Vertex Environmental Inc.

LNAPL Remediation in Bedrock:
Combining MPE and Injection of a Carbon-Based Remedial Amendment

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Battelle

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Background

Bruce Tunnicliffe, M.A.Sc., P.Eng.

- Masters – U of Waterloo. Remediation
- Founder – Vertex Environmental Inc.

Vertex Environmental Inc.

- Founded July 2003
- Environmental Contractor

Talk Concept

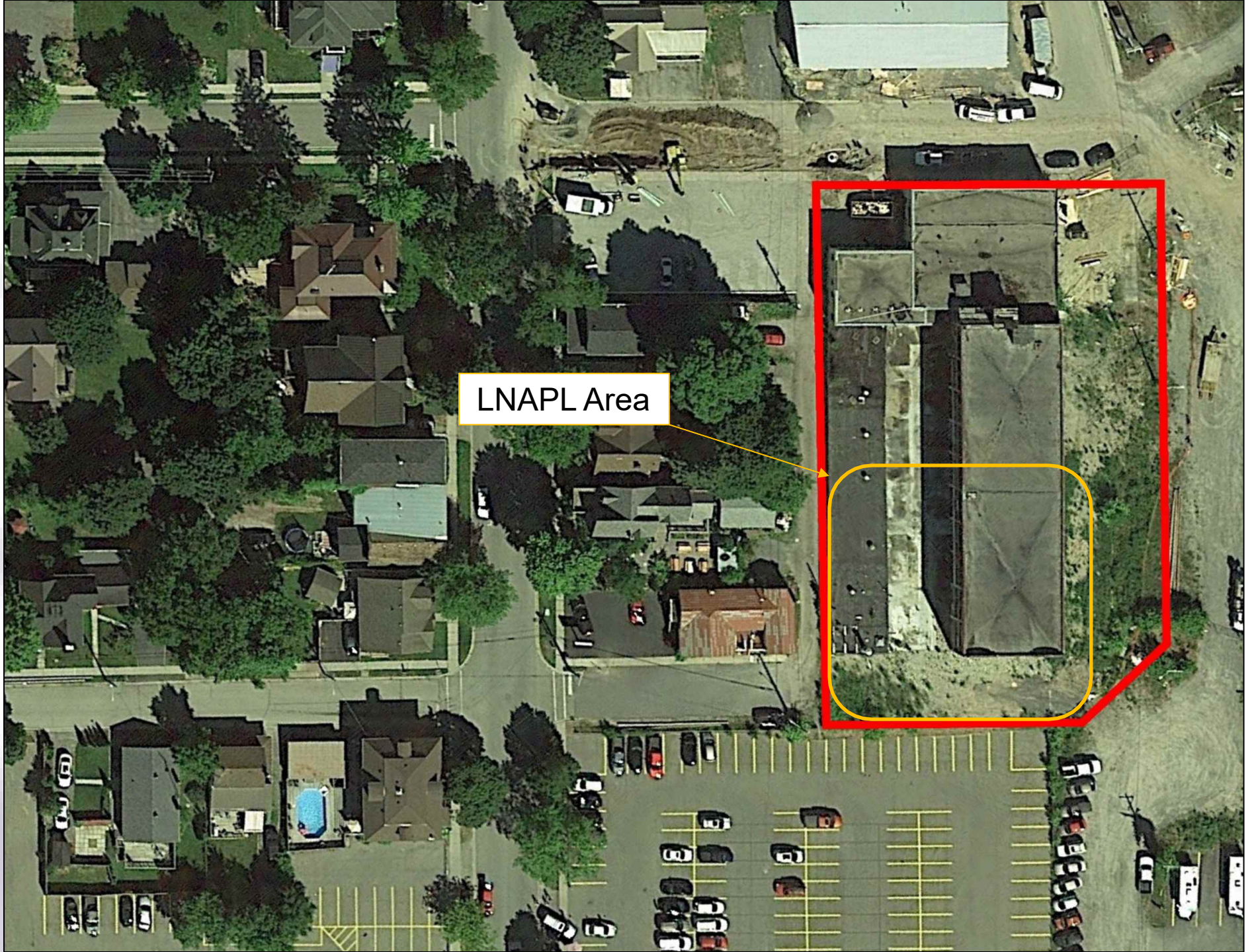
- Light, non-aqueous phase liquid (LNAPL) remediation in fractured bedrock has been very challenging in the past, with a low probability of success
- This talk presents a case study
- All work was proposed and completed in a budget restricted environment
- “Old” technologies were used
  - Excavation
  - Multi-phase Extraction (MPE)
- Followed by a “new” technology
  - In-Situ remediation, using an activated carbon-based amendment and novel injection approach
- This talk will showcase the successful sequential use of these 2 technologies

Outline

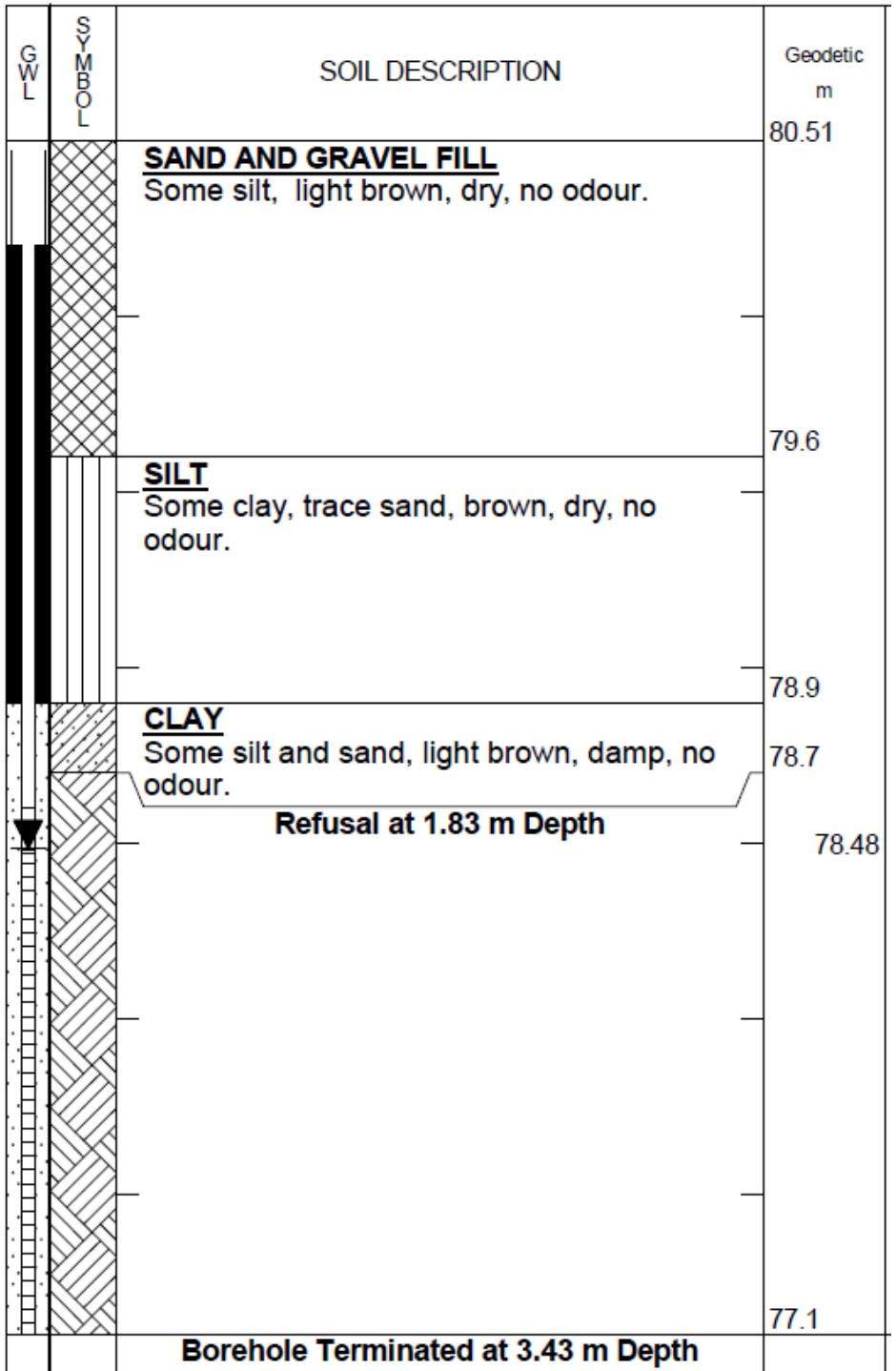
- Case Study – Background
  - The Site
  - Geology and LNAPL
- “Old” Remediation Technologies
  - Excavation
  - Multiphase Extraction
- “New” Remediation Technology
  - In-Situ Activated-Carbon Based Amendment
- Closing

Background – The Situation

- Confidential site in eastern Ontario, Canada
- Contamination primarily in the underlying bedrock aquifer
- Historical industrial operations:
  - Leaky fuel tank
  - PHCs (petroleum hydrocarbons) and LNAPL
- Future redevelopment planned:
  - Residential redevelopment
  - RA (risk assessment) and redevelopment permit process underway
  - Active remediation was required to address free product (LNAPL)
- Staged remedial approach:
  - Source Removal = Decommission fuel tank & removal of impacted soil
  - MPE System = Direct LNAPL removal
  - In-Situ Injection = Polishing step to address residual/remaining PHCs & LNAPL


