Float your boat remotely

Oceanscience Group explains how its new Z-Boat is improving the safety and accuracy of surveying mine tailings impounds and process ponds

The benefits of using modern positioning equipment in open-pit mining are fairly obvious; elevations within the pit and across much of the mine site need to be known accurately for construction and safety purposes. Equipment operating in the pit must also be tracked and monitored in order to optimise production. These requirements are now intrinsically linked with global navigation satellite system (GNSS) and GPS equipment.

Land surveyors gather traditional GNSS point measurements to update topographic maps of the mine in specialised software programs. The recent introduction of small fixed- and rotary-wing unmanned aerial vehicle platforms for aerial mapping of mine sites has further advanced the collection of relatively inexpensive, accurate survey data. However, one part of mining operations that has largely remained untouched by such technological advances in surveying is the area that is hidden under water in reservoirs or tailings dams.

Water management is a key discipline of overall mine management, but often there is limited knowledge regarding the water resources at a mine. The main reason for this is the relative difficulty in obtaining survey data for these resources, including the tailings settling facility (TSF), process leachate ponds and mine pit lakes at the heart of the site.

The water is often hazardous, access for a survey boat may be difficult, and there exists no standard method or equipment for the mine site to use easily. In the absence of a good methodology for surveying the bathymetry of these water reserves, mine surveyors are often forced to resort to rustic methods to obtain bathymetry data when it is needed. Surveyors in small boats may simply use a long pole, weighted line or recreational fish-finder to obtain an approximate depth to the sediment surface at discrete positions.

Traditional hydrographic surveys using single-beam echo-sounders on dedicated survey boats might be conducted periodically to obtain high-quality bathymetry, either using the mine survey equipment or a contracted surveyor.

An early survey application for the Z-Boat in Africa

However, this method requires personnel on the water and is relatively costly, reducing the potential frequency of data collection.

THE Z-BOAT

Adrian McDonald of the Oceanscience Group, headquartered in San Diego, US, says that mine operators have long been seeking alternatives. "Mine operators have recognised that if available TSF bathymetry data across many of their sites could be improved by faster, easier or more cost-effective surveys, then operational decision-making and planning could be improved," he explains.

Oceanscience has come up with a solution that is quickly gaining traction at mine sites in North America. At first glance, the 27kg, 1.8m-long remote-control Z-Boat 1800 could be mistaken for a toy. However, it is actually a sophisticated hydrographic surveying system.

The boat's position is monitored using GNSS, and an echo-sounder typically working at 33kHz or 200kHz is used to precisely measure the depth under the boat. The sonar 'ping' (or more accurately up to 20 'pings' per second) travels down from the transducer in the boat hull, reflects off the terrain and is received back at the transducer a certain time later; this time is directly proportional to the depth of water under the boat.

Instead of having this survey equipment directly connected to a laptop or data collector, as on a typical survey launch, the Z-Boat's long-range wireless link is used to transmit survey data to the shore, where the operator can be positioned in safety and comfort to conduct the survey using remote navigation. The display on the shore computer assists the operator by displaying the boat position, heading and the completed survey track from a distance of over 1,500m.

According to McDonald, mine engineers interested in gathering TSF bathymetry using a remotely operated boat typically have similar requirements, independent of where the mine is located.

"They're looking for low complexity and high ease of use," he says. "Mine surveyors tasked with generating the bathymetry data usually require a system with simple work processes to limit the requirement for additional training or technical support. They also require resistivity to corrosion and degradation, even in solutions as aggressive as 20% sulphuric acid (pH 0.5)."

He adds: "They need flexibility to match GNSS and sonar instrumentation to the mine's individual needs. Most sites already have access to accurate real-time kinematic [RTK] receivers used with the site corrections network on a remote survey platform. They also need modular construction to allow easy servicing. Since mine sites are often in remote locations, having discrete components that can be stocked as spares prevents downtime." ►

"One part of mining that has largely remained untouched by technological advances in surveying is the area hidden under water in reservoirs or tailings dams"

Tailings dams are difficult to survey

TAILINGS STORAGE FACILITIES

The most obvious application for a remotely operated survey boat is the TSF. As the water stored in the TSF is recycled, water balance engineering models rely on knowledge of the water volume in the impoundment. Additionally, the mine may have a legal obligation to report the TSF water volume periodically. There exists a strong need on the part of the mine operator to understand TSF bathymetry, yet there is no conventional survey method that offers an effective way to complete this task.

Tailings impoundments are characterised by shallow gradients of soft sediment, often with poor access for launching a full-size boat – Oceanscience says that a remote survey boat is an ideal solution for these challenges.

Z-Boats have been deployed in tailings facilities in North America, Africa and Australia. These boats have been equipped with single-frequency 200kHz echo-sounders to detect the 'mudline' and use existing mine RTK GNSS receivers.

For Oceanscience, the tailings impoundment was a new application area for the Z-Boat, which was previously used on rivers and lakes. Electronics engineer Adrian Abordo reviewed available sonar options for the first project.

"Although I was confident that the Z-Boat system would perform as planned, it was certainly new territory to deploy the system in a tailings environment, with challenges from suspended sediment and gradual bottom-hardness transitions," he says.

