A-050, in K.A. Fields and G.B. Wickramanayake (Chairs), *Remediation of Chlorinated and Recalcitrant Compounds—2010.* Seventh International Conference on Remediation of Chlorinated and Recalcitrant Compounds (Monterey, CA; May 2010). ISBN 978-0-9819730-2-9, Battelle Memorial Institute, Columbus, OH, **www.battelle.org/chlorcon**.

Understanding the Source: A Critical Factor in Achieving Remedial Success

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Implementing a cleanup remedy without performing a detailed source characterization is common practice due to stakeholder reluctance to conduct "more assessment". Many stakeholders feel reducing time spent on assessment and moving sites quickly to remedial implementation will save them money. However, remedial success and reducing cleanup costs often hinge on an accurate source characterization. Understanding the "value added" of using appropriate tools and techniques to implement source assessments justifies the performance of detailed source investigations. Three case study NASA sites, all located at the Kennedy Space Center, Florida, highlight how innovative source characterization techniques significantly altered the understanding of the site conceptual site models, distribution of mass, and site remediation approach.

At Launch Complex 39A, a RCRA Facility Investigation (RFI) identified and delineated a CVOC plume. The RFI identified a logical and limited CVOC "hot spot" at the discharge point of a drainage pipe. Follow-up measures deployed to treat the "hot spot" reduced CVOC concentrations, but within a year the concentrations within the "hot spot" re-bounded. A detailed source investigation ensued which revealed a shallow dense non-aqueous phase liquid (DNAPL) source area approximately 20 feet upgradient of the original "hot spot", underlying a surface water ditch. Follow-up actions resulted in the excavation of the source area with enhanced bioremediation of the dissolved CVOCs.

Investigations at the GSA Seized Property site identified and delineated a vinyl chloride plume in excess of 1,400 feet in length. While the plume was fully delineated, NASA supported a recommendation to perform supplemental investigations in an effort to identify a source area. The resulting additional sampling identified and delineated a PCE source area sorbed within an organic-rich zone. The identification of the source area enabled remedial actions to actively address the source area. Without identification of the PCE source area, dissolved plume treatment would have been hindered by the long term diffusion of PCE from the source area.

At Central Heat Plant, remedial measures were implemented for CVOCs in groundwater after completing delineation to meet regulatory requirements of the RFI. An air sparging and soil vapor extraction system were installed and operated for approximately five years. The remedial system reduced CVOC concentrations; however, recalcitrant concentrations of CVOCs were observed in the upgradient portion of the plume. Additional investigations identified a DNAPL source located upgradient of the influence of the remedial system. Given the identification of a previous unknown source, actions are being taken to mitigate the identified DNAPL source area.

The case study sites will demonstrate to stakeholders and environmental professionals that while just meeting regulatory requirements and understanding the distribution of a dissolved plume is important, remedial success and cost ultimately hinge on understanding the location and architecture of the source area.

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Understanding the Source: A Critical Factor in Achieving Remedial Success

May 25, 2010

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Seventh International Conference on the Remediation of Chlorinated and Recalcitrant Compounds

Geosyntec consultants

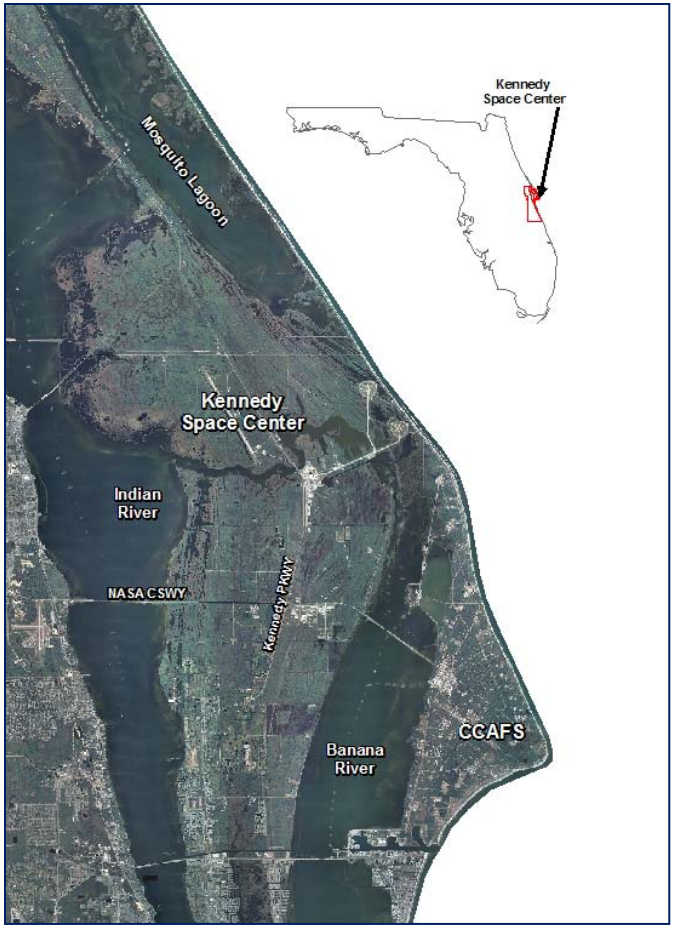
engineers | scientists | innovators

Acknowledgements

- Tom Peel, Ph.D., Geosyntec
- Michael Deliz, P.G., NASA
- Bob Kline, P.E., NASA
- Joe Applegate, P.G., ARCADIS
- Scott Starr, P.E., ARCADIS

Outline

- Source assessment obstacles
- Source assessment tools
- Case studies
  - *Launch Complex 39A*
  - *Central Heat Plant*
  - *GSA Seized Property*
- Implications to conceptual site models
- Lessons learned



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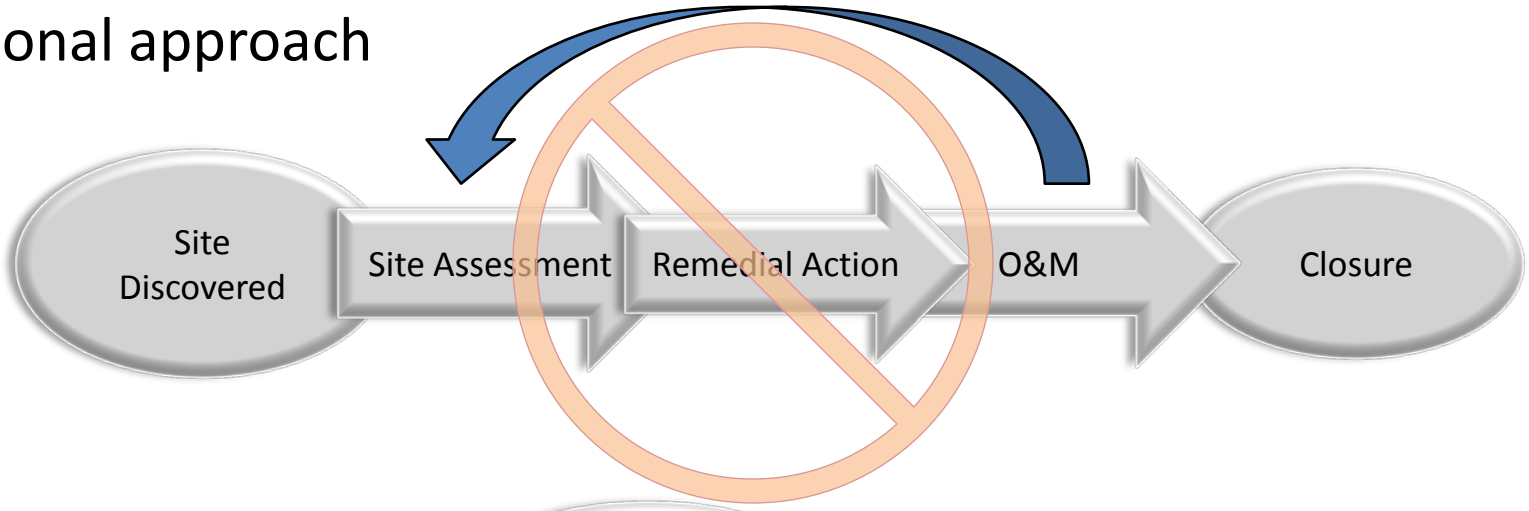
Source Assessment Obstacles

