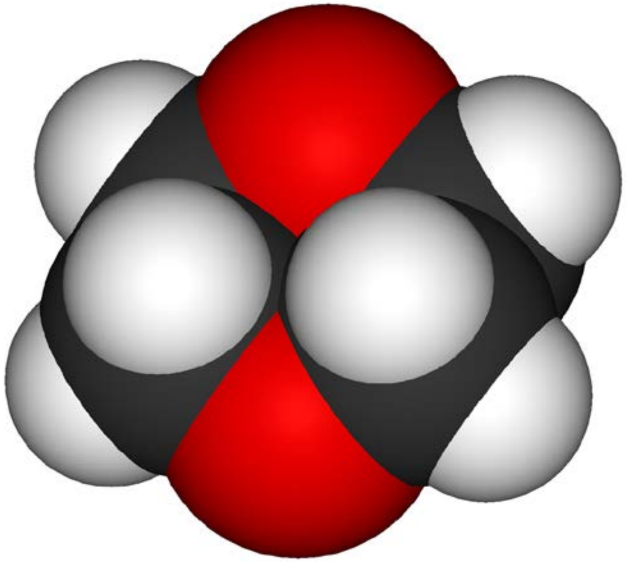
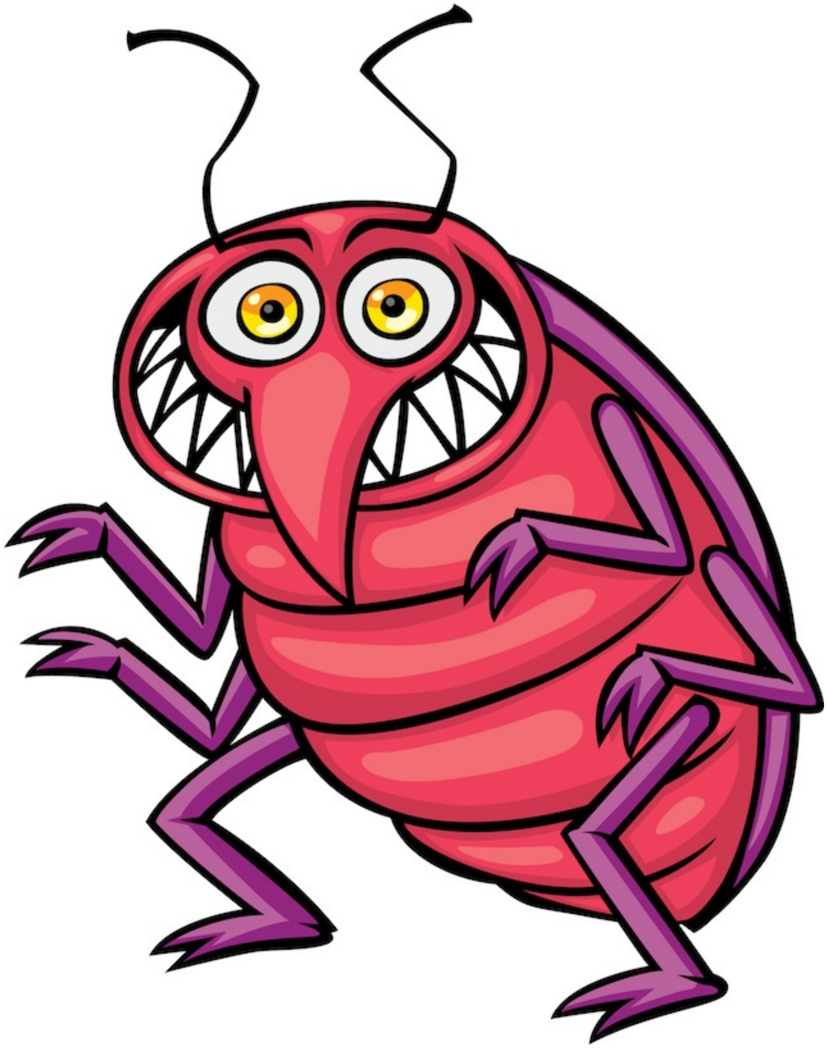
MDEQ Project Update

First Quarter 2016 Progress Report

RACER Lansing, Plants 2, 3 & 6

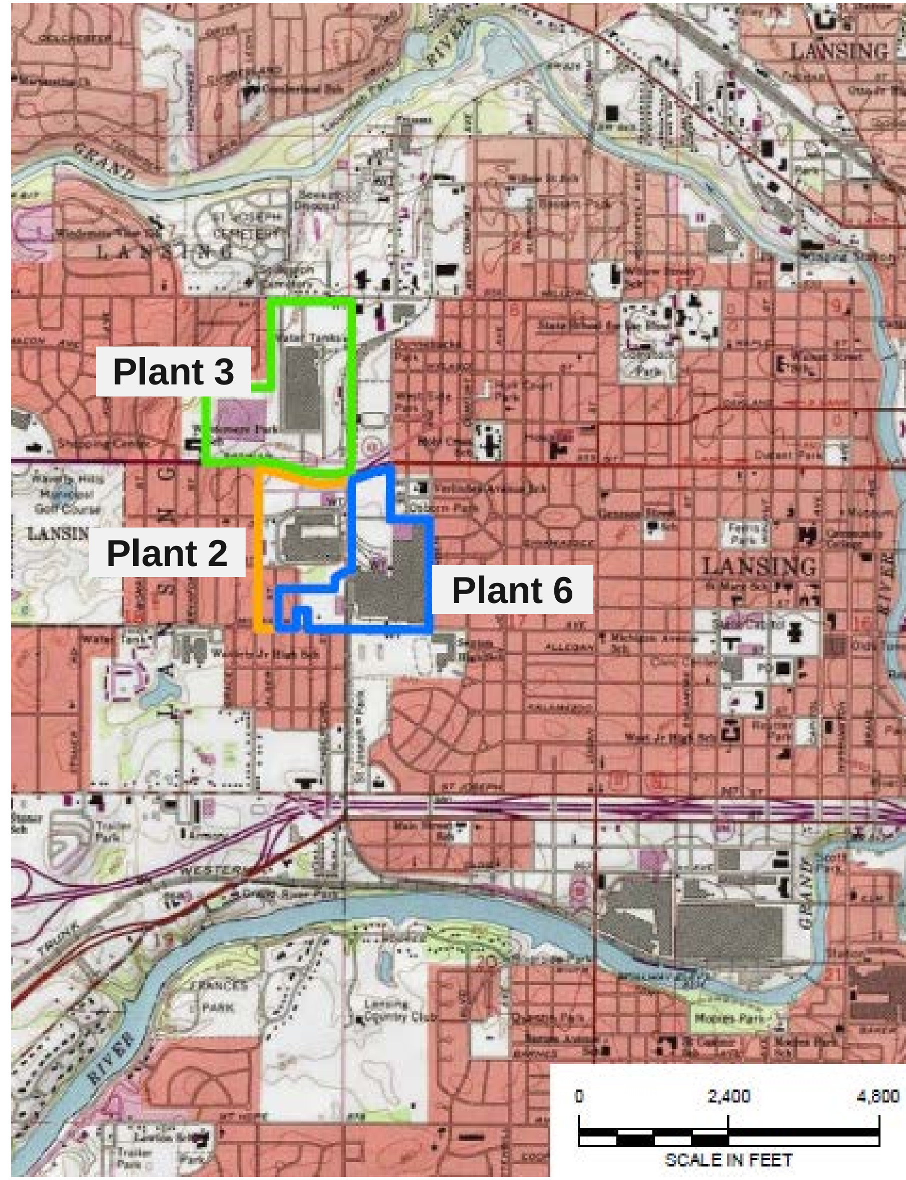
Shared with MDEQ on April 14, 2016





Agenda

- Lower 1,4-Dioxane Toe Investigation Review
  - Data Gaps
  - Proposed Supplemental Toe Investigation
  - Implications for CMS
- Lower 1,4-D Remedy 2014 vs 2016
- 2016 Updated Lower 1,4-D Remedy Options
  - Bioremediation Technology Overview
  - Bioreactors
  - Biosparging
  - Pilot Testing
- First Quarter 2016 Sampling Results
- No Purge Sampling
- Budget Amendment
- Schedule



Lower 1,4-Dioxane Toe Investigation Review

Toe Investigation Recap

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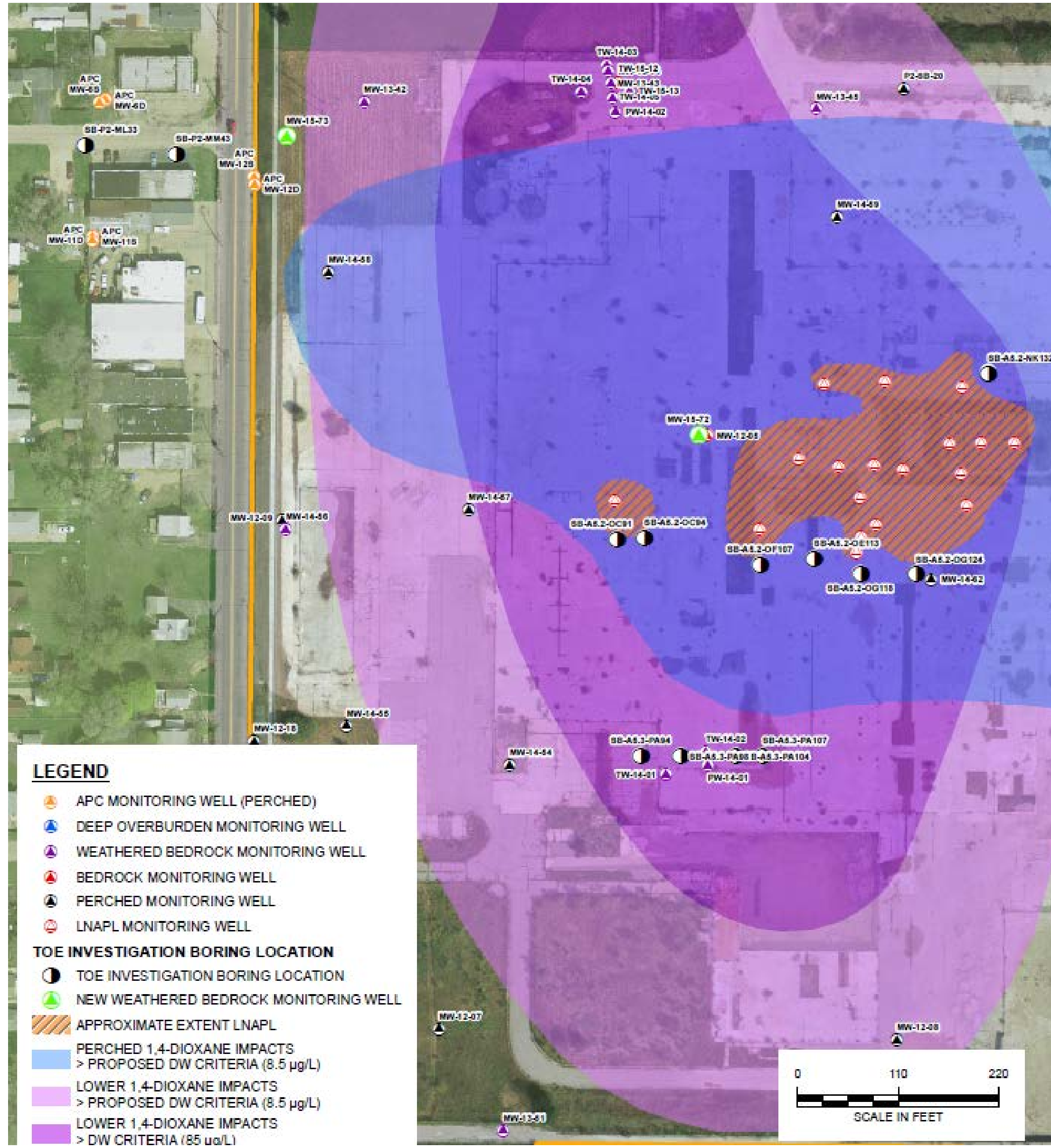
1. Further characterize the core of the lower 1,4-dioxane plume
2. Evaluate if LNAPL area or APC is contributing to the lower 1,4-dioxane plume
3. Delineate extent of 1,4-dioxane at western boundary
4. Verify continuity of the plume from north to south



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Cross-Section A-A’

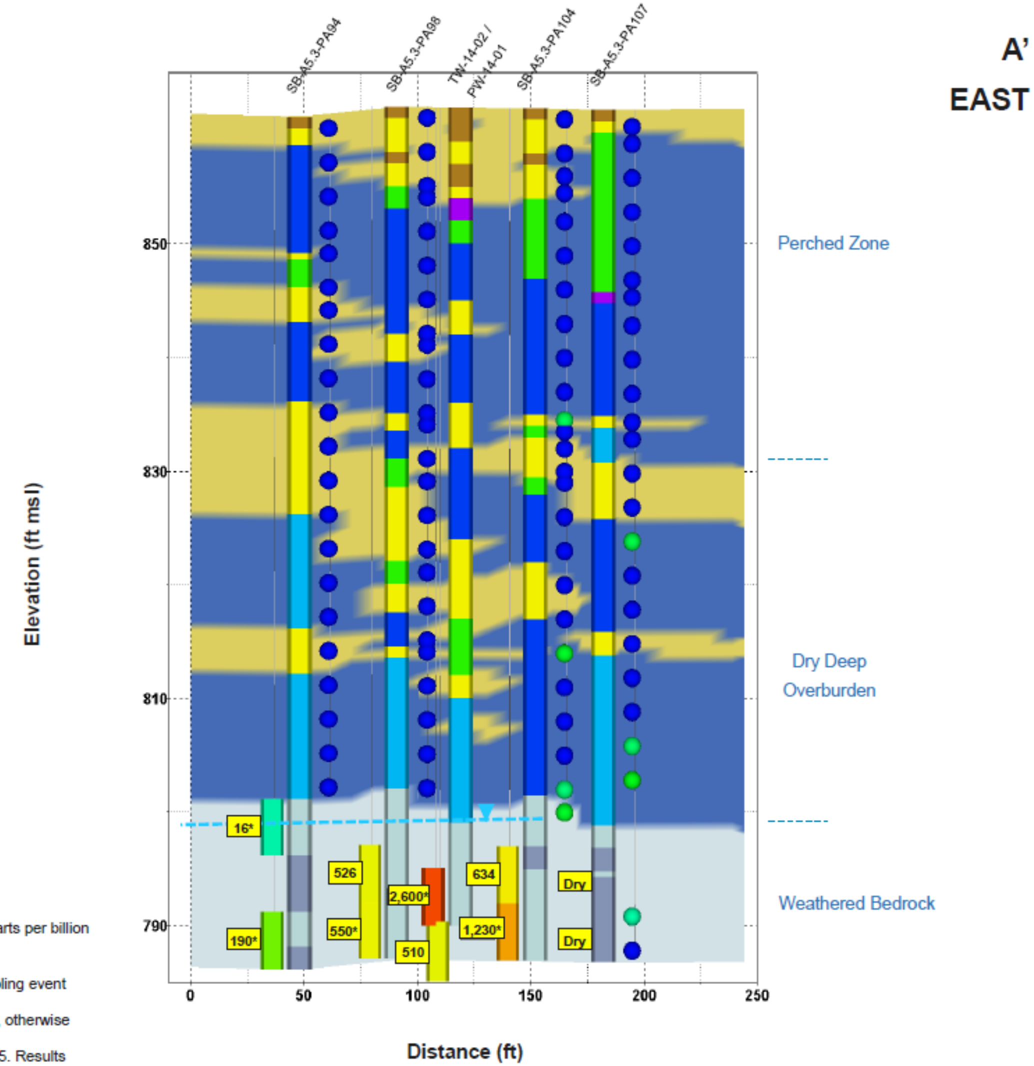
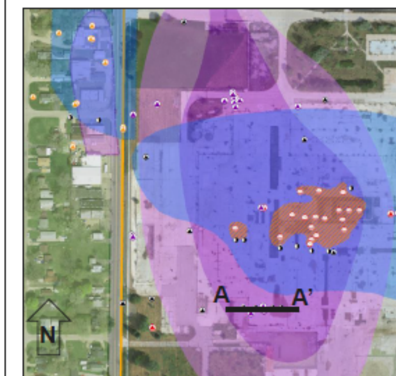
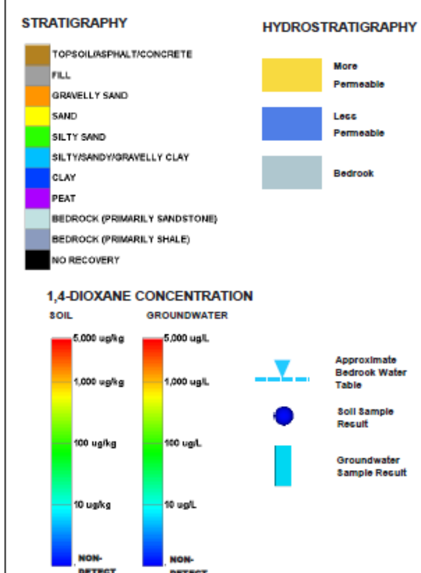


Figure 3
Cross-Section A – A’
RACER Trust
Lansing, Michigan



LEGEND



NOTE:
1. Soil and groundwater concentrations provided in parts per billion
   - µg/L – micrograms per liter
   - µg/kg – micrograms per kilogram
2. Monitoring well results represent most recent sampling event (December 2015)
3. * - VAP sample analyzed via GC-MS Method 8260, otherwise DSITMS Method 8265
4. Soil samples are provided by DSITMS Method 8265. Results could potentially be three to four times higher if analyzed using standard Method 8260-SIM.

