Dipole Leak Location Survey on woodchip: unusual but possible.

C. Charpentier. Groupe Alphard, Canada. ccharpentier@alphard.com
F. Labonté. Groupe Alphard, Canada. flabonte@alphard.com
T. Jacquelin. Groupe Alphard, Canada. tjacquelin@alphard.com

ABSTRACT

This paper will summarize Electrical Leak Location (ELL) activities that occurred at an anonymous landfill extension in Canada, 2016. Characteristics encountered on that job include: attempting to get electrical isolation at the periphery; heterogeneous covering (including woodchip cover for frost protection); and a poor-quality subgrade filled with metallic components. Another feature, unfortunately not uncommon within landfill construction, was the high amount of defects found within the geomembrane, including punctures made while isolating the site. Our objective with this paper is to explain our response methods to different issues, in order to maximize the precision of the Dipole Method, give advice to others experiencing similar conditions, and provide relevant information about hole simulation signals, real hole signals, and their interpretations, to show that the site response was ASTM compliant, even if surveyed over woodchip.

1. INTRODUCTION, CONTEXT

Geomembranes are used more and more frequently in many types of impervious works: water ponds, mining waste cappings, heap leach pads, contaminated soils and toxic waste disposal, and many more. It is also common to see them in domestic waste landfills, as is the case in this paper. Electrical leak location is also gaining in popularity because its benefits are clear to the industry and some states in USA made a dipole survey mandatory in every landfill construction.

The primary objective of this paper is to share knowledge about dipole electrical leak location on a woodchip layer, which is really uncommon, and a first time for us. Then, as is the case for almost all sites the first time a leak location survey is performed, a lot of adaptations and adjustments were required; the solutions we found to enhance the dipole sensitivity will also be discussed. A summary of found defects with their size and type will be added. Finally, the conclusion will summarize our observations and suppositions, but our mandate was terminated before we could shed light on all of the remaining question.

2. PROJECT DESCRIPTION

The project was a simple landfill extension—no need for leachate ponds, pumping station or annexe works—just a rectangular extension sloping toward the last active cell. The exact location of the landfill will not be mentioned because of the negative impact this paper could have, but it occurred in Canada during summer 2016.

The area of the extension was 30,000 m², and its design consisted of (from bottom to top):

- Prepared subbase (at least 1 m thick of clay);
- 80-mil white HDPE geomembrane;
- Puncture-protection geotextile;
- 300 mm of gravel;
- 150 mm of soil.

In the end, about half the site was covered with 10 to 20 cm of woodchips for frost protection that could not be removed. We insisted that it was unusual to conduct a dipole survey on wood, as it is not electrically conductive, but with enough surface watering, it might work (soak the wood layer so it becomes conductive). Thickness of the natural material layer was really heterogenous, varying from approximately 20 cm to 60 cm. The geosynthetics had been completed installed for a few months and the general contractor had completed their work six weeks before the dipole survey.

3. DIPOLE METHOD DESCRIPTION

The dipole geoelectrical method (ASTM D7007) relies on the intrinsic insulation properties of geomembranes for the detection of perforations that were created during the installation of the cover material (see following figure). This means that geomembranes that are electrically conductive, such as EPDM (Ethylene Propylene Diene Terpolymer) due to its large concentration of carbon black. Water impermeable but non-isolating materials such as composite clay liner (CCL) or geocomposite clay liner (GCL) are also incompatible.

To do a dipole survey, a current of about 500 V DC (DIRECT CURRENT) is injected into the cover material, usually sand, clay, gravel or crushed stones, and a grounding electrode is placed outside the limits of the geomembrane. As a law of nature, electricity always tries to go from a different potential to a ground to discharge and reach equilibrium, but with a non-conductive geomembrane, it can't. If a defect is present, the current will pass through the hole to reach the ground (electrode), which then generates a distinct electrical signature that can be identified and located by a specialized technician.