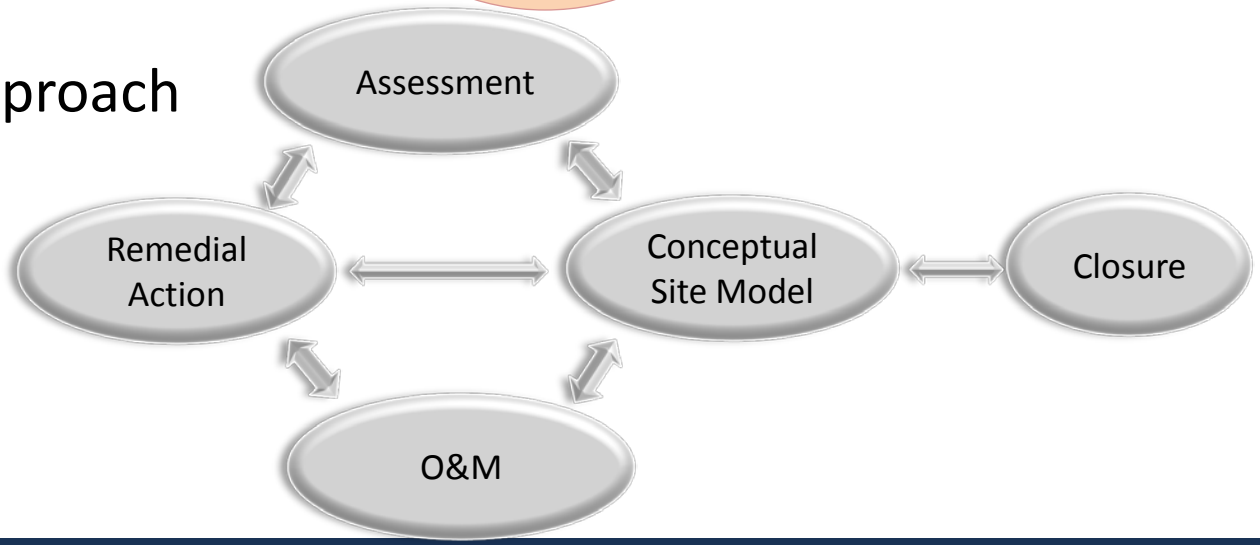
- Stakeholder reluctance
  - *Assessment is approved – "more assessment?"*
  - *DNAPL denial*
  - *Benefits may not be understood ($ savings)*
  - *Deployed tools may not be "standard" or "required"*
  - *Site is already in remediation – "more assessment?"*
- Regulatory drivers
  - *Schedules may be driven by dates/timeframes*
  - *Could warrant changes to decision memo/ROD, etc. (delay)*
  - *Technical understanding*
- Conceptual Site Model (CSM) modification

Source Assessment Obstacles

- Traditional approach



- Non-linear approach



Case Study #1: Launch Complex 39A

- NASA shuttle launch pad
- TCE, cDCE and VC identified in groundwater at concentrations exceeding MCLs
- LOX tank area
  - *Discharge pipes extend from LOX tank*
  - *Perimeter ditch discharges to the adjacent surface water bodies*

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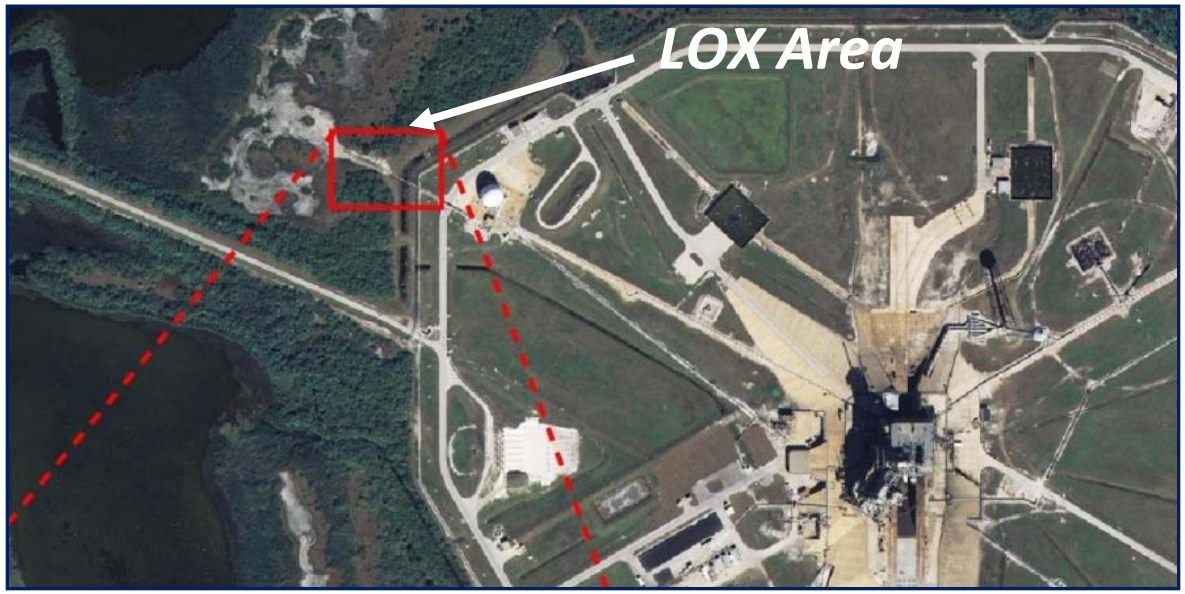
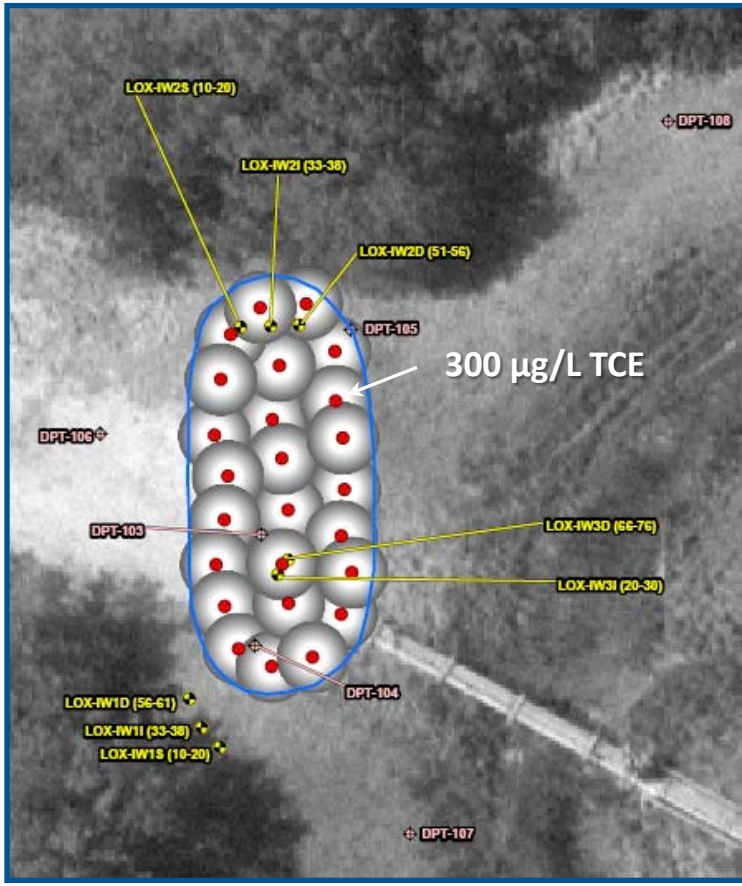
LC39A Conceptual Site Model