LNAPL Area

Site Stratigraphy



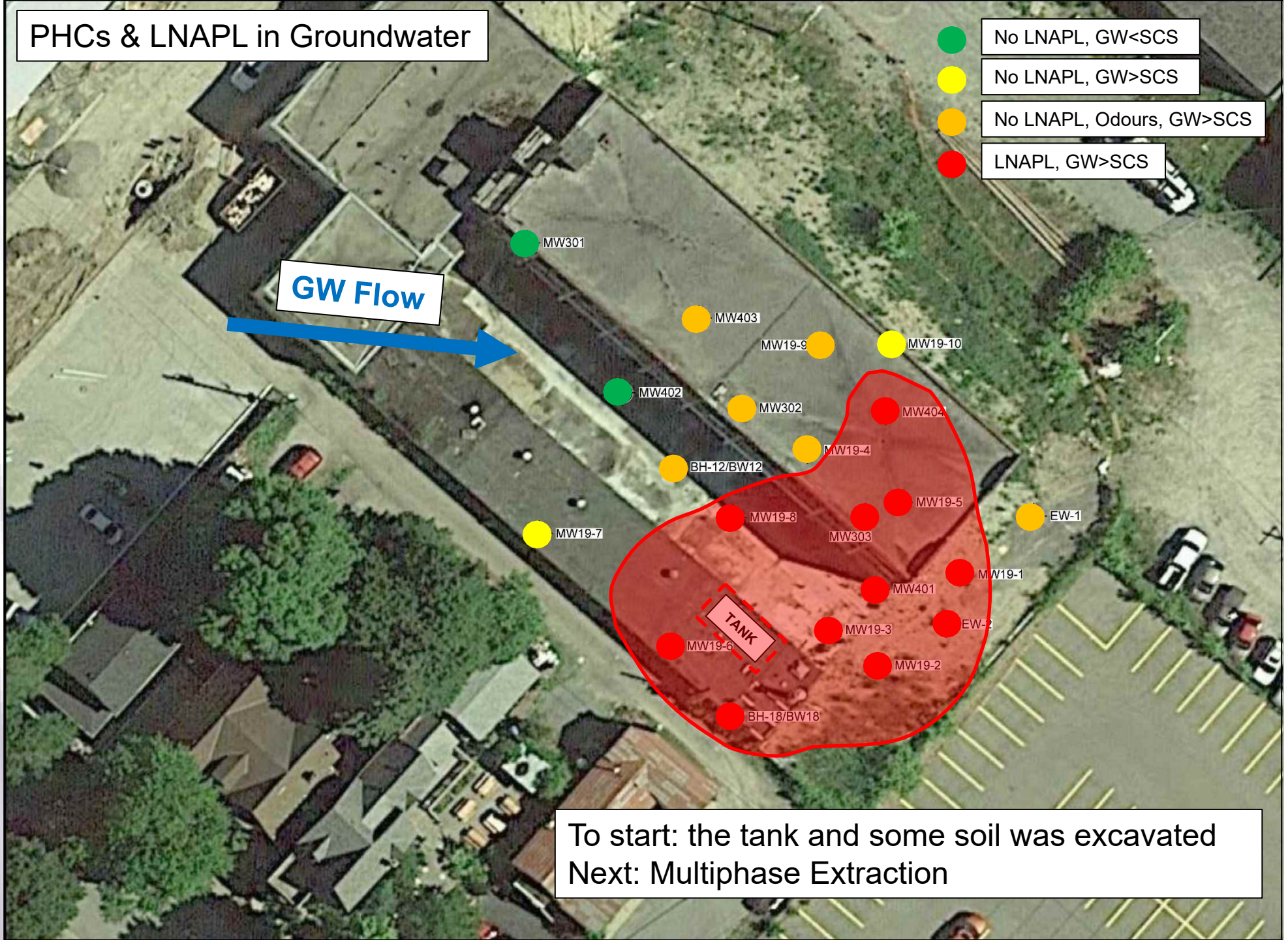
0 feet – ground surface

6.5 feet – water table

6 feet – top of bedrock (Dolostone)

The Source

PHCs & LNAPL in Groundwater



SCS = Site Condition Standards

To start: the tank and some soil was excavated
Next: Multiphase Extraction

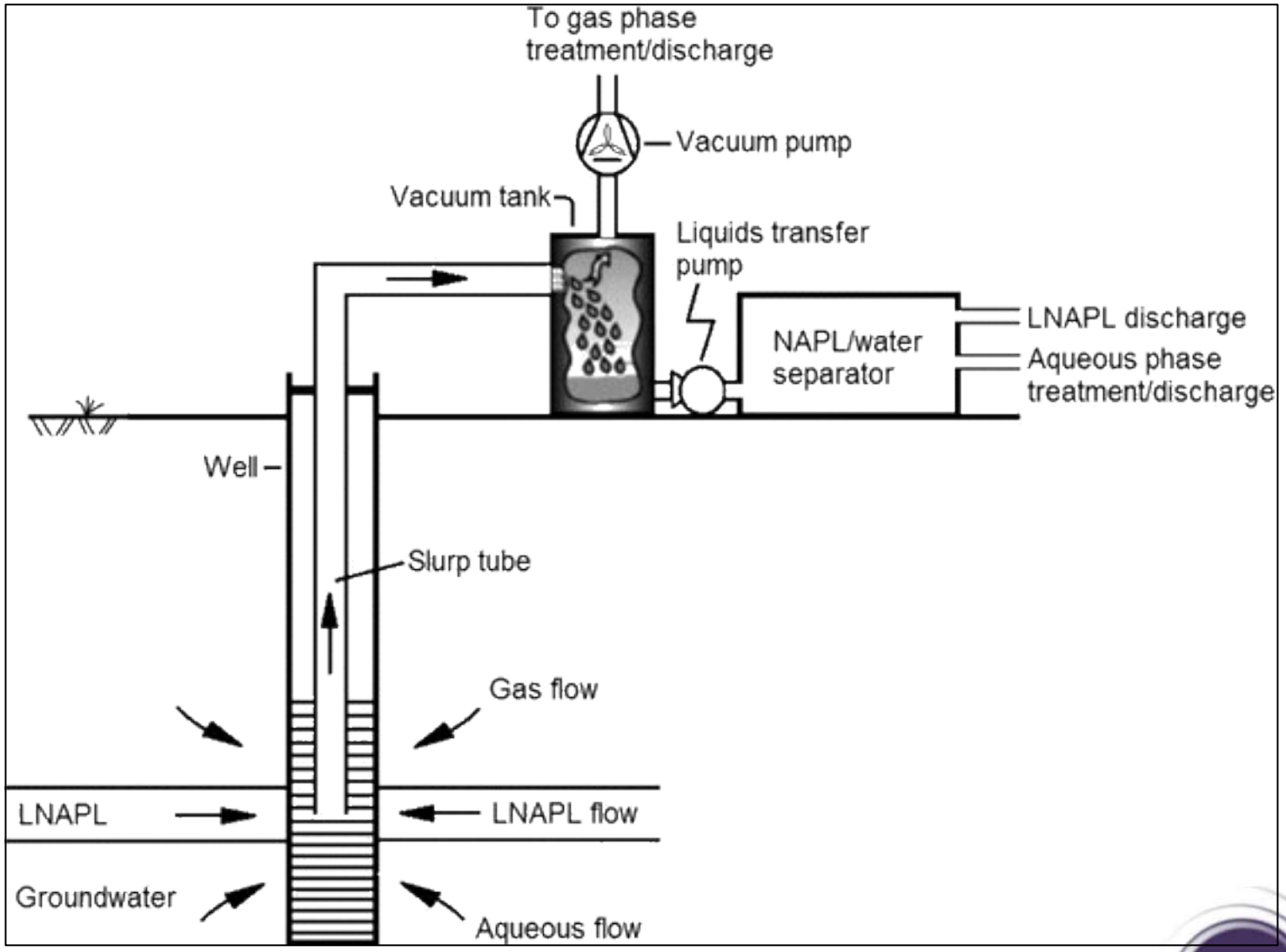
VERTEX

What is Multi-Phase Extraction (MPE)?

