THE SECESSION GOLF COURSE EFFLUENT FORCE MAIN PROJECT:
EXPANDING THERMOPLASTIC HDD APPLICATIONS

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ABSTRACT: Trenchless technology continues to expand with the introduction of new equipment, industry knowledge, and materials, and nowhere is this more evident than the Beaufort-Jasper Water and Sewer Authority's (BJWSA) Secession Golf Course Effluent Force Main Project (Secession Project), in Beaufort, SC.

The crossing of the Beaufort River by HDD techniques required just under a mile of pipe to be installed in a single pull – a feat never before completed with thermoplastic piping. The use of Fusible PVC\textsuperscript{TM}, a PVC pipe technology that combines traditional PVC piping with thermoplastic butt-fusion joining techniques, has enabled this distance to be accomplished.

Selection of a cost effective and adequate pipe material, along with a procurement and bidding process that maximized savings and minimized unqualified drillers, all led to the best possible set up for a design solution and execution of this complex crossing. BJWSA enlisted the help of Hussey, Gay, Bell and DeYoung to design the crossing, and the Mears Group, as the driller for this project, has completed this HDD industry first.

The Secession Project showcases a team effort to the design challenges and contracting issues that were negotiated to complete the crossing. It also details why this project stands as an HDD first with thermoplastic pipe, and what it means to the future of HDD in the water and wastewater industries.
1. INTRODUCTION

The Beaufort Jasper Water and Sewer Authority (BJWSA) is a non-profit, non-taxing public service organization that provides water and sewer service to an area of approximately 750 square miles including two counties in South Carolina (See figure No. 1). BJWSA provides potable water service to over 125,000 people, as well as seven wholesale customers, including 2 Hilton Head Island utilities and the United States Military.

BJWSA also provides wastewater treatment for approximately 50,000 customers with seven treatment and water reclamation facilities. Between 2004 and 2006, the Port Royal Wastewater Reclamation Facility (Port Royal WRF) (See Figure No. 2) was constructed to meet new TMDL based discharge limits. Two older plants on Port Royal Island that could not meet the new, more stringent discharge limits were replaced by the new Port Royal WRF, and the new plant produces a reclaimed water quality effluent which allows it to be used for mostly unrestricted irrigation purposes.

The Secession Golf Club (Secession GC), a member’s only facility created by famed architect Bruce Devlin, is situated on Lady’s Island, a landmass located at the mouth of the Beaufort River and the Atlantic Ocean. The Secession GC could be tied into the Port Royal WRF effluent force main on Port Royal Island near McTeer Bridge, which traverses the Beaufort River from Port Royal Island to Lady’s Island. Once back on to Lady’s Island, traditional construction methods would suffice in getting the effluent reuse water to the Secession GC and eventually other end users of the water. The only question was how to get across the Beaufort River, and the marshy areas on either side of it. Construction in this delta area can be difficult, due to the abundant surface and groundwater present, as well as the tidal influence on those water levels.

Horizontal directional drilling (HDD) was considered early on in the design process as a possibility to install the pipe under the river. Hussey, Gay, Bell, and DeYoung (HGBD) was employed by BJWSA to design the Secession Reclaimed Water Main project and determine the most economical way to complete the HDD. Although the pipeline did not need to be very large in diameter, the limiting factor on the installation was the distance that needed to traversed across the river and subsequent wetland areas on either side. This distance amounted to almost a mile of pipe required to be installed via the drill – a distance traditionally reserved for coated steel piping, or HDPE within a steel casing.

Figure No. 1 – South Carolina, shaded counties show region served by BJWSA

Figure No. 2 – Port Royal Wastewater Reclamation Facility
2. PROJECT HISTORY AND AWARD

BJWSA and HGBD initially bid the project calling for a coated steel pipeline with an alternative option using HDPE within a steel casing. The prices that were submitted were prohibitive to the budget of the project due mainly to material costs.

