A combined thermal treatment and MPE solution for a chlorinated solvent source area and groundwater plume in a fractured bedrock system

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With thanks to: Andrew Morgan, Jim Wragg, Sean Needham, Marcus Ford

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Overview

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- Definitions of ERH and MPE
- Site Background
- Contaminant Distribution
- Remediation Design & Installation
- Remediation Implementation
- Remediation Verification - Results
- Conclusions / Key Takeaways

Definitions - What is ERH & MPE?

- ERH = Electrical Resistive Heating
- MPE = Multi-Phase Extraction

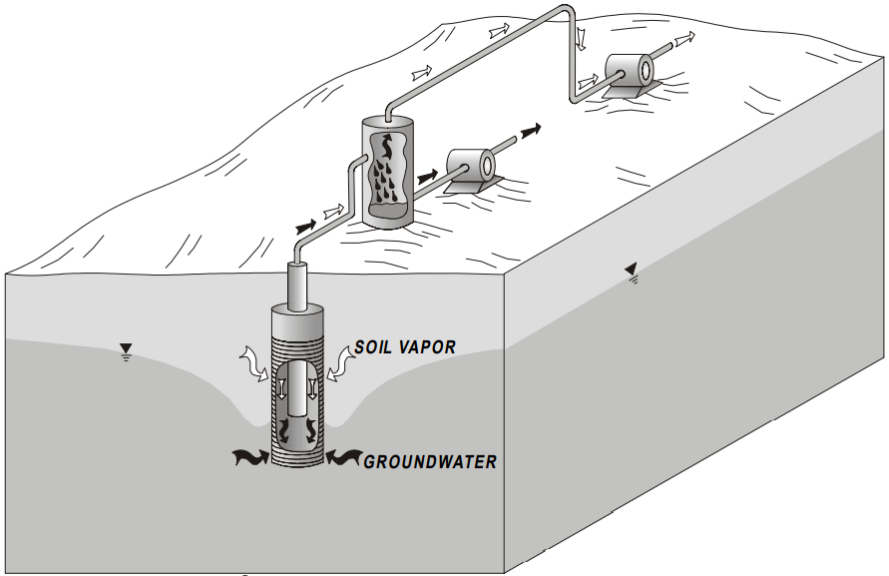


Image courtesy of USGS

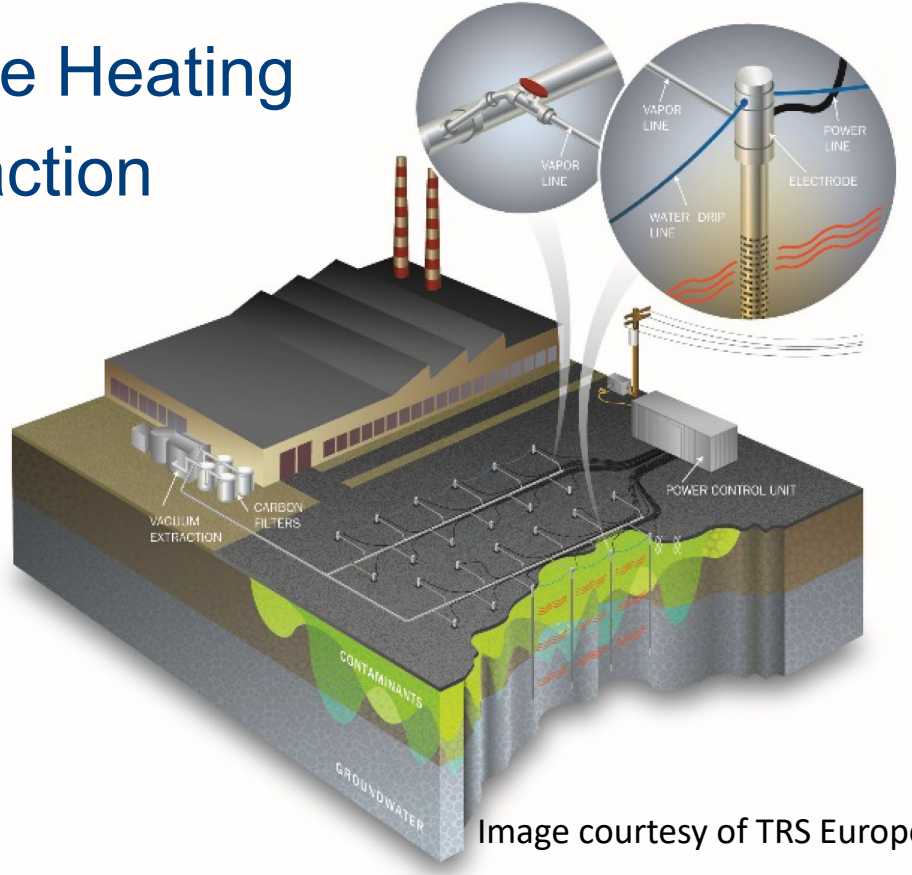
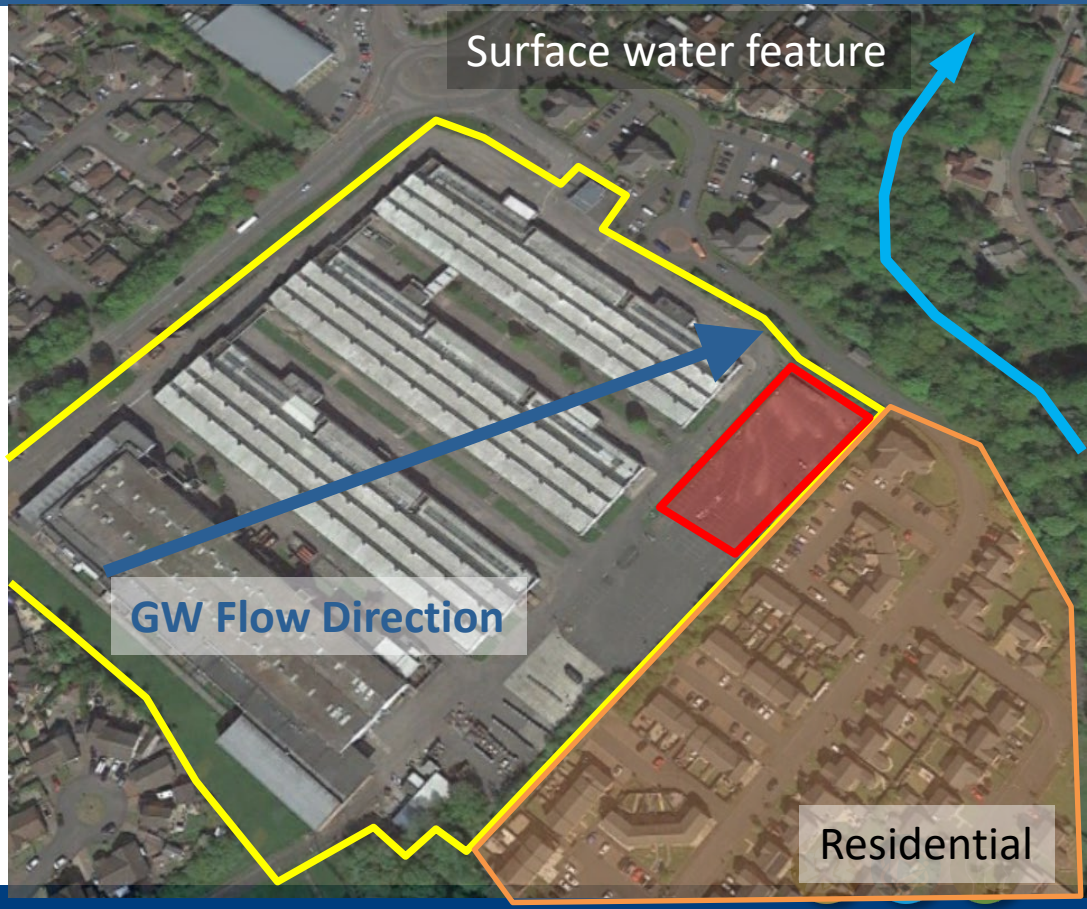


