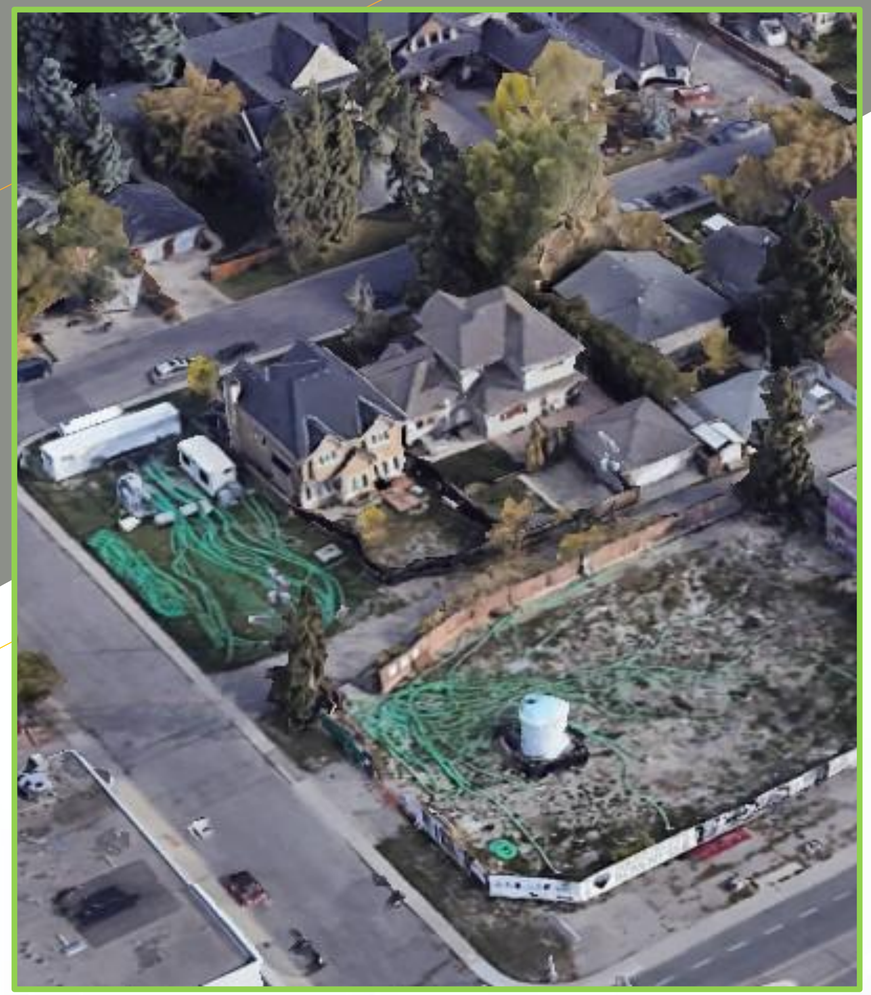

Case Studies of Dynamic Remediation Strategies for Urban Project Success

J. Waddell
CLRA
May 4, 2022

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Outline

- Collaboration
- Outline of “Remediation Train”
- Overview of technologies
- Case 1 – Residential gas station – Multi technology challenges
- Case 2 – Metals Impacted Mall – New technology challenges
- Outcomes

Sta
Se

Bioremediation

Thermal Extraction
& Recovery

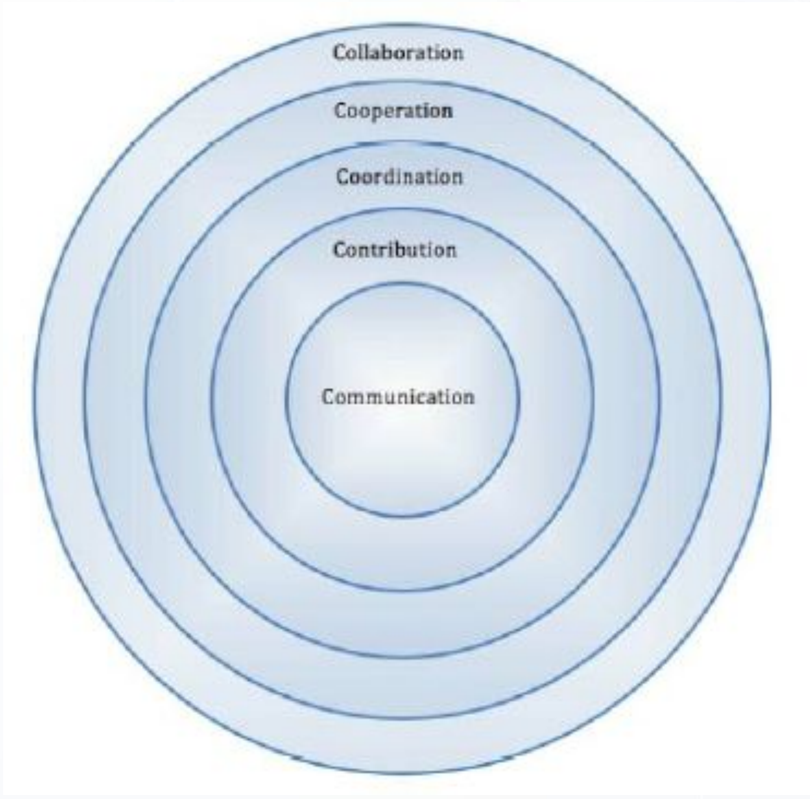
Collaboration

- Oxford Dictionary defines:
  - Collaboration is the process of two or more people, entities or organizations working together to complete a task or achieve a goal.