An alternative material, Fusible PVC™ had been considered as a possible pipeline material prior to and during the initial bid phase of the project. Fusible PVC™ had been recognized as having several advantages and disadvantages in respect to the project. First, on the advantageous side, the favorable weight to tensile strength of the plastic meant that it should be able to accomplish the span without a casing. Secondly, the thermoplastic butt-fusion joining procedure used with the material assured a continuous, leak-free, fully structural pipeline without mechanical joints, just like the other piping options considered. Thirdly, the all-plastic constituency of the product and the joining methodology meant that there would be no concerns regarding corrosion of the pipeline in the future. As far as the product risk was concerned, Fusible PVC™ had only been in the market place for about 5 years prior to this project. Also, this particular pull-in represented the longest single pull-in for the material for any diameter or wall thickness to date. Finally, the HDD contractors bidding on the project had limited knowledge and experience with handling Fusible PVC™ pipe. Owing primarily to the bidders reluctance to provide an acceptable pull force that they may need with their particular equipment in this application, the initial bid solicitation did not provide an option of using Fusible PVC™ pipe.

With the initial bids being at a level that prevented the project from continuing, BJWSA chose to re-bid the project using Fusible PVC™ and adopting a risk-sharing approach unique to the municipal market between owner, contractor, and material supplier. The project risk for the installation was shared in the following manner:

1.) Underground Solutions, Inc. (UGSI) was the nominated supplier of the pipe and provider of fusion services. UGSI provided fusion services for the plastic pipe prior to and during the pull-in and guaranteed the pipe up to a certain axial stress.

2.) Mears Group, Inc. was the low bidder for the construction of the HDD crossing. Mears performed the HDD installation, and took responsibility for the pipe, should the pull-in require more force than they predicted.

3.) BJWSA, as owner of the project, provided all the connections, hardware, and testing required to finalize and certify the crossing.

Mears, in bidding the project, proposed an alternative, modified, drill path and construction layout to assure success, reduce the price of construction, and reduce some social impacts of the work.
Figure No. 3 – Plan View of HDD Crossing of the Beaufort River and Other Piping to the Secession Golf Club
3. HORIZONTAL DIRECTIONAL DRILLING OPERATION

Mears had originally submitted a base work plan in accordance with specifications that called for the drilling to be undertaken from the west side of the river to the east side. This would have required the fusion to take place on the east side of the installation along Route 802 (Lady’s Island Drive). The plan called for all 5000 (+/-) linear feet (LF) of pipe for insertion to be fused in one length above grade, winding through a culvert beneath a main highway, through a tidal marsh, and then along a drainage ditch by Route 802. (See Figure No. 3) Mears submitted an alternative proposal that switched the drill and insertion sides in order that the drill rig would be set up on the east side and the pipe insertion would be initiated from the west. This moved the drilling away from residential areas on the west side to help with construction noise concerns, but it required that intermediate fusions needed to be performed during pull-in, due to the lack of layout room on the west bank. Also, Mears proposed to amend the alignment at the road crossing, increased the depth of the bore under the river to 65 feet, and increased the planned vertical radii to 2000 feet. These changes eliminated the potential problems of fabricating pipe in the tidal marsh and of pulling it through an existing culvert. This alternate was accepted by BJSWA on a practical basis and allowed it to realize a reduction of the HDD construction price.

In order to utilize this alternate plan, the drill rig and setup had to be placed on the east side of the alignment, and on the east side of McTeer Bridge. This would normally not cause an issue for the mobilization of the rig spread, but this was complicated by a collision of a dredge’s boom with the center span of the bridge just prior to the mobilization of the project. This mishap had forced the partial closure of the bridge for repair and also required that Mears find another way to transport its drilling equipment to Lady’s Island. An alternate route was found that required the crossing of another bridge that normally was not rated to carry the full weight of the drill rig. BJWSA was able to obtain a permit for crossing the bridge from the State of South Carolina, and the work was able to commence with minimal impact to schedule. However, if this permit had not been attained, the project would have had to either revert to the more expensive and invasive base plan or wait for the repairs to the McTeer Bridge to be completed, and this would have forced the delay of construction well past the July deadline for project completion and initial reclaimed water delivery.

The Main drill rig was moved onto the site on Friday, May 18th, 2007 and initial set up started on the east side of the alignment on Lady’s Island on Saturday, May 19th. The AA330 drill rig is capable of producing a maximum force of 330,000 pounds of thrust and pull back.