Technology has been used from 1980s to Present

Multiphase Extraction (MPE):

- Extracts 3 phases:
  - NAPL
  - Groundwater
  - Vapours
- Uses slurp tubes at the air-liquid interface
- Separates 3 phases and treats simultaneously



Source: Simulation of Subsurface Multiphase Contaminant Extraction Using a Bioslurping Well Model (2016)

Multi-Phase Extraction – Preliminary Work

- Vacuum Extraction Testing (Spring 2020)
  - Using Vacuum truck, measured radius of influence (ROI) and product recovery rates
  - Useful in sizing system and extraction well (EW) placement
- MPE Power Connections
  - Work with local utility to install new poles and service
- Sewer Discharge Agreement
  - Process with municipality
  - Install a new lateral connection to Sanitary sewer from the Site

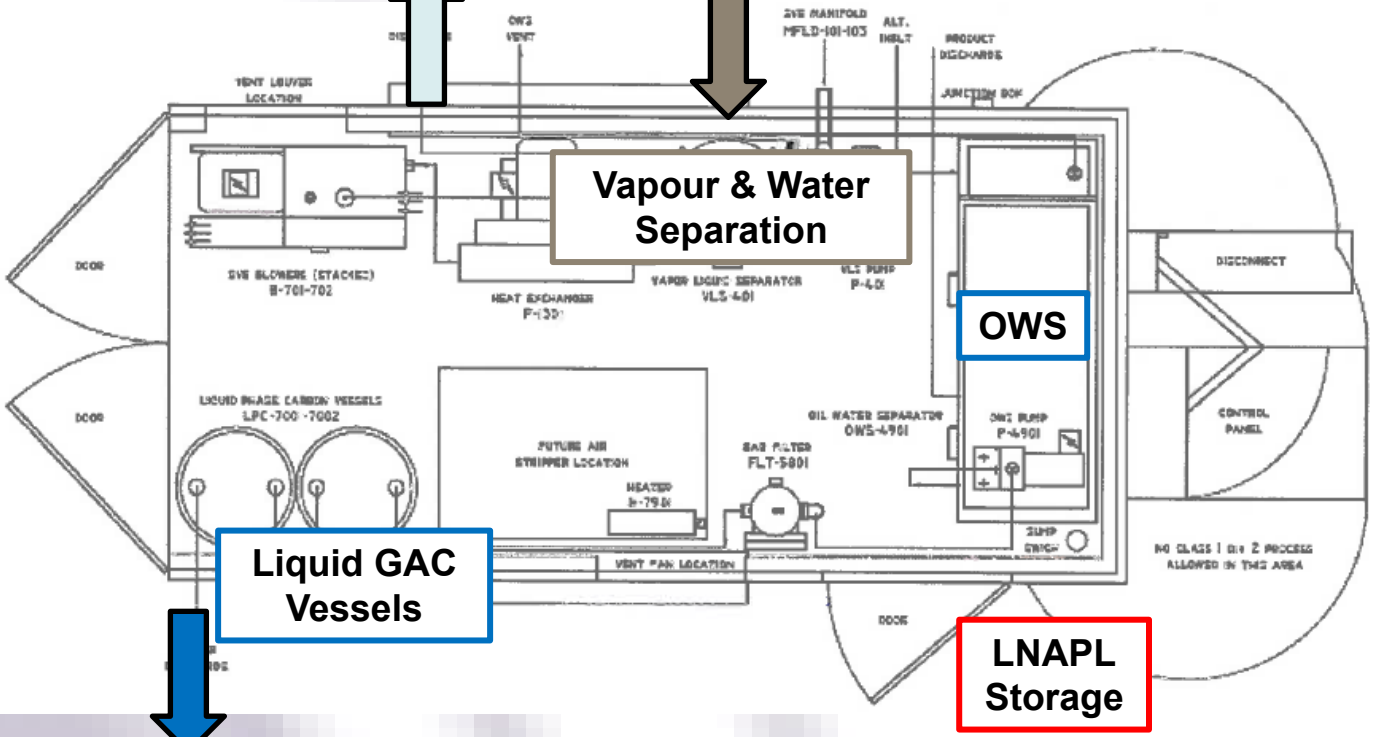
Multi-Phase Extraction – The System

Multi-Phase Extraction – The System

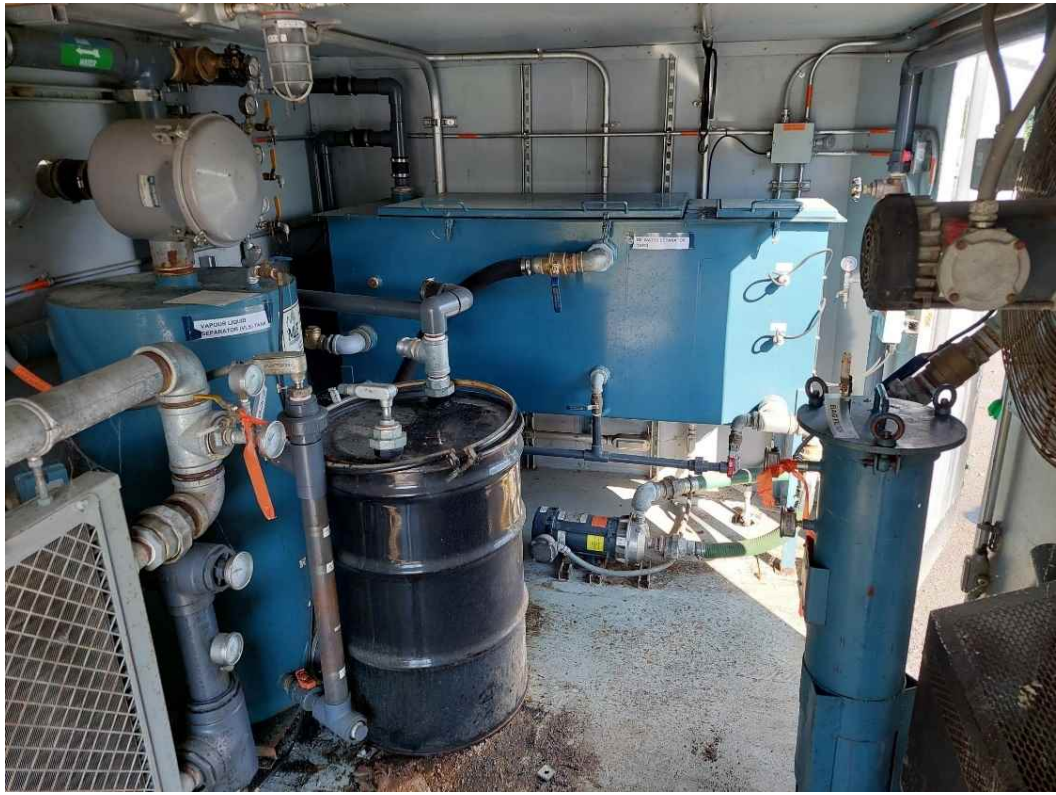
Air Discharge (Stack)

