The Art of the Deal: Negotiating a High-Risk, Contractor-Proposed HDD on the Fly

Will Gibson, P.E., AECOM, Norfolk, Virginia
Tim Marsh, Hampton Roads Sanitation District, Virginia Beach, Virginia
Daniel Rickmond, P.E., Tidewater Utility Construction, Inc., Suffolk, Virginia
Matthew Francis, P.E., AECOM, Salt Lake City, Utah

1. ABSTRACT

During force main construction in Downtown Norfolk, Virginia, the general contractor wanted to avoid an especially challenging segment of open-cut installation adjacent to a high-end shopping mall. After considering and excluding several ideas, a 1,000-LF 30-inch horizontal directional drill (HDD) was proposed at no cost to the project. The proposed HDD alignment through a high-rise and utility-rich corridor, with complex natural and manmade geology and subsurface features made it particularly challenging. The complicated nature of Downtown Norfolk’s subsurface required historical reviews of land reclamation and advanced geotechnical considerations, increasing risk. Additionally, the proposed HDD path was alongside the oldest structure in Norfolk: a colonial-era historic church constructed in the 1730s.

This paper explains the vetting strategies of the expeditious design and proactive observation measures implemented to reduce risk and comfort skeptical stakeholders. It also details how the contractor, engineer, and owner collaboratively negotiated this major change in work and garnered buy-in from City officials and local stakeholders. In addition, the financial and contractual terms of the change order, including concessions, are presented to show how all parties came together for the mutual benefit of the project. Results of negotiations included City requirements for an overnight pipe-pull, purposely leaving most of Downtown Norfolk unaware of the major event. Additionally, of historically significant, the owner agreed to its first use of fusible PVC as the HDD pipe material.

Ultimately, the paper provides owner, engineer, and contractor perspectives of the negotiation and construction process, including valuable lessons learned from proposal to execution.

2. INTRODUCTION

The Hampton Roads Sanitation District (HRSD) owns and operates a large, regional force main interceptor system and 13 wastewater treatment plants providing service to 18 counties and cities and approximately 1.7 million residents in the Hampton Roads region of Virginia.

In 2011, HRSD (owner) initiated the South Trunk Sewer Section G Force Main Replacement Project to replace approximately 6,000 linear feet (LF) of a large-diameter interceptor force main in Downtown Norfolk. The owner had determined that the force main piping, constructed of prestressed concrete cylinder pipe (PCCP) in the 1940s,
was beyond its designed service life and at-risk of failure. In addition, a specific section of the force main was under an Environmental Protection Agency Consent Order to be replaced by 2018.

During construction, the general contractor, Tidewater Utility Construction, Inc. (contractor), decided that it was worth exploring options to avoid a particular section of the pipeline, designed to be installed through open-cut methods. In an effort to avoid this troublesome section of the alignment, the project team, comprising the owner, engineer, and contractor, considered many options. Ultimately, the contractor proposed a 1,000 LF horizontal directional drill (HDD) to circumvent this section of the alignment, as shown in Figure 1. Capturing how this proposal went from idea to rapid successful installation, this paper details the following:

- Project background and how the history and geographic area of this project played into the original design and the proposed HDD
- How the HDD was proposed and negotiated within the team and sold to stakeholders
- Advantages and disadvantages as a result of this proposed change to the design from owner, engineer, and contractor perspectives
- How the team approached the design, monitoring, and execution of the HDD in a downtown corridor and next to a historical landmark dating back to Colonial times
- Results of the installation and corresponding overall impacts to the project schedule and budgets

![Figure 1. Original force main alignment and contractor-proposed HDD alignment.](image)

### 3. PROJECT BACKGROUND

The owner awarded the project to AECOM (engineer), who began by studying and comparing many alignment alternatives to navigate the new 30-inch ductile iron pipe (DIP) force main through the major and minor arterial
streets of Downtown Norfolk to replace the aforementioned aging section of PCCP force main. After significant stakeholder coordination and preliminary engineering, including complex route studies, most of the new DIP force main was to be located along Saint Paul’s Boulevard (generally running north-south), a heavily traveled arterial roadway for commuters and residents of Downtown Norfolk.

