**A Comparison of Geoelectric Survey Methods for Heap Leach Applications**

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Geoelectric leak surveys for geomembranes typically pay for themselves simply by the value of solution that would otherwise be lost. Integrating a survey into the construction process rather than as a mitigation effort avoids costly or often unfeasible repairs as well as possible regulatory problems due to excessive leakage. Two survey methods are available: the water puddle or water lance method and the dipole method. This article discusses these two methods and the technical and financial benefits of each.

The water lance method is performed on the bare geomembrane after installation and CQA but before placement of the overliner. This method is the most sensitive of the two and can pinpoint holes invisible to the naked eye. As long as the equipment is calibrated correctly and good survey methods are employed, missed defects should be very rare. There is a decrease in sensitivity on steep slopes, as the water tends to flow down the slope rather than through a small hole in the liner, but even a 2 mm diameter hole can usually be found on a 2.5:1 slope. The water lance method is applicable to leach pads, dry ponds or any other uncovered liner installation.

The dipole method is performed on a covered geomembrane, after the placement of the overliner layer material on a leach pad or in a pond already filled with water. The dipole-on-soil method is much less sensitive than dipole-on-water, and both are less sensitive and less accurate then the water lance. As the cover soil thickens or the soil conductivity decreases (typically dependent on water content and mineralogy), the minimum detectable hole size increases and the overall reliability of the method decreases. The accuracy becomes unreliable beyond a couple of meters in cover thickness. The dipole-on-water is inherently more sensitive, but this method produces many false positive signals.

In performing a survey on a leach pad one can choose to use the water lance after liner installation, the dipole method after overliner placement, or both. The advantage of the water lance is both the sensitivity and the ease of repair. The inherent risk in only performing a water lance survey is that most of the major undetected damage to a liner occurs during overliner placement. A single “nick” from a dozer can easily produce more leakage than all other common defects combined. On the other hand, if only a dipole survey is performed, most small holes will go undetected. For low hydraulic head installations small hole leakage may be insignificant - unless there is an excessive number of such defects. By performing both a water lance survey (before overliner placement) and a dipole survey (after), there is a very high confidence that every major and minor defect will be found before leach operations begin.

Either method can be used for a pond. A water lance survey can be performed before filling with solution, with the advantage of easier repair. A pond can also be surveyed using the dipole-on-water technique after it is filled, with the advantage that hydraulic head is applied to the liner which often triggers leaks that did not exist at lower

pressures. The disadvantage of using the dipole-on-water method is that it tends to produce false positive signals, which must all be investigated.

To make a strictly financial comparison of performing the different survey methods, the benefit-to-cost ratio analysis used by Smith et al (2005) was modified with current prices for gold and copper and updated hole size and frequency statistics (Forget et al, 2005). Though greatly simplified from the probabilistic approach taken by Smith, this analysis compares the financial benefits of performing the different types of surveys on a leach pad and a pond. The price of gold is taken at $600 USD/oz. and copper at $2.80 USD/lb. The following table shows the parameters used to analyze the benefits of choosing either the water lance method, dipole method, or both, and the resulting benefit-to-cost ratios. All assumptions and parameters not shown in the table are the same as used by Smith. All analyses assume that conventional CQA was performed prior to the geoelectric survey. The leakage rates were calculated using the stated frequencies of the average hole sizes (10 or 1,500 $mm^2$) that would typically be found for each scenario.

| | Hole Freq./ha | | Head | Survey Cost/ha | Leakage Avoided L/day/ha | Benefit/Cost | |
|---|---|---|---|---|---|---|---|
| | 10 $mm^2$ | 1,500 $mm^2$ | | | | Au | Cu |
| Pond (either method) | 4 | 0 | 5 m | $5,382 | 3,205 | 7.3 | 8.3 |
| Pad w/ W.L. & Dipole | 4 | 0.5 | 1 m | $6,458 | 606 | 1.1 | 1.3 |
| Pad w/ W.L. only | 4 | 0 | 1 m | $3,229 | 502 | 1.9 | 2.2 |
| Pad w/ Dipole only | 3 | 0.5 | 1 m | $3,229 | 481 | 1.8 | 2.1 |

This analysis shows that in high head applications such as ponds, the benefit-to-cost ratio can be extremely high, making a geoelectric survey an obvious final step in construction or repair. Performing both water lance and dipole surveys on a leach pad results in a modest financial benefit (a B/C of 1.1 to 1.3); however, this creates a far superior containment system with a significantly reduced risk of environmental or compliance problems, at a net operating cost benefit. Across the board, the survey cost is a small initial investment to ensure a lifetime of outstanding performance.

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