4.4.3 Sediment Sluicing by New Gate

The method is to sluice the incoming sediment-laden flood inflows from the Keduang River to the downstream reaches of Wonogiri dam through the new gates before deposition in the reservoir. This method requires modification of the current reservoir operation rule due to the requirement of massive releasing water and has to lower the water level near sediment deposit elevation.

Wonogiri reservoir is very large and storage capacity is so huge that it takes a long time to lower the water level in the reservoir. In addition, a reservoir turn-over rate is very small as 2-3 times per year on average. It may be difficult to carry out sediment sluicing by the existing operation rule in the Wonogiri reservoir. However, this method could be applied preferably at the beginning of wet season when the water level is the lowest.

(1) Layout of Facility and the Operation

Existing spillway is located at the left abutment of the dam, the opposite side of Keduang River, and elevation of the crest is EL.131m. The above simulations show that the flow from the Keduang River hits the right side of dam abutment and turned its direction to the left. SS concentration at right end of the dam is higher than that at the existing spillway. In consequence, existing spillway is not effective for sediment sluicing. For effectively sluicing sediment during flood in Keduang river, a new gate near the right end of the dam is installed and its crest is set to 127m. Facility items are shown in Table 4.4.4. Please refer to Chapter 6 of Interim Report in the Study for the details of the facility.
This facility serves both as sediment flushing and spillway for PMF.

Table 4.4.4 Facility Plan of Sediment Sluicing by New Gates

Facility	Dimension	
Sediment flushing gates	Radial gate	H 12.6m x B 7.5m x 4nos
Spillway	Chute type spillway and channel	B=30m, L=723m, I=1/108
Forebay excavation	Sediment deposit level	EL.127.0m

Source : JICA Study Team

In evaluating the efficiency on sediment release, the gate is assumed to be fully opened from the beginning of wet season to the end of next January when flood discharge in Keduang river exceeds $10m^3/s$. The total outflow volume is limited to maximum 200 million m^3. In addition, the release flow through the new gate is controlled to not exceed 400 m^3/s according to the current reservoir operation rule.

(2) Reservoir Sedimentation Simulation

a) Computational Conditions

Computational conditions are listed in Table 4.4.5.

Table 4.4.5 Input Data for the Simulation (Sediment Sluicing by a New Gate)

Item	Data	Note
Methodology	Depth-integrated 2-dimensional sediment transport model—NKhydro2D model	Based on boundary-fitted orthogonal curvilinear grids
Topogrphical Map	Topographical map with the scale 1:25,000	Published in 1999
Bathymetric data	Cross-section data measured in October 2004	
Inflow Discharge	Temporal discharge (hourly) is employed. Hydrological drought year: Figure 4.4.2 and 4.4.3 Hydrological average year: Figure 4.4.4 and 4.4.5 Hydrological flood year: Figure 4.4.6 and 4.4.7	Data in rainy season are used.
Water Release through intake	Monthly-averaged discharge at Colo weir: Table 4.4.1	
Water Release through existing spillway	No water released through the existing spillway	
Water Release through a new gate	The gate is fully opened by the end of next January when flood discharge in Keduang river is greater than $10m^3/s$. The total outflow volume is limited to maximum 200 million m^3. In addition, the release flow through the new gates is controlled to not exceed 400 m^3/s.	The crest is at the level 127m
Water Level	The initial water level is specified to 129m.	
Bed Material	Data of particle size distribution at different locations sampled in October 2004. As non-uniform material (consists of 9 classes in simulation)	The size in deeper area is quite fine.
Sediment Transport Mode	As both the bed load and suspended load	Non-uniform sediment (consists of 9 classes in the simulation)
Sediment Supply	Sediment transport rate for bed load is calculated by Ashida & Michiue's formula. Concentration of suspended sediment is specified as function of river discharge.	Particle size distribution is considered.
Sediment Release	Sediment release accompanied with water release through the spillway and intake is considered.	Bottom concentration of suspended sediment is specified as the release concentration from the intake.
Other Information	Rainfall, Evaporation, etc.	

b) Computational Results: Water Release from the New Gate and Reservoir Water Level

Water release discharge and its total volume through the new gate, reservoir water level under different inflow conditions are shown in Figure 4.4.26 ~ 4.4.31. Similar to the case in which water releases from the existing facilities only, water level in the reservoir is lower in the season and the level cannot be recovered to the NWL (Normal Water Level: 136m) by the end of the rainy season in hydrological drought year.

On the other hand, in both hydrological average year and hydrological flood year, the water level in the reservoir can be recovered to NWL in the rainy season.

c) Computational Results: SS Concentration at Different Locations

SS (Suspend Sediment) concentrations at four (4) locations in the reservoir (the existing spillway, the intake, the right end of dam, bypass entrance) are shown in Figure 4.4.32 ~ 4.4.34.

The maximum SS concentrations through the new gate in the early stage (first month) of the season are about 16.2g/l in hydrological drought year, 17.3g/l in hydrological average year and 22g/l in hydrological flood year, respectively. After the first stage, the SS concentration becomes lower and the maximum is lower than 6g/l. The concentration is almost in the same order as that in the above basic case. However, check and monitoring are needed from social environmental viewpoint.

In the early stage of the rainy season, the reservoir water level is lower and there is no remarkable difference between SS concentration at the new gate and that at the bypass entrance. It is believed that the efficiency of sediment release at this stage should be higher than that in other stage. However, there is risk on the recovery of the reservoir water level before the end of the wet season.

d) Computational Results: Sedimentation Distribution

Sediment release volume through the intake and the new gate and sediment transport volume through cross section No.1 (Figure 3.1.1) are shown in Figure 4.4.35 ~ 4.4.43. The released sediment is quite fine.

Sediment transport volumes through cross section No.1 in hydrological drought year, hydrological average year and hydrological flood year are 16000m^3、10000m^3、8000m^3, respectively. The results show that the sediment transported to the area near the dam from the upstream rivers except from Keduang river is less, although there is a little bit increase comparing with those in the above basic cases.

Sedimentation volume in different area of the reservoir (Figure 3.2.1) is listed in Table 4.4.6. In the ‘Area’ column of Table 4.4.6 and hereinafter, ‘SandGate’ represents the new sediment flushing gate. By the results, it can be calculated that sediment trap ratios under different inflow conditions are 78.5％、83.4％、80.7％, respectively. Comparing with those in the above basic cases, the sediment trap ratio in the reservoir decreases about 1.6~4%. Total sediment release from the reservoir increases about 80,000m^3 although there is a little bit reduction of sediment release through the intake. Efficiency of sediment release through the new gate is higher than that through the existing spillway. Volume of released water is 200 million m^3, which is less than that in the above basic cases.