During the design phase, the City of Norfolk Utilities and Public Works Departments prohibited any proposed force main work through the Market Street and City Hall Avenue intersections with Saint Paul’s Boulevard. These intersections are vital to commuter access to/from Saint Paul’s Boulevard and Interstate 264, a major regional highway adjacent to downtown. Trenchless crossings were explored at the time in an effort to go under the intersections and eliminate traffic disruptions. However, some construction projects in adjacent areas had experienced problematic trenchless crossings and/or post ground settlement. As a result, the City preferred finding open-cut solutions around the intersections in lieu of allowing trenchless crossings in the design with limited control over to which the project would be awarded during a required competitive bid. Therefore, the design was modified to align the force main down a small side street adjacent to Norfolk’s busiest shopping mall, MacArthur Center, to avoid these intersections. The design through the tight corridor presented various challenges, including deep utility crossings, very restrictive work hours and significant demolition and restoration adjacent to high-end department stores associated with MacArthur Center.

Early in the construction phase, the contractor evaluated the challenges of this alignment deviation along the shopping mall and proposed several ideas to avoid this segment of the open-cut installation. After several concepts were considered and eliminated, the contractor submitted a design-build proposal using a 1,000 LF, 30-inch HDD along Saint Paul’s Boulevard, continuing with the overall alignment, as shown in Figure 1.

4. NEGOTIATIONS

Although the original open-cut design had its challenges, the engineer was confident the new force main was constructible along the shopping mall. Therefore, the engineer and owner were not willing to entertain the contractor’s proposed HDD concept if it was going to increase the contractual amount of the overall project. As a result, the goal was to implement the HDD at zero cost by offsetting the lump-sum cost of the HDD with costs of the pipe and corresponding line items that would be circumvented by the HDD.

The engineer reviewed the bid’s line items and estimated the reduction in quantities because of the HDD. During this time, the contractor drafted the HDD design, contacted HDD subcontractors and developed its estimate for the costs to perform the HDD. The engineer and contractor communicated and worked together to negotiate a no-cost contract modification (i.e. HDD additive costs equal savings of deducted open cut costs). Initially, the cost of the HDD was coming in higher than the cost of items offset. To lower costs, the contractor proposed using a regional HDD subcontractor in lieu of mobilizing a larger national firm as initially proposed by the prime contractor. Also, the engineer was able to perform the additional geotechnical borings, needed for the HDD alignment, from the construction administration (CA) budget based on the assumption that compaction and pavement testing would not be needed anymore along the original section offset by the HDD, therefore minimizing change to the CA budget.

Ultimately, the team reached the agreed to cost of the HDD, $1.4 million (M) and realized the necessary reductions in the original bid items. As a result, a change order for the HDD was executed for zero additional costs to the project. The contractor would be able to invoice the $1.4M upon successful completion and the relevant items were subtracted from the contractor’s bid quantities. Table 1 shows an abbreviated sample of the negotiated HDD cost and bid-item quantity reductions.

<table>
<thead>
<tr>
<th>Bid Item No.</th>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>30” Ductile Iron Force Main</td>
<td>-1,464</td>
<td>LF</td>
<td>$565.00</td>
<td>$(827,160.00)</td>
</tr>
<tr>
<td>5.0-5.5</td>
<td>30” Ductile Iron Fittings</td>
<td>-24</td>
<td>EA</td>
<td>$8,237.50</td>
<td>$(200,200.00)</td>
</tr>
<tr>
<td>7</td>
<td>Air Vent</td>
<td>-3</td>
<td>EA</td>
<td>$2,800.00</td>
<td>$(8,400.00)</td>
</tr>
<tr>
<td>12-16</td>
<td>Pavement Restoration Items</td>
<td>-998</td>
<td>SY</td>
<td>$197.62</td>
<td>$(197,140.00)</td>
</tr>
<tr>
<td>17-20</td>
<td>Site Restoration Items</td>
<td>-1</td>
<td>LS</td>
<td>$55,600.00</td>
<td>$(55,600.00)</td>
</tr>
<tr>
<td>24</td>
<td>Select Material</td>
<td>-2,000</td>
<td>CY</td>
<td>$32.00</td>
<td>$(64,000.00)</td>
</tr>
<tr>
<td>Bid Item No.</td>
<td>Item</td>
<td>Quantity</td>
<td>Unit</td>
<td>Unit Price</td>
<td>Total Price</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>------</td>
<td>-----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>29</td>
<td>Traffic Control</td>
<td>-0.13</td>
<td>LS</td>
<td>$380,000.00</td>
<td>$(50,000.00)</td>
</tr>
<tr>
<td>N/A</td>
<td>Horizontal Directional Drill</td>
<td>1</td>
<td>LS</td>
<td>$1,402,500.00</td>
<td>$1,402,500.00</td>
</tr>
<tr>
<td>Total Change Order Amount</td>
<td></td>
<td></td>
<td></td>
<td>$0.00</td>
<td></td>
</tr>
</tbody>
</table>

