JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

FINAL REPORT

VOLUME III-2

FEASIBILITY STUDY

(SUPPORTING REPORT)

DECEMBER 1997

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
SANYU CONSULTANTS INC.
PASCO INTERNATIONAL INC.

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Topographic Survey Results

The cost estimates in this Study are based on the price levels indicated below and expressed in Philippine Peso according to the following exchange rates:

Master Plan	:	US$1.00 = Philippine Peso 26.00
		= Japanese Yen 105, as of August 1996
Feasibility Study	:	US$1.00 = Philippine Peso 26.00
		= Japanese Yen 115, as of June 1997

FEASIBILITY STUDY

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CHAPTER I SABO DAM HEIGHT AND SEDIMENTATION CAPACITY

1.1 Objectives

The design dam heights and sedimentation capacities of the following five(5) sabo dams, which were proposed as structural components of the urgent plan, were reviewed based on the detailed cross-sectional survey data.

1) Cura No.1 Sabo Dam
2) Labugaon No.1 Sabo Dam
3) Solsona No.1 Sabo Dam
4) Madongan Sabo Dam
5) Papa Sabo Dam

1.2 Estimation Process

The design dam height was determined through the following processes.

1) Selection of the optimum dam site in due consideration of the geological conditions of the abutments where the dam wings will be constructed,
2) Estimation of the original riverbed gradient by using the river cross-section survey with intervals of 250 m,
3) Delineation of the design sedimentation basin with a slope of 75 % (3/4) of the original riverbed,
4) Estimation of the sedimentation capacity corresponding to dam height at 0.5 m intervals by using the said cross-sections, and
5) Determination of the dam height which will meet the required sedimentation capacity as estimated in the master plan.

1.3 Design Dam Height and Sedimentation Capacity

The design dam heights and sedimentation capacities of the five (5) dams are determined as follows.

Sabo Dam	Dam Height (m)	Sedimentation Capacity (m^3)
Cura No.1	8.0	422,000
Labugaon No.1	10.0	1,197,000
Solsona No.1	10.0	242,000
Madongan	7.0	2,207,000
Papa	5.5	794,000

Their plans and longitudinal profiles are presented in Fig. A.1.1.

The design dam heights of the five (5) sabo dams are slightly different from those proposed in the master plan study as shown in the following table.

Sabo Dam	Dam Height (m)	
	Master Plan	Feasibility Study
Cura No.1	6.5	8.0
Labugaon No.1	10.0	10.0
Solsona No.1	10.0	10.0
Madongan	7.0	7.0
Papa	7.0	5.5

CHAPTER II SEDIMENT TRANSPORT ANALYSIS

2.1 Objectives

The sediment transport analysis in this study was conducted for the following purposes.

1) To verify the sediment control effects of the proposed sabo dam,
2) To predict the future riverbed aggradation/degradation with and without the project,
3) To predict the sediment balance in the design flood, and
4) To apply the predicted results in order to establish the baseline data, such as high water level and structural foundation depth of the proposed channel.

Thus, the sediment transport was analyzed for the two period, the design flood and the long term of 20 years.

2.2 Calculation Methodology

2.2.1 Formulae and Equations

The sediment transport of the river is simulated through the following basic calculations.

(1) Hydraulic calculation

Non-uniform flow is adopted to calculate flow velocity, water depth and hydraulic gradient of the river.

(2) Sediment transport rate

Ashida-Michiue's formula [1] is used to calculate bed loads and suspended loads in the river (refer to Appendix F of the Master Plan supporting report for details).

The equation for calculation of bed loads is given below.

$$q_B/\{(\sigma/\rho-1)gd^3\}^{1/2}= 17\tau_{*e}^{3/2}\ (1-\tau_{*c}/\tau_*)\ (1-U_{*c}/U_*)$$

Where q_B is sediment runoff per unit river width per unit time, σ is sediment particle density, ρ is water density, g is gravitational acceleration, d is sediment particle diameter, τ_{*e} is effective shear stress, τ_{*c} is critical shear stress, U_{*c} is critical shear velocity, τ_* is shear stress, and U_* is shear velocity $[\tau_*=U_*^2/\{(\sigma/\rho-1)gd\}]$.

The equation for calculation of suspended loads [2),3)] is given below.

$$Q_S= C_B\ [\{1+U_*/(\kappa\ U_0)\}\ A_1+A_2\ U_*/(\kappa\ U_0)]\ Q$$

Here, $A_1=\{a/(h-a)\}^Z\int_{a/h}^{1}\{(1/\eta)-1\}^Z d\eta$

$A_2=\{a/(h-a)\}^Z\int_{a/h}^{1}\ln\eta\ \{(1/\eta)-1\}^Z d\eta$

$\eta=Z/h$

$Z=w_0/(1.2\ \kappa\ U_*)$

Where Q_S is sediment discharge per time, C_B is sediment concentration at a height of [a] above bed surface, κ is Karman constant, A_1 and A_2 are parameters of concentration distribution, and h is flow depth, and w_0 is terminal settling velocity of sediment particle.

(3) Riverbed variation

Riverbed variation in a certain river section is estimated by calculating the balance between sediment inflow from the upstream section and sediment outflow from the downstream section. The sediment inflow and outflow volumes are calculated based on each grain size so that the sieving effect of sabo dam and armoring effect can be evaluated by using this model. Finally, predicted riverbed can be obtained by time sequential computation for the necessary time period.

Riverbed variation is computed by solving simultaneously the following three continuity equations[4].

Continuity equation of rivebed:
$\partial z/\partial t+\{1/(1-\lambda)B\}\ \partial(q_B B)/\partial x=0$

Continuity equation of individual grain in the case of aggradation:
$\partial i_b/\partial t=(1/a)(i_B-i_b)\partial z/\partial t-\{q_B/\{a(1-\lambda)\}]\partial i_B/\partial x$

Continuity equation of individual grain in the case of degradation:
$\partial i_b/\partial t=(1/a)(i_B-i_{b0})\partial z/\partial t-\{q_B/\{a(1-\lambda)\}\}\partial i_B/\partial x$

Where z is riverbed elevation, t is unit time, λ is void ratio in the riverbed, B is flow width, q_B is sediment runoff per unit river width per unit time, x is longitudinal distance, i_b is ratio in volume of gravel with diameter of d_i in surface bed layer, a is thickness of surface bed layer, i_B is ratio in volume of gravel with diameter of d_i in transported sediment from upstream section, and i_{b0} is ratio in volume of gravel with diameter of d_i in lower bed layer.

2.2.2 Basic Data

The following data were used for the sediment transport analysis.

(1) Hydrological data

Design flood hydrograph and flood discharge series in a hydrological average year for the long term period. (In this study, 1968 is assumed to be hydrologically average.)

(2) Cross-section

River cross-sections surveyed in the course of the master plan and F/S studies.

(3) Riverbed materials

Grain size and its distribution as surveyed in the course of the master plan study.

(4) Sediment supply

Sediment runoff from the mountain valley as enumerated in the following table, and its grain size distribution as estimated in the master plan study.

River	Sediment Supply in Design Flood (m^3)	Annual Sediment Supply (m^3/year)
Cura	71,300	54,600
Labugaon	185,200	154,700
Solsona	166,900	114,500
Madongan	454,500	223,100
Papa	147,300	99,600

2.3 Prediction of Sabo Dam Sedimentation

Sediment simulation was conducted targeting the proposed sabo dams in the five rivers. In the Cura, Labugaon and Solsona rivers, simulation was carried out in accordance with the construction schedule of series dams proposed in the Master Plan.

The simulation results are illustrated in Fig. A.2.1. The following facts are derived from the results.

2.3.1 Sedimentation Capacity

Computed sediment capacity is summarized in the following table, in comparison with design capacity as proposed in the Master Plan or determined in Chapter I.

Sabo Dam	Design Volume (m^3)	Simulated Volume (m^3)
Cura No.1	422,000	322,000
Cura No.2	150,000	147,000
Labugaon No1	1,197,000	913,000
Labugaon No.2	511,000	734,000
Solsona No.1	242,000	313,000
Solsona No.2	233,000	332,000
Madongan	2,207,000	2,768,000
Papa	794,000	877,000

As evident from the table, the computed sedimentation volume shows the similarity to the design one. This means that reliability of the design sedimentation slope and volume was proven through the simulation.

2.3.2 Sediment Control Effect

Sediment control effect is also delineated in Fig. A.2.1 in comparison with sediment inflow and outflow of sabo dam. The following table presents the maximum sediment outflow per annum computed in the simulation.

Sabo Dam	Sediment Inflow (m3/year)	Sediment Outflow (m3/year)		
		10 year after	20 year after	Average in 20 years
Cura No.1	54,600	40,200 (74%)	40,000 (73%)	20,900 (38%)
Labugaon No.1	154,700	91,800 (59%)	91,000 (59%)	57,300 (37%)
Solsona No.1	114,500	110,700 (97%)	105,500 (92%)	69,700 (61%)
Madongan	223,100	36,500 (16%)	116,500 (52%)	51,900 (23%)
Papa	99,600	16,700 (17%)	83,900 (84%)	36,200 (36%)

Note: Figures in the parenthesis indicate the rate of outflow to inflow.

The results also indicate that sabo dam is a effective measure to control excessive sediment inflow from the mountains. The rate of outflow to inflow ranges from 23 to 61 % on average in 20 years. It means that control effects of sabo dam can last for a long time.

2.4 Prediction of Long Term Riverbed Variation

The riverbed variations with and without the sabo dam were simulated for the alluvial fan rivers between the diversion dam/irrigation intake and river mouth. The simulation results are shown in Table A.2.1 and Fig. A.2.2. Further, riverbed variation is summarized in Table A.2.2. In this table, riverbed variation is summarized, averaging in a river stretch between salient hinge points of present riverbed slope.

The average riverbed variation in a whole stretch is also enumerated in the following table

River	Average Riverbed Variation	
	With Sabo Dam	Without Sabo Dam
Cura/Labugaon	0.01 m	0.51 m
Solsona	0.62 m	1.38 m
Madongan	0.03 m	1.51 m
Papa	0.28 m	1.20 m

The tables and figure show the following characteristics of river bed variation and information on river improvement and maintenance.

1) In general, relatively heavy aggradation will occur in the lower stretch, while mild aggradation/degradation will occur in the upper stretch.

2) The sabo dam can properly mitigate riverbed aggradation over the whole stretch of the alluvial rivers.

3) Serious degradation will not occur due to sediment supply reduction by sabo dam construction in any stretch.

4) The lower Solsona river will suffer from heavy sediment accumulation even though the proposed sabo dams are constructed due to constraint of sedimentation volume in sabo dams.

5) In the Solsona headwaters, there is no more suitable sabo damsite with large sedimentation volume, so that effective dredging work should be considered in the future.

2.5 Prediction of Riverbed Variation in Design Flood

Sediment transport analysis was also conducted to clarify the riverbed variation in the design flood, based on the following conditions:

1) The sediment inflow from the mountain areas is controlled by sabo dam under the sedimentation conditions in 20 years after construction.

2) The alluvial fan channel is set under the condition in 20 years after construction of sabo dam as computed in Section 2.4. The channel receives the sediment outflow of sabo dam.

The sediment balance in each river in the design flood is shown in Fig. A.2.3. The location and height of maximum riverbed aggradation in each river are estimated as follows.

River	Stretch	Sediment Deposit (m^3)	Maximum Riverbed Aggradation Height (m)
Cura	4.0 - 4.55K	30,200	0.18
Labugaon	2.87 - 3.53K	26,500	0.25
Solsona	10.5 - 10.84K	17,400	0.45
Madongan	9.0 - 9.1K	19,700	0.50
Papa	7.0 - 7.27K	30,000	0.53

As shown in the above table, most of the riverbed aggradation occurs at the fan apexes, the uppermost sections along the channels. The maximum riverbed aggradation height is within the range of 0.45 to 0.53 m in the Solsona, Madongan and Papa rivers. The existing cross-sections at the apexes, however, have enough capacity to absorb the sediment deposits because of the prevailing channel incision caused by the sediment control effect of the irrigation diversion dams.

CHAPTER III RIVER MORPHOLOGICAL STUDY

3.1 Hydraulic Characteristics of Alluvial Fan Rivers

Prior to the survey, the following hydraulic parameters of the alluvial fan rivers were computed using non-uniform flow equation.

1) Flow velocity
2) Flow depth
3) Flow width
4) Flow width and depth ratio
5) Non-dimensional shear stress

The design river cross-section was used in this computation. The computation was made under two hydraulic conditions, design discharge and 2-year flood discharge. The latter flood has the greatest influence to riverbed formation, such as sand bar and low-water channel, because of the most frequent occurrence.

Fig. A.3.1 presents the hydraulic parameters of each alluvial fan river. The following characteristics are derived from this figure.

1) Down-most reaches of the Cura, Solsona and Papa rivers are influenced by the back water of the Laoag/Bongo River. This effect is more notable in the design flood. However, it is limited only to the stretch of 500 to 1000 km upstream of each confluence.

2) At immediately upstream sections of the confluences of Cura and Labugaon, Solsona and Madongan rivers, the flow velocity suddenly decreases due to back water effect. In proportion to this, the shear stress also decreases. This effect may cause the sediment accumulation just upstream of the confluences.

3) The flow width and depth ratio (B/hm) falls into the ranges of 100 to 250 in 2-year flood. Further, non-dimensional shear stress has the range of 0.1 to 0.2 in this flood. Referring to the research results of river morphology, these hydraulic conditions fall under the transition between single and double bar formation.

3.2 River Morphological Survey

The river morphological survey was made for the following purposes;

1) To determine the required foundation depth of such bank protective structures as revetment, toe protection and spur dike.

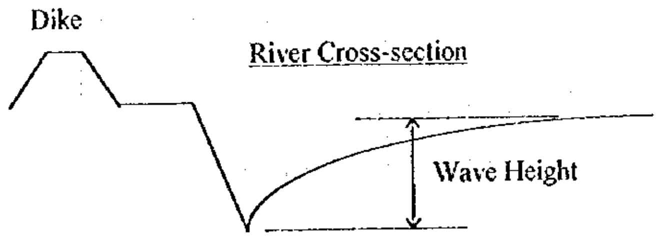
2) To determine the location where construction of the above protective structures is necessary.

The survey was conducted for the Solsona, Madongan and Papa rivers. These rivers are provided with temporary dikes for the entire river sections and the diking systems have comparatively confined floods for four (4) years although the dikes were breached at many locations during the same period. The existing river morphologies of the above rivers are considered to show the morphological characteristics of the improved river channels in the alluvial fan areas.

3.3 Sand Bar Formation

The river morphological conditions of the three (3) rivers are illustrated in Fig. A.3.2. This figure provides the following information;

1) Sand bar formation in macroscopic view,
2) Main flood stream lines during typhoon Gloring and these were estimated by tracing the existing deep water ways in the river bed, and
3) Wave height of sand bar measured in the following manner.



(1) Solsona River

The alternating sand bars in a single row are formed in the upper and lower reaches, while the double row bars are formed in the middle reaches. Their locations are shown in Fig. A.3.2(1). The facts found out are as follows.

1) The predominant sand bar formation changes in accordance with the variation of riverbed slope.
2) In the river stretch of 8.0 km to the diversion dam, single bars with a wave length of 650 m to 850 m are formed. They did not move downward during the flood of typhoon Gloring, due to restraint of the channel bends.
3) In the stretch of 5.0 km to 8.0 km, double bars with a wave length of 450 m to 750 m are predominant. The flood water flowed down, forming many sub-main streams within the river channel. It is due to this that movable scale-like sand bars are formed on the double sand bars.
4) In the downstream reaches of 5.0 km, single bars are formed again with a wave length of about 1,000 m. The sand bars in this stretch can hardly move due to restraint exerted by the channel bends.

(2) Madongan River

Alternating sand bars in double rows are predominant in the whole stretch except for the immediate downstream reaches of the diversion dam as shown in Fig. A.3.1(2). The characteristics of the sand bar formation are as follows.

1) In the stretch of 7.0 km to the diversion dam, single bars are formed. They can hardly move due to restraint of the channel bend.
2) In the downstream reaches of 7.0 km, double bars with a wave length of 300 m to 1,000 m are formed. As easily movable scale-like sand bars are formed on the double bars, the flood water flowed forming many sub-main streams within the river channel.

(3) Papa River

Alternating sand bars in a single row are clearly formed in the river channel as shown in Fig. A.3.2(3). The following facts were found out in the course of the survey.

1) After the flood of typhoon Gloring, no significant change of water ways was identified in the entire reaches.

2) The wave length of the single bars ranges from 550 m to 950 m.

3) The flood water convergence points created by sand bars tend to coincide with the branching directions of the former river courses located outside the diking system.

As mentioned above, the single bars formed in the following river sections hardly move downward and as a result, the flood water convergence points are fixed.

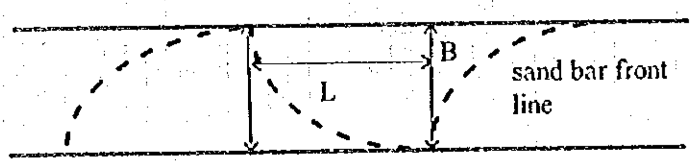
1)	Solsona River	:	lower reaches (0-5 km)
			upper reaches (8 km-)
2)	Madongan River	:	upper reaches (7 km-)
3)	Papa River	:	whole stretches

Bank protection structures can be concentrated around the existing flood water convergence sections in the above river stretches.

On the other hand, the double sand bars formed in the remaining stretches of the Solsona and Madongan rivers easily move downward in flood time, being accompanied by the movement of flood water convergence points. Hence, continuous bank protection structures may be necessary for these river stretches.

3.4 Direction of Sand Bar Front Line

The sand bar front lines alternately changes their directions towards right and left as shown in Fig. A.3.1. Main flood flow generally runs along the sand bar front lines. Hence, the tangent of the sand bar front lines is considered to be one of the important indexes for the bank protection design, especially for the design interval and length of spur dike/groin. The tangent of the sand bar front line defined as shown below are also calculated from the Fig. A.3.2.



The tangent of the sand bar front lines (L/B) is larger in the river sections of gentle slope, while smaller in the river sections of steep slope as shown in Fig. A.3.3. From the above figure, the tangent of the sand bar front lines are classified by riverbed slope as shown below.

Riverbed Slope (%)	Tangent (L/B)
S < 0.8	4.0
S > 0.8	2.0

The ratio of length and interval distance of spur dikes will be determined based on the above tangents of sand bar front line.

3.5 Local Scouring

In order to estimate the depth of local scouring on the foot of dike, the wave height of sand bar at flood water convergence points was measured. The locations and measured wave heights are also shown in Fig. A.3.2. The measured wave height and the average channel slope in each location are tabulated in Table A.3.1. Fig. A.3.4 illustrates the relationship between wave height and channel slope.

No close correlation is recognized between the measured wave height and channel slope, and the figures widely vary. It is because the wave height is governed not only by channel slope but also by the degree of flood water convergence. Local scouring in the river section with steep slope is generally caused by the convergence of flood water. If flood water converges into one water way along the dike, serious local scouring and bank erosion will take place.

However, a tendency that the wave height increases in proportion to the increase of channel slope can be observed. Therefore, the scouring depth to be reflected in the structural design is obtained by enveloping the measured depth data as shown in Fig. A.3.3. The enveloping line is as follows.

Riverbed Slope (%)	Wave Height (m)
$S < 0.8$	1.5 m
$0.8 < S < 1.3$	1.8 m
$1.3 < S < 1.5$	2.4 m
$1.5 < S < 2.0$	2.8 m

The design scouring depth will be discussed in the succeeding chapter.

CHAPTER IV DESIGN CONSIDERATION OF BANK PROTECTION WORKS

4.1 High Water Level in Alluvial Fan Rivers

Based on the results of sediment transport simulation, the riverbed in the alluvial fan will be influenced by sabo dam construction, and may change in the future due to the short duration lapsed after the completion of the diking system. Thus, high water level for river improvement works in the alluvial fan rivers is determined through the following procedure.

1) Computing water level of design flood peak discharge in the present channel and the predicted future channel with sabo dam, using non-uniform calculation,

2) Comparing both water levels and selecting the higher one in each section, and

3) Determining design high water level to adapt the selected water level.

Design high water level and related ground height, such as present and future riverbed, existing dike and ground level on the landside are enumerated in Table A.4.1. Longitudinal profile of design high water level in each alluvial fan river is illustrated in Fig. A.4.1. Further, relative height of riverbed, existing dike and ground level from design high water level is longitudinally delineated in Fig. A.4.2.

These figures and table indicate the following facts.

1) In general, water level and riverbed elevation exponentially increases as it goes upstream. However, the lowermost stretch of Solsona River is exceptional due to strong influence caused by the Madongan River as shown in Fig. A.4.1(1).

2) Except for the Cura/Labugaon River where the diking system will be constructed, both existing and future riverbeds are lower than ground level in the landside almost over the entire stretch. In the Papa River, ground level of 23 % out of the whole sections is higher than high water level.

3) From the viewpoint of comparison of height difference among riverbed, ground level, high water level and existing dike, the Papa River has the highest safety against flood disaster. Then comes Madongan and Solsona in that order.

4) Fig. A.2.1(1) indicates that the new diking system with 3 to 4 m high is required in the entire stretch of the Cura/Labugaon River.

4.2 Design Structural Base in Alluvial Fan Rivers

The prevailing local scouring was clarified through river morphological survey described in the preceding chapter. The following are basic considerations in the structural design against local scouring based on the survey results.

1) Wave height of existing sand bar is clarified as shown in Fig. A.3.3.

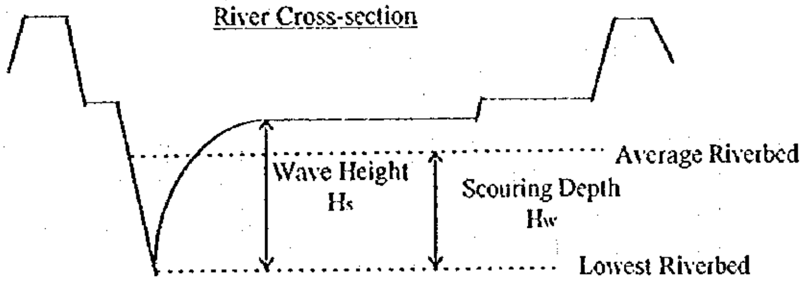
2) In order to design the proper toe protection work, some appropriate depth should be determined from a certain elevation.

3) Such baseline can be set at the average riverbed which is a lower one between the present and future riverbeds in each cross-section.

4) Measured wave height can be converted to scouring depth from the average riverbed, using the following experimental equation.

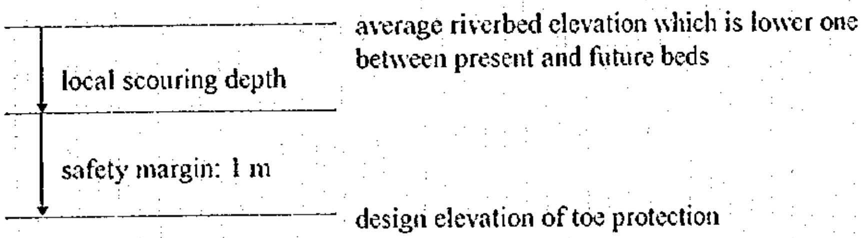
$H_s = 0.8\,H_w$

Where H_s is scouring depth from the average riverbed, and H_w is wave height of sand bar.



5) Fig. A.4.3 illustrates relationship between actual scouring depth Hs estimated using cross-section survey results in 1996, and converted envelop line as derived from Fig. A.3.2. The converted line also covers scouring depth at each section over the entire stretch.

6) Finally, the following method is proposed to determine the depth of toe protective structures.



The determined design scouring depth is tabulated in the following table. Further, the design base elevation of toe protective works is enumerated in Table A.4.2, following this criteria.

