2.2 Alternatives for Reducing Sediment Deposition within the Reservoir

2.2.1 Keduang River Sediment Bypass

(1) Features of Sediment Bypassing

Sediment bypassing is the method that river flow having high concentrated sediment is diverted into the bypass channel, whose inlet mouth is laid out at the portion of upperstream end of reservoir and bypass channel detour the dam and discharged into the downstream river of the dam. This method is effective in case that it is difficult to lower the dam water level and the reservoir is relatively small. Manner of bypassing is natural flushing without artificial manipulation. However usually high construction cost is required. There are basically two type of concept for sediment bypassing, and merits and demerits are shown in Tables 2.2.1 and 2.2.2.

Table 2.2.1 Two Type of Concept for Sediment Flushing

a) Flood bypassing	b) Sediment flushing bypass
Only wash-load should be diverted without deposition in diverting weir reservoir. Bed-load is expected to be deposit in the reservoir. This sediment should be removed by excavation.	Most of the sand included in flood shall be diverted into bypass. And even existing sediment deposited at past flood is expected to be flushed out with flood flow.

Source: JICA Study Team

Table 2.2.2 Merits and Demerits of Sediment Bypassing

Merits	Demerits
1. Few problems for environmental factor may be occurred because the sediment flushing to the downstream can be carried out before the quality of sediment changes worse due to the long term deposition. 2. It is possible to install the facilities after dam completion because the facility shall be planned at separated place from dam body and reservoir. 3. From this method, sediment flow into the dam reservoir should be reduced, thus this will contribute to the Dam life lengthening. Further, by diverting weir which shall be arranged across the river, a certain sediment trapping effectiveness is anticipated.	1. In case of Wonogiri dam, gradient of the channel is expected to be small due to the flat topographic conditions. Therefore dimension of the facility such as channel and tunnel which should be regulated by gradient Consequently, dimension of the facility should be large. All of the flood cannot be diverted, so considerably large volume of flood should be flowed into the dam reservoir. 2. Back water induced by the diverting weir shall lower the safety ratio against flooding upstream. 3. In areas between Keduang and Solo Rivers, there are many properties such as houses, farmland, road and so on. As the route of bypass channel should be planned under these areas, social and environmental problems such as transfer, land acquisition shall be arisen.

Source: JICA Study Team

(2) Possibility of Application

1) Applicability

Gradient of bypass channel is commonly adopted around I=1/100 to secure enough tractive force to bypass bed-load or suspended load including wash-load. In case of Wonogiri dam, gradient of bypass channel is secured only I=1/1,000 due to the flat topographic condition. So it is likely difficult to bypass bed-load and suspended load. However by targeting on only wash-load as object sediment shall be realized sediment bypassing.

2) Layout of the Facilities

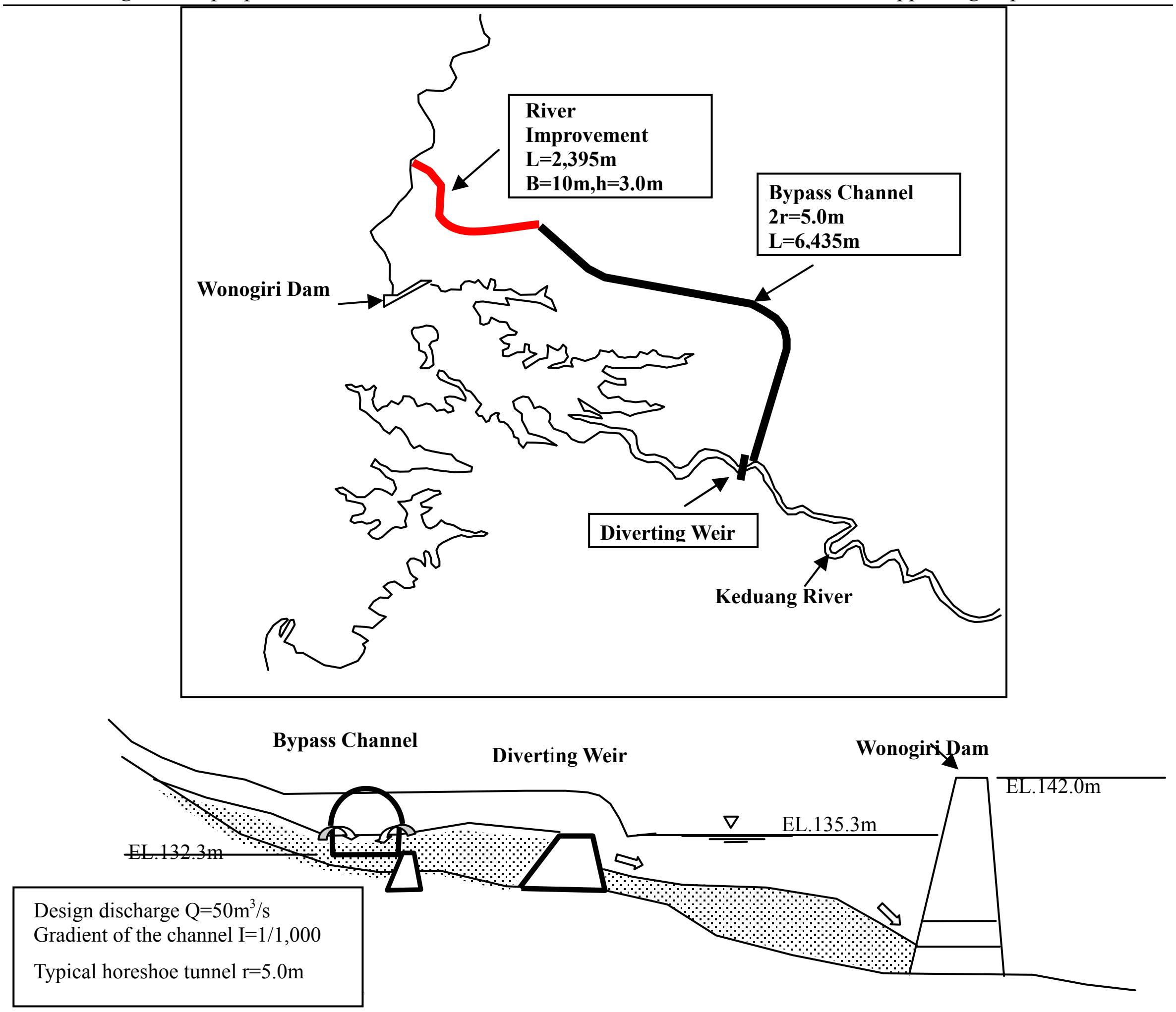


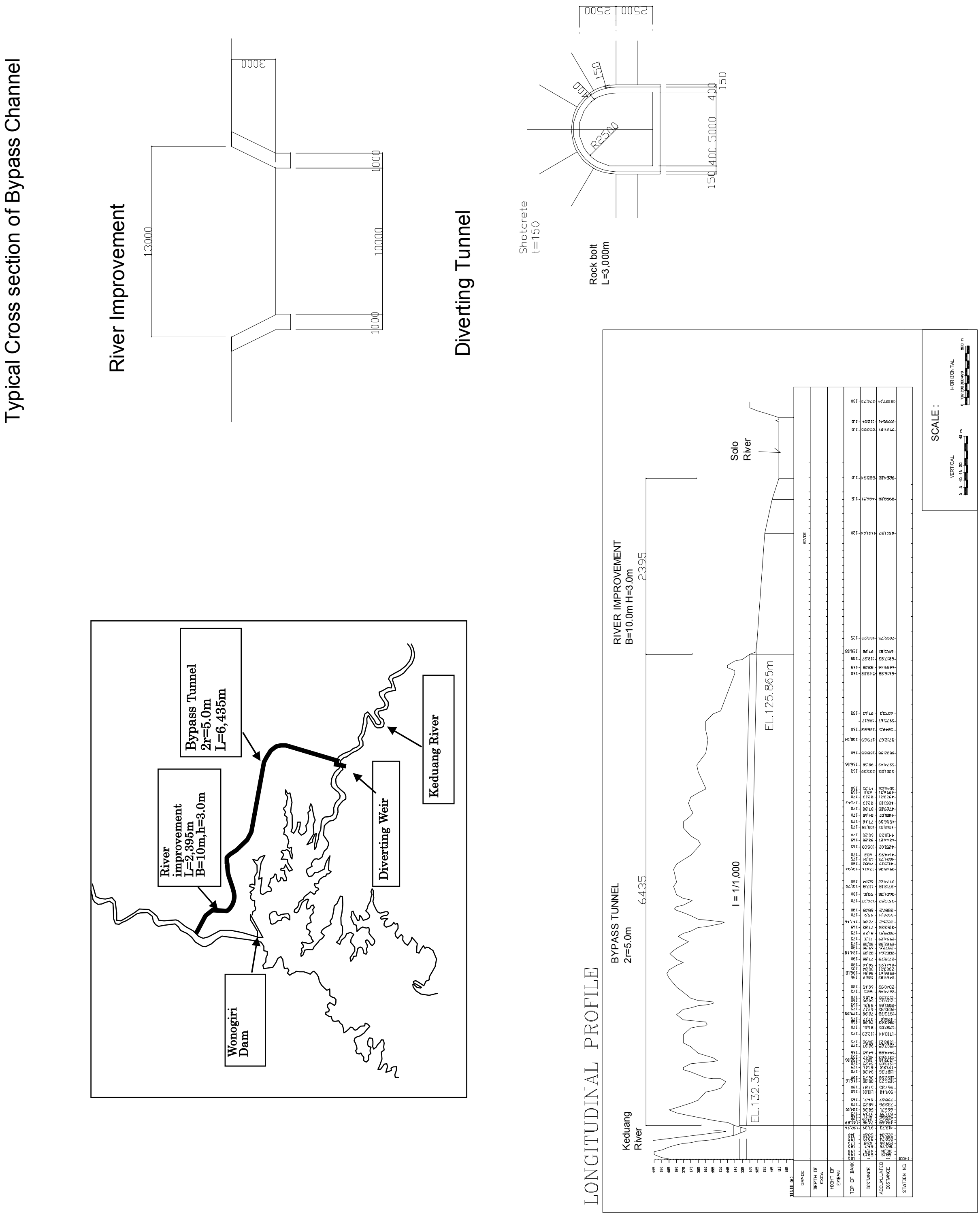
Figure 2.2.1 Illustrates of Layout and Alignment of Bypass Channel

System of the sediment bypassing is composed of four (4) facilities, a diverting weir, control gates, a bypass channel and river improvement. Dimension of each facilities are shown in Table 2.2.3.

Table 2.2.3 Dimension of Facility

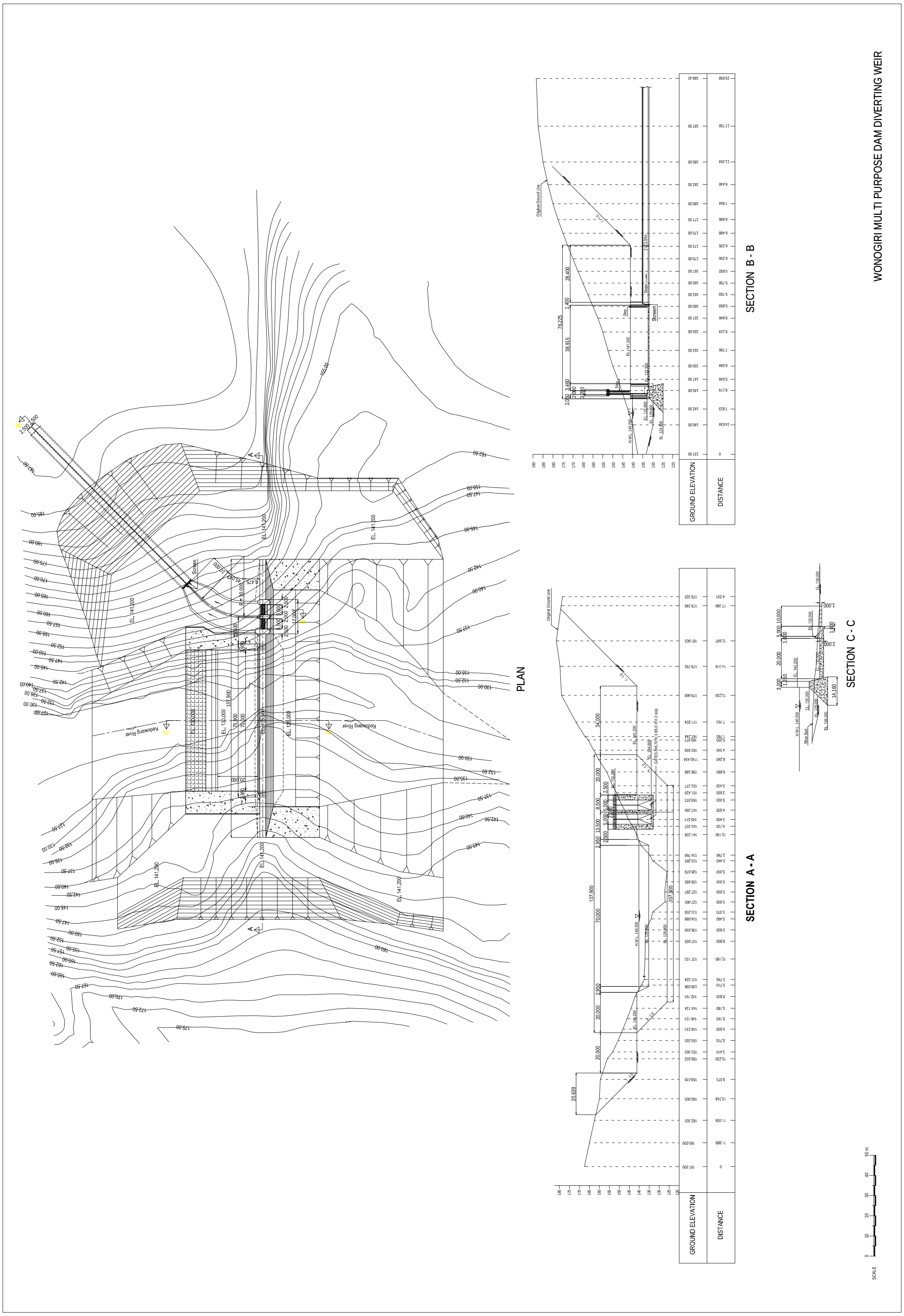
Plan	Dimension	
Diverting Weir	Design Discharge	Q=1,370m^3/s
	Width of flow area	70m
	overflow depth	4.9m
	Height of Dam	9.3m
	width of Dam	137.9m
Control Gates	Roller Gate x 2 nos	H6.7m×B5.0m×2
	Foundation height	EL.134.0m
Bypass Channel	Gradient of channel	I = 1/1,000
	Horseshoe channel	2R = 5.0m
	Length of channel	L = 6,435m
River improvement	Gradient of channel	I = 1/200
	Length of channel	L = 2,395m
	Width of Bottom	B=10.0m
	High of channel	H=3.0m