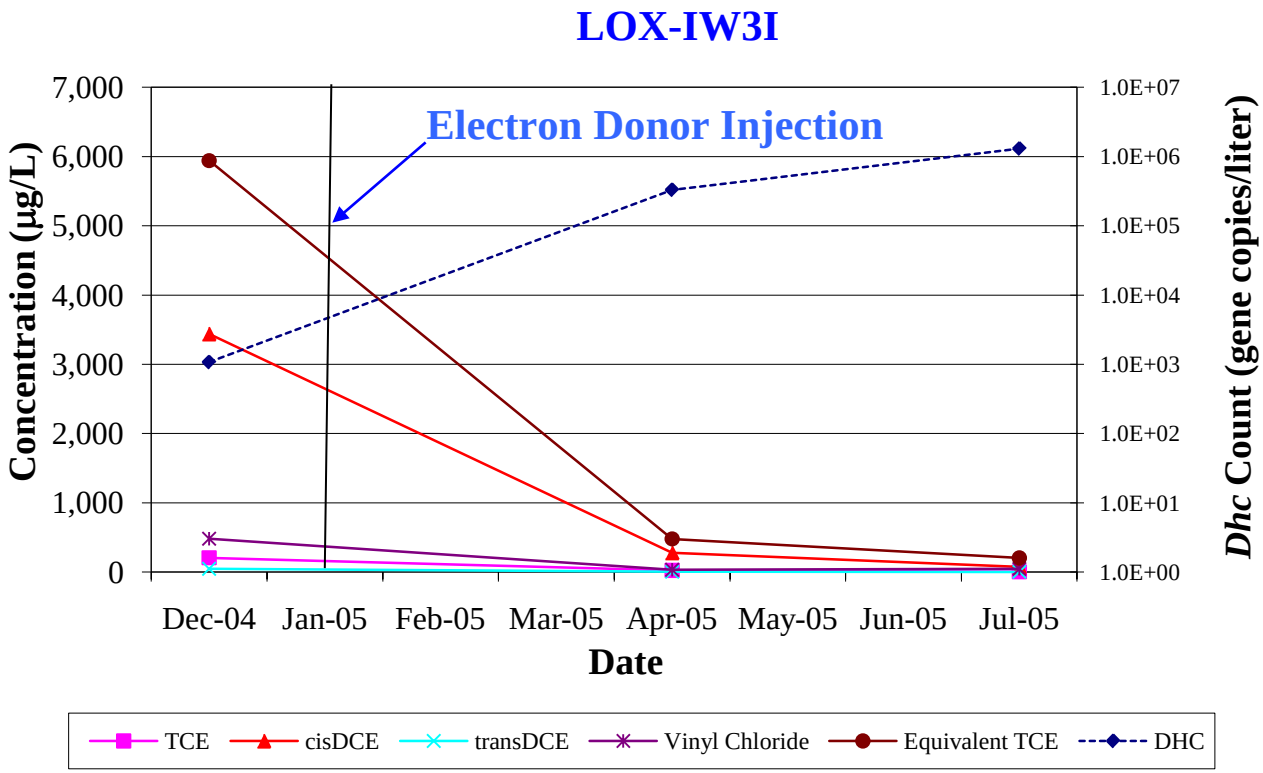
- TCE release occurred at LOX pipe discharges
- Maximum VOC concentrations at LOX pipe discharge
- TCE plume w/ daughter products

LC-39A Interim Measures

- Based upon assessment results, Interim Plan (October 2004) prepared to:
  - *Reduce VOC concentrations to less than Florida Natural Attenuation Criteria*
  - *Facilitate long term monitoring*
- *Slow release electron donor injected in January 2005 to stimulate microbial reductive dechlorination*
  - *25 injection locations*
  - *25 to 35 feet below land surface (ft BLS)*
  - *Total of 2,280 pounds injected*

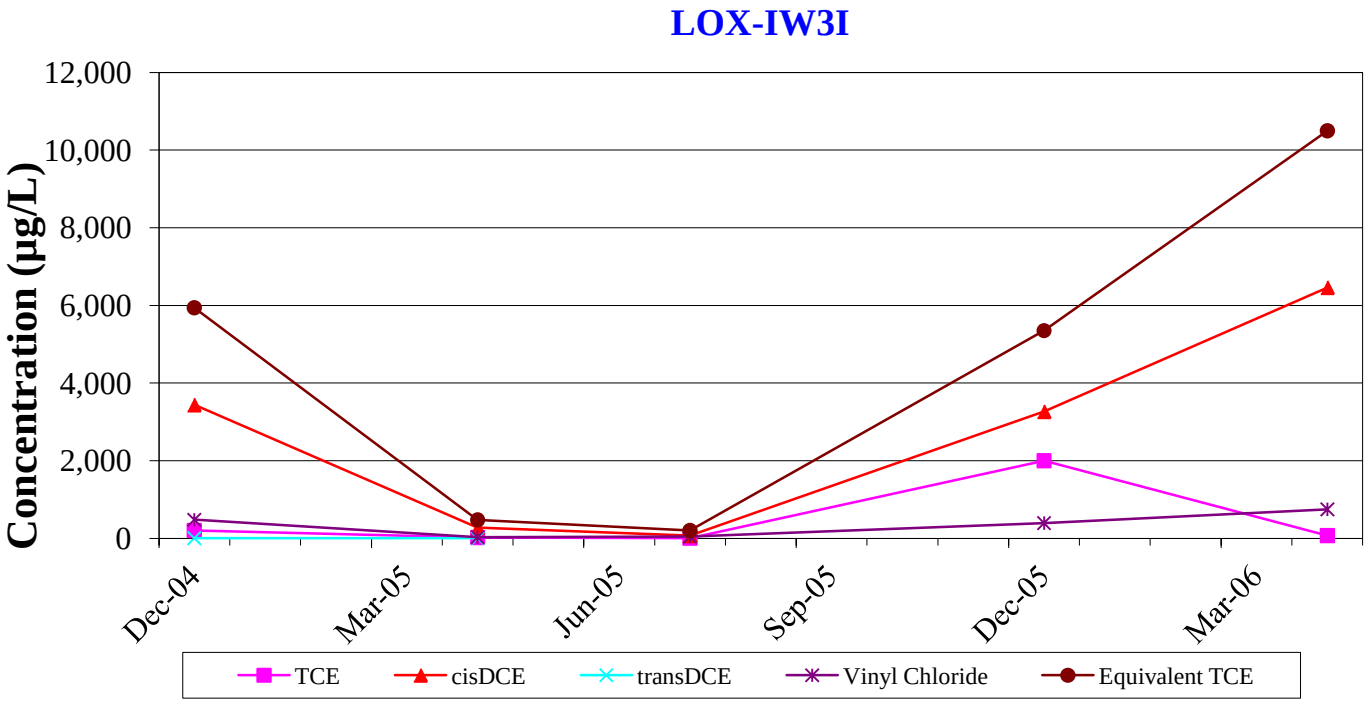


LC39A IM – 6 Months Post Injection



- Mass reduction: 98.3% TCE, 97.9% cDCE, 90.6% VC
- *Dehalococcoides* increase (3 orders of magnitude)
- Ethene production (711 µg/L)