In hydrological drought year, sedimentation in the effective storage zone is less because the reservoir water level is lower. However, water level in the reservoir is lower in the season and the level cannot be recovered to the NWL (Normal Water Level: 136m) in the rainy season. The dam operation should be careful.

Sedimentation in area ‘Center’ and ‘CenterUP’ (see Figure 3.2.1 for the location) reduces when inflow increases. In both hydrological average year and hydrological flood year, sedimentation in the reservoir center area decreases and sedimentation in effective storage area in Keduang increases a lot, although sediment release through the new gate increases.

Comparing with those in the above basic cases, sedimentation in Keduang area and that in ‘Solo&Alang’ area reduces about 60,000m^3 and 60,000~100,000m^3, respectively. Sedimentation in 'Center' area increases 50,000~90,000m^3. Sedimentation in 'Dam' area decreases 20,000~40,000m^3.

Table 4.4.6 Sedimentation Distribution and Sediment Release Volume (Sediment Sluicing by New Gate)

Area	Sedimentation Volume (m3)		
	Drought Year	Average Year	Flood Year
Dam	87,100	82,200	69,500
Keduang	224,100	667,000	772,000
Tirtomoyo	252,800	494,600	607,800
Temon	90,700	78,000	149,800
Solo&Alang	-75,800	576,800	679,500
CenterUP+ Wuryantoro3	694,000	581,400	572,300
Center	517,000	325,500	312,400
Wuryantoro	77,500	195,000	185,900
Wuryantoro2	24,700	52,400	47,700
PowerPlant	285,100	264,000	344,100
SandGate	233,300	343,500	509,600
Total	2,410,000	3,660,000	4,250,000

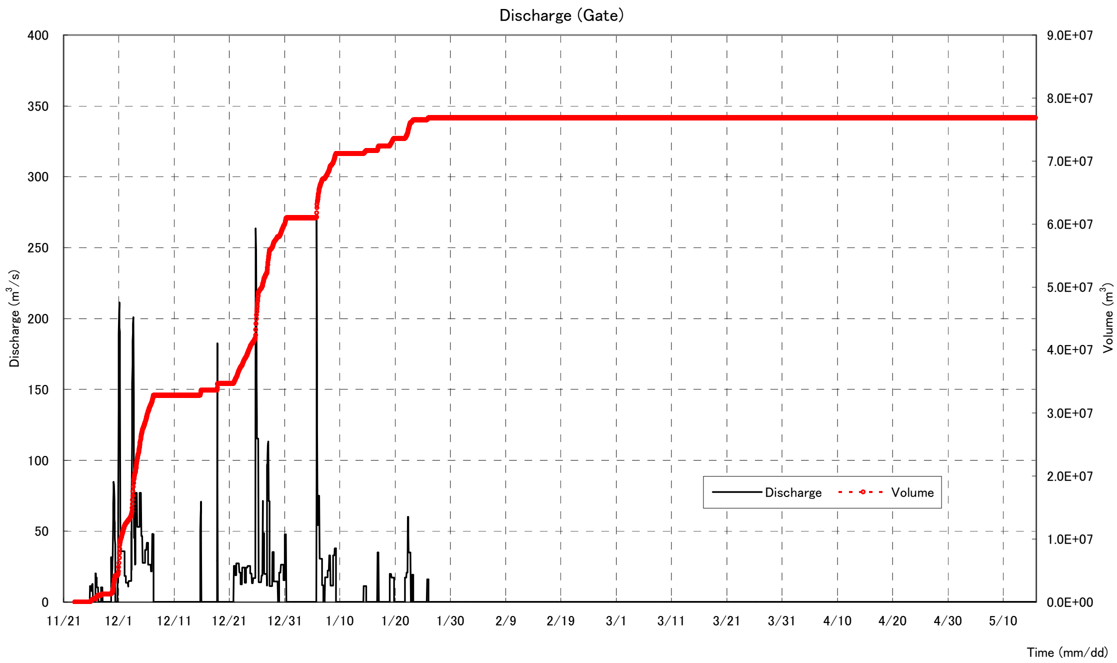

Figure 4.4.26 Release Discharge and its Total Volume through the New Gate in Hydrological Drought Year

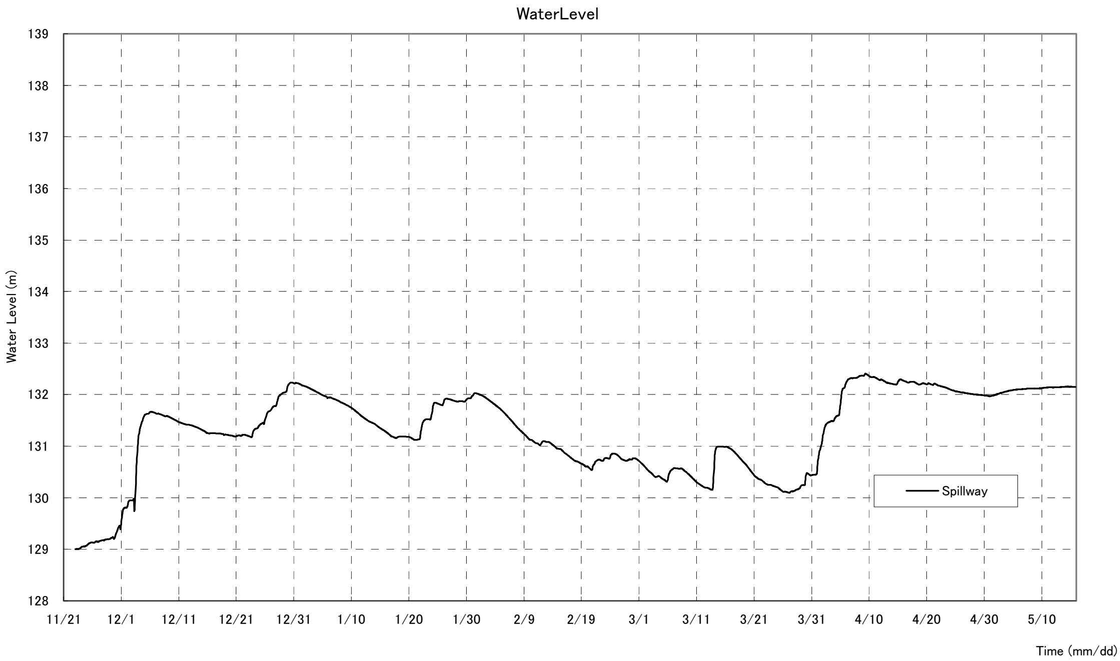

Figure 4.4.27 Water Level in the Wonogiri Reservoir in Hydrological Drought Year (New Gate)

