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**Sliplining 36-in. PCCP with Fusible PVC -
DC Water's Long-Term Control Plan 'Division E'**

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1. ABSTRACT

The District of Columbia Water and Sewer Authority (DC Water) is implementing its Long Term Control Plan (LTCP) for the District's combined sewer system. The LTCP is divided into several contract divisions; the work under Division E is located on M Street SE, between 9th Street SE and 14th Street SE. Under this project, combined sewer overflows (CSOs) will be diverted from existing combined sewers to the future tunnel system along M Street SE through a series of large diameter diversion sewers constructed using trenchless methods. Due to concerns of potential damage during construction of the sewers, the work includes the rehabilitation of selected portions of the existing 36-inch Southeast Relief Water Main (SRWM).

During design, the feasibility of several Class IV structural rehabilitation methods was evaluated for this prestressed concrete cylinder pipe (PCCP), and construction bid documents were prepared allowing contractors to choose one of three options. The rehabilitation of roughly 1800-feet of PCCP line was performed through a sliplining operation in which Fusible PVC™ pipe was fused together from 40-foot sections and pulled sequentially into the host pipe.

This paper provides a case study of the design considerations and construction techniques which allowed successful installation and testing of the line. Material covered will include the selection of pit locations, survey and video of the host pipe for potential pinch points or obstacles, a brief description of the product pipe, equipment used to pull pipe through the host pipe, grouting methods and connections to DIP fittings, and challenges encountered during construction.

2. INTRODUCTION

DC Water's Long Term Control Plan (LTCP) is comprised of a system of tunnels and diversion sewers for the capture of combined sewer overflows (CSOs) to Rock Creek and the Anacostia and Potomac rivers for treatment at DC Water's Blue Plains Advanced Wastewater Treatment Plant. Implemented under a Federal Consent Decree between the United States, District Government and DC Water, the LTCP is divided into several contract divisions; the entire project, however, will reduce CSOs annually by 96 percent throughout the system and by 98 percent for the Anacostia River alone.

The work under Division E will occur on M Street SE, between 9th Street SE and 14th Street SE. Under the project, CSOs will be diverted from existing combined sewers using three diversion chambers, then conveyed to the future tunnel system along M Street SE through a series of 48-inch and 108-inch diameter diversion sewers constructed using trenchless methods. CSOs totaling 695 million gallons per day will be delivered to the LTCP tunnel system.

The work also includes the rehabilitation of selected portions of the existing Eastside Interceptor (ESI) sewer and the Southeast Relief Water Main (SRWM).



Figure 1. Schematic of Division E Project Location (courtesy of DC Water).

3. DESIGN CONSIDERATIONS AND ALTERNATIVES ANALYSIS

Construction of the M Street diversion sewer project includes 48-inch and 108-inch diversion sewers, CSO diversion chambers and manholes, and an open cut approach channel/junction sewer installed in close proximity to the existing ESI and SRWM. Based on geotechnical investigations and evaluations of potential construction methods, it was determined that an unacceptable amount of settlement and/or displacement of the 36-inch SRWM (from 11th Street to Water Street) was possible. Therefore, structural rehabilitation was evaluated and designed to occur in advance of the construction of new facilities.

The subject section of the SRWM transitions from 36-inch steel to prestressed concrete cylinder pipe (PCCP) on the east side of the 11th Street intersection, and continues east beyond Water Street and the limits of this project. The proposed diversion sewer is located below and to the south of the SRWM from 11th Street to Water Street. The SRWM was constructed in the early 1960s at a depth of cover from 4-feet to 12-feet, with the deepest section between 14th Street and Water Street. There is an existing access manhole about 100-feet west of the steel-PCCP transition. There are six existing connections (hydrants and connecting mains) to the SRWM within the section of concern, ranging in diameter from 4-inch to 12-inch, at various "clock" positions on the pipe (typically tangential to the pipe top or bottom), which must be maintained or restored following rehabilitation. Control valves for the 36-inch SRWM are located at 11th Street and east of Water Street. All valves were assessed and confirmed operational ahead of design, and it was determined that this section of the SRWM may be taken out of service during the period of low demand, from October through April.