Image courtesy of TRS Europe

Site Background

- Former manufacturing facility active since1940s, operations ceased 2018
- Glacial Till underlain by Carboniferous Upper Coal Measures (Sandstone & Mudstone Facies)
- Surface water feature 40-50m beyond NE site boundary
- Residential area down and cross-hydraulic gradient
- Client seeking to surrender environmental permit and achieve regulatory sign-off



Contaminant Distribution

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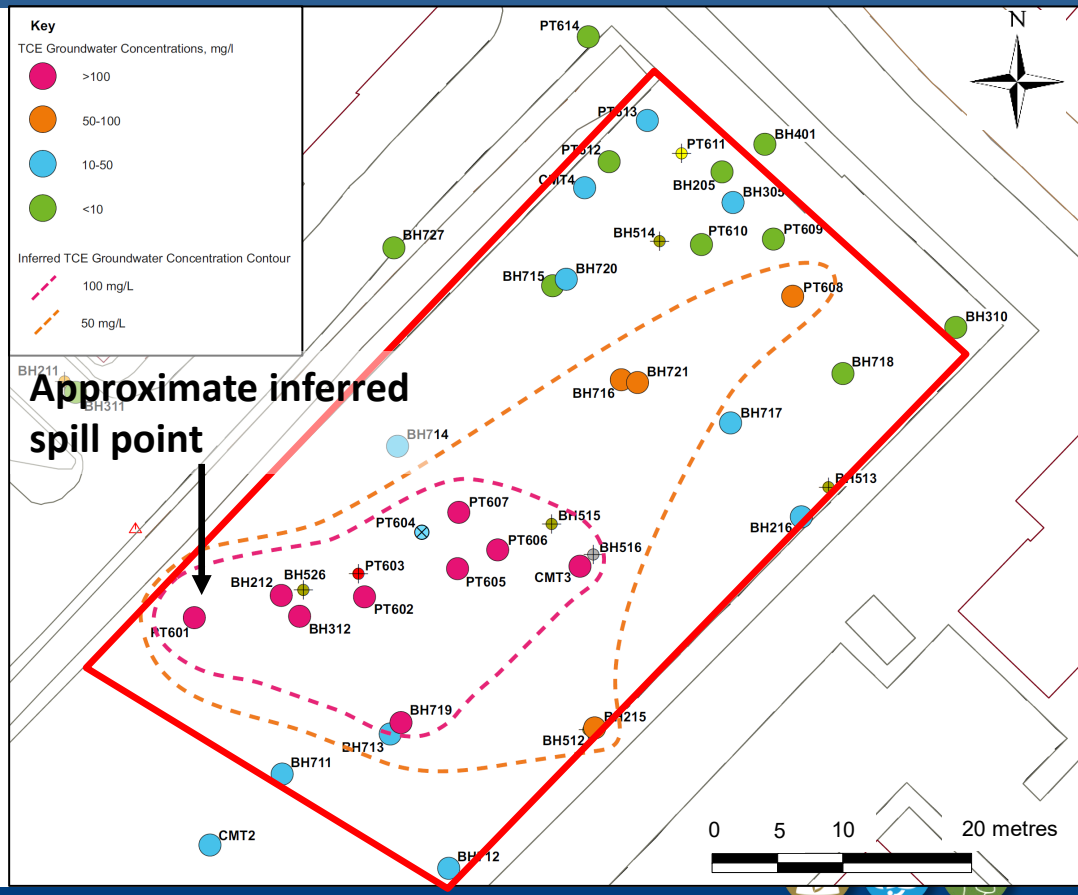
- Historical release of TCE 40+ years ago
- Soil concentrations of up to 380 mg/kg TCE in glacial clay around inferred spill point
- Created a 100 mg/l TCE groundwater plume in bedrock



