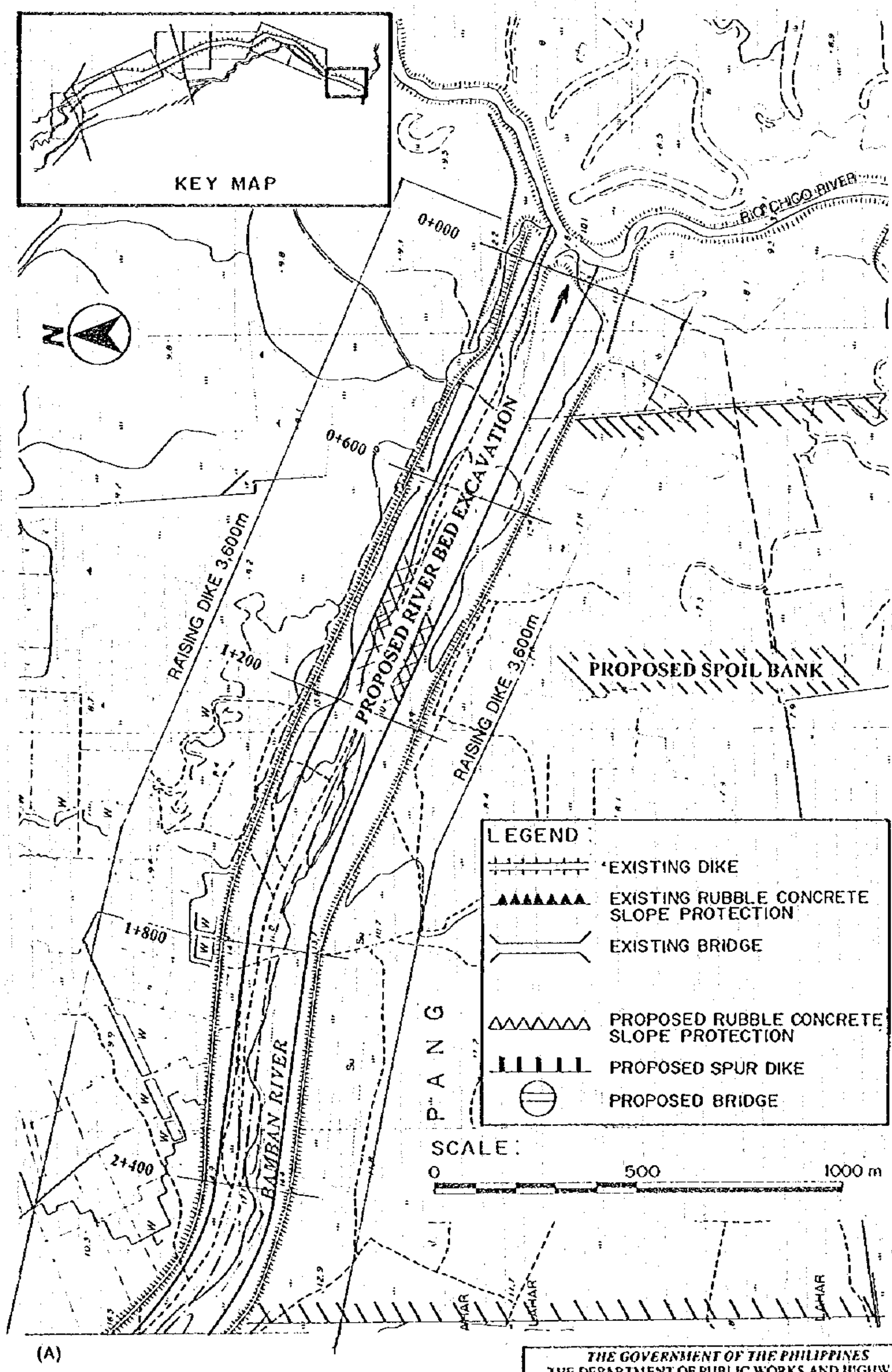
ANNEX A2

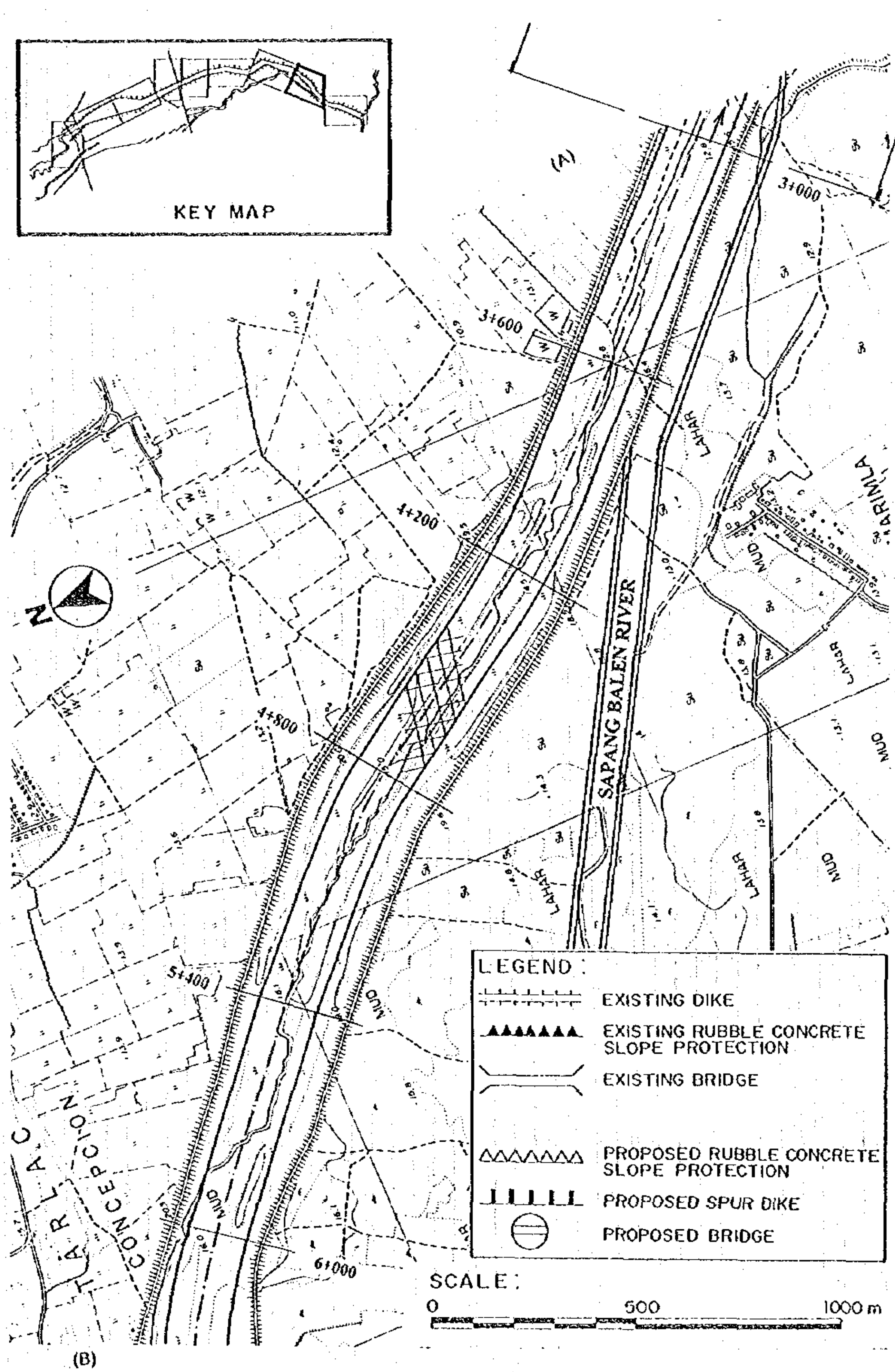
PLAN OF RIVER CHANNEL IMPROVEMENT

A2.1 BAMBAN RIVER IMPROVEMENT



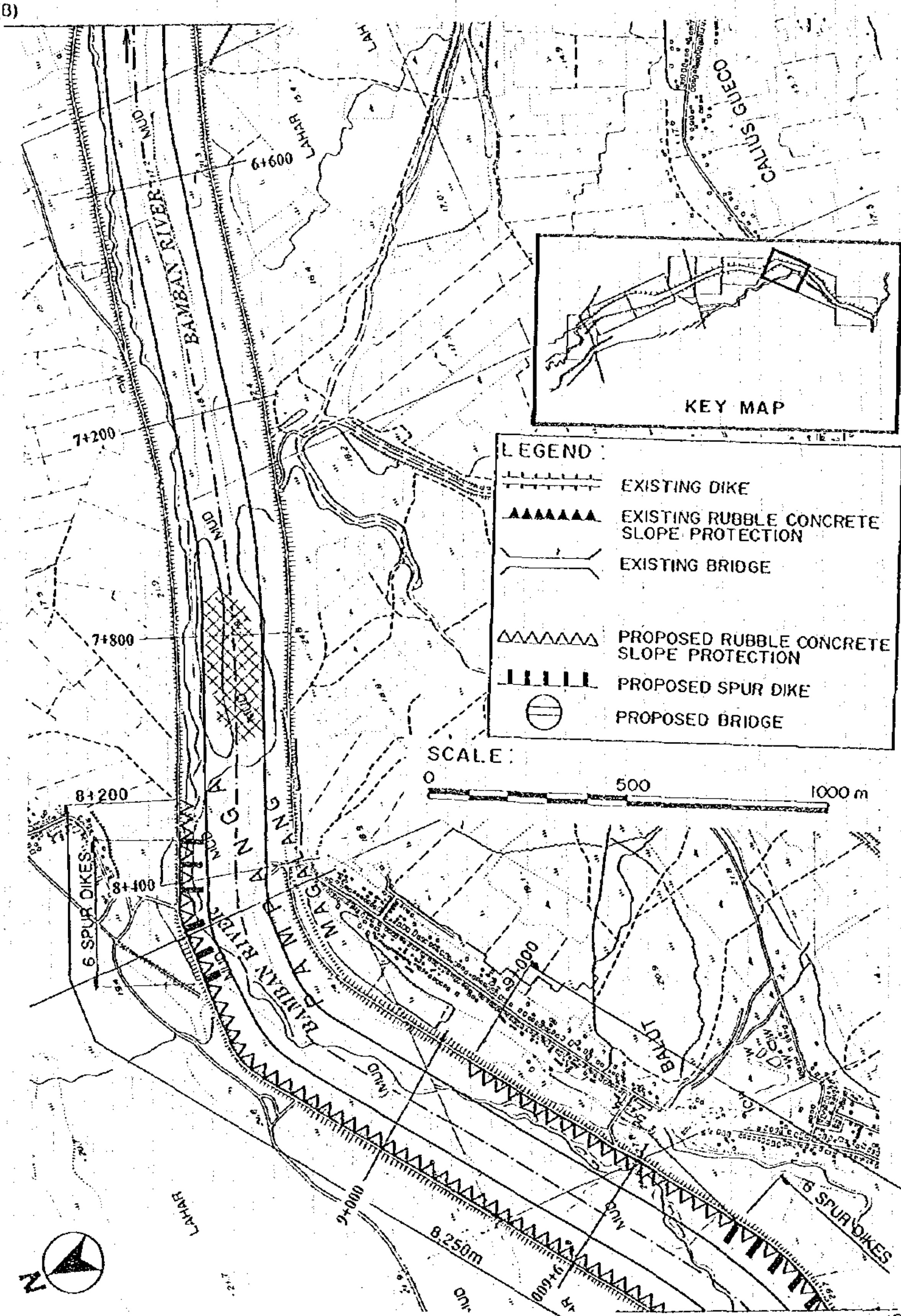
Bamban River Improvement (1/9)

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



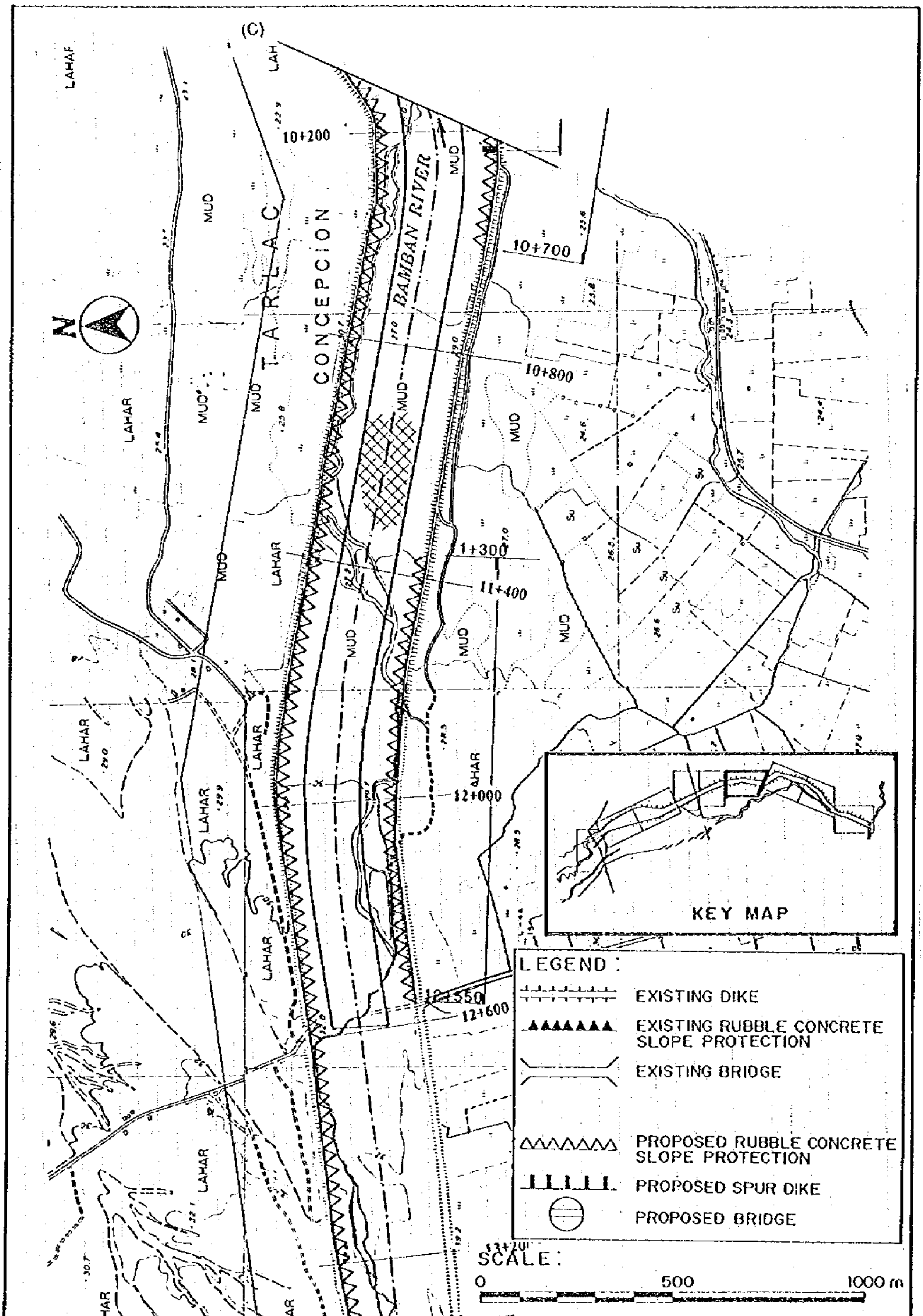
Bamban River Improvement (2/9)

