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# Slipline Method Used to Repair Cast Iron Transmission Main in Coatesville

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## 1. ABSTRACT

Pennsylvania American Water, Pennsylvania's largest regulated water and wastewater service provider, serves approximately 2.3 million people with high quality water and wastewater solutions. The Rock Run Reservoir is the source water for Pennsylvania American Water's Coatesville service area in southeastern Pennsylvania, 45 miles west of Philadelphia. While Rock Run has consistently served the community with approximately 4 million gallons of quality water per day, the existing 24-inch cast iron transmission main had exceeded its service life expectancy and needed to be replaced. In addition, the transmission main provided significantly more capacity than the system required, which could result in water quality issues. The engineering staff at Pennsylvania American Water performed hydraulic calculations to determine the size of a new transmission main that would be adequate for both current and future use. They discovered that demands could be met using a pipe that had an internal diameter of 11.5 inches for most of the line and 15 inches at the lower end of the system. The need for a reduced internal diameter and a relatively straight alignment presented the perfect opportunity for Pennsylvania American Water to consider using the trenchless technique of sliplining the 24-inch cast iron transmission main with a smaller pipeline. Determining the pipe material to be used was only one of many factors considered during the design process.

Further review of the evaluation process of selecting sliplining as the installation method, the new pipe's material, and end results of the installation will be explored.

## 2. INTRODUCTION

Pennsylvania American Water serves approximately 2.3 million people in more than 400 communities across 36 counties (see Figure 1). It is the largest regulated water and wastewater utility in the state, and takes pride in providing high-quality and reliable water and wastewater services to its customers. In the Pennsylvania American Water system, there are 36 treatment plants, 16 wastewater plants, and 101 groundwater well entry points. The Rock Run Reservoir is the source of water for Pennsylvania American Water's Coatesville service area in southeastern Pennsylvania, located 45 miles west of Philadelphia. Although Rock Run has consistently served the community with an average of four million gallons of high quality water per day, the age and diameter of some of the existing pipeline infrastructure prompted Pennsylvania American Water to use costly treatment processes and programs to continue to meet the water quality standards its customers expect.

