WESTPORT'S PUMP STATION NO. 2 FORCE MAIN REPLACEMENT PROJECT USING HDD: A CASE STUDY

By: Bryan Thompson, Town of Westport, CT
Abhinav Huli, Haley & Aldrich, Inc.
Lori Carriero, Tighe & Bond

Figure 1: Project Location in Westport, CT


Figure 2: Work area west of Saugatuck River, Westport CT

INTRODUCTION

The Town of Westport had experienced several sanitary sewer force main breaks on pipes of similar age and material and decided to proactively replace the Pump Station 2 force main to avoid the catastrophic environmental impacts that would result from a force main break under the river.

Pump Station No. 2 is a sanitary sewer pump station located in the Town of Westport, CT that provides service to 25 per cent of the sewer customers on the western side of the Town. The station is located on the western shore of the Saugatuck River. The river crossing is near the confluence of the river with Long Island Sound and hence the river is influenced by tidal activity. The existing force main is a 10-inch cast iron pipe that crosses the river to connect the station to the Westport Water Pollution Control Facility (WWPCF) located to the east of the river. The force main was originally constructed in 1959 by floating it across the river and sinking the pipe to the river bottom. Traditional methods of pipeline replacement such as open cut excavation or sinking a replacement pipe were not feasible given the need for a tidal river crossing and expected difficulties in obtaining permits for this type of installation. Horizontal directional drilling was therefore selected as the preferred installation method to install the new 14-inch HDPE force main. Figure 1 shows the project location.

HORIZONTAL DIRECTIONAL DRILL DESIGN

Logistical Challenges:

As is the case for most trenchless projects in busy areas, it is critical to address the stakeholder challenges and logistics before tackling the technical

Figure 3: View of the HDD rig, overhead lines, I-95 bridge, site access and the conductor sleeve


Figure 4: Work area east of Saugatuck River, Westport CT

Figure 5: Marsh grass along with bedrock outcrops indicating steep joint sets west of Saugatuck River, Westport CT

Figure 6: Sample rock core showing Precambrian Gneissic bedrock

challenges. In that regard, the project location posed a few logistical challenges.

West Side:

The existing main is located to the south of the I-95 Bridge over the Saugatuck River and is within the right-of-way for Interstate 95. The bridge was constructed in 1957 and rehabilitated in 1992 with additional width expansion of 14 feet on both sides. This required the HDD alignment to be of sufficient depth so as to not affect the bridge foundation. The Metro-North commuter rail line's Westport train station is located to the south of the project site. This resulted in heavy traffic movement along Riverside Avenue through the course of the day and especially during the peak hours. Therefore, the traffic movement along this road could not be disturbed during construction. The commuter parking lot located north of Pump Station 2 between Riverside Avenue and the Saugatuck River and beneath the I95 Bridge had to be closed during construction. Based on review of CDOT drawings, a portion of the existing parking lot north of the pump station beneath I95 was a former gas station with underground storage tanks. The project site was also adjacent to numerous restaurants, one of which was on the water and was pile supported.

East side:

The east side contained the WPCF, the Town Animal Shelter and a boat ramp. The HDD exit location and pipe assembly area were also partially within the right-of-way for Interstate 95. It was crucial to maintain access to these facilities at all times during construction.

Technical Challenges

The technical challenges included underground and overhead utilities, potential settlement of nearby buildings and I-95 bridge foundation, subsurface conditions, potential inadvertent returns and the HDD alignment design.

Underground utilities and Instrumentation plan

Underground and overhead utilities were of concern, especially on the west side of the river. The west side HDD entry area was in close proximity to a 36-inch diameter storm pipe and a storm manhole. The 36-inch diameter storm sewer pipe terminated in an outfall into the river. In addition, the new force main was proposed to cross underneath the existing force main from Pump Station No. 2. This force main had to remain in operation throughout the drilling operation.

An extensive instrumentation plan was designed due to the presence of a restaurant on piles, Pump Station No. 2, and the bridge foundations near the HDD alignment on the west side. On the east side, the animal control facility and existing infrastructure conveying sewage to the WPCF were of concern. A combination of utility monitoring points, inclinometers, two types of deformation monitoring points were installed at strategic locations and monitored on a regular basis. The bridge piers were surveyed daily to ensure that no movement was observed.

