LINING TECHNOLOGIES

Literature Review

GCLs FOR ANIMAL WASTE CONTAINMENT

Today, large commercial farms are operating with herds numbering in the hundreds and even thousands of head of livestock. These farms generate a tremendous amount of waste and the impact of the local environment can be significant. It is estimated that 70% of animal waste now comes from 5% of the operations.

Environmental agencies are concerned about the potential groundwater contamination that can occur from these large livestock operations. To determine the compatibility of livestock waste with a GCL, a hydraulic conductivity test was performed by an independent laboratory on a membrane-backed GCL in accordance with ASTM D 5887. The GCL was permeated with animal waste leachate in this evaluation. Permeation was allowed to continue for four pore volumes.

Test data resulted in a hydraulic conductivity of 4.8×10^{-10} cm/s when permeated with animal waste. This permeability is below the product specification and below the USDA-NRCS permeability requirement of 1×10^{-9} cm/s.

Following the testing program, it was concluded that a membrane backed GCL is acceptable for use as a lagoon liner in an animal waste application.

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GCLs for animal waste containment

By James T. Olsta, P.E., Steve Fishman, and Greg Wright

More large commercial farms with more livestock increase environmental impact

Photo 1. Pipe penetration sealed with a secondary GCL collar and a bentonite-based mastic.

In the past, agricultural operations were primarily family farms with small livestock herds that generated relatively little waste—and environment impact was insignificant. Today, large modern commercial farms, with herds numbering in the hundreds, or thousands, are common. So are significant waste-management problems. The Environmental Protection Agency (EPA) estimates that there are approximately 450,000 animal-feeding operations (AFOs) in the United States. They also estimate that, due to industry consolidation, 70% of the animal residual comes from 5% of the operations.

Animals are kept in barns with elevated walking surfaces and slatted floors that allow waste to be flushed into waste-containment pits that hold the waste until the liquefied manure can be removed and applied to nearby crop fields, an application typically restricted to before or after the growing season. The waste-containment pits protect groundwater. This article discusses the use of geosynthetic clay liners (GCLs) in waste-containment pits.

National Pollutant Discharge Elimination System (NPDES) regulatory effluent guidelines call for no discharge from AFOs, except during a 25-year, 24-hour storm event. Thus, sufficient storage capacity is required to handle both the animal residuals and rainfall. Many AFO owners prefer lagoons because of their low cost per unit volume. A United States Department of Agriculture–National Resource Conservation Service (USDA-NRCS) survey of agricultural waste-management systems constructed in Minnesota reported that from 1994-97, 62 unlined lagoons, 57 soil-lined lagoons, 16 membrane-lined lagoons, 7 concrete-lined lagoons, 29 concrete tanks and 8 metal tanks were in use.

State EPAs are concerned about groundwater contamination from waste leaching from lagoons. The USDA-NRCS has determined that many natural soils will seal themselves at least partially as the result of exposure to manure solids. Physical, chemical and biological processes occur that reduce the permeability of the soil-manure interface. For these cases, USDA-NRCS recognizes an acceptable initial seepage loss of 1×10^{-5} $cm^3/cm^2/s$ (9200 gallons/ acre/ day).

However, many state AFO lagoon design regulations do not take manure sealing into account and require the same seepage loss as allotted to municipal wastewater treatment lagoons—less than 5.4×10^{-7} $cm^3/cm^2/s$ (500 gallons/ acre/day).

GCL characteristics

Since their introduction in the 1980s, geosynthetic clay liners (GCLs) have become a common material in the design of landfills and wastewater treatment lagoons.

A GCL consists of a layer of sodium bentonite bonded to one or more geosynthetics. Several different types of GCLs are currently produced in the United States: 1) bentonite adhesive-bonded between two geotextiles, 2) bentonite needlepunch-bonded between two

Photo 2. Unrolling a GCL at Welch Farms in Winona, Minn.

geotextiles, 3) a thin membrane laminated to one of the above, 4) bentonite adhesive-bonded to a geomembrane. GCLs without a membrane have a hydraulic conductivity of $\leq 5 \times 10^{-9}$ cm/s and a typical hydrated thickness of 0.7 cm. Membrane-backed GCLs have a hydraulic conductivity of $\leq 5 \times 10^{-12}$ cm/s. Using Darcy's Law, one can determine the acceptability of GCLs as follows: assume a state where USDA-NRCS allowance for manure sealing is accepted and the required seepage loss is 1×10^{-5} $cm^3/cm^2/s$ (9200 gallons/acre/day).

