Air Force Center for Engineering and the Environment

Integrity - Service - Excellence

Approaching MCLs in a Large Dilute Plume – Former Reese AFB Case Study

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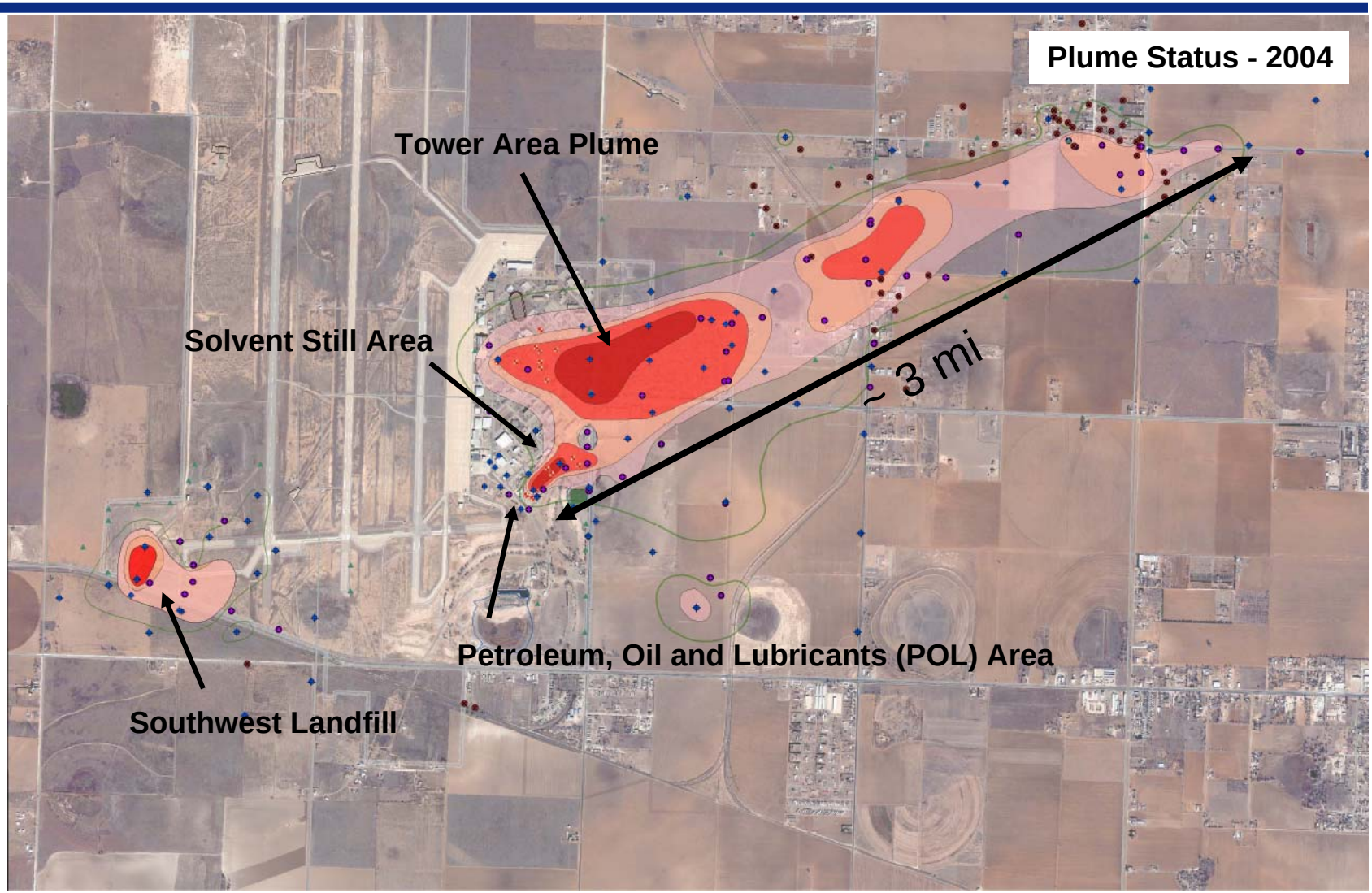
Outline

- Pre-performance based contract (PBC) cleanup history
- PBC contract summary
- Site-wide remedial strategy
- Progress to-date
- Principle source zone challenge – TCE storage in the dispersed plume

Scope of PBC

- Three major sites; 7 minor sites
  - Tower Area – 3 mil TCE plume covering over 250 acres
  - Petroleum, Oil and Lubricant s (POL) Area – fuel contaminated soil covering 11 acres
  - Southwest Landfill (SWLF) – TCE plume covering 50 acres
  - Seven miscellaneous SWMUs with various COCs
- PBC awarded and managed by U.S. Army Corps of Engineers, Tulsa District
  - AFCEE provides remedial program execution and oversight
  - 10 year period of performance (2004-2014)
  - 2002 Air Force Report to Congress completion date was 2029+
- Contract performance objective was fence-to-fence responsibility for all environmental liabilities. Prime objective was to close all sites
  - Site/regulatory closure – SWLF & POL Area
  - OPS for Tower Site w/eventual closure
  - O&M of existing pump and treat systems – compliance plan under Texas RRS
  - EPA RCRA 7003 Order compliance and satisfaction
- Total Cost was 64% of the CTC including 100% cost-cap/PLL insurance

Former Reese AFB Environmental Sites



Pre-PBC Cleanup History

- 1996 Basewide RFI – over 35 SWMUs were identified
- Three major active remediation systems constructed:
  - Tower Area Pump-and-Treat
  - Southwest Landfill Pump-and-Treat
  - POL Area SVE System
- Several large landfill caps constructed
- CTC and LOE estimates escalated annually

PBC Strategy

- Site was “fully characterized” prior to RFP
- Fence-to-Fence Approach
- Allow for Cost-cap and PLL insurance to cover uncertainties
- All inclusive approach
  - Public involvement programs
  - Compliance reporting and permitting
  - Property transfer responsibilities (e.g., surveying)
  - LUC/IC compliance
  - Site restoration including system demolition and well abandonment

Status at Transfer to ARCADIS

- Three contractors performing integrated duties
- Construction complete (almost) on all remedial systems required by Compliance Plan
- All systems operating Properly and Successfully (OPS pending) – hydraulic control of the GW Plume
- High Performing BCT with long term members

