CHAPTER 3 STUDY ON OPERATION OF SEDIMENT STORAGE RESERVOIR

3.1 Flood Routing of Sediment Storage Reservoir

3.1.1 Introduction

A small sediment storage reservoir will be constructed in the Wonogiri reservoir by installation of a closure dike. The Wonogiri reservoir will be thus separated into two reservoirs; the sediment storage reservoir and Wonogiri main reservoir. These two reservoirs will be operated separately and independently. It will be possible to release the sediment deposits, from the Keduang River, stored in the sediment storage reservoir whenever necessary without using the stored water in the Wonogiri main reservoir. The reservoir water level in the main reservoir would not be lowered when the sediment release operation is carried out at the sediment storage reservoir.

This section describes the flood routing simulation that was carried out. The purpose of flood routing was to:

i) Verify the flood control function, against several design floods, with the joint operation of both two reservoirs,

ii) Determine the design flood for the spillway structure and gates of the sediment storage reservoir, and

iii) Determine the length of overflow dike for dam safety against the PMF.

3.1.2 Review of Basic Concept of Wonogiri Reservoir Operation

(1) Design Flood

Inflow exceeding 400 m^3/s is called as a flood in the Wonogiri reservoir operation rules. Three design floods had been defined to determine the operating water level and also the design of the spillway and dam main body as shown in the Table 3.1.1 below.

Table 3.1.1 Design Floods of Wonogiri Reservoir

Design Flood		Peak Inflow Discharge	Remark
Standard Highest Flood Discharge	(SHFD)	4,000 m^3/s	Project design flood for flood control corresponding to the Recorded maximum flood in 1966 which recurrence interval of 60 years
Spillway Design Flood Discharge	(Design Flood)	5,100 m^3/s	1.2 times of 100-year flood
Probable Maximum Flood	(PMF)	9,600 m^3/s	(Extraordinary flood)

Source: Wonogiri Multipurpose Dam Project, Part I Summary Report on Detail Engineering Services, January 1978

(2) Flood Control Operation

Flood period and non-flood period are defined as follows:

Flood period : December 01 to April 15
Non-Flood period : May to November 30
Recovery period : April 16 to April 30

During the flood period, the reservoir water level shall be maintained at EL.135.30 m, so that the reservoir has a storage capacity of 220 x 10^6 m^3 to control flood discharge.

When the inflow exceeds 400 m^3/sec, releasing of the water in the reservoir shall be made to keep the total outflow discharge at 400 m^3/s constantly, allowing the surcharge to be stored in the reservoir. Gate at the spillway shall be operated with partial opening until the reservoir water level reaches to EL.138.20 m (Surcharge Water Level). When the reservoir water level rises over EL.138.20 m, water shall be released in a free overflow condition. For which all the spillway gates shall be set at the full opening position. No partial operation shall be allowed until the reservoir water level lowers to EL. 137.70 m. Table below gives current operation rule for the spillway gates.

Table 3.1.2 Gate Control for Flood Operation by Existing Spillway

Condition	Outflow (m^3/s)	Gate Control
RWL < CWL (El.135.3 m)	0	No control
CWL (El.135.3 m) < RWL < SWL (El.138.2 m)	0-400	Gate control
SWL (El.138.2 m) ≦ RWL < EFWL(El.139.1 m)	400-1,360	Free flow

Source: Wonogiri Multipurpose Dam Project, Part I Summary Report on Detail Engineering Services, January 1978

<Spillway Gate>

Height of Crest	:	EL.131.0 m
Gate Type	:	Radial Gate
Width	:	B = 30 m in total
Nos.	:	4 nos. (7.5 m in width)

(3) Design Reservoir Water Levels

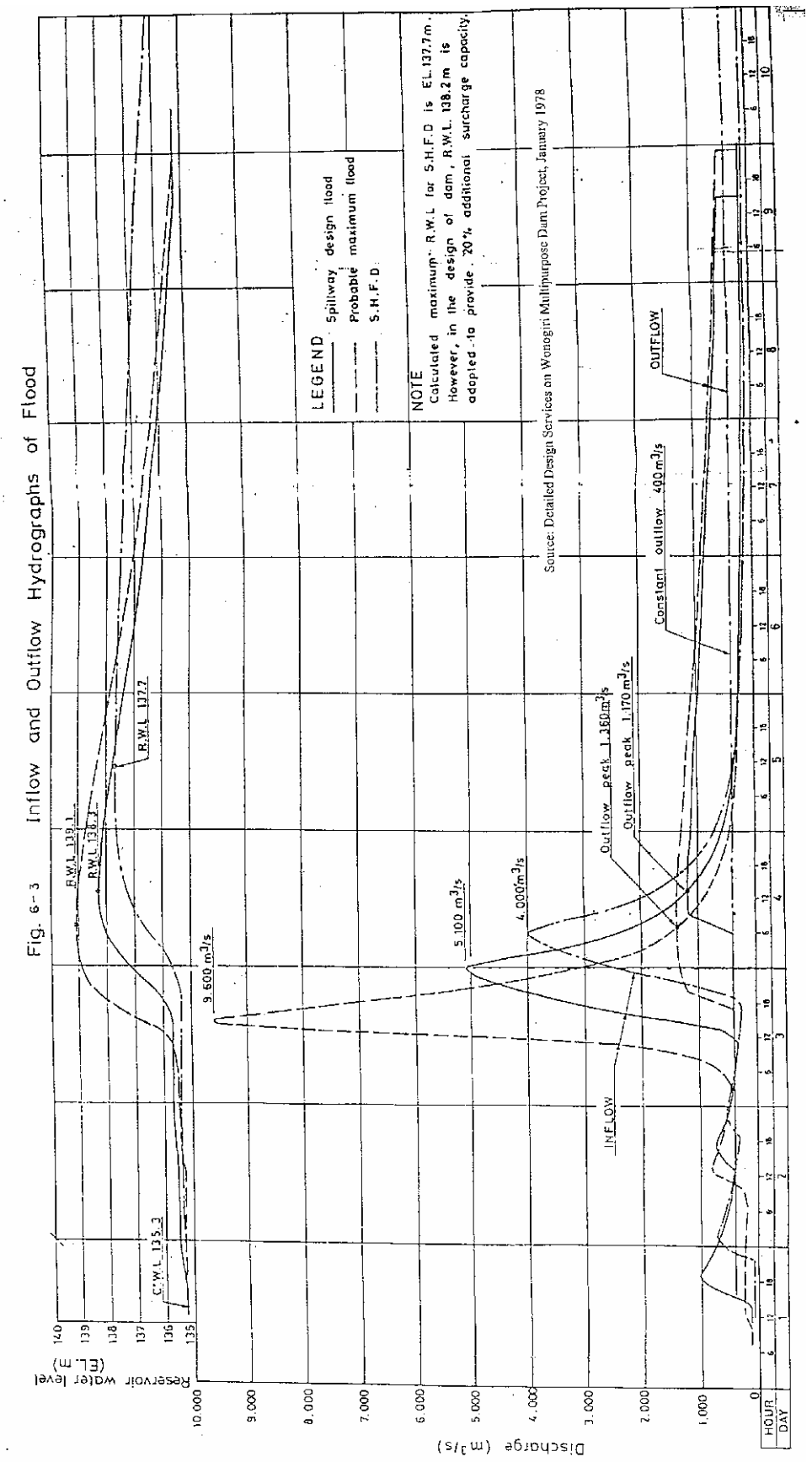
Flood control simulation based on the operation rule above was used to determine several reservoir water levels for design floods. Flood operation hydrographs in the Wonogiri reservoir are shown in Figure 3.1.1. Maximum stored volume, reservoir water level and outflow of design floods are summarized in table below:

Table 3.1.3 Design Reservoir Water Levels in Wonogiri Reservoir

Design Flood		Peak Inflow Discharge (m^3/s)	Maximum Stored Volume (MCM)	Maximum Reservoir Water Level (EL. m)	Maximum Outflow (m^3/s)
Standard Highest Flood Discharge	(SHFD)	4,000	183	137.7	400
Spillway Design Flood	(Design Flood)	5,100	228	138.3 Design Flood Water Level (DFWL)	1,160
Probable Maximum Flood	(PMF)	9,600	305	139.1 Extra Flood Water Level (EFWL)	1,360

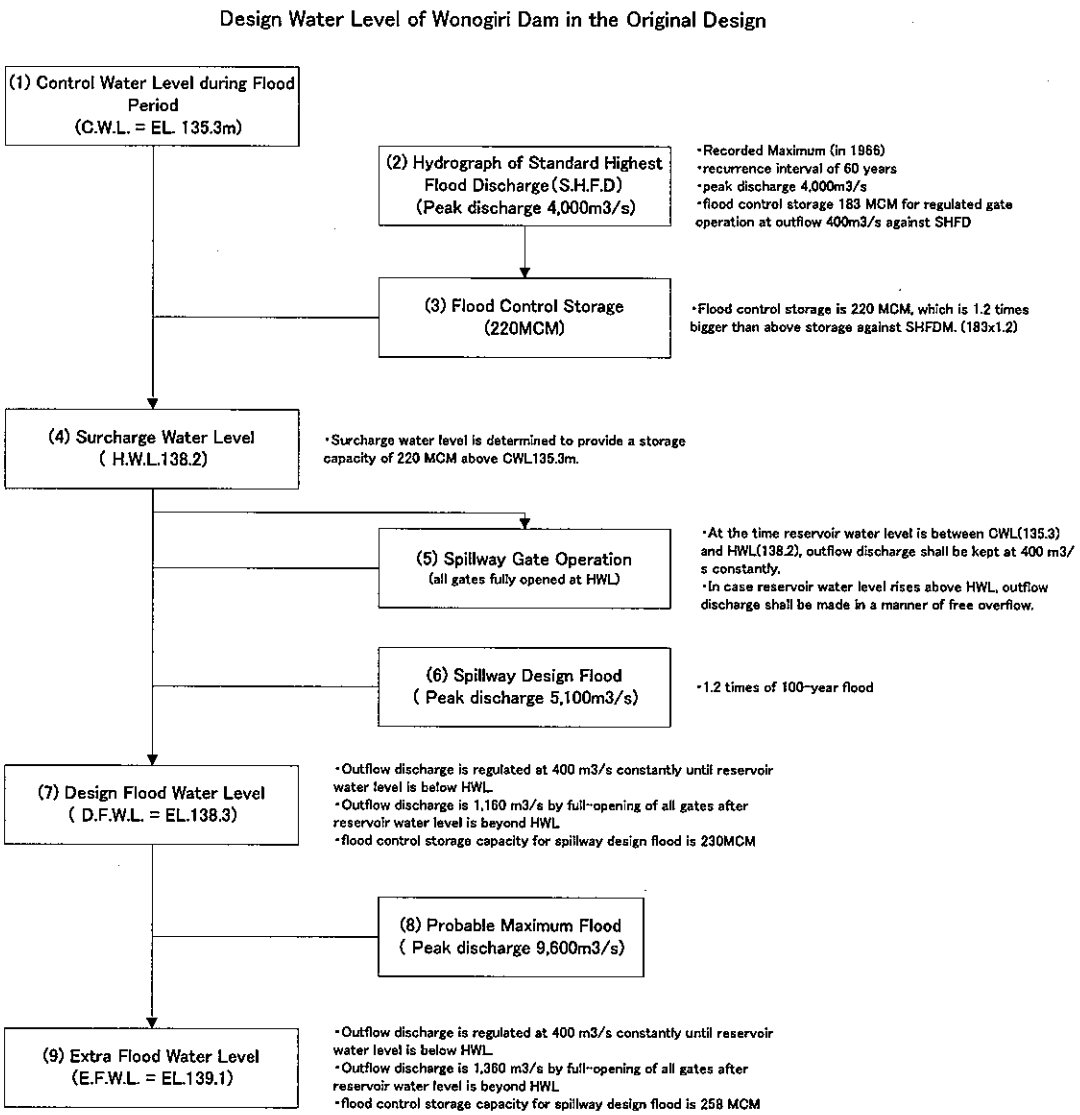
Source: Wonogiri Multipurpose Dam Project, Part I Summary Report on Detail Engineering Services, January 1978

In addition to the design water levels above, a surcharge water level of EL. 138.2 m was established to maintain a flood control storage capacity of 220 x 10^6 m^3, which is 1.2 times larger than the control storage capacity for the Standard Highest Flood Discharge (SHFD) of 4,000 m^3/s. In case the reservoir water level exceeds the surcharge water level, all spillway gates shall be set at the full opening position. The flow chart for establishment of the design water level is illustrated in Figure 3.1.2.



Source: Wonogiri Multipurpose Dam Project, Part I Summary Report on Detail Engineering Services, January 1978

Figure 3.1.1 Inflow and Outflow Hydrographs of Design Flood



Source: Wonogiri Multipurpose Dam Project, Part I Summary Report on Detail Engineering Services, January 1978

Figure 3.1.2 Flow Chart for Determination of Design Reservoir Water Levels

3.1.3 Freeboard of Wonogiri Dam

Freeboard is the vertical distance between the top of the impervious core zone of embankment (without camber) and the reservoir water surface. The freeboard provides a safety factor against many contingencies, such as settlement of the dam, occurrence of an inflow flood somewhat larger than the design flood, or malfunction of spillway controls or outlet works etc.

To establish the freeboard and to determine the top elevation of the impervious core zone of the main dam, the following three (3) cases were considered in its detailed design in 1978. The criteria of Cases 1 and 2 are given in " Design of Small Dams" and that of Case 3 is given in "Design Criteria for Dams of Japan".

Case 1: PMF occurs and the spillway functions as planned. In this case the freeboard is provided to prevent the water surface rising over the impervious core zone of the embankment by wave action, which may coincide with the occurrence of the probable maximum flood.

Case 2: PMF occurs when the spillway malfunctions as a result of human or mechanical failure to open gates. In such instances, allowances for wave action or other contingencies are not made, but the dam should not be overtopped.

Case 3: Design flood occurs when the spillway functions as planned. In this case the freeboard consists of allowance for wave action, malfunction of spillway gates and allowance due to the dam type whether fill type or not. If the half of wave height due to earthquake exceeds the wave height due to wind, the former is adopted instead of the latter.

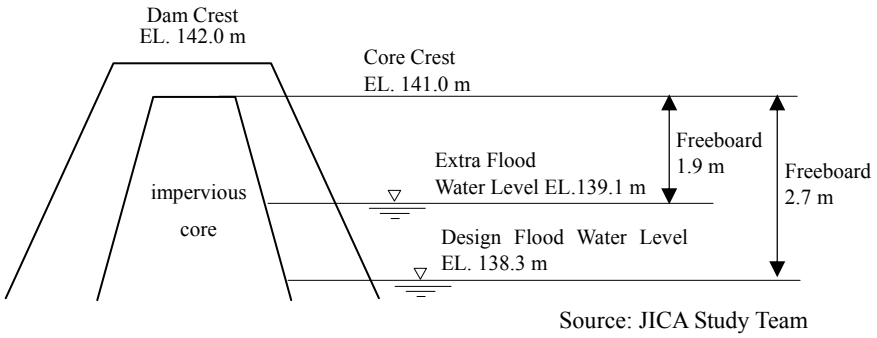
The results of examination are summarized below:

Table 3.1.4 Summary of Examination Results on Freeboard of Wonogiri Dam

Case	Maximum Reservoir Water Level		Freeboard							Necessary top elevation of impervious core zone	
1	EFWL		wave								
	139.1	+	1.8						=	140.9	≦ EL.141.0m
2											
	140.9	+	0						=	140.9	≦ EL.141.0m
3	DFWL		wave		gate		Earth fill dam				
	138.3	+	1.2	+	0.5	+	1.0		=	141.0	≦ EL.141.0m

Source: Wonogiri Multipurpose Dam Project, Part I Summary Report on Detail Engineering Services, January 1978

As a result, the top elevation of the impervious core zone was determined at EL. 141.0 m as illustrated below. Freeboard is 1.9 m against the extra flood water level of El. 139.1 m and 2.7 m against the DFWL of El. 138.3 m to prevent the reservoir water surface from overtopping the impervious core zone of the embankment.



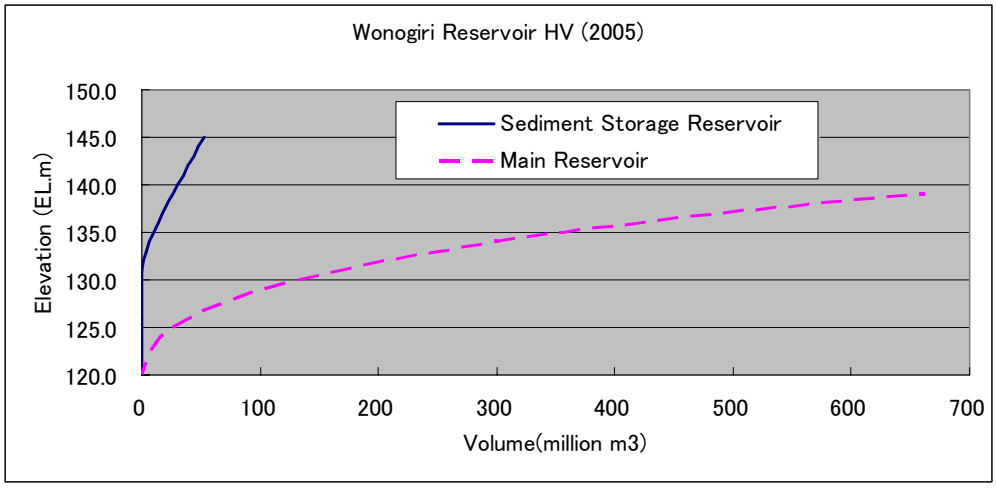
Source: JICA Study Team

Figure 3.1.3 Freeboard of Wonogiri Dam

3.1.4 Basic Conditions for Flood Routing

(1) Reservoir Capacity (H-V) Curves in Two Reservoirs

The current reservoir capacity curves of both the sediment storage reservoir and Wonogiri main reservoir were developed from the reservoir sedimentation survey in 2005. Figure 3.1.4 below presents the reservoir capacity curves. The storage capacity of sediment storage reservoir is around 11 million m^3 at CWL. 135.3 m.

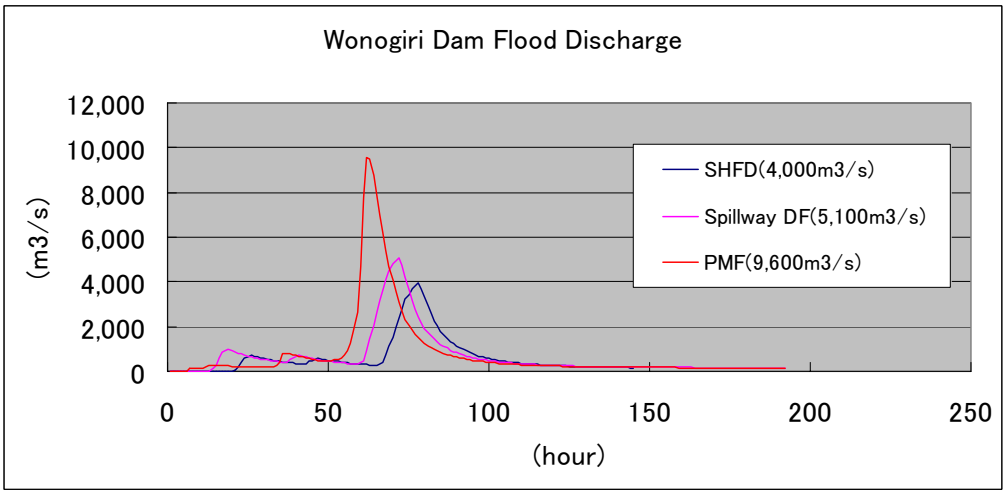


Source: JICA Study Team

Figure 3.1.4 Reservoir Capacity Curves in 2005

(2) Design Flood Inflows into Two Reservoirs

As shown in Table 3.1.3 in subsection 3.1.2, three design floods were assumed for the detailed design of Wonogiri dam and reservoir as illustrated below. These design flood inflows into the sediment storage reservoir and Wonogiri main reservoir are divided into respective flood inflows applying the catchment area ratio.



Source: JICA Study Team

Figure 3.1.5 Design Floods of Wonogiri Reservoir in Detailed Design in 1978

(3) Discharge Capacity Curve of Gates of the Sediment Storage Reservoir

Two sets of gates (W7.5 m x 2 nos.) will be installed on the right abutment of the dam. The gate discharge is estimated by the following formula:

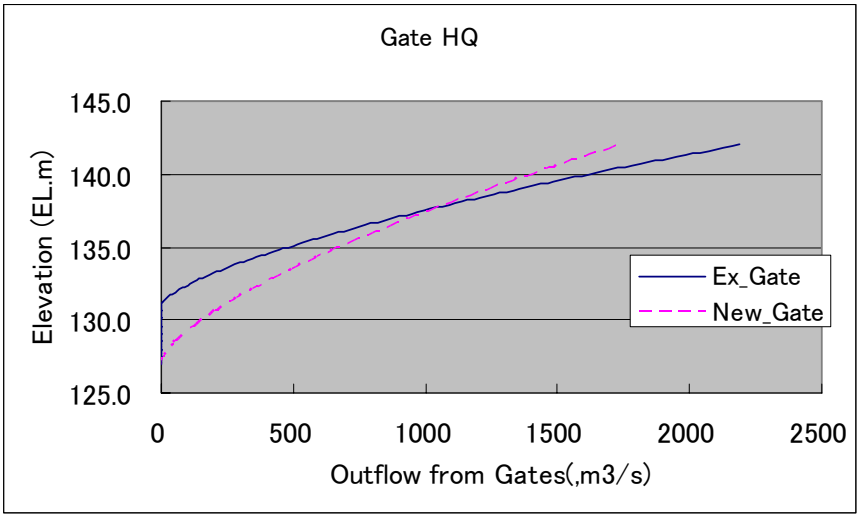
$$Q = C \times B \times H^{3/2}$$

where, C : Flow coefficient (= 2.0)

B : Gate width (= 15.0 m)

H: Water depth (m)

The water depth-discharge (H-Q) curve for the new gates as well as the curve for the existing spillway gate are shown in Figure 3.1.6 below.



Source: JICA Study Team

Figure 3.1.6 Gate Discharge Capacity Curves

As shown above, spillway crest elevations are set at EL. 131.0 m for the existing spillway and EL. 127.0 m for the new gated spillway of sediment storage reservoir.

(4) Closure Dike of the Sediment Storage Reservoir

Length of the closure dike is 650 m. Crest height of the closure dike is set at EL. 138.3 m that is, the design flood water level (DFWL) (see Table 3.1.3).

(5) Overflow Dike of the Sediment Storage Reservoir

Length of the overflow dike is variable and subject to determination through the flood routing calculation. Crest height of the overflow dike is set at NHWL 136.0 m.

3.1.5 Operational Assumptions for the Sediment Storage Reservoir in Flood Routing

For the flood routing operation, the following operational assumptions are applied:

i) Initial reservoir water levels of two reservoirs for the flood routing calculation are both set at CWL 135.3 m.

ii) Constant discharge of 75 m^3/sec is released from the Wonogiri main reservoir for hydropower generation.

iii) The current authorized flood operation rule of the Wonogiri reservoir shall be observed and thus the design flood reservoir water levels (see Table 3.1.3) are unchanged.

iv) The current gate control of the existing spillway for flood operation (see Table 3.1.2) shall be applied to the operation of the new gates of the sediment storage reservoir.

v) In case of operation with the PMF, water in the sediment storage reservoir is allowed to overflow the closure dike into the Wonogiri main reservoir.