For the purposes of finalizing the selection and design process in advance of project bidding, the feasibility of three specific rehabilitation options was evaluated, including sliplining and cured in place pipe (CIPP) lining by two separate systems/vendors. Each system met the requirement to provide a standalone, structural rehabilitation solution. In the case of sliplining, a new pipeline is inserted into the existing pipe. After the pipe is inserted, connections are made to the existing pipeline on both sides of the sliplined portion with transition couplings. Additionally, grout is pumped to fill the annular space that is created between the existing pipeline and the new pipe material. The grouting process locks the new pipe in place and also eliminates void space from around the new asset.

CIPP rehabilitation systems typically entail the insertion of a resin-soaked liner into the existing pipe. The liner is then expanded against the inner wall of the existing host pipe, which acts as a form for the CIPP material. The liner is then cured with water or steam, providing a fully structural solution, following which end connections are made.

For the sliplining option, concerns were raised regarding reduction of the inside diameter of the pipe, relative to maintaining operating pressure and flow. Fusible polyvinylchloride pipe (FPVCP) was identified in a 30-inch, ductile iron pipe (IP) size, DR 25, pressure class 165 psi, with an outside diameter (OD) of 32-inches. This meant that it could be inserted into the existing PCCP, which had an inside diameter of 36-inches. Additionally, due to the material characteristics, the required wall thickness for the given pressure class meant that the new FPVCP pipe would have an average inner diameter of approximately 29.2-inches. Other pipe materials, such as high density polyethylene (HDPE), are regularly used in sliplining and other trenchless technologies. However, in order to maintain a similar flow area or inside diameter with a similar pressure rating, a nominal 36-inch IP size HDPE would be required. This would preclude sliplining as a rehabilitation option. Further, it was determined that a smaller 34-inch IP size HDPE section would result in an unacceptable flow reduction (see Figure 2). Therefore, FPVCP was selected as the acceptable material for the sliplining option. Sliplining and pressure CIPP installation methods were bid competitively on this project, and the sliplining solution was provided by the successful bidder.