Groundwater-Surface Water Interaction

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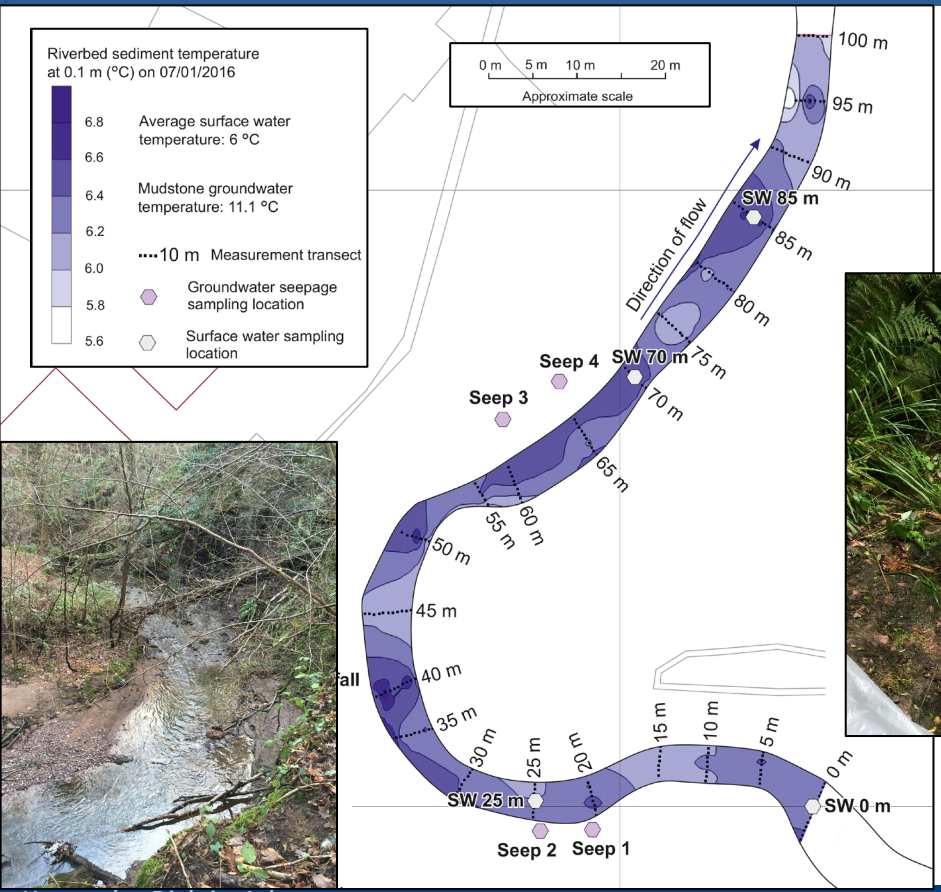

