

# Civil Engineering

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## MOVING INTO THE FUTURE

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Drilling across a Riverbed

*The replacement of a critical water main beneath the Raritan River in New Jersey by means of horizontal directional drilling established a world record for the length of 24 in. diameter fusible polyvinyl chloride pipeline installed using this precise and difficult method.*

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**By David J. Tanzi, P.E., BCEE,  
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**S**PANNING New Jersey's Raritan River, a crucial but aging water main connects the northern and southern distribution systems of the Middlesex Water Company (MWC). The northern system is in Perth Amboy and the southern in Sayreville. With the frequency and costs of repairs escalating, MWC set out to plan, design, and construct a replacement that would continue to provide high-quality water service to residents in the southernmost portion of its distribution system.

Based in Iselin, New Jersey, MWC is a 113-year-old, publicly traded company providing water, wastewater, and related utility services to nearly 400,000 residents of central New Jersey and Delaware. Through a partnership, an impressive solution to the water main problem was achieved by using horizontal directional drilling (HDD) to install 5,365 ft of 24 in. diameter fusible polyvinyl chloride (FPVC) pipe beneath the Raritan River. In addition to MWC, the partnership involved the international consulting engineering firm CDM, of Cambridge, Massachusetts; Northeast Remsco Construction, Inc. (known as Remsco), of Farmingdale, New Jersey; and Mears Group, Inc., of Rosebush, Michigan. The use of FPVC pipe—supplied by Underground Solutions, Inc. (UGSI), of Poway, California—enabled the team to set a world record for HDD installation of this type of pipe at this size and length.

The strategic and well-coordinated partnership enabled MWC to deliver this project in a short and challenging time frame. The project was released for bids in November 2009, and construction was completed before the Memorial Day holiday in 2010, in time for MWC's peak water demand.

The cast-iron pipeline that was replaced conveyed potable water across the Raritan River. It had a long history of service dating to its original installation, in 1904, by the City of Perth Amboy and was eventually taken out of service because of damage believed to be caused by a ship collision. In the 1980s the unused 24 in. water main was leased by MWC from the City of Perth Amboy, which carried out a series of repairs



## UNPARALLELED

to return the pipeline to service for conveying potable water. The repairs were a fast-tracked interim solution intended to extend the pipeline's life in what the State of New Jersey had designated critical water supply area number 1. The repairs took place in 1987; a 1,700 ft section of the 24 in. water main was sliplined with a high-density polyethylene (HDPE) pipe having an internal diameter of 17 in. As part of that work, a 3,700 ft section of the same water main located along the south bank of the river was cleaned and lined with cement.

These repairs served the community well for a number of years, and MWC purchased the pipeline outright in 2002. However, it soon faced increasing and escalating challenges with the pipeline's continuing operations and maintenance, especially with the sections of the water main located within

COURTESY OF MIDDLESEX WATER COMPANY

The 5,365 ft of 24 in. diameter fusible polyvinyl chloride pipeline to be used in the project was strung in 1,550 ft lengths at a staging site in Perth Amboy. As the pipeline extended from the staging area to the entrance of the horizontal directional drilling bore, it had to be supported over a steep hillside and suspended above a major roadway.



would have involved additional cleaning and a structural rehabilitation of the entire water main.

Ultimately, MWC decided that a complete replacement of the water main would be more advantageous. Although it had had success for a number of years in repairing and reinforcing the pipeline, expensive breaks continued to occur in the pipeline within the marsh area. Moreover, the previous rehabilitation and sliplining project limited the flow capacity. MWC retained CDM in March 2008 for the planning, design, and construction phases of this project.

Once the decision had been made to replace the water main, the first phase of the project involved an examination of alternative routes on the basis of property rights, the availability of easements, accessibility and operations concerns, utility conflicts, constructability considerations, environmental effects, permitting requirements, and estimated costs. The selected route called for approximately 500 ft of water main to be installed on land, while 5,365 ft would cross the Raritan River and adjacent marshlands (see the route map on page 75).

After selecting the new water main route and examining the conditions for construction and installation, CDM worked with MWC to select the proper design and materials to address this challenging project. The engineers at CDM evaluated various construction methods, including an open-cut approach, pipe jacking, microtunneling, conventional tunneling, and HDD. After an extensive evaluation phase, HDD was selected on the basis of project conditions and cost-effectiveness.

A geotechnical investigation of the site, which was developed by CDM and carried out by Melick-Tully and Associates, P.C., of South Bound Brook, New Jersey, under a subcontract to CDM, revealed layers of soft clay overlying stiff, silty clay with sand underlain by weathered rock on the north side of the crossing (see the sub-surface profile on page 74). In view of these conditions, the final drill path selected was at a depth of 65 ft. This depth made it possible for the drilling to remain above the bedrock layer and to avoid a shipping channel.

