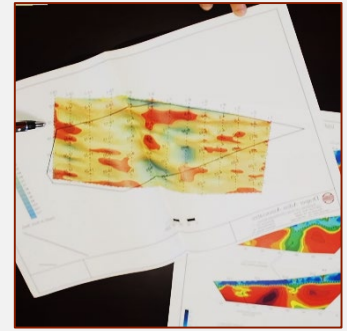


The Combined Use of Non-Invasive Geophysical Methods with Invasive Geotechnical Sampling for Karst Characterization



**Presented by: Johanna M. Vaughan, P.G.
Geologist**

**10th Annual Geo3T2 Conference
April 10th 2019
Raleigh, NC**



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Topic Synopsis

- Importance of Site Characterization
- Influence of Karst Geology
- Invasive Geotechnical Sampling
- Non-invasive Geophysical Investigation
- Combined Method Approach



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Importance of Site Characterization



Site Characteristics

- Developability of the Site
- Remediation Plan

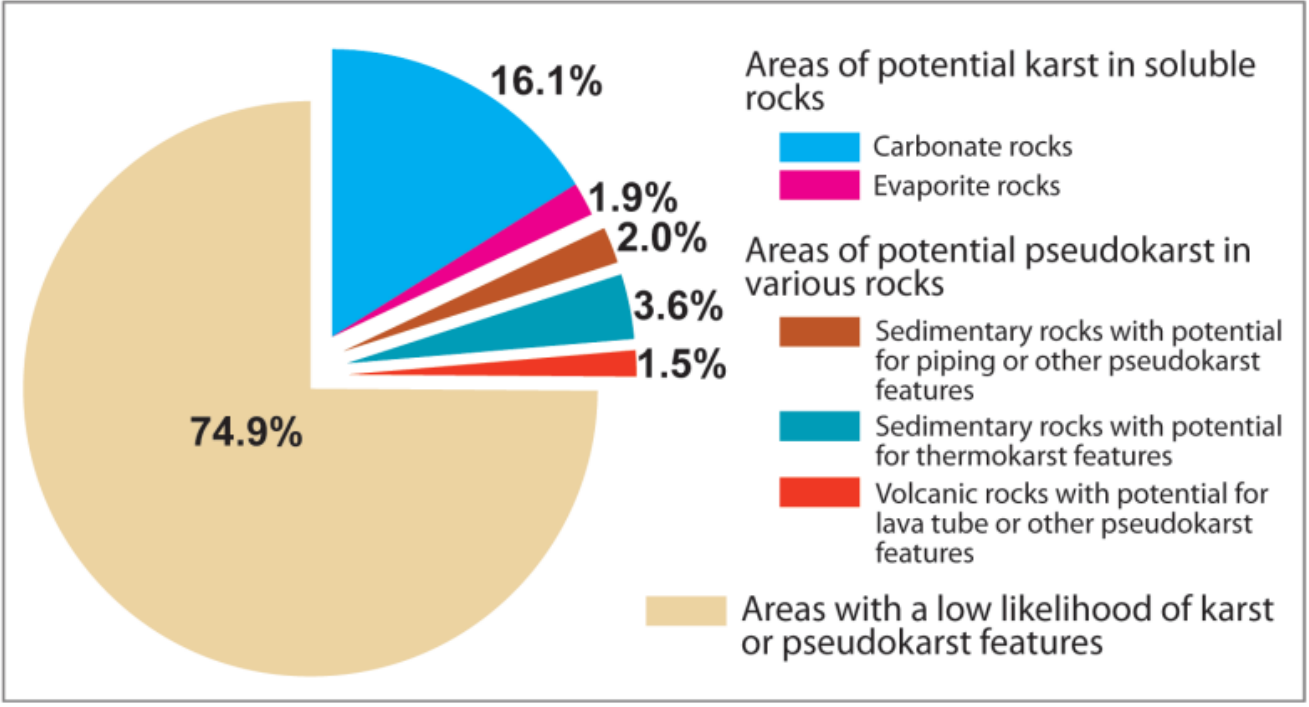
Project Profitability \$\$\$

Geologic Conditions



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Influence of Karst Geology

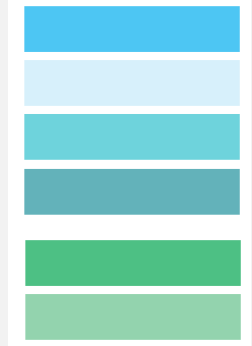
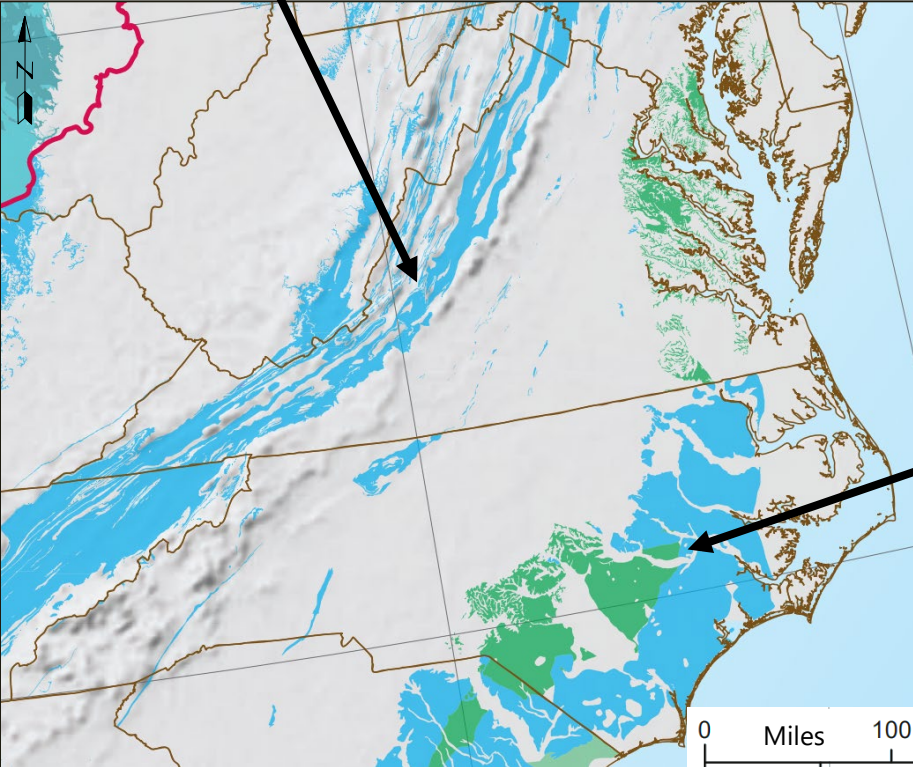


Weary, D. J., & Doctor, D. H. (2014)