Riverbed Slope	Design Scouring Depth	Safety Margin	Design Depth from Average Riverbed
- 0.8%	1.2 m	1.0 m	2.2 m
0.8 - 1.3%	1.5 m	1.0 m	2.5 m
1.3 - 1.5%	2.0 m	1.0 m	3.0 m
1.5 - 2.0%	2.3 m	1.0 m	3.3 m

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TABLES

Table A.2.1(1) Riverbed Prediction in Cura/Labugaon River

Distance (km)	Riverbed Elevation (m)								
	Average Original Bed	With Sabo Dam				Without Sabo Dam			
		5 Years	10 Years	15 Years	20 Years	5 Years	10 Years	15 Years	20 Years
Cura									
0.0	23.79	23.497	23.406	23.430	23.494	23.456	23.400	23.438	23.509
0.5	25.06	24.981	24.936	24.978	25.046	24.979	24.931	24.988	25.063
1.0	26.33	26.375	26.431	26.503	26.580	26.373	26.428	26.519	26.604
1.5	27.60	27.661	27.730	27.779	27.822	27.741	27.898	28.031	28.136
2.0	28.89	29.004	29.105	29.170	29.643	29.165	29.389	29.559	29.687
2.5	30.42	30.540	30.650	30.721	30.777	30.706	30.956	31.140	31.277
3.0	32.29	32.327	32.428	32.495	32.526	32.381	32.620	32.791	32.919
3.5	33.84	33.982	34.068	34.122	34.167	34.164	34.371	34.513	34.625
4.0	35.39	35.536	35.600	35.644	35.673	35.724	35.887	35.985	36.073
4.5	38.18	36.798	36.893	36.937	36.953	36.800	36.892	36.929	36.995
5.0	40.00	40.095	40.108	40.099	40.080	40.092	40.087	40.091	40.161
5.5	42.00	42.158	42.111	42.064	42.052	42.158	42.091	42.086	42.177
6.0	44.37	44.279	44.230	44.196	44.207	44.280	44.226	44.247	44.373
6.5	46.47	46.722	46.704	46.693	46.724	46.723	46.707	46.771	46.925
7.0	50.20	49.672	49.636	49.614	49.642	49.674	49.648	49.719	49.857
7.5	53.10	52.683	52.760	52.725	52.745	52.866	52.812	52.882	52.985
8.0	55.67	55.927	55.828	55.810	55.840	55.937	55.920	56.024	56.125
8.5	59.05	58.970	58.920	58.940	58.939	58.994	59.057	59.187	59.293
9.0	62.76	62.366	62.337	62.367	62.323	62.408	62.509	62.614	62.698
9.5	66.22	65.933	65.917	65.902	65.873	66.003	66.112	65.177	65.220
10.0	69.48	69.355	69.374	69.341	69.352	69.465	69.584	69.643	69.690
10.5	72.38	72.751	72.833	72.819	72.832	72.899	72.974	73.038	73.119
11.2	79.57	79.476	79.406	79.379	79.329	79.478	79.427	79.473	79.559
11.85	82.00	82.478	82.846	83.090	83.317	82.562	83.210	83.826	84.170
12.7	90.50	90.505	90.493	90.351	90.376	90.580	90.847	90.936	90.940
13.22	94.40	94.541	94.768	94.641	94.749	94.948	95.424	95.514	95.535
13.72	99.00	98.975	98.988	98.835	98.886	99.561	99.769	99.829	99.849
14.18	103.60	103.613	103.686	103.571	103.588	104.294	104.380	104.402	104.403
15.22	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00	111.00
Labugaon									
0.0	77.99	78.046	78.065	78.038	78.078	78.290	78.771	79.167	79.517
0.5	82.54	82.268	82.162	82.093	82.128	82.821	83.208	83.581	83.928
1.0	88.44	87.925	87.690	87.665	87.672	88.896	89.257	89.463	89.615
1.5	92.95	92.630	92.526	92.482	92.493	93.659	94.017	94.237	94.396
2.0	97.93	97.731	97.801	97.723	97.713	98.837	99.140	99.432	99.729
2.87	106.50	105.966	106.115	105.833	105.883	106.685	106.979	107.271	107.558
3.53	112.80	112.80	112.80	112.80	112.80	112.80	112.80	112.80	112.80

Table A.2.1(2) Riverbed Prediction in Solsona River

Distance (km)	Riverbed Elevation (m)								
	Average Original Bed	With Sabo Dam				Without Sabo Dam			
		5 Years	10 Years	15 Years	20 Years	5 Years	10 Years	15 Years	20 Years
0.0	24.0	24.491	24.691	24.864	25.083	24.536	24.913	25.201	25.505
0.5	25.3	25.296	25.509	25.697	25.913	25.371	25.750	26.043	26.404
1.0	26.1	26.210	26.416	26.611	26.842	26.363	26.674	27.032	27.484
1.5	26.5	27.206	27.460	27.666	27.903	27.363	27.755	28.247	28.775
2.0	27.4	27.859	28.106	28.350	28.613	27.939	28.267	28.686	29.089
2.5	28.5	28.590	28.880	29.089	29.380	28.602	28.876	29.176	29.441
3.0	29.3	29.546	29.772	29.918	30.081	29.723	30.130	30.460	30.775
3.5	30.3	30.779	31.020	31.176	31.336	31.132	31.578	31.952	32.344
4.0	32.3	32.638	32.855	32.997	33.176	32.913	33.328	33.763	34.231
4.5	35.5	35.172	35.447	35.599	35.810	35.239	35.603	36.118	36.633
5.0	37.2	37.509	37.622	37.795	38.023	37.865	38.276	38.886	39.424
5.5	39.7	40.155	40.260	40.544	40.754	40.743	41.367	42.057	42.609
6.0	43.7	43.735	43.960	44.193	44.338	44.168	45.013	45.701	46.232
6.5	48.2	47.728	48.080	48.488	48.602	48.297	49.223	49.828	50.301
7.0	53.5	52.332	52.917	52.983	52.988	53.209	54.006	54.466	54.829
7.5	59.6	59.604	60.222	59.981	60.085	59.414	59.796	59.996	60.172
8.0	66.6	66.582	67.326	66.904	67.057	67.007	67.030	67.014	67.022
8.5	74.4	74.525	74.846	74.319	74.518	74.794	74.716	74.570	74.462
9.0	81.6	82.190	82.420	81.855	82.108	82.283	82.211	82.085	81.971
9.5	89.7	90.022	90.020	89.552	89.782	90.212	90.110	90.005	89.923
10.0	96.7	97.345	97.368	96.829	96.958	97.862	97.619	97.543	97.483
10.5	102.9	103.699	103.863	103.439	103.592	104.153	104.193	104.199	104.191
10.838	110.8	110.8	110.8	110.8	110.8	110.8	110.8	110.8	110.8

Table A.2.1(3) Riverbed Prediction in Madongan River

Distance (km)	Riverbed Elevation (m)								
	Average Original Bed	With Sabo Dam				Without Sabo Dam			
		5 Years	10 Years	15 Years	20 Years	5 Years	10 Years	15 Years	20 Years
0.0	26.5	27.206	27.460	27.666	27.903	27.363	27.755	28.247	28.775
0.5	28.6	29.261	29.499	29.692	29.892	29.450	29.873	30.515	31.110
1.0	31.2	31.318	31.493	31.633	31.774	31.530	32.043	32.859	33.523
1.5	33.5	33.716	33.777	33.844	33.918	33.900	34.591	35.502	36.202
2.0	36.8	36.651	36.648	36.640	36.642	36.779	37.680	38.575	39.263
2.5	40.1	40.064	39.961	39.927	39.927	40.175	41.256	42.050	42.690
3.0	44.5	44.043	43.896	43.825	43.863	44.243	45.347	45.969	46.508
3.5	48.8	48.517	48.323	48.224	48.284	48.743	49.884	50.361	50.764
4.0	54.4	54.033	53.804	53.637	53.760	54.501	55.210	55.487	55.697
4.5	61.3	60.553	60.257	60.046	60.255	61.413	61.543	61.565	61.612
5.0	67.0	67.043	66.709	66.456	66.758	67.927	68.031	68.039	68.033
5.5	74.4	73.953	73.733	73.650	73.841	74.881	74.798	74.766	74.734
6.0	81.4	81.219	81.128	81.234	81.408	82.175	82.021	81.946	81.900
6.5	87.9	88.023	88.050	88.288	88.346	88.933	88.914	88.895	88.858
7.0	95.2	95.114	95.038	95.271	95.305	95.970	95.911	95.890	95.884
7.5	102.3	102.027	101.961	102.119	101.984	102.891	102.788	102.757	102.754
8.0	108.0	107.979	108.106	108.130	108.013	109.134	109.097	109.131	109.177
8.5	115.0	114.928	115.140	115.211	115.171	115.909	116.032	116.145	116.210
9.0	121.0	121.107	121.339	121.431	121.449	122.520	122.653	122.754	122.806
9.095	125.3	125.3	125.3	125.3	125.3	125.3	125.3	125.3	125.3

Table A.2.1(4) Riverbed Prediction in Papa River

Distance (km)	Riverbed Elevation (m)								
	Average Original Bed	With Sabo Dam				Without Sabo Dam			
		5 Years	10 Years	15 Years	20 Years	5 Years	10 Years	15 Years	20 Years
0.0	41.8	41.801	41.922	42.008	42.108	41.739	41.782	41.842	42.058
0.5	44.5	44.671	44.788	44.878	44.990	44.531	44.596	44.725	45.024
1.0	47.2	47.823	47.941	48.034	48.158	47.528	47.646	47.949	48.384
1.5	51.5	51.347	51.427	51.501	51.628	51.137	51.258	51.704	52.173
2.0	55.1	55.175	55.187	55.230	55.401	55.125	55.306	55.868	56.328
2.5	58.5	59.108	59.170	59.216	59.525	59.030	59.555	60.289	60.805
3.0	64.2	63.796	63.742	63.772	64.272	63.659	64.516	65.255	65.790
3.5	69.3	69.338	69.151	69.165	69.773	69.550	70.466	71.003	71.441
4.0	76.2	75.771	75.505	75.508	76.085	76.290	77.126	77.457	77.741
4.5	83.7	82.785	82.512	82.593	83.077	84.142	84.662	84.837	84.957
5.0	92.2	92.030	91.803	92.003	92.213	92.842	93.072	93.146	93.185
5.5	100.6	100.672	100.516	100.898	100.980	101.417	101.561	101.613	101.623
6.0	109.8	109.268	109.020	109.611	109.712	110.837	110.979	111.016	111.009
6.5	119.8	119.656	119.685	120.162	120.134	120.645	120.713	120.740	120.745
7.0	128.7	128.666	129.033	129.403	129.285	129.782	129.801	129.818	129.820
7.237	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5

Table A.2.2 Summary of Riverbed Prediction (after 20 years of Construction)

		Cura		Labugaon		Solsona		Madongan		Papa	
		With Sabo Dam	Without Sabo Dam	With Sabo Dam	Without Sabo Dam	With Sabo Dam	Without Sabo Dam	With Sabo Dam	Without Sabo Dam	With Sabo Dam	Without Sabo Dam
Average Riverbed Variation	by Stretch	(0.0-6.0 km)		(0.0-2.0 km)		(0.0-3.0 km)		(0.0-4.0 km)		(0.0-3.0 km)	
		0.16 m	0.36 m	-0.35 m	1.47 m	0.96 m	1.48 m	0.24 m	2.24 m	0.47 m	1.11 m
		(6.5-11.85 km)				(3.5-5.5 km)		(4.5-9.0 km)		(3.5-7.0 km)	
		0.00 m	0.25 m			0.78 m	2.05 m	0.04 m	0.85 m	0.12 m	1.28 m
						(6.0-10.5 km)					
						0.31 m	0.97 m				
	Whole Stretch	0.09 m	0.31 m	-0.35 m	1.47 m	0.62 m	1.38 m	0.06 m	1.51 m	0.28 m	1.20 m
Maximum Aggradation		1.32 m (11.85 km)	2.17 m (11.85 km)	0.09 m (0.0 km)	1.80 m (2.0 km)	1.40 m (1.5 km)	2.91 m (5.5 km)	1.40 m (0.0 km)	2.70 m (1.5 km)	1.03 m (2.5 km)	2.31 m (2.5 km)
Maximum Degradation		-0.56 m (7.0 km)	-0.34 m (7.0 km)	-0.77 m (1.0 km)	- -	-0.51 m (7.0 km)	- -	-1.05 m (4.5 km)	- -	-0.62 m (4.5 km)	- -

Table A.3.1 Measured Wave Height of Sand Bar

No.	Location (km)	Bank	Wave Height (m)	Channel Slope (%)	No.	Location (km)	Bank	Wave Height (m)	Channel Slope (%)
Solsona River					11	3.6	Left	1.2	1.20
1	10.4	Right	2.5	1.54	12	3.2	Right	1.1	1.20
2	9.8	Left	2.0	1.54	13	2.9	Left	1.0	0.85
3	9.6	Right	2.1	1.54	14	2.6	Right	1.3	0.85
4	9.3	Left	2.8	1.54	15	2.2	Left	0.6	0.85
5	8.9	Right	2.6	1.54	16	2.0	Right	1.0	0.85
6	8.5	Left	2.1	1.54	17	1.8	Left	0.9	0.85
7	8.2	Right	2.3	1.54	18	1.2	Right	0.7	0.85
8	7.4	Right	1.7	1.12	19	0.8	Left	1.0	0.54
9	6.9	Right	1.7	0.92	20	0.5	Right	1.0	0.54
10	6.7	Right	1.3	0.92	Madongan River				
11	6.3	Left	1.4	0.92	1	8.6	Left	3.3	1.35
12	5.3	Left	1.4	0.39	2	7.7	Left	2.2	1.35
13	4.9	Right	1.3	0.39	3	7.4	Right	1.6	1.35
14	4.1	Left	1.0	0.39	4	6.9	Left	2.0	1.35
15	3.8	Right	1.2	0.39	5	6.5	Right	2.3	1.35
Papa River					6	6.8	Right	2.4	1.35
1	7.0	Left	3.2	1.85	7	5.7	Left	1.5	1.35
2	6.8	Left	3.6	1.85	8	4.8	Right	1.6	1.35
3	6.4	Right	2.7	1.85	9	4.2	Right	1.8	1.35
4	5.9	Left	1.9	1.85	10	3.5	Left	1.8	0.86
5	5.6	Right	2.7	1.85	11	2.6	Left	1.4	0.86
6	5.2	Left	2.2	1.85	12	2.4	Right	0.6	0.86
7	4.9	Right	2.5	1.54	13	2.4	Left	1.5	0.86
8	4.3	Left	1.4	1.54	14	1.8	Left	1.5	0.60
9	3.9	Right	1.6	1.20	15	1.7	Right	1.0	0.60
10	3.7	Right	1.8	1.20	16	1.1	Left	1.4	0.60

Table A.4.1(1) Design High Water Level and Related Elevation

CURA/LABUGAON RIVER

Cross-section No. (km)	Elevation (m)					High Water Gradient
	Present Average Riverbed	Future Average Riverbed	Design High Water Level	Ground Level		
				Right	Left	
Cura						
0.0	23.79	23.494	27.960			
0.5	25.06	25.046	28.650	25.59	25.60	0.138%
1.0	26.33	26.580	29.339			
1.5	27.60	27.822	30.911	27.62	28.18	
2.0	28.89	29.643	32.483			
2.5	30.42	30.777	34.055			0.314%
3.0	32.29	32.526	35.626	33.04	32.64	
3.5	33.84	34.167	37.198			
4.0	35.39	35.673	38.770			
4.5	36.94	36.953	40.443			0.335%
5.0	40.00	40.080	42.115	40.48	41.16	
5.5	42.00	42.052	44.955	42.80	43.17	
6.0	44.37	44.207	47.795	45.41	45.63	
6.5	46.47	46.724	50.635	48.47	46.20	
7.0	50.20	49.642	53.476	51.74	51.44	0.568%
7.5	53.10	52.745	56.316	55.32	53.65	
8.0	55.67	55.840	59.156	57.50	55.95	
8.5	59.05	58.939	61.996	60.29	59.82	
9.0	62.76	62.323	64.836	63.22	63.51	
9.5	66.22	65.873	68.349	66.44	67.58	
10.0	69.48	69.352	71.862	71.03	70.88	0.703%
10.5	72.38	72.832	75.375	74.89	73.14	
11.2	79.57	79.329	81.067	80.31	78.92	0.813%
11.85	82.00	83.317	86.352	82.87	-	
Labugaon						
0.0	77.99	78.078	81.422	80.59	78.01	
0.5	82.54	82.128	85.741	83.52	82.78	0.864%
1.0	88.44	87.672	90.060	88.91	88.74	
1.5	92.95	92.493	94.802	94.35	92.25	0.948%
2.0	97.93	97.713	99.543	99.47	100.12	

PAPA RIVER

Cross-section No. (km)	Elevation (m)							High Water Gradient
	Present Average Riverbed	Future Average Riverbed	Design High Water Level	Existing Dike		Ground Level		
				Right	Left	Right	Left	
0.0	41.80	42.108	44.760	45.12	42.88	42.59	42.44	
0.5	44.50	44.990	47.238	47.86	47.26	46.39	45.67	0.496%
1.0	47.20	48.158	49.715	51.59	50.82	49.70	49.06	
1.5	51.50	51.628	53.421	55.14	54.79	52.61	52.41	
2.0	55.10	55.401	57.127	58.53	58.09	57.00	56.92	0.741%
2.5	58.50	59.525	60.833	62.77	62.27	59.08	60.65	
3.0	64.20	64.272	66.061	67.64	67.75	65.58	66.65	1.046%
3.5	69.30	69.773	71.289	73.65	72.91	70.61	72.33	
4.0	76.20	76.085	78.750	79.36	79.65	78.96	77.51	
4.5	83.70	83.077	86.211	86.64	84.99	84.86	85.56	1.492%
5.0	92.20	92.213	93.672	94.95	94.92	93.12	92.89	
5.5	100.60	100.980	102.941	103.59	103.65	103.33	102.04	
6.0	109.80	109.712	112.211	113.21	113.77	112.99	112.85	1.854%
6.5	119.80	120.134	121.480	123.65	125.11	119.91	120.60	
7.0	128.70	129.285	130.749	134.64	133.16	129.92	132.32	

Table A.4.1(2) Design High Water Level and Related Elevation

SOLSONA RIVER

Cross-section No. (km)	Elevation (m)							High Water Gradient
	Present Average Riverbed	Future Average Riverbed	Design High Water Level	Existing Dike		Ground Level		
				Right	Left	Right	Left	
0.0	24.0	25.083	29.700	28.90	-	27.12	26.49	
0.5	25.3	25.913	30.459	29.93	28.72	28.30	26.92	
1.0	26.1	26.842	31.219	30.27	30.78	28.29	27.33	0.152%
1.5	26.5	27.903	31.978	30.58	31.32	29.24	29.26	
2.0	27.4	28.613	32.737	31.37	30.78	28.62	28.63	
2.5	28.5	29.380	33.093	31.34	32.62	29.86	30.44	0.0711%
3.0	29.3	30.081	33.448	32.97	32.81	32.04	31.49	
3.5	30.3	31.336	34.691	33.77	33.64	31.58	31.62	0.249%
4.0	32.3	33.176	35.934	35.96	35.91	34.23	33.22	
4.5	35.5	35.810	38.188	38.10	39.25	36.69	36.57	0.451%
5.0	37.2	38.023	40.442	41.28	40.92	39.22	38.39	
5.5	39.7	40.754	43.507	43.43	43.38	40.97	40.91	0.613%
6.0	43.7	44.338	46.571	46.34	46.77	44.21	43.99	
6.5	48.2	48.602	50.964	51.74	51.74	49.33	49.79	0.879%
7.0	53.5	52.988	55.357	56.65	56.47	53.24	54.83	
7.5	59.6	60.085	62.588	62.75	62.96	61.60	61.04	
8.0	66.6	67.057	69.819	70.15	69.59	69.35	66.97	1.446%
8.5	74.4	74.518	77.049	77.26	76.44	74.79	74.50	
9.0	81.6	82.108	84.280	84.41	84.54	82.58	83.01	
9.5	89.7	89.782	91.511	92.24	92.51	89.17	91.67	
10.0	96.7	96.958	99.222	99.95	100.15	100.91	101.08	1.542%
10.5	102.9	103.592	106.933	-	-	110.09	107.63	

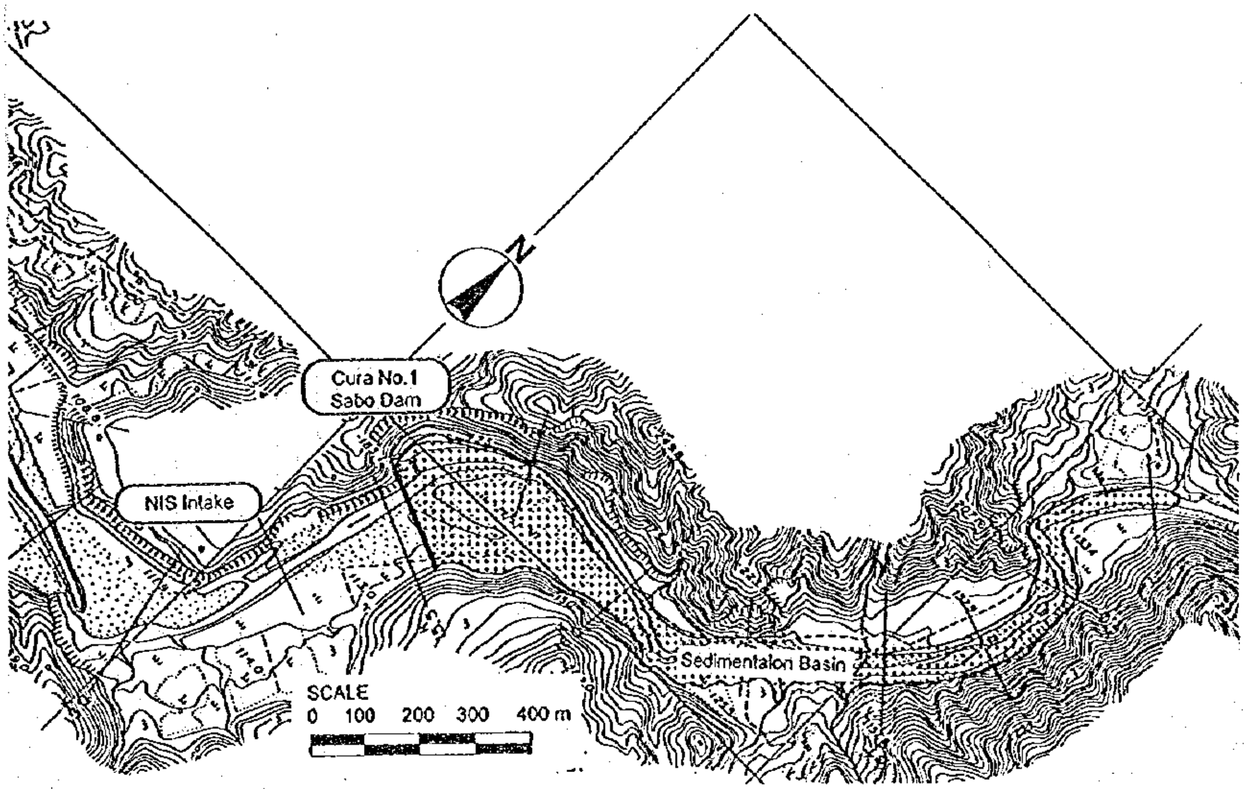
MADONGAN RIVER

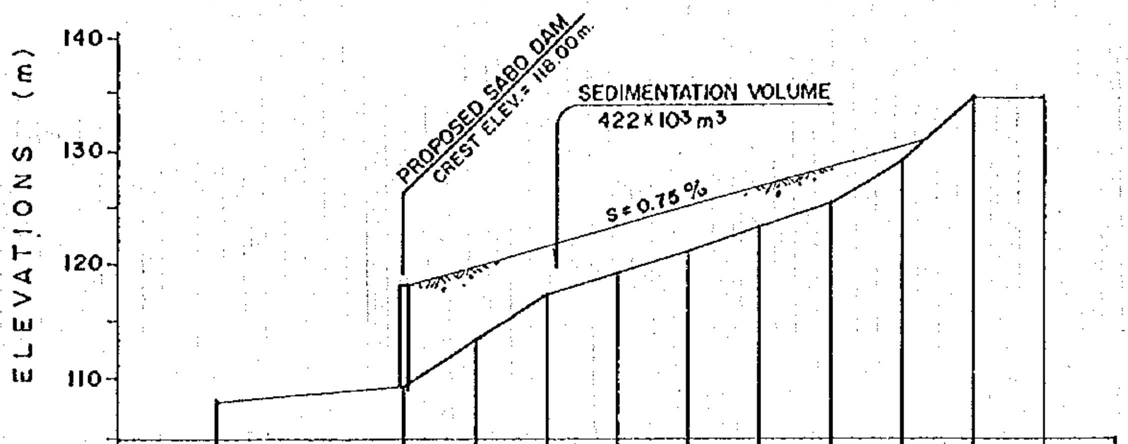
Cross-section No. (km)	Elevation (m)							High Water Gradient
	Present Average Riverbed	Future Average Riverbed	Design High Water Level	Existing Dike		Ground Level		
				Right	Left	Right	Left	
0.0	26.5	27.903	31.978	30.83	30.95	-	29.22	
0.5	28.6	29.892	33.142	32.59	31.93	29.66	30.59	0.233%
1.0	31.2	31.774	34.306	34.63	34.61	32.73	32.46	
1.5	33.5	33.918	36.975	37.00	37.44	34.21	34.89	
2.0	36.8	36.642	39.644	40.40	39.59	38.40	38.12	0.534%
2.5	40.1	39.927	42.313	43.63	44.54	40.64	41.04	
3.0	44.5	43.863	47.093	49.89	47.98	46.33	45.93	
3.5	48.8	48.824	51.874	52.90	52.96	49.96	50.12	0.956%
4.0	54.4	53.760	56.654	58.11	58.01	55.87	55.26	
4.5	61.3	60.255	63.513	64.43	64.22	62.68	61.74	
5.0	67.0	66.758	70.372	70.38	70.86	69.15	68.06	
5.5	74.4	73.841	77.230	77.89	78.12	76.14	75.85	
6.0	81.4	81.408	84.089	85.00	85.04	82.83	83.15	1.372%
6.5	87.9	88.346	90.948	91.51	91.74	90.57	90.15	
7.0	95.2	95.305	97.807	99.39	99.30	98.25	96.97	
7.5	102.3	101.984	104.666	106.73	105.52	104.29	103.17	
8.0	108.0	108.013	111.524	112.74	113.29	109.91	111.11	
8.5	115.0	115.171	118.383	118.35	119.30	-	-	
9.0	121.0	121.449	125.242	125.47	125.43	-	-	