3.1.6 Results of Flood Routing

(1) Length of Overflow Dike

In view of safe reservoir operation against extreme flood events, it would be fairly desirable to keep the difference in water levels between the sediment storage reservoir and Wonogiri main reservoir small. As described in Figure 3.1.2, the Surcharge Water Level of 138.2 m was determined for the SHFD with a peak discharge of 4,000 m^3/sec.

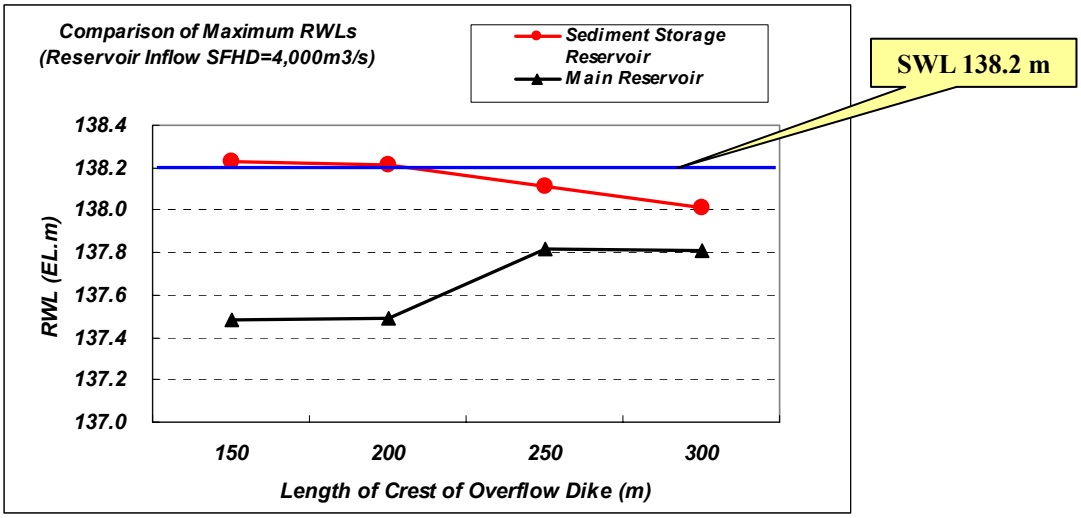
Table 3.1.5 shows the results of flood routing to compare the maximum reservoir water level of the two reservoirs under different lengths of overflow dike.

Table 3.1.5 Results of Flood Routine with Focus on Length of Overflow Dike

Case No.	Unit	1	2	3	4
Length of Dike	m	150	200	250	300
Sediment Storage Reservoir	EL. m	138.23	138.21	138.11	138.01
Wonogiri Main Reservoir	EL. m	137.48	137.49	137.82	137.81
Difference of Water Level	m	0.75	0.72	0.24	0.20
Overflowed Discharge	m^3/s	440	650	550	580
Release from New Gates	m^3/s	1,130	1,130	400	400
Release from Existing Spillway	m^3/s	0	0	0	0

Source: JICA Study Team

Figure 3.1.7 illustrates the results of flood routing. If the length of the overflow dike is less than 200 m (Cases 1 and 2 above), the maximum water levels of both reservoirs exceeds SWL 138.2 m and thus the water release from new gates exceeds 400 m^3/s because of full opening of gates. On the other hand, an overflow dike with a length of longer than 250 m (Cases 3 and 4) gives the maximum water level below SWL and thus the water release from the new gates is regulated to be 400 m^3/sec. This would satisfy the flood control requirement of the Wonogiri reservoir to regulate SHFD (4,000 m^3/sec) to the constant outflow of 400 m^3/s. The length of overflow dike proposed is therefore 250 m in view of cost effectiveness. Figure 3.1.8 presents the results of Case 3 above.



Source: JICA Study Team

Figure 3.1.7 Gate Discharge Capacity Curves

(2) Spillway Design Discharge

Flood routing of the sediment storage reservoir with a 250 m long overflow dike was conducted against the Spillway Design Discharge (SDD) with a peak discharge of 5,100 m^3/sec. The SDD was applied to the design of the existing spillway structure. The results are shown in Figure 3.1.9 and summarized below:

Maximum water level at sediment storage reservoir	:	EL. 138.27 m
Maximum water level at Wonogiri main reservoir	:	EL. 138.15 m
Maximum overflow discharge from overflow dike	:	700 m^3/sec
Maximum water release from new gate	:	1,140 m^3/sec

Maximum water release from existing spillway : 0 m^3/sec

Behavior of both two reservoirs is almost the same as the case of SHFD above. The maximum water release from the sediment storage reservoir through new gates is 1,140 m^3/sec because it exceeds SWL 138.2 m. No water release is conducted from the existing spillway because the reservoir water level in the Wonogiri main reservoir is below SWL. The design discharge of new spillway structure and gates of the sediment storage reservoir is thus determined to be 1,140 m^3/sec.

(3) Probable Maximum Flood (PMF)

Flood routing of the sediment storage reservoir with a 250 m long overflow dike was conducted against the PMF with a peak discharge of 9,600 m^3/sec. The results are shown in Figure 3.1.10 and summarize below:

Maximum water level at sediment storage reservoir	:	EL. 138.61 m
Maximum water level at Wonogiri main reservoir	:	EL. 138.95 m
Maximum overflow discharge from overflow dike	:	1,220 m^3/sec
Maximum overflow discharge from closure dike	:	650 m^3/sec
Maximum water release from new gate	:	1,270 m^3/sec
Maximum water release from existing spillway	:	1,360 m^3/sec

The maximum reservoir water level reaches EL. 138.95 m in the Wonogiri main reservoir and EL. 138.61 m in the sediment storage reservoir. Both maximum levels are below the Extra Flood Water Level of 139.1 m. Thus the Wonogiri reservoir is judged to be safe against PMF because the original freeboard against overtopping the dam is secured.

3.2 Results of Turbidity Analysis for Downstream Reaches from Wonogiri Dam

3.2.1 Outline of Analysis

In the master plan, construction of a sediment storage reservoir with new gates was proposed as one of the urgent measures. This measure aims at securing the existing intake function through a sediment sluicing/flushing system on the sediment storage reservoir without using the stored water in the main reservoir. Through this operation, a sustainable use of the Wonogiri reservoir and an appropriate sediment balance in the Bengawan Solo River basin may be achieved in the future. However, while the sediment sluicing/flushing system is operated, plenty of highly turbid water will be released to downstream reaches for a period of time. There would be a threat of adverse impacts on social and natural environments in the downstream reaches. The allowable volume of sediment release would be the technical factor to control to mitigate adverse impacts.

In this section, aimed at examination of suitable operation to minimize the impacts to the downstream reaches, sediment hydraulic analysis was carried out to simulate the fluctuation of turbidity due to release of highly turbid water from the sediment storage reservoir.

3.2.2 Turbidity Analysis Model

(1) Objective Area

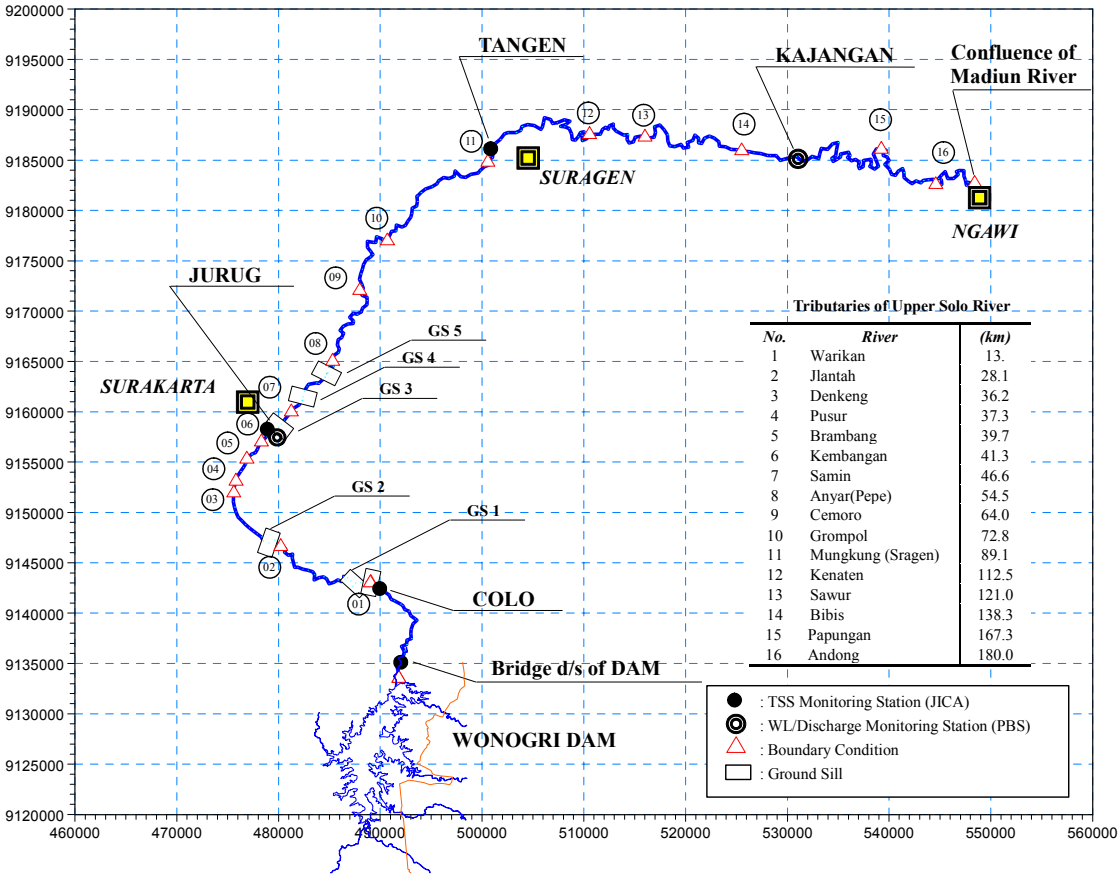
The objective area for turbidity analysis is the mainstream of Upper Solo River from the Wonogiri dam to Ngawi, the confluence with the Madiun River. The objective river stretch is 200 km long. The location map of the Upper Solo basin applicable for the turbidity analysis model is presented in Figure 3.2.1 in the next page. The design was

based on the model where there are 16 main tributaries entering into the mainstream between the Wonogiri dam and Ngawi, and the Colo intake weir and five (5) groundsills were constructed between Jurug and Colo, which help stabilize the river bed.

In this stretch, two (2) water level gauging stations have been installed at the Jurug (51 km downstream of the dam) and the Kajangan (131 km downstream of the dam). SS concentration in the mainstream has been periodically observed by JICA Study Team at four (4) locations, i) the bridge immediately downstream of the Wonogiri dam, ii) the Colo weir, iii) Jurug bridge and iv) Tangen bridge.

(3) Analysis Model

For the turbidity analysis model the MIKE 11, which is in wide usage as commercial software, was used because of its high versatility. The calculation method on the turbidity analysis model used basically the same equations as the reservoir sedimentation model as described in the Supporting Report II Annex No.4 "Reservoir Sedimentation Analysis". The outline of the calculation method and basic conditions is presented in the Table 3.2.1 in the next page.



Source: JICA Study Team

Figure 3.2.1 Location Map for Turbidity Analysis Model

For the downstream reaches, a one-dimensional model was applied because the fluctuations of flow in the cross sectional direction become negligibly small. For the riverbed movement, fixed bed condition was assumed because the Colo weir and five groundsills have been placed from the Colo to Jurug, and hard bed rocks/soils without erosion widely appeared over the objective stretches such as at Lawu. In addition, the

wash load would be mainly composed of the released sediments from the Wonogiri dam and they tend not to be deposited at the velocity of the river flow. An important issue to be considered in the analysis is the impact to the downstream reaches from the wash load, not riverbed movement.

Table 3.2.1 Calculation Method and Basic Condition of Turbidity Analysis Model

Item	Condition	Remarks
i) Hydraulic parameters	One-dimensional unsteady flow	
ii) Riverbed Movement	Fixed bed condition	
iii) Sediment Transportation	Advection-Diffusion Equation of Concentration	
iv) Interaction between bed materials and suspended load	Re-suspension and settling velocity of non-cohesive sediment	
v) Cross Section	Totally 163 cross sections in Upper Solo River mainstream from Wonogiri dam to the Madiun River confluence with the intervals of 500 m	Cross Section Survey from 2004 JICA, 2004 WECFR&CIP
vi) Existing River Structures	Colo weir and Ground Sills no.1 to no.5 of fixed weir.	Cross Section Survey from 2004 WECFR&CIP
vii) Riverbed material	Totally 17 samples taken at intervals of 10 km and analyzed for grain size distribution	2004 JICA, WECFR&CIP

Source: JICA Study Team

(4) Boundary Conditions of Analysis

Boundary conditions are set out at three locations as presented in Table 3.2.2 below. In view of accuracy of the simulation, the boundary conditions of sediment inflows and outflow over the stretch are vitally important. However, as for the SS concentration data of the Wonogiri dam outflow, no field measurement data has been available since its completion. In this model, the simulation results of the reservoir sedimentation analysis were applied to the SS concentration of the dam outflow. For the inflow from the tributaries, the SS concentrations were calculated applying sediment rating curves that were created based on the past field data measured in tributaries by PBS in 1988 - 1995.

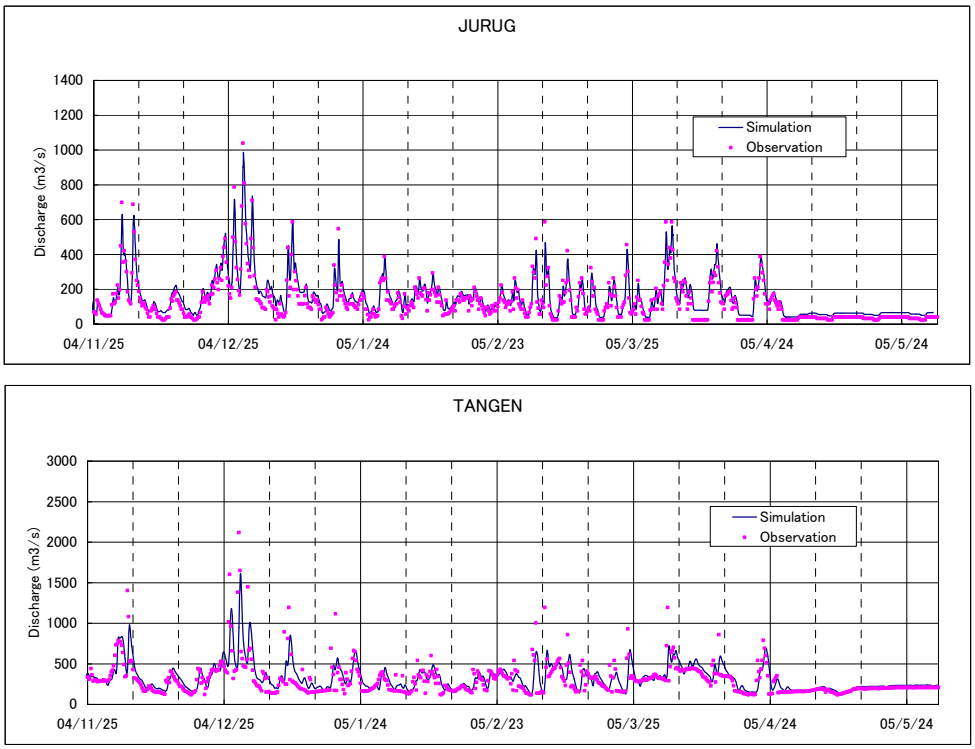
Table 3.2.2 Boundary Conditions of Dam Outflow and Inflow from Tributaries

Item	Data Type	Interval	Source
i) Dam Outflow	Available records of hourly power discharge and spillout discharges released from the Wonogiri dam.	hourly	PJT-1
ii) Colo Intake	Available discharge records of intake discharge to west canal, east canal and overflow discharge at Colo weir.	Monthly(1986-1999) Hourly(2000-2005)	PJT-1
iii) Inflow from tributaries	Using the unit discharge per catchment area estimated from the observation discharge at Jurug sta. and Kajangan sta., inflows from major 16 tributaries between Wonogiri - Ngawi were determined.	Daily (1986-1999), 3 times per day at 6:00, 12:00, 18:00 (2000-2005)	JICA Study Team
iv) SS Concentration of dam outflow	Reservoir sedimentation analysis results of SS concentration at both intake and spillway	hourly	JICA Study Team
v) SS Concentration of inflow from tributaries	Computed from sediment rating curve of tributaries based on the field data at major tributaries in 1988 to 1995	Daily (1986-1999), 3 times per day at 6:00, 12:00, 18:00 (2000-2005)	JICA Study Team

Source: JICA Study Team

3.2.3 Calibration of Analysis Model

The turbidity analysis model was calibrated based on the field observation data on both discharge and SS concentration in the wet season in 2004/2005 as presented in Figures 3.2.2 and 3.2.3. As shown in the figures, the simulation results well reproduced the field observation data. Judging from the calibration results, this model can be applied on an hourly simulation basis for the analysis of SS concentration in the Upper Solo mainstream.



Source: JICA Study Team

Figure 3.2.2 Calibration Result for Discharge at Jurug and Tangen in 2004/05 Wet Season

3.2.4 Case for Turbidity Analysis

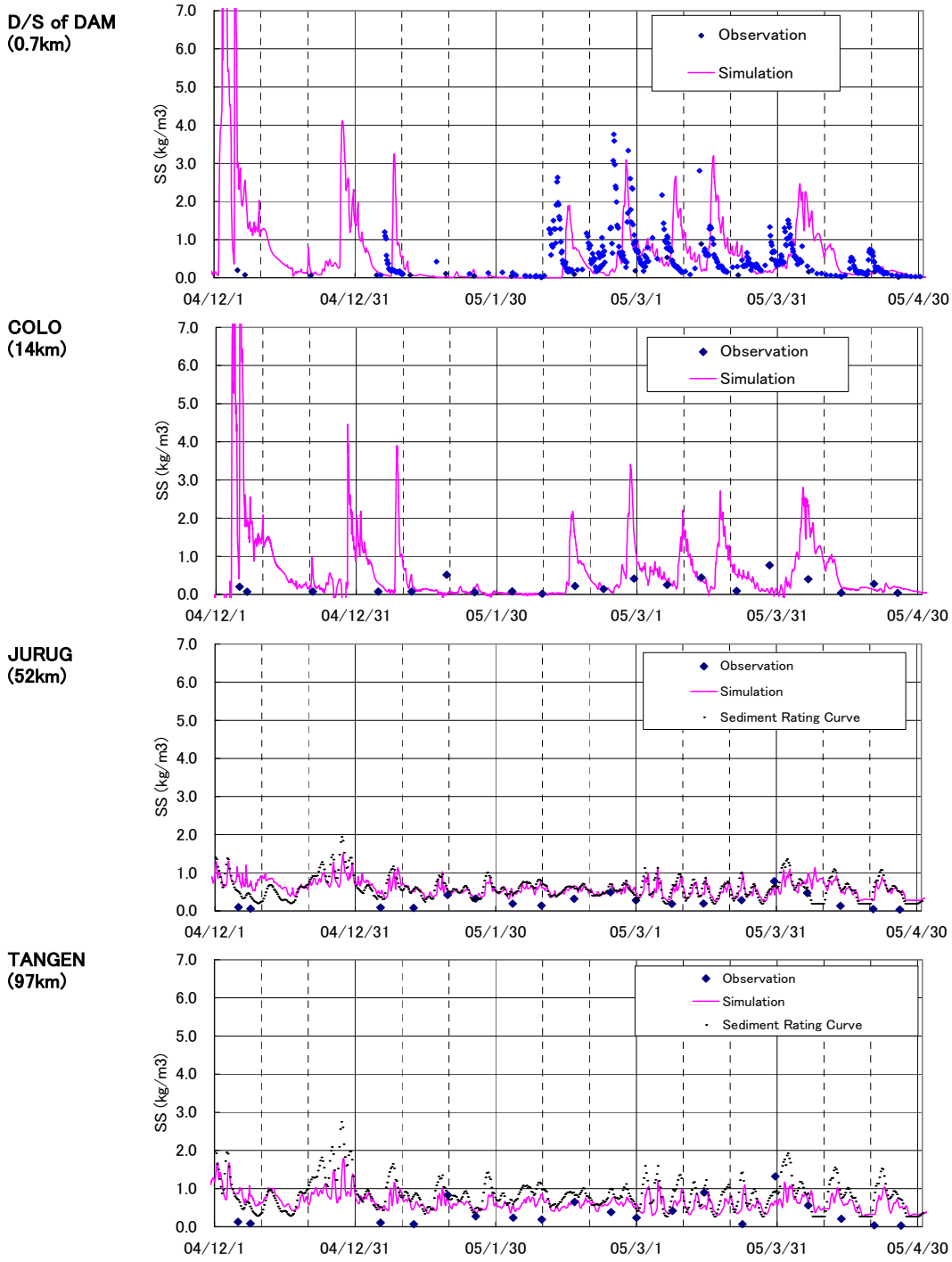
To assess i) the current sediment hydraulic conditions "*Without Measure"*, ii) the impacts of the proposed urgent measure (a sediment storage reservoir with new gates) to the downstream reaches "*With Measure*", turbidity analysis was carried out using the boundary conditions in three distinct hydrological years as shown in Table 3.2.3.

Table 3.2.3 Annual Reservoir Inflow and Outflow of Selected Hydrological Years

(Unit : million m^3)

Hydrological Year	Period	Reservoir Inflow	Reservoir Outflow
Wet Year	1998/99	1,385	1,545
Normal Year	1995/96	1,176	1,254
Dry Year	2004/05	668	469

Note : Above data is a hydrological year from November 1 to October 31. The data of 2004/2005 is up to June 2005
Source : JICA Study Team



note : 1) "Observation" is the result of field measurement for water samples.
2) "Simulation" is the result obtained by turbidity analysis model.
3) "Calculation" is the result obtained from the sediment rating curve at Jurug.

