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"Status of the Electrical Leak Location Survey (ELLS) Method Among State Environmental Protection Agencies in the USA"

by

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Status of the Electrical Leak Location Survey (ELLS) Method Among State Environmental Protection Agencies in the USA

Background

The origin of electrical leak location surveys (ELLS hereafter) was via the Southwest Research Institute under contract to the U.S. Environmental Protection Agency in about 1980. Bob Landreth was the project officer for the EPA out of the RRL in Cincinnati, Ohio. For the next few years development work was undertaken including proof testing on a relatively large geomembrane lined pond at their facility in San Antonio, Texas. The method was patented and commercialized in about 1985. Capitalizing on the rapidly growing use of geomembranes in landfills and surface impoundments, Glen Darilek and Daren Laine founded a specialty company, Leak Location Services, Inc. (LLSI), focused completely on the technique in 1992. The company continues to be very active throughout the world having surveyed more than one million square meters in the last three years alone.

Of the many organizations that followed LLSI, the implementation of the technique by Ian Peggs of I-Corp and Andre Rollin of Solmers spurred TRI-Environmental Inc. (Sam Allen and Abigail Gilson-Beck) to initiate a separate division, titled Liner Integrity Services, to provide expertise, equipment, services, training and certification of the method. Presently there are six variations of the ELLS method as follows; all are ASTM Standards.

1. ASTM D7007; Soil and water-covered dipole method
2. ASTM D7703; Water lance method
3. ASTM D7002; Water puddle method
4. ASTM D7240; Spark testing method
5. ASTM D7953; Arc testing method
6. ASTM D7909; Guide for placing blend leaks

Concept of the ELLS Method

The ELLS method uses a DC power source having high voltage and very low amperage from which the cathode $^{(-)}$ and anode$^{(+)}$ emanate. The cathode is grounded beneath the geomembrane (in foundation soil, compacted clay liner, geosynthetic clay liner, geocomposite drain, bottom surface of conductive geomembrane, etc.) which must have adequate moisture (or be conductive) so as to conduct current flow. The anode is placed in water above the geomembrane via ponding, puddling or water lance procedure. When there is no hole (or other continuous defect) there is no current flow, and conversely when there is a hole an electrical current is completed; see Figure 1. Figure 1a is for the geomembrane with no soil cover and Figure 1b is for a soil cover of up to 450 mm thickness, i.e., after an initial lift of backfill. The location of the hole is sensed by a technician holding a voltage indicator which responds immediately since a hydraulic circuit is completed at the precise location of the hole. The identification of the hole is then recorded for subsequent repair. So as to cover the entire footprint of a facility a technician generally walks on a grid pattern. The closer the grid pattern, the more sensitive is the technique insofar as locating smaller-and-smaller holes; see Figure 2.

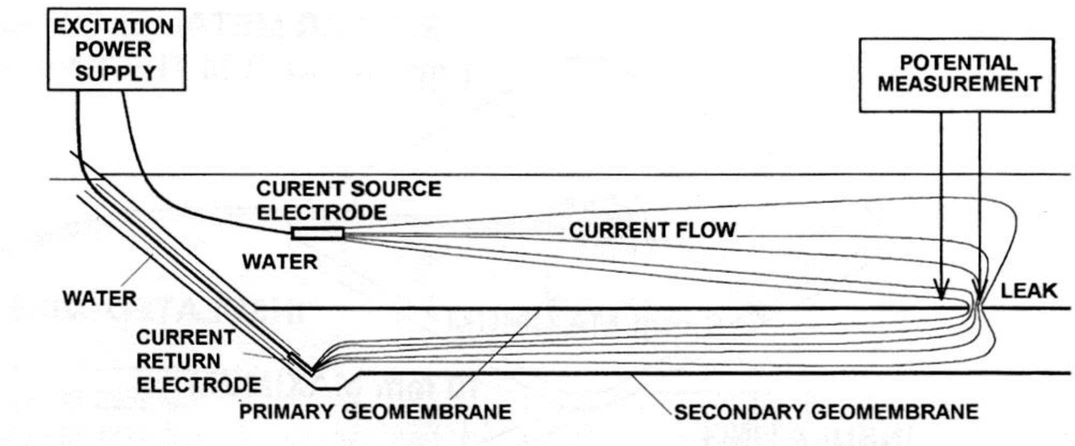


Figure 1a - Diagram of the Electrical Leak Location Method for surveys with water covering the geomembrane (compliments of ASTM).

