

Geophysical Applications for Environmental and Geotechnical Issues

Exploring the subsurface using innovative, accurate, and cost-effective techniques

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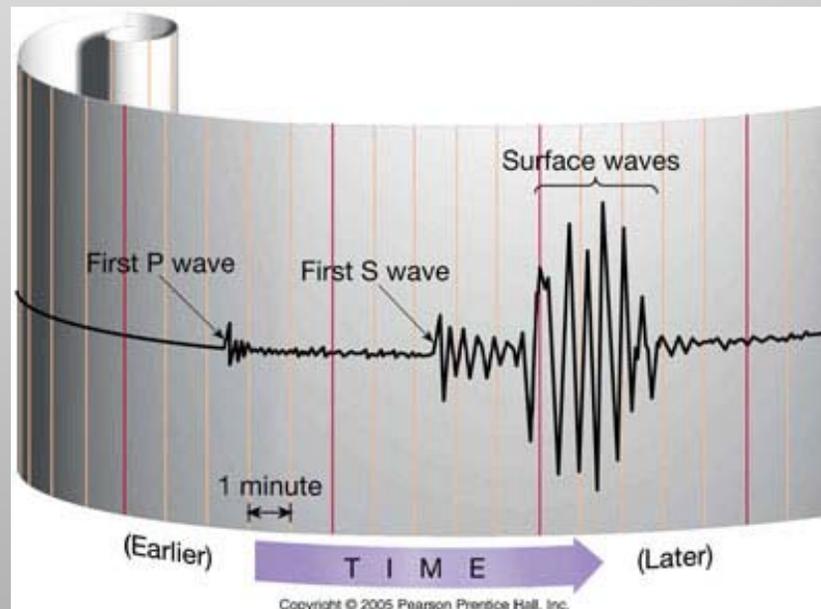
What is Geophysics?

And how can it help me?...



Definition of Geophysics

- The non-invasive investigation of subsurface conditions in the Earth through measuring, analyzing and interpreting physical fields at the surface. Some studies are used to determine what is directly below the surface (the upper meter or so); other investigations extend to depths of 10's of meters or more.



Applications of Geophysics

- Landfill delineation and characterization
- Characterization and depth to bedrock, permeable pathways for groundwater flow
- Investigation of boring sites for geologic characteristics and interferences
- Location of Underground Storage Tanks, landfills, abandoned wells, utilities, rebar, drums and voids
- Water supply investigations, hydrogeologic site characterization, and groundwater quality mapping
- Geotechnical investigations
- Karst Investigations

Specific Geotechnical Applications

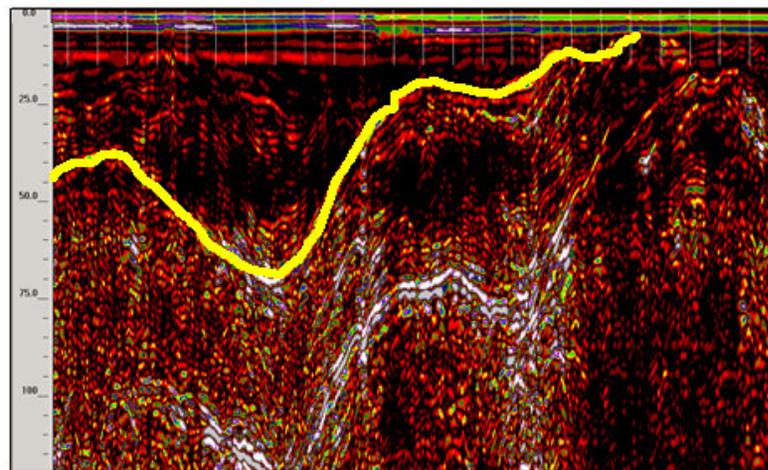
- Depth and integrity of subsurface rock formations
- Soil type, thickness, and distribution
- Aid in pile design and location, foundation design
- Cut-fill operations – map soil type, rock integrity/depth, quantify pre- and post-compaction densities
- IBC Site Classification
- Concrete inspection – map rebar locations, moisture intrusion, identify the presence of reinforcement mesh, etc.
- High speed roadway/pavement mapping for highway maintenance

Types of Geophysics

- Ground Penetrating Radar (GPR)
- Electrical Resistivity (ER)
- Electromagnetics (EM)
- Seismic (Refraction and Surface Waves)
- Borehole Geophysics

Ground Penetrating Radar (GPR)

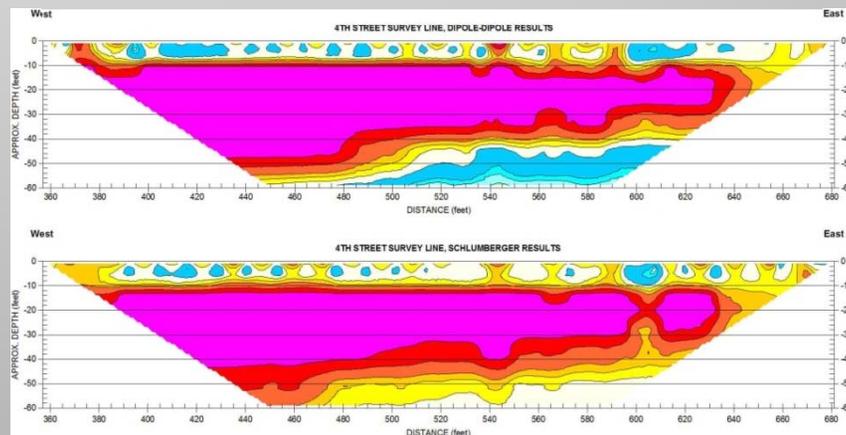
- Geologic mapping (depth to rock, karst)
- Buried debris (landfill delineation)
- Underground Storage Tank (UST) locates
- Utility locates
- Buried remains (archaeology)



— Bedrock interface

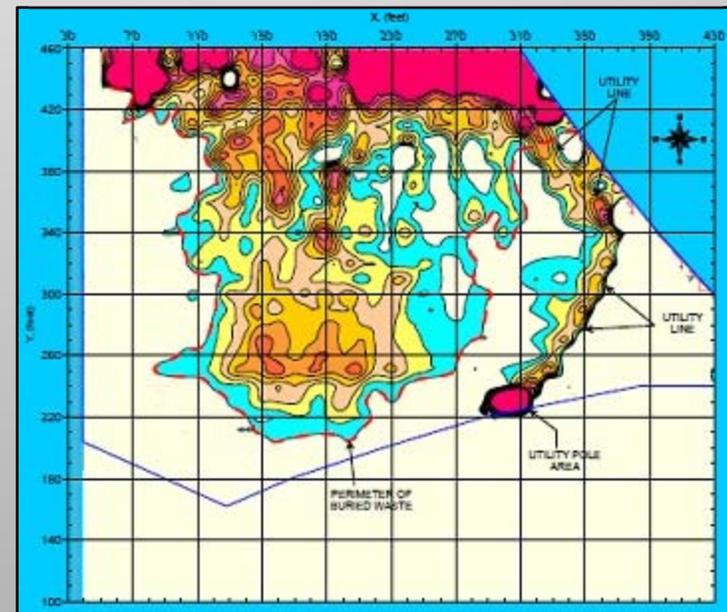
Electrical Resistivity (ER)

- Soil type and bedding changes
- Depth to rock
- Groundwater analysis (water table, salinity)
- Cavity/void detection
- Contaminant plumes



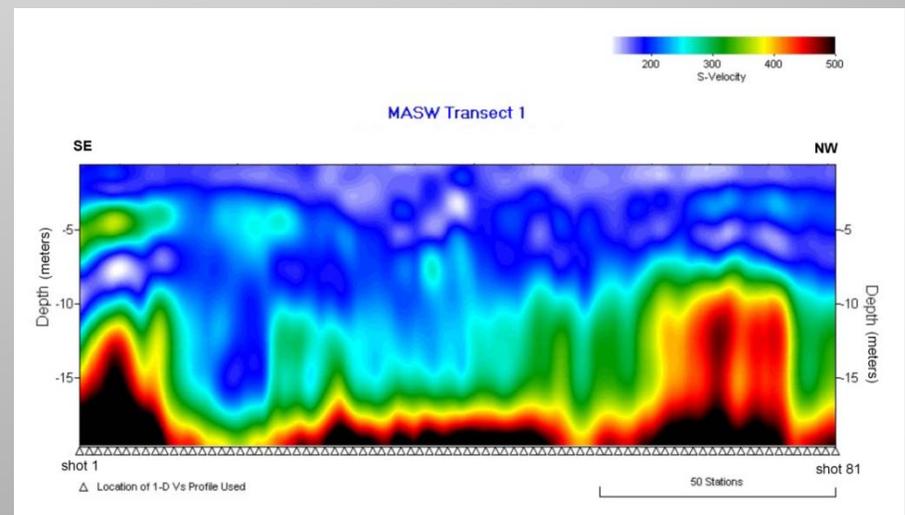
Electromagnetics

- Used for conductivity and metal detection
- Underground Storage Tank (UST) locates
- Buried debris
- Buried metallic objects
- Contaminated soil mapping



Seismic Methods (Refraction and MASW)

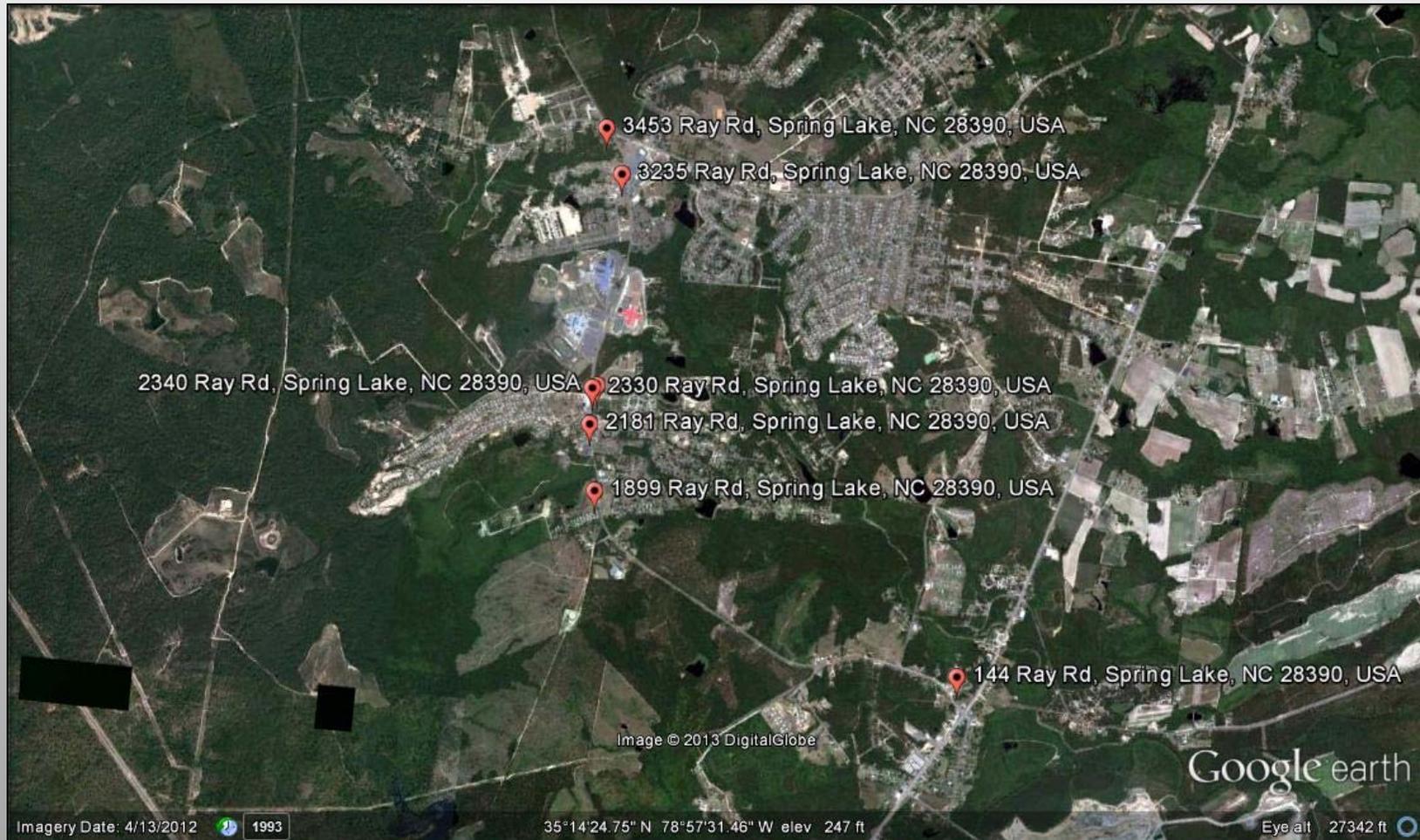
- Geologic mapping (depth to rock, depth to clay, etc.)
- Density data (geotechnical design)
- Cavity/void detection



Benefits of Geophysical Surveys

- Rapid assessment of site geology and subsurface characteristics across large areas
- Continuous profiles
- Non-invasive techniques avoid the need for extensive drilling, groundwater sampling, and disturbance of the property
- Cost-effective
- Require low numbers of personnel, often only one technician
- Portable equipment
- Can provide multiple data sets with a single survey (i.e. buried debris and contaminants, geology, groundwater table, geologic hazards)

