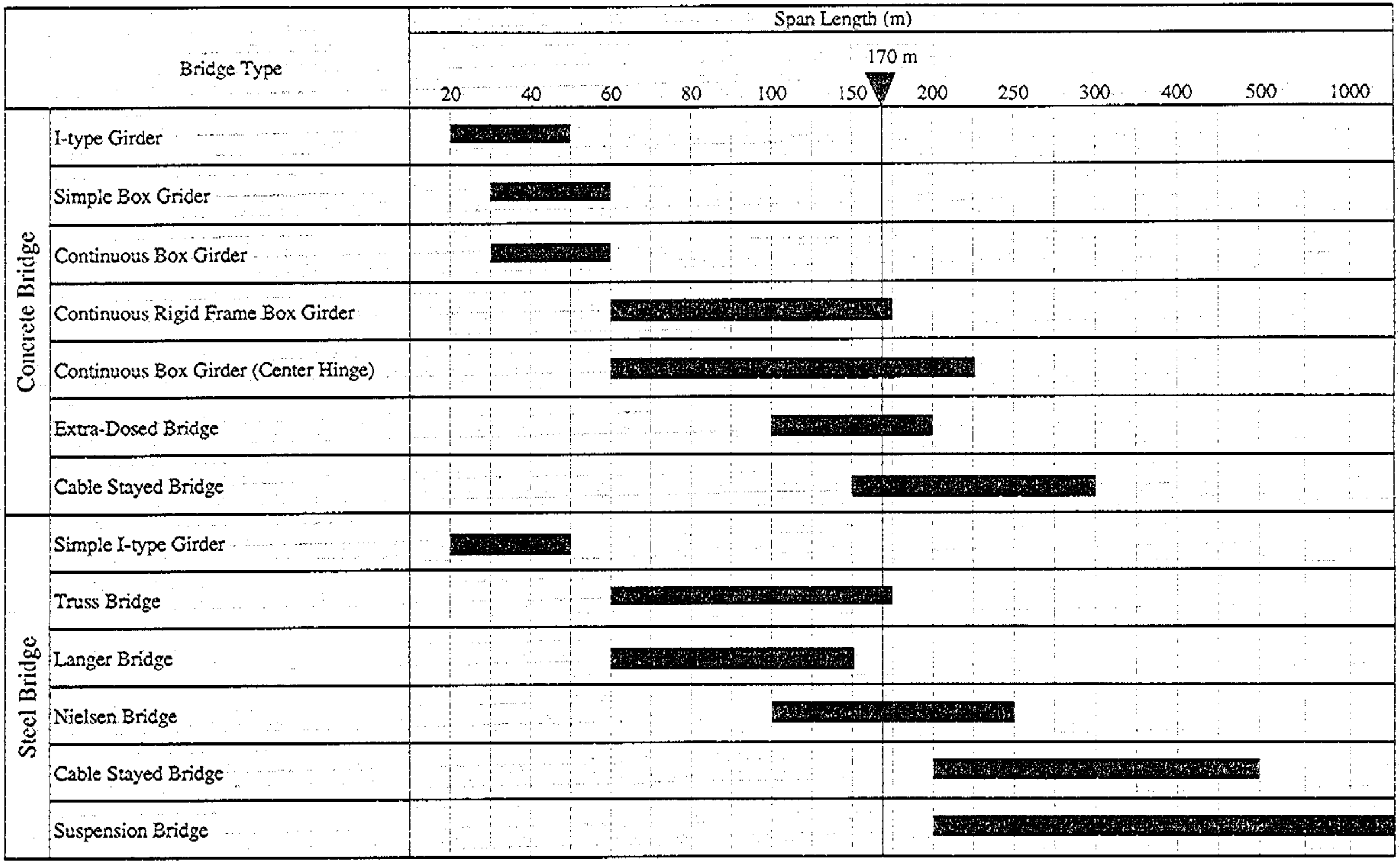


Table 8.9 Evaluation of Alternative Bridge Type

Item	PC I-Girder Bridge	PC Box Girder Bridge	Extra-Dosed Bridge	Nielsen Bridge
Required Total Bridge Length	170m (5@34m)	290m (1@170m + 2@60m)	350m (1@170m + 2@90m)	170m (1@170m)
Construction Period	1.5 years	2.0 years	2.0 years	1.5 years
Technical Aspect	Conventional method and technically feasible	Conventional method and technically feasible	High-tech method but technically feasible	Conventional method and technically feasible
Aesthetic View	fair	Good	Very good	Very good
Actual Experience of Construction in Japan	Many bridges applied for short span	Many bridges applied for long span	A few bridges but several applied in future	Many bridges applied for long span
Construction Cost	₱ 80 million	₱ 420 million	₱ 500 million	₱ 150 million
Maintenance Requirement	Almost maintenance free	Almost maintenance free	Cables and cable sockets needed but possible to change cables	Arch, slab and cables needed
Influence by the future riverbed degradation	Influence for pier	No influence	No influence	No influence
Evaluation	◎	△	△	○

Table 8.10 Project Cost for Sacobia-Bamban River Basin

Unit : Pesos

Work Items	Unit	Quantity	F.C. Portion Unit Cost	F.C. Portion Amount	L.C. Portion Unit Cost	L.C. Portion Amount	Total Unit Cost	Total Amount
1. MAIN CONSTRUCTION COST				1,184,362,734		746,616,292		1,930,979,027
1.1 Preparatory Works	l.s.			51,494,032		32,461,578		83,955,610
1.2 Main Works				1,029,880,638		649,231,559		1,679,112,197
1.2.1 Sand Pocket				157,719,682		96,735,358		254,455,040
(1) Road Dike	m	1,650		37,413,982		30,932,008		68,345,990
1) Sapang Balen Bridge	m2	363	15,000	5,445,000	10,600	3,847,800	25,600	9,292,800
2) Box Culverts	m3	963	2,735	2,633,805	2,969	2,859,147	5,704	5,492,952
3) Embankment & Concrete Pavement	m	1,612	4,346	7,006,220	5,398	8,701,906	9,744	15,707,526
4) Rubble Concrete type Slope Protection	m	1,612	9,873	15,915,517	5,637	9,086,195	15,510	25,001,712
5) Others	l.s.			6,413,440		6,437,560		12,851,000
(2) Lateral Dike	m	5,960		72,616,000		36,129,600		108,745,600
1) 1st-Row Lateral Dike	m	1,110	12,156	13,493,000	6,048	6,713,400	18,204	20,206,400
2) 2nd-Row Lateral Dike	m	2,130	12,094	25,761,000	6,018	12,817,800	18,112	38,578,800
3) 3rd-Row Lateral Dike	m	2,720	12,265	33,362,000	6,102	16,598,400	18,368	49,960,400
(3) Raising & Clothing of Open Dikes	m	3,050		23,804,750		14,378,280		38,183,030
1) Embankment, Mountain Soil and Gravel Pvt.	m	3,050	758	2,310,850	590	1,798,180	1,347	4,109,030
2) Rubble Concrete type Slope Protection	m	3,050	7,047	21,493,900	4,125	12,580,100	11,172	34,074,000
(4) Raising/Slope Prot. of San Nicolas Balas Dike	m	2,100		12,664,500		8,140,500		20,805,000
1) Embankment, Mountain Soil and Gravel Pvt.	m	2,100	2,458	5,182,500	1,785	3,747,900	4,253	8,930,400
2) Rubble Concrete type Slope Protection	m	2,100	3,563	7,482,000	2,092	4,392,600	5,655	11,874,600
(5) Raising/Slope Prot. of Parua R. Dike	m	2,090		11,220,450		7,154,970		18,375,420
1) Embankment, Mountain Soil and Gravel Pvt	m	2,090	1,354	2,830,300	999	2,088,200	2,353	4,918,500
2) Rubble Concrete type Slope Protection	m	2,090	4,014	8,390,150	2,424	5,066,770	6,439	13,456,920
1.2.2 Maskup Consolidation Dam				86,189,531		39,055,093		125,244,624
(1) Steel Sheet Piling	m	36,915	1,260	46,512,900	144	5,315,760	1,404	51,828,660
(2) Reinforced Concrete	m3	2,368	2,735	6,471,010	2,969	7,024,654	5,704	13,495,664
(3) Plain Concrete	m3	6,806	1,620	11,025,720	2,482	16,892,492	4,102	27,918,212
(4) Gabion Mattress	m3	5,937	1,210	7,183,770	597	3,544,389	1,807	10,728,159
(5) Wing Dike Embankment	m	542	927	502,434	746	404,332	1,673	906,766
(6) Wing Dike Rubble Conc. Slope Protection	m3	3,333	1,516	5,052,828	936	3,119,688	2,452	8,172,516
(7) Others	l.s.			9,440,869		2,753,778		12,194,647
1.2.3 Sacobia River Training Work				325,935,001		177,930,870		503,865,871
(1) Groundsills	set	6		157,124,990		70,599,730		227,724,720
1) Steel Sheet Piling	m	65,200	1,260	82,152,000	144	9,388,800	1,404	91,540,800
2) Reinforced Concrete	m3	5,410	2,735	14,796,350	2,969	16,062,290	5,704	30,858,640
3) Plain Concrete	m3	11,920	1,620	19,310,400	2,482	29,585,440	4,102	48,895,840
4) Gabion Work	m3	20,020	1,210	24,224,200	597	11,951,940	1,807	36,176,140
5) Others	l.s.			16,642,040		3,611,260		20,253,300
(2) Channel Excavation	m3	2,800,000	40	112,000,000	24	67,200,000	64	179,200,000
(3) Rubble Concrete type Slope Protection	m	10,356	5,486	56,810,011	3,875	40,131,140	9,361	96,941,151
1.2.4 Bamban River Improvement				278,039,675		195,845,597		473,885,272
(1) Channel Excavation (Upper Reach)	m3	2,000,000	40	80,000,000	24	48,000,000	64	128,000,000
(2) Raising Dikes (Embank., Mount. Soil & Pvt)	m	7,200	3,544	25,516,800	2,594	18,678,920	6,138	44,195,920
(3) Rubble Concrete type Slope Protection	m	29,150	5,344	155,786,900	3,866	112,697,200	9,210	268,484,100
(4) Spur Dike	set	12	158,240	1,898,875	242,748	2,912,977	400,988	4,811,852
(5) Dike Reinforcement Work	m	12,500	1,187	14,837,500	1,085	13,556,500	2,272	28,394,000
1.2.5 Sapang Cauayan River Training Works	m	2,650	3,862	10,233,435	2,765	7,326,068	6,626	17,559,503
1.2.6 Sapang Balen River Improvement Works				29,016,060		18,933,120		47,949,180
(1) Channel Straightening	m	2,000	5,580	11,160,000	3,390	6,780,000	8,970	17,940,000
(2) Rubble Concrete type Slope Protection	m	1,200	11,505	13,806,060	7,743	9,291,120	19,248	23,097,180
(3) Additional Span for Bartolome Bridge	m2	270	15,000	4,050,000	10,600	2,862,000	25,600	6,912,000
1.2.7 Restoration of Highway Route 3	m	3,400		142,747,255		113,405,452		256,152,707
(1) Bamban Bridge	m2	2,041	21,000	42,861,000	14,840	30,288,440	35,840	73,149,440
(2) Mabalacat Bridge	m2	2,751	21,000	57,771,000	14,840	40,824,840	35,840	98,595,840
(3) Embankment & Concrete Pavement	m	3,023	13,932	42,115,255	13,990	42,292,172	27,922	64,407,427
1.3 Miscellaneous Works	l.s.			102,988,064		64,923,156		167,911,220
2. LAND ACQUISITION	ha	456		0		34,200,000		34,200,000
(1) Route 329 Road Dike	ha	5	0	0	75,000	375,000	75,000	375,000
(2) Dikes in Sand Pocket	ha	10	0	0	75,000	750,000	75,000	750,000
(3) Sacobia River Sediment Control Works	ha	90	0	0	75,000	6,750,000	75,000	6,750,000
(4) Highway Route 3	ha	1	0	0	75,000	75,000	75,000	75,000
(5) Spoil Bank	ha	350	0	0	75,000	26,250,000	75,000	26,250,000
3. ADMINISTRATION COST				0		98,258,951		98,258,951
4. ENGINEERING SERVICE COST				173,788,112		19,309,790		193,097,903
5. PHYSICAL CONTINGENCY				135,815,085		80,012,608		215,827,693
Total				1,493,965,931		978,397,642		2,472,363,574
6. PRICE CONTINGENCY				112,646,000		249,111,000		361,757,000
Grand Total				1,606,611,931		1,227,508,642		2,834,120,574
7. MAINTENANCE WORKS (Desilting Work, 1996-2024) (Excluding price escalation)	m3	13,500,000			60	810,000,000	60	810,000,000

Note:
(1) Preparatory Works = 5% of Main Works of 1.
(2) Miscellaneous Works = 10% of Main Works of 1.
(3) Administration Cost = 5% of 1. and 2.
(4) Engineering Service Cost = 10% of 1.
(5) Physical Contingency = 10% of 1., 2., and 4.
(6) Price Contingency = 2.5% for F.C. and 8.7% for L.C. from 1. to 5.
(7) Exchange Rate : US$ 1.00 = 100 Yen = 25 Pesos

Table 8.11 Annual Disbursement Schedule for Sacobia-Bamban River Basin

Unit : 1,000 Pesos

Work Items	Total F.C.	Total L.C.	Total Total	1996 F.C.	1996 L.C.	1996 Total	1997 F.C.	1997 L.C.	1997 Total	1998 F.C.	1998 L.C.	1998 Total	1999 F.C.	1999 L.C.	1999 Total
1. MAIN CONSTRUCTION COST	1,184.383	746.616	1,930.980	112.651	76.570	189,221	156.346	97.301	253.648	483.177	297.684	780.861	432.189	275.062	707.251
1.1 Preparatory Works	51.494	32.462	83.956	4.898	3.329	8,227	6.798	4.230	11,028	21.008	12.943	33.950	18.791	11.959	30.750
1.2 Main Works	1,029.881	649.232	1,679.113	97.957	66.582	164.540	135.953	84,610	220.563	420.154	258.855	679.009	375.816	239.184	615,001
1.2.1 Sand Pocket	157.720	96.736	254.456	37.638	21.833	59.472	59.556	37.451	97.007	60.525	37.452	97.977	0	0	0
1) Road Dike	37,414	30.932	68.346	0	0	0	18.707	15,466	34.173	18,707	15.466	34.173	0	0	0
2) Lateral Dike	72.616	36.130	108.746	13.071	6.503	19.574	26,142	13.007	39.149	33.403	16.620	50.023	0	0	0
3) Raising/Closing of Open Dikes	23.805	14.378	38.183	11.903	7.189	19.092	11.903	7.189	19.092	0	0	0	0	0	0
4) Raising of San Nicolas Dike	12.665	8.141	20.806	12.665	8.141	20.806	0	0	0	0	0	0	0	0	0
5) Raising of Parua Dike	11.220	7.155	18.375	0	0	0	2,805	1,789	4.594	8.415	5.366	13.781	0	0	0
1.2.2 Maskup Consolidation Dam	86.190	39.055	125.245	0	0	0	8,619	3.906	12.525	43,095	19.528	62,623	34,476	15,622	50.098
1.2.3 Sacobia River Training Works	325.935	177.931	503.866	0	0	0	21.394	11,073	32.467	134,968	72.166	207.133	169.574	94,692	264.266
(1) Groundsills	157.125	70.600	227.725	0	0	0	15.713	7.060	22.773	78.563	35.300	113.863	62.850	28.240	91.090
(2) Channel Excavation	112.000	67,200	179.200	0	0	0	0	0	0	28,000	16.800	44.800	84.000	50.400	134.400
(3) Slope Protection	56.810	40.131	96,941	0	0	0	5.681	4,013	9.694	28.405	20.066	48.471	22.724	16,052	38.776
1.2.4 Bamban River Improvement Works	278.040	195.846	473.886	38,206	30.462	68.668	35.195	24,508	59.702	125.902	87.869	213.771	78,736	53.009	131.745
(1) Channel Excavation	80,000	48,000	128,000	0	0	0	8,000	4.800	12.800	40.000	24,000	64,000	32,000	19.200	51,200
(2) Raising Dikes	25,516	18.679	44,195	0	0	0	3.827	2.802	6,629	21.689	15.877	37.566	0	0	0
(3) Slope Protection	155.787	112.697	268.484	23.368	16.905	40.273	23.368	16.905	40,273	62.315	45,079	107.394	46.736	33.809	80.545
(4) Spur Dikes	1,899	2.913	4.812	0	0	0	0	0	0	1.899	2.913	4,812	0	0	0
(5) Dike Reinforcement Works	14.838	13.557	28,395	14.838	13.557	28,395	0	0	0	0	0	0	0	0	0
1.2.5 S. Cauayan River Training Works	10,233	7.326	17.559	0	0	0	0	0	0	0	0	0	10.233	7.326	17,559
1.2.6 S. Balen River Improvement Works	29.016	18.933	47,949	22.113	14,288	36.401	6.903	4.646	11.549	0	0	0	0	0	0
(1) Straightening of Channel	11,160	6.780	17.940	11.160	6.780	17.940	0	0	0	0	0	0	0	0	0
(2) Slope Protection	13.806	9.291	23.097	6.903	4.646	11,549	6.903	4.646	11.549	0	0	0	0	0	0
(3) Expansion of Bartolome Bridge	4.050	2.862	6.912	4,050	2.862	6.912	0	0	0	0	0	0	0	0	0
1.2.7 Restoration of Highway Route 3	142.747	113.405	256,152	0	0	0	4,286	3,029	7.315	55.664	41,841	97.505	82,737	68.535	151,332
(1) Bamban Bridge	42,861	30,288	73,149	0	0	0	4.286	3.029	7.315	38,575	27,259	65.834	0	0	0
(2) Mabalacat Bridge	57,771	40,825	98,596	0	0	0	0	0	0	8,666	6.124	14.789	49,105	34,701	83,807
(3) Embankment & Concrete Pavement	42,115	42.292	84.407	0	0	0	0	0	0	8.423	8.458	16.881	33.692	33.834	67.526
1.3 Miscellaneous Works	102.988	64,923	167.911	9.796	6.658	16,454	13,595	8.461	22,056	42.015	25.886	67,901	37.582	23.918	61.500
2. LAND ACQUISITION	0	34,200	34,200	0	17,100	17.100	0	17.100	17.100	0	0	0	0	0	0
3. ADMINISTRATION COST	0	98.259	98.259	0	10,316	10.316	0	13,537	13,537	0	39.043	39.043	0	35,363	35.363
4. ENGINEERING SERVICE COST	173.788	19,310	193.098	60,826	6.758	67,584	52.136	5.793	57,929	30.413	3.379	33.792	30,413	3.379	33,792
5. PHYSICAL CONTINGENCY	135.815	80.013	215.828	17.348	10,043	27.391	20,848	12.019	32.868	51.359	30.106	81.465	46.260	27.844	74.104
Total	1,493.966	978.397	2,472.365	190.825	120.787	311.612	229.331	145.751	375.082	564.949	370.212	935.161	508.862	341.548	850.510
6. PRICE CONTINGENCY	112.646	249.111	361.757	4.771	9.611	14,382	11.610	24.006	35.616	43.439	94.173	137.612	52.826	121.321	174.148
Ground Total	1,606.613	1,227.508	2,834.122	195.595	130.398	325.993	240.941	169.757	410.698	608.388	464.385	1,072.773	561.688	462.969	1,024.658
7. MAINTENANCE WORKS (Desilting Works) (Excluding price escalation)	60 pesos x 1,500,000 m3 /year = 90 million peso/year (1996 - 2004)														

