7 References

Table of Contents

Tables

Figures

7.1 Estimation of Annual Sedimentation into the Wonogiri Dam Reservoir

7.1.1 Estimation of Annual Sediment Volume into the Wonogiri Reservoir

(1) Erosion rate in the Wonogiri watershed

The erosion rate in the Wonogiri watershed was estimated at 8.8 mm/year in the CDMP Study. This erosion rate is judged to have been in error for the following reasons:

1) The cross sections in the Wonogiri reservoir prepared at the detailed design (D/D) stage were used to estimate the sedimentation volume since the dam construction completion and they had been prepared based on the topographic map (1/5,000). However the maps are not existing at the moment and these could not be checked so the accuracy is judged to be very questionable.

   Also, the manner in which the water depth survey to estimate the sedimentation volume was conducted by PBS to date have not been satisfactory because the positioning of the survey boat was not properly made according to hearing from PBS.

2) is the sedimentation rate is judged to be much higher than the design value of the other 51 dams on Java Island. These values are shown in Table. A7.1.1 and Fig. A7.1.1

Java island (mean)	2.11 mm
Java island (maximum)	3.87 mm
Central Java (mean)	2.86 mm

3) Also, decrease of the Wonogiri reservoir volume below EL. 138.0 m was estimated in the report, "PEKERJAAN MONITORING SEDIMENTASI WADUK WONOGIRI DAN BENDUNG COLO PT. CITRA MANDALA AGRITRANS 1993".

1981-1985 $711 \times 10^6 - 524 \times 10^6 = 187 \times 10^6\ m^3$

$187 \times 10^6\ m^3 / 5year / 1350\ km^2 = 27.7$ mm/year

1986-1993 $524 \times 10^6 - 472 \times 10^6 = 52 \times 10^6\ m^3$

$52 \times 10^6\ m^3 / 8year / 1350\ km^2 = 4.8$ mm/year

Therefore, the new estimation is made as follows:

Sediment yield of each tributary is estimated from the land use based on the each Kecamatan in Kabupaten Wonogiri as shown in Table. A7.1.2. The mean erosion depth is assumed from the following table because data of erosion depth in Indonesia is not collected, annual rainfall in Japan (Tokyo: 1500mm) is approximate to the one at Wonogiri dam and the pattern of rainfall during Typhoon in Japan is similar to the pattern of rainy season, except for rainfall duration.

Erosion Depth of Land Use

	Devastated	Dry	Irrigated	Grass	Forest
Erosion depth(mm)	10^1-10^2	10^0-10^1	10^{-1}-10^0	10^{-2}-10^{-1}	10^{-2}-10^{-1}

Land Use and Sediment Yield

Sub-basin	C.A. (km^2)	Irrigation (%)	Rainfed (%)	House (%)	Forest (%)	Dry (%)	Others (%)	Sediment yield (mm)
Erosion depth		0.1 mm	0.1 mm	0.1 mm	0.01 mm	10.0 mm	1.0 mm	
Keduwang R.	426	22.4	3.5	29.5	14.3	26.8	3.5	2.77
Tirtomoyo R.	206	11.7	5.5	24.3	16.0	38.3	4.2	3.92
Upper B. Solo	200	3.5	4.8	7.5	32.1	46.7	5.4	4.74
Alang R.	235	5.2	0.2	14.2	30.3	48.1	2.0	4.85
Temon R.	73	11.8	4.2	17.9	5.5	23.6	37.0	2.76
Wuriyantoro R.	69	13.2	3.0	15.5	1.0	22.3	55.0	2.81

Mean 3.64 mm/year

The denudation rate of the Wonogiri reservoir is estimated 4.0 mm/year based on (2) and (4). The inflow of the sediment is about 5.4 x 10^6 m^3/year.

(2) Trap efficiency of Wonogiri reservoir

Trap efficiency of the Wonogiri reservoir is calculated by the following formulas to estimate sedimentation.

Brown : $E_T = 100\left(1 - \frac{1}{\left(1+K\frac{C}{F}\right)}\right)$

Brun : $E_T = 100 \times 0.97^{0.19^{\log C/I}}$

Kira : $E_T = 100 \times 0.96^{0.25^{\log C/I}}$

where, E_T: trap efficiency (%), F: catchment area (km^2), C: reservoir volume (m^3), K: constant (K_{max}=0.0021, K_{min}=0.0001,K_{mean}=0.00021), I: mean annual inflow (m^3)

For Wonogiri dam,

F = 1,350 km^2,

C = 735 x 10^6 m^3, I = 44.4 m^3/s x 86,400 x 365 = 1,400 x 10^6 m^3

Broun: 98.2~99.9 % (average: 99.1 %)

Brun: 95.3 %

Kira: 94.2 %

The trap efficiency of the Wonogiri dam adopted is 95%. The sedimentation volume in the reservoir is estimated as follows.

5.4 x 10^6 m^3/year x 0.95 = **5.1 x 10^6 m^3/year**

7.1.2 Sediment yield in Keduwang River

Sediment yield in Keduwang River is estimated as follows.

1) Land use 2.77 mm/year (3.04 mm/year*)

2) Design value of dams in central Java 2.86 mm/year

3) Measurement value at Sembukan 2.09 mm/year

Note; *: Conversion value assuming that the average value for the whole basin being 4.0 mm/year

(2.77 x 4.0/3.64 = 3.04)

Measurement value at Sembukan is underestimated because the sampling of suspend load was not carried out during the flood.

Sediment yield in the Keduwang river adopted is 3.0 mm/year based on the 1) and 2).

Sediment yield = $3.0 \times 10^3 \times 426 \times 10^6 = 1.28 \times 106\ m^3$

7.2 Middle and Long Term Countermeasure for Sedimentation Problem in the Wonogiri Multipurpose Dam (Draft)

7.2.1 Necessity of sediment control

It is necessary to design and execute middle and long term countermeasures for the sedimentation in Wonogiri dam because the efficiency of the dredging works by the Japan grant aid is only five year. However, the knowledge from the field work and general countermeasures only are mentioned because of this study being out of the scope of works of this study.

Sediment inflow in the reservoir is estimated at about 5 million m^3/year, that is, 3.5 times the design value due to following reasons.

- Change of land use due to increase of the population in the Wonogiri dam catchment area (about 710,000 persons at present)
- Soil erosion was accelerated due to cultivated land development under inadequate agricultural management

At the present, the water supply to the power station and the Wonogiri irrigation system from the reservoir is not affected from the decrease of the reservoir volume, although the intake has a risk of plugging. In future, if the countermeasures are not taken , it will seriously affect the water supply for irrigation and hydropower generation, as well as flood control.

Therefore, the watershed management of the catchment area of the Wonogiri dam must be addressed before tackling the sediment problem directly.

7.2.2 Organization of the Watershed Management

The execution agencies for the watershed management are proposed as follows:

(1) Ministry of Settlement and Regional Development

(2) Ministry of Forestry

(3) Ministry of Agriculture and Plantation

Further, there are implementation agencies needed for each of the above ministries with responsibility for the watershed management.

7.2.3 Watershed Management Plan for the Wonogiri Multipurpose Dam

(1) Abstract

The problem of the intake water from the Wonogiri multipurpose dam will not deteriorate for about five years after this urgent dredging works. It is very necessary during the five years that the extensive and integrated study for the counter measures through watershed management and the prioritization shall be executed. The watershed management plan is proposed as shown in Fig. A7.2.1 and as below.

Watershed Management Plan

<table>
<tr><td>5 years</td><td colspan="2">Urgent Countermeasure
・Dredging Work in front of the intake
(by Japan's Grant Aid)</td><td>Master Plan of Watershead Management of Catchment of Wonogiri Multipurpose Dam
Feasibility Study of Watershead Management of Catchment of Wonogiri Multipurpose Dam
Detailed Design of the structural matter / Soft component of the Watershead area</td></tr>
<tr><td>Middle & Long Term</td><td>(Structural Measure)
・Mechanical Raking system
・Dredging system
・New construction of intake
・Sediment flushing tunnel
・Reshape of the spillway crest elevation
・By-pass tunnel/ channel
・Check Dam</td><td>(Soft Component)
・Sediment control
・Consciousness raising of farmer
・Contour line cultivation
・Catch crop
・Cutting of list due to drain purpose
・Rapid repair work of gully erosion
・Slope management of terrace
・Soil amelioration
・Construction of drainage and retaining work</td><td>Monitoring
・Echo sounding survey in the reservoir
・Measurement of Suspended load on the main tributaries
・Update of the critical land map
・Trend of the farmer's income
・Grasp of the construction situation of small structures</td></tr>
</table>

(2) Monitoring

1) Sediment situation in the reservoir

The new echo sounding survey system to be given by this Japan's grant aid and monitoring around the intake is recommended. In addition, to grasp the sedimentation situation in the whole reservoir area, it is necessary that the echo sounding survey be carried out at least once a year. This result is useful to study the middle and long term countermeasures and quantify the results of these countermeasures.

2) Sediment volume from the main tributaries

The suspended load from each main tributary needs to be determined to calculate the sediment volume into the reservoir. The trend of the sediment volume should be monitored before and after application of the middle and long term countermeasures

3) Concentration of the suspended solid at downstream of the dam

The present situation of water quality downstream of the dam is to be grasped from the result of the environmental impact survey, which is executed by PBS at moment.

The monitoring of the impact at the downstream of the dam is needed because water with sediment is discharged from the spillway crest (refer to (5)5) of this sub-clause) and bypass tunnel at the Keduwan River(refer to (4) of this sub-clause).

(3) Sediment Control

1) Improvement of Agricultural Method

Paddy is mainly cultivated in the upstream area of the Wonogiri dam because paddy cultivation is less risky than vegetables and other crops from the point of view of sediment control. However, cassava is cultivated in rain-fed areas during the dry season. Although cassava cultivation accelerates soil erosion, the farmers are willing to cultivate the cassava as they are in lower income brackets.

Therefore, it is considered that the agronomist and agro-technician shall study the selection of crops, improvement of their agricultural method and so on. Education of farmers is needed by agricultural experts and/or NGO groups over the long term.

2) Countermeasure by af-forestation

According to Forestry law UU No.41/1999 clause 18, forest area is required to be more than 30% of the watershed area by the af-forestation. Therefore, a tree-planting project shall be executed as a long term countermeasure.

(4) Control of Suspended Load

Many structural measures could be constructed on each tributary for the control of the suspended load. The following countermeasures are recommended:

- Cascade construction of sabo dams on each tributary
- Construction of small earth-fill dams on the secondary or tertiary tributaries
- Bypass tunnel/ channel

Prioritization study for the structural measures has to be executed.

Plan of the bypass tunnel/channel route from the Keduwang River to Alan River is tentatively shown in Fig. A7.2.2.

(5) Removal Sediment from the Reservoir

1) Mechanical Raking System

Although much garbage accumulates around the intake facilities at the beginning of the rainy season, a floating log boom is not set around the intake at present. In this Japan grant aid, a floating log boom will be installed around the intake facilities, and most of the garbage shall be discharged over the spillway with the remaining garbage to be removed by man power from around the floating log booms and the screen of the intake. Care will be in the course of the operation to prevent the remaining garbage from plugging the screen of the intake. To remove the garbage on the intake screen a mechanical raking system on the screen would be useful.