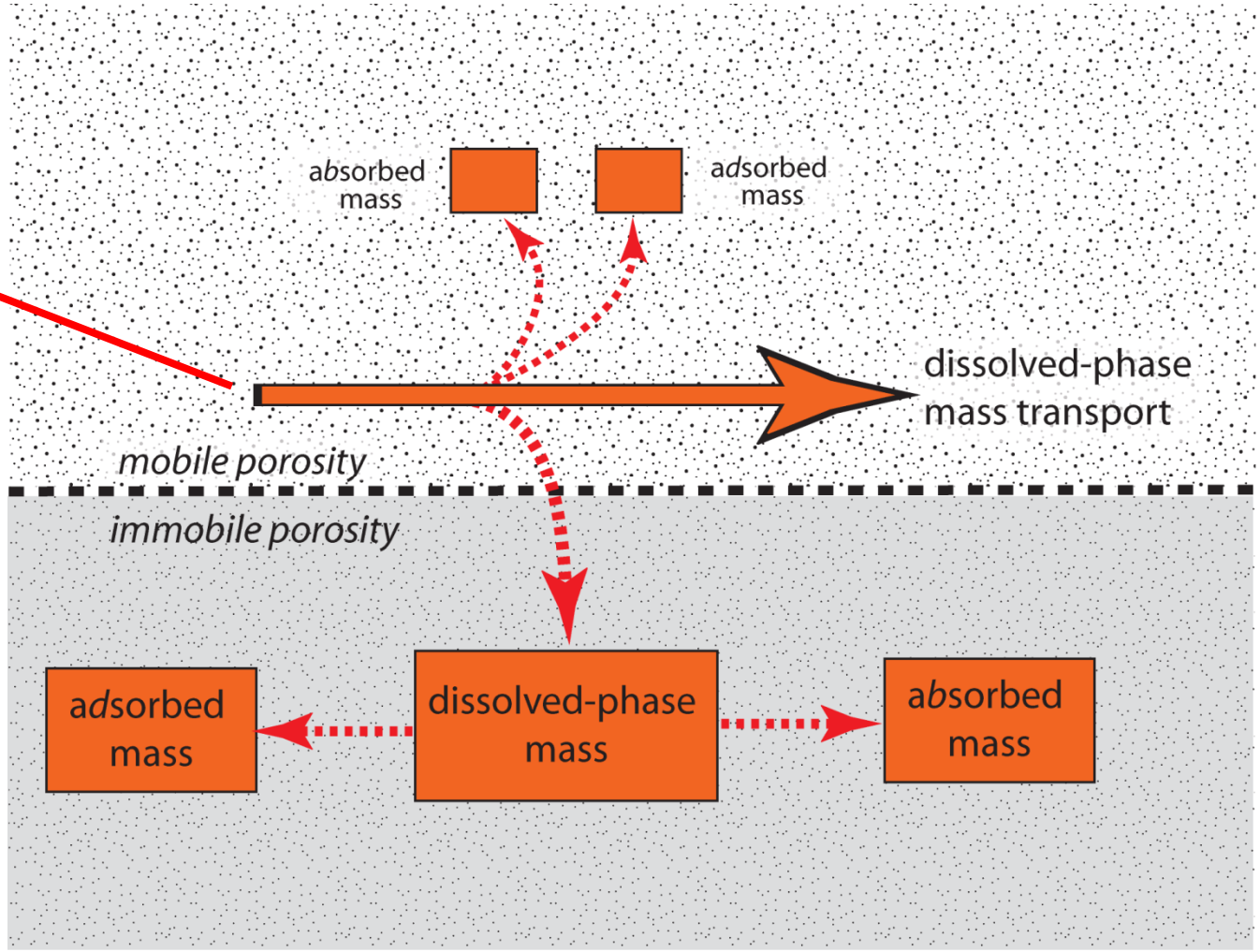
Principle Site Remediation Challenge – TCE Transport and Storage in the Dispersed Plume

Discussion Outline

- Importance of higher-resolution mapping
- Dissolved-phase storage: concept; site-specific issues; achievable endpoints
- Impact of horizontal anisotropies on transport: concept and site-specific
- ERD for treatment of TCE in interbedded source zones
- Key to Success – Continual re-assessment of the site conceptual model and corresponding adjustments to the remedy

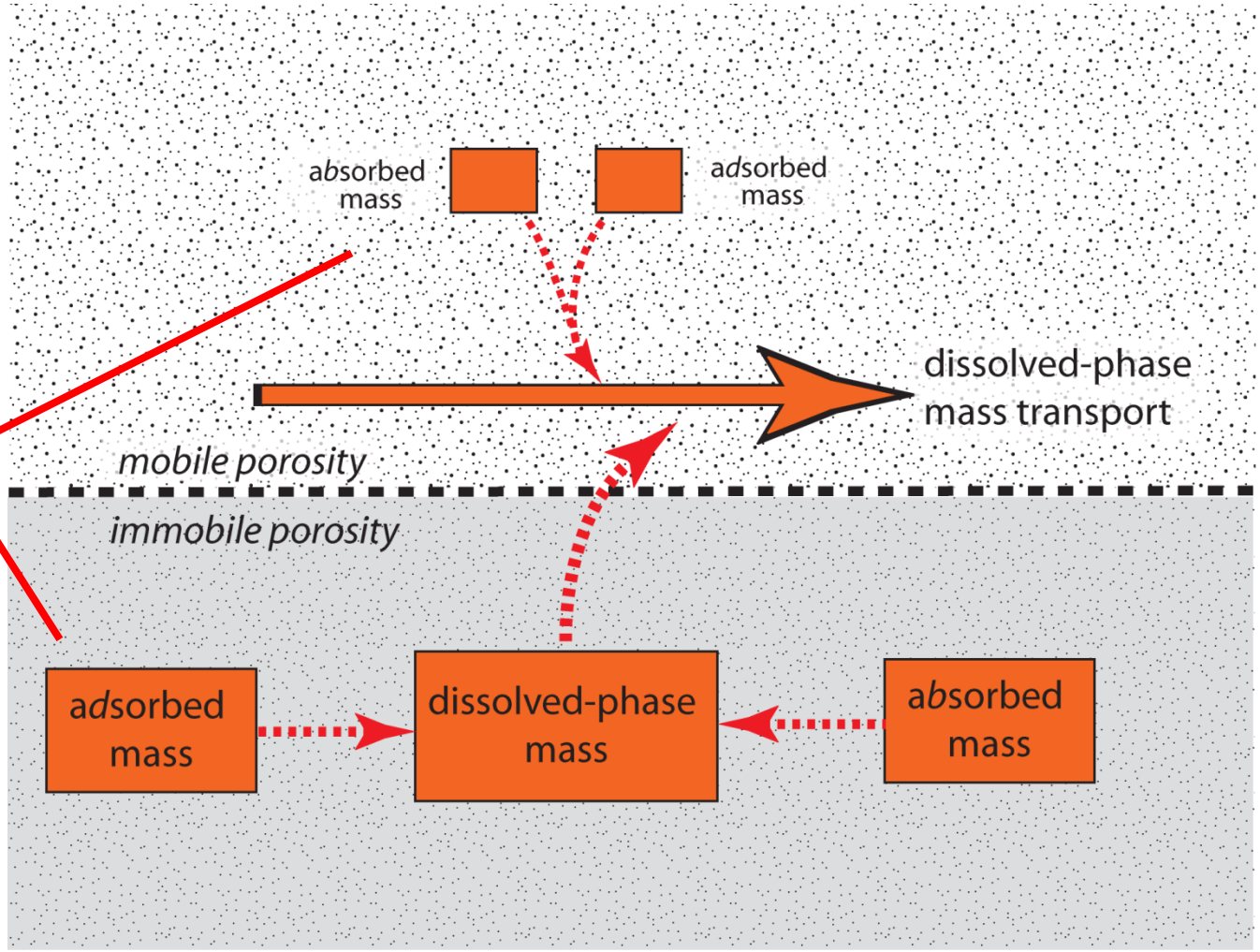
A Multi-Compartment Model of Solute Transport

