Site Cleanup in 3 Years and $350K
COLUMBIA
TECHNOLOGIES

Goals

Introduction

The Challenge of Aging USTs

What's Coming

A Word About HRSC

The Case for Sustainability

Case Study

Lessons Learned from Hundreds of Sites

Questions

SOCIAL
ECONOMIC
ENVIRONMENT

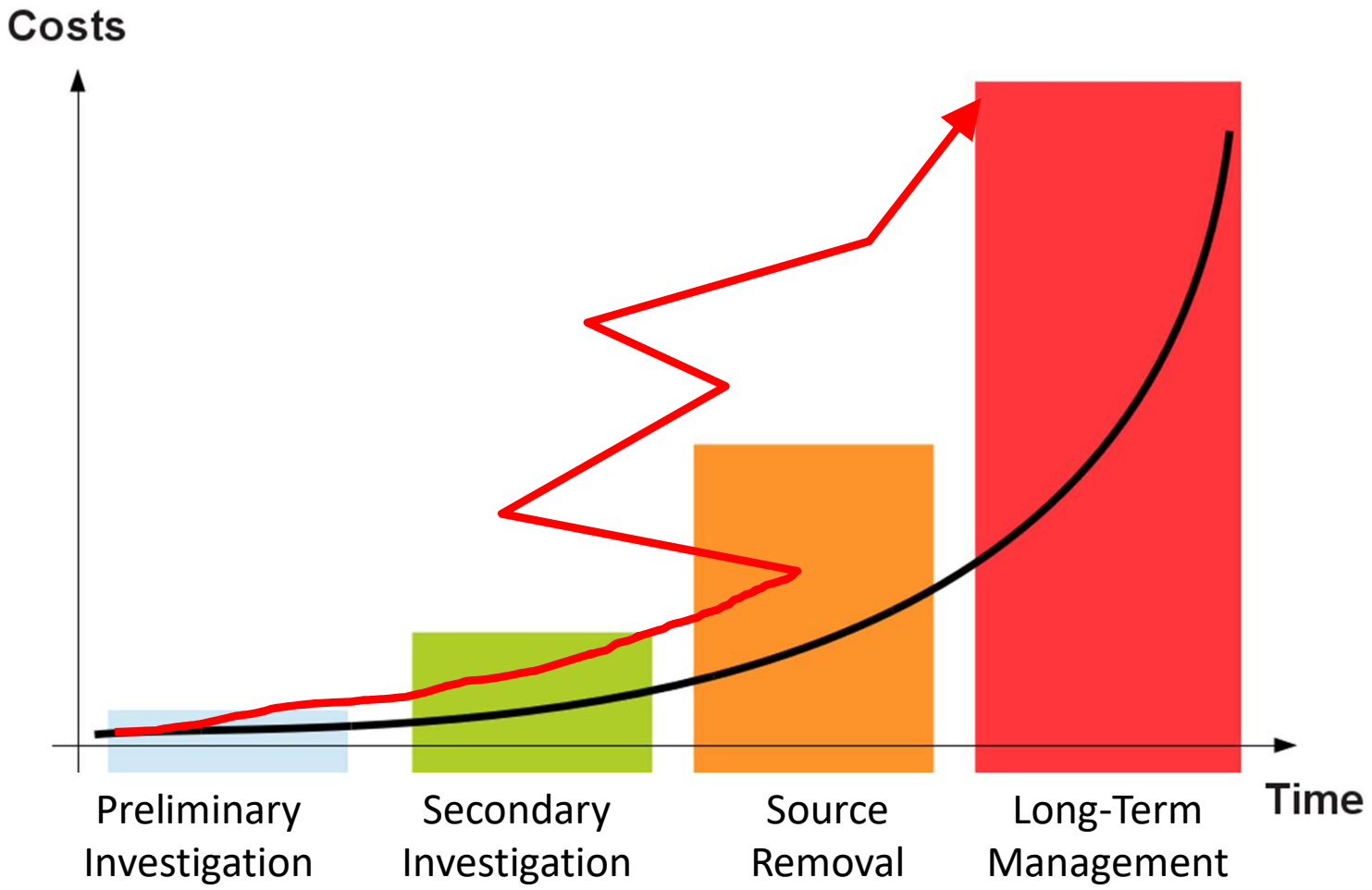
The Challenge

The Challenge

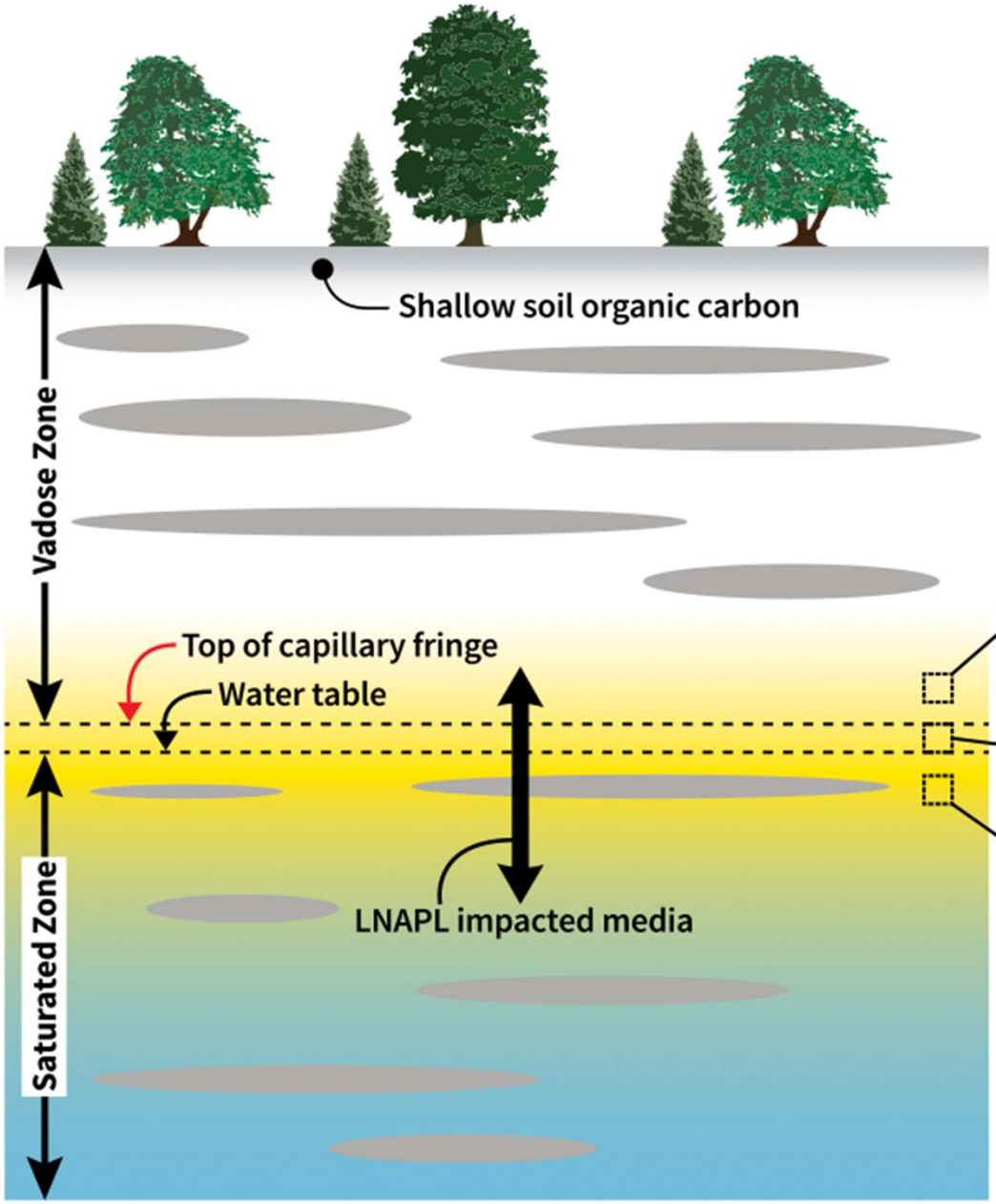
60,000
200,000
$130K
$8B
10X

222		15.8 yrs
2342		28.4 yrs
164		29.4 yrs
3419	Active	8719

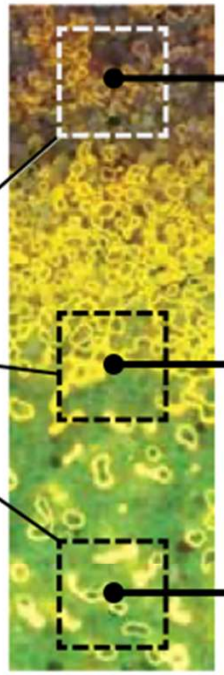
Unsustainable Cost Curve



LNAPL Disassociation



Skinner (2013) and Tracy (2015)



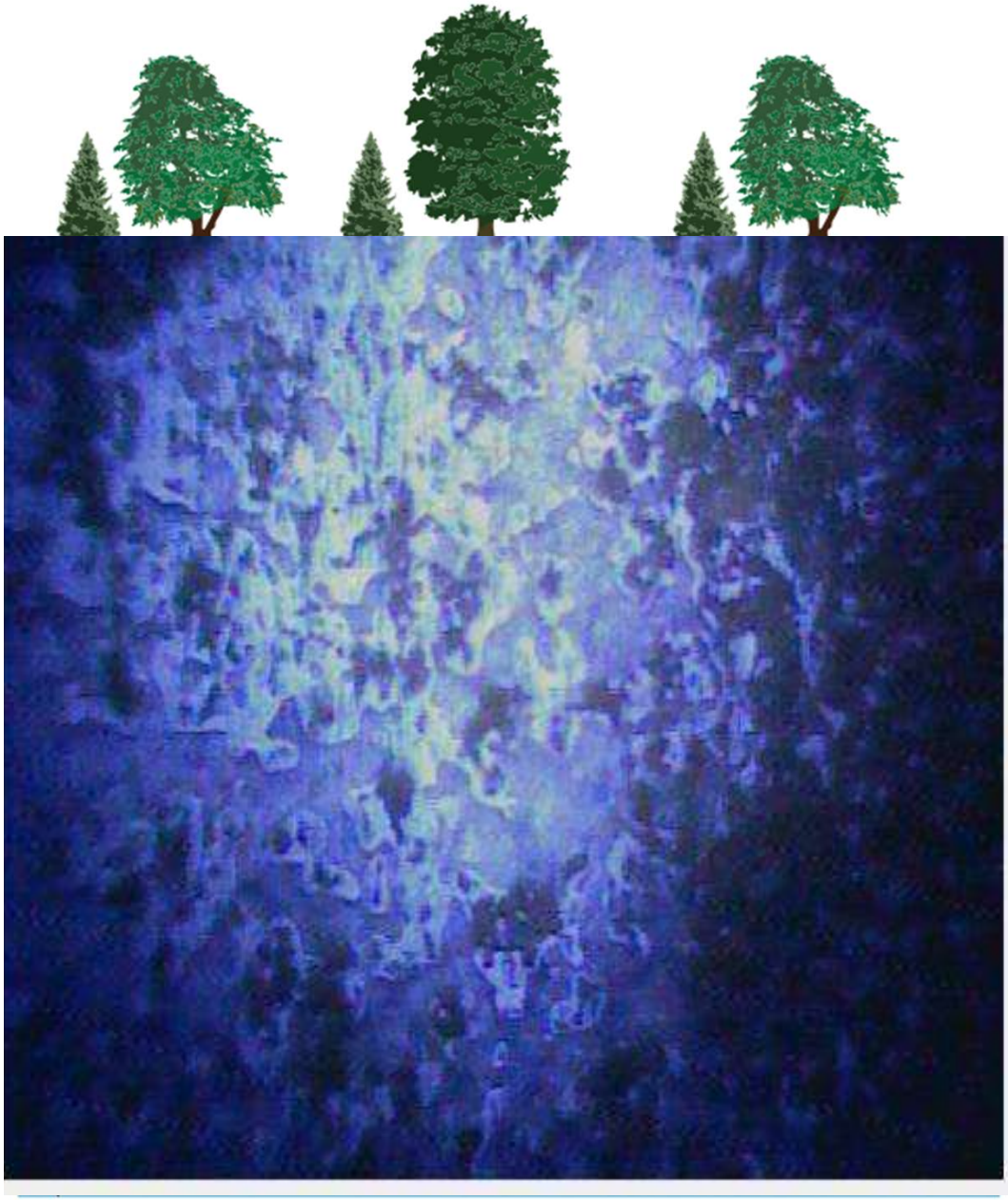
Zone 1 – Water wet sand, continuous non-wetting soil gas, continuous intermediate wetting LNAPL

Zone 2 – Water wet sand, discontinuous non-wetting soil gas, continuous non-wetting LNAPL

Zone 3 – Water wet sand, discontinuous non-wetting soil gas, discontinuous non-wetting LNAPL