Source: JICA Study Team

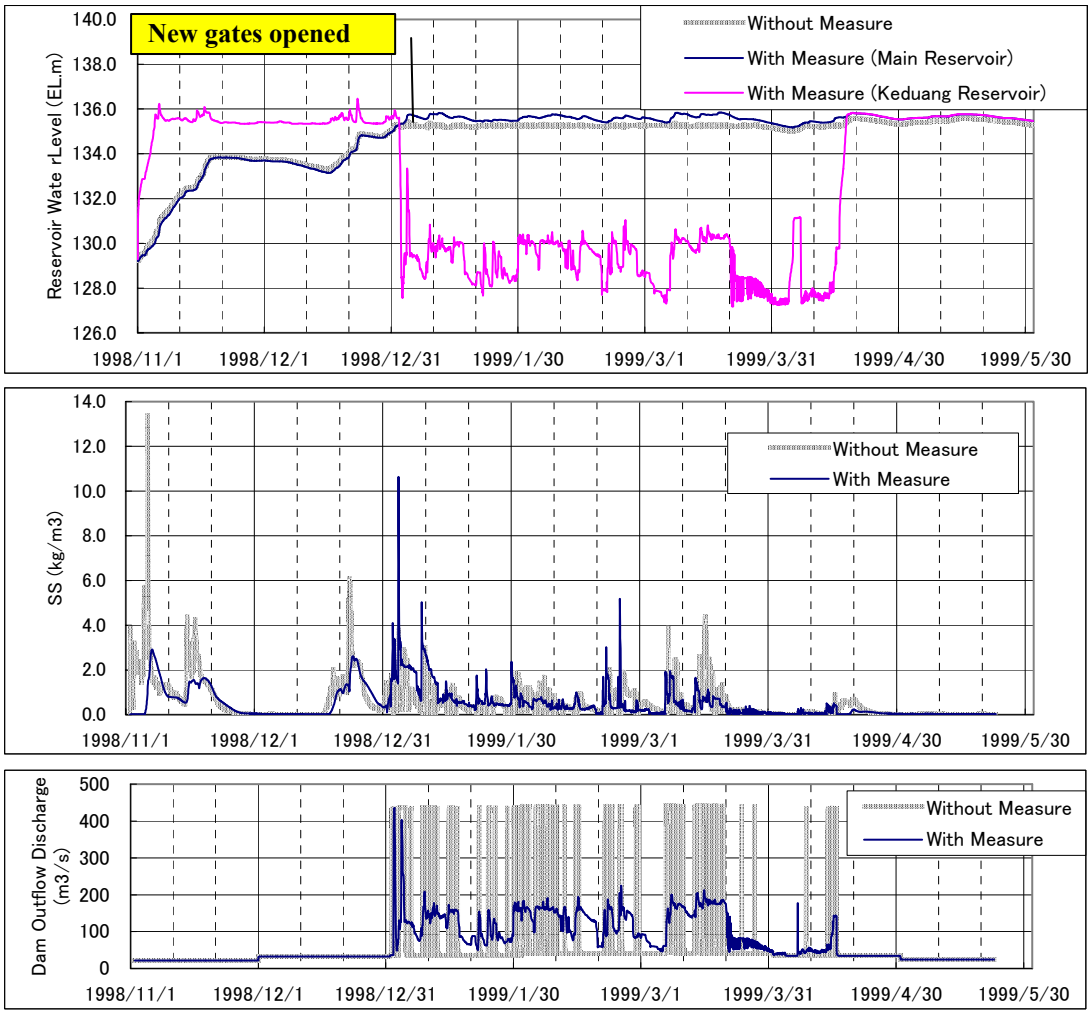
Figure 3.2.3 Calibration Result for SS Concentrations in 2004/05 Wet Season

3.2.5 Results of Turbidity Analysis

As a result of the turbidity analysis in the three hydrological years mentioned above, similar characteristics were obtained the conditions of "With" and "Without" measures. The results of wet year are discussed in detail below:

(1) Dam Outflow and SS Concentration

The hourly outflow from the reservoir and its SS concentration are presented in the Figure 3.2.4 below together with the hydrograph of the reservoir water level. In this case, the new gates are fully opened from the beginning of January to the middle of April.



Source : JICA Study Team

Figure 3.2.4 Comparison of Reservoir Water Level, SS Concentration and Discharge of Dam Outflow between With and Without Measures in Wet Year (1998/1999)

(2) SS Concentration and Discharge in the Upper Solo Mainstream

SS concentration and peak SS concentration in the Upper Solo mainstream are presented together with the comments in the Figures 3.2.5 to 3.2.7. Major findings revealed are summarized below:

(1) Before Opening New Gates (beginning of Wet Season)

i) Before opening the new gates, the SS concentrations of dam outflow and that in the downstream stretch were significantly lower than current condition (case of Without measure). This was due to the highly turbid inflow from the Keduang River retained in the sediment storage reservoir.

ii) At Jurug and Tangen, the high SS concentration at the beginning of wet season disappeared. Before opening the new gates, the dam outflow was only released from the outlet of power station and its discharge was relatively small (Max. 60

m^3/s) compared to the inflow from the tributaries. The impact to downstream reaches would be significantly smaller due to the attenuation effect on the inflow from tributaries.

(2) After Opening the New Gate

D/S of Dam and Colo weir

iii) After opening the new gate, the dam outflow and mainstream below the dam contained highly turbid water from the sediment releasing operation. The frequency of occurrence of higher SS concentration increased as well.

iv) It was, however, revealed that downstream of the dam and Colo, the peak value of SS concentration was almost the same as those observed at the beginning of wet season on the current conditions.

v) The discharge in the stretch Wonogiri - Colo was strongly affected by dam outflow. After opening the new gates, the discharge in this stretch would be almost the same as that of the Keduang River, which would be released from the new gates.

Jurug and Tangen

vi) During the opening of the new gates, the peak of SS concentrations at Jurug and Tangen were significantly higher than those of current conditions in the case when inflow from the tributaries is small. In such condition, the impact of the sediment releasing operation would be relatively severe.

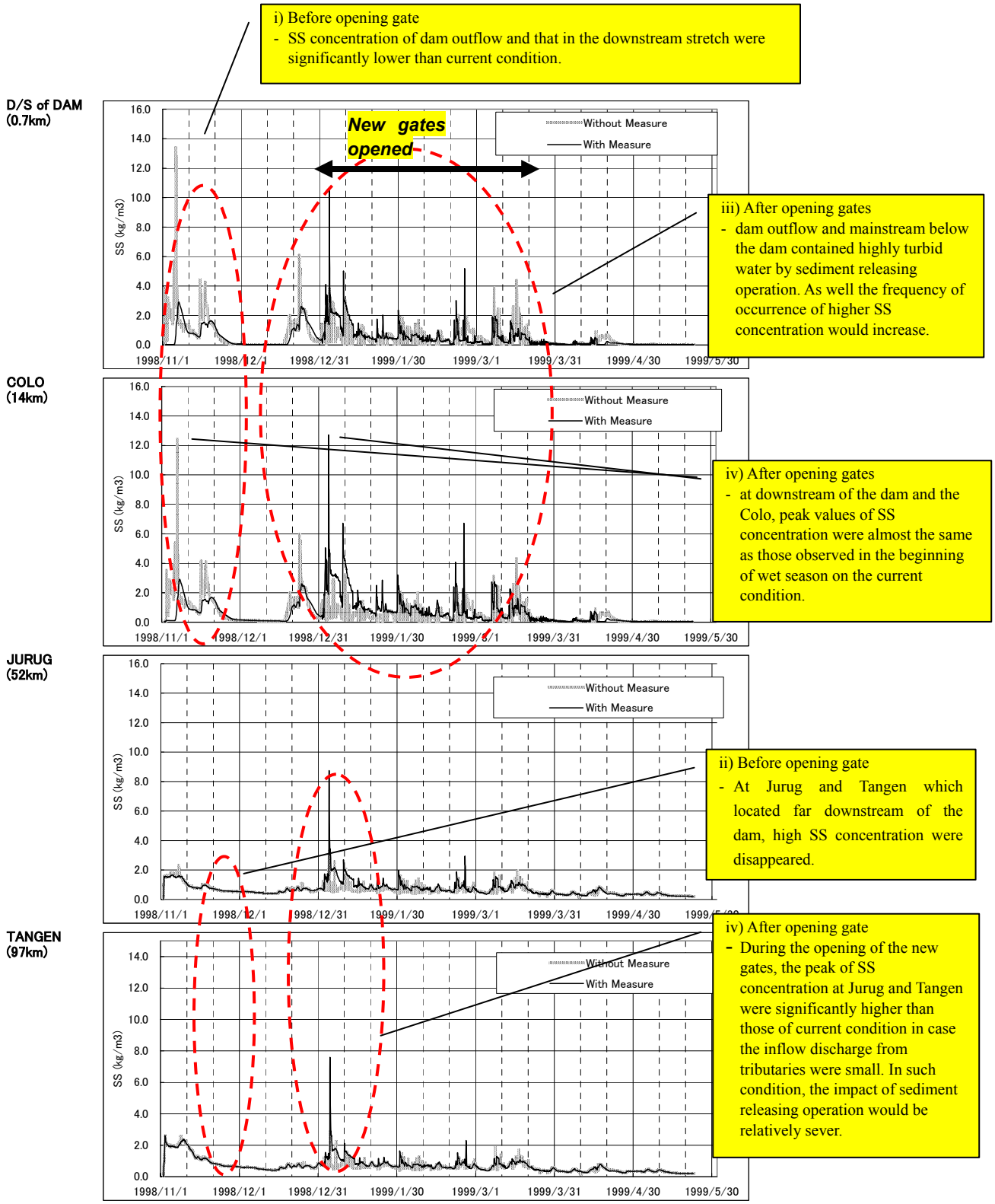
vii) Fluctuations of river flow discharge at Jurug and Tangen were almost the same as current conditions. The impact on the river flow discharges would be less because the river flow discharges in these stretches are dominated by the inflow from the tributaries.

(3) After Closing the New Gates (end of Wet season)

viii) No impact would be observed in the downstream reaches.

(4) Peak SS Concentration along the Upper Solo Mainstream（1999/01/01 - 1999/01/10）

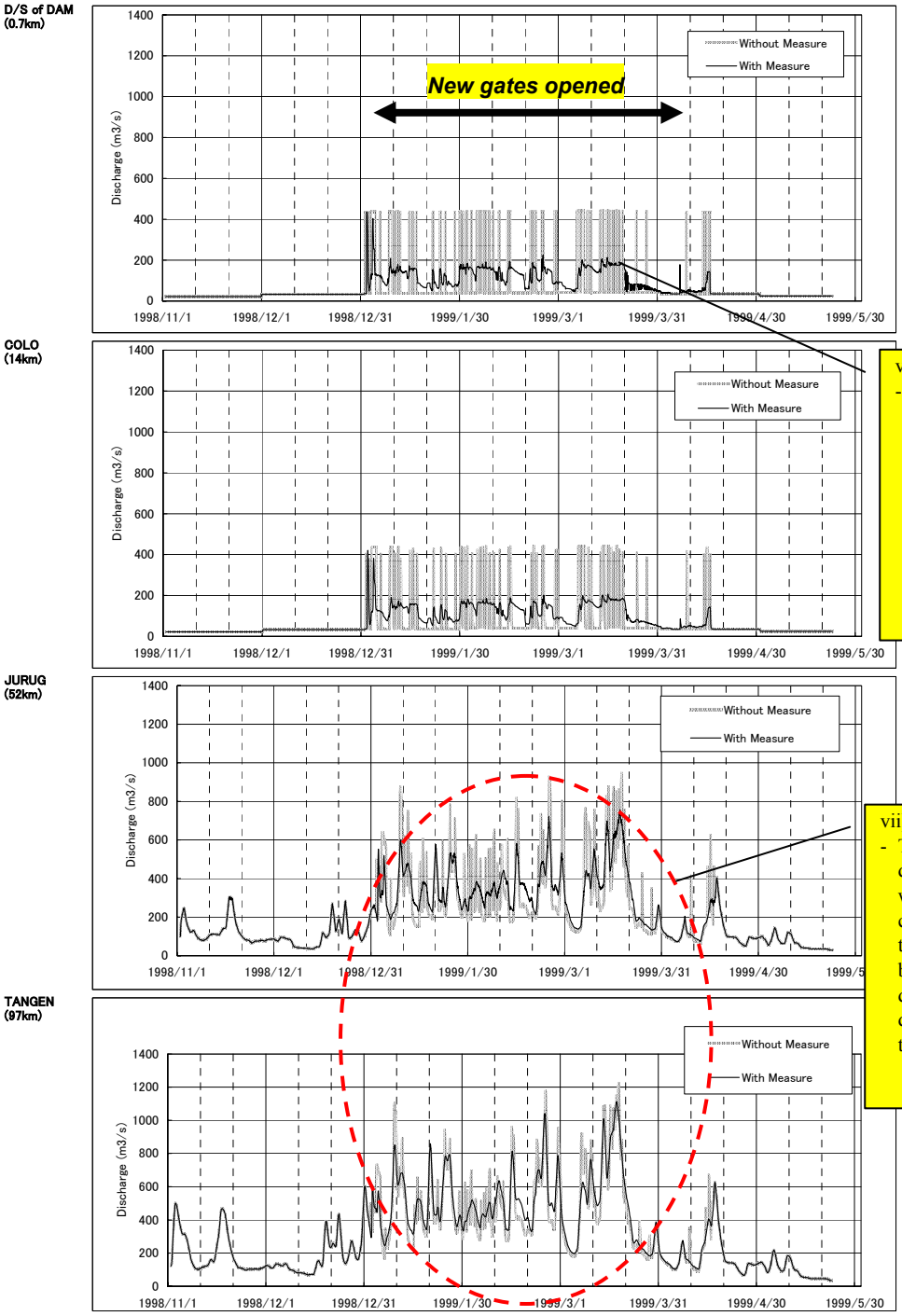
Focusing on the propagation of the peak SS concentration along the mainstream, the characteristics were examined in detail to compare both cases of Without and With measures, as presented in the Figure 3.2.7 below:



Note:" Without Measure" is the case in present condition assuming that the dam operation to follows the existing rule. "With Measure" is the case after implementation of the measure (Sediment storage reservoir with new gates).

Source : JICA Study Team

Figure 3.2.5 Comparison of SS Concentration in Upper Solo Mainstream between With and Without Measures in Wet Year (1998/1999)



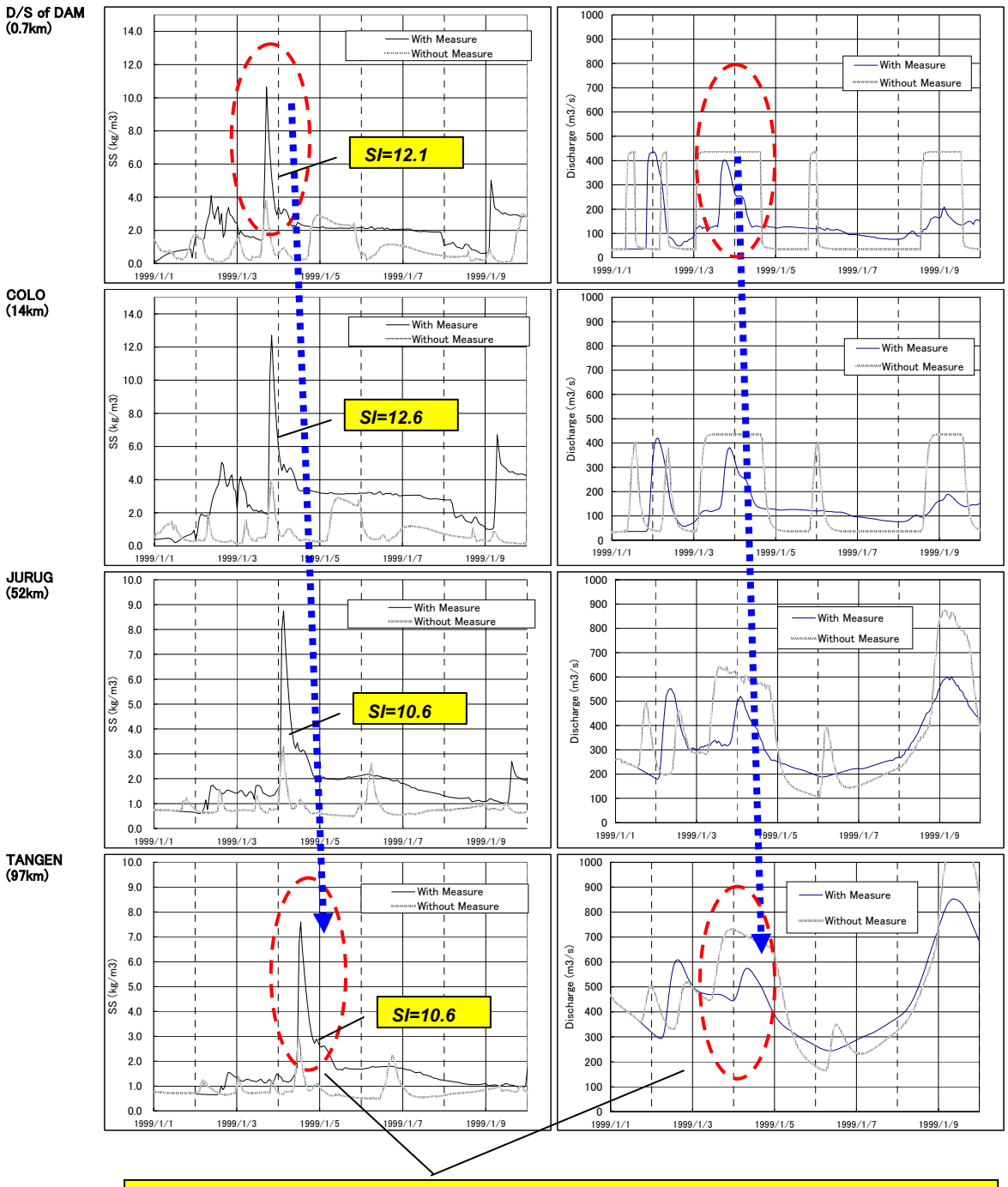
v) After opening gates
- -The discharge in the stretch Wonogiri - Colo would be strongly affected of the dam outflow. After opening the new gates, the discharge in this stretch was almost the same as that of the Keduang River which would be released from the new gates.

vii) After opening gates
- The fluctuations of river flow discharge at Jurug and Tangen was almost the same as current condition. The impact to river flow discharge would be less because the river flow discharge in this stretches was dominated on the inflow from tributaries.

Note:" Without Measure" is the case in present condition assuming that the dam operation to follows the existing rule. "With Measure" is the case after implementation of the measure (Sediment storage reservoir with new gates).

Source : JICA Study Team

Figure 3.2.6 Comparison of Discharge in Upper Solo Mainstream between With and Without Measures in Wet Year (1998/1999)



iv) After opening gate

- During opening the new gates, the peak of SS concentration at Jurug and Tangen would be significantly higher than those of current condition in case the inflow discharge from tributaries were small during opening the gate. In such condition, the impact of sediment releasing operation would be relatively sever.

Note:" Without Measure" is the case in present condition assuming that the dam operation to follows the existing rule. "With Measure" is the case after implementation of the measure (Sediment storage reservoir with new gates).

Source : JICA Study Team

Figure 3.2.7 Comparison of Peak SS Concentration in Upper Solo Mainstream between With and Without Measures in Wet Year (1998/1999)

3.2.6 Evaluation of Impacts for Downstream Reaches

Based on the results of turbidity analysis, the impacts of the proposed urgent measure (a sediment storage reservoir with new gates) to the downstream reaches were assessed on the following criteria:

i) Impact on discharge (monthly mean, monthly maximum, and discharge duration curve)
ii) Impact on SS concentration (monthly mean, monthly maximum, and duration curve of SS concentration)
iii) SI (Stress Index)

The results of assessment by above criteria are summarized below and detailed comparisons are presented in the Supporting Report I Annex No.6.

(1) Impact on Discharge

Monthly Mean Discharge

i) In each of dry, normal and wet year and at each station in the Upper Solo River downstream of the Wonogiri dam, no significant impact would occur.

Monthly Maximum Discharge

ii) In dry years, no impact would occur because the spillout discharge would be minimal or zero.
iii) In normal and wet years in the stretch of the Wonogiri - Jurug, the monthly maximum discharges would be slightly decreased due to operation of the proposed measure.
iv) At Tangen, the impact would be less because the river flow discharge in this stretch is dominated by the inflow from tributaries.

Discharge-Duration Curve

v) In the stretch of Wonogiri – Colo, the discharge duration curve would be a little smoother due to operation of the proposed measure. In the stretch of Jurug – Tangen, no significant impact would occur.

(2) Impact onr SS Concentration

Monthly Mean SS Concentration

i) In dry years at each station, no significant impact would occur as the monthly mean and monthly maximum discharge would be the same because the spillout discharge would be minimal or zero.
ii) In normal and wet years at each station, the monthly mean SS concentrations would increase by 1.3 - 2.9 times while the new gates are opened.

Monthly Maximum SS Concentration

iii) Before opening the new gates, the monthly maximum SS concentration would decrease due to the effect of the proposed measure by which the existing intake would be protected from turbid inflow from the Keduang River.
iv) During opening of the new gates, the monthly maximum SS concentrations would increase by 2 - 3 times due to the released turbid water from the sediment storage reservoir.

Duration Curve of SS Concentration

v) In dry years at each station, no impact would occur.
vi) In normal and wet years in the stretch of Wonogiri - Colo, the duration of SS concentration would slightly increase from 0.5 to 2.5 kg/m^3.

vii) In each year at Tangen, the duration curve of SS concentration would be unchanged because the SS concentration in this stretch would be dominated by the sediment inflow from tributaries, not the dam outflow.

(3) Impact for Stress Index

There is a criteria named Stress Index (SI) that is used to assess a short time impact of a sediment flushing/sluicing operation in the downstream stretch. The Stress Index is given by following equation:

$SI = \log_e (SS \times T)$

where, SI : Stress Index
SS : Suspended Solid Concentration (mg/l)
T : Duration (hr)

Applying this index to the result of the turbidity analysis, the preliminary assessment was that there would be a short-term impact to the downstream of the Wonogiri. For the calculation of SI the threshold value of SS was assumed to be 2,000 mg/ltr so that a few significant peak fluctuations could be selected for respective wet seasons. An example of SI on the hydrograph of SS concentration is shown in the Figure 3.2.7. As a result of calculation of SI on the simulated SS hydrographs, the monthly maximum SI at each location in each hydrological year are classified in Table 3.2.4 and plotted in Figure 3.2.8 below.

