Closing Chlorinated Solvent Sites
A Regulatory Perspective in the San Francisco Bay Region

Alec Naugle
California Water Quality Control Board
San Francisco Bay Region
alec.naugle@waterboards.ca.gov
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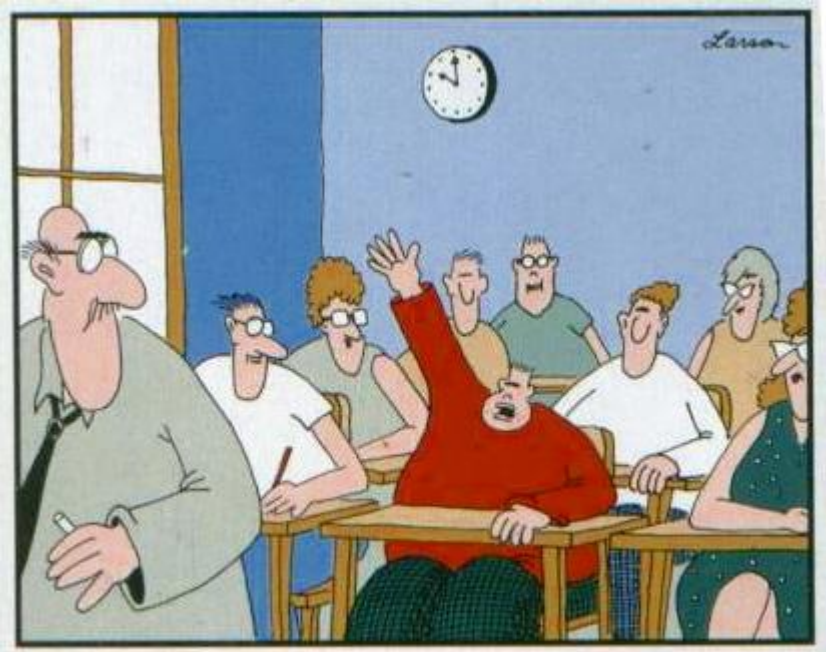
A Geologist's Perspective



A geologist is someone who learns a little bit about many things. He continues to learn less and less about more and more until, ultimately, he knows absolutely nothing about everything.

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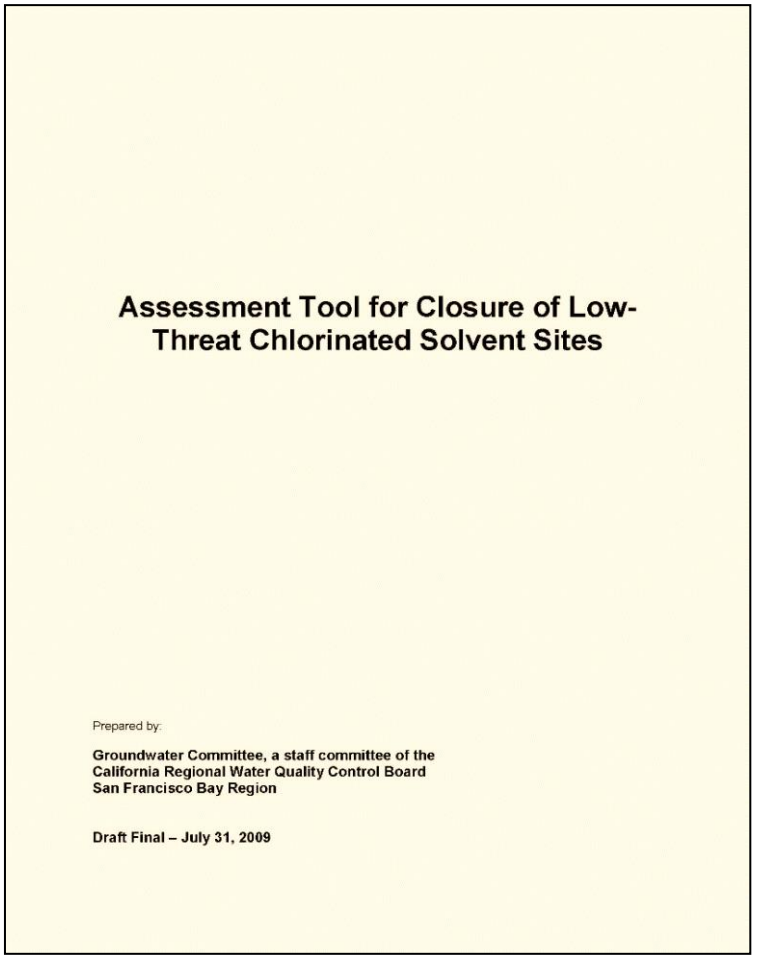
Presentation Overview

1. **Low-Threat Assessment Tool (LTAT)**
2. **L-T case closures (SF Bay Region)**
3. **Assessing complex sites for closure**
4. **Planned LTAT updates**

Topic 1: L-T Assessment Tool SF Bay Region

- 2009 SF Bay Water Board guidance
- Roadmap for assessing solvent sites


Assessment Tool for Closure of Low-Threat Chlorinated Solvent Sites

Prepared by:

Groundwater Committee, a staff committee of the
California Regional Water Quality Control Board
San Francisco Bay Region

Draft Final – July 31, 2009

SF Bay Water Board Low-Threat Assessment Tool

L-T Criteria
SF Bay Region

Similar to State Water Board's 2012 UST Closure Policy, but…

- **More qualitative**
- **Relies on convincing evidence of decreasing plumes**
- **Considers need for long-term O&M**

L-T Criteria
SF Bay Region

1. **Complete conceptual site model**
   a) **Pollutant sources adequately identified / evaluated**
   b) **Site adequately characterized**
   c) **All risks / threats / concerns identified**
2. **Risks / threats mitigated**
   a) **Pollutant sources remediated to extent feasible**
   b) **Risks to human and ecological health mitigated**
   c) **Threats to water resources mitigated**
3. **Residual contamination adequately addressed**
   a) **Groundwater plume is decreasing**
   b) **Cleanup standards to be met in reasonable timeframe**
   c) **Risk management measures are self-implementing**

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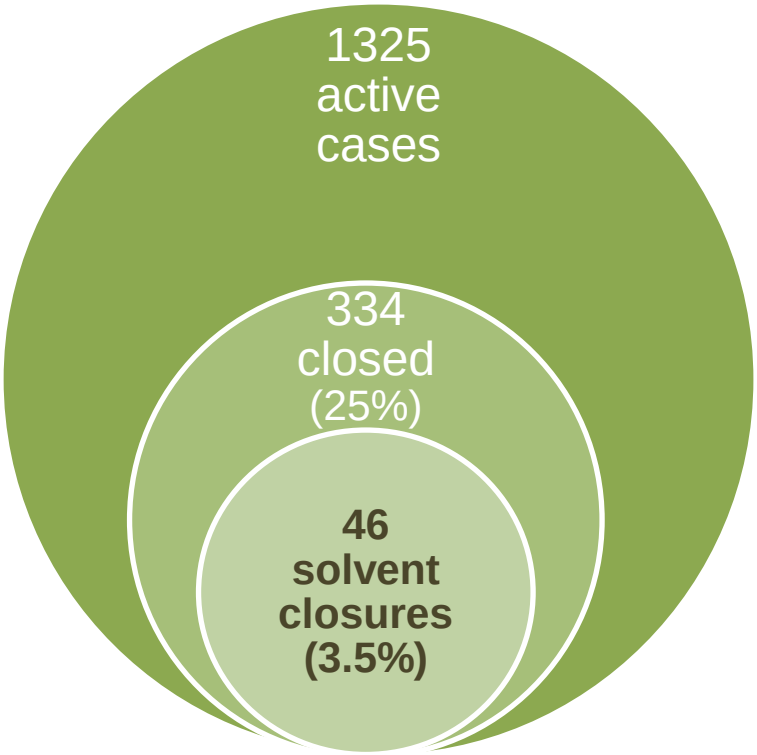
Topic 2: L-T Case Closures
SF Bay Region

