Large Diameter Trenchless Pipeline Construction

Paul Nicholas

2016

Trenchless Methods

Trenchless methods for direct installation of larger diameter pipes over 48in and for long drives over 1000ft

- Microtunneling (MT)
- Horizontal Directional Drilling (HDD)
- Direct Pipe Method (DP) – MT / HDD Hybrid

AECOM

Microtunneling

- Pipe Jacking – 12 to 144in
- Remote Controlled
- Closed Face - supports and controls ground and ground water pressure
- Accurate +/- 1 in
- No man entry to tunnel required

Microtunneling – MT

AECOM

Microtunneling

Advantages

- Suitable for most ground types
- Accuracy +/- 1in - suitable for gravity sewers
- Provides ground support and ground water control
- One pass system
- Moderate footprint requirement
- Diameters from 12in to 144in
- Long drives over 2000ft for 48in+ ID RC pipe (60in OD)
- Curved drives vertically and horizontally

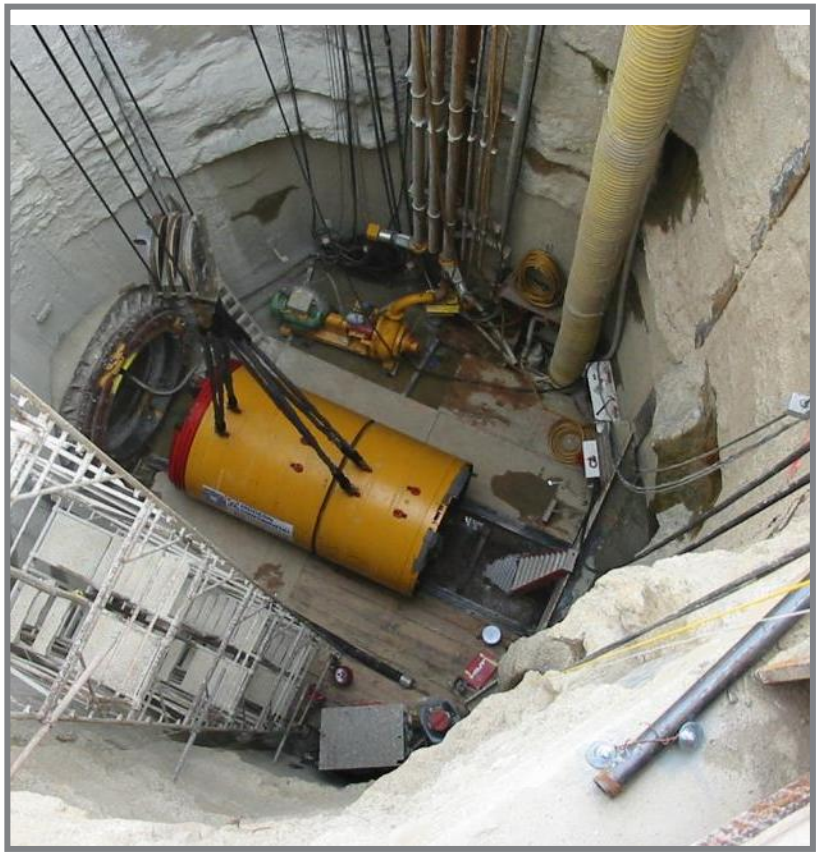
Disadvantages

- Requires shafts for launch and retrieval of the MTBM 12 to 20ft Dia.
- Long construction period for welded steel pipes (ex Permalok)
- Preferable to use short length pipes <10ft with flush bell & spigot type push fit joint
- Higher cost
- Typically drive lengths do not exceed 2000ft however drives of 8000ft have been completed

AECOM

Potential Problems with Microtunneling Procedure

- Shaft or thrust wall failure
- Exit entry seal failure
- Obstructions
- Jacking Pipe failure
- Pipe freezing (High jacking loads)
- MTBM mechanical failure
- Excess settlement due to over excavation
- Blocked slurry system / cutter chamber
- Excessive Tooling wear