  OR

  - Traitorous cooperation with an enemy.

Thanks to the teams at Hemmera and Jakobs for the opportunity to collaborate on these projects. Jake Gossen of Langan also for his scientific support.



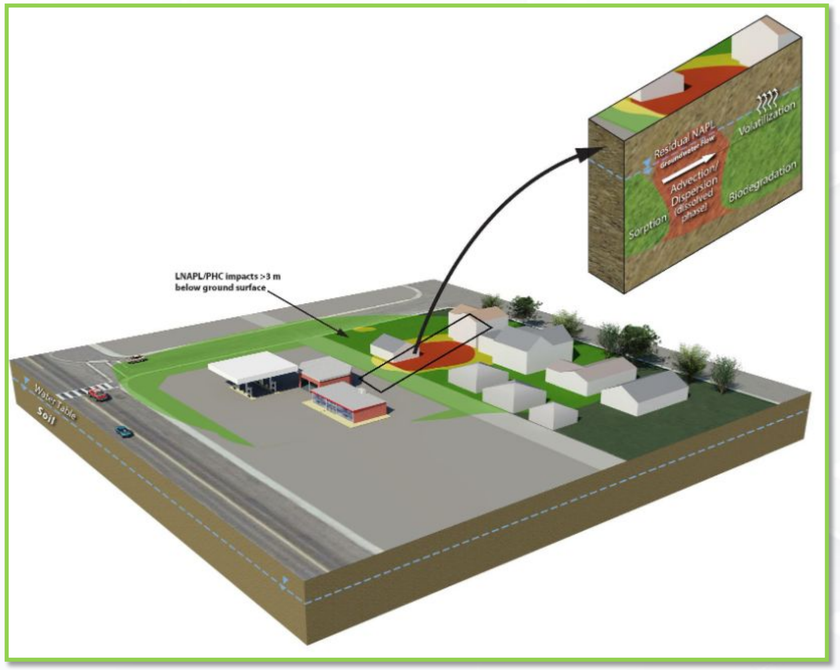
“Remediation Train”

- CLU-IN (US EPA)[1] –
  - Multiple technologies may be require over its life
  - Complex sites may require more than technology
  - 2-part process
    - 1. Ensure chosen technology is best s immediate scope
    - 2. Monitor and adjust including deplo technology as evolves

[1] - https://clu-in.org/products/combinedremedies/

Case 1 – Multiple Technology

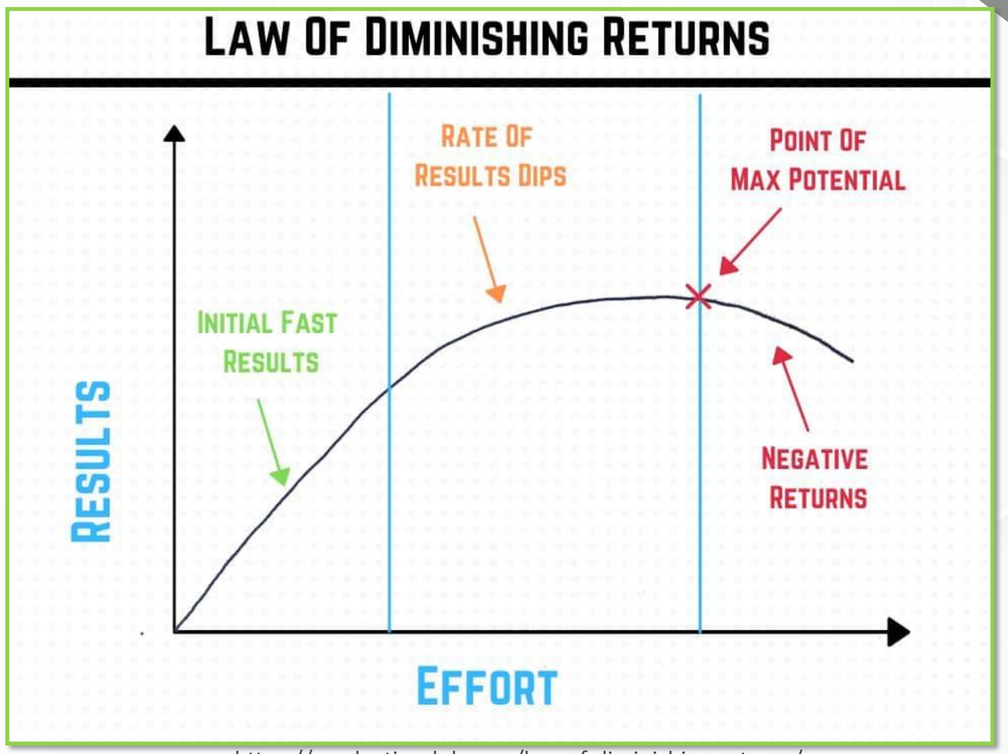
- Former gas station adjacent to residential neighbourhood
- Vapour intrusion into nearby residence
- Proximity to major river
- Impacted >3 mbg in fractured and competent siltstone and sandstone
- Target of >95% reduction in <2 years.