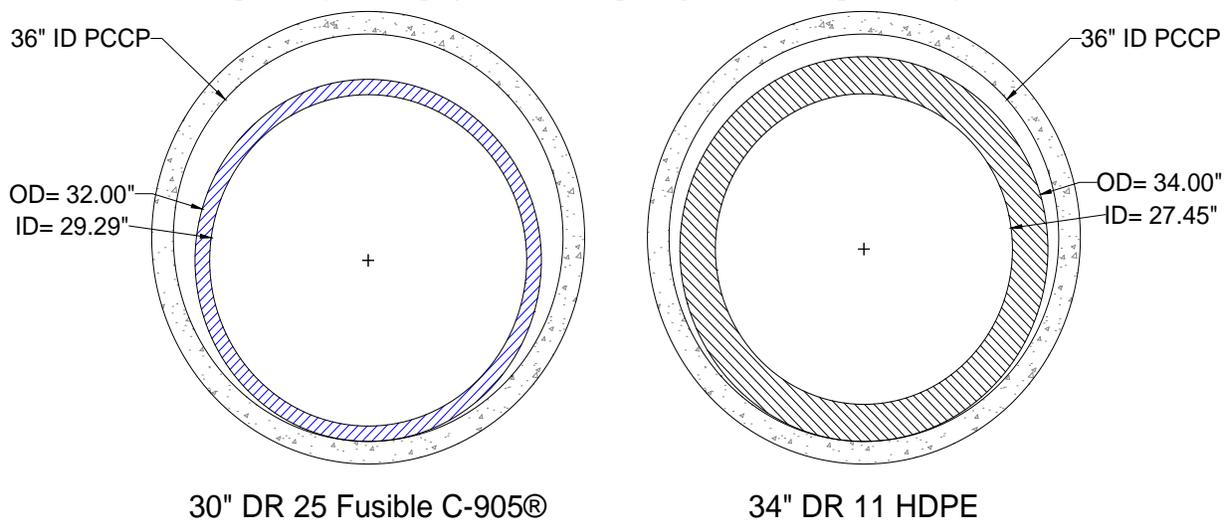


Figure 2. Comparison of potential sliplining pipe materials. For the same pressure class and outside diameter constraints, the inside diameter of the FPVCP section is about 2-inches larger than the HDPE section.

4. SLIPLINE INSTALLATION PROCESS

Rehabilitation of the 1,800-foot pipe length was completed in three sections, with conventional connections made to reconnect the pipeline in between segments and at the ends. Four access pits were excavated at points along the line as required. The first pit was the connection point for the west end of the project. The second pit served as a pipe fusion and launch pit for the pipe, to be pulled west to the first pit, and then also east towards the third pit location. This pit was placed at the location of a horizontal bend, which required excavation to facilitate installation. The third pit location coincided with a vault that was to be constructed, along with about 200-feet of pipe with several direction changes which was completed using direct bury installation techniques. The fourth pit coincided with the eastern end of the project. Connections were restored to the existing steel pipeline on the western end, and the existing PCCP at the eastern end. Allowable pit locations were defined in the bid documents, as shown in Figure 3.

Prior to the beginning of the sliplining process, a closed-circuit television (CCTV) survey was completed to make sure that there were no unknown obstructions, alignment issues or appurtenances in place that would obstruct the sliplining insertion process. There were several locations where vertical deflection of the existing alignment was verified during this survey, to ensure that the bend radius of the FPVCP could be accommodated. This was accomplished by calculating whether the bend radius of the FPVCP would be capable of navigating the deflection within the annular space available between the existing PCCP pipeline and the new FPVCP sliplined pipe. Figure 4 shows an example calculation for one of the vertical deflection locations, estimated at 2.7 degrees of deflection.