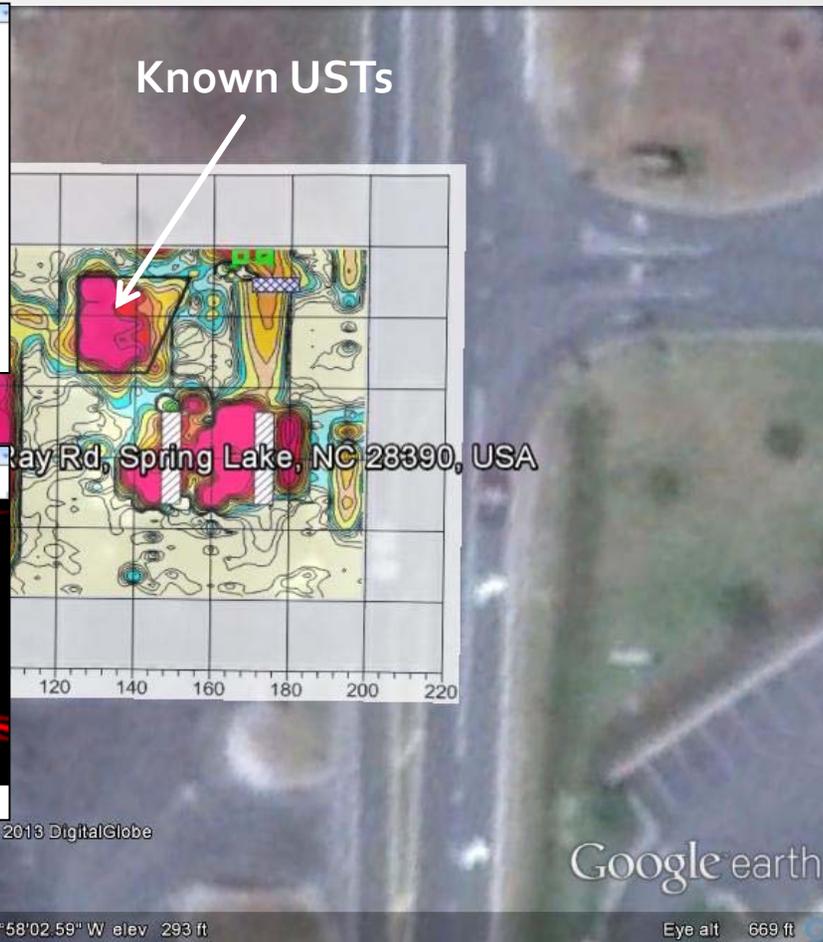
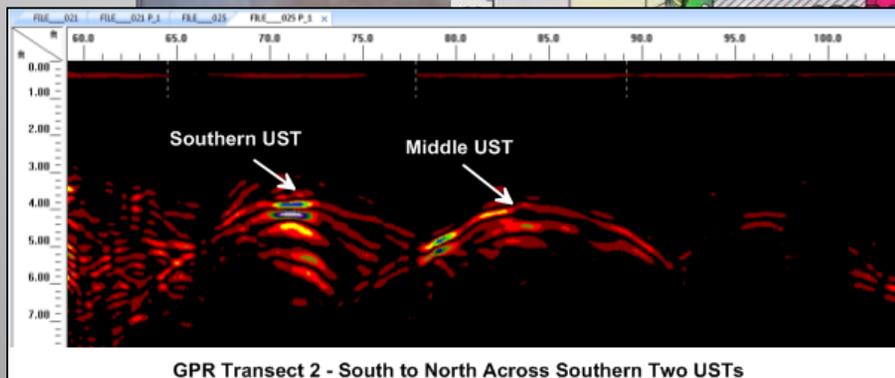
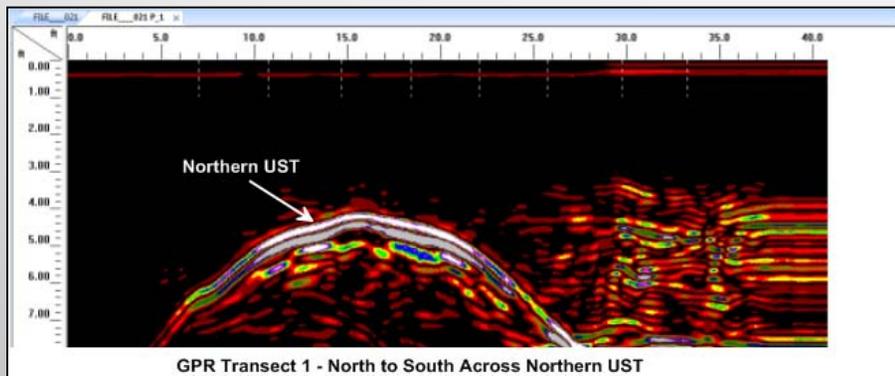
Case Study: EM and GPR to Locate Buried UST's



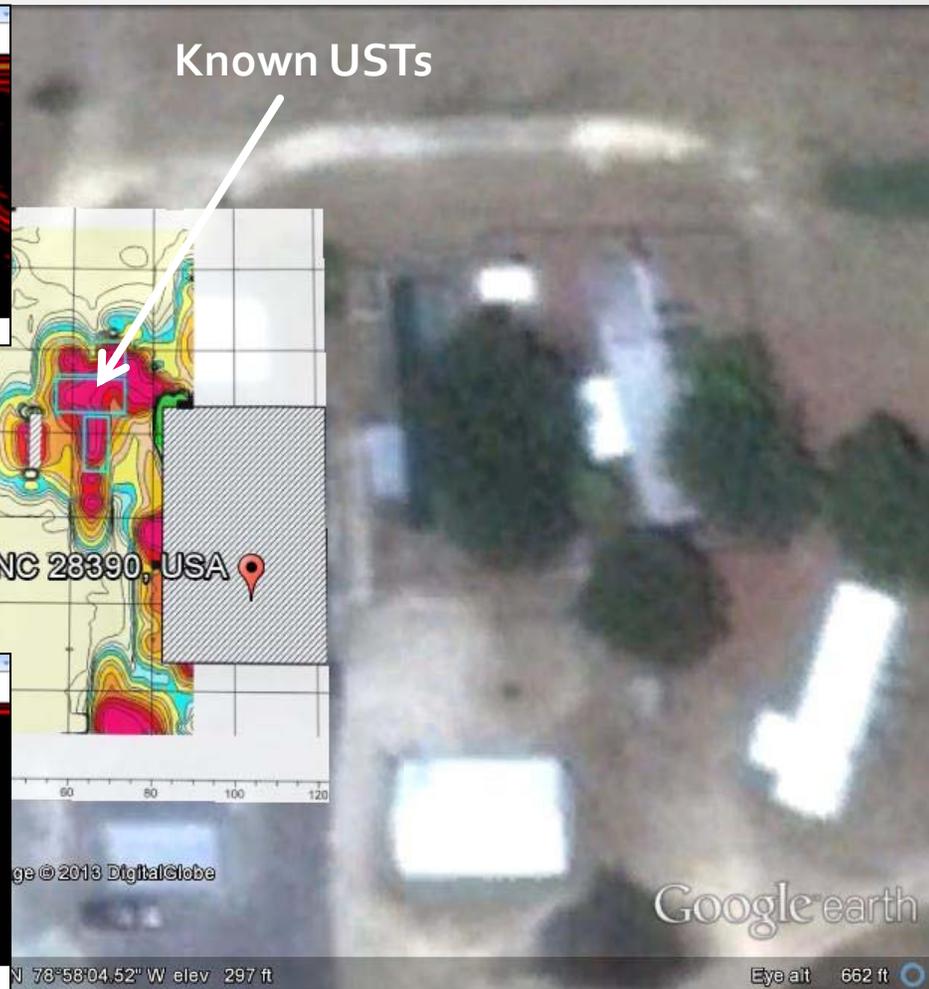
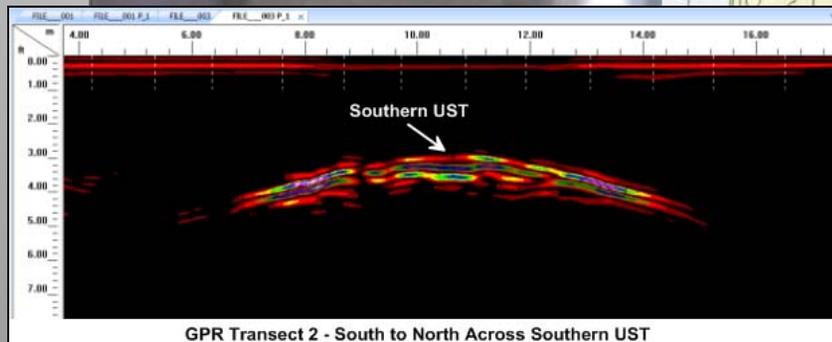
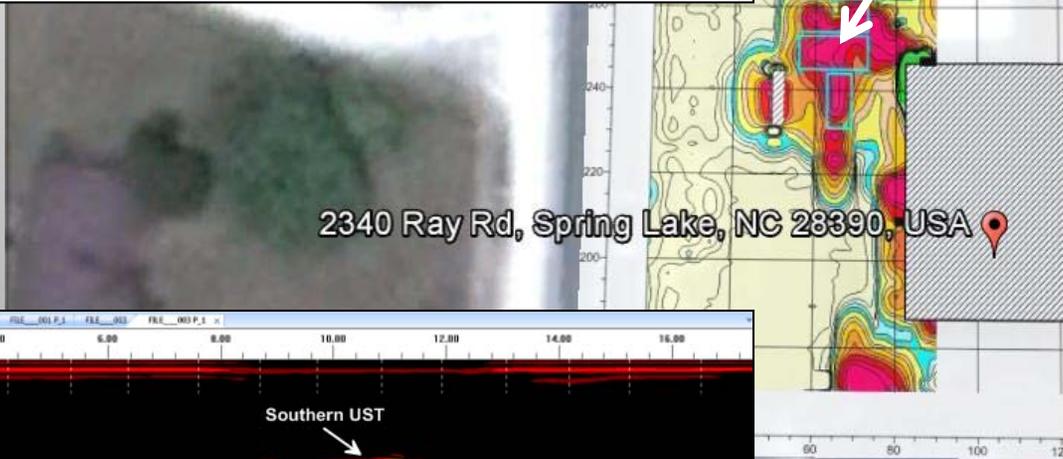
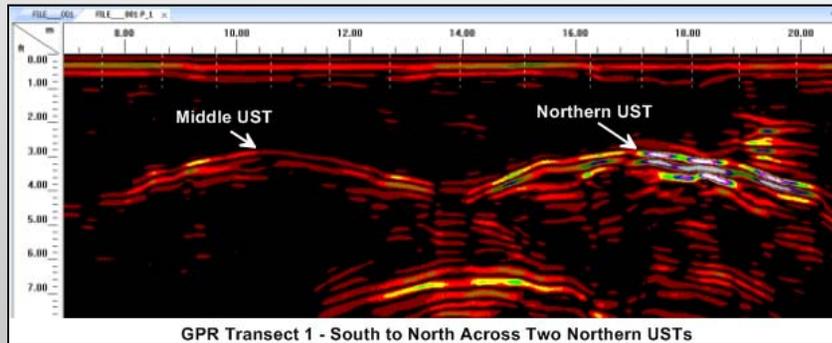
Example 1: EM Differential Results