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.2 Alignment and Structure of Bypass Channel

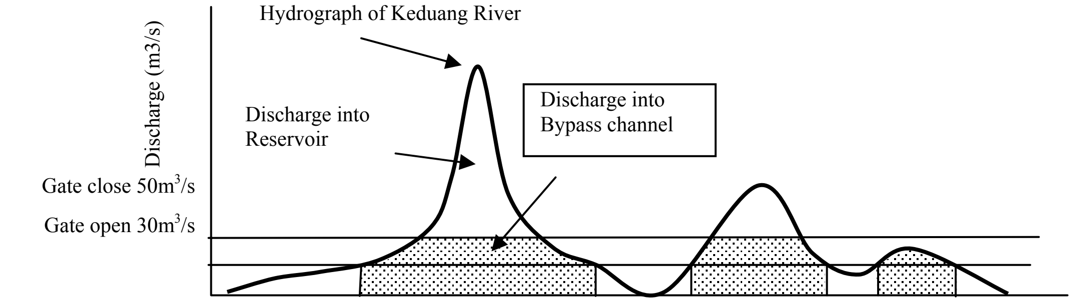


Source: JICA Study Team

Figure 2.2.3 Plan and Profile of Diverting Weir

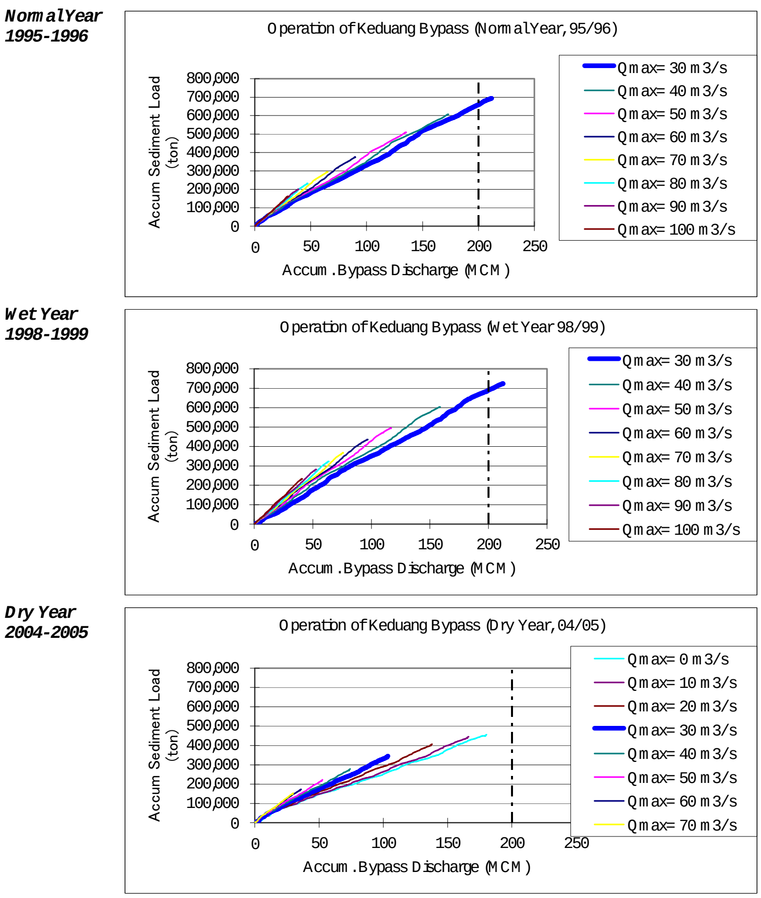
3) Operation

Discharge into the bypass channel is brought in by natural flow force as far as possible. The control gates are installed out on the right side abutment of the diverting weir. When flood discharge exceeds 30m^3/s, the gates are fully opened to divert flood of 50m^3/s at the maximum, directly into the bypass channel. When flood discharge decline to 30 m^3/s, the gates are closed. Consequently, parts of the flood flow less than 30 m^3/s and more than 50 m^3/s directly enter into the Wonogiri reservoir. The image of operation of sediment bypassing is shown in Figure 2.2.4



Source: JICA Study Team

Figure 2.2.4 Design Discharge of Bypass Channel



Source: JICA Study Team

Figure 2.2.5 Comparison of Bypass Cut Discharge

Table 2.2.4 Comparison of Bypass Cut Discharge

<NORMAL YEAR, 95/96>

Target discharge for opening the Keduang bypass gate	Accumulated discharge into bypass	Accumulated sediment load into bypass	Average Concentration in byapass
Qmax	ΣQ_bypass	ΣQs_bypass	
(m3/s)	(MCM)	(ton)	(kg/m3)
30	211	692,881	3.280
40	173	606,378	3.514
50	135	508,620	3.773
60	89	374,221	4.183
70	65	293,659	4.544
80	47	230,484	4.925
90	39	199,580	5.157
100	30	162,247	5.496

<WET YEAR, 98/99>

Target discharge for opening the Keduang bypass gate	Accumulated discharge into bypass	Accumulated sediment load into bypass	Average Concentration in byapass
Qmax	ΣQ_bypass	ΣQs_bypass	
(m3/s)	(MCM)	(ton)	(kg/m3)
30	212	723,301	3.412
40	158	602,664	3.813
50	116	494,117	4.249
60	96	435,071	4.509
70	75	366,431	4.859
80	63	322,434	5.103
90	52	280,968	5.364
100	40	231,683	5.746

<DRY YEAR, 04/05>

Target discharge for opening the Keduang bypass gate	Accumulated discharge into bypass	Accumulated sediment load into bypass	Average Concentration in byapass
Qmax	ΣQ_bypass	ΣQs_bypass	
(m3/s)	(MCM)	(ton)	(kg/m3)
0	180	455,565	2.526
10	166	445,073	2.677
20	138	406,919	2.949
30	104	344,688	3.324
40	74	277,948	3.741
50	53	221,634	4.202
60	36	172,905	4.803
70	30	153,242	5.129

Source: JICA Study Team

4) Reservoir Sedimentation Simulation at Rainy Season.

By use of the developed Wonogiri reservoir sedimentation analysis model (detailed in Supporting Report Annex No.5), simulation of reservoir sedimentation was carried out applying the condition that the sediment bypass system is provided. Due to the limited calculation time for simulation, the reservoir inflow of the hydrological wet year 1998/99 (reservoir inflow volume in the wet season is around 1.4 billion m^3) was applied. Results of analysis are summarized in Table 2.2.5 and Figures 2.2.6 and 2.2.7 below. It was assumed that the bypassing water volume would be up to around 200 million m^3 at maximum, which is almost equivalent to the mean annual excess water volume released from the existing spillway in 1983-2005.

(3) Evaluation

1) Environmental Aspect

Alignment of this bypass tunnel can be laid out under the private land. Therefore, serious resident transfer would not be occurred. Open channel can be laid out in existing tributary river course. Dimension of open channel is almost same one with existing river, so land acquisition is small.

2) Effectiveness

From the reservoir sedimentation analysis it appears that:

i) The diverted sediment volume into the bypass tunnel would be around 476,000 m^3, which corresponds to around 28% of the total sediment inflow volume of Keduang River in 1998/99 (1,710,000 m^3).

ii) Sediment outflow volume from the existing intake would be reduced to be 289,000 m^3 from 638,000 m^3. The excess volume would be 349,000 m^3, which is about 55.0%.

iii) Consequently, the net increase in volume of sediment released by provision of the sediment bypass system would be only 118,000 m^3, which is only 6.9% of the sediment inflow from the Keduang River.

iv) The diverted water volume is 182 million m^3 and average sediment concentration is 2,789 ppm.

3) Constraints of Construction

6,435m tunnel length is long and 2r =5.0m hoarse shoe is small for excavation work, therefore constructivity is not good results in high construction cost.

4) Reliability

High sediment concentration flood is take in on the Keduang River before enter the Dam reservoir, so bypassing is very reliable among countermeasures.

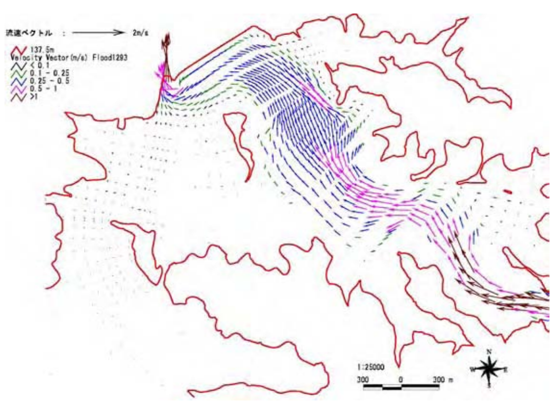
5) Cost

Construction cost and maintenance and operation cost is highest among countermeasures.

Table 2.2.5 Sediment Balance of Sediment Bypass

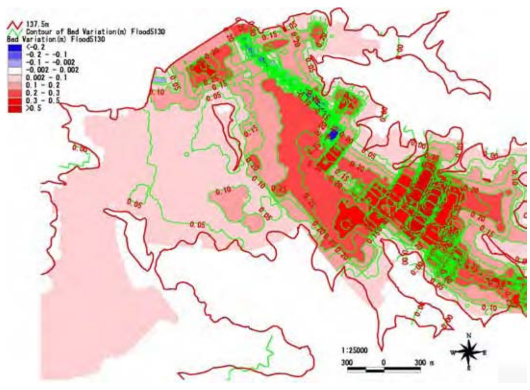
Facility	Unit	Sediment outflow				Sediment Deposit in the Reservoir	Total Sediment Inflow from Keduang
		Intake	Existing spillway	Bypass tunnel	Total		
Existing condition	1,000 m^3	394	244	-	638	1,071	1,710
Bypass system	1,000 m^3	189	91	476	757	953	1,710
(Difference)	1,000 m^3	-205	-152	476	118	-118	
Released water	MCM	806	90	182	1,078	-	
Concentration	ppm	250	1,077	2,789	747	-	