The necessity of the mechanical raking system should be judged through monitoring the condition of the screen and intake area after completion of this Japan grant aid (the Assistance Project).

The general layout of the mechanical raking system for the screen of the Intake is shown in Fig. A7.2.3.

Outline of the mechanical raking system is as follows:

(a)	Type	;	Trash Car Type, Electric Driven Mechanical Rake System with Chain Conveyor
(b)	Setting Elevation of Fixed Trash Rack		
	Bottom	;	EL. 116.0 m
	Top	;	EL.142.0 m (Dam Crest)
	Difference	;	26.0 m
(c)	Inclination	;	60° against Ground Line
(d)	Raking Length	;	30,022 mm
(e)	Performance		
a)	Rated Raking Capacity	;	0.50 ton/m
b)	Dead Weight of Rake	;	800 kg Approx.
c)	Hoisting Speed	;	15 m/min.
d)	Conveyor Speed	;	10 m/min.
e)	Rated Output	;	3.7 kW, 4 poles
f)	Electric Source	;	400 V / 200 V, 50 Hz
g)	Width of Conveyor	;	600 mm
h)	Width of Apron	;	4,800 mm
i)	Width of Rake	;	2,800 mm
j)	Overall Width	;	8,000 mm
k)	Overall Height	;	4,500 mm
l)	Lightening	;	500 W × 1 no. 300 W × 2 nos.

In addition, a simply supported steel bridge (effective width: 1.8 m, design load: 350 kg/m^2) having three spans (two spans of 30 m and one span of 25 m) between the dam crest and the raking tower will be required for the transportation of the removed garbage.

The preliminary cost estimate for the above is as follows:

-	Mechanical raking system	1 set	Japanese yen 18,000,000
-	Steel bridge（around 70 ton）	1 set	Japanese yen 21,000,000

In the above, the construction cost of the civil works such as concrete structures supporting the raking system and sub-structure of the steel bridge are not included.

2) Input of the dredgers

As explained in 2.2.2 of the report, the component of a dredging system to dredge the sediment from near the intake and other areas is dropped from this Japan's grant aid. However, in future, of the choice between an ordinary dredge or grab bucket dredging system, and the hydro type dredging system, the latter (the hydro type dredging system) is strongly recommended because of the cost being greatly lower than the former.

On the other hand, both the dredging in the water and the open excavation in the air should be considered for the dredging works in the whole reservoir area. In this case, the dredging method, the area and the volume should be decided from the point of view of the effect on reservoir operation.

3) New construction of another intake

Considering the fact that the actual low water level in the present reservoir operation is limited to around EL.130.0 m although it might be obliged due to the sedimentation problems in front of the intake, construction of a new intake with a sill elevation of EL. 128-130 m, higher than the originally planned sediment level (EL.127.0 m), and abandoning the current intake, are strongly recommended to prevent similar sedimentation problems in the future. Then, the reservoir spaces required for irrigation, power generation, and flood control should be reviewed, along with the restricted water level in the rainy season and the normal full water level considering the recent situation of the reservoir utilization, the recent river improvement situation of the Solo river down-stream of the dam and the recent hydro-meteorological data.

4) Sediment flushing tunnel

A sediment flushing tunnel is shown in Fig. A7.2.4. Sediment from the channel upstream of the intake is conveyed downstream of the dam through a sediment flushing tunnel

This method is useful to remove the sedimentation urgently in front of the intake but the amount of sediment removed is not great.

5) Reshape of spillway crest elevation

The river course of the Keduwang River is likely to clearly appeare in the reservoir at the early rainy season because the reservoir water level is near the designed sediment level or the low water level (EL.127.0m).

If the reservoir should be operated in such manner that all four (4) spillway gates be fully opened when flood occurring during the early rainy season, much sediment could be removed along the river course and over the spillway crest because the sediment is likely to be flowing down to the downstream by the tractive force during the flood under the above condition.

To efficiently remove the sediment from the reservoir, it is best that the crest elevation of the spillway be modified to be set as low as possible. The crest elevation can be lowered by 1 m without large-scaled reconstruction as shown in Fig. A7.2.5.

The most important requirement in the reservoir operation of the Wonogiri multipurpose dam is for the water level to recover normal water level (EL. 136.0) by May 1. Therefore, the start date for the recovery of the normal water level should be decided from the past inflow record into the reservoir.

7.3 Hydro-Type Dredging System

For future reference, the following dredging system to dredge sediment continuously in front of the intake after the completion of this urgent dredging works are introduced:

A hydro-type dredging system is divided in two major components as described below (ref. Figs. A7.3.1 and A7.3.2).

- Hydro-J system — To dredge the sedimentation locally
- Hydro-pipe system — To dredge the sedimentation widely and discharge the sediment by a siphon system, by means of fixed pipe on the invert of the channel in front of the intake. The pipe shall be installed after leveling the invert of the channel by dredging the sediments by means of Hydro-J system. After that, the pipe will be backfilled by 1.0 to 1.5 m thickness of sand before the operation.

7.3.1 Hydro-J System

(1) System Component

The operation shall be made as follows:

1) To install a 35-ton crawler crane on Uni.-float

2) To perform the dredging works by hydro-J system suspended with the ability for vertical and horizontal positional adjustment .

The required auxiliary equipment are as follows:

- Anchor barge (7.5 ton, 95 PS)
- 1.0 m^3 grab bucket as ‘front attachment’ of 35 ton class crane.
- Commuter boat (4.9 ton, 50 PS)
- Diesel Generator (50 kVA)
- Submerged Pump (100 mm diameter, 22 kVA)
- J-pipe Swing equipment
- High-pressure jet nozzle, 3 to 4 units
- Portable winch and anchor
- Aqualung
- Flash Light
- Fender Beam
- Life jacket
- Float with wire rope

(2) Modification of existing civil structure

To apply the Hydro-J system, the following modification of existing civil structures and are necessary:

- To construct the opening portion (1.0 m W x 1.2 m H) at the right side bottom of spillway weir, a H.D.P. pipe (350 mm dia.) would be installed in the opening portion and plugged by mixed concrete
- Hydro-pipe would be installed at EL. 128.0 m on the upstream side of the spillway and a T-Branch pipe with stop valves would be connected to the Hydro-pipe.
- For the purpose of protecting the pipe from buckling by negative pressure, the gradient of the H.D.P pipe along the shoot portion of the spillway in the downstream will be limited to between 1/500 and 1/1000. The route of the pipeline will be shifted from inside to outside the spillway guide wall after the pipe reaches the same level as the top elevation of the wall.

7.3.2 Fixed Hydro-pipe System

(1) Setting Method

Fixed hydro-pipe is set in the following procedure:

- The sediment at the bottom of the channel in front of the intake will be removed by Hydro-J system. The channel in front of intake will be reformed to the original shape.
- The H.D.P. pipe would be laid on a wooden sleeper floating in the water and a counter weight installed to sink the pipe to the designated position.
- The end of the H.D.P. pipe will be at the top of the fixed screen on the intake and the other end will be connected to the installed valve in front of the spillway. A new vacuum pump would be installed to remove the air inside the pipe and start the siphon system.

(2) Key Points for the Operation

Before the practical operation, the following remarks should be key points:

- After installation of H.D.P. pipe at the designated position, well-graded sand (less than 5 mm) will be backfilled on the pipes with 1.0 m to 1.5 m thickness. Without the backfilling, the suction phenomenon can appear at any points other than the end of the pipes and only the dredging at the upstream from that suction phenomenon point will be operational and the dredging at the downstream from that suction point will not.
- After the dredging work is completed along the channel in front of the intake, the dredging work has to be suspended until the sediment on the Hydro-pipe becomes even as the depth of 1.0 to 1.5 m is. Otherwise the function of Hydro-pipe can not be recovered.

It is noted that there is a 1.5-m high temporary concrete weir 25 m from the screen (trash rack) in the channel in front of the intake.

Table A7.1.1 Design Value of Annual Sedimentation in Java Island

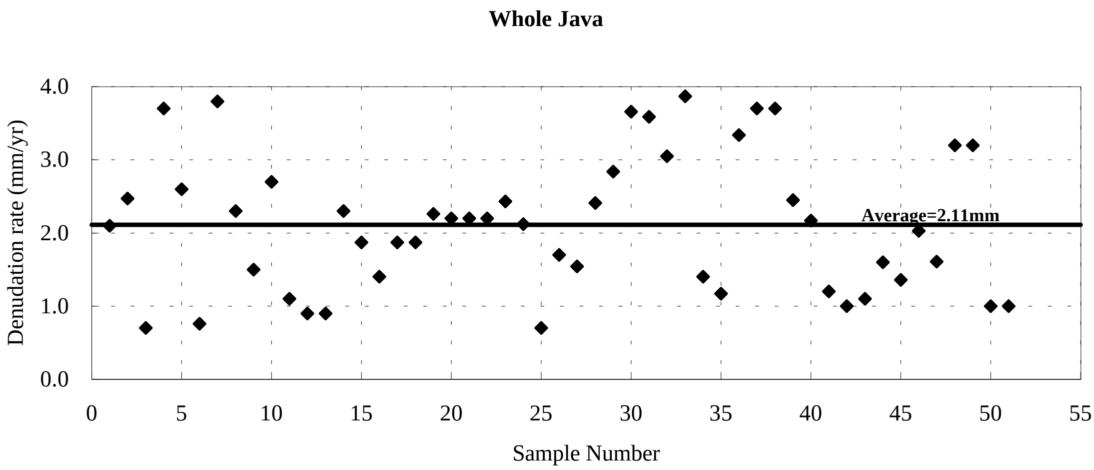
No.	Scheme	River	Province	Catchment Area (km^2)	Denudation rate (mm/year)	Remarks
1	Saguling	Citarun	W. Java	2,285	2.10	D/D
2	Palumbon	Citarun	W. Java	4,150	2.47	
3	Hulu Wadak	Citarun	W. Java	-	0.70	
4	Jatigede	Cimanuk	W. Java	1,460	3.70	D/D
5	Cipasang	Cimanuk	W. Java	1,190	2.60	F/S
6	Kadumalik	Cilutung	W. Java	419	0.76	
7	Cipelo	Cimanuk	W. Java	-	3.80	
8	Cimuntur	Citanduy	W. Java	-	2.30	
9	Cijolang	Citanduy	W. Java	-	1.50	
10	Cikawung	Citanduy	W. Java	-	2.70	
11	Ciseel	Citanduy	W. Java	-	1.10	
12	Cibanten	Cibanten	W. Java	73	0.90	F/S
13	Krenceng	Cibanten	W. Java	14	0.90	F/S
14	Pasir Kopo	Ciujung	W. Java	172	2.30	Pre F/S
15	Bojongmanik	Ciujung	W. Java	159	1.87	Pre F/S
16	Pamarayan	Ciujung	W. Java	1,451	1.40	D/D
17	Cilawang	Cidurian	W. Java	93	1.87	Pre F/S
18	Tanjung	Cidurian	W. Java	280	1.87	F/S
19	Parungbadak	Cisadane	W. Java	860	2.26	F/S
20	Cibuni-3	Cibuni	W. Java	1,124	2.20	5 F/S Projects
21	Cibuni-4	Cibuni	W. Java	1,274	2.20	21 Pre-F/S Projects
22	Cikaso-3	Cikaso	W. Java	610	2.20	21 Pre-F/S Projects
23	Cimandiri-3	Cimandiri	W. Java	1,302	2.43	F/S
24	Sempor	K. Jatinegara	W. Java	42	2.12	D/D
25	Sempor	K. Progo	W. Java	-	0.70	
26	Sempor	K. Oyo	W. Java	-	1.70	
27	Kedung ombo	K. Serang	C. Java	614	1.54	
28	Sedari Weir	K. Serang	C. Java	868	2.41	
29	Ngrambat dam	K. Serang	C. Java	607	2.84	
30	Godong	K. Serang	C. Java	3,047	3.66	
31	Karang Anyar	K. Comal	C. Java	520	3.59	
32	Bantarkawung	K. Pemali	C. Java	350	3.05	
33	Purwodadi	K. Lusi	C. Java	1,966	3.87	
34	Bendo	B. Solo	C. Java	138	1.40	F/S
35	Wonogiri	B. Solo	C. Java	1,350	1.17	D/D
36	Banyumas	K. Serayu	C. Java	2,665	3.34	
37	Maung	K. Serayu	C. Java	213	3.70	F/S
38	Gintung	K. Gintung	C. Java	340	3.70	21 Pre-F/S Projects
39	Karangsamburug	K. Lukulo	E. Java	198	2.45	
40	Paniton	K. Gowong	E. Java	76	2.17	
41	Grindulu-2	K. Grindulu	E. Java	350	1.20	21 Pre-F/S Projects
42	Karangkates	K. Brantas	E. Java	2,050	1.00	Surveyed ('78-'82)
43	Selorejo	K. Brantas	E. Java	233	1.10	Surveyed ('78-'82)
44	Lumbangsari	K. Brantas	E. Java	892	1.60	
45	Sengguruh	K. Brantas	E. Java	1,659	1.36	D/D
46	Wlingi	K. Brantas	E. Java	2,890	2.03	D/D
47	Gubuklakah	K. Amprong	E. Java	40	1.61	
48	Genteng 1	K. Lesti	E. Java	103	3.20	
49	Lesti III	K. Lesti	E. Java	381	3.20	F/S
50	Segawe	K. Song	E. Java	126	1.00	under construction
51	Wonorejo	K. Gondang	E. Java	83	1.00	under construction

