Understanding Dipole Method Testing Results

Speaker: Abigail Gilson

TRI Environmental, Inc.

GEOANZ #1 ADVANCES IN GEOSYNTHETICS
7–9 JUNE 2022 | BRISBANE CONVENTION & EXHIBITION CENTRE

Dipole Method Testing

- Covered geomembrane testing (soil, water)
- Most critical Electrical Leak Location (ELL) testing method
- Effectiveness is dependent on site conditions
  - Sufficient moisture
  - Electrical isolation of testing area
- Two different ASTM standard practices can be used for dipole testing
  - ASTM D7007 (2003)
  - ASTM D8265 (2019)

For more on this: Gilson, A. (2021). "Advancements in Field Testing for Locating Geomembrane Installation Damage", *International Journal of Geosynthetics and Ground Engineering*, 7:72.

ASTM D7007

- No data recording for water-covered surveys
- Data recording along string lines for soil-covered surveys but no requirement to provide data as part of final report
  - Raw data files provided if requested by client or contract
- Functionality demonstration over actual or artificial leak
  - No requirement for detection; mandates increase in measurement density if not detectable

Dipole Method Testing Realities

- Most functionality testing performed with artificial leak
- Artificial leak may not be representative of signal of actual leak
- Signal produced by leak function of:
  - Position of leak relative to other features of the testing area
  - Electrical contact through leak
  - Survey area isolation (including the presence of more significant leaks in testing area)
- Detection/non detection of artificial/actual leak only one piece of the puzzle
  - Used in tandem with site response current and evaluation of survey area isolation to determine method effectiveness
- Increase in method effectiveness can only be done through modifying site conditions (provided already applying best practices)

Note on Measurement Density

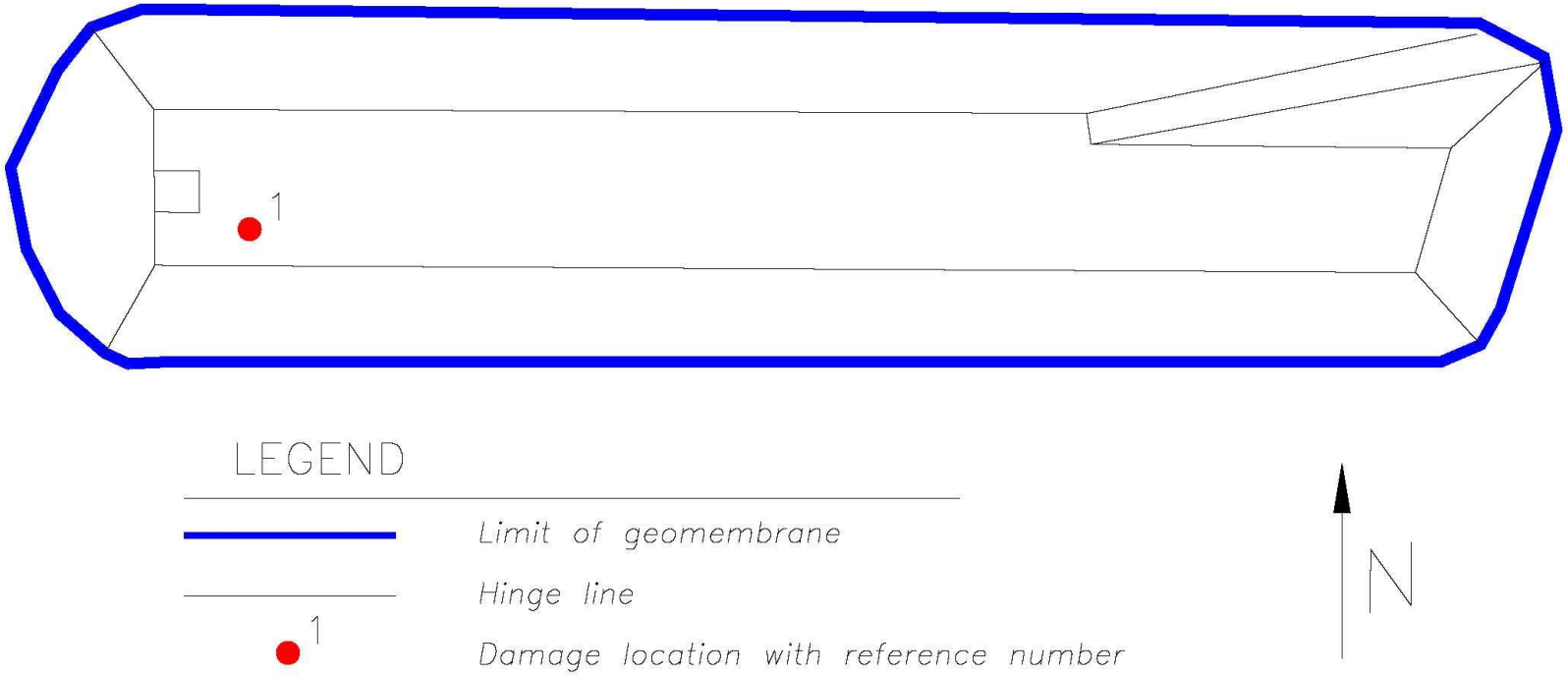
- Increases **resolution** of survey area, not detection sensitivity
- To increase detection sensitivity aside from site conditions:
  - Increase dipole spacing*
  - Enhance data analysis method (mapping)
- Increasing measurement density will result in much more costly survey that does not increase detection sensitivity
  - Unless: dipole used has a spacing that is less than measurement grid spacing
- Best practice: measurement grid spacing equal to dipole spacing

*Source: Gilson-Beck (2021). "Dipole Measurement Density and Dipole Spacing for Electrical Leak Location", *Proceedings of Geosynthetics Conference*, February 22-25.