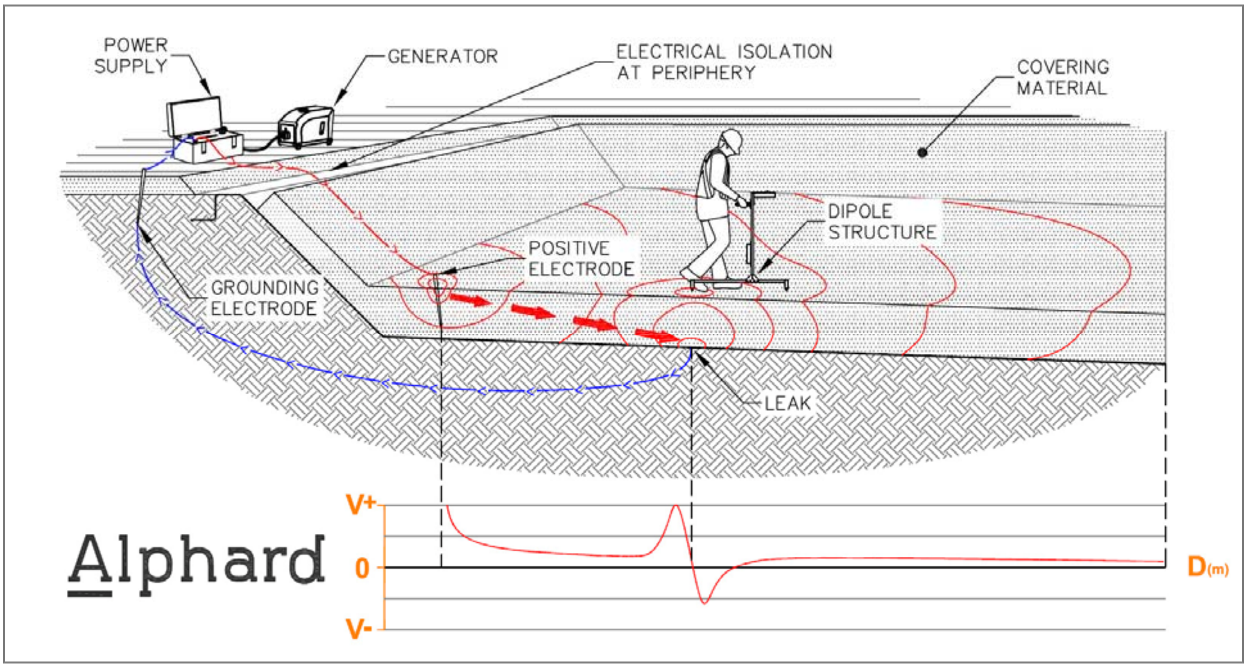

Figure 1. Dipole method schematic

4. REQUESTS TO ENHANCE DIPOLE SURVEY BEFOREHAND AND SITE CONDITIONS UPON ARRIVAL

Our first request before moving to the site was a standard one: provide electrical isolation. As shown in Figure 1, the top of the slopes is exposed so that cover material is not in contact with the surrounding ground. Electrical isolation is the critical factor that will determine if the dipole survey will be precise or not (minimal size of defects that can be found). Other important factors are the covering thickness— the thinner the better—and the homogeneity of the natural material layer, it works better on a single material layer, as opposed to multi-layered systems, for example sand and clay with topsoil on a capping.

Electrical leak location is easier when planned at an early stage of a cell construction. This way, it can be built following a few guidelines that will enhance the leak location, and will make it faster and simple. When a leak location survey is requested after the construction of a cell has been completed, can add extra costs, since the isolation trench needs to be excavated all around the periphery of the cell, as was the case here. This operation can be tricky because the liner is fragile and must be preserved, and in most cases, it is impossible to gently dig by hand. Our preferred way to achieve electrical isolation with an isolation trench is to rent a shopvac truck that will drive all around the cell and "pump" a trench about 20 cm wide, without any risk of damaging any of the geosynthetics. That solution was not retained because of the extra cost, and standard excavation with an excavator has been conducted.

