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Designer's Forum- Beneath the bubble: industrial lagoon closure

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Editor's note: In the August issue, Designer's Forum featured part one of two on geocellular system performance. Part two will be published in October.

Many industrial waste treatment systems include lagoons that become regulated under RCRA once the treatment system is closed. Most of these lagoons were originally permitted with little regard to their impact on anything other than the water quality of treated effluent. However, under RCRA the historic impact of the lagoon on the immediate ground water quality and potential hazardous constituents in the contained sludges must be addressed. This article presents the design considerations for closure of a lagoon leaving the sludge in place. The interesting twist to this closure is the presence of an air-support "bubble" structure over the lagoon during much of the closure.

Lagoon background

This 1.5 acre sludge lagoon was the last step in the wastewater treatment process. Historically, the facility effluent was chemically treated to flocculate out solids in the lagoon. Several decades of operations had left a significant volume of sludge within the lagoon. The wastewater was also aerated by two large pile-supported aerators mounted within the lagoon and a number of small floating aerators to remove volatile wastes. As a result of this aeration, the lagoon had been covered by the "bubble" to contain odors as shown in **Photo 1**.

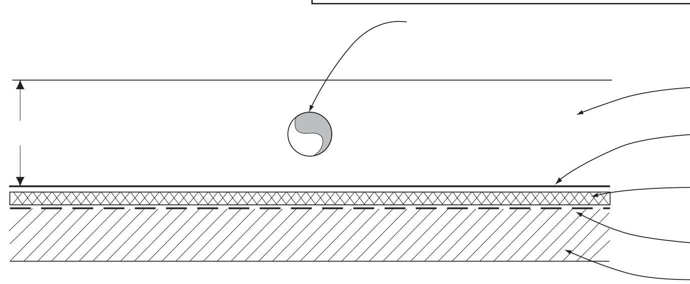
Photo 1. Inside the "bubble."

The client required that this bubble remain in place until the sludge was contained by an equally effective means of controlling the odor. This meant that a portion of the closure work would have to take place beneath the bubble. The presence of the bubble limited equipment access to the lagoon and meant that all construction materials had to pass through air portals.

Extensive field and laboratory geotechnical testing of the sludge was performed to define shear strength and consolidation characteristics. Existing shear strengths of the sludge ranged from essentially zero to 50 psf. Consolidation testing of the sludge indicated that the water content of the sludge could be significantly reduced with even minor loading. The dewatering of the sludge increased its shear strength sufficiently so that it became an acceptable subgrade material.

Based on the geotechnical testing, a closure plan was developed that called for a staged loading of the sludge to increase its shear strength to at least 65 psf. Additionally, the final stage of consolidation loading was to be larger than the loading applied by the RCRA final cover. This would produce an over-consolidated condition in the sludge that would limit future movement of pore water into the surrounding groundwater. The mechanism for consolidation also had to be compatible with the goal of limiting air emissions.

Figure 1. Phase 1 geosynthetics.



Reflecting the site constraints, the final cover design included three phases: 1—isolation and initial consolidation, 2—fill placement, and 3—placement of RCRA cover. Each phase had distinct design challenges.

Phase 1—isolation and initial consolidation

The initial and most difficult phase of closure had the dual goals of containment of the sludge related to air emissions and the initial consolidation of the sludge itself. All of the Phase 1 work was performed under the bubble. **Figure 1** shows the geosynthetic components that were key to the success of Phase 1.

A 36-mil metalocene (mPE) geomembrane provided isolation of the sludge. A drainage composite and high strength woven polypropylene reinforcement fabric are below the geomembrane: the drainage composite to collect consolidation water coming from the sludge, and the high strength woven reinforcement to aid in load distribution.

Photo 2 shows the completed geosynthetic system in place beneath the bubble. This photo is generally referred to as "walking on water." Each layer was fabricated outside of the bubble, rolled up and passed through a modified airlock portal and then unrolled for final deployment.

Photo 2. "Walking on water."