VAP – Vertical aquifer profiling
DSITMS – Direct ion trap mass spectrometry
GC-MS – Gas chromatography-mass spectrometry
ft msl – feet above mean sea level

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Cross-Section B-B’

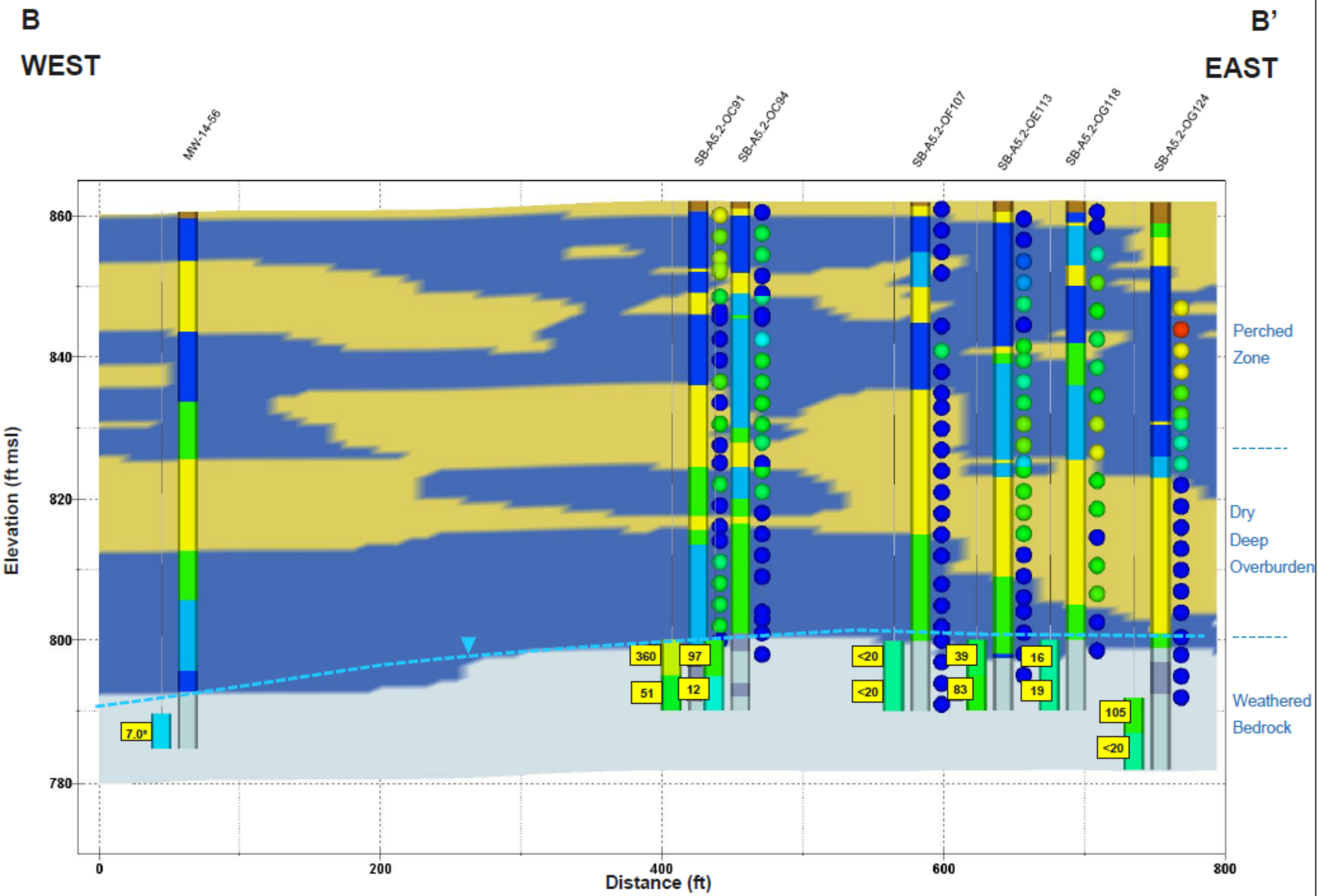

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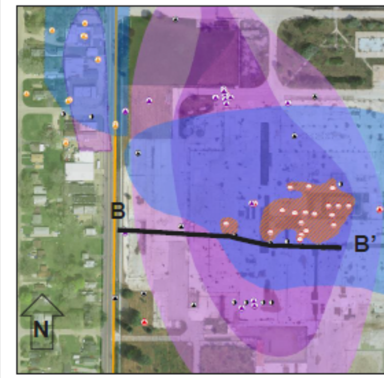
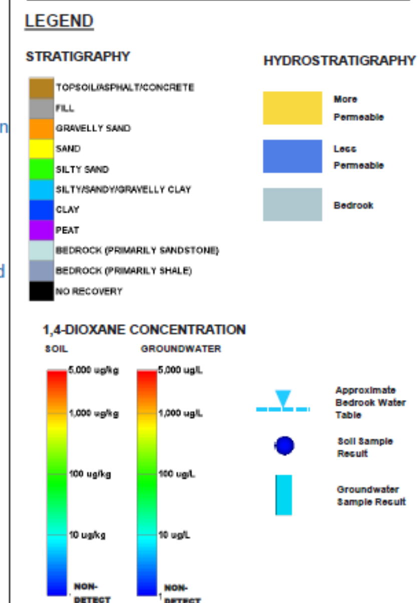
Figure 4
Cross-Section B – B’

RACER Trust
Lansing, Michigan





Cross-Section C-C’

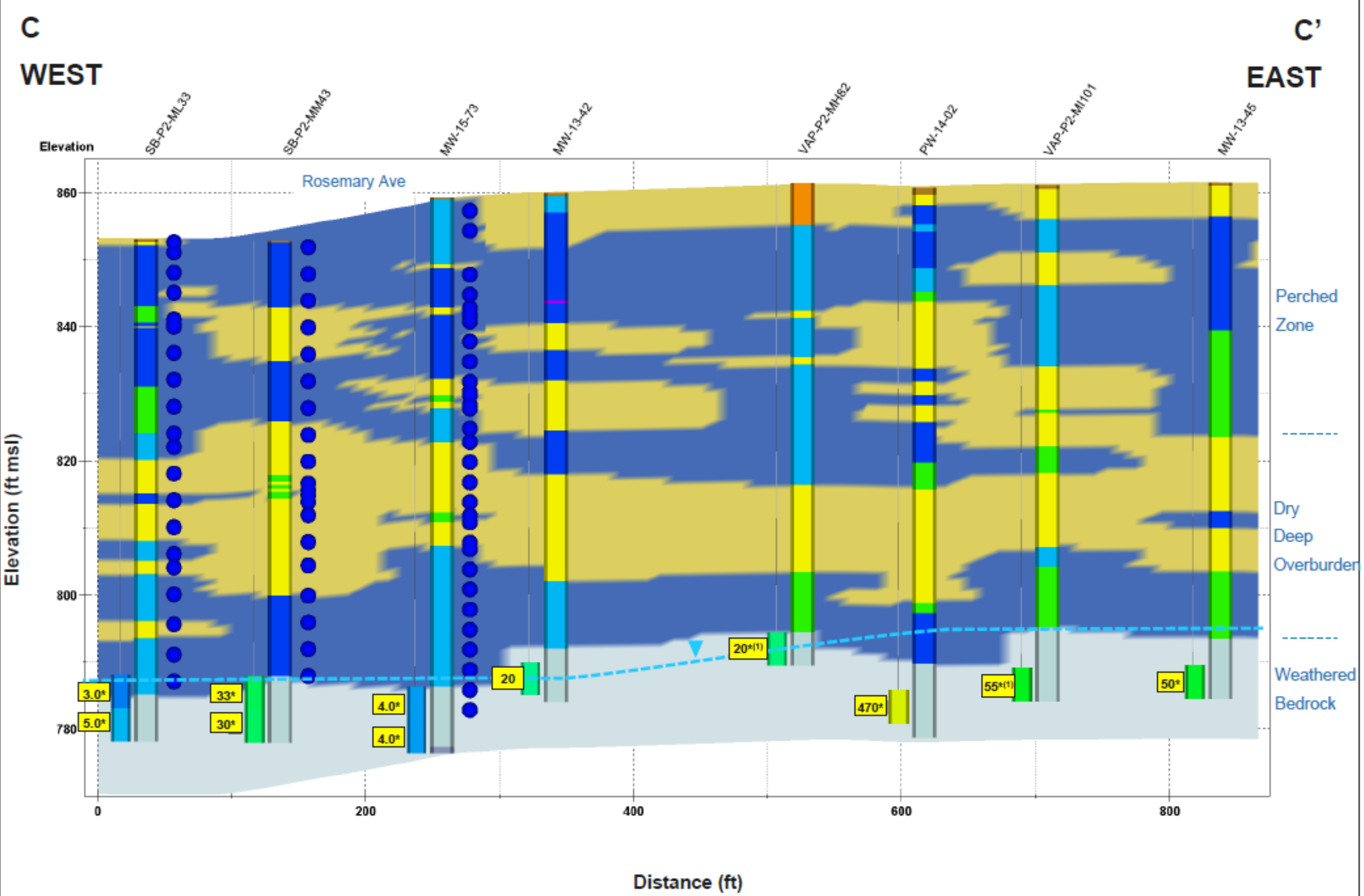
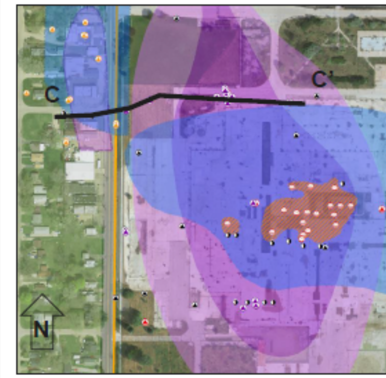
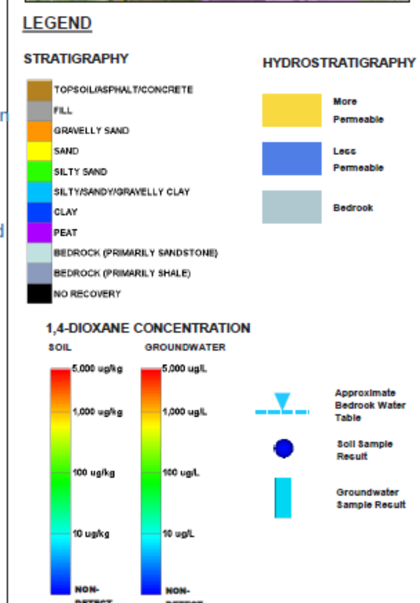


Figure 5
Cross-Section C – C’
RACER Trust
Lansing, Michigan





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5. (1) - VAP Samples collected in August 2013

VAP – Vertical aquifer profiling
DSITMS – Direct ion trap mass spectrometry
GC-MS – Gas chromatography-mass spectrometry
ft msl – feet above mean sea level

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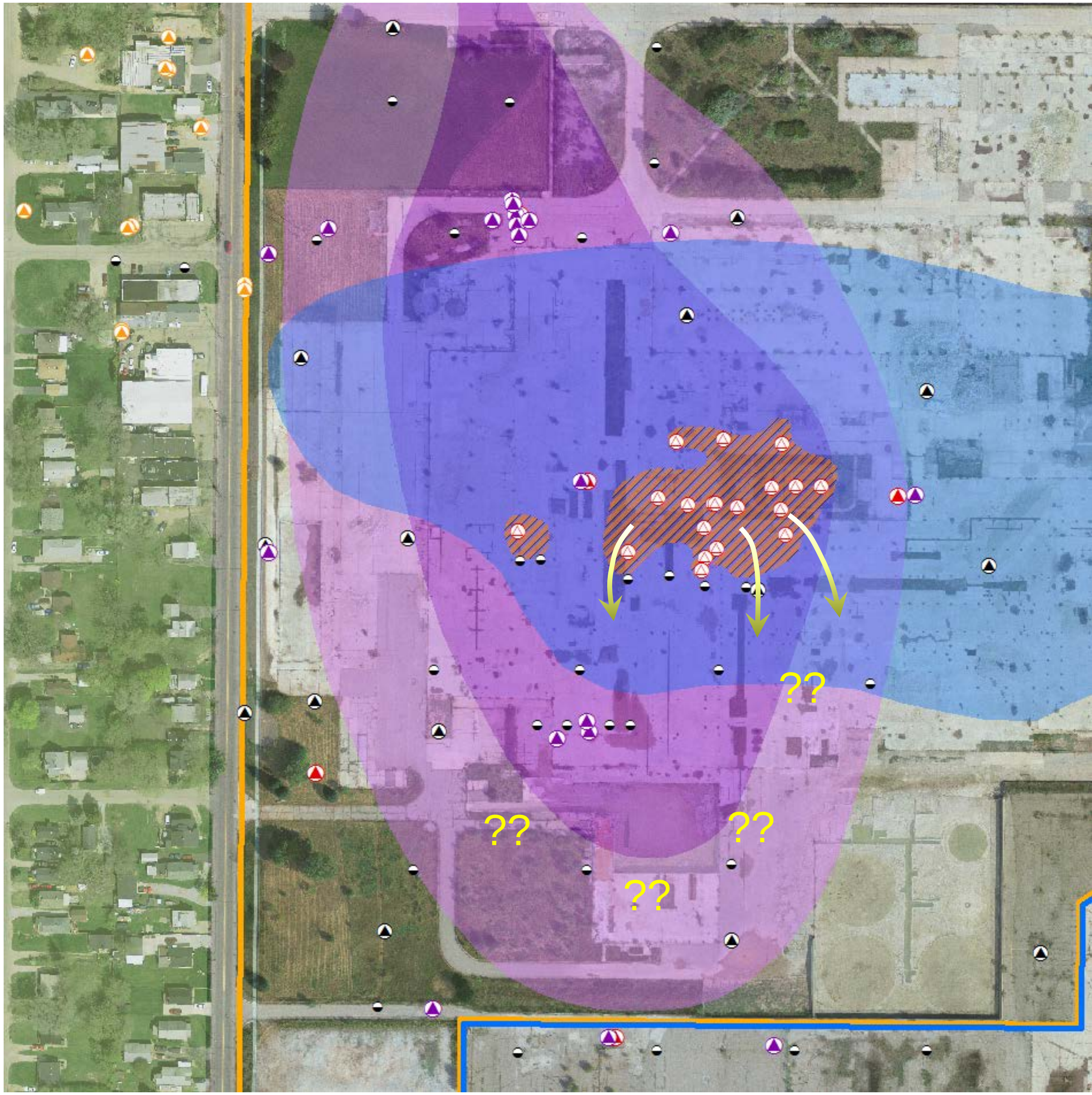
Toe Investigation Summary

