In Situ Accelerated Anaerobic Bioremediation of the Area 6 Solvent Plume, Dover Air Force Base, DE

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Presented by

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Introduction

- Many Department of Defense facilities historically have used large quantities of chlorinated solvents
- DAFB is typical of many of these facilities
- 50 years of aircraft maintenance activities have resulted in contamination of the shallow water table aquifer in several locations at the base
- Chlorinated ethenes and ethanes

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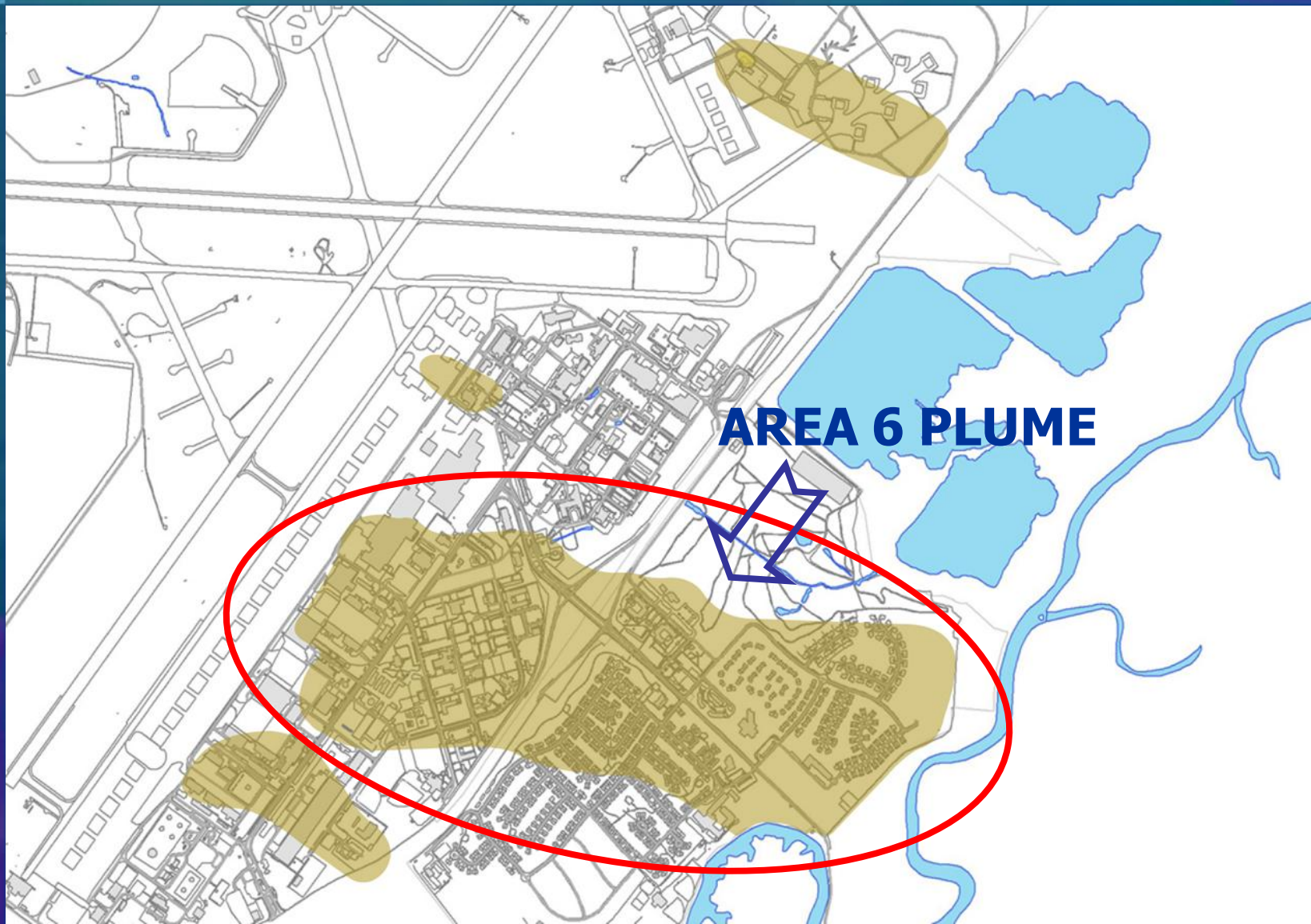
Chlorinated Solvent Sites at DAFB



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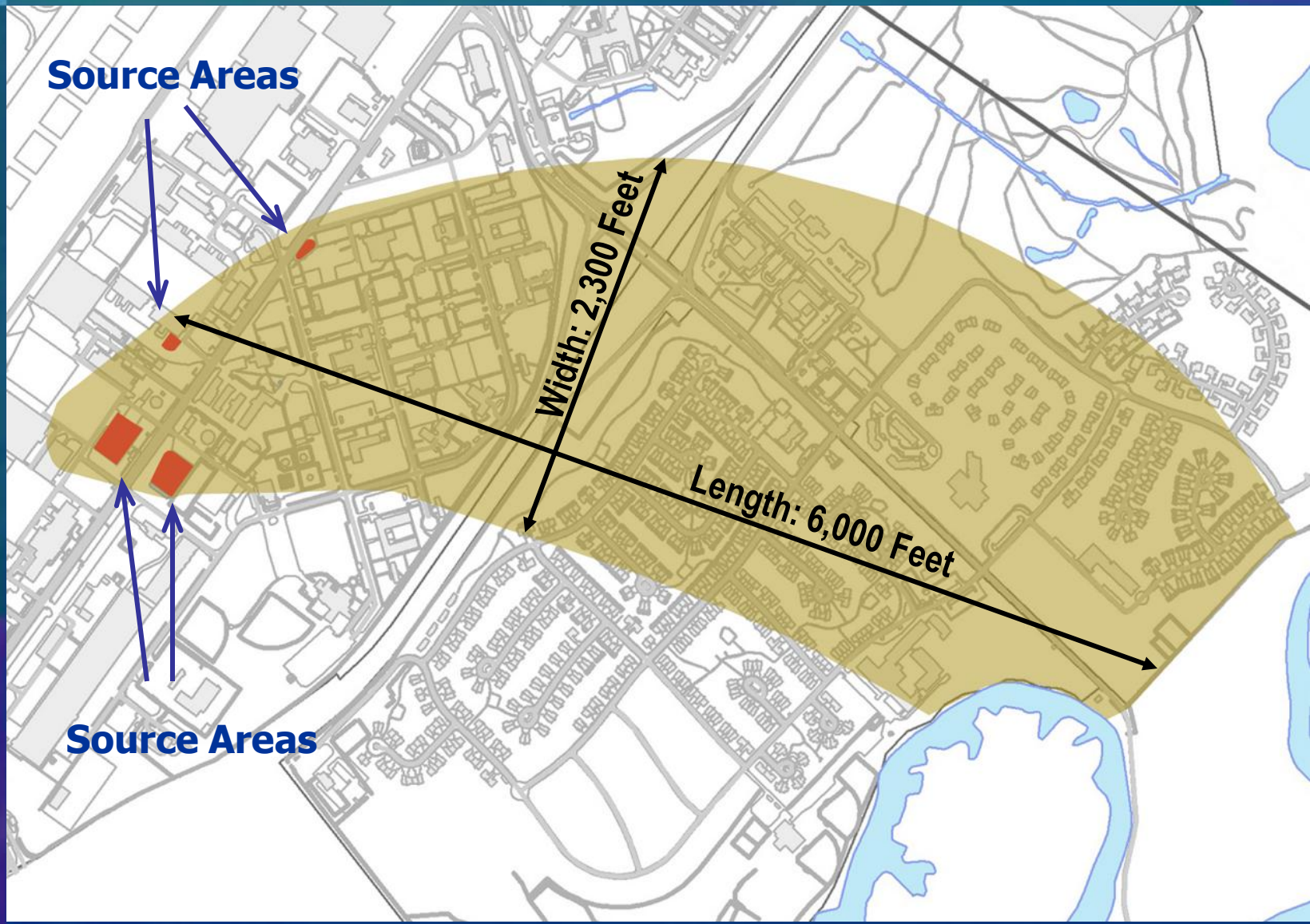
Area 6 Plume