Vapour GAC Vessels

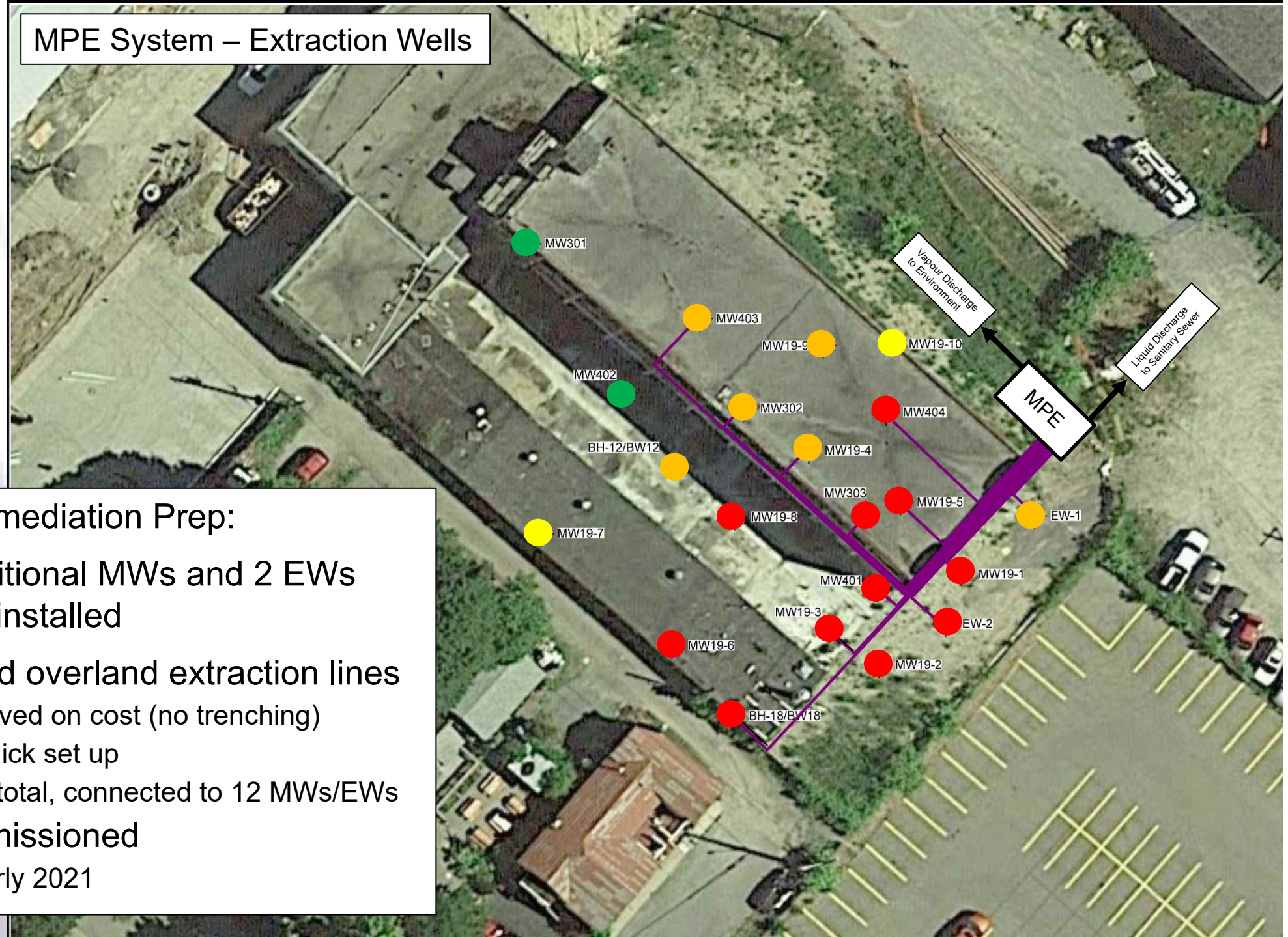
Influent from Wells



Discharge to SANI Sewer



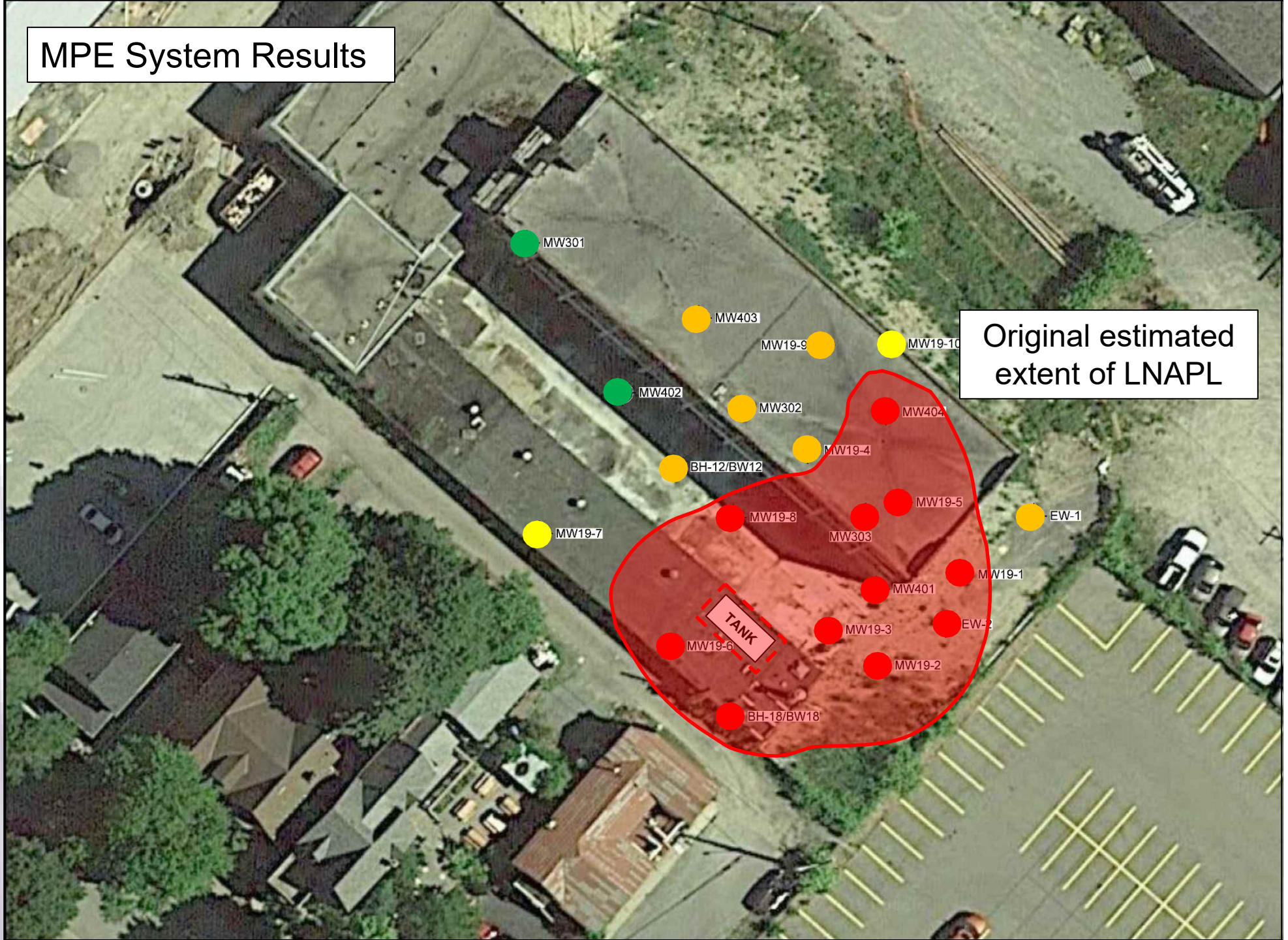
MPE System – Extraction Wells



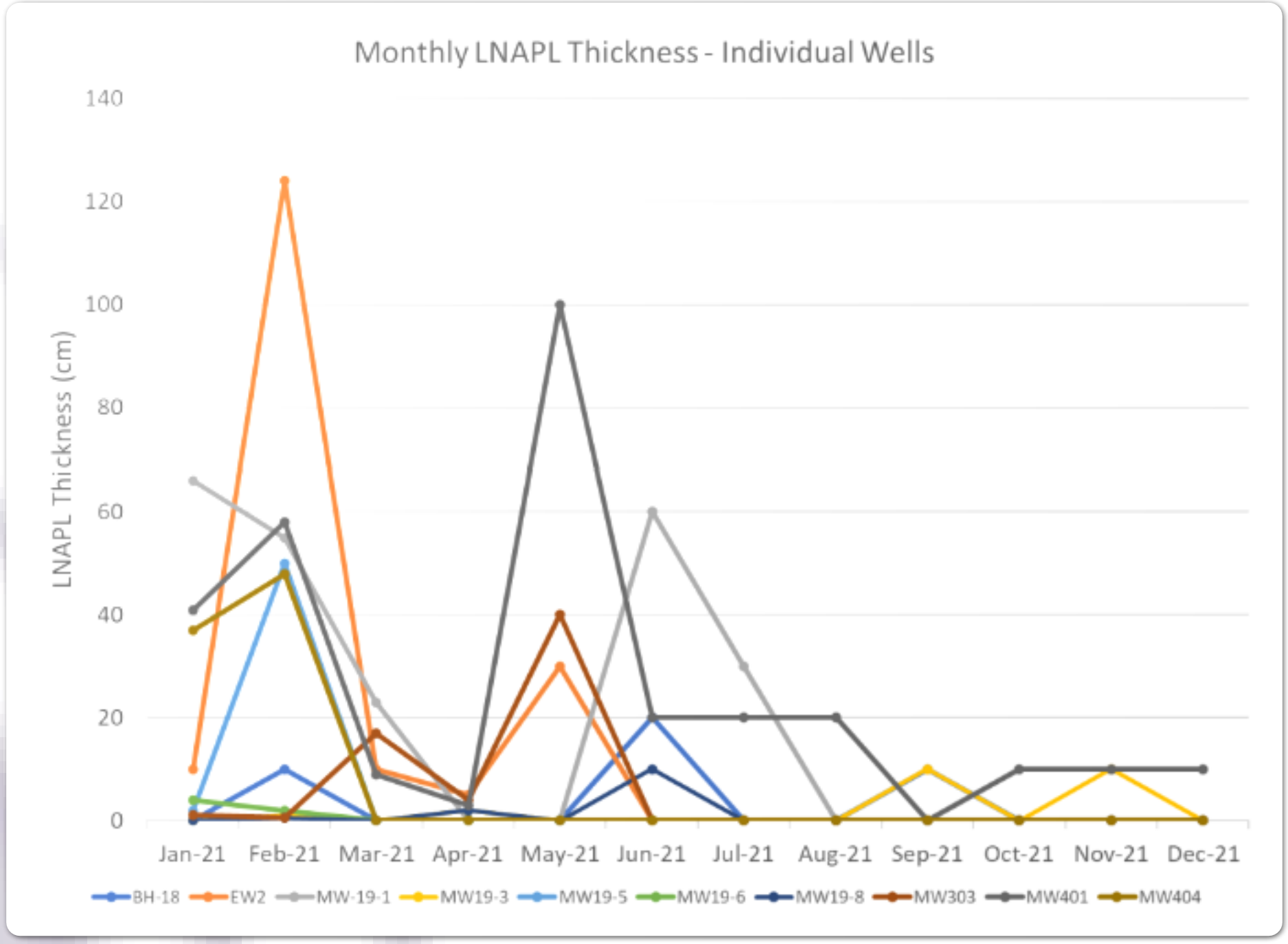
MPE Remediation Prep:

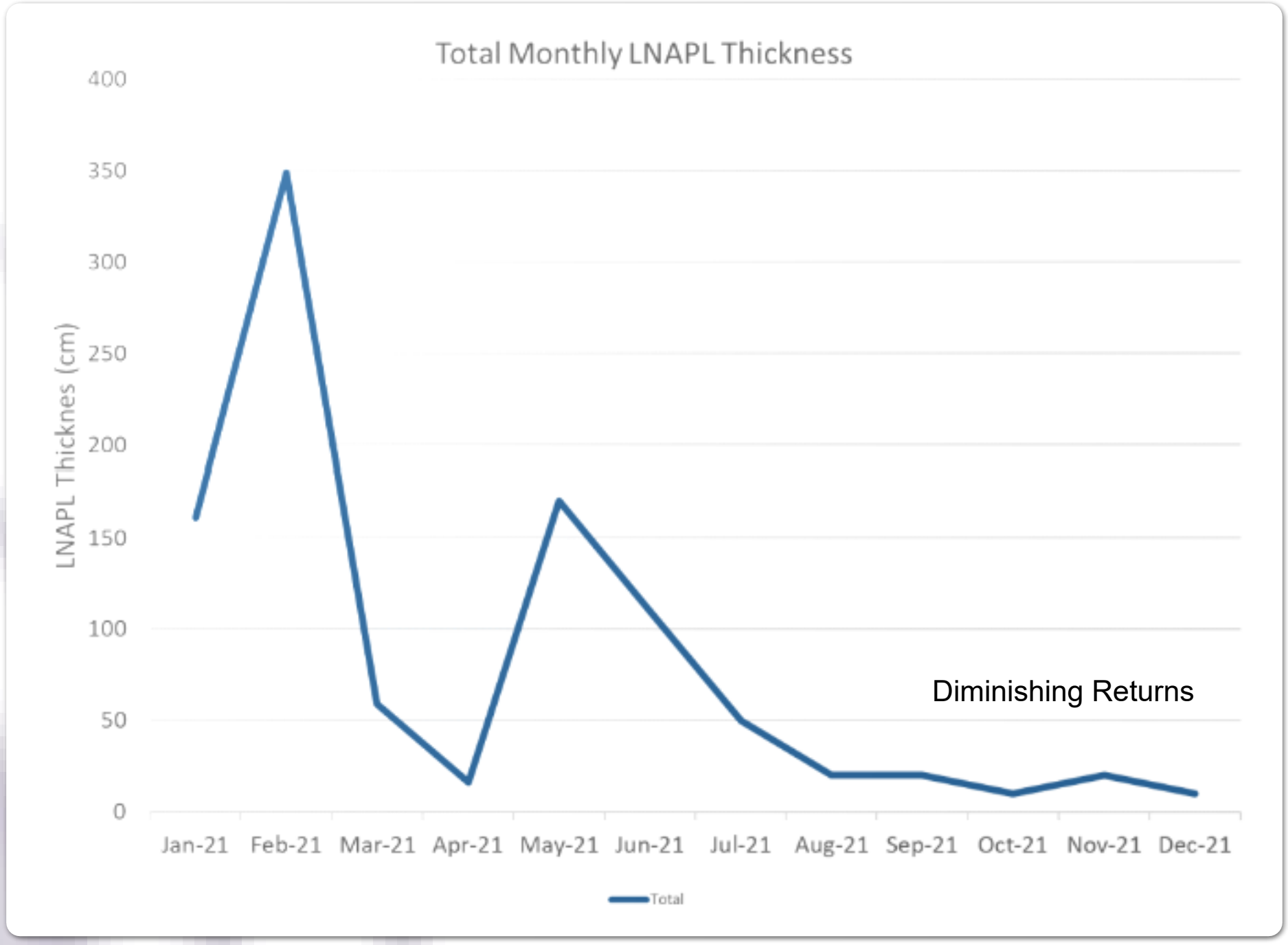
- 4 additional MWs and 2 EWs were installed
- Placed overland extraction lines
  - Saved on cost (no trenching)
  - Quick set up
  - In total, connected to 12 MWs/EWs
- Commissioned
  - early 2021

MPE System Results



At the start LNAPL between 2 to up to 4 feet in thickness

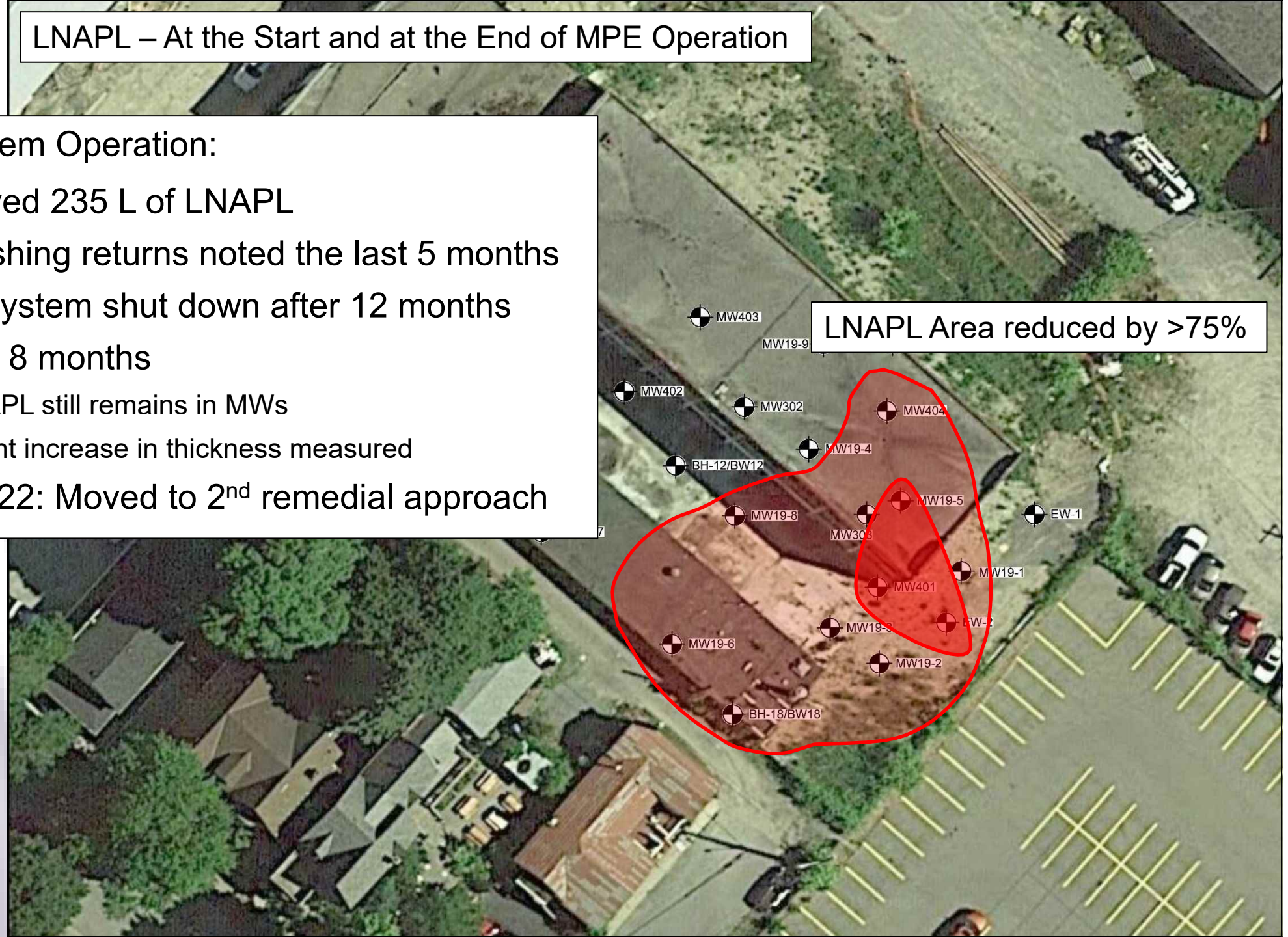



Total Monthly LNAPL Thickness
LNAPL Thicknes (cm)
400
350
300
250
200
150
100
50
0
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Total
Diminishing Returns