Influence of Karst Geology

Valley and Ridge Geologic Province



Carbonate Rocks

Unconsolidated Calcareous or Carbonate Rocks

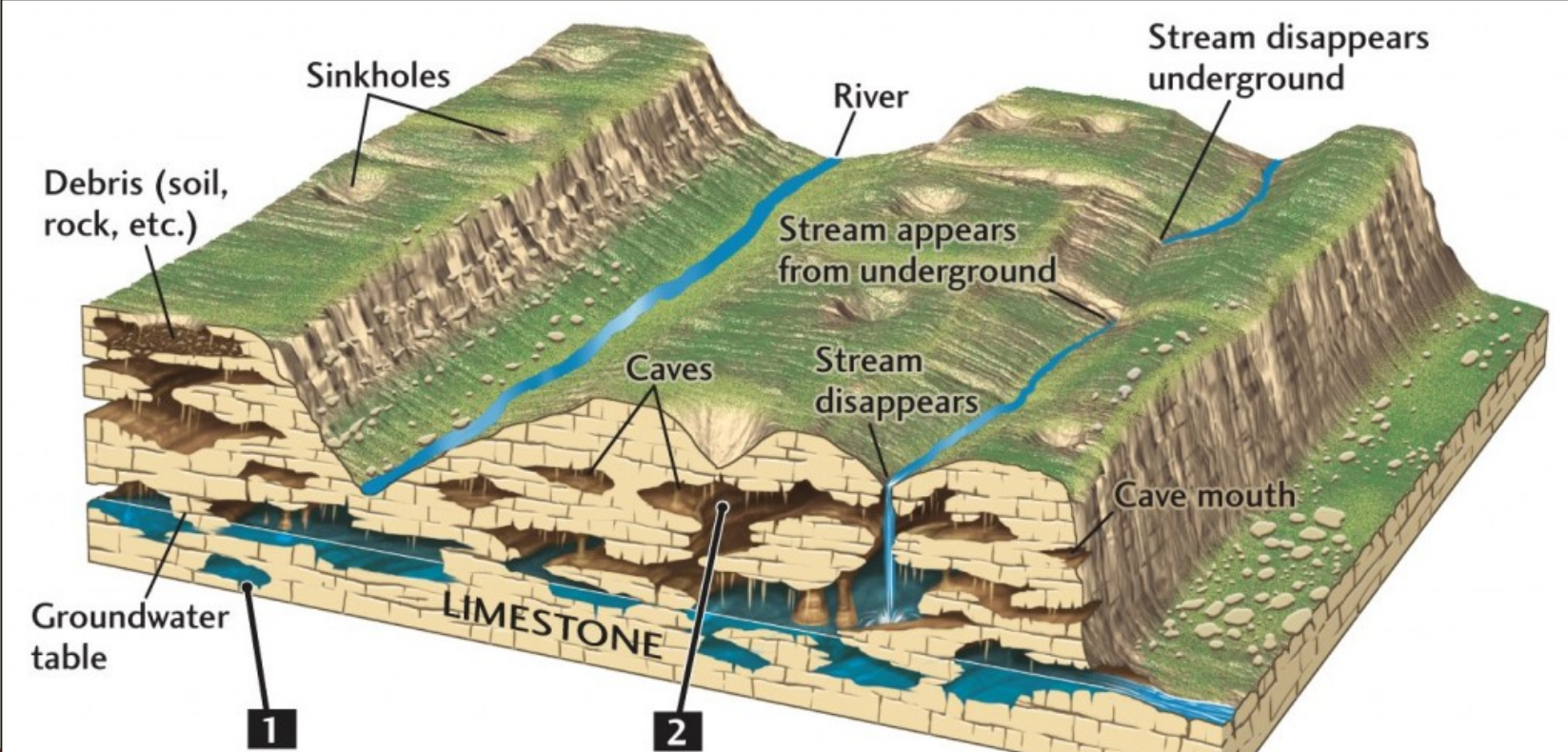
Coastal Plain Geologic Province



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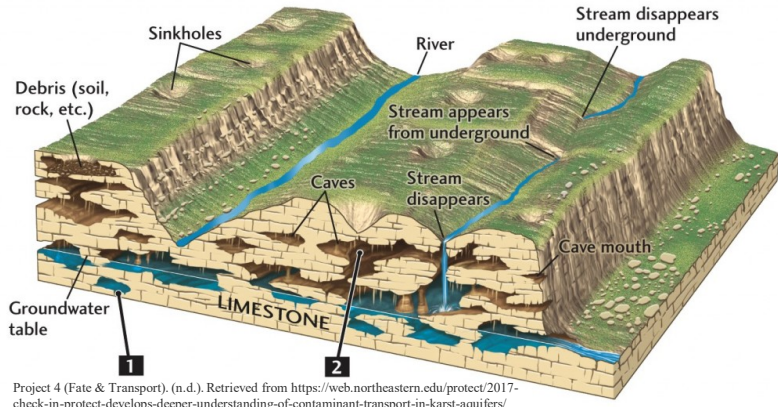
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Influence of Karst Geology



Project 4 (Fate & Transport). (n.d.). Retrieved from <https://web.northeastern.edu/protect/2017-check-in-protect-develops-deeper-understanding-of-contaminant-transport-in-karst-aquifers/>

Influence of Karst Geology



Project 4 (Fate & Transport). (n.d.). Retrieved from <https://web.northeastern.edu/protect/2017-check-in-protect-develops-deeper-understanding-of-contaminant-transport-in-karst-aquifers/>