AECOM

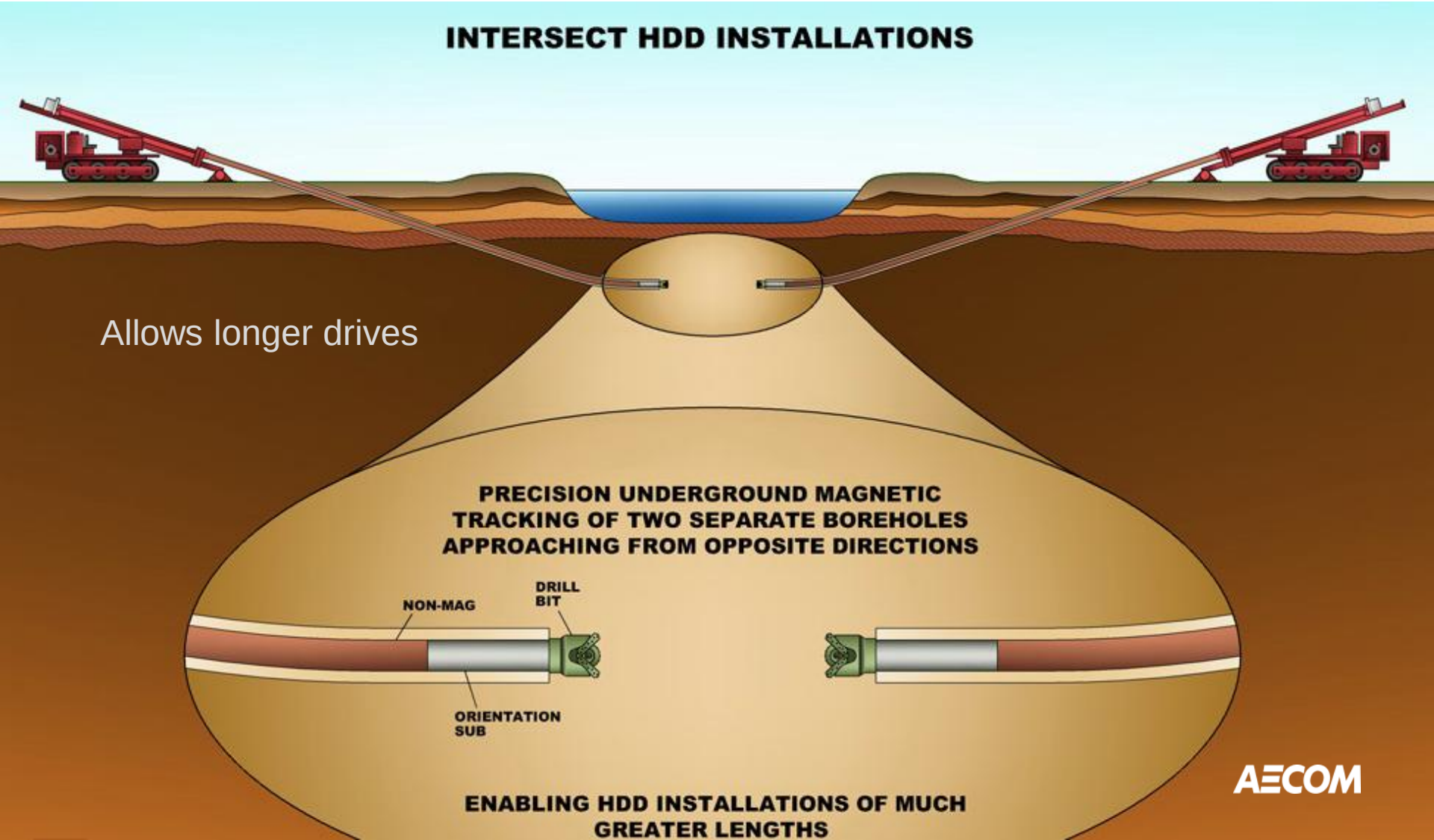
Horizontal Directional Drilling – HDD

Horizontal Directional Drilling - HDD

- Directional drilling method with multiple drilling and reaming phases
- Generally for conduits or pressure lines
- Guided system - accuracy dependent on guidance system and type of drill head
- Open hole method with bentonite slurry providing ground support
- Normally a curved drive from surface to surface without the need for shafts
- No man entry below ground level
- The pipe is pulled back through the drilled and reamed bore and requires a pipe laydown area

AECOM

HDD Intersect Method – For longer drives



Large Diameter 48in HDD

Advantages

- Minimal or No shafts required
- Shorter Construction time
- Generally lower cost
- Risk reduced as pilot bore may find any existing obstructions
- Long drives -10,000+ft without intermediate shaft with Intercept method
- Vertical and horizontal curves
- Suitable for HDPE pipe as well as steel
- No workers below ground surface

Disadvantages

- Mainly For pressure pipes and conduits, steep grade gravity sewers are possible but not normal.
- Large site requirement on the pipe pullback side (Pipe Laydown area)
- Risk of hole collapse
- Risk of fluid loss (Frac-out) in particular under water bodies with possible environmental issues
- Multi pass system with several reaming passes for large diameter
- Less accuracy than MT or DP

AECOM

Large Diameter 48in HDD – Equipment Advances

- Down hole Jet Pump / Reamer
- The Downhole Jet Pump (DHJP) is a device designed for reaming in soft ground and cleaning boreholes
- by mechanically and hydraulic absorption of the cuttings through a sized grid
- integrated jet pump. The Jet pump transports the the cuttings through the drill string towards the exit of the borehole directly to the separation plant.

