Design and Construction

Day 2

Excellence. Innovation. **Solutions that work.**



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engineering + construction management

PART 1 – Open-cut Construction and Methods

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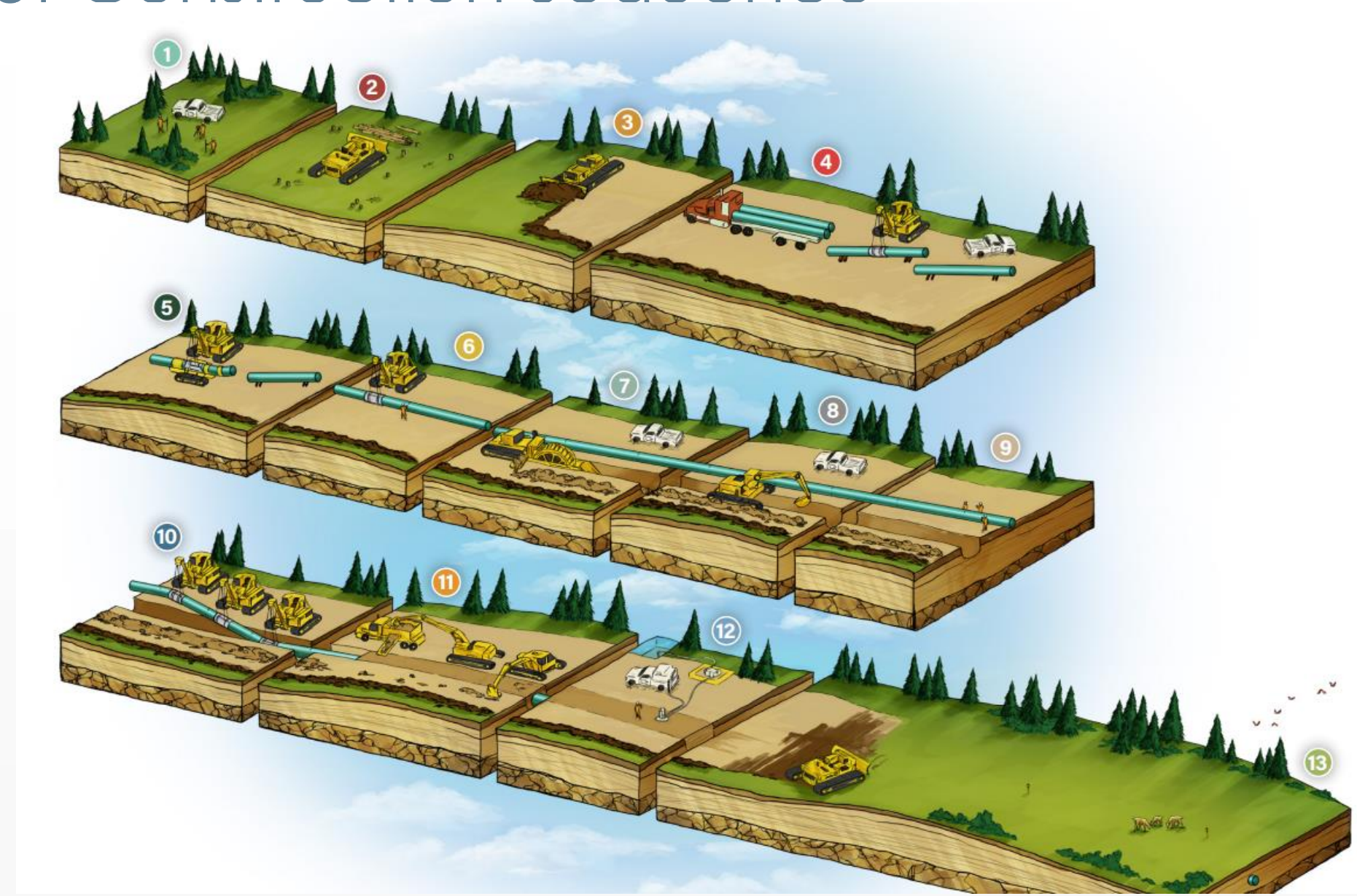
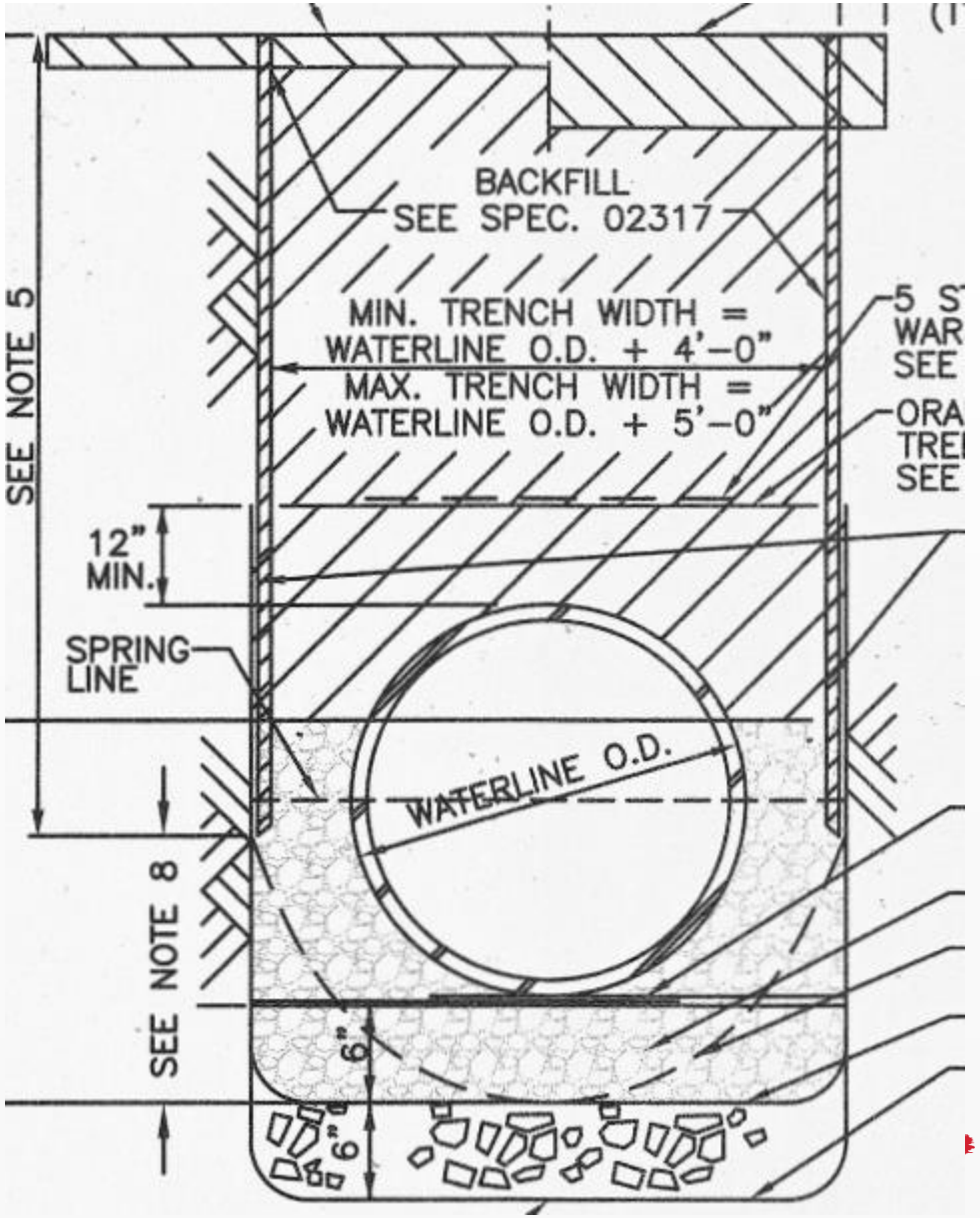
Open-Cut Construction Seauence