From a schedule perspective, no time was lost from the above price negotiations. Construction continued in other locations without delay. From an owner’s perspective, the HDD proposal offered significant advantages, especially at zero net costs to the project. With the project on schedule, if successful, the HDD would have potentially zero traffic implications to the mall property and the two major intersections, reduced site restoration along significant commercial properties, and an estimated 5 to 6 month reduction in construction time.

The owner’s Operations Division was also on board. The portion of the alignment offset would have been troublesome to access if a failure were to occur and equally burdensome for standard maintenance (e.g., exercising air vents). Additionally, the lack of mechanical joints and ferrous pipe material meant the HDD alignment would lack concerns of deterioration from corrosive soils and corresponding failures.

After the successful cost negotiations, the team approached the City and downtown stakeholders. Satisfied with the progress of the project and the ongoing performance of contractor, the City and downtown stakeholders were receptive to the HDD concept. The team presented the advantages and risk considerations of the HDD and ultimately convinced the City and downtown stakeholders to allow the team to move forward, assuming all risk-mitigation efforts would be considered.

5. **LOCATIONAL CHALLENGES**

The entire 6,000 LF of 24-inch to 36-inch diameter force main is located in the downtown area of Norfolk, Virginia. Norfolk is a city rich with history dating back to the colonial times of the 17th century. Through the generations of wars, boom and bust cycles and the industrial revolution, Downtown Norfolk’s geographic and geophysical features detail the evolution of the City’s always changing landscape. From the 20th century to present day, Downtown Norfolk has rebuilt itself into a vibrant downtown environment with high-rise buildings, community events, nightlife and easy access to major interstates.

Understanding the history and evolution of this City was critical during design of the proposed pipeline. Abandoned infrastructure and land reclamation activities influenced how the engineer approached subsurface work such as open-cut and trenchless pipe work. The following sections detail how the engineering team used historical and geotechnical information to design this project and the new HDD alternative.

Prior to the HDD proposal, the engineer had considered trenchless crossings at other locations along the alignment. During those reviews, the locations had to be evaluated against maps of Norfolk, pre-land reclamation, because of the potential obstructions related to the fill used to build land mass into the water. As shown in Figure 2, much of the land and streets of Downtown Norfolk, including parts of the proposed alignment, were previously natural waterways. The fill used to create the expanded land mass contained uncontrolled landfill, large debris, and abandoned concrete/brick structures. At a few locations, the engineer recommended open-cut because of the risks of a potential failed bore/drill resulting from large obstructions.

During open-cut construction in the areas previously occupied by water, the contractor uncovered large, indiscernible concrete or brick masses or, what was thought to be, abandoned footings or sea walls. The team quickly reviewed the maps and other information showing historical land limits of Downtown Norfolk. Like Figure 2, most of the available information showed land occupying the area of the proposed HDD. The team concluded that the challenges related to the old waterways and corresponding fill were not a major concern going forward.

However, the church shown in the maps along Saint Paul’s Boulevard was a substantial consideration. This church and historic landmark, known today as the Saint Paul’s Episcopal Church, is the oldest structure in Norfolk (Figure 3). The church was constructed in the 1730s and is on the National Register of Historic Places (Ref. Virginia Department of Historical Resources, 1971). Extra precaution and risk-mitigation guidelines were established along the Church property during the development of the design and monitoring plans for the HDD work.
Figure 2. Proposed force main alignment overlaid on map of downtown Norfolk with pre-20th Century land limits.

The brick wall surrounding the Church prompted considerable concern after further research and site investigations. Although the brick wall has been damaged many times from other events, there was considerable lean along the southern section. Any potential settlement from vibrations or HDD inadvertent returns could undermine the foundation and cause the wall harm.

