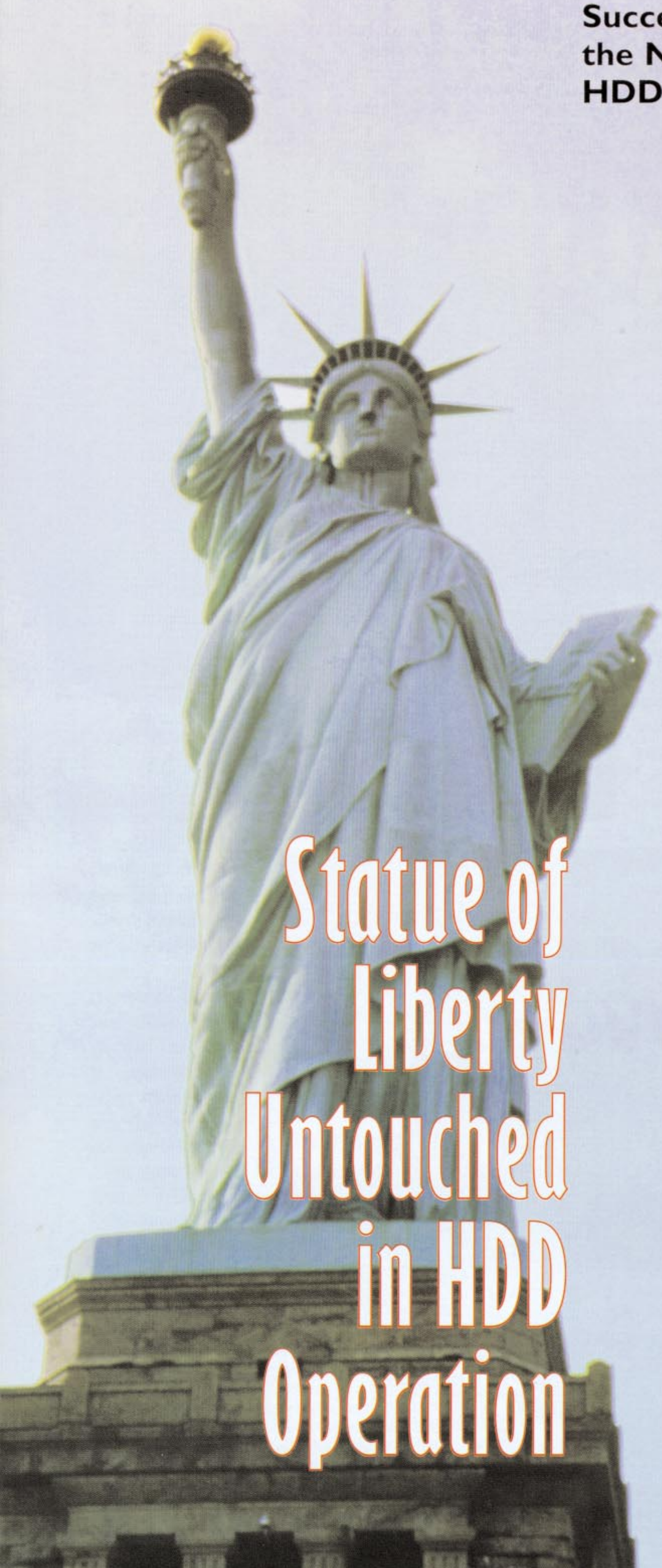


Statue of Liberty Untouched in HDD Operation

Success of this project could lead the National Park Service to employ HDD in future projects

by Richard Yach

The Statue of Liberty had sprung a leak.

Underground lines piping fuel oil from holding tanks to the boiler in the base of the famous American national historic monument were deteriorating. Since 18,000 tourists take the ferry over to Liberty Island each day — 364 days a year in all sorts of New York harbor weather — heating of the visitor center and the statue could not be jeopardized.

It was a project where horizontal directional drilling made a big difference, not only in minimizing disruption to the on-going, high volume tourist traffic, but also in minimizing excavations to the landscape surrounding the world's best known monument to political freedom.

To assure this, the National Park Service had an archeologist and a horticulturist on-site during the drilling to advise the crew at each step of the way. Planning for the fuel line replacement started two months before the actual operation. Prestige Environmental was awarded the contract to replace fuel lines and add additional monitoring wells so that any future problems could be quickly detected. These new lines were to be placed in conduits that had to be buried underground so that the old fuel lines could be abandoned.