1. Survey & Stacking
2 & 3. Clearing Site
4 & 5. Stringing Pipe
6. Connection Pipe
7 & 8. Trench Excavation
9 & 10. Laying Pipe
11. Backfilling
12. Site Restoration



Open-Cut Construction Design Consideration

- Trench Width needs to be accounted for in design
- Where utilities extend across trench, plans need to indicate if it needs to be braced or replaced
- Trench limits should not encroach on the backfill of other utilities
- Where trench encroaches near existing utilities (<WL OD), special support is needed – Special Shoring
- Design needs to account for groundwater dewatering



Open-Cut Construction Trench Support

Sloped Excavation

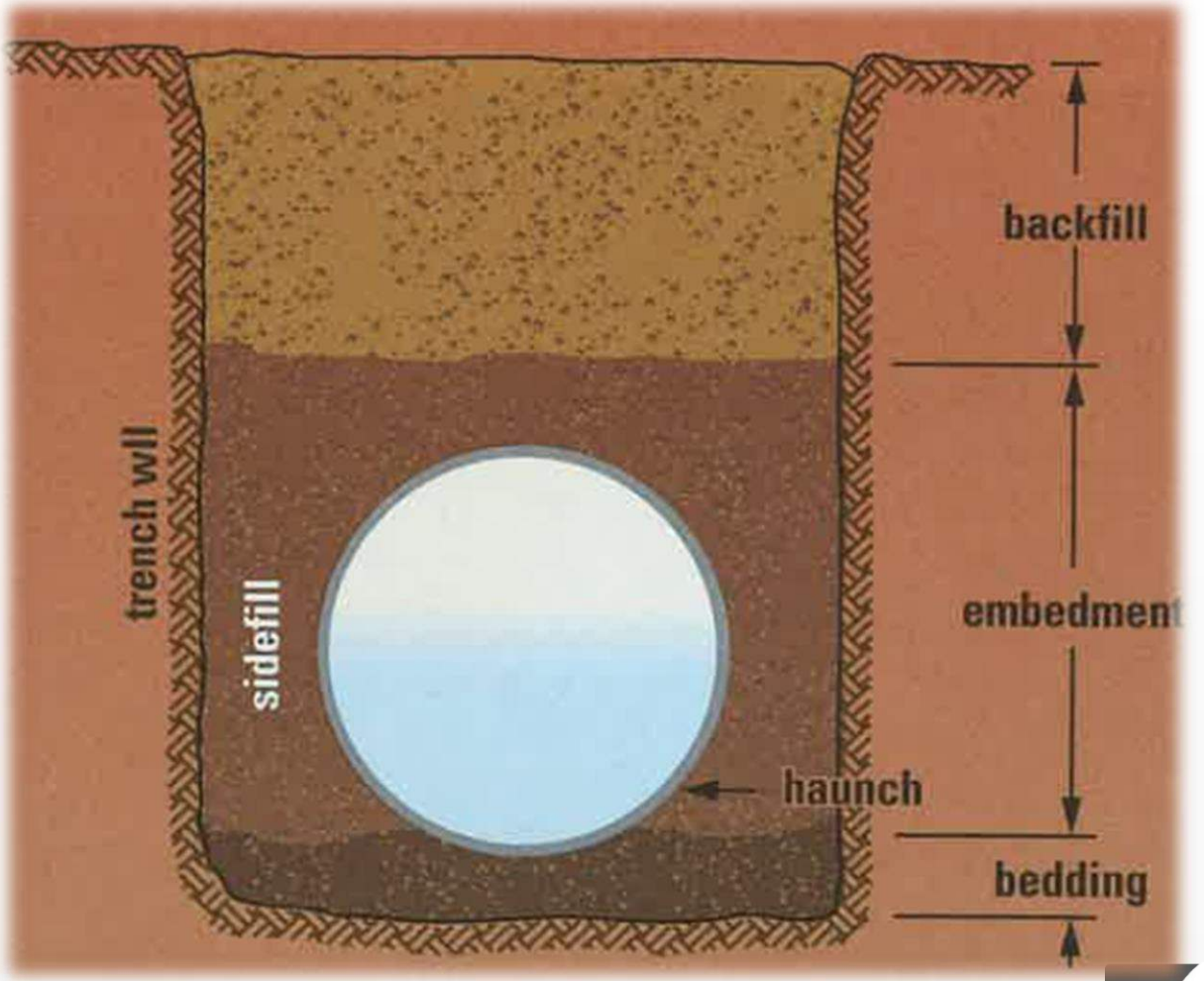
Trench Boxes

Solid Shoring

Open-Cut Construction Trench Backfill

- Haunching most important part of Trench. Typically needs to be compacted adequately
- Main Types of Embedment:
  - Cement Stabilize Sand