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



Bamban River Improvement (3/9)

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

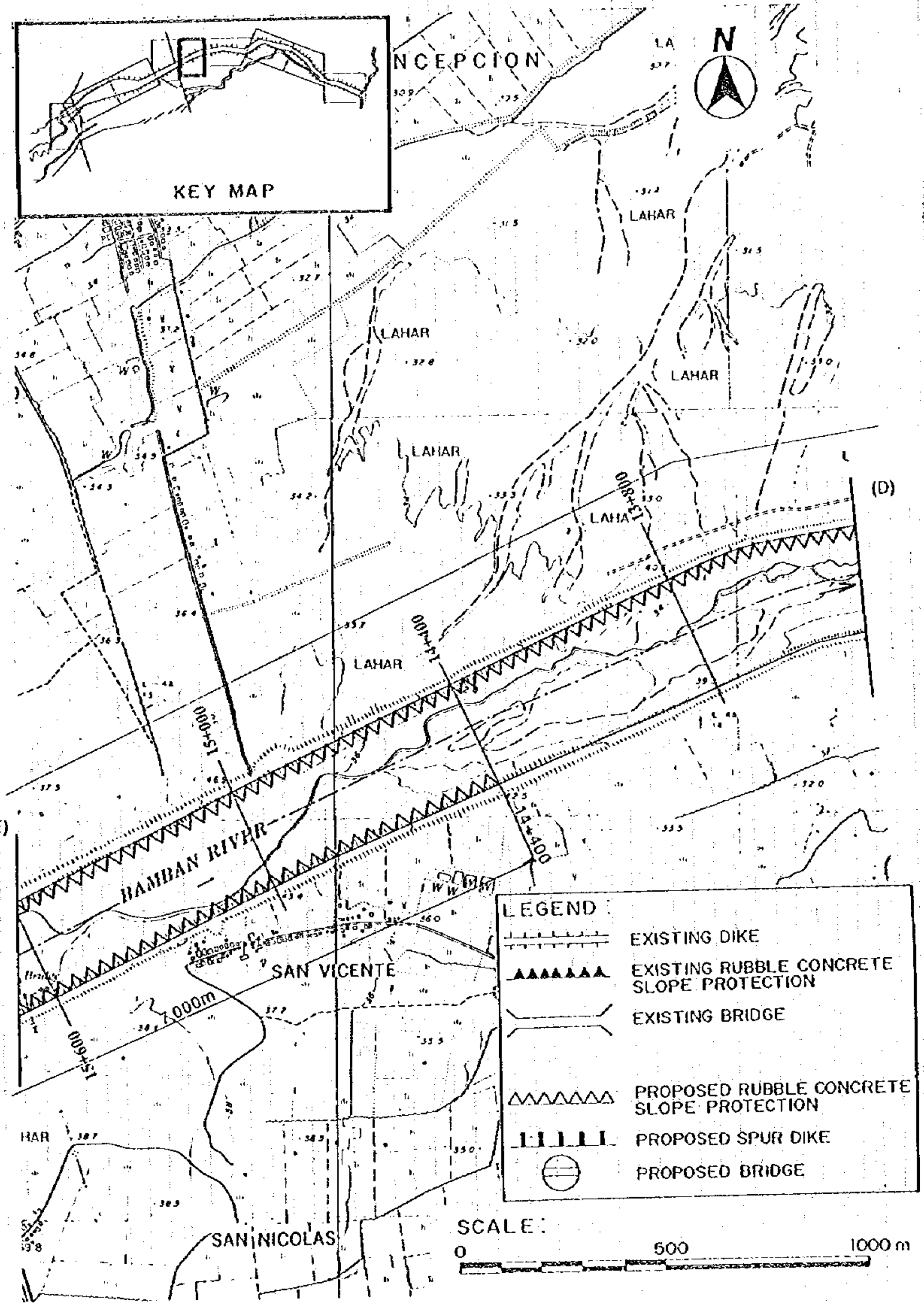


Bamban River Improvement (4/9)

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

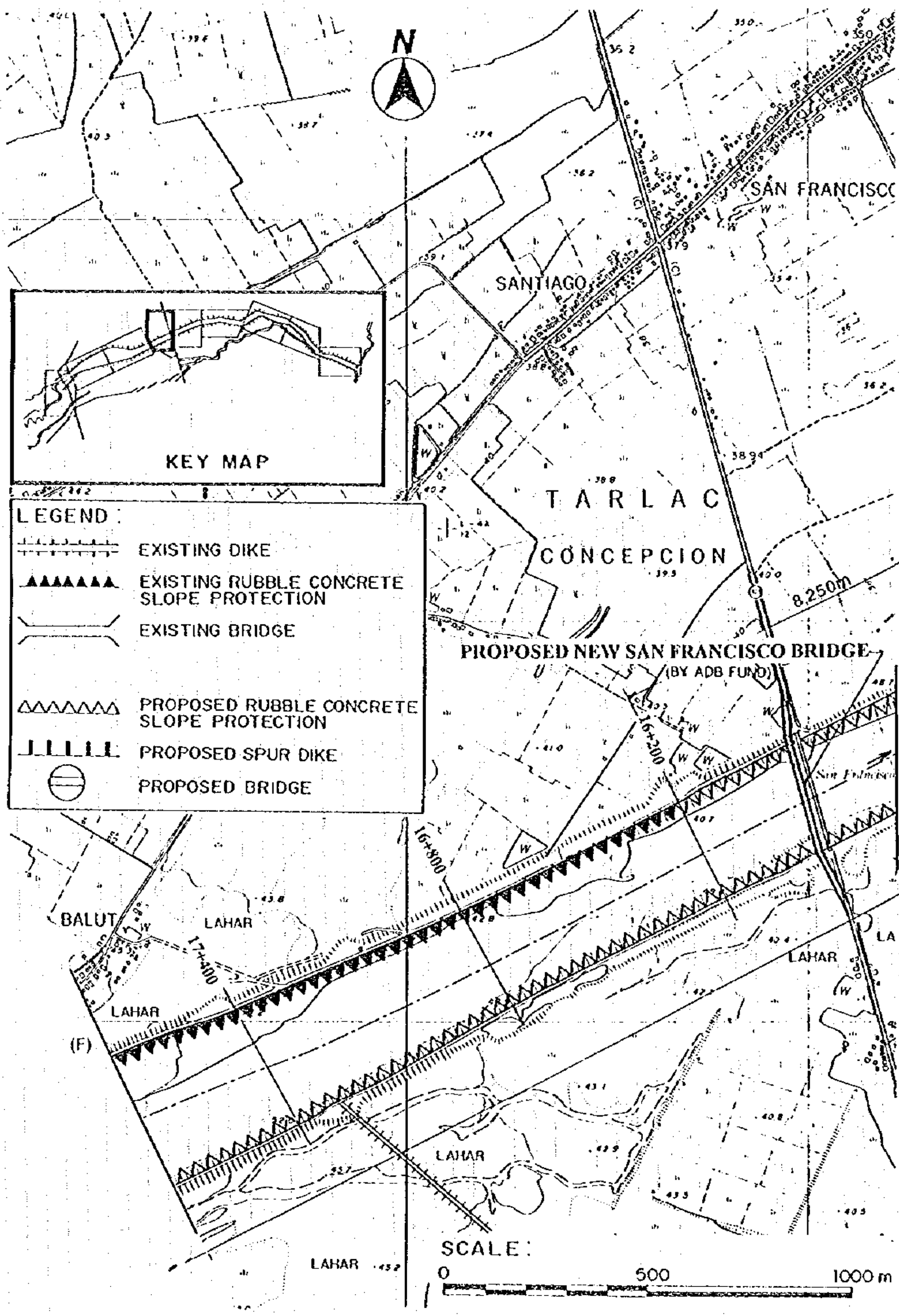
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY



Bamban River Improvement (5/9)

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

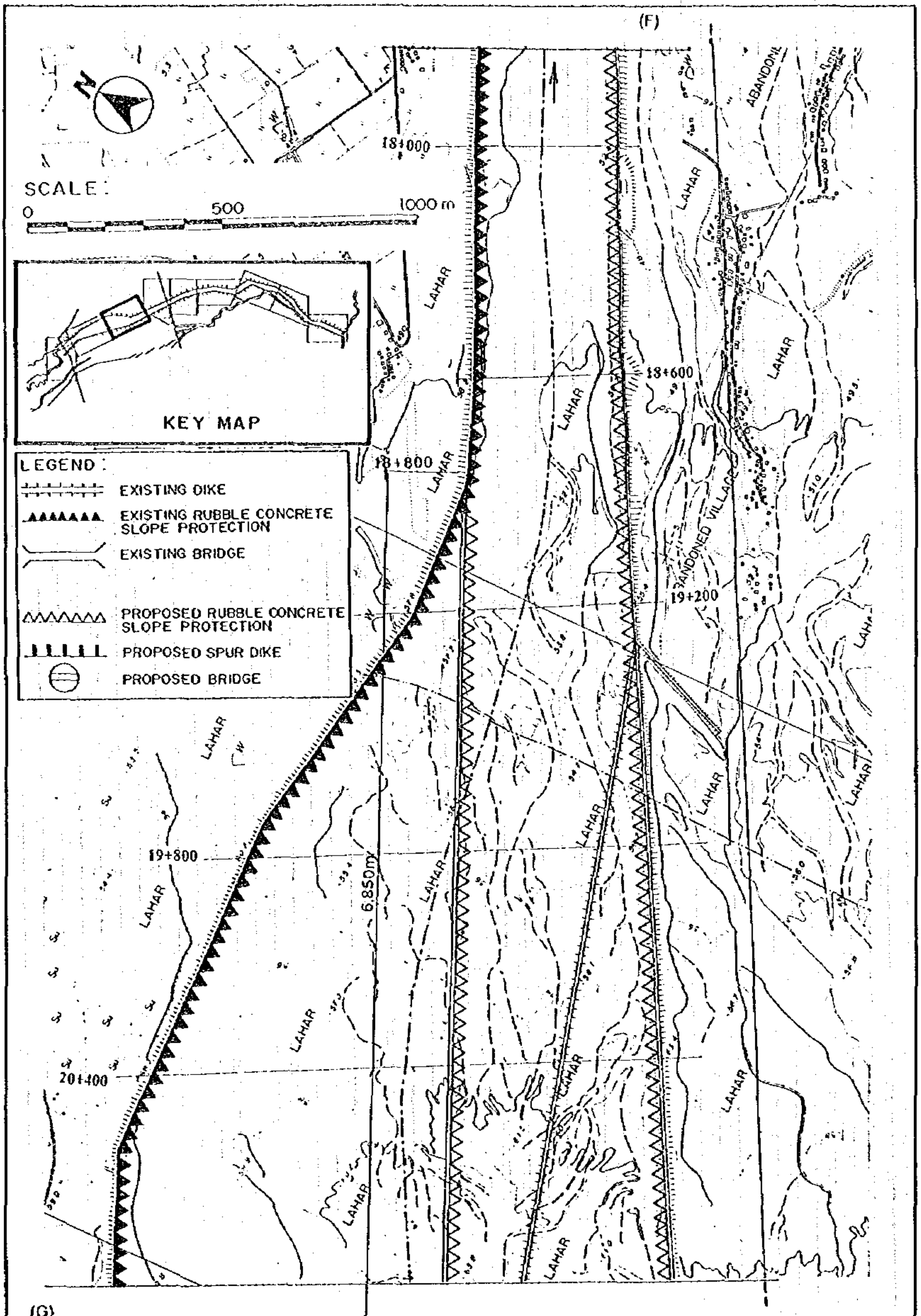


Bamban River Improvement (6/9)

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

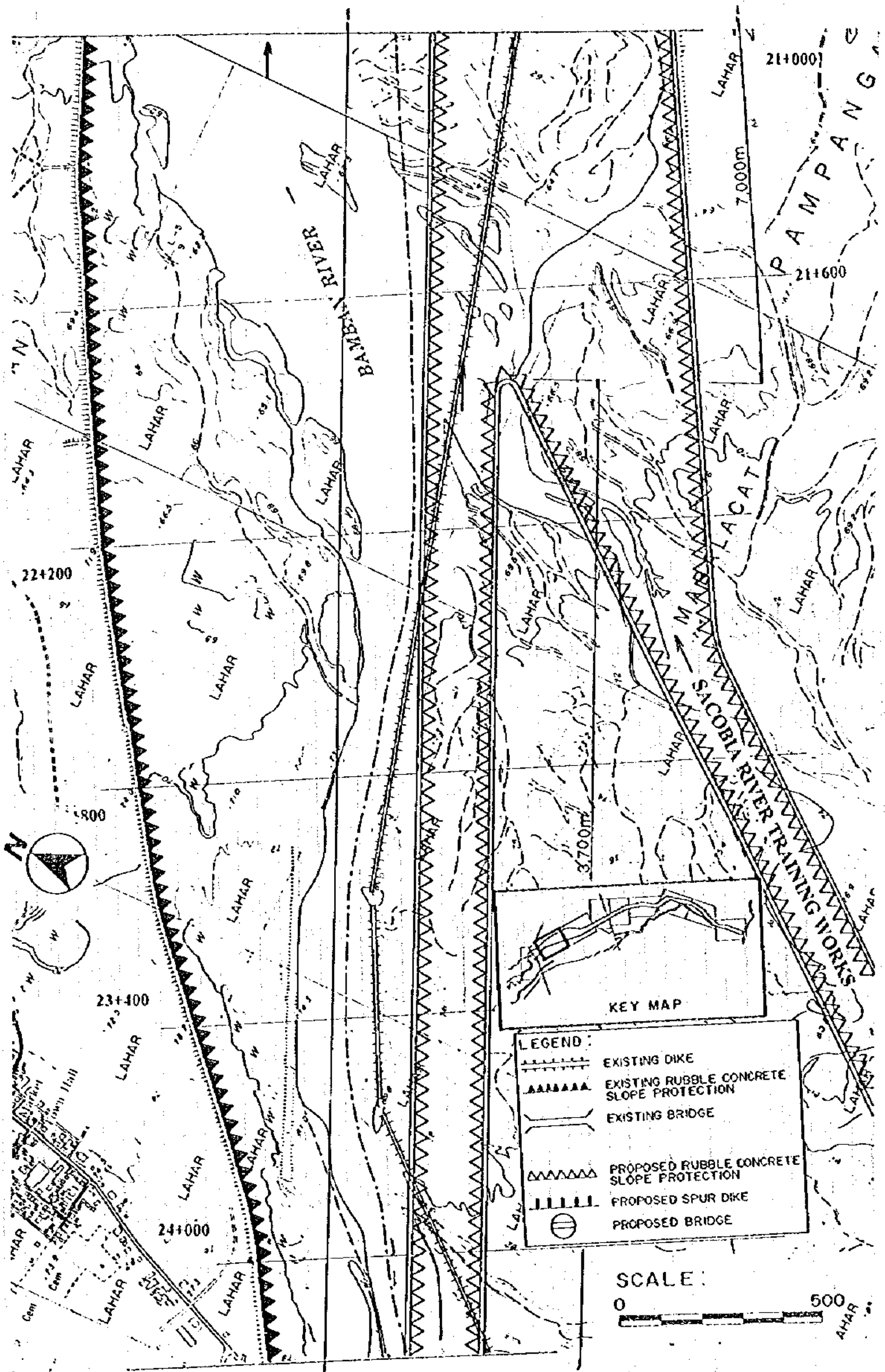
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY



Bamban River Improvement (7/9)

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

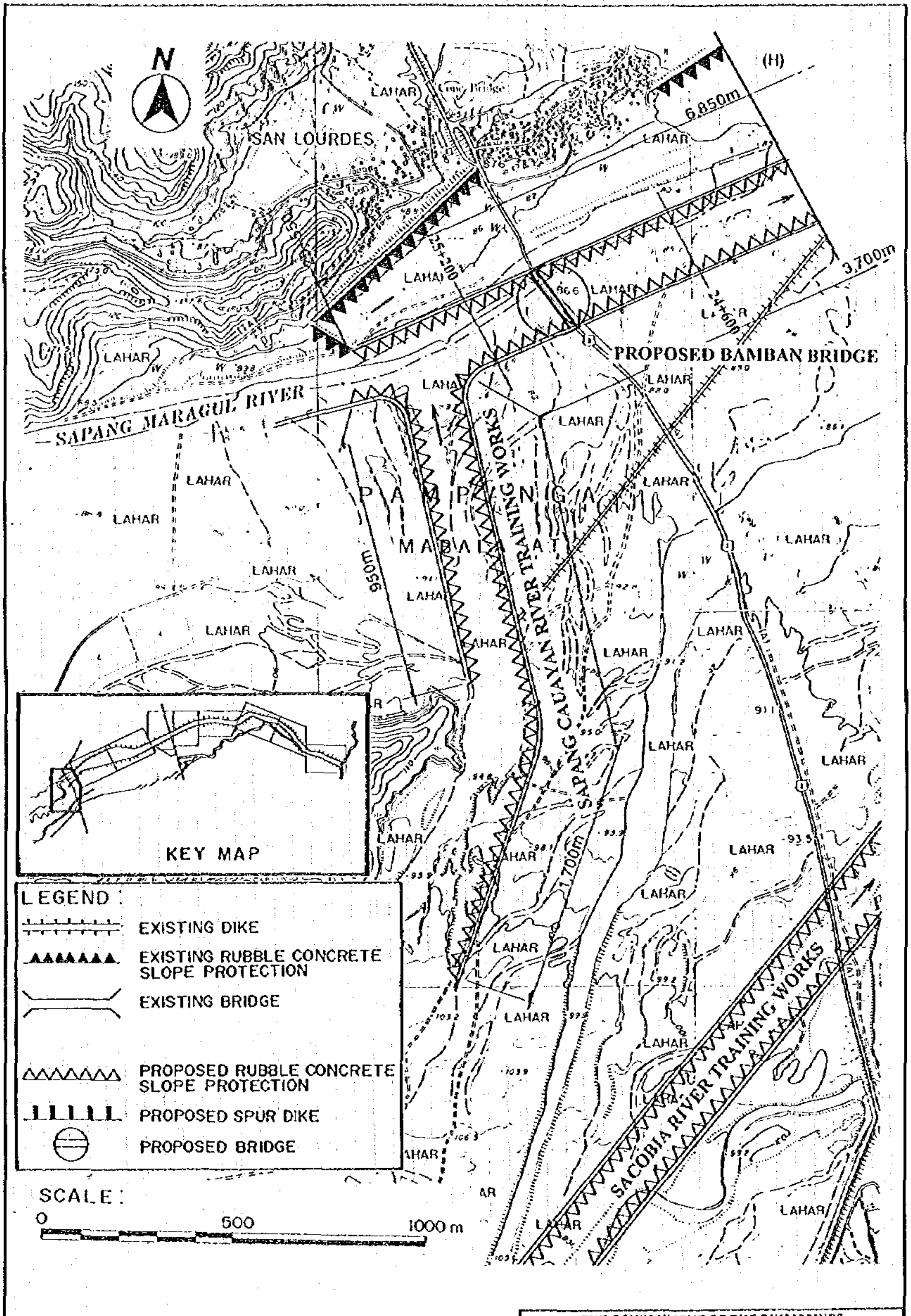


Bamban River Improvement (8/9)

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

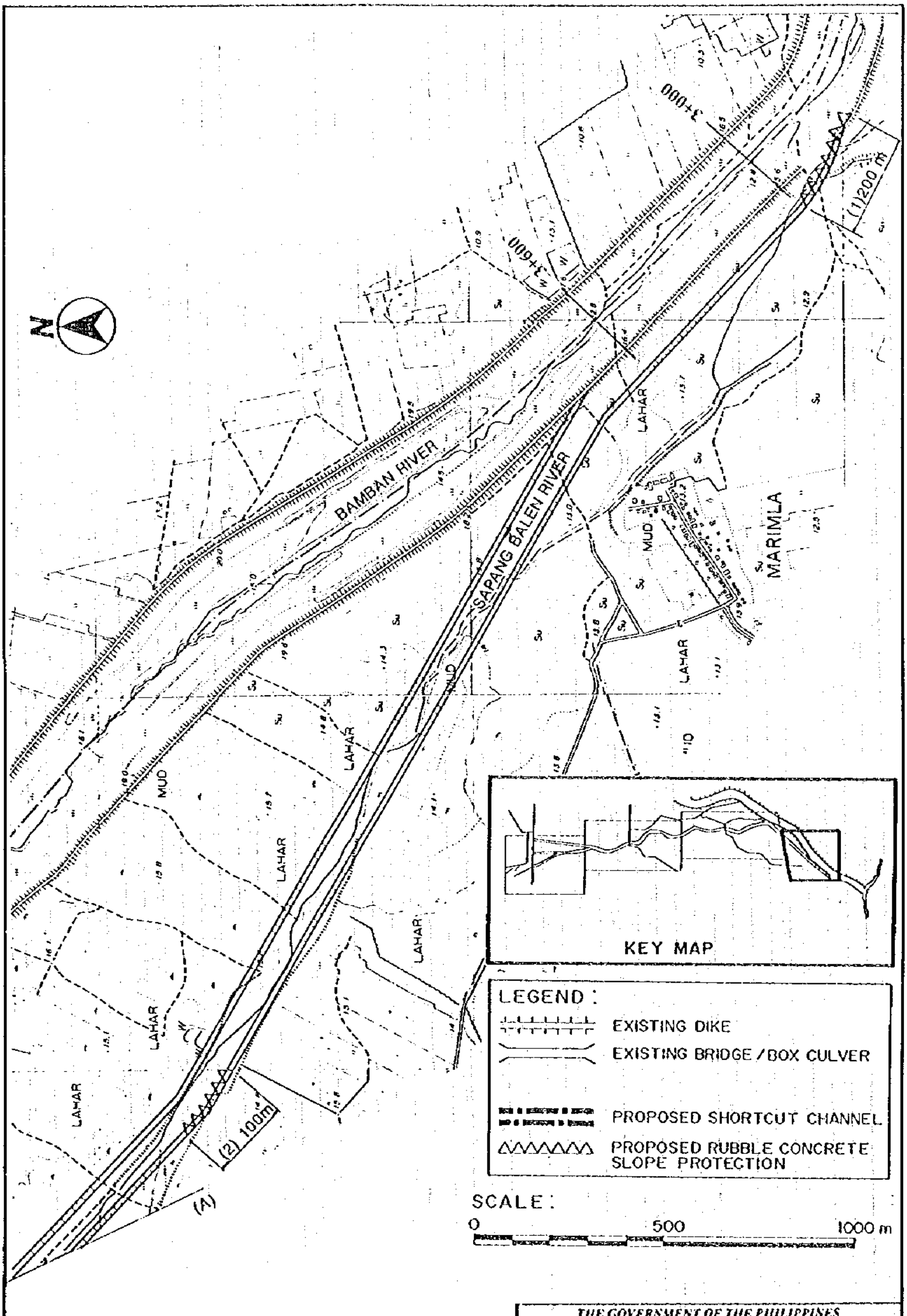
JAPAN INTERNATIONAL COOPERATION AGENCY



Bamban River Improvement (9/9)

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

A2.2 SAPANG BALEN RIVER IMPROVEMENT

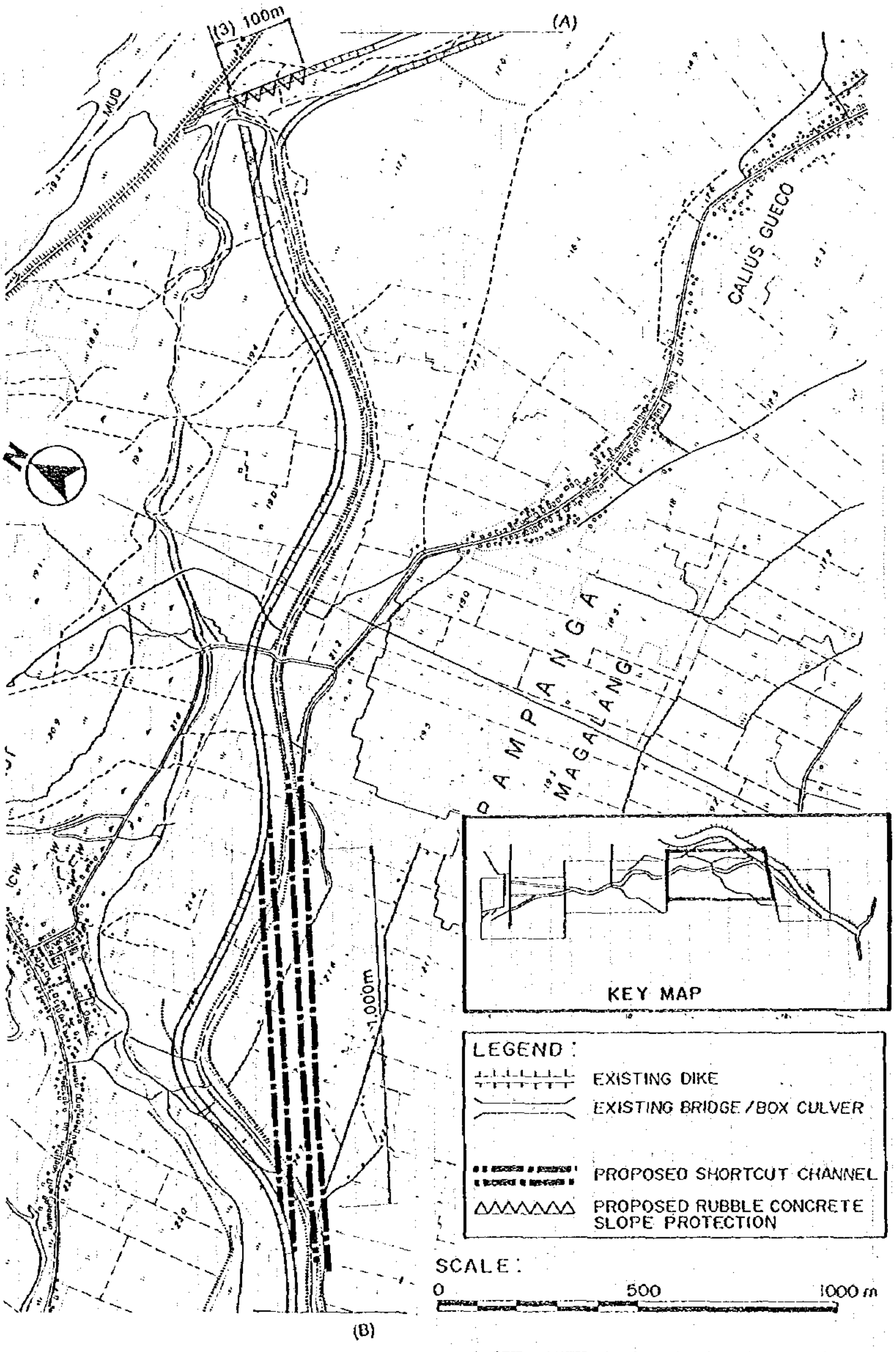


Sapang Balen River Improvement (1/4)

