

2016 International Petroleum Environmental Conference

**HORIZONTAL DIRECTIONAL DRILLING AND WELL
INSTALLATION AT SMALL SITES**



HORIZONTALDRILL.COM

History of Horizontal Environmental Wells

- **Horizontal/Directional Oil Wells in the 1930s – Present**
- **Directional “River Crossings” in the 1970s**
- **Environmental Applications for the Department of Energy in 1988**
- **Utilized for Most Remediation Applications by 2015**



Environmental Applications

- **Sampling under obstructions**
- **Extraction techniques**
 - Groundwater
 - Free phase product – NAPL and DNAPL
 - Vapors
 - Dual phase
- **Injection techniques**
 - ISCO
 - Nutrient injection
 - Air sparge
 - Bio sparge
 - Barriers – PRBs/HRx
- **Thermal treatment**
 - Hot air/steam injection
 - Electrical resistance heating
- **Dewatering**
- **Slope stability**
- **Mine tailings**
- **Ground water production**



Applications/ Advantages of Horizontal Wells

Three Major Advantages

- **Geometry**
- **Access areas unreachable to vertical wells**
- **Minimal site impact**



Directional Control

- The bit is navigated along a prescribed path
- The well need not be horizontal
- Bore path is design is based on
 - Allowable bending radius of drill pipe and well materials
 - Geology
 - Treatment objective
 - Surface constraints



Directional Control/Steering

- The drill string is steered by pushing the drill pipe against an asymmetric bit with a hydraulic jet; “duck bill” or bent sub
- The force against the bit or sub forces the drill pipe in direction of the bit orientation
- When the entire assembly is rotated, the drill string goes straight
- A sensor behind the bit sends the direction/orientation of the bit to the surface



Directional Control/Steering



Locating Technologies

- **Several Options Available**
 - Walkover/Radio Beacon
 - Wireline
 - Oil Field Technology
 - Short Steering Tool (SST)
 - Gyroscopic
- Selection based on bore path, interference risk, depth and cost
- All methods have $\pm 0.5 - 2\%$ depth accuracy



Drilling Fluids are Required

- **Maintain hole stability**
- **Remove cuttings**
- **Limit drilling fluid loss to the formation**
- **Cool bit and steering tools**
- **Two types commonly utilized**
 - **Bentonite**
 - **Biodegradable polymer**

