Vertex Environmental Inc.

In-Situ Remediation of Petroleum Hydrocarbons – Combining Remedial Techniques

SMART Remediation
Toronto, ON
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Overview

- Background
  - Vertex
  - Remediation Technologies
- Case Studies
  - Commercial Redevelopment
  - Residential Oil Spill
  - Flowing Sands
- Conclusions
- Questions

Background

- Bruce Tunnicliffe, P.Eng., M.A.Sc.
- Vertex = Environmental contracting
- Remediation & Delineation Services:
  - High-Resolution Characterization
  - Remedial Design
  - Bench, pilot, and full-scale
  - ISCO, ISCR, enhanced biodegradation
  - Treatment systems work (MPE, SVE, etc)

Remediation Technologies

- Excavation
- Systems Technologies
  - Pump and Treat, Multi-Phase Extraction, Soil Vapour Extraction
- In-Situ Chemical Oxidation
  - Fenton's Reagent, Permanganate, Persulphate, Percarbonate
- In-Situ Chemical Reduction
  - Zero Valent Iron (ZVI), edible oils, lactates
- Enhanced Bioremediation
- Risk Assessment

Excavation

Case Study #1

Commercial Redevelopment

Former Car Dealership

Commercial Redevelopment

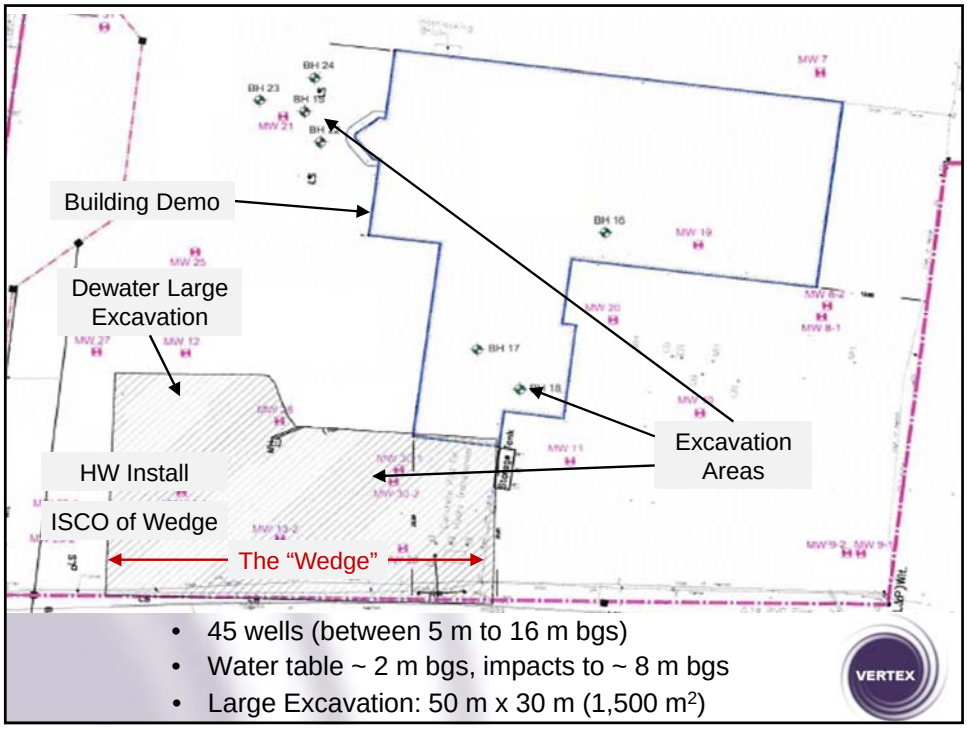
- Residential redevelopment proposed
  - Formerly used for automotive servicing, gasoline service station, painting and automotive repair
  - Record of Site Condition (RSC) required
- PHC impacts identified in the soil and groundwater (to 8 m bgs):