AECOM

Large Diameter 48in HDD – Equipment Advances

- Full Face Rock Reamer
- One pass to 42in (previously 3-4)
- Two pass to 72in (previously 5-6)

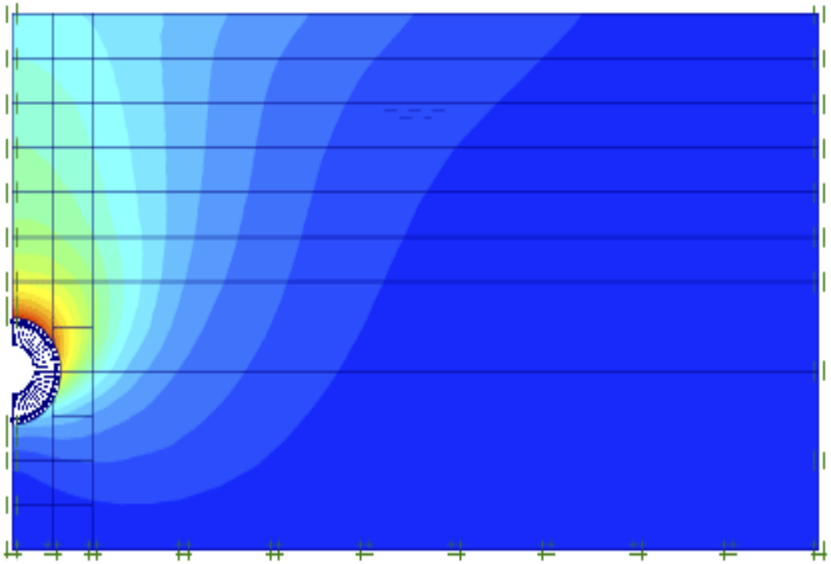
- Full Face Reamer with Jet pump reamer for removal of cuttings

AECOM

Directional Drilling Design

Loads

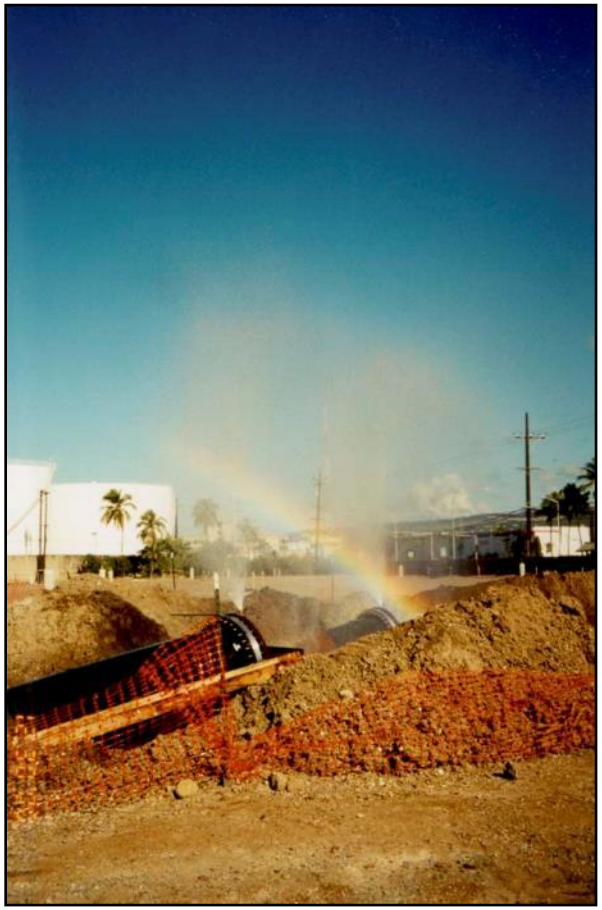
- Pressure (Internal)
- Depth (Overburden)
- Bend Radius (Elastic)
- Tensile loads (Pulling)
- Thermal Effects
- Surface Loads
  - » Static
  - » Dynamic
- Seismic Loads



AECOM

Potential Problems with HDD Pilot Drilling Procedure

- Bad Pilot Hole
  - » Unacceptable product pipe radius
  - » Unacceptable drill pipe radius
  - » Sharp Corners
- Failure, damage or loss of downhole assemblies (e.g. drill pipe, motors, cutting bits)
- Failure or damage of drill pipe
- Hydraulic Fracture
  - » Inadequate underground cover
  - » Improper use of drilling fluids



AECOM

Potential Problems with Pullback Procedure

- Stability of Bore Hole
  - » Potential for cave-ins with soft soils
  - » Failure to carry away/out cuttings/aggregate
  - » Blockage from cobbles and gravel

- *Incorrect reaming equipment and reaming steps*
- *Pullback failure by exceeding pipe bend and /or tensile limits*