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

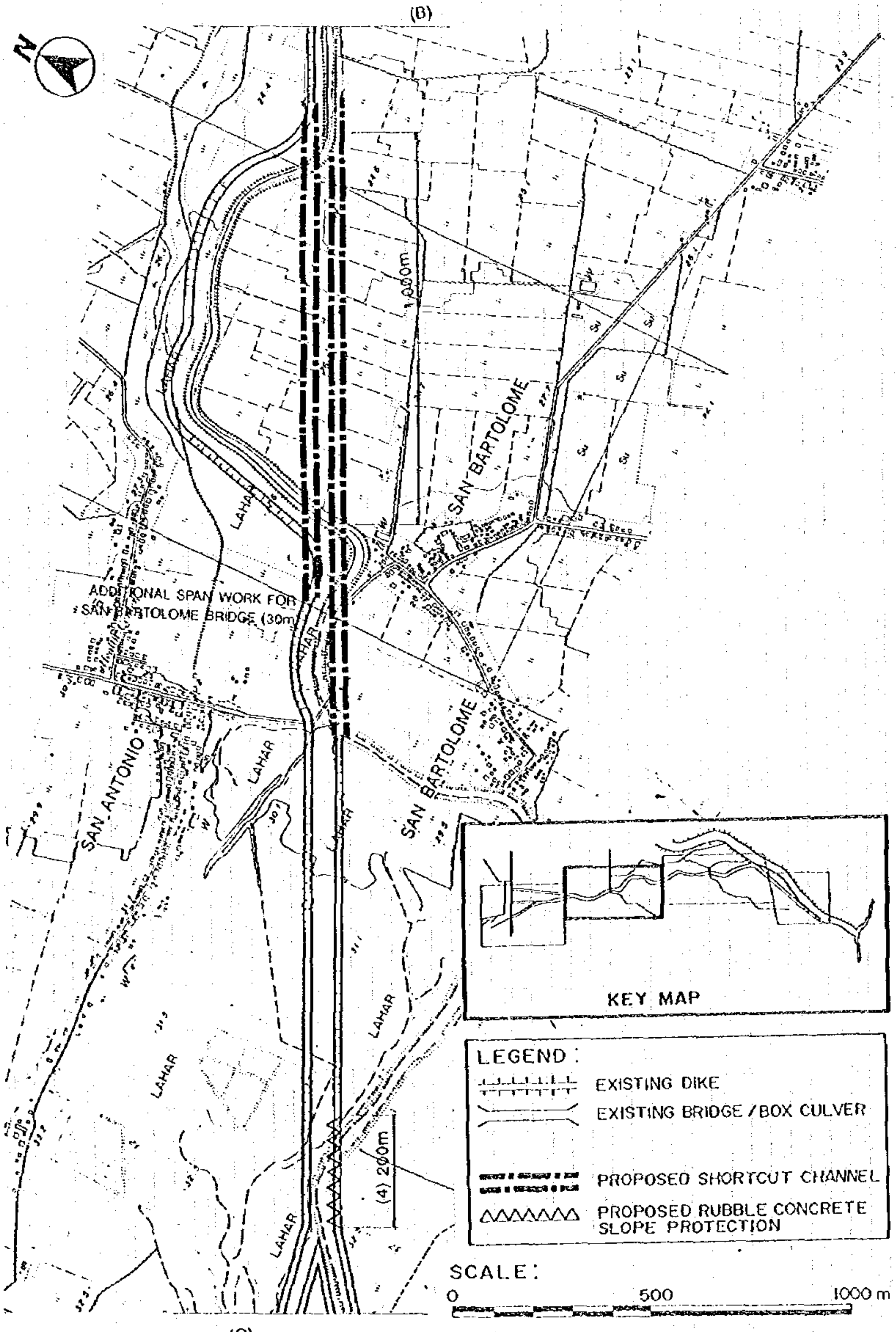
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY



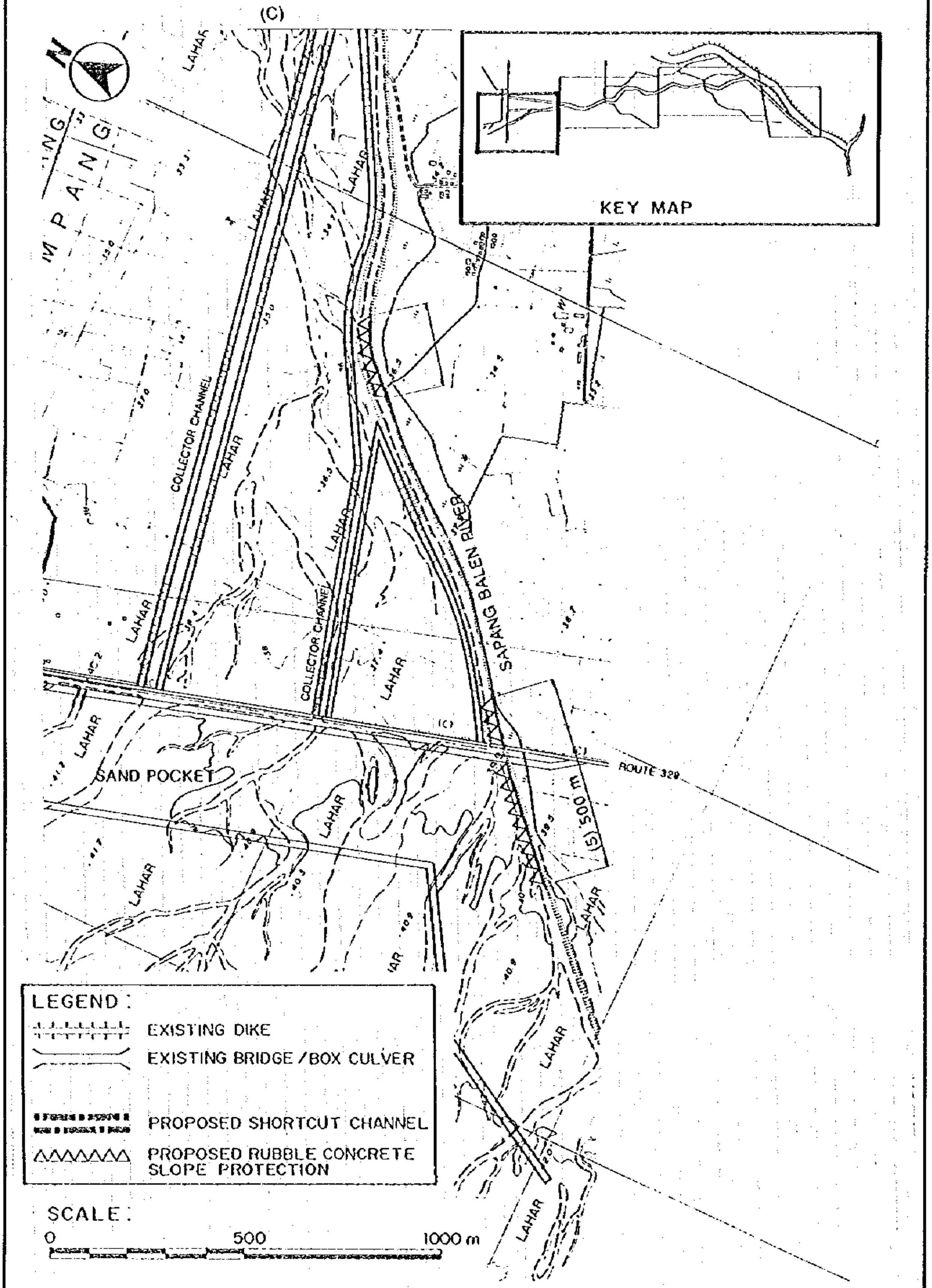
Sapang Balen River Improvement (2/4)

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



Sapang Balen River Improvement (3/4)

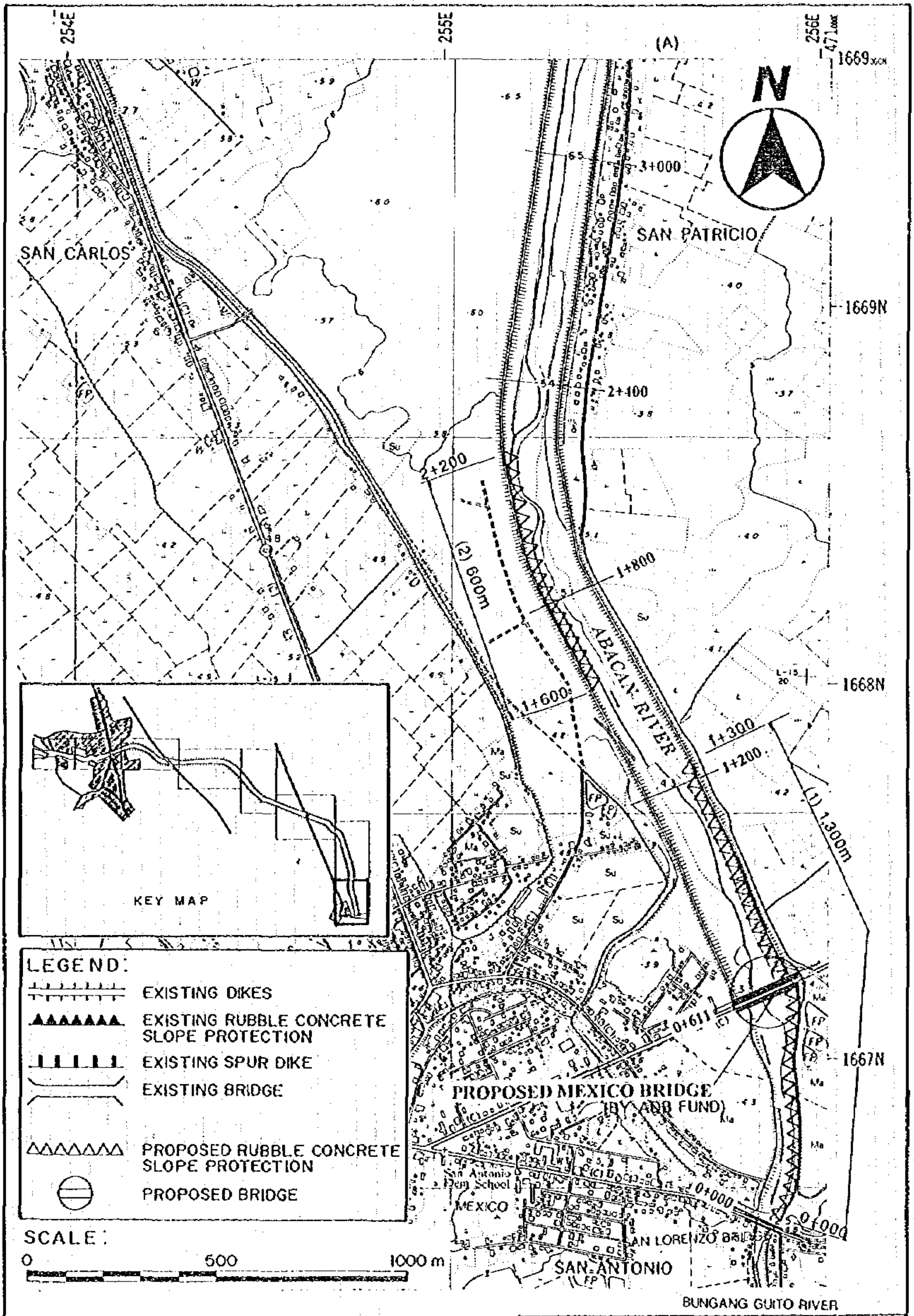
THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY



Sapang Balen River Improvement (4/4)

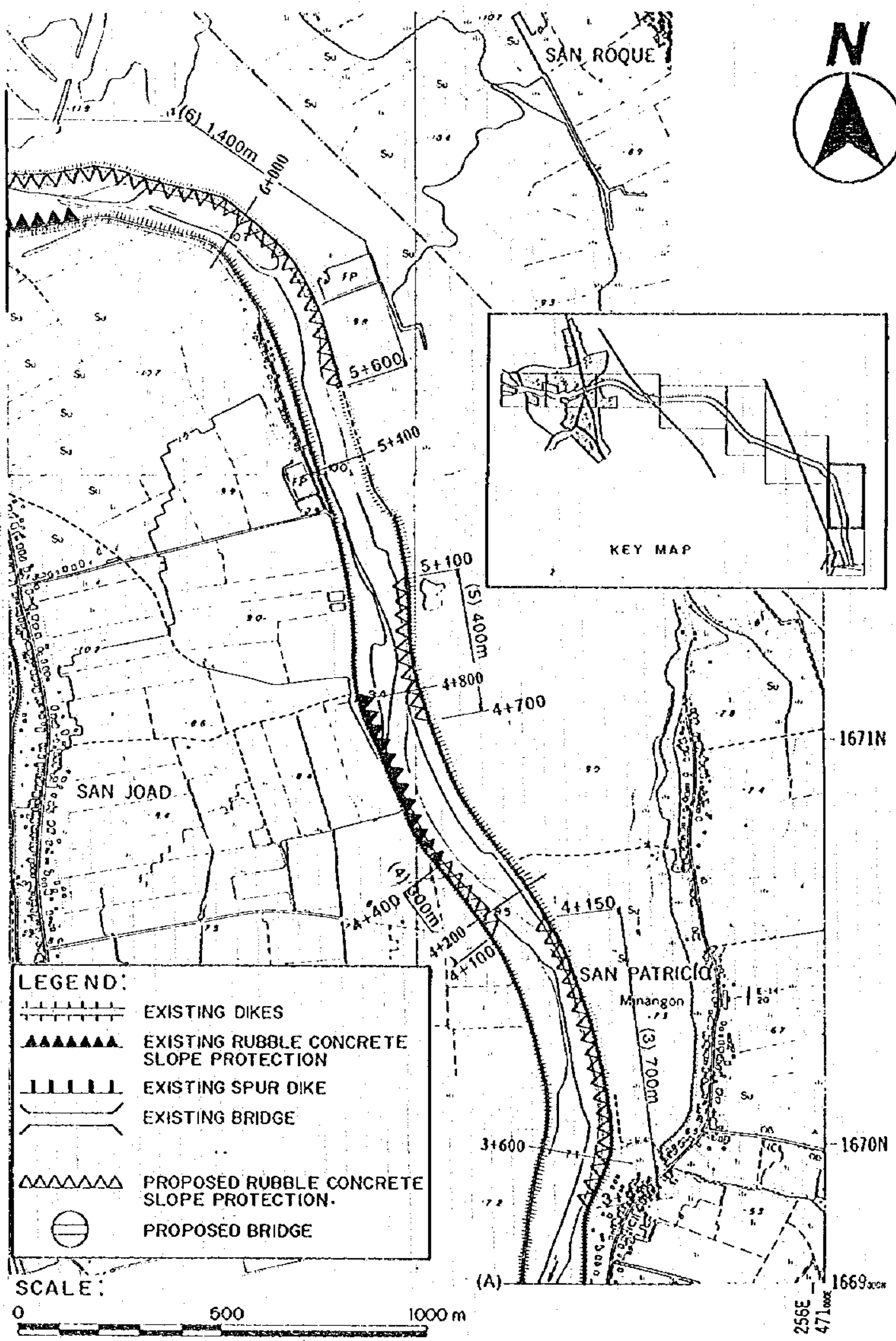
THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

