Use of Mass Discharge as a Performance Metric in CERCLA Decision Documents

Case Study of the Time Oil Well 12A Site

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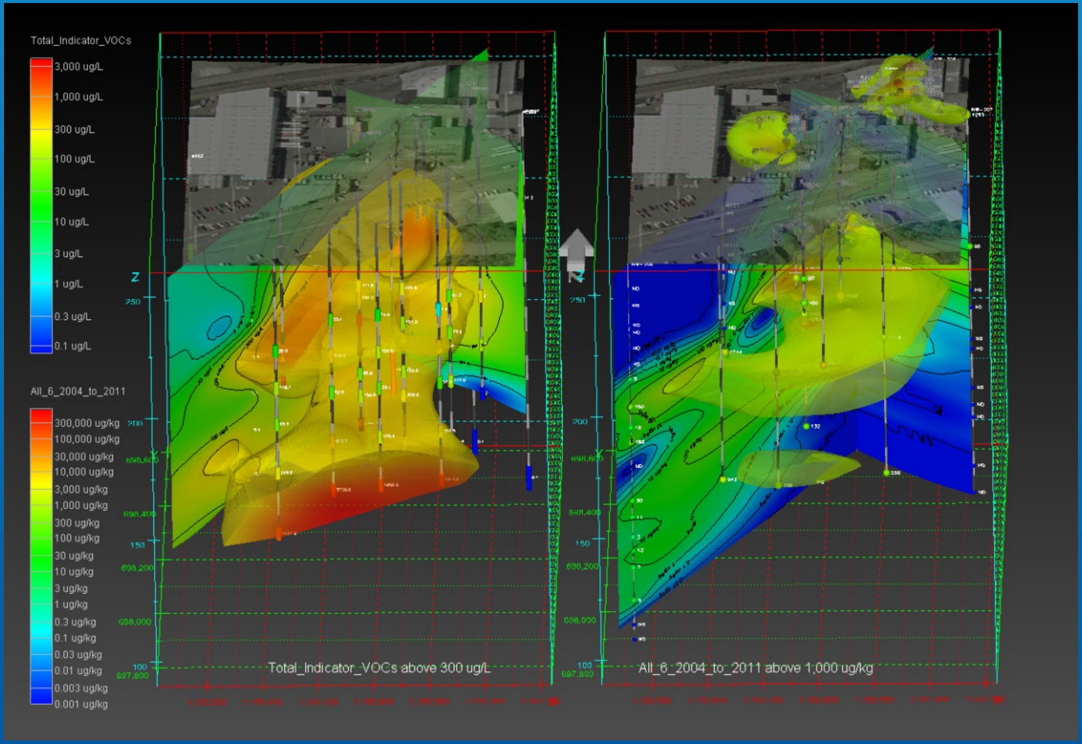
- Kira Lynch
- Howard Orleans (EPA Region 10)
- Tamzen Macbeth (CDM Smith)

Presentation Context

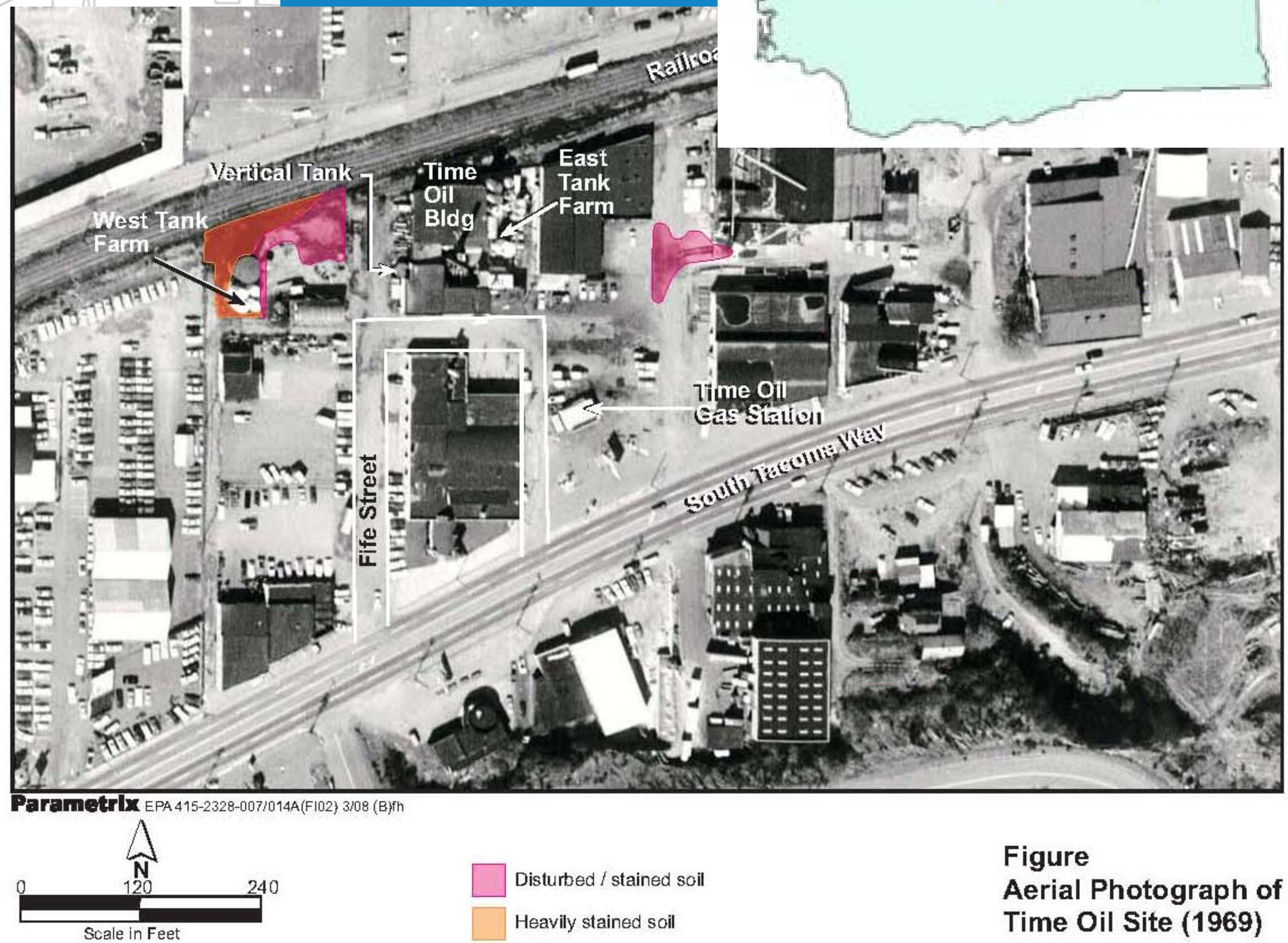
- Many CERCLA decision documents for dense non-aqueous phase liquid (DNAPL) site remediation lack clear remedial action objectives for determining and documenting when sufficient source treatment has been completed.
- Mass flux /discharge can be used to document when source treatment is considered "complete" and long-term groundwater restoration projects considered operational and functional.
- Discuss how mass flux /discharge goals can be incorporated into long-term plume management strategies with ultimate goals of meeting Maximum Contaminant Levels (MCLs).