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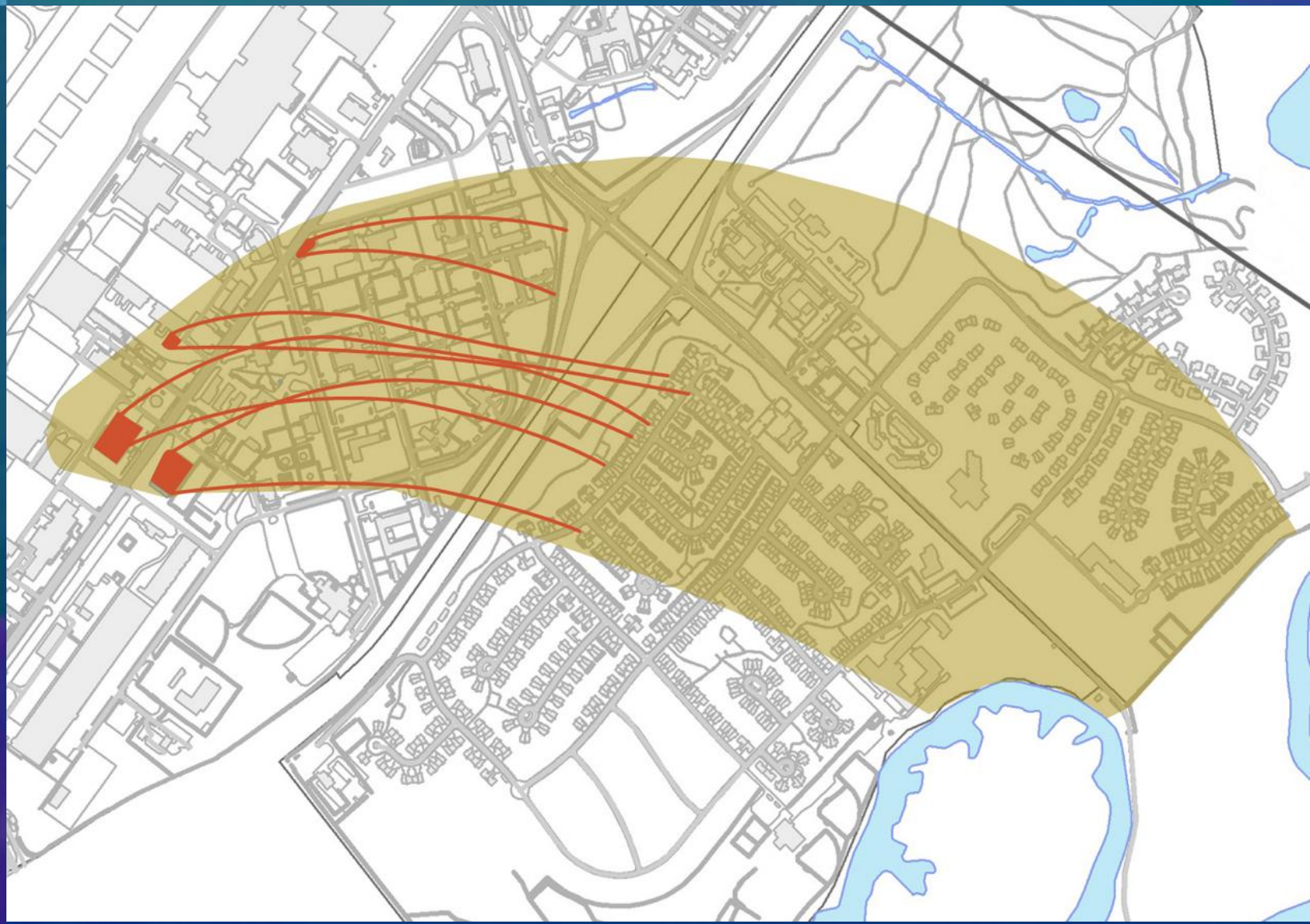
Area 6 – Source Area Migration



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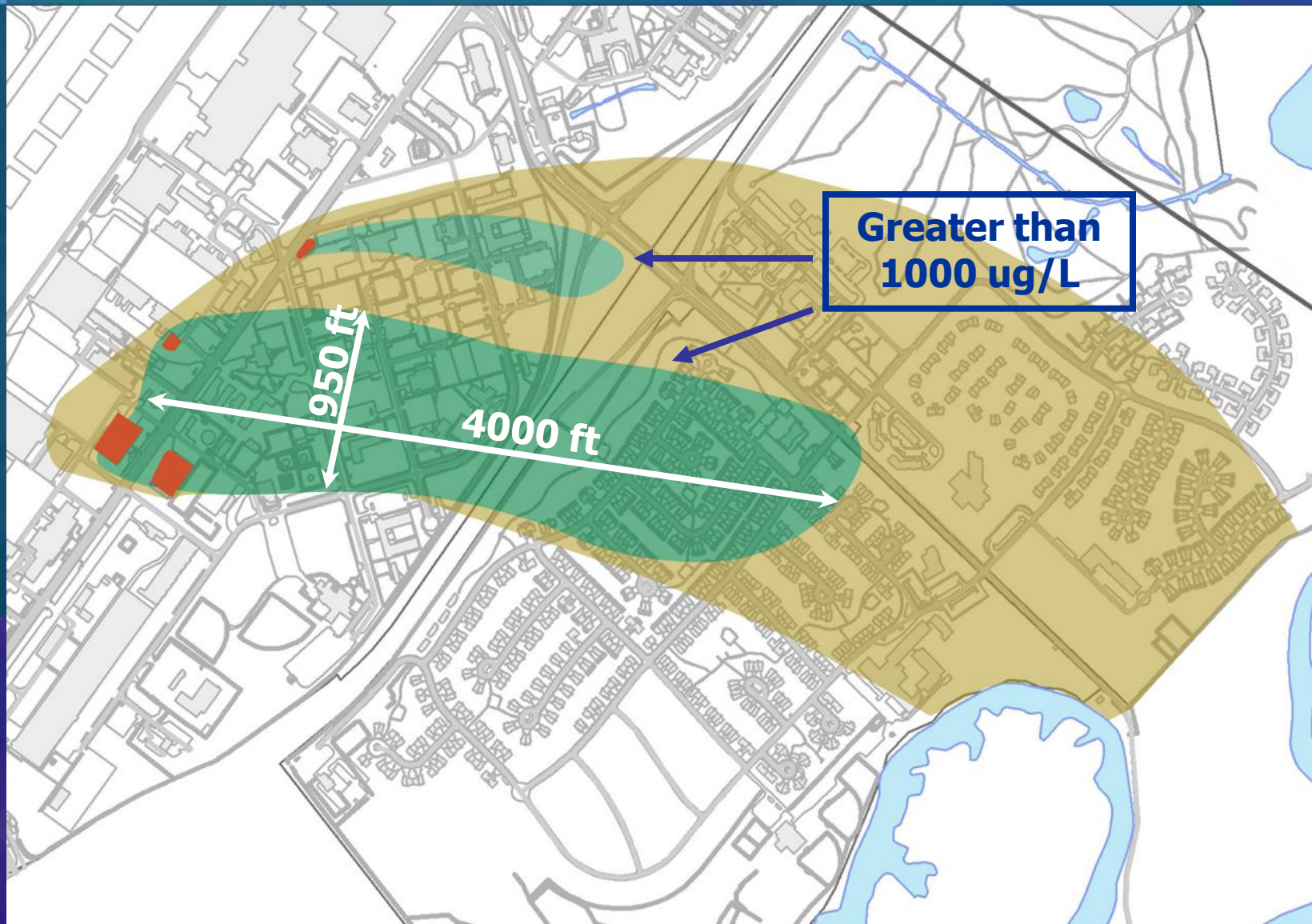
Area 6 with Plume Core



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Remediation

- Objective:
  - Restore aquifer to usable conditions (MCLs)
- Approach:
  - Accelerated Anaerobic Bioremediation (AAB) treatment of source areas and plume cores
  - NA for peripheral portions of plumes
- Obstacles:
  - Size of treatment area
  - Multiple treatment sites

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AAB Design

- Design Goal: Distribute sufficient carbon substrate to treatment zones in an efficient manner
  - Source Areas
  - Plume Core
- Design Considerations:
  - Injection solution
  - Delivery method
  - Number of injection events
  - Base infrastructure

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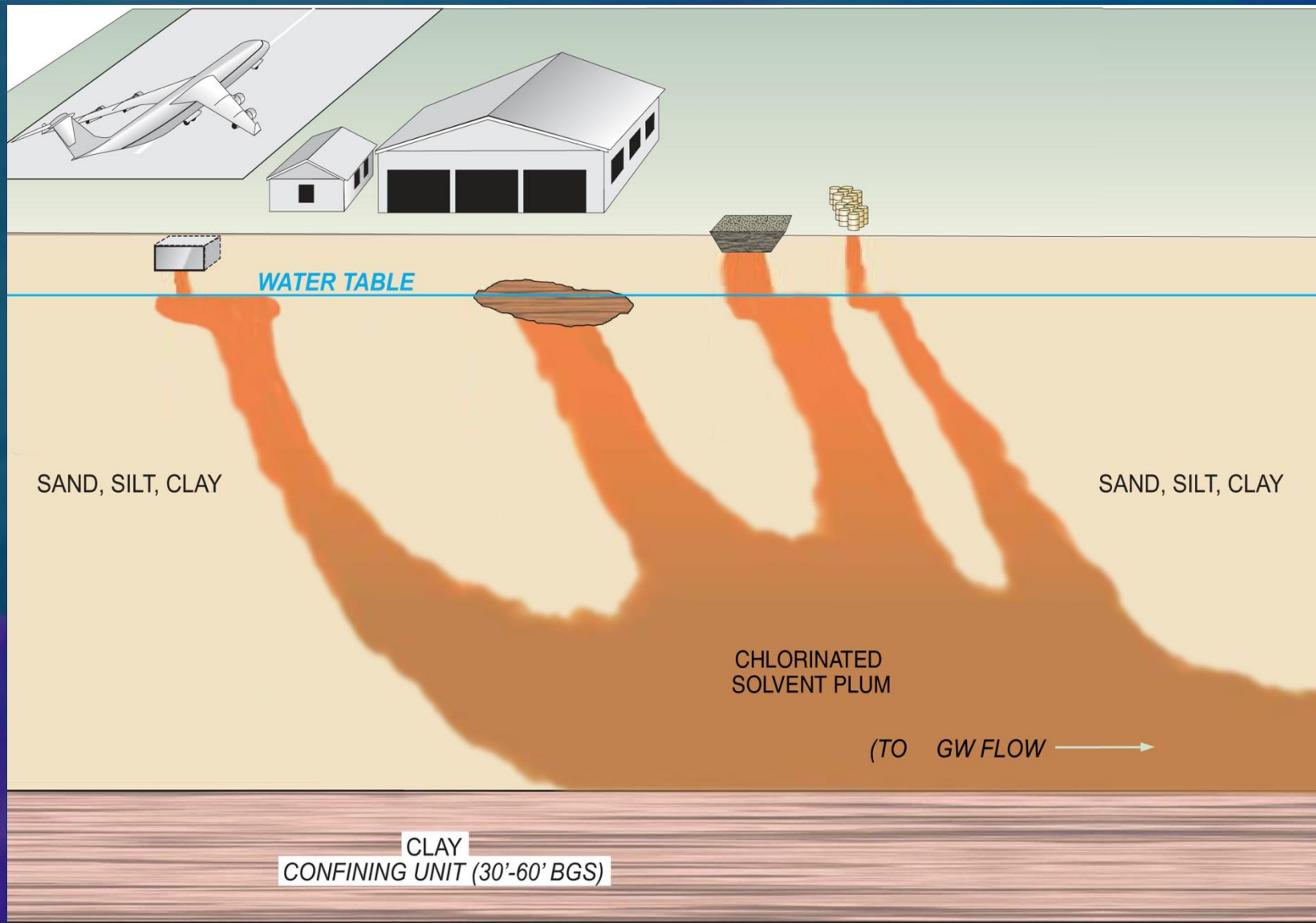
Conceptual Model: Cross Section