Invasive Geotechnical Sampling

- Traditional method of subsurface exploration
- Detailed Results

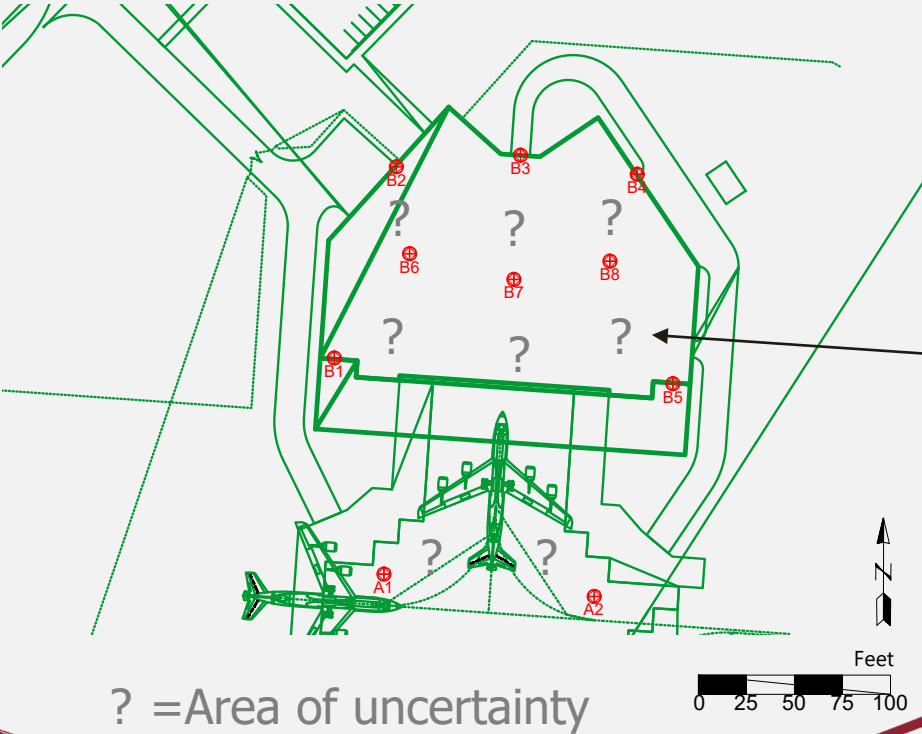


Elev.	Depth	DESCRIPTION (USCS)	Blow Counts / Recovery (%)	N Value
		Approximately 3" Topsoil		
		LEAN CLAY (CL), Reddish brown, Damp to Moist, Medium stiff	7-4-2-2 21	6
2060			2-4-2-4 100	6
	5		2-3-3-4 83	6
		PARTIALLY WEATHERED ROCK (PWR) sampled as SANDY SILT (ML), Dark grayish brown, Fine grained, With trace gravel, Moist, Hard	0-50 73	50/5'
2045			50 100	50/5'
		Auger refusal at 10.0 feet.		
	10			
		DOLOMITE, highly weathered to completely weathered, medium hard, light gray to dark gray, close to medium fracture spacing, medium massive, calcareous, RCD = 47%		93
2040				
	15			
		Approximately 2" of completely weathered to saprolite at the TOP of this run, approximately 15 feet below existing grade.		
		DOLOMITE, completely weathered to highly weathered, medium hard, light gray to dark gray, close to medium fracture spacing, medium massive, calcareous, RCD = 37%		93
2035				
	20			
		Bottom of borehole at 20.0 Feet. Rock core terminated		



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Invasive Geotechnical Sampling



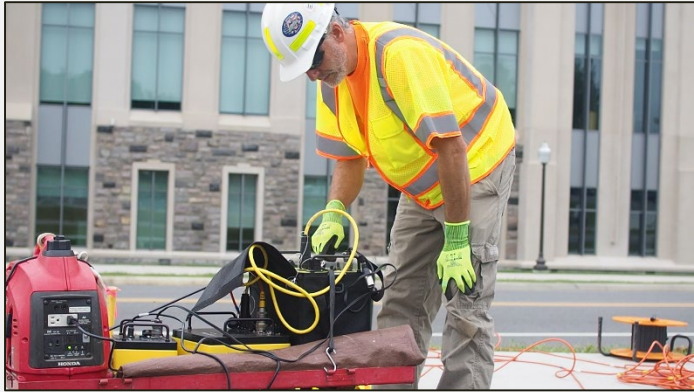
Proposed Airplane Hanger

How do we understand subsurface conditions in areas where physical samples are not obtained?



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Non-invasive Geophysical Investigation



Resistivity Imaging Studies

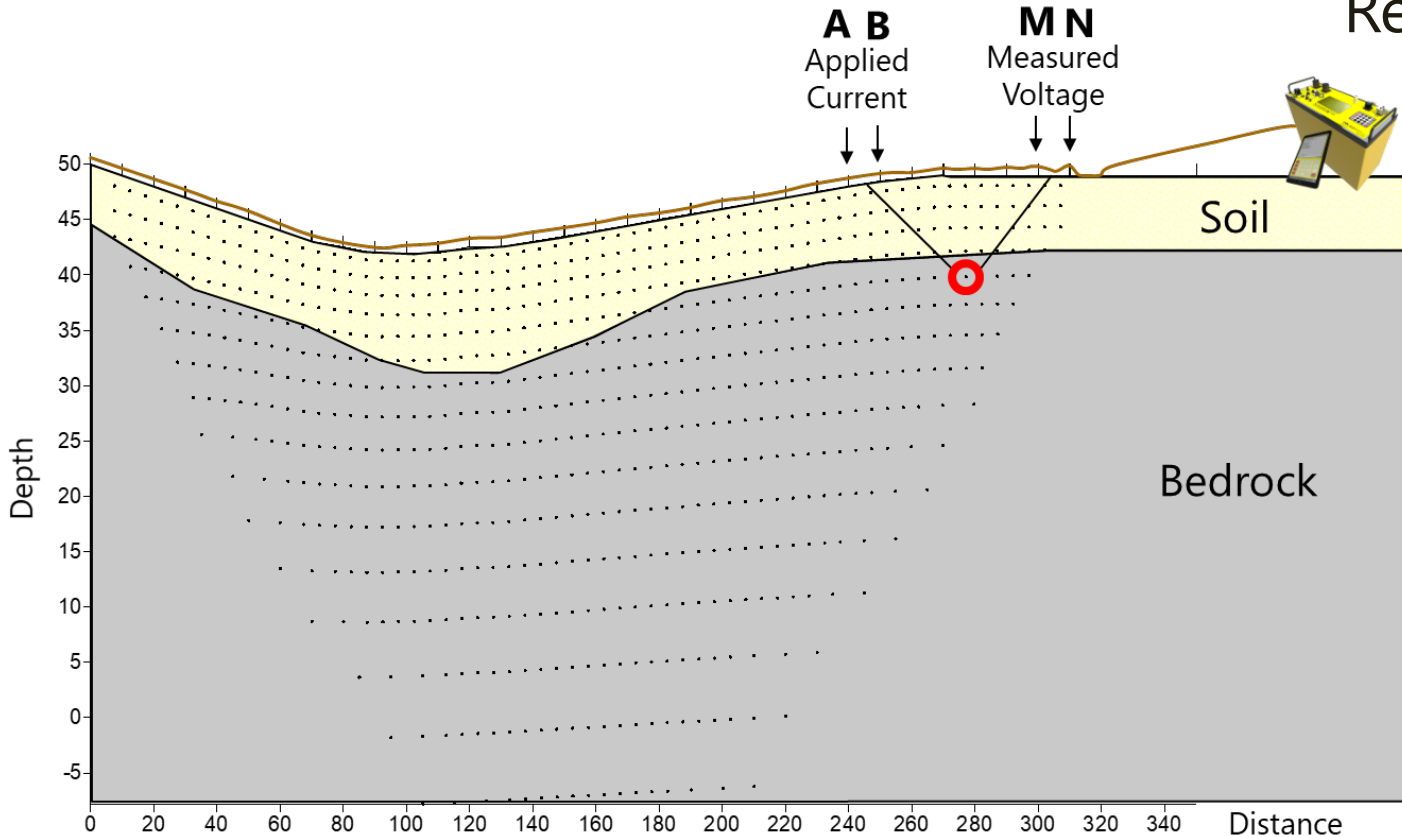
Resistivity: The property of a material to inhibit or resist the flow of electric current.



