The Use of Remediation-Driven Characterizations to Develop a Multi-Faceted Remedial Program

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Presentation Outline

- Introduction and Overview of Hydrocarbon Impacts
- Development of Remedial Action Plan
- Remediation-Driven Characterization & Pilot Testing
- Re-evaluation of Remedial Action Plan
- Conclusions
- Questions

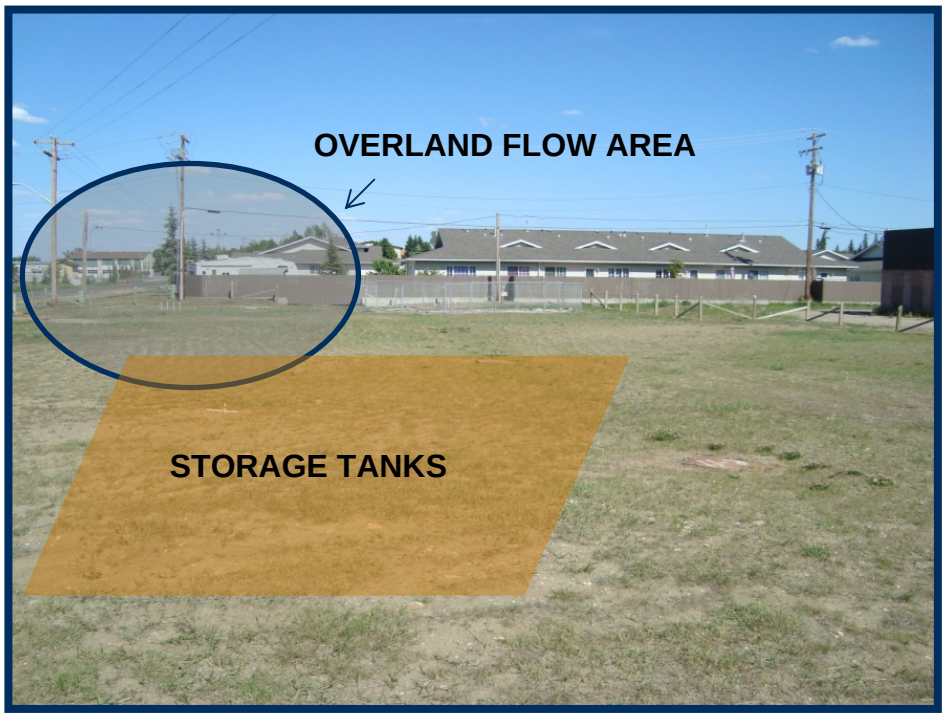
Introduction
A Brief Site History

The site is located in northern Alberta.