Note:

(1) Preparatory Works = 5% of Main Works of 1.
(2) Miscellaneous Works = 10% of Main Works of 1.
(3) Administration Cost = 5% of 1. and 2.
(4) Engineering Service Cost = 10% of 1.
(5) Physical Contingency = 10% of 1., 2., and 4.
(6) Price Contingency = 2.5% for F.C and 8.7% for L.C of sum from 1. to 5.
(7) Exchange Rate : US$ 1.00 = 100.0 Yen = 25.0 Pesos

Table 8.12 Unit Values of Damageable Properties applied for Project Evaluation

Items	Unit Value	Unit Value
I. Direct Damage		
1. Buildings*		
1) Residential Buildings	51,000	Pesos/building
2) Non-Residential	265,000	Pesos/building
3) Household effects	14,000	Pesos/building
4) Inventory stock/equipment	143,000	Pesos/building
2. Agricultural Crops		
Paddy	10,650	Pesos/ha
Upland Crops	9,810	Pesos/ha
Sugar Cane	17,740	Pesos/ha
Fruit Trees	20,930	Pesos/ha
5) Livestock	(estimated by 7% of crop damage)	
3. Infrastructure		
6) Road		
National Road	1,750	Pesos/m
Other Roads	1,400	Pesos/m
7) Bridge		
National Bridge	60,000	Pesos/m
Local Bridge	50,000	Pesos/m
8) Irrigation System	640	Pesos/m
II. Indirect Damage		
9) Additional Transportation Cost	(c.f. Tables 10.4 and 10.5)	
10) Interruption of Economic Activity	(c.f. Table 10.6)	
11) Evacuation Cost	216	Pesos/family/week
12) Emergency Clean-up Cost	150	Pesos/day/building

Basic Source of Data:

- "Study of Agno River Basin Flood Control" Final Report Vol.V, Supporting Report Part II Feasibility Study, Dec. 1991
- "Mount Pinatubo Recovery Action Plan , Long Term Report" Technical Appendix C Economic Analysis, March 1991
- "Capital Outlays, Average Unit Cost" DPWH, December 1990
- Interview at the Site

Note:

* Values assumed as those after depreciated by 50%.

Table 8.13 Probable Flood Damage for each Flood Return Period for Sacobia / Bamban Rivers

Unit:Pesos 10^3

	Buildings	Crops & Livestock	Infrastructure	Total
Return Period				
2 years	55,215	21,356	19,334	95,905
5	60,264	21,776	19,759	101,800
10	63,541	22,680	19,284	105,505
20	72,255	23,615	19,893	115,763
50	75,912	26,678	21,047	123,637
100	119,069	35,913	21,803	176,785

Table 8.14 Estimated Average Annual Damage under without-Project Conditions for Sacobia / Bamban Rivers

(A) Return Period	(B) Average Annual Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Flood Damage up to Indicated Return Period (Pesos 10^6)	(E) Average Flood Damage (Pesos 10^6)	(F) Flood Damage within Intervals (Pesos 10^6)	(G) Average Annual Flood Damage up to Indicated Return Period (Pesos 10^6)
2	0.5		95.91			0.00
		0.3		146.81	44.04	
5	0.2		197.71			44.04
		0.1		250.46	25.05	
10	0.1		303.21			69.09
		0.05		361.09	18.05	
20	0.05		418.97			87.14
		0.03		480.79	14.42	
50	0.02		542.61			101.57
		0.01		631.00	6.31	
100	0.01		719.40			107.88

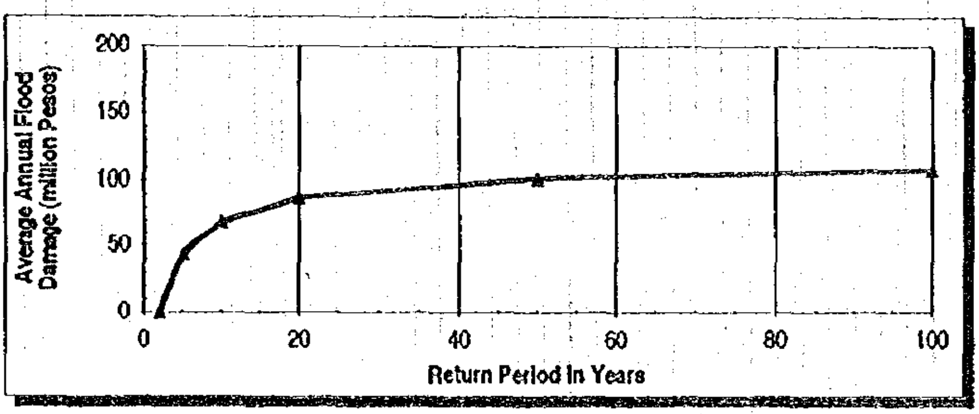


Table 8.15 Detour Cost Computation

Unit : Peso thousand

Normal Route					Dry/Rainy Season : 11 months						Flooding Period : 30 days in total					
	Route	Vehicle	Bridg	(km)		Route	Vehicle	Bridg	(km)	Detour Cost		Route	Vehicle	Hwy	(km)	Detour Cost
N.1.	MLL-N-B-TLC	6000	B	87.6	D.1	MLL-N-S-TLC	6000	S	91.3	24952	R.1	MLL-F-TLC	6000	F	112.0	14959
N.2	MLL-B-TLC	2500	B	86.5	D.2	MLL-F-TLC	2500	F	111.6	70530	R.2	MLL-F-TLC	2500	F	111.6	6412
N.3	S/F-B-TLC	2000	B	57.5	D.3	S/F-S-TLC	2000	S	62.3	10790	R.3.1	S/F-F-TLC	1500	F	136.6	16165
											R.3.2	S/F-F-LPZ-CC-CPS	500	F	147.8	4613
N.4	S/F-S-CC	500	S	44.3	D.4	S/F-S-CC	500	S	44.3	0	R.4	S/F-F-CC	500	F	149.0	5349
N.5	AGL-B-TLC	2000	B	39.7	D.5.1	AGL-S-TLC	1500	S	44.5	8093	R.5.1	AGL-F-TLC	1500	F	154.4	23440
					D.5.2	AGL-S-CC-CPS-BB	500	S	39	15399	R.5.2	AGL-F-LPZ-CC-BB	500	F	153.8	5829
Total		13000					13000			129764			13000			76768.3
Detour Cost by 2010 :																
	Bamban Bridge=			201183						129764						71419
	San Francisco Bridge=			5349						0						5349
	Grand Total=			206532												
Detour Cost after 2011 :																
	Bamban Bridge=			161272						104812						56460
	San Francisco Bridge=			5349						0						5349
	Grand Total=			166621												

Abbreviations:

B : Bamban Bridge	MLL : Malolos AGL : Angeles	F : Friendship Highway	AGL : Angeles
S : San Francisco Bridge	TLC : Tarlac	BB : Bamban	LPZ : Lapaz
N : North Luzon Expressway	S/F : San Fernando	CC : Concepcion	CPS : Capas

Note :

1) The impassable period of access roads to San Francisco Bridge in typhoon season was assumed 30 days in total : ten times of each three days. In this period, it was assumed that vehicles make a detour via Santa Rita in stead of taking a route of Mexico-Arayat to avoid the flood prone areas.

2) It was assumed that some vehicles bound to Tarlac from Manila make a detour and take the Friendship Highway to avoid the congestion near the San Francisco Bridge in all the seasons except the above 30 days.

3) The new North Luzon Expressway was assumed to be opened in 2010, thereafter it was assumed that all the traffic in the current NLE will shift to the new NLE.

Table 8.16 Data for Additional Transportation Cost

(1) Computation Formula :

$$SCF = CFw/o - CFw/$$
$$CF = TDC * DF$$
$$TDC = (\sum_{i=1}^{4} VOCi * ADTi) * DL$$

where , SCF = Cost saving by reduction of risk for road unserviceability caused by flood(P)
CF = Cost by flood(P)
TDC = Total traffic diversion cost(P)
DF =Duration of unserviceability(days)
VOCi = Vehicle operation cost of vehicle type i(P / vehicle-km)
ADTi = Average daily traffic volume of vehicle type i (vehicle / day)
DL = Detouring length (km)

(2) Vehicle Operating Cost(VOC)

	Car/van	Jeepney	Bus	Truck	
Vehicle Mix	0.469	0.235	0.156	0.141	
Running Cost(P/km)	2.29	1.61	3.65	4.93	
Fixed Cost(P/min.)	0.123	0.593	0.835	0.937	
ditto (P/km)	0.185	0.89	1.253	1.406	
Totl Cost for Modal Mix(P/km	1.161	0.587	0.765	0.893	3.406

(3) Averag Average speed assumed : 40km / hr

(4) Assumed Detour Routes, Distance and Duration of Unserviceability

Season/ Duration	Route Code	Distance (km) Detour	Normal	Bridge / Highway	No. of Vehicle	Route Alternatives
Normal Condition	N.1 :	-	87.6	B	6000	MLL-N-B-TLC
(through the year)	N.2 :	-	86.5	B	2500	MLL-B-TLC
	N.3:	-	57.5	B	2000	S/F-B-TLC
	N.4:	-	44.3	S	500	S/F-S-CC
	N.5 :	-	39.7	B	2000	AGL-B-TLC
	Total				13000	
For Dry/Rainy Season	D.1 :	3.7	91.3	S	6000	MLL-N-S-TLC
(11 months)	D.2 :	25.1	111.6	F	2500	MLL-F-TLC
	D.3:	4.8	62.3	S	2000	S/F-S-TLC
	D.4:	0	44.3	S	500	S/F-S-CC
	D.5.1:	4.8	44.5	S	1500	AGL-S-TLC
	D.5.2:	27.4	39.0	S	500	AGL-S-CC-CPS-BB
	Total				13000	
For Typhoon Season	R.1:	24.4	112.0	F	6000	MLL-F-TLC
(30 Days)	R.2 :	25.1	111.6	F	2500	MLL-F-TLC
	R.3.1:	79.1	136.6	F	1500	S/F-F-TLC
	R.3.2:	90.3	147.8	F	500	S/F-F-LPZ-CC-CPS
	R.4:	104.7	149.0	F	500	S/F-F-CC
	R.5.1 :	114.7	154.4	F	1500	AGL-F-TLC
	R.5.2:	114.1	153.8	F	500	AGL-F-LPZ-CC-BB
	Total				13000	

Note : 1) "Vehicle Mix" was derived from the Traffic Survey conducted by JICA Study Team in August 1994.
2) Abbreviations : AGL:Angeles BB: Bamban CC: Concepcion MLL: Malolos
S/F: San Fernando LPZ:Lapaz TLC: Tarlac
CPS: Capas F : Friendship Highway
B : Bamban Bridge *S : San Francisco Bridge*

Table 8.17 Basic Data for Estimate of GRDP Loss by Interruption of Economic Activities caused by Flood

(1) GRDP of Region 3 in 1990 and Projection in 2010 (by CLDP Study)

(Peso 10^6, at 1990 price)

	1990	2010	Growth(%p.a.)
Agriculture	21,468	51,700	4.49
Industry	36,910	214,300	9.19
Services	35,780	192,100	8.77
Total	94,158	458,100	8.23

(2) Per Capita GRDP of Region 3 (Peso)

	1990	2010	Growth(%p.a.)	1994(estimated)
Population Region 3	6,199,016	10,501,000	2.67	6,888,061
Per capita GRDP(1990 price)	15,189	43,624	5.42	18,760
Per capita GRDP(1994 price)				26,710

(3) Per Capita GRDP of non-agricultural sector in Region 3 (Peso)

(Peso 10^6, at 1990 price)

		1990	2010	Growth(%p.a.)	1994
GRDP :	Industry	36,910	214,300	9.19	
	Services	35,780	192,100	8.77	
	Total	72,690	406,400	8.99	
	Urban Population in Region 3	3733797	8034000	3.91	
	Per cap. GRDP of NAS(Peso1990 pric	19468	50585	4.89	
	Ditto (Peso 1994 price)	27719	72023	4.89	33551

(4) Urbanization Ratio in Study Area in 1994: 54.60%

(5) Assumed Duration of Interruption of Economic Activities: 10 Days in a Year

(6) Loss of GRDP caused by the Interruption of Economic Activities
= Number of affected Population * Urbanization Ratio* Per Capita GRDP of Non-agricultural Sector * 10 Days

(6) GDP Deflator(IFS data)

	1989	1990	1991	1992	1993	1994(est)
GDP(P 10^9)	925.4	1073.1	1244.4	1351.6	1466.3	
GDP 1990price	1045.3	1073.1	1067.7	1074.4	1095.6	
GDP Deflator	88.53	100.00	116.55	125.80	133.84	142.38

Table 8.18 Probable Indirect Damage by Flood Return Period

Unit: Pesos million

Flood Return Period	Evacuation & Clean-up Costs	Loss of GRDP	Total
2 years	9.70	8.18	17.88
5	9.89	8.30	18.19
10	10.16	8.53	18.69
20	10.89	9.14	20.03
50	12.29	10.31	22.60
100	19.59	16.45	36.04

Table 8.19 Average Annual Indirect Damage in Sacobia-Bamban River Basin

(A) Return Period	(B) Average Annual Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Evacuation and Clean-up Costs up to indicated Return Period (Pesos 10^6)	(E) Estimated Loss of GRDP up to indicated Return Period (Pesos 10^6)	(F) Average Value (Pesos 10^6)	(G) Average Value within Intervals (Pesos 10^6)	(H) Average Annual Value up to Indicated Return Period (Pesos 10^6)
2	0.5		9.70	8.18			0.00
		0.3			26.98	8.09	
5	0.2		19.59	16.46			8.09
		0.1			45.42	4.54	
10	0.1		29.75	25.01			12.63
		0.05			64.78	3.24	
20	0.05		40.64	34.15			15.87
		0.03			86.09	2.58	
50	0.02		52.93	44.46			18.46
		0.01			115.41	1.15	
100	0.01		72.52	60.91			19.61