Well 12a Case Study:
Applying Mass Flux/Mass Discharge

- Well 12A is a case study for how to evaluate a Remedy treatment of dense non-aqueous phase liquid (DNAPL) source.
- Discuss the process of how mass flux/discharge was incorporated into:
  - Record of Decision (ROD).
  - Technology Selection,
  - Remedy Design,
  - Optimization of the Remedy



Site Location

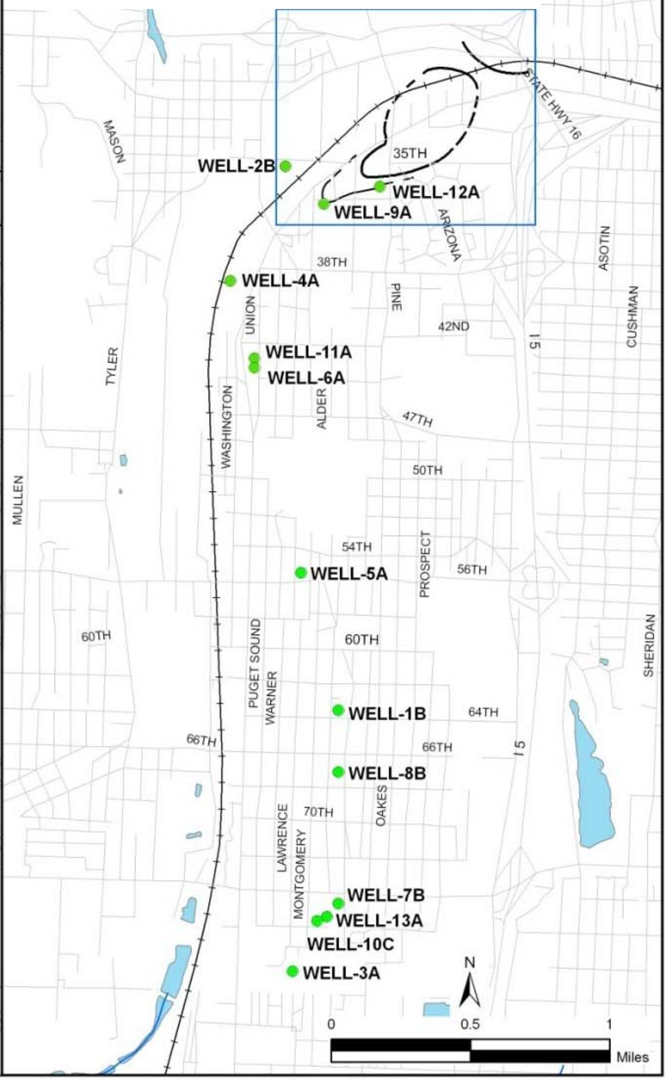


Contamination Summary

- Six COCs in soil and groundwater
  - PCE
  - TCE (ubiquitous)
  - cis-1,2 DCE
  - trans-1,2 DCE
  - Vinyl Chloride
  - 1,1,2,2-PCA

2D Perspective: TCE Plume

Tacoma supply wells are green symbols



Historical RA Summary

- 1983- Original signed ROD
  - Wellhead treatment system at Well12A
- Groundwater Extraction Treatment System (GETS)
  - 1988 – 2001
  - 550 million gallons of groundwater extracted/treated,
  - removed 16,000 pounds VOCs
- Vapor Extraction System (VES)
  - 1993 – 1997/Removed 54,100 pounds VOCs
- Filter cake/contaminated soil removal
  - BNRR excavated 1,200 cy along rail line
  - VES construction/removed 5,000 cy of filter cake

Desired End State

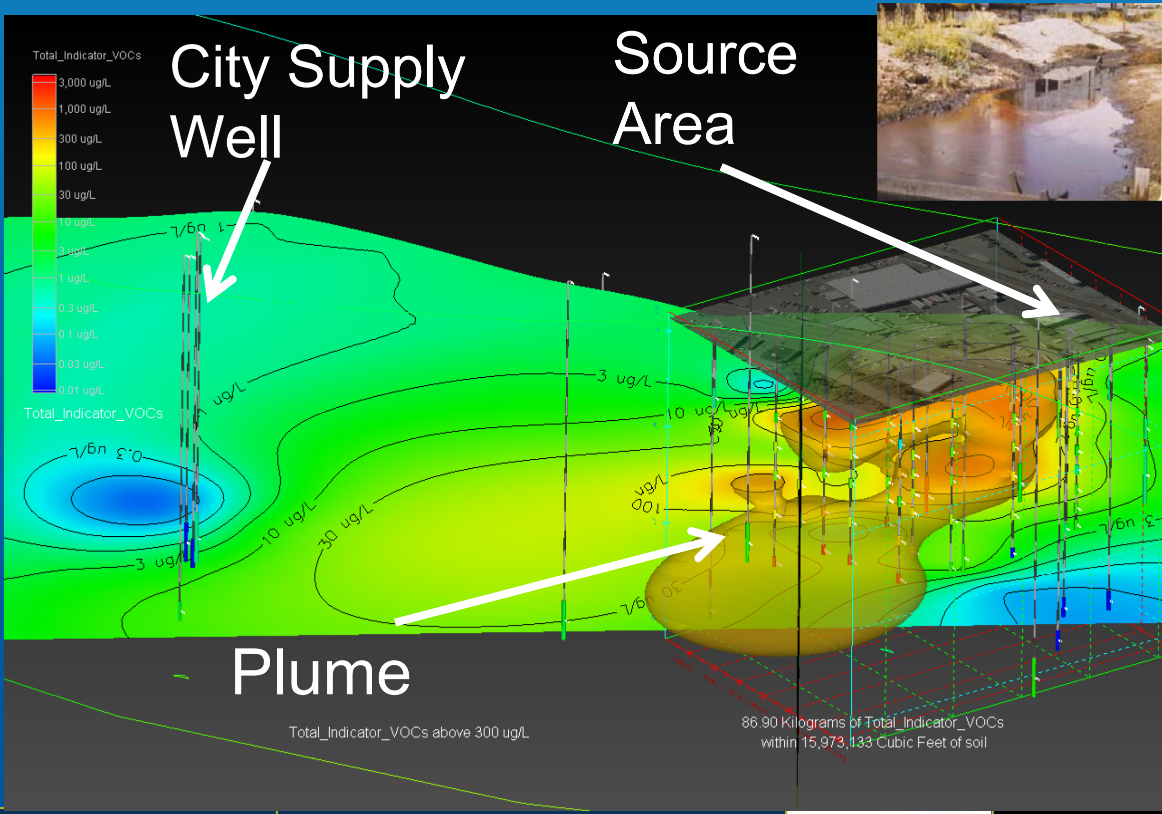
- Adequate use of robust source removal technologies.
- Timely transition to cost-effective 'polishing' step(s).
- Reduce/eliminate need for pump and treat.
- Appropriate reliance on monitored natural attenuation (MNA).
- Adaptive, flexible implementation
  - *"Sources begin to reveal themselves as remediation progresses"*

Building the Well 12A Remedy

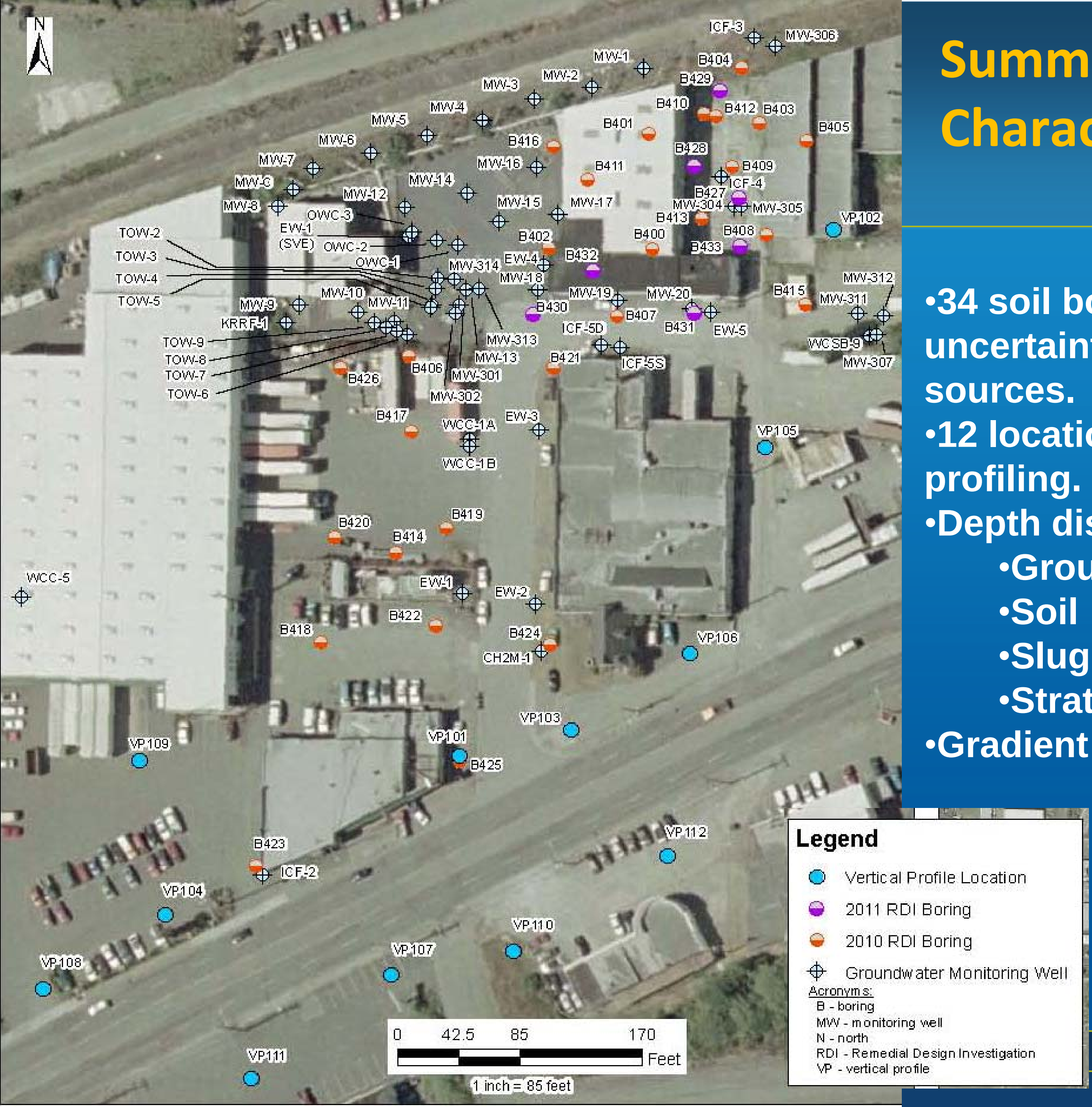
Focused Feasibility Study evaluation: Reduce source strength (Md) by 90%, MNA sufficient to achieve **compliance**

