

DIRECTIONAL
Technologies, Inc
Horizontal Directional Drilling Services

Horizontal Remediation Wells

Horizontal Remediation Technologies • Installation • Design • Engineered Well Screens • Services



Horizontal Wells for Remediation of Chlorinated Solvent Sites

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Brief Company Introduction

- Directional Technologies, Inc. is Celebrating 25th Anniversary.
- Horizontal Well Technology Company
Specializing in:
 - Horizontal Remediation Well (HRW) System Design.
 - HRW Screen Engineering.
 - HRW Installation with Horizontal Directional Drilling.
 - HRW Development, and O&M Support.
- Installed over 1,000 HRWs for the Environmental Industry.
- International Experience and Recognition.
- Woman Owned Small Business.

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Presentation Outline



- Part 1: Horizontal Remediation Overview
 - Horizontal Directional Drilling Technology.
 - Horizontal Remediation Well (HRW) Design.
 - Applications & Advantages.
- Part 2: Horizontal Remediation Case Studies/Example Projects
 - 1) Horizontal ISCO Injection – PCE Brownfield Site.
 - 2) Horizontal Groundwater Extraction – Landfill.
 - 3) Horizontal Bio-amendment Injection – Perchlorate Site Near River.



Installing first ever horizontal remediation wells (HRWs) in South Korea

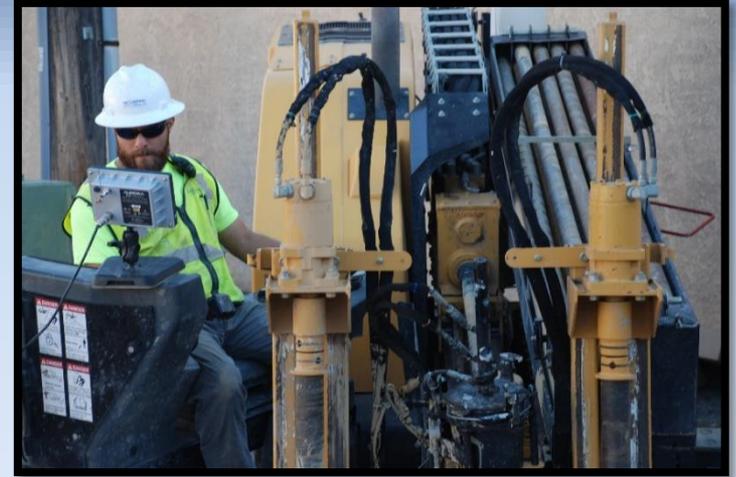


Horizontal Directional Drilling (HDD) Technology



HDD Rigs

- Angled for near horizontal entry.
- Capable of depths ranging from 1 feet BGS to 100 feet BGS, (but can also drill up-hill).
- Horizontal Bore lengths of over 1,000 feet BGS.
- Steerable drill bits for horizontal and vertical adjustments during drilling.
- Track mounted for off-road mobility.
- Safety built into the design (hands free drilling).





HDD Technology (continued)

Real-Time Drill Bit Tracking Systems:

- Walk-over locators (most commonly used)
 - Depths to 50 feet BGS
 - Data relayed: depth, pitch (bit inclination), tool-face, and temperature
- Wire-line locators
 - For greater depths >50 feet BGS
 - Good for inaccessible areas (busy roads, restricted buildings, water or wetlands, etc.)
 - However, more time consuming, and therefore increased costs.



Walk-over Locating System (DigiTrac F5 Falcon)



Real time tracking beneath building slab.



Angled face for steering



Drill bit housing with sonde

Horizontal Remediation Well (HRW) Design

Design Considerations: Entry-Exit Wells vs. Blind Wells

- Entry-Exit Wells:
 - Two access points.
 - Larger diameter wells: 2-inch to 12-inch.
 - Easier Maintenance.
- Blind Wells (do not daylight):
 - Exit point not required.
 - More layout options.
 - Reduced total linear feet (cost effective).
 - Limited to 2-inch and 3-inch diameter wells.

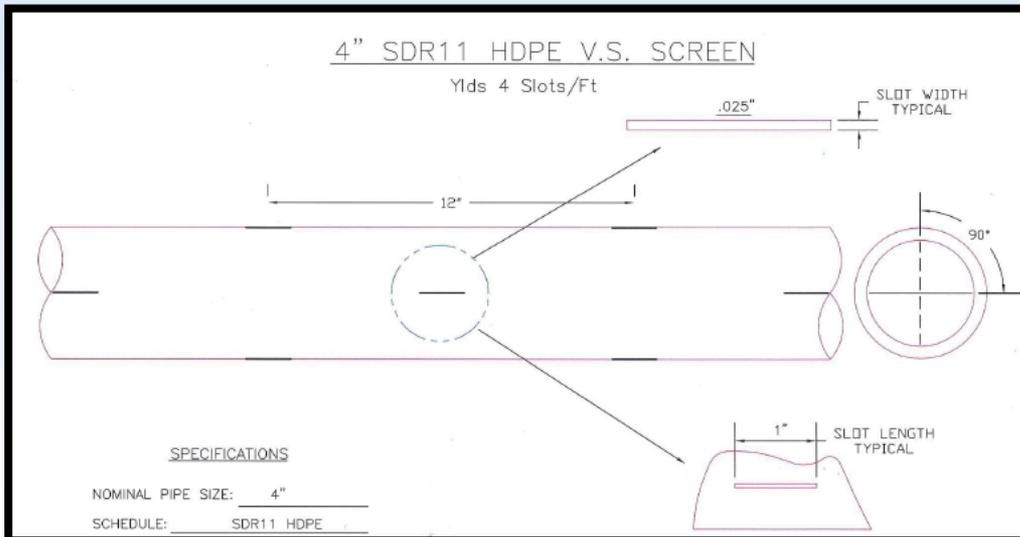


Drill Bit Exiting for Entry-Exit Well

Horizontal Well Screen Design

Design Considerations: Well Screen Engineering:

- Critical to the success of a horizontal well.
- Horizontal wells must be properly designed for the application.
- Proper design ensures desired fluid flow through the entirety of the horizontal well.
- Directional Technologies owns proprietary wells screen design software.
- Multiple types of well materials: HDPE, Schedule 80 PVC, Stainless Steel.
- Custom slot lengths, widths, and spacing for the desired application.