Ref: API Guide for LNAPL Sites

LNAPL Disassociation



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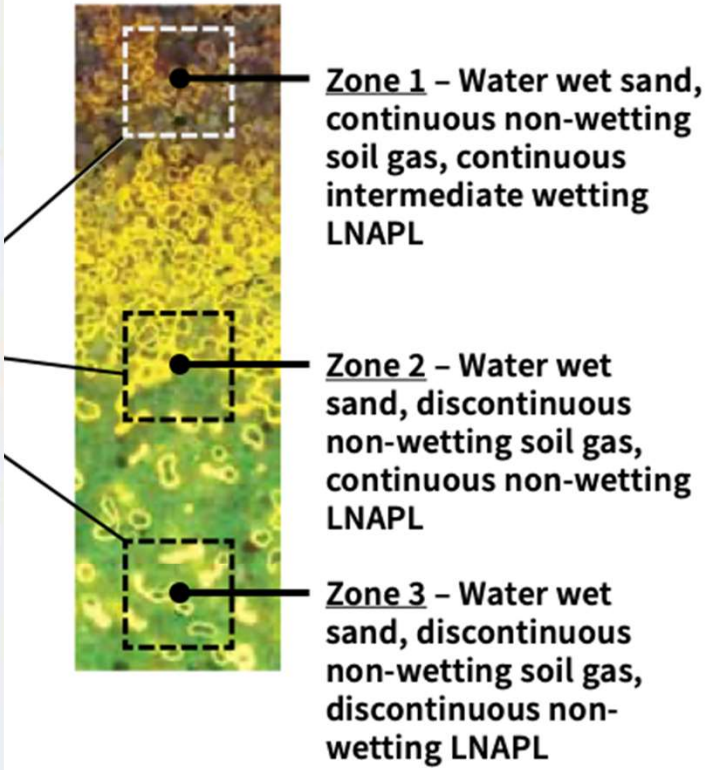

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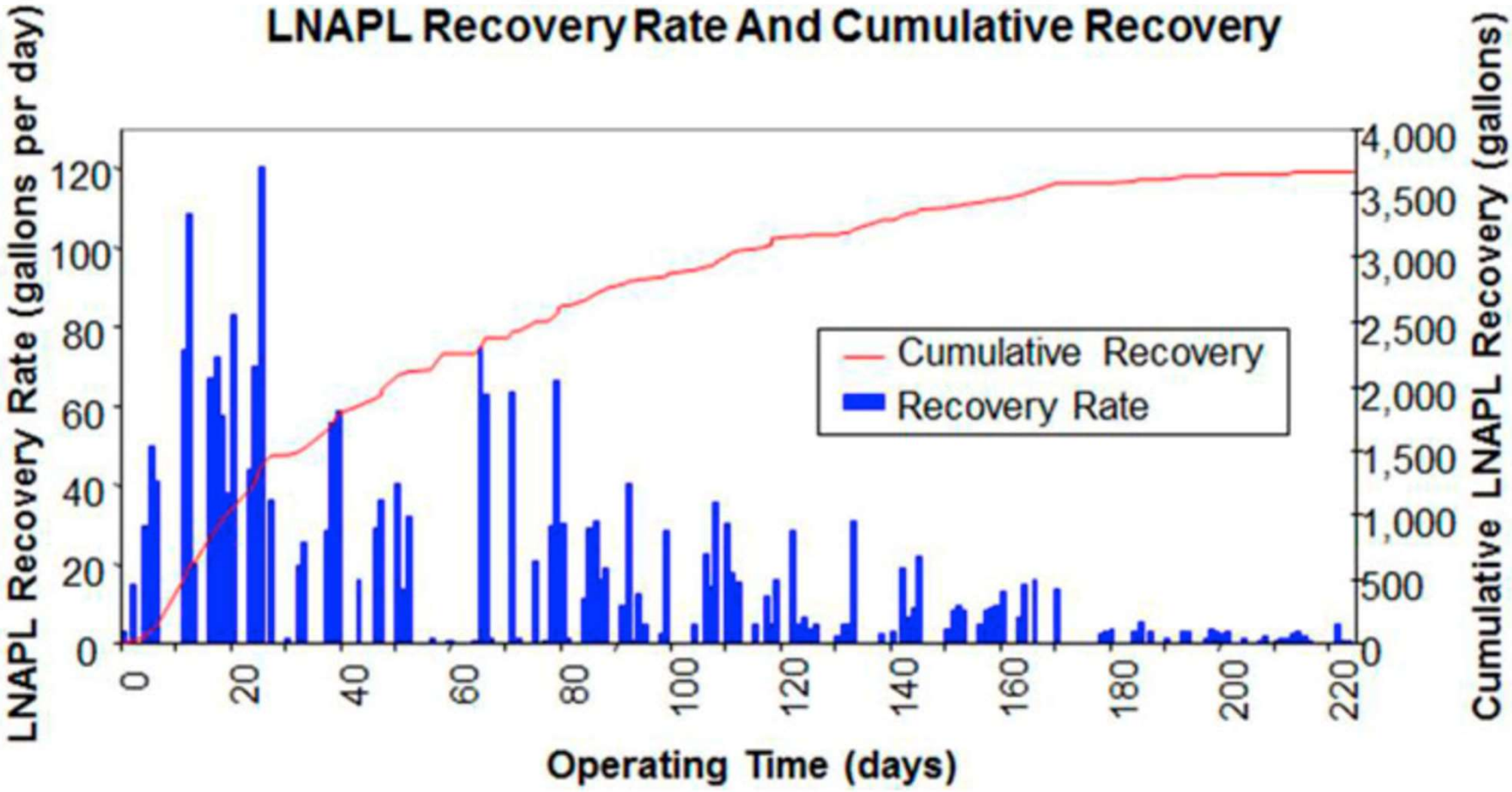


Ref: https://lnapl-3.itrcweb.org/

tetra LV

Observations for U.S. EPA

Technical Issues

- Poor or inadequate LNAPL characterization
- Difficult soil conditions
- Focus on risk-based action levels in groundwater rather than remediation parameters

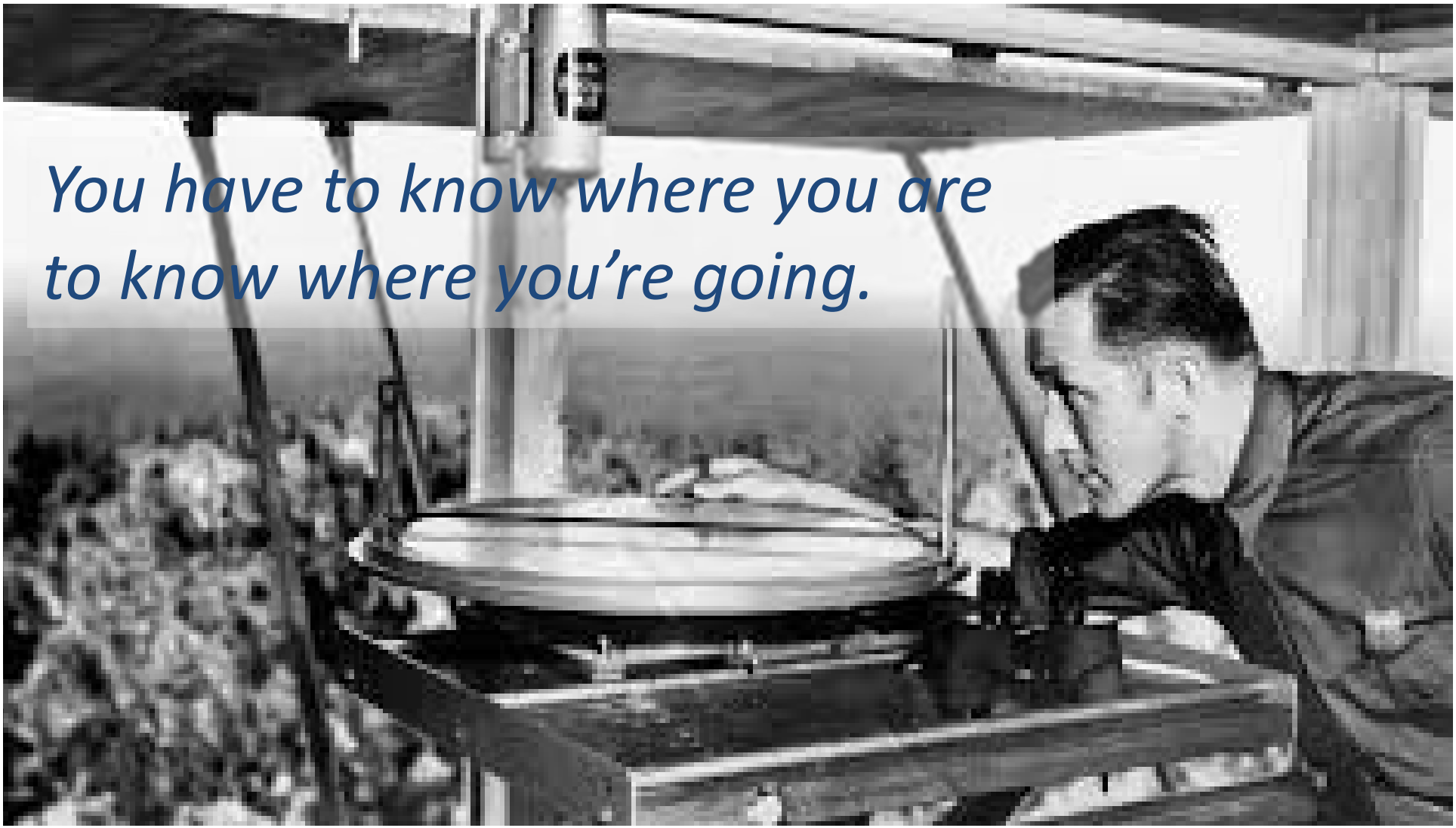
Non-Technical Issues

- Unidentified or uncooperative site owners
- Outdated state mandated protocols, regulations, and reimbursement parameters

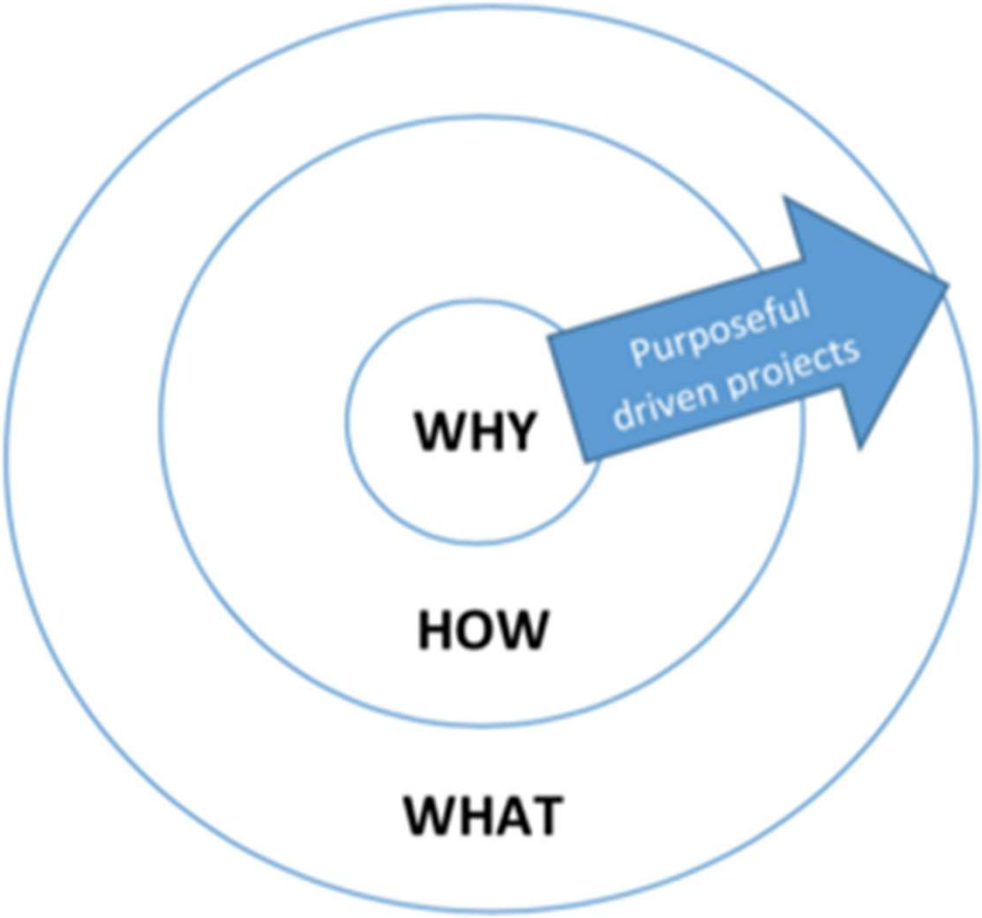
Moving Sites to Closure (U.S. EPA)

- ASTM E50.04
- Risk-based Closure
- Technical Issues
  - Vapor / Soil / Groundwater / LNAPL
- Demonstrate satisfaction of Closure Criteria
- Propose Closure
- Develop & Implement Closure Plan
- Modify Remedy