ROD amendment: Multi-component remedy- reduce source discharge Md by 90% & transition technology (if necessary)

- **Well 12A Superfund Site, WA**
  - Performance metric → remedy Operational and Functional



Summary of Site Characterization



- •34 soil borings to reduce uncertainty and delineate sources.
- •12 locations for vertical profiling.
- •Depth discrete samples:
    - •Groundwater
    - •Soil
    - •Slug testing.
    - •Stratigraphy
- •Gradient assessment.

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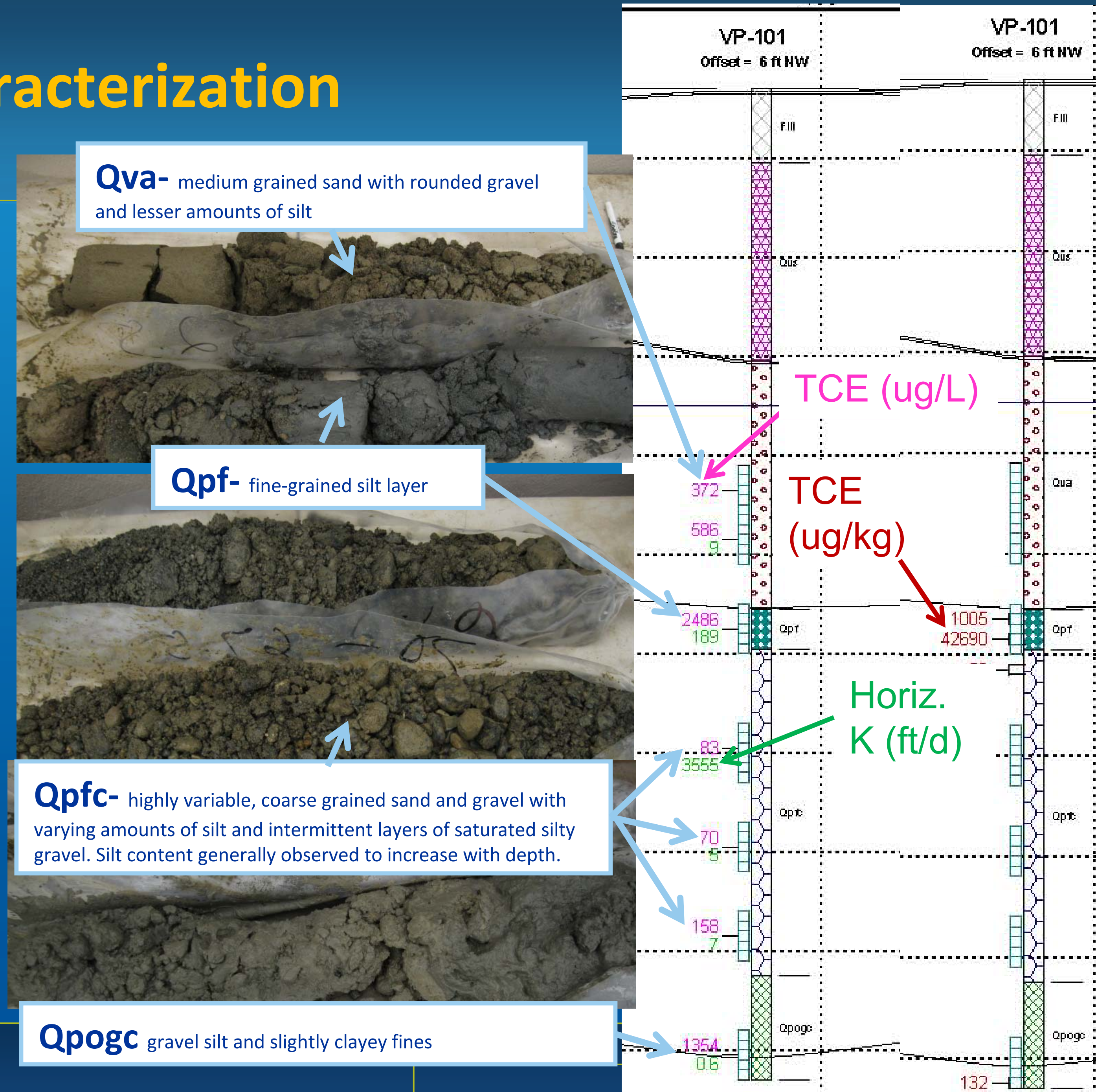
Vertical Characterization