Information reference “An In Situ Treatment Train for Mitigation of Vapour Intrusion from LNAPL in a Residential Area”, Calgary, Alberta. RemTech 2021, A.Hachkowski

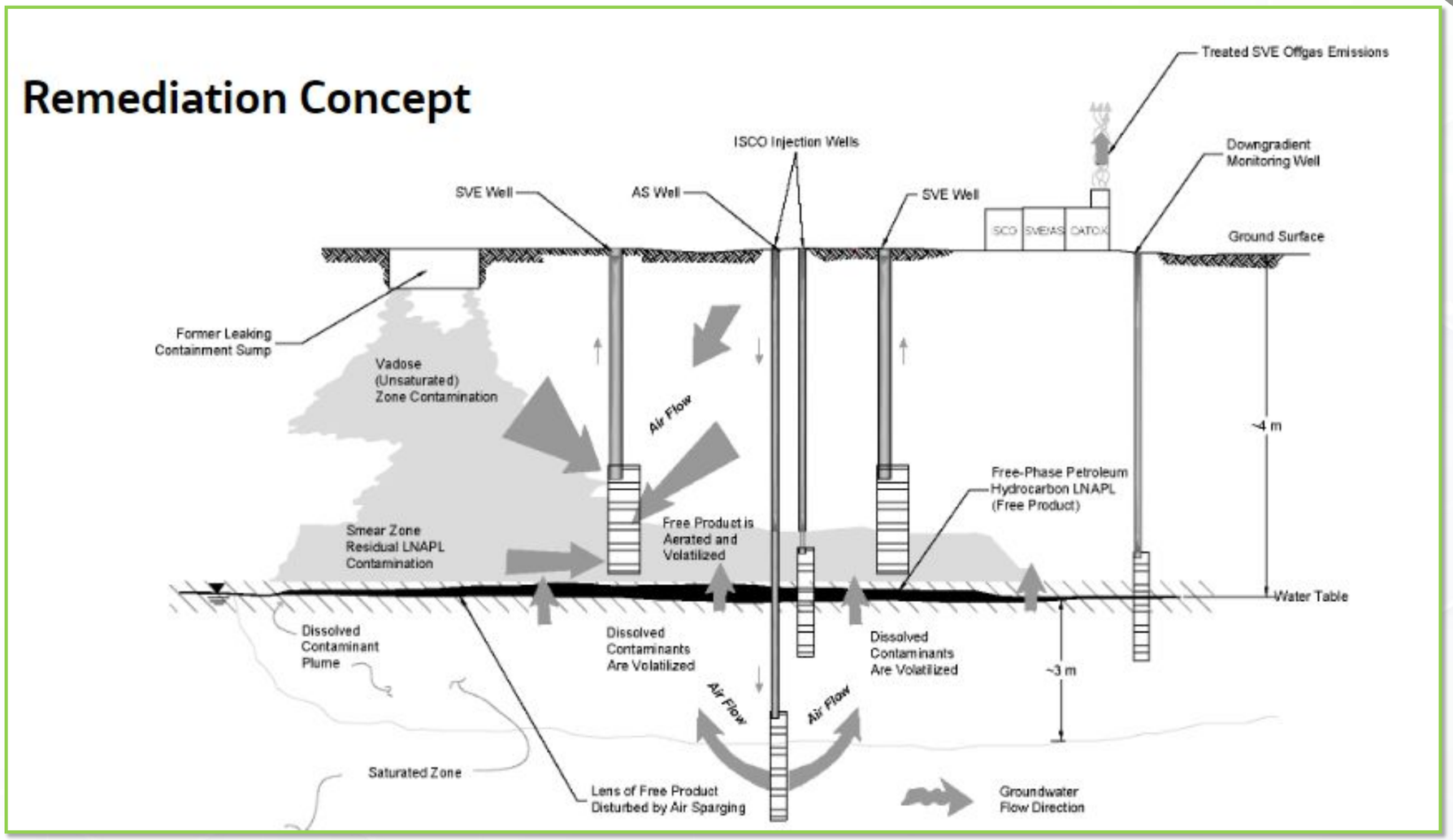
Technology Train

- Phase I – Air Sparge/SVE
  - Fastest way to remove volatile LNAPL mass in conductive soils.
  - Immediate risk mitigation for residence
  - Established technology
  - Monitored and adjusted daily
- Phase II – In-situ chemical oxidation with SVE
  - Activated hydrogen peroxide
    - Oxidation plus SVE recovery increase



https://productiveclub.com/law-of-diminishing-returns/

Remediation Concept



Information reference “An In Situ Treatment Train for Mitigation of Vapour Intrusion from LNAPL in a Residential Area, Calgary, Alberta”. RemTech 2021, A.Hachkowski