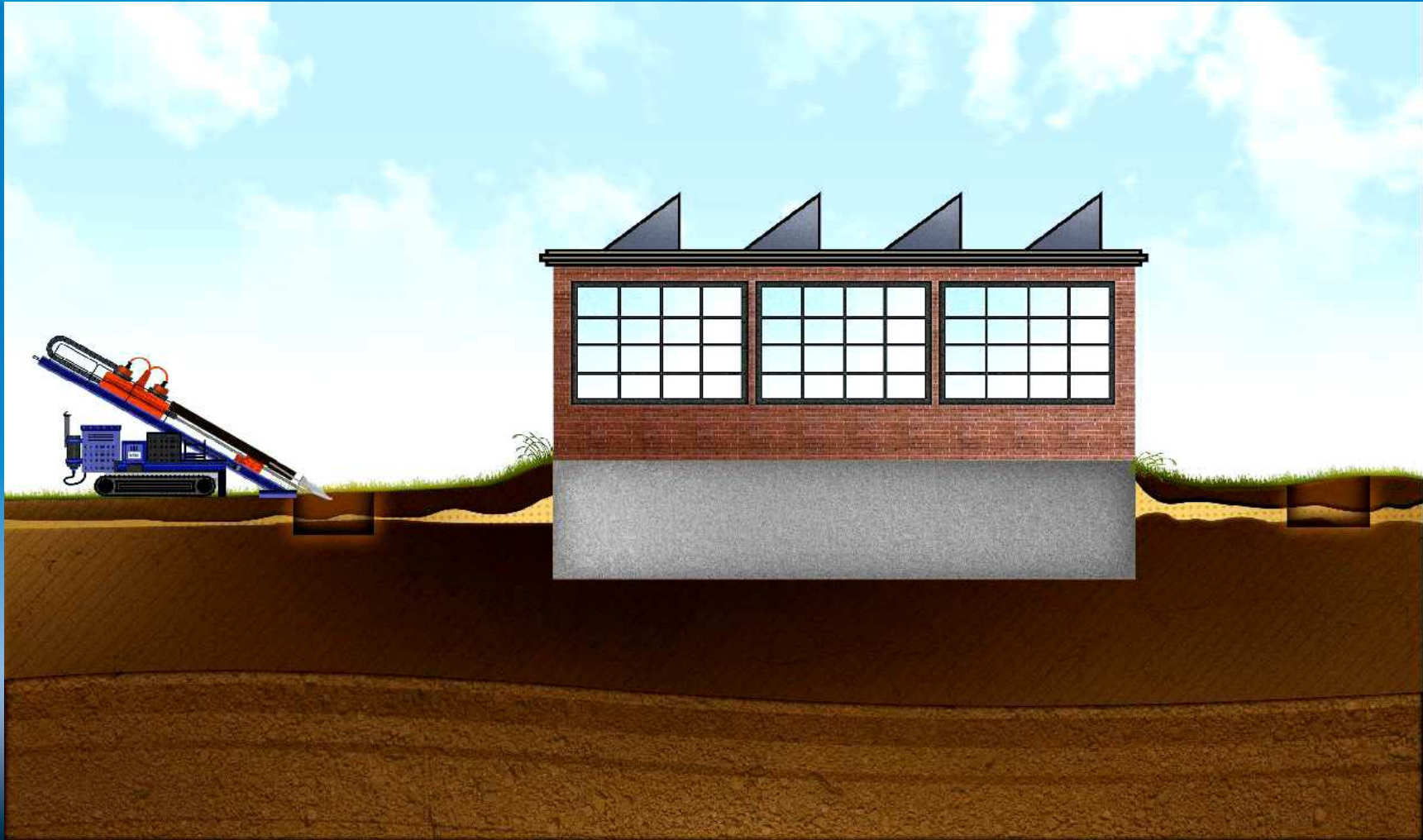


Well Materials (Screen & Casing)

- **Similar materials to vertical well installations**
 - PVC
 - Carbon steel
 - Stainless steel (304 and 316L)
 - HDPE
 - Fiberglass