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Delivery Methods

- Source Areas
  - Direct-push borings
    - Injection points spaced closely together
- Plume Cores
  - Transects perpendicular to groundwater flow
    - Permanent wells
    - Allows injection points to be spaced farther apart (groundwater recirculation)
    - Workable with Base infrastructure
    - Usable for multiple injection events

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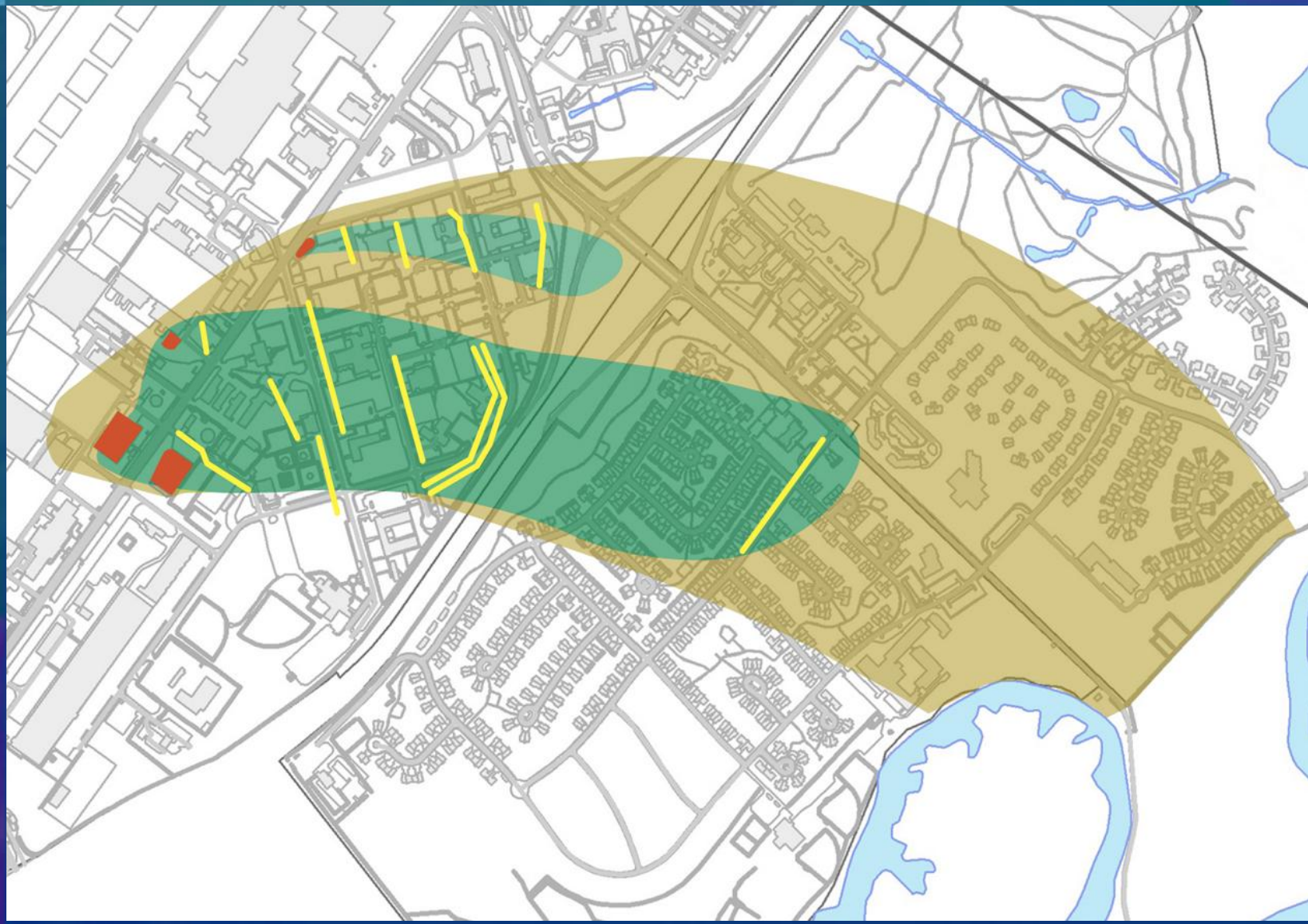
Area 6 with AAB Transects



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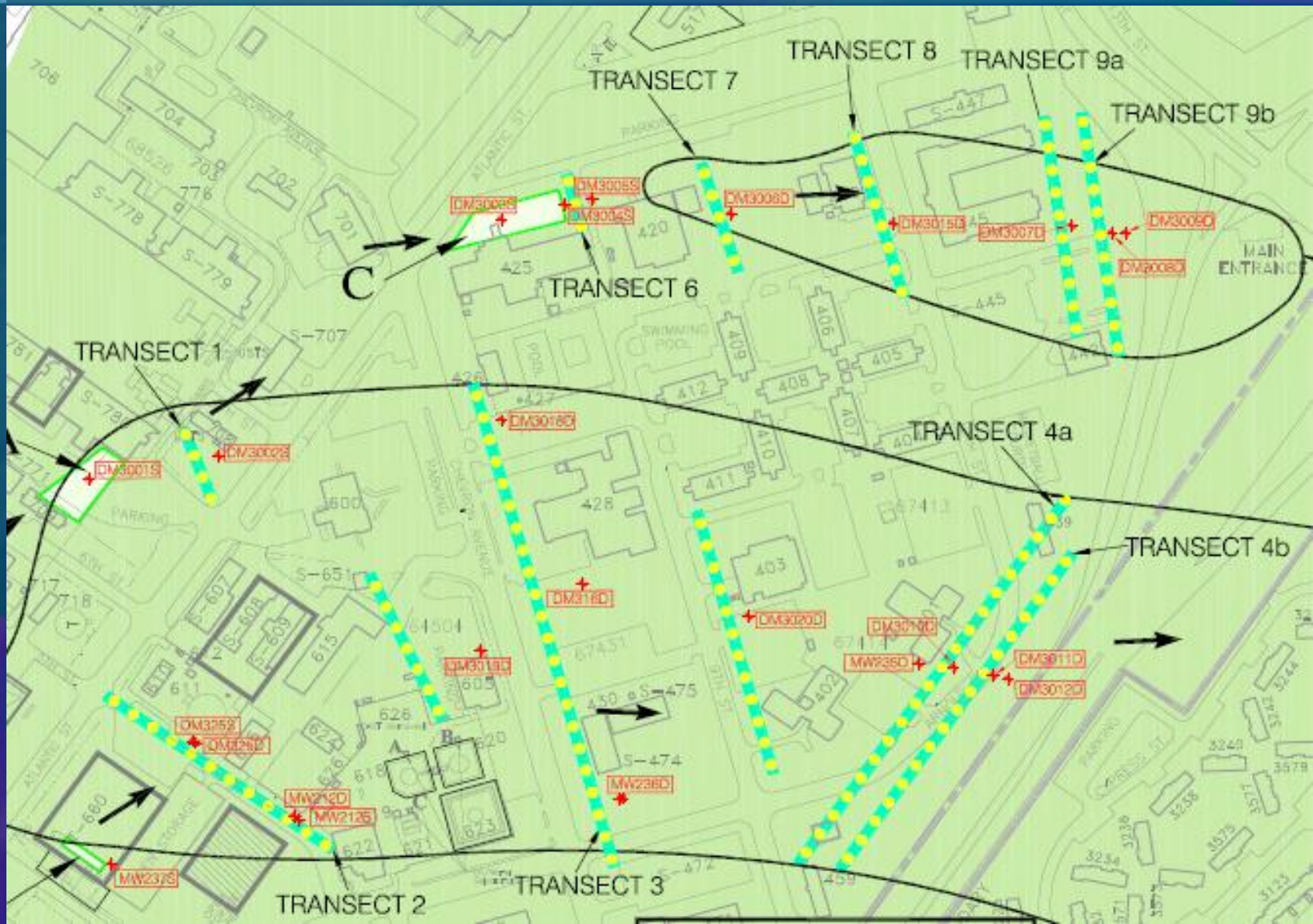
Area 6 AAB Transects



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Carbon Substrate Mixture

- Sodium lactate
  - Soluble, easily utilized by bacteria
  - Able to create a robust anaerobic environment in a short period of time
  - 1,000 to 3,000 ppm TOC
- Emulsified vegetable oil (EVO)
  - Not as soluble, less quickly utilized by bacteria
  - Able to maintain a sufficiently anaerobic environment for longer periods of time
  - 1,000 to 3,000 ppm TOC

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AAB Implementation: Source Area Direct Push Injection