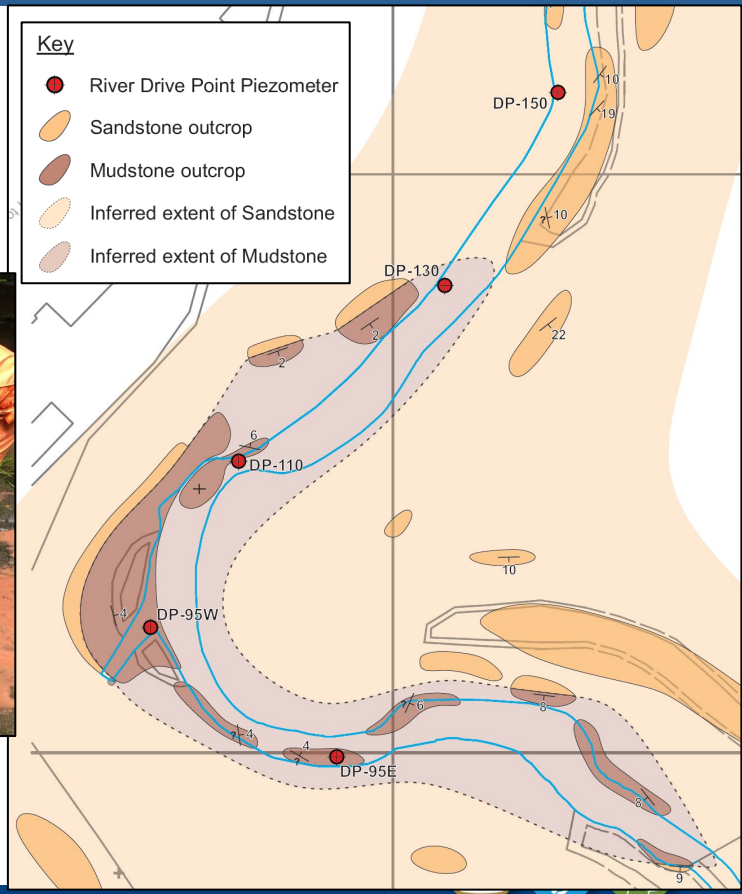

Contaminant Distribution - CSM

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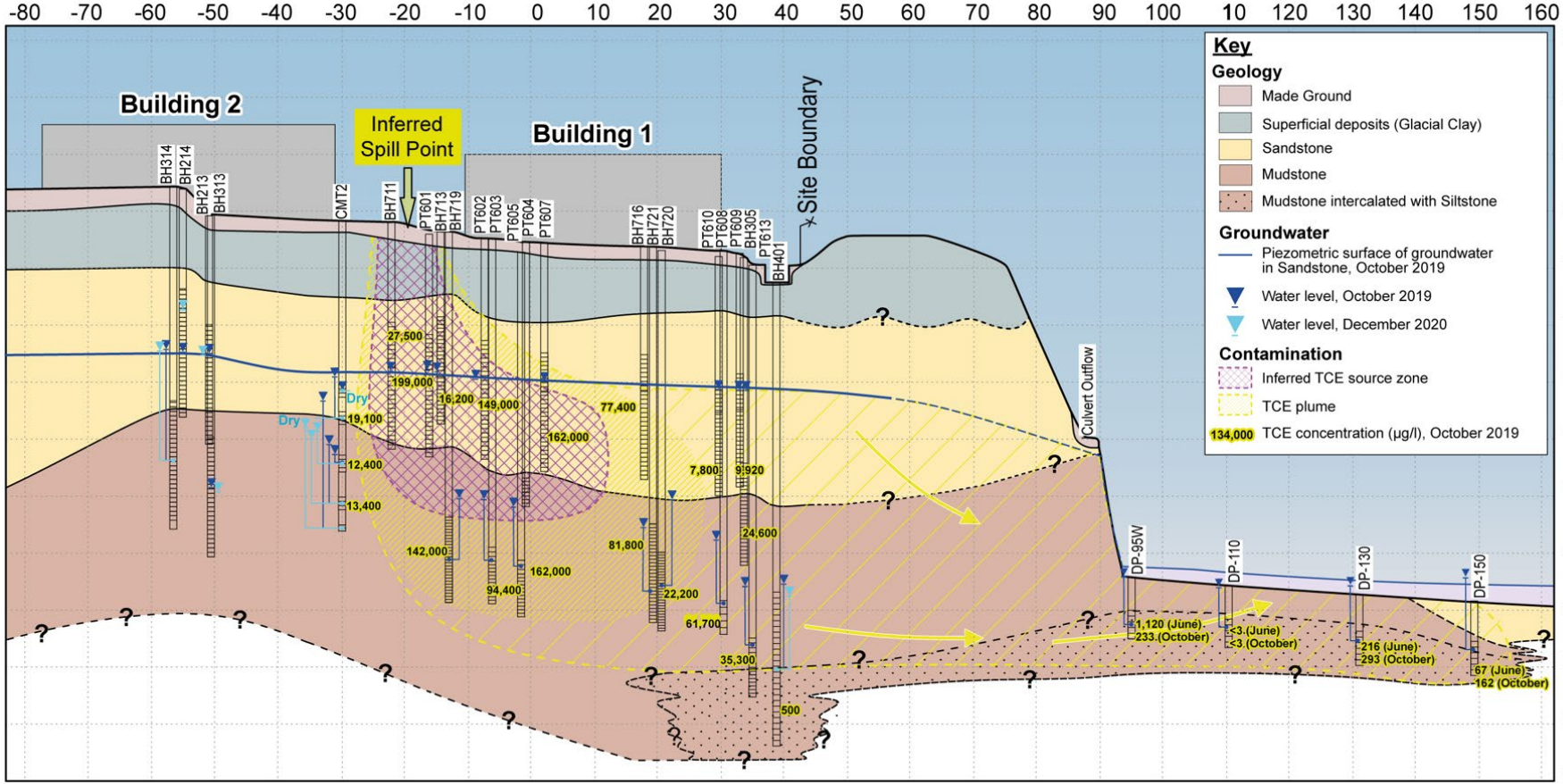

Remedial Objectives

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1. Reduce soil TCE concentrations from 200-300 mg/kg to <1 mg/kg

2. Remove 90% of total TCE source
   - Reduce groundwater TCE concentrations from ~200 mg/l to <5 mg/l

3. Show TCE betterment
   - Groundwater quality in river drive points

4. Provide multiple lines of evidence verifying ERH treatment does not exacerbate soil vapour intrusion potential to nearby residential zone

Remediation strategy

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- **Why thermal remediation?**
  - Difficult remedial goals for traditional technologies (ISCO, MPE, etc) in fractured bedrock, supported by contractor engagement
  - Thermal alternative approach was considered BAT by project team and regulator
- **Why combine ERH and MPE?**
  - Regulatory concerns / remediation objectives
    - Regulator was nervous of vapour / hot groundwater migration potential
  - Known effects of drilling
    - Observations during previous investigations showed that drilling works mobilised TCE mass locally