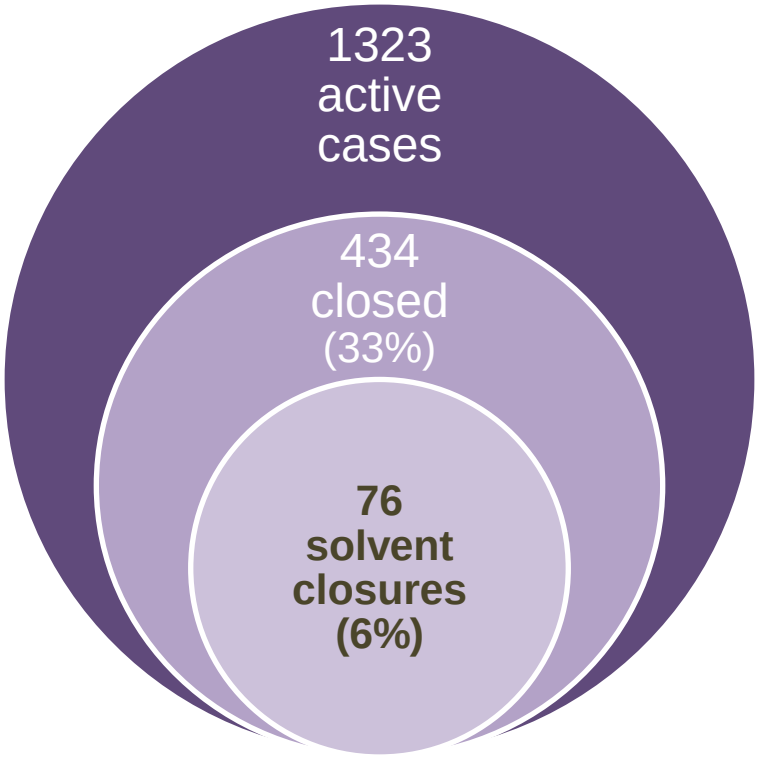
- **Low-threat case closures, 2009-2018 (non-petroleum sites)**
- **Lessons learned**

L-T Closures
SF Bay Region

2009 – 2013



2014 – 2018



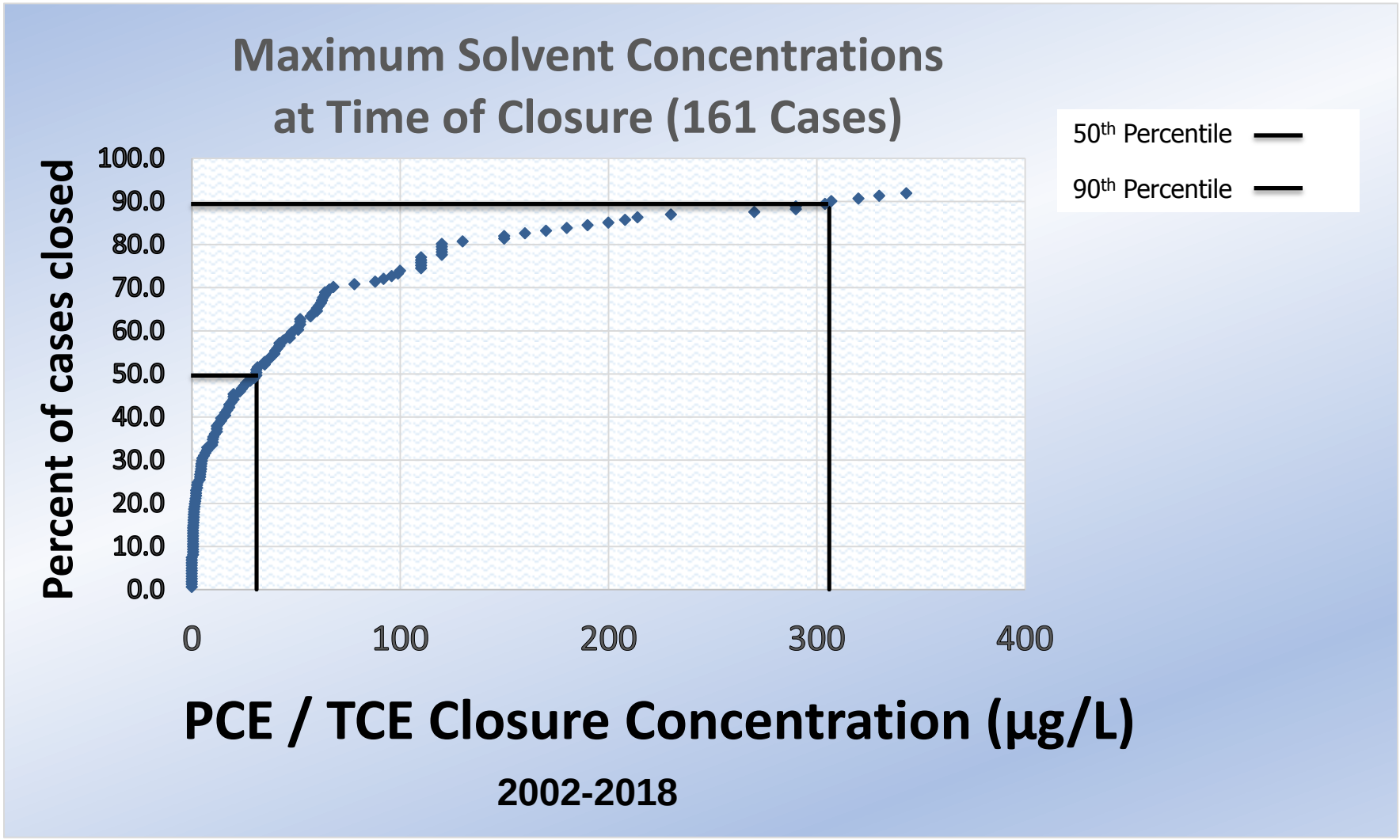
L-T Closures
SF Bay Region

Environmental Screening Levels

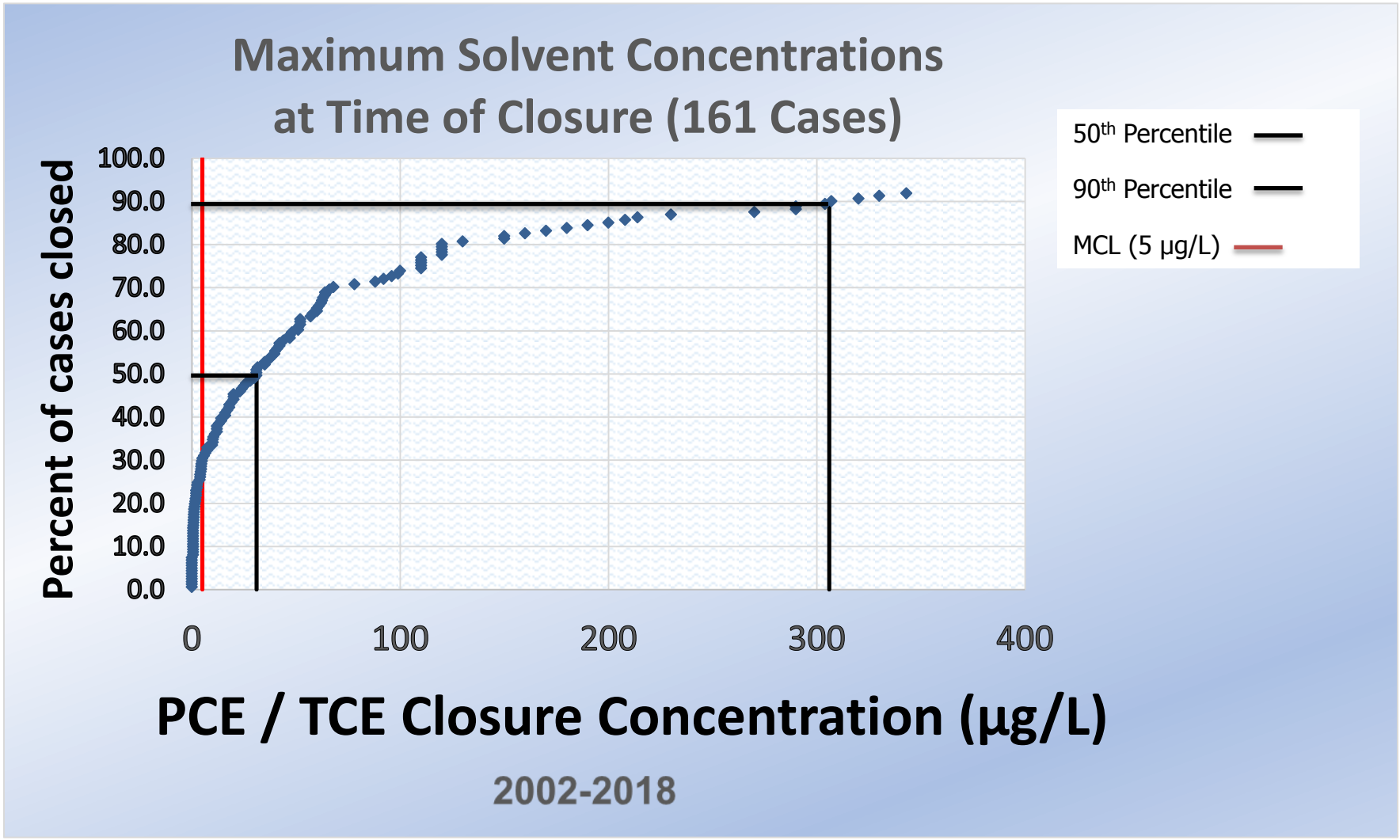
- **Drinking water standard = 5 ug/L (TCE, PCE)**
- **Groundwater ESLs for vapor intrusion concerns have changed:**

