Adaptive Management for Characterization and Remediation of DNAPL in Fractured Crystalline Bedrock

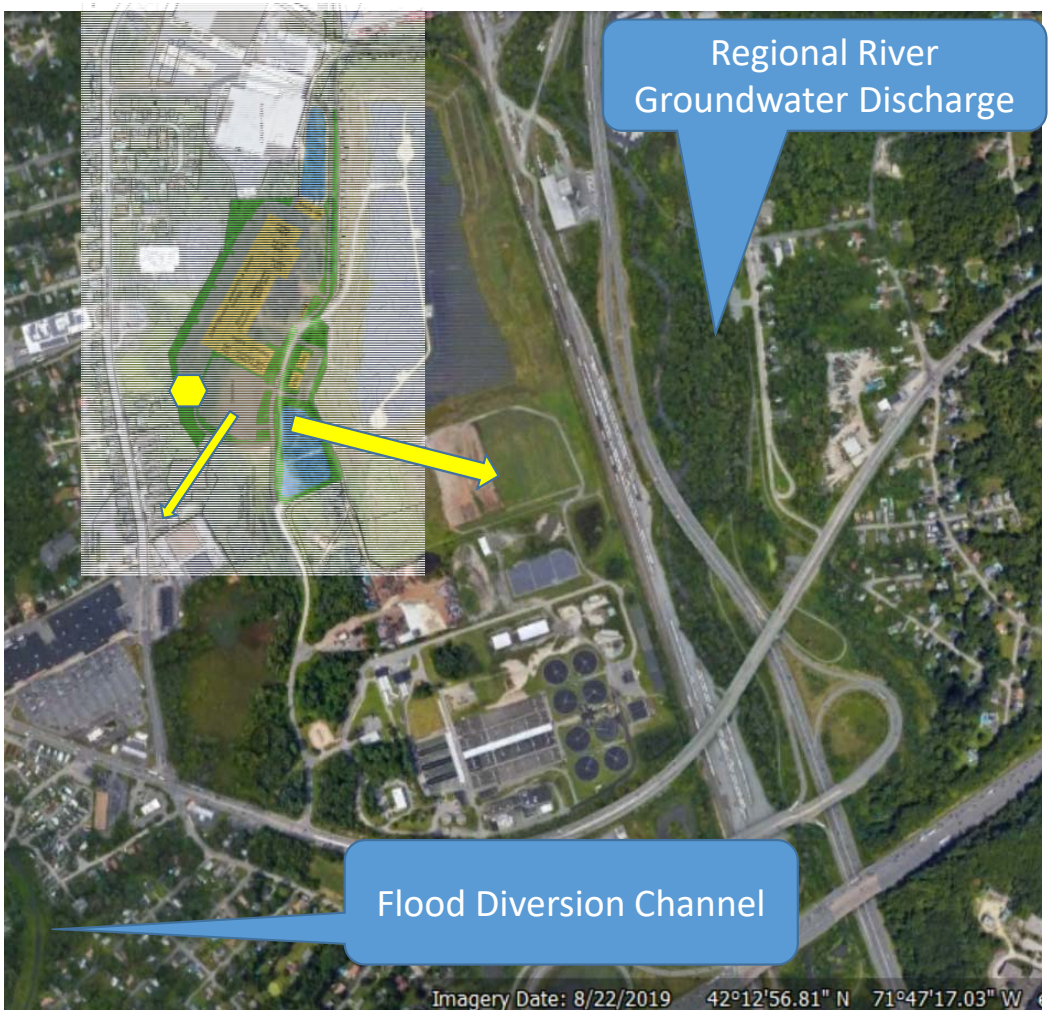
Ernest Ashley, PG, LSP, BCES

Problem Statement

- Characterization and remediation of DNAPL in fractured crystalline bedrock can be the most challenging and most expensive of remediation efforts.
- Meeting regulatory expectations and timeframes within the fiscal and functional capabilities of a municipality significantly add to the challenge.
- Recognizing that potential DNAPL in fractured bedrock would present technical, regulatory and financial challenges for the municipality, an adaptive, phased bedrock characterization program was implemented.
- Adaptive approach resulted in delineation of DNAPL in fractured bedrock and designs for groundwater plume containment and site remediation.