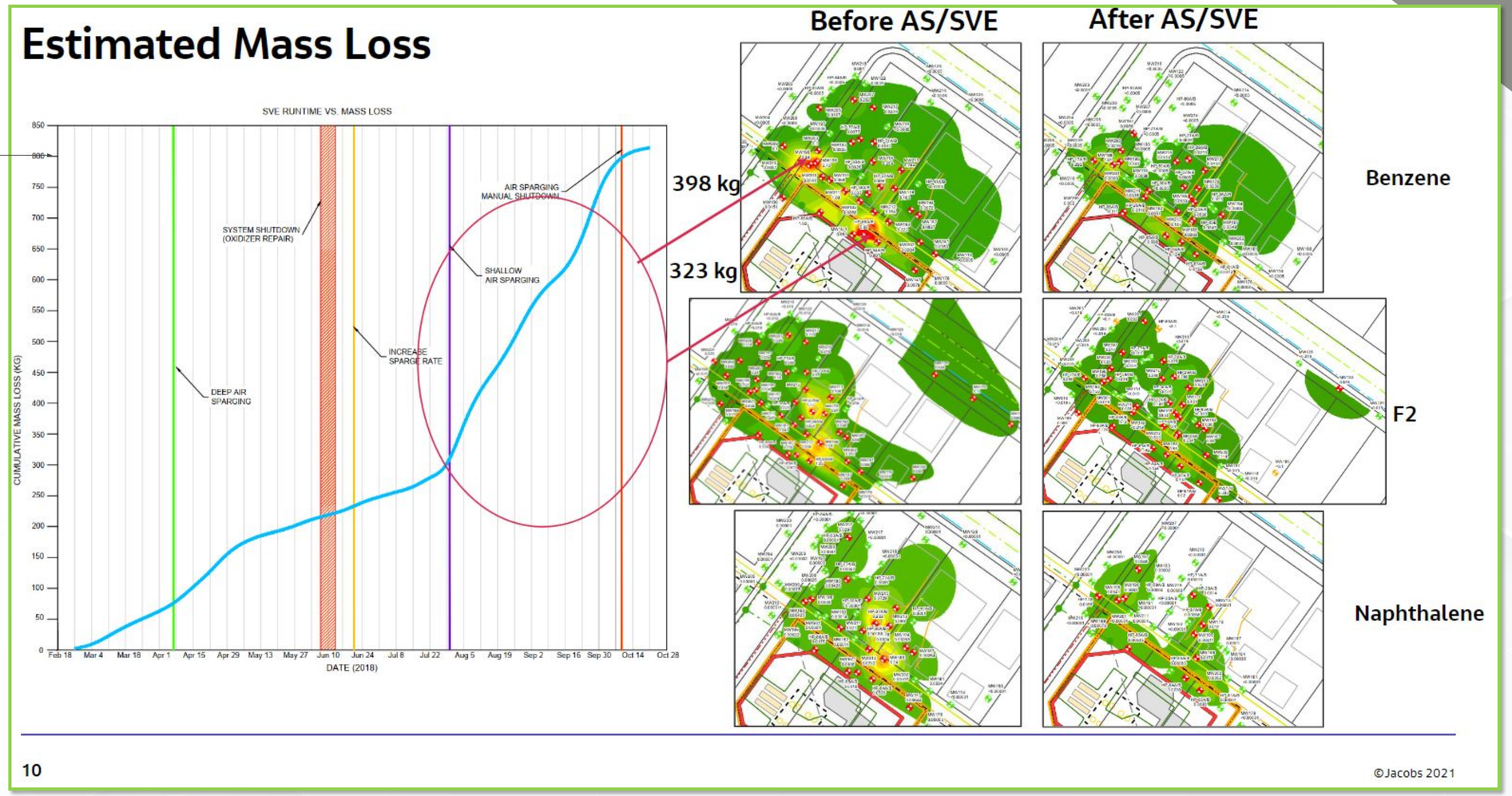
AS/SVE Phase

- 47 nested well pairs (shallow and deep) and 30 SVE wells
- 16 line sparge manifold with SVE capture
  - 2:1 SVE to AS ratio for vapour control
- Gas stream treatment
- Sub slab vapour systems in residences with continuous monitoring/alarm.
- Operated for 1 year

Information reference “An In Situ Treatment Train for Mitigation of Vapour Intrusion from LNAPL in a Residential Area, Calgary, Alberta”. RemTech 2021, A.Hachkowski