ESLs for VI concerns	PCE (ug/L)		TCE (ug/L)	
	Res	Com	Res	Com
2013	63	630	130	1300
2016	3	26	5.6	49
2019	0.64	2.8	1.2	7.5

L-T Closures
SF Bay Region



L-T Closures
SF Bay Region



L-T Closures
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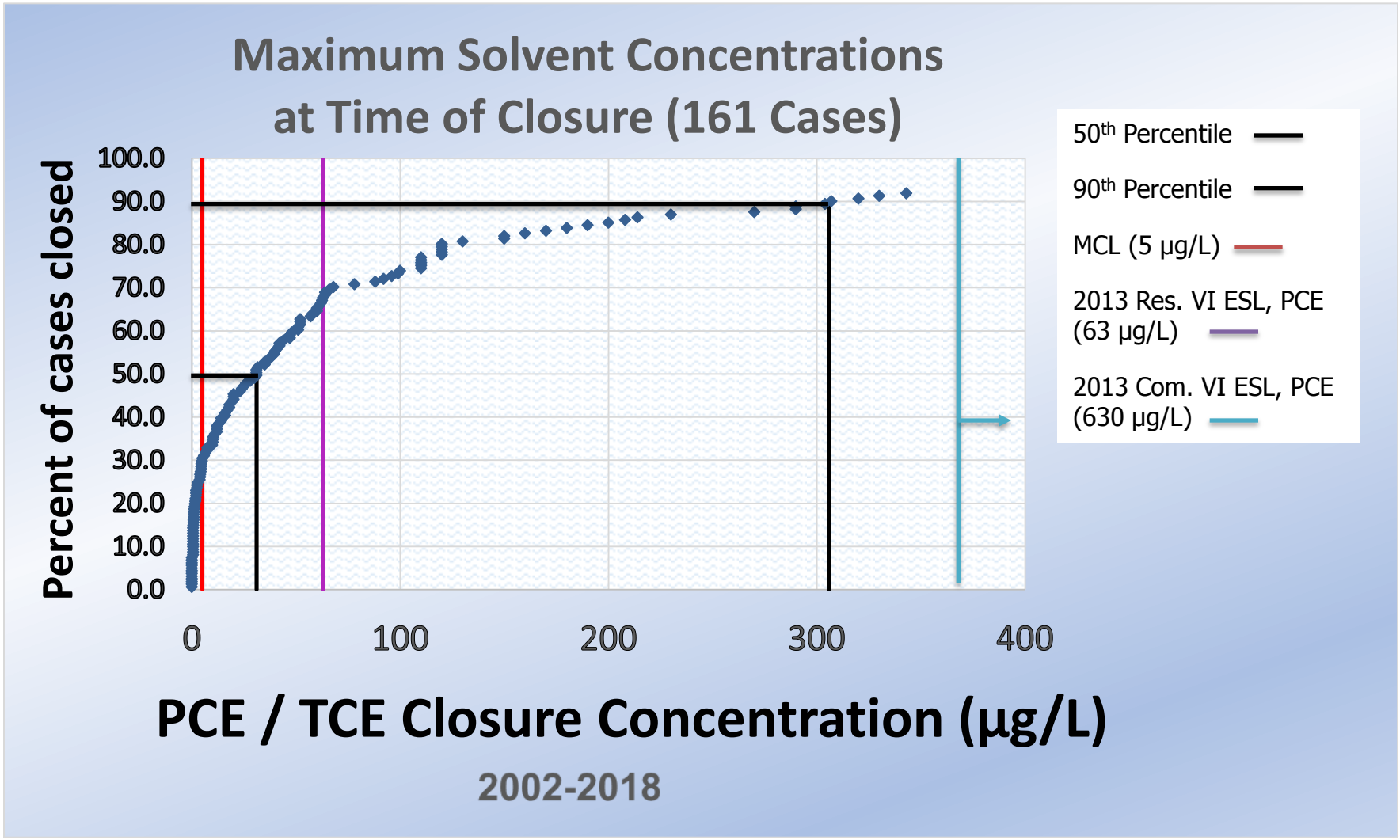

L-T Closures
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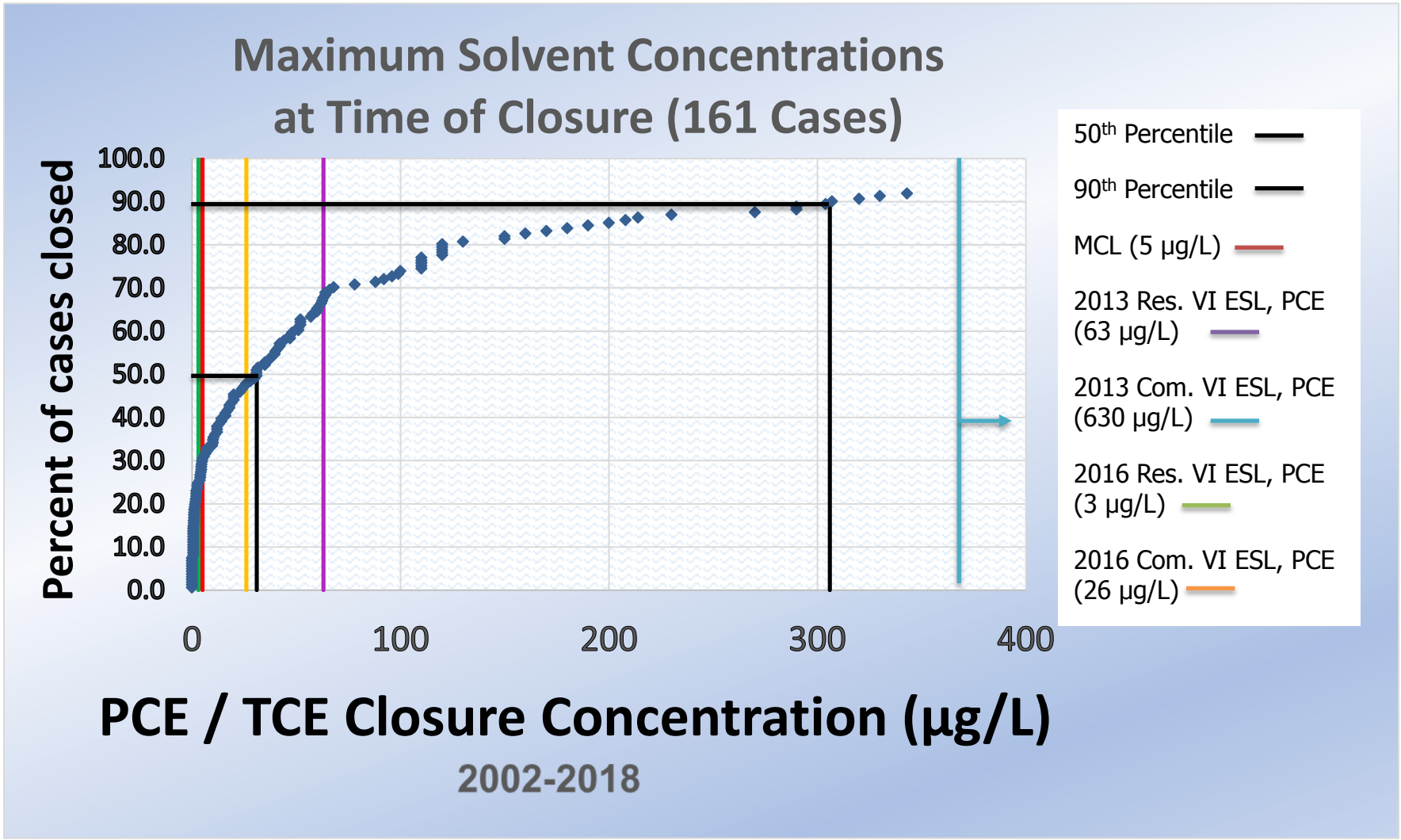

L-T Closures
SF Bay Region

Maximum Initial Concentrations
L-T Closures, 2009-2018

PCE / TCE (ug/L)	Order of magnitude above MCL	Number of Closures
<100	1-2	41
100 – 1,000	2-3	28
1,000 – 10,000	3-4	32

L-T Closures
SF Bay Region

Remediation Methods
L-T Closures, 2009-2018

Remediation Methods	Number of Sites
Excavation	48
MNA/No Remediation	34
Groundwater extraction	17
In-Situ (ISB, ISCO, ISCR)	9

L-T Closures
SF Bay Region

Concentration Reductions
L-T Closures, 2014-2018

Order of Magnitude Reduction to reach MCL	0-1	1-2	2-3	3-4	>4
Excavation/Source Removal	16	11	3	4	2
Groundwater Extraction	4	2	1	2	2
Bioremediation	0	3	2	0	0
Chemical Oxidation	0	1	0	1	0
MNA / No Remediation	19	2	0	0	0
Thermal	0	0	0	0	0