Table A.4.2 Design Base Elevation for Toe Protection

Kilo-post (km)	Average Riverbed (m)	Structural Base (m)	Kilo-post (km)	Average Riverbed (m)	Structural Base (m)	Kilo-post (km)	Average Riverbed (m)	Structural Base (m)
Cura			Solsona			Madongan (continuation)		
0.0	23.49	21.29	0.0	24.00	21.80	3.5	48.80	46.30
0.5	25.05	22.85	0.5	25.30	23.10	4.0	53.76	50.76
1.0	26.33	24.13	1.0	26.13	23.93	4.5	60.26	57.26
1.5	27.60	25.40	1.5	26.50	24.30	5.0	66.76	63.76
2.0	28.89	26.69	2.0	27.40	25.20	5.5	73.84	70.84
2.5	30.42	28.22	2.5	28.50	26.30	6.0	81.40	78.40
3.0	32.29	30.09	3.0	29.30	27.10	6.5	87.90	84.90
3.5	33.84	31.64	3.5	30.30	28.10	7.0	95.20	92.20
4.0	35.39	33.19	4.0	32.30	30.10	7.5	101.98	98.98
4.5	36.94	34.74	4.5	35.50	33.30	8.0	108.00	105.00
5.0	40.00	37.80	5.0	37.20	35.00	8.5	115.00	112.00
5.5	42.00	39.80	5.5	39.70	37.20	9.0	121.00	118.00
6.0	44.21	42.01	6.0	43.70	41.20	Papa		
6.5	46.47	44.27	6.5	48.20	45.70	0.0	41.80	39.60
7.0	49.64	47.44	7.0	52.99	50.49	0.5	44.50	42.30
7.5	52.75	50.55	7.5	59.60	56.30	1.0	47.20	44.70
8.0	55.67	53.47	8.0	66.60	63.30	1.5	51.50	49.00
8.5	58.94	56.74	8.5	74.40	71.10	2.0	55.10	52.60
9.0	62.32	60.12	9.0	81.60	78.30	2.5	59.50	57.00
9.5	65.87	63.67	9.5	89.70	86.40	3.0	64.20	61.70
10.0	69.35	67.15	10.0	96.70	93.40	3.5	69.30	66.80
10.5	72.38	70.18	10.5	102.90	99.60	4.0	76.09	72.79
11.2	79.33	77.13	Madongan			4.5	83.08	79.78
11.85	82.00	79.80	0.0	26.50	24.30	5.0	92.20	88.90
Labugaon			0.5	28.60	26.40	5.5	100.60	97.30
0.0	77.99	75.49	1.0	31.20	29.00	6.0	109.71	106.41
0.5	82.13	79.63	1.5	33.50	31.30	6.5	119.80	116.50
1.0	87.67	85.17	2.0	36.64	34.14	7.0	128.70	125.40
1.5	92.49	89.99	2.5	39.93	37.43			
2.0	97.71	95.21	3.0	43.86	41.36			

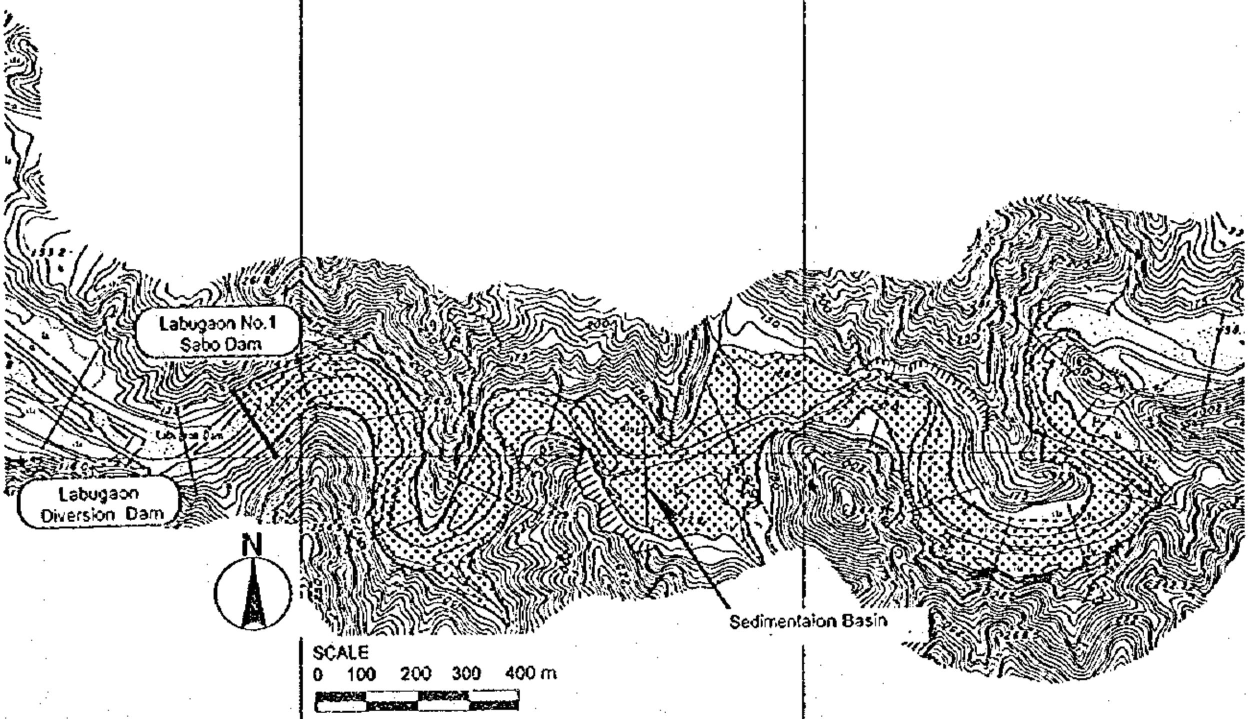
FIGURES

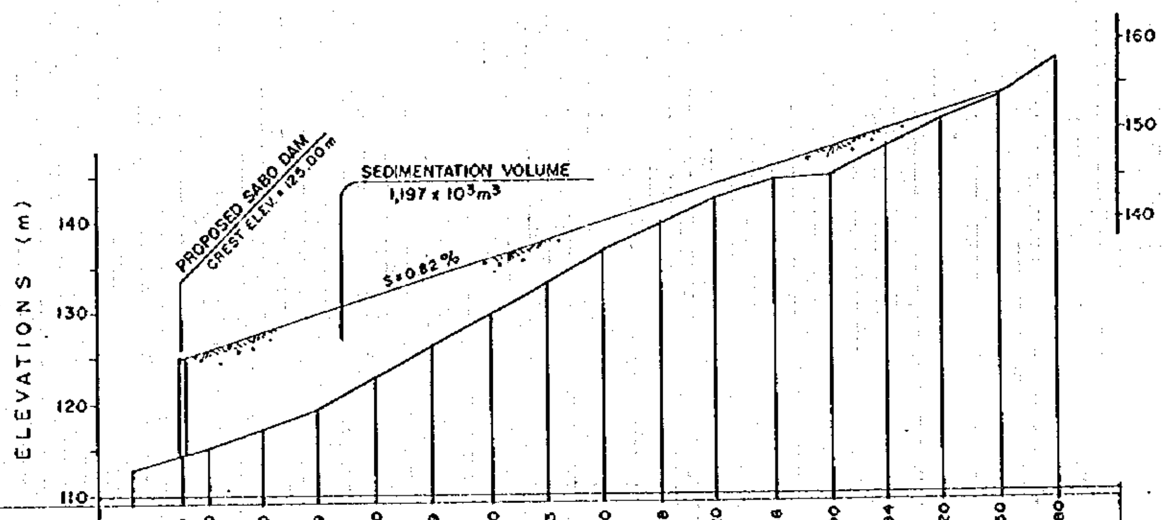




RIVER BED ELEVATION (m.)	108.04	109.45	113.50	117.44	119.30	121.10	123.50	125.26	129.50	134.80	134.80
CUMMULATIVE DISTANCE (m.)	14,860	15,550	15,750	16,000	16,250	16,500	16,750	17,000	17,250	17,500	17,750
DISTANCE (m.)	0	690	200	250	250	250	250	250	250	250	250
SLOPE (%)	1.00										

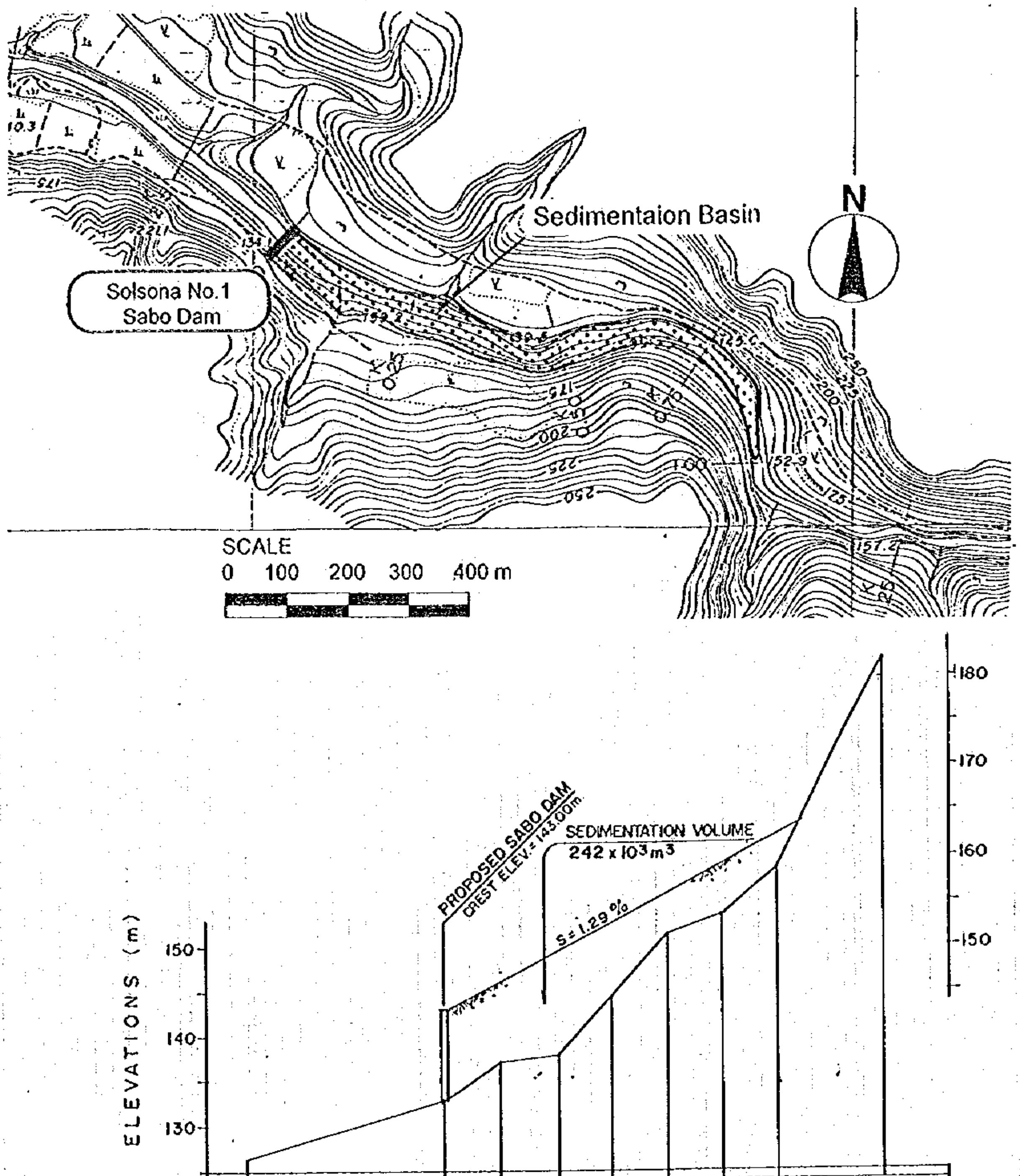
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.1.1 (1) Plan and Longitudinal Profile of Proposed Sabo Dam (Cura No.1)
JAPAN INTERNATIONAL COOPERATION AGENCY	





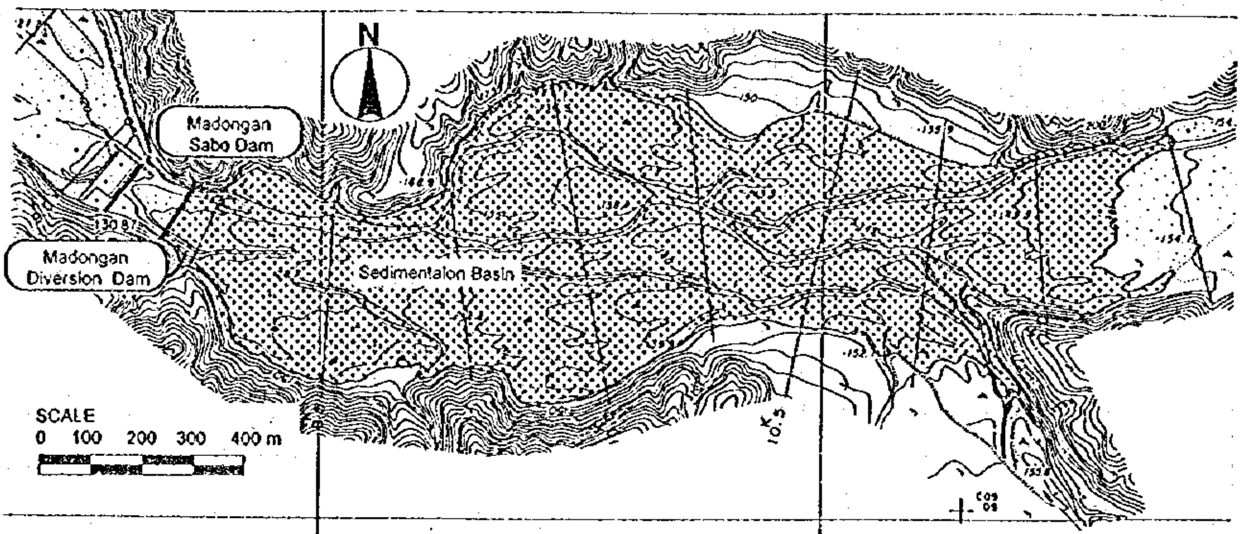
RIVER BED ELEVATION (m)	112.81	114.70	115.20	117.40	119.49	123.00	126.49	129.90	133.25	136.60	139.88	142.20	144.48	144.90	147.84	151.20	154.50	157.80
CUMMULATIVE DISTANCE (m)	3,658	3,893	4,000	4,250	4,500	4,750	5,000	5,250	5,500	5,750	6,000	6,250	6,500	6,750	7,000	7,250	7,500	7,750
DISTANCE (m)	0	235	107	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
SLOPE. (%)	1.09																	

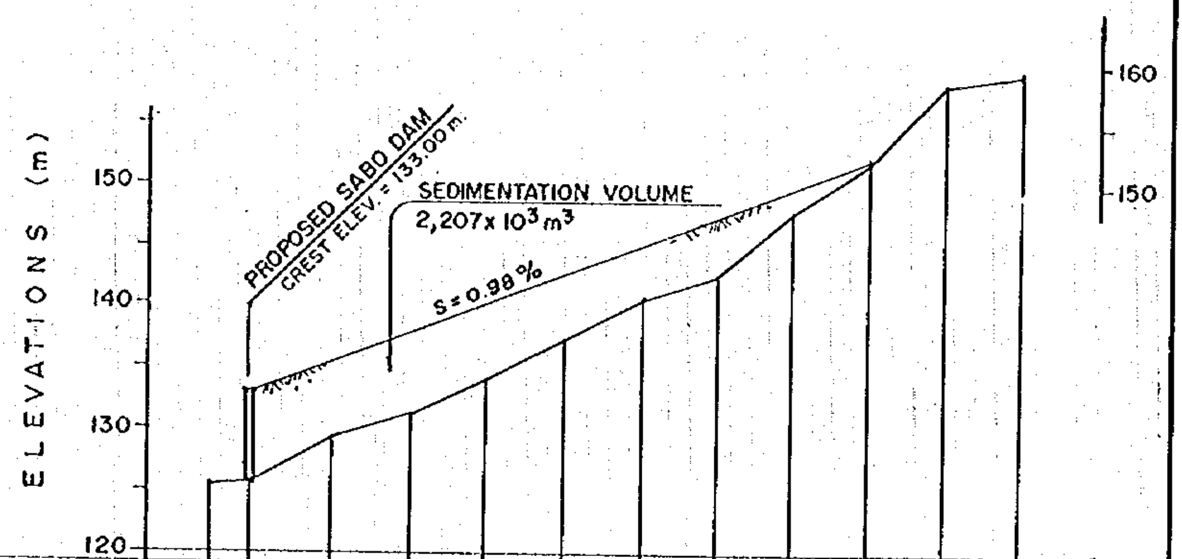
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.1.1 (2) Plan and Longitudinal Profile of Proposed Sabo Dam (Labugaon No.1)



RIVER BED ELEVATION (m)	126.31	132.99	137.10	138.11	144.17	151.44	153.74	158.75	181.15
CUMMULATIVE DISTANCE (m)	12,060	12,970	13,220	13,470	13,720	13,970	14,220	14,470	14,960
DISTANCE (m.)	0	870	250	250	250	250	250	250	490
SLOPE (%)	1.72								

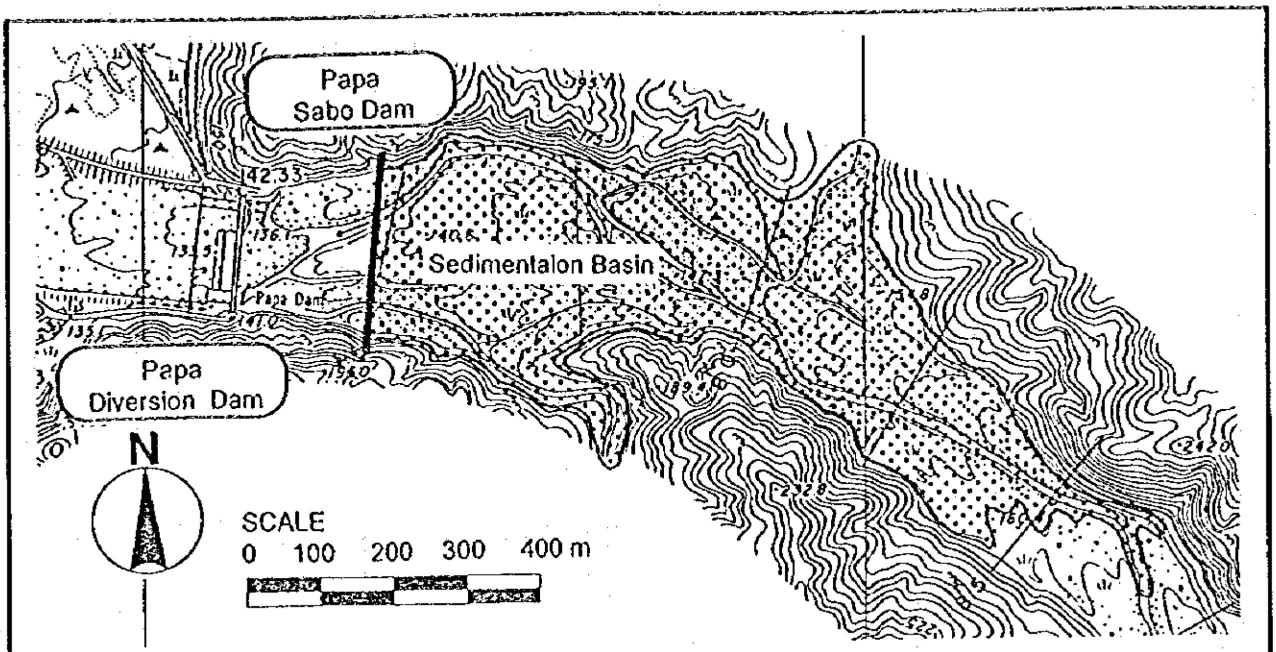
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.1.1 (3) Plan and Longitudinal Profile of Proposed Sabo Dam (Solsona No.1)

