Application of Water Supply Exploration Techniques to Contaminant Transport Investigations in Fractured Bedrock, a Toolbox Discussion

BIA NHDES
2024 New Hampshire Environmental Regulatory Conference

September 10, 2024

Ottati & Goss Superfund Site-Kingston, New Hampshire

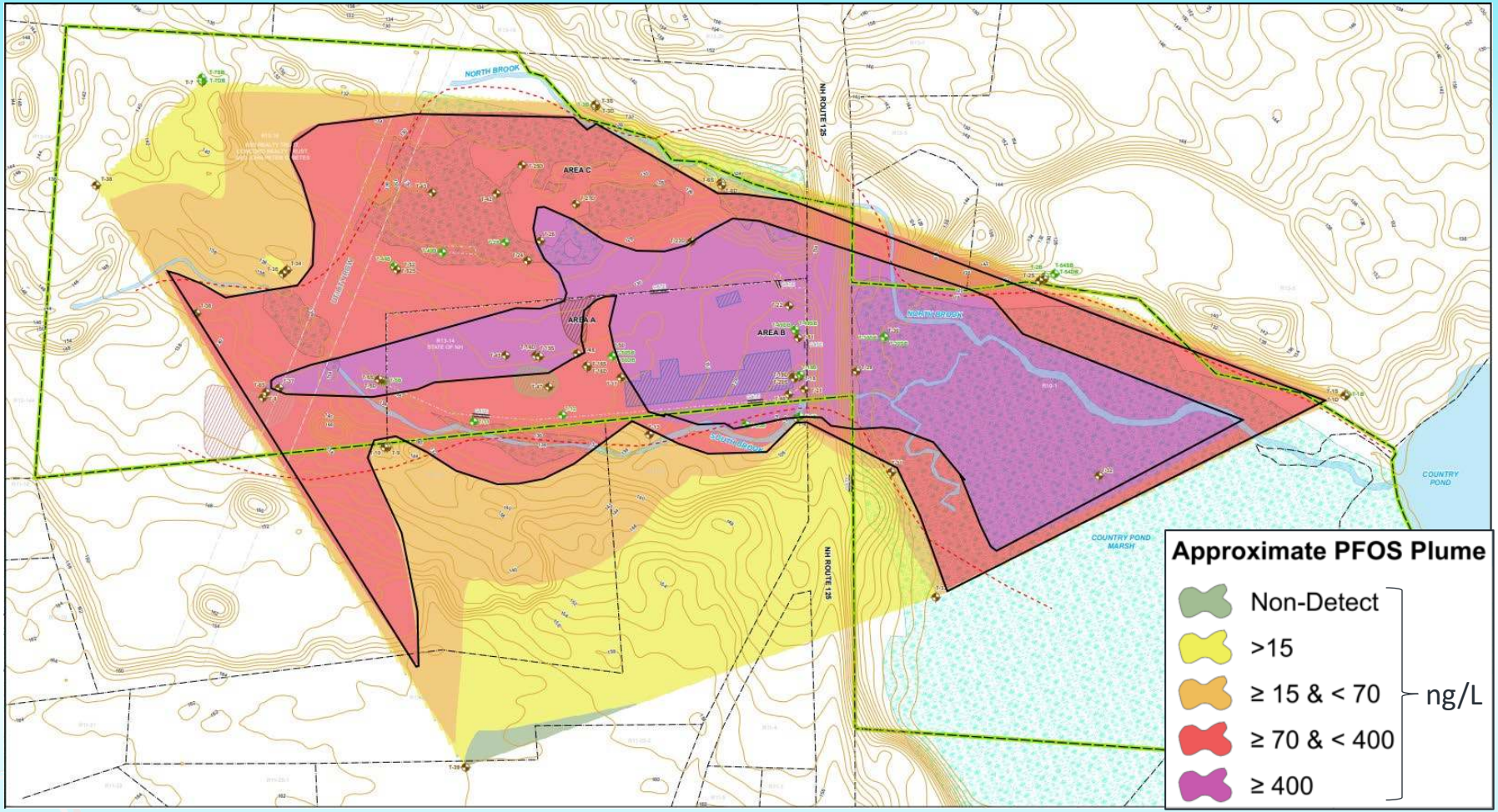
Former Drum Reconditioning Site surrounded by residential and recreational properties.

Has undergone investigation under Superfund since the early 1980s.