L-T Closures
SF Bay Region

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Lessons Learned

1. **L-T closures tend to be simple sites with weaker / shallow sources and no (*current*) groundwater use**
2. **Excavation, groundwater extraction, MNA remain the most common remedial methods for L-T case closures**
3. **Vapor intrusion (VI) is often a driver for additional investigation, but unclear if/how affecting closure decisions**
4. **Expect VI cases to require long-term O&M with continued oversight (closure paradox?)**

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Lessons Learned

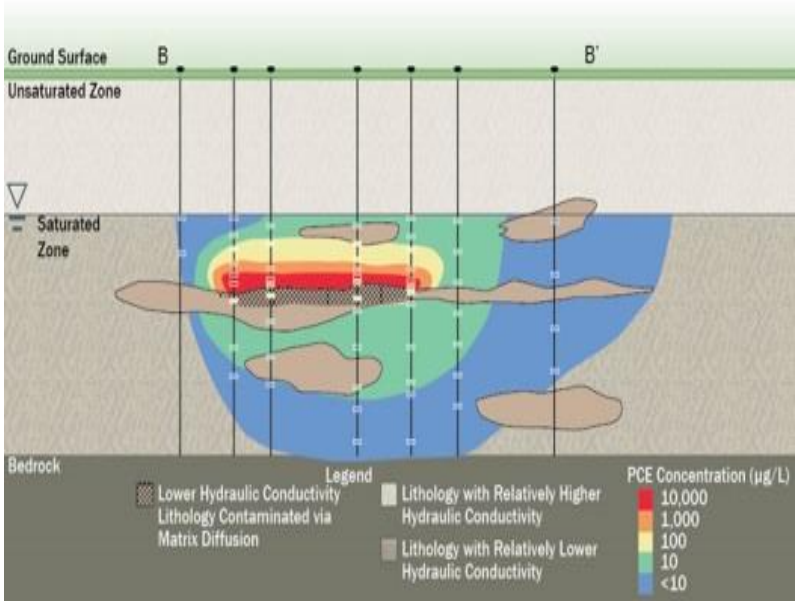
5. **Need standardized approach(es) to demonstrating decreasing plumes (i.e., post-rebound attenuation) and cleanup timeframe**
6. **Closures should clearly identify cleanup levels and land and groundwater use assumptions**
7. **LTAT is a good case management tool, even if closure is not warranted**

Topic 3: Assessing Complex Sites for Closure

- **Complex site characteristics**
- **Sources**
- **Plume response to remediation**
- **Case example**
- **Recommendations and conclusions**

Complex Site Characteristics

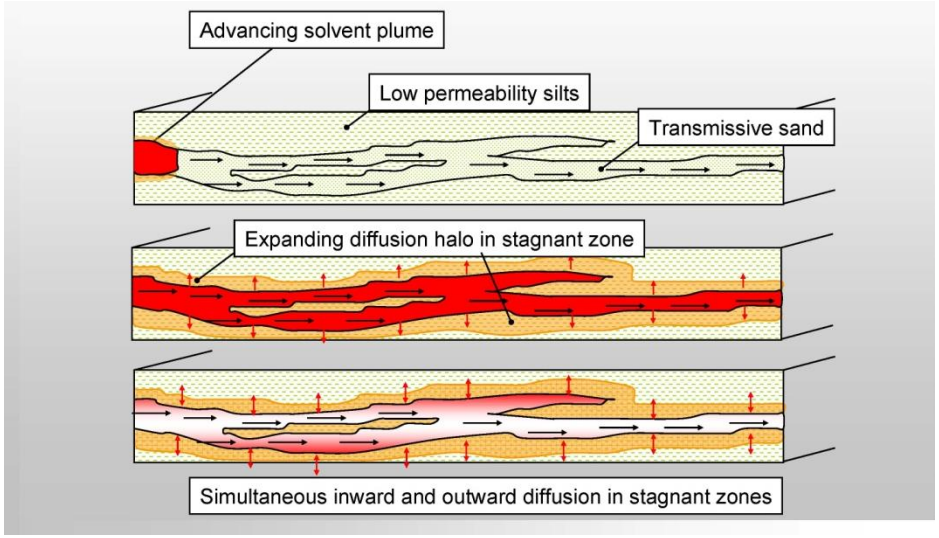
1. Heterogeneity controls distribution
2. Sources are strong, deep, or diffuse
3. Limited response to remediation with long cleanup timeframes
4. Higher resolution methods needed to bridge gaps



Complex Sources

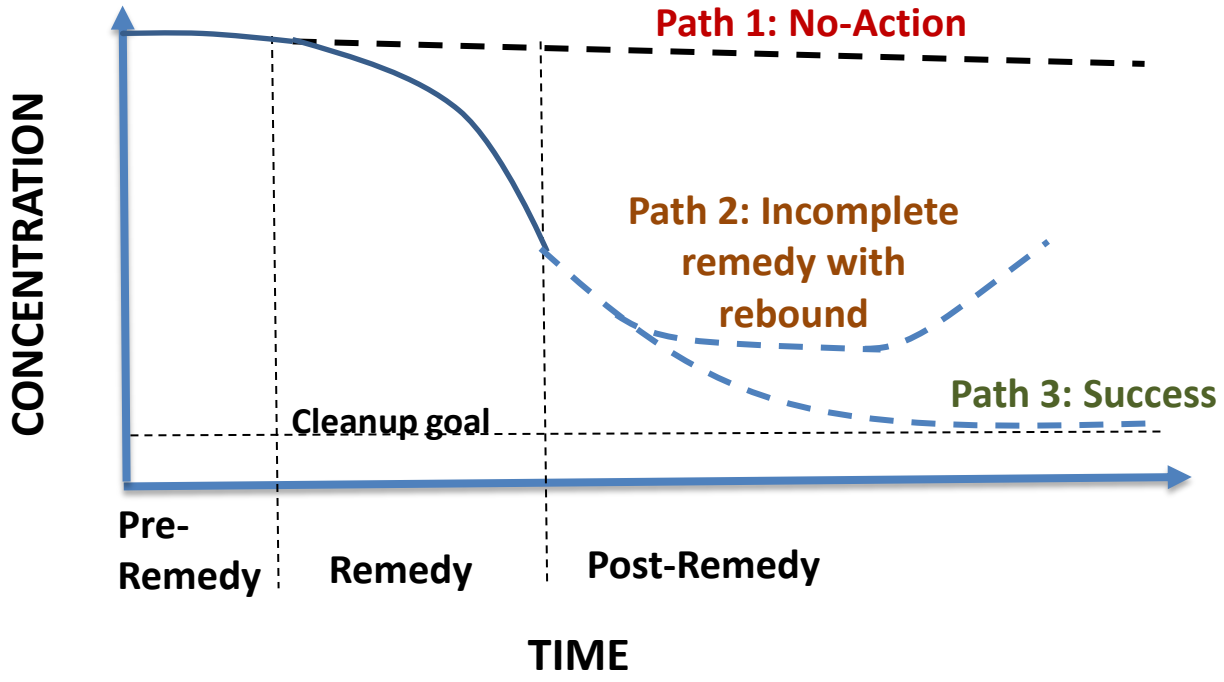
Source Identification and Control (NRC, 2005)

- **A subsurface reservoir sustaining groundwater or vapor plumes**
- **Includes DNAPL & high concentration dissolved- and sorbed-phases**
- **Persist long after DNAPL is gone (e.g., back diffusion)**



Depletion models suggest a 1 to 3 order of magnitude reduction in the near-term (5-10 yrs?) may be the best to expect for sites with diffusion-limited sources