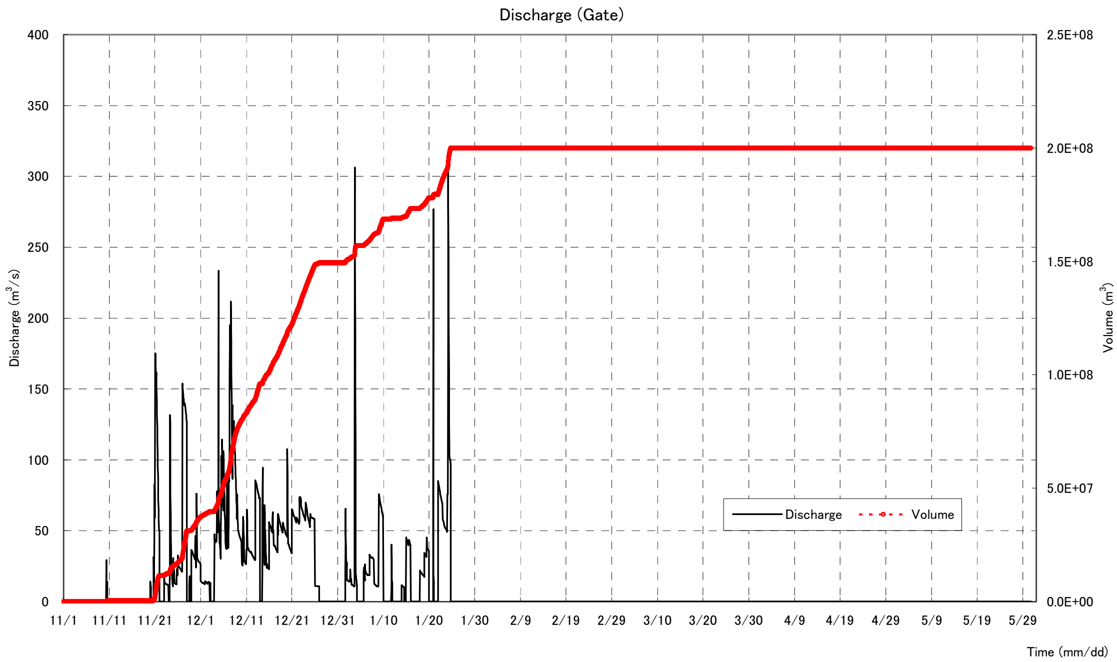

Figure 4.4.28 Release Discharge and its Total Volume through the New Gate in Hydrological Average Year

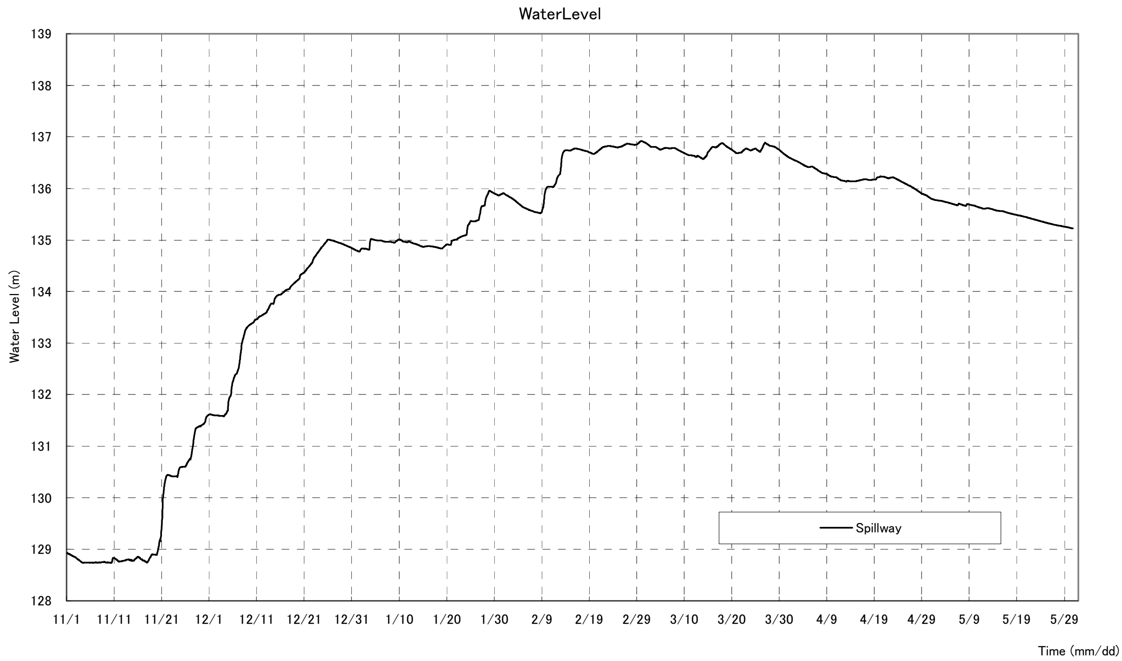

Figure 4.4.29 Water Level in the Wonogiri Reservoir in Hydrological Average Year (New Gate)