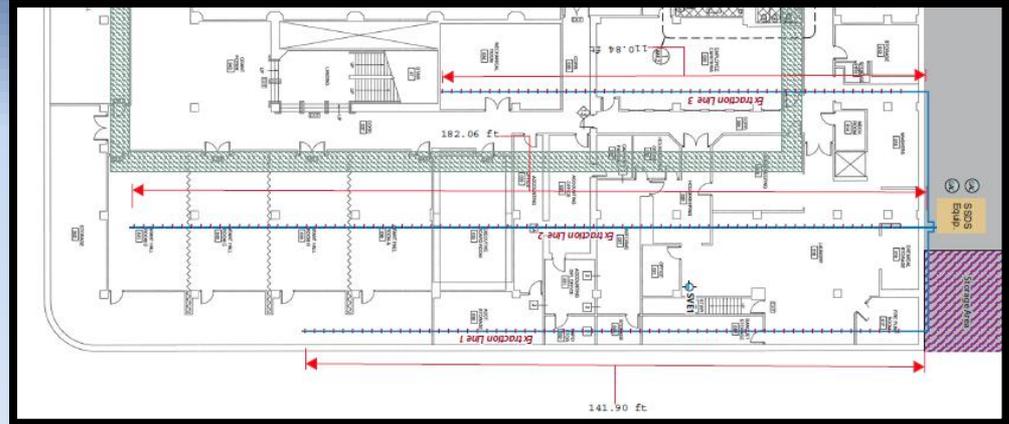
Applications of Horizontal Wells:

Remedial Applications:

- Soil Vapor Extraction
- Air/Oxygen/Ozone Sparge
- Dual Phase/Multiphase Extraction
- Sub-Slab Vapor Intrusion Mitigation
- ISCO Injection
- Bio-augmentation Injection
- Hydraulic Control/Dewatering
- Electrical Resistance Heating (ERH)

Any vertical remediation well technology can be successfully applied horizontally

Assessment: HDD/HRW technology can be used for horizontal soil & groundwater sampling.



Horizontal Hydraulic Control Well for Landfill Leachate Containment



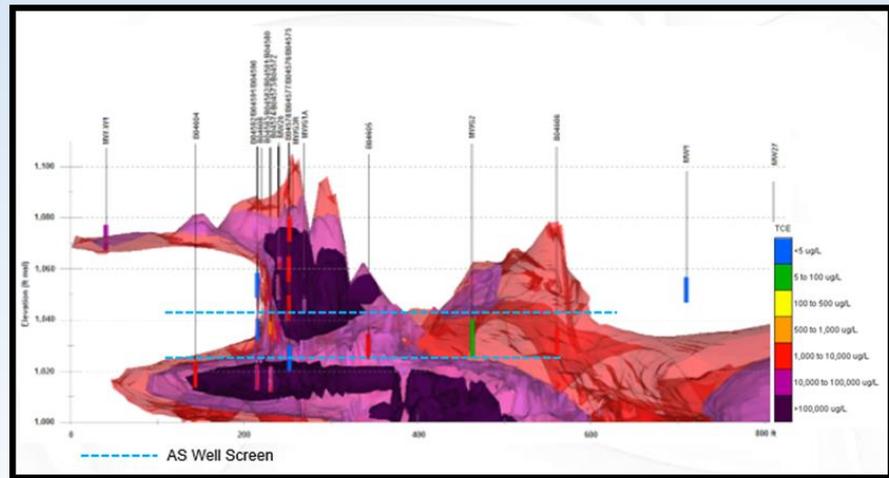
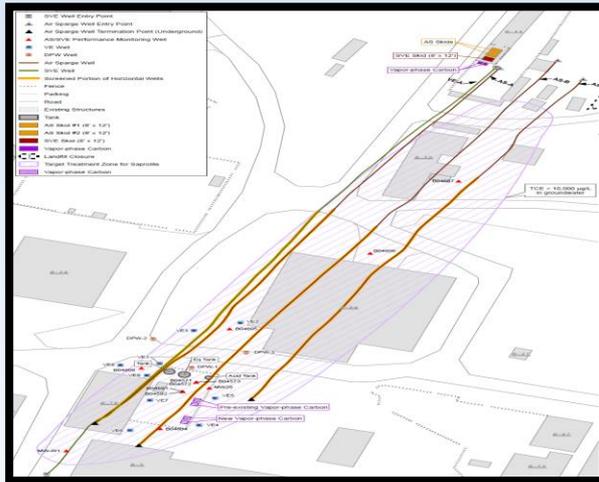
Horizontal Hydraulic Control Well for Landfill Leachate Containment



Advantages of Horizontal Wells:

- #1: Access: Horizontal directional drilling enables access beneath surface obstructions.
- #2: Normal Business Activities Continue without Interruption.
- #3: More screen contact with planar contaminate plumes = Expedited site cleanup.
- #4: Remediation of large areas: One horizontal well can take the place of multiple vertical wells within a linear path (see below example site).
- #5: Safety.

Horizontal wells: ~800 feet long, 60 feet to 80 feet deep, beneath multiple buildings.



Part 2: Horizontal Remediation

Example Projects



- 1) ISCO Injection – PCE Brownfield Site
- 2) Horizontal Groundwater Extraction – Landfill.
- 3) Horizontal Injection – TCE Site – Urban Setting.

Example Site # 1: ISCO Injection – PCE Brownfield Site - Maryland

Acknowledgements:

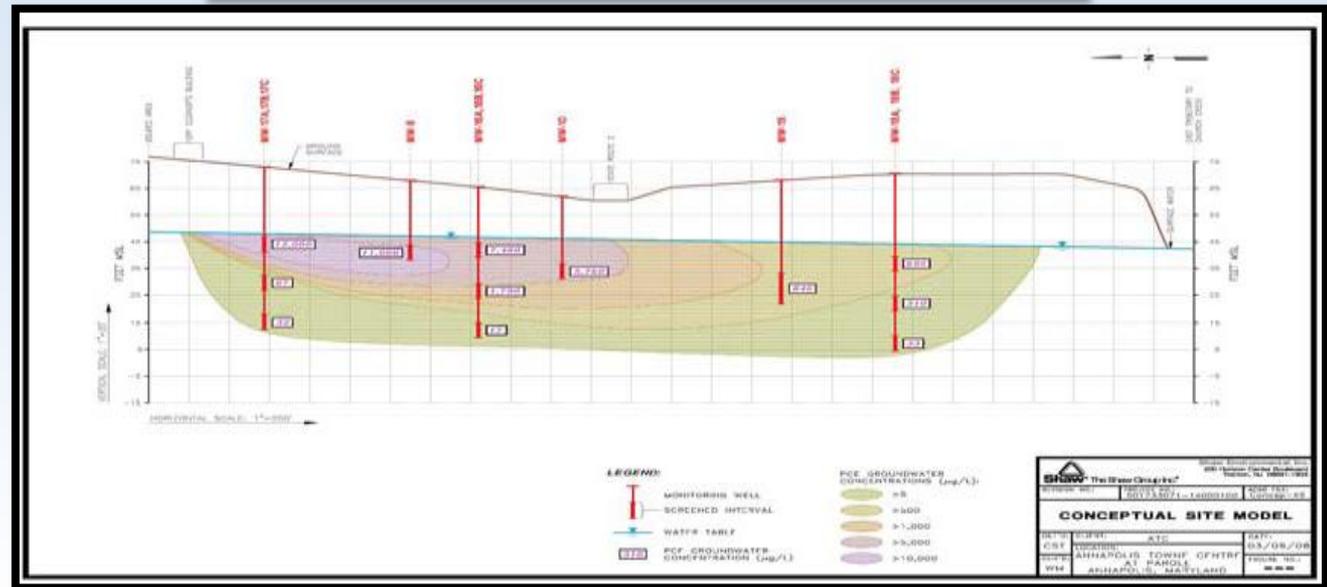
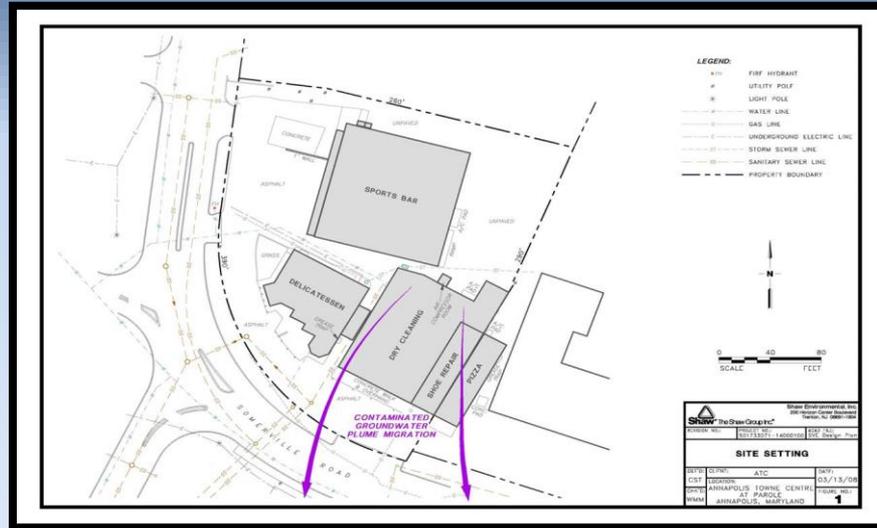
Moran, William et al. 2008. The Shaw Group. Enhanced Delivery of Potassium Permanganate Using Horizontal Remediation Wells. Proceedings of the Sixth International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Monterey, CA. May 2008)

Maryland Department of the Environment (MDE). 2010. Facts About Annapolis Towne Center at Parole Main Parcel & Annex Properties. October 2010.

Example Site #1: Chlorinated Solvent Site, Maryland

Background:

- Major redevelopment project in suburban Baltimore.
- Chlorinated solvent plume extended 1,600 feet in groundwater.
- An In-situ chemical injection method needed to be installed while redevelopment continued.



Example Site #1: Chlorinated Solvent Site, Maryland

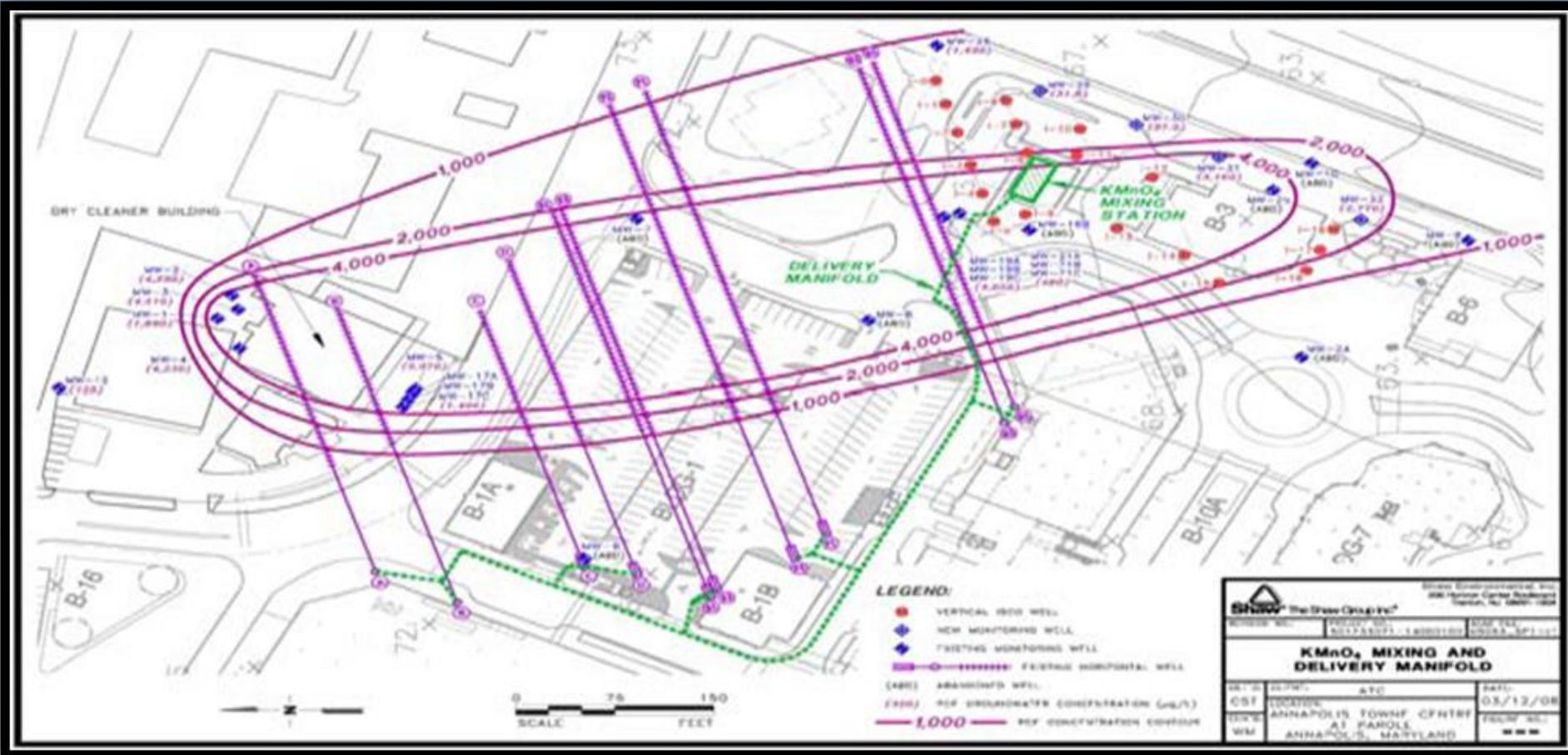


Remedial Strategy:

- Install 10 Potassium permanganate (KMNO₄) Horizontal Injection Wells,
- Perpendicular to groundwater flow.
- 5 horizontal SVE wells beneath former dry-cleaner.
- Blind Method Installation.
- 2,300 total linear feet of well screen.