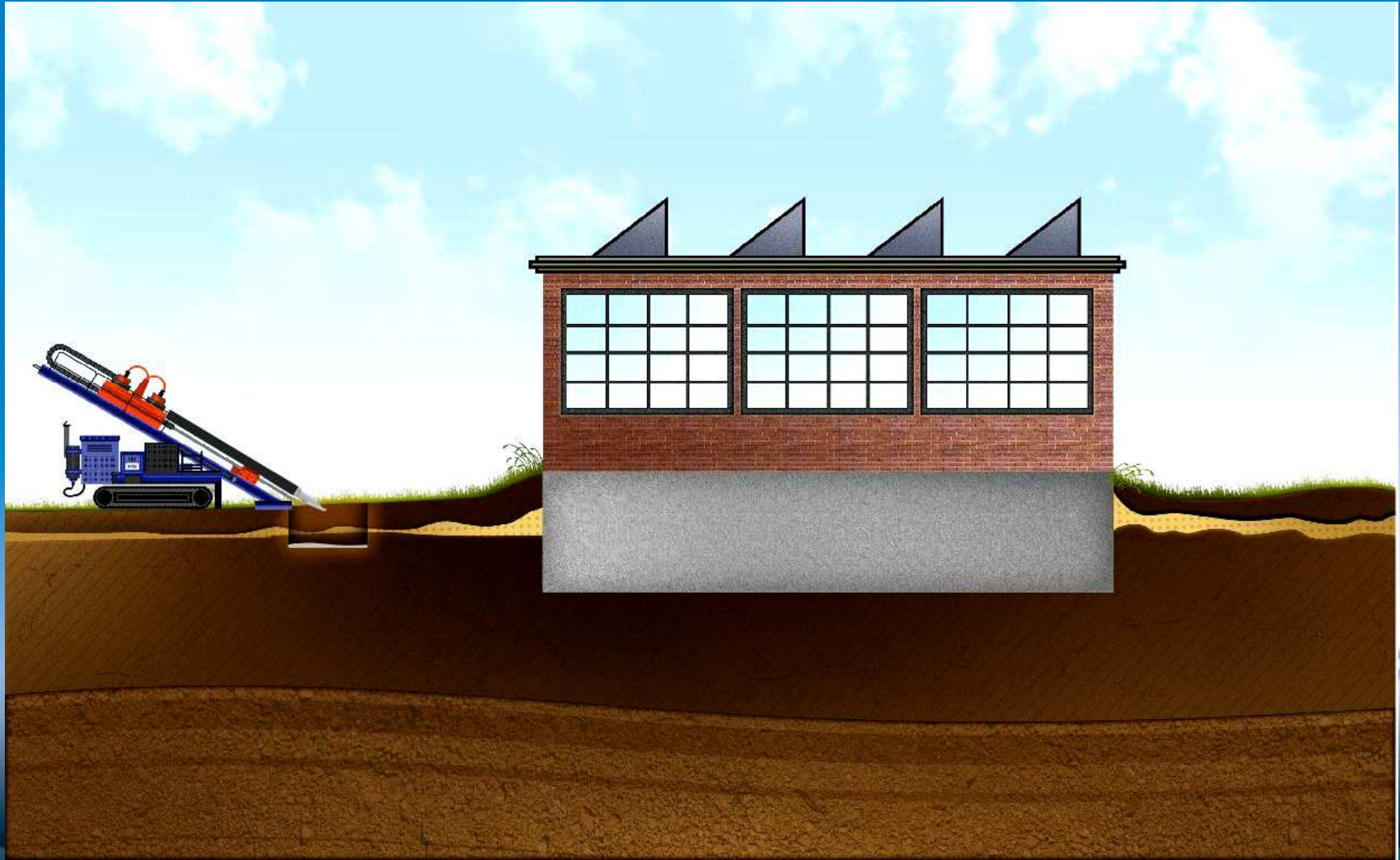
Continuous Well Installation



Continuous Well Installation



Blind Well Open Hole



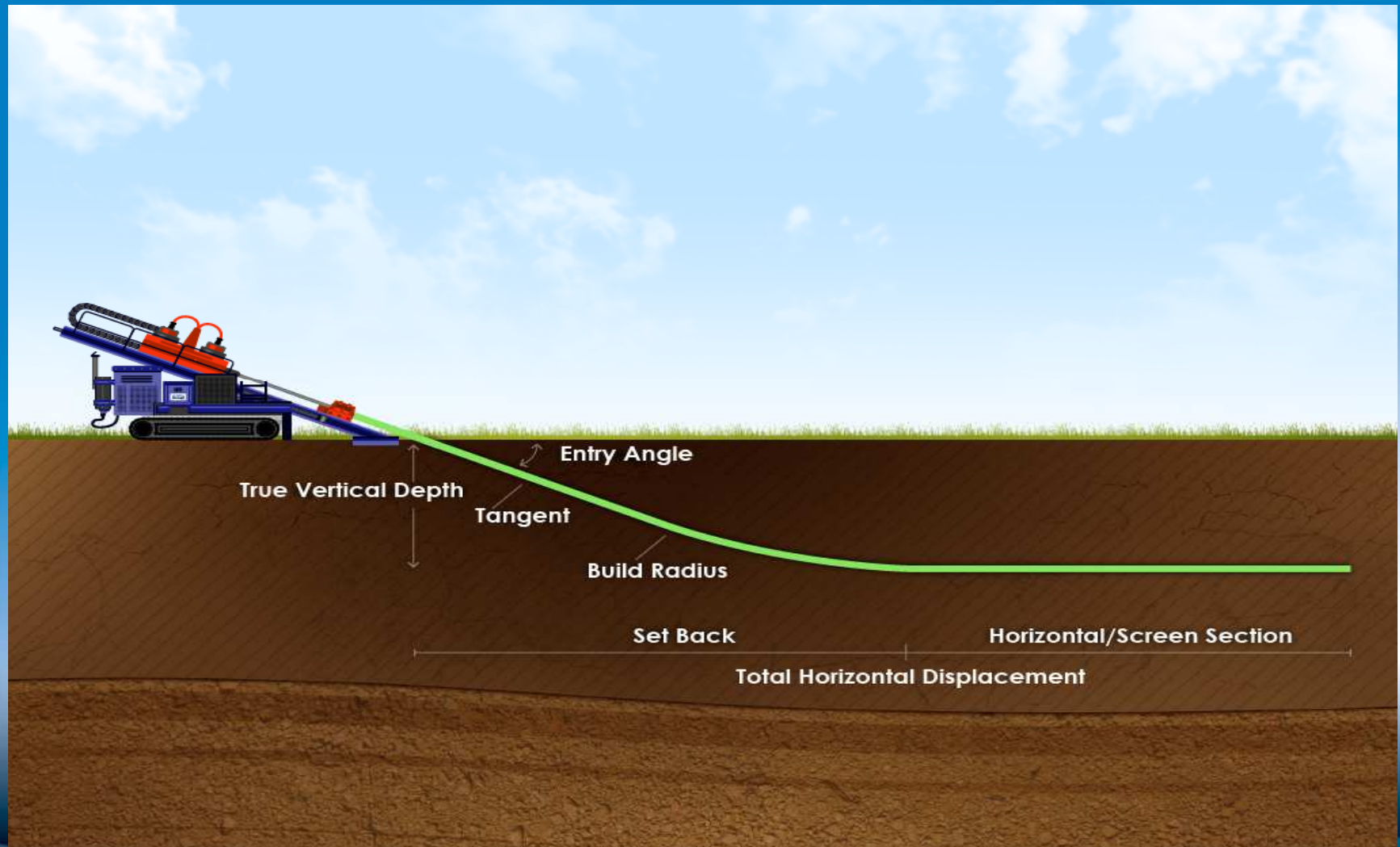
Borepath/Well Geometry

- **Terminology**

- **Entry angle**
- **Tangent**
- **Radius of curvature (build radius)**
- **Horizontal section**
- **True vertical depth**
- **Measured depth/pipe length**
- **Set back – determined by combination of the above**



Borepath/Well Geometry



Drilling Equipment

- **Drill rig**
- **Fluid cleaning/recycling system**
- **Pipe trailer**
- **Support vehicles**
 - **Water truck**
 - **Crew truck**



Small Rig Set Up Area

- 7,000 lb. capacity rig
- 30' x 50' area
- Continuous well requires area at exit point



Sparge/SVE

- Former dry cleaning facility, Los Angeles Basin
- Active retail site
- Contaminant mass in soil and groundwater under building
- Remedy could not impact ongoing operations
- Original plan included 20 vertical wells – businesses closed for 60 days for construction
- Horizontal wells to the rescue