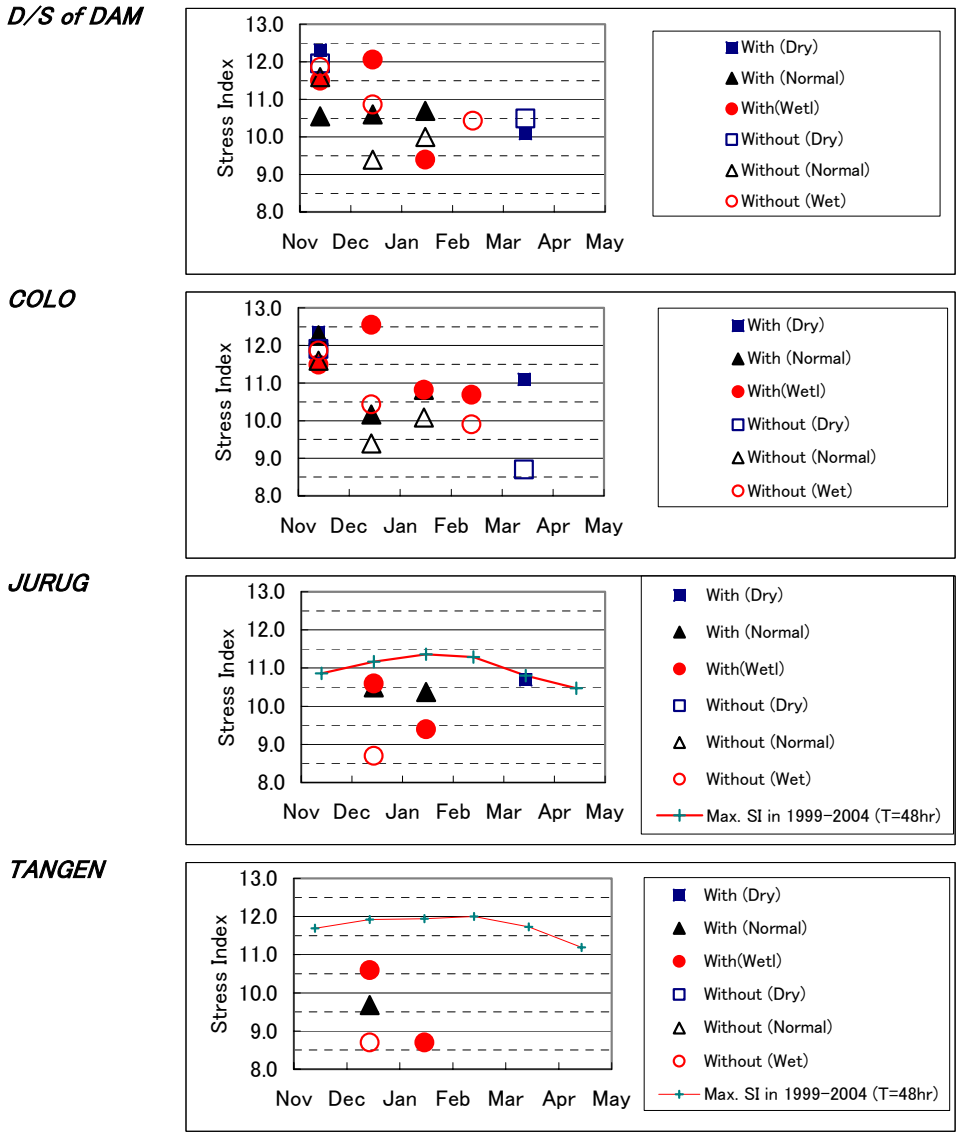
Though only three hydrological years were analyzed, the SI varies in a wider range along the upper Solo River mainstream depending on the duration and peak value of SS. From the overall points of view, it is indicated that the monthly maximum SI would slightly increase after implementation of the proposed measure.

The simulated monthly maximum SI was compared with the envelope curve of the estimated monthly maximum SI from the recorded SS at Jurug and Tangen in 1990 – 2004. The results are summarized in Figure 3.2.8. In this estimation, the duration of SS was assumed to be 24 hour because the daily base data is available. As shown in the figure, all of the simulated monthly maximum SI results from November to May were smaller than that of the recorded maximum. It is judged that the short-term impact to the downstream of the Wonogiri dam would be slightly smaller than the recorded maximum SI in the stretch.

Table 3.2.4 Characteristics of Monthly Maximum of SI

Location	Monthly Maximum SI (Dec.-May.)					
	Without			With		
D/S of Dam	***9.4***	**-**	***12.0***	***9.4***	**-**	***12.3***
COLO	***8.7***	**-**	***11.9***	***10.2***	**-**	***12.5***
JURUG		**-**	***8.7***	***9.4***	**-**	***10.7***
TANGEN		**-**	***8.7***	***8.7***	**-**	***10.6***

Source : JICA Study Team



Source : JICA Study Team

Figure 3.2.8 Comparison of Monthly Maximum SI in Upper Solo Mainstream between With/Without Measures

(4) Impact of Sediment Loads

The accumulated volume of SS passing each station from November 1 to May 20 in each hydrological year was estimated as compared in Table 3.2.5. The average accumulated volume of SS passing was increased by 239,200 m^3 immediately downstream of the dam, 474,600 m^3 at the Colo, 478,500 m^3 at Jurug and 469,200 m^3 at Tangen. The increment in volume from the dam to the Colo was considered to be due to the high concentration of sediments supplied from tributaries and re-suspension of the riverbed materials. The decrease in the volume from the Colo to Tangen indicates that the sediment loads released from the sediment storage reservoir would become smaller with distance from the dam.

Even if the sediment load in the Upper Solo mainstream were to increase, sediments released from the Wonogiri reservoir would not be deposited in the river stretch because they are composed of 93-97% of wash load composed of clay and silt.

Table 3.2.5 Comparison of Accumulated Volume of SS Passing along the Upper Solo River in Wet Season (November 1 to May 20)

(Unit: ton)

Location	Hydrological Year	Accumulated passing Volume of SS (November 1 – May 20)		
		Without	With	Increment
D/S of Dam	Dry	266,600	249,100	-17,500
	Normal	438,400	737,100	298,700
	Wet	437,900	874,300	436,400
	Average	***381,000***	***620,200***	***239,200***
COLO	Dry	297,700	291,900	-5,800
	Normal	501,300	1,074,800	573,500
	Wet	418,000	1,274,100	856,100
	Average	***405,700***	***880,300***	***474,600***
JURUG	Dry	1,861,000	1,862,800	1,800
	Normal	2,019,100	2,511,900	492,800
	Wet	2,262,400	3,203,400	941,000
	Average	***2,047,500***	***2,526,000***	***478,500***
TANGEN	Dry	3,441,900	3,449,200	7,300
	Norma	4,276,700	4,768,000	491,300
	Wet	3,727,200	4,636,200	909,000
	Average	***3,815,300***	***4,284,500***	***469,200***

Source: JICA Study Team

3.3 Preliminary Study for New Gate Operation in Sediment Storage Reservoir

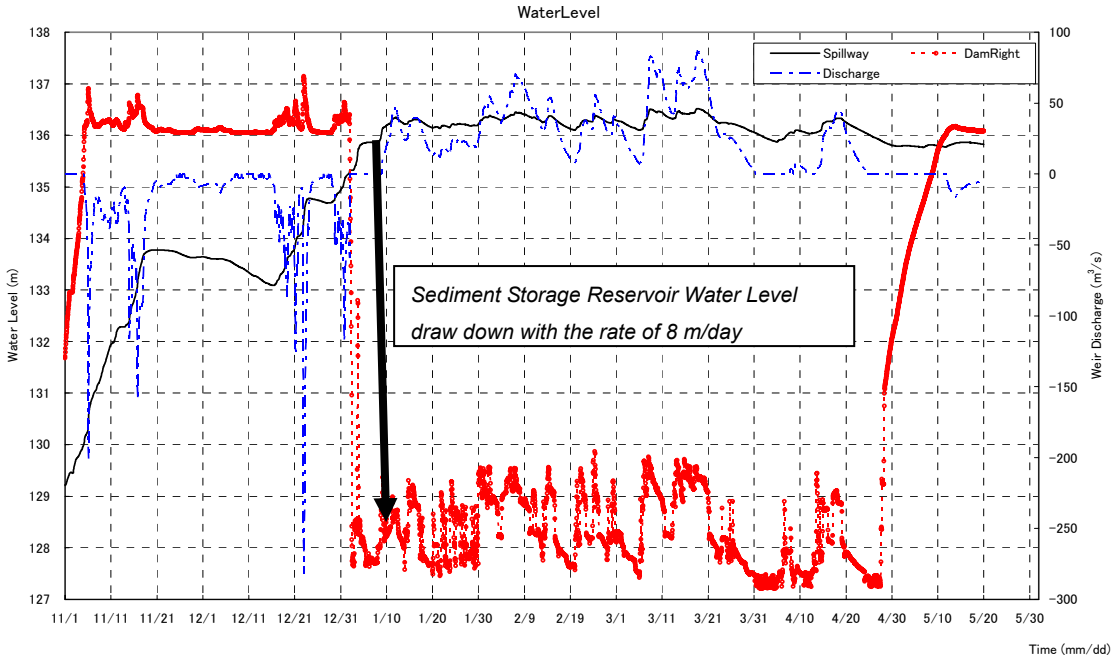
3.3.1 Necessity of Control on Drawing Down of Water Level in Sediment Storage Reservoir

In the reservoir sedimentation analysis, with a sediment storage reservoir, that was carried out during the master plan formulation to evaluate the capacity of sediment release through the new gates, it appeared that the water level in the sediment storage reservoir would rapidly draw down at a rate of 8 m/day after opening the new gates as shown in Figure 3.3.1. Figures 3.3.2 and 3.3.3 present the simulation results. This is due to the simulation condition that the maximum water release from the new gates is set at 400 m^3/s according to the current reservoir operation rule. However a large amount of water could be released from the sediment storage reservoir in short time. There are several threats that a rapid drawing down of the reservoir water level might cause, such as the following adverse impacts:

i) Increased probability of the surrounding area sliding into the sediment storage reservoir due to the remaining water pressure in the ground;
ii) Decreased stability of structures such as the sub-dam, closure dike and overflow dike, due to the remaining water pressure inside of the embankment;
iii) Increase of SS concentration in the released water from the new spillway.

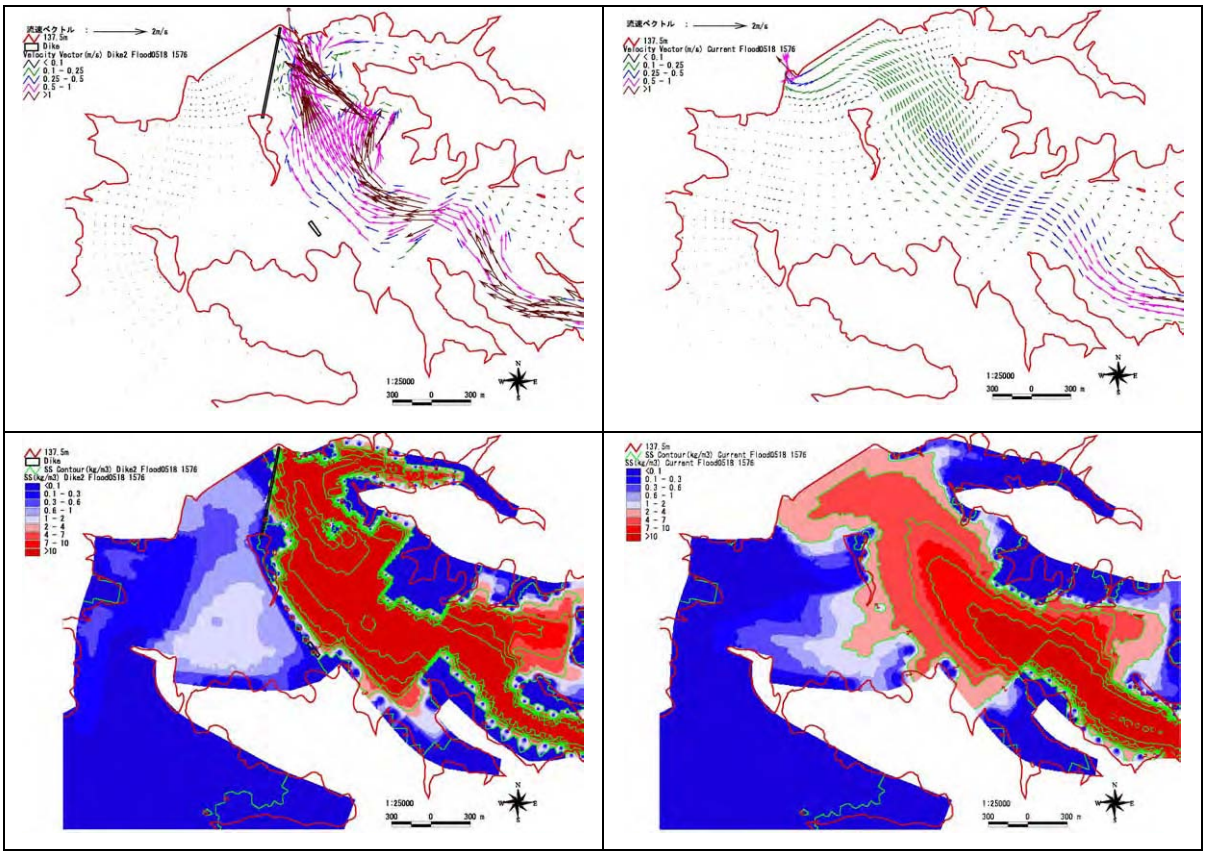
Especially in the Wonogiri reservoir, the above issues of i) and ii) will not cause serious impacts because i) no land slides were found in the Wonogiri reservoir and ii) the upstream slope of the sub-dam are already covered by substantial sediment deposits over EL.131 m.

The main issue due to rapid drawing down of the water level in the sediment storage reservoir would be high concentration of SS to be released after opening the new gates.



Source: JICA Study Team

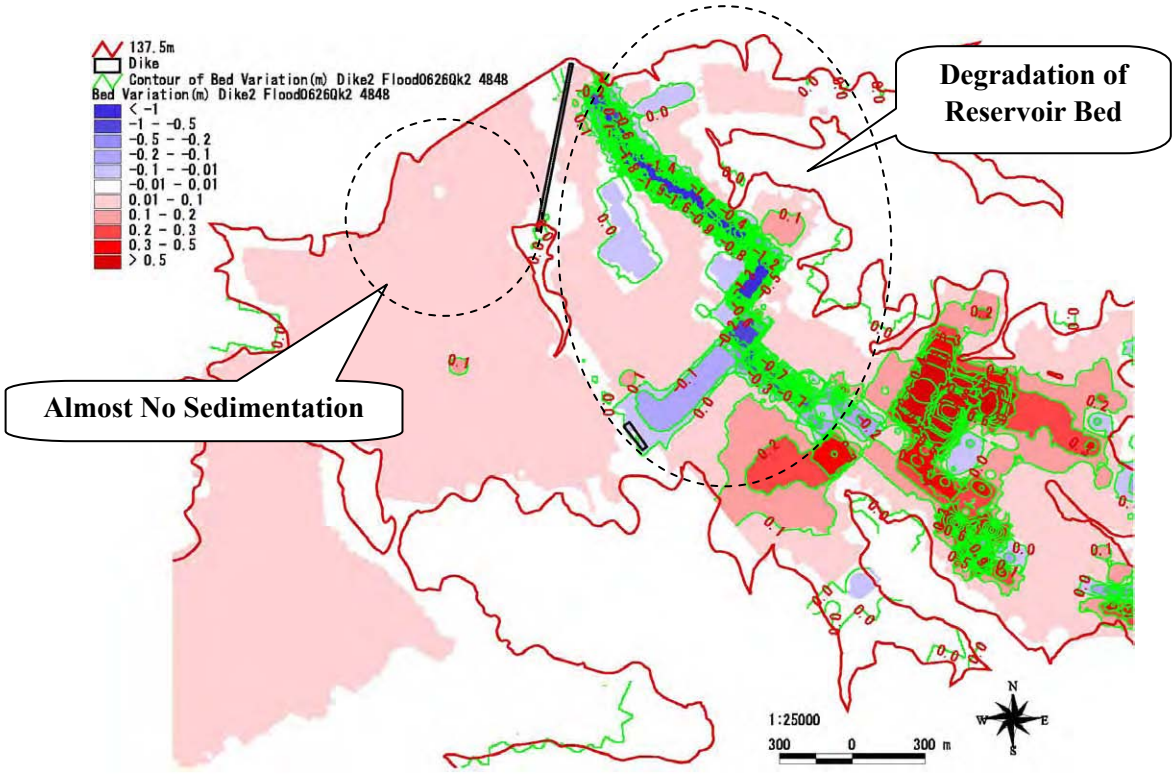
Figure 3.3.1 Simulation Results of Water Levels in Sediment Storage Reservoir and Main Reservoir, and Overflow Discharge from Overflow Dike



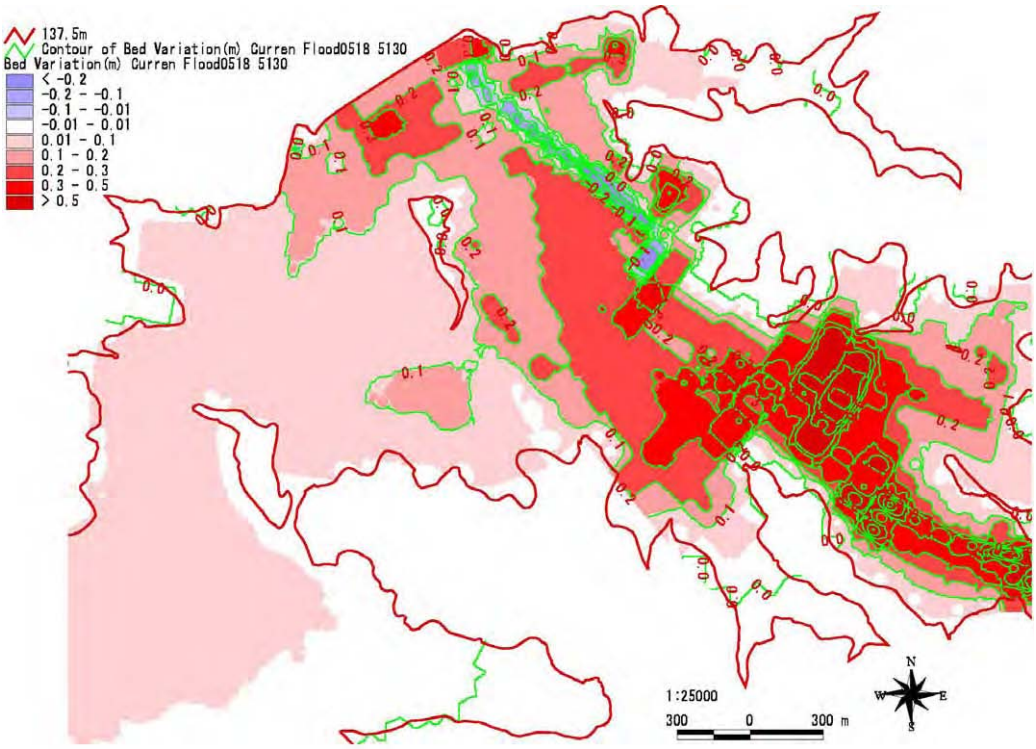
(a) Sediment Storage Reservoir | (b) Without

Source: JICA Study Team

Figure 3.3.2 Simulation Result of Distributions of Velocity (above) and SS Concentration (below) in Sediment Storage Reservoir immediately after Sediment Releasing



(a) Sediment Storage Reservoir



(b) Without

Source: JICA Study Team

Figure 3.3.3 Simulation Result of Sedimentation in Sediment Storage Reservoir after Wet Season (Case : Wet Year in 1998-1999)

3.3.2 Proposed Gate Control

To avoid the rapid drawing down of the water level in the sediment storage reservoir, the following gate control was examined.

Table 3.3.1 Proposed Control of New Gates

CASE	(Case A) New gate control based on the present reservoir operation rule	(Case B) New gate control by the modified rule
Water release from new gates	Qspill ≤ 400 m^3/s	Qspill ≤ 100 m^3/s

Source : JICA Study Team

3.3.3 Result of Reservoir Sedimentation Analysis

Reservoir sedimentation analysis were carried out for Cases A and B above applying the hydrological condition of a normal year (1995/1996) and a wet year (1998/1999). The simulation results for the sediment storage reservoir are presented in Figure 3.3.4 below for comparison.

3.3.4 Evaluation of Result

(1) Water Level in Sediment Storage Reservoir

As is apparent from the figure above, the rate of drawing down of the water level in the sediment storage reservoir was decreased to 3 m/day from 8 m/day in both normal and wet years.

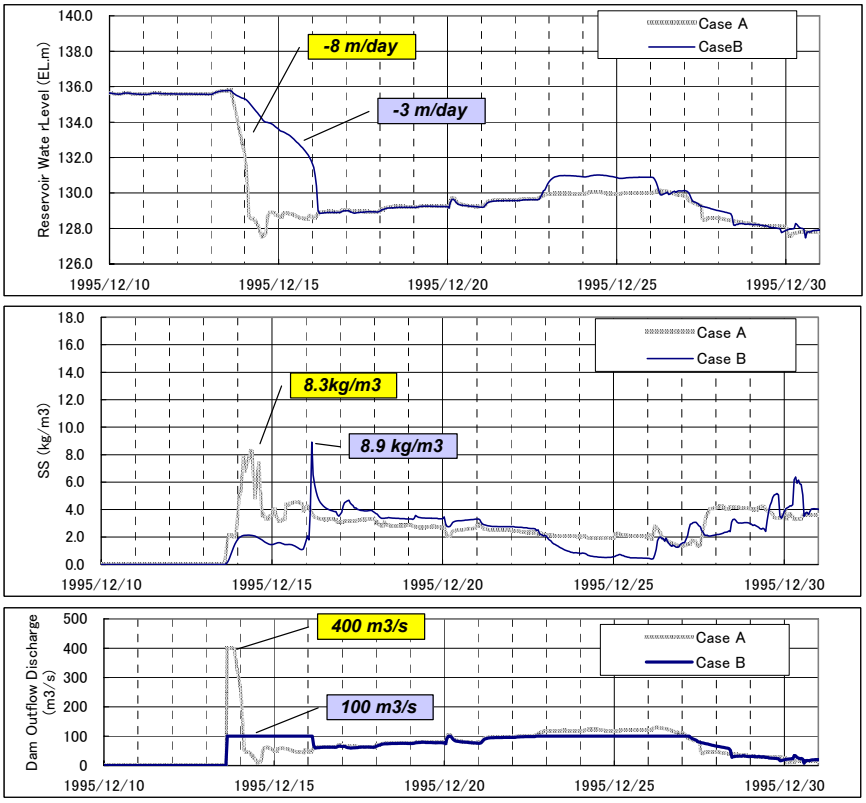
(2) SS Concentration

In case of the normal year, almost no difference was found on the peak SS concentration in the middle of December in 1995, although the duration was slightly shorter. This implies that the rate of draw down of the reservoir water level has no significant impact on the peak SS concentration of the released water in case the sediment storage reservoir is completely emptied.