Example Site #1: Chlorinated Solvent Site, Maryland

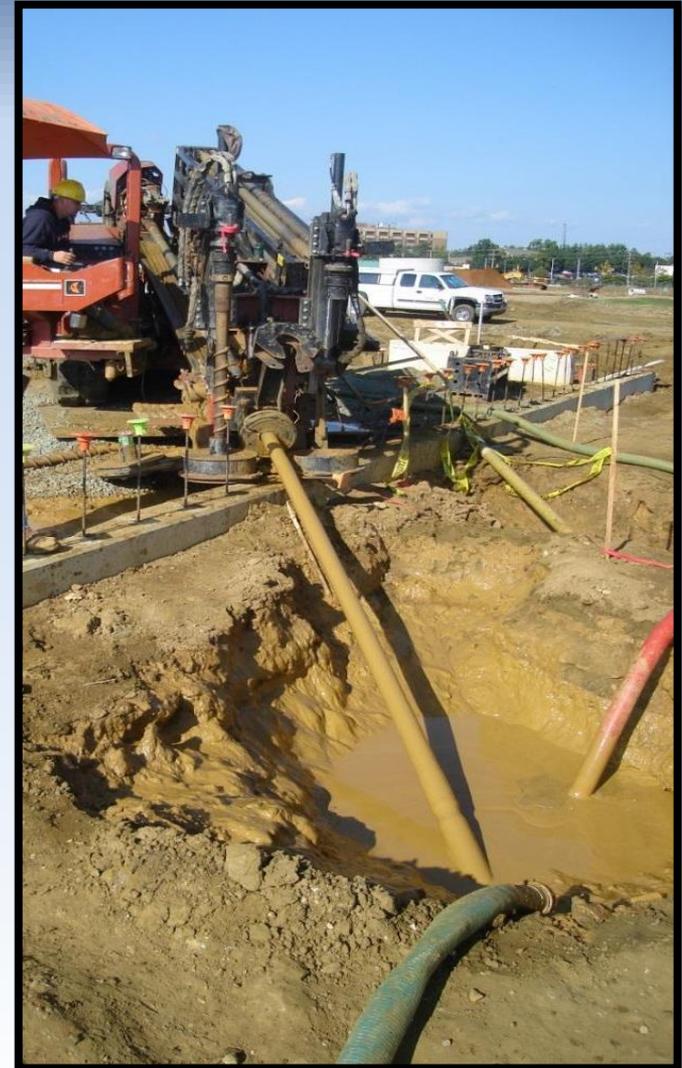
Remedial Strategy: Horizontal Injection Well Layout



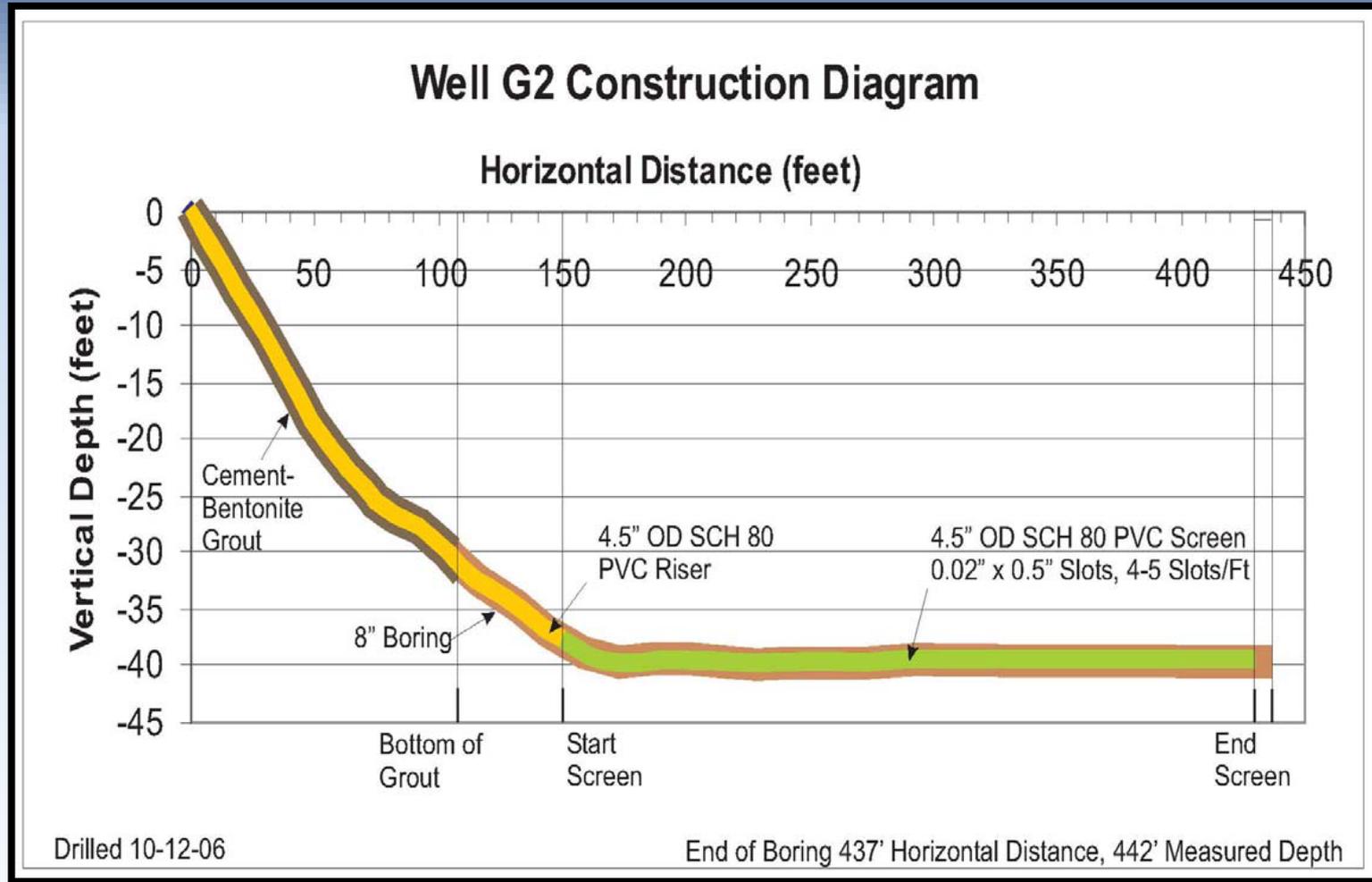
Example Site #1: Chlorinated Solvent Site, Maryland