A2.3 ABACAN RIVER IMPROVEMENT



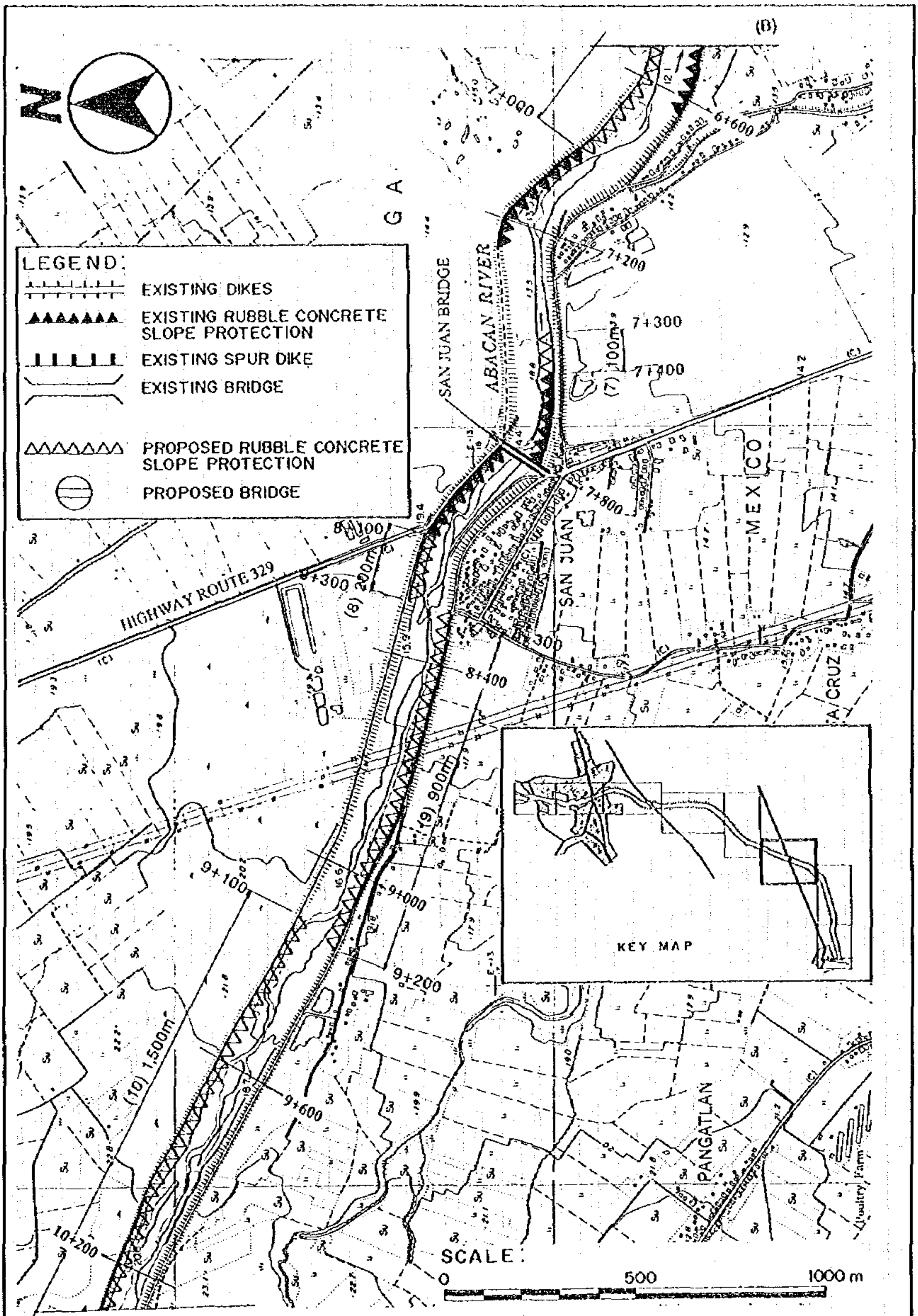
Abacan River Improvement (1/8)

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



Abacan River Improvement (2/8)

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



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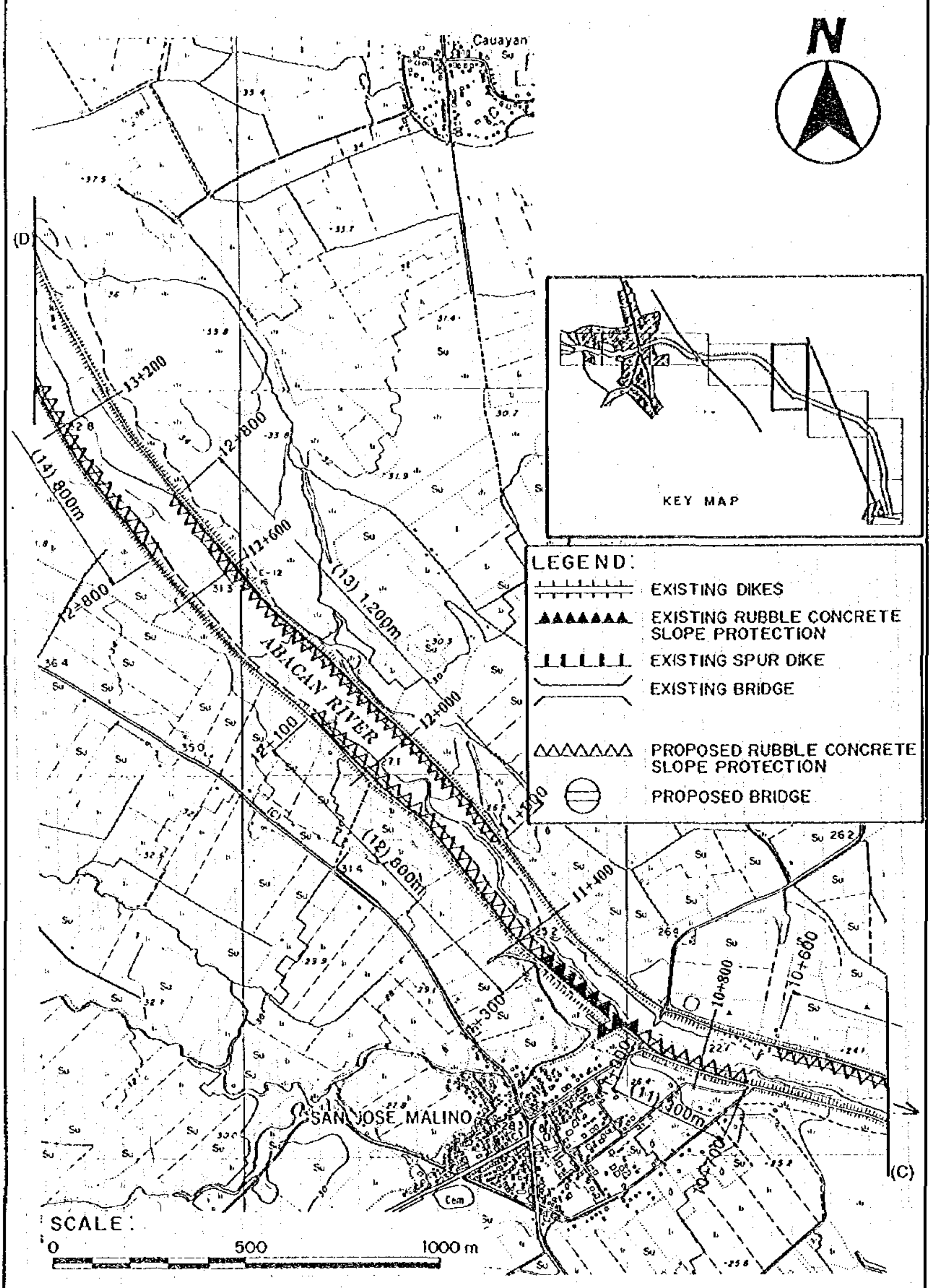
Abacan River Improvement (3/8)

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



Abacan River Improvement (4/8)

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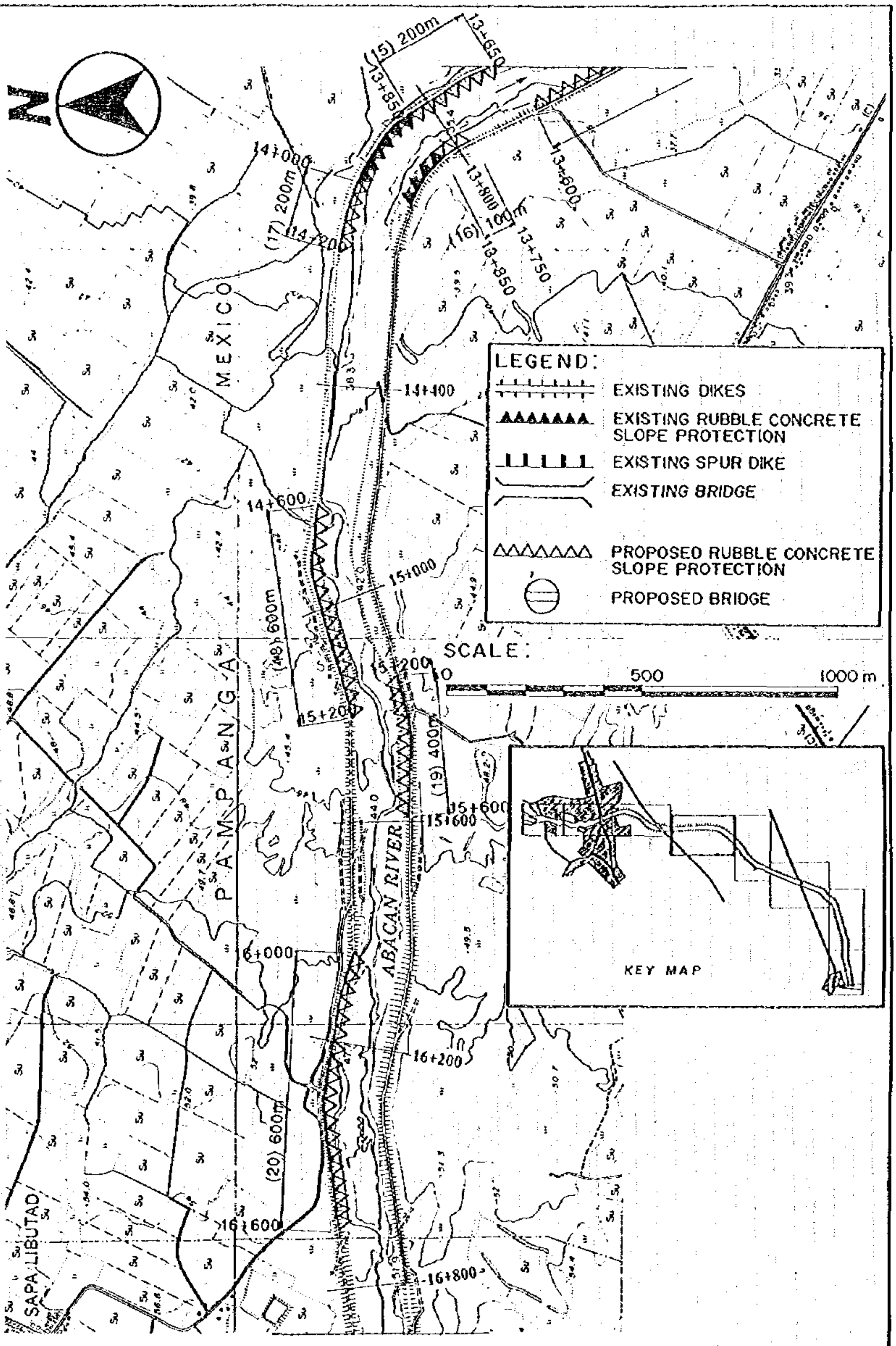
JAPAN INTERNATIONAL COOPERATION AGENCY



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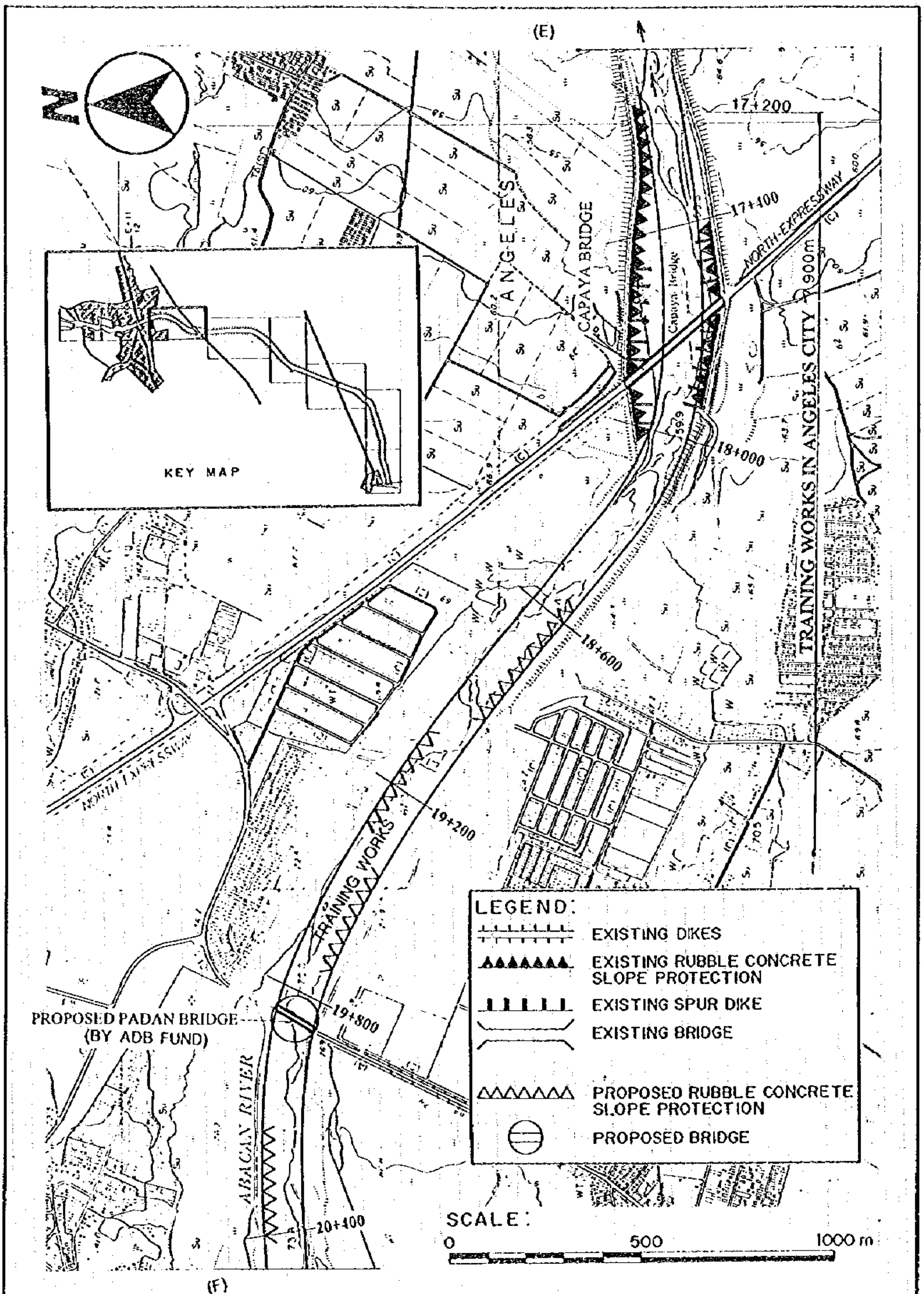
Abacan River Improvement (5/8)