AECOM

Direct Pipe Method - DP

A hybrid of HDD & MT

AECOM

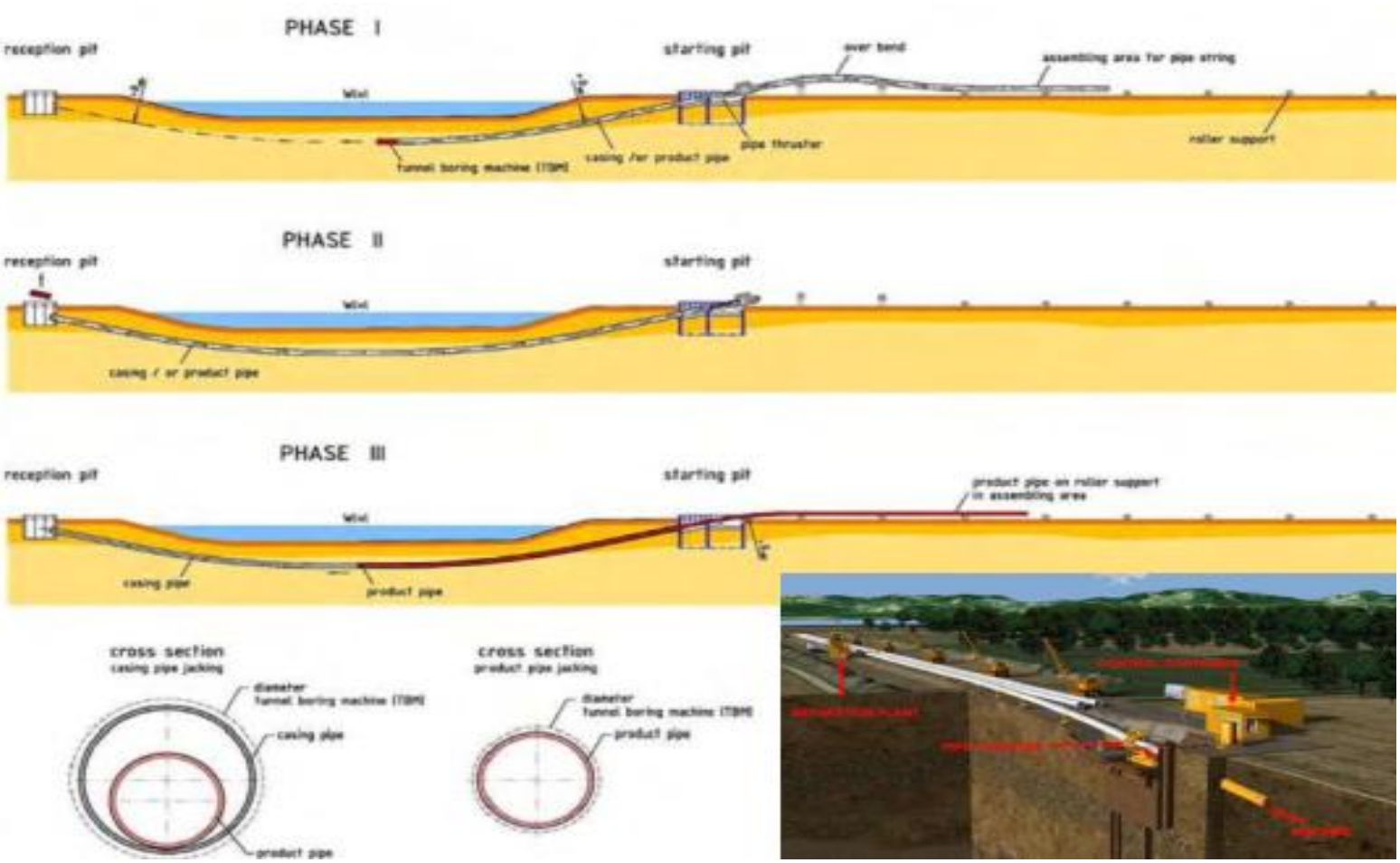
Direct Pipe Method

This is a hybrid of Microtunneling and HDD

- A MTBM is used sized for the required pipe diameter (30 – 60in)
- Guidance is normally with a Gyro system accurate to 3in
- The MTBM is launched from a shallow surface pit and curves down and back to surface or a shaft similar to HDD
- The pipe laydown area is required but at the same location as the drilling side
- The MTBM is directly attached to the required pipe and thrust into the ground by a pipe pushing unit in a single phase operation (similar to pipe Jacking)
- Possible to use pipes that are only suitable for thrust loads typically RC,PC and MS

AECOM

Direct Pipe Method



AECOM

Direct Pipe – Netherlands – 48in 4600ft

Direct pipe Set up

Direct pipe thrusting unit

AECOM

Direct Pipe v HDD

Advantages

- Single phase installation – No Reaming
- Pipe directly installed during excavation removes the risk of hole collapse
- Reduced risk of lost circulation (Frac-out) or fluid loss
- One main working site
- Potentially the shortest construction time
- Lower Risk

Disadvantages

- Capital cost of equipment – requires MT system and the pipe pusher system
- Higher cost / ft than HDD
- Heavier foundation for pushing unit (750t of thrust for 56in)
- Maximum length to date 4600ft of 48in and largest diameter 2800ft of 56in steel pipe (UK)