This is what a monitoring well "sees" and contaminants diffuse from the high-K flow zones into low-K zones



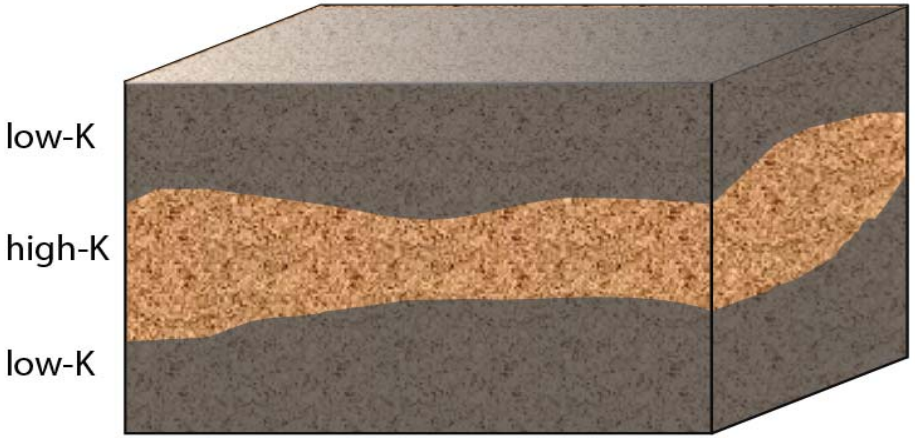
A Multi-Compartment Model of Solute Transport

Back-diffusion from stored mass causes rebound and long treatment times



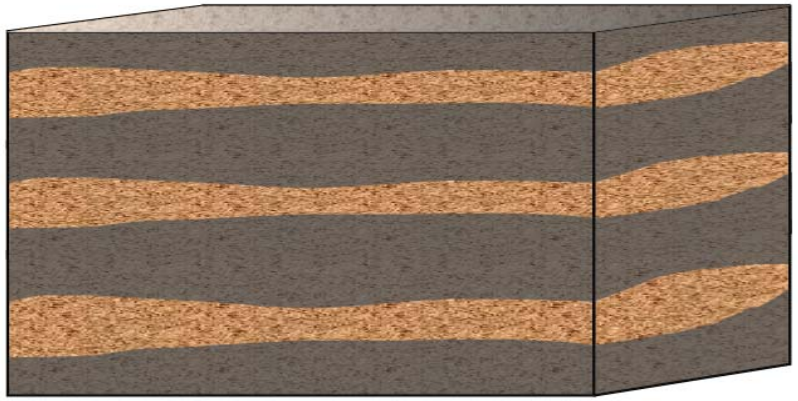
Aquifer Matrix Challenges

- **Two aquifer blocks with equal:**
  - Average hydraulic conductivity
  - Mobile porosity
  - Groundwater transport velocity



low mass transfer

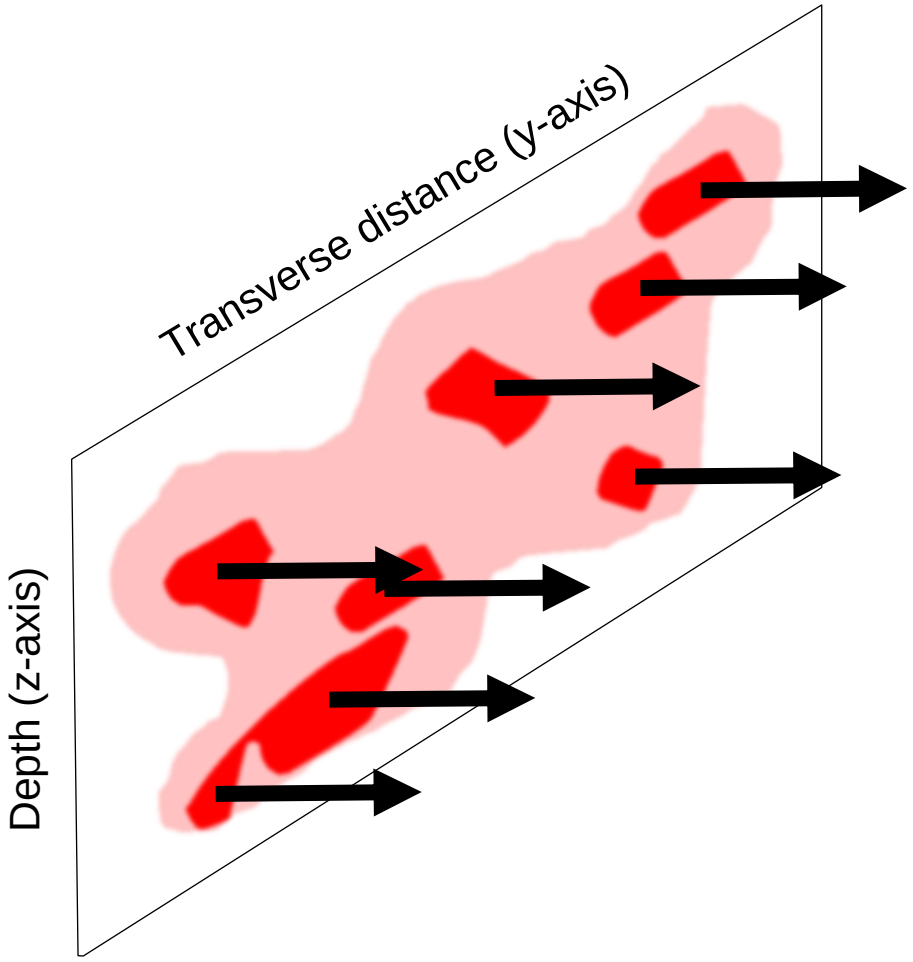
- **In the high-mass-transfer geometry, the rate of diffusive migration into the low-K zones is approximately 10-fold greater than for the low-mass-transfer case.**


high mass transfer

Three Premises on Getting Plumes to Closure

- Aquifer matrix structure, chemical properties and exposure duration control how easily we can get to site closure.
- For small plumes, intensive remedial action can often defeat the matrix structure and exposure duration problems, allowing us to reach a cost-effective site closure.
- For large plume footprints, intensive treatment of the entire footprint is normally not affordable and we work toward site closure with a combination of active treatment zones and zones of clean water flushing. In these cases, the target compound, the age of release and the aquifer matrix structure are all critical determinants in how easily we get to closure.