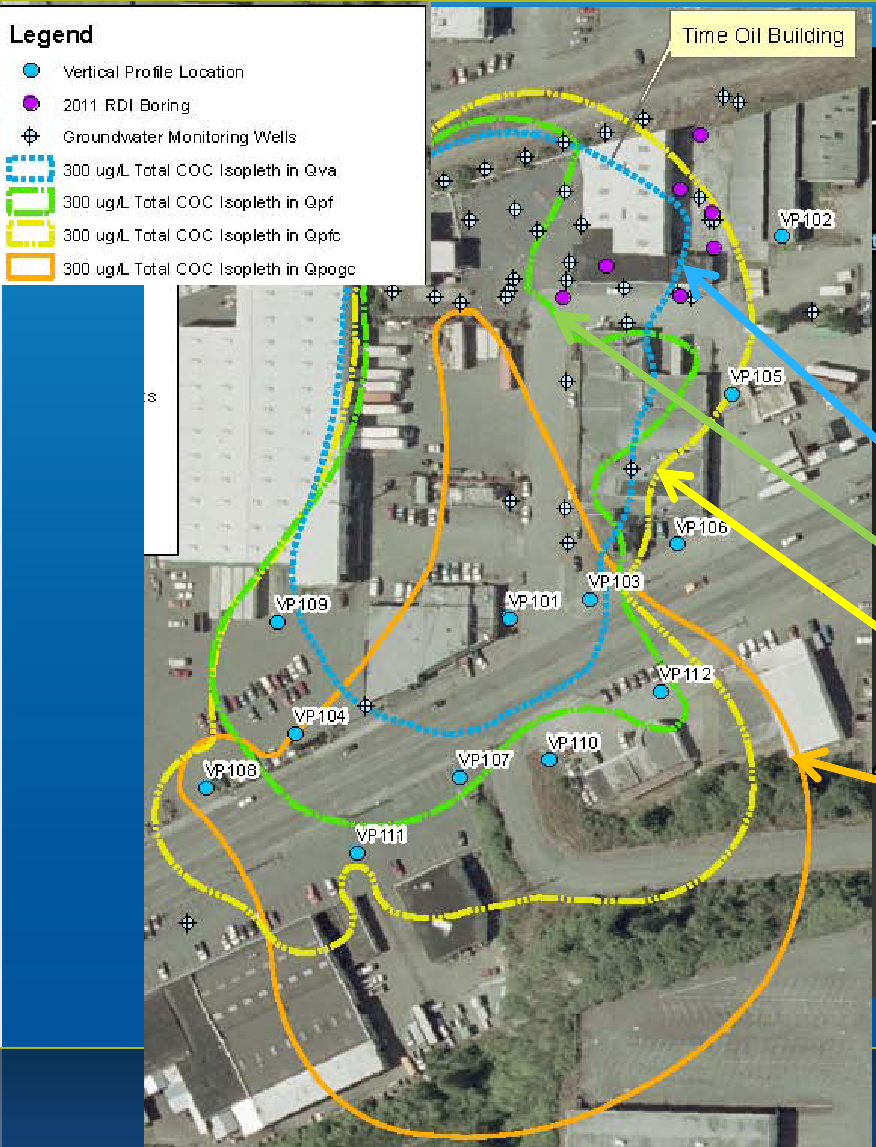
Hydraulic Conductivity: Slug Testing

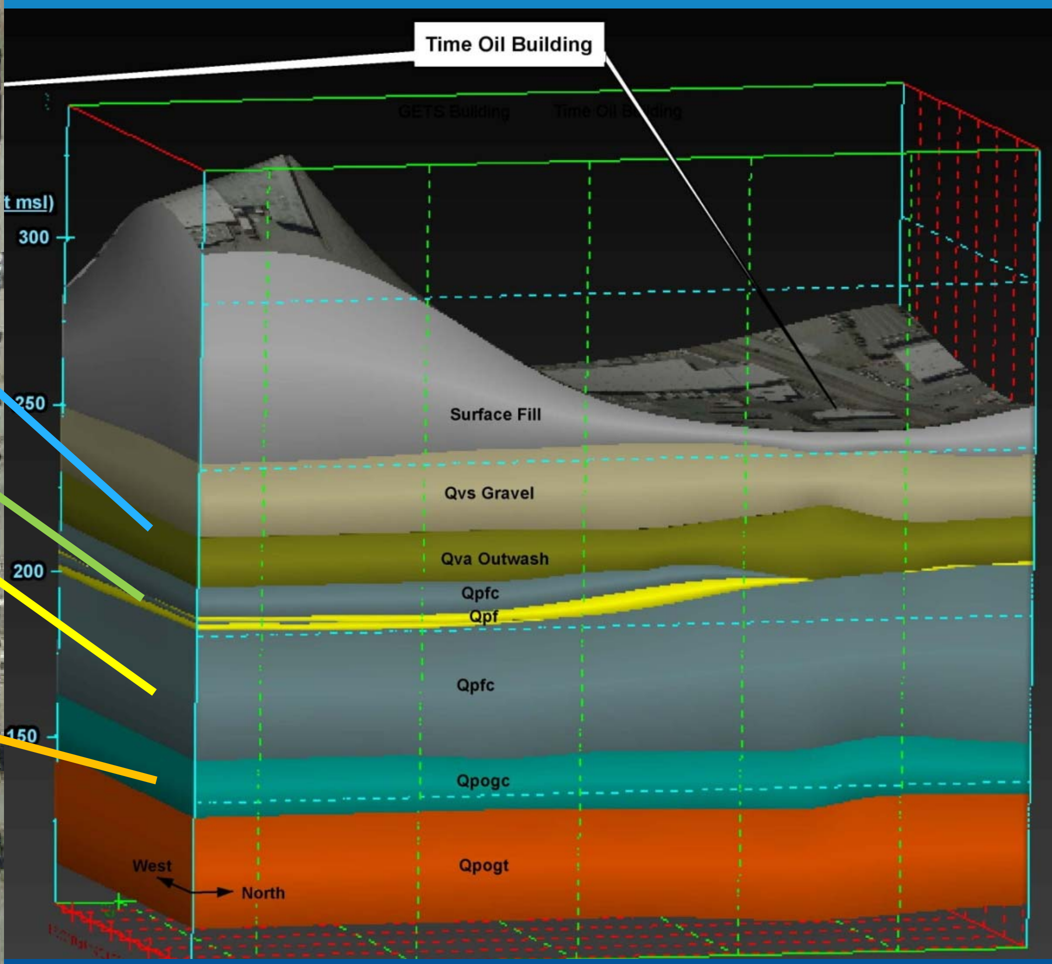
Stratigraphic Unit	Range Horizontal K (ft/d)	Average Horizontal K (ft/d)	Vertical K (ft/d) [a]
Average K per Stratigraphic Unit Used in MVS			
Qva	7-56 (n=4)	21	5.18
Qpf	0.12-0.5 (n=2)	0.3	NA
Qpfc	0.5-3555 (n=14)	293	0.79
Qpogc	0.6-2 (n=5)	1	0.30
Qpogt	0.5 (n=1)	0.5	0.03

Average K per Depth Measured in Qpfc

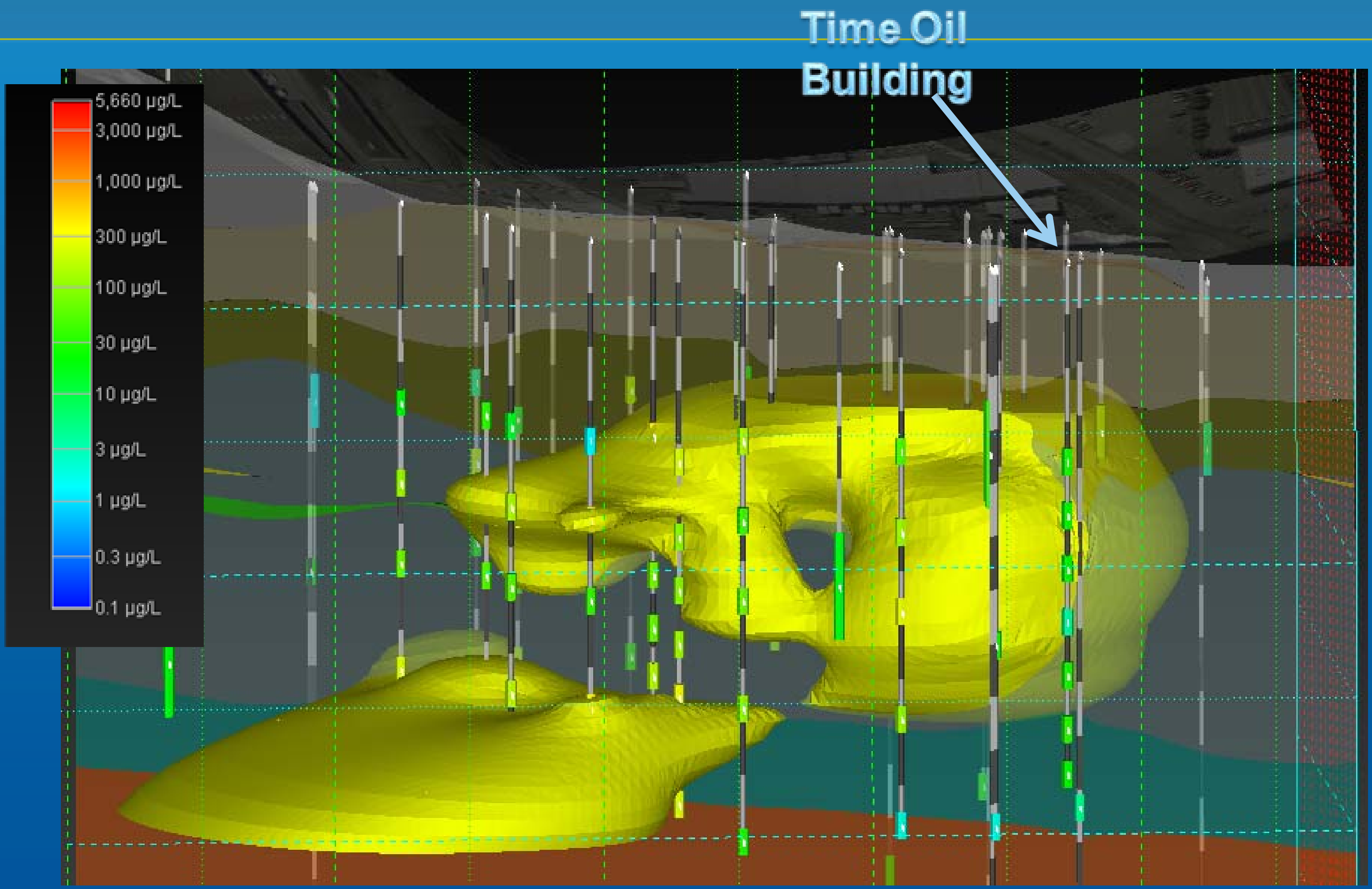
	Depth Interval (ft bgs)	Number Samples	Horizontal K (ft/d)
Qpfc1	50-60	5	35
Qpfc2	70-75	5	782
Qpfc3	80-90	4	2