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



Abacan River Improvement (6/8)

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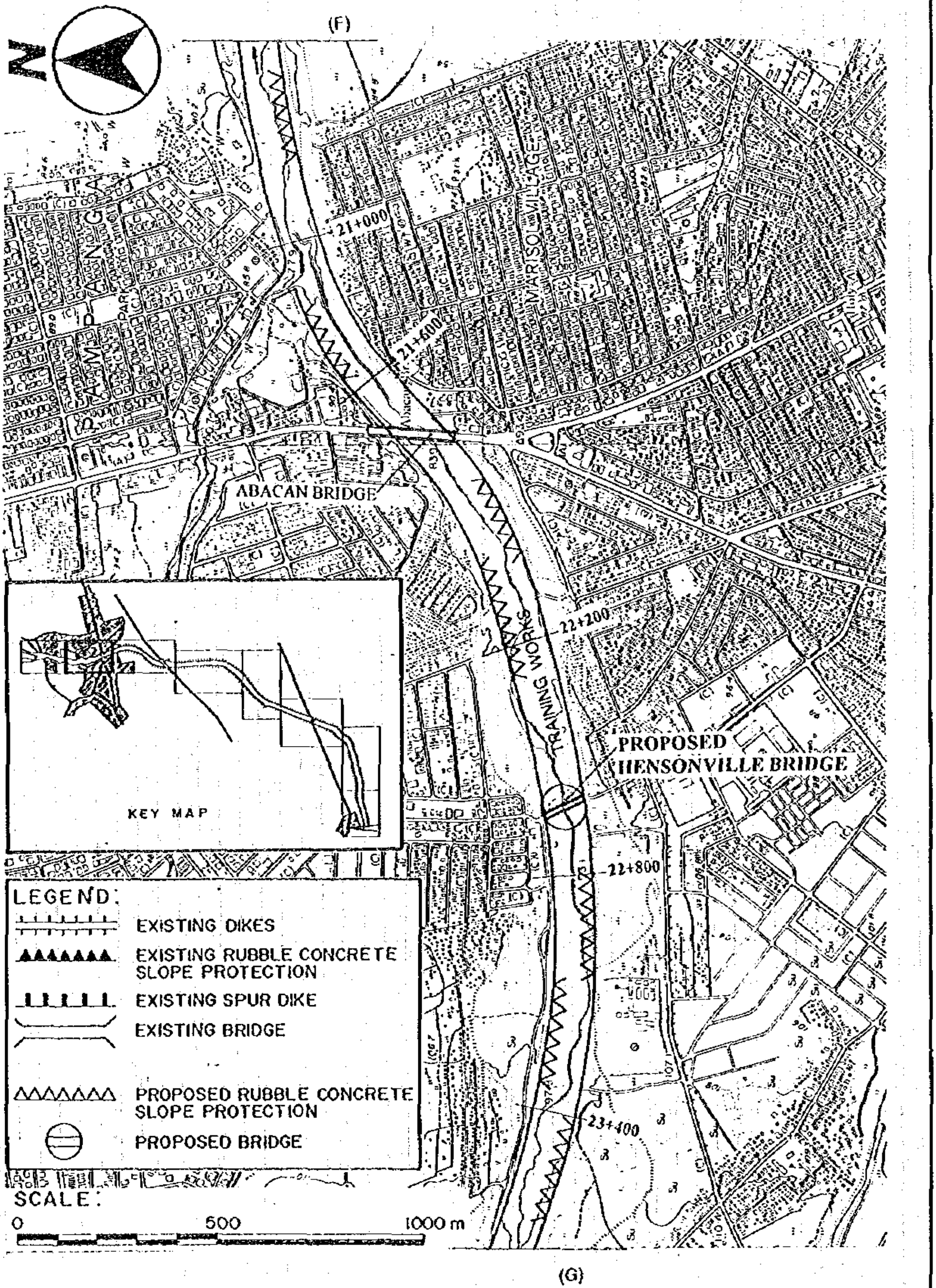
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY



Abacan River Improvement (7/8)

THE GOVERNMENT OF THE PHILIPPINES   THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
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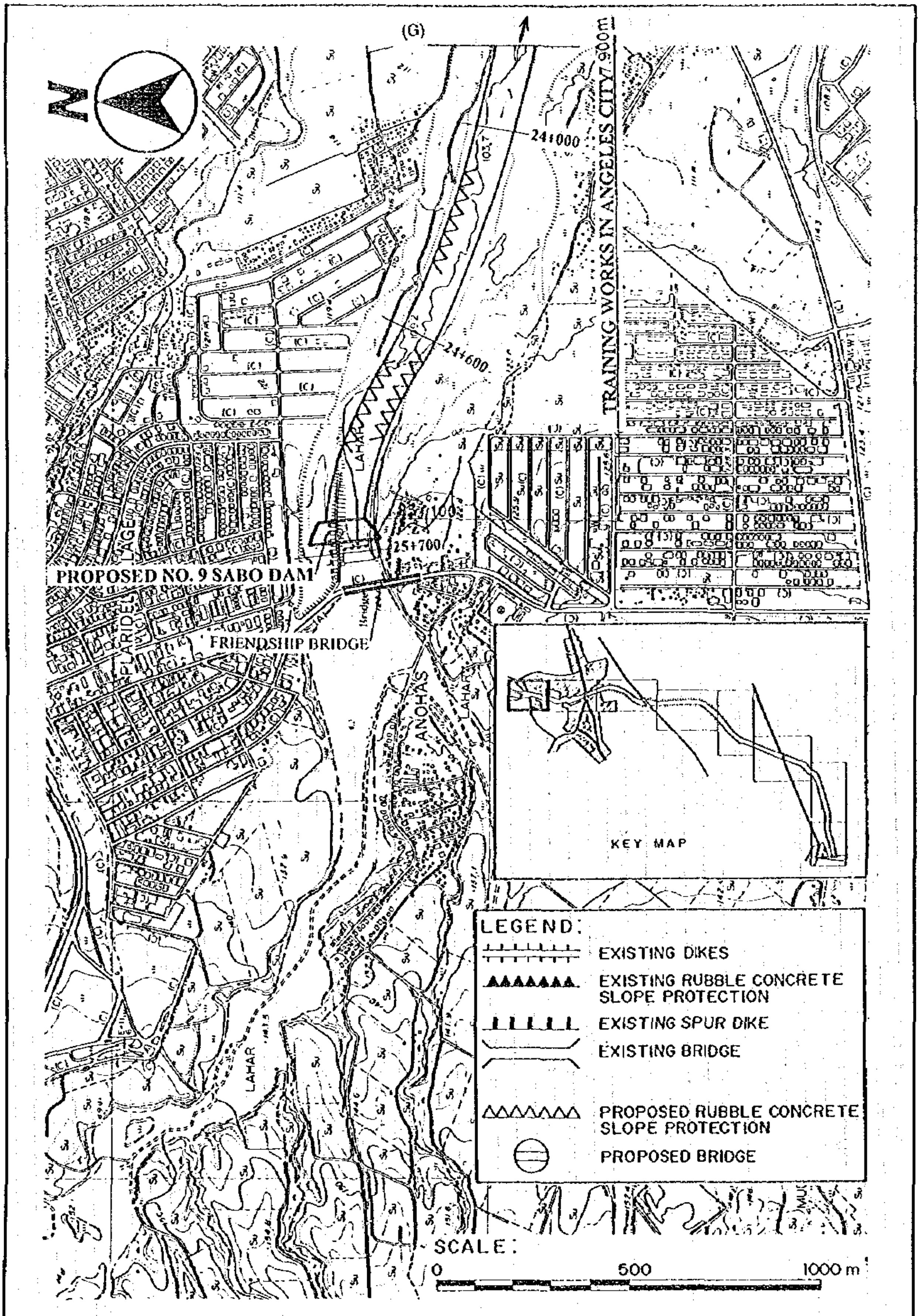
JAPAN INTERNATIONAL COOPERATION AGENCY



Abacan River Improvement (8/8)

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
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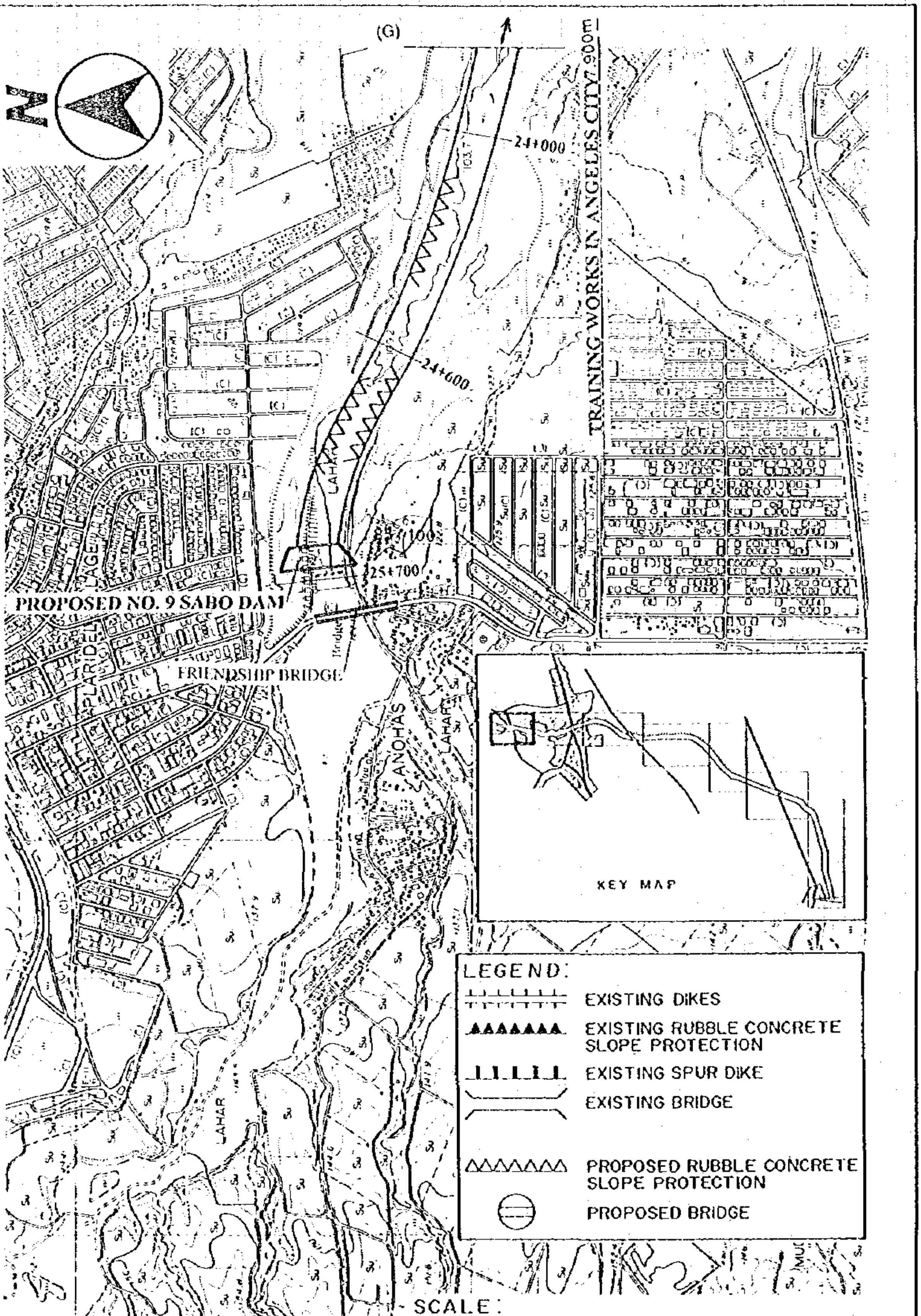
JAPAN INTERNATIONAL COOPERATION AGENCY



Abacan River Improvement (8/8)

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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

APPENDIX B

ROAD AND BRIDGES

APPENDIX B

ROAD AND BRIDGES

TABLE OF CONTENTS

LIST OF TABLES

B.1 INTRODUCTION

1.1 BACKGROUND

The June 15, 1991 eruption of Mt.Pinatubo, one of the largest eruption of the century, produced remarkable volume of pyroclastic flow and ash fall deposits. The pyroclastic flow deposits covered thousands of square kilometers and the volume was estimated at 7 billion m^3 on the slopes of Mt.Pinatubo. Lahar generated by heavy rain falling on erodible pyroclastic flow deposits pose continuing and grave danger to human lives and property in the low-lying areas. Among the major rivers surrounding Mount Pinatubo, the Abacan River and the Sacobia-Bamban River possess a great danger to the outlying areas, where Angeles City and Clark Field are located, currently used for residential, commercial and industrial purposes.

In the Study Area, Sacobia-Bamban and Abacan river basins which drain from the eastern slope of Mt.Pinatubo, major trunk lines are organized into the north-south vital link such as North Luzon Expressway, Manila North Road (MacArthur Highway : Highway Route 3) and Magalang-Concepcion Road (Highway Route 329). But after eruption, the Mabalacat-Bamban section of Highway Route 3 and bridges/spillways crossing the Abacan River were destroyed and buried by frequent lahars and floods.

1.2 OBJECT OF THE STUDY

The study contains the following objectives and activities:

(1) Route comparison, most suitable route selection and alignment design of Highway Route 3 in consideration of the Sacobia-Bamban River improvement plan

(2) Route comparison, most suitable route selection and alignment design of Highway Route 329 in consideration of the Sacobia and the Sapang Balen River improvement plan

(3) Data collection of existing bridges and detailed design drawings in the future, and restoration plan for remaining bridges crossing the Abacan River in the Study area

B.2 EXISTING CONDITION IN THE STUDY AREA

2.1 GENERAL

The Study Area is located at one of the most important parts to sustain the transportation system in the Central Luzon. Major trunk lines are organized into the north-south vital link such as North Luzon Expressway, Manila North Road (MacArthur Highway : Route 3) and Magalang-Concepcion Road (Route 329).

North Luzon Expressway provides toll motorway services between Metro Manila and Pampanga Province. The section between Metro Manila (Balintawak) and Valenzuela of 5.84 km long is organized into a north-bound 3-lane and a south-bound 2-lane carriageways. The section between Valenzuela and San Fernando of 50.4 km long has 4-lane for both directions, while those between San Fernando and Sta. Ines has been used as a temporary extension of 22.9 km long with 2-lane for both directions. Traffic growth on the North Luzon Expressway shows the annual growth rate of 1.9 % annum. According to the traffic volume data for a week from July 16 to July 24, 1995, the daily traffic volume at Dau is counted at 8,000 vehicles of which 60 % traffic volume bound for Balintawak.