Mainly used in the petroleum and utility industries, HDD is a trenchless method for directly installing underground pipelines and conduits and does not rely on traditional trenching methods, many of which can have deleterious effects on the environment. It is typically implemented by means of flexible drilling equipment that is capable of being maneuvered horizontally and vertically in order to adhere to a predetermined alignment. The pipeline is installed in three main stages: drilling a pilot hole, reaming the hole to the required diameter, and pulling back the pipeline.

Several pipeline materials were investigated, including ductile iron, FPVC, HDPE, and steel. A material review and selection process helped to narrow the choices. Ductile iron did not have a good record under these conditions for the given length, and there were concerns that HDPE pipe might not be able to

# ACHIEVEMENT

marshlands and wetlands that were often covered with less than 2 ft of muck and reeds during low tide. Because of the age of the pipeline and the corrosiveness and unstable nature of the surrounding soils, the water main experienced several breaks that required costly emergency repairs, and the breaks became more frequent. The outages caused major disruptions to operations, and the repairs proved costly because of the impediments to accessing the pipeline in the river, the soft sediments present, and the regulatory considerations associated with the adjacent wetlands and river navigation.

Because of the outages, MWC determined that the 24 in. water main had to be either replaced or further rehabilitated in order to provide a reliable source of drinking water to its customers south of the Raritan River. Rehabilitating the water main

withstand the forces associated with the pullback. Steel could have been used successfully, but it could have become costly because joints would have had to be welded and interior and exterior coatings would have had to be applied at the joints in the field. FPVC has recently gained acceptability in HDD installations and has shown itself to be a viable material. Before this project, it had never been used at this diameter and at this length, but the engineering team was able to draw on similar project experience and was confident of success.

Building a strong team was vital to the success of this design/bid/build project. While CDM served as the design engineer, several other players helped to make the partnership a successful one. Prior to project bidding, CDM and MWC undertook an extensive prequalification process to find general contractors and HDD subcontractors that had the proper experience to complete a high-risk project of this nature. The chosen construction team consisted of Remsco as the general contractor and Mears as the HDD subcontractor. The FPVC pipe, as mentioned above, was supplied by UGSI. The awarded contract price was within \$10,000 of CDM's opinion of the probable construction costs for the project.

A number of meetings and workshops were held to discuss operations and plan for contingencies prior to the start of construction and during construction activities, and these meetings proved to be of capital importance. The team members held risk mitigation and contingency planning meetings before the contract was awarded, before the pilot hole was drilled, before the reaming, before the pullback operations, and before the hydrostatic testing of the pipeline. All members of the team met before these key project milestones to discuss potential risks and obstacles and to develop answers and contingency plans for addressing potential problems during construction and operations.

The installation of the pipeline beneath the Raritan River required the acquisition of several environmental permits and approvals, including those from the U.S. Army Corps of Engineers, the New Jersey Department of Environmental Protection, and the Freehold Soil Conservation District of New Jersey.