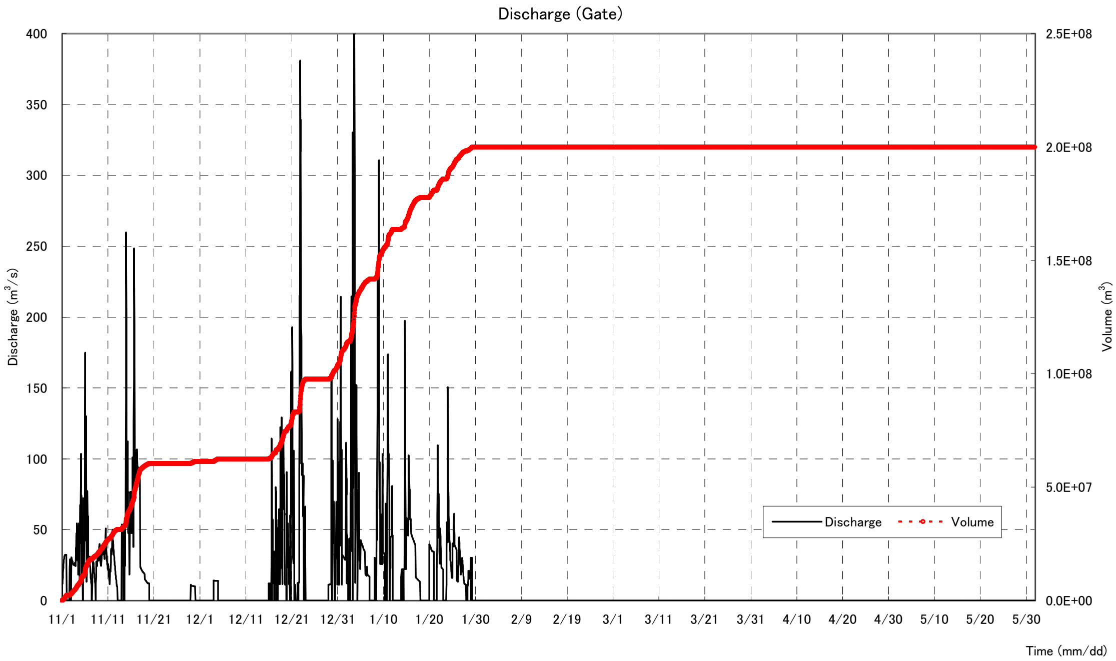

Figure 4.4.30 Release Discharge and its Total Volume through the New Gate in Hydrological Flood Year

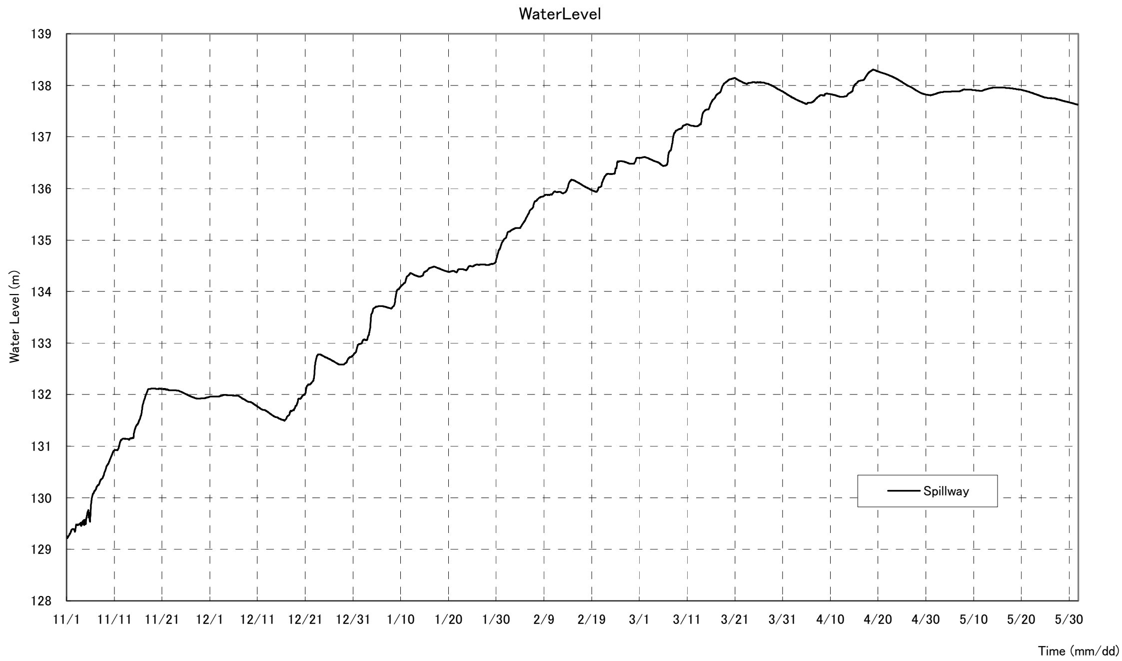

Figure 4.4.31 Water Level in the Wonogiri Reservoir in Hydrological Flood Year (New Gate)

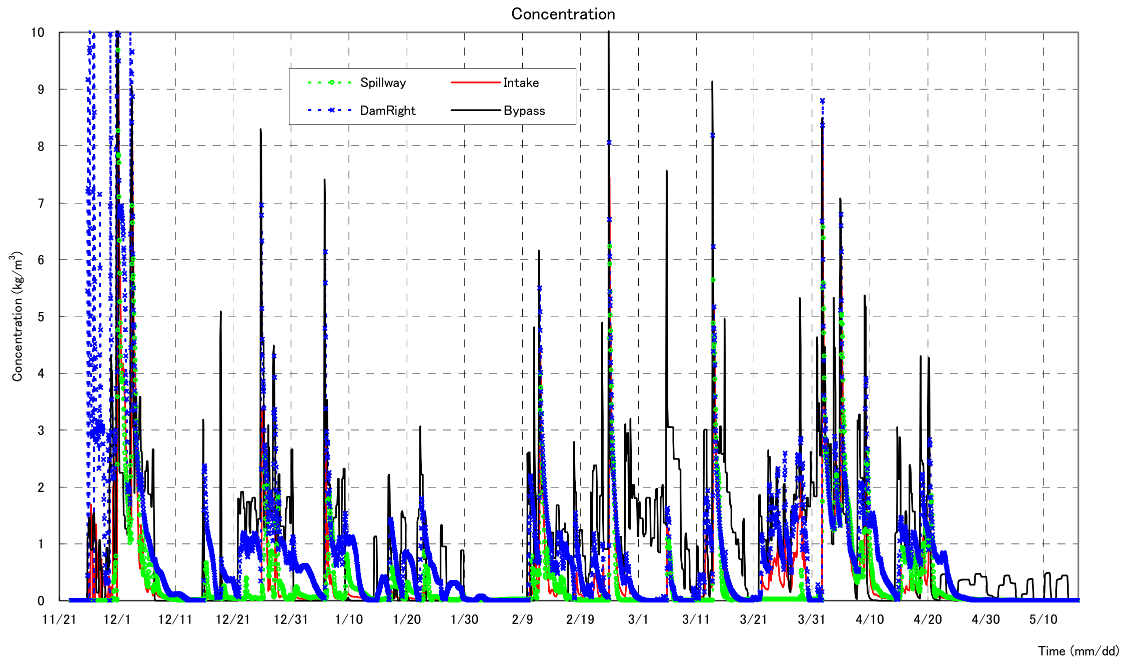

Figure 4.4.32 SS Concentration at Different Locations in the Wonogiri Reservoir in Hydrological Drought Year (New Gate)