The initial pilot bore was accomplished with a mud motor and a 12 1/4” bit. Drilling fluid was based on a high yield Wyoming bentonite clay. (See Figure No. 5) The down hole survey was accomplished with the ParaTrack-2 system. Both surface coils and individual beacons (magnets) were used to ensure accurate placement of the crossing. In view of the property restrictions, particularly on the west bank of the river, the drill was further complicated by incorporating considerable horizontal curves in the
alignment. Drilling of the pilot hole was started on Tuesday, May 22\(^{nd}\), and was complete on June 1\(^{st}\). The drill bit reached the west side of the alignment around May 29th, but due to incorrect as-built drawings that had been provided of an existing 36” diameter gravity outfall that runs parallel to the new pipeline (see Figure 3), the drill alignment was approaching its exit under the 36” outfall. The outfall was found to be about 5’ south of the plan position indicated by the as built information. The drill’s bottom hole assembly was pulled back approximately 600 feet and this final section of the crossing was re-drilled along a redirected path allowing the drill bit to exit the ground along side the 36” outfall. This event delayed the schedule by about 2 days.

For the final 100 (+/-) LF to the exit pit location, drilling fluid returns to the 330 rig was lost and the returns seeped up to the ground surface. The cause of this frac-out was a combination of the reduced overburden, the relatively high annular pressure at the end of the pilot hole, and the disturbed soils in the area resulting from the previous construction of the 36” outfall. The returns were easily contained and pumped from the frac-out location to a holding tank and then trucked to the site of the 330 rig to be cleaned and reused, or taken directly to the disposal site. This frac-out location was then monitored for the rest of the installation as the returns location.

The pilot hole was pre-reamed in a single pass with a 17.5” diameter reamer. Reaming was started on June 2\(^{nd}\) and was complete on June 7\(^{th}\). During this process, Mears utilized a second, 60,000 pound capacity, drilling rig, located on the west side of the river. The function of the second rig was to exert tension on the drill pipe string while the primary, 330, rig provided rotation. Using this method of “forward reaming” Mears was able to take advantage of sending the vast majority of the drilling fluid returns back to the 330 rig, and by using a secondary drilling rig it was able to make and break the drill pipe joints in a very controlled, efficient, and most importantly, safe manner. After completing the pre-ream operation the crossing was swabbed by passing the reamer back through a second time to ensure the cuttings had been removed from the bore and that the density of the drilling fluid within the hole was correct.

4. PRODUCT PIPE PREPARATION

Fusible PVC™ is shipped in standard 40 foot lengths from the extruder. From these lengths, longer strings, including the entire length of the installation were eventually assembled. The thermal butt-fusion joining technique for the pipe is a patented process. UGSI, the makers of Fusible PVC™ performed all the fusion for this project with a qualified fusion technician.

Due to the change in the drilling plan, which moved the insertion side from the east to the west side of the bore, shorter sections of pipe had to be pre-fused, and then final assembly took place during the pull-in of the pipe. Initially, 760 foot lengths were fused due to space limitations and the necessity to maintain an open road near the insertion pit area. Permission for a road closure was implemented on June 12\(^{th}\), which allowed an additional 240 LF of pipe to be added to each pipe string length to give five, 1000 (+/-) LF strings of pipe. The actual time to complete the fusion schedule was approximately 16 days. This schedule included impacts by site parameters such as weather and coordination of the road closure for fusion layout, but coincided with the other schedule adjustments for the project. Fusion actually started on May 22\(^{nd}\) and was completed on June 6\(^{th}\). This left 4 intermediate fusions to be performed during the pull-in. The fusion machine was relocated to the west end of the pipe lengths, and an additional 40’ length was added to the first string for insertion for a total of 1040 LF, and two 20 foot lengths were added to the last insertion string for a total of 1080 LF. This resulted in a total pipe length, with the three other pipe lengths being 1000 LF, of 5120 LF of pipe for the total pipe string after intermediate fusions were completed.

