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TACOMA PUMP STATION 4103 FORCE MAIN HDD PROJECT: A SHORT BORE WITH TALL CHALLENGES

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ABSTRACT: The City of Tacoma has determined that an existing sanitary sewer force main that extends beneath the Hylebos Waterway requires replacement. The 1,060-foot Horizontal Directional Drill (HDD) crossing is located in the Port of Tacoma industrial area. An 18-inch HDPE pipeline is being installed in conjunction with upgrades to an existing pump station in order to achieve the desired design flows. This paper examines the challenges associated with the project design and construction. Challenges included very soft soils with blow counts of zero in the vicinity of the entry location, wooden piles within the waterway, and the presence of poorly graded gravel in sections of the bore. Additionally, the design incorporates steep entry and exit angles, conductor casings at entry and exit, and challenging site constraints requiring vertical and horizontal curves in order to achieve the fixed entry and exit points for the existing pipe system.

1. INTRODUCTION

This paper presents a discussion of the design considerations and solutions along with the construction of an 18-inch HDPE sanitary sewer force main pipeline beneath the Hylebos Waterway. The project is located in the highly industrialized Port of Tacoma area with large volumes of heavy trucking and shipping traffic. Horizontal Directional Drilling (HDD) was selected as the preferred installation method due to the low construction impacts to surrounding businesses and the cost effectiveness of the method. Although the 1,060-foot HDD crossing is considered relatively short by comparison to the record breaking HDD lengths of today, this paper examines the challenges unique to the project along with solutions developed during the design and throughout construction.

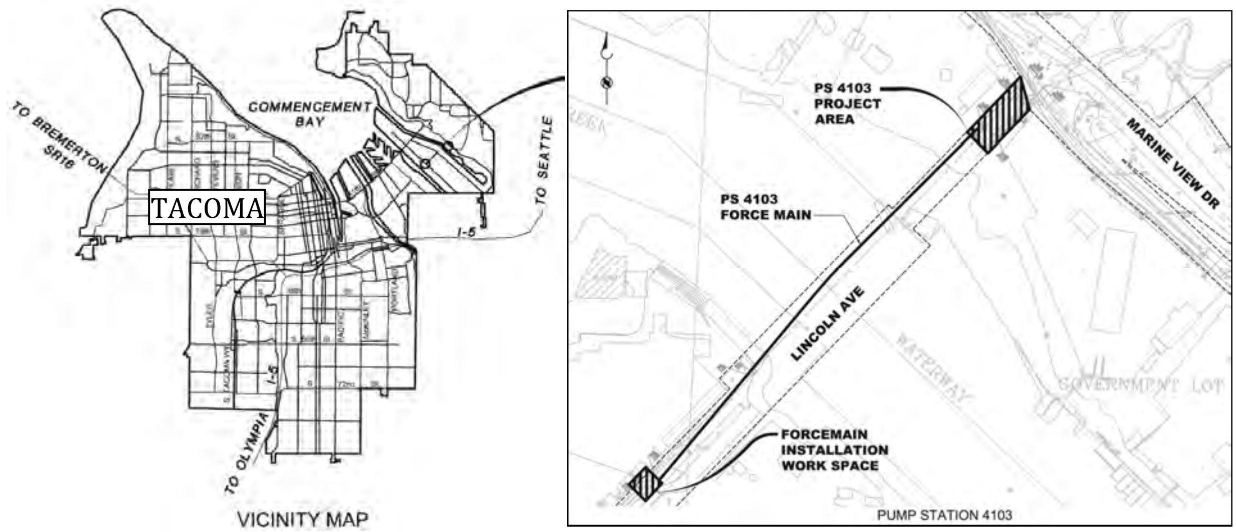

Figure 1. Vicinity map and project location (Brown and Caldwell, 2010).

2. DESIGN CONSIDERATIONS

Physical constrains of the project during the design phase consisted of restricted construction areas both at the entry and exit locations, critical sensitive pump station structures including a wet and dry well, utilities both above and below ground, and impacts to the surrounding businesses.

Figure 2. Plan View of the Hylebos Channel HDD Crossing

Figure 3. Exit Site View (left) and Entry Site View (right) with HDD alignment as dashed line.