AS/SVE Phase

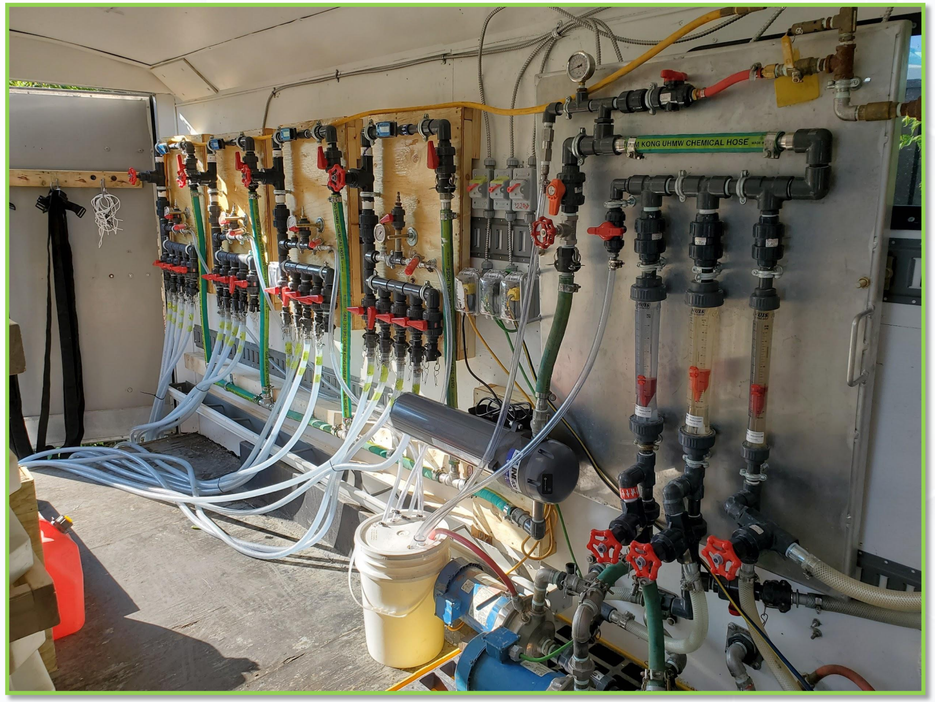
800 kg



Information reference “An In Situ Treatment Train for Mitigation of Vapour Intrusion from LNAPL in a Residential Area, Calgary, Alberta”. RemTech 2021, A.Hachkowski

ISCO Phase

- Activated hydrogen peroxide selected due to geology and contaminant
- Required specialized continuous dilution system
  - Concurrent injection into multiple well pairs
  - Injection parameters maintained (<20 psi and <20 LPM)
  - Monitor SVE capacity to manage gas generation



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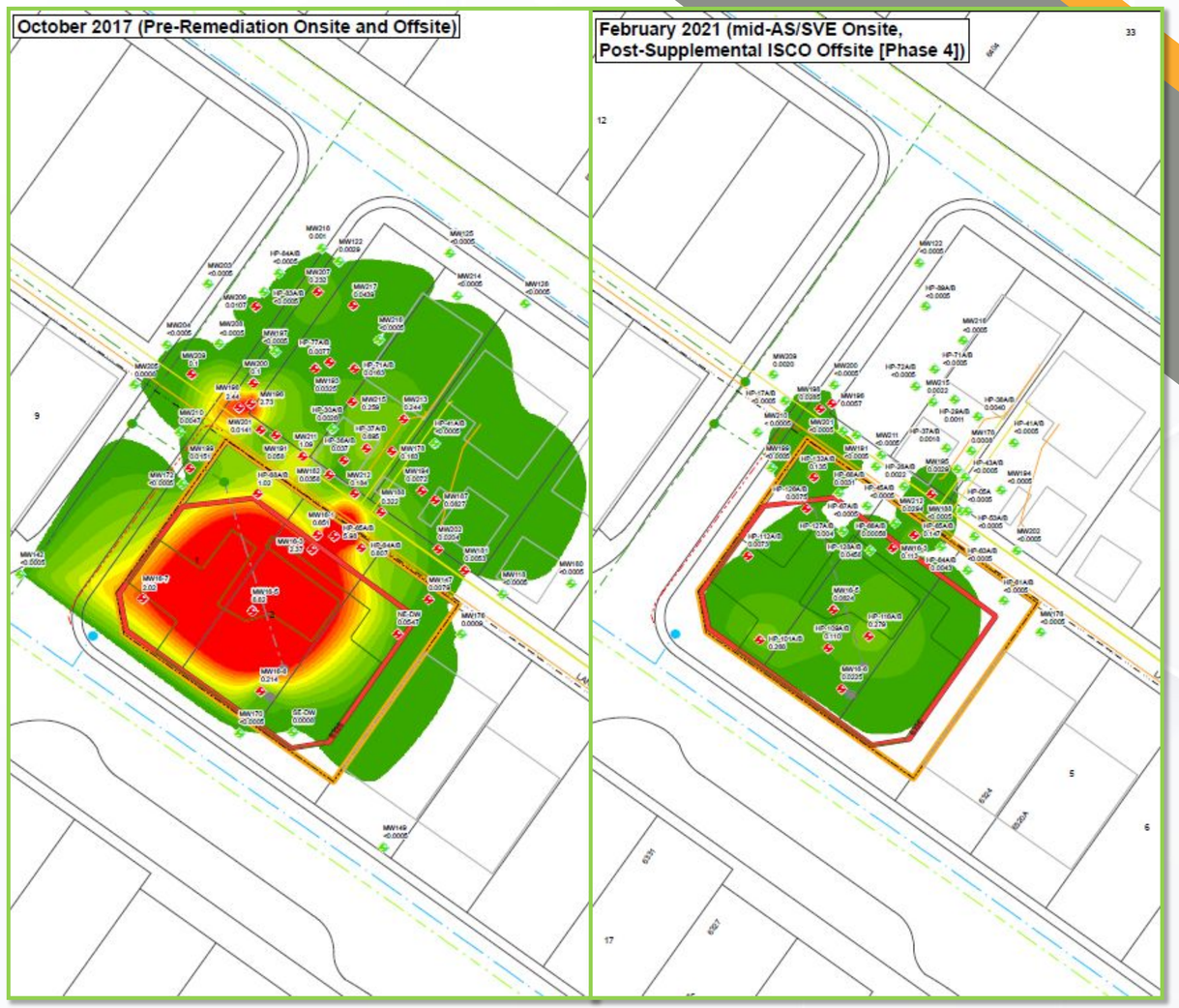
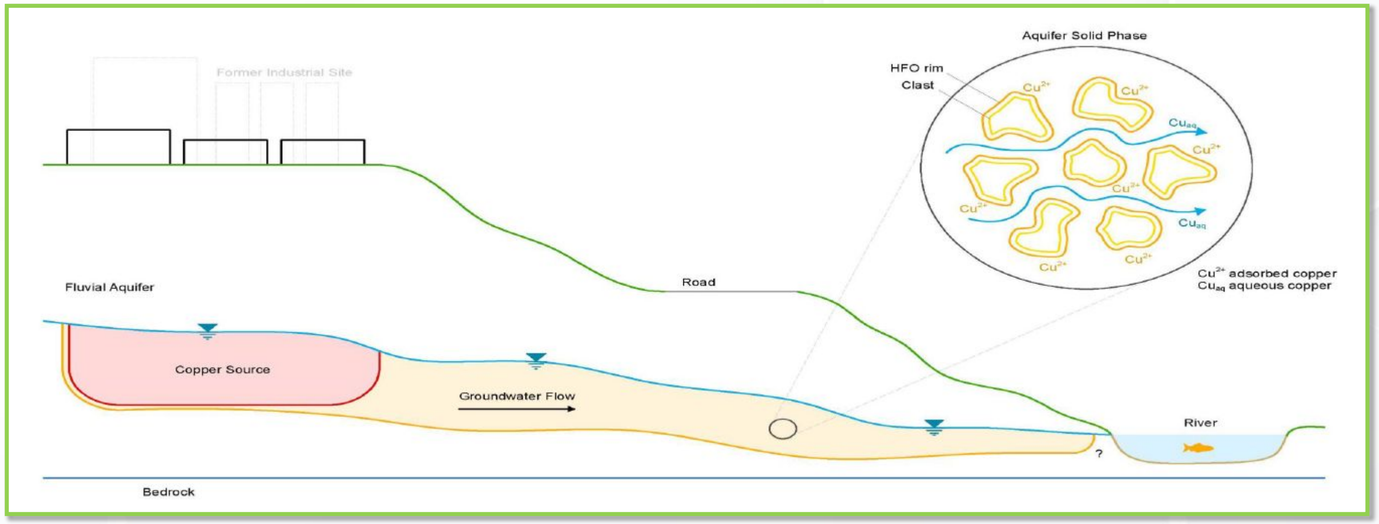
ISCO Phase

