EXPERIENCE WITH GCLs USED AS A CONDUCTIVE LAYER IN GEOMEMBRANE LEAK-LOCATION SURVEYS

With the increasing use of GCLs as the low permeability soil component in a composite liner, questions have been raised about the electrical conductivity that can be expected through a GCL. This issue is important to many contractors who use electrical leak-location systems to detect leaks in installed geomembranes, because a source of electrical conductivity is needed for the equipment to accurately locate leaks. The authors of the following paper have used electrical leak-location devices on GM/GCL liners for 10 years and have found a GCL to be an excellent conductor, primarily because of the moisture contained in the bentonite layer. In addition, the authors state that a GCL with as-manufactured moisture content provides adequate conductivity, although the field moisture content will typically be much higher, due to moisture from the subgrade. Based on the discussion above and the data and remarks presented in the following paper, a GCL is fully compatible with electrical leak-location systems.

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Experience with GCLs used as a conductive layer in geomembrane leak-location surveys

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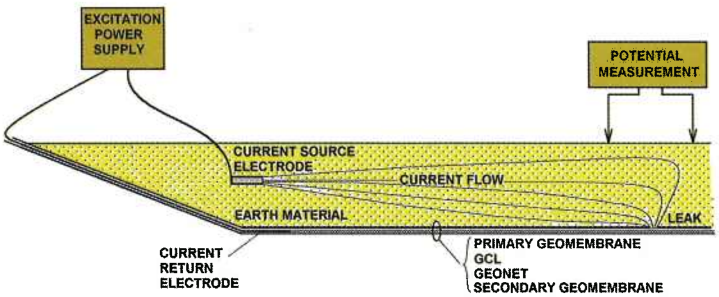

Figure 1 | Principle of the geomembrane leak-location method

Engineers, installers, regulators, and owners are starting to rely on geomembrane leak-location surveys as part of the construction quality assurance for landfills. The various methods are described in ASTM Standard D 6747.[1] Standard procedures for conducting leak-location surveys of geomembranes covered with earth materials are described in ASTM Standard D 7007.[2]

Figure 1 shows the principle of the method. The electrical method is to detect the points where electrical current flows through holes in the geomembrane and requires electrically conductive media above and below the geomembrane being tested. For leak-location surveys of landfill geomembranes covered with earth materials, the earth materials provide the conductive layer above the geomembrane.

Often a geosynthetic clay liner (GCL) is used under the primary geomembrane. This GCL has been used as the conductive layer under the geomembrane on many successful geomembrane leak location surveys for more than 10 years.

Design and preparation factors

In some cases, a successful geomembrane leak-location survey depends not only on the proper performance of the survey itself, but also on the design of the liner system and proper preparation of the liner system prior to testing. Smith et al.[3] describe in detail those factors that will influence the performance and sensitivity of a geomembrane leak-location survey. The technical paper provides excellent guidance and should be consulted during the design of geomembrane liner systems if a leak-location survey is specified or evenly remotely possible.

Although major construction damage can usually be found, certain landfill liner designs can reduce leak detection sensitivity and hinder the detection of holes. In single-geomembrane designs, or in double-geomembrane designs with a clay or drainage layer between the geomembranes, the earth materials readily provide the required conduction layer under the primary geomembrane.

In some applications, instead of using a thick earth material layer between the geomembranes, a GCL is installed. Most GCLs consist of a thin layer of sodium bentonite sandwiched between two geotextiles. Sometimes the bentonite/adhesive layer is laminated to a geomembrane.

GCLs are used in place of a thick compacted clay liner where clay is not available or is expensive. GCLs provide an equivalent low permeability layer with the advantages of being very easy to install, not requiring a nearby clay source, not taking up air space, and not being subject to construction delays that may be needed to dry or wet the clay to allow proper clay compaction.

GCLs for leak-location surveys

GCLs have sufficient electrical conductivity for performing electrical leak-location surveys of an overlying geomembrane. Although GCLs are delivered in the so-called "dry state," they typically contain 10-25% moisture by weight. The bentonite clay is hygroscopic, and attracts water moisture from the air. In fact, as the bentonite is mined, it is allowed to air dry from its native state and then kiln dried to remove more moisture from the clay. Even then, the bentonite retains 8-10% moisture. This moisture is enough to make the GCL electrically conductive.