Given the urban surroundings along

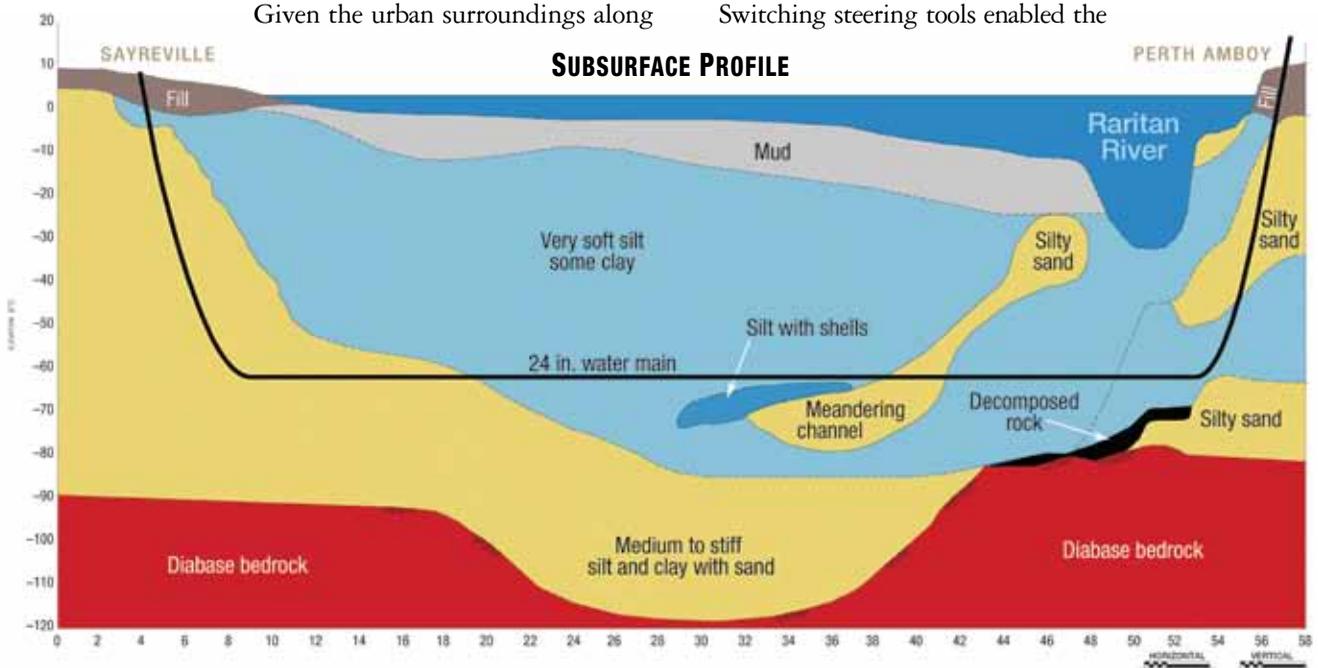
both sides of the Raritan River, creative pipe staging areas had to be found. Before the start of construction, MWC secured a pipe staging site in Perth Amboy that featured abandoned concrete foundations with vegetative growth at varying elevations. The total pipe staging area was approximately 2.5 acres, which afforded room to string pipe in sections of only 1,550 ft. Additional area was secured for storing the pipe, the fusing equipment, and other construction material.

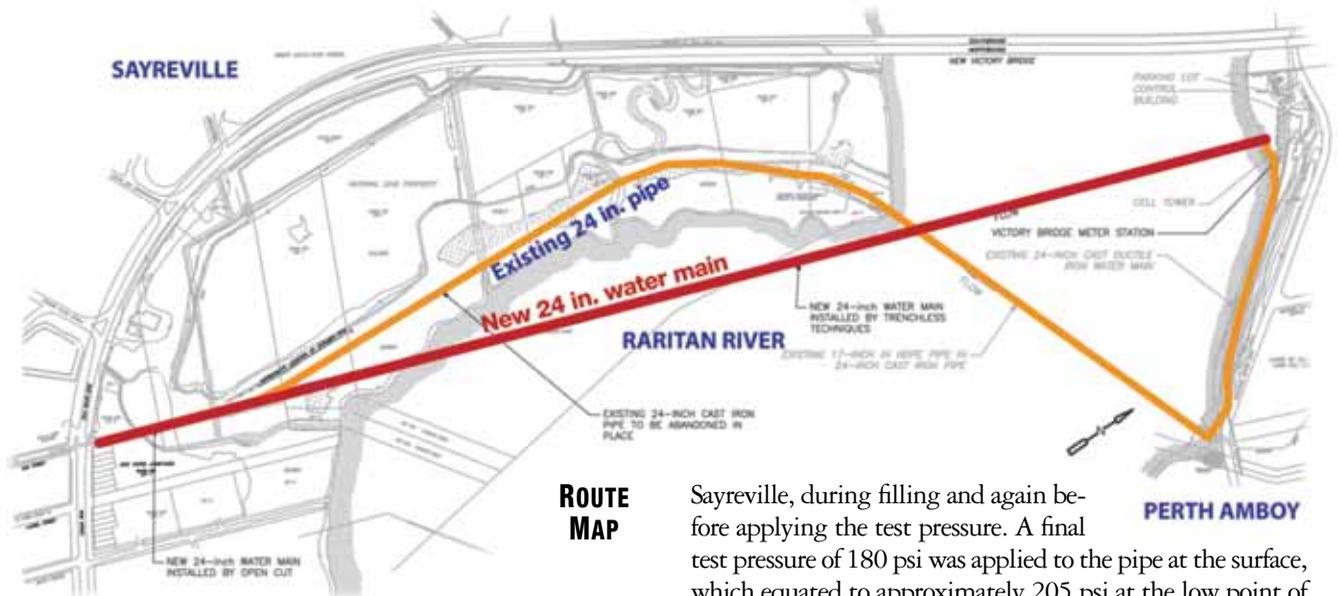
The selected site had been designated a mixed-use area, and construction activities were not allowed to cause any site changes that might undermine this designation. The work to be performed on the property was limited to pipe staging, operations related to pipe fusing, and pipe stringing prior to installation; the contractor was not allowed to perform any excavation or earthwork within the area. The relatively small space available meant that the pipeline installation had to be completed in four pieces using three intermittent fuses. While it would have been ideal to pull the entire pipeline at once, the staging area would have had to be able to accommodate more than 1 mi of pipe. Even though there are risks associated with multiple pullbacks, the urban setting of the project necessitated the intermediate fusing of the FPVC pipeline during pullback.

