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THE REPUBLIC OF THE PHILIPPINES

MINISTRY OF PUBLIC WORKS

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT

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JAPAN INTERNATIONAL COOPERATION AGENCY

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MAYON VOLCANO SABO AND

FLOOD CONTROL PROJECT

DESIGN REPORT
ON
SABO FACILITIES IN THE
PAWA-BURABOD RIVER
A TRIBUTARY OF THE YAWA RIVER

FEBRUARY 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In accordance with the scope of works presented in the Implementing Arrangement and/or Inception Report of the Mayon Volcano Sabo and Flood Control Project (hereinafter referred to as the PROJECT), the Japanese Study Team (hereinafter referred to as the STUDY TEAM) has proceeded the detailed design of Sabo Facilities since mid October 1979 in the office of Task Force for Flood Control and Related Activities of the Philippine Government (hereinafter referred to as TFFCRA).

The detailed design herein submitted has been also prepared in accordance with the mutual agreement between TFFCRA and STUDY TEAM, which was concluded in the meeting held on October 22, 1979 (to be referred to the minutes of meeting No. MVS-M-2). Namely, the site and type of Sabo facilities to be designed were selected as follows.

Site :	Pawa-Burabod river, a tributary of the Yawa river
Structure:	One Sabo dam in the upstream reaches, debris retarding basin consisting of some of spur dikes in the middle reaches, and consolidation works in the lower reaches

As for the lower reaches, more extensive study has been made of not only consolidation works but also river canalization with levee. The detail design submitted herein, therefore involves river canalization with the structures of levees, cribworks, and groundsill (consolidation works).

This report deals with the design of the above Sabo facilities, and also construction method and construction cost estimate thereof.

The report was prepared by the STUDY TEAM in close cooperation with TFFCRA's members together with his staffs as counterparts to the Japanese experts.

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CONTENT

I. GENERAL

1.1 Background

In accordance with the scope of works expressed in the Implementing Arrangement and/or Inception report, both which were submitted to and duly accepted by TFFCRA on September, 1979, the STUDY TEAM should prepare detailed design of two typical Sabo facilities.

The design works have had to be proceeded in advance of the master plan formulation which will be executed in 1980 by the STUDY TEAM. Therefore, the detail design submitted herein was prepared for the site and structures which will be expected to be taken up as higher priority in the master plan in accordance with the mutual agreement between TFFCRA and STUDY TEAM.

1.2 Selection of Site

There are many torrents originating in the slope of Mayon Volcano, which presently produces plenty debris and causes serious debris and flood damages.

Based on the reconnaissance made by the STUDY TEAM, the Pawa-Burabod river was selected for the sites (the river) which should be subject to the design of Sabo facilities.

The reasons why the Pawa-Burahod river was selected are as explained below.

1) Proper river structures such as river canalization, levees, consolidation works, etc. should carefully be designed with detailed overall studies of rivers.

   If improper design would be applied without detail studies, there would happen several unforeseen trouble in a stability of river, Therefore, the Quinali river which is very much complicated with many tributaries and branches, is excluded from the objectives of the detailed design.

2) There are several torrents which have produced plentry debris, caused debris and flood damages, and have important infrastructures, houses, paddy filed, etc. The Nasisi river, Camalig river, Maninila river, and Yawa river have suffered from flood and debris damages seriously.

Among these rivers, the Pawa-Burabod river was selected to be a river subject to the detailed design for the following reasons.

a) The Yawa river has actually heavily eroded and supplied huge amount of debris from the upstream reaches. Vast devastated land has been extended in the middle reaches. Debris flow gushes out in the area and threatens coconut plantation, villages, paddy field, etc. Further in the downstream reaches, there are some villages, national road, Legaspi City, etc., all which are threatened by flood.

b) The Yawa river is rather simple river which has river length about 20 Km only and four tributaries, of which two tributaries are most seriously devastated and supplies much debris. They are the most western (upstream) tributary and the most eastern (downstream) tributary called the Pawa-Burabod river. Among these, the Pawa-Burabod river is the most important river which gives much influence of flood damages to the surrounding area including Legazpi City.

c) When detailed design will be prepared with concentration in one river, the fruit will be very valuable for the Philippine Government counterpart in view of the transfer of Sabo technology.

d) Economic justification is not made yet for selection of the Pawa-Burabod river. The justification will be made inclusively in the master plan formulation in 1980. However, it could be expected that the Sabo works applied herein for the Pawa-Burabod river would be justified economically.

1.3 Selection of Structures

As aforementioned, the Pawa-Burabod river has extruded huge amount of debris from its upstream reaches, and has made deposition in the middle reaches, of which deposition has caused secondary erosion and debris supply to the more downstream. In the downstream, there are several villages, coconut plantation, paddy field, etc. all whcih have threatened from flood damages.

For such river basin conditions, the following countermeasures would be advisable to be adopted.

1) Sabo dams will be constructed in the upper reaches to mitigate debris production.

2) Low Sabo dams so called consolidation dams will be constructed in the downstream of the above Sabo dams. These dams would work as joint or series of consolidation dams to settle river bed and river course.

3) Debris retarding basin consisting of masonry spur dikes will be constructed in more downstream reaches where presently be occupied by vast debris deposition. The debris retarding basin will function as temporary retardation of debris at flood time and then flowing out debris during normal.

4) In the lower reached adjacent to the junction of the main Yawa river, river canalization with the construction of levees will be provided.

Training walls like a levee are only the existing structures constructed in the limited part of the Pawa-Burabod river. The river channel confined by the existing training walls has suffered from sediment deposition on it or partly erosion in its foundation scouring.

With the progress of Sabo works in the upstream reaches, the sediment discharge in the lower reaches will become less and less. Thus the river bed in the lower reaches will be descended bringing dangerous case of scouring in the existing training walls foundation. For preventing such a case, consolidation works together with foot protection of training wall will be needed.

All the above countermeasures should be implemented step by step observing carefully the changes of river condition with the progress of

Sabo works. All the works may not be implemented at once. For the first implementation, the following structures are recommendable to be constructed.

a) A Sabo dam in the upstream reaches

b) Two spur dikes consituting members of debris retarding basin in the middle reaches

c) River canalization including levees cribworks for protection of levee foot and groundsill (consolidation work)

The above structures are desinged herein. The general plan and profile of the Pawa-Brubod river are shown in Fig. 1.1 and 1.2 in the Appendix I.

II. PRINCIPAL FEATURES OF SABO FACILITIES

As explained in the previous chapter, the following works are proposed to be executed as the first stage construction.

1) A Sabo dam in the upstream reaches

2) Two spur dikes in the middle reaches

3) River canalization including levees foot protection of training walls and groundsills in the lower reaches.

The principal features of the above structures are summarily shown below together with topographical and hydrological characteristics.

Sabo Dam

Topography:

Location	About EL.400 m
Drainage area	2.5 Km^2
River length upstream from the dam	4.4 Km
Average river bed slope for the above	1/2.3
River bed slope at the dam site	1/11.1

Main Dam:

Type	Concrete gravity type
Crest elevation	
Overflow section	EL.398.55 m
Non-overflow section	EL.402.05 m
Height	
Overflow section	10.0 m
Non-overflow section	13.5 m
Crest length	
Total	79.5 m
Overflow section	30.0 m
Crest Width	3.0 m
Upstream slope of dam body	1:0.4
Dowstream slope of dam body	1:0.2
Design flood (100-yr flood)	103.1 m^3/s

Trap capacity	13,000 m^3
Concrete volume of dam body	5,220 m^3

Sub-Dam

Type	Concrete gravity type
Height	
Overflow section	5.0 m
Non-overflow section	7.5 m
Crest length	
Total	57.5 m
Overflow section	30.0 m
Crest Width	2.0 m
Upstream slope of dam body	1:0.4
Downstream slope of dam body	1:0.2
Concrete volume	1,170 m^3

Spur Dikes

Topography:

Drainage area	7.3 Km^2
River length upstream from the most downstream dike	7.8 Km
Average river bed slope for the above	1/3.8
River bed slope at the dike site	1/16

No. 1 Spur Dike

Type	Sand and gravel fill covered by wet masonry wall
Height	4.5 m
Length	200 m
Surface slope	1:0.7 both up and down-stream slopes

No. 2 Spur Dike:

Type	Sand and gravel fill covered by wet masonry wall
Height	4.5 m
Length	162 m
Surface slope	1:0.7 both up and downstream slopes

River Canalization

Topography:

Location	Up to 3,900 m upstream from the junction with the main Yawa river.
Drainage area	10.5 Km^2 at the junction with the main Yawa river
River length	11.0 Km for total length of the Pawa-Burabod river
Average river bed slope	1:10 for whole river length
River bed slope	1/43 to 1/17 for the reaches subject to canalization

River Channel (Canalization)

Length	2,800 m
Channel width	60 m
River bed slope	1/28.1 - 1/17.5

Levee:

Type	Sand and gravel fill with slope protection by wet masonry wall
Length	
Left bank - Total	2,799 m
- Existing	1,477 m
- New	1,352 m
Right bank - Total	2,808 m
- Existing	204 m
- New	2,604 m
Embankment volume	62,800 m^3
Wet masonry wall	3,956 m

Cribworks (Foot protection):

Type	Log crib filled by cobble stone
Size and arrangement	Three lines with crib of 2.0 m long x 2.0 m wide x 0.8 m depth
Total no. of cribs	6,993 nos.

Groundsills:

Type	
Type A	Long crib, 2.0 m long x 2.0 m wide x 0.8 m depth filled by cobble stone.
Type B	Cross concrete block, 2.0 m long x 2.0 m wide x 0.8 m depth
Number of groundsill	
Type A	9 nos.
Type B	2 nos.
Number of blocks	
Type A (crib)	970 nos.
Type B (concrete block)	305 nos.

III. DESIGN OF STRUCTURES

3.1 Sabo Dam

1) Location

The proposed Sabo dam site is located in the upstream reaches of Pawa-Burabod river at about EL.400 m, where the topography forms like a mouth from which debris gushes out. Suitable dam sites for rather high dam could not be found out in more downstream reaches because both left and right banks along the river are so low as 3-5 meters or less.

2) Type of dam

Conventional type of Sabo dam, i.e. concrete gravity type, is adopted. There are several types of Sabo dams such as crib type, block type, etc. other than gravity type. However, these types are not suitable for such very steep torrents with possibility of occurrence of mudflow as the Pawa-Burabod river.

3) Dam height

The purpose of dam construction is mainly to mitigate or prevent debris production due to side erosion in the torrent, but not to trap debris or to control debris flow.

From the topographical point of view, such a high Sabo dam as 15 m - 20 m can be constructed in this damsite. However, such a high dam is not always suitable from the economical point of view. Side erosion in the torrent seems to have occurred because of erosion due to mudflow in the foot of both banks of the torrent. The Sabo dam to be constructed there is so designed that the foot of banks will be protected or covered by natural deposition in the upstream of the dam. From such consideration, the Sabo dam is designed to have 7 m in effective height.

The dam is obliged to be designed as a floating type one because of no rock foundation in the river bed. To ensure safety of Sabo dam against foundation scouring, the dam foundation is designed to reach about 3 m below the present river bed surface. Accordingly, the dam height is designed to be 10 m in the overflow section. Non-overflow section is 13.5 m high with 2.5 m high opening for overflow and 1.0 m allowance with taper 1:15 toward abutment, which will be explained in the following paragraph.

4) Overflow section

Overflow section of the Sabo dam is designed against 100-year probable flood. No run-off data are available in the Pawa-Burabod river. Therefore, 100-year probable flood is estimated from rainfall record in Legaspi City near Pawa-Burabod river by means of Rational Formula. 100-year probable flood thus estimated is 103.1 m^3/s, which is the peak run-off containing debris (mudflow).

Overflow section of Sabo dams is generally designed so that the overflow crest length is almost the same as or slightly narrower than the present river course. The present river width is about 40 to 50 m. Therefore, the crest length of overflow section is taken at 30 m with some allowance for abutment erosion in the immediate downstream of the dam body.

Overflow depth in 30 m crest length is calculated at about 1.6 m. Taking 0.9 m freeboard above water surface on the overflow section, the height of opening for flood release is designed at 2.5 m. Further, the abutment of the Sabo dam is tapered by 1:15 with 1.0 m height difference between the shoulder of overflow section and the abutment. Therefore the height of non-overflow section is designed at 13.5 m.

The details of the design should be referred to Appendix IV attached at the end of this report.

5) Shape of dam body

The structural details of dam body such as crest width, upstream and downstream slopes, etc. are designed as follows.

The width of dam crest in overflow section is taken at 3.0 m so that the dam crest is enough strong against impact force of mudflow.

The downstream slope of Sabo dams are generally designed to protect dam body from destruction due to heavy materials (cobbles and boulders) falling down over the crest. Therefore, a slope of 1:0.2 is adopted.

Considering safety of dam body against overturning, sliding, and bearing, the upstream slope of the dam is decided at 1:0.4. The dam body is designed for the following conditions.

i) The working point of resultant shall be within the middle third zone of dam base.

ii) Safety factor against sliding shall be larger than 1.2.

iii) Foundation bearing stress shall be smaller than 70 ton/m^2 which is an estimated allowable bearing capacity of compacted gravel, with earth and sand foundation.

The present design is summarized below.

Safety factor against overturning	$e = 1.4m < \frac{B}{3} \times \frac{1}{2} = 1.5m$ e=Eccentricity of resultant force B=Bottom width
Safety factor against sliding	$2.5 > 1.2$
Bearing stress	$38\ ton/m^2 < 70\ ton/m^2$

The details calculation of dam stability should be referred to the Appendix I.

6) Apron protection

The river bed at Sabo dam site seems to be easily scoured by debris flow and mudflow, therefore, the protection work for Sabo dam should be performed for preventing from the erosion just downstream of the Sabo dam and thus for keeping safety of the Sabo dam. For such a case, a sub-dam is to be constructed in the downstream of the main dam to form apron.

The sub-dam has a height of 5.0 m which are the sum of overlap height with the main dam about 3.0 m,foundation depth 3.0 m into riverbed and double counting by 1.0 m (-1.0 m) for the overlap height and the foundation depth.

The sub-dam is located apart by 22 m from the main dam so that the energy of falling water through overflow section of the main dam can be discipated enough in the basin to be formed by the sub-dam. The details of the apron design should be referred to the Appendix IV.

3.2 Spur Dike

1) Location

The proposed spur dikes are located in the middle reaches of the Pawa-Burabod river. The spur dikes designed will constitute one of the members of debris retarding basin, which will finally be constituted with many spur dikes, cross dikes, etc. However, such structures will be constructed step by step. For the first stage construction, two spur dikes are proposed to be constructed. These two dikes are located near the beginning point of the channel works (downstream levee) at about EL.165 m.

2) Type of spur dikes

Spur dikes comprise wet masonry walls in both upstream and downstream slopes with filling by sand and gravel in its inside, so that the dikes are strong enough against impact force of mudflow.

3) Height of dikes

The stream in the reaches where the dikes will be constructed forms no definite channel section. Therefore, practicable river width is assumed at 30 m by an empirical formula applicable for such streams.

The flow depth in the above assumed river width is estimated at about 1.1 m.

In the proposed site, flow direction is not definite and severe river bed fluctuation by scouring and rising are anticipated. Therefore, the height of dikes above ground surface is determined at 3.0 m taking enough allowance. Furthermore, foundation depth is taken at more than 1.0 m below ground surface to keep the safety of dikes against scouring. Accordingly, the height of spur dikes is determined to be 4.5 m or so.

4) Length of dikes

The stream in the proposed area has no definite river channel. The vast devastated land is extended with much debris deposition and flow meandering. For the purpose of ristricting the flow so that the flow would not run away from the proposed retarding basin, rather long dikes are adapted considering present topographic condition.

From the above consideration, the length of dikes is determined as:

No. 1 dike	L = 200 m
No. 2 dike	L = 162 m

5) Typical cross section of dikes

The side slopes of dikes are designed to be 1:0.7 (both upstream and downstream slopes) so that mudflow hardly overtops there. The width of dike crest is designed at 3.0 m considering the safety against impact force of mudflow and stability of dikes.

The riverbed scouring is anticipated to occur in the foot of dikes. Therefore, a foot protection concrete blocks such large size as shown Fig. 3.1 in the Appendix I is provided.

3.3 River Canalization

3.3.1 Basic Consideration

The Legaspi City Engineering has executed the construction of levees along the lower reaches of the Pawa-Burabod river for 1,447 m long in the left bank and about 204 m in right bank as of October 1979. The levee construction is scheduled tobe continued extending up and downstream from the existing ones.

The Pawa-Burabod river is presently not a stable river yet with plenty debris intrusion in it from the upstream reaches. It seems that there would be dangerous case if the levees and permanent river structures will be constructed at once along whole the river reaches. The construction should be step by step observing the changes of river condition with the progress of Sabo and river improvement works.

There are some places where the river bed erosion and scouring in the foot of existing levees have been occurred locally. To prevent such local erosion and scouring, foot protection and consolidation works are proposed to be executed urgently. Such erosion and scouring will become serious more and more with the progress of the Sabo works in the upstream reaches.

In this Chapter, proposed river canalization is firstly presented and then each structure involved is expalined.

3.3.2 River Channel Design

1) Present river condition

The discharge capacity, sediment discharge capacity as well as the river width under the present condition of the Pawa-Burabod river are estimated based on the investigations of river bed materials, river profile and cross section. The results of study are summarily shown in Fig. 4.2 in the Appendix I.

From Fig. 4.2 above, the following are clarified:

- Present river width varies from about 100 m to 30 m, about 60 m on an average.
- Discharge capacity along the river course varies largely from almost nil to over 500 m^3/s. If critical discharge capacity (considering no allowance or freeboard) is taken into consideration, river reaches from Sta. 1 + 100 (1,100 m upstream from the junction of the Yawa river, and the same hereunder) to Sta. 2 + 400 has very small discharge capacity smaller than 240 m^3/s which corresponds to 50-year flood later explained. Further, the upstream from Sta. 2 + 800 where is the upstream end of the existing levee has no definite discharge capacity because the course extends to wide area and has no definite channels.
- Sediment discharge capacity along the river course seems to vary largely with variation of 3 times between the upstream and the downstream. However, considering difficulties of sediment problem in the current sediment engineering, such variation is not so serious for the river channel.

The Pawa-Burabod river joins with the main Yawa river at about 2.3 Km upstream from the river mouth. The river conditions of the Yawa river and the Pawa-Burabod river are affected to each other relating to the sediment discharge amount. The river channel (profile and cross section) should theoretically be decided so as to be an equilibrium condition as for sediment discharge capacity.

If an excess amount of sediment would be supplied into the main Yawa river, it will suffer from sediment deposition causing the river bed rising. Theoretically, the Yawa river has a certain limited sediment transport capacity. Therefore, the sediment discharge in the Pawa-Burabod river should be limited to such amount as allowable sediment discharge into the Yawa river. According to rough study so far made based on the river bed materials investigation and other hydrological data, an equilibrium river bed slope of the Pawa-Burabod river (corresponding to the allowable sediment discharge) is estimated at about 1/80, while the present river profile is ranged from 1/43 to 1/17.

The slope of 1/80 above is an idealized river bed slope which could be realized after complete Sabo works in the upstream reaches would be executed, and therefore would probably not be realized in so short term.

Under the present condition, sediment discharge capacities in the main Yawa river and the Pawa-Burabod river are considerably different. The former has less capacity than the later.

From the above considerations, the upper Sabo works are judged to be most important countermeasures against the stability of the river.

2) Basic design of river canalization

- Design flood

  Design flood for river canalization and the structures to be involved therein is decided to be taken at 50-year probable flood considering river scale. Since no run-off data are available, the 50-year flood is estimated from rainfall records as same method as applied in the design of Sabo dam previously explained.

50-year probable flood thus estimated is 240 m^3/s (drainage area = 10.5 Km^2, specific discharge = 22.86 $m^3/sec/Km^2$) which is the peak run-off not considering mud contained, while the design flood containing mud is applied for the design of the Sabo dam.

- River reach to be canalized

The reaches from the junction of the main Yawa river up to Sta. 3 + 900 where the sand retarding basin is located, are taken up for the objectives of the river canalization.

As aforementioned, the river reaches from Sta. 1 + 100 to Sta. 3 + 900 have no enough capacity to discharge 50-year flood except for the reaches of existing levee. Therefore, these reaches are taken up for the river canalization for the first stage works.

The remains between Sta. 0 + 000 to Sta. 1 + 100 are recommended to be canalized as the future extension. The future extension should be carefully again studied observing the changes of the river condition at the time of implementation.

- River width

As aforementioned, the present river width is about 60 m on an average, but not so stable presently. Therefore, practicable river width is estimated by an empirical formula of regime theory. The practicable river width thus estimated is about 60 m. The river width in the reaches with the existing levee varies from 60 m to 90 m. From the above considerations, the design river width is decided at 60 m. According to Legaspi City Engineering who executed the existing levee, the designed river width is taken at 60 m, which is judged to be very suitable for the Pawa-Burabod river.

- Alignment of river channel

The present river channel meanders considerably in the lower reaches. Such channels would be better to reform as good alignment as possible. The alignment of river channel is designed considering the following:

a. The alignment will meet as good as possible to the present river channel.

b. The radius of curvature of river channel should be larger than 10 times of river width. Even in special cases when such large curvature cannot be applied topographically, the minimum radius should be kept at 5 times of river width.

c. Existing levees are kept as it is.

d. The land occupied by houses, paddy field, etc. should not be involved in the river channel to be newly constructed as much as possible.

- River profile

As stated before, the equilibrium river bed slope of the Pawa-Burabod river is estimated at about 1/80 assuming that the complete Sabo works in the upstream reaches would be executed. The slope of 1/80 above, however, is an idealized river bed slope and therefore would probably not be realized in so short time.

Accordingly, river profile should principally be designed to meet the present river bed slope as good as possible to minimize the construction cost for the present. The river bed slope thus is designed ranging from 1/28.1 to 1/17.5 as shown in the design drawings.

- River cross section

The Pawa-Burabod river has a very steep slope over whole reaches. The river cross section therefore is designed as a simple section. The dimension of cross section is determined by Manning's Formula assuming the uniform flow. The freeboard is 1.0 m taking into account some allowance.

The typical cross section is shown in the design drawings.

- River structures

Relating to the above-mentioned river canalization, the following river structures are needed and they are designed hereinafter.

(i) Levee
(ii) Foot protection (Cribworks)
(iii) Ground-sill
(iv) Irrigation intake

Basic features of river canalization are shown in the Design Drawings.

3.3.3 Levee

1) Location

Levees will be constructed on both the left and right banks along whole the reaches of river to be canalized. Total length of levee is 5,607 m including the existing levee of 1,651 m.

2) Type of levee

Sand and gravel fill type with surface protection by wet rubble masonry is adopted because that such material can be gathered from the river bed.

3) Height of levee and crest width

Based on the designed profile, designed cross sections, and the present river cross section, the height of levee varies from 2.0 to 2.1 m above designed river bed to allow discharge of design flood 240 m^3/s with 1.0 m freeboard. The crest width of levee is designed at 3.0 m which is the minimum width to be applicable for such embankment type of levee.

4) Slope and slope protection

The stream in the proposed reaches of canalization have considerably high velocity as 4.3 - 5.1 m/s. Therefore, considerable slope erosion is anticipated if no slope protection is provided.

Slope protection by wet rubble masonry will be adopted to resist against such erosion effect of flow. On surface of the protection, cobble stone surface is exposed to make roughness of river channel increase. The surface slope is designed at 1:2.5 based on the stability calculation by means of circular arc method under the following design conditions.

Density of embankment materials (sand and gravel)	2.0 t/m^3
Density of water	1.0 t/m^3
Internal friction angle of embankment materials	$\phi = 35^o$

Earthquake is not taken into consideration

Under the above design conditions, the safety factor for sliding of designed levee is about 1.2.

5) Revetment

The foundation of the slope protection is designed to have a concrete base which is burried about 1.0 m below ground surface to be protected from scouring. Foundation concrete is a size of 1.0 m wide and 1.0 m deep.

6) Comments for existing levee

The slope of existing levee is ranged from 1:0.6 to 1:1.8 and therefore the existing levee requires its reinforcement. But the existing levee reinforcement is not taken up at the 1st stage construction, because the 1st stage construction aims at building the levee which is urgently needed and that the existing levee would not be immediately destroyed.

3.3.4 Foot Protection (Cribworks)

Since the Pawa-Burabod river is rather steep river, and so the river bed fluctuates with sediment deposition and scouring, there would occur scouring in the foot of levees. To prevent such scouring, crib works are provided in front of the foot of levee.

Crib works are designed to be made of log crib filled with boulder. Each crib is designed in a size of 2.0 m wide, 2.0 m long and 0.8 m high referring to the examples in Japan which are shown in Fig. 4.49 and 4.50 in the Appendix I. Three cribs will be placed in line in front of the levee foot and will be connected by reinforcement bar each other.

3.3.5 Ground-sill

1) Purpose

Since the Pawa-Burabod river presently discharges plenty sediment, river bed scouring along the river profile will hardly occur. However, there are some places where the river bed is locally scoured especially at curved point of river course. Such scouring will become more serious with the progress of the upper Sabo works as well as the canalization which have an effect to concentrate flow and thus increase erosion. To prevent such river bed scouring, ground-sill will be provided.

2) Location

The ground-sill will finally be needed to be provided at an interval of about 100 m to 300 m when the river will become almost stable condition in future. Presently the river is still unstable. Therefore the ground-sill is provided only such limited places as indicated below:

a. Changing point of river bed slope

b. End point of curvature of river course

c. Just downstream of roadway on the river bed and irrigation intake facilities

d. Beginning point of river canalization

3) Type

Two types of ground-sill are designed. One is made of crib works filled with boulders, and the other is made of concrete block. Concrete block type is of cross block with a size of 2.0 m wide, 2.0 m long and 0.8 m high referring to the examples in Japan which are shown in Fig. 4.51 in the Appendix I.

Concrete block ground-sill will be set in two places, one is at the beginning point of river canalization and one is just downstream of existing levee in right bank, where an irrigation intake facility will be constructed. As for the irrigation intake, explanation will be made later.

3.3.6 Irrigation Intake

A very simple irrigation intake with brush dam exists in the right bank near the existing levee in Pawa village.

When the levees will newly be constructed there, an irrigation intake facility is obliged to be constructed so that irrigation water can be taken in through levee as it is done.

The intake is designed to comprise an inlet, pipe culvert, sand stilling basin and stoplogs. The stoplog has to be operated carefully at flood time so that artificial flooding will not occur.

Details of intake structure should be referred to the design drawing.

IV. WORK QUANTITY

The major work quantity of the Sabo dam, the spur dikes, and the river canalization with related structures is estimated as summarily shown below. The work quantity estimated herein is limited to the 1st stage construction work.

Sabo dam (including main dam and sub dam)

Excavation common	11,600 m^3
Excavation rock	380 m^3
Concrete	7,170 m^3

No. 1 Spur dike

Excavation common	3,590 m^3
Embankment	1,720 m^3
Concrete	560 m^3
Wet masonry wall	2,290 m^2

No. 2 Spur dike

Excavation common	4,310 m^3
Embankment	1,130 m^3
Concrete	690 m^3
Wet masonry wall	1,720 m^2

River canalization (levee)

Excavation	87,900 m^3
Embankment	62,800 m^3
Concrete	9,140 m^3
Wet masonry slope protection	32,380 m^2

Cribworks

Number of crib	6,993 nos.
Timber log	151,050 m
Rubble	14,150 m^3

Ground-sill

Type-A (9 nos.)

Excavation common	3,180 m^3
Timber log	20,950 m
Rubble	1,960 m^3

Type-B (2 nos.)

Excavation common	1,170 m^3
Concrete	430 m^3
Rubble	860 m^3

Irrigation intake (1 no.) L.S.

V. CONSTRUCTION PLAN AND SCHEDULE

5.1 General

Construction plan and schedule for the first stage works are described herein, in which the following works are involved.

1) Preparatory works

2) Main construction works

   - Sabo dam
   - Spur dikes
   - Levee
   - Ground-sill
   - Irrigation intake

5.2 Construction Time Schedule

Construction time schedule for the above works are proposed to be established under the following considerations and assumptions.

1) Preparatory works will be commenced at the beginning of August 1980 including mobilization.

2) The main construction works will be commenced at the beginning of November 1980 (even in wet season, construction works could be executed according to the hydrological judgement) and will be completed all by the end of July 1985.

3) Sabo works including the Sabo dam, and spur dikes (both No. 1 and No. 2) will be completed within two years after commencement.

4) River works including levee, ground-sill and irrigation intake will take about 5 years for completion.

   It is assumed that river works will take about 5 years for construction which are rather slow construction pace. This is because that very urgent construction of river works would bring possibly dangerous cases owing to the changes of river condition due to Sabo river works.

5.3 Preparatory Works

Before commencement of main construction works, following preparatory works should be executed.

1) Access road
2) Temporary buildings
3) Power supply system
4) Water supply system

Based on the work quantities and the construction time schedule described in the previous paragraphs, the following temporary works would be required.

1) Access road	L = 4,000 m
2) Temporary building	930 m^2
Construction Buildings	230 m^2
Residential buildings	700 m^2
3) Power supply system	75 kW
Portable batching plant	15 kW
Repair shop	30 kW
Quarter	30 kW
4) Water supply system	
Construction use	16 m^3/day (to be supplied by water tanker)

5.4 Main Work

It is assumed that all the main works will be executed with simple and conventional equipment and by a local contractor.

The equipment required for the construction are summarized below:

Equipment	Type and Size	Nos.
Bulldozer	21 ton	2
Bulldozer	11 ton	2
Tractor shovel	1.4 m^3	2
Backhoe	1.6 m^3	2
Dump truck	6 ton	8
Track crane	20 ton	1
Vibratory roller	3 ton	1
Rammer and tamper	60 to 100 Kg	8
Jade hammer	20 Kg	5
Pick hammer	7 Kg	10
Air compressor	10 m^3/min	1
Portable batching and mixing plant	0.75 m^3	1
Light mixer	0.2 m^3	5
Agitator truck	1.7 m^3	3
Concrete vibrator	60 mm dia.	5
Concrete vibrator	40 mm dia.	20
Generator	15 kW	1
Generator	30 kW	2
Water pump	3.5 ps	4
Ordinary truck	6 ton	1

The construction methods of each structure should be referred to the Appendix II attached at the end of this report.

VI. COST ESTIMATE

The construction cost for the first stage construction works and assumptions is estimated herein under the following conditions.

1) Unit prices of labor, materials, and machineries are based on the price level as of November 1979 in Legaspi.

2) The construction cost is estimated on the assumption that the construction works will be implemented by a local contractor in contract system.

3) The construction cost comprises contract cost, engineering cost, administration cost and contingency.

4) The construction cost is estimated on the basis of the standard procedure being applied in MPW of the Philippine Government.

The construction cost for the first stage construction works thus estimated is summarized below:

Description		Cost (PESO)
1. Contract Cost		
1) Direct Cost		
Section-1	General	2,088,000
Section-2	Sabo dam	2,222,000
Section-3	Spur dike No.1	857,000
Section-4	Spur dike No.2	734,000
Section-5	Levee	9,221,000
Section-6	Groundsill, Type A	271,000
Section-7	Groundsill, Type B	269,000
Section-8	Irrigation intake	18,000
Sub-total (1)		15,680,000

Description		Cost (PESO)
2)	Contingency (5% of sub-total (1))	784,000
	Sub-total (2)	16,464,000
3)	Contractor's Profit (10% of sub-total (2))	1,646,000
4)	Surcharges (5% of sub-total (2))	823,000
Contract Cost		18,933,000
2.	Engineering Cost	732,000
3.	Administration Cost	947,000
4.	Contingency (Physical and escalation)	6,688,000
	Total Construction Cost	27,300,000

The breakdown of the above cost estimate should be referred to the Appendix III.

APPENDIX I

DESIGN CALCULATION

APPENDIX I - DESIGN CALCULATION

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I. GENERAL

This is the design calculation report of the sabo facilities to be constructed in the Pawa-Burabod river, a tributary of the Yawa river which is located in south-eastern slope of the Mayon Volcano.

This report is an appendix to be attached to the main report of "Design Report on Sabo Facilities in the Pawa-Burabod River, A Tributary of the Yawa River, February 1980".

The report deals with the design calculations of Sabo facilities involving the Sabo dam, spur dikes, and river canalization works including river channel, levees, cribworks and groundsills.

II. SABO DAM

2.1 General

The proposed Sabo dam is located in the upstream reaches of the Pawa-Burabod river at about EL.400 m.

The topographic condition of the basin and the principal features of the dam are summarized below:

Topography

Location	About EL.400 m
Drainage area	2.5 km^2
River length upstream of the dam site	4.4 km
Average river bed slope for the above	1 / 2.3
River bed slope at the dam site	1 / 11.1

Main Dam

Type	Concrete gravity type
Crest elevation	
Overflow section	EL.398.55 m
Non-overflow section	EL.402.05 m
Height	
Overflow section	10.0 m
Non-overflow section	13.5 m
Crest length	
Total	79.5 m
Overflow section	30.0 m
Crest width	3.0 m
Upstream slope of dam body	1 : 0.4
Downstream slope of dam body	1 : 0.2
Design flood (100-year flood)	103.1 m^3/s
Trap capacity	13,000 m^3
Concrete volume of dam body	5,220 m^3

Sub-dam

Type	Concrete gravity type
Height	
Overflow section	5.0 m
Non-overflow section	7.5 m
Crest length	
Total	57.5 m
Overflow section	30.0 m
Crest width	2.0 m
Upstream slope of dam body	1 : 0.4
Downstream slope of dam body	1 : 0.2
Concrete volume	1,170 m^3

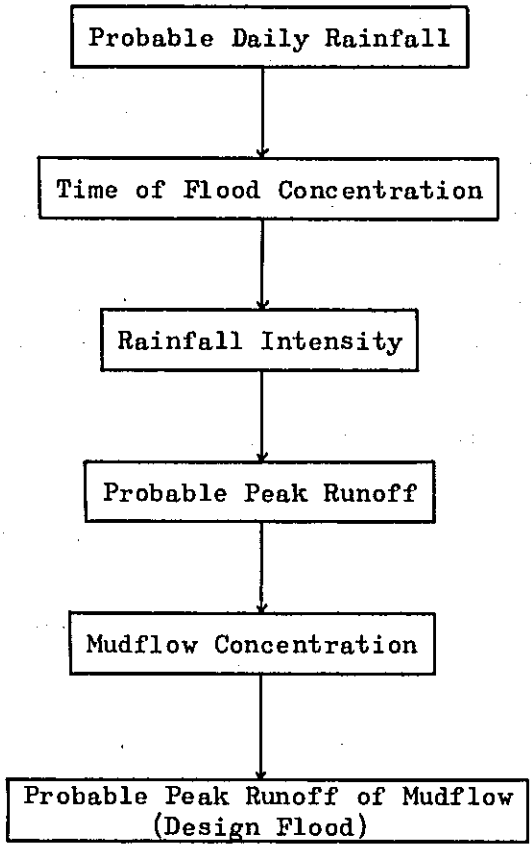
Hereunder, calculation of design flood, design of overflow section, stability of dam body, and protection works for the dam apron are presented.

2.2 Design Flood

The design flood for Sabo dams is generally taken as either 100-year probable flood or the recorded maximum flood, whichever is the larger, according to the Japanese standard.

Since flood data are not available in this project area, 100-year probable flood is applied for the design of the Sabo dam and the design flood is estimated from rainfall data by applying the Rational Formula.

The estimation of design flood is proceeded by the following procedure:



1) Probable Daily Rainfall

No rainfall record is available in this project basin. Legaspi rain-gage station has a long-term daily rainfall record and also is nearest to the project basin. Therefore, Legaspi is selected as a representative station for the said basin.

The probable daily rainfall is computed by three methods of Iwai's, Hazen's and Gumbel's one and shown in Table 2.1 and Fig. 2.1 using the recorded annual maximum daily rainfalls mentioned in the report of "Bicol River Basin Comprehensive Water Resources Development Study", which cover 27 years from 1949 to 1975.

The 100-year probable daily rainfall for design flood is estimated at 595 mm/24-hr by Hazen's method which indicates the largest values among three methods.

Fig 2.1 Probable Daily Rainfall at Legaspi

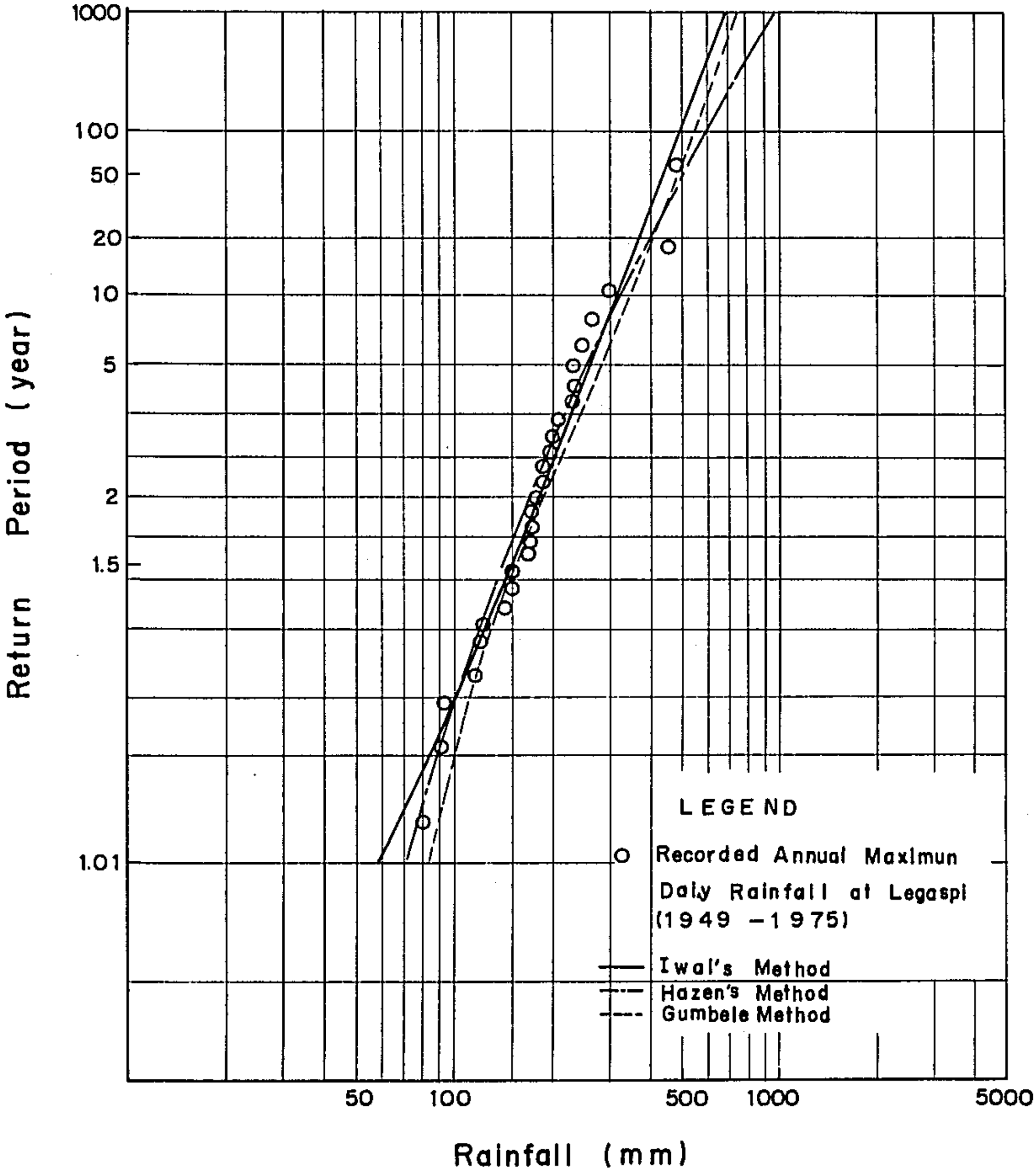


Table 2.1 Probable Daily Rainfall at Legaspi

Return Period (year)	Probability	Probable Daily Rainfall (mm)		
		IWAI	HAZEN	GUMBEL
1.01	0.9901	59	71	84
1.5	0.6667	149	140	144
2	0.5000	180	170	184
4	0.2500	240	235	258
5	0.2000	257	256	280
8	0.1250	291	301	324
10	0.1000	307	323	344
20	0.0500	355	396	405
25	0.0400	371	421	424
40	0.0250	403	476	465
50	0.0200	418	504	484
80	0.0125	450	565	524
100	0.0100	465	595	543
200	0.0050	513	697	602
250	0.0040	528	732	621
400	0.0025	561	809	661
500	0.0020	577	848	680
1000	0.0010	626	977	739

2) Time of Flood Concentration

Time of flood concentration is given by the following formula after Kraven.

$$T = L/w \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

where, T : time of flood concentration (sec.)

L : river length upstream from the dam site (m)

w : flood velocity which is empirically given as shown in Table 2.2 below (m/sec)

Table 2.2 Flood Velocity

River bed slope	> 1/100	1/100-1/200	< 1/200
w (m/sec)	3.5	3.0	2.1

Since average river bed slope is 1/2.3 which is steeper than 1/100, w is taken at 3.5 m/sec from the above table. Thus, T is calculated below:

$$T = \frac{4.4\text{km} \times 1{,}000}{3.5\ \text{m/sec}} = 1{,}257\ \text{sec} = 21\ \text{min.}$$

3) Rainfall intensity

Dr. Ito's formula expressed below is used for the calculation of rainfall intensity.

$$Rt = \frac{R24}{24} \cdot \frac{24}{100} \cdot \left(\frac{34{,}710}{T^{1.35} + 1{,}520}\right) \quad --(2.2)$$

where, Rt : mean rainfall intensity in a period of time, T (mm/hr)

R24 : rainfall in a 24-hr duration (mm)

T : time of flood concentration (min)

According to Table 2.1, the 100-year probable rainfall in a 24-hr duration is taken as 595 mm at Legaspi station.

But, Legaspi is located at the low elevation, so that the above values should be used after being increased in an appropriate rate, because it is known that the rainfall generally increases with the elevation and the project area is located at an elevation of more than 400 m while the elevation at Legaspi station is 19 m.

In this study, the above probable rainfall, 595 mm, is increased 10 per cent referring to the empirical standard in Japan, in which the annual rainfall amount increases at 5 to 10 per cent per 500 m in elevation.

Finally, the probable rainfall for design flood comes to 660 mm/24-hr and the rainfall intensity for the time of flood concentration (= 21 min.) is calculated by equation (2.2) as,

$$Rt = 144.9 \text{ mm/hr}$$

4) Peak run-off

The Rational Formula expressed below is used for calculation of peak run-off.

$$Qp = \frac{1}{3.6} \times f \times A \times Rt \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.3)$$

where,
- Qp : peak run-off (m^3/sec)
- f : run-off coefficient (= 0.80)
- A : drainage area (km^2)
- Rt : mean rainfall intensity during the time of flood concentration (mm/hr)

Adopting f=0.80, A=2.5 km^2 and Rt=144.9 mm/hr, the peak run-off of 100-year probable flood is calculated at Qp 100-year = 80.5 m^3/sec.

5) Mud concentration in mudflow

Mud concentration in mudflow is given by Takahashi's formula which is expressed in the following form:

$$C = \frac{\rho \cdot \tan\theta}{(\sigma - \rho)(\tan\phi - \tan\theta)} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2.4)$$

where,
- C : mud concentration
- ρ : density of water (gram/cm^3)
- $\tan\theta$: gradient of river bed slope
- σ : density of river bed materials (gram/cm^3)
- ϕ : internal friction angle of river bed materials ($^\circ$)

It has been generally recognized that Sabo dam construction will change its upstream river bed slope to about 1/2 to 2/3 of the original river bed slope according to the flow condition. Generally said, in case of flow dominant to mudflow, the river bed will be changed to about 2/3 of the original river bed slope.

In the proposed dam site, the flow regime would be assumed to be mud flow since the river bed slope is so steep as 1/11.1. Therefore, the planned river bed slope in the upstream of the Sabo dam is assumed to be 1/17 (= 1/11.1 x 2/3).

Assuming the other constants in equation (2.4) as

$\rho = 1.0$ g/cm^3 $\quad \tan\theta = 1/17$

$\sigma = 2.5$ g/cm^3

$\phi = 20^\circ$

Mud concentration is calculated as follows.

Table 2.3 Mud Concentration (C)

	River Bed Slope	Mud Concentration
Original river	1/11.1	0.219
After construction of Sabo dam	1/17.0	0.129

6) Peak run-off in mud flow

Peak run-off in mud flow is calculated by the following formula.

$$Qp' = Qp \times \frac{1}{1-c} \quad \cdots\cdots\cdots \quad (2.5)$$

where, Qp : peak run-off (m^3/sec)

c : mud concentration

Peak run-off in mud flow for 100-year probable flood is thus calculated as follows:

Table 2.4 Peak Run-off in Mud Flow (100-year probable flood)

	Peak Run-off (water)	Mud Concentration	Peak Run-off (mud flow)
Original river condition	80.5 m^3/sec	0.219	103.1 m^3/sec
After construction of Sabo dam	80.5 "	0.129	92.4 "

2.3 Design of Overflow Section

Overflow section of the Sabo dam should be designed to keep safety of dam against flood flow. Firstly, the width of overflow section (crest length of overflow section) will be decided and then the height of overflow opening will be decided hereunder.

1) Width of overflow section (crest length of overflow section)

Study will firstly be made of the practicable river width, which is preferable to be adopted as the width of overflow section of the Sabo dam.

The practicable river width in case of rivers without levees or dikes is empirically given by the following formula.

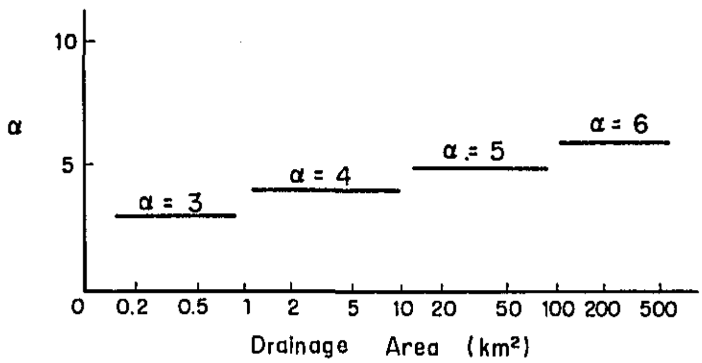
$$B = \alpha \cdot Q^{1/2} \quad \text{..................................} \quad (2.6)$$

where, B : river width (m)

Q : mud flow peak run-off (m^3/sec)

α : coefficient shown in Fig. 2.2

Fig. 2.2 Relation between α and Drainage Area



In case of Mayon Projects, it may be taken at 4, since the drainage area at the proposed dam site is 2.5 km^2. Therefore, the river width is calculated as follows by adopting 100-year probable flood.

$$B = 4 \times 103.1^{1/2} = 40.6 \text{ m}$$

From the topographic features at the dam site, the river width in the downstream of the dam will be about 50 m.

Based upon the above studies, the width of overflow section is decided at 30 m taking some allowance to prevent scouring in the dam abutment.

2) Overflow depth

Overflow depth is calculated by the following formula.

$$Q = \frac{2}{15} \times C \times ho \times \sqrt{2 \times g \times ho} \times (3\ bo + 2\ bl) \quad \text{--(2.7)}$$

where, Q : discharge (m^3/sec)

C : coefficient of contraction (= 0.6)

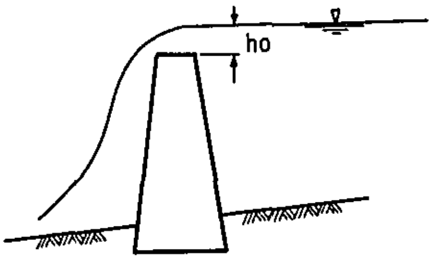
g : acceleration of gravity (9.8 m/sec^2)

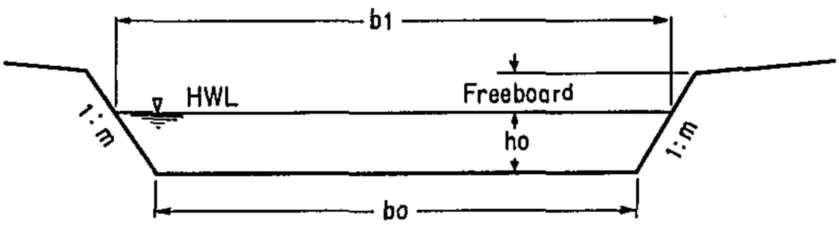
ho : overflow depth (m)

bo : base width of overflow section (30 m)

bl : flow width in water surface (m)

Fig. 2.3 Overflow Section





Adopting m = 0.5

bl = bo + 0.5 ho + 0.5 ho = 30 + ho

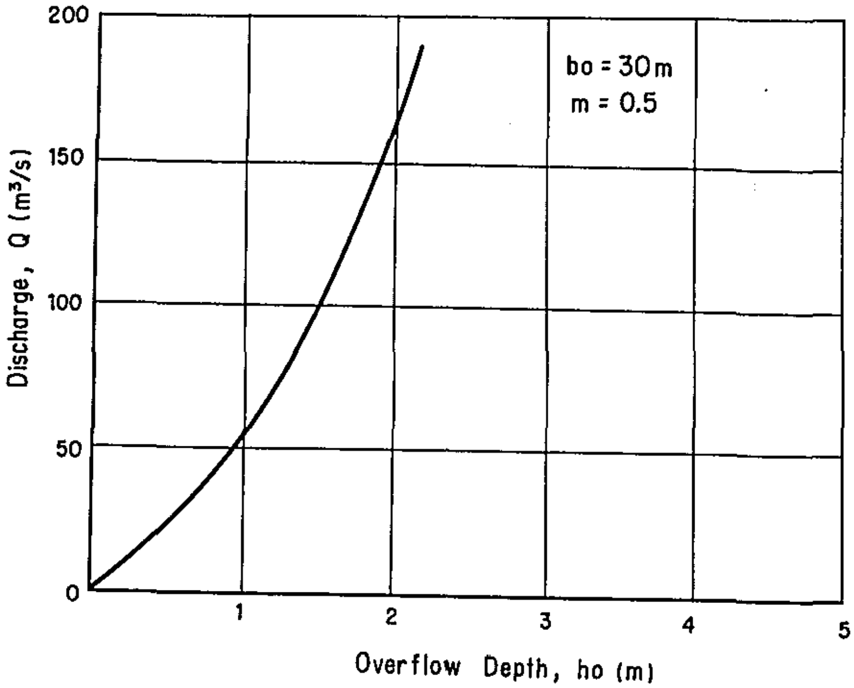
substituting the above to eq. (2.7),

$$Q = \frac{2}{15} \times 0.60 \times ho \times \sqrt{2 \times 9.8 \times ho} \times \{3 \times 30 + 2 \times (30 + ho)\}$$

$$= 0.708\ ho^{2/3} \times (75 + ho) \quad \text{.................... (2.8)}$$

The above equation is graphically shown in Fig. 2.4.

Fig. 2.4 Relation between Overflow Depth and Discharge



From Fig. 2.5, the overflow depth corresponding to the design flood is obtained below.

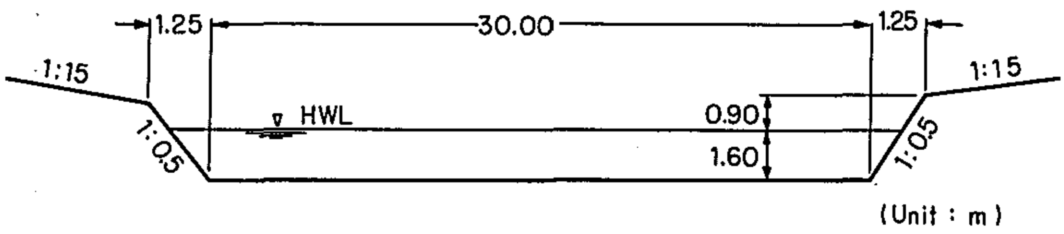
Table 2.5 Overflow Depth

Condition	Peak Run-off (mud flow)	Overflow Depth
Original river condition	103.1 m^3/sec	1.53 m
After construction of Sabo dam	92.4 "	1.43 "

(Overflow crest length = 30 m)

As the results of the above calculation, overflow depth is assumed at 1.6 m taking some allowance and rounded up the calculated figures.

Fig. 2.5 Designed Overflow Section



2.4 Design of Dam Body

The mechanism of mudflow has not been made clear so far. The height of Sabo dam is empirically decided so as to be effective to reduce the energy of mudflow referring to the past engineering experiences, structures actually constructed and economical conditions.

In general, the height of more than 7 m is proposed to be effective to control the mudflow.

In case of Mayon Project, the main Sabo dam is designed with a total height of 10.0 m at overflow section based upon the topographic conditions as well as the considerations of the erosion control effect especially for side erosion.

The other structural features such as crest width, down and upstream slopes of dam body, etc. are designed below.

1) Width of crest

Width of dam crest in overflow section is decided at 3.00 m so that the dam crest will not be destroyed by mud flow.

2) Downstream slope

The downstream slope of Sabo dams are generally designed to avoid destruction due to heavy materials (cobbles and boulders) falling down over the crest. Therefore, a slope of 1:0.2 is adopted.

3) Upstream slope

Considering the safety of dam body against overturning, for which stability will be checked in the next paragraph, the upstream slope of dam is decided at 1:0.4.

The upstream slope of Sabo dams can be decided by the following formula in general.

$$(1+\alpha)m^2 + \left\{2 \times (n+\beta) + n(4\alpha+\gamma) + 2\alpha\beta\right\}m + \alpha\beta(4m+\alpha) + (3n\beta + \beta^2 + n^2) - (1+3\alpha) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2.9)$$

where,
- H : height of dam at overflow section (m)
- b : width of crest (m)
- ho : overflow depth (m)
- m : upstream slope
- n : downstream slope
- W_o : density of water including earth (= 1.1 ton/m^3)
- W_c : density of concrete (2.5 ton/m^3)

with W_o = 1.1 ton/m^3 and W_c = 2.4 ton/m^3, other variables of eq. 2.9 are tabulated for convenience in Table 2.6.

Table 2.6 Dam Slope

$w_o = 1.1$, $w_c = 2.4$

b/H \ h/H	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
0.00	0.625	0.713	0.782	0.837	0.883	0.921	0.954	0.982	1.007	1.029	1.048
0.02	0.600	0.689	0.758	0.814	0.860	0.899	0.932	0.960	0.985	1.007	1.027
0.04	0.575	0.665	0.735	0.791	0.837	0.876	0.909	0.938	0.963	0.985	1.006
0.06	0.549	0.640	0.711	0.767	0.814	0.853	0.887	0.916	0.941	0.963	0.983
0.08	0.523	0.615	0.686	0.743	0.790	0.830	0.864	0.893	0.918	0.941	0.960
0.10	0.495	0.589	0.664	0.719	0.767	0.807	0.841	0.870	0.896	0.918	0.938
0.12	0.469	0.563	0.636	0.694	0.743	0.783	0.817	0.847	0.873	0.895	0.916
0.14	0.441	5.537	0.610	0.670	0.718	0.759	0.794	0.823	0.850	0.872	0.893
0.16	0.413	5.510	0.584	0.644	0.694	0.735	0.770	0.800	0.826	0.849	0.870
0.18	0.384	0.482	0.558	0.619	0.669	0.710	0.746	0.736	0.803	0.826	0.847
0.20	0.354	0.454	0.531	0.593	0.643	0.685	0.721	0.752	0.779	0.803	0.824
0.22	0.324	0.426	0.504	0.567	0.618	0.660	0.697	0.728	0.755	0.779	0.800
0.24	0.294	3.397	0.477	0.540	0.592	0.635	0.672	0.704	0.731	0.755	0.777
0.26	0.262	0.368	0.449	0.513	0.566	0.610	0.647	0.679	0.707	0.731	0.753
0.28	0.231	0.339	0.421	0.486	0.539	0.581	0.622	0.654	0.682	0.707	0.729
0.30	0.198	0.308	0.392	0.459	0.513	0.558	0.596	0.629	0.658	0.683	0.705
0.32	0.165	0.278	0.363	0.431	0.486	0.532	0.570	0.604	0.633	0.658	0.681
0.34	0.131	0.246	0.334	0.402	0.458	0.505	0.544	0.578	0.608	0.633	0.656
0.36	0.096	0.214	0.304	0.374	0.431	0.478	0.518	0.552	0.582	0.608	0.632
0.38	0.060	0.182	0.273	0.345	0.403	0.451	0.492	0.526	0.557	0.583	0.607
0.40	0.024	0.149	0.242	0.315	0.374	0.423	0.465	0.500	0.531	0.558	0.582
0.42	−0.013	0.115	0.211	0.285	0.346	0.395	0.438	0.474	0.505	0.532	0.557
0.44	−0.051	0.081	0.179	0.255	0.316	0.367	0.410	0.447	0.479	0.507	0.531
0.46	−0.091	0.046	0.146	0.224	0.287	0.339	0.383	0.420	0.452	0.481	0.506
0.48	−0.131	0.010	0.113	0.193	0.257	0.310	0.355	0.393	0.426	0.454	0.480

By adopting the following values, the upstream slope of Sabo dam can be calculated;

H = 10.0 m	ho = 1.60 m	b = 3.00 m
W_o = 1.1 ton/m^3	W_c = 2.4 ton/m^3	n = 0.2

$$\alpha = \frac{ho}{H} = \frac{1.60}{10.00} = 0.16$$

$$\beta = \frac{b}{H} = \frac{3.00}{10.00} = 0.30$$

$$\gamma = \frac{W_c}{W_o} = \frac{2.4}{1.1} = 2.18$$

From Table 2.5, "m" is obtained at about 0.36. Taking some allowance, m = 0.40 is adopted.

2.5 Stability Calculation

For the designed dam body in the previous chapter, stability analysis is made hereunder. The stability of gravity type dams should be checked in the following terms.

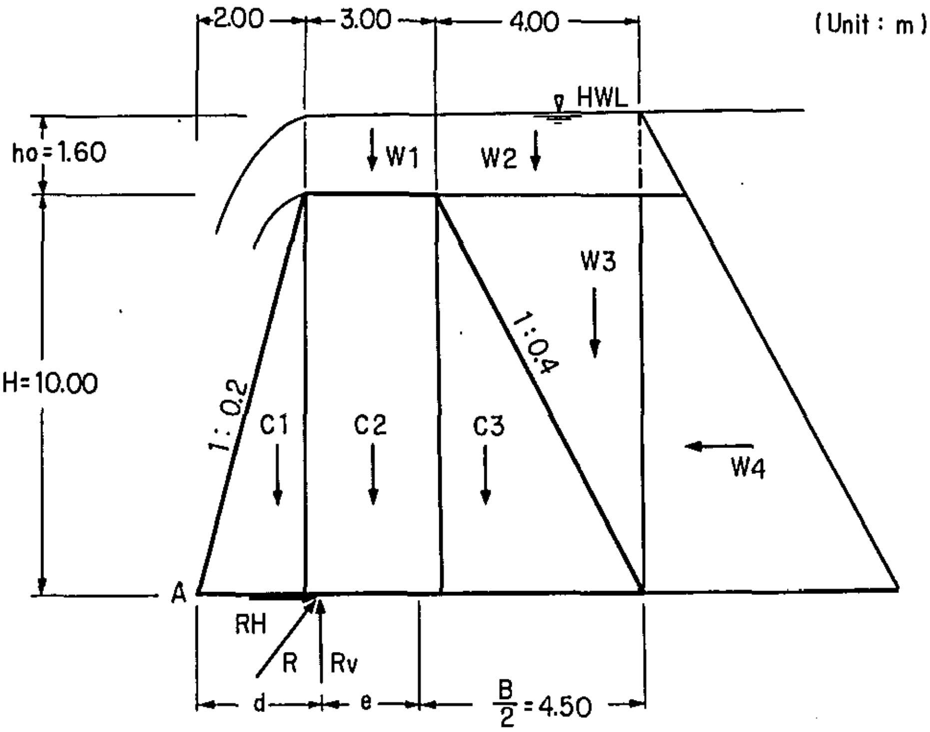
a. Stability against overturning
b. Stability against sliding
c. Stability against bearing

The typical section of dam body is shown in Fig. 2.6. For calculation on overturning, summation of causing and restraining moments will be taken at the toe with the former considered negative (-) and latter positive (+). The results of calculation are shown in Tab.e 2.7.

Table 2.7 Moment Calculation

Forces (Tons)	Lever Arm (m)	Moment (t.m)
$C_1 = \frac{1}{2} \times 2 \times 10 \times 2.4 = 24.00$	$2 \times \frac{2}{3} = 1.33$	+ 32.00
$C_2 = 3 \times 10 \times 2.4 = 72.00$	$2 \times \frac{3}{2} = 3.50$	+ 252.00
$C_3 = \frac{1}{2} \times 4 \times 10 \times 2.4 = 48.00$	$5 + \frac{1}{3} \times 4 = 6.33$	+ 304.00
$W_1 = 1.6 \times 3 \times 1.1 = 5.28$	$2 + \frac{3}{2} = 3.50$	+ 18.48
$W_2 = 1.6 \times 4 \times 1.1 = 7.40$	$5 + \frac{1}{2} \times 4 = 7.00$	+ 51.80
$W_3 = \frac{1}{2} \times 10 \times 4 \times 1.1 = 22.00$	$5 + \frac{2}{3} \times 4 = 7.67$	+ 168.67
$W_4 = \frac{1}{2} \times 10 \times (1.6 + 11.6) \times 1.1 = 72.60$	$\frac{10}{3} \times (10 + 3 \times 1.6) \div (10 + 2 \times 1.6) = 3.74$	- 271.52
	$\Sigma =$	+ 555.43
$R_v = C_1 + C_2 + C_3 + W_1 + W_2 + W_3 = 178.68$	d	- 178.68d

Fig. 2.6 Typical Section of Dam Body



The point where the base reaction falls can now be readily calculated by taking summation of moments at the toe considering the total amount of external forces against that caused by the vertical component of reaction, that is R_v,

$$555.43 - 178.68d = 0$$

$$d = 3.11 > B/3 \quad (= \frac{9.00}{3} = 3.00 \text{ m})$$

This means that the reaction fell within the middle third of base.

Internal stresses will be calculated based upon the following formula:

$$\sigma = \frac{R_V}{B}(1 \pm \frac{6e}{B}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.10)$$

where, σ : internal stress (ton/m^2)

R_V : total base pressure (ton)

e : eccentricity $(= \frac{B}{2} - d)$ (m)

B : width of dam base (m)

From Fig. 2.6

$$e = \frac{B}{2} - d = \frac{9.00}{2} - 3.11 = 1.39$$

Taking stress at the toe as

$$\sigma_1 = \frac{178.68}{9.00} (1 + \frac{6 \times 1.39}{9.00}) = 38.25 \text{ ton/m}^2$$

Taking stress at the heel as

$$\sigma_2 = \frac{178.68}{9.00} (1 - \frac{6 \times 1.39}{9.00}) = 1.46 \text{ ton/m}^2$$

From the above computations it is concluded that no tension will occur anywhere on the dam foundation. Safety factor against sliding taking $f = 0.70$

$$F.S.S = \frac{f \times R_V}{RH} = \frac{0.70 \times 178.68}{72.6} = 2.46 > 1.2$$

This Sabo dam site's foundation is judged as compacted gravel and sand. The allowable bearing capacity is therefore assumed to be 70-110 ton/m^2 from the Table 2.8. As preceeding computation, the stress at the toe of dam is 38.25 ton/m^2, so it's pressure is allowable.

Table 2.8 Types of Foundation and Allowable Bearing Capacity

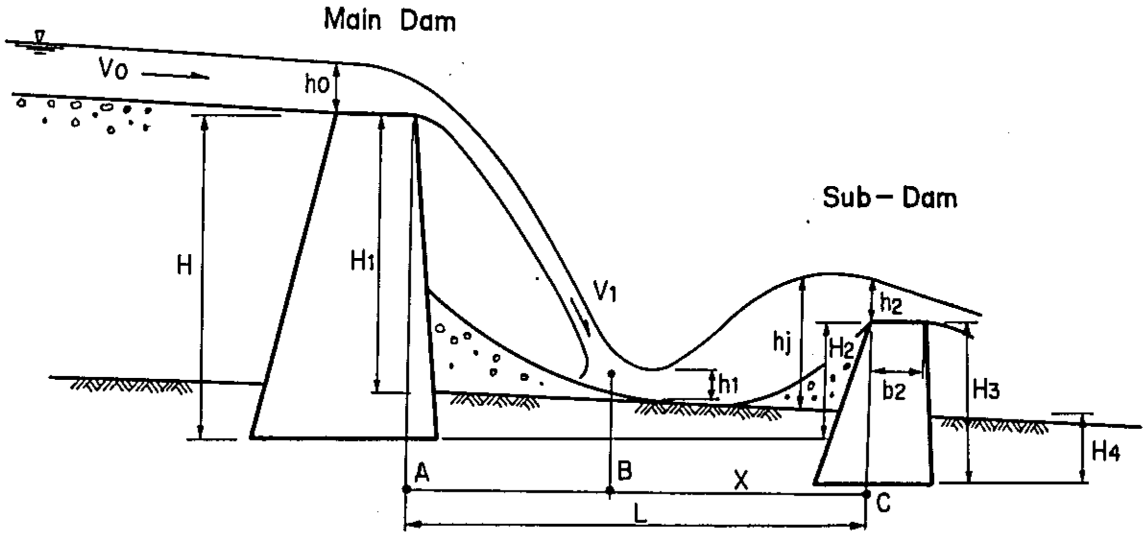
Type of Foundation	Bearing Capacity (ton/m^2)
Hard rock	160 - 270
Soft rock	70 - 160
Compacted gravel, earth and sand	70 - 110
Coarse sand and cobble stone	30 - 70
Sand and clay	20

From the preceeding computations, it can be concluded that the design is satisfactory.

2.6 Apron Protection

For preventing the erosion just downstream of the main dam and thus for keeping stability of the main dam, a sub-dam is to be constructed in the downstream of the main dam to form apron.

Fig. 2.7 Arrangement of Sub-dam



1) Overflow depth

The water depth at overflow section of main dam is calculated by Manning's formula assuming that the main dam is filled with debris and sediment load and the flow becomes uniform.

$$Q = AV' \qquad (2.11)$$

$$V' = V \times \frac{\rho}{\rho + C(\sigma - \rho)} \qquad (2.12)$$

$$V = \frac{1}{n} R^{2/3} I^{1/2} \qquad (2.13)$$

where,
- Q : discharge including earth (m^3/sec)
- A : flow area (m^2)
- V : velocity (m/sec)
- V' : velocity including earth (m/sec)
- R : hydraulic radius (m)
- I : assumed future river bed slope upstream from Sabo dam (about 1/17)
- ρ : density of water (ton/m^3)
- C : mud concentration
- σ : density of river bed materials (ton/m^3)
- n : Manning's roughness coefficient

Substituting the following values to eq. (2.11), (2.12) and (2.13), the overflow depth (ho) is obtained as

$$ho = 0.77 \text{ m}$$

2) Distance between main dam and sub-dam

The distance between main dam and sub-dam (L) is given by the following equation.

$$L \geqq \ell + X + b_2 \quad \dots\dots\dots\dots\dots\dots\dots\dots \quad (2.14)$$

$$\ell = V_o \cdot \left\{ \frac{2\ (H_1 + 0.5\ ho)}{g} \right\}^{1/2}$$

$$V_1 = \sqrt{2 \cdot g \cdot (H_1 + ho)}$$

$$X = \beta \cdot hj \qquad \beta: \ 4.5 - 5.0$$

$$V_o = qo/ho$$

$$h_1 = q_1/V_1$$

$$hj = \frac{h_1}{2} \cdot (\sqrt{1 + 8F^2} - 1)$$

$$F_1 = V_1 / \sqrt{g \cdot h_1}$$

where,

- ℓ : distance between point A and B (m)
- X : distance of hydraulic jump (m)
- b_2 : sub-dam crest width (m)
- V_o : overflow velocity at main dam (m/sec)
- g : gravity acceleration (m/sec^2)
- hj : depth of hydraulic jump (m)
- V_1 : flow velocity at point B (m/sec)
- h_1 : super critical flow depth before hydraulic jump (m)
- q_o : discharge per unit width at main dam crest ($m^3/sec/m$)
- q_1 : discharge per unit width at point B ($m^3/sec/m$)
- F : Froude number before hydraulic jump

The calculation is made by the following procedure.

(i) overflow velocity at main dam (V_o)

$$V_o = \frac{103.1}{0.5 \times (30 + 30 + 0.7) \times 0.77}$$

$= 4.40$ m

(ii) distance of water fall reach (ℓ)

$$\ell = 4.40 \times \left\{ \frac{2 \times (7.0 \times 0.5 \times 0.77)}{98} \right\}^{1/2}$$

$= 5.40$ m

(iii) velocity of water falling at point B (V_1)

$$V_1 = \sqrt{2 \times 9.8 \times (7 + 0.77)}$$

$= 12.34$ m/sec

(iv) super critical flow depth before hydraulic jump (h_1)

$$h_1 = (103.1/30)/12.34$$

$= 0.28$ m

(v) Froude number before hydraulic jump (F_1)

$$F_1 = 12.34/\sqrt{9.8 \times 0.28}$$

$= 7.45$

(vi) depth of hydraulic jump (hj)

$$hj = \frac{0.28}{2} \times \left(\sqrt{1 + 8 \times 7.45^2} - 1 \right)$$

$= 2.81$ m

(vii) distance of hydraulic jump (X)

$$X = 4.5 \times 2.81 \quad (\beta = 4.5)$$

$= 12.66$ m

(viii) distance between main dam and sub-dam (L)

$$L \geqq 5.40 + 12.66 + 2.00$$

$= 20.06$ m

From the result of above calculation, the distance between main dam and sub-dam is determined as 22 m taking some allowance.

3) Height of sub-dam

The height of sub-dam is empirically given by the equation below.

$$H_2 = \alpha H \quad \cdots\cdots\cdots\cdots \quad (2.15)$$

where, H_2 : overlap height shown in Fig. 2.7 (m)

α : coefficient (1/3 - 1/4)

H : main dam height (m)

Substituting H=10 to above euqation, the overlap height is calculated at 2.5 m to 3.0 m. Taking sub-dam height as 5.0 m and foundation depth as 3.0 m, the overlap height is estimated at 2.75 m at the sub-dam site and it satisfies the above conditions. Therefore, the height of 5.0 m is adopted.

III. SPUR DIKE

3.1 General

Sand retarding basin is proposed to be constructed in the middle reaches with spur dikes, cross dikes, training dikes, etc.

Such retarding basin seems not practical to be constructed at once because of very wide areas to cover, and further it may be dangerous to construct it at once because there are many unknown factors involved in retarding basin. From such considerations, two dikes (spur dikes) only are proposed to be constructed for the first.

These dikes aim at preventing mud flow from entering into the villages of Pawa, Bonga, Burabod, etc. so that mud flow can be sustained in the middle reaches.

The topographic condition of the basin and the principal features of the spur dikes are summarized below.

Topography

Drainage area	7.3 km^2
River length upstream of river canalization	7.8 km
Average river bed slope	1/3.8
River bed slope around the spur dikes	1/16

3.2 Design Flood

The design flood is calculated by the same method applied for the Sabo dam design. The 1.5-year probable flood and 50-year probable flood are estimated herein. The former flood is used for estimating the practicable river width and the latter for designing of structures of the spur dikes.

1) Probable daily rainfall

From Fig. 2.1 and Table 2.1, the probable daily rainfalls for the return periods of 1.5-year and 50-year are 140 mm and 504 mm respectively by Hazen's method.

The above values are used by adding 10 per cent according to the reason mentioned in previous chapter.

R_{24} 1.5-year = 160 mm/24-hr

R_{24} 50-year = 560 mm/24-hr

2) Time of flood concentration

Using Kraven's Formula

$$T = \frac{7,200}{3.5} = 2,229 \text{ sec} = 37 \text{ min.}$$

3) Rainfall intensity

Dr. Ito's Formula will be used for this calculation from eq. 2.2 previously presented.

Rt 1.5-year = 33.6 mm/hr

Rt 50-year = 117.7 mm/hr

4) Peak run-off

Using Rational Formula

Qp 1.5-year = 47.4 m^3/sec

Qp 50-year = 165.9 m^3/sec

5) Mud flow concentration

Using Takahashi's Formula

C = 0.138

From eq. 2.5 the peak run-off in mud flow is otabined as follows.

Qp 1.5-year = 55.0 m^3/sec

Qp 50-year = 192.5 m^3/sec

3.3 Height of Spur Dike

1) Practicable river width

In the proposed area for retarding basin, streams form no definite channel section. Therefore, practicable river width is estimated by eq. 2.6 and Fig. 2.2 as previously presented. In this case, assuming that river width is formed by dominant flow, it is calculated by applying 1.5-year probable flood.

$$B = 4 \times 55.0^{1/2} = 29.7 \doteqdot 30 \text{ m}$$

2) Design high water level

Assuming the river width of 30 m calculated above and rectangular section of river channel, the approximate water depth at the time of design flood will be calculated by applying Manning's formula.

$$h = \left(\frac{n \cdot Q}{B \cdot I^{1/2}}\right)^{3/5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

where,
- h : water depth (m)
- n : Manning's roughness coefficient
- Q : run-off (m^3/sec)
- B : river width (m)
- I : river bed slope

Substituting the values previously calculated, water depth is obtained as:

$$h = \left(\frac{0.045 \times 192.5}{30 \times 0.0625^{1/2}}\right)^{3/5} = 1.09 \text{ m}$$

3) Height of spur dike

In the proposed area, the stream has no definite flow direction. Besides, severe river bed variation is anticipated by scouring and deposition. Therefore, the height of spur dikes is taken at 3.0 m above ground surface taking enough allowance. Foundation of spur dikes will be designed to reach 1 m depth or more below ground surface. Thus the height of spur dike will be 4.0 m at lowest.