The physical constraints were compounded by the geotechnical considerations which together shaped the design. Soils with low to zero blow counts were encountered to depths of approximately thirty feet below ground surface on both sides of the channel. Gravels intermixed with sand were also found throughout the upper 30 foot which pose a concern for bore hole stability or potential collapse. Geotechnical exploration revealed the groundwater at a depth of five feet below grade (Brown and Caldwell, 2010). The existence of abandoned wooden piles of unknown location and depth played a role in selecting bore alignment and geometry as well, with likely pile locations avoided altogether. The fill material near the surface consisted of gravels, sands, large amounts of wood and fully intact railroad crossties from an abandoned and buried rail line at the exit location.

3. DESIGN SOLUTIONS

Steep entry and exit angles of 24 and 18 degrees, respectively, were chosen to quickly advance the bore path through the less desirable materials in order to limit the geotechnical risks presented by the soft soils and open graded gravels discovered in the geotechnical exploration. Due to the limited setback distances of the entry and exit locations from the channel, the steep angles also allowed the rapid development of ground cover, or depth, vital in preventing inadvertent returns along the planned alignment in addition to a decreased likelihood of encountering abandoned piles anticipated in the area.

Conductor casings were incorporated into the design for both the entry and exit locations at lengths of 86-feet and 124-feet respectively. The casing was chosen as a means to contain the pressurized drilling fluid and to ensure bore-hole stability as the bore alignment at entry passed within 5-feet adjacent to the existing operational wet and dry wells of the City of Tacoma's existing wastewater pumping station.

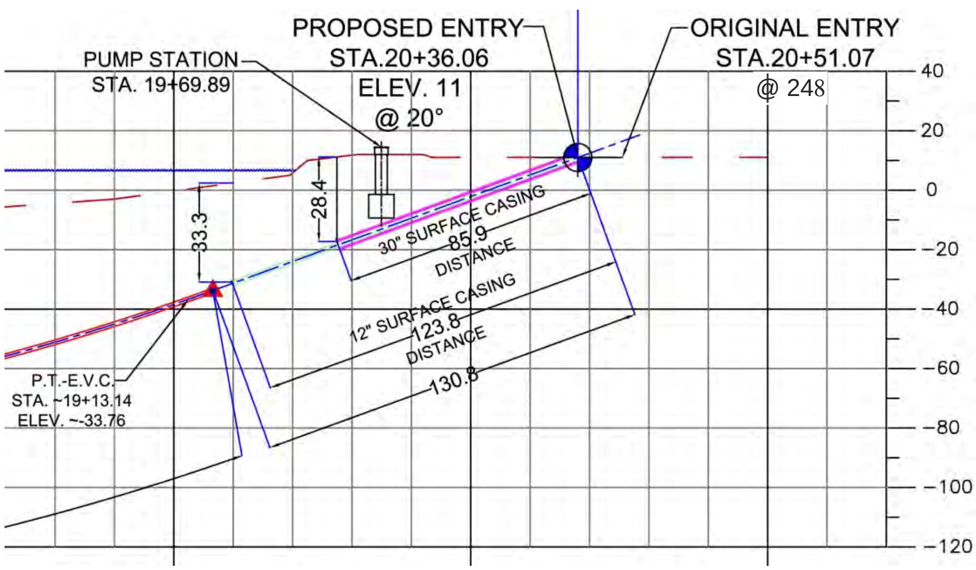

Figure 4. Contractor's Approved Entry Side Profile with Wet Well Pump and Conductor Casings.

The exit side conductor casing was utilized to mitigate the risk of inadvertent returns and moreover, to ensure the integrity of the bore and prevent catastrophic settlement due to over excavation in poor soils beneath the adjacent roadway and business driveway. Large volumes of daily traffic consisting of oversized heavy equipment deliveries cross the bore alignment within feet of the exit location where ground cover is at a minimum.