Table 8.20 Cost-benefit Analysis of Sacobia-Bamban Flood/Mudflow Control Project

Unit : Peso million

		Economic Cost			Benefit				
No	Year	Capital	O & M	Cost Total	Flood Cntrol	Detour Cost	Indirect Damage	Benefit Total	B - C
1	1996	266.41	71.98	338.39	0.00	0.00	0.00	0.00	-338.39
2	1997	322.89	72.81	395.70	0.00	0.00	0.00	0.00	-395.70
3	1998	832.48	73.94	906.42	0.00	82.77	0.00	82.77	-823.65
4	1999	755.71	77.40	833.11	0.00	84.34	0.00	84.34	-748.77
5	2000		80.53	80.53	140.06	231.22	18.59	389.87	309.34
6	2001		80.53	80.53	151.58	235.62	19.08	406.28	325.75
7	2002		80.53	80.53	164.06	240.09	19.59	423.75	343.22
8	2003		80.53	80.53	177.56	244.66	20.12	442.33	361.80
9	2004		80.53	80.53	192.17	249.30	20.65	462.13	381.60
10	2005		8.55	8.55	207.99	254.04	21.21	483.24	474.69
11	2006		8.55	8.55	225.11	258.87	21.77	505.75	497.20
12	2007		8.55	8.55	243.63	263.79	22.35	529.77	521.22
13	2008		8.55	8.55	263.68	268.80	22.95	555.43	546.88
14	2009		8.55	8.55	285.39	273.91	23.56	582.85	574.30
15	2010		8.55	8.55	308.87	279.11	24.19	612.17	603.62
16	2011		8.55	8.55	334.29	229.45	24.84	588.58	580.03
17	2012		8.55	8.55	361.81	233.81	25.50	621.12	612.57
18	2013		8.55	8.55	391.58	238.25	26.18	656.02	647.47
19	2014		8.55	8.55	423.81	242.78	26.88	693.47	684.92
20	2015		8.55	8.55	458.69	247.39	27.60	733.68	725.13
21	2016		8.55	8.55	496.44	252.09	28.34	776.87	768.32
22	2017		8.55	8.55	537.30	256.88	29.09	823.27	814.72
23	2018		8.55	8.55	581.52	261.76	29.87	873.15	864.60
24	2019		8.55	8.55	629.37	266.74	30.67	926.78	918.23
25	2020		8.55	8.55	681.17	271.81	31.49	984.46	975.91
26	2021		8.55	8.55	737.23	276.97	32.33	1046.53	1037.98
27	2022		8.55	8.55	797.91	282.23	33.19	1113.33	1104.78
28	2023		8.55	8.55	863.57	287.59	34.08	1185.24	1176.69
29	2024		8.55	8.55	934.65	293.06	34.99	1262.69	1254.14
30	2025		8.55	8.55	1011.57	298.63	35.92	1346.11	1337.56
		1568	432	2000	1392	1367	113	2873	873
					(48.5%)	(47.6%)	(3.9%)	(100)	
								EIRR=	16.43%
								NPV(12%)	873

Table 8.21 Sensitivity Analysis of Sacobia-Bamban Flood/Mudflow Control Project

(%)

Benefit	-20%	-10%	Normal	+10%	+20%
Cost					
-20%	16.43	18.10	19.72	21.28	22.81
-10%	14.88	16.43	17.92	19.36	20.77
Normal	13.59	15.04	**16.43**	17.77	19.06
+10%	12.48	13.86	15.17	16.43	17.65
+20%	11.53	12.83	14.06	15.27	16.43

Estimated Average Annual Damage(Direct) for Abacan River

(A) Return Period	(B) Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Flood Damage up to Indicated Return Period: Buildings (Pesos 10^6)	(D) Agr'l Crops (Pesos 10^6)	(D) Infrastructure (Pesos 10^6)	(E) Average Flood Damage (Pesos 10^6)	(F) Flood Damage within Intervals (Pesos 10^6)	(G) Average Annual Flood Damage up to Indicated Return Period (Pesos 10^6)
2	0.5		123.41	16.48	17.78			0.00
		0.3				240.47	72.14	
5	0.2		253.32	33.36	36.58			72.14
		0.1				411.23	41.12	
10	0.1		390.06	51.14	58.00			113.26
		0.05				597.16	29.86	
20	0.05		541.49	70.40	83.24			143.12
		0.03				816.65	24.50	
50	0.02		729.58	91.69	116.91			167.62
		0.01				1064.38	10.64	
100	0.01		925.35	115.96	149.27			178.26

Estimated Average Annual Damage(Direct) for Sacobia/Bamban Rivers

(A) Return Period	(B) Average Annual Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Flood Damage up to Indicated Return Period: Buildings (Pesos 10^6)	(D) Agr'l Crops (Pesos 10^6)	(D) Infrastructure (Pesos 10^6)	(E) Average Flood Damage (Pesos 10^6)	(F) Flood Damage within Intervals (Pesos 10^6)	(G) Average Annual Flood Damage up to Indicated Return Period (Pesos 10^6)
2	0.5		49.25	21.73	19.33			0.00
		0.3				137.07	41.12	
5	0.2		101.01	43.73	39.09			41.12
		0.1				232.37	23.24	
10	0.1		156.12	66.41	58.38			64.36
		0.05				331.58	16.58	
20	0.05		214.11	89.88	78.27			80.94
		0.03				436.15	13.08	
50	0.02		273.17	117.56	99.32			94.02
		0.01				553.72	5.54	
100	0.01		342.07	154.22	121.12			99.56

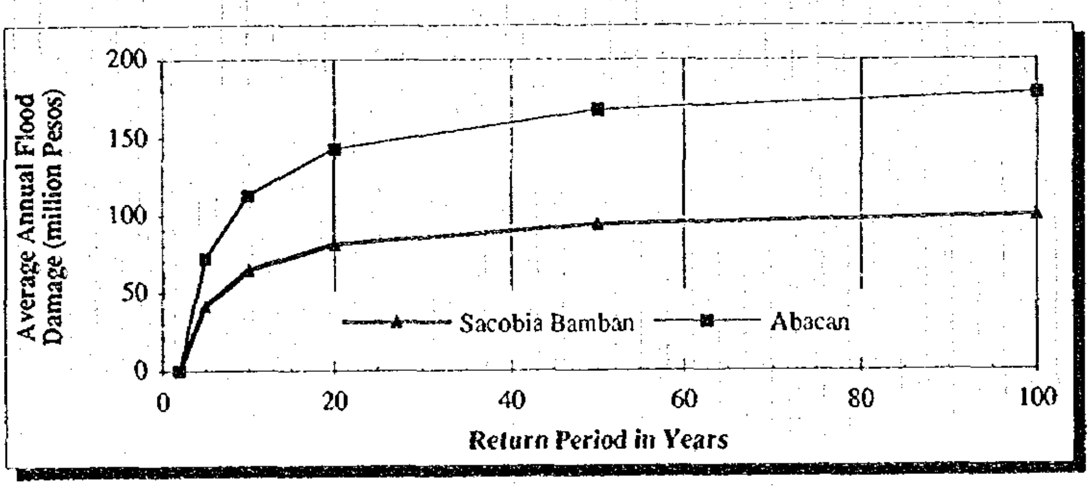


Figure 8.1 Average Annual Direct Damage

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

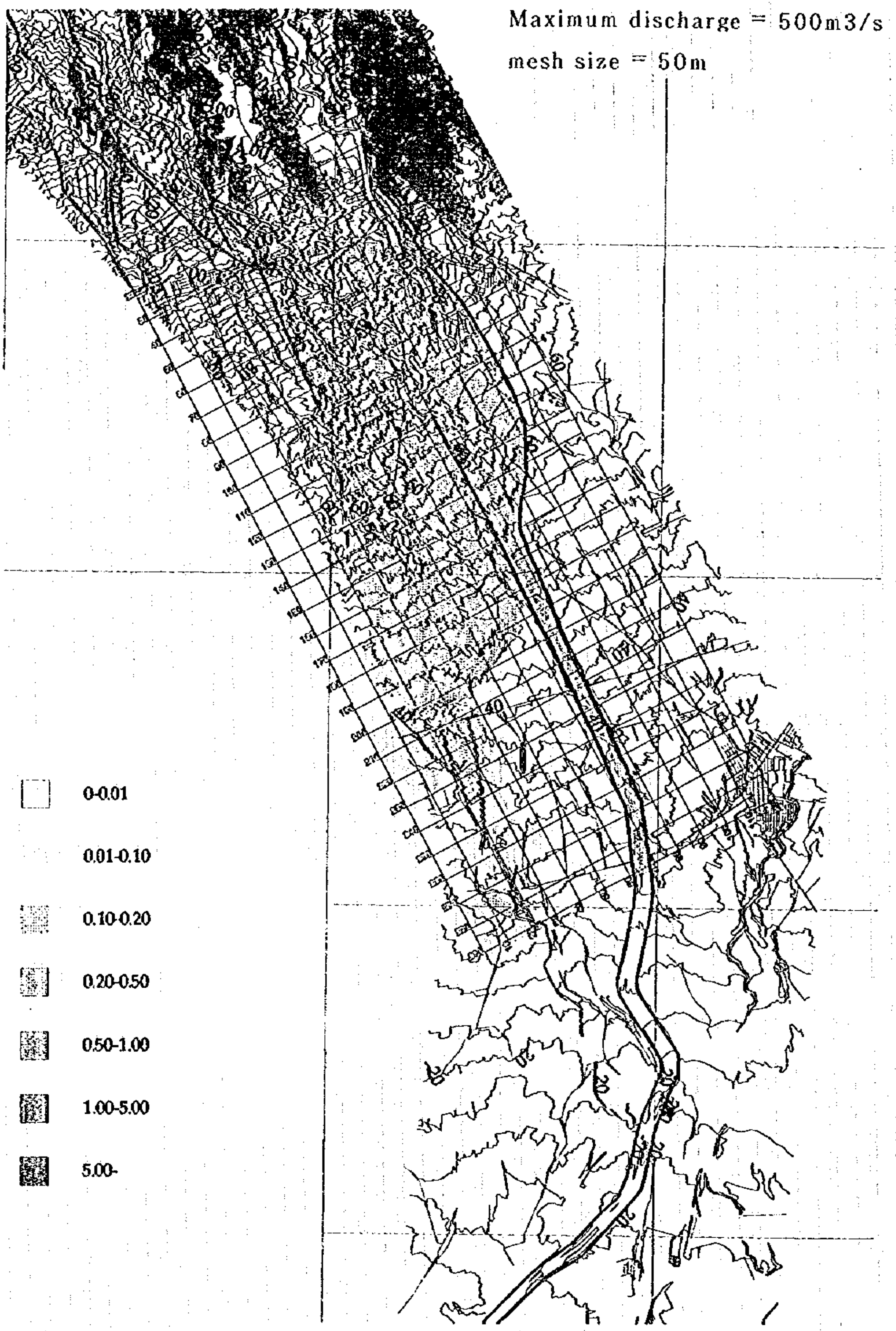


Figure 8.2

Flood and Mudflow Inundation in 1994 on DTM

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY

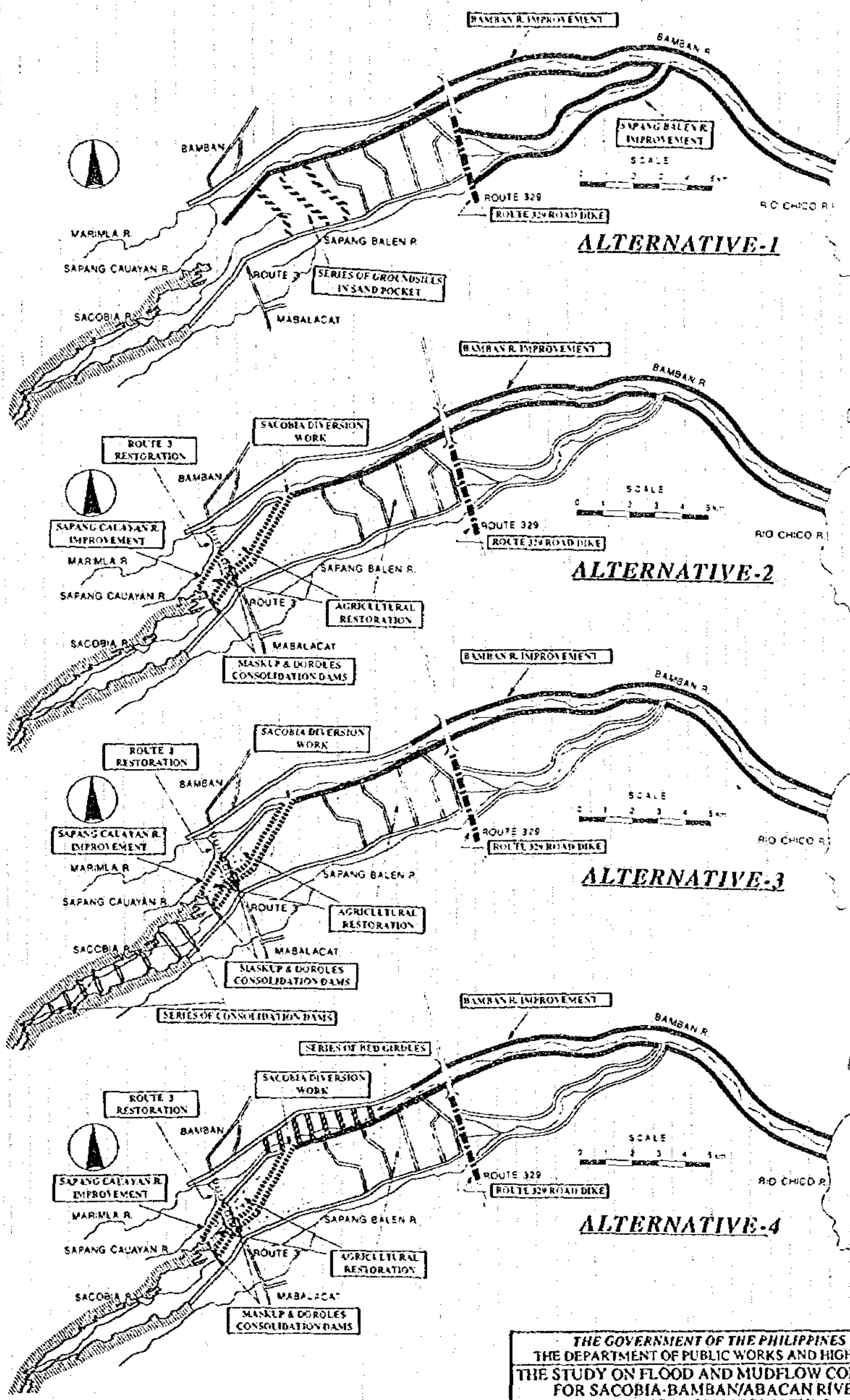


Figure 8.3 Schematic Plan of Alternatives

THE GOVERNMENT OF THE PHILIPPINES   THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL   FOR SACOBIA-BAMBAN/ABACAN RIVER   DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