- Interbedded shale and sandstone and varying degrees of weathering creates a complex zone of migration for the lower 1,4-dioxane plume
- The source of the elevated 1,4-dioxane at well TW-14-02 is unclear
  - No direct connection to overlying perched groundwater impacts - possible contribution occurs further upgradient
  - Potentially associated with mass released early in the development of the plume that migrated to the present location from Plant 3
- 1,4-Dioxane impacts extend through the perched zone, confining glacial till layer, and into the dry deep overburden at several locations and indicate a portion of the lower 1,4-d plume may be attributed to leakage from the perched zone
- Adams Plating Company (APC) may contribute 1,4-dioxane to the weathered bedrock zone
- MW-15-72 - lower 1,4-dioxane plume core -1,4-dioxane generally consistent with other wells and verifies the continuity of the plume from north to south across Plant 2
- MW-15-73 - western Plant 2 property boundary - 1,4-dioxane at a concentrations less than 7.2 µg/L

Remaining Data Gaps

- Current extent of lower 1,4-d plume extrapolated based on existing monitoring wells
- Contribution from perched zone is poorly understood
  - Timing
  - Variability
  - Vertical Flux
  - Stability



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Proposed Supplemental 1,4-Dioxane Toe Investigation

Goals:

- Further evaluate the magnitude and potential influence of 1,4-dioxane migration from LNAPL area to weathered bedrock
  - Downgradient flux perimeter will determine if 1,4-dioxane sources are isolated or widespread
  - Aid in selection for source treatment or plume management strategy
- Confirm extent of the lower 1,4-dioxane plume to the south & southeast
  - Evaluate plume migration via borings co-located with 2013 investigation
- Install more robust sentinel monitoring well network to west, south & southeast
  - Evaluate stability and potential natural degradation at toe of lower plume
  - Provides initial network of performance monitoring wells

Supplemental Investigation Scope of Work

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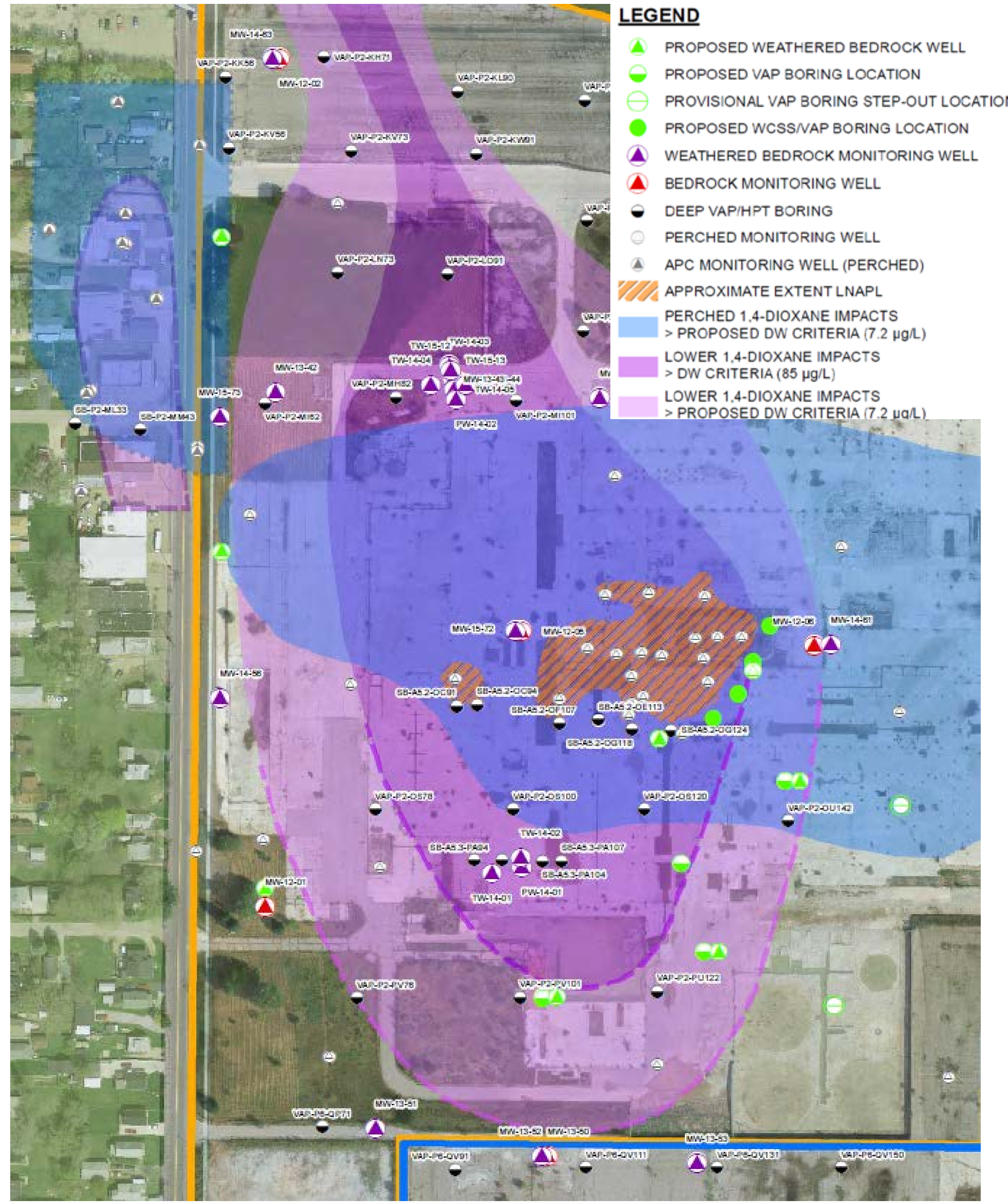
- 4 WCSS/VAP Borings around southeast perimeter of LNAPL
- 4 VAP borings south/southeast of LNAPL
- 3 MWs around southeast perimeter of plume
- 3 MWs along western property boundary
- If necessary:
  - 2 step-out VAP borings to southeast
  - 1 additional MW adjacent to LNAPL



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Supplemental Investigation Scope of Work

- Two sonic drilling rigs – one focused on monitoring well installation, second to complete VAP and WCSS
- Soil and groundwater samples analyzed on-site using Cascade Technical Services mobile lab (formally Stone Environmental)
  - GC/MS USEPA Method 8260 SIM
    - Select VOCs
    - 1,4-Dioxane
  - Detection Limits
    - Soil: VOCs - 40 µg/Kg, 1,4-dioxane - 55 µg/Kg
    - GW: VOCs - 1 µg/L, 1,4-dioxane - 2 µg/L

Revised CSM & Implications for Lower 1,4-D Remedy

2014 - the CMS for lower 1,4-dioxane was developed based on the following assumptions:

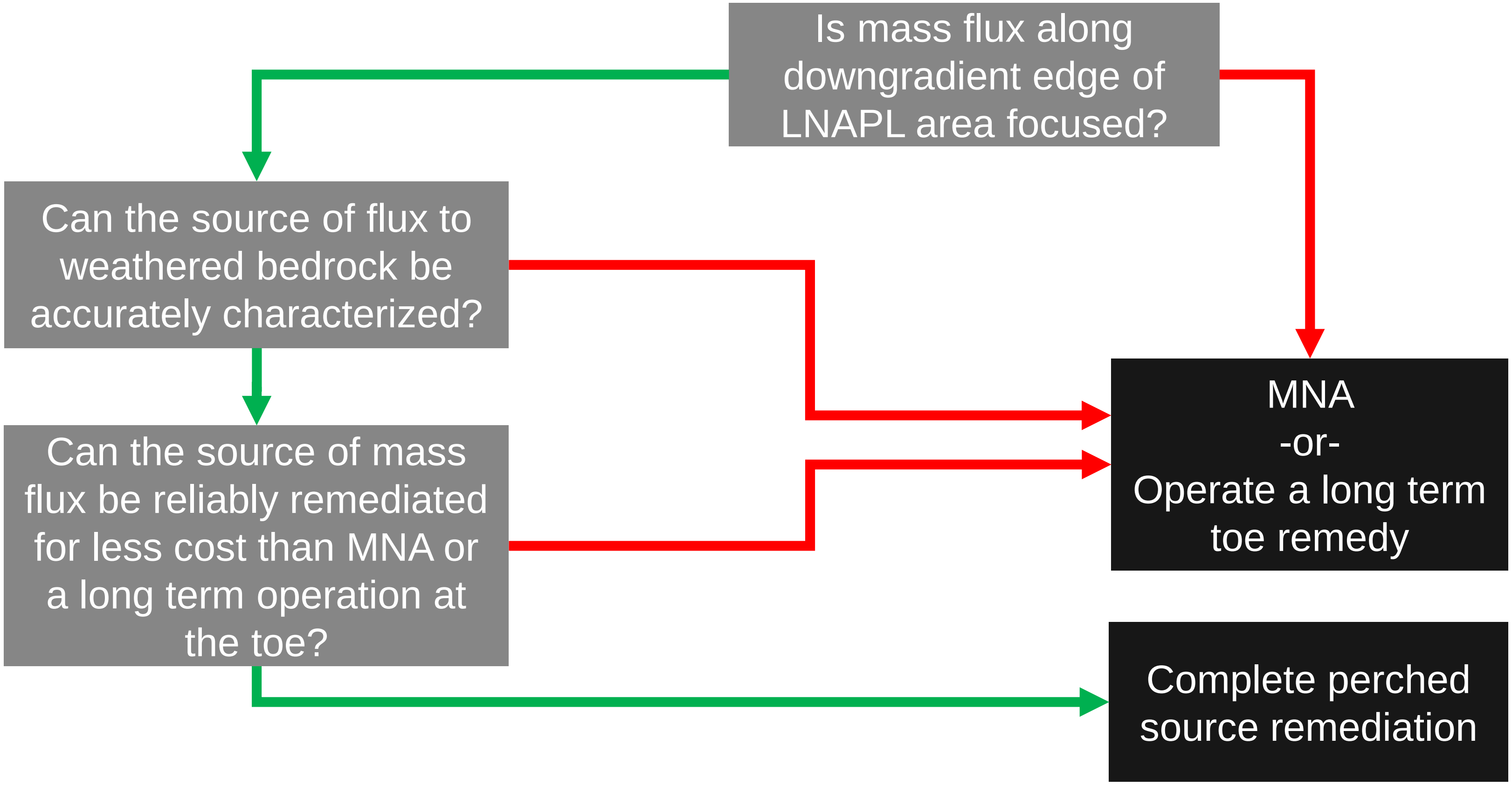
- Limited / no contribution from perched zone to the weathered bedrock at Plant 2
- Source mass at Plant 3 coliseum feeding the plume

2016 - need to account for changes to the CSM:

- Contribution from the perched to the weathered bedrock at Plant 2
- No significant source remaining at Plant 3
- Potential for storage in overlying till along length of the plume
- Proposed criteria is now 7.2 µg/L for 1,4-dioxane
- Lower 1,4-dioxane plume potentially larger than accounted for in 2014
  - Increasing trends observed in weathered bedrock at Plant 2 at several locations
  - Function of additional data and/or extrapolation of monitoring well data?

Key Questions

- Is source treatment needed?
- Is MNA viable?
- Can source treatment be cost effective?



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Lower 1,4-Dioxane Remedy 2014 vs 2016

2014 CMS Remedy Basis

2014 CMS evaluated the following options:

- Containment (hydraulic control at the toe)
- Aggressive (ISCO, aggressive P&T, recirculation)
- All pumping remedies utilize AOP for treatment of 1,4-dioxane

Key 2014 objective was to collect data to further vet feasibility and cost for the aggressive options

Field work/testing completed since 2014:

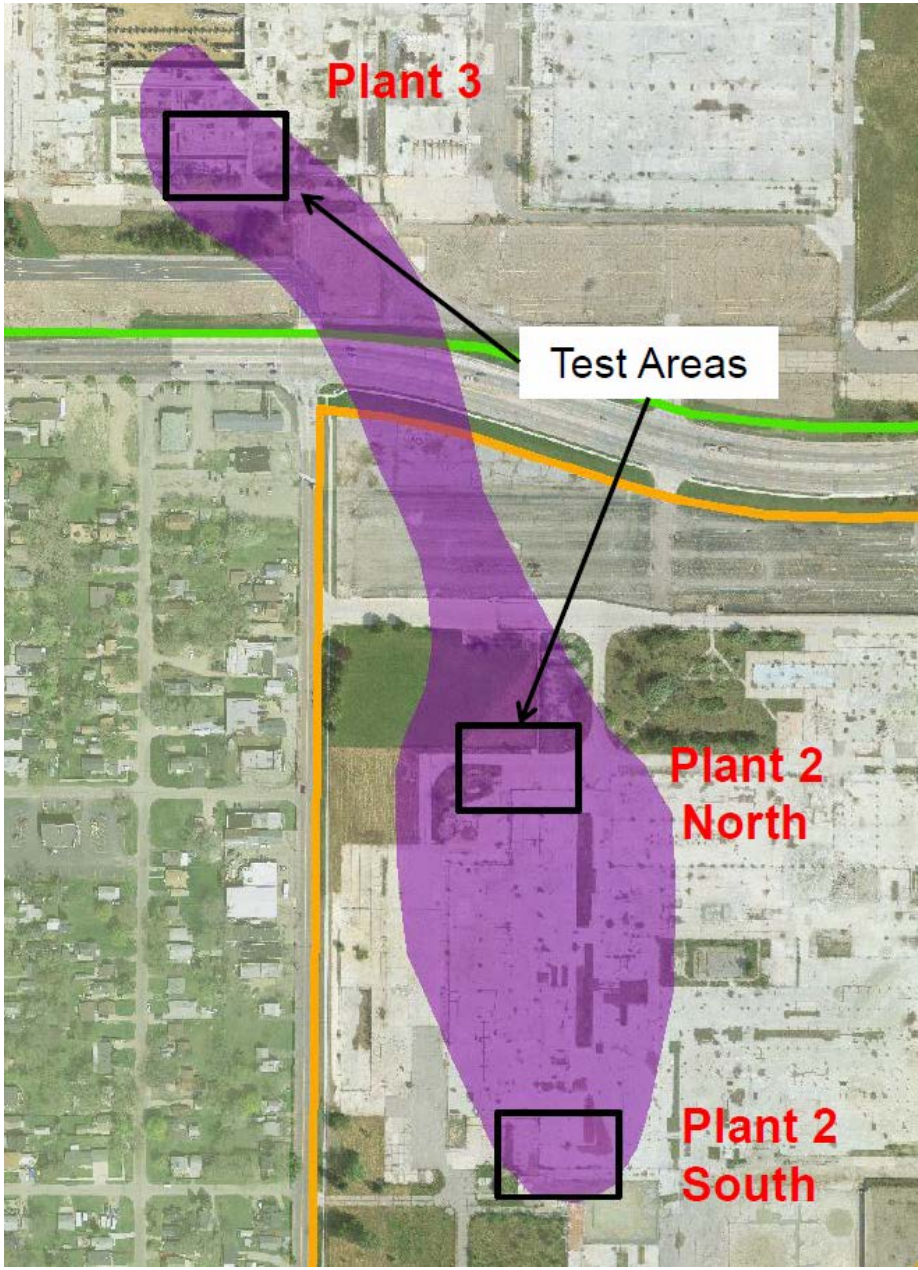
- Hydraulic tests
- ISCO pilot study
- Tracer study
- Interim Measures Excavation

Extraction / Hydraulic Testing

2014 hydraulic testing completed in three areas.