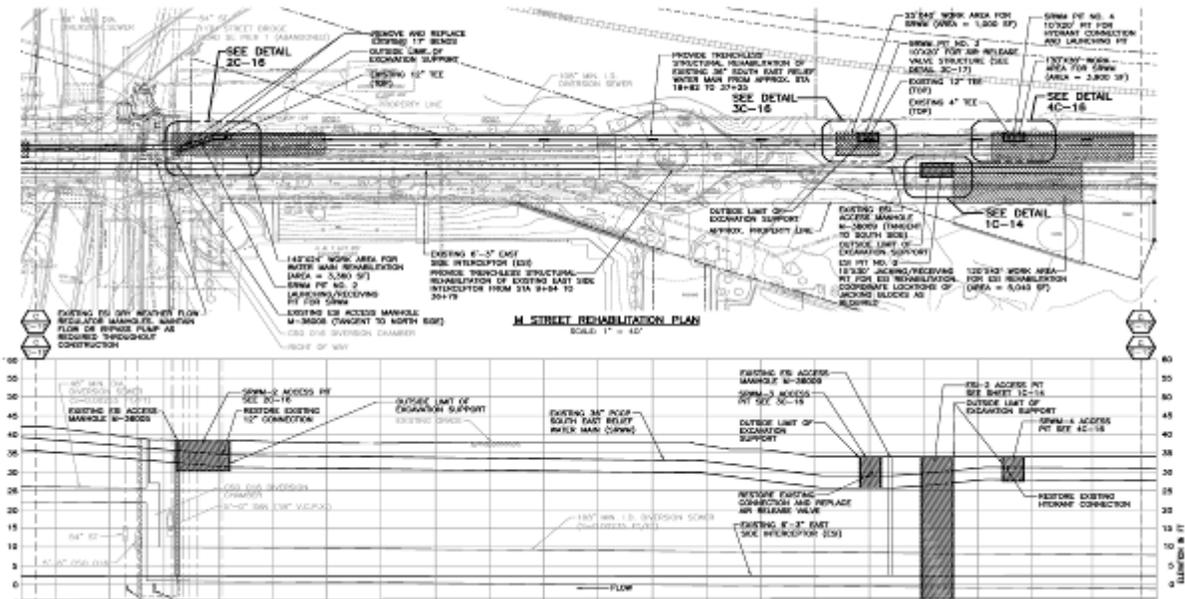


Figure 3. Excerpt from Pre-Bid plan sheet set noting allowable pit locations.

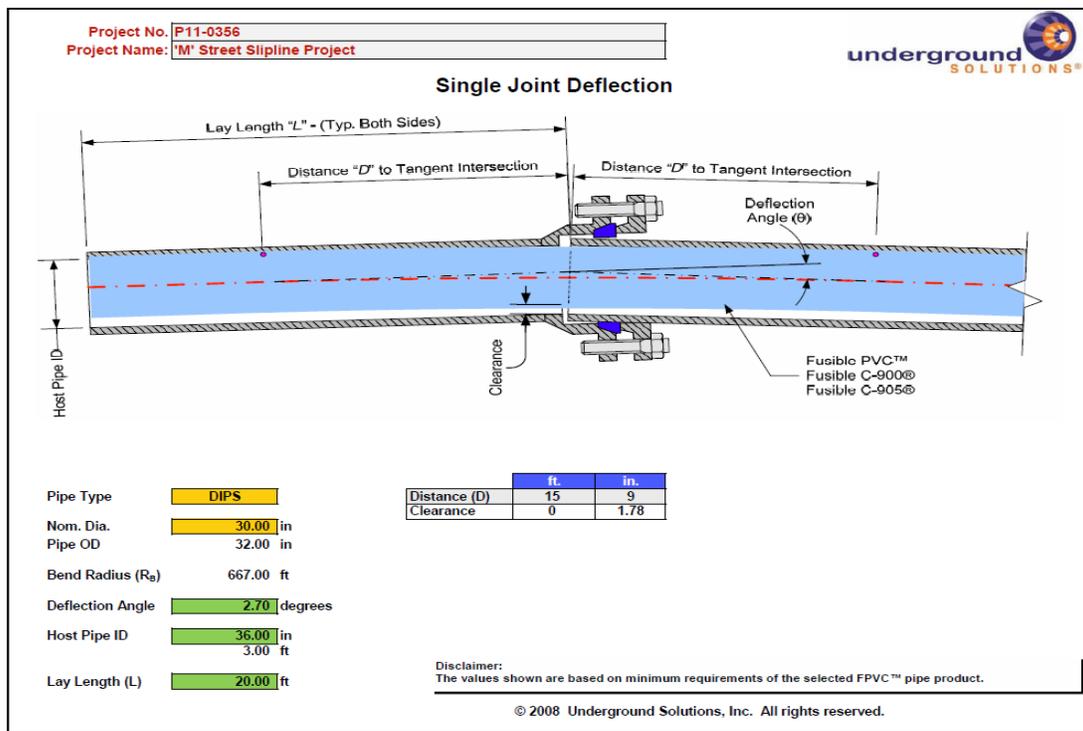


Figure 4. Sample calculation to evaluate deflection of FPVCP pipe within host pipe. This example shows that at a deflection angle of 2.7 degrees, the 30-inch FPVCP is capable of navigating the deflection within the allowable bending limitations of the pipe.

For each slipline insertion, the FPVCP was assembled in an excavated pit which was aligned with the host pipe on one end. A McElroy T900 fusion machine was placed in the excavated pit and used to thermally butt-fuse the pipe joint for the given insertion (See Figure 5). This required an excavation sized for the fusion operation, but also limited the footprint of the excavation as compared to the required pit and tail ditch that would have been needed if

the pipe was fused at grade and then pulled into the alignment at one time. This also limited the project area needed to fuse pipe lengths together prior to insertion.



