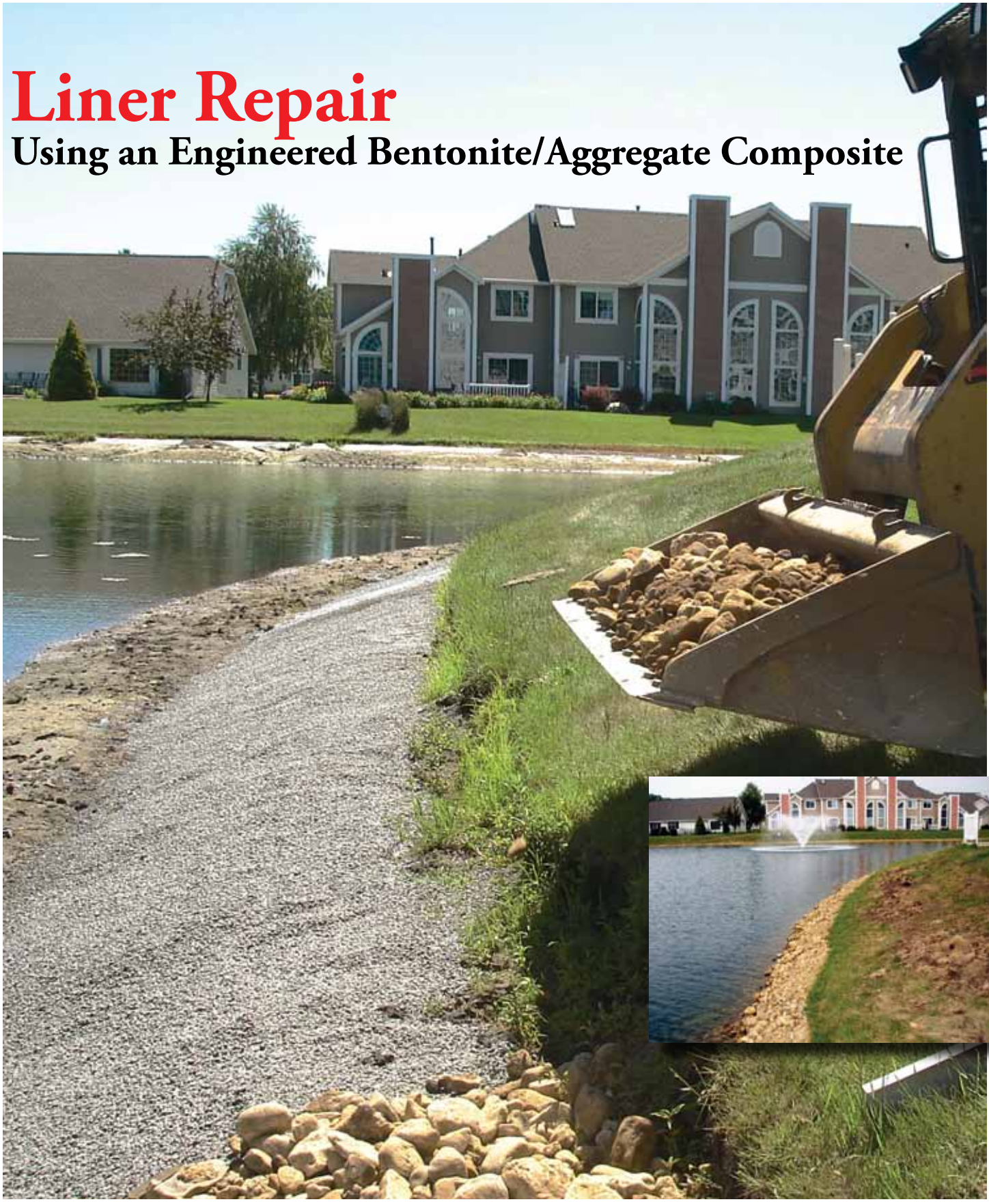
Liner Repair

Using an Engineered Bentonite/Aggregate Composite



Above: Placement of armor stone (for erosion protection, site safety, and visual appeal) atop the pre-hydrated bentonite/aggregate composite. Inset: Waterford Lake, post-liner repair. Note water level has returned to desired/designed level.