Source: JICA Study Team



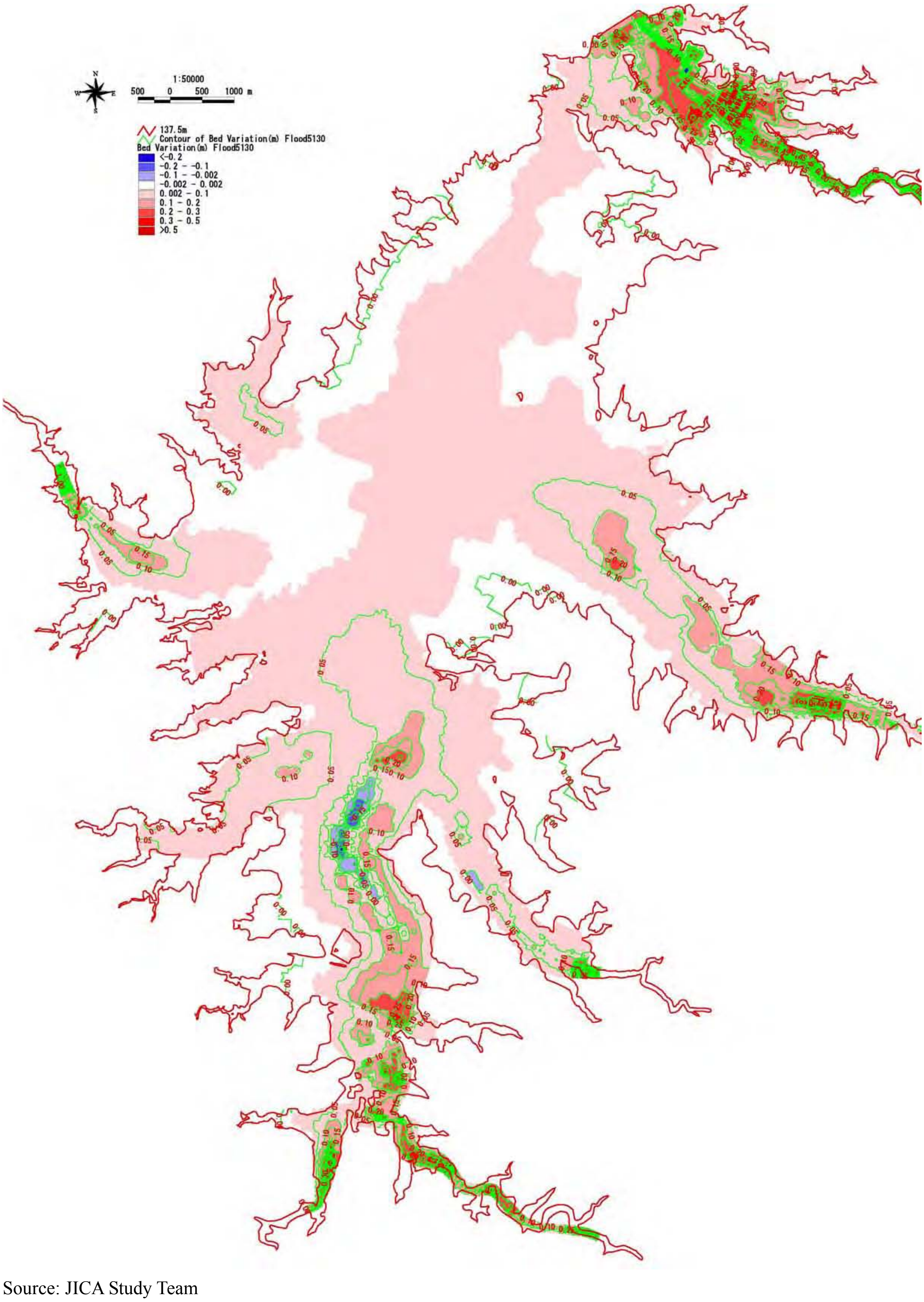
Source: JICA Study Team

Figure 2.2.6 Velocity Distribution



Source: JICA Study Team

Figure 2.2.7 Sedimentation at Keduang

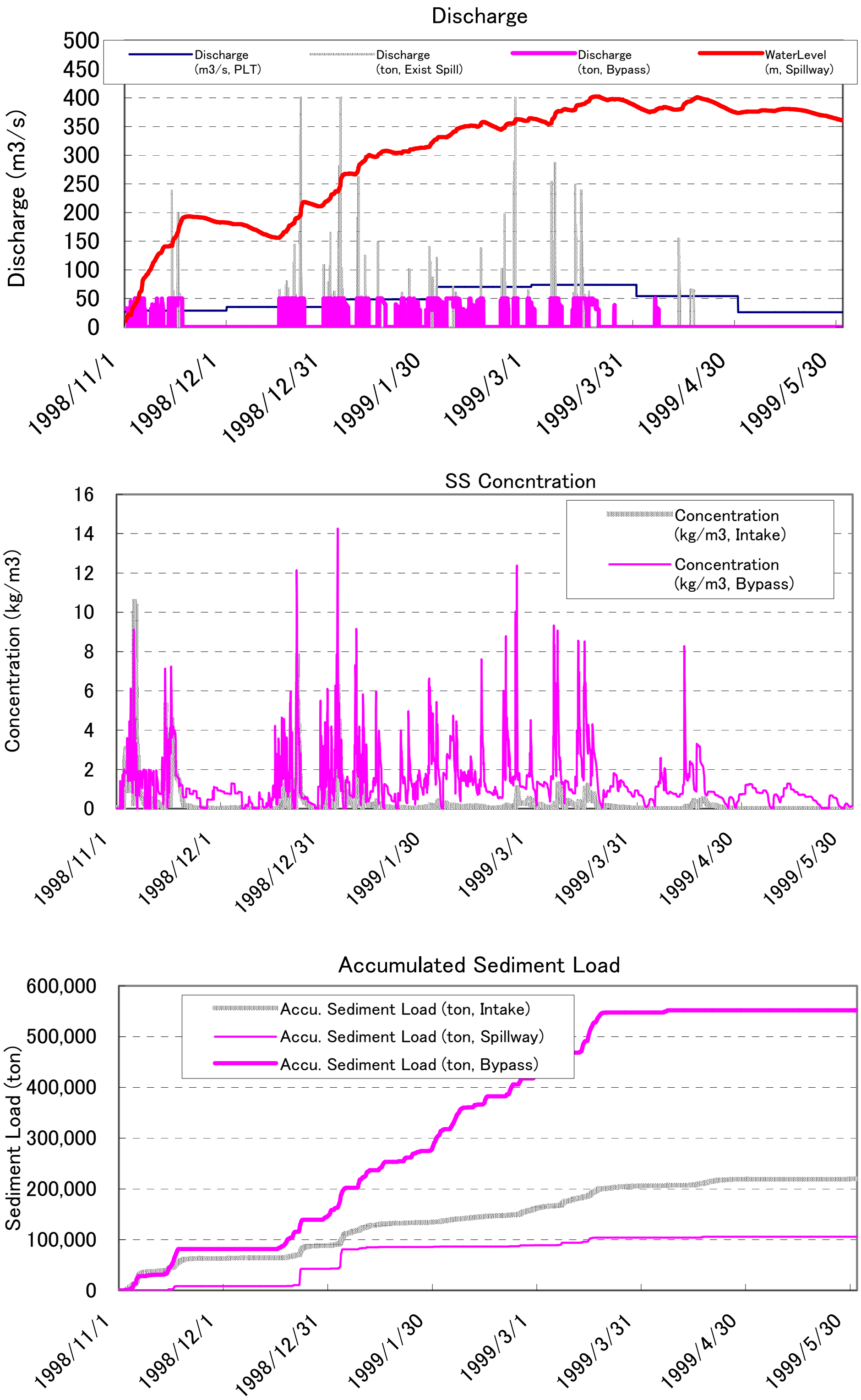


Source: JICA Study Team

Figure 2.2.8 Sedimentation at Whole Reservoir

Source: JICA Study Team

Figure 2.2.9 Velocity Vector at Whole Reservoir



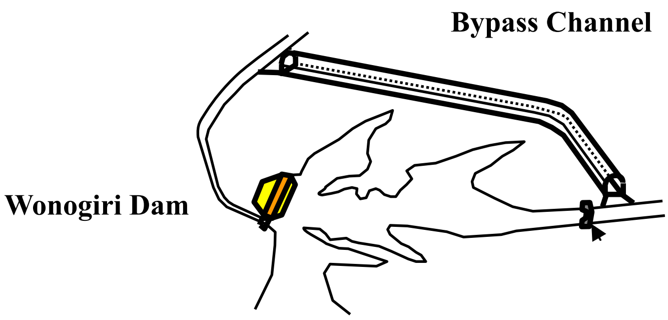
Source: JICA Study Team

Figure 2.2.10 Result of Reservoir Sedimentation Analysis

(Case : Sediment Bypassing)

(4) Candidate Bypass Channel Route

Figure 2.2.11 shows the candidate bypass routes.



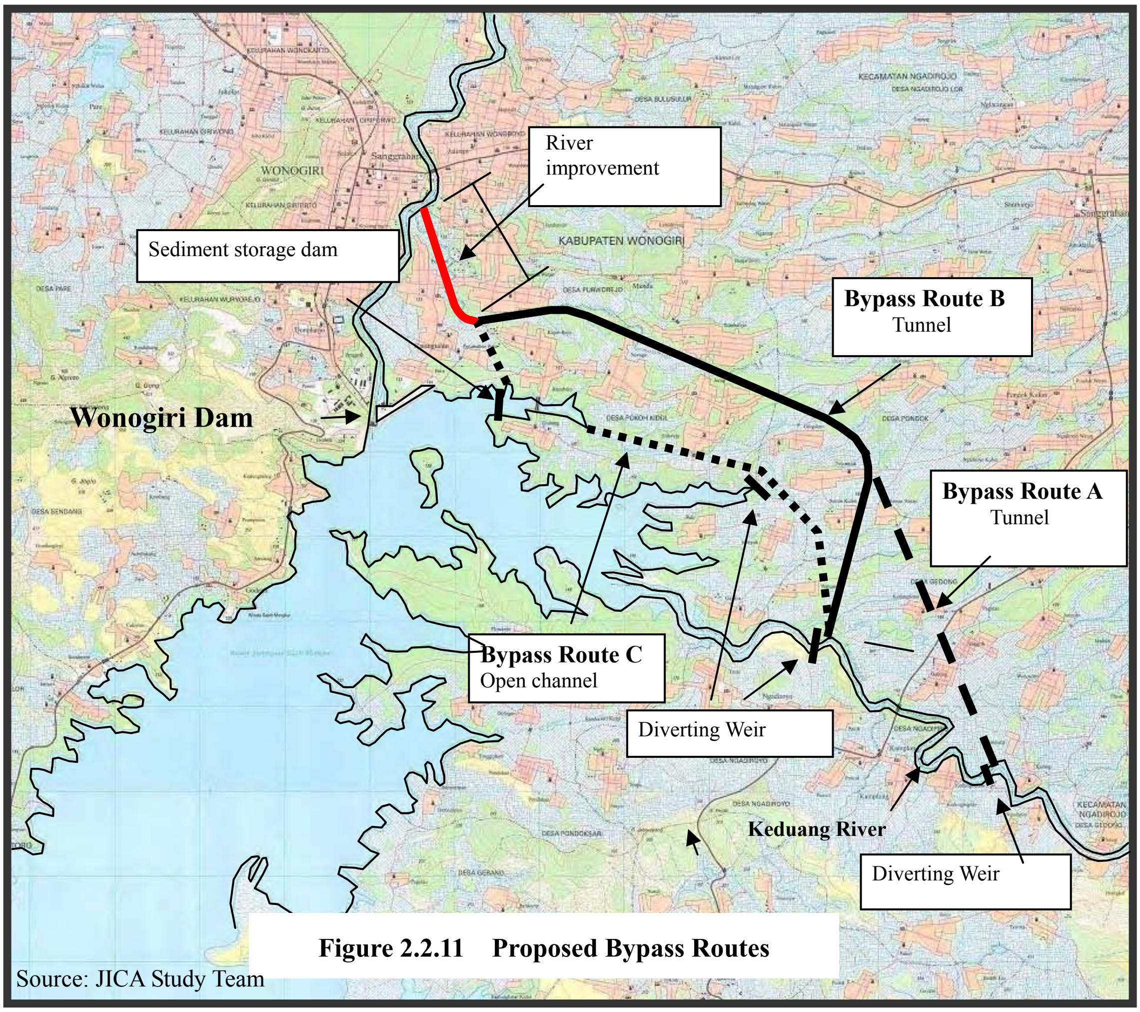


Figure 2.2.11 Proposed Bypass Routes

Source: JICA Study Team

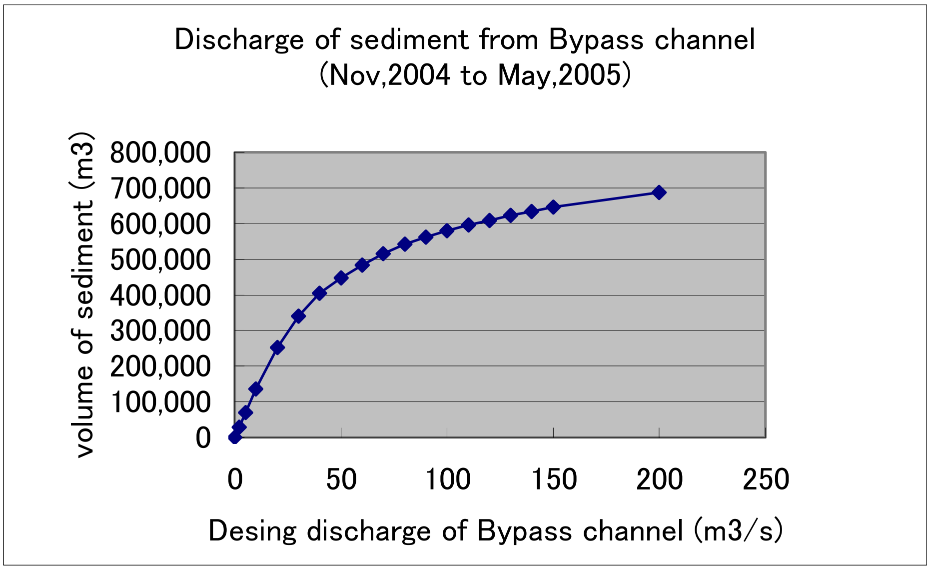
(5) Design Discharge of Bypass Channel

Figures 2.2.12 and 2.2.13 show the discharge of sediment and flow at Nov. 2004 to May 2005. From the figure, inflection point is identified on 50 m^3/s in both graph of sediment and flow. When bypass channel capacity is under 50 m^3/s, total volume of sediment and flow which are discharged from bypass channel are sharply increased. While, when flow out become over 50 m^3/s, those of them are declined to increase. From the result of this analysis, design discharge of bypass channel is decided to be 50 m^3/s .