Key results:

- Easier to inject than extract due limited weathered bedrock saturated thickness
- Extraction rates 0.1 to 2 gpm. Lower extraction rates to the south.
- Specific capacity can be increased by recirculation



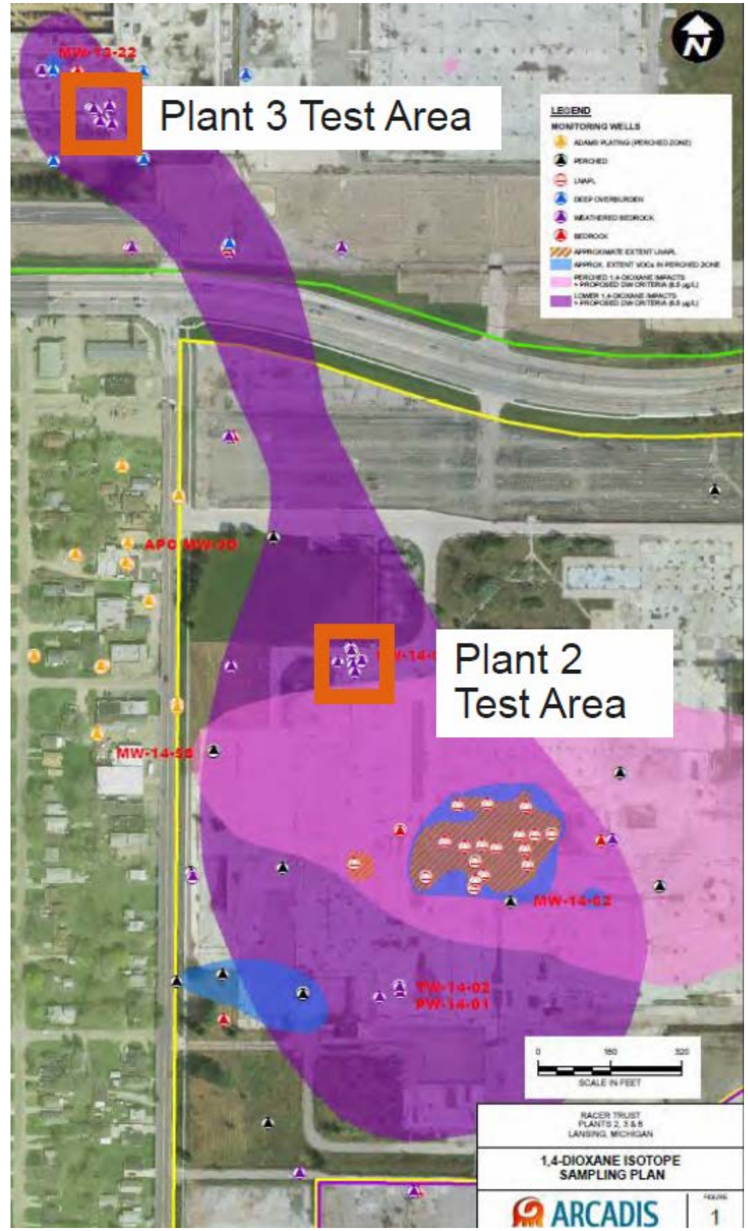
Injection / Chemical Oxidation Pilot Test

2015 ISCO Pilot testing completed in two areas

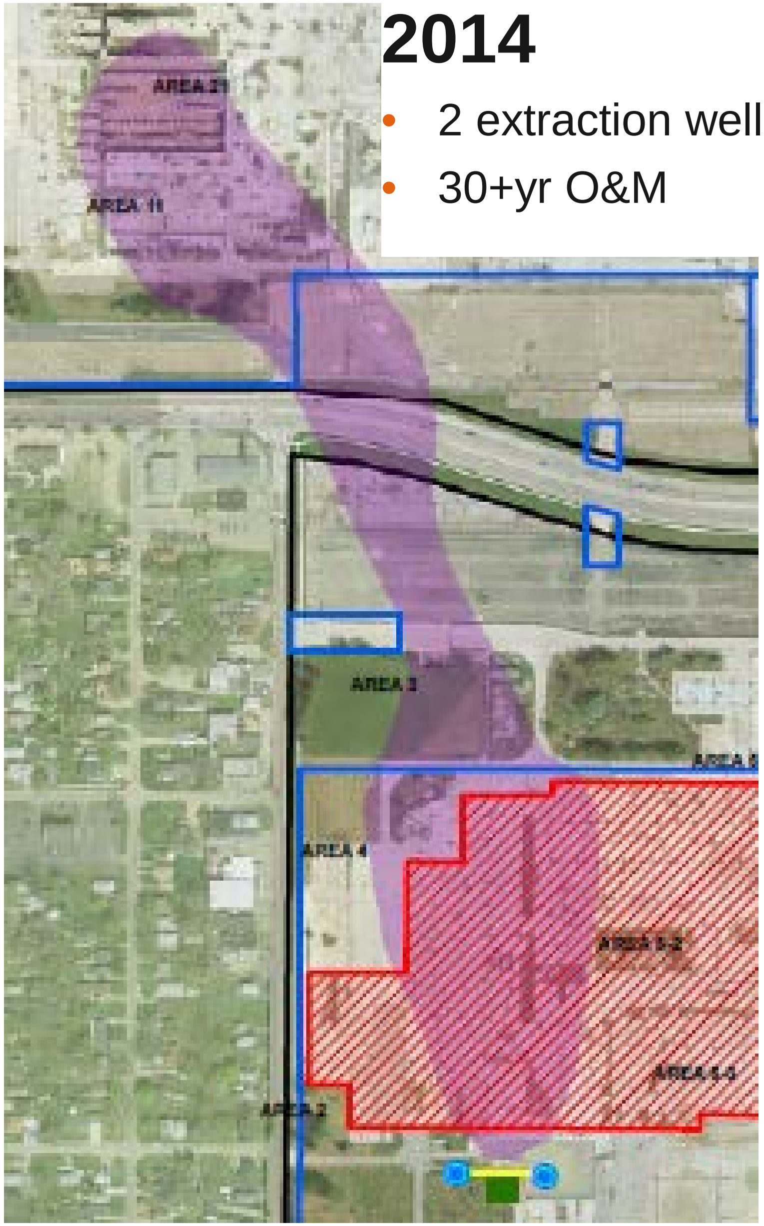
Key results:

- Sodium persulfate can reduce 1,4-D concentrations with adequate oxidant strength and persistence
- Distribution of working strength of oxidant limited to injection and dose response wells.
- No drift of working strength oxidant.
- Increased concentrations of 1,4-dioxane observed in surrounding network:
  - Displaced from storage fraction by injection
  - Potentially in till mobilized by mounding

Cost prohibitive to implement full scale

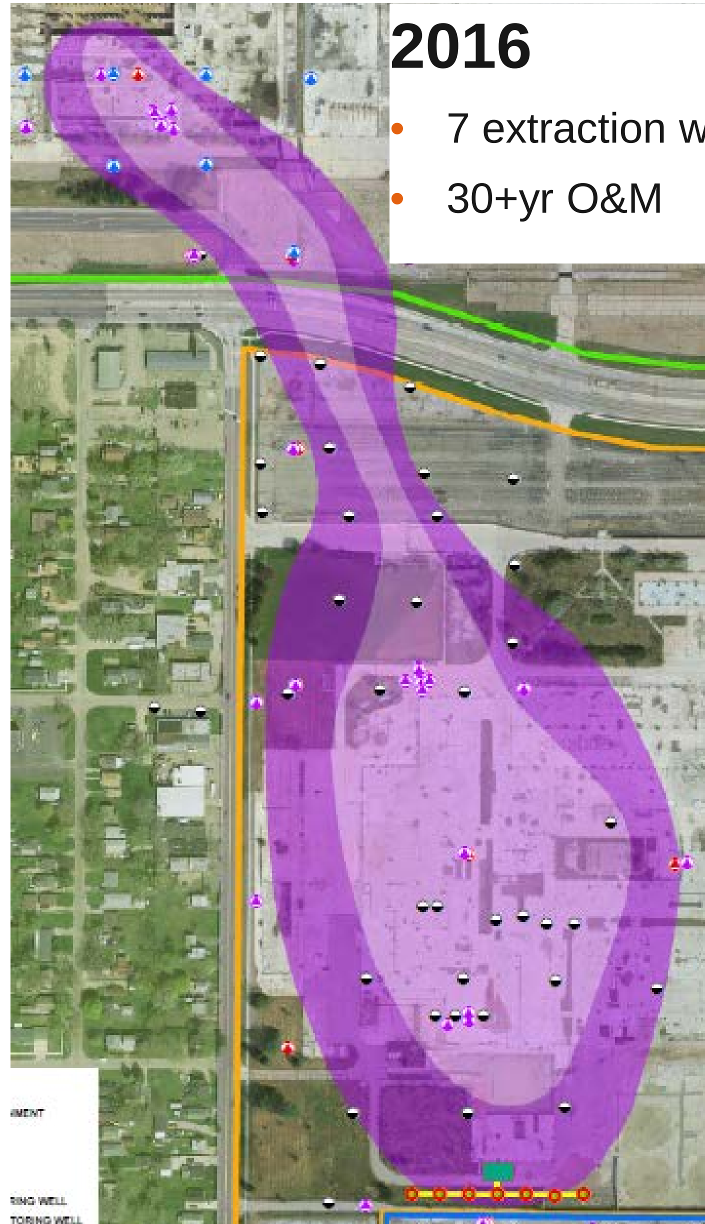


Hydraulic Containment



2014

- 2 extraction wells
- 30+yr O&M



2016

- 7 extraction wells
- 30+yr O&M

Aggressive Pump and Treat

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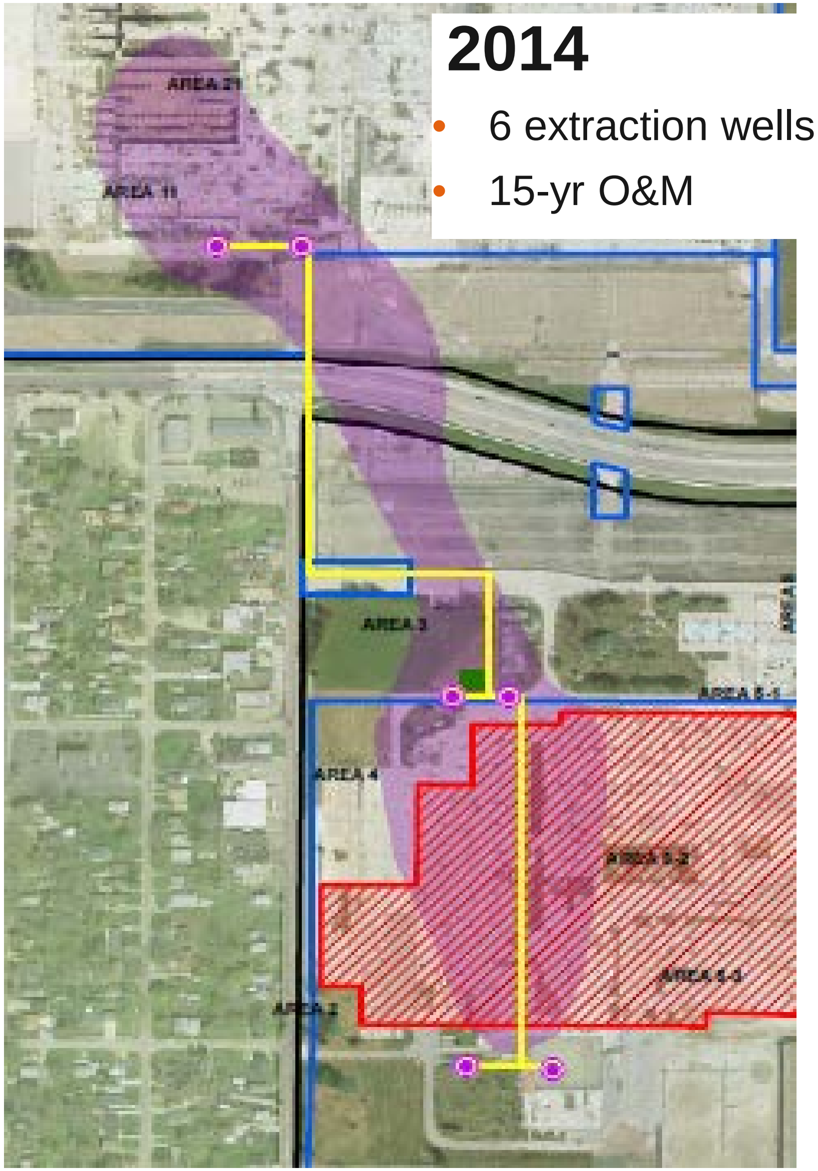
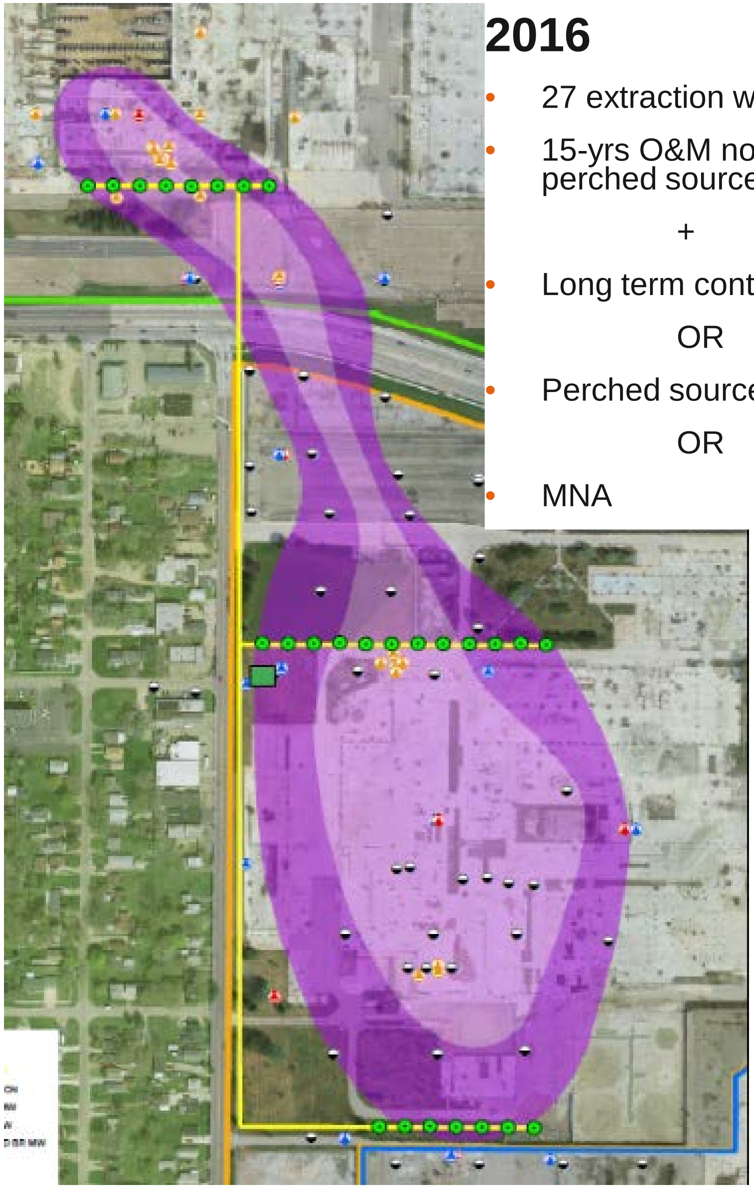