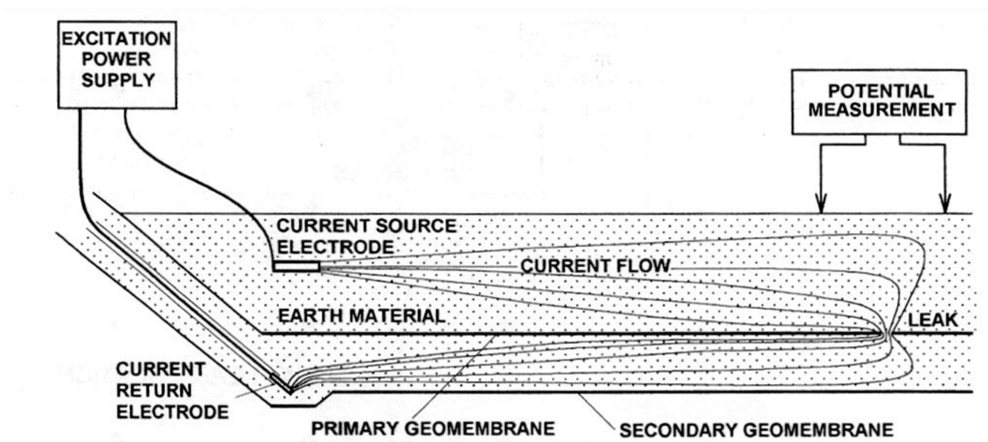
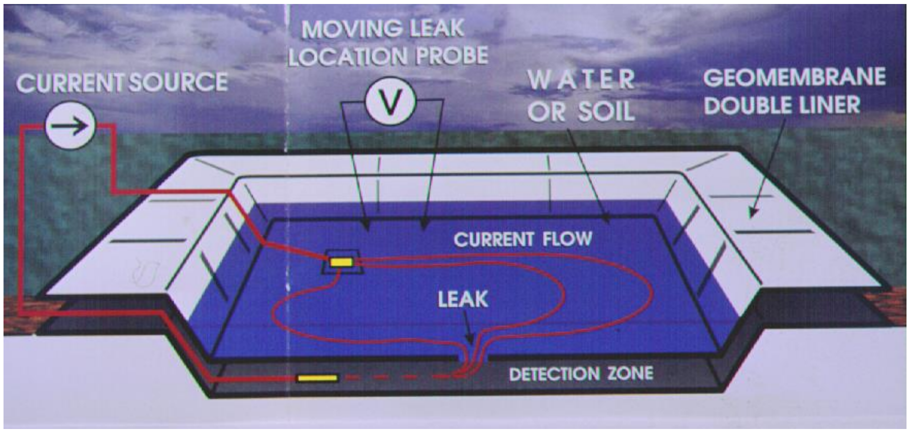
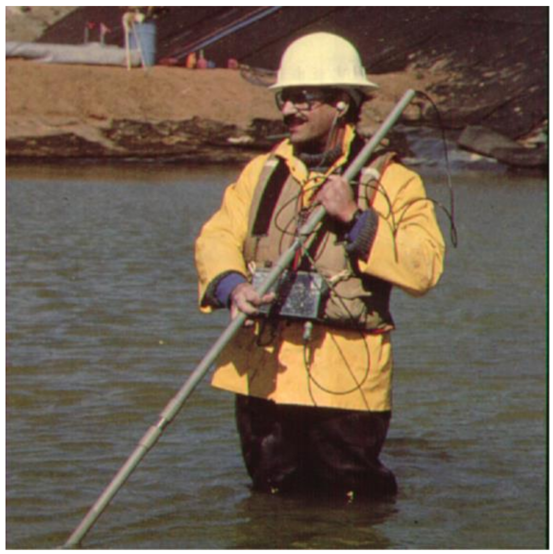