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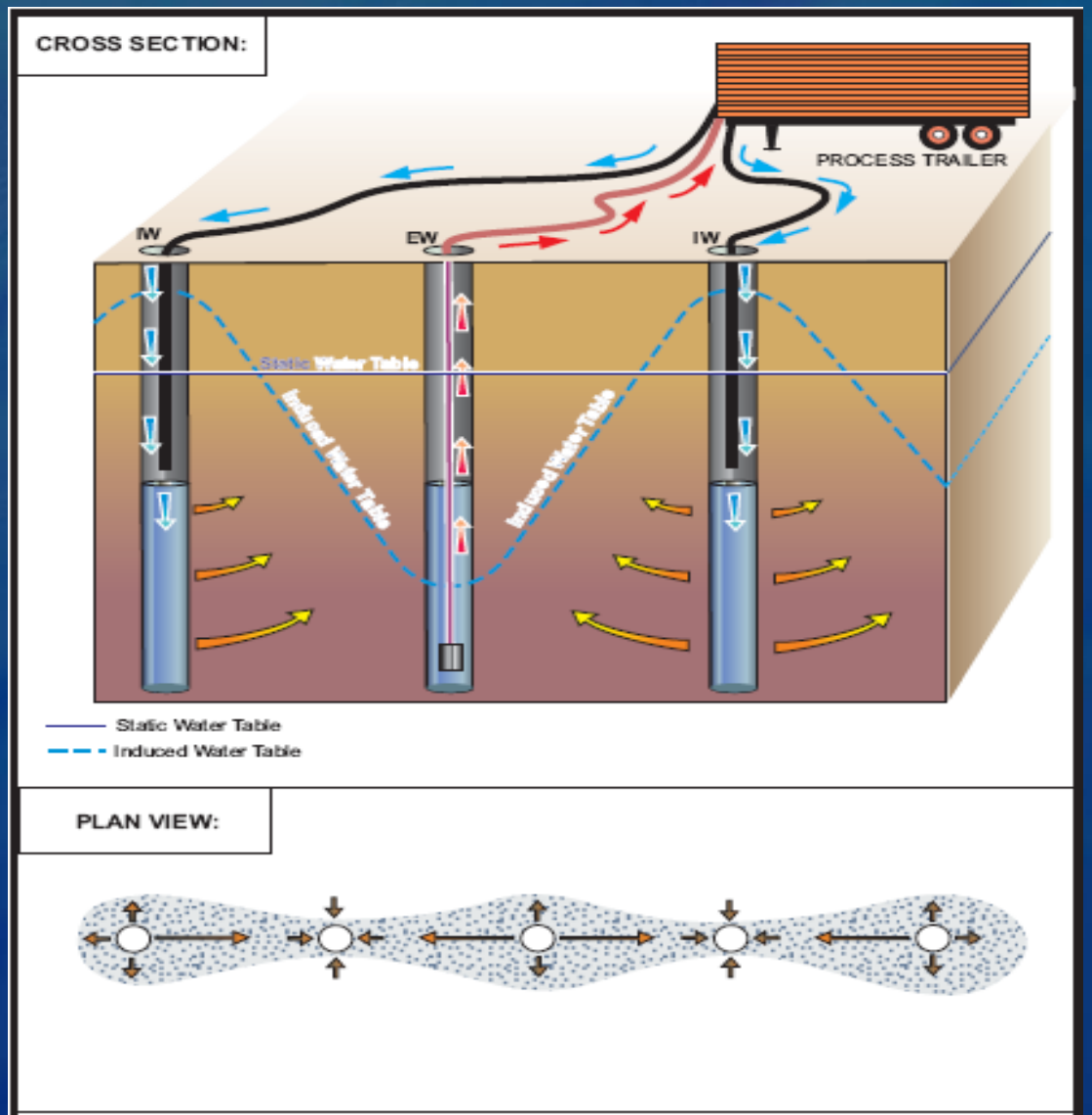
Conceptual Model: Push-Pull Delivery Method



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AAB Process Trailer

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AAB Process Trailer

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AAB Process Trailer

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Assessment

- TOC distribution?
- Reductive dechlorination?
  - PCE ▸ TCE ▸ cis-1,2-DCE ▸ VC ▸ ethene

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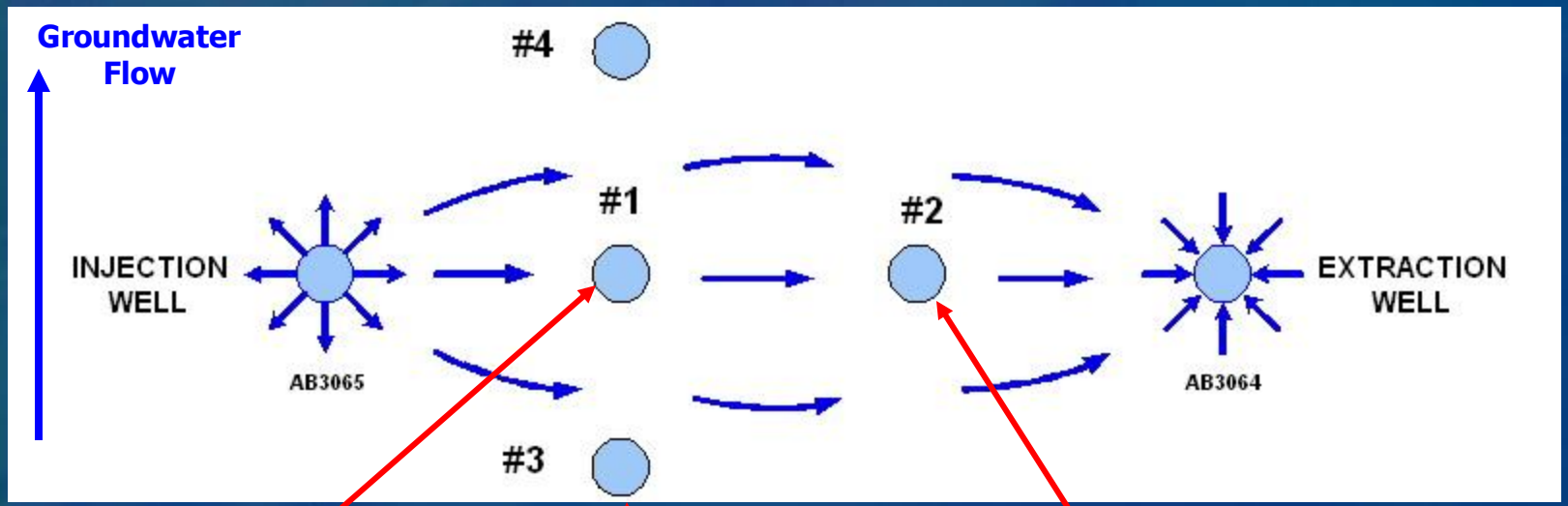
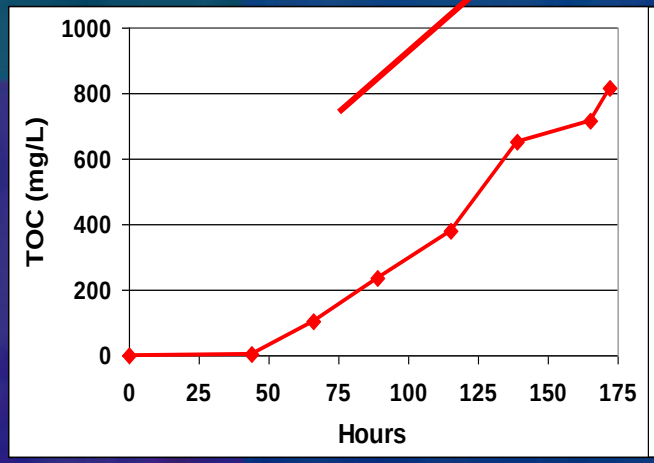
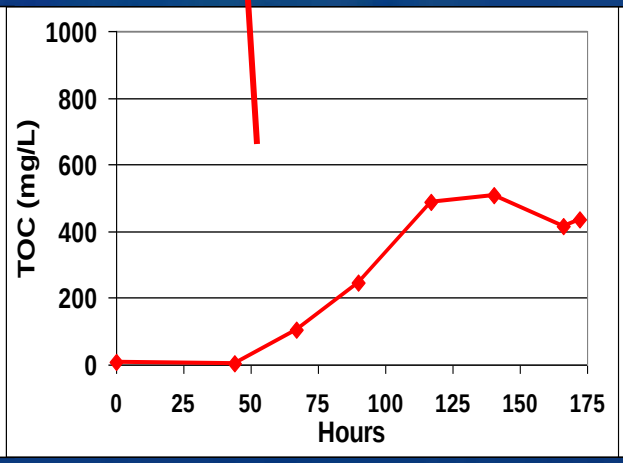
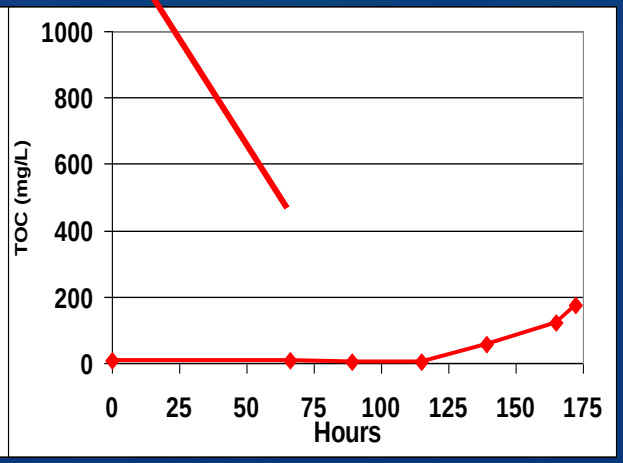
TOC Distribution