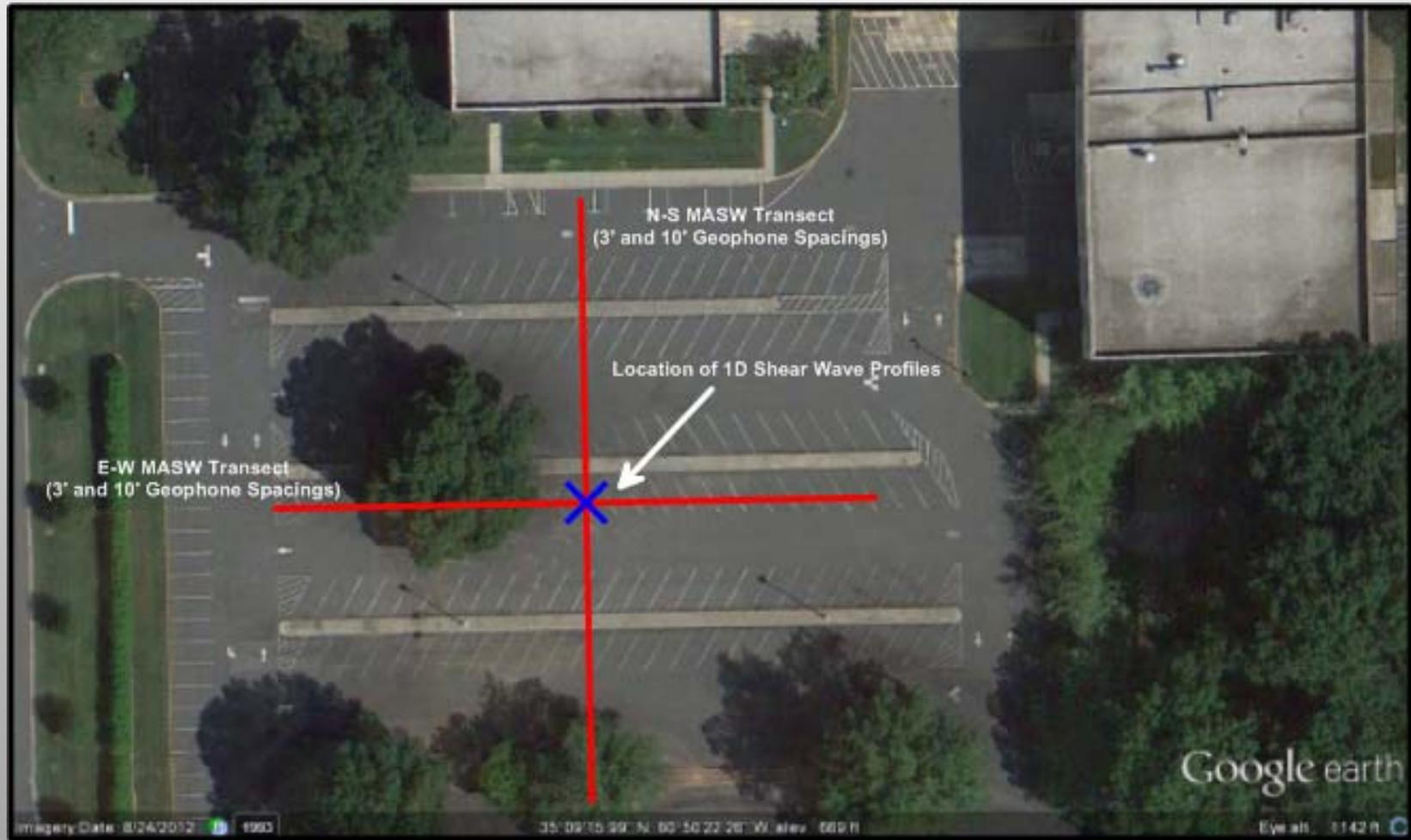
Example 2: EM Differential Results



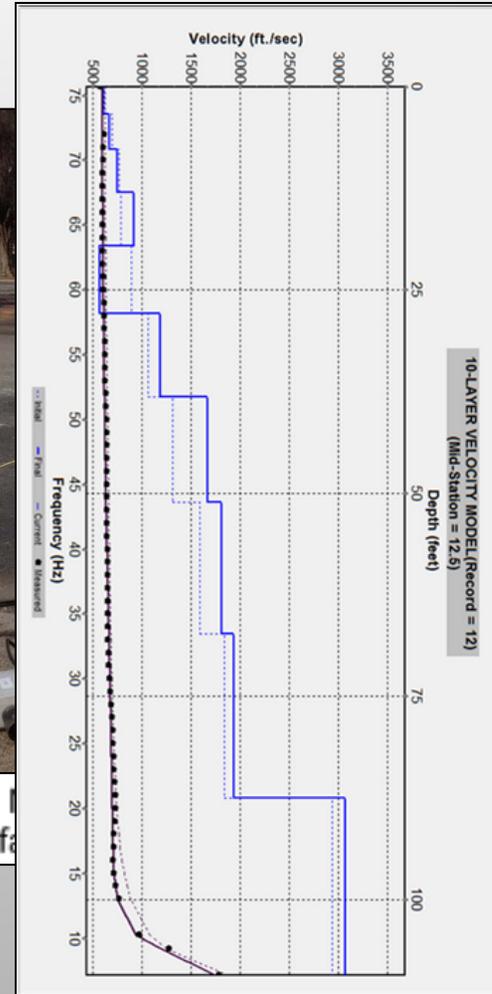
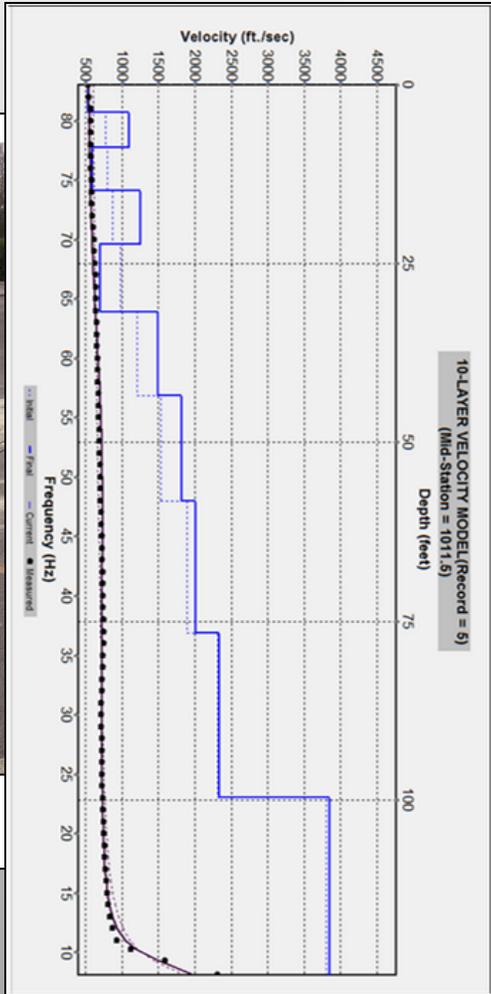
Example 2: EM Differential Results



Case Study: Seismic Survey for IBC Site Classification



MASW Survey Site Photos



Case Study: Resistivity to Delineate Sinkhole Adjacent to Roadway (FDOT)



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Project Goals

- Utilize MER technology to accurately map the depth and extent of karst features along road
- Confirm anomalous features found in the MER profiles using Cone Penetration Testing (CPT)
- Quantify the necessary amount of flowable fill to inject into void spaces (where feasible)

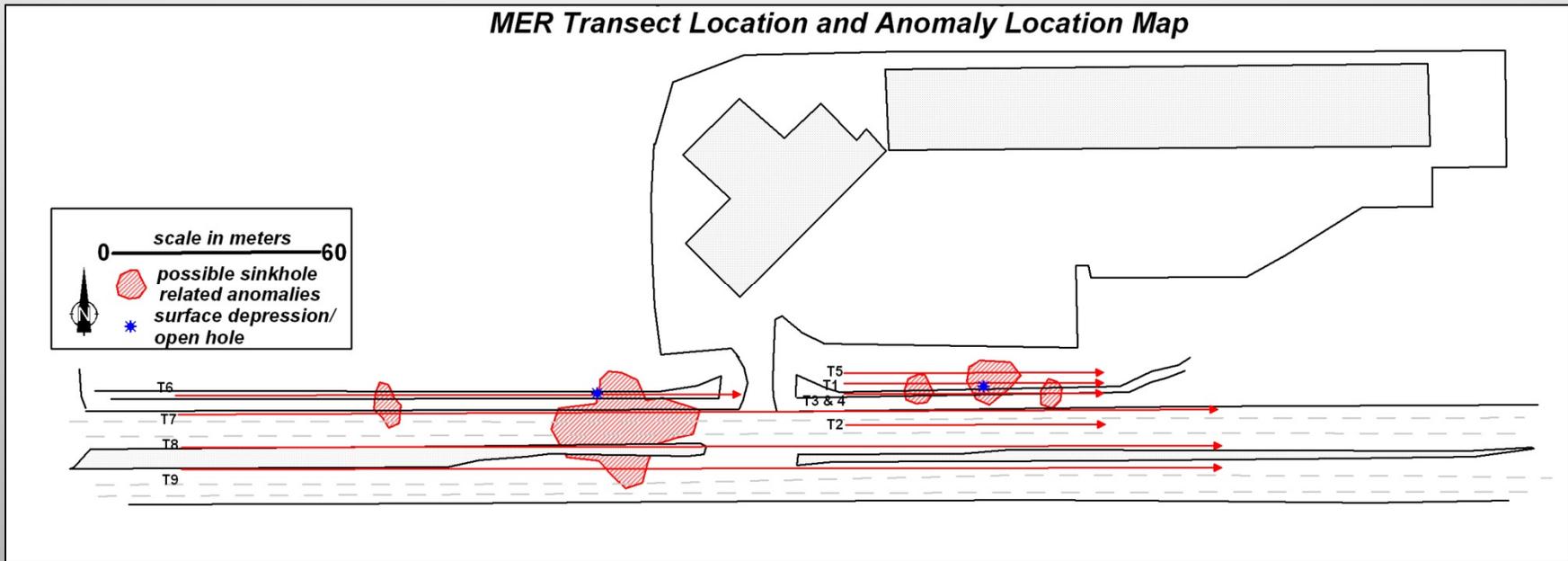
MER Mapping In Roadway



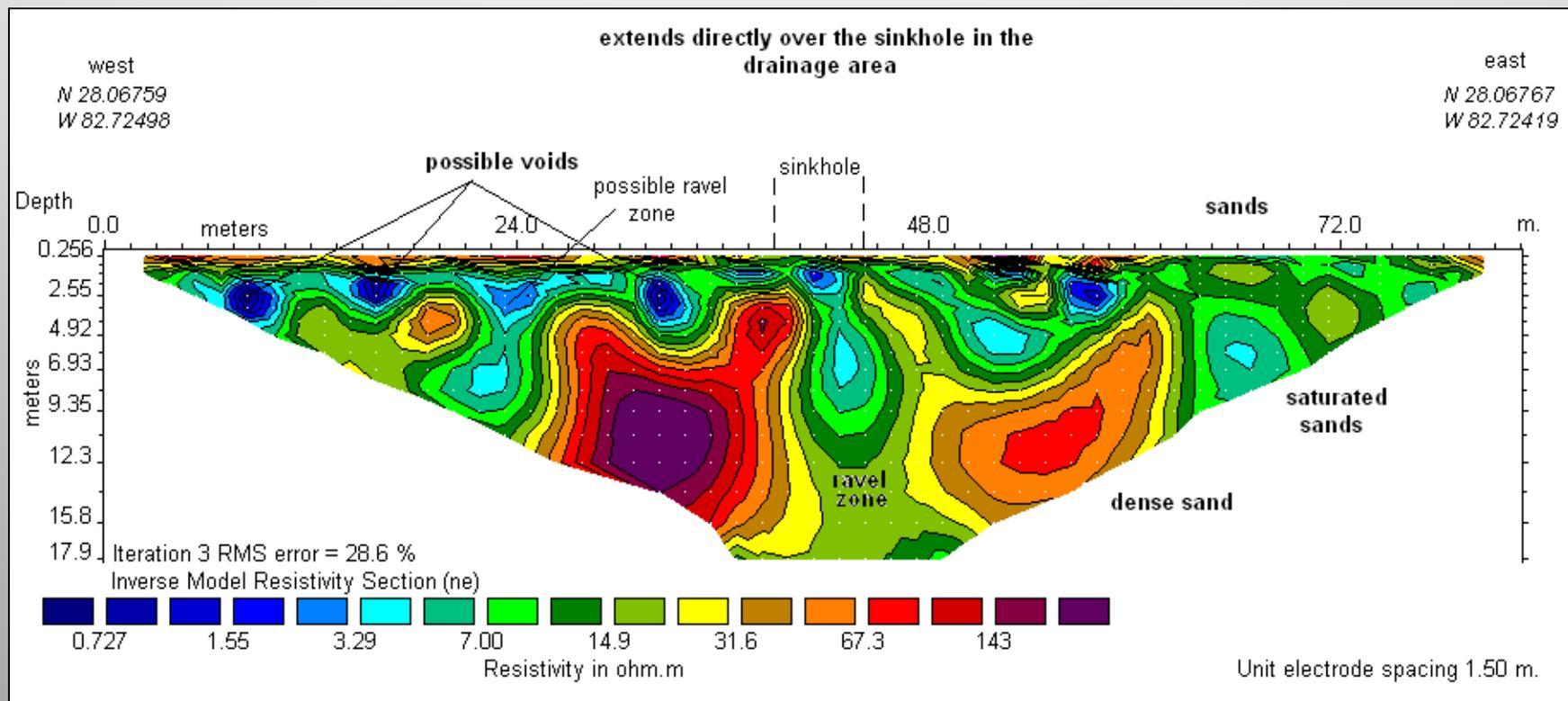
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Results of Anomalous Geologic Features

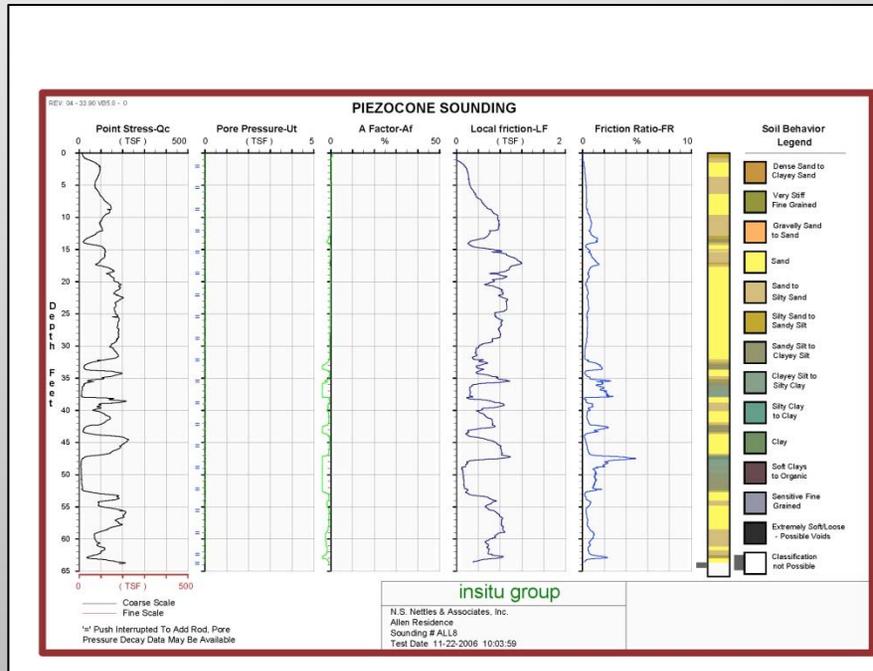
MER Transect Location and Anomaly Location Map