(6) Basic Policy

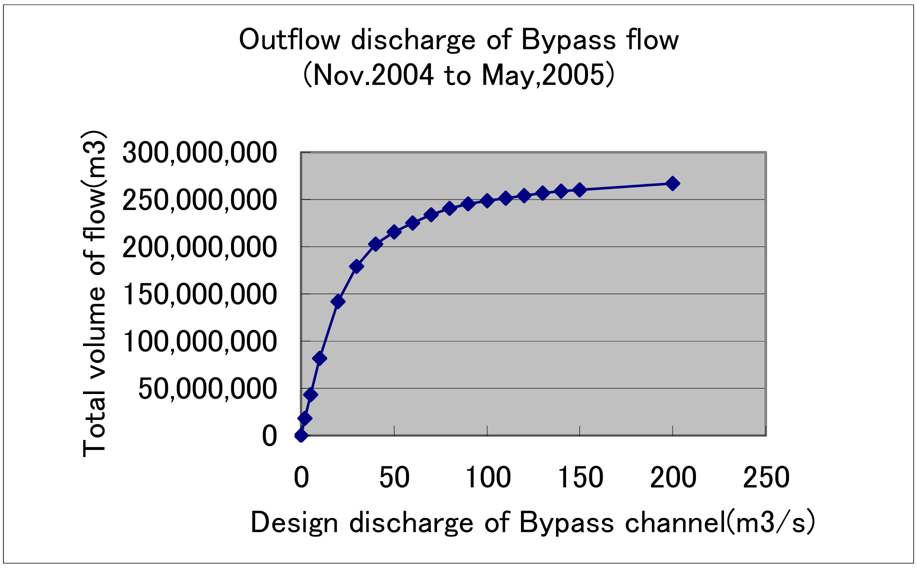
Inflow to the bypass channel should be taken by natural force of flow as far as possible.

Diverting channel is set at downstream of bypass intake. In all flood flow into the diverting weir, until less than 50 m^3/s flood is diverted into the bypass directly. More than 50 m^3/s flood is overflowed the diverting weir and run into the dam reservoir. According to the analysis of this system, sediment volume of reservoir is reduced to be 318,190 m^3 (41.4%) from 765,248 m^3 (100%). However, water volume of the Keduang River is reduce from 277,366,658 m^3 (100%) to 61,742,703 m^3 (22.2%). This means 77.8% of water volume(215,623,955 m^3) of the Keduang River should be abandoned. This is the almost same with the average of past spill out from the dam.



Source: JICA Study Team

Figure 2.2.12 Discharge of Sediment from Bypass Channel



Source: JICA Study Team

Figure 2.2.13 Outflow Discharge of Bypass Flow

Table 2.2.6 Discharge of Bypass Flow

Table 2.2.6 Discharge of Bypass Flow

Bypass flow	Inflow to Dam reservoir			Sediment inflow to reservoir			Bypass volume			
	Qindam			Qins			Qbf		Qbs	
m3/s	m3	%	Δ	m3	%		flow	Δflow	sdiment	Δsediment
0	277,366,658	100	0.0	765,248	100	0.0	0	0	0	0
2	259,437,097	93.5	6.5	737,268	96.3	3.7	17,929,561	17,929,561	27,980	27,980
5	234,052,612	84.4	9.2	695,775	90.9	5.4	43,314,046	25,384,485	69,473	41,493
10	195,448,009	70.5	29.5	628,940	82.2	8.7	81,918,649	38,604,603	136,308	66,835
20	135,307,790	48.8	21.7	512,199	66.9	15.3	142,058,868	60,140,219	253,049	116,741
30	98,482,463	35.5	13.3	425,520	55.6	11.3	178,884,195	36,825,327	339,728	86,679
40	74,836,242	27.0	8.5	361,233	47.2	8.4	202,530,416	23,646,221	404,015	64,287
50	61,742,203	22.3	4.7	318,190	41.6	5.6	215,624,455	13,094,039	447,058	43,043
60	52,057,959	18.8	3.5	282,649	36.9	4.6	225,308,699	9,684,244	482,599	35,541
70	43,356,663	15.6	3.1	249,751	32.6	4.3	234,009,995	8,701,296	515,497	32,898
80	36,680,250	13.2	2.4	222,641	29.1	3.5	240,686,408	6,676,413	542,607	27,110
90	32,280,936	11.6	1.6	202,421	26.5	2.6	245,085,722	4,399,314	562,827	20,220
100	28,708,597	10.4	1.3	184,934	24.2	2.3	248,658,061	3,572,339	580,314	17,487
110	25,848,692	9.3	1.0	169,979	22.2	2.0	251,517,966	2,859,905	595,269	14,955
120	23,283,041	8.4	0.9	156,104	20.4	1.8	254,083,617	2,565,651	609,144	13,875
130	20,900,610	7.5	0.9	142,944	18.7	1.7	256,466,048	2,382,431	622,304	13,160
140	18,801,127	6.8	0.8	130,949	17.1	1.6	258,565,531	2,099,483	634,299	11,995
150	16,901,335	6.1	0.7	119,823	15.7	1.5	260,465,323	1,899,792	645,425	11,126
200	10,263,231	3.7	2.4	77,520	10.1	5.5	267,103,427	6,638,104	687,728	42,303

Source: JICA Study Team

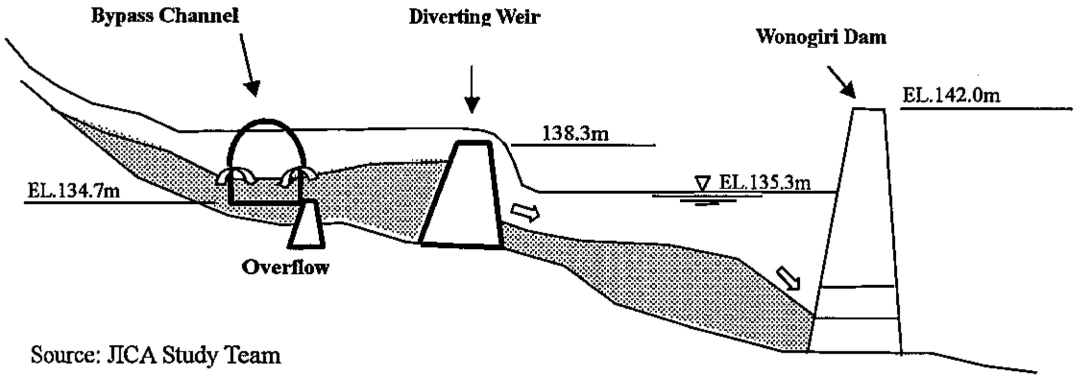
(7) Facility Plan

Dimension of the bypass channel at $50m^3/s$ is shown in Table 2.2.7. Longitudinal section of the bypass channel is shown in Figure 2.2.16.

Table 2.2.7 Dimension of Facility

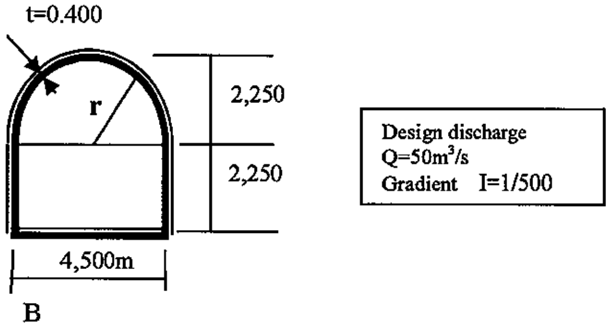
Plan	Dimension	
Plan -A	Gradient of channel	I = 1/500
	Horseshoe channel	2R = 4.5m
	Length of channel	L = 7,500m
Plan-B	Gradient of channel	I = 1/500
	Horseshoe channel	2R = 4.5m
	Length of channel	L = 5,200m
Plan-C	Gradient of channel	I = 1/4,200
	Open channel	B= 20.0 m h=3.0m
	Length of channel	L = 5,200m

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.14 Profile of Diverting Weir and Inlet of Bypass Channel



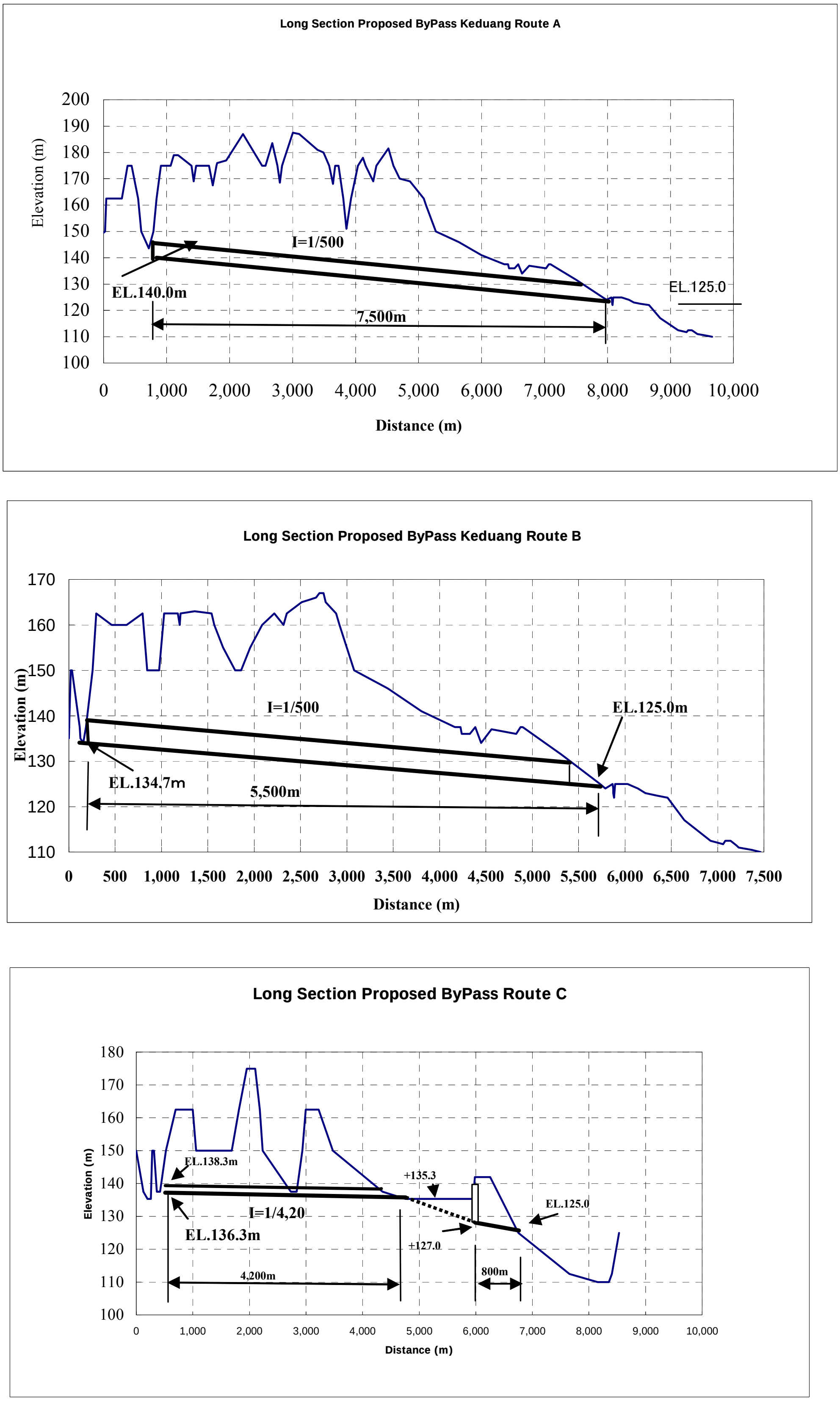
Source: JICA Study Team

Figure 2.2.15 Typical Cross Section of Bypass Channel

Table 2.2.8 Horseshoe Section of Bypass Flow

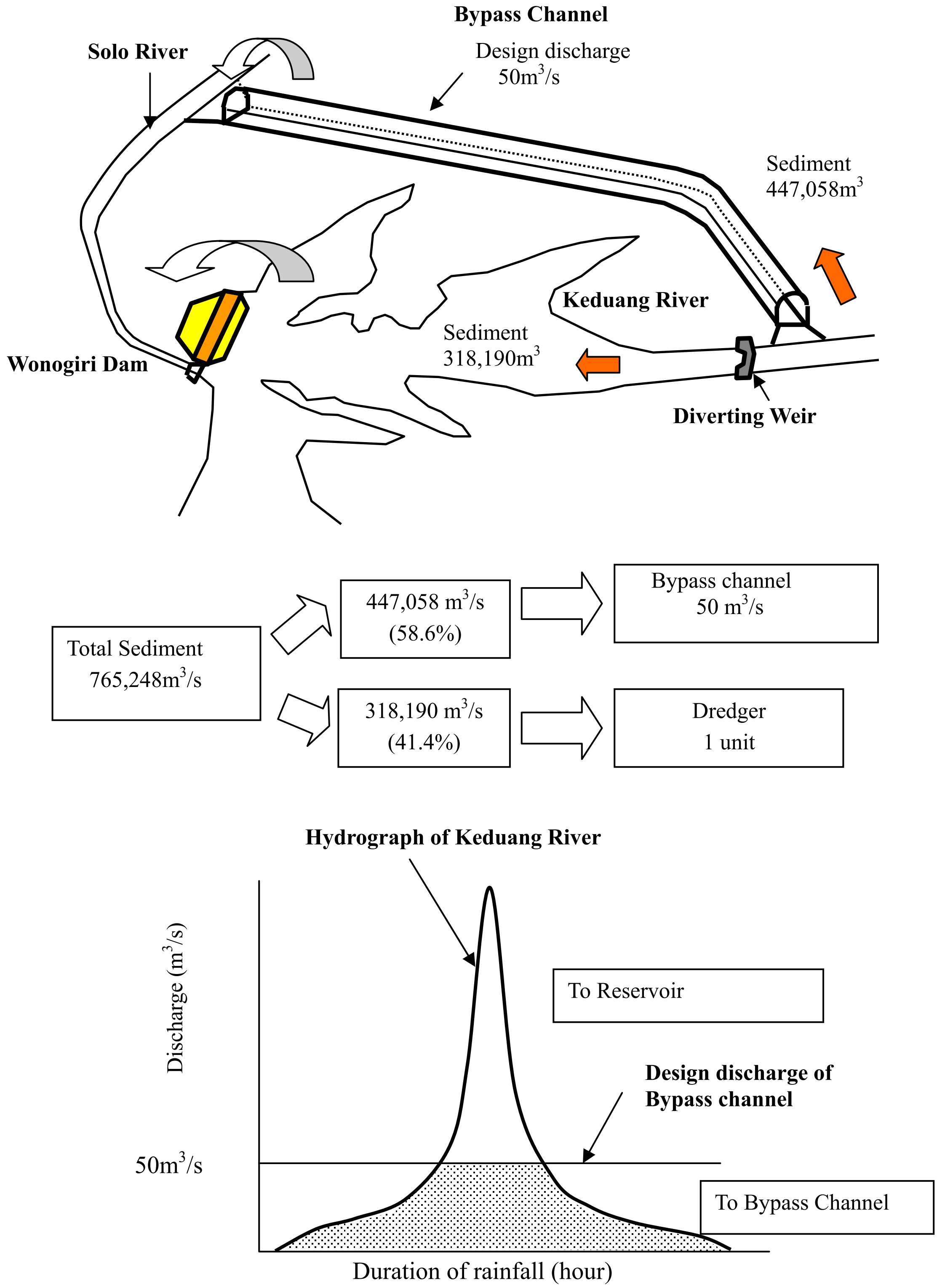
Bypass flow	Horseshoe Section	
m3/s	B(m)	
	1/500	1/1,000
0	-	-
10	2.5	3.0
20	3.2	3.6
30	3.7	4.2
40	4.1	4.6
50	4.5	5.0
100	6.0	6.5
150	6.7	7.6
200	7.5	8.5
250	8.1	9.2