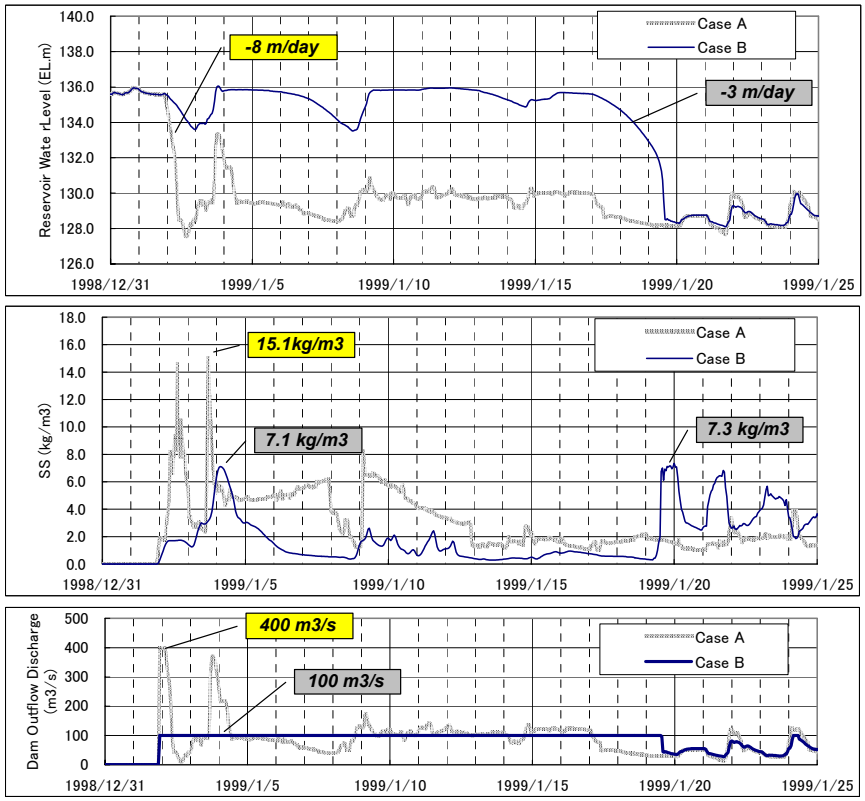
On the other hand, in the case of the wet year, the peak SS concentration was significantly decreased from 15.1 kg/m^3 to 7.1 kg/m^3 at the beginning of January in 1998. In this period, the reservoir water level was kept at El 134 m to 136 m without being emptied because consecutive flood flows enter the sediment storage reservoir from the Keduang River. Such being the case, the peak SS concentration of released water would be decreased by applying the proposed gate control. Subsequently, at the end of January in 1998, the SS concentration of the released water was significantly increased to 7.3 kg/m^3 immediately after emptying the sediment storage reservoir.

In the both years, it was indicated that the sediment flushing/sluicing operation could release high concentration of suspended sediments from the reservoir while the reservoir water level was kept lower.

Normal Year : 1995/1996



Wet Year : 1998/1999



Source : JICA Study Team

Figure 3.3.4 Comparison of Effects of Gate Control in Sediment Reservoir in Normal Year (1995/1996) and Wet Year (1998/1999)

(3) Released Volume of Sediments

The analysis results on the volume of released sediments from the power station and the new gate of the sediment storage reservoir are summarized in the Table 3.3.2 below. Comparing to the results on Case B and Case A, the released sediment volume from the new gates was decreased around 120,000 m^3 in the wet year but slightly increased in the normal year. As mentioned above, the difference between normal and wet years was caused by the difference of water level in the sediment storage reservoir after opening the new gates. Whether the high concentration is released or not was strongly influenced by the inflow pattern from the Keduang River, which is the dominant affect on the water level in the sediment storage reservoir after opening the new gates.

Table 3.3.2 Comparison of Released Sediments Volume from Power Station and New Gate of the Sediment Storage Reservoir

(Unit m^3)

Year	Area	Case A (Qspill ≤ 400 m^3/s)	Case B (Qspill ≤100 m^3/s)	(Case B – Case A)
Normal Year (1995/1996)	New Gates	933,900	957,500	+23,600
	Power Station	98,500	98,700	+200
	Total	***1,032,400***	***1,056,200***	***+23,800***
Wet Year (1998/1999)	New Gates	1,114,500	989,300	-125,200
	Power Station	112,200	116,100	+3,900
	Total	***1,226,700***	***1,105,400***	***+129,100***

Source : JICA Study Team

3.3.5 Conclusion

By restriction of the maximum water release from the new gates, it will be possible to avoid rapid drawing down of the water level in the sediment storage reservoir. However, the rate of draw down has no significant impact on the peak SS concentration of released water in case the sediment storage reservoir is completely emptied.

To decrease the peak of SS concentration of released water, it would be convenient to control the water level so the sediment storage reservoir is not emptied. As this study was a preliminary examination of a certain case, it is suggested that various cases should be examined to determine the operation rule for the new gate.

CHAPTER 4 FEASIBILITY DESIGN OF SEDIMENT STORAGE RESERVOIR

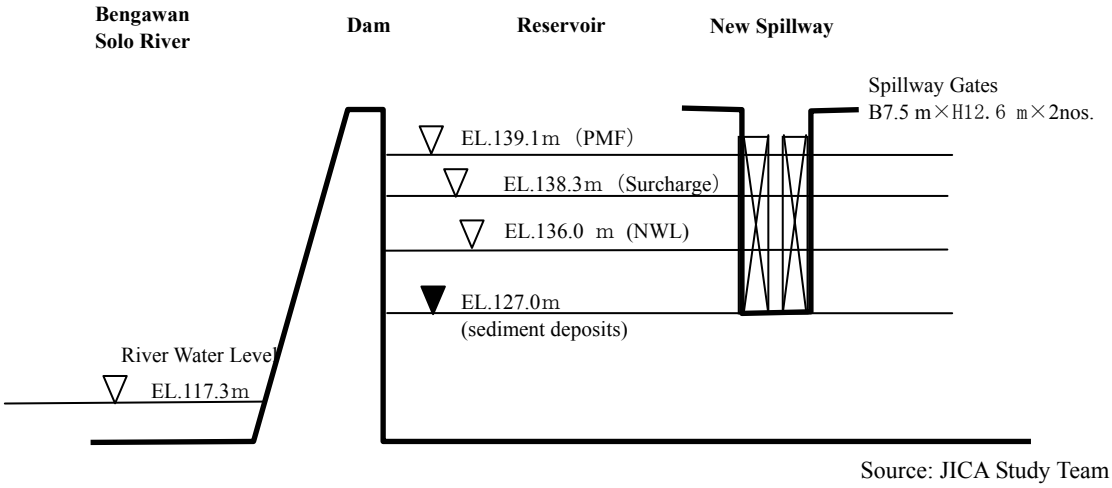
4.1 Design Condition and Criteria

The sediment storage reservoir structures subject to feasibility design are the new spillway, closure dike and overflow dike. The layout of the facilities is shown in Figure 4.1.1. Design conditions and criteria are set out as listed in Table 4.1.1. Design water levels for design of the new spillway structure are illustrated in Figure 4.1.2.

Table 4.1.1 Design Conditions and Criteria

Structure	Item	Condition and Criteria
(1)New Spillway	Type	Front overflow weir
	Elevation of Inlet	EL.127.0 m (Design deposits level)
	Design discharge	Q=1,270 m^3/s (at PMF)
	Water level	EL.139.1 m
(2) Closure Dike	Crest elevation	EL.138.3 m（Surcharge water level）
	Elevation of foundation	EL.127.0 m（Design sediment deposits level）
	Width of crest	W=10.0 m
(3) Overflow Dike	Crest height	Crest Height EL.136.0m
	Design discharge	Q=550 m^3/s (at SHFD) Sediment storage reservoir: EL. 138.1 m Main reservoir: EL. 137.8 m.

Note; Design discharges are discussed in subsection 3.1.6.
Source: JICA Study Team



Source: JICA Study Team

Figure 4.1.2 Design Water Levels for Design of New Spillway

4.2 New Spillway

The new spillway is planned at the right abutment of the Wonogiri dam. Layout plan and profile of the new spillway are shown in Figures 4.2.1 and 4.2.2 respectively.

Required function of the new spillway is to release the design flood discharges safely and to smoothly flush out the sediment-laden flood inflow from the Keduang River as well as the sediment deposits in the sediment storage reservoir. Feasibility design of the new

spillway is described as follows:

4.2.1 Layout Plan of New Spillway

(1) Concept of Plan

Concept of layout plan are as follows:

The concept of layout plan is as follows:

a) The new spillway is to be constructed within the premises of PBS or PJT I Bengawan Solo.
b) The inlet of the spillway is placed about 100 m in front of the Wonogiri dam axis to avoid giving negative impacts to the dam body during the construction and the operation after the completion.
c) A training channel is placed from the inlet of spillway to the end of curved portion of the spillway. Gradient of the channel is about 1/108.
d) A chute channel is placed from the end of training channel to the inlet of the energy dissipater. Gradient of the chute channel is 1/108, the same as the training channel.
e) The chute channel is curved to connect smoothly with the Bengawan Solo River.
f) Width of the channel is set out 15 m from the beginning of training channel to end of the chute channel.

(2) Type of Inlet

A front overflow weir type is adopted as the new spillway inlet to secure effective functioning for sediment flushing.

(3) Gate

Gate size has been determined to accommodate the design discharge from the sediment storage reservoir. A radial gate type has been adopted to reduce the impact caused by sediment releasing.

(4) Type of Energy Dissipater

A ski jump type is adopted as the energy dissipater because of the reasons as listed below. Bed elevation of the plunge pool is set at EL.100 m applying the same elevation to the plunge pool as the existing spillway.

a) The area along the spillway channel route is underlain by a very stiff layer (hard rock) suitable for foundation (see subsection 2.7.2). The ski jump type dissipater requires not little excavation. If a hydraulic jump type dissipater is adopted, the excavation volume might be larger than that of ski jump type.
b) Gradient of the chute channel slope is very gentle at 1/108. Therefore, the flow velocity in the channel is not so high. Flow velocity in the chute channel is around 9.7 m^3/s when the flow is 400 m^3/s.
c) A ski jump dissipater was adopted for the existing spillway.

4.2.2 Design

(1) Inlet of Spillway

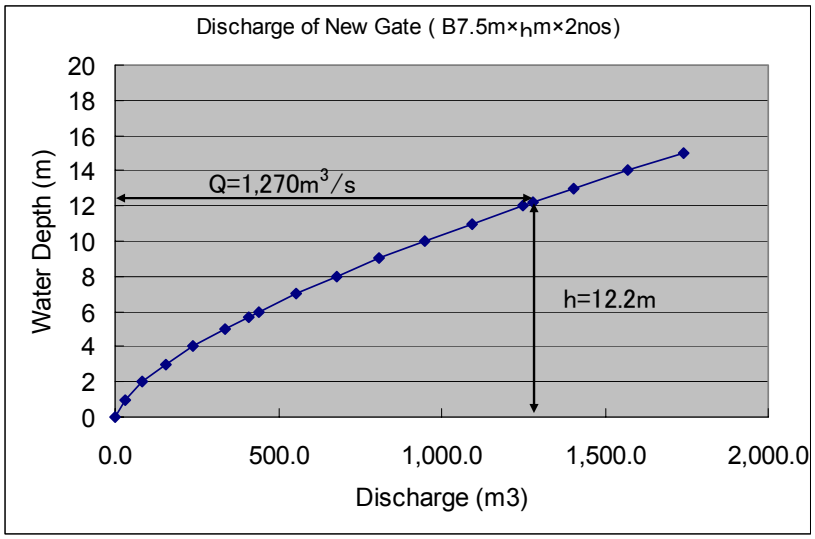
Foundation elevation of the inlet is set at EL.127.0 m, the same elevation as the design level of sediment deposits to allow the sediment flushing function. Maximum design discharge is 1,270 m^3/s at PMF (water level EL.139.1 m). Design discharge to be released is 400 m^3/s at SHFD with a peak discharge of 4,000 m^3/sec.

Width of inlet is required to be more than B=15.0 m to keep the water level, from the overflow weir equation below, under EL.139.1 m at PMF.

In this design, a two gate (B =7.5 m) system is adopted due to maintenance work. Usually, more than two gates are recommended for sediment flushing in terms of maintenance.

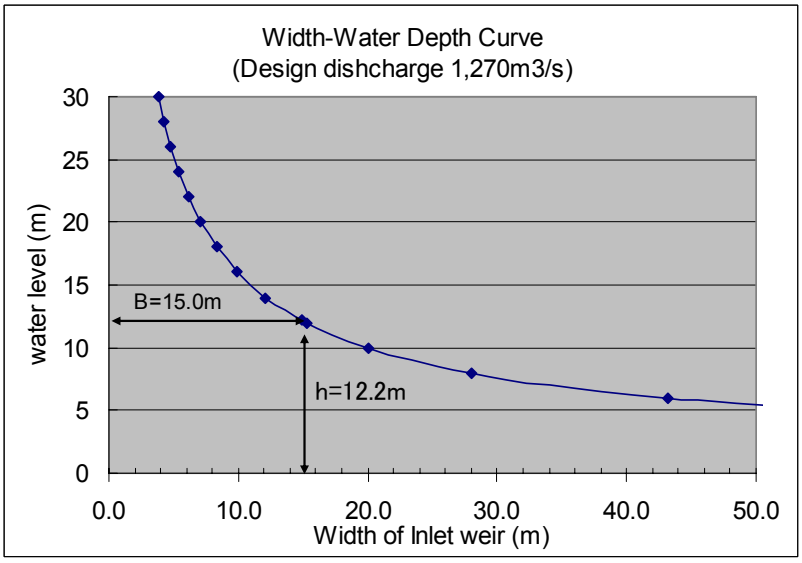
$$Q = CBH^{3/2}$$

where, C : Coefficient of overflow weir C=2.0
B : Width of inlet (m)
H : Water depth at inlet (m) 139.1-127.0 = 12.1 m
Q : Discharge (m^3/s)



Source: JICA Study Team

Figure 4.2.3 H-Q Curve of New Gates



Source: JICA Study Team

Figure 4.2.4 Width Water Depth Curve of New Gates

(2) Training Cannel Portion

The training channel crosses the dam axis and runs close to the dam body. A gravity type retaining wall is adopted for the training channel. Typical cross section is shown in Figure

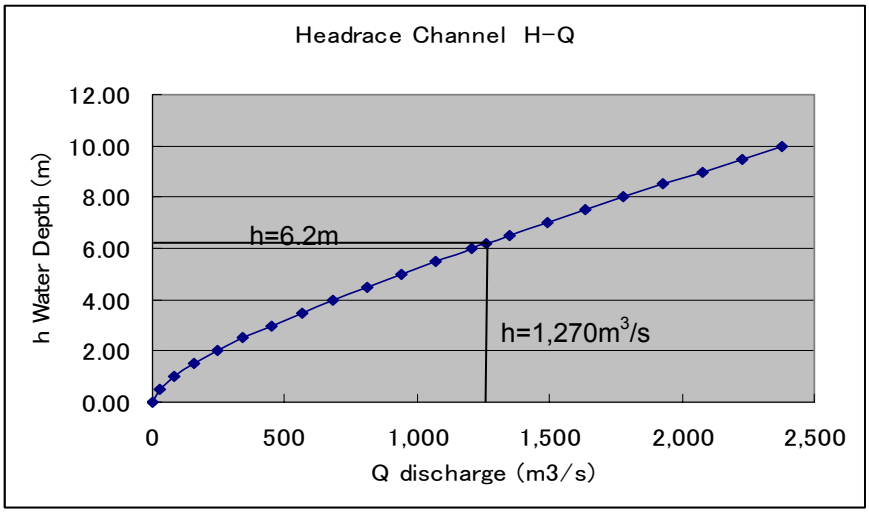
4.2.5. Principal design conditions are set at:

- Slope of back face of the wall is 1:0.7 due to the stability of the wall.
- Slope of training channel is 1/108.
- Design discharge is 1,270 m^3/s.
- Water depth at design discharge h=6.2 m is given from below Manning formula.
- Free board, h=0.8 m is applied.
- Height of wall H=6.2+0.8= 7.0 m.

Manning formula $v = 1/n \cdot R^{2/3} \cdot I^{1/2}$

$$Q = A \cdot v$$

where, n : Coefficient of roughness, n=0.016 (concrete channel)
A : Flow area (m^2)
V : Velocity (m/s)
Q : Discharge (m^3/s), Design discharge Q=1,270m^3/s
I : Gradient 1/108
R : Hydraulic mean depth (R=S/h)
S : Total edge length in water (m)
H : Water depth (m)
V : Velocity (m/s),V=13.6 m/s at 1,270 m^3/s, V=9.7m/s at 400 m^3/s



Source: JICA Study Team

Figure 4.2.6 H-Q Curve of Training Channel

(3) Chute Channel Portion

Gradient of the chute channel is I=1/108, which is the same with the training channel.

Reinforced concrete walls are adopted for the walls of the chute channel to reduce excavation volume and concrete volume. Typical cross section is shown in Figure 4.2.5. Principal design conditions are set at:

- Slope of chute channel is I=1/108.
- Design discharge is 400 m^3/s at surcharge water level and 1,270m^3/s at PMF.
- Water depth at design discharge h=6.2 m.
- Free board h=0.8 m.

- Height of wall H=6.2+0.8= 7.0 m.
- Velocity V = 9.7 m/s at 400 m^3/s, V = 13.6 m/s at 1,250 m^3/s.

(4) Energy Dissipater

A ski jump type energy dissipater is adopted for new spillway. Target discharge is 400 m^3/s at the SHFD. Flow velocity is 9.7 m/s, which is very low due to gentle chute channel gradient of 1/108. Gradient of 1/108 is categorized as a natural river.

a) Features of ski jump bucket for energy dissipater

This type of energy dissipater has an advantage in the construction cost, while the effectiveness as a dissipater is less compared with the normal type, and the flow regime of the plunge pool and downstream river is unstable.

b) Trajectory and extent of the area of falling jet

Trajectory of free-discharging jet is estimated by the following formula:

$$y = \tan\theta \cdot x - \frac{x^2}{4\cos\theta^2 \cdot KHo}$$

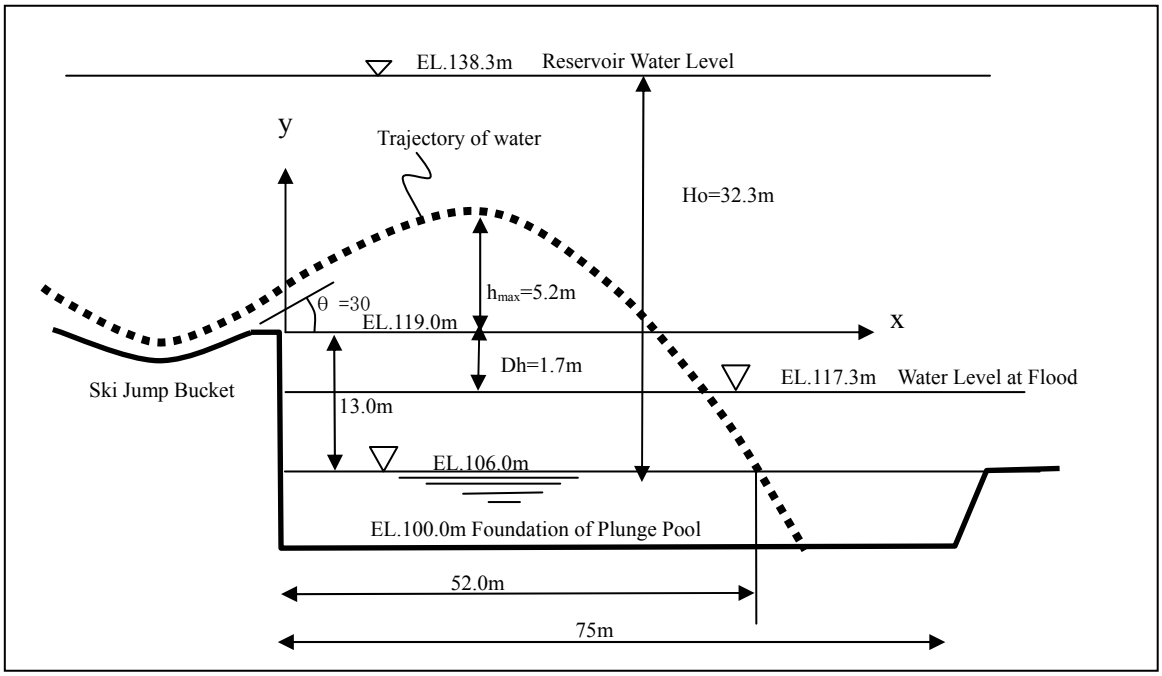
where,

K: Coefficient obtained after deducting friction loss and other losses in the channel from 1.0 are as shown below.

K=0.69 (Q=1,000 m^3/s)
K=0.73 (Q=1,600 m^3/s)
K=0.65 (Q=400 m^3/s)
K=0.71 (Q=1,250 m^3/s)

K values come from the "Report on the Hydraulic Model Test on Revised Spillway of Karangkates Project (1971)"

θ : Angle of Jet jumping θ =30°



Source: JICA Study Team

Figure 4.2.7 Trajectory of Jet Water

Table 4.2.1 Trajectory of Jet Water

Water Level of Reservoir	Water Level of River	Difference △h(m)	Xmax (m)	Ymax (m)
EL.138.3m	EL.106.0m	32.3	52.0	5.19
EL.139.1m	EL.106.0m	33.1	53.0	5.34

Source: JICA Study Team

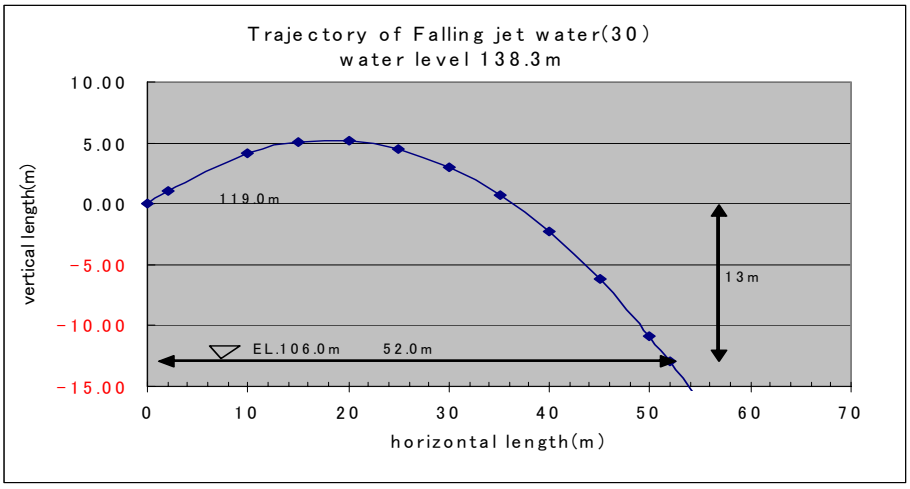
(5) Quantities

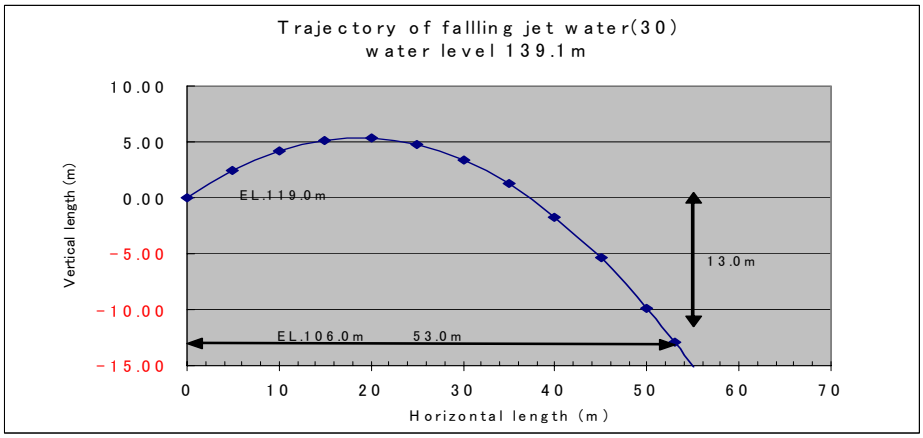
Quantities for the closure dike are shown in Table 4.2.2.

