

Application of ERH and SEE to Address Complex Geology and High Groundwater Flux Zones to Treat a PCE DNAP Source Zone

John LaChance, TerraTherm, Inc.

One Partner. Many Solutions.



www.cascade-env.com



www.terratherm.com

Hamilton/Labree Roads Superfund Site In Situ Thermal Remediation (ISTR) Project

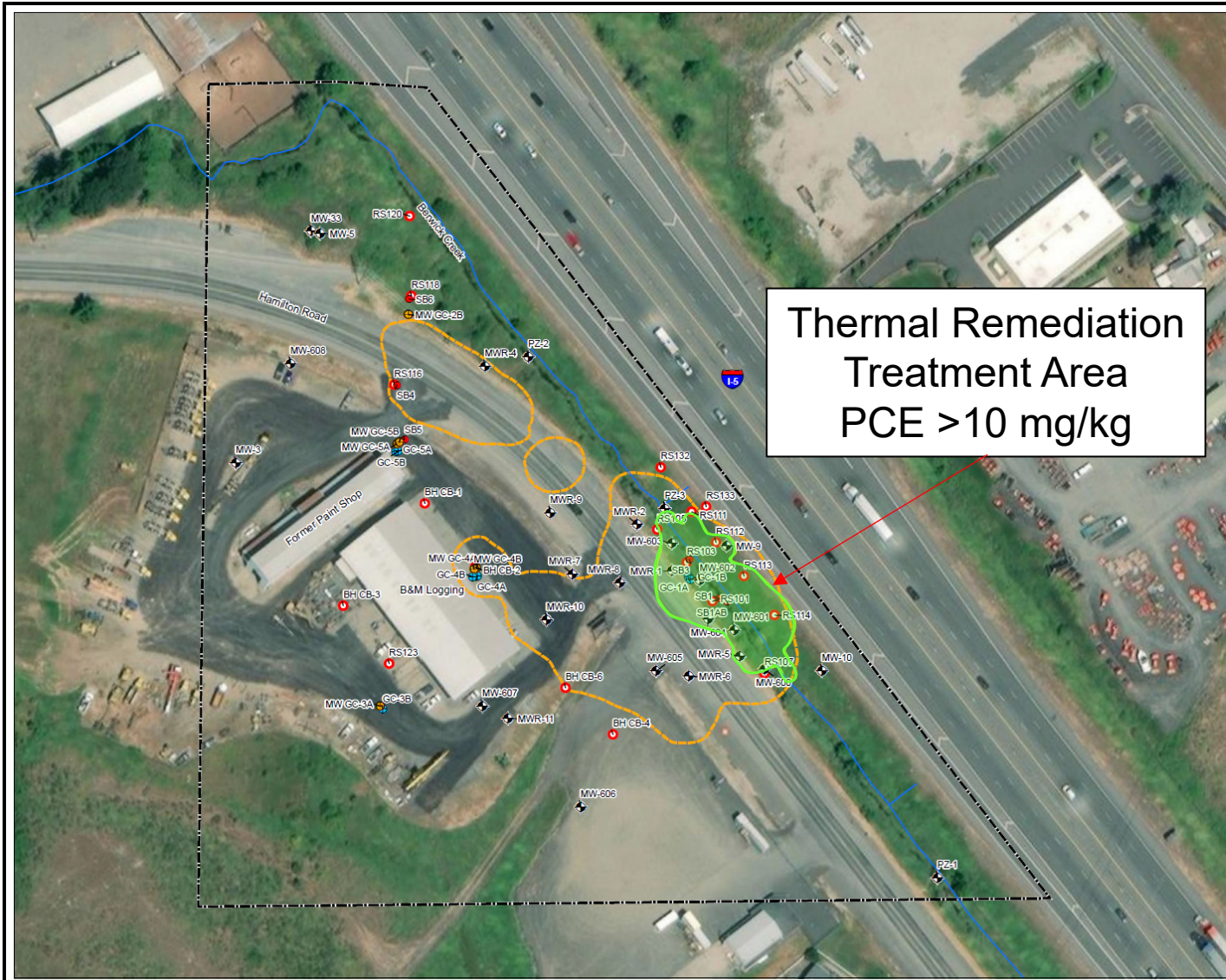
Outline

- Background
- Geology/Hydrogeology
- ISTR Heating Approach
- ISTR Wellfield Design
- Heating and Operations
- Remediation Results

Acknowledgements

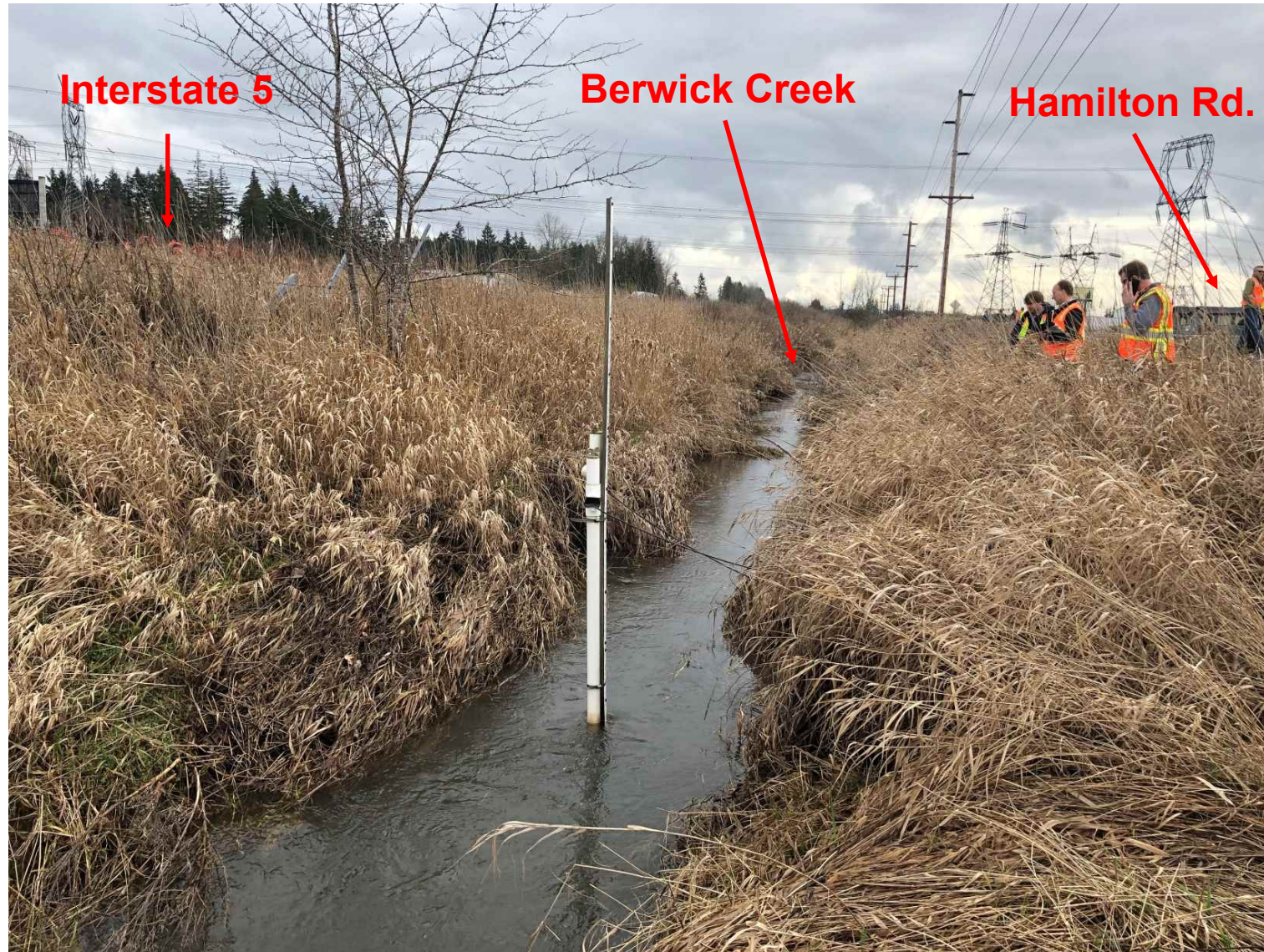
- USACE Seattle District
- EPA Region 10
- Washington Department of Ecology
- CDM
- URS/AECOM

Site Location and Background



- PCE spill adjacent to highways
- DNAPL source zone beneath creek
- 1,800 lbs of PCE estimated to be present
- Use In Situ Thermal Remediation (ISTR) to remediate PCE source zone
 - Goal: <10 mg/kg of PCE
- ERD used on downgradient plume post ISTR
 - Thermal enhancements from ISTR treatment zone