A Word About HRSC



High Resolution Data Collection Reduces Uncertainty and Cost

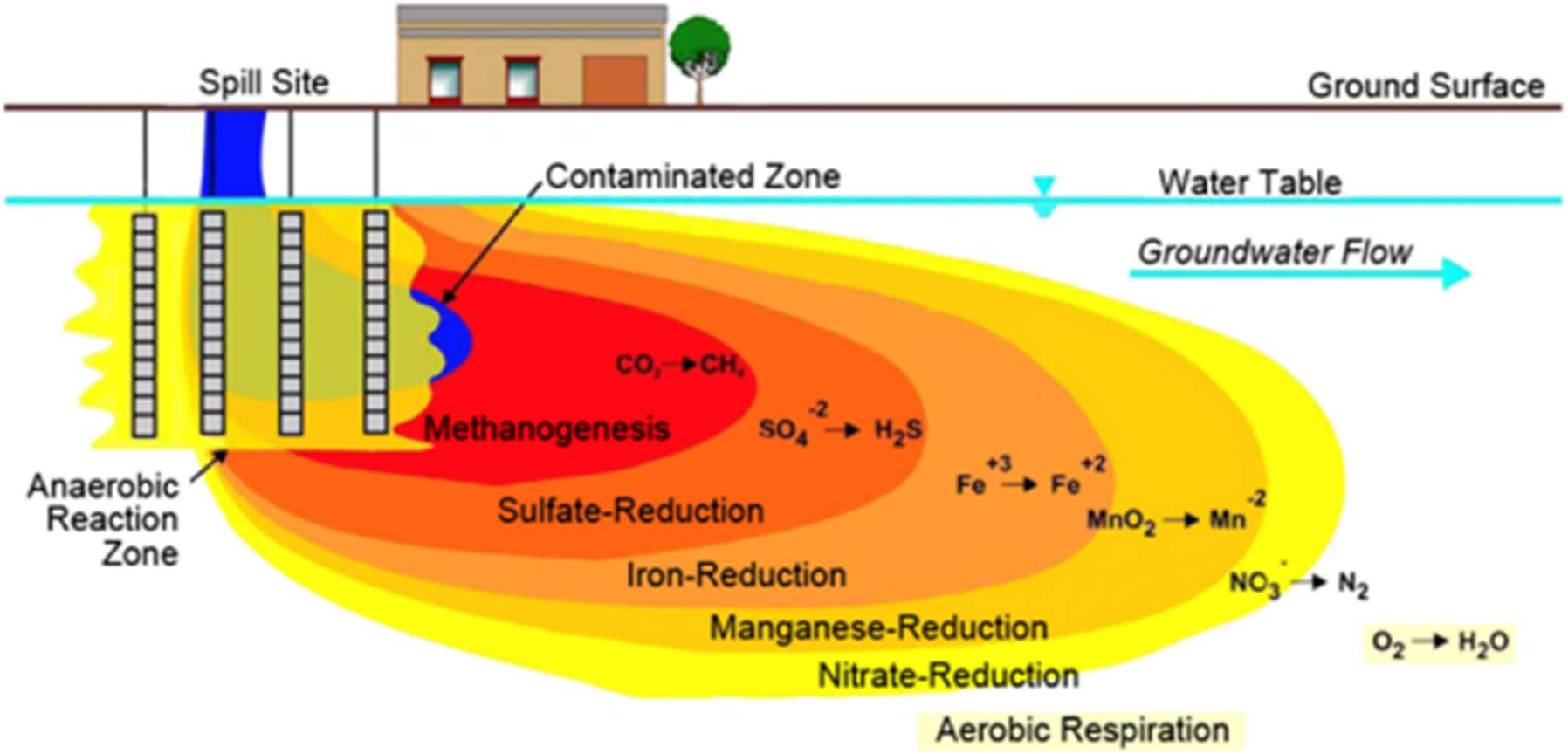


WHY do you need a better remedial design characterization?

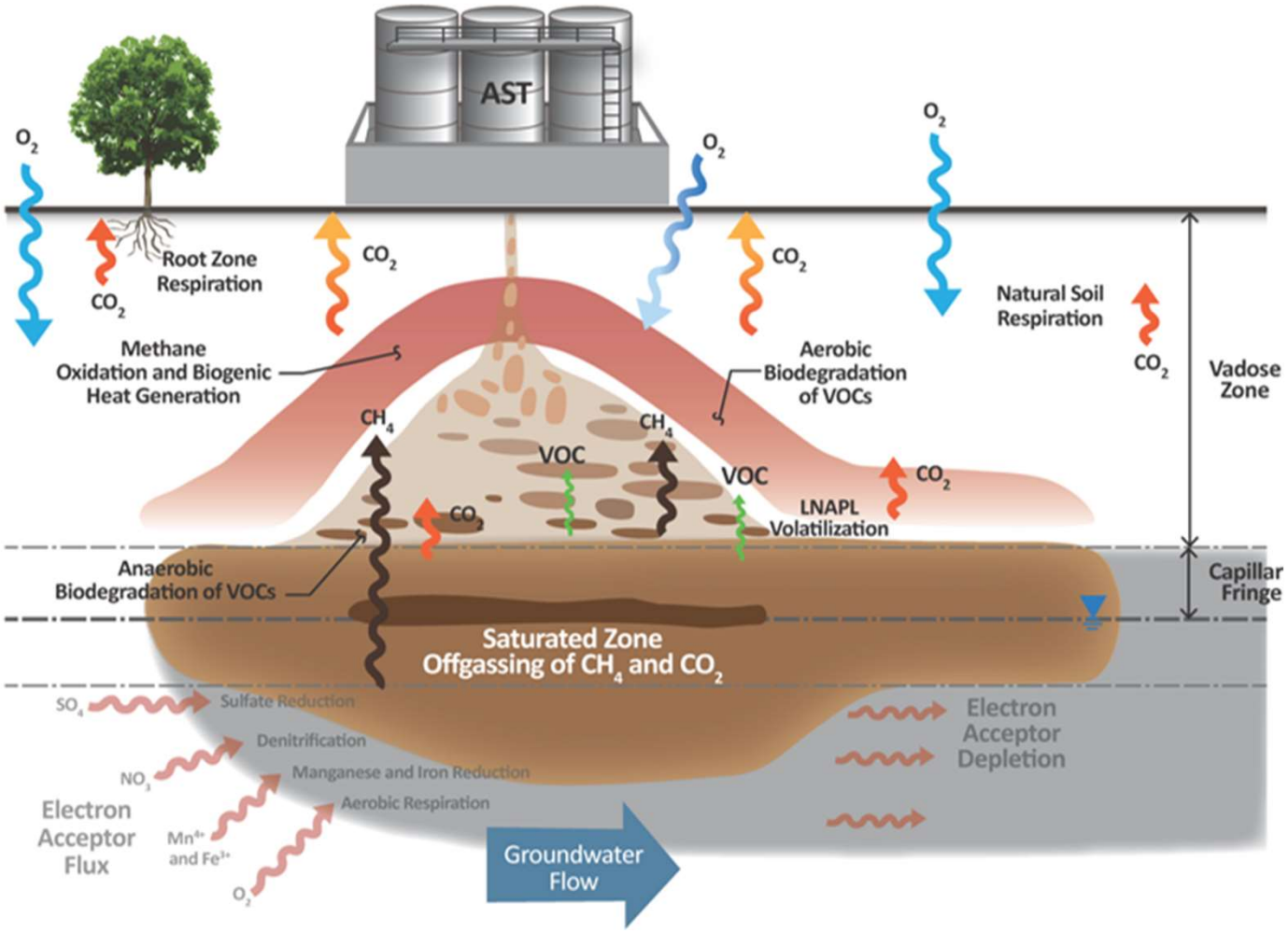
HOW you can most cost-effectively get the design parameters you need: chemical, geology, hydrology, AND biology

Finally consider WHAT tools you're going to use to obtain the necessary information

MNA - Understand the site and plume chemistry



NSZD – Natural Source Zone Depletion



COLUMBIA TECHNOLOGIES

Case Study

Gasoline release discovered in 1992 during UST closure

Several investigations have been conducted including

- Preliminary
- Secondary
- Data Acquisition
- Groundwater Monitoring

ARBCA - site-specific target levels were developed for the site

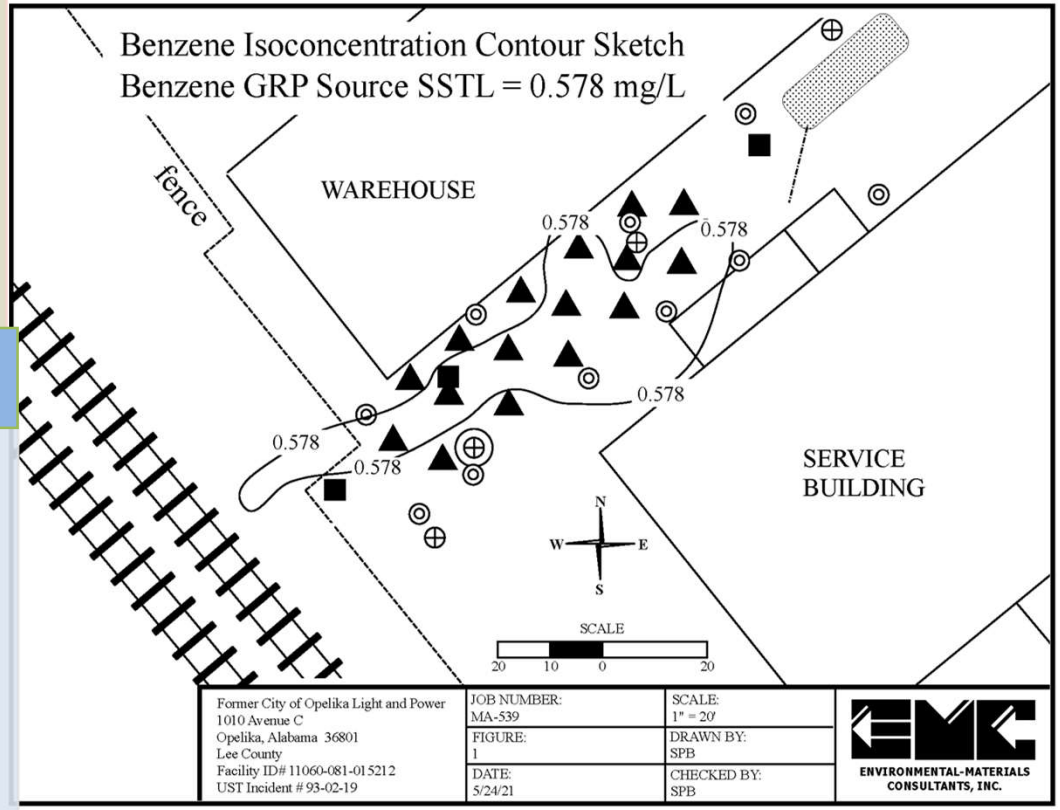
Site Conditions

Soil

- Saprolite derived from metamorphic rocks of the Opelika Complex
  - Clay, silt, and sand layers
  - Not as permeable as sand, but not as impermeable as clay

Groundwater

- Benzene in several wells has commonly exceeded the source area target level (0.578 mg/L)
- Naphthalene has periodically exceeded the point-of-compliance target level in one downgradient well
- Other chemicals of concern have rarely exceeded target levels



COLUMBIA TECHNOLOGIES

Historic Remedial Action & Results

Mobile Extraction Events

- 34 events were conducted from 2006 through 2016
- Most were 8-hour
- Most were conducted as part of the 2007 CAP implementation, but 3 were conducted just prior to ISCO events
- 20,000 gallons of liquids recovered
- 250 gallons of gasoline-equivalent recovered (calculated from vapor emissions)

Benzene concentrations decreased in some wells with lower initial concentrations

RW1

- 2008 average benzene concentration was 0.232 mg/L
- 2014 average benzene concentration was <0.001 mg/L (BDL)

Benzene concentrations did not decrease in wells with the highest concentrations

RW6

- 2008 average benzene concentration was **21.633** mg/L
- 2014 average benzene concentration was **26.500** mg/L (BDL)

Benzene GRP Source SSTL = 0.578 mg/L

Action & Results - Continued

In-Situ Chemical Oxidation (ISCO)

Several phases were conducted:

- August 2014 – 5 days of injection
- November 2014 – 5 days of injection
- April 2015 – 5 days of injection
- November-December 2015 – 5 days of injection
- March 2016 – 5 days of injection
- August 2016 – 4 days of injection

Benzene decreased in some wells, but long-term averages showed little change

MW9

- 2013 average benzene was 3.413 mg/L
- 2017 benzene was 3.900 mg/L

RW6

- 2013 average benzene was 26.433 mg/L
- 2017 benzene was 25.400 mg/L

JW(0

Lessons Learned from Previous Remedial Action

- ISCO recommended amount of chemicals was not applied
- Incorrect implementation
  Maybe should have used direct-push instead of pre-installed IWs
- Inaccurate measurement of total hydrocarbon mass – *requires saturated soil samples and TPH*L
- NAPL trapped in low permeability soils – *difficult for MEME or gravity feed of ISCO*
- Extended screen interval on recovery wells – *ineffective vacuum extraction, draw down water table, extends smear zone of hydrocarbons*