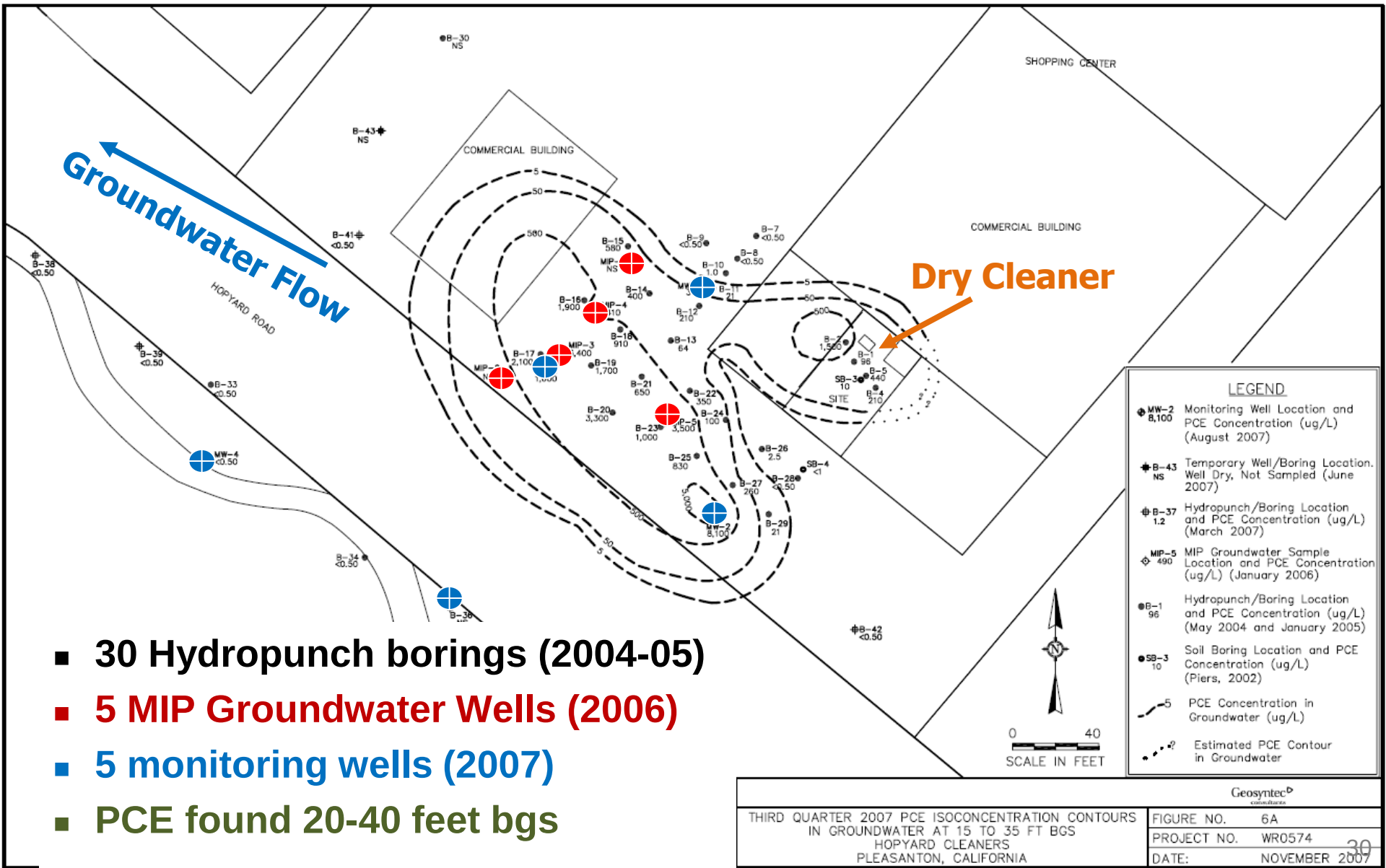
Plume Response to Remediation



Case Example: Hopyard Cleaners

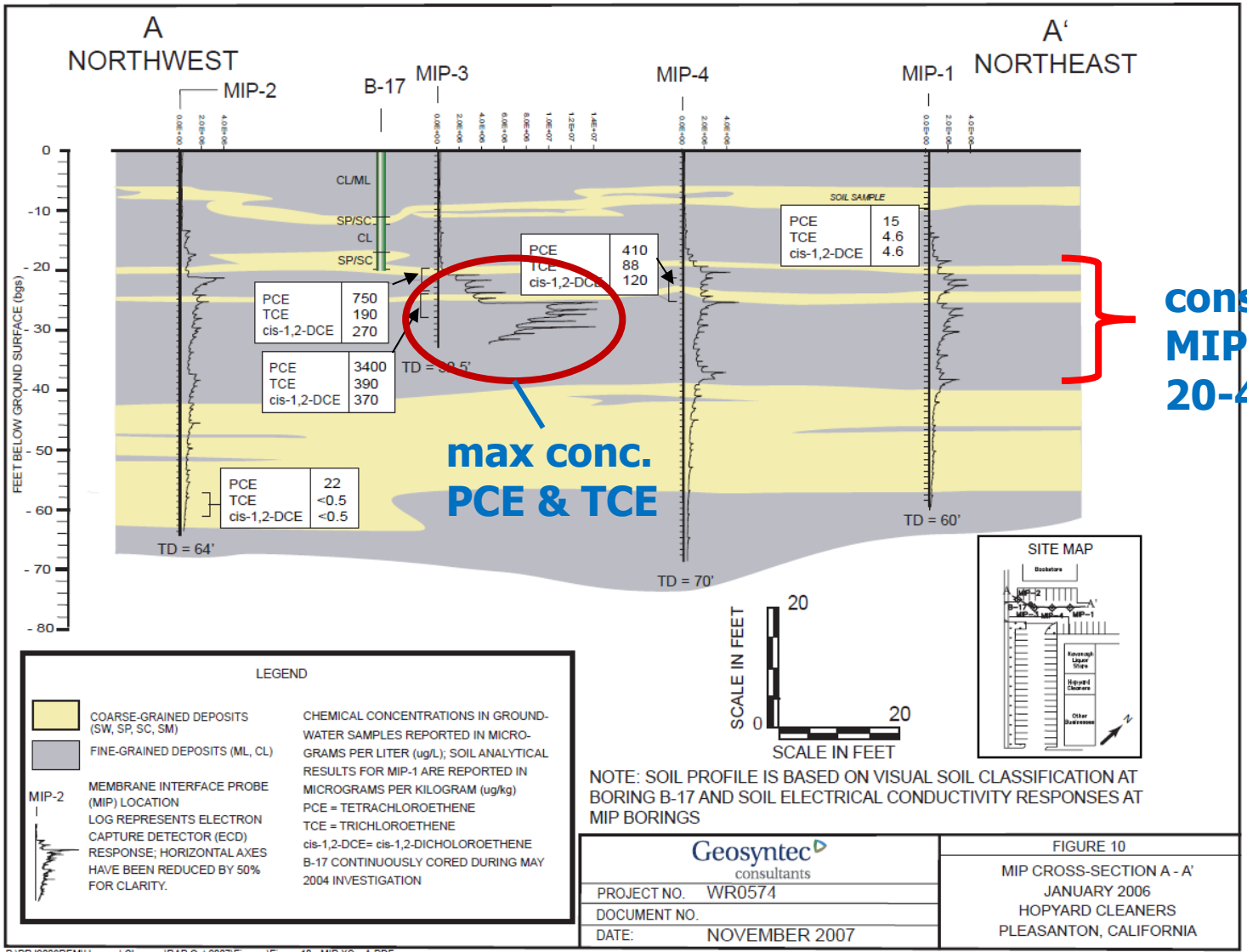
- Commercial Dry Cleaner
- Used PCE from 1960s to 2001.
- Initially investigated in 2002

Pre-Remediation Extent



- 30 Hydropunch borings (2004-05)
- 5 MIP Groundwater Wells (2006)
- 5 monitoring wells (2007)
- PCE found 20-40 feet bgs

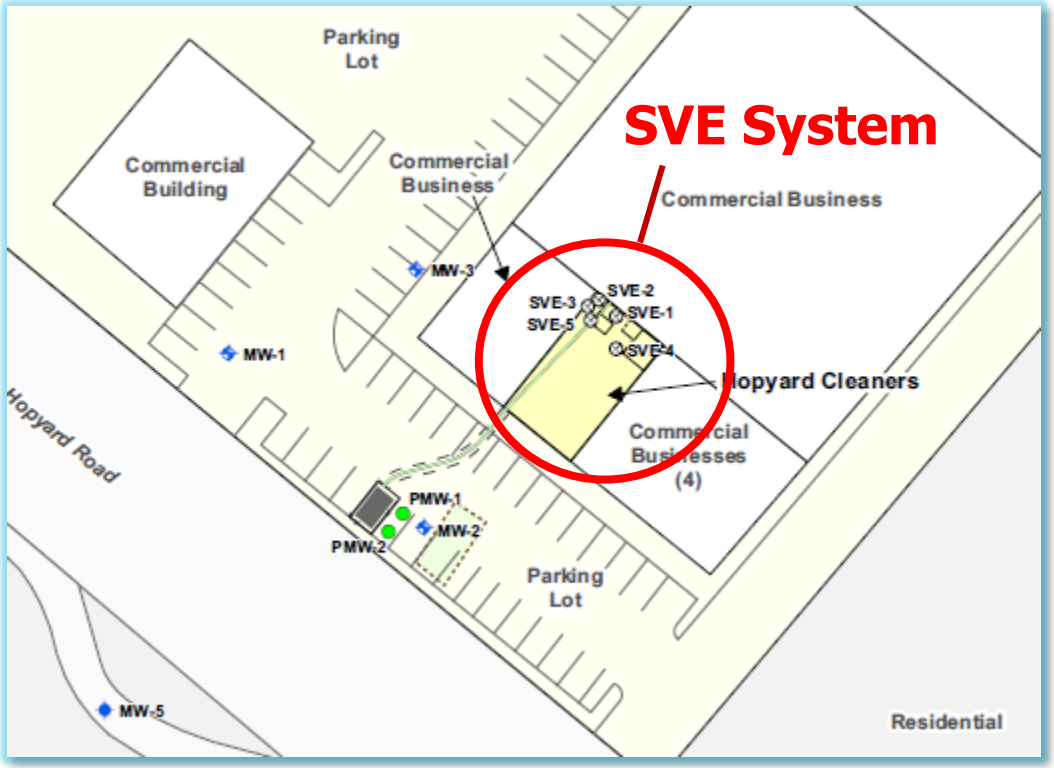
Cross Section of MIP Borings



Source Remediation

Soil Vapor Extraction (SVE)