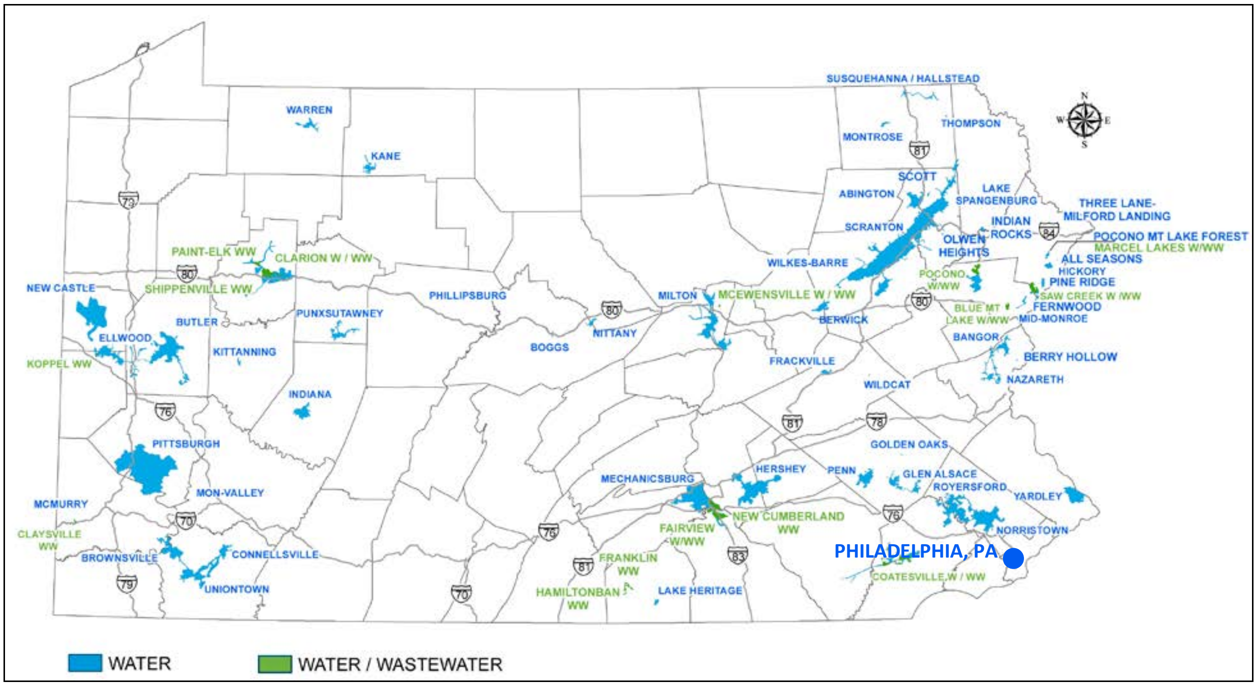

Figure 1. Pennsylvania American Water services more than 400 communities in 36 counties.

Pennsylvania American Water's 24-inch cast iron water main was installed in the early 1900s and serves the communities of West Sadsbury Township, Atglen Borough, Sadsbury Township, and Bart Township. Measuring approximately 9.5 miles long, the original purpose of the water main was to provide water to numerous steam-powered locomotives that powered industrial growth in the early 20th century. Steam-powered locomotives used track pans to retrieve water for the locomotive while in motion. After the introduction of diesel locomotives in the mid-20th century, the demand for steam locomotives began to decline. They required more personnel to operate, and required more maintenance than diesel locomotives. In 1957, steam locomotives were removed from active service in the Pennsylvania Railroad fleet. While the cast iron water main was still functional and served its customers, it was providing significantly more capacity than the system required when the steam-powered locomotive demand was present. Overcapacity of a pipeline results in costly treatment processes and programs to ensure that water age and stagnation doesn't adversely impact water quality for its customers. In addition, extra costs are experienced due to the increased water pressure and additional pumping stations needed to maintain water velocity in the pipeline.

As a result of the amount of money that was being spent on its maintenance and repairs and concerns regarding water quality, the Pennsylvania American Water put together an extensive infrastructure program in January of 2015. The program was designed primarily to improve its water system by replacing aging pipe, prevent costly emergency repairs, improve flows for fire protection, and ensure that the customers receive quality, reliable water service for many years to come.

## 3. PROJECT DESIGN

Pennsylvania American Water serves a substantial amount of customers and it has a diverse workforce with more than 6,700 employees, including its own Engineering Department. The mission of the Engineering Department includes conducting research to determine a service area's most efficient water service options, as well as site evaluations to determine optimum locations for facilities and infrastructure. Based on the existing conditions of this particular water main and the issues in water quality due to overcapacity, the engineering group knew that the proposed water main would have to be considerably smaller than the existing 24-inch main. In order to determine the cross sectional flow requirements of the replacement pipe, Pennsylvania American Water had to analyze the hydraulics of the service area. Without the steam locomotive demand, Pennsylvania American Water only had to consider service to the hydrants, residents and businesses in the area (see Figure 2). Based on their calculations and evaluation of the project area, the Pennsylvania American Water engineers determined that the water transmission line could be replaced with both an 8-inch nominal size for one portion and a 12-inch ~~nominalsize~~nominal size for the rest of the alignment. The additional capacity was simply not needed.