PFAS

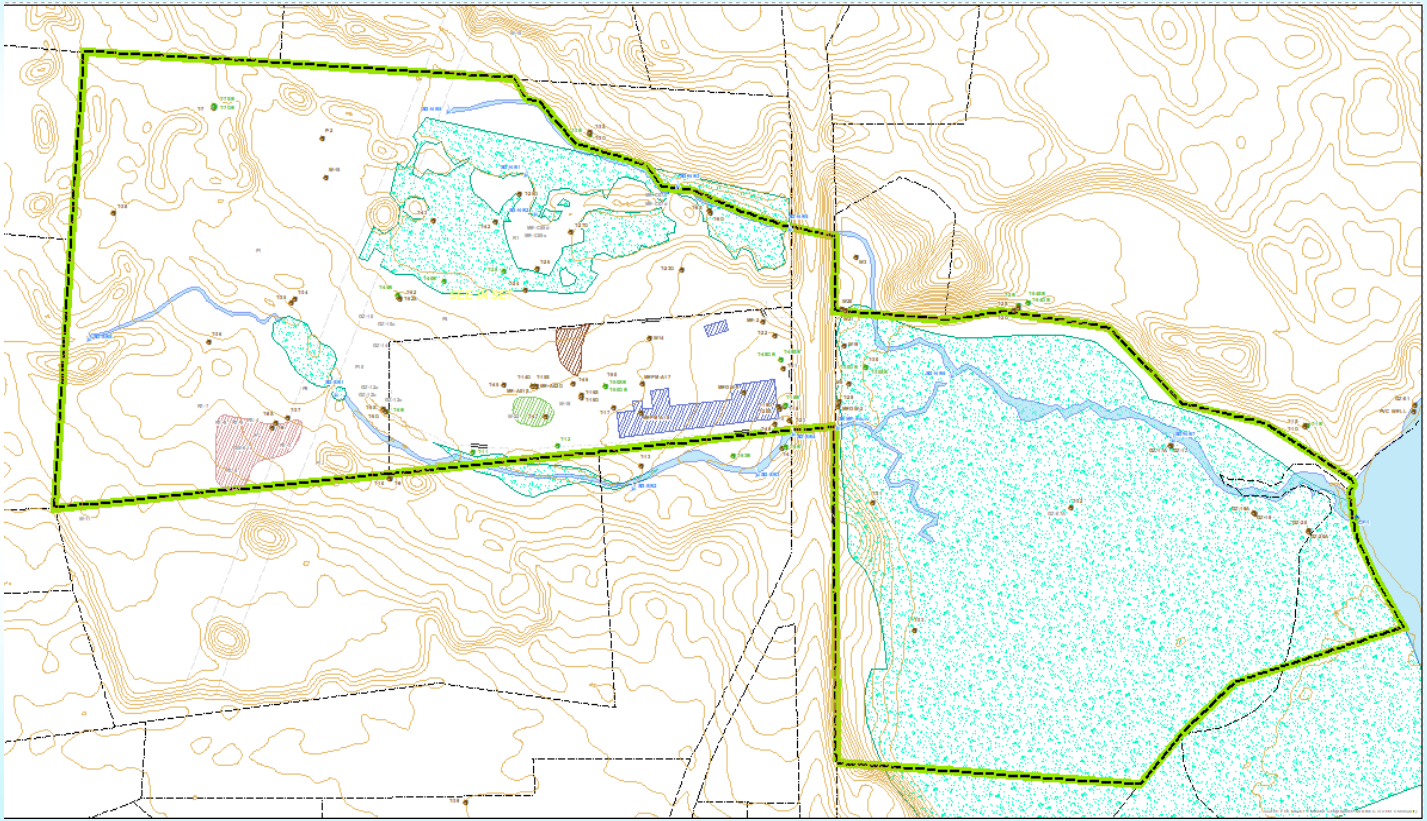
Ottati & Goss Superfund Site

1979

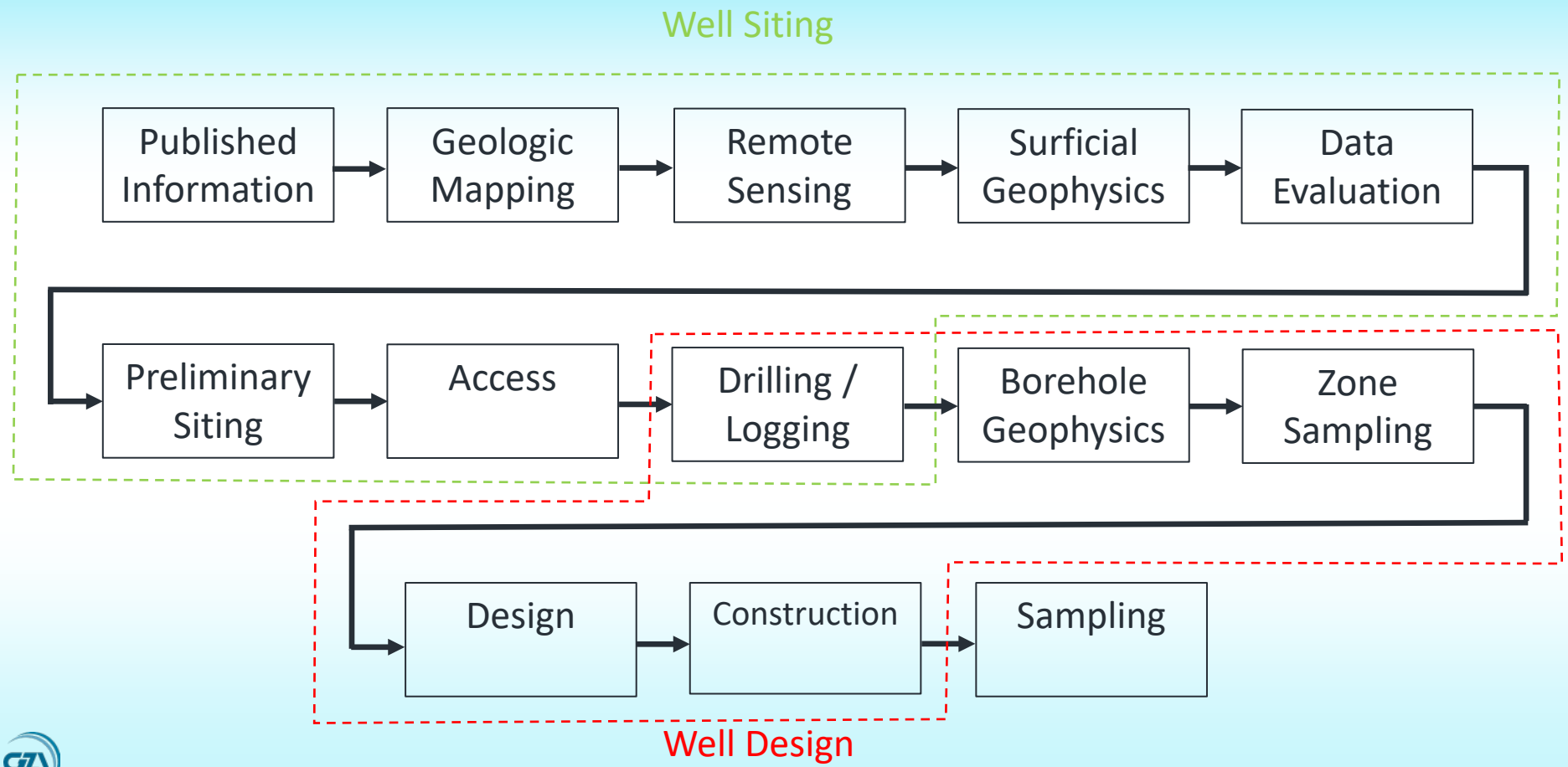


Technical Challenge: Evaluate PFAS in Local Bedrock Aquifer

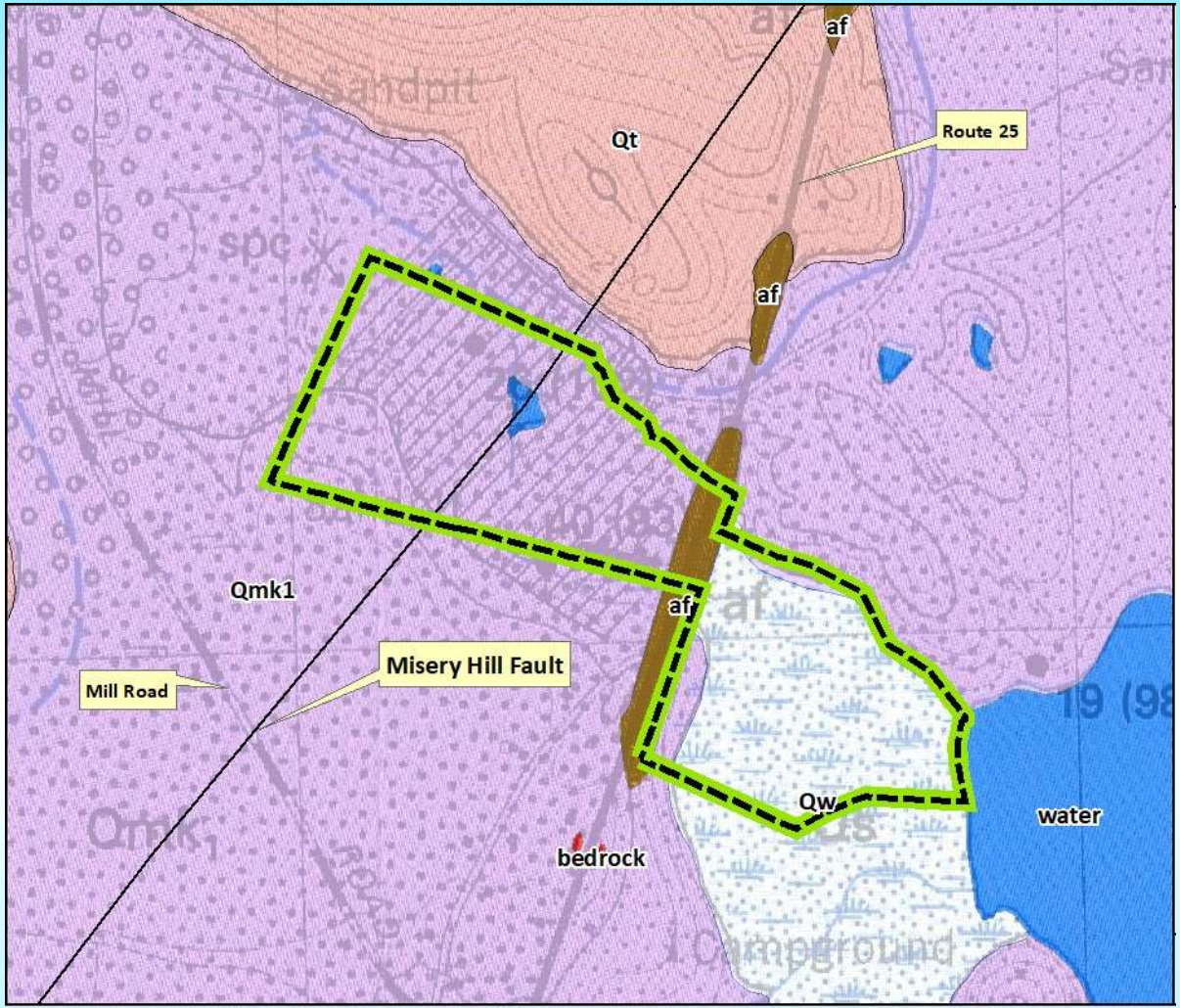
Evaluate the presence and transport of PFAS in fractured bedrock to enhance the site conceptual model and assess risks to human and ecological receptors.



Fractured Bedrock Monitoring Well Siting and Design Overview



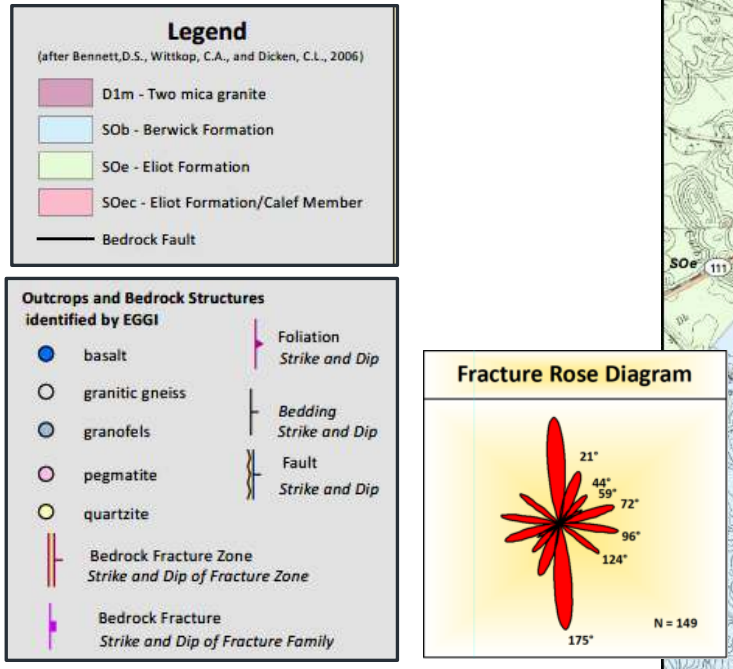
Surficial Geology at Ottati & Goss Project Site

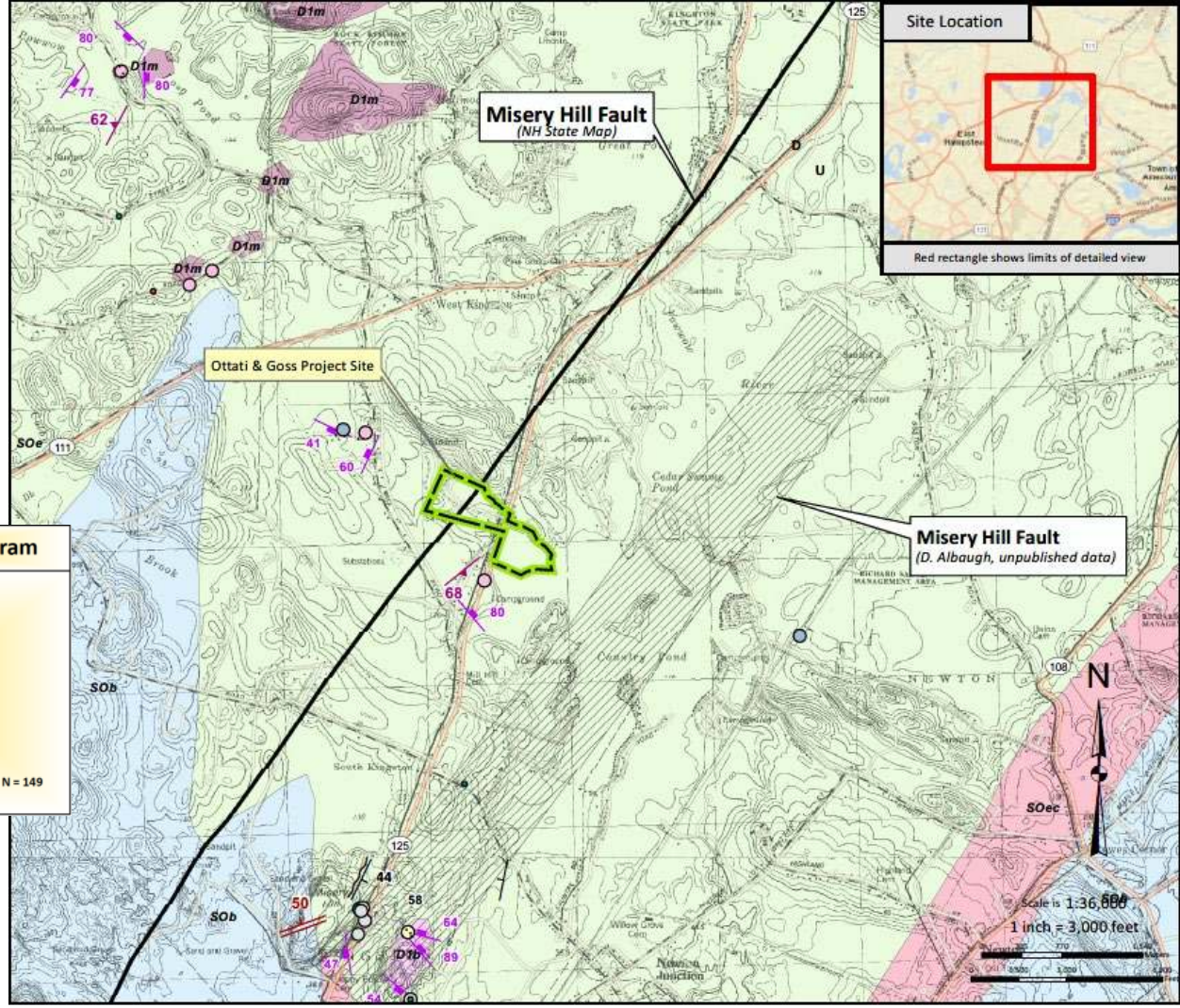


Fractured Bedrock Investigation

- Remote Sensing/Lineament Analysis
- Bedrock Structural Mapping/Faults
- Surficial Geophysics
- Bedrock Well Drilling
- Borehole Geophysics, Zone Sampling

Bedrock Structural Mapping





- 149 fracture measurements were collected for this Study

Rock Types Identified within the Misery Hill Fault Zone

Polished surface in fault zone

Northeast trending fault zone

Regional Coincident Lineaments

- Lineaments were drawn of four image types
- A total of 2,119 lineaments were identified within 3km of the project site during this investigation
- A synoptic rose diagram graphically displays the most common orientations

