The Use of Adaptive Management Approaches in Support of Remedial Design Activities at Two EPA Superfund Sites

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Integrated DNAPL Site Strategy

ITRC Technical and Regulatory Guidance Document: **Integrated DNAPL Site Strategy (IDSS-1, 2011)**

- Comprehensive site management
- Use at any point in site lifecycle
- Key topics
  - Conceptual site model (CSM)
  - Remedial objectives
  - Remedial approach
  - Monitoring approach
  - Evaluating your remedy
- CDM Smith co-authors and instructors

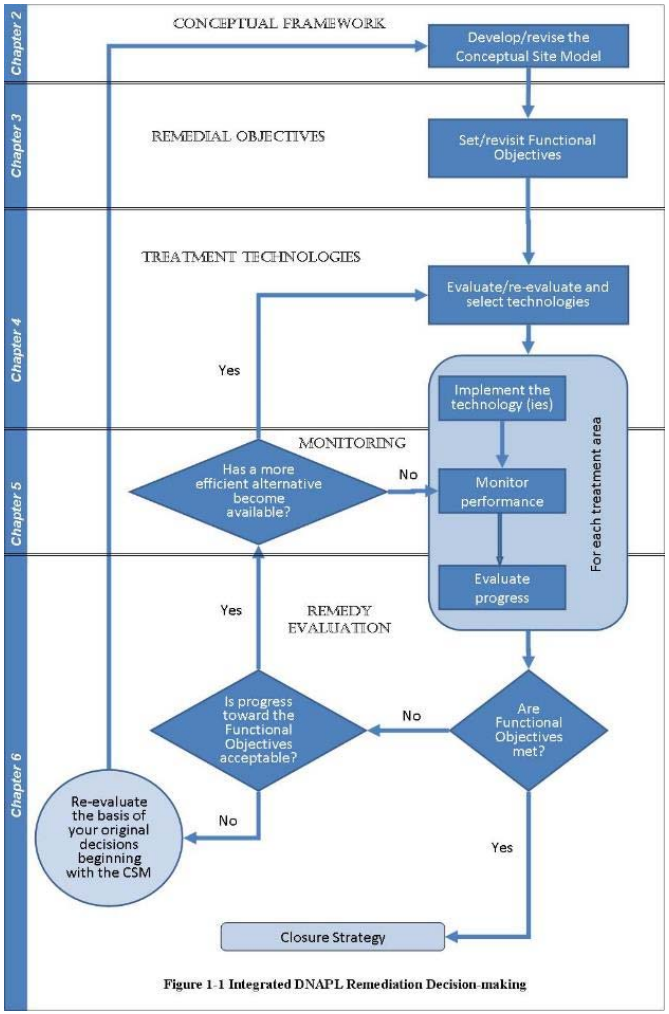


Figure 1-1 Integrated DNAPL Remediation Decision-making

Adding to the Strategy: Integrated DNAPL Site *Characterization*

ITRC Technical and Regulatory Guidance Document: **Integrated DNAPL Site Characterization (ISC-1, 2015)**

- More accurate conceptual site models (CSMs)
- Improved predictability of plume behavior and risks
- More defensible knowledge of contaminant distribution
- Facilitates communication
- Reduced uncertainty
- Better performing remedies

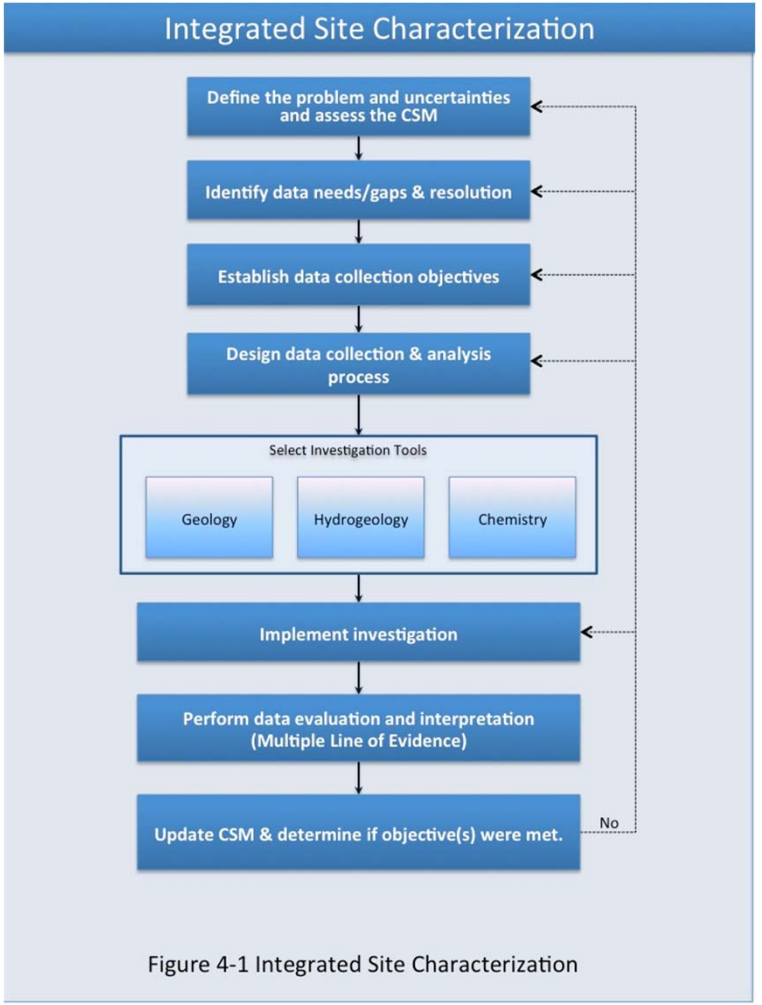


Figure 4-1 Integrated Site Characterization

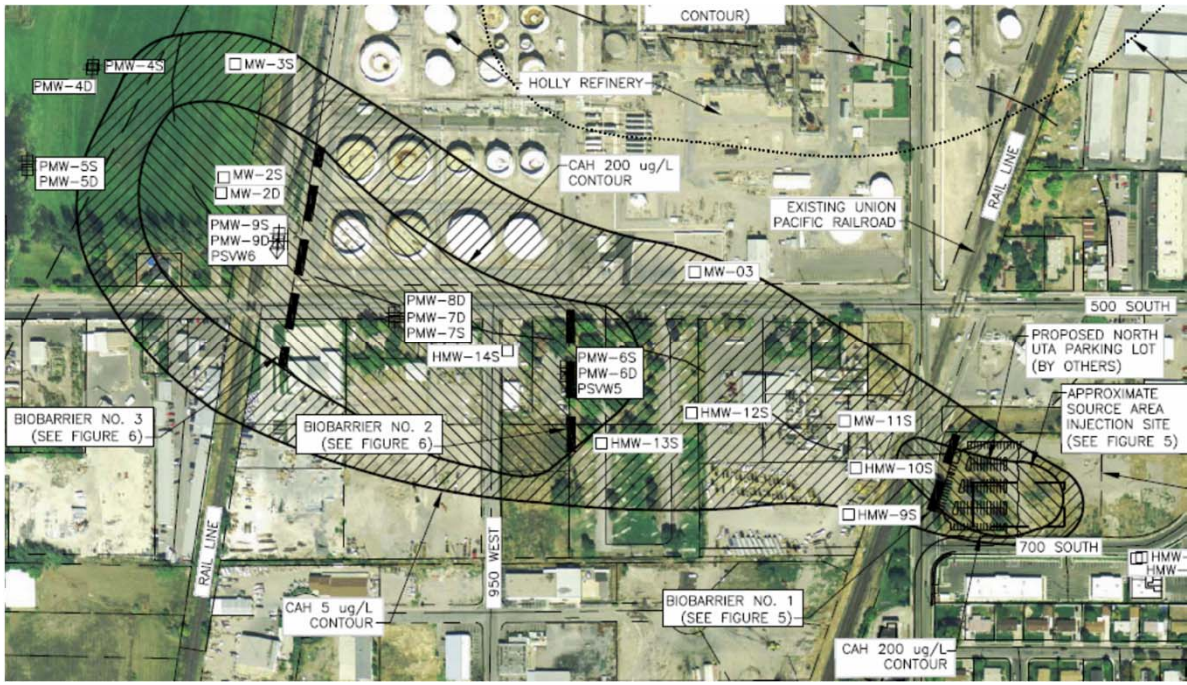
Outline: Examples of Adaptive Management

- Bountiful OU 1 Superfund Site, Bountiful, UT
  - Sitewide nature and extent of contamination
  - Biobarrier installation
  - Far downgradient plume extent
- Commerce Street Plume Superfund Site, Williston, VT
  - Delineation of TCE hotspot
  - Technology selection for pilot testing and full-scale remedial design (RD)