New York Trenchless, Inc., headquartered in Port Washington, N.Y., on Long Island, won the bid to bury the conduits on Liberty Island. Once Peter Kenny, owner of New York Trenchless, visited the site, he suggested using horizontal directional drilling in order to minimize "the footprint" of the installation over auger boring, which had been the original method in the specifications.

With horizontal directional drilling now confirmed up as the installation method, the project was split up into three separate bores. The first, three 6-in. (150-mm) conduits would be pulled in 150 ft (45 m). Inside one of the conduits would be four, 2-in. (50-mm) conduits. The second bore would be 190 ft (58 m) and would pull in two, 6-in. (150-mm) conduits. Inside one of these would be three, 2-in. (50-mm) ducts. The third bore would turn out to be 240 ft (73 m) pulling in the same duct configuration as the second bore.

A Little Background on the Statue

The reason for the separate conduits was for the fuel lines and electric lines for the monitoring systems. Despite the shortness of the three bores, it took the crews 10 days to complete the bore and pullbacks of the conduits. This was due to the tough drilling conditions and the care and concern everyone had for the existing above ground and below-ground structures.

The reasons for the tough subterranean drilling conditions are as old as Liberty Island itself. Even before the Statue of Liberty was erected on this site in 1886, Bedloe's Island, as it was called back then, had once been the site of an old fort. This may have explained the existence of a buried 18-in. (450-mm) solid granite wall that one of the bores ran into.

In the early 1980s, prior to the grand lady's 100th birthday, the National Park Service redesigned and rebuilt the landscape and all the brick walkways, breaking up and covering over the old ones and elevating the ground on which were erected the walkways that exist today. This raised the ground level in some places 3 ft (0.9 m) higher than what it once was. That made locating existing water, sewer and fuel oil lines more difficult. Add to this the broken concrete, brick and cinder that was used as fill when the centennial landscaping was done and you have some idea of the difficulties that the driller had to deal with.

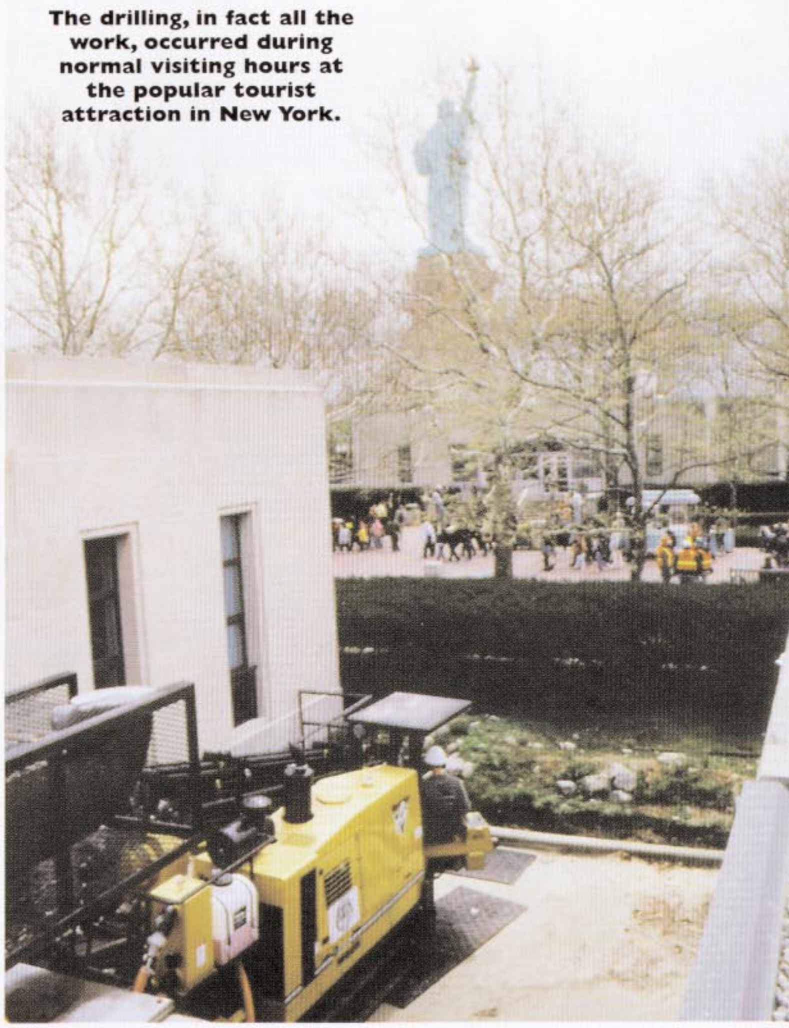
All of the equipment for the installation of the new conduits had to be taken onto the island by barge. It wasn't a typical suburban fiber-optic installation where you could run to the hardware store for something.