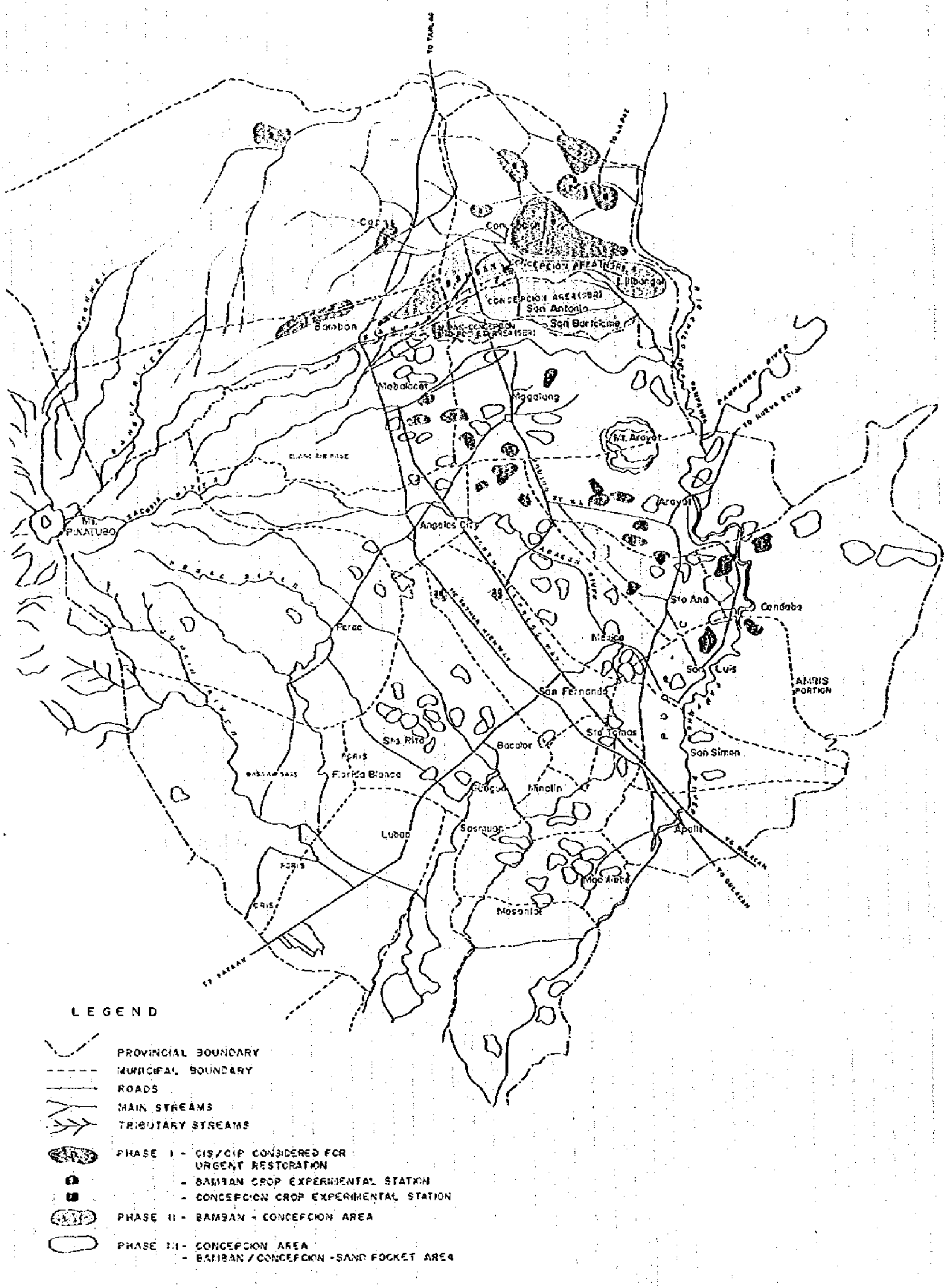


Figure 8.4
General Layout of Agricultural Rehabilitation Schemes

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

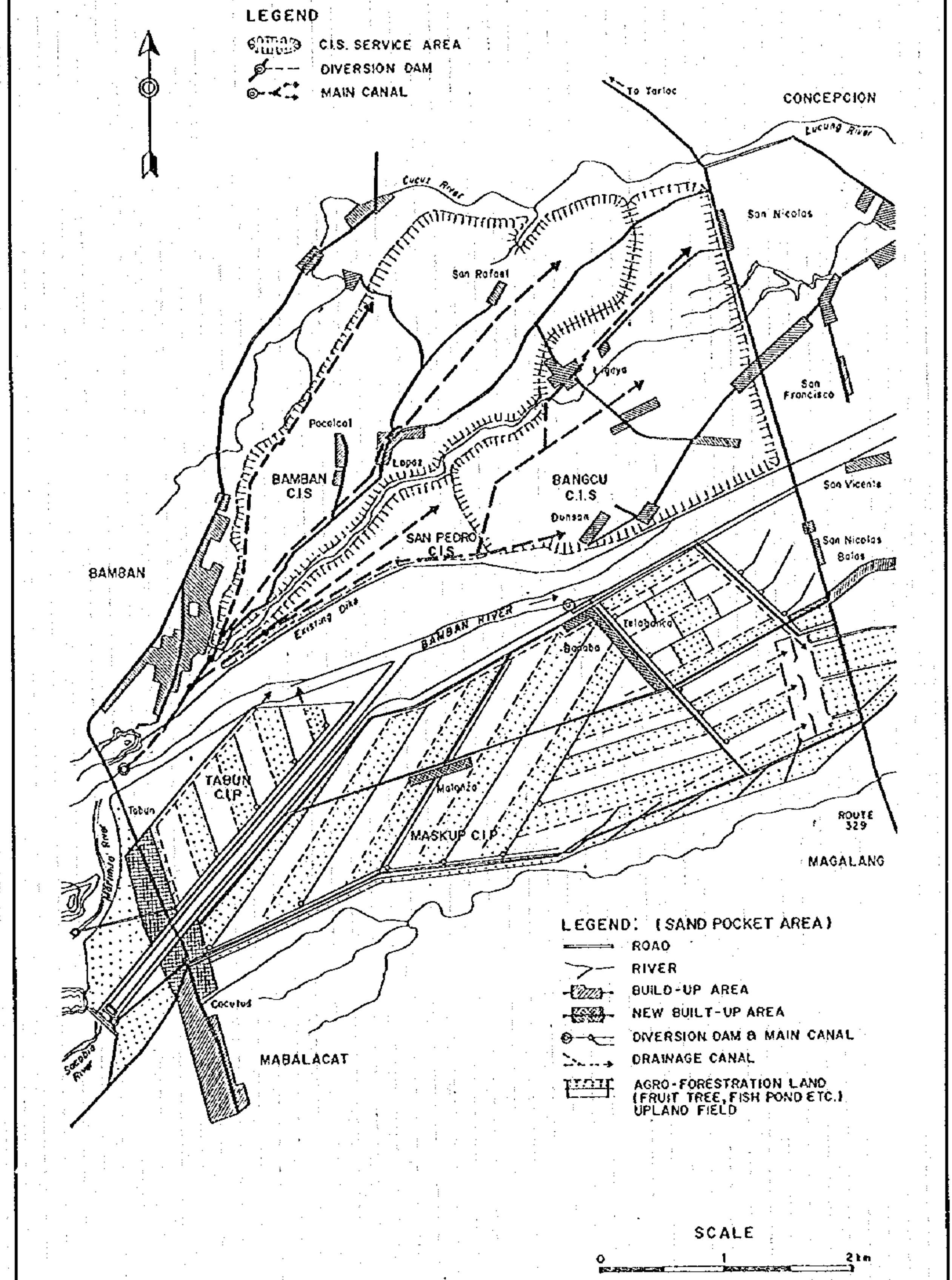


Figure 8.5 **Location Map of the Proposed Project in Upper Sacobia-Bamban River Basin Area**

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY

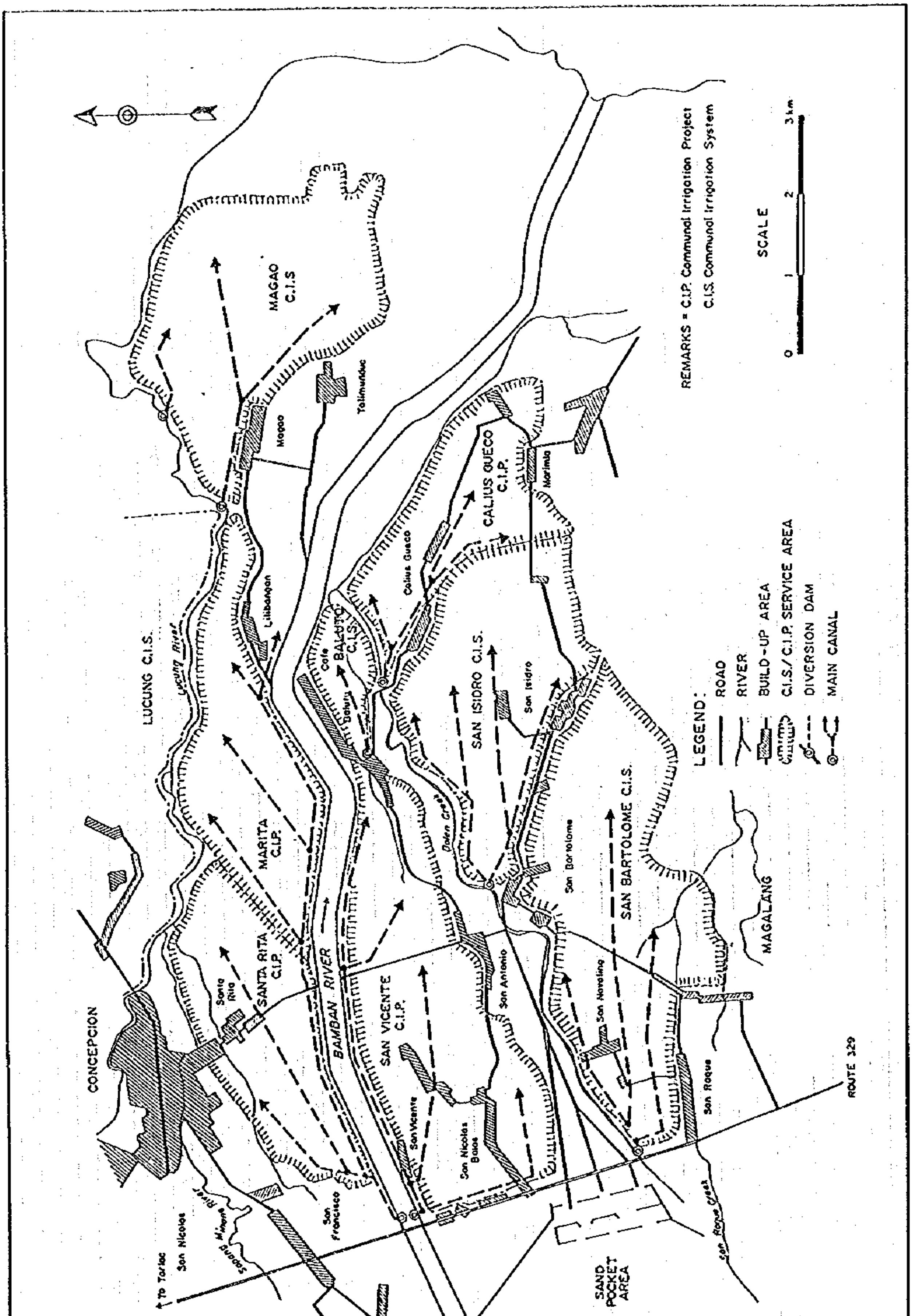


Figure 8.6 **Location Map of the Proposed Project in Lower Sacobia-Bamban River Basin Area**

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

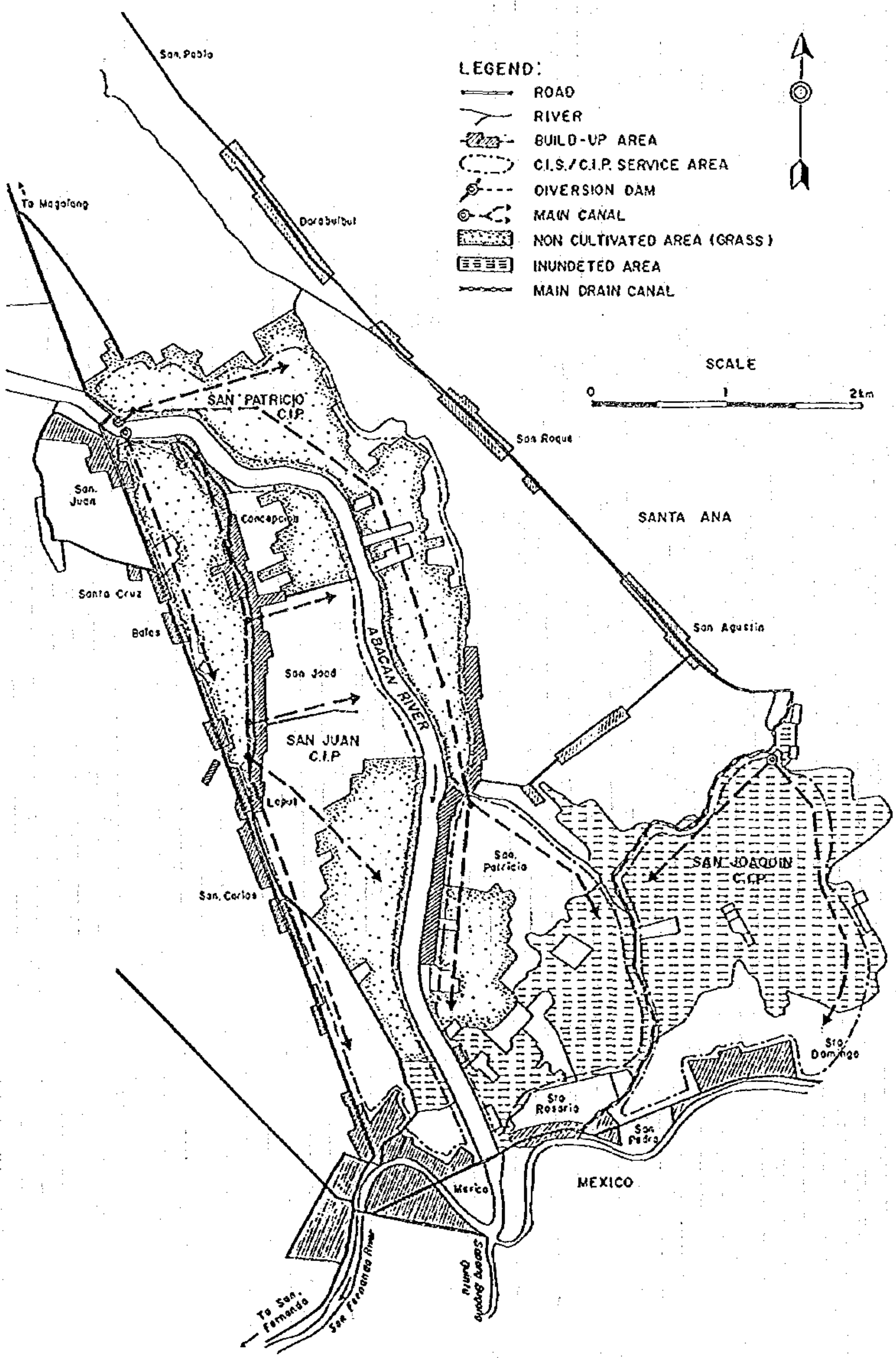
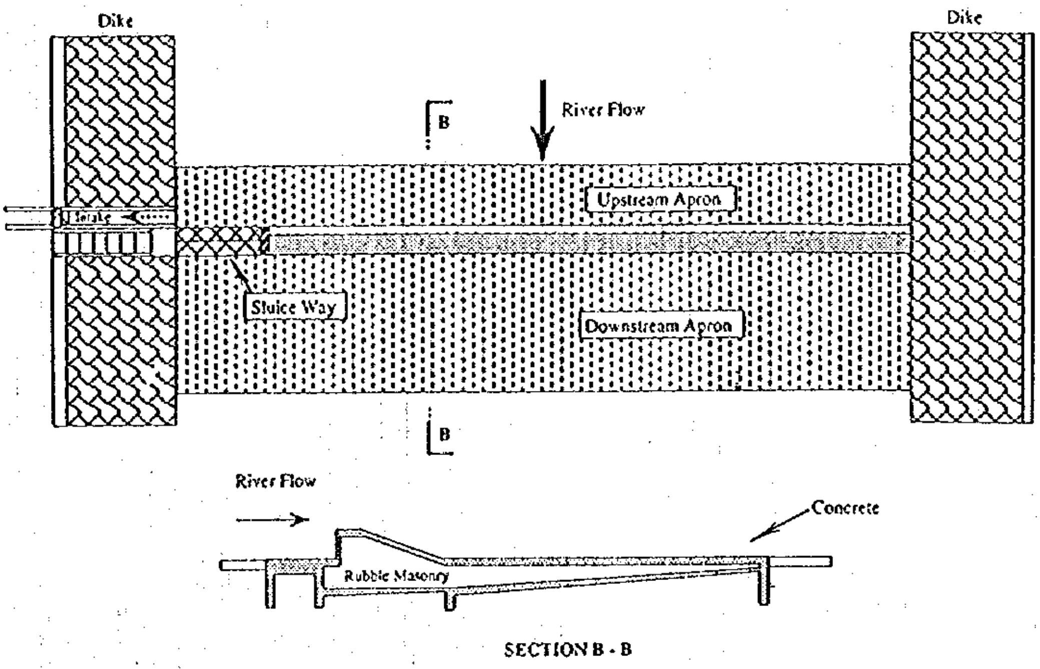
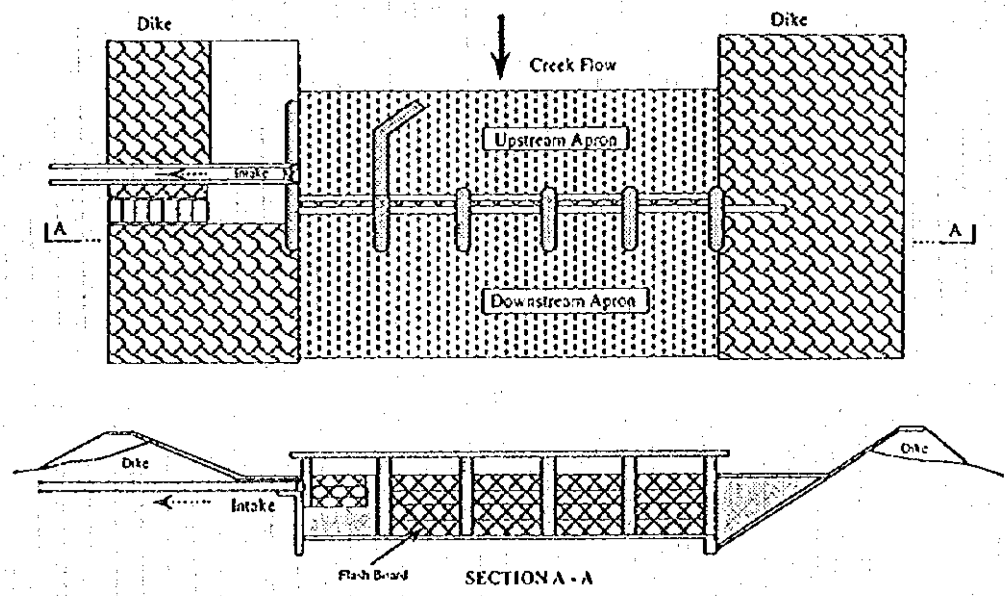