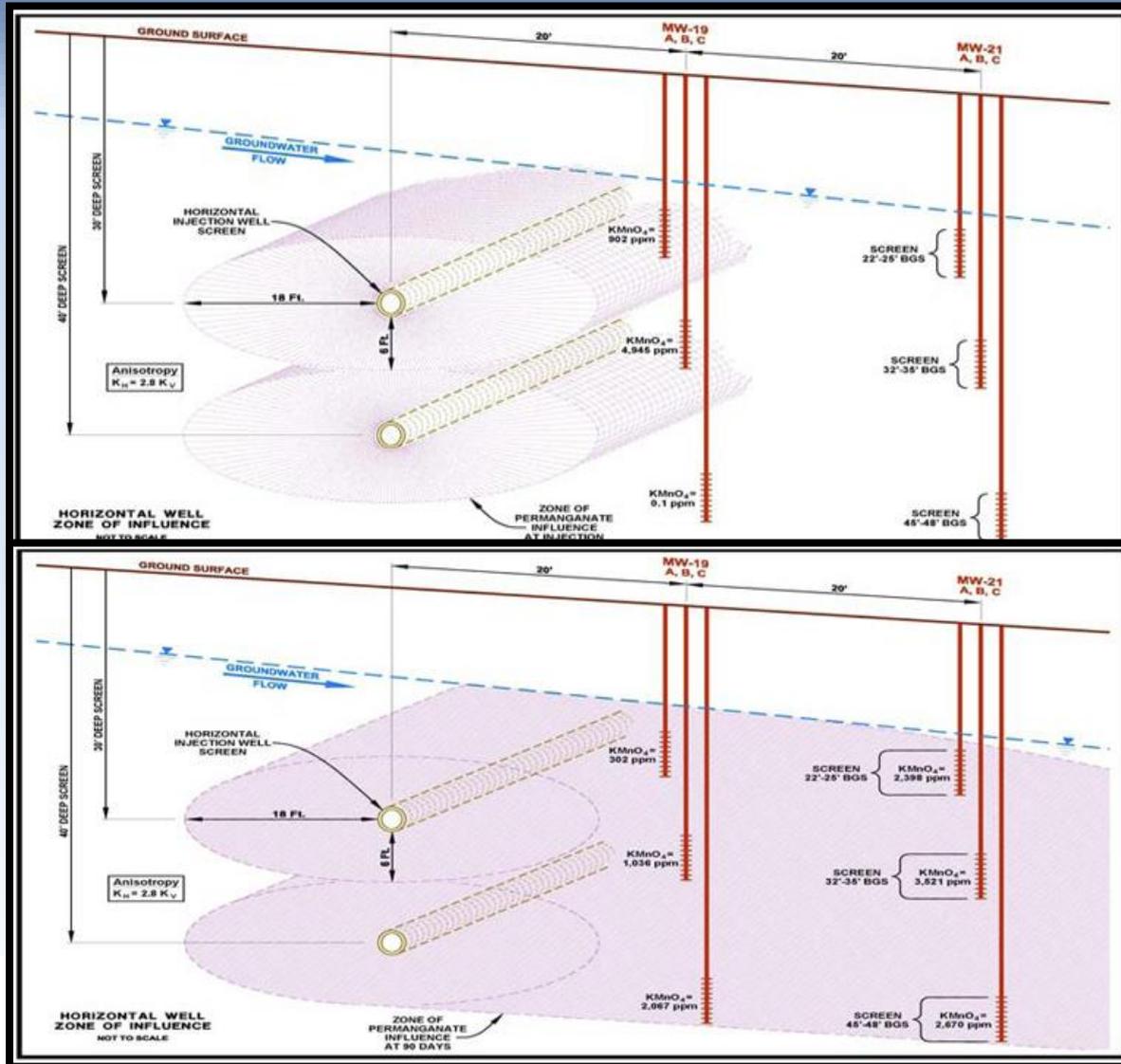
Horizontal Injection Well Installation
during site redevelopment construction.



Example Site #1: Chlorinated Solvent Site, Maryland



Example Site #1: Chlorinated Solvent Site, Maryland



Example Site #1: Chlorinated Solvent Site, Maryland



Permanganate Mixing Station:



Example Site #1: Chlorinated Solvent Site, Maryland



Injection Results:

- 1.4 million gallons of KMNO₄ solution injected over two major events
- TCE Concentrations reduced from 12 mg/L to non-detect.
- PCE concentrations significantly reduced.
- Maryland Department of the Environment touted project as a major success through the Land Restoration Program

2nd Injection	Monitor Well Depth (ft)	Well ID Distance	Day 19 8/29/2007	Day 83 11/1/2007	Day 159 1/16/2008	Day 207 3/4/2008
ISCO-2 Injected Volume = 1,412,333 gal.	25	MW-19a 20 ft	68.9	302	20.8	<10
	35	MW-19b 20 ft	1036	2067	30	<10
	45	MW-19c 20 ft	2607	564	23.9	<10
	25	MW-21a 40 ft	247	2398	1351	595
	35	MW-21b 40 ft	10	3521	1986	84.4
	45	MW-21c 40 ft	10	2670	996	11.8

Time	Well MW-5 Screen -20-40 ft	Well MW-17a Screen 25-30 ft	Well MW-17b Screen 40-45 ft	Well MW-17c Screen 55-60 ft
Prior to First ISCO	6,270	16,600	960	532
6 Months After 1 st ISCO	3,970	6,400	555	212
3 Months After 2 nd ISCO	2,970	1,410	ND (Purple)	66.8
5 Months After 2 nd ISCO	ND (Purple)	757	ND (Purple)	95.9

Example Site # 2: Groundwater Extraction Well - Landfill

Acknowledgements:

Soukup, William G. P.G. (Cornerstone Environmental) and Sequino, Mike (Directional Technologies, Inc.) Using Horizontal Extraction Wells to Contain Leachate Plumes near Landfills. Presented at the Battelle Bioremediation Symposium 2016.