Subsurface conditions

Haley & Aldrich, Inc. had previously performed geotechnical engineering for the I-95 bridge expansion in 1992. The bridge was originally constructed in 1957 and consisted of two abutments and nine piers. The foundation consisted of steel H piles, cast-in-place concrete piles (mandrel driven concrete drilled steel shells), cast on bedrock or dense granular deposits.

Haley & Aldrich, Inc had also performed temporary excavation support and subsurface evaluation for the improvements to the Westport WPCF in 2003. Based on the available information, a desktop study was performed to establish

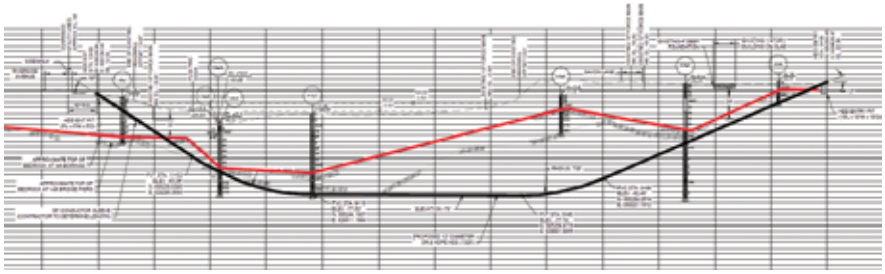

Figure 7: HDD alignment profile. Red line indicates the approximate top of bedrock.

Figure 8: Installation of the conductor sleeve

Figure 9: The Magnetic Beacon system

Figure 10: 22-inch diameter reamer on the HDD rig before starting the ream

the subsurface exploration program for the HDD alignment.

A total of 6 borings were performed as a part of the subsurface exploration program. Based on a review of the existing I-95 bridge borings and the six test borings, the subsurface profile at the project HDD crossing includes Fill soils, Organic Deposits and granular Glaciofluvial Deposits overlying gneissic bedrock. Bedrock outcrops were observed near the WPCF along the eastern river bank.

Bedrock was cored in the borings and was generally described as a hard to very hard, fine to very coarsegrained foliated Gneiss with high to extreme abrasivity, unit weight of 150 to 175 pcf, and a compressive strength of up to 34,000 psi.

Figure 11: 22-inch diameter reamer exiting on the east side

Multiple joint sets (discontinuities) were noted with joint spacing judged to be very close to moderately spaced. The top of bedrock elevations varied widely along the project alignment. A Fault line was located along the eastern side of the Saugatuck River. Subsequent glacial scouring removed broken rock from faulted bedrock zones, likely contributed to the highly variable and weathered top of bedrock elevations which ranged from 9 to 56 feet below ground surface.

HDD Alignment Design

Various HDD alignment alternatives were examined to minimize the disturbance to the various stakeholders. Considering the changes in subsurface conditions, the HDD alignment was designed almost entirely within bedrock to minimize the potential for inadvertent return of drill fluids in the river and to avoid drilling in potentially unstable borehole conditions. In general, rock was expected to be very hard and very abrasive to cutting tooling.

The hydraulic design of the new force main in combination with the expected HDD installation stresses and pull loads resulted in a 14-inch diameter DIPS DR9 HDPE pipe. The DR9 thickness was selected to provide a wall thickness that could not only sustain higher installation loads but also potential gouges since the drill was almost entirely in rock.

The final HDD alignment was designed with HDD entry/exit angles of 18 degrees and 12 degrees on west and east sides with a total length of 1,300 feet and approximately 90 feet in depth from the HDD entry location. The pipe laydown for pullback was designed east of the river along the treatment plant access road. A combination of a steep entry angle and use of a steel conductor sleeve was recommended to be used on the HDD entry (west) side to mitigate the potential for inadvertent returns while drilling from the ground surface to the top of bedrock. This was also intended to mitigate the potential for over-excavation and settlement of the nearby utilities and

Figure 12: HDPE product pipe fused laid for pullback along Elaine road. WWPCF and I-95 are to the left and right side of the photograph respectively

Figure 13: View of the east side work area at the at the beginning of pipe pullback

pile supported buildings. As required by regulatory agencies, the specifications also required the contractor to submit a detailed inadvertent return contingency plan delineating the steps that would be implemented in case of inadvertent returns.