All pipe and equipment were loaded onto a huge 10,000-sq ft (900-sq m) barge and pushed out to the island by a tugboat. Once on the island, all the equipment stayed until the end of the job with the crew leaving in the evenings, sometimes late. Because of the tourist boats using the docks during the day, the only time the equipment barge could go to the island and be off-loaded was after visiting hours.

On the equipment barge was a Vermeer D50x100 Navigator horizontal directional drill and its DT750 drilling fluid tank trailer, a front end loader with a backhoe attachment, a dump truck filled with pea gravel, a Vermeer TriHawk drill head, DCI Mark IV locating equipment, two fluted backreamers, a service truck, a vacuum unit, a skid steer unit, and a pallet of 450 ft (136 m) of schedule 40 special Carlon® Bore-Gard® PVC conduit.

"We knew beforehand that we would need a special type of conduit over and above what fused HDPE could offer," said Kenny. "These twenty-foot (six-meter) sections of restrained joint PVC that we used have locking rings or splines that fit into a mating groove on a pipe. We could put together two to three sections at a time at the most because of the limited space we had to work in.

"We knew beforehand that we would never have one hundred to one hundred and fifty (thirty to forty-five meters) of room to stretch out a fused string of HDPE pipe. In fact, this was a good horizontal directional



The drilling, in fact all the work, occurred during normal visiting hours at the popular tourist attraction in New York.

All of the equipment, including the Carlon Bore-Gard PVC conduit shown here, was loaded and unloaded at the job site from a barge.

Digital Control Inc. workers survey the area behind the Statue of Liberty. DCI provided the locating system for the logistically complex job.

drilling application for the Bore-Gard conduits since they were designed to handle the radius bending that we put them through."

Each of the three bores was a test of the equipment and the crew. The first bore called for the drilling machine to be tucked behind some 8-ft (2.5-m) hedges and bore 150 ft (45 m) from west to east under a bricked walkway to the corner of a gift shop. The crew attached the drill head so it could get through any below-ground obstacles.

"We weren't sure about what was underground," stated Kenny. "But our bore path was at a six-foot (two-meter) depth and when we ran into the buried granite wall and chunk rock fill on this first bore, we were glad we had brought in the TriHawk head."

The first bore took three hours. When they first hit this wall and tripped back out, they brought pieces of flint rock, quartz and granite, which gave them some clue as to what they were dealing with.

During the pilot bore through this tough spot, they used a Vermeer Navtec system that the D50x100 horizontal directional drilling machine had. When making steering corrections in rock, this computer assisted steering automatically takes over and cuts a ramp or zone for the drill rods to follow.

Subsequently, the crew pre-reamed the bore with a 10-in. (250-mm) fluted backreamer, then pre-reamed again with a 16-in. (400-mm) backreamer before pulling in the bundle of three six-in. (150-mm) conduits.

All throughout the drilling of the pilot bore and the pullback operations, the vacuum truck kept removing drilling fluid, making it a very clean and environmentally friendly operation.