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.16 Longitudinal Section of Bypass Channel



Source: JICA Study Team

Figure 2.2.17 Design Discharge of Bypass Channel

Table 2.2.9 Comparison of Bypass Route

	Case-A	Case-B	Case-C
Feature	Inlet of the bypass is set at the location, where riverbed elevation is higher than the elevation of HWL138.3m and as far as it shall be tunnel.	Inlet of the bypass is set at as far as downstream to shorten Baypass length. Riverbed elevation is lower than the CWL 135.3m. Therefore Diverting dam whose overtopping elevation is more than NWL136.0m is needed.	This route is considered to reduce the length and the portion of tunnel. Hence this route is winding along with the coastal line. Riverbed elevation is lower than the CWL 135.3m. Therefore Diverting dam whose overtopping elevation is more than NWL136.0m is needed.
Dimension	Design flow = 200m^3/s Gradient of Bypass I=1/500 Total lenth L= 7,020 m Tunnel Lt=3,900m D=7.5m Channel Lc=3,120m B=10.0m Slope of bank = 1:1.5 Excavation =1,623,000m^3 Other facility Diverting weir 1 Gates on Inlet 1 Bridge 5 Sabo Dam 1	Design flow = 200m^3/s Gradient of Bypass I=1/500 Total length L= 5,430 m Tunnel Lt=1,710m D=7.5m Channel Lc=3,720m B=10.0m Slope of bank = 1:1.5 Excavation =1,461,000m^3 Other facility Diverting weir 1 Gates on Inlet 1 Bridge 7 Sabo Dam 2	Design flow = 200m^3/s Gradient of Bypass I=1/500 Total length L= 5,120 m Tunnel Lt=590m D=7.5m Channel Lc=4,530m B=10.0m Slope of bank = 1:1.5 Excavation =2,184,000m^3 Other facility Diverting weir 1 Gates on Inlet 1 Bridge 8 Sabo Dam 4
Cost	53.,3 million US$ (only for Tunnel and Channel)	34,2 million US$ (only for Tunnel and Channel)	26,8 million US$ (only for Tunnel and Channel)
Impact for social environment	Impact of social environment is relatively small compared with other route, because the length of channel is short	Impact of social environment is a little larger than Route-A.	Impact of social assessment is largest among three alternative Bypass Route. Because channel portion is longest.
Evaluation	Construction cost is highest. About two-times of the Route C construction cost. However portion of open channel is shortest among three. Therefore Rand acquisition will smallest.	Construction cost is 1.2 times higher than Route-A, and 0.6 times lower than Route-A. Length of the Route is approximately 1,590m shorter than Route-A. However portion of open channel is 600m longer than Route A.	Construction cost is smallest among three Route. However portion of open channel is approximately 1410m longer than Route A therefore land acquisition will be largest.

Source: JICA Study Team

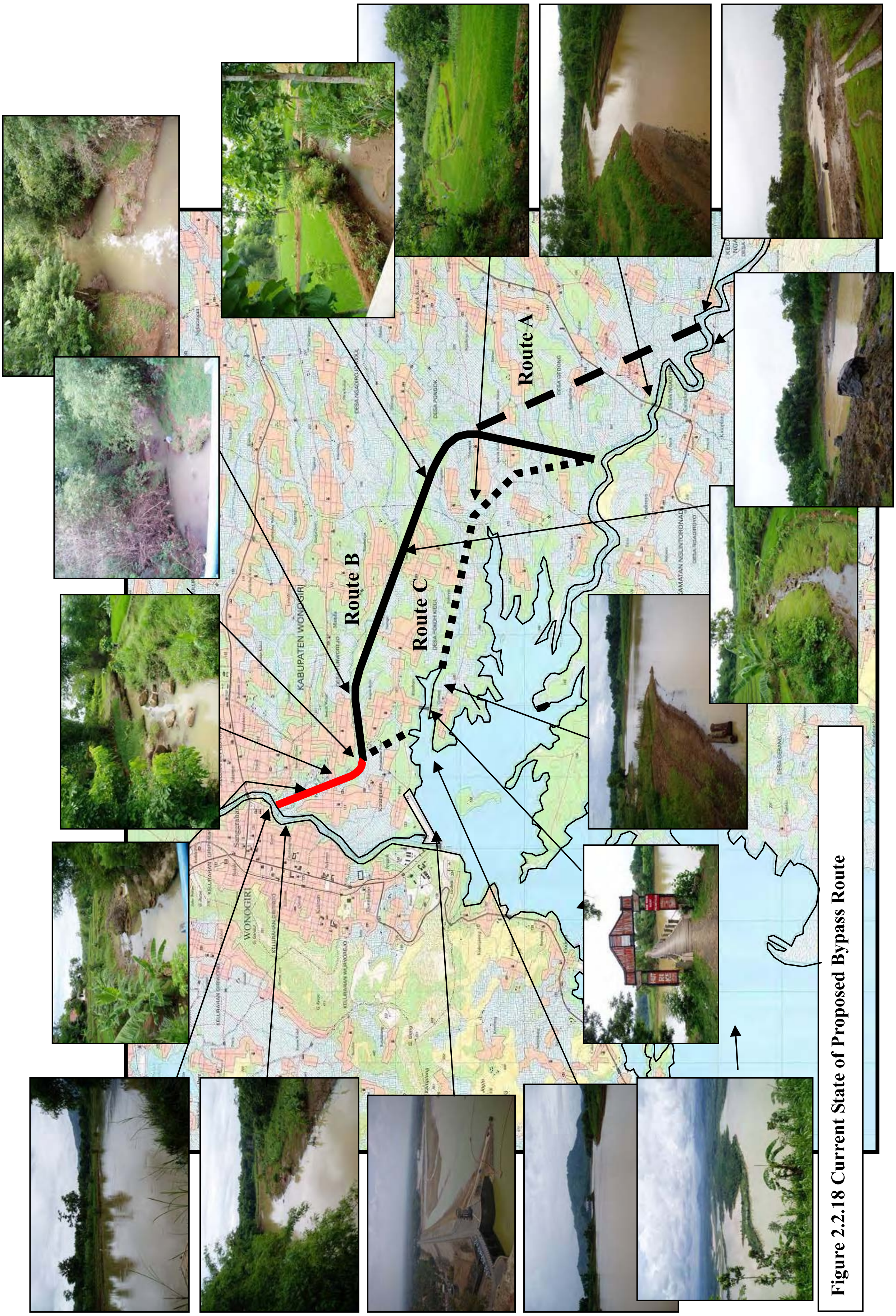


Figure 2.2.18 Current State of Proposed Bypass Route

Source: JICA Study Team

(8) River improvement plan of downstream of bypass tunnel outlet

i) Foundation height

Upstream of the river	EL.125.0m
End of river (Confluence of Solo River)	EL.110m

ii) Length of the river 2,890m

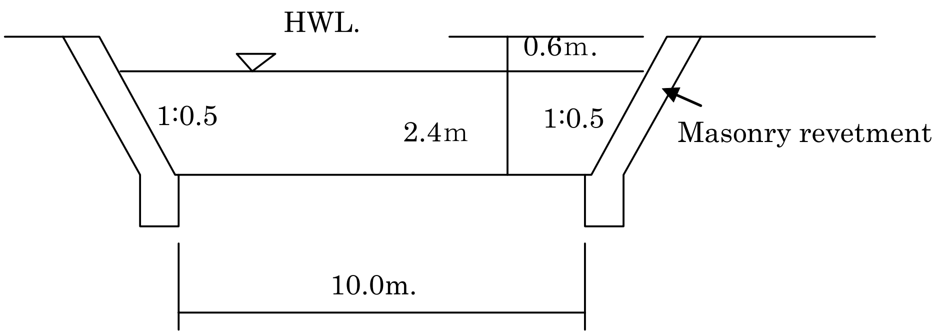
iii) Gradient of the river I= （125－110）／2,890 ＝ 1/200

iv) Design discharge $Q=65\ m^3/s$

- 10 years occurrence discharge of the rive	$Q=11.5m^3/s$
- Specific flow of average Solo River tributary	$Qs=1.12m^3/s/km^2$
- Tributary basin	$A=10km^2$
Out flow from bypass tunnel	$Qb=50m^3/s$

v) Cross section of the river

- Width of river bed	B=10.0m
- Slope of the bank	1:0.5
- Depth of design flow	h=2.4m
- Free board	△h=0.6m



2.2.2 Sediment Sluicing by New Gates

(1) Features and Objectives of this Method

By lowering water level during certain period, sediment tractive force is to be restored more than threshold of sediment movement, and to make sediment flush out from the dam reservoir. This method is to slue flood flow including high concentration sediment before soil particles being settled down in the reservoir. In most of the case, water level at flooding is managed on low of it, and the sediment transportation force shall make enough recover to flush sediment out. This method needs modification of reservoir operation rule due to the requirement of massive water and has to lower water level near sediment deposit elevation. If lowering the dam is difficult, this method can not be adopted, and is very useful for such reservoir as relatively small and lowering the water level can be carried out during short time. In case it takes long time to lower the water level, sediment flushing might be difficult to carry out.

(2) Possibility of Application

1) Applicability

In generally, Wonogiri dam is very large and water volume is so huge that it takes long time to lower the water level in the reservoir. That reservoir turn-over rate is very small as 2.3 times a year on average. Therefore, it is difficult in Wonogiri reservoir to carry out sediment sluicing by common operation. However, this method can be carried out at the beginning of rainy season when the water level is the lowest. This method is taken backward process as common sluicing. At first, it looks like sediment flushing, and then water level increased during sluicing.

2) Layout of the facilities

As the sediment sluicing facilities, spillway is adopted. However, as overflow foundation height is EL.131.0 m, which is 4.0 m higher than sediment deposit level. Existing spillway is laid out at the left abutment of the dam, where is opposite side of the Keduang River. In consequence, the Keduang River flow go through in front of Intake and convey garbage and sediment accumulating around Intake.

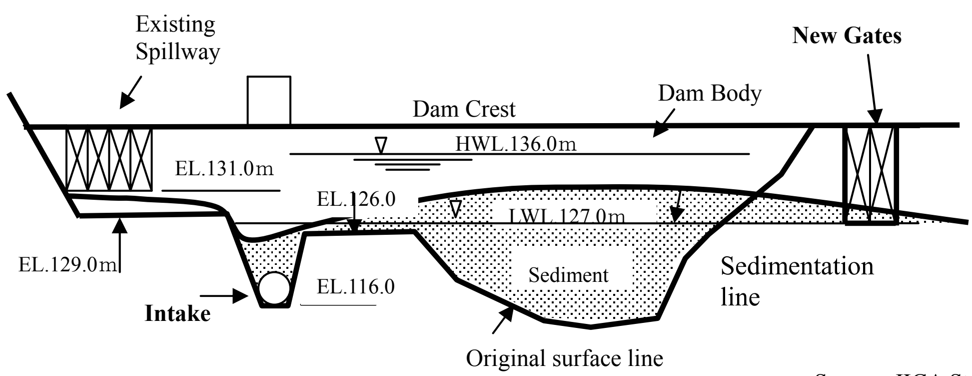
According to the analysis of the Keduang River flow, it strikes the right dam abutment and turn its direction to the left. Therefore, to slue the sediment flow smoothly to down stream of the dam, new spillway shall be laid out at the right abutment. And overflow foundation height should be adopted EL.127.0 m to remove sediment effectively. This facility serves both as sediment flushing and spillway for PMF.

Facility plan is shown in Table 2.2.10 and location map is shown the Figure 2.2.20.