D7007 Report Output

9.1.1 Description of the survey site,
9.1.2 Weather conditions,
9.1.3 Cover material description,
9.1.4 Type of geomembrane,
9.1.5 Liner system layering,
9.1.6 Description of the leak location method,
9.1.7 Survey methodology,
9.1.8 Description of the artificial or actual leak used,
9.1.9 Results of leak detection distance tests,
9.1.10 Results of periodic leak detection distance tests,
9.1.11 Specific parameters of survey including dipole spacing, spacing between measurements or scans, spacing between survey lines, and dipole orientation along survey lines as applicable,
9.1.12 Location of detected leaks,
9.1.13 Where visible, type and size of leaks, and
9.1.14 Map of the surveyed areas showing the approximate locations of the leaks.

9.2 For surveys with earthen materials covering the geomembrane, raw data files or records shall be maintained. They should be provided to the client if specified by contract or other specification.



D8265 Report Output

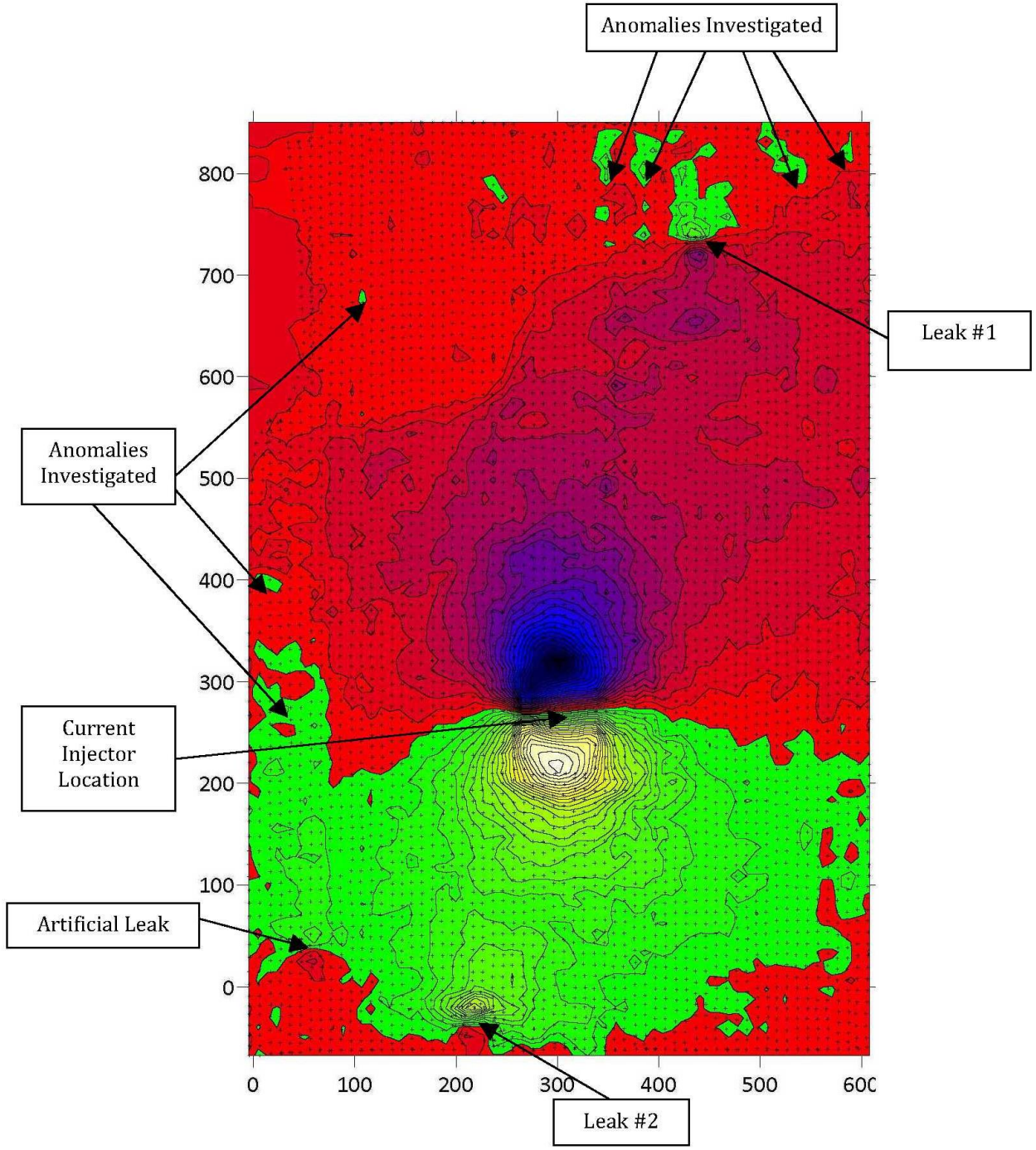
Table 1: Dipole Measurements of Artificial Leak Per ASTM D8265, Section 7.2.5.1