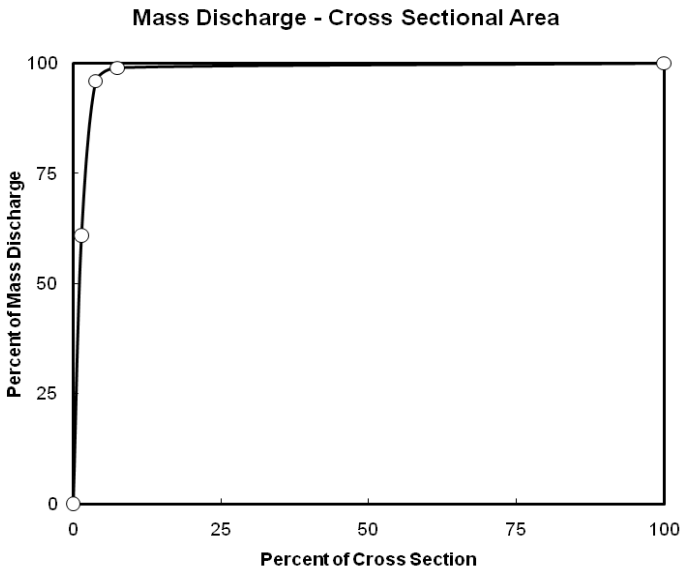
Three Lessons Learned in Groundwater Restoration

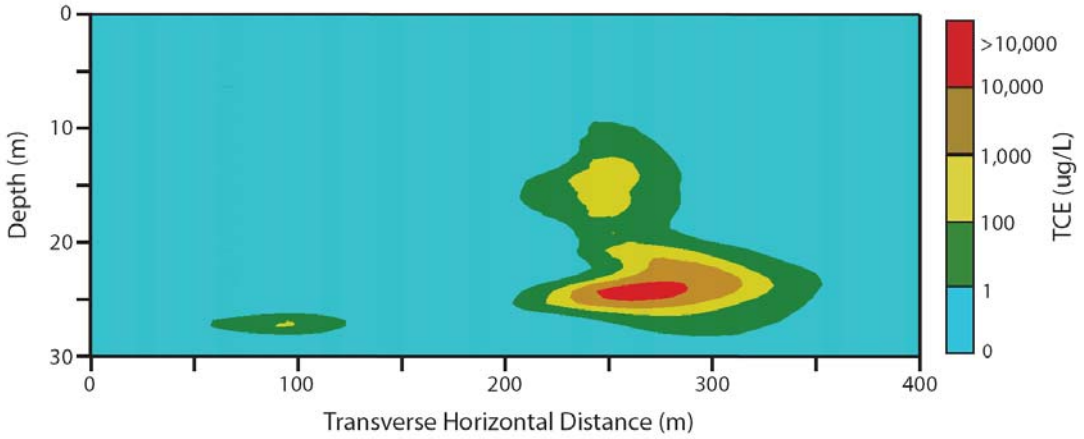


1. Groundwater flow (and target compound mass transport) is often concentrated in a small portion of the aquifer cross-section

Example: Muskegon, Michigan Site

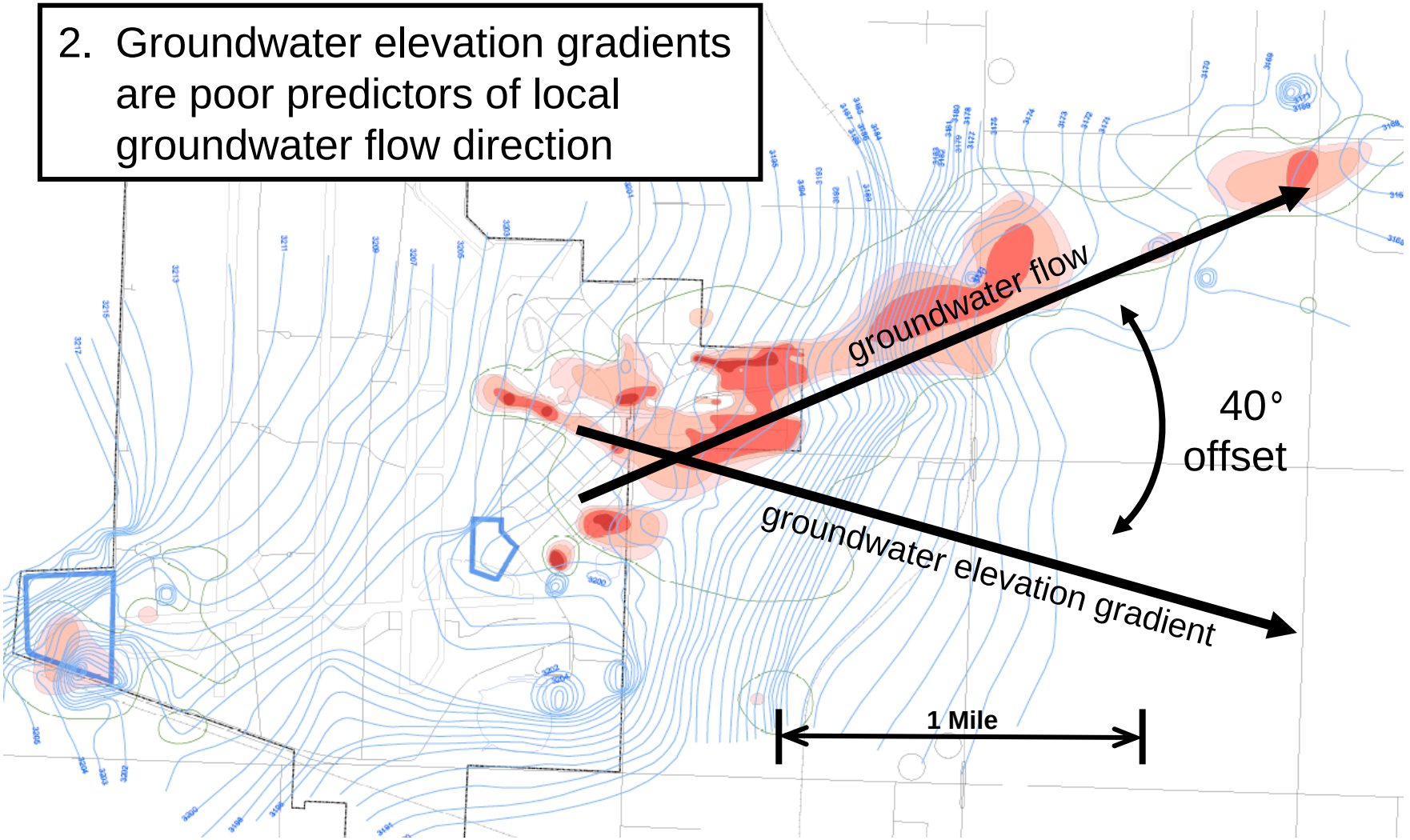
- More than 95% of the mass discharge occurs in less than 10% of the cross-section
- High-definition plume mapping will focus remedy