  - Flowable Fill



PART 2 – Tunnel Construction

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Tunnel Construction Design Considerations

- When to tunnel:
  - Roadways/Highways with lots of Traffic
  - Active Driveways
  - Limited ROW
  - Large Diameter Utility Conflicts
  - Railroads
  - Bayous, Channels, Creeks
  - Large Mature Trees

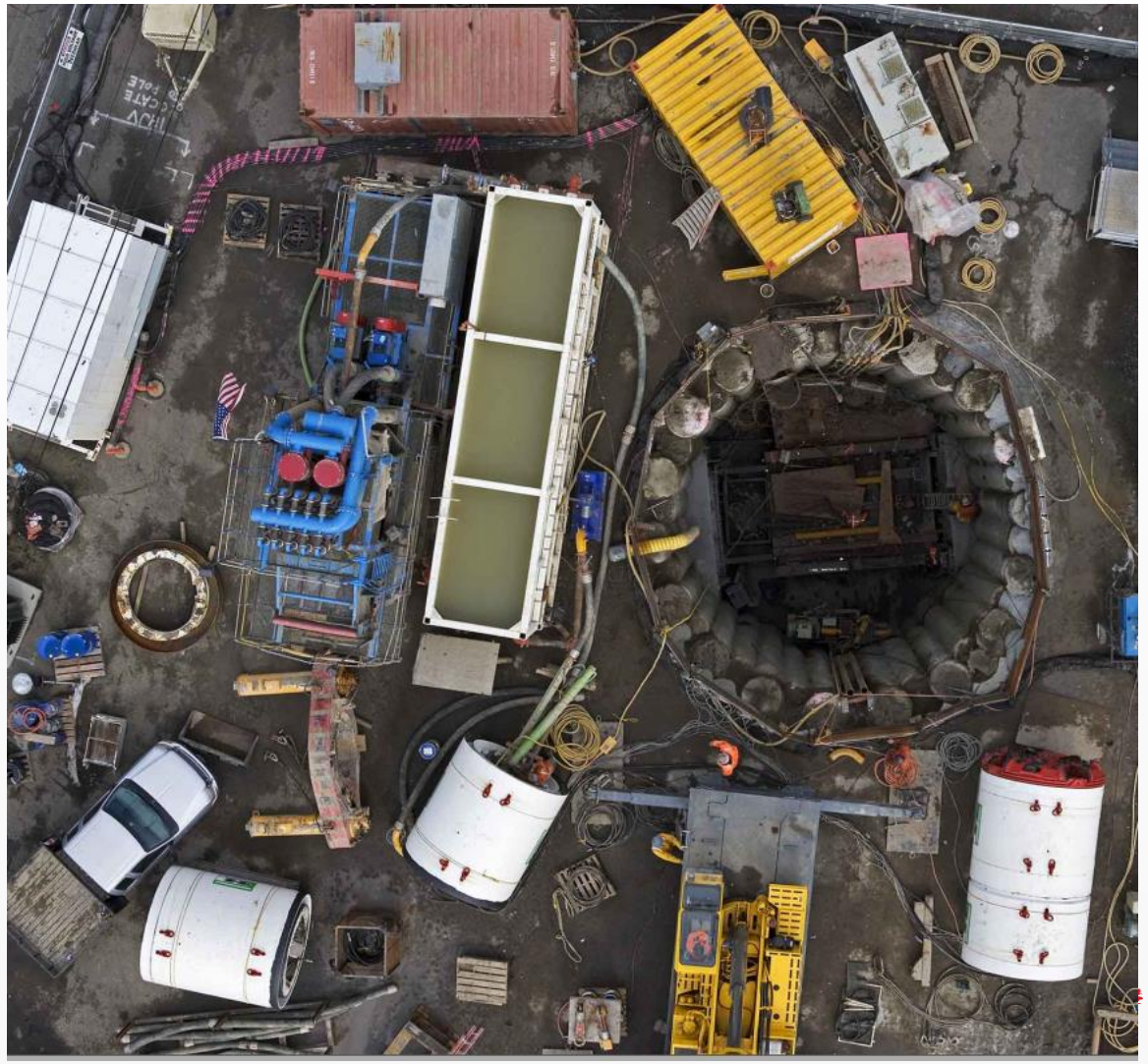
Tunnel Advantages & Disadvantages

- Minimize traffic impacts
- Mitigate disturbance to adjacent structures
- Reduce site restoration
- Limit staging or work area
- Minimize utility impacts
  - Maintain services
  - Avoid relocations

- Cost – minimum 2x cost of open cut
- Often requires night work
- Duration – tunnels take long time to construct
- Can still encounter utilities

Tunnel Shafts Considerations

- Required at both ends of Tunnels
- Launching and Receiving Shaft different sizes
- Consider utility conflicts when placing shafts
- Consider work area required



Tunnel Shafts Types

- 2 main shapes:
  - Circular or Semicircular
    - No Internal Bracing required
    - Larger footprint
  - Rectangular
    - Internal Bracing Required
    - Can be watertight