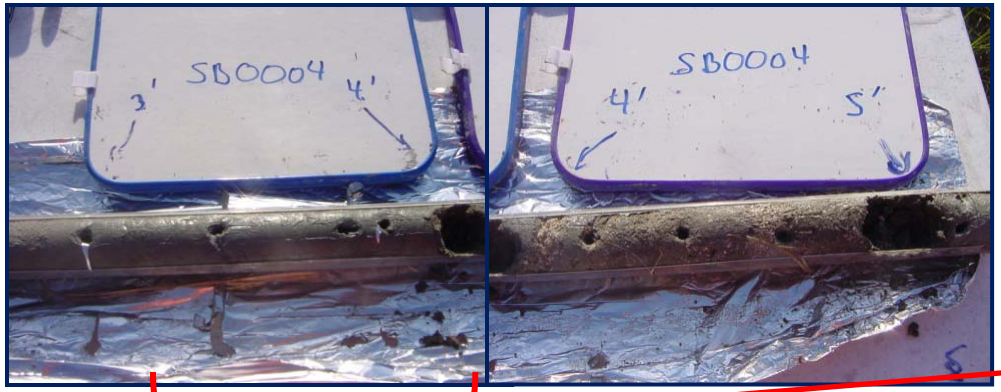
LC39A IM – 24 Months Post Injection



- Continue remedial action?
- Inject more electron donor?
- Continue monitoring?
- **Do we truly understand the source and CSM?**

Source Assessment – Tools and Approach

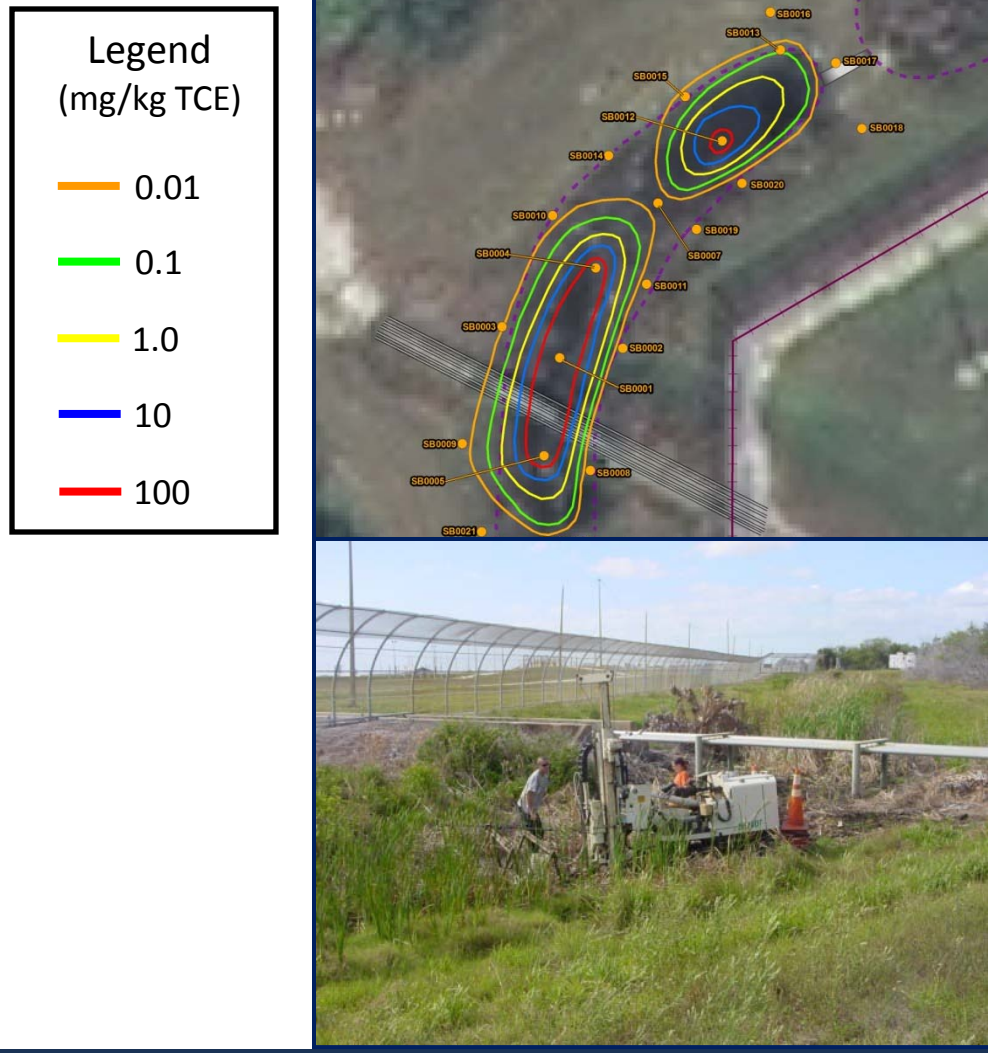
- DPT investigation
  - *Soil borings w/ PID screening and saturated zone soil sampling*
    - 21 boring locations
    - >50 saturated zone soil samples
  - *Groundwater sampling*
    - >200 DPT samples at 37 locations
    - Dynamic location selection



Sandy CLAY ditch lining

Source Assessment Results

- Soil PID responses to >9,999 ppm
- Maximum saturated zone soil concentrations
  - *TCE = 27,500 mg/kg*
  - *cDCE = 82.5 mg/kg*
- Maximum groundwater TCE = 499,000 µg/L
- Mass focused from 1 to 5 ft below base of ditch
- Mass sorbed within clay layer
- Maximum soil concentrations indicative of TCE DNAPL



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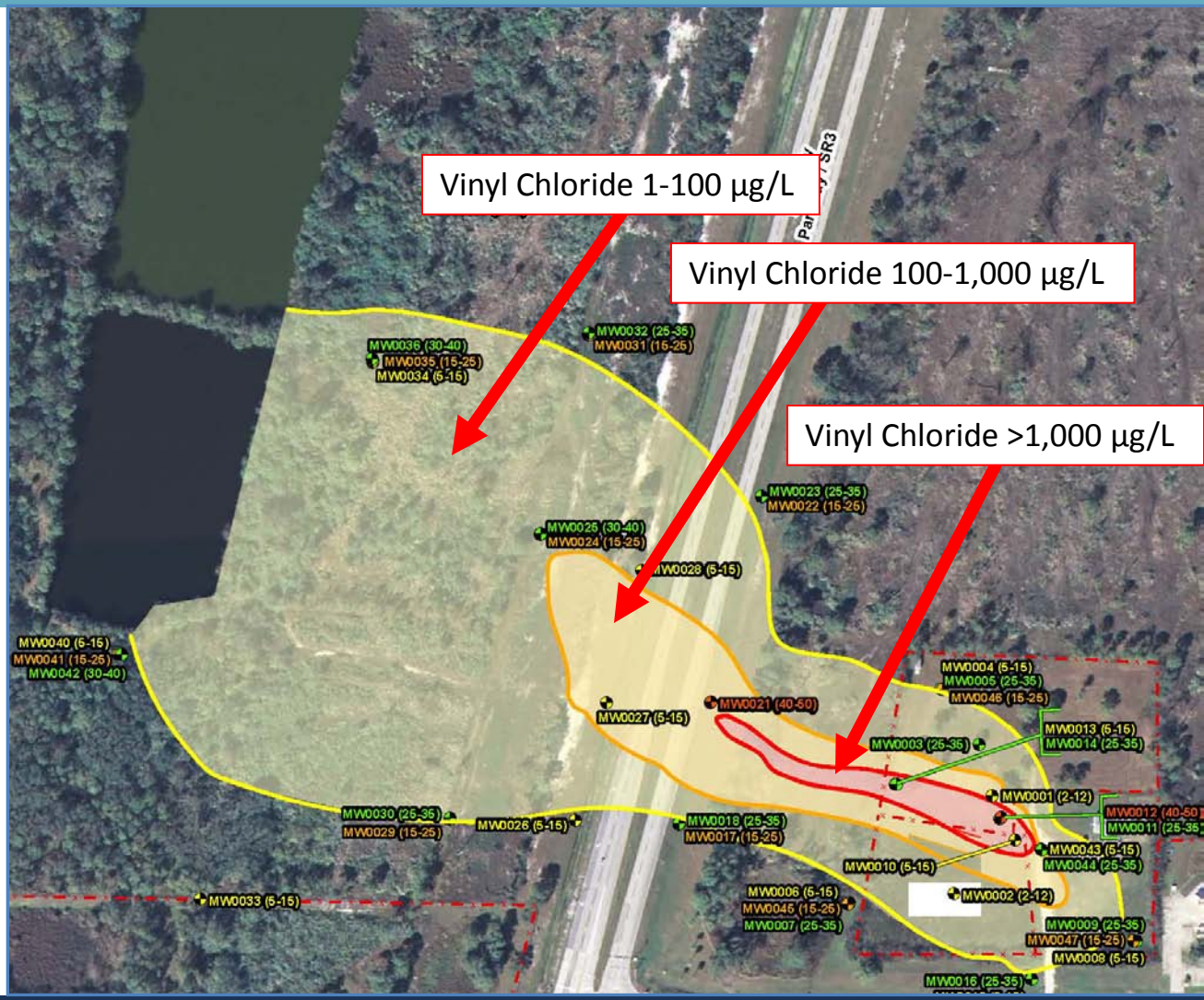
LC39A Source Assessment Conclusions