Even in the "Land of 10,000 Lakes," soil conditions are not always conducive to holding water when trying to construct a lake or pond. This was the case for the Waterford townhome development in Rochester, Minnesota. The on-site soils contained a high percentage of sand, so the decision was made to utilize a high-density polyethylene (HDPE) synthetic geomembrane liner in the construction of the basin at the center of the development. The liner was installed in 1994 and served well in keeping the 2.6-acre "lake" at the designed level for 15 years.

The Problem

In 2009 the Townhome Association noticed that the lake was no longer maintaining its designed level. Even after being filled by snow melt and rain fall events it took just a few days for the lake to drop below its desired level. With leaking lakes or ponds just finding the source of the leak can present a herculean challenge. Fortunately that was not the case with this project. With some careful inspection, homeowners discovered that over the years the cover material (~12-inches of sand and gravel) on sections of the upper slopes of the liner had washed away, leaving it exposed to the ultra violet rays of the sun and increased stress from ice and even from simple foot traffic. While known for UV resistance (even without cover), HDPE – like any synthetic geomembrane – has its vulnerabilities and life expectancy. Inherent lack of flexibility can cause brittleness in the material and, especially when exposed to the elements (e.g. shifting ice), problems can develop. These forces combined to cause damage to the liner at Waterford. They resulted in tears and holes ranging in size from three inches to five feet. As water crested compromised portions of the liner, it could now easily seep down into the sandy soil.

The Townhome Association approached Jonathon Kusa, P.E., with HR Green, Inc. for advice on how to remedy the problem. In his words, he advised "not (to) fix the liner, but cover it with some impervious fill." Even though this solution was much more cost-effective than patching the individual holes and voids in the liner using traditional methods, the Townhome Association was forced to put the project on hold until the summer of 2012 because of budgetary restraints.

Contractor removing up to 12-inches of cover sand/soil atop the compromised HDPE liner using a power washer at moderate pressure.

Construction Challenges & Solutions

Fraser Construction from Rochester, Minnesota was the contractor selected for execution of the repair project. There were a total of 2,560 linear feet or just over 10,000 square feet of shoreline identified to be addressed (2,560 linear feet x 4 foot width, on average). The Association passed along the engineer's recommendation of a very low-permeability, bentonite-based barrier, and the contractor was left to determine the proper course of action.

First, extrusion welding was eliminated as an option fairly early on because of the extensive preparation necessary (i.e. drying, cleaning, priming, and welding). In addition, this alternative is further complicated when attempting to adhere new liner material to geomembrane that is weathered and generally structurally unstable.

Second, traditional compacted clay was considered as an option, but classic challenges again made this alternative less than attractive. Sourcing reliable and consistent clayey soils in the immediate area is difficult (adding material cost in delivery). Material quantities and associated handling would be substantial because a minimum of 18-24" of compacted clay was being contemplated (not only would this need to be added, it would also need to be removed from the basin to maintain the existing grade). Additionally, site access and confined space would have made placement and desired compaction very difficult, if not impossible. Feet of native clay would have been necessary, but thickness alone is not the entire fix. Countless experiences from the field make clear that proper compaction – typically using substantial equipment like a sheep's foot roller – is typically a must for a native clay liner to be effective.

Finally, a manufactured composite of crushed stone aggregate wrapped with powdered sodium bentonite (patented and trade named as AquaBlok®) was evaluated as a sealant to cover and protect the failing portions of the HDPE liner. As a pour-in-place backfill, the engineered bentonite does not need to be field blended (i.e. mixed with the on-site soil) because, for the particular formulation used on the project at least, it is 20% bentonite and 80% stone core, by weight, right out of the packag-

A typical cut in the HDPE liner impacting an approximately 2′ x 6′ area of the basin's shoreline edge - probably caused by a combination of UV exposure, ice damage, and age.

ing. And because of the weight and density of the stone aggregate, it does not need to be mechanically compacted. Instead of truckload after truckload of local material hauled out (with truckload after truckload of clay hauled in), just under 60 tons (less than three total truckloads) of the bentonite/aggregate composite completed the sealing job. The material was applied at a targeted 1.5-inch material thickness (~10 lbs per square foot) by direct placement from its shipping unit (packaged in a super sack or bulk tote). It was raked by hand to ensure uniform coverage.