3.4 Foot Protection

As mentioned above, the river bed is anticipated to be scoured severely by flood. To prevent damage from scouring, a foot protection concrete block will be provided close to the base of the dike.

In this case, the volume of concrete block will be calculated based on the tractive force of the stream and thrust force.

1) Tractive force

The tractive force of stream is calculated using the following equation:

$$\tau = \rho \cdot g \cdot R \cdot I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.2)$$

where, τ : tractive force ($ton \cdot m/sec^2$)
ρ : density of water (ton/m^3)
g : acceleration of gravity (m/sec^2)
R : hydraulic radius (m)
I : slope of river bed

The density of water will be calculated considering mud flow, using concentration of mud flow. From preceeding calculations, mud flow concentration, $C = 0.138$. This gives, $\rho = 1.0958 \doteqdot 1.1$.

Assuming the channel cross section is rectangle, hydraulic radius is assumed to be equal to the water depth. Substituting the above values in eq. (3.2), $\rho = 1.1 \times 9.8 \times 1.09 \times 0.0625 = 0.7344$ $ton.m/sec^2$

2) Critical tractive force

By Iwagaki's Formula, the relation between diameter of river bed materials and critical tractive force is shown in the following expression.

$$
U_*^2c = \left.\begin{array}{ll} 80.9 \cdot d & d > 0.303 \\ = 134.6 \cdot d^{33/21} & 0.118 \leqq d \leqq 0.303 \\ = 55.0 \cdot d & 0.0565 \leqq d \leqq 0.118 \\ = 8.41 \cdot d^{11/32} & 0.0065 \leqq d \leqq 0.0565 \\ = 226 \cdot d & d < 0.0065 \end{array}\right\} \quad \cdots\cdots\cdots \quad (3.3)
$$

$$
U_* = \sqrt{\tau/\rho} \quad \cdots\cdots\cdots \quad (3.3')
$$

where, U_*c : critical friction velocity (cm/sec)
d : diameter of material (cm)
U_* : friction velocity (cm/sec)

The critical diameter of river bed material corresponding to the above tractive force is calculated by the following equation;

$$
0.7344 \times 10^4 \times \frac{1}{1.1} = 80.9 \cdot d
$$

$$
d = 83 \text{ cm} = 0.83 \text{ m}
$$

in terms of weight, this diameter is equivalent to $4/3 \times \pi \times (\frac{0.83}{2})^3 \times 2.5 = 0.748$ tons.

3) Thrust force

The thrust force for block is expressed in the form.

$$
F = C_o \cdot W_o \cdot \varepsilon \cdot S \cdot \frac{V_2}{2g} \quad \cdots\cdots\cdots \quad (3.4)
$$

where, F : thrust force (ton)
C_o : coefficient of drag (= 1.0)
W_o : density of water (≒ 1.1) (ton/m^3)
ε : coefficient of correction (= 1.0)
S : surface area of block against flow (m^3)
V : velocity of flow (m/sec)
g : acceleration of gravity (= 9.8 m/sec^2)

The velocity of flow is calculated by using Manning's Formula expressed below.

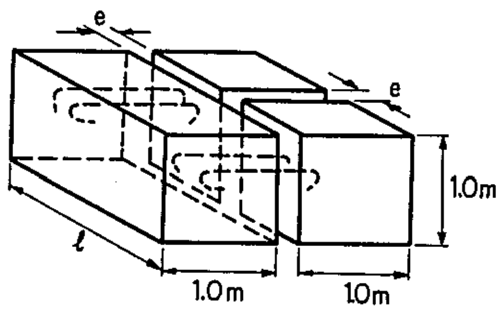
$$V = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2}$$

$$= \frac{1}{0.045} \times 1.09^{2/3} \times 0.0625^{1/2}$$

$$= 5.88 \text{ m/sec}$$

The surface area against the flow is taken as 2 m^2 assuming the shape of concrete block shown in Fig. 3.1.

Fig. 3.1 Concrete Block for Foot Protection



Substituting above values to eq. (3.4), the thrust force is calculated as

$$F = 1.0 \times 1.1 \times 1.0 \times 2 \times \frac{5.88^2}{2 \times 9.8}$$

$$= 3.881 \text{ tons}$$

On the other hand, the resisting force of concrete block is calculated by the following equation.

$$R = \tan \phi \left(1 - \frac{W_o}{W_c}\right) W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.6)$$

where, R : resisting force of block

ϕ : friction angle between block and river bed

W_o : density of water (= 1.1)

W_c : density of concrete (= 2.4)

W : weight of concrete block

Letting ϕ be 35^o, eq. (3.6) is changed as below.

$$R = \tan 35^o \left(1 - \frac{1.1}{2.4}\right) W = 0.379W$$

Therefore, the weight of concrete block is given as follows assuming that the resisting force of block is equal to the thrust force of flow.

$$0.379W = 3.881$$

$$W = 10.24 \text{ tons}$$

Now, taking ℓ=3.0m and e=0.3m in Fig. 3.1, the weight of concrete block comes to 27.36 tons as calculated below and it is enough to resist the thrust force of flow.

$$W = \left\{ 2 \times 3 + 2 \times 1.35 \times 2 \right\} \times 2.4 = 27.36 \text{ tons}$$

IV. RIVER CANALIZATION

4.1 General

The river canalization will be adopted for the lower reaches of the Pawa-Burabod river. The topographic condition of the basin and the principal features of the river canalization are summarized below.

Topography

Drainage area	10.5 km^2
River length	11.0 km for total length of the Pawa-Burabod river
Average river bed slope	1 : 15 for whole river length
River bed slope	1/43 to 1/17 for the reaches subject to canalization

River channel

Length	2,800 m
Channel width	60 m
River bed slope	1/28.1 - 1/17.5

Levee

Type	Sand and gravel fillwwith slope protection by wet masonry wall
Length	
Left bank - Total	2,799 m
- Existing	1,447 m
- New	1,352 m
Right bank - Total	2,808 m
- Existing	204 m
- New	2,604 m
Embankment volume	62,800 m^3
Wet masonry wall	3,956 m

Cribworks

Type	Log crib filled by cobble stone
Size and arrangement	Three lines with crib of 2.0m long x 2.0m wide x 0.8m depth
Total no. of cribs	6,993 nos.

Groundsills

Type	Type A	Log crib, 2.0m long x 2.0m wide x 0.8m depth filled by cobble stone
	Type B	Cross concrete block, 2.0m long x 2.0m wide x 0.8m depth
Number of groundsill		
	Type A	9 nos.
	Type B	2 nos.
Number of blocks		
	Type A (crib)	970 nos.
	Type B (concrete block)	305 nos.

4.2 Flood Analysis

1) General

Since no run-off data are available in the lower Pawa-Burabod river, probable flood is estimated from rainfall data. The calculation method is the same as applied in the previous chapters.

The probable flood is estimated herein about 1.01-yr., 1.5-yr., 5-yr., 10-yr., 30-yr. and 50-yr. flood respectively. These floods are utilized for the analysis of sediment load and practicable river width and the 50-yr. flood will be applied as the design flood of river canalization and the related structures.

The flood calculation will be made hereunder at the selected three base points as shown in Fig. 4.1, i.e.

No. 1 B.P	At the junction of the Yawa river and the Pawa-Burabod river for the drainage area of the main Yawa

No. 2 B.P	At the junction of the Yawa river and the Pawa-Burabod river for the drainage area of the Pawa-Burabod river
No. 3 B.P	River mouth of the main Yawa river

2) Drainage area

Drainage area at each base point is estimated as shown in Table 4.1.

Table 4.1 Drainage Area

Base Point	Drainage Basin	Drainage Area (km^2)
No. 1	No. I	53.5
No. 2	No. II	10.5
No. 3	No. III	6.0 (Sub-basin)
No. 3	No. I,II,III	70.0 (Total)

3) Run-off coefficient

Run-off coefficient in each divided sub-basin is estimated below considering topography, geology and land use.

Table 4.2 Run-off Coefficient

Drainage Basin	Basin Area	Run-off Coefficient	Remarks
No. I	53.5	0.6	Farm land
No. II	10.5	0.7	Mountaneous area
No. III	6.0	0.6	Farm land
Total	70.0	0.62	Weighted

4) Time of flood concentration

Time of flood concentration is calculated by Kraven's formula as previously presented. The results of calculation are summarily shown below.

Table 4.3 Time of Flood Concentration

Base Point	L (m)	I	V (m/s)	t (min.)
No. 1	15,500	1/40	3.5	75
No. 2	11,000	1/15	3.5	50
No. 3	18,000	1/50	3.5	85 (Total)

5) Average rainfall intensity in a period of "Time of Flood Concentration"

By using Ito's formula previously presented, rainfall intensity is calculated for each return period at every site. The results of calculation are shown below.

Table 4.4 Average Rainfall Intensity in a Period of "Time of Flood Concentration"

Return Period (year)	24 (mm)	r (mm/hr) Point No. 1 (t=75 min.)	Point No. 2 (t=50 min.)	Point No. 3 (Total) (t=85 min.)
1.01	80	15	16	14
1.5	160	30	32	29
5	290	54	59	52
10	360	67	73	65
30	490	91	99	88
50	560	104	113	101

6) Peak run-off

Peak run-off is calculated by Rational formula by applying the values obtained above. The results are as summarized below.

Table 4.5 Calculation of Peak Discharge

Return Period (year)	Peak Discharge : Q (m^3/sec) Specific Discharge : q (m^3/sec/km^2) Point No. 1 (f=0.60) (A=53.5 km^2) (t=75 min.)	Point No. 2 (f=0.70) (A=10.5 km^2) (t=50 min.)	Point No. 3(Total) (f=0.62) (A=70.0 km^2) (t=85 min.)
1.01	140 (2.62)	40 (3.81)	170 (2.43)
1.5	270 (5.05)	70 (6.67)	350 (5.00)
5	490 (9.16)	130 (12.38)	630 (9.00)
10	600 (11.21)	150 (14.29)	790 (11.29)
30	820 (15.33)	210 (20.00)	1,070 (15.29)
50	930 (17.38)	240 (22.86)	1,220 (17.43)

The 50-year probable flood is used as the design flood for the Pawa-Burabod river. The calculated value will be appropriate comparing with the Japanese standard which are represented by the relation between the drainage area and specific discharge shown in Table 4.6.

Table 4.6 Relation between Drainage Area and Specific Discharge

Drainage Area (km^2)	0-5	5-10	10-20	20-40	40-60	60-80	80-100
Specific Discharge (m^3/sec/km^2)	28	25	20	15	12	10	8

The 1.5-year probable flood is used for the study of sediment discharge capacity in the Yawa river and the Pawa-Burabod river assuming that such scale of flood is dominant to form a river channel or to be approximately such average run-off as to give average sediment discharge during a hydrological year, so called dominant flow, which is shown in the figures from Fig. 4.39 to Fig. 4.47.

4.3 Sediment Study

1) Sediment in the Yawa River

Aiming at grasping the sediment balance in the main Yawa river and the Pawa-Burabod river, sediment discharge in the Yawa river will firstly be estimated at the point of junction of the Yawa river and the Pawa-Burabod river.

The sediment discharge is calculated by using Brown's formula below.

$$\frac{Qs}{U_* \cdot dm \cdot T} = K \left\{ \frac{U_*^2}{(\sigma/\rho - 1) \cdot g \cdot dm} \right\}^2 \qquad \text{(4.1)}$$

where,

- Qs : sediment discharge (m^3/sec)
- U_* : friction velocity (m/sec)
  $U_* = \sqrt{gRI}$
- g : acceleration of gravity (9.8 m/sec^2)
- R : hydraulic radius (m)
- I : river bed slope
- dm : mean diameter of river bed materials (d65 = 0.001 m)
- T : river width (m)
- K : constant (=1.0)
- σ: density of river bed materials (2.5 g/cm^3)
- ρ: density of water (1.0 g/cm^3)

Eq. 4.1 can be rewritten by substituting the above figures as follows:

$$Qs = 1,390\,(RI)^{2.5} \cdot T \qquad \text{(4.2)}$$

By using eq. (4.2), the sediment discharge was calculated as shown in Table 4.7 and 4.20.

Table 4.7 Sediment Discharge in the Yawa River

	1.5-year Probable Flood	Sediment Discharge at 1.5-year Probable Flood (average)
Yawa river upstream	270 m^3/sec	0.40 - 0.49 (0.45)
Yawa river downstream	340 "	0.65 - 1.20 (0.92)
Difference		(0.47)

*Figures in ( ) show the average.

2) Sediment discharge in the Pawa-Burabod river

By applying the same calculation method and equation, the sediment discharge is also calculated at several points along the Pawa-Burabod river. The results of calculation is as follows:

Table 4.8 Sediment Discharge in the Pawa-Burabod River
(1.5-year probable flood 70 m^3/sec)

Station	Sediment Discharge
Sta. 0 + 100	1.5 m^3/sec
0 + 200	1.9
0 + 300	1.7
0 + 400	1.7
0 + 500	1.3
0 + 600	1.6
0 + 700	1.6
0 + 900	1.7
1 + 000	1.5
1 + 100	1.4
1 + 300	1.6
1 + 500	2.4
1 + 600	7.2
1 + 700	3.0
1 + 800	6.6
1 + 900	5.7
2 + 000	7.2

Station	Sediment Discharge
Sta. 2 + 100	3.1 m^3/sec
2 + 200	2.9
2 + 400	5.4
2 + 500	5.8
2 + 600	5.4
2 + 700	5.1
2 + 800	5.0
Average	3.42
Range	1.2 - 7.3

3) Consideration

Sediment discharge at 1.5-year probable flood at the Yawa river and the Pawa-Burabod river are summarized below.

Table 4.9 Summary of Sediment Discharge

Rivers	Sediment Discharge
Pawa-Burabod river	1.2 - 7.3 (3.42)
Yawa river	
Downstream from junction	0.65 - 1.20 (0.92)
Upstream from junction	0.40 - 0.49 (0.45)

From the above, the following can be supposed:

1. The difference of sediment discharges between the upstream Yawa and downstream Yawa is about 0.47.

2. Sediment discharge in the Pawa-Burabod is considerably larger than that in the Yawa river.

3. Therefore, theoretically, the allowable sediment discharge to the Yawa river is 0.47 while the present sediment discharge there is 3.42.

4. Therefore, the upper Sabo works in the Yawa river is needed.

The above calculation gives only suggestive figures or qualitative characteristics, since sediment problems are very much complicated and difficult to be clarified in quantitative.

4.4 Discharge Capacity of the Present Pawa-Burabod River

Discharge capacity of the Pawa-Burabod river under the present condition is estimated at several points along the river course. The discharge capacity is calculated by non-uniform flow calculation method.

$$\frac{Q^2}{2gA_1^2} + H_1 + \frac{n^2Q^2\ell}{2}\left(\frac{1}{A_1^2R_1^{4/3}} + \frac{1}{A_2^2R_2^{4/3}}\right) = \frac{Q^2}{2gA_2^2} + H_2$$

where, Q : discharge (m^3/sec)
g : gravity acceleration (9.8 m/sec^2)
A : flow area (m^2)
H : water level (m)
n : coefficient of roughness (= 0.045)
ℓ : distance (m)
R : hydraulic radius (m)
Suffix 1 : downstream section
Suffix 2 : upstream section

Based on the surveyed cross section, and profiles, the discharge capacity is calculated as shown below.

Table 4.10 Discharge Capacity of Present River Condition

Station	Critical Discharge Capacity	Discharge Capacity at Water Level with 1 m Allowance
Sta. 0 + 100	more than 500 m^3/sec	more than 500 m^3/sec
0 + 200	"	410
0 + 300	"	190
0 + 400	"	more than 500
0 + 500	360	80
0 + 600	290	80
0 + 700	250	50
0 + 900	320	100
1 + 000	400	90
1 100	170	40
1 + 300	250	30
1 + 500	0	0
1 + 600	130	10
1 + 700	120	10
1 + 800	400	100
1 + 900	320	160
2 + 000	320	100
2 + 100	220	30
2 + 200	200	10
2 + 400	210	30
2 + 500	more than 500	more than 500
2 + 600	"	"
2 + 700	"	"
2 + 800	"	"
more upstream	inundated	inundated

Since 50-year probable flood is 240 m^3/sec, the river reach between Sta. 1 + 100 and Sta. 2 + 400 has less capacity, and the more upstream reaches from Sta. 2 + 800 has no any discharge capacity because of no definite river channel there, and inundation has been frequently occurred.

4.5 Design of River Channel

The river channel will be canalized between Sta. 1 + 100 and Sta. 3 + 900.

1) Channel width

The practicable river channel width is calculated by the following empirical formula.

$$B = 3.5 \sim 7.0 \sqrt{Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.4)$$

where, B : practicable river width (m)
Q : run-off (m^3/sec)

Assuming that dominant flow to form a river bed is 1.5-year flood (70 m^3/sec), the practicable river channel width is calculated at 29-59 m. If the designed flood, 50-year probable flood (240 m^3/sec) is applied, the practicable river width is calculated at 54 m to 108 m.

The present river width varies from about 30 m to 100 m, 60 m on an average. From the above considerations, the designed river width is taken at 60 m.

2) Equilibrium bed slope

If allowable sediment discharge, which may be discharged out into the Yawa river from the Pawa-Burabod river, is taken for the design sediment discharge for the Pawa-Burabod river, the equilibrium bed slope is calculated by the following formula.

$$H = \left(\frac{nQ}{\sqrt{I}\ T} \right)^{3/5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.5)$$

and

$$Qs = 1{,}390\ (HI)^{2.5} T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.6)$$

From the above two equations, Qs is rewritten as follows:

$$Qs = 1,390\ n^{1.5}\ Q^{1.5}\ I^{1.75}/T^{0.5}$$

where, n=0.045 T=50 m to be assumed

$$Qs = 1.88\ Q^{1.5} \times I^{1.75}$$

$$Is = 0.7\ Qs^{0.57}/Q^{0.86} \quad \text{....................} \quad (4.7)$$

By using equation (4.7) the equilibrium river bed slope is calculated as follows.

Table 4.11 Equilibrium River Bed Slope

Flood	Peak Run-off	Allowable Sediment Load	Equilibrium River Bed Slope
1.5-year	70 m^3/sec	0.5 m^3/sec	1/82
50-year	240 "	1.8 "	1/114

From the above calculation results, the equilibrium river bed slope will be about 1/80.

3) River cross section

For the design discharge of 240 m^3/sec, and river width designed 60 m, the cross section is calculated by Manning's formula assuming the slope of revetment is 1:2.5. The results of calculation are summarily shown in Fig. 4.2 and Table 4.12.

4.6 Design of Levee

Existing levee has the following principal dimensions.

Crest width	5-7 m
Slope	1:0.6 - 1:1.8

According to the check calculation of stability such steep slope levee seems dangerous in case that heavy rain occurs and the embankment materials are saturated by rainwater. Therefore, the levee with more gentle slope is applied. Typical levee section is assumed as follows:

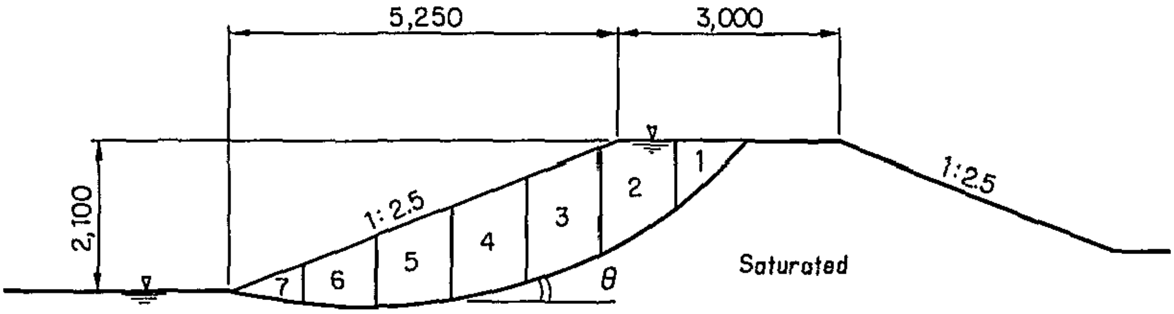
Crest width	3 m
Slope	1 : 2.5

Stability calculation of the typical design above is made by the circular arc method under the following conditions.

Density of embankment material	2.0 ton/m^3
Internal friction angle	$\phi = 35^o$

The calculation results are shown in Table 4.13.

Table 4.13 Stability Calculation of Levee



$$Fs = \frac{\Sigma W' \cos\Theta \tan\phi}{\Sigma W \sin\Theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.8)$$

where, $\gamma = \gamma sat = 2.0$ (ton/m^3)

$\gamma' = \gamma sat - 1.0 = 1.0$ (ton/m^3)

$\phi = 35^o$

No.	A (m^2)	θ (o)	W= γ·A (ton/m)	W'= γ'·A (ton/m)	tan ϕ	Wsinθ (ton/m)	W'cosθ x tanϕ (ton/m)
1	0.45	43	0.90	0.45	0.70	0.61	0.23
2	1.21	33	2.42	1.21	0.70	1.32	0.71
3	1.50	22	3.00	1.50	0.70	1.12	0.97
4	1.45	13	2.90	1.45	0.70	0.65	0.99
5	1.15	6	2.30	1.15	0.70	0.24	0.80
6	0.78	-4	1.56	0.78	0.70	-0.11	0.54
7	0.28	-10	0.56	0.28	0.70	-0.10	0.19
Total						3.74	4.44

$$Fs = \frac{4.44}{3.74} = 1.19$$

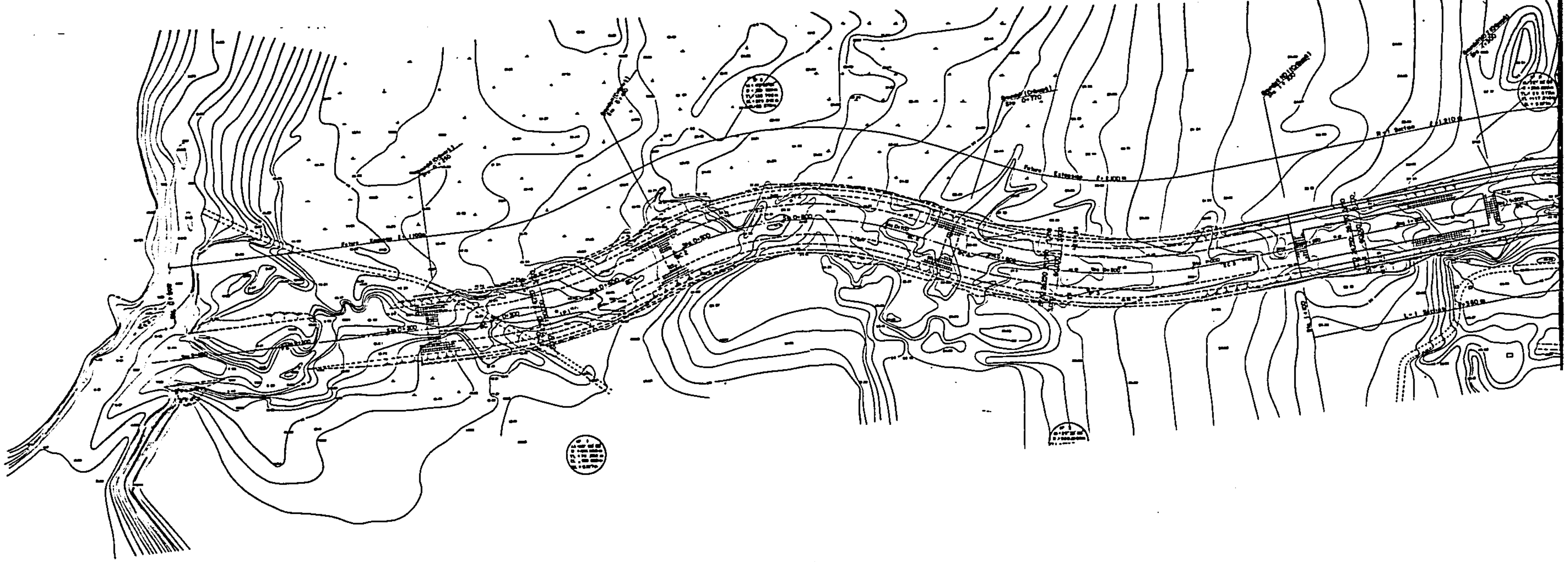


Fig. 1.1 General Plan of

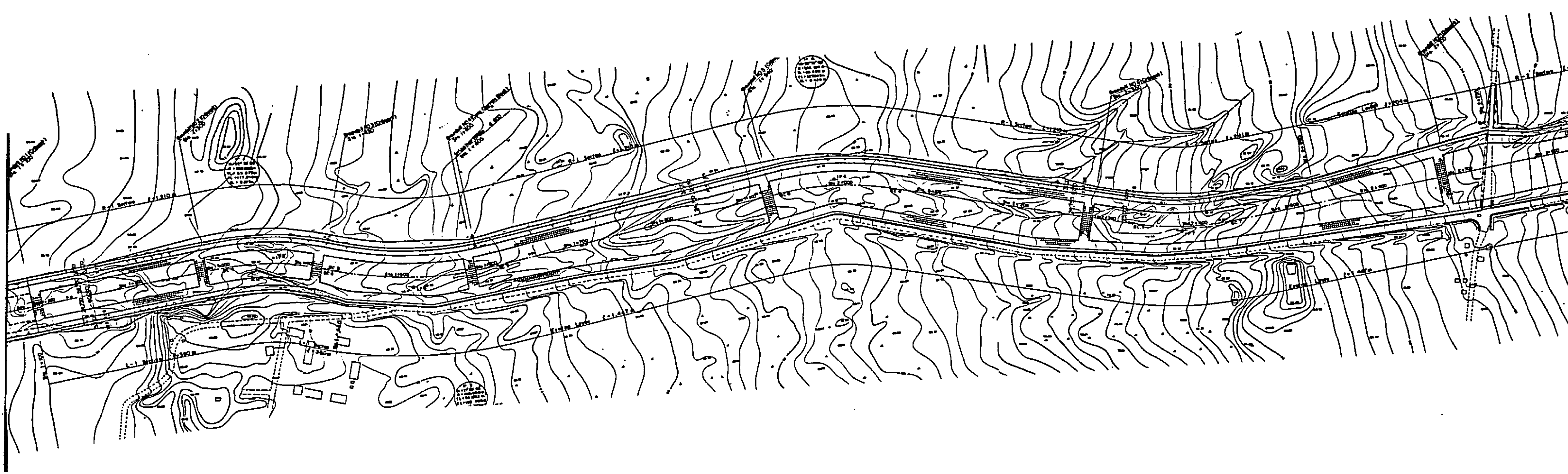
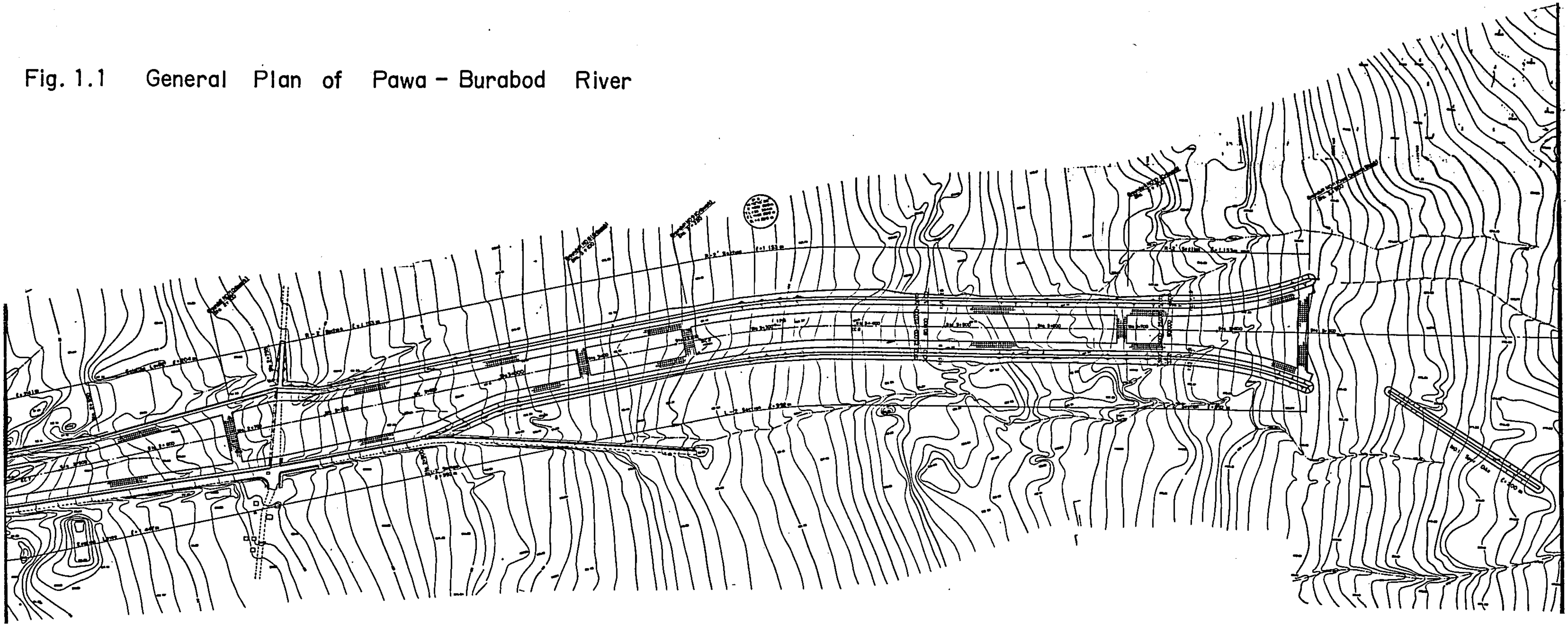
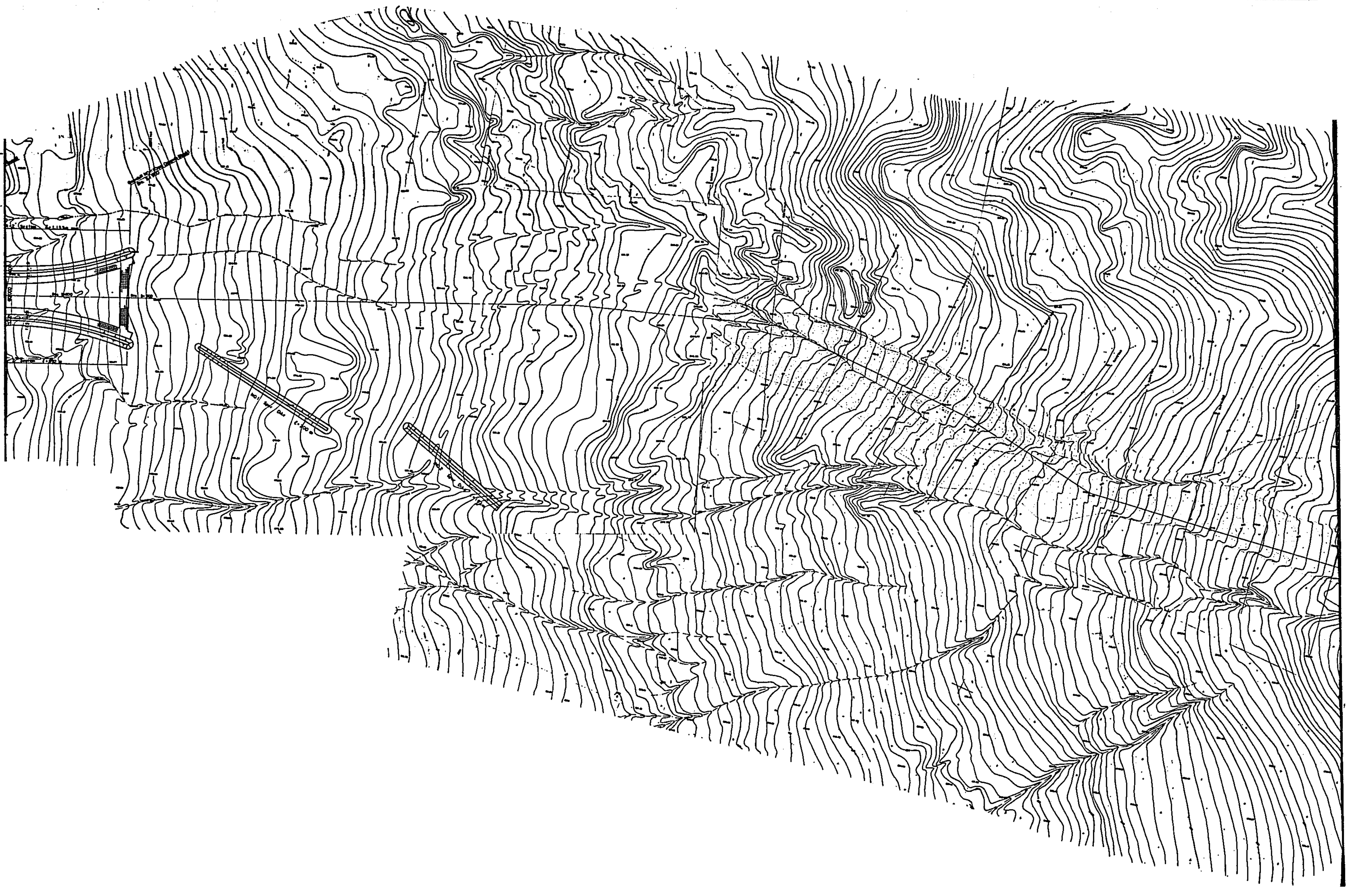
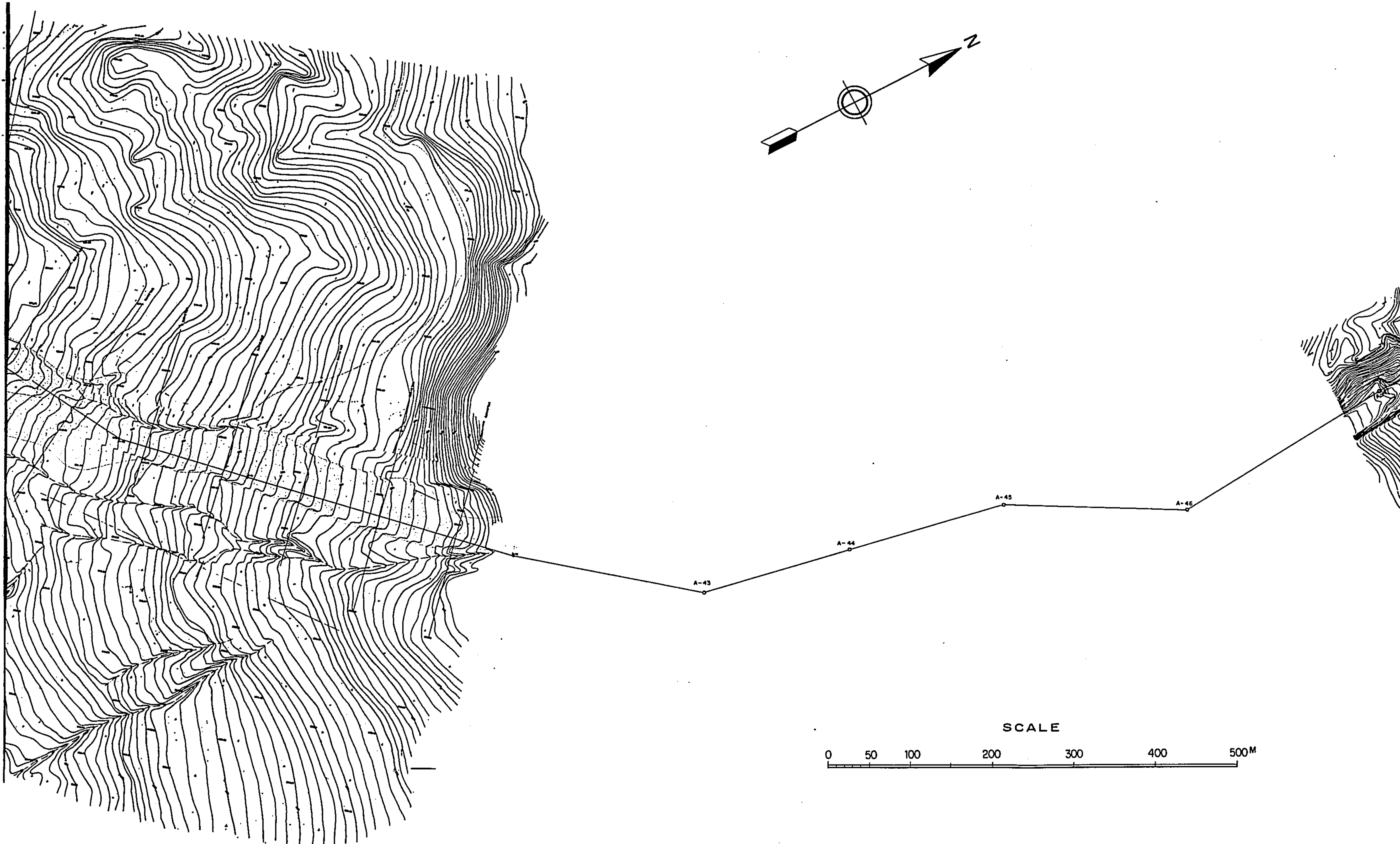


Fig. 1.1 General Plan of Pawa - Burabod River






N
A-43
A-44
A-45
A-46
SCALE
0 50 100 200 300 400 500M

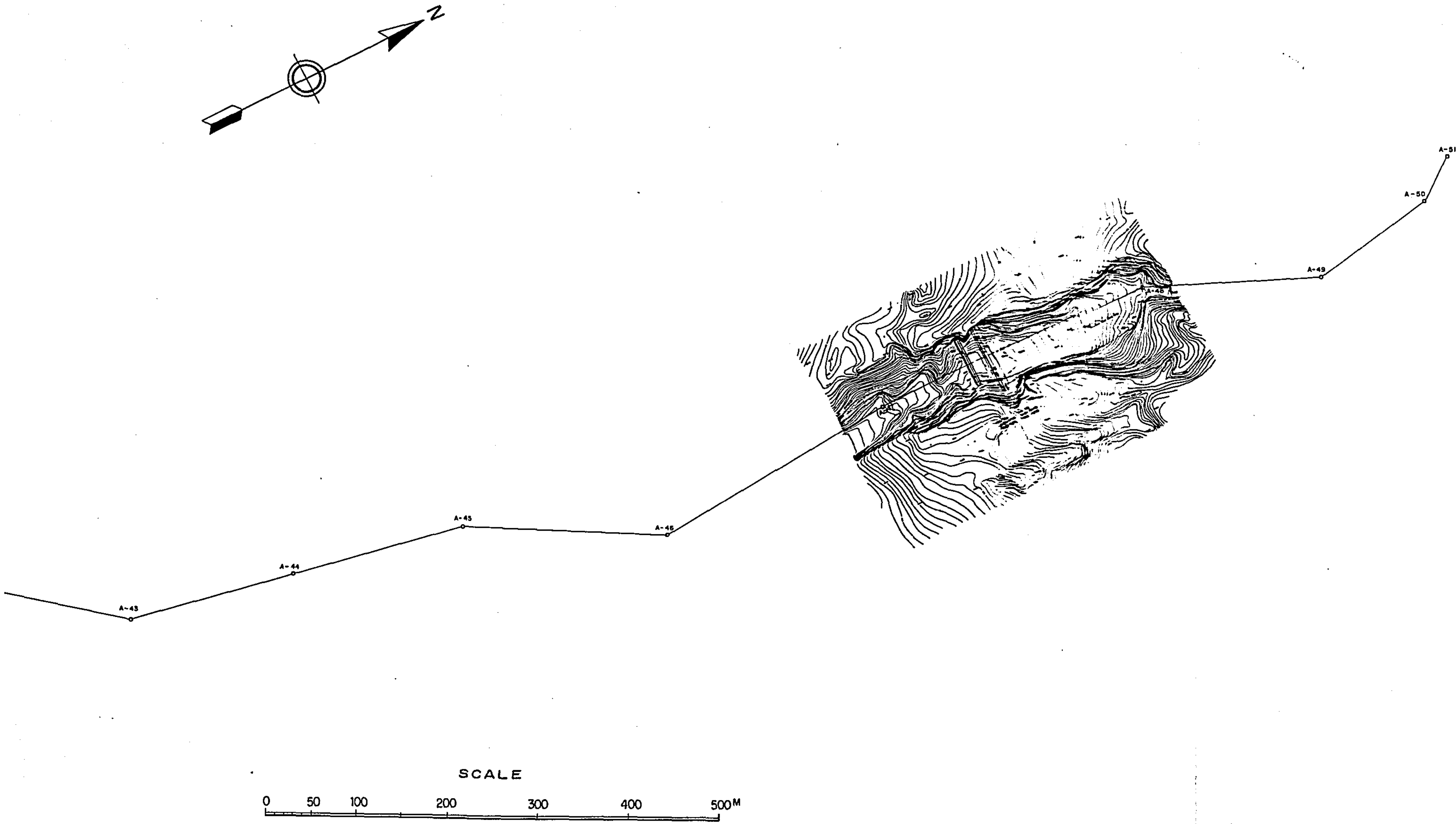
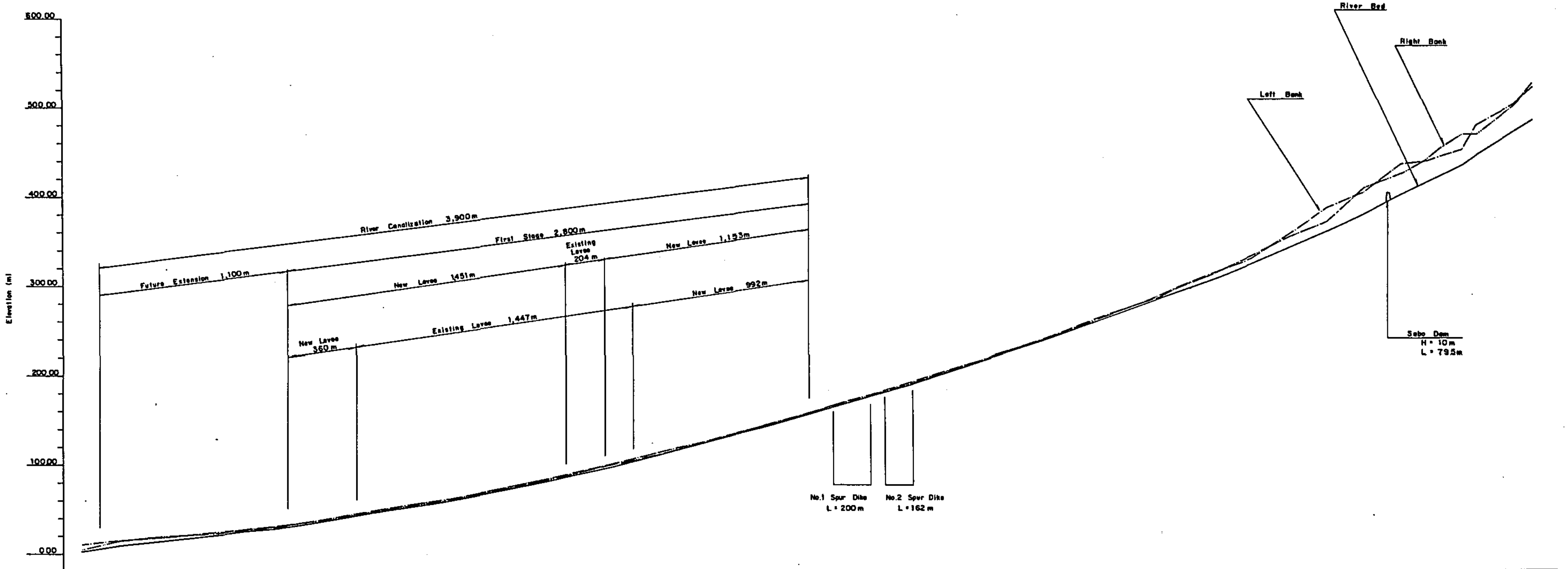

N
A-43
A-44
A-45
A-46
A-48
A-49
A-50
A-51
SCALE
0 50 100 200 300 400 500M

Fig. 1.2 Profile of Pawa - Burabod River



Existing River Bed Slope: 1/43, 1/27, 1/21, 1/17, 1/15, 1/13, 1/11, 1/9, 1/75

Existing Elevation	Right Levee (m)	Left Levee (m)	River Bed (m)
	5.72	10.48	2.52
	15.09	15.41	10.01
	18.98	16.72	14.63
	22.19	23.57	19.88
	26.40	26.85	24.35
	31.54	31.82	29.21
	36.33	36.30	34.93
	42.43	44.60	42.39
	50.90	51.51	49.37
	57.40	59.01	58.11
	65.08	65.78	63.47
	72.89	74.32	71.91
	81.94	83.49	79.99
	92.55	92.60	88.98
	101.48	102.04	98.85
	110.07	112.87	109.95
	121.24	122.08	121.22
	132.80	133.66	132.35
	143.87	143.72	142.59
	155.41	155.39	155.00
	169.12	168.00	167.13
	180.48	180.56	179.84
	192.90	193.97	191.15
	206.77	207.53	205.63
	219.64	219.37	218.55
	232.66	232.86	232.29
	247.88	248.10	248.26
	263.50	265.04	261.37
	278.83	278.85	278.18
	294.84	287.56	284.00
	295.91	298.58	290.85
	312.74	313.24	305.81
	331.47	328.67	322.83
	353.42	355.50	340.84
	369.60	385.72	358.74
	407.53	403.24	378.56
	423.80	434.58	400.27
	438.00	437.04	413.84
	450.55	443.23	–
	467.76	451.13	432.70
	467.76	478.34	444.42
	498.89	501.78	470.47
	525.74	518.91	483.70

Accumulated Distance (m)
0, 200, 400, 440, 600, 640, 800, 840, 1,000, 1,050, 1,200, 1,250, 1,400, 1,450, 1,600, 1,650, 1,800, 1,875, 2,000, 2,075, 2,200, 2,275, 2,400, 2,475, 2,600, 2,675, 2,800, 2,875, 3,000, 3,075, 3,200, 3,275, 3,400, 3,475, 3,600, 3,675, 3,800, 3,875, 4,000, 4,075, 4,200, 4,275, 4,400, 4,475, 4,600, 4,675, 4,800, 4,875, 5,000, 5,075, 5,200, 5,275, 5,400, 5,475, 5,600, 5,675, 5,700, 5,775, 5,800, 5,875, 6,000, 6,075, 6,200, 6,275, 6,400, 6,475, 6,600, 6,675, 6,800, 6,875, 7,000, 7,075, 7,200, 7,275, 7,400, 7,475, 7,600, 7,675, 7,775

Distance (m)
200, 200, 40, 160, 40, 160, 40, 160, 50, 150, 50, 150, 50, 150, 50, 150, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 25, 75, 25, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 125, 75, 100

Station No.
0+000, 0+200, 0+400, 0+600, 0+800, 1+000, 1+200, 1+400, 1+600, 1+800, 2+000, 2+200, 2+400, 2+600, 2+800, 3+000, 3+200, 3+400, 3+600, 3+800, 4+000, 4+200, 4+400, 4+600, 4+800, 5+000, 5+200, 5+400, 5+600, 5+800, 6+000, 6+200, 6+400, 6+600, 6+800, 7+000, 7+200, 7+400, 7+600, 7+800

Fig. 4.1

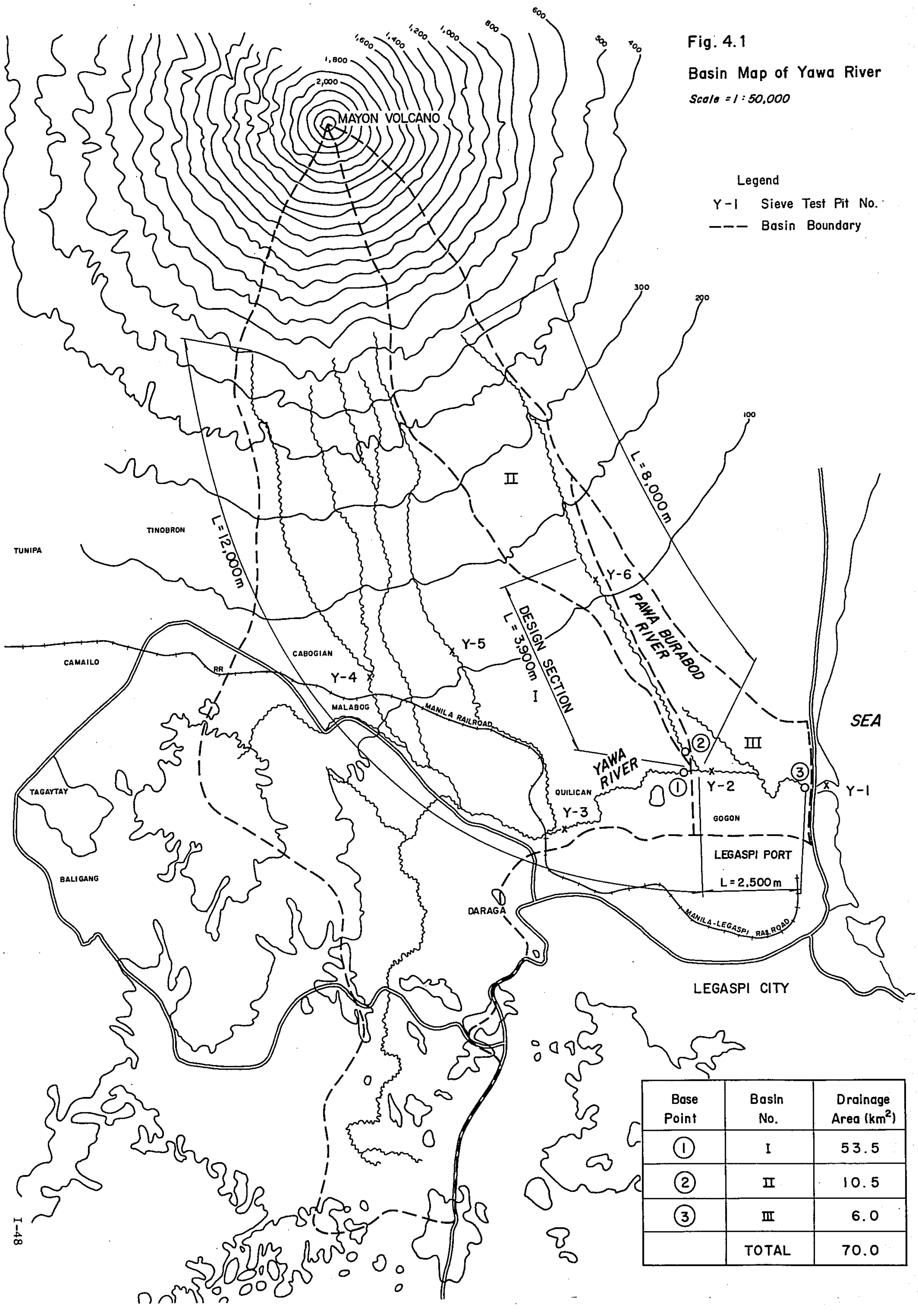
Basin Map of Yawa River

Scale = 1 : 50,000

Legend

Y-1 Sieve Test Pit No.

--- Basin Boundary



Base Point	Basin No.	Drainage Area (km^2)
①	I	53.5
②	II	10.5
③	III	6.0
	TOTAL	70.0

Fig.4.2 Present Condition of Pawa - Burabod River

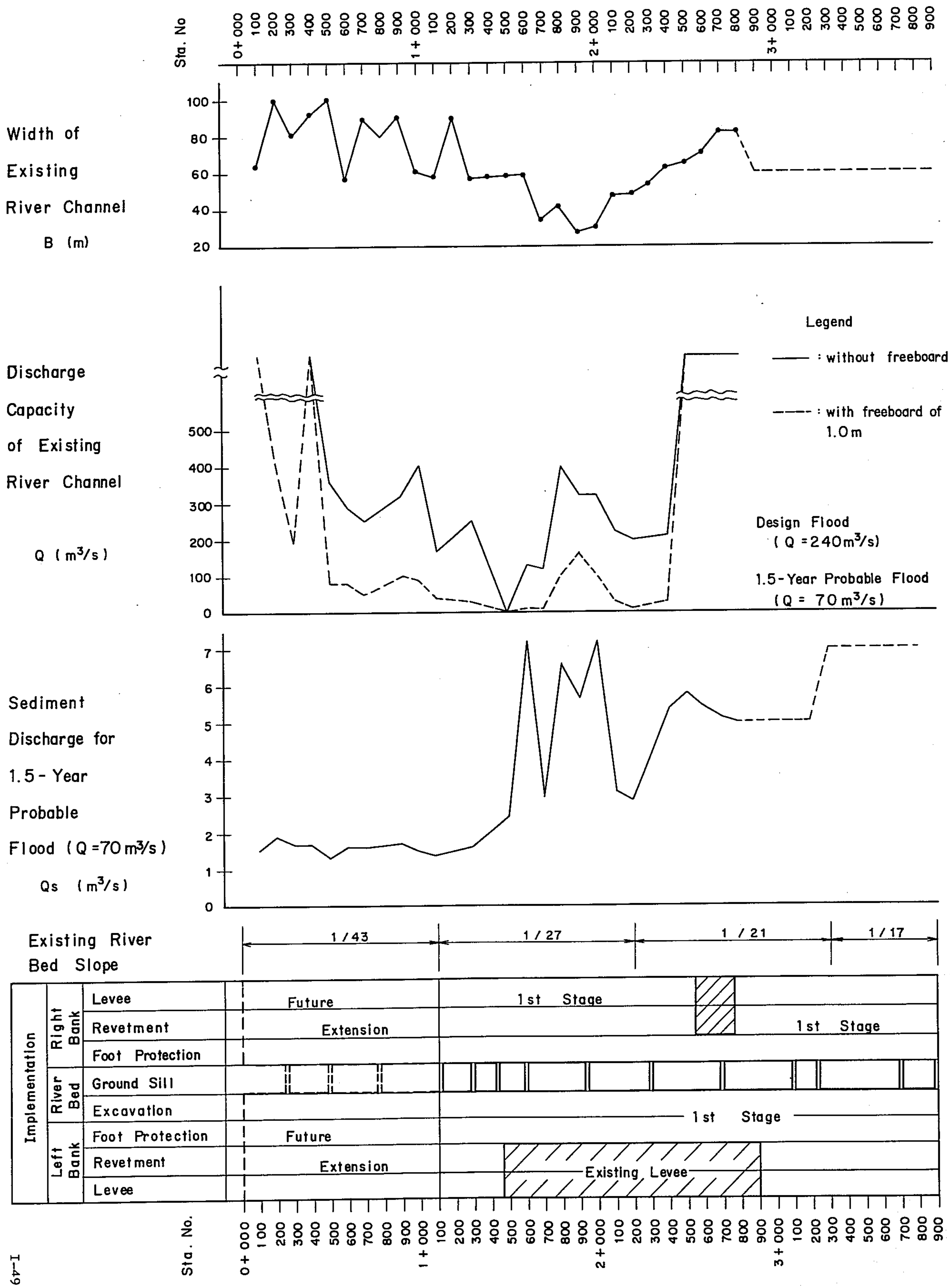


Fig. 4.3 Typical Cross Section VS = 1 : 100 HS = 1 : 500

Sta. 0 +000 ~ Sta. 1 + 100 (L = 1,100 m)

Sta. 1 + 100 ~ Sta. 2 +300 (L = 1, 200 m)

Sta. 2 + 300 ~ Sta. 3+700 (L = 1, 400 m)

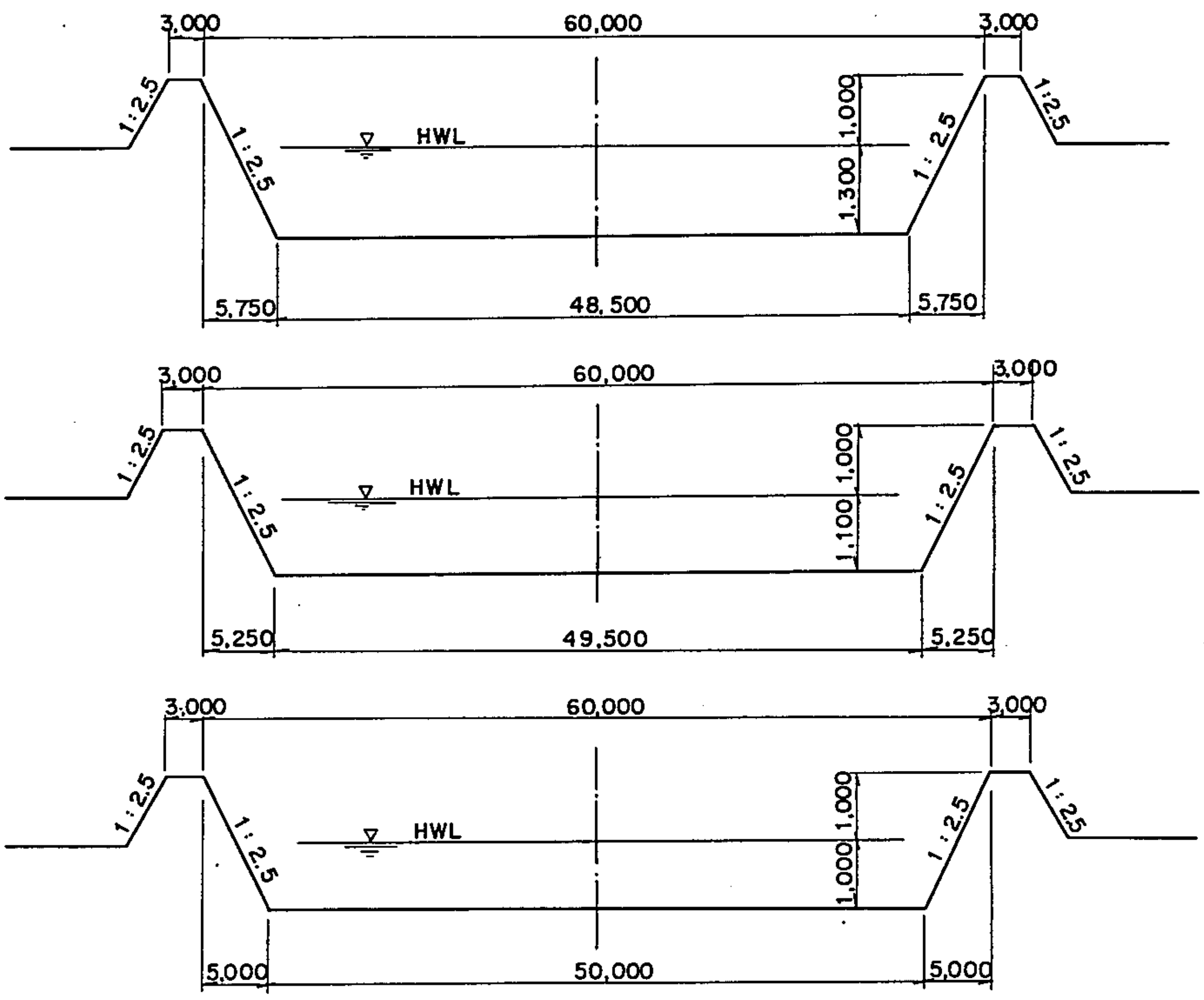


Table 4.12 Check of Discharge Capacity

Section \ Item	Design Flood Discharge Q (m³/sec)	Roughness Coefficient n	River Bed Slope I	Flow Area A (m)	Wetted Perimeter S (m)	Hydraulic Radius R (m)	Flow Velocity V (m/sec)	Calculated Discharge Qc(m³/sec)	Froude Number Fr	Remarks
Sta. 0 + 000 ~ Sta. 1 + 100	240	0.045	1 / 45.8	67.3	55.5	1.21	3.73	251	1.08	Super Critical Flow
Sta. 1 + 100 ~ Sta. 2 + 300	240	0.045	1 / 28.1	57.5	55.4	1.04	4.30	247	1.35	
Sta. 2 + 300 ~ Sta. 3 + 100	240	0.045	1 / 20.6	52.5	55.4	0.95	4.73	248	1.55	
Sta 3 + 100 ~ Sta. 3 + 700	240	0.045	1 / 17.5	52.5	55.4	0.95	5.13	269	1.68	

Fig. 4.4 Grain Size Distribution Curve of Yawa River Bed Materials

Location : Bogtong

Test Pit No : Y-1 (See Fig. 4.1)

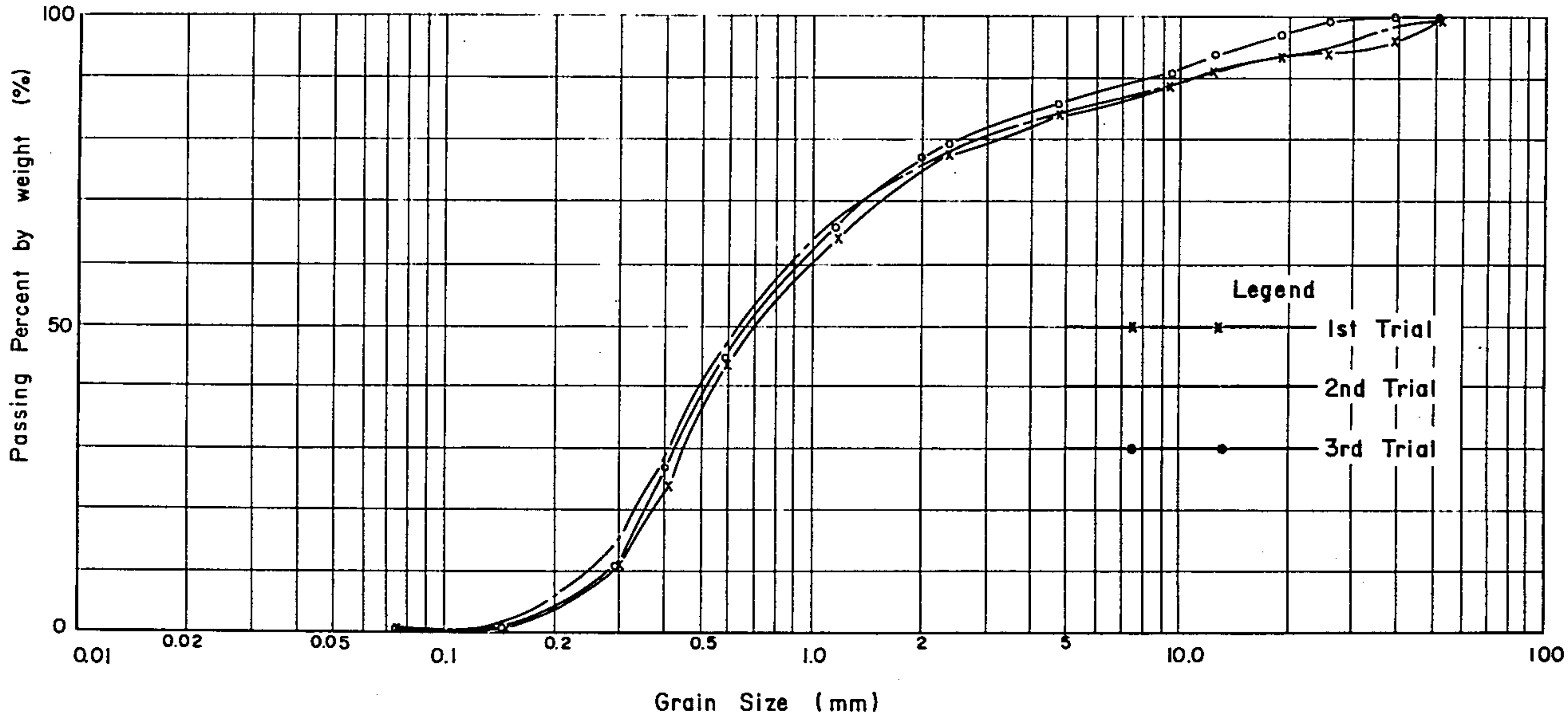


Fig. 4.5 Grain Size Distribution Curve of Yawa River Bed Materials

Location : Bogtong

Test Pit No : Y-2 (See Fig. 4.1)

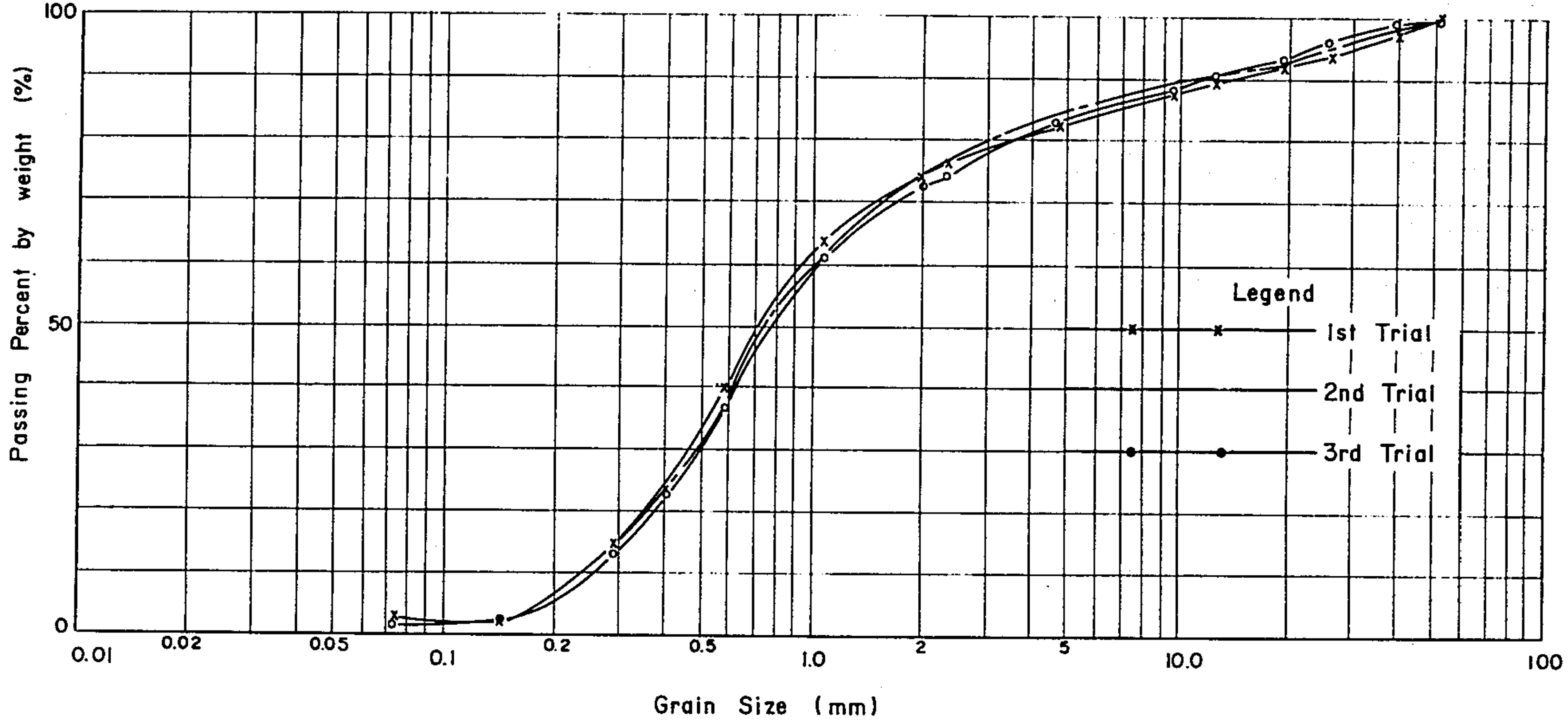


Fig. 4.6 Grain Size Distribution Curve of Yawa River Bed Materials

Location : Yawa

Test Pit No : Y-3 (See Fig. 4.1)

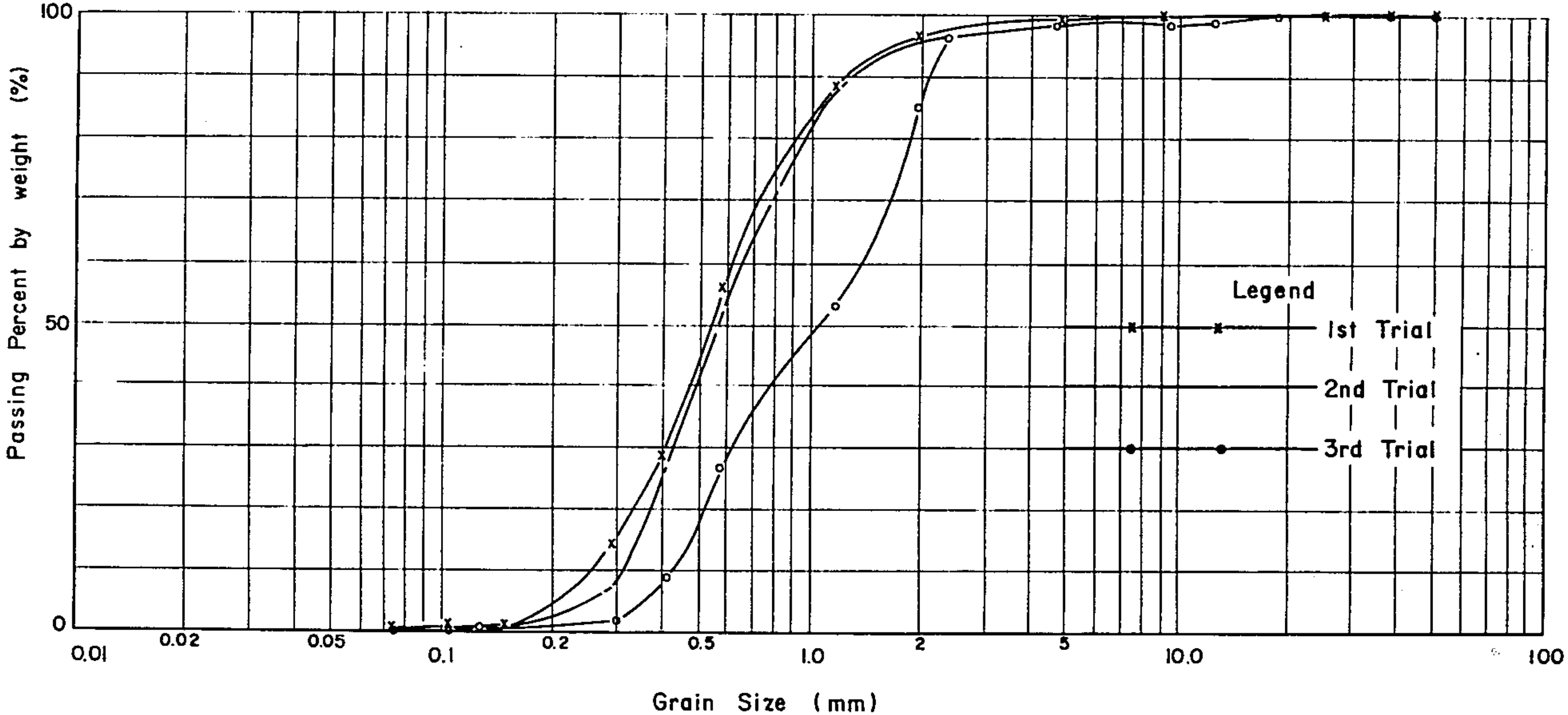


Fig. 4.7 Grain Size Distribution Curve of Yawa River Bed Materials

Location : Malabog

Test Pit No : Y-4 (See Fig. 4.1)

