

Vertex Environmental Inc.



Case Study:
PHC Remediation of a Complicated Site
Using a Multi-Technology Approach

October 10, 2018

RemTech

Bruce Tunncliffe





Outline

- Background
- Remediation
 - Bench and Pilot
 - Full-Scale Remediation
 - Results
- Take Aways / Lessons Learned
- Questions

Vertex Environmental Inc.

Contracting Company



**In-Situ
Remediation**



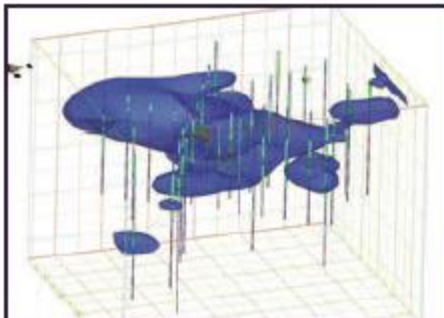
**Ex-Situ
Remediation**



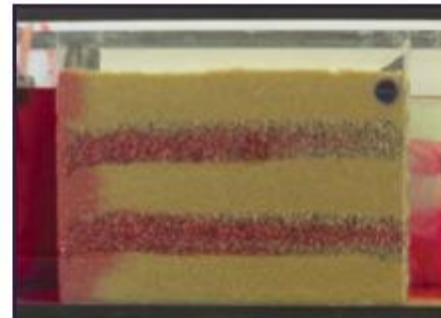
**High Resolution
Characterization**



**Treatment
Systems**



**Remedial
Design**



**Bench-Scale
Testing**

Background – The Situation

- Confidential Site
- One large corporation purchased operations and land from another
- Seller retained environmental liability
- Buyer took over the Site, rebranded and operated the facility
- Petroleum Hydrocarbons (PHCs) in subsurface
- Contract in place with regards to PHCs:
 - Work Plan to be produced by Seller
 - Work Plan to be approved by Buyer
 - Work to be executed and paid for by Seller



Background – The Situation

The Contract specified contamination will be addressed as follows:

- **contaminated soil:** removed and disposed off-site;
 - **free phase:** removed and disposed off-site;
- but the Work Plan can consider
- **in-situ treatment:** at locations not reasonably accessible, or,
 - **risk assessment** and **risk management:** if above is technically impracticable.

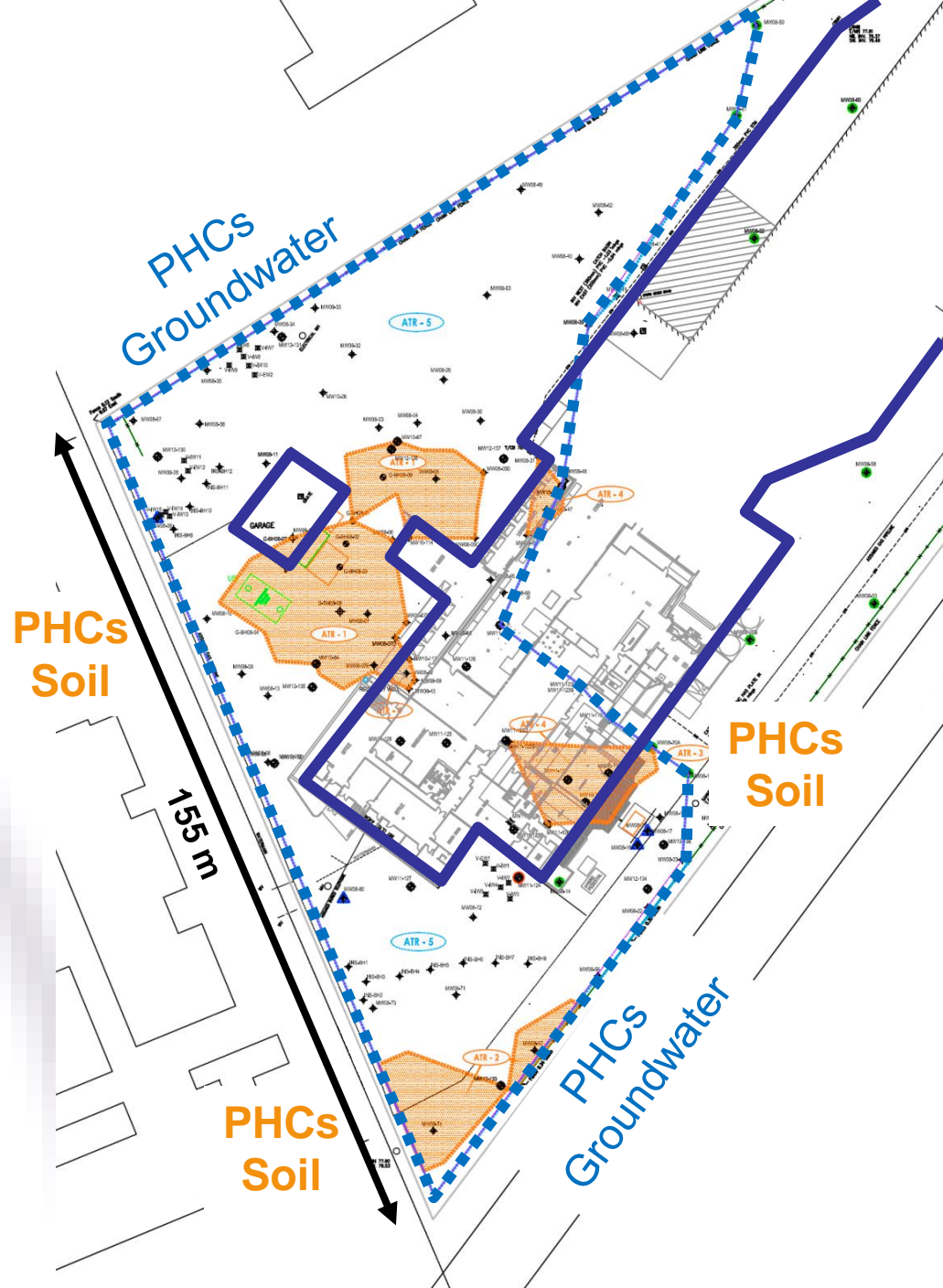


Site Layout



Contamination

Areas To
Remediate
2012



Analytical

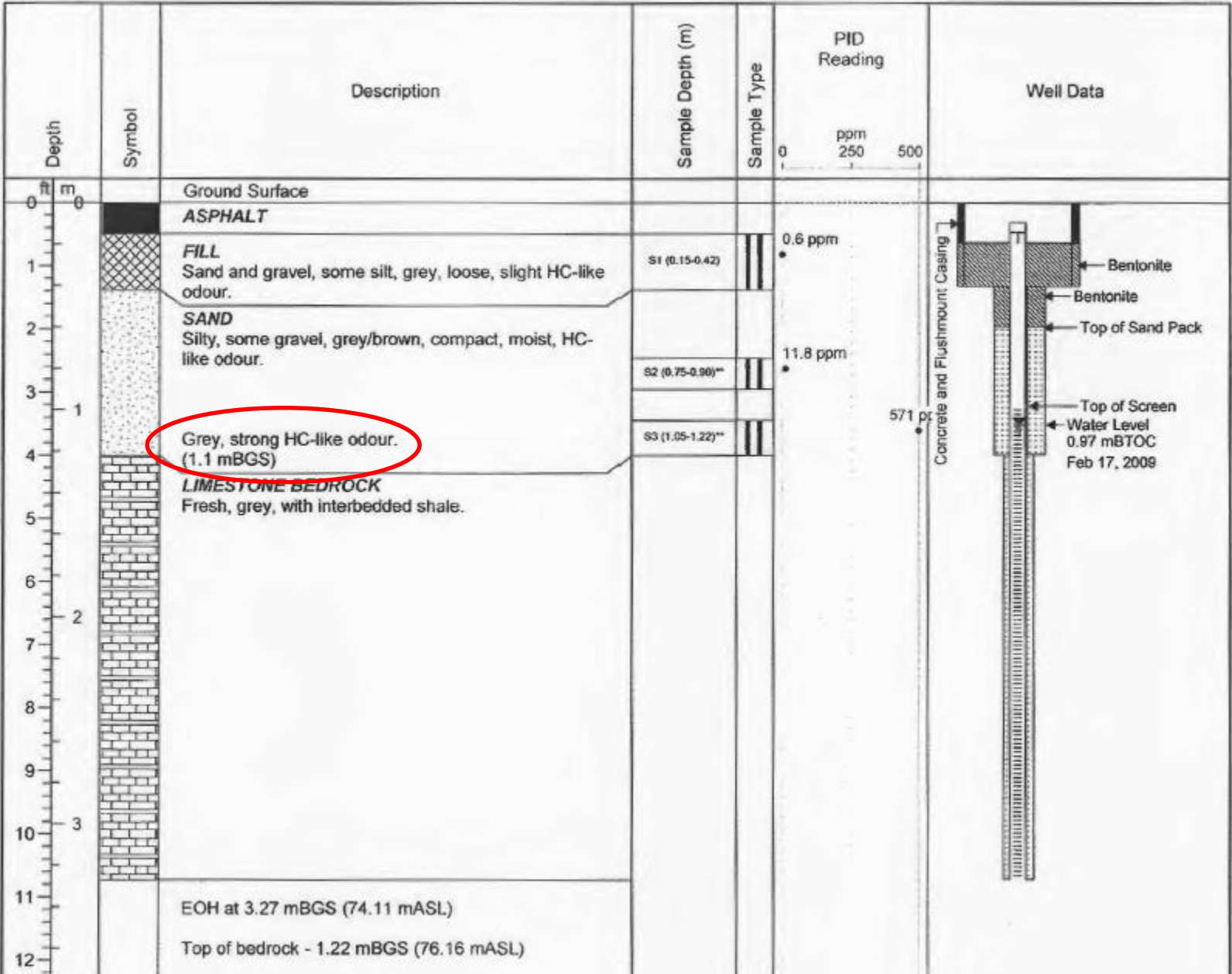
Analytical	Groundwater	Soil
PHCs – Source	LNAPL	15,000 mg/kg
PHCs – Plume	10,000 ug/L	1,000 mg/kg
Benzene	10 ug/L	-

Generic Standards	Groundwater	Soil
PHC(F1)	420 ug/L	65 mg/kg
PHC(F2)	150 ug/L	250 mg/kg
Benzene	0.5 ug/L	0.4 mg/kg