Tunnel Shafts – Trench Box

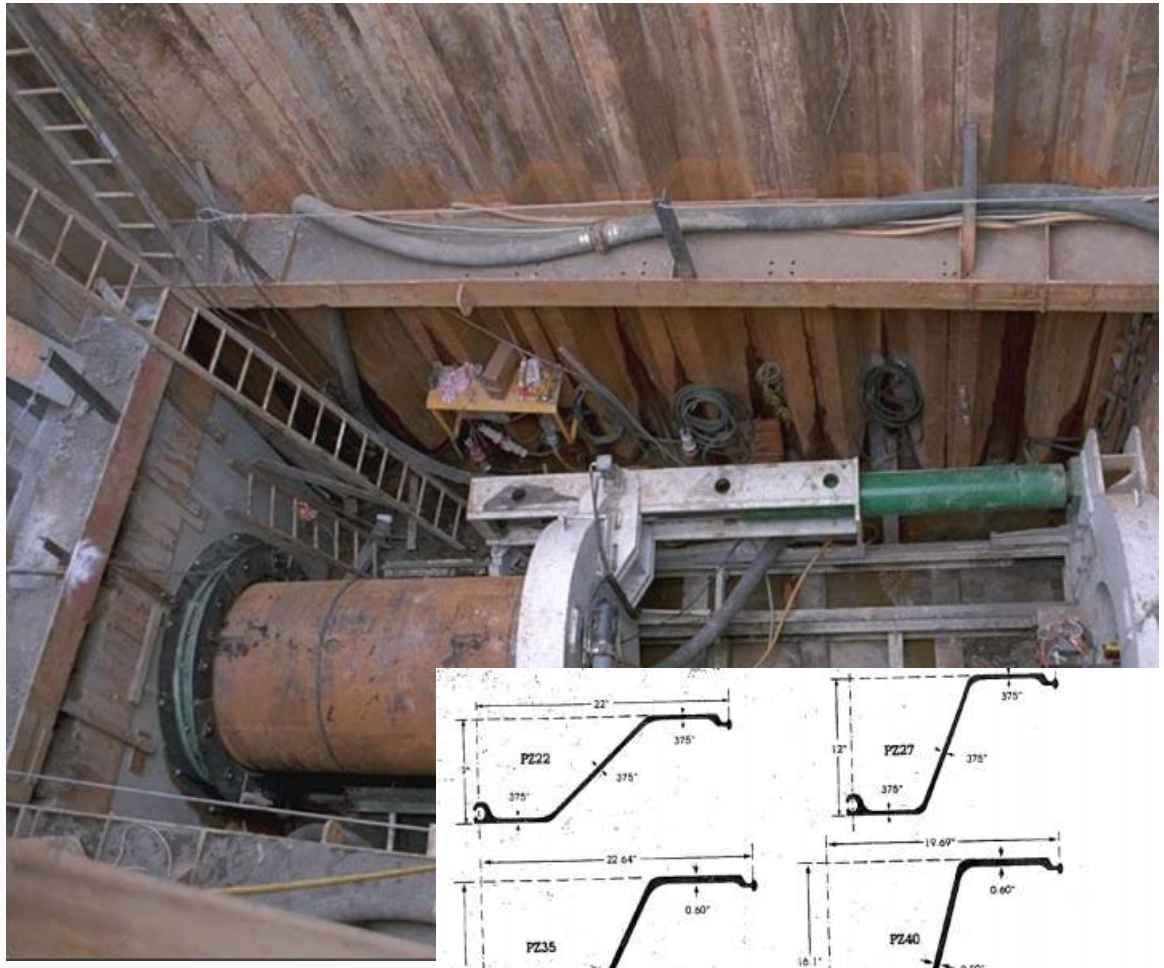
- Rectangular Shape
- Advantages:
  - Easy to install
  - Cheapest support method
- Disadvantage:
  - Only allowed for short installation time
  - Maximum depth = 20 ft
  - Not Watertight
  - Cannot accommodate utilities

Tunnel Shafts Support – Soldier Piles

- Rectangular Shape
- Advantages:
  - Solid Shoring, very secure method to support soils
  - Existing utilities can be accommodated
  - Can be use for depth up to 50 ft
- Disadvantage:
  - Limited cantilever depth before bracing needed
  - Not Watertight

Tunnel Shafts Support – Sheet Piles

- Rectangular Shape
- Advantages:
  - Solid Shoring, very secure method to support soils
  - Work in most soils
  - Watertight
  - Can be use for deeper depths
- Disadvantage:
  - Noise and Vibrations
  - Cannot accommodate existing utilities