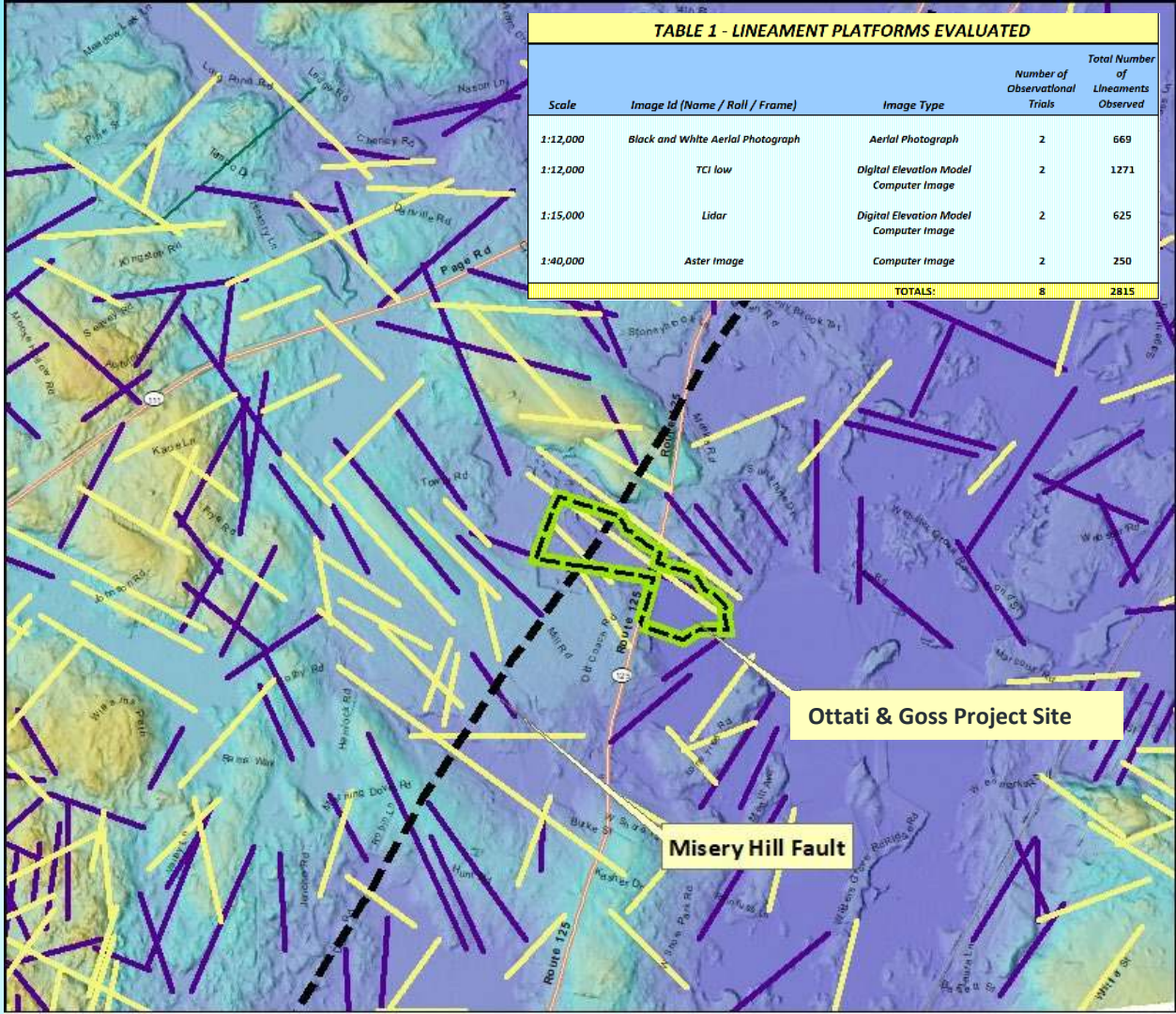
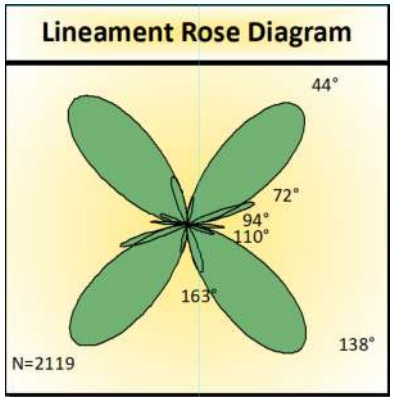


TABLE 1 - LINEAMENT PLATFORMS EVALUATED

Scale	Image Id (Name / Roll / Frame)	Image Type	Number of Observational Trials	Total Number of Lineaments Observed
1:12,000	Black and White Aerial Photograph	Aerial Photograph	2	669
1:12,000	TCI low	Digital Elevation Model Computer Image	2	1271
1:15,000	Lidar	Digital Elevation Model Computer Image	2	625
1:40,000	Aster Image	Computer Image	2	250
		TOTALS:	8	2815

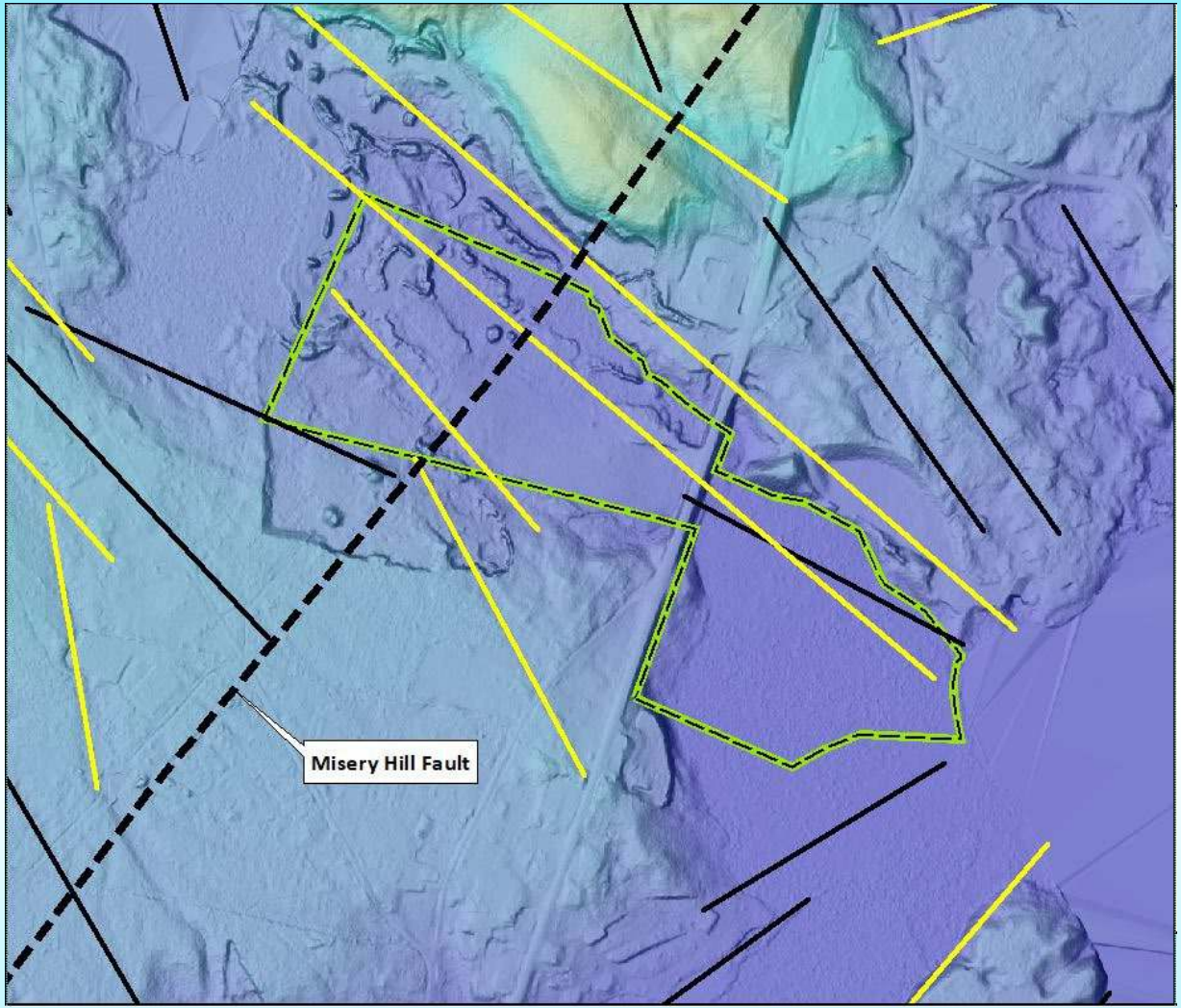
Remote Sensing/Lineament Analysis



Fracture-Supported Coincident Lineaments
Observed on more than three scales of imagery AND co-parallels nearby fracture family or bedding trends.

Coincident Lineaments
Observed on more than three scales of imagery. (trend is posted in degrees east of north)

Groundwater Management Zone (GMZ)



Misery Hill Fault

- Part of a Multiple deformed regional fault system
- High Angle Thrust Fault
- Formed about 350 million years ago during the building of the Appalachian Mountains
- Extension of significant lineament that traces across southern New Hampshire

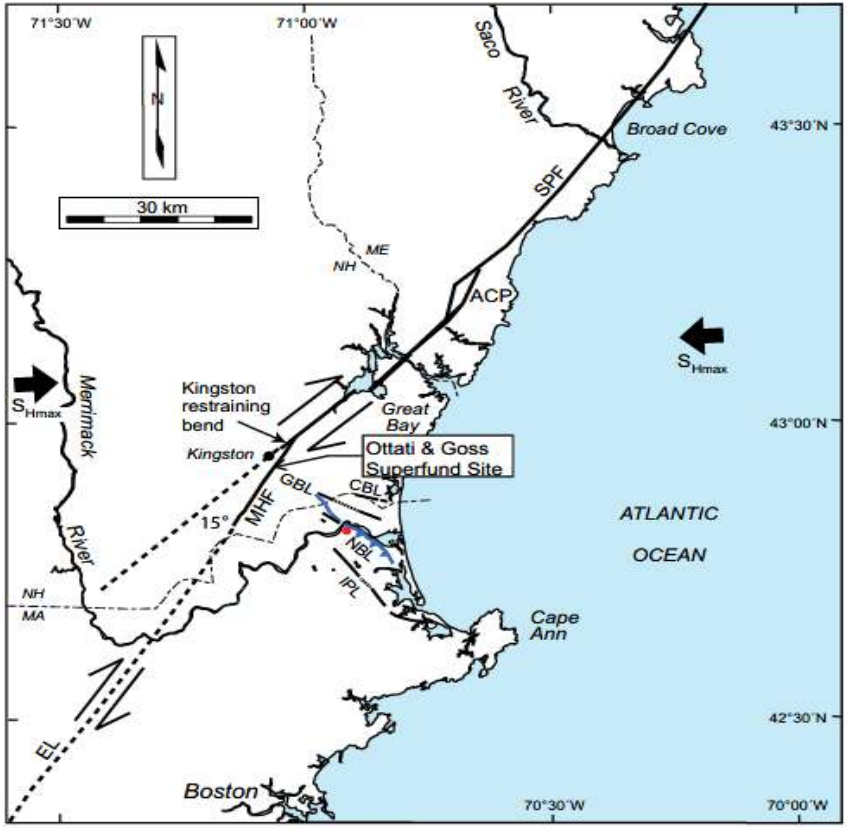
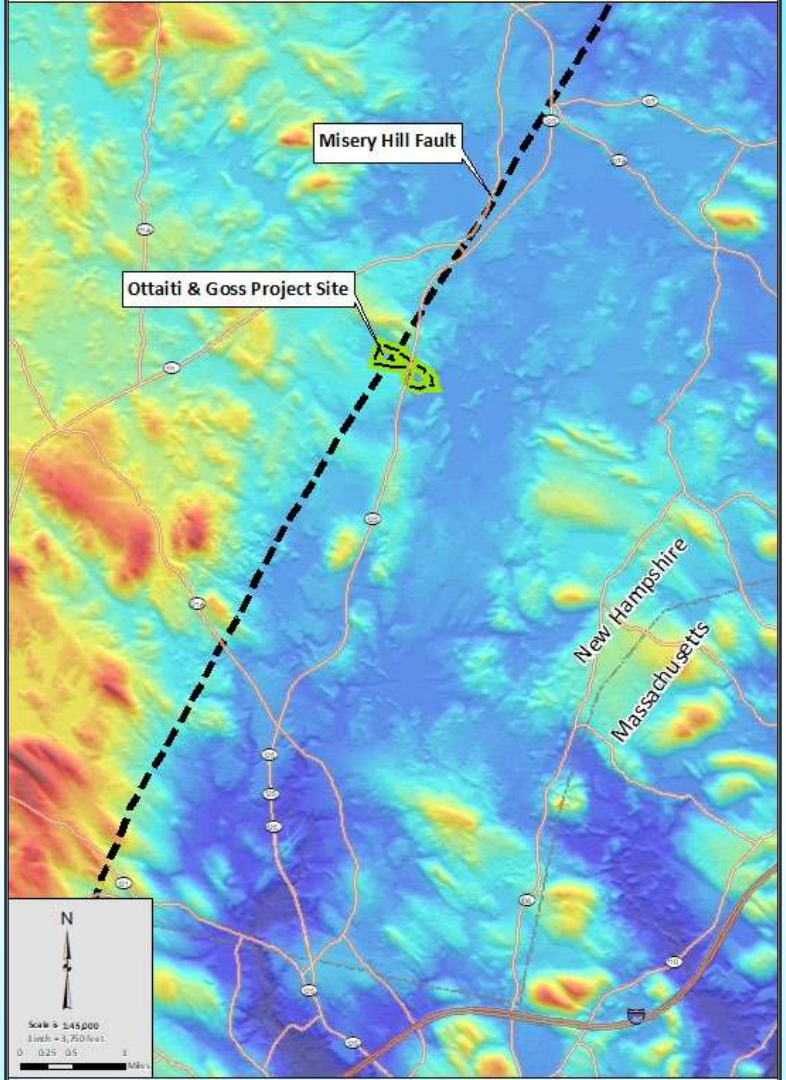