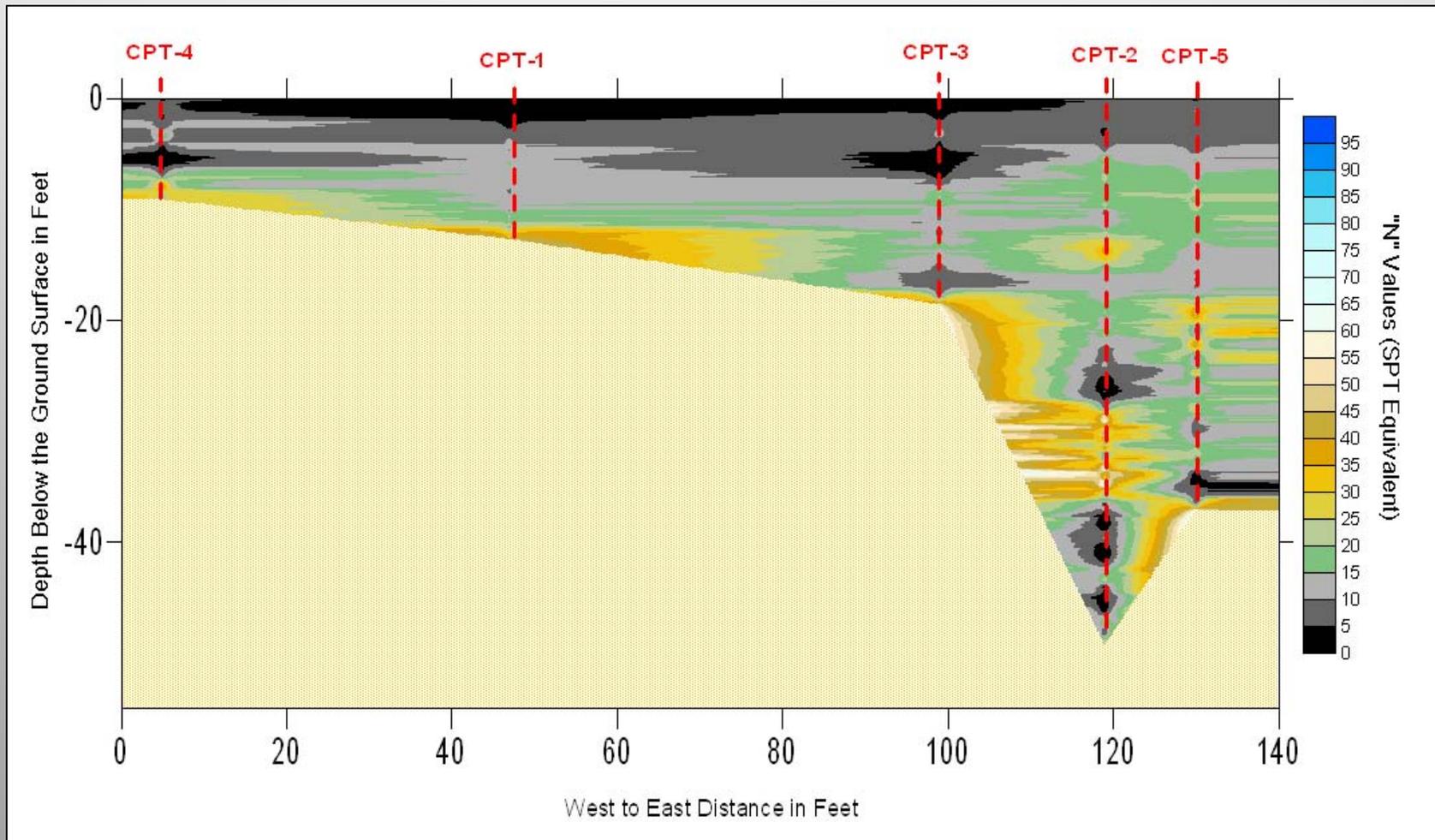
Representative MER Profile Across Sinkhole



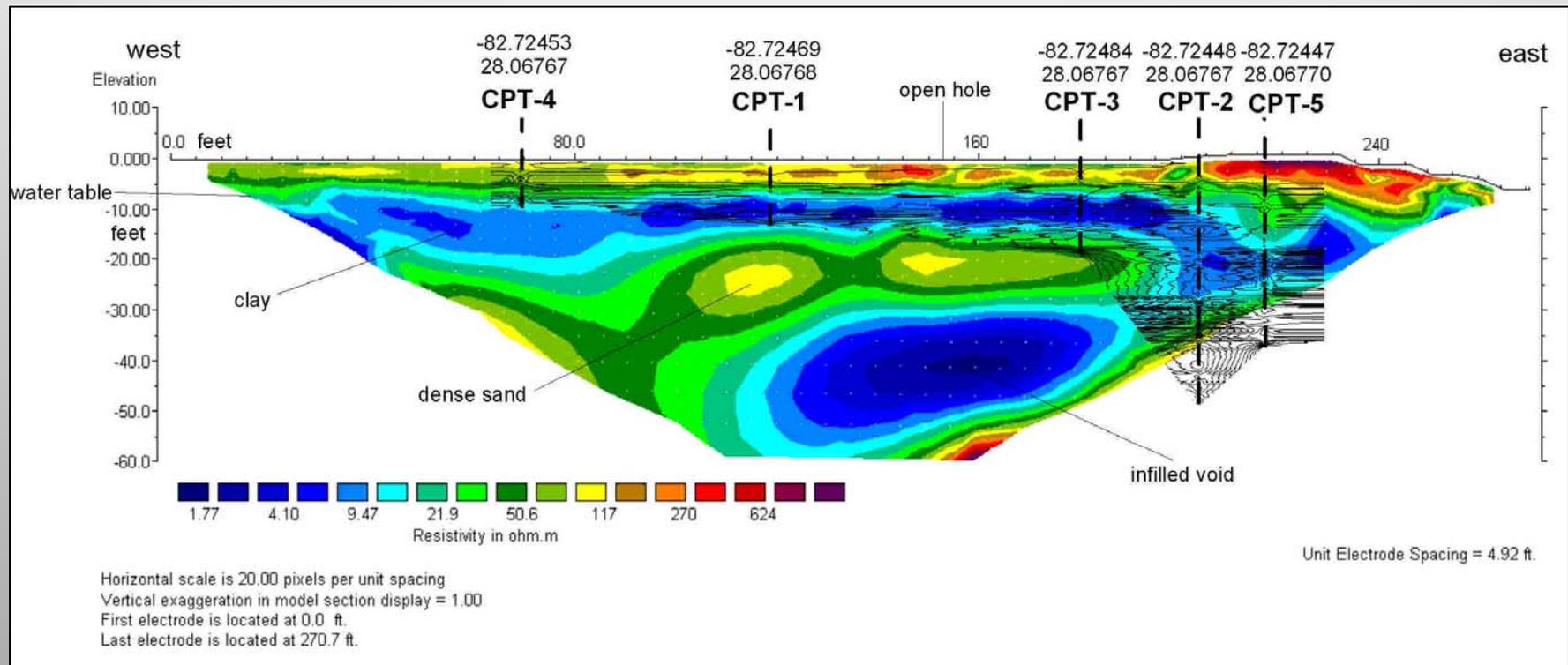
Cone Penetration Testing (CPT) to Groundtruth Geophysical Data



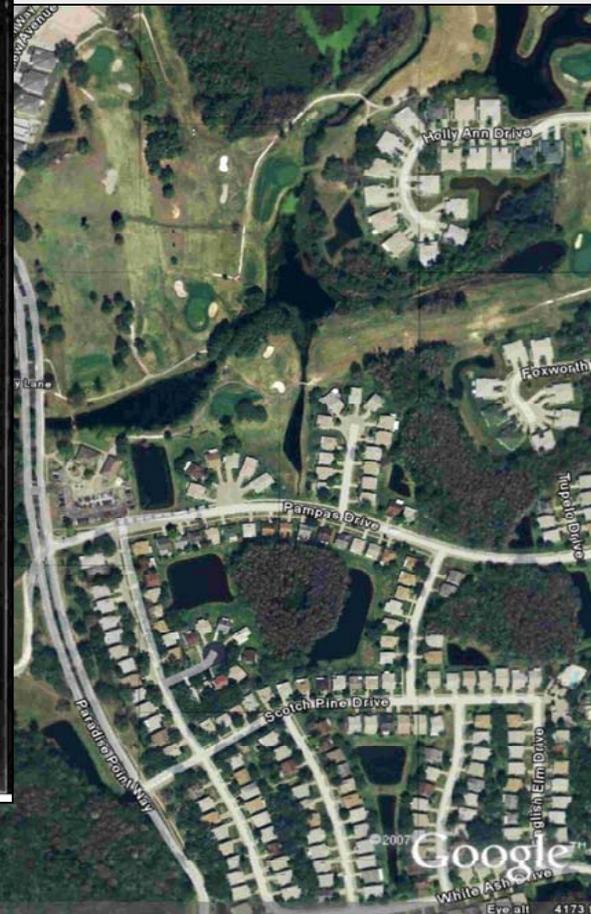
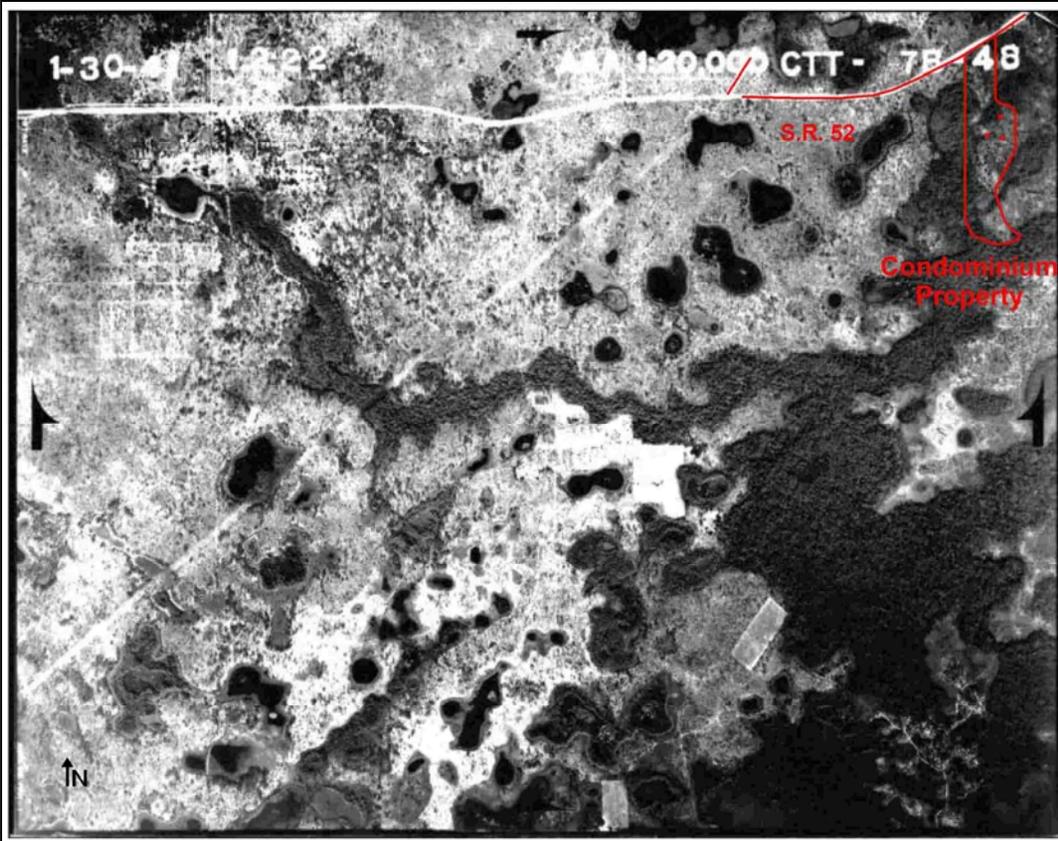
CPT Calculated "N" Values Cross Section



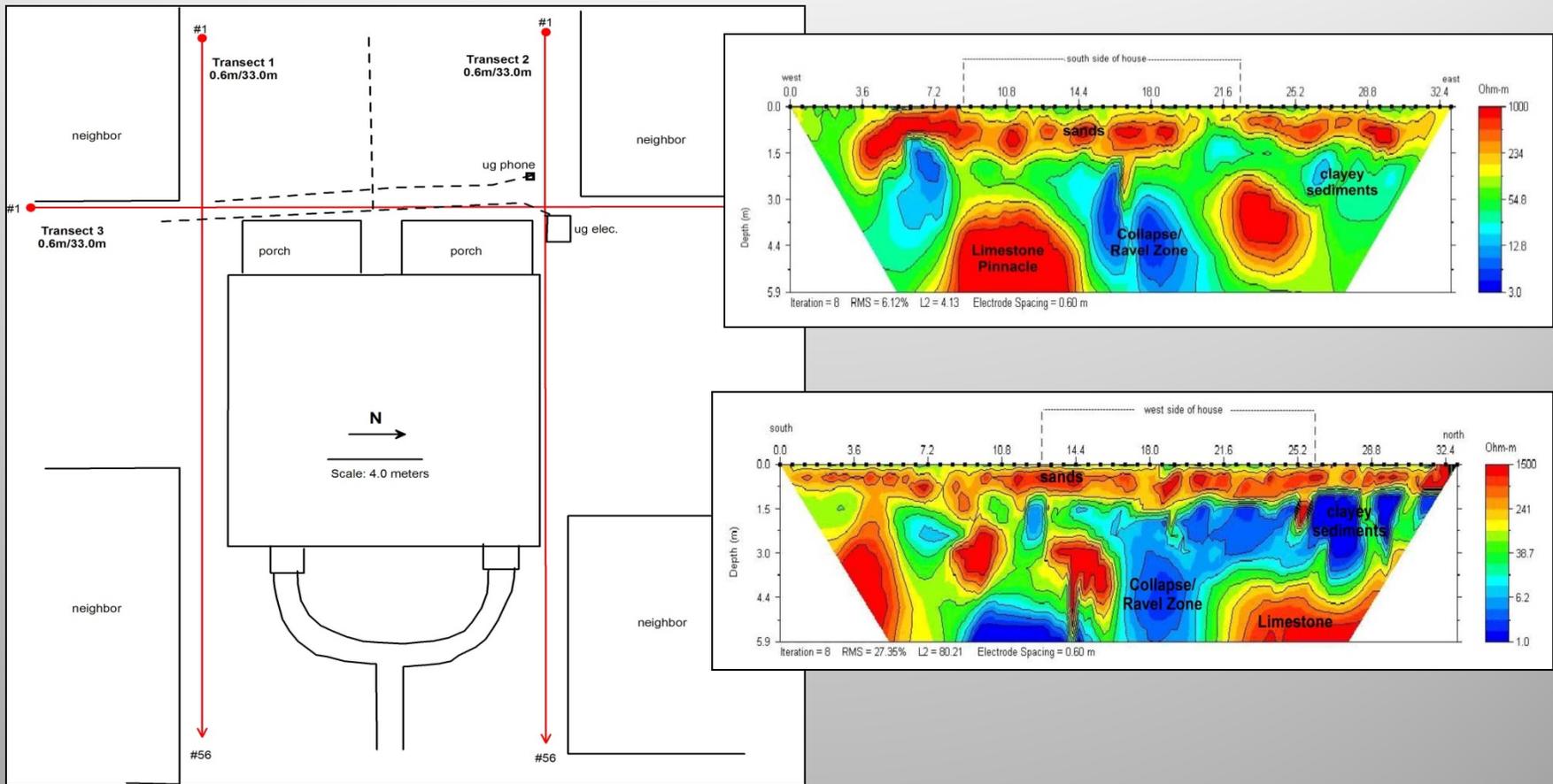
Overlay of CPT Data with Resistivity Data