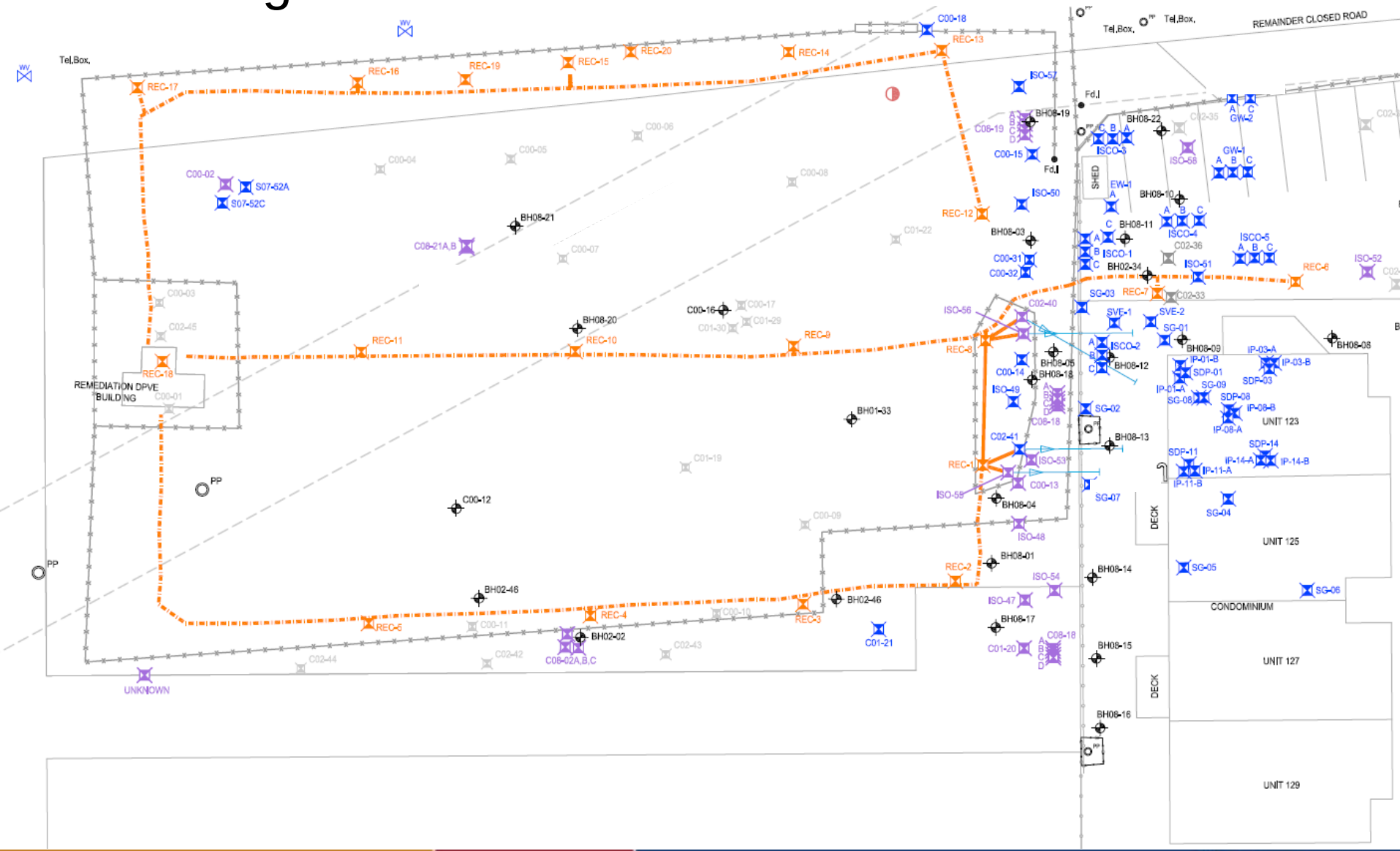
Operated as a UFA bulk and retail fuel facility from 1959 - 1999.

LNAPL & PHC impacts observed during the Site decommissioning in 2000.

Anecdotal evidence of significant surface releases with overland flow.



Introduction
Site Diagram



Introduction
Historical Activities

2000 Initial delineation

2002 Soil excavation (6,400 m^3)

2002 Indoor air sampling program initiated

2003 *In Situ* Chemical Oxidation (ISCO) injection (unsuccessful)

2005 Multiphase extraction (MPE) system installed (still operating)

2007 Subslab Depressurization (SSD) system installed beneath condos (still operating)

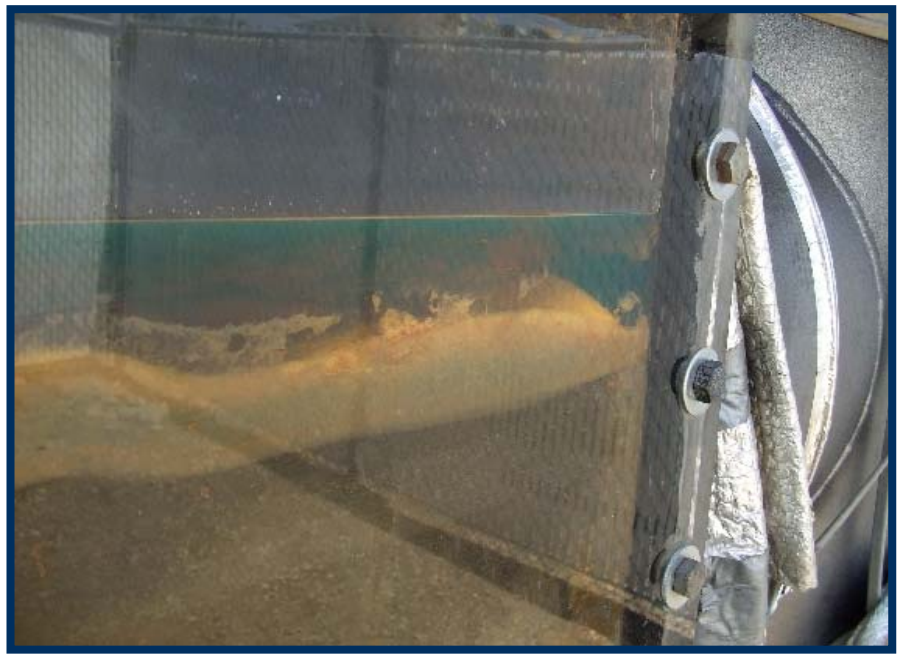
2008+ Additional delineation and remediation evaluation

