A novel approach was taken to cost-effectively close a 4.86 ha unlined industrial wastewater sludge lagoon in North Carolina and reduce leachate production. A floating geosynthetic cover system gave crews and equipment access to the lagoon surface.

By David T. Farber, P.E., M.ASCE, and Phil Comstock

The Syracuse, New York, office of O’Brien & Gere was hired by an industrial client to decommission a manufacturing facility located in North Carolina. A portion of the decommissioning process involved closing a 4.86 ha sludge lagoon that was used to store and dewater waste material from an on-site wastewater treatment facility. The record of decision required that a cap meeting the requirements set by North Carolina’s Department of Environmental Quality be put in place.

The lagoon closure process would require the following:

- Installing a cover over the sludge lagoon to control odors;
- Minimizing leachate generation;
- Preventing contamination of groundwater and surface water;
- Maintaining a stable and secure site.

Determining how to cost-effectively close the lagoon proved to be a challenge. To accomplish the closure and minimize the leachate generated, the amount of precipitation allowed to seep through the sludge had to be reduced. It was first thought that this would require the sludge to be solidified through in situ stabilization methods and then be disposed of off-site or capped in place using a low-permeability cap system.

Based on preliminary testing, disposal of the sludge off-site was deemed impractical because of the sludge’s characteristics, namely, significant water retention, difficulty in dewatering or solidifying the material, and significant volume.

Stabilization and capping in place, which were preferred to reduce leachate from being generated, proved to be just as difficult because of a number of obstacles. For instance, the sludge consisted of polymers used in an industrial wastewater treatment process. These polymers were part of the sludge by-product that would not freely release the water, making in situ stabilization very difficult and costly. Furthermore, the thickness of the sludge ranged from 2.13 m to 2.74 m, and the sludge could neither stand on its own (having no shear strength) nor support a work crew or the equipment needed to install a low-permeability cap system. Finally, without sludge solidification, a low-permeability geomembrane and a thin soil cap system would undergo excessive settlement, which could adversely affect the effectiveness of a low-permeability cap system.

From these considerations, it was clear that an innovative solution for closing the sludge lagoon and reducing the generation of leachate would be needed.

Finding the solution began with field activities to collect samples of the sludge at varying depths using a grid pattern. Of the samples collected, 24 were tested for moisture content, pH, and organic content. The tests yielded the following results:

- The sludge did not act or react as a soil. It had the consistency of a gel-like material that chemically affixed water to the sludge. This chemical bonding of the water mole-
Solidification testing involved taking multiple samples of the sludge and performing bench-scale solidification tests using a variety of admixtures:

- Slag cement;
- A blend (60/40) of portland cement and bentonite;
- Portland cement only;
- A blend (60/40) of portland cement and lime;
- Agricultural lime;
- Quicklime.

The percentages of the solidification agents added ranged from 10 to 60.

Bench-scale solidification testing revealed that the water-bonding properties of the sludge limited the effectiveness of dewatering and stabilization through solidification. The amendments typically used in the solidification process, such as cement (portland and lime), rely on the water within the sludge to activate the amendment and increase the stability of the sludge. The tests also revealed that since the admixtures were not able to absorb the water from the sludge, it would not be possible to strengthen the sludge to any extent. Finally, the sludges exhibited practically no shear strength increase after amendment addition. Testing the shear strength of the amended sludge was attempted but could not be performed because the amended sludge was unable to support its own weight.

The bench-scale sludge solidification analysis established that the sludge could not be cost-effectively stabilized by amendment addition to the sludge to migrate or generate leachate on its own. Precipitation, however, if allowed to flow through the sludge, could generate leachate that would need to be collected and treated. The sludge would not be able to support the weight of a covered system. It was predicted that a very limited amount of biogas would be produced for a short period of time after the floating cover had been put in place. A passive vent system could not be installed because of the risk of wind or air blowing back under the cover and creating an unstable uplift condition. The solution for this was to install six manually operated valves to release the biogas that would be generated after construction. The sludge produced a limited amount of biogas during the first six months after capping. With the removal of precipitation, the sludge has not produced any additional biogas since that time.

As more industrial and municipal facilities modify their processes or look to close aging sludge lagoons, the need for a cost-effective closure method that does not require sludge handling or stabilization that can be implemented in a relatively short time frame will become more pressing. A floating geosynthetic cover system can be used either as a temporary cover or as a means of permanently closing a lagoon system in a way that also manages leachate generation. This project demonstrated that a sludge lagoon can be closed in a cost-effective manner using a floating geosynthetic cover as an alternative to the more traditional approaches of sludge solidification or dewatering and off-site disposal.

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**PROJECT CREDITS**