Remediation Design & Implementation

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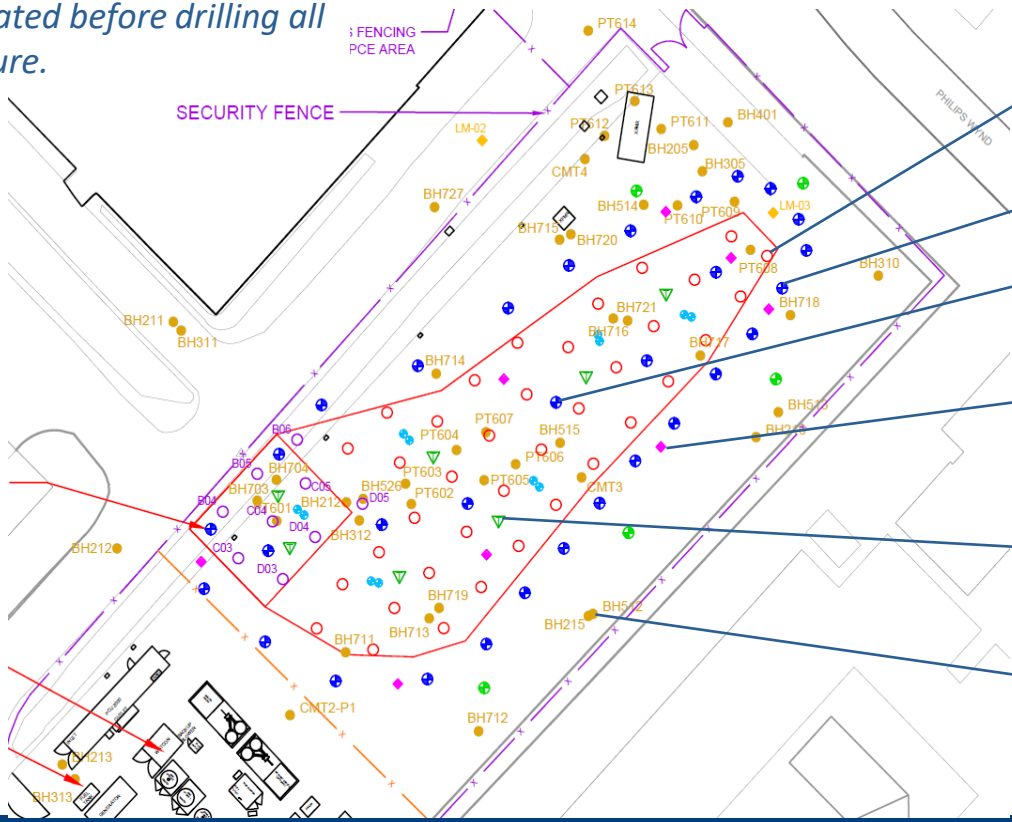
**All MPE wells drilled first enabling MPE to be operated before drilling all ERH infrastructure.*



Edge of heating electrode network (6.5m spacing)