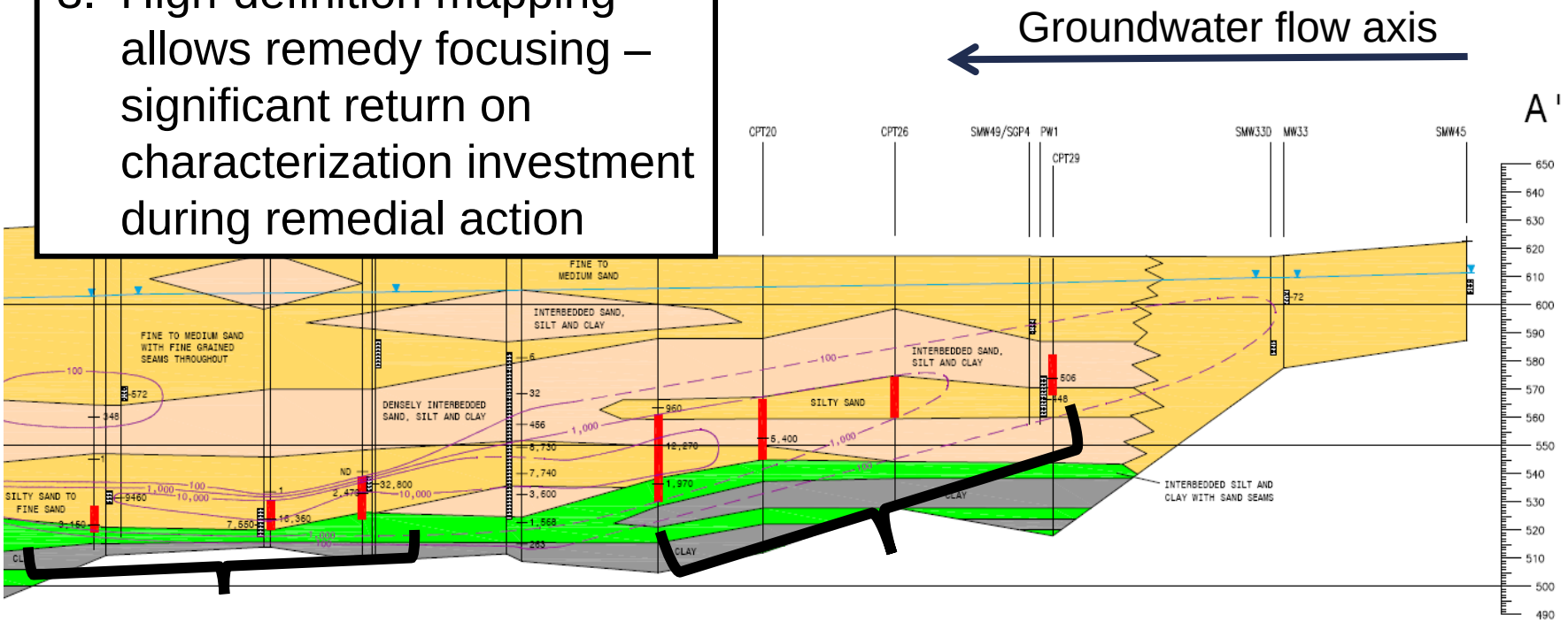
Three Lessons Learned in Groundwater Restoration

2. Groundwater elevation gradients are poor predictors of local groundwater flow direction



Three Lessons Learned in Groundwater Restoration

3. High-definition mapping allows remedy focusing – significant return on characterization investment during remedial action



Invasion front, with mass concentrated in higher-flow zones

Mature plume area with mass concentrated in lower-flow (especially interbedded) zones

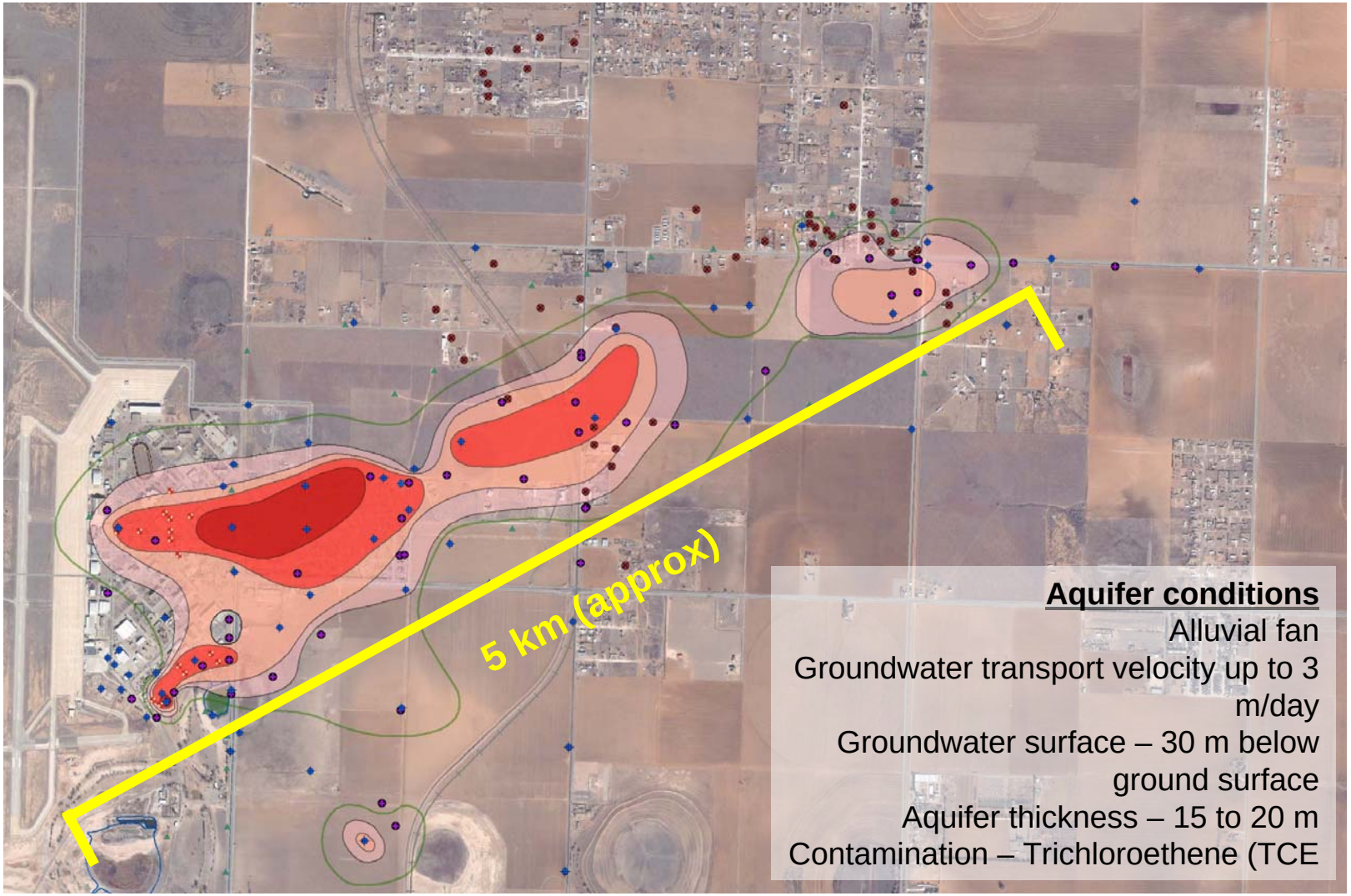
Three-Fold Characterization Strategy

1. **Direct mapping framework**: geology and target compound sample collection to build a rudimentary three-dimensional mapping;
2. **Interpolation** (extending the mapping between points of direct observation) and **extrapolation** (extending the mapping outside the range of direct observations) – for example, hydrostratigraphic analysis to form an interpolated mapping from the explicit mapping points and to guide further sample collections, and;
3. **Stimulus-response** and **hypothesis testing** – on-going refinement of the target compound distribution and hydrogeology interpretations in response to pumping and injection trials, remedy pilot testing and other transient-state system observations.