![Figure No. 6 – Pipe hydrostatic testing prior to pull-in](image)
The specifications for the project required that all pipe be tested above ground before installation by HDD. Hydrostatic testing was required at 100 psi test pressure held for 2 hours (See Figure No. 6). Using end caps and restraint hardware as provided by BJWSA, all sections were tested at the same time on June 8th. Pressure gauges were installed on each string and pressure was held at 30 psi until just before insertion was to begin. This was done to ensure no vandalism or tampering occurred to the pipe after the test and prior to insertion.

The pull head design for this installation needed to be adjusted to account for the 100,000 pound maximum allowed pull force requirement for the pull-in. The original standard pull head design utilizes three, \(\frac{3}{4}\)”, smooth-shank through bolts and a steel head design that accounts for, with safety factor, around 72,000 lbs of force. A fourth bolt was added to this design to bring it line with the requirements for this installation. Mears agreed with the design, but wanted added safety built in to the head, so an additional 12 inch long ring was added to the head, with an additional 4 bolts placed in this extended section. The new pull head, with the extended section and 8 total bolts, was also modified to fit the swivel configuration of the drilling string.

On June 9th the pull head was installed on the first string to be pulled in the directional crossing. When installed on the pipe, the bolts were sealed with rubber hose type washers and the end of the head, where it meets the pipe, was sealed with silicone caulking. Mears also installed a bladder-type sewer plug approximately one foot further into the pipe past the end of the pull head. This was inflated to help separate fill water from leaks of drilling fluid, if they should occur. The bladder was further secured by attaching a chord to it and looping the chord around the nearest through bolt. After the bladder was inserted and inflated, a pneumatic pressure of about 7 psi was re-introduced to the first insertion length to provide tangible evidence of its integrity post test and pre-insertion.

Mears provided rollers for the 1000 LF length leading to the insertion point (See Figure No. 8). For the 10” DR 14 pipe section being installed, the rollers were spaced between 30’ and 40’ apart. Drag performance was exceptional for these rollers, especially during the intermediate fusion joints that needed to be performed during the pull-in. Mears also supported the pipeline via a cradle roller held by an excavator to raise the pipe prior to its “break-over” into the insertion pit. This was done to assure that the pipeline’s profile matched the angle of insertion for the drill alignment upon entering the insertion pit without exceeding radius limits.
Finally, for the pipe assembly and preparations, the external bead present on the fusion joints was removed. This step is not a necessary step but was performed to reduce any additional drag that the pipe may incur on the bore hole during the pull-in due to the external bead present at the fusion joints. This process is performed with a rotary cutting tool and jig to control the depth of bead removal.

5. PIPE INSTALLATION

Pipe pullback started on Monday, June 11th, 2007 (See Figure No. 10). Preparations were made and pipe connected to the drill string between 6 AM and 9 AM with actual pipe pullback starting at approximately 9 AM. The main pullback with pipe exiting the alignment on the east side took approx 17 1/4 hours. Removal of reamer and final positioning took an additional 1 ¼ hours for a total of 18 1/2 hours. The following Table No. 1 summarizes the time line for the installation:

<table>
<thead>
<tr>
<th>Event</th>
<th>Start Time</th>
<th>Complete Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull #1 1040’</td>
<td>9:00 AM</td>
<td>10:45 AM</td>
<td>105 Minutes</td>
</tr>
<tr>
<td>Pipe Handling #1</td>
<td>10:45 AM</td>
<td>11:38 AM</td>
<td>53 minutes</td>
</tr>
<tr>
<td>Fusion #1</td>
<td>11:38 AM</td>
<td>12:40 PM</td>
<td>62 minutes</td>
</tr>
<tr>
<td>Pull #2 1000’</td>
<td>12:40 PM</td>
<td>2:45 PM</td>
<td>125 minutes</td>
</tr>
<tr>
<td>Pipe Handling #2</td>
<td>2:45 PM</td>
<td>3:30 PM</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Fusion #2</td>
<td>3:30 PM</td>
<td>4:20 PM</td>
<td>50 minutes</td>
</tr>
<tr>
<td>Pull #3 1000’</td>
<td>4:20 PM</td>
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<td>107 minutes</td>
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<td>Pipe Handling #3</td>
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<td>6:35 PM</td>
<td>28 minutes</td>
</tr>
<tr>
<td>Fusion #3</td>
<td>6:35 PM</td>
<td>7:20 PM</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Pull #4 1000’</td>
<td>7:20 PM</td>
<td>9:10 PM</td>
<td>90 minutes</td>
</tr>
<tr>
<td>Pipe Handling #4</td>
<td>9:10 PM</td>
<td>9:55 PM</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Fusion #4</td>
<td>9:55 PM</td>
<td>10:43 PM</td>
<td>48 minutes</td>
</tr>
<tr>
<td>Pull #5 1040’</td>
<td>10:43 PM</td>
<td>1:15 AM</td>
<td>152 minutes</td>
</tr>
<tr>
<td>Removal of Reamer and Final Position</td>
<td>1:15 AM</td>
<td>2:30 AM</td>
<td>75 minutes</td>
</tr>
</tbody>
</table>