Vertical Stratification of the Groundwater Contaminant Plume

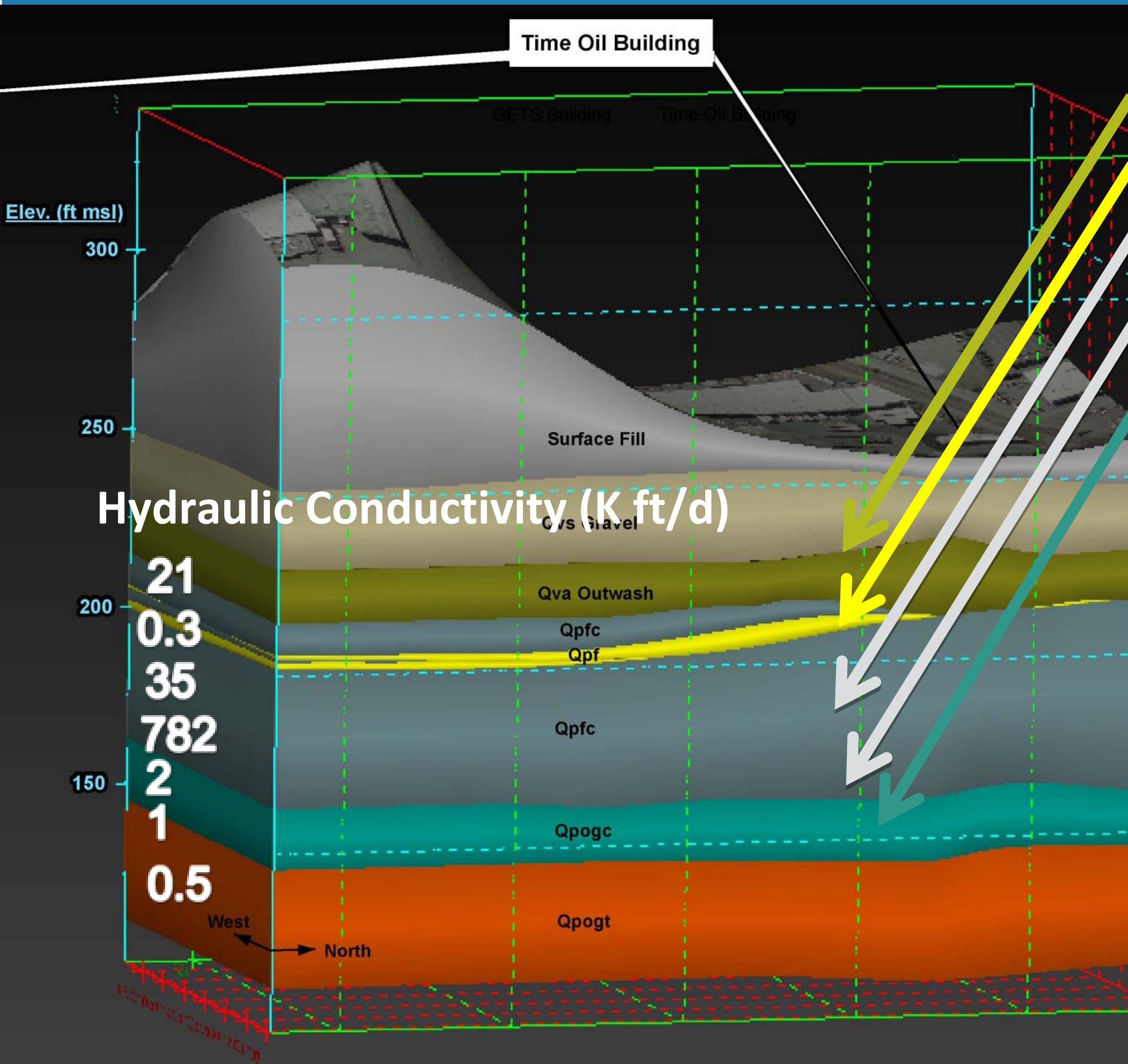




Cross Section of Contaminant Plume



Mass Discharge Across Transects

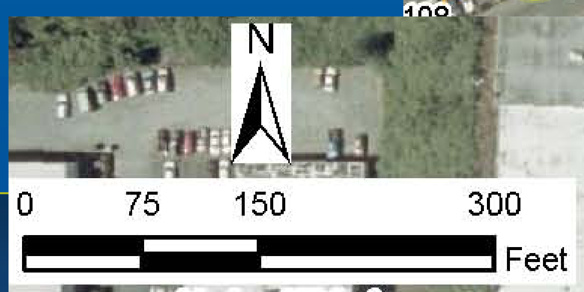


	Total VOC MD (kg/yr)	% of Total MD
Transect 1		
Qva	0.1	1%
Qpfc1/Qpf	2.9	31%
Qpfc2	5.9	64%
Qpfc3	0.06	1%
Qpogc	0.3	4%
Total	9.3	
% of Total		
Transect 2		
Qva	0.01	0.4%
Qpfc1/Qpf	0.2	7%
Qpfc2	1.7	57%
Qpfc3	0.1	3%
Qpogc	1.0	33%
Total	3.0	