Figure 8.7 **Location Map of the Proposed Project in Abacan River Basin Area**

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY



PROPOSED OGEE-TYPE DIVERSION DAM



PROPOSED CHECK-GATE TYPE DIVERSION DAM

Figure 8.8 **Typical Section of Proposed Diversion Dam**

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

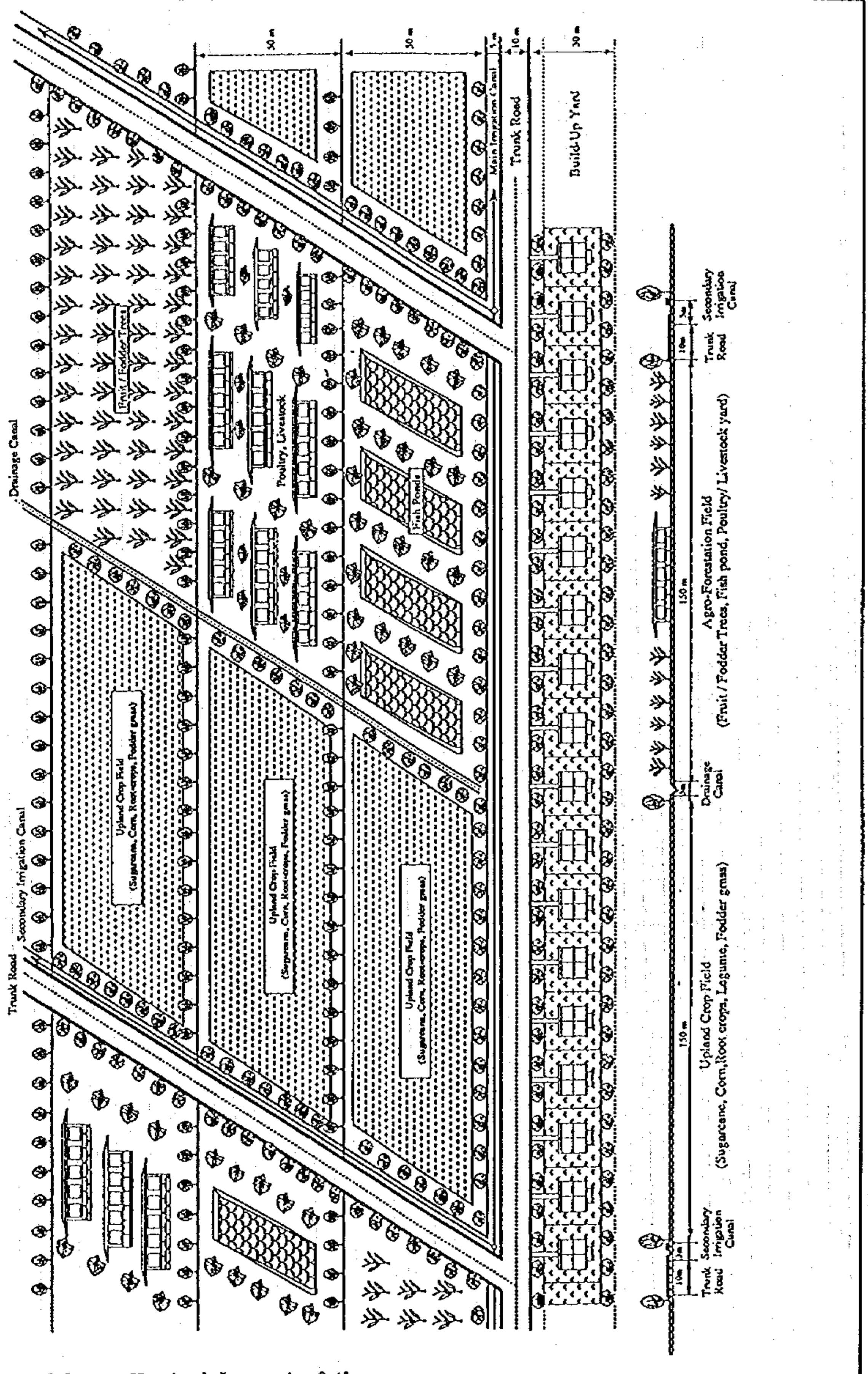


Figure 8.9 Typical Layout of the Land and Agriculture Development Project in Lahar Affected Area

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

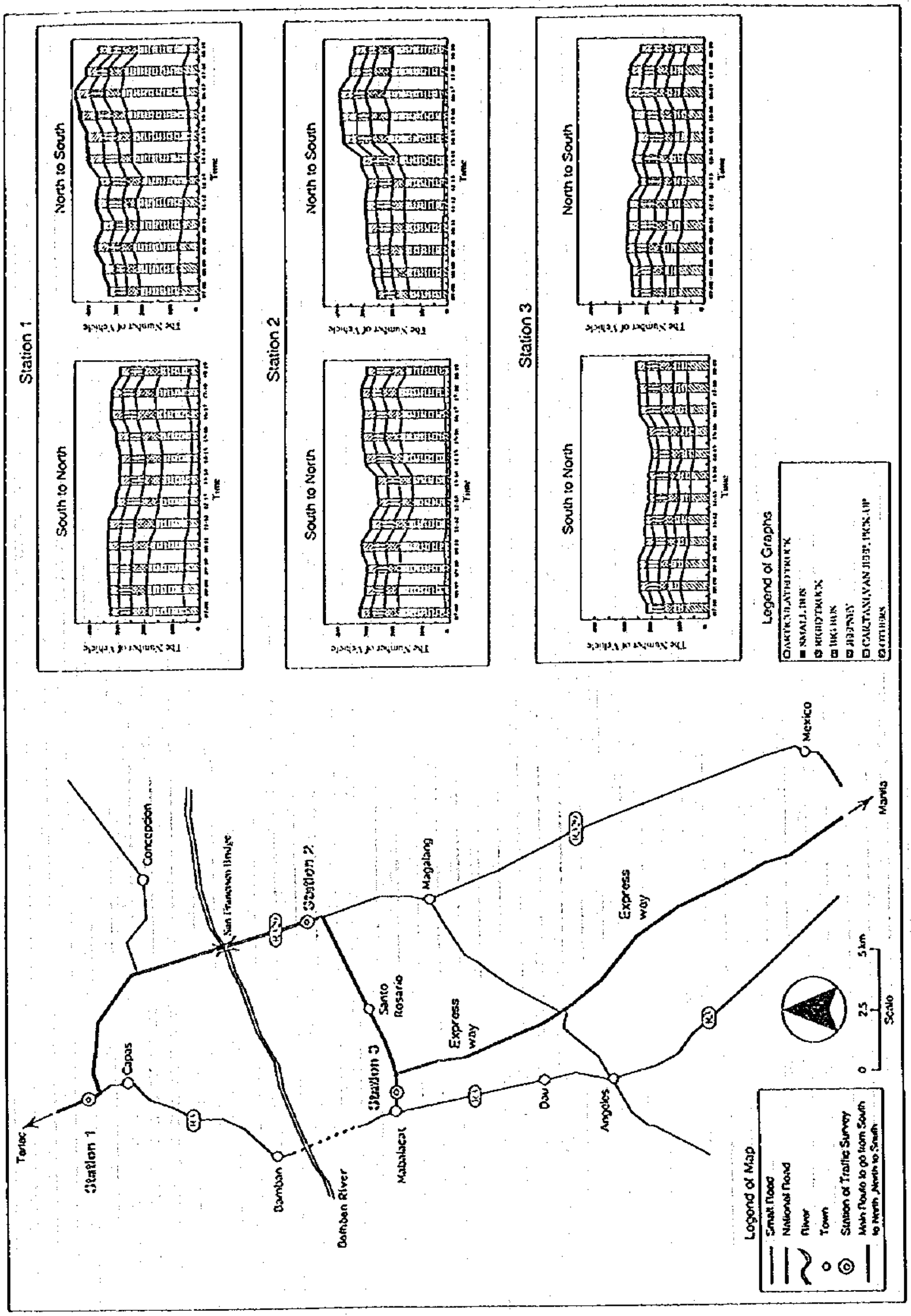


Figure 8.10 Average Traffic Volume for 12 hours (July 16 to 23, 1995)

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY

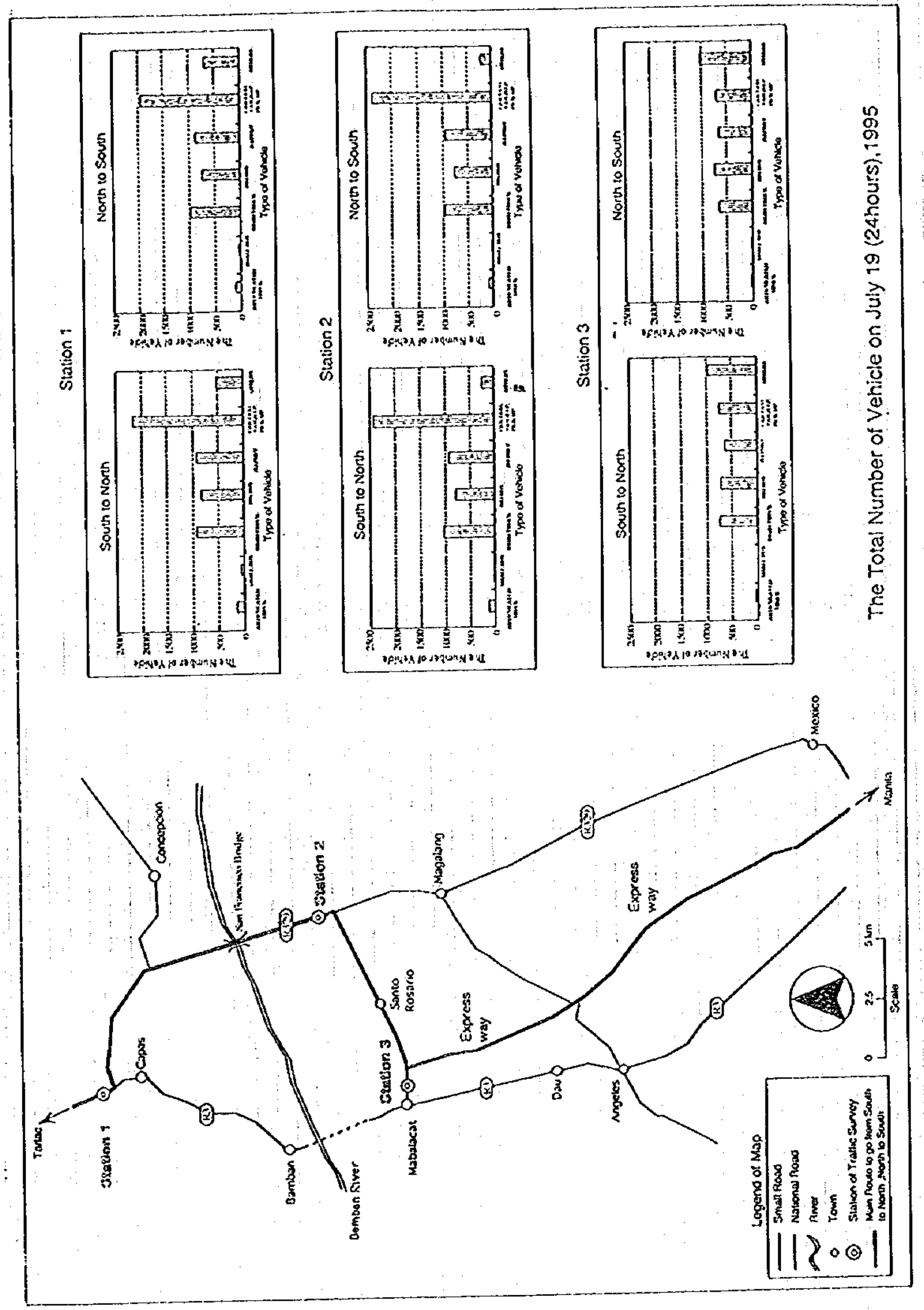


Figure 8.11 24-hour Traffic Volume by Type of Vehicles (July 19, 1995)

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

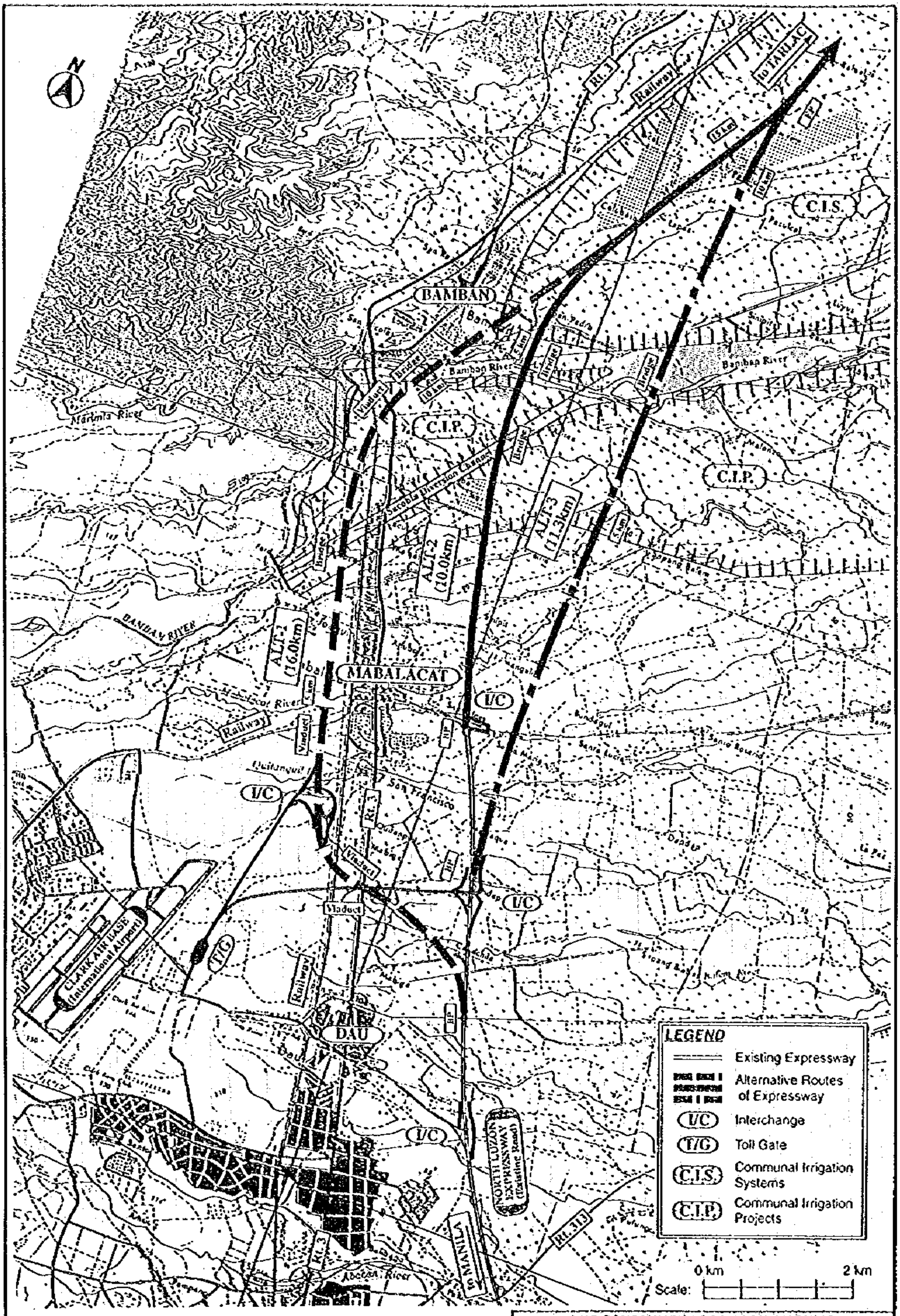
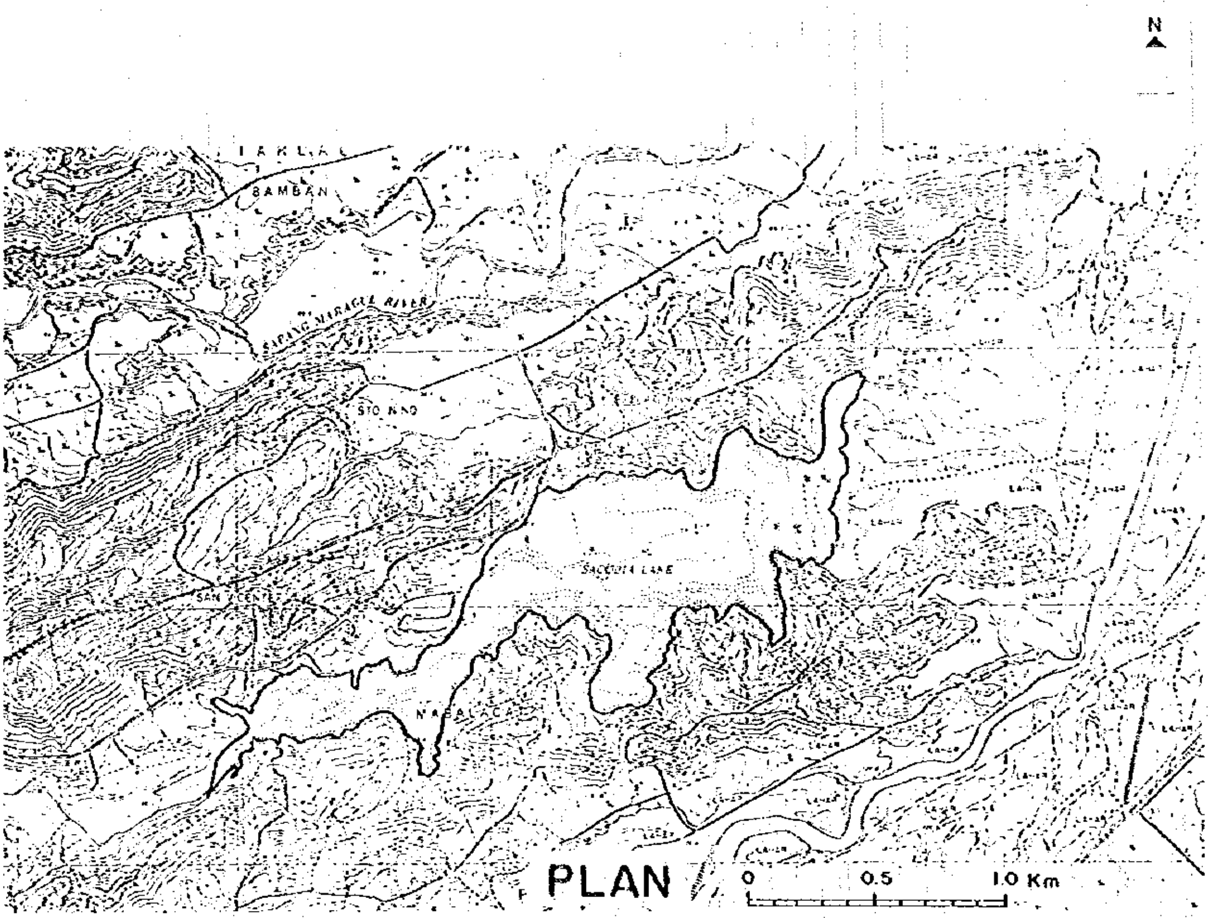
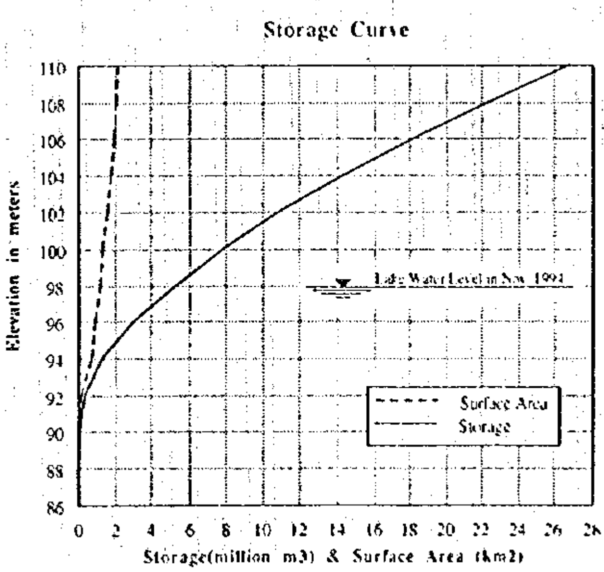