Adaptive Management Example:

Bountiful Full-Scale RD

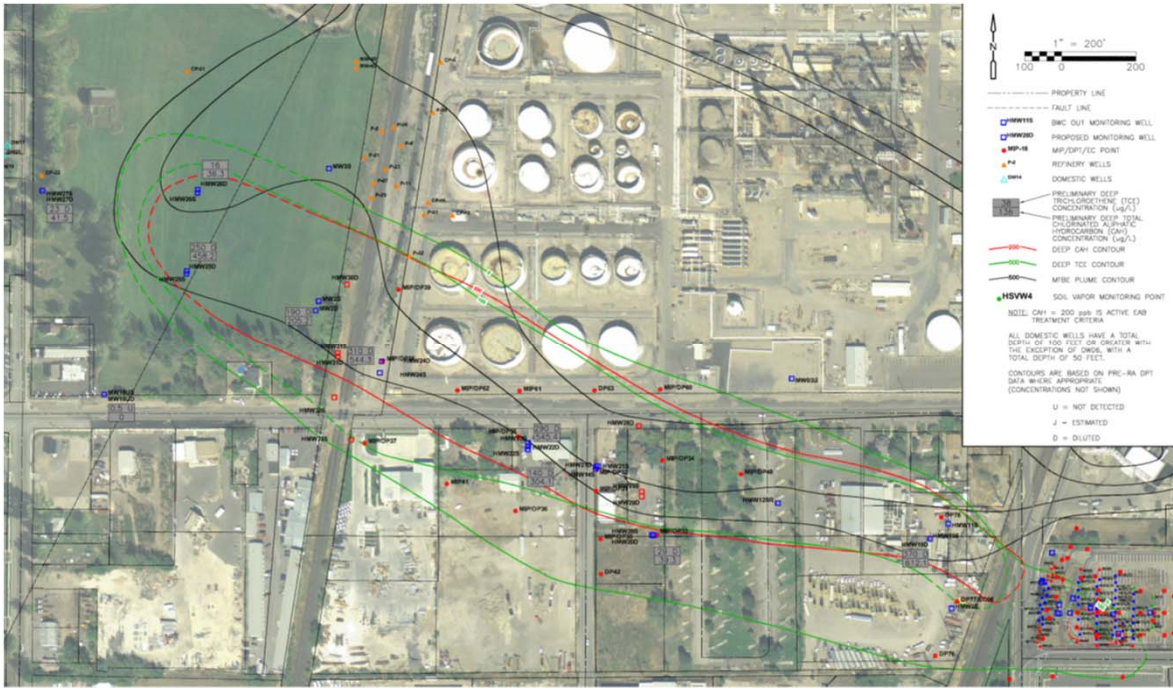
- Initial RD prepared based on preliminary CSM but recognized data gap with contaminant depth
- Used ISC process to set data collection objectives and select tools
- Used Direct Push Technology (DPT) soil and groundwater sampling, and Membrane Interface Probe (MIP)



Pre-RA Characterization Results:

Contaminant Distribution

- Membrane-interface probe (MIP) used to determine areas with high concentrations of VOCs
- MIP results showed responses at depths greater than 40 ft. throughout the source area and downgradient plume
- DPT sampling confirmed MIP results as source concentrations greater than 15,000 ppb were found below 40 ft.
- Downgradient concentrations were greater than 3,000 ppb in one location

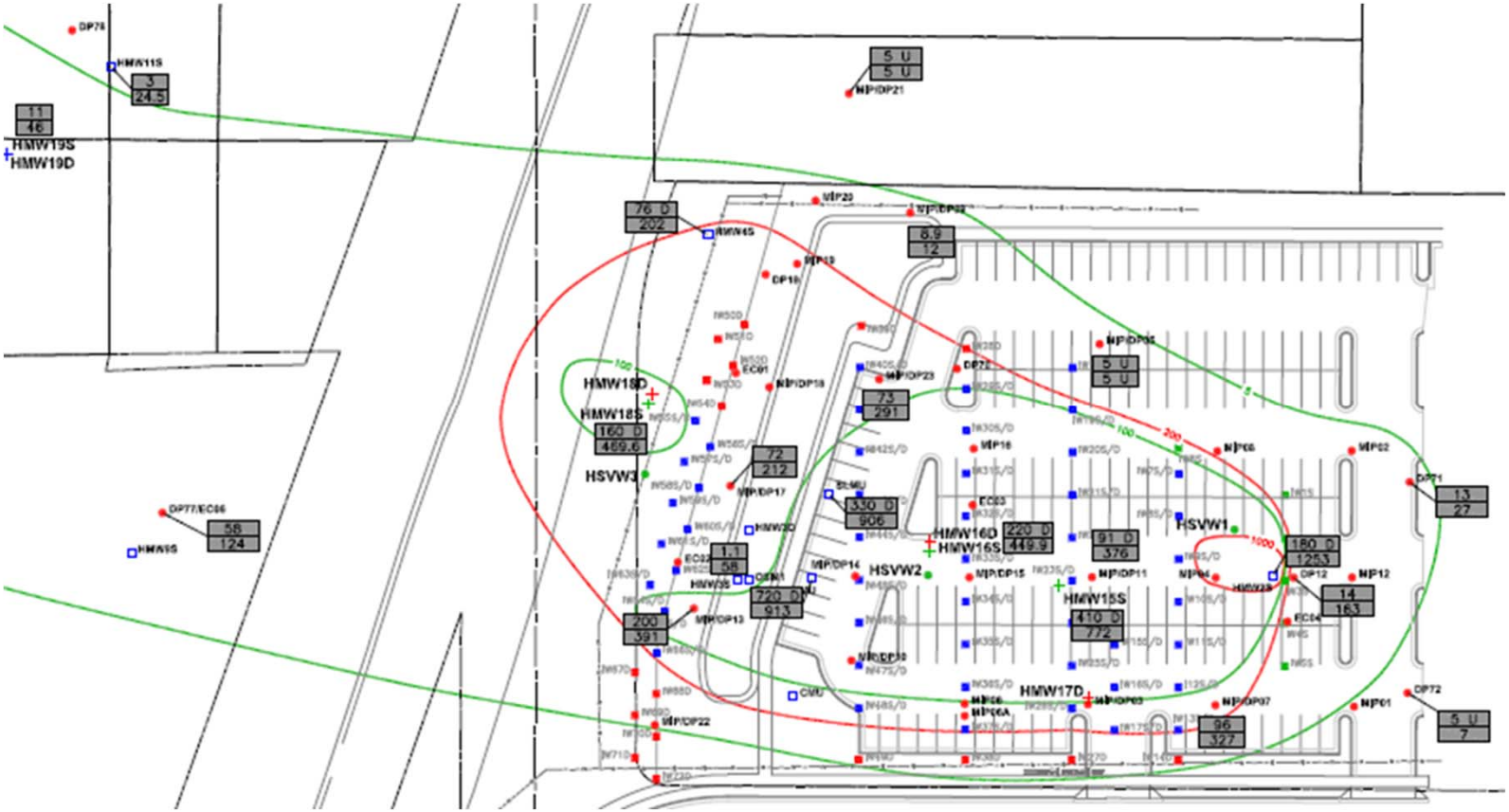


Pre-RA Characterization Results:

Hydrogeology

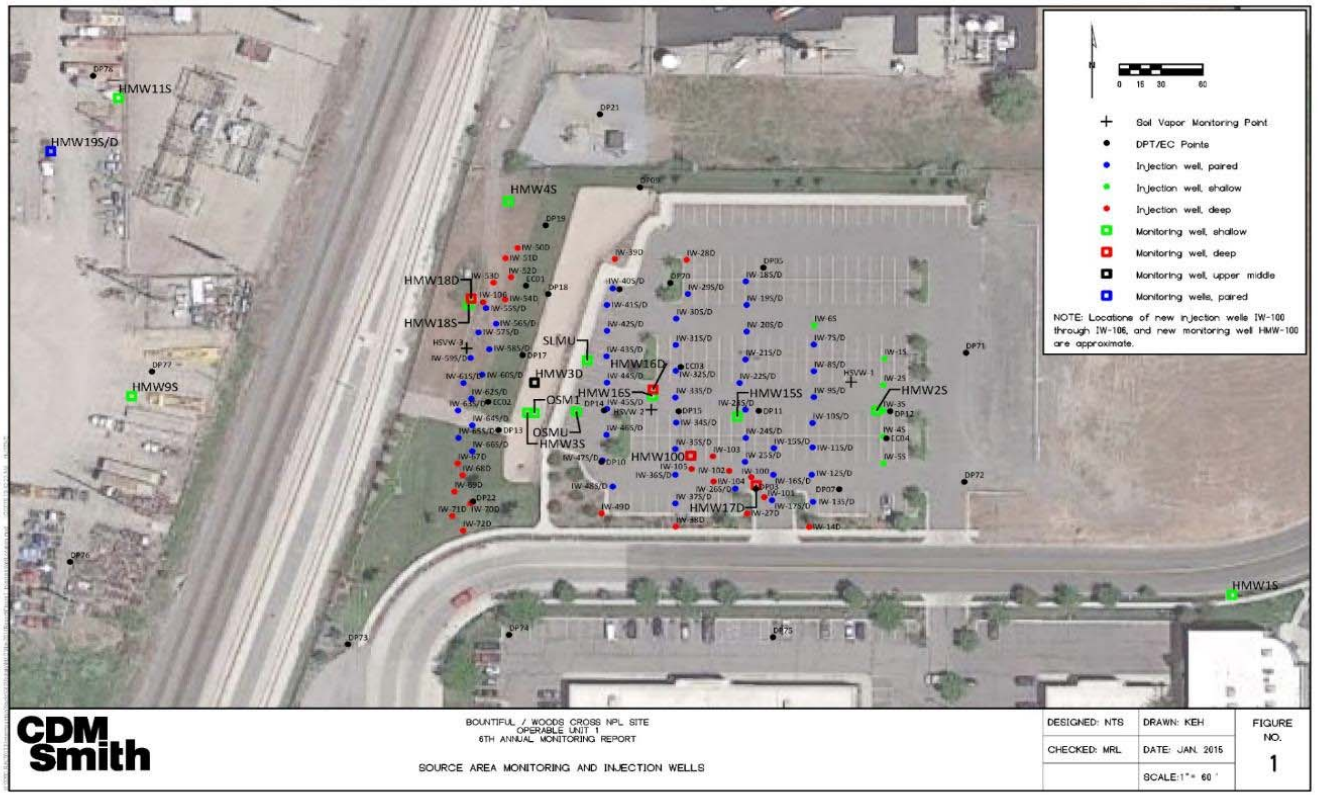
- Clay layer at 35 ft. bgs was found to be laterally discontinuous
- Modified DPT/EC approach was used to investigate hydrogeology below 60 ft.
- Below 35 ft., layers of sand and gravel exist to 80 feet bgs, with intermittent thin clay layers present in some areas
- A several foot thick clay layer was found at depths of approximately 80 ft. throughout the source area
- The deep clay layer was confirmed in the downgradient area during other site drilling activities

Baseline Shallow Zone Concentrations



Updated RD: Source Area Grid and Biobarriers

- Injection wells installed with dual completions to treat multiple vertical intervals
- Grid of wells in source to aggressively remediate NAPL area
- “Biobarriers” designed to intercept plume in downgradient areas



Adaptive Management Example:
Downgradient Biobarriers

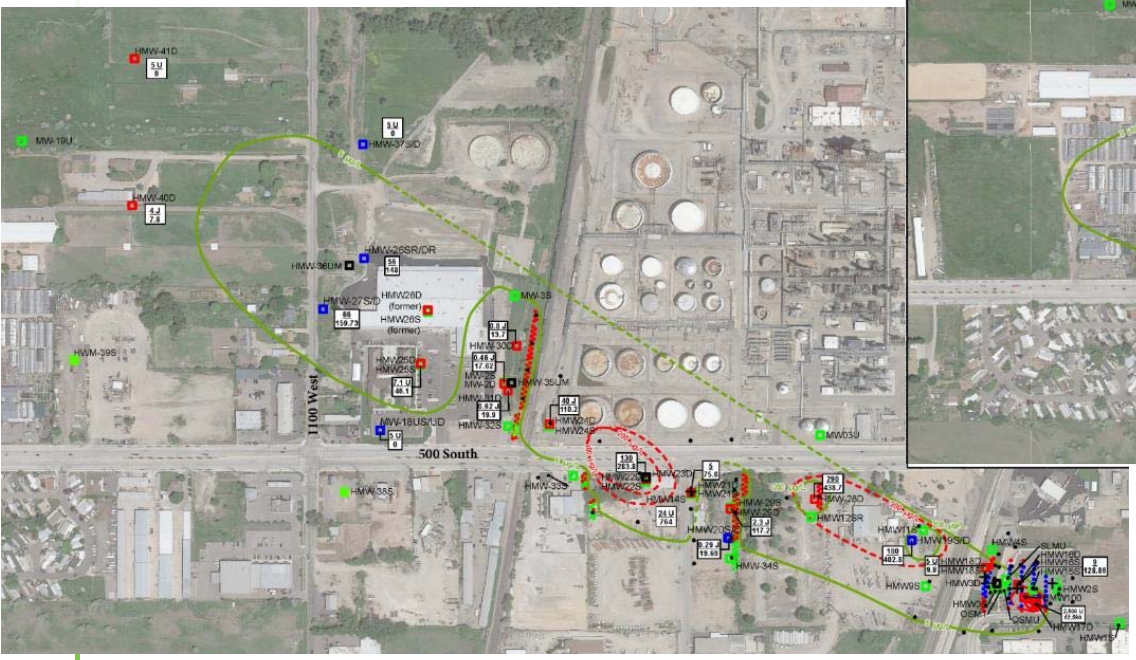
- Completed biobarrier #2 and 3 installation March – May 2011
- Used DPT to install 1.5” pre-pack injection wells
- Utilized Geoprobe® 7822 and 8040 direct push drill rigs – capable of pushing 3.25” or 3.5” casing to depths of 50 feet and 70 feet, respectively
- Performed EC logging and DPT confirmation soil sampling prior to installation to determine lithology and target treatment intervals

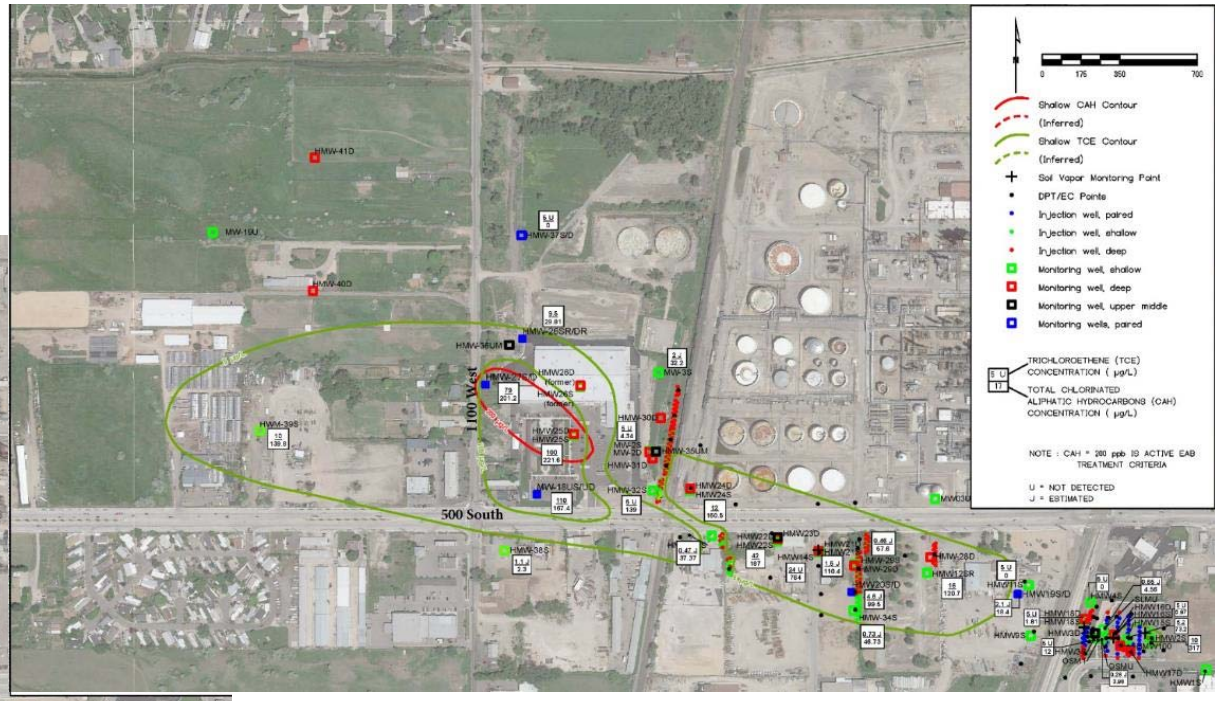
Downgradient Biobarriers – cont.