Figure 11. Conceptual diagram showing the Kingston restraining bend along the proposed fault system formed by the Misery Hill fault (MHF) segment of the Eastford lineament (EL) and the southwest continuation of the South Portland fault segment (SPF) of the Norumbega fault system. S_{Hmax} (between the opposing arrows) is the axis of the maximum horizontal compressive stress field of Zoback and Zoback (1991). Abbreviations CBL, GBL, IPL, and NBL are the Coins Brook, Grassy Brook, Ipswich, and Newburyport lineaments, respectively. The postulated Newburyport fault is along the NBL (teeth on upthrown side). The small red dot is the location of the 1999 Amesbury, Massachusetts, earthquake. ACP is the Agamenticus compressional pop-up of Marple *et al.* (2014a).

Misery Hill Fault Shown on Digital Elevation Model of Southeast New Hampshire

Location of Fault is not definitive and, in part, is why a multi-discipline approach to investigate the subsurface geology was selected for this project.

- The Misery Hill Fault was mapped in Kingston, NH by D. Albaugh in 1983.
- The Misery Hill Fault is likely comprised of multiple fault segments

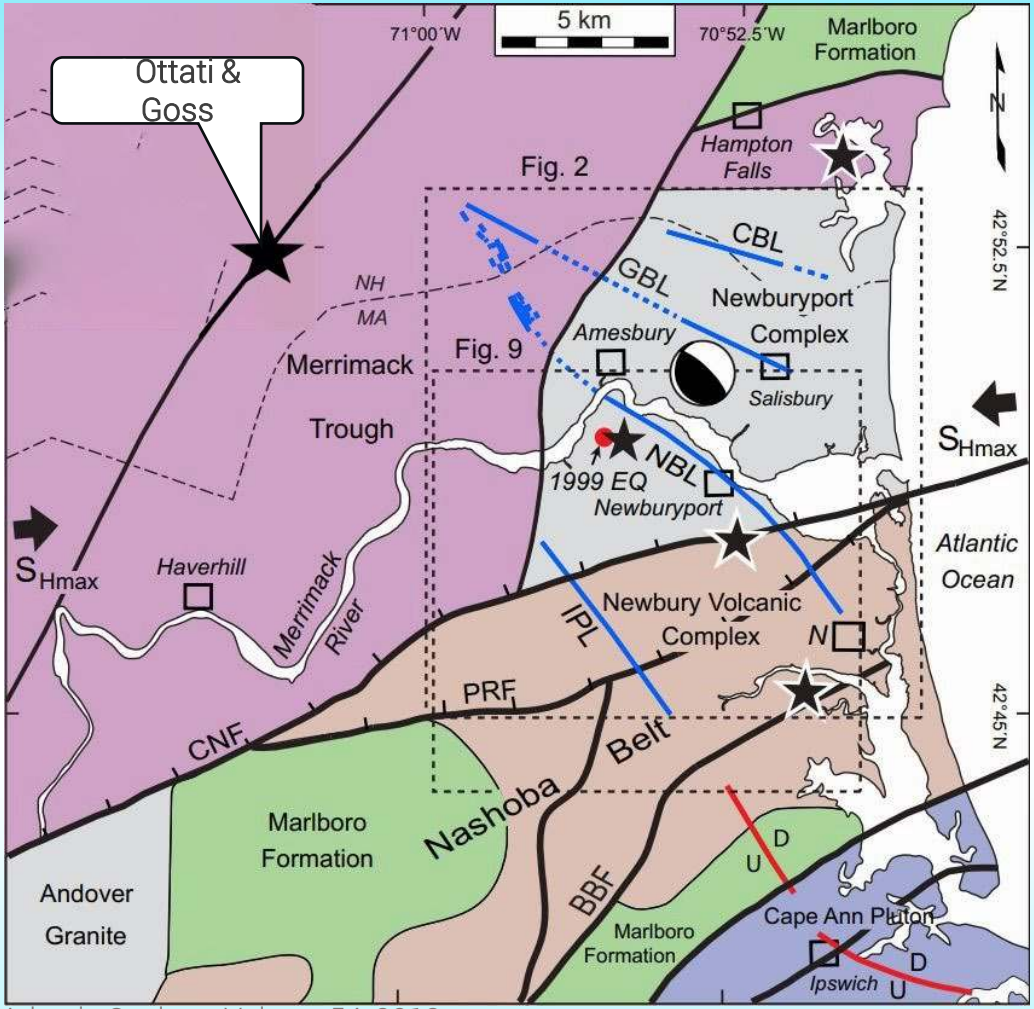


Additional Local Fault Information

Map of Paleozoic faults (solid lines) and bedrock units modified from Hibbard *et al*. (2006).

Also shown

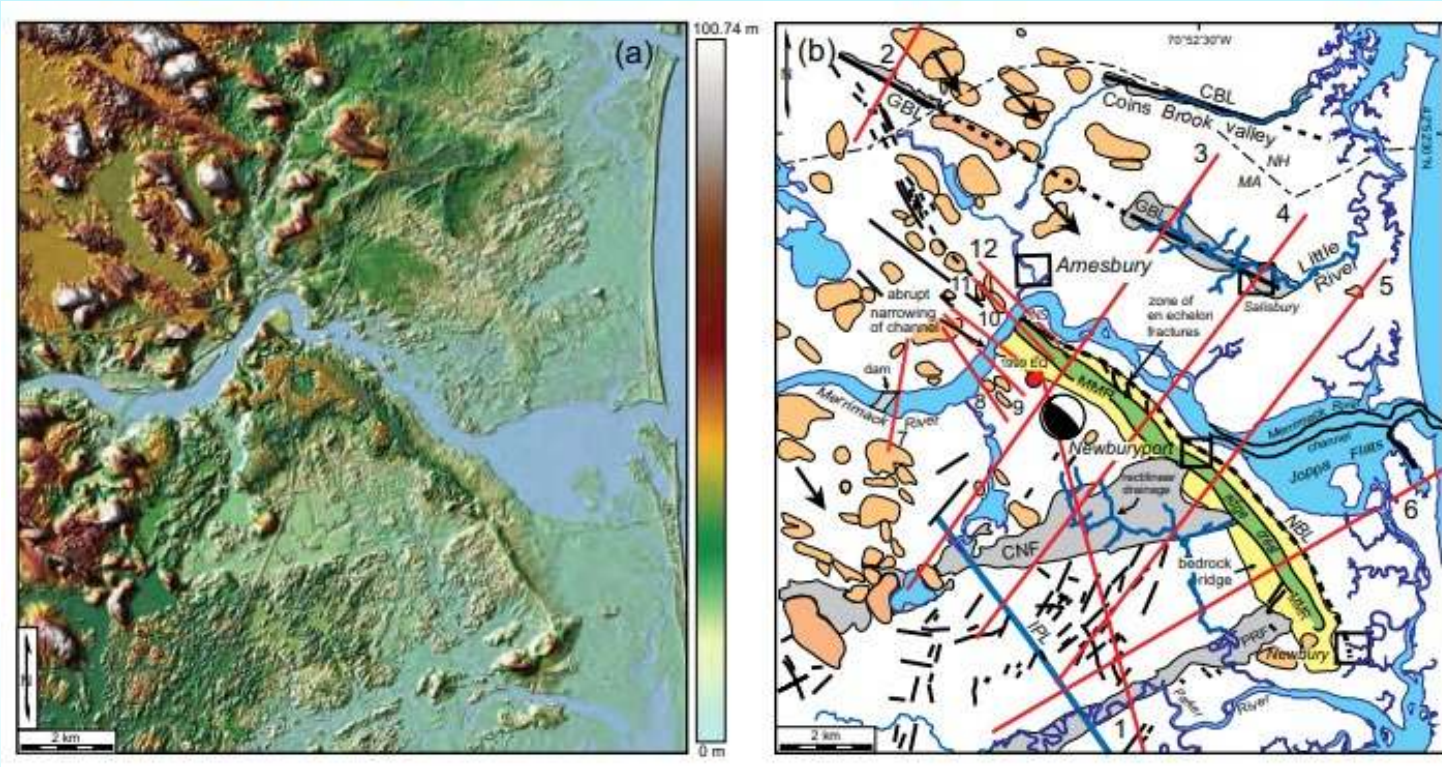
- LiDAR lineaments (blue lines, dashed where inferred),
- The epicenter of the 1999 Amesbury earthquake (red dot),
- Sites of 1727 liquefaction (Tuttle and Seeber 1991; Tuttle 2007) (stars),
- The lower-hemisphere focal mechanism solution for the 1999 Amesbury main shock (Ebel 2000).



Additional Local Fault Information

(a) Raised-relief color LiDAR image of the Newburyport, Massachusetts, area (illumination azimuth = 300°).

(b) Interpretive map of (a). NS is the Newburyport scarp (tics are on the downthrown side). The solid red dot is the epicenter of the 1999 Amesbury earthquake (Ebel 2000). Thick black lines are faults and LiDAR lineaments (dashed where inferred). Abbreviations CBL, GBL, and NBL are the Coins Brook, Grassy Brook, and Newburyport lineaments, respectively.