Table 4.2.2 Main Quantity of New Spillway

Item	Unit	Quantity
Length of Spillway	m	708.79
Training Channel	m	162.55
Chute Channel	m	452.24
Energy dissipater	m	94
Width of Spillway	m	15.00
Concrete Volume	m^3	93,320
Excavation	m^3	389,240
Backfill	m^3	134,970

Source: JICA Study Team





Source: JICA Study Team

Figure 4.2.8 Trajectory of Falling Jet Water

4.3 Closure Dike

(1) Design Conditions and Criteria

Purpose of the closure dike is to separate the sediment storage reservoir from the Wonogiri main reservoir up to the surcharge water level. However, when the water level is over the surcharge water level, the closure dike is designed to be submerged. A closure dike should be safe from sudden lowering of water level from EL. 136.0 m (normal water level) to EL. 127.0 m (designed sediment deposits level).

Therefore, design condition and criteria shall be as follows,

Height of Closure Dike : EL.138.3 m (Surcharge water level)
Free Board : △h=0 m
Foundation height : EL.127.0 m
Face Slope of Dike : 1:3.0

(2) Layout Plan

The closure dike is planned to run from the right abutment of the Wonogiri dam to the top edge of the peninsula that is located in front of the dam. Another purpose of the closure dike is to prevent sediment inflow from the Keduang River from flowing into the intake directly and to reduce garbage gathering at in front of the intake.

Layout plan of the closure dike is shown in Figure 4.3.1.

(3) Type of the Closure Dike

The earth-fill cofferdam type is selected for the closure dike for economic reasons and to secure the sand spoil bank resulting from the spillway excavation. However, there will be overflow over the closure dike during floods, from the water level of the Design flood (EL.138.3 m) to the PMF (EL.139.1 m). There might be the possibility of scouring at the foot and face of the closure dike during sediment flushing. Therefore, a double-wall constructed from steel sheet piles with a penetration depth reaching the original ground, is designed to be incorporated at the top of the closure dike. Width of the closure dike is 10 m, which is determined by stability analysis of the double-sheet pile wall.

Face slope of the dike is adopted at 1:3.0 to secure the safety of slope from failure with the rapid lowering of water level from 136 m to 127 m in one day.

Typical cross section of the closure dike is shown in Figure 4.3.1.

(4) Quantities

Quantities for the closure dike are shown in Table 4.3.1.

Table 4.3.1 Main Quantity of Closure Dike

Item	Unit	Quantity
Length of dike	m	658.00
Height of dike	m	Top of dike EL.138.3 m Foundation height EL.127.0 m H_{max} = 11.3 m
Embankment volume	m^3	167,800
Steel sheet pile	t	4,450

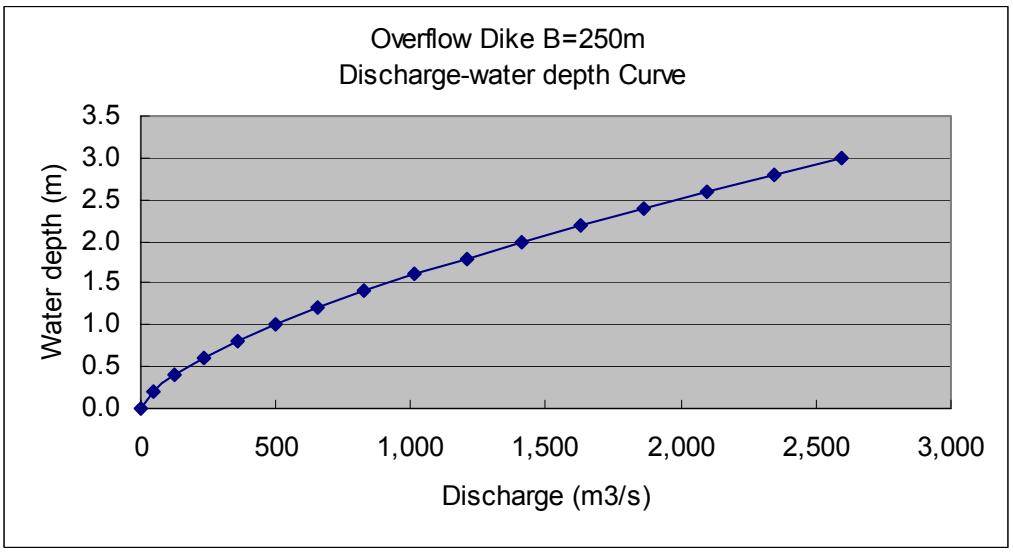
Source: JICA Study Team

4.4 Overflow Dike

(1) Design Condition and Criteria

The overflow dike is designed to transfer water from the sediment storage reservoir to the main reservoir, and vice versa when the reservoir water level is over EL. 136.0 m (normal water level) in the main reservoir. Length of the overflow dike was determined by the flood routing calculation (discussed in subsection 3.1.6). Plan and typical cross section are shown in Figure 4.4.1. Conditions and criteria are as follows:

- Crest height of overflow dike EL.136.0 m
- Difference in height between the crest and apron is 2.0 m from topographical and geological conditions
- Design discharge Q=550 m^3/s (at water lever EL.138.1 m in the sediment storage reservoir and EL.137.8 m in the main reservoir)
- Direction of flow is both sides



Source: JICA Study Team

Figure 4.4.2 H-Q Curve of Overflow Dike

(2) Layout Plan

Overflow dike is planned to be on the peninsula lying from the opposite shore of the Wonogiri dam. The location of the overflow dike is selected on ridge of peninsula due to geological conditions. Both sides of the overflow dike are embanked up to EL.138.3 m and connected to the closure dike and the shore opposite the dam.

In the overflow dike, a connecting conduit (2.0 m×2.0 m) with a gate is installed to transfer water in the sediment storage reservoir between EL. 136.0 m and 132.0 m to the main reservoir in the dry season. Width of the dike is about 250 m to satisfy the required function. Plan and section of connecting conduit is shown in Figure 4.4.3.

(3) Type of Overflow Dike

A concrete fixed weir type is adopted for the overflow dike because it is maintenance free.

Direction of flow on the dike is considered reversible. Therefore, the layout needs to have apron works on both sides. Distance between both weirs is set at 10 m to secure

maintenance and allow an access road.

(4) Quantities

Quantities for the overflow dike are shown in Table 4.4.1

Table 4.4.1 Main Quantity of Overflow Dike

Item	Unit	Quantity
Length of the dike	m	250.00
Height of dike	m	Crest height EL.136.0 m Apron EL.134.0 m
Excavation	m^3	29,750
Concrete	m^3	11,000
Earth filling	m^2	61,600

Source: JICA Study Team

CHAPTER 5 FEASIBILITY DESIGN OF WATERSHED CONSERVATION IN KEDUANG WATERSHED

5.1 Basic Concepts and Approaches

The annual average soil loss in the Keduang watershed is estimated at 4.79 million tons, most of which comes from the land surface (agricultural lands). The soil loss from off-farm areas such as landslides, riverside soil erosion and gullies is very small. As previously mentioned, the main erosion sources are uplands, uplands in the settlement area and the settlement areas and the most urgent objective is soil erosion control for these areas.

The local people in the Keduang watershed understand that crop yields are seriously affected by degradation of soil fertility due to soil erosion and are keenly interested in soil conservation. The results of the survey made it clear that an increase in the agricultural incomes of the local farmers is essential.

In order to solve such urgent objectives, it is necessary that watershed conservation be promoted by considering the approaches from the view points of; i) water/soil conservation, ii) agricultural issues and iii) socio-institution

As soil textures in the watershed is very fine, the construction of the large-scale Sabo dams is not seen as an economical or functional solution for soil erosion control. So these structures will not be included in this Study.

In this Feasibility Study, (1) Introduction of the improved bench terrace, which is very effective for soil erosion control as shown by the results of soil erosion tests carried out in the Keduang watershed. (2) In addition, soil conservation will be made by reinforcement of terrace risers and lips by covering with grasses. (3) Agro-forestry systems will be introduced for soil erosion control, improvement for agricultural productivity and transfers of agricultural productivity improvement and agricultural income sources to future generations. (4) Soil conservation based on the introduction of improved technology on water/soil conservation, appropriate cropping patterns, crop yield and soil management. (5) Furthermore, hedgerows and side ditches will be used for prevention of soil erosion from the fringe of the settlement areas. (6) Various support programs are included for smooth and effective performance of the project.

Most of the watershed projects in the Wonogiri dam watershed were conducted by introducing a top-down system, but it is said that these projects did not produce the benefits expected. (1) Basically, a community based bottom-up system will be adopted in this plan. The plan is that local people should participate from the planning stage to monitoring stage after implementation. Work of socialization will be carried out by NGOs, and governmental officers and consultants will assist with technical issues. (2) It is very important to guarantee the transparency of all the project activities including capital for smooth implementation of the project. For this purpose an implementation committee should be instituted. (3) Considering the low benefit in the short-term from the agriculture improvements in the project, proper incentives should be introduced for the beneficiaries. It is planned that materials and farm inputs necessary for the project will be entirely subsidized. About 50~75% of the all project works such as physical strengthening of terraces, and vegetative terrace reinforcement will be charged to the project and the remaining works will be performed by a voluntary work force of beneficiaries.

Details of the approach to the Keduang watershed conservation project are mostly the same as mentioned in subsection 9.2.2 in Part I: Master Plan Study.

5.2 Demarcation of Target Areas for the Watershed Conservation Project

5.2.1 Classification of Subject Area

The planned subject area for the Keduang watershed conservation project consists of lands consisting of uplands, uplands in the settlement area and the settlement areas.

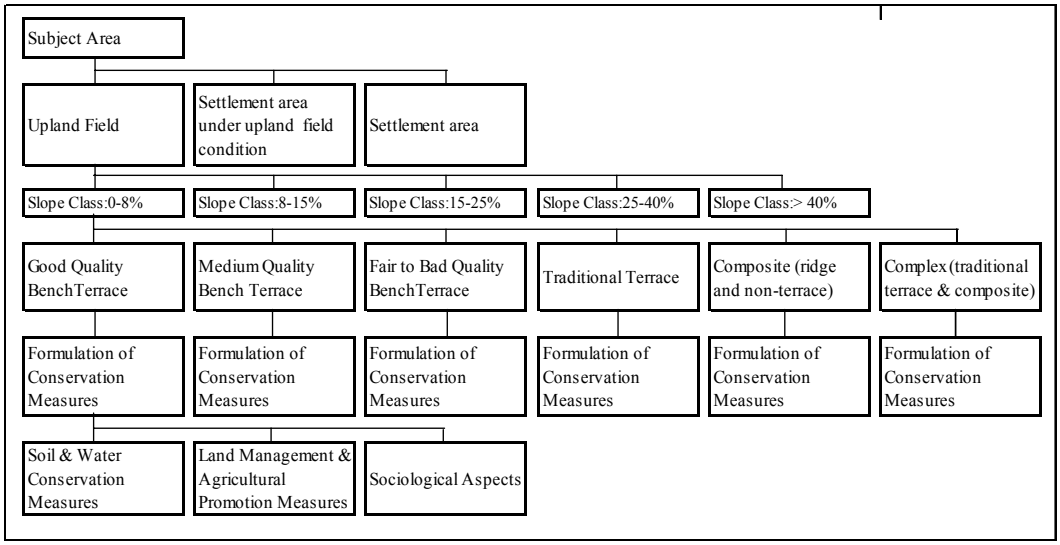
The factors of USLE that could be managed or mitigated through watershed conservation measures are P factor (land conservation factor) and C factor (vegetative/cultivation factor). Accordingly, for the formulation of the watershed conservation measures, the subject areas have been classified into sub-units (land units) in order to facilitate formulation of a conservation plan composed of soil/water conservation measures and agricultural measures. The land conservation factor, which could be the target for soil and water conservation measures, is the terrace type and its condition. The vegetative/cultivation factor, which could be the target under the agricultural measures, will be land use modification through agro-forestry development under the scope of the present study. The criteria applied for the classification of subject areas into land units in the present study are as follows:

Table 5.2.1 Classification Criteria of Subject Area

Factor	Classification Criteria	Code
Land Use	Upland Field	U
	Upland in the Settlement Area (Pekarangan*)	P
	Housing Yard**	H
Slope	0 - 8%	S1
	8 - 15 %	S2
	15 - 25 %	S3
	25 - 40 %	S4
	>40 %	S5
Terrace Type and Condition	Bench Terraced Land - Good quality bench terrace	T1
	- Medium quality bench terrace	T2
	- Fair to bad quality bench terrace	T3
	Traditional Terrace Land	T4
	Composite (mix of ridge and non-terrace)	T5
	Complex (traditional terrace and composite)	T6

Remarks; *: Settlement area under upland field condition **: Housing yard in settlement area
Source: JICA Study Team

The processes for the classification of subject areas into land units for watershed conservation are illustrated in the following figure.



Source: JICA Study Team

Figure 5.2.1 Classification of Subject Areas into Land Unit for Formulation of Watershed Conservation Countermeasures

Based on the classification criteria for the subject areas, coding of land units in the subject areas is shown in the following table:

Table 5.2.2 Coding of Land Units in Subject Areas

Terrace Type & Condition	Slope Class (%)				
	0-8	8-15	15-25	25-40	>40
Upland Field					
- Good Quality BT*	US1T1	US2T1	US3T1	US4T1	US5T1
- Medium Quality BT	US1T2	US2T2	US3T2	US4T2	US5T2
- Fair/Bad Quality BT	US1T3	US2T3	US3T3	US4T3	US5T3
- Traditional Terrace	US1T4	US2T4	US3T4	US4T4	US5T4
- Composite**	US1T5	US2T5	US3T5	US4T5	US5T5
Settlement area under Upland Field Condition					
- Complex (traditional terrace & composite)	PS1T6	PS2T6	PS3T6	PS4T6	PS5T6
Housing Yard	HS1	HS2	HS3	HS4	HS5

Remarks; *: BT = bench terrace **: Association of ridge & non-terrace
Source: JICA Study Team

The subject areas were classified into 35 land units in total based on 'Coding of Land Units' for watershed conservation.

5.2.2 Target Areas for Watershed Conservation Project

The target areas for the Keduang watershed (areas for Watershed Conservation project) were selected from the subject areas mentioned above based on the following procedures.

- The Keduang watershed conservation project is carried out with the people in the local community (village) as practitioners. The boundary map of villages in Keduang watershed was prepared based on the topographic maps on a scale of 1/25,000 made by BAKOSURTANAL. Village names and village areas were identified.
- All the information and data necessary for estimate of soil loss were collected and input to the GIS system that was made in this Study for watershed management.
- Annual average soil loss for each village within the Keduang watershed was calculated. Then the villages with area of more than 100 ha in area and/or annual average soil loss per ha of over 50 tons/ha/year, were screened for the Keduang

watershed conservation.

- For each of the villages screened above, the annual average soil loss for the three kinds of the area of upland field, settlement areas under upland field condition and settlement areas was calculated. Then the villages with a total annual average soil loss per ha from the three kinds of area of less than 50 ton/ha/year, were excluded from the target areas.
- The State Forest area in the Keduang watershed is excluded from the target subject areas in this watershed conservation project.

The target areas for watershed conservation in Keduang watershed are about 11,100 ha as shown below. The total number of selected villages in the Keduang watershed is 82. The number of villages based on Kecamatans is shown below.

Table 5.2.3 Selected Villages in Kecamatan

Name of Kecamatan	Number of villages selected
Girimarto	12
Jatipurono	11
Jatiroto	10
Jatisrno	15
Ngadirojo	6
Nguntoronadi	1
Sidoharjo	12
Slogohimo	14
Wonogiri	1
Total	**82**

Source: JICA Study Team

List of the selected villages and annual average soil loss and soil loss per ha are shown in Tables 4.6.2 and 4.6.3 in Section 4.6.4 in Supporting Report II Annex No.9.

Table 5.2.4 Target Area for Watershed Conservation for Keduang Watershed

Land use			Code of land	Area (ha)	Land use	Code of land	Area (ha)
Upland Field	Bench terrace	good	US1T1	0	Uplands in settlement area (complex)	PS1T6	1,520
			US2T1	0		PS2T6	1,765
			US3T1	0		PS3T6	1,039
			US4T1	0		PS4T6	394
			US5T1	0		PS5T6	365
			sub-total	0	sub-total		5,083
		medium	US1T2	0	Settlemt area	HS1	0
			US2T2	6		HS2	569
			US3T2	8		HS3	372
			US4T2	7		HS4	185
			US5T2	3		HS5	270
			sub-total	24	sub-total		1,396
		fair/poor	US1T3	0			
			US2T3	984			
			US3T3	1,027			
			US4T3	870			
			US5T3	1,392			
			sub-total	4,273			
	Traditional terrace		US1T4	3			
			US2T4	40			
			US3T4	33			
			US4T4	26			
			US5T4	71			
			sub-total	173			
	Composite (ridge and non terrace)		US1T5	1			
			US2T5	9			
			US3T5	31			
			US4T5	44			
			US5T5	82			
			sub-total	167	Total		11,116

Source: JICA Study Team

5.3 Proposed Watershed Conservation Plan

The proposed basic watershed conservation measures consist of: i) soil conservation measures of physical and vegetative measures, ii) agro-forestry development and iii) farming support programs. The target areas of the measures are upland fields, upland fields in settlement area and settlement area as discussed earlier. The basic directions applied, in the present proposed watershed conservation plan, for individual land units being classified by slope classes and current terrace type and condition are presented in Tables 4.3.1 and 4.3.2 in Supporting Report II Annex No.9 and briefly discussed in the following.

5.3.1 Soil Conservation Measures

For planning soil conservation measures the cost for the watershed conservation should be minimized and the project works should be easily carried out by beneficiaries of the project. The proposed soil conservation measures consist of physical measures of terrace improvement and construction works and side ditches in the settlement area, and vegetative measures for vegetating the terrace lip, riser and fringe of home settlement (housing yard) with grass or shrub for their stabilization as shown in the following table.

Rate of implementation of terrace improvement and terrace formation/upgrading works was planned for 100% of the total subject areas of less than 25% in steepness, 80% for the total subject areas of the terrace rehabilitation works with 25-40% in steepness and 60% for the subject areas with over 40% from the viewpoint of access conditions to the sites, difficulties of terrace construction due to deep roots of big trees, very steep topographic conditions, uncertain farmers` intention about terrace making, etc.

Implementation for settlement areas (housing yards) by planting shrubs at the fringe of village was planned as 60% of the total settlement areas.

Table 5.3.1 Proposed Soil Conservation Measures

Measures	Components
Physical Measures	Bench Terrace Improvement/Construction Works - Terrace bench improvement or construction - Terrace lip improvement - Terrace riser improvement Improvement of waterway & drop structure
	Improvement of side ditch in settlement
	Improvement of side ditches in the settlement area
Vegetative Measures	Lip stabilization (Bench terrace & ridge terrace) Riser stabilization Hedge row at fringe of housing yard

Source: JICA Study Team

The dimensions of standard designs for the major physical works are shown below:

Table 5.3.2 Dimension of Major Works

	Terracing				Drain	Lip	Riser	Drop
Land gradient (%)	Average gradient (%)	Height of a terrace (m)	Nr. of terrace (nr/ha)	Width of a terrace* (m)	Width of bench drain (m)	Width of a lip (m)	Slope length (m)	Height of drop (m)
0-8	4	0.6	6.67	14.99	0.25	0.20	0.63	0.6
8-15	12	0.7	17.14	5.83	0.25	0.20	0.73	0.7
15-25	20	0.8	25	4.00	0.25	0.20	0.84	0.8
25-40	33	1.0	33	3.03	0.25	0.20	1.04	1.0
>40	50	1.0	50	2.00	0.25	0.20	1.04	1.0
*: slope= 1:0.3								

	Waterway				Lateral drain of side ditch		Collector drain of side ditch	
Land gradient (%)	Catchment area (ha)	Height of drain (m)	Interval (m)	Nr. of drain (nr./100m)	Width of canal (m)	Interval (m)	Width of canal (m)	Interval (m)
0-8	4-5	0.2	75	1.33	-			
8-15	3-4	0.2	75	75	0.4	200	0.2	100
15-25	2-3	0.2	75	75	0.4	200	0.2	100
25-40	1-2	0.2	75	75	0.3	200	0.2	100
>40	0.5-1	0.2	75	75	0.3	200	0.2	100

Source: JICA Study Team

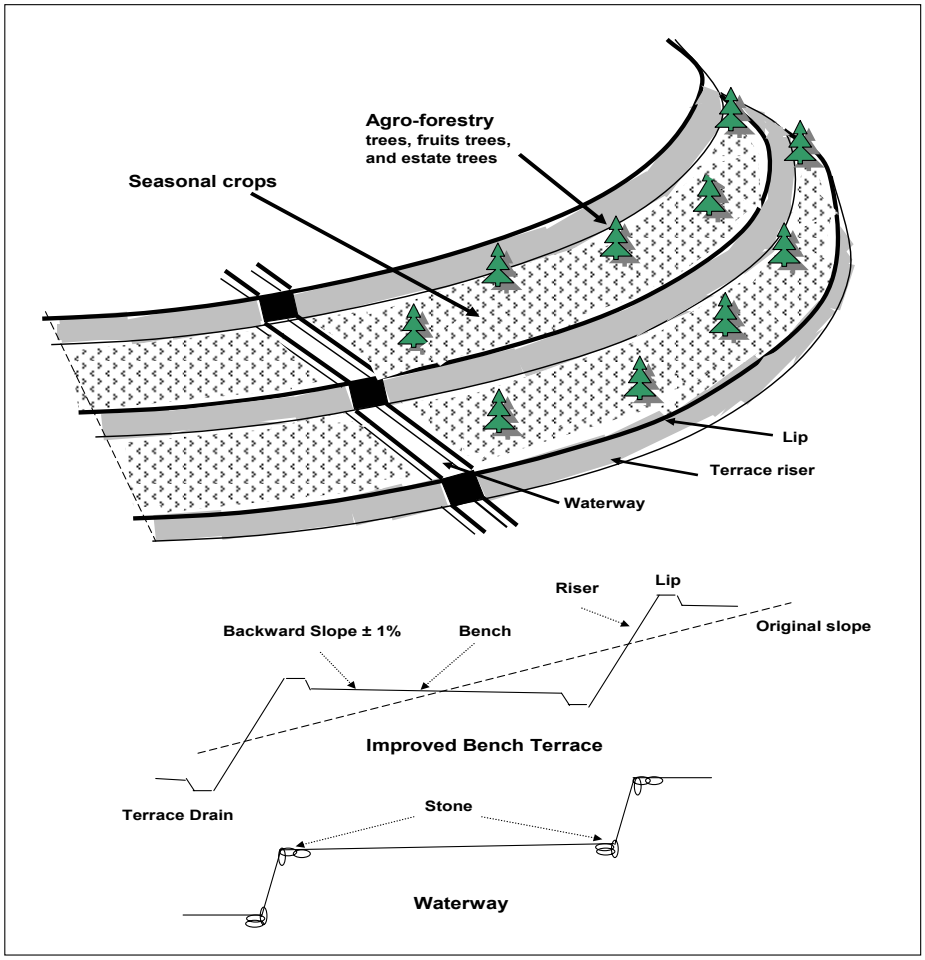
Aiming at accommodating such experiences into the formulation of the present study, vegetative measures in the past have been assessed. The criteria applied for the assessment include: i) degree of plant cover, ii) speed or easiness of establishment of vegetation, iii) economic use or value, and iv) field performances. Details of assessment are shown in Supporting Report II Annex No.9. The following table indicates the recommended varieties for stabilization of lips, risers and hedgerow at the fringe of housing yards.