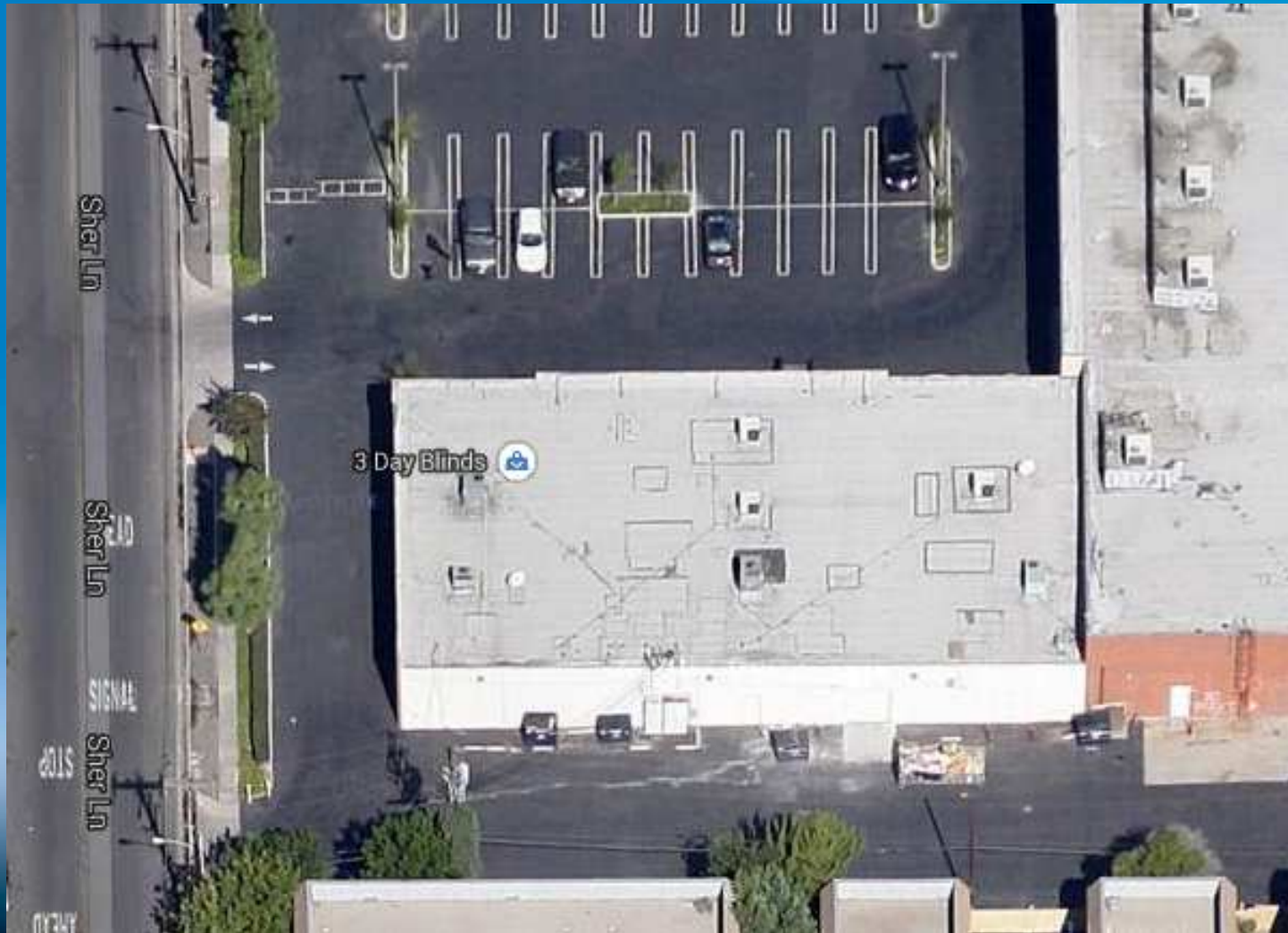


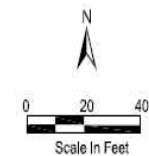
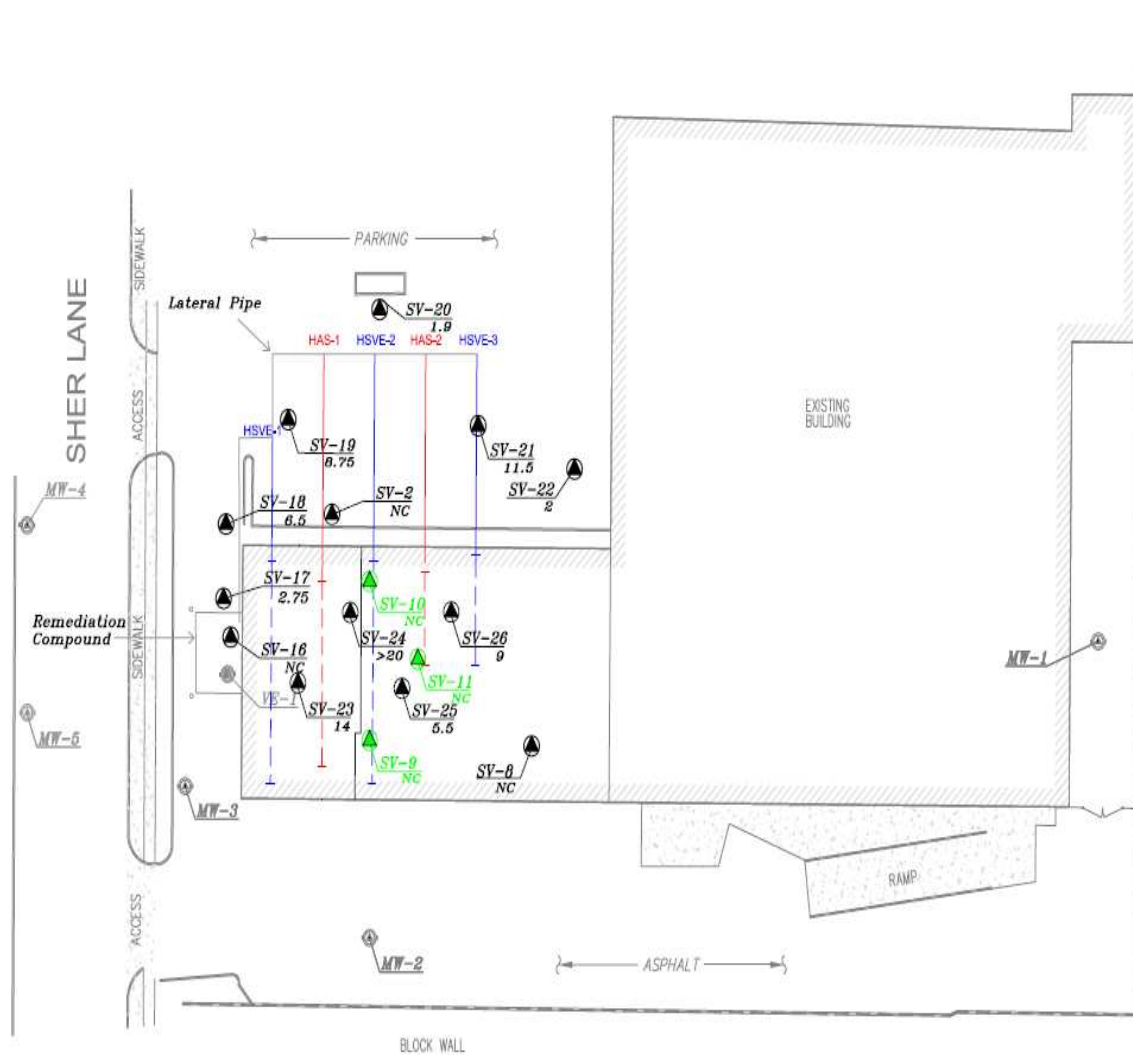
Sparge/SVE

- **Original design called for continuous wells**
 - Three SVE
 - Two sparge
- **Site constraints altered design**
- **Blind well technology was utilized**
 - Three SVE wells: 99' long, 4' deep, 2" sch. 80 PVC
 - Two sparge wells: 99' long, 11' deep, 2" sch. 80 PVC



SVE





LEGEND

- SV-23
5.5 Soil Vapor Probe (probes in green have been abandoned)
- SV-18
8.5 Vacuum Pressure (inches of water)
- MW-2 Groundwater Monitoring Well
- VE-1 Vapor Extraction Well
- Air Sparge Well (screened interval is dashed)
- Soil Vapor Extraction Well (screened interval is dashed)
- NC - Vacuum Pressure Reading Not Collected

Sparge/SVE

- All wells installed in three days with no impact to ongoing operations
- Soil vapor probe observed negative pressure 68' from the horizontal well screen
- Concentration of PCE was reduced by 99% in three months
 - Data provided by Rincon Consultants, Inc.
 - Mr. Torin Snyder
 - 760.918.9444
 - tsnyder@rinconconsultants.com



Western US Site

- **Challenging site conditions**
 - Highly urbanized/residential area
 - Very small site
 - No room for set back
 - Cobbles from surface to 12' bgs
 - Sparge and SVE well pair





Western US Site

- **Solution**
 - **Place rig in tank pit excavation**
 - Borehole starts below cobble zone
 - Significant decrease in set back distance