Surrounding MPE wells

Central MPE wells

Temperature and pressure monitoring points

Temperature monitoring point

Boundary groundwater monitoring wells

Remediation Infrastructure

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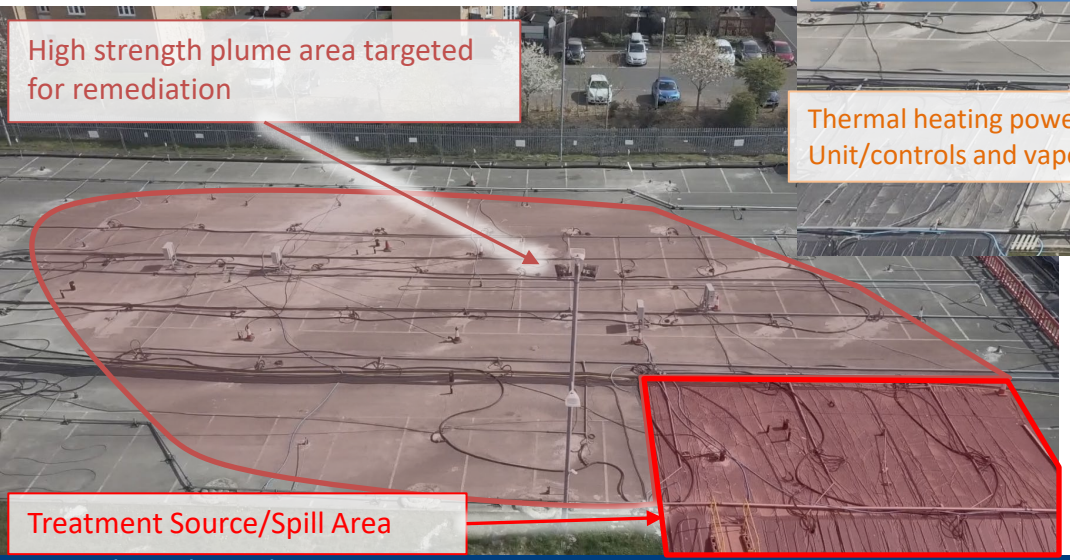
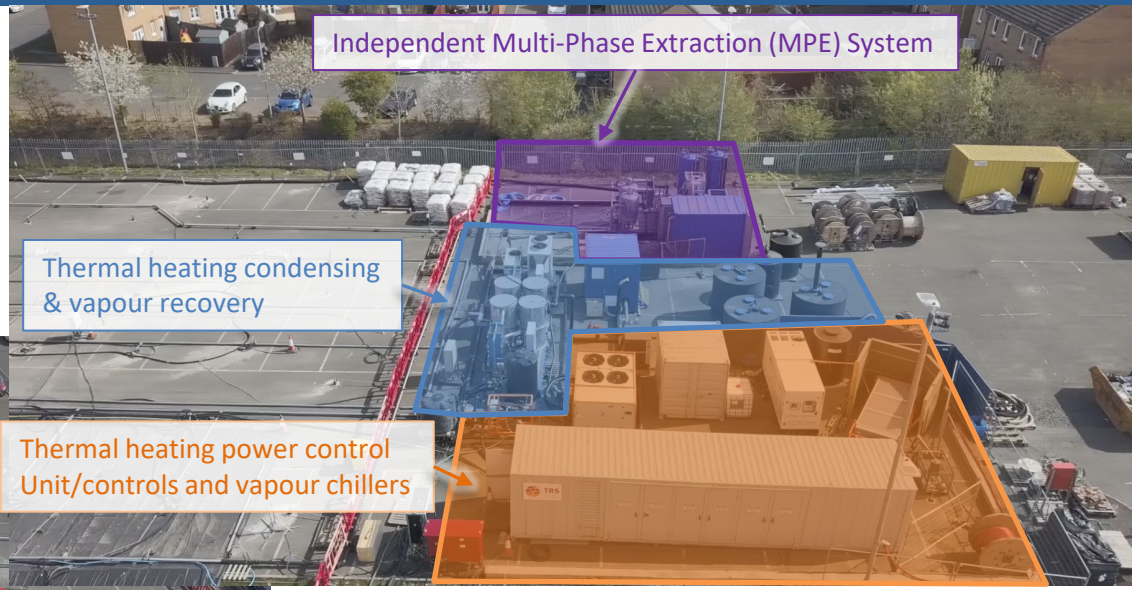
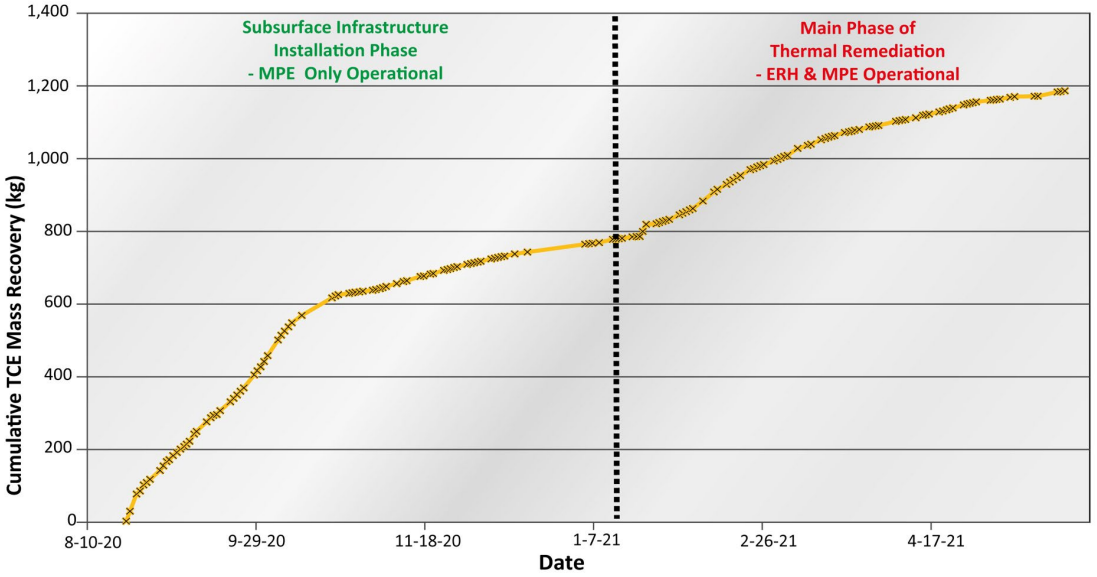
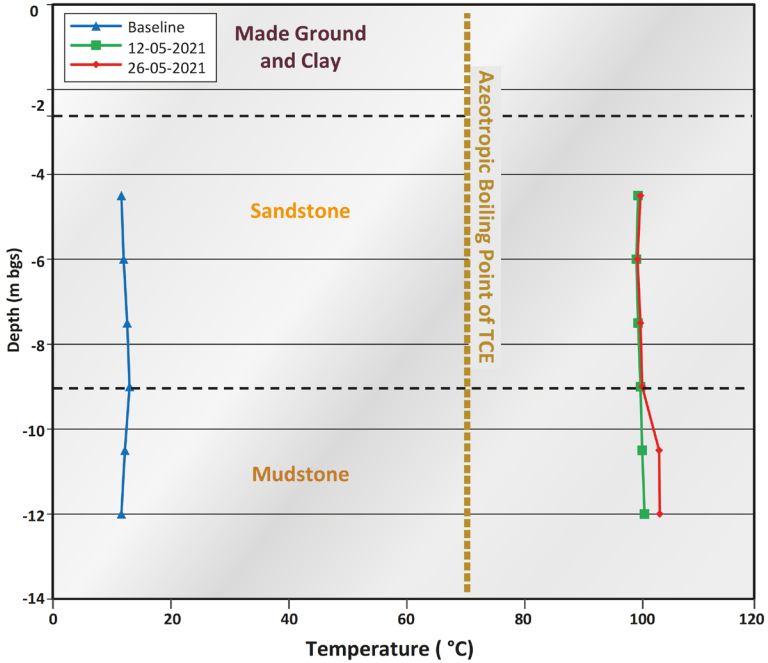