GCLs used under single geomembranes will also attract moisture from the underlying soil, so one can expect good conductance. GCLs are also used between the geomembranes in double-geomembrane installations in conjunction with a drainage layer consisting of geonet, earth materials, or both, or with only a GCL between two geomembranes in an encapsulated liner. GCLs are used directly below the geomembrane to seal small leaks in the geomembrane. Preferably, geomembranes

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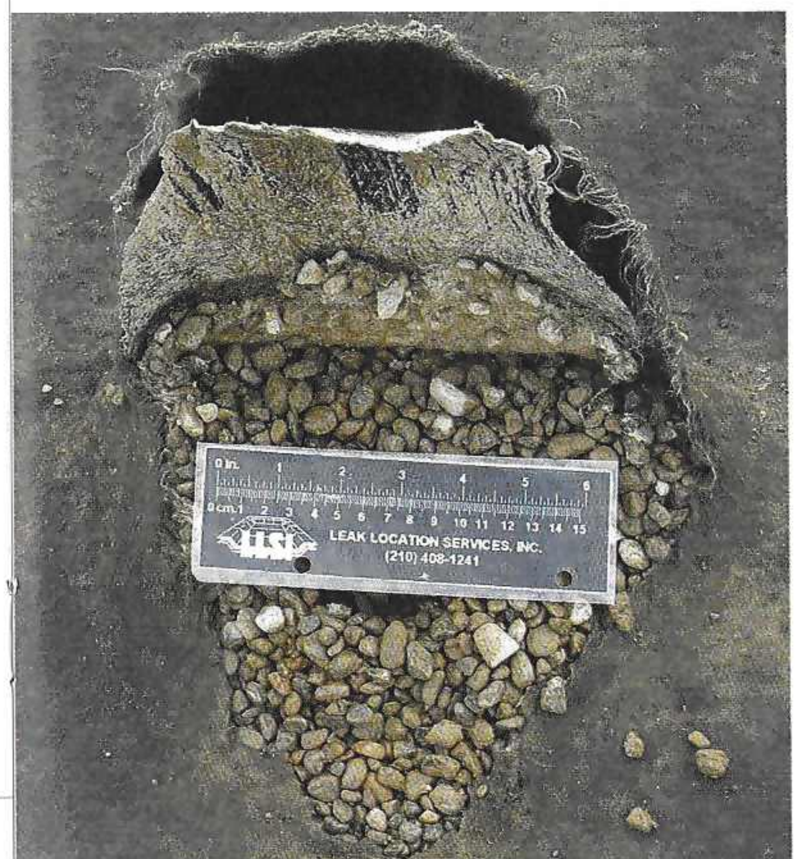
| Leak location survey on geomembrane covered with earth materials.



| Construction damage through geomembrane and GCL.

are installed in intimate contact with the GCLs so any leakage is confined to a small area. The leakage through a GCL depends on the size and shape of the defect, the permeability of the underlying soil, and the contact conditions between the geomembrane and the underlying soil (Toutze-Foultz and Giroud[4]).

The industry is concerned about leaks in a geomembrane even when the geomembrane is underlain by a GCL to seal any holes. This is because GCLs are most effective in sealing leaks 1 in. or less in diameter. Also, the most serious holes in geomembranes are from construction damage occurring during the placement of the earth materials above the geomembrane (Nosko et al.[5]). These are typically large holes. Furthermore, if the primary geomembrane is damaged during the installation of the earth materials, the damage will most likely breach the GCL as well. The secondary geomembrane could also be breached if a thick soil layer is not placed between the geomembranes.

The keys to performing a successful leak-location survey when using GCLs as a conductive layer are: provide good electrical contact between the leak location electrode(s) and the clay component of the GCL; maintain adequate moisture in the materials above the geomembrane; and provide intimate contact between the GCL and the geomembrane. There are too many combinations of layering, types of GCLs , and site conditions to provide recommendations in this article, but knowledgeable and experienced leak location contractors can be consulted to provide the best approach to meet these requirements.