Table 5.3.3 Basic Vegetative and Agro-forestry Measures in Improved Bench Terrace

Target Place	Vegetative Measures	Vegetation	Kinds/Species
Terrace Lip	Lip Stabilization	Grass	Elephant Grass, *Panicum muticum,* King Grass
		Shrub	Lamtoro, *Glyricideae speium, Flemingia congesta Roxb etc.*
Terrace Riser	Riser Stabilization	Grass	BB (*Brachiaria brizantha*), BD (*Brachiaria decumbens*), Local creeping grasses
Housing Yard*	Hedge row	Shrub	*Flemingia congesta Roxb etc.*

Remarks; *: Housing yard in home settlement
Source: JICA Study Team

The image of an improved bench terrace is illustrated as shown below.



Source: JICA Study Team

Figure 5.3.1 Image of Improved Bench Terrace

5.3.2 Agro-forestry Development

The agro-forestry development will be introduced into uplands and uplands in the settlement areas. The basic direction for the proposed agro-forestry development (proportions of annual crops and tree crops/trees) and slope classes has been studied considering the following issues:

- Sustainable soil and water conservation measures and agricultural productivity increase and diversification through the promotion of agro-forestry, and
- Mitigating labor burden in future farming activities through the expansion of fruit/estate crops cultivation to meet gradual aging of farming communities and tendency for seeking non-farm job opportunities of next generation.

The direction set for the proposed land use depending on slope classes of areas is as shown in the following table. Rate of introduction of perennial crops/trees are realistically determined taking into consideration farmer's interview. 50% of the figure proposed by the Government of Indonesia was taken.

Table 5.3.4 Slope Classes and Agro-forestry Development

Slope Class	Proposed Land Use		Agro-forestry Features
	Annual Crops	Perennial Crops/Trees	
0 - 8%	95%	5%	Mixture of tree crops & trees depending on farmers preference
8 - 15 %	87.5%	12.5%	
15 - 25 %	75%	25%	Mixture of tree crops & trees under grown with medical crops etc.
25 % - 40 %	62.5%	37.5%	
> 40 %	50%	50%	

Source: JICA Study Team

Selection of crops/trees to be introduced in the agro-forestry development was made principally based on the assessment that Wonogiri Agricultural Services Office made on the adaptability of trees and perennial crops (fruits and estate crops) for the project kecamatans. Details of assessment study are shown in Supporting Report II Annex No.9.

The recommended trees and perennial/estate crops for the agro-forestry development are teaks, Sonokeling, Merkusi pine, Mahogany, Eucalyptus, Sengon, Bamboo, Mango, Durian, Rambutan, Cashew nut, Clove, Cacao, Mlingo, Citrus and so on.

Furthermore, inter-cropping with medicinal crops such as Turmeric, Ginger, etc will be introduced into the agro-forestry areas where the slope steepness is over 15% in order to increase farm income.

5.3.3 Farming for Vegetative Measures

Basic farming for vegetative and agro-forestry measures is principally based on the data from Pola Penanganan Erosi dan Sedimentasi Dengan Pembangunan Hutan Rakyat Kabupaten Wonogiri, 2005[1] and details are presented in Table 4.3.10 in Supporting Report II Annex No.9.

5.4 Support Program for Promoting Watershed Conservation Projects in Keduang Watershed

5.4.1 Support Program for Promoting Watershed Conservation Projects

The proposed soil and water conservation measures are approaches having direct and immediate effect on soil conservation and support programs for practitioner farmers should be included to ensure these benefits are realized. The proposed support programs include: i) empowerment of beneficiary farmers and farmer groups and ii) support programs for operation/implementation of conservation measures. In addition, the empowerment of field staff providing technical guidance and support to farmers and farmer groups is an essential initial and periodic step to be taken for the efficient and successful implementation of the measures. The program description is shown in Table 4.4.1 in Supporting Report II Annex No.9.

(1) Farmers and Farmer Groups Empowerment Package Program

The package program aims at formation and empowerment of farmer groups by supporting the formation of beneficiary farmer groups and providing technical guidance to farmers and farmer groups as a preparatory stage for the implementation of the conservation measures. Accordingly, the program is composed of: i) a farmer group

[1] Study report prepared by Faculty of Forestry, Gajah Mada University & LHKP, Wonogir

formation program and ii) a farmer group empowerment program. In addition, a needs assessment of target farmers should be made for the formulation of a definite plan for conservation measures as follows:

Farmer Group Formation Program

- Farmer group formation (socialization/workshop and support for formation)

Farmer Group Empowerment Program

- Key Farmer Training
- Conservation demonstration activities operated by Key Farmer
- Mass guidance on conservation measures to all members of farmer groups (farmer field day at demonstration site)
- Needs inventory of individual farmers for grasses, tree crops and trees to be introduced in the proposed measures

(2) Package Program for Operation/Implementation of Conservation Measures

The package program aims at providing technical and financial support for beneficiary farmers or practitioners and consists of: i) Terrace Formation Guidance Program, ii) Agro-forestry Development Program and iii) Field Guidance Program as follows:

Terrace Formation Guidance Program

- Technical guidance on proposed soil and water conservation measures
- Support package for provision of grasses/trees for terrace stabilization,
- Labor cost subsidy for physical measures (terrace improvement/ formation/upgrading works)

Agro-forestry Development Program

- Technical guidance on agro-forestry development
- Provision of support package (seedlings and farm inputs) for agro-forestry development envisaged in the proposed measures

Farming Support Program

- Technical guidance on farming system improvement
- Provision of soil ameliorant and farm inputs

Field Guidance Program

- Inception technical guidance and support to beneficiary farmers and farmer groups
- Follow-up technical guidance and support

(3) Field Staff Empowerment Program

The program is to provide induction and periodic refresher training or technical guidance for field staff involved in the implementation of the proposed measures as explained in Table 4.4.1 in Supporting Report II Annex No.9.

5.4.2 Support Programs for Land Management & Agricultural Promotion

The support programs are formulated with the aim of strengthening of extension activities for land management and agricultural promotion and consist of: i) Technology Development Program, ii) Demonstration Program, iii) Establishment of pilot demonstration field of tree crops and trees, iv) Farmer and Farmer Group Training

Program, v) Palawija Seed Production Program, vi) Livestock Promotion Program and vii) Strengthening of Logistics Support for Extension Activities as shown in Table 4.4.1 in Supporting Report II Annex No.9.

Technology Development Program

- Research–extension dialog team
- Sample trial and adaptability trial

Demonstration Program

- Demonstration plot for improved farming
- Cropping pattern demonstration for improved cropping patterns

Pilot Demonstration Field of tree Crops/trees

- Village operated demonstration activity on agro-forestry development under guidance of technical and research agencies

Farmer and Farmer Group Training Program

- Farmer and farmer group training program
- Mass Guidance/Campaign/workshops

Palawija Seed Production Program

- Palawija seed production program
- Seed campaign

Strengthning of Logistics Support for Extension Activities

- Kecamatan level
- District level

5.4.3 Support Programs for Community Development

The support programs are formulated aiming at empowerment of village people and organizations. The support programs consist of: i)Village Action Plan (VAP) for soil conservation ii) Establishment of implementation committee, iii) Guidance of village grant fund,, and iv) Education program on watershed conservation and as shown in Table 4.4.2 in Supporting Report II Annex No.9.

(1) Village Action Plan (VAP) for soil conservation

Implementation of village assessment

Formulation of VAP

- Formulation of draft VAP
- Discussion with executing agency
- Finalization MOU for VAP
- Conclusion of MOU for VAP

(2) Establishment of Implementation Committee

Election of Committee member

(3) Guidance for Village Grant Fund

Formulation of Fund Use Plan

- Explanation of guideline

- Formulation of draft plan
- Consensus building

Agreement with Executing Agency

-Conclusion of agreement for the fund

Operation the Fund

- Provision of fund
- Follow-up technical guidance and support

(4) Education Program

Preparation Materials

Implementation of Special Lecture and Campaign

The outlines of the village grant fund and education program on watershed conservation are shown in Table 4.4.3 and Table 4.4.4 in Supporting Report II Annex No.9.

5.5 Project Works

The project works for the Keduang watershed conservation project are shown in the following table. Project works will be performed by introduction of the farmer participation system. Works such as cutting/filling, excavation, masonry and vegetation planting will be shared by the Government and beneficiaries of the project. All the materials necessary for the project such as farm inputs and construction material will be purchased by the Government.

Table 5.5.1 Project Works for Keduang Watershed Conservation Project

Items		Total Project Work	Share of Project Works	
			Government	Beneficiary
1. Land preparation				
1) Terracing	unit:			
(1) Cutting and filling	1,000m^3	6,231	4,673	1,558
2) Waterway and drop				
(1) stone material	1,000m^3	59	44	15
(2) Excavation	1,000m^3	83	62	21
(3) Masonry work	1,000m^3	53	40	13
3) Lip and rizer, planting				
(1) Seedling, grass for lip	1,000nr.	838,585	838,585	0
(2) Seedling, shrub for lip	1,000nr.	5,032	5,032	0
(3) Seedling, grass, for rizer	1,000nr.	115,938	115,938	0
(4) Planting work, for lip	1,000m	50,316	25,158	25,158
(5) Planting work, for rizer	1,000m2	46,376	23,188	23,188
2. Side diches (for housing yard)				
1) Side ditch				
(1) Stone material	1,000m^3	26,667	20,000	6,667
(2) Excavation	1,000m^3	38,667	29,000	9,667
(3) Masonry work	1,000m^3	24,000	18,000	6,000
2) Headgerow				
(1) Shrub, for hedger row	1,000nr.	4,467	4,467	0
(2) planting work, hedge ro	1,000m2	11,160	558	558
3. Agro-forestry and annual crops				
1) Agro-forestry and annual crops	Ls	Ls	Ls	-
4. Support program	Ls	Ls	Ls	-
1) Support program				

Source: JICA Study Team

5.6 Reduction of Soil Loss

The project works for the watershed conservation project consist of i) terrace improvement works, ii) terrace formation/upgrading works, iii) Agro-forestry development works, iv) farming support programs, v) hedge row works, vi) side ditch construction works, and vii) other support programs for land management and agricultural promotion. After implementation of the project, all the present upland fields consisting of upland field with bench terrace, traditional terrace area, upland field with composite and settlement area under upland field condition will become upland field with improved bench terrace. Agro-forestry development will be made in some of the improved terrace lands. Except for the settlement areas, soil amelioration will be carried out under the farming support program. Hedgerow works and construction of side ditches will be provided for some settlement areas.

Reduction of soil loss in the Keduang watershed is expected after implementation of the watershed conservation projects. The water conservation projects will be carried out about for 11,100 ha of the target area as mentioned in section 4.2.2. The soil loss in the Keduang watershed after implementation of the watershed conservation projects is estimated by USLE.

The parameters used for calculation of soil loss after implementation of the project are shown below:

Table 5.6.1 Parameters Used for Estimation of Soil Loss after Implementation of Projects

Parameters		Parameters	
K factor		**P factor**	
(1) Mediteran soil	0.31	(1) Orchard/plantation	0.4
(2) Grumusols	0.48	(2) Bench terrace	
(3) Latosol	0.32	(i) good quality	0.04
(4)Lithosols	0.015	(ii) medium quality	0.2
L factor		(iii) fair/poor quality	0.4
(1) Upland field, Paddy field, Orchard/plantation, upland field in settlement area		(3) Composite (non treatment and ridge)	0.8
(1) Class of slope: <8%	8m	(4) Uplands in settlement area	0.65
(2) Class of slope:8-15%	8m	(5) Terrace of paddy field	0.02
(3) Class of slope : 15-25%	4m	(6)Forest	1
(4) Class of slope: 25-40%	3m	(7) Home settlement area	0.8
(5) Class of slope: >40%	2m	(8) Bare land	1
(2) Other land use	50m	**Rate of implementation of terrace works**	
C factor		Class of slope: <8%	100%
(1) Paddy field	0.05	Class of slope: 8-15%	100%
(2) Home settlement area	0.1	Class of slope : 15-25%	100%
(3) Uplands in settlement area	0.7	Class of slope: 25-40%	80%
(4) Upland		Class of slope: >40%	60%
		Rate of reforestation in state forest	90%
(i) MT-1	0.6	**Rate of agro forest in terrace lands**	5-50%
(ii) MT-II	0.45	**Rate of implementation of planting shrub at fringe of villages in settlement area and constructing side ditches in settlement area**	60%
(iii) MT-III	1		
(ii) MT-II	0.45		
(5) Grassland, Bush land	0.02		
(6) Forest	0.01		
(7)Orchard/plantation	0.3		
(8) Bare land	1		
Water body	0		

Source: JICA Study Team

Based on the above parameters, the annual average soil loss in the entire Keduang

watershed is estimated and shown in the following tables. After the implementation of the projects, it is estimated that the soil loss will be reduced about 1.8 million tons from the Keduang watershed as shown in the following tables:

Table 5.6.2 Reduction of Annual Average Soil Loss in Keduang Watershed

Land Categories	Annual Average Soil Loss (1,000 ton)		Reduction of Annual Average Soil Loss (1,000 tons)
	Present condition	After implementation	
(1) Paddy field	11	11	0
(2) Settlement area			
(i) Home settlement area	957	849	108
(ii)Uplands in settlement area	1,698	803	895
(3) Uplands	1,465	751	714
(4) Orchard and Plantation	363	363	0
(5) Forest	11	11	0
(6) State forest land*			
(i) forest land	5	5	0
(ii) other land use	264	176*	88
(7) Other land use	4	4	0
Total	**4,778**	**2,973**	**1,805**

Note: In this feasibility study, a detailed land use survey was carried out for the Keduang River basin. The accuracy of current land use has been increased compared to that in the master plan stage. Therefore, the estimated average soil loss in this table is different from that in Table 9.3.12 which was estimated in the master plan stage.
Remarks: *:This annual average soil loss is estimated and assumes that 90% of the other land use in the state forest land will be reforested.
Source: JICA Study Team

Details on annual average soil loss and annual average soil loss /ha for the entire Keduang watershed after implementation of project on the villages are shown in Supporting Report II Annex No.9.

Details on annual average soil loss and annual soil loss /ha at a village level under present conditions and after implementation of the project at the villages are illustrated in Supporting Report II Annex No.9.

It may be concluded from the above table that 38% (=1,805/4,778) of the total annual average soil loss at present is trapped or reduced after implementation of the project.

CHAPTER 6 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

6.1 Introduction

The main purposes of EIA Study are:

i) To grasp the current environmental conditions in detail in and around the anticipated impact affected areas,
ii) To predict and evaluate environmental and social impacts to be caused by the implementation of the Project (urgent countermeasures),
iii) To disclose the anticipated impacts as the results of EIA Study to the stakeholders to understand the impacts as well as the benefits of the Project, and
iv) To establish environmental management plan and monitoring plan to mitigate the anticipated negative impacts in order to make the Project sustainable.

This EIA Study is not exactly identical with, or does not follow the required procedures of AMDAL in Indonesia. However, the methodology and scope of this EIA study is basically the same as those of AMDAL system, and therefore the study results can be utilized for preparation of AMDAL documents at the implementation of the Project.

6.2 Project Description

6.2.1 Target Project Components

The targeted project components subject to EIA are the priority activities proposed as urgent countermeasures in the Master Plan (the Project). The priority activities are:

a. Sediment Storage Reservoir with New Gates, to pass through and flush out the sediment inflow as well as sediment deposits and garbage from the Keduang River,

b. Watershed Conservation in the Keduang catchment, to mitigate sediment yield in the catchment and thereby reduce sediment inflow into the reservoir, and

c. Periodic Maintenance Dredging at the existing Intake, to avoid blocking due to sediment deposits and garbage.

Table 6.2.1 briefs the outline of the Project:

Table 6.2.1 Outline of Priority Project Components

Components	Structure / Works	Dimension / Details
a. Sediment Storage Reservoir	Spillway with gate	Spillway: L=720m, B=15m, Gate: Two units of radial gate, B=7.5m, H=7.5m
	Closure dike	Embankment (earthfill with sheet pile): L=650m, H=12m (max), and B=10m (crown)
	Overflow dike	Weir: L=250m, B=6m (crown), crest level=136m, Access road: approx. L=1,000 m, B=10 m
b. Watershed conservation in Keduang catchment	Terracing	Nos. of selected villages: 82 Target area : approximately 11,000 ha
	Agro-forestry	Mixture of tree crops and trees, medical crops depending on slope of target area
	Supporting program	Empowerment of beneficiary farmers and farmer groups, support programs for operation/ implementation of conservation measure
c. Periodic maintenance dredging at intake	Procurement of equipment	Cutter-suction dredger: 600PS, one (1) unit
	Periodic dredging	Dredging operation

Source: JICA Study Team

6.2.2 Operation of Sediment Storage Reservoir

Operation rule of sediment storage reservoir is to be fixed through repeated trial and monitoring after the completion in terms of effectiveness of sediment releasing, environmental impact, etc. Table 6.2.2 shows the tentative operation method conceived in this Study. The general operation of the sediment storage reservoir is illustrated in Figure 10.3.2

Table 6.2.2 Tentative Operation Method of Sediment Storage Reservoir

Period	New gate	Water storage / sediment releasing	Water level
Wet season			
1) Beginning of wet season	Closed	Highly turbid water from the Keduang River basin flows into sediment storage reservoir.	Water level will rises over EL. 136 m and freely overflow to the main reservoir.
2) Mid and late wet season until April 15th.	Open	Highly turbid water from Keduang River basin is drained through the new gate	Basically less than 136 m.
Dry Season			
From April 15th to end of dry season	Closed	The stored water is to be drained through a connecting conduit into the main reservoir depending on water level.	The stored water in the main reservoir is to be used for power generation and irrigation water supply.

Source: JICA Study Team

6.3 Existing Environment

6.3.1 Physical Components

(1) Groundwater

In villages of Petir, Pokoh and Karangtalun, which are the residential areas near the sediment storage reservoir facilities, groundwater is taken from wells for domestic use (cooking, drinking and bathing)l, plant watering and livestock husbandry. But at the same time, PDAM, or municipality water supply company, covers this area.

The observed average groundwater elevation varied from 126.57m to 133.71m in September, 2006, and from 125.40m to 131.70m in December, 2006. These elevations of ground water table are higher than designed bottom elevation (119.8 – 125.0 m) of the spillway facilities.

(2) Air quality, noise and vibration

The observed concentration of air quality parameters was far below the environmental standard stipulated by Governor's Decree of Central Java Province No. 8/2001 regarding Ambient Air Quality Standard.

Regarding ambient noise, noise level at nearby villages exceeded the Environmental Standard of ambient noise for housing and residential area (55dB(A)) stipulated by the Decree of State Minister of Environment No. 48/MENLH/11/1996 regarding Noise Level Standard.

Measurement results indicated that ambient vibration level was below the convenience and health level stipulated by the Decree of State Minister of Environment No. 49/MENLH/11/1996 regarding Vibration Level Standard.

(3) Downstream river environment

Survey on river channel and river water use in the downstream reach of the Bengawan Solo River was conducted concerning sand mining, inland navigation, water use for water supply and irrigation, and fishery.

There are three types of sand mining activity in terms of mining method: i) motor pump, ii) boat or raft and iii) manual tools. Sand mining is mainly done during dry season, but sand mining by motor pump can be conducted also during wet season. Locations of sand mining activity spread along the river reaches from Wonogiri reservoir until the confluence with the Madiun River.

At present, there are 10 navigation routes in operation crossing the Bengawan Solo River until the confluence with the Madiun River. Inland navigation on the Bengawan Solo River is usually done all through the year. During flooding in wet season, however, it cannot be operated because of safety reason.

The water of the Bengawan Solo River is used as a source of drinking water at PDAM (water supply campany) of Wonogiri and Jurug. The two PDAM take water by submerged water pump with a capacity of 60 l/s. and 100 l/s, respectively.

There is the Colo weir on the Bengawan Solo River 14 km downstream of Wonogiri dam, where two (2) irrigation canals, the East Canal and West Canal, convey irrigation water for 27,740 ha of paddy field.

Inland fishery is conducted on the Bengawan Solo River. The fish species for fishing include: Bader (*Cyclocheilichthys enoplos*), Jambal (*Pangasius nasutus*), Betutu (*Oxyeleotris marmorata*), Nila (*Oreochromis niloticus*), Sogo (*Mystus nemurus*), Kutuk (*Channa striata*), Udang (*Macrobrachium sp.* / P*alaemon sp.*). According to the interview survey with local fishermen in the river, fishing is not a main job but they work as laborer at construction site.

6.3.2 Biological Components

(1) Terrestrial Flora and Fauna

As a result of inventory surveys in October (dry season) 2006 and January (wet season) 2007, 220 wild plants and 48 cultivation crops were identified by line census method. Of all the plant species, there was no protected species designated by the Government Regulation No. 7/1999 regarding Conservation of Plant and Animal Species.

As a result of inventory survey, five species of mammals, 21 species of wild birds, two species of reptile and amphibian and 19 species of insects were identified. Of all the fauna species, there was no Protected Species designated by the Regulation above.

(2) Aquatic organisms

The number of inventoried macro-benthos is nine in total, of which *Margaritiferidae, Sphaeriidae* and *Thiaridae* are dominant and identified to habit at every sampling station.

Fourteen (14) fish species were identified by the field inventory. All of inventoried fish species are commonly found in the waters in Indonesia and none of species is listed as protected ones designated by the Regulation above. According to interview survey, it was found that 32 fish species were caught in the river last year, of which dominant family is Cyprinidae (consisting of 11 species), Cichlidae (4species), Pangasidae (3 species), Bagridae (3 species) and Ospronemidae (2 species).

Most of Cypinidae species are herbivorous feeding phytoplankton, plant, algae, root of plant, or omnivorous which can also feed zoo benthos, worm, insect, detritus. Family of Cyprinidae spawns in the wet season, especially in early wet season when water level begin to rise although some species can spawn throughout the wet season such as *Hampala sp.* On the other hand, fish species of Pangasidae, Bagridae family spawns in dry season.

(3) Protected species

The IEE survey revealed that five (5) species of protected species of mammal and four (4) of birds are identified to inhabit in Wonogiri reservoir basin. According to field inventory, none of protected species was identified. But according to interview survey, the nest of Porcupine (*Hystrix brachyura*) was identified in Desa Jendi, Kecamatan Girimarto, which is located in the Keduang River basin where watershed conservation is proposed.

6.3.3 Socio-economic Components

(1) Socio-economy

Farmer is the majority (85%) in the Study area, followed by laborers (5%), office workers (3%) and fishermen (3%). Most of people have two types of occupation: primary occupation and secondary one.

