# Sediment Management Measures at the Miwa Dam

**Yasushi Enomura**
*Director, Mibugawa River Comprehensive Development Office,*
*Ministry of Land, Infrastructure and Transport, Japan*

## 1. Outline of the Miwa Dam Redevelopment Project

Originating in Lake Suwa, the Tenryu River flows in the central portion of Japan's main island, conjoining branch streams from the southern and central Japan Alps, passes through several gorges and alluvial plains before finally pouring into the Pacific Ocean. With a total basin area of 5,090 km$^2$ and a total river length of 213 km, it is one of the most precipitous rivers in Japan. Characterized by rainfall in steep mountain areas, the river runs down rapidly and carries a large quantity of sediment in its upstream course. For this reason, it has been called the "Wild Tenryu," frequently causing damages to food production, notably in 1961, 1982 and 1983. Figure 1 shows a diagram of the river basin.

The Mibugawa River Comprehensive Development Project focuses on the redevelopment of the existing Miwa Dam located on the Mibu River, the Tenryu River system's largest tributary.

In the Miwa Dam redevelopment project, sediment excavation in the reservoir and permanent sediment management measures were formulated to maintain as well as reinforce the flood control and water supply functions of the Miwa Dam, a multipurpose concrete gravity dam with a height of 69.1 m, a crest length of 367.5 m and a gross storage capacity of approximately 30 million m$^3$. The dam was completed in 1959 by the then Ministry of Construction (now Ministry of Land, Infrastructure and Transport) for the purpose of flood control, irrigation and power generation.

During the last 46 years, the dam has contributed to the region's safety and industrial development by preventing flooding, providing water for nearly 2,500 ha of downstream paddy fields and supplying electricity to meet the demand of some 43,000 households.

Yet, the flood-induced sediment inflow has brought about such an accumulation of sedimentation that effective storage capacity is barely secured. If large-scale flooding occurred, it is possible that there would be damage to the flood control and water supply functions of the Miwa Dam. Thus, excavation in the reservoir as well as measures to prevent further sedimentation (permanent sediment management) are vitally important. Photo 1 illustrates the sedimentation, and Figure 2 is a chart of yearly sediment change.

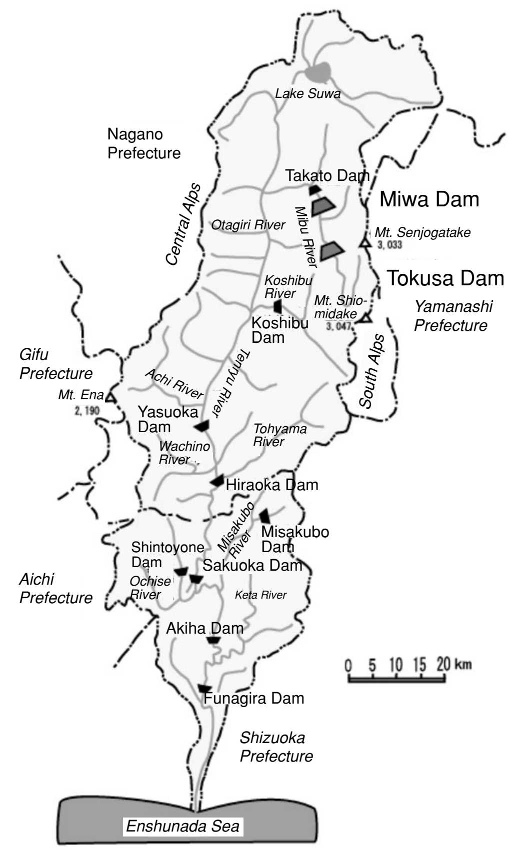


Figure-1 Tenryu drainage basin

An study on the execution plan was launched in 1987, and construction work started in 1989 under the Mibugawa River Comprehensive Development Project. Regarding permanent sediment management measures, a check dam was installed in 1993, and a flood bypass tunnel and a diversion weir were completed in 2005. Work on sediment excavation was begun in 1999 and nearly two million m$^3$ of sediment has been excavated so far to restore the reservoir capacity. The excavated soil sediment is used effectively in public works as banking materials for relocated roads and farmland consolidation.