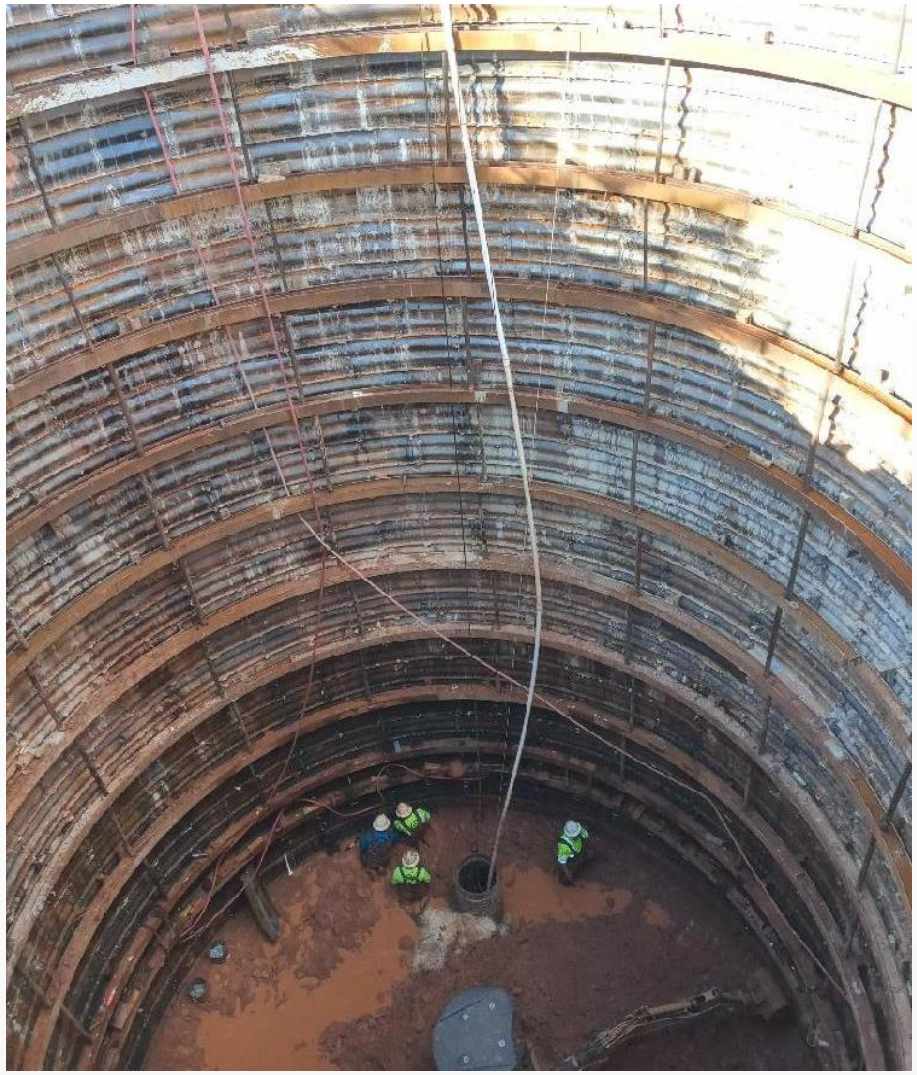


Tunnel Shafts Support – Soils Nails & Shotcrete

- Rectangular Shape
- Advantages:
  - Best method for hard rock soils Work in most soils
  - Can be use for deeper depths
- Disadvantage:
  - Expensive
  - Specialized Equipment Required
  - Use above groundwater

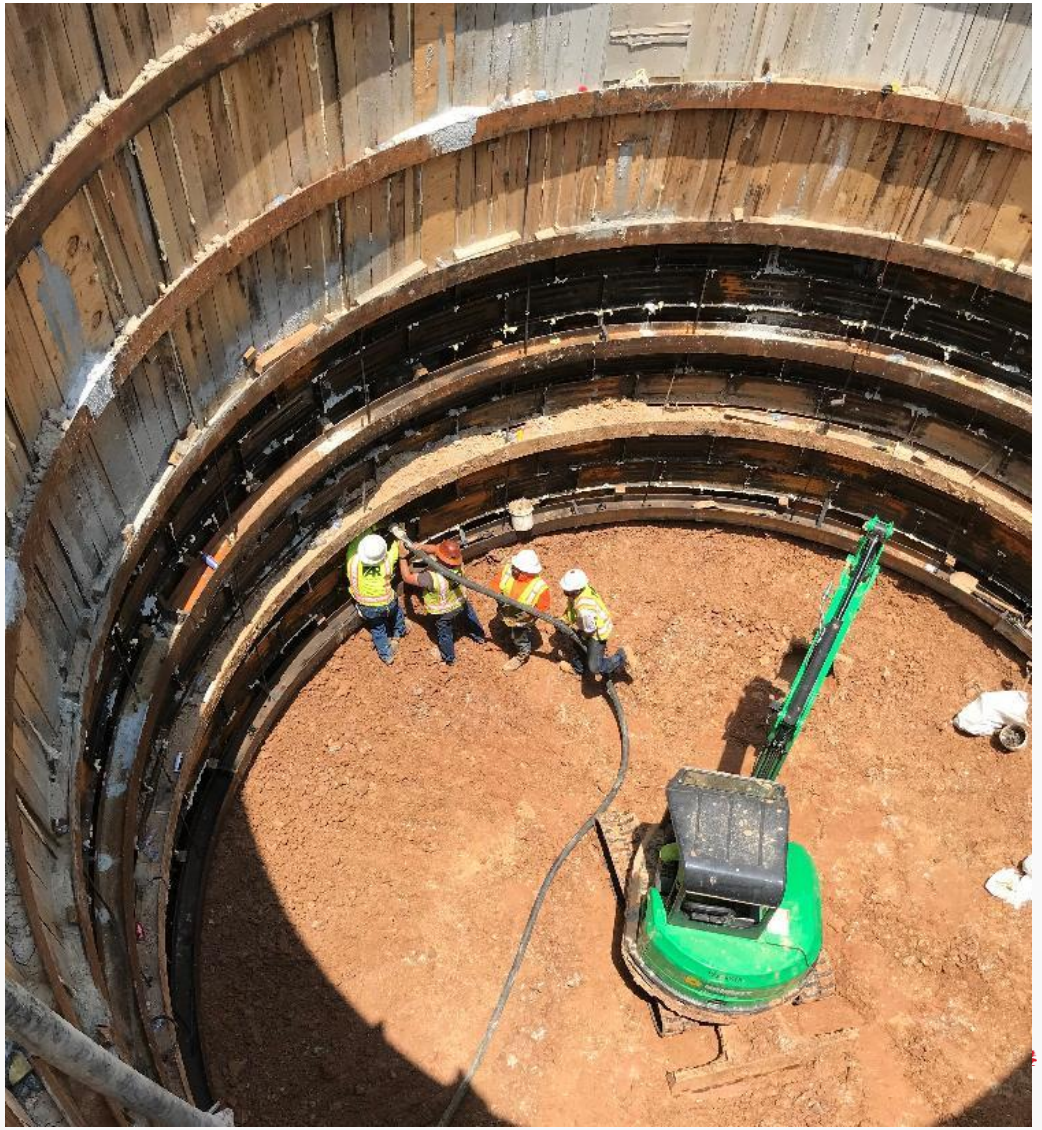
Tunnel Shafts – Liner Plates

- Circular Shape
- Advantages:
  - Flexible
  - Adaptable to various sizes
- Disadvantage:
  - Costly
  - Requires adequate time to stand-up and install
  - Cannot accommodate utilities



Tunnel Shafts – Ring Beams & Lagging

- Circular Shape
- Advantages:
  - Flexible
  - Adaptable to various sizes
  - Can accommodate existing utilities
- Disadvantage:
  - Requires adequate time to stand-up and install