$Q = k * i = 1 \times 10^{-5}\ cm^3/cm^2/s$

where Q = seepage loss

k = hydraulic conductivity of the GCL

i = hydraulic gradient = (head + liner thickness)/liner thickness

Assuming a 10-ft-deep lagoon:

$k * ((10\ ft)(30.48\ cm/ft)+0.7\ cm)/0.7\ cm$

$= 1 \times 10^{-5}\ cm^3/cm^2/s$

or $k = 2 \times 10^{-8}$ cm/s.

Under USDA-NRCS guidelines allowing for manure sealing, any type of GCL is an acceptable lagoon liner. However, in states that do not allow for manure sealing, the seepage loss and required hydraulic conductivity decreases by one order of magnitude. In these cases, where the liner must achieve a 1×10^{-9} cm/s hydraulic conductivity, a membrane-backed GCL is required.

To determine the compatibility of livestock waste with a membrane-backed GCL, a compatibility hydraulic test was performed by an independent laboratory. A thin (4-mil polyethylene) membrane-backed GCL was assembled in a flexible wall permeameter device per ASTM D 5887. The membrane-backed GCL was hydrated and then permeated with leachate from dairy waste supplied by a Minnesota USDA-NRCS office. Permeation was allowed to continue for four pore volumes. The final hydraulic conductivity was 4.8×10^{-10} cm/s, below the product specification, and indicated that the membrane-backed GCL was compatible with the livestock waste.

GCLs have been installed at several Minnesota animal residual containment sites, where they provide several advantages to AFO owners over compacted clay liners and geomembranes. A foot of 1×10^{-7} cm/s compacted clay is required to meet the USDA-NRCS requirement without allowance for manure sealing. Compacted clay is not always readily available in sufficient quantities. Even when it is available, additional variables need to be taken into consideration to achieve a low-permeability compacted clay liner, including removing vegetation and large stones, breaking up clods, reaching proper moisture content and obtaining compaction equipment. Additionally, geomembranes typically require special crews for installation and seaming. Also, geomembranes cannot be seamed during cold weather and do not provide self-healing capability. Owners have found that GCLs are easily installed by local contractors, amenable to cold weather installations, self-healing and cost-effective.

Photo 3. Partially installed GCL at Welch Farms.

In GCL installations, contractors shape the lagoon with a bulldozer and smooth roll the subgrade. Pipe penetrations are sealed with a secondary GCL collar and a bentonite-based mastic (**Photo 1**). A front-end loader with a spreader bar attachment is used to maneuver the GCL. A crew of four laborers can unroll the GCL into place. Adjacent GCL panels are overlapped 15 cm (6 in.) with a 0.37 kg per lineal meter (0.25 lb per lineal foot) bead of granular bentonite placed between them. A 0.3-m (1-ft) cover is placed over the GCL to create confining pressure.

Welch Farms, Winona, Minn., installed a 3,000 m^2 (30,000 ft^2) waste-containment pit using a membrane-backed needlepunched GCL, Bentomat CL™, **Photos 2 and 3**. A needlepunched GCL was used because the waste containment pit had 3:1 side slopes. A membrane-backed GCL was used to meet the Minnesota Pollution Control Agency's regulatory requirements. The job was performed by a local excavation firm using a spreader bar rented from the GCL distributor. The GCL was placed membrane-side-down to provide optimal slope stability while helping protect the membrane from damage during installation.

A GCL installation is typically completed in one or two days, with an average 4,200 m^2 (45,000 ft^2) placed per day . Materials and installation costs range from \$0.52 to \$0.72/sf, depending on the location and size of the lagoon. GFR

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