Photo-1 Miwa Dam during dewatering (the photo taken in 1989)

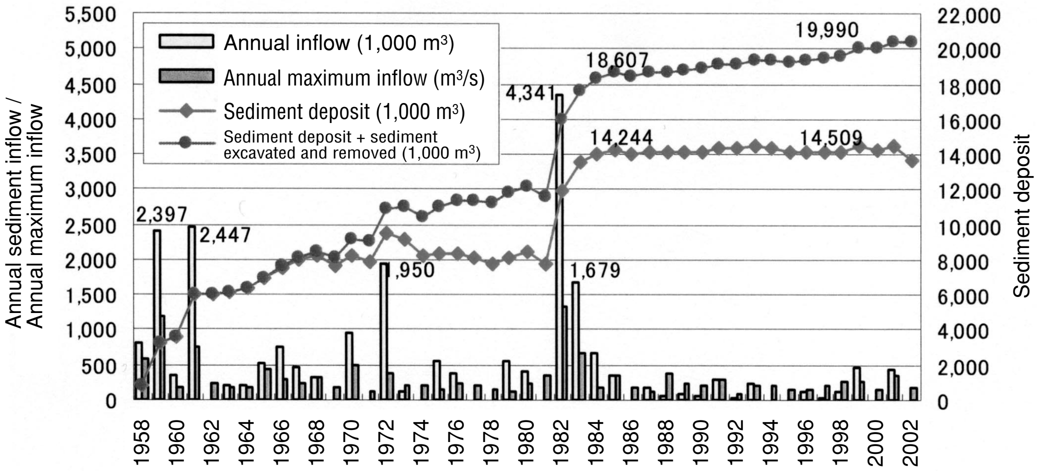


Figure-2 Yearly sediment change

## 2. Overview of the permanent sediment control facilities

The permanent sediment management measures aim at checking the reduction in reservoir capacity that has occurred as a result of sediment flowing into the Miwa Dam from flooding by trapping it upstream of the reservoir or bypassing it down below the reservoir.

Because the inflow sediment in the Miwa Dam characteristically includes many fine-grained fractions (wash load), a plan was made for the check dam in the upstream reaches above the reservoir to trap all the coarse-grained fractions (bed load and suspended load) so that only the wash load would be bypassed down below the dam. The bed load and suspended load trapped in the upstream reaches was to be collected by privately owned gravel gathering agencies for utilization as construction materials. Figure 3 is a chart of the annual volume of sediment removed (annual average expectation value).

The permanent sediment management facilities consist of the installations described below. Figure 4 shows a map of the permanent sediment control facilities.

### ① Check dam

From the total inflow sediment, this facility traps bed load and suspended load. Its sediment storage capacity is 200 thousand m$^3$. The sediment is excavated and removed by private gravel agencies.

### ② Diversion weir

The diversion weir combines the functions of training and trapping the sediment. Wash load, which flows down through the check dam, is guided together with floodwater from a bypass channel into a bypass tunnel. When large-scale flooding occurs, the facility