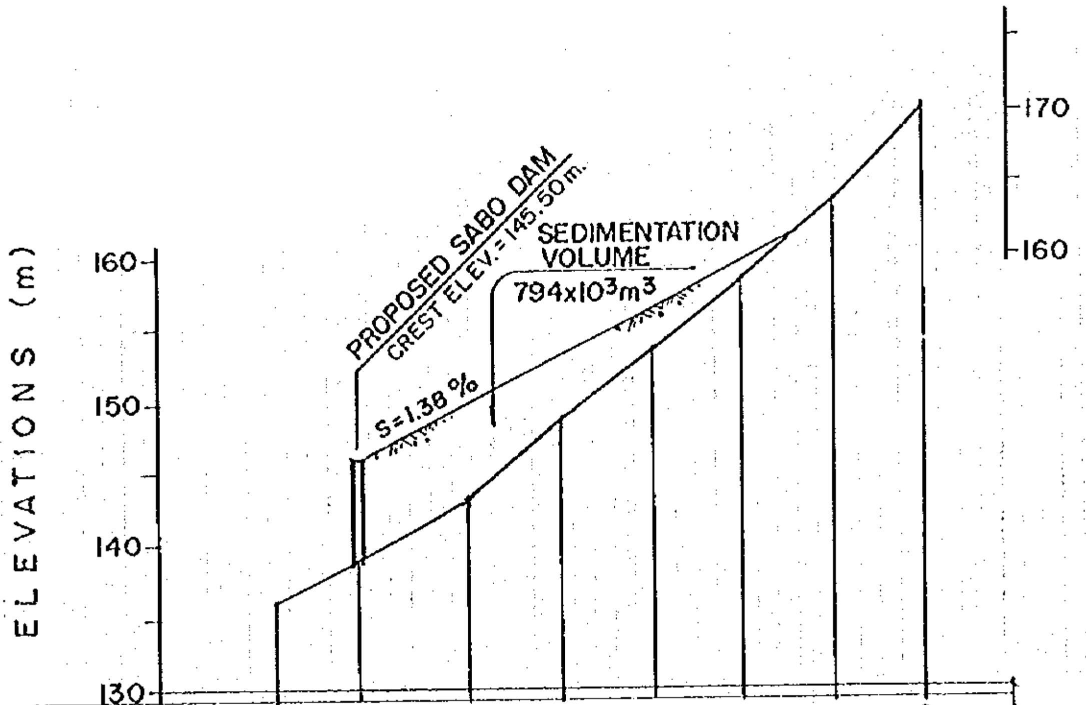




RIVER BED ELEVATION (m.)	125.34	125.46	129.99	131.50	134.09	137.40	140.94	142.80	147.36	151.80	158.52	159.40
CUMMULATIVE DISTANCE (m.)	9,095	9,228	9,500	9,750	10,000	10,250	10,500	10,750	11,000	11,250	11,500	11,750
DISTANCE (m.)	0	133	272	250	250	250	250	250	250	250	250	250
SLOPE (%)	1.30											

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.1.1 (4)
JAPAN INTERNATIONAL COOPERATION AGENCY	Plan and Longitudinal Profile of Proposed Sabo Dam (Madongan)



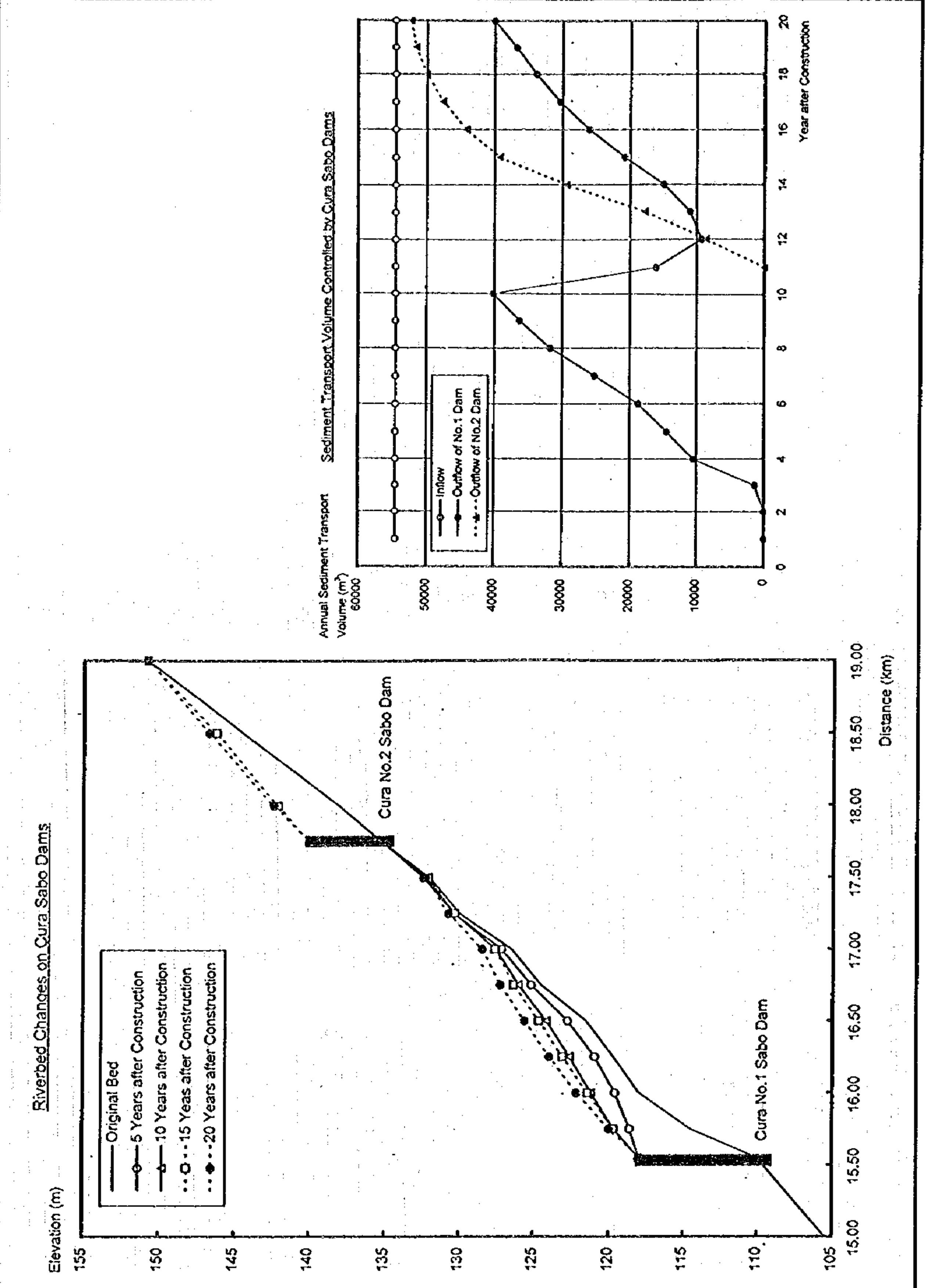


RIVER BED ELEVATION (m.)	136.06	138.99	142.60	148.43	153.30	158.12	163.60	169.99
CUMMULATIVE DISTANCE (m.)	7,237	7,455	7,750	8,000	8,250	8,500	8,750	9,000
DISTANCE (m.)	0	218	290	250	250	250	250	250
SLOPE (%)	1.84							

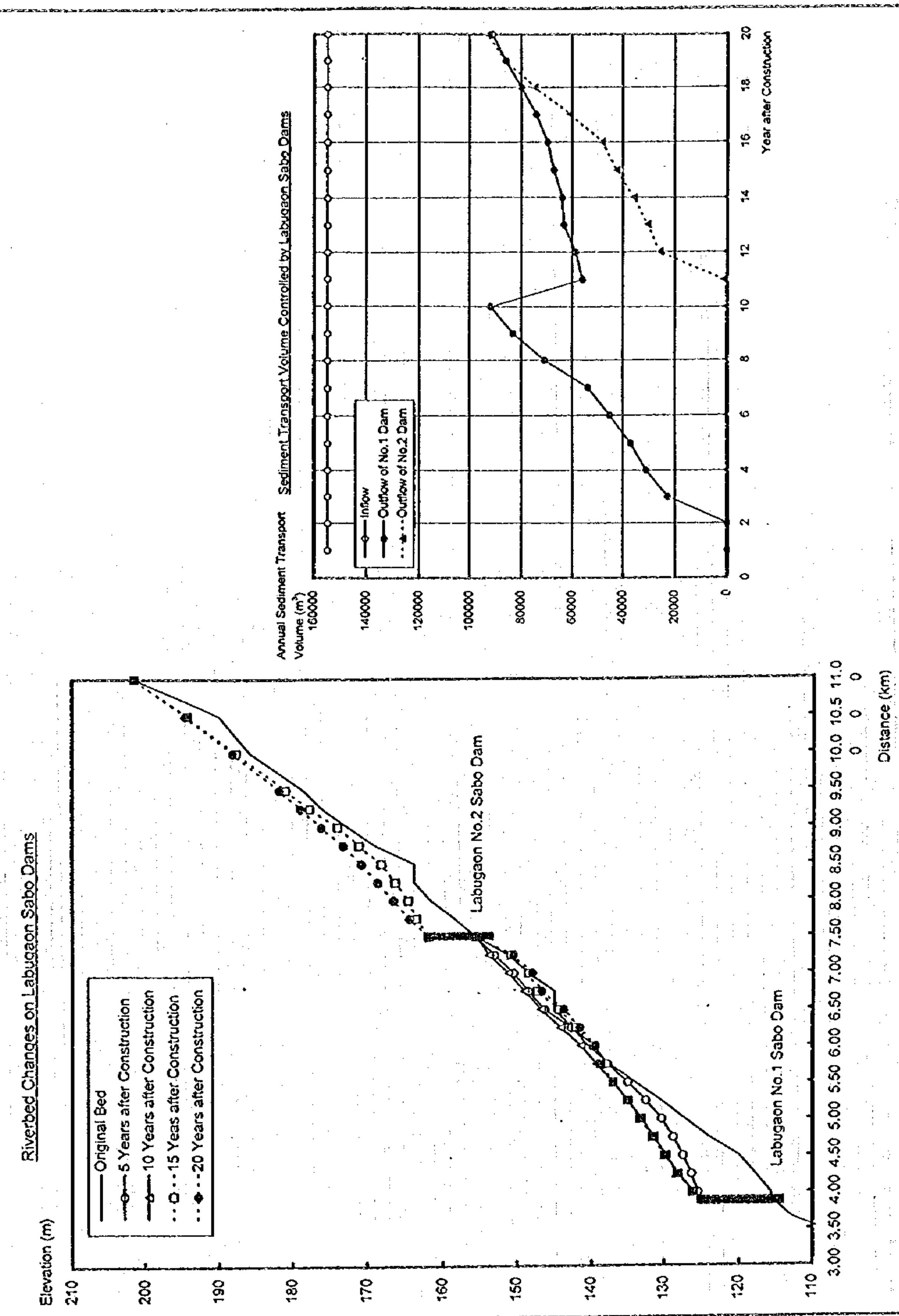
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

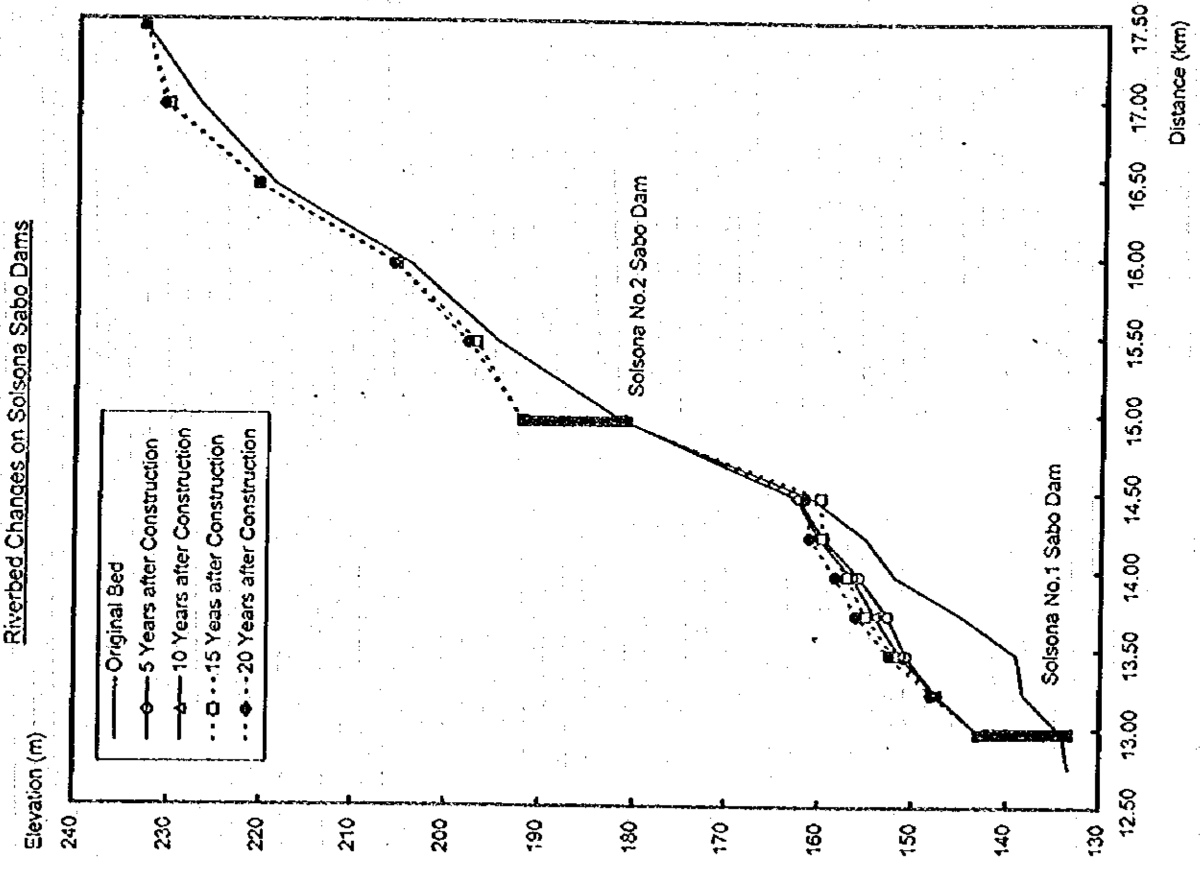
Fig. A.1.1 (5)
Plan and Longitudinal Profile of Proposed Sabo Dam (Papa)

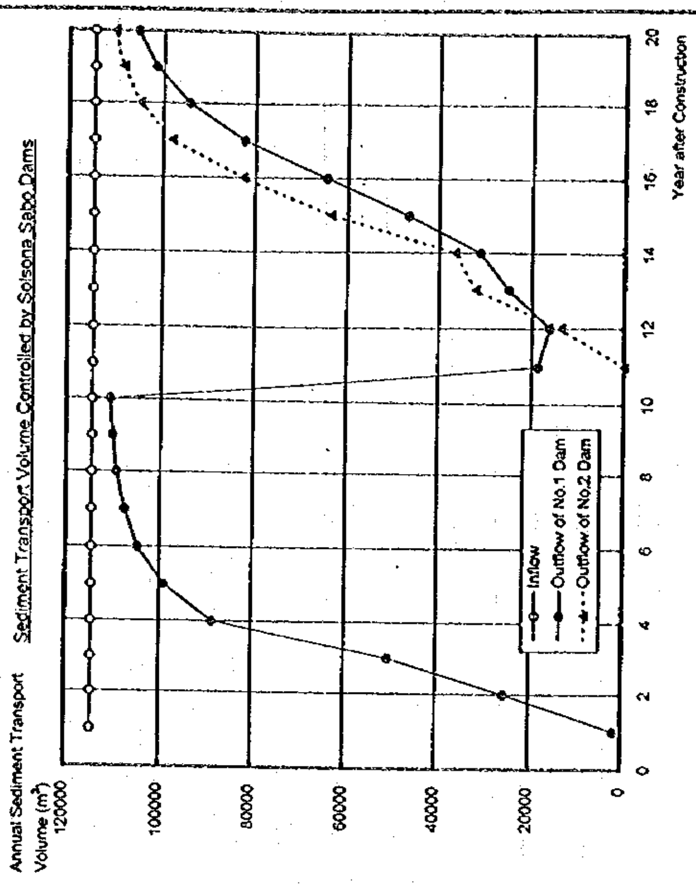


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.2.1 (1) Riverbed Variation and Sediment Control (Cura Dams)

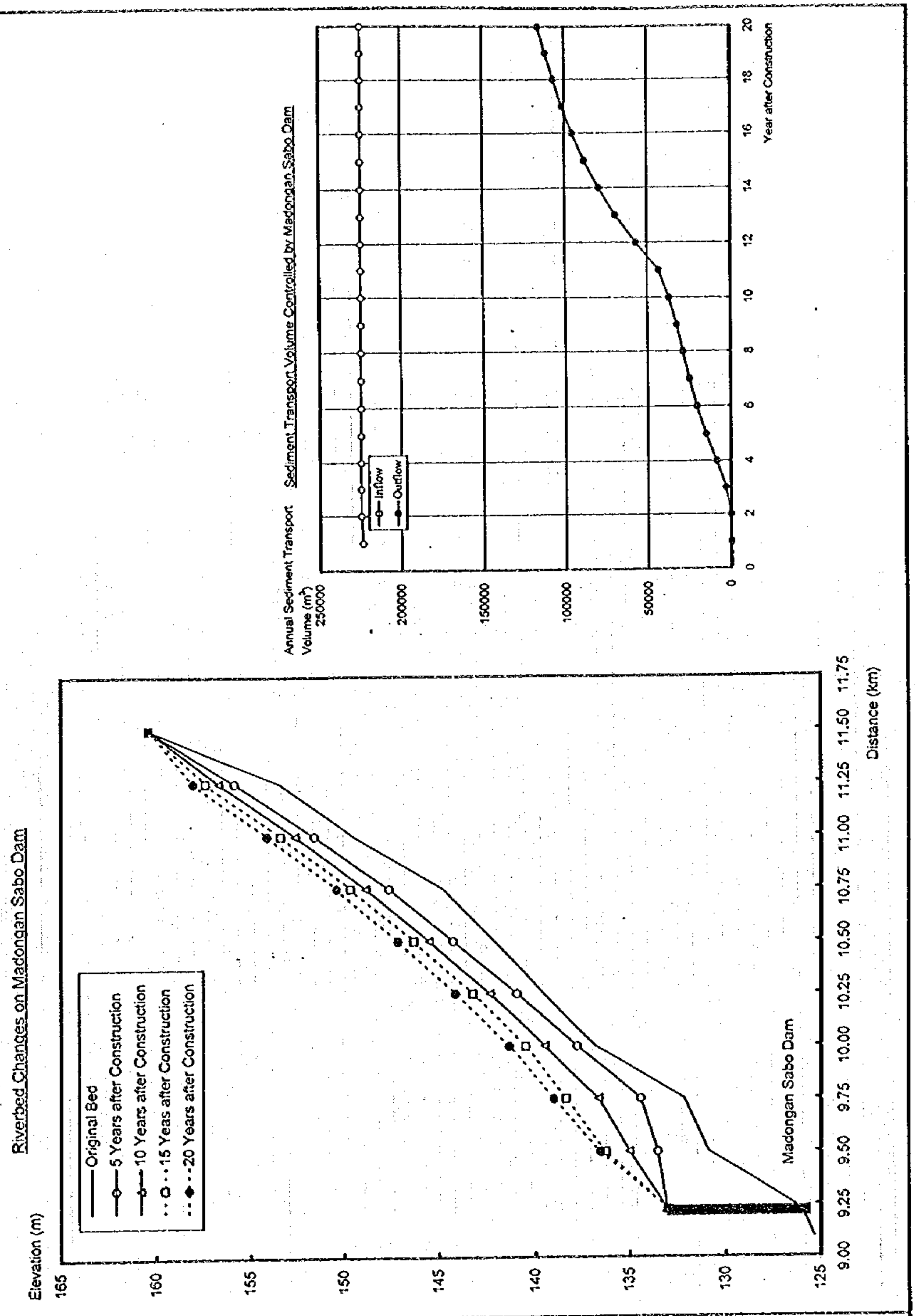


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.2.1 (2) Riverbed Variation and Sediment Control (Labugaon Dams)

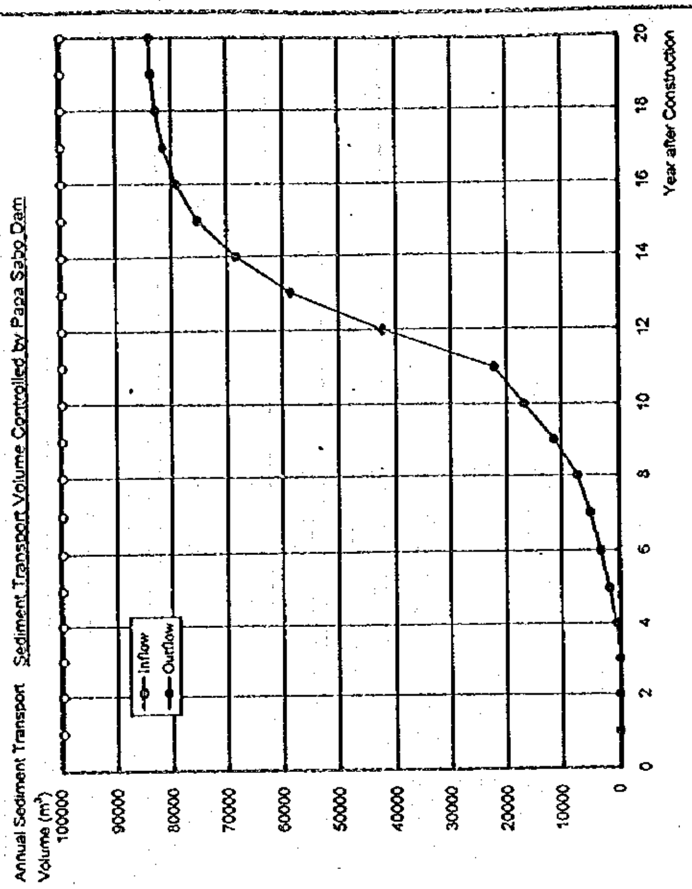


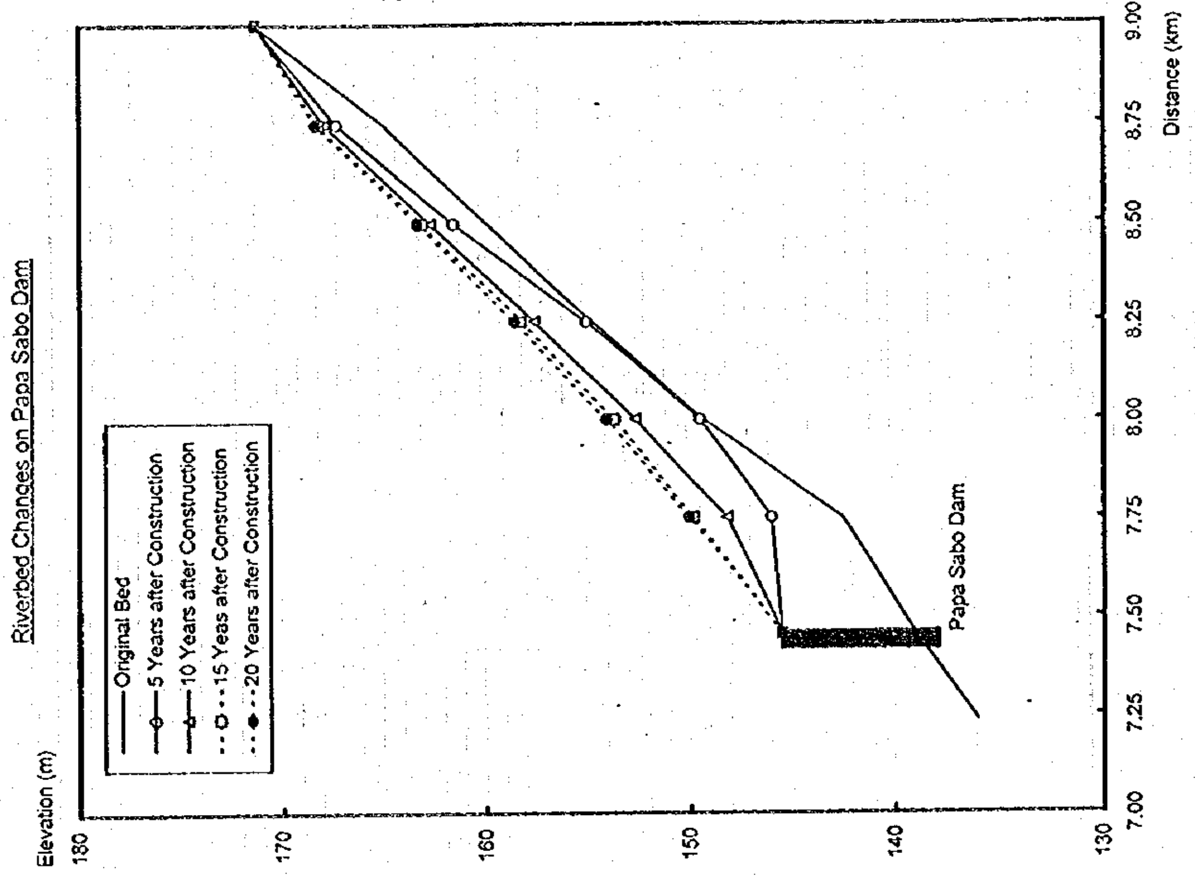


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.2.1 (3) Riverbed Variation and Sediment Control (Solsona Dams)