Introduction
Remedial Objectives

Client wanted to pursue active remediation as opposed to risk management strategies.

The primary goal was to sell condominium properties near market value.

Remediate the site to AENV Tier 2 Guidelines.

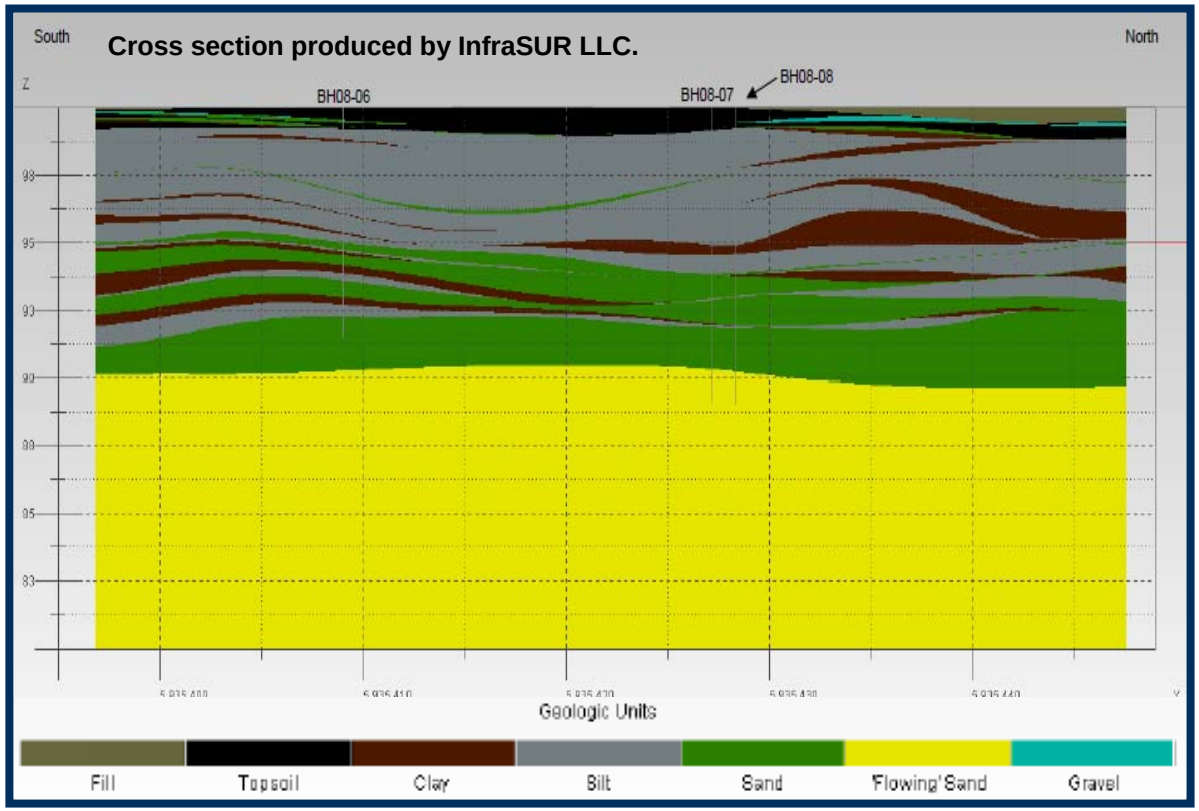


Introduction
Lithology

The site presents a complex lithology and hydrogeology, divided into two zones:

Zone A – Low permeability, partly saturated, glacial sediments (clay and silt)