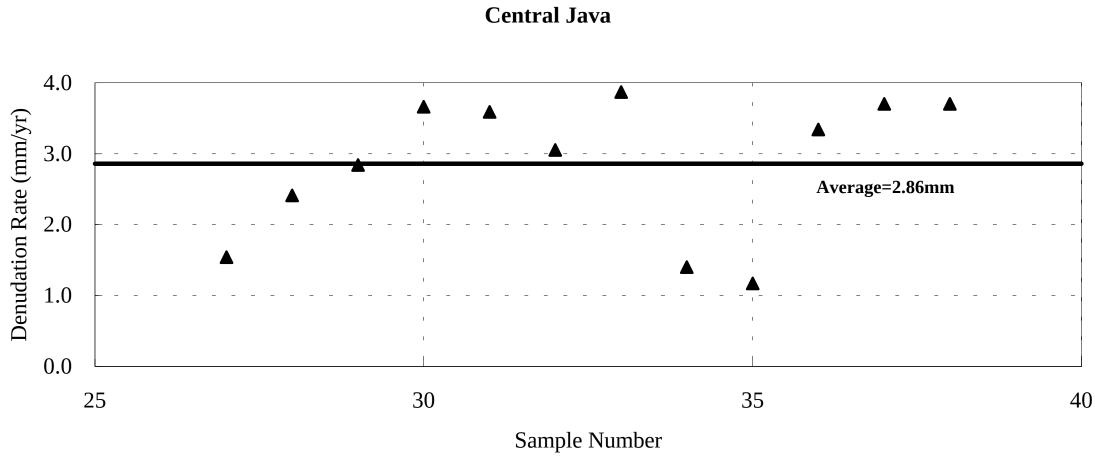
Source: CDMP Study

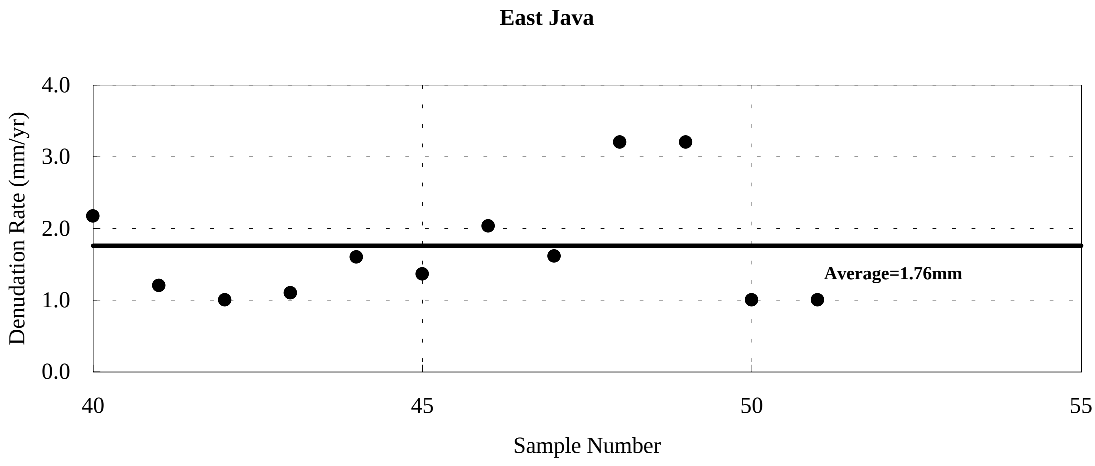
Table A7.1.2 Land Use in Kabupaten Wonogiri (1998)

(Unit: ha)

Province / Kabupaten / Kecamatan				Total Area	Wet Land (Lahan Sawah)						Non-Wet Land (Dry Land)									
					Irrigation		Rainfed		Sub-Total		House Comp. & Surroundings		Estates	Swamp	Water Pond	Forest	Dry Land		Others	Sub-Total
Central Java Province																				
Kab. Wonogiri																				
01.	3.01	Kec. Pracimantoro	010	12,790	670	*97%*	20	*3%*	690	5%	1,820	14%	-	-	-	3,870	6,150	48%	260	12,100
02.	3.02	Kec. Giritontro	020	6,160	90	*100%*	-	-	90	1%	200	3%	20	-	-	3,950	1,780	29%	120	6,070
03.		*Kec. Paranggupito*	021	1,300	-	-	-	-	0	0%	30	2%	-	-	-	690	550	42%	30	1,300
04.	3.12	Kec. Giriwoyo	030	10,070	800	*58%*	590	*42%*	1,390	14%	980	10%	-	-	-	1,060	6,570	65%	70	8,680
05.	3.13	Kec. Batuwarno	040	6,310	150	*35%*	280	*65%*	430	7%	940	15%	-	-	-	700	3,340	53%	900	5,880
06.		*Kec. Karangtengah*	041	14,040	40	*7%*	560	*93%*	600	4%	830	6%	-	-	-	6,690	4,680	33%	1,240	13,440
07.	3.03	Kec. Tirtomoyo	050	9,310	1,240	*70%*	530	*30%*	1,770	19%	2,410	26%	-	-	-	1,570	3,340	36%	220	7,540
08.	3.14	Kec. Nguntoronadi	060	8,050	250	*19%*	1,050	*81%*	1,300	16%	310	4%	230	-	-	720	1,790	22%	3,700	6,750
09.	3.04	Kec. Baturetno	070	8,930	1,350	*78%*	370	*22%*	1,720	19%	1,690	19%	-	-	-	310	1,180	13%	4,030	7,210
10.	3.15	Kec. Eromoko	080	12,040	1,560	*87%*	240	*13%*	1,800	15%	2,570	21%	-	-	-	1,300	6,170	51%	200	10,240
11.	3.05	Kec. Wuryantoro	090	7,280	960	*81%*	220	*19%*	1,180	16%	1,130	16%	-	-	-	70	1,620	22%	3,280	6,100
12.	3.16	Kec. Manyaran	100	4,510	220	*29%*	530	*71%*	750	17%	1,140	25%	-	-	-	110	1,690	37%	820	3,760
13.	3.06	Kec. Selogiri	110	5,030	1,290	*65%*	680	*35%*	1,970	39%	100	2%	-	-	-	1,290	490	10%	1,180	3,060
14.	3.17	Kec. Wonogiri	120	8,300	940	*78%*	260	*22%*	1,200	14%	2,260	27%	-	-	-	1,680	2,470	30%	690	7,100
15.	3.18	Kec. Ngadirojo	130	9,330	1,840	*75%*	620	*25%*	2,460	26%	1,870	20%	-	-	-	250	4,470	48%	280	6,870
16.	3.07	Kec. Sidoharjo	140	5,720	1,650	*87%*	250	*13%*	1,900	33%	1,560	27%	-	-	-	740	1,300	23%	220	3,820
17.	3.08	Kec. Jatiroto	150	6,290	1,010	*74%*	360	*26%*	1,370	22%	2,500	40%	-	-	-	1,320	1,010	16%	90	4,920
18.	3.09	Kec. Kiswantoro	160	7,000	810	*86%*	130	*14%*	940	13%	2,260	32%	-	-	-	2,430	1,260	18%	110	6,060
19.	3.10	Kec. Purwantoro	170	5,960	1,260	*100%*	-	-	1,260	21%	1,390	23%	-	-	-	500	2,090	35%	720	4,700
20.	3.11	Kec. Bulukerto	180	7,210	1,160	*100%*	-	-	1,160	16%	3,280	45%	0	-	-	840	1,190	17%	740	6,050
21.	3.19	Kec. Slogohino	190	6,420	1,550	*94%*	100	*6%*	1,650	26%	2,600	40%	-	-	-	1,490	490	8%	190	4,770
22.	3.20	Kec. Jatisrono	200	5,010	1,240	*96%*	50	*4%*	1,290	26%	970	19%	-	-	-	-	2,250	45%	500	3,720
23.	3.21	Kec. Jatipuro	210	5,550	1,140	*100%*	-	-	1,140	21%	1,730	31%	-	-	-	1,210	1,240	22%	230	4,410
24.	3.22	Kec Girimarto	220	6,240	1,680	*100%*	-	-	1,680	27%	1,390	22%	-	-	-	650	2,090	33%	430	4,560
		Sub-Total		**178,850**	**22,900**	***77%***	**6,840**	***23%***	**29,740**	**17%**	**35,960**	**20%**	**250**	**0**	**0**	**33,440**	**59,210**	**33%**	**20,250**	**149,110**
				100%	13%		4%		17%		20%		0%	0%	0%	19%	33%		11%	83%