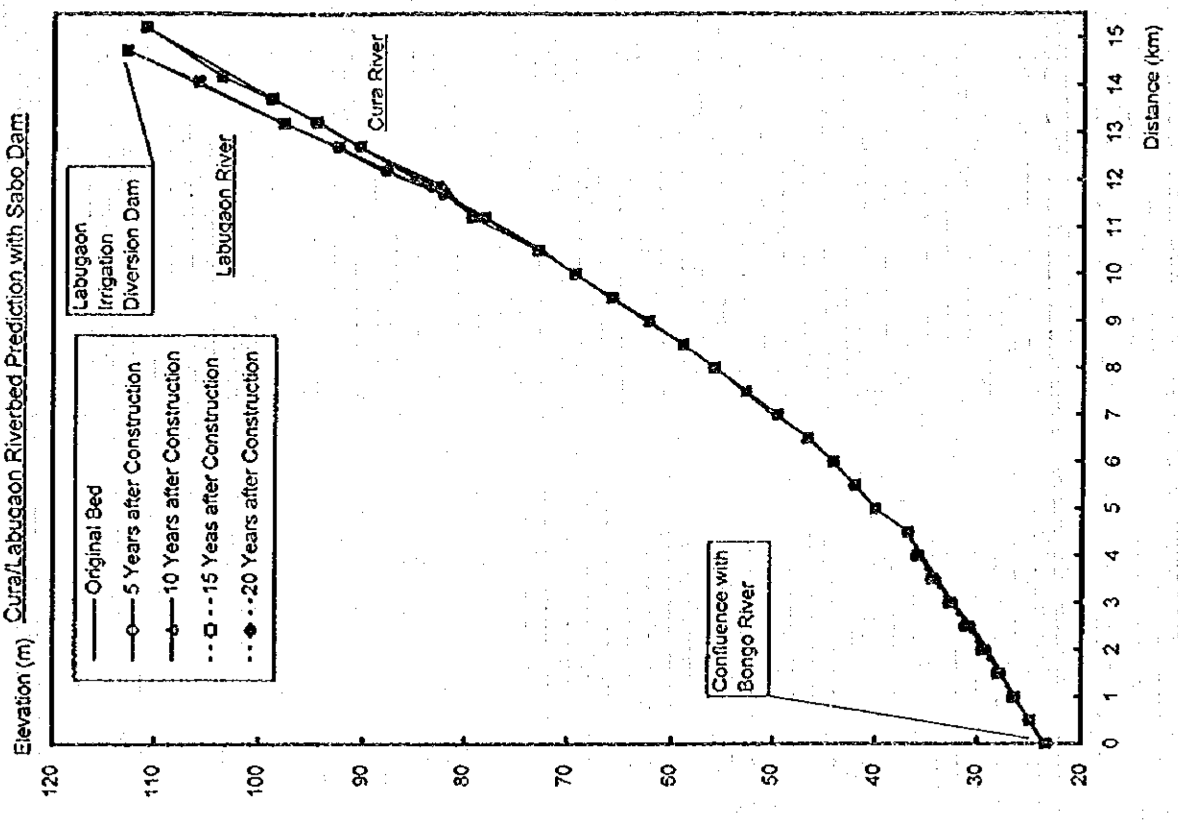


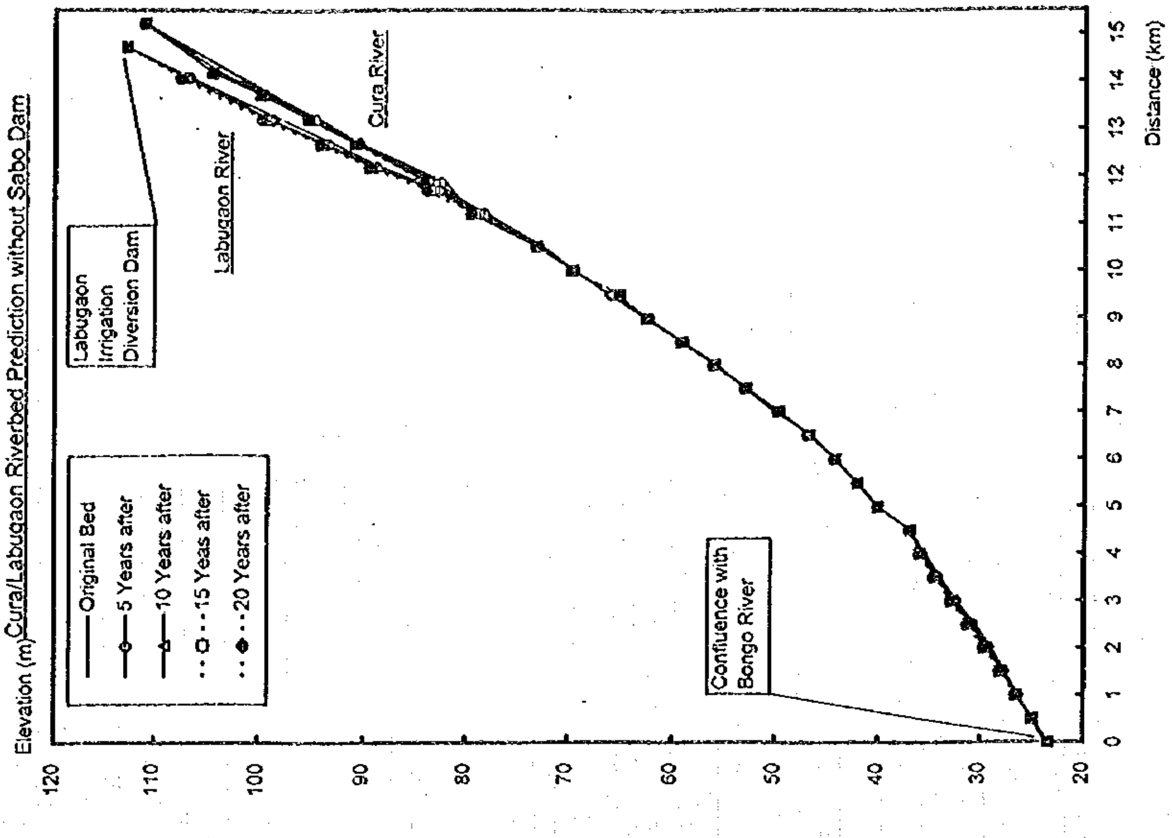
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.2.1 (4) Riverbed Variation and Sediment Control (Madongan Dams)





THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.2.1 (5) Riverbed Variation and Sediment Control (Papa Dams)

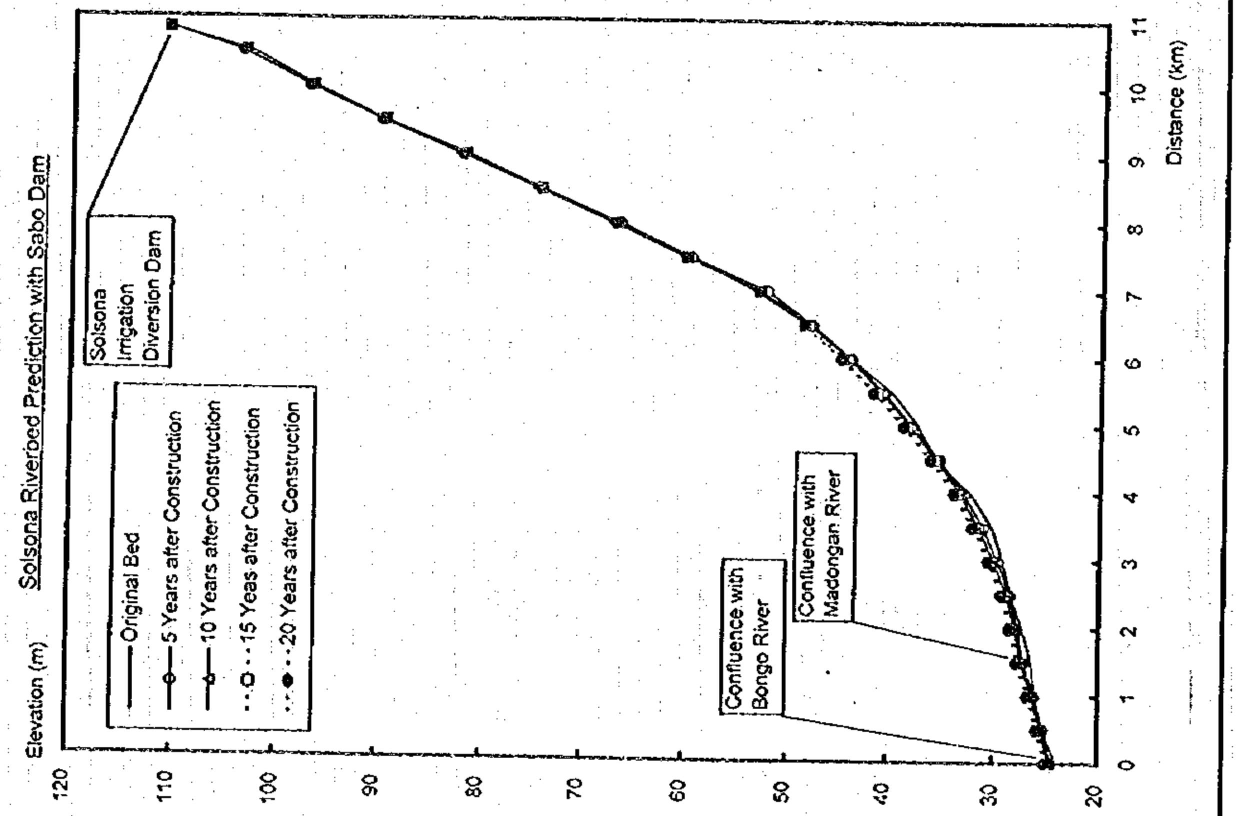


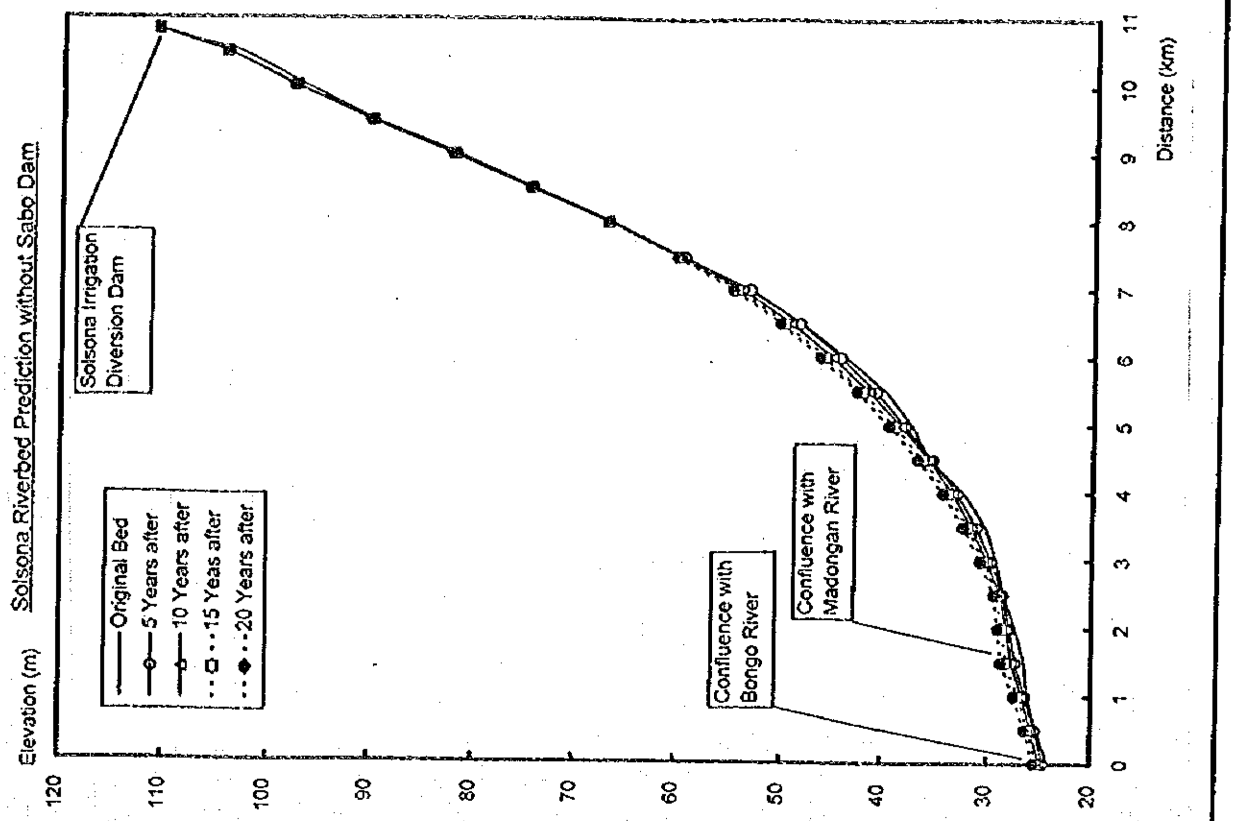


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

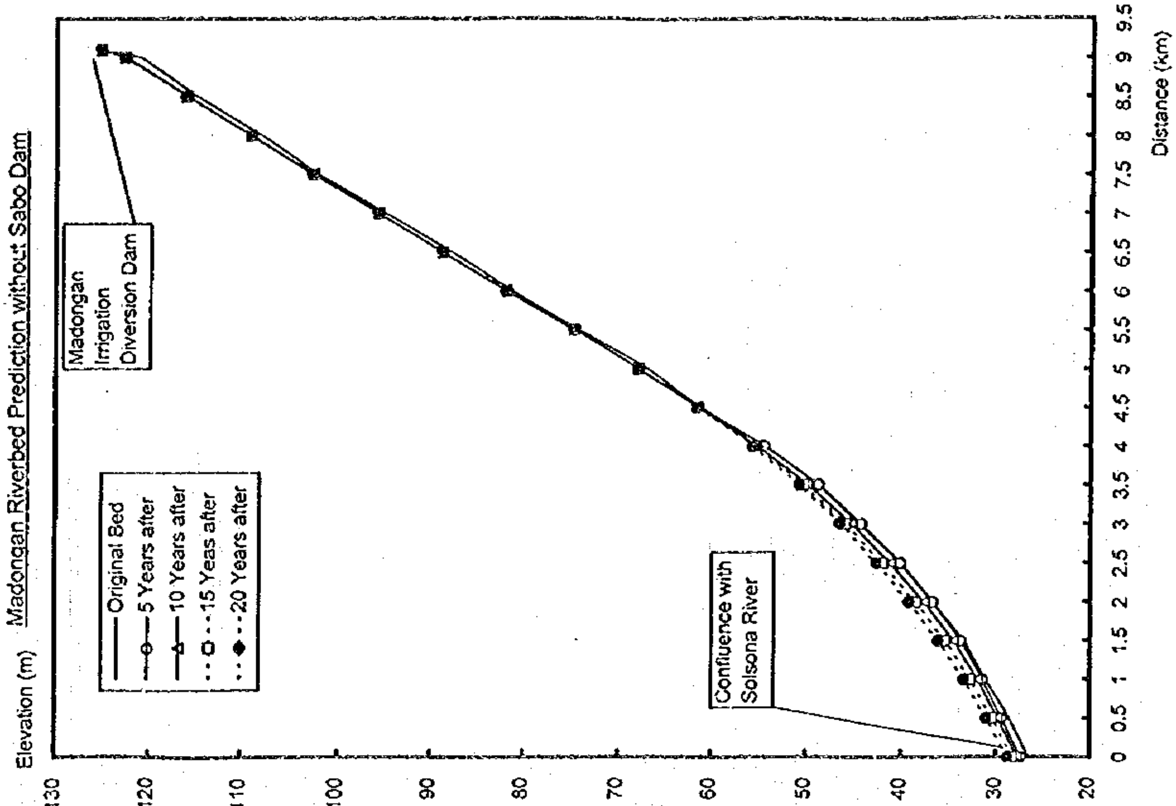
JAPAN INTERNATIONAL COOPERATION AGENCY

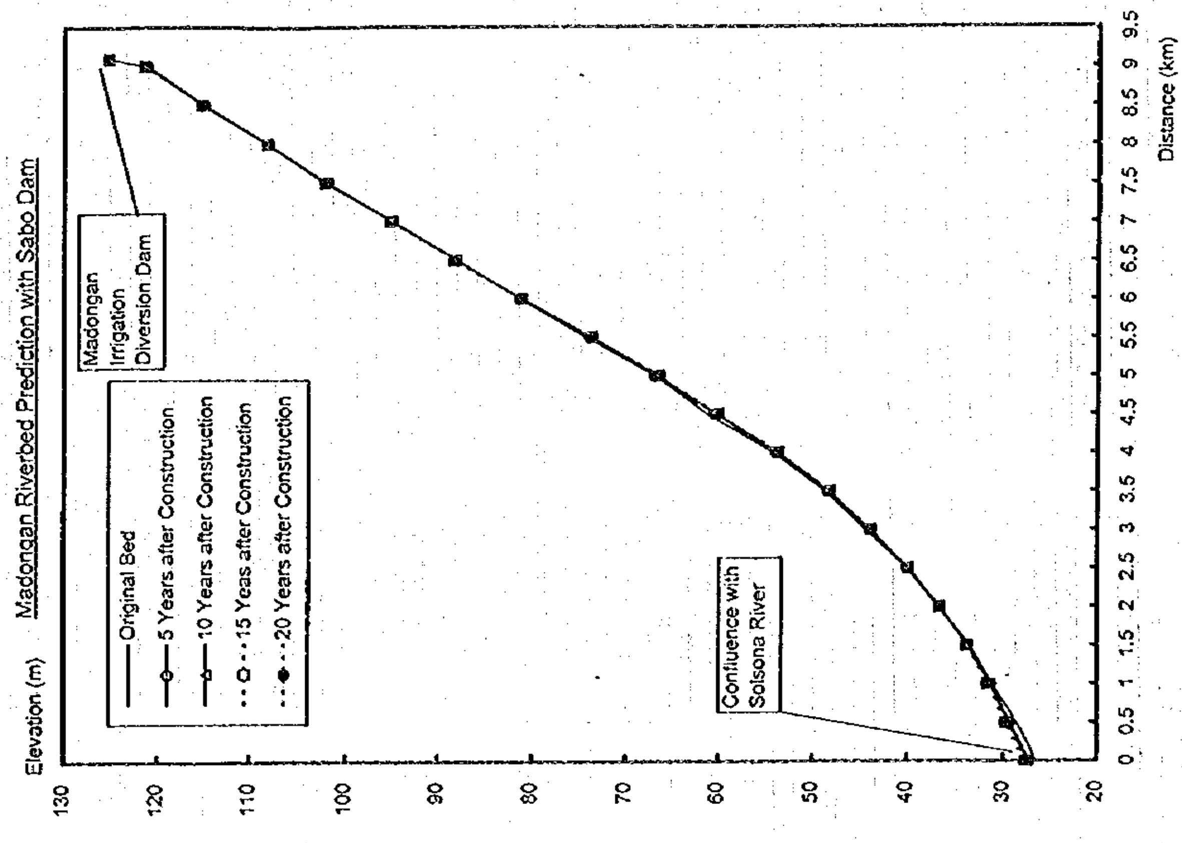
Fig. A.2.2 (1)
Riverbed Variation in Alluvial Fan River
(Cura/Labugaon River)



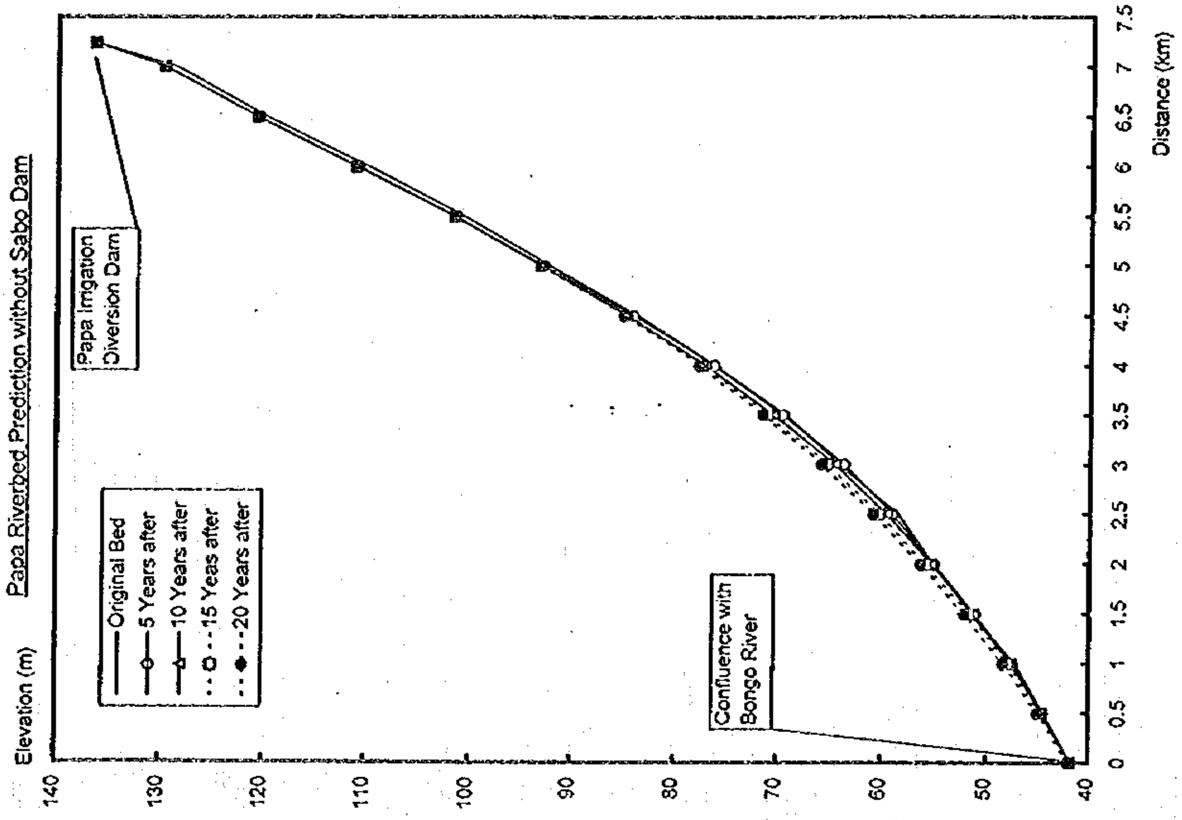


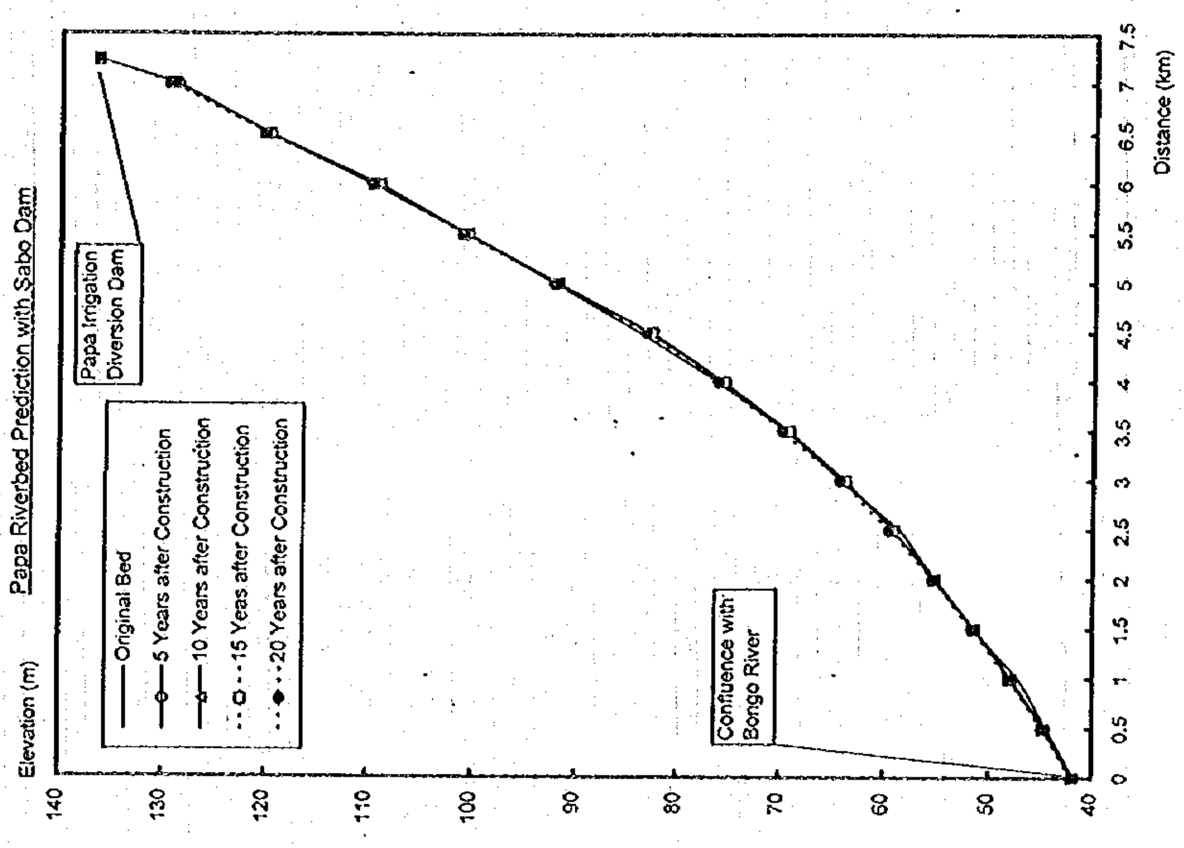
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.2.2 (2) Riverbed Variation in Alluvial Fan River (Solsona River)
JAPAN INTERNATIONAL COOPERATION AGENCY	