Example Site #2: Groundwater Extraction Well - Lanfill



Background:

- A vertical series of extraction wells for a hydraulic barrier needed replacement.
- Goal, prevent 1,4 dioxane leachate off of the landfill site.
- Need high yield groundwater extraction.



Example Site #2: Groundwater Extraction Well

Approach:

- 1 Horizontal GW Extraction Well.
- 800 feet long.
- Entry-Exit.
- 500 feet of screen at target depth.



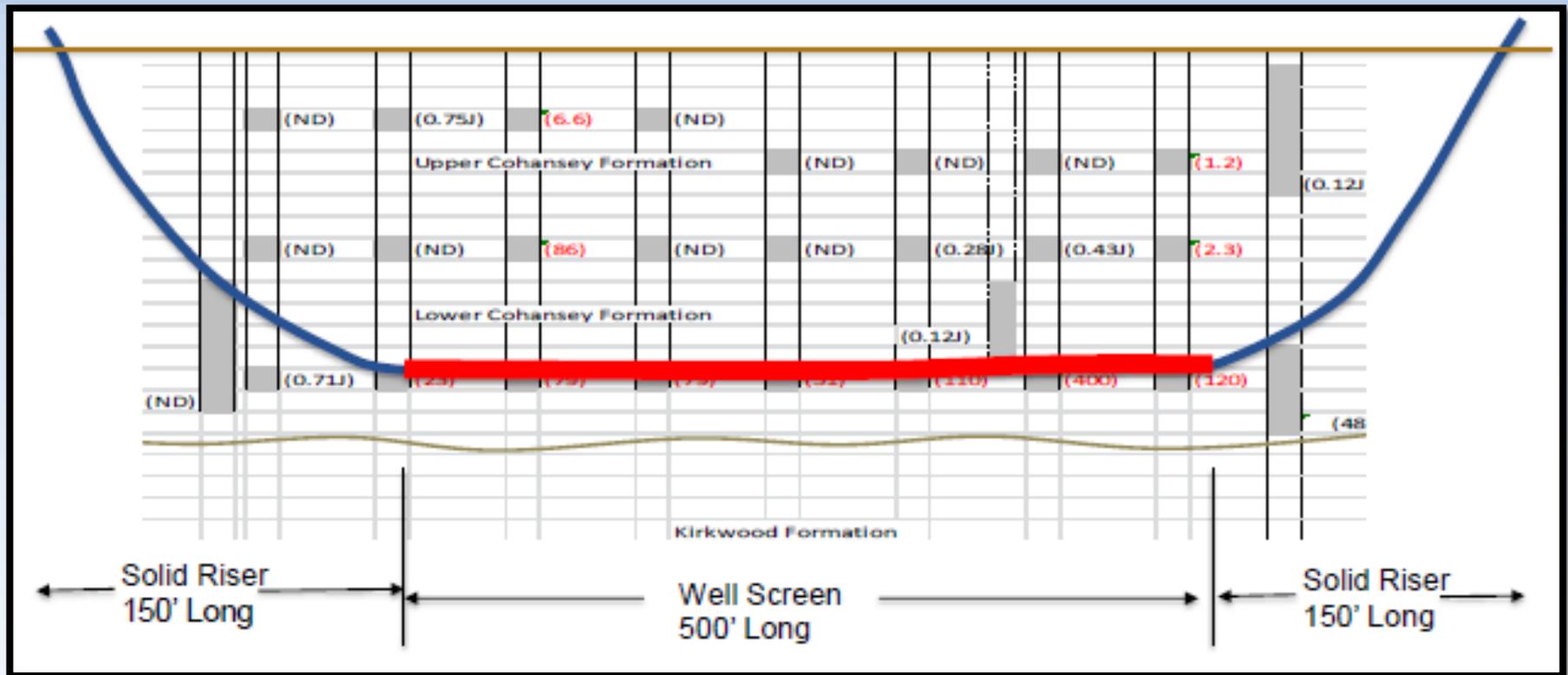
Example Site #2: Groundwater Extraction Well

Horizontal GW Extraction Well Layout



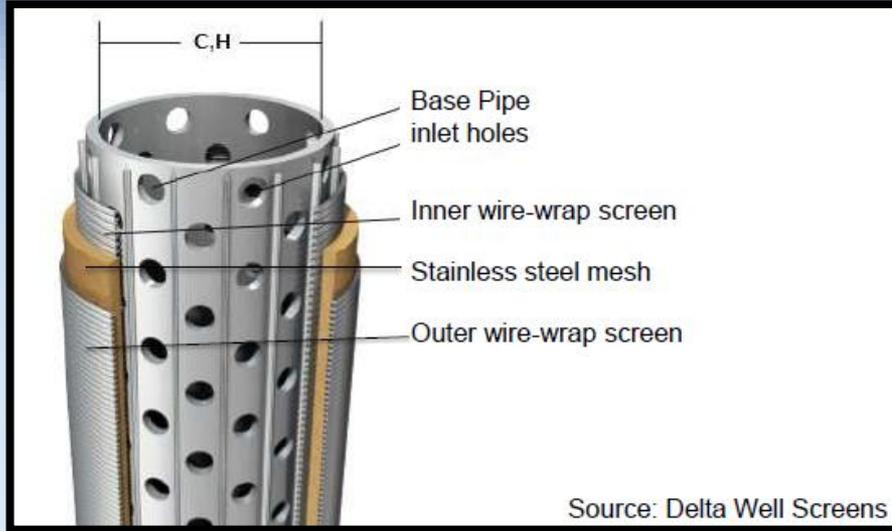
Example Site #2: Groundwater Extraction Well

Horizontal GW Extraction Well Profile:



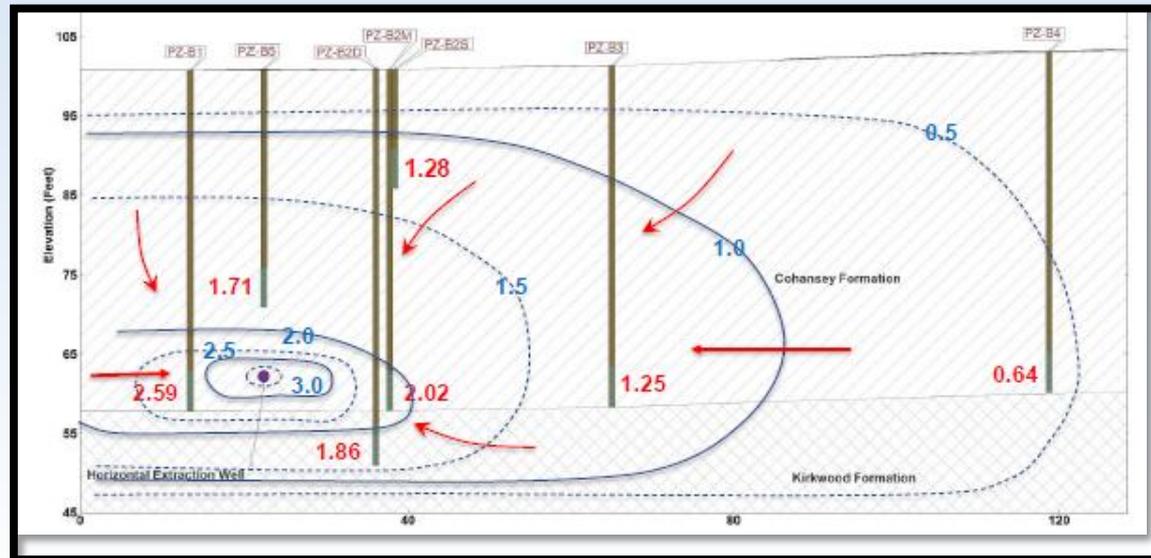
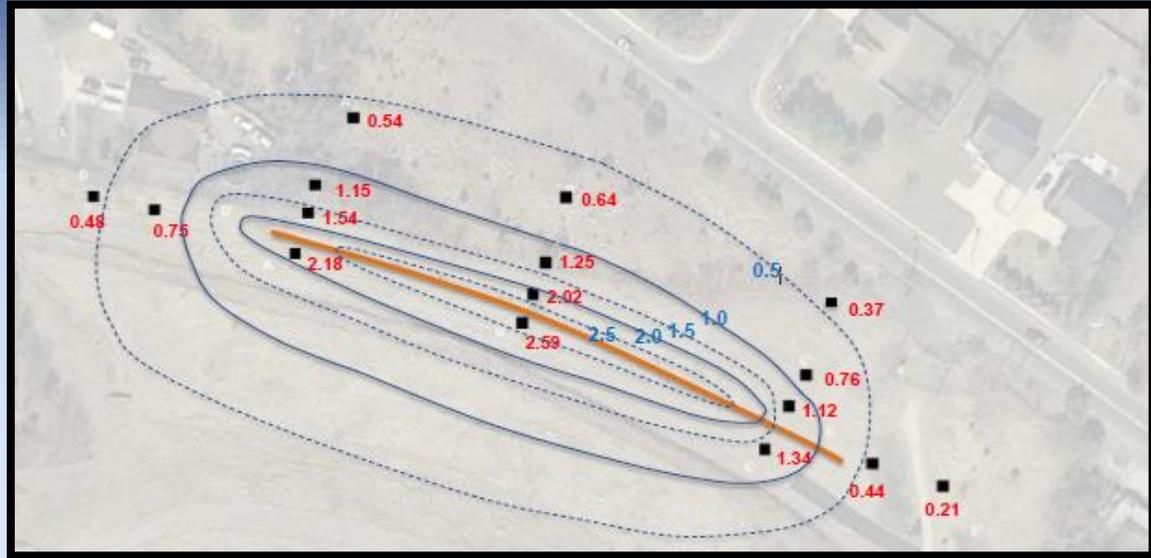
Example Site #2: Groundwater Extraction Well

Horizontal GW Extraction Well Screen – 6-inch Diameter:



Example Site #2: Groundwater Extraction Well

Horizontal GW
Extraction Well
Pump Test:



Example Site # 3: Perchlorate Site, Massachusetts

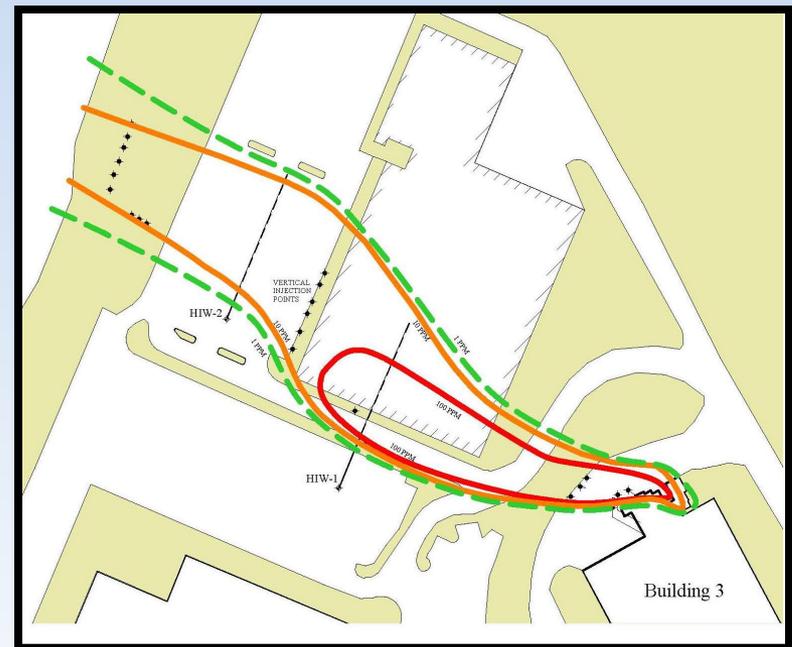
Acknowledgements:

Irwin, J. Andrew, PE, LSP (IRWIN Engineers) and Sequino, Mike (Directional Technologies, Inc.) Horizontal Remediation Injection Wells (HRIW) Solution to Slow Uptake via Vertical Injection Wells. Presented at the Battelle Bioremediation Symposium 2015.

Case Study #3: Perchlorate Site, Massachusetts

Background:

- Perchlorate in groundwater from a leaking wastewater line undetected for 8 to 10 years.
- Perchlorate plume extended 900 feet toward a river.
- The formation permeability was calculated to 3.5 ft/day.
- Concentrations were between 10 mg/L to 500 mg/L.
- Total calculated mass of 1,500 pounds of perchlorate.
- Challenging geology: heterogeneous alluvium with overlying glacially deposited sand, gravel, and till.