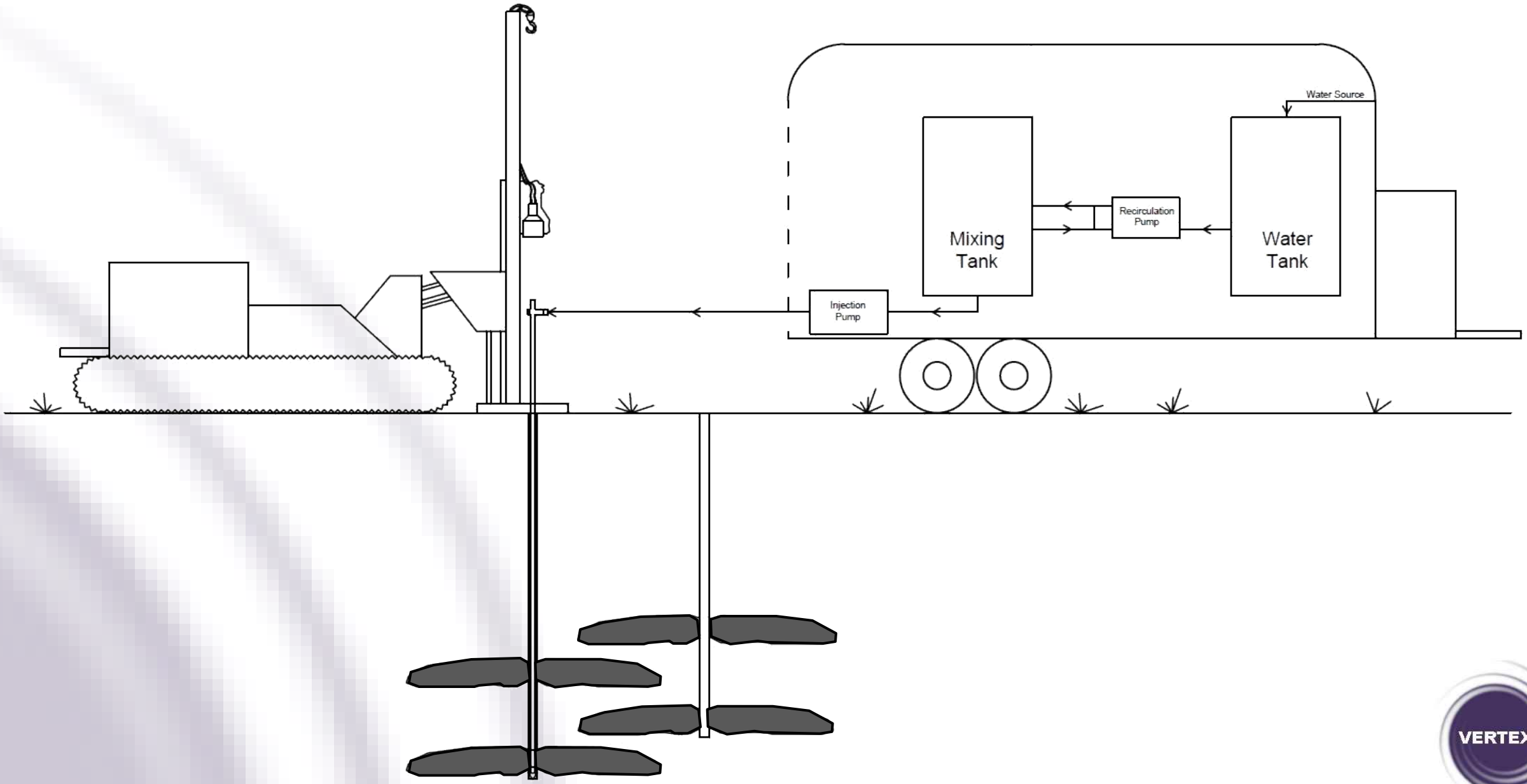
LNAPL – At the Start and at the End of MPE Operation

MPE System Operation:

- Removed 235 L of LNAPL
- Diminishing returns noted the last 5 months
- MPE System shut down after 12 months
- Waited 8 months
  - LNAPL still remains in MWs
  - Slight increase in thickness measured
- Fall 2022: Moved to 2nd remedial approach



Injection Program – Carbon-Based Amendment



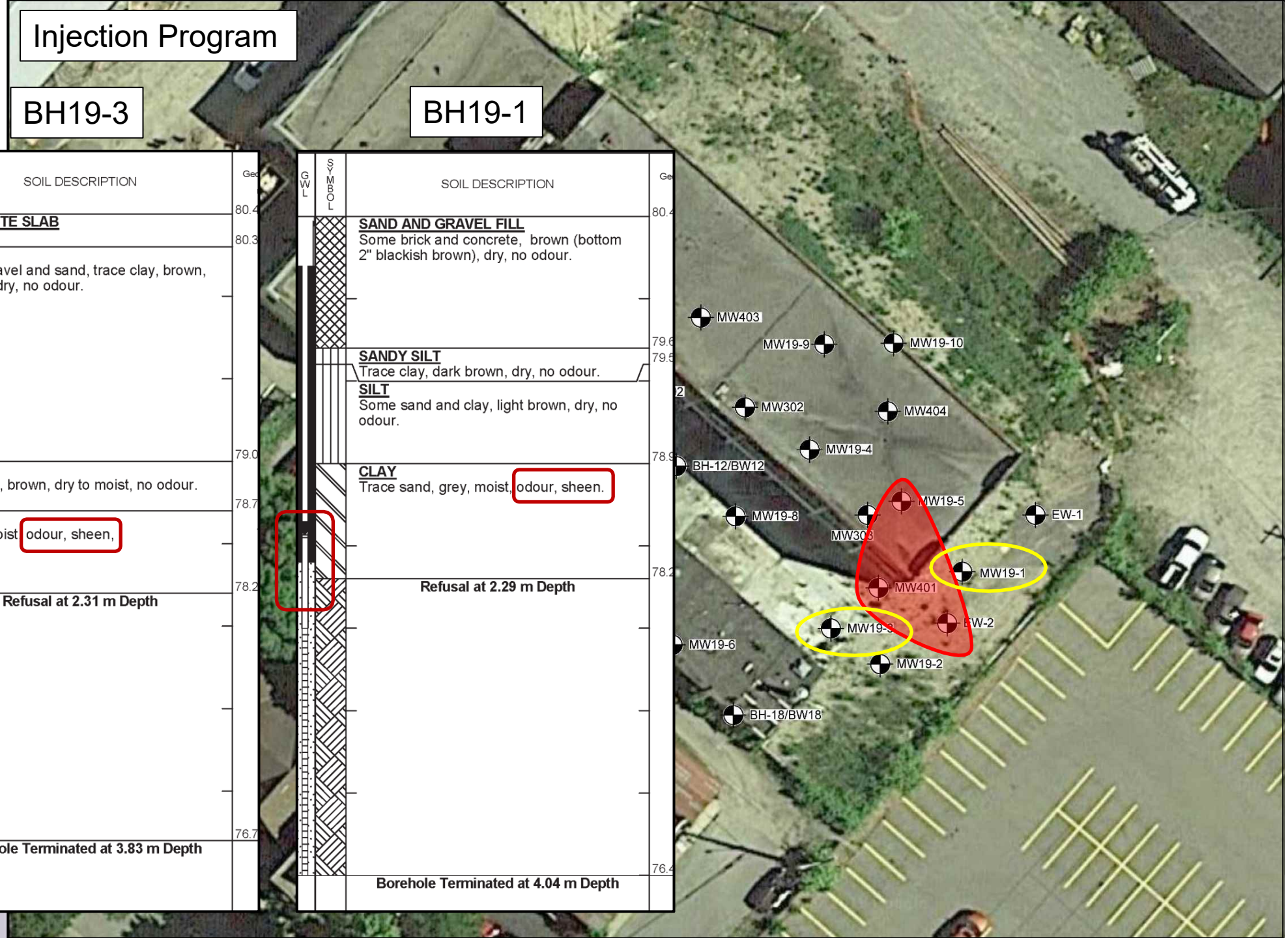
Injection Program

BH19-3

GWL	SYMBOL	SOIL DESCRIPTION	Ge
			80.4
		CONCRETE SLAB	80.3
		SILT Some gravel and sand, trace clay, brown, moist to dry, no odour.	79.0
		CLAY Trace silt, brown, dry to moist, no odour.	78.7
		CLAY Grey, moist, odour, sheen,	78.2
		Refusal at 2.31 m Depth	
			76.7
		Borehole Terminated at 3.83 m Depth	