AECOM

Method Comparison

PARAMETER	MICROTUNNELING	HDD	DIRECT PIPE
Diameter Range (installed pipe OD)	6 -144in	4 - 56in	30-60in
Longest length	8200ft	12000ft	4600ft
Shafts Required	Yes	No	No
Pipe laydown area required	No (offsite)	Yes	Yes
Long 20ft Steel pipes	Yes	Yes	Yes
HDPE 20ft sections	No	Yes	No
Short 4-10ft Collar & Spigot pipes	Yes	No	Not Normally
Multi or single pass	Single	Multi	Single
Ground type	soft - Rock	soft - Rock	Soft – Rock
Ground support	Good	Moderate	Good
Site space	Moderate	High	High
Cost	High	Lower	High
Speed of construction	Slow	Fast	Fastest

AECOM

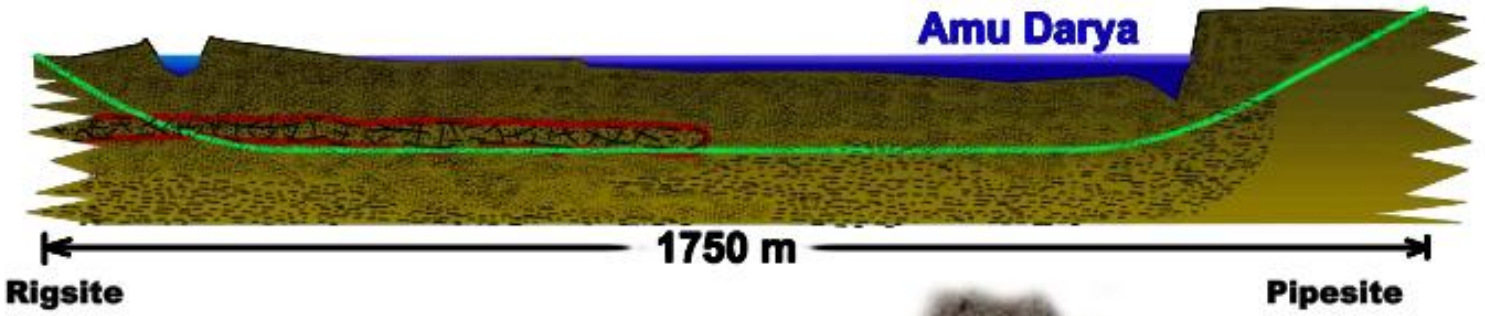
Projects

HDD In Turkmenistan – 56in 5700ft

THE PIPELINE PROJECT, FACTS & FIGURES.

Challenges

Elevation:	rigsite 209 m	pipesite 220 m
Entry angle	rigsite 7°	pipesite 6°



Main Component	sand & fine gravels
Minor Component	silt & clay
Minor Component	pelitic sand stone

AECOM

Risk Issues

Risk Analysis and Risk Management.

- High pull forces during pullback
  - 750t pipe-thruster installed on pipe side to be used if required
  - Accurate pilot bore and reaming up to 72”
  - Proper buoyancy control of the 56” product pipe
- Geological risk
  - Change to a deeper profile
  - Make a Deeper pit on one side to remove effect of different elevation
  - Change direction of pilot bore
  - Use 8” crossing bore as a test bore for the real geological conditions
- Delay Mitigation
  - Execution of the work by using 2 independent HDD rigs (400 & 250t)
  - Have a pipe pushing rig installed and available

AECOM

Pipe Site with Thruster Unit

Pull back 56” product pipeline

- Full length pipe laydown area is preferred but multiple sections may be used
- Requires welding or fusion jointing during pullback which causes delays and higher risk of the pipe pullback loads increasing and possible failure to move the pipe

AECOM

Reaming Stages

On this project 2 HDD rigs (400 &250 t) were utilized to rotate the pilot drill and for the reaming.

- Reaming: 18-32-44-58-66 &72 in
  Fly cutters with Barrel reamers were used for each size increment