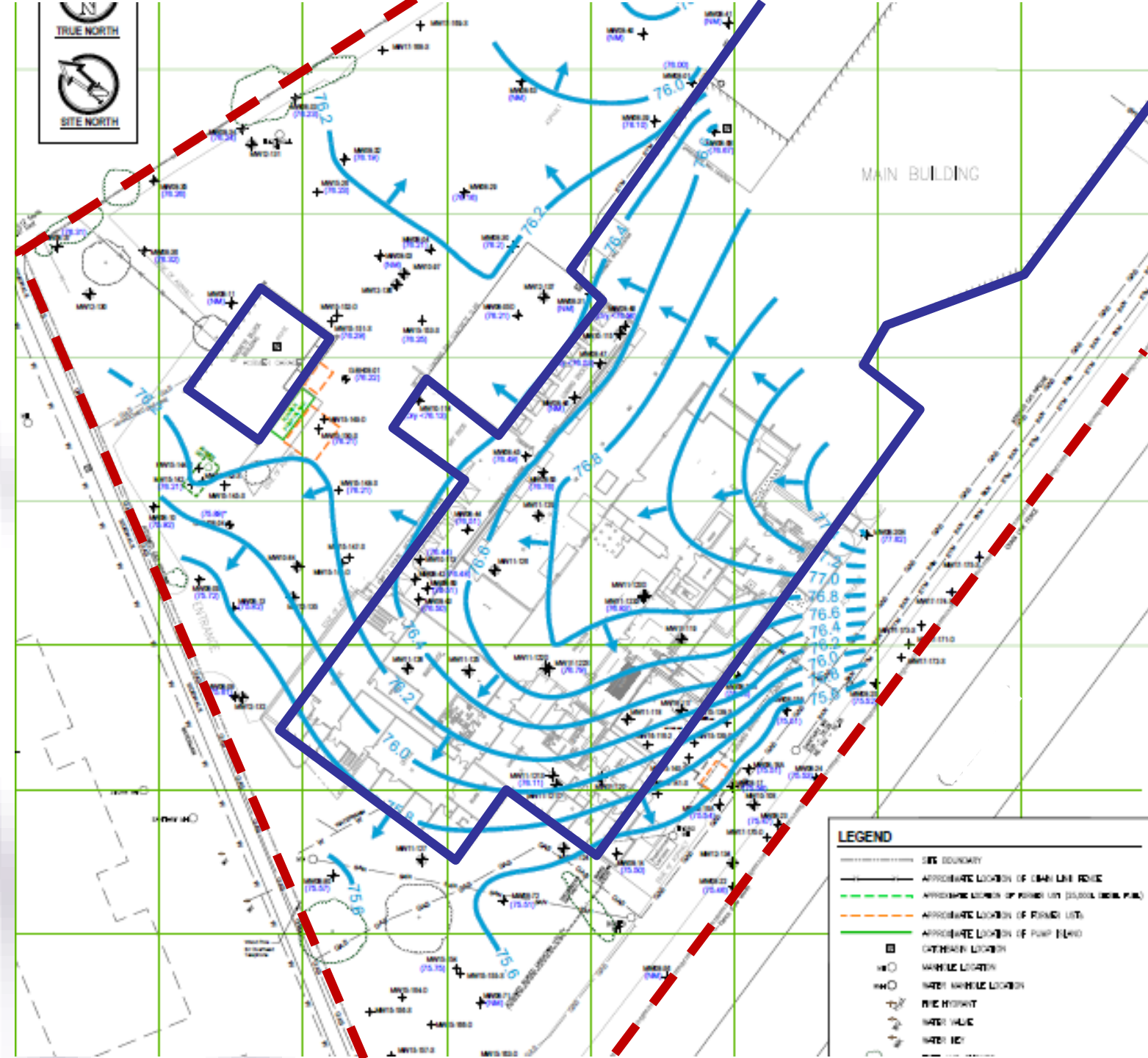




Subsurface



Groundwater Flow



Radial groundwater flow due to leaking pipes

February 2016



Remediation



- Designs
- Bench / Pilot
- Multi-Technology Remediation Approach
- Results

Conceptual
Remediation Plan
May 2012

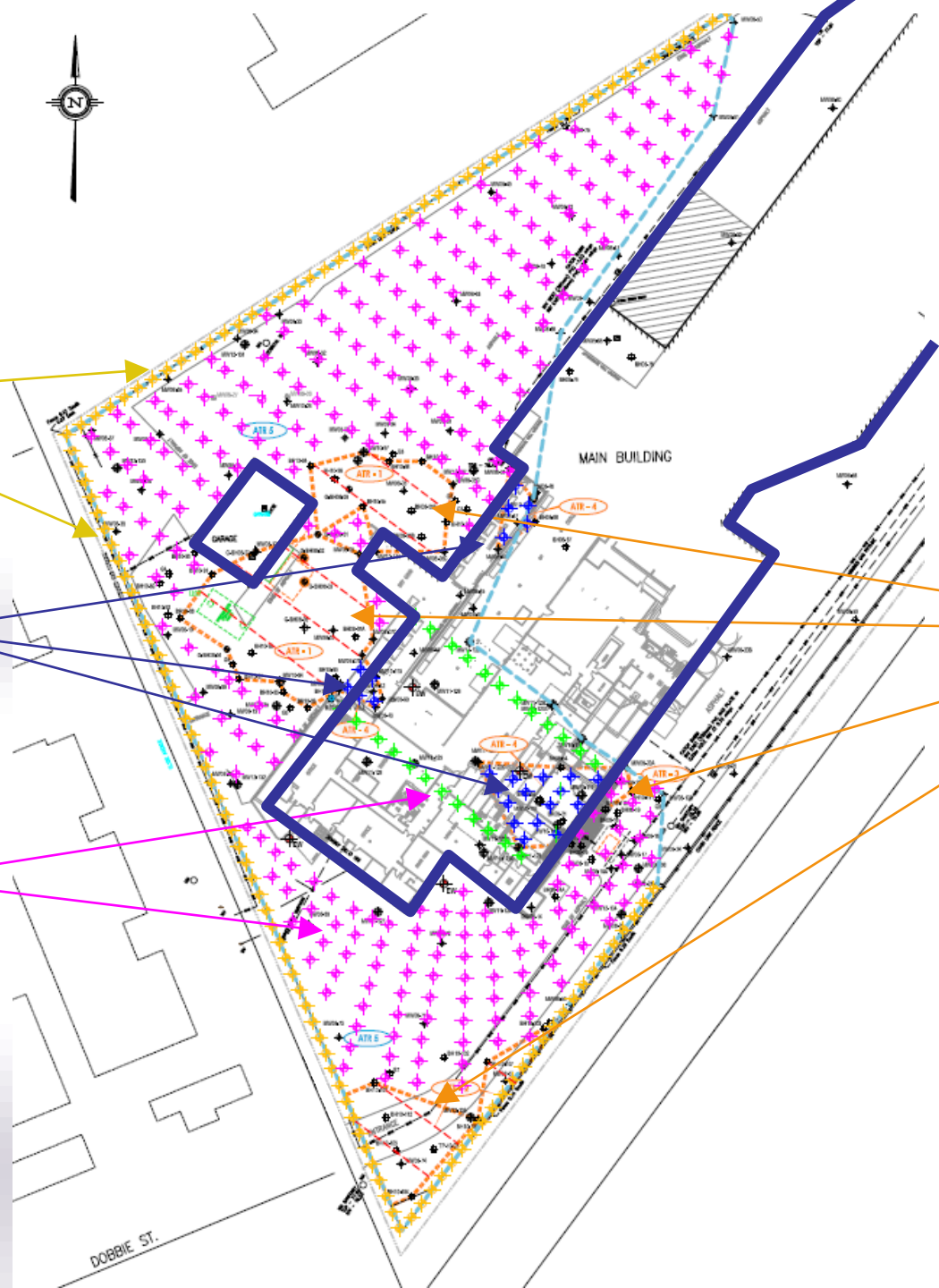
In-Situ for
Groundwater
(wells PRB)
Permeable Reactive
Barrier

In-Situ for
Soil and LNAPL
at Interior Areas

In-Situ for
Groundwater
(vertical wells)

Excavate
Soil and LNAPL
at Exterior Areas

In-Situ for
Groundwater
(horizontal wells)



Remediation – Unknowns

- Ground Truth remedial design assumptions
- Complication: Buyer - no inside work
- Solution: Enhanced-gradient approach
 - Could remedial amendments be ‘pulled’ underneath the building?
- Injection: was it possible? and to what extent?
- Extraction: was it possible? and to what extent?
- Bench and Pilot Work
- Additional GW Sampling around “fringe”



Remediation – Bench Tests

Bioremediation Bench Test

- PHC-impacted soil (50 days):
 - Aerobic trial PHC ↓ 60%
 - Anaerobic trials PHC ↓ 50-60%
- Take Aways (Bio):
 - Aerobic & Anaerobic possible

Natural Oxidant Demand Bench Test

- NOD for persulphate (base activated)
 - 1.8 g/kg Silt overburden
 - 1.2 g/kg Bedrock
- Take Aways (NOD):
 - Low NOD = ISCO could be effective



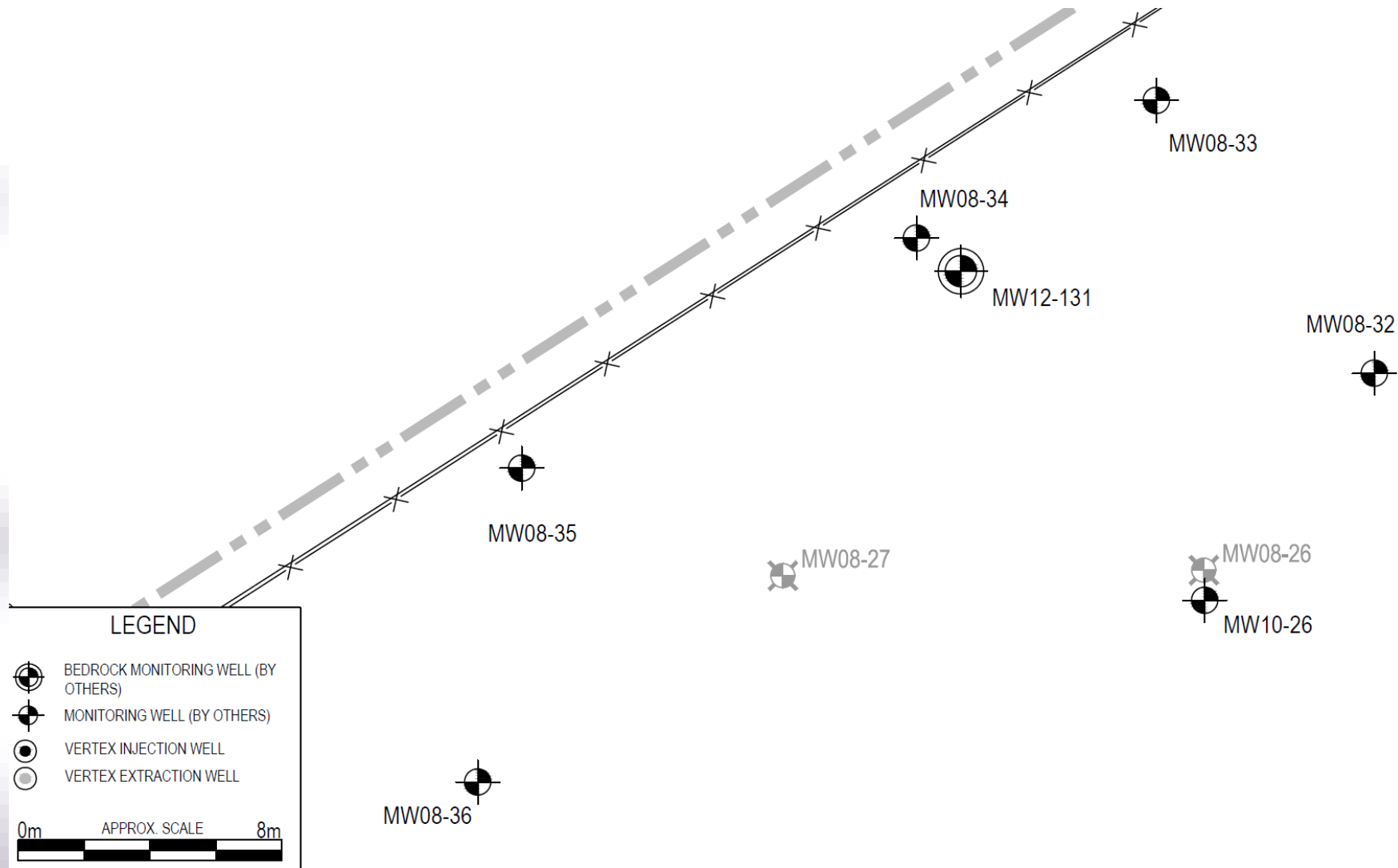
Remediation – Pilot Tests

Injection and Extraction Pilot Tests

- Three pilot test areas
 - Wells: 15 Injection Wells, 2 Extraction Wells
 - Injection: water and oxidant
 - Extraction: 12 hrs extraction, 12 hrs recovery