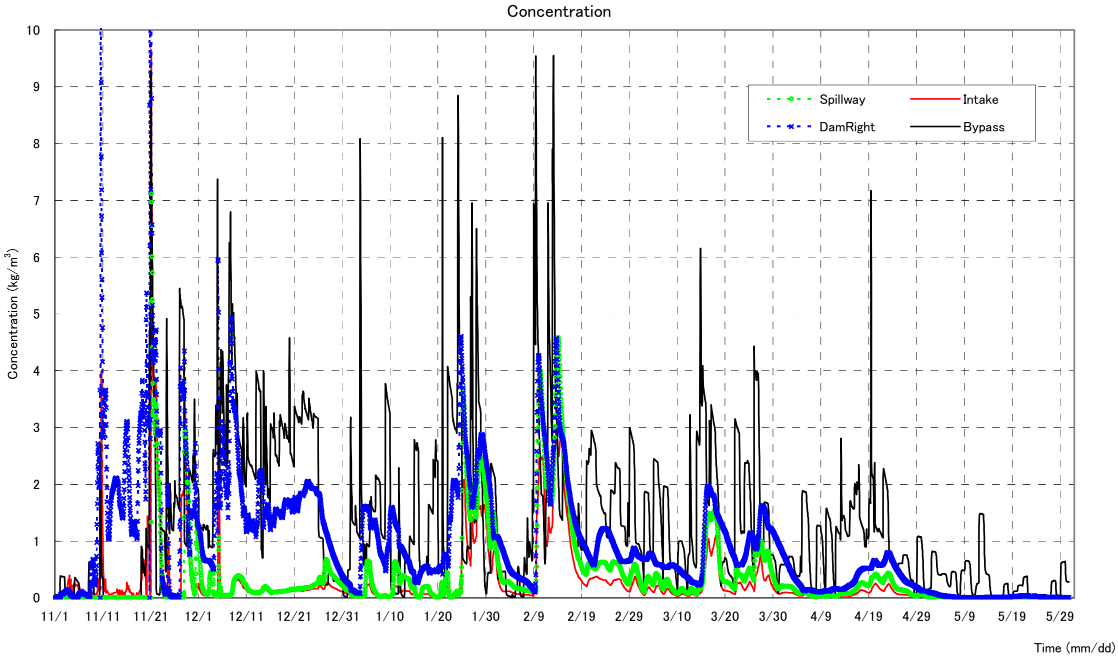

Figure 4.4.33 SS Concentration at Different Locations in the Wonogiri Reservoir in Hydrological Average Year (New Gate)

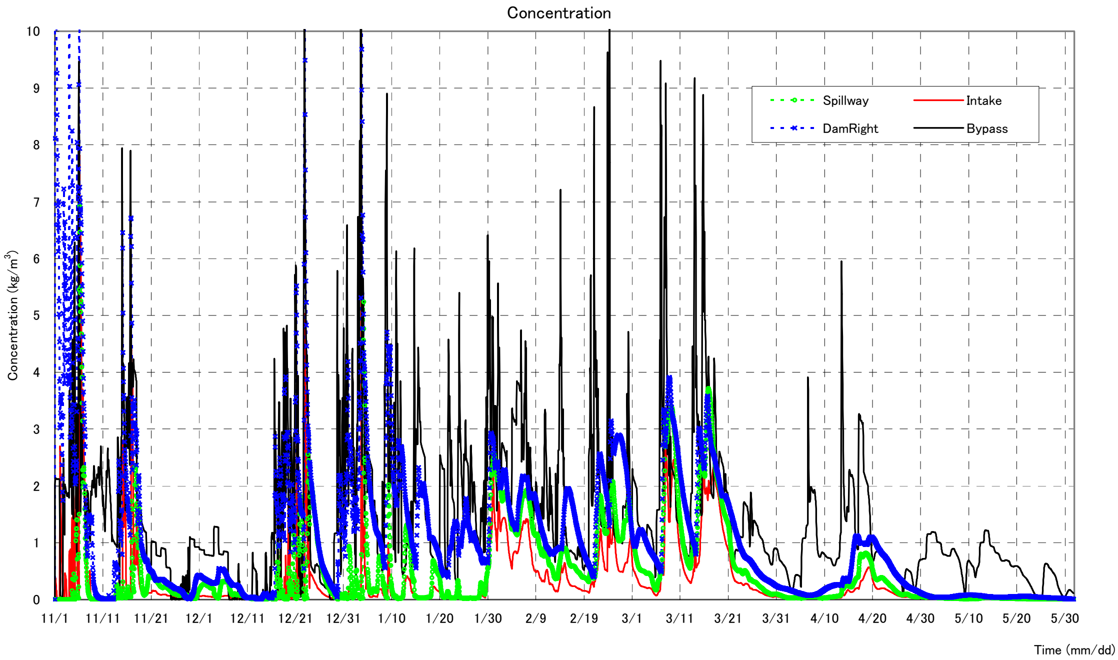

Figure 4.4.34 SS Concentration at Different Locations in the Wonogiri Reservoir in Hydrological Flood Year (New Gate)