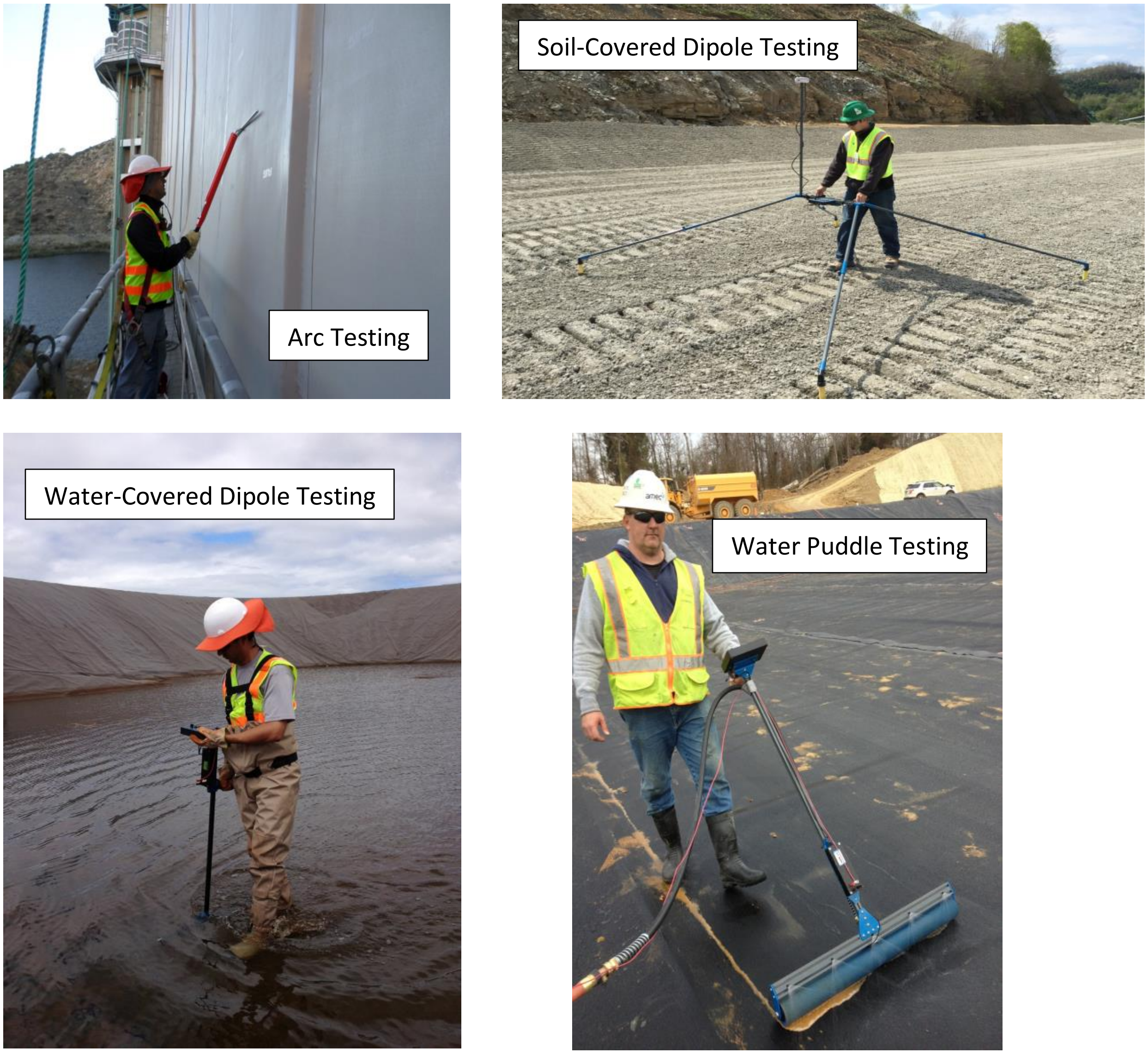
Figure 1b - Diagram of the Electrical Leak Location Method for surveys with earth material covering the geomembrane (compliments of ASTM).