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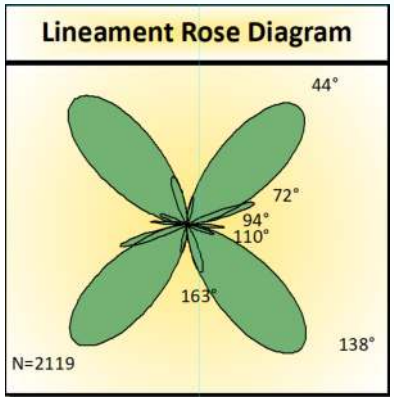
Remote Sensing/Lineament Analysis



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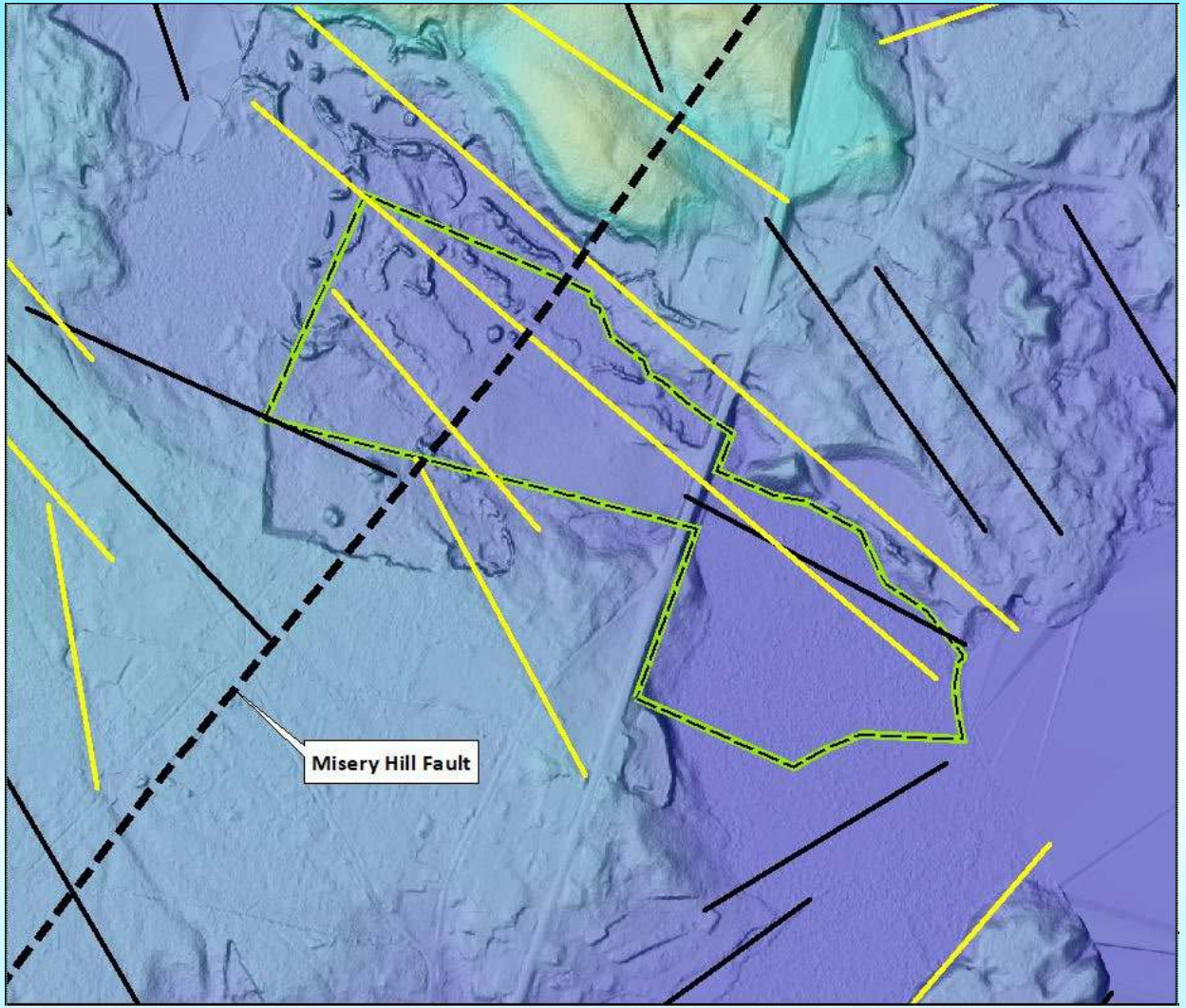
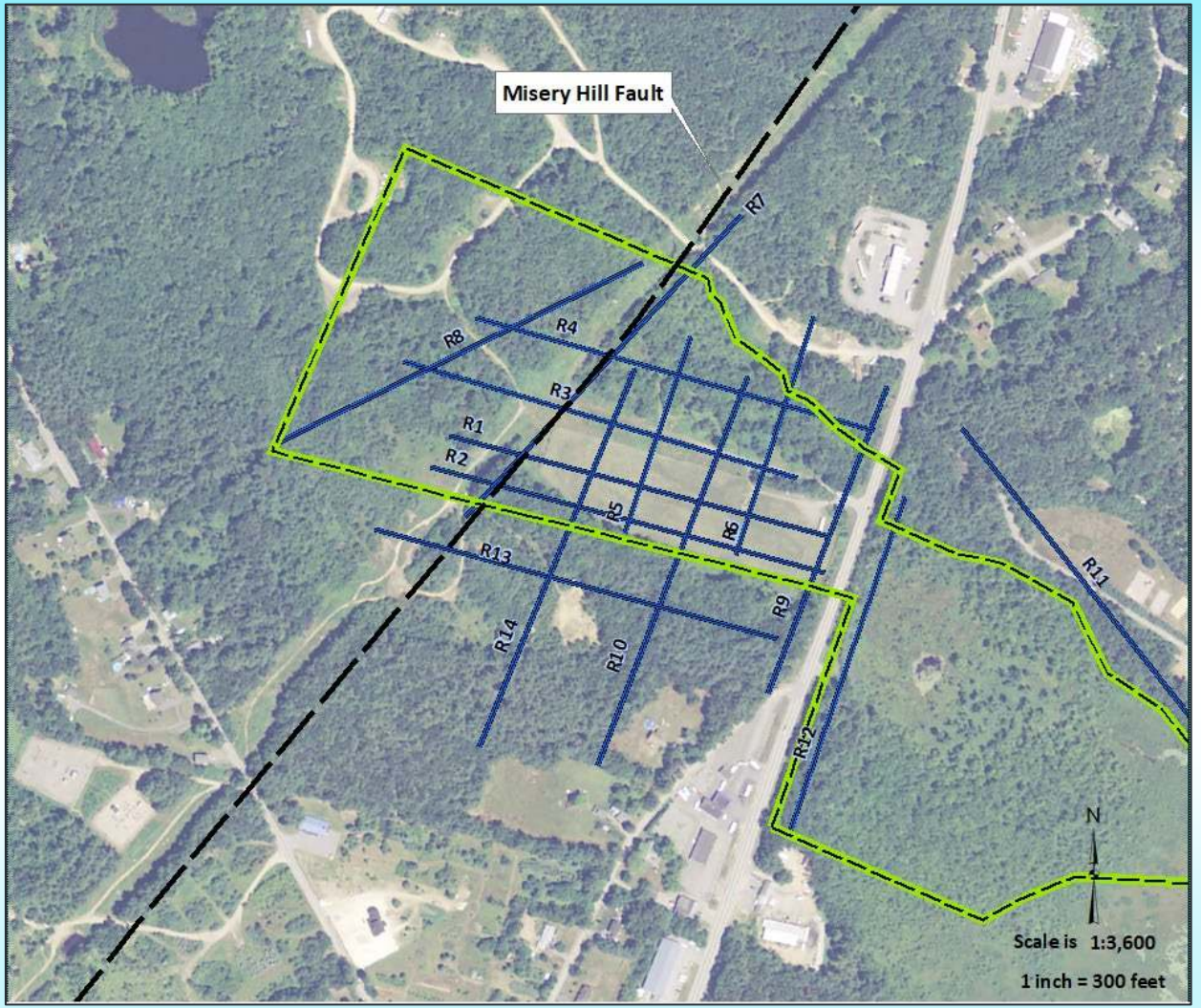


Surficial Geophysics

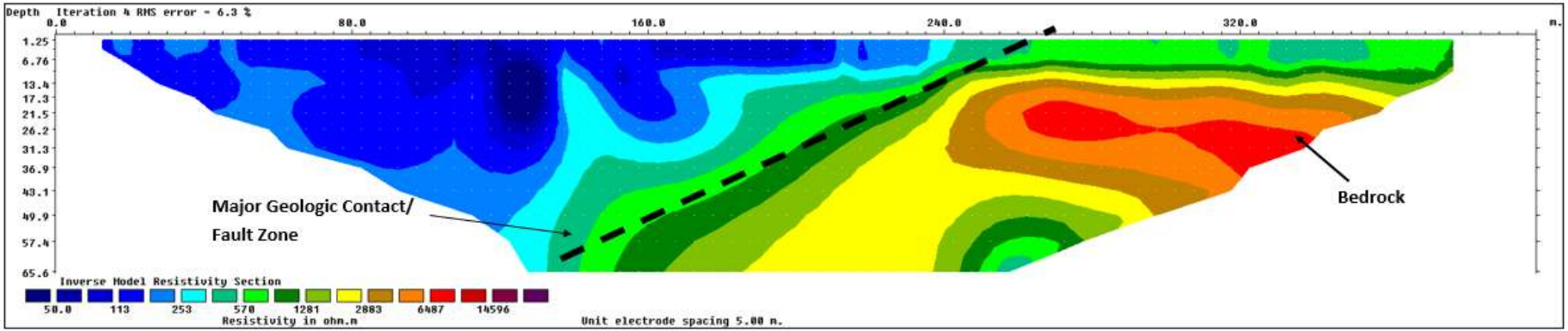
- 12 Electrical Resistivity Surveys Lines were conducted in and around the Project Site.
- Dipole-Dipole, Gradient, and IP data was collected along each survey line.
- 36 Models of the geophysical data was analyzed.