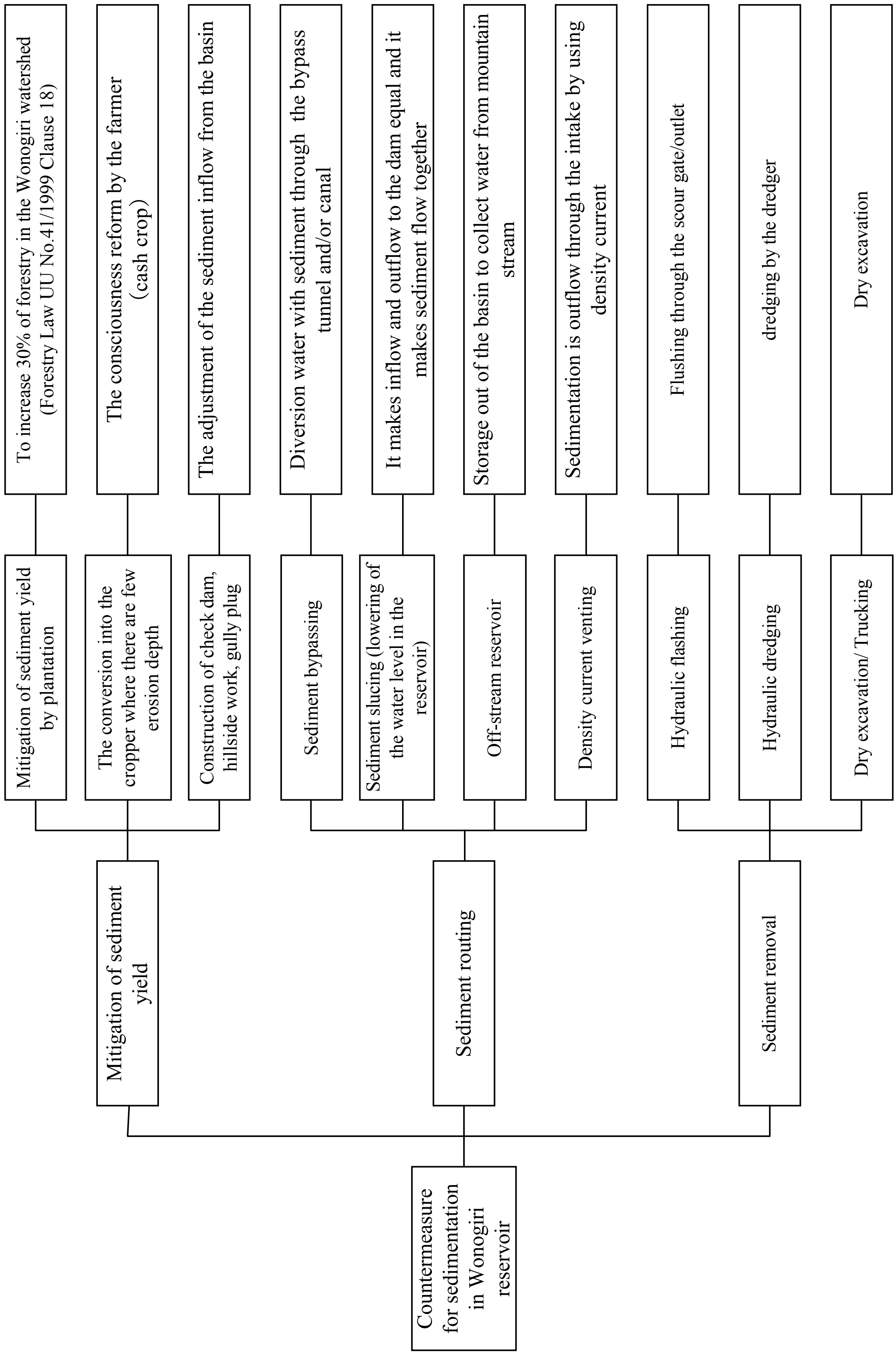




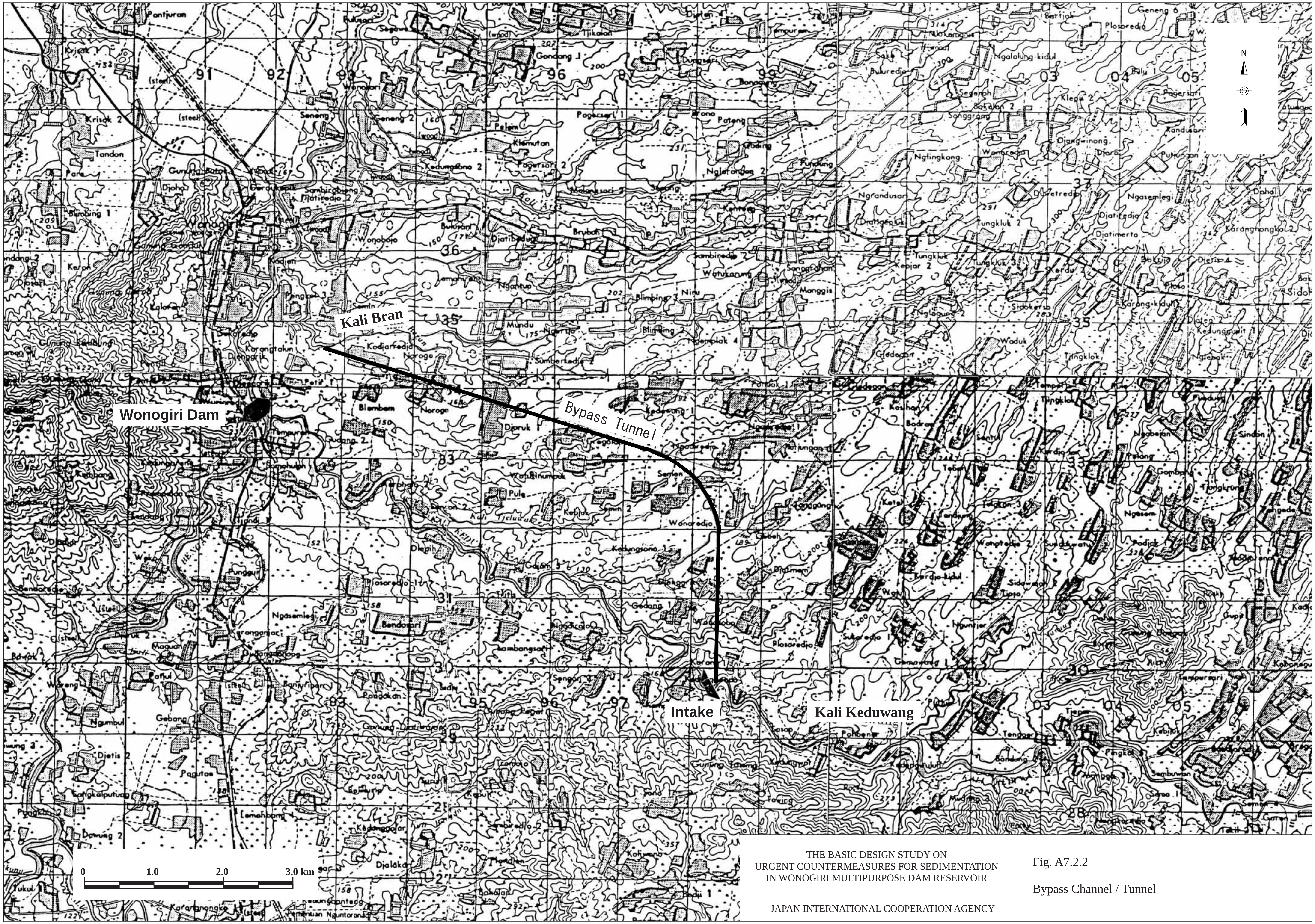


Source: CDMP Study

BASIC DESIGN STUDY ON URGENT COUNTERMEASURES FOR SEDIMENTATION IN WONOGIRI MULTIPURPOSE DAM RESERVOIR IN THE REPUBRIC OF INDONESIA	Fig. A7.1.1 Design Value of Annual Sedimentation
JAPAN INTERNATIONAL COOPERATION AGENCY	



BASIC DESIGN STUDY ON URGENT COUNTERMEASURES FOR SEDIMENTATION IN WONOGIRI MULTIPURPOSE DAM RESERVOIR IN THE REPUBRIC OF INDONESIA	Fig. A7.2.1 Countermeasure for Sedimentation
JAPAN INTERNATIONAL COOPERATION AGENCY	