- Used well installation “step-out” approach to confirm necessary extent of each barrier section
  - As approach edge of barrier, install every 4th well
  - Collect groundwater sample from each well; rapid turn analysis provided onsite by EPA mobile laboratory
  - If VOC concentrations below targeted concentration, additional step-outs not required
- 181 total injection wells installed
- Many wells in biobarrier #3 artesian
- Emulsified injections completed summer 2011, 2013, and 2015
- Downgradient plume characterization conducted in 2014

Example Results from Remedial Action

Deep Zone





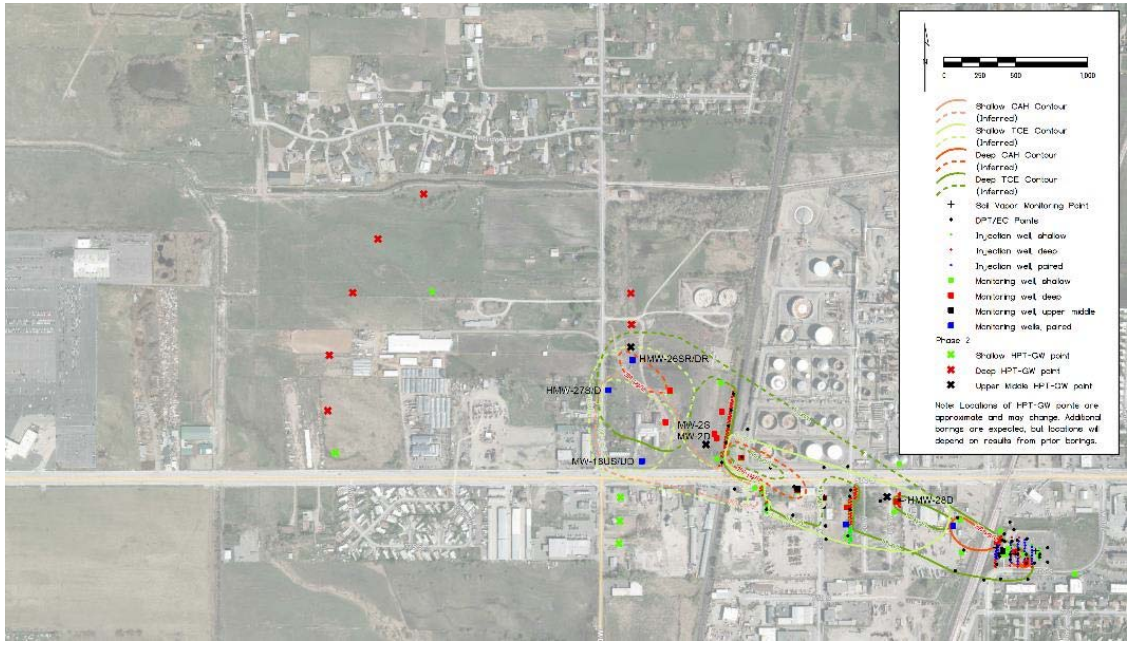
Shallow Zone

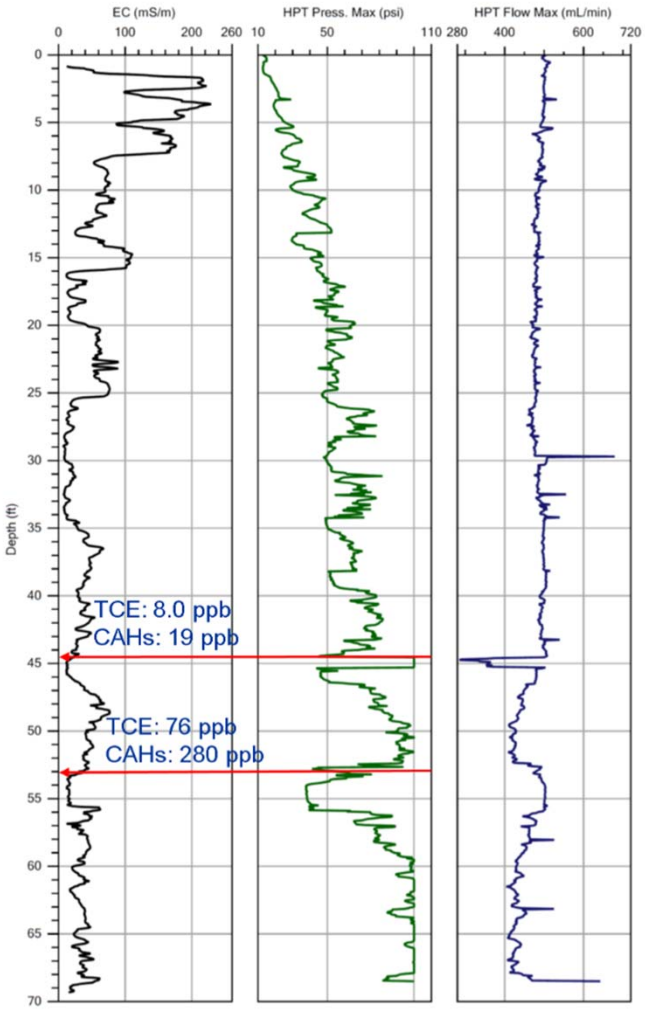
Adaptive Management Example:

Far Downgradient Plume

- Followed ISC process
- Objective: plume delineation to MCLs
- Adaptive approach with EPA mobile lab
- Continuous hydraulic profiling using Hydraulic Profiling Tool (HPT)
- GW samples collected at high conductivity zone
- Lithologic and analytical data used to guide well installation

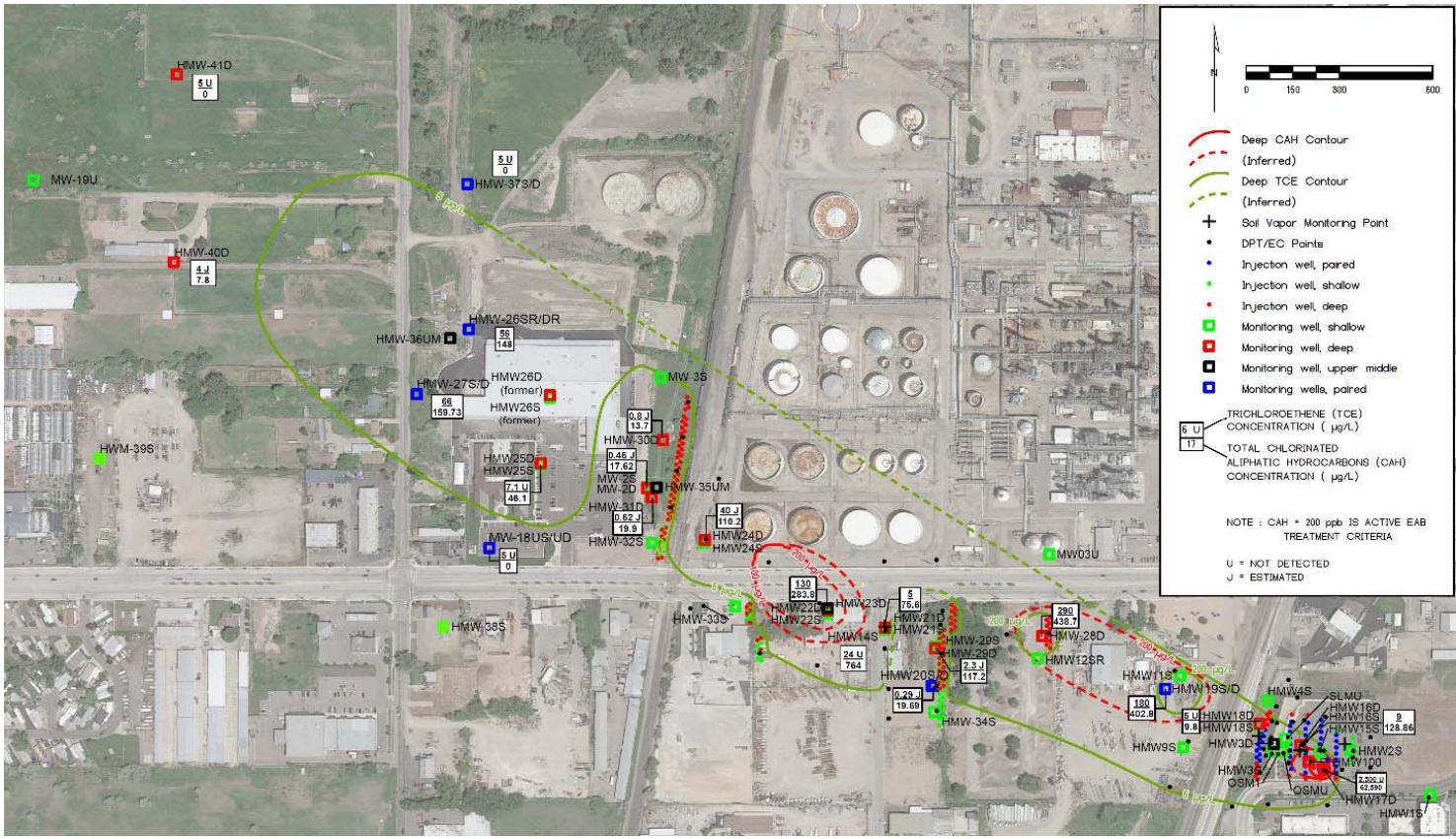
Far Downgradient Plume Profiling Locations