Contaminant	Max Soil Impact (ug/g)	Soil Std (ug/g)	Max GW Impact (ug/L)	GW Std (ug/L)
Benzene	-	0.17	880	5
PHC (F1)	1,300	65	2,800	750
PHC (F2)	1,800	150	30,000	150
PHC (F3)	-	1300	6,500	500
MtBE	-	1.4	60	15

Commercial Redevelopment

Proposed Remedial Approach:

1) Demolish existing building
2) Excavate impacted soil except property boundary wedge
3) Dewater the excavation, treat & discharge
4) Install horizontal wells to treat gw & the wedge
5) ISCO for remaining PHCs in gw & in soil in the wedge
6) Confirmatory sampling



- 45 wells (between 5 m to 16 m bgs)
- Water table ~ 2 m bgs, impacts to ~ 8 m bgs
- Large Excavation: 50 m x 30 m (1,500 m^2)

1) Demolish existing building

2) Excavate impacted soil except property boundary wedge

3) Dewater the excavation, treat and discharge

4) Install horizontal infrastructure within the open excavation

Horizontal Wells

Installing HWs into Excavation

5) ISCO for remaining GW impacts and wedge area soil impacts

OR

Commercial Redevelopment

Summary:

- Work completed between Sept 2012 and Jan 2013
- 3 excavations completed
- 2,600,000 L of PHC impacted groundwater treated
- 28 horizontal wells installed in large excavation
- 2 ISCO injection rounds completed
  - into temporary injection points within the wedge
  - into horizontal wells
  - Approx. 8,000 kg: persulphate and base activation
  - Approx. 65,000 L of solution

Commercial Redevelopment

Results:

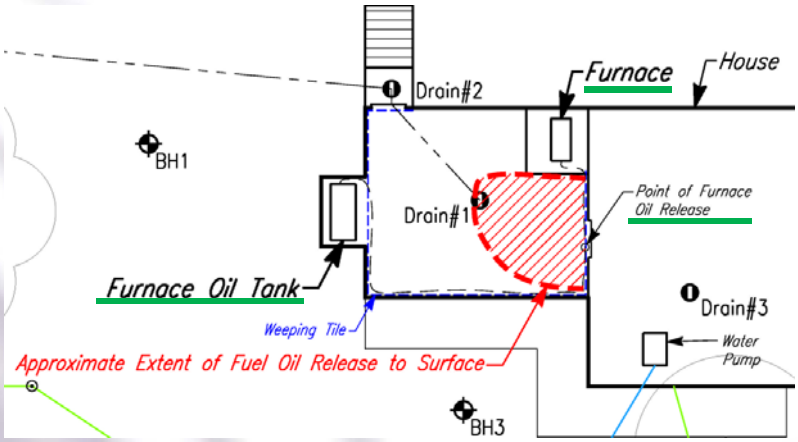
- After excavation, soil impacts removed, except in wedge
- After excavation, PHC groundwater impacts remained (10,000 ug/L)
- After 1 injection, PHC groundwater and soil impacts, but greatly diminished (<1,000 ug/L)
- After 2 injections:
  - All soil samples in the wedge met the Standards (>95% treatment)
  - All groundwater samples met the Standards (>99.5% treatment)
- A third injection round was planned, but was not required
- Successful clean-up

Case Study #2

Residential Oil Spill

- 150 year old stone farm house with fuel oil AST
- Fuel line between AST and furnace leaked
- Oil entered basement floor drain
- Migrated through weeping tiles and to the subsurface