The Second Bore

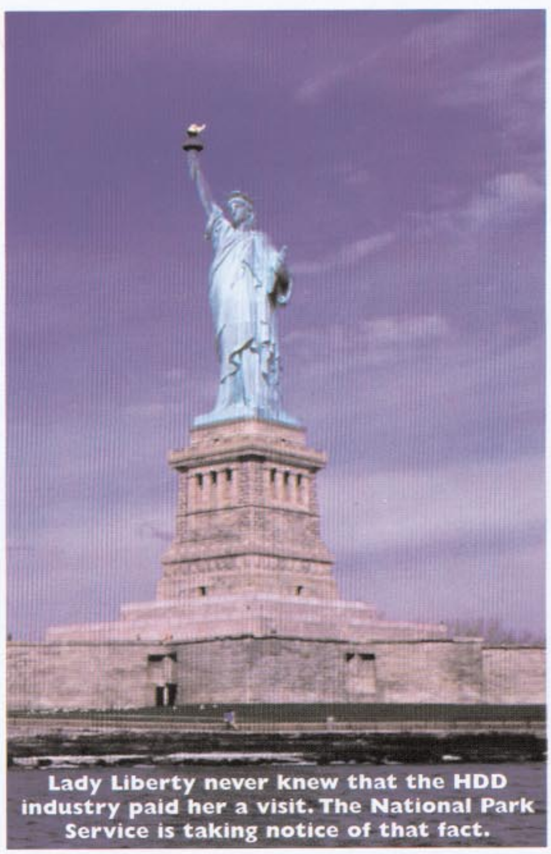
The plan called for the new fuel lines and monitoring lines to go into the basement of the gift store and be joined by the Prestige Environmental company to the start of the second 190-ft (58-m) bore, which was perpendicular to the first. This indirect route was largely influenced by the archeologist and his concerns about what lay beneath the earth and the existence of some old buried fuel tanks. This bore path was 13 ft (4 m) deep at times to avoid possible artifacts.

The path for the second bore was also dictated by the horticulturist who wanted the bore path to be at least 5 ft (1.5 m) to the right of the drip line of a row of oak trees. The locator also had to keep the path 3 ft (1 m) to the left of the existing sewer, water and fuel lines, which had been buried 3 ft (1 m) deep in a shared trench. This left a narrow easement for the new fuel line.

The bore and pullback went relatively smooth given the fill conditions that the backreamers had to pull through. The third bore of 240 ft (73 m) connected the previous exit point to a concrete bunker near the base of the statue. This bore path had to go below a recessed walkway that was at least a 3-ft (1-m) drop from ground level.

Ten days after they started, the conduits were all in the ground and ready for the installation crew to start putting in the carrier lines and the monitoring systems.

"The Vermeer dealership along with Chris McKay from Vermeer Manufacturing helped a great deal with the planning, equipment availability and directional drilling expertise," commented Kenny. "This project was so successful, it opened up the eyes of the National Park Service to the benefits of horizontal directional drilling. It's a method that gets the job done while the tourists can still visit and enjoy the public site." ◆

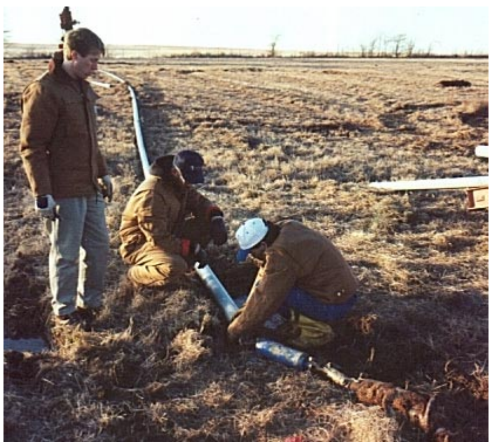

Lady Liberty never knew that the HDD industry paid her a visit. The National Park Service is taking notice of that fact.

Bore-Gard® Installation - 1,000 ft.

Perry, Oklahoma

Distance of Installation:	1,000 feet
Maximum Pulling Force on Pipe:	Approx. 7,500 pounds
Reamer Diameter:	8 inch "Beaver Tail"
Soil Conditions:	Wet Clay

To test the upper limit of Bore-Gard, a 1,000 foot run was installed at the Ditch Witch® test facility. Both 10 and 20 ft. lengths were randomly assembled together. The challenging installation was successfully completed in only a few hours. Even this long installation did not exceed Bore-Gard's maximum load rating of 8,700 pounds.



Above Left: *Bore-Gard PVC pipe is being attached to the Condux® pulling eye and Ditch Witch® 8 inch "Beaver Tail" reamer.* ***Above Right:*** *Bore-Gard pipe before the 1,000 ft. installation.*

At Left: *In the foreground is the reamer attached to the drill string. Barely visible from 1,000 feet on the horizon is the drilling machine.* ***Above Right:*** *A close-up look at the powerful Ditch Witch® JT2720 that quickly and easily pulled in the 1,000 ft. string of Bore-Gard.*

Bore-Gard® Installation - 220 ft.
Long Island, NY

Pipe Pull Force Data
Maximum 1,560 lbs.