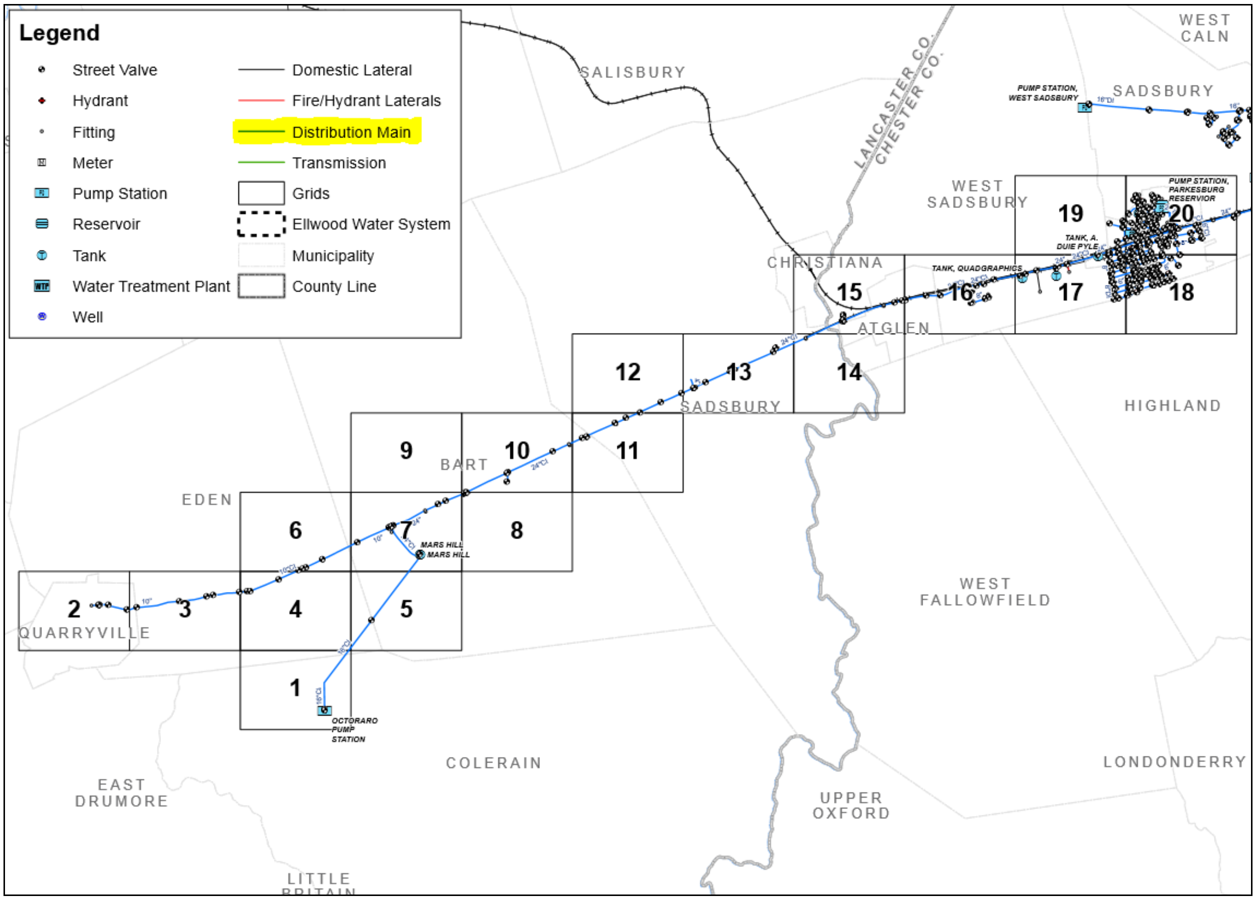

Figure 2. Area map of project alignment

The existing water main was located under a roadway, along an abandoned railroad right-of-way, underneath several trees, and near residential and business districts. Installation of a new water main using conventional open trench techniques in these locations would mean soil conditions along the entire alignment would have to be evaluated. Open trenching would cause a disturbance not only to residents and businesses in the area, but it would have significant impact to the environment, especially to a significant amount of trees. These circumstances led Pennsylvania American Water engineers to entertain alternate methods for pipe installation. They determined that the best option for this transmission main installation was to slipline the new pipe inside the existing pipe. Sliplining pipe would minimize disruption of the existing alignment and would be the least intrusive to the environment. It also utilizes the existing asset location and easement space without creating redundant pipeline locations. Most importantly, it would be the most cost effective installation method since there is substantially less excavation involved. Soil excavation is a costly process as it stood to include extensive soil treatment and disposal as necessary based on the potential contaminants present in the area.