2014

- 6 extraction wells
- 15-yr O&M



2016

- 27 extraction wells
- 15-yrs O&M north of perched source

  +

- Long term containment

  OR

- Perched source remedy

  OR

- MNA

Groundwater Recirculation

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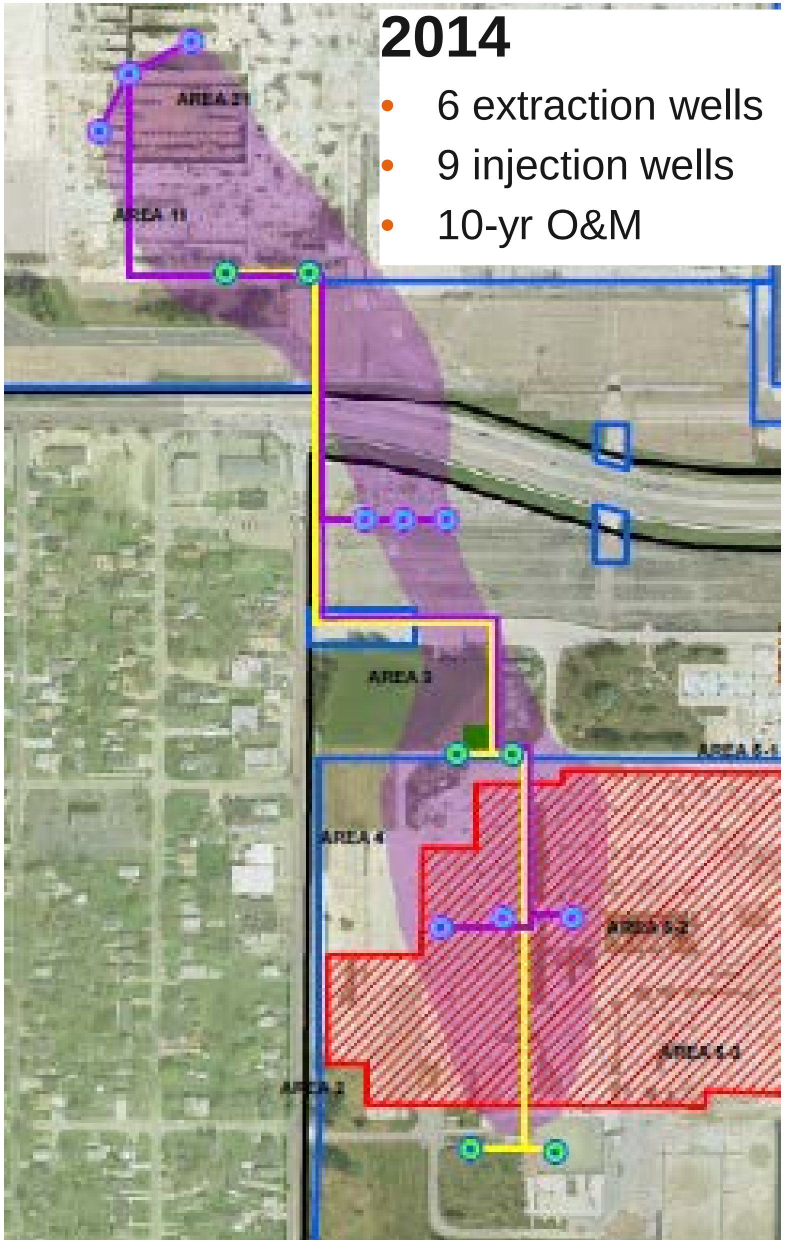
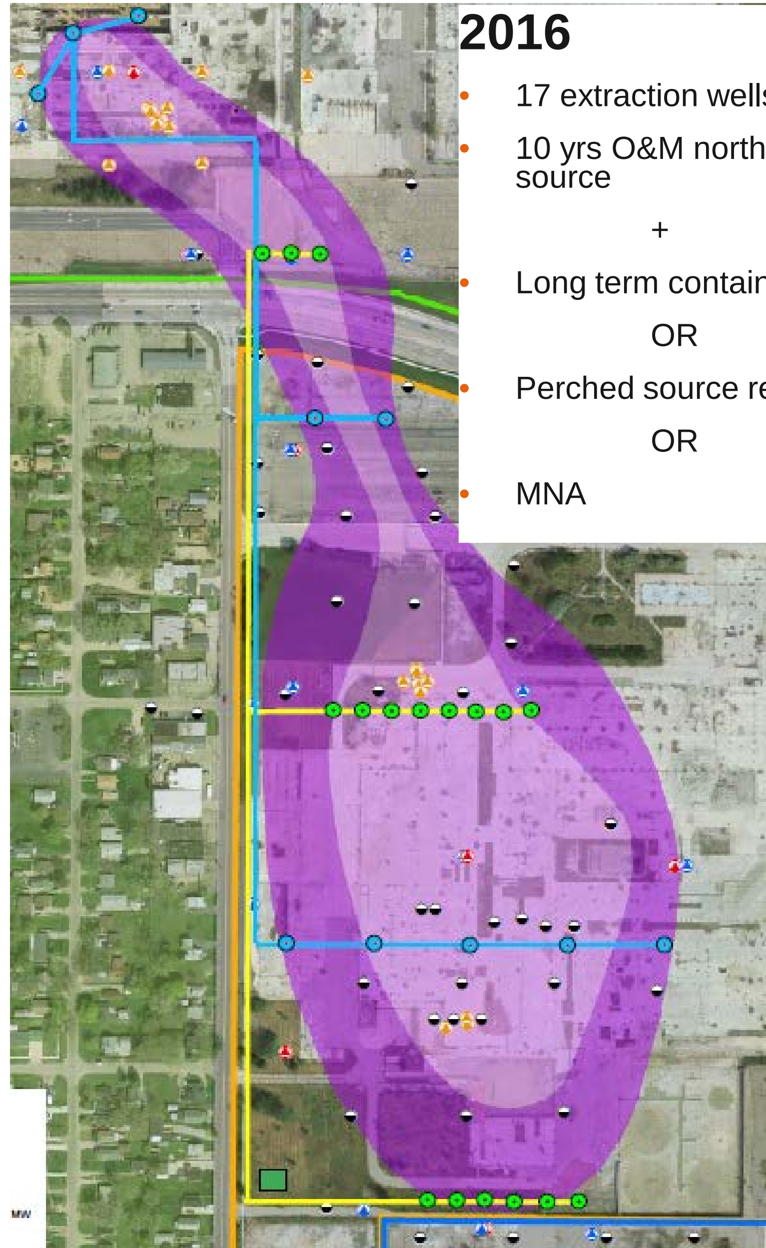


2014

- 6 extraction wells
- 9 injection wells
- 10-yr O&M



2016

- 17 extraction wells
- 10 yrs O&M north of perched source

+

- Long term containment

OR

- Perched source remedy

OR

- MNA

Summary 2014 vs 2016

- ISCO not feasible and will not be carried forward.
- All pumping remedies require more capital based on additional wells/piping
- Aggressive P&T and GW recirculation could require the addition of a source remedy or a long term containment remedy to address perched contribution
- AOP is a viable treatment technology for 1,4-dioxane but is high capital cost and expensive to operate
- Evaluate alternatives that could be cheaper and easier to implement
  - Research and field demonstrations show enhanced biodegradation of 1,4-dioxane is a viable alternative
  - Data collected at the Site indicate enhanced biodegradation of 1,4-dioxane is viable

Roadmap – 2016 Path Forward

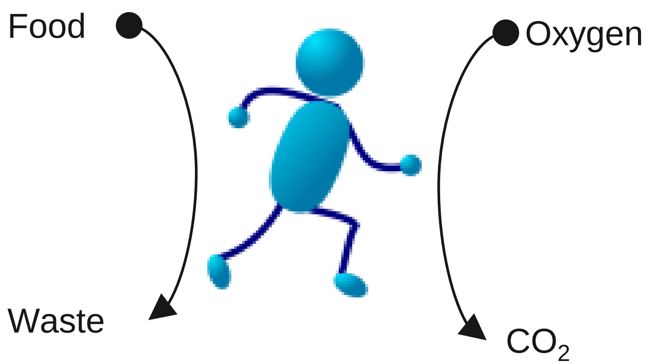
- Define remedial objective:
  - Non-residential on-site, per settlement agreement
  - Target active treatment of core to approximately 10x criteria: 72 µg/L
  - Natural attenuation to achieve residential criteria 7.2 µg/L off-site
- Explore variations of bioremediation
- Compare bioremediation options to advanced oxidation process
- Evaluate long term containment or MNA vs. perched source zone treatment
- Field pilot tests to prove the concept, vet cost assumptions, and provide basis for full scale design, if appropriate

2016 Updated Lower 1,4-Dioxane Remedy Options

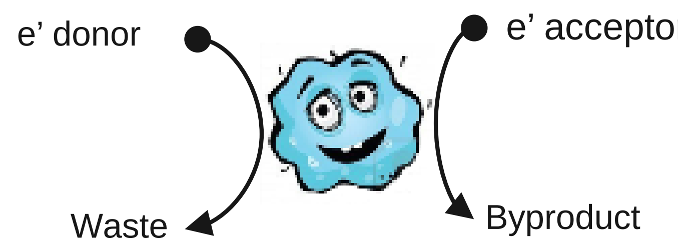
Bioremediation
Metabolism vs. Co-Metabolism