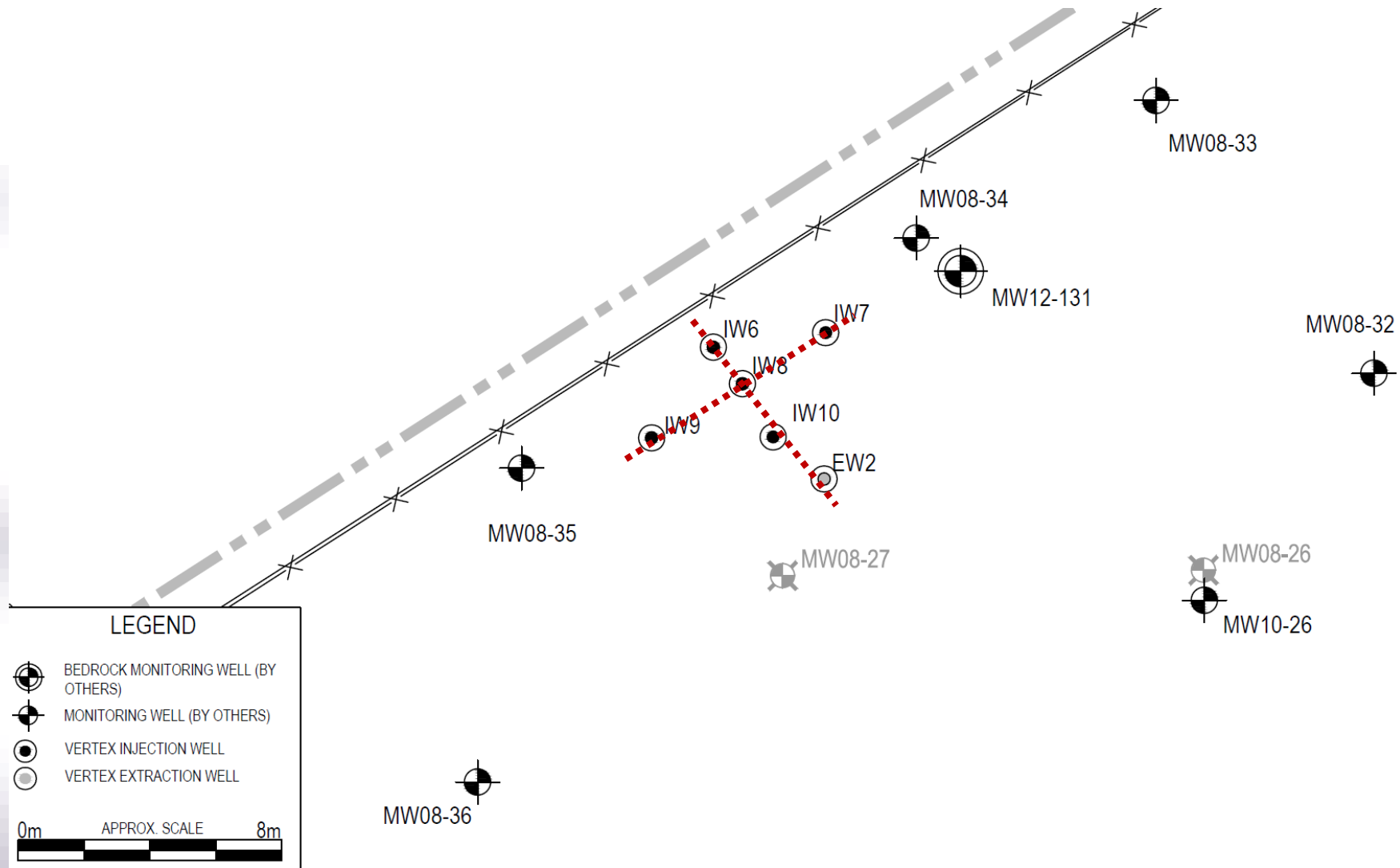
Remediation – Pilot Test Area 2



Pilot-Test Area 2: Injection and Extraction



Remediation – Pilot Test Area 2



Pilot-Test Area 2: Injection and Extraction

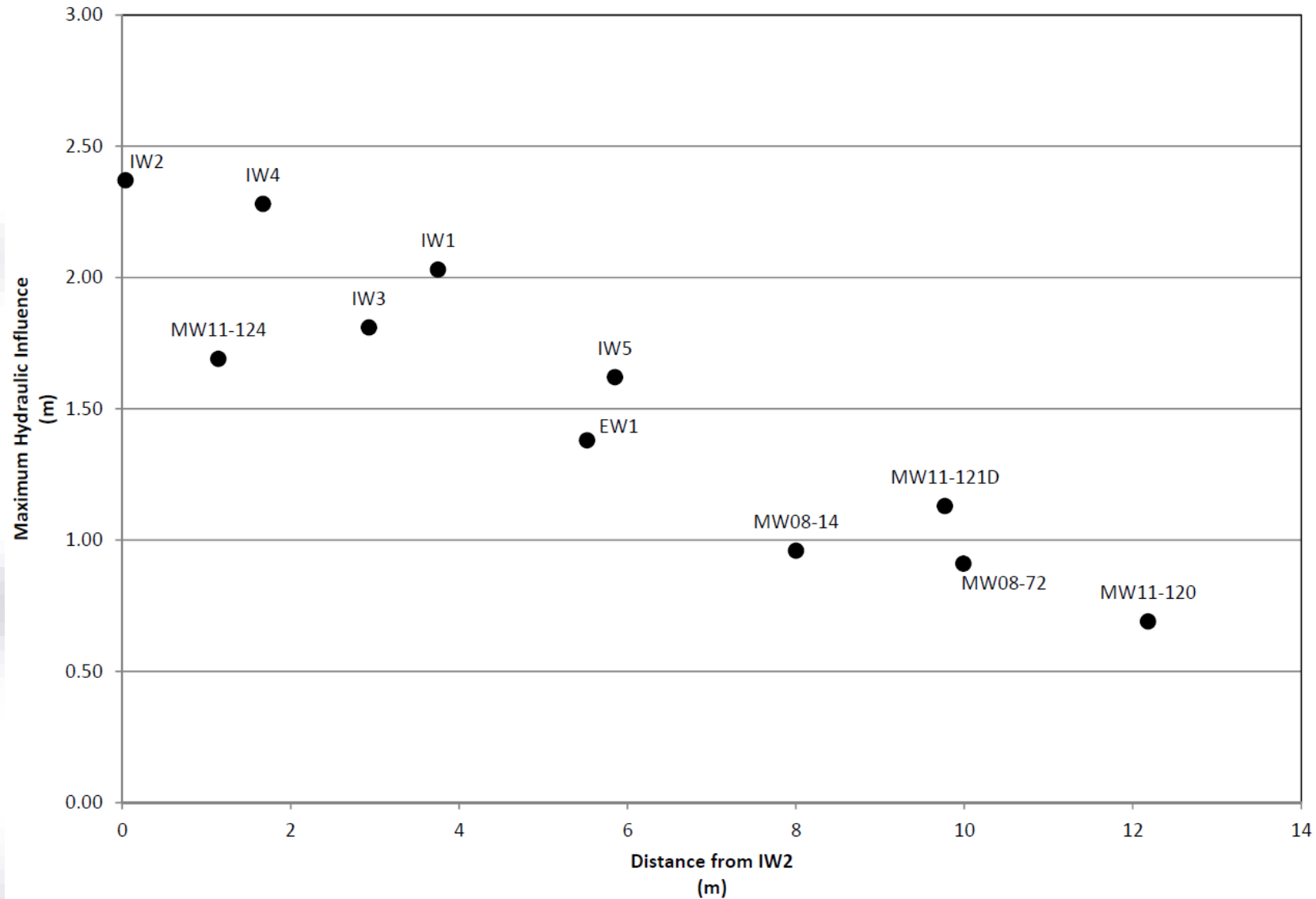


Figure 10 is a scatter plot showing Drawdown (m) versus Distance from EW2 (m). The y-axis ranges from -0.20 to 0.80 m, and the x-axis ranges from 0 to 20 m. The plot includes data points for various wells (EW2, IW6, IW7, IW8, IW9, IW10, MW08-33, MW08-34, MW08-35, MW08-36, MW10-26, MW12-131, MW10-26, MW08-32) and a dashed line representing a theoretical drawdown curve. The data points generally follow the trend of the dashed line, indicating a consistent drawdown behavior across the different wells.

Well	Distance from EW2 (m)	Drawdown (m)
EW2	0	0.63
IW10	2	0.45
IW8	4	0.32
IW7	4.5	0.29
IW9	5.5	0.32
IW6	5.5	0.28
MW08-34	8	0.22
MW08-35	9.5	0.20
MW08-33	15.5	0.18
MW10-26	12.5	0.12
MW08-36	17.5	0.38
MW12-131	18.5	0.78
MW08-32	20.5	0.70



Remediation – Pilot Test

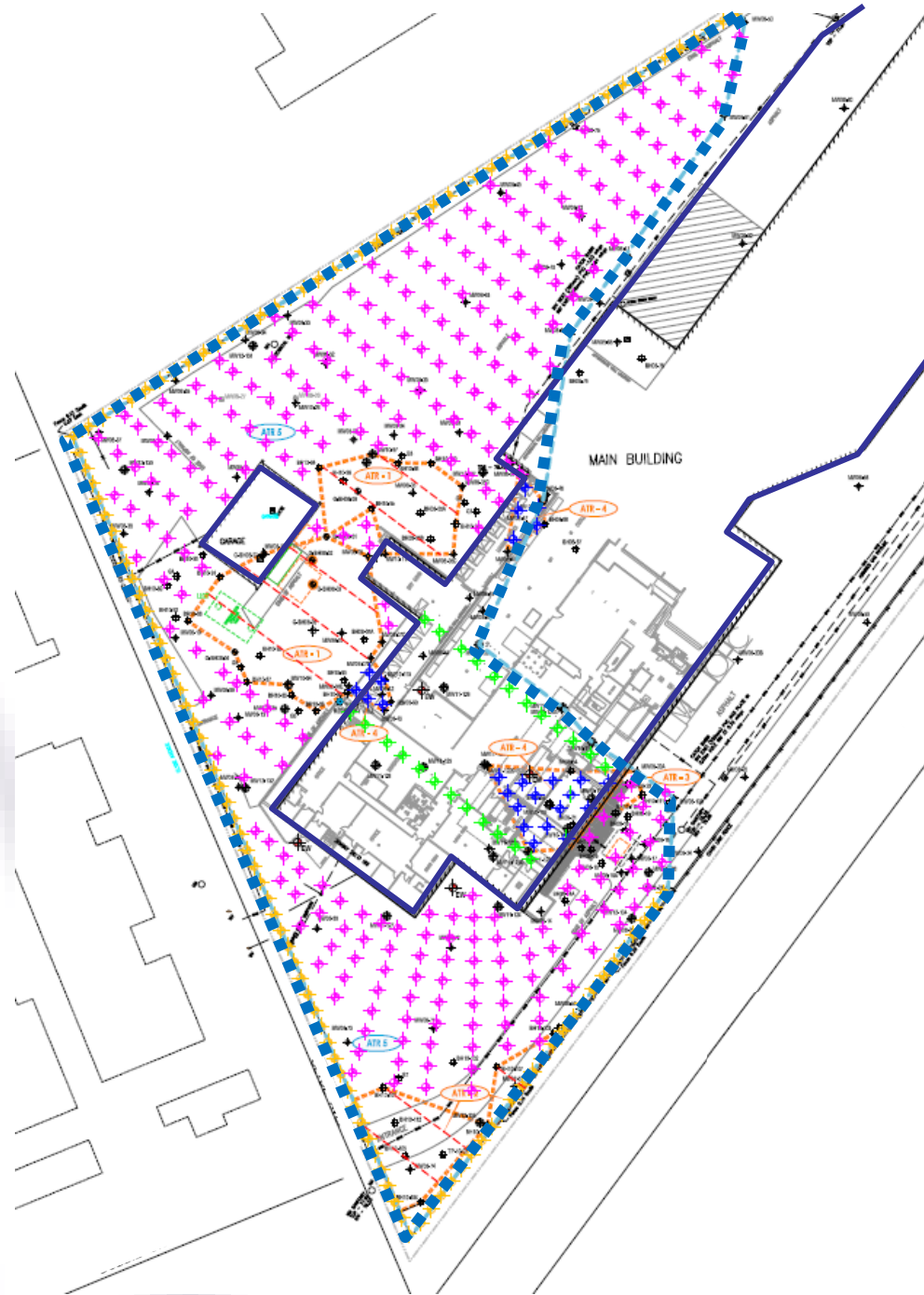


Injection Results: Pilot-Test Area 1



Conceptual
Remediation Plan
May 2012

Before Pilot and
Additional Delineation



Conceptual Remediation Plan 2014

After Pilot and Additional Delineation



Alterations 2012 v 2014:

- < GW area
- Wider IW spacing
- Extraction & enhanced gradient

Remediation – Full-Scale



2015

- Excavation
- Installation of Wells
- Pump and Treat system
- Injection (In-Situ Remediation)
 - ISCO (In-Situ Chemical Oxidation)
 - Surfactant Injection

2016

- Pump and Treat system
- Injection (In-Situ Remediation)
 - ISCO
 - Surfactant Injection