Manila North Road (Route 3 : MacArthur Highway) connects between Manila and Rosario, through San Fernando, Angeles City and Tarlac. The Abacan Bridge across the Abacan River in Angeles City was collapsed due to lahar avalanche immediately after the eruption of Mt.Pinatubo in 1991. The bridge was reconstructed in 1992. However, the segment between Mabalacat and Bamban of 3 km long was covered by lahar deposits and the all type of vehicles are unpassable during flooding period although the DPWH has embanked lahar materials every dry season for temporary road.

Route 329 (Magalang - Concepcion Highway) takes the most important role as a vital link between North Luzon and Metro Manila since the Manila North Road was buried with lahar after the eruption of Mt.Pinatubo in 1991. The traffic volume data counted for a week on July 16 to 24 in 1995 by the Study Team shows that 13,000 vehicles/day are passing through the San Francisco Bridge as shown in Figures B.1 and B.2. However, the section was designed as 2-lane for both directions and the traffic jam is experienced everyday at the junction of Magalang. Furthermore, the present road surface elevation is almost equivalent to the surface elevation at downstream end of sand pocket. All type of vehicles are unpassable during the flooding period.

The San Francisco Bridge on Route 329 astride the Bamban River at Concepcion is under the critical condition in 1995. Its freeboard was at 72 cm on October 10, 1995. The DPWH commenced the reconstruction works of New San Francisco Bridge at 30 m upstream of existing bridge. The clearance is planned to be about 5 m above existing one.

B.3 ROAD DIKE ON ROUTE 329

3.1 GENERAL

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.

3.2 BASIC 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 B.3.

5) In the Master Plan, an elevating of Route 329 by 5 m was proposed taking into account the training works of the Sacobia River would be completed 4 years later after the completion of new Route 329. Since 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.

3.3 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 B.4. 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 B.5.

3.4 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 B.6.

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 San Nicolas Balas box culvert will be a main drainage as a permanent structures to release the flood peak discharge and the Bidbid box culvert will not be required.

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)

3.5 SAPANG BALEN BRIDGE

A pre-stressed concrete (PC) girder with single span 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 Philippines.

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

The general plan and profile are shown in Figure B.7.

3.6 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 B.8.

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 B.8.

3.7 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 B.9.

B.4 RECONSTRUCTION OF ROUTE 3

4.1 GENERAL

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).

4.2 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 B.10 and advantages and disadvantages of each alternative are summarized in the Table below.

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

1) the construction cost of ALT-1 is the lowest.
2) the route length of ALT-1 are the shortest.
3) the horizontal alignment of ALT-1 is smooth.

4.3 ROAD ALIGNMENT AND STANDARD CROSS SECTION

In order to follow the design criteria of DPWH, route alignment and composition of cross section of ALT-1 are designed. The criteria adopted for the proposed ALT-1 are those for Annual Average Daily Traffic (AADT) between 10,000 and 20,000 and flat topographic condition as summarized below, (Design Standard of Philippine Highways is attached in Appendix B.6)

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 B.11.

4.4 MABALACAT BRIDGE

Mabalacat bridge is designed as PC girder type as shown in Figure B.12 under the following reasons;

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

2) Material for steel bridge is not domestic products of 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 162.5 m, consisting of 6-span of 32.5 m long girder because the bridge will cross over the 150 m width channel at 75 degree skew. The span length is determined to be 32.5 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)

4.5 BAMBAN BRIDGE

The suitability of the various bridge types is governed primarily by the span length. Table B.2 shows the applicable ranges of span length for different types of concrete and steel bridges.

The four alternative bridge types as shown in Figure B.13 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 select the most suitable bridge type, the above criteria are studied for four types. The evaluation results are summarized in Table B.3 and

Bamban bridge is designed as PC girder type as shown in Figure B.14 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.

5) Future riverbed elevation around Bamban bridge is degraded about 10m, however it is possible to deal with this problem by adoption of bored pile type pier and pier design in consideration of future riverbed degradation.

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)

B.5 BRIDGES ACROSS THE ABACAN RIVER

5.1 GENERAL

Before the 1991 eruption of Mt.Pinatubo, there exits five (5) bridges and a spillway bridge; they are, Friendship, Hensonville, Abacan, Pandan and Capaya Bridges and San Juan (Ninoy Aquino) Spillway Bridge. Immediately after the eruption, three (3) bridges, Hensonville, Abacan and Pandan Bridges, were destroyed by rapid current of lahar flow and the access road for Friendship Bridges was washed away. Mexico spillway bridge was constructed across the Abacan River at Mexico on Gapan-San

Fernando Road in 1992. Location map is shown in Figure B.15 and the present condition by bridges are described hereinafter.

(1) Friendship Bridge

Friendship Bridge located at the confluence between Taug and Sapangbato rivers was constructed in 1968. Immediately after the eruption of Mt.Pinatubo in 1991, the left approach to Friendship Bridge had badly eroded by lahar. However, the piers and girders of the bridge still remained at original position. The DPWH then embanked lahar material at left approach road to the bridge and sabo dam No.9 was constructed to protect the foundation of the bridge in 1992. However, the left bank dike of sabo dam No.9 was washed out in spite of continuous rehabilitation works by the DPWH in 1995, so that the surface of sediment deposits in the storage of sabo dam No.9 forms rather steep gradient and the piers were exposed above the surface of sediment deposits.

(2) Hensonville Bridge

Hensonville Bridge connecting between Angeles City and Dau on municipal road was also collapsed immediately after the eruption in 1991. Although the bridge was reconstructed by the municipal office of Angeles City in 1994/1995, the newly constructed bridge was washed away during flood on July 30, 1995.

(3) Abacan Bridge

Abacan Bridge ensures a vital transportation on Route 3. The bridge was collapsed immediately after the eruption of Mt.Pinatubo, and reconstructed with 4-lane highway in 1992. In 1995, the protection works of abutment have been a source of worry concern to DPWH in these years.

(4) Pandan Bridge

Pandan Bridge is located at 500 m downstream from Abacan Bridge on Angeles-Magalang Road, of which the road is utilized as a access road to North Luzon Expressway. The bridge was washed away at the same time of collapse of Abacan Bridge. In 1995, the detailed design of Pandan Bridge has been completed by the DPWH under ADB loan. The DPWH envisages that the design works of bridge would proceed the construction stage.

(5) Capaya Bridge

Capaya Bridge is located at North Luzon Expressway across the middle stream of the Abacan River. Although the abutment of the bridge was damaged during lahar flow, the bank protection works such as spur dike with gabion have been carried out by DPWH. The riverbed degradation of the Abacan River is major have been a source of worry concern to DPWH in these years. The bridge piers for future extension of North Luzon Expressway have already constructed immediately downstream of existing bridge.

Although the slippage of bridge girder and slight tilting of bridge piers were identified, they may occur by the earthquake in 1990.

(6) San Juan (Ninoy Aquino) Bridge

The Abacan River bifurcated into several small creeks in the vicinity of San Juan Bridge and the spillway bridge was maintained by the DPWH on the Magalang-Mexico Road before the eruption. However, the river channel of the Abacan River was improved by 75 m wide with dike system of 5 m high in 1992. The bridge was newly constructed with shortest span. Since the bridge was constructed immediately upstream of previous spillway bridge, the riverbed elevation is fairly stable because that the previous spillway bridge functions as groundsill.

One of the serious problem is a discrepancy of alignment between Magalang-Mexico Road and San Juan Bridge. The Magalang-Mexico Road is aligned on a skew line with the Abacan River, and the bridge is constructed at right angle with the Abacan River. Therefore, the all the vehicles detour on the left dike of 200 m long and connects with Magalang-Mexico Road, although the right abutment of the bridge is coincide with the road. The access road for the bridge is preferable to realign smoothly with Magalang-Mexico Road.

(7) Mexico Spillway Bridge

Mexico spillway bridge across the newly improved river channel with 75 m wide, located at 2 km east of the center of Mexico municipality, was constructed on Gapan-San Fernando Road (Highway Route 10) in April, 1992 and the bridge has already buried with sediment in September 1992. In spite of the continuous desilting works in the vicinity of the bridge by the DPWH, the sediment deposition occurred frequently by 0.5 m in 1993. The DPWH then constructed the Bailey Bridge immediately downstream of spillway bridge and one-way traffic is secured in 1995. And the detailed design of Mexico Bridge has been completed by the DPWH under ADB loan in 1995. The DPWH envisages that the design works of bridge would proceed the construction stage.

5.2 PRESENT CONDITION

Present condition are enumerated in Table B.4 and Figure B.16.

5.3 STRUCTURAL PLAN

Among the bridges, three (3) bridges, Hensonville, Pandan and Mexico Bridges, are crucial to be reconstructed as early as possible before the year 2000. While, Pandan and Mexico Bridges would proceed to the construction stage under the ADB fund. *Therefore, Hensonville Bridge is adopted for the Feasibility Study.*

Hensonville Bridge is designed as PC girder and balcony type with spiral stairs as shown in Figure B.17 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.

4) The wide riverside land scoured out by lahar flow is made use of as a community zone for the residents.

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

The total length of Hensonville bridge crossing Abacan river is determined to be 150 m, consisting of 6-span of 25 m long girder. The span length is determined to be 25 m by applying the Japanese Structural Standard given as following formula,

$L = 20 + 0.005Q$

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	:	$Q = 430\ m^3/s$ (a 50-year return period)
Riverbed elevation	:	$H = 91.4$ m (for Abacan River)
Longitudinal profile	:	$I = 1/115$ (for Abacan River)
Freeboard	:	1.0 m (Design Criteria of DPWH)
Roughness coeff.	:	0.035 (for Abacan River)

The structural plan is shown in Figure B.17.

B.6 DESIGN CRITERIA

6.1 APPLICABLE DESIGN STANDARD

In studying and determining the design criteria, the following standards were considered .

1) DESIGN Guidelines, Criteria and Standards for Public Works and Highways (VOLUME-II / PART 3 Highway Design), DPWH, Philippines

2) DESIGN Guidelines, Criteria and Standards for Public Works and Highways (VOLUME-II / PART 4 Bridge Design), DPWH, Philippines

3) AASHTO, A policy on Geometric Design of Highway and Streets

4) AASHTO, STANDARD SPECIFICATION for Highway Bridges

5) SPECIFICATION for Highway Bridges, Japan Road Association

6) Structural Standards for River Management Facilities, Ministry of Construction of Japan

6.2 GEOMETRIC DESIGN STANDARD

The geometric design standards being applied to this study are derived from DESIGN Guidelines, Criteria and Standards for Public Works and Highways (VOLUME-II / PART 3 Highway Design), as tabulated as follows.

ADT	under 2000	2000 - 4000	4000 - 10000	
	Minimum	Desirable	Minimum	Desirable
Design Speed (km/h)				
• Flat Topography	60	70	70	90
• Rolling Topography	40	50	60	80
• Mt. Topography	30	40	40	50
Min. Radius (m)				
• Flat Topography	120	160	160	280
• Rolling Topography	55	85	120	220
• Mt. Topography	30	50	50	80
Grade (%)				
• Flat Topography	6.0	60.	5.0	3.0
• Rolling Topography	8.0	7.0	6.0	5.0
• Mt. Topography	10.0	9.0	8.0	6.0
Pavement Width (m)	4.0	5.5 - 6.0	6.10	
Shoulder Width (m)	0.50	1.00	1.50	2.00
Right of Way Width (m)	20	30	30	
Non Passing Sight Distance (m)				
• Flat Topography	70	90	90	135
• Rolling Topography	40	60	70	115
• Mt. Topography	40	40	40	60
Passing Sight Distance (m)				
• Flat Topography	420	490	490	615
• Rolling Topography	270	350	420	560
• Mt. Topography	190	270	270	350

ADT	10000 - 20000		more than 20000	
	Minimum	Desirable	Minimum	Desirable
Design Speed (km/h)				
• Flat Topography	80	95	90	100
• Rolling Topography	60	80	70	90
• Mt. Topography	50	60	60	70
Min. Radius (m)				
• Flat Topography	220	320	260	350
• Rolling Topography	120	220	160	280
• Mt. Topography	80	120	160	160
Grade (%)				
• Flat Topography	4.0	3.0	4.0	3.0
• Rolling Topography	5.0	5.0	5.0	4.0
• Mt. Topography	7.0	6.0	7.0	5.0
Pavement Width (m)	6.70		6.70	7.30
Shoulder Width (m)	2.50	3.00	3.00	
Right of Way Width (m)	30		60	
Non Passing Sight Distance (m)				
• Flat Topography	115	150	135	160
• Rolling Topography	70	115	90	135
• Mt. Topography	60	70	70	90
Passing Sight Distance (m)				
• Flat Topography	560	645	615	675
• Rolling Topography	420	560	490	615
• Mt. Topography	360	420	420	490

6.3 *BRIDGE DESIGN STANDARD*

1) Freeboard

The elevation of girder soffit shall be designed not to be lower than of the design flood water level with addition of freeboard. The freeboard is considered to be 1.5 m for streams carrying debris and and 1.0 m for others based on DESIGN Guidelines, Criteria and Standards for Public Works and Highways .

2) Minimum Required Span Length of Bridges

Minimum required span length of bridges is determined by Japanese Structural Standard as following formula,

$$L = a + 0.005Q$$

where, L : minimum span length (m)
a : constant (m)
a = 12.5m : design discharge < 500m3/sec and river width <30m
a = 15.0m : design discharge < 500m3/sec and river width >30m
a = 20.0m : 2000m3/sec < design discharge < 500m3/sec
a = 30.0m : urban area, important area and etc.
Q : 50-year return period discharge (m^3/sec)

3) Dead Load

The following unit weights are to be used in computing the dead load.

Item N/m^3 Steel or cast steel 76.913 Cast iron 70.635 Aluminum alloys 27.469 Timber (treated or untreated) 7.848 Concrete, plain or reinforced 23.545 Compacted sand, earth, gravel or ballast 18.836 Loose sand, earth and gravel 15.687 Macadam or gravel, rolled 21.975 Cinder filling 9.418 Pavement, other than wood block 23.545 Railway rails, guard rails and fastening (per linear foot of track) 31.393 Asphalt plank, 25.40mm thick 0.431(N/m^2)

4) Live Load

The live load shall consist of the weight of the applied moving load of vehicles, cars and pedestrians.