Tunnel Shafts Support – Secant Piles

- Circular Shape
- Advantages:
  - Solid Shoring
  - Watertight
- Disadvantage:
  - Costly
  - Limited depth
  - Cannot accommodate existing utilities

Tunnel Shafts Support – Drilled Shaft

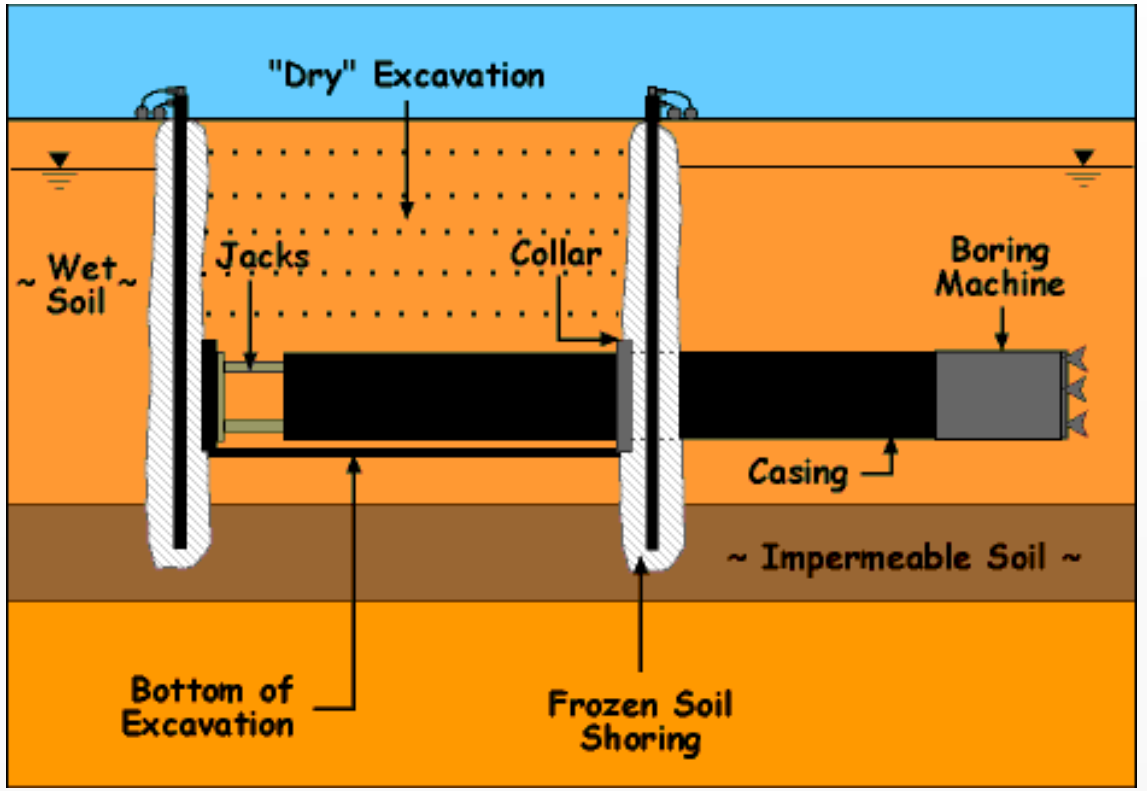
- Circular Shape
- Advantages:
  - Fast installation
  - Simple installation
- Disadvantage:
  - Costly
  - Limited diameter
  - Cannot accommodate utilities

Tunnel Methods – 2 Pass Installation

- Involves installation of Primary Liner, then installation of carrier pipe

Tunnel Methods – 1 Pass Installation

- Involves installation of Primary Liner, then installation of carrier pipe



Tunnel Methods – Hand Mining

- Advantages:
  - Simplest installation & Cheapest
- Disadvantage:
  - Slowest installation Method
  - Requires Stable and Dry Soils

Tunnel Methods – Jack & Bore

- Advantages:
  - Fast & Simple installation
- Disadvantage:
  - Limited <48" diameter
  - Limited to lengths < 300 ft

Tunnel Methods – Boring Shield

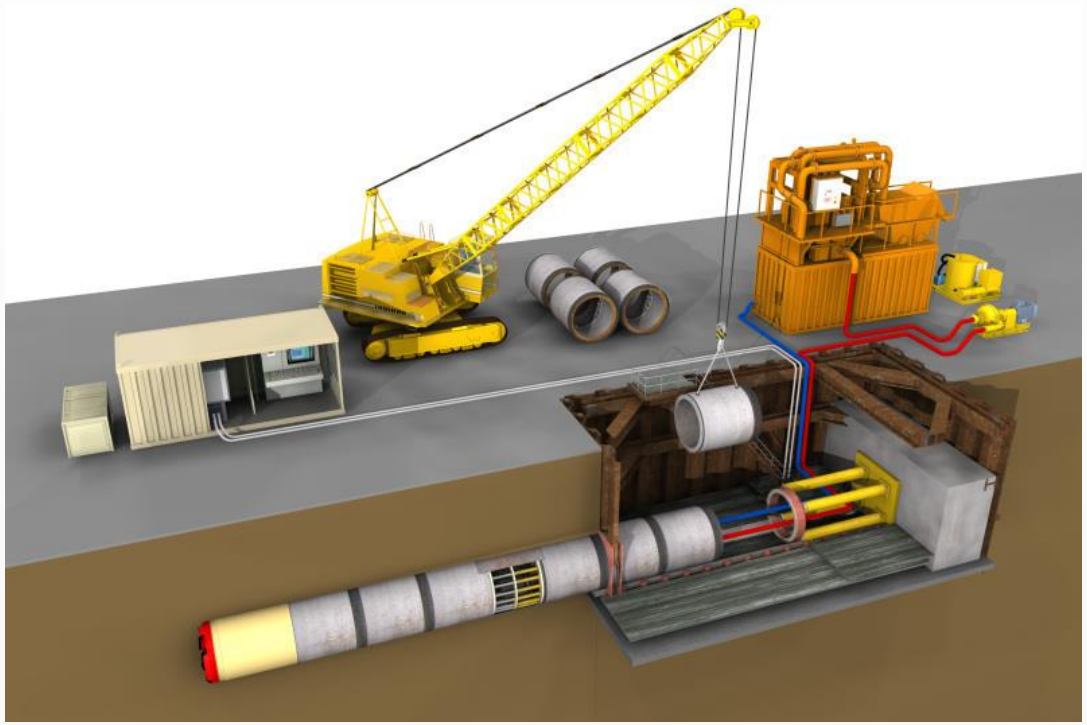
- Advantages:
  - Provides additional protection than hand mining
  - Can be used on Large Diameters
- Disadvantage:
  - Requires stable and dry soils