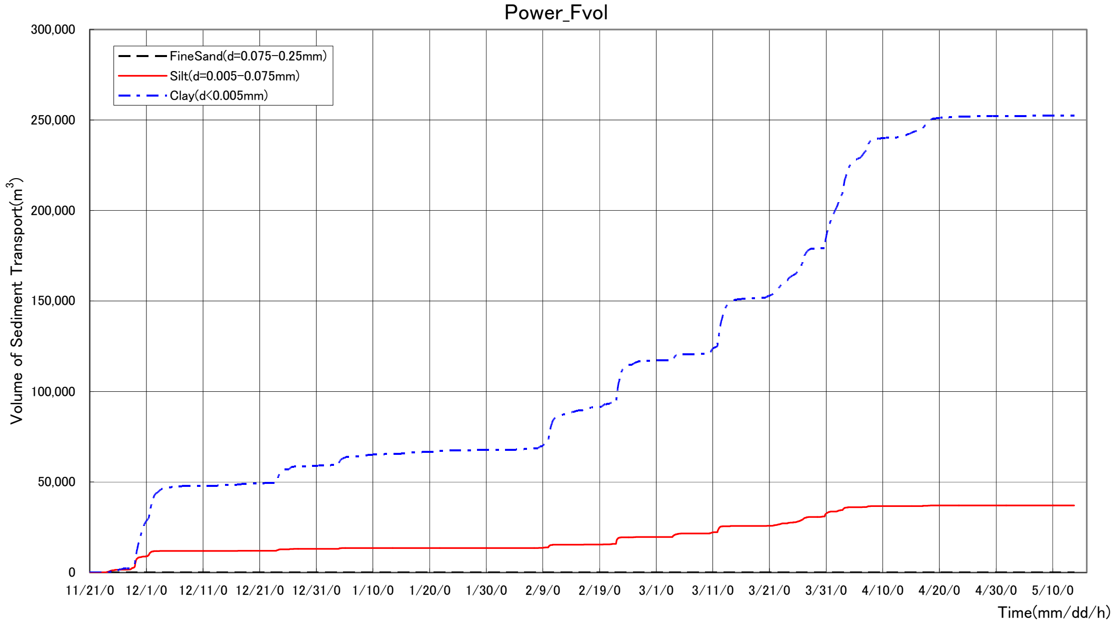

Figure 4.4.35 Sediment Release through the Intake in the Wonogiri Reservoir in Hydrological Drought Year (Deposition Volume) (New Gate)

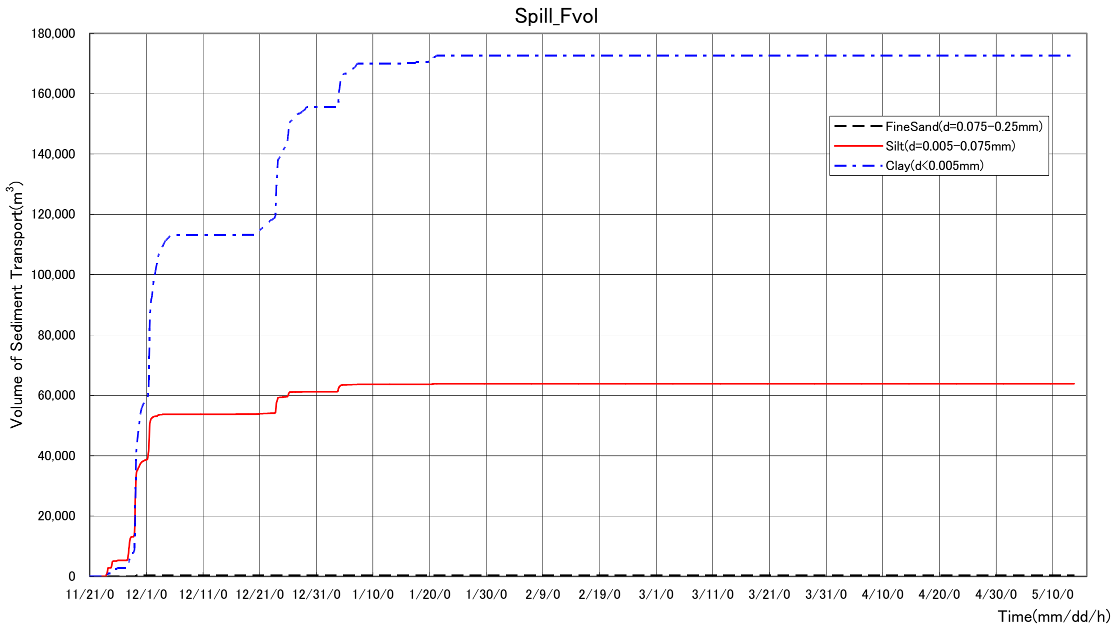

Figure 4.4.36 Sediment Release through the New Gate in the Wonogiri Reservoir in Hydrological Drought Year (Deposition Volume) (New Gate)

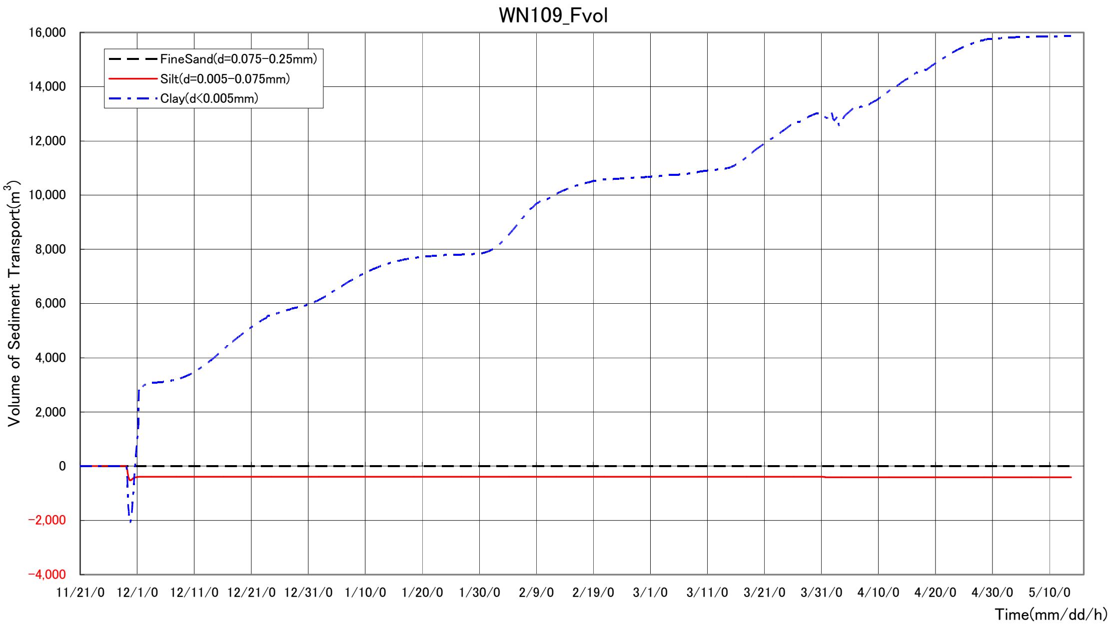

Figure 4.4.37 Sediment Transport Volume through Cross Section No.1 in the Wonogiri Reservoir in Hydrological Drought Year (Deposition Volume) (New Gate)