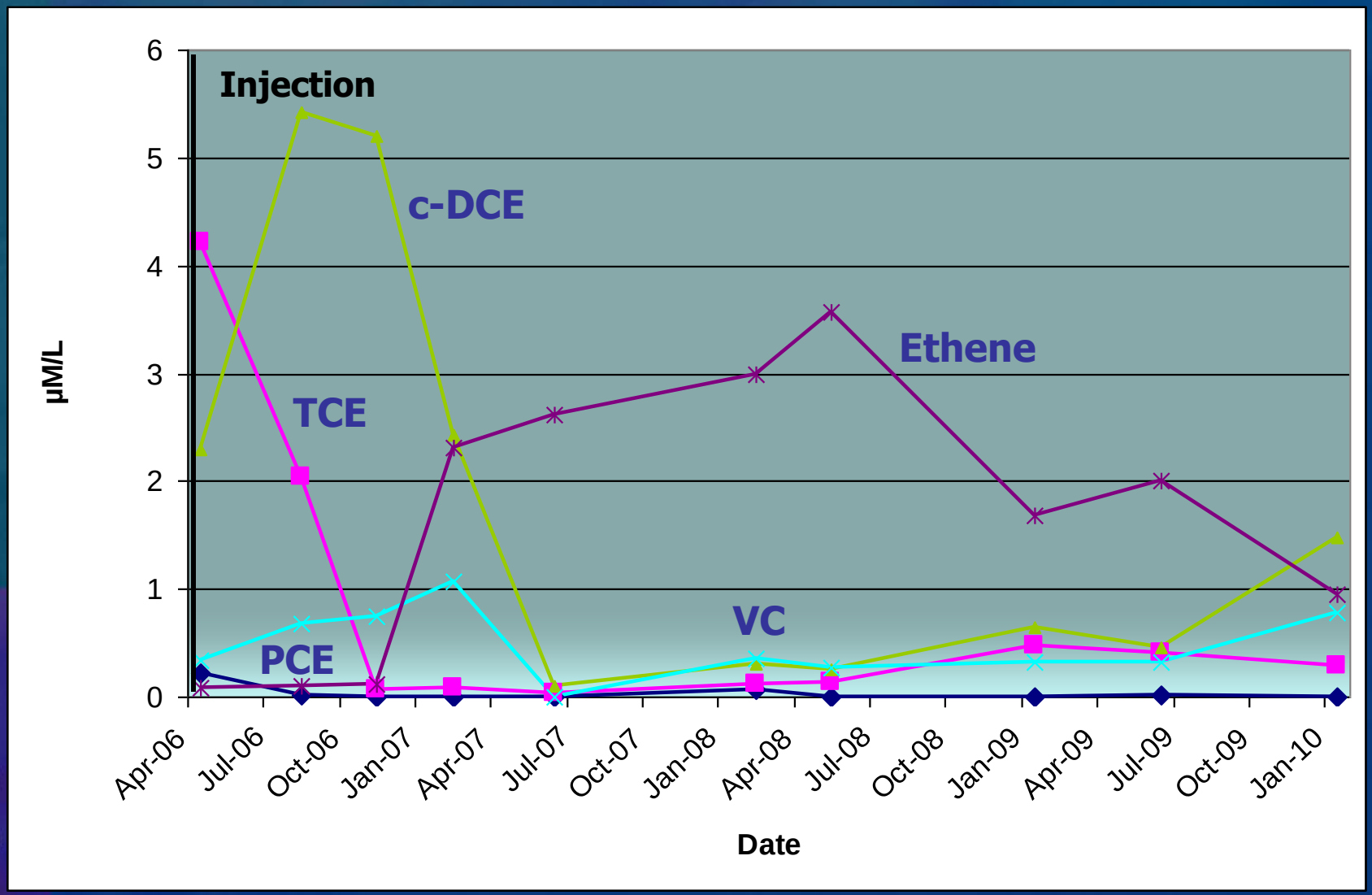








Source Area Monitoring Well



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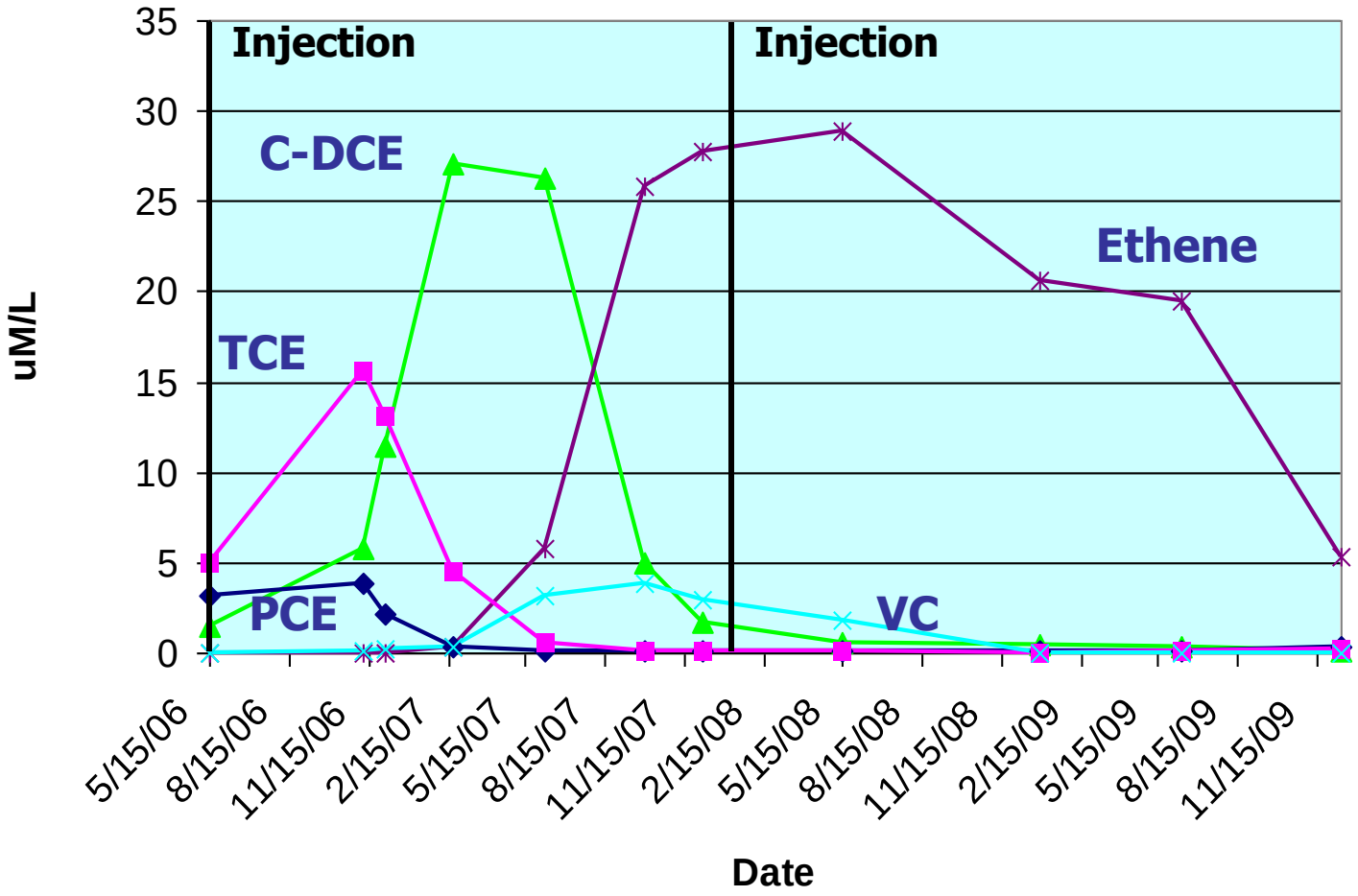
PICT Monitoring Well



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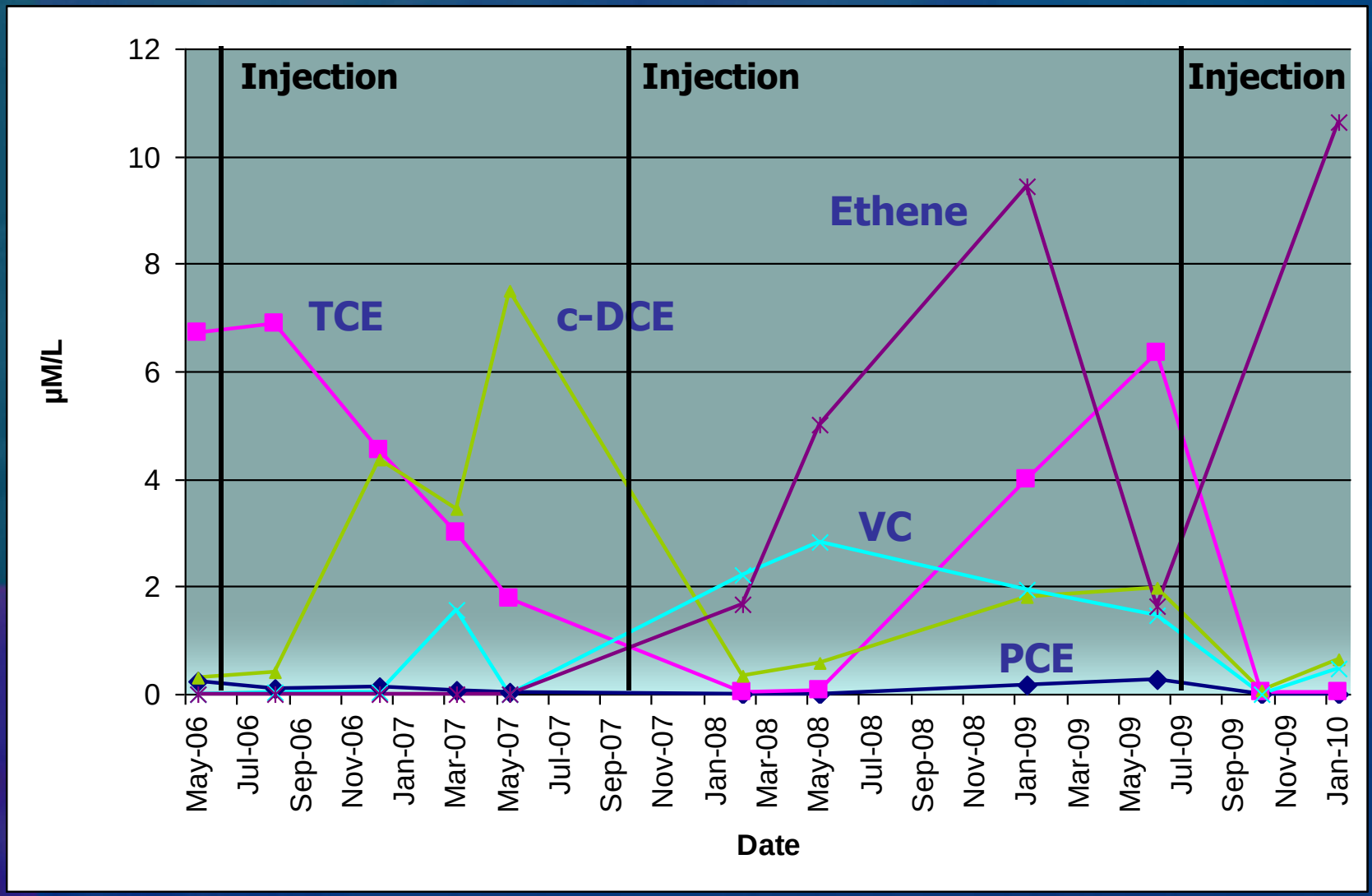