Note: Pull force data generated from self-contained on-board strain gauge and data gathering computer mounted between pipe lead end and reamer. Data samples taken at a rate of 10 per second. See picture below.

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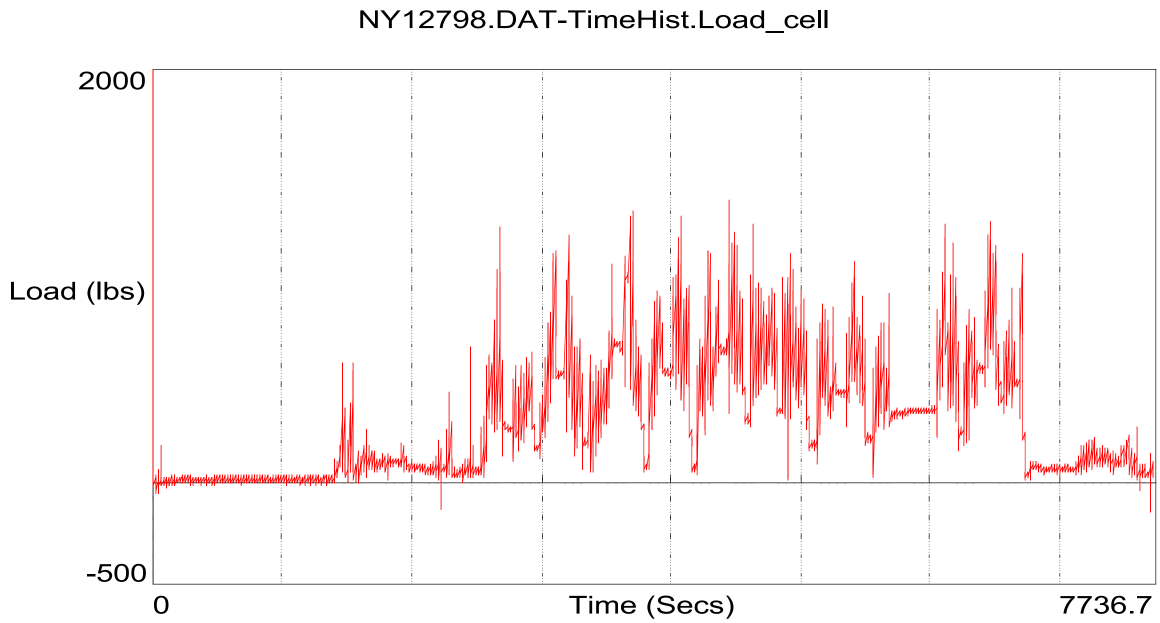
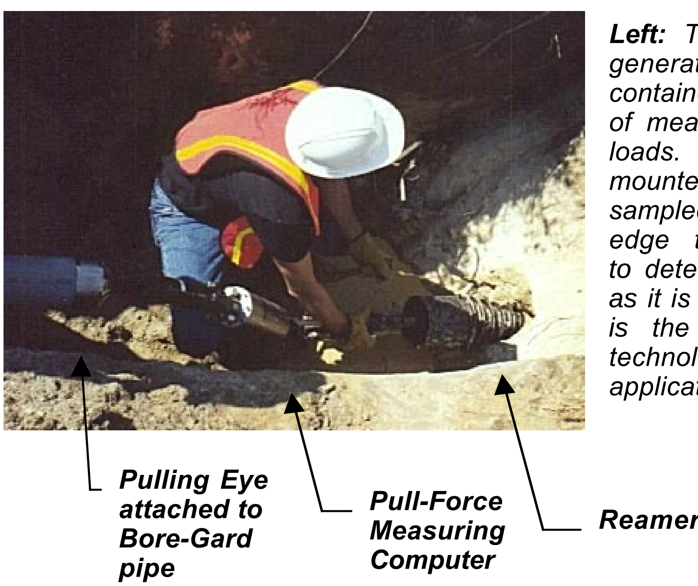