Slide 21

JW(0

- If we would like to be a bit more “diplomatic”, perhaps we could say something like “Lessons Learned from Previous Remedial Action”

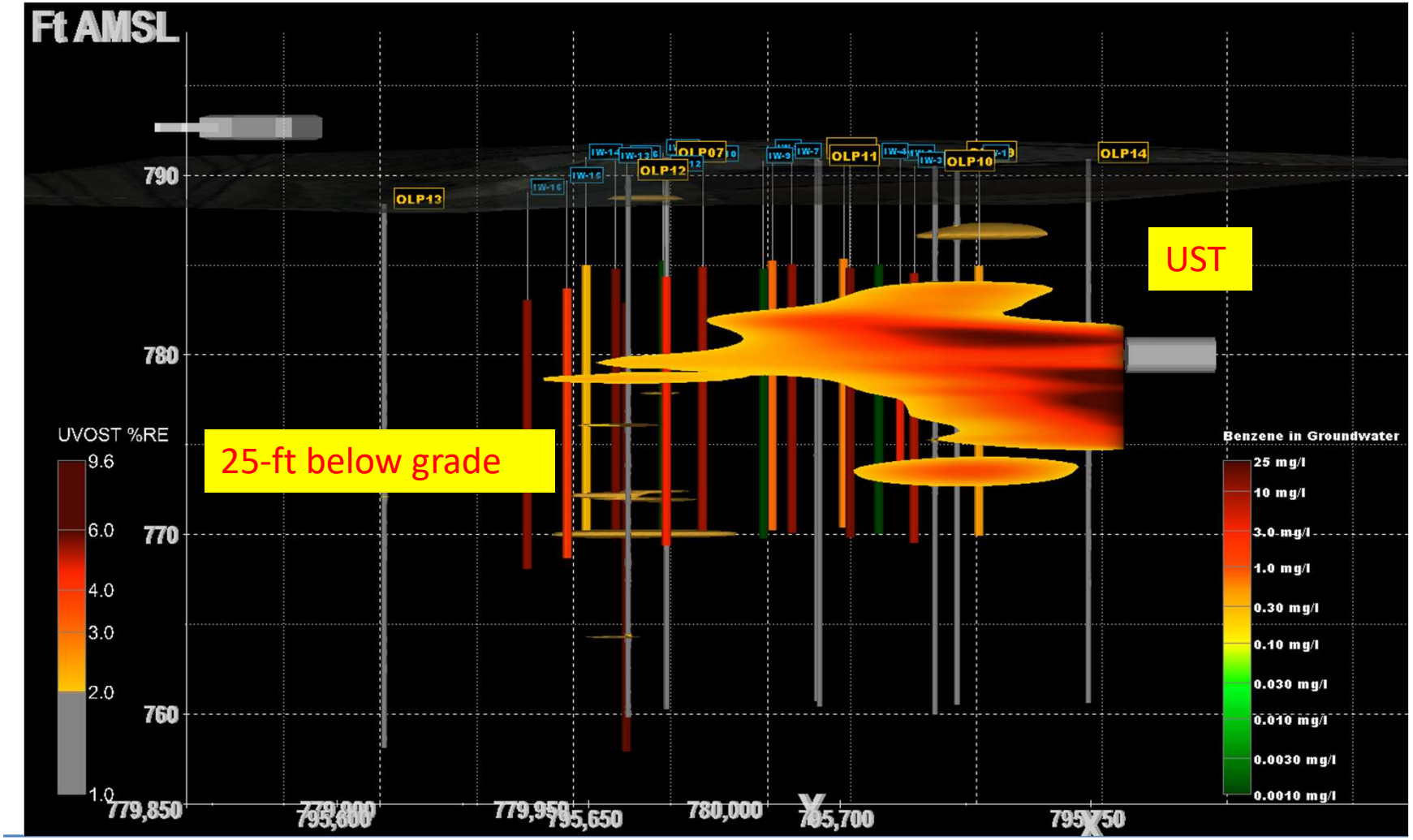
- Font size could be increased.

- Is TPHL the same as TPH-GRO? This is for MY education :-)

Johnson, West (EEC), 2022-08-11T18:41:59.670

JW(0

Locate the source problem



Slide 22

JW(0 Recommend using areas to specify the UST and the “25-ft below grade” line.
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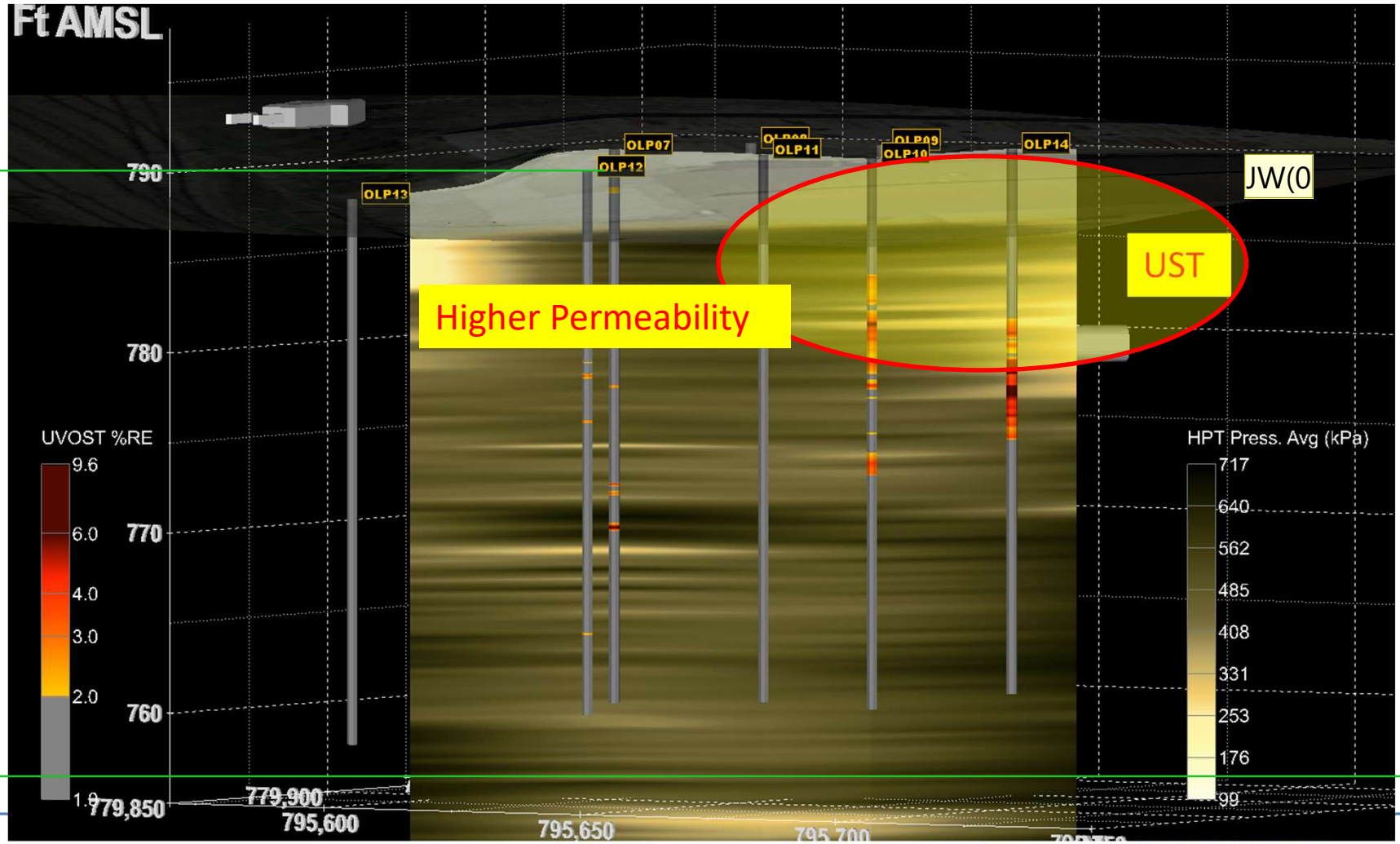
Understand the Soil Permeability



Slide 23

JW(0 Perhaps arrows would help on this slide as well?
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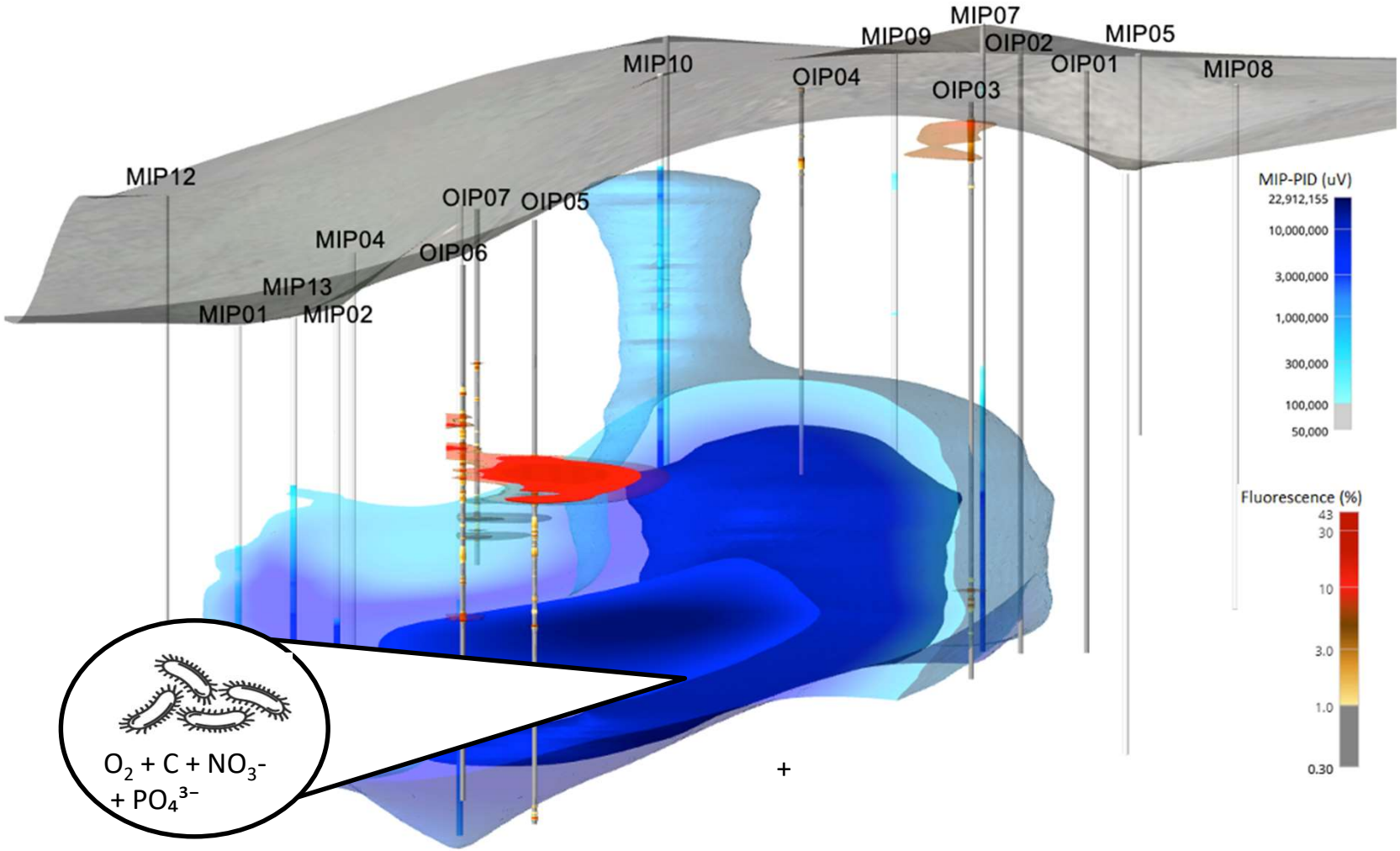
HRSC Multiple Lines of Evidence