Figure 8.12 Alternative Routes of North Luzon Expressway Extension

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY





Water Level (El.m)	Surface Area (km2)	Storage (million m3)
110	2.229	26.819
108	2.132	22.338
106	2.002	18.254
104	1.847	14.405
102	1.679	10.879
100	1.336	7.864
98	1.225	5.303
96	1.001	3.077
94	0.737	1.339
92	0.210	0.392
90	0.077	0.105
88	0.014	0.014
86	0.000	0.000

Figure 8.13 Dammed Lake in Sapang Cauayan River

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

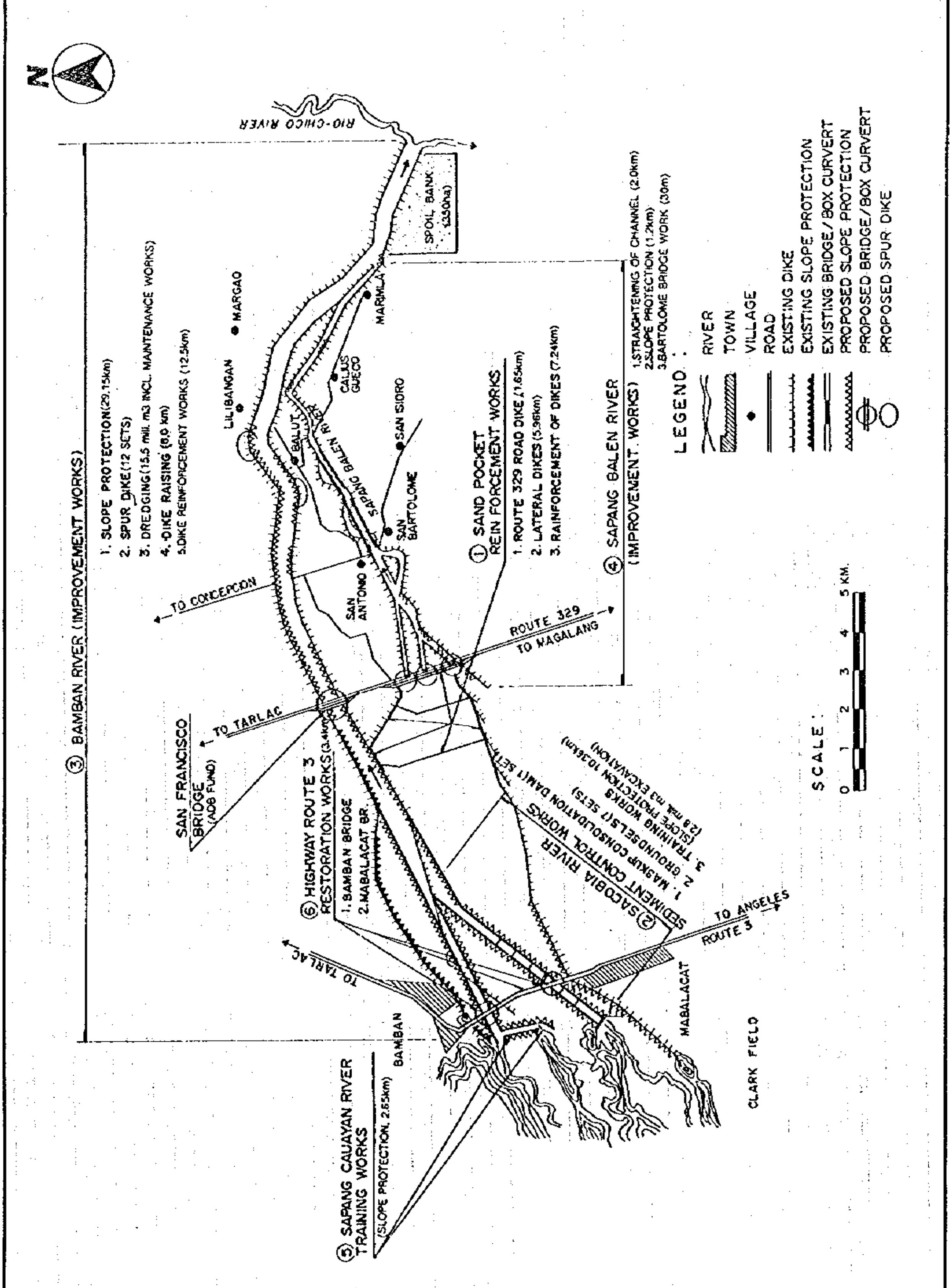


Figure 8.14 Priority Schemes for Sacobia-Bamban River Basin

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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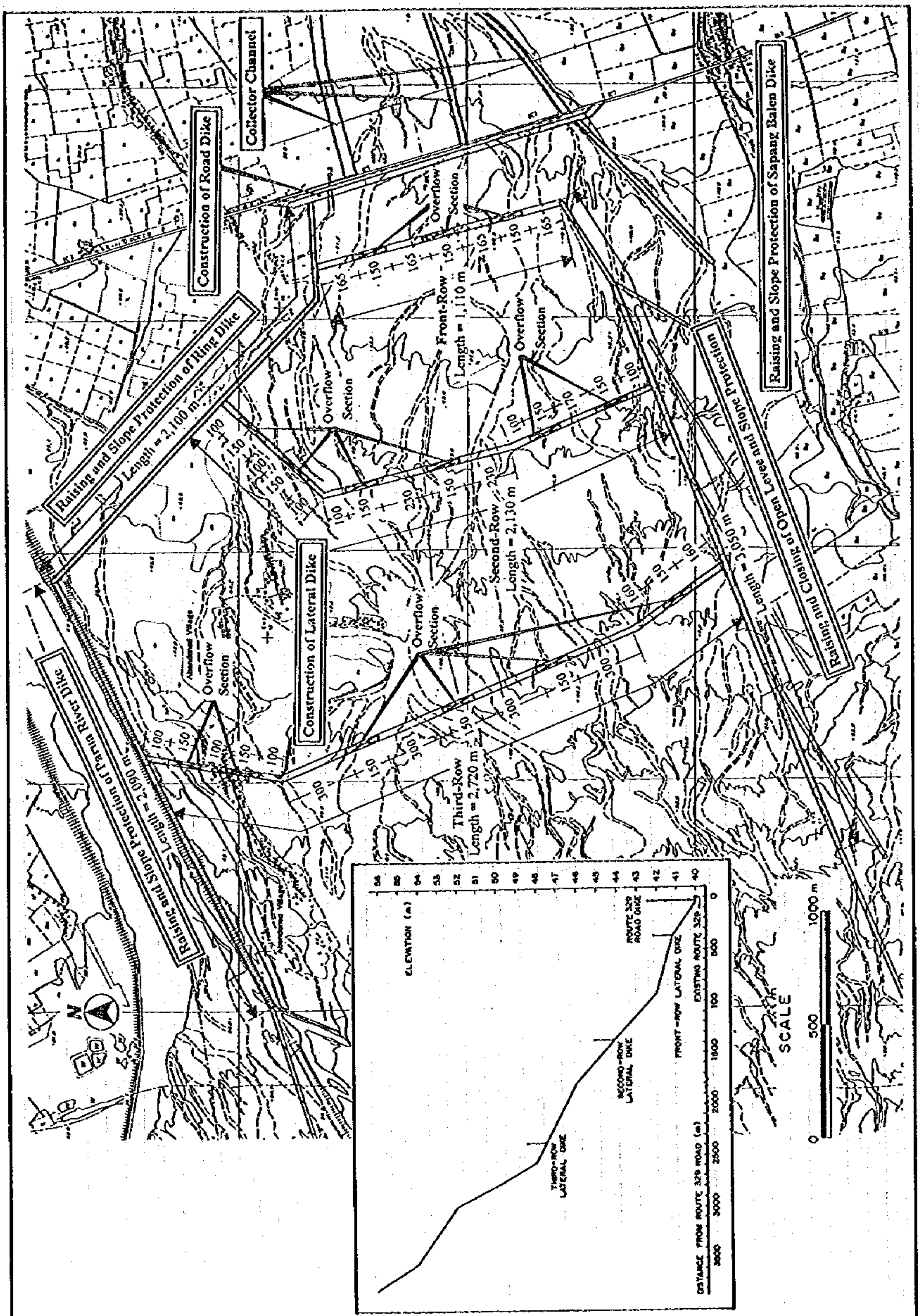

Figure 8.15 Sand Pocket Structures

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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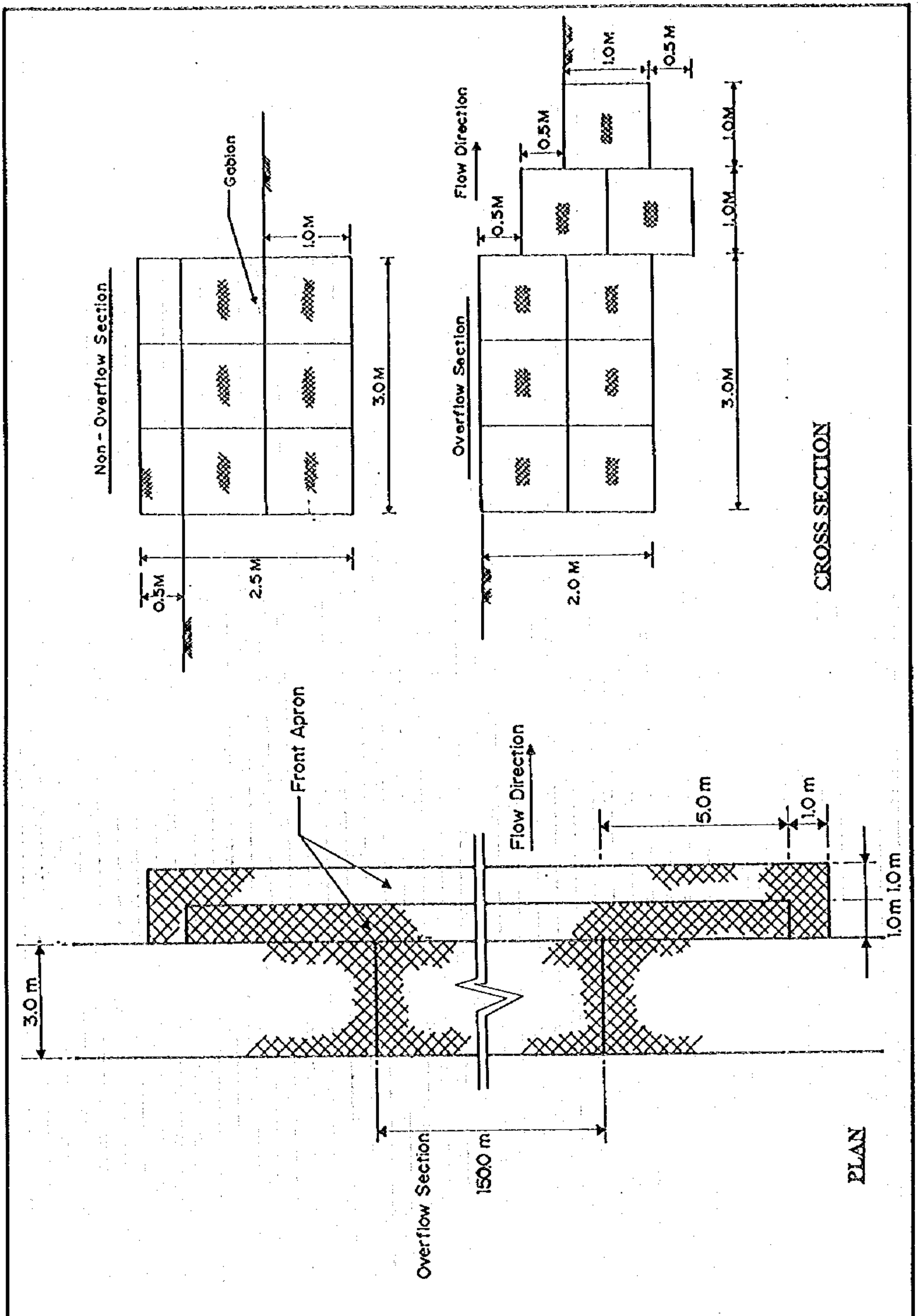

Figure 8.16 Proposed Lateral Dike

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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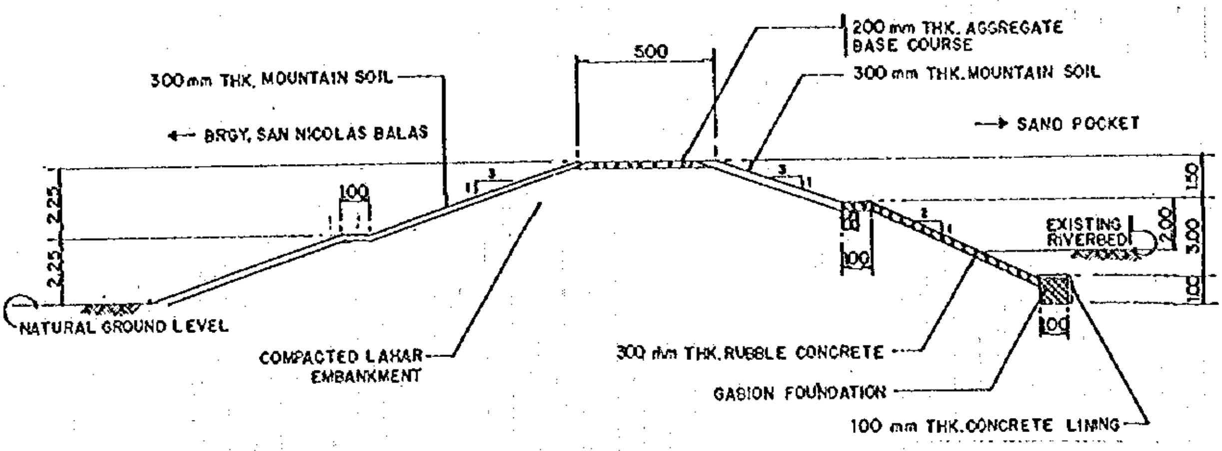
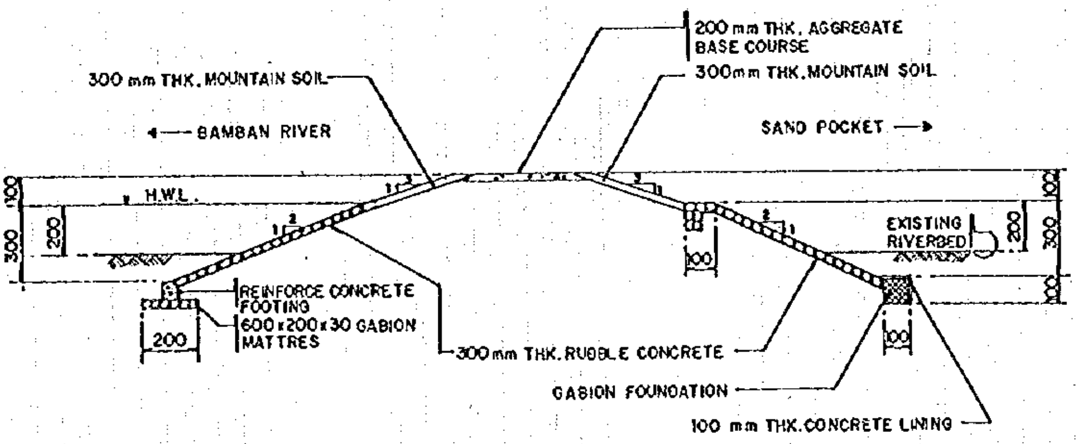
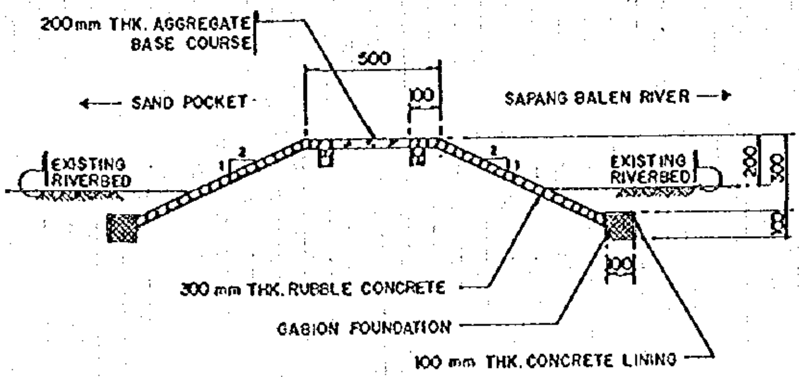