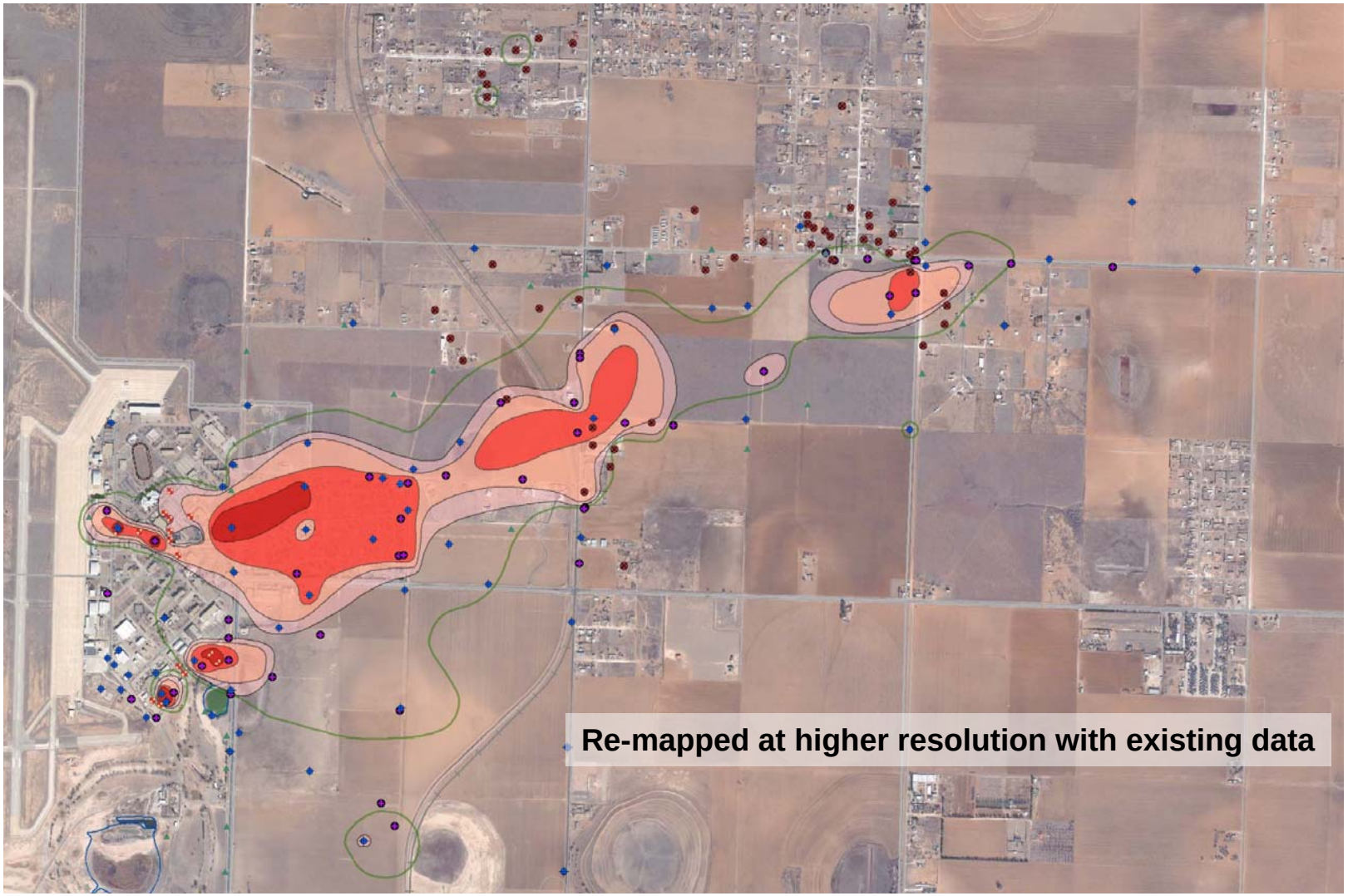
Basic Approaches to Building Scale-Dependent Characterization Datasets

- Direct Characterization
  - Discrete-interval samples
  - Continuous lithologic logs
  - Hydraulic profiling
- Interpolation and Extrapolation
  - Hydrostratigraphic analysis
  - Geophysical testing
- Stimulus-Response Testing
  - Tracer injection
  - Slug and pumping tests – focus on transients