GCLs are most advantageously installed directly under the geomembrane. The geomembrane/GCL can be installed primarily in three configurations: 1) over a prepared earth subgrade, 2) over an earth material drainage layer and a secondary geomembrane, or 3) over a geosynthetic layer and secondary geomembrane. Note that the third configuration is an encapsulated system where a GCL is the only electrical conductor between the geomembranes. Each configuration presents different conditions for leak-location surveys. The examples presented in the next section offer results of several cases for each configuration.

Documented case histories

The authors have performed more than 100 successful geomembrane leak-location surveys with a GCL under the geomembrane. To limit the number of examples without a biased selection, only the surveys performed in 2006 are presented here. In addition, the cases are limited to those installations where earth materials were placed above the geomembrane. A summary of these cases follows.

Atlantic island – Six leak signals were found using a leak-location survey with earth materials on the geomembrane of half of a 7-acre landfill cell. The single geomembrane had 24 in. of organic material and a geocomposite above the geomembrane and a GCL under the geomembrane. The locations of the leak signals could not be excavated for inspection because they were underwater.

California landfill cell – Eight leaks were found in a 16-acre single geomembrane cell with a GCL and clay under the white geomembrane, and a geocomposite and 2ft of leachate rock on top of the geomembrane. The leaks included six 0.12-in. rock punctures, a 0.03-in. staple hole, and a 0.6-in. rock puncture.

California landfill cell – A 3.5-acre encapsulated geomembrane landfill cell with a GCL between two geomembranes and a geocomposite and 2 ft of sandy, silty operations material on top of the textured geomembrane was surveyed. No leaks were found. The signal to noise ratio from a 0.25-in. artificial leak was 7 or more on survey lines 7.5ft away.

California landfill cell – A 4.4-acre double-geomembrane landfill cell with a GCL and a geocomposite between the geomembranes and a layer of gravel, geotextile, and operations earth material layer on top of the textured primary geomembrane was surveyed for leaks. No leaks were found. The signal to noise ratio from a 0.25-in. artificial leak was 6 or more on survey lines 5ft away.

Colorado landfill cell – Two leaks in a long score in the geomembrane were found in the 2.8-acre floor area of a double-geomembrane cell. The layering included a secondary textured geomembrane, a geocomposite, GCL, textured primary geomembrane, geocomposite, 12in. of sand, geotextile, and 24in. of soil operations layer.

Maine landfill cell – A 6-acre textured single geomembrane landfill cell with a GCL under the geomembrane and geocomposite and 12 n. of sand on top of the geomembrane was surveyed. No leaks were found. A 0.25-in. artificial leak could be easily detected from 10ft away.

Maryland landfill cell - A geonet and GCL were installed under the primary geomembrane in the sump area of a double-geomembrane landfill cell. The sump area had drainage gravel in the sump. No leaks were found in the 0.25-acre area.

Massachusetts landfill cell – Five leaks were found in a 5.5-acre double-geomembrane cell with a GCL and geocomposite drain under the primary geomembrane and 18 n. of sand on top of the primary geomembrane. The leaks included punctures with diameters of 1.0, 0.5, and 0.25 in. and two 0.06-in. holes.

Massachusetts landfill cell – Three leaks were found in a 4.5-acre double-geomembrane cell with a GCL and geocomposite under the primary geomembrane and 18in. of sand on top of the primary geomembrane. The leaks included a 100-in.^{2} tear, a 2--in.^{2} tear, and a 0.75-in.-diameter puncture.

Minnesota monofill cell – Two leaks were found in a 1.5-acre cell with single textured geomembrane underlain by a GCL. The geomembrane was covered with 12in. of sand. The leaks were a 3-in. linear cut, and a 0.5- x 1- x 1-in. triangular tear. A 0.25-in. actual calibration leak could be easily detected from 10ft away.