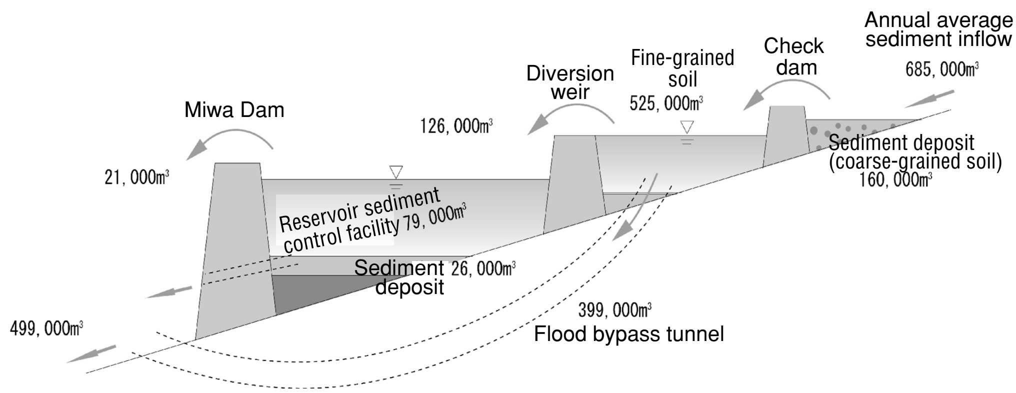


Figure-3 Predicted annual sediment discharge

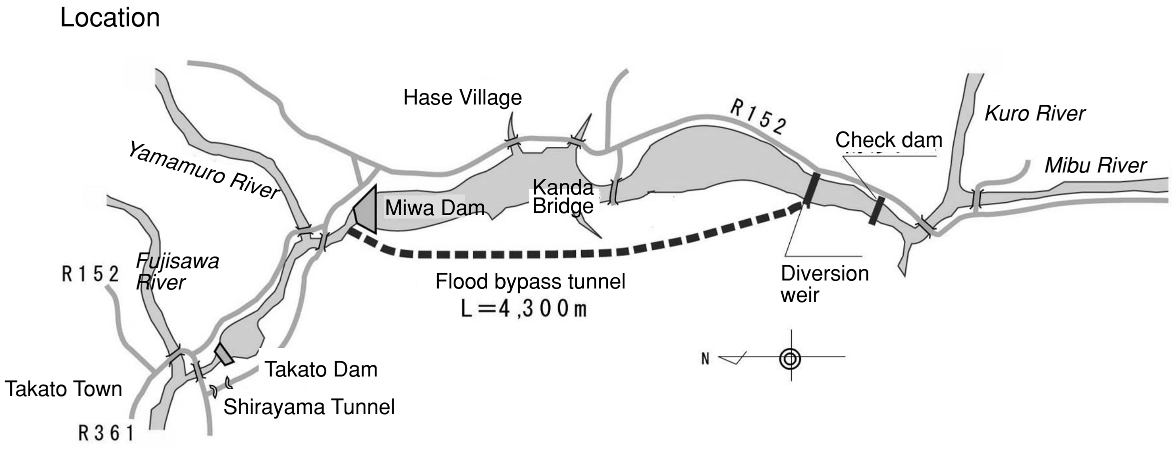


Figure-4 Location map of the permanent sediment control facilities

allows a training dike and a trap weir to catch coarse-grained fractions that overflow from the check dam to prevent them from flowing into the flood bypass tunnel. The storage volume of the diversion weir is 520 thousand $m^3$.

③ Flood bypass tunnel

The facility bypasses wash load together with floodwater to the area downstream of the dam. Its maximum flow rate is about 300 $m^3/s$.

④ Reservoir sediment control facility

A facility is currently being designed that will discharge wash load, which flows into the reservoir together with floodwater, into the reaches downstream of the dam, as a flood control measure.

## 3. Outline of the construction works

1) Diversion weir

The diversion weir installed in the upstream reaches of the Miwa Dam reservoir is a concrete gravity structure 20.5 m in height and 244.5 m in length. The construction works were begun in October 2001 and nearly 53,800 $m^3$ of concrete was placed into the body of the structure in February 2005. By the end of fiscal 2004, the bypass channel on the left side connecting the bypass tunnel intake to the diversion weir, the main and secondary gates and the diversion weir access bridge were completed. The ancillary structures, including a power supply device, a gate operating apparatus and a monitoring facility were finished by May 2005.