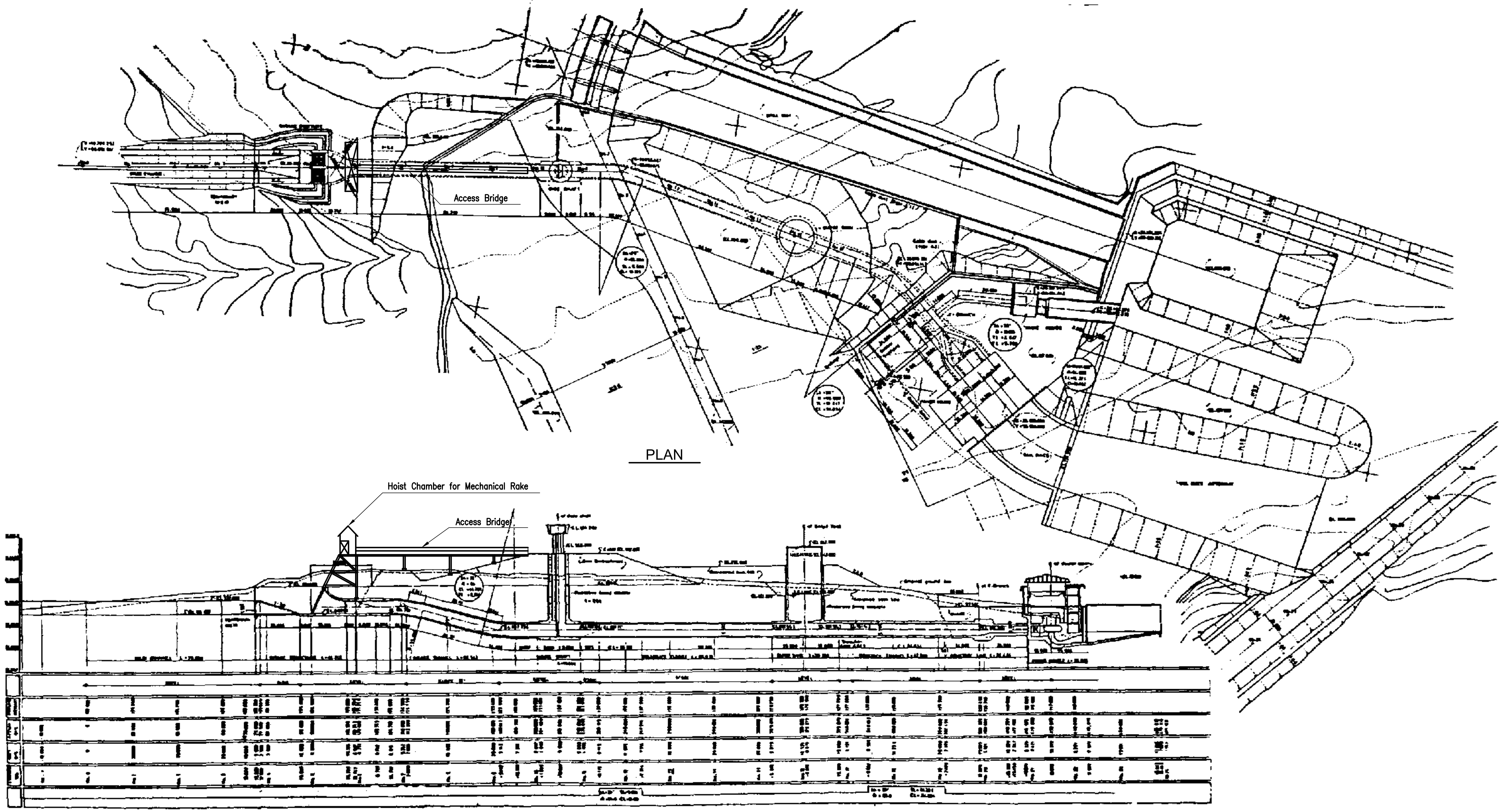


THE BASIC DESIGN STUDY ON
URGENT COUNTERMEASURES FOR SEDIMENTATION
IN WONOGIRI MULTIPURPOSE DAM RESERVOIR

JAPAN INTERNATIONAL COOPERATION AGENCY

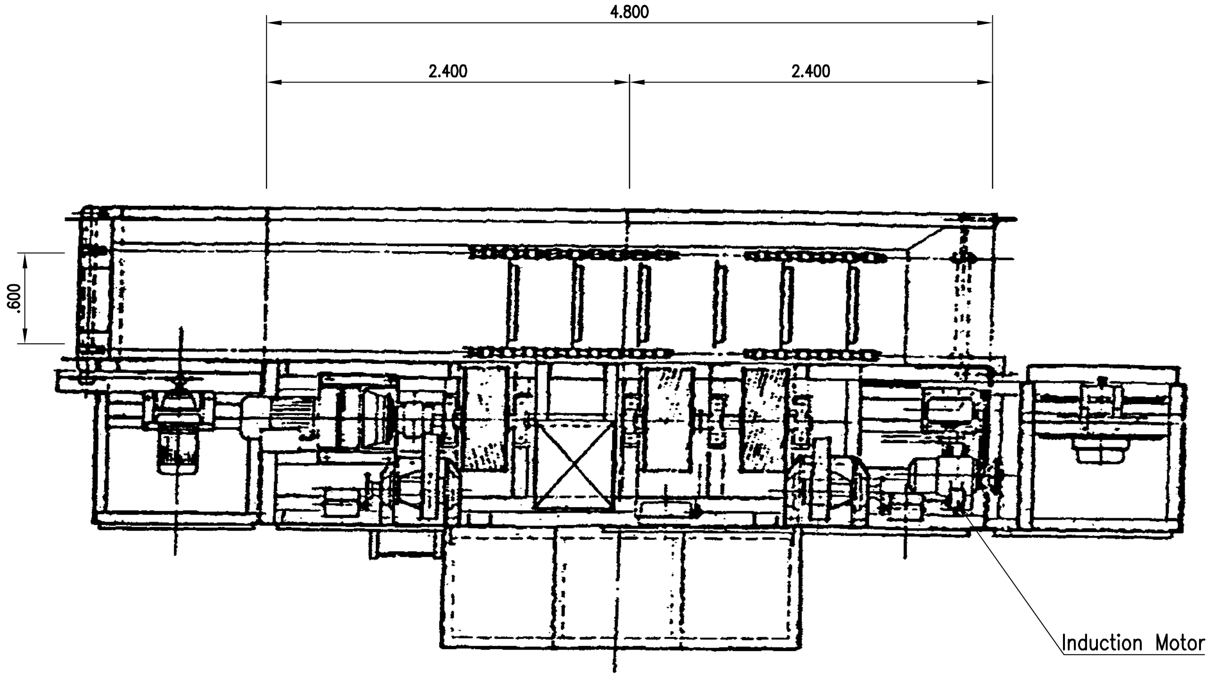
Fig. A7.2.2

Bypass Channel / Tunnel

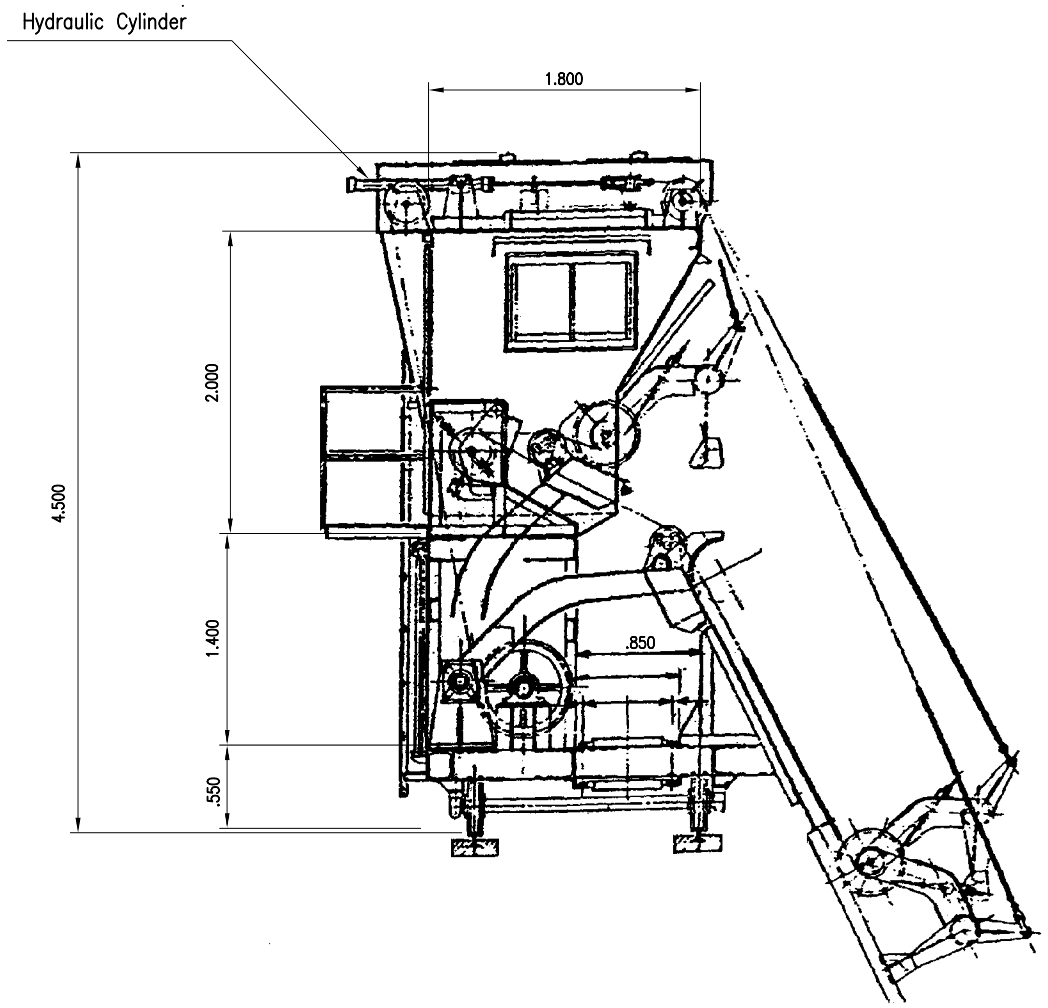


PROFILE

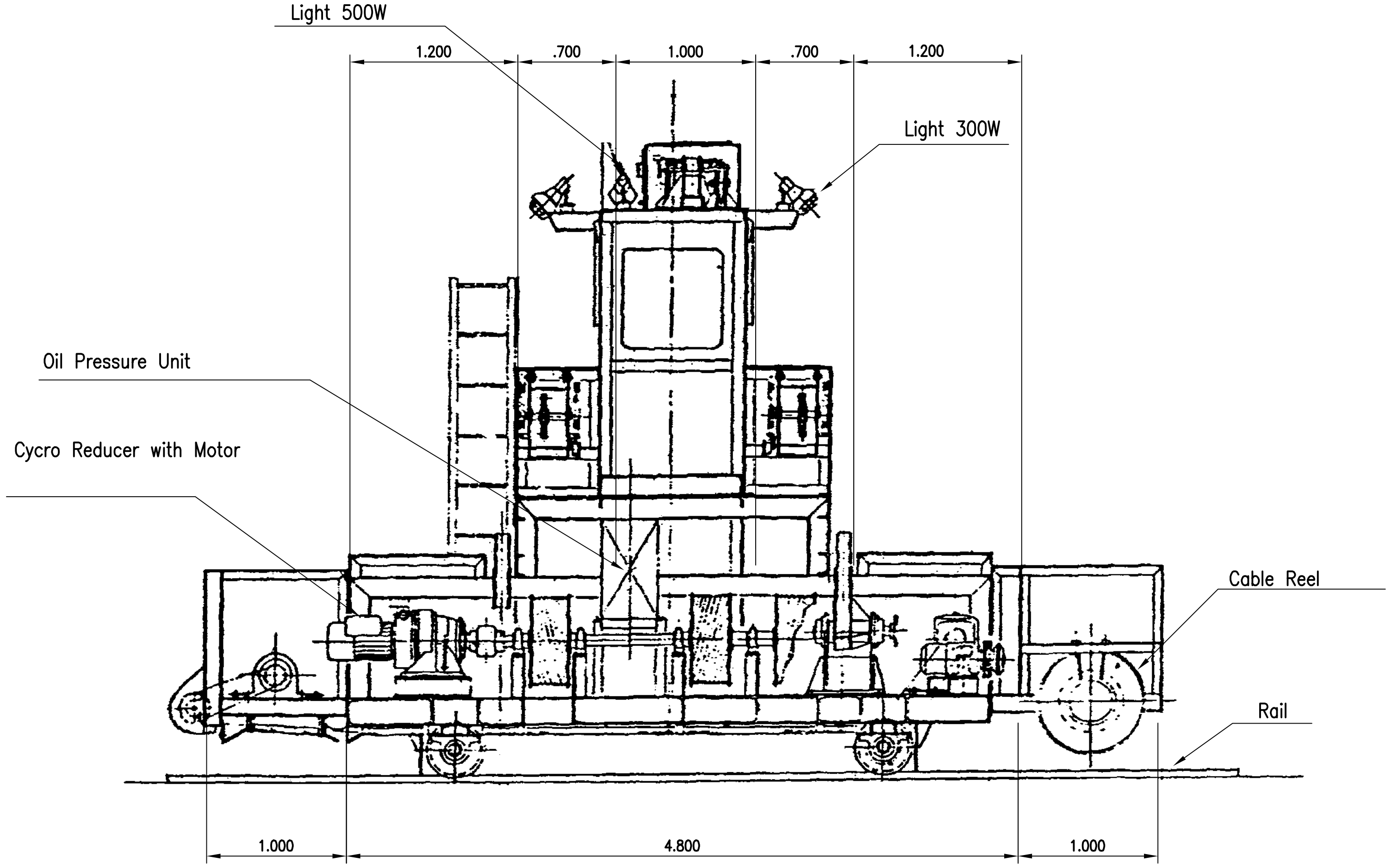
THE BASIC DESIGN STUDY ON URGENT COUNTERMEASURES FOR SEDIMENTATION IN WONOGIRI MULTIPURPOSE DAM RESERVOIR IN THE REPUBLIC OF INDONESIA	Fig. A7.2.3 Mechanical Raking System (1/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