Upon arrival on-site, the first thing that got our attention was the location of the isolation trench. As seen on the dipole schematic on previous page, the best way to make such a trench is on top of the slope, for easy access, and also to keep as much surface as possible inside the boundary of the isolation trench. In this case, they decided to build it at the toe of the slope. This decision resulted in numerous geomembrane tears, slopes with really poor isolation and poor leak location precision, highly risks for stability, and other problems that will be described in the next section.

Figure 2. Electrical isolation trench at the bottom of external slope

The second thing that was easily noticeable was the heterogeneity of the covering material. What was called gravel was in fact a mix of gravel, crushed stones, and dirt. The thickness varied greatly, going up to one meter, and sometimes the covering did not have any rocks, just sand and woodchips. The frost protection layer was also variable, and some pieces of wood were actually logs, with potential risks for the geomembrane's integrity. Many objects were seen in the gravel layer, such as broken glass, boots, and even a phone.

Figure 3. Woodchip containing big particles (logs)

Last observation was the dryness of the site. The little precipitation that happened prior to our mobilization on site had already been absorbed by the woodchips, and the gravel/sand/dirt layer was desiccated. It was made clear that surface watering would be mandatory to get sufficient moisture in the woodchips layer so that electricity could pass through the whole protection layer.

5. CHALLENGES AND SOLUTIONS

The usual way to kick-off an electrical leak location survey is to walk the whole site to see the conditions, to check the electrical isolation to make sure it is optimal, to wet the top of the natural material if necessary, and then to proceed with the calibration using the leaks simulations.

5.1 Isolation trench

There is no doubt that the excavation of the trench was challenging, being at the toe of slopes. Walking the trench all around the cell, multiple tears and punctures were found. A total of 25 leaks of different sizes were marked with paint, and their location was recorded using a GPS. The amount of damage done during the excavation of the isolation trench gives a bad first impression on the global quality of the cell. Beside the extra cost to repair all those, these defects pose a great threat to achieving electrical isolation, because any dirt touching a hole will draw current and will diminish the signal of other surrounding holes. The whole trench had to be checked, and all defects were carefully excavated for two reasons: the electrical isolation, but also to make some room for the installer to repair the defects when returns to site.

Figure 4. Geomembrane damage example caused during excavation

Based on the initial leak simulation results, the site was not sufficiently isolated, even with most defects along the periphery excavated and isolated. When the isolation trench is located on top of slopes, the presence of a puncture-resistant geotextile on top of the geomembrane does not affect isolation much, because the water held in the geotextile will dry, but given that the geotextile was located at the bottom it kept its moisture. The calibration was therefore not successful enough, and the geotextile had to be cut all along the isolation trench, so that the geomembrane could dry.

5.2 Wetting the dry surface

We knew a lot of surface watering would be required to get electrical signal through the wood layer. In fact, it was part of the first communication we had: uncertainty about the kind of results, if any, we would get surveying on wood. The plan was to soak the whole cell, and lots of water was required. Turned out we did not have the same opinion on “what is a lot of water”.

Figure 5. Water reservoir problems

The woodchips were absorbing water like a sponge would. Constant verification was needed to make sure that the moisture penetrated the soil deep enough to reach the gravel/sand/dirt layer. With the improved isolation trench and moisture content, the simulations started to give acceptable signals, but not for long. Added water in the cell transited to the lowest point corner of the cell, and a puddle formed in the isolation trench, breaking the isolation by bridging both sections (isolated bottom vs. slope covering material). Furthermore, leaks were present in the puddle area, thereby drawing even more electrical current.

It took three days to have sufficient water supply in order to do a full days work without being stopped waiting for the water reservoir to be refilled. The client preferred that the installer arrive only at the end of the project to reduce costs, so the defects in the lowest point area had to be temporarily repaired with duct-tape to reduce their signal noise.