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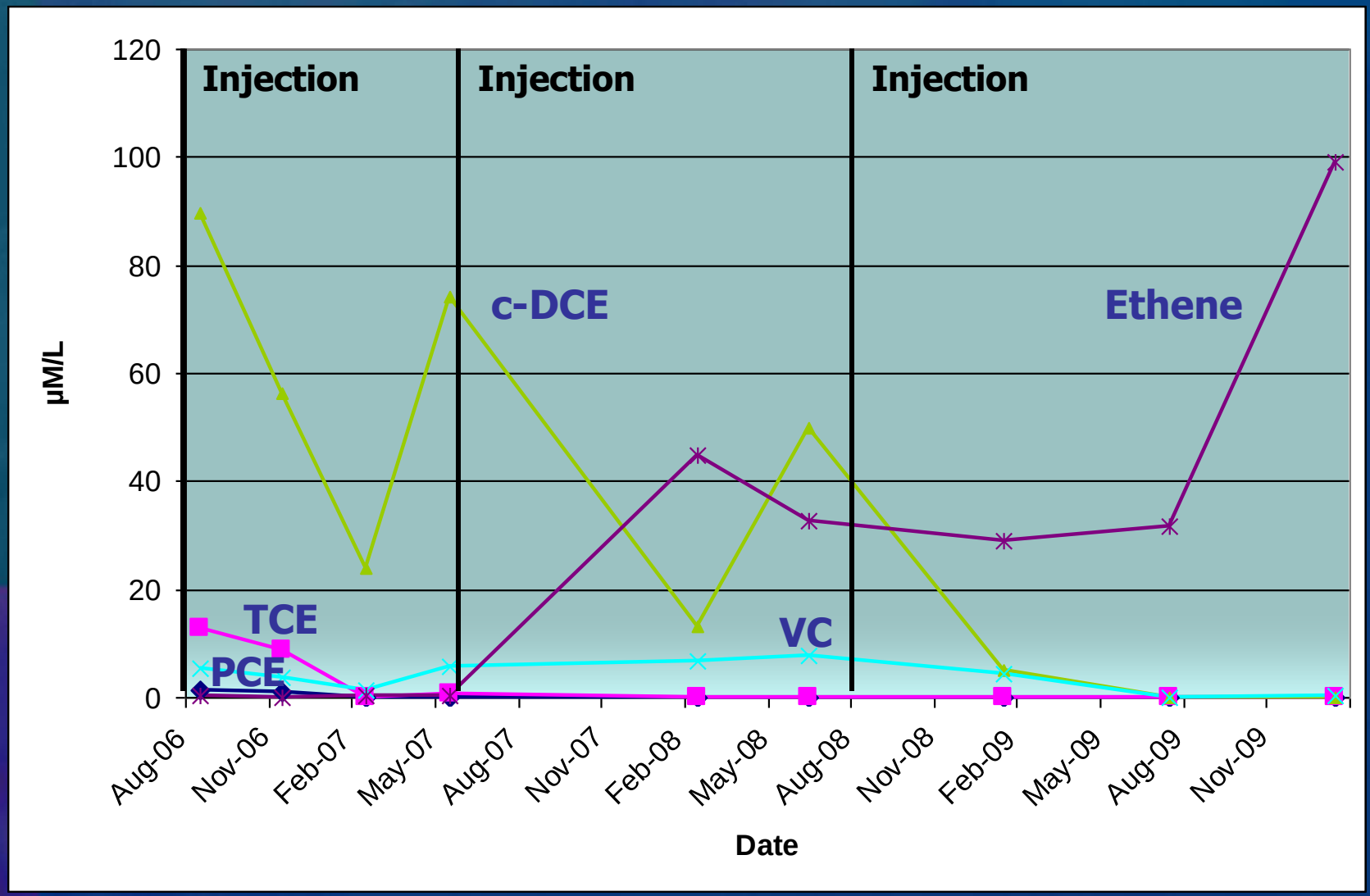

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Assessment Summary:

- TOC successfully distributed
- Favorable anaerobic conditions were created and persist
- Reduction of PCE and TCE
- Increasing / decreasing cis-1,2-DCE and VC
- Complete dechlorination demonstrated by presence of ethene