New Jersey landfill cell – A 16.7-acre double-geomembrane landfill cell was surveyed with a geonet and GCL under and 12in. of sand on top of the textured geomembrane. Three leaks were found. The leaks included a 0.06-in.-diameter hole, a 1.75-in.-long tear, and a 0.75-in.-diameter hole.

New Jersey landfill cell – A single 0.12-in.-diameter puncture was found in a survey of 7 acres of a double-geomembrane landfill cell. A GCL and geocomposite were under the primary geomembrane and a geocomposite and 18in. of sand were on top of the geomembrane.

New Jersey landfill cell – Four leaks were located in the primary geomembrane of a 15.8-acre double-geomembrane landfill cell. A GCL and double-sided geocomposite were under the primary geomembrane and a nonwoven geotextile and 18in. of sand were on top of the textured primary geomembrane. The leaks included a 0.7-in. cut, a 5-in. cut, and two 0.25- in.-diameter punctures.

New York landfill cell – A 2.2-acre part of one cell was surveyed. The cell had a geocomposite, 12in. of structural fill, and a GCL under the primary textured geomembranes and a geotextile and 12in. of stone on the primary geomembranes. The cell had four leaks including a rough 1-in. tear, multiple rock punctures from 0.5 to 1.5in. in diameter, and 0.5- and 0.7-in. rock punctures.

New York landfill cell – The 4.4-acre floor area of a landfill cell was surveyed. The cell had a geocomposite, 12in. of structural fill, and a GCL under the primary textured geomembranes and a geotextile and 12in. of stone on the primary geomembranes. The cell floor had three leaks including a 1.5-in. rough tear, and two 0.75-in. rock punctures.

New York landfill cell – More than 100 leaks were found in the primary geomembrane of a 24-acre double-geomembrane landfill. A GCL and 12in. of structural fill were under the textured geomembrane and a geotextile and 12in. of selected fill were placed on top of the geomembrane. The leaks were typically 0.5 to 1in. in diameter and ranged in size from 0.03in. to 7.5in.

New York landfill cell – A 2.4-acre area of a double-geomembrane-lined landfill cell was surveyed. The landfill cell had 12 to 14 in. of sand and a GCL under the primary textured geomembrane and a geotextile and a minimum of 12 in. of drainage stone on top of the geomembrane. The area surveyed had three leaks including a 1-in. linear cut, and 0.5- and 1-in. tears. No leaks were found in a long, 0.9-acre area where a rain flap had been removed from an area that had been previously surveyed for leaks.

New York landfill cell – Three leaks were found in the primary geomembrane of 4.8 acres of a double-geomembrane landfill. A GCL and geocomposite were under the textured geomembrane and a double geocomposite, and 12 in. of drainage sand were placed on top of the geomembrane. The leaks were a 0.5-in. puncture and two 0.25-in. punctures.