PLAN



VIEW B-B



VIEW A-A

0 2.5m

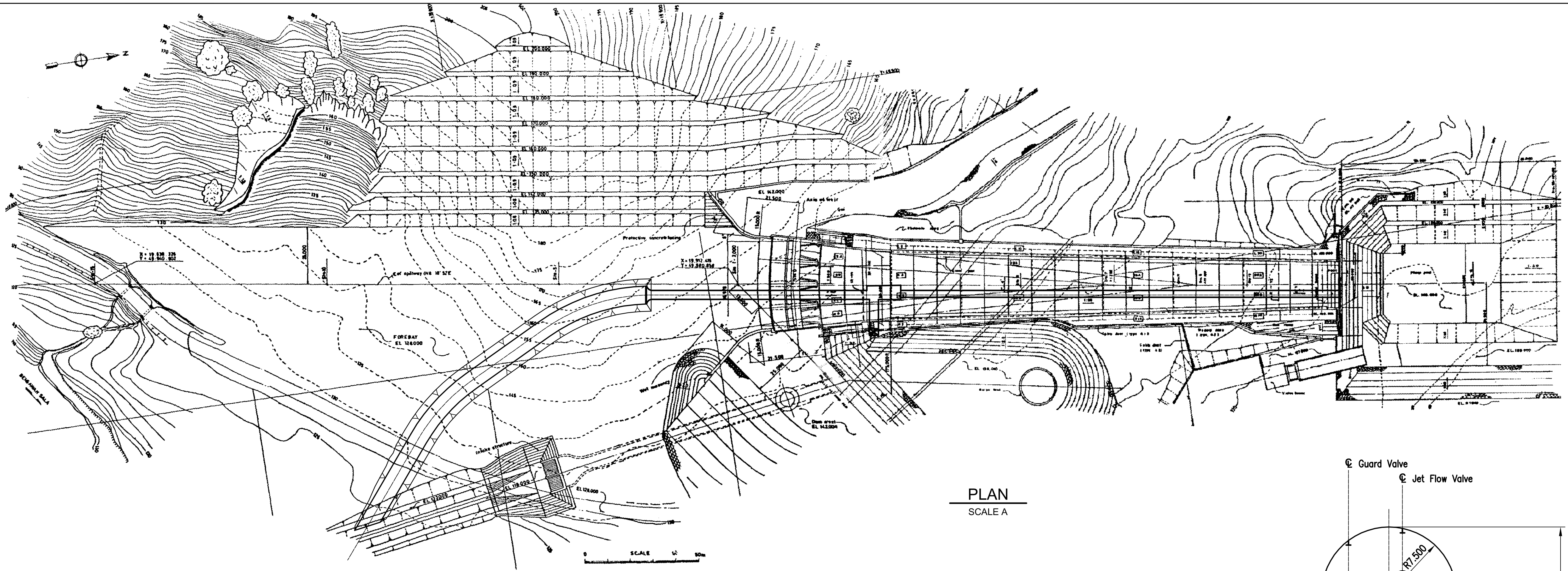
Design Data
Type : Trash Car Type
Rated Raking Capacity : 0,5 ton/m
Dead Weight of Rake : 800 kg Approx
Hoisting Speed : 15 m/min
Conveyor Speed : 10 m/min
Electric Source : 400 V/200 V, 50 Hz

THE BASIC DESIGN STUDY ON
URGENT COUNTERMEASURES FOR SEDIMENTATION
IN WONOGIRI MULTIPURPOSE DAM RESERVOIR
IN THE REPUBLIC OF INDONESIA

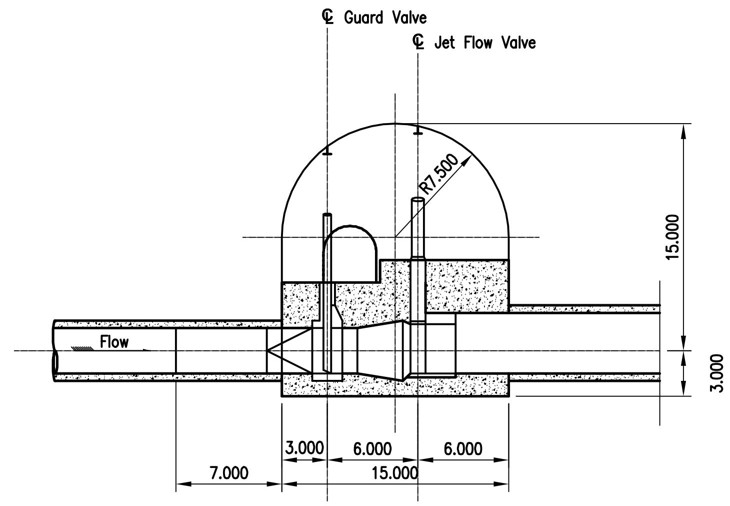
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A7.2.3

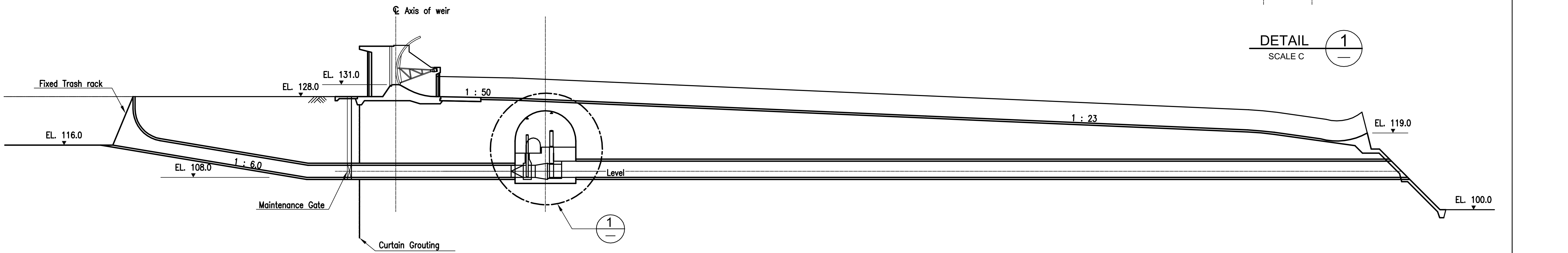
Mechanical Raking System (2/2)



PLAN
SCALE A



DETAIL 1
SCALE C



PROFILE
SCALE B

SCALE A 0 100m

SCALE B 0 50m

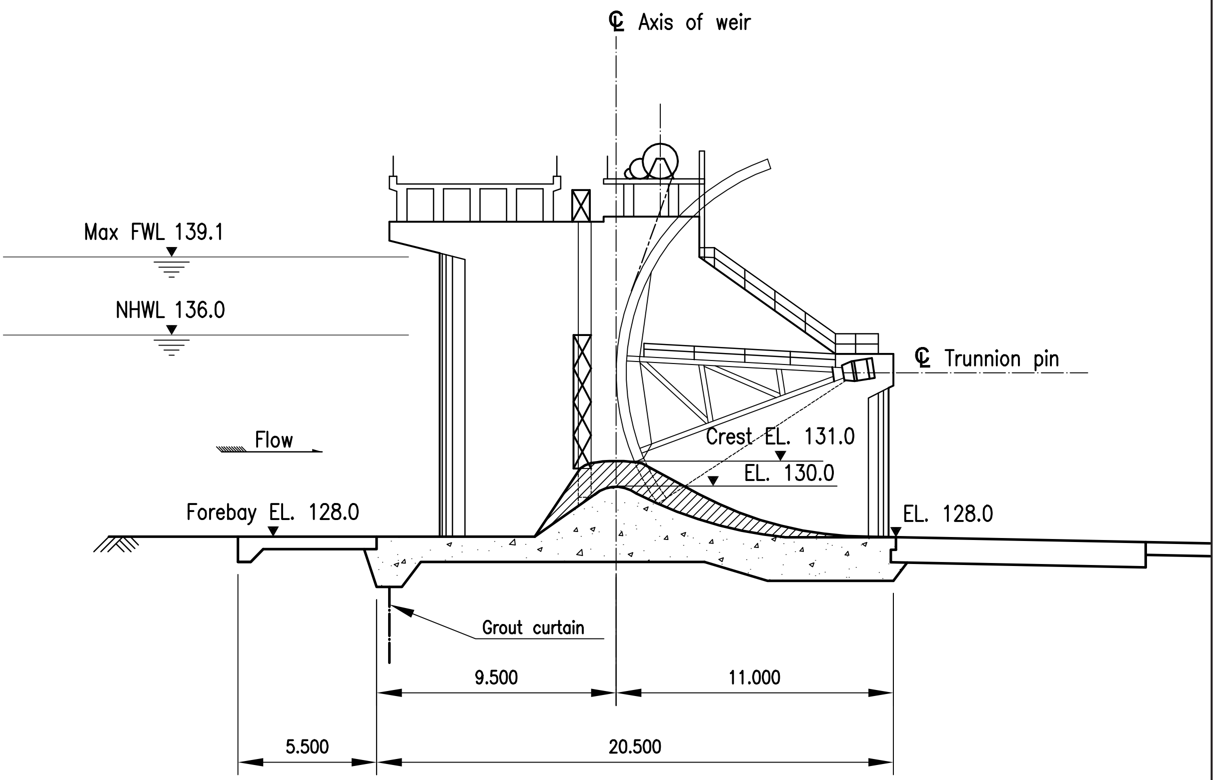
SCALE C 0 25m

THE BASIC DESIGN STUDY ON
URGENT COUNTERMEASURES FOR SEDIMENTATION
IN WONOGIRI MULTIPURPOSE DAM RESERVOIR
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