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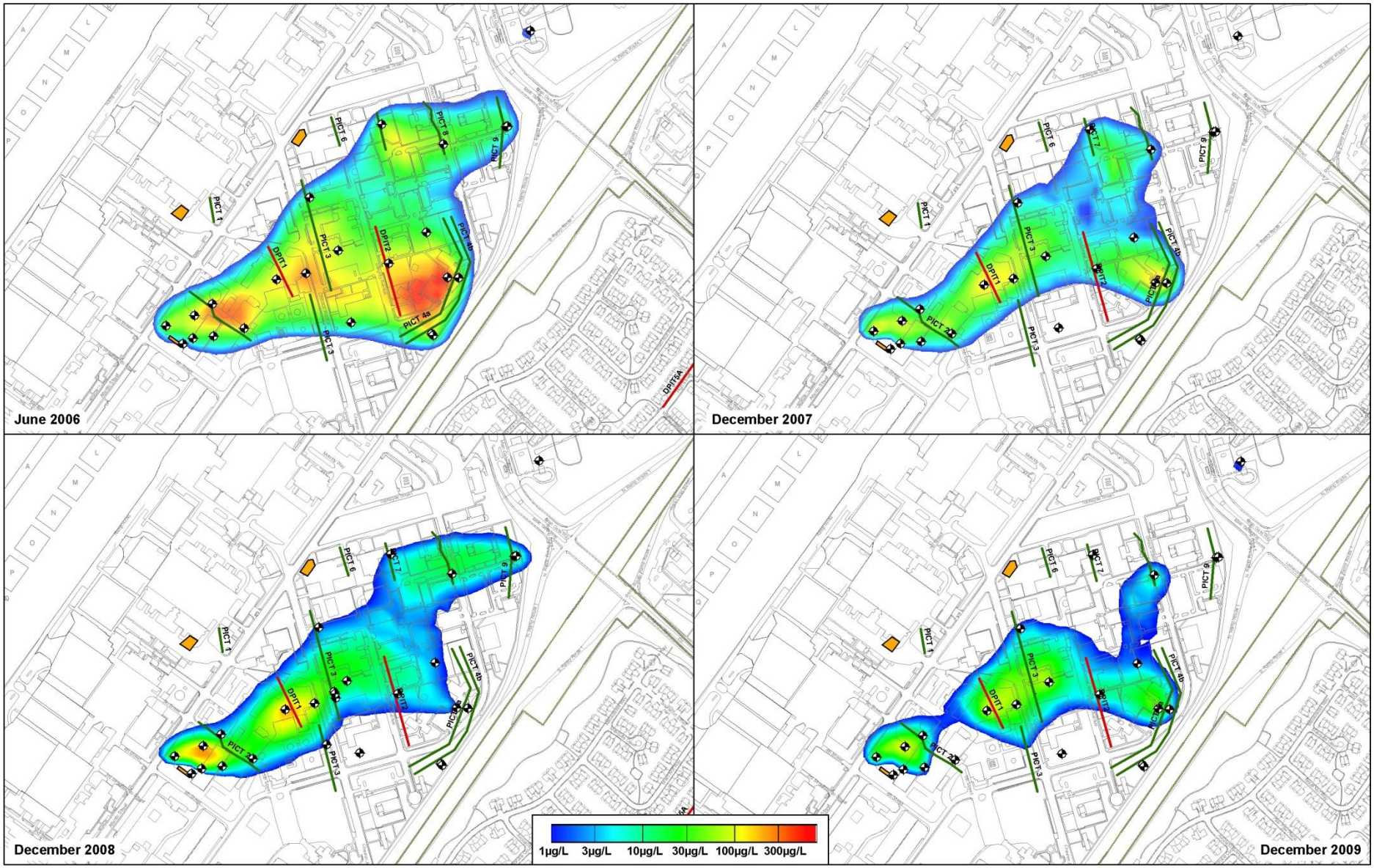
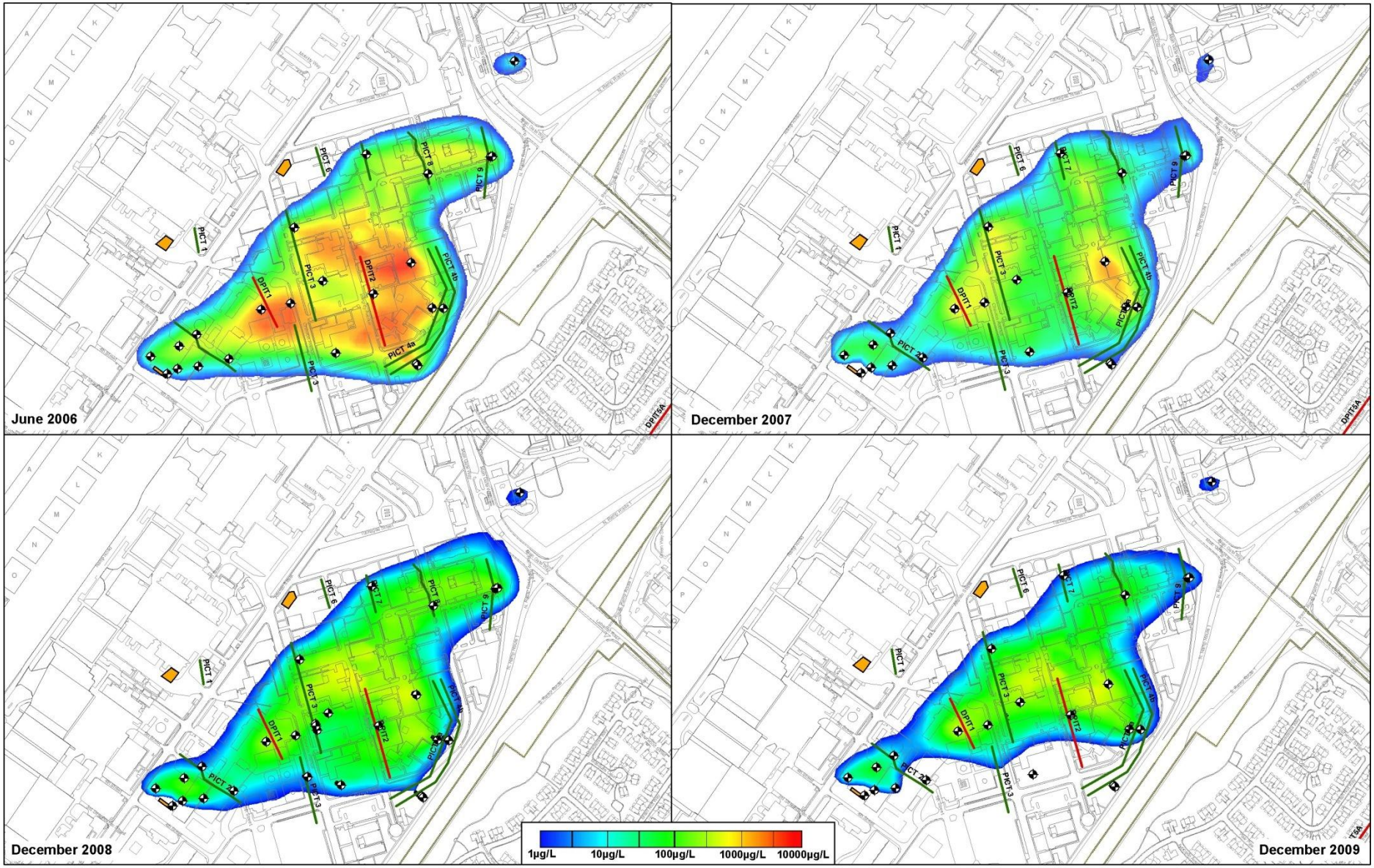
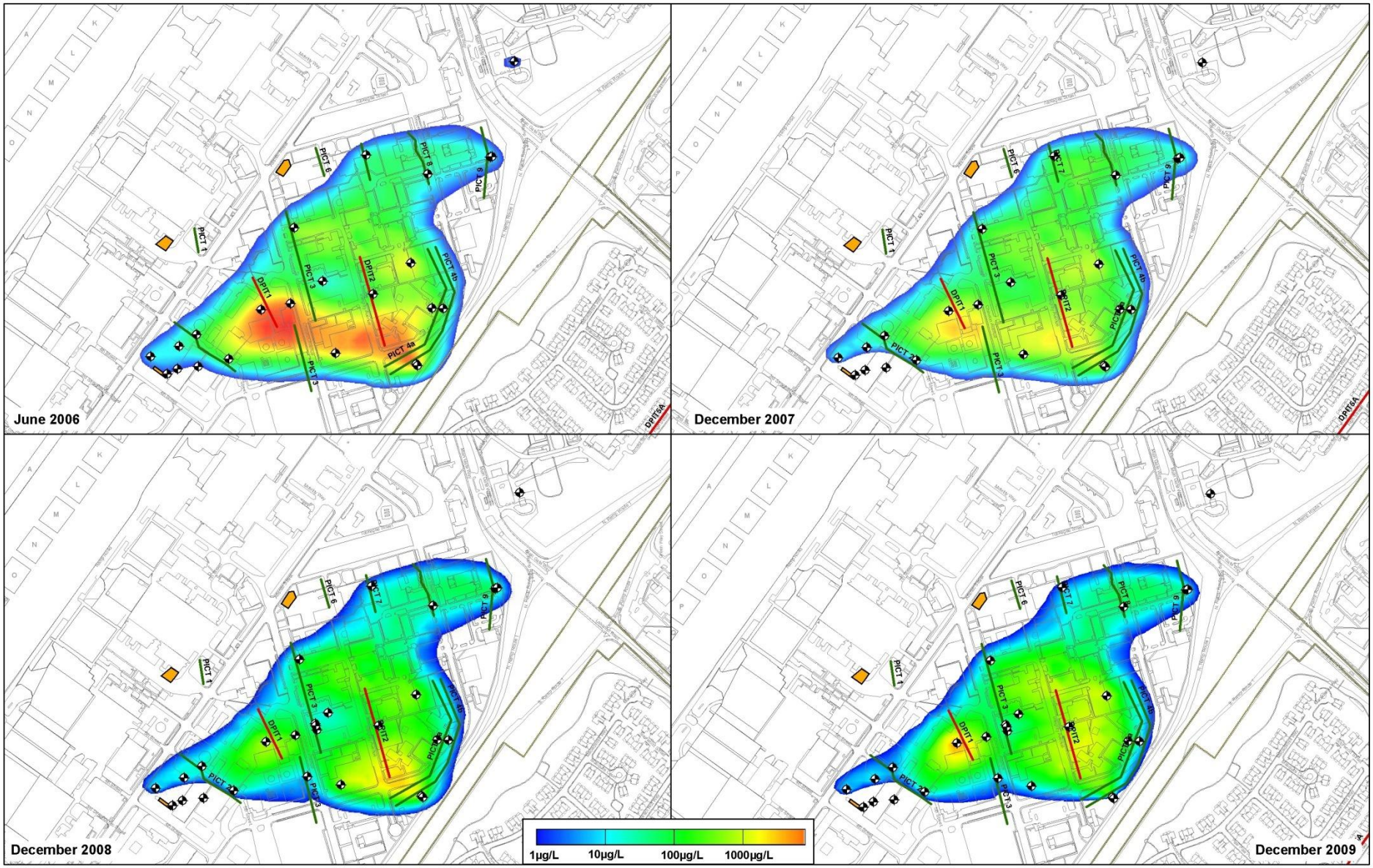
PCE Over Time