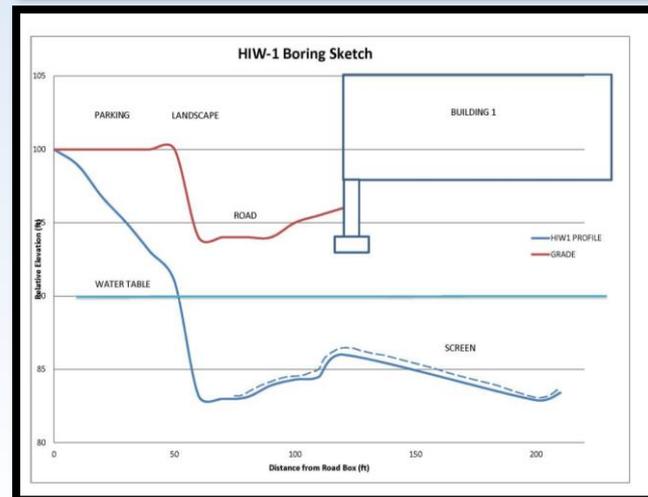
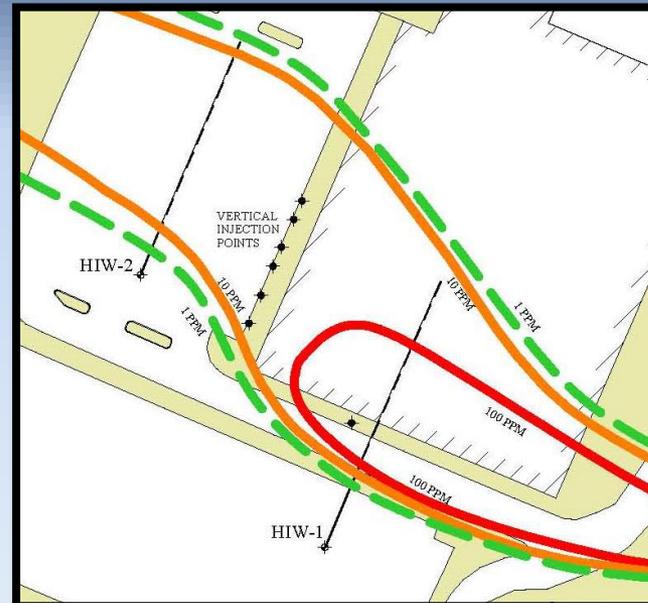


**Groundwater Contaminate Plume
Before Bioremediation:**

Case Study #3: Perchlorate Site, Massachusetts

Remedial Strategy:

- Installed 2 horizontal injection wells for bacterial culture gravity injection.
 - 3-inch diameter well screen
 - Blind well installation method (no exit point required)
 - Wells were installed above the till layer for injection deeper into the saturated zone
- Twice as much submerged well screen vs vertical injection well row.
 - 160 linear feet of submerged screen.
 - Distribution of additive across width of plume without gaps.
- Limited site disturbance.
- Single gravity-feed injection point for simplified operation and maintenance.

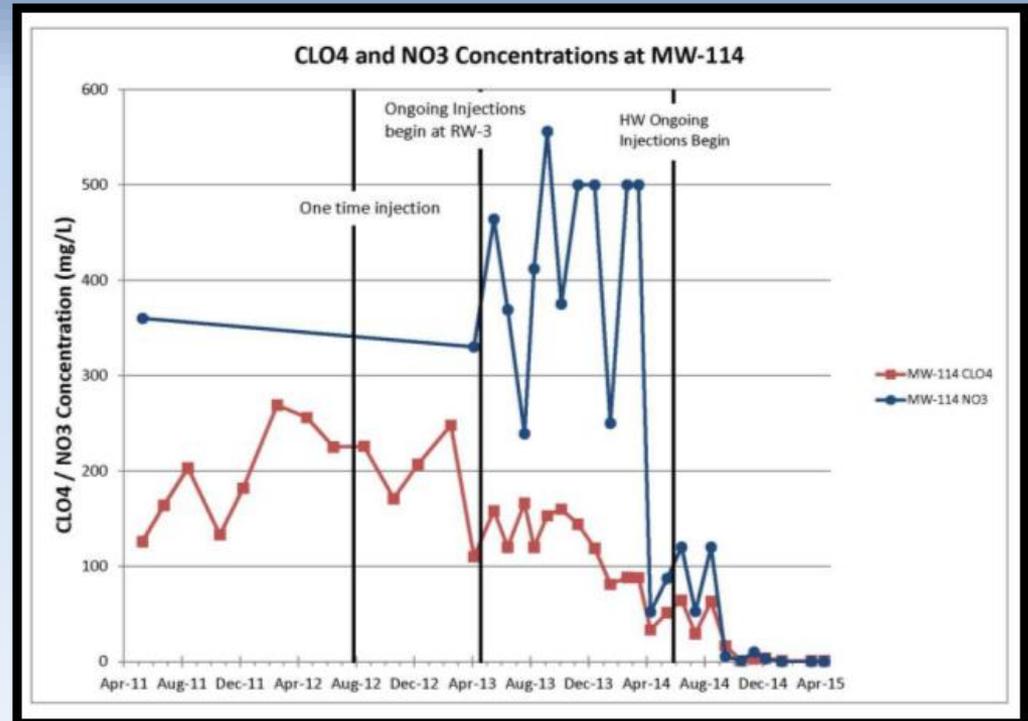


Case Study #3: Perchlorate Site, Massachusetts

Gravity Injection

Flow Rates:

- 2,000 Gallons per day horizontal injection compared to 2,000 gallons per week vertical injection.
- Achieved injection rates of up to ~83 gallons per hour.
- Increased injection due to submerged screen increasing from 45 ft to 350 ft

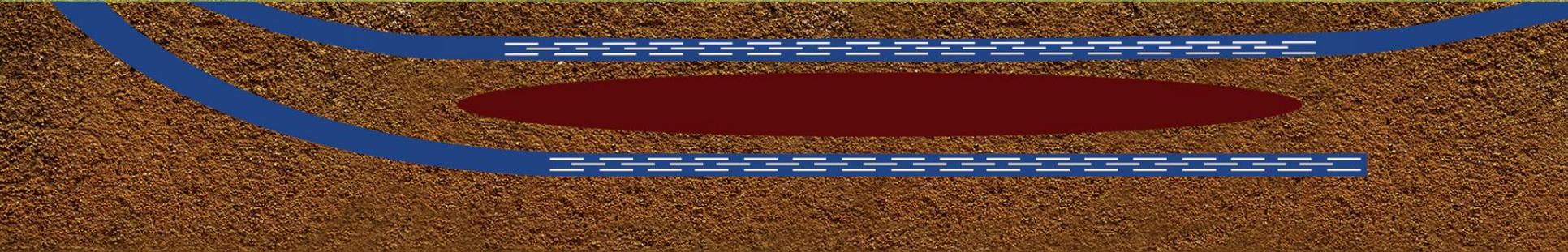


Summary



- Horizontal Remediation Well systems are mature technology with 25+ years of case studies, site closures, and regulatory acceptance.
- Numerous remedial applications.
- HRWs allow for a creative placement to avoid obstructions and minimize disruptions.
- HRW can lower project costs when compared to multiple vertical wells.





Questions?

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