Understand the microbial community

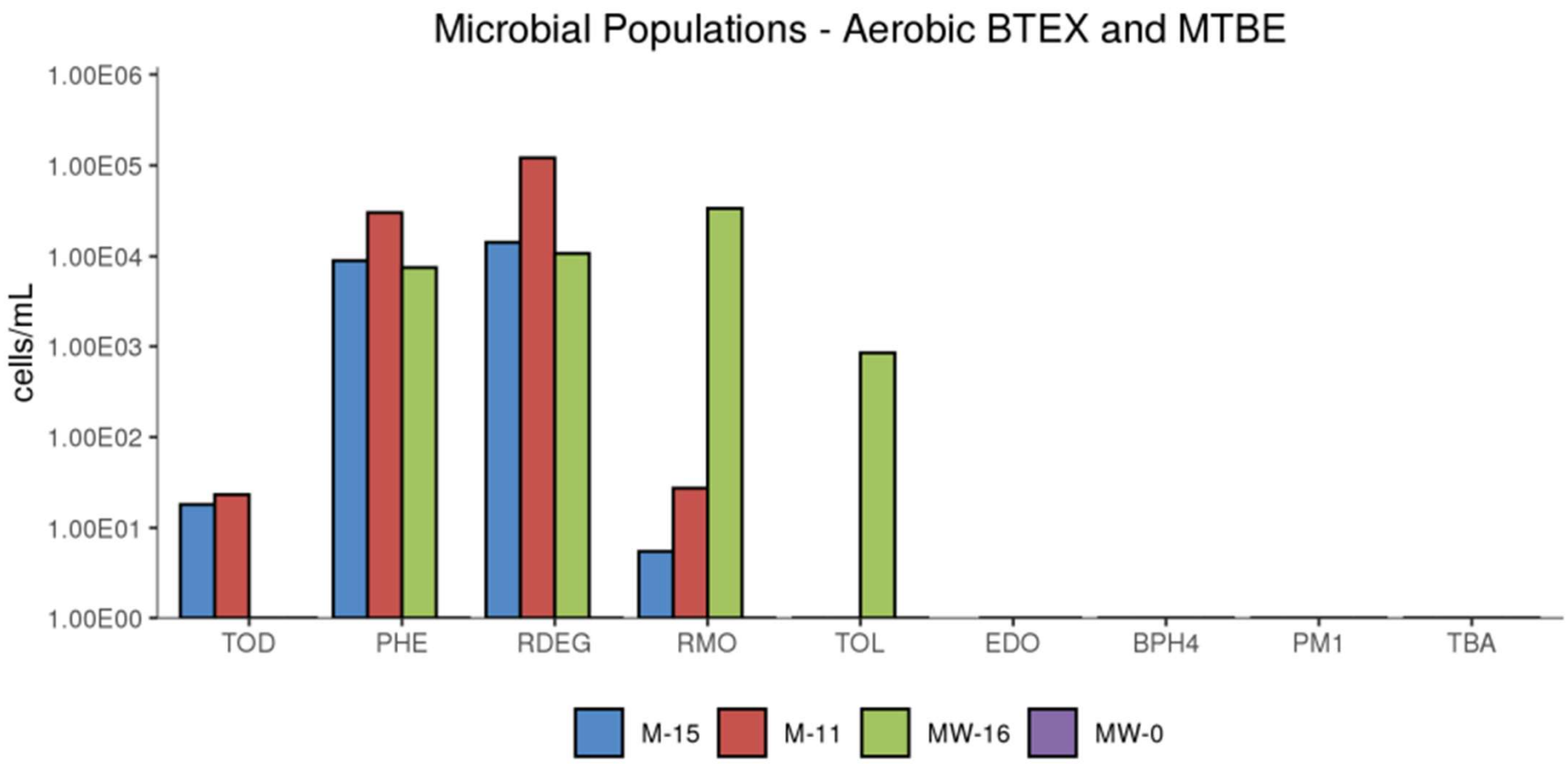


Figure 9: Comparison - microbial populations involved in aerobic biodegradation of BTEX and MTBE.

What microbial conditions are present?

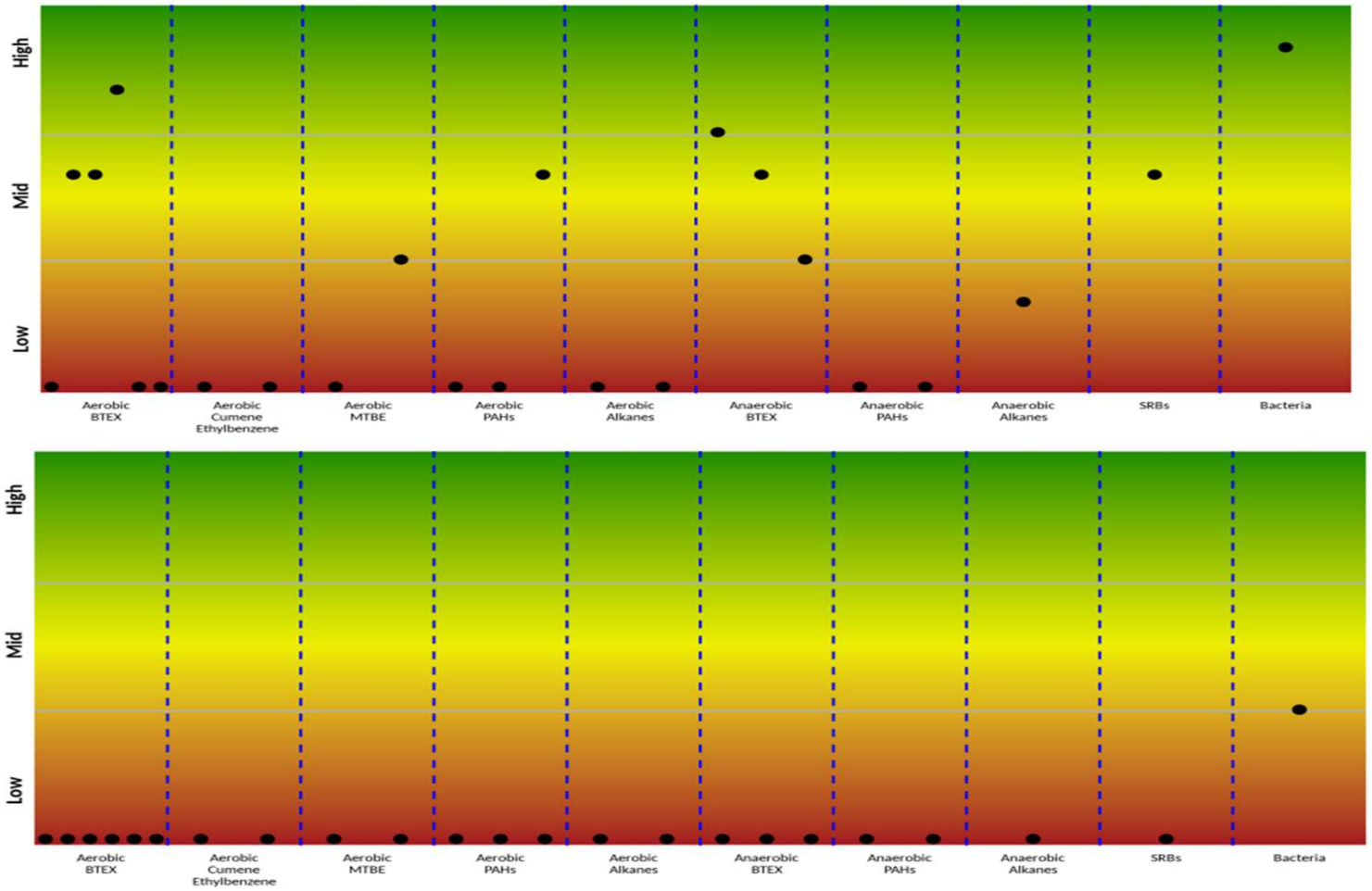


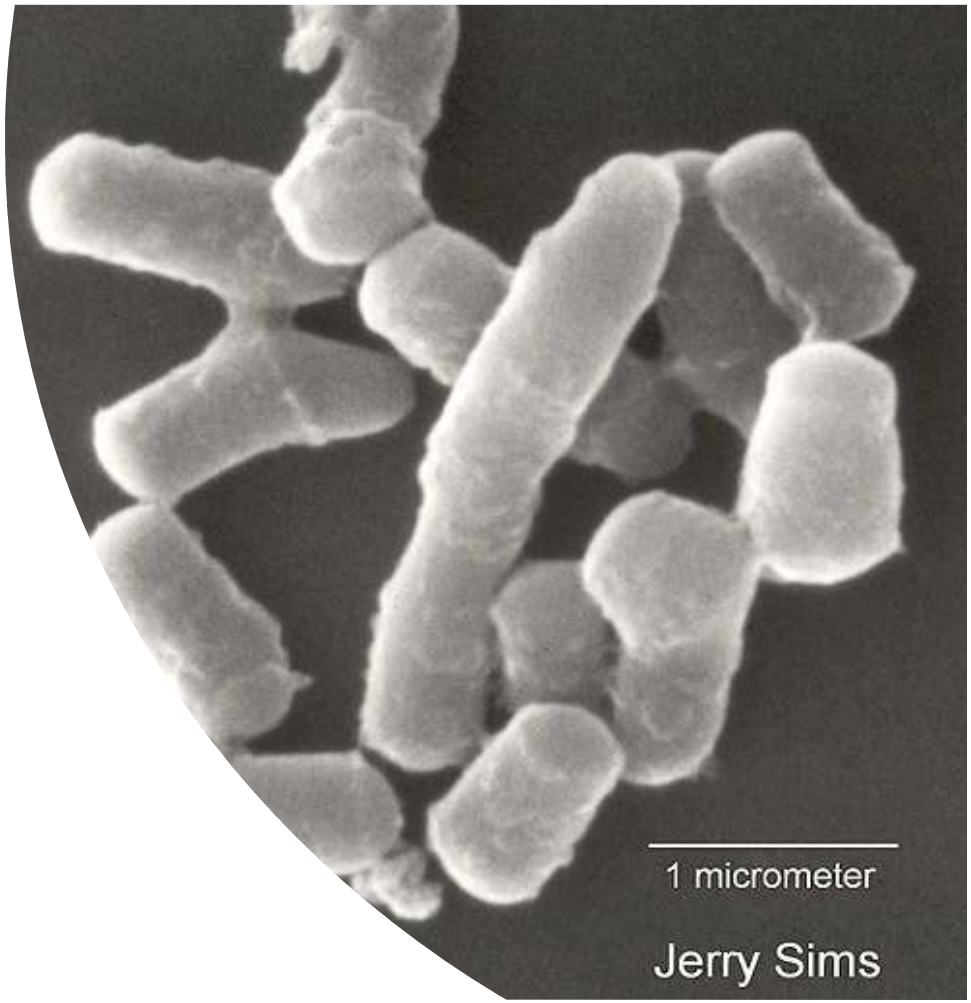
Figure 5: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

HRSC Study Results

- Delineation of the residual LNAPL (OIP & MIP)
- Soil permeability where the LNAPL resides (HPT)
- LNAPL composition, concentrations, mass, and stability (High-resolution soil sampling)
- Extent of the groundwater plume (MiHPT + existing GW monitoring wells)
- Relationship of monitoring well screens to the actual site conditions
- Microbiological conditions (qPCR)

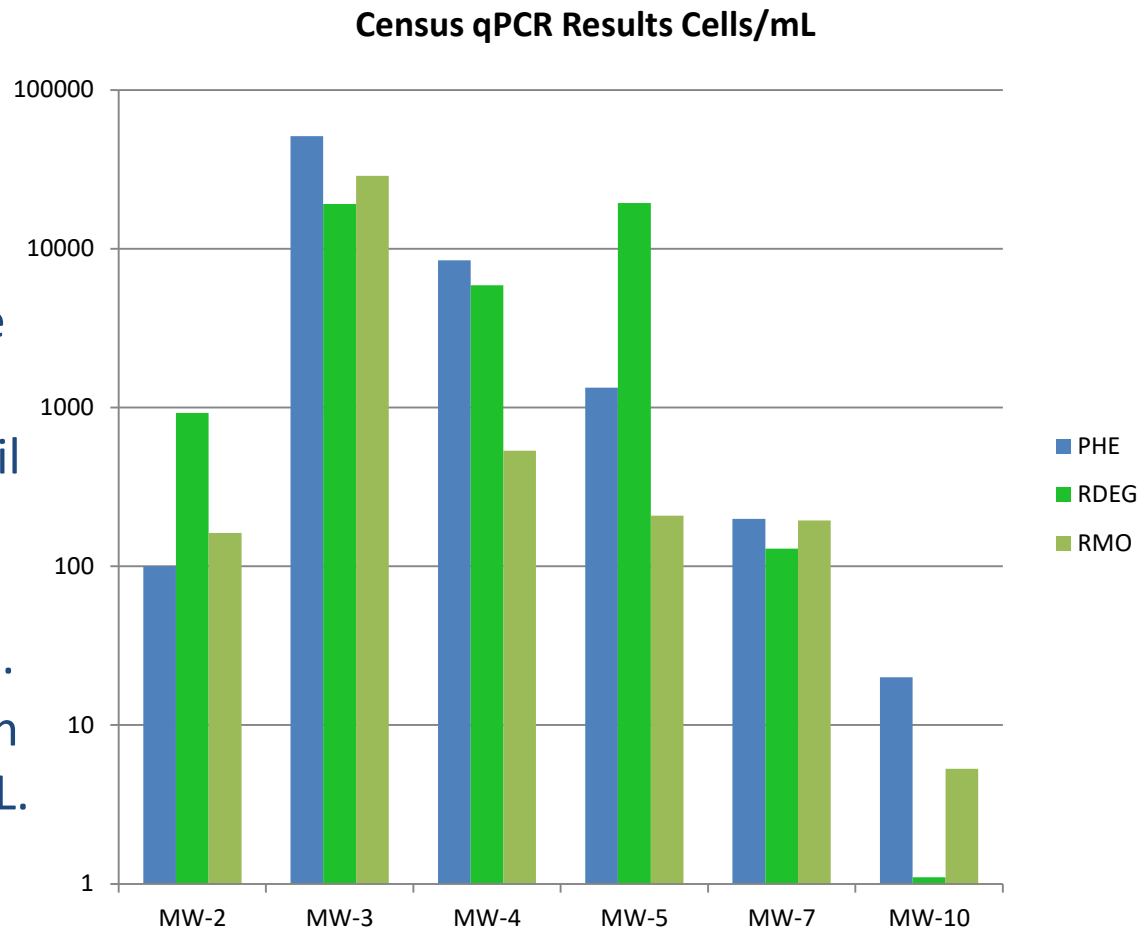
Nutrient Enhanced Bio-Stimulation

- Nutrient injection to stimulate indigenous bacteria cell division and metabolism.
- Independently controlled, pulsed air sparge. Flows from 0.5 to 2.0 cfm per injector.
- PLC controlled dosage:
  - Air/Oxygen
  - Bio-Available Nitrogen
  - Reactive Phosphate
  - Methane/Propane/Butane as Co-metabolites