Results – TCE Mass Recovery





TCE Groundwater Concentration – Post Remediation

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Shallow Sandstone Wells	Nearest Environmental Charaterisation well / TCE Concentration	Containment MPE Operational - Baseline Monitoring Period				ERH Operational from 15/1/20 - 28/5/21 MPE Operational from 17/3/21 - 10/6/21				Onsite Validation Period ERH + MPE System Shutdown		
	Oct-19	01-Dec-20	09-Dec-20	14-Dec-20	06-Jan-21	09-Feb-21	09-Mar-21	12-May-21	18-May-21	21-May-21	15-17-Jun-21	12-14 july 2021
CMW-D04S	PT601 - 199mg/l	dry	dry	dry	dry	dry	dry	dry	0.020	0.013	0.029	0.504
CMW - F03S	BH719 - 142mg/l	dry	dry	dry	dry	24.69	38.61	0.477	dry	0.107	0.15	0.57
CMW - D06S	BH607 - 162mg/l	2.61	dry	dry	36.7	dry	dry	dry	0.075	0.052	0.063	0.054
CMW - G05S	BH605 - 162mg/l	21.5	dry	dry	51.5	1.98	0.728	dry	0.194	0.095	0.109	0.182
CMW - G08S	BH716 - 77.4mg/l	dry	0.393	0.201	0.423	0.015	0.600	0.417	dry	0.249	0.235	0.064
CMW - F11S	BH717 - 42.7mg/l	1.02	1.17	3.64	5.01	2.3	0.996	0.450	dry	0.460	0.448	0.395

Deeper Mudstone Wells	Nearest Environmental Charaterisation well / TCE Concentration	Containment MPE Operational - Baseline Monitoring Period				ERH Operational from 15/1/20 - 28/5/21 MPE Operational from 17/3/21 - 10/6/21				Onsite Validation Period ERH + MPE System Shutdown		
	Oct-19	01-Dec-20	09-Dec-20	14-Dec-20	06-Jan-21	09-Feb-21	09-Mar-21	16-Apr-21	12-May-21	21-May-21	15-17-Jun-21	12-14 july 2021
CMW - D04D	PT601 - 199mg/l	9.04	11.8	9.78	8.87	20.44	11.45	0.362	0.198	1.782	2.16	0.04
CMW - F03D	BH719 - 142mg/l	31.9	43.2	62.5	90.7	72.66	42.14	0.321	0.004	0.005	0.004	0.003
CMW - D06D	PT607 - 162mg/l	34.3	19.8	16.7	31.1	12	4.70	2.857	8.585	1.815	0.104	2.41
CMW - G05D	PT605 - 162mg/l	39.8	20.9	22.4	54.5	17.86	8.56	0.014	3.470	0.401	0.107	1.52
CMW - G08D	BH716 - 77.4mg/l	11.4	13.0	7.98	18.4	14.06	7.26	0.140	0.023	0.049	0.24	0.082
CMW - F11D	BH717 - 42.7mg/l	27.9	20.4	23.7	41.9	21.4	0.82	0.394	0.607	0.591	0.381	0.7

Peripheral TCE Groundwater Concentration – Post Remediation

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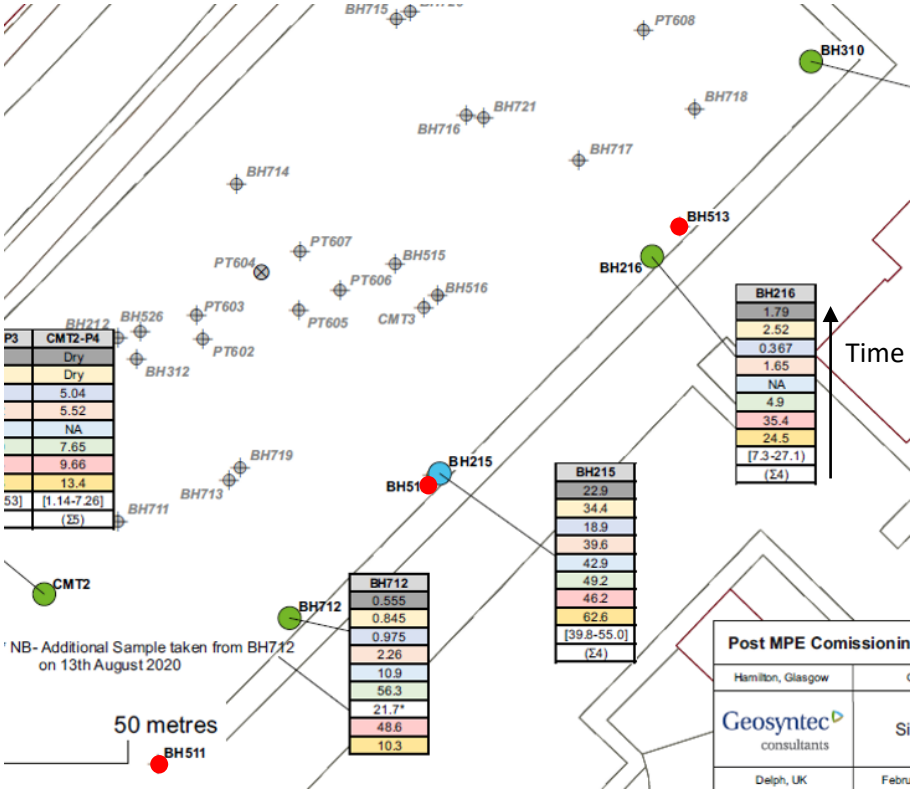