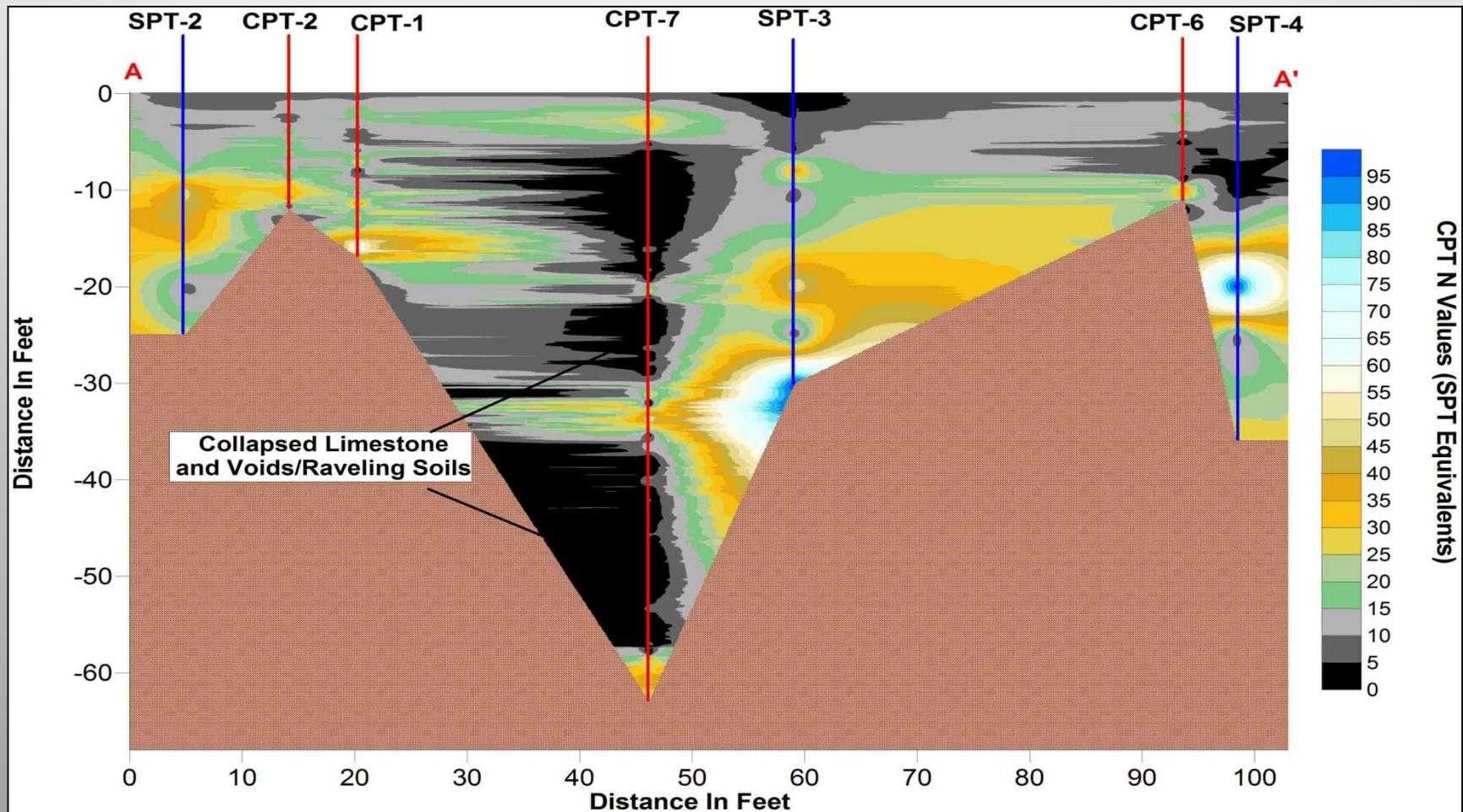
Case Study: Karst Mapping in West-Central Florida



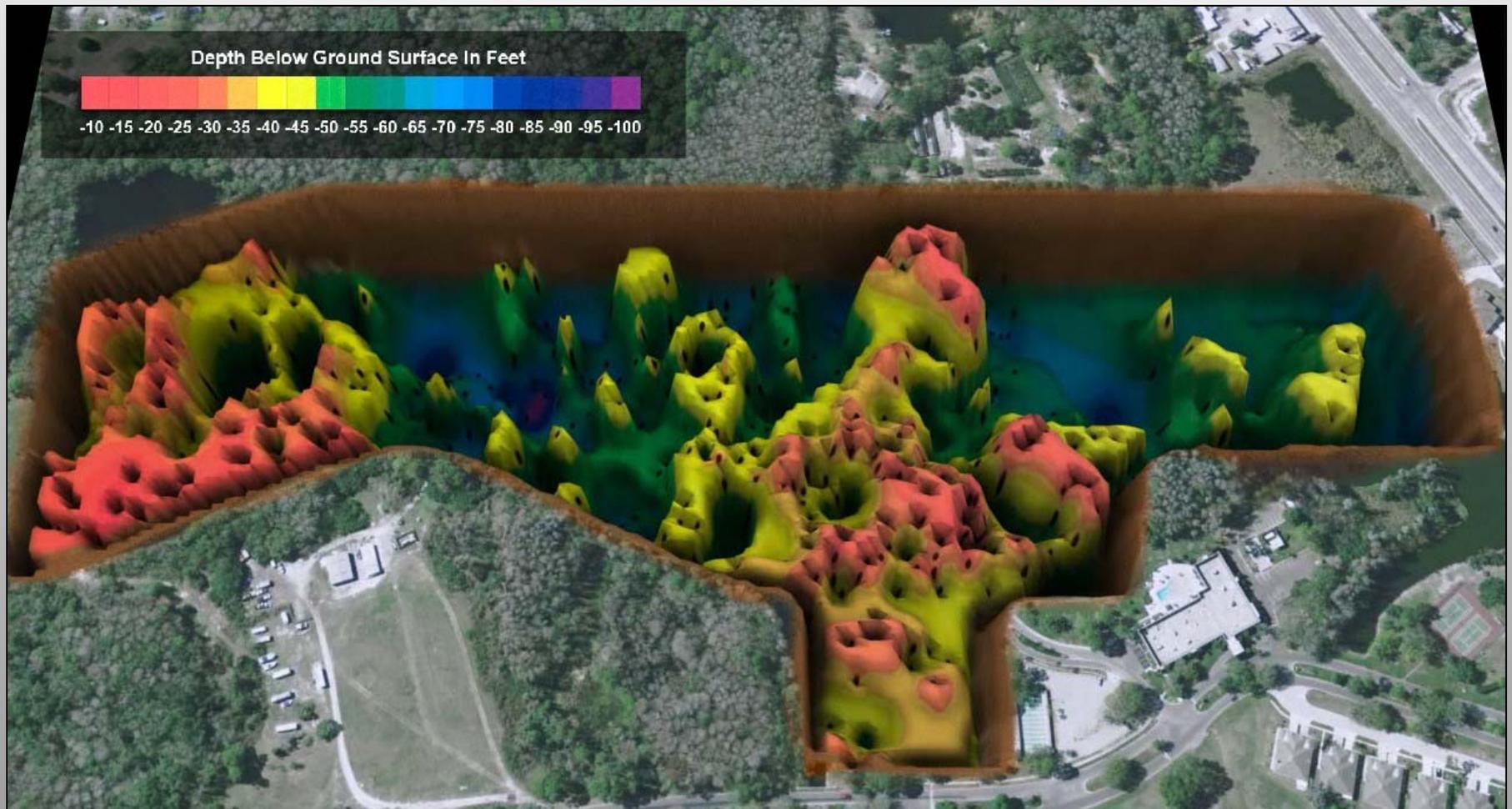
Resistivity Mapping Around Buildings



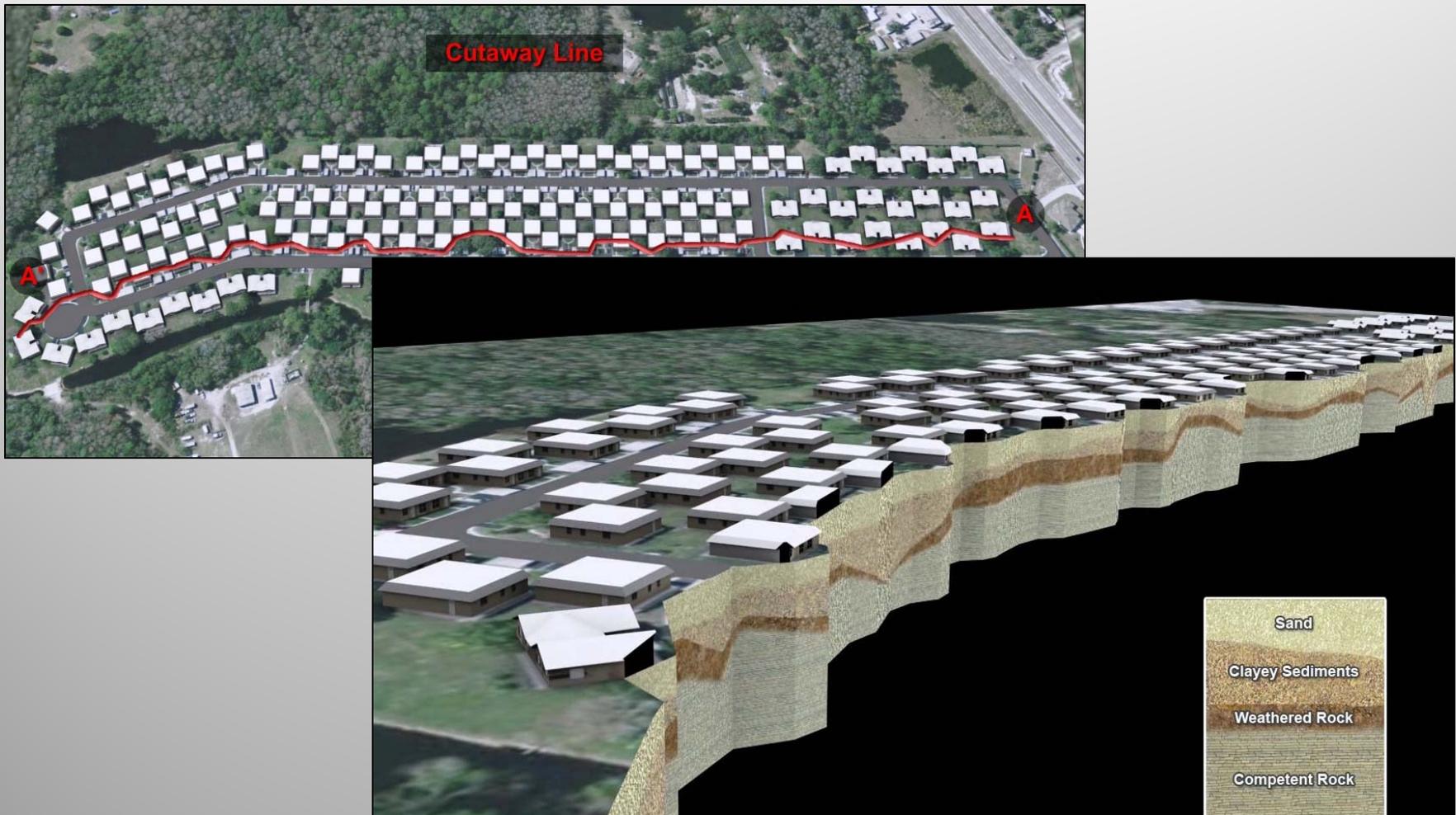
Groundtruthing With SPT Borings and CPT Soundings