- 25 ft can make a big difference when it comes to source assessment!
  - *LOX pipes were extended in early 1970's ~25 ft*
  - *LOX pipe outfall historically was the ditch*
- Clay ditch lining provided mechanism for significant mass diffusion
- Source is shallow – excavate and enhance bioremediation in dissolved plume

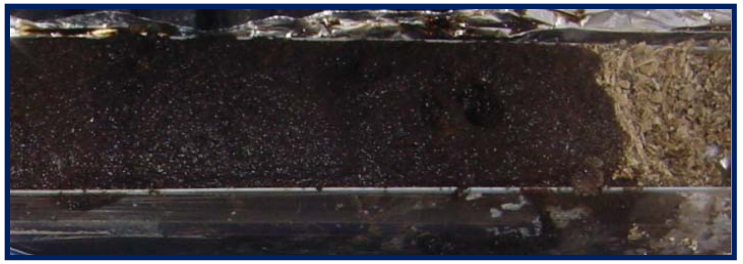
Case Study #2: GSA Seized Property

- Vinyl chloride detections (<5 µg/L) led to assessment in 2007-2008
- Vinyl chloride plume >1,500 ft length and 27 acres
- Plume fully delineated (horizontally and vertically)
- No source identified
- CSM questioned?



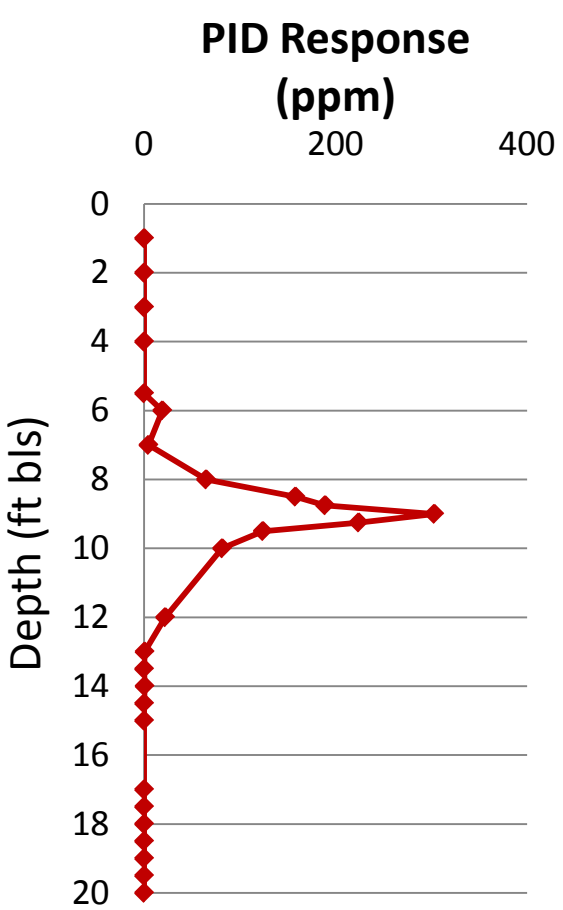
Understanding the Source - Lithology

- Lithology:
  - *Fine to medium sand from land surface to 4 to 8 ft bls*
  - *Dark brown to black organic/peat layer below the sand, 2 to 4 ft thick*
  - *Underlain by a tan shelly sand layer*