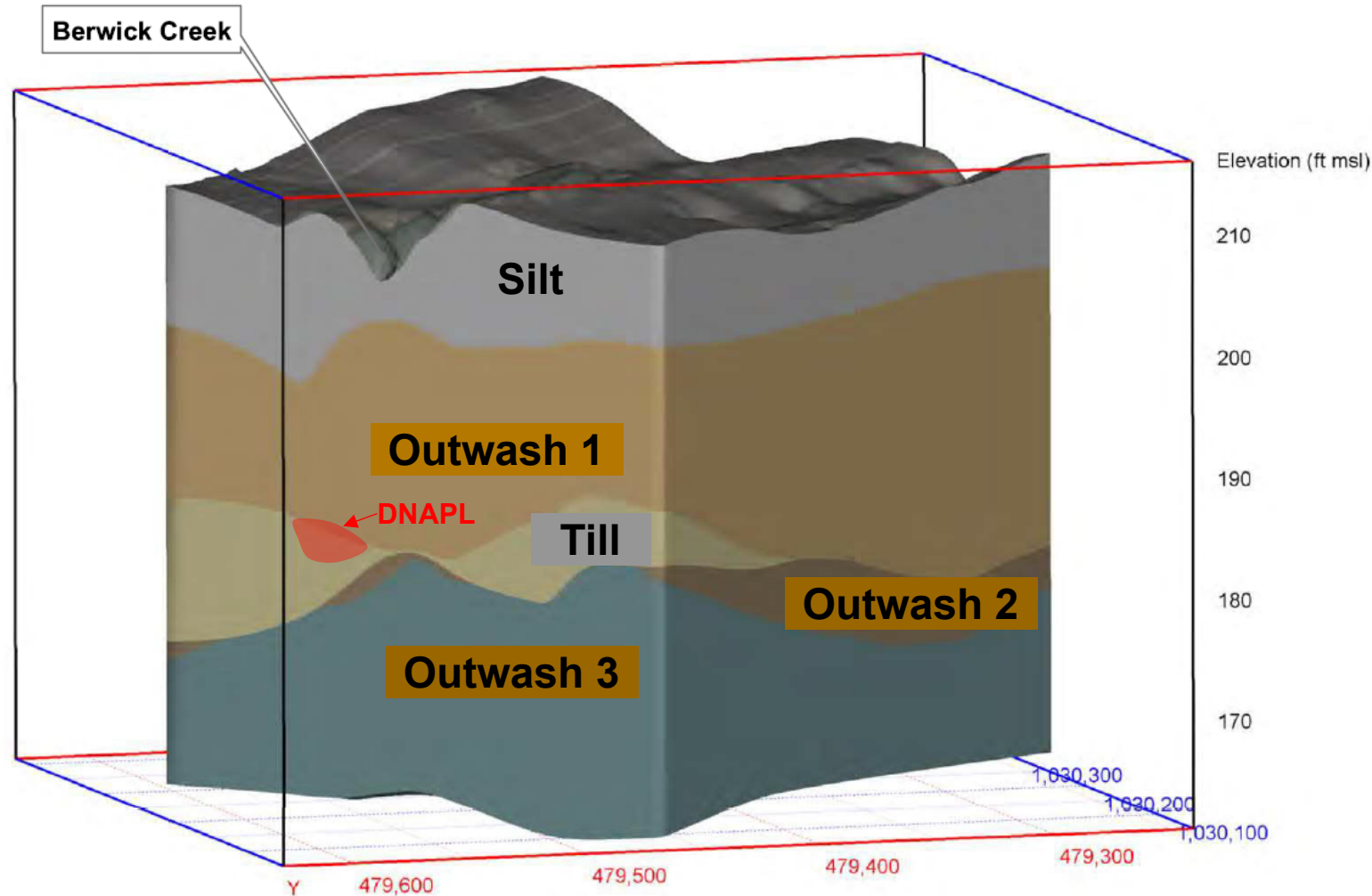
Stream Problem Through the Treatment Zone?!!



Thermal Remedy
Must Protect
Stream From:

- CVOC flux
- Temperature

Site Geology and Hydrogeology



**Hydraulic Conductivity
of Outwash:**

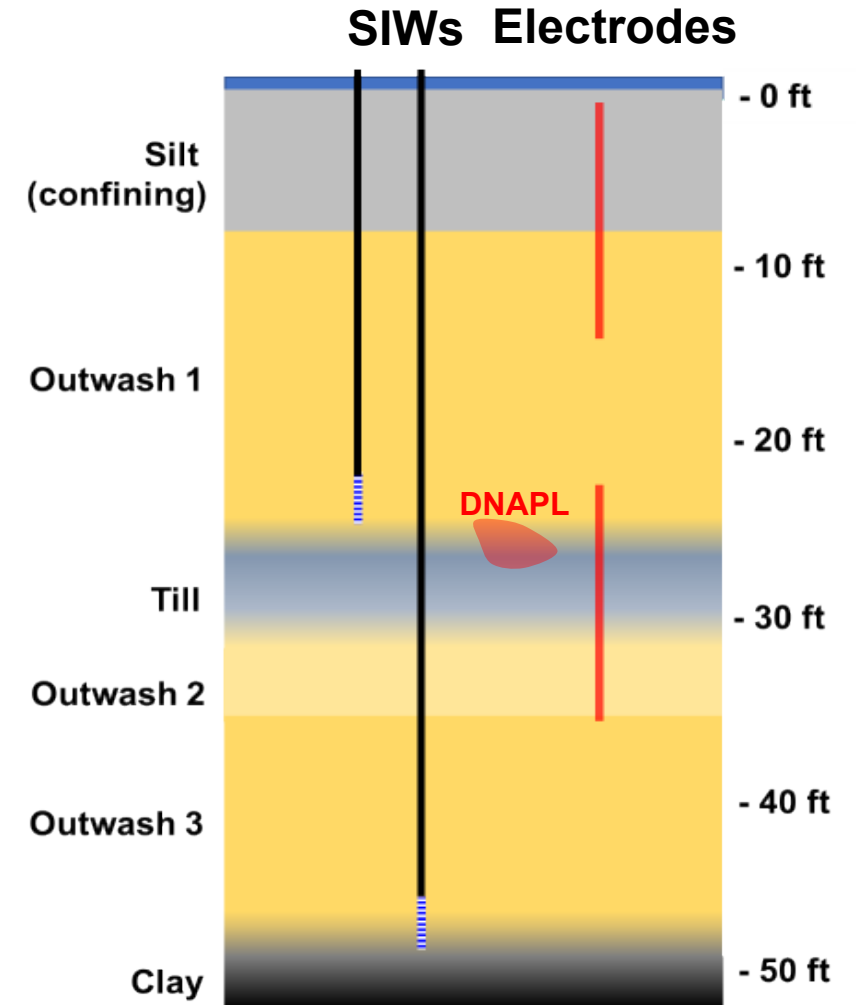
5 to 140 ft/day

**Groundwater Velocity of
Outwash:**

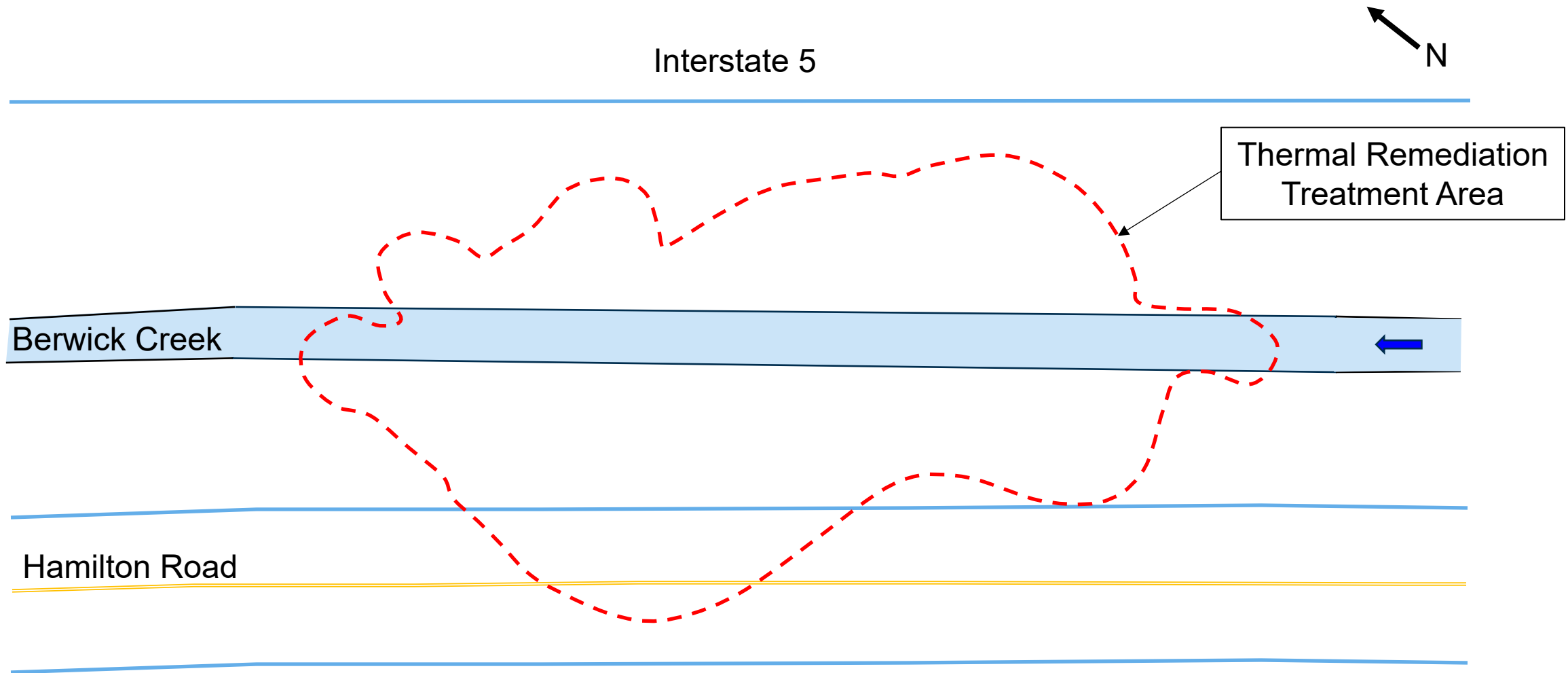
20 to 110 ft/year

Heating Approach

- Stacked electrodes targeting:
 - Silt cap
 - Till (high PCE concentrations / DNAPL)
 - 82 electrodes in 49 locations
- SEE targeting:
 - Upper outwash sand
 - Lower outwash sands
 - 49 SIWs in 40 locations
- Thermally enhanced ERD of downgradient groundwater plume was focused on lower outwash sands



Targeted Treatment Zone (TTZ)



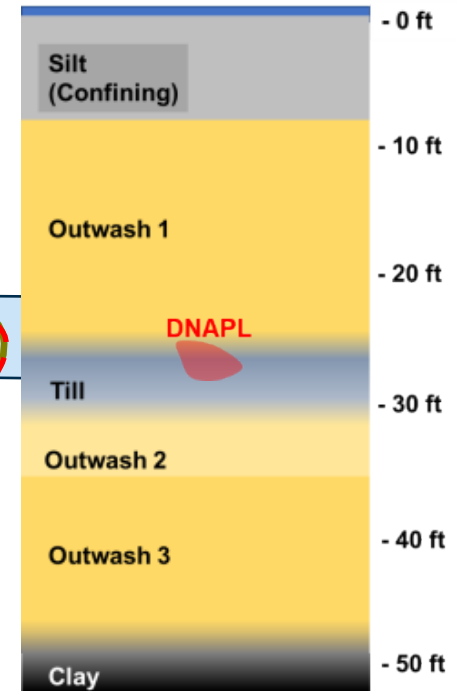
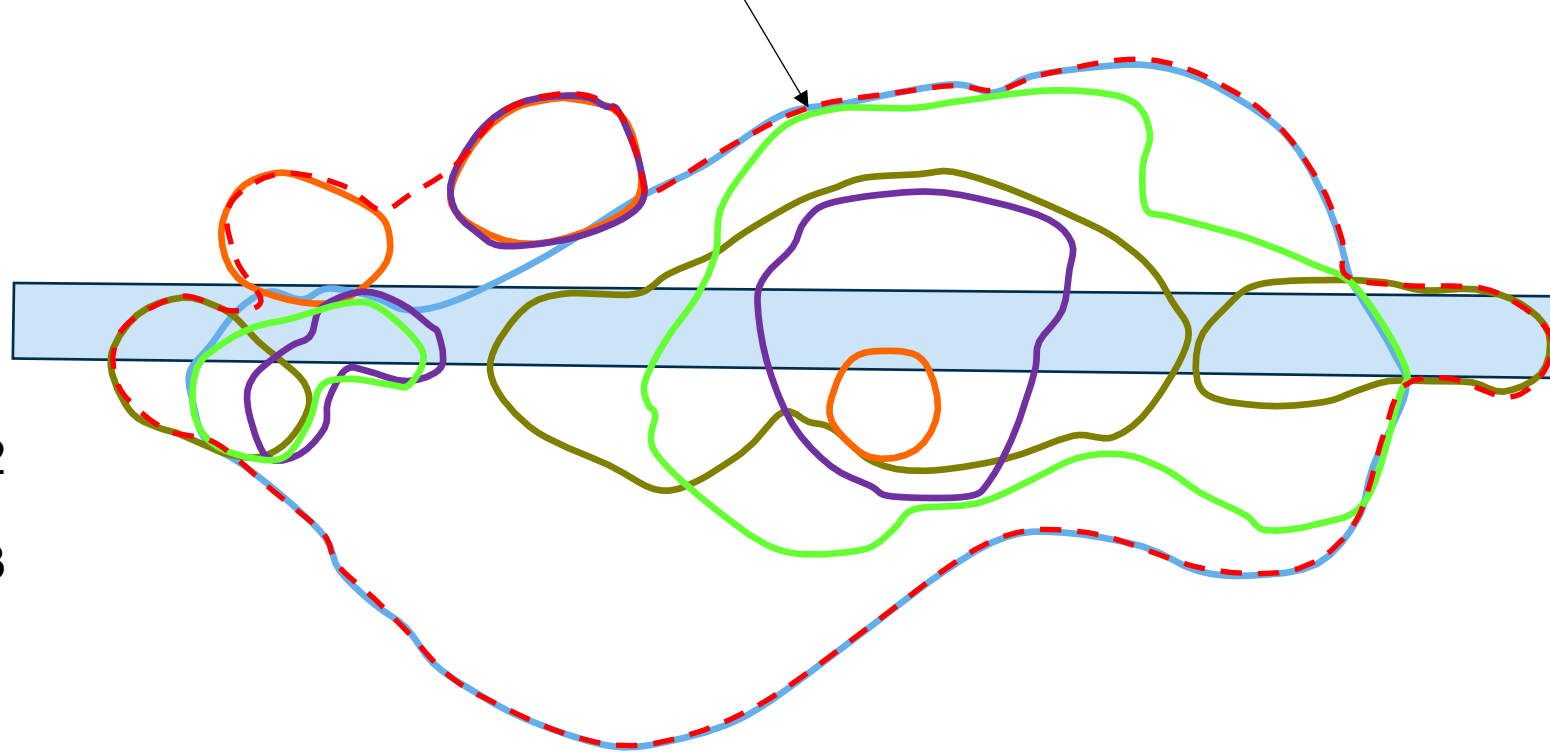
Targeted Treatment Zone (TTZ)

Area: 28,919 ft² (2,687 m²)

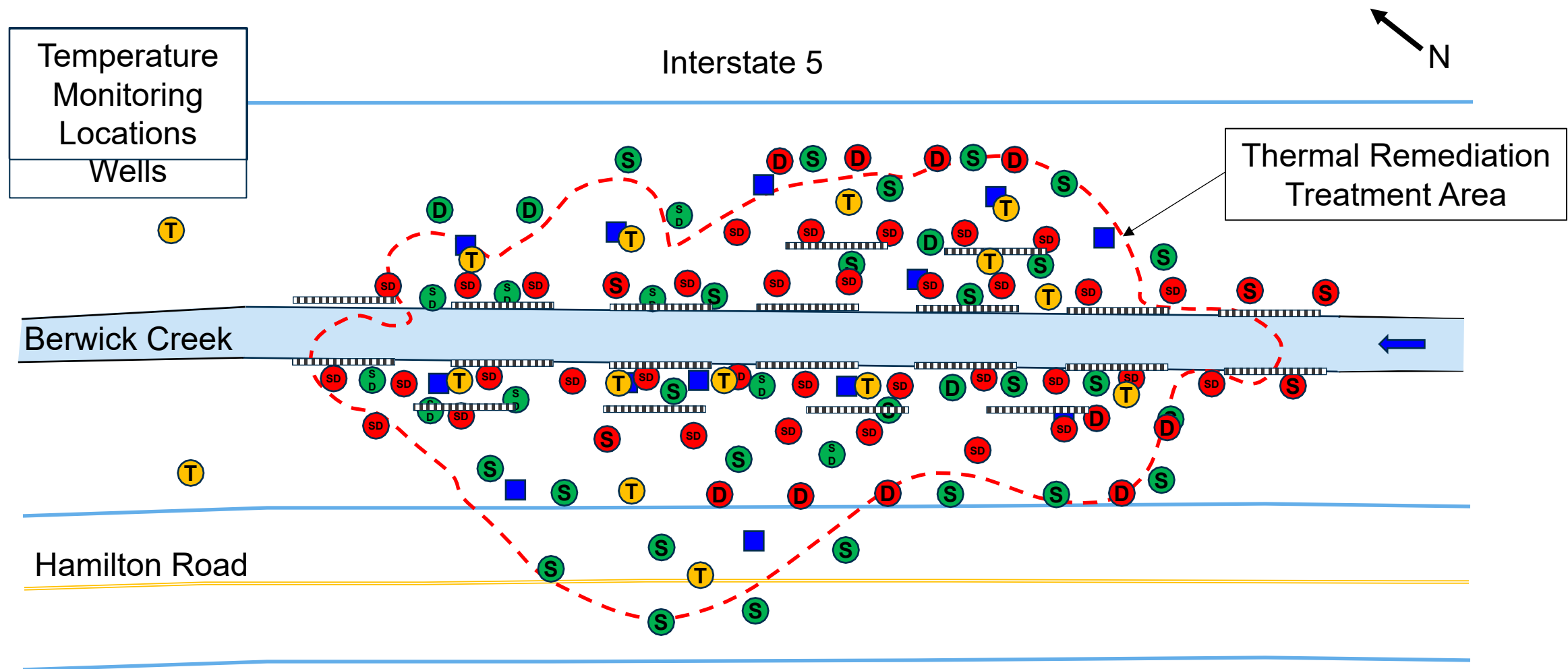
Volume: 11,904 yd³ (9,101 m³)