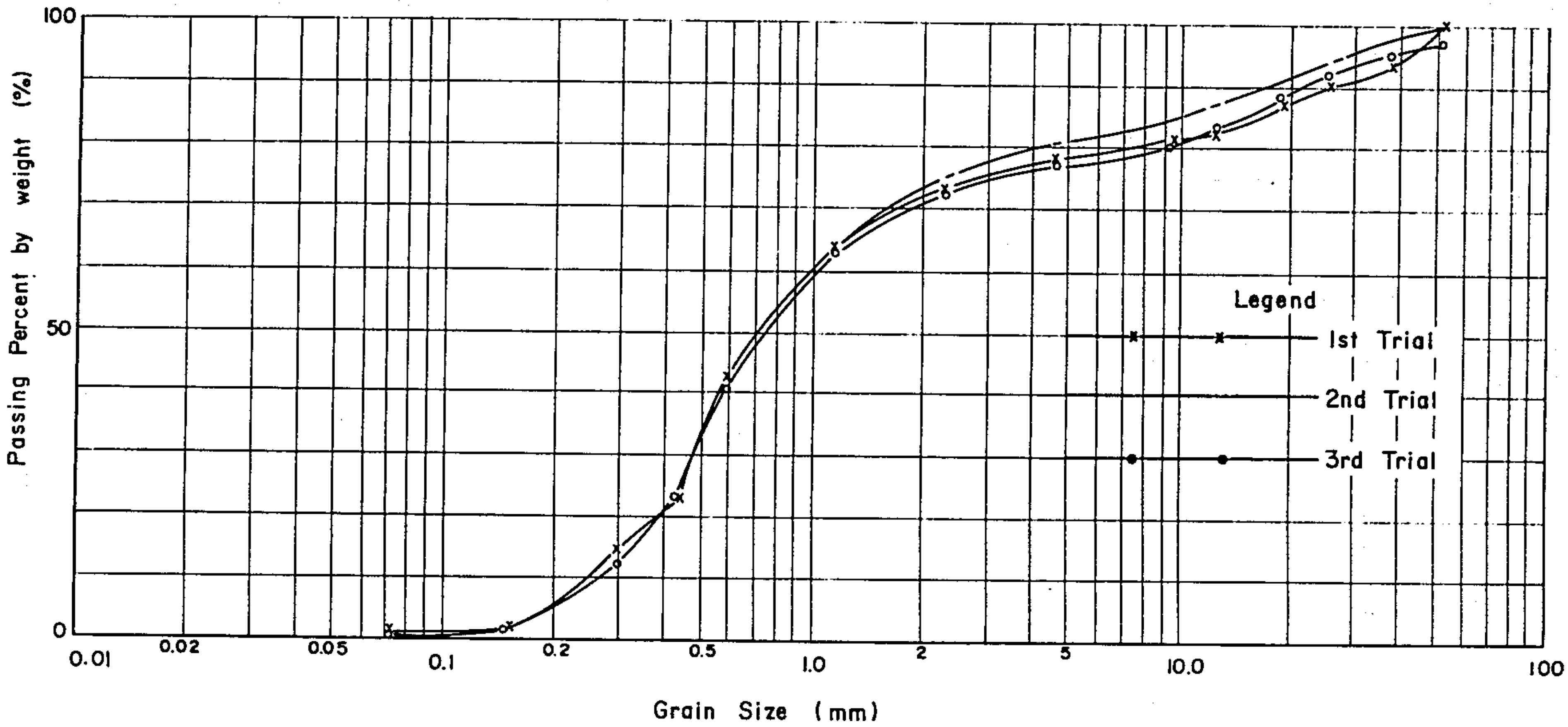


Fig. 4.8 Grain Size Distribution Curve of Yawa River Bed Materials

Location : Budiad

Test Pit No : Y - 5 (See Fig. 4.1)

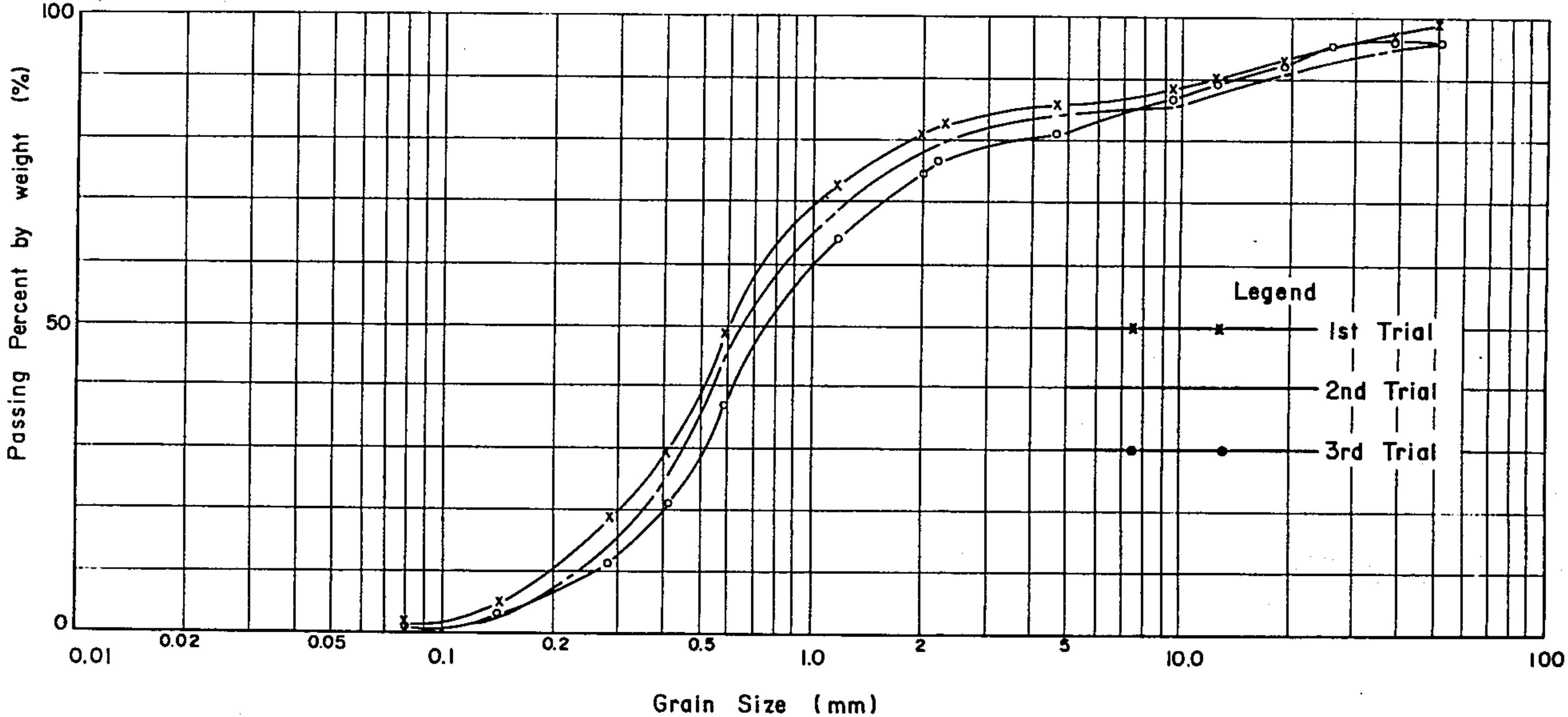


Fig. 4.9 Grain Size Distribution Curve of Yawa River Bed Materials

Location : Bonga

Test Pit No : Y-6 (See Fig. 4·1)

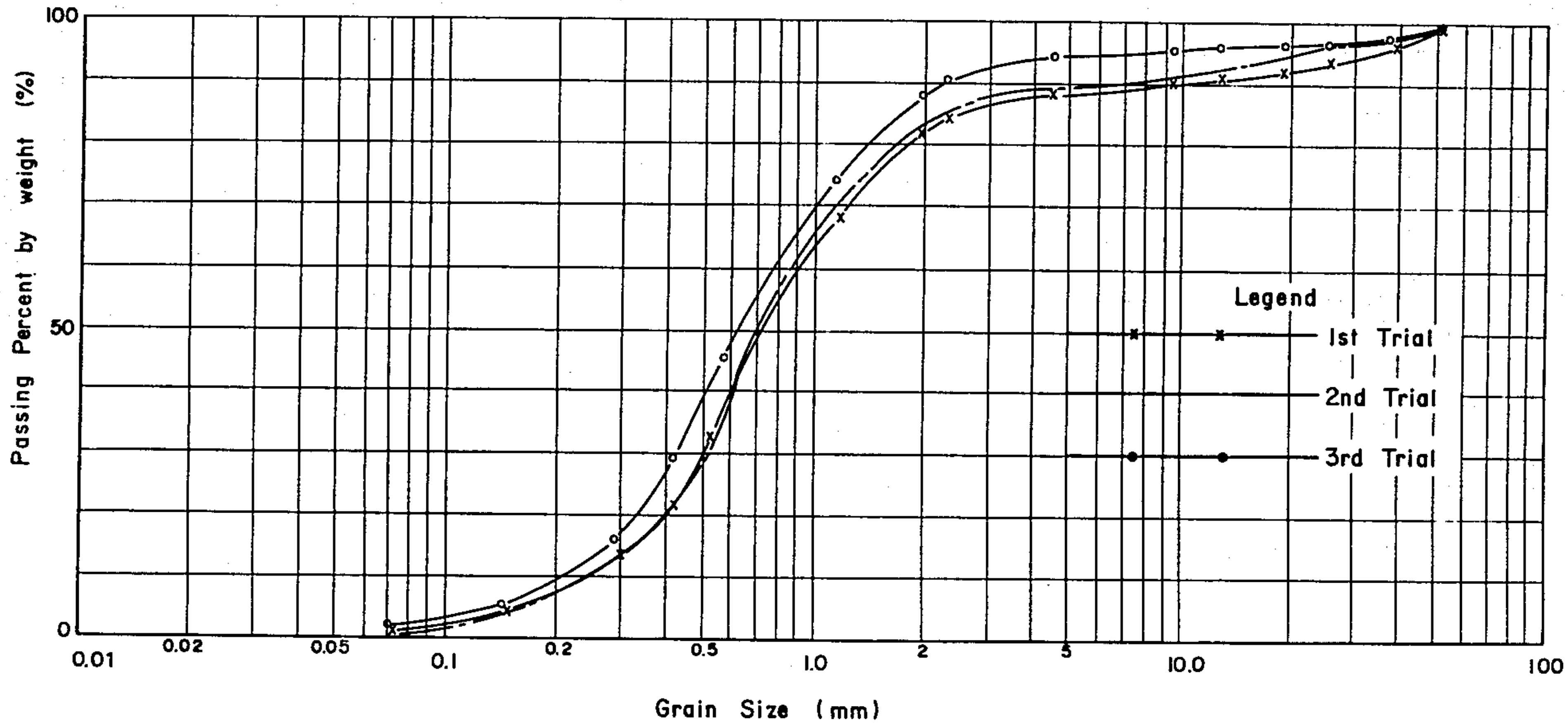


Fig.4.10 Profile of Main Yawa River

VS = 1 : 200
HS = 1 : 20,000

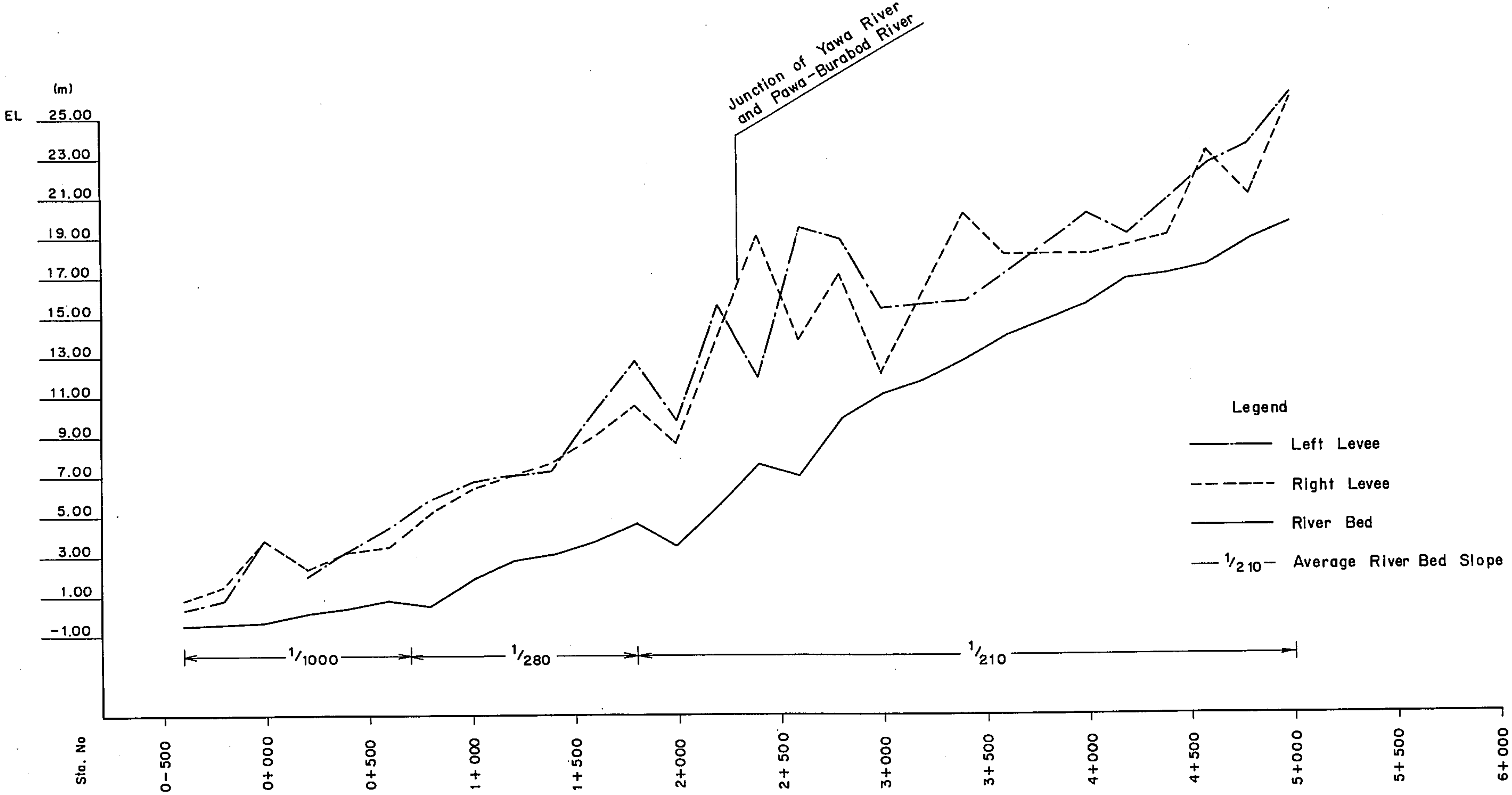


Fig.4.11 Cross Section of Main Yawa River S = 1 : 200

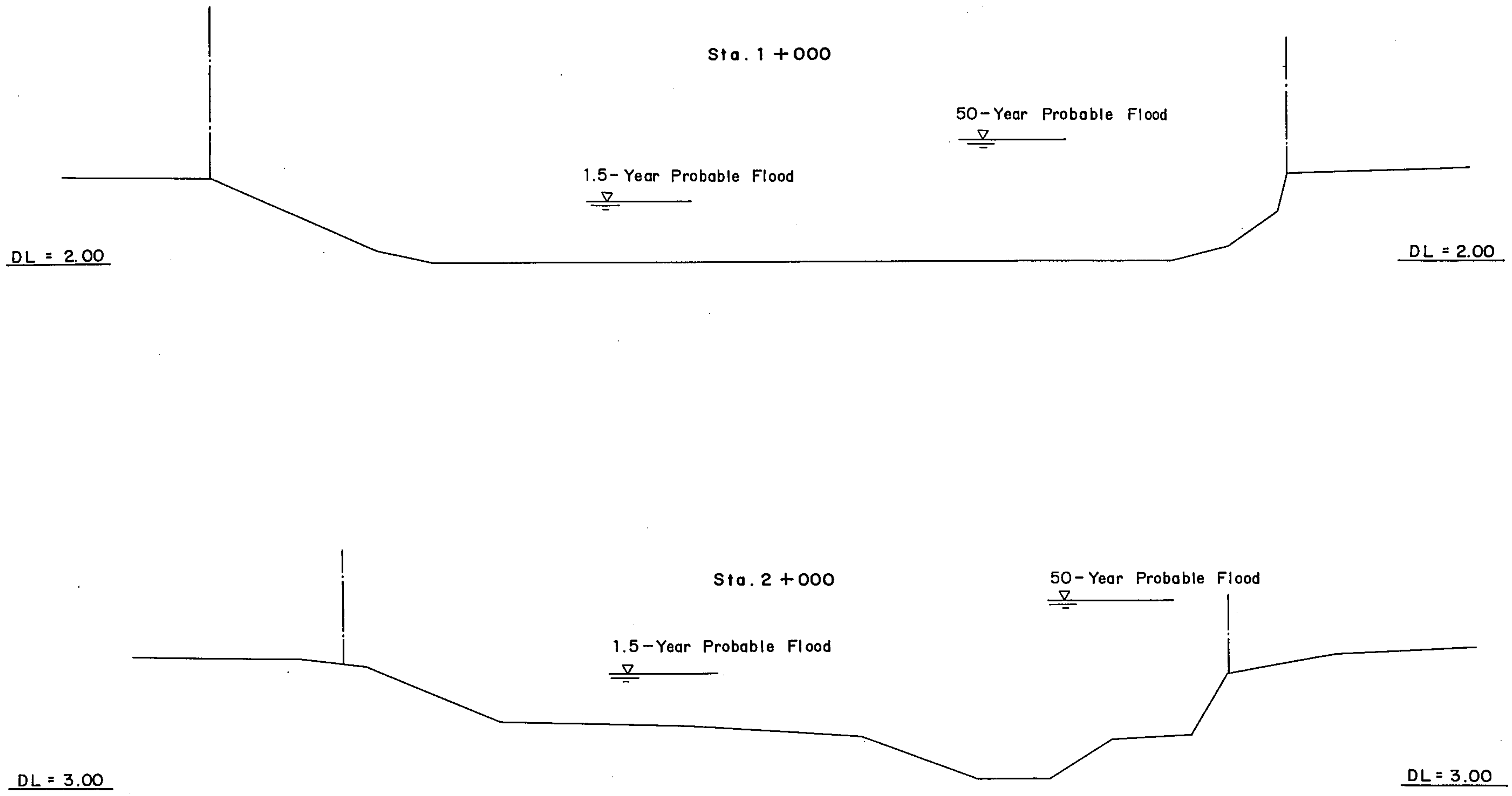
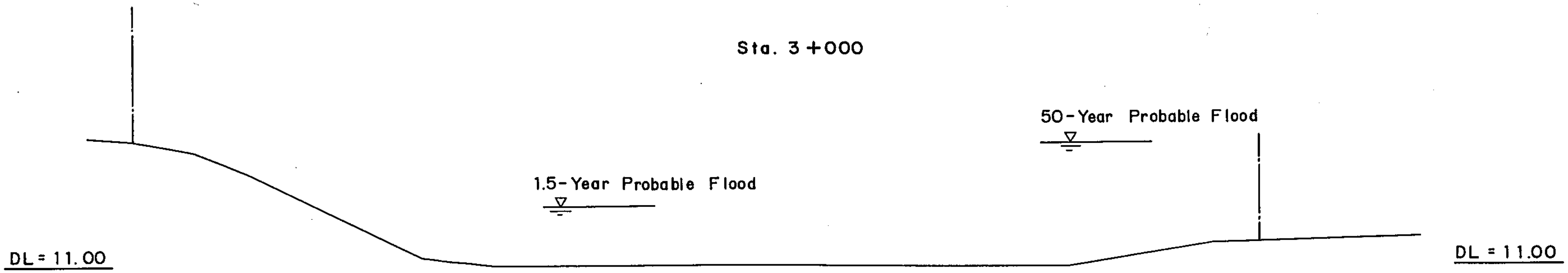


Fig. 4.12 Cross Section of Main Yawa River S = 1 : 200



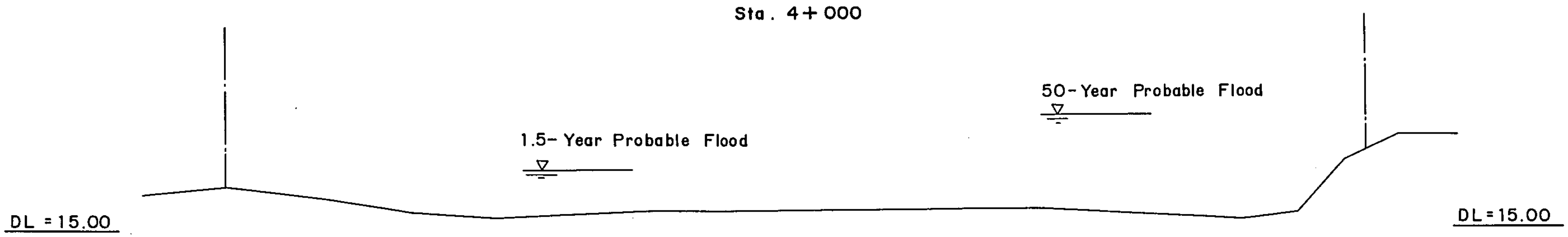
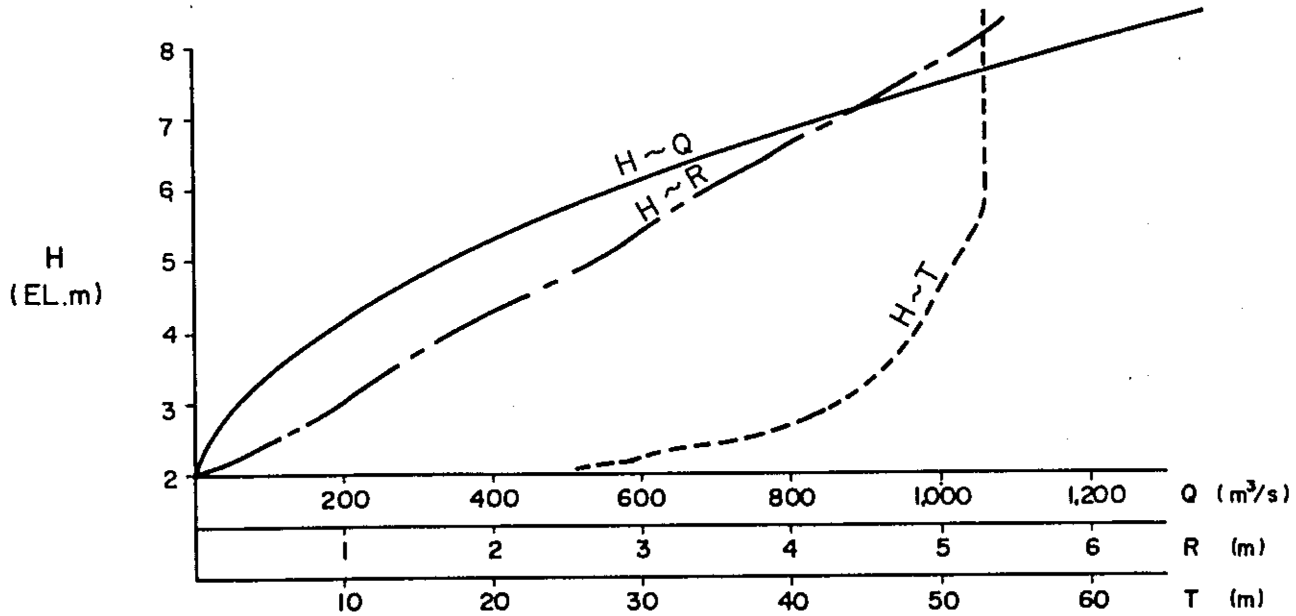


Fig. 4.13　H~Q, R, T Curve of Main Yawa River

STA. 1 + 000 (n = 0.045, I = 1/280)



STA. 2 + 000 (n = 0.045, I = 1/210)

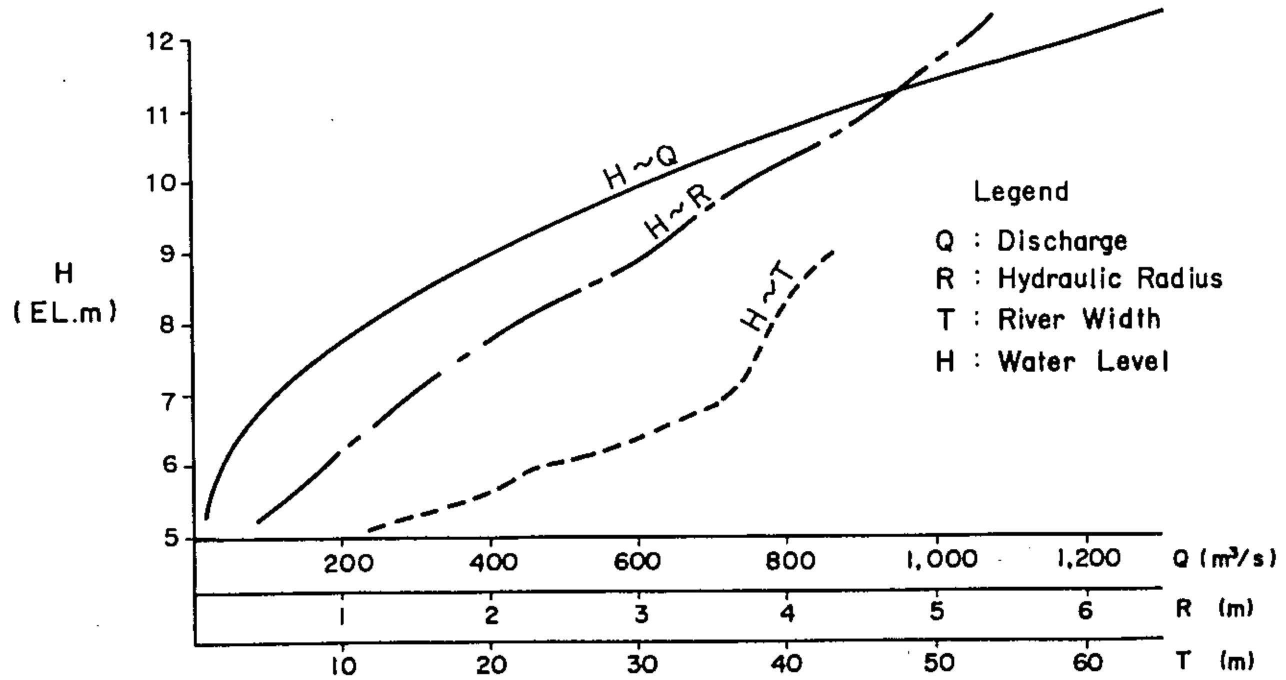
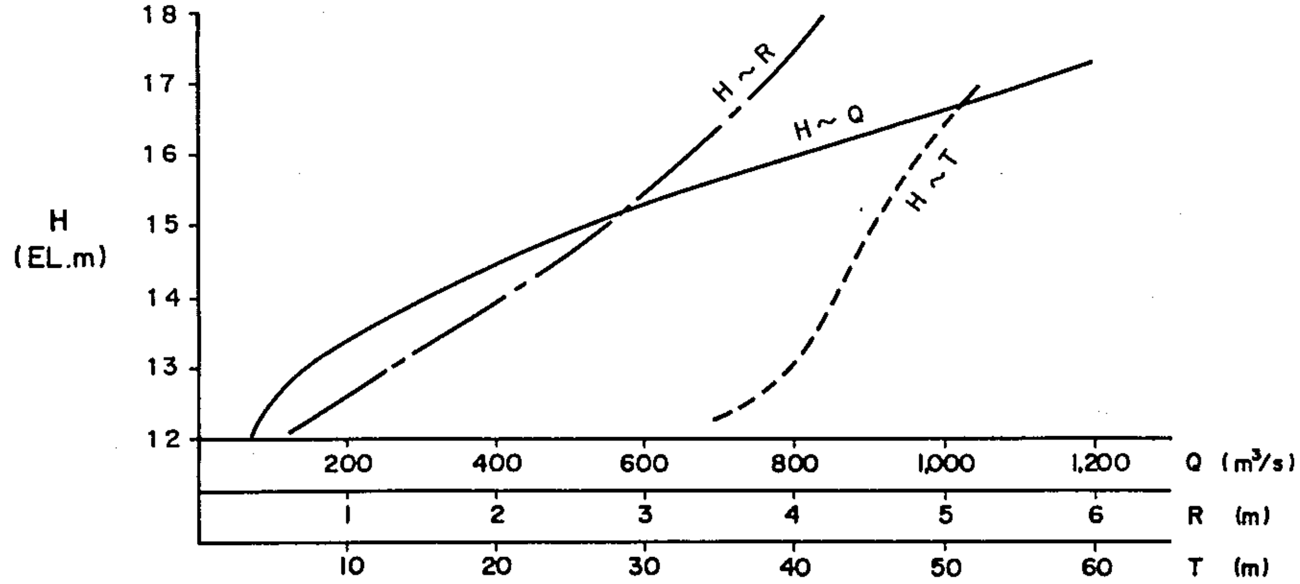


Fig. 4.14 H~Q, R, T Curve of Main Yawa River

STA. 3 + 000 (n=0.045, I= 1/210)



STA. 4+000 (n=0.045, I= 1/210)

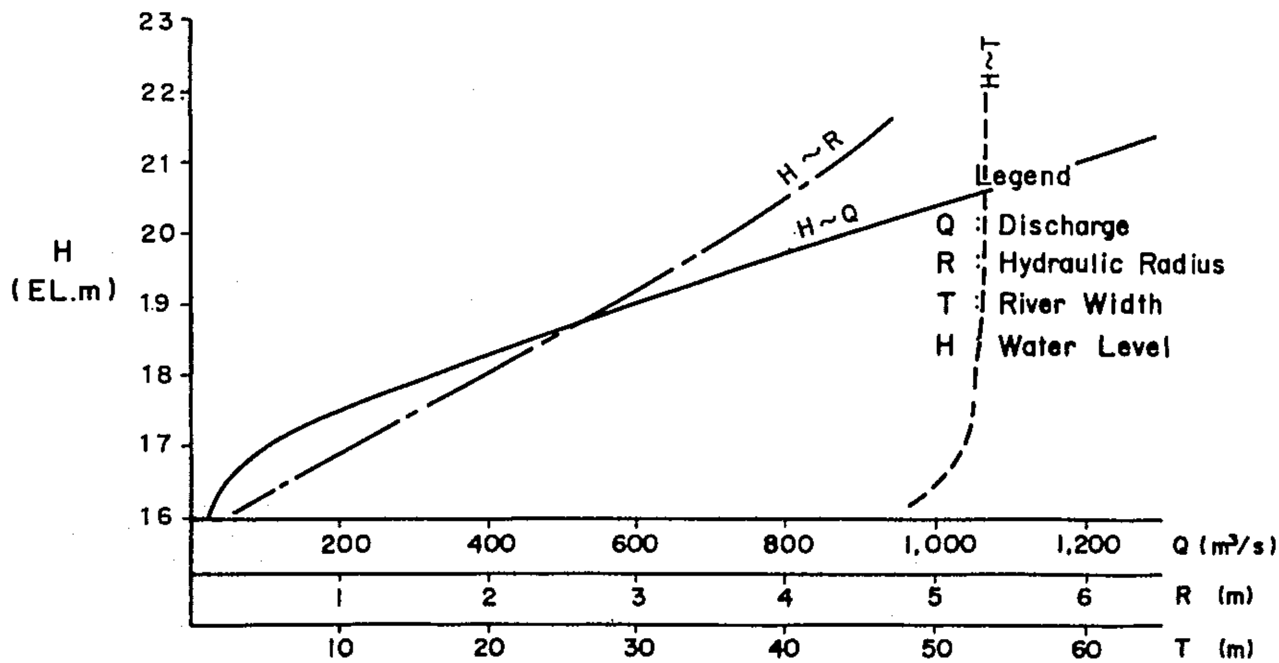


Fig. 4.15 H~Q, R, T Curve of Pawa - Burabod River

STA. 0+100 (n = 0.045 dm = 1 mm)