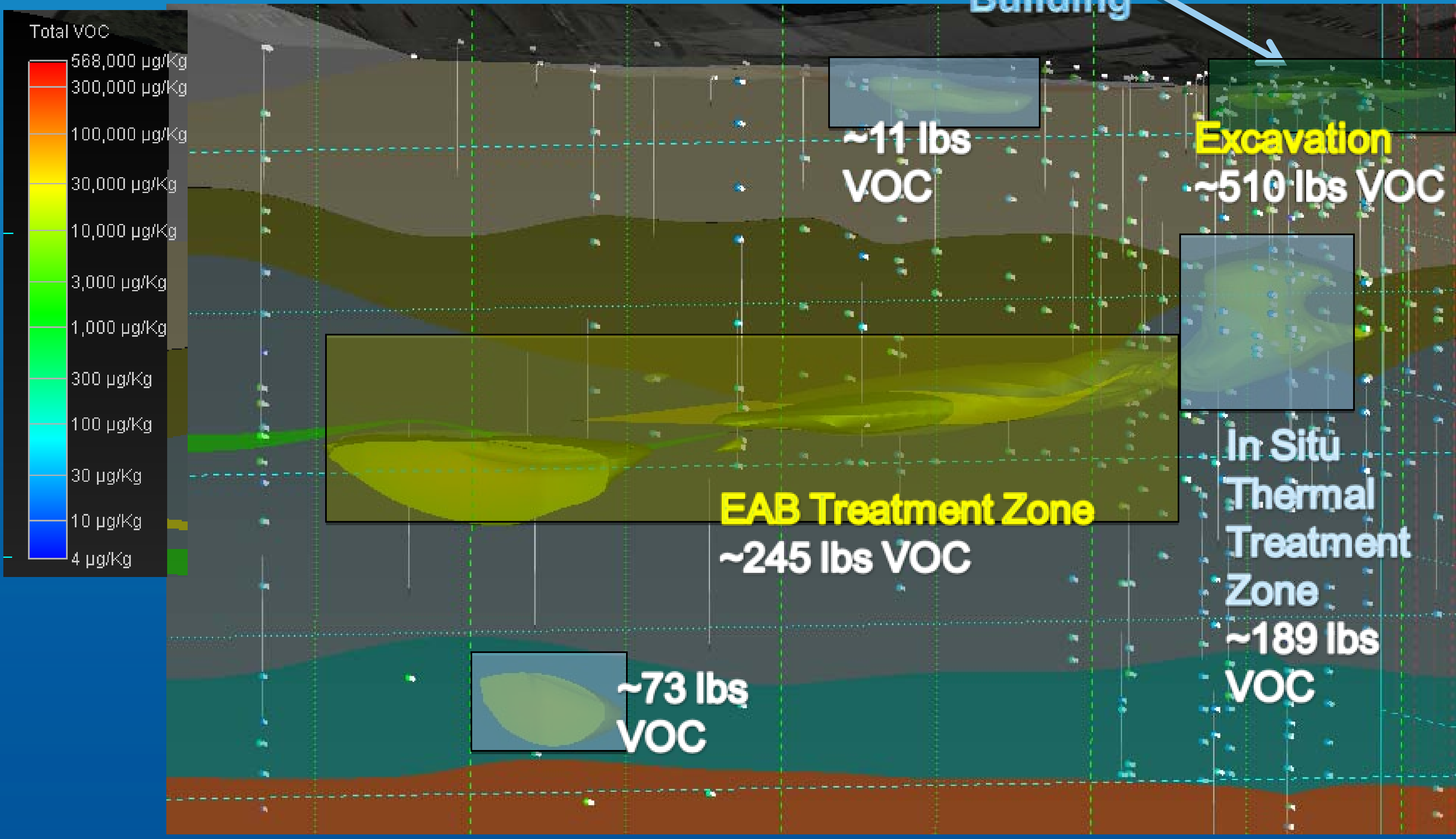
96%

Mapping Technologies

Zone	Surface Area (ft^2)	VOC Mass (kg)	% Discharge to GETS
Excavated Zone	3819	510	NA
Thermal Treatment Zone	11,746	~189	70 kg/yr
In Situ Bioremediation	162,005	~245	25 kg/yr



Treatment Zones: Selecting Vertical Intervals



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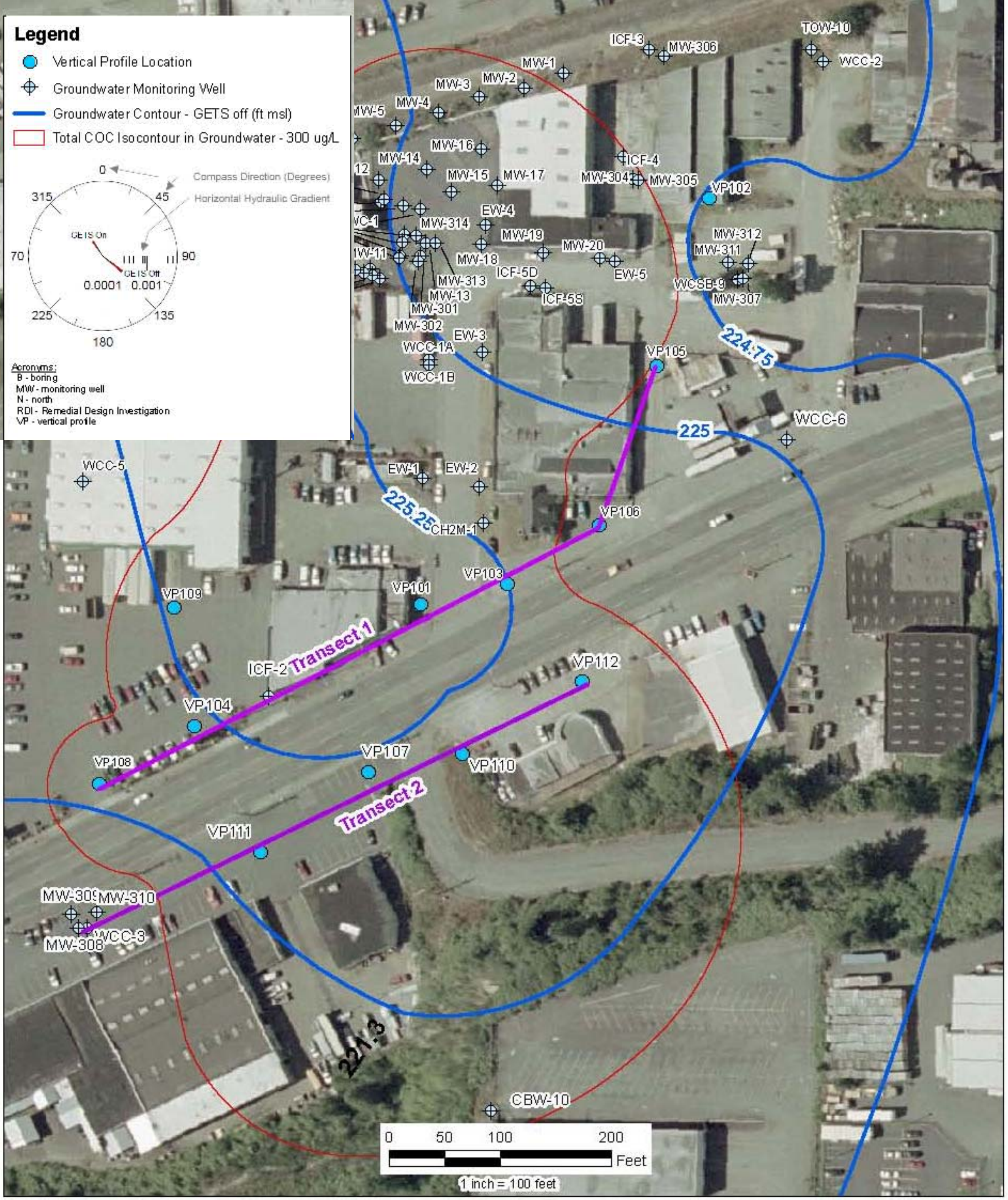
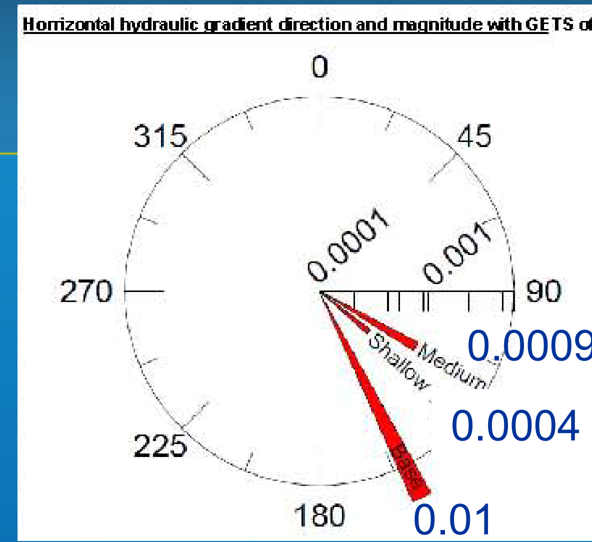
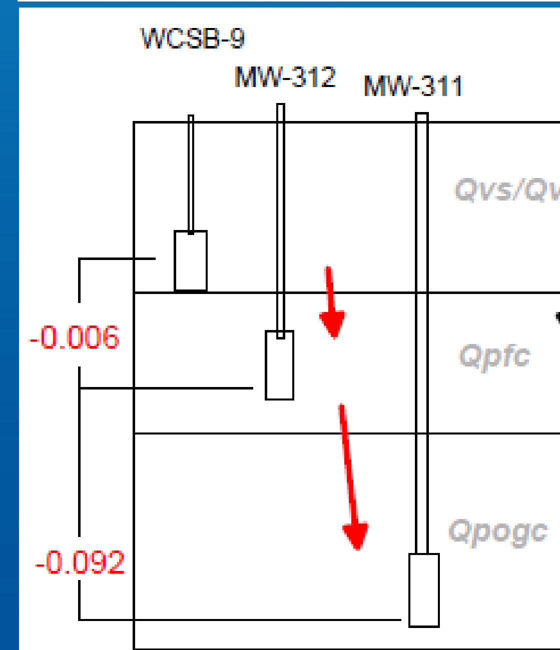
Challenges with Mass Discharge at Well 12A

- Assessing impacts from secondary sources, residual phase contaminants and back diffusion from low permeability layers.
- Managing complex hydraulics, including substantial changes in gradient magnitude and direction due to seasonal variations and operating Well 12A.
- Obtain realistic parameters such as porosity and hydraulic conductivity within vertically-discrete zones within the contaminant plume.