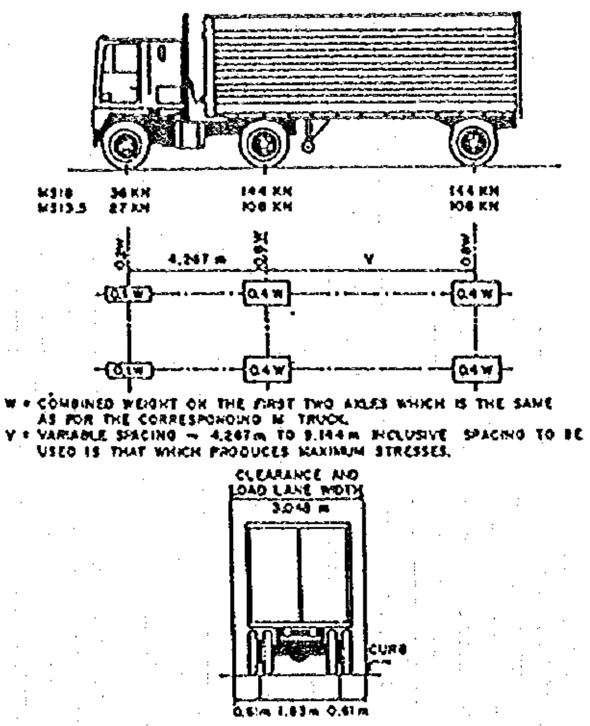
5) Highway Load

The loads being adopted on this study are from DESIGN Guidelines, Criteria and Standards for Public Works and Highways (VOLUME-II / PART 4 Bridge Design), as follows.

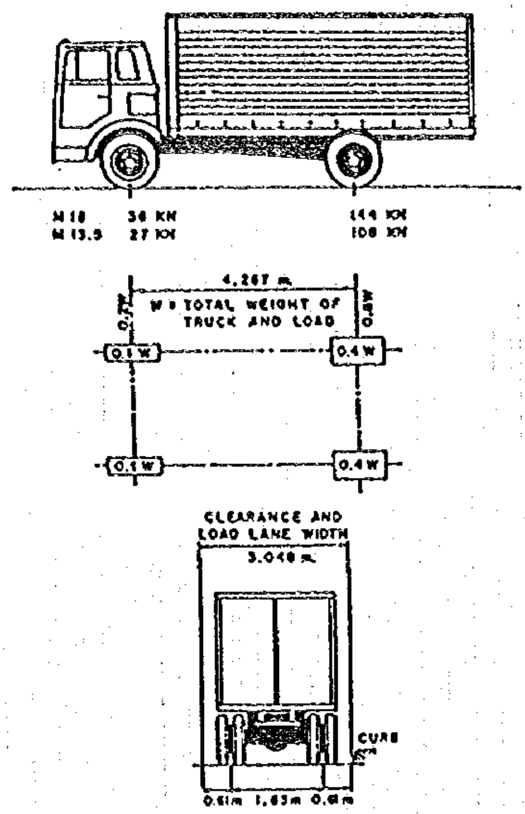
5-1) Standard truck and lane load

The highway live loading in the roadways of bridges or incidental structures shall consist of standard trucks or lane loads that are equivalent to truck trains. Two systems of loading are provided, the M (H) loadings and the MS (HS) loadings being heavier than the corresponding M (H) loadings.

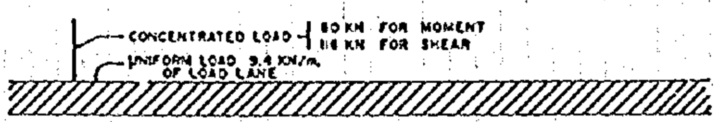
STANDARD MS TRUCKS



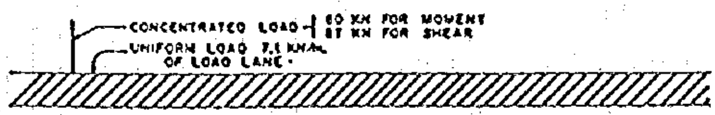
STANDARD M TRUCKS



M LANE AND MS LANE LOADING



M 18 LOADING
MS 18 LOADING



M 13.5 LOADING
MS 13.5 LOADING

5-2) M (H) loadings

The consist of a two-axle truck or the corresponding lane loading . The M (H) loadings are designated M (H) followed by a number indicating the gross weight of the standard truck in kilonewton.

5-3) MS (Hs) loadings

The MS (HS) loadings consist of a tractor truck with semi-trailer or of the corresponding lane loading. The MS (HS) loadings are designated by the letters MS (HS) followed by a number indicating the gross weight of the tractor truck in kilonewtons. The variable axles spacing has been introduced in order that the spacing of axles may approximate more closely the tractor trailers now in use. The variable axle spacing also provides a more satisfactory loading for continuous spans, in that heavy axle loads may be so placed in adjoining spans as to produce maximum negative moments.

5-4) Class of loading

There are four (4) standard classes of highway loading: M18 (H20), M13.5 (H15), MS18 (HS20) and MS13.5 (HS15). Loading M13.5 is 75% of loading M18 and loading MS13.5 is 75% of loading MS18.

5-5) Minimum loading

For truck highways, or for other highways which carry, or which may carry heavy truck traffic, the minimum live load shall be the MS13.5 (HS15) designated herein.

6) Seismic Force

The J.P. Hollings report entitled "Earthquake Engineering for the Manila North Expressway Structures in Luzon, Philippines" is recommended guide for earthquake design criteria, provided that the result is greater than the force produced by 10% (DL + 1/2 LL).

7) Design Methodology

The service load (working stress) and the load factor (ultimate strength) design method were used for the design of substructure and superstructure respectively. For columns, the load factor design method was partially used for a more effective analysis of stresses caused by seismic and other lateral forces.

6.4 DRAINAGE FACILITIES

The highway drainage design standards being applied to this study are derived from DESIGN Guidelines, Criteria and Standards for Public Works and Highways (VOLUME-II / PART 3 Highway Design), as follows:

1) Design Flood Return Period

The design flood return period for drainage facilities crossing highway is applied as follows.

Drainage Facility	Design Flood Return Period
Bridges	50-year
Box Culverts	25-year
Pipe Culverts	10-year
Embankment	10-year
Ditches and Road Surface	10-year

2) Design Discharge

Determination of the design discharge is applied the Rational Formula, as follows.

$$Q = CIA/3.6$$

where, Q : design discharge (m^3/sec)
C : coefficient of discharge
I : rainfall intensity (mm/hr)
$I = a / (t^{0.5} + b)$
where, t : rainfall duration time
a and b : constant
A : catchment area (km2)

Coefficient of discharge (C) is applied the below table.

Surface	Value Proposed
Concrete or Asphalt Pavement	0.9 - 1.0
Bit. Macadam and Double Bit. Surface Treatment	0.7 - 0.9
Gravel Surface Rd. and Shoulder	0.3 - 0.6
Resident Area (City)	0.3 - 0.6
Resident Area (Town and Village)	0.2 - 0.5
Rocky Surface	0.7 - 0.9
Bare Clay Surface (faces of slips, etc.)	0.7 - 0.9
Forested Land (sandy to clay)	0.3 - 0.5
Flattish Cultivated areas (not flooded)	0.3 - 0.5
Steep or Rolling grassed area	0.5 - 0.7
Flooded or Wet Paddied	0.7 - 0.8

Determination of the concentration time (Tc) is applied the below formula.

$$Tc = L^{1.15} / (51xH^{0.385})$$

where, Tc : concentration time (minutes)
L : length of watershed along the mainstream (m)
H : difference in elevation between the most distant ridge in the watershed and point under review (m)

3) Design Discharge

Determination of the capacity of drainage facilities crossing highway is applied the following formula.

$$Q = VA$$

where, Q : discharge (m^3/sec)
A : flow area (m^2)
V : mean velocity (m/sec)

The mean velocity (V) is obtained by the Meaning's Formula.

$$V = (1/n) R^{2/3} S^{1/2}$$

where, R : hydraulic radius (m)
R = A/P
where, A : flow area (m^2)
P : wetted perimeter (m)
S : water surface slope (m/m)
n : Roughness coefficient

Roughness coefficient (n) is applied the below table.

Surface	Range
Natural river after training	0.035
Man-made Channels and Ditches	
Earth, straight and uniform	0.017 - 0.025
Grass covered	0.035 - 0.050
Dredged	0.025 - 0.033
Stone lined and rock outs, smooth and uniform	0.025 - 0.035
Stone lined and rock cuts, rough and irregular	0.035 - 0.045
Lined - metal corrugated	0.021 - 0.024
Lined - smooth concrete	0.012 - 0.018
Lined - grouted riprap	0.017 - 0.030
Pipes	
Cast iron	0.011 - 0.015
Wrought iron	0.012 - 0.017
Corrugated steel	0.021 - 0.035
Concrete	0.010 - 0.017

TABLES

Table B.1 Evaluation of Alternative Routes of North Manila Highway

Rt. Name	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 : 3.1 km Bridge (L>100m) : 330m (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 : 3.3 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

Table B.2 Appricable Ranges of Span Length by Bridge Type

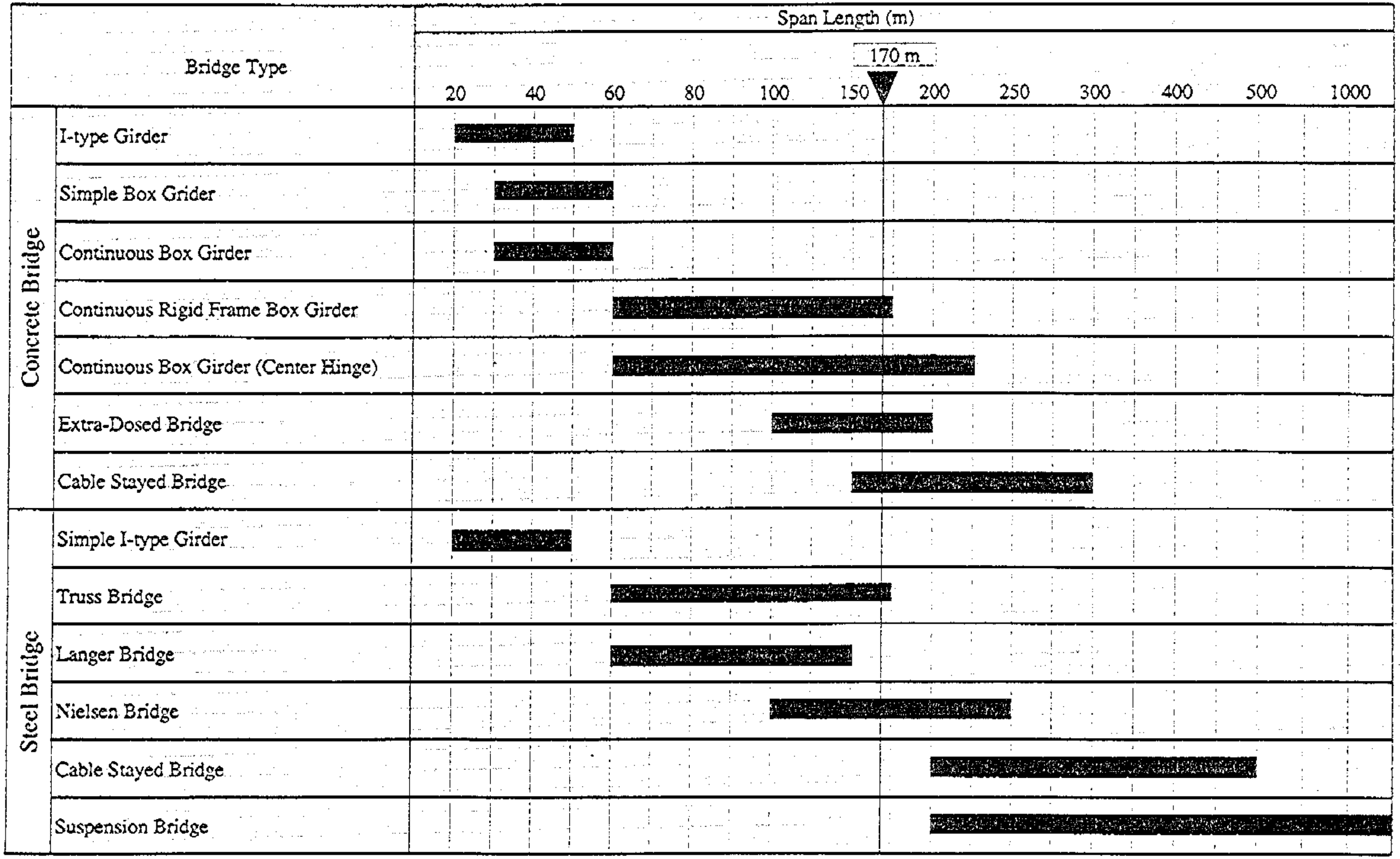


Table B.3 Evaluation of Alternative Bridge Type

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	P 80 million	P 420 million	P 500 million	P 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 B.4 Present Condition of Bridges in the Abacan River Basin

Bridge (Station)	Route	Condition after Eruption	Present Condition	Remarks
(1) Friendship (25+300)	City Rd.	Heavy damage for access road and foundation	1) Existing RC channel bridge 2) Construction of the temporary sabo dam for protection of bridge foundation 3) Bridge dimensions, L= 209m (19@11m), W= 8.15m (0.7 + 6.75 + 0.7)	1) No construction of transverse stress 2) Insufficient span length of the existing bridge for the Japanese Structural Standard 3) The existing bridge location is no good for malinfluence of two direction turbulent flow from Sapang Bato River and Taug River.
(2) Hensonville (22+600)	City Rd.	Bridge collapse	1) No bridge 2) No access road	1) No restoration plan
(3) Abacan (21+600)	Rt.3	Bridge collapse	1) Reconstruction of PC girder bridge 2) Bridge dimensions, L= 230m (4@40m + 2 @ 35m), W= 18.6m (1.5 + 7.3 + 1.0 + 7.3 + 1.5)	
(4) Pandan (19+900)	Rt.313	Bridge collapse	1) No bridge 2) Detailed design under ADB Loan 3) Future bridge dimensions, L= 128m (3@40m+1@8m) / W= 9.54m (1.11 + 7.32 +1.11)	1) Designed location is no good because bridge wreckage and existing transmission line will be disturb the construction.
(5) Capaya (17+625)	North Luzon Expres s-way	Damage for abutment on right bank	1) Existing RC slab bridge 2) Bridge dimensions, L= 210m (14@15m), W= 16.9 m (0.25 + 11.9 + 0.25)	
(6) Ninoy Aquino (7+831)	Rt.3	Buried in riverbed	1) Construction of RC slab bridge 2) Bridge dimensions, L= 210m (8@15m), W= 9.54m (1.11 + 7.32 + 1.11)	1) Unfavorable access road alignment on left bank
(7) Mexico (0+611)	Rt.10	Buried in riverbed	1) Construction of Temporary bailey bridge and existing spillway 2) Detailed design under ADB Loan 3) Bridge dimensions, L= 170m (6@23m+ 2 @ 16m), W= 9.54m (1.11 + 7.32 + 1.11)	1) Designed location is no good because existing spillway will be disturb the construction.