The rate that water could be removed from beneath the geomembrane was limited by the capacity of a newly constructed wastewater treatment facility to receive it. Initial loading of the geomembrane was accomplished using only clean water to surcharge the geomembrane. While producing only a limited increase in the strength of the underlying sludge, completion of this phase allowed removal of the bubble shown in **Photo 3**. Prior to removal of the bubble, Styrofoam sheets were floated over the pond to further protect the geomembrane from potential damage from the steel cabling used to secure the bubble. Bringing the bubble down took less than 10 uneventful minutes due to these precautions

Photo 3. Removal of the bubble.

Phase 2—fill placement

With the bubble removed, clear access was available around the full perimeter of the pond. The clean water over the geomembrane was pumped off as the soil cover was placed over the area. Soil cover placement began on the eastern end of the lagoon and moved west. Initially, soil was placed using conventional equipment. This unfortunately resulted in much of the lower strength sludge being squeezed to the west which, in turn, led to a bulge beneath the geosynthetics by the time soil placement reached the middle of the lagoon. The contractor continued placement until this bulge led to a tear in the geomembrane. Fortunately, the tear occurred high on the bulge, so no supernatant from below the geomembrane was released. The tear was repaired, and the contractor realized the need for a new approach to soil placement.

The revised soil placement technique centered around a unique conveyor truck originally designed for placement of rip-rap. As shown in **Photo 4**, the conveyor truck (Telebelt) allowed pinpoint placement of soil without the need for equipment directly on the geosynthetics. The Telebelt could place up to 1500 cubic yards of fill in an eight hour shift and enabled all bulges to be loaded and flattened. The rate of fill placement was limited by the rate of treatment of the new wastewater plant and not the Telebelt. The Telebelt was used to place approximately 5 ft. of cover over the geosynthetics. After this placement, conventional means could again be used to place the fill.

Photo 4. Placement of soil.

During placement and throughout the next year, settlement of the sludge was monitored using settlement platforms installed while the fill was being placed. In addition to the platforms, pore pressure monitoring was conducted by using vibrating wire transducers within piping below the geosynthetics. Plotting this data verses time provided an indication of what stage of consolidation the underlying sludge was in. After one year, the consolidation was sufficiently completed so that placement of the final cover could occur. In addition to fill during this phase, perforated pipe was installed over the metalocene geomembrane to allow future removal of liquids on top of it. This will provide a measure of the long term performance of a very common RCRA final cover system.

Phase 3—placement of RCRA cover

Once the majority of primary consolidation was finished in the sludge, the fill was regraded to final cover contours. The RCRA final cover consisted of the following from bottom up:

- reinforced geosynthetic clay liner (GCL)
- 60-mil HDPE geomembrane
- geosynthetic drainage composite
- 28-in. of sandy vegetative support soil
- 6-in. of topsoil with grass cover.

Photo 5 shows the construction of the final cover moving west to east. The soil was graded to provide a typical slope of 3% to the perimeter. **Photo 6** shows the completed final cover over the lagoon.

During this same time, the pipes placed over the consolidation geomembrane, immediately over the waste, were brought to the surface through the cap. As mentioned earlier, these pipes allow for actual leakage monitoring of the final cover. Future infiltration data from these collector pipes will be of great interest.

Photo 5. Geomembrane installation.

Photo 6. Completed final cover.

Summary

The in-place closure of the lagoon provides a strong demonstration of the powerful roles geosynthetics play in environmental applications. The design followed the "design-by-function" mantra with each geosynthetic component performing a specific function in the overall project. In essentially 18 months, the sludge was transformed from a material that could not support a man to a suitable foundation for a RCRA final cover. No other alternatives would allow in-place closure of this lagoon without a high potential for significant air emissions. GFR

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Call for submissions

GFR is currently seeking submissions for its March and April issues. Some of the scheduled topics for March include road and rail longevity, landfill expansion, stormwater management, CQA and risk assessment, and hazardous waste containment. For April, the editors seek articles on shoreline development, sediment control, groundwater protection, leachate management and drainage.

Other topics and projects welcomed. Deadlines begin in early December. Contact the editors for writer's guidelines: The Editors, GFR Magazine, 1801 County Rd. B W., Roseville, MN 55113-4061; +1 651 225 6988, fax +1 651 225 6966, e-mail gfr@ifai.com, Web site www.gfrmagazine.info.