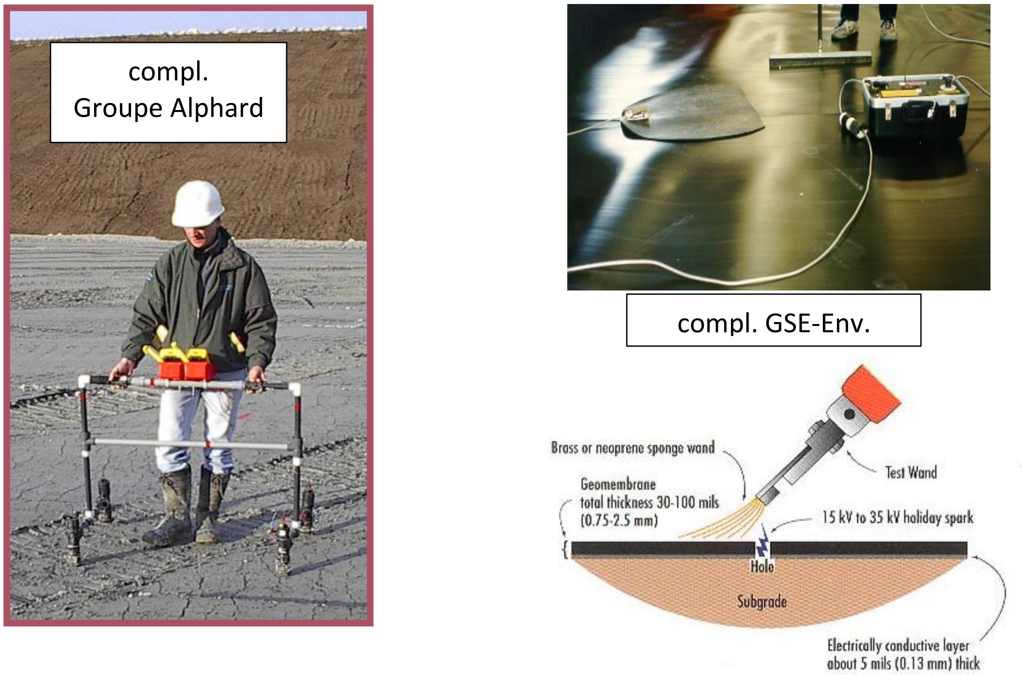


(a) Concept of ELLS Method and technician with voltmeter hole detector (compliments of LLSI).

Figure 2 - Concept and examples of the ELLS method to detect geomembrane holes after initial field deployment.



(b) Examples of ELLS Method (compliments of TRI Env.).



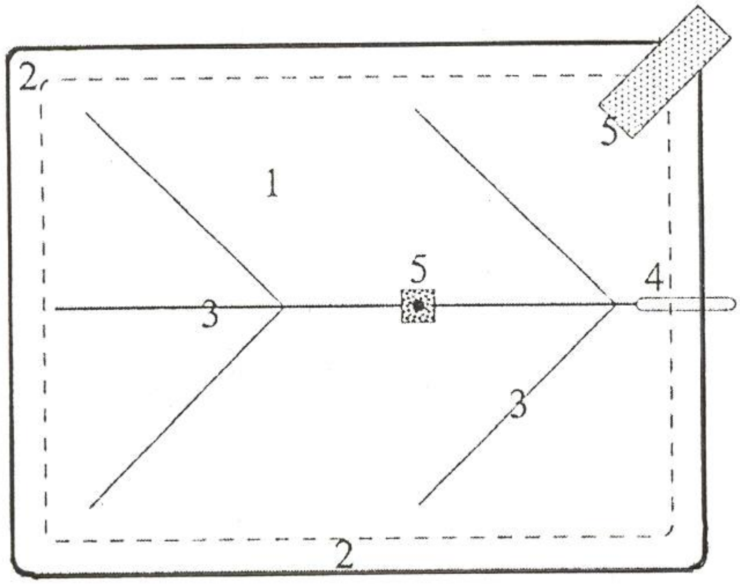
(c) Examples of soil covered (left) and conductive sheet (right) approaches

Figure 2 - (continued)

Past Electrical Leak Location Surveys of Field Sites

There are many technical papers written on and about the ELLS method, most of which are in the geosynthetics literature. Perhaps the most illustrative (in the authors opinion) is that of Noski and Touze-Foltz[*]. They surveyed 300 geomembrane lined sites consisting of over 3,000,000 m^2 in total. The leaks were placed into five location categories as shown below.