To add to the initial concerns, there was also the potential for graves, associated with the Church’s graveyard, to be discovered outside the limits of the brick wall and be damaged by the drill head. The team talked to a number of Church representatives to understand the limits of existing graves and where new discoveries had been made. They determined that the entry and exit points of the drill were well outside the limits of possible grave embedment. Although immediately adjacent to existing and possible undiscovered grave locations, the drill would be approximately 50 feet below the ground surface; thus, the graves would not be affected by the drilling operation.
6. DESIGN AND MONITORING PLANS

The contractor’s team for this project included a project manager with experience designing trenchless crossings and HDDs for various markets (e.g., water, wastewater, natural gas), which allowed the contractor to start the design process internally, immediately. The contractor’s design efforts started with a review of existing information of the subsurface conditions. Based on documentation of nearby borings completed for the original design and the contractor’s experience with deep gravity sanitary sewer construction performed nearby, the contractor had a high level of confidence that a large, dense layer of clay (known as the Yorktown Formation) lay between the surface of the road and the bore path. This dense clay layer was helpful in this situation for two reasons: it would provide for a stable borehole during drilling and it would provide an overlying protective layer for confining drilling fluid underneath the surface to prevent inadvertent returns.

The contractor then looked for available bore path alignments that would avoid the major conflicts of the open cut alignment within the tolerances of the carrier pipe and have the least impact to traffic. The contractor initially looked at alignments closer to the original design, but most turned out to be too short to accommodate the depth necessary to avoid existing structures while staying within the carrier pipe’s maximum bending radius. The next alignment explored was the one that was ultimately chosen, as previously shown in Figure 1. This alignment presented the additional challenge of a compound horizontal curve within the vertical curve that exiting the borehole. This challenge coupled with the very narrow workspace allowed at the drill entry pit caused constructability concerns. The contractor and Spring and Associates, Inc. (HDD subcontractor) agreed to a very specific equipment layout to fit the cramped work site. Eventually, the layout shown in Figure 4 was approved by the City and local stakeholders.

The alignment was further explored by conducting test holes on all known existing utilities along the bore path. The results of these test holes were used to determine the necessary entry and exit angles. While entry and exit angles between 8 to 10 degrees are preferred for most HDD operations, the existing utilities necessitated a 14-degree entry angle and a 9-degree exit angle. These angles allowed the bore path to travel under the closest existing utility with a clearance of over 10 feet.

With the necessary entry and exit angles determined, the design of the bore path alignment was finalized. The necessary radius of curvature and a desire to limit the size of the borehole led to the selection of fusible polyvinyl chloride (FPVC) pipe. High-density polyethylene (HDPE) pipe is very popular for use with HDD because of its fusibility fully restrained joints), flexibility (high maximum curvature), and strength (maximum pull force).
However, to meet the specified pressure capacity of 100 pounds per square inch (psi) and inside diameter of 30 inches, the design would generally require 36-inch outer diameter HDPE Dimension Ratio (DR) 11 pipe or a very similar product. FPVC is similarly fusible, flexible, and strong. For the design, the 32-inch outer diameter, DR-21 FPVC pipe was selected for its 29-inch inside diameter and 200-psi pressure rating. The reduction in outer diameter facilitated reaming of a smaller borehole (44-inch vs a 48-in needed for HDPE) contributing to cost savings and reduced risk.

With the preliminary alignment and pipe material selected, the contractor performed pipe stress and pullback calculations of FPVC using the Pipeline Research Council International’s design method to determine if the pipe material could withstand the pullback, external pressure, and buckling pressure within a factor of safety. The preliminary calculations showed that the pipe material could withstand the forces that would be expected during installation (Ref. J.D. Hair and Associates, 2008; Hair et. al., 2005). The FPVC manufacturer and vendor, Underground Solutions, Inc., provided design and calculation assistance.

Once the preliminary alignment and pipe material were determined to be feasible, new geotechnical borings along the proposed HDD alignment were needed. Four 65-foot deep geotechnical borings were completed at approximately 325-foot intervals. The borings revealed four general soil strata as shown in Table 2 (Ref. GET Solutions, Inc., 2015). The new borings confirmed the historical data; the first stratum was sand followed by a second stratum of thick clay and a third stratum of sand. This information aided the design by confirming that the designed depth of drill of 50 feet would allow the bore path to travel through the clay and then underneath it before resurfacing.

Table 2. Soil Stratums along HDD Path.

