Application Note

Unattended Water Quality Monitoring Protects Domestic Water Supply at Taiwan's Shimen Reservoir

The steep 500-meter (1,600-foot) peaks and dramatic canyons that have made the Shimen Reservoir one of Taiwan's popular tourist attractions are the products of massive erosion – erosion that threatens the reservoir's role as a key supply of domestic water.

The problem came to a dramatic head in August 2004, when Typhoon Aili unleashed 20 million metric tons of sediment and debris into the reservoir from the surrounding mountains. Turbidity climbed from the usual 40 NTU to spike at 70,000 to 120,000 NTU. The sediment choked the reservoir's water treatment plant, which was equipped to handle water with no more than 3,000 NTU. Tap water was cut off for days to thousands of households, and residents were forced to rely on water trucked in by the Taiwan Water Supply Corp.

Above: Plumes of suspended sediment from landslides following a typhoon spiked turbidity readings to 120,000 NTU in Taiwan's Shimen Reservoir.

Below: Autonomous vertical profiling systems mounted to pontoons help managers of the Reservoir track turbidity throughout the water column.

The 2004 typhoon was big – at 973 mm (38 inches) of rain, it represented half of a typical year's precipitation – but it wasn't unusual. The area around Shimen Reservoir is typically hit by two to four typhoons per year, and suspended solids discharged by landslides around the reservoir present a constant challenge to the Ministry of Economic Affairs' Water Resources Agency's Northern Region. Adding to the challenge, the sediments often travel in subsurface plumes across the 800-hectare (1,977-acre) reservoir, presenting a hidden hazard that can quickly overwhelm the dam's water treatment facility.

Vertical Profiling

Before the 2005 typhoon season, the Water Resources Agency deployed YSI Vertical Profiling Systems mounted to pontoons at two points in the reservoir. Each profiling system uses a YSI multiparameter sonde to conduct autonomous vertical profiles of the water column as the water approaches the Shimen Dam. The YSI 6600EDS sondes report back to the dam's operations office every three hours, logging **turbidity, chlorophyll, pH, and dissolved oxygen readings every five meters from surface to bottom**. When turbidity reaches critical levels, the profilers' data trigger an emergency plan at the water treatment plant, according to Bergius Su of Taipei-based Smartec, which provided and services the equipment. A team of technicians promptly begins a program of manual sampling to confirm the problem and determine its extent.

Finding the size, shape and depth of the plume allows the water treatment plant managers to choose among several management options:

- Accelerating the fill-up of the storage pond immediately above the water treatment plant;
- Closing any of the plant's five water intakes and opening others to draw in water from clearer levels in the water column and avoid the turbidity plume;
- Drawing water into the plant from a backup source in a nearby river.

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Careful Positioning

Smartec used a SonTek/YSI ADP (Acoustic Doppler Profiler) to identify the optimal deployment locations with minimal current for the Vertical Profiling Systems. The system closest to the dam is anchored in 50 meters (164 feet) of water; the more distant sampling site is 40 meters (131 feet) deep. Forty-kilogram (88-pound) anchors hold the pontoons in place.

Those anchored floats have weathered several typhoons, though vertical profiling is sharply curtailed in rough weather, notes Keith Leung of YSI's office in Hong Kong. When storms hit, Smartec remotely locks the sondes in position immediately beneath the floating platform. At the dam management's request, Su and his team can activate the sondes remotely or manually to sample at 10-meter intervals, or the Smartec crew can begin conducting manual readings with YSI 6600EDS sondes and grab-sampling equipment.

Above: Bergius Su and his team used a SonTek/YSI acoustic Doppler velocimeter to identify optimum sites for the profiling systems deployed to protect Shimen Reservoir's water treatment plant.

Below: Each vertical profiling system features a YSI 6600EDS multiparameter sonde that measures turbidity, chlorophyll, pH, and dissolved oxygen every 5 meters from surface to bottom.

Smartec also conducts monthly calibrations and maintenance of the equipment. Leung notes that the self-wiping feature of the sondes reduces buildup of biofouling, and points out that calibration is a quick process. He adds that the Water Resources Agency staff was already quite familiar with maintenance of YSI equipment because of its years of experience with the 6600EDS sondes, so the dam's staff is quite comfortable with handling the profilers.

Data Flow

The sondes make their journey from the reservoir's surface to the bottom and back every two hours, and report values via wi-fi for all parameters back to the dam office – about 5 kilometers (3 miles) away – every three hours. Their data are integrated with information gathered at eight grab-sample stations. The data are primarily used for managing the dam and water treatment plant; however, the Water Resources Agency has also contracted with a professor from Taiwan University to develop a data-gathering and analysis protocol and develop a water quality model. Ultimately, predicts Su, data from the continuous vertical profilers could be integrated into the Shimen Runoff Forecast Model or the dam's flood control operations.

The chlorophyll and dissolved oxygen sensors on the sondes could someday be used to track the movement of algae in the reservoir, adds Leung, protecting the lake's carp fishery and helping managers prevent anoxic events.

For now, the mission to track suspended sediment is important enough, says Leung. "Every year, landslides triggered by typhoons represent a significant threat to the water treatment plant at the Shimen Reservoir," he points out. "Using long-term, unattended monitoring technology throughout the water column protects the plant from unseen sediment. Doing that, it protects the people who count on water from the reservoir for their household needs. The project at Shimen is an outstanding use of this equipment, going beyond pure science into public service."

Taiwan's Shimen Reservoir

When it was completed in 1953, Taiwan's Shimen Dam was the largest dam in Southeast Asia. At 133 meters (436 feet) high and 330 meters (1,082 feet) wide, the dam holds back 218 million cubic meters (177,448 acre-feet) of water, and its impressive scale and breathtaking scenery make it a favorite stop for tourists in the region.

Some sediment travels into the lake with the flow of the Da-Han River, but the biggest threat from suspended solids comes from landslides in the steep mountains surrounding the reservoir triggered by annual monsoons. The Shimen Dam's water treatment plant can handle water of as much as 3,000 NTU, but plumes of turbid water with many times that concentration of sediment can clog the works in minutes.

The water treatment plant has five separate intakes from the reservoir. Unattended monitoring of the water column helps ensure that intakes are opened and closed to draw clean water and avoid turbid supplies after typhoons, preventing costly damage to the plant and interruptions in the region's water supply.

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