Position	Description of Position	Value (V)
1	Front Foot Directly over Artificial Leak	-0.223
2	Back Foot Directly over Artificial Leak	+0.278
3	Front Foot on MP1 (Worst Case position of 10' x 10' measurement grid)	-0.035
4	Back Foot on MP2 (Worst Case position of 10' x 10' measurement grid)	+0.085

A log of site response current with changing survey conditions is required per ASTM D8265. The site response current log is presented as Table 2.

Table 2: Voltage and Site Response Current Log

Description of Condition	Applied Voltage (V)	Measured Current (mA)
Site Response Current – Initial	500	<1
Site Response Current –1/4"Artificial Leak Connected	500	<1
Site Response Current – End of Survey	500	1
Site Response Current – After CI moved	500	6
Site Response Current – End of Leak Pinpointing and Excavation	500	2



D8265 Report Output

9. Report

9.1 The leak location survey report shall contain the following:

9.1.1 Identification of any site conditions that do not conform to Section 6.

9.1.2 A log of voltage and site response current measurements for each condition of the survey area, including when the actual or artificial leak is connected and disconnected.

9.1.3 The electrical measurements described in 7.2.5.1.

9.1.4 The actual or artificial leak size documented by the electrical mapping.

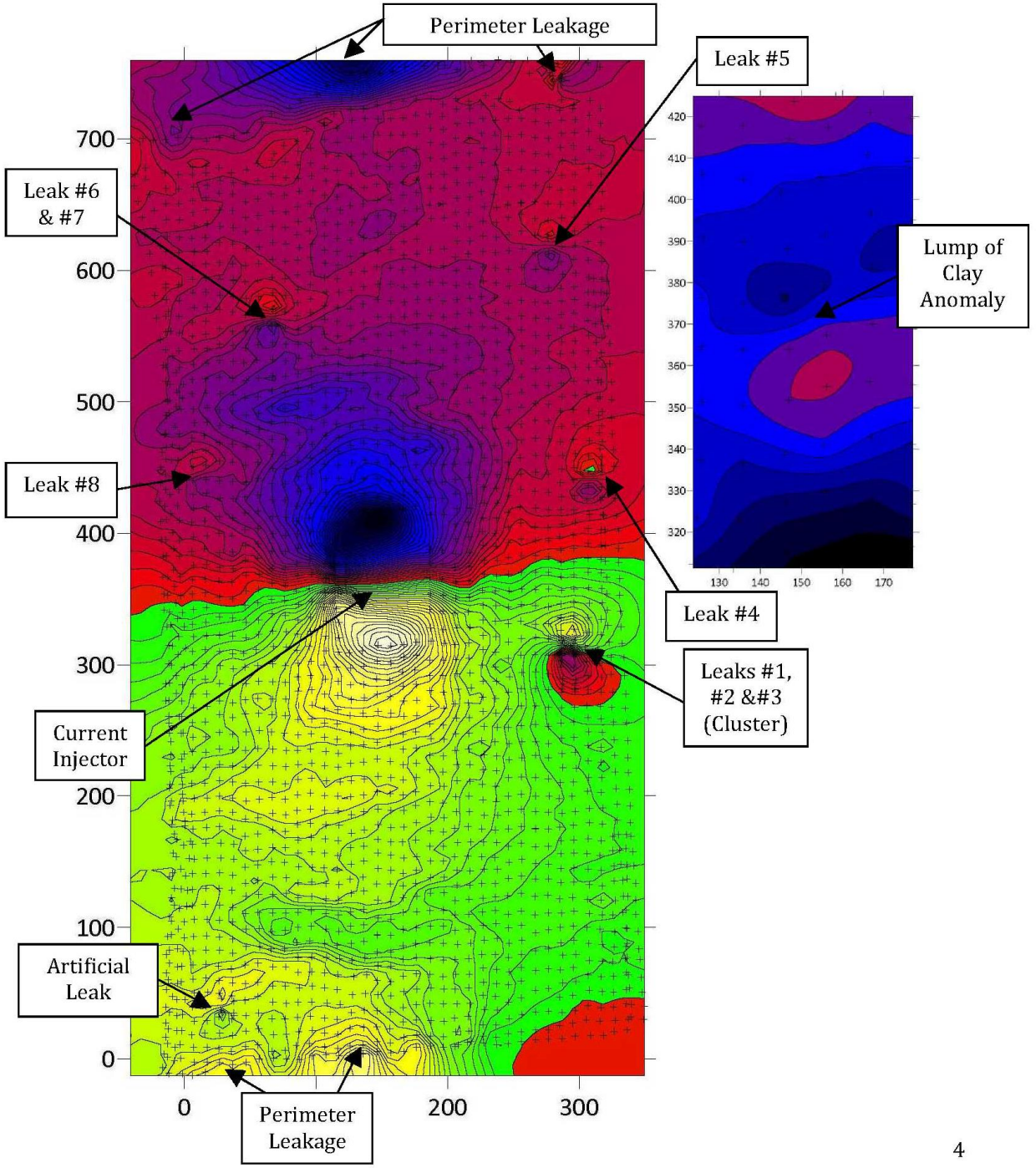
9.1.5 The condition of the material directly above the geomembrane in the location of the actual or artificial leak, if applicable.