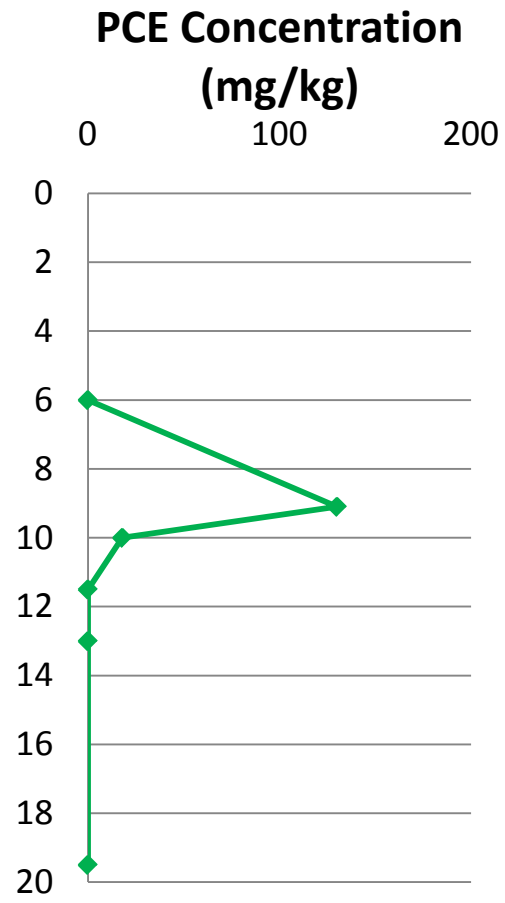


Organic Interval

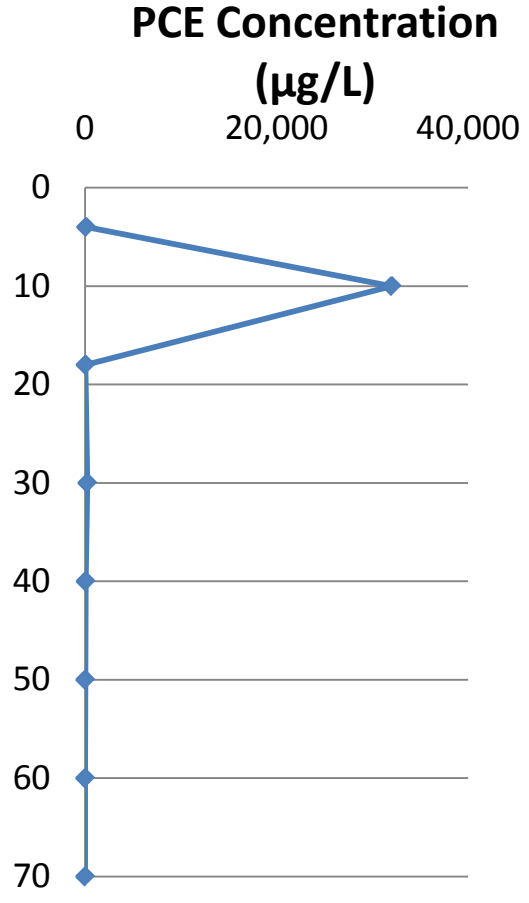
Source Area Assessment - Tools



Photoionization Detector Screening



Discrete Interval Saturated Zone Soil Sampling



Targeted DPT Groundwater Sampling w/mobile lab

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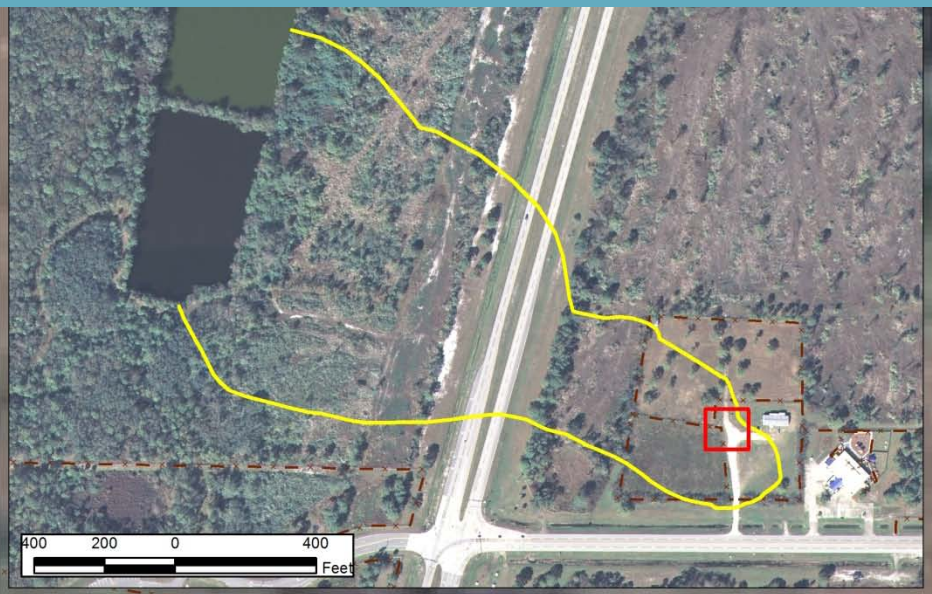
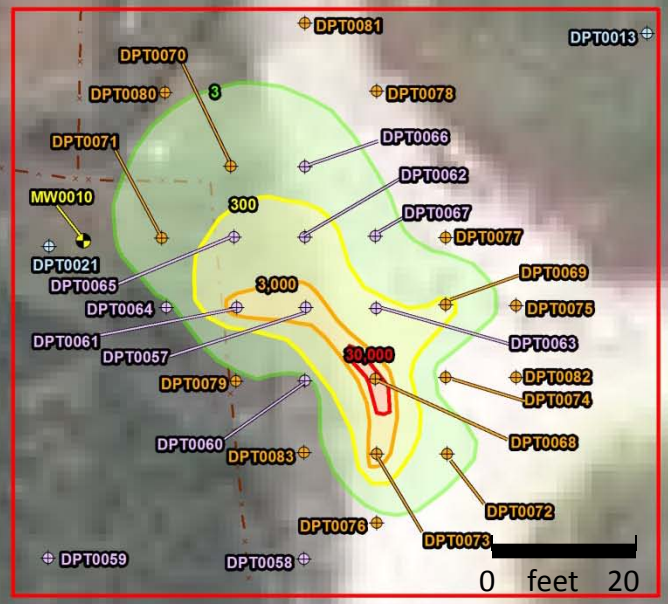
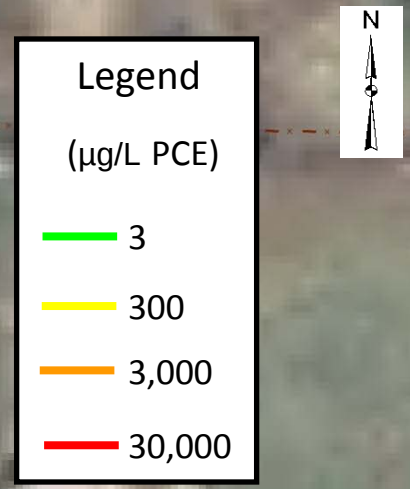
Source Area Assessment
Groundwater – PCE Contours

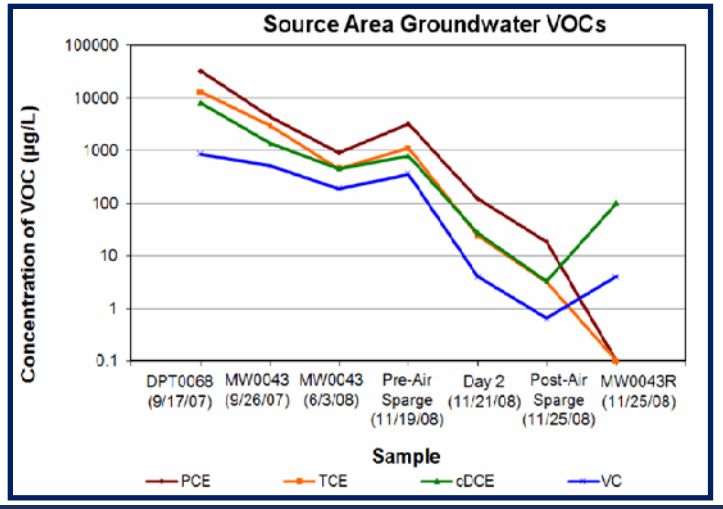






GSA Seized Property Source Assessment – Conclusions

- 1,500 ft vinyl chloride plume emanating from shallow PCE source area of less than ¼ acre
- PCE only detected within shallow source area
- Dissolved plume transport in sands underyling organic zone
- Remediation of site would have been significantly hampered if source area was not identified
- Source removed via wet excavation



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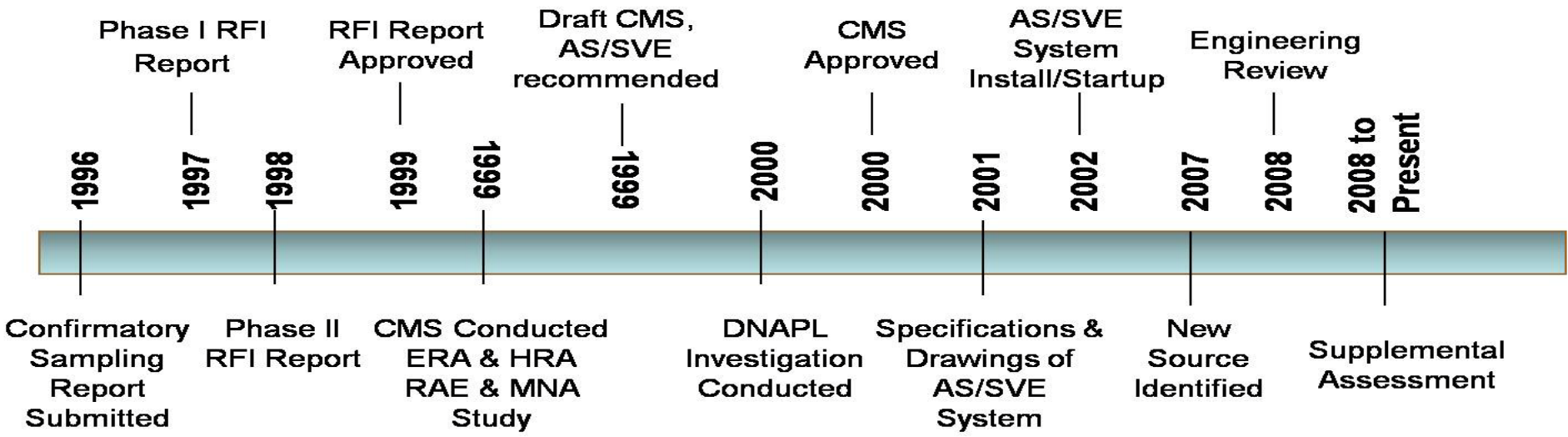
Case Study #3: Central Heat Plant