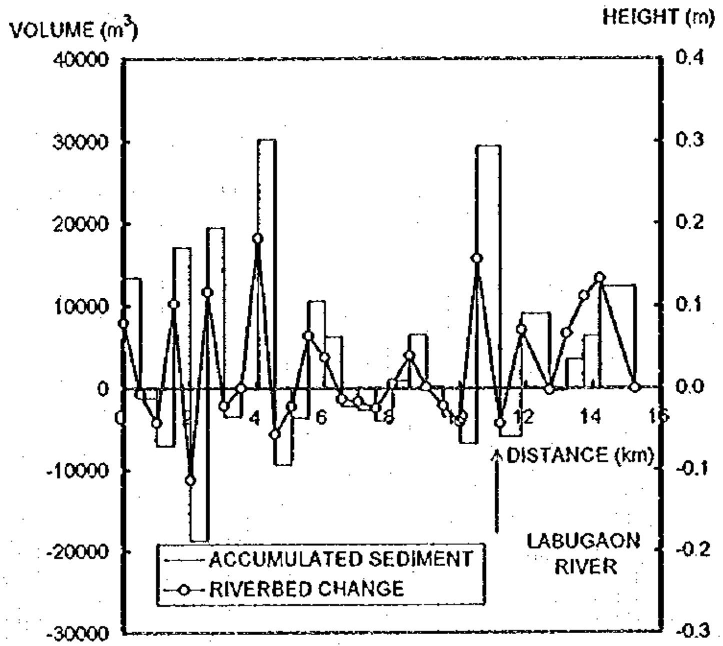
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.2.2 (3) Riverbed Variation in Alluvial Fan River (Madongan River)
JAPAN INTERNATIONAL COOPERATION AGENCY	



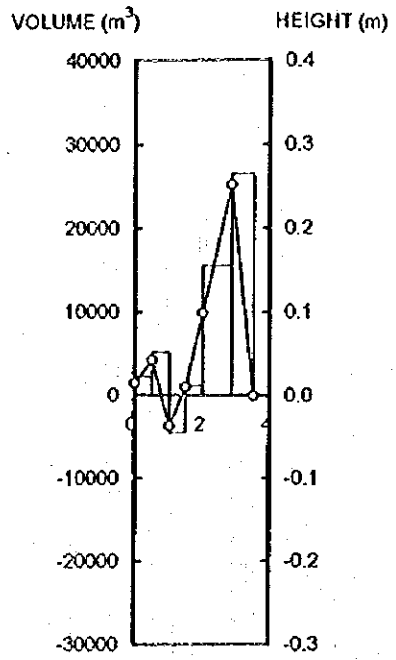


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.2.2 (4) Riverbed Variation in Alluvial Fan River (Papa River)
JAPAN INTERNATIONAL COOPERATION AGENCY	

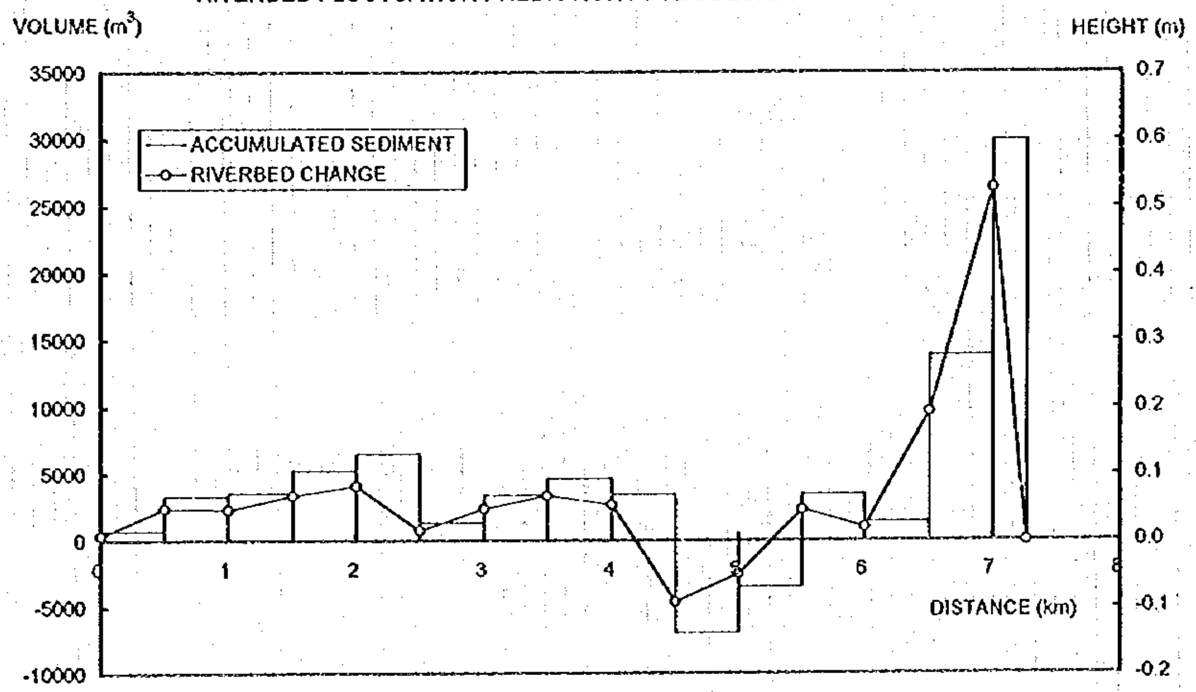
RIVERBED FLUCTUATION PREDICTION AFTER DESIGN FLOOD IN CURA RIVER



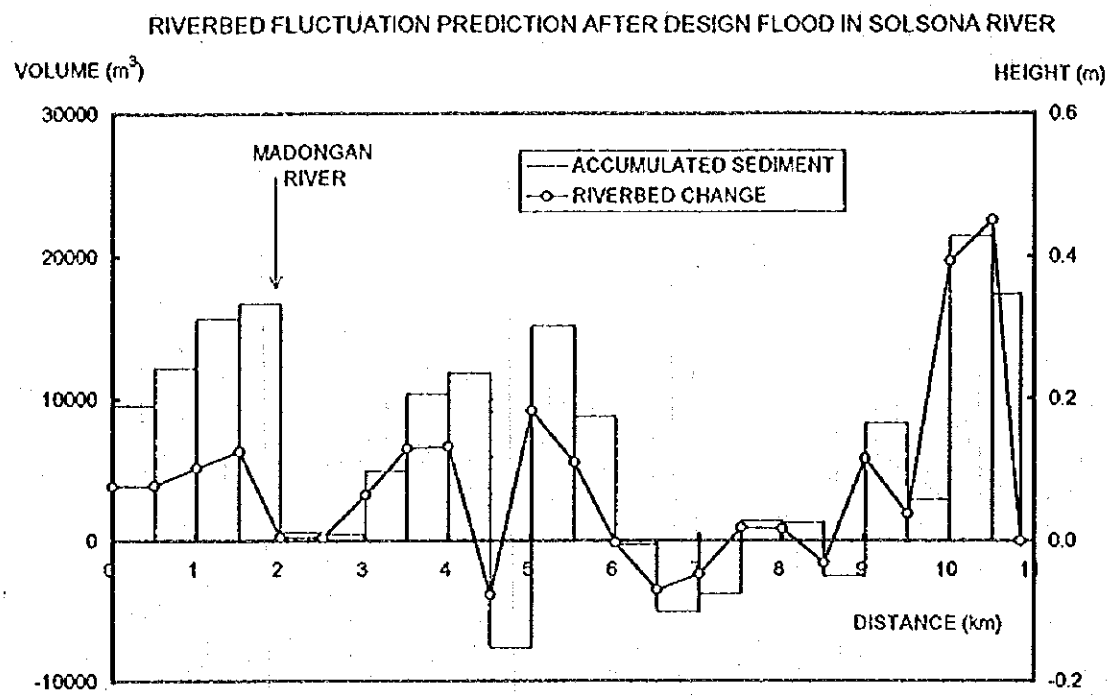
LABUGAON RIVER

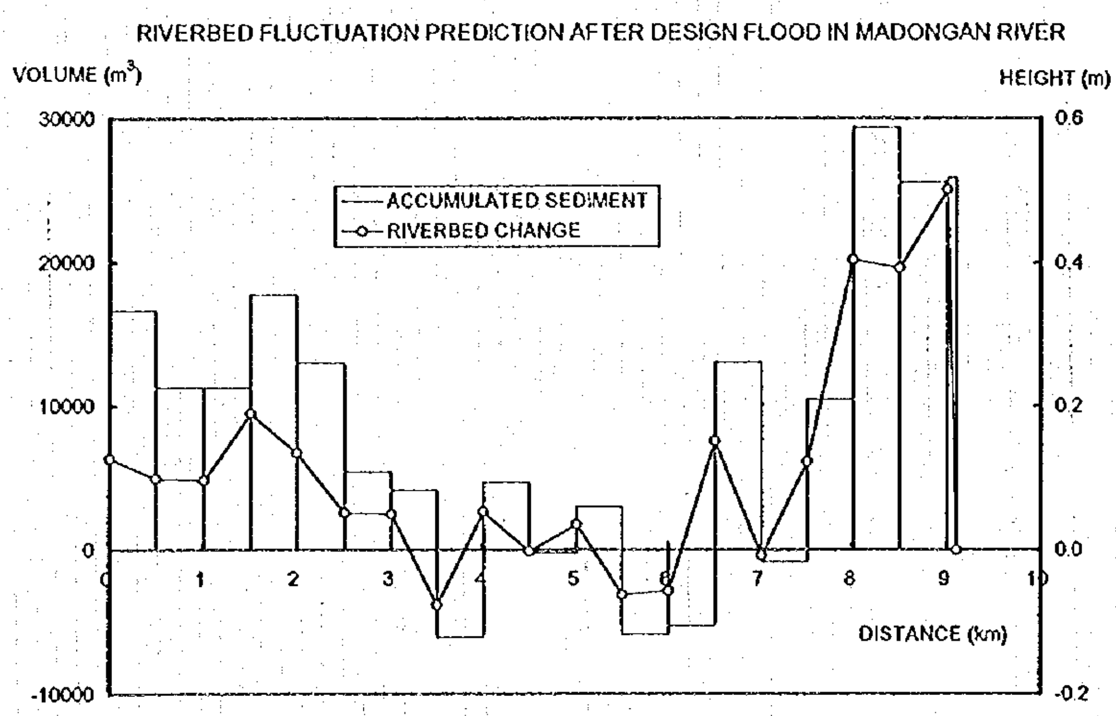


RIVERBED FLUCTUATION PREDICTION AFTER DESIGN FLOOD IN PAPA RIVER

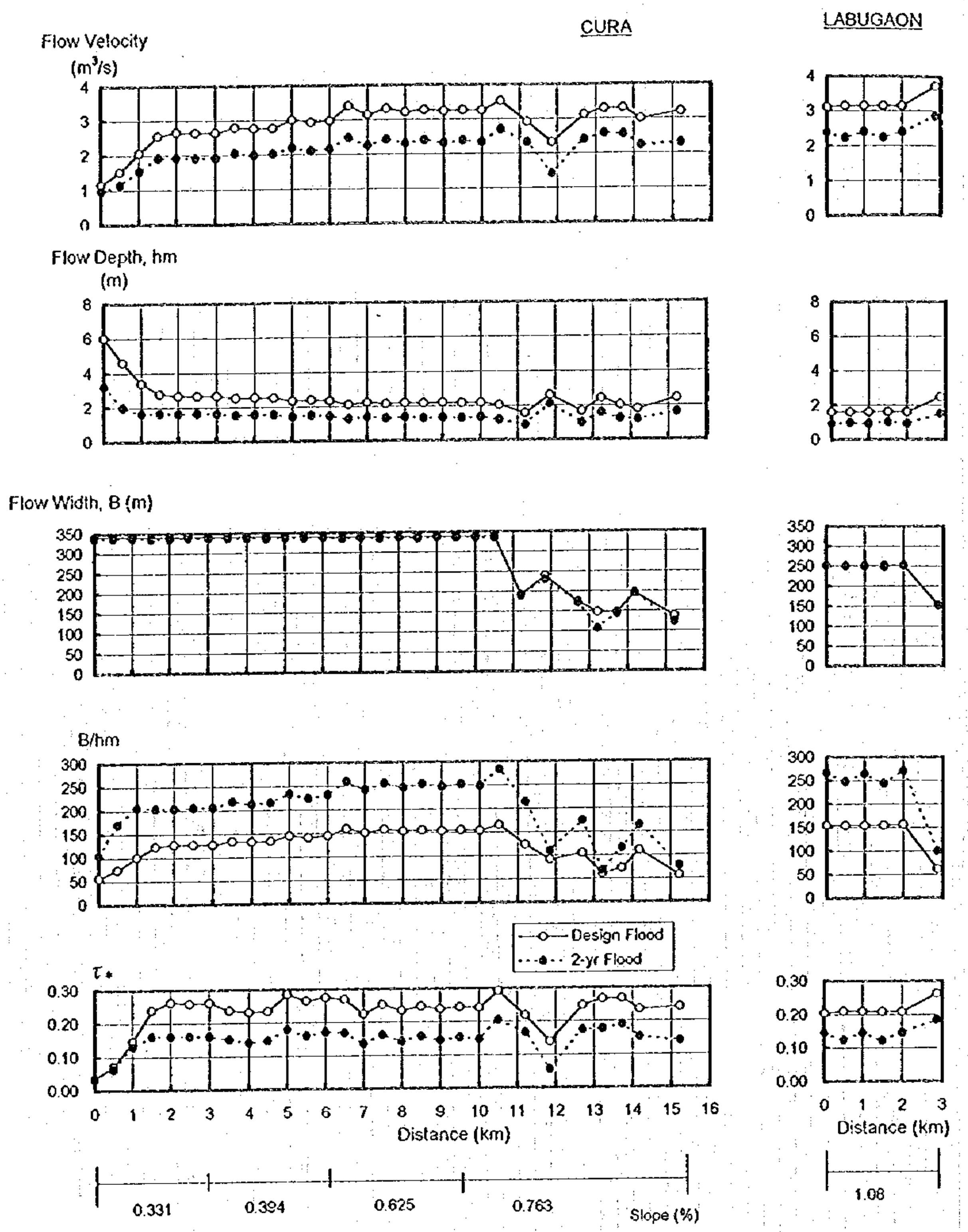


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.2.3 (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	Riverbed Variation in Design Flood (Cura/Labugaon, Papa)

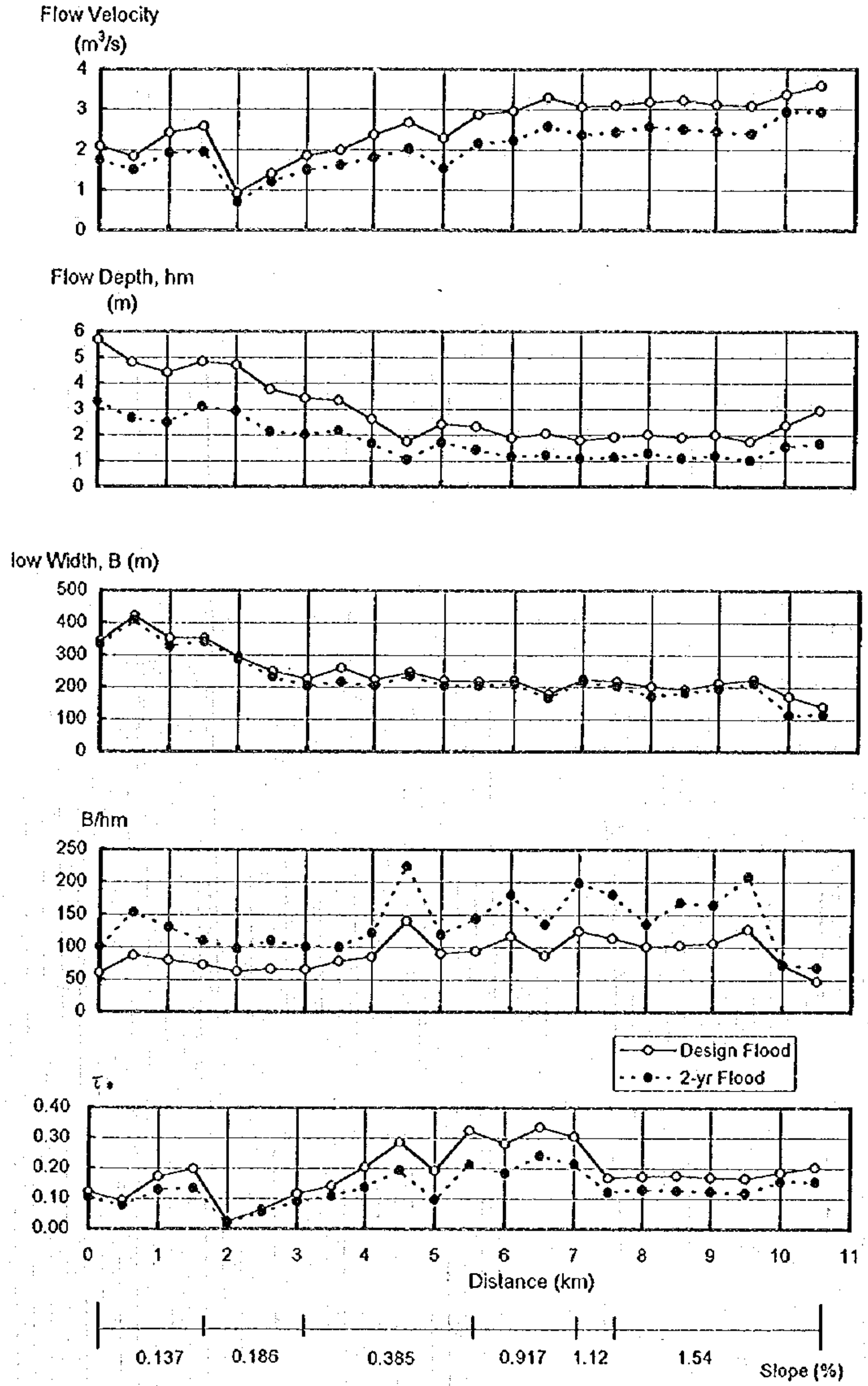




THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.2.3 (2) Riverbed Variation in Design Flood (Solsona, Madongan)



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.3.1 (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	Hydraulic Parameters in Cura/Labugaon River

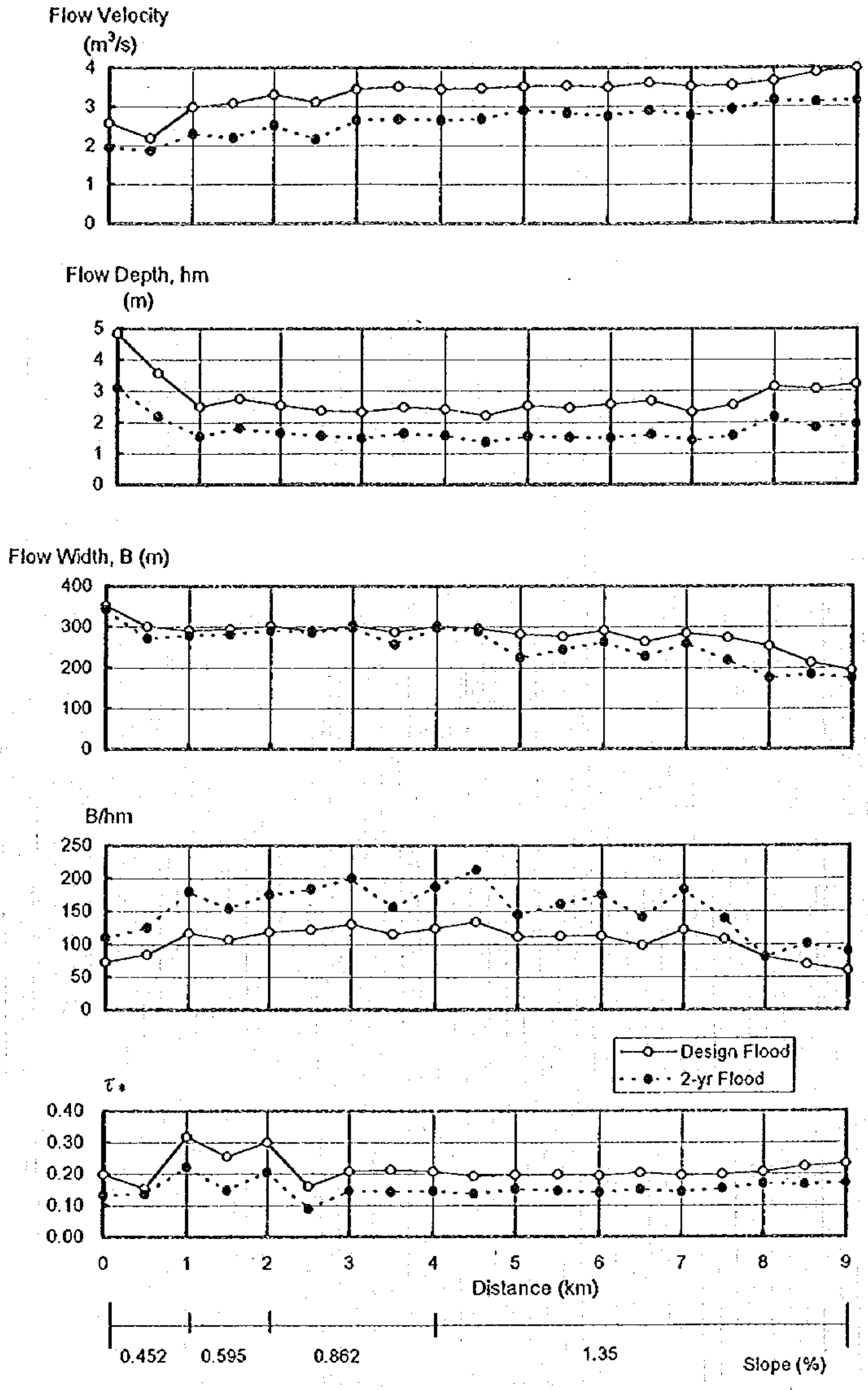


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A.3.1 (2)

