Horizontal Directional Drilling: An Approach to Design and Construction
Presentation Outline

- General HDD overview
- Conceptual-level evaluation
- Detailed HDD design
- Contract documents
- Construction oversight and lessons learned
- Questions
General HDD Overview
Typical HDD Vertical Alignment

HDD Entry/Rig Side

HDD Exit/Pipe Side

Radius of Curvature

Reference: ASTM F1962-11
HDD Installation Methodology

- **Pilot hole**
  - First guided pass of HDD process

- **Reaming**
  - Secondary guided passes to enlarge borehole

- **Pullback**
  - Drill pipe, swivel and product pipe pulled towards borehole entry
HDD Site Layout – HDD Entry/Rig Side

- Crane
- Vacuum Excavation Truck
- Soil Separation Plant
- Power Unit
- Mud Pump
- Mud Pit
- Drill Pipe Storage
- HDD Drill Rig
- Operator Control Cab

Horizontal Directional Drilling: An Approach to Design and Construction
HDD Site Layout – HDD Exit/Pipe Side

- Vacuum Excavation Truck
- Mud Pit
- Tracer Wire
- Pull Head and Swivel
- Reamer
- Pipe Roller
- HDD Pipe String
Conceptual-Level Evaluation
Conceptual-Level Evaluation

- Pipe type selection
  - HDPE, fusible PVC (fPVC), restrained joint ductile iron, steel, etc.

- Easement requirements
  - HDD entry and exit areas
  - Pipe laydown area

- Route evaluation
  - Obstruction including foundations, utilities, etc.
  - Wetland boundaries
Conceptual-Level Evaluation

- Typical HDD limitations
  - 2 to 60 inch diameter pipe size
  - Up to 7,500 ft crossing length
  - Favorable ground conditions include sands, clays, silts and bedrock
  - Unfavorable ground conditions include boulders, weathered rock, hard to very hard rock, and manmade obstructions
Detailed HDD Design
Geotechnical Investigation Program

- Review existing geotechnical and geologic data
- HDD horizontal alignment alternatives
- Develop geotechnical investigation program
  - Site survey
  - Test borings
Geotechnical Laboratory Testing – Soil Testing

- **Index testing**
  - Sieves
  - Atterberg limits

- **Strength testing**
  - Triaxial (unconsolidated undrained)
Geotechnical Laboratory Testing – Rock Testing

- Rock testing
- Rock strength
  - UCS test
- Brazilian tensile
  - Point load index
- Abrasivity
  - CERCHAR
  - Rock type
  - Unit weight, porosity and specific gravity
  - Petrographic analyses
Design Analyses

- Perform hydraulic fracturing (frac-out) analyses
  - Areas of minimal cover such as low point beneath river, near HDD entry/exit

- Perform pullback analyses
  - Estimating pullback forces
  - Pipe tensile stress calculation
  - Pipe ring deflection calculation
Contract Documents
Contract Drawings

- HDD vertical and horizontal alignments
  - Stationing including HDD entry/exit points and points of curvature
  - HDD entry/exit angles
  - Minimum radii of curvature
  - Delineate temporary easements
  - Temporary casing (Yes or No?)

- Additional pertinent information
  - Test boring locations
  - Known utilities and obstructions
  - Wetlands boundaries
Specifications

- Contractor qualifications
  - Minimum years experience and successful installations
- Ballasting required (yes or no?)
- Allowable horizontal and vertical tolerances
- Borehole monitoring requirements
  - Drill head location
  - Drilling speed
  - Drilling fluid pressures and flow rates
  - Drilling fluid viscosity and density
Specifications

- **Submittals**
  - HDD work plan
  - Calculation packages
  - Contingency plans

- **Project kick-off risk meeting or conference call discussions**
  - Proposed schedule
  - Major milestones (pilot drilling, reaming, pullback, pipe testing)
  - Lines of communication
Construction Oversight and Lessons Learned
Mill Creek Force Main HDD – Columbia, South Carolina Coastal Plains Geology

- 1,650 ft wetlands crossing
- 30” fPVC DR 21 water force main
- Subsurface conditions
  - Approx. 30 ft loose poorly-graded sand to silty sand and soft to medium stiff silt (alluvium)
  - Approx. 6 to 15 ft hard silt or very dense clayey gravel (coastal plains deposit/“hardpan”)
  - Greater than 10 ft medium dense silty sand (coastal plains deposit)
Mill Creek Force Main HDD – Columbia, South Carolina

