SOIL SAMPLING UTILIZING HORIZONTAL/DIRECTIONAL DRILLING METHODS
Directional Control

- The bit is navigated along a prescribed path
- The bore path need not be horizontal or straight
- Bore path is design is based on
  - Allowable bending radius of drill pipe
  - Geology
  - Sample location
  - 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 ± 0.5 – 2% depth accuracy
Walkover Navigation Systems

- Walkover navigation systems
  - Low cost
  - Ease of use
  - Battery or wireline powered
  - Requires access to surface over the bore path
  - Depth limited to about 80’
Drilling Fluids are Required

- Maintain hole stability
- Remove cuttings
- Limit drilling fluid loss to the formation
- Cool bit and steering tools
Bore Path 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
Bore Path Geometry

- True Vertical Depth
- Tangent
- Build Radius
- Entry Angle
- Horizontal/Screen Section
- Set Back
- Total Horizontal Displacement
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
Soil Sampling

• Goals
  – Obtain representative samples at a predetermined target
  – Challenges
    • Sample location
    • Avoid “scraping” sample from side wall or bottom of borehole
    • Exclude drilling fluids
    • Retain unconsolidated material
    • Quick visual identification
Tooling

• Two types of samplers
  – Set screw/bullet nose

Set screw
DTD “Bullet” Sampler
Tooling

- Two types of samplers
  - Piston
Tooling

- Sample recovery
  - 2” diameter up to 18” long
  - Standard acetate sleeves allows for visual inspection
Soil Sampling

• **Methodology**
  – Drill/steer to sampling point
  – Remove drill rod
  – Push sampler to end of bore
  – Obtain sample
  – Pull sampling tool
  – Repeat
Project Sites

- Past Projects
  - DOE Site, OH/building slab
  - Belle Chase, LA/1,000,000 gallon tank
  - Pasco, WA/unlined landfill
  - Belle Chase, LA/concrete revetment
  - Urban Site, CA/occupied housing
  - Industrial Facility, IL/under pond
Soil Sampling Case Study

• Urban location
  – Obtain soil samples under occupied residences
  • Unconsolidated formation
  • Sample locations up to 50’ from entry location and 3’ - 4’ sub slab
  • Drilling fluid containment critical
Case Study - Urban
Case Study – Urban
Case Study – Urban

Diagram showing ground surface and as-built measurements with sample location labeled as Sample 1: STA 35, Depth -2.9' bgs.
Case Study – Urban

• Ten samples obtained
• No impact to residents
• Drilling fluids contained
• Eleven days on site
  – Test event
  – Decon
• $10,000/sample
Case Study – WA Landfill

- Closed mixed waste facility
- Buried stacked drums
- Engineered cap, no liner
- Adjacent to active transfer station
- Challenging drilling conditions
  - Locating interference from drums
  - Soil conditions
Case Study - WA Landfill
Case Study – WA Landfill
Case Study – WA Landfill

The graph shows the bore elevation (feet) plotted against the distance from the entry (feet). The graph includes three profiles:

1. **Original Profile** (red line): This profile starts at the entry point and shows a gradual decrease in bore elevation as the distance increases.
2. **Deeper Attempt 1** (green line): This profile also starts at the entry point and follows a similar trend to the original profile but appears to be slightly deeper.
3. **Deeper Attempt 2** (brown line): This profile starts at the entry point and shows a deeper trend compared to the other two profiles.

Key points:
- **Entry**:
- **Casing**
- **H-Intercept**

The graph helps in understanding the progression and depth of the drilling process at the WA Landfill.
Case Study – WA Landfill

• 70 soil samples obtained
• 2,290’ total footage drilled
• Over 91,000’ of drill pipe tripped
• $3,560/Sample
In Summary

- The technology is innovative - not experimental
- New tooling provides for sample quality
- Method is expensive and site specific
- Allows for soil samples to be obtained in areas unreachable by traditional vertical/angle drilling
- The technology is innovative – not experimental
Contact Information

• David Bardsley – david@horizontaldrill.com

• Office locations
  – Bellefonte, PA
  – Mineral Wells, TX
  – Bremerton, WA
  – www.horizontaldrill.com
  – 800.239.5950
  – Follow DTD on LinkedIn/Twitter
  – Like DTD on Facebook