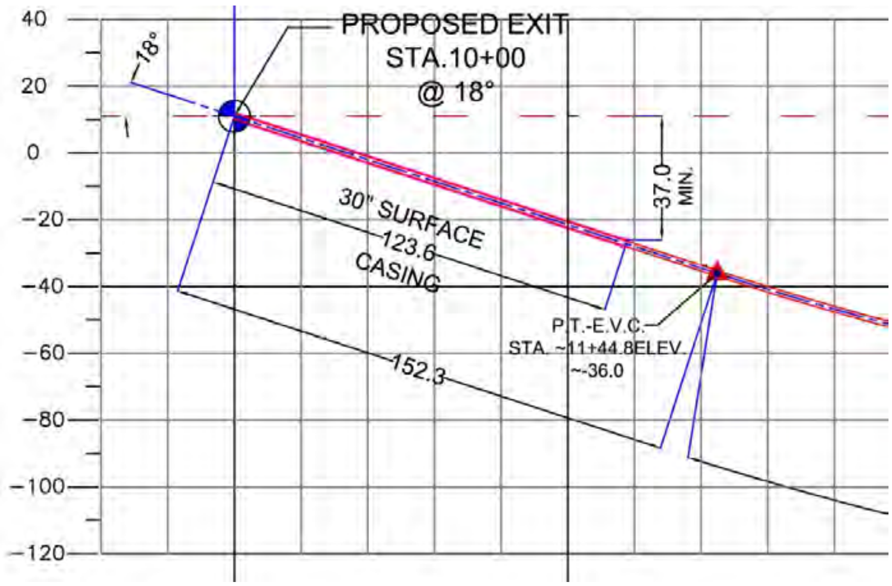

Figure 5. Exit Side Profile with Conductor Casing.

The bore consisted of both vertical and horizontal curves chosen to adequately distance the alignment from the previously discussed critical structures, utilities, and obstacles, while achieving the proper pipe pullback angle to the pipe fusion and layout area. This ultimately proved beneficial during construction since the Contractor only had to contend with lofting the product pipe vertically due to the steep exit angle but required little adjustment laterally to align the fused pipe string with the bore.

4. CONSTRUCTION

The Contractor elected to use a 900,000lb HDD rig for the crossing with the engineer's calculated maximum pullback force of 55,000lb (Staheli, K., Bennett, R.D., O'Donnell, H., Hurley, T., 1998). This choice necessitated moving the entry point closer to the channel to accommodate the increased rig length and prevent the elevated end of the rig from encroaching on the nearby existing overhead power lines. A request to decrease the entry angle by four degrees was also approved to aid in distancing the rig from the overhead power during rig setup and drilling operation. The decreased entry angle shifted the bore closer to the below grade dry well, increasing risk to the structure that the Contractor offset with additional conductor casing (HDD Good Practices Guidelines, 2008).

Figure 7. Drill rig setup at 20 degrees.

Additional entry conductor casing was installed by the Contractor in order to reach the minimum depth of the bore required by the plans due to the decreased entry angle of 20 degrees.

Figure 6. Installation of the 86LF entry conductor casing at 20 degrees.

To provide additional protection of the adjacent wet and dry wells during drilling, the Contractor elected to install 120 feet of wash-over pipe, i.e., a smaller 12-inch diameter casing than that of the conductor casing, extending through and beyond the conductor casing by 40 additional feet. The wash-over pipe was used while drilling the pilot and removed when reaming the bore.

Figure 8. Installation of 120 feet of 12-inch wash over casing.

The Contractor extended the surface-laid TruTrack coil as far into the channel as possible during the low tide in order to increase the tracking distance during the pilot bore. Cement blocks were used to fix the coil wire along the channel floor. A second coil was placed at the exit side in a similar manner to track the pilot bore once across the channel. Due to the shortened crossing length from moving the entry point, along with the increased length of steel casing, the drill operator had only a few drill pipe to establish a heading before exceeding the limits of the entry side tracking coil. This proved inadequate on the first crossing attempt as the pilot bore was off both line and grade by 20-feet and 3-feet respectively, when reaching the exit side tracking coil. The operator was able to pull back and attempt a new heading that was successful on the second attempt and the pilot bore was completed within tolerance at the planned exit location.