Restrained pipe was a prerequisite for the final pipe material selection because the pipe would be pulled into the existing pipe. The Engineering Department staff researched the properties of both fusible polyvinyl chloride pipe (FPVCP) and high density polyethylene (HDPE) pipe, to determine what material would be acceptable for the application.

FPVCP provides a larger inside diameter (ID) for commensurately sized outside diameters (OD) and pressure rating when compared to HDPE pipe. The larger hydrostatic design basis of PVC pipe material means that a thinner pipe wall will provide the same internal pressure carrying capacity as HDPE pipe material will. A thinner wall translates into a larger internal diameter and a greater cross-sectional flow area with PVC pipe. As a result, the diameter of the

HDPE pipe was upsized to the next available nominal diameter (see Figure 3) so that both pipe materials were equivalent in flow are and long term pressure carrying capacity.

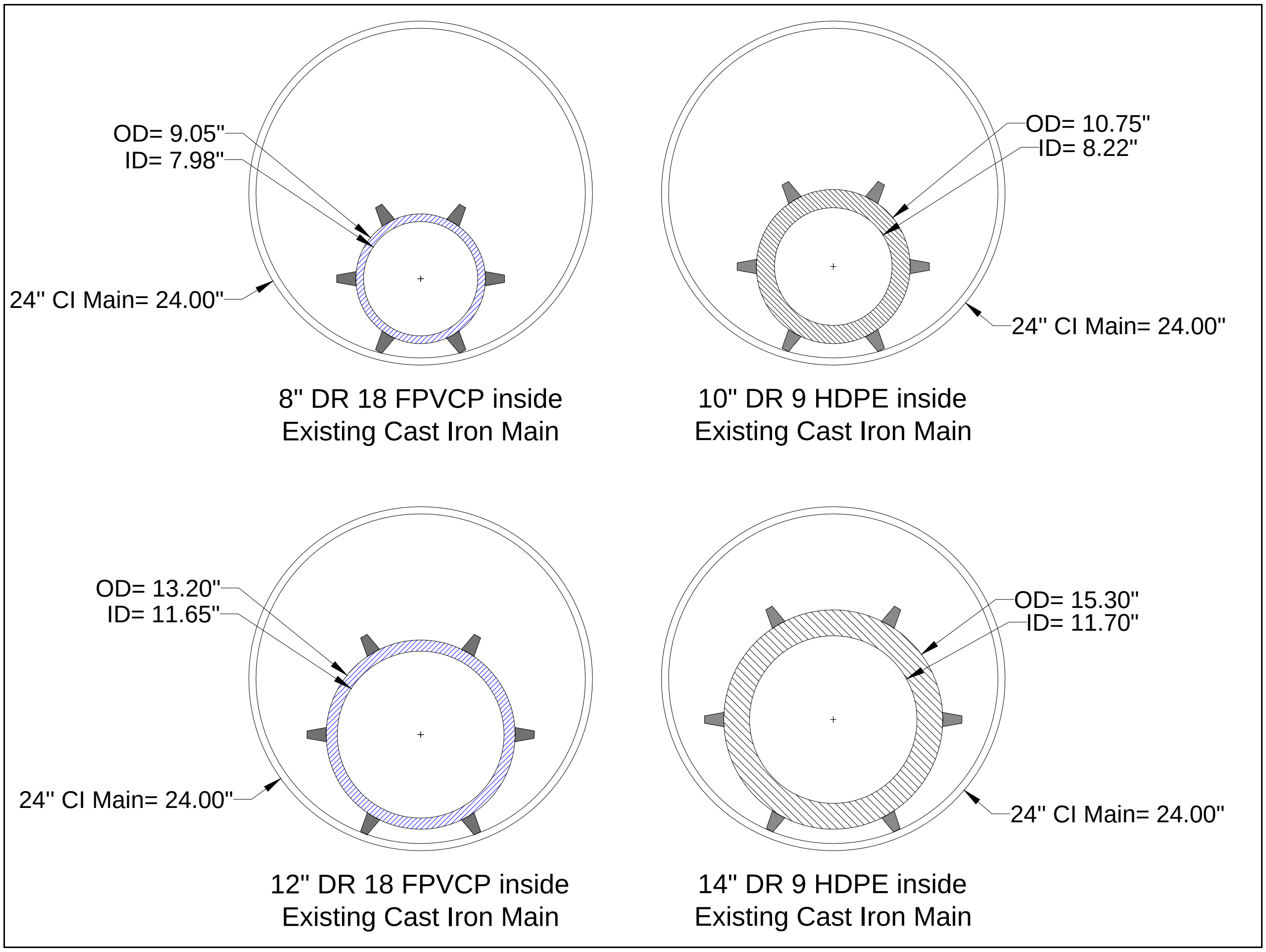


Figure 3. Comparison between FPVCP and HDPE Pipe

## 4. PROJECT BIDDING

The project was advertised to prospective bidders on June 4, 2015. The bid form included both 8-inch and 12-inch pipe to be sliplined inside the existing 24-inch cast iron main. Bid item G specified 31,200 linear feet (LF) of 8-inch FPVCP or 10-inch HDPE pipe and bid item H specified 8,300 LF of 12-inch FPVCP or 14-inch HDPE pipe. For both bid items, the contractor was required to circle either ‘Fused PVC’ or ‘HDPE’ as their pipe material of choice. In addition to the pipe, stainless steel casing spacers were specified in the base bid. The spacers are designed with risers to support the carrier pipe within the casing, and maintaining a minimum clearance of 1 inch between the ID of the casing and the OD of the carrier pipe with a minimum arm length of 7 inches. The alternative of grouting the annular space was added to the bid form and would be considered in lieu of the casing spacers, if the contractor recommended this option.

Because all bidders were required to select which pipe material they intended to use for the project on bid day, Pennsylvania American Water would know as part of the bid which pipe material would be installed for their project in addition to whether casing spacers or annular space grouting would be used. When contractors and suppliers are required to make a selection on bid day, they provide their most competitive pricing at that time and it eliminates post-bid negotiations. Otherwise, contractors and suppliers would be free to shop for the best price following the project award. Ultimately, this requirement reduces the overall project bid price for the Pennsylvania American Water on the day of bidding.