9.1.6 Measurement grid spacing and dipole measurement spacing (if applicable).

9.1.7 Type and size of leaks found, if applicable.

9.1.8 Electrical maps of the areas detailed in either 7.3.7 or 7.3.8, as applicable.

9.1.9 Electrical map(s) of the entire survey area(s) with current source electrode, location of actual or artificial leak (as applicable), and any suspected or confirmed leak locations called out per 7.3.9.



Site Response Current

- Ohm's law: V = I R
  - Provides insight into how electrically isolated the testing circuit is
- Used to assess (and improve) site conditions
- Taking measurement throughout testing shows changing conditions of survey area
- Critical information for third party reviewer to be used in tandem with signal over artificial leak and evaluation of site conditions

D8265 Other Methodology Enhancements

- Specifies measurement grid spacing no larger than dipole spacing
  - Standardizes sensitivity for various dipole sizes*
- Requires measurement of site response current with and without artificial leak
  - If artificial leak draws more than 10% of initial site response current, then leave disconnected during test (map separately)
- Requires survey parallel to every edge
- Requires systematic leak excavation (where possible) to increase detection sensitivity
- Recognizes potential need for resurvey to locate all leaks

*Source: Gilson-Beck (2021). "Dipole Measurement Density and Dipole Spacing for Electrical Leak Location", *Proceedings of Geosynthetics Conference*, February 22-25.

Dipole Method Specifications

- Simply specifying D8265 ensures that good practices are followed
  - AND provides actual data in meaningful, concise, reviewable format
- Focus on project-specific site preparation and testing support requirements
  - Moisture
  - isolation
- Consider use of actual leak instead of artificial leak for functionality testing (Per ASTM D7909)

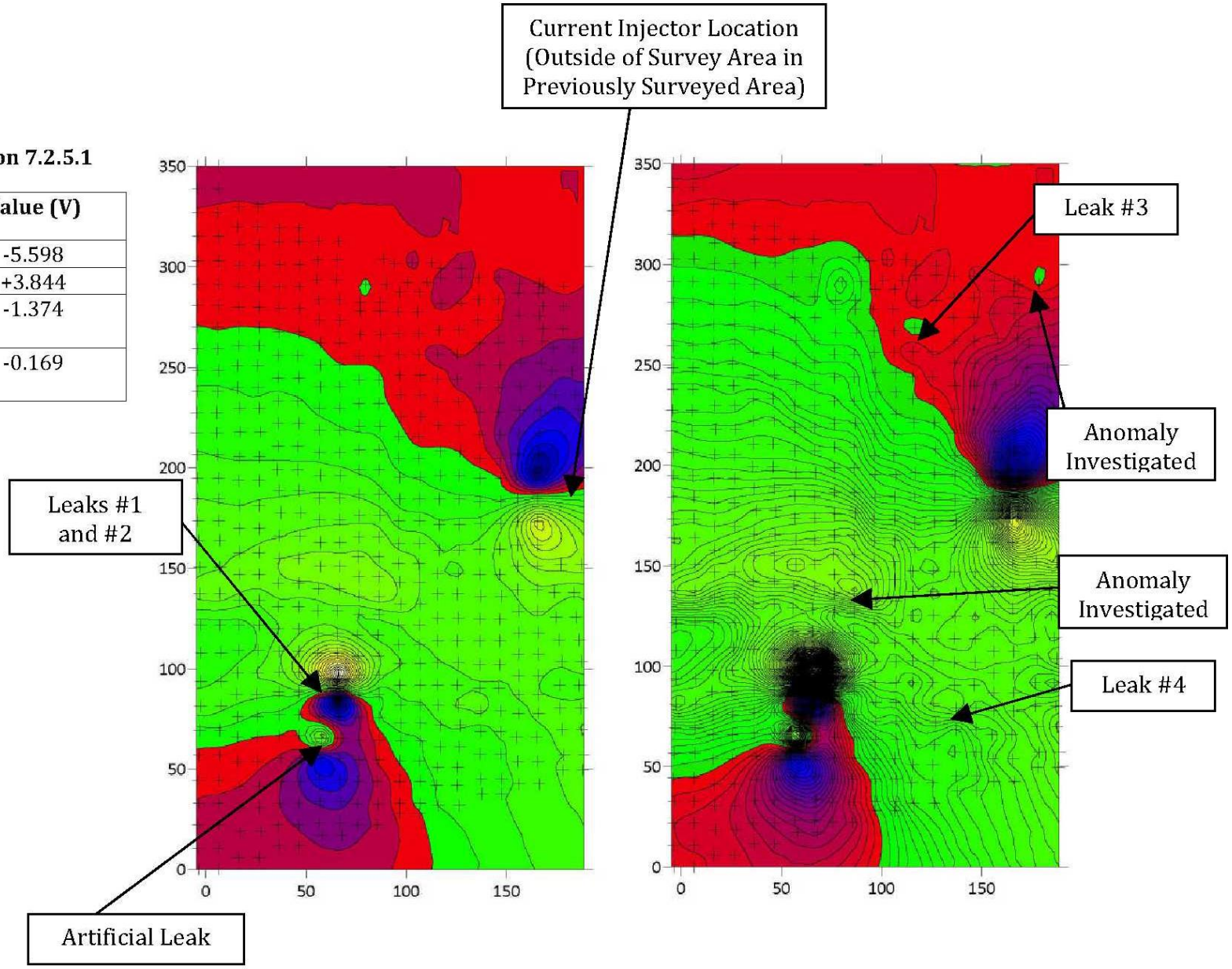
Source: Gilson-Beck (2021). “Dipole Measurement Density and Dipole Spacing for Electrical Leak Location”, *Proceedings of Geosynthetics Conference*, February 22-25.