Site History and Conditions

CHP Timeline



- ARCADIS involvement initiated in 2005
- In 2006 began questioning effectiveness of AS/SVE remediation system
  - Additional sampling approved to evaluate recalcitrant areas and conceptual site model

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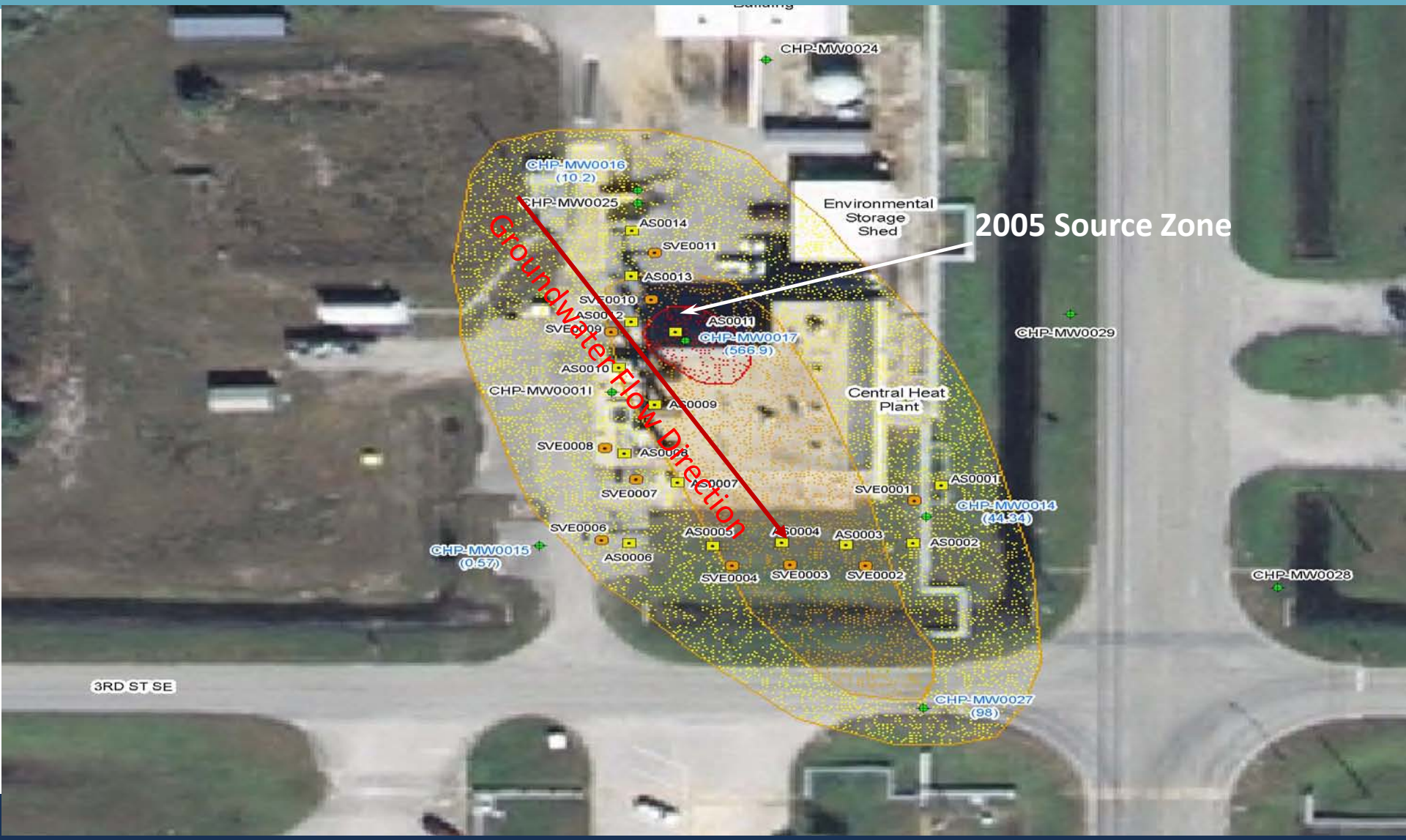
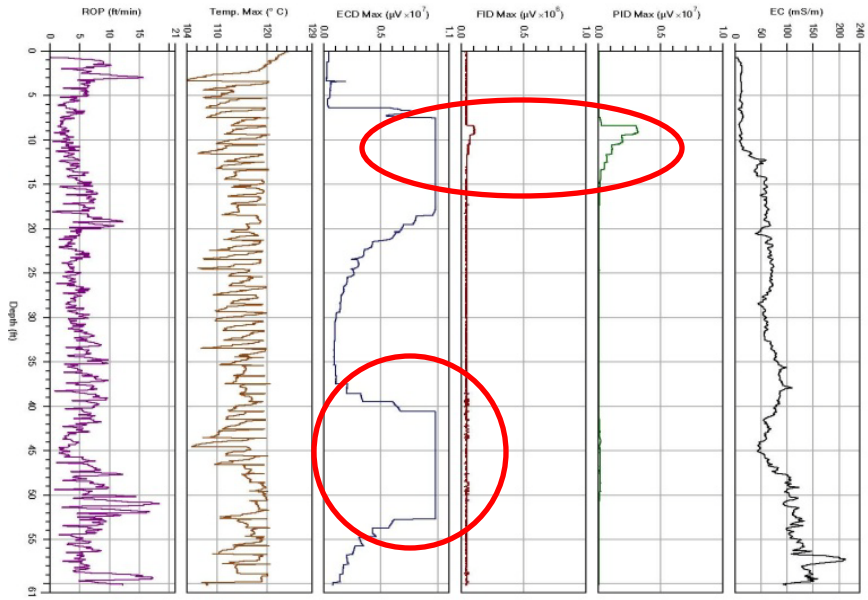
2005 Conceptual Site Model



Supplemental Assessment - Tools

- 65 DPT sample locations
  - *Multiple Mobilizations beginning in 2006*
  - *265 samples collected for analysis*
  - *Utilized mobile laboratory and fixed-based laboratory*
- 21 Membrane Interface Probe (MIP) locations
  - *Continuous from surface to 50 feet bls*
- 14 additional monitoring wells