SAN NICOLAS BALAS RING DIKE



PARUA RIVER DIKE



MABALACAT-MAGALANG-SAN FRANCISCO BRIDGE DIKE

Figure 8.17 Proposed Closing Dike

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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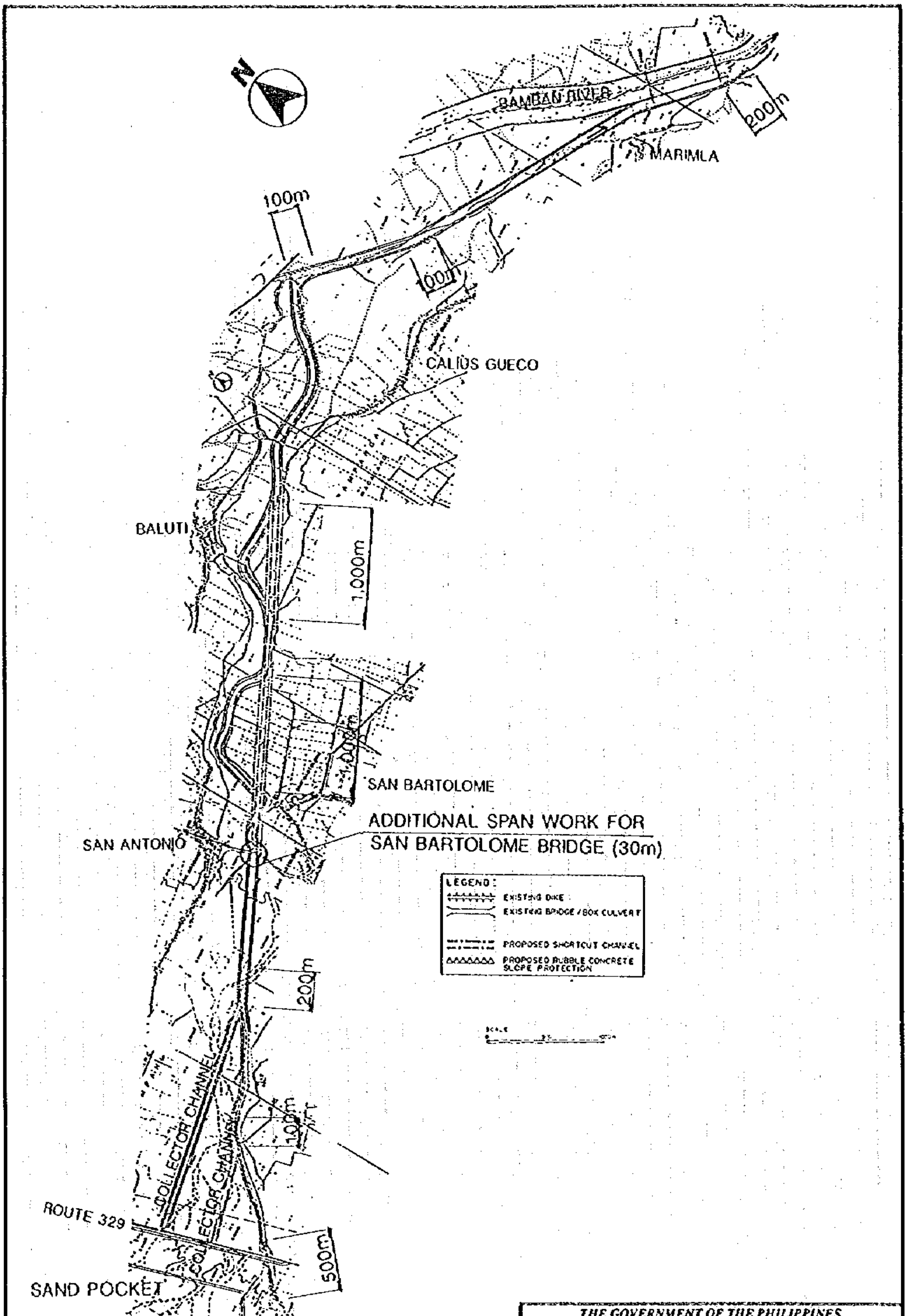

Figure 8.18 Channel Alignment of Sapang Balen River Improvement

THE GOVERNMENT OF THE PHILIPPINES   THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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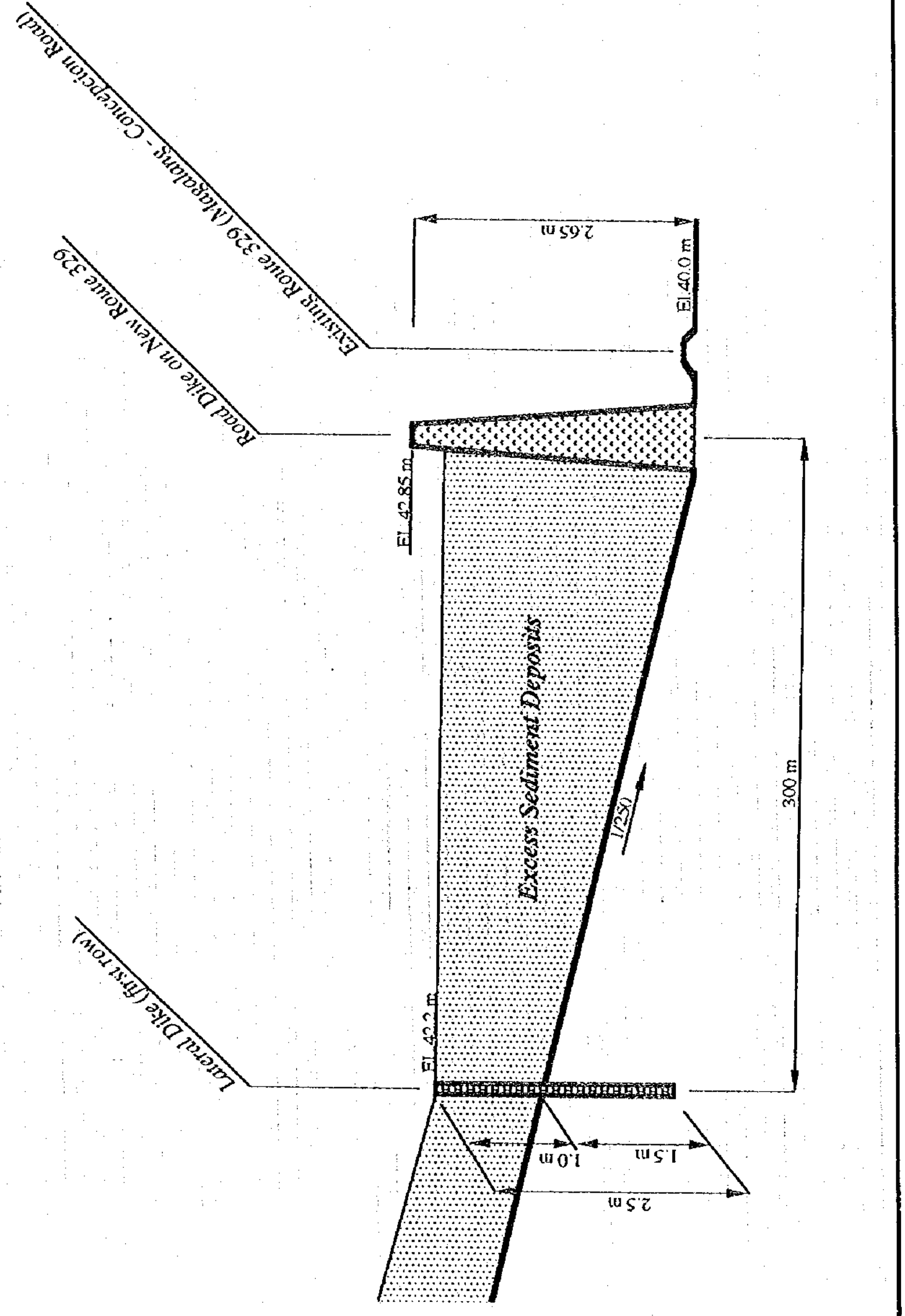

Figure 8.19 Schematic Diagram of Elevating Route 329

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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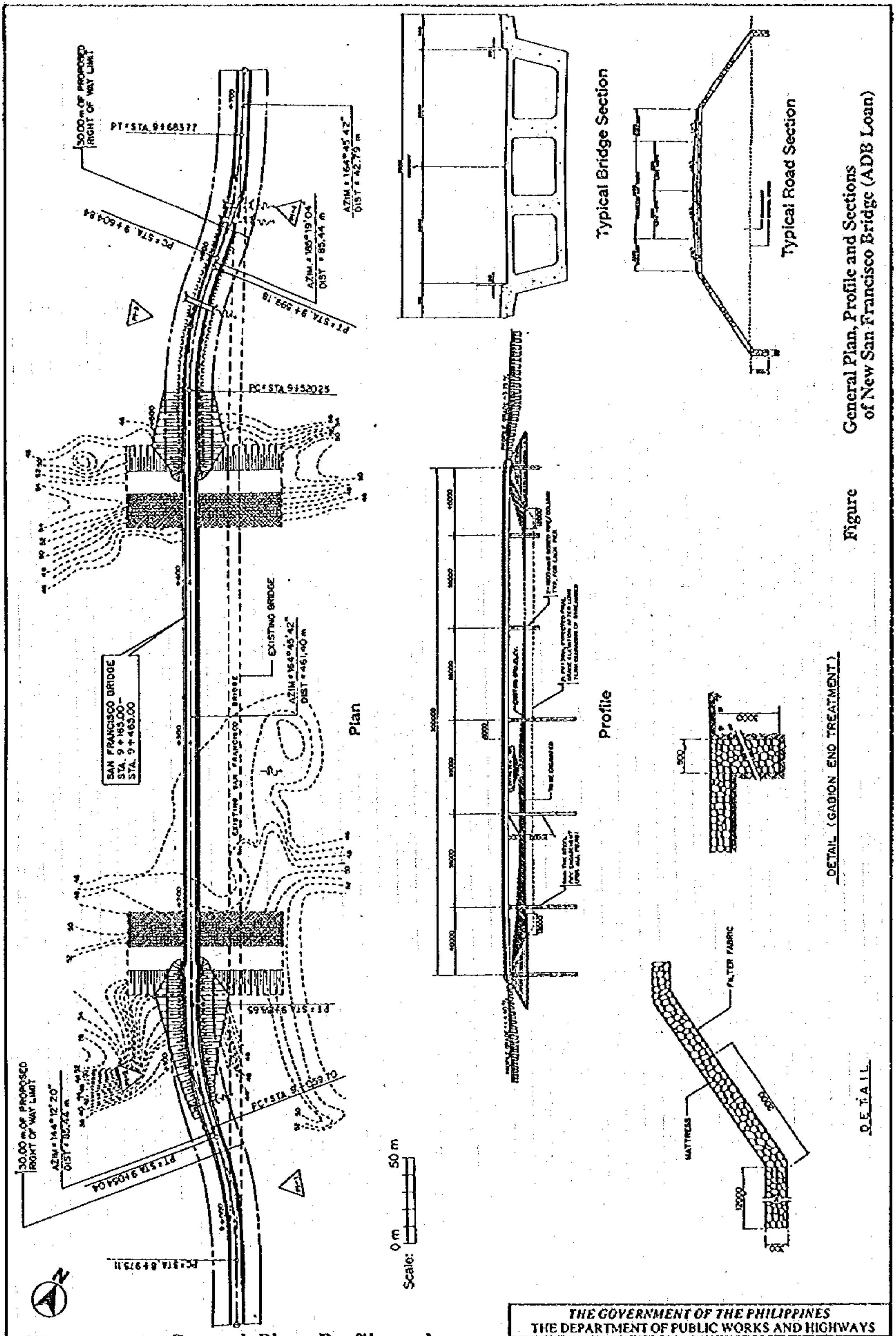
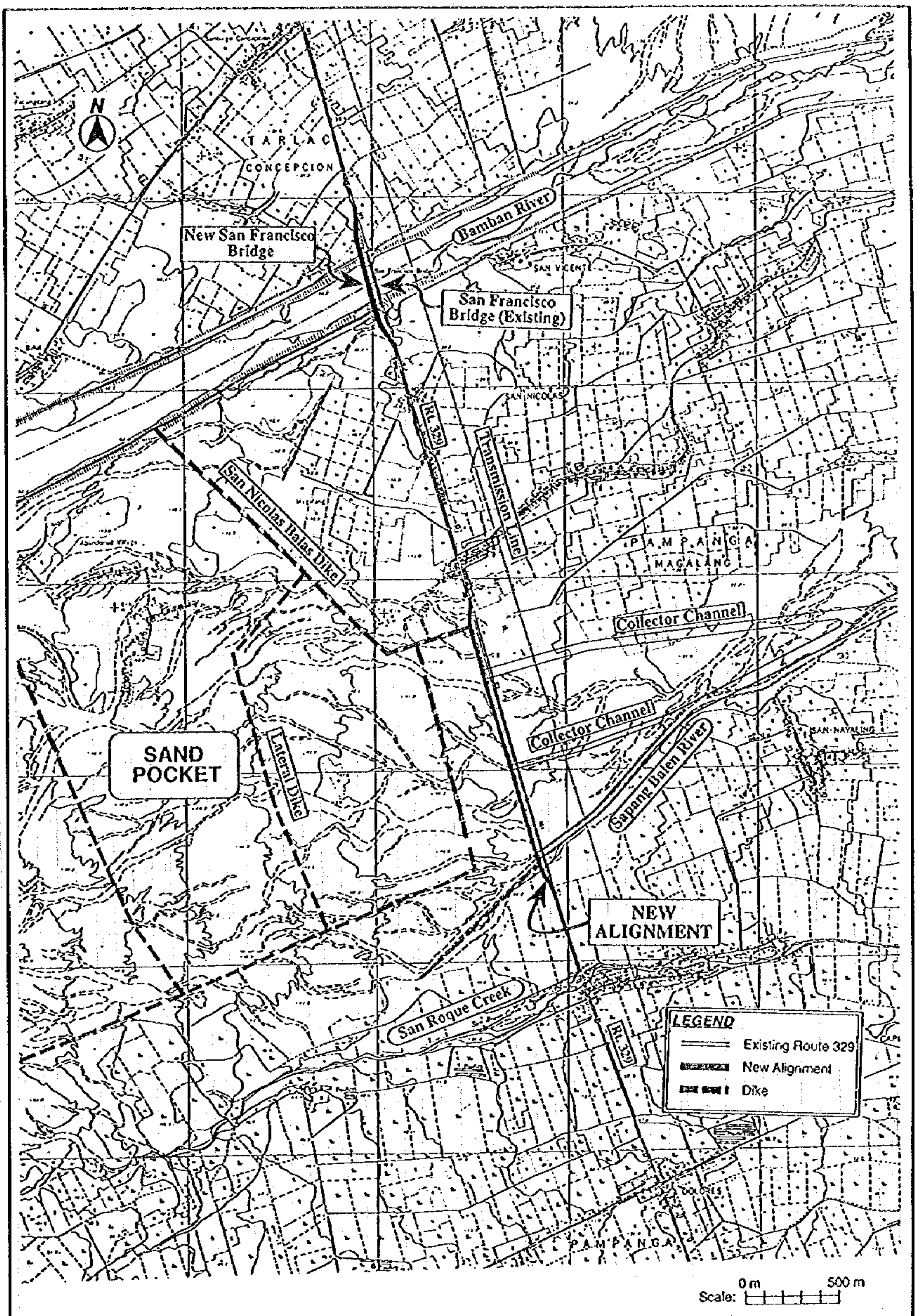