Making Sense of the Data

Table 1: Dipole Measurements of Artificial Leak Per ASTM D8265, Section 7.2.5.1

Position	Description of Position	Value (V)
1	Front Foot Directly over Artificial Leak	-5.598
2	Back Foot Directly over Artificial Leak	+3.844
3	Front Foot on MP1 (Worst Case position of 10' x 10' measurement grid)	-1.374
4	Back Foot on MP2 (Worst Case position of 10' x 10' measurement grid)	-0.169

Figure 1: Voltage Map of Survey Area; Contour Interval 0.40 on Left, Contour Interval 0.10 on Right



Making Sense of the Data

Figure 2: Voltage Map of Artificial Leak Area (while disconnected); Contour Interval 0.10

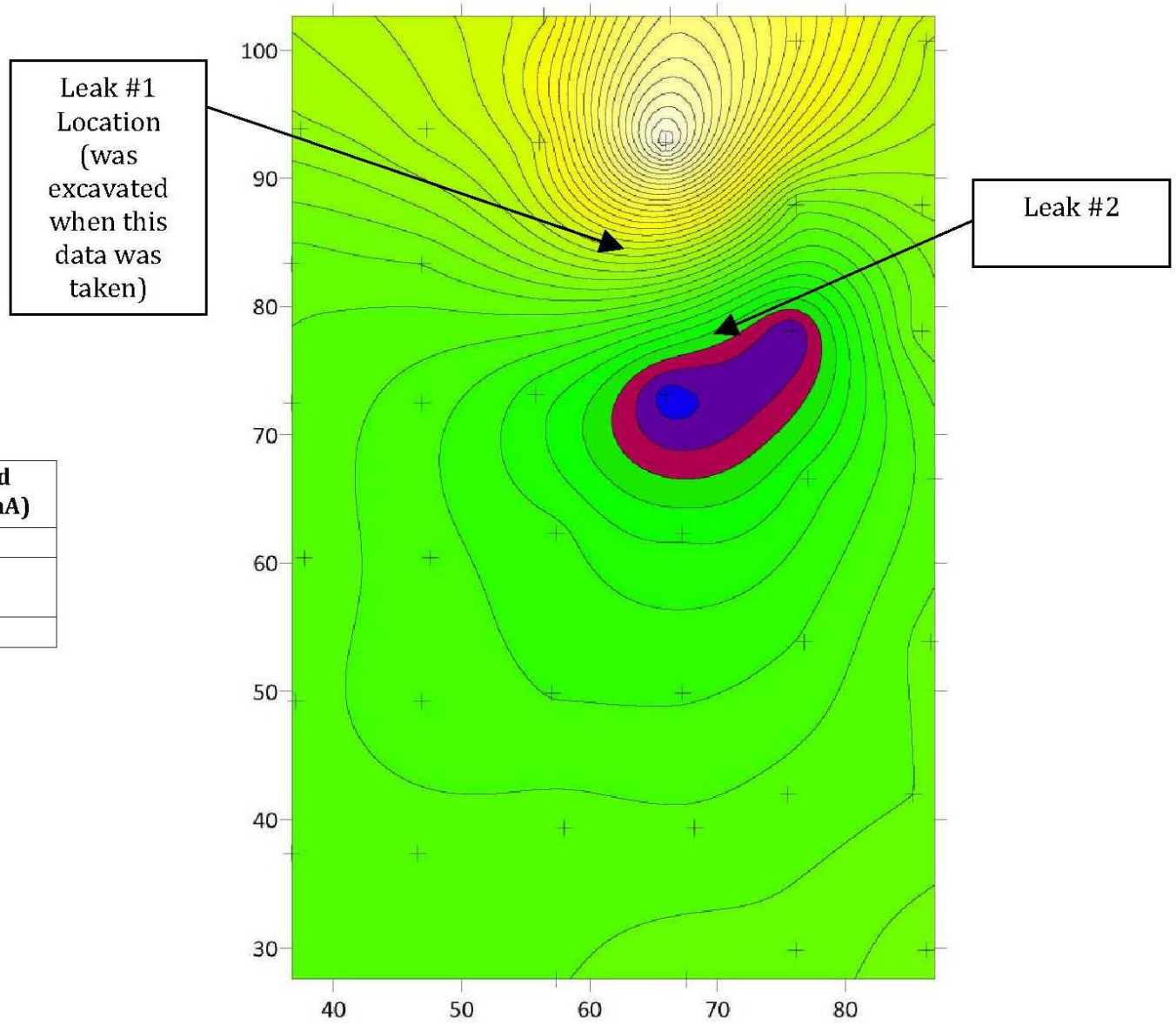
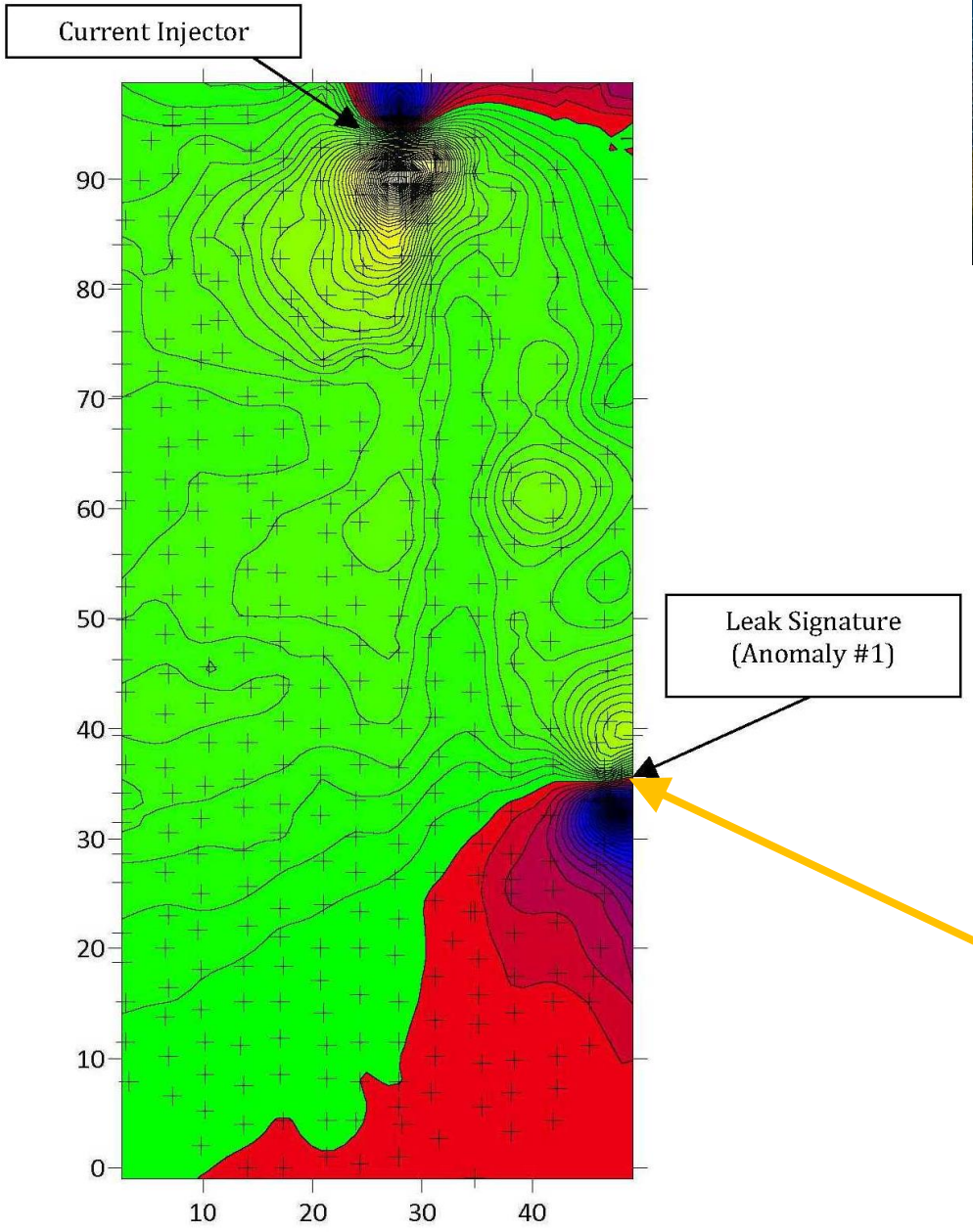


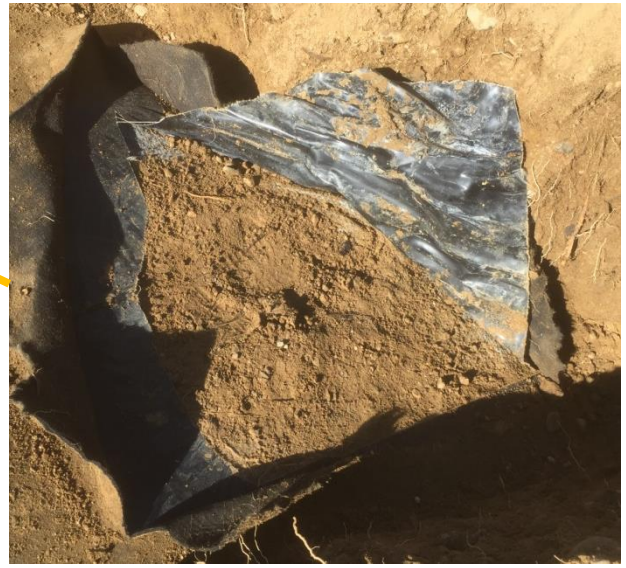
Table 2: Voltage and Site Response Current Log