- Summary
  - 1,088 m^3 total over 13 week period
    - Up to 36,000 L/day
  - Estimated ISCO mass removal of 242 kg
  - No vapour or dissolved phase rebound
  - 2 year post monitoring stable and below Tier 1 offsite.
  - On-site program in progress with significant reductions shown



Case 2 – New Technology

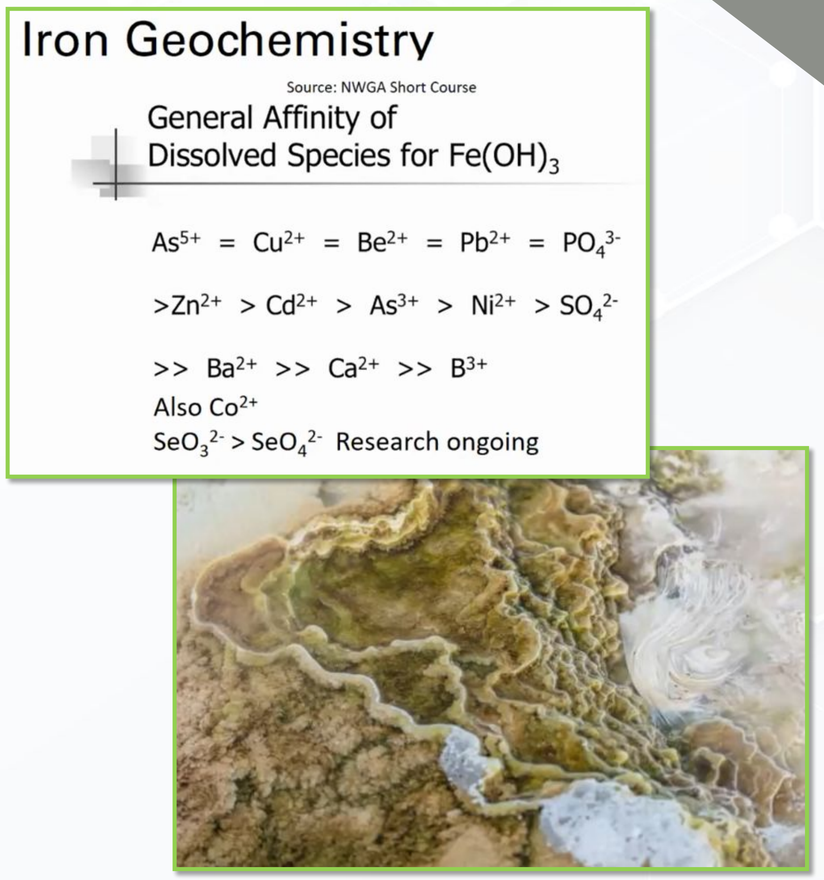
- Former industrial operation developed commercial
- Copper impacts with discharge conditions to nearby river.
- Impacted >3 mbg in sand and gravel
- Target of >100 year permeable barrier.