AECOM

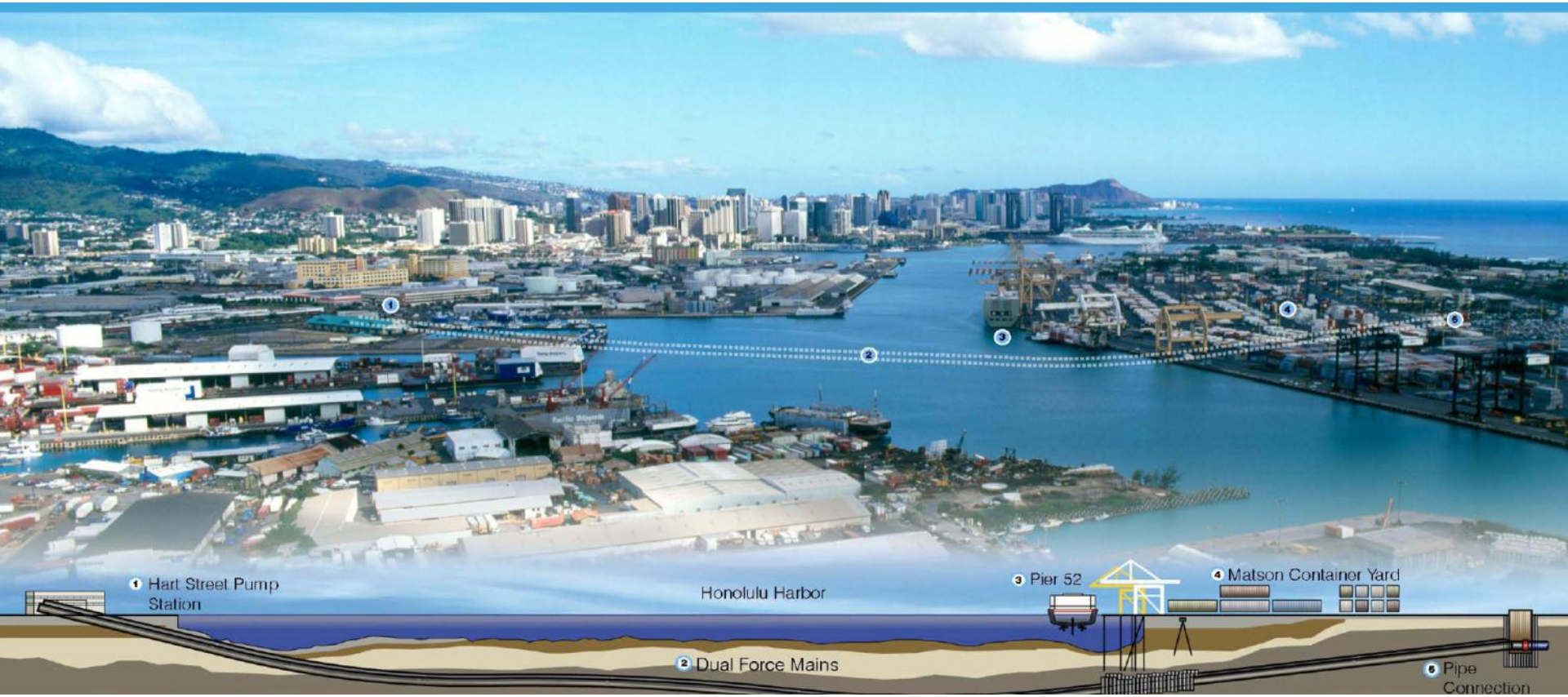
Successful Completion

Pull back 56'' product pipeline

- 30 hours for pullback
- Average pull force of 135 to (metric)
- Only 4 damaged pipe rollers (sun)