Residential Oil Spill



Residential Oil Spill

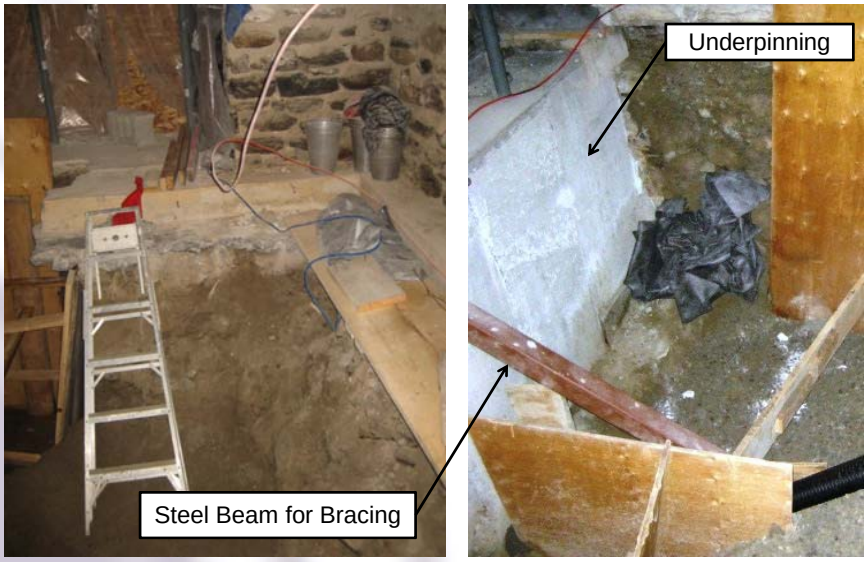
Conditions:

- Free phase PHC(F2) oil on concrete floor
- Floating free phase oil
- Soil: boulders, cobbles, sand till over sandy silt till
- Soil underlain by fractured limestone bedrock
- Water table at 2.2 m below basement floor
- GW – 1,000,000,000 ug/L PHCs
- Soil - >10,000 ug/g PHCs

Remedial Approach:

- Excavation with underpinning
- Possible ISCO

Residential Oil Spill



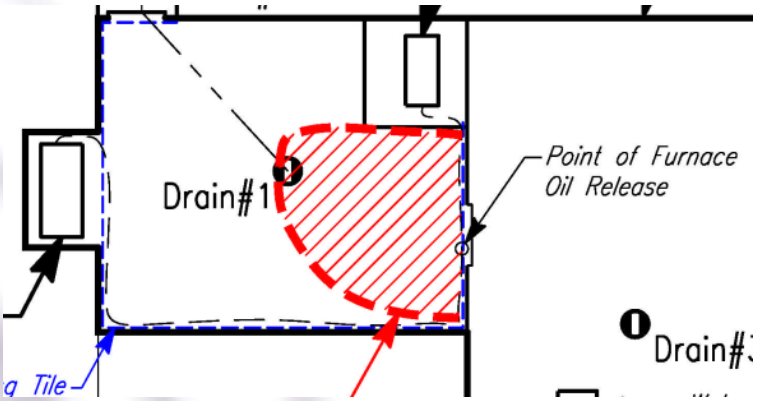
Residential Oil Spill

Conditions (after excavation):

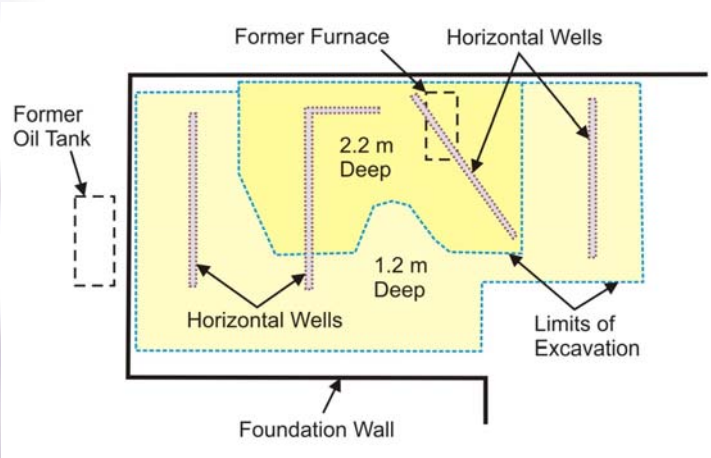
- Bedrock outcrops in excavation
- Significant remaining PHC impacts
- Free phase oil at base of excavation