Thermal Remediation
Treatment Area

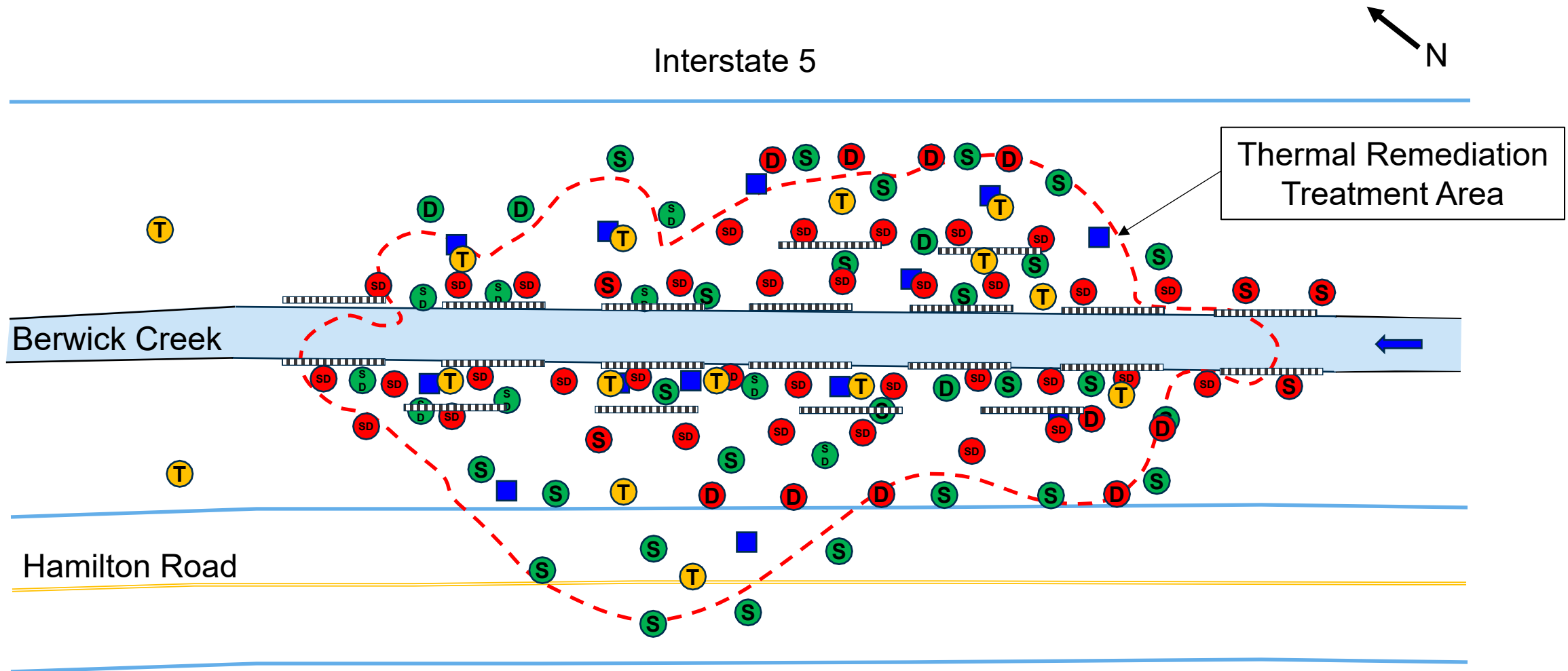
- Silt
- Outwash 1
- Till
- Outwash 2
- Outwash 3