Leak-location survey

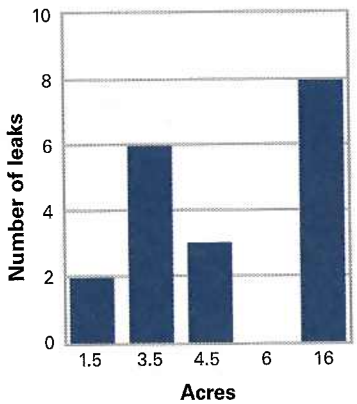


Figure 2 | Results with geomembrane/GCL/earth materials

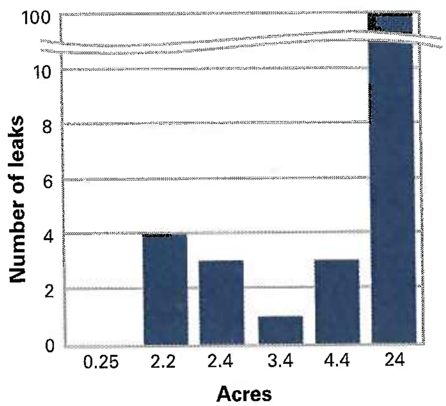


Figure 3 | Results with geomembrane/GCL/earth materials/geomembrane

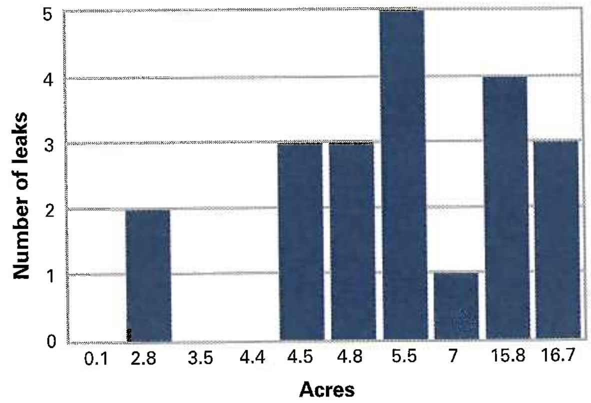


Figure 4 | Results with geomembrane/GCL/(geocomposite)/geomembrane

New York landfill cell – One 0.25-in. puncture was found in the primary geomembrane of a 3.4-acre, double-geomembrane landfill. A GCL, 12 in. of compacted soil, and a geosynthetic drainage layer were under the primary geomembrane and a geotextile and 2-ft layer of stone were placed on top of the geomembrane.

Oregon landfill cell – A limited area of a double-geomembrane landfill cell was surveyed with a GCL and geocomposite under the geomembrane and geocomposite and 18in. of operations earth materials on the primary geomembrane. No leaks were found in the 0.1-acre area. A 0.25-in. artificial leak could be detected from 7.5ft away.

Wisconsin landfill cell – Three leaks were found in a 4.5-acre, single geomembrane installation with a GCL under the geomembrane and geotextile and 12in. of drainage rock on the geomembrane. The leaks were an irregular 1.5- by 2-in. hole, a 2-in. irregular tear, and a 0.38-in. tear.

Analysis and conclusions

A total of 21 sites were surveyed ranging in area from 0.1 acre to 24 acres. Leaks were located at 76% of the sites comprising 90% of the survey area. A total of 151 leaks were located. They ranged in size from a 0.06-in.-diameter hole to a 100-in.^{2} tear.

Figures 2, 3, and **4** show the results of the surveys for the three cell construction types. The types are: 1) Single geomembrane over a GCL placed on the soil sub-grade; 2) A double geomembrane system with a GCL and a layer of earth materials between the geomembranes; and 3) An encapsulated system where a GCL is the only electrical conductor between the geomembranes. Note that the vertical scale on **Figure 3** is broken to accommodate the large number of leaks found in one installation.

Leaks were found in all but 5 of the sites surveyed. Two of the sites with no leaks were where the survey area was less than 0.3 acres. This is expected for a small area. The other surveys, where no leaks were found, are expected because some installations have no leaks. With the exception of one landfill with an abnormal number of leaks not considered, a similar number of leaks were found for all three configurations of liner construction. This shows that a GCL alone provides a conductance comparable to a GCL placed on earth materials.

These examples illustrate the successful use of GCLs as a conductive layer for geomembrane leak-location surveys. Electrical leak-location surveys using GCLs under the geomembrane have been provided for more than 10 years. The benefits of an electrical leak-location survey make it a prudent step for any geomembrane installation. After all, it does not make sense to install a geomembrane to prevent leakage and not test the geomembrane for leaks. This is particularly true when the cost to perform the leak-location survey is a fraction of a percent of the cost of the landfill.

References

[1]ASTM D 6747, Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes.

[2]ASTM D 7007, Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials.

[3]Smith, B.L., Darilek, G.T., and Laine, D.L., "Enhanced Geomembrane CQA Through Proper Application of Geomembrane Leak Location Surveys," Geosynthetics 2007 Conference Proceedings, Washington, D.C., USA, January 16-19, 2007.

[4]Touze-Foltz, N. and Giroud, J.P., "Empirical equations for calculating the rate of liquid flow through composite liners due to geomembrane defects," Geosynthetics International, Vol. 10, No. 6, pp. 215-233, Jan. 12, 2003.

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