The Site

- Municipal Solid Waste Landfill and “Development Parcels”
- 270,000 µg/L of 1,2-DCE detected in what was supposed to be an “upgradient” well
- Fractured gneiss bedrock
- TCE & DNAPL detected in quarry
- Contamination not identified “downgradient”
- Indication of cross gradient transport



The Adaptive Management Approach

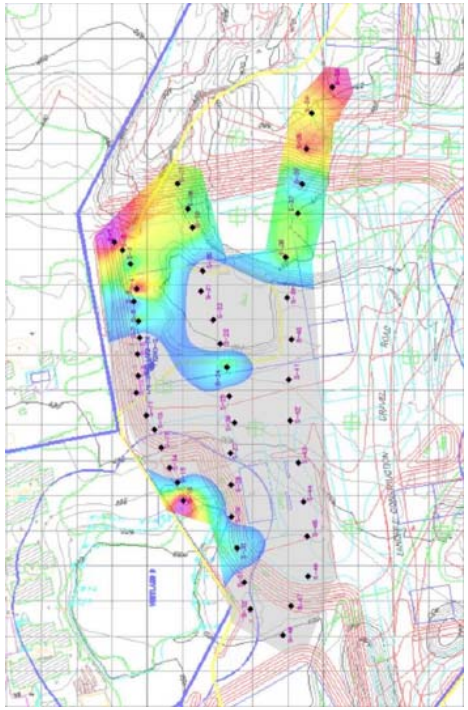
- A systematic and formal process for identifying areas of uncertainty and determining ways to reduce them.
  - Conduct uncertainty analysis; identify and prioritize key uncertainties
  - Identify potential actions
  - Design sampling needs base on remedy decision requirements
  - Maintain remedial action contracting flexibility
- Implement characterization
  - Use multiple data quality objectives
  - Obtain real-time data, evaluate relative to an established decision logic
  - Perform frequent Conceptual Site Model reassessment
- Monitor and evaluate outcomes, take steps accordingly

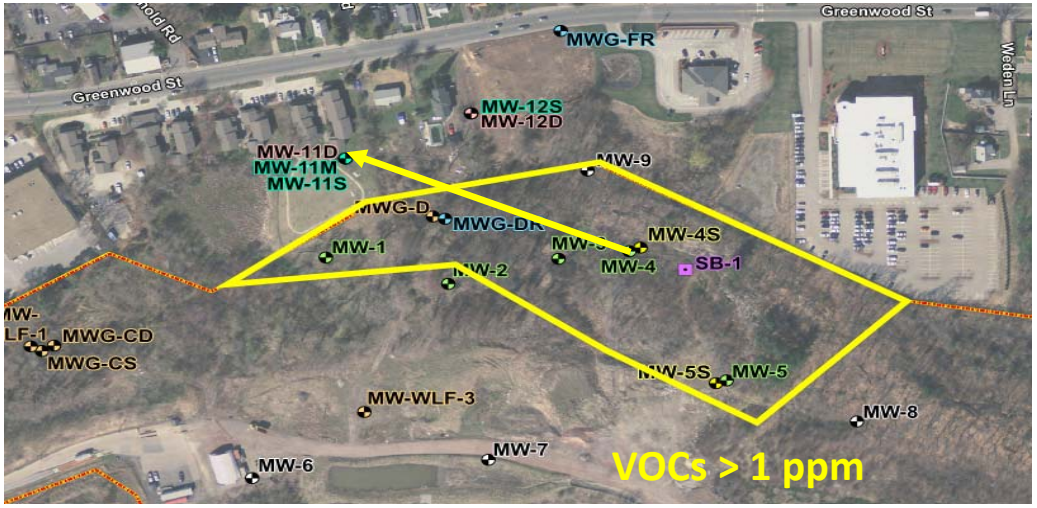
Greenwood Street Project “Adaptations”