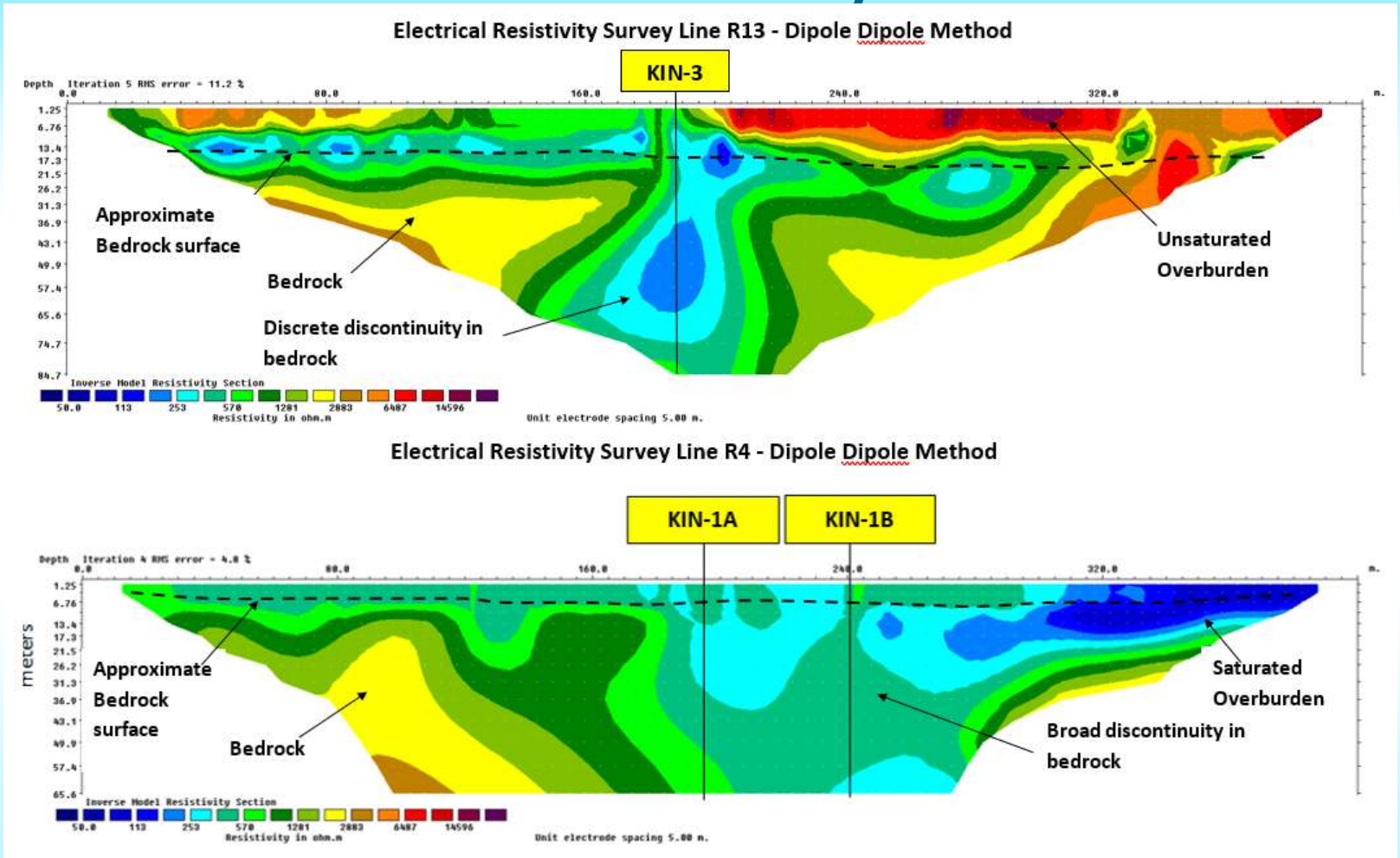
An Example Electrical Resistivity Model of Fault Zone

Interpretation of Electrical Resistivity Models

Electrical Resistivity Survey Line - Dipole Dipole Method



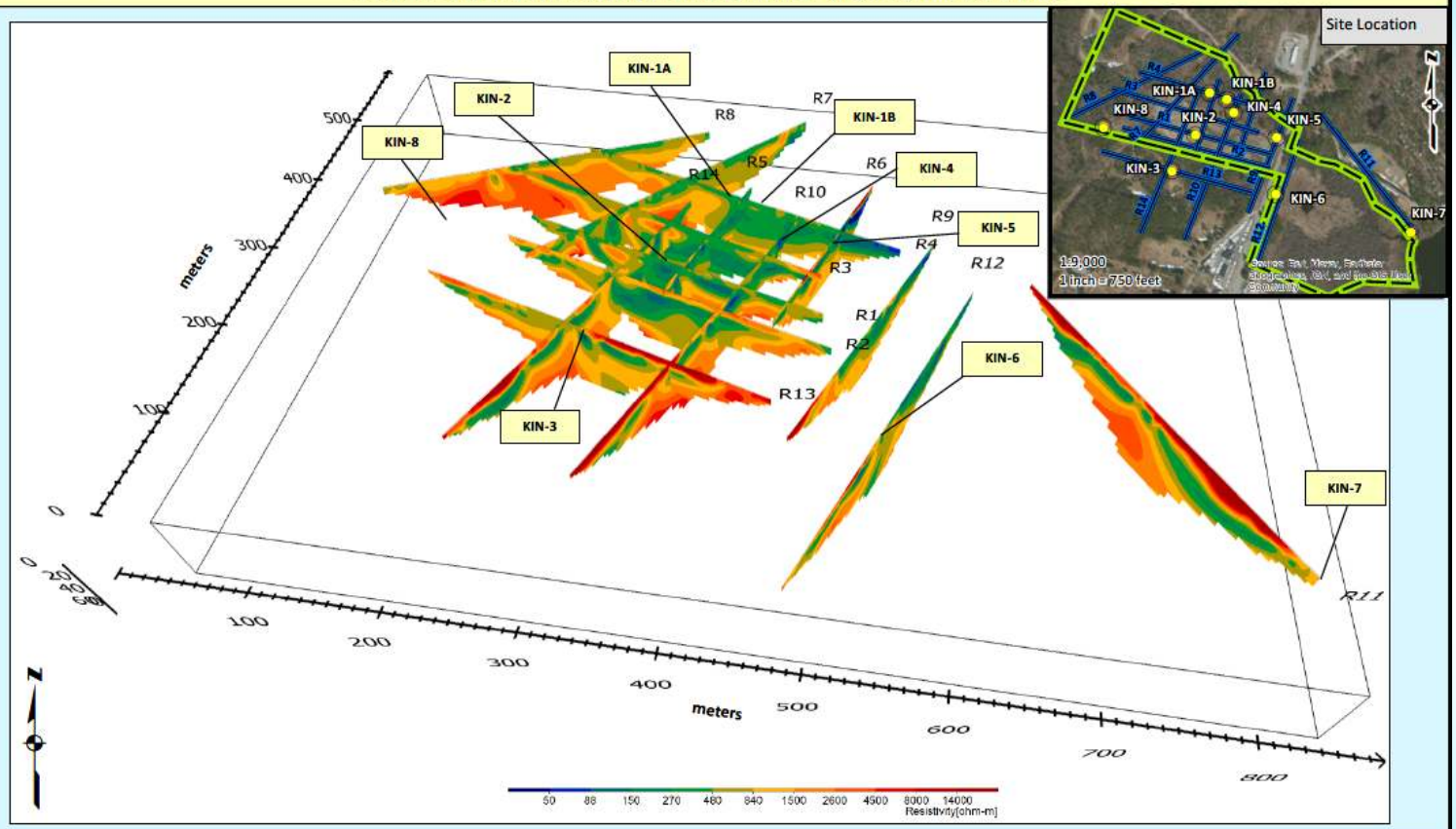
On-Site Electrical Resistivity Models



Fence Diagram of Gradient Electrical Resistivity Models

FIGURE 1

Location of Electrical Resistivity Survey Lines - Gradient Method
Ottati & Goss Kingston Steel Drum Superfund Site - Kingston, New Hampshire