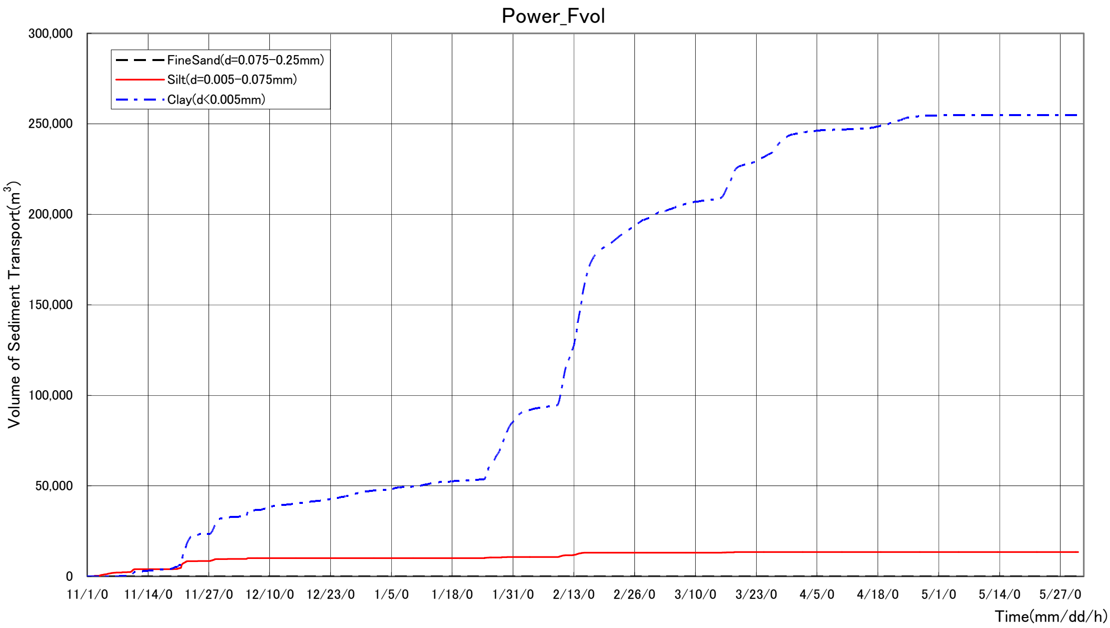

Figure 4.4.38 Sediment Release through the Intake in the Wonogiri Reservoir in Hydrological Average Year (Deposition Volume) (New Gate)

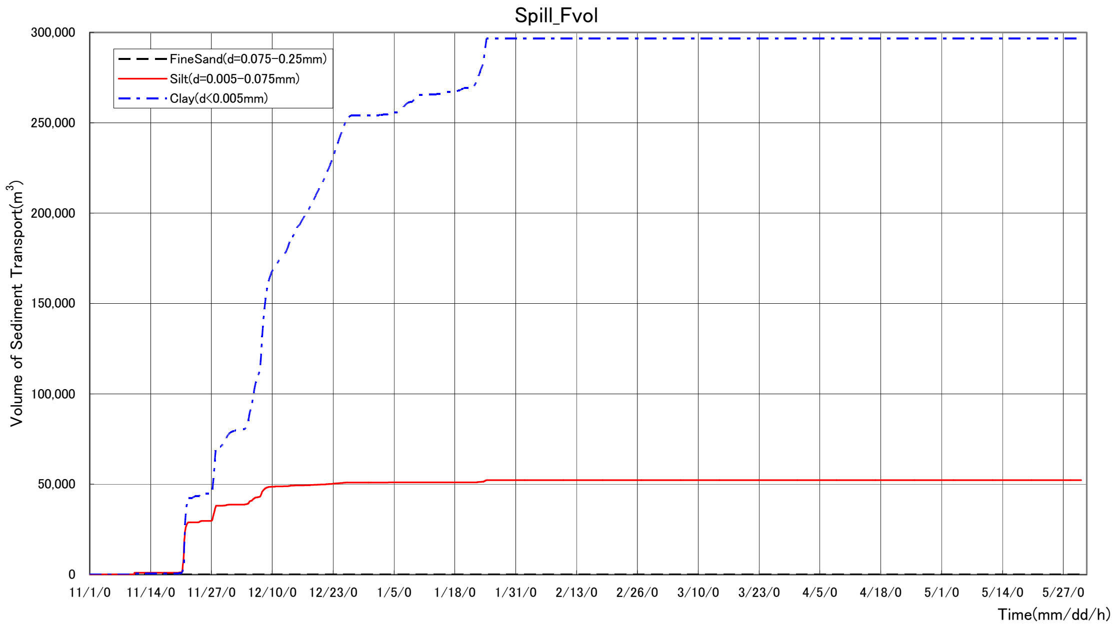

Figure 4.4.39 Sediment Release through the New Gate in the Wonogiri Reservoir in Hydrological Average Year (Deposition Volume) (New Gate)