2017

- Injection (In-Situ Remediation)
 - Enhanced Bio Injection

Excavation



Excavation



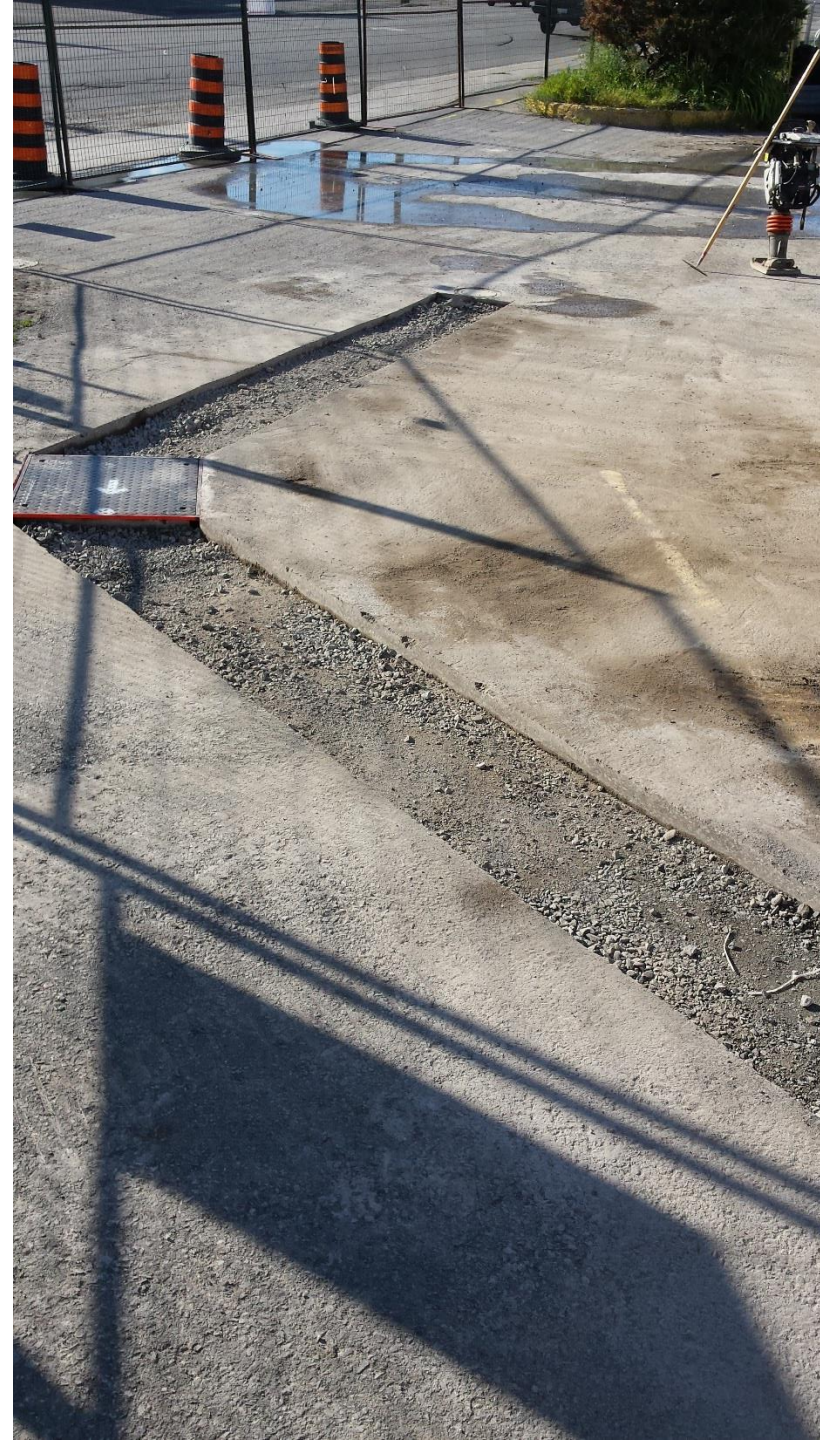
Excavation



Horizontal Injection Wells



Vertical Injection Wells



Pump and Treat System



[GO TO ALARM PAGE](#)



RUN TIME 775:7



RUN TIME 970:32

FLOW METER USG 36915

EW 4 PUMP



OFF / AUTO



EW 4 LEVEL 0

EW 6 PUMP



OFF / AUTO



EW 6 LEVEL 64

EW 3 PUMP



OFF / AUTO



EW 3 LEVEL 138

EW 1 PUMP



OFF / AUTO



EW 1 LEVEL 101

EW 5 PUMP



OFF / AUTO

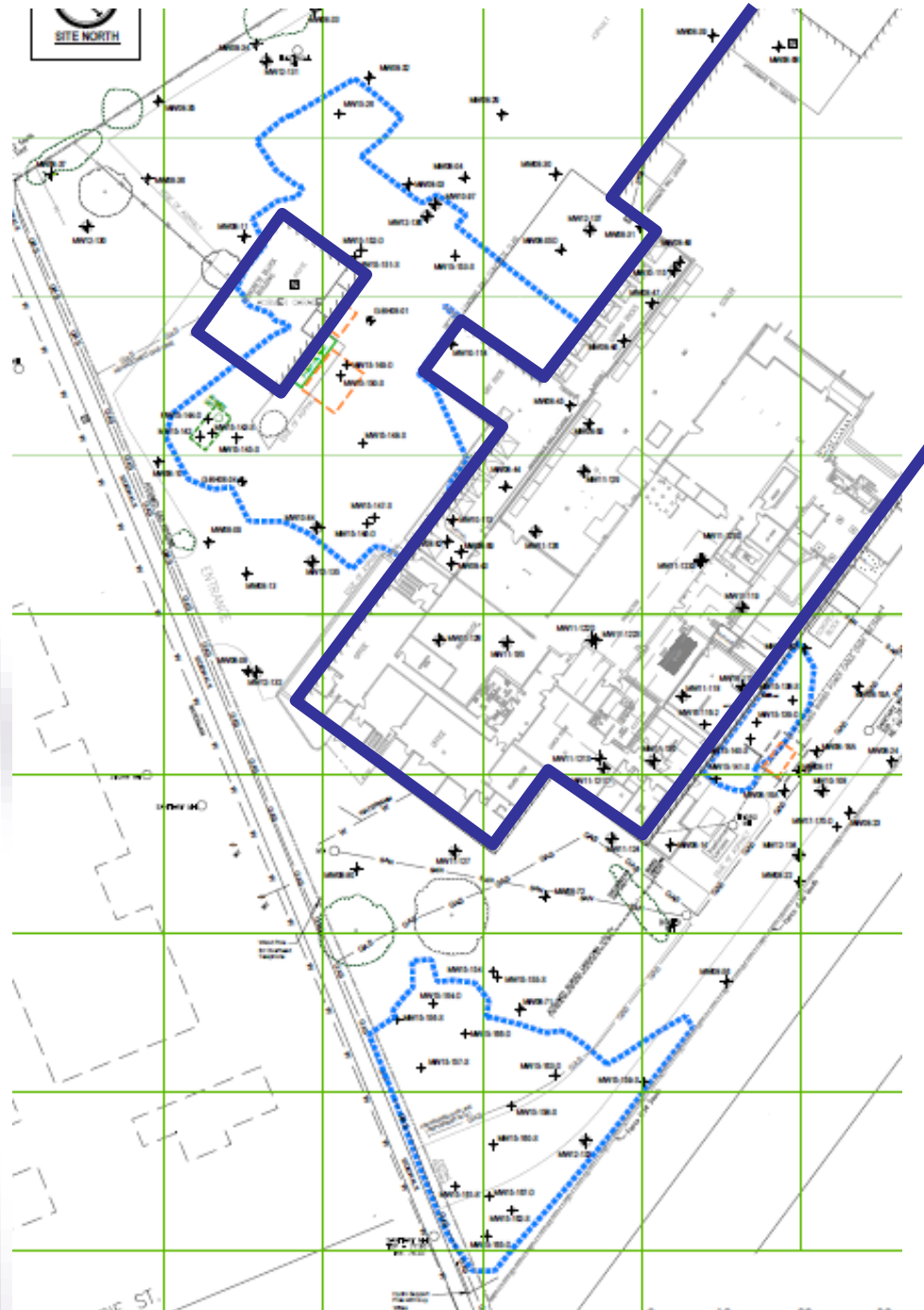


EW 5 LEVEL 138

Remediation Results
2014 Plan



Remediation Results Excavation Areas - 2015



Results:

- All accessible PHCs removed
- Tore into Bedrock at 2 locations
- 5,500 MT soil: off-site
- 70 MT bedrock: off-site

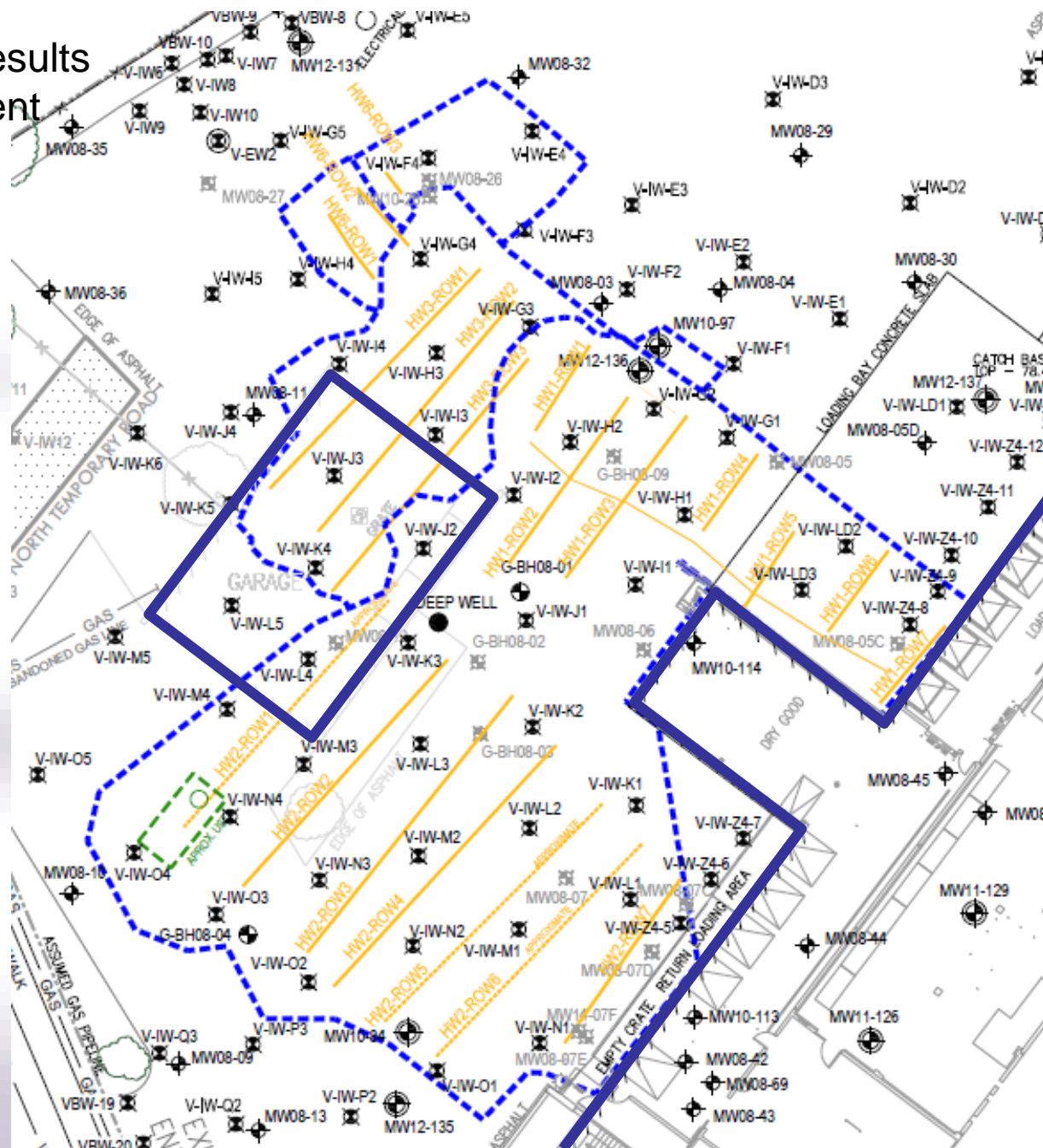


Remediation Results
Excavation Analytical

Parameter	Groundwater Concentration	Soil Concentration
Before Excavation		
PHCs – Soil Aquifer	LNAPL	15,000 mg/kg
PHCs - Bedrock	LNAPL	-
After Excavation		
PHCs – Soil Aquifer	1,000 – 10,000 ug/L	<25 mg/kg
PHCs - Bedrock	LNAPL	-