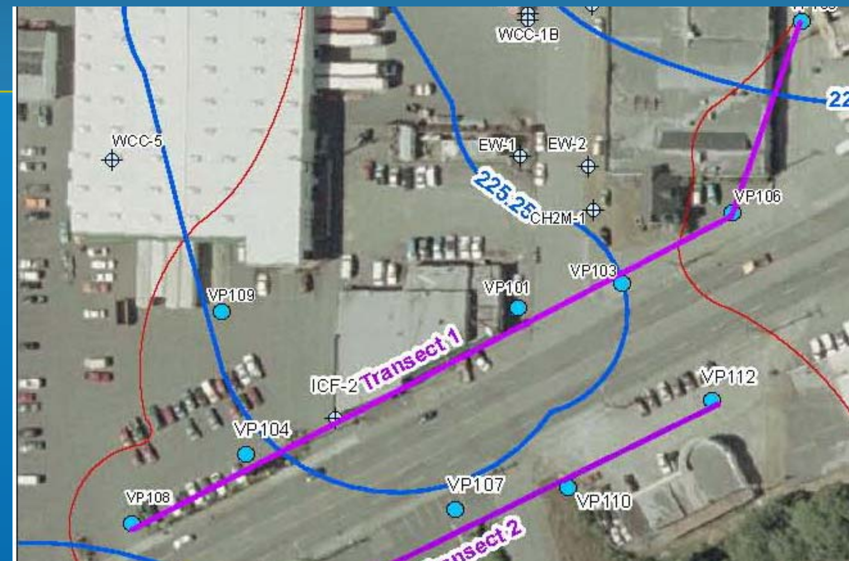
Site Gradient







Calculating Mass Discharge: Transect Method

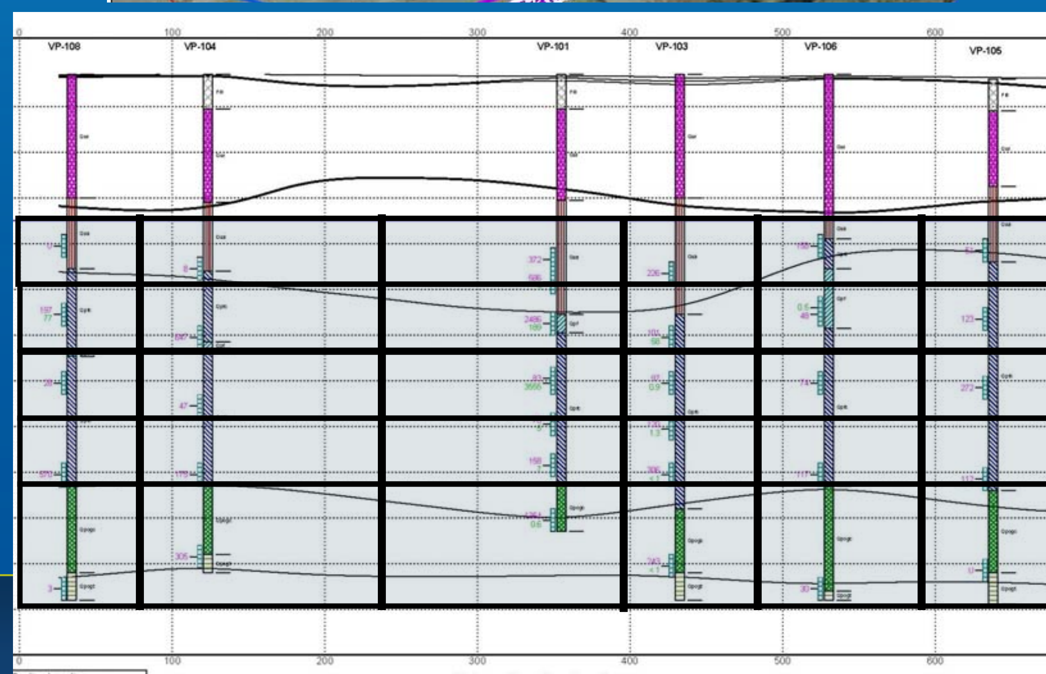


Steps for Well 12A:

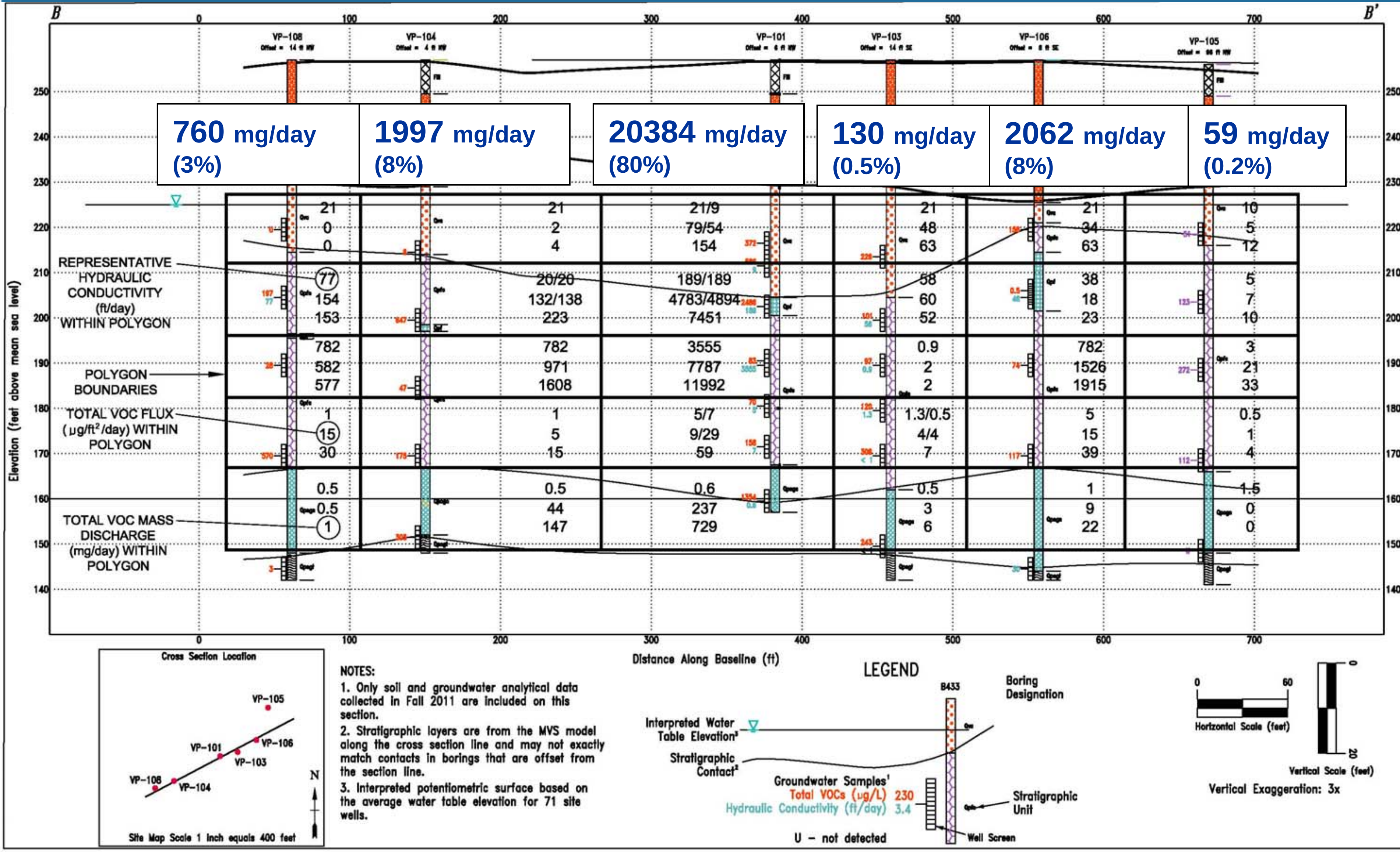
1. Draw polygons (use Theissen)
2. Calculate Darcy velocity (q) for each polygon: q=K•I
3. Characterize polygon flux ($Mf=q \bullet C_n$)
4. Determine area (W • b = A)
5. Evaluate mass discharge:

$$M_d = \Sigma\,(Mf \bullet A_n)$$

M_f = Mass flux
M_d = Mass discharge
C_n = concentration in polygon n
A_n = Area of segment n