<table>
<thead>
<tr>
<th>Average Depth (feet)</th>
<th>Approx. Layer Thickness (feet)</th>
<th>Description</th>
<th>Ranges of SPT(1) Uncorrected N-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1.08–1.20</td>
<td>N/A</td>
<td>9.5 to 11 inches of concrete pavement underlain by 3 to 4 inches of aggregate base material</td>
<td>-</td>
</tr>
<tr>
<td>Average Depth (feet)</td>
<td>Approx. Layer Thickness (feet)</td>
<td>Description</td>
<td>Ranges of SPT(1) Uncorrected N-Values</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------</td>
<td>-------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>1.08–1.2 to 18–20</td>
<td>18</td>
<td>SAND (SM, SP-SM, SC, SC-SM) with varying amounts of silt, clay, fine gravel, and fibrous organics</td>
<td>Non-cohesive 2–18 Cohesive 12</td>
</tr>
<tr>
<td>18–20 to 38.5–45</td>
<td>23</td>
<td>CLAY (CH) with varying amounts of silt, sand, and marine shell fragments</td>
<td>2–3</td>
</tr>
<tr>
<td>38.5–45 to 49.5–53</td>
<td>10</td>
<td>SAND (SP, SP-SM) with varying amounts of silt and fine gravel</td>
<td>7–34</td>
</tr>
<tr>
<td>49.5–53 to 65</td>
<td>14</td>
<td>SAND (SC, SM) with varying amounts of silt, clay, and marine shell fragments – Yorktown Formation</td>
<td>9–18</td>
</tr>
</tbody>
</table>

With the alignment and depth selected based upon the geotechnical characterization, the general contractor hired a third party professional engineering consultant (Brierly Associates) to perform the design basis HDD pipe stress and pullback calculations, incorporating all of the data and confirm the preliminary calculations and serve as the design basis. The contractor’s design-consultant’s calculations were consistent with the preliminary calculations. The consultant included the new subsurface data to also perform a borehole stability analysis. They performed calculations of annular borehole pressure to develop curved plots of allowable borehole pressure along the HDD alignment. These pressure curves were compared with plots of total allowable confining stress to ensure a factor of safety of greater than one under the specified drilling pressure limits, to confirm conditions to minimize risk of inadvertent returns in accordance with the standard of care.

With the data gathered and the design completed, the contractor submitted a design package consisting of the following elements:

- HDD Work Plan
- Schedule
- Disposal of Spoils and Drilling Fluid Plan
- Equipment Layout Plan
- Inadvertent Return and Surface Spill Contingency Plan
- Maximum Allowable Drilling Fluid Pressure Calculations
- Materials and Equipment
- Protection of Adjacent Structures and Facilities Plan
- Pipe Stress and Pullback Calculations
- Qualifications
- Safety Plan
- Survey Equipment and Procedures
- Test Holes
- HDD Plan and Profile
- Pipe Stringout Alignment

The engineer (AECOM) provided in-house HDD expertise to assist with reviewing the contractor’s HDD design package including suitability of the FPVC material for the HDD installation in the ground conditions and site constraints. This would be the owner’s first use of FPVC. The engineer worked with the contractor and Underground Solutions to check material properties, evaluate past installations, and understand any differences (from HDPE) during design and installation. Ultimately, the engineer and owner agreed to the material.

The engineer also developed the monitoring plan, which included topographic survey, vibration monitoring, and installation of monitoring wells. The presence of a historic structure, in addition to the major commercial developments, along the alignment was atypical of this HDD application. As a result, additional consideration was given to available monitoring options to warn of inadvertent returns approaching the church.

The topographic survey was a way to document the before and after elevations of aboveground features (e.g., roadway, curb and gutter, church wall) to protect the owner from potential claims for issues that may or may not have been a result of the HDD. The surveyor recorded topographic elevations along the route prior to the HDD and post HDD, after 1 month and then again after 6 months.

Vibration monitoring took place during the entire drilling and pipe-pull efforts. Any particle-velocity readings exceeding the predetermined threshold of 0.5 inch per second required the drilling work to stop until all efforts could be made to determine and remedy the cause of the vibrations.
Unique to most HDD efforts, the engineer required the contractor to install monitoring wells parallel to the borepath located between the alignment and the church. The wells allowed any hydrofracture of drilling fluid a preferential flowpath upward to the surface if inadvertent returns progressed in the direction of the church. This effort was implemented as an early warning system and protective pressure relief to avoid compromising any structural support (Ref. Francis et. al., 2003). Any settlement of the church foundation could have had detrimental effects on the historic sensitive aged church structure.