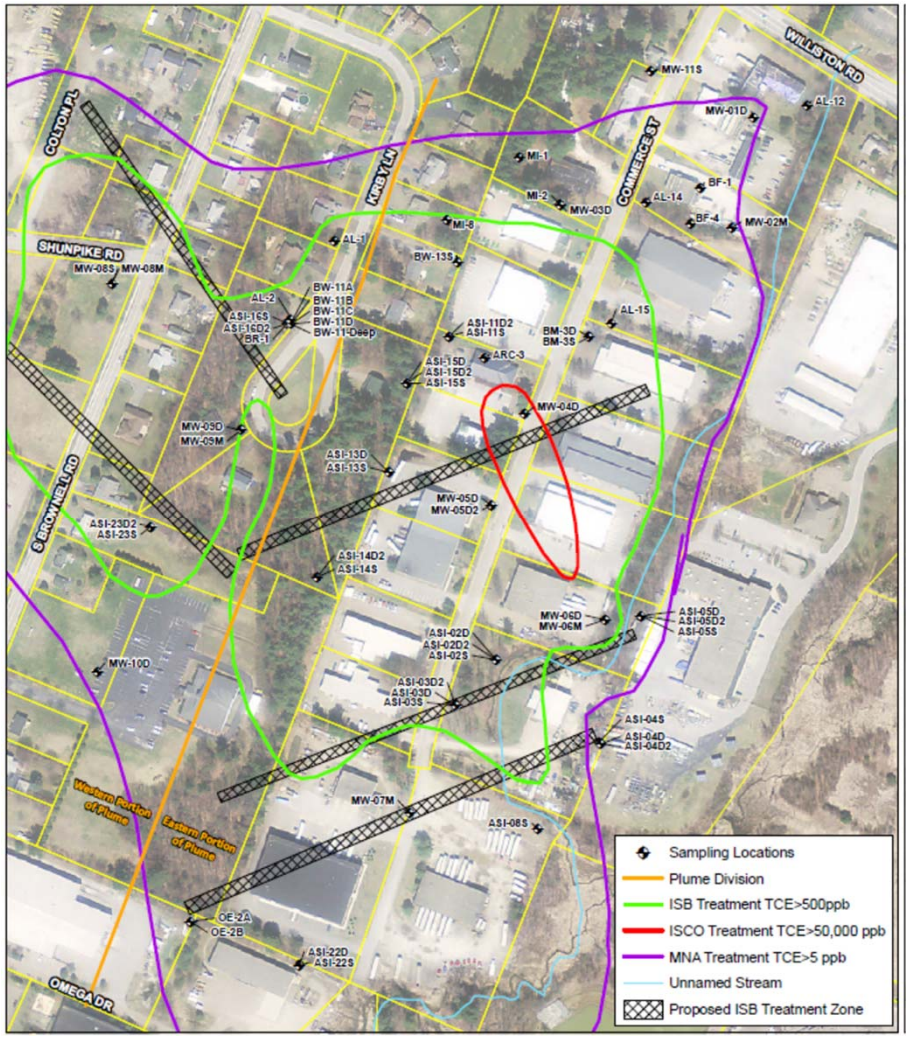
Delineated plume

- 900 total vertical feet
- 14 boreholes drilled
- 36 samples collected & field analyzed
- 75 acres investigated
- No IDW waste requiring disposal
- Entire plume delineated to MCLs in 8 days
- Monitoring wells ideally located



Commerce Street Plume Superfund Site

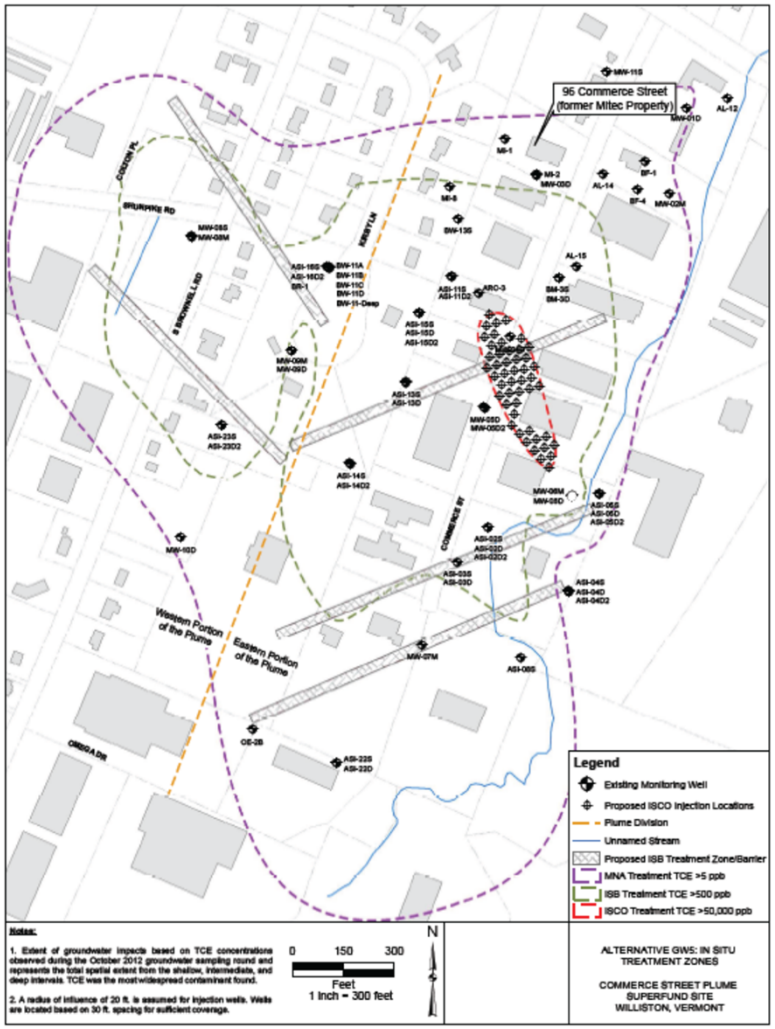
- TCE plume in mixed-use area
- ROD-selected remedy:
  - In situ chemical oxidation (ISCO) for TCE > 50,000 ppb
  - In situ bioremediation (ISB) for TCE > 500 ppb but <50,000 ppb
  - Monitored natural attenuation (MNA) for TCE < 500 ppb
- IDSS step – design and implement remedy
- Follow ISC process to define data gaps, set objectives, and select tools



High Resolution Site Characterization

Initial CSM

- TCE DNAPL released into sandy aquifer
- Sand unit:
  - Shallow zone 10-20 ft below ground surface (bgs)
  - Intermediate zone 20-30 ft bgs
  - Deep zone 30-40 ft bgs
- Continuous clay unit underlying sand unit (40 ft bgs)