Tunnel Methods – Tunnel Boring Machine (TBM)

- Advantages:
  - Can handled multiple type soil conditions
  - Can be used for Large Diameters
- Disadvantage:
  - Costly
  - "Blind" excavation

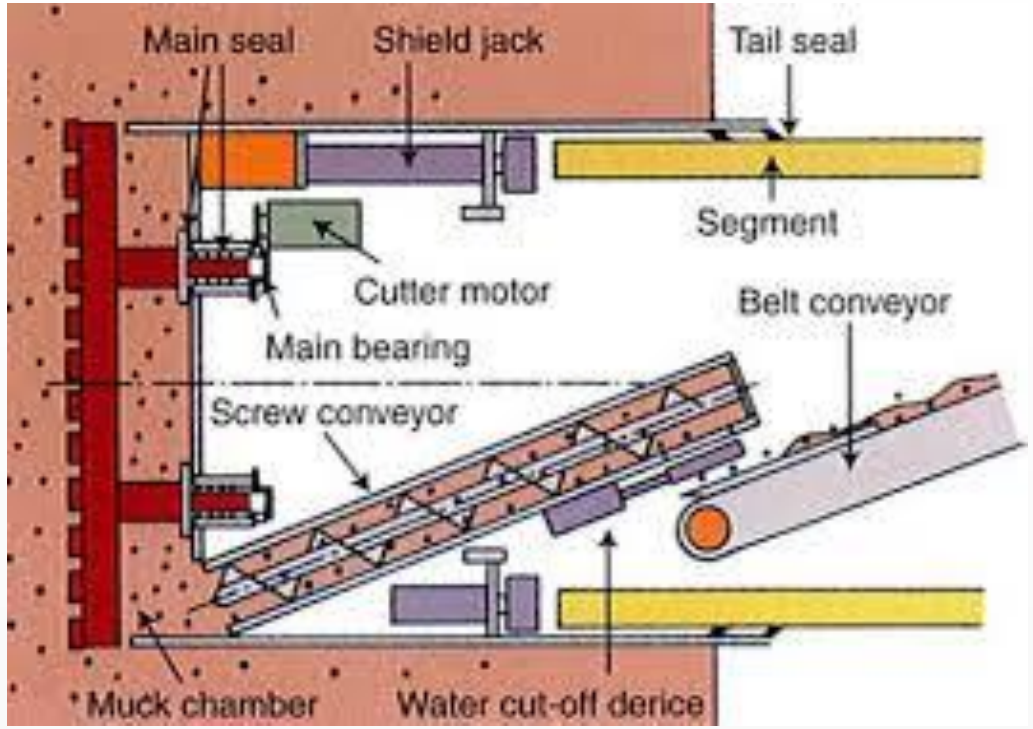
Tunnel Methods – Microtunneling

- Advantages:
  - No manned entry required
  - Can handle difficult soil conditions
  - Can be used in soils that cannot be dewatered
- Disadvantage:
  - Expensive
  - Limited pipe diameter
  - Requires large work area



Tunnel Methods – Earth Pressure Balance Marchine (EPBM)

- Advantages:
  - Best suited for difficult soil conditions
  - Soils don't need to be dewatered
- Disadvantage:
  - Most expensive
  - Requires specialized crew