Description of Condition	Applied Voltage (V)	Measured Current (mA)
Site Response Current – Initial	250	60
Site Response Current –1/4"Artificial Leak Connected	250	61
Site Response Current – End of Survey	250	24

Making Sense of the Data

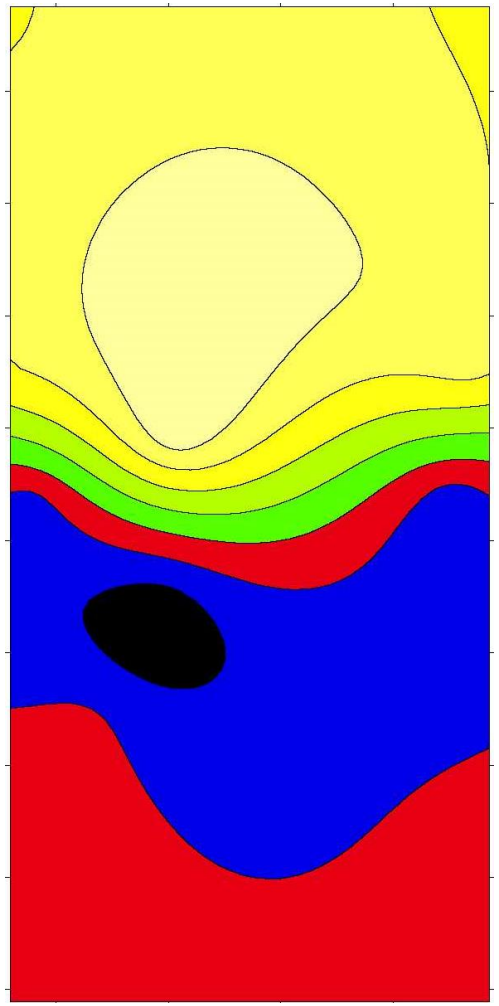


- Voltage applied: 125 V
- Site Response Current: 116 mA
- Artificial Leak Signal Magnitude: 0.9 V
- Leak #1 Signal Magnitude: 4.2 V

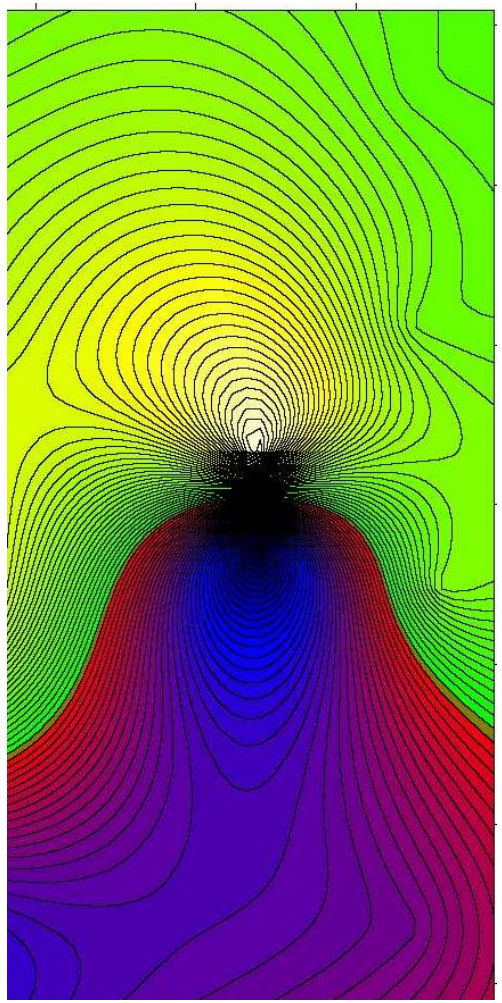


Making Sense of the Data

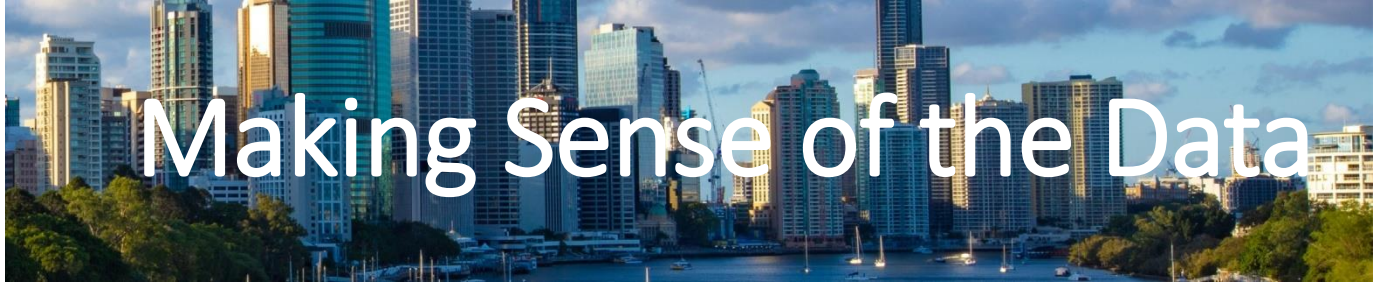
- Artificial leak signals before and after excavation of Leak #1 (plotted at some contour interval)