Horizontal Injection Wells



Remediation Results
In-Situ Remediation

Item	Amount
Infrastructure	
Injection Wells – vertical	111
Injection Wells – horizontal	35
Extraction Wells – active	5

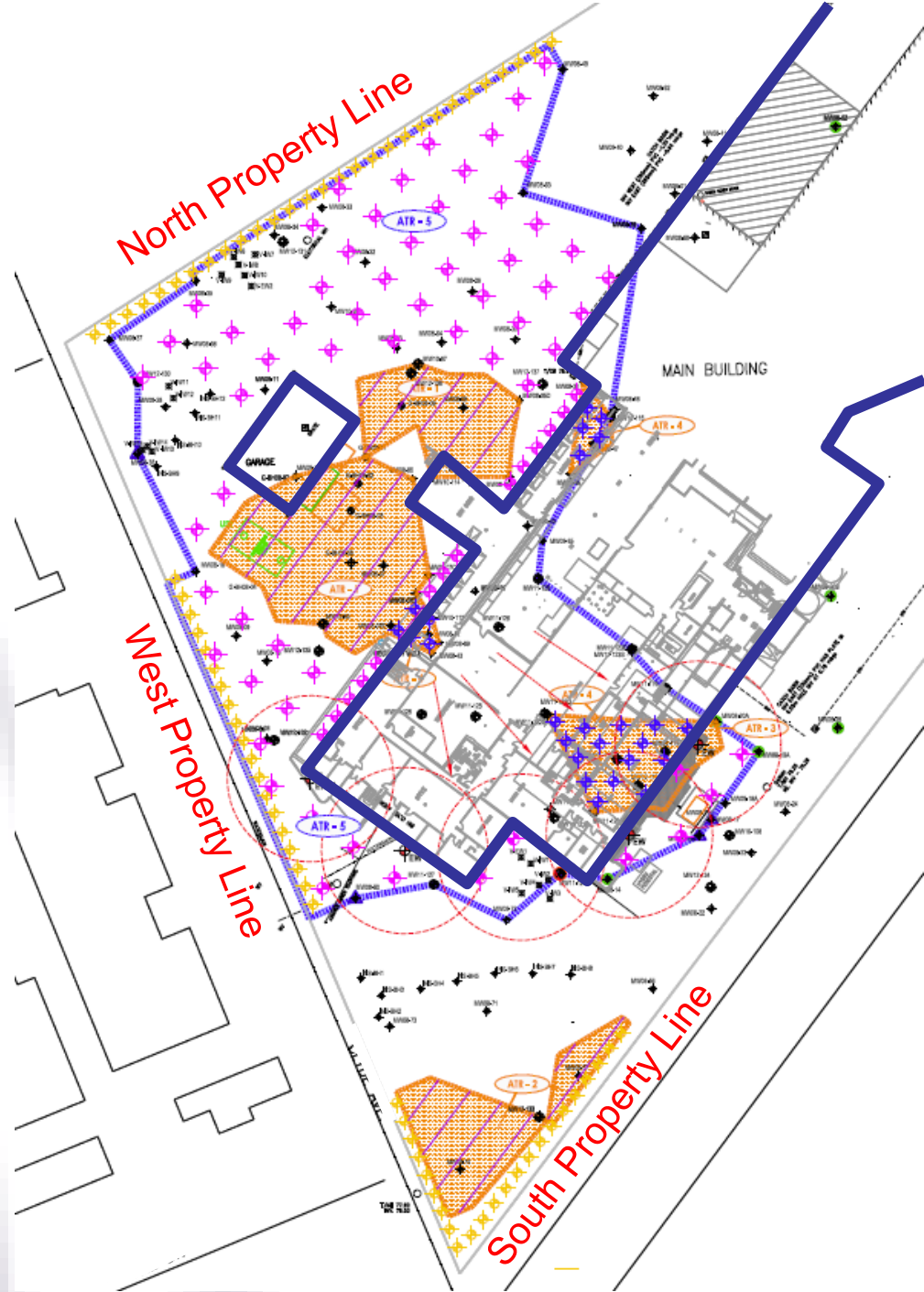


Remediation Results
In-Situ Remediation

Item	Amount
Infrastructure	
Injection Wells – vertical	111
Injection Wells – horizontal	35
Extraction Wells – active	5
Injections	
ISCO Injections	2
Persulphate	84,500 L
Peroxide	35,000 L
Surfactant Injections	4
Volume	18,000 L