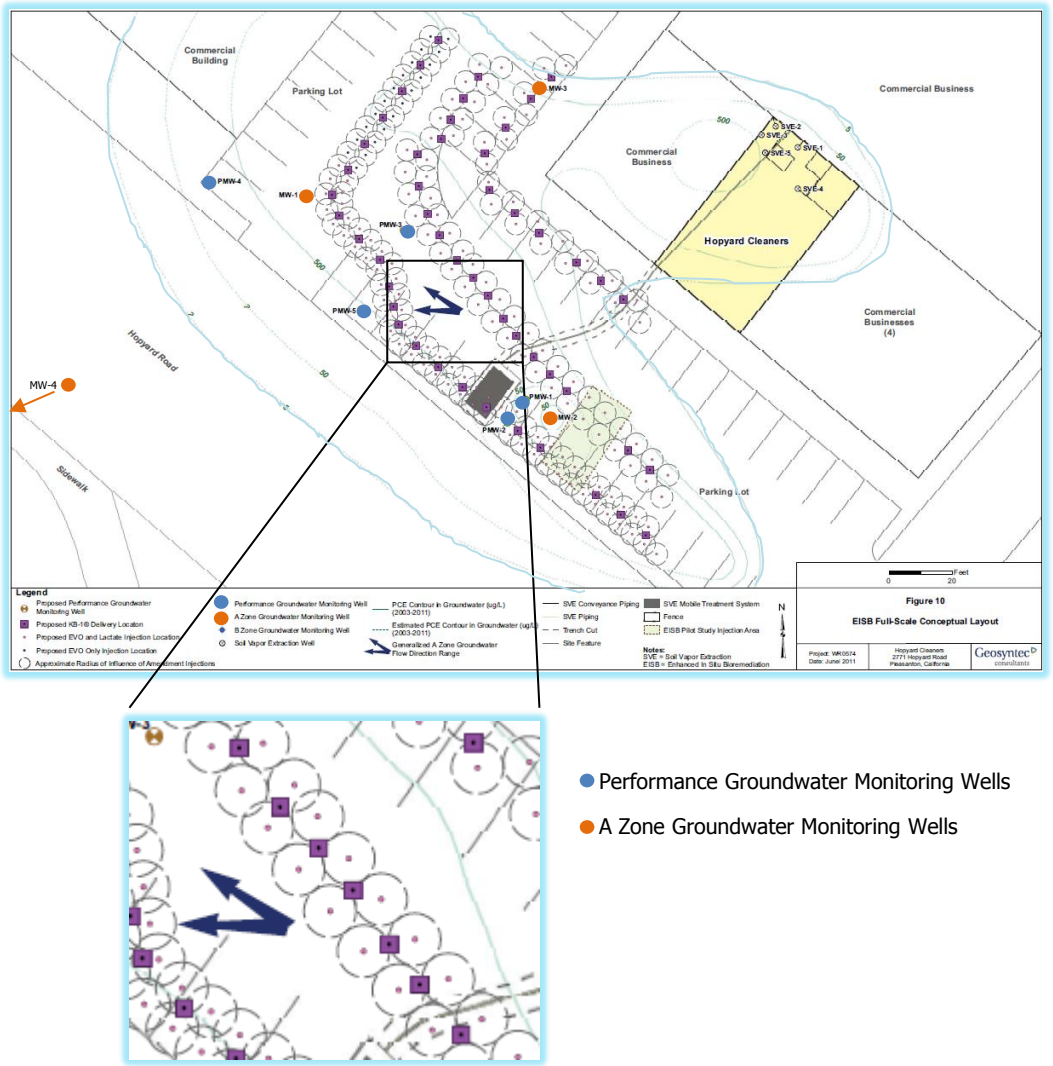
- 5 SVE wells inside drycleaner bldg (2008)
- Operated 5 years
- Removed 27 pounds PCE



Plume Remediation

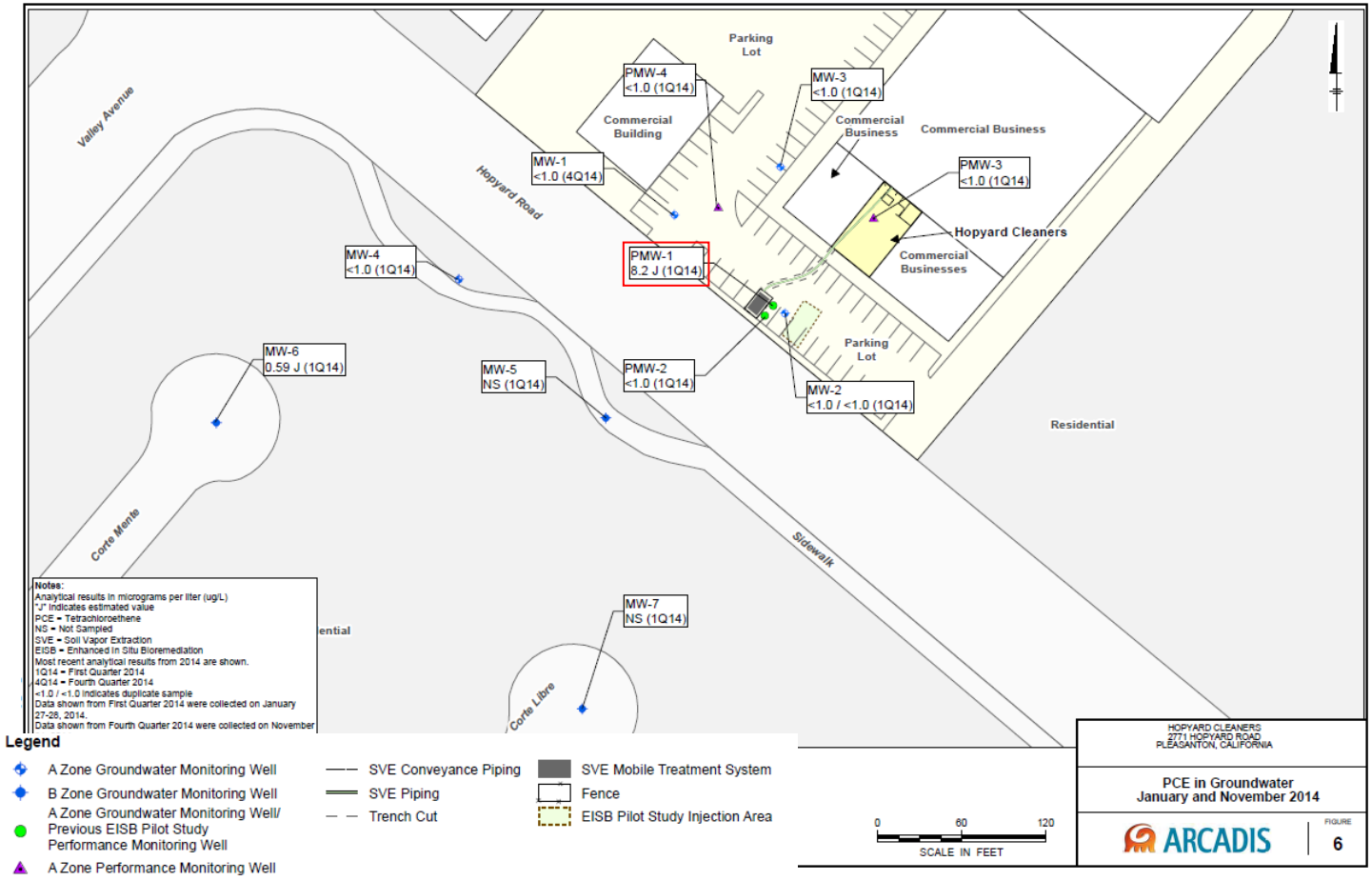
Enhanced In Situ Bioremediation (EISB)

- **Enhanced Reductive Dechlorination (ERD) 2010-2014**
- **52 A-zone injections (20 to 30 feet bgs)**
- **MW concentrations reduced to trace levels.**