Permitting Efforts

The proposed drilling work required extensive permitting efforts as part of the design phase, including:

– CTDEEP Office of Long Island Sound Approval was required due to work within a tidal wetland area. This permit required the following:

- Review and approval from the Army Corps of Engineers, Westport Shellfish Commission,
- Natural Diversity Data Base (NDDB) State species review
- Review and approval from the CT Department of Agriculture/Bureau of Aquaculture
- Notification of all property owners within 500 feet of either side of river

– CTDOT Approvals for work in right of way of Interstate 95, State Route alongside the project site, and boat ramp access on the east side of the river

The NDDB review resulted in peregrine falcons having known nesting locations within the project area. Because of this, construction was prohibited from taking place between March and July.

Resident/Agency Coordination Efforts

The Town of Westport directly handled all coordination and communication with local businesses, train commuters and the CT DOT. This included all resident notifications required by permitting agencies. The construction of the new force main required the closure of the commuter parking lot throughout the drilling work. The commuter lot, although State of CT property, is maintained and operated by the Westport Office of Railroad Parking, a division of the Westport Police Department. In November 2017, (one-month prior to expected start date), the Police Department notified all commuters with parking passes that the lot would be closed from January 1, 2018 to March 5, 2018. Notification was in form of an email as well as on a tow behind variable message board positioned in the parking lot stating the dates of the closure.

Extensive coordination was also required with the CT DOT during the permitting phase and throughout the construction phase. The Town worked directly with the State to obtain the necessary approvals. The Town's longstanding working relationship with the DOT ultimately resulted in a much shorter approval process and reduced the overall project cost as consulting fees were reduced accordingly.

Bid Phase Issues

The contract was initially advertised for bid in April 2017, with a scope of work including both the directional drilling and piping connections on either side of the river, and a construction cost estimate of $2.5M. The contract specifications indicated that all drilling work should be completed in August and September both to adhere to DEEP permit requirements and coincide with lowest use of the commuter parking lot due to summer vacations.

Only one bid was received which was well above the cost estimate. Conversations with potential drilling contractors revealed that the proposed time frame was too restrictive given their existing project workloads. In addition, combining the drilling and piping connection work was adding subcontractor markups to already high drilling prices. The decision was made to separate the drilling work from the piping connection work and allow proposed drilling contractors to specify the drilling timeframe (which had to be in accordance with DEEP permit limitations).

The project was re-bid in June 2017. A total of three bids were received, and the contract was awarded to Carson Corporation of Lafayette, NJ who was the low bidder with a bid price of $1.4M. A meeting with Carson prior to contract award confirmed their intent to perform construction in January and February of 2018.

Construction Specifics/Photos

In view of logistical and technical constraints, Carson Corporation chose

Figure 14: Product pipe pullback complete

Figure 15: View of the I-95 Bridge and the product pipe

Figure 16: Flooding during one of the nor'easters

to drill from west to east so that drilling and pullback could be performed from the same side. Carson used an American Auger D210 with a smaller footprint to fit in the available work area.

A 36-inch diameter steel conductor sleeve was installed on the HDD entry side. TT Technologies pneumatic hammer "Goliath" was used to install approximately 85 feet of casing at an angle of 18 degrees until the refusal criteria of 1ft/10 min was met.

Upon completing the installation of the conductor sleeve, the HDD rig and associated support equipment were mobilized into the commuter parking lot underneath the I-95 Bridge. Limited site access and tight work space resulted in the drill rig partially hanging over the sidewalk which required installation of scaffold over the sidewalk to protect pedestrians from potential falling objects. Because of the hard bedrock Carson also had spare mud motors and drill bits onsite. Simultaneously on the west side, three 500-foot sections of new force main pipe were fused, and low-pressure tests were performed in preparation for the pipe pullback.

The contractor used a magnetic beacon system with a range of approximately 300 feet. Due to this limited range, the beacon was moved to strategic locations along the alignment as the drill progressed.

Carson began drilling the pilot hole using a 9.625-inch diameter pilot head. Inadvertent returns were observed when the drill head exited the conductor sleeve at approximately 90 feet at what appeared to be the interface of the conductor sleeve and possible weathered rock. Drill rig chatter was also observed when the drill head passed through this location. Carson immediately stopped the drilling operations and implemented the inadvertent return contingency plan which included containing the inadvertent returns using silt curtains and sand bags as applicable, using appropriate loss prevention material such as magma fiber and cedar chips, having a mud engineer reassess the drill mud parameters to ensure appropriate properties to mitigate inadvertent returns and finally, increasing the depth of the alignment so as to increase the capacity of the overburden to sustain drill mud pressures. Tidal fluctuations of approximately 7 feet resulted in Carson having to work during low tide. Drilling was resumed after establishing drill mud circulation and plugging the inadvertent returns. As the drill progressed toward the east, the rock was observed to be harder based on the production rates, HDD rig behavior, and the soil cuttings.