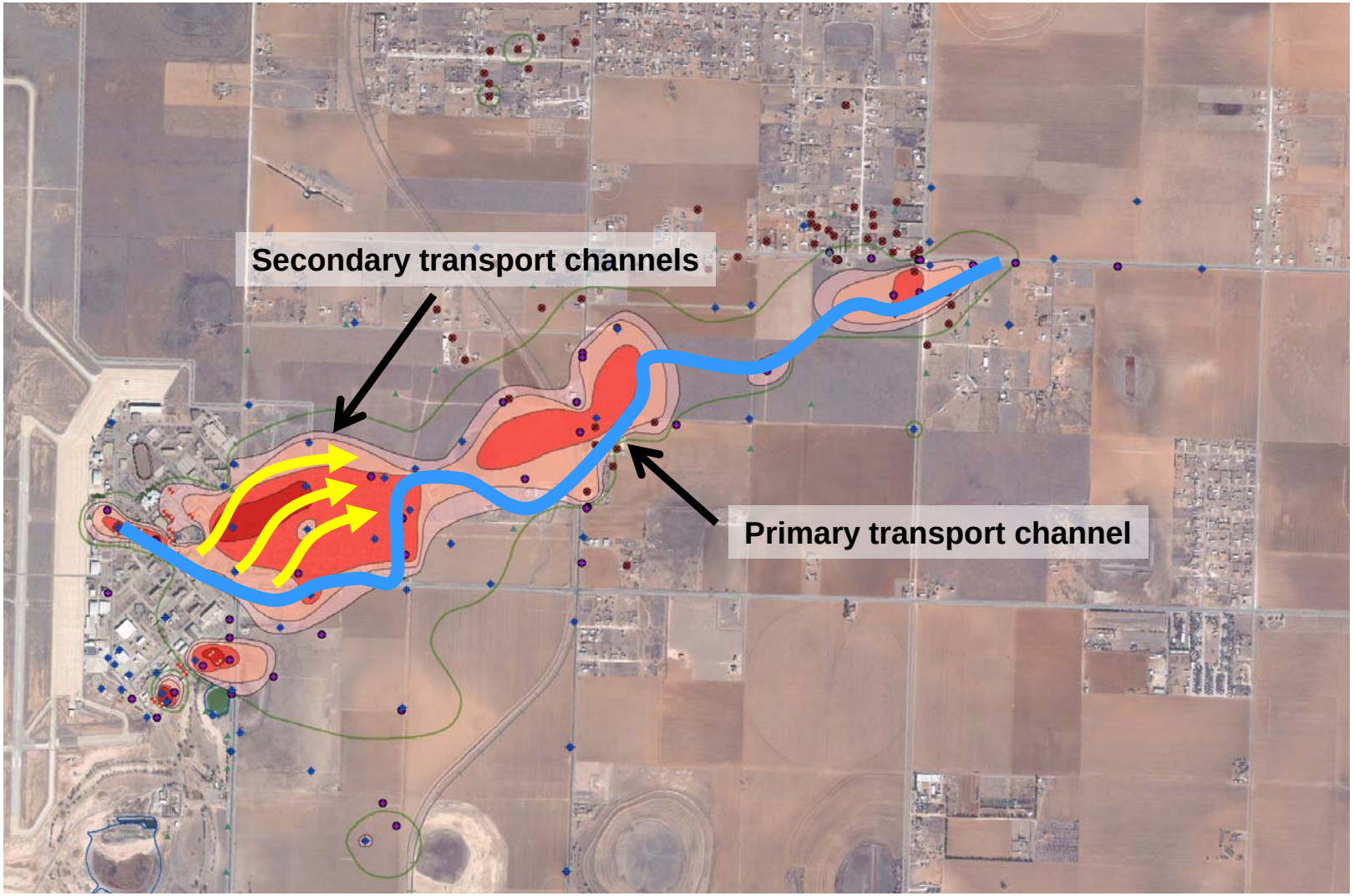
2005 Tower Area Plume



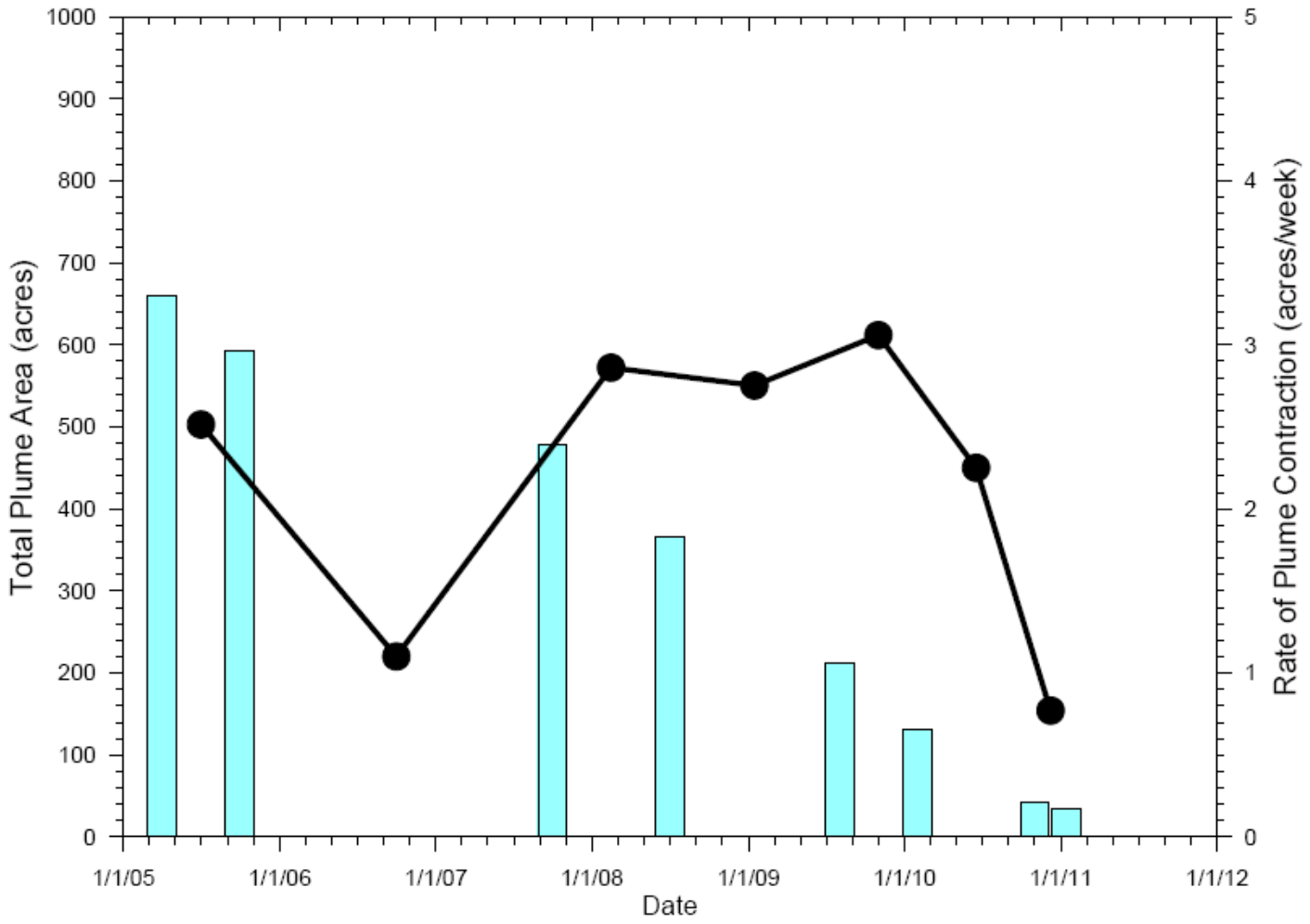
2007 Tower Area Plume



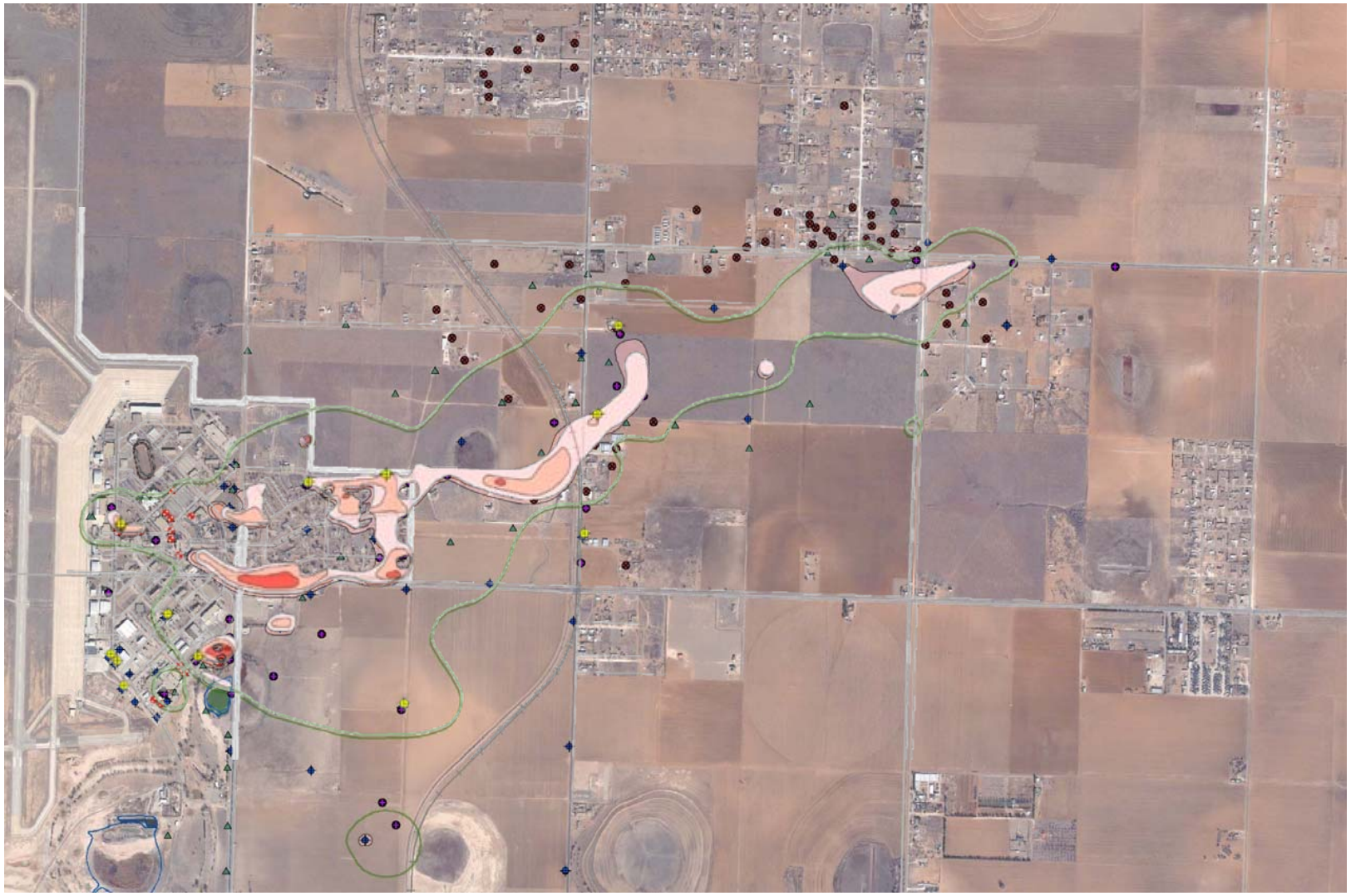
2007 Tower Area Plume Hydrogeologic Interpretation