Hydraulic Parameters in Solsona River

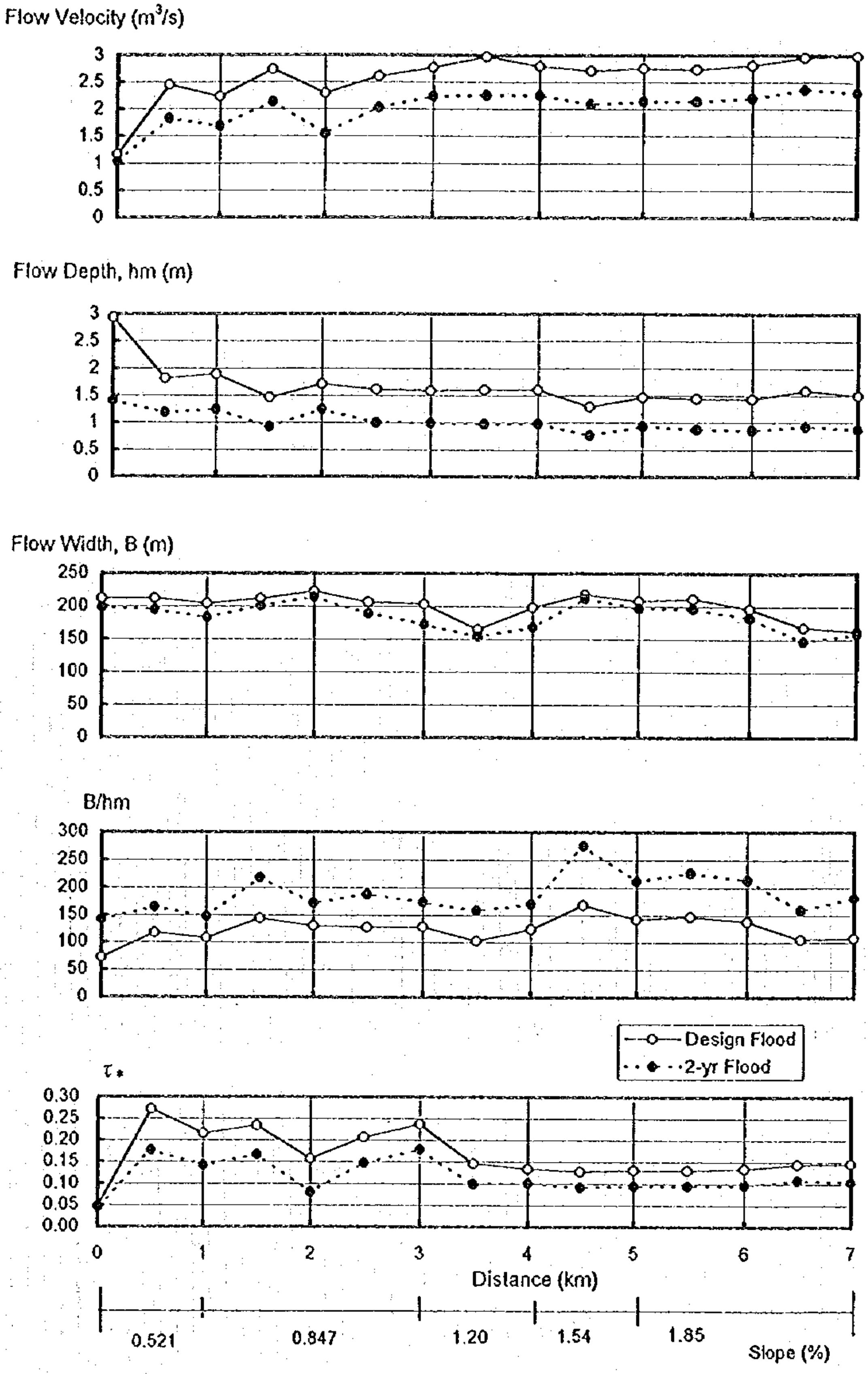


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

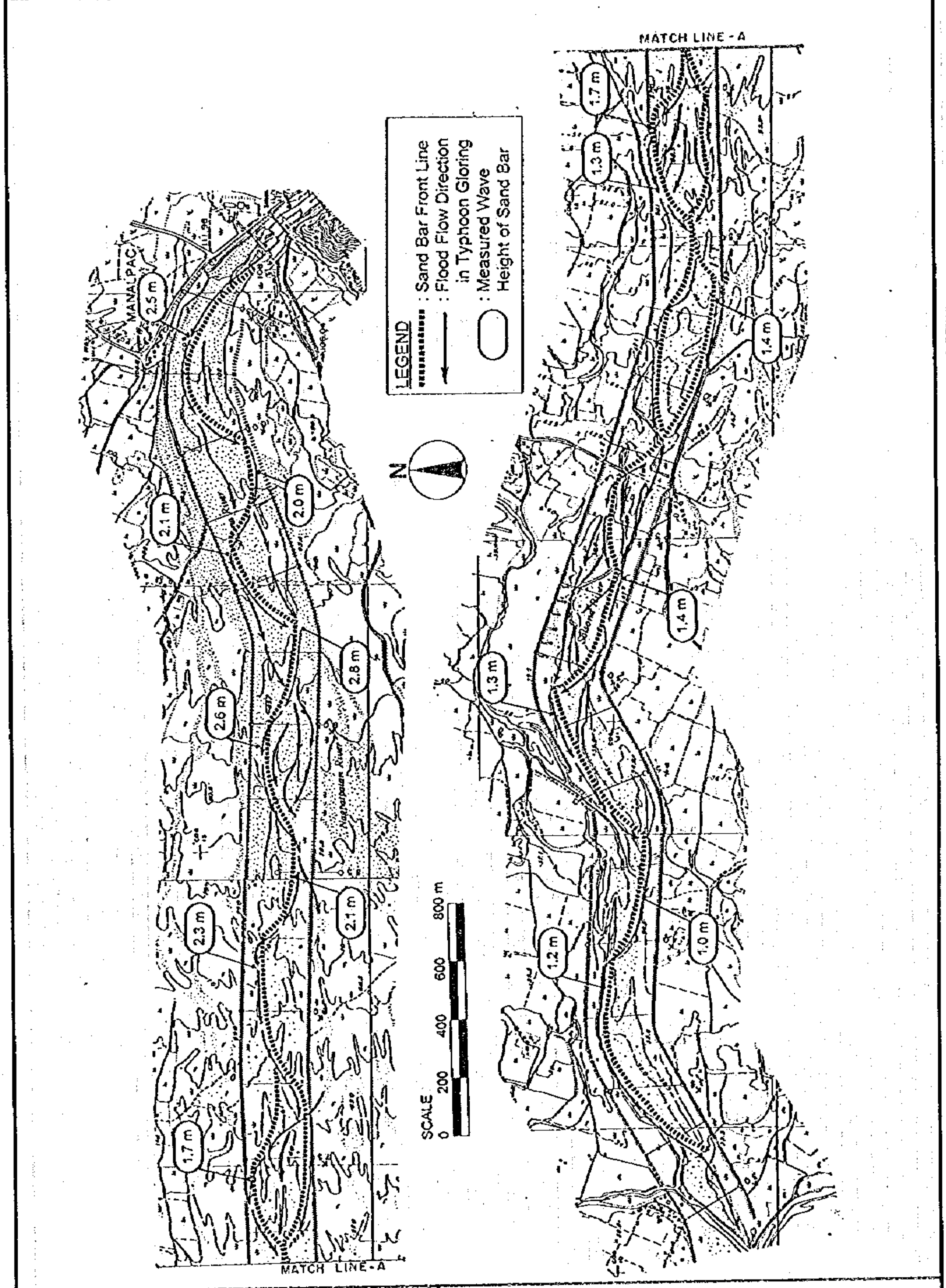
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A.3.1 (3)

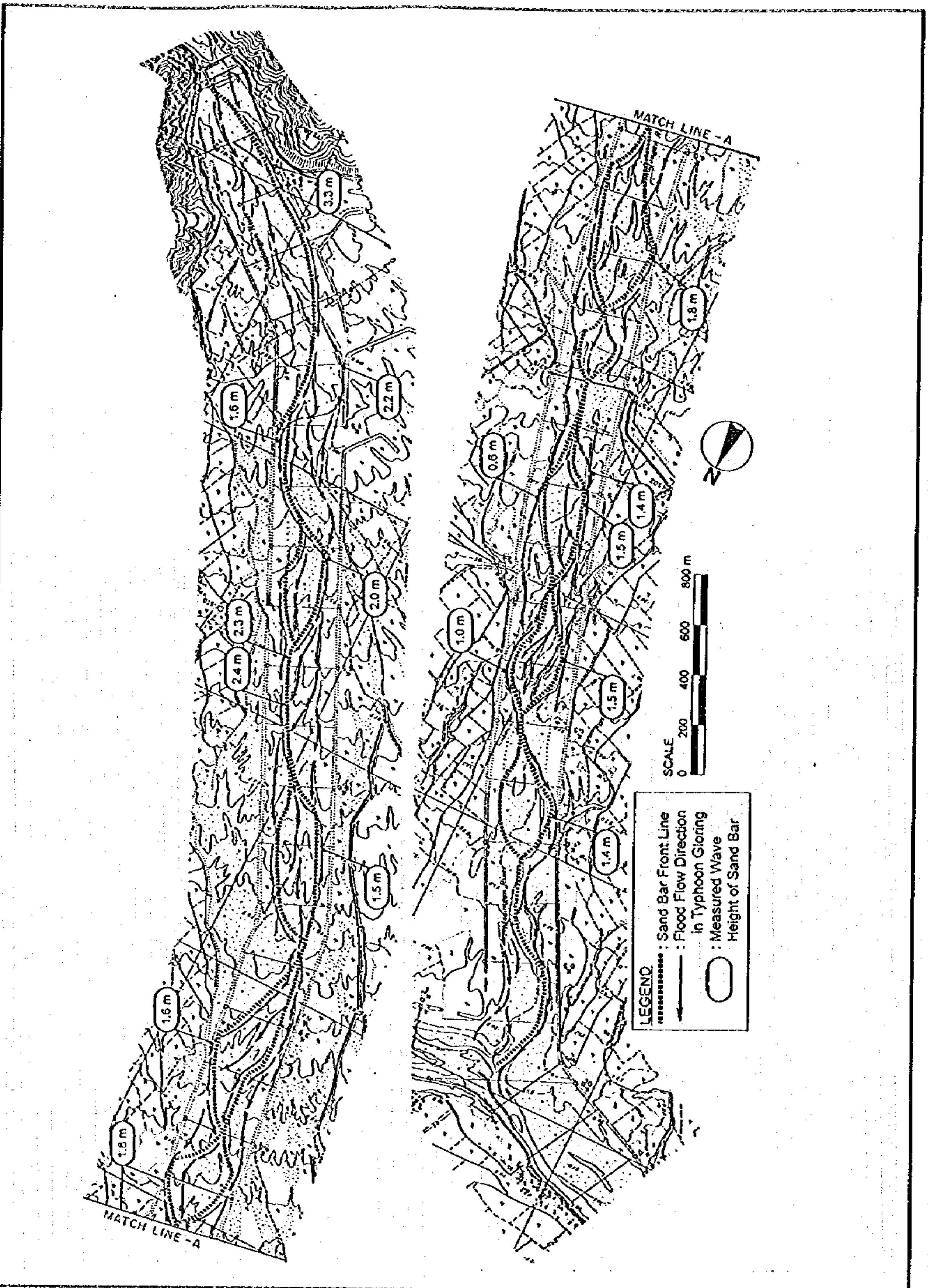
Hydraulic Parameters in Madongan River



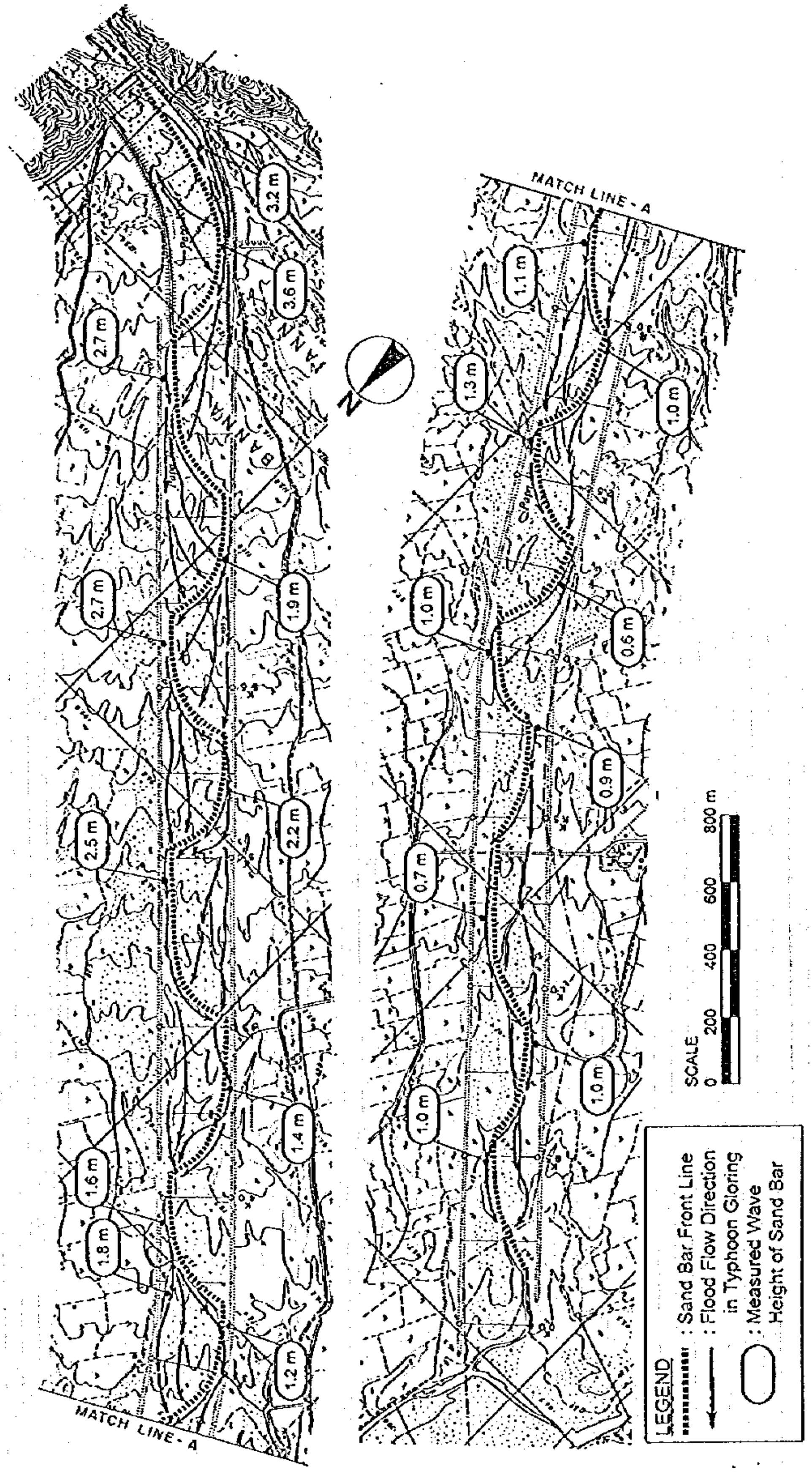
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.3.1 (4) Hydraulic Parameters in Papa River



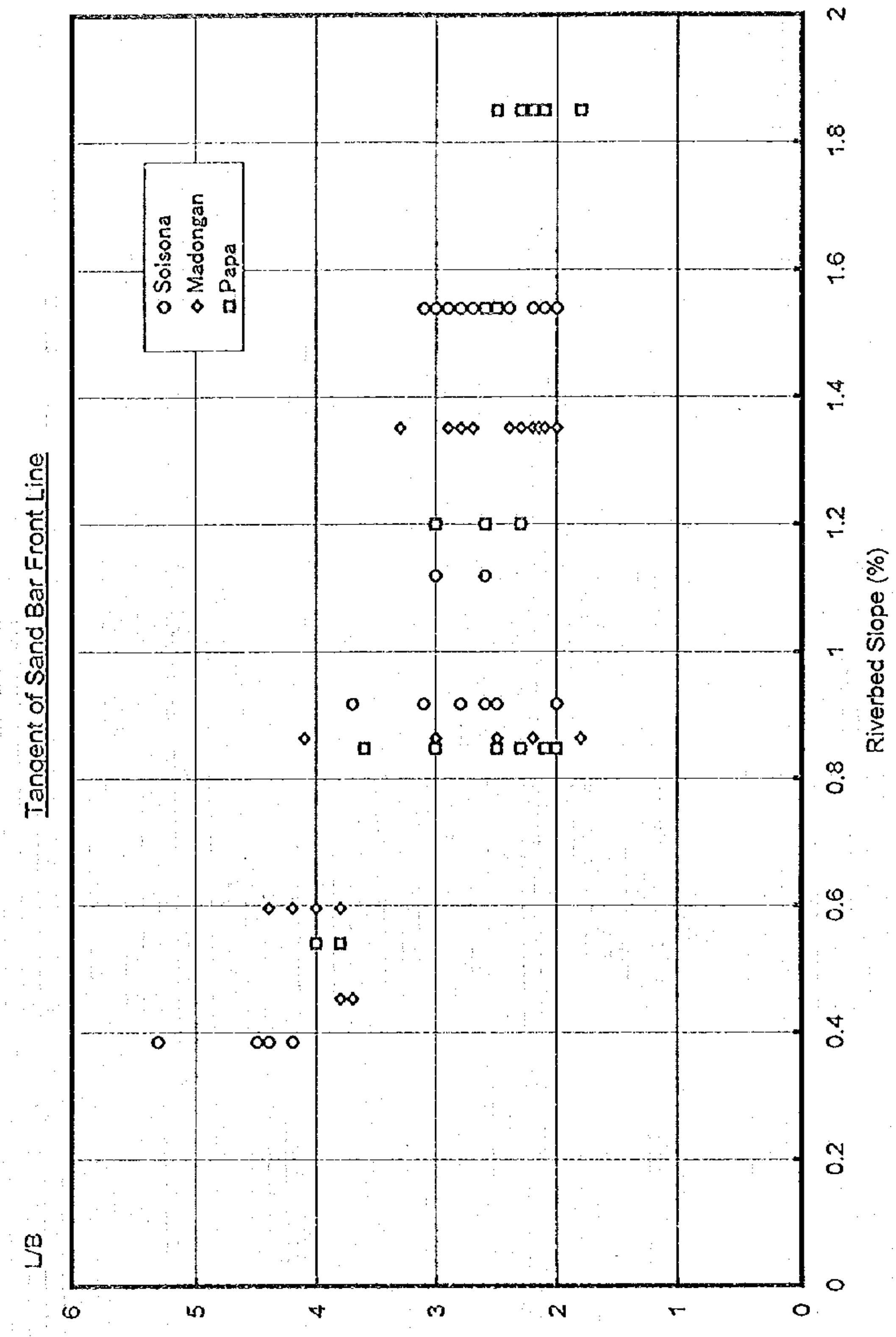
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.3.2 (1) River Morphological Condition (Solsona River)
JAPAN INTERNATIONAL COOPERATION AGENCY	



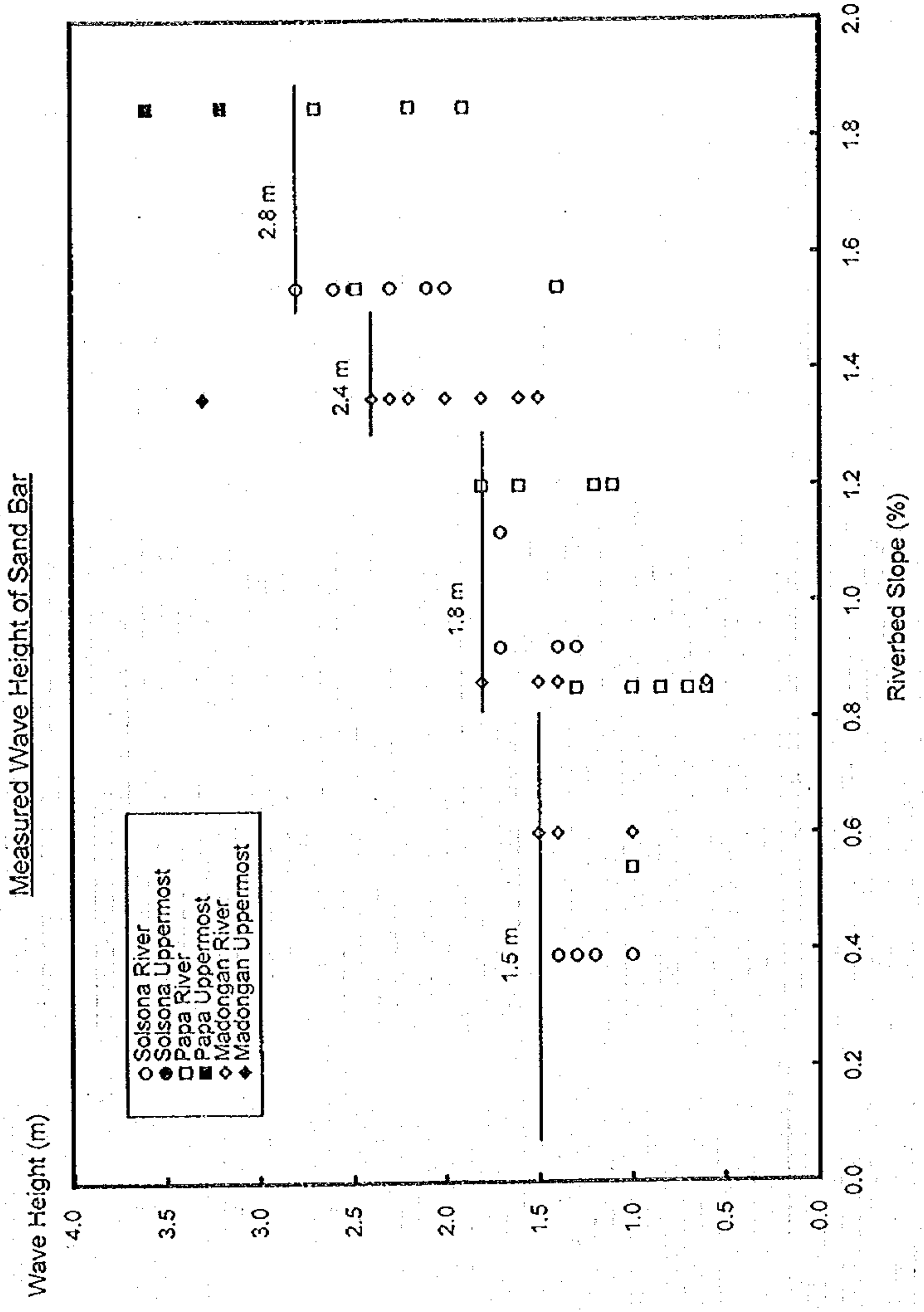
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.3.2 (2)
	River Morphological Condition
JAPAN INTERNATIONAL COOPERATION AGENCY	(Madongan River)