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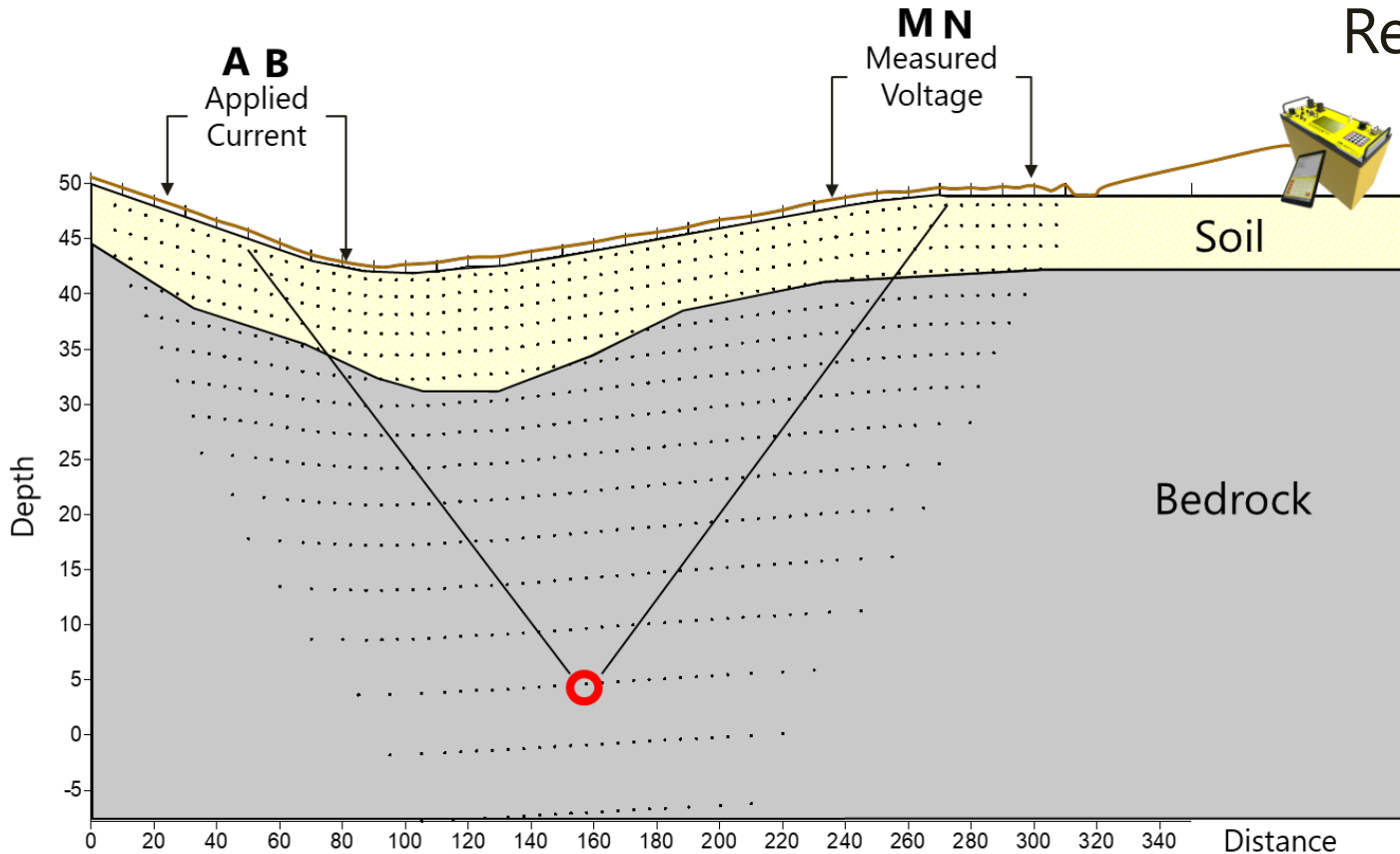
Non-invasive Geophysical Investigation

Resistivity Imaging



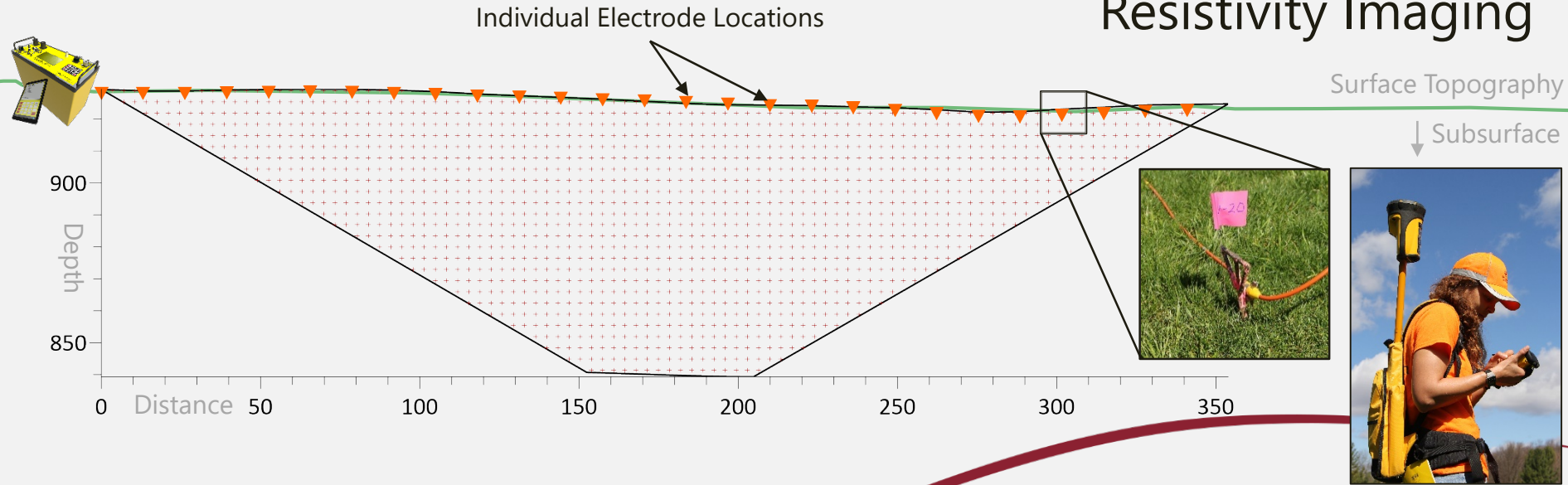
Non-invasive Geophysical Investigation

Resistivity Imaging



Non-invasive Geophysical Investigation

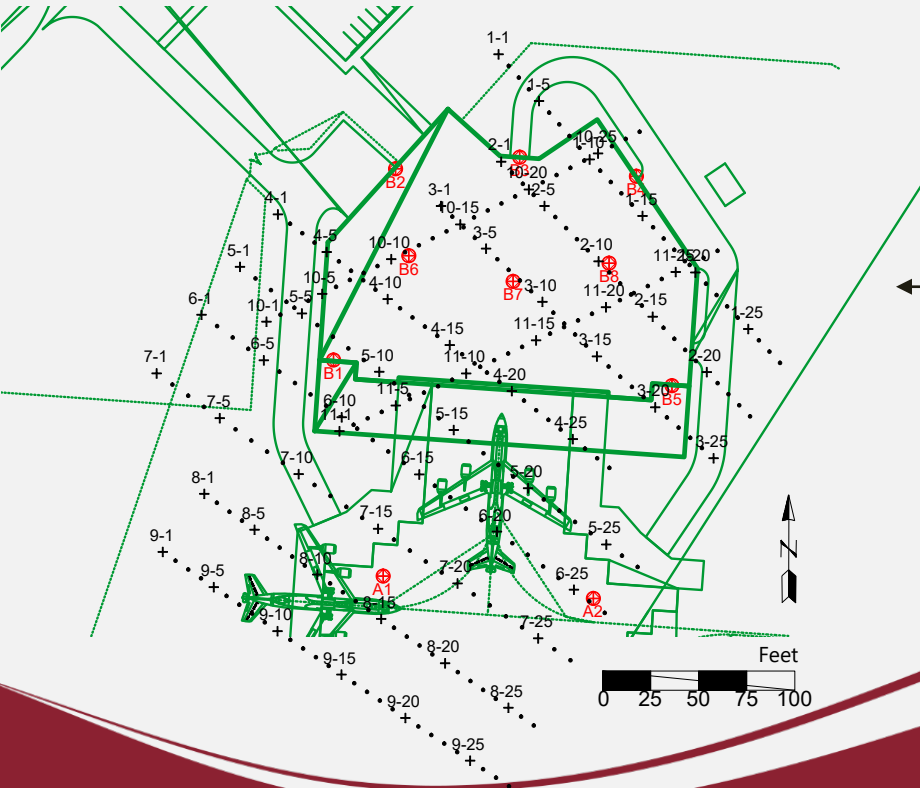
Resistivity Imaging



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Non-invasive Geophysical Investigation