Metabolism: the goal is to produce energy

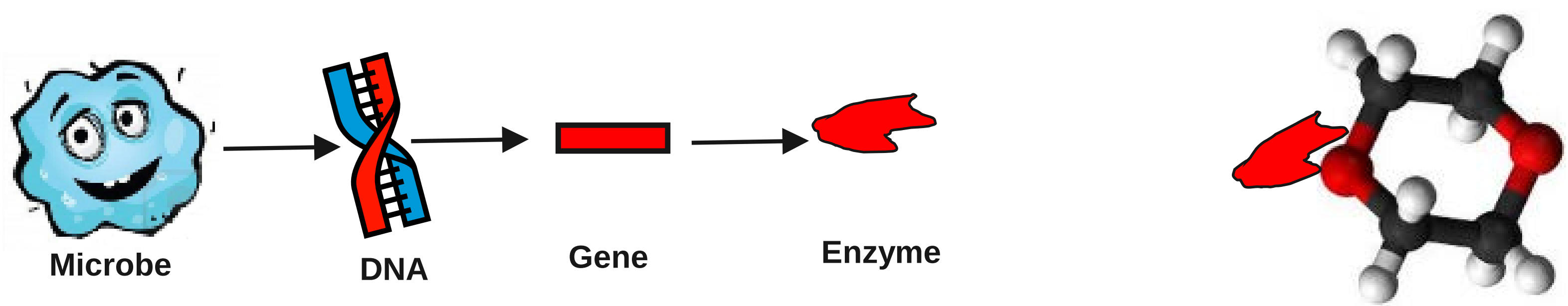
Humans



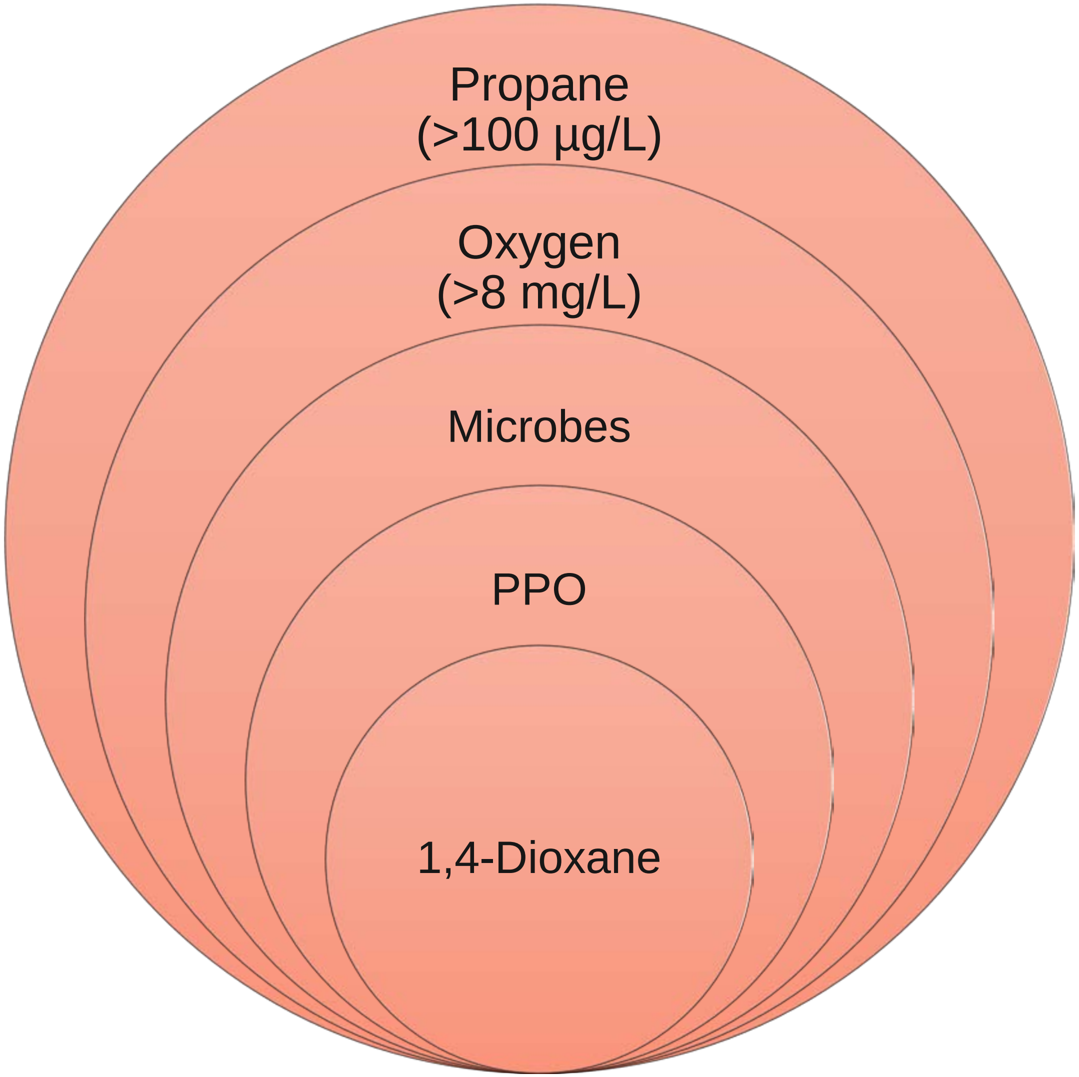
Microbes



Co-Metabolism: a fortuitous side reaction



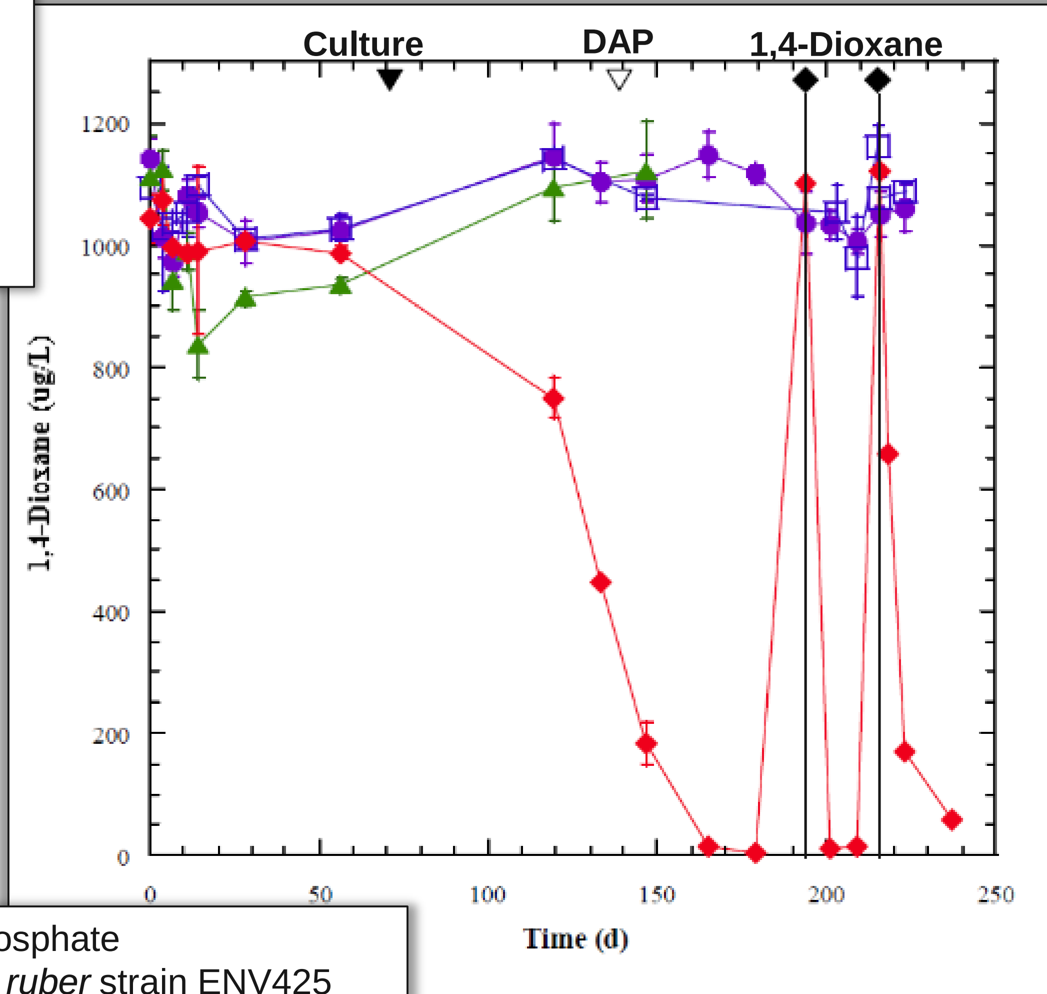
Co-Metabolic Components



Treatability Testing

Positive bench-scale results

- O2 only
- O2+propane
- O2+propane+ culture
- Control



DAP: diammonium phosphate
Culture: *Rhodococcus ruber* strain ENV425

Also enriched propane-oxidizing cultures that degraded 1,4-dioxane as part of pre-field activities

Source: CB&I, July 2014

Biosparging Pilot Testing

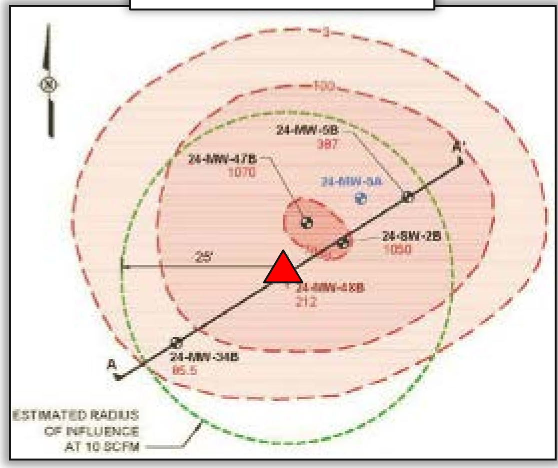
Criteria	Deep Zone
Sparge points	1
Propane dosing	0.65 lb/day/well
Sparge rate	10 scfm/well, pulsed
Bioaugmentation	37 L/well
Nutrient addition	20 lb/well
Operational Period	Apr13-Dec13

Source: CB&I, July 2014

Source: CB&I, June 2014

Source: CB&I, August 2014

Deep Zone



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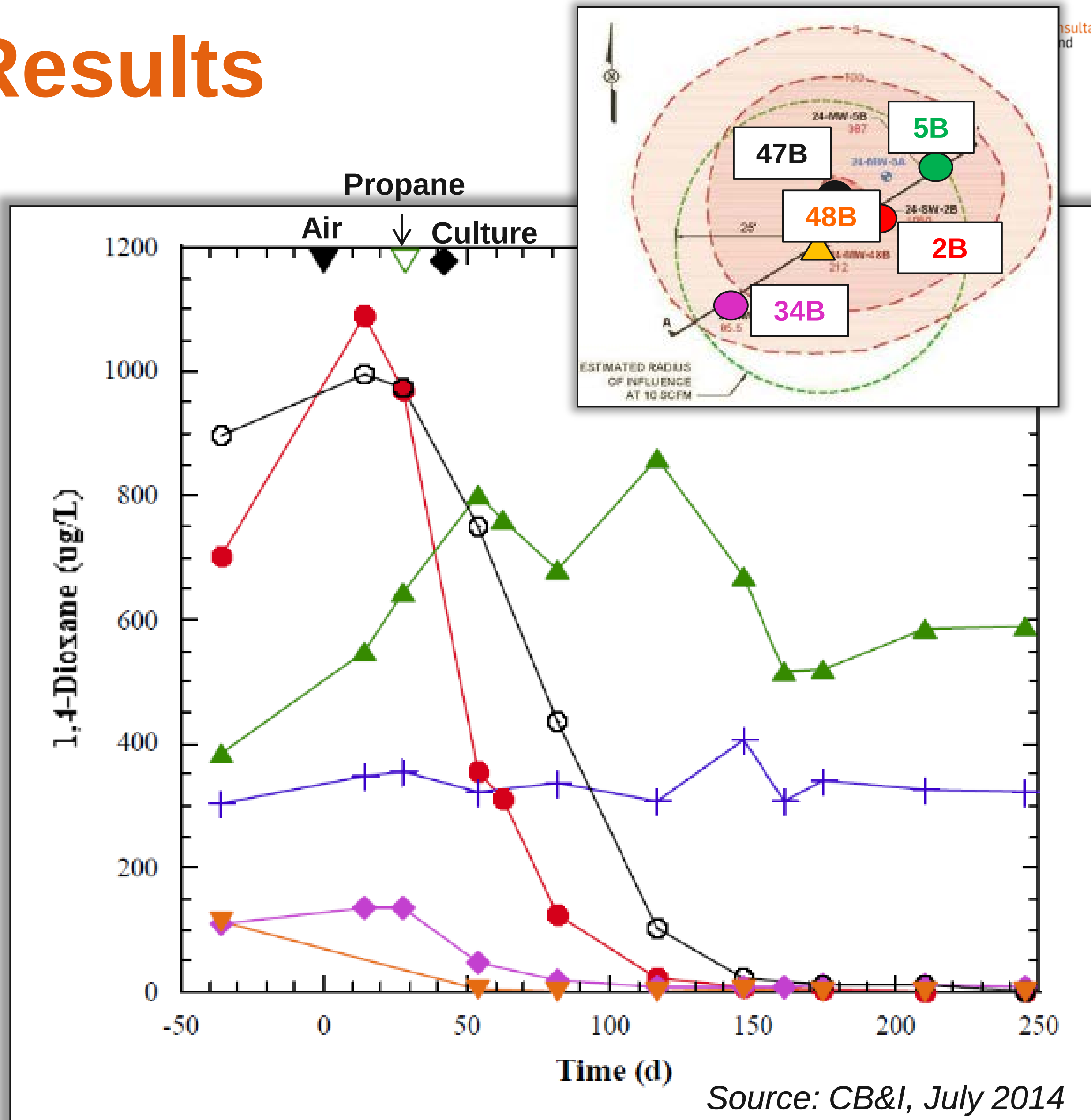
Deep Zone Results

1,4-Dioxane

- ○ **24-MW-47B**
- ◆ **24-MW-34B**
- ● **24-SW-2B**
- ▲ **24-MW-5B**
- ▼ **24-MW-48B (sparge)**
- \+ **24-MW-5A (control)**

Location	1,4-Dioxane Reduction (Day 245)
47B	>99%
34B	91%
2B	>99%
5B	<1%
48B	>99%



Source: CB&I, July 2014

Bioremediation Strategies

Ex-Situ Bioreactor

- Above grade treatment of 1,4-D via a bioreactor
- Replaces AOP in hydraulic containment, aggressive pump and treat, or recirculation remedy
- Proven effective for 1,4-dioxane in field applications
  - Colorado Site 20+ yrs
- Controlled process
- Engineering cost estimate
  - Bioreactor ~15% less capital cost than AOP
  - Bioreactor ~40% cheaper to operate than AOP.

Bioremediation Strategies
Recirculation Layout

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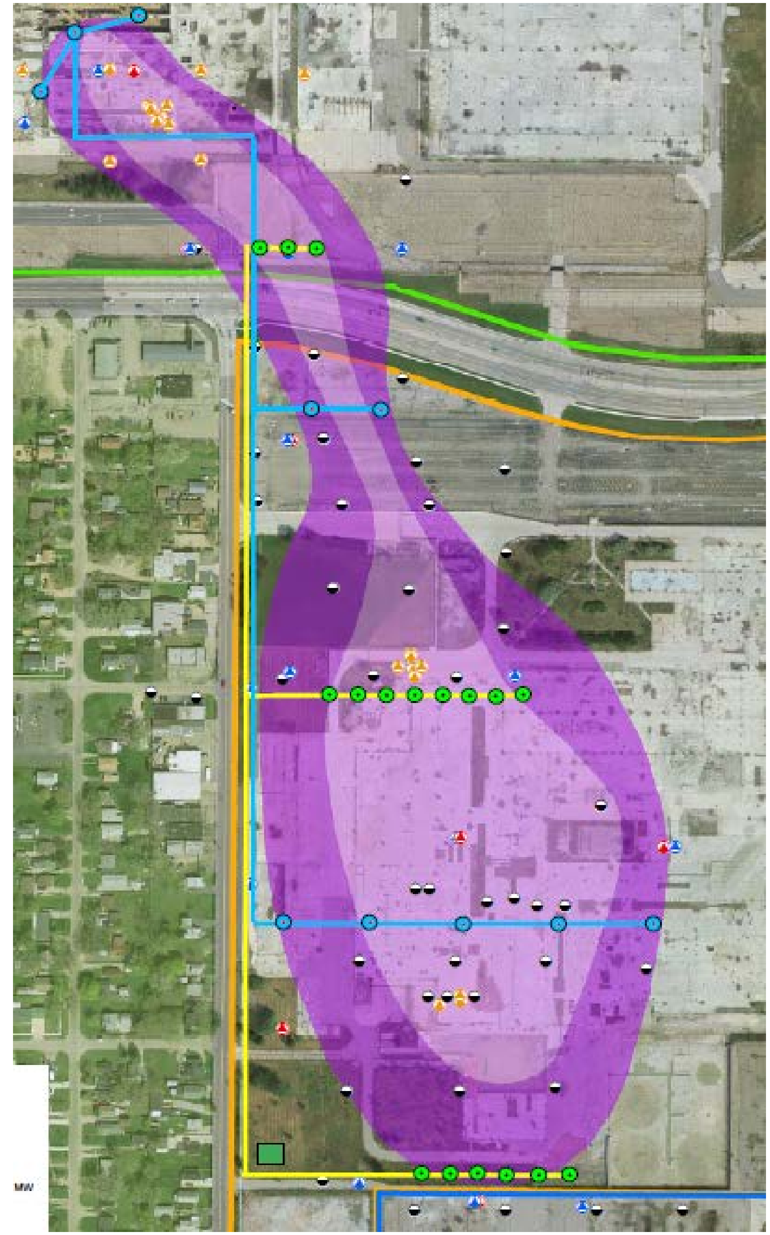
Layout for Bioreactor:

- 17 extraction wells
- 10 injection wells
- 10-yr O&M upgradient of perched source
- Long term operation at toe of plume

OR

- Perched source treatment or MNA



Bioremediation Strategies

Biosparging with Propane and Air:

- Direct injection of propane gas and air, in situ bio of 1,4-dioxane
- No groundwater extraction or injection
- Significantly less above grade infrastructure than recirculation options
  - Field application currently underway @ California site w/ good results
  - Engineering cost estimate
    - ~25% less capital cost than bioreactor
    - ~50% cheaper to operate than bioreactor
  - Maybe difficult to inject gas to weathered bedrock

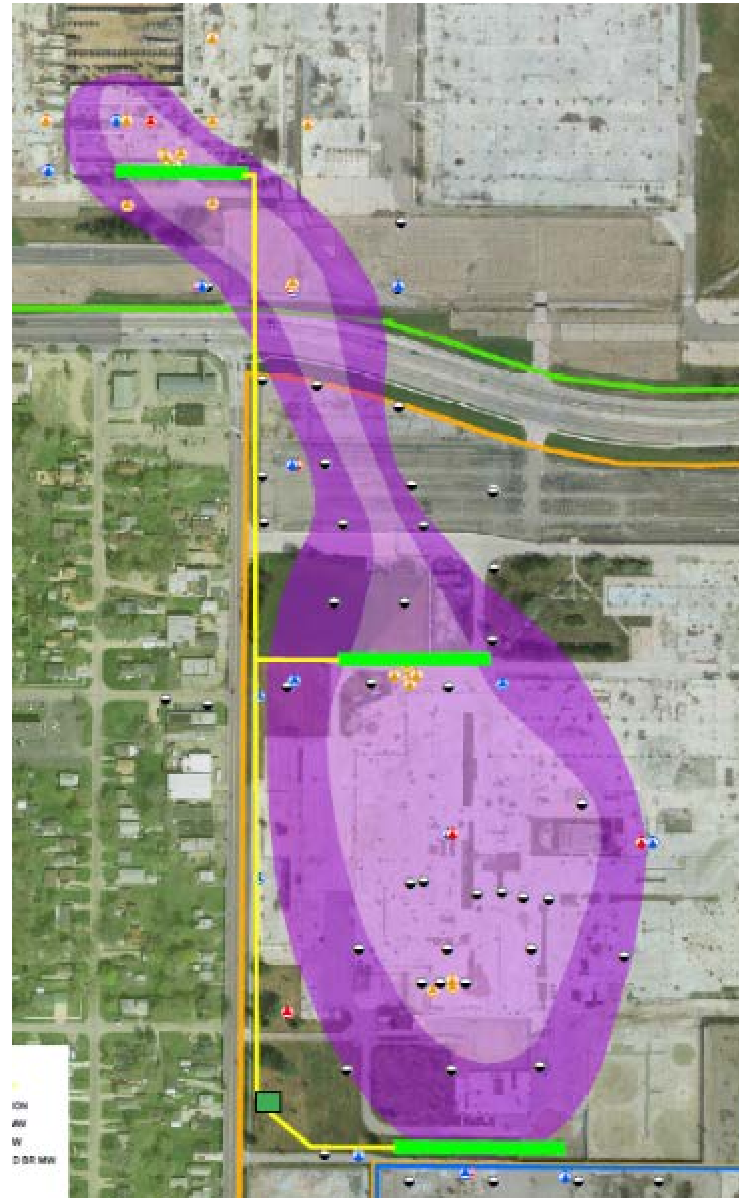
Bioremediation Strategies
Biosparge

Injection of propane gas and air:

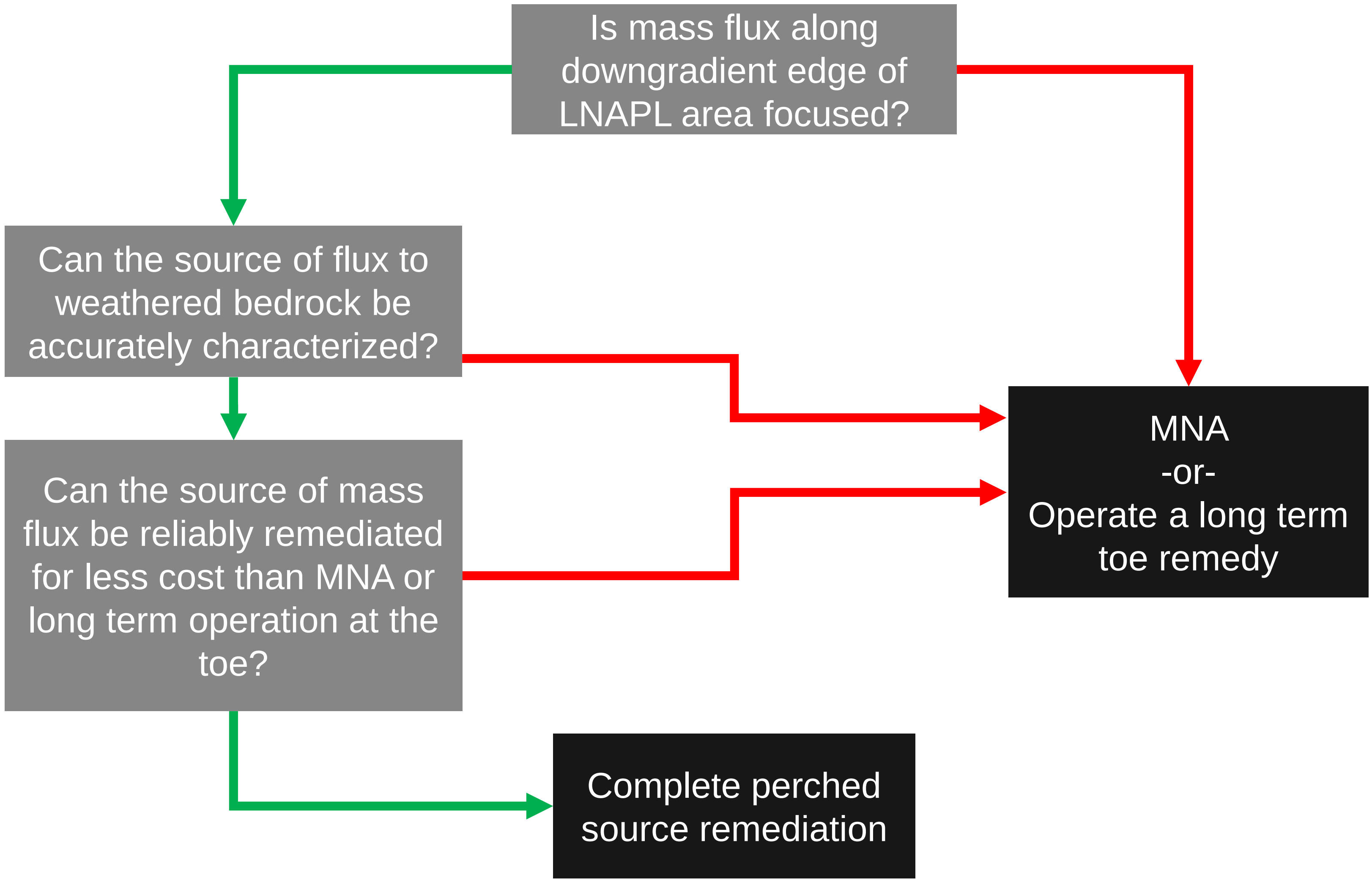
- 3 horizontal injection wells
- 20-yr O&M upgradient transects
- Long term operation at toe of plume

OR

- Perched source treatment or MNA



Long Term Operation or Source Treatment?

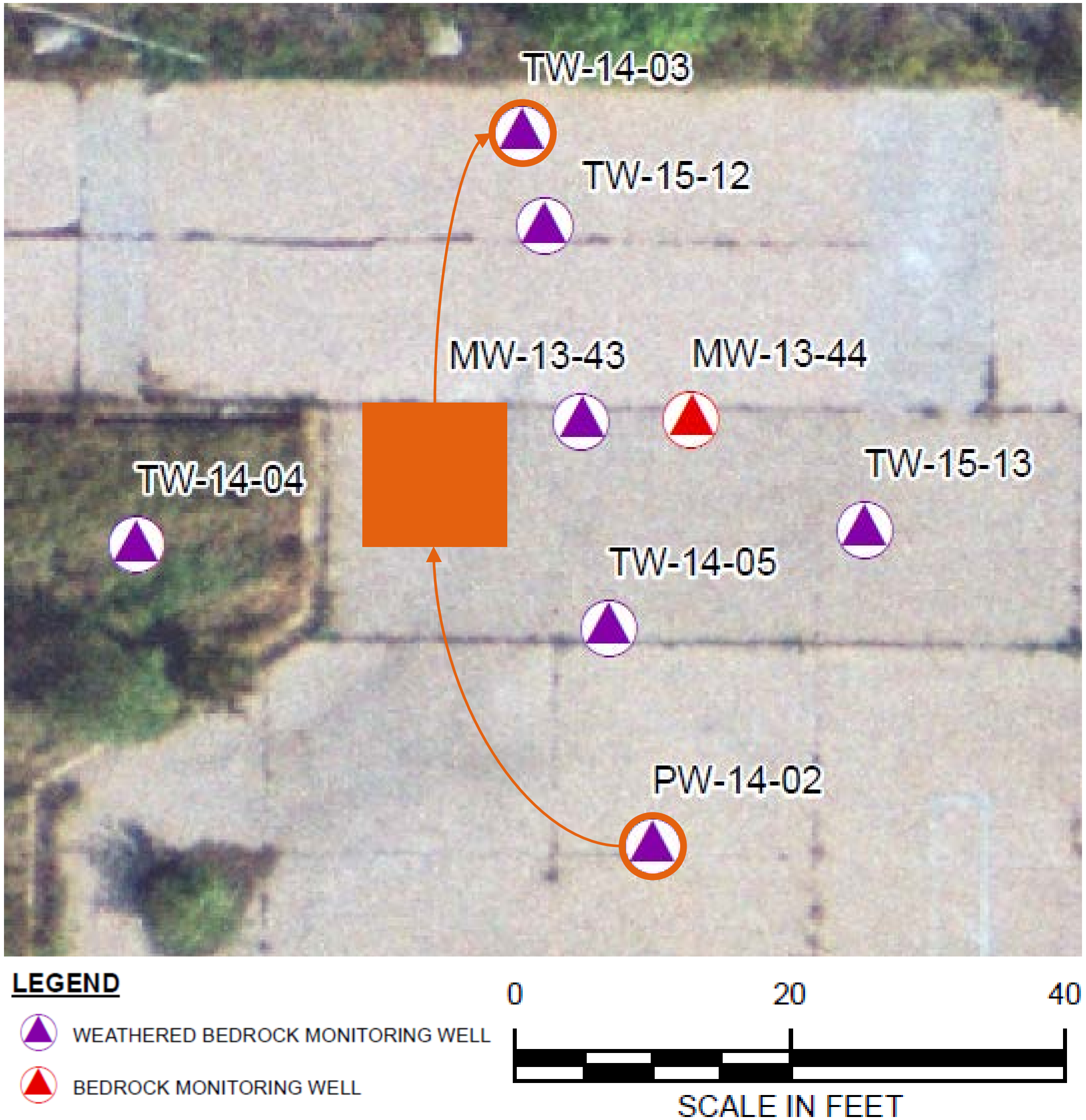


Proposed Pilot Tests

Proposed Ex-Situ Bioreactor Pilot Test

Northern Plant 2:

- Extract from PW-14-02 (0.4-1.7 gpm)
- Treatment via Bioreactor
  - Three moving bed bioreactors (MBBRs) operating in parallel to maximize testing & minimize time
  - Two with propane, oxygen, ENV425
  - One with oxygen, CB1190
- Inject into TW-14-03



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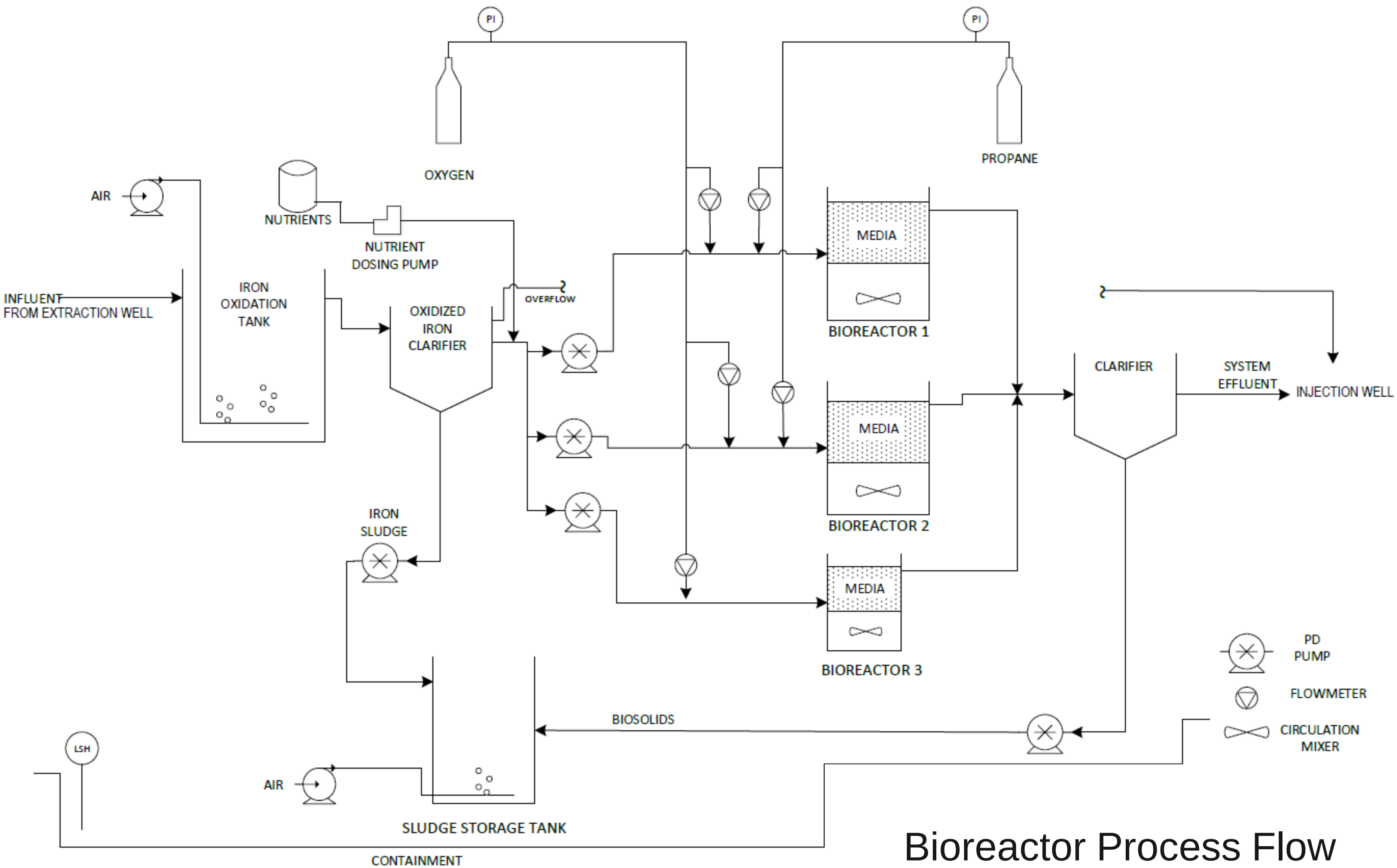

Bioreactor Process Flow Diagram

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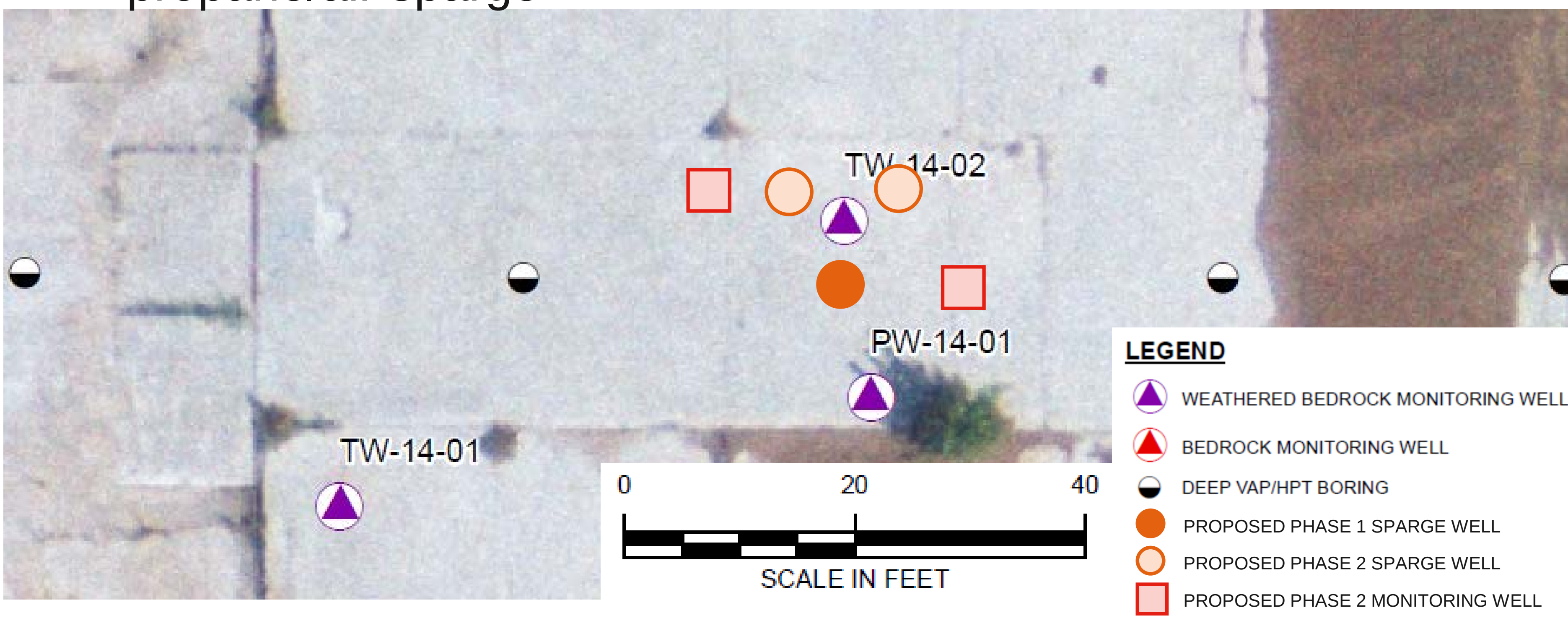
Proposed In Situ Biosparge Pilot Test