AECOM

Hart Street Crossing - Hawaii



AECOM

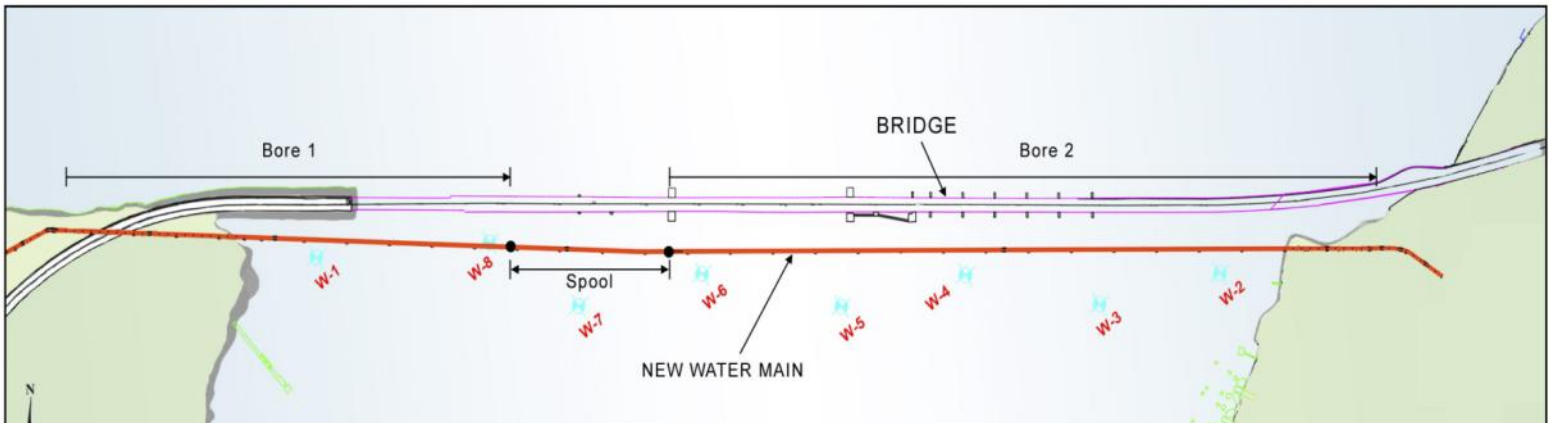
Hart Street Hawaii – 46in HDD

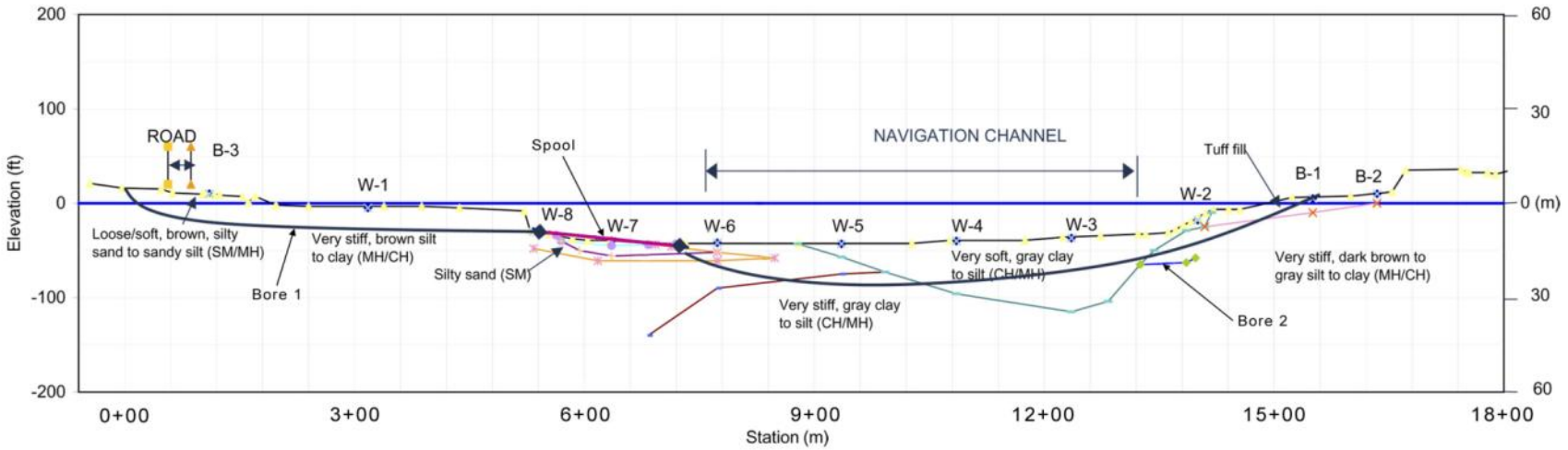
PROJECT DESCRIPTION

- Wastewater pump station force main replacement
- Twin 46in steel casings 3200ft long were installed by HDD methods under the main shipping channel of Honolulu Harbor from Hart St to Sand Island.
- 34in HDPE pipes were installed inside the casings
- A depth of 120ft was required to pass underneath piles
- Complex grouting / ground improvement was required

AECOM

Alignment and Subsurface





AECOM

Pilot Bore

AECOM

Pullback

AECOM

Microtunneling - Portsmouth Force Main - Oregon

- Final section of Portland's $600m CSO project to reduce CSO outfall into the Willamette & Columbia rivers, **includes the longest microtunneling drive in the USA of 3055ft of 84in RC pipe on the East side project.**
- Segment 1&2 =16,000ft of pipeline :

  6000ft of 120in Conventional soft ground tunneling with GFRP

  3000ft of 84in Microtunneling with steel pipe

  7000ft of Open cut construction

- 3000ft of 84in Microtunneling using internally and externally welded 20ft steel pipe sections.
- 3 Drives of 836, 163 and 1903ft (A record drive for steel pipe in the USA)