The bedrock was observed to be shallow (<10 feet) on the eastern side and inadvertent returns were observed at the interface of top of rock and soil when the pilot drill proceeded past the animal shelter location. Carson implemented contingency plans and installed haybales and sand bags around the affected area and vacuumed the inadvertent returns. The pilot drill was completed approximately 23 feet short of the designed location.

Upon completion of the pilot drill, given the prior observations, a 20-inch diameter reamer was used to push-ream up to 210 feet from the entry location to assess drilling conditions at the end of conductor sleeve and check for inadvertent returns at the previously observed location, if any. No inadvertent returns were observed. The 20-inch diameter reamer was replaced with a 22-inch diameter reamer and push-reamed to the east side. The combination of push-reaming and an elevation difference of 11 feet between entry and exit location assisted the drill mud flowing back to the HDD entry side for processing. During the reaming process, a 22-inch diameter reamer had to be swapped with a new reamer due to wear on the cutting head.

A pit was excavated at the exit location for multiple purposes:

- To expose the shallow bedrock and prevent any broken rock from falling into the borehole
- Temporarily contain the drill mud until completion of the pipe pullback.
- Use trucks to transport the contained mud from the exit side to the entry side for processing.

A final swab was completed using a 22-inch diameter reamer. The 14-inch diameter HDPE product pipe was then pulled in place over a two- day period. Considering that the drill was completed almost entirely in rock, Carson pulled approx. 500 feet of pipe on day one and left the pipe in the borehole overnight. The remainder of the pipe was pulled on day two without any issues. A hydrostatic pressure test was successfully performed upon completion of the pipe pullback.

The tidal fluctuations of approximately 7 feet combined with the risk of flooding due to the three nor'easters resulted in Carson having to take precautions to avoid damage to equipment and personnel and avoid flooding the entry pit. The snow plows driving on I-95 Bridge resulted in the snow falling over the bridge and onto the equipment layout. Carson took

precautions to avoid overhead risks and called off operations when the conditions were deemed unsafe.

Once the drilling work had been completed, the Town worked with Tighe & Bond to bid a separate contract to make the connections between the newly drilled force main to the influent WPCF piping and Pump Station No. 2. This work was successfully completed in the spring of 2018.

CONCLUSION

The construction of this force main replacement contract was ultimately a successful project. Lessons learned/ takeaways from this project include:

- Separating the drilling work from the pipe connections avoided excessive markup on subcontractors and allowed drillers to bid the work directly, resulting in lower costs for the client
- Allowing flexibility in the construction time period allowed drilling contractors to plan the work around existing projects, resulted in more bids being submitted, and ultimately lower bid prices
- Having the Owner directly involved in permitting efforts, agency coordination during construction, and resident communication helped to speed up the overall permitting timeline during the design phase and also allowed swift emergency approvals when needed during construction

ABOUT THE AUTHORS:

Bryan H. Thompson *has been serving the Town Of Westport, Connecticut for over 29 years. As the WPCA Collection System Supervisor he is responsible for all facets of the Town's sanitary sewer collection system, including oversight of collection system operation and maintenance as well as the design and construction of facility improvements and sewer extension projects. Through his role with the Town, he has developed an expertise in coordinating with residents and contractors, as well as local, State and Federal regulatory agencies.*

Lori Carriero *is a Project Manager with Tighe & Bond who has significant experience in the evaluation and rehabilitation of sanitary sewer systems. She has overseen the evaluation and installation of numerous trenchless technology products, and has presented papers on trenchless technology at various seminars and conventions. Lori is a member of the NASTT-NE Chapter.*

Abhinav Huli *is a senior trenchless engineer with Haley & Aldrich, Inc. He has 8 years of experience in preparation of contract documents, design calculations, and with onsite construction monitoring of various new trenchless installations including Horizontal Directional Drilling, Microtunneling and Horizontal Auger Boring.*