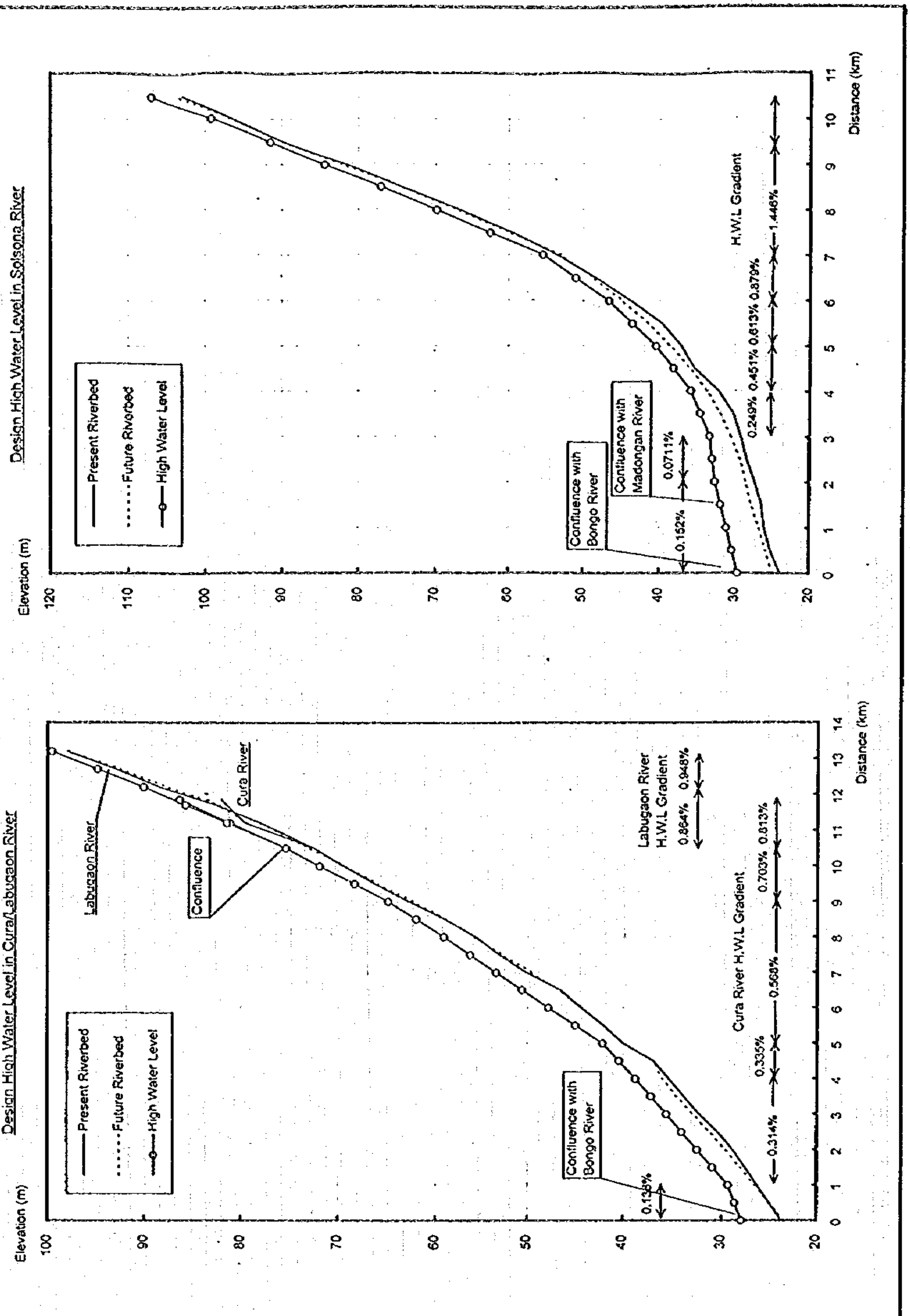
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.3.2 (3) River Morphological Condition (Papa River)



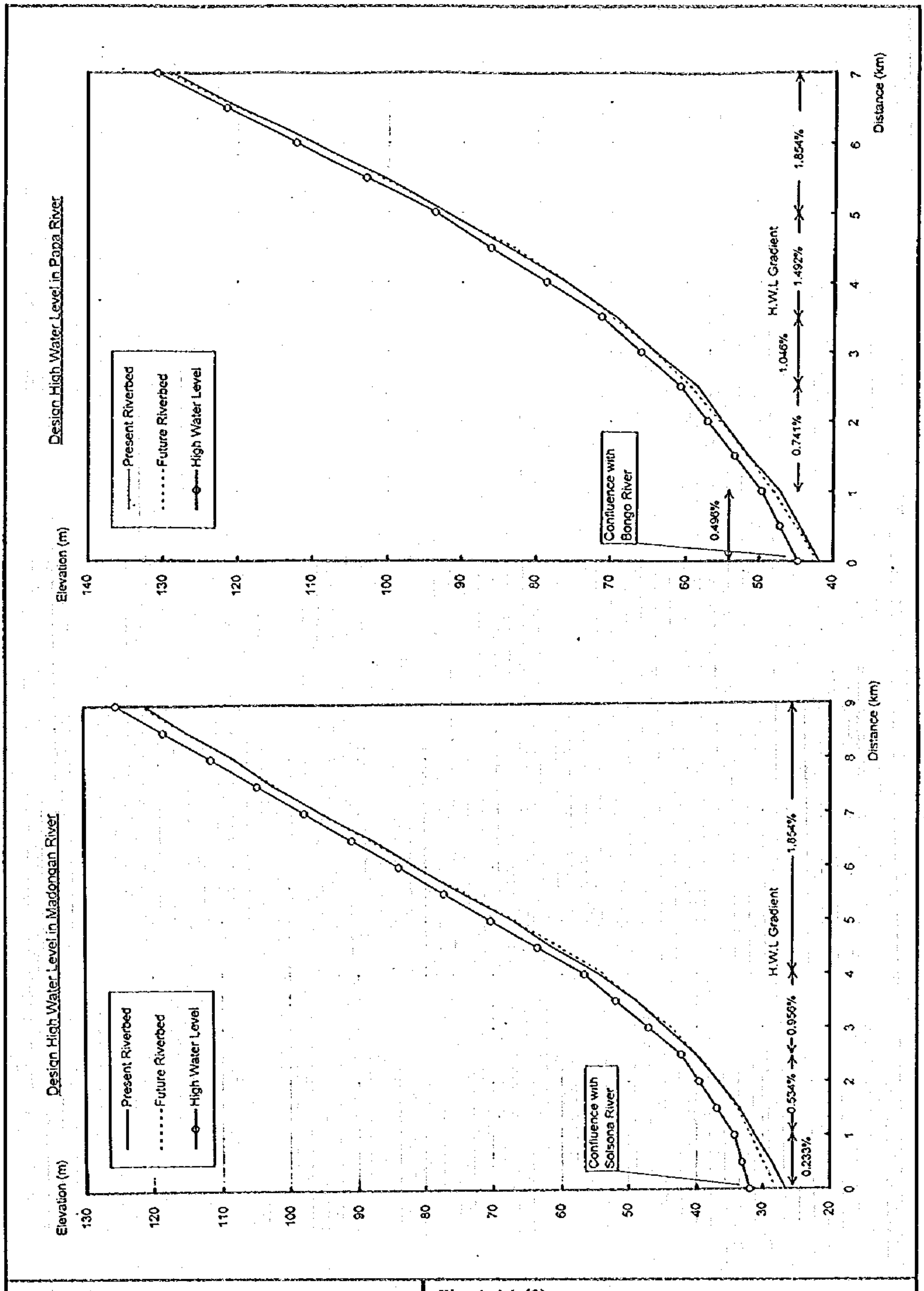
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.3.3
JAPAN INTERNATIONAL COOPERATION AGENCY	Relation between Tangent of Sand Bar Front Line and Riverbed Slope



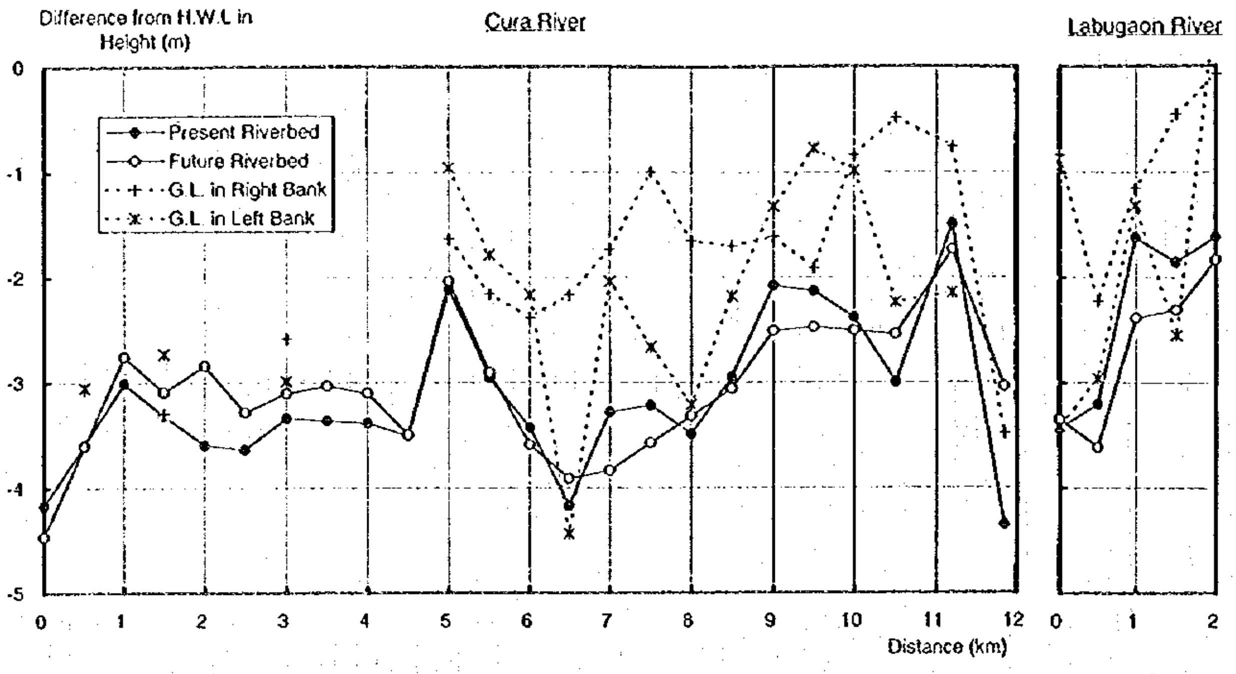
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.3.4
JAPAN INTERNATIONAL COOPERATION AGENCY	Relation between Wave Height and Riverbed Slope

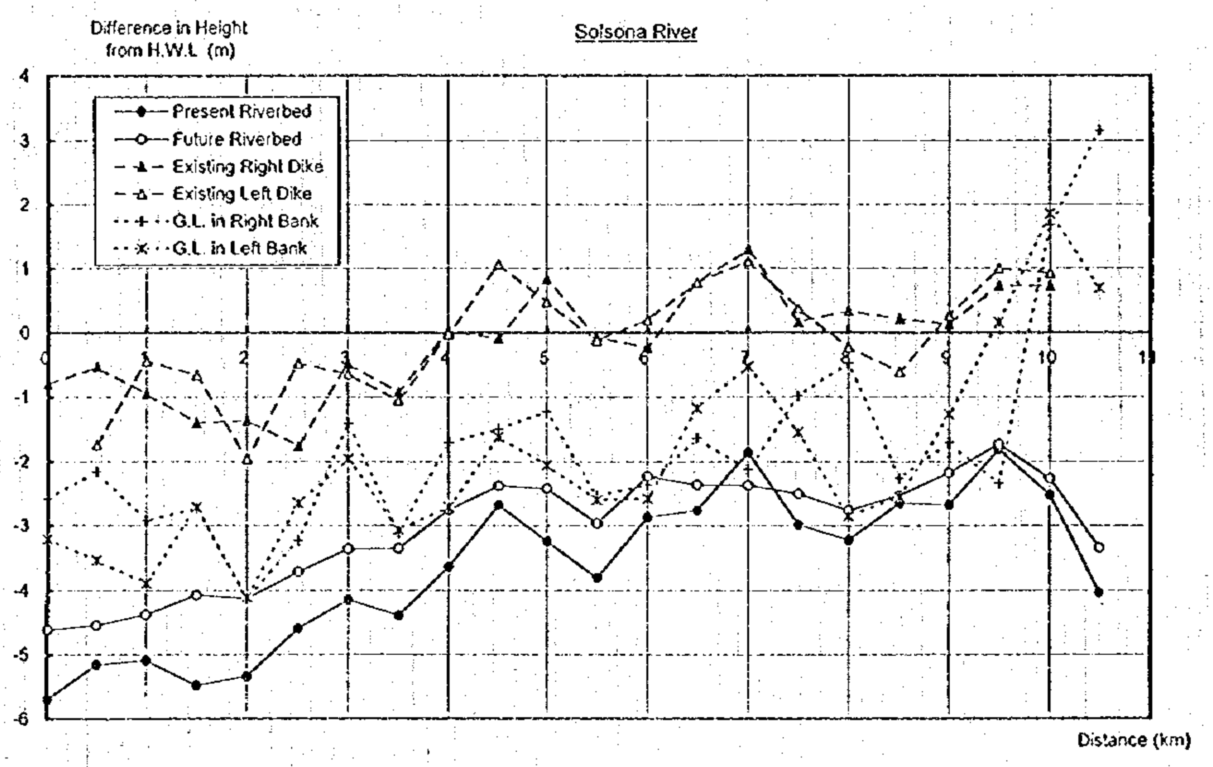


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.4.1 (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	Design High Water Level in Alluvial Fan River (Cura/Labugaon and Solsona Rivers)

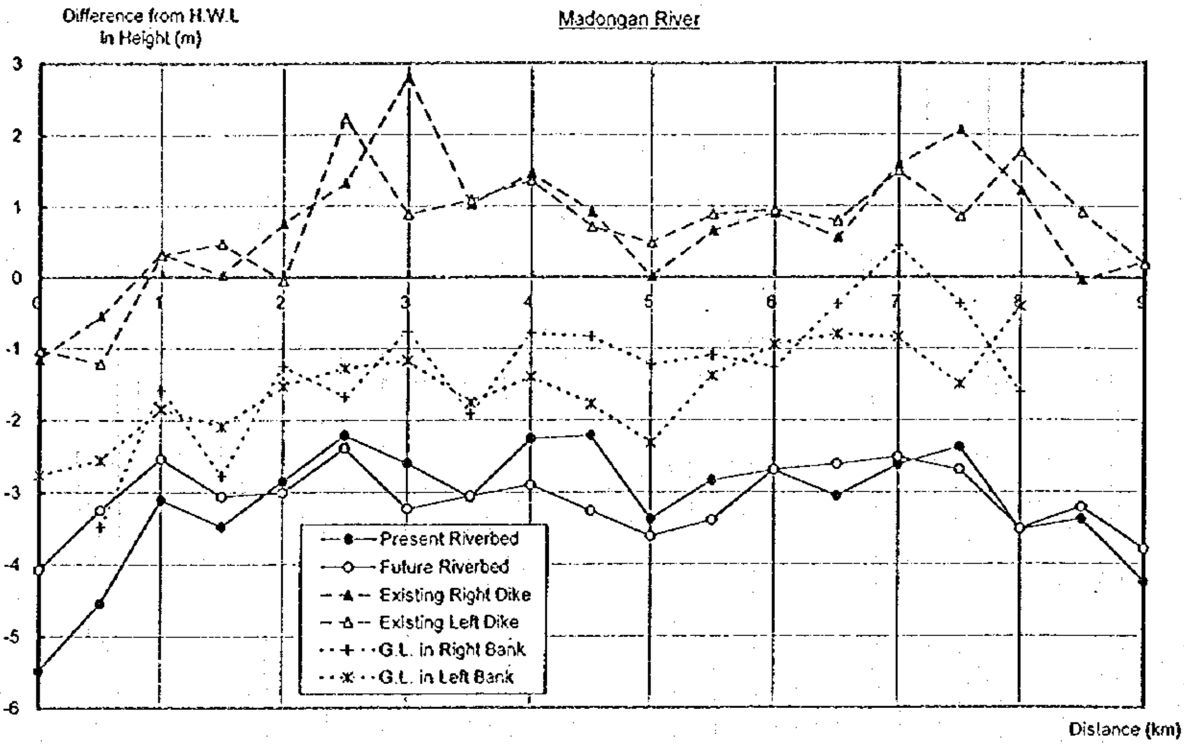


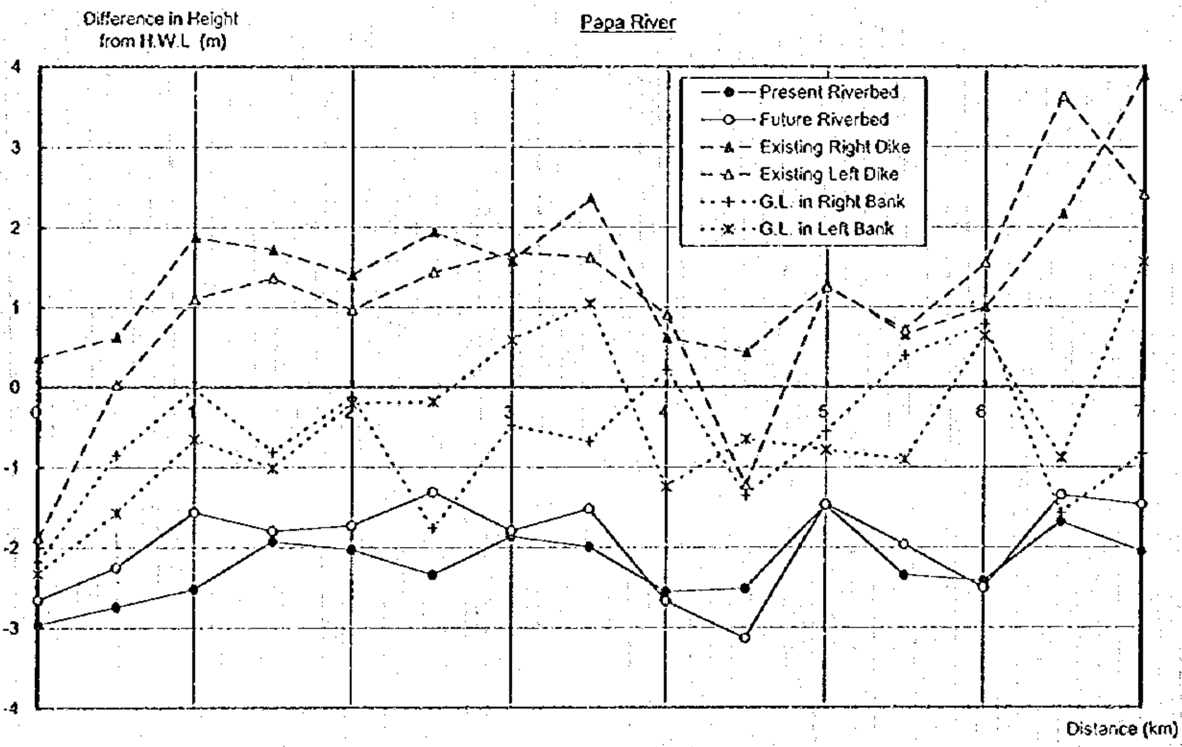
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.4.1 (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	Design High Water Level in Alluvial Fan River (Madongan and Papa Rivers)



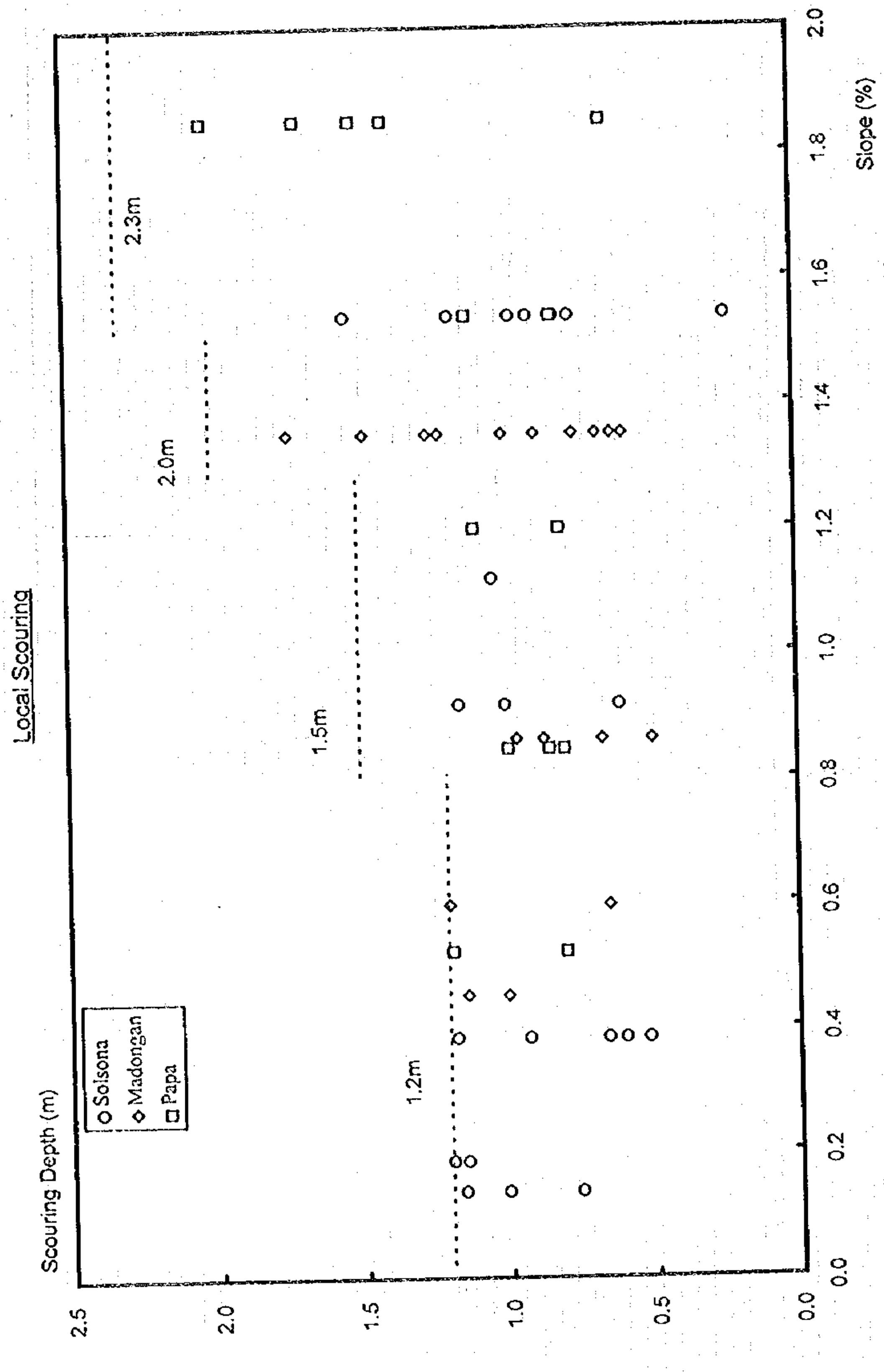


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. A.4.2 (1) Comparison among Riverbed, Landside and Dike Elevation (Cura/Labugaon and Solsona Rivers)
JAPAN INTERNATIONAL COOPERATION AGENCY	





THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.4.2 (2) Comparison among Riverbed, Landside and Dike Elevation (Madongan and Papa Rivers)



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. A.4.3 Relation between Lower Riverbed Depth and Riverbed Slope