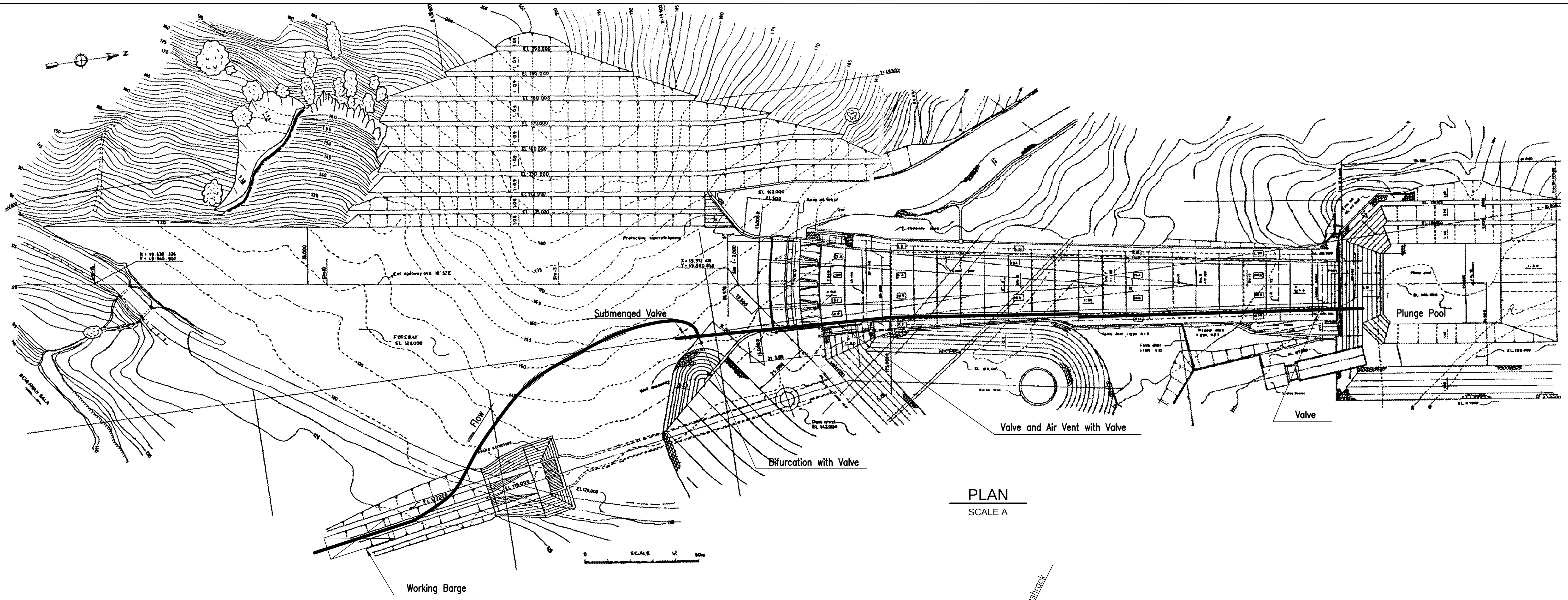
Fig. A7.2.4

Flushing Tunnel

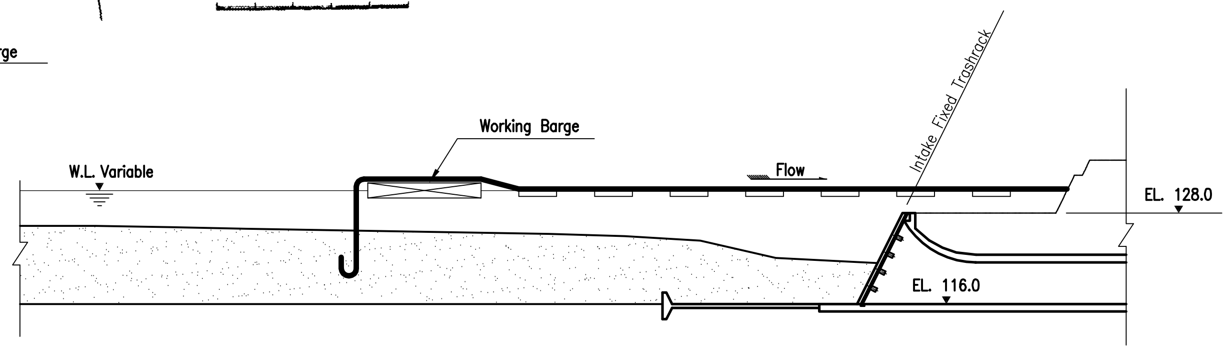


Longitudinal Profile of Spillway Crest

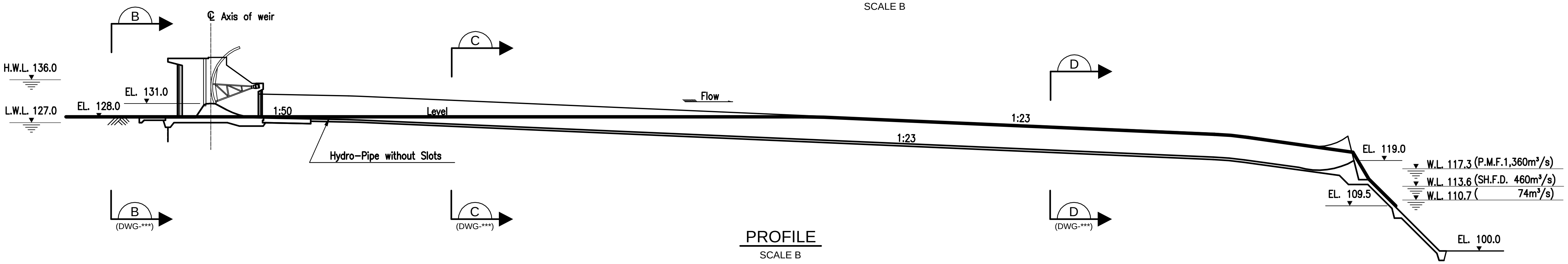
BASIC DESIGN STUDY ON URGENT COUNTERMEASURES FOR SEDIMENTATION IN WONOGIRI MULTIPURPOSE DAM RESERVOIR IN THE REPUBRIC OF INDONESIA	Fig. A7.2.5 Modification of Spillway Crest
JAPAN INTERNATIONAL COOPERATION AGENCY	



PLAN
SCALE A



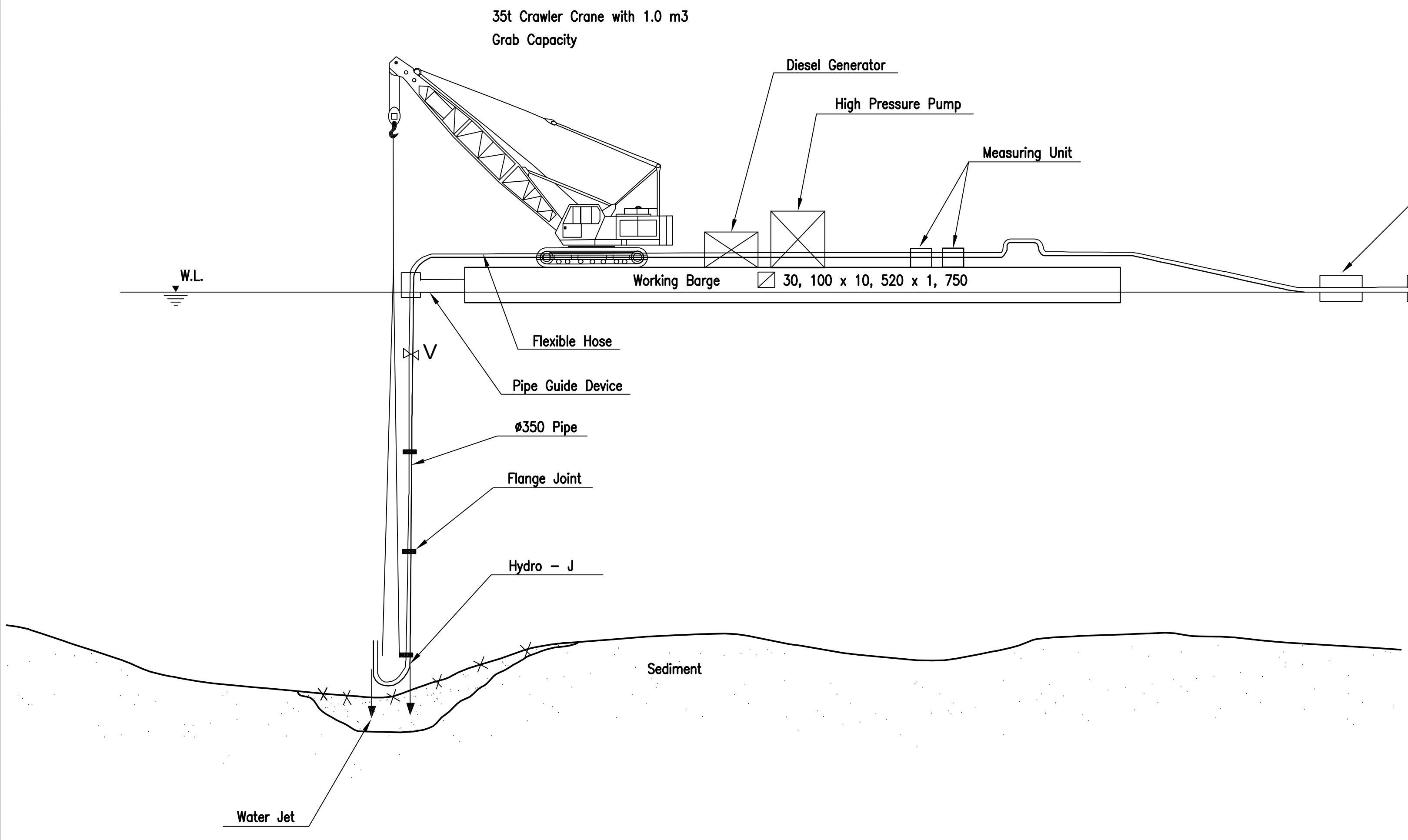
HYDRO-J
SCALE B



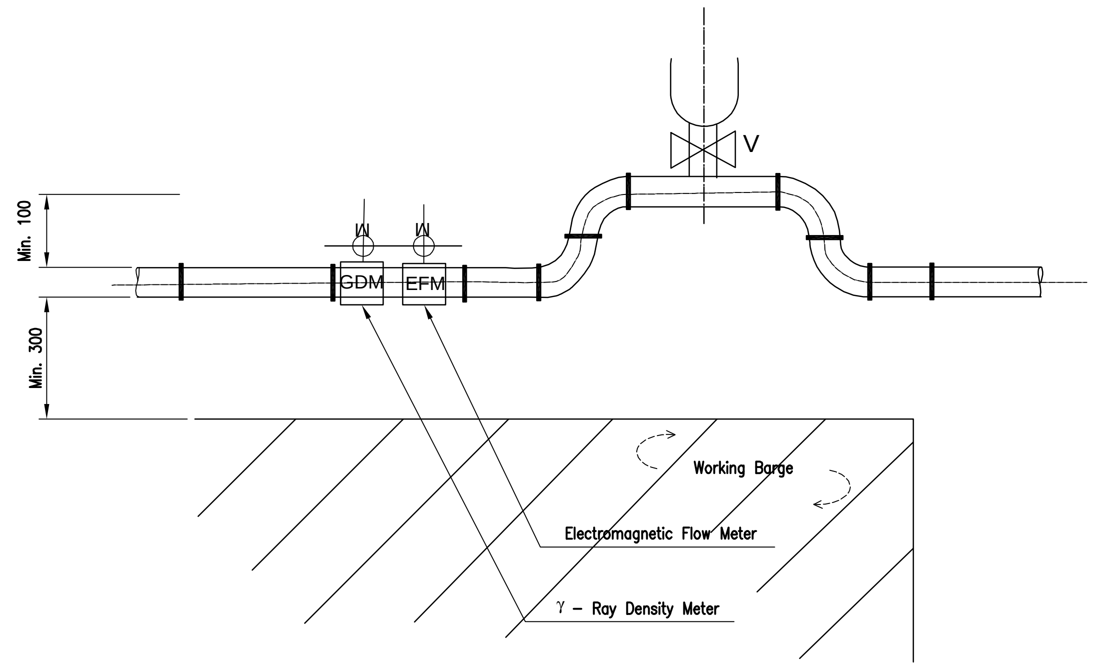
PROFILE
SCALE B

SCALE A 0 100m SCALE B 0 50m

THE BASIC DESIGN STUDY ON URGENT COUNTERMEASURES FOR SEDIMENTATION IN WONOGIRI MULTIPURPOSE DAM RESERVOIR IN THE REPUBLIC OF INDONESIA	Fig. A7.3.1 Hydro-type Sediment Discharge System (1/2) (Hydro-J Type)
JAPAN INTERNATIONAL COOPERATION AGENCY	