[*]Nosko, V. and Touze-Foltz, N. (2000), "Geomembrane Liner Failures," Proc. 2nd European Geosynthetics Conference, Bologna, Italy, pp. 557-560.



Notes:
1 = flat floor
2 = corners and edges
3 = under drainage pipes
4 = pipe penetrations
5 = other (access roads, temporary storage, concrete structures)

Figure 3 - Locations where holes occurred from 300 sites and over 3M m^2 of geomembrane liner (ref. Noski and Touze-Foltz, 2000).

The results of their survey are shown in Tables 1 and 2 for location of the holes and cause/size of the holes, respectively.

Table 1 - Location of Holes

No. of Holes	Flat Floor (1)	Corners and Edges (2)	Under Drainage Pipes (3)	Pipe Penetrations (4)	Other (5)
4194 100%	3261 77.8%	395 9.4%	165 3.9%	84 2.0%	289 6.9%

Table 2 - Cause of Holes vs. Size of Holes

Size of Holes (cm^2)	Stones	%	Heavy Equip.	%	Welds	%	Cuts	%	Worker Directly	%	Total
<0.5	332	11.1	-	-	115	43.4	5	8.5	195	-	452
0.5-2.0	1720	57.6	41	6.3	105	39.6	36	61.0	105	84.4	2097
2.0-10	843	28.2	117	17.9	30	11.3	18	30.5	36	15.6	1044
>10	90	3.0	496	75.8	15	5.7	-	-	-	-	601
Amount	2985		654		265		59		231		4194
Total	71.17%		15.59%		6.32%		1.41%		5.51%		100%

These results are most significant in that such details are simply not available based on conventional methods such as destructive seam tests and/or observation. In Table 1 the most significant finding is that 77.8% of all holes are in the flat floor with no unusual construction, such as pipes or penetrations, interfering with the placement and seaming of the geomembrane itself. Complimenting and elaborating on Table 1 is Table 2 which details the cause and size of holes. Here is seen the following:

- Stones caused 71.2% of the holes (unfortunately there is no indication if the stones were beneath or above the geomembrane).
- Heavy equipment caused 15.6% of the holes (soil coverage thickness is an ongoing issue of regular concern as far as trucks and equipment trafficking is concerned).
- Seam welding caused only 6.3% of the holes (this is surprisingly low in comparison to the perceived concern which requires considerable destructive and nondestructive seam testing protocols).

- Regarding the size of the holes, 74.9% were in the range of 0.5 to 10 cm^2 (larger holes contributed 14.3% which are most significant since leakage rates are in direct proportion to the size of holes).

Insofar as a generalized statement leading to the GSI survey of state environmental agencies which will follow, the authors feel that the ELLS method is excellent in identifying, locating and (subsequently) repairing holes in geomembrane liners which obviously leads to improved short and long term performance of such barrier materials.

Results of this GSI Survey Regarding the ELLS Method

In the summer of 2016, GSI contacted all fifty U.S. state environmental agencies concerning their knowledge and use of the ELLS method. Twenty-nine (58%) of the states responded. Questions were grouped into five categories:

1. Familiarity with the method.
2. Actual use of the method.
3. Focus of the method insofar as cross-sections are concerned.
4. Stage or timing of construction for method's use.
5. Alternative methods for determining leaks.

Table 3 presents these results…

1. *Regarding familiarity* of the method, 17 of the responding 29 states (59%) said that they were familiar, 9 said somewhat (31%), and 3 said they were not familiar (10%). It is assumed (although not confirmed) that many of the 21 state agencies not responding were not familiar with the method.