Planning a Resistivity Study

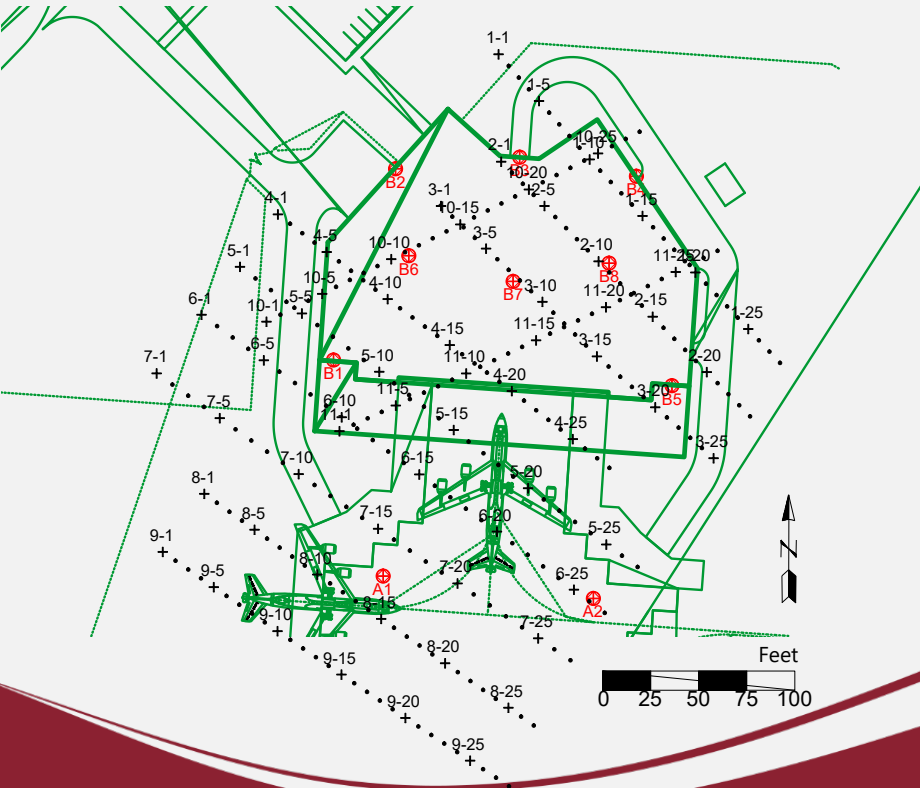


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Non-invasive Geophysical Investigation

Planning a Resistivity Study

- Geologic Conditions
- Site Plans

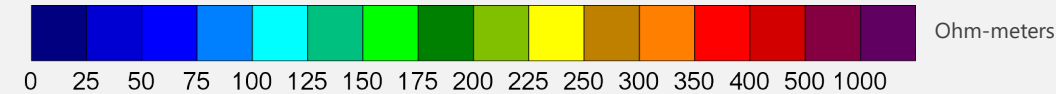


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Non-invasive Geophysical Investigation

Factors affecting resistivity:
Moisture content
Material grain size

Low resistivity material ← → High resistivity material



Moist ← → Moisture Content → Dry

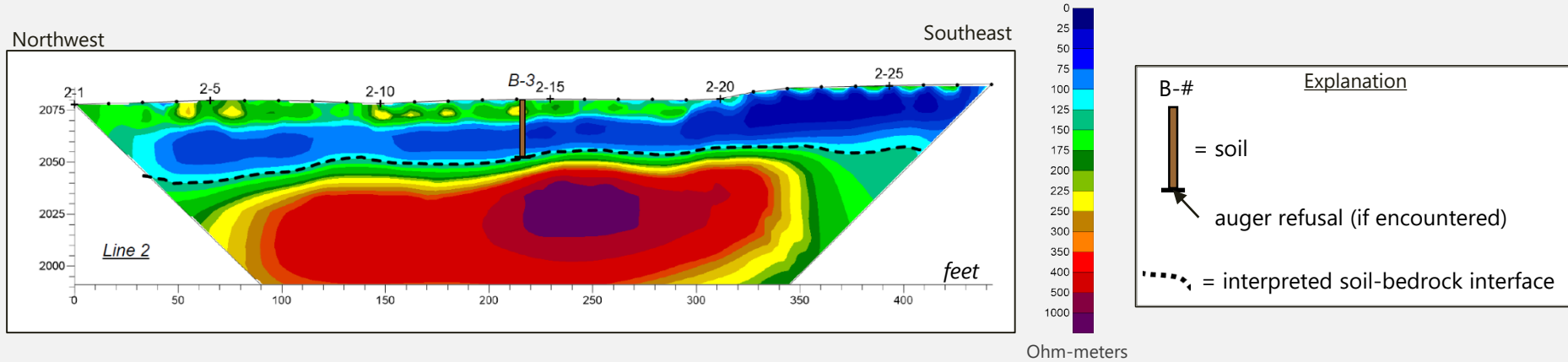
Fine ← → Material Grain Size → Coarse



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Non-invasive Geophysical Investigation