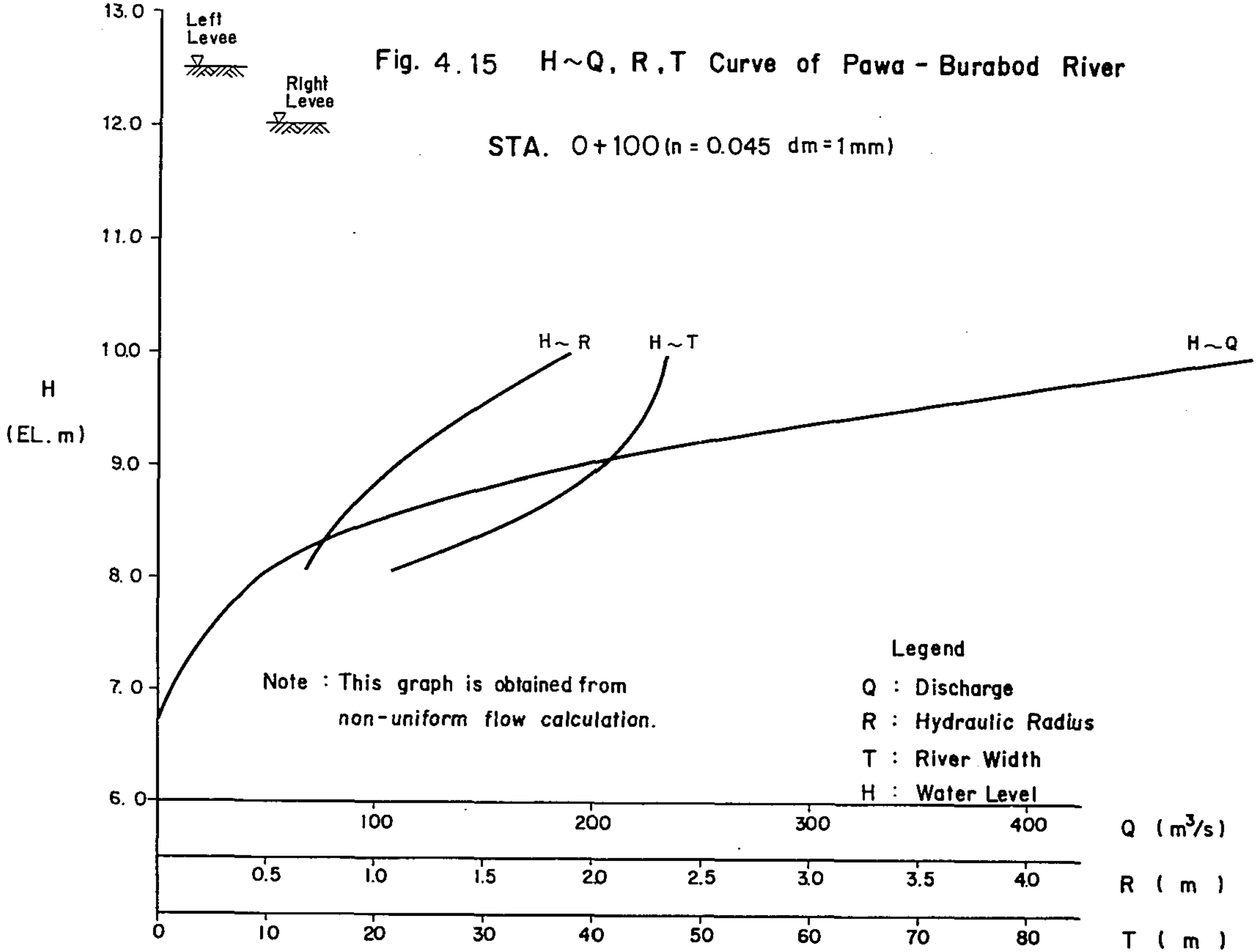


Fig. 4.16 H~Q, R, T Curve of Pawa - Burabod River

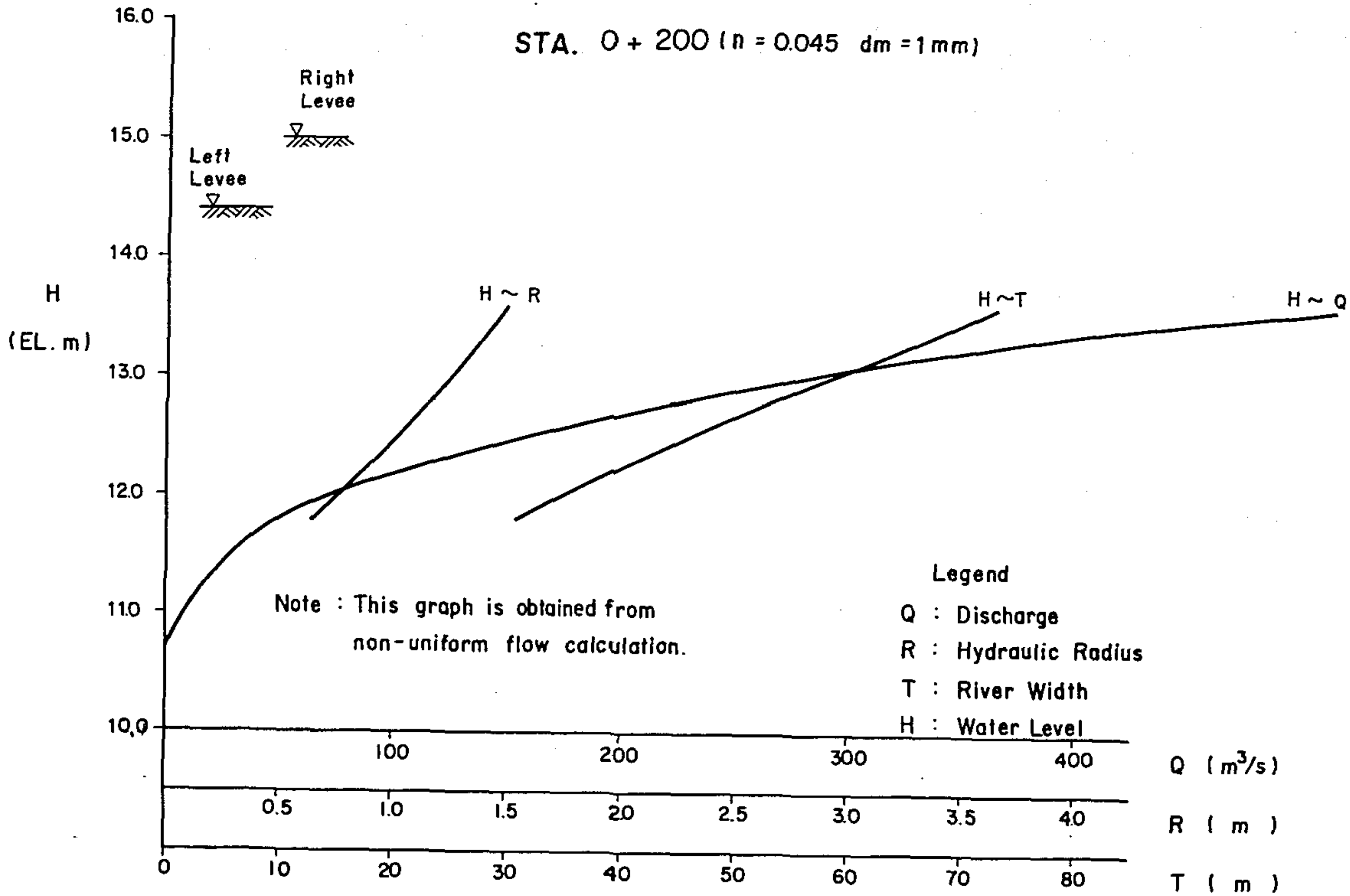


Fig. 4.17 H~Q, R, T Curve of Pawa - Burabod River

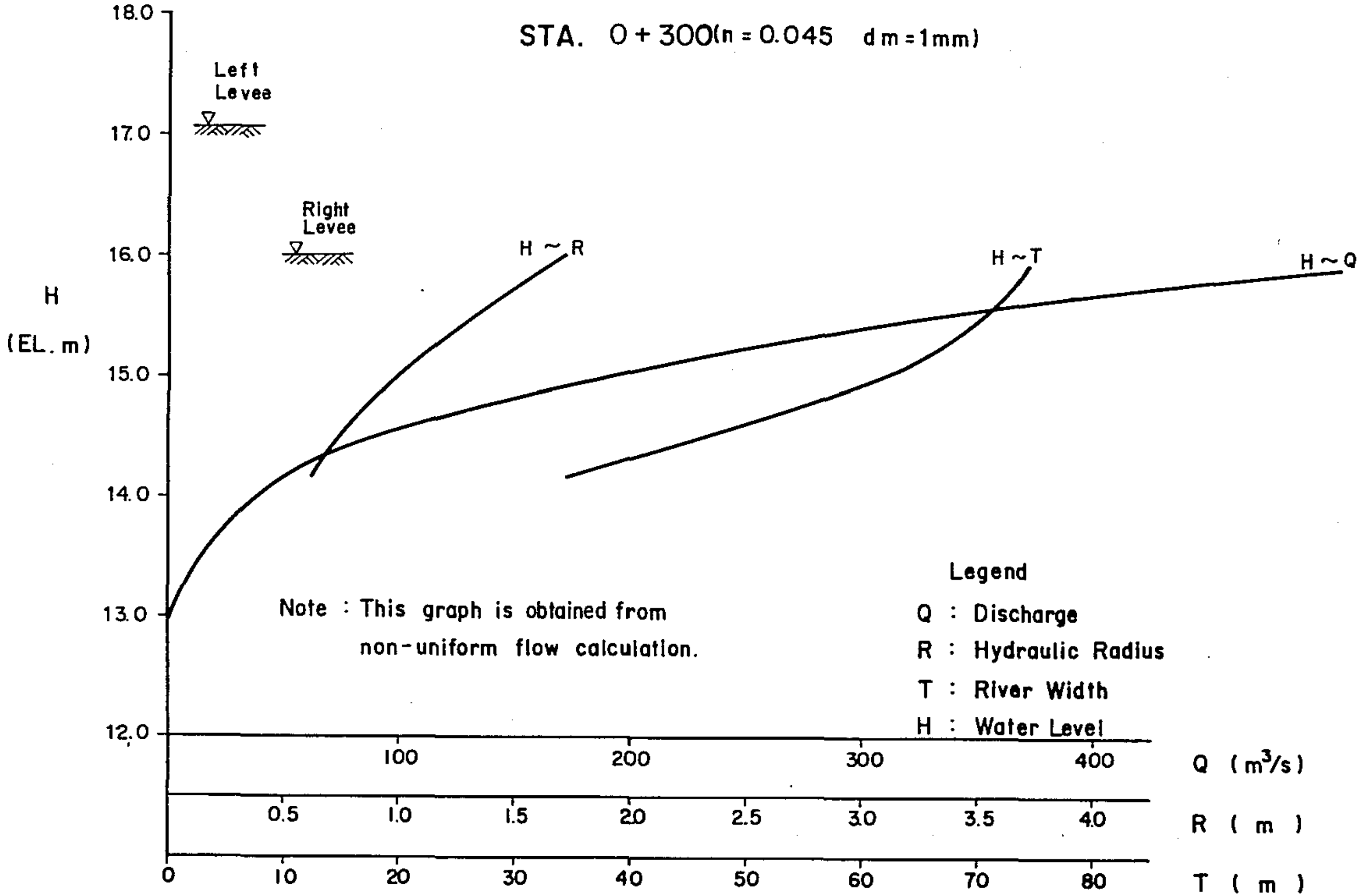


Fig. 4.18 H~Q, R, T Curve of Pawa - Burabod River

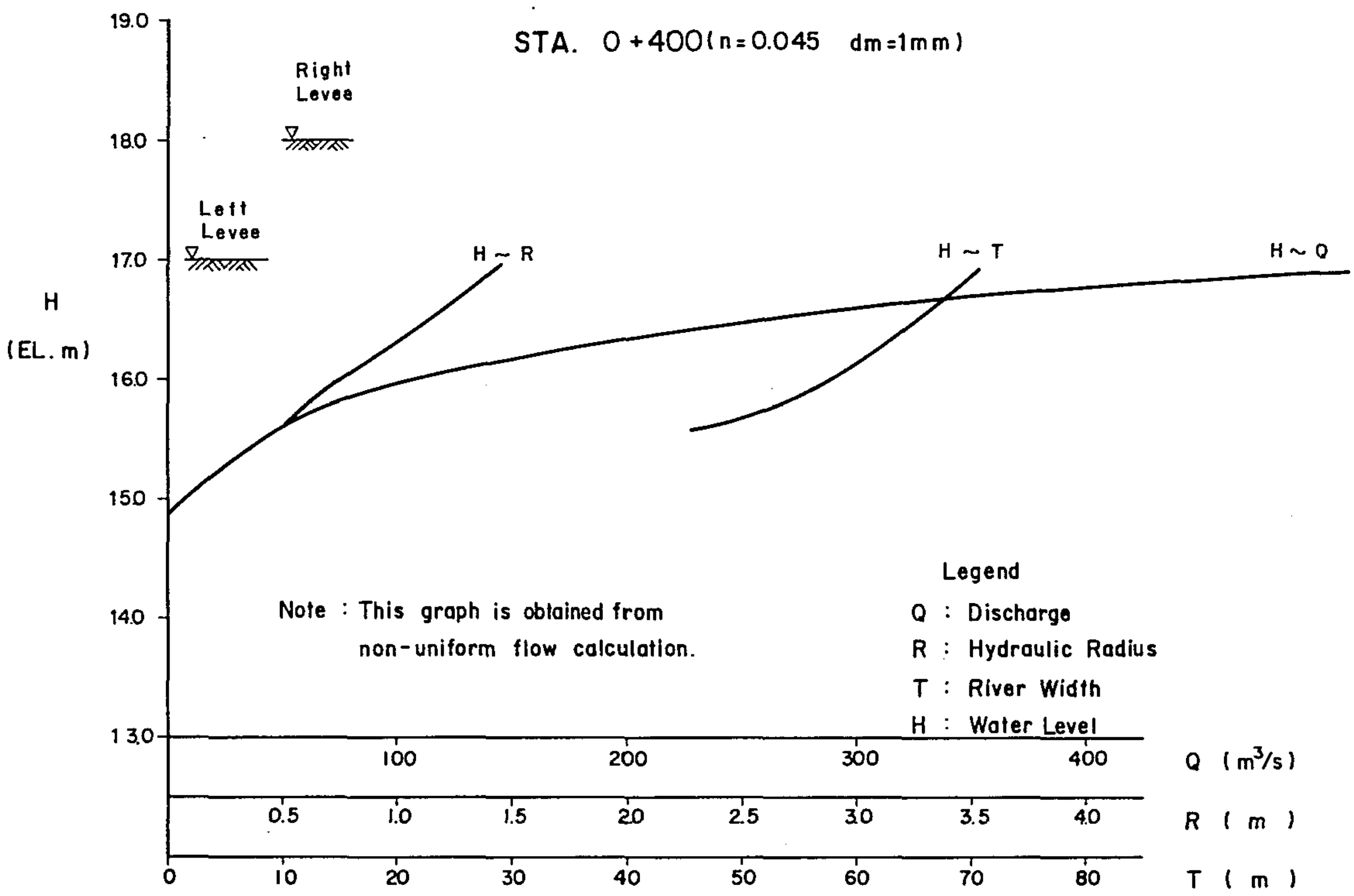


Fig. 4.19 H~Q, R, T Curve of Pawa - Burabod River

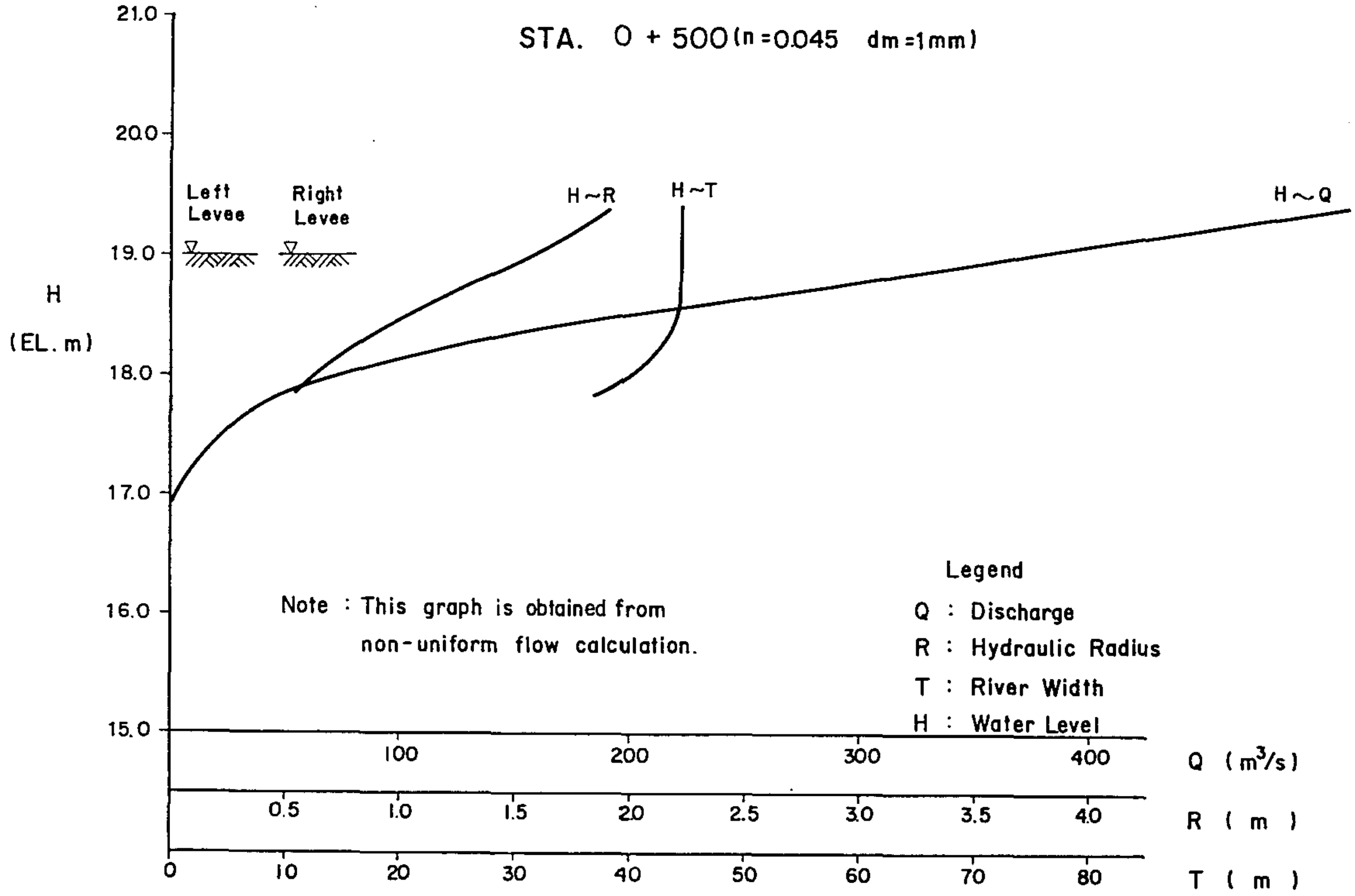


Fig. 4.20 H~Q, R, T Curve of Pawa - Burabod River

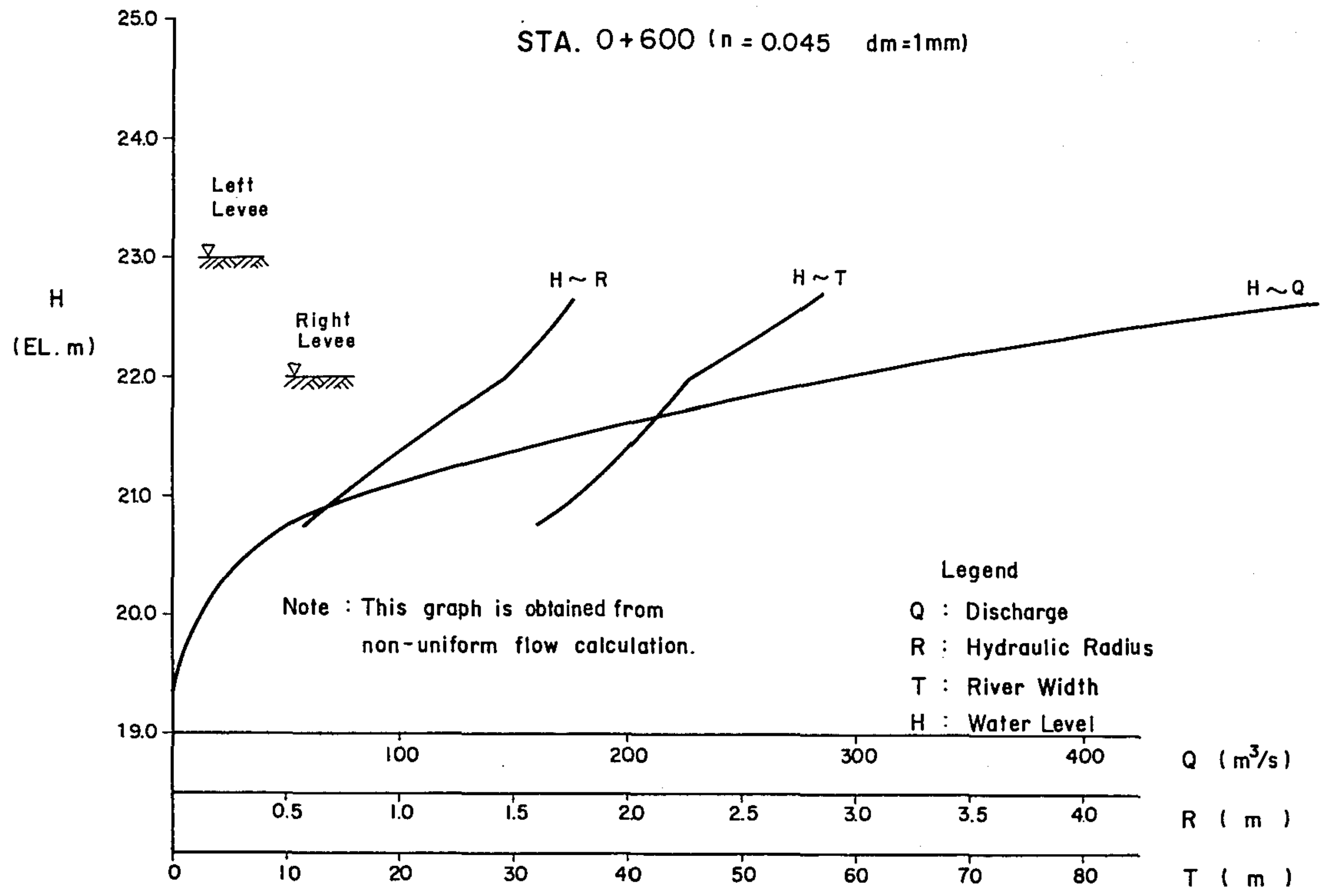


Fig. 4.21 H~Q, R, T Curve of Pawa - Burabod River

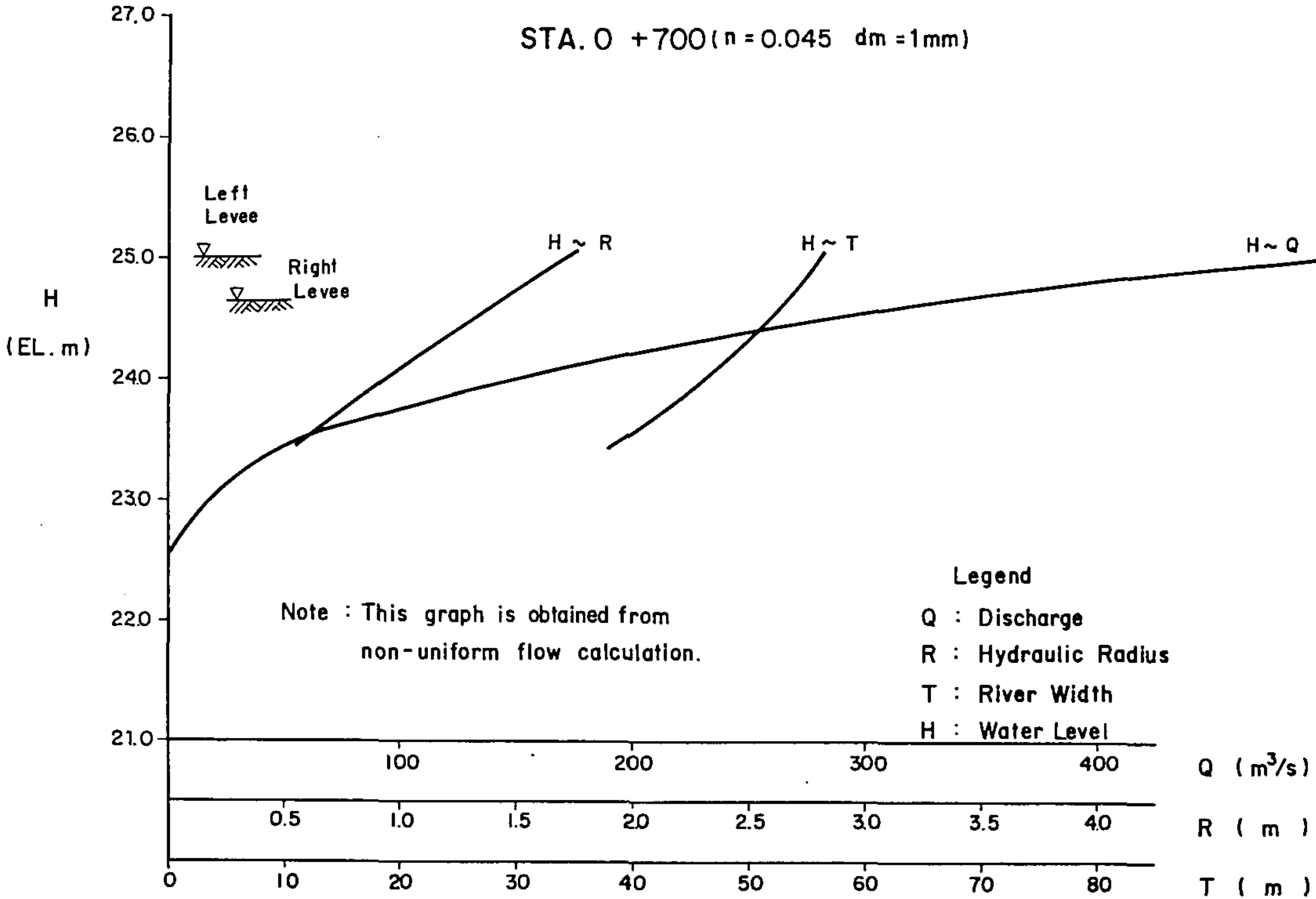


Fig. 4.22 H~Q, R, T Curve of Pawa - Burabod River

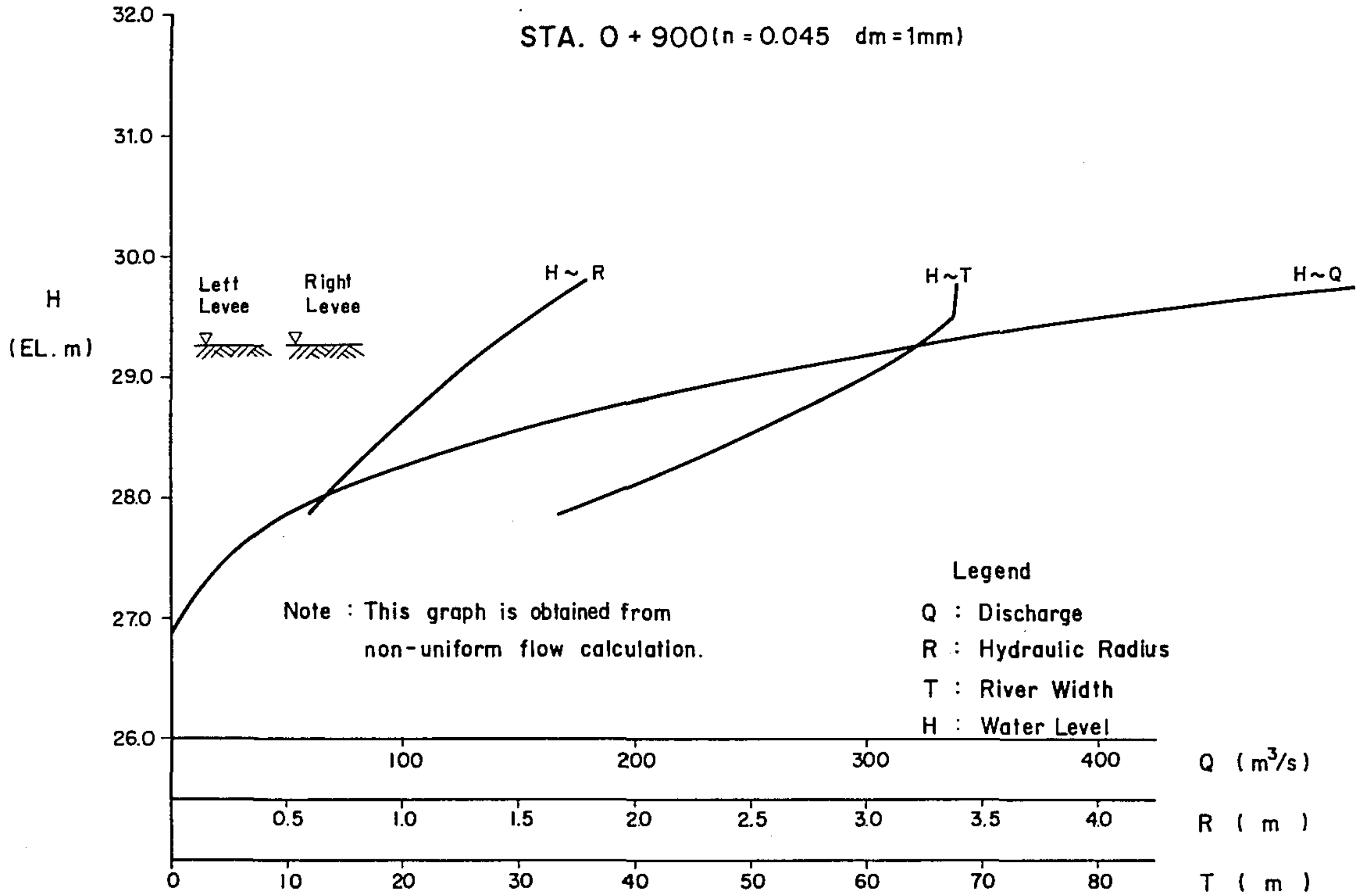


Fig. 4.23 H~Q, R, T Curve of Pawa - Burabod River

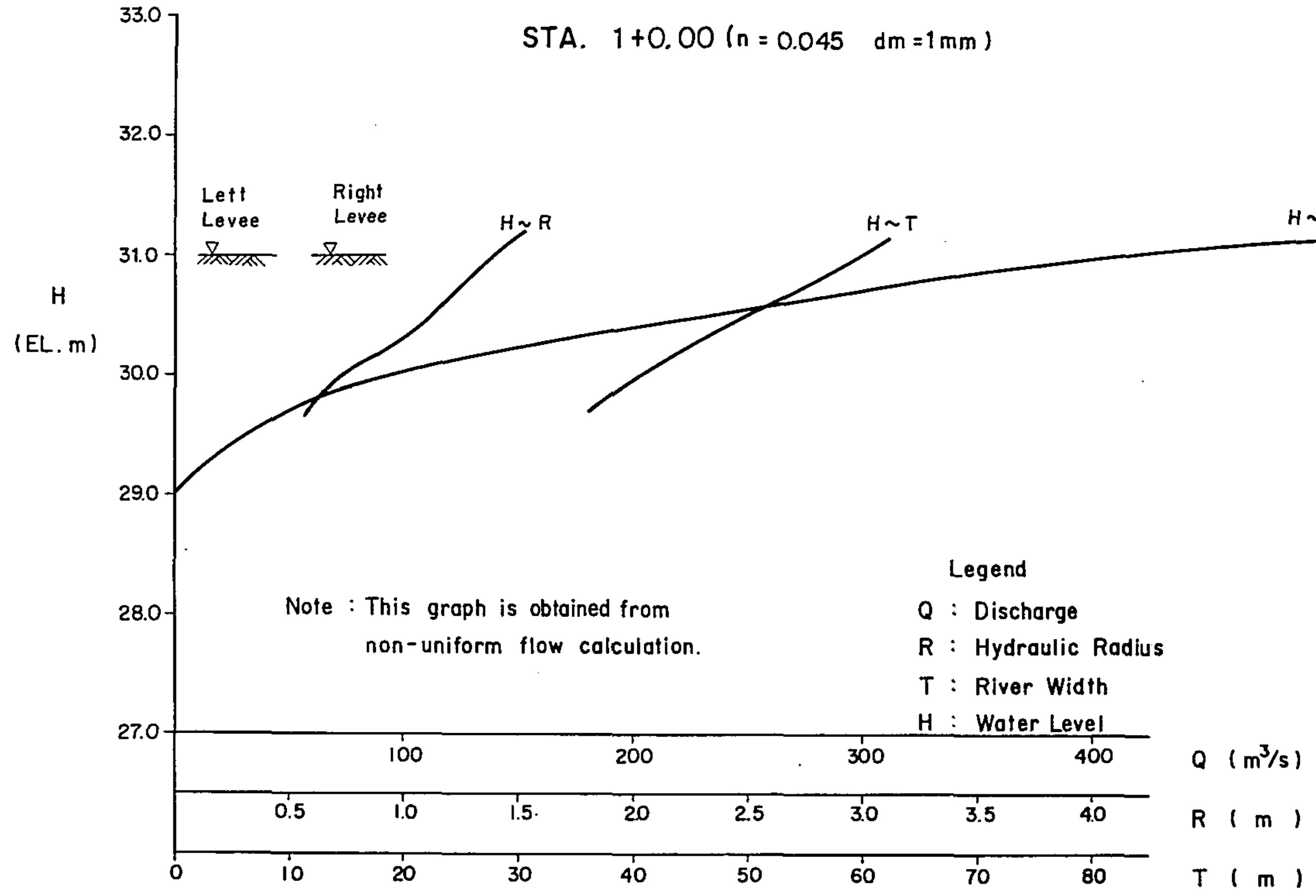


Fig. 4. 24 H~Q, R, T Curve of Pawa - Burabod River

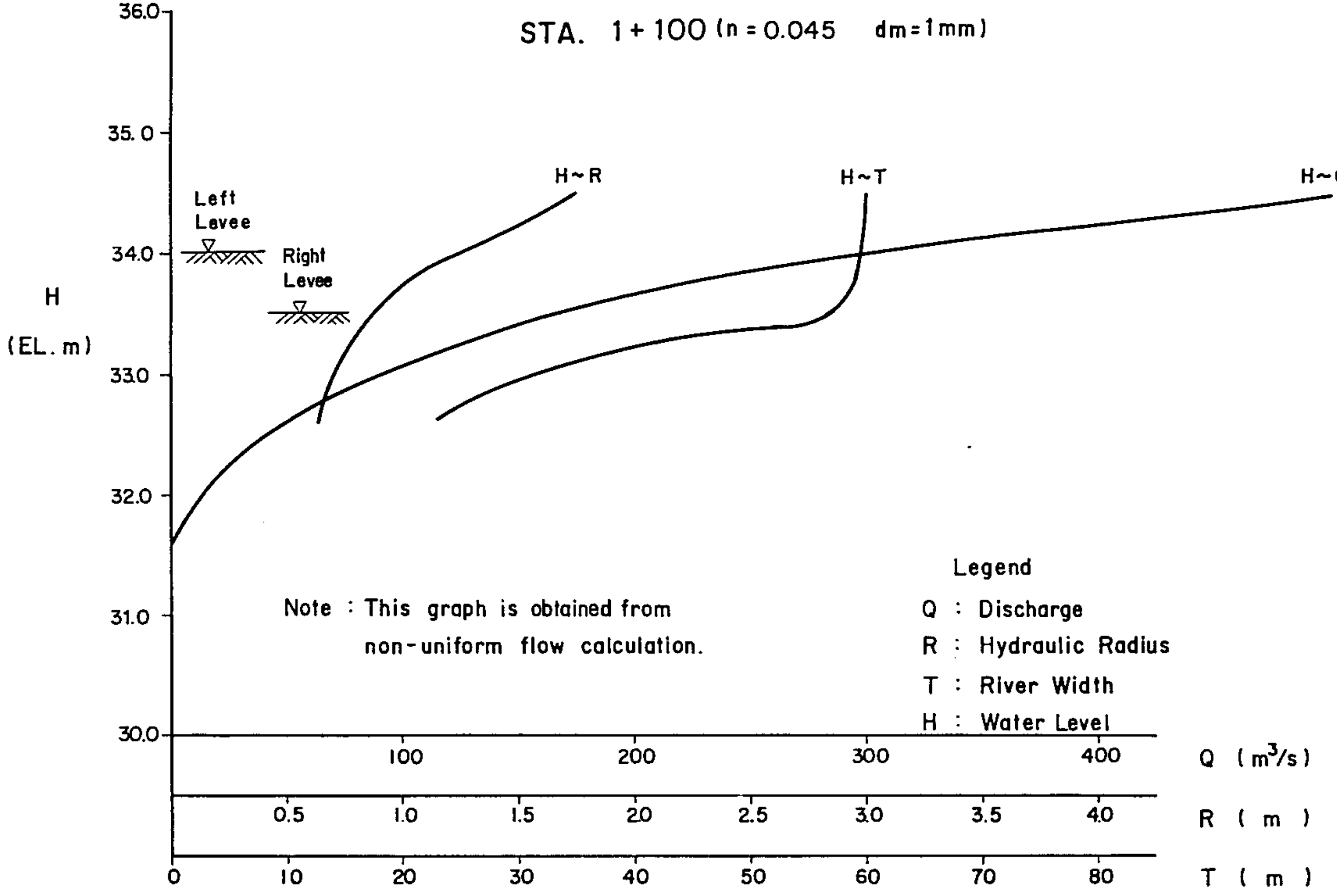


Fig. 4.25 H~Q, R, T Curve of Pawa - Burabod River

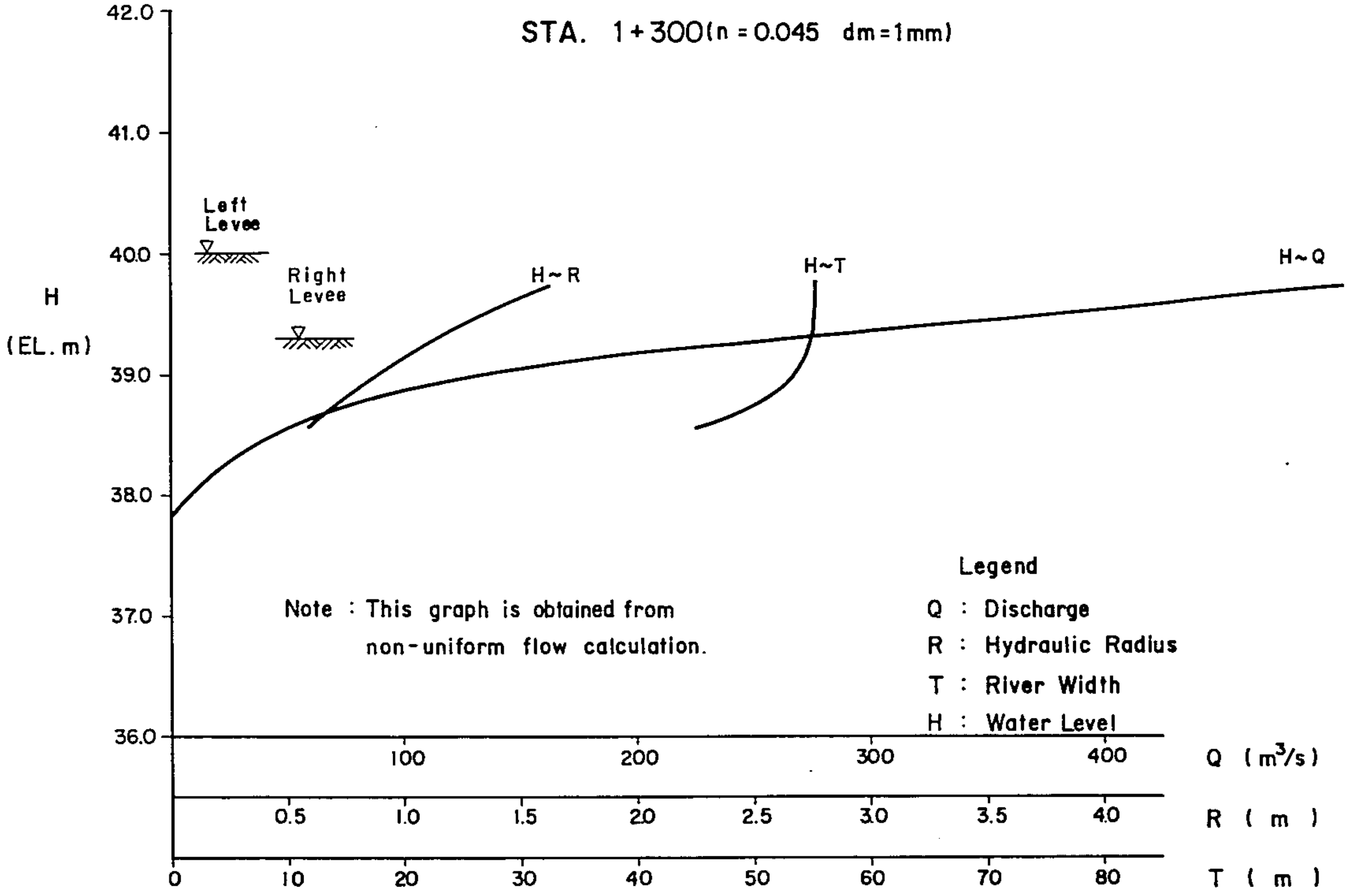


Fig. 4. 26 H~Q, R, T Curve of Pawa - Burabod River

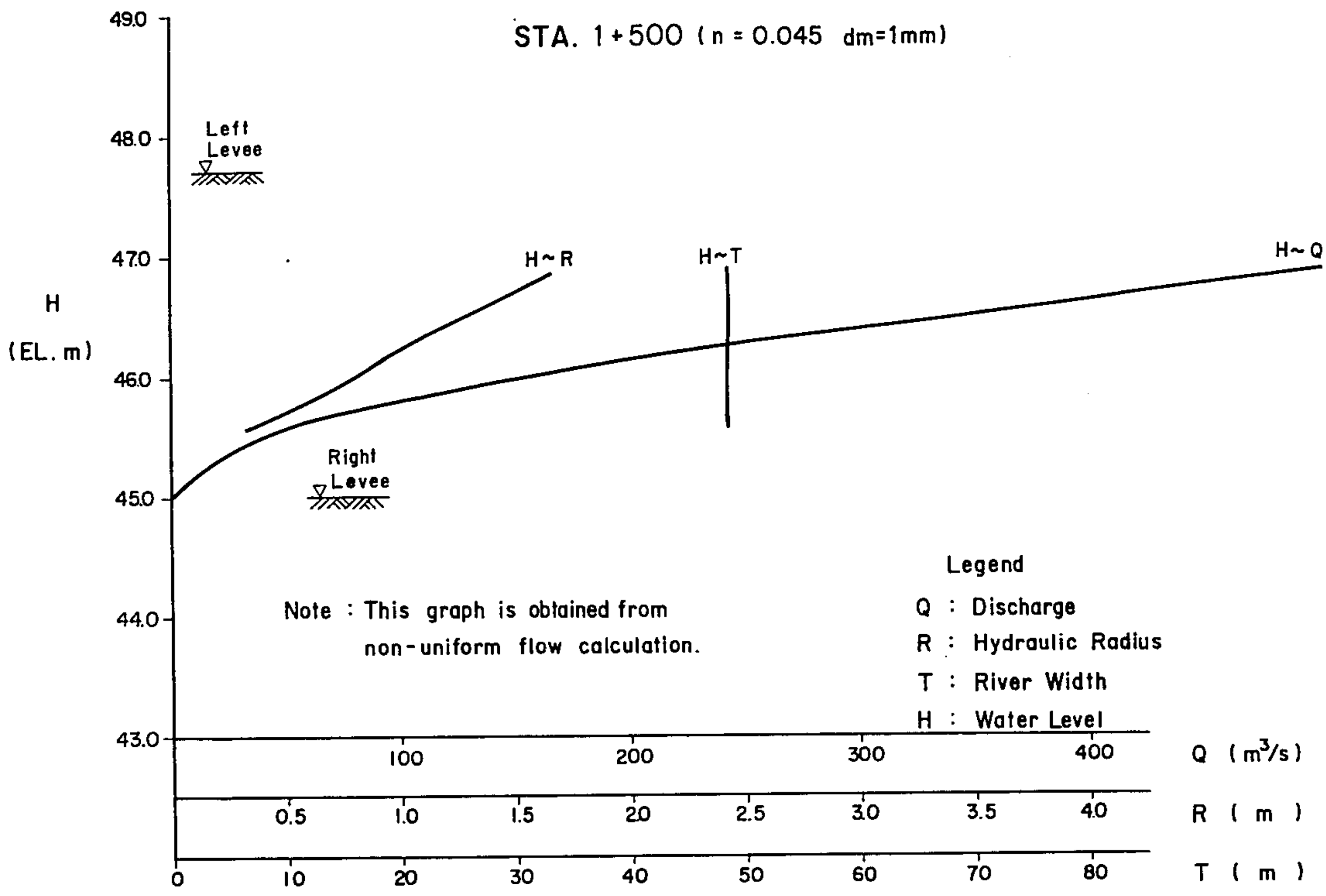


Fig. 4. 27 H~Q, R, T Curve of Pawa - Burabod River

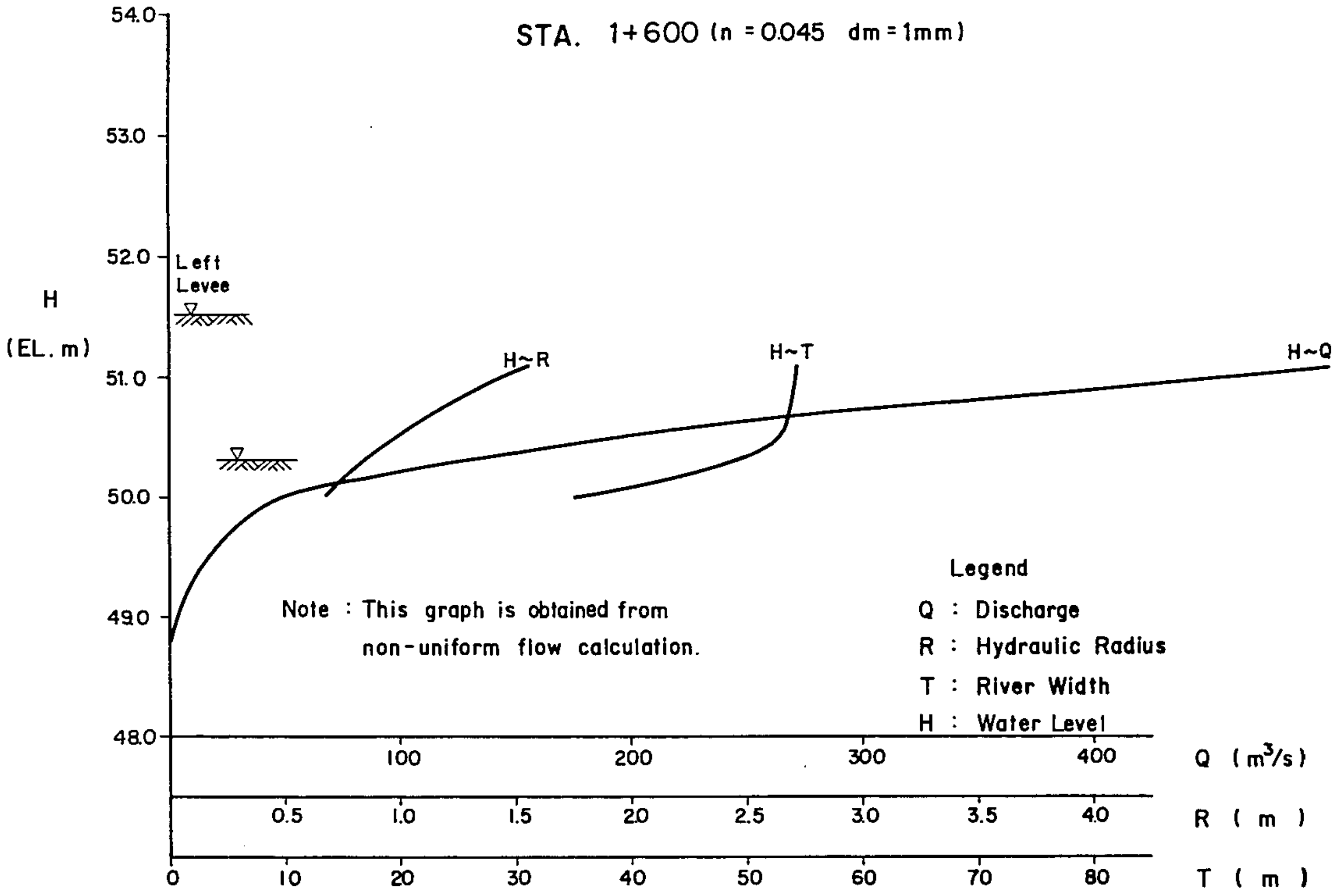


Fig. 4. 28 H~Q, R, T Curve of Pawa - Burabod River

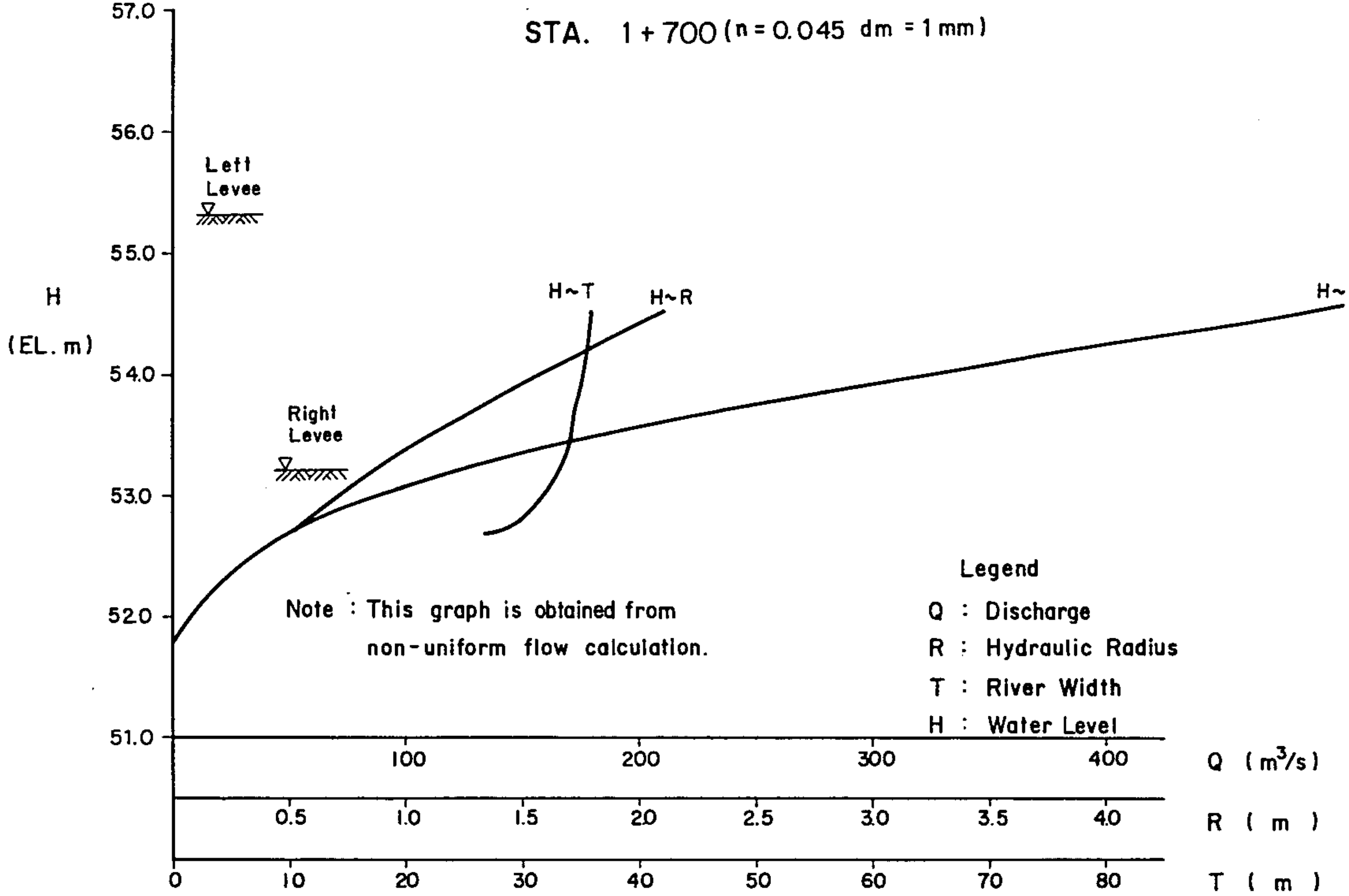


Fig. 4. 29 H~Q, R, T Curve of Pawa - Burabod River

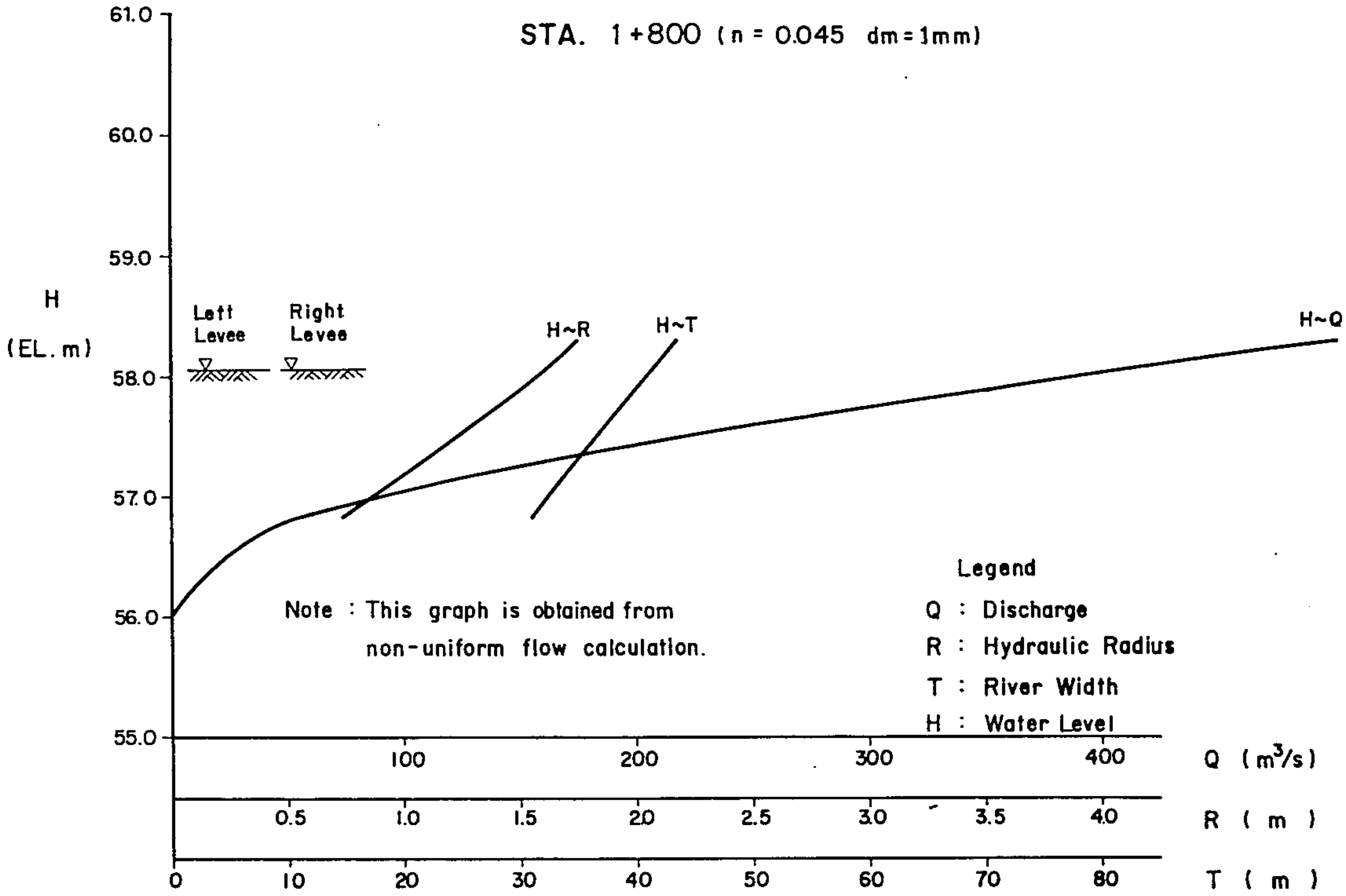


Fig. 4.30 H~Q, R, T Curve of Pawa - Burabod River

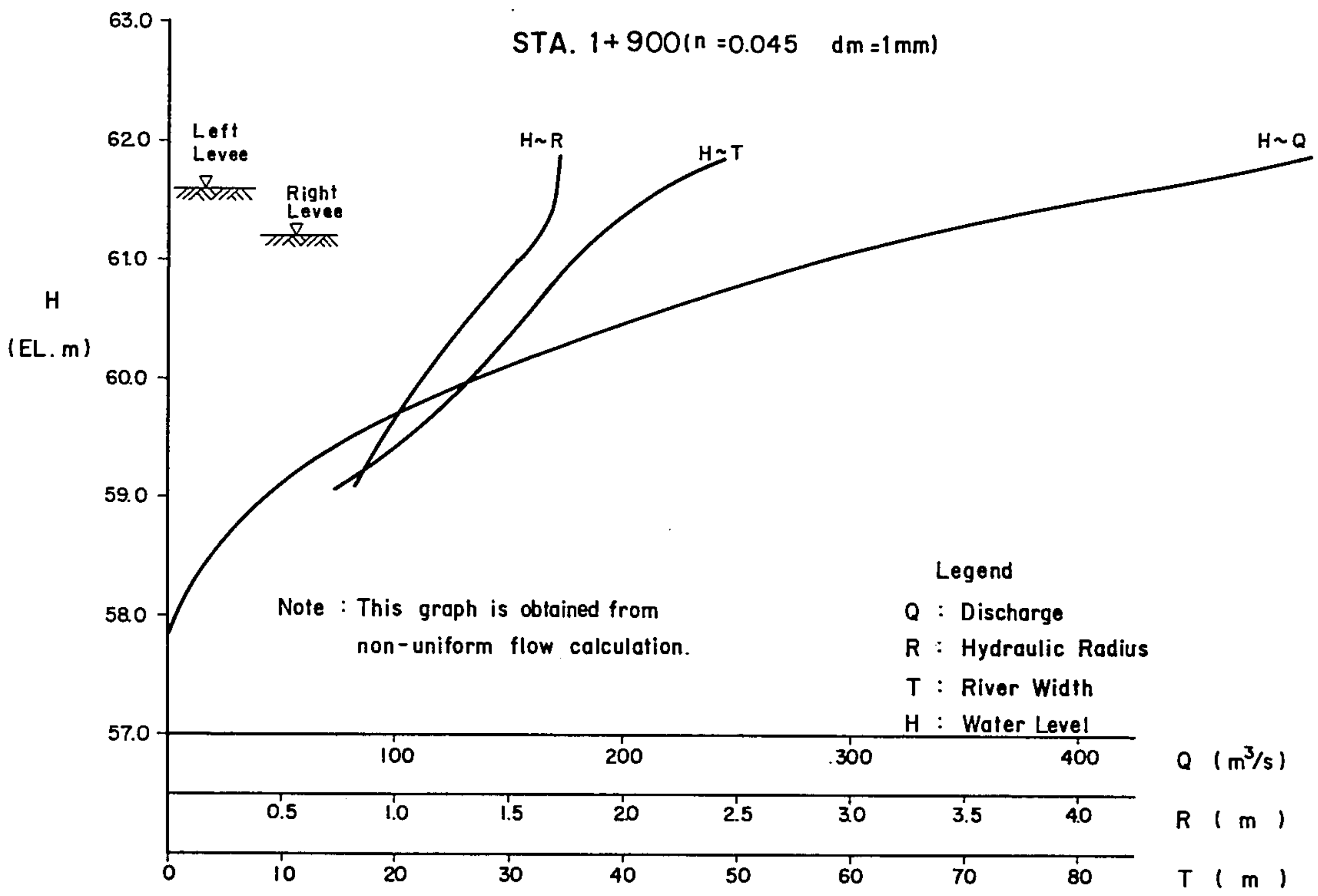


Fig. 4. 31 H~Q, R, T Curve of Pawa - Burabod River

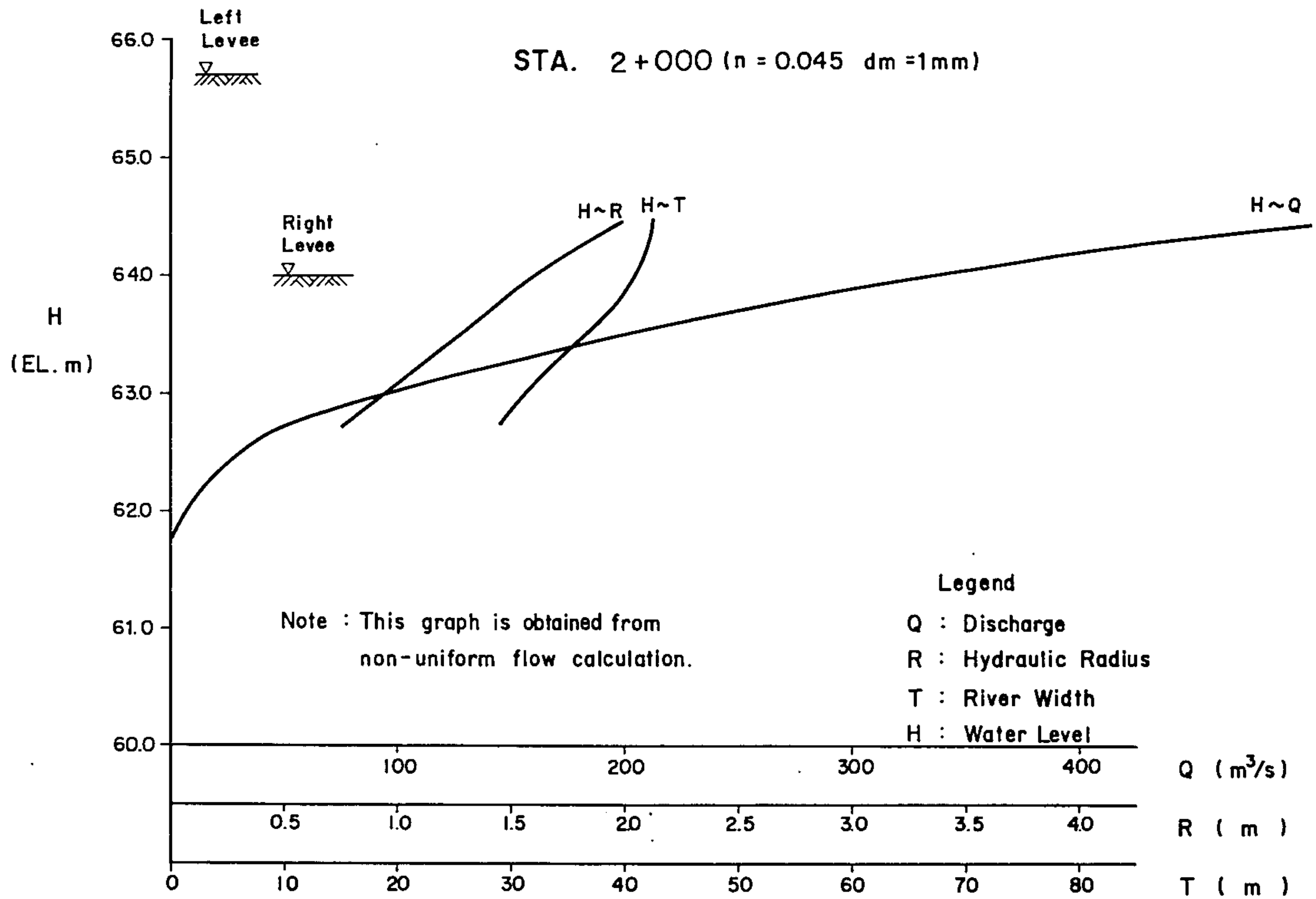


Fig. 4.32 H~Q, R, T Curve of Pawa - Burabod River

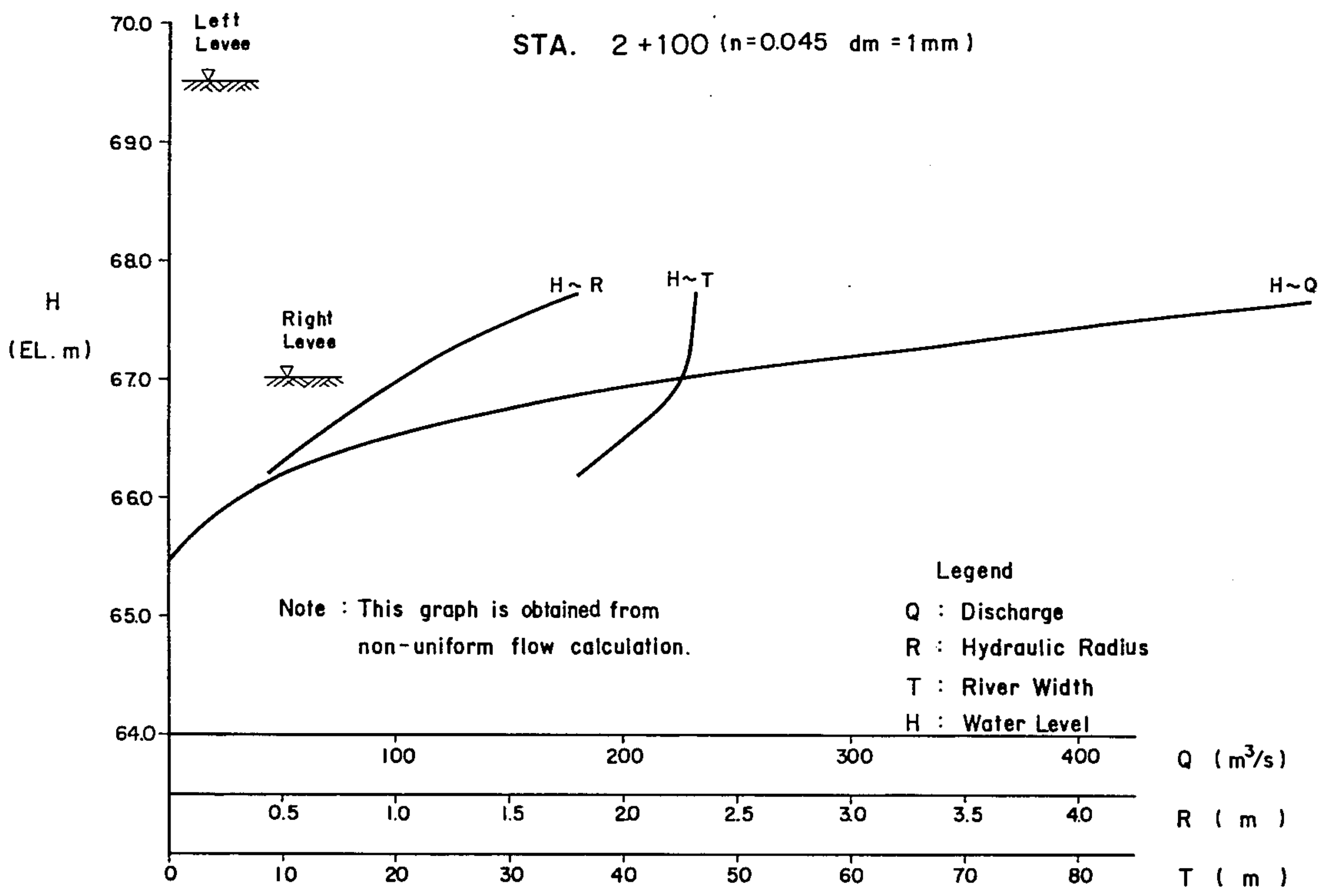


Fig. 4.33 H~Q, R, T Curve of Pawa - Burabod River

STA. 2+200 (n = 0.045 dm = 1mm)

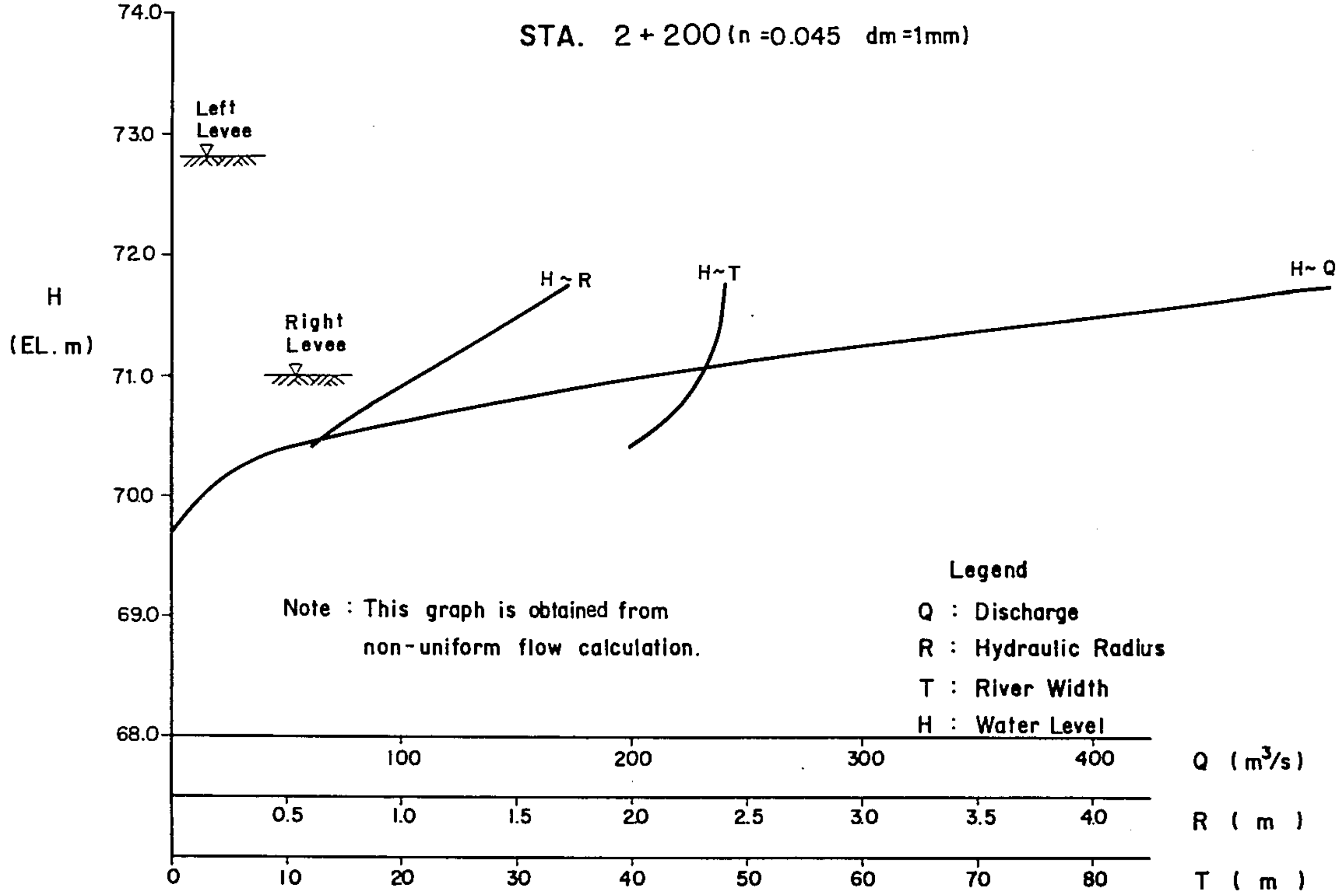


Fig. 4. 34 H~Q, R, T Curve of Pawa - Burabod River

STA. 2+400 (n = 0.045 dm = 1mm)

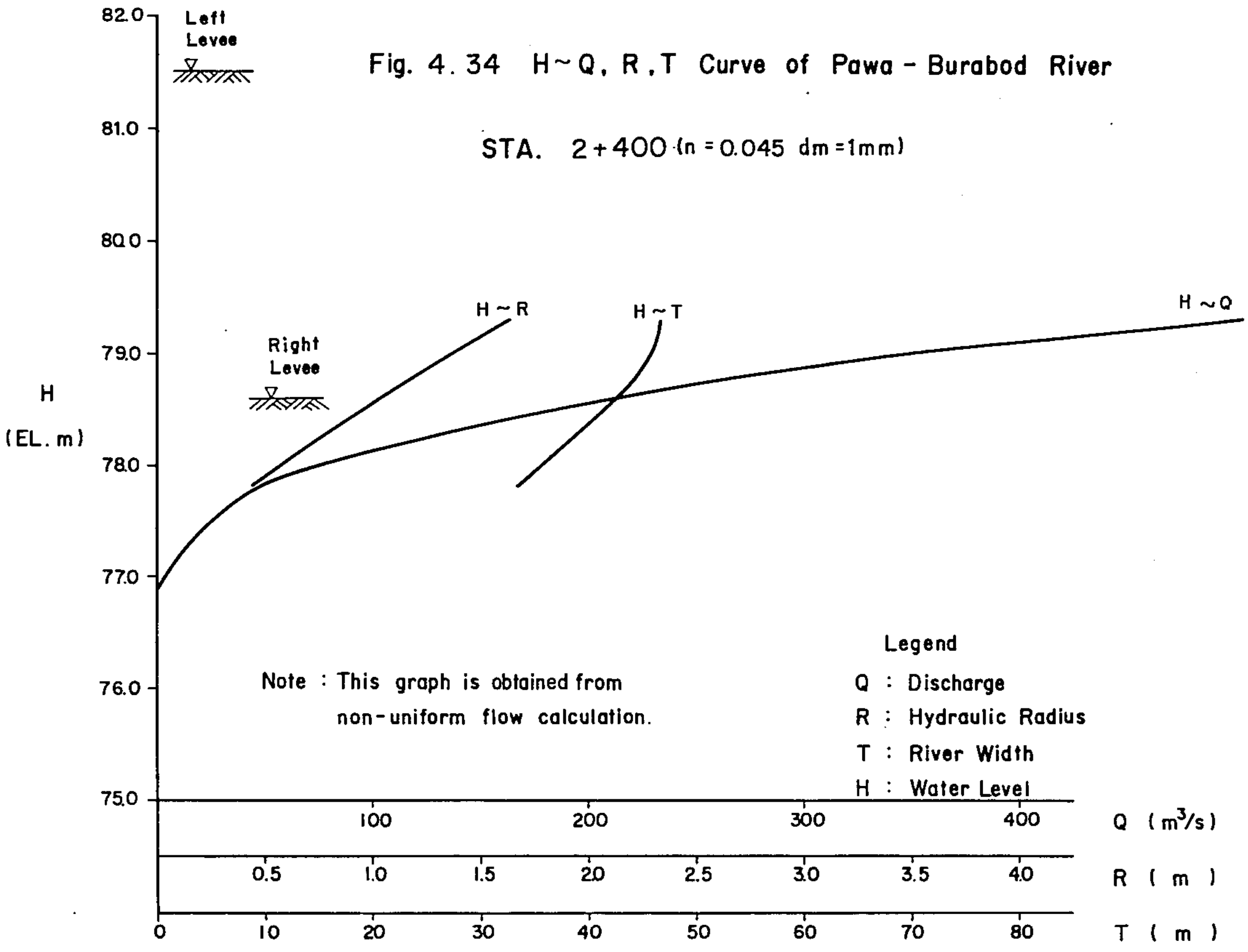


Fig. 4. 35 H~Q, R, T Curve of Pawa - Burabod River

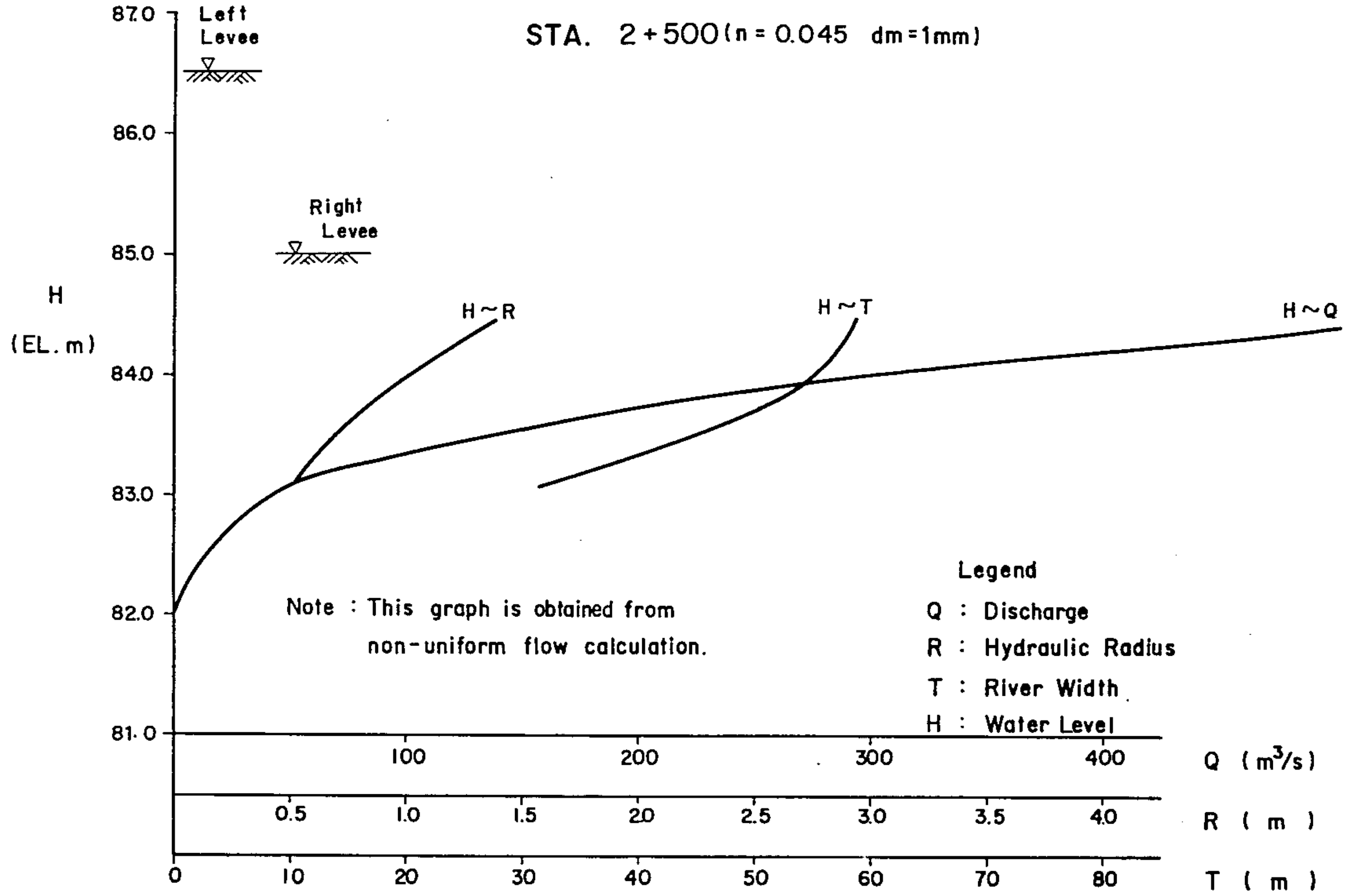


Fig. 4. 36 H~Q, R, T Curve of Pawa - Burabod River

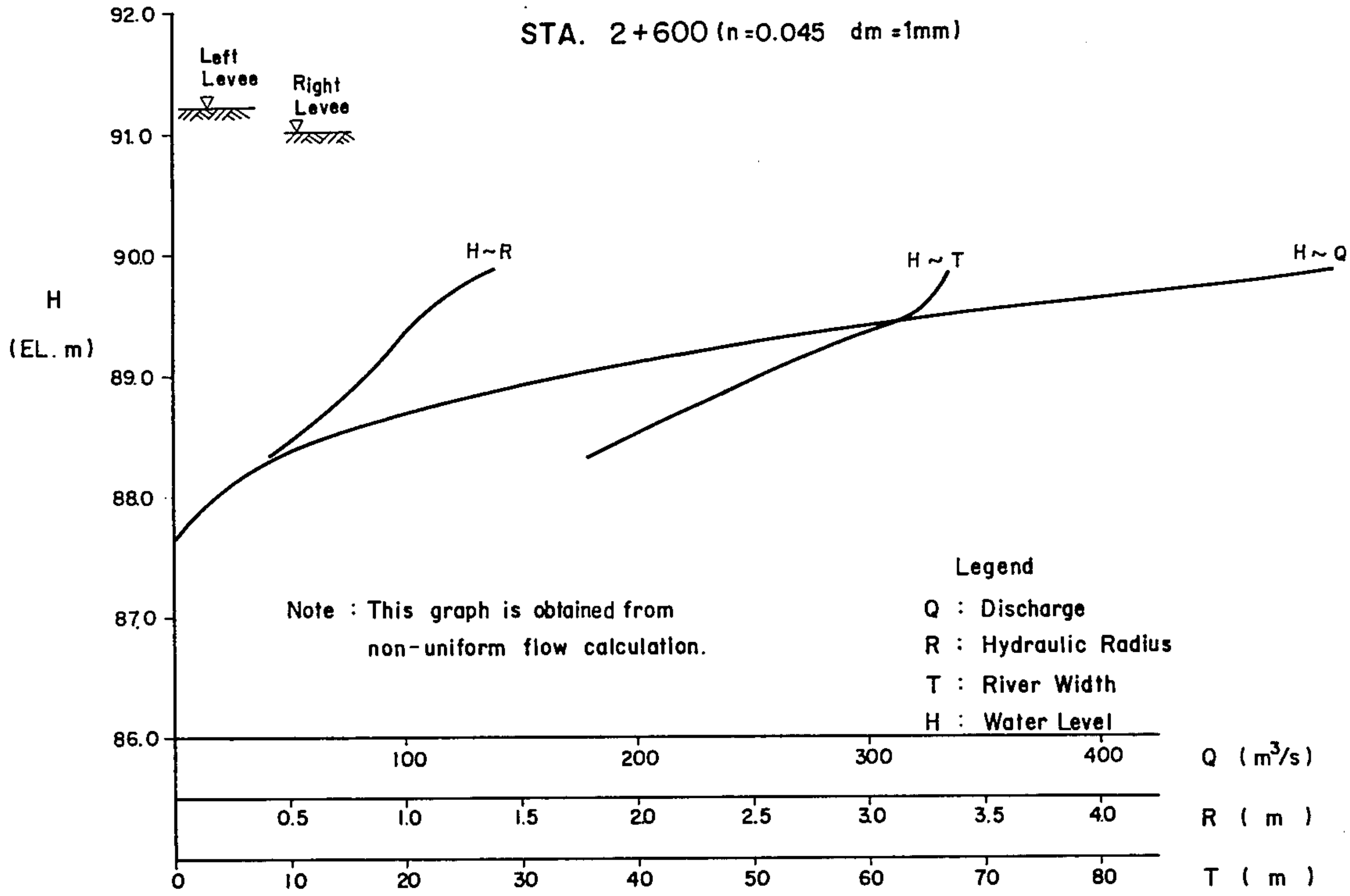


Fig. 4.37 H~Q, R, T Curve of Pawa - Burabod River

STA. 2+700 (n = 0.045 dm = 1mm)

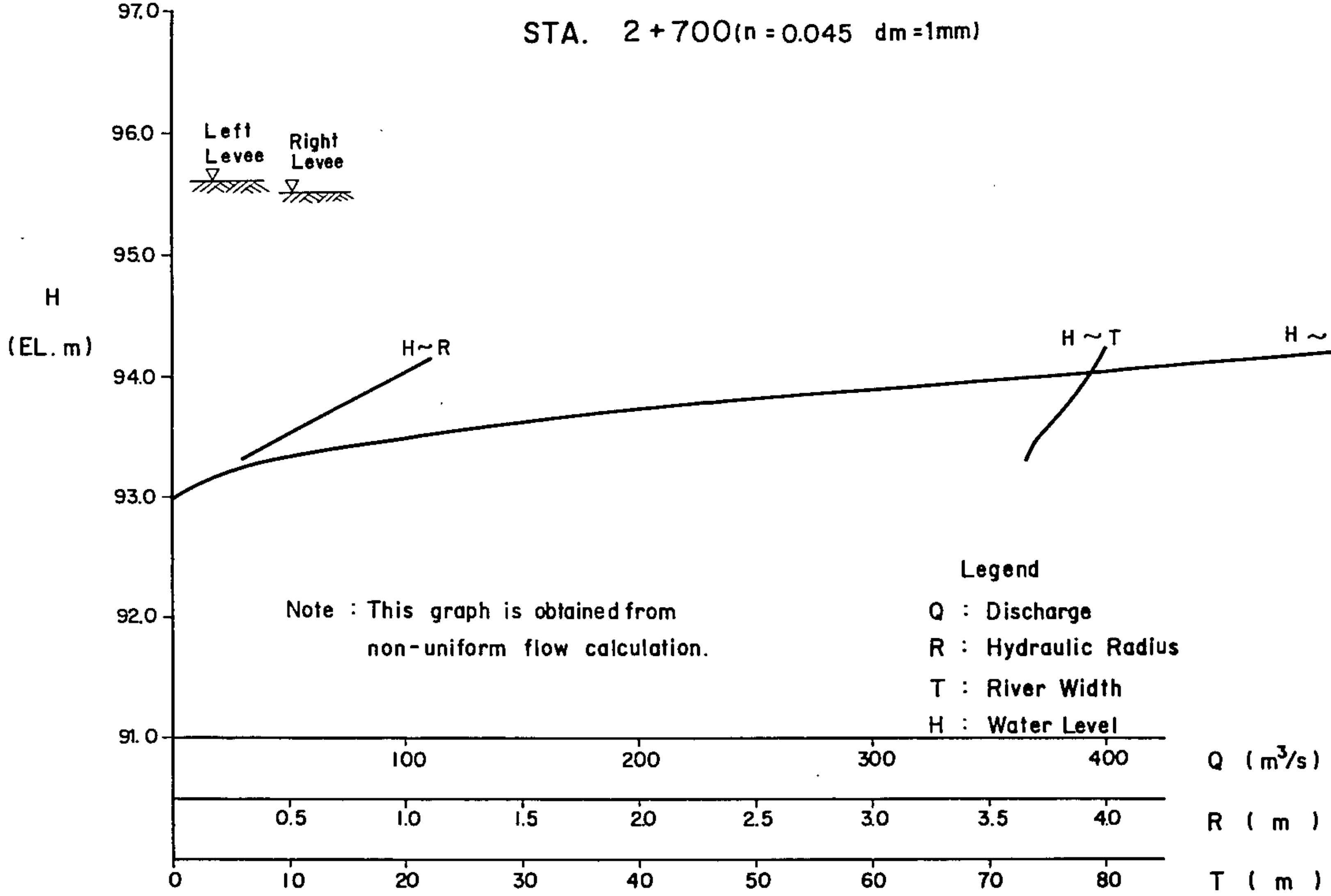


Fig. 4.38 H~Q, R, T Curve of Pawa - Burabod River

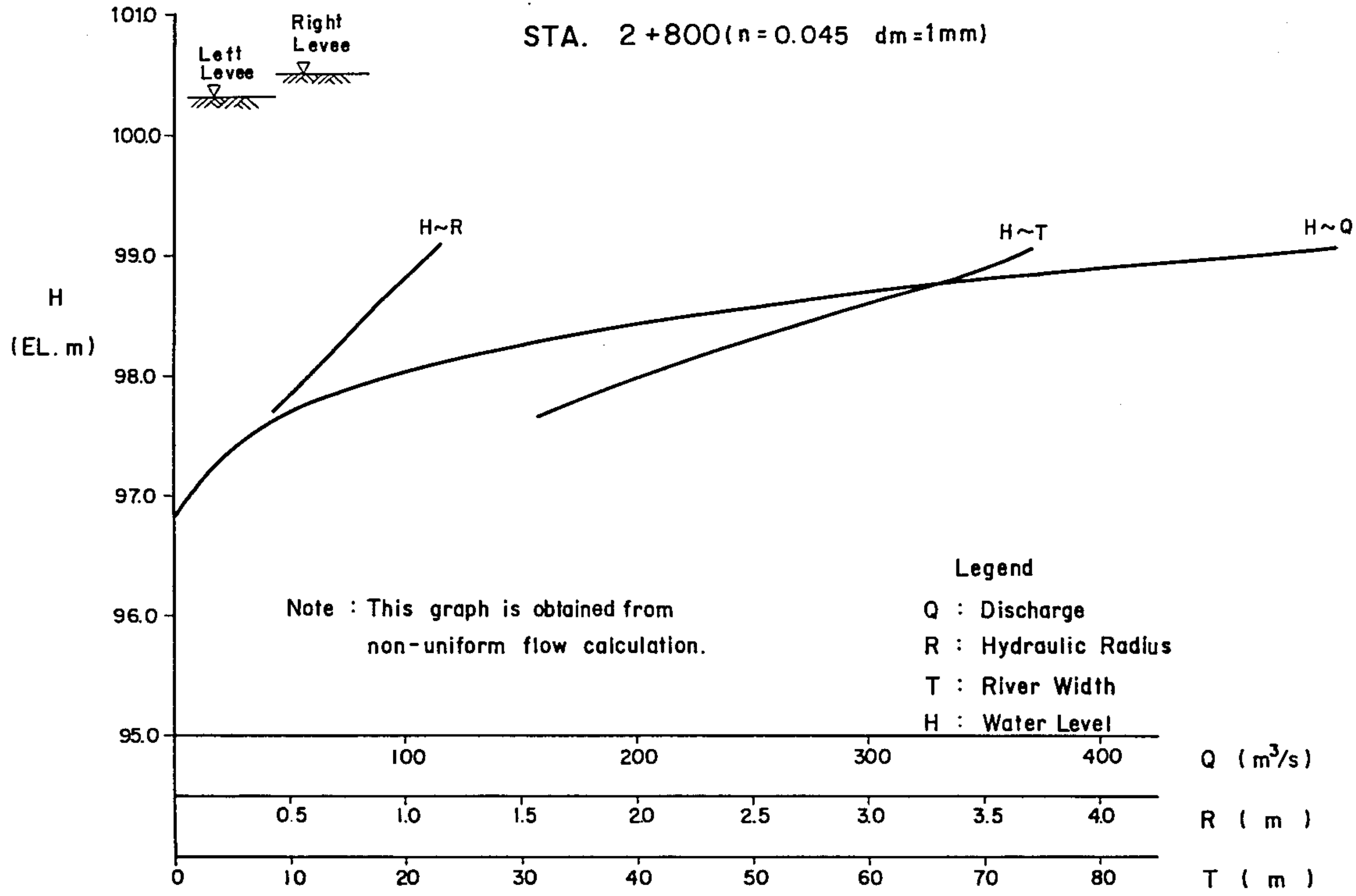
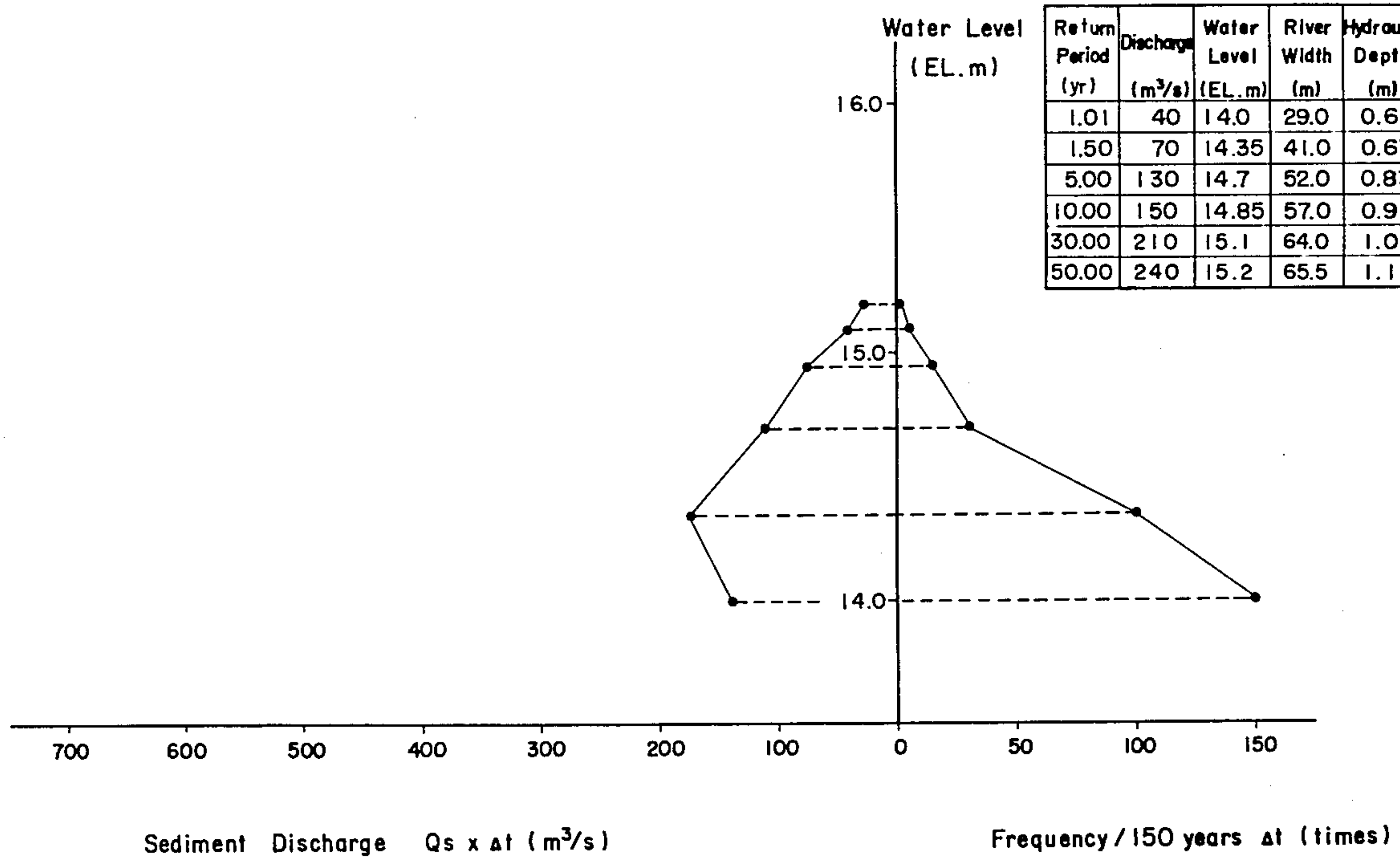


Fig. 4.39 Dominant Flow of Pawa - Burabodo River



Caluculation Table(Sta,0+300)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL. m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m^3/sec)
1.01	40	14.0	29.0	0.6	0.93
1.50	70	14.35	41.0	0.67	1.73
5.00	130	14.7	52.0	0.83	3.74
10.00	150	14.85	57.0	0.9	5.02
30.00	210	15.1	64.0	1.05	8.29
50.00	240	15.2	65.5	1.1	9.53

Fig. 4.40 Dominant Flow of Pawa - Burabodo River

Caluculation Table (Sta, 0+600)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL. m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs (m^3/sec)
1.01	40	20.60	29.0	0.45	0.45
1.50	70	20.90	34.0	0.70	1.60
5.00	130	21.26	38.5	0.93	3.48
10.00	150	21.40	39.5	1.03	4.88
30.00	210	21.65	42.0	1.20	7.60
50.00	240	21.80	48.0	1.30	10.60

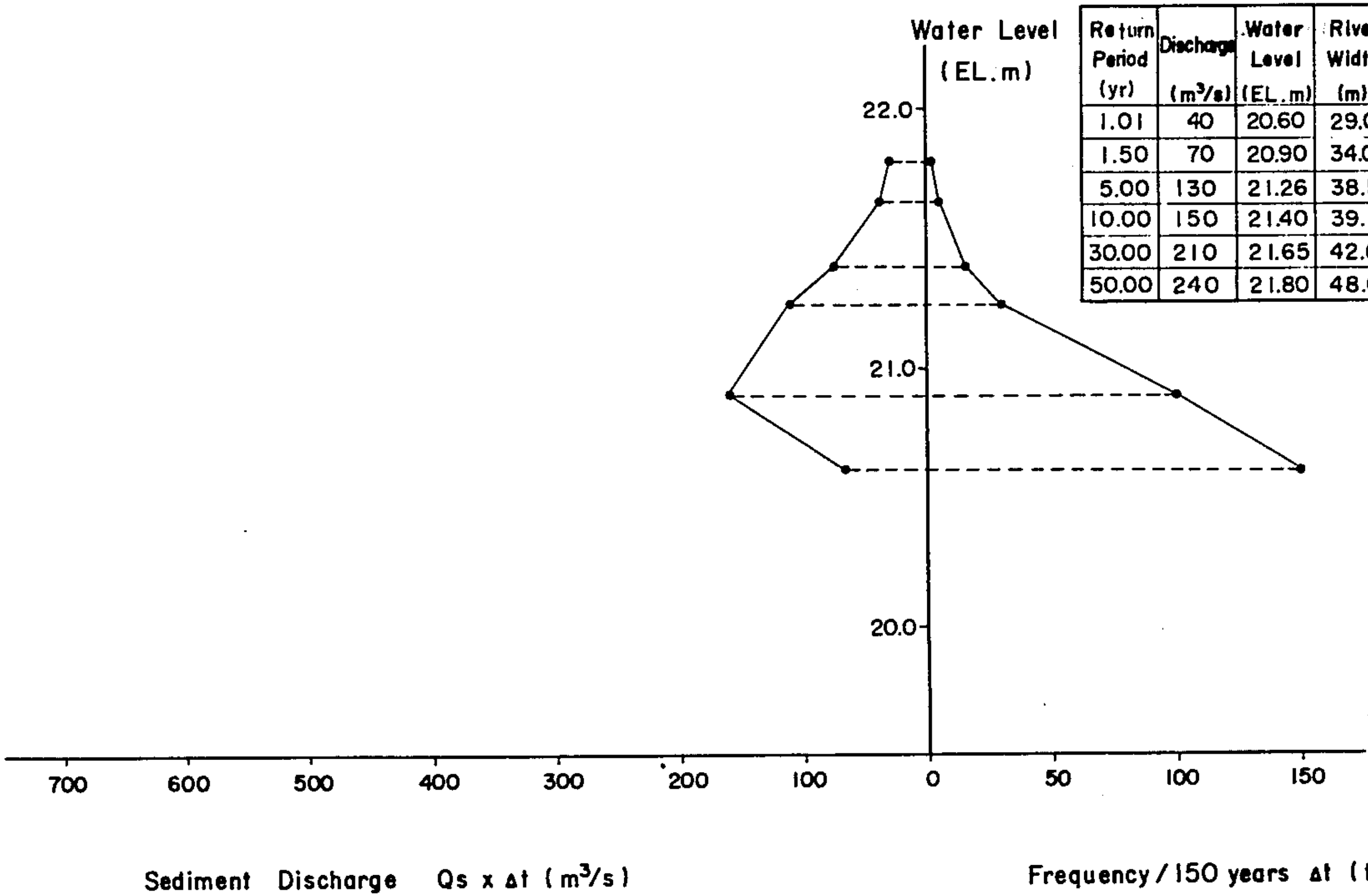
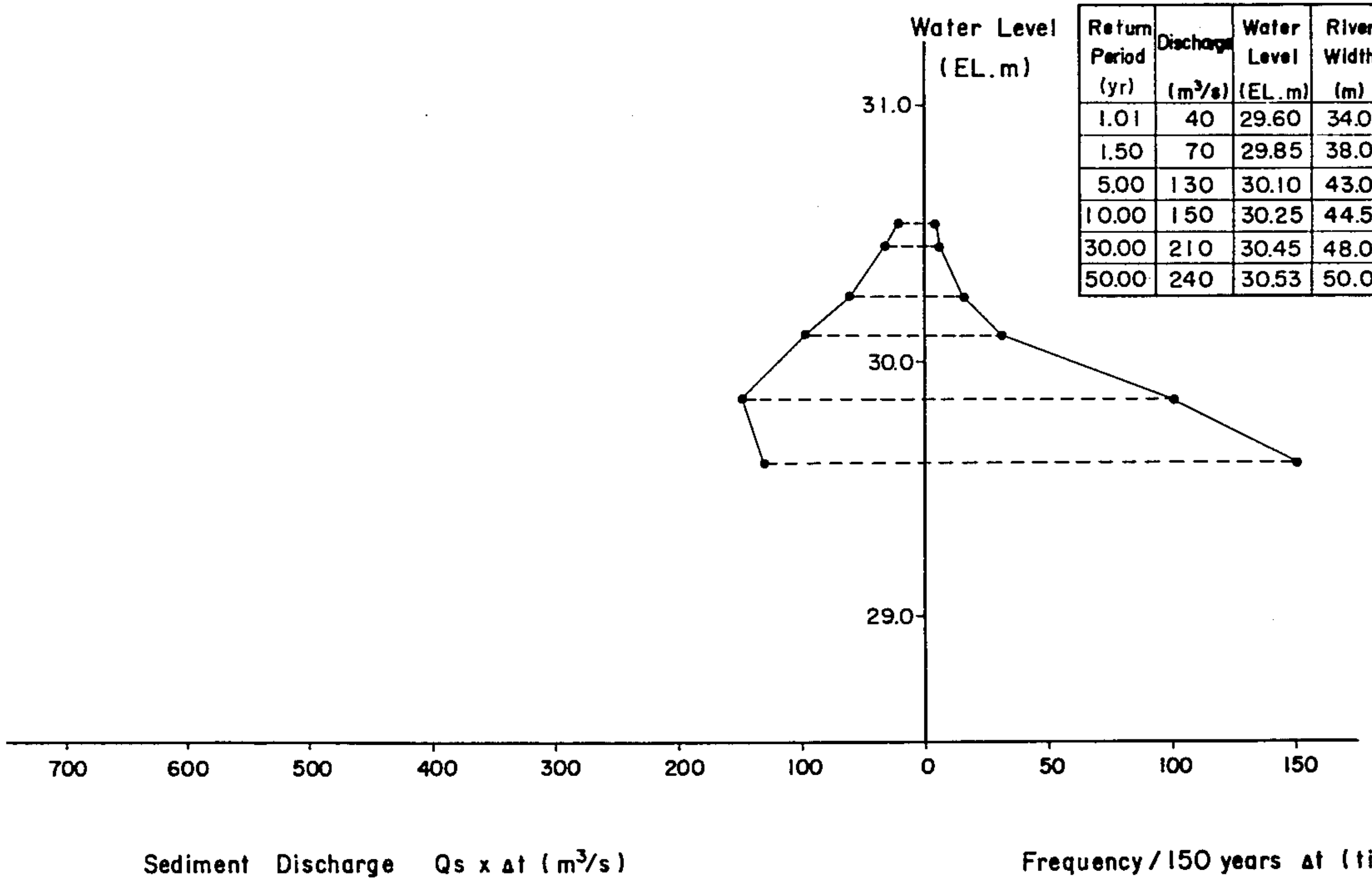


Fig. 4.41 Dominant Flow of Pawa - Burabodo River



Caluculation Table (Sta, 1+000)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL.m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m^3/sec)
1.01	40	29.60	34.0	0.55	0.87
1.50	70	29.85	38.0	0.65	1.48
5.00	130	30.10	43.0	0.85	3.28
10.00	150	30.25	44.5	0.92	4.14
30.00	210	30.45	48.0	1.10	6.98
50.00	240	30.53	50.0	1.13	7.78

Fig. 4.42 Dominant Flow of Pawa - Burabodo River

Caluculation Table (Sta. 1+600)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL.m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m^3/sec)
1.01	40	49.90	31.0	0.63	3.58
1.50	70	50.10	40.0	0.75	7.15
5.00	130	50.25	48.5	0.85	11.85
10.00	150	50.30	49.5	0.90	13.96
30.00	210	50.50	53.0	1.00	19.45
50.00	240	50.60	53.5	1.07	23.25

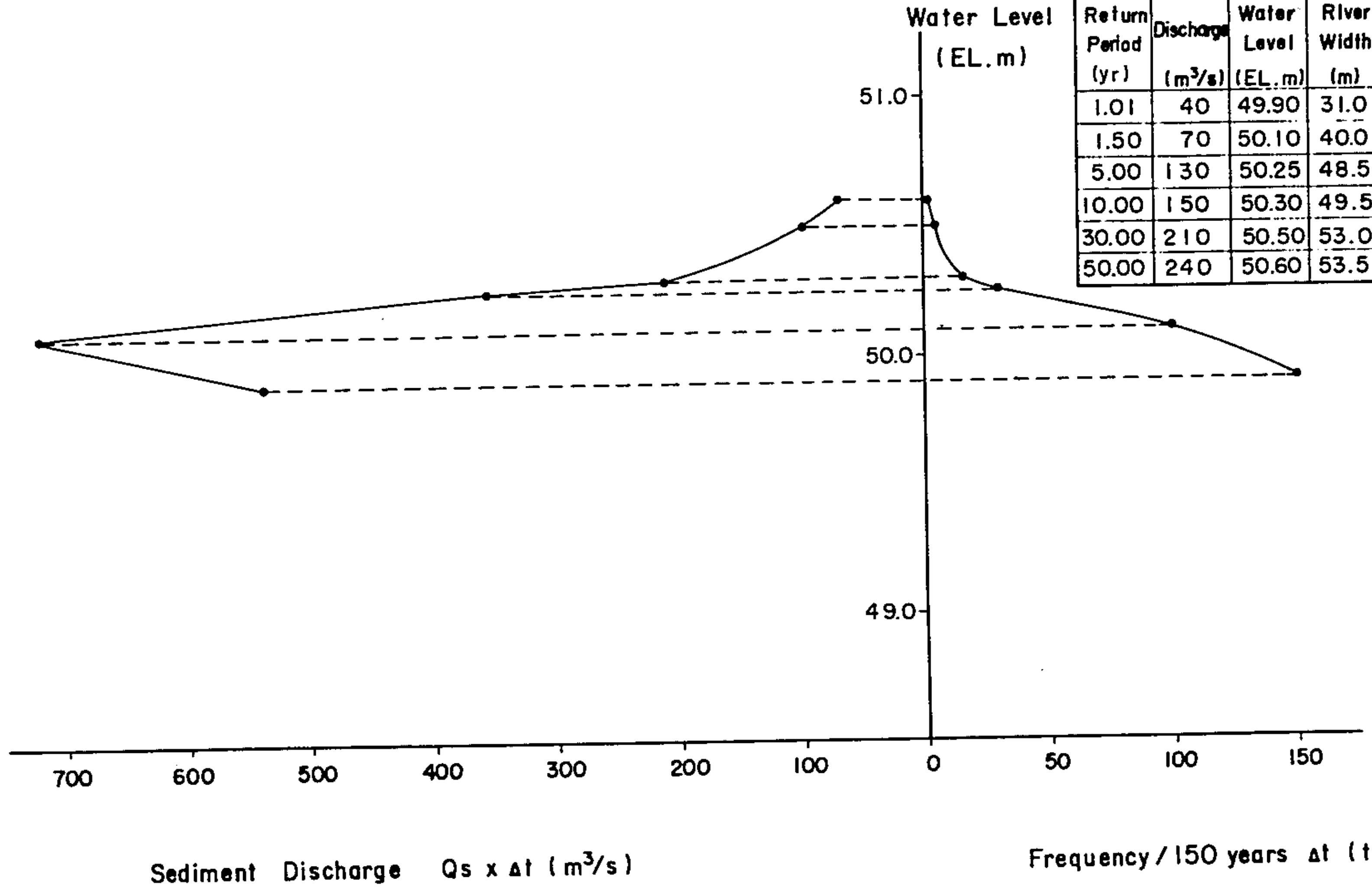


Fig. 4.43 Dominant Flow of Pawa - Burabodo River

Caluculation Table (Sta, 1+800).