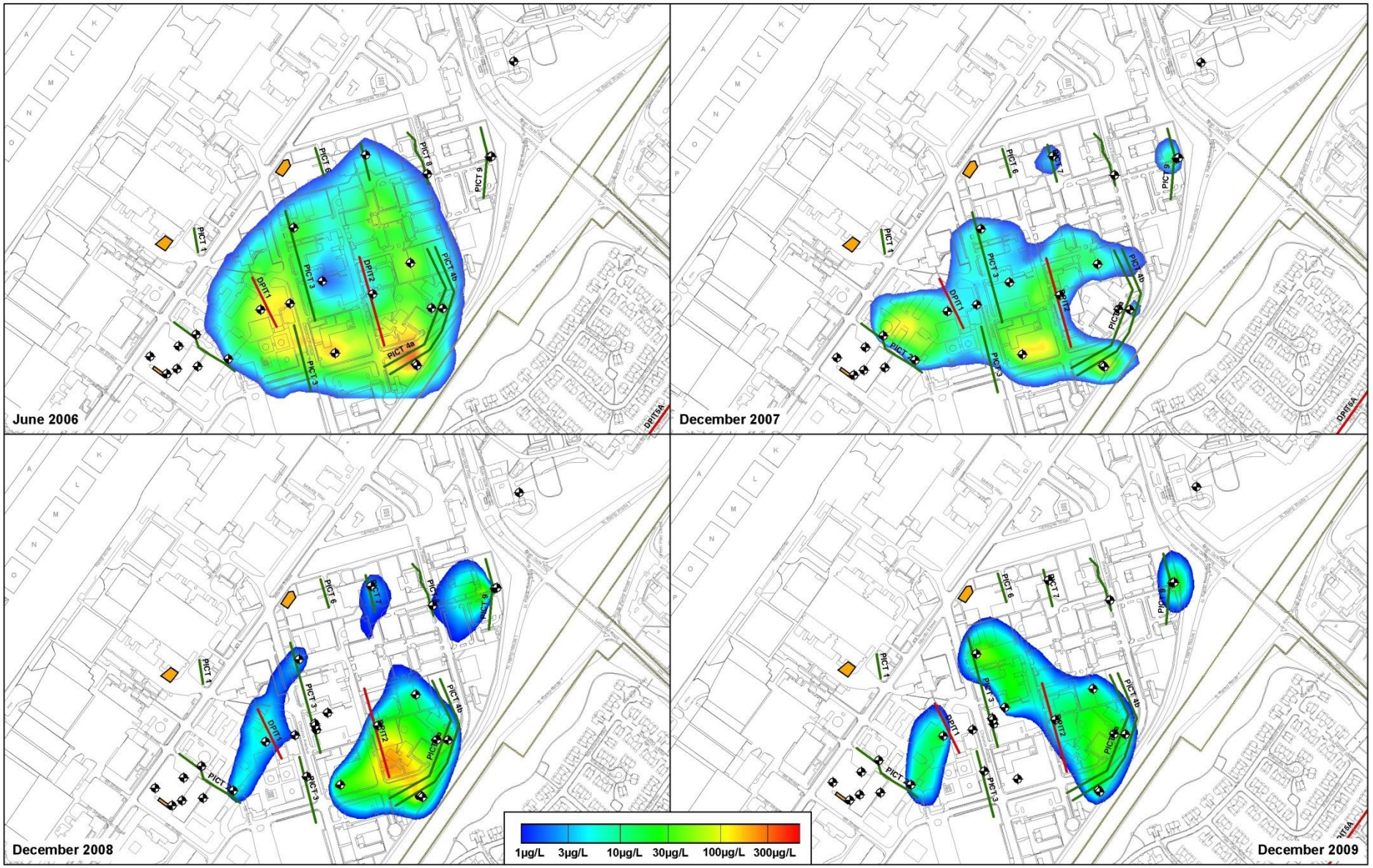
TCE Over Time



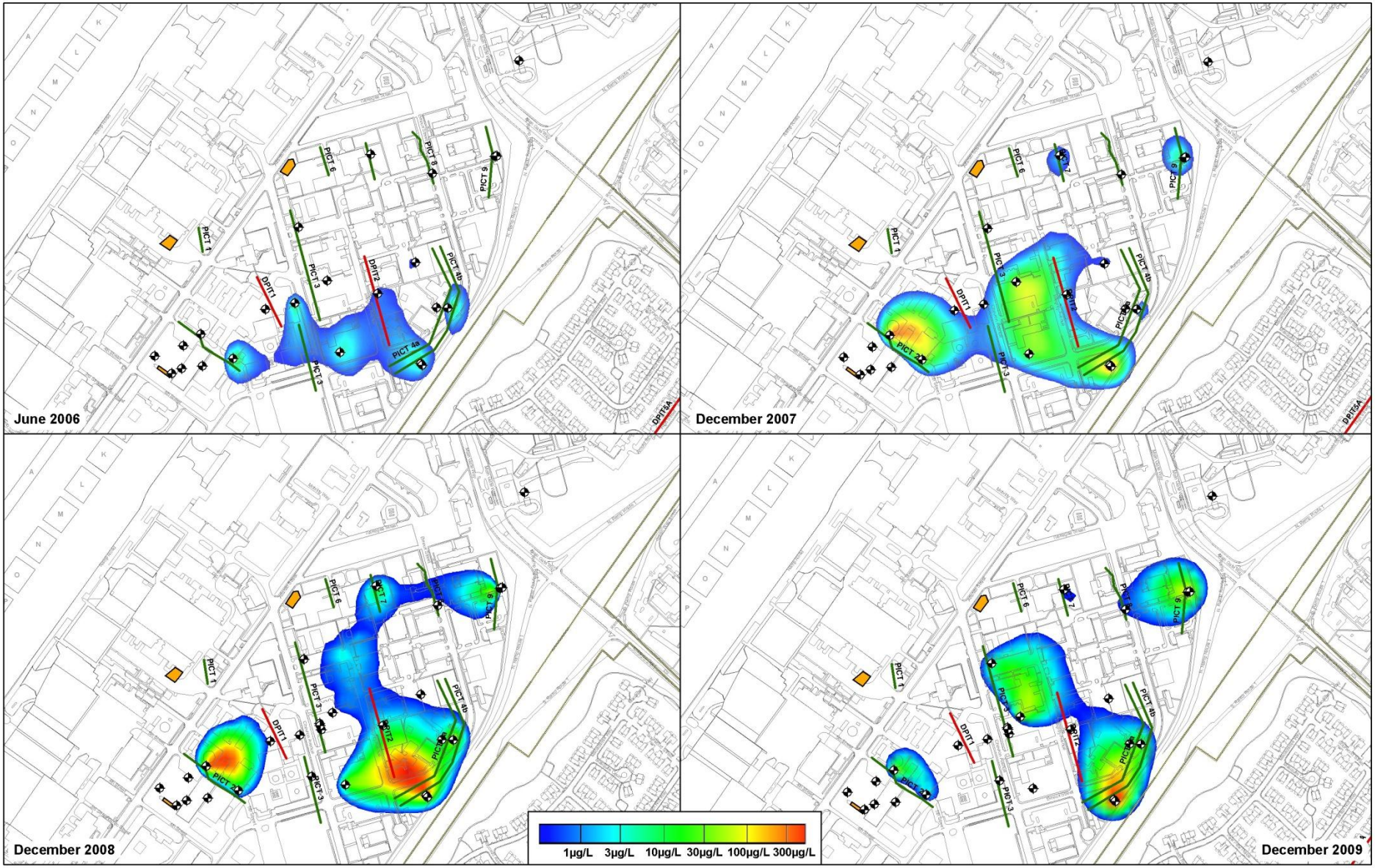
Cis-1,2-DCE Over Time



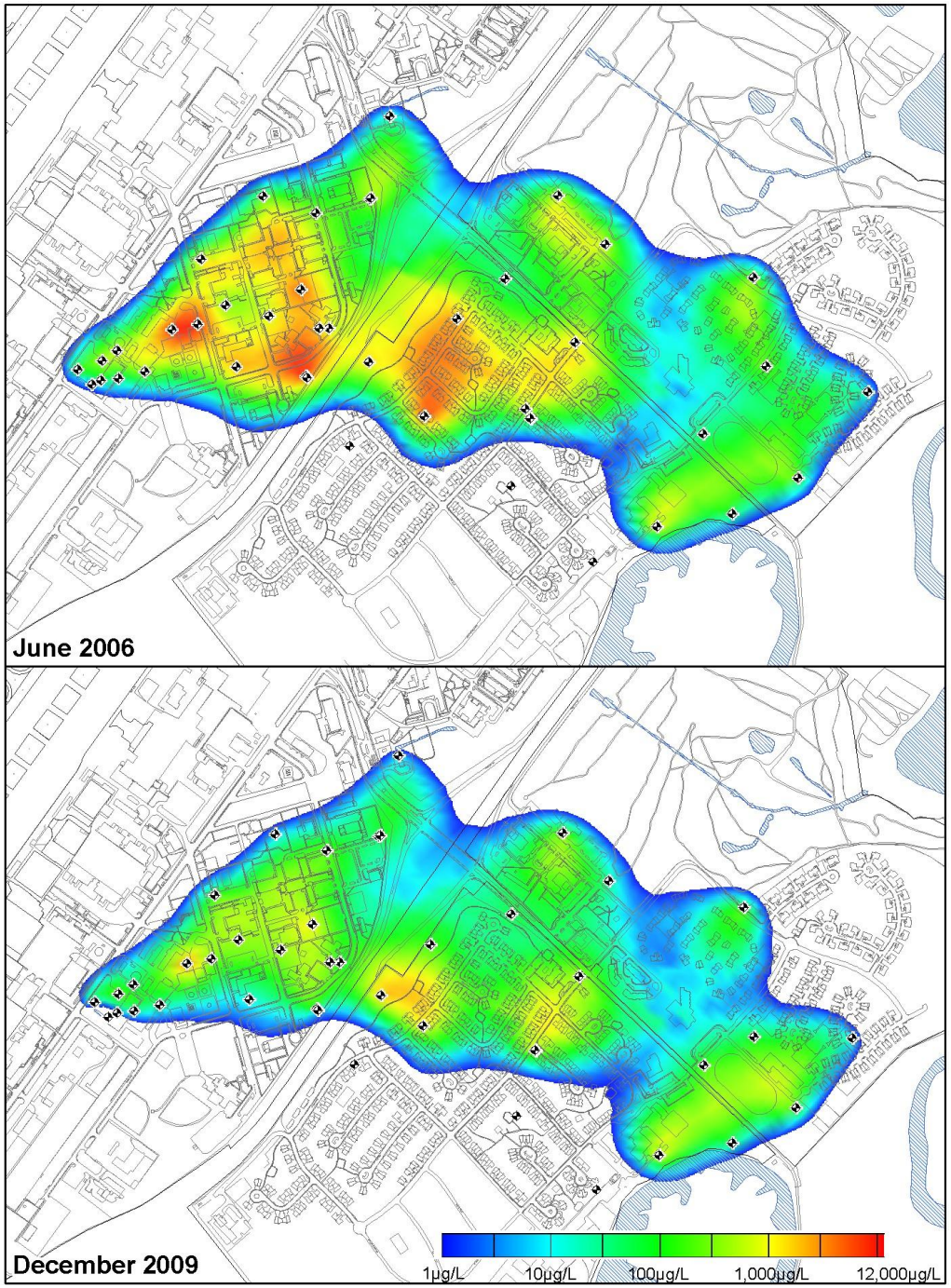
VC Over Time


June 2006
December 2007
December 2008
December 2009
1µg/L
3µg/L
10µg/L
30µg/L
100µg/L
300µg/L

Ethene Over Time



Total COCs
Entire Plume



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Conclusions

- Treatment of large multi-source plumes using AAB technology is feasible and effective
- A flexible approach using multiple substrate delivery techniques is necessary at large complicated sites
- The "Push-Pull" technique is an effective method of delivering and distributing substrate across plume cores

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Lessons Learned

- Be Flexible
- Hydraulic conductivity variations affected ability to distribute substrate
  - Low Conductive areas poor distribution
  - Modified injection to all but one or two wells
  - Added supplemental wells if needed
- EVO affected aquifer
  - Reduced hydraulic conductivity / flow rates
  - Increased well development and cleaning procedures

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The End

Questions ? ?

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