The project was bid on June 19, 2015 and was awarded to Spiniello Companies of Baltimore, Maryland. Spiniello selected FPVCP as the pipe material and contracted with Underground Solutions of Poway, California to provide pipe and fusion services for the entire length of proposed water main. In addition, Spiniello elected to grout the annular space rather than use casing spacers. The OD of the fusion joint of FPVCP is the same as the OD of the actual pipe, which eliminates the need for keeping the pipe joints off the bottom of the ID of the casing. As a result, casing spacers are not a necessity for a FPVCP carrier inside a casing or existing pipeline.

After the project was awarded, Pennsylvania American Water reevaluated the need for two pipe sizes and decided to eliminate the 8-inch pipe in favor of 12-inch pipe for the entire alignment. Pennsylvania American Water felt that having the entire 39,500 feet of pipe installed as 12-inch pipe would be the best suitable size to meet current conditions, and would also better accommodate potential future conditions. Since the contractor had already been selected, there was no addendum issued for the modification of the proposed pipe size. In addition to this size change, Pennsylvania American Water also decided to add 10,000 feet of 16-inch water main installation to the project, almost fully replacing the total length of the transmission pipeline. Installation using the slipline method provided large cost savings, enough cost savings to allow for the extra pipeline replacement while staying within budget. The 16-inch pipe would be sliplined into the existing 24-inch cast iron pipe and would be installed near larger businesses and commercial demand.

## 5. CONSTRUCTION

Construction began in September 2015 on the west side of the project area on Mount Pleasant Road near Quarryville; the installation continued east from there. Due to the extensive length of the pipe installation, the project was sectioned into five separate pull or installation sections. Each section measured roughly 8,000 to 9,000 feet long. With each section, the existing pipe was taken out of service and a 4-inch bypass pipe was installed, providing temporary water service to both residences and businesses until that section could be completed. Once the bypass line was installed and operating, the contractor cleaned and inspected the interior of the existing pipe to ensure that there were no significant variations in the alignment that would interfere with the installation. While the condition of the existing pipe was being verified, fusion technicians worked to assemble the pipe sections and prepare the sections for installation. Once the contractor verified the existing pipe the contractor was ready to begin the slipline process. Each assembled length measured anywhere from 1,000 to 2,000 feet and was inserted into the existing pipe and pulled into place using a winch. After each assembled section of FPVCP was installed, flowable grout was then pumped into the annular space and properly vented to ensure a complete void fill. These procedures were followed for the entire project until all 39,500 feet of pipe was completed (see Figure 4).