Table 2.2.10 Facility Plan

Facility	Dimension	Remarks
Sediment Sluicing Gates	H12.6m×B7.5m×4nos	Radial gate
Spillway	B=30m, L=723m I=1/108	Chute type spillway and channel
Forebay excavation	EL.127.0m	Sediment deposit level

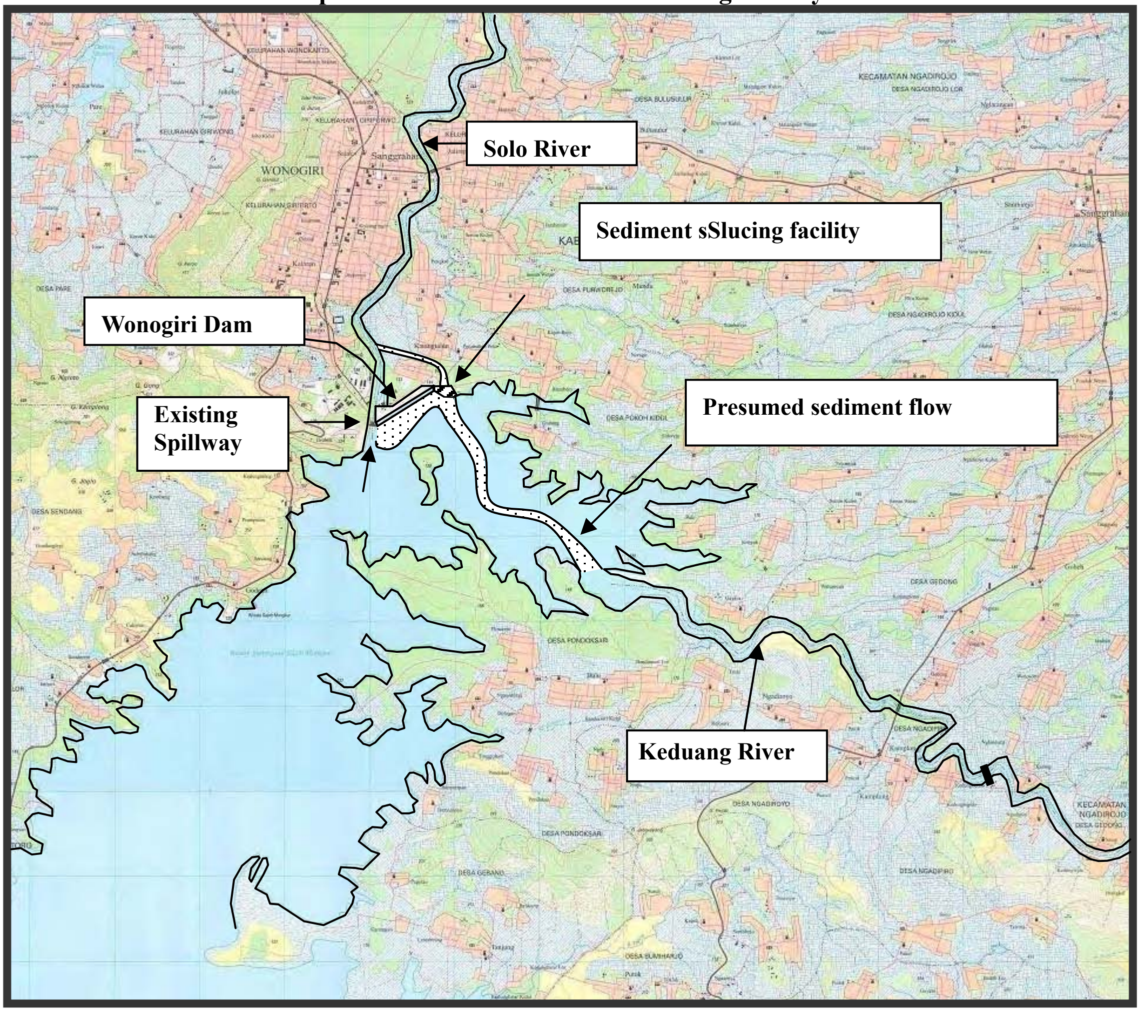
Source: JICA Study Team



Source: JICA Study Team

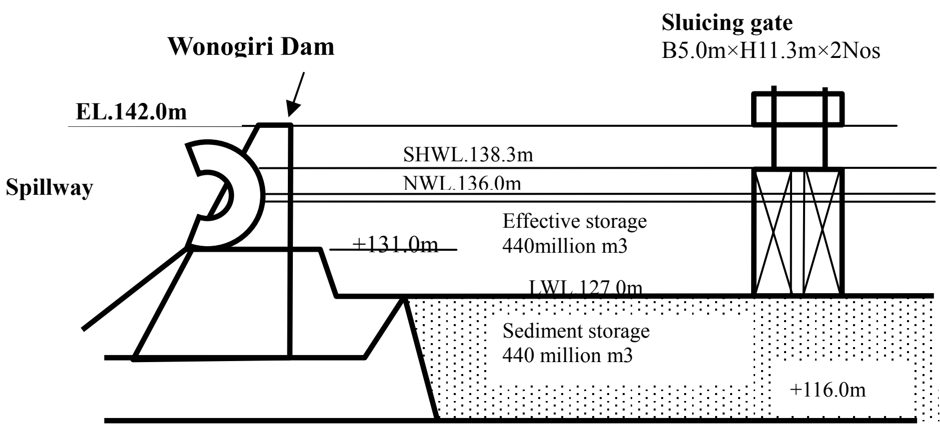
Figure 2.2.19 Image of Profile of Conceivable Sediment Sluicing Facility

Proposed Location of Sediment Sluicing Facility



Source: JICA Study Team

Figure 2.2.20 Location of Proposed Sediment Sluicing Facility



Source: JICA Study Team

Figure 2.2.21 Location of Sluicing Gate

3) Operation

Sediment sluicing method shall be used at the beginning of rainy season when water level is the lowest. From the first flood until total discharge reaching at 200

MCM, which is the allowable discharge from reservoir per year, sediment sluicing operation is continued.

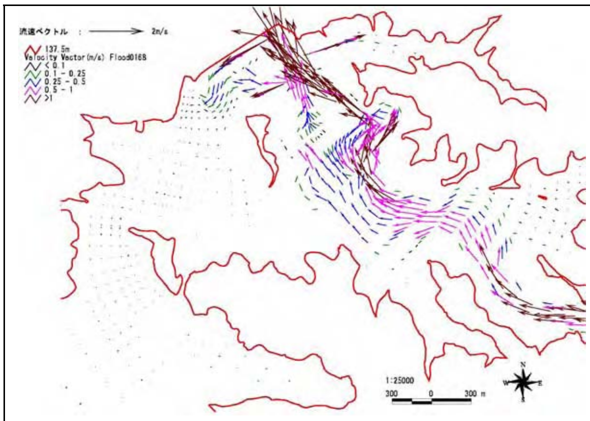
4) Reservoir Sedimentation Simulation at Rainy Season

A reservoir sedimentation analysis was made applying the operation for the new sluicing gates mentioned in the above. The applied hydrological information is from the reservoir inflow in 1998/99. Results of the analysis are summarized in Table 2.2.11 and Figures 2.2.22 and 2.2.23 below.

Table 2.2.11 Sediment Balance of Sediment Sluicing by New Gates

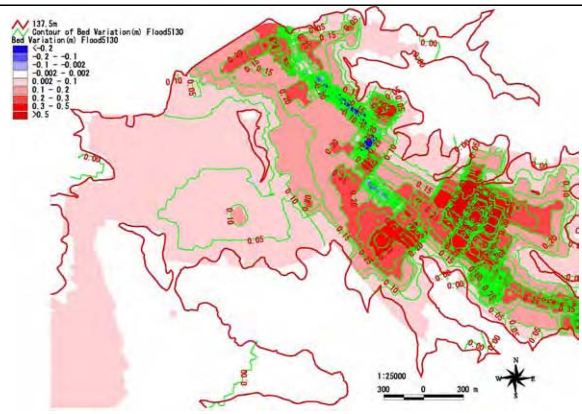
Facility	Unit	Sediment outflow				Sediment Deposit in the Reservoir	Total Sediment Inflow from Keduang
		Intake	Existing spillway	New gate	Total		
Existing condition	1,000 m^3	394	244	-	638	1,071	1,710
Sluicing	1,000 m^3	334	-	509	843	866	1,710
(Difference)	1,000 m^3	-60	-244	509	205	-205	
Released water	MCM	878	-	200	1,078	-	
Concentration	ppm	405	-	2,712	832	-	