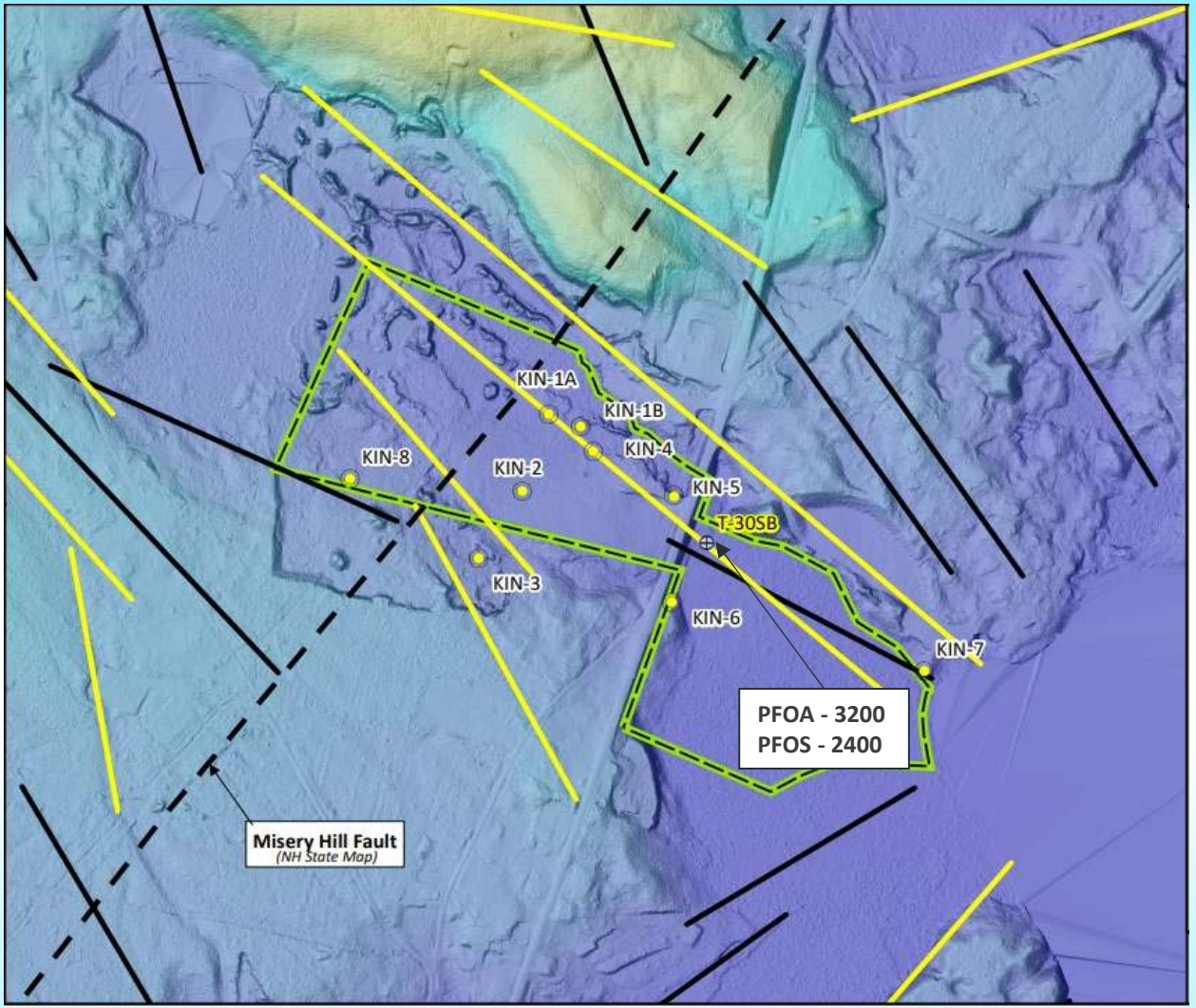


Emery & Garrett
Groundwater Investigations, A Division of GZA

FIGURE 1

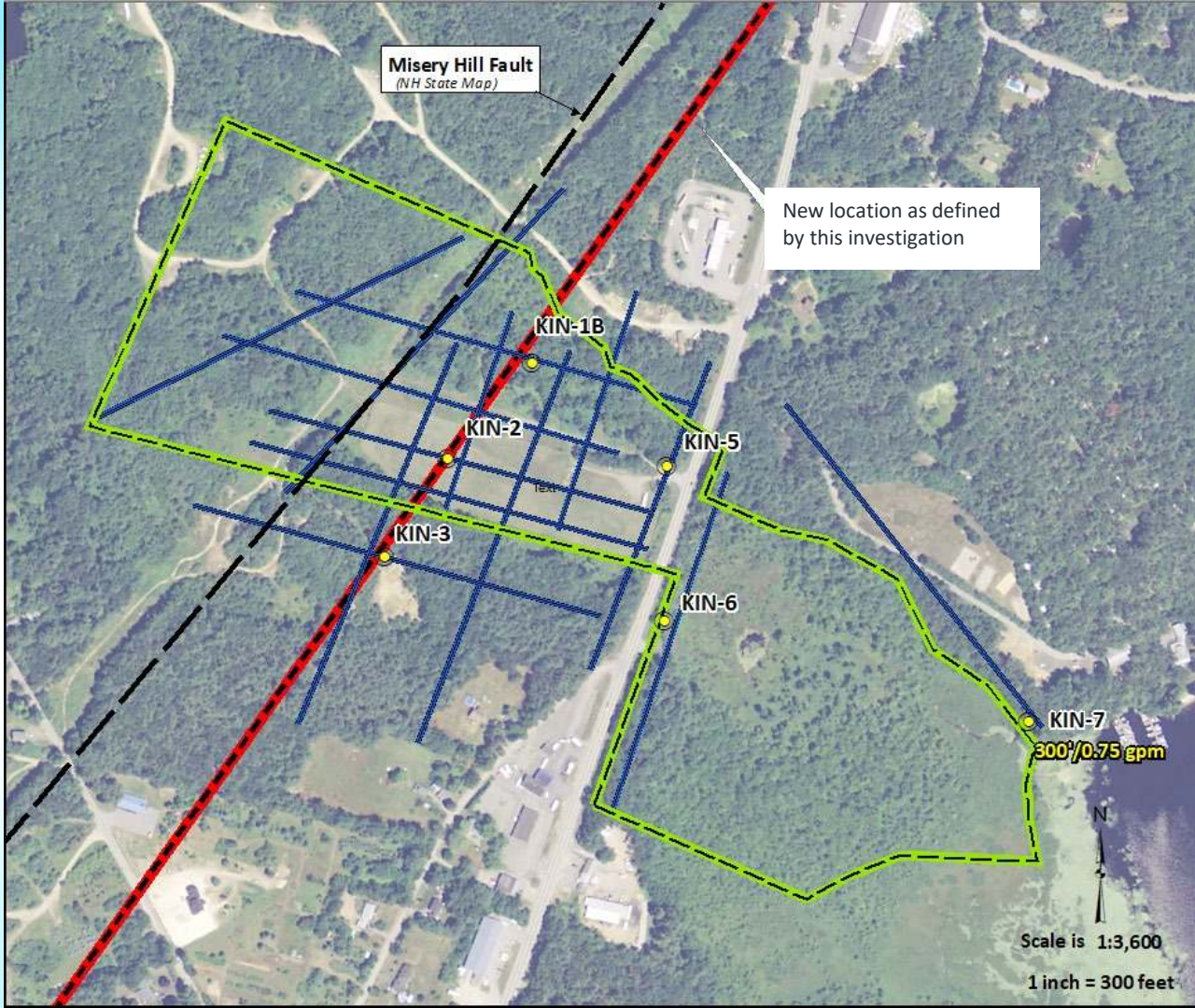
Lineaments and Proposed Exploratory Test Well Sites

- 4 out of 8 potential test well sites are located near fracture supported coincident lineaments



Surficial Geophysics and Proposed Exploratory Monitoring Well Sites

- 6 out of 8 potential monitoring well sites are located on geophysical anomalies.



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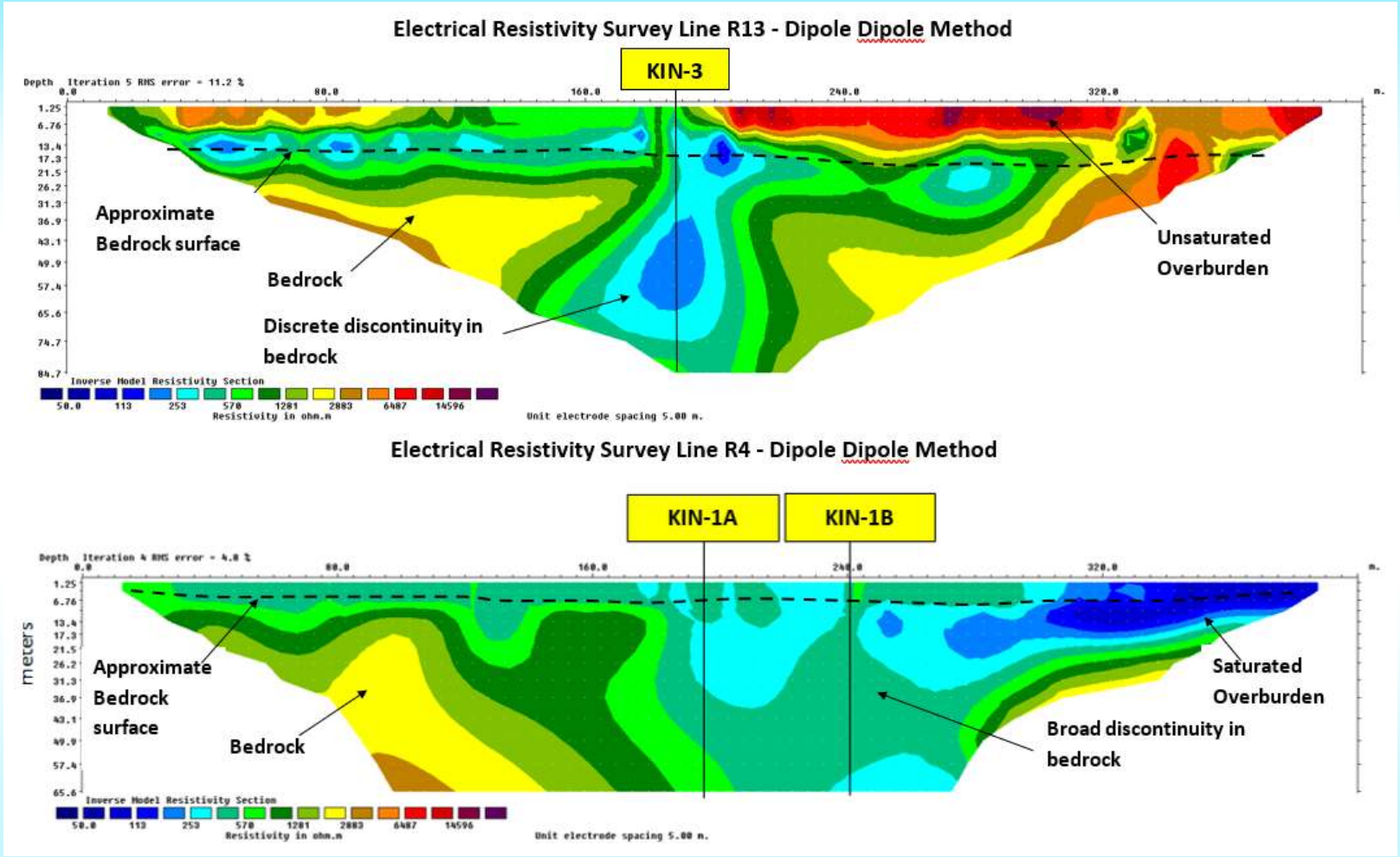
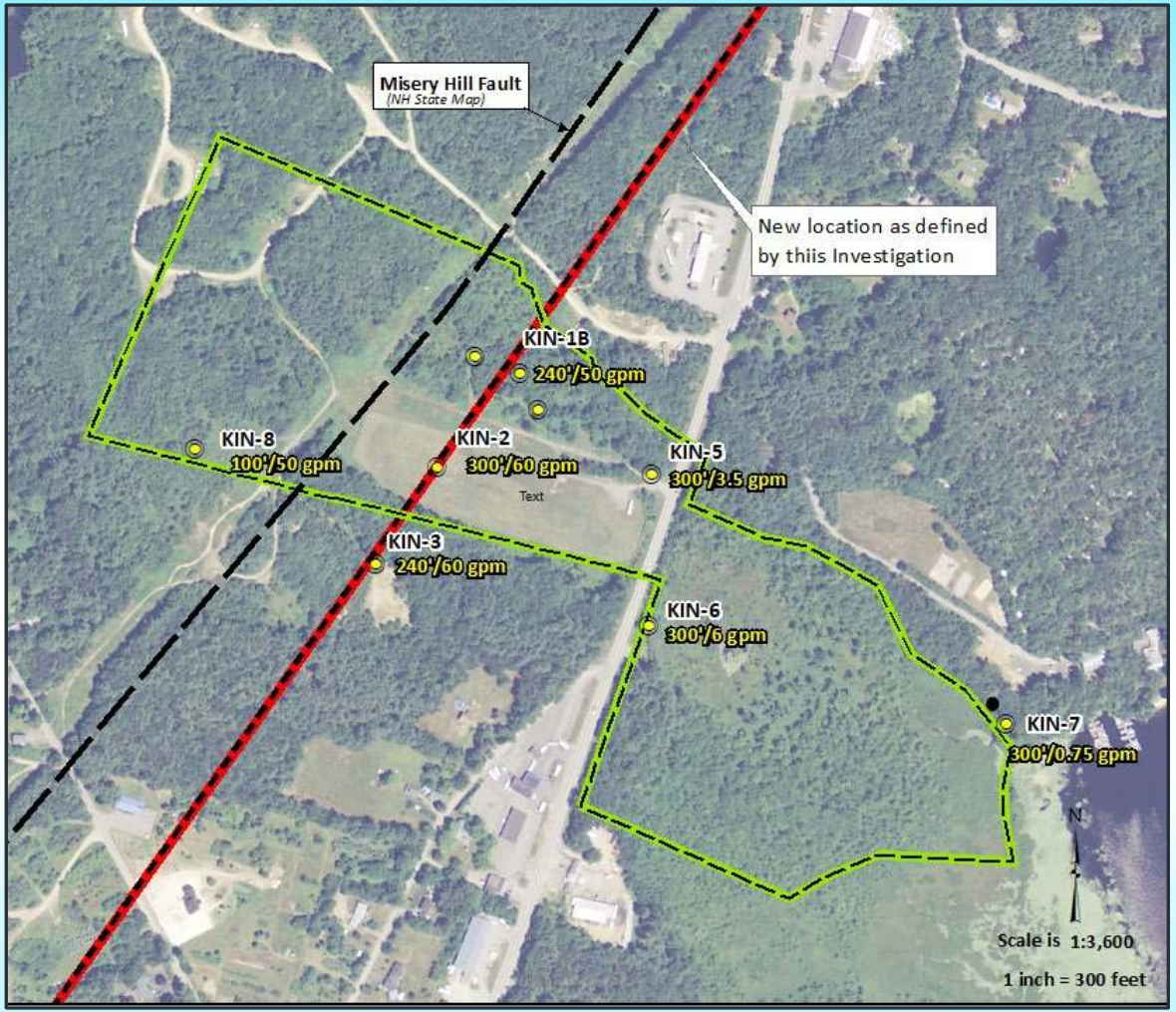