Zone B – Moderate permeability saturated sand layer that fines upward to silt



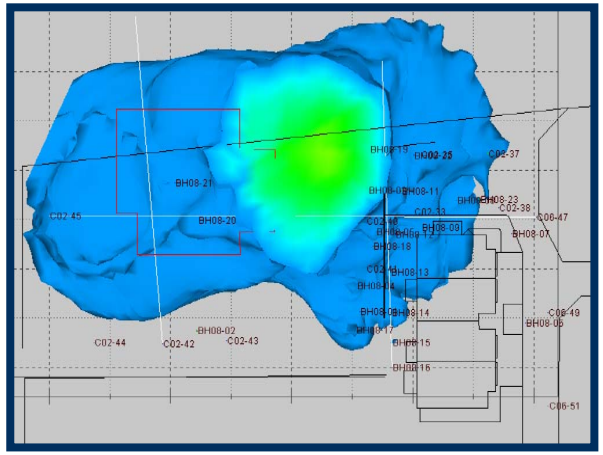
Introduction
Contaminant Migration

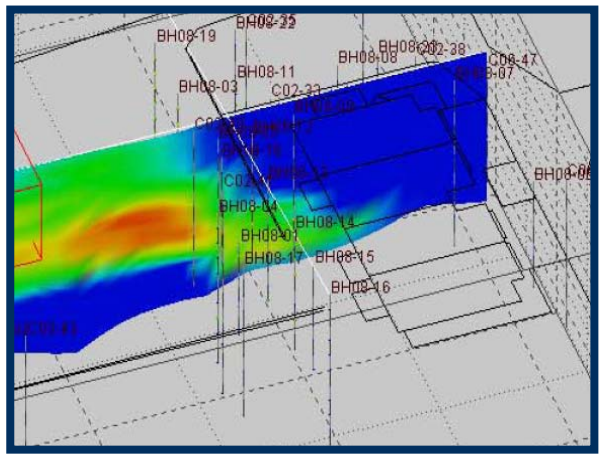
Extensive NAPL smear zone, extending into Zone B

NAPL in Zone A
+ heterogeneous sand/silt layers
+ VOC presence under northern condo unit
= *Potential Vapour Inhalation Concern*

NAPL in Zone B
+ strong downward hydraulic gradient
+ high benzene solubility
= *Domestic Use Aquifer Concern*

NAPL source zone remaining on the UFA property





Remedial Action Plan
Outline

An intensive phase approach was initiated:

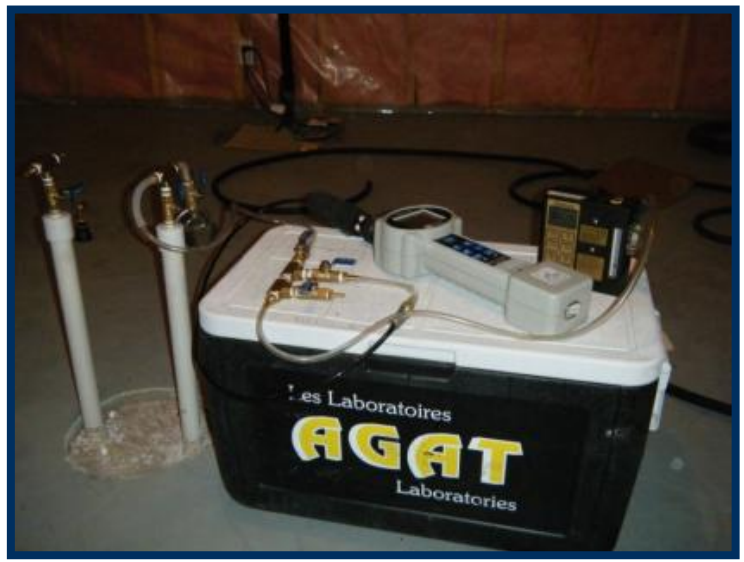
Conceptual Design

Drilling & Baseline Sampling

Pilot Testing & Feasibility Studies

Development of Site Specific Guidelines

Detailed Design and Implementation



Remedial Action Plan
Conceptual Design

Develop a multi-faceted remediation program to address each of the aspect of the contamination plume on the site.