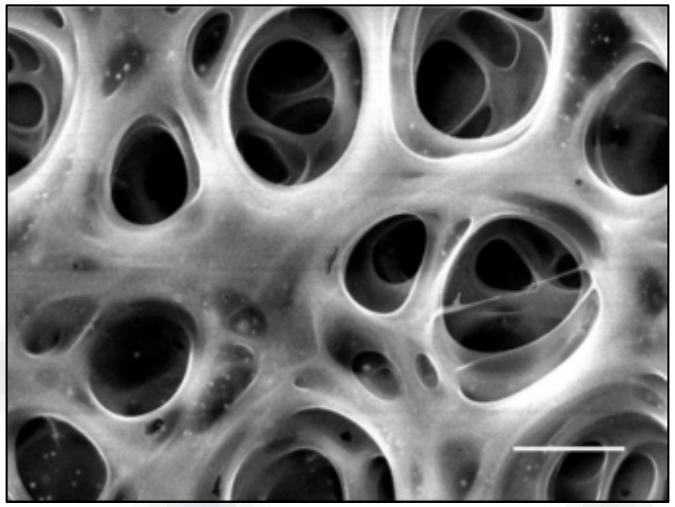
BH19-1

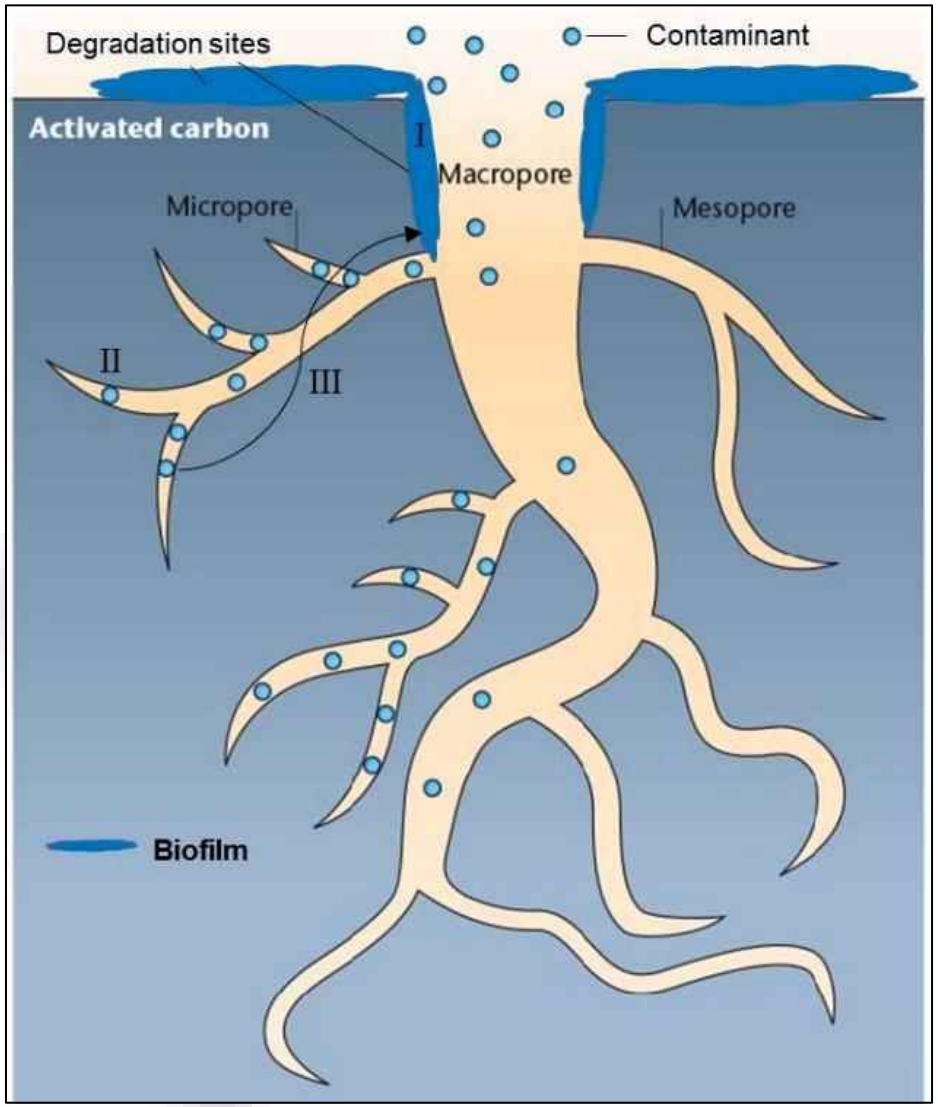
GWL	SYMBOL	SOIL DESCRIPTION	Ge
			80.4
		SAND AND GRAVEL FILL Some brick and concrete, brown (bottom 2" blackish brown), dry, no odour.	79.6
		SANDY SILT Trace clay, dark brown, dry, no odour.	79.5
		SILT Some sand and clay, light brown, dry, no odour.	78.9
		CLAY Trace sand, grey, moist, odour, sheen.	78.2
		Refusal at 2.29 m Depth	
			76.4
		Borehole Terminated at 4.04 m Depth	

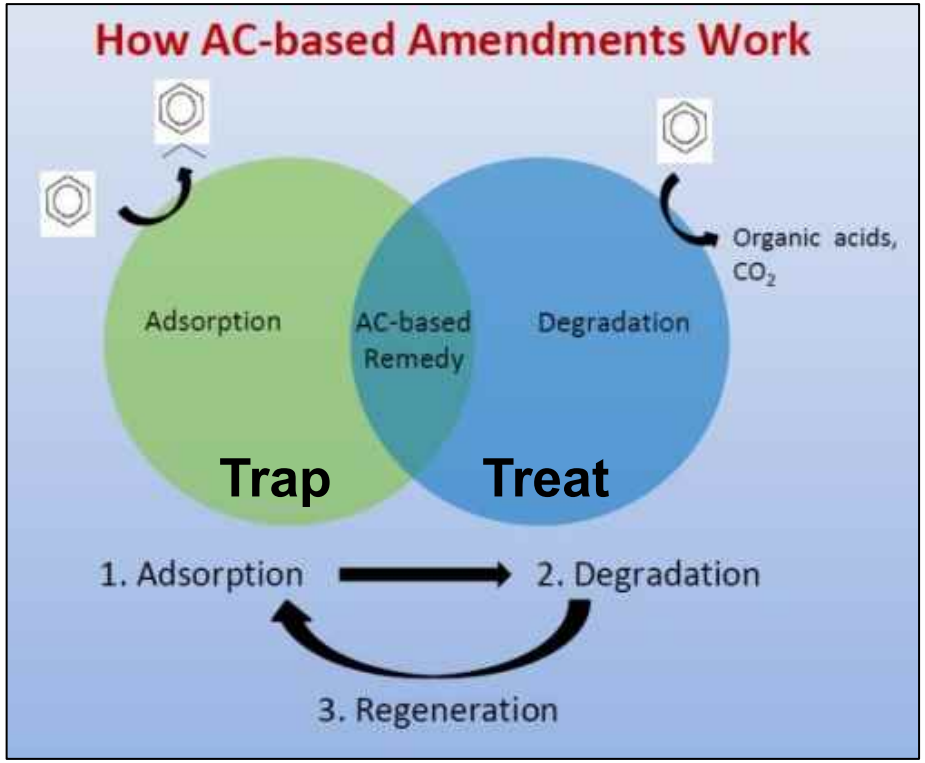


GeoTAP™ (Pre-Drill) Method

Trap & Treat® BOS 200+®



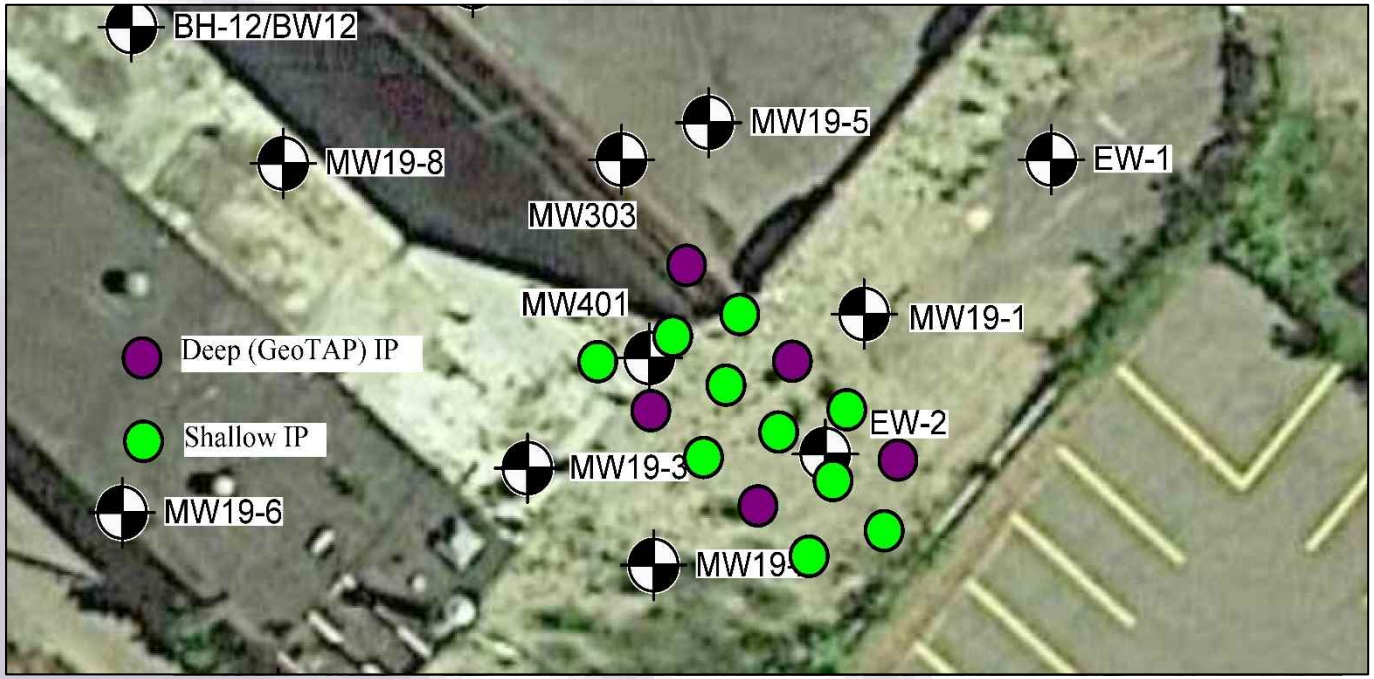




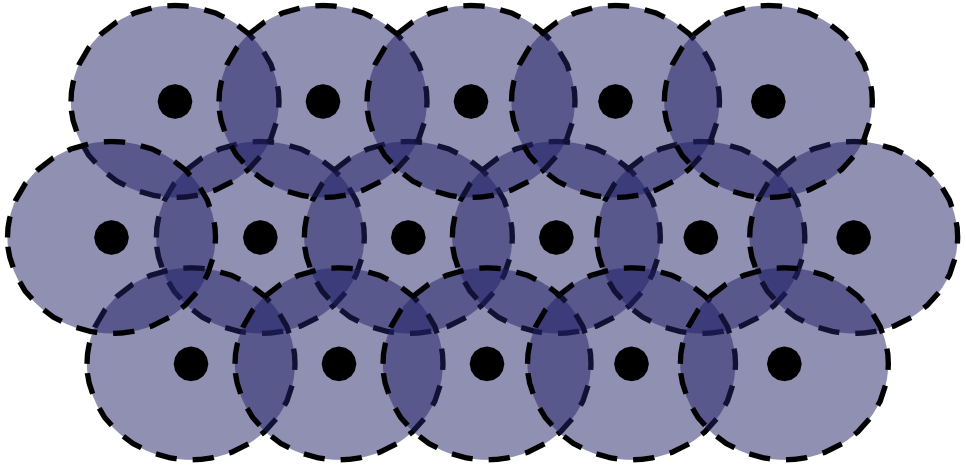
BOS 200+® incorporates activated carbon (AC), nutrients (complex carbohydrates & amino acids), and microbes to synergistically degrade contaminants while renewing the AC platform