Because it was necessary to carry out work on the diversion weir inside the reservoir, the execution period was restricted to six months during the non-flood season between October and March. Construction efficiency is also affected by the fluctuation in the reservoir level. For this reason, the reservoir level was lowered during the non-flood period to secure the construction term while the reduced energy output was compensated for by the power plant on the Miwa Dam. Furthermore, to facilitate concrete placement under circumstances where the average temperature was below zero, an appropriate winter concreting measure (use of warm water for mixing and jet heater after placement) was adopted to ensure high quality. Photos 2 and 3 show the diversion weir under construction and after completion.

2) Flood bypass tunnel

The flood bypass tunnel was excavated on the left mountain side of the Miwa Dam reservoir. It extends

Photo-2 Construction of the diversion weir

Photo-3 Current diversion weir

Photo-4 Construction of the tunnel entrance

Photo-5 Current tunnel entrance

nearly 4,300 m and the finished sectional area is approximately 47 $m^2$.

The section to be excavated basically consists of Mesozoic granodiorite formed in an area known as the Ryoke belt, and was constructed using the NATM method. The work was launched in February 2001 and all the lines were totally penetrated by March 2004.

Because the width of the finished sectional area of the tunnel is 7.8 m, too narrow for heavy dump trucks to pass, a conveyer belt was used to remove the excavated rock and mud. The use of this method provided an even greater enhancement of safety management, as it made the construction process shorter and improved the working environment as the conveyer belt emitted far less exhaust gas than vehicle transportation would have, had it been used.

The ventilation system for the tunnel construction consists of a central air supply and an end dust-collecting system placed near the facing site to filter out the dust particles that the facing work would produce.

There was some concern about incidental water leaking in during the facing work, as the tunnel was to be excavated alongside the Miwa Dam reservoir, below the water level of the reservoir, and construction was to be carried out in the proximity of the median tectonic line. Therefore, a seismic reflection method (TSP method) using elastic waves and a hydraulic rock drill search boring method was applied to anticipate any fracture zones and geologically transitional areas. As a result, there was no significant water inflow. Thus, the excavation was carried out smoothly, according to the construction schedule.

Later, the tunnel was lined and the concrete floor slabs were placed. Work on the tunnel outfall was begun in June 2004 and was completed by the end of May, 2005. Photographs 4 and 5 illustrate the flood bypass tunnel under construction and after completion.

## 4. Test operation/monitoring plan

In the construction of the permanent sediment management facilities in the Miwa Dam, the flood bypass tunnel, the diversion weir and the check dam have been completed, and test operations have been underway since June 2005.

The current Miwa Dam operation rules have been implemented so that fixed release-rate operations are applied when inflow the exceeds 300 $m^3/s$ and fixed release-volume operations are carried out when the outflow rate exceeds 500 $m^3/s$. As a result, water,