Effectiveness

Final PCE Groundwater Concentrations



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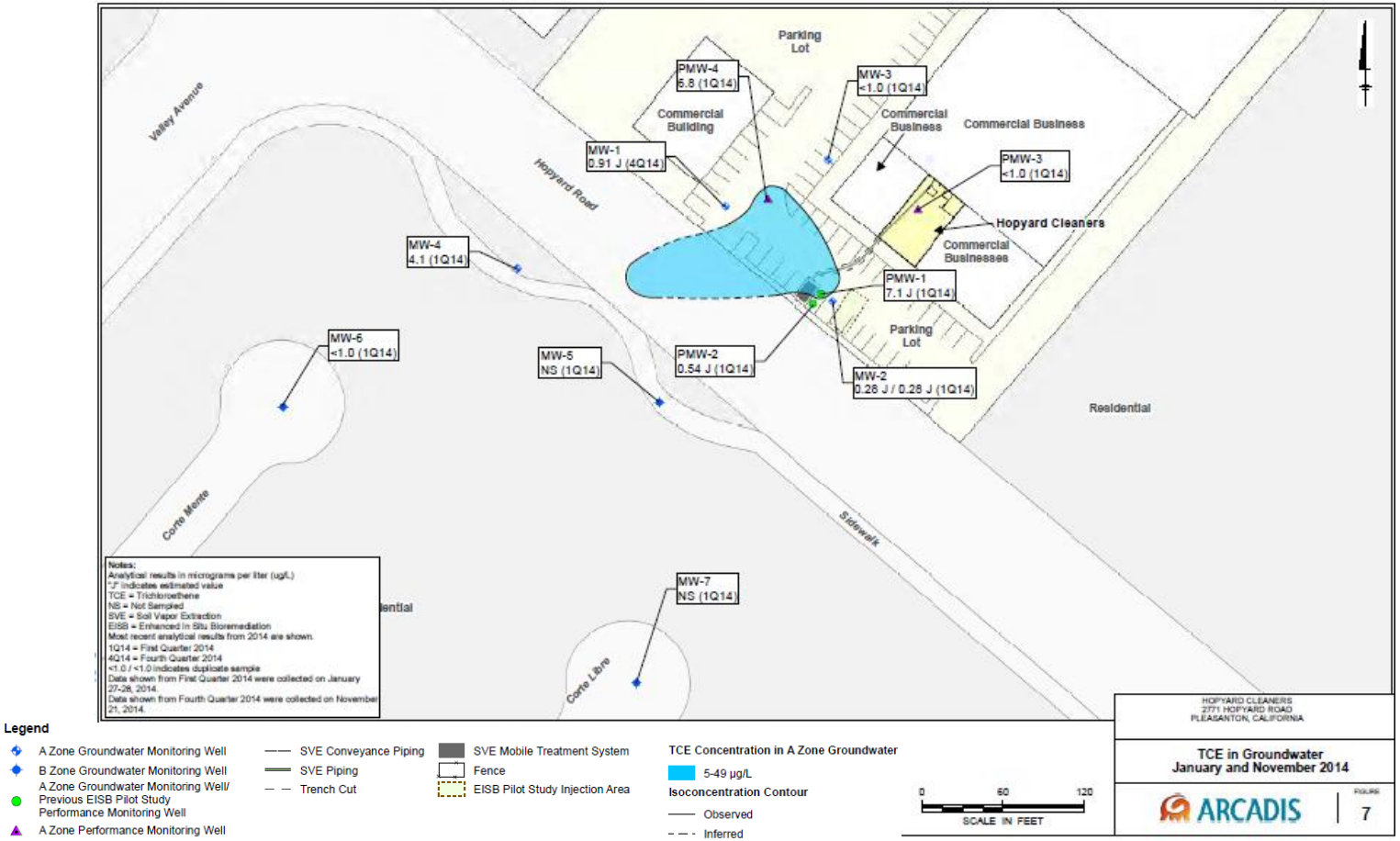
Effectiveness

Final TCE Groundwater Concentrations



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Effectiveness

Pre and post-remediation PCE and TCE concentrations (ug/L)

Well Name	MW-1	MW-2	MW-3	MW-4	PMW-1	PMW-2	PMW-3	PMW-4
PCE pre-remedy	3100	5800	93	ND	8200	3800	1.5	103
PCE post-remedy	ND	ND	ND	ND	8.2	ND	ND	ND

Well Name	MW-1	MW-2	MW-3	MW-4	PMW-1	PMW-2	PMW-3	PMW-4
TCE pre-remedy	370	370	7.2	3.5	900	290	8.7	447
TCE post-remedy	0.9	0.3	ND	4.1	7.1	0.54	ND	6.8

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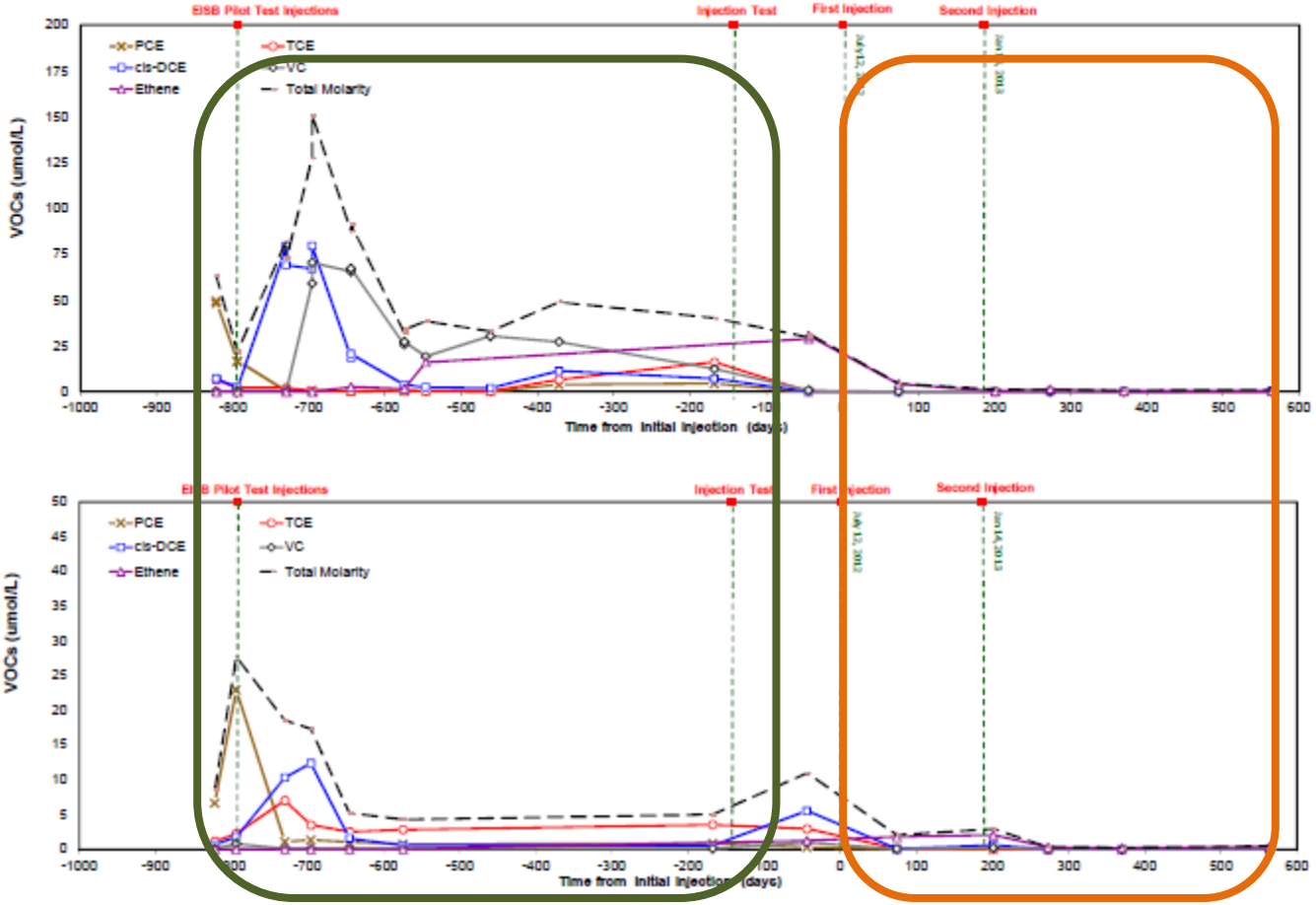
Effectiveness

Time-Concentration Graphs for MW-1 and MW-2



Parent-daughter trends

Post-remediation rebound

Recommendations for Complex Sites

- **Pre-characterize to match heterogeneity scale**
- **Define contaminant distribution with matching resolution**
- **Optimize effectiveness monitoring**
  - **Consider representative volume and uncertainties**
  - **Measure concentration / mass reduction trends**
  - **Develop decision points for future optimization**

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Conclusions

1. **Reducing uncertainty is critical and higher resolution methods are an effective solution**
2. **Defining the source zone in three dimensions improves remedy selection, targeting, and efficiency**
3. **Many complex sites require long-term operation, maintenance, and monitoring with ongoing regulatory oversight**

Topic 4: LTAT Updates
SF Bay Region

A case management path forward for all sites; not just a closure checklist applied at the end…

Planned Updates for 2019

1. **Encourage use as a case management tool, not just for closure.**
2. **Broaden applicability to all non-UST cleanup sites, not just solvent sites.**
3. **Incorporate soil vapor plume characterization, spatially and temporarily, same as groundwater plumes.**
4. **Consider limits on reasonable timeframes based on location, risks/threats, and likelihood of future beneficial use.**
5. **Revisit self-implementing risk management measures considering the need for ongoing O&M and monitoring.**

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Next Steps

- Seek input from State and Regional Board Cleanup Programs
- Synchronize with ESL User's Guide and VI Framework Updates
- Conduct internal road-testing
- Conduct limited external peer review
- Release by fall 2019

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Questions?

