UK’s first Commercial Augmented Bioremediation Remediation

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Background

- Utilise TCE to recover excess oil from manufacturing process.
- Historic TCE, DCE … present within site
- Aim to remove contamination liability
- First UK deployment of MTL/EP for this technology
- ECI played a major part in delivering the scheme
- Consultant Contractor partnership focused to deliver
Site Layout
- Made Ground to approx. 2.0 m.
- Fine Glacial silty sandy horizon approx. 2.5 m thick.
- Glacial Till (Clay) proven to be more than 3.5 m in thickness.
- Bedrock Comprises Coal Measures
- Shallow groundwater within sandy horizon
- TCE contamination predominantly confined within sandy Horizon.
- Site predominantly hard surfaced and vapour exposure managed through HS.
- Semi confined (but perched) water body made it complex to inject and recirculate
Groundwater Contamination
(Before Remedial Activities - TCE)
Groundwater Contamination
(Before Remedial Activities – cis 1,2-DCE)
Key Initial Actions

- Determine liability with regard operational activities (UK Law)
  - Detailed ground investigation and risk assessment (human health and groundwater) completed.
  - Findings indicate that site is unlikely to be determined as CL under P2A.
  - Negotiations held with UK regulators (EA and LA) to agree site is not deemed as contaminated under the requirements of P2A.
- Define Voluntary Remediation scope
  - Site to be remediated on a voluntary basis to remove contamination liability.
  - Agree voluntary remediation approach with Regulators.
  - Determine appropriate remedial targets and measures.
  - Define remediation timescales
- Zone the site to work around manufacturing process, site construction activity and to manage spend
TCE is problematic to remediate because of:

- its complex migration patterns
- ability to migrate long distances in groundwater
- resistance to aerobic degradation and
- the difficulty of naturally achieving optimum anaerobic conditions in the environment naturally.

Conventional technologies can be environmentally and economically unsustainable;

- often requiring large amounts of bulk material to be excavated for treatment and/or disposal
- the use of large volumes of chemical oxidants
- or the use of large amount of electricity to power dual phase plants.
2008 Commence Augmented Bioremediation phase to manage spend and accommodate site owners activities

- Project managed under the Contractors Environmental Permit, authorised by the Environment Agency (EA)
  - Results and actions reported on a monthly basis to EA

- Stringent trigger levels established for perimeter sentinel wells to establish a complete monitoring regime to ensure treatment is confined to site

2009 - Implementation of hydraulic controls (sheet pile wall and groundwater extraction) to ensure retention of treatment within site boundary.

2010 to 2012 - Continued optimization of remedy (pH, electron donor, and bacteria)

Future project closure 2014/2015

Client aspiration of NON-DETECT for TCE and associated species!
Remedial Activities

- Design and planning of the works
- Design and install delivery and recirculation wells
- Install ducts and chambers to accommodate on going site manufacturing
- Install and commission treatment and abstraction equipment
- Prepare conditioned water and bioreactors
- Commence re-circulation treatment phases
- Undertake direct injection
- Undertake reactive barrier
- Hydraulic Control of Groundwater Plume
- Bioremediation of Groundwater Plume
  - Bio-barrier works along northern road, west side, and in source area
  - Bio-barriers constructed using direct injection and groundwater recirculation
The Process

- Conditioned abstracted water
- Injected sodium lactate in source area and in west boundary wells as electron donor
- Followed by injected emulsified vegetable oil (EVO) into the source area and downgradient plume to serve as electron donor
- Injected sodium bicarbonate for pH control
- Injected TCE-degrading bacteria (KB-1) into to plume (after favorable conditions achieved)
- No tap water used all plume derived water
- Extensive monitoring. Injections and recirculation's controlled and informed by on site monitoring for pH, EC, DO and ORP supplimented with lab testing.
Phase 1 Boreholes
Wells and Pipework

Abstraction well

Injection wells
The Equipment

• Unit containing injection and abstraction pumps
The Process and Equipment

- Abstraction Wells
- External Water Supply with Valve
- Level Control to all 8 Pumps
- Emergency High Level Switch Off
- Sodium Lactate or Emulsified Oil
- 2000L Tank
- Bypass Loop with Valve
- Pump
- Dosing Pump
- Injection Wells

Images of the equipment setup are also shown.
Bio Augmentation

$O_2$ Free Nitrogen

KB-1 culture
Monitoring to Inform Process
The Treatment Method

- REDUCTIVE DEHALOGENATION
- TCE to DCE easy to achieve!
- DCE to VC difficult
- VC to Ethene relatively less complex (anaerobic/aerobic)
- Often stalls and thus requires management and possibly augmentation
- Naturally self limiting which is made worse by basic enhancement without very close control
- Ground prepared first to correct conditions then bioculture added
- KB-1, cultured by SiREM lab comprising a natural dechlorinating microbial consortium that contains phylogenetic relatives of *Dehalococcoides ethenogene*
- Ph Control and “top ups” regularly required to maintain condition
Summary of Bioremediation
Groundwater Contamination (TCE)

Before Remediation

2011

NOTE:
CB wells were installed in July 2011 during the replacement of the carbon beds. Bioremediation work will be completed in November 2011 in these wells.
Groundwater Contamination (cis 1,2-DCE)

Before Remediation

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Conclusions

- Augmented Bio is a viable remedial technique for the treatment of Chlorinated Solvents (soils and groundwater) and doesn’t have to accumulate DCE or VC.
- Simple effective technique but complex bio-geo-chemistry considerations require close control and management.
- Conceptual model is important to decide on technique but more importantly understanding the actual conditions pre and during are much more important.
- You will have to change your plans many times and be prepared to adjust pH.
- A strong technical commitment is required as is a bio-geo-chemist or two!
- Low on equipment and plant requirements but needs more human resource to deliver with confidence and without incident.
- The technique can achieve really low remedial criteria with careful control.
- Perhaps we should address some of the complex TCE plumes in our aquifers this way?
- It is viable in the UK and can achieve goals in difficult conditions.
Thank You

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