Figure 4. Pipe Installation [12-inch FPVCP water main entering 24-inch cast iron main (left); grouting of annular space with vent tubes and service connections (right)]

The areas around the project included open grassy fields, residential yards, and forested areas. Overall, there were minimal shut downs and temporary outages to the water service, with no major disturbances to the environment during construction. On the east side of the project there was a large brewery that used a considerable amount of water each day, so Spiniello decided to use an 8-inch bypass pipe in addition to the 4-inch bypass pipe already installed for that section when it was completed.

Although most of the construction took place in open fields, there were areas next to trees and residences where pipe staging and positioning presented a few challenges. Spiniello and its crew, however, were able to use the space they had to maneuver the pipe sections as needed in order to make the installation a successful one. In areas where space was limited, Spiniello would stage and fuse in the nearest open area and pull the assembled pipe string from the fusion area to the installation pit. Figure 5 shows two of the pipe sections staged for fusion along a narrow roadway and around trees. All movement of the pipe was coordinated to assure that the pipe was properly supported and that it did not exceed the minimum bend radius recommended by the pipe supplier.

Figure 5. Pipe string staged along through trees, ready for pull-in

The project took place during the winter season so Spiniello and Underground Solutions worked to protect the pipe and fusion process from inclement weather. Cold weather tents were established to protect the fusion machines, and the pipe was capped off at all open ends so that snow wouldn't enter them (see Figure 6). There were a few days where a snow storm and blizzard caused the crew to temporarily shut down the project. Once the storm passed, they were able to resume the project and complete the installation. Although the snow storm caused a suspension in production, there were no delays in the overall project and the completion date was not postponed. A key factor that led to the efficiency of the installation and on-time completion was the use of multiple fusion machines when assembling the FPVCP.

Once the 12-inch pipe was installed, Pennsylvania American Water began construction of the 10,000 feet of 16-inch FPVCP inside the existing 24-inch pipe on the east side of the project. This 16-inch pipe began at the end of the new 12-inch pipe and the two were connected using a ductile iron mechanical joint reducer.

Figure 6. Pipe fusion during the cold weather season  (machine setup (left); pipe layout after snow storm (right))

Spiniello utilized multiple fusion machines on the project to increase the pipe assembly production rate.  The fusion machines were set up side-by-side and fusion was performed simultaneously.  Multiple machines allowed for increased production and an early completion date – or in this case, completion on schedule despite weather delays (see Figure 7).

Figure 7. Fusion machines side by side

One challenge Spiniello faced was the presence of groundwater in the soil.  They had to carefully choose the locations of the installation pits and keep a pump in the pit in order to keep water out of the existing pipe.  Spiniello took extra safety measures to ensure that if they did encounter groundwater, then proper dewatering and groundwater control methods were implemented.  Fortunately, they did not face major groundwater issues, since the amount of excavation in the project was very minimal.

## 6. CONCLUSION

The 39,000 feet of 12-inch pipe was completed successfully in January 2016 and the 10,000 feet of 16-inch pipe was installed without delay in February 2016. Using the temporary bypass pipeline, Spiniello installed the pipe efficiently and there were little to no interruptions in water usage to residents. The decision to slipline the new water main into the existing main turned out to be the most beneficial for everyone involved. Because very minimal soil excavation was needed, this created less concerns for soil treatment and disposal and ultimately significant cost savings. There were no delays in traffic since obstructions on roadways were very limited. The decommissioned railroad still exists and remains intact as a historic icon of the town since all of the installation took place beneath it.

## 7. REFERENCES

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