1 – Existing **MPE** Recovery (UFA)

(Source Control and Removal)

2 – **VE** System (Condo)

(Vapour / Injectate Capture)

3 – **Ozone** Injection System

(Condo Specific)

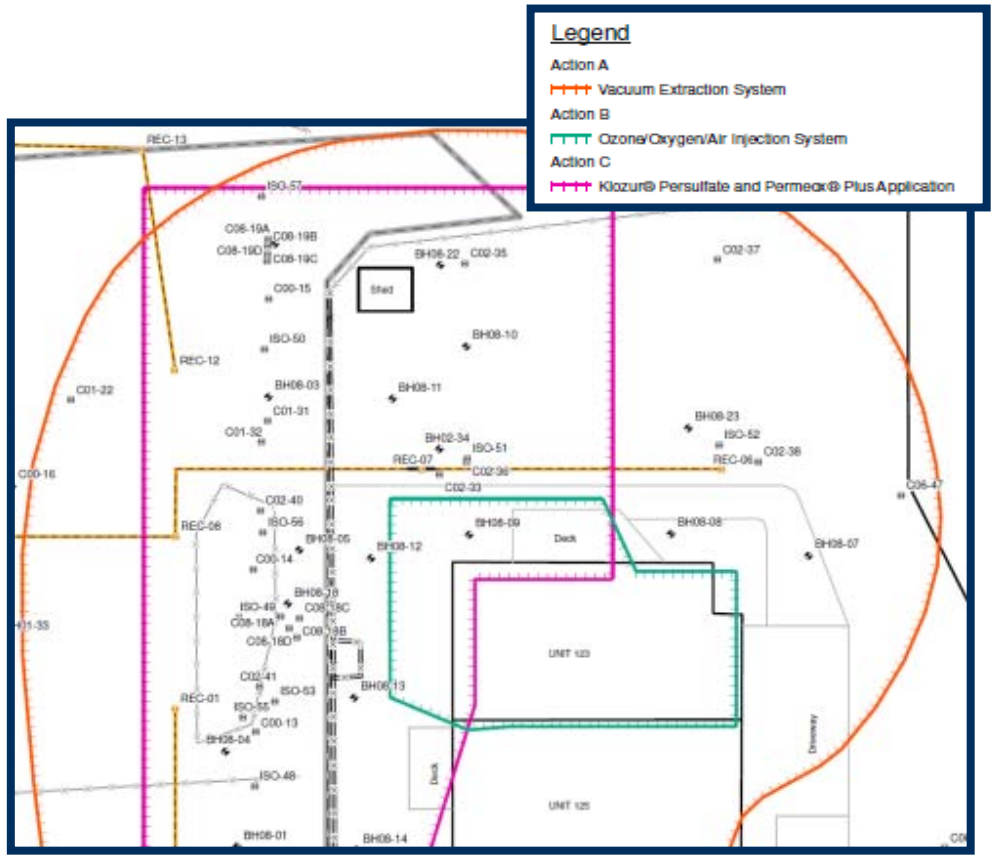
4 – **ISCO** in Saturated Zone

(Persulfate)

5 – Enhanced **LNAPL** Removal

(Surfactants /

Solubility Enhancers)



Characterization

Baseline Sampling & Outdoor Drilling

Baseline sampling was conducted to achieve a solid understanding of the current site status. Baseline sampling included:

Groundwater Sampling

Physical Parameter Analysis

Passive Soil Gas Sampling

Carbon Stable Isotope Analysis

Aerobic and Anaerobic Microbial Profiling

The Geoprobe 8040 was successfully used to collect continuous core samples and install prepack monitoring wells where other methods failed.

Characterization
Indoor Drilling

Retained a specialized indoor drilling company to characterize impacts below the Condo using a combination of direct push, solid stem, and hollow stem drilling.

Installed prepack injection points for remediation and monitoring.

Pilot Testing
Overview

Extensive bench-scale and pilot-scale testing was conducted to evaluate the feasibility of the remediation concepts.