L-T Closures, SF Bay Region

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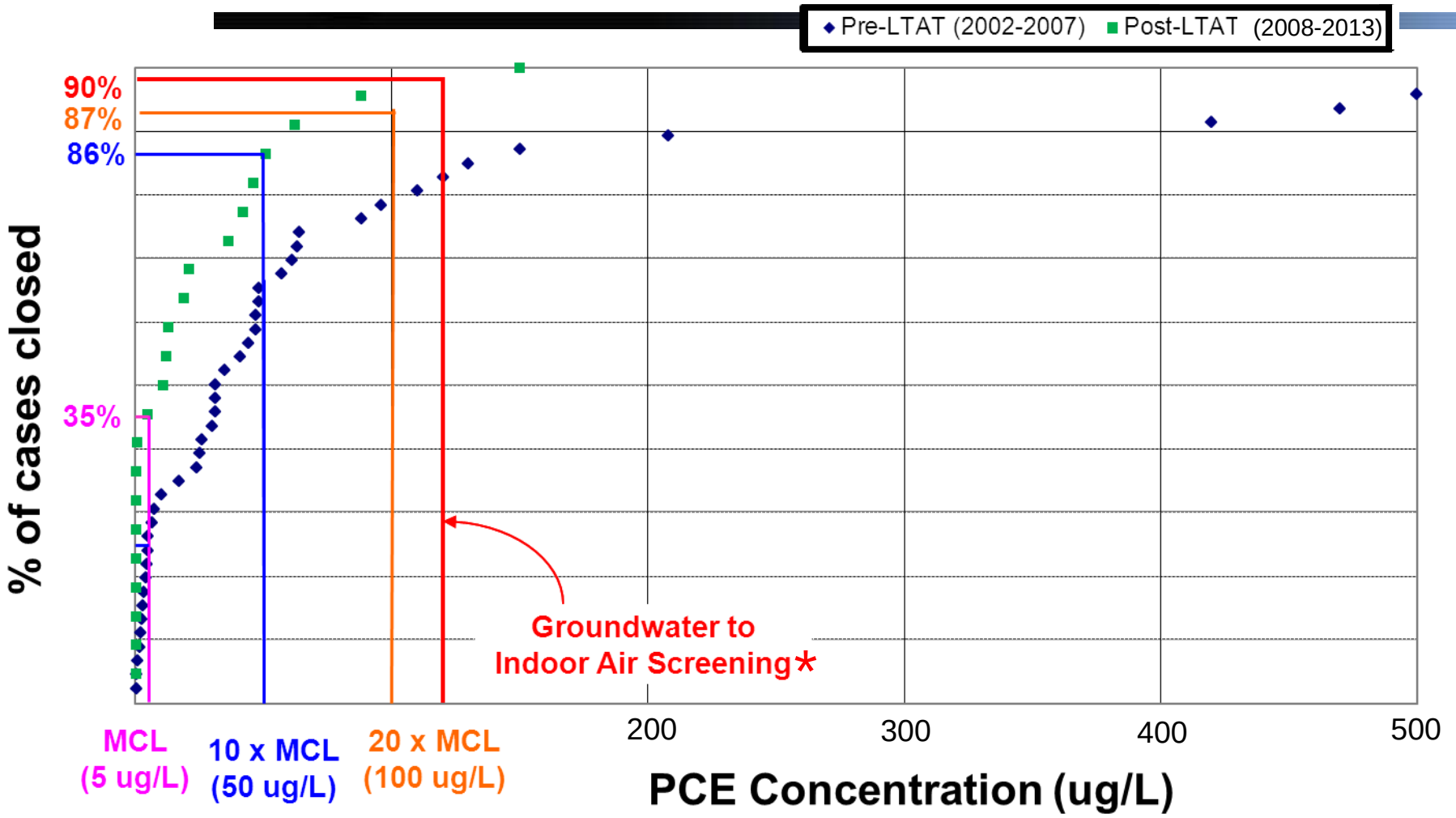
Maximum PCE Concentration in Groundwater at Case Closure (87 Cases Surveyed during 2002-2007 and 2008-2013



* R2 ESL = 63 ug/L as of Feb 2013

L-T Criteria
SF Bay Region

Define nature and extent, receptors, and exposure pathways (1a,b,c)

Control sources, remediate plumes, and mitigate risks (2a,b,c,)

Demonstrate decreasing plumes; reasonable timeframe; no continued regulatory oversight (3a,b,c)

https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/sitecleanup

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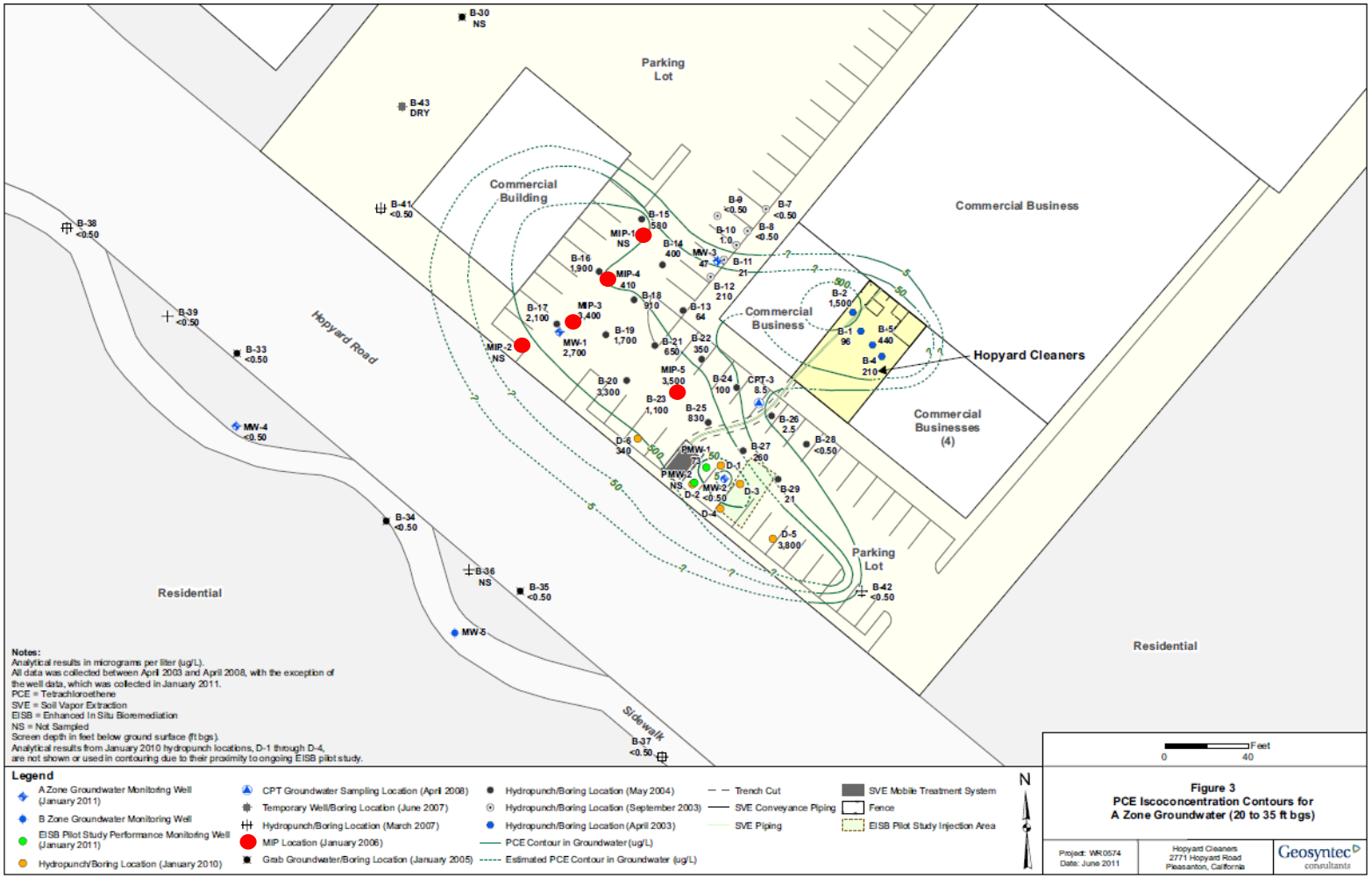
2006 MIP Boring Locations



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Effectiveness

Time-Concentration Graphs for MW-3 and MW-4