Southern Plant 2:

- Phase 1 – sparge well install, short-term air-only sparge
- Phase 2 – additional sparge well and monitoring well installs, baseline monitoring, bioaugmentation, operation (3 months) propane/air sparge



Groundwater Sampling

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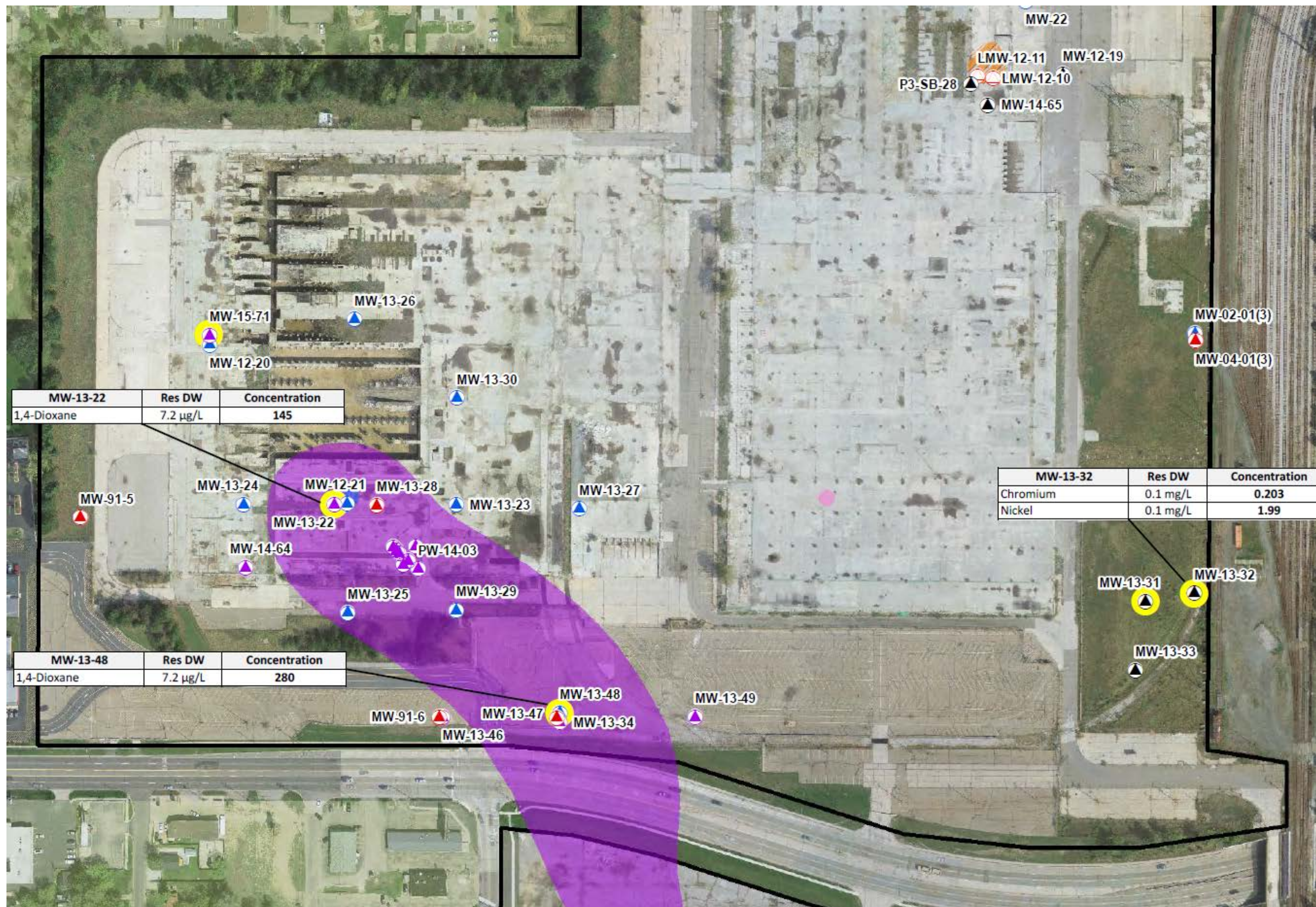
First Quarter Sampling Results

The first quarter event is a quarterly event – 9 wells sampled

- Includes wells that have shown increasing concentration trends or wells with < 4 sampling events

Plant 3 Results

- Nickel > 0.1 mg/L at MW-13-32
- Nickel < 0.1 mg/L at MW-13-31



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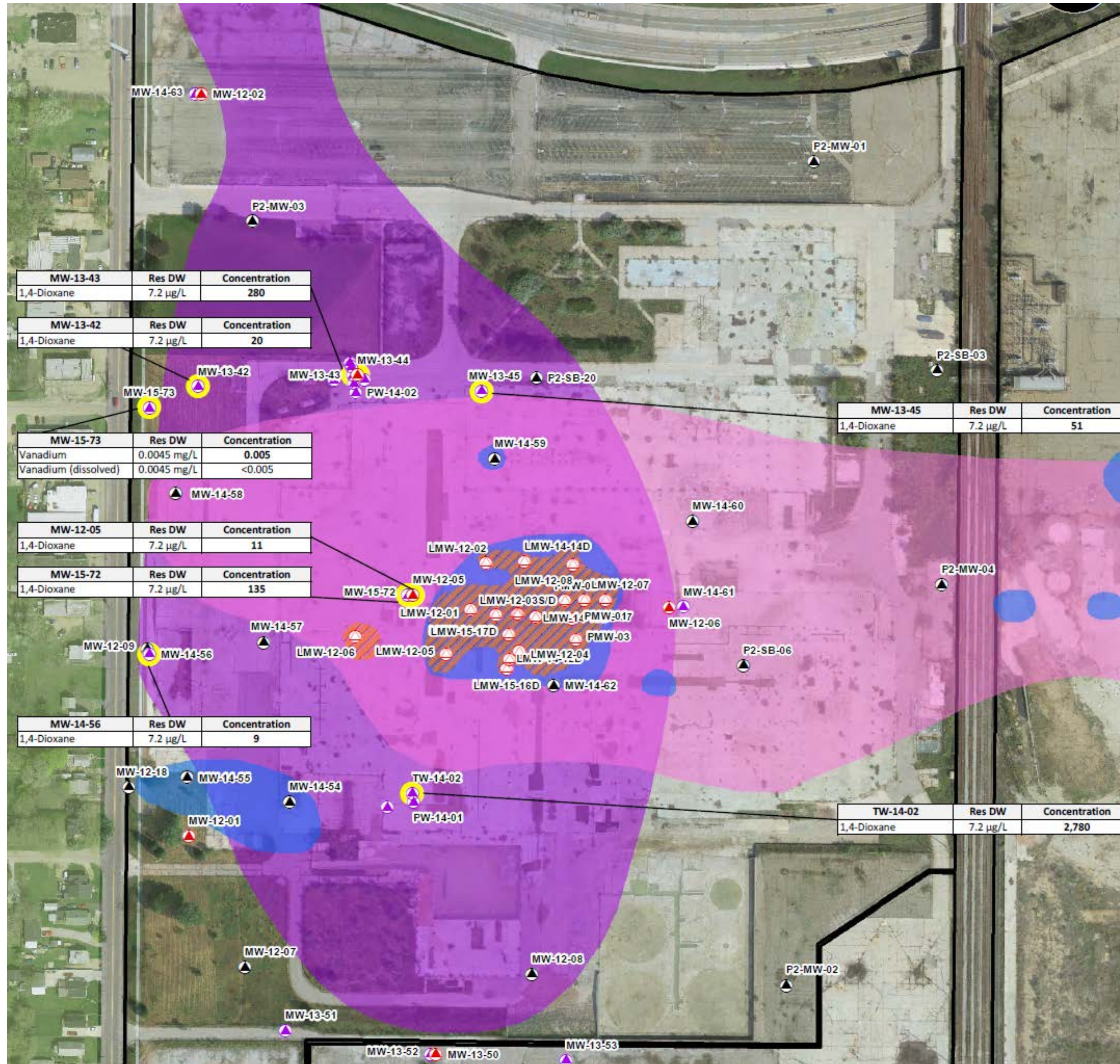
First Quarter Sampling Results

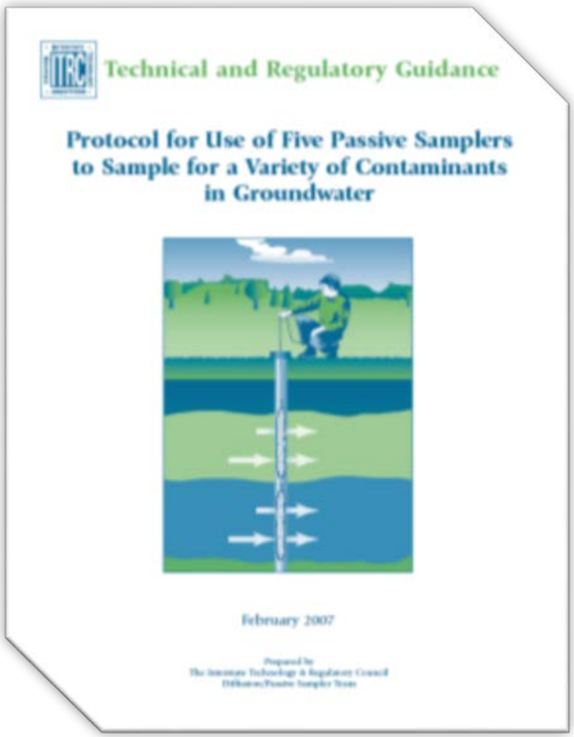
Plant 2 Results

- 1,4-d < 7.2 ug/L at MW-15-73
- 1,4-d > 7.2 at MW-14-56
- 1,4-d > 7.2 at bedrock well MW-12-05



DRAFT – For Discussion Purposes Only

No-Purge Sampling


Technical and Regulatory Guidance

Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater

February 2007

Evaluate a no-purge sampling approach for Site.

- Employed for routine monitoring
- Can reduce field sampling time by up to 50%
- Has been shown to produce reliable data
- Agency Support:
  - ITRC (2006, 2007)
  - USGS (2001)
  - USACE (2002, 2005)
  - USACE/AFCEE (2005)
  - UST Programs for AL, GA, KY, Miss, NC, SC, TX and EPA Region 4 (2004)
  - EPA/Sandia NL (2000)
  - API (2000)

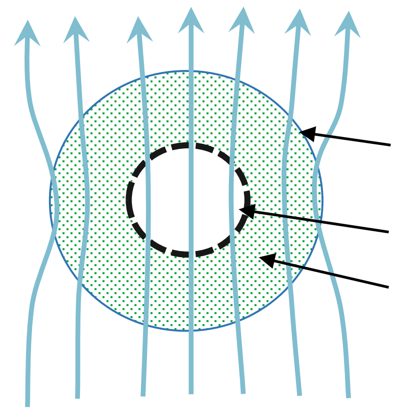
Approach

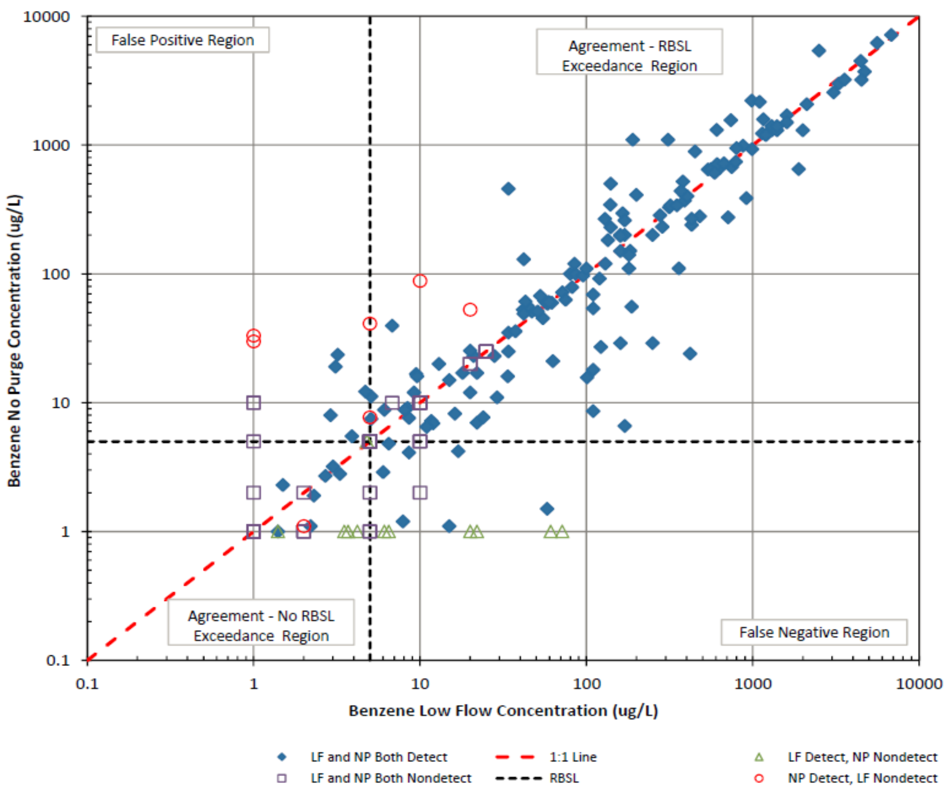
Groundwater *continuously* flows through the screen

- Purging is not necessary to obtain representative water quality samples (same as low-flow)

No-purge sampling technology could be employed in many of the wells at the Site

- Stable wells with robust historical dataset
- Initial data compared to historical data to verify representative





Hydrasleeve®

Hydrasleeve sampling technology:

Pros

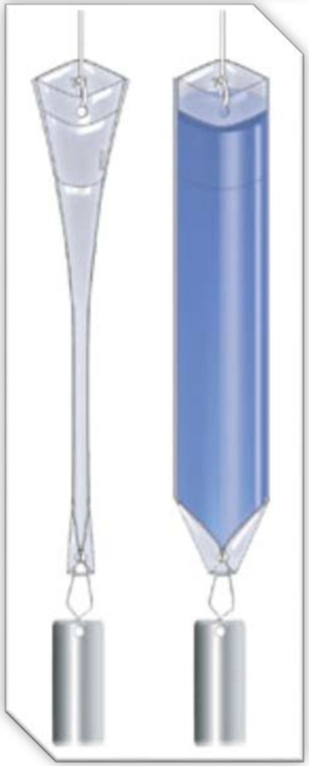
- Simple – deploy, allow to equilibrate, pull up to fill and retrieve
- Low cost
- No analyte limitations
- Minimal risk of mixing with casing water
- Disposable – good for QA/QC
- Good volume – up to 1 L in 2” well

Cons

- Required equilibration time not “cut and dry”

Cautions

- Deployment may temporarily increase turbidity



Schedule 2016

- April 2016 – Budget Amendment
- May 2016 - Annual Groundwater Monitoring Report
- June 2016 – Supplemental 1,4-dioxane Toe Investigation
- June 2016 – Phase 1 Biosparge Pilot Test
- July/August 2016 – Stakeholder Meeting
- June-November – Bioreactor Pilot Test
- July-October – Phase 2 Biosparge Pilot Test (if appropriate)
- September/October 2016 – MDEQ Update Meeting
- November/December 2016 – Data Evaluation and Reporting