Information reference “In-Situ Remediation of Dissolved Metals Plume From Concept to Full-Scale Remediation”. RemTech 2021, M. Beveridge

Application Concept

- Create a reactive mineral PRB for adsorption of metals using change solution composition approach
  - 3 PRB Transects
  - Injectable solution and precipitate
- Novel approach
  - Metal oxides very effective for heavy metals adsorption
  - Tested but not full scale deployed
- Challenges
  - Ecological receptors
  - Business operations
  - Confidence and monitoring



Information reference “Remediating Metals with Iron”. GeoPro Talks, 2022, J. Gossen

Technology Train

- Phase I – Benchscale/Column
  - Novel approach required, possibly first in Canada
  - Two reactive materials
  - Cost evaluation
- Phase II – Pilot and Full Scale
  - Inject 100 Tonnes of soluble iron
  - Ensure transect placement
  - Don’t effect the businesses

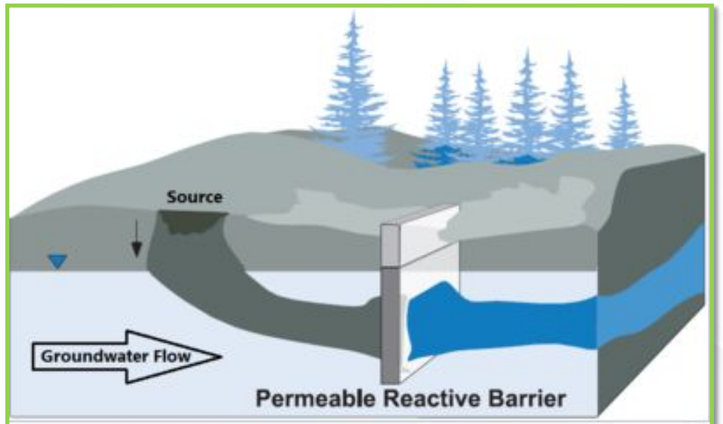
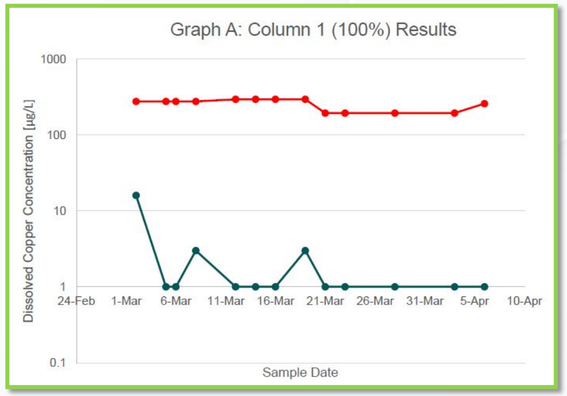


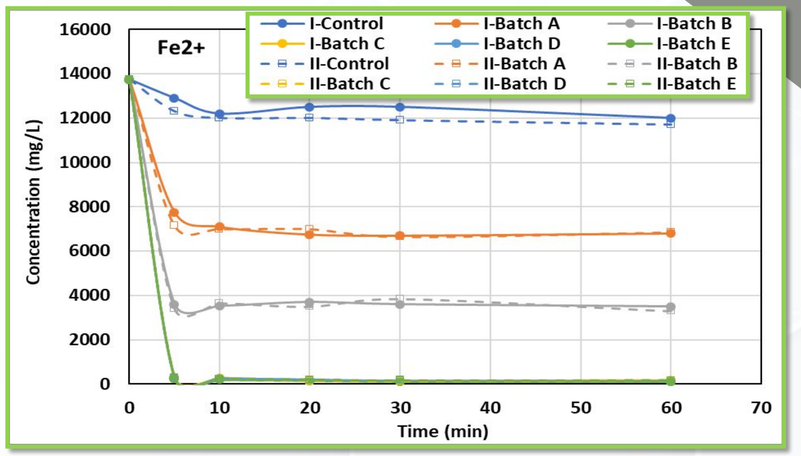
Figure 1. Conceptual Model of PRB. Adapted from Wilkin, et al., 2002[3]

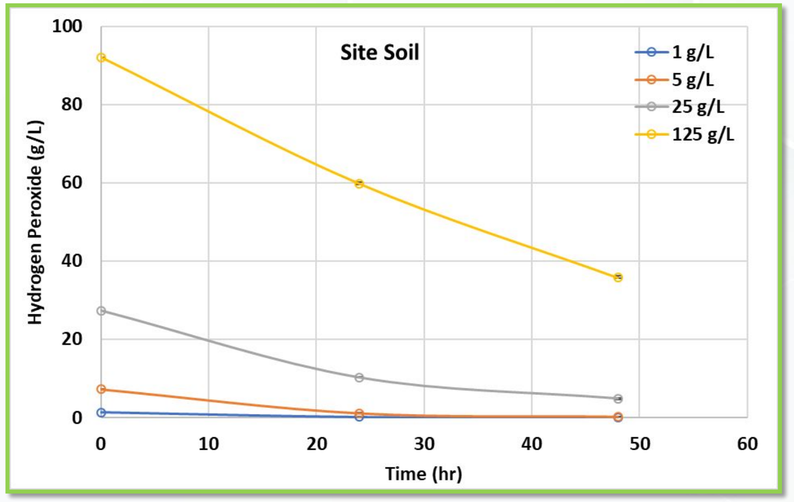


Information reference “Remediating Metals with Iron”. GeoPro Talks, 2022, J. Gossen