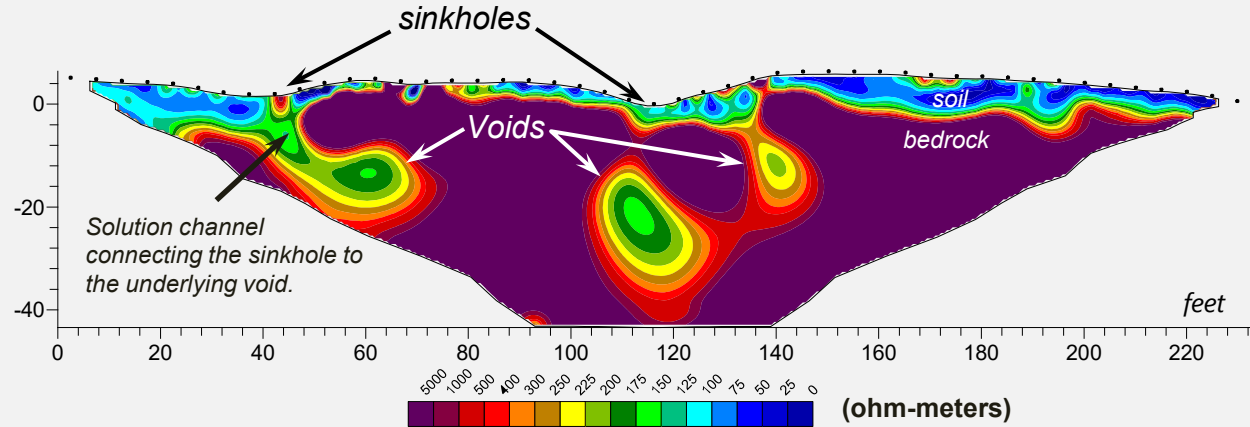
Resistivity Data Analysis



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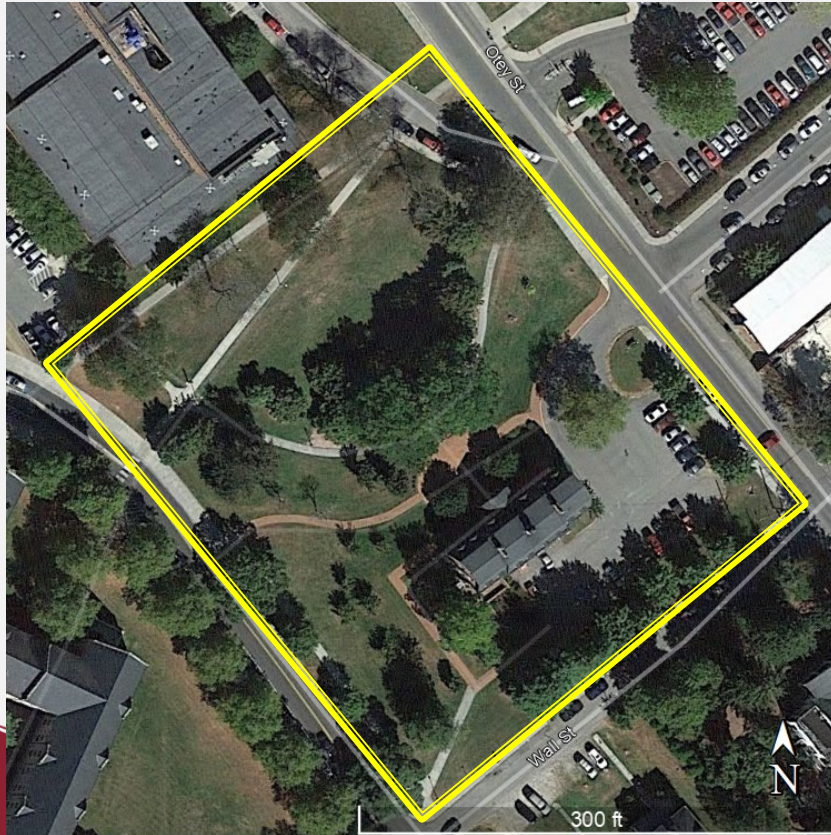
Non-invasive Geophysical Investigation

Resistivity Data Analysis



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Case Study – Proposed Building



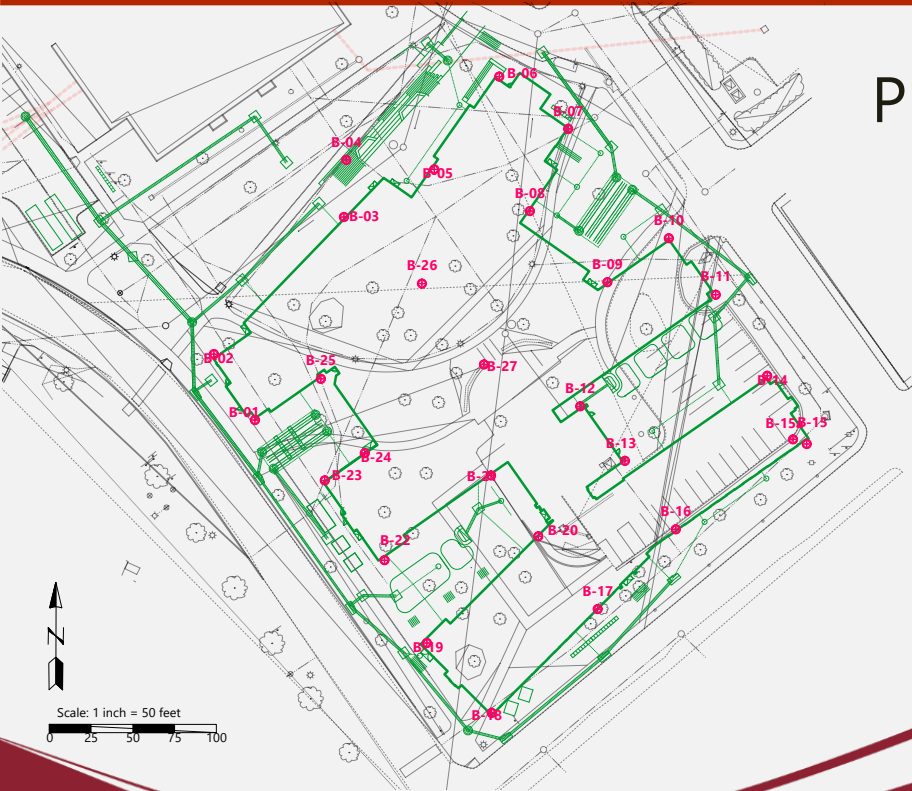
Site Characteristics:

- Proposed building site
- Previously developed site
- 2.67 Acres
- Approximately 29 feet of topographic relief



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Case Study – Proposed Building



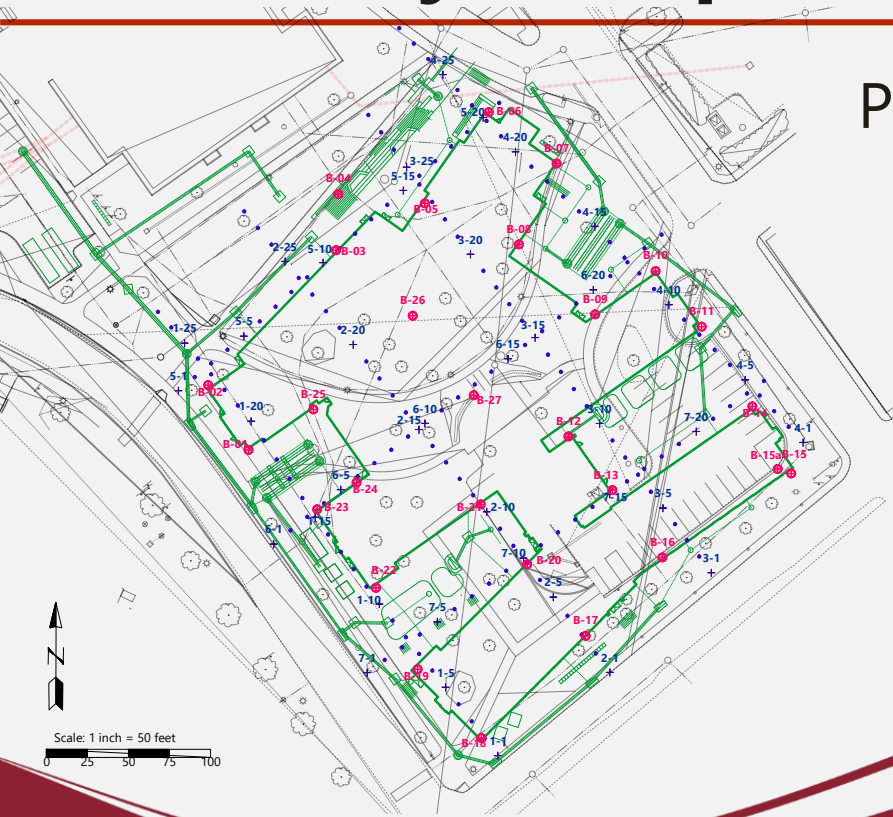
Proposed vs. Current Development:

- Approximate location of known utilities
- Existing features
- Proposed structures
- Proposed boring locations



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Case Study – Proposed Building



Planning of a resistivity survey:

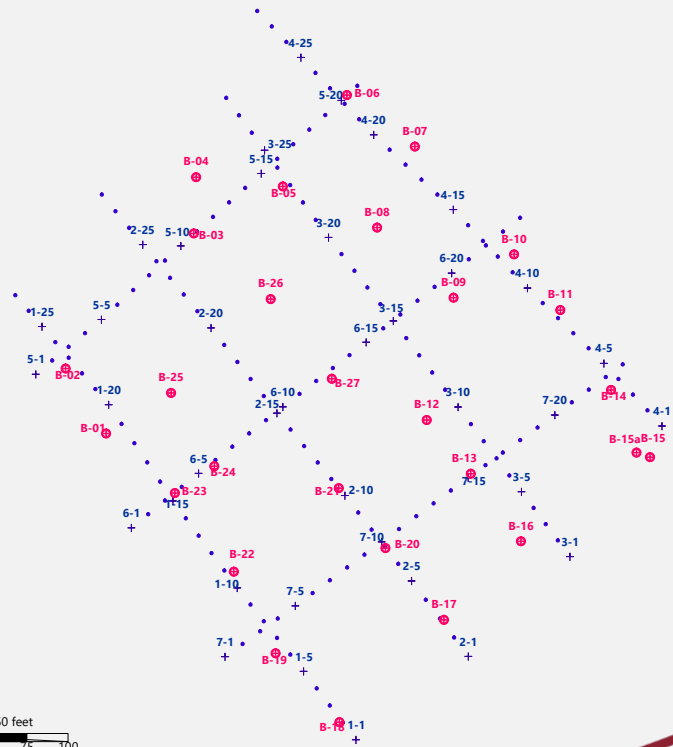
- Robust site coverage
- Compliment drilling program
- High density of data collection
- ■ Proposed resistivity electrode locations



Case Study – Proposed Building

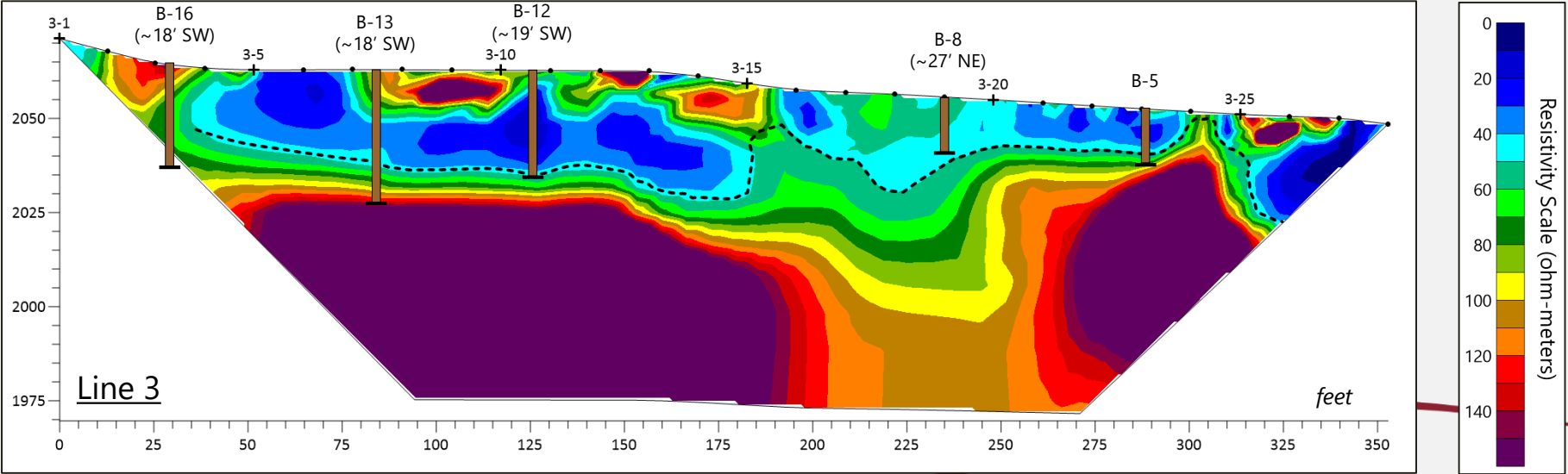
- Combination of non-invasive resistivity imaging and invasive drilling program

- ■ Proposed boring locations
- ■ Proposed resistivity electrode locations



Case Study – Proposed Building

Combined Resistivity and Boring Data Analysis



B-#	Explanation
	= soil
	= auger refusal (if encountered)
	= interpreted soil-bedrock interface