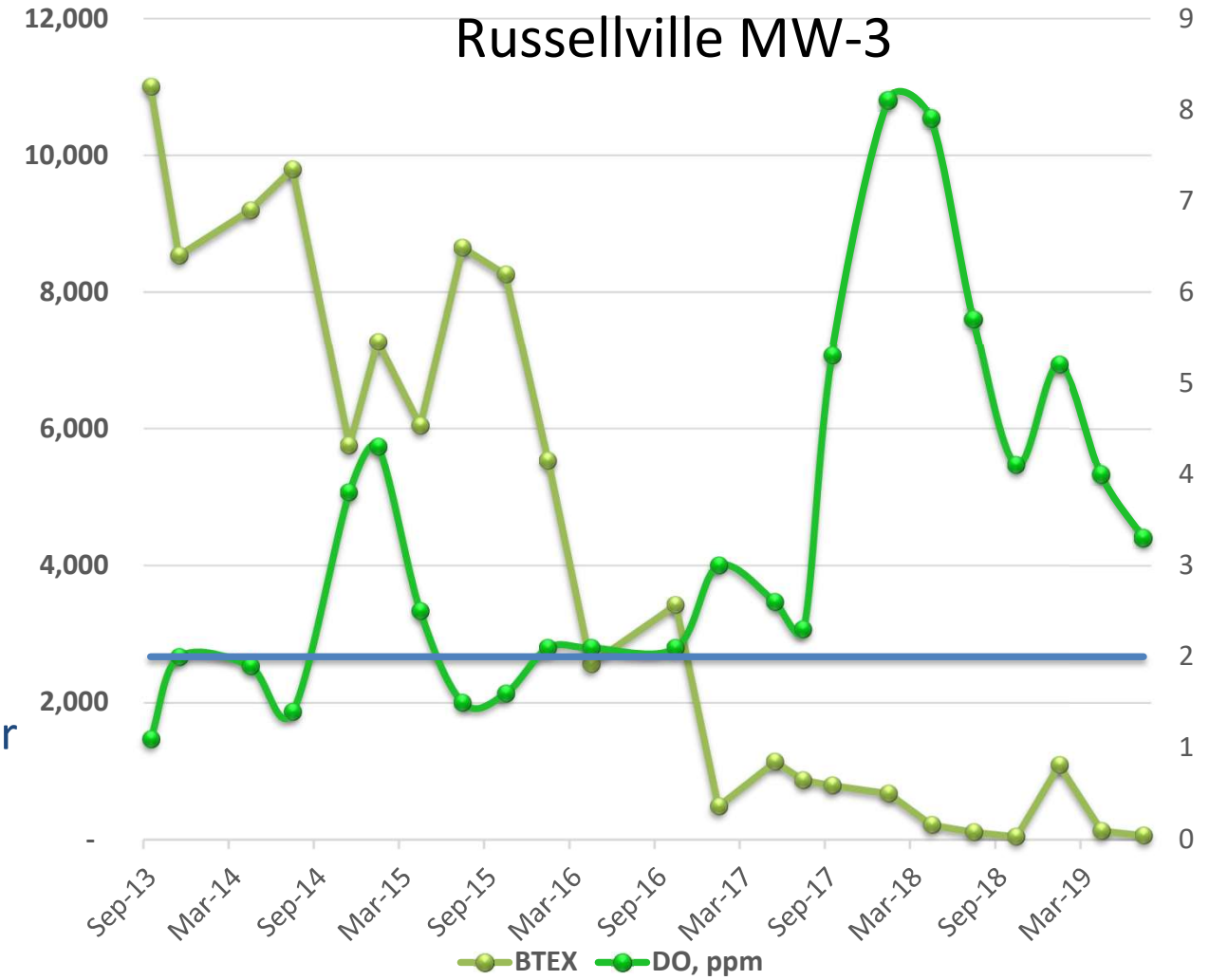
Building a Population

- Bacteria Macro-Nutrient Molar Ratio: $C_{100}N_{10}P$.
- Addition of Nutrients slow dose/low dose.
- Establish Cell Counts of more than 10^5 cells/mL.
- Build Aerobic Population until Respiration Rates are Maximized.
- Establish an Oxygen Demand.
- Cease nutrient addition when active sparge zone DO≈2 mg/L.

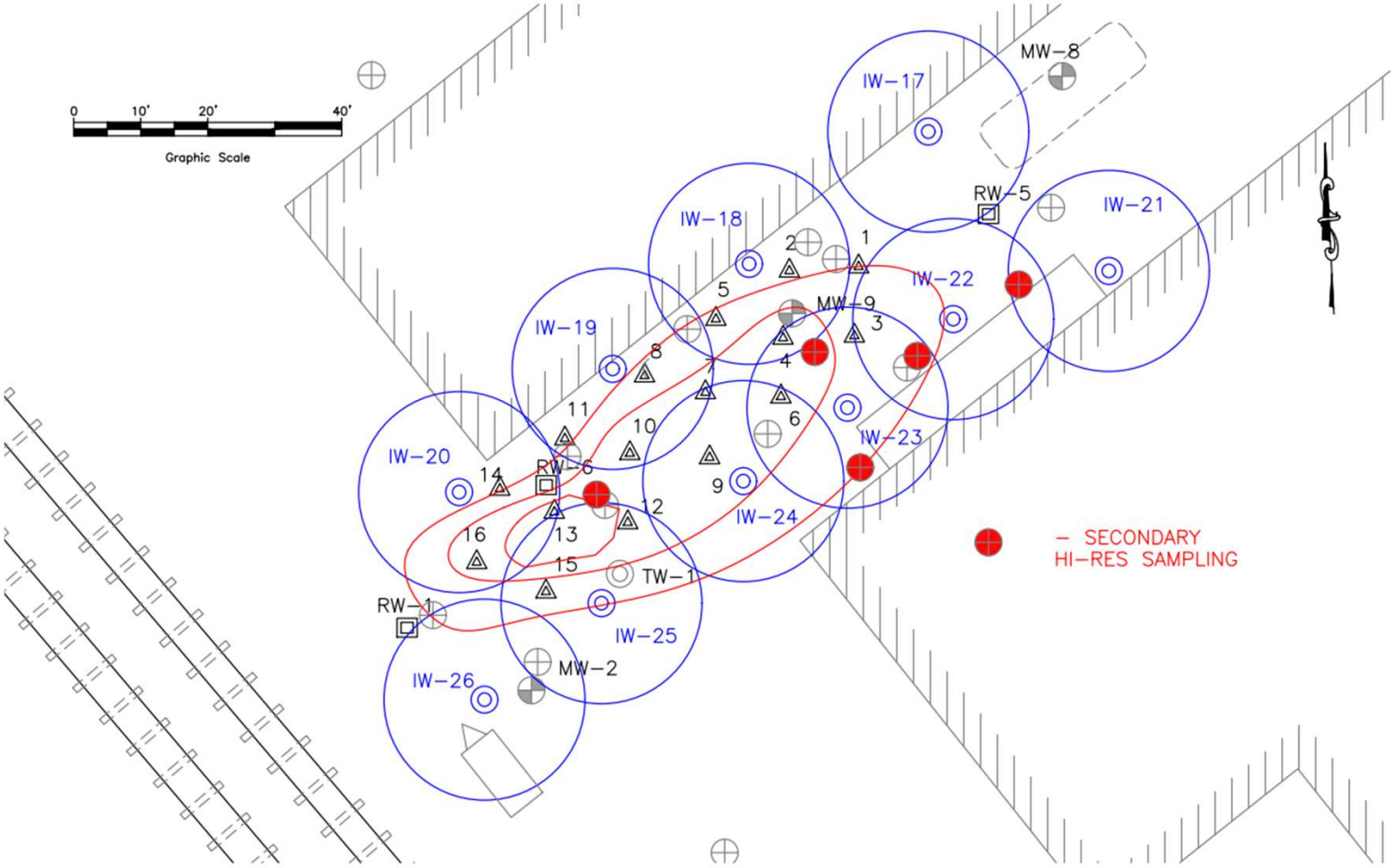


Establish Oxygen Demand

- MW-3 was the Source Area well at the Russellville Site.
- Clean Closure Obtained in 2019.
- O2 demand keeps DO near 2 mg/L.
- DO remains in lower aerobic range until demand eases.