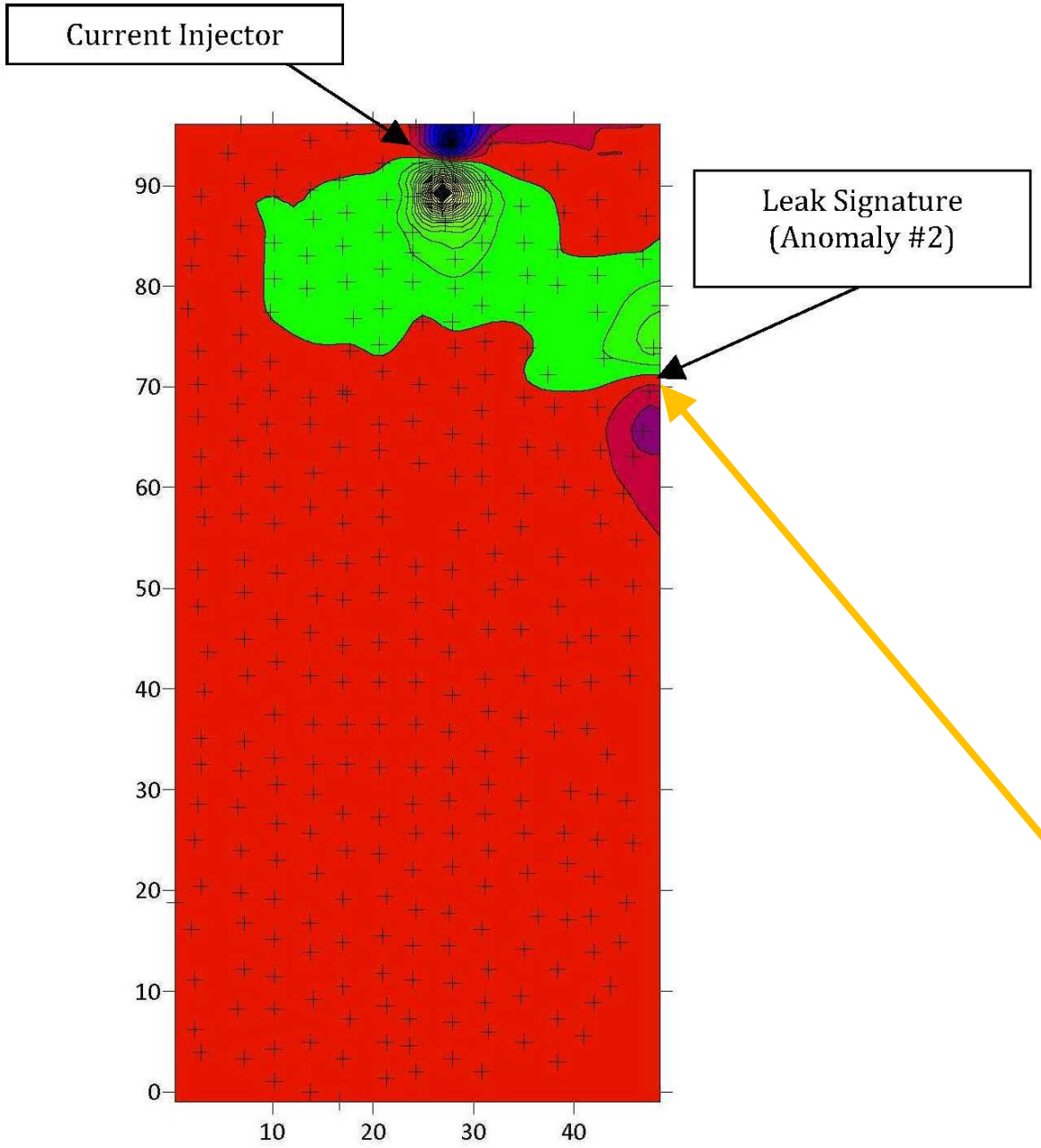
BEFORE



AFTER



Making Sense of the Data



- Voltage applied: 500 V
- Site Response Current: 15 mA
- Artificial Leak Signal Magnitude: 7.0 V
- Leak #2 Signal Magnitude: 0.5 V

Questions?

For more on this: Gilson, A. (2021). "Advancements in Field Testing for Locating Geomembrane Installation Damage", *International Journal of Geosynthetics and Ground Engineering*, 7:72.

TRI ENVIRONMENTAL

Contact Info:

Abigail Gilson

Email: abeck@tri-env.com

ELL Services inside of Australia:

Warren Hornsey

Email: whornsey@tri-env.com.au

Phone: 0419 145 750