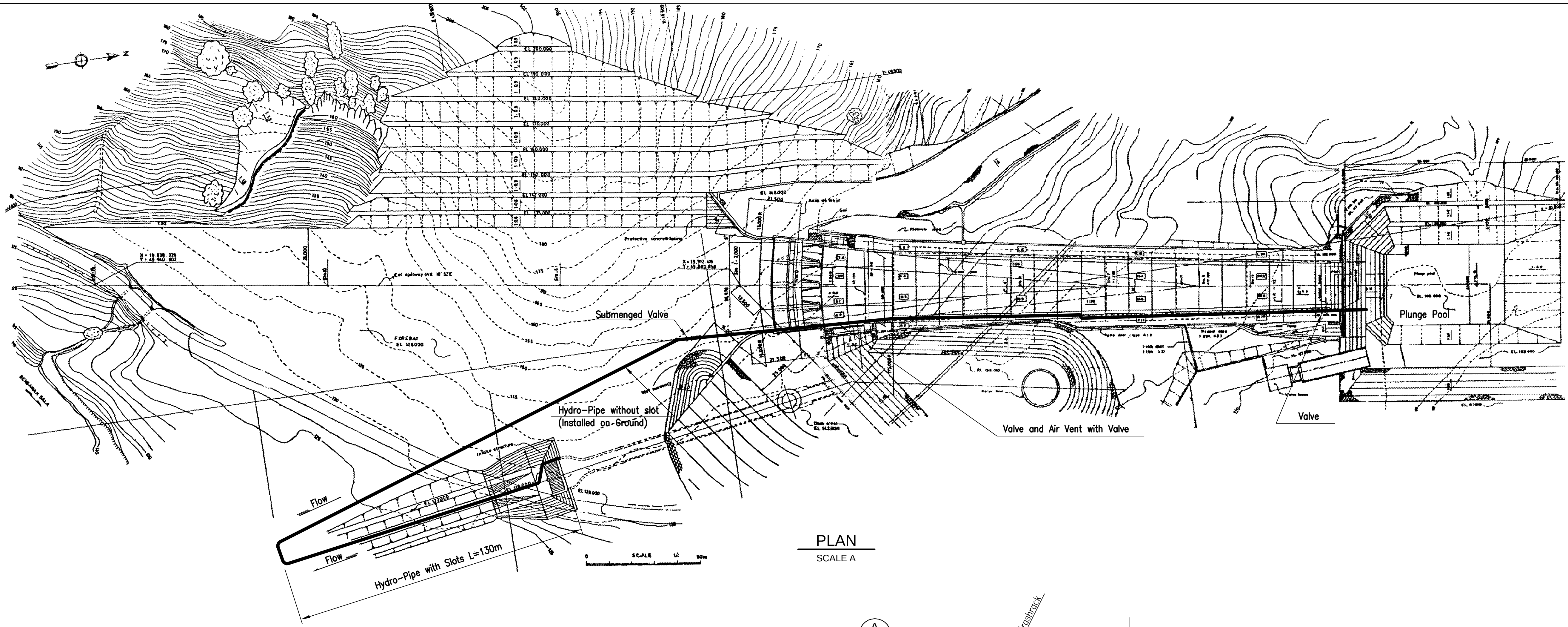
Hydro-J Schematic Diagram



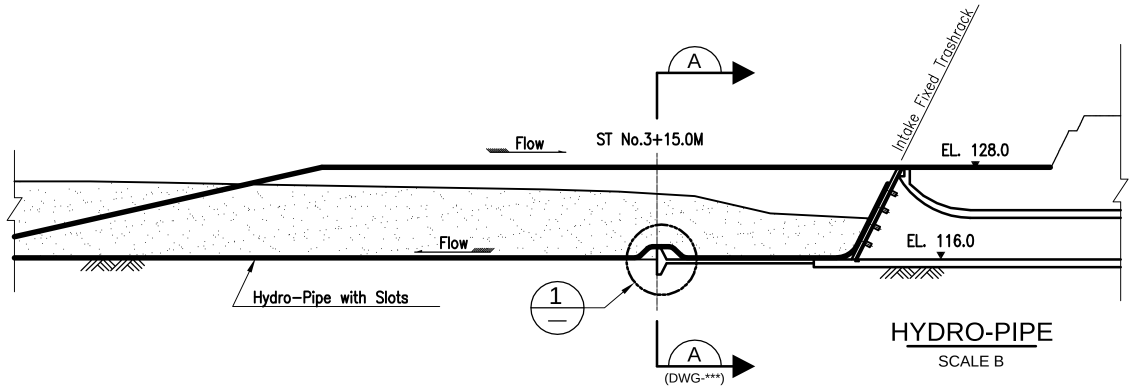
Details of Measuring Apparatuses

Note;
GDM: γ-Ray Desity Meter
EFM: Electromagnetic Flow Meter
⧖ : Valve

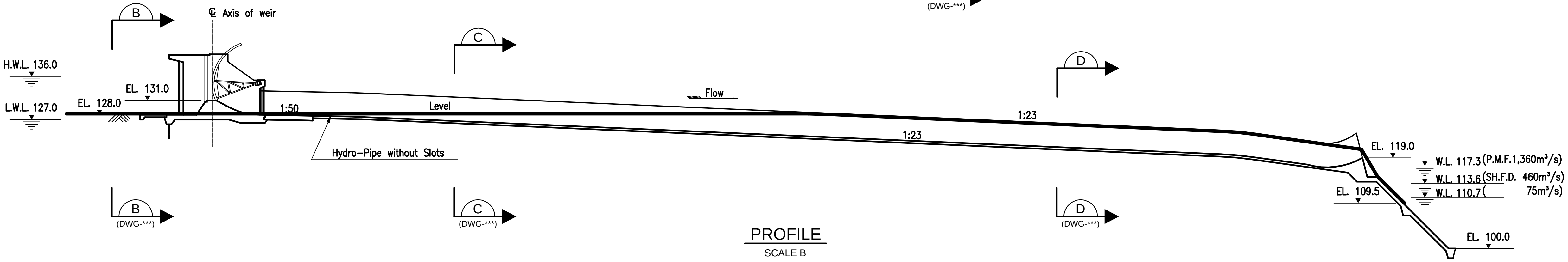
THE BASIC DESIGN STUDY ON URGENT COUNTERMEASURES FOR SEDIMENTATION IN WONOGIRI MULTIPURPOSE DAM RESERVOIR IN THE REPUBLIC OF INDONESIA	Fig. A7.3.1 Hydro-type Sediment Discharge System (2/2) (Layout of Hydro-J Type)
JAPAN INTERNATIONAL COOPERATION AGENCY	



PLAN
SCALE A



HYDRO-PIPE
SCALE B



PROFILE
SCALE B

SCALE A 0 100m

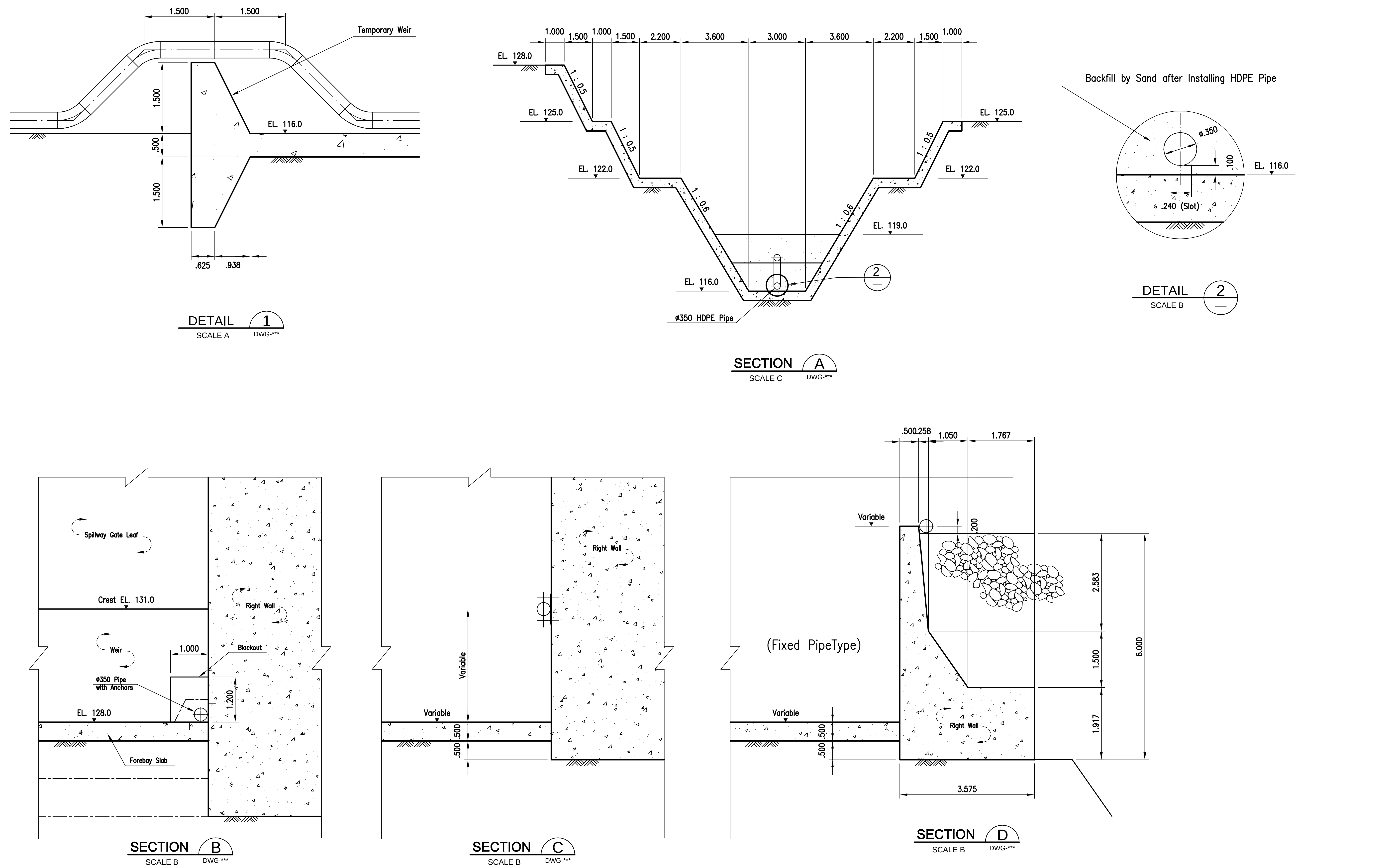
SCALE B 0 50m

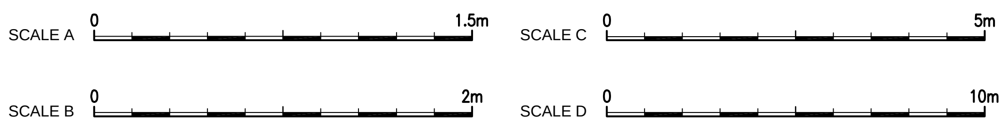
THE BASIC DESIGN STUDY ON
URGENT COUNTERMEASURES FOR SEDIMENTATION
IN WONOGIRI MULTIPURPOSE DAM RESERVOIR
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A7.3.2

Hydro-type Sediment Discharge System (1/2)
(Fixed PipeType)





THE BASIC DESIGN STUDY ON
URGENT COUNTERMEASURES FOR SEDIMENTATION
IN WONOGIRI MULTIPURPOSE DAM RESERVOIR
IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A7.3.2

Hydro-type Sediment Discharge System (2/2)
(Section Details)