Benchscale

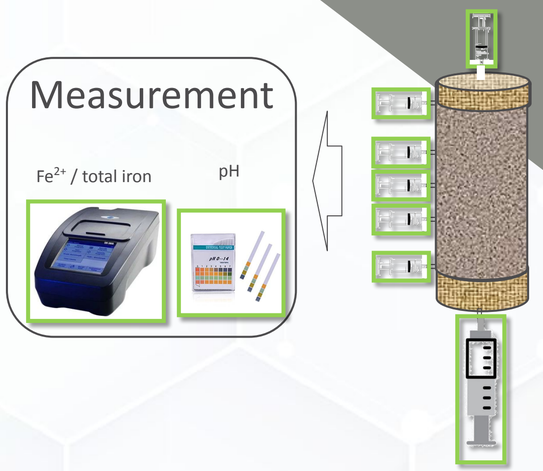
- Reactivity and Precipitation Testing
  - Fe(II) converted to Fe(III) within 10 minutes
  - Vigorous and gas generating reactions expected and observed – safety!
- NOD Testing
  - No appreciable losses measured within 10 minutes
  - Oxidant reaction will be dominated by Fe(II)





Column Testing

- Reaction Timeframe
  - HFO reduced with distance from injection port
  - Proof that precipitation in aquifer can be controlled in target PRB zone
  - Soil pores noted to be restricted at location of injection point
    - Required higher pressure for further dosing
    - Field program would focus on large batch injections with higher flow rates for more even distribution



Pilot/Full Scale

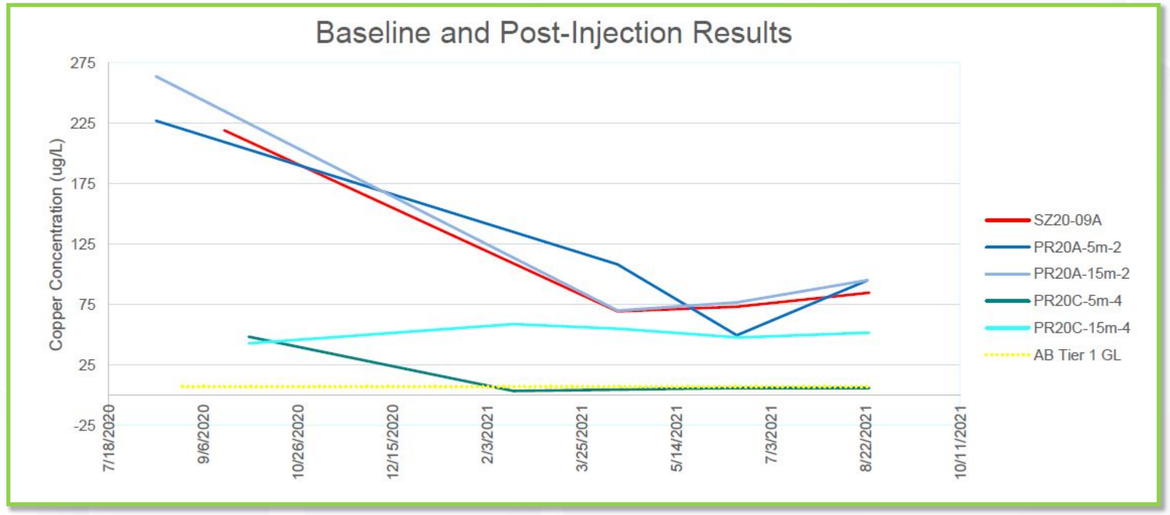
- Well pack system
  - Extraction in 3 upgradient wells
  - Concurrent injection in 3 downgradient wells
    - Create a reverse flow condition
    - Issues with rate to create dispersive flow
    - Groundwater blended with Fe(II)
    - Combined with hydrogen peroxide at wellheads.
    - Well downgradient (5 and 15 meters) and extraction wells continuously monitored for Total Fe, pH, DO for breakthrough.

Pilot/Full Scale

- Challenges Overcome
  - Visibility and Operations
    - Night time operations and logistics
    - Material handling
    - Optics and attention
    - Sensitive ecological receptor
  - Safety
    - Reactive mixture and gas generation
    - Ongoing monitoring and precipitation
  - Injection
    - Well clogging
    - Dispersive flow vs “sheer” flow

Results

- Up to 99% decrease in dissolved copper
- A couple weak points noted in PRB (37% removal)
  - Localized injections being planned
- Risk management objectives exceeded with ongoing monitoring



Summary

- Pre-planning is key
- Don’t get caught in a one solution mindset
  - The planned coupling of technologies at the front end saves later.
- Results are a direct effect of planning, effort and a consistent strategy
- Great teams figure out ways to overcome the challenges
  - Trust and collaboration among the parties

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Thank You.

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