PHYTO-INTEGRATED™ Remediation System to Address CCl_4 Contaminated Groundwater in Low-Permeability Aquifer

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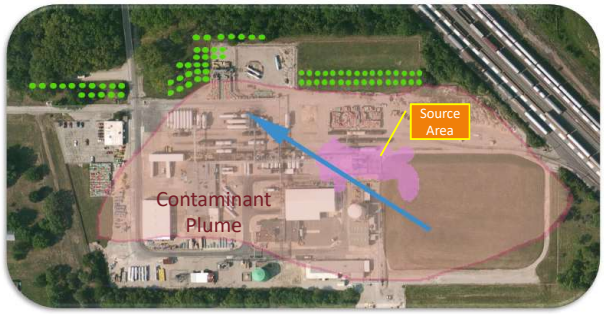
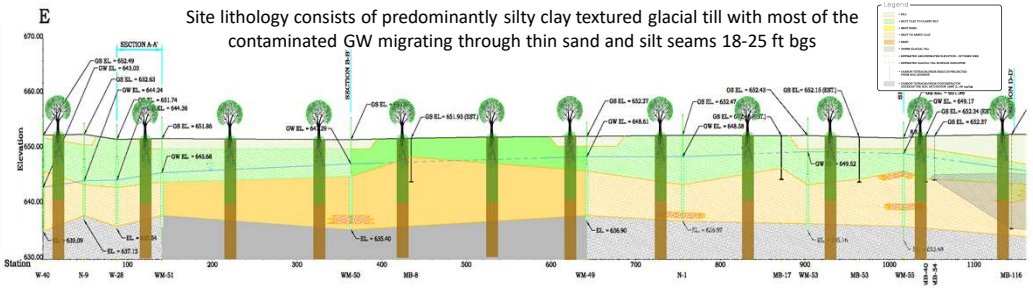
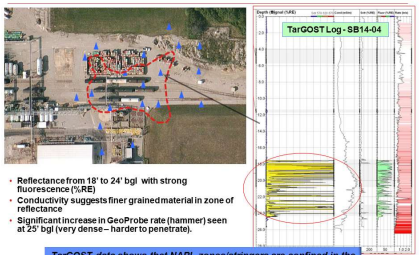
SITE CONDITIONS – EASTERN ILLINOIS : LOW YIELDING SILTY-CLAY TILL TO 25 FT BGS – GW MOVING IN SAND, SILT, & GRAVEL STREAMERS 18-25 FT BGS



Site lithology consists of predominantly silty clay textured glacial till with most of the contaminated GW migrating through thin sand and silt seams 18-25 ft bgs



TarGOST Investigation



- Reflectance from 18' to 24' bgl with strong fluorescence (%RE)
- Conductivity suggests finer grained material in zone of reflectance
- Significant increase in GeoProbe rate (hammer) seen at 25' bgl (very dense – harder to penetrate).

TarGOST data shows that NAPL zones/stringers are confined in the low permeability material above the aquitard at approx. 25' bgl.

BACKGROUND/OBJECTIVES

Site History

- 1955 through 1994 – Production and packaging of chlorofluorocarbon refrigerants – Conversion to packaging only in 1994
- 1978 – Identification of release of carbon tetrachloride (CCl_4) in the rail loadout area - 1979 – Entered Pre-Notice Site Cleanup Program and transitioned into IEPA Site Remediation Program
- 1980 – Implementation of Interim Remediation Measure pump-and-treat system
- 2008 through 2009 – Phase I, REC Identification, Site Investigation Report
- 2014 – Remedial Alternatives Evaluation
- 2015 – Initial *TreeWell* Unit Implementation
- 2016 – Pump-and-treat system idled due to hydraulic effectiveness of *TreeWell* Technology
- 2016/2017 - Secondary *TreeWell* Unit Implementation to capture western edge of the plume

Recent History

- Following completion of a Remedial Alternatives Evaluation, a combination of in-situ electrical resistance heating and engineered phytoremediation was selected. In 2015 a *PHYTO-INTEGRATED™* remediation system employing patented *TreeWell®* technology was installed to replace a recovery well system and capture and remediate the CCl_4 plume. Groundwater migrates through a low permeability glacial till approximately 25 feet deep and underlain by a denser till that functions as an aquitard. In general, the saturated thickness of the shallow aquifer within the till material ranges from 8 to 25 feet below ground surface (bgs). The upper portion of the saturated horizon consists primarily of tight silty clay while the basal portion consists of silty to sandy clay with some thin gravel and sand/silt lenses. In general, these lenses occur 18 to 25 feet bgs and constitute most of the contaminant plume's migratory pathway.
- In early 2015, 51 *TreeWell* units (*Units*) were installed; 33 units south of Solid Waste Management Unit (SWMU) #4 and 18 units west of SWMU #4. The 51 TreeWell units installed in 2015 were placed in 42-inch diameter soil borings that were advanced to a depth of 30 below ground surface (bgs).
- The initial 2015 planting areas were installed to evaluate the effectiveness of the *TreeWell* Technology to remove dissolved-phase contaminants; eliminate potential for off-site migration of dissolved phase contamination; and to evaluate tree species applicability. Species utilized for the trial were Hybrid Poplar and Willow. To monitor the hydraulic effects of the phytoremediation system, pressure transducer dataloggers were installed in piezometers located inside selected *Units* as well as in existing monitoring wells placed in and around the installation. To monitor the remedial effects, groundwater samples were collected from piezometers installed inside *Units* and/or monitoring wells during subsequent sampling events.
- An additional 28 *TreeWell* units were installed at the site in the fall of 2016. Of the 28 total units, 18 units were drilled alongside a cluster the *TreeWell* units that were installed in 2015 west of SWMU #4 and 13 units were drilled in an existing lawn area to the north of the main office building at the site. The 28 units installed in 2016 were strategically placed to capture the westerly flow of the dissolved phase groundwater plume at the Site. The *TreeWell* units installed in 2016 were placed in soil borings that were advanced to a depth of 18 feet bgs with a 42-inch diameter auger and then continued to a depth of 30 bgs with a 24-inch diameter auger.
- **Results/Lessons Learned.**
- Positive hydraulic and remedial effects have already been realized and confirm the predictive modeling.