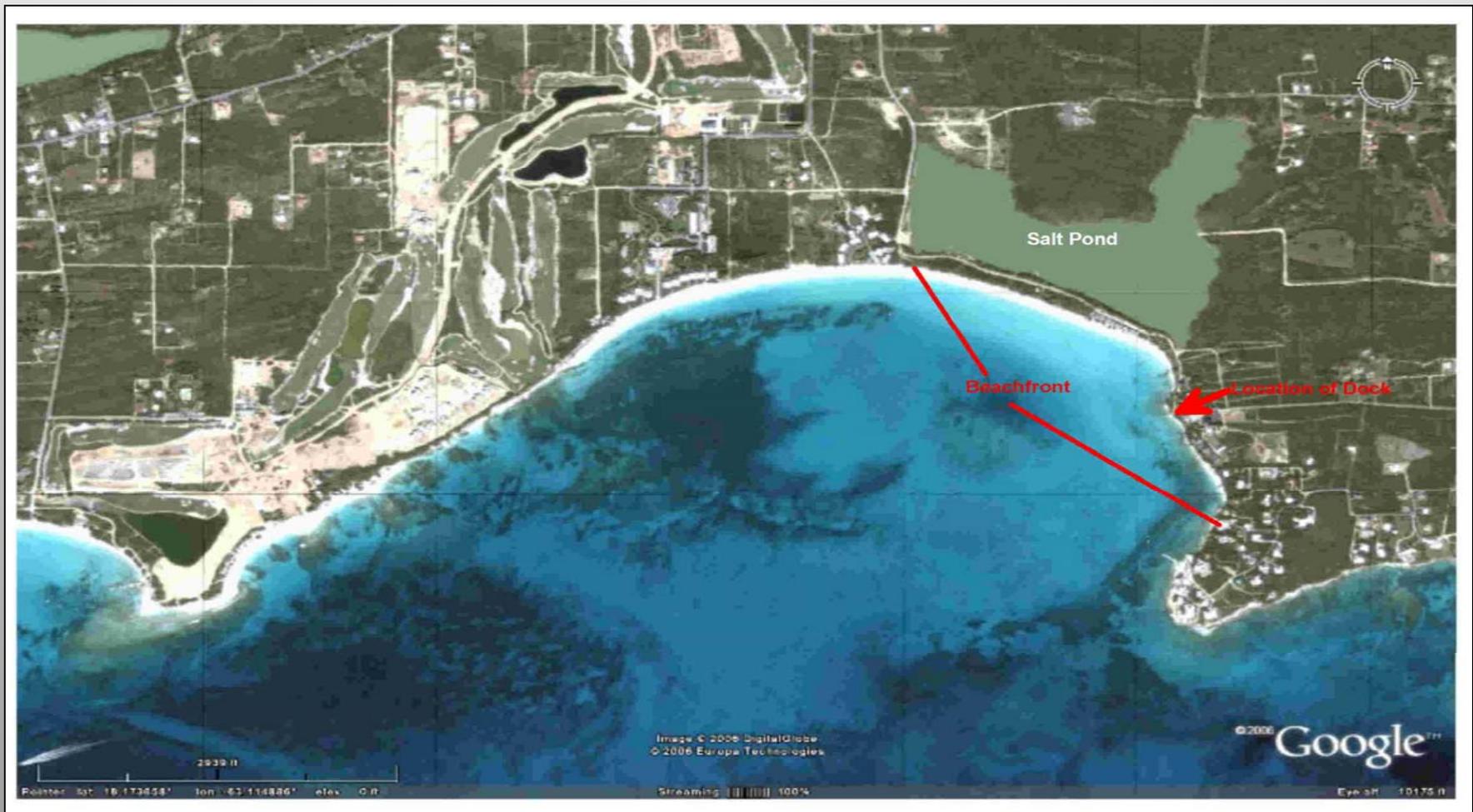
Depth to Rock Mapped Using Geophysical Data AND Borings



Geologic Cross Sections

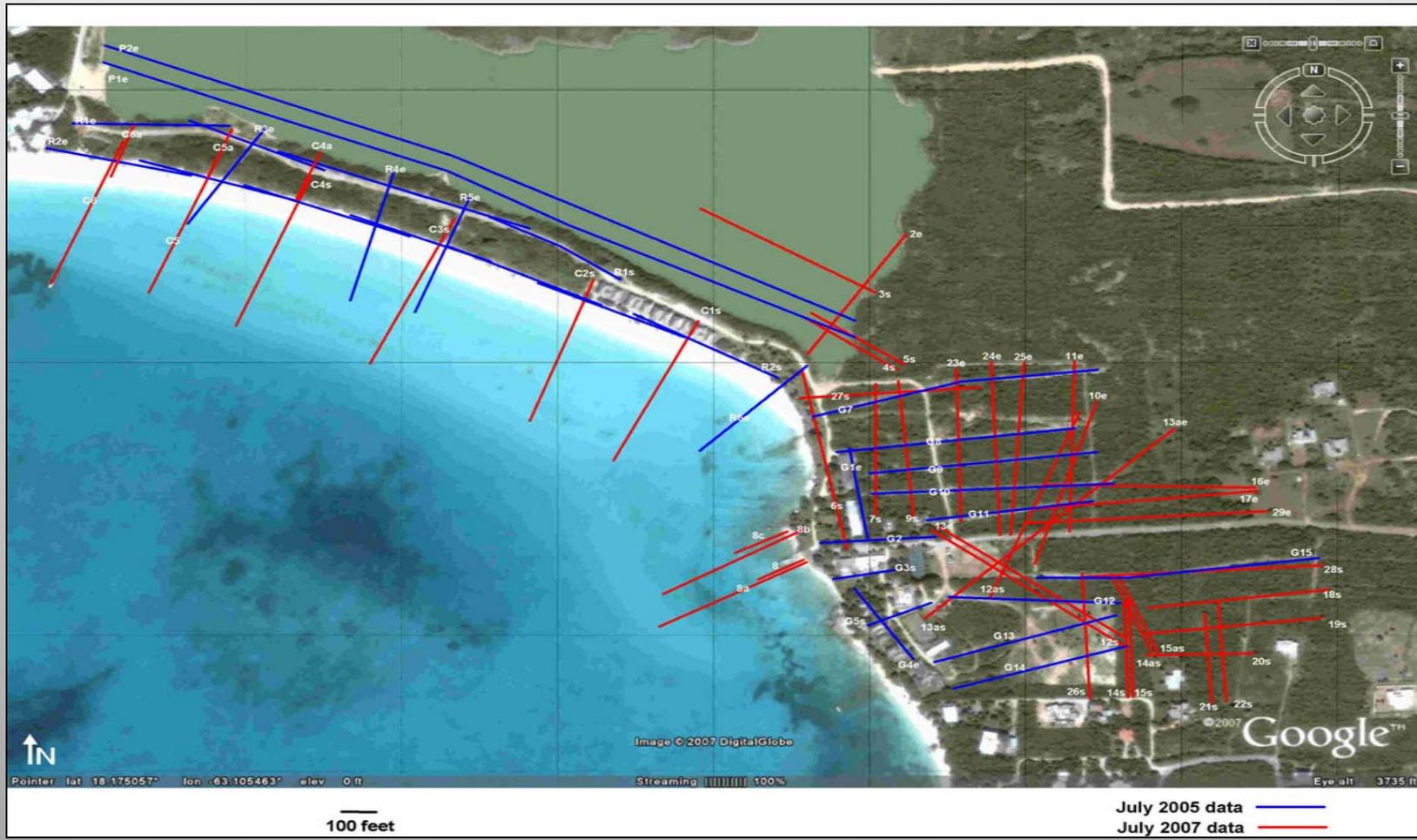


Case Study: Correlations of Resistivity Data to Soil Borings and Rock Cores

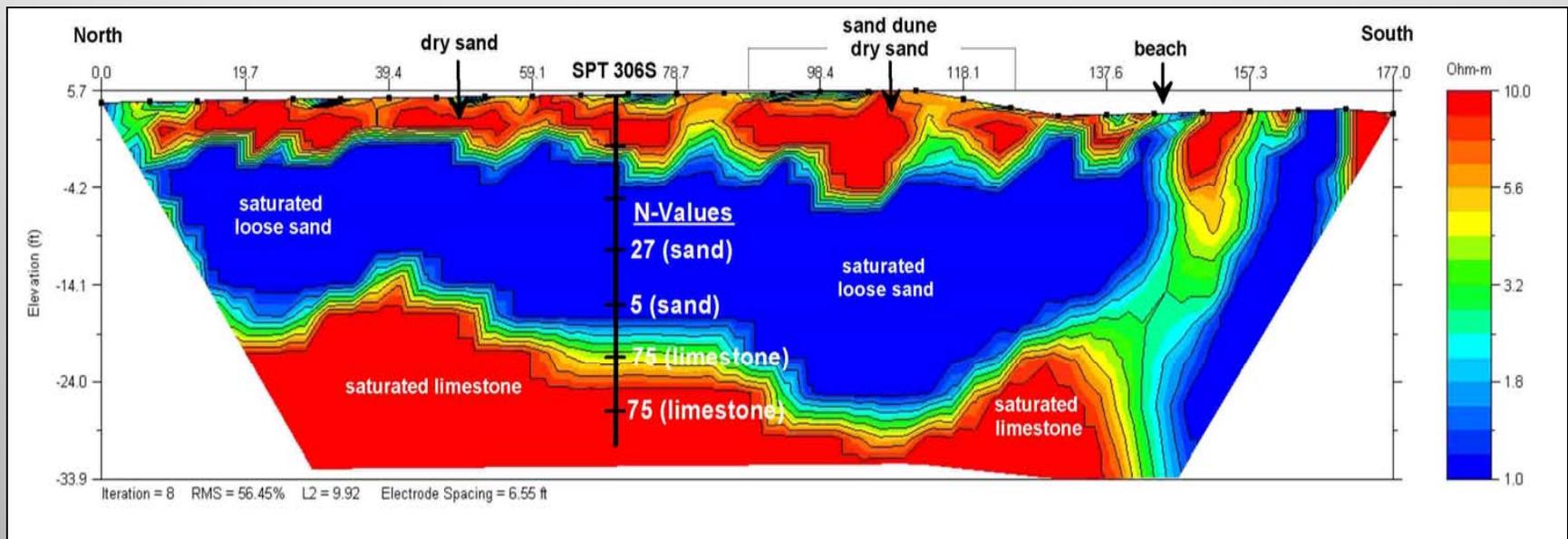


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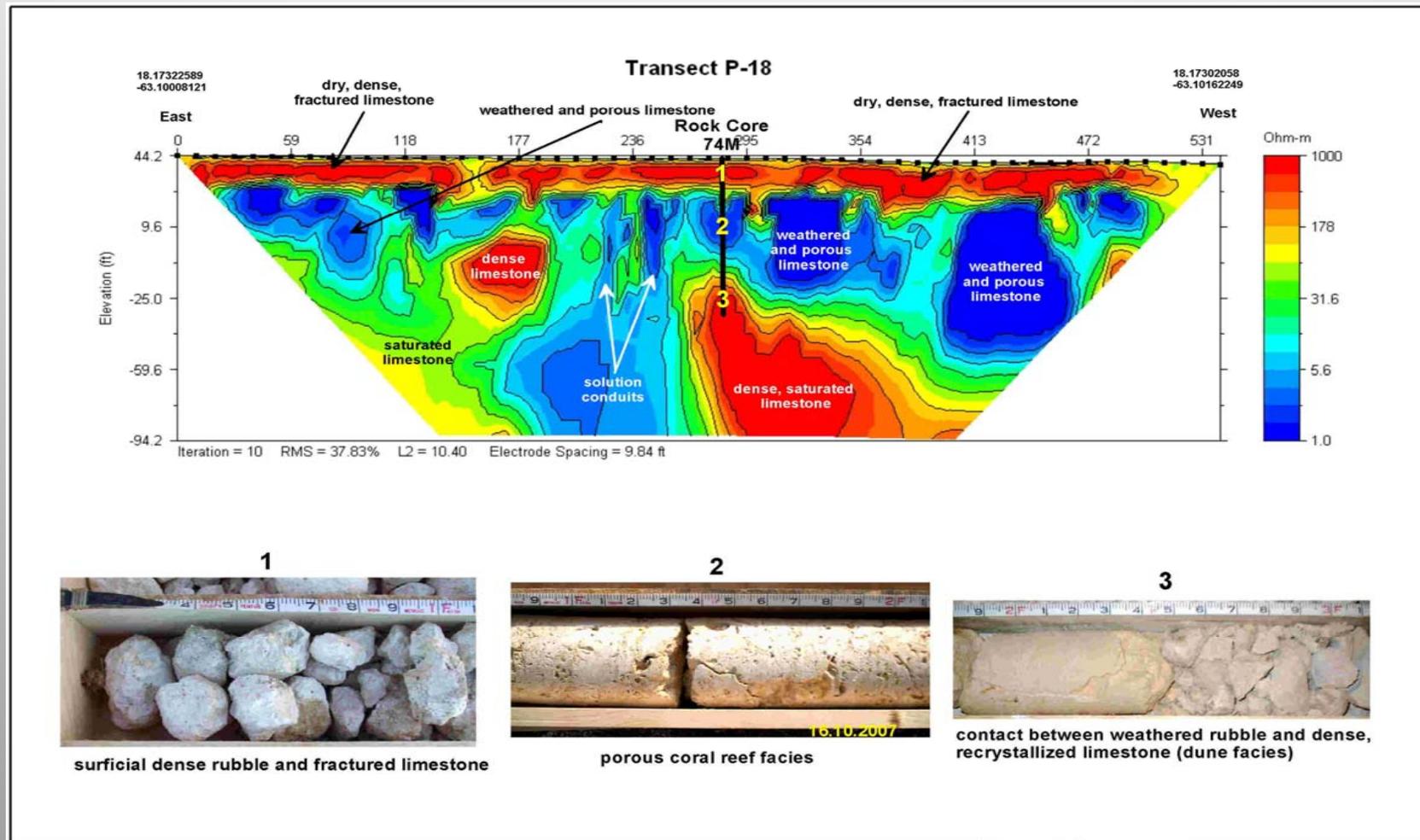
Geophysical Transect Locations