The first TSF survey was undertaken at a mine in the US. While watching the Z-Boat position on the shore laptop using the DrDepth mapping software package, the mine surveyors guided the Z-Boat around the TSF, obtaining data to about the 0.6m depth contour.

The survey teams recount the previous methodology: "In order to report the water depth and volume in our TSF, we took our GPS rover out on a small boat with a fish-finder to give us a depth reading. As we shot single GPS point co-ordinates, we wrote down the depth from the fish-finder. The process was laborious, produced sparse data, and we had to be out on the TSF for several hours. It was not ideal. Now with the Z-Boat, the survey quality is vastly improved and at the same time we are using safer work processes."

Shortly after the first Z-Boat TSF survey was completed in the US, the second Z-Boat 1800 was in action in Africa. Before the arrival of the Z-Boat, the main problem at this site was the large areas of the TSF that could not be

Ponds and reservoirs

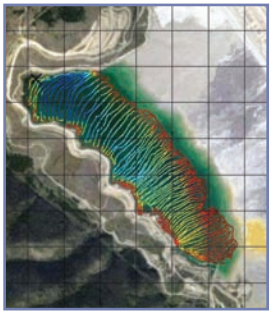
There may be the opportunity to survey TSFs using a conventional survey boat, but process ponds in the mine may simply be too hazardous to employ a manned boat; in which case there is no effective way to conduct a hydrographic survey.

Aggressive leachate solutions may be present, and as water is recycled and invariably carries sediment, these ponds may fill up with sludge. Reliable information on sludge accumulation and water volume is therefore hard to obtain. Pit lakes are usually deep, with regular steep sides from previous mining activities, and are not suited to safely launching a manned boat to conduct a survey.

Instead of focusing on the TSF, engineers at a large mine in the southwest US saw the Z-Boat as a way to obtain regular water-volume data for these reservoirs. Owing to the depth of the pit lakes at this site, the regular 200kHz echo-sounder on the Z-Boat was replaced with a high-specification CEE HydroSystems dual-frequency 33/200kHz CEESCOPE sonar. The powerful low-frequency sonar 'ping' is able to penetrate the deep turbid water of the pit lake, whereas the standard sonar would have been entirely attenuated before even reaching the bottom.

Some components of the Z-Boat propulsion system were changed to resist the corrosive nature of the water, but the basic principle of the surveying procedure remained as for the TSF. Using dual-frequency sonar has long been standard in hydrographic surveying supporting dredging operations. As well as penetrating turbid water, the low-frequency sonar is also able to pass through the upper layers of sediment, while the higher-frequency sonar channel is quickly attenuated in the uppermost few inches of sediment. The differential transmission of the two sonar channels can be used to obtain qualitative estimates of sediment accumulation over a hard bottom, which can be useful for sedimentation or sludge-removal projects.

Survey results from a mine in the US



surveyed, which led to very poor coverage of the total area and highly uncertain volume estimates.

The site surveyor was enthusiastic but apprehensive: "We were primarily interested in acquiring the capability to survey the whole of the tailings dam, but we were concerned about the time requirements for learning an entirely new system".

After solving the inevitable learning-curve problems, the Z-Boat began conducting surveys every two weeks to give a near real-time view of the evolution of the TSF.

HUGE LEAP FORWARD

Reflecting on the first round of Z-Boat applications, McDonald summarises the value of the Z-Boat system.

"With an echo-sounder 'ping' rate set at 2-10Hz, the Z-Boat presents a huge leap forward in survey coverage of the TSF compared with point shots using a sounding pole or a rudimentary sonar system," he says. "Not only is there far better accuracy, but confidence in the calculations that are based on this dataset increases significantly."

Of course, obtaining accurate bathymetry is the start of the process, McDonald adds: "On completion of the survey, depths are converted to elevation and the data set is imported into ArcMap (ESRI), MineSight, AutoCAD or other mine-management software. The bathymetry dataset is merged with existing land-survey topographic data to generate stage/volume/area curves for the TSF, offering engineers accurate existing water volumes and available storage above the existing water, along with identifying deposition patterns in the TSF."

The stage-volume-area curves are vital pieces of information for site-wide water balance models. Engineers know how much water is sent out to the TSF, and how much is pumped back (through flow meters), but often evaporation, seepage and void loss are estimated.

Because these models are used to evaluate water security risks, not knowing the volume of recoverable water in the TSF can be a big data gap. Using a Z-Boat, better estimates of bulk dry density of the tailings are possible, which can be used for future expansion projects.

Consistency is also important, says McDonald: "When you throw a line over the side of a boat, what do you call the bottom? With the Z-Boat, measurements are consistent, so estimates of water-volume change are more reliable."

Z-Boat being launched at a leach solution pond

SAFETY FIRST

While the most obvious outcome of the Z-Boat project across all the sites where the boat has been implemented so far is the data generated, safety was also a key element of the attractiveness of the solution.

"Any industrial process operator is always looking for ways to improve safety incrementally; some locations will inherently have more risks concerned with surveying than others, but in every single case, getting people off the water in an industrial setting is a step in the right direction," concludes McDonald.