Return Period (yr)	Dischage (m³/s)	Water Level (EL. m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m³/sec)
1.01	40	56.80	31.0	0.73	5.18
1.50	70	56.90	31.5	0.80	6.62
5.00	130	57.15	33.5	0.98	11.69
10.00	150	57.20	34.5	1.04	13.96
30.00	210	57.45	36.5	1.20	21.13
50.00	240	57.55	37.0	1.27	24.68

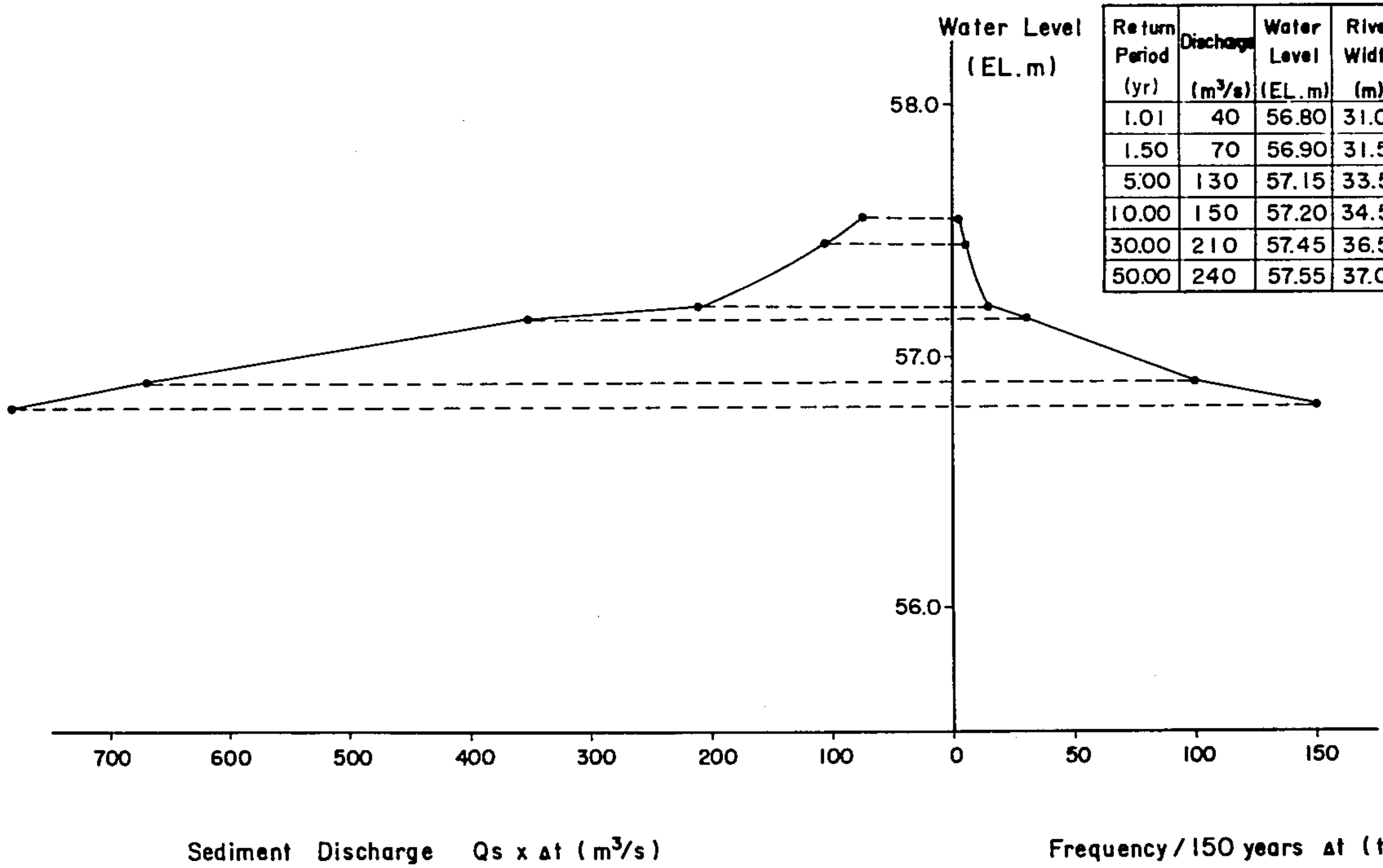


Fig. 4.44 Dominant Flow of Pawa - Burabodo River

Caluculation Table(Sta, 2+000)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL.m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m^3/sec)
1.01	40	62.65	28.0	0.70	4.21
1.50	70	62.85	29.5	0.85	7.21
5.00	130	63.17	33.0	1.05	13.68
10.00	150	63.25	33.5	1.13	16.69
30.00	210	63.55	36.5	1.33	27.32
50.00	240	63.70	38.0	1.40	32.34

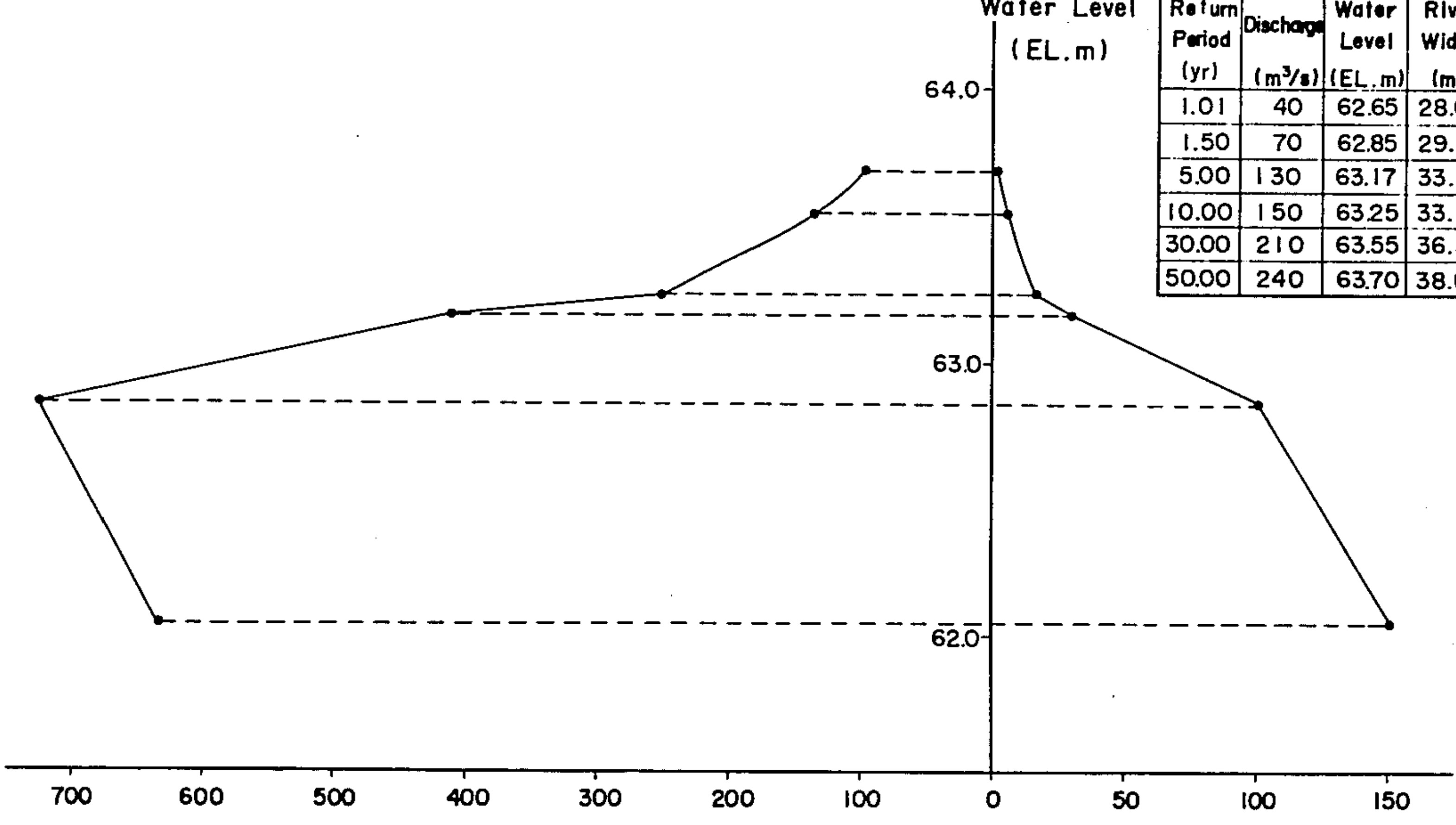
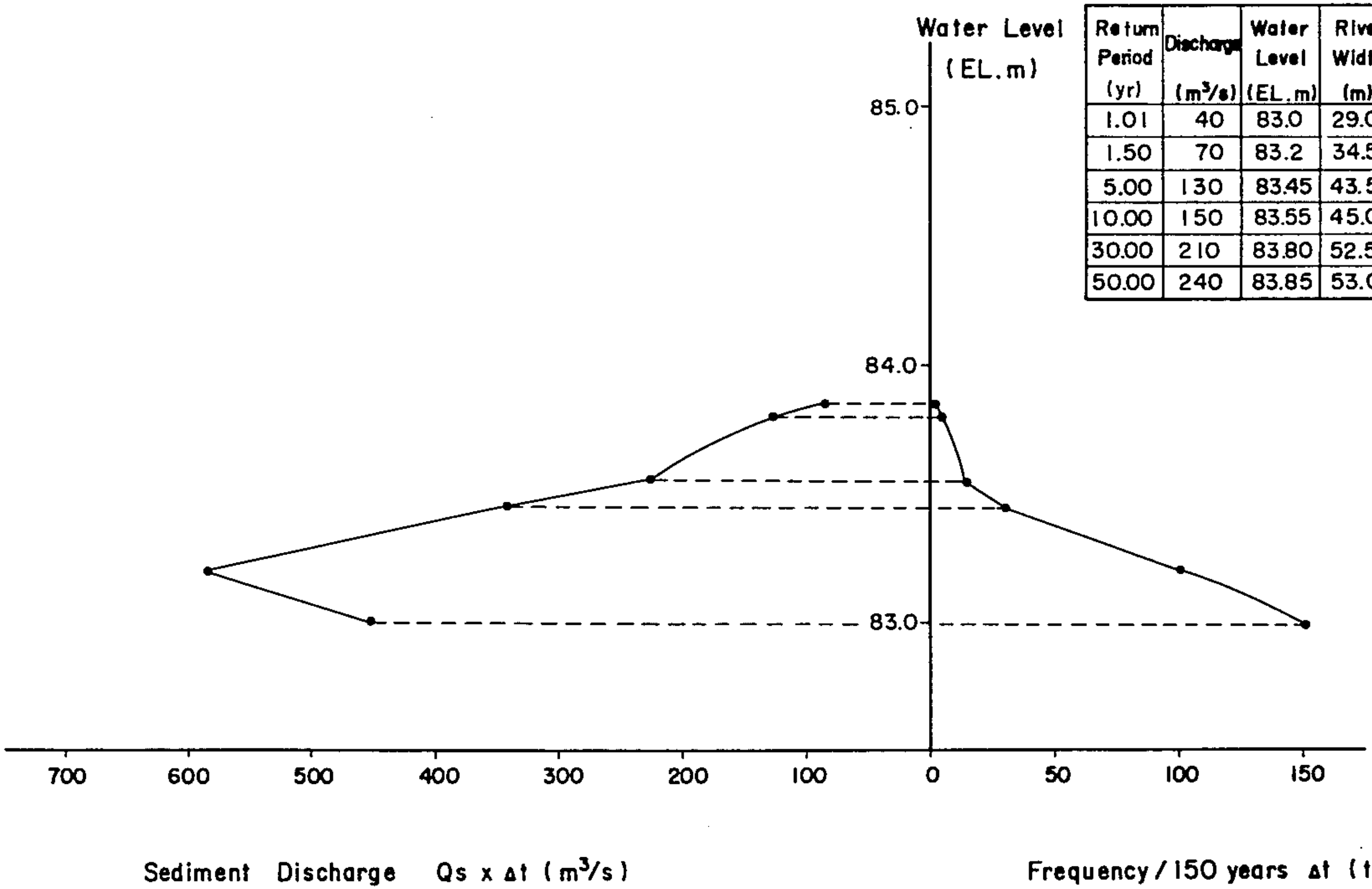


Fig. 4.45 Dominant Flow of Pawa - Burabodo River



Caluculation Table (Sta, 2+500)

Return Period (yr)	Discharge (m³/s)	Water Level (EL.m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m³/sec)
1.01	40	83.0	29.0	0.47	3.02
1.50	70	83.2	34.5	0.57	5.82
5.00	130	83.45	43.5	0.68	11.41
10.00	150	83.55	45.0	0.75	15.08
30.00	210	83.80	52.5	0.86	24.77
50.00	240	83.85	53.0	0.90	28.01

Fig. 4.46 Dominant Flow of Pawa - Burabodo River

Caluculation Table (Sta, 2+600)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL.m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs(m^3/sec)
1.01	40	88.30	35.0	0.40	2.44
1.50	70	88.50	40.0	0.55	6.17
5.00	130	88.80	46.5	0.72	14.07
10.00	150	88.90	48.0	0.80	18.90
30.00	210	89.10	54.0	0.90	28.54
50.00	240	89.20	57.0	0.95	34.49

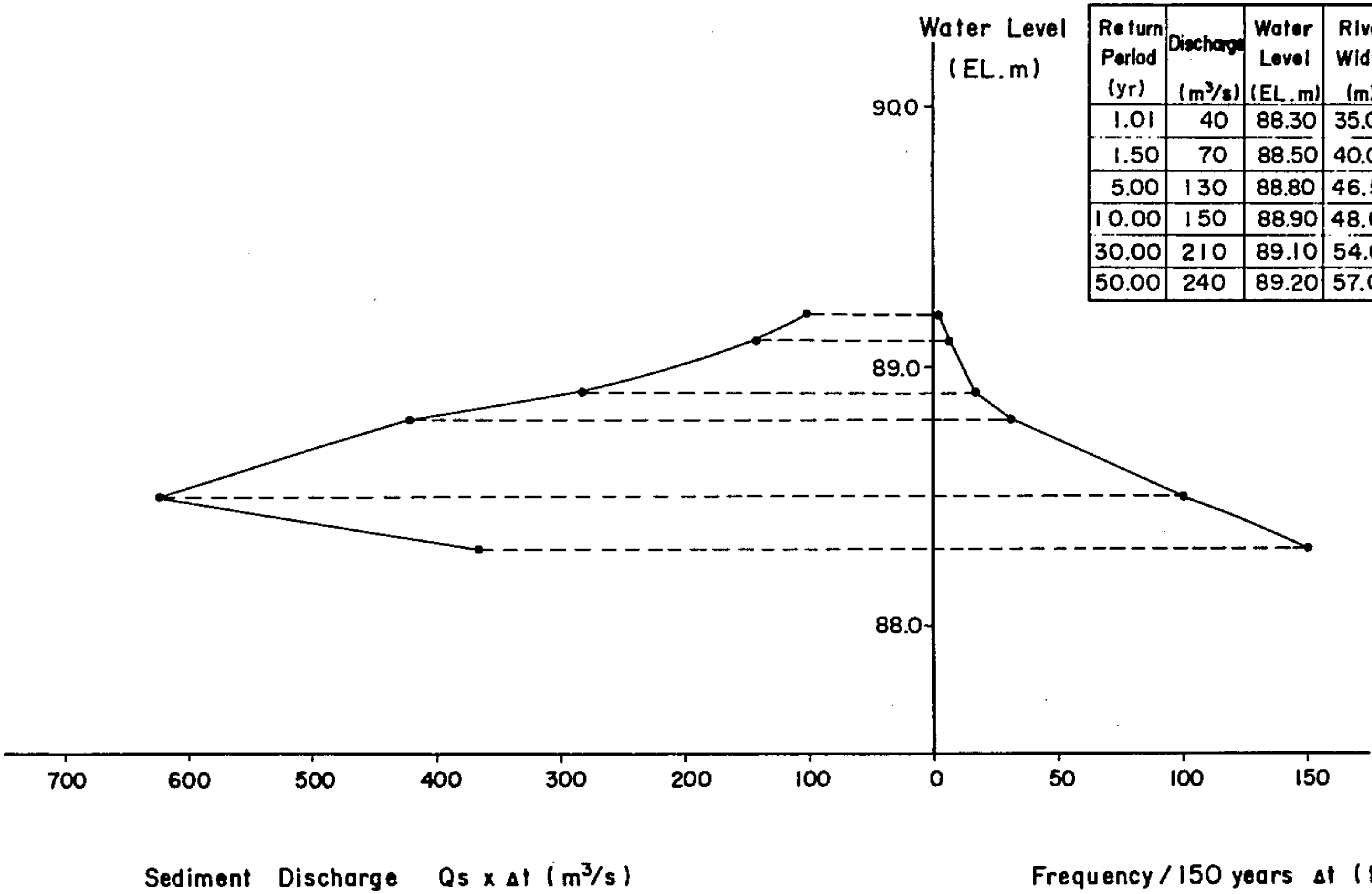
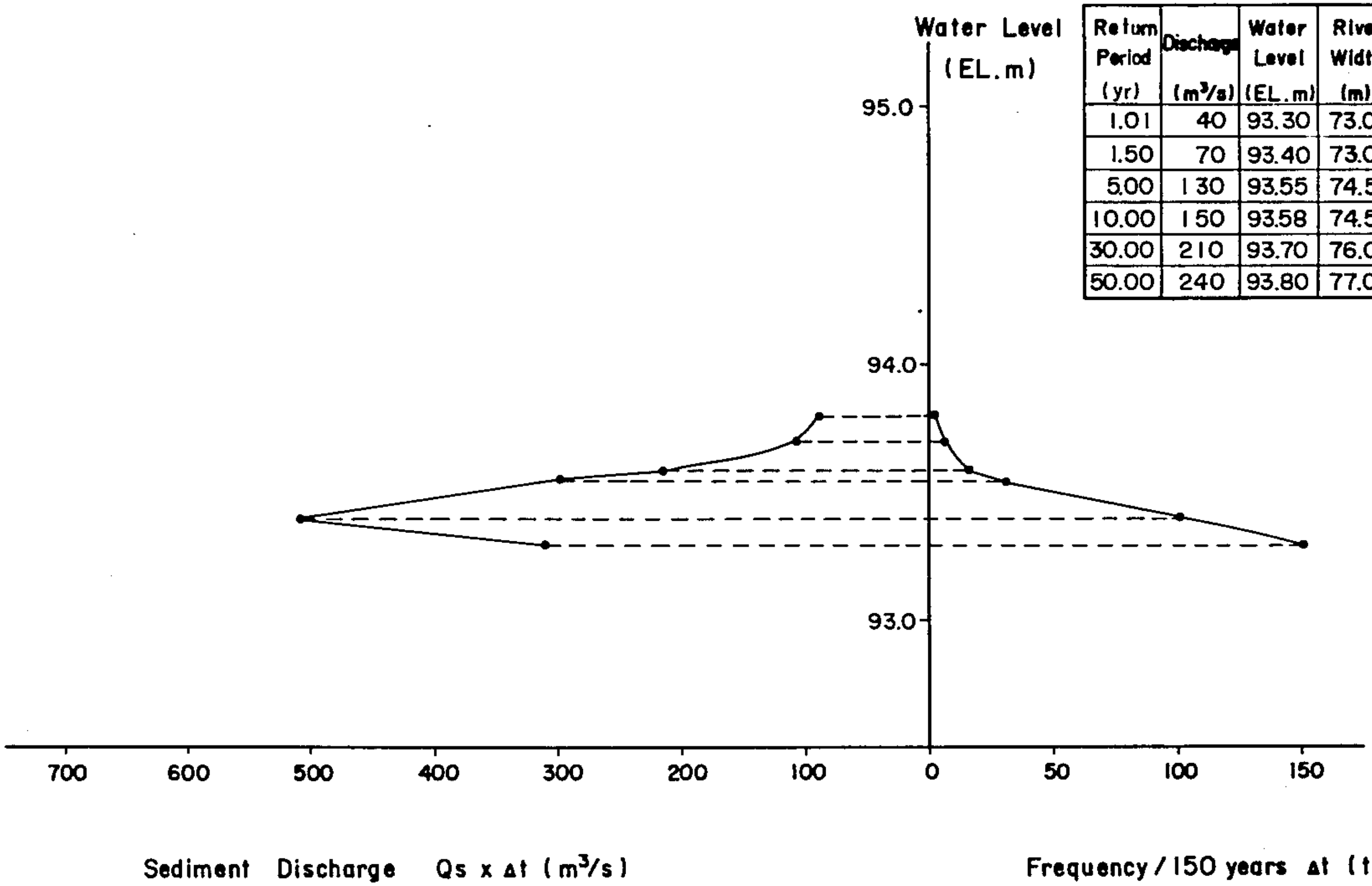


Fig. 4.47 Dominant Flow of Pawa - Burabodo River



Caluculation Table (Sta. 2+700)

Return Period (yr)	Discharge (m^3/s)	Water Level (EL.m)	River Width (m)	Hydraulic Depth (m)	Sediment Discharge per Flood Qs (m^3/sec)
1.01	40	93.30	73.0	0.28	2.08
1.50	70	93.40	73.0	0.40	5.08
5.00	130	93.55	74.5	0.50	9.99
10.00	150	93.58	74.5	0.60	14.29
30.00	210	93.70	76.0	0.70	21.43
50.00	240	93.80	77.0	0.80	30.32

Fig. 4.48 Standard Relation between Levee Slope and Levee Height due to Soil Classification

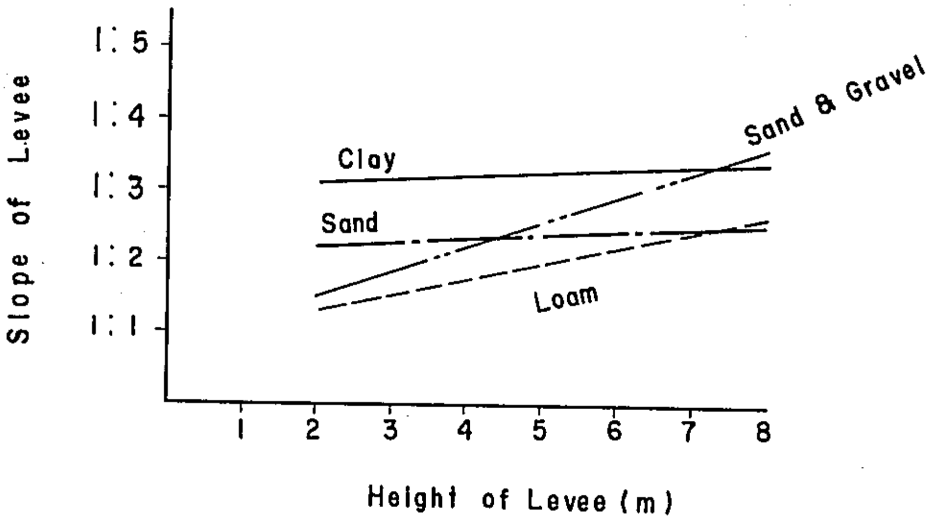


Fig. 4.49 Example of Foot Protection in Japan

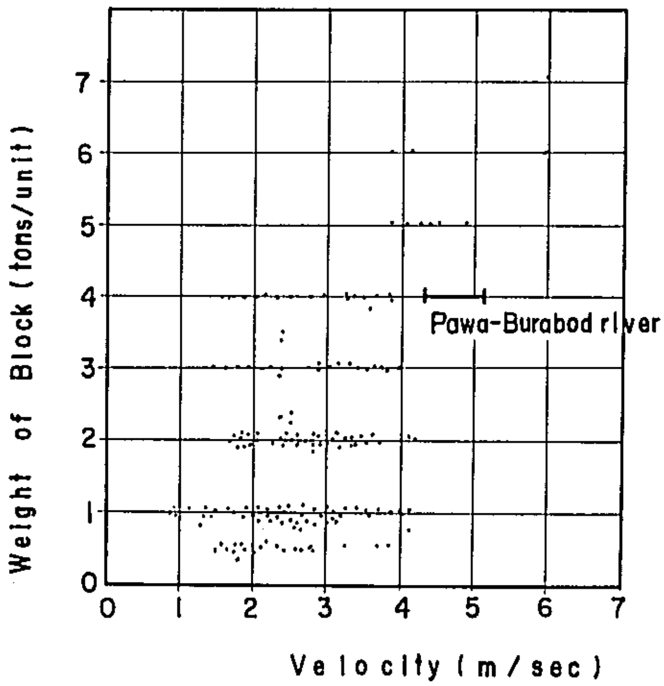
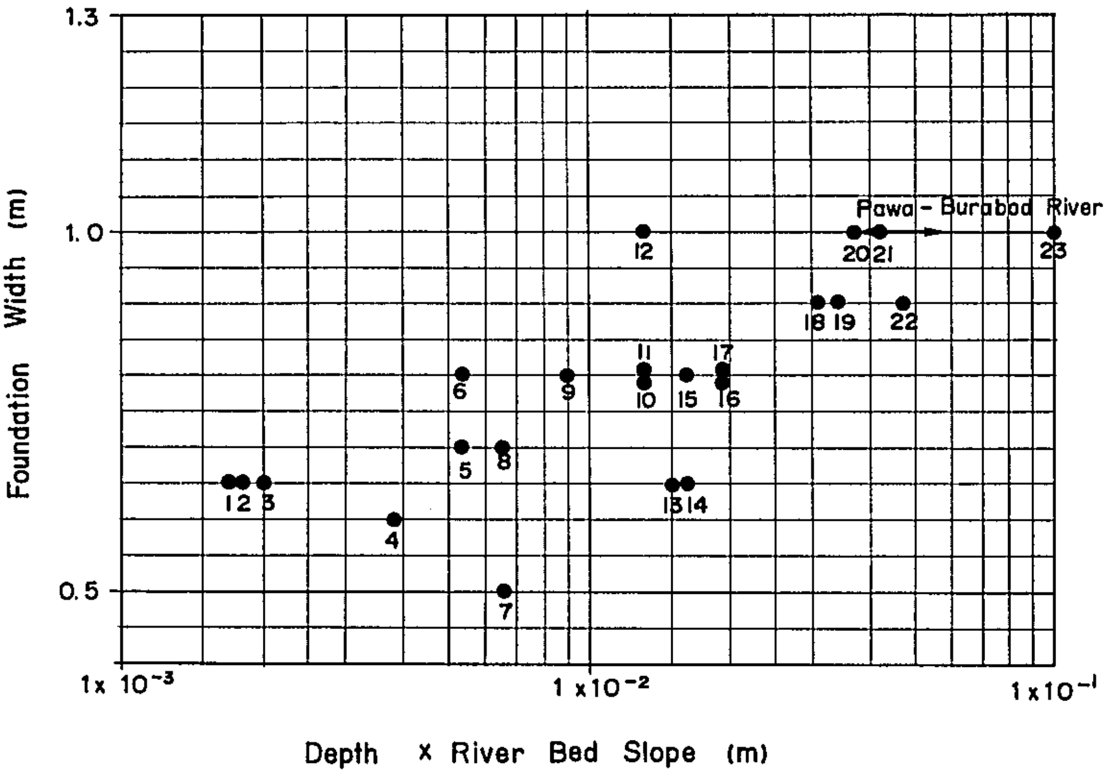


Table. 4.14 Standard Weight of Foot Protection in Japan

Flow Velocity (m/sec)	~2	2~4	4~
Weight of Block(tons/unit)	0.5~1	1~4	2~6

Fig 4. 50 Example of Foundation width in Japan

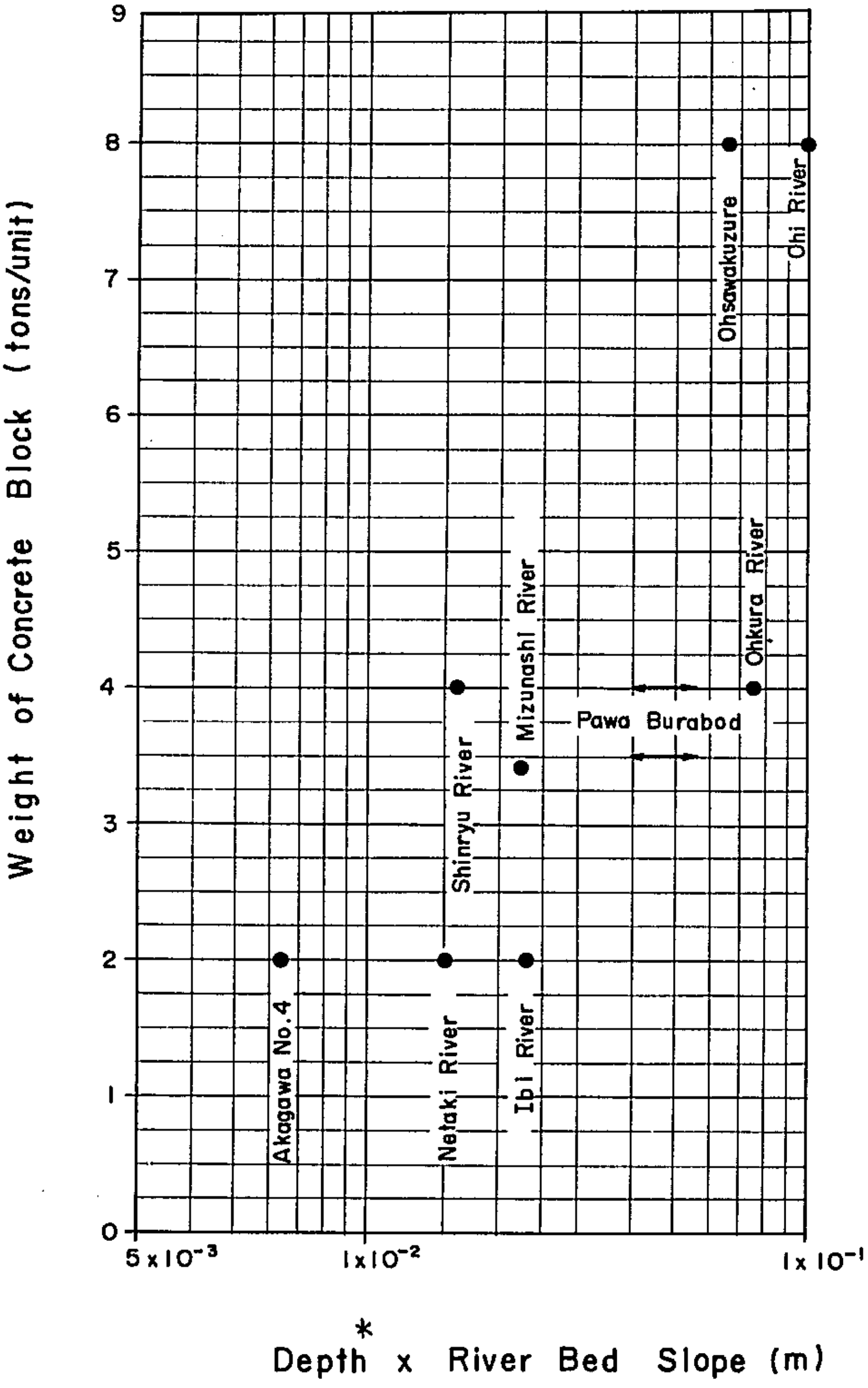


Legend

1 ... Ibi River (LR)
2 ... Nagara River (LR)
3 ... Kiso River (LR)
4 ... Shonai River
5 ... Yahagi River
6 ... Tenryu River (LR)
7 ... Kiku River
8 ... Kano River
9 ... Koyabe River
10 ... Jintsu River (LR)
11 ... Sho River (LR)
12 ... Toyo River
13 ... Ohoi River
14 ... Abe River
15 ... Joganji River (LR)
16 ... Ida River
17 ... Kumano River
18 ... Sho River (MR)
19 ... Jintsu River (MR)
20 ... Sho River (UR)
21 ... Jintsu River (UR)
22 ... Joganji River (MR)
23 ... Joganji River (UR)

Note: * - Depth at design high-water level
UR - Upper Reach
MR - Middle Reach
LR - Lower Reach

Fig 4.51 Example of Weight of Concrete Block for Ground-Sill in Japan



Note ; * Depth at design high Water level

********** NON-UNIFORM FLOW CALCULATION OF PAWA-SURABOD RIVER (Table 4.15) **********

CASE NO. 1 ($Q = 50\ m^3/sec$)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	97.700	14.6	0.453	3.429	0.045	50.0	0.	8.600	0.1628E 01	0.6845E-01
2+700	93.337	26.5	0.362	1.888	0.045	50.0	-100.00	13.448	0.1003E 01	0.2799E-01
2+600	88.367	15.7	0.425	3.179	0.045	50.0	-100.00	8.889	0.1558E 01	0.6407E-01
2+500	83.123	16.8	0.528	2.985	0.045	50.0	-100.00	10.948	0.1312E 01	0.4223E-01
2+400	77.836	15.3	0.458	3.272	0.045	50.0	-100.00	9.078	0.1545E 01	0.6144E-01
2+200	70.338	21.5	0.554	2.330	0.045	50.0	-200.00	14.482	0.1000E 01	0.2414E-01
2+100	66.229	16.4	0.453	3.040	0.045	50.0	-100.00	9.705	0.1442E 01	0.5375E-01
2+000	62.623	19.2	0.694	2.606	0.045	50.0	-100.00	15.034	0.1000E 01	0.2240E-01
1+900	59.155	13.4	0.783	3.731	0.045	50.0	-100.00	11.385	0.1347E 01	0.3906E-01
1+800	56.715	19.8	0.654	2.531	0.045	50.0	-100.00	14.881	0.1000E 01	0.2286E-01
1+700	52.723	14.9	0.542	3.352	0.045	50.0	-100.00	9.910	0.1455E 01	0.5154E-01
1+600	49.772	19.6	0.661	2.545	0.045	50.0	-100.00	14.914	0.1000E 01	0.2276E-01
1+500	45.573	17.9	0.369	2.792	0.045	50.0	-100.00	9.206	0.1469E 01	0.5974E-01
1+300	38.473	22.2	0.518	2.252	0.045	50.0	-200.00	14.315	0.1000E 01	0.2470E-01
1+100	32.653	16.5	0.675	3.022	0.045	50.0	-200.00	12.734	0.1175E 01	0.3122E-01
1+000	29.655	19.2	0.540	2.609	0.045	50.0	-100.00	12.709	0.1134E 01	0.3134E-01
0+900	27.381	20.5	0.607	2.438	0.045	50.0	-100.00	14.699	0.1000E 01	0.2343E-01
0+700	23.478	21.3	0.561	2.343	0.045	50.0	-200.00	14.509	0.1000E 01	0.2405E-01
0+600	20.771	19.0	0.589	2.634	0.045	50.0	-100.00	13.338	0.1096E 01	0.2846E-01
0+500	17.861	19.6	0.535	2.547	0.045	50.0	-100.00	12.938	0.1112E 01	0.3025E-01
0+400	15.611	22.7	0.497	2.207	0.045	50.0	-100.00	14.217	0.1000E 01	0.2505E-01
0+300	14.145	20.6	0.604	2.433	0.045	50.0	-100.00	14.694	0.1000E 01	0.2345E-01
0+200	11.791	19.8	0.648	2.529	0.045	50.0	-100.00	14.807	0.1004E 01	0.2309E-01
0+100	8.020	13.9	0.667	3.597	0.045	50.0	-100.00	10.608	0.1407E 01	0.4499E-01

CASE NO. 2 ($Q = 100\ m^3/sec$)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.050	26.4	0.628	3.789	0.045	100.0	0.	19.351	0.1528E 01	0.5408E-01
2+700	93.456	34.9	0.476	2.864	0.045	100.0	-100.00	21.286	0.1326E 01	0.4469E-01
2+600	88.689	28.3	0.640	3.534	0.045	100.0	-100.00	21.020	0.1411E 01	0.4583E-01
2+500	83.370	25.4	0.637	3.936	0.045	100.0	-100.00	18.818	0.1575E 01	0.5719E-01
2+400	78.138	26.0	0.698	3.842	0.045	100.0	-100.00	20.481	0.1469E 01	0.4828E-01
2+200	70.599	31.7	0.747	3.157	0.045	100.0	-200.00	26.065	0.1167E 01	0.2981E-01
2+100	66.515	26.9	0.670	3.713	0.045	100.0	-100.00	20.625	0.1449E 01	0.4760E-01
2+000	62.988	29.3	0.951	3.419	0.045	100.0	-100.00	28.291	0.1120E 01	0.2530E-01
1+900	59.684	23.2	1.107	4.317	0.045	100.0	-100.00	24.786	0.1311E 01	0.3296E-01
1+800	57.024	29.0	0.896	3.446	0.045	100.0	-100.00	26.971	0.1163E 01	0.2784E-01
1+700	53.081	25.0	0.763	3.998	0.045	100.0	-100.00	20.890	0.1462E 01	0.4641E-01
1+600	50.175	35.9	0.791	2.784	0.045	100.0	-100.00	30.732	0.1000E 01	0.2144E-01
1+500	45.762	27.1	0.558	3.695	0.045	100.0	-100.00	18.337	0.1580E 01	0.6022E-01
1+300	38.791	37.1	0.742	2.696	0.045	100.0	-200.00	30.405	0.1000E 01	0.2191E-01
1+100	33.094	28.9	0.802	3.456	0.045	100.0	-200.00	24.987	0.1232E 01	0.3243E-01
1+000	29.966	30.3	0.770	3.302	0.045	100.0	-100.00	25.435	0.1202E 01	0.3130E-01
0+900	28.282	35.5	0.812	2.819	0.045	100.0	-100.00	30.864	0.1000E 01	0.2126E-01
0+700	23.800	34.5	0.791	2.902	0.045	100.0	-200.00	29.480	0.1042E 01	0.2330E-01
0+600	21.123	30.6	0.829	3.266	0.045	100.0	-100.00	27.028	0.1146E 01	0.2772E-01
0+500	18.158	30.8	0.741	3.243	0.045	100.0	-100.00	25.259	0.1203E 01	0.3174E-01
0+400	15.935	38.3	0.696	2.612	0.045	100.0	-100.00	30.075	0.1000E 01	0.2239E-01
0+300	14.560	36.3	0.773	2.751	0.045	100.0	-100.00	30.615	0.1000E 01	0.2161E-01
0+200	12.176	32.4	0.850	3.083	0.045	100.0	-100.00	29.117	0.1068E 01	0.2389E-01
0+100	8.449	24.6	0.830	4.060	0.045	100.0	-100.00	21.745	0.1424E 01	0.4283E-01
Station Number	Water Level (EL.m)	Flow Area (m^2)	Hydraulic Radius (m)	Flow Velocity (m/sec)	Roughness Coefficient	Discharge (m^3/sec)	Distance (m)		Froude Number	Energy Gradient

NON-UNIFORM FLOW CALCULATION OF PAJA-BURABOD RIVER (Table 4.16)

CASE NO. 3 ($Q = 150\ m^3/sec$)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.250	36.0	0.727	4.172	0.045	150.0	0.	29.080	0.1563E 01	0.5388E-01
2+700	93.585	44.4	0.595	3.376	0.045	150.0	-100.00	31.420	0.1399E 01	0.4615E-01
2+600	88.915	38.2	0.792	3.931	0.045	150.0	-100.00	32.658	0.1411E 01	0.4272E-01
2+500	83.578	33.9	0.740	4.429	0.045	150.0	-100.00	27.711	0.1645E 01	0.5933E-01
2+400	78.366	34.6	0.869	4.333	0.045	150.0	-100.00	31.520	0.1485E 01	0.4586E-01
2+200	70.793	40.0	0.905	3.750	0.045	150.0	-200.00	37.439	0.1259E 01	0.3251E-01
2+100	66.728	35.8	0.838	4.187	0.045	150.0	-100.00	31.853	0.1461E 01	0.4491E-01
2+000	63.262	38.1	1.130	3.939	0.045	150.0	-100.00	41.320	0.1184E 01	0.2669E-01
1+900	60.097	31.8	1.387	4.714	0.045	150.0	-100.00	39.581	0.1278E 01	0.2908E-01
1+800	57.225	35.9	1.040	4.183	0.045	150.0	-100.00	36.800	0.1311E 01	0.3364E-01
1+700	53.334	33.5	0.990	4.484	0.045	150.0	-100.00	33.235	0.1439E 01	0.4125E-01
1+600	50.337	43.8	0.882	3.425	0.045	150.0	-100.00	40.263	0.1165E 01	0.2811E-01
1+500	45.942	35.8	0.738	4.189	0.045	150.0	-100.00	29.250	0.1557E 01	0.5325E-01
1+300	39.049	49.7	0.925	3.015	0.045	150.0	-200.00	47.233	0.1001E 01	0.2042E-01
1+100	33.390	41.9	0.816	3.582	0.045	150.0	-200.00	36.569	0.1267E 01	0.3407E-01
1+000	30.230	41.6	0.933	3.608	0.045	150.0	-100.00	39.693	0.1193E 01	0.2892E-01
0+900	28.565	48.6	0.972	3.086	0.045	150.0	-100.00	47.692	0.1000E 01	0.2003E-01
0+700	24.026	44.4	0.965	3.381	0.045	150.0	-200.00	43.312	0.1100E 01	0.2429E-01
0+600	21.395	40.9	1.036	3.670	0.045	150.0	-100.00	41.835	0.1152E 01	0.2603E-01
0+500	18.353	39.2	0.910	3.822	0.045	150.0	-100.00	36.858	0.1280E 01	0.3354E-01
0+400	16.168	51.6	0.864	2.909	0.045	150.0	-100.00	46.779	0.1000E 01	0.2082E-01
0+300	14.935	50.8	0.889	2.951	0.045	150.0	-100.00	46.997	0.1000E 01	0.2063E-01
0+200	12.487	44.3	0.999	3.386	0.045	150.0	-100.00	44.270	0.1082E 01	0.2325E-01
0+100	8.723	33.9	0.945	4.431	0.045	150.0	-100.00	32.604	0.1456E 01	0.4286E-01

CASE NO. 4 ($Q = 200\ m^3/sec$)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.400	43.1	0.802	4.638	0.045	200.0	0.	37.228	0.1654E 01	0.5845E-01
2+700	93.712	54.0	0.709	3.706	0.045	200.0	-100.00	42.884	0.1407E 01	0.4404E-01
2+600	89.035	46.7	0.891	4.282	0.045	200.0	-100.00	43.241	0.1449E 01	0.4332E-01
2+500	83.738	41.9	0.834	4.769	0.045	200.0	-100.00	37.154	0.1668E 01	0.5868E-01
2+400	78.554	42.1	1.009	4.752	0.045	200.0	-100.00	42.347	0.1511E 01	0.4517E-01
2+200	70.970	47.6	1.051	4.200	0.045	200.0	-200.00	49.212	0.1309E 01	0.3345E-01
2+100	66.911	43.5	0.984	4.599	0.045	200.0	-100.00	43.008	0.1481E 01	0.4379E-01
2+000	63.512	46.2	1.292	4.326	0.045	200.0	-100.00	54.342	0.1216E 01	0.2693E-01
1+900	60.476	40.6	1.549	4.931	0.045	200.0	-100.00	54.294	0.1266E 01	0.2748E-01
1+800	57.420	42.5	1.179	4.709	0.045	200.0	-100.00	47.398	0.1385E 01	0.3606E-01
1+700	53.547	40.6	1.188	4.926	0.045	200.0	-100.00	45.546	0.1444E 01	0.3905E-01
1+600	50.489	51.3	0.967	3.902	0.045	200.0	-100.00	50.112	0.1268E 01	0.3226E-01
1+500	46.104	43.6	0.900	4.583	0.045	200.0	-100.00	40.680	0.1543E 01	0.4895E-01
1+300	39.160	55.8	1.028	3.585	0.045	200.0	-200.00	56.838	0.1129E 01	0.2507E-01
1+100	33.636	54.5	0.933	3.667	0.045	200.0	-200.00	52.101	0.1212E 01	0.2984E-01
1+000	30.410	49.4	1.041	4.045	0.045	200.0	-100.00	50.782	0.1266E 01	0.3141E-01
0+900	28.796	61.0	1.099	3.280	0.045	200.0	-100.00	64.919	0.1000E 01	0.1922E-01
0+700	24.214	53.4	1.107	3.744	0.045	200.0	-200.00	57.180	0.1136E 01	0.2477E-01
0+600	21.630	50.3	1.206	3.975	0.045	200.0	-100.00	57.018	0.1156E 01	0.2491E-01
0+500	18.524	46.7	1.062	4.286	0.045	200.0	-100.00	48.586	0.1328E 01	0.3431E-01
0+400	16.364	63.5	1.014	3.151	0.045	200.0	-100.00	64.055	0.1000E 01	0.1974E-01
0+300	15.064	63.7	1.006	3.139	0.045	200.0	-100.00	63.952	0.1000E 01	0.1981E-01
0+200	12.702	55.1	1.094	3.632	0.045	200.0	-100.00	58.483	0.1109E 01	0.2368E-01
0+100	8.976	42.8	1.054	4.669	0.045	200.0	-100.00	44.352	0.1453E 01	0.4118E-01

********** NON-UNIFORM FLOW CALCULATION OF PAWA-BURABOD RIVER (Table 4.17) **********

CASE NO. 5 (Q = 250 m^3/sec)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.550	51.1	0.877	4.892	0.045	250.0	0.	46.812	0.1669E 01	0.5776E-01
2+700	93.811	61.4	0.798	4.069	0.045	250.0	-100.00	52.951	0.1455E 01	0.4531E-01
2+600	89.248	55.9	0.971	4.471	0.045	250.0	-100.00	54.822	0.1450E 01	0.4211E-01
2+500	83.881	49.2	0.918	5.084	0.045	250.0	-100.00	46.452	0.1695E 01	0.5866E-01
2+400	78.716	49.2	1.127	5.084	0.045	250.0	-100.00	53.249	0.1530E 01	0.4464E-01
2+200	71.128	54.8	1.174	4.564	0.045	250.0	-200.00	60.956	0.1346E 01	0.3406E-01
2+100	67.075	50.6	1.113	4.945	0.045	250.0	-100.00	54.291	0.1497E 01	0.4294E-01
2+000	63.716	53.8	1.416	4.644	0.045	250.0	-100.00	67.874	0.1247E 01	0.2747E-01
1+900	60.791	49.2	1.678	5.084	0.045	250.0	-100.00	69.448	0.1254E 01	0.2624E-01
1+800	57.597	48.9	1.301	5.113	0.045	250.0	-100.00	58.253	0.1432E 01	0.3730E-01
1+700	53.740	47.2	1.364	5.302	0.045	250.0	-100.00	57.981	0.1450E 01	0.3765E-01
1+600	50.602	57.2	1.071	4.367	0.045	250.0	-100.00	59.922	0.1348E 01	0.3525E-01
1+500	46.253	50.8	1.049	4.919	0.045	250.0	-100.00	52.457	0.1534E 01	0.4599E-01
1+300	39.268	61.7	1.130	4.050	0.045	250.0	-200.00	66.965	0.1217E 01	0.2822E-01
1+100	33.305	64.4	1.091	3.881	0.045	250.0	-200.00	68.262	0.1187E 01	0.2716E-01
1+000	30.569	57.1	1.132	4.380	0.045	250.0	-100.00	61.982	0.1315E 01	0.3294E-01
0+900	29.008	72.4	1.216	3.452	0.045	250.0	-100.00	82.515	0.1000E 01	0.1859E-01
0+700	24.385	61.6	1.237	4.056	0.045	250.0	-200.00	71.006	0.1165E 01	0.2510E-01
0+600	21.838	59.1	1.351	4.229	0.045	250.0	-100.00	72.268	0.1162E 01	0.2423E-01
0+500	18.677	53.3	1.214	4.689	0.045	250.0	-100.00	60.675	0.1359E 01	0.3438E-01
0+400	16.517	72.8	1.130	3.432	0.045	250.0	-100.00	79.014	0.1031E 01	0.2027E-01
0+300	15.234	75.0	1.133	3.332	0.045	250.0	-100.00	81.556	0.1000E 01	0.1903E-01
0+200	12.906	65.4	1.184	3.822	0.045	250.0	-100.00	73.220	0.1122E 01	0.2361E-01
0+100	9.153	50.2	1.188	4.983	0.045	250.0	-100.00	56.269	0.1461E 01	0.3997E-01

CASE NO. 6 (Q = 300 m^3/sec)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.700	60.7	0.951	4.942	0.045	300.0	0.	58.709	0.1619E 01	0.5288E-01
2+700	93.889	67.4	0.868	4.454	0.045	300.0	-100.00	61.308	0.1527E 01	0.4849E-01
2+600	89.416	65.5	1.054	4.583	0.045	300.0	-100.00	67.789	0.1426E 01	0.3966E-01
2+500	84.007	55.6	0.994	5.396	0.045	300.0	-100.00	55.382	0.1729E 01	0.5942E-01
2+400	78.871	56.0	1.239	5.360	0.045	300.0	-100.00	64.563	0.1538E 01	0.4372E-01
2+200	71.262	61.0	1.289	4.918	0.045	300.0	-200.00	72.244	0.1384E 01	0.3492E-01
2+100	67.215	56.9	1.247	5.273	0.045	300.0	-100.00	65.900	0.1509E 01	0.4197E-01
2+000	63.900	60.7	1.528	4.943	0.045	300.0	-100.00	80.505	0.1277E 01	0.2812E-01
1+900	61.031	57.5	1.799	5.214	0.045	300.0	-100.00	85.093	0.1242E 01	0.2517E-01
1+800	57.756	54.9	1.406	5.463	0.045	300.0	-100.00	68.919	0.1472E 01	0.3837E-01
1+700	53.922	53.4	1.530	5.622	0.045	300.0	-100.00	70.852	0.1452E 01	0.3631E-01
1+600	50.703	62.6	1.168	4.791	0.045	300.0	-100.00	69.442	0.1416E 01	0.3779E-01
1+500	46.392	57.6	1.188	5.211	0.045	300.0	-100.00	64.568	0.1527E 01	0.4372E-01
1+300	39.371	67.4	1.226	4.453	0.045	300.0	-200.00	77.169	0.1285E 01	0.3060E-01
1+100	33.963	73.6	1.238	4.074	0.045	300.0	-200.00	84.885	0.1170E 01	0.2529E-01
1+000	30.707	64.5	1.206	4.653	0.045	300.0	-100.00	73.045	0.1354E 01	0.3416E-01
0+900	29.176	83.2	1.327	3.605	0.045	300.0	-100.00	100.509	0.1000E 01	0.1804E-01
0+700	24.544	69.5	1.355	4.314	0.045	300.0	-200.00	85.164	0.1184E 01	0.2513E-01
0+600	22.079	67.3	1.485	4.458	0.045	300.0	-100.00	87.592	0.1169E 01	0.2375E-01
0+500	18.820	59.5	1.356	5.038	0.045	300.0	-100.00	72.951	0.1382E 01	0.3425E-01
0+400	16.619	79.7	1.206	3.764	0.045	300.0	-100.00	90.280	0.1095E 01	0.2236E-01
0+300	15.394	85.6	1.253	3.504	0.045	300.0	-100.00	99.506	0.1000E 01	0.1841E-01
0+200	13.076	75.0	1.261	4.000	0.045	300.0	-100.00	87.539	0.1138E 01	0.2378E-01
0+100	9.318	57.2	1.321	5.247	0.045	300.0	-100.00	68.854	0.1458E 01	0.3844E-01

********** NON-UNIFORM FLOW CALCULATION OF PAJA-BURABOD RIVER (Table 4.18) **********

CASE NO. 7 (Q = 350 m^3/sec)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.800	67.1	1.001	5.216	0.045	350.0	0.	67.136	0.1666E 01	0.5504E-01
2+700	93.987	74.7	0.956	4.684	0.045	350.0	-100.00	72.539	0.1530E 01	0.4714E-01
2+600	89.535	72.5	1.125	4.828	0.045	350.0	-100.00	78.412	0.1454E 01	0.4035E-01
2+500	84.115	61.7	1.088	5.669	0.045	350.0	-100.00	65.313	0.1736E 01	0.5815E-01
2+400	79.004	61.8	1.336	5.663	0.045	350.0	-100.00	74.969	0.1565E 01	0.4414E-01
2+200	71.393	67.1	1.414	5.215	0.045	350.0	-200.00	84.533	0.1401E 01	0.3471E-01
2+100	67.342	62.6	1.367	5.592	0.045	350.0	-100.00	77.094	0.1528E 01	0.4174E-01
2+000	64.076	67.4	1.633	5.194	0.045	350.0	-100.00	93.445	0.1298E 01	0.2841E-01
1+900	61.317	65.0	1.931	5.388	0.045	350.0	-100.00	109.714	0.1239E 01	0.2446E-01
1+800	57.908	60.7	1.507	5.767	0.045	350.0	-100.00	79.769	0.1501E 01	0.3898E-01
1+700	54.091	59.2	1.682	5.914	0.045	350.0	-100.00	83.687	0.1457E 01	0.3542E-01
1+600	50.800	67.8	1.260	5.166	0.045	350.0	-100.00	79.045	0.1470E 01	0.3970E-01
1+500	46.522	63.9	1.318	5.480	0.045	350.0	-100.00	76.771	0.1525E 01	0.4209E-01
1+300	39.471	72.8	1.319	4.805	0.045	350.0	-200.00	87.615	0.1336E 01	0.3232E-01
1+100	34.105	82.0	1.376	4.267	0.045	350.0	-200.00	101.479	0.1162E 01	0.2409E-01
1+000	30.841	71.7	1.278	4.885	0.045	350.0	-100.00	84.360	0.1381E 01	0.3486E-01
0+900	29.334	93.4	1.432	3.746	0.045	350.0	-100.00	118.722	0.1000E 01	0.1760E-01
0+700	24.688	77.2	1.457	4.535	0.045	350.0	-200.00	99.210	0.1200E 01	0.2520E-01
0+600	22.208	76.0	1.566	4.608	0.045	350.0	-100.00	102.427	0.1176E 01	0.2364E-01
0+500	18.964	65.8	1.499	5.316	0.045	350.0	-100.00	86.250	0.1387E 01	0.3335E-01
0+400	16.704	85.4	1.269	4.097	0.045	350.0	-100.00	100.163	0.1161E 01	0.2473E-01
0+300	15.543	95.7	1.366	3.658	0.045	350.0	-100.00	117.773	0.1000E 01	0.1788E-01
0+200	13.218	84.0	1.327	4.169	0.045	350.0	-100.00	101.368	0.1156E 01	0.2414E-01
0+100	9.482	64.1	1.454	5.459	0.045	350.0	-100.00	82.290	0.1446E 01	0.3663E-01

CASE NO. 8 (Q = 400 m^3/sec)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	98.900	73.5	1.050	5.442	0.045	400.0	0.	75.949	0.1696E 01	0.5617E-01
2+700	94.075	81.6	1.032	4.901	0.045	400.0	-100.00	83.367	0.1541E 01	0.4662E-01
2+600	89.634	78.9	1.209	5.067	0.045	400.0	-100.00	89.618	0.1472E 01	0.4034E-01
2+500	84.215	67.5	1.176	5.930	0.045	400.0	-100.00	75.146	0.1747E 01	0.5738E-01
2+400	79.118	67.1	1.444	5.963	0.045	400.0	-100.00	85.686	0.1585E 01	0.4413E-01
2+200	71.513	72.7	1.527	5.503	0.045	400.0	-200.00	96.379	0.1423E 01	0.3488E-01
2+100	67.464	68.1	1.483	5.875	0.045	400.0	-100.00	88.531	0.1541E 01	0.4134E-01
2+000	64.220	73.2	1.746	5.465	0.045	400.0	-100.00	106.111	0.1321E 01	0.2878E-01
1+900	61.515	71.4	2.102	5.603	0.045	400.0	-100.00	117.164	0.1234E 01	0.2360E-01
1+800	58.044	66.0	1.596	6.059	0.045	400.0	-100.00	90.153	0.1532E 01	0.3986E-01
1+700	54.254	64.9	1.826	6.165	0.045	400.0	-100.00	96.935	0.1457E 01	0.3448E-01
1+600	50.891	72.6	1.347	5.512	0.045	400.0	-100.00	88.522	0.1517E 01	0.4135E-01
1+500	46.645	69.8	1.441	5.729	0.045	400.0	-100.00	89.084	0.1524E 01	0.4083E-01
1+300	39.566	78.0	1.411	5.128	0.045	400.0	-200.00	93.155	0.1379E 01	0.3363E-01
1+100	34.235	89.8	1.506	4.456	0.045	400.0	-200.00	117.941	0.1160E 01	0.2329E-01
1+000	30.971	78.6	1.347	5.088	0.045	400.0	-100.00	95.899	0.1400E 01	0.3523E-01
0+900	29.486	103.2	1.533	3.875	0.045	400.0	-100.00	137.235	0.1000E 01	0.1720E-01
0+700	24.824	84.4	1.554	4.738	0.045	400.0	-200.00	113.271	0.1214E 01	0.2525E-01
0+600	22.378	84.3	1.638	4.744	0.045	400.0	-100.00	117.178	0.1184E 01	0.2360E-01
0+500	19.104	71.9	1.638	5.562	0.045	400.0	-100.00	99.945	0.1388E 01	0.3244E-01
0+400	16.784	90.8	1.329	4.405	0.045	400.0	-100.00	109.771	0.1221E 01	0.2689E-01
0+300	15.680	105.4	1.471	3.796	0.045	400.0	-100.00	136.327	0.1000E 01	0.1743E-01
0+200	13.356	92.7	1.390	4.316	0.045	400.0	-100.00	115.439	0.1169E 01	0.2431E-01
0+100	9.633	70.8	1.575	5.648	0.045	400.0	-100.00	95.871	0.1438E 01	0.3525E-01

********** NON-UNIFORM FLOW CALCULATION OF PAWA-BURABOD RIVER (Table 4.19) **********

CASE NO. 9 ($Q = 450\ m^3/sec$)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IF
2+800	99.000	79.9	1.100	5.632	0.045	450.0	0.	85.142	0.1715E 01	0.5657E-01
2+700	94.156	88.0	1.102	5.115	0.045	450.0	-100.00	93.857	0.1557E 01	0.4655E-01
2+600	89.731	85.3	1.292	5.277	0.045	450.0	-100.00	101.180	0.1483E 01	0.4006E-01
2+500	84.310	72.9	1.259	6.175	0.045	450.0	-100.00	84.959	0.1758E 01	0.5681E-01
2+400	79.227	72.2	1.547	6.236	0.045	450.0	-100.00	96.530	0.1601E 01	0.4401E-01
2+200	71.624	78.0	1.631	5.772	0.045	450.0	-200.00	108.023	0.1444E 01	0.3514E-01
2+100	67.531	73.4	1.593	6.131	0.045	450.0	-100.00	100.115	0.1552E 01	0.4091E-01
2+000	64.348	78.5	1.863	5.734	0.045	450.0	-100.00	113.827	0.1342E 01	0.2904E-01
1+900	61.704	77.5	2.265	5.805	0.045	450.0	-100.00	133.722	0.1232E 01	0.2293E-01
1+800	58.167	71.2	1.674	6.324	0.045	450.0	-100.00	100.303	0.1562E 01	0.4076E-01
1+700	54.414	70.5	1.968	6.383	0.045	450.0	-100.00	110.728	0.1453E 01	0.3345E-01
1+600	50.976	77.1	1.429	5.835	0.045	450.0	-100.00	97.847	0.1559E 01	0.4283E-01
1+500	46.763	75.5	1.559	5.959	0.045	450.0	-100.00	101.514	0.1525E 01	0.3979E-01
1+300	39.655	82.9	1.501	5.425	0.045	450.0	-200.00	108.725	0.1415E 01	0.3469E-01
1+100	34.358	97.1	1.628	4.636	0.045	450.0	-200.00	134.299	0.1161E 01	0.2274E-01
1+000	31.082	85.1	1.417	5.285	0.045	450.0	-100.00	107.404	0.1418E 01	0.3555E-01
0+900	29.613	111.8	1.655	4.027	0.045	450.0	-100.00	156.371	0.1000E 01	0.1677E-01
0+700	24.953	91.3	1.646	4.927	0.045	450.0	-200.00	127.313	0.1227E 01	0.2530E-01
0+600	22.534	92.3	1.705	4.877	0.045	450.0	-100.00	131.703	0.1193E 01	0.2364E-01
0+500	19.241	77.9	1.774	5.777	0.045	450.0	-100.00	114.152	0.1386E 01	0.3147E-01
0+400	16.860	95.9	1.385	4.694	0.045	450.0	-100.00	119.150	0.1274E 01	0.2888E-01
0+300	15.811	114.7	1.573	3.924	0.045	450.0	-100.00	155.092	0.1000E 01	0.1705E-01
0+200	13.488	101.1	1.452	4.453	0.045	450.0	-100.00	129.564	0.1181E 01	0.2443E-01
0+100	9.779	77.3	1.692	5.819	0.045	450.0	-100.00	109.799	0.1429E 01	0.3401E-01

CASE NO. 10 ($Q = 500\ m^3/sec$)

NO	H	A	R	V	N	Q	DX	A*R**(2/3)	FROUD	IE
2+800	99.100	87.4	1.185	5.723	0.045	500.0	0.	97.805	0.1680E 01	0.5292E-01
2+700	94.214	92.6	1.152	5.399	0.045	500.0	-100.00	101.806	0.1606E 01	0.4885E-01
2+600	89.840	92.3	1.385	5.414	0.045	500.0	-100.00	114.726	0.1470E 01	0.3846E-01
2+500	84.396	77.8	1.334	6.427	0.045	500.0	-100.00	94.295	0.1777E 01	0.5694E-01
2+400	79.335	77.2	1.650	6.476	0.045	500.0	-100.00	107.786	0.1611E 01	0.4358E-01
2+200	71.728	82.8	1.727	6.035	0.045	500.0	-200.00	119.267	0.1467E 01	0.3559E-01
2+100	67.695	78.5	1.699	6.366	0.045	500.0	-100.00	111.836	0.1560E 01	0.4048E-01
2+000	64.472	83.5	1.975	5.985	0.045	500.0	-100.00	131.539	0.1360E 01	0.2926E-01
1+900	61.987	83.4	2.423	5.992	0.045	500.0	-100.00	150.529	0.1230E 01	0.2234E-01
1+800	58.284	76.1	1.748	6.572	0.045	500.0	-100.00	110.410	0.1588E 01	0.4153E-01
1+700	54.568	75.9	2.103	6.586	0.045	500.0	-100.00	124.607	0.1451E 01	0.3260E-01
1+600	51.058	81.5	1.507	6.132	0.045	500.0	-100.00	107.166	0.1596E 01	0.4408E-01
1+500	46.875	81.0	1.671	6.177	0.045	500.0	-100.00	113.991	0.1526E 01	0.3896E-01
1+300	39.742	87.7	1.587	5.700	0.045	500.0	-200.00	119.348	0.1445E 01	0.3554E-01
1+100	34.473	103.9	1.742	4.813	0.045	500.0	-200.00	150.389	0.1165E 01	0.2238E-01
1+000	31.176	90.8	1.509	5.507	0.045	500.0	-100.00	119.431	0.1432E 01	0.3549E-01
0+900	29.734	119.9	1.775	4.171	0.045	500.0	-100.00	175.757	0.1000E 01	0.1639E-01
0+700	25.068	97.6	1.745	5.123	0.045	500.0	-200.00	141.443	0.1239E 01	0.2530E-01
0+600	22.662	99.6	1.762	5.020	0.045	500.0	-100.00	145.313	0.1208E 01	0.2397E-01
0+500	19.381	84.0	1.914	5.951	0.045	500.0	-100.00	129.523	0.1374E 01	0.3018E-01
0+400	16.930	100.6	1.437	4.972	0.045	500.0	-100.00	128.097	0.1325E 01	0.3085E-01
0+300	15.937	123.6	1.670	4.044	0.045	500.0	-100.00	174.048	0.1000E 01	0.1671E-01
0+200	13.594	108.9	1.501	4.593	0.045	500.0	-100.00	142.746	0.1197E 01	0.2484E-01
0+100	9.930	84.1	1.813	5.947	0.045	500.0	-100.00	124.994	0.1411E 01	0.3240E-01

Table 4.20 Calculation of Sediment Load

Return Period	Item	Main Yawa River Downstream from Confluence with Pawa-Burabod River			Main Yawa River upstream from Confluence with Pawa-Burabod River		
		Sta.1+000	Sta.2+000	Average	Sta.3+000	Sta.4+000	Average
1.01 Year	Q (m^3/s)	170	170		140	140	
	R (m)	1.7	1.8		1.3	1.3	
	I	1/280	1/210		1/210	1/210	
	U*(m/s)	0.24	0.29		0.25	0.25	
	T (m)	48	38		40	52	
	Qs(m^3/s)	0.29	0.36	0.3	0.17	0.22	0.2
	Qs/Qx100	0.17	0.21	0.2	0.12	0.16	0.1
1.5 Year	Q	350	350		270	270	
	R	2.7	2.8		1.8	1.8	
	I	1/280	1/210		1/210	1/210	
	U*	0.31	0.36		0.29	0.29	
	T	51	42		42	52	
	Qs	0.65	1.20	0.9	0.40	0.49	0.4
	Qs/Qx100	0.19	0.35	0.3	0.15	0.18	0.2
5 Year	Q	630	630		490	490	
	R	3.8	3.8		2.7	2.5	
	I	1/280	1/210		1/210	1/210	
	U*	0.36	0.42		0.35	0.34	
	T	53	43		45	53	
	Qs	1.58	2.63	2.1	1.17	1.14	1.2
	Qs/Qx100	0.25	0.42	0.3	0.24	0.23	0.2
10 Year	Q	790	790		600	600	
	R	4.0	4.3		2.9	2.7	
	I	1/280	1/210		1/210	1/210	
	U*	0.37	0.45		0.37	0.35	
	T	53	43		46	53	
	Qs	1.80	3.59	2.7	1.43	1.38	1.4
	Qs/Qx100	0.23	0.46	0.3	0.24	0.23	0.2
30 Year	Q	1,070	1,070		820	820	
	R	4.9	5.0		3.3	3.5	
	I	1/280	1/210		1/210	1/210	
	U*	0.41	0.48		0.39	0.40	
	T	53	43		48	53	
	Qs	2.98	5.23	4.1	2.07	2.64	2.4
	Qs/Qx100	0.28	0.48	0.4	0.25	0.32	0.3
50 Year	Q	1,220	1,220		930	930	
	R	5.3	5.3		3.6	3.8	
	I	1/280	1/210		1/210	1/210	
	U*	0.43	0.50		0.41	0.42	
	T	53	43		50	53	
	Qs	3.63	6.05	4.8	2.49	3.24	2.9
	Qs/Qx100	0.30	0.49	0.4	0.27	0.35	0.3

APPENDIX II

CONSTRUCTION PLAN AND SCHEDULE

APPENDIX II - CONSTRUCTION PLAN AND SCHEDULE

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ANNEX

1. PREAMBLE

This is a report on construction planning and schedule for the Sabo facilities to be constructed in the Pawa-Burabod river, a tributary of the Yawa river which is located in a south-eastern slope of the Mayon Volcano near Legaspi City. The Pawa-Burabod river is taken up as a site (river) subject to the detailed design for the Mayon Volcano Sabo and Flood Control Project in accordance with the mutual agreement between TFFCRA and the STUDY TEAM.

The Sabo facilities herein subject to the formulation of planning and schedule comprise a Sabo dam, two spur dikes and channel works involving levee, cribwork, groundsill, and irrigation intake.

All the above structures construction is herein referred to as the Project all inclusive.

2. PRINCIPAL FEATURES OF STRUCTURES

The construction works include a Sabo dam with subdam, two spur dikes, levees, groundsills and an irrigation intake. The Sabo dam is located at El. 400.00 meters and the two spur dikes are at El. 190.00 meters approximately. The levees are located in the reaches from El. 100.00 meters near the Bonga village to the confluence of the Yawa river.

2.1 The Kind of Works and Main Structures

The kind of works and main structures are summarized below:

Sabo Dam No. 1

(1) Main Dam

Type	Concrete gravity dam
Height of overflow section :	10.00 m

Crest length of dam	79.50 m
Crest elevation of overflow section	398.55 m
Dam volume	5,750 cu.m.

(2) Sub-Dam

Type	Concrete gravity dam
Height of overflow section	3.00 m
Crest length of dam	57.50 m
Crest elevation of overflow section	391.80 m
Dam volume	1,420 cu.m.

Spur Dike

(1) Spur Dike No. 1

Type	Embankment protected by wet masonry
Length	200 m
Embankment volume	1,720 cu.m.
Slope	1:0.7
Wet masonry	2,290 sq.m.

(2) Spur Dike No. 2

Type	Embankment protected by wet masonry
Length	162 m
Embankment volume	1,130 cu.m.
Slope	1:0.7
Wet masonry	1,720 sq.m.

Levees

Type	Embankment protected by wet masonry on the river side
Levee length	3,956 m
Embankment volume	62,800 cu.m.
Wet masonry	32,380 sq.m.

Crib work	6,993 nos.
Groundsill	
(1) Type-A	
Type	Timber log crib
Crib work	970 nos.
(2) Type-B	
Type	Cross type concrete block
Crib work	305 nos.
Irrigation Intake	L.S.

3. CONSTRUCTION TIME SCHEDULE

All the construction works are assumed to be commenced from August 1980, and will be completed by July 1985 through a period of five years. The date of commencement is assumed to be required four months for preparation of tendering and evaluation after detail design completed.

Construction works will be commenced at first from the construction of the access road which will be completed within the period of two months from the beginning of August 1980.

Earthwork of the Sabo dam and levee is to be commenced from the beginning of November 1980, after providing construction facilities.

Concrete works of the Sabo dam including main dam and sub-dam are to be started immediately after the excavation is completed, and are to be completed by late February 1982 within the period of fourteen months.

Since the spur dikes are located near the levee work site, the construction thereof is to be performed in parallel work each other, considering convenience of the seasonable period during the levee construction period.

The levee works are to be started from the beginning of November 1980 and will be completed by late July 1985 through approximately five years.

The ground-sills and the irrigation intake are to be constructed at the seasonable period in the parallel work with levee.

More detailed information on the construction time schedule is shown in Fig. 3.1.

4. BASIC CONDITIONS

In working out the construction method and time schedule, basic conditions for construction planning are assumed as follows:

4.1 Construction Time Target

All the construction works will be completed by the end of July 1985 and construction period is to be five years.

Tender preparations for the construction works are assumed to be finished up by the end of July 1980.

4.2 Workable Days and Hours for the Construction Works

4.2.1 Workable Days

Generally, civil works will be affected by weather conditions, especially by rainfall. Workable days for the construction works are estimated as follows:

Calendar days	365	days per year
Unworkable days caused by rainfall more than 15mm/days	57	"
National holidays	12	"
Unworkable days caused by Labor Law	104	"

Unworkable days caused by rainfall are assumed to duplicate 50 percent of national holidays and unworkable days caused by Labor Law. Therefore workable days are estimated as follows:

Workable days

$$365 - 57 \times 0.5 - 12 - 104 = 221 \text{ days per year}$$

Average workable days per month

$$221 \text{ days} \div 12 \text{ month} = 18 \text{ days per month}$$

4.2.2 Daily Working Hours

Working hours a day are estimated 8 hours taking consideration of standard working hours in the Philippines. In this construction planning, working hours are estimated without considering overtime and 2-shift system.

4.3 Coefficient of Earth Volume Conversion

Coefficient of earth volume conversion is assumed in consideration of soil mechanical properties. Convertible coefficient is estimated as shown in Annex.

4.4 Hourly Production Rate of Construction Equipment

Hourly production rate of main construction equipments is estimated as shown in Annex.

5. PREPARATORY WORKS

5.1 Access Road

Existing road from Legaspi City reaches near the Bonga village.

Access roads to the site of levee, ground-sills, irrigation intake and spur dikes are planned in the river bed. Construction cost of this road is to be considered to include in excavation of river bed.

After completion of levee, the crest can be used for the access road.

For the construction of the Sabo dam, access road is required to lead into the site of Sabo dam from the Bonga village. Route alignment of access road is to be located on the right side of Pawa-Burabod.

The feature of access road is shown as follows:

Distance	4,000 m
Road width	5.5 m
Road gradient	7.0 %

The access road is to be constructed by dozing of bulldozer and the pavement is not necessary for it.

5.2 Temporary Buildings

Buildings are classified into two groups; 1) construction buildings and 2) residential buildings. Both groups require the area as shown below:

Description	Area of Buildings
Construction buildings	
Office	100 sq.m.
Repair shop	50 sq.m.
Warehouse	30 sq.m.
Cement store	40 sq.m.
Magazine	10 sq.m.
Residential buildings	
Staff quarter	100 sq.m.
Labor camp	600 sq.m.

Residential buildings and office are to be tentatively located in the area near the Bonga village.

The land area required is estimated at 2,000 sq.m.

5.3 Power Supply System

All construction equipment and plants are planned to be of diesel engine and/or gasoline engine driven type except portable batching plant for sabo dam construction.

Electric supply is to be limited to the temporary building, and batching plant.

In whole construction period, portable generators will be required for the execution of the works.

Power requirement: The total required capacity of construction plant and facilities including those for the government and contractor's quarter is to be decided as follows:

i)	Portable batching plant	15 KW
ii)	Repair shop	30 KW
iii)	Quarter camp	30 KW

5.4 Water Supply System

Water supply is required for concrete works and life water. Life water for the office and residential quarter is required to deliver from Legaspi City. Construction water is available from the water seeping from riverbed near Bonga village.

Water required in the construction is as shown below:

Residential : Life water is assumed to be supplied from Legaspi City (15 cu.m./day)

Construction:

Concrete mixing	10 cu.m./day
Curing the concrete and others	6 cu.m./day

Construction water is pumped up by centrifugal pumps, transported by water tanker and stored in a water tank with a capacity for one day consumption.

5.5 Cement Supply

Cement is delivered from Legaspi City to the work site and is stocked in a cement store which has a capacity of about 3 to 7 days consumption. Considering concrete placing schedule, it is required to stock more than 1300 bags of cement.

5.6 Aggregate Supply

Aggregates both fine and coarse are supplied and purchased from river deposit. It is not necessary to provide crushing and screening plant.

Aggregates are stocked in the field close to batching and mixing plant.

5.7 Batching and Mixing Plant

Batching and mixing plant of Sabo dam is to be installed near the dam site area. Concrete placing schedule is planned, as follows:

Concrete volume	5,750	cu.m.
Average placing concrete a day	50	cu.m./day
Maximum placing concrete a day	75	cu.m./day

Therefore, considering the required output (75 cu.m./day) of the construction mixers and batching time (around 15 times)), it is necessary to provide the mixer with 0.75 cu.m. one component drum.

Placing concrete except for Sabo dam uses o.2 cu.m. class light mixer. The light mixer is to be transfered to the other work site to meet the requirements of works.

Area of batching and mixing plant including aggregates stock piles is to be required 500 sq.m.

6. CONSTRUCTION METHOD

Taking the construction time schedule and local circumstances into consideration, the construction method is worked out together with the selection of equipments. Especially, the construction method is planned in consideration of available materials and equipments in the Philippines.

6.1 Sabo Dam

6.1.1 General

The concrete gravity type Sabo dam is constructed across the Pawa-Burabod river. The dam consists of a main dam and a sub-dam.

The main dam is 10.00 m in height, the sub-dam is 5.00 m in height.

The main dam will be completed at the end of December 1981, through the concrete placing period of twelve months from early January 1981. The sub-dam will be carried out in the period of two months before the completion of the main dam for preventing the scouring at the downstream portion of the main dam.

Through the rainy season is the period from July to December, considering the rainfall data, it is possible to work in rainy season. Annual workable days for construction is estimated 221 days.

The dam foundation consists of deposit of sand and gravel, rubble and boulder. Right abutment comprises rock and left abutment comprises deposit.

Constructing the Sabo dam, special river diversion and care of river are not required and flood discharge in rainy season will be overflowed at the dam during construction.

Therefore, no work item of river diversion and care of river is involved in work quantity.

6.1.2 Major Work Quantity

Major work quantities for the dam works are as follows:

Works	Work Quantity
Earthwork (Dam Foundation)	
Excavation, common	11,600 cu.m
Excavation, rock	380 cu.m
Backfill	840 cu.m
Concrete	
Main dam	5,220 cu.m
Sub dam	1,170 cu.m
Backfill concrete	780 cu.m

6.1.3 Main Dam

(1) Earthwork

Prior to placing concrete, the excavation works of dam foundation will be started from the beginning of November 1980.

Common materials of abutment and riverbed are excavated by 21 ton class bulldozer and are loaded by 1.4 cu.m class tractor shovel into 6 ton dump truck to haul them to the spoil bank within the distance of 500 m.

Since rock excavation of right abutment amounts small quantity, it is performed drilling and blasting by hand with jabkhammer.

Boulders are gathered by bulldozer. They are crushed by drilling and blasting if necessary and are removed to the deppsit area out of riverbed.

Main construction equipments to be used for the works are listed as follows:

Equipment	Type and Size	Numbers
Bulldozer with ripper	21 ton	1
Bulldozer	11 ton	1
Tractor shovel	1.4 cu.m	2
Dump truck	6 ton	4
Air compressor	106 ps	1
Jackhammer	24 kg	3
Pickhammer	7 kg	6

(2) Concrete Works

Main dam includes four transverse joints and max. monolith (concrete block unit) width is 25.00 m. Considering the batching and mixing plant capacity, placing concrete in monolith is estimated at max. 75 cu.m/day. Therefore, main dam concrete requires onc longitudinal joint in the early placing period for the construction. Joint grouting there is not necessary.

Placing height is planned to be 0.50 m/lift in considering capacity of batching and mixing plant, temperature control of concrete without cooling pipe, and suitability of construction method.
Concrete is placed into unit of monolith under layer method.

Prior to place the concrete on rock and previous concrete, clearing of surface is to be required.

Concrete is to be mixed by portable batching and mixing plant, complete, with 0.75 cu.m one component drum. Concrete is to be placed into agitator truck of 1.7 cu.m and is transported to the spot of placing concrete of dam. Concrete is placed into concrete bucket with 0.80 to 1.00 cu.m and concrete bucket is to be handled into monolith by 20 ton truck crane.

During placing concrete, concrete is to be compacted by flexible internal vibrator of more than 60 mm diameter.

After placing concrete, curing concrete is to be required until placing fresh concrete. Curing is to be made by water and hemp clothes.

Main construction equipment to be used for the works are listed below:

Equipment	Type and Size	No.
Portable batching and mixing plant	0.75 cu.m x 1 completed unit excluding belt conveyor	1 set
Agitator truck	1.7 cu.m.	3
Truck crane	20 ton	1
Concrete bucket	0.8 - 1.0 cu.m	4
Concrete vibrator	60 mm. dia.	5

6.1.4 Sub Dam

The construction of sub dam is to be performed on the same process and method of main dam works.

6.2 Spur Dikes

6.2.1 General

Spur dikes are to be constructed as embankment protected by wet masonry and are formed to a gradient of riverbed accompaniment. As shown on the Drawings, the crest elevation varies from upstream downwards. As shown on the construction time schedule, spur dike works are lapped with levee works.

6.2.2 Major Work Quantity

Major work quantities for the spur dikes are as follows:

Work	Work Quantity Spur Dike No. 1	Work Quantity Spur Dike No. 2
Excavation, in common	3590 cu.m	4310 cu.m
Embankment	1720 cu.m	1130 cu.m
Backfilling cobble of masonry	1280 cu.m	790 cu.m
Riprap bedding	470 cu.m	380 cu.m
Backfill	1990 cu.m	1600 cu.m
Concrete	560 cu.m	690 cu.m
Wet masonry	2290 sq.m	1720 sq.m

6.2.3 Construction Method

Excavation under ground surface is to be performed by 21 ton class bulldozer and 0.6 cu.m class backhoe and is loaded by 1.4 cu.m class tractor shovel into 6 ton dump truck.

Embankment materials are to be the selected materials less than 20 cm dia. gathered from river deposit. The selected materials are transported at the work site and spreaded by 11 ton class bulldozer over the sruface by 20 cm. thick compacted layer, and compacted by 3 to 4 ton vibratory roller with passing more than 4 times on material. At the embankment spot of adjacent cobble stone behind masonry, materials are compacted by rammer and tamper.

Then there seems not to have effect in compaction of the materials because of its dry condition yet, the moisture content is to be again adjusted to secure the required content by spraying water through hose or water tanker over the materials.

Embankment is performed in parallel wet masonry works, because of slope is steep as shown drawings. Embankment and wet masonry are to be limited approximately 1.00 m high for construction speed and after finishing one layer, next embankment and wet masonry are to be started.

All works except excavation and embankment are performed by hand. Concrete is to be mixed by light mixer at work site, is transported by one-wheel concrete trucks and compacted by internal vibrator of 40 to 45 mm dia.

Rubble stones of wet masonry are to be supplied from river deposit in the Pawa-Burabod.