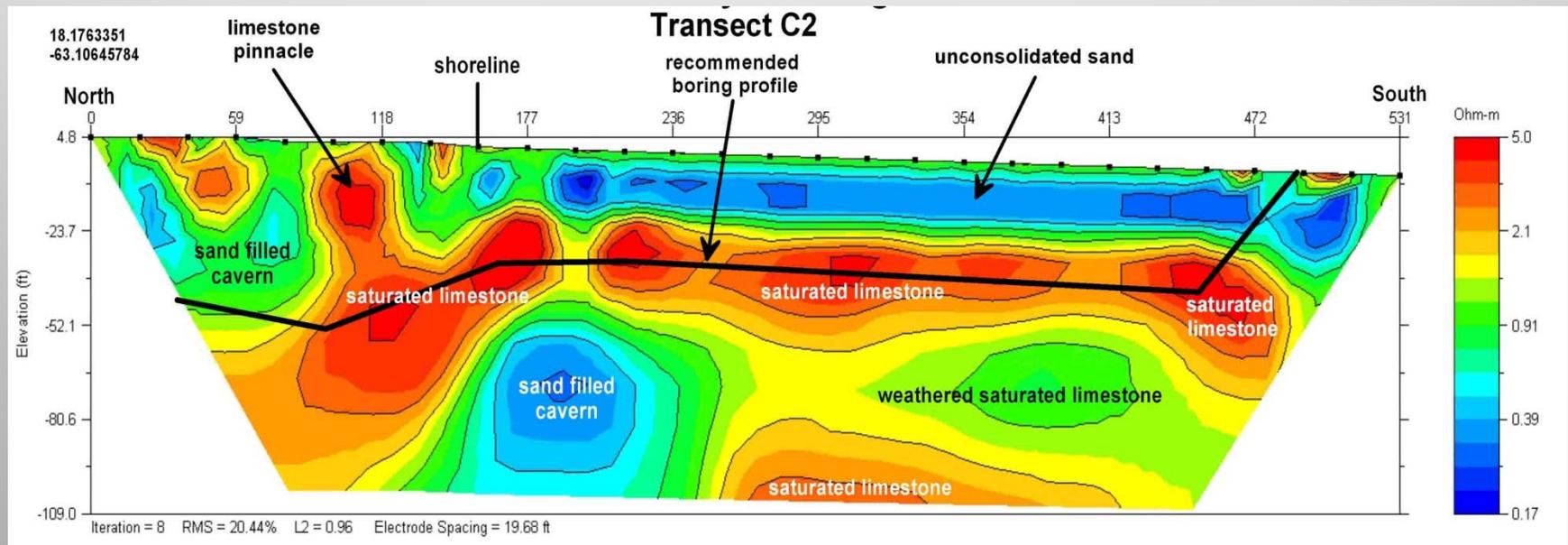
Correlation of MER Data with SPT "N" Values



Correlation of MER Data with Rock Core Samples



MER Data Used for Directional Bore Location and Design

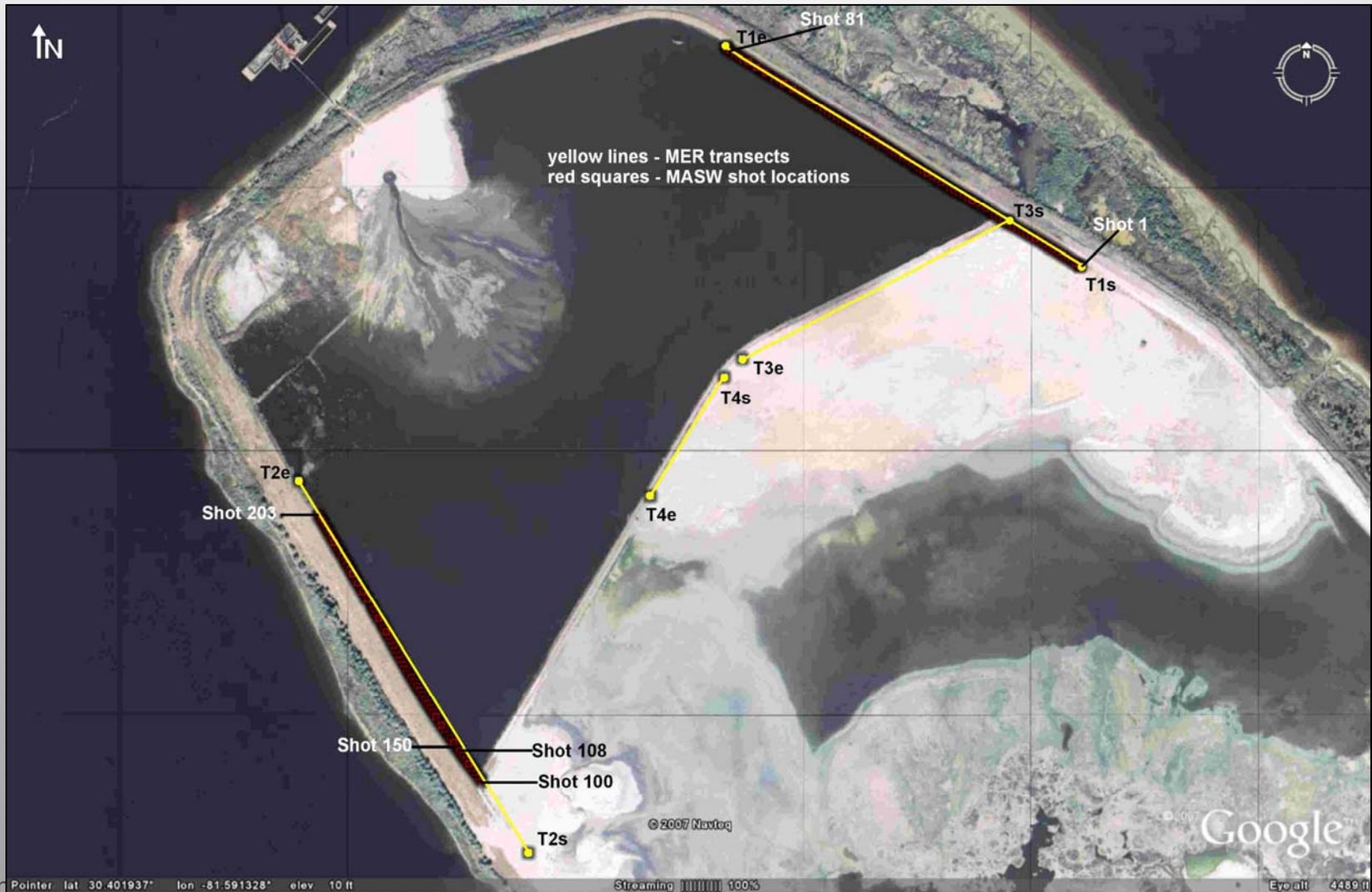


Case Study: Geophysical Analysis of Slope Failure Along a Berm

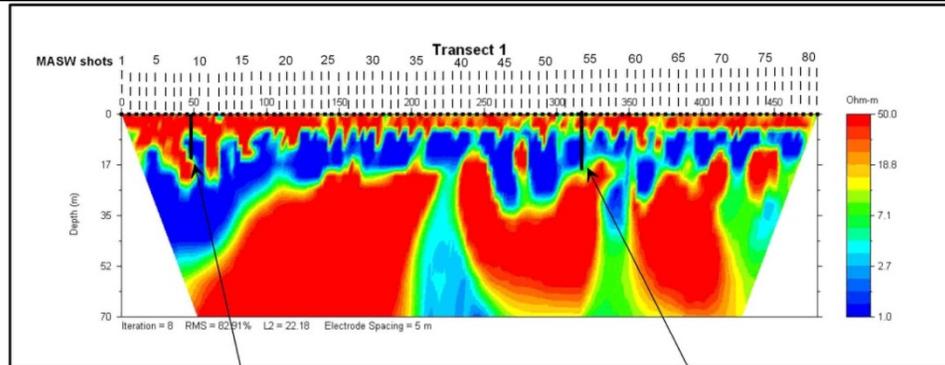


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Geophysical Transect Locations