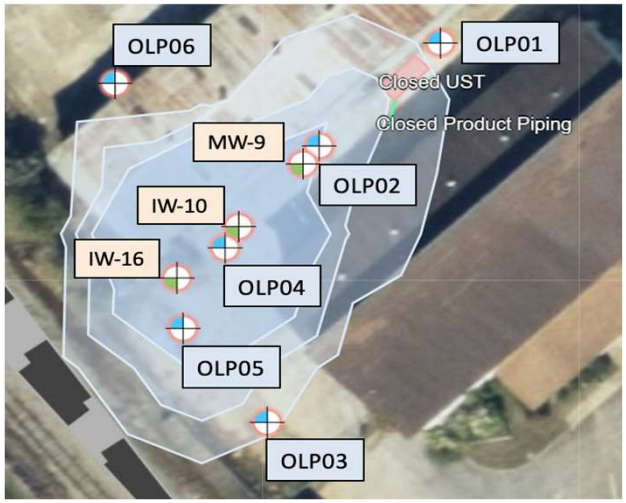
NEBS Installation

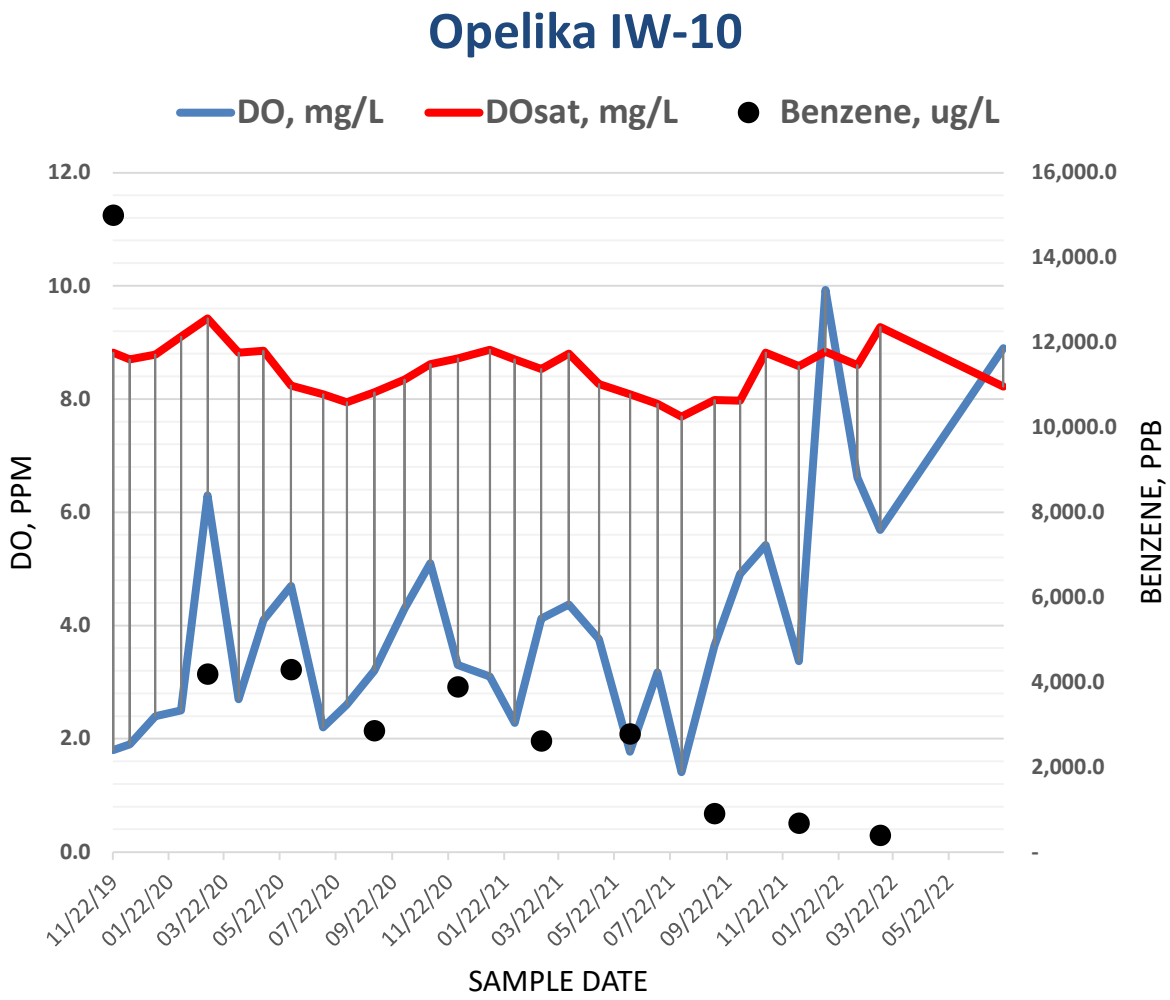


Secondary Hi–Resolution Sampling

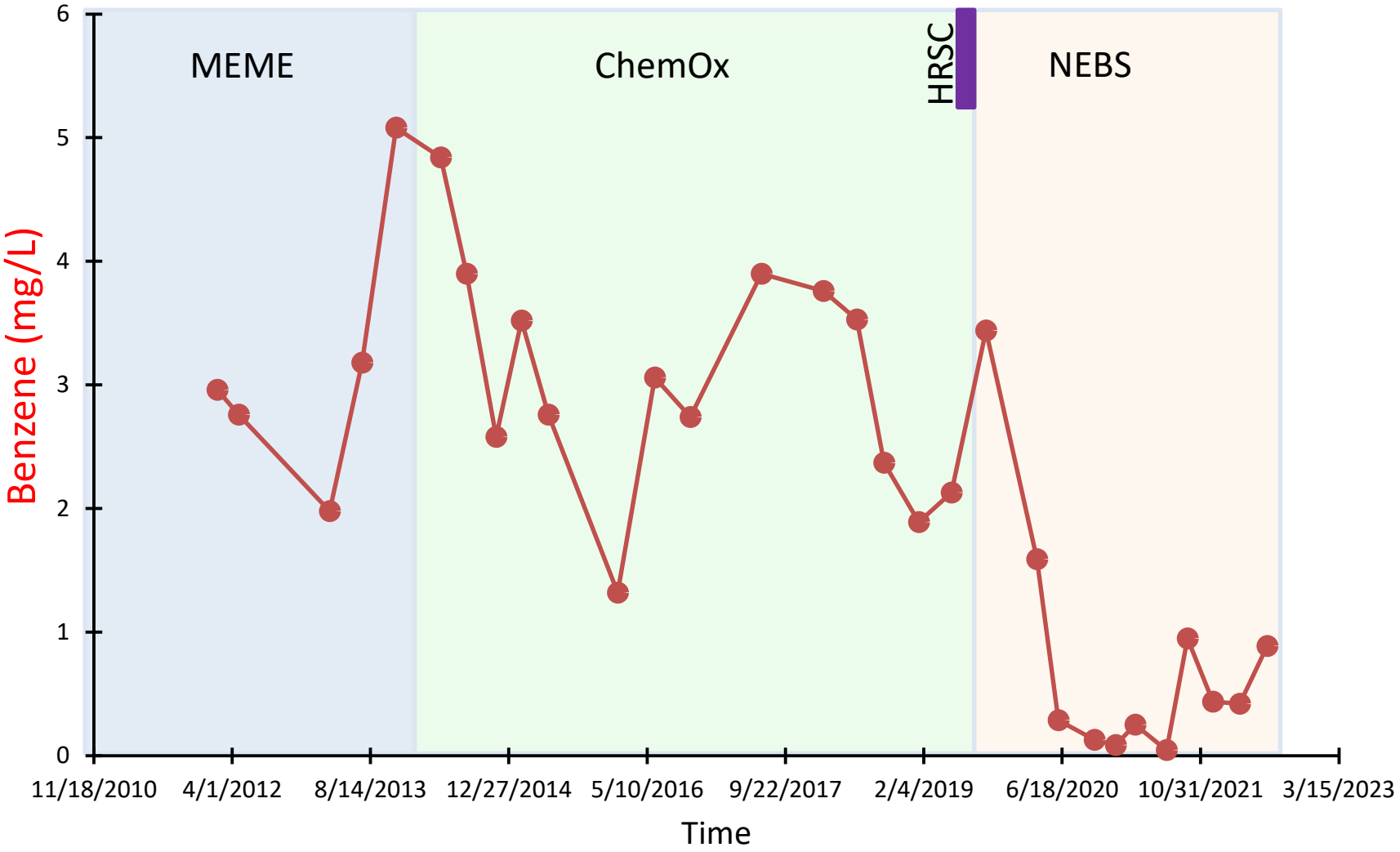
DO Increases

- Red line is DO at saturation.
- Blue is monthly DO.
- DO trends toward saturation as mass is oxidized.





MW-9 Benzene concentration across remediation methods



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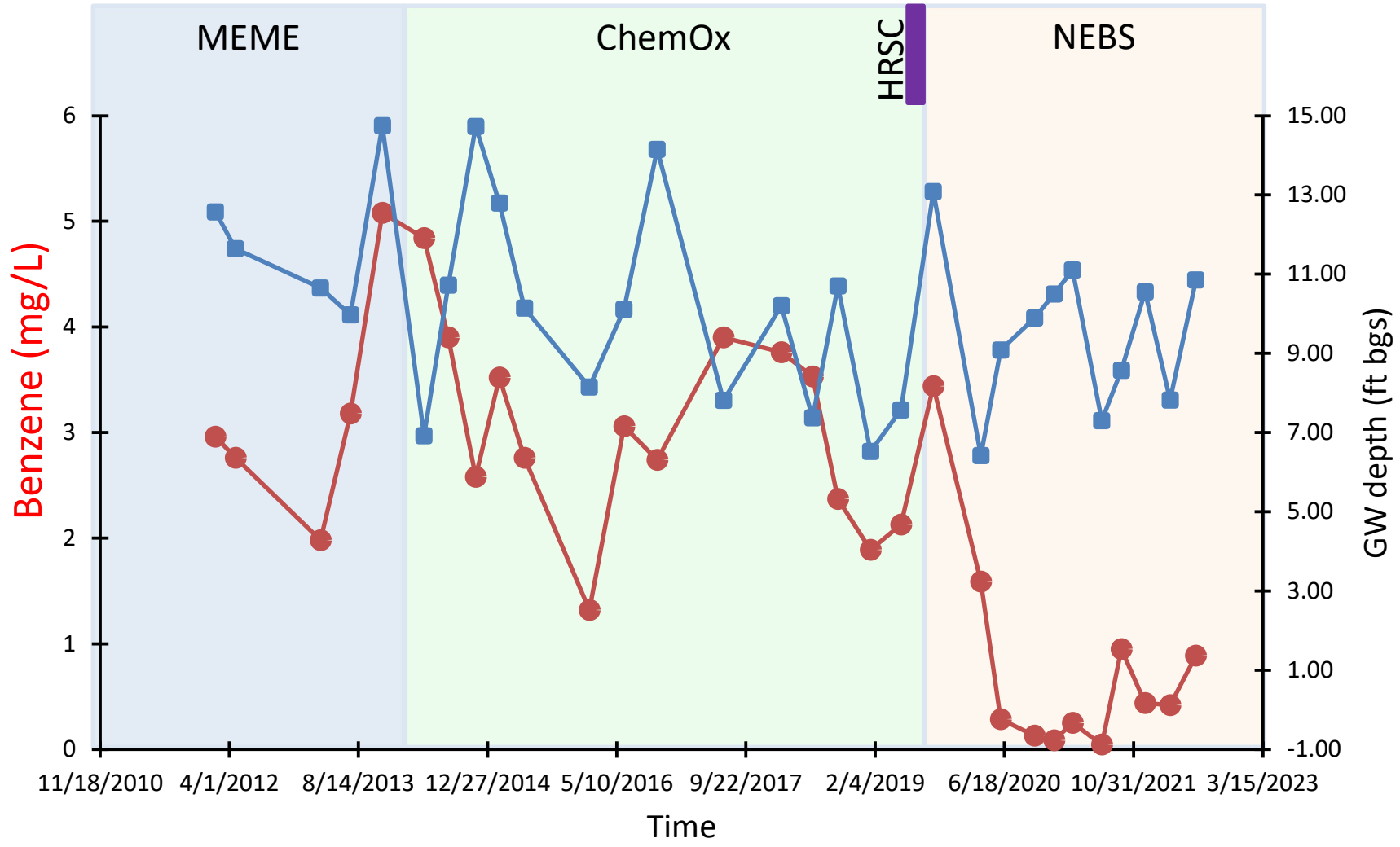
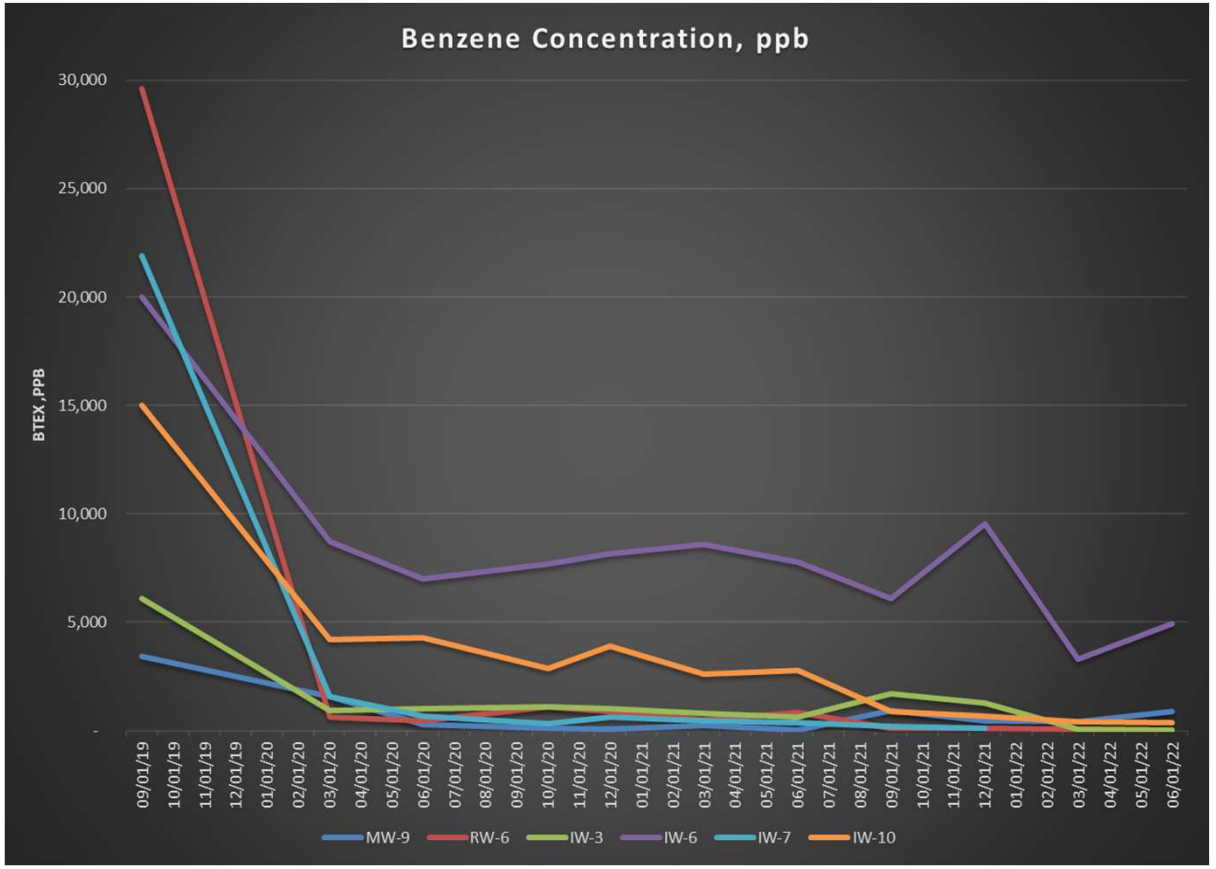