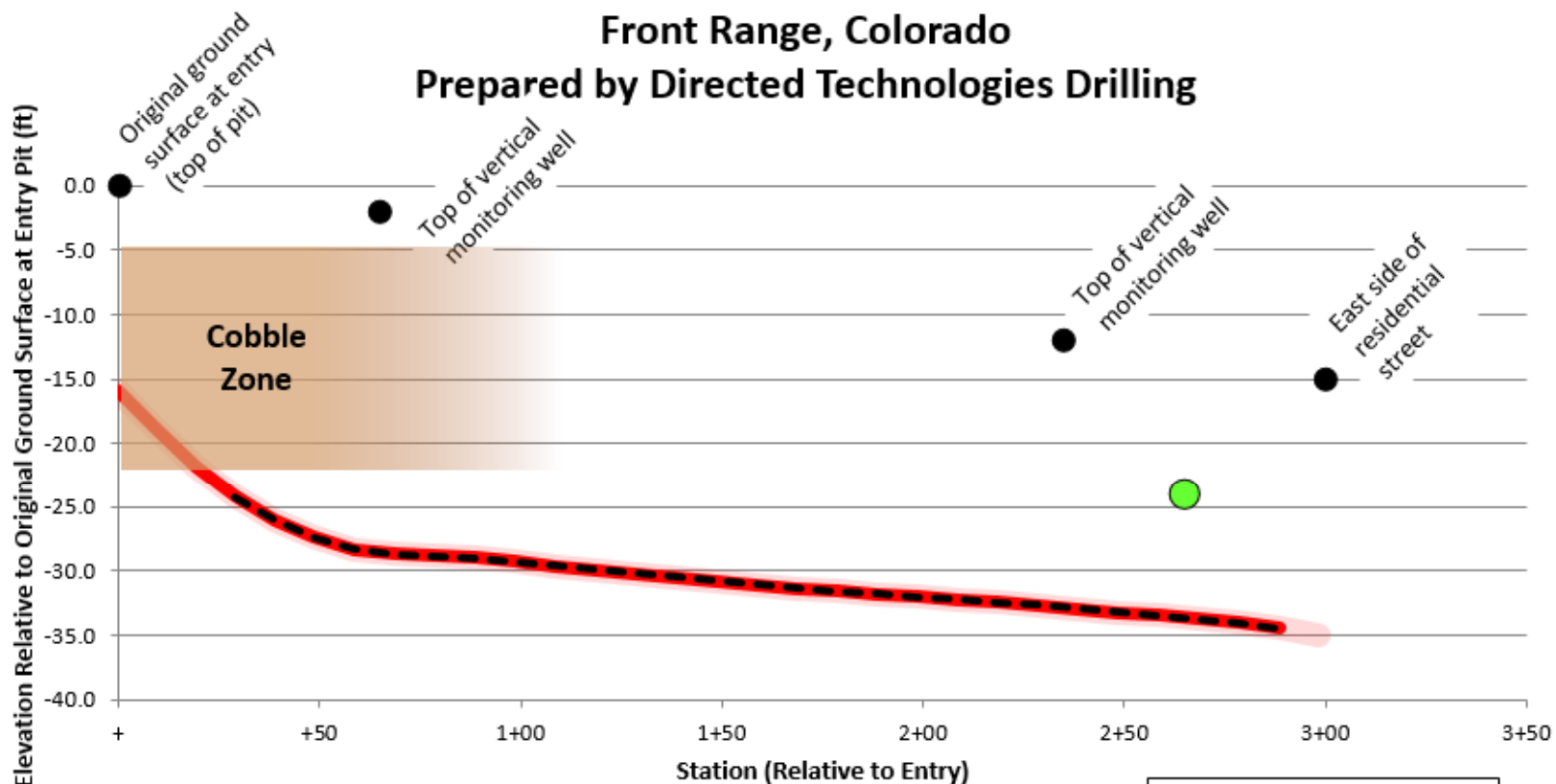






UST Remediation Site 3-inch Diameter HDPE Sparge Well For Undisclosed Client Front Range, Colorado

Prepared by Directed Technologies Drilling



Bore Notes:
 Borehole drilled length - 300 ft
 Borehole horizontal length - 298 ft
 Well overall length - 290 ft
 Well screen length - 260 ft

- Air sparge bore
- - - Air sparge well
- - - Air sparge screen
- Nearby surface locates
- Sewer/Stormwater line

Western US Site

- **Creative Thinking Overcame Site Challenges**
- **Total of 255' of drilling**
- **Seven rig days**
- **Cost for drilling and well installation**
 - **\$85,000**
 - **\$153/ft.**
 - **Costs do not include excavation, shoring and waste containment and disposal**



In Summary

- The technology is innovative - not experimental
- Horizontal wells are a proven, cost effective installation method
- Thousands of wells have been successfully completed in the US
- Horizontal wells can be used with all remediation technologies
- The technology is innovative – not experimental