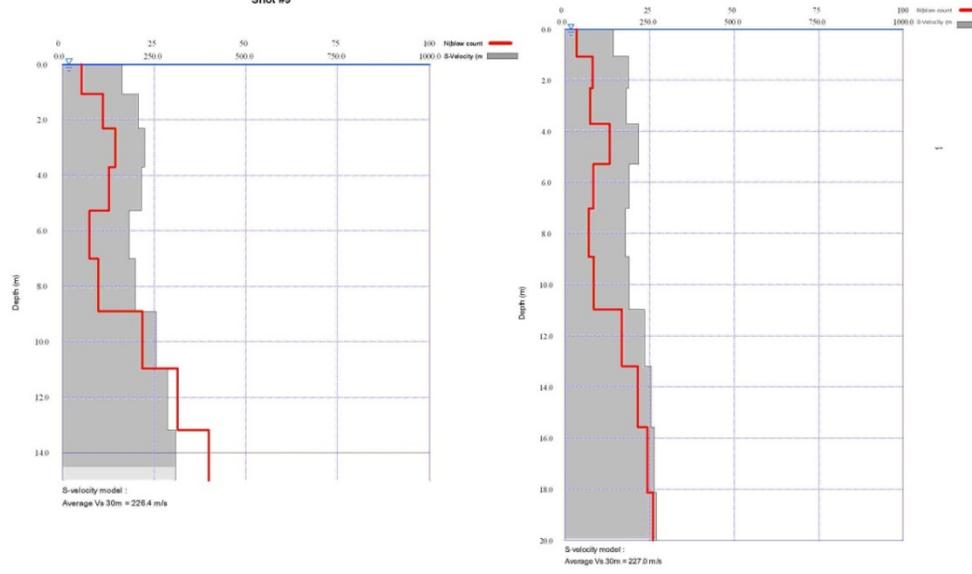


Seismic and MER Data

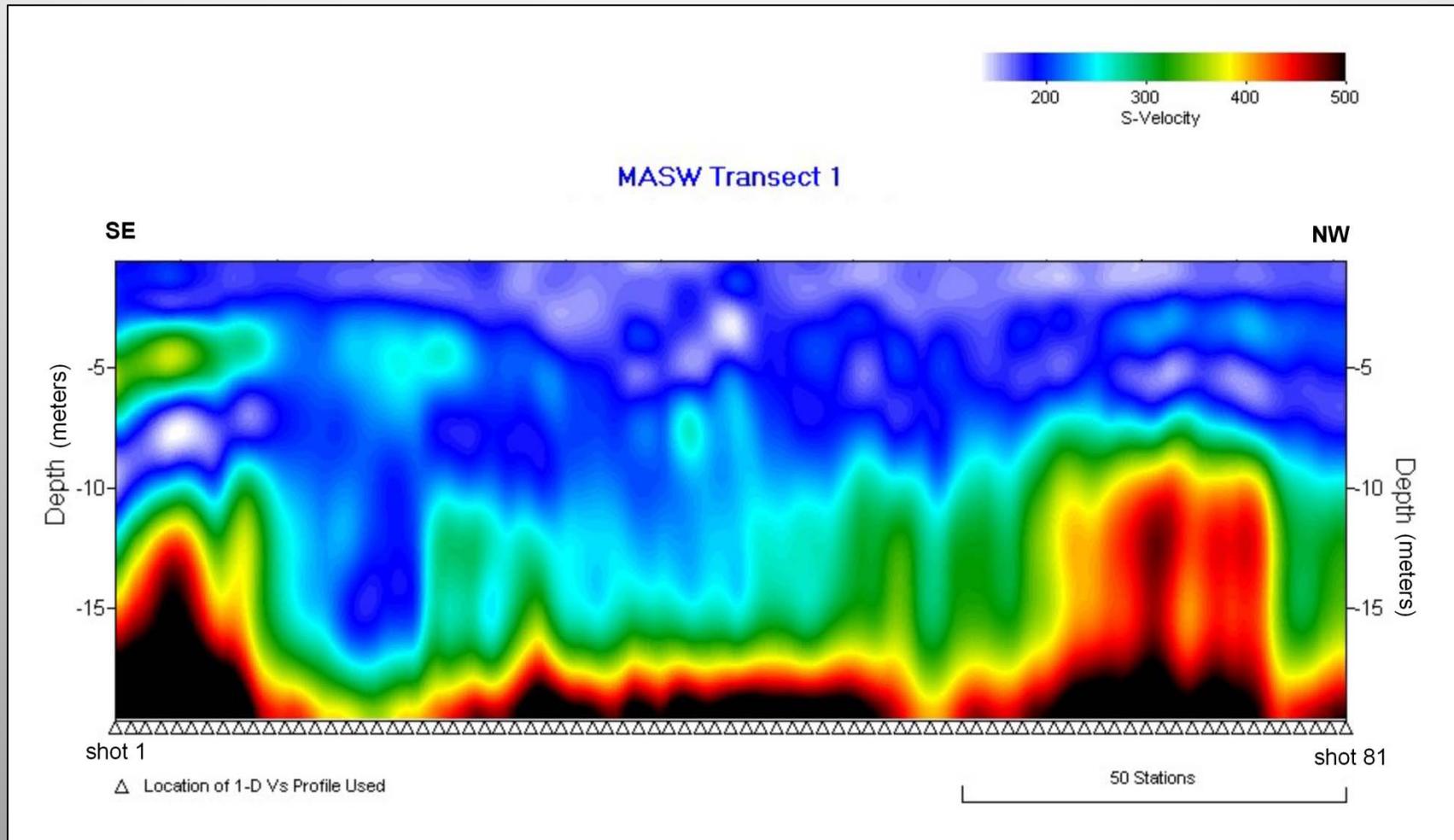


Shot #9

Shot #54



MASW Transect Across Berm



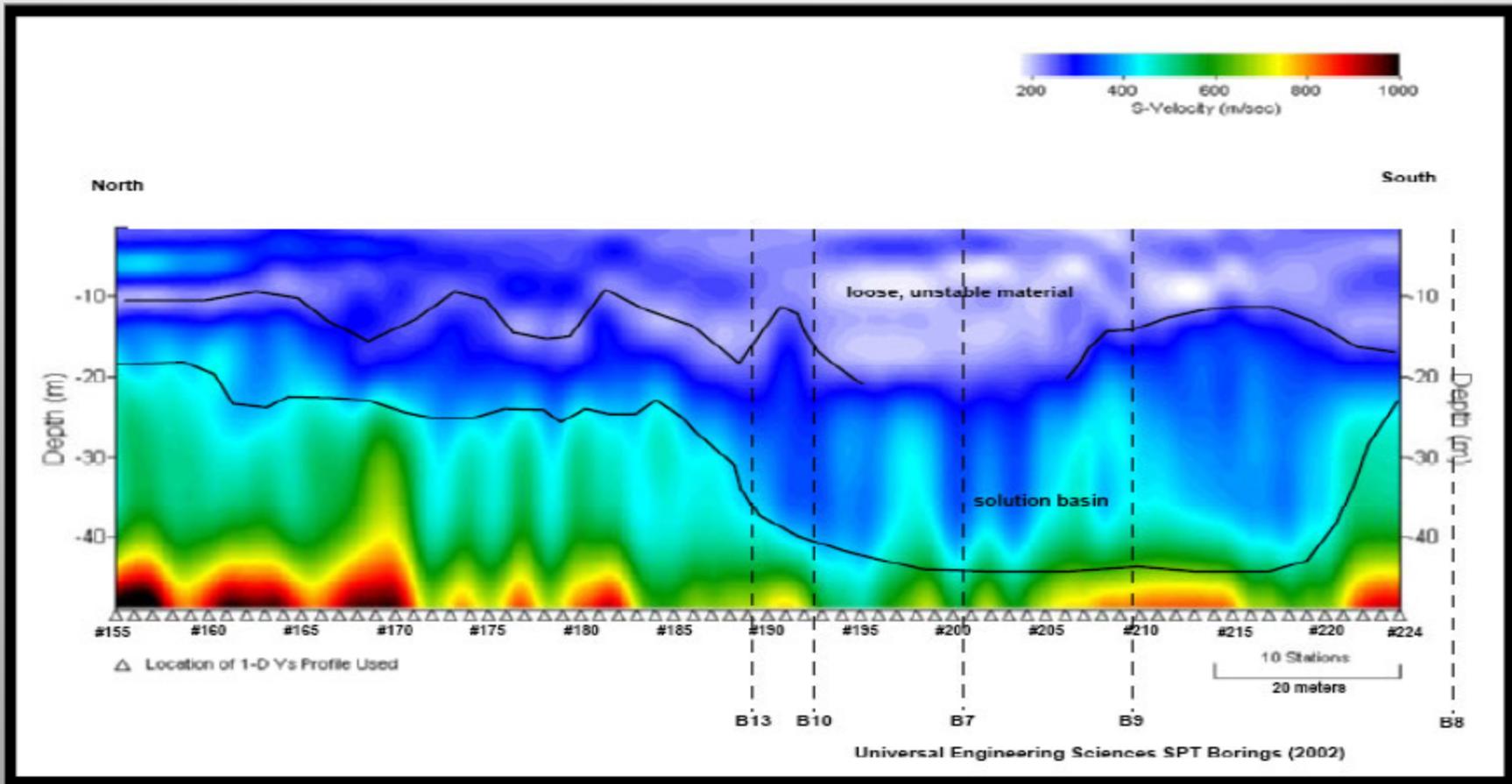
MASW Mapping For Depth to Rock and Geotechnical Design



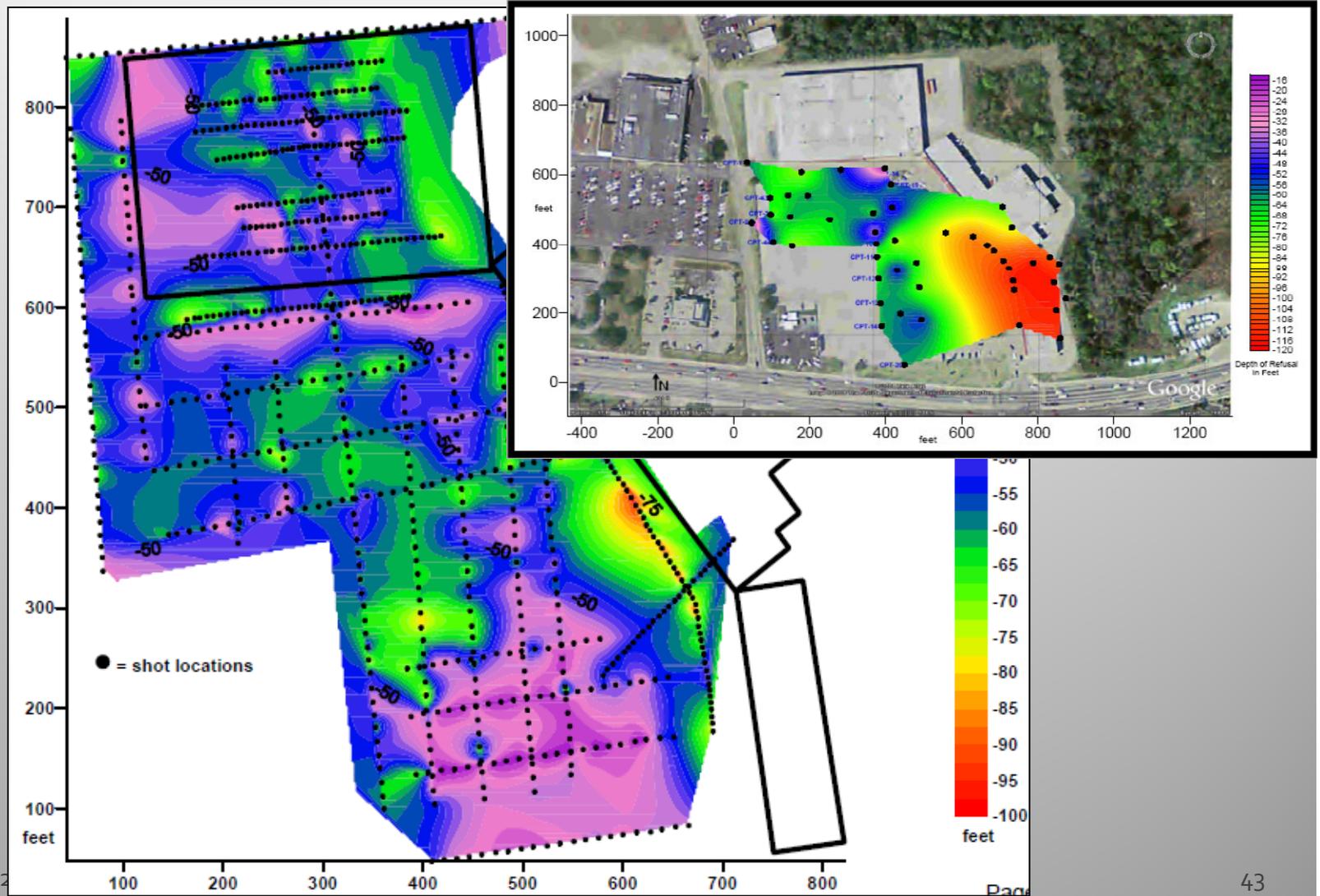
Locations of MASW Transects



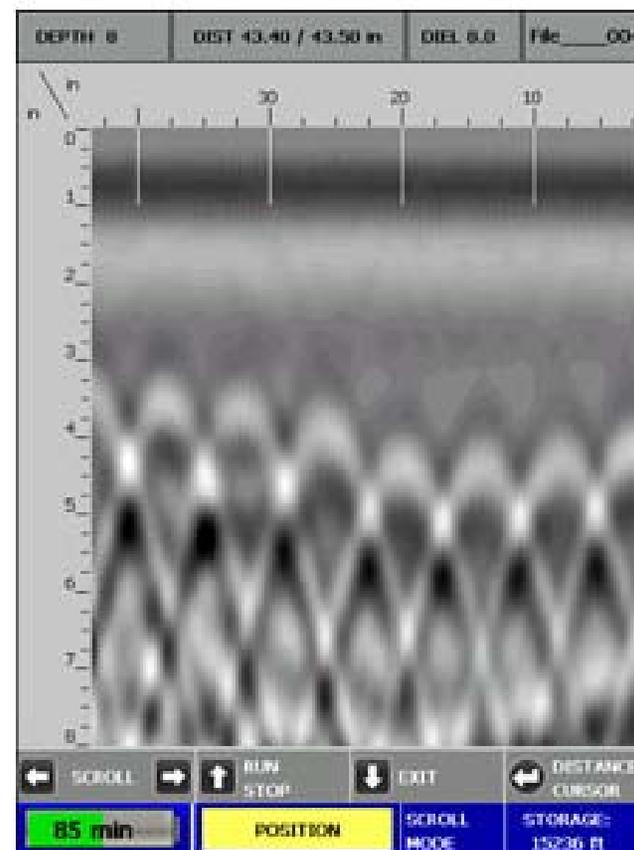
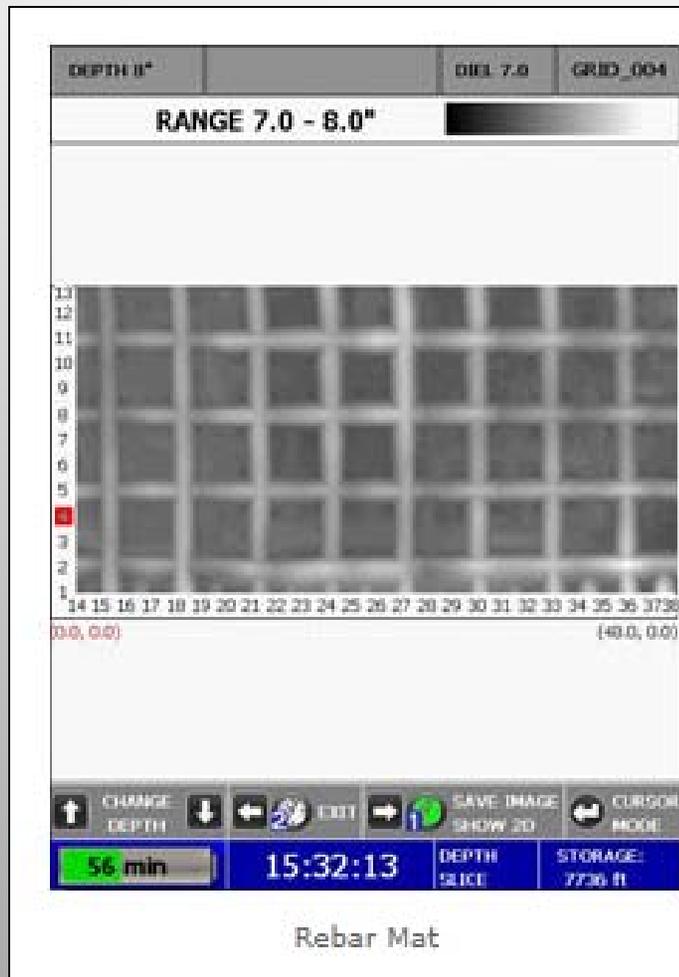
MASW Transect Across Collapse Zone



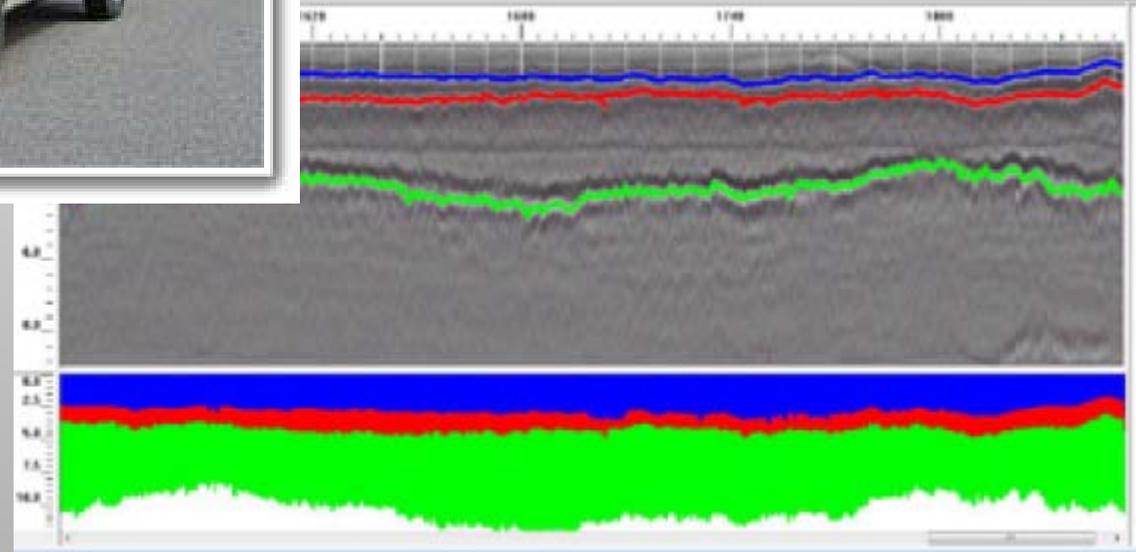
Depth to Rock Contour Map Calculated from MASW Data



Example of StructureScan GPR – Concrete Mapping of Rebar



RoadScan GPR Pavement Mapping Systems



Limitations of Geophysics

- Geophysical surveys are just a tool!
- Ground-truth data are essential to accurately interpret geophysical results
 - Soil sampling/drilling
 - Groundwater sampling
 - Hand probes
 - Cone Penetration Tests
 - Historic geologic data and maps
- Each geophysical method has depth/capability limitations:
 - Interference caused by buried metal objects, ambient noise
 - Depth limitations based on conductivity and geology
 - Site accessibility limitations

Summary of Capabilities

- Geophysics is rapidly becoming an essential tool for site investigations
- Choosing the correct geophysical method is essential for each situation, from a cost and results perspective
- Geophysics can aid in the assessment of the subsurface geology, of structures, and of hydrogeologic characteristics

What Is Next For Geophysics in NC?

- Improvement on EM and GPR surveys
 - GPS integration
 - GIS integration
- Implementing other techniques (i.e. Resistivity and Seismic) into geotechnical investigations
- Combining techniques for more accurate site characterization
- Willingness to try new things!

If only we had used Geophysics!