6. RESULTS

6.1 Calibration results, leak simulations

Upon arrival, the first simulations indicated that only holes greater than 30 cm x 30 cm could be found in the given conditions. After improving the isolation trench, blocking leaks in the lowest point, and improving the surface moisture, leaks 10 cm² and greater were “findable”. It is still bigger than what we had expected, but it was worth starting the survey, knowing that every hole detected would be excavated (and isolated from the cover material), allowing more current to go to the remaining leaks and the signal to keep improving.

As a side note, Groupe Alphard's calibration differs from ASTM D7007, being more demanding. Based on ASTM basic guideline, with the basic parameters of the site, a 6 mm leak simulation could be found, and we would have been allowed to conduct the survey without improving the site's conditions, and still be ASTM compliant, but we believe that the standards are way too easy to meet, even in bad conditions.

6.2 General survey

Values measured with the dipole varied more than usual, because of the heterogeneity of the cover material (variation in thickness and in moisture content). Thin layers can amplify values for two reasons:

- Electrical resistivity is higher on a thin layer, and since we are reading voltage loss with dipole, more resistivity means greater voltage loss and therefore higher values;
- If there is a hole, its impact will be easier to measure when close to it.

Same thing goes for moisture. When it is really moist, resistivity lowers, and values measured are also lower, BUT if there is a leak, more current will be drained and more voltage will be generated. In all cases, it is better to have good conductivity in the natural material layer. The lack of constant moisture resulted in dry spots with higher readings, not provoked by hole signals, and made the survey more complicated to analyse, lots of area had to be excavated with a shovel to see if voltage variation was generated by leaks or any of the above-mentioned parameters.

6.3 Real defects found

Surface watering and varying readings were slowing the survey, but the fact that the real holes had to be excavated by hand had the most impact on the survey speed. A total of 27 leaks were found using the dipole method, and only on a third of the area to survey. Because of the delays at the beginning of the job and various problems that slowed us, we surveyed at an average of 910 m²/day, which is really slow compared to normal conditions.

No.	Date	Leak Type	Dimensions	No.	Date	Leak Type	Dimensions
1	Sep. 15	Puncture	5 mm.	15	Sep. 19	Puncture	1 mm. 3x
2	Sep. 15	Puncture	4 cm. 4x	16	Sep. 20	Puncture	<1 mm.
3	Sep. 15	Puncture	1 mm.	17	Sep. 20	Puncture	+-1mm. 6x
4	Sep. 15	Puncture	1 mm.	18	Sep. 20	Puncture	< 1mm.
5	Sep. 16	Puncture	2 cm²	19	Sep. 20	Puncture	5mm.
6	Sep. 16	Puncture	1 mm. 2x	20	Sep. 20	Puncture	< 1 mm.
7	Sep. 16	Puncture	1 mm.	21	Sep. 20	Puncture	2 mm.
8	Sep. 18	Puncture	1 mm. 4x	22	Sep. 20	Puncture	5mm.
9	Sep. 18	Puncture	1mm./2cm.	23	Sep. 20	Puncture	2 mm.
10	Sep. 18	Puncture	1mm.	24	Sep. 21	Puncture	1mm.-25cm.
11	Sep. 19	Puncture	2 mm.	25	Sep. 21	Puncture	5 mm.
12	Sep. 19	Puncture	1 cm.²	26	Sep. 21	Puncture	< 1 mm.
13	Sep. 19	Puncture	1 cm.	27	Sep. 22	Puncture	1.5cm
14	Sep. 19	Puncture	< 1mm.				

Table 1. Size of defects found with the dipole method.