Figure 8.20 General Plan, Profile and Sections of New San Francisco Bridge (ADB Loan)

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY

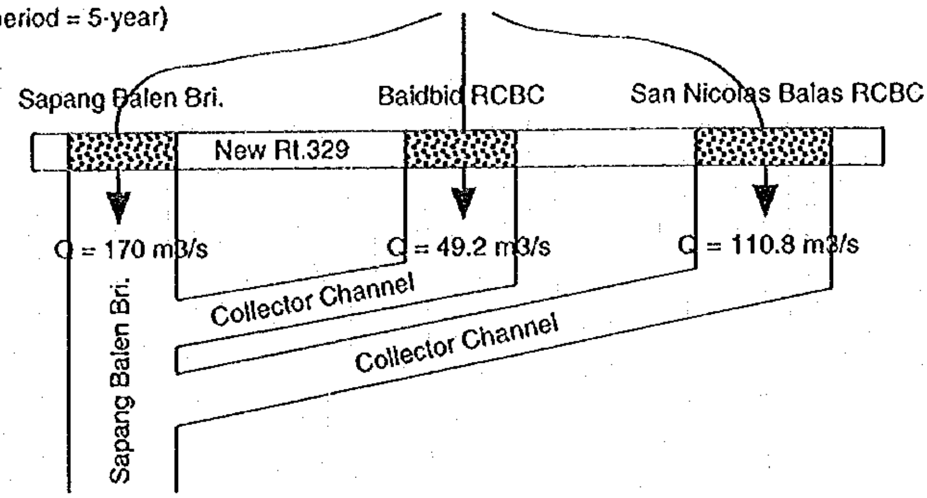


THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 8.21 Location Map of Route 329

Case - 1 : Before the training works for the Sacobia River

(Return period = 5-year)



Case - 2 : After the training works for the Sacobia River

(Return period = 50-year for bridge and 25-year for RCBC)

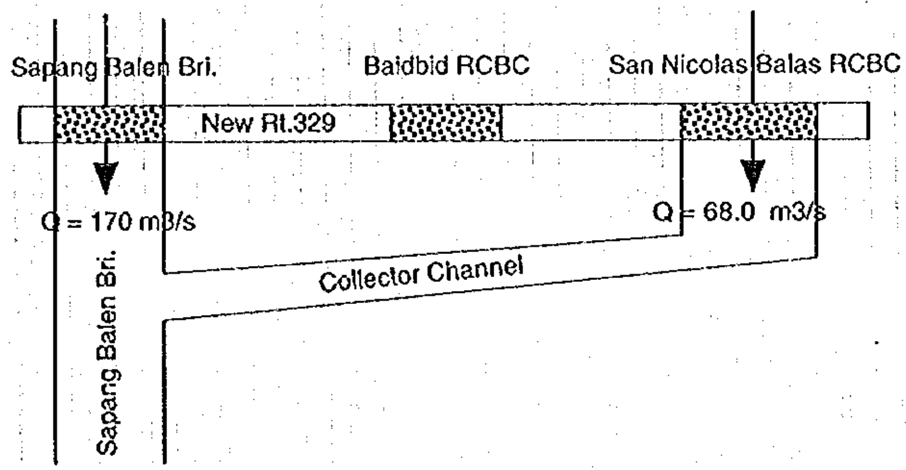


Figure 8.22 Flood Control Condition

THE GOVERMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN.ABACAN RIVER DRAINING FROM MT.PINATUBO
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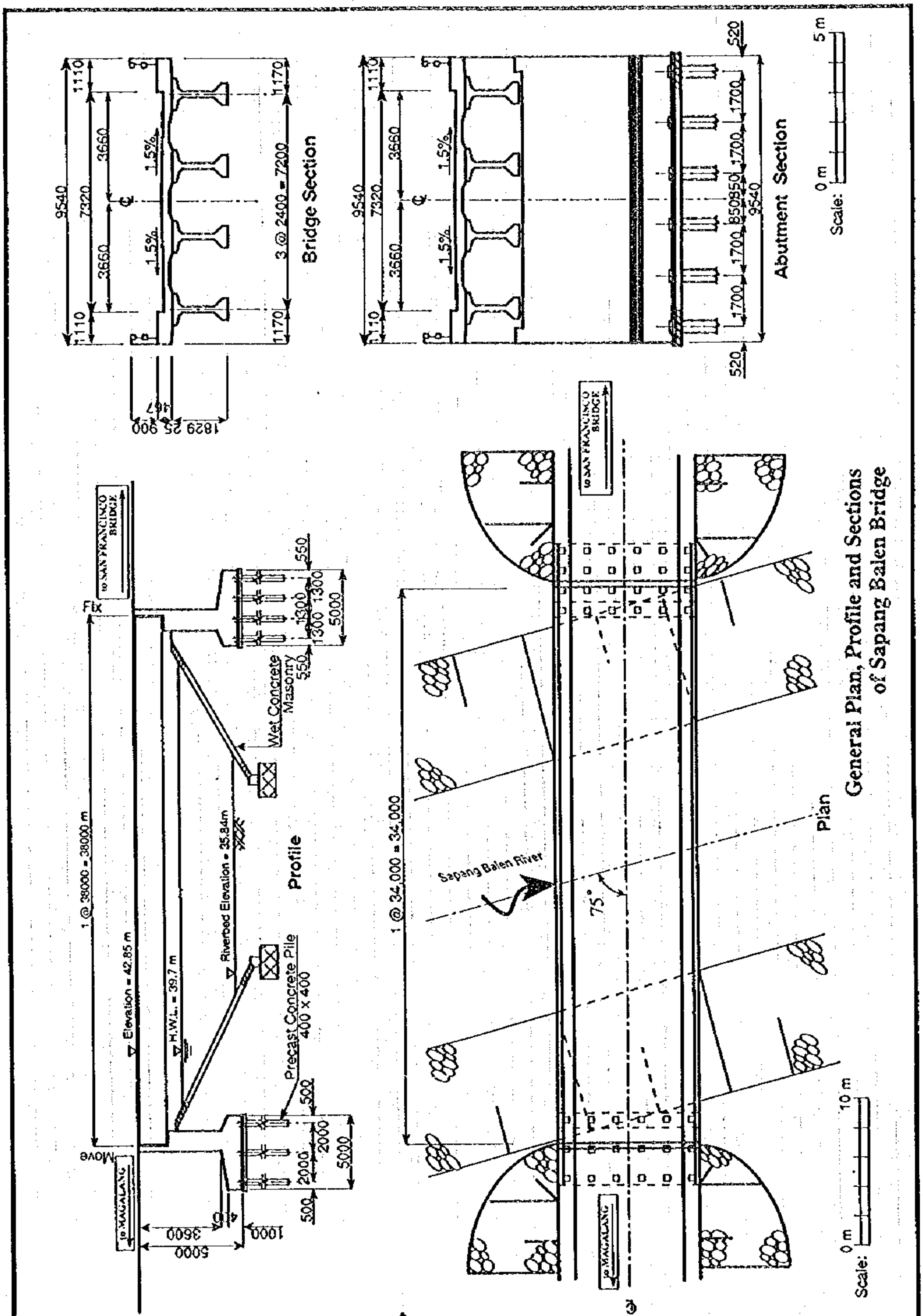


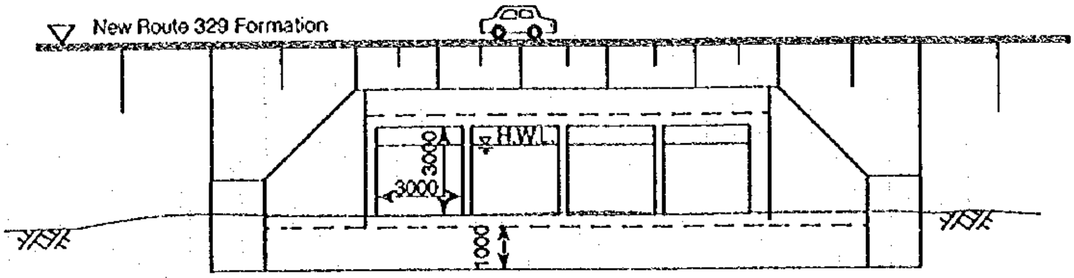
Figure 8.23

General Plan, Profile and Sections of Sapang Balen Bridge

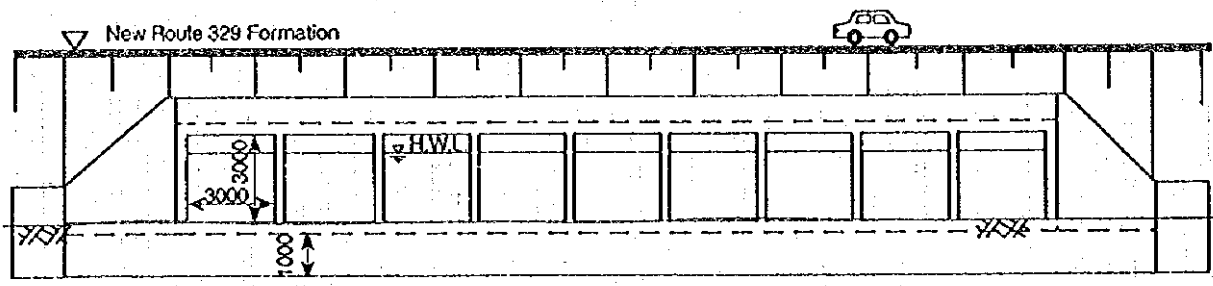
THE GOVERMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN.ABACAN RIVER DRAINING FROM MT.PINATUBO

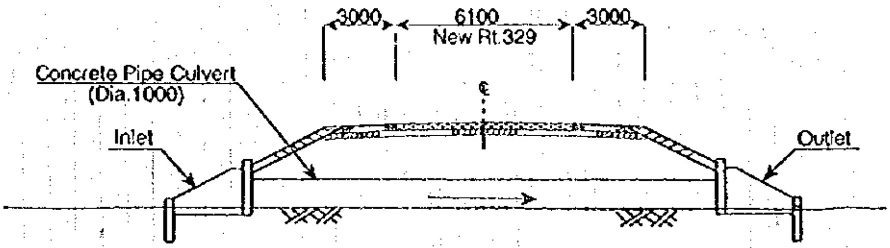
JAPAN INTERNATIONAL COOPERATION AGENCY



General Section of Baidbid Box Culvert



General Section of San Nicolas Balas Box Culvert



General Section of Pipe Culvert

Figure 8.24 General Sections of Box Culvert and Pipe Culvert

THE GOVERMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN.ABACAN RIVER DRAINING FROM MT.PINATUBO

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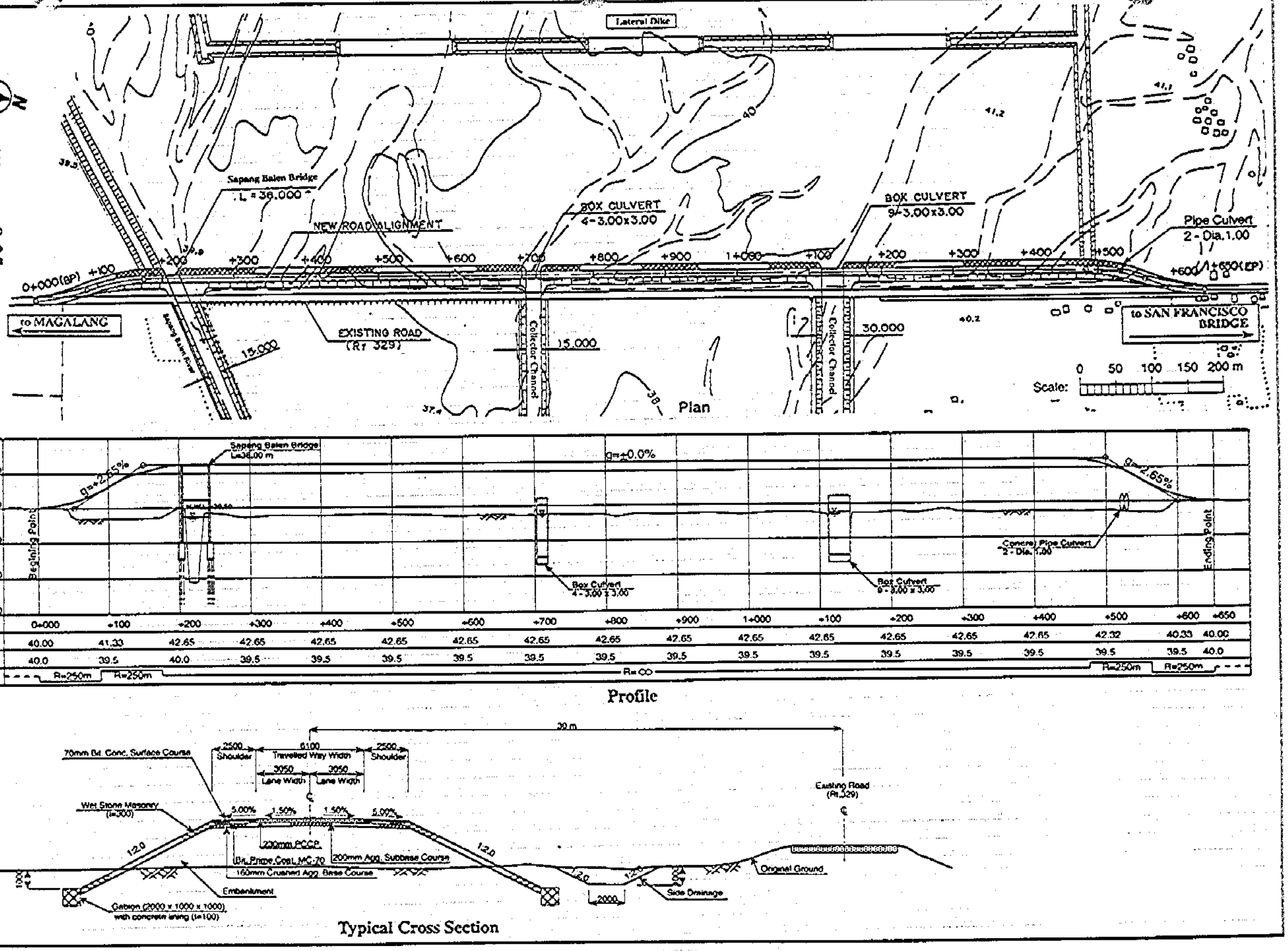
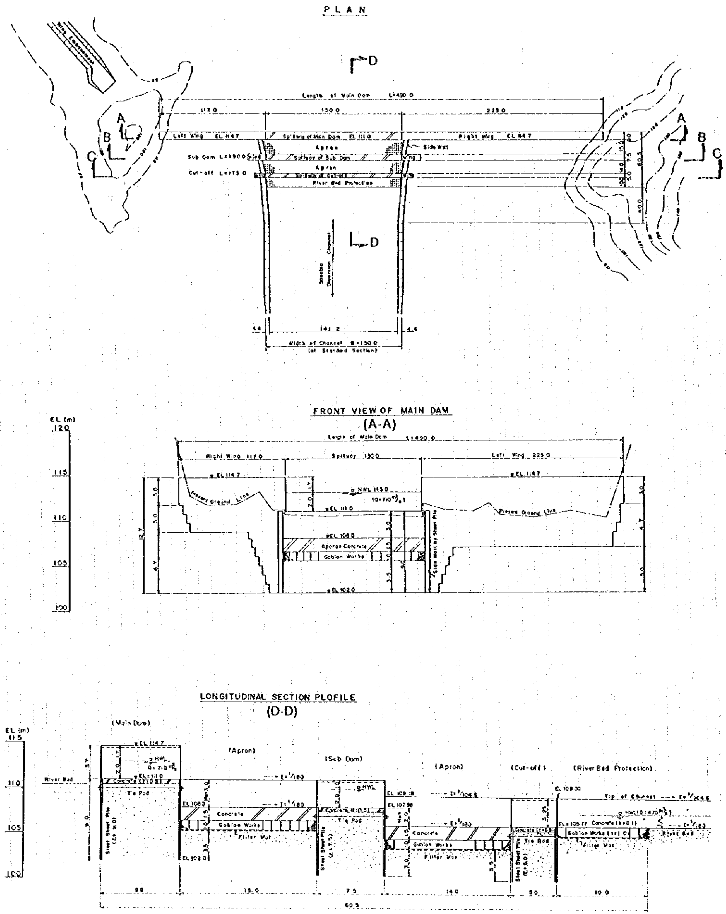


Figure 8.25

Plan, Profile and Section of Route 329



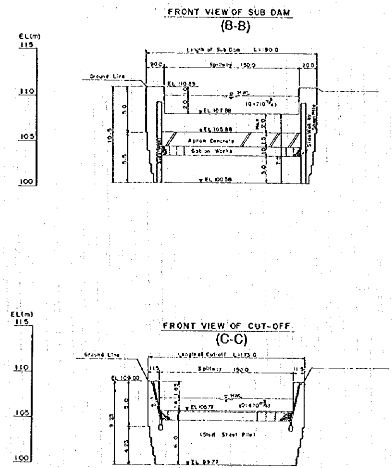


Figure 8.26
Maskup Consolidation Dam (1/2)

THE GOVERNMENT OF THE PHILIPPINES
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