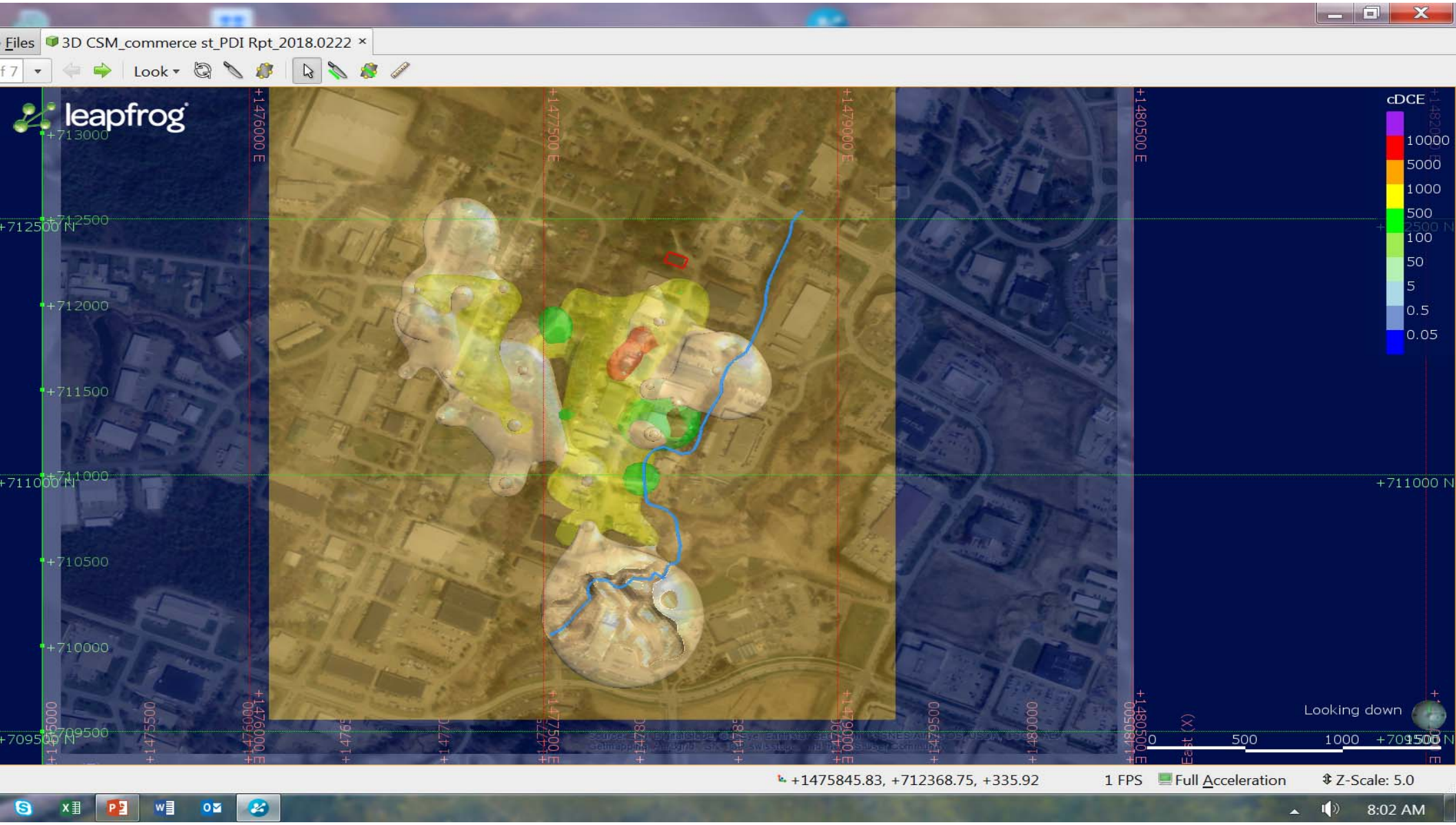
Characterization Activities and Preliminary Results

Characterization program

- Membrane interface probe/hydraulic profiling tool (MiHPT)
- Waterloo Advanced Profiling System (APS)
- DPT soil and groundwater sampling
- Onsite VOC analysis