All of the defects found were the same type: metal object scattered in the bedding clay or in the covering material that punctured the HDPE geomembrane. It was surprising to find only metallic object and not a single rock puncture or tear. Voltage signals generated by metallic objects are higher than one with natural material contact. Our impression was that all "metallic holes" were generating bigger signals than "natural contact holes" and were in fact masking smaller signals. We suggested to the site owner that all "metallic holes" should be found and excavated in a survey, and a second survey should be conducted for the rest of the defects.

The strangest defect found was again a small piece of metal puncturing the liner. We tried to pull it off the ground with clamps to remove threat to the liner integrity right away, but could not. After enlarging the hole in the geomembrane and removing a little bit of clay on the side, we still had no success, even with help. Finally the hole had to be opened on nearly a meter, and a mini-excavator pulled the metallic item with chains. It was an entire bicycle in the subgrade; the tip of the handlebar had pierced the geomembrane!

Figure 6. Defect made from a bicycle in the subgrade

6.4 Explanation for the exceptional amount of metallic parts in the bedding clay

After so many random metal scraps found in the subgrade, we asked the site owner and the general contractor if they had any clue as to why the subgrade was that poor quality. The reason they gave us is that the natural clay on site was not thick enough (one meter minimum per spec), so they had to bring in more clay and compact it after scraping off the topsoil. And, since the clay borrow area was so close to the cell, instead of putting clay in Haul truck to bring it to the work area, they simply pushed it with bulldozers. And their route was going over an active cell, so they collected lots of scraps and garbage in their clay.

6.5 Abrupt survey stop

After 11 days of survey, it has been decided that it was enough. That is why only 10,000 m² out of the 30,000 m² cell were surveyed, and only an initial survey had been completed of that area, assuming we would be able to make a second one as per our recommendations. It is probable that the owner had doubts on the quality of the field job, and wanted a third-party expert to confirm. If so, he had already lots of information after 11 days of test, findings, and a full report.

7. CONCLUSION

Geoelectrical leak location methods like dipole require electrically conductive subgrade and cover material. Wood is not conductive, but with enough water, electricity is able to go through the whole cover system and give us the required signals to indicate leaks. Water management becomes a crucial part of the leak location, and must be taken seriously. On this particular project, 27 geomembrane penetrations were found using the dipole method, on only 10,000m², and we think a lot more holes would have been found in the area, if all holes with metallic parts had been found in the remaining area of the cell, and it would have been isolated.

As for site conditions, it is easier and cheaper to plan leak location ahead of field construction, so isolation is dealt with during the placement of the covering material, and minimal excavation is required for access ramps and such. The result is better, and the risks and the costs are lower. It is crucial that all parties involved understand how leak location works and why, so when certain requests are made, we do not end up with isolation trenches at the bottom of slopes that automatically exclude all slopes from the survey.

This project is another fine example of the importance of Construction Quality Assurance, to make sure the subgrade is properly built, and cell design is followed rigorously. Every stage of the construction is important and should be supervised and approved by an experienced CQA inspector.

References

ASTM D7007. Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials, American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA.

Forget, B. et al., (2005). Lessons Learned from 10 Years of Leak Detection Surveys on Geomembranes, Sardinia Symposium, Sardinia, Italy.

Beck. (2014). Designing to minimize geomembrane leakage, Geosynthetics Magazine, August/September Issue.

Darilek, G.T. and Laine, D.L. (1999), Performance-based specification of electrical leak location surveys for geomembrane liners, Geosynthetics '99, Boston, Massachussetts, USA, April 28-30 1999, p. 645-650.

N. Touze Foltz. (2002). Méthodes de détection et de localisation de défauts dans les géomembranes. Ingénieries - E A T, 2002, p. 17 - p. 25. <hal-00465455>

Thiel, R., Beck, A. & Smith, M.E. (2005). The Value of Geoelectric Leak Detection Services for the Mining Industry, Geofrontiers, ASCE, Waste Containment and Remediation. pp. 1-

Darilek, G.T. and Laine, D.L., (2010). Leak Location Surveys, The Past, The Present, The potential, GSI Annual Meeting 2010