Parameter	Max Soil Impact (µg/g)	Soil Std (µg/g)	GW from Sump (µg/L)	GW Std (µg/L)
PHC (F1)	250	55	4,400	750
PHC (F2)	3,100	98	770,000	150
PHC (F3)	1,000	300	260,000	500

Residential Oil Spill



Residential Oil Spill



Residential Oil Spill

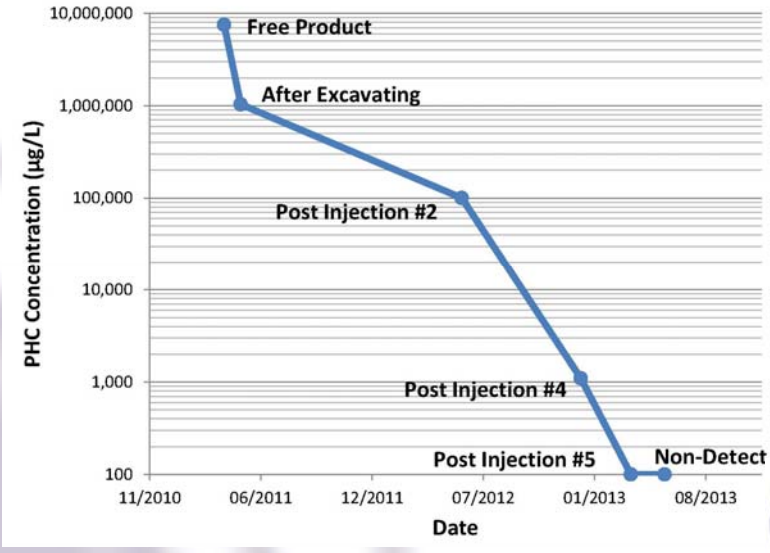
- Five ISCO injections into HWs
- Total:
  - 14,000 L of 15% to 20% base-activated persulphate

Results:

Parameter	GW Std (µg/L)	Groundwater (µg/L)			
		Pre-ISCO	Post Inj #2	Post Inj #4	Post Inj #5
F1 PHC	750	4,400	<100	<100	<100
F2 PHC	150	770,000	61,000	860	<100
F3 PHC	500	260,000	39,000	240	<100
Total	-	1,034,400	100,000	1,100	<100

- Greater than 99.99% treatment
- All PHCs below Standards
- Successful clean-up

Residential Oil Spill Case Study



Case Study #3

Flowing Sands

Flowing Sands

Background:

- Leaking fuel oil UST
- Surgical excavation to remove soil directly around UST
- Pump and treat system operated at the site for >two years
- More aggressive approach requested

Initial Conditions for Vertex:

- 70 cm of free-product at one location
- Free-product present at 7 MW locations
- Up to 7,500,000 µg/L PHCs in groundwater