Main construction equipments to be used for the works are listed below:

Equipment	Type and Size	Numbers
Bulldozer	21 ton	1
Bulldozer	11 ton	1
Tractor shovel	1.4 cu.m	1
Dump truck	6 ton	1
Vibratory roller	3 to 4 ton	1
Rammer and tamper	80 to 100 kg	2
Light mixer	0.2 cu.m	2
Internal vibrator	40 to 45 mm	4

6.3 Levee

6.3.1 General

Levees are constructed on the both banks along the Pawa-Burabud river. The length of levees are approximately 4 km from the confluence of the Yawa river toward sabo dam site. Levee height is about 2.0 to 2.1 m above the original riverbed and both slope gradient is 1 : 2.5.

Embankment surface is protected by wet masonry along the whole length of levee and at toe of embankment, three raw cribs are to be required along the levee to protect scouring caused by flood flow.

Levee is to be commenced from the beginning of November 1980 and will be completed at the end of June 1985. Levee, wet masonry and crib works are lapped with each others.

Geological conditions of riverbed in the area of construction of levee consists mainly of sand and gravel.

6.3.2 Major Work Quantity

Major work quantities for the levee and wet masonry are as follows:

Work	Work Quantity
Earthwork	
Excavation, common	87,900 cu.m
Embankment	62,800 cu.m
Backfill cobble stone	13,280 cu.m
Filling rubble in crib	14,150 cu.m
Backfill in crib	10,560 cu.m
Concrete	9,140 cu.m
Wet masonry	32,380 sq.m
Crib work	6,993 nos.

6.3.3 Construction Method

(1) Earthwork

Excavation and embankment of levee are to be ahead of wet masonry and crib works. Excavation underground surface and in the riverbed is to be performed by 21 ton class bulldozer and 0.6 cu.m class backhoe. Excavated materials are loaded by 1.4 cu.m class tractor shovel into 6t dump truck and are transported to the deposit area within 500 m. Bolders to be impossible to transport by dump trucks are gathered, removed and filled under proposed ground level of riverbed.

Embankment materials are to be the selected materials less than 20 cm dia. from river deposit. The method of embankment is similar with the construction of spur dike.

(2) Related Structures and Wet Masonry

After the excavation and embankment are completed for some ten meters long, gravel base is placed directly on the embankment slope by hand and foundation concrete and wet masonry works are conducted continuously. After the part of masonry works is completed, crib work will be commenced. All these works are constructed by hand.

Rubbles of wet masonry are to be supplied and transported by tractor shovel as selected materials from river deposit.

Concrete is to be mixed by light mixer at work site, is transported by one-wheel concrete trucks and compacted by internal vibrator of 40 to 45 mm dia.

(3) Crib Work

Crib work is to be commenced continuously after finished wet masonry portions. The cribs to be furnished and installed in work site and rubbles are transported by tractor shovel and filled in the crib by hand. Crib materials are used coconut trunk supplied from coconut plants and equivalent to materials timber logs.

Main construction equipments to be used for the work are listed below:

Equipment	Type and Size	Numbers
Bulldozer	21 ton	1
Bulldozer	11 ton	1
Tractor shovel	1.4 ton	2
Dump truck	6 ton	4
Vibrating roller	3 to 4 ton	1
Rammer and tamper	80 to 100 kg	4
Light mixer	0.2 cu.m	3
Concrete vibrator	40 to 45 mm	10

6.4 Groundsill

6.4.1 General

Groundsills are to be provided in the riverbed at right angles to the levee. Groundsills involve two type ones, one is the timber log crib and the other is the cross type concrete block groundsill as shown on the Drawing, as type-A and type-B respectively.

The space of groundsills are to be classified approximately 100 m, 150 m and 300 m towards the upstream of Pawa Burabod from the confluence of Yawa river. The numbers of groundsill are eleven including two cross type concrete block groundsills.

6.4.2 Major Quantity

Major work quantities for the groundsills are as follows:

Work	Work Quantity
Type - A	
Excavation, in common	3,180 cu.m
Backfill for groundsill	440 cu.m
Filling rubble in crib	1,960 cu.m
Crib work	970 nos.
Type - B	
Excavation, in common	1,170 cu.m
Backfill for groundsill	160 cu.m
Filling rubble in the space of concrete block	860 cu.m
Concrete (365 nos. block)	430 cu.m

6.4.3 Construction Method

The construction of groundsill is to be performed on the same process and method of levee and pavement works and it is to be planned as a part of levee and pavement works. All construction equipments are transported from other works.

6.5 Irrigation Intake

Irrigation intake is to be constructed near No. 7 groundsill. Earthwork for irrigation intake is included in the construction of levee and after completing the structure, embankment and backfilling are to be commenced by the same method of levee. Quantities of irrigation intake are shown in the Bill of Quantity.

7. MAIN CONSTRUCTION EQUIPMENTS

Main construction equipments to be used on this project are summarized as follows:

Equipment	Type and Size	Nos.
Bulldozer	21 ton	2
Bulldozer	11 ton	2
Tractor shovel	1.4 cu.m	4
Backhoe	0.6 cu.m	2
Dump truck	6 ton	8
Track crane	20 ton	1
Vibratory roller	3 ton	1
Rammer and tamper	60 to 100 kg	8
Jackhammer	20 kg	5
Pick hammer	7 kg	10
Air compressor	10 cu.m/min.	1
Portable butching and mixing plant	0.75 cu.m	1
Light mixer	0.2 cu. m	5
Agitator truck	1.7 cu.m	3
Concrete Vibrator	60 mm dia.	5
Concrete Vibrator	40 mm. dia.	20
Generator	15 KW	1
Generator	30 KW	2
Water pump	3.5 ps	4
Ordinary truck	6 ton	1

ANNEX

HOURLY PRODUCTION RATE OF CONSTRUCTION EQUIPMENT

1. The Foundation on the Calculation of Output

1.1 Formula of Output is shown below for each equipment, considering with the works and job-management factor.

1.2 Coefficient of Earth Volume Conversion

In the result of investigation of the site, excavating and embankment materials are classified into common and rock. Common material is defined to contain sand, gravel, stone and boulder. Rock material is defined to be the materials which requires drilling and blasting. Convertible coefficient is estimated as follows:

Coefficient / Material	Bank Volume	Loose Volume	Compacted Volume
Common Material	1.00 (1.05)	1.15 (1.21)	0.95 (1.00)
Rock Material	1.00 (0.77)	1.60 (1.23)	1.30 (1.00)

1.3 Job-management Factor

Job-management factor is to be affected by weather conditions, working sites, materials, available equipments, skill of operators and so forth.

2. Bulldozer

2.1 Excavating and Gathering (Dozing)

$$Q = \frac{60 \times Q1 \times E \times F}{Cm}$$

where; Q : Output per hour (cu.m/hr)

Q1 : Mouldboard capacity (cu.m.)

E : Job-management factor

F : Coefficient of Earth Volume Conversion

Cm : Cycle time (min.)

$Cm = 0.038 \times D + 0.33$

D : Hauling Distance (m)

(1) Common Material, Bank Volume

	D	Cm	Q1	E	F	Q
Bulldozer, 21t	20	1.09	2.89	0.6	1/1.15	83
	30	1.47	2.89	0.6	1/1.15	62
	50	2.23	2.89	0.5	1/1.15	34

(2) Rock Material, Bank Volume

	D	Cm	Q1	E	F	Q
Bulldozer, 2HRP	20	1.09	2.89	0.5	1/1.60	50

(3) Common Material, Compacted Volume

	D	Cm	Q1	E	F	Q
Bulldozer, 21t	20	1.09	2.89	0.6	1/1.21	78

2.2 Spreading

$$Q = \frac{W \times V \times D \times E \times F}{N1}$$

where; Q : Output per hour (cu.m/hr)

W : Effective Spreading width (m)

V : Working speed (m/hr)

D : Spreading depth (m)

E : Job-management factor

F : Coefficient of Earth Volume Conversion

N1 : Number of spreading

(1) Common Material, Compacted Volume

	W	V	D	E	F	N1	Q
Bulldozer 11t	3.0	2000	0.3	0.7	1.0	6	210

2.3 Compacting

$$Q = \frac{V \times B2 \times E \times D \times F}{N}$$

where; Q : Output per hour (cu.m/hr)
B2 : Effective Compaction width (m)
E : Job-management factor
D : Compacted depth (m)
F : Coefficient of earth volume conversion
N : Number of compaction
V : Working speed (m/hr)

(1) Common Material, Compacted Volume

	V	B2	E	D	F	N	Q
Bulldozer 11t	3000	0.32	0.7	0.3	1.0	6	34

3. Backhoe

$$Q = \frac{3600 \times Q2 \times E \times F}{Cm}$$

where; Q : Output per hour (cu.m/hr)
Q2 : Handling volume per cycle (cu.m)
Q2 = Q1 x B
Q1 : Bucket capacity (struck)
B : Coefficient of bucket
E : Job-management factor
F : Coefficient of earth volume conversion
Cm : Cycle Time (sec.)

		Q2	E	F	Cm	Q
Backhoe	$0.2m^3$	0.16	0.6	1/1.15	36	8
Backhoe	$0.4m^3$	0.32	0.6	1/1.15	36	17
Backhoe	$0.6m^3$	0.48	0.6	1/1.15	36	25

4. Tractor Shovel

$$Q = \frac{60 \times Q2 \times E \times F}{Cm}$$

where; Q : Output per hour (cu.m/hr)

Q2 : Handling volume per cycle (cu.m.)

Q2 = Q1 x B

Q1 : Bucket capacity (heaped)

B : Coefficient of bucket

E : Job-management factor

F : Coefficient of earth volume conversion

Cm : Cycle time, loading and spotting (min.)

(1) Tractor Shovel, $1.4m^3$ Class

	Q2	E	F	Cm	Q
Common, Bank	1.05	0.75	1/1.15	0.93	44
Common, Compacted	1.05	0.75	1/1.24	0.93	42
Rock, Bank	0.91	0.6	1/1.60	0.93	22
Rock, Compacted	0.91	0.6	1/1.23	0.93	29

(2) Tractor Shove, $1.8m^3$ Class

	Q2	E	F	Cm	Q
Common, Bank	1.35	0.75	1/1.15	0.93	57
Common, Compacted	1.35	0.75	1/1.21	0.93	54
Rock, Bank	1.17	0.6	1/1.60	0.93	28
Rock, Compacted	1.17	0.6	1/1.23	0.93	37

5. Dump Truck

$$Q = \frac{60 \times Q2 \times E \times F}{Cm}$$

Where, Q : Output per hour (cu.m/hr)

Q2 : Loading volume per cycle (cu.m)

E : Job-management Factor

F : Coefficient of Earth Volume Conversion

Cm : Cycle Time (min)

(1) Cycle Time

$$Cmt = \frac{Cms \times n}{60 \times Es} + \frac{D}{V1} + \frac{D}{V2} + t$$

Where, Cmt : Cycle time of dump truck

Cms : Cycle time of loading equipment

n : Number of cycle of loading - equipment for one unit dump truck

Es : Job-management factor of loading equipment

D : Hauling Distance (m)

V1 : Hauling Speed (m/min)

V2 : Returning Speed (m/min)

t : Dumping and spotting time (min)

Distance	V1	V2	D/V1	D/V2	$\frac{Cms.n}{60.Es}$	t	Cmt
200	166	166	1.2	1.2	4.8	1.7	8.9
300	166	250	1.8	1.2	4.8	1.7	9.5
400	250	250	1.6	1.6	4.8	1.7	9.7
500	250	250	2.0	2.0	4.8	1.7	10.5
1000	333	417	3.0	2.4	4.8	1.7	11.9
2000	333	500	6.0	4.0	4.8	1.7	16.5

(2) Output per hour

Q2 : Loading volume per cycle

Dump Truck	6t	4.0 cu. m
"	8t	5.3 cu. m
"	10t	6.7 cu. m

E : Job-Management Factor, E = 0.85

1) Dump Truck, 6t

	200	300	400	500	1000	2000	F
Common, Bank	19.9	18.7	18.3	16.9	14.9	10.8	1/1.15
Common, Compacted	18.9	17.7	17.4	16.1	14.2	10.2	1/1.21
Rock, Bank	14.3	13.4	13.1	12.1	10.7	7.7	1/1.6
Rock, Compacted	18.6	17.5	17.1	15.8	13.9	10.4	1/1.23

ii) Dump Truck, 8t

	200	300	400	500	1000	2000
Common, Bank	26.4	24.7	24.2	22.4	19.7	14.3
Common, Compacted	25.0	23.4	23.1	21.3	18.8	13.5
Rock, Bank	18.9	17.7	17.4	16.0	14.2	10.2
Rock, Compacted	24.6	23.2	22.7	20.9	18.4	13.4

iii) Dump Truck 10t

	200	300	400	500	1000	2000
Common, Bank	33.3	31.3	30.7	28.3	25.0	18.1
Common, Compacted	31.7	29.6	29.1	27.0	23.8	17.1
Rock, Bank	24.0	22.4	21.9	20.3	17.9	12.9
Rock, Compacted	31.2	29.3	28.6	26.5	23.3	16.9

6. Vibrating Roller

$$Q = \frac{V \times B2 \times E \times D \times F}{N}$$

Where, Q : Compacted Volume per hour (cu.m/Hr)

V : Working Speed (m/Hr)

E : Job-management Factor

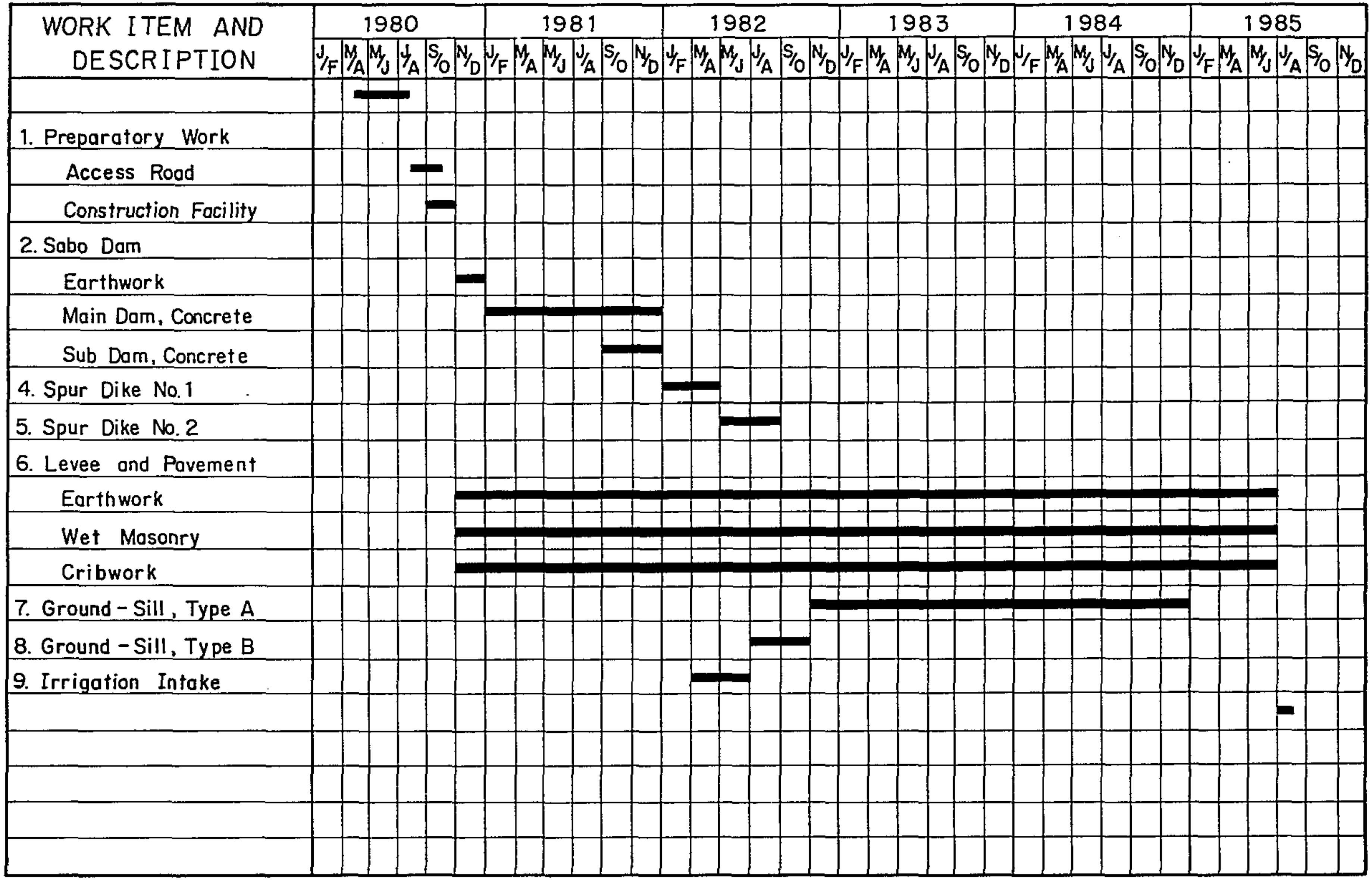
D : Compacted depth (m)

F : Coefficient of earth volume conversion

N : Number of Compaction

		V	B2	E	D	F	N	Q
Vibrating	3-4t	2000	0.90	0.6	0.30	1.0	6	54

Fig.3.1 CONSTRUCTION TIME SCHEDULE



APPENDIX III

ESTIMATE OF CONSTRUCTION COST

APPENDIX-III ESTIMATE OF CONSTRUCTION COST

TABLE OF CONTENTS

1. GENERAL

Construction cost of the construction of Sabo facilities of the Pawa-Burabod river, a tributary of Yawa river, under the MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT is estimated in considering local conditions of the Philippines, as available equipments and materials, suitability of construction method, working rules, etc.

Construction cost comprises Contract Cost and Indirect Cost. Contract Cost includes direct cost of material, labor, PD#390 and equipment, and contingencies, Contractor's profit and surcharges. Indirect cost includes Engineering cost, Administration cost and contingencies of phisical and price escalation.

Contract cost and indirect cost are estimated on the basis of the Government estimate procedure and all unit price and summary cost are in local currency, pesos and centavos.

2. CONTRACT COST (DIRECT COST)

2.1 Material Cost

Main material cost is presented in the table below. It is based on the price in Albay on November 1979. The material which is not available in Albay is estimated on the basis of the price in Manila.

Material cost estimated is to be purchase price at the Project Site, including transportation cost.

Material Cost

Material	Unit	Local Currency (PESO)
Gasoline	liter	2.82
Light Oil	liter	2.68
Lubricant	liter	10.04
Grease	kg	19.82
Cement, Portland	ton	700.00
Aggregate, Fine	cu.m	25.00
Aggregate, Coarse	cu.m	35.00
Reinforcement bar	ton	4,300.00
Timber	cu.m	1,101.70
Plywood	cu.m	2,648.00
Dynamite	kg	50.00

2.2 Labor Cost

Direct daily wages of local labor applied to the construction cost estimates are presented in the table below. Labor wages estimated are based on the price in Albay on November 1979.

The labor cost estimated does not include any daily oevertime and overtime for Sunday and Holiday. Working days a week and working hours a day are assumed five days and eight hours respectively according to Labor Law in the Philippines.

Daily Wages of Local Labor

Classification	Wage Rate (PESO)
Foreman	24.84
Mechanic	17.55
Electrician	17.25
Operator, heavy equipment	23.65
Operator, light equipment	19.36
Assistant operator	17.55
Driver, dump truck	19.36
Carpenter	17.55
Mason	17.55
Concrete worker	16.25
Reinforcement worker	16.25
Skilled labor	17.55
Common labor	16.25

2.3 Equipment Cost

Equipment cost is estimated on the basis of depreciation cost, repair cost and administrative cost in considering daily rental rate in the Philippines. Equipment cost is not included in the material cost and labor cost respectively.

Major equipment cost is estimated as hourly cost and daily cost, and is listed in the table below.

Construction Equipment Cost

Description	Hourly Cost (PESO/Hr. or Day)
Bulldozer, 21 ton	350 ₱/Hr
Bulldozer, 11 ton	160 ₱/Hr
Backhoe, 0.6 cu.m	190 ₱/Hr
Tractor Shovel, 1.4 cu.m	110 ₱/Hr
Dump Truck, 6 ton	80 ₱/Hr
Track Crane, 15 to 20 ton	230 ₱/Hr
Portable Batcher Plant, 0.75 cu.m	210 ₱/Hr
Concrete Mixer, 0.2 cu.m	200 ₱/Day
Hand Hammer, 20 kg	30 ₱/Day
Pick Hammer, 7 kg	10 ₱/Day
Air Compressor, 7 cu.m/min	320 ₱/Day
Vibratory Roller, 3 ton to 4 ton	80 ₱/Hr
Truck Mixer, 1.7 cu.m	60 ₱/Hr
Tamper and Rammer, 60 to 100 kg	50 ₱/Hr

2.4 Breakdown and Unit Price

Unit price is estimated as the direct cost as shown in the report of ANNEX II Breakdown of Unit Price, and the Unit Price comprises total cost of materials (a), labor (b), PD#390 (c) and equipment expense (d).

The cost of PD#390 in the Breakdown of Unit Price includes the cost of Leaves, Medical and Insurance of Social Security System for employed labor, and is the cost of 4.5 percent of labor cost (b) as specified Presidential Decrease in the Philippines.

Unit price of each item for civil works presented in the Bill of Quantities is estimated in accordance with the said composition, condition and the proposed construction method presented in the report of Appendix II.

2.5 Contract Cost (Direct Cost)

Contract Cost (Direct cost) in the Proposed Schedule is presented below:

1) Direct Cost (Estimated Cost)

Section - 1	General
Section - 2	Sabo Dam
Section - 3	Spur Dike No.1
Section - 4	Spur Dike No.2
Section - 5	Levee
Section - 6	Groundsill, Type A
Section - 7	Groundsill, Type B

2) Contingency

3) Contractor's Profit

4) Surcharges

Estimated contract cost is shown in the table of Estimated Construction Cost and it is estimated on the basis of the Government estimate procedure as follows:

Contingency is the cost of five percent (5 %) of the direct cost

Contractor's profit is the cost of ten percent (10 %) of the sum of direct cost plus contingencies.

This percentage is based on the Memorandum on the 1st of April, 1973, as allowable Percentage of Contractor's Profit.

Surcharges are the cost of five percent (5 %) of the sum of direct cost and contingencies.

3. INDIRECT COST

Indirect cost for the Government comprises Engineering Cost, Administration Cost and Contingencies. These indirect costs are shown in the table of Estimated Construction Cost.

3.1 Engineering Cost

Engineering cost is the cost of 353,000 ₿ plus two percent of the contract cost. This engineering cost is estimated on the basis of the Memorandum on the 1st of April, 1973 of a new schedule of engineering surcharges for all Public Works Project.

3.2 Administration Cost

Administration cost is the cost of five percent (5 %) of the contract cost.

3.3 Contingency

The contingency is provided to cope with unforeseen physical conditions and price escalation due to inflation.

The rate of physical contingency varies with conditions of construction and the physical contingency is influenced by the following factors:

1) Physical conditions of construction site
2) Technically unknown difficulty
3) Exactness of investigation and study undertaken
4) Exactness and base of cost estimate
5) Exactness of work quantity calculation
6) Variation in design
7) Occurence of unforeseen condition due to natural phenomena
8) Exactness of estimate of construction period

In view of the above conditions, the physical contingency is estimated to be ten percent (10 %) of the contract cost.

The rate of price escalation contingency varies with inflation in the Philippines. On the assumption that the annual escalation rate is seven percent and the cost of price escalation is basis of disbursement schedule, the price contingency is estimated in the table of Disbursement Schedule.

4. CONSTRUCTION COST

The summary of the estimated construction cost is presented below. The priced bill of quantities is as shown ANNEX I.

Estimated Construction Cost

Description		Cost (PESO)
1. Contract Cost		
1) Cirect Cost (Estimated Cost)		
Section-1	General	2,088,000.00
Section-2	Sabo dam	2,222,000.00
Section-3	Spur dike No.1	857,000.00
Section-4	Spur dike No.2	734,000.00
Section-5	Levee	9,221,000.00
Section-6	Groundsill, Type A	271,000.00
Section-7	Groundsill, Type B	269,000.00
Section-8	Irrigation intake	18,000.00
Sub-total (1)		15,680,000.00
2) Contingency (5% of sub-total (1))		784,000.00
Sub-total (2)		16,464,000.00
3) Contractor's Profit (10% of sub-total (2))		1,646,000.00
4) Surcharges (5% of sub-total (2))		823,000.00
Contract Cost		18,933,000.00
2. Engineering Cost		732,000.00
3. Administration Cost		947,000.00
4. Contingency (Physical and escalation)		6,688,000.00
Total Construction Cost		27,300,000.00

Engineering Cost and Contractor's Profit

December 15, 1976

MEMORANDUM For:
The Assistant Director
All Chiefs of Division
All Regional Supervisors
All Public Works District and
City Engineers
This Bureau

Effective April 1, 1973, a new schedule of engineering surcharges for all Public Works projects will be adopted for the observance and compliance of all concerned as follows:

Estimate Cost of Projects	Engineering Surcharges
₱50.00 and below	10 of Estimated Cost
Over ₱50,000.00 up to ₱100,000.00	₱5,000 plus (0.08) (Estimated Cost over ₱50,000)
Over ₱100,000.00 up to ₱500,000.00	₱9,000 plus (0.06) (Estimated Cost over ₱100,000)
Over ₱500,000.00 up to ₱1,000,000.00	₱33,000 plus (0.05) (Estimated Cost over ₱500,000)
Over ₱1.0 M. up to ₱2.0 M.	₱58,000 plus (0.04) (Estimated Cost over ₱2.0 M.)
Over ₱2.0 M. up to ₱5.0 M.	₱98,000 plus (0.035) (Estimated Cost over ₱2.0 M.)
Over ₱5.0 M. up to ₱10.0 M.	₱203,000 plus (0.03) (Estimated Cost over ₱5.01 M.)
Over ₱10.0 M.	₱353,000 plus (0.02) (Estimated Cost over ₱10.0 M.)

This supersedes the memorandum of this Office dated March 19, 1973

(SGD.) DESIDERIO ANOLIN
Director of Public Works

Allowable Percentage of Contractor's Profit

Not exceeding ₱100,000.00	15%
Over ₱100,000.00 but not exceeding ₱300,000.00	14%
Over ₱300,000.00 but not exceeding ₱500,000.00	13%
Over ₱500,000.00 but not exceeding ₱700,000.00	12%
Over ₱700,000.00 but not exceeding ₱900,000.00	11%
Over ₱900,000.00	10%

5. DISBURSEMENT SCHEDULE

The disbursement schedule is estimated as shown below based on the construction cost and the construction time schedule previously presented.

Disbursement Schedule

(Unit in 1,000 ₱)

Description	1980	1981	1982	1983	1984	1985	Total
1. Contract Cost							
1) Direct cost							
General	2,088						2,088
Sabo dam		2,222					2,222
Spur dike, No.1			857				857
Spur dike, No.2			734				734
Levee	332	1,974	1,974	1,974	1,974	993	9,221
Groundsill, Type A			21	125	125		271
Groundsill, Type B			269				269
Irrigation intake			18				18
2) Contingency	121	210	193	105	105	50	784
3) Contractor's profit	254	441	406	220	220	105	1,646
4) Surcharges	127	220	204	110	110	52	823
2. Engineering Cost	113	196	181	98	98	46	732
3. Administration Cost	146	253	234	127	127	60	947
4. Contingency							
1) Physical	293	508	469	254	254	121	1,899
2) Price escalation	223	799	1,146	857	1,111	653	4,789
Total	3,697	6,823	6,706	3,870	4,124	2,080	27,300

ANNEX I

Priced Bill of Quantities

BILL OF QUANTITIES

SECTION - 1

GENERAL

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
1.01	Access road for Sabo dam	Lump	Sum		237,700.00
1.02	Temporary Buildings	Lump	Sum		319,000.00
1.03	Electric Supply	Lump	Sum		713,200.00
1.04	Water Supply	Lump	Sum		647,800.00
1.05	Geological Investigation, Check Survey and Redesign	Lump	Sum		170,000.00
Grand Total to General					2,087,700.00

SECTION - 2

SABO DAM (Main and Sub Dam)

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Earthwork				
2.01	Excavation, in common, in foundation of main dam	7,300	cu.m	16.57	120,961.00
2.02	Excavation, in common, in foundation of sub dam	4,300	cu.m	16.57	71,251.00
2.03	Excavation, in rock, in foundation of sub-dam	250	cu.m	70.14	17,535.00
2.04	Excavation, in rock, in foundation of main dam	130	cu.m	70.14	9,118.20
2.05	Backfill for main dam and sub dam	840	cu.m	18.94	15,909.60

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Concrete and Formwork				
2.06	Concrete, type A, in main dam	320	cu.m	296.72	94,950.40
2.07	Concrete, type A, in sub dam	230	cu.m	296.72	68,245.60
2.08	Rubble concrete, in main dam	4,900	cu.m	237.96	1,166,004.00
2.09	Rubble concrete, in sub dam	940	cu.m	237.96	223,682.40
2.10	Backfill concrete, type B, in main dam	530	cu.m	258.35	136,925.50
2.11	Backfill concrete, type B, in sub dam	250	cu.m	258.35	64,587.50
2.12	Form work, F2 finish, in main dam	1,400	sq.m	79.85	111,790.00
2.13	Form work, F2 finish, in sub dam	420	sq.m	79.85	33,537.00
2.14	Form work, Fl finish, in main dam	1,400	sq.m	36.76	51,464.00
2.15	Form work, Fl finish, in sub dam	350	sq.m	36.76	12,866.00
	Miscellaneous				
2.16	Furnishing and placing 300 mm dia concrete drain pipe in main dam	11	lin.m	302.76	3,330.36
2.17	Furnishing and installing water stop in main dam	40	lin.m	94.19	3,767.60
2.18	Furnishing and placing joint filler in main dam	220	sq.m	60.30	13,266.00
2.19	Furnishing and placing joint filler in sub dam	40	sq.m	60.30	2,412.00
Grand Total to Sabo Dam					2,221,603.16

SECTION - 3

SPUR DIKE NO. 1

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Earthwork				
3.01	Excavation, in common, at the toe of embankment	3,590	cu.m	16.57	59,486.30
3.02	Embankment for spur dike	1,720	cu.m	21.80	37,496.00
3.03	Backfilling cobble stone behind wet masonry	1,280	cu.m	41.49	53,107.20
3.04	Riprap bedding	470	cu.m	30.60	14,382.00
3.05	Backfill under ground surface	1,990	cu.m	18.94	37,690.60
	Concrete and Formwork				
3.06	Concrete, type B, in foot protection block	110	cu.m	235.05	25,855.50
3.07	Concrete, type B, at crest of embankment	260	cu.m	235.05	61,113.00
3.08	Concrete, type B, in foundation of wet masonry	190	cu.m	235.05	44,659.50
3.09	Formwork Fl finish, in foot protection block	440	sq.m	36.76	16,174.40
3.10	Formwork Fl finish, in foundation of wet masonry	670	sq.m	36.76	24,629.20
3.11	Formwork Fl finish for concrete in joint	100	sq.m	36.76	3,676.00
3.12	Formwork Fl finish for concrete in backfilling	2,290	sq.m	36.76	84,180.40
	Wet Masonry				
3.13	Backfill Concrete, type B, behind wet masonry	920	cu.m	235.05	216,246.00
3.14	Wet-rubble masonry	2,290	sq.m	52.24	119,629.60
3.15	Inter locking mortar in wet masonry	120	cu.m	429.02	51,482.40
3.16	Joint filler	100	sq.m	60.30	6,030.00
3.17	Reinforcing bar, 16mm, dia	0.21	5on	4,799.48	1,007.89
Ground Total to Spur Dike No.1					856,845.99

SECTION - 4

SPUR DIKE NO. 2

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Earthwork				
4.01	Excavation, in common, at the toe of embankment	4,310	cu.m	16.57	71,416.70
4.02	Embankment for spur dike	1,130	cu.m	21.80	24,634.00
4.03	Riprap bedding	380	cu.m	30.60	11,628.00
4.04	Backfill under ground surface	1,600	cu.m	18.94	30,304.00
4.05	Backfill cobble stone behind wet masonry	790	cu.m	41.49	32,777.10
	Concrete and Formwork				
4.06	Concrete, type B, in foot protection block	330	cu.m	235.05	77,566.50
4.07	Concrete, type B, at crest of embankment	200	cu.m	235.05	47,010.00
4.08	Concrete, type B, in foundation of wet masonry	160	cu.m	235.05	37,608.00
4.09	Formwork Fl finish, in foot protection block	1,320	sq.m	36.76	48,523.20
4.10	Formwork Fl finish, in foundation of wet masonry	530	sq.m	36.76	19,482.80
4.11	Formwork Fl finish, for concrete joint wet masonry	70	sq.m	36.76	2,573.20
4.12	Formwork Fl finish for concrete in backfilling	1,720	sq.m	36.76	63,227.20
	Wet Masonry				
4.13	Backfill concrete, type B, behind wet masonry	560	sq.m	235.05	131,628.00
4.14	Wet-rubble masonry	1,720	cu.m	52.24	89,852.80
4.15	Joint filler	70	sq.m	60.30	4,221.00
4.16	Inter locking mortar in wet masonry	90	cu.m	429.02	38,611.80
4.17	Reinforcing bar 16 mm. dia	0.51	ton	4,799.48	2,447.73
Grand Total to Spur Dike No.2					733,512.03

SECTION - 5

LEVEE

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Earthwork				
5.01	Excavation, in common, in foundation of levee and river bed	87,900	cu.m	16.57	1,456,503.00
5.02	Embankment for levee	62,800	cu.m	21.80	1,369,040.00
5.03	Backfill cobble stone behind wet masonry and at toe of levee	13,280	cu.m	41.49	550,987.20
5.04	Filling rubble, in cribwork	14,150	cu.m	30.60	432,990.00
5.05	Backfill in cribwork	10,560	cu.m	18.94	200,006.40
	Concrete and Formwork				
5.06	Concrete, type B, in top protection block	380	cu.m	235.05	89,319.00
5.07	Backfill concrete, type B, behind wet masonry	4,860	cu.m	235.05	1,142,343.00
5.08	Concrete, type B, in foundation of wet masonry	3,900	cu.m	235.05	916,695.00
5.09	Formwork Fl finish, in top protection block	1,860	sq.m	36.76	68,373.60
5.10	Formwork Fl finish, in wet masonry	1,680	sq.m	36.76	61,756.80
5.11	Formwork Fl finish, in foundation of wet masonry	8,190	sq.m	36.76	301,064.40
	Cribwork				
5.12	Coconut trunk	151,050	lin.m	5.43	820,201.50
5.13	Split bamboo	279,720	lin.m	0.50	139,860.00
5.14	Reinforcing bar, 1/2 mm. in. dia.	23.4	ton	4799.48	112,307.83

Item No.	Description	Quantity	Unit	Rate	Amount	
					PESO	: CEN
	Miscellaneous					
5.15	Joint filler, in top protection block	19	sq.m	60.30	1,145.70	
5.16	Joint filler, in wet masonry	489	sq.m	60.30	29,486.70	
5.17	Joint filler, in foundation of wet masonry	196	sq.m	60.30	11,818.80	
5.18	Weep hole, 5 cm. dia.	716	lin.m	30.69	21,974.04	
	Wet Masonry					
5.19	Wet masonry	32,380	sq.m	46.18	1,495,308.40	
Grand Total to Levee					9,221,181.37	

SECTION - 6

GROUNDSILL, TYPE - A

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Earthwork				
6.01	Excavation, in common	3,180	cu.m	16.57	52,692.60
6.02	Backfill, in groundsill	440	cu.m	18.94	8,333.60
6.03	Filling rubble, in cribwork	1,960	cu.m	30.60	59,976.00
	Cribwork				
6.04	Coconut trunk	20,950	lin.m	5.43	113,758.50
6.05	Split bamboo	38,800	lin.m	0.50	19,400.00
6.06	Reinforcing bar, 12 mm. dia.	3.5	ton	4799.48	16,798.18
Grand Total to Groundsill, Type A					270,958.88

SECTION - 7

GROUNDSILL, TYPE - B

Item No.	Description	Quantity	Unit	Rate	Amount	
					PESO	: CEN
	Earthwork					
7.01	Excavation, in common	1,170	cu.m	16.57	19,386.90	
7.02	Backfill, in groundsill	160	cu.m	18.94	3,030.40	
7.03	Filling rubble, in cross concrete block	860	cu.m	30.60	26,316.00	
	Cross Concrete Block					
7.04	Concrete, Type A	430	cu.m	255.10	109,693.00	
7.05	Formwork F1 finish	1,950	sq.m	36.76	71,682.00	
7.06	Reinforcing bar	8.0	ton	4799.48	38,395.84	
Grand Total to Groundsill, Type B					268,504.14	

SECTION - 8

IRRIGATION INTAKE

Item No.	Description	Quantity	Unit	Rate	Amount PESO : CEN
	Concrete and Formwork				
8.01	Concrete, Type C, in intake	9.4	cu.m	298.70	2,807.78
8.02	Concrete, Type C, in sedimentary tank	7.2	cu.m	298.70	2,150.64
8.03	Formwork Fl finish, in intake	37	sq.m	36.76	1,360.12
8.04	Formwork F2 finish, in intake	12	sq.m	79.85	958.20
8.05	Formwork Fl finish, in sedimentary tank	22	sq.m	36.76	808.72
8.06	Formwork F2 finish, in sedimentary tank	15	sq.m	79.85	1,197.75
	Furnishing and Placing bars				
8.07	Reinforcing bar, in intake	0.61	ton	4799.48	2,927.68
8.08	Reinforcing bar, in sedimentary tank	0.63	ton	4799.48	3,023.67
	Miscellaneous				
8.09	Finishing and placing 600 mm. dia. concrete drain pipe	8.0	lin.m	378.19	3,033.52
Grand Total to Irrigation Intake					18,268.08

ANNEX II

Breakdown of Unit Price

Breakdown of Unit Price

Item No. ________ Work Site General

Work Access Road

Price 237,700 ₽

Remark : Width 5.50 m, Length 4,000 m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	147.00			2.68	393.96
Lubricant		ℓ	3.50			10.04	35.14
Grease		kg	0.11			19.82	2.18
Sub total							431.28
b. Labor							
Foreman		M.D	0.500			24.84	12.42
Operator		M.D	1.000			23.65	23.65
Assistant operator		M.D	1.000			17.55	17.55
Common labor		M.D	2.000			16.25	32.50
Sub total							86.12
c. PD #390	4.5% of b						3.88
d. Equipment expense							
Bulldozer	21 ton	Hr	7.00			350.00	2,450.00
Total							2,971.28

Construction cost for Access Road
(2,971.28 ₽/50 m/day) @4,000 m
= 237,700 ₽

Breakdown of Unit Price

Item No. ________ Work Site General

Work Temporary Buildings

Price 319,000 ₽

Remark :

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Buildings							
Office		sq.m	100.00			400.00	40,000
Temporary Building (Repair shop, Warehouse, Cement store, Magazine, etc.)		sq.m	130.00			300.00	39,000
Staff Quarter		sq.m	100.00			400.00	40,000
Labor Camp		sq.m	600.00			300.00	180,000
Sub total							299,000
Land Reclamation							
Reclamation		sq.m	2,000.00			10.00	20,000
Total							319,000

Breakdown of Unit Price

Item No. ________ Work Site General

Work Water Supply

Price 647,800 ₱

Remark :

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Gasolin		ℓ	2.10			2.82	5.92
Light oil		ℓ	56.00			2.68	150.00
Lubricant		ℓ	1.60			10.04	16.06
Grease		kg	0.08			19.82	1.59
Sub total							173.57
b. Labor							
Driver		M.D	1.00			19.36	19.36
Common labor		M.D	1.00			16.25	16.25
Sub total							35.61
c. PD #390	4.5% of b						1.60
d. Equipment expense							
Water pump	200 ℓ/min	Day	2.00			20.00	40.00
Water tanker	1,750 ℓ	Day	1.00			240.00	240.00
Sub total							280.00
Total							490.78

The cost of Water Supply
490.78 ₱/day x 22 days x 12 months
x 5 years = 647,800 ₱

Breakdown of Unit Price

Item No. ________ Work Site General

Work Electric Supply

Price 713,200 ₱

Remark : Diesel generator for Temporary Buildings

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Fuel	For Buildings						123,500
	20kW x 6Hr x 0.8 x 30 days x 12 month x 5 years = 172,800 kWH						
	172,800kWH ÷ 0.75 x 0.2ℓ x 2.68 ₱ = 123,500 ₱						
	For Repair shop						34,700
	15kW x 6Hr x 0.5 x 18 days x 12 month x 5 years = 48,600 kWH						
b. Labor							
Electrician		M.D	1,800			17.55	31,600
Common labor		M.D	3,600			16.25	58,500
c. PD #390	4.5% of b						4,100
d. Equipment expense							
Diesel generator	25 kVA	Day	1,800			160.00	288,000
Diesel generator	20 kVA	Day	1,080			160.00	172,800
Total							713,200

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam, Spur dike, Groundsill

Work - Excavation, in common

Price 16.57 P/cu.m

Remark : 300 cu.m/day

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Material							
Light oil		ℓ	362.40			2.68	971.23
Lubricant		ℓ	10.20			10.04	102.41
Grease		kg	0.532			19.82	10.54
Sub total							1,084.18
b. Labor							
Foreman		M.D	1.000			24.84	24.84
Operator		M.D	1.49			23.65	35.24
Assistant operator		M.D	1.49			17.55	26.15
Driver		M.D	2.54			19.36	49.17
Common labor		M.D	4.00			16.25	65.00
Sub total							200.40
c. PD#390	4.5% of b						9.02
d. Equipment expense							
Bulldozer	21 ton	Hr	3.60			350.00	1,260.00
Tractor shovel	1.4 m^3	Hr	6.80			110.00	748.00
Dump truck	6 ton	Hr	17.80			80.00	1,424.00
Sub total							3,432.00
e. Spoil banking		cu.m	300.00			0.82	246.00
Total							4,971.60

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam

Work Excavation, in rock

Price 70.14 P/cu.m

Remark : 100 cu.m/day

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	244.80			2.68	656.06
Lubricant		ℓ	6.95			10.04	69.78
Grease		kg	0.37			19.82	7.33
Sub total							733.17
b. Labor							
Foreman		M.D	0.50			24.84	12.42
Operator		M.D	0.94			23.65	22.23
Assistant operator		M.D	0.94			17.55	16.50
Driver		M.D	1.86			19.36	36.01
Common labor		M.D	2.00			16.25	32.50
Sub total							119.66
c. PD#390	4.5% of b						5.38
d. Equipment expense							
Bulldozer	21 ton	Hr	2.00			350.00	700.00
Tractor shovel	1.4 m^3	Hr	4.55			110.00	500.50
Dump truck	6 ton	Hr	13.00			80.00	1,040.00
Sub total							2,240.50
e. Blasting		cu.m	100.00			38.19	3,819.00
f. Spoil banking		cu.m	100.00			0.96	96.00
Total							7,013.71

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam, Spur dike, Levee

Work Backfill

Price 18.94 P/cu.m

Remark : 100 cu.m/day

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Light oil		ℓ	117.86			2.68	315.87
Lubricant		ℓ	3.30			10.04	33.13
Grease		kg	0.17			19.82	3.37
Sub total							352.37
b. Labor							
Foreman		M.D	0.50			24.84	12.42
Operator		M.D	0.52			23.65	12.30
Assistant operator		M.D	0.52			17.55	9.13
Driver		M.D	0.76			19.36	14.71
Common labor		M.D	2.00			16.25	32.50
Sub total							81.06
c. PD#390	4.5% of b						3.65
d. Equipment expense							
Bulldozer	21 ton	Hr	1.28			350.00	448.00
Tractor shovel	1.4 m^3	Hr	2.38			110.00	261.80
Dump truck	6 ton	Hr	5.29			80.00	423.20
Sub total							1,133.00
e. Filling with hand		cu.m	100.00			3.24	324.00
Total							1,894.08

Breakdown of Unit Price

Item No. ________ Work Site Spur dike, Levee

Work Embankment

Price 21.80 P/cu.m

Remark : 100 cu.m/day

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Light oil		ℓ	130.10			2.68	348.67
Lubricant		ℓ	4.61			10.04	46.28
Grease		kg	0.19			19.82	3.77
Sub total							398.72
b. Labor							
Foreman		M.D	0.50			24.84	12.42
Operator		M.D	0.85			23.65	20.10
Assistant operator		M.D	0.85			17.55	14.92
Driver		M.D	0.76			19.36	14.71
Common labor		M.D	2.00			16.25	32.50
Sub total							94.65
c. PD#390	4.5% of b						4.26
d. Equipment expense							
Bulldozer	21 ton	Hr	1.28			350.00	448.00
Tractor shovel	1.4 m^3	Hr	2.38			110.00	261.80
Dump truck	6 ton	Hr	5.29			80.00	423.20
Bulldozer	11 ton	Hr	0.48			160.00	76.80
Vibratory roller		Hr	1.85			80.00	148.00
Sub total							1,357.80
e. Filling with hand		cu.m	100.00			3.24	324.00
Total							2,179.43

Breakdown of Unit Price

Item No. ________ Work Site Spur dike, Levee

Work: Backfilling cobble stone behind wet masonry

Price: 41.49 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Sand and gravel		cu.m	1.100			35.00	38.50
Gasoline		ℓ	0.060			2.82	0.17
Sub total							38.67
b. Labor							
Foreman		M.D	0.007			24.84	0.17
Skilled labor		M.D	0.014			17.55	0.25
Common labor		M.D	0.114			16.25	1.85
Sub total							2.27
c. PD#390	4.5% of b						0.10
d. Equipment expense							
Rammer	80 - 100 kg	Day	0.009			50.00	0.45
Total							41.49

Breakdown of Unit Price

Item No. ________ Work Site Spur dike,

Work Riprap bedding

Price 30.60 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Supplying rubble	stone	cu.m	1.000			25.16	25.16
Filling with hand		cu.m	1.000			5.44	5.44
Total							30.60

Breakdown of Unit Price

Item No. ________ Work Site Levee, Groundsill

Work Filling rubble in crib work

Price 30.60 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Supplying rubble	stone	cu.m	1.000			25.16	25.16
Filling with hand		cu.m	1.000			5.44	5.44
Total							30.60

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Excavation with hand, sand and gravel

Price: 10.60 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
b. Labor							
Foreman		M.D	0.010			24.84	0.25
Skilled labor		M.D	0.100			17.55	1.76
Common labor		M.D	0.500			16.25	8.13
Sub total							10.14
c. PD#390	4.5% of b						0.46
Total							10.60

Breakdown of Unit Price

Item No. ________ Work Site ________________

Work: Excavation with hand, weathered rock

Price: 49.12 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	3.700			2.68	9.92
Lubricant		ℓ	0.150			10.04	1.51
Grease		kg	0.010			19.82	0.20
Sub total							11.63
b. Labor							
Foreman		M.D	0.021			28.84	0.52
Driller		M.D	0.214			17.55	3.76
Skilled labor		M.D	0.043			17.55	0.75
Common labor		M.D	0.214			16.25	3.48
Sub total							8.51
c. PD#390	4.5% of b						0.38
d. Equipment expense							
Air compressor	3.5 m^3/min	Day	0.143			190.00	27.17
Pickhammer	7 kg	Day	0.143			10.00	1.43
Sub total							28.60
Total							49.12

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Filling with hand, sand and gravel

Price: 3.24 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
b. Labor							
Foreman		M.D	0.014			24.84	0.35
Skilled labor		M.D	0.027			17.55	0.47
Common labor		M.D	0.140			16.25	2.28
Sub total							3.10
c. PD#390	4.5% of b						0.14
Total							3.24

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Filling with hand, rock and rubble

Price: 5.44 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
b. Labor							
Foreman		M.D	0.024			24.84	0.60
Skilled labor		M.D	0.046			17.55	0.81
Common labor		M.D	0.234			16.25	3.80
Sub total							5.21
c. PD#390	4.5% of b						0.23
Total							5.44

Breakdown of Unit Price

Item No. ________ Work Site ________________________

Work Spoil Banking, sand and gravel

Price 0.82 P/cu.m

Remark : 100 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Light oil		ℓ	4.723			2.68	12.66
Lubricant		ℓ	0.095			10.04	0.95
Grease		kg	0.006			19.82	0.12
Sub total							13.73
b. Labor							
Foreman		M.D	0.005			24.84	0.15
Operator		M.D	0.045			23.65	1.07
Assistant operator		M.D	0.045			17.55	0.79
Common labor		M.D	0.900			16.25	14.63
Sub total							16.64
c. PD#390	4.5% of b						0.75
d. Equipment expense							
Bulldozer	11 ton	Hr	0.317			160.00	50.72
Total							81.84

Breakdown of Unit Price

Item No. ________ Work Site ____________________

Work: Excavating rock with hand

Price: 63.63 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	4.300			2.68	11.52
Lubricant		ℓ	0.137			10.04	1.38
Grease		kg	0.004			19.82	0.08
Sub total							12.98
b. Labor							
Foreman		M.D	0.080			24.84	1.99
Driller		M.D	0.850			17.55	14.92
Common Labor		M.D	0.850			16.25	13.81
Sub total							30.72
c. PD#390	4.5% of b						1.38
d. Equipment expense							
Pickhammer	7.5 kg	Day	0.159			10.00	1.59
Air compressor	7 m^3/min	Day	0.053			320.00	16.96
Sub total							18.55
Total							63.63

Breakdown of Unit Price

Item No. ________ Work Site ________________

Work: Spoil Banking, weathered rock and rock

Price: 0.96 P/cu.m

Remark : 100 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	6.616			2.68	17.73
Lubricant		ℓ	0.133			10.04	1.34
Grease		kg	0.009			19.82	0.18
Sub total							19.25
b. Labor							
Foreman		M.D	0.006			24.84	0.15
Operator		M.D	0.063			23.65	1.49
Assistant operator		M.D	0.063			17.55	1.11
Common labor		M.D	0.127			16.25	2.06
Sub total							4.81
c. PD#390	4.5% of b						0.22
d. Equipment expense							
Bulldozer	11 ton	Hr	0.444			160.00	71.04
Total							95.32

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: *Excavating rock with explosive*

Price: 38.19 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Taper rod	22 mm. dia	No	0.005			340.00	1.70
Cross bit	36 mm. guage	No	0.005			900.00	4.50
Dinamite		kg	0.010			50.00	0.50
Detonator		No	1.000			6.00	6.00
Light oil		ℓ	2.440			2.68	6.54
Lubricant		ℓ	0.080			10.04	0.80
Grease		kg	0.002			19.82	0.04
Sub total							20.08
b. Labor							
Foreman		M.D	0.005			24.84	0.12
Driller		M.D	0.300			17.55	5.27
Powderman		M.D	0.100			17.55	1.76
Common labor		M.D	0.200			16.25	3.25
Sub total							10.04
c. PD#390	4.5% of b						0.47
d. Equipment expense							
Jack hammer	20 kg	Day	0.040			30.00	1.20
Air compressor	7 m^3/min	Day	0.020			320.00	6.40
Sub total							7.60
Total							38.19

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam

Work Concrete, type A

Price 296.72 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Concrete material		cu.m	1,000				198.15
Mixing concrete (Portable batcher)		cu.m	1,000				34.60
Carrying concrete		cu.m	1,000				22.90
Placing concrete (concrete bucket)		cu.m	1,000				40.11
Curing concrete		cu.m	1,000				0.96
Total							296.72

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam

Work Concrete, rubble concrete

Price 237.96 ₽/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Concrete, type A		cu.m	0.75			296.72	222.54
Rubble aggregate		cu.m	0.25			61.67	15.42
Total							237.96

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam, Rubble concrete

Work Rubble aggregate

Price 61.67 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	3.500			2.68	9.38
Lubricant		ℓ	0.245			10.04	2.46
Grease		kg	0.035			19.82	0.69
Rubble aggregate		cu.m	1.000			25.16	25.16
Sub total							37.69
b. Labor							
Foreman		M.D	0.005			24.84	0.13
Concrete worker		M.D	0.400			16.25	6.50
Common labor		M.D	0.200			16.25	3.25
Operator		M.D	0.050			23.65	1.18
Assistant operator		M.D	0.050			17.55	0.88
Sub total							11.94
c. PD #390	4.5% of b						0.54
d. Equipment expense							
Track crane	15 ton	Hr	0.050			230.00	11.50
Total							61.67

Breakdown of Unit Price

Item No. ________ Work Site Sabo dam

Work Backfill concrete, type B

Price 258.35 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Concrete material		cu.m	1.000				178.10
Mixing concrete (Portable batcher)		cu.m	1.000				34.60
Carrying concrete		cu.m	1.000				22.90
Placing concrete (chute)		cu.m	1.000				22.75
Curing concrete		cu.m	1.000				0.96
Total							258.35

Breakdown of Unit Price

Item No. ________ Work Site Spur dike

Work: Concrete, type B, in foot protection block, at crest of embankment, in wet masonry

Price: 235.05 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Concrete material		cu.m	1.000				178.10
Mixing concrete (Light mixer)		cu.m	1.000				33.24
Placing concrete		cu.m	1.000				22.75
Curing concrete		cu.m	1.000				0.96
Total							235.05

Breakdown of Unit Price

Item No. ________ Work Site Levee

Work Concrete, type B, in top protection block, in wet masonry

Price 235.05 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount

Breakdown of Unit Price

Item No. ________ Work Site Cross concrete block

Work Concrete, type A

Price 255.10 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Concrete material		cu.m	1.000				198.15
Mixing concrete (Light mixer)		cu.m	1.000				33.24
Placing concrete		cu.m	1.000				22.75
Curing concrete		cu.m	1.000				0.96
Total							255.10

Breakdown of Unit Price

Item No. ________ Work Site Irrigation intake

Work Concrete, type C

Price 298.70 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
Concrete material		cu.m	1.000				241.75
Mixing concrete (Light mixer)		cu.m	1.000				33.24
Placing concrete		cu.m	1.000				22.75
Curing concrete		cu.m	1.000				0.96
Total							298.70

Breakdown of Unit Price

Item No. ________ Work Site Spur dike, wet masonry

Work Mixing mortar with hand, 1:3

Price 429.02 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Portland cement		ton	0.530			700.00	371.00
Aggregate	Fine	cu.m	1.050			25.00	26.25
Sub total							397.25
b. Labor							
Foreman		M.D	0.030			24.84	0.75
Skilled labor		M.D	0.300			17.55	5.27
Common labor		M.D	1.500			16.25	24.38
Sub total							30.40
c. PD #390	4.5 % of b						1.37
Total							429.02

Breakdown of Unit Price

Item No. ________ Work Site ____________________

Work: Concrete material, type A

Price: 198.15 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Portland cement		ton	0.215			700.00	150.50
Aggregate	Fine	cu.m	0.520			25.00	13.00
Aggregate	Coarse	cu.m	0.990			35.00	34.65
Sub total							198.15

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Concrete material, type B

Price: 178.10 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Portland cement		ton	0.185			700.00	129.50
Aggregate	Fine	cu.m	0.530			25.00	13.25
Aggregate	Coarse	cu.m	1.010			35.00	35.35
Sub total							178.10

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Concrete material, type C

Price: 241.75 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Portland cement		ton	0.280			700.00	196.00
Aggregate		cu.m	0.500			25.00	12.50
Aggregate		cu.m	0.950			35.00	33.25
Sub total							241.75

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Mixing concrete with light mixer, 0.2 cu.m

Price: 33.24 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	0.556			2.68	1.49
Lubricant		ℓ	0.010			10.04	0.10
Sub total							1.59
b. Labor							
Foreman		M.D	0.012			24.84	0.30
Concrete worker		M.D	0.123			16.25	2.00
Common labor		M.D	0.368			16.25	5.98
Sub total							8.28
c. PD #390	4.5 % of b						0.37
d. Equipment expense							
Concrete mixer	0.2 m^3	Day	0.100			230.00	23.30
Total							33.24

Breakdown of Unit Price

Item No. ______ Work Site ______

Work: Mixing concrete with portable batcher, 0.75 cu.m

Price: 34.60 ₱/cu.m

Remark : 1 cu.m/day

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Light oil		ℓ	0.900			2.68	2.41
Lubricant		ℓ	0.034			10.04	0.34
Grease		kg	0.002			19.82	0.04
Sub total							2.79
b. Labor							
Foreman		M.D	0.006			24.84	0.15
Operator		M.D	0.048			19.36	0.93
Mechanic		M.D	0.024			17.55	0.42
Electrician		M.D	0.024			17.55	0.42
Common labor		M.D	0.214			16.25	3.48
Sub total							5.40
c. PD #390	4.5 % of b						0.24
d. Equipment expense							
Concrete mixer	0.75 m^3	Hr	0.067			210.00	14.07
Belt conveyor		Day	0.032			90.00	2.88
Bulldozer	3 ton	Hr	0.111			60.00	6.66
Generator	20 kVA	Day	0.016			160.00	2.56
Sub total							26.17
Total							34.60

Breakdown of Unit Price

Item No. ________ Work Site ________________

Work: Carrying concrete with agitator truck, 1.7 cu.m

Price: 22.90 P/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Light oil		ℓ	2.188			2.68	5.87
Lubricant		ℓ	0.078			10.04	0.79
Grease		kg	0.001			19.82	0.02
Sub total							6.68
b. Labor							
Foreman		M.D	0.005			24.84	0.13
Driver		M.D	0.053			19.36	1.03
Sub total							1.16
c. PD #390	4.5 % of b						0.06
d. Equipment expense							
Agitator	1.7 m^3	Hr	0.250			60.00	15.00
Total							22.90

Breakdown of Unit Price

Item No. ________ Work Site ____________________

Work Placing concrete with hand

Price 22.75 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Gasoline		ℓ	2,300			2.82	6.49
b. Labor							
Foreman		M.D	0.053			24.84	1.32
Concrete worker		M.D	0.525			16.25	8.53
Common labor		M.D	0.263			16.25	4.27
Sub total							14.12
c. PD #390	4.5 % of b						0.64
d. Equipment expense							
Vibrator	45 mm.dia	Day	0.050			30.00	1.50
Total							22.75

Breakdown of Unit Price

Item No. ________ Work Site ________________

Work: Placing concrete with concrete bucket

Price: 40.11 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Gasoline		ℓ	2.000			2.82	5.64
Light oil		ℓ	0.460			2.68	1.23
Lubricant		ℓ	0.015			10.04	0.15
Grease		kg	0.003			19.82	0.06
Sub total							7.08
b. Labor							
Foreman		M.D	0.045			24.84	1.12
Operator		M.D	0.023			23.65	0.54
Assistant operator		M.D	0.023			17.55	0.40
Concrete worker		M.D	0.450			16.25	7.31
Common labor		M.D	0.225			16.25	3.66
Sub total							13.03
c. PD #390	4.5 % of b						0.59
d. Equipment expense							
Truck crane	16 ton	Hr	0.077			230.00	17.71
Concrete bucket	0.6 m^3	Day	0.005			40.00	0.20
Vibrator	45 mm. dia	Day	0.050			30.00	1.50
Sub total							19.41
Total							40.11

Breakdown of Unit Price

Item No. ________ Work Site ____________________

Work: Curing concrete with mat

Price: 0.96 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
b. Labor							
Foreman							
Concrete worker		M.D	0.001			24.84	0.03
Common labor		M.D	0.005			16.25	0.08
Sub total		M.D	0.050			16.25	0.81
							0.92
c. PD #390	4.5 % of b						0.04
Total							0.96

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Formwork F1

Price: 36.76 ₱/sq.m

Remark : 1 sq.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Timber	Plank	cu.m	0.010			1,101.70	11.02
Timber	Square	cu.m	0.008			1,101.70	8.82
Timber	Log	cu.m	0.002			1,101.70	2.21
Nail		kg	0.380			8.00	3.04
Annealed iron wire		kg	0.070			8.50	0.60
Sub total							25.69
b. Labor							
Foreman		M.D	0.002			24.84	0.05
Carpenter		M.D	0.417			17.55	7.32
Common Labor		M.D	0.198			16.25	3.22
Sub total							10.59
c. PD #390	4.5 % of b						0.48
Total							36.76

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Formwork F2

Price: 79.85 ₱/sq.m

Remark : 1 sq.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Plywood		cu.m	0.011			2,648.00	29.13
Timber	square	cu.m	0.016			1,101.70	17.63
Nail		kg	0.470			8.00	3.76
Timber	log	cu.m	0.005			1,101.70	5.51
Annealed iron wire		kg	0.100			8.50	0.85
Sub total							56.88
b. Labor							
Foreman		M.D	0.059			24.84	1.47
Carpenter		M.D	0.891			17.55	15.63
Common Labor		M.D	0.300			16.25	4.88
Sub total							21.98
c. PD #390	4.5% of b						0.99
Total							79.85

Breakdown of Unit Price

Item No. ________ Work Site ________________

Work Reinforcing bar, deformed bar

Price 4,799.48 ₱/ton

Remark : 1 ton

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Deformed bar		ton	1,030			4,300.00	4,429.00
Annealed iron wire		kg	4,000			8.50	42.50
Sub total							4,471.50
b. Labor							
Foreman		M.D	0.880			24.84	21.86
Reinforcement worker		M.D	8.800			16.25	143.00
Common Labor		M.D	9,200			16.25	149.50
Sub total							313.86
c. PD #390	4.5 % of b						14.12
Total							4,799.48

Breakdown of Unit Price

Item No. ________ Work Site ________________

Work: Waterstop, width 300 mm

Price: 94.19 ₱/m

Remark : ~~1 Lin.m~~

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Water stop	P.V.C	Lin.m	1.000			90.00	90.00
b. Labor							
Foreman		M.D	0.030			24.84	0.75
Concrete worker		M.D	0.100			16.25	1.63
Common Labor		M.D	0.100			16.25	1.63
Sub total							4.01
c. PD #390	4.5 % of b						0.18
Total							94.19

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Joint filler, expansion joint

Price: 60.30 ₱/sq.m

Remark : 1 sq.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Joint filler	Elastite	sq.m	1.050			55.00	57.75
b. Labor							
Foreman		M.D	0.030			24.84	0.75
Carpenter		M.D	0.050			17.55	0.88
Common labor		M.D	0.050			16.25	0.81
Sub total							2.44
c. PD #390	4.5% of b						0.11
Total							60.30

Breakdown of Unit Price

Item No. ________ Work Site ________

Work R.C pipe, 300 mm. dia.

Price 302.76 ₱/m

Remark : 1 Lin.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
R.C. pipe	300 mm	Lin.m	1.000			290.00	290.00
Portland cement		ton	0.006			700.00	4.20
Aggregate	Fine	cu.m	0.009			25.00	0.23
Sub total							294.43
b. Labor							
Foreman		M.D	0.020			24.84	0.50
Pipe fitter		M.D	0.165			16.25	2.68
Common labor		M.D	0.295			16.25	4.79
Sub total							7.97
c. PD #390	4.5% of b						0.36
Total							302.76

Breakdown of Unit Price

Item No. ________ Work Site ________

Work R.C pipe, 600 mm. dia.

Price 378.19 ₱/m

Remark : 1 Lin.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. *Total cost of material*							
R.C. pipe	600 mm.	Lin.m	1.000			355.00	355.00
Portland cement		ton	0.010			700.00	7.00
Aggregate	Fine	cu.m	0.013			25.00	0.33
Sub total							362.33
b. Labor							
Foreman		M.D	0.050			24.84	1.24
Pipe fitter		M.D	0.255			16.25	4.14
Common Labor		M.D	0.603			16.25	9.80
Sub total							15.18
Total							378.19

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Wet rubble masonry, spur dike

Price: 52.24 ₱/sq.m

Remark : 1 sq.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Rubble		cu.m	0.300			25.16	7.55
Portland cement		ton	0.028			700.00	19.60
Aggregate	Fine	cu.m	0.080			25.00	2.00
Aggregate	Coarse	cu.m	0.152			35.00	5.32
Light oil		ℓ	0.095			2.82	0.27
Sub total							34.74
b. Labor							
Foreman		M.D	0.030			24.84	0.75
Mason		M.D	0.198			17.55	3.47
Concrete worker		M.D	0.025			16.25	0.41
Common Labor		M.D	0.610			16.25	9.91
Sub total							14.54
c. PD #390	4.5 % of b						0.66
d. Equipment expense							
Concrete Mixer	0.2 m^3	Day	0.010			230.00	2.30
Total							52.24

Breakdown of Unit Price

Item No. ________ Work Site ____________________

Work: Wet-rubble masonry, Levee work

Price: 46.18 ₱/sq.m

Remark : 1 sq.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Rubble		cu.m	0.150			25.16	3.77
Portland cement		ton	0.028			700.00	19.60
Aggregate	Fine	cu.m	0.080			25.00	2.00
Aggregate	Coarse	cu.m	0.152			35.00	5.32
Light oil		ℓ	0.095			2.82	0.27
Sub total							30.96
b. Labor							
Foreman		M.D	0.025			24.84	0.62
Mason		M.D	0.168			17.55	2.95
Concrete worker		M.D	0.021			16.25	0.34
Common Labor		M.D	0.520			16.25	8.45
Sub total							12.36
c. PD #390	4.5 % of b						0.56
d. Equipment expense							
Concrete mixer	0.2 m^3	Day	0.010			230.00	2.30
Total							46.18

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Weep hole, 5 cm. dia.

Price: 30.69 ₱/m

Remark : 1 Lin.m

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
P.V.C pipe		Lin.m	1.000			28.50	28.50
b. Labor							
Foreman		M.D	0.010			24.84	0.25
Common labor		M.D	0.113			16.25	1.84
Sub total							2.09
c. PD #390	4.5 % of b						0.10
Total							30.69

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Crib work

Price: 5.43 ₱/m

Remark : 1 No. timber length 21.6 m/No.