Mears used two drilling rigs manufactured by American Augers, of West Salem, Ohio, on the river crossing. A 140,000 lb rig was staged in Perth Amboy to drill the pilot hole, and a Drillguide gyro steering tool system—manufactured by SlimDril International, of Houston—was used for the first portion of the full hole. An 880,000 lb rig was staged in Sayreville for reaming and pullback.

Because of the entry hole's proximity to the river edge and the shallow depth of cover, a 42 in. steel casing pipe was installed through the rubble and concrete debris at the entry site in Perth Amboy. Once complete, the casing was cleared and centralizers were installed to initiate the pilot hole drilling. When the pilot hole reached 700 ft, Mears switched from the Drillguide gyro steering tool to an HDD guidance system called ParaTrack-2—produced by Prime Horizontal, Inc., of Dallas, Pennsylvania—combined with a pressure probe.

Switching steering tools enabled the





**ROUTE  
MAP**

team to avoid exceeding the allowable overburden pressures and to monitor the annular pressures to minimize any inadvertent spills (“frac-outs”) into the river of the returning drilling fluid. The allowable overburden strength for the profile along the Raritan River ranged between 45 and 58 psi, and the targeted drilling pressures ranged between 40 and 44 psi. The steering challenges that resulted from the variable geotechnical conditions throughout the installation were managed by Mears’s steering technician, who handled the switch from the Drillguide gyro steering tool to the ParaTrack-2. A surface grid could not be established until the drill was within 1,000 ft of the exit hole on the Sayreville side, but the final exit point of the pilot hole was only 1 ft off-line and 5 ft short of the target location.

The precision of the drilling, the effectiveness of the reaming and swab pass, and the use of a carefully designed and managed buoyancy plan ensured that the pullback forces were kept well below the established maxima during the 23-hour pullback process. To minimize the pulling force for installation of the 24 in. FPVC pipe, it was required that the portion of this pipe that had entered the bore and was below ground level be filled with water during the entire pullback process. This process, known as ballasting, commenced approximately half way during the pullback of the first string of pipe and was performed by using a 6 in. HDPE pipe inserted into the 24 in. FPVC pipe. Approximately 30,000 gal of water was required for each of the four strings of host pipe, and a total of approximately 112,000 gal of water was used during the pullback.

Aboveground, as the pipeline extended from the staging area to the entrance of the HDD bore, it had to be suspended above a major roadway and supported over a steep hillside that had numerous elevation changes. Remsco proficiently handled this with cranes and track hoes.

After the pullback was completed and the drilling equipment was demobilized, the new water main was swabbed with a 24 in. diameter flexible polyurethane foam pig and prepared for hydrostatic testing. After all of the land connections were made, the pipeline was slowly filled with water from the Perth Amboy side of the crossing. Air was expelled by an air vacuum valve located on the south side of the crossing, in

Sayreville, during filling and again before applying the test pressure. A final test pressure of 180 psi was applied to the pipe at the surface, which equated to approximately 205 psi at the low point of the pipeline beneath the river. After the hydrostatic test was deemed successful, the new water main was disinfected, connected at both ends, and placed into service in May 2010.

The teamwork, good communication, and professionalism demonstrated by MWC, CDM, Remsco, Mears, and UGSI throughout the project contributed significantly to its success. With the complexity of the design and the ingenuity demonstrated by all parties involved, this record-breaking installation was a tremendous achievement. The project team was able to execute the project safely and successfully before peak summer water demands set in. On time and within budget, MWC completed this critical water

infrastructure project and was able to maintain reliable service for its customers when they most needed it. **CE**



**Tanzi**

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**Andreasen**

**PROJECT CREDITS Owner:** Middlesex Water Company, Iselin, New Jersey **Design engineer, geotechnical investigation scheme development, laboratory testing of the samples, and construction oversight:** CDM, Edison, New Jersey **General contractor:** Northeast Remsco Construction, Inc., Farmingdale, New Jersey **Horizontal directional drilling subcontractor:** Mears Group, Inc., Rosebush, Michigan **Pipe supplier:** Underground Solutions, Inc., Poway, California **Geotechnical subconsultant and laboratory testing of the samples:** Melick-Tully and Associates, P.C., South Bound Brook, New Jersey **Drilling of borings:** Warren George, Inc., Jersey City, New Jersey **Equipment suppliers:** American Augers, West Salem, Ohio; SlimDril International, Houston; and Prime Horizontal, Inc., Dallas, Pennsylvania

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