Results Summary

- 50,000 ppb hotspot no longer exists
- In east-central portion of site, TCE is almost completely converted to c-DCE
- Sand unit is hydraulically somewhat variable and not related to previous designations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leapfrog
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+712500 N
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+711500
+711000 N
+710500
+710000
+709500 N
+1476000 E
+1477500 E
+1479000 E
+1480500 E
+711000 N
Looking down
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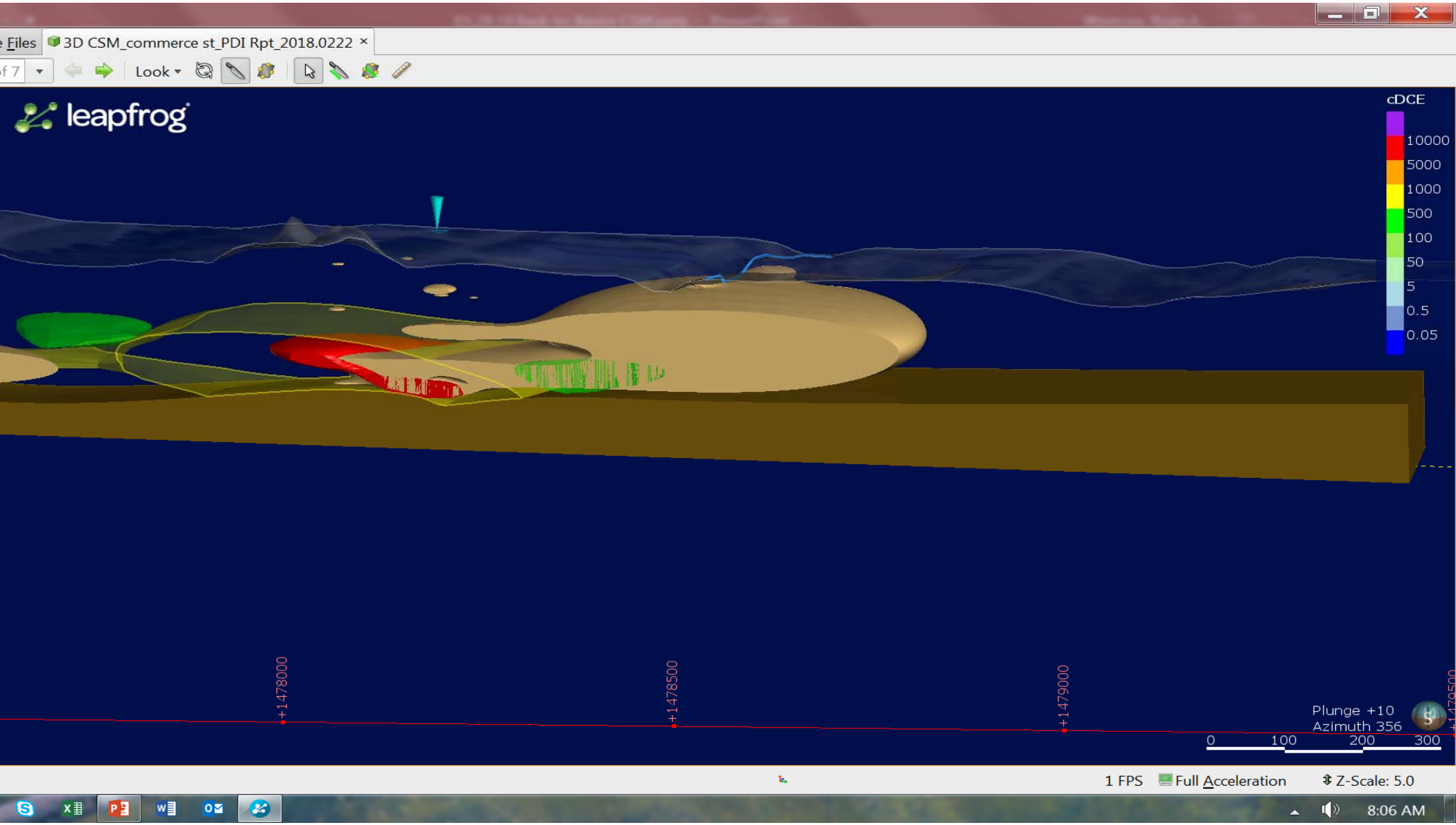
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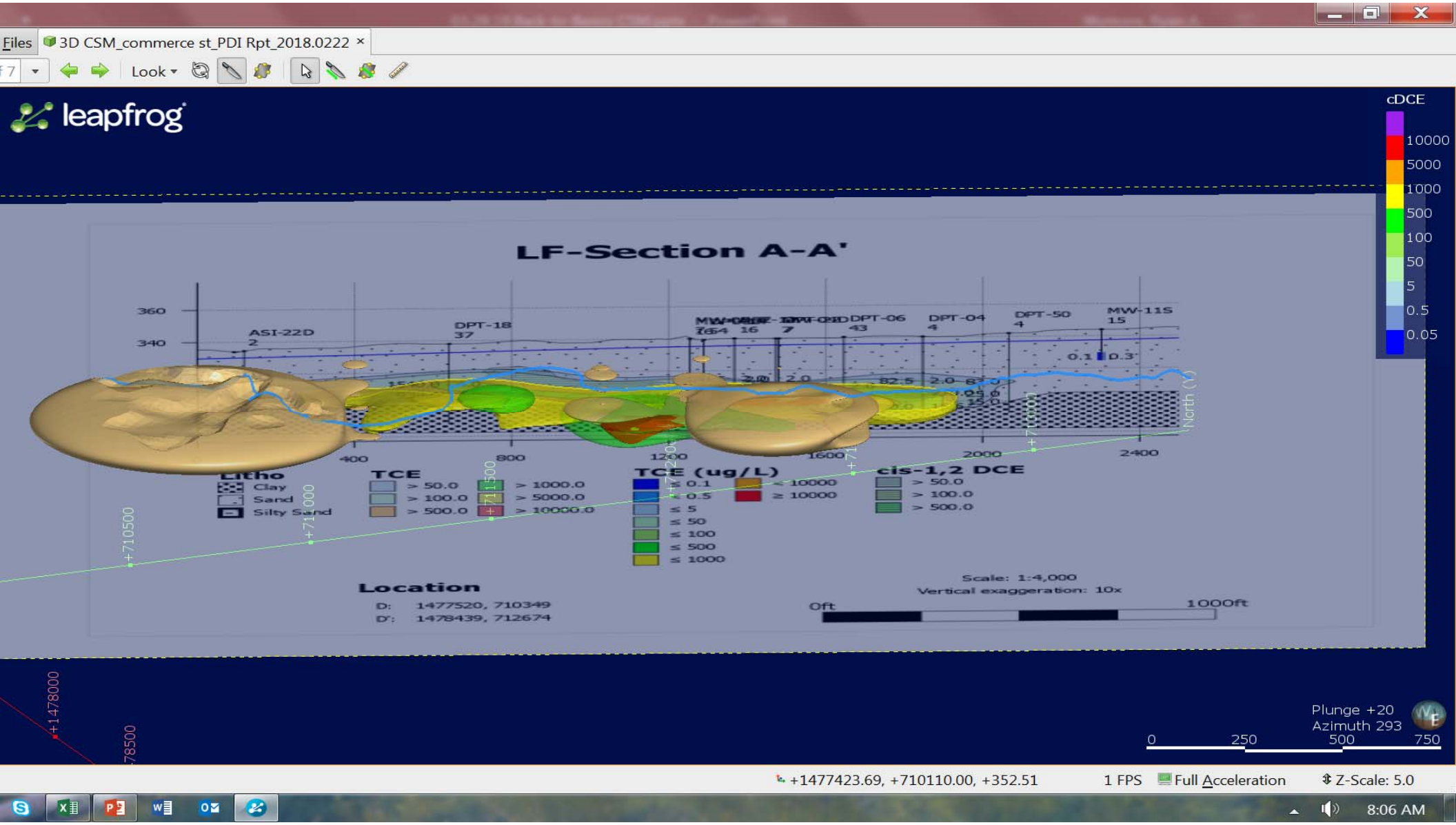
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DPT-18
DPT-06
DPT-04
DPT-50
MW-11S
Litho
Clay
Sand
Silty Sand
TCE
TCE (ug/L)
cis-1,2 DCE
Location
D: 1477520, 710349
D': 1478439, 712674
Scale: 1:4,000
Vertical exaggeration: 10x
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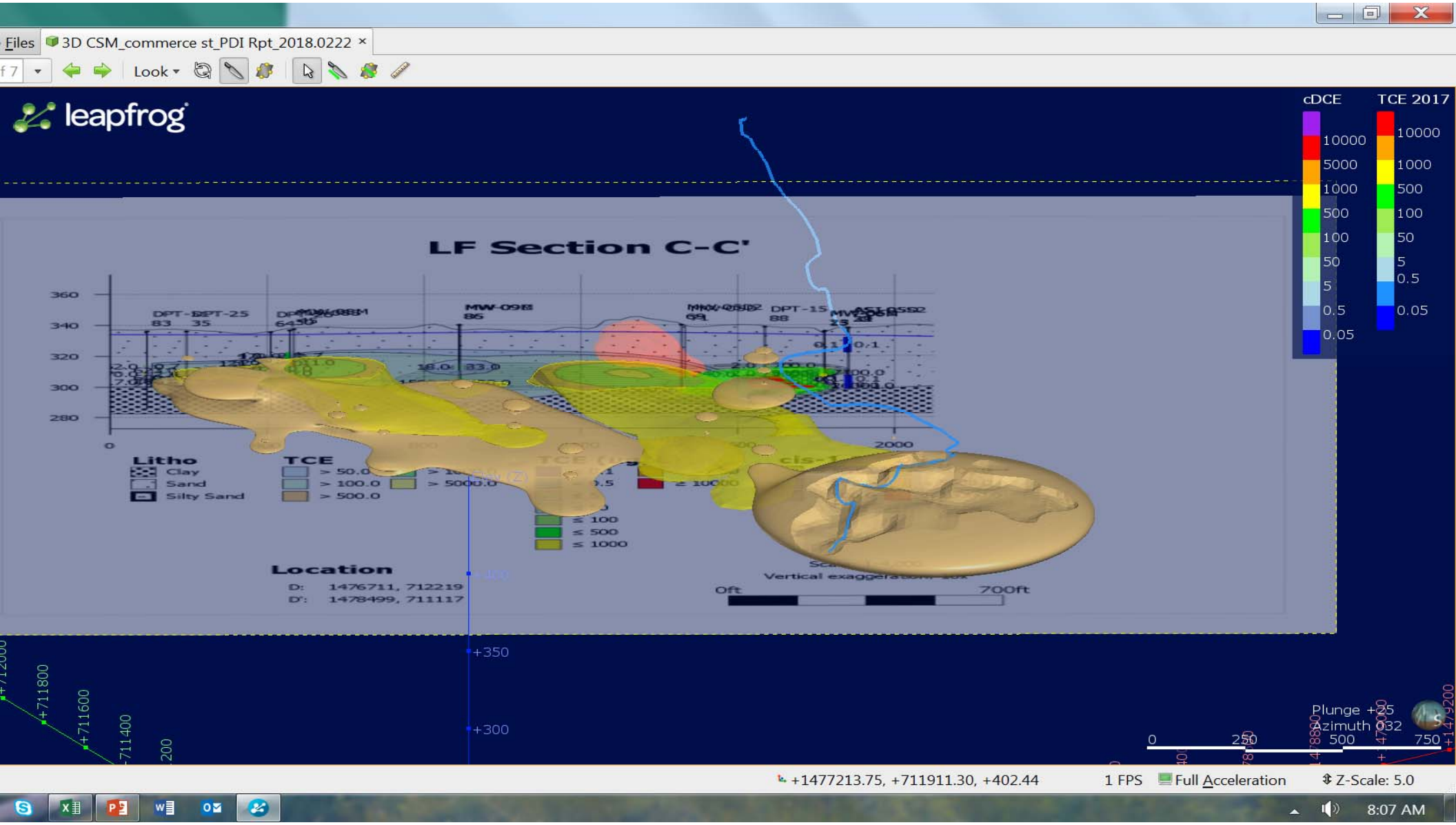
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leapfrog
cDCE
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Litho
Clay
Sand
Silty Sand
TCE