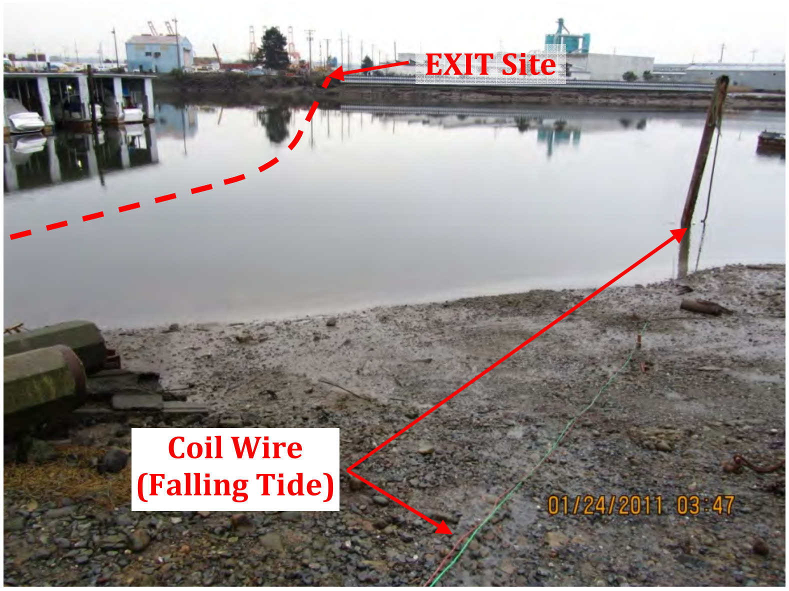

Figure 9. Wire coil extending into the Hylebos Channel.

Steel plates were placed directly over the bore where the alignment crossed beneath the adjacent roadway and business driveway at the exit site as added protection to the heavy traffic traversing the shallowest portion of the alignment. This measure was performed in lieu of installing the exit side conductor casing prior to completing the pilot bore. Once the pilot bore was completed, the Contractor installed the exit side conductor casing as planned and the steel plates were removed. Inadvertent returns were observed approximately 20-feet from the exit location when drilling the last 30-feet of the pilot bore. This was due to the Contractor drilling all but the last 30-feet of the pilot bore on one day, and then completing the bore the next morning after preparing the exit excavation. Increased fluid pressures were required to resume drilling the remaining 30-feet on the second day. The hydrofracture was minor and immediately contained and cleaned.

Figure 10. Exit Site with Existing Sewer and Steel Plates Over the Bore.

One reaming pass was utilized from the pilot bore diameter of 9-7/8 inches to the final reamed diameter of 26 inches utilizing a fly cutter reamer that proved efficient through the ground conditions encountered. Given that this style of reamer could not be easily pulled into the entry side casing without damage, the reamer was placed on the drill string at the exit and back-reamed to the entry side conductor casing. A barrel swab was then placed on the drill string at the entry and the fly cutter with the newly placed barrel was pushed back through the bore along with the tail string.

The fly cutter was then removed from the drill string and the barrel swab was pulled back through the bore for a final swab and proof of the bore.

Figure 11. Fly cutter and barrel assembly used for back reaming.

Pullback of the product pipe was completed expediently once preparations for buoyancy control were made. Buoyancy control was accomplished with a 2-inch PVC tremie pipe run inside the length of the product pipe and adding water while pulling back the product pipe. The short exit side layout area for the product pipe necessitated two segments of pipe and a fuse mid pullback. After stopping to fuse the pipe and allowing time for it to cool, the pullback resumed without any appreciable increase in pullback forces and the remaining product pipe was installed successfully in less than an hour. The total duration for the pullback was approximately 5 hours, including the 3 hours required to fuse and cool the HDPE pipe. The total pullback force was approximately 22,000 lbs and varied only slightly over the duration of the pullback.

5. CONCLUSION

This project presented challenges during the design that were overcome by weighing the available engineering solutions and tailoring these to balance the project risks with constructability issues. Although the channel crossing was relatively short, this fact magnified specific challenges that would constitute minor concern for lengthier crossings. Bore alignment and geometry were critically important given the geotechnical conditions and the site characteristics that constrained the design. The Contractor also brought solutions to issues that arose during construction and through active and thoughtful communication with the Engineer and Owner challenges during the drilling were resolved and construction progressed and culminated in the completion of a successful project.

6. REFERENCES

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