Table No. 1 – Summary timeline for installation

Total pulling time, by the drilling rig, was 504 minutes. This averaged out to 10 LF/minute during the pullback. Each pipeline handling event included positioning the next pipe string on the roller system and clamping both ends into the fusion machine. This totaled 171 minutes or 43 minutes per event. Fusion time from start of facing to resumption of pullback totaled 205 minutes or 51 minutes per fusion. Weather played a part in the 4th to 5th section transition and fusion as thunder storms and lightning entered into the area at that time. A canopy was erected to shield the joint from the weather in order to complete Fusion #4.
Pull force was monitored in two ways for this installation. First, for each joint of drill pipe, the drill rig's hydraulic pressures were recorded. This captured the pull force based on the rig's hydraulics. The appropriate conversion factor from hydraulic gauge pressure to pull force was used to provide the pull force exerted by the rig. The second measurement was taken by a down-hole sub rented from Horizontal Technologies of Houston, TX (see figure no. 12). This device records down-hole information as it relates to the pipe and the borehole. The sub was connected between the swivel and the reamer with standard threaded connections. The sub could not be hard wired to the surface for real time data gathering. This particular device has an onboard data storage capability with a limited battery life. Luckily, all data was recorded for the entire length and duration of the pull, even though it lasted over 18 hours. The sub measured tensile force, annular pressure, and torsional forces, among other parameters. Data was recorded every 10 seconds, and stored on board the device. After the pullback was complete, the device was returned to Horizontal Technologies for data retrieval. This data allowed comparisons to be made of the pull force at the pipeline’s pull head to the pull force at the drilling rig. Per the data collected from the down-hole recorder, the pipeline was subject to only about 2/3rds of the pull exerted by the drilling rig, and this was only towards the end of the installation when most of the pipe was in the ground. UGSI will be using this data along with other installation data from similar HDD installations of Fusible PVC™ to further correlate HDD projects with the estimated amount of force required to install the pipe.
5. CONCLUSIONS

The Fusible PVC™ pipe string, after all the intermediate fusion, handling, and of course pulling, appeared on the east side of the installation at the drill rig around 1:30 AM, June 12th, 2007. It was a little muddy, but not any worse for the wear (See Figure No.14). A post pullback hydro-pressure test was completed several days later. It was administered to the same requirements as before, namely, 100 psi for 2 hours. The successful test was performed by Mears and completed late Wednesday afternoon, June 13th. Connection of the new line was complete and the line was actually put into service later in the summer. The entire system has been operating per the design of the system and Secession GC is receiving reclaim water as intended.

This crossing is not the longest HDD installation ever performed, but it is however, the longest installation performed to date with thermoplastic pipe without a casing. This is significant due to the many potential projects, like this one, that include long HDD crossings that could benefit from the use of thermoplastic pipe. Factor in the prevalence of PVC piping in the water and wastewater industry, and there is a viable need for compatible, HDD capable PVC piping that truly expands the limits of what PVC pipe can do in the trenchless world.

This project demonstrates the goals that can be attained when a successful procurement process (not necessarily using standard contracting arrangements), coupled with a true team-oriented design and construction approach, creates the foundation to not only complete a project as intended, but accomplish a record-breaking first in the trenchless and horizontal directional drilling industries.

5. REFERENCES