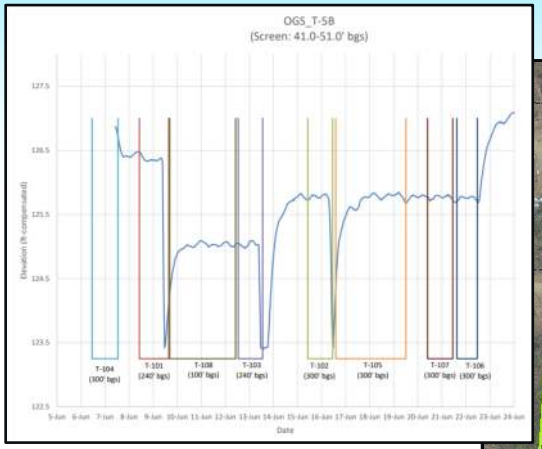
Results of Well Drilling

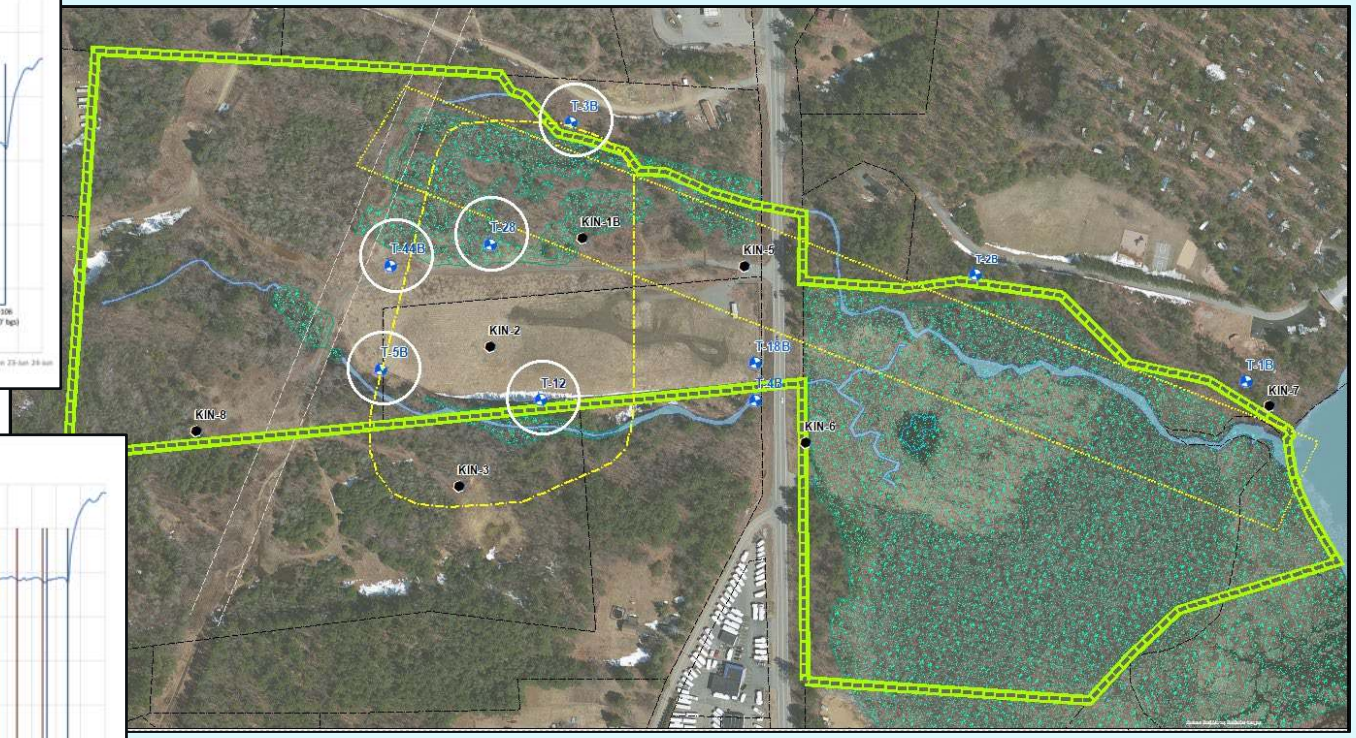
Legend

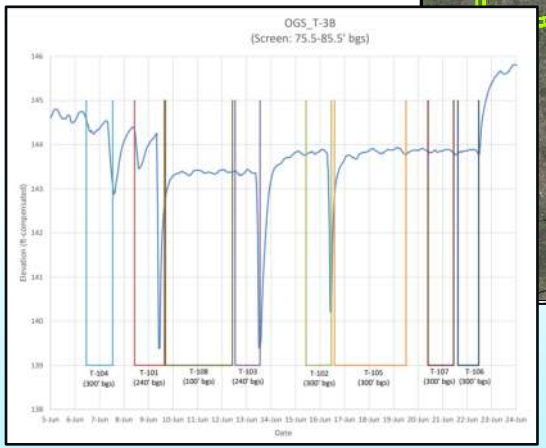
- Bedrock Well
- 240'- Total Depth
- 50 gpm- Yield of Well measured at the end of drilling



Water Levels in Selected Monitoring Wells Observed During Drilling

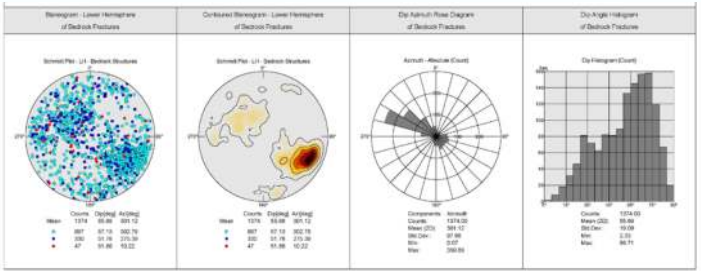


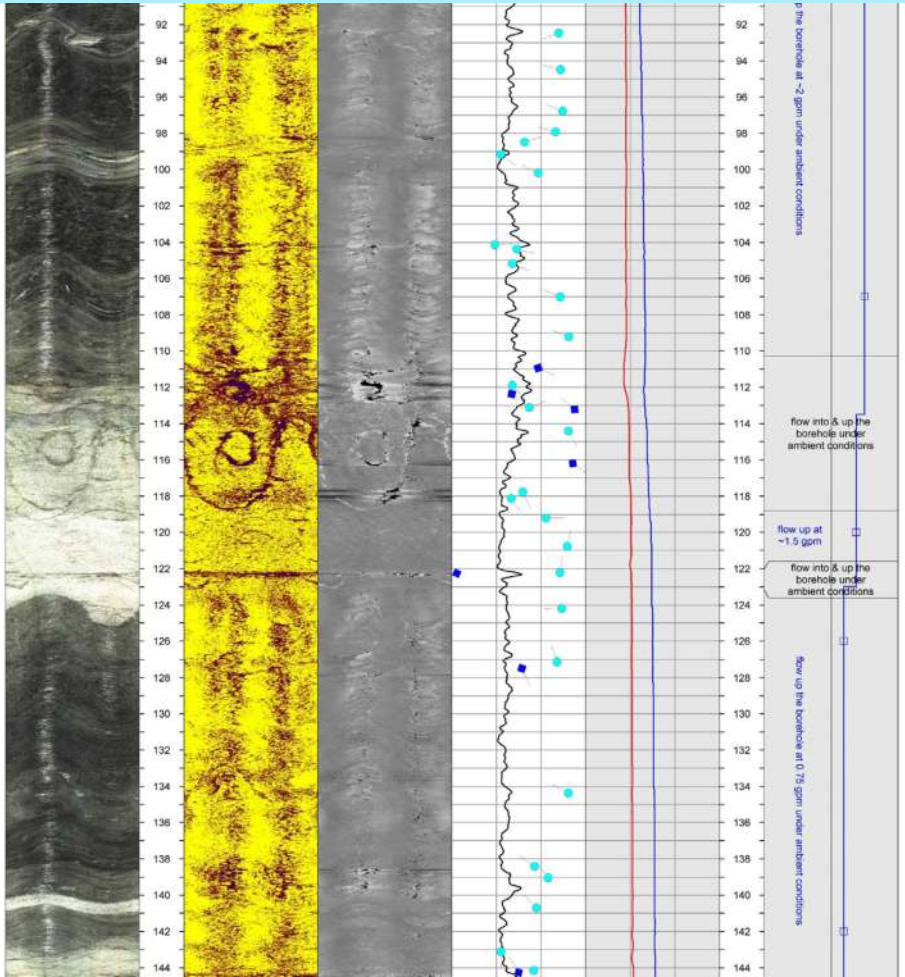




Borehole Geophysics and Zone Sampling

- Borehole Geophysical Methods Used
  - Caliper
  - Optical and acoustic televiewer
  - Heat pulse flow meter
  - Fluid temp and conductance
  - Evaluation of fractures
- Sampling of vertical zones using borehole packers
- Collective results used to refine CSM and select fracture zones for monitoring





What Did We Learn

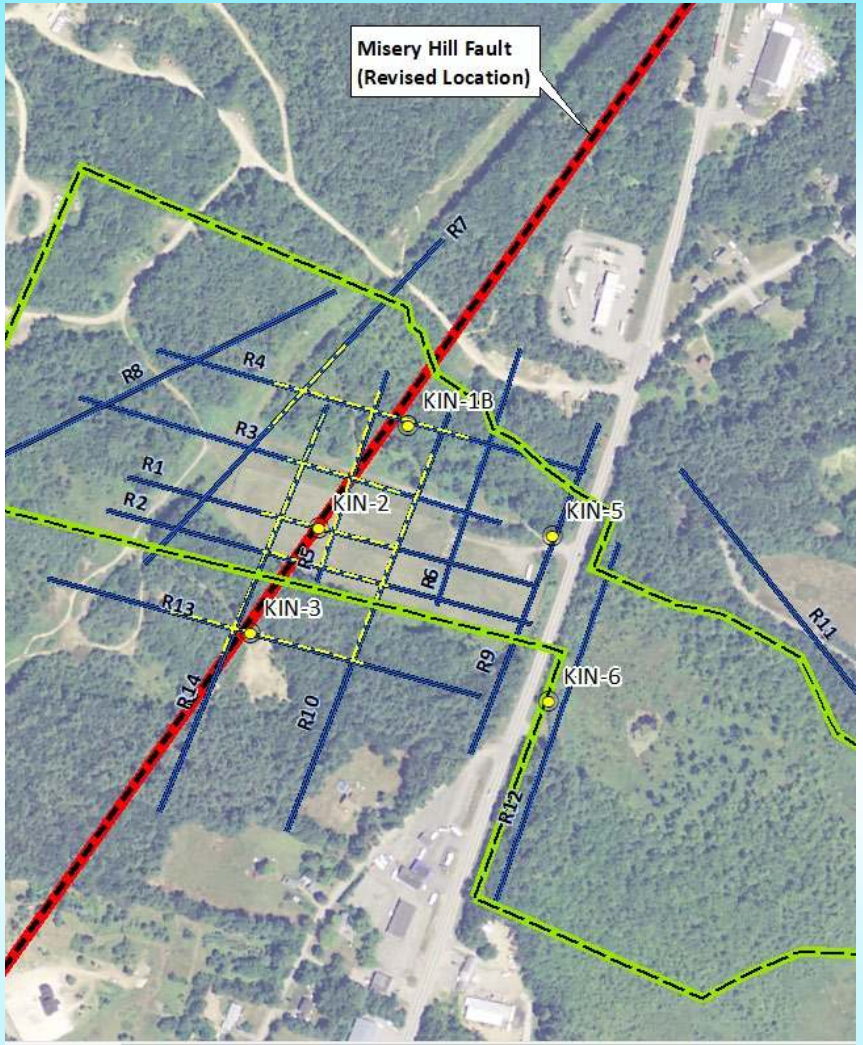
We were able to identify where the Misery Hill fault transected the Site and the most transmissive areas within the underlying fractured bedrock with the use of Photo lineament analyses, Bedrock Geologic mapping, Bedrock structural mapping and Geophysical surveys.

This was a critical approach to inform the selection of locations to drill boreholes to assess and monitor PFAS transport downward through the overburden into the bedrock.

We were then able to use the results of the borehole selection process, borehole geophysics, and zone sampling to characterize the fractured bedrock and select monitoring well designs.

EPA:

GZA's bedrock aquifer assessments "are great protocols to apply to the other [Superfund] Sites in the nation when identifying contaminants in the bedrock is needed."



Thank You.

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