Source : JICA Study Team



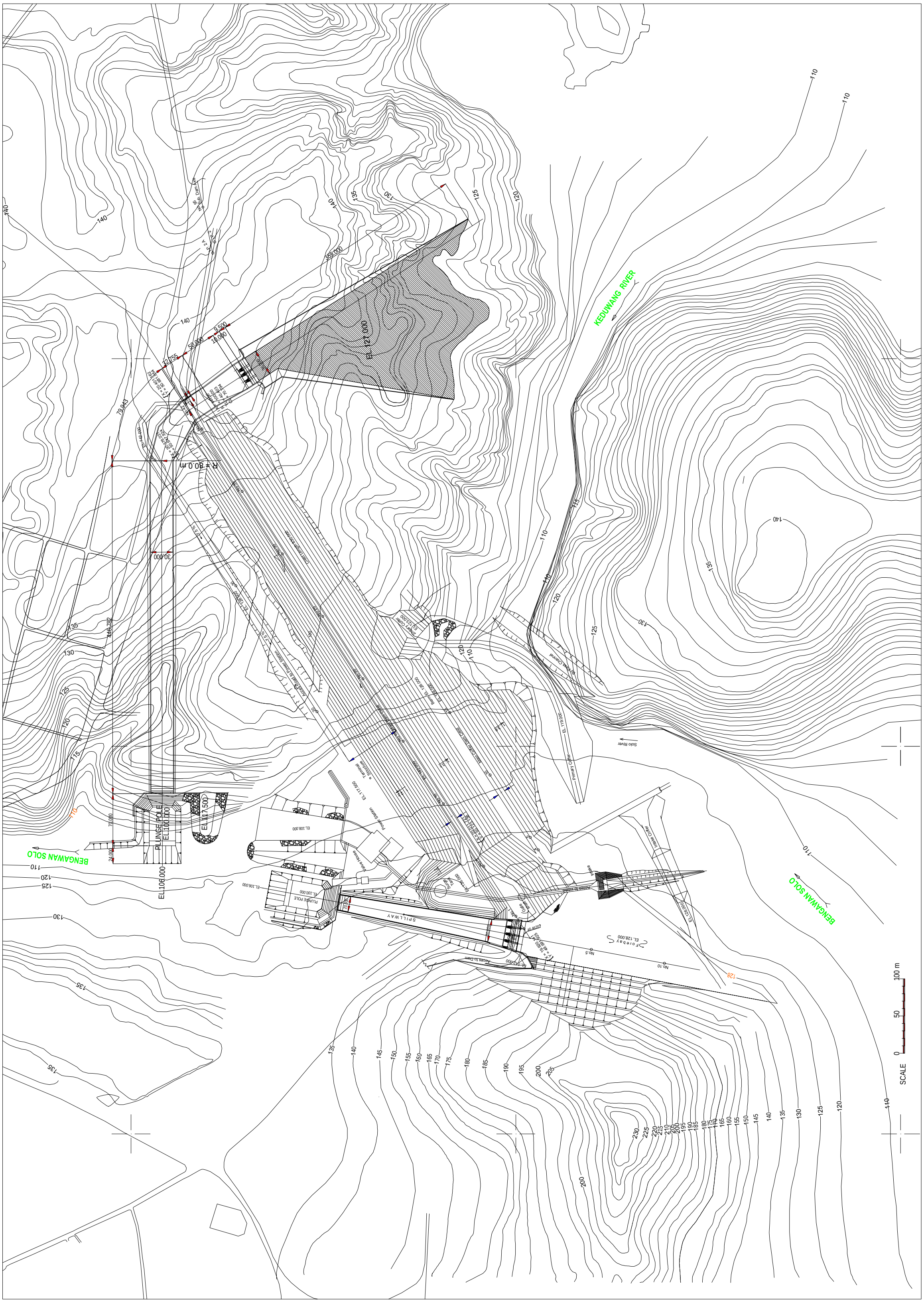
Source: JICA Study Team

Figure 2.2.22 Velocity



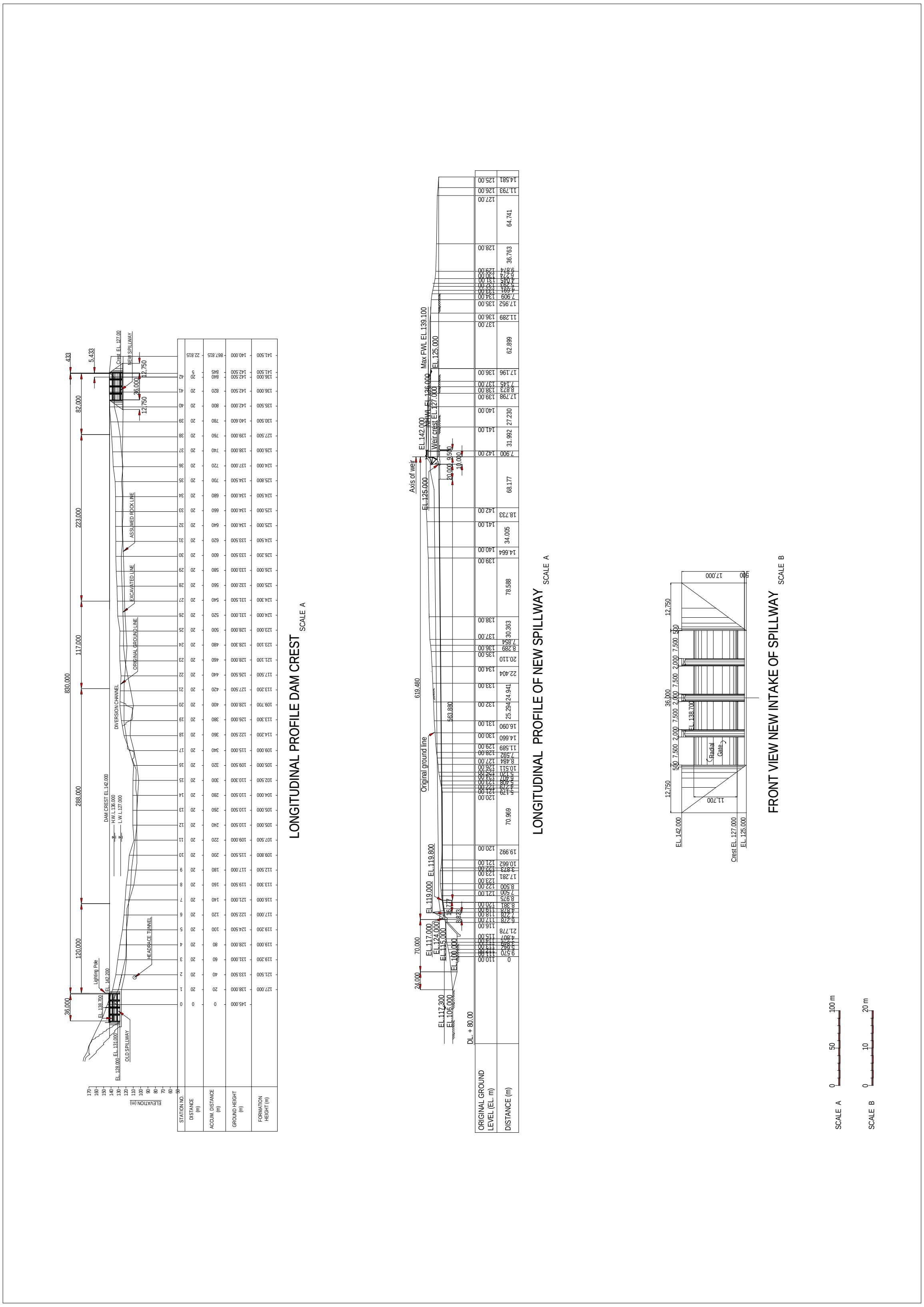
Source: JICA Study Team

Figure 2.2.23 Sedimentation



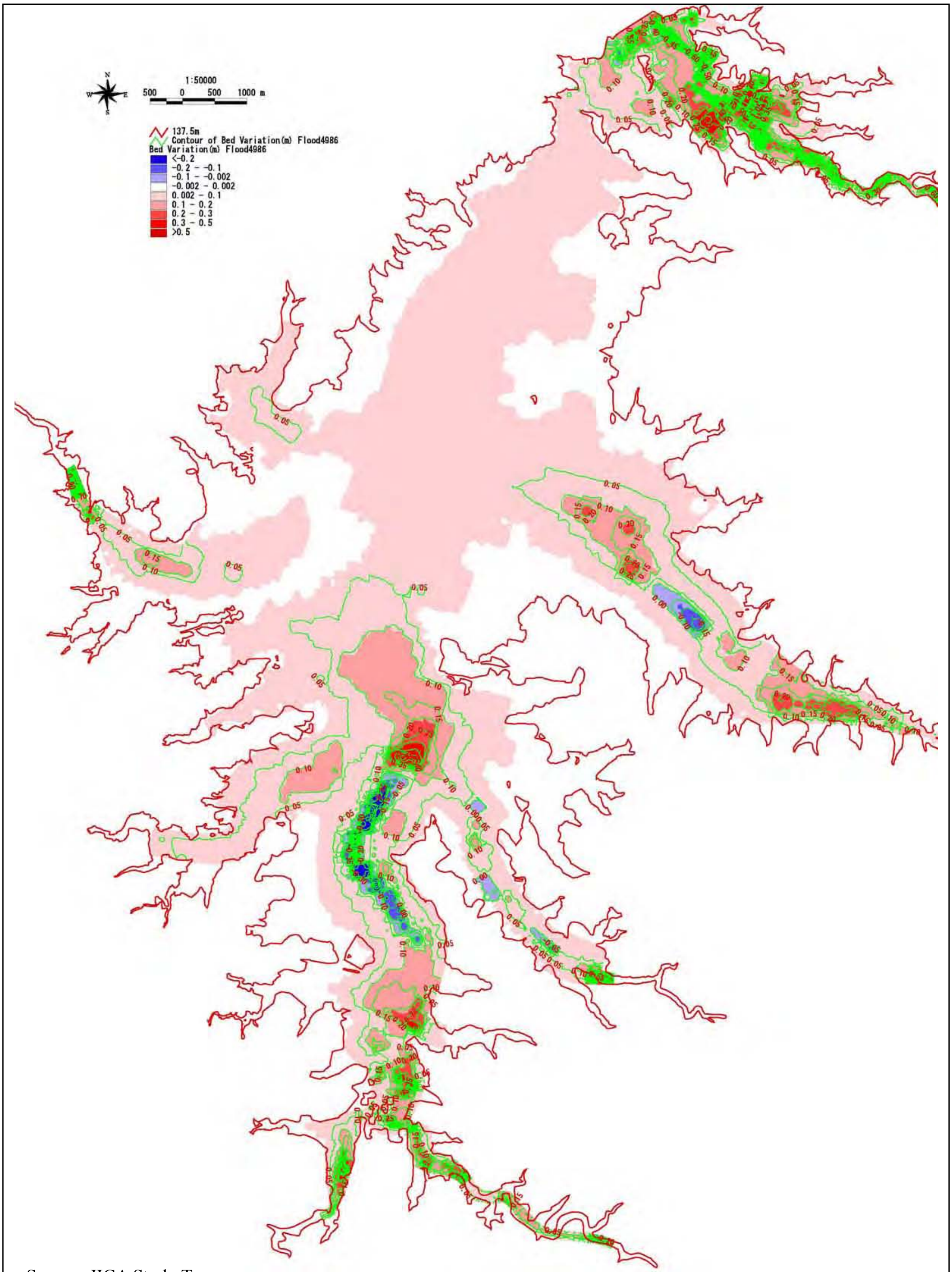
Source: JICA Study Team

Figure 2.2.224 Layout Plan of New Sediment Sluicing Gate



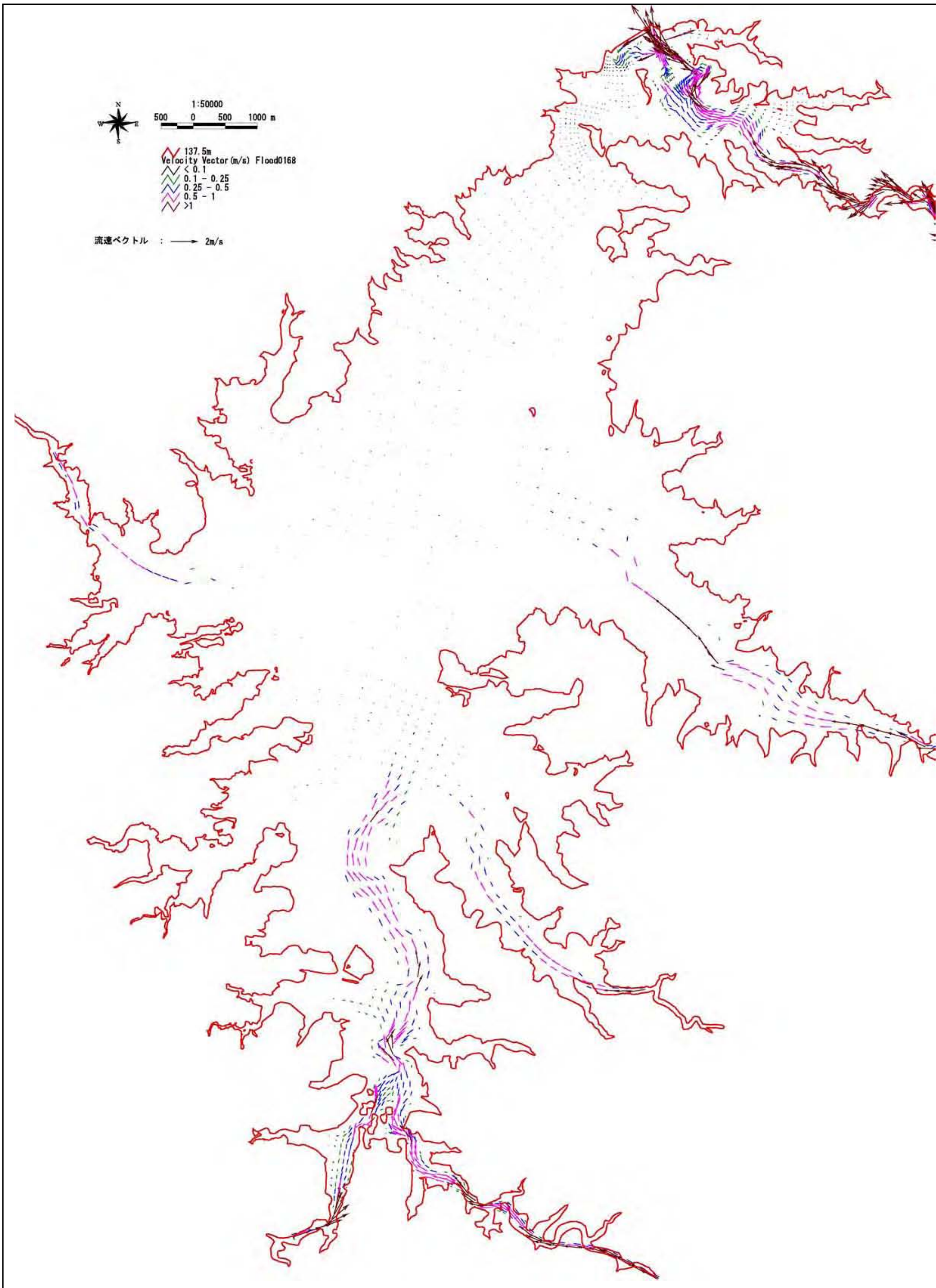
Source: JICA Study Team

Figure 2.2.25 Profiles of Dam Axis and New Spillway



Source: JICA Study Team

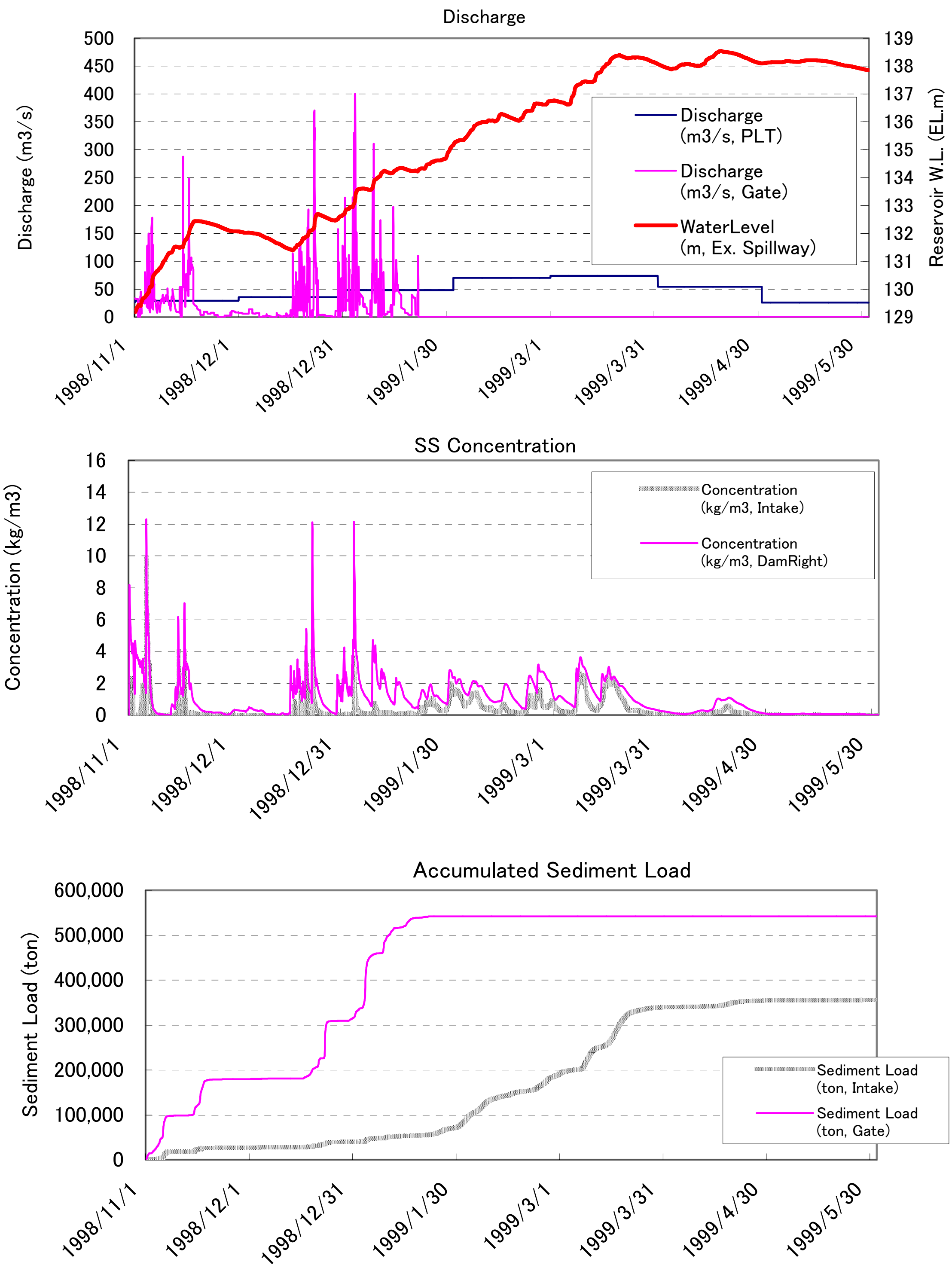
Figure 2.2.26 Sedimentation at Whole Reservoir



Source: JICA Study Team

Figure 2.2.27 Velocity Vector at Whole Reservoir

MEASURE Sediment Sluicing by New Gate
HYDRO WET YEAR
DATE 1998/11/01-1999/5/31



Source: JICA Study Team

Figure 2.2.28 Result of Reservoir Sedimentation Analysis

(Case : Sediment Sluicing by New Gate)

(3) Evaluation

1) Environmental Aspect

This facility can be constructed in Dam area. Therefore environmental social consideration would not be serious for construction. However in operation, high sediment concentration flow might be discharged into downstream of river.