Other unique physical properties made this final engineered bentonite product the logical choice. Even at this relatively thin application rate, AquaBlok achieves a consistent hydraulic conductivity of 10^{-7} to 10^{-8} cm/s and remains structurally stable and highly durable – due, in large part, to the internal stone structure coupled with the natural properties of high-quality sodium bentonite. Dusting is minimal and the composite material can even be placed through standing water without drift or clay loss. It heals if disturbed, withstands repeated freeze/thaw cycles, and reseals when re-hydrated following exposure to extreme drought conditions.

Application Method

The contractor determined that the first step in this application would be to lower the lake level to improve access to the target areas. They then needed to remove the

Placement of the bentonite/aggregate composite directly out of a shipping tote (note suspension of the bulk super sack on a long-reach forklift).

remaining cover material. However, any attempt to do this mechanically (i.e. with a loader bucket or even shovels) would have done even more damage to the already compromised and fragile liner. To prevent this, they elected to use recirculating trash pumps and power washers (at moderate pressure) to displace the remaining cover material on the upper five feet of the basin's shoreline slope. They had two operators, each with their own equipment, to expedite the process. Although somewhat time consuming, the method was very effective in cleaning off the cover material and in revealing all the damaged areas that needed to be treated.

With the lake nestled within the townhomes and the associated manicured landscape, access to the site was one of the obstacles the contractor had to overcome. Working in such confined quarters, the contractor was limited to using only a Caterpillar skid steer loader and Telehandler (long-reach) forklift. The forklift served two proposes – first to unload the totes from the delivery trucks, and second to carry the totes between buildings and along the shoreline to extend the material over the application zone. The totes came equipped with a bottom, draw-string closure discharge spout. However, the contractor found it was easier to cut the side of the totes facing the water from the top down using a utility knife as they moved down the shoreline. Between the forklift operator and one laborer cutting bags and

raking the product out (again, to ensure uniformity of material thickness) they were able to cover around 320 square feet per hour treating the entire shoreline in around 32 hours. A cubic yard (2,400 lbs) could be discharged from a bag and spread over the corresponding 240 square feet in a matter of 20 minutes or less, but a fair amount of time was needed to shuttle the sealant material back and forth between the pond and an adjacent parking lot/staging area.

This cover layer accomplishes three primary goals: (a) it provides erosion protection from wind and waves by armoring the sealant layer beneath, (b) it provides a barrier above the sealant which, like any clay, tends to be slippery when wet (a safety consideration), and (c) it offers a decorative and aesthetically pleasing boarder for the basin.

The final step in the process was to cover the bentonite/aggregate composite with a layer of two to three inch riprap using the skid steer loader. This cover layer accomplishes three primary goals: (a) it provides erosion protection from wind and waves by armoring the sealant layer beneath, (b) it provides a barrier above the sealant which, like any clay, tends to be slippery when wet (a safety consideration), and (c) it offers a decorative and aesthetically pleasing boarder for the basin. To keep the bentonite/aggregate composite material from shifting and sliding as the riprap was placed the contractor sprayed the sealant with lake water so the bentonite would begin to hydrate and stick together as it started to swell.

Cleaning of the liner and riprap placement were the two most time consuming parts of the project. Fraser Construction finished the project, from mobilization through cleanup, over a 2.5 week period in June of 2012.

The residents are pleased with the finished results. Dirk Erickson, representative with the Townhome Association, commented "This product was easily applied to the intact and ripped portions of the Lake Waterford liner. To date, the water level of the lake has remained at the desired level." In fact they are utilizing the bentonite/aggregate composite on other problem areas in other lakes that they maintain. Not a silver bullet, but another tool in the proverbial toolbox for sealing applications in Minnesota's 10,000 lakes . . . and beyond. **L&W**

by Kevin VanTuyl & Brent Vatland

Latitude: 44° 0' 55.6749" N
Longitude: -92° 28' 40.5699"W

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