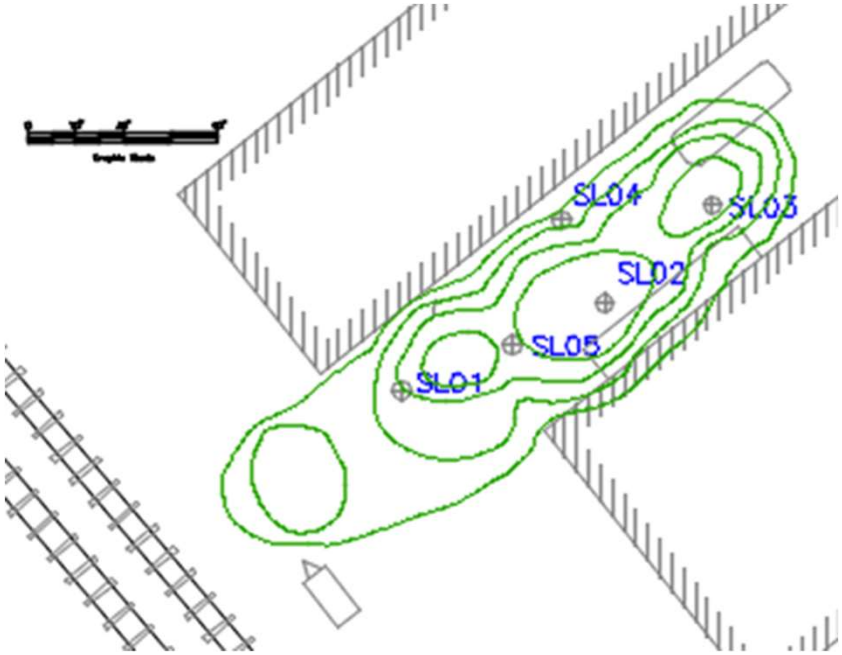
Benzene in GW SSTL 578 ppb

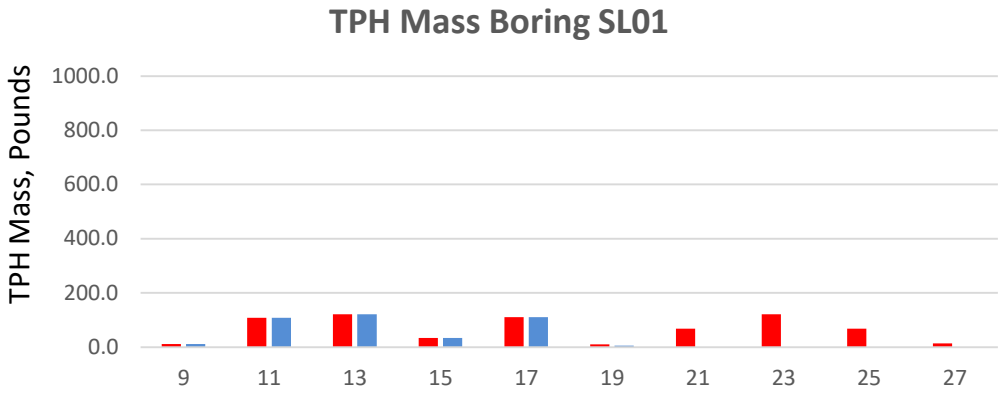
- Initial concentrations up to 30 mg/L.
- 97% reduction @ RW-6 in the 1st quarter.
- Originally 11 MW exceeded benzene target level.
- The site meets the benzene criteria in all but two monitoring wells.

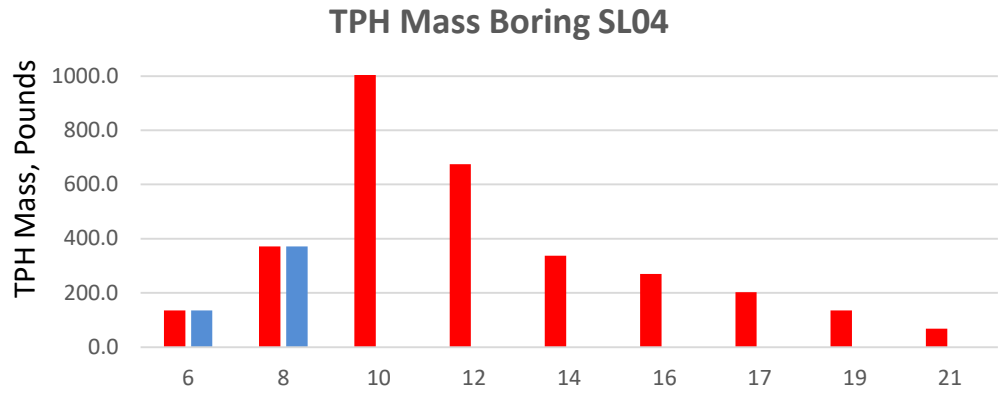


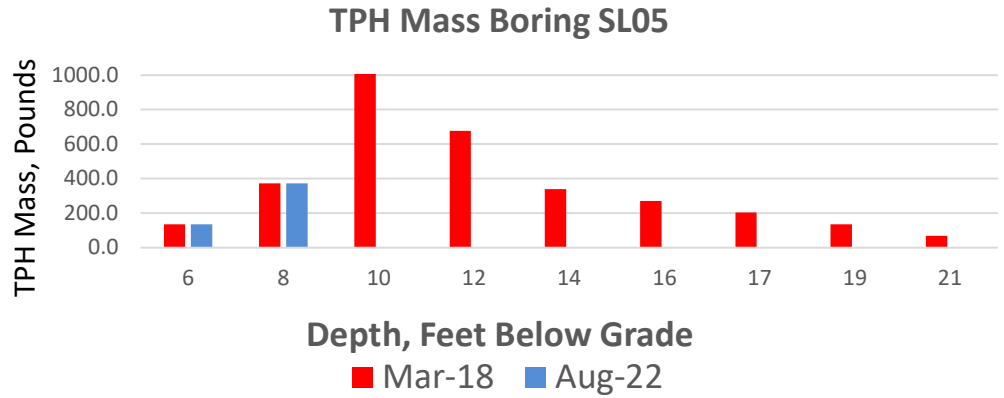
Soil sampling for LNAPL mass August 2022

- Bottom of NAPL mass rises with degradation

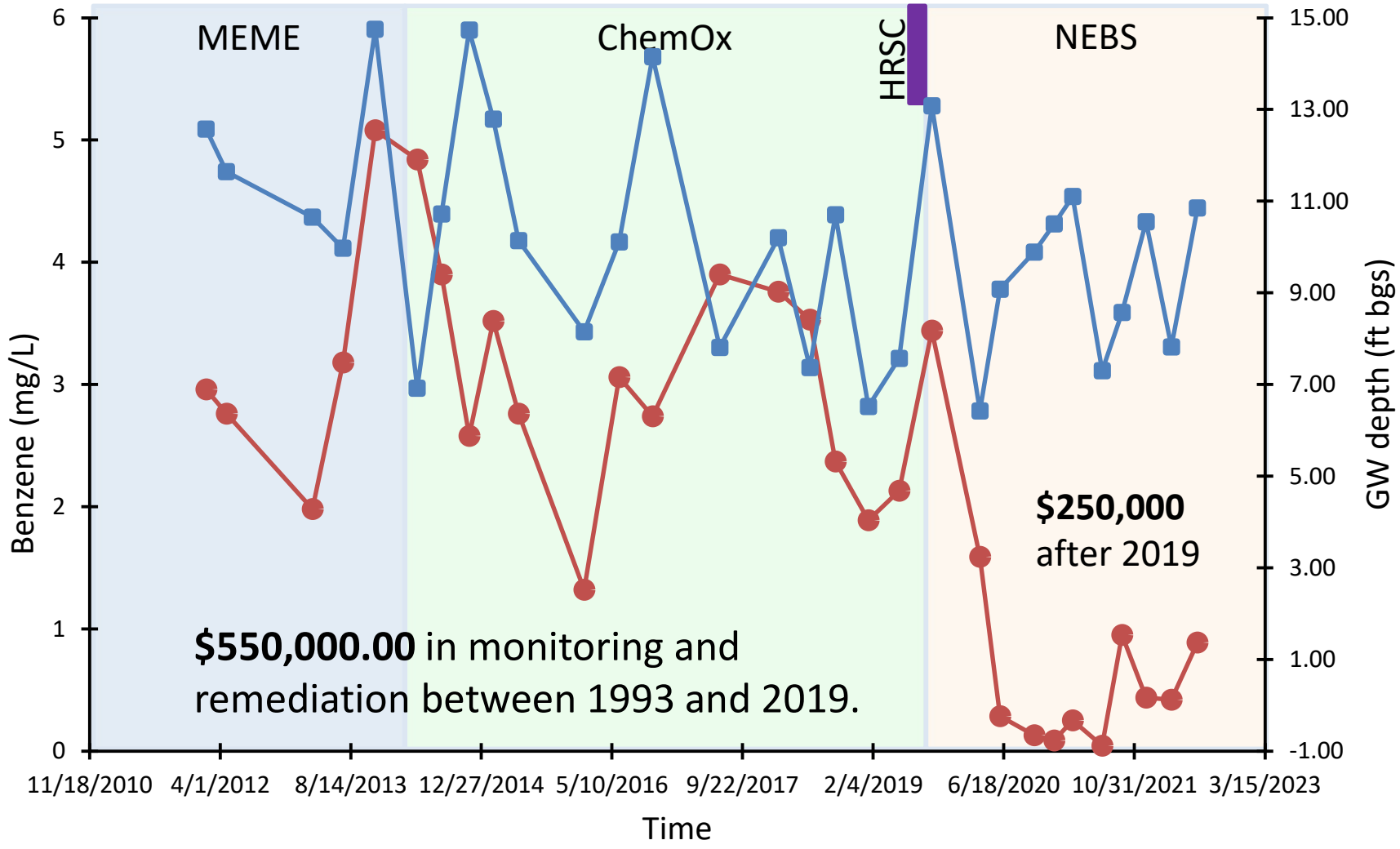




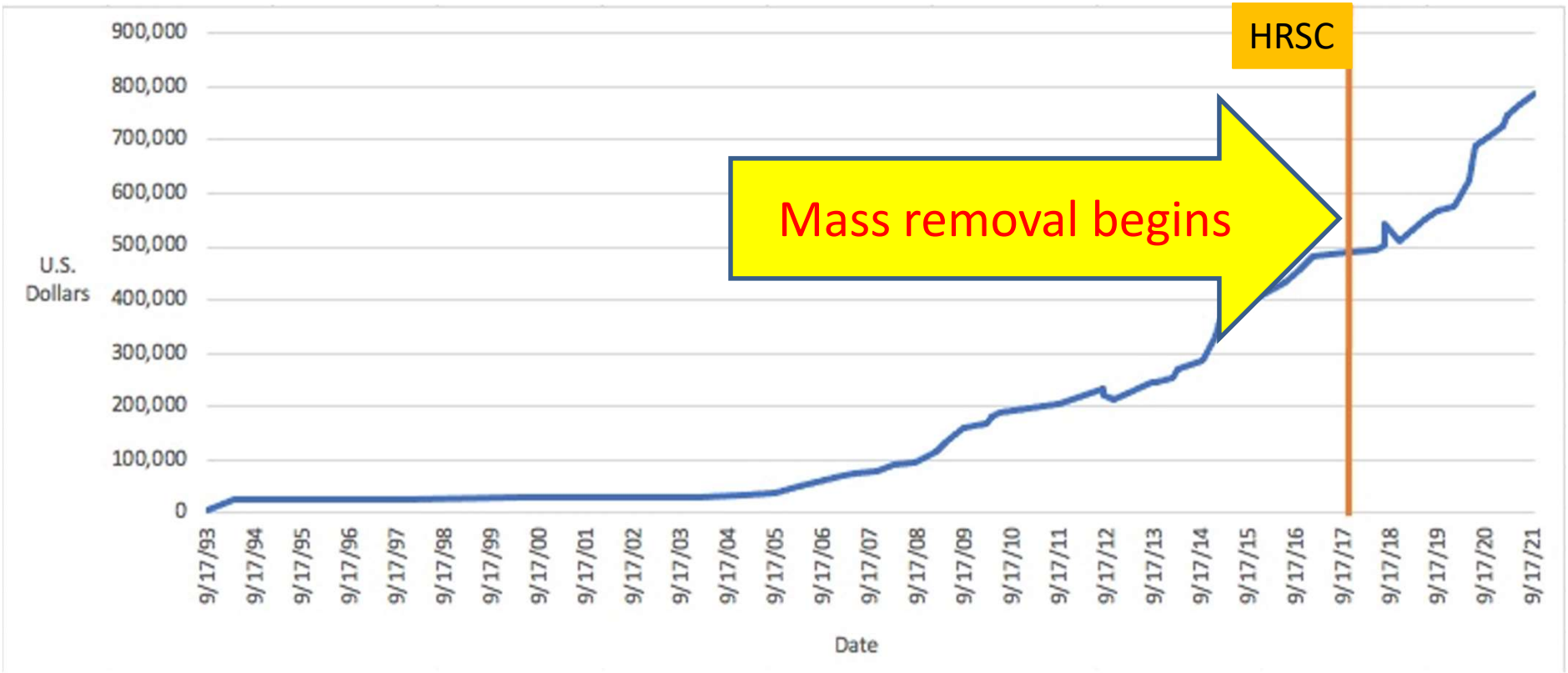




Cost vs. Methodology



Business case for HRSC and NEBS



Lessons Learned

- Challenges with low LNAPL transmissivity
- Challenge at the air-water interface and changing GW levels
- Better characterization is critical
- Soil sampling plays an important role in controlling the costs
- Role of microbial activity and nurturing through the process
- Performance metrics and mid-course corrections are needed
- Trend data (Benzene, TPH-LNAPL mass, DO, groundwater levels)
- Cost vs performance i.e. *mass removal* curves
- Sustainability aspirations (water, air, carbon, waste, fuel, etc.)

Acknowledgments

- Alabama Dept Environmental Management
- Co-Authors
  - Sam Beckum with EMC
  - Rick Smith with Smith Engineering
  - Dr. Briana McDowell - Bioremediation
  - West Johnson – Oil & Gas

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Partnering for Smarter Sustainable Solutions

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RESTORE,
Sustainably

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