- 270,000 µg/L 1,2-DCE detected in “upgradient” well
- Contaminant transport not towards downgradient regional river
- DNAPL detected – new reporting condition and response action plan
- Artesian conditions encountered during drilling
- Volatilization criteria exceeded in monitoring well <30’ from building
- Drilling, packer and injection testing documented fracture architecture
- Bench scale testing identified optimum amendment component
- Remedial design addressed offsite migration and source area
- Pilot testing to confirm remedy implementation construction

Adaptive Management at Greenwood Street

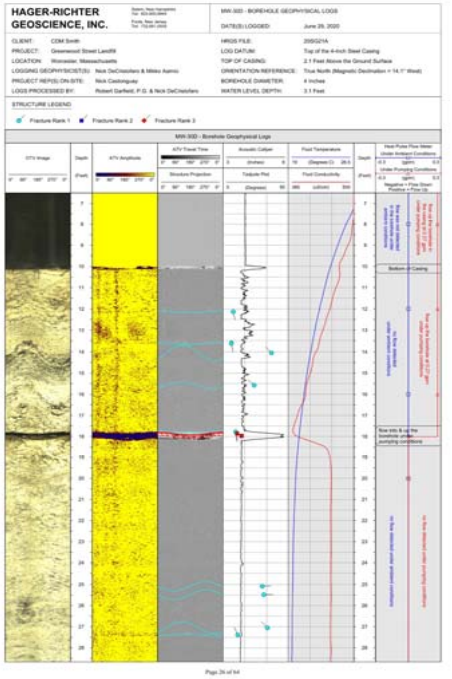
- Bedrock Outcrop Mapping
- Soil Gas Survey
- Drilling, logging, well installation and sampling
- Address findings
  - DNAPL detection
  - lateral contaminant migration
  - offsite migration
  - VI concerns
- Communications Plans
- Drilling, logging, well installation and sampling - 2nd phase
  - Understanding Development Plans
  - Including potential remediation infrastructure
- Packer testing, injection testing, bench scale and pilot testing
- Finalize remedial design

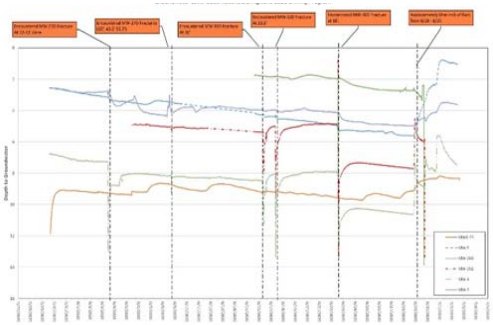



Greenwood St
Weiden Ln
MWG-FR
Greenwood St
MW-12S
MW-12D
MW-11D
MW-11M
MW-11S
MW-9
MWG-D
MW-1
MW-4S
MW-4
SB-1
MW-2
MWG-CD
MWG-CS
MW-5S
MW-5
MW-WLF-3
MW-8
MW-7
MW-6
VOCs > 1 ppm