7. EXECUTION

After the HDD subcontractor’s staging and setup, drilling efforts were initiated, as shown in Figure 5. The drill rig and corresponding equipment was limited to one lane of Saint Paul’s Boulevard and the sidewalk area. Pedestrian traffic was routed around the site, and outside rush hour, the contractor was allowed to shut down the adjacent lane. The contractor worked closely with the City on the staging plan and distributed electronic and hard copy notifications to businesses to avoid disruptions to downtown flow during the equipment setup and related detour efforts.

![Figure 5. Drill rig and corresponding drill rods along Saint Paul’s Boulevard in Downtown Norfolk.](image)

The presence of the monitoring program encouraged increased care by the HDD contractor. The initial pilot drill to completion of the 44-inch ream conditioning was completed and the pipe pullback occurred in approximately 2 weeks. Monitoring wells and vibration monitoring detected no inadvertent returns or concerning particle velocities, respectively.
Fusing of the FPVC pipe took place concurrently with the drilling activities. Multiple crossroads to Saint Paul’s Boulevard were without through traffic during the fusing and pipe stringout activities. However, the City limited the stringout to Charlotte Street (because of heavy commercial traffic associated with this street) on the north end. As a result, the stringout area was limited to about 600 feet. Consequently, the original sequence of construction was to first fuse two 500-foot FPVC segments and lay them parallel. During the pipe pull, one segment would be pulled into the borehole, and then be fused to the second segment, before restarting pulling. This typically causes a halt to the pulling efforts for approximately 2 hours. During this time, soils can constrict causing greater frictional force than the drill rig can pull against. For this reason, the team negotiated with the City to allow full stringout, and fusing (final abutment of 1,000 LF of FPVC pipe), prior to pipe-pull efforts. The City and the team agreed to complete the above activities between the nighttime work hours of 7 pm to 5 am.

The staging of the equipment to support the pipe during pulling efforts required the use of several lanes of Saint Paul’s Boulevard as shown in Figures 6 and 7. Traffic control was frequently adjusted to the changing setup during the night; however, the amount of traffic was negligible during the actual pulling efforts, which took place well after midnight.

Construction related to the pipe pull took place along several well-known downtown residential properties, such as the Rotunda Building shown in the background of Figure 6. As a testament to the well-planned and successful execution, most of Downtown Norfolk was unaware of a major overnight construction event occurring along the major corridor.

![Figure 6. Crews elevating pipe prior to pulling efforts along Saint Paul’s Boulevard in Downtown Norfolk.](image)

8. RESULTS

Although the HDD installation accounted for installation of approximately 1,000 LF of pipe out of the project’s total of more than 6,000 LF, the impact was substantial. The project benefited from the use of HDD in the following ways:

- MacArthur Center, the high-end shopping mall and movie theater complex, was relieved of potentially disruptive traffic associated with the open-cut work from the original design.
- No settlement or damage was detected on the historical Saint Paul’s Episcopal Church and associated brick wall.
• Traffic disruption was avoided completely at two major intersections with Saint Paul’s Boulevard.
• The project was the owner’s first use of fusible polyvinyl chloride (FPVC), facilitating consideration of the material for future installations.
• The HDD eliminated what was estimated to be a time consuming segment of open-cut work and, as a result, the project reach substantial completion 4 months early.

![Figure 7. Photo showing pipe curvature along the pipe’s entry point into the borehole.](image)

The reduction in construction time eliminated the need for a force main tie-in to redirect flows around proposed construction along the projects alignment. As a bonus, elimination of the tie-in line item saved the owner approximately $500,000.00. The early finish also saved the owner approximately $60,000 in construction inspection fees under the engineer’s contract. These significant time-related savings frequently present in urban settings should not be forgotten in cost and value analysis comparing open-cut vs HDD.

The use of HDD made a significant contribution to the project’s overall success and recognition. After the project was completed, the team received a letter of recommendation from the City’s Right-of-Way administrator, praising the high-level of engagement with the City, including the constant communication during the HDD effort. The project was also awarded the 2016 Engineering Achievement Award by the Engineer’s Club of the Hampton Roads, an organization serving the technical, educational, civic, and social needs of local business and professional communities.

9. REFERENCES