AECOM

Portsmouth Force Main Microtunneling Drives

AECOM

Portsmouth 81.6in Steel Pipe

AECOM

Microtunneling Long Drive Issues

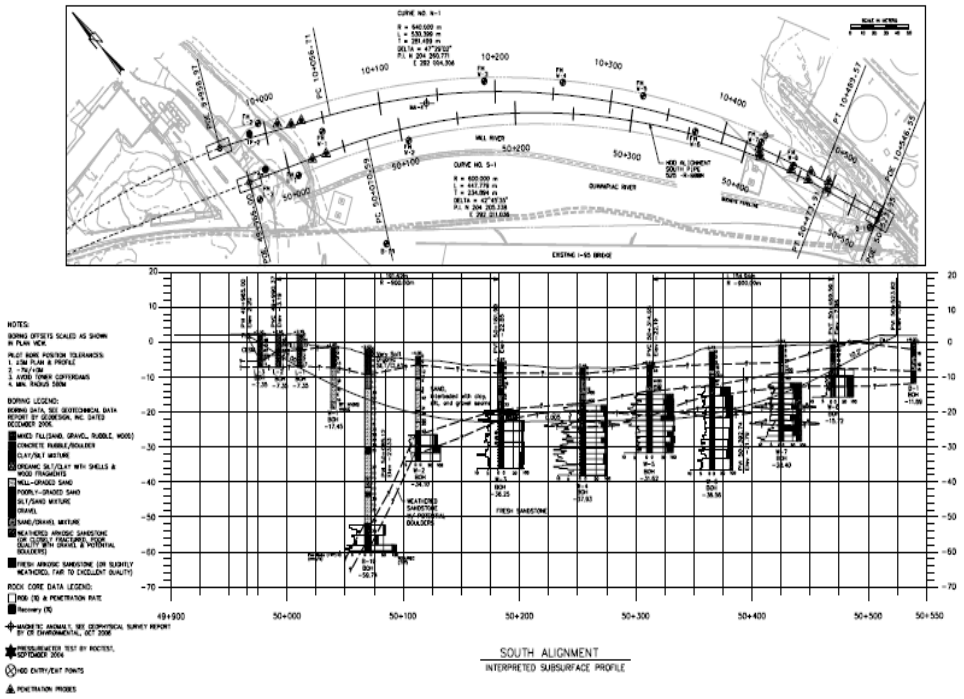
- Ground Conditions
  - *Material & WT (Portsmouth Wet unstable Silt & fine grained sand)*
  - *Obstructions (Portsmouth Timber logs and wood piles 18-24in in diameter)*
- Pipe – Jacking Loads
  - *Pipe Lubrication (ABIS)*
  - *3 x Intermediate Jacking Stations (IJS)*
- Equipment
  - *MTBM (Torque & RPM)*
  - *Guidance (Laser , Gyro, Laser Tachymeter)*
  - *Slurry pumps*
  - *Slurry treatment*
- PEOPLE

AECOM

Trenchless Project Design

Installation Design

- Establish alignment profile based on site and underground investigation.
- Estimate installation loads on pipe during Jacking /pullback
- Compare pullback / Jacking force with allowable tensile / thrust force. (HDD may fail if curvature is excessive)
- Check safety factor against buckling & tensile strength needs MT Pipe compressive strength



AECOM

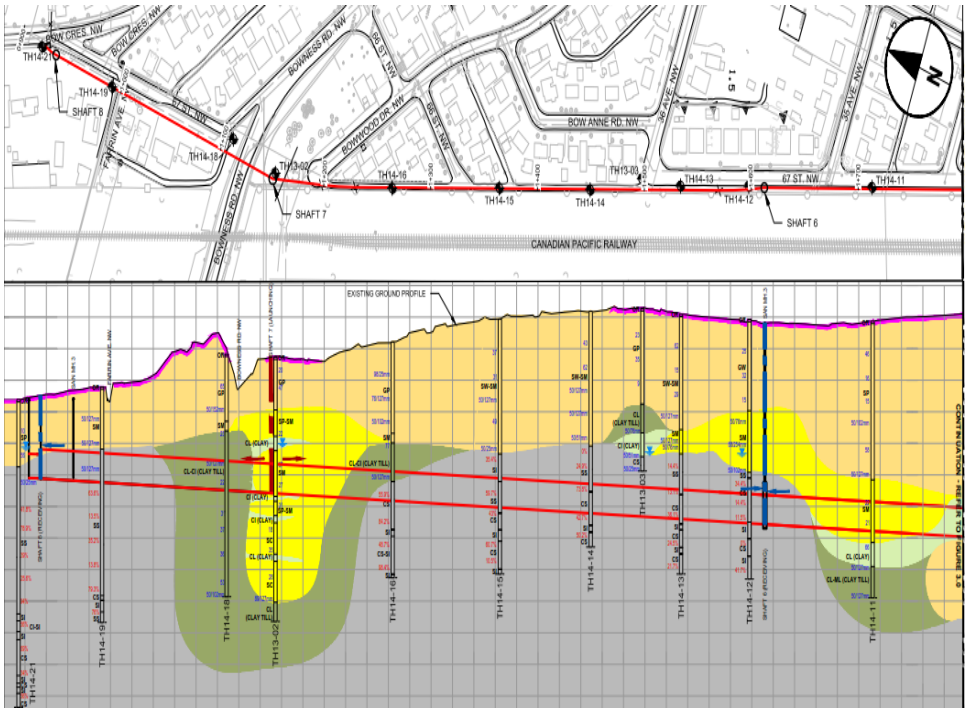
Failure Profile

- Obstructions
  - » Natural
  - » Man-Made
- Shaft Failure
- Machine Failure
- Pipe Failure
- Main causes for failure are man-made and could be avoided with proper planning, design, and/or site engineering.

AECOM

Detailed Subsurface Investigation

- Detailed drilling program
- Laboratory testing
- Geophysics
- Geotechnical Report
  - *GDR*
  - *GBR*



Geophysics

Identifying obstructions, Utilities, Rock lines

- Ground penetrating radar
- Seismic reflection
- Cross-hole tomography
- Aerial magnetic survey
- Microgravity

AECOM

Thank You.