1 – Helium Tracer Testing

Evaluate the vapour intrusion pathway and soil gas transport mechanisms

2 – Subslab Pressurization / Depressurization Testing

Test vapour intrusion mitigation methods

3 – Vacuum Extraction Pilot Testing

Test vapour and injectate capture efficiency

4 – Hydraulic and Multiphase Extraction Pilot Testing

Feasibility assessment of aquifer dewatering and groundwater recovery

5 – Bench-Scale and Pilot-Scale ISCO Testing

Test the feasibility and costs for persulfate and ozone remediation

6 – Surfactants / Solubility Enhancers Bench Scale Testing

Feasibility assessment of surfactants for enhancing LNAPL recovery

Pilot Testing
Helium Tracer Testing

Completed soil gas advection and diffusion tests combined with modeling.

Advective Test

Demonstrated that advection is the dominant process and that the SSD system effectively enhanced soil gas transport near the Condo

Diffusive Test

Demonstrated that diffusion is slow on the site, which provided an important line of evidence in subsequent risk management and vapour intrusion activities

Pilot Testing
Subslab Testing

Evaluated the feasibility of using positive or negative pressure systems as a barrier to soil gas intrusion and potential injectates.

Pressurization Testing

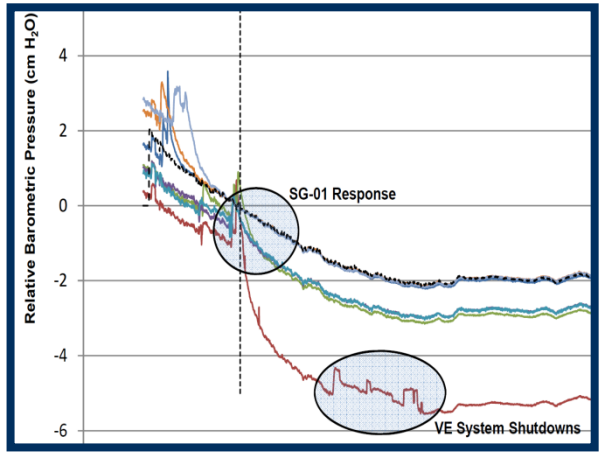
No significant pressure buildup was achieved due to air leakage to surface and/or the large storativity of the subslab materials (**Infeasible**)

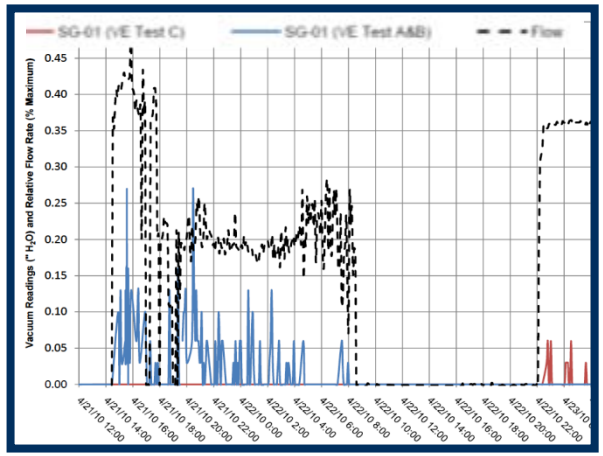
Depressurization Testing

~100% helium capture observed, demonstrating that an enhanced SSD system can capture the majority of soil gas and injectates prior to entering the condo **(Feasible)**

Pilot Testing
Vacuum Extraction Testing

Evaluated the feasibility of VE for remediation and injectate capture.





Observations

Minimal radial influence (<1m)

Significant groundwater mounding

Suggested a large capillary fringe, later verified by other methods

VE remediation and capture impracticable

Pilot Testing
MPE & Hydraulic Testing

Completed dewatering and hydraulic testing to evaluate injection and surfactant scenarios. Attempted to lower the capillary fringe.

Results

Lower permeability than expected

Zone A & Upper Zone B hydraulics inadequate for confident surfactant or ISCO application

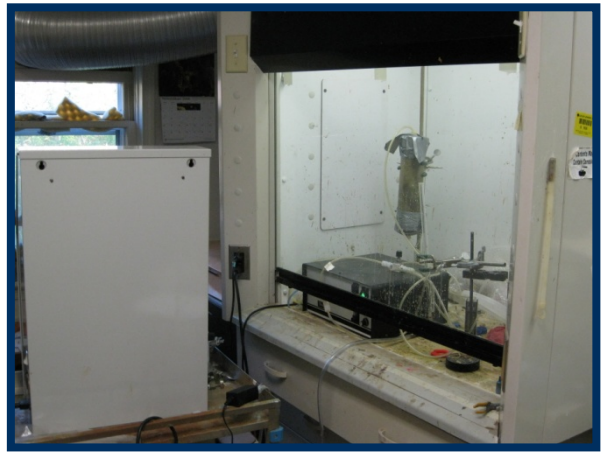
Dewatering / lowering capillary fringe impracticable