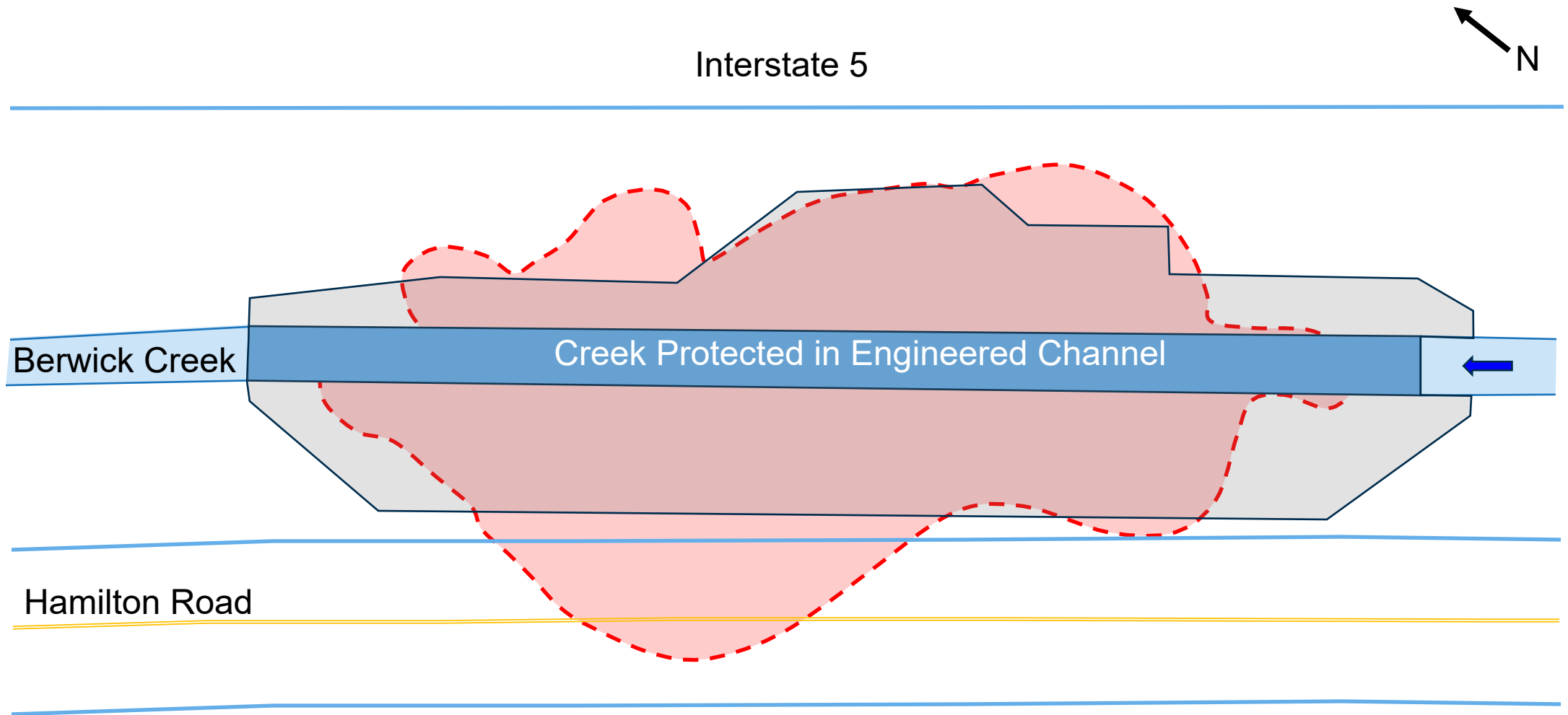
ISTR Wellfield Design



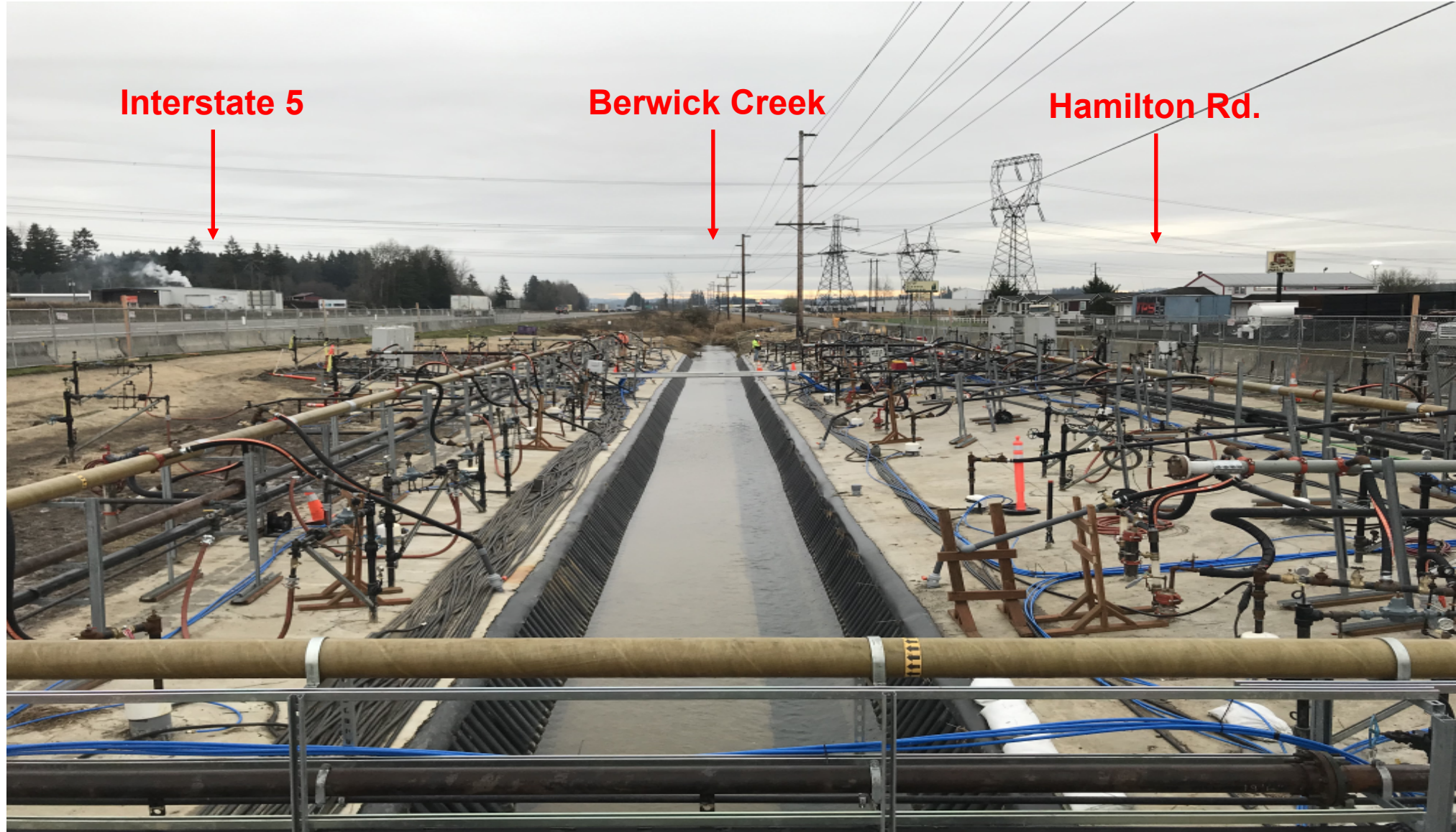
ISTR Wellfield Design



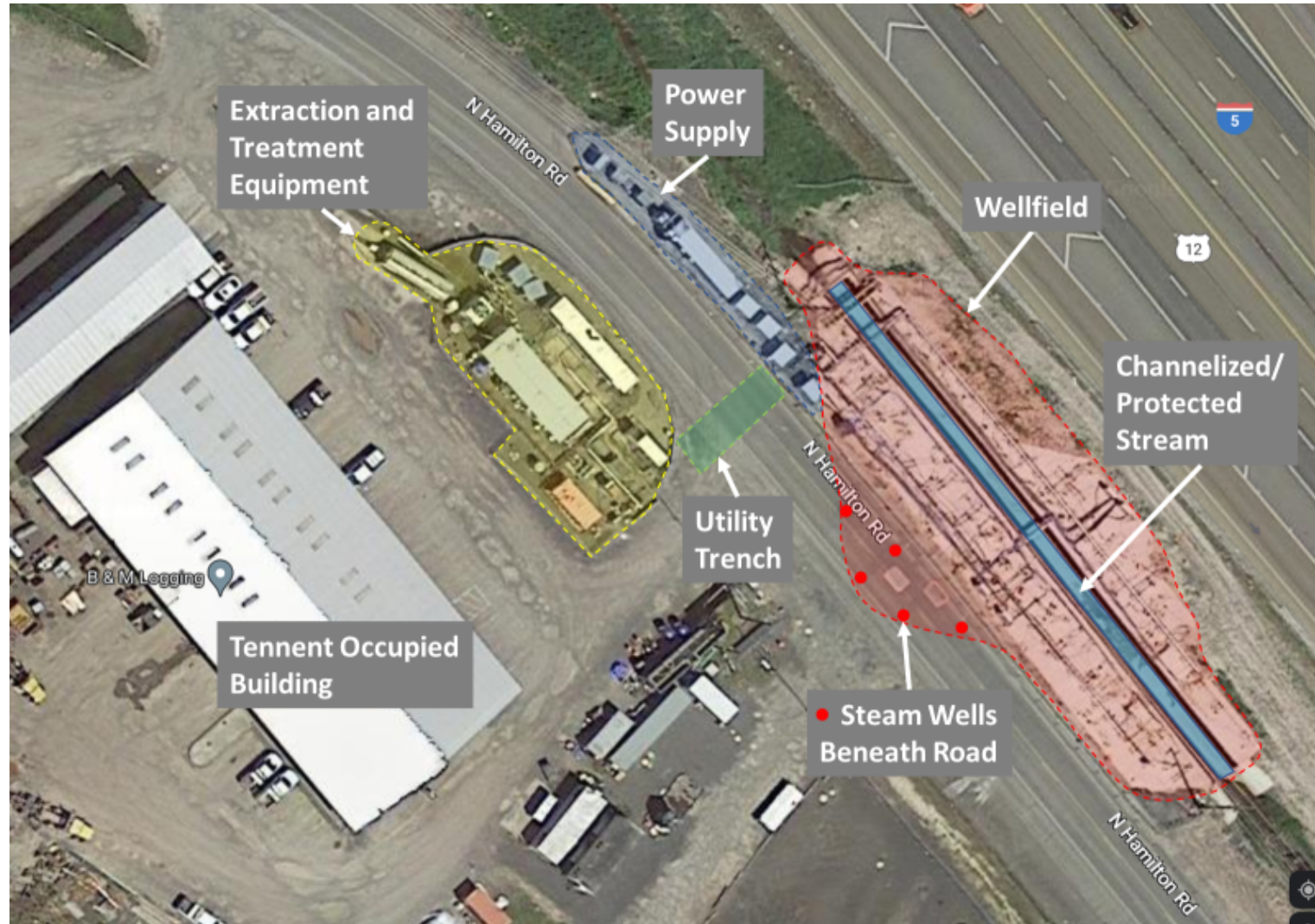
Insulated Vapor Cover/Channelized Stream