2) Effectiveness

i) The released sediment volume through the new sluicing gates is around 509,000 m^3, which is about 33,000 m^3 larger than that of Keduang River sediment bypassing. Net increase of sediment released by sluicing is estimated 205,000 m^3.
ii) It is expected that most of the garbage from the Keduang River would be released through the new gates to the downstream reach from the dam.
iii) Released water volume would be 200 million m^3 and average sediment concentration 2,712 ppm.

3) Constraints of Construction

There are no difficult condition for construction.

4) Reliability

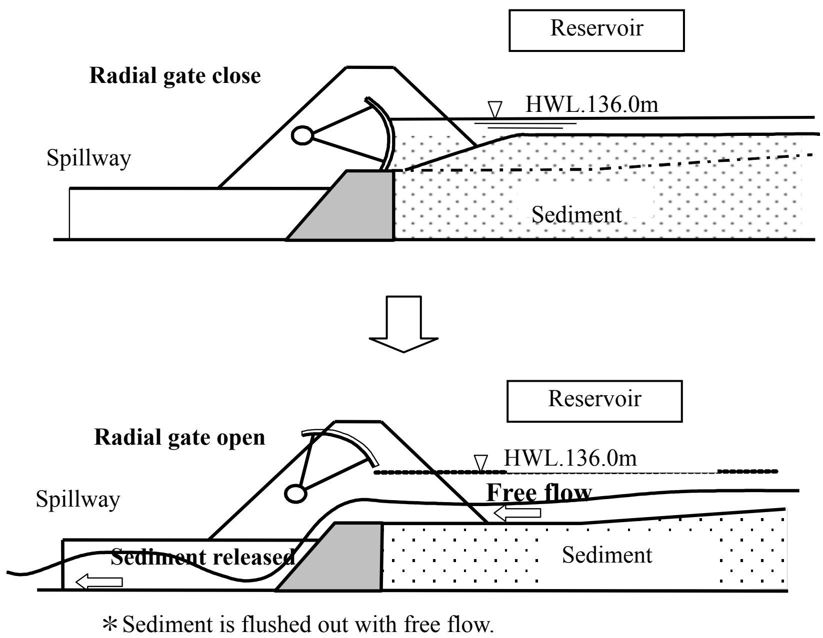
There are many examples to utilize spillway for sediment flushing. This method is common way.

5) Cost

Initial cost is a little expensive.

(4) New Sediment Sluicing Gate

By lowering the water level in the reservoir and opening the gate fully, sediment deposited in the reservoir shall be flushed out with running water from the Keduang River. Sediment flushing cannot be carried out effectively until the sediment deposits elevation reaches more than foundation height of flushing gates.



Source: JICA Study Team

Figure 2.2.29 Image of Sediment Flushing

In Indonesia , this method have been adopted commonly at existing dam such as Wlingi dam and Lodoyo dam, and operated periodically. However sediment flushing is can be done when water level is lowered until almost same level with planned sediment deposit level, while water level is high, this method become sediment sluicing. This method needs modification of operation rule of reservoir due to the requirement of massive water and must to lower water level near sediment deposit elevation. If lowering the dam is difficult, this can not be adopted, and is very useful for such reservoir as relatively small and lowering the water level can be carried out during short time. In case it takes long time to lower the water level, sediment flushing might be difficult to carry out. Below figure shows the image of sediment flushing.

	
Sediment Flushing by Spillway at Wlingi Dam	**Sediment Flushing by Spillway at Wlingi Dam**
	
Sediment Flushing by Spillway at Wlingi Dam	**Sediment Flushing by Spillway at Wlingi Dam**
	
Restored low water channel at Wlingi Dam	**Sediment deposited at the front of Intake**

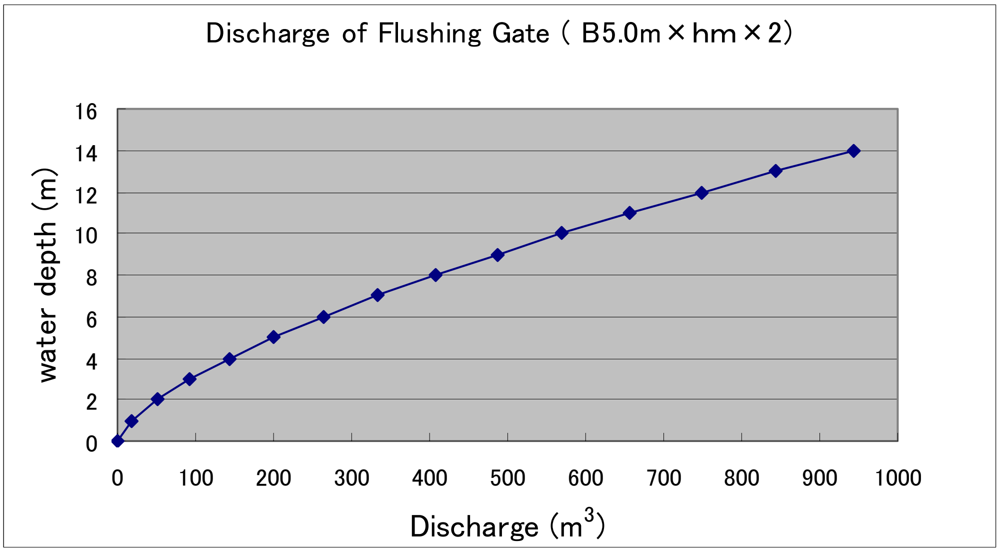
Sediment Flushing Practice at Wilingi Dam on May, 2004

(5) Preliminary Study of Gate Operation

To carry out sediment flushing effectively, it is important to lower the water level and recreate free flow on the reservoir. However, if sediment flushing is carried out at high water level, it takes long time to lower water level. As mentioned below, it was estimated to take 11.6 days to lower water lever from EL.135.3 m to EL.127.0 m. Therefore this method should be used when water level is low such as under EL.131.0 m which is kept at the end of rainy season and the same height with existing spillway foundation.

Required time to lower the reservoir water level from El 135.3 m to El. 127.0 m

- Storage volume between EL.135.3 m and EL.127.0 m : 200,000,000 m^3
- Average discharge capacity of new gate : about 20 m^3/s
- Time = 200,000,000 m^3÷200 m^3/s = 1000,000s = 11.6 day

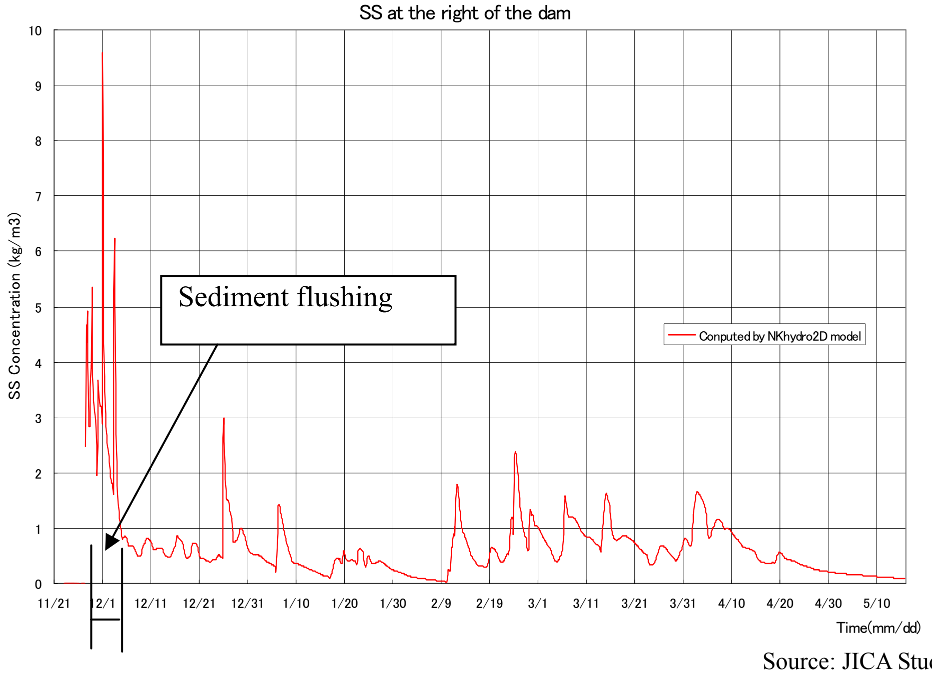


Source: JICA Study Team

Figure 2.2.30 Discharge Ability of Flushing Gate

Sediment Discharge from New Gates

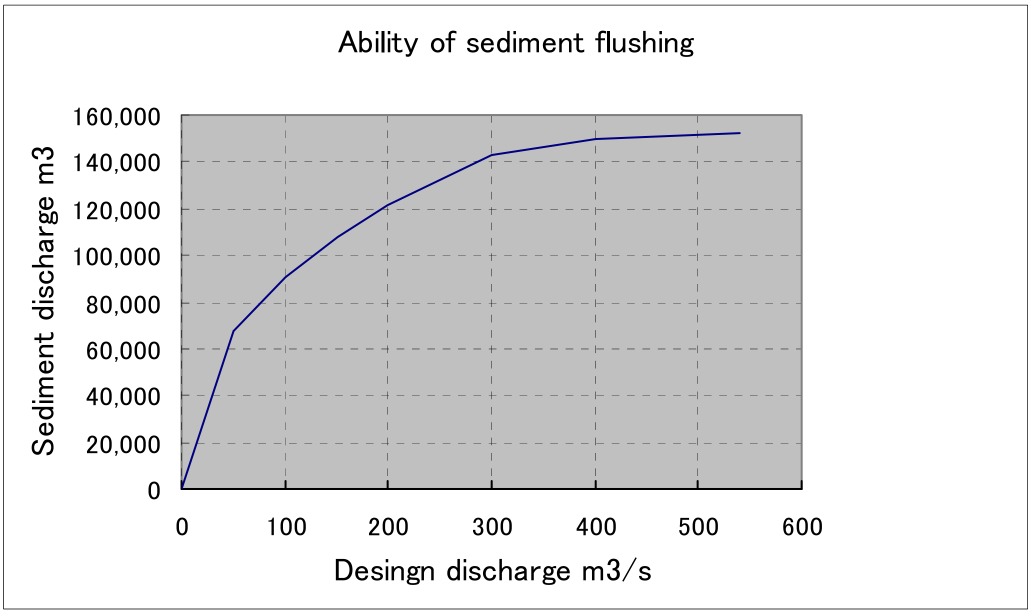
In this section, ability of sediment releasing from the new gate was considered using the last rainy season data. Figure 2.2.31 shows the simulation result of the SS concentration at the right side of the dam where the new gate is expected to be constructed. In this case, the new gate would be opened from Nov. 27, 2004 to Dec. 4, 2004, while high concentration sediment is flowing down. In this period, sediment concentration becomes 9.58 kg/m^3 (9,580 ppm) at maximum, 3.19 kg/m^3 (3,190 ppm) on average, while 0.69 kg/m^3 (690 ppm) on average during rainy season.



Source: JICA Study Team

Figure 2.2.31 SS Concentration of Keduang River (21 Nov, 2004 – 15 May, 2005)

Figure 2.2.32 and Table 2.2.12 show the relation between sediment discharge form the new gate and volume of sediment flushing. According to these analysis, until ability of gate is 50 m^3/s, graph rise sharply, and 50 m^3/s to 300 m^3/s, graph is declined, and more than 300 m^3/s, incremental ratio become very small. Thus, dimension of flushing gate is recommended to adopt from 100m^3/s to 300m^3/s. If 200 m^3/s flushing gate is selected, 121,726 m^3/s sediment with 36,539,460 m^3/s water is flushed out. These occupy the 16.7% of inflow sediment and only 13.2% of flow water from the Keduang River



Source: JICA Study Team

Figure 2.2.32 Relation of Design Discharge and Sediment Discharge