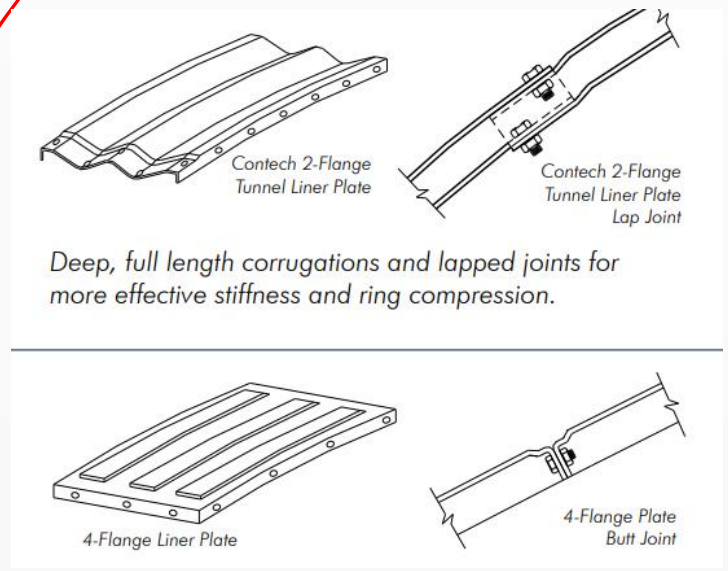


Primary Liner- Casing

- Most common method
- Pipe does not need to be coated or lined

Tunnel Primary Liner – Liner Plate

- Assembled by hand
  - Bolted together
- Two variants
  - 2-flange
  - 4-flange

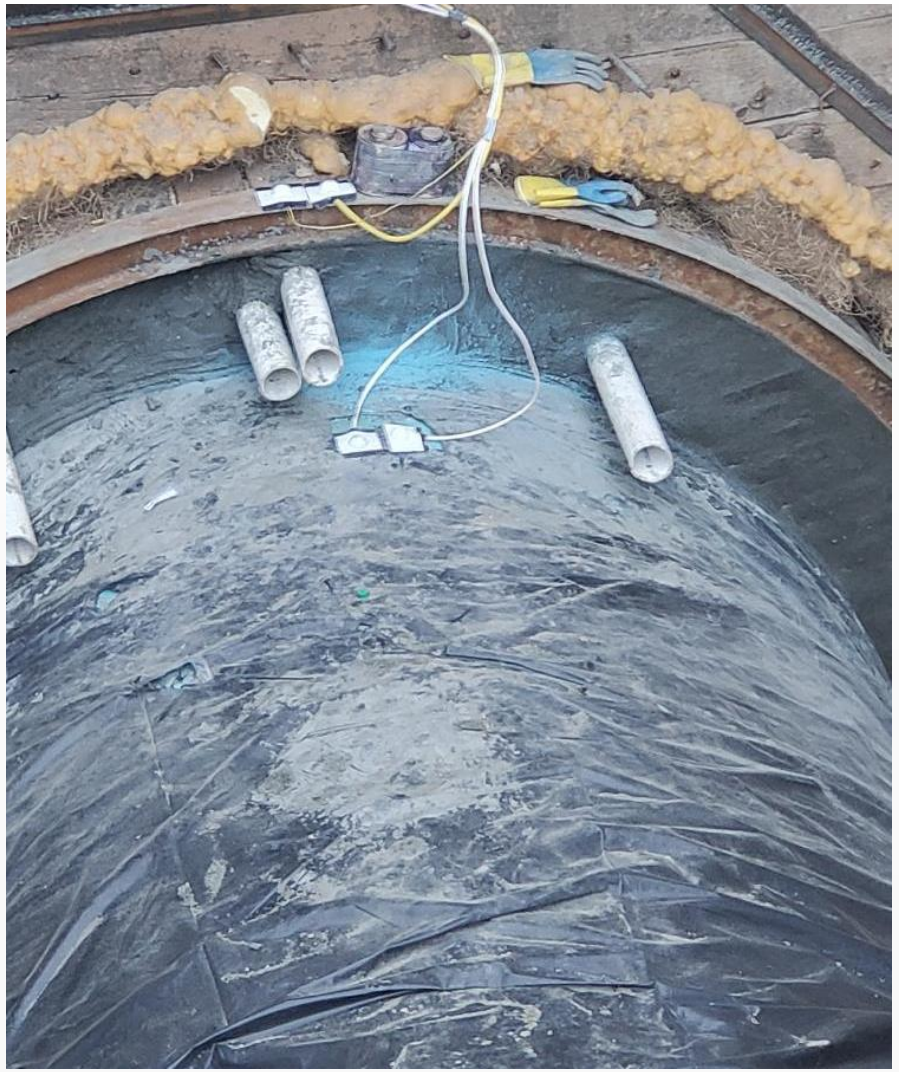


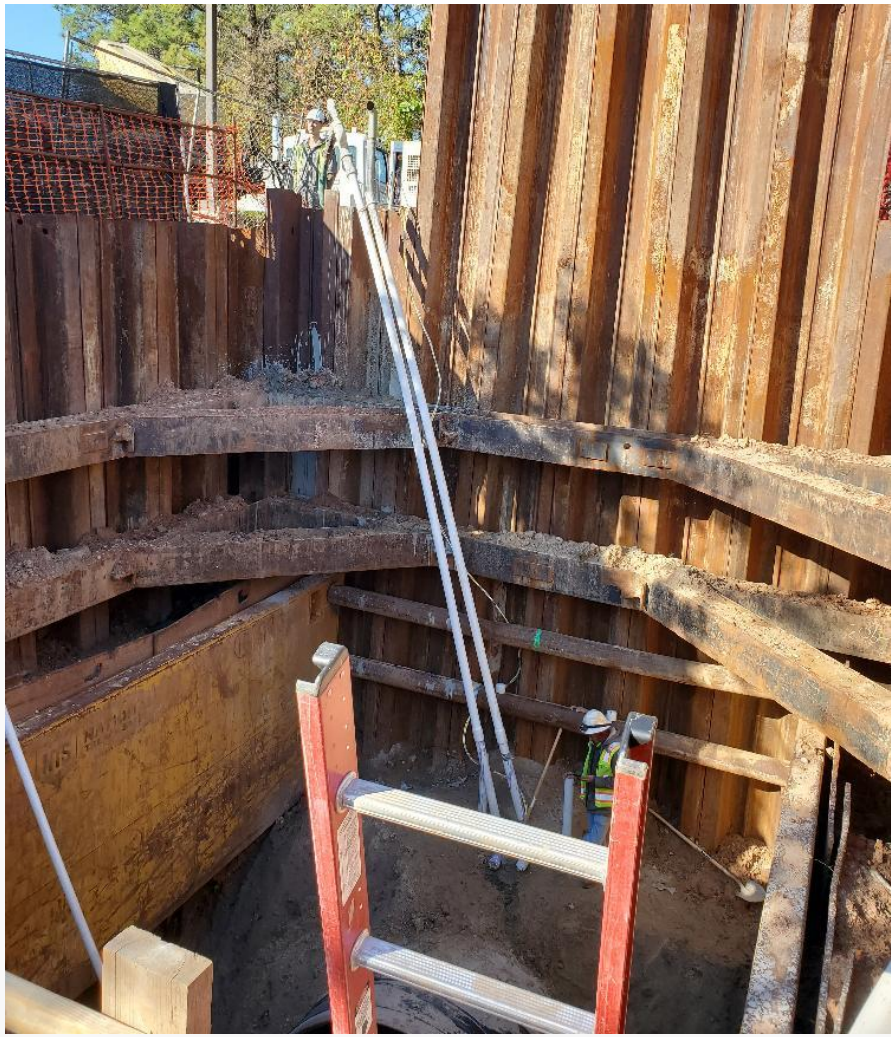
Primary Liner – Ring Beams & Lagging

- Wood lagging
- Steel lagging

Grouting Tunnel

- Buoyant force
- Vent air and excess grout





Tunnel Settlement

- Ground Loss Events
- Overcut
- Flowing Soils
- Settlement trough