- Critical Success Factors
  - Identification of “hardpan” layer during geotechnical investigation and submittal review process
  - Kick-off meeting
  - Coordination between engineer and HDD Contractor’s engineer during construction

Reamer Damage due to Hardpan
Mill Creek Force Main HDD – Columbia, South Carolina

- Lessons Learned
  - During Submittal Review Process, Confirm Contractor’s Equipment Acceptable for Hard Drilling Conditions
  - Prior to Drilling, Confirm Contractor’s Equipment Same as Submittals Prepared by Contractor’s Engineer
  - Frequently Monitor Bore Path for Frac-Out Conditions
  - Confirm Contractor has Frac-Out Contingencies Prepared Prior to Drilling
Neely Road Force Main – Brevard, North Carolina Piedmont Geology

- 350 ft French Broad River Crossing
- 24” HDPE DR 9 Sanitary Sewer Force Main
- Subsurface Conditions
  - Approx. 12 to 14 ft Very Loose to Loose Sand and Very Soft to Medium Stiff Silt (Alluvium)
  - Approx. 0 to 11 ft Hard Silt or Medium Dense Sand (Residual Soils)
  - Approx. 7 to 22 ft Partially Weathered Rock (PWR)
  - Moderately Hard to Hard Gneiss
Neely Road Force Main – Brevard, North Carolina

- Open cut of French Broad river proposed for original design due to:
  - High rock strength (Gneiss with UCS of up to 22,000 psi)
  - High frac-out potential for overburden drill (through soil and PWR)

- Critical success factors
  - flexibility to allow contractor to submit bid alternate for HDD
  - contractor accepting responsibility for monetary and schedule impacts from frac-out within French Broad River
  - Detailed HDD design review
Neely Road Force Main – Brevard, North Carolina

**Lessons Learned**

- Obtain test boring within waterbody, if possible, and/or bathymetric survey to identify actual subsurface stratigraphy
- For water drills, confirm contractor frac-out contingencies are prepared prior to drilling
- Present options to owner to determine allowable risk tolerance for high-risk HDD drills
G. Robert House WTP Force Main Extension – Suffolk, Virginia - Coastal Plains Geology

- 3,865 ft Nansemond River crossing
- 18” fPVC DR 18 sanitary sewer force main
- subsurface conditions
  - Approx. 5 to 64 ft very soft to soft clay or loose sand (Alluvium)
  - Greater than 10 ft medium dense sand
G. Robert House WTP Force Main Extension – Suffolk, Virginia

- Critical success factors
  - Bathometric survey identified obstructions including abandoned bridge abutment and piers
  - Geotechnical baseline report resulted in lower than anticipated bids
G. Robert House WTP Force Main Extension – Suffolk, Virginia

- Lessons Learned
  - Perform route evaluation to determine potential utility conflicts and identify man-made obstructions
  - Preparation of GBR may reduce bidding costs
  - Use of conductor casing during pilot hole drilling may prevent frac-out in loose or soft soils

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Notes:
1. Baseline soil properties are based on CDM Smith interpretation of GET subsurface investigation.
Governors Island Water Main – New York, New York
Similar to Carolinas Mountain Geology

- 2,275 ft New York Harbor crossing
- 24” Steel casing pipe with 12” ductile iron sanitary sewer carrier pipe
- Subsurface conditions
  - Approx. 4 to 10 ft sandy fill (land)
  - Approx. 3 to 25 ft of very stiff clay
  - Approx. 8 to 30 ft sand or sand and silt
  - Approx. 11 to 42 ft of glacial till
  - Schist
Governors Island Water Main – New York, New York

- Critical success factors
  - Identification of glacial till layer with boulders during geotechnical investigation
  - Extensive geotechnical laboratory testing program on rock core samples
Lessons learned

- Drilling through unfavorable layers, such as glacial till, consider the following:
  - Minimize distance drilled through layer
  - Require contractor to submit contingency plans for obstructions
- Use of conductor casing during pilot hole drilling near HDD entry may prevent frac-out in loose or soft soils
Questions?