Figure 5. Length of FPVCP being thermally butt-fused within the pit.

Each 40-foot section of pipe was fused to the previous section, allowed to cool, and then pulled from the fusion machine into the host pipe, which then allowed the next 40-foot length to be lowered into the pit. The fusion unit was located within the pit, and situated such that, upon exiting the fusion machine, the new pipe lined up directly with the existing pipe (see Figure 6).



Figure 6. Close up view of new FPVCP inserted into the existing PCCP.

The pipe was pulled into place through the existing 36-inch PCCP host pipe using static pipe bursting equipment (TT Technologies Grundoburst 800G) as shown in Figure 7. After each fusion joint was completed, the Grundoburst unit pulled the 40-foot pipe string into the existing pipe, setting up the next fusion joint. The steel bursting rods were connected to the FPVC pipe via tie rods placed through-wall at the end of the pipe, with a nylon strap woven through the cross connection of the tie-rods on the inside diameter of the pipe.

After each pipe length was inserted and connections were made at the pit excavations, grout was used to fill the annular space between the FPVCP and the existing PCCP. The grout filled in the void space, locking the sliplined pipe in place and eliminating voids along the alignment. The pipe was bedded and backfilled within the excavated pit locations as per typical direct bury process.



Figure 7. Grundoburst 800G static bursting unit set up and blocked in place in the receiving pit to pull in the new pipe. The steel rods are shown in the machine as well as in their storage packs for removal from the pit.

5. OTHER CONSTRUCTION CONSIDERATIONS

During preliminary construction of the M Street improvements, the SRWM was exposed in one location due to the configuration of the shoring system for the deeper sewer work. Field condition assessment of the PCCP indicated that bracing of the line was required before additional excavation could occur. A steel frame was erected within the shoring and the PCCP was braced and protected through a system of cables, steel members, grating and timber. With this system in place (Figure 8), the deeper work continued.



Figure 8. Protection of the 36-inch PCCP within the shoring system.

In addition, although modeling of the water system confirmed that the 36-inch SRWM could be taken out of service for a longer period than initially indicated, the rehabilitation work required removal of pipe segments adjacent to existing valves which were closed to isolate flow. The need for thrust restraint at these locations led to the development of a concrete thrust block system, which encased both the pipe and a set of helical tension anchors installed in the ground on either side of the SRWM. This system also allowed the work to proceed safely.

Another challenge that occurred during construction involved ground settlement. Due to the location of an old streambed along the project site, ground settlement of 4-feet was encountered during drilling and tunneling of the deeper sewer work. Chemical grouting and compaction grouting techniques were subsequently employed to stabilize the area and allow construction to continue. Additional sections of the rehabilitated SRWM were removed and restored in this case through open cut techniques, though connections were simplified by the use of the FPVCP material.

6. CONCLUSIONS

Significant planning was involved in the design, bidding, and construction of improvements to the utilities within the Division E project. Sliplining of the 36-inch PCCP SRWM with fusible polyvinylchloride pipe (FPVCP) was found to be the most cost effective Class IV structural solution applicable to the project per the bid, and it also accommodated the necessary pressures and flows. The sliplined pipe was installed in three segments using four excavated pits. The FPVCP was reconnected to the existing system as well as all required appurtenances using standard DI fittings and connections. Several techniques were used to protect the existing PCCP from issues related to the tunneling work adjacent to the rehabilitation project site and ensure that the PCCP remained in service.

7. REFERENCES

DC Water Website, Anacostia River Tunnel Project - Project Information Sheet Section, CSO 015/016/017, accessed 10/30/13: http://www.dewater.com/workzones/projects/anacostia_river_information_sheet.cfm