The average area of lands owned by local people is 0.59 ha. In upland fields, the products of *palawija* crops, e.g., maize and cassava, are dominant. Average income of local people is estimated to be Rp. 7.265 million / year, or Rp. 605,000/month. Assuming the average family size as 4.5 persons, per capita income is Rp. 1.614 million / year, which is equivalent to 428 kg of rice (as a price of rice is Rp. 3,600/kg.) and is categorized as "poor people (<480 kg of rice)" based on the criteria of Sayogya (1978).

Local people often use vacant lands in the premise of Wonogiri reservoir area belonging to the government for their recreational and education activities, including:

- Football and valley ball,
- Boyscout training, and
- Motocross.

Among these activities, the event of motocross is not to be continued because it is often criticized by nearby residents due to noise problem.

(2) Socio-culture

Most of the local people (73%) agree to the Project activities to release sediment deposits in the reservoir to the Bengawan Solo River while there is a few people (4%) who disagree to the Project and feel worry since they believe that sediment releasing may be harmful for the paddy field and fish in the river.

One of the people's need/hope is to get detailed information about the project activities. Many people expect the socialization of the Project activities prior to its commencement and recruitment of them for the Project, especially of farmers who do not have fields or the unemployed.

Most of inhabitants (more than 62.5%) are in a low level of education as they do not graduated from any of school or only from elementary school.

Based on the in-depth interview, it was revealed that no conflict which arouses a violence has occurred in the Study area, which indicates that this area is a rather peaceful and

moderate environment.

There are several traditional customs in Central Java Province. *Kungkum* is an activity to sit periodically in a river for a certain hours to have heart contemplation. The Bengagawan Solo River is one of the target rivers.

6.4 Environmental Impact and Evaluation

6.4.1 Impacts on Physical Components

(1) Impacts on groundwater

The possible impact is drawdown of groundwater level due to the excavation for construction of spillway and as a consequence, the inconvenience of well water use. The elevation of groundwater (in domestic well) at the nearest village (Dusun Petir) ranged from 118.14 to 130.94 m while the elevation of bottom of spillway is planned to range from 125.0 to 119.8m. The distance between the spillway and the nearest house (well) is about 50 m, and therefore the drawdown of groundwater might cause inconvenience of the wells in the nearest village. **This impact is evaluated to be negative but not significant** because the alternative water supply system (PDAM) is available in the village.

(2) Impacts on air quality, noise and vibration

1) Air quality

An analogous study (measurement of air quality) was conducted at the site of sand mining project with an activity of excavation for the reference of impact prediction. The measurement result of the case study indicated that concentration of NO_2, SO_2, CO, Dust (TPS) and Hydrocarbon will increase in the vicinity of construction site, namely the excavation for spillway. As for Dust, it is predicted that its concentration will exceed environmental standard (230 $\mu gr/Nm^3$), especially in dry season. Accordingly, **the impact is evaluated to be negative and significant.**

2) Noise

An analogous case study was conducted and the measurement of noise level near the mining project indicated that the noise level at a distance of 15 m from the noise source would be higher than 70 dB. In addition, using mathematical model, theoretical propagation equation from point source, noise level was calculated, indicating that noise from construction work would be more than 70 dB at peak level. **This impact, therefore, is evaluated to be negative and significant.**

3) Vibration

Similar to noise level, an analogous case study was conducted and the measurement of vibration near the mining project indicated that the vibration at a distance of 10 m from the vibration source, or mining activity, exceeded the vibration standard level. In addition, using mathematical model, theoretical propagation equation from point source, vibration level was calculated. The result says that vibration from construction work would be more than 60 dB at peak level. Accordingly, **the impact is evaluated to be negative and significant.**

Regarding these impacts of air quality, noise and vibration, however, the impacts can be mitigated by appropriate countermeasures. The dust to be generated by earth works can be minimized by watering on excavation sites and roads for transportation and by covering sheet to prevent from scattering. Noise can be

mitigated by establishment of a noise insulation wall and vibration can be mitigated by establishment of trench in-between vibration source and residential area (impact receiver) when necessary. Introduction of low-noise construction machines would also be effective to mitigate noise problem. Therefore, these negative impacts during construction stage are not evaluated to be serious ones.

(3) Water quality

According to the SS simulation in case of with Project (W/ Project) and without Project (W/O Project), the following results were obtained (refer to Table 6.4.1):

At the beginning of wet season, SS concentration at Bengawan Solo River is higher in case of W/O Project because the highly turbid water from Keduang River directly reaches to the existing intake, some portion of which is released to the Bengawan Solo River through power generation. Under W/ Project, on the contrary, highly turbid water from Keduang River is retained in the sediment storage reservoir and not released to the river because the new gate is not opened yet.

After commencement of sediment releasing in mid and late wet season, highly turbid water (more or less 12,000 mg/l at maximum) is released , which increases SS in Bengawan Solo River. Comparing SS concentration in the two cases, SS concentration under W/O Project is higher, with concentration of more than 15,000 mg/l.

Table 6.4.1 Comparison of SS Concentration under W/ or W/O Project Cases

Item	At the beginning of wet season	Mid and late period of wet season
Sediment releasing	Not yet commenced	Commenced
SS concentration	W/ Project < W/ O Project (> 15,000 mg/l)	W/ O Project < W/ Project (approx. 12,000 mg/l)

JICA: Study Team

Based on these results, it was concluded that sediment releasing would bring about high turbidity in Bengawan Solo River, but its magnitude is within ordinary condition under W/O Project. **Accordingly, the impact on water quality (SS concentration) in downstream of Bengawan Solo River is evaluated to be negative but not significant.**

6.4.2 Impacts on Biological Components

(1) Impacts on terrestrial flora and fauna

The possible impact on terrestrial flora is decrease of individuals of flora species due to clearance of vegetation with an area of approximately 3.4 ha, for preparation of project site, including spillway, forebay, overflow dike and its access roads. Responding to this site clearance, habitats for terrestrial fauna will be disturbed, especially that of birds inhabiting around the Wonogiri reservoir. The impact magnitude of site clearance, however, is predicted to be minor considering relative areas of site clearance within the whole basin of Keduang River (approx. 42,100 ha).

Regarding impact of watershed conservation of Kedang River basin, it is not anticipated to cause any significant negative impacts in terms of decrease of vegetation or habitat disturbance of terrestrial fauna. The project components (activities) of watershed conservation include (1) terrace works (improvement and construction) including construction of side ditches and vegetative measures, (2) agro-forestry development, and (3) support programs for promoting watershed conservation.

Terrace works are aimed to mitigate soil erosion at upland field, upland in the settlement

area and housing yard. Terrace works will include alteration of farm land and the total amount of earth works will be large but the modification of landform at each farm land is minor. The reduction of soil erosion will be synergized by construction of side ditches and vegetative measures. Accordingly, it is predicted that terrace works will not cause any significant negative impacts on topography, terrestrial flora and fauna but are anticipated to bring about positive impact.

Agro-forestry development is planned to achieve sustainable soil and water conservation and improvement of agricultural productivity by the introduction of mixture of tree crops and trees depending on the slope of upland fields. It may, therefore, not cause any negative impact on terrestrial flora and fauna. The potential impact is on the social unrest and conflict for the introduction of the new agricultural technology. However, this potential negative impact can be mitigated by the supporting programs which is the third component of watershed conservation. The negative impact on social unrest and conflict will be described in Section 6.4.3.

Consequently, **impact on terrestrial flora and fauna is evaluated to be negative but not significant.**

(2) Impact on aquatic organisms

The possible impact on aquatic organisms is death / injury of fish due to respiratory problem to be caused by high concentration of SS during sediment releasing. The simulation result of SS concentration during sediment releasing indicated that predicted SS concentration will be confined below that of ordinary flooding period under without Project condition (refer to (3) Water quality, Sub-section 6.4.1 Impacts on Physical Components). Accordingly, **the impact on aquatic organisms is evaluated to be negative but not significant.** However, impact on fish is not only caused by increase of SS concentration but also other parameters of water quality, mainly DO. Thus, there is still unclear part to evaluate the impact on fish.

(3) Impact on protected species

One species of mammal, Porcupine (*Hystrix brachyura*), was identified to inhabit in Keduang River basin in Desa Jendi, which is included as part of watershed conservation. Watershed conservation, however, does not cause any disturbance of habitat of mammals, but it will bring about planting and facilitate agro-forestry, which will result in improving vegetation. **Thus, it is evaluated that no impact will be brought about on the protected species.**

6.4.3 Impacts on Socio-economic Components

(1) Land acquisition and resettlement

In this Project, land acquisition is basically not required for procuring the land for Project facilities, although some areas (private lands) in the vicinity of the Project facilities would be temporary utilized for construction works. All of the proposed facilities and spoil bank area is located within the premise of Wonogiri reservoir area, which is owned by Indonesian Government. Accordingly, resettlement of existing residents is not required. The temporary land utilization is to be carried out in land lease with adequate compensation. Accordingly, **there will be no impact of land acquisition or resettlement.**

(2) People's unrest and conflict/opposition

People's unrest would generate when a socialization of Project to local people is implemented. Local people who would have unrest are:

- People around the reservoir who often use tidal low land area (the area between normal high water level and low water level) and green belt for farming.
- People who often use some areas around the Wonogiri dam for football, valley ball, boyscout, motocross, etc.

However, these people know the land for these activities is owned by Government.

In addition to these two points, farmers in the Keduang watershed will have social unrest and conflict when they are instructed to accommodate agro-forestry development as a project activity for watershed conservation. This negative impact, however, can be mitigated by the supporting programs, which include empowerment of farmers and farmer groups through technical guidance on agro-forestry development. According to the support program, through the intensive training and dissemination, the social unrest and conflict can be minimized.

Consequently, **the impact of social unrest and conflict/opposition is evaluated to be negative but not significant.**

(3) Job opportunity

It is necessary to procure about 230 workers per day for construction of sediment storage reservoir. Of which 120 people are common worker, who should be hired from villagers. The recruitment of local people may brought about increase of income, which may result in improving livelihood. **The impact of increase of job opportunity is evaluated to be positive and significant.**

(4) Livelihood change

The possible impact on livelihood change is that cultivating land within the premise of reservoir area is to be used for the Project site. The use of cultivated land would cause decrease of agricultural production and income. However, most of the cultivated land to be affected is located in green belt and/or tidal low land area, and is not owned by local people but by the Government. The local people know the land ownership, and they are to be hired as construction worker by the Project. Consequently, **the impact of use of cultivated land on livelihood of farmers is evaluated to be negative but not significant.**

(5) Economic activities of downstream area

Impacts on downstream river environment were conducted for 1) sand mining, 2) inland navigation, 3) water use for PDAM, 4) water use for irrigation, and 5) fishery.

1) Sand mining

Taking into account the timing of sediment releasing which is to be conducted in wet season, no impact will occur on sand mining by boat or raft and manual tools because these are not done in wet season. Regarding the sand mining by motor pump, however, it might be needed to temporarily stop the mining activity for safety reason because increased discharge (400 m3/s at maximum) will be released through the new gate during sediment releasing. **This impact is evaluated to be negative but not significant.**

2) Inland navigation

The sediment releasing from sediment storage reservoir is proposed to be done

during wet season. But it is not limited only during flooding period. Accordingly, if the sediment releasing is conducted when inland navigation is in operation, it might bring about large volume of water in the Bengawan Solo River and the inland navigation has to be stopped temporarily because of the safety reason. **This impact is evaluated to be negative but not significant.**

3) Water use for PDAM

There are two (2) intakes of PDAM (Wonogiri and Jurug) on the Bengawan Solo River between the river reach from Wonogiri dam and the confluence with the Madiun River. Although SS concentration of Bengawan Solo River at downstream reaches will increase during sediment releasing, the impact of it on water intake by PDAM is predicted to be minimal, because predicted SS concentration, which is less than approx. 6,000 mg/l, is within the level that often occurs during the ordinary flooding period. **This impact is evaluated to be negative but not significant.**

4) Water use for irrigation

The total water release from Wonogiri reservoir will basically not change even after the sediment storage reservoir is constructed. Accordingly, no impact will occur on water use for irrigation at Colo weir.

Regarding the possibility of sedimentation at the Colo weir and irrigation canal, more than 90 % of sediment to be released by releasing is wash load materials, suggesting almost all of released sediment will pass through the Colo weir to downstream. It is recommended, however, that intake gates of irrigation canals should be closed during the sediment releasing. According to this countermeasure, **the impact of sedimentation in Colo weir and irrigation canals is evaluated to be negative but not significant.**

5) Fishery

Possible impact is the death of fish or injury due to the respiratory problem of fish caused by high concentration of SS, which might cause decrease of fish for fish catching. However, as described is (2) Impacts on aquatic organisms, Sub-section 6.4.2 Impacts on Biological Components, the impact of sediment releasing on fish in the Bengawan Solo River is not predicted to be significant. Accordingly, **the impact on fishing activity in the Bengawan Solo River is basically evaluated to be negative but not significant.**

In order to secure the evaluation result, the following data collection and monitoring are required in the next stage, i.e., AMDAL procedures:

- Characteristics (tolerance for high turbidity) of fish species inhabiting in Bengawan Solo river,
- Past cases which brought about impacts of sluicing and/or flushing on fish in Indonesia / foreign countries, and
- Monitoring of impacts on fish when sluicing and/or flushing is conducted at major rivers in Indonesia (e.g., Berantas river)

(6) Traffic and transportation

During the construction stage, vehicles for transportation of excavated materials to spoil bank and temporary stock yard would cause impact on local traffic and transportation. Estimated volume to be transported is approximately 324,000m^3. Owing to this

project-related transportation activity, local people would undergo negative impacts such as inconvenience of transportation and commute due to traffic jam and possibly traffic accidents at the existing roads in Desa Pokohkidul. **This impact is evaluated to be negative and significant.**

(7) Historical and cultural heritage

Kungkum, a traditional custom in Central Java and nearby areas, is the possible object to be caused by sediment releasing because it is an activity to enter and sit in the flow of the Bengawan Solo River for a certain time. If no announcement is given about schedule of sediment releasing in advance, it might cause a dangerous situation due to a sudden increase of discharge. **This impact is evaluated to be negative but not significant.**

(8) Public health

Possible impacts of the Project on public health is as follows:

- Impacts of waste from base camp for construction works on sanitary condition,
- Impacts of degradation of air quality, noise and vibration generated from construction works and mobilization of heavy equipments, and
- Impacts of sediment releasing on the sanitary condition of Bengawan Solo River.

Impact of base camp establishment on sanitary condition includes wastewater (effluent from lavatory) and garbage. The emergency clinic would be equipped for work accident, from which medical waster would generate. These wastes are possible source to deteriorate sanitary condition around the base camp unless proper treatment is made.

Impact of construction works on air quality, noise and vibration would spawn health problem and psychology issues of the people living near the construction site. Traffic accident and workplace accident are also included as possible impacts.

Impact of sediment releasing on the Bengawan Solo River includes deterioration of river water with turbidity and garbage. The impact on SS concentration is not significant as indicated in the previous section while the impact of garbage to be released through the new gate is estimated not to be minor, but the magnitude of the impact is not clear at this moment. Consequently, **the impact on public health is negative and estimated to be not significant.** However, it is necessary to identify the impact by environmental monitoring after the implementation of the Project.

Table 6.4.2 summarizes the evaluation result of environmental impact.

Table 6.4.2 Evaluation Result of Environmental Impact of the Project

Environmental Components \ Project Activity		Project Stage: Pre-Construction		Construction						Operation & Maintenance	
		Socialization of the Project	Procurement of land required for project facilities	Mobilization and Establishment of base camp	Site clearance for project facilities	Construction work, especially excavation for work	Transportation of excavated materials	Recruitment as construction worker	Watershed management in Keduang river basin	Sluicing of sediment deposits from the reservoir	Periodic maintenance dredging
Physical Components	Groundwater					-TP					
	Air Quality					-P	-P				-TP
	Noise and Vibration					-P	-P				
	Water Quality and River Discharge									-TP	
Biological Components	Terrestrial Flora and Fauna				-TP				+TP		
	Aquatic Organisms									-TP	
	Protected Species										
Socio-economic Components	Land Acquisition and Resettlement										
	People's Unrest	-TP			-TP					-TP	
	Income and Livelihood Change				-TP			+P		-TP	
	Economic Activities of Downstream Areas*									-TP	
	Local Traffic and Transportation			-TP			-P				
	Public Health			-TP		-TP	-TP			-TP	

Note) -P: Negative and significant, -TP: Negative but not significant, +P: Positive and significant, +TP: Positive but not significant
*: This items include: 1) sand mining, 2) inland navigation, 3) water use by PDAM and irrigation, and 5) fishery,
Source: JICA Study Team

6.5 Environmental Management and Monitoring

Table 6.5.1 summarizes environmental management and monitoring activities required for minimizing the environmental negative impacts of the Project.

Environmental Monitoring shall be conducted by Project implementer, BBWS Bengawan Solo. Among the monitoring items listed in Table 6.5.1, important ones are summarized in the table below, showing the frequency, timing of monitoring and cost estimate. The total cost necessary to monitor these important environmental elements will be $98,500. Assuming that these monitoring activities requires 4 years to complete, annual cost will be $24,600.

Table 6.5.2 Frequency, Timing and Cost Estimate of Environmental Monitoring

No.	Monitoring Parameter	Monitoring item, Frequency and Timing	Monitoring Cost (incl. direct cost, personnel cost and reporting and transportation)
1	Groundwater	Well water inventory : - Before project: once, - During project: quarterly during construction (8 - times in total during 2 years), - After project: once	$14,000
2	Air quality, noise and vibration	Field investigation and laboratory analysis: - Before project: once,	$26,200

		- During project: three times at peak intensity	
3	Water quality	Water sampling and laboratory analysis, - Water sampling at 2 locations in Wonogiri reservoir and 4 locations of Bengawan Solo river, - Four times of sluicing during operation period	$30,100
4	Impacts on fish	Visual inspection and fish catch during sluicing, - Inspection and fish catch at 4 locations of B. Solo river, - Four times of sluicing during operation period	$10,700
5	Socio-economic and cultural components	Interview and questionnaire survey: - Before project: once, - During construction: once a year during construction (in total, 4 times) - During operation: three times	$17,500

Source: JICA Study Team

6.6 Conclusion

The result of EIA Study indicated that there will be several environmental impacts evaluated as "**negative and significant**," including,

- Impacts on air quality, noise and vibration exceeding environmental standard level due to construction works, especially excavation for spillway,
- Impacts on local traffic and transportation due to transportation of excavated materials,

These impacts are the ones only during construction works and therefore the period of impact is limited. The area of impact is limited to the nearest village as well. Accordingly, these impact is judged not to cause serious problem but to be mitigated by proper socialization and appropriate compensation. In order to secure the environmental management to mitigate negative impacts, environmental monitoring is needed.

Among other possible impacts, the following ones should be paid attention although they are predicted to be not significant.

- Impacts on fish species of downstream of Bengawan Solo River due to the change of water quality during sediment releasing,
- Impacts on downstream river environment due to garbage release through the new gate during sediment releasing from the sediment storage reservoir.

In order to secure the environmental management of these negative impacts, it is necessary to carry out monitoring of river environment during sediment releasing focusing on water quality and sanitary condition of Bengawan Solo River as described in previous section so that the optimal operation of sediment storage reservoir can be established for minimizing environmental impacts.

In conclusion, the Project can be concluded to be valid in environmental point of view under the appropriate management and monitoring activities.

6.7 Information Disclosure

For the purpose of information disclosure about the results of Master Plan formulation and Feasibility Study, a workshop and a public consultation meeting was held.

6.7.1 The 4th Workshop

The 4th workshop was held on January 18th to present the study results of Master Plan (M/P) for countermeasures for sedimentation in the Wonogiri multipurpose dam reservoir, aiming at understanding, opinion exchange for realization of the M/P.

Participants of the workshop are about 110 persons, consisting of Steering Committee members from Jakarta, government officials from Central Java Province, Kabupaten, University researchers, P3A Kabupaten, Forestry agency, PLTA Wonogiri, Farmer Group and Forum.

In the workshop, 8 presentations were made, including the following subjects: (1) Summary of Master Plan, (2) Structural countermeasures in reservoir, (3) Hydrologic modeling for sediment control and water resources management, (4) Introduction to noon session on watershed management, (5) Non-structural / vegetative watershed countermeasures, (6) Organizational set-up in the implementation of watershed management activities, (7) Research and development of social economy for Bengawan Solo watershed conservation and (8) Direction and policy in the implementation of GN-KPA (National Movement of the Partnership for Water Preservation).

The workshop was not aimed only for the discussion on environmental impacts to be caused by the Project implementation but the whole project activities. The discussion focused on the necessity of public participation in the project, considering the local culture and economic condition for Kuduang river watershed conservation, and necessity of empowerment of local farmers.

6.7.2 Public Consultation Meeting (PCM)

Public Consultation Meeting (PCM) was held in Kabupaten Wonogiri by BBWS Bengawan Solo assisted by JICA Study Team, aiming at disclosure of the result of Environmental Impact Assessment (EIA) for the priority project to local stakeholders and obtaining comments to incorporate into design of project components. The details of the PCM are summarized below.

- Date: March 1st, 2007
- Venue: BAPPEDA Office of Kabupaten Wonogiri
- Attendants invited:
  - Government Official of Bappedalda (Environmental Agency), Central Java Province,
  - Government Officials of Kabupaten Wonogiri (LHKP (Environmental Agency), Agricultural Agency, Fishery Agency, Regional Development and Planning Agency and Local Government Secretary),
  - Government Officials of relevant Kabupaten and Kota (Sukoharjo, Karanganyar, Klaten, Sragen and Surakarta),
  - Government Officials of relevant Kecamatan (Wonogiri, Jatipurno, Ngadirojo, Jatiroto, Nguntoronadi, Jatisrono, Sidoharjo, Slogohimo, Girimarto),
  - Government Officials of relevant 15 Desa (villages),
  - Representatives of relevant organizations (K2TA: Farmers conservation group for soil and water, GP3A: Farmers association),
  - Representative of local people and NGOs
  - Nos. of Participants: 86 (incl. PPWS Bengawan Solo and JICA Study Team)
- Presentation Topics:

No.	Agenda	Presenter
1	**Presentation I:** Outline of Priority Project	Ms. Lilik Retno, BBWS Bengawan Solo
2	**Presentation II:** Environmental Impacts of the Project on Physical Elements	Mr. Ari Handono and Mr Mukhlisin (JICA Study Team / Sebelas Maret University).

3	**Presentation III:** Environmental Impacts of the Project on Biological Elements	Mr. Sajidan and Mr. Murwantoko (JICA Study Team / Sebelas Maret University).
4	**Presentation IV:** Environmental Impacts of the Project on Socio-economic Elements	Mr. Maulana (JICA Study Team)

The attendants pointed out the following concerns of environmental impacts:

- Impacts on well water use due to excavation works,
- Impacts on Colo weir and irrigation canals due to sluicing or flushing,
- Impact of dredging and dumping of dredged materials to spoil bank,
- Impact of civil works on dust generation,
- It is necessary to conduct AMDAL for the Project, and
- Who will be responsible for managing the environmental impacts by the Project.

BBWS Bengawan Solo answered that AMDAL would be done when it is required by competent authority in the next stage, that the possible impacts would be managed and monitored, including compensation if necessary, by the Project executor, and that the monitoring results would be reported to competent authority and disclosed to stakeholders in timely manner.