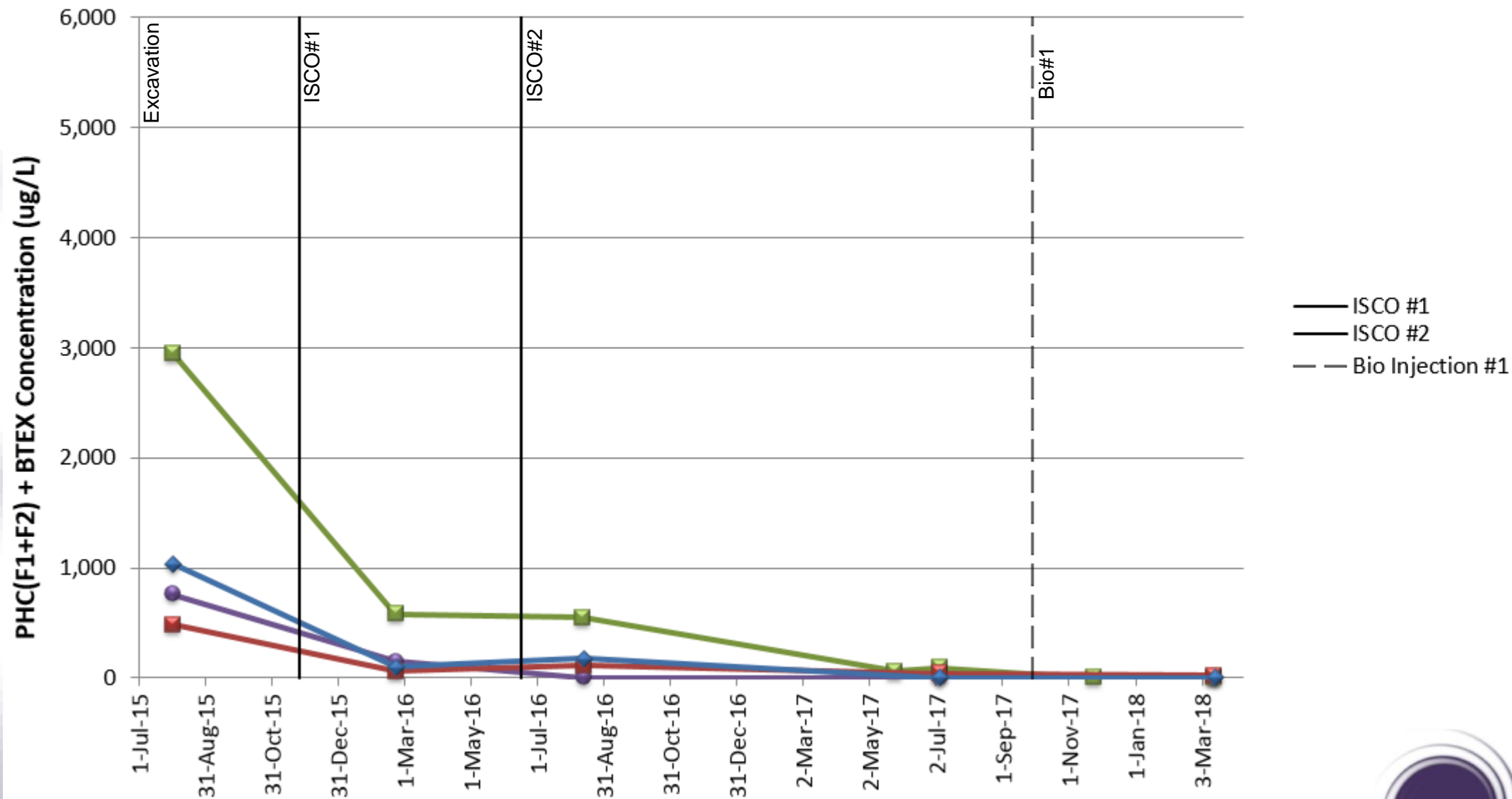


Remediation Results
GW Analytical



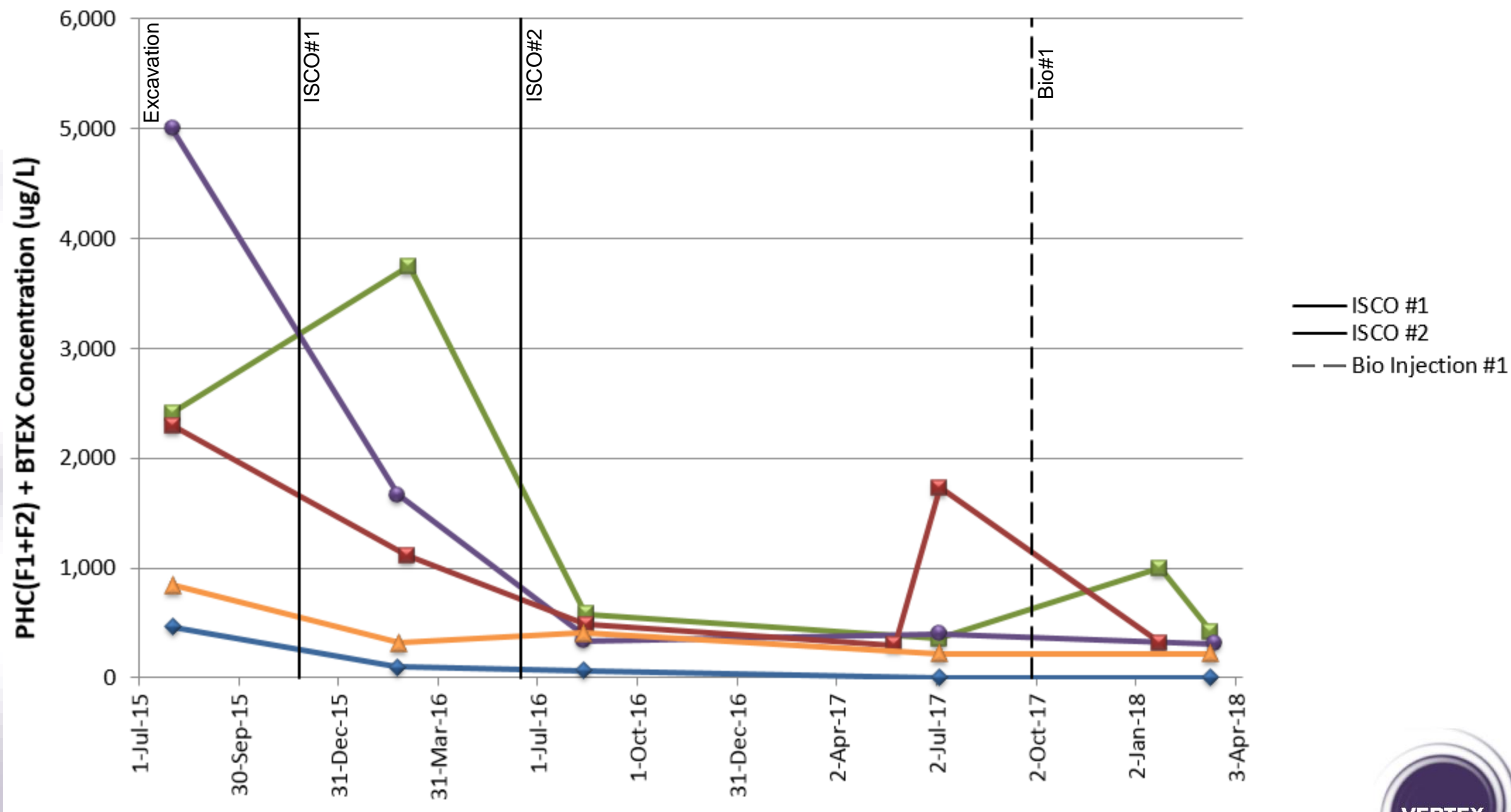
Remediation Results
GW Analytical

Groundwater Concentration - North Property Line



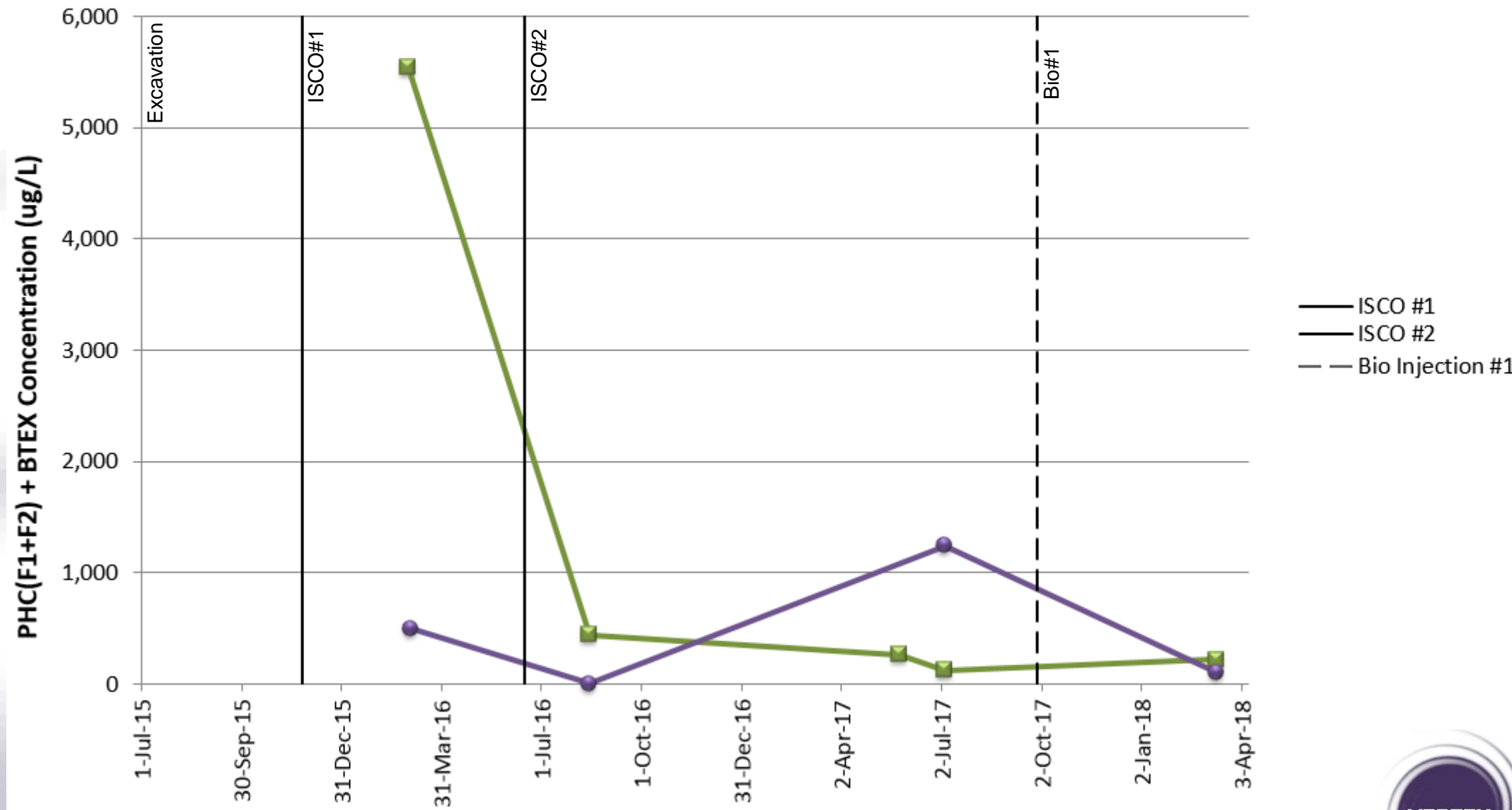
Remediation Results
GW Analytical

Groundwater Concentration - West Property Line

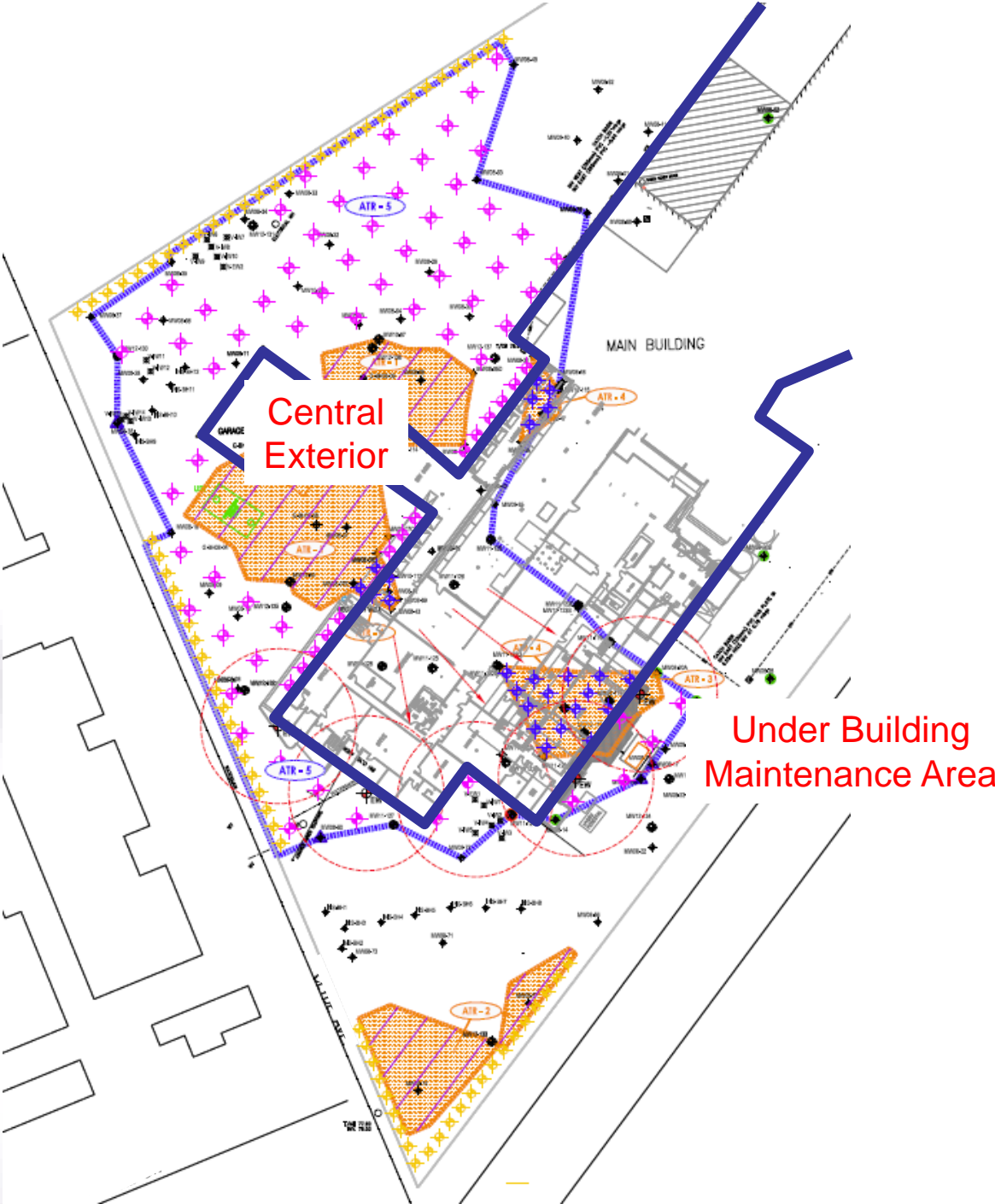


Remediation Results
GW Analytical

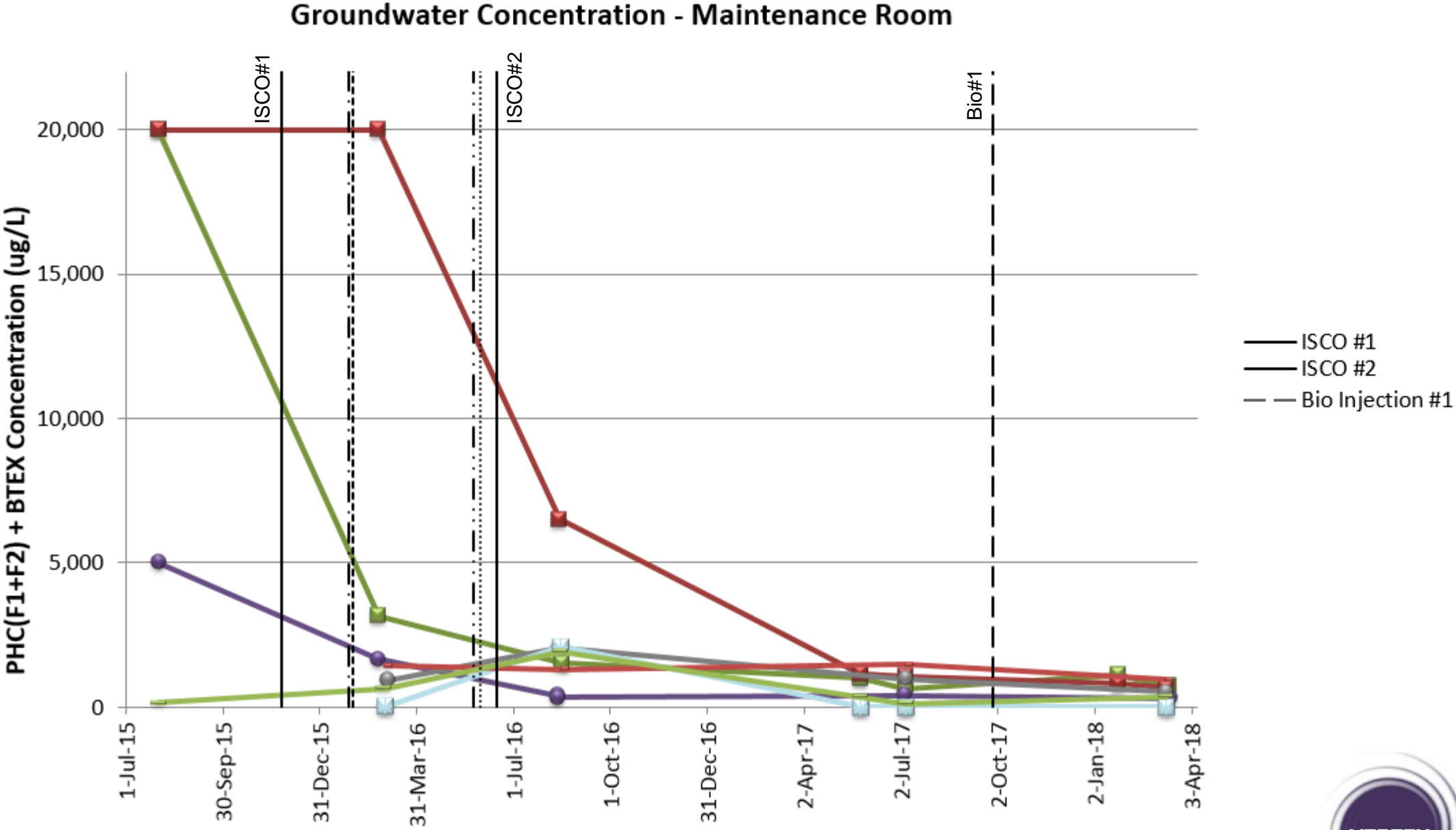
Groundwater Concentration - South Property Line