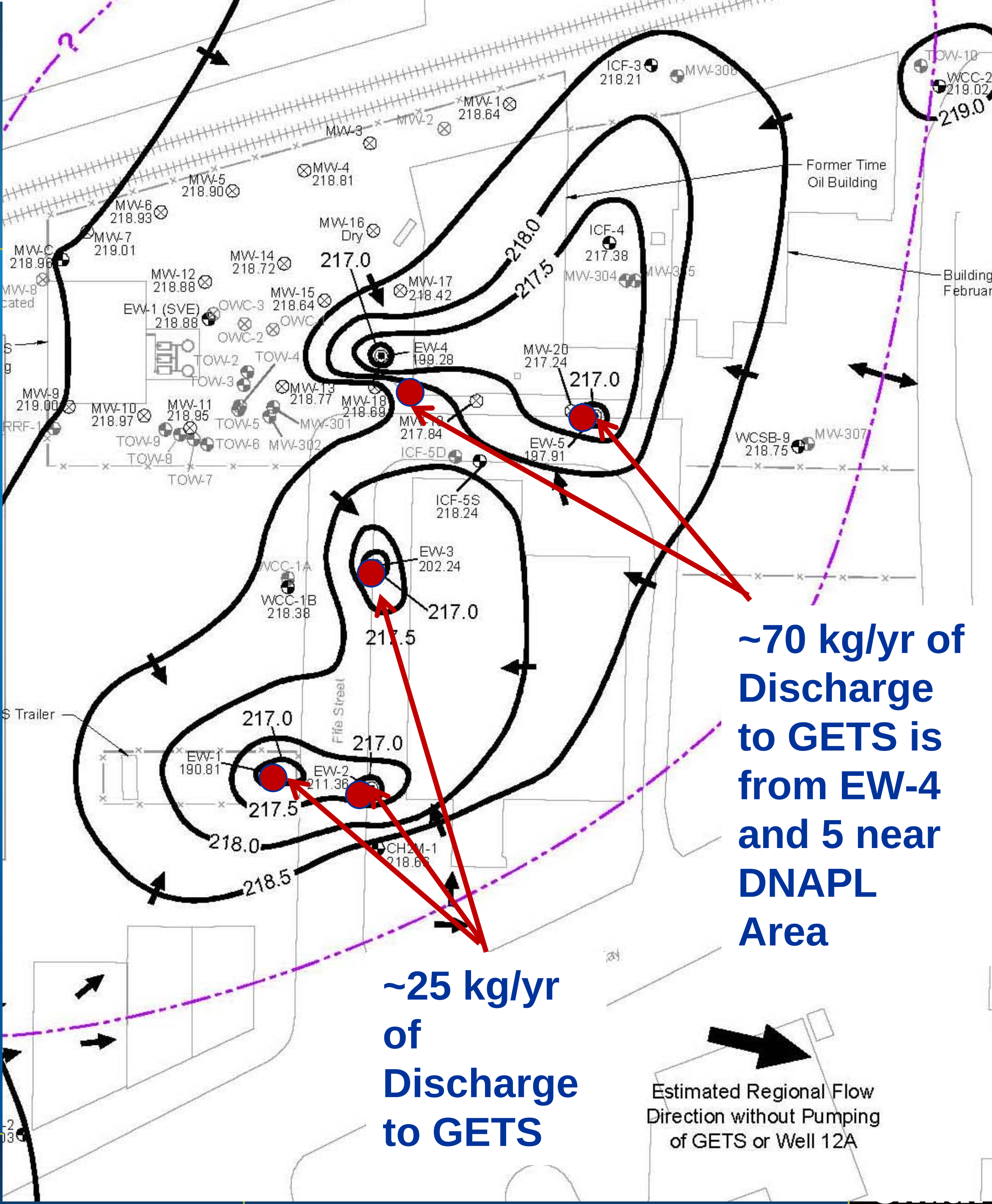
Transect 1



B
B'
VP-108
VP-104
VP-101
VP-103
VP-106
VP-105
760 mg/day (3%)
1997 mg/day (8%)
20384 mg/day (80%)
130 mg/day (0.5%)
2062 mg/day (8%)
59 mg/day (0.2%)
REPRESENTATIVE HYDRAULIC CONDUCTIVITY (ft/day) WITHIN POLYGON
POLYGON BOUNDARIES
TOTAL VOC FLUX (µg/ft²/day) WITHIN POLYGON
TOTAL VOC MASS DISCHARGE (mg/day) WITHIN POLYGON
Elevation (feet above mean sea level)
Distance Along Baseline (ft)
Cross Section Location
Site Map Scale 1 inch equals 400 feet
NOTES:
1. Only soil and groundwater analytical data collected in Fall 2011 are included on this section.
2. Stratigraphic layers are from the MVS model along the cross section line and may not exactly match contacts in borings that are offset from the section line.
3. Interpreted potentiometric surface based on the average water table elevation for 71 site wells.
LEGEND
Boring Designation
Interpreted Water Table Elevation
Stratigraphic Contact
Groundwater Samples
Total VOCs (ug/L) 230
Hydraulic Conductivity (ft/day) 3.4
Stratigraphic Unit
Well Screen
U – not detected
Horizontal Scale (feet)
Vertical Scale (feet)
Vertical Exaggeration: 3x

Mass Discharge: Pumping Test

- Capacity 500 gpm
- Screens 50-70 ft bgs
- Operation
  - EW-1, 40 gpm
  - EW-2, 8-16 gpm
  - EW-3, 7-9 gpm
  - EW-4, 6-15 gpm
  - EW-5, 6-12 gpm
- **Mass Rate Treated (kg VOCs/yr)**
  - **EW-1, 4-8**
  - **EW-2, 4-12**
  - **EW-3, 8-12**
  - **EW-4, 24-48**
  - **EW-5, 24-48**



Site Specific Uncertainties with Pumping Method

Uncertainty

- Pumping induced changes to natural flow regime
- Impacts of secondary sources on mass discharge assumptions
- Increase gradients through significant contaminant sources

Impact to the Estimate

- Potential to draw water from low permeability zones that would not normally contribute mass flux
- Potential to enhance dissolution/diffusion from sources increase estimates
- Potential that mass discharge from "sources", i.e. $Qpog_c$ and Qpf_c downgradient of pumping wells not accounted for.

What's Next?

- Assess critical information needed to determine if can use GETS to evaluate mass discharge,
- Determine if additional field data is needed to evaluate mass discharge methods,
- Pick a mass discharge measurement method,
- Measure baseline mass discharge,
- Implement ISTR, and EAB remedial actions to achieve mass discharge reduction goal,
- Two post-RA mass discharge,
  - 1^{st} ~18 months post-Bioremediation,
  - 2^{nd} contingency if additional Bioremediation needed to achieve objective.

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Conclusions

- Mass Flux and Mass Discharge can improve management of complex contaminant sites and new technologies are increasing the confidence in these metrics.
- Use of new technologies has significantly improved remedial decision-making in developing, designing and implementing Remedial Actions.
- Well 12A will be a case study in how to use these approaches under the Superfund regulatory framework.

Questions and Answers

Q&A