Duke Energy Hubline Project

By James W. Rush

Large-diameter crossings. Hard rock. Offshore operations. Bad weather. High-profile location. Individually, each of those elements can make for a challenging horizontal directional drilling project. And when you combine all of the above, you have the 2004 *Trenchless Technology* Project of the Year-New Installation.

For the Duke Energy natural gas hubline project near Boston, Michels Corp., Brownsville, Wis., overcame all these obstacles in a project that advances the state-of-the-art for large diameter crossings.

The project consisted of seven separate bores – all with their own share of challenges – that showcase the ability of directional drilling as an alternative to disruptive open-cut or dredging.

"This project has pushed the envelope ... it's already opened the door for future projects of this nature," said Tim McGuire, project manager for Michels Corp. "We currently have a project under way in which we're using lessons learned from the Hubline project."

The Duke Energy Hubline project consisted of seven separate bores, showcasing the ability of HDD as an alternative to open-cut or dredging.

Background

The Hubline project connects the 650-mile Maritimes & Northeast Pipeline north of Boston to the 1,000-mile Algonquin system to the south. The project, which was put in service in November 2003, consists primarily of about 30 miles of 30-in. diameter gas transmission main. The Hubline starts in Beverly, Mass., and travels under Massachusetts Bay to Weymouth, Mass. The offshore route was selected to minimize challenges associated with finding and constructing a route through some of the oldest established communities in the United States. The majority of the pipeline was constructed using a pipe-laying barge.

Once the offshore route was selected – based on minimal impact to aquatic life in addition to commercial and recreation facilities – seven sections were targeted for directional drilling. The directionally drilled sections included three land-to-land river crossings to reroute the pipeline offshore, two landfalls to connect the offshore pipeline to the mainland and two water-to-water crossings to reduce disruption in existing harbors.

All of the bores entailed drilling through the notoriously rocky conditions of New England. All of the projects entailed installing 30-in. steel pipe in lengths ranging from 1,500 to 4,870 ft.

To complete the project, Michels deployed five rigs in excess of 840,000 lbs thrust capacity, including two 1.2 million-lb rigs, the biggest in its fleet. Michels also mobilized two 240,000-lb rigs to support the larger rigs once operations moved offshore.

Each of the bores began with a 12 ¼-in. pilot bore that was reamed to the required diameter in two to three passes. Because of the nature of the terrain – rock overlain with cobbles and boulders – Michels used an assortment of tooling, frequently having to change tooling to accommodate differing geology in mid-bore.

River Crossings

River crossings are nothing new to experienced contractors like Michels, but the winter temperatures and the tough ground conditions made these crossings especially challenging. The crossings included a 1,500-ft bore under the Merrimack River; a 2,000-ft bore under the Emerson Brook Reservoir and a 3,600-ft bore under the Waters River.

The Emerson Brook Reservoir Crossing traversed mixed rock conditions and was perhaps the most environmentally sensitive of the bores as it crossed under a major fresh water source for the communities of Middleton and Danvers. As a result, officials mandated that frac-outs would not be permissible.

The 3,600-ft Waters River Crossing was the longest of the on-shore bores and was constrained by tight working conditions and soil potentially contaminated by petroleum hydrocarbons. Ground conditions in this area included fractured rock, dense glacial till, cobbles and boulders. Social considerations included working in proximity to an exclusive golf club on the exit side.

Landfalls

The landfalls were among the most challenging directional drilling projects ever undertaken in the HDD industry. The Salem Landing, which connected the pipeline to the offshore loop at the northern end of the project, included some of the hardest rock in the area. Tests showed the granite rock to have an unconfined compressive strength in excess of 50,000 psi.

This leg of the project involved drilling more than 4,800 ft from land to a point in the Danvers River outlet. The alignment crossed under a commuter rail bridge and the Route 1A bridge (as well as the jobsite trailer) and then out into the Beverley Harbor. In addition to the strength of the rock, crews faced fractured rock and magnetic interference that hampered guidance from the wireline system.

To support marine operations, four 200-class jackup vessels were mobilized from the Gulf of Mexico. The drill rigs were mounted on platforms and support equipment, including spud barges, shale barges and water barges, were tethered to the platform. Tugboats and crew boats were also needed to ferry in equipment and personnel.

"The Salem Landing portion of this project was one of the longest installations in hard rock to date," said Scott Thornburg, design engineer with J.D. Hair & Associates. "This section alone was a substantial accomplishment."

Boring of the pilot hole included 20- to 48-in. casing from above the high-water mark to the rock-soil interface. Goalpost structures, H-shaped supports upon which the steel casing was placed, were utilized to support the casing until the pilot hole was drilled and the product pipe pulled into place.

Working in a navigable channel further complicated the logistics of the projects as the Coast Guard, Harbormasters and other local authorities had to be kept apprised of the operations.

The Weymouth Landfall, the southern terminus of the loop, was a 3,000-ft bore similar to the Salem project. The alignment at Weymouth ran adjacent to and underneath a major shipping channel that serves commuter ferries, oil tankers, cargo ships and U.S. Navy vessels.

Water-to-Water Crossings

In addition to the landfalls, which required drilling from land to a point on water, the water-to-water crossings required drilling from a platform on water to another platform on water that would tie in to the pipeline installed by the pipeline-laying vessel. These were the first water-to-water pipeline projects performed under this unique combination of geological and marine conditions in the United States — and possibly anywhere.

The first project tied in to the Salem Landfall and took place in Beverley Harbor in an area of commercial and recreational boating. Drilling once again utilized jackup vessels for support operations at the entry and exit points. Pilot hole operations began in the middle of winter to avoid disruption of boating traffic during the busy spring and summer seasons. Wind chill conditions reached as low as minus 40 F.

Once the pilot hole was complete and the hole reamed, two jackup vessels were tethered together to provide additional support for pullback of the pipeline. Before pullback, crews floated the pipeline to the surface using a series of buoys to assure appropriate angle of entry and avoid damage to outer coating.

The final segment involved a similar water-to-water bore near George's Island, near the entrance of Boston Harbor. This 4,200-ft bore was needed to deepen the alignment to allow for future dredging of the channel. Crews worked in 40-ft deep water and drilled to depths as low as 120 ft below the seafloor.

On the George's Island bore, crews were unable to complete the pilot hole due to the difficult nature of the rock. Crews had difficulty keeping the hole open and maintaining circulation because of the high degree of fractures in the rock. In addition, seawater infiltrating the hole further complicated the drilling. As a result, crews set up a rig on the exit side and drilled an intercept to complete the pilot hole. Location was critical in successfully drilling intercept.

Tides were also a major factor on the marine works. The tidal cycle affected fluid circulation due to changes in head pressure, and the changing tides tended to destabilize the holes due to surcharging. In addition, the 3 to 4 knot currents caused by the tidal fluctuations required careful planning and execution of the marine support teams.

"These crossings were all state of the art," said John Hair of J.D. Hair & Associates. "There have been bores done from jackups, bores done in rock and large-diameter bores, but never before has anyone tried to tackle all of these challenges at the same time. It was quite an achievement from a technical standpoint."

"The HubLine Pipeline project was the first high-pressure pipeline to be built off of the New England coast," said Dave Neal with Duke Energy "There were a number of issues to deal with including public and government relations, community concerns, as well as permitting and construction issues. HDD eliminated near shore impacts which were viewed favorably by federal, state and local environmental permitting authorities. The bores were extremely time-consuming and more costly than the open-trench excavation method, however, this represented HubLine's commitment to minimizing the impact to the environment."