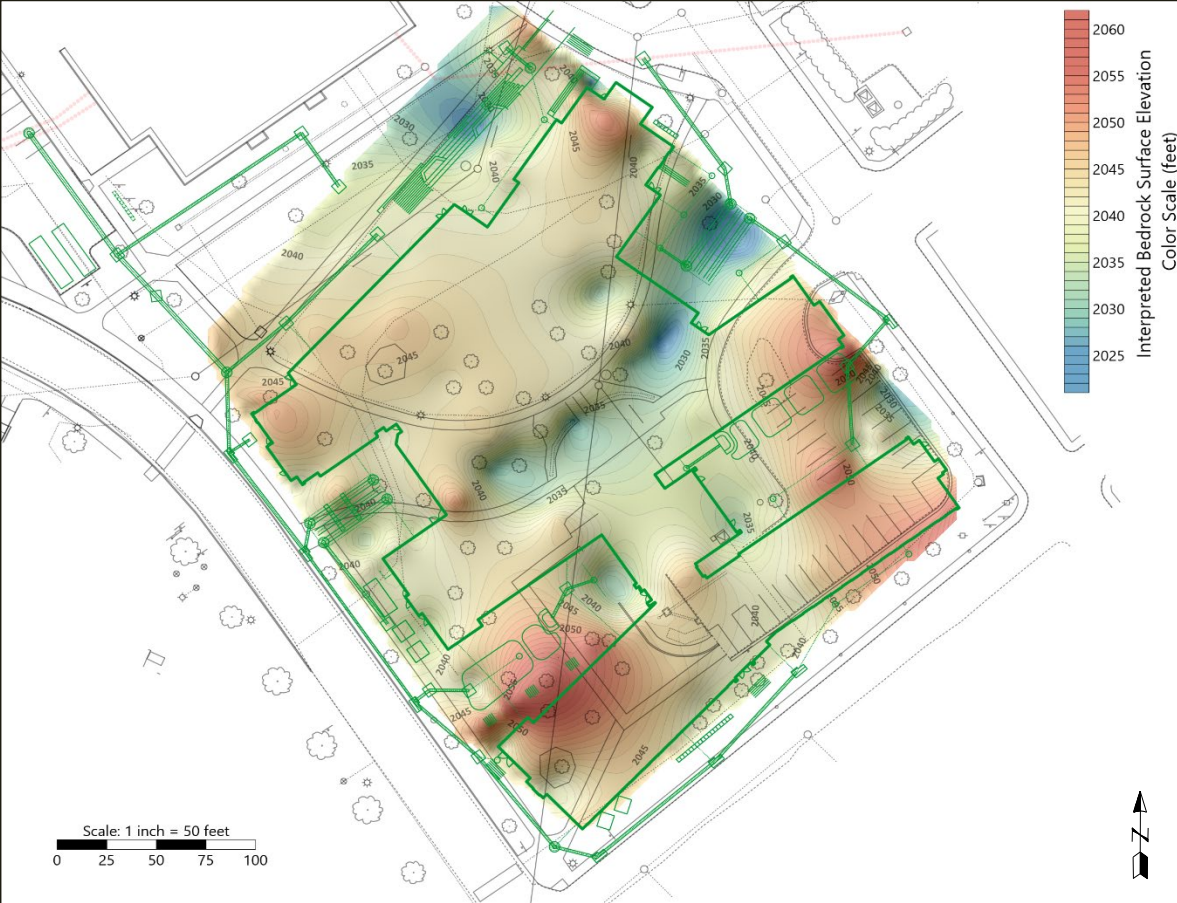


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Case Study – Proposed Building

Bedrock Elevation Model:

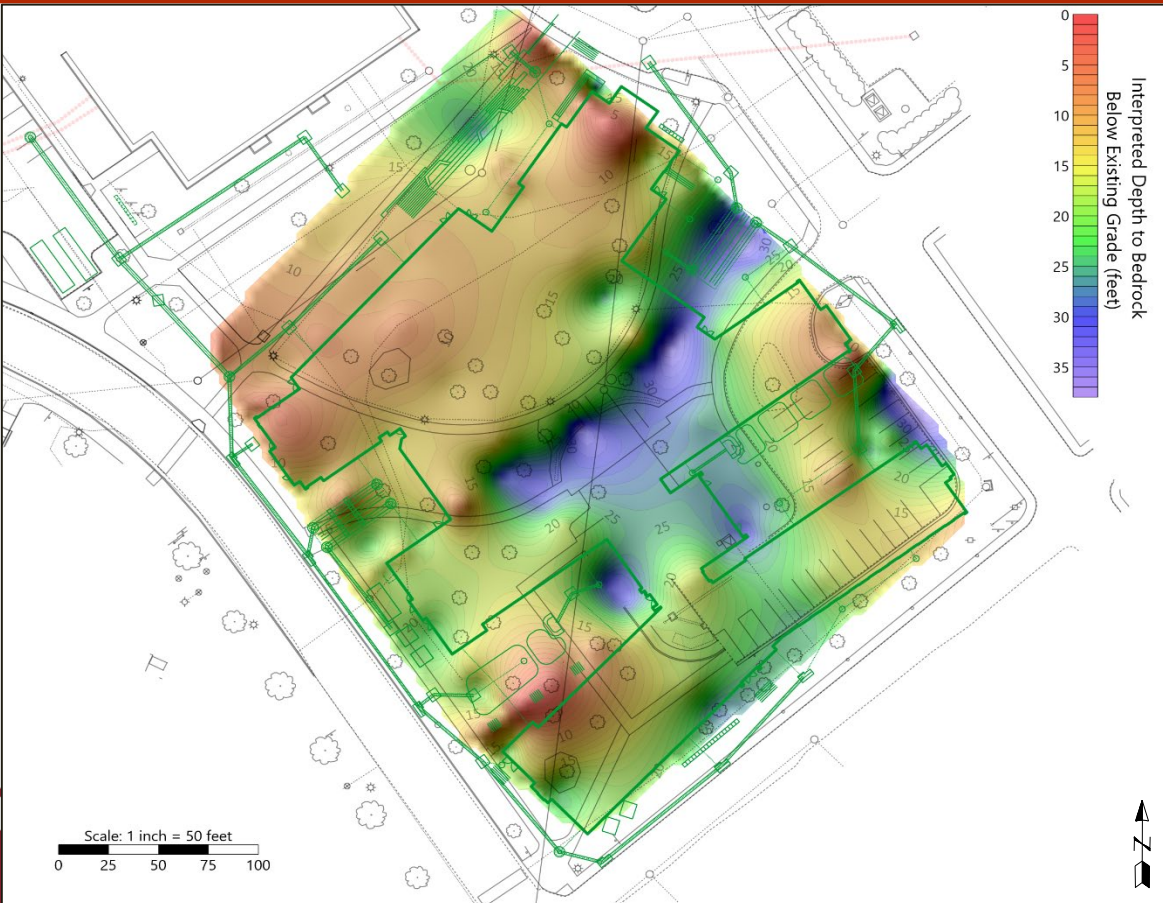
- Site Planning
- Grading Plans



Case Study – Proposed Building

Depth to Bedrock Model:

- Site Planning
- Grading Plans



Case Study – Proposed Building

3D rendering of
invasive and
non-invasive
spatially
referenced data



Case Study – Proposed Building

3D rendering
of spatially
referenced
invasive
drilling data



Case Study – Proposed Building

3D rendering of
invasive and
non-invasive
spatially
referenced data



Case Study – Proposed Building

3D rendering of
invasive and
non-invasive
spatially
referenced data

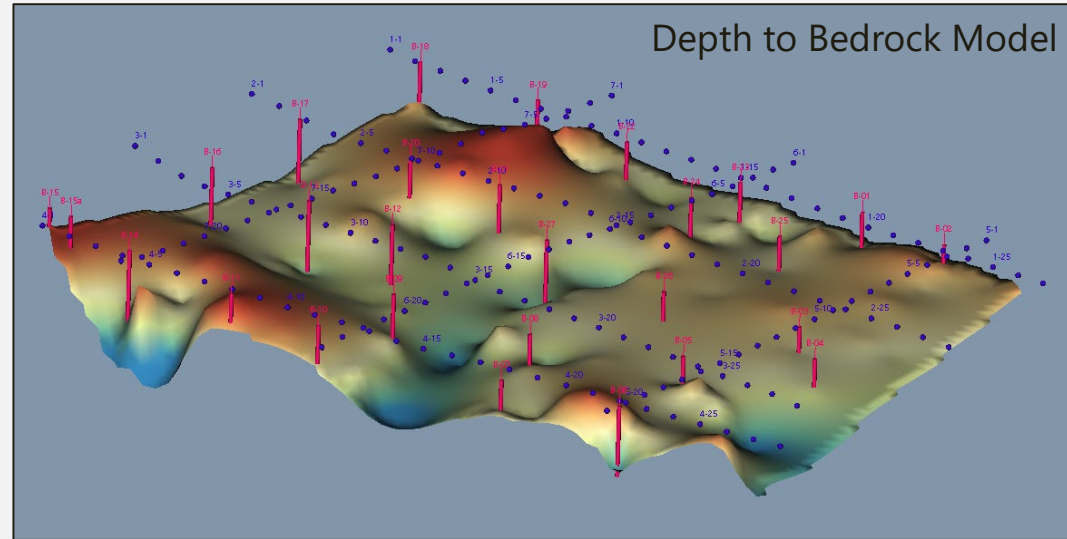
Data derived
model of the
interpreted
bedrock surface
elevations



Case Study – Proposed Building

Integration of data into:

- ArcGIS
- AutoCAD
- Google Earth



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Thank you for your time – Questions?



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