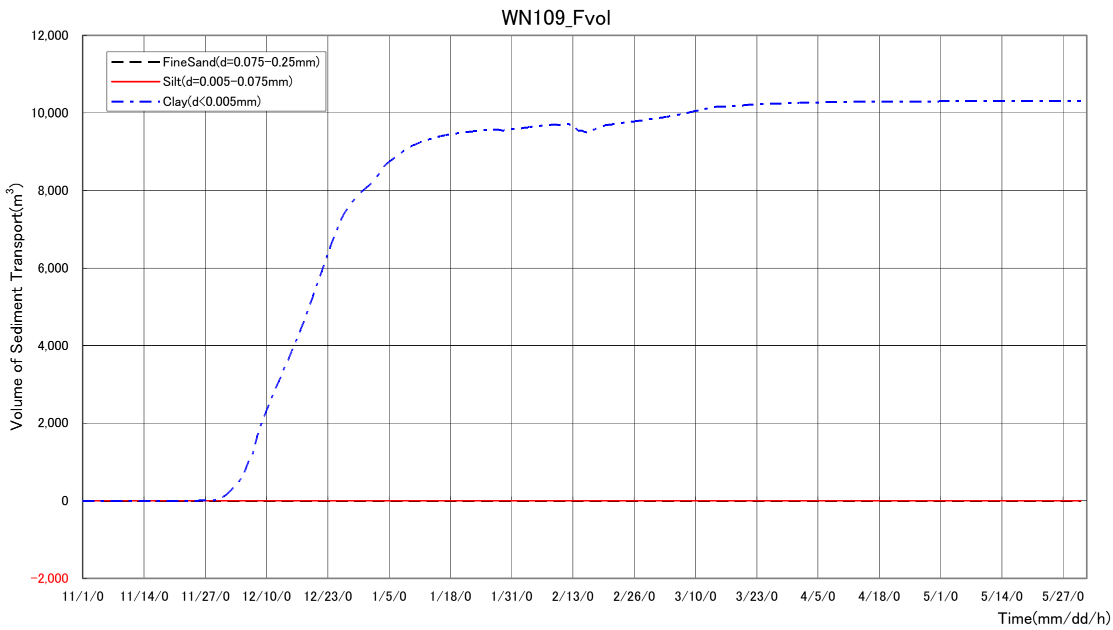

Figure 4.4.40 Sediment Transport Volume through Cross Section No.1 in the Wonogiri Reservoir in Hydrological Average Year (Deposition Volume) (New Gate)

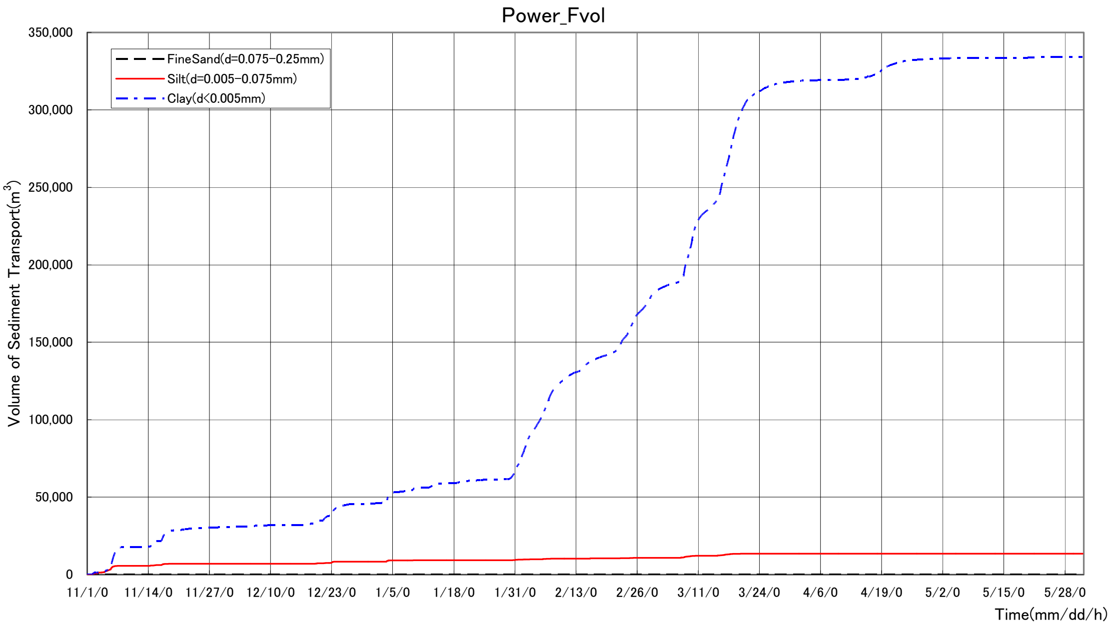

Figure 4.4.41 Sediment Release through the Intake in the Wonogiri Reservoir in Hydrological Flood Year (Deposition Volume) (New Gate)

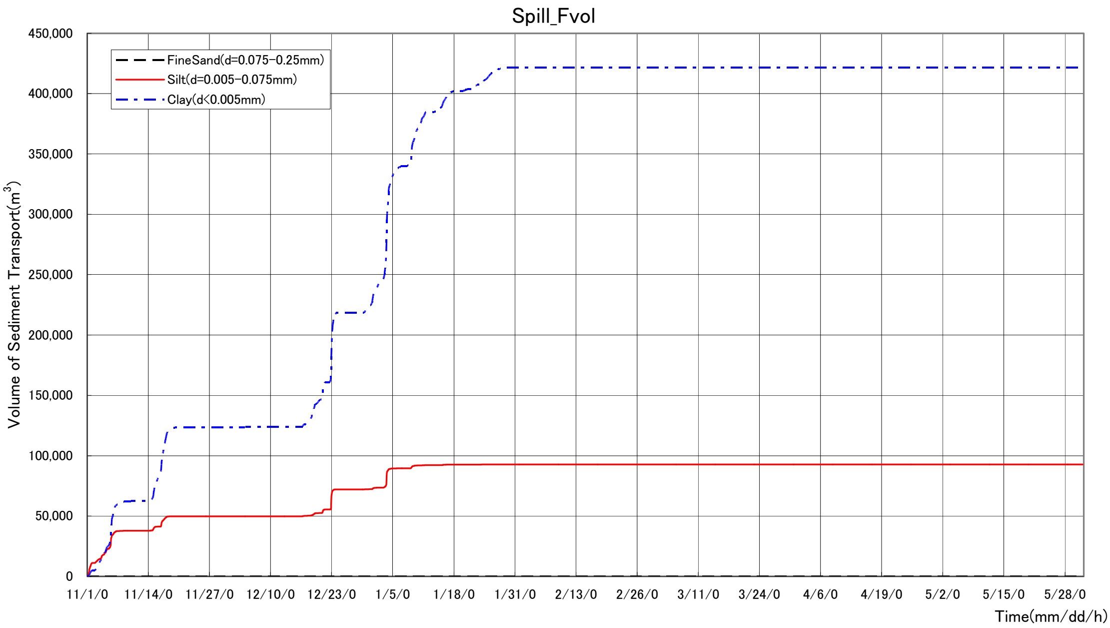

Figure 4.4.42 Sediment Release through the New Gate in the Wonogiri Reservoir in Hydrological Flood Year (Deposition Volume) (New Gate)