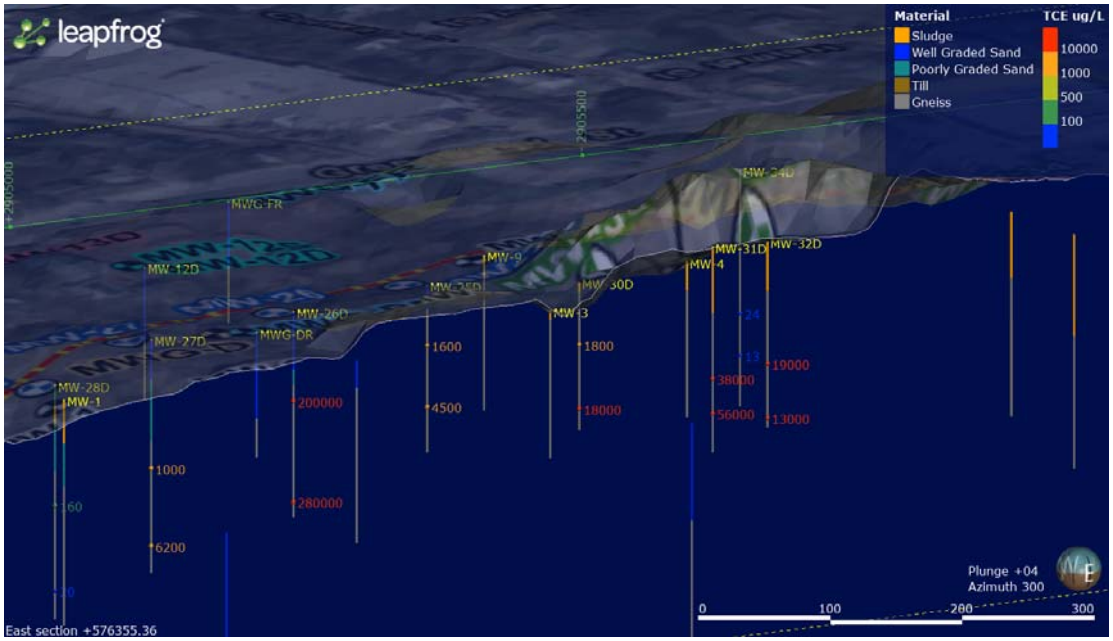
Adaptive Bedrock Site Characterization

- Utilize regional and local geologic maps and available site history information
- Inspect local outcrops
- Utilize surface screening and geophysical techniques
- Coring – provides most relevant information and highest quality borehole
- Borehole geophysics, heat pulse flow meter, packer testing, pressure transducers
- Discrete water quality sampling
- 3-D visualization
- Additional data collection as necessary to complete the CSM and support the FS and RD

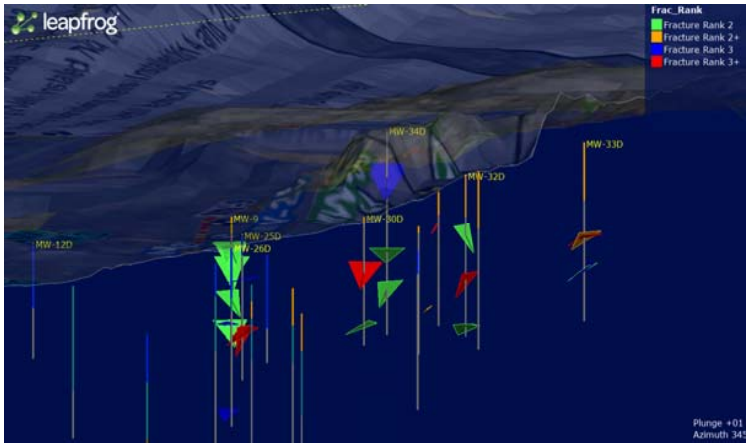




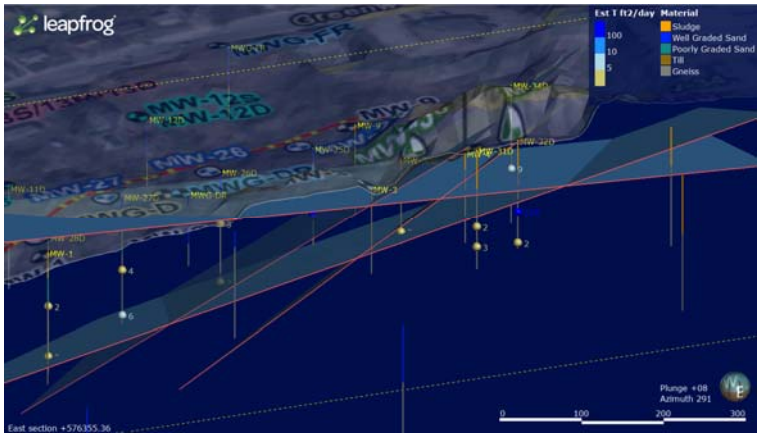
3-D Visualization of Bedrock Architecture



Packer Testing Results – TCE concentrations per fracture interval



Fracture orientation by Rank



Fracture Planes and Transmissivity

Adapting for Client Considerations

- Establish good communications
- Understand Fiscal Year and financial forecasting requirements
- Explain the CSM & recognize unknowns
- Address risks & evaluate uncertainty
- Establish Scope of Work flexibility
- Phase work across fiscal years
- Project project costs early
- Coordinate with regulators
- Maintain contracting flexibility

Thank you for your interest. Questions?

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CDM Smith

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