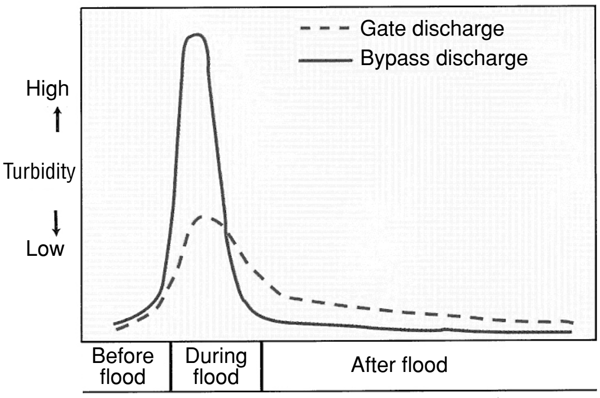


Figure-5 Conceptual diagram of change of turbid water

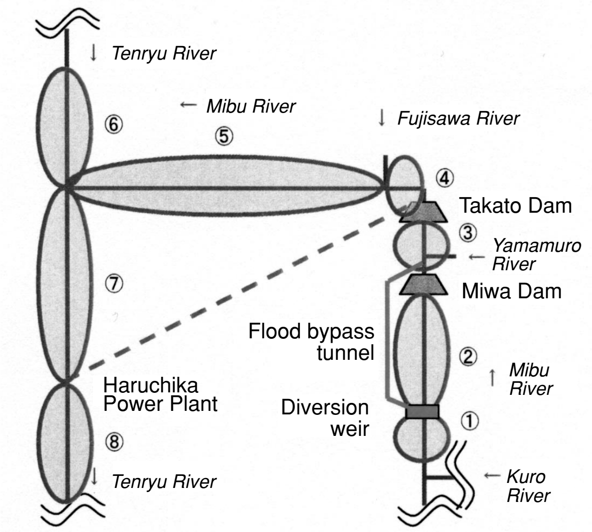


Figure-6 Area surveyed

which had been previously discharged by the main gate of the Miwa Dam, is now partially released through the bypass gate without flowing into the reservoir.

Specifically, bypass operations are performed when the Miwa Dam is required to conduct a gate discharge during flooding, which is expected to occur four or five times a year at a peak inflow rate of $100m^3/s$ or over. Floodwater is discharged from the bypass gate at a rate of up to $300m^3/s$, and the bypass operation is terminated after the inflow rate reaches its peak and declines below $100m^3/s$.

Regarding operational requirements including the inflow rate to start and finish bypassing, the monitoring research results obtained from test operations are analyzed and fed back in order to draw up the most effective operation plan.

In order to examine the scouring effects and evaluate the impact on the downstream environment, the following items are investigated in the monitoring survey.

① Evaluation of the sediment balanced plan

The measured values and assumed values regarding the following four items were compared to evaluate the validity of the plan.

- the amount of wash load flowing into the Miwa Dam
- bed load and suspended load trapped by the diversion weir and the check dam
- sedimentation in the Miwa Dam reservoir
- sedimentation in the Takato Dam reservoir located immediately downstream from the Miwa Dam

② Evaluation of the facility structure

The characteristics of separated flow at the diversion weir, the sedimentation in the flood bypass tunnel and equipment abrasion are examined.

③ Evaluation of effluent turbidity

In comparison with conventional gate discharge through a reservoir, the water washed down by the bypass discharge is of higher turbidity (see Figure 5). Therefore, it is expected that the turbidity of water in the reservoir will be reduced so that the time taken to discharge turbid water from the dam after flooding should be shortened. These effects are being evaluated.

④ Evaluation of impact on local organisms

The impact of changing turbidity in the dam discharge on downstream organisms is being evaluated.

The river section between the upstream area of the Miwa Dam on the Mibugawa River and the confluence of discharge from the Haruchika Power Plant with the Tenryu River is divided into eight areas (see Figure 6), where the following items are being observed: the flow rate, water quality (temperature, DO, SS and SS grain size), the sediment volume in the area downstream of the dam, the riverbed materials, organisms (fish species, zoobenthos and attached algae) and the dry riverbed (water route, vegetation zone and sedimentation). In addition to the regular times of inspection, observations are carried out for certain durations during and after the bypass discharge operation to grasp any changes in the sediment regime and the environment induced by the bypass operation.

A period of approximately five years is allotted for monitoring after the commencement of test operations, during which time the items surveyed and inspection frequency may be reexamined appropriately, depending on the situation. A preliminary survey was begun in 2004, one year prior to the test operation, to compare results with those obtained while operations were in progress. These data will be scientifically and objectively evaluated by the management follow-up committee for dams in the Chubu region organized by the Chubu Regional Development Bureau.

## 5. Conclusion

The major facilities for the permanent sediment management measures of the Miwa Dam redevelopment project, such as the diversion weir and the flood bypass tunnel, were completed and test operations begun. This is the first time that a bypass tunnel has been used to control sediment in a multipurpose dam in Japan and its achievement has attracted a great deal of attention. In addition to restoring and maintaining the functions of the dam, it is expected that the sediment control measures will cause sediment to flow down as naturally as possible from the perspective of the comprehensive sediment management of the basin.

It is hoped that we will be able to contribute to the dam and river basin management not only for this dam, but also for other dams and river systems, by closely studying the results and impact of the permanent sediment control facilities.