2. *Regarding actual use* of the method, 4 of the 29 responding states (14%) require it by regulations and 10 of the states (34%) require it on a site-specific basis. Fifteen states (52%) know of the method but do not require its use.
3. *Focus of the method's* location insofar as its application is concerned, is mainly on the primary geomembrane (17 out of 23 responses or 74%), although in most states only single lined facilities are used for municipal solid waste (MSW) and construction and demolition (C&D) waste. Four out of 23 agencies (17%) require the method's use on the secondary geomembrane. Two agencies (9%) require the method's use on the cover geomembrane.
4. *The stage of timing* of the method's use resulted in 8 of 21 responses (38%) to be used after the geomembrane's installation, 11 of 21 responses (52%) after soil cover (presumably the leachate collection system) and 2 of 21 responses (10%) after operations begin. It should be recognized, however, there is a limit of soil cover thickness beyond which the method is not effective.
5. Regarding *alternative leak location methods*, no regulations are active at present. That said, 8 of the 28 responses (29%) stated that there was a site specific method but no details were provided. That said, we presume that all waste facilities have downgradient monitoring wells required and this is an on-going practice per U.S. federal regulations.

Interestingly, California not only responded to our questionnaire, they also questioned each of their state regions. This data is given in Table 4. As seen, the responses vary greatly even within the state. In some respect California reflects the nation as a whole. Note that we used their average values in Table 3. It should be mentioned that each Regional Board has autonomy such that they can include specifications for ELLS in individual waste disposal permits.

Table 3 - Results of 2016 Survey of State Environmental Agencies with Regard to Use of the Electrical Leak Location Survey (ELLS) Method

	Is Your agency familiar with ELLS?			What is your position on its use in a GM lined Landfill facilitiy?			Where in the cross section is your agency's focus?			Which stage of construction is ELLS to be performed?			What is your agency's position on ELLS for locating leaks in surface impoundments?		
	YES	Somewhat	NO	Regs Require	Site Specific	None	Primary FML	Secondary FML	Final Cover	After GM Installation	After Soil Cover	After Operations begin	Regs Require	Site Specific	None
AZ		X				X									X
CA		X			X		X			X	X			X	
CT			X			X									X
FL	X				X		X	X			X			X	
GA			X			X									X
HI			X			X									X
ID	X					X				X					X
IL		X			X					X					X
IO	X					X	X			X					X
KY	X					X	X			X					X
LA		X			X		X		X	X				X	
MD		X				X									X
ME	X				X		X				X			X	
MI	X					X	X			X					X
MO	X				X		X				X				X
MT	X				X		X				X			X	
NJ	X			X			X			X					X
NY	X			X			X	X			X			X	
NC	X			X			X				X				X
OH	X				X		X				X				
PA	X					X									X
RI		X				X		X				X			X
SD		X				X									X
TN		X				X	X	X	X		X				X
TX		X				X									X
UT	X					X	X					X			X
VA	X				X									X	
WI	X			X			X				X				X
WY	X				X		X				X			X	
Total	**17**	**9**	**3**	**4**	**10**	**15**	**17**	**4**	**2**	**8**	**11**	**2**	**0**	**8**	**20**
		29			**29**			**23**			**21**			**28**	

Table 4 - Results of California by Region with Regard to Use of the Electrical Leak Location Survey (ELLS) Method

	Is Your agency familiar with ELLS?			What is your position on its use in a GM lined Landfill facilitiy?			Where in the cross section is your agency's focus?			Which stage of construction is ELLS to be performed?			What is your agency's position on ELLS for locating leaks in surface impoundments?		
	YES	Somewhat	NO	Regs Require	Site Specific	None	Primary FML	Secondary FML	Final Cover	After GM Installation	After Soil Cover	After Operations begin	Regs Require	Site Specific	None
1	X				X				X					X	
2															
3	X				X		X		X		X			X	
4		X				X	X			X				X	
5															
6	X			X	X		X			X				X	
7					X		X	X			X			X	
8		X				X	X				X			X	
9		X			X		X			X					X
AVG		**X**			**X**		**X**			**X**	**X**			**X**	

Conclusions

The electrical leak location survey (ELLS) method has had a rather long time interval between its initiation in 1980 to the present. The initial years delay were likely due to the original patent which has long since expired. Subsequently, only a few firms were experienced enough for its use. However, when ASTM formalized the five standards mentioned in Table 1, activity sharpened considerably. As shown in Table 3, the current status can be described as being that the method is reasonably known to the geomembrane industry and is somewhat known from an agency perspective. This White paper is meant to present the current status in this regard.

Acknowledgement

GSI wishes to thank the 29 state environmental agencies (and particularly California which queried all nine regions in their state) for responding to our survey. They have all been sent a copy of the results.