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Location
D: 1476711, 712219
D': 1478499, 711117
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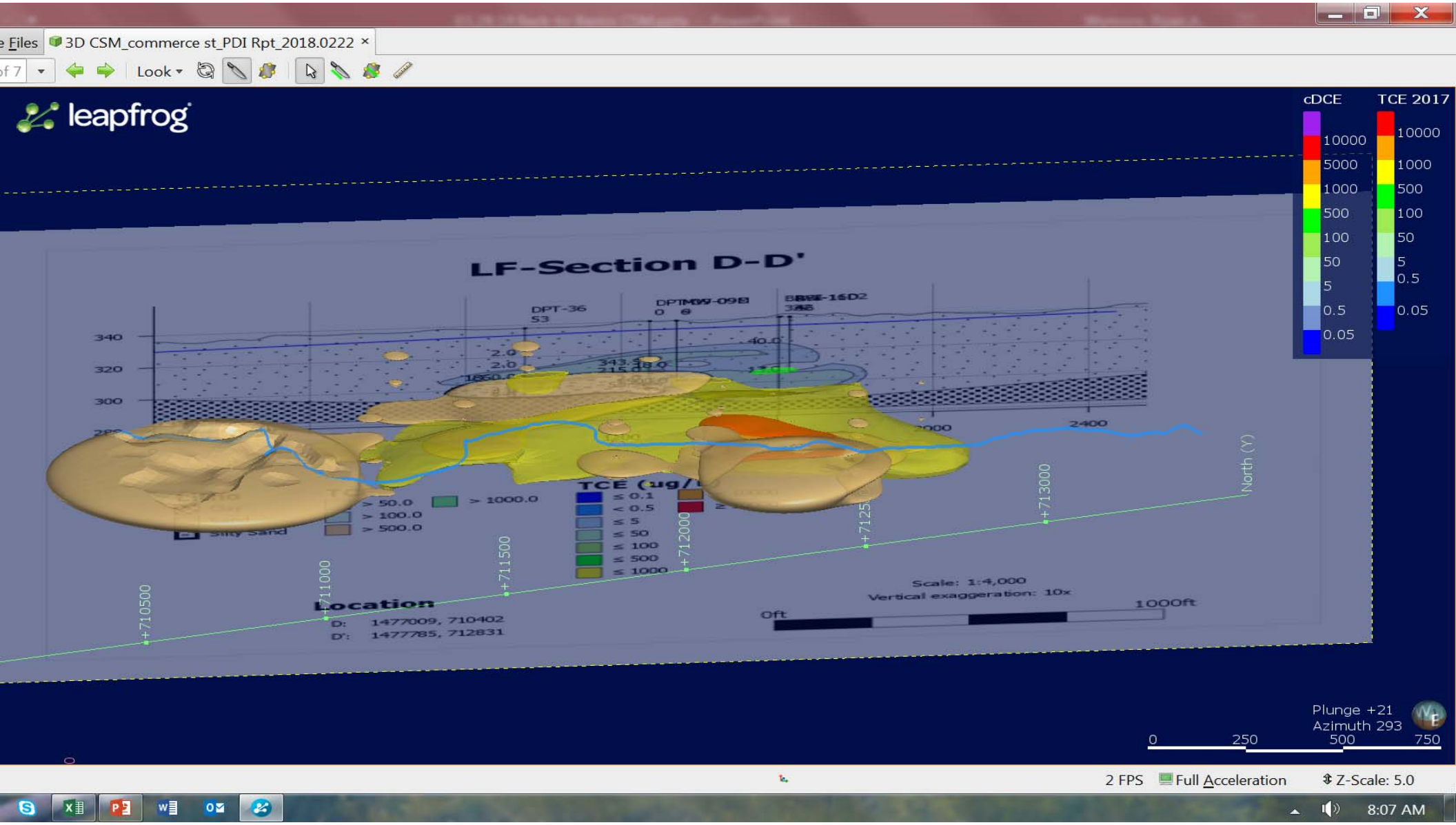
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North (Y)
Location
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D': 1477785, 712831
Scale: 1:4,000
Vertical exaggeration: 10x
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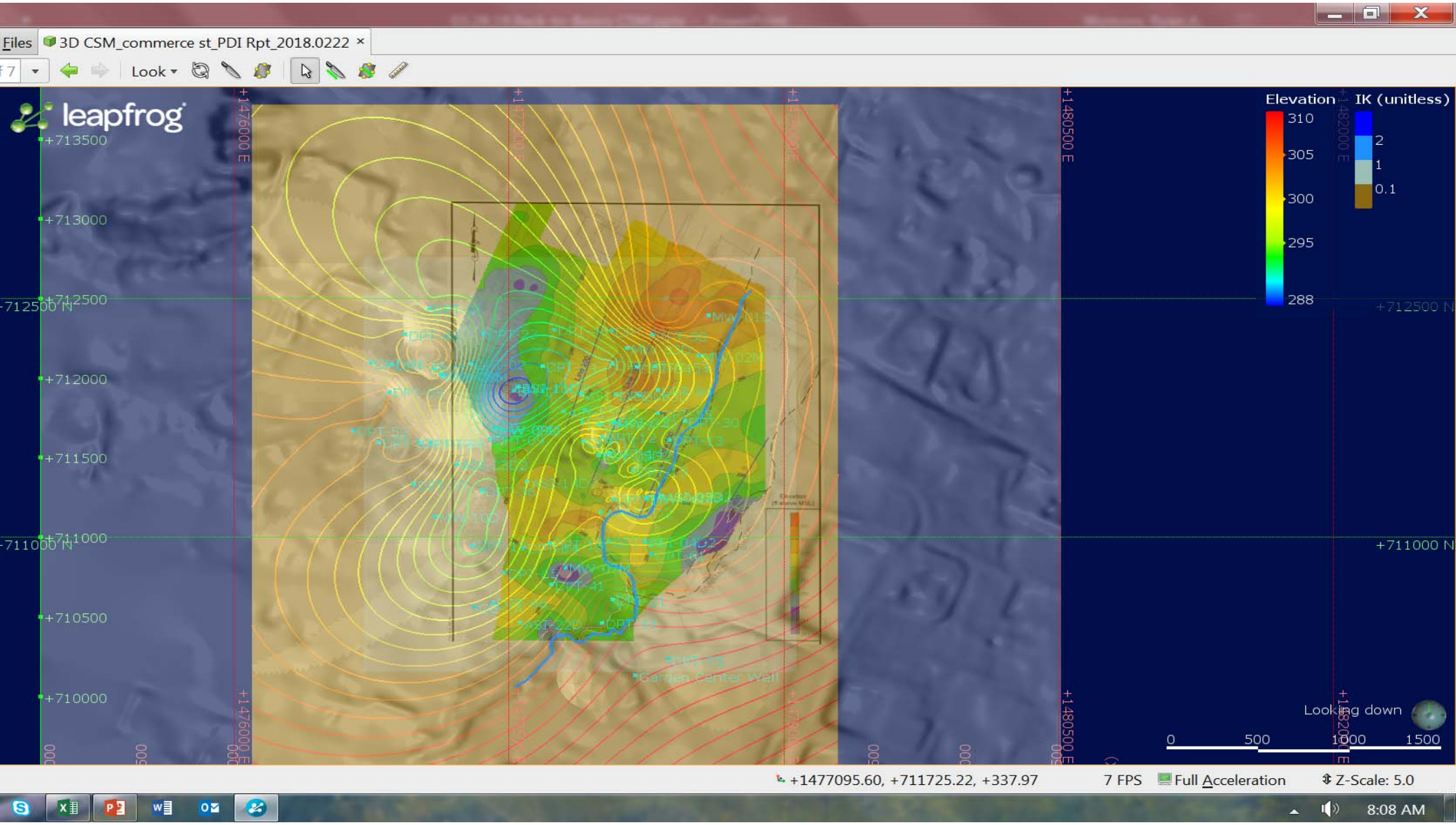
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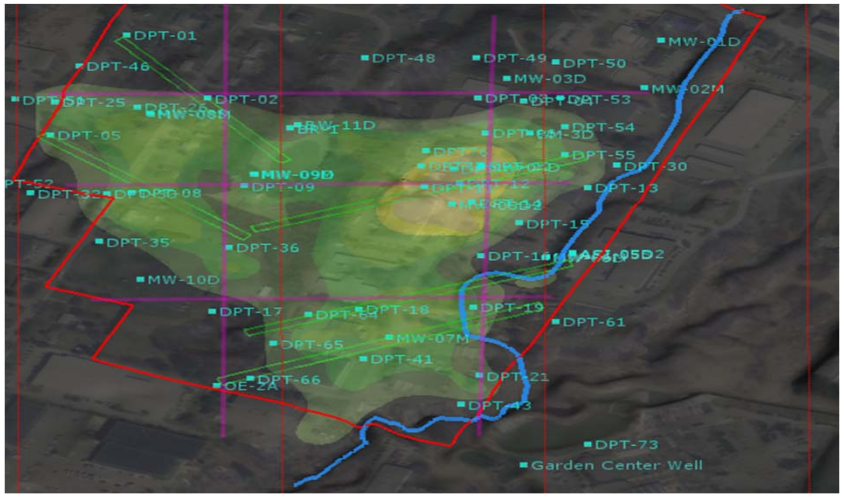
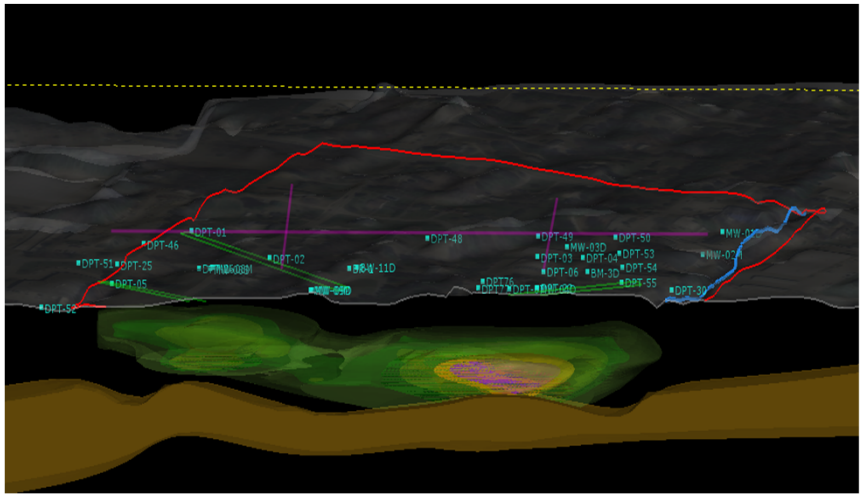
Path Forward

- ISCO may no longer be needed
- Current nature and extent of contaminants could be treated by ISB and MNA
- Bench and pilot testing approach is being modified
- RD will incorporate new CSM and bench/pilot results





Summary and Conclusions

- Adaptive management principles can be followed during any project phase
  - Characterization
  - Remedy selection
  - Pilot testing
  - RD
  - RA
- High resolution characterization tools and approaches can facilitate efficient decision making
- CSM should be updated continuously during project implementation