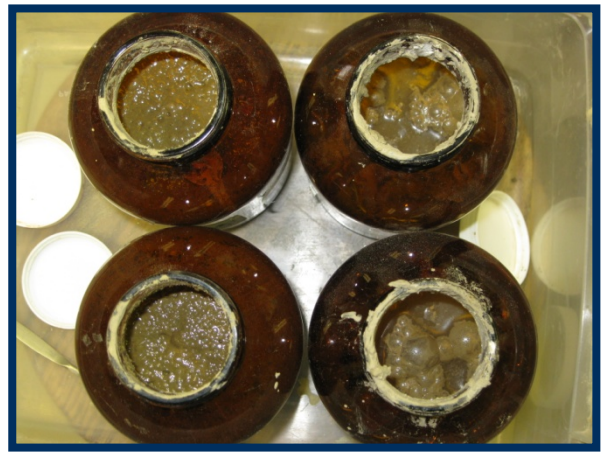
Pilot Testing
Ozone, Persulfate and Surfactants

Ozone Injection
Bench scale – **Successful**
Pilot scale – Ozone simulated with Helium, demonstrated connectivity between Zone A & Zone B (**Potentially Feasible)**

Persulfate Injection
Bench scale – **Uncertain**
- Unactivated persulfate may work in A Zone
- Activated persulfate may work in B Zone
(Cost prohibitive, technically uncertain)

Surfactant Testing
Bench scale – **Successful**
(Technically uncertain due to low permeability)





Pilot Testing
Conclusion

Remedial Method	Result	Decision
MPE Operations	Needs Optimization	**Continue Operations** Decrease well spacing & optimize
Vacuum Extraction	Infeasible	**Remove from RAP**
Ozone Injection	Feasible	Full scale too risky without VE system **Limited implementation?**
Persulfate Injection	Inconclusive	Low confidence and cost prohibitive **Remove from RAP**
Surfactant Flushing	Low feasibility	Low confidence due to permeability **Remove from RAP**
Hydraulic Control	Infeasible	**Remove from RAP**
SSD System	Needs Optimization	**Install upgraded SSD system**

Site Re-evaluation
Technical Impracticability

Characterization and pilot testing demonstrated that aggressive short term remediation was technically impracticable, despite the extensive effort and costs.

The result was not as desired and demonstrated that despite very comprehensive characterization and pilot testing efforts, in-situ remediation is difficult to implement and is not always feasible.

Remaining Options

Upgraded SSD System (Mitigation)

Optimized MPE Operations (Source Removal)

Limited Ozone Injection (Questionable Effectiveness)

Additional Components Needed >>> Risk Assessment

Site Re-evaluation
Risk Management Approach

A change in direction has been adopted by UFA and the project team, based on the knowledge gained. The project has now shifted to a risk management approach.

The impacts remaining onsite need to be carefully managed in order to protect the occupants of the condominium and the domestic use aquifer.

Risk Management Approach

Additional Source Removal – MPE and Excavation

Human Health Risk Assessment

Enhanced SSD System Beneath North Condo Unit

Manage Risks to the Domestic Use Aquifer

Conclusions

- The initial plan was to aggressively remediate the Condo property, which required a multi-faceted remedial strategy.
- Significant planning was completed to develop a conceptual strategy.
- Remediation-driven characterization and pilot testing activities were conducted.
- The evaluations concluded that the RAP had a low probability of success and was deemed technically impracticable, as were alternative methods.
- The RAP was re-evaluated to focus on risk management and source removal, using the existing characterization data for support.
- The characterization and pilot testing activities cost a significant amount of money; however, significantly less than early full scale implementation.
- The project demonstrated that in-situ remediation is difficult and not always technically practicable, despite the most extensive characterization and pilot testing efforts.
- Always expect surprises.

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QUESTIONS