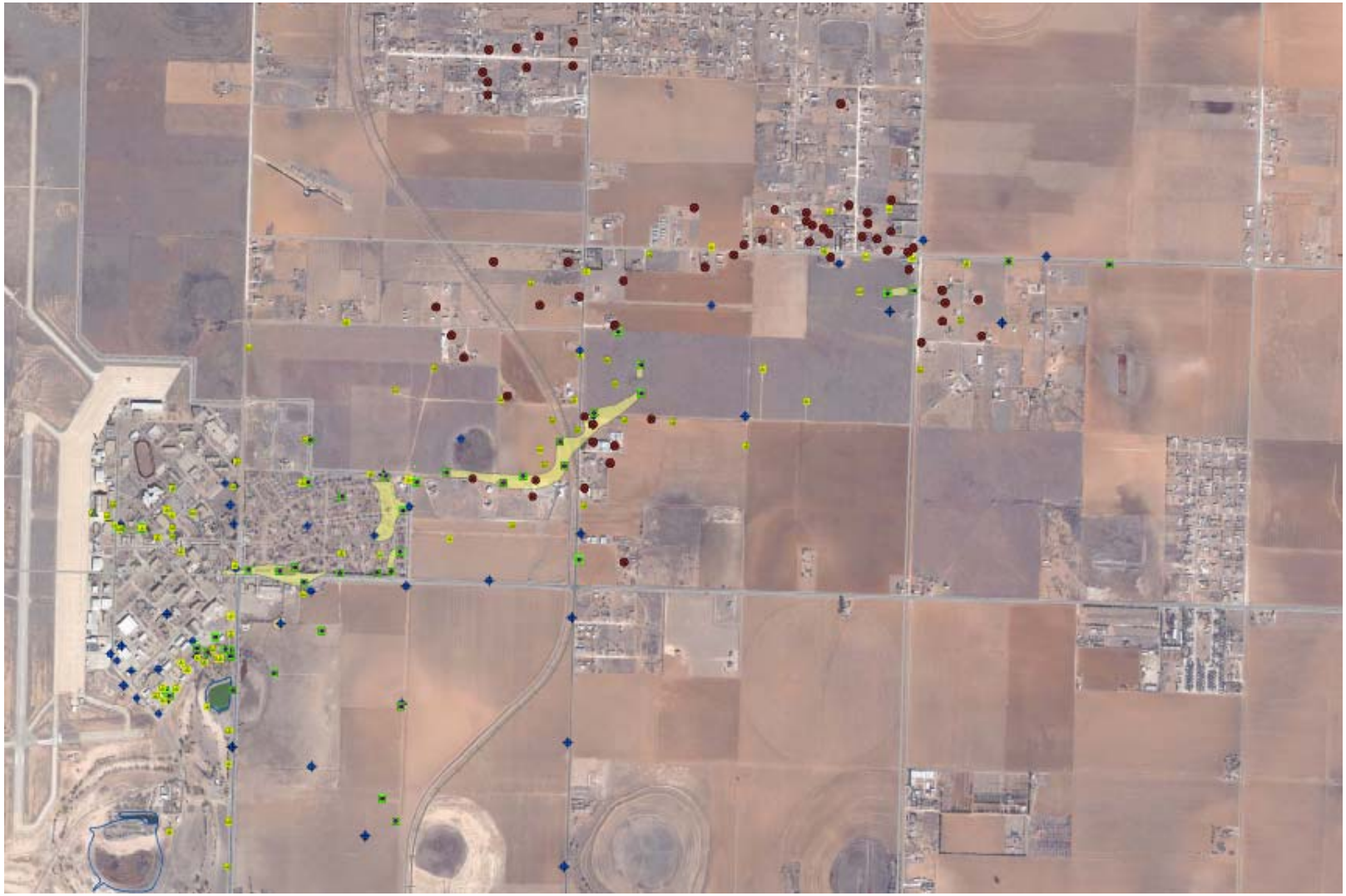
Maintaining the Pace of Remediation



2010 Tower Area Plume



2011 Tower Area Plume



Estimated Completion Dates

Area	Primary Remedy	Completion of Active Remediation	Completion of Post Closure Monitoring
Southwest Landfill	Groundwater Extraction	2010	2012
Tower Area Plume	Combined Remedies	2012	2014
TP-Area 1	Enhanced Bio / P&T	2012	
TP-Area 2	Groundwater Extraction	2012	
TP-Area 3	Enhanced Bio / P&T	2011	
TP-Area 4	Groundwater Extraction	2011	
TP-Area 5	Groundwater Extraction	2011	
Petroleum, Oil and Lubricants Area	Enhanced Bio / P&T	2011	2013

Why are MCLs Possible at This Site?

- **Site Hydrogeology**
  - No DNAPL was found below the aquifer surface
  - Vadose zone source mass was completely removed
  - Fast flowing, low-mass-transfer groundwater system
  - Diffusive interaction limited – no significant mass storage
- **Site Characterization**
  - Hydrogeology and conceptual site model continually re-assessed
  - Remedy adjusted as-needed
- **Regulatory**
  - Allows flexibility in site operation
  - Collaborative environment
- **Relations with Adjacent Landowners**
  - Gaining site access where it was previously denied
  - Maintaining good working relationships was critical to the success of this project