Particular	Description	Unit	Q'ty	Currency		Currency	
				Unit Cost	Amount	Unit Cost	Amount
a. Total cost of material							
Coconut trunk		Lin.m	21.600			3.00	64.80
Tie wire		kg	3.000			8.00	24.00
Sub total							88.80
b. Labor							
Foreman		M.D	0.100			24.84	2.48
Common Labor		M.D	0.730			16.25	11.86
Carpenter		M.D	0.730			17.55	12.81
Sub total							27.15
c. PD #390	4.5 % of b						1.22
Total							117.17

Breakdown of Unit Price

Item No. ________ Work Site ________

Work: Supplying rubble stone from riverbed

Price: 25.16 ₱/cu.m

Remark : 1 cu.m

Particular	Description	Unit	Q'ty	Currency Unit Cost	Currency Amount	Currency Unit Cost	Currency Amount
a. Total cost of material							
Light oil		ℓ	1.600			2.68	4.29
Lubricant		ℓ	0.045			10.04	0.45
Grease		kg	0.001			19.82	0.02
Sub total							4.76
b. Labor							
Foreman		M.D	0.005			24.84	0.12
Common labor		M.D	0.400			16.25	6.50
Operator		M.D	0.100			23.65	2.37
Sub total							8.99
c. PD #390	4.5% of b						0.41
d. Equipment expense							
Tractor shovel		Hr	0.100			100.00	11.00
Total							25.16

APPENDIX IV

DESIGN DRAWINGS

THE REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT
SABO FACILITIES IN THE PAWA - BURABOD RIVER

A TRIBUTARY OF THE YAWA RIVER

DESIGN DRAWINGS

FEBRUARY 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

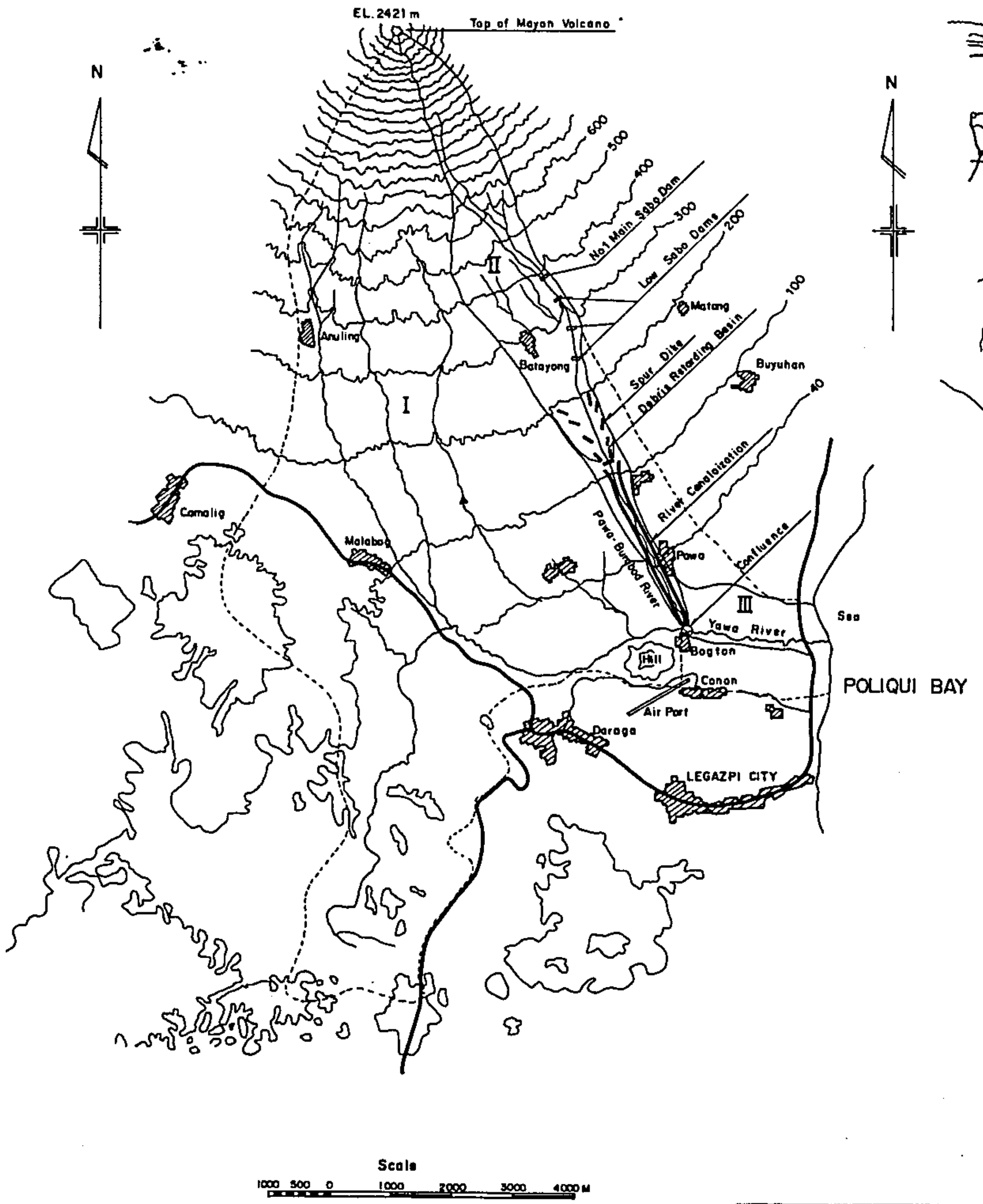
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT

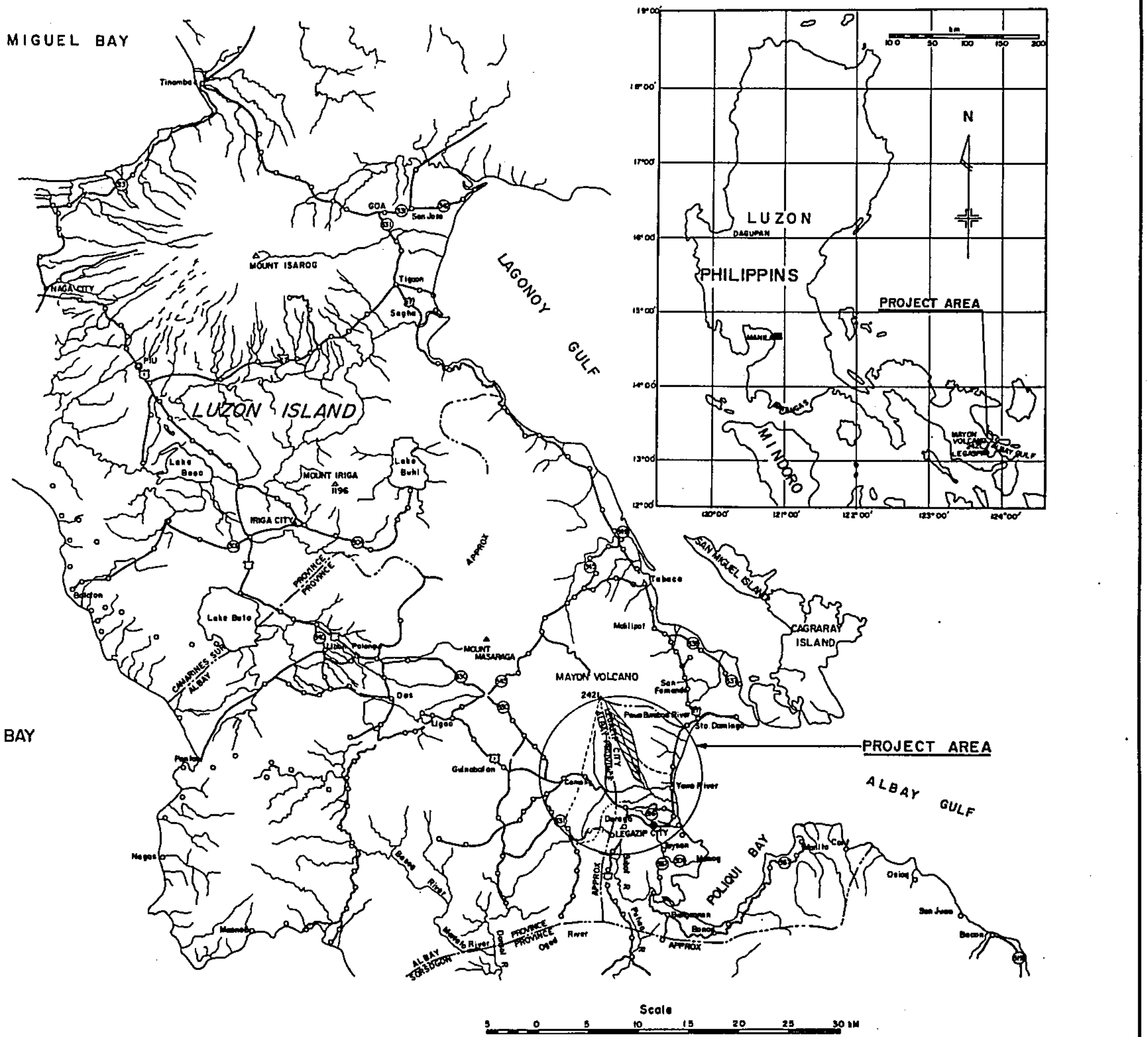
SABO FACILITIES IN THE PAWA-BURABOD RIVER A TRIBUATARY OF THE YAWA RIVER

LIST OF DESIGN DRAWINGS

D.W.G NO.	TITLE OF DRAWING
M.V.S-D 001	LOCATION MAP OF THE PAWA-BURABOD RIVER
M.V.S-D 002	NO. I SABO DAM, GENERAL PLAN
M.V.S-D 003	NO. I SABO DAM, STRUCTURAL DETAIL (1)
M.V.S-D 004	NO. I SABO DAM, STRUCTURAL DETAIL (2)
M.V.S-D 005	SPUR DIKES, GENERAL PLAN
M.V.S-D 006	NO. I SPUR DIKE, PLAN, PROFILE & SECTION
M.V.S-D 007	NO.2 SPUR DIKE, PLAN, PROFILE & SECTION
M.V.S-D 008	RIVER CANALIZATION, PLAN (6-1)
M.V.S-D 009	〃 (6-2)
M.V.S-D 010	〃 (6-3)
M.V.S-D 011	〃 (6-4)
M.V.S-D 012	〃 (6-5)
M.V.S-D 013	〃 (6-6)
M.V.S-D 014	RIVER CANALIZATION, PROFILE (2-1)

D.W.G NO.	TITLE OF DRAWING
M.V.S-D 015	RIVER CANALIZATION, PROFILE (2-2)
M.V.S-D 016	RIVER CANALIZATION, CROSS SECTION (10-1)
M.V.S-D 017	〃 (10-2)
M.V.S-D 018	〃 (10-3)
M.V.S-D 019	〃 (10-4)
M.V.S-D 020	〃 (10-5)
M.V.S-D 021	〃 (10-6)
M.V.S-D 022	〃 (10-7)
M.V.S-D 023	〃 (10-8)
M.V.S-D 024	〃 (10-9)
M.V.S-D 025	〃 (10-10)
M.V.S-D 026	RIVER CANALIZATION, TYPICAL CROSS SECTION
M.V.S-D 027	RIVER CANALIZATION, STRUCTURAL DETAIL OF LEVEE
M.V.S-D 028	RIVER CANALIZATION, STRUCTURAL DETAIL OF GROUNDSILL
M.V.S-D 029	RIVER CANALIZATION, IRRIGATION INTAKE

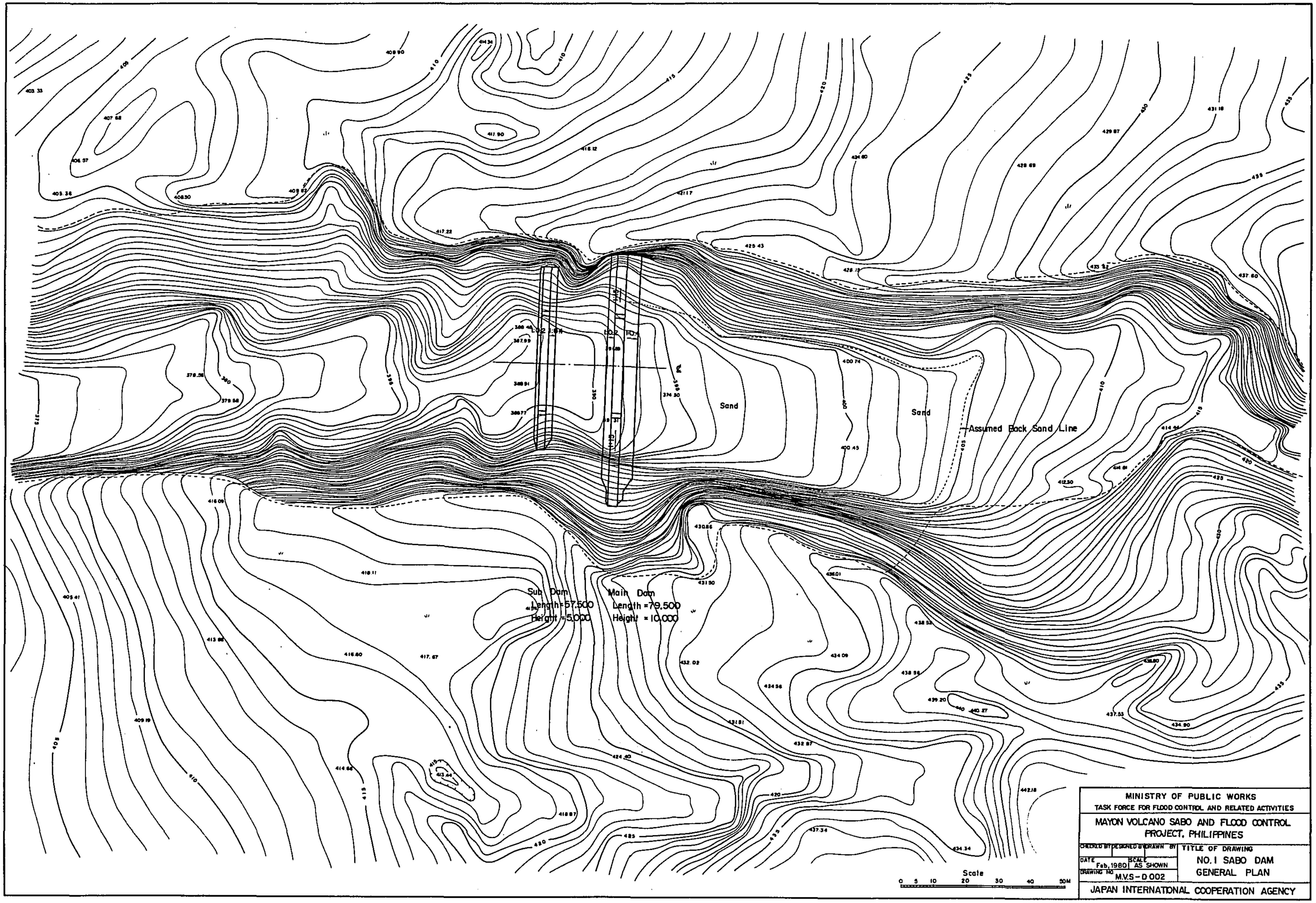




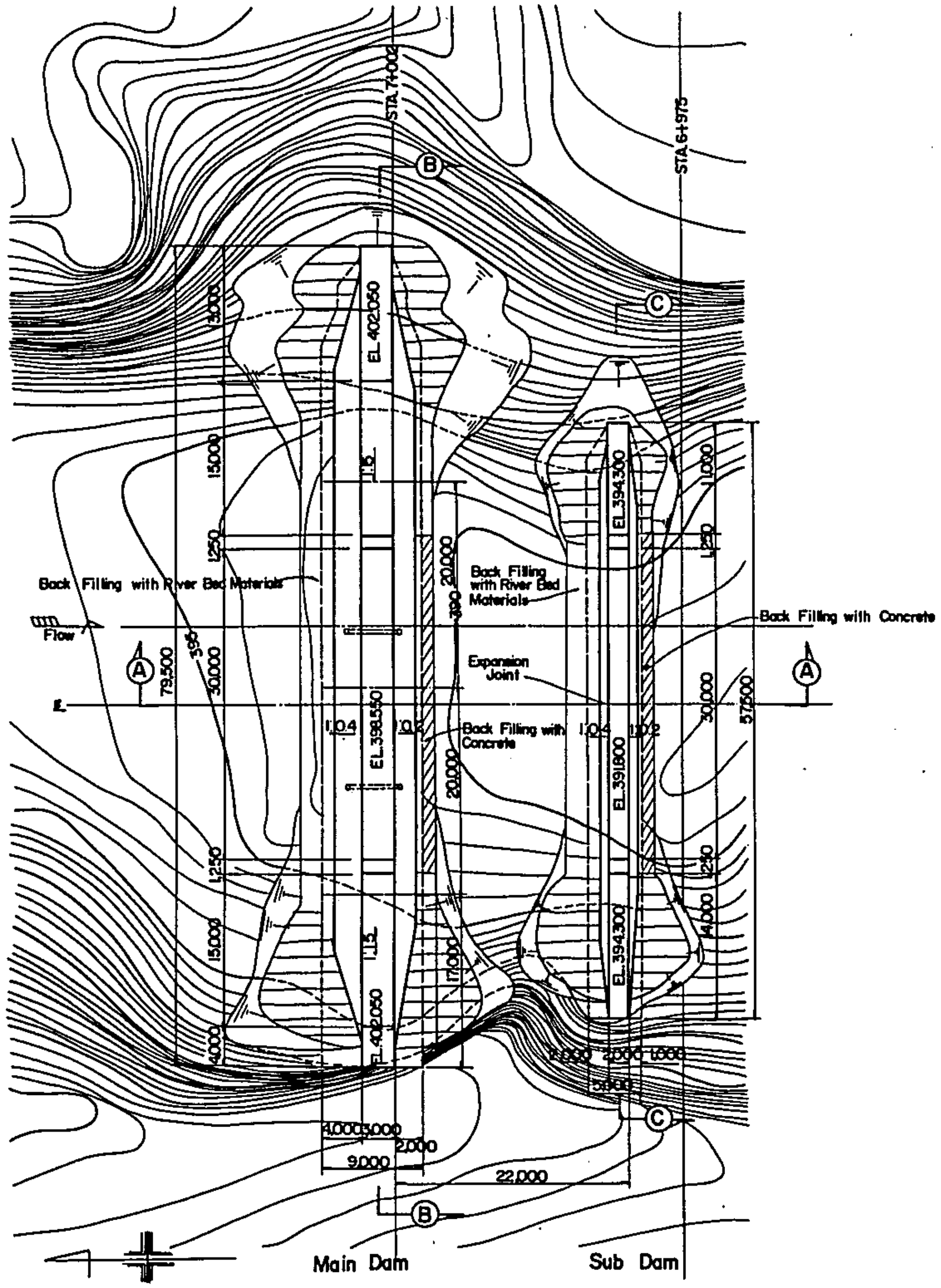
Legend

— · — · —	Provincial boundary
═══○═══	First and second class roads
(hatched)	village, town
Y– O	Denotes site and Number of Sieving Test Pit for river bed materials

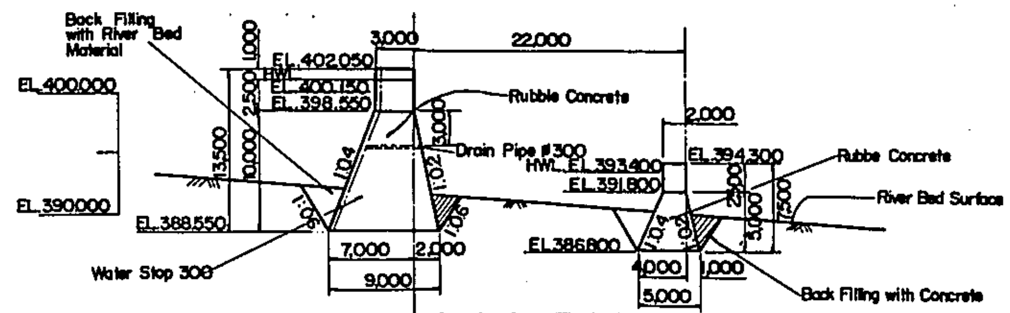
MINISTRY OF PUBLIC WORKS TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES		
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES		
CHECKED BY / DESIGNED BY / DRAWN BY		TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN	LOCATION MAP OF THE PAWA - BURABOD RIVER
DRAWING NO. M.V.S - D 001		
JAPAN INTERNATIONAL COOPERATION AGENCY		



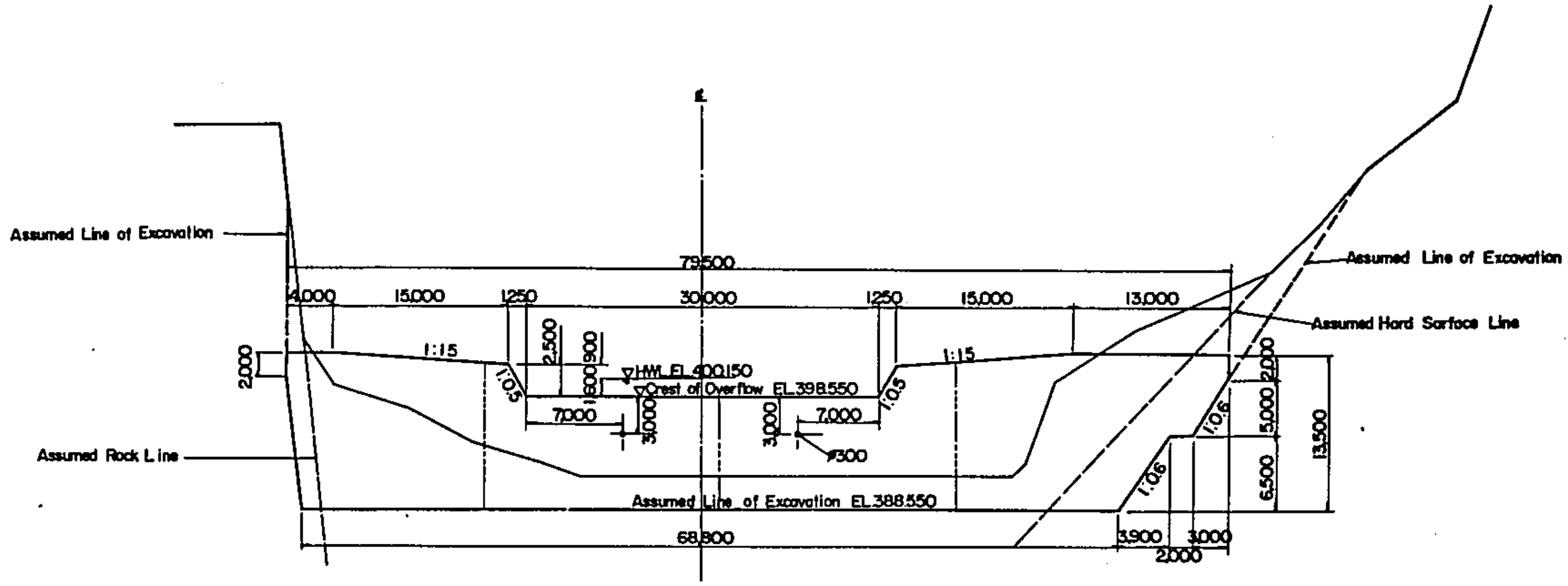
Sand
Sand
Assumed Back Sand Line
Sub Dam
Length =57.500
Height =5.000
Main Dam
Length =79.500
Height =10.000
Scale
0 5 10 20 30 40 50M
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES
CHECKED BY DESIGNED BY DRAWN BY
TITLE OF DRAWING
DATE Feb. 1980
SCALE AS SHOWN
DRAWING NO M.V.S-D 002
NO. 1 SABO DAM GENERAL PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY



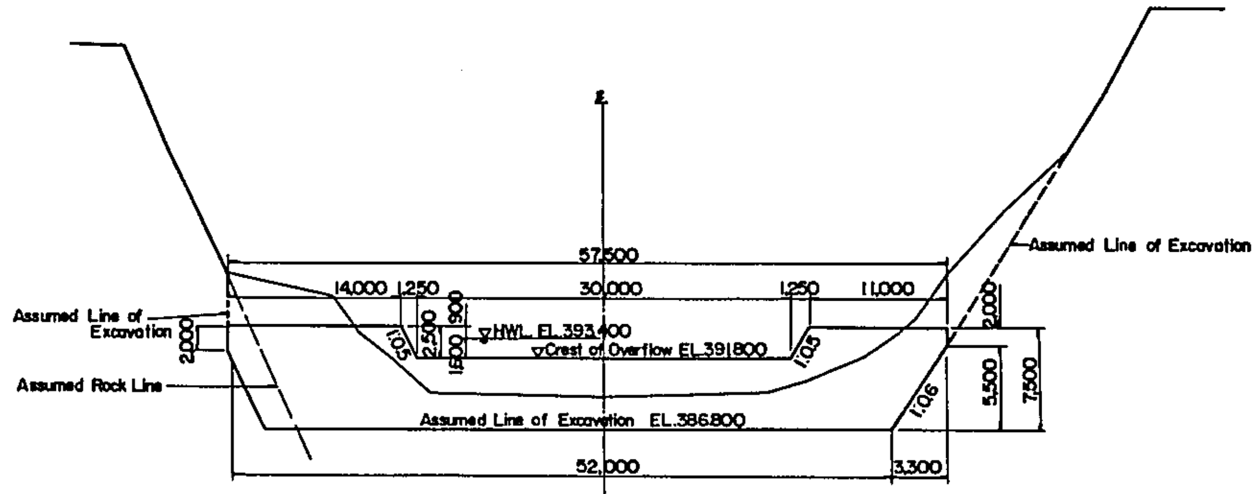
PLAN



A-A SECTION



B-B SECTION



C-C SECTION

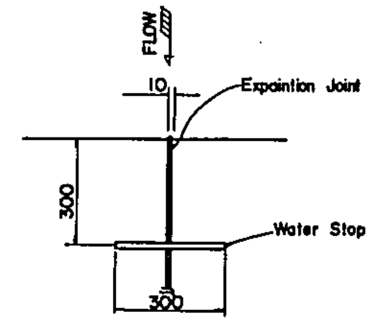
Scale 0 5 10 20M

MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

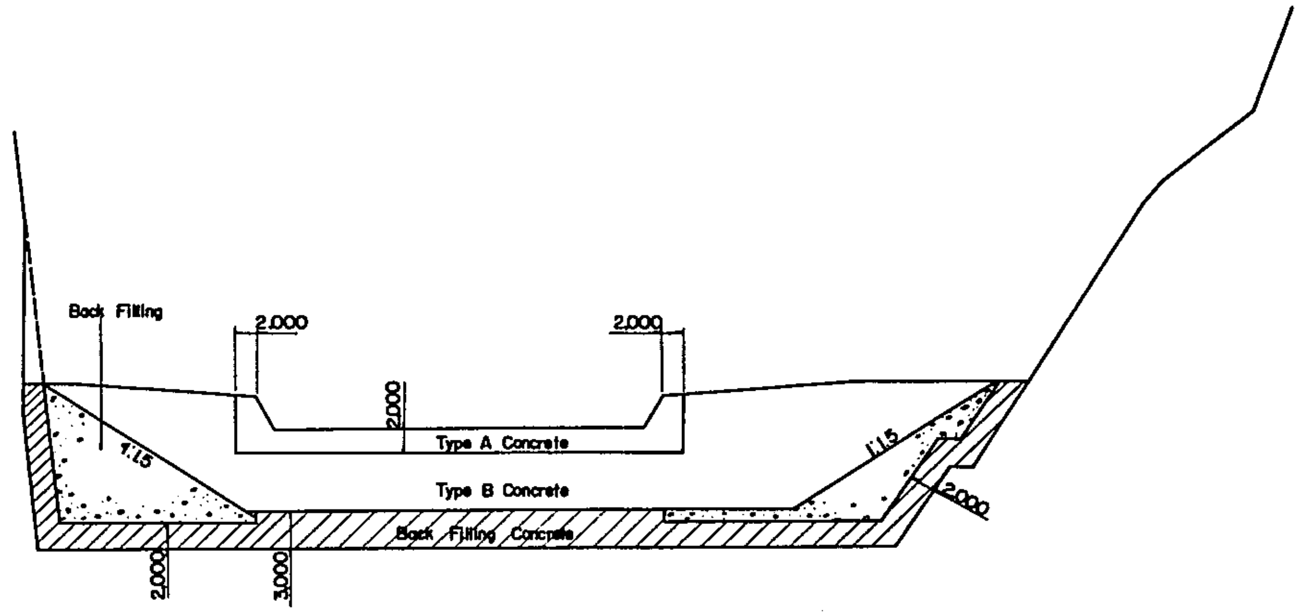
CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980		SCALE AS SHOWN	NO. 1 SABO DAM
DRAWING NO. M.V.S D-003			STRUCTURAL DETAILS (1)

JAPAN INTERNATIONAL COOPERATION AGENCY



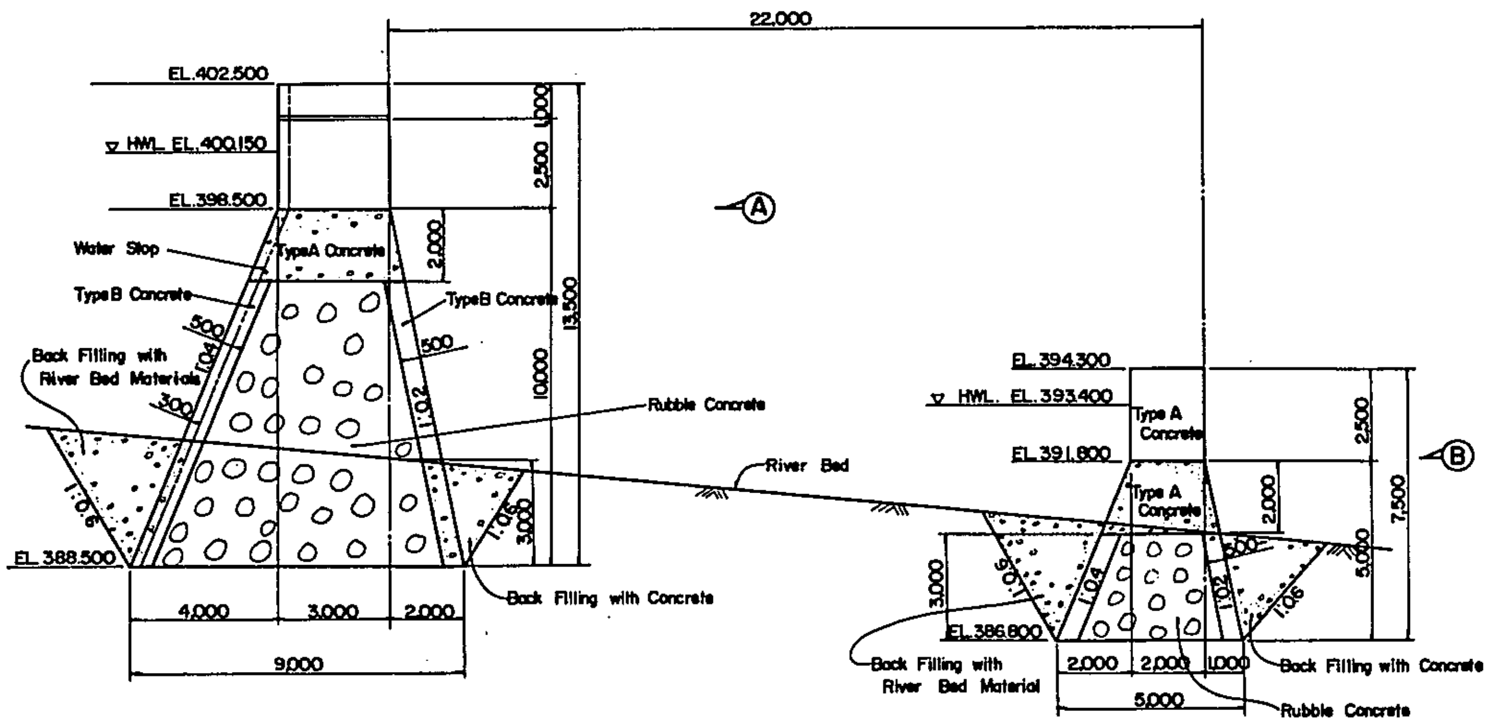
TYPICAL PLAN OF EXPANSION JOINT & WATER STOP

Scale 0 01 02 03 04 05M



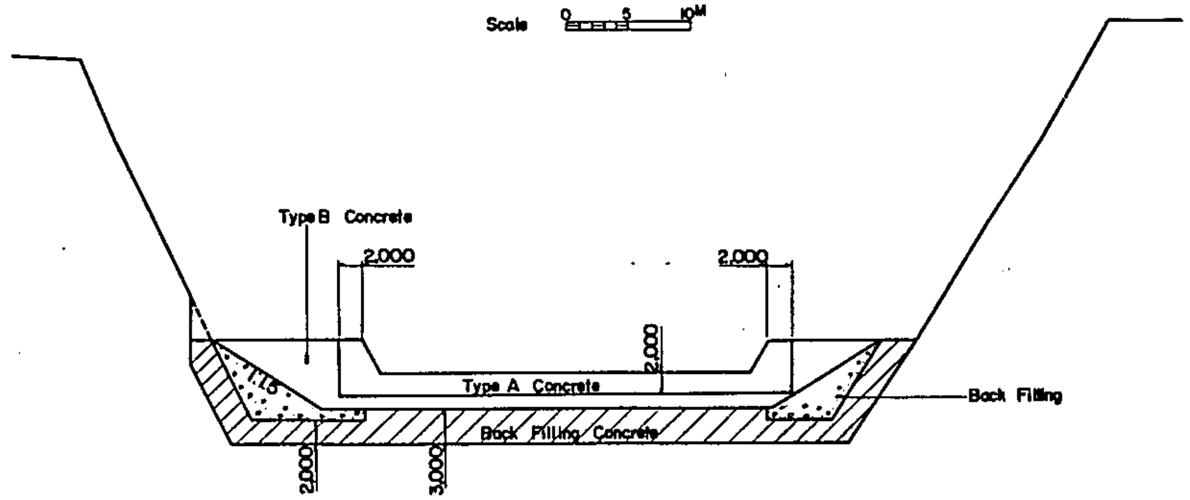
A FRONT VIEW

Scale 0 5 10M



TYPICAL SECTION OF MAIN AND SUB DAMS

Scale 0 1 2 3 4 5M



B FRONT VIEW

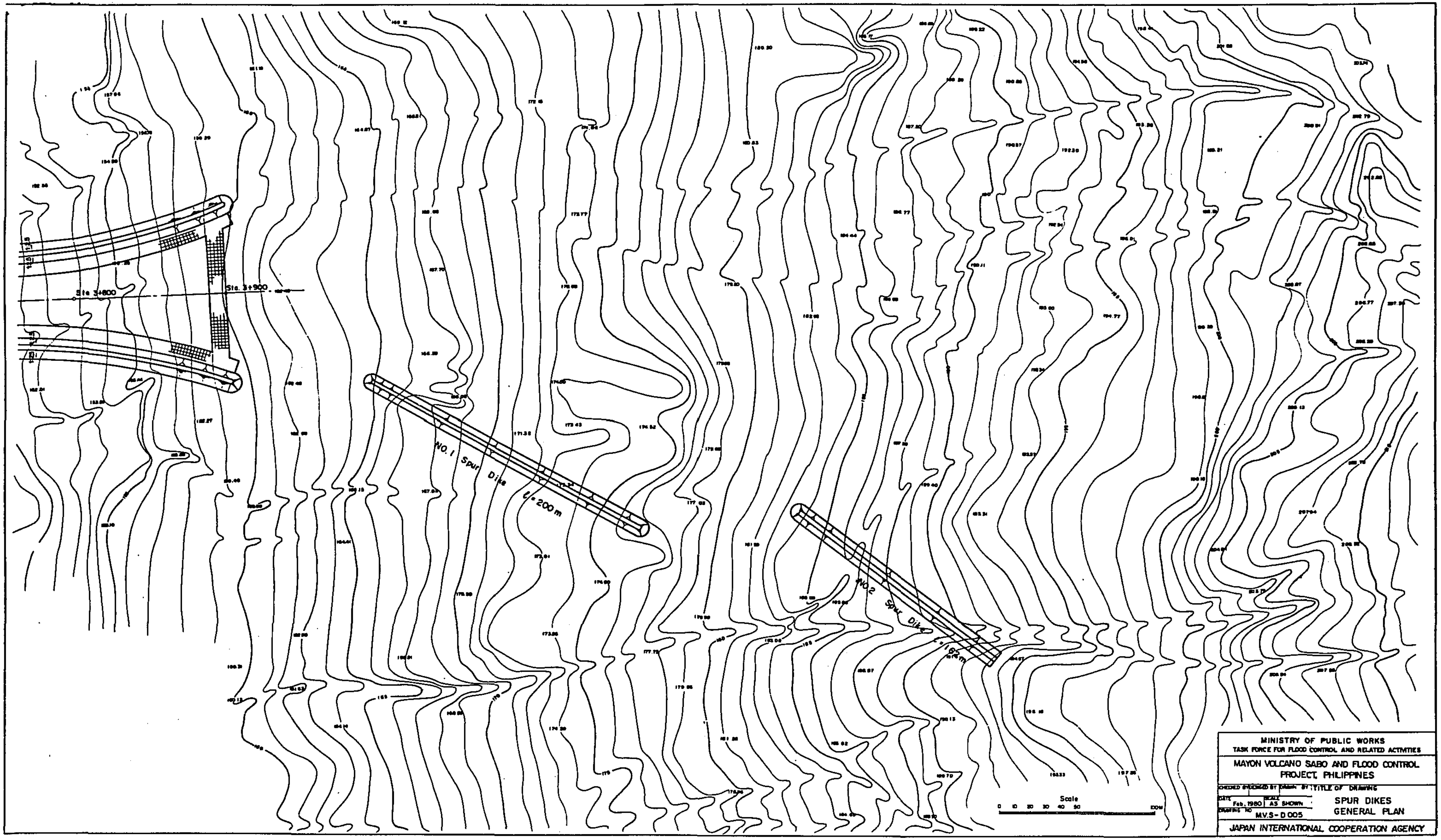
Scale 0 5 10M

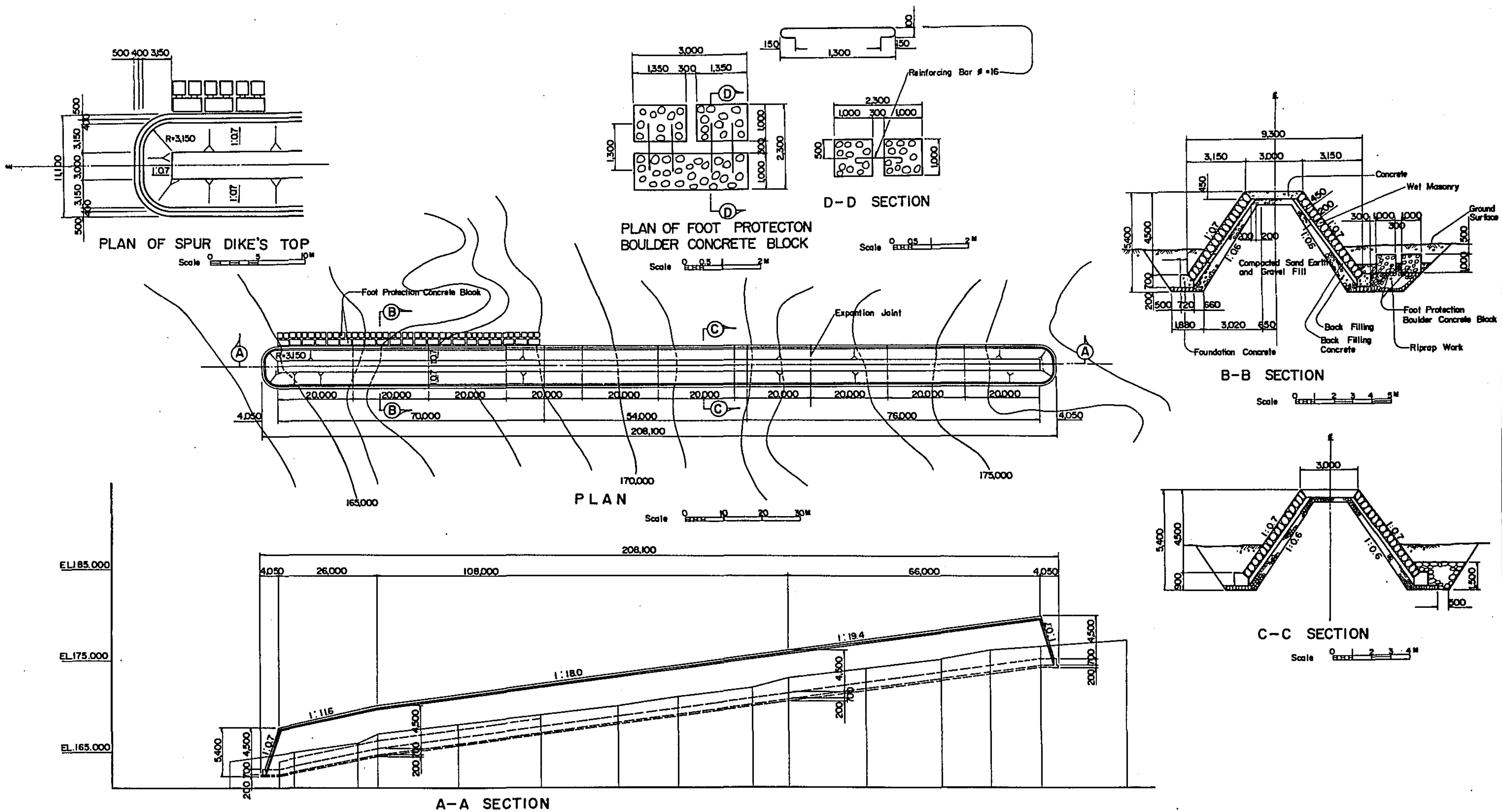
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		NO. 1 SABO DAM STRUCTURAL DETAILS (2)
DRAWING NO. M.V.S.-D 004			

JAPAN INTERNATIONAL COOPERATION AGENCY


Sta. 3+800
Sta. 3+900
NO. 1 Spur Dike
L=200m
NO. 2 Spur Dike
Scale
0 10 20 30 40 50 100M
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES
TITLE OF DRAWING
SPUR DIKES
GENERAL PLAN
DATE Feb. 1980
SCALE AS SHOWN
DRAWING NO M.V.S-D 005
JAPAN INTERNATIONAL COOPERATION AGENCY



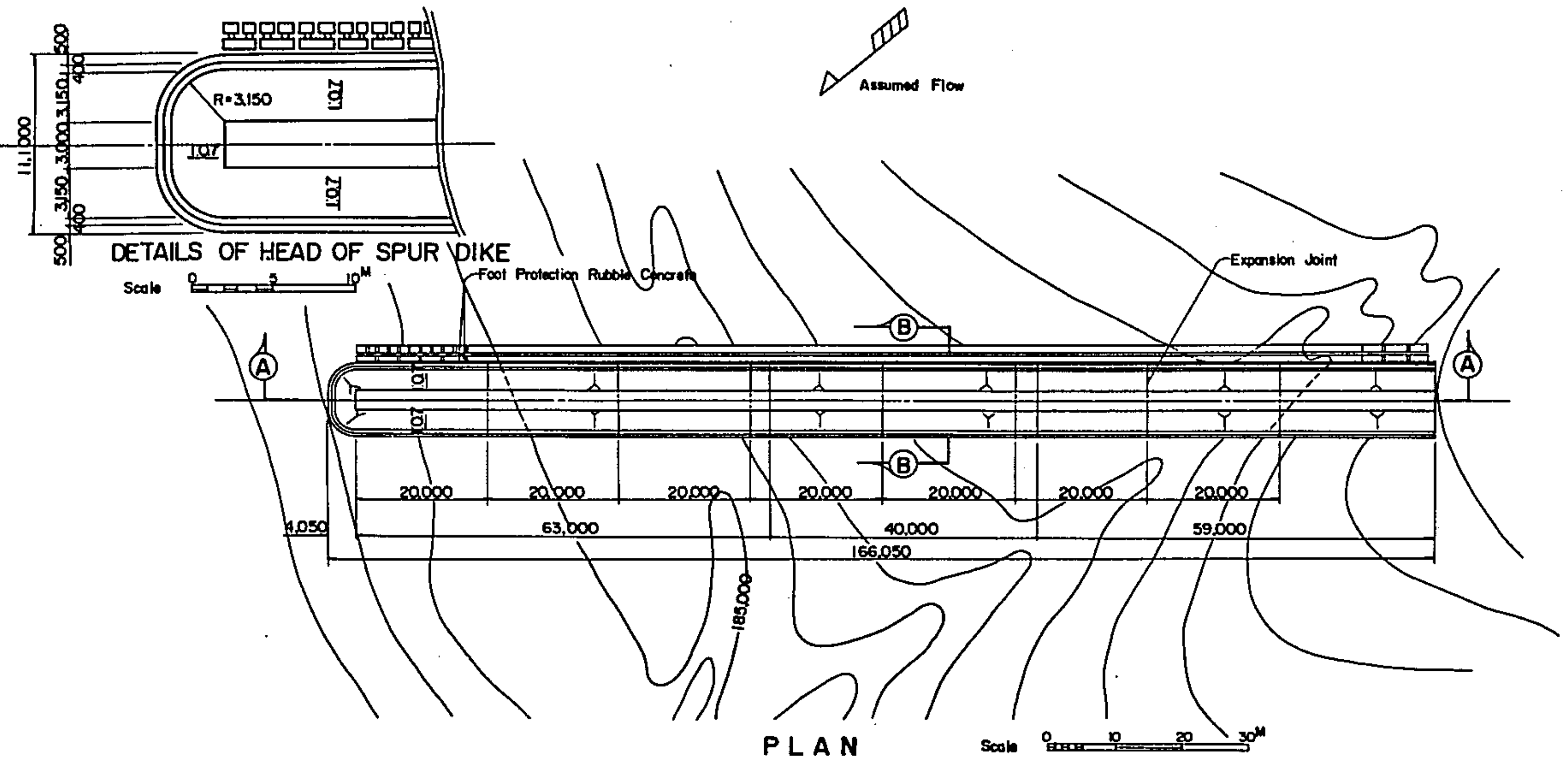
Distance	0.000	13.000	4.000	17.000	5.000	21.000	22.000	20.000	16.000	19.000	10.000	20.000	19.000	13.000	14.000	36.000
Accumulated Distance	0.000	13.000	17.000	34.000	39.000	60.000	82.000	102.000	118.000	137.000	147.000	167.000	186.000	199.000	213.000	235.000
Ground Elevation	164.000	164.750	165.000	166.000	167.000	168.000	169.000	170.000	171.000	172.000	173.000	174.000	175.000	176.000	176.400	177.000
Formation Height of Top of Spur Dike		167.750			170.000						178.000				179.000	
Original Ground Surface Slope	1/13.0				1/18.0						1/22.0					

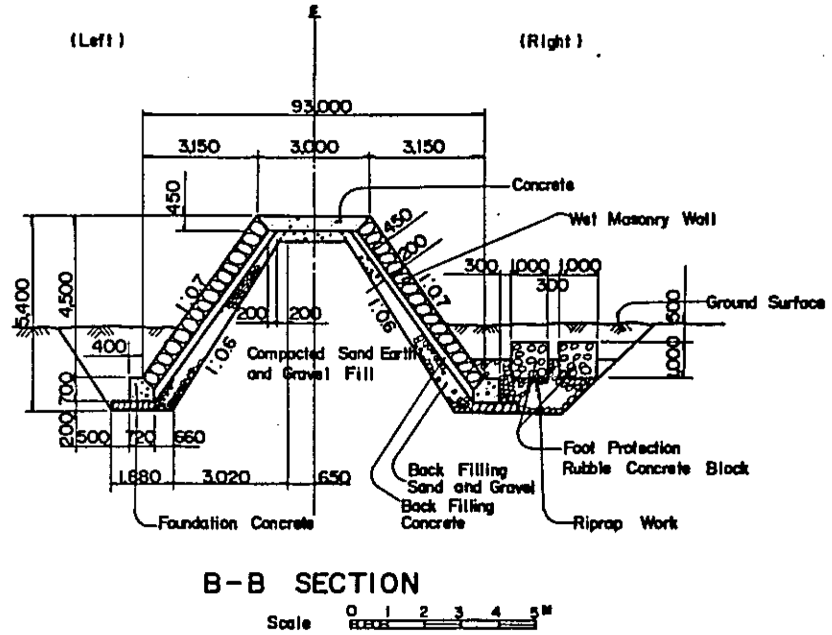
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITES
MANILA , PHILIPPINES

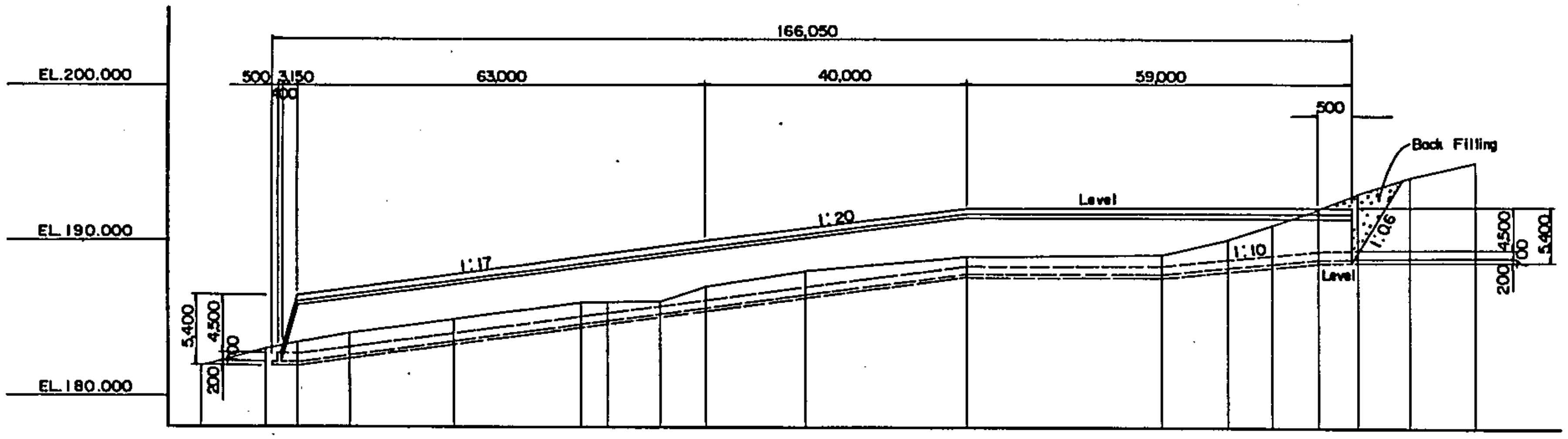
MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

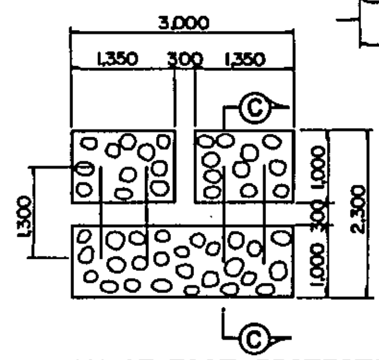
CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980		SCALE AS SHOWN	NO. 1 SPUR DIKE
DRAWING NO M.V.S-D 006			PLAN, PROFILE & SECTIONS

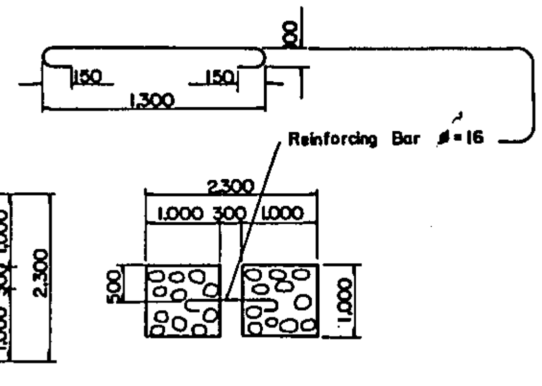
JAPAN INTERNATIONAL COOPERATION AGENCY











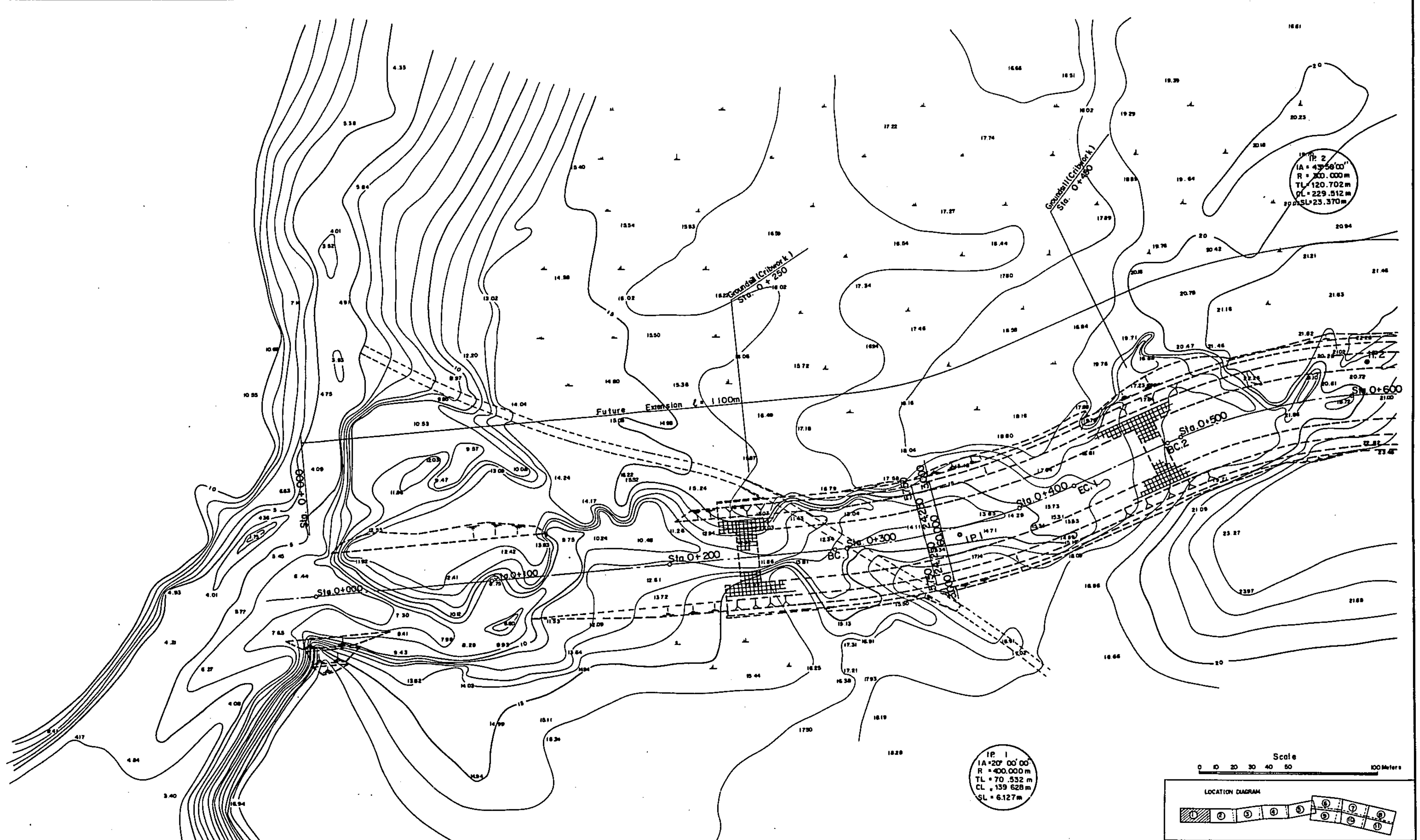
Distance	0.000	10.000	5.000	8.000	16.000	20.000	4.000	8.000	7.000	15.000	25.000	30.000	10.000	7.000	7.000	6.000	8.000	10.000
Accumulated Distance	0.000	10.000	15.000	23.000	39.000	59.000	63.000	71.000	78.000	93.000	118.000	148.000	158.000	165.000	172.000	178.000	186.000	196.000
Ground Elevation	182.000	183.000	183.380	184.000	185.000	186.000	186.000	186.000	187.000	188.000	189.000	189.000	190.000	191.000	192.000	193.000	194.000	195.000
Formation Height of Top of Spur Dike			186.380						190.090		192.000					192.000		
Original Ground Surface Slope	1/10.9		1/16.8			Level		1/7.0	1/20.0		Level	1/8.0						

MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA, PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		NO. 2 SPUR DIKE
DRAWING NO. M.V.S.-D. 007			PLAN, PROFILE & SECTION

JAPAN INTERNATIONAL COOPERATION AGENCY

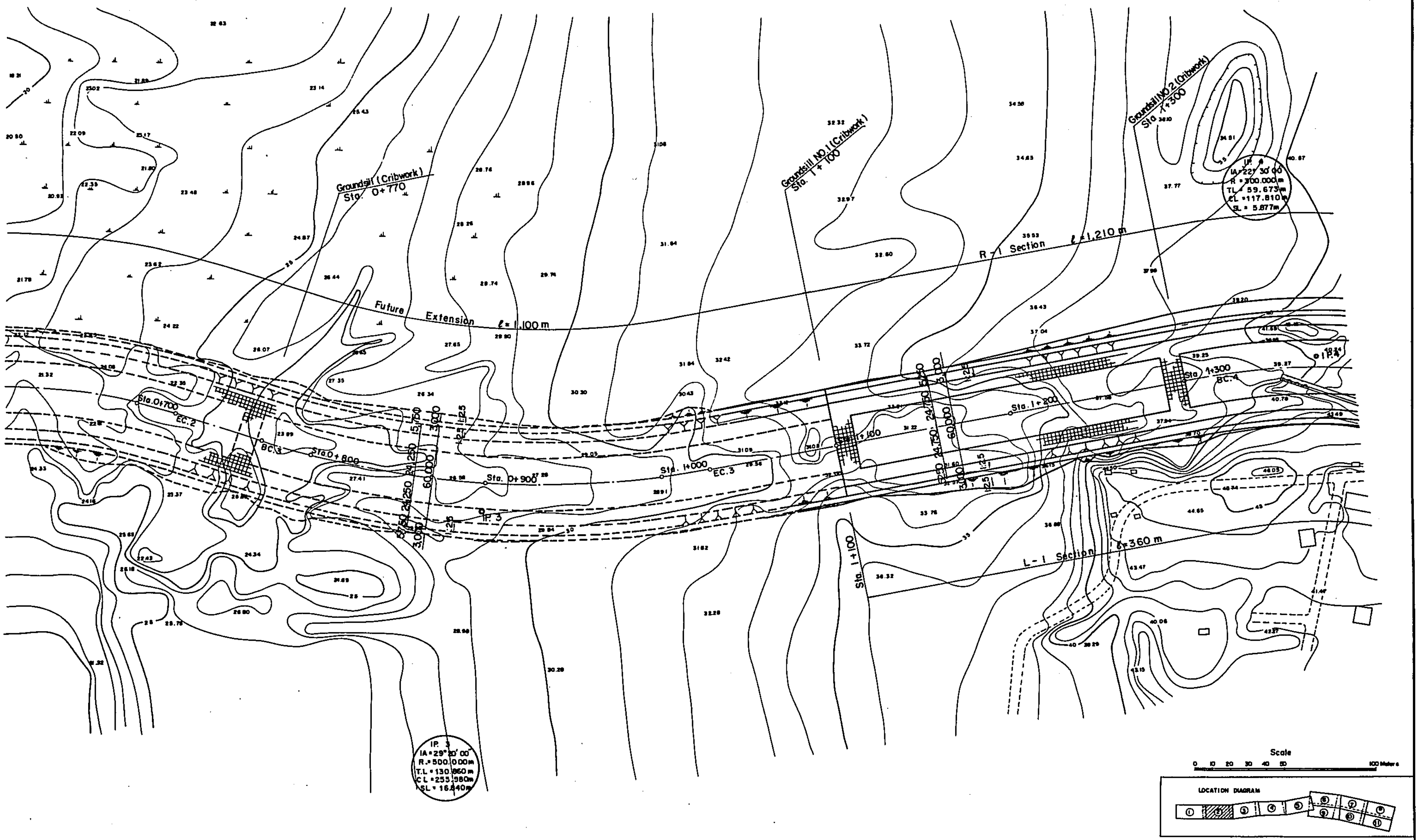


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb.1980		SCALE AS SHOWN	RIVER CANALIZATION PLAN (6-1)
DRAWING NO. M.V.S - D 008			

JAPAN INTERNATIONAL COOPERATION AGENCY

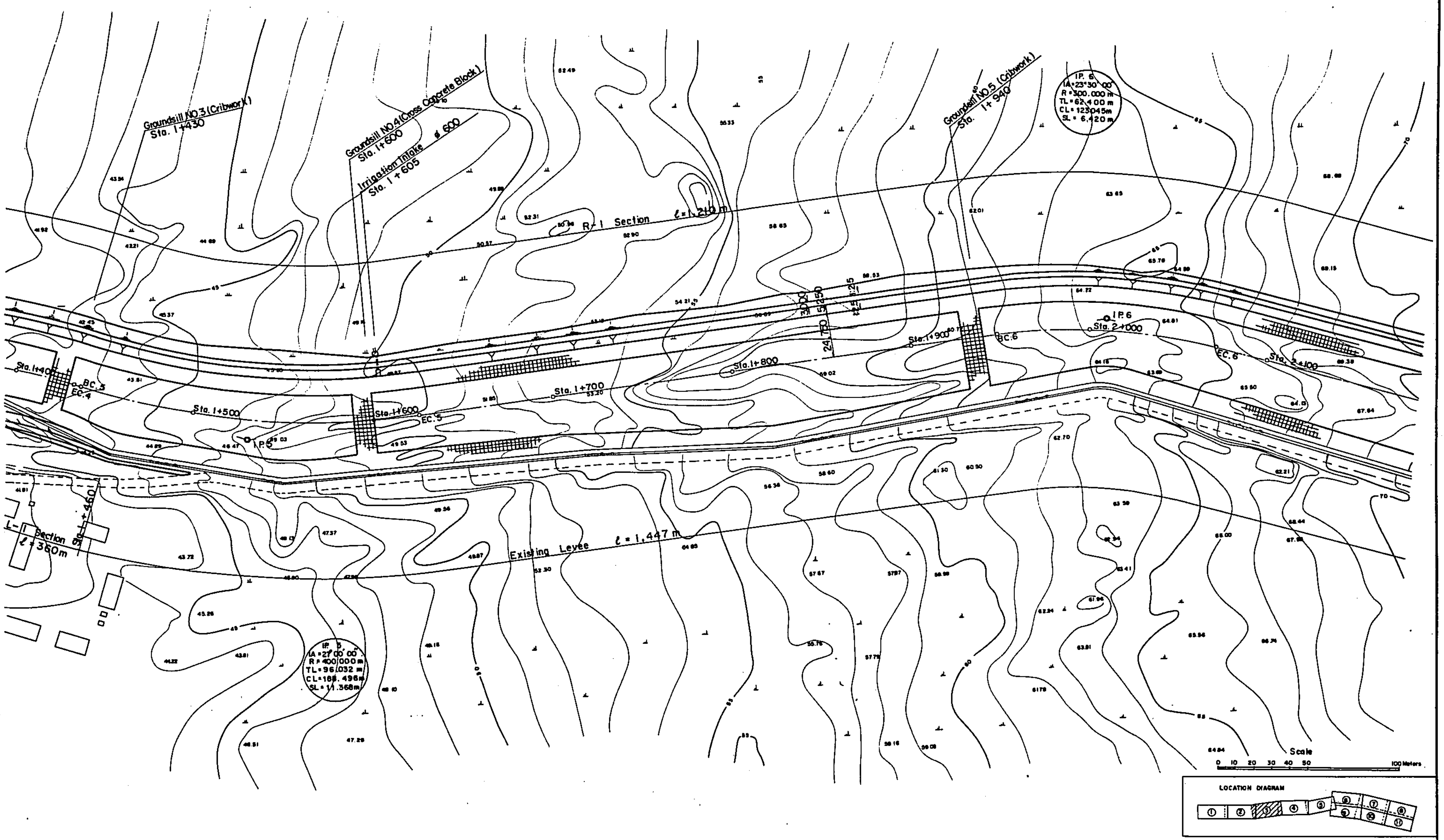


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb.1980	SCALE AS SHOWN		RIVER CANALIZATION PLAN (6-2)
DRAWING NO. M.V.S-D 009			

JAPAN INTERNATIONAL COOPERATION AGENCY



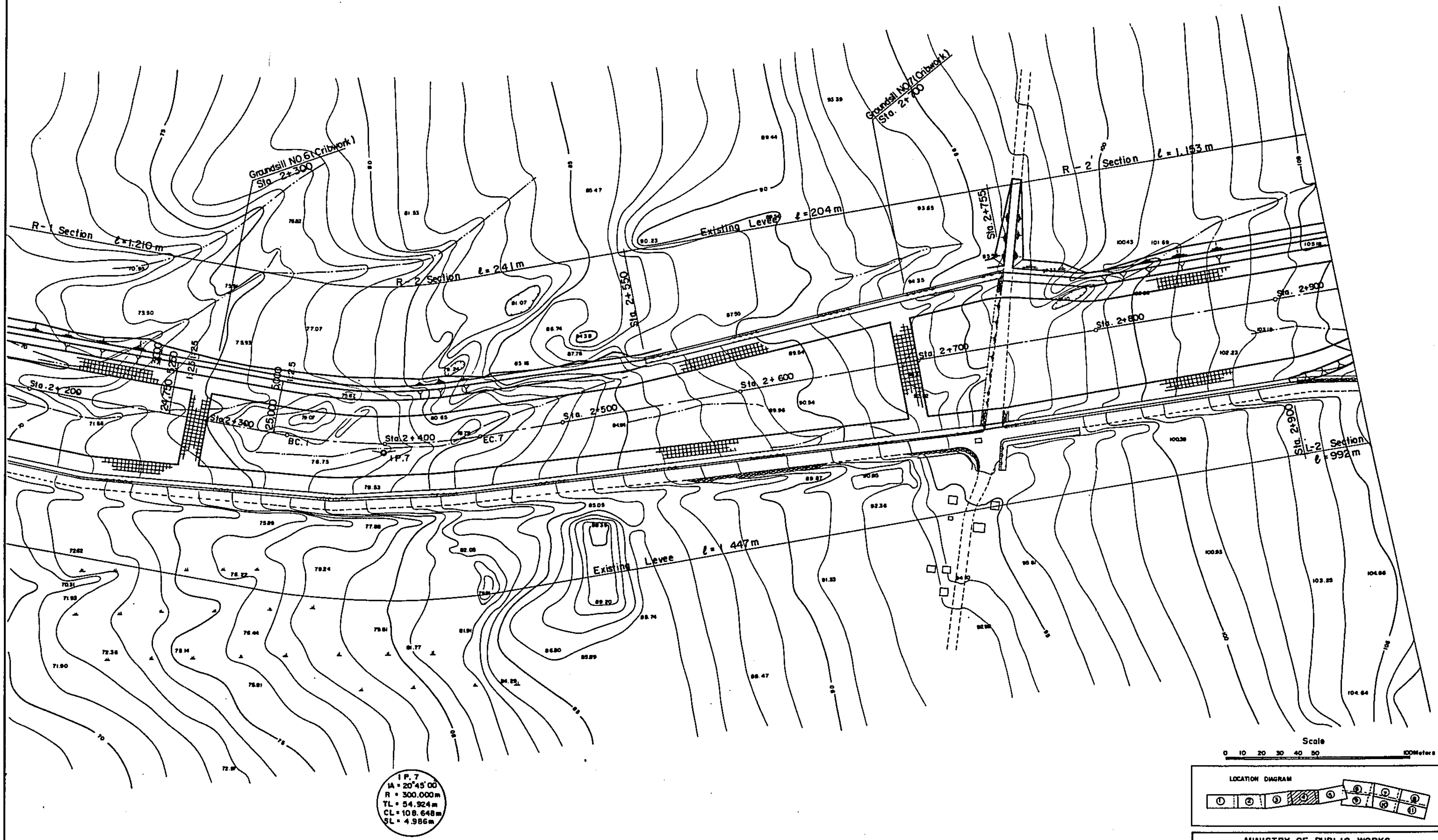
MINISTRY OF PUBLIC WORKS

TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980		SCALE AS SHOWN	RIVER CANALIZATION PLAN (6-3)
DRAWING NO. M.V.S-D 010			

JAPAN INTERNATIONAL COOPERATION AGENCY



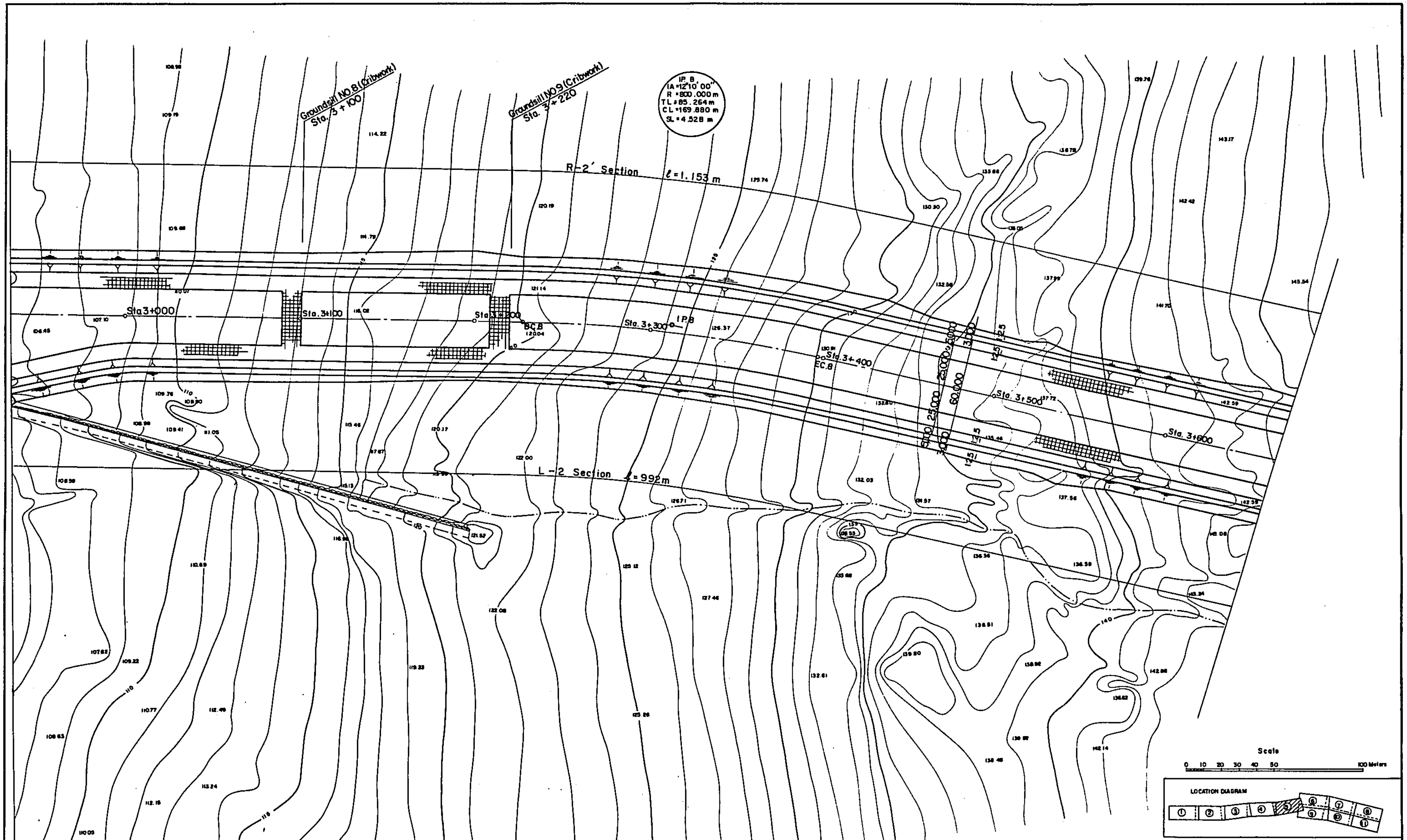
MINISTRY OF PUBLIC WORKS

TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb, 1980	SCALE AS SHOWN		RIVER CANALIZATION PLAN (6-4)
DRAWING BY M.V.S-D 011			

JAPAN INTERNATIONAL COOPERATION AGENCY



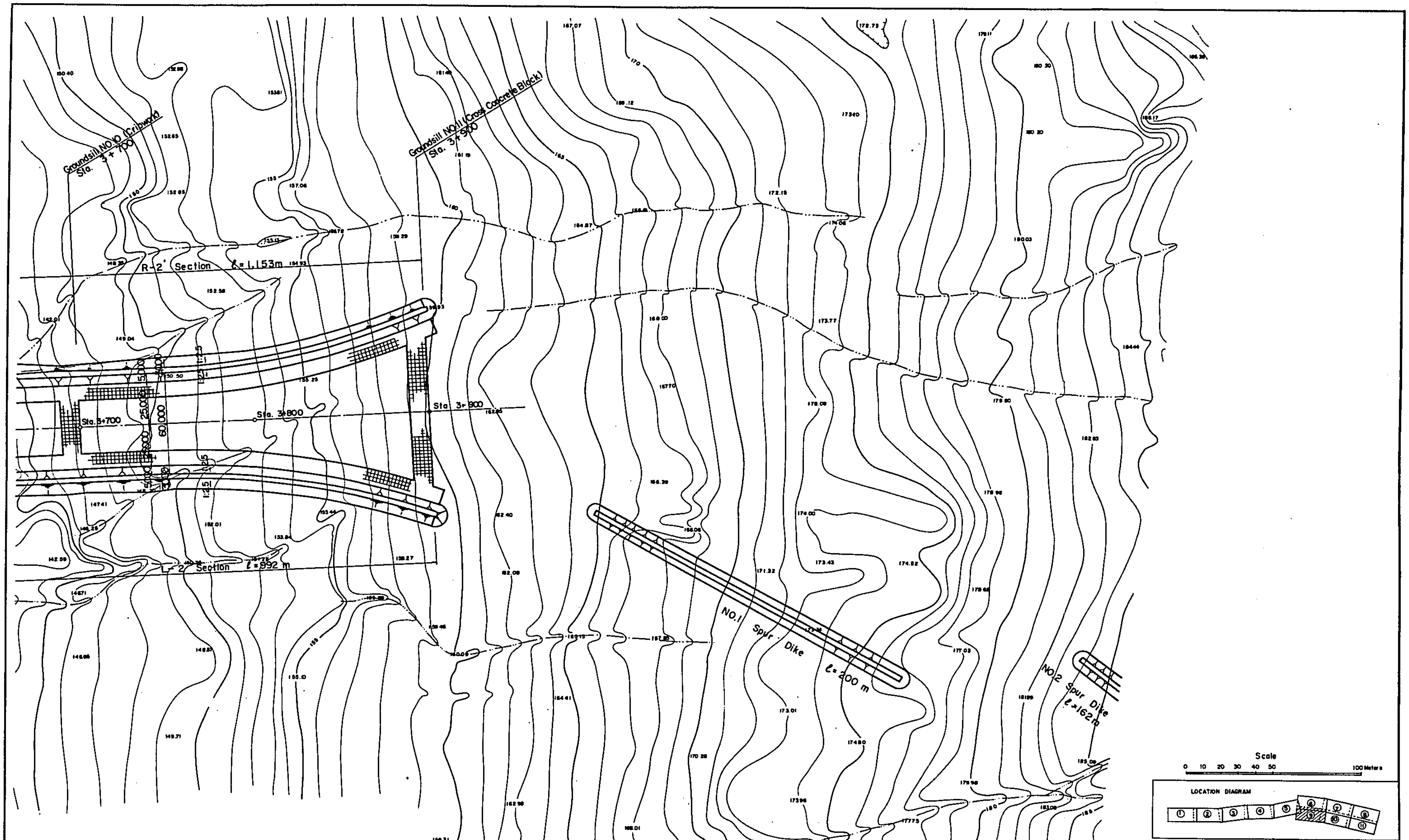
MINISTRY OF PUBLIC WORKS

TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING:
DATE Feb. 1980		SCALE AS SHOWN	RIVER CANALIZATION PLAN (6-5)
DRAWING NO. M.V.S - D 012			

JAPAN INTERNATIONAL COOPERATION AGENCY

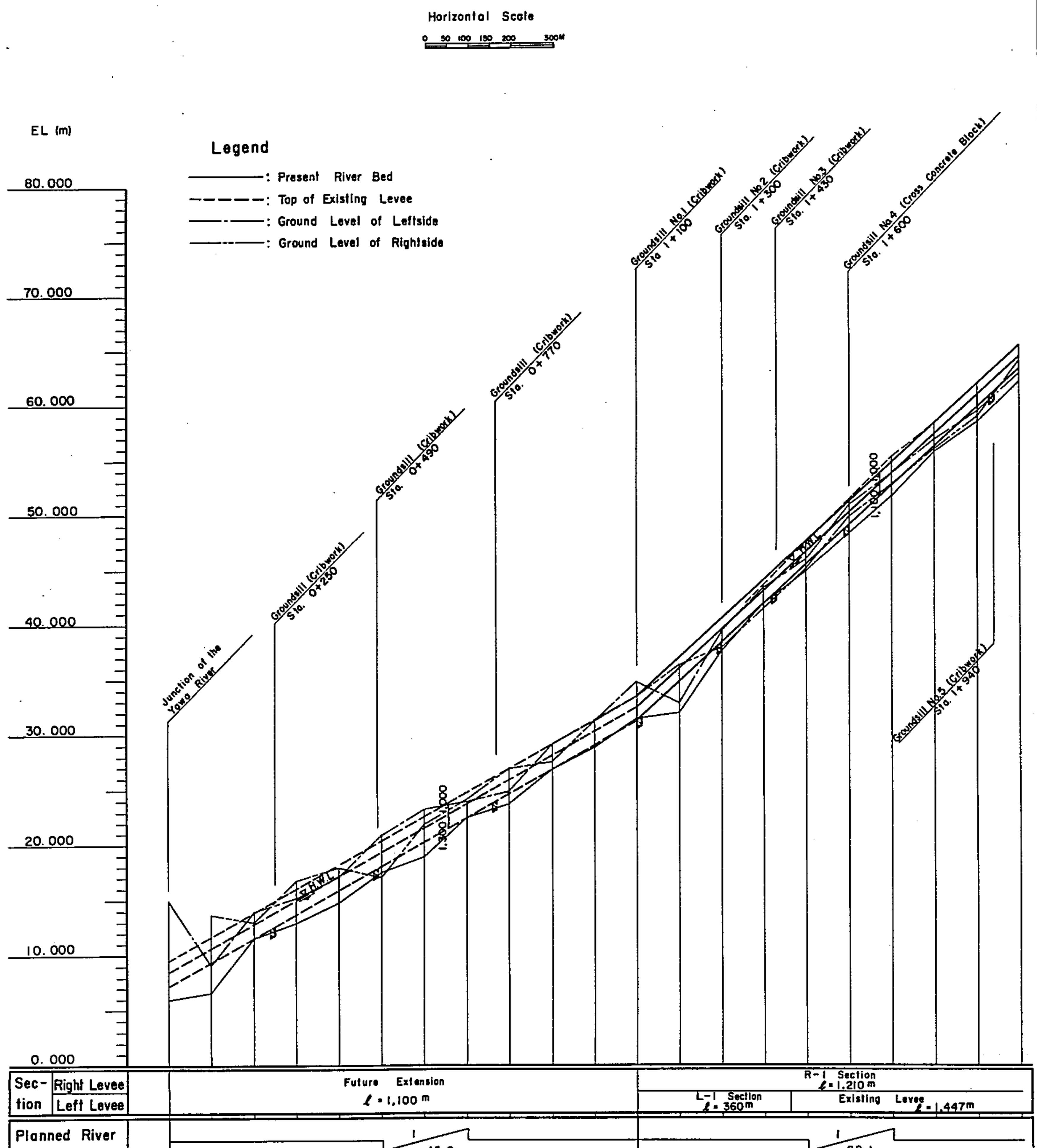


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES

MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT, PHILIPPINES

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING:
DATE Feb. 1980		SCALE AS SHOWN	RIVER CANALIZATION PLAN (6-6)
DRAWING NO. M.V.S - D 013			