Remediation Results
GW Analytical

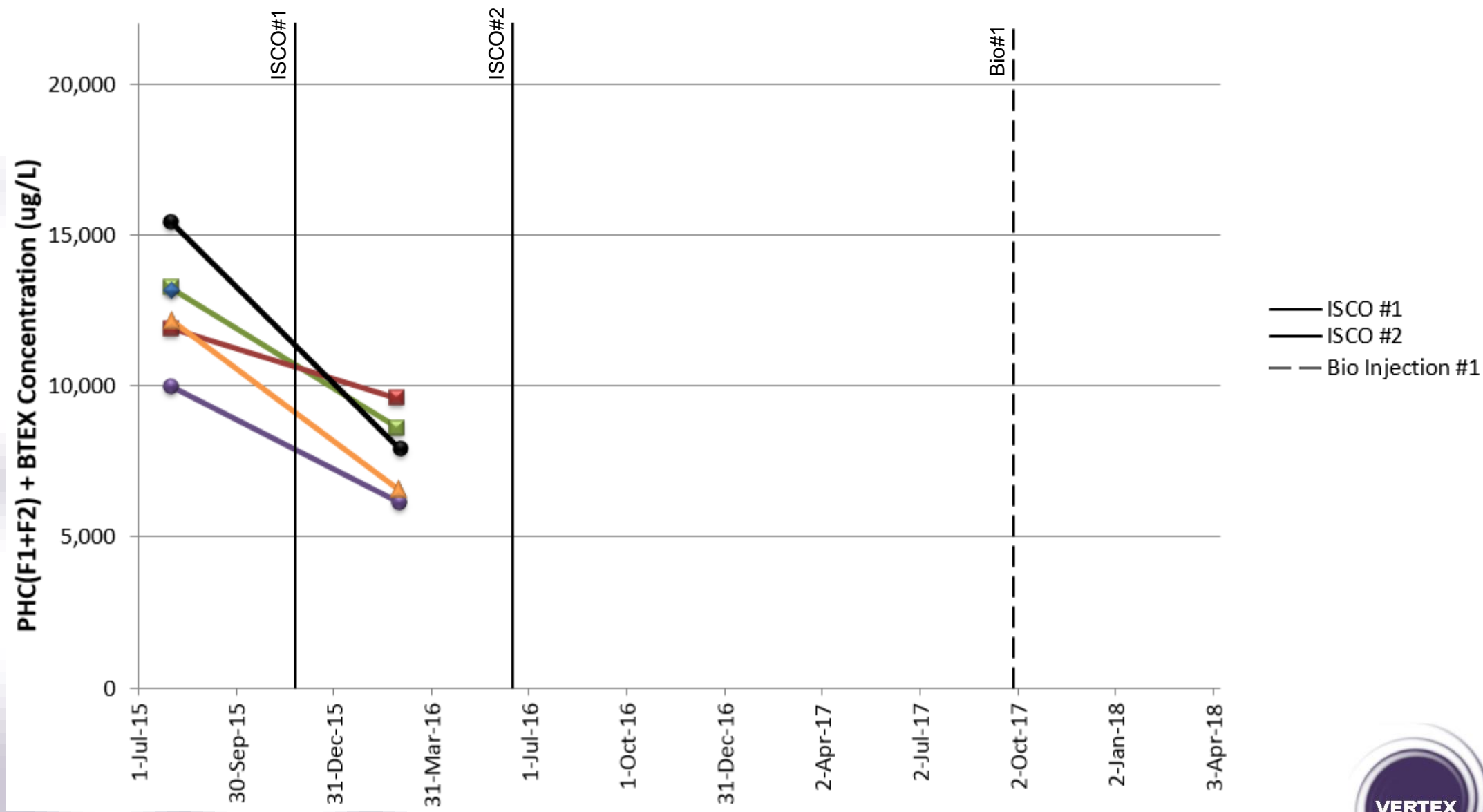


Remediation Results
GW Analytical

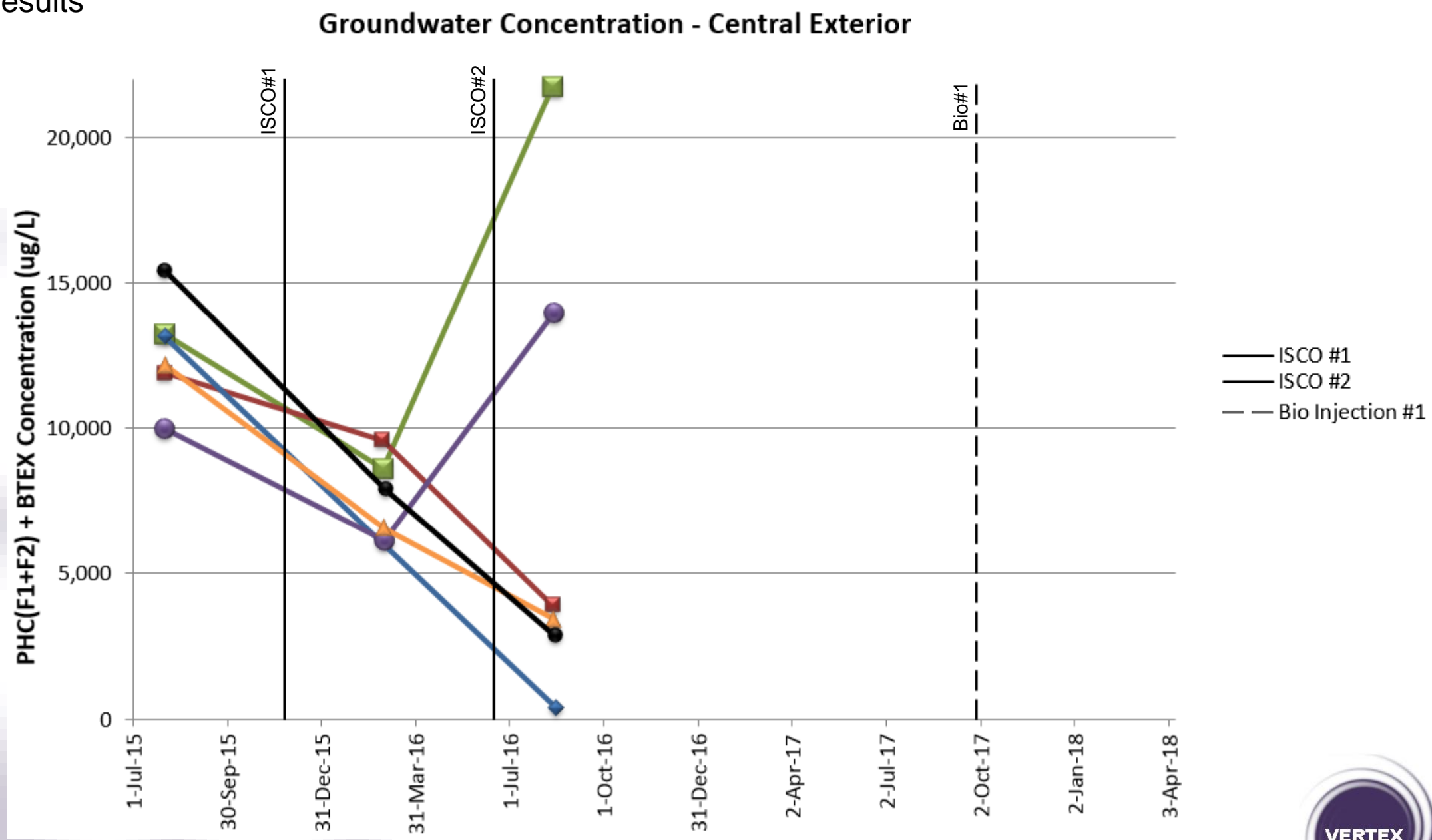


Remediation Results
GW Analytical

Groundwater Concentration - Central Exterior

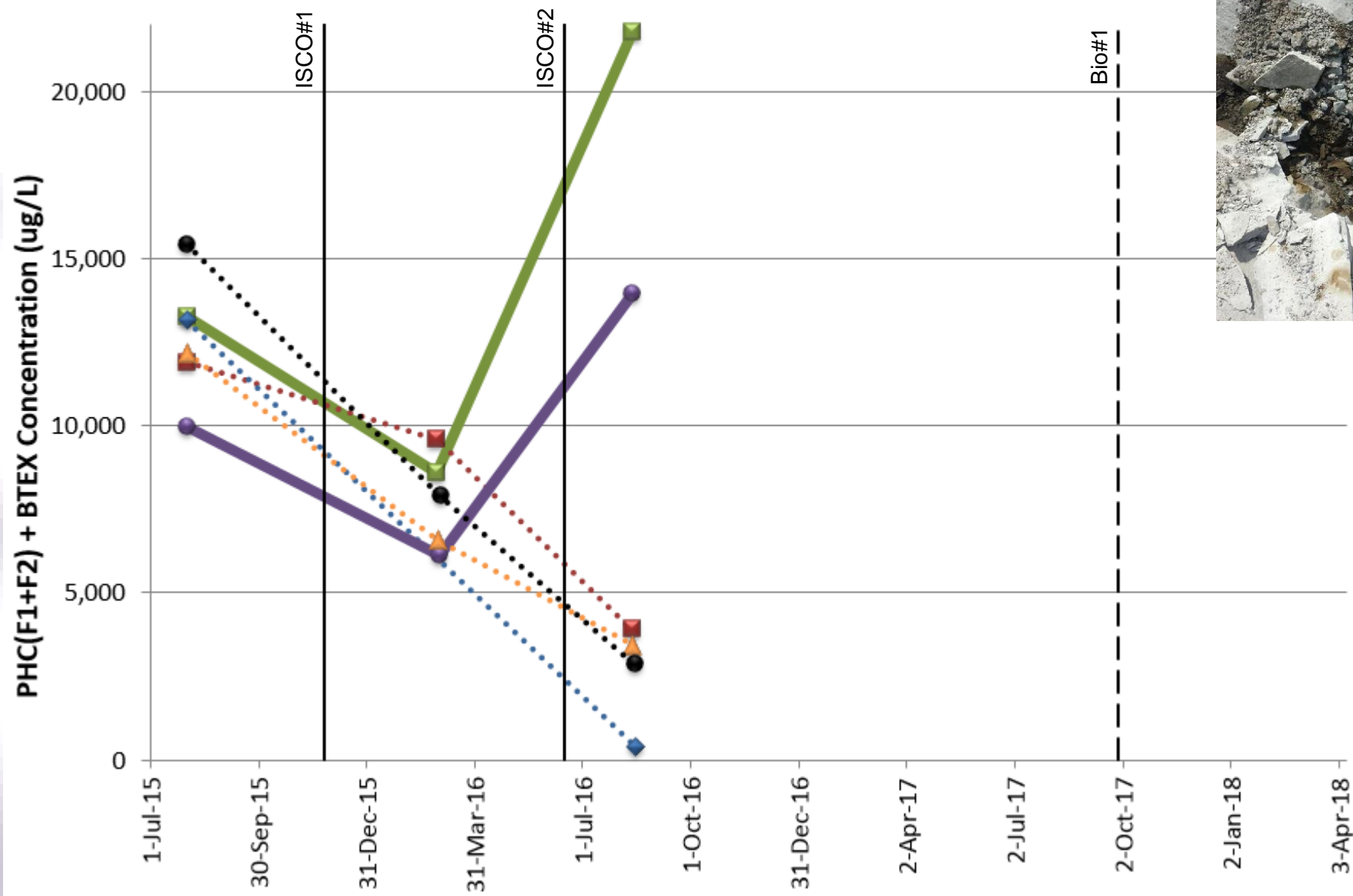


Remediation Results
GW Analytical



Remediation Results
GW Analytical

Groundwater Concentration - Central Exterior



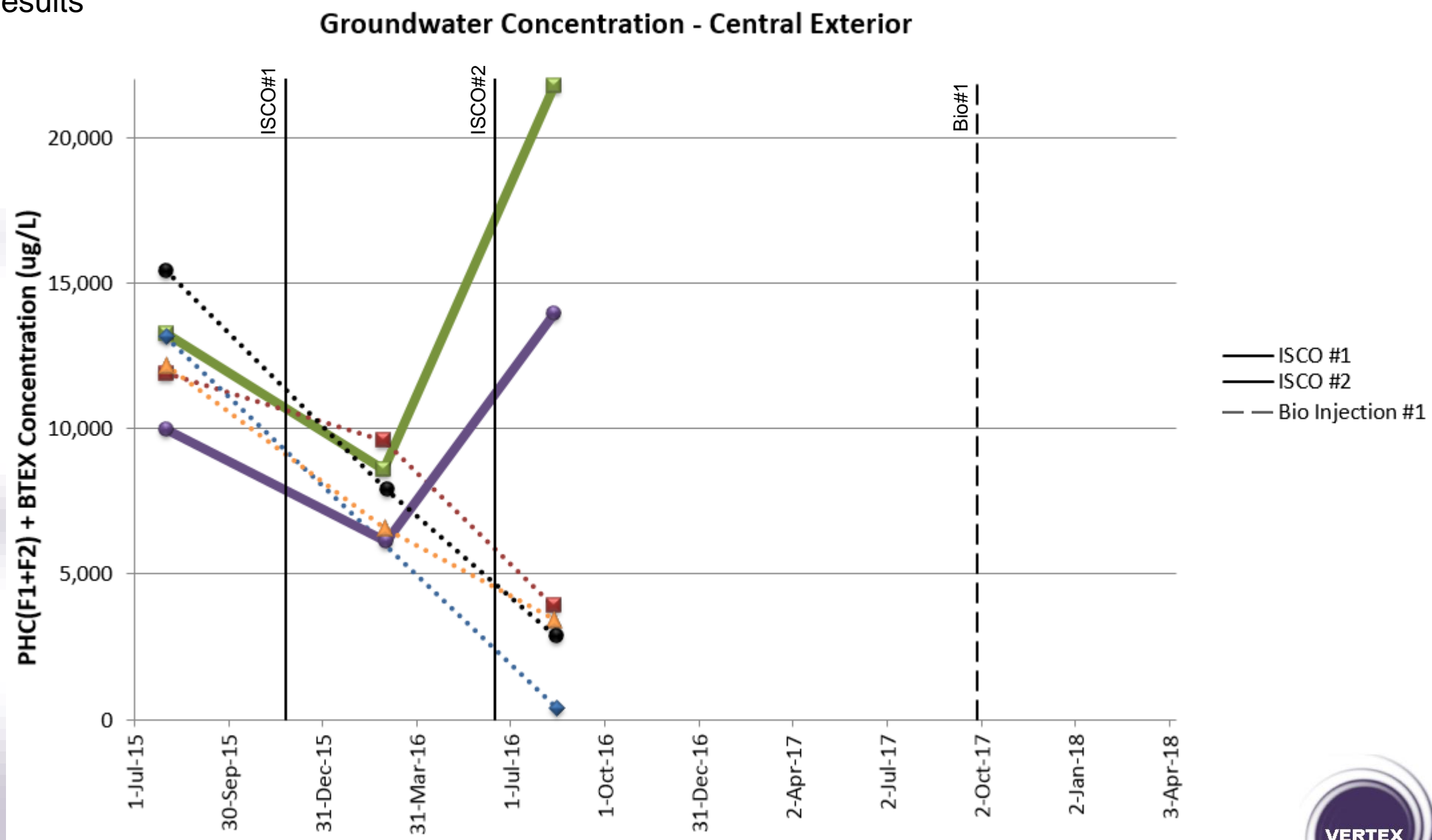
— ISCO #1
— ISCO #2
- - Bio Injection #1



The site plan illustrates the layout of the 10000th Avenue Station. Key features include:

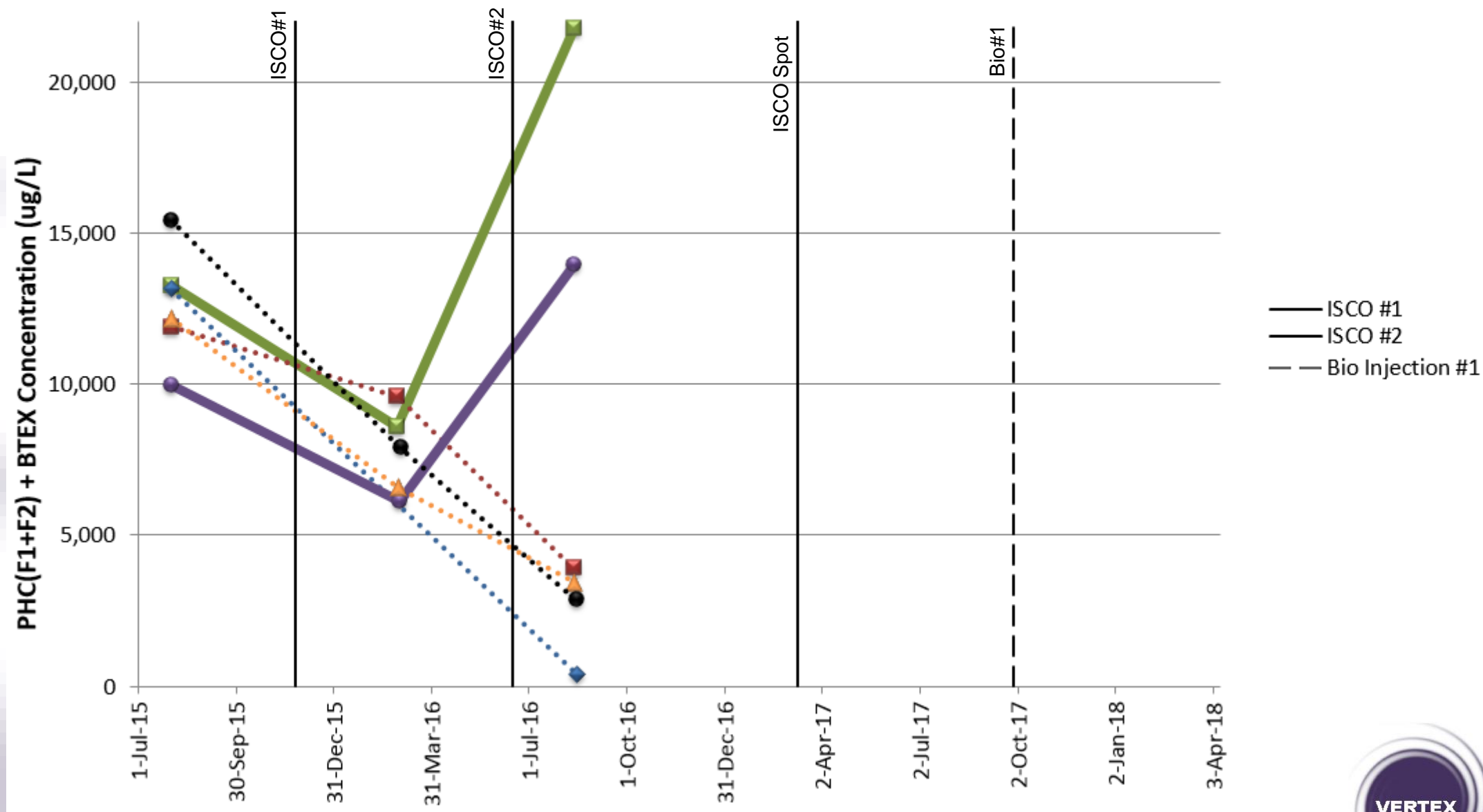
- Monitoring Wells (MW):** Numerous wells are marked with black dots and labels, including MW08-01 through MW12-135. Two wells, MW08-32 and MW08-04, are highlighted with red circles.
- Ventilation Wells (V-IW):** A large number of ventilation wells are shown, labeled V-IW-01 through V-IW-50.
- Infrastructure:** The plan shows roads (e.g., NORTH TEMPORARY ROAD, EDGE OF ASPHALT), a GARAGE, a DEEP WELL, and various utility lines (GAS, ELECTRIC).
- Other Features:** Labels include "DRY GOOD", "RETURN LOADING AREA", and "EMPTY CRATE".

Remediation Results
GW Analytical



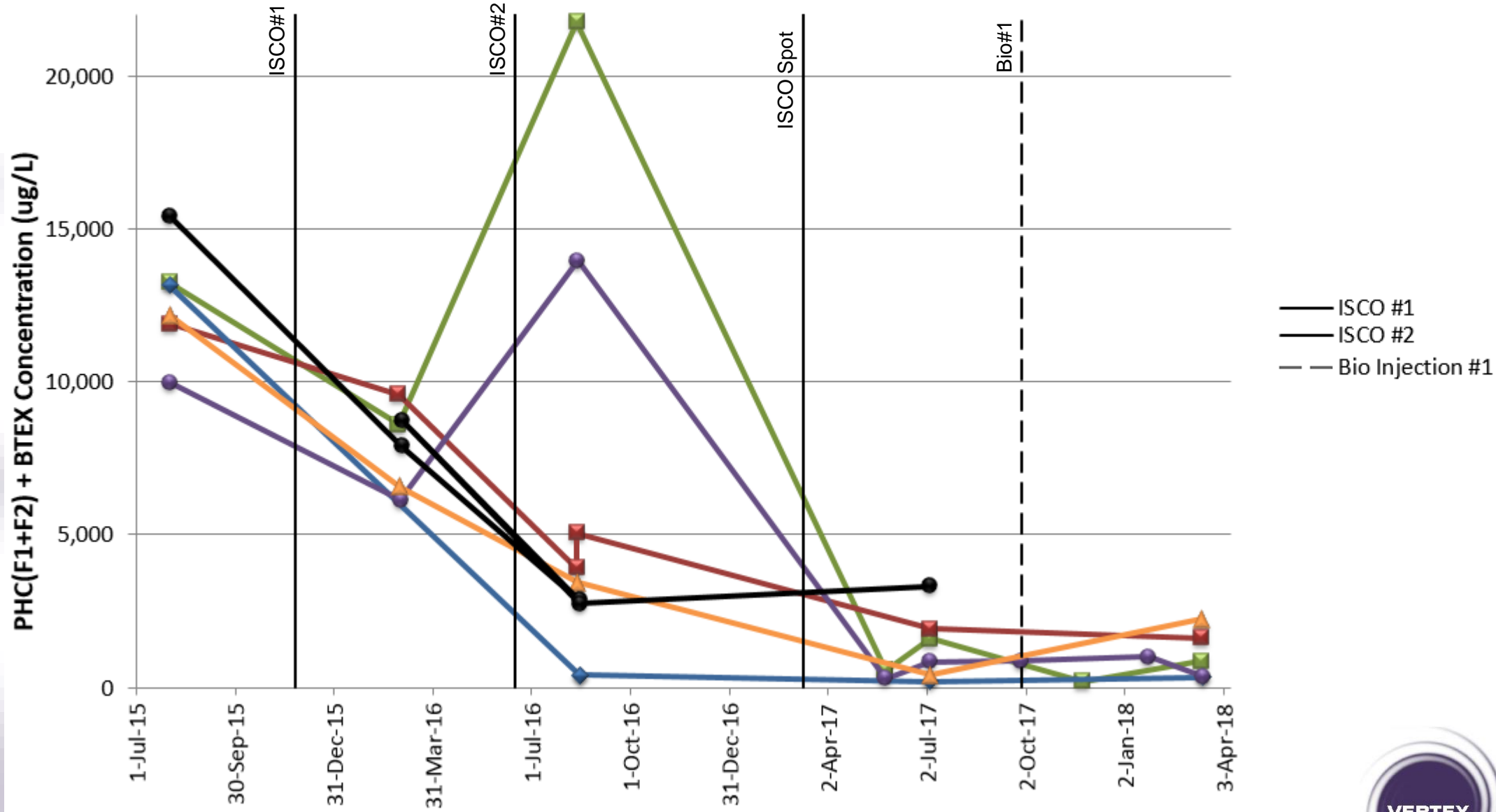
Remediation Results
GW Analytical

Groundwater Concentration - Central Exterior



Remediation Results
GW Analytical

Groundwater Concentration - Central Exterior



Take Aways / Lessons Learned

- Focus on LNAPL
 - During excavation, all soil removed & some bedrock removed = effective
 - Not noting all LNAPL zones lead to later confusion (and delay in treatment)
- Contract / Upfront Plan
 - Negotiate good contract: allow for flexibility in remedial approach
 - Plan for eventualities so Project Team is accepting of those options later on
 - Helpful to define terms upfront if possible (e.g. technically impracticable)
- Groundwater Remediation
 - Have many delivery locations for remediation amendments (111 IWs, 35 HWs – was good)
 - Have the ability to control delivery (e.g. separate lines to each IW & HW)
 - Find & fix leaking water or sewer pipes ASAP
- If Time, allow it
 - Bioremediation has the ability to deal with contaminant Back Diffusion
- Consider Anaerobic Bio of PHCs



Closing

Conclusions

- Remediation approach resulted in happy Seller and Buyer
- Aggressive excavation and surfactant flushes removed LNAPL
- Aggressive ISCO lowered groundwater concentrations
- Passive biological polishes groundwater over time
- Multi-technology approach was logical and worked for Seller and Buyer





Questions?

Thank You for Your Time

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