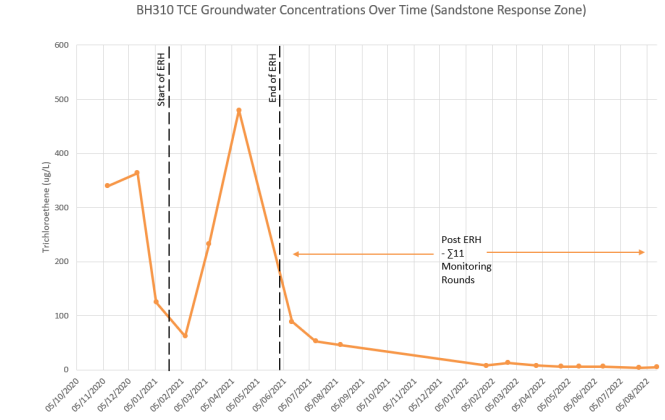

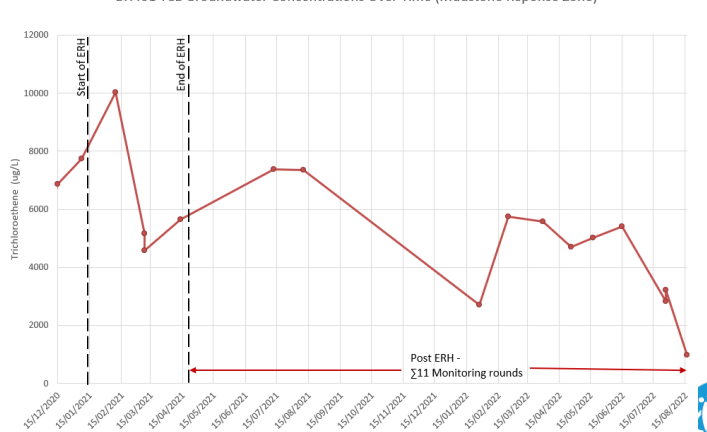

Groundwater Quality Entering River

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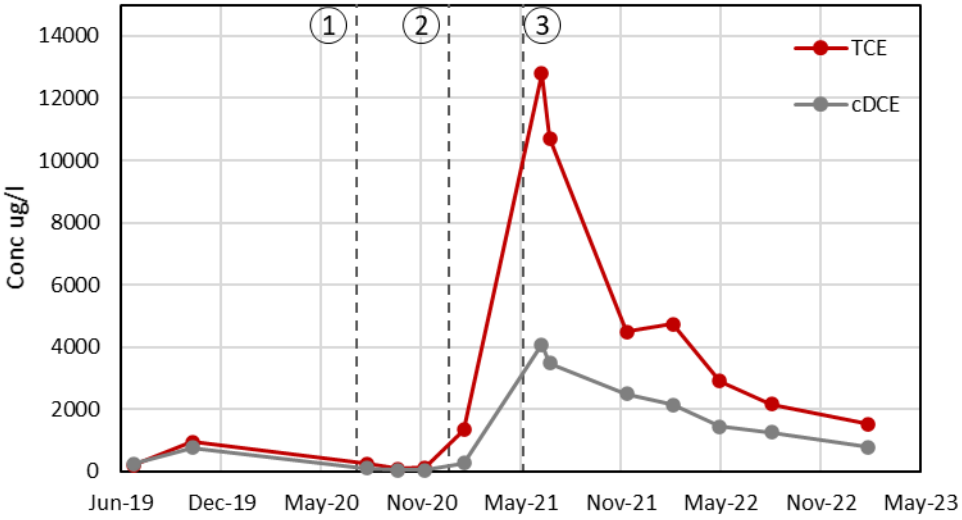
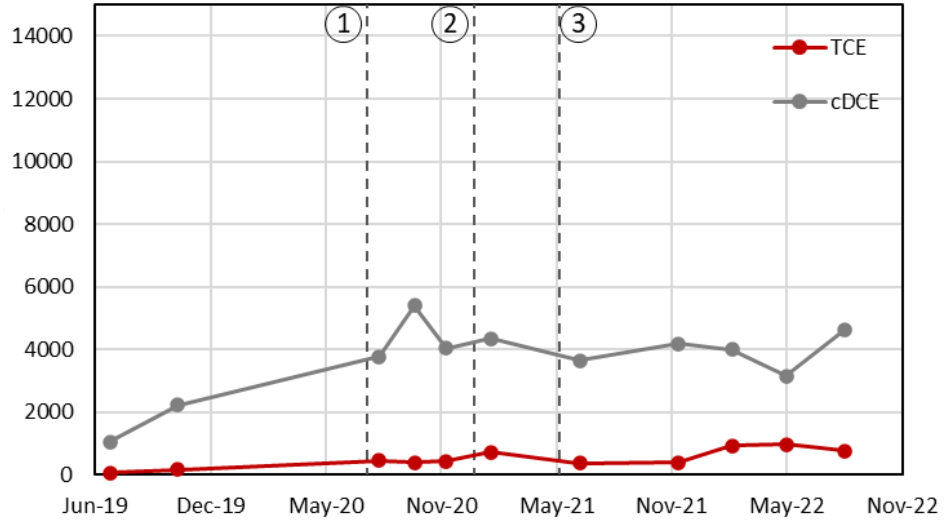
95 m from edge of source zone



150 m from edge of source zone



① Start of drilling of Remediation Wells in Car Park

② Start of ERH treatment

③ End of ERH treatment

Conclusions & Key Takeaways

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1. Combined MPE and ERH successfully addressed regulator concerns and site objectives

2. The combined approach did not adversely affect ERH performance
   - Estimated timeframe maintained
   - Same energy provision used

3. Operating MPE and ERH in parallel requires continual performance assessment and optimisation to achieve “balance” between both systems

4. MPE during subsurface infrastructure phase of ERH was a key benefit for a fractured bedrock with a mass flux remediation objective

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