Injection Summary

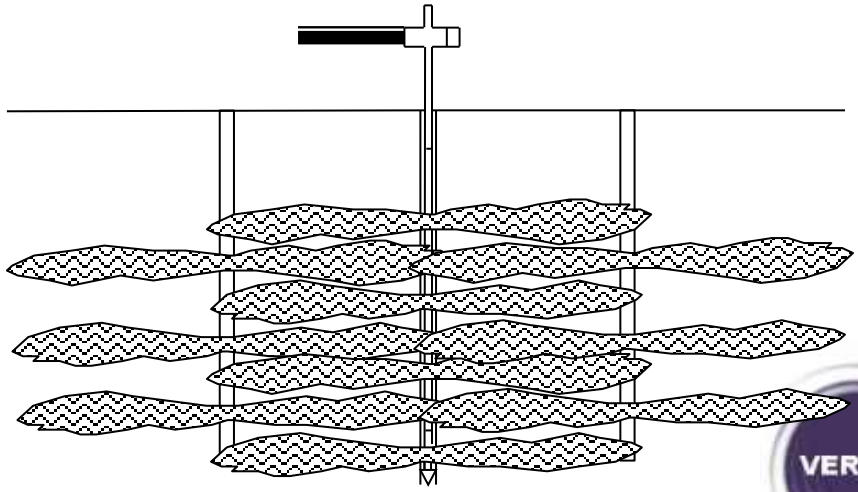
- Completed over 2 days in Fall 2022
- 5 bedrock GeoTAP™ injection points (IPs)
- 10 overburden direct-push IPs
- 15 IPs in total to target “Hot Spot” area
- Injected 2,200 kg BOS 200+® in 4,000 L



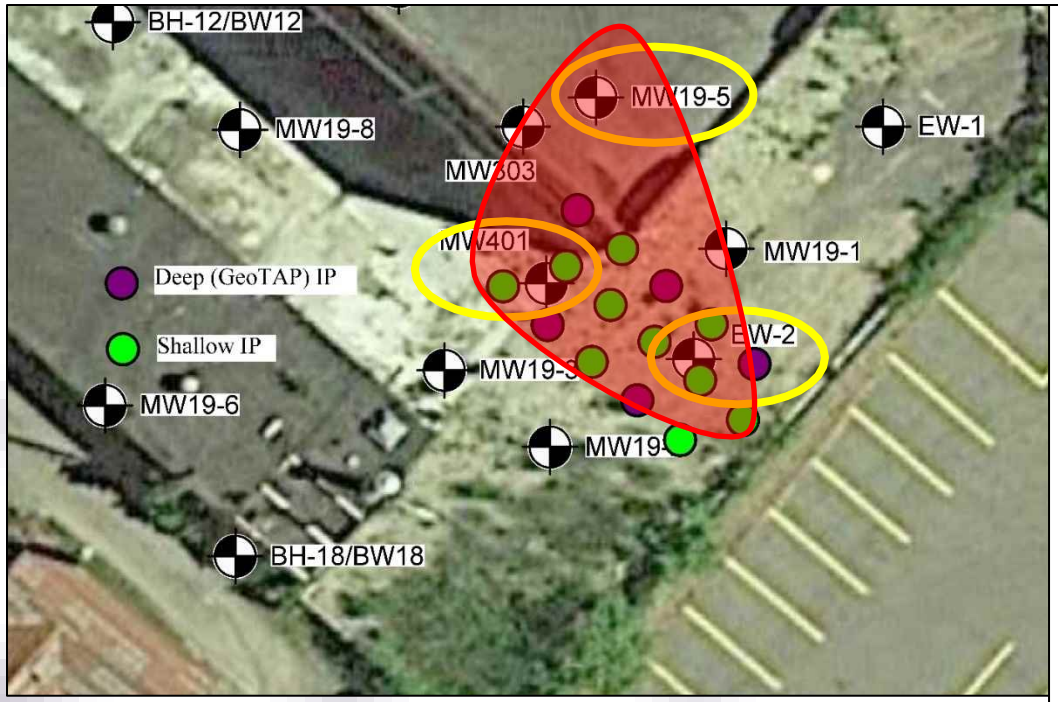
Plan View

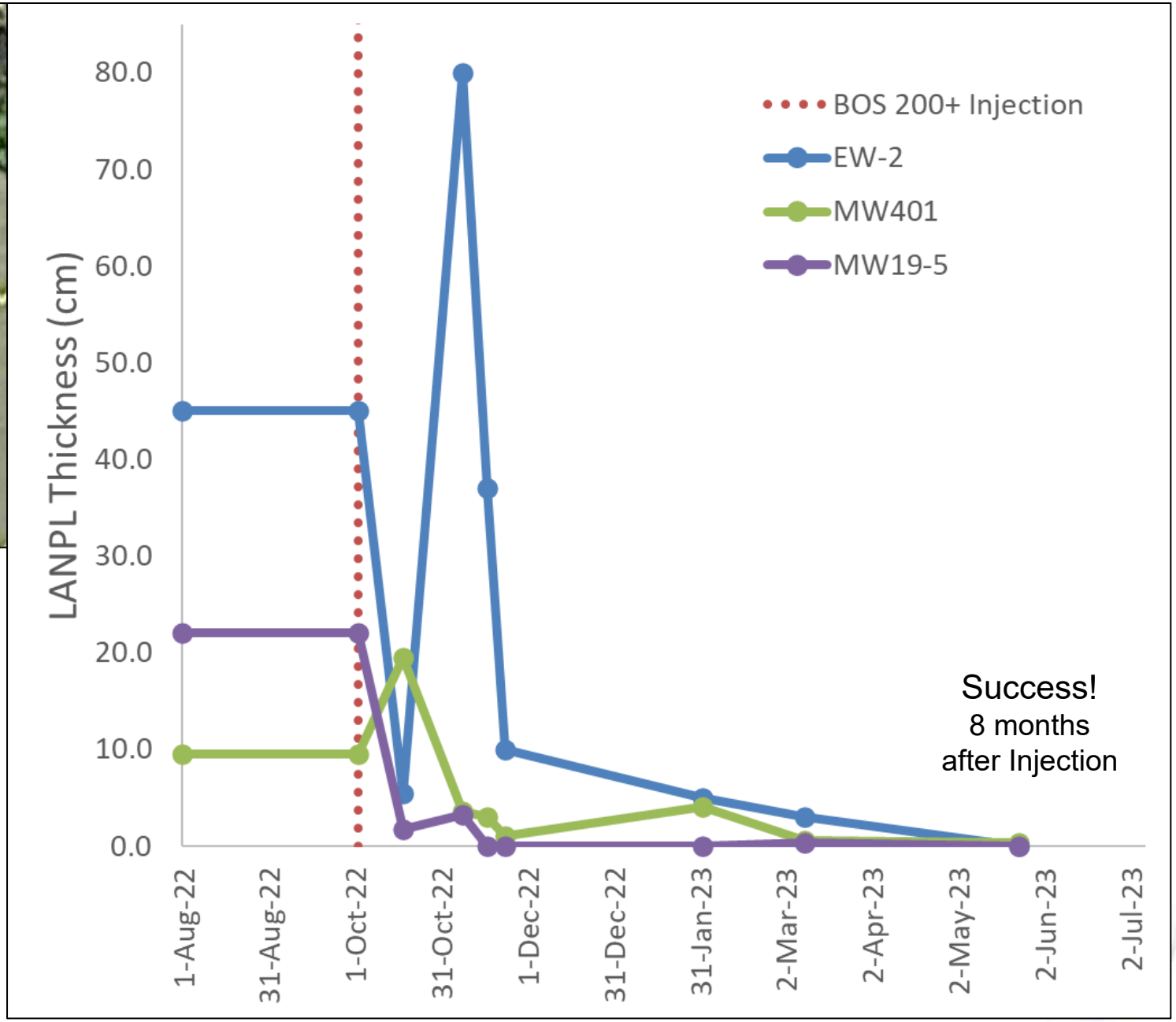


Profile View



Injection Results – Post Injection Analytical





LNAPL Remediation in Bedrock - Closing

Remediation of Bedrock with LNAPL:

- Its possible with a multi-technology approach
- UST Removal & Excavation:
  - Source removed
- MPE System:
  - Implemented for a period of 12 months
  - Removal of majority (~75 %) of the LNAPL area
- Trap and Treat® BOS 200+® Injection:
  - Implemented GeoTAP™ method: allowed injection into fractured bedrock **and** at the overburden bedrock interface
  - BOS 200+ handled LNAPL and back diffusion of PHCs
  - Sustained reduction in LNAPL achieved

Questions?

Thank You for Your Time

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