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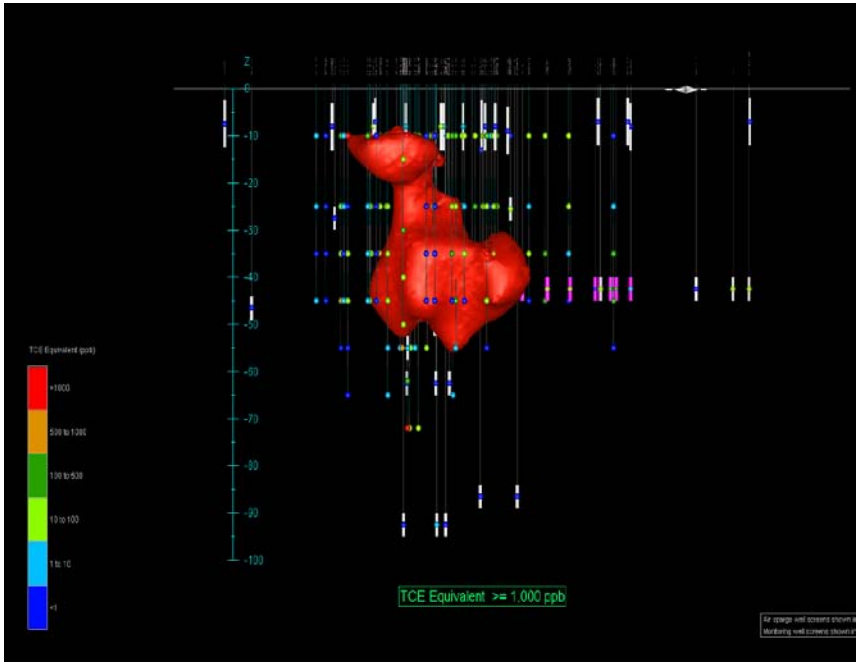
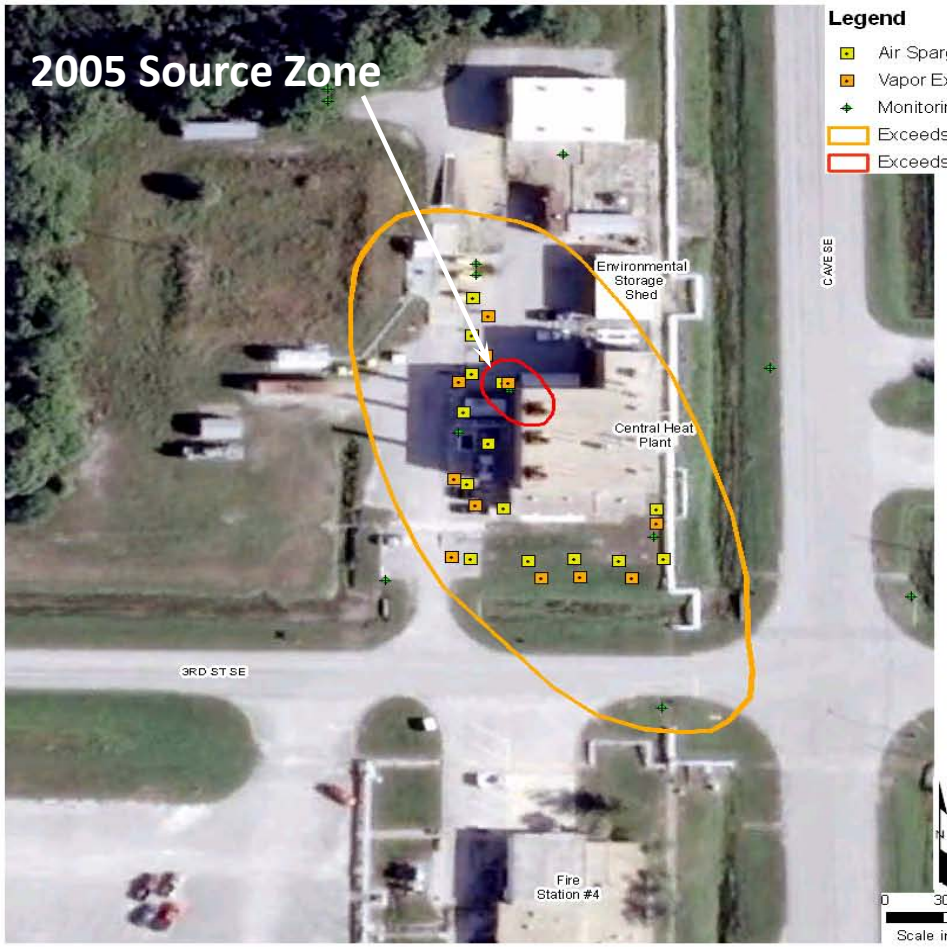
Supplemental Assessment Findings

- Two separate source areas identified beyond the influence of the remediation system (upgradient)
- Source areas indicate presence of DNAPL
  - *Tetrachloroethene maximum concentration = 200,000 µg/L*
  - *Trichloroethene maximum concentration = 35,000 µg/L*

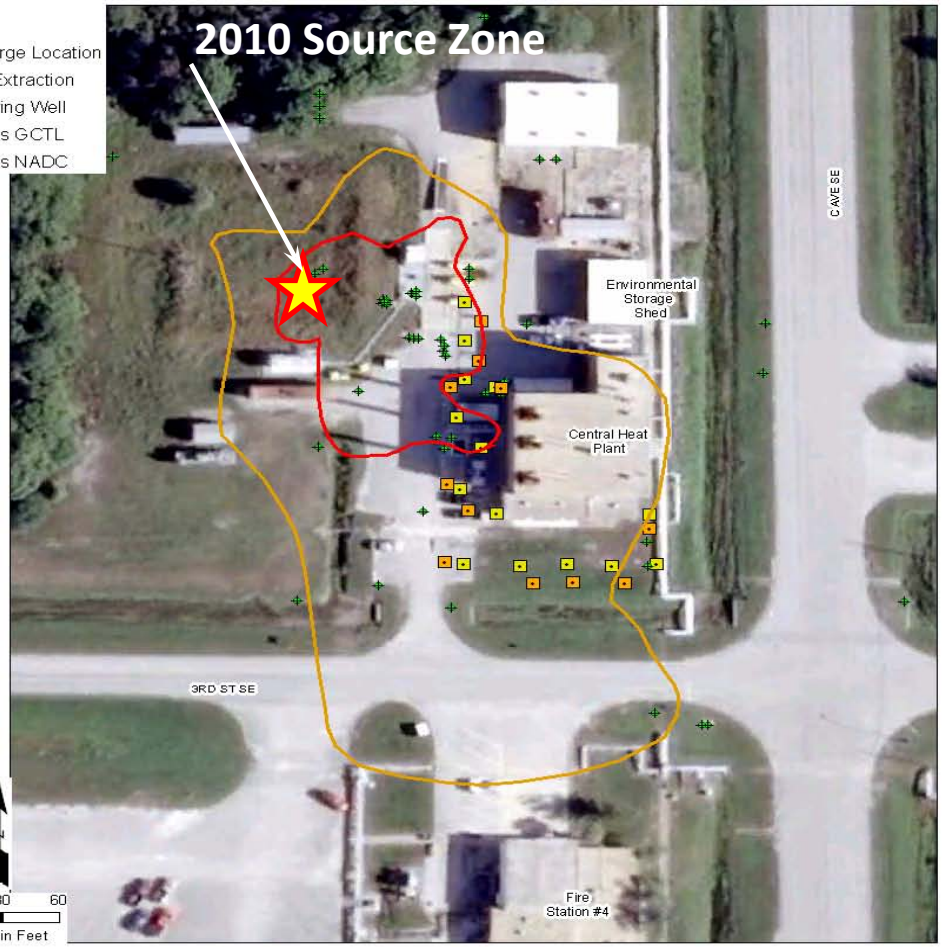


Revised Conceptual Site Model

2005 Conceptual Site Model



2010 Conceptual Site Model



Conclusions/Observations

- Unidentified sources can significantly impact remediation performance
- Spending the $ to perform "more assessment" can provide significant value and changes to the CSM
  - *Potential reduction in actual source area/volume*
  - *Selection of appropriate remedial technology*
  - *Changes to existing system operations/optimization*
- Many Monitored Natural Attenuation (MNA) sites are not reaching cleanup levels predicted because source area(s) are present
- A number of assessment tools are available and can be used at any time during project life cycle


Questions?