Flowing Sands

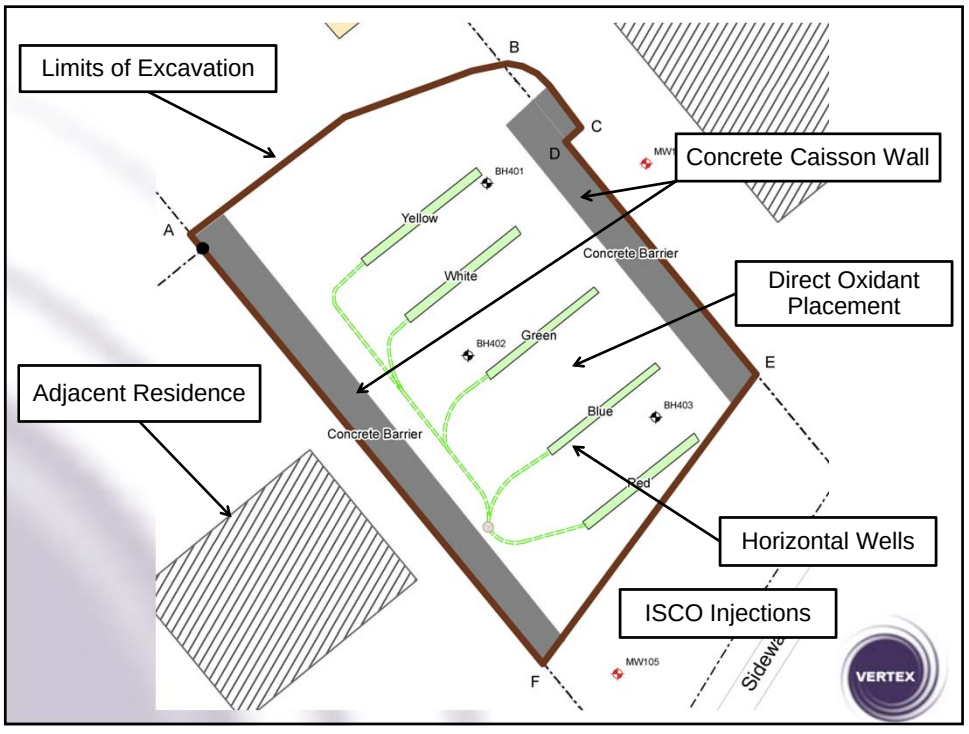
Staged Remedial Approach:

1. Demolish residential house
2. Install concrete caisson wall on either side of property
3. Excavate PHC impacted soils to practical limits
4. Direct placement of oxidant in excavation
5. Installation of horizontal well infrastructure
6. ISCO Injections
7. Confirmatory Sampling

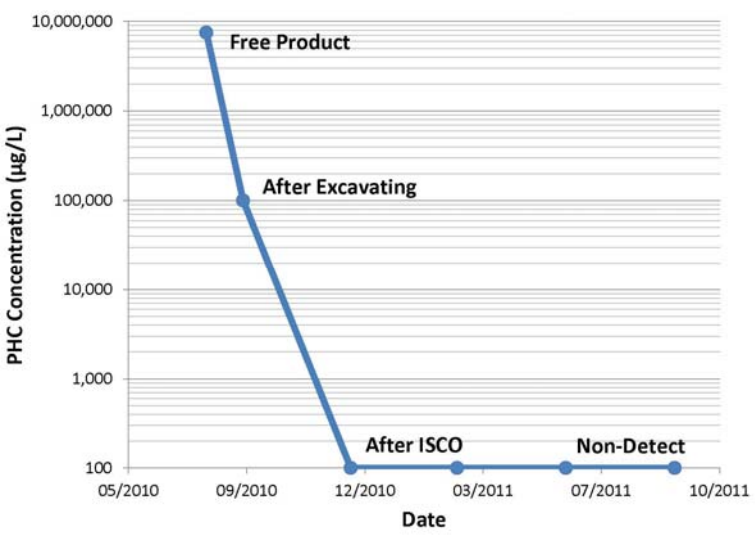
Direct placement of 1,500 kg oxidant (sodium persulphate) and base activator

Flowing Sands

Horizontal wells installed in the trenches at the base of the excavation



Flowing Sands Case Study



Flowing Sands

Summary:

- "Surgical" removal of impacted soils and pump and treat was ineffective.
- Caissons installed, soils excavated, chemical oxidation (direct placement and injection).
- Approx. 2,000 kg of persulphate and associated base activation used.

Results:

- Greater than 99.99% treatment obtained.
- All wells below drinking water standards for four consecutive events.
- Successful clean-up (after unsuccessful start).

Closing

Conclusions

- Single remediation approach not always the best approach to PHC remediation
- Excavation – excellent remedial approach, but:
  - Inaccessible soils can be expensive to remove
    - i.e. property boundary, beneath footings, close to or in bedrock
  - Impacted groundwater can remain after a dig
  - Digging impacted groundwater not cost effective
- ISCO can be applied by direct placement, injection through horizontal wells and/or through temporary injection points
- Stringent GW Standards reached with ISCO

Questions?

Thank You for Your Time

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