JAPAN INTERNATIONAL COOPERATION AGENCY



Station No.	Distance (m)	Accumulated Distance (m)	Formation Height of River Bed (m)	Design Flood Water Level (m)	Formation Height Top of Levee (m)
0+000	0	0	7.200	8.500	9.500
100	100	100	9.382	10.682	11.682
200	100	200	11.564	12.864	13.864
300	100	300	13.745	15.045	16.045
400	100	400	15.927	17.227	18.227
500	100	500	18.109	19.409	20.409
600	100	600	20.291	21.591	22.591
700	100	700	22.473	23.773	24.773
800	100	800	24.655	25.955	26.955
900	100	900	26.836	28.136	29.136
1+000	100	1,000	29.018	30.318	31.318
100	100	1,100	31.200 / 31.400	32.500	33.500
200	100	1,200	34.958	36.058	37.058
300	100	1,300	38.517	39.617	40.617
400	100	1,400	42.075	43.175	44.175
500	100	1,500	45.633	46.733	47.733
600	100	1,600	49.192	50.292	51.292
700	100	1,700	52.750	53.850	54.850
800	100	1,800	56.308	57.408	58.408
900	100	1,900	59.867	60.967	61.967
2+000	100	2,000	63.425	64.525	65.525

Planned River Bed Slope: 1/45.8 (0+000 – 1+100); 1/28.1 (1+100 – 2+000)

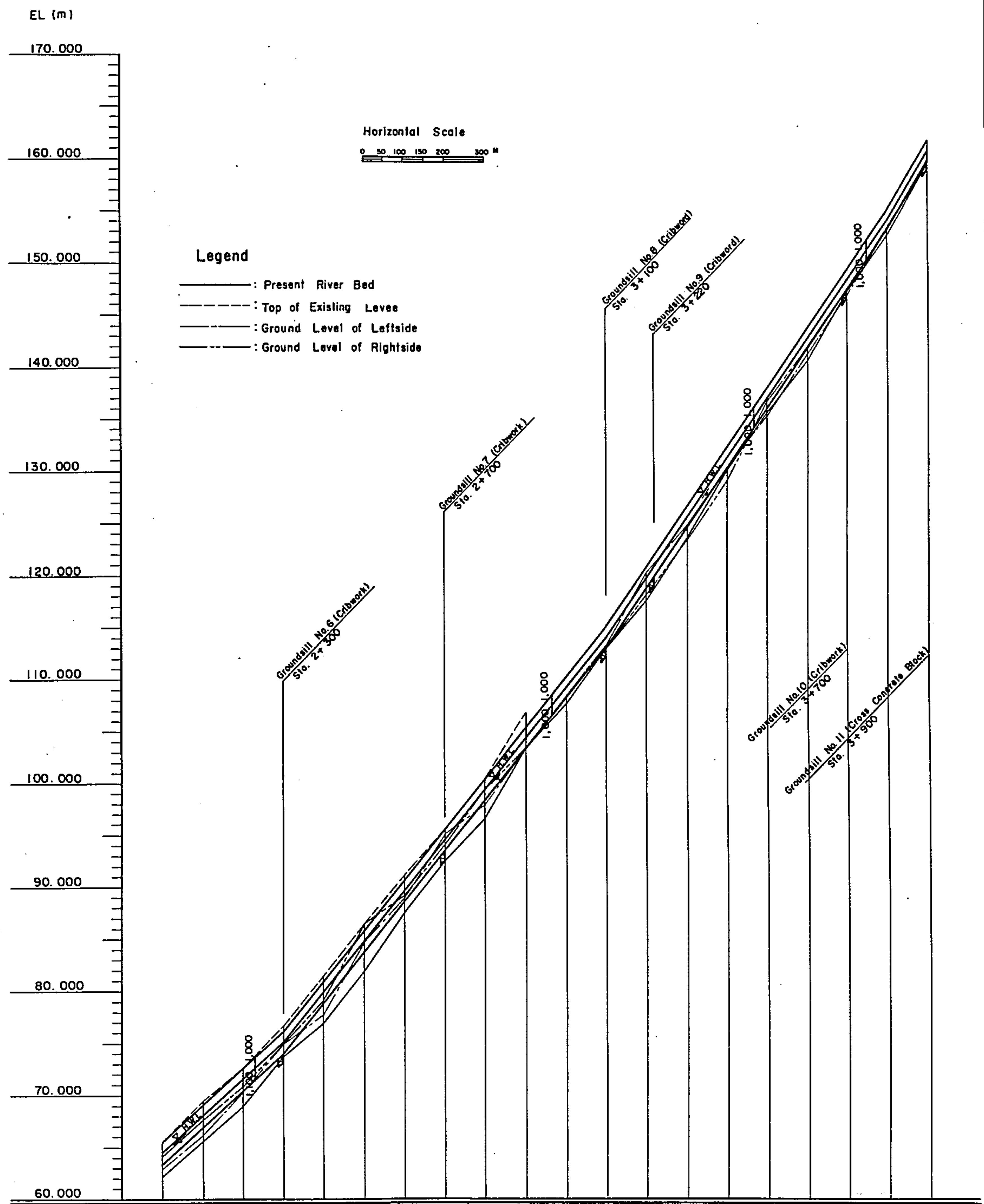
Section		
Right Levee	Future Extension ℓ = 1,100 m	R-1 Section ℓ = 1,210 m
Left Levee		L-1 Section ℓ = 360 m; Existing Levee ℓ = 1,447 m

MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		RIVERCANALIZATION PROFILE (2-1)
DRAWING NO. M.V.S-D 014			

JAPAN INTERNATIONAL COOPERATION AGENCY



Section — Right Levee: R-1 Section ℓ = 1.210 m; R-2 Section ℓ = 241 m; Existing Levee ℓ = 204 m; R-2' Section ℓ = 1.153 m

Section — Left Levee: Existing Levee ℓ = 1.447 m; L-2 Section ℓ = 992 m

Planned River Bed Slope: 1/28.1; 1/20.6; 1/17.5; Existing River Bed Slope

Station No.	Distance (m)	Accumulated Distance (m)	Formation Height of River Bed (m)	Design Flood Water Level (m)	Formation Height Top of Levee (m)
2+000	100	2.000	63.425	64.525	65.525
100	100	2.100	66.983	68.083	69.083
200	100	2.200	70.542	71.642	72.642
300	100	2.300	74.100 74.200	75.200	76.200
400	100	2.400	79.050	80.050	81.050
500	100	2.500	83.900	84.900	85.900
600	100	2.600	88.750	89.750	90.750
700	100	2.700	93.600	94.600	95.600
800	100	2.800	98.450	99.450	100.450
900	100	2.900	103.300	104.300	105.300
3+000	100	3.000	108.150	109.150	110.150
100	100	3.100	113.000	114.000	115.000
200	100	3.200	118.717	119.717	120.717
300	100	3.300	124.433	125.433	126.433
400	100	3.400	130.150	131.150	132.150
500	100	3.500	135.867	136.867	137.867
600	100	3.600	141.583	142.583	143.583
700	100	3.700	147.300	148.300	149.300
800	100	3.800	152.950	153.950	154.950
900	100	3.900	159.650	160.650	161.650

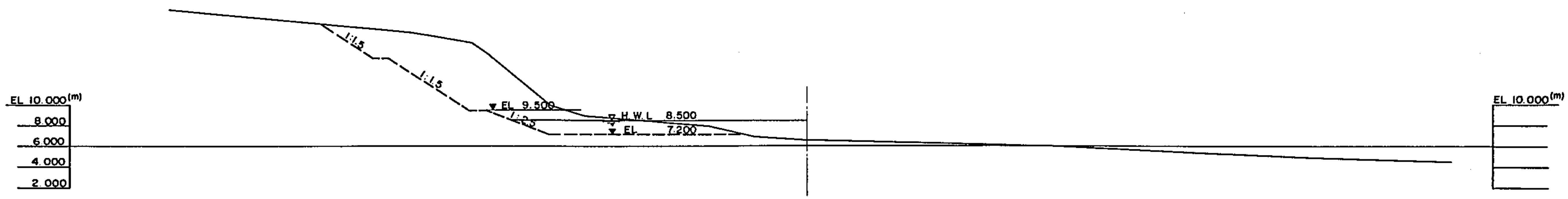
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA, PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

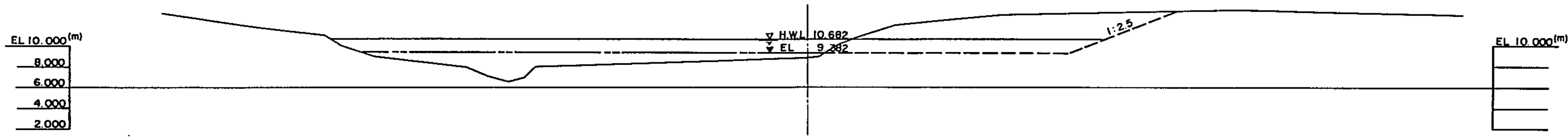
CHECKED BY | DESIGNED BY | DRAWN BY
DATE Feb. 1980 | SCALE AS SHOWN
DRAWING NO. M.V.S-D 015
TITLE OF DRAWING: RIVER CANALIZATION PROFILE (2-2)

JAPAN INTERNATIONAL COOPERATION AGENCY

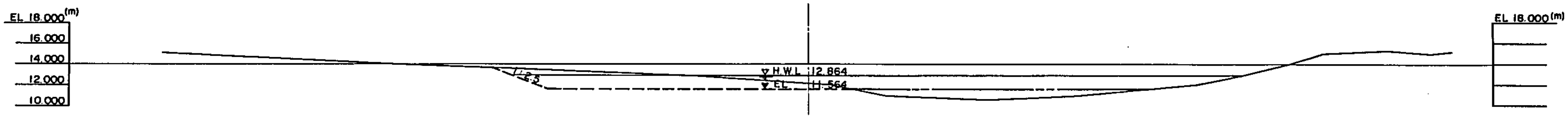
STA. 0+000



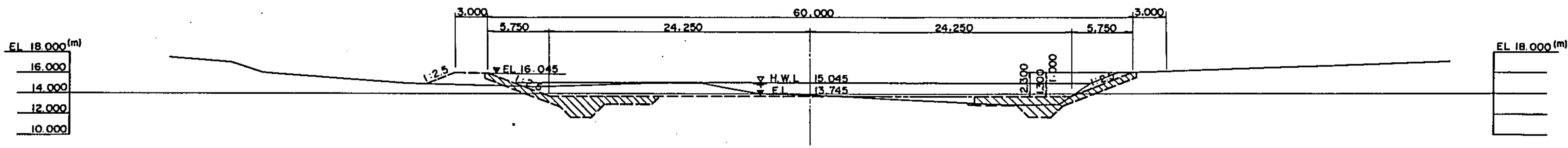
STA. 0+100



STA. 0+200



STA. 0+300



Scale
0 1 2 3 4 5 10 15 20M

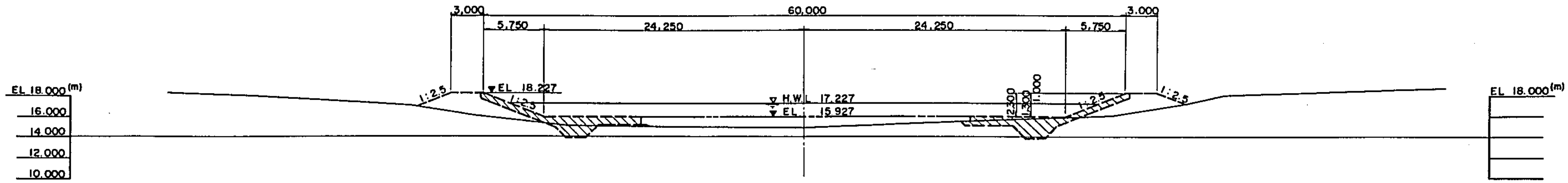
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

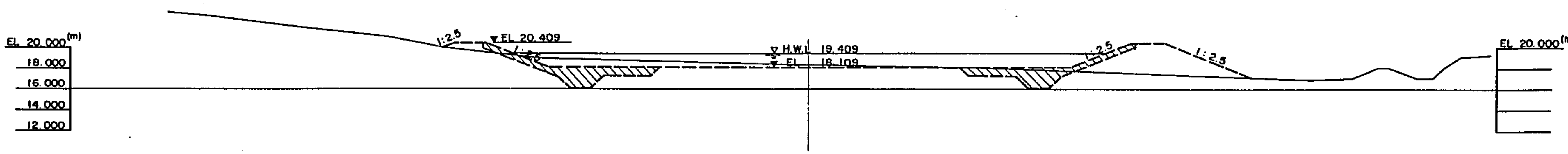
CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb., 1980	SCALE AS SHOWN		RIVER CANALIZATION CROSS SECTION (10-1)
DRAWING NO M.VS-D. 016			

JAPAN INTERNATIONAL COOPERATION AGENCY

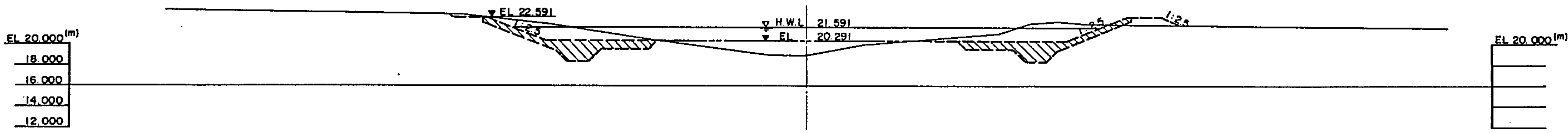
STA. 0+400



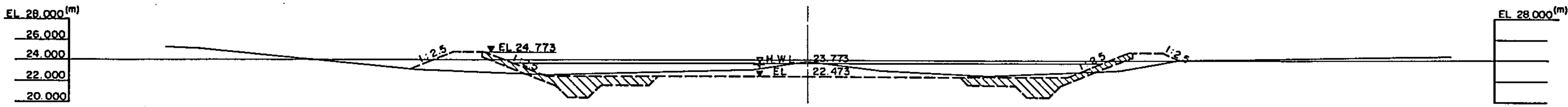
STA. 0+500



STA. 0+600



STA. 0+700



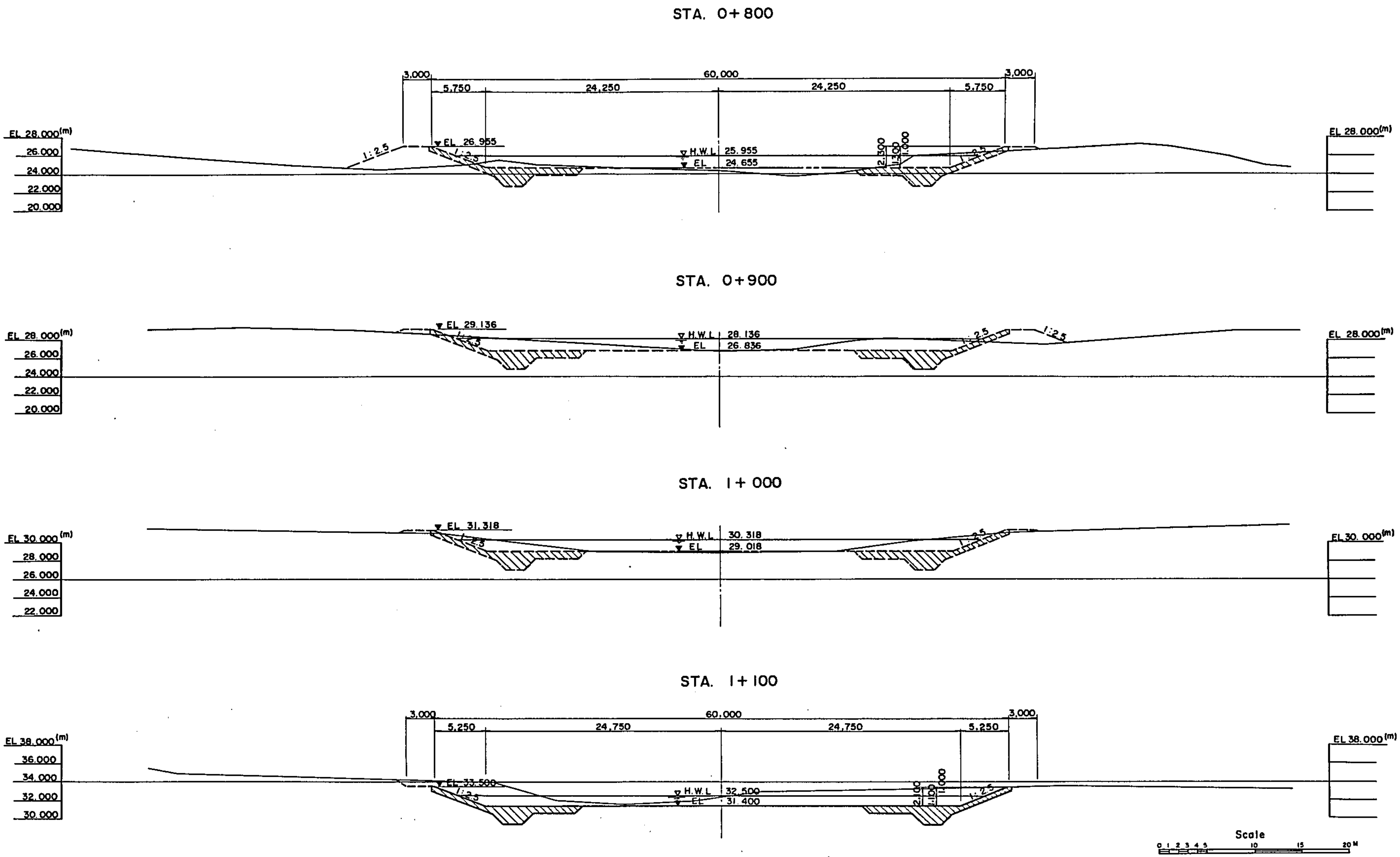
Scale

MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980		SCALE AS SHOWN	RIVER CANALIZATION CROSS SECTION (10-2)
DRAWING NO M.V.S-D 017			

JAPAN INTERNATIONAL COOPERATION AGENCY

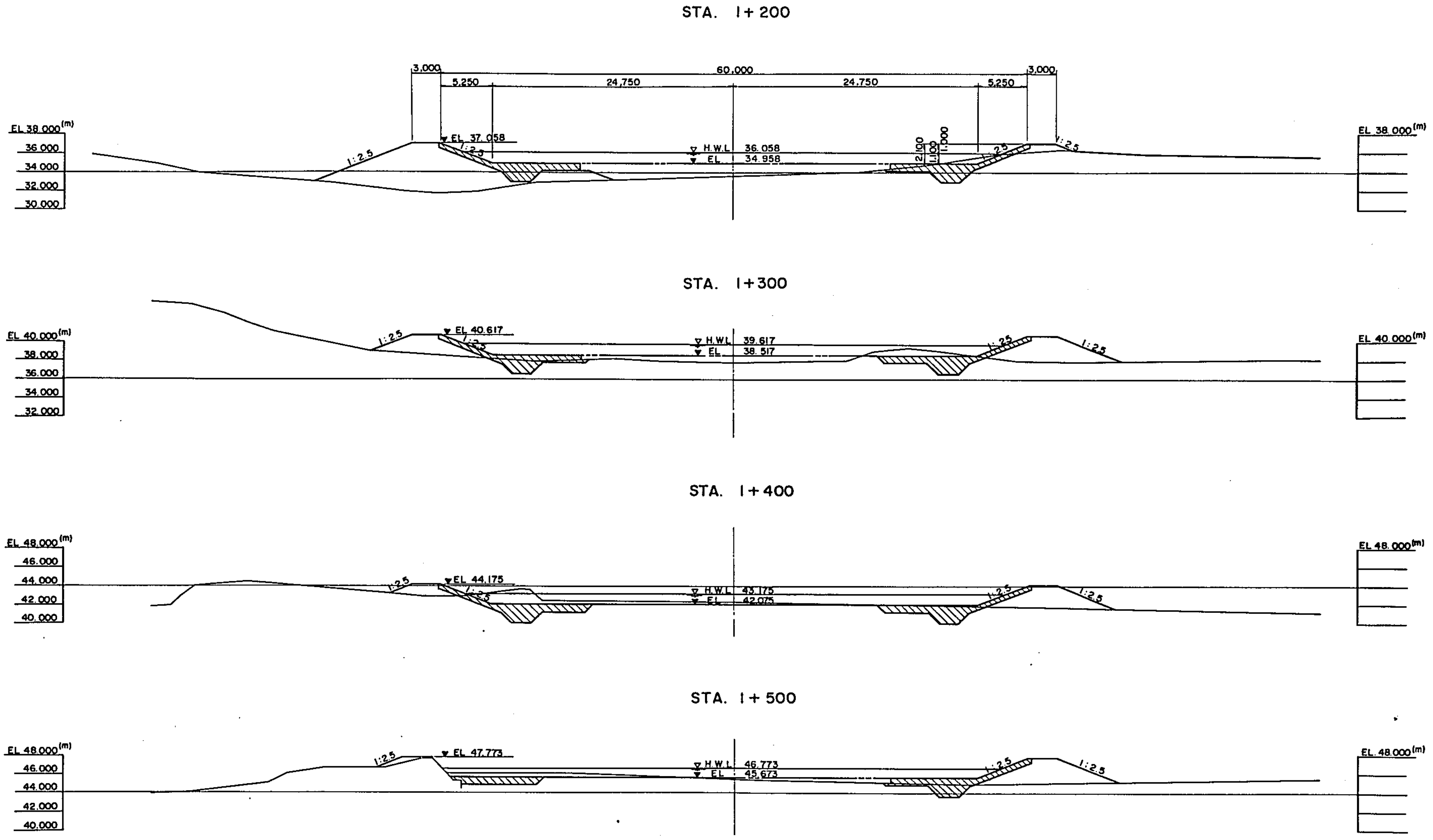


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb, 1980		SCALE AS SHOWN	RIVER CANALIZATION CROSS SECTION (10-3)
DRAWING NO. M.V.S-D 018			

JAPAN INTERNATIONAL COOPERATION AGENCY



Scale

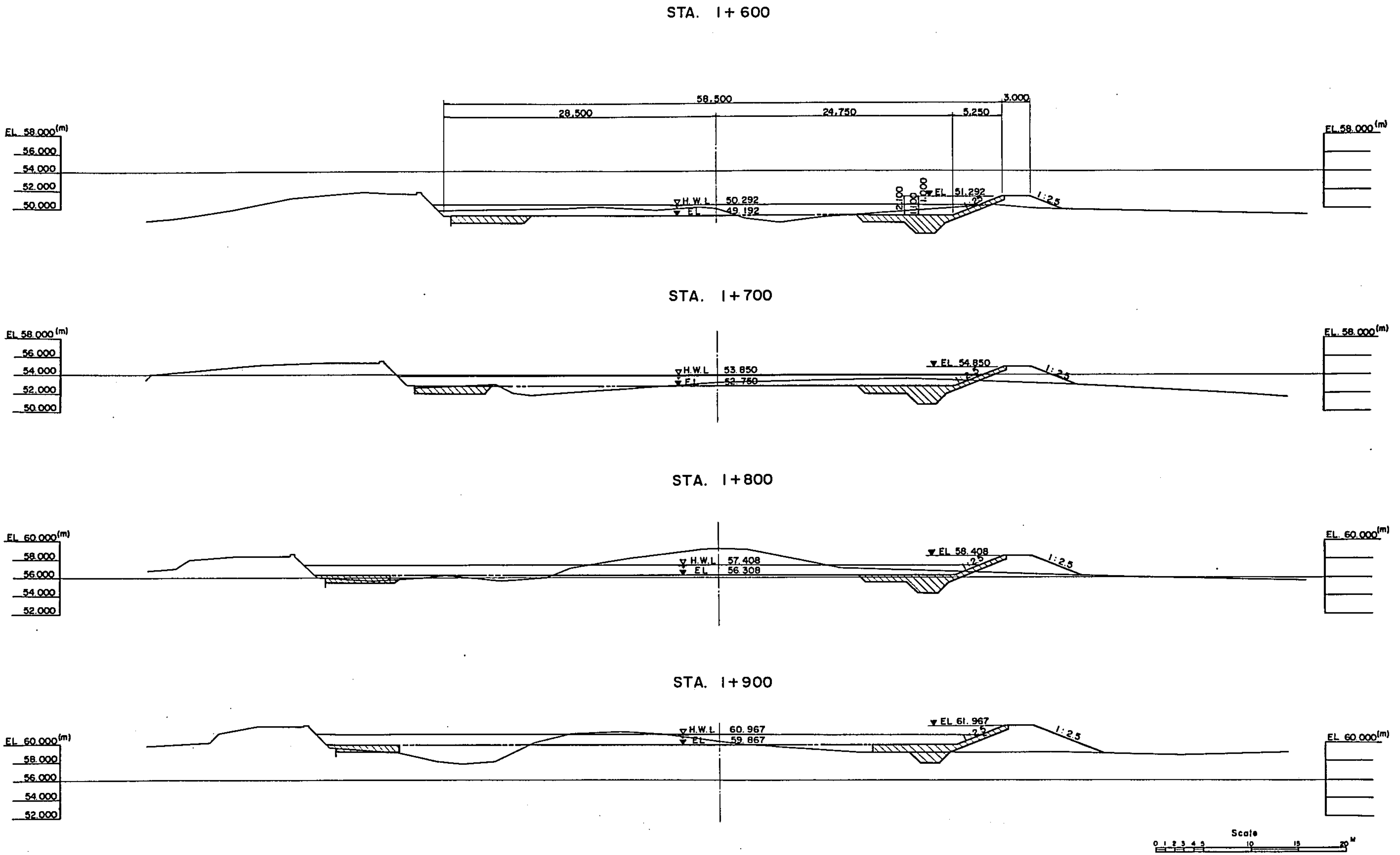
0 1 2 3 4 5 10 15 20 M

MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA, PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		RIVER CANALIZATION CROSS SECTION (10-4)
DRAWING NO M.V.S-D 019			

JAPAN INTERNATIONAL COOPERATION AGENCY

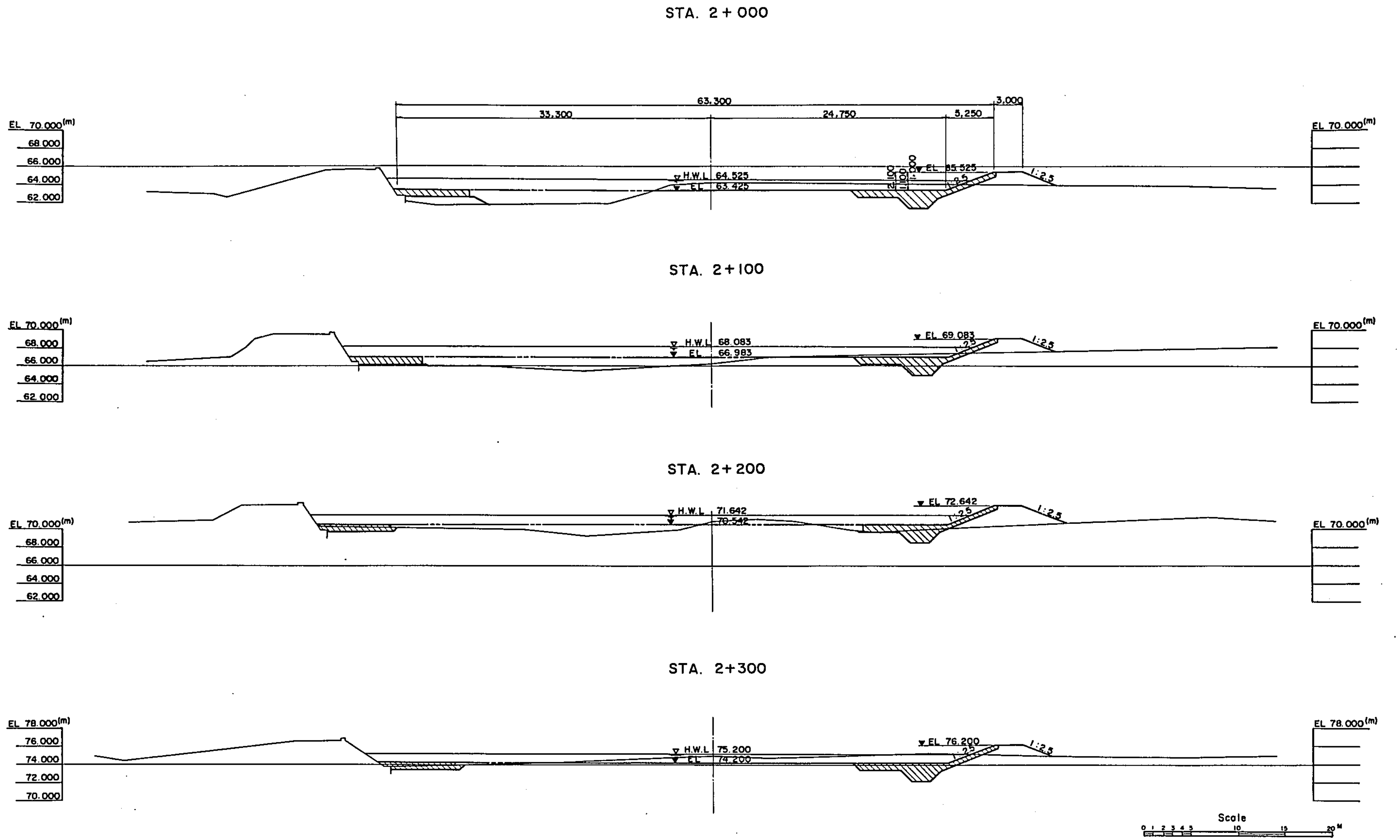


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb, 1980	SCALE AS SHOWN		RIVER CANALIZATION CROSS SECTION (10-5)
DRAWING NO. M.V.S - D 020			

JAPAN INTERNATIONAL COOPERATION AGENCY

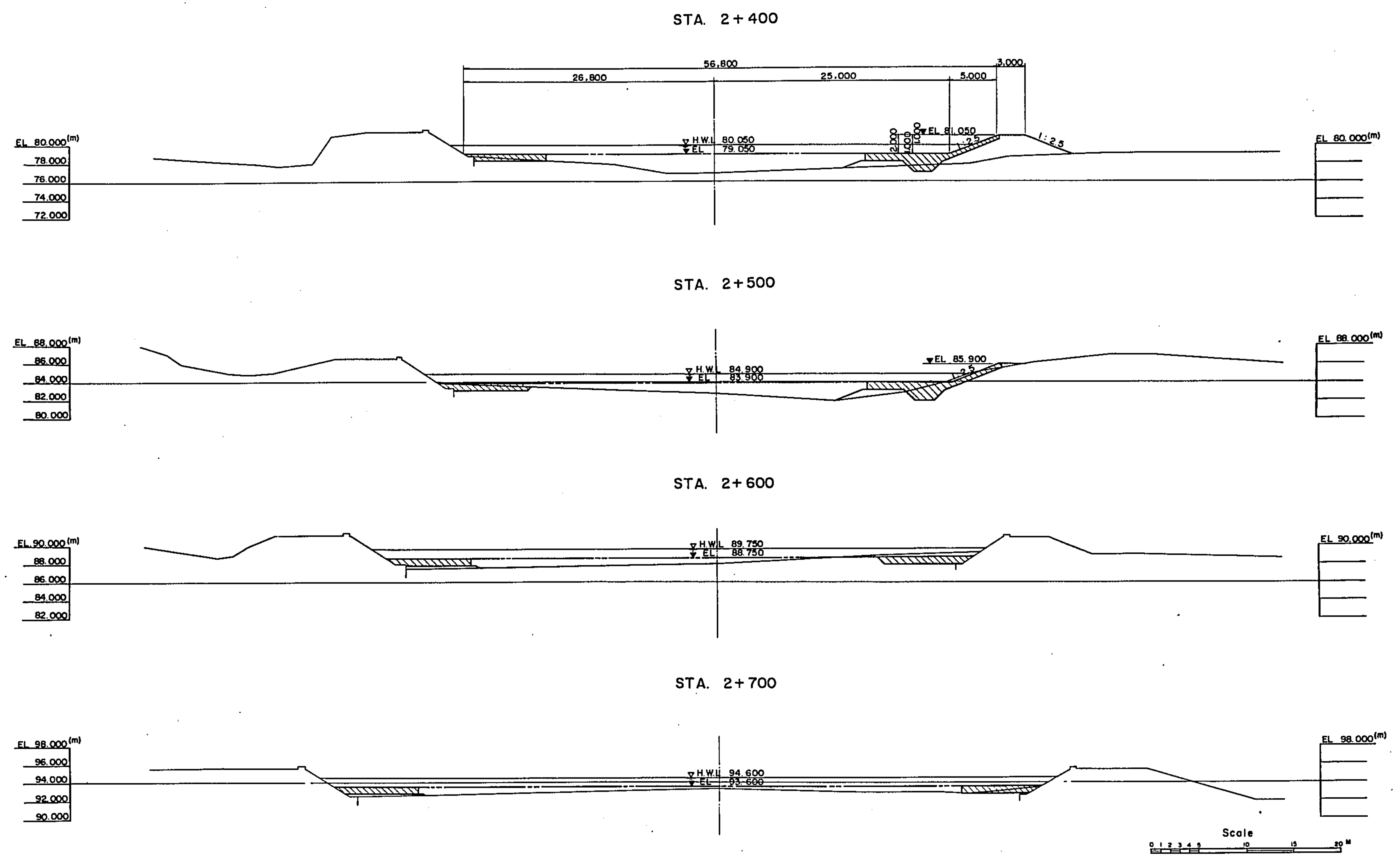


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		RIVER CANALIZATION, CROSS SECTION (10-6)
DRAWING NO M.V.S-D 021			

JAPAN INTERNATIONAL COOPERATION AGENCY

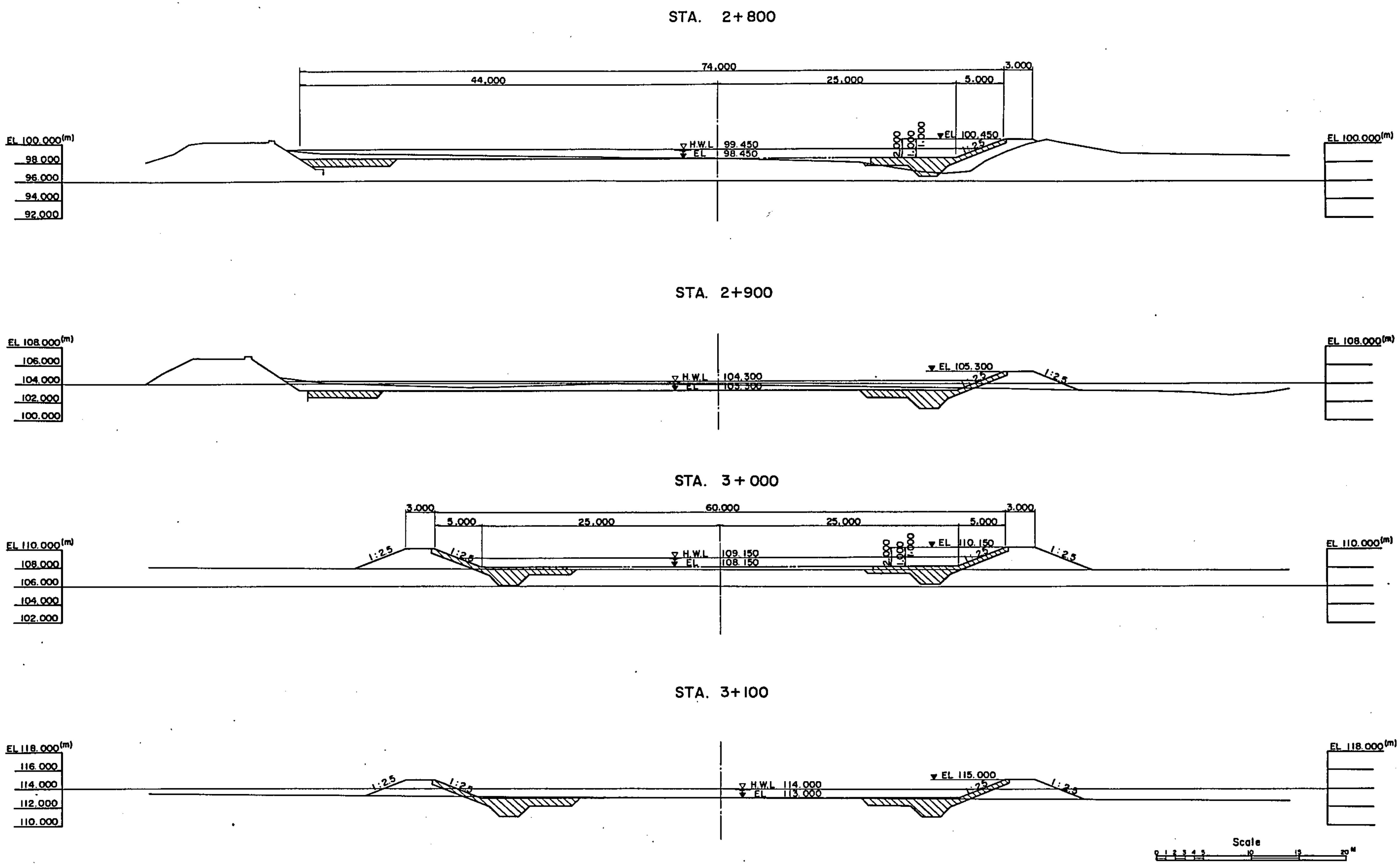


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		RIVER CANALIZATION CROSS SECTION (10-7)
DRAWING NO. M.V.S - D 022			

JAPAN INTERNATIONAL COOPERATION AGENCY

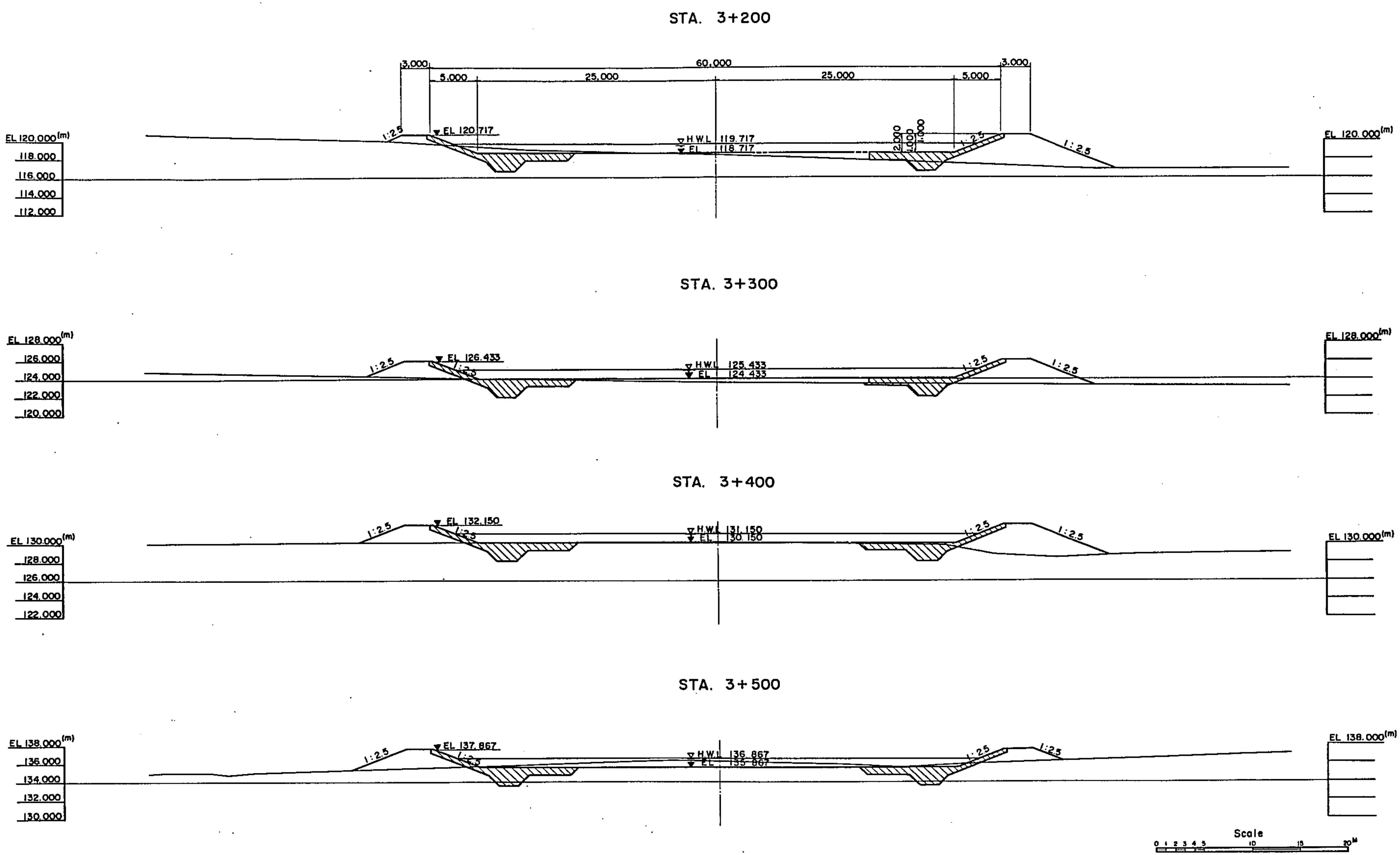


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980		SCALE AS SHOWN	RIVER CANALIZATION CROSS SECTION (10-8)
DRAWING NO. M.V.S -D 023			

JAPAN INTERNATIONAL COOPERATION AGENCY

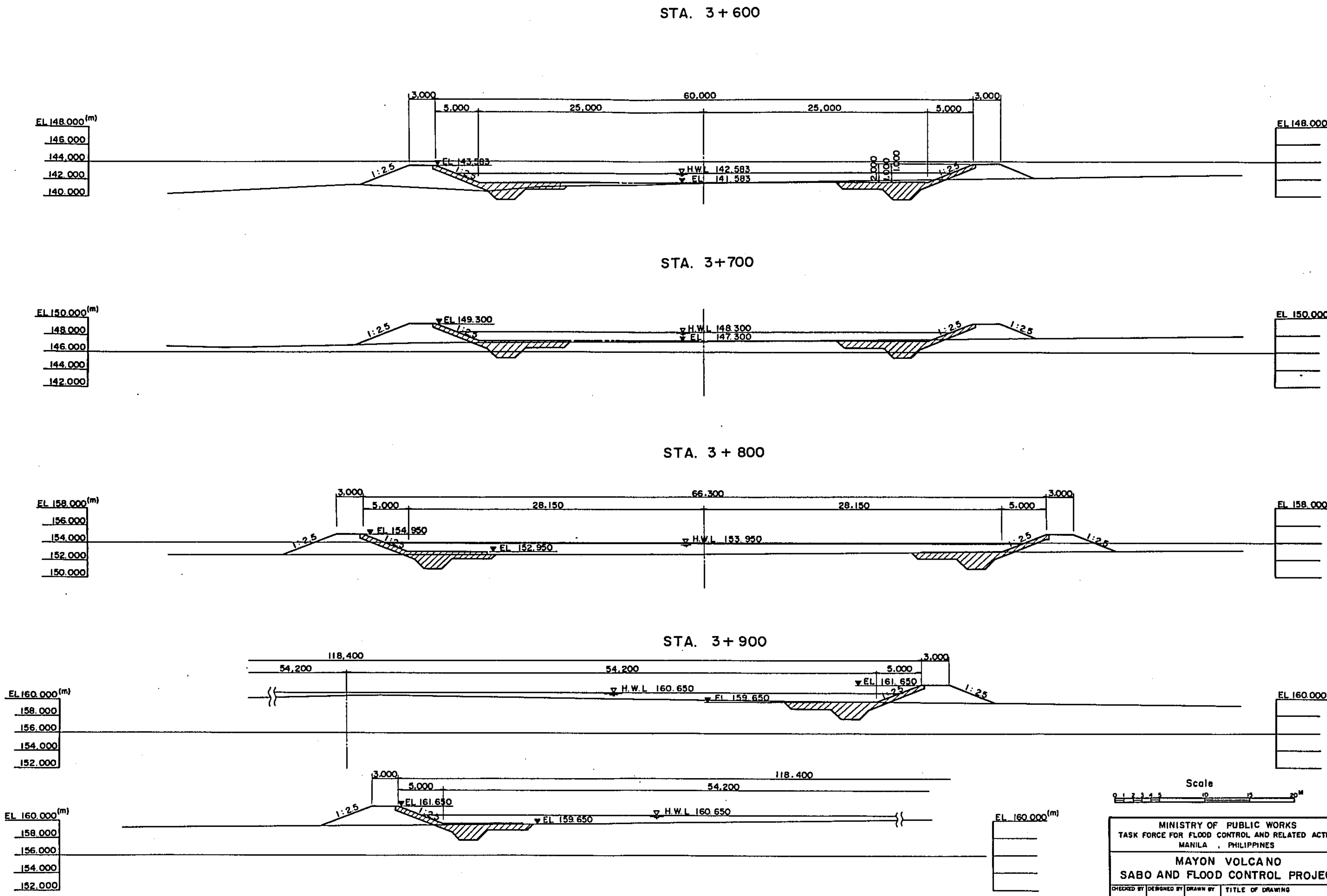


MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		RIVER CANALAZITION CROSS SECTION (10-9)
DRAWING NO M.V.S-D 024			

JAPAN INTERNATIONAL COOPERATION AGENCY



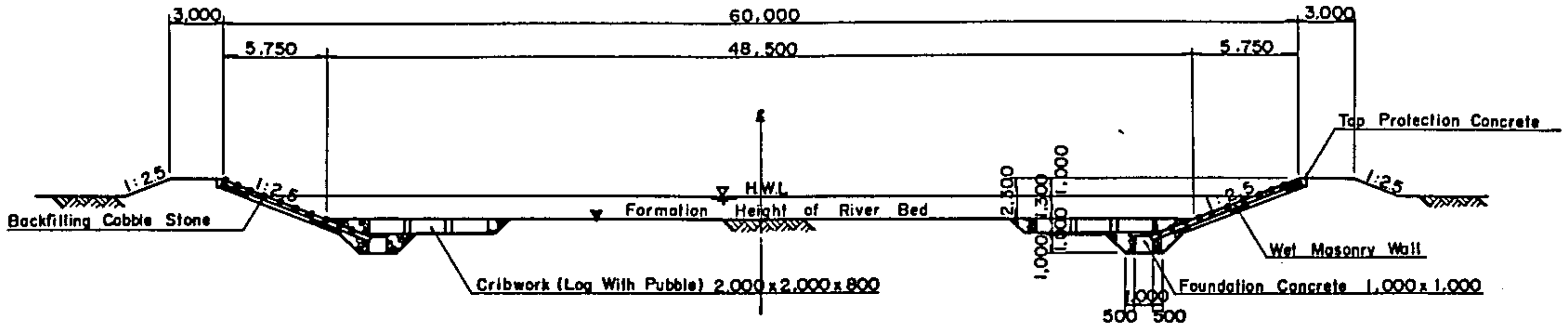
MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA , PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

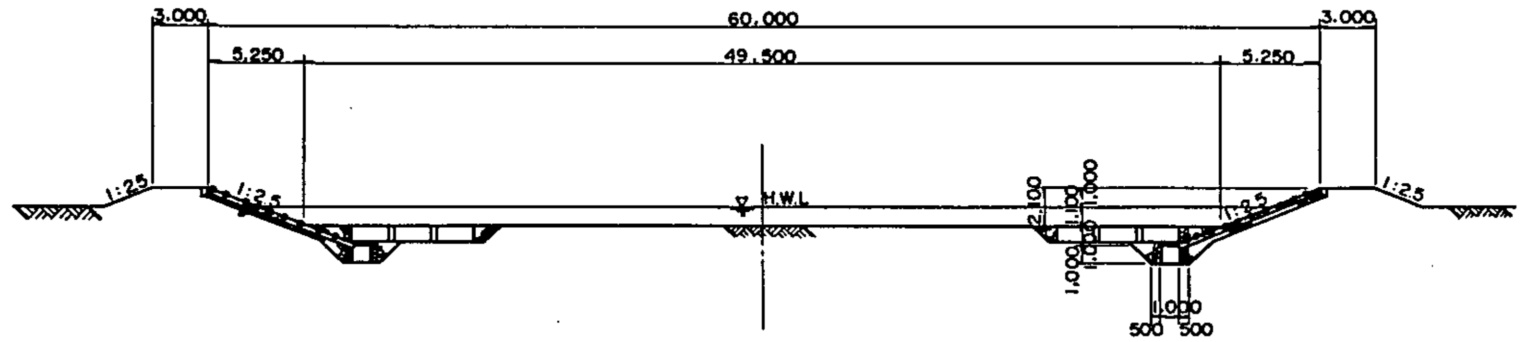
CHECKED BY	DESIGNED BY	DRAWN BY	TITLE OF DRAWING
DATE Feb. 1980	SCALE AS SHOWN		RIVER CANALIZATION CROSS SECTION (10-10)
DRAWING NO M.V.S-D 025			

JAPAN INTERNATIONAL COOPERATION AGENCY

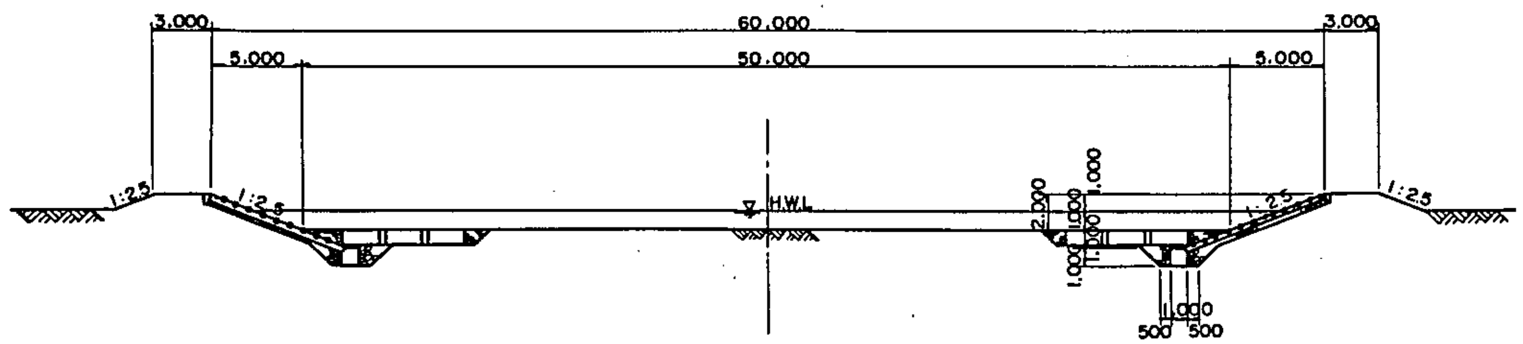
STA.0+000 ~ STA.1+100



STA.1+100 ~ STA.2+300



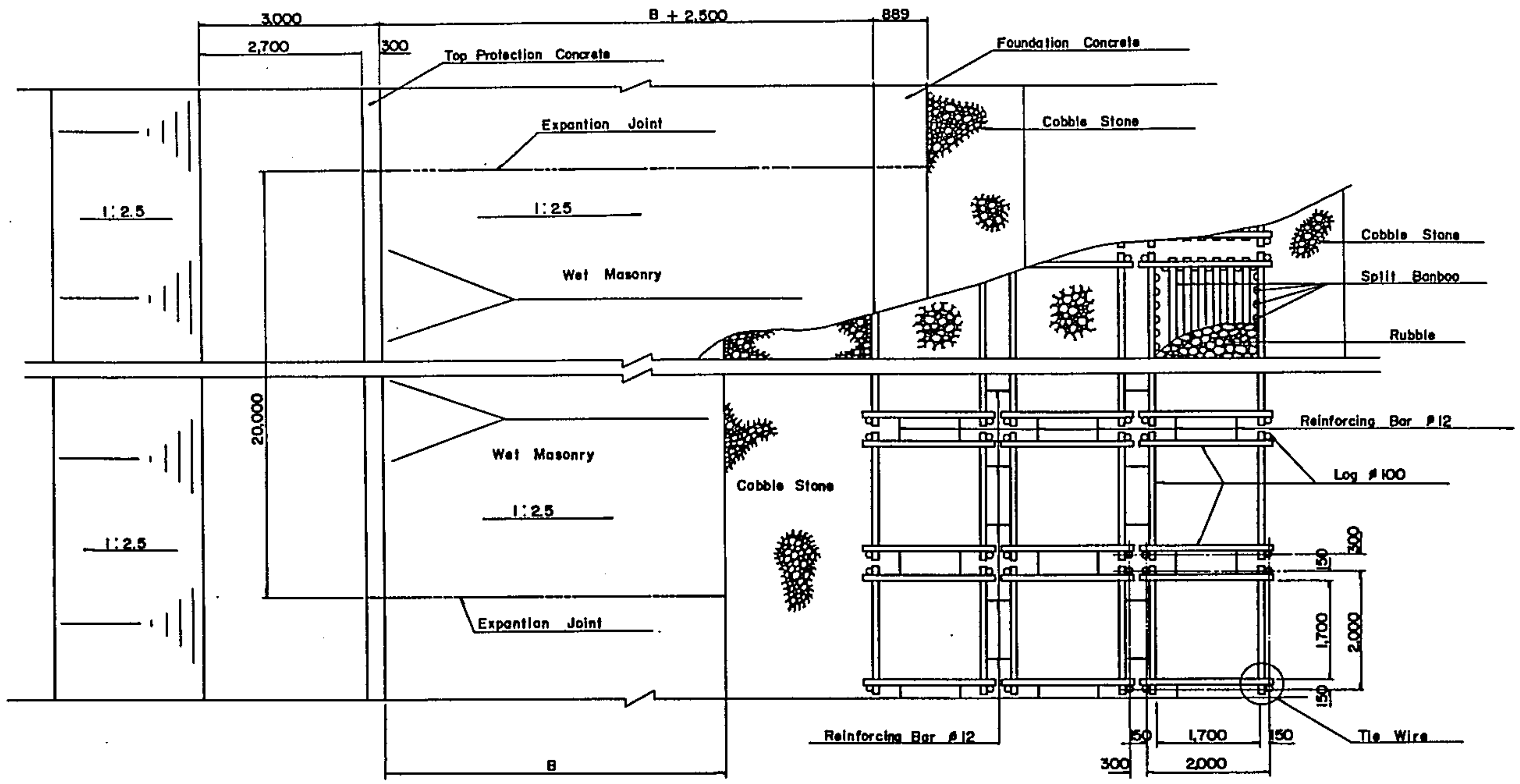
STA.2+300 ~ STA.3+700



TYPICAL CROSS SECTION

Scale 0 1 2 3 4 5 10 15 20M

MINISTRY OF PUBLIC WORKS TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES MANILA , PHILIPPINES	
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT	
CHECKED BY / DESIGNED BY / DRAWN BY DATE Feb. 1980 / SCALE AS SHOWN DRAWING NO M.V.S-D 026	TITLE OF DRAWING RIVER CANALIZATION TIPICAL CROSS SECTION
JAPAN INTERNATIONAL COOPERATION AGENCY	

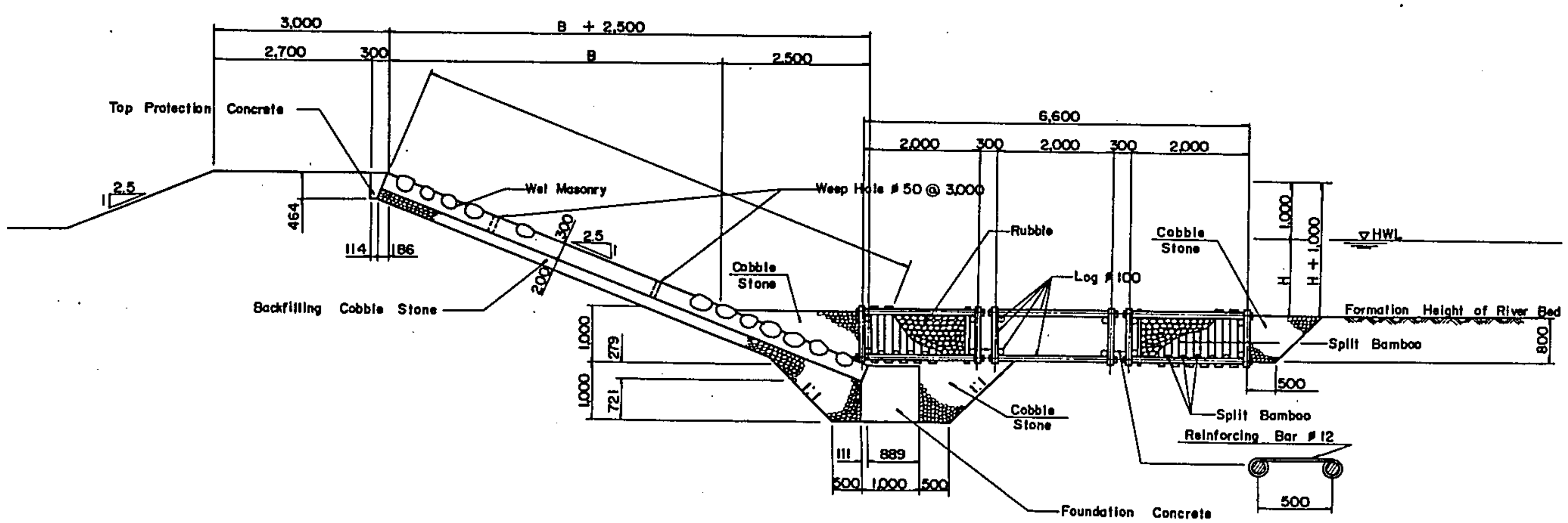


PLAN

Scale 0 0.5 1 2 3M

TABLE OF DIMENSION

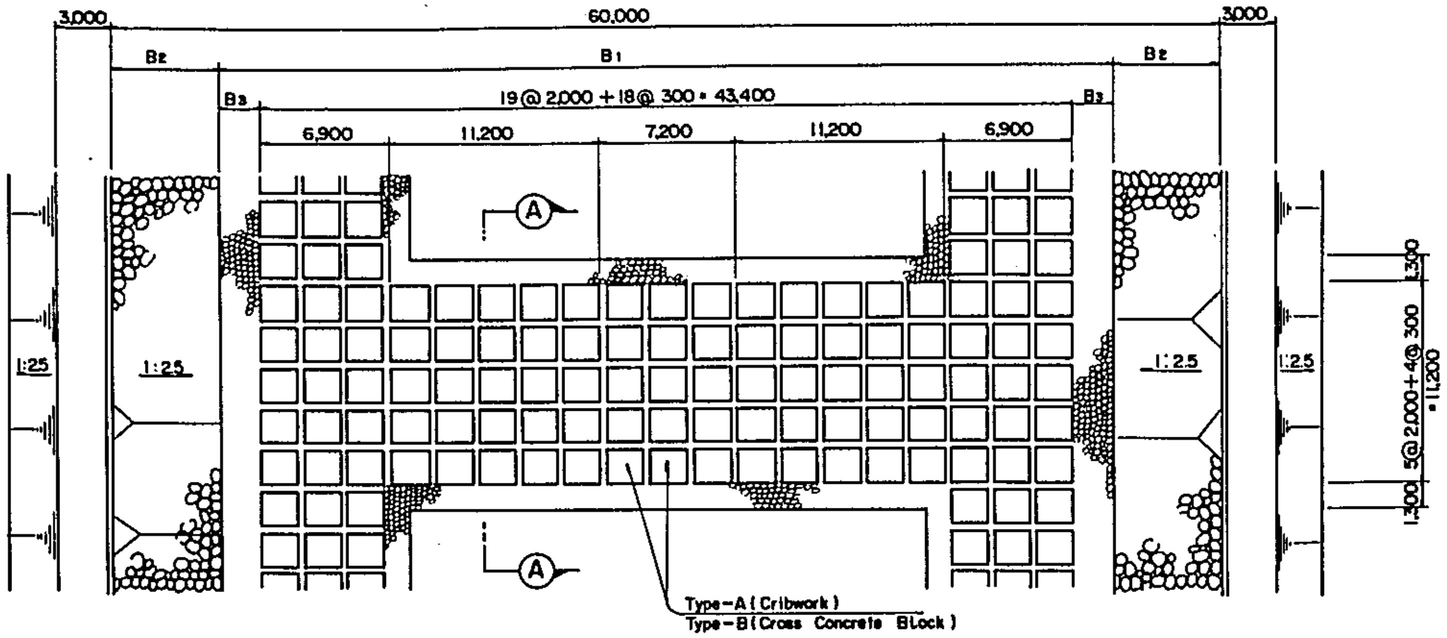
Section	B	H	L	Remarks
Sta. 0+000 ~ Sta. 1+100 (Future Extension)	5,750	1,300	8,887	
Sta. 1+100 ~ Sta. 2+300 (R1, L1)	5,250	1,100	8,348	
Sta. 2+300 ~ Sta. 3+900 (R2, R2, L2)	5,000	1,000	8,079	



TYPICAL SECTION OF REVETMENT AND FOOT PROTECTION

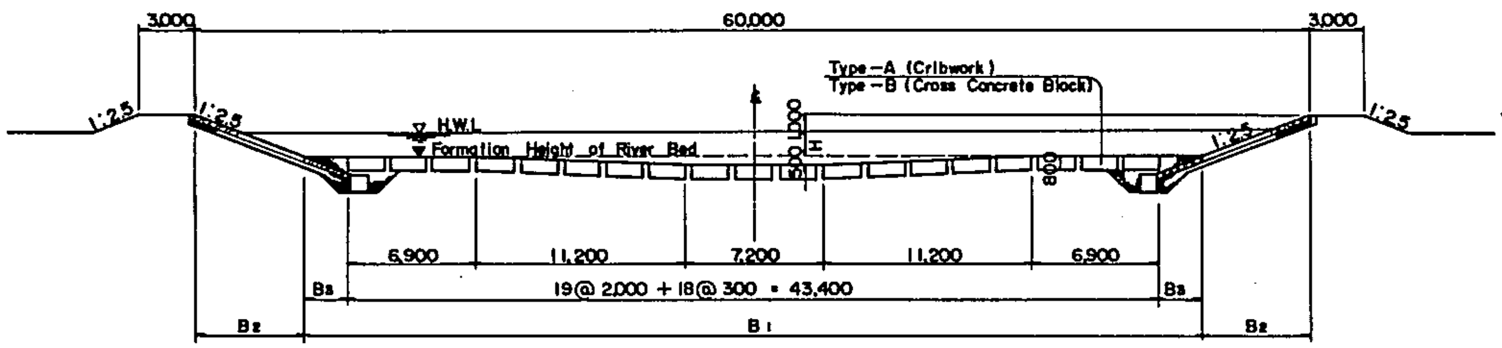
Scale 0 0.5 1 2 3M

MINISTRY OF PUBLIC WORKS TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES MANILA, PHILIPPINES	
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT	
CHECKED BY / DESIGNED BY / DRAWN BY	TITLE OF DRAWING RIVER CANALIZATION STRUCTURAL DETAIL OF LEVEE
DATE Feb. 1980 SCALE AS SHOWN	
DRAWING NO. M.V.S-D 027	
JAPAN INTERNATIONAL COOPERATION AGENCY	



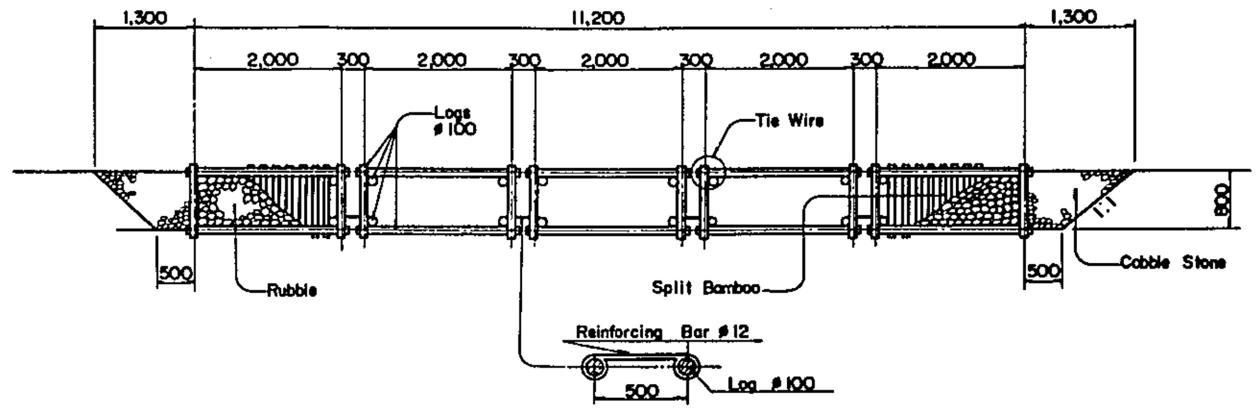
PLAN

Scale 0 5 10M



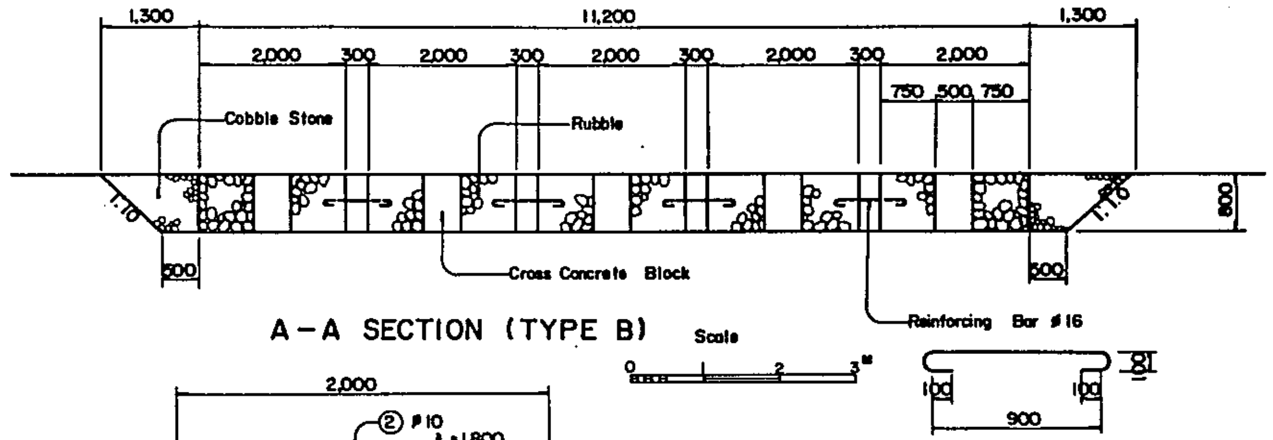
FRONT VIEW

Scale 0 5 10M



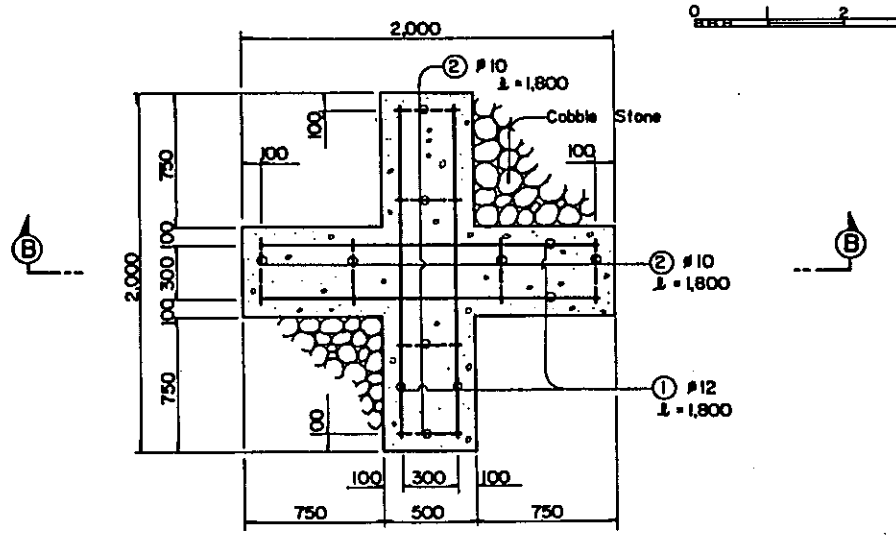
A-A SECTION (TYPE-A)

Scale 0 1 2 3M

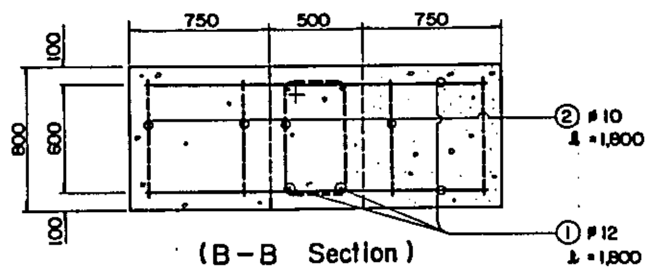


A-A SECTION (TYPE B)

Scale 0 1 2 3M



(PLAN)



(B-B Section)

DETAILE OF CROSS CONCRETE BLOCK

Scale 0 0.5 1M

TABLE OF DIMENSION

Section	H	B1	B2	B3
Sta. 0+000 ~ Sta. 1+100	1,300	48,500	5,750	2,550
Sta. 1+100 ~ Sta. 2+300	1,100	49,500	5,250	3,050
Sta. 2+300 ~ Sta. 3+700	1,000	50,000	5,000	3,300

MINISTRY OF PUBLIC WORKS
TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES
MANILA, PHILIPPINES

MAYON VOLCANO
SABO AND FLOOD CONTROL PROJECT

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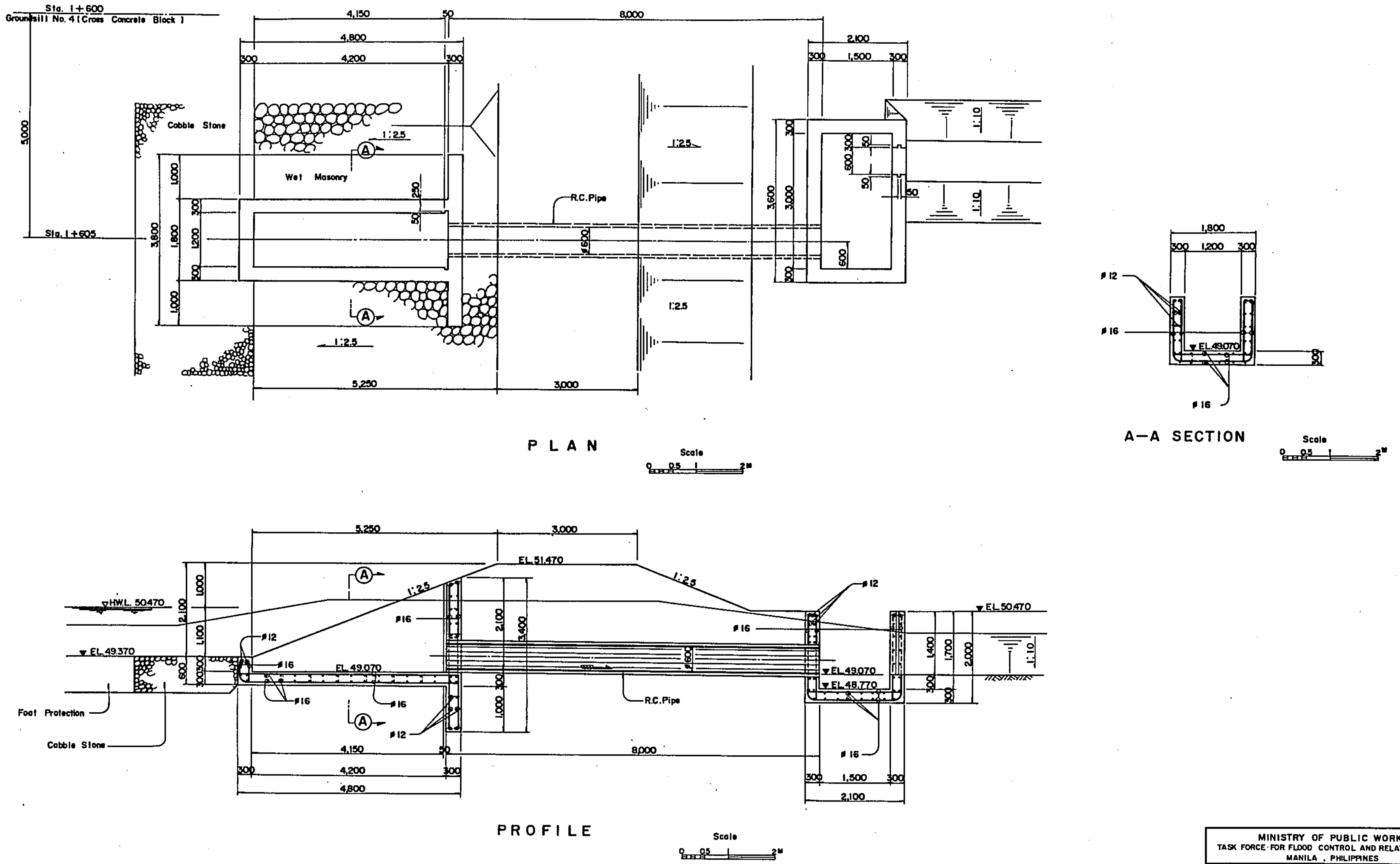
DATE Feb, 1980 SCALE AS SHOWN
DRAWING NO. MVS-D-028

TITLE OF DRAWING
RIVER CANALIZATION
STRUCTURAL DETAIL OF
GROUNSILL

JAPAN INTERNATIONAL COOPERATION AGENCY



MINISTRY OF PUBLIC WORKS TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES MANILA, PHILIPPINES	
MAYON VOLCANO SABO AND FLOOD CONTROL PROJECT	
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DATE Feb. 1980 / SCALE AS SHOWN	
DRAWING NO. M.V.S-D 029	
JAPAN INTERNATIONAL COOPERATION AGENCY	