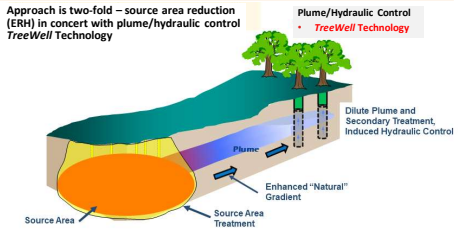
Objectives

- Hydraulic and Plume control of groundwater downgradient of the source area with TreeWell Technology
- Reduction of Carbon Tetrachloride contaminant mass in the source area with Electrical Resistance Heating (ERH)

IMPLEMENTATION – *TREEWELL* UNITS MAY 2015 & APRIL 2017 || ERH – SPRING 2018

Conceptual Design – *PHYTO-INTEGRATED™* Remediation System

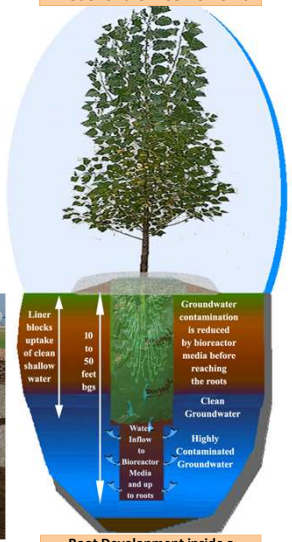
Approach is two-fold – source area reduction (ERH) in concert with plume/hydraulic control *TreeWell* Technology



Source Area Treatment

- Thermal Remediation (ERH)

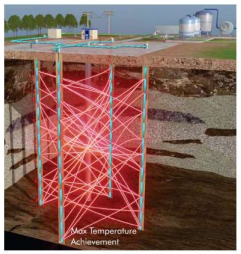
Model of the *TreeWell* Unit



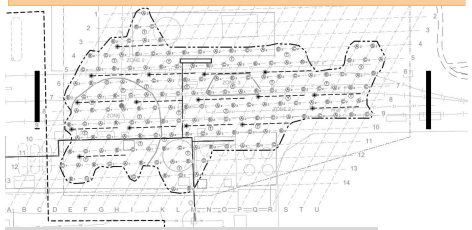
Electrical Resistive Heating (ERH)

- Electro-Thermal Dynamic Stripping Process (ET-DSP™) is used to heat the soil to volatilize contaminants.
- Electrodes are placed in the ground and three phase power is applied such that the current causes the soil temperature to increase.
- Temperature increases result in volatilization of contaminant mass
- The vapor is extracted with a soil vapor extraction system
- Extracted vapor is captured and treated.

The conceptual model to the right is being applied for source area remediation. Below is the Electrode and Sensor Layout in the Source Area



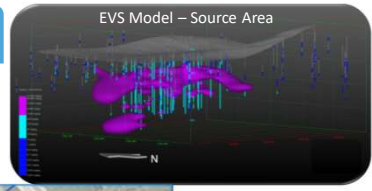
Source Area – Electrode and Sensor Layout

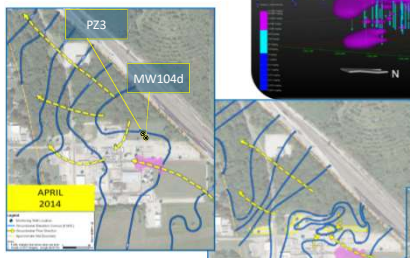


- 166 electrodes spaced 17 feet apart. Depths ranging from 20 to 30 ft bgl
- 26 temperature and vapor monitoring points

Root Development inside a *TreeWell* Unit

RESULTS TO DATE





Systems Installed May, 2015 & April 2017

As trees matured groundwater was drawn from the upgradient source area toward the *TreeWell* Plantation (see MW104d). Piezometer PZ3 (non-detect at installation – May 2015) exhibits low concentrations of CCl4, increasing only slightly from Nov, 2015 to Feb, 2018. Hydraulic control was established in 3rd year of impressive tree growth.

TreeWell Technology vs Pump-&-Treat

- **Pumping potential at full canopy (79 trees): ~1.5 gpm or ~800k/yr**
- **Function of tree type, leaf area, sun exposure, depth to water, soil hydraulic conductivity, and soil/groundwater chemistry**
- **Pumping Potential for P&T (2 Horiz. Wells) : ~ 1.5 gpm or ~ 800k/yr**

Small Pump & Treat System

- **Capital Cost: $400,000 (first year)**
- **O&M Cost: $75,000/yr (20 years)**
- **Cumulative Cost: $1,900,000/20 years**
- **NPV@3% $1,515,811**

Phytoremediation

- **Capital Cost: $600,000 (2015+2017)**
- **O&M Cost: avg $10,000/yr (20 years)**
- **Cumulative Cost: $800,000/ 20 years**
- **NPV@3% $766,523**

Potential Cost Savings of $750,000