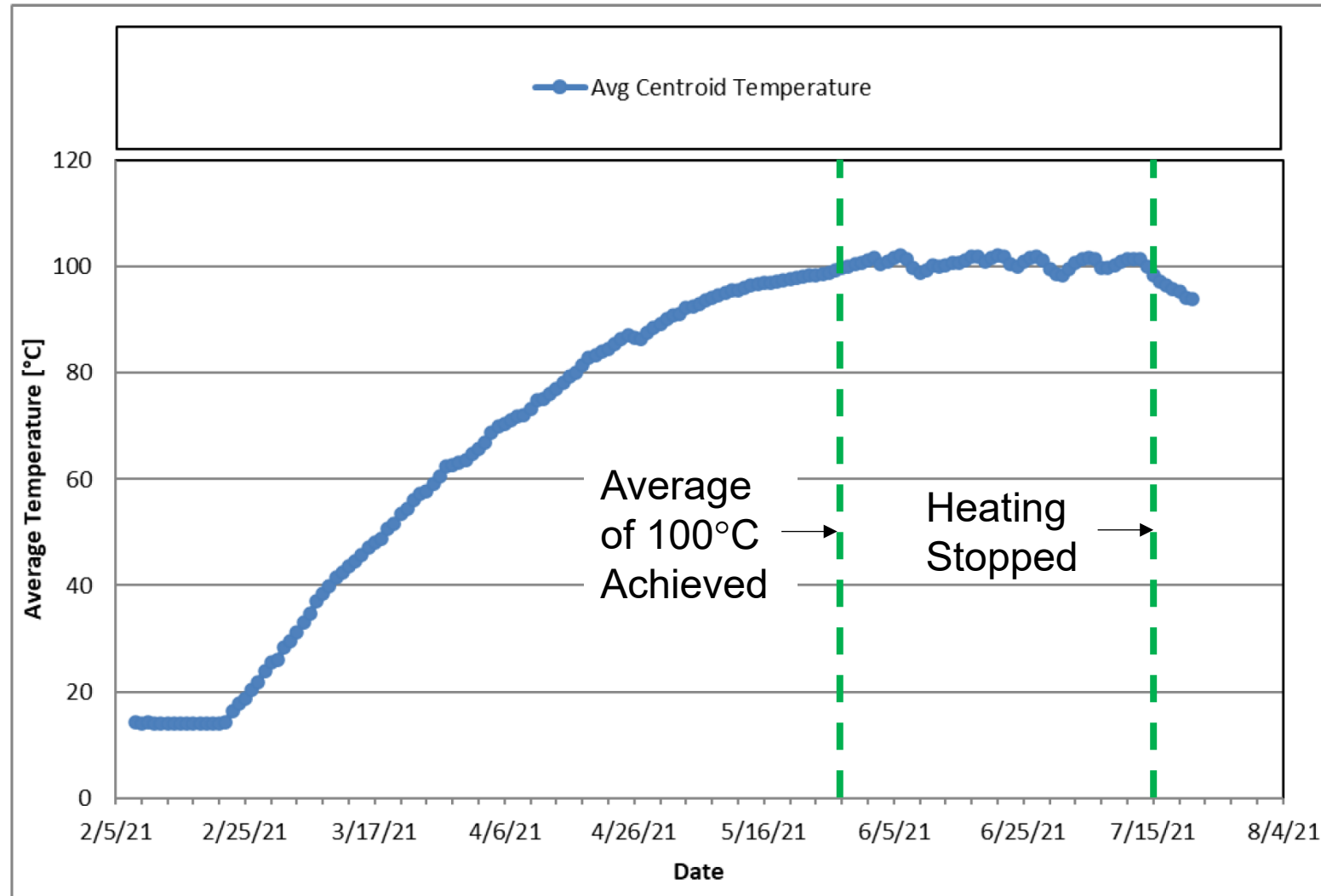
Completed ISTR Wellfiled



Areal View of ISTR System



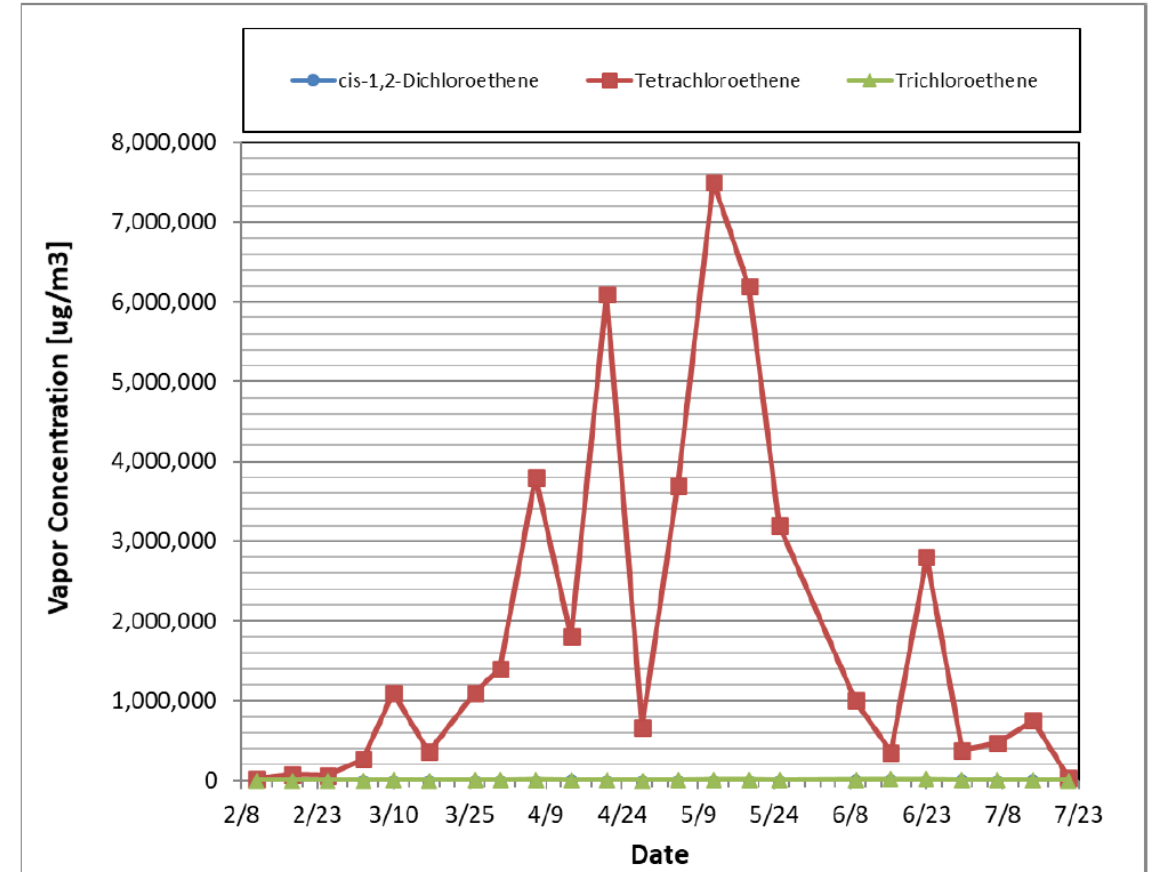
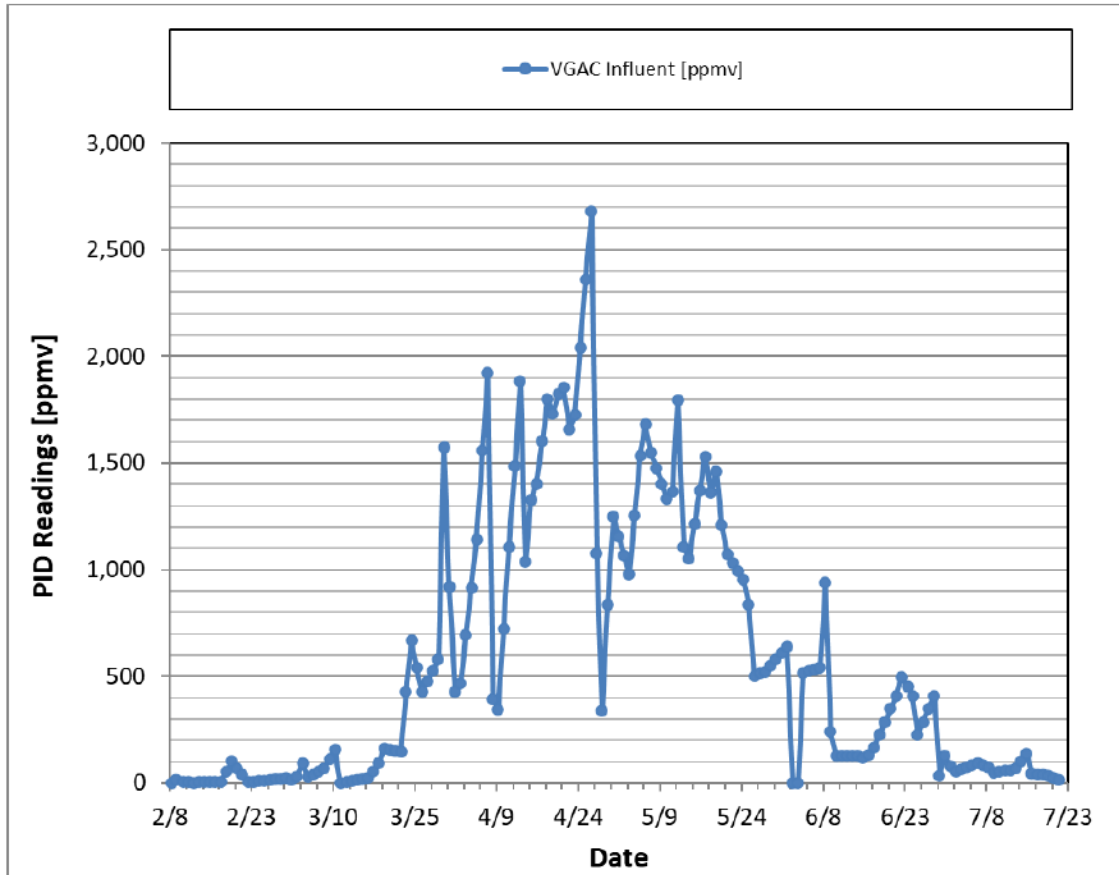
Heating and Treatment Progression



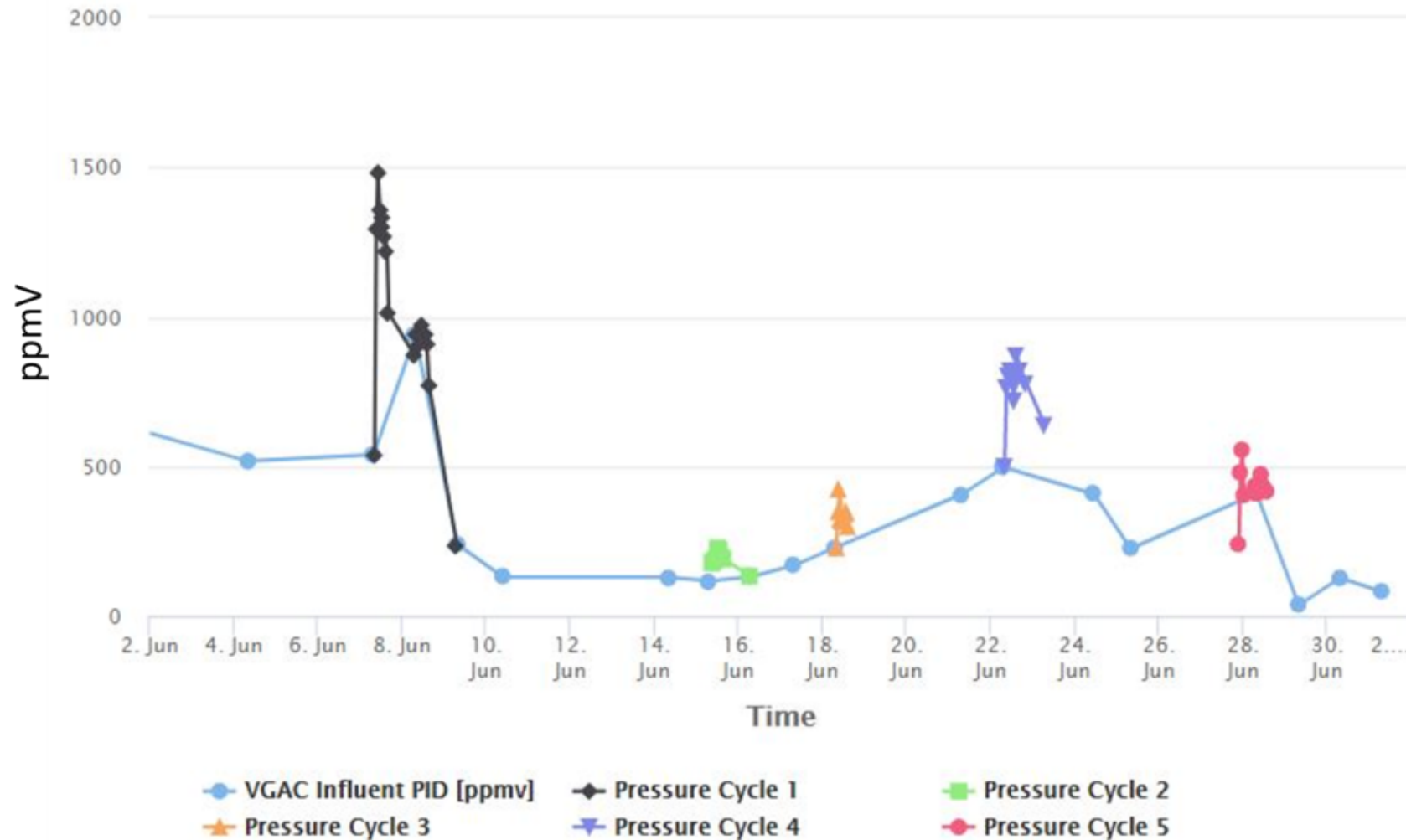
Average of
100°C
Achieved After
98 Days of
Heating

Remedial Goals
Achieved After
145 Days of
ISTR:
PCE <10 mg/kg

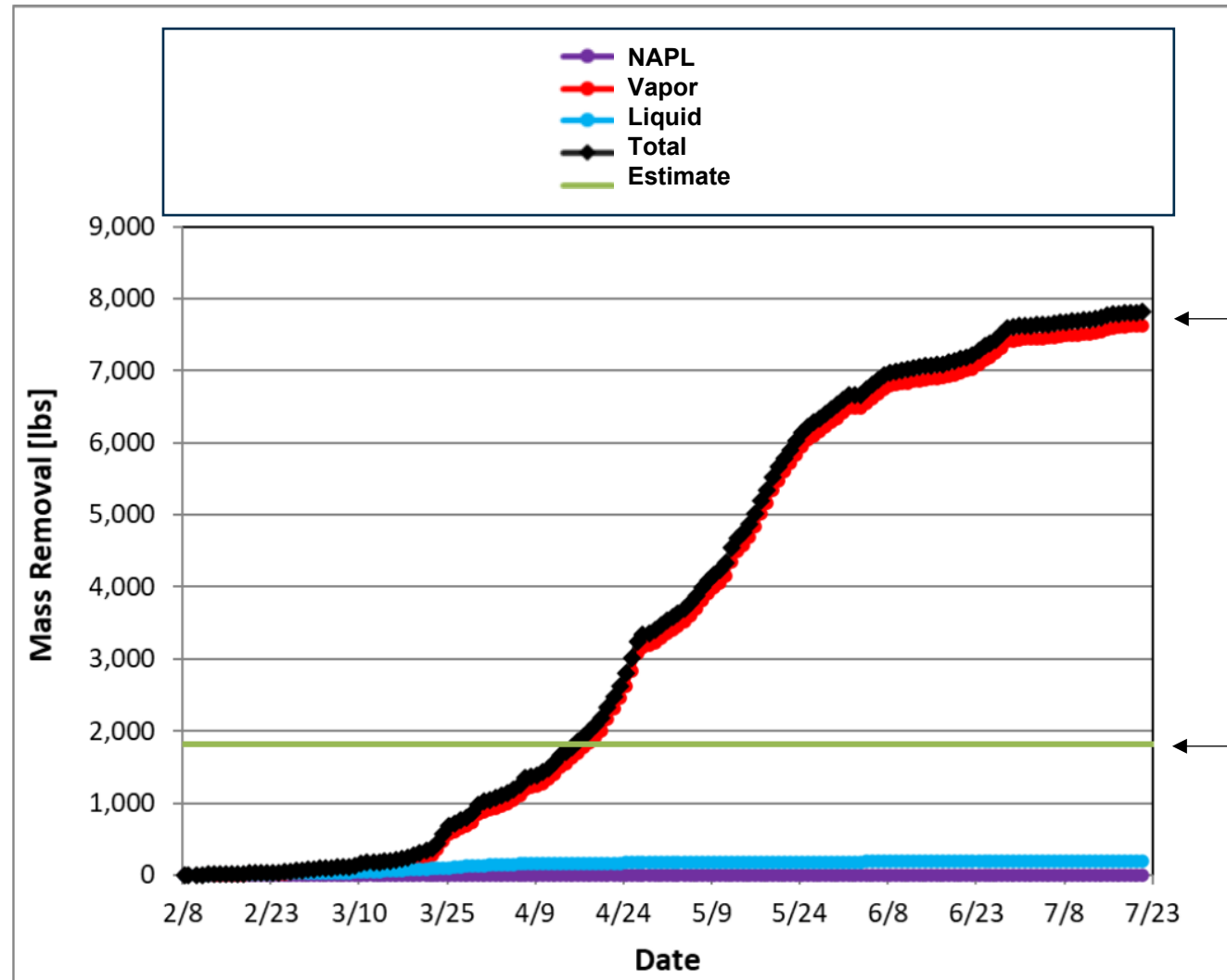
Vapor Concentrations From Wellfield



Results of Steam Pressure Cycling



Mass Removal



**7,700 lbs
Actual Removed**

**1,800 lbs
Starting Estimate**

System Performance

Vapor Extraction

- 650 to 750 scfm total
 - 300 scfm non-condensables
 - 350 to 450 scfm steam

Steam Injection

- 3,000 to 5,000 lbs/hr
- Average of ~10 gpm

GW and Steam Extraction

- Average of ~20 gpm
- 2x steam injection rate

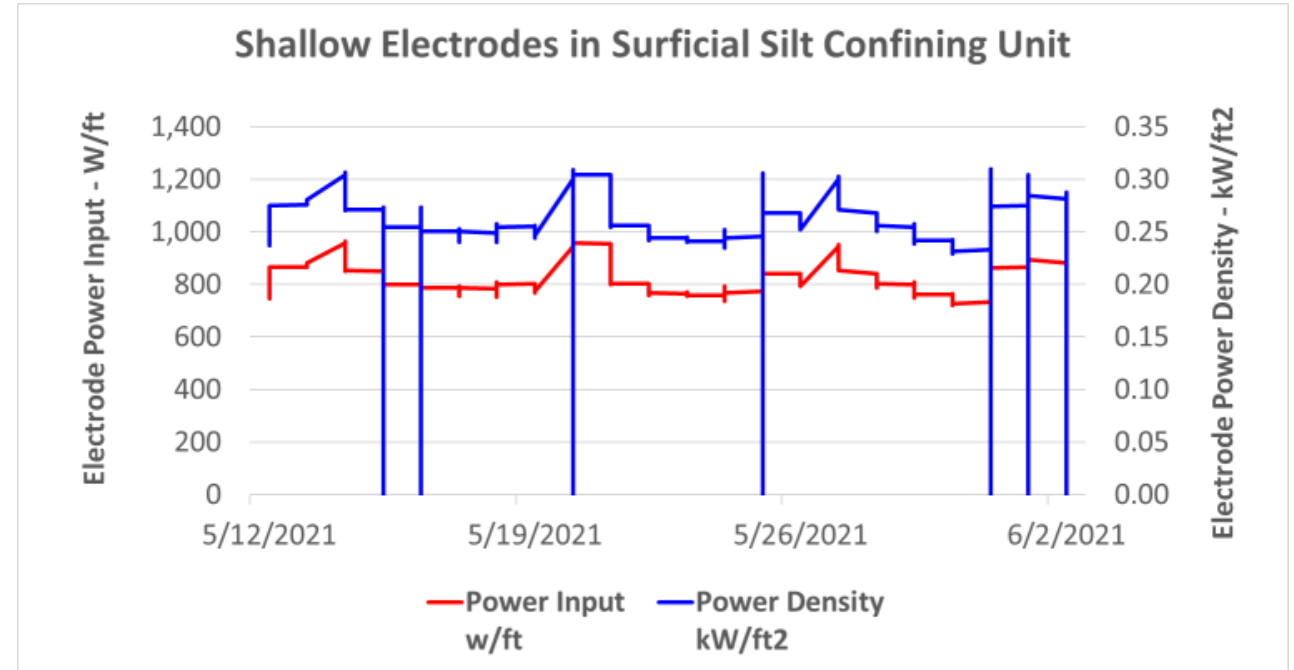


Steam Boiler and Extraction and Treatment Equipment

System Performance

ERH

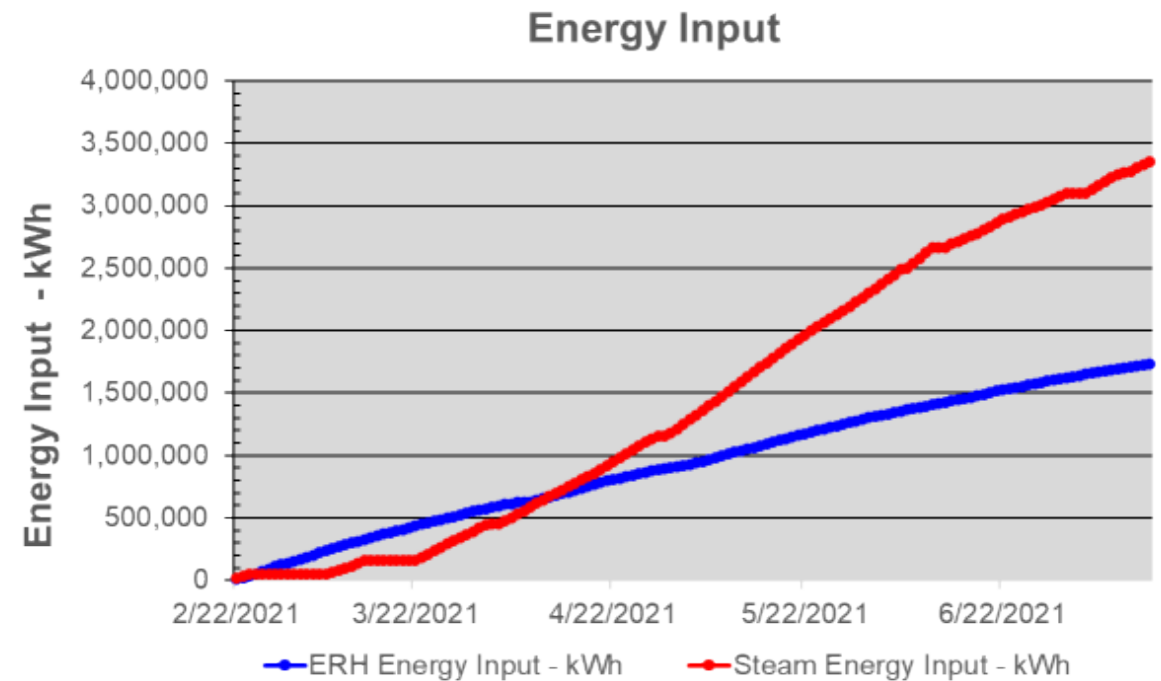
- Power input rate
 - 700 to 400 kW
 - Average of 550 kW
- 5 to 10 kW per electrode
- 800 to 900 W/ft
- 0.25 kW/ft² average power input density



Energy Usage and Contribution

	Total [kWh]	ERH [kWh]	Steam [kWh]
Energy Input	5,086,577	1,733,040	3,353,537
Percentage		34%	66%

	Total Volume [cy]	Targeted with ERH [cy]	Targeted with Steam [cy]
Treatment Volume	11,904	3,809	8,095
Heated Volume	16,979	5,433	11,546
Percentage		32%	68%



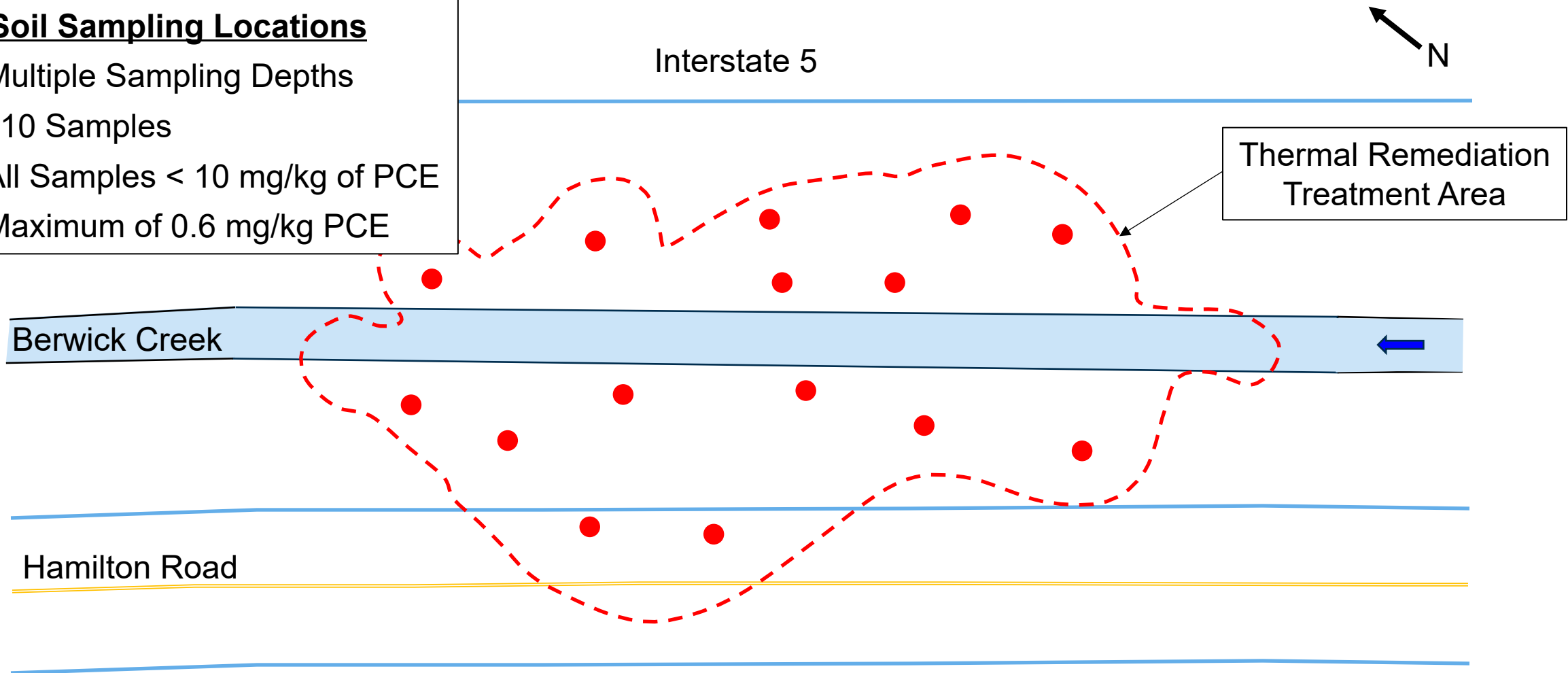
427 kWh/cy – Treated Volume

300 kWh/cy – Heated Volume

Confirmation Soil Sampling

15 Soil Sampling Locations

- Multiple Sampling Depths
- 110 Samples
- All Samples < 10 mg/kg of PCE
- Maximum of 0.6 mg/kg PCE



Summary

- 5 months of operations
- ~7,800 lbs of PCE removed
 - >3 times estimate
- 110 soil confirmation samples
 - 15 locations
 - Multiple depths
 - All <10 mg/kg of PCE
- No temperature of COC impacts to stream
- ERD remedy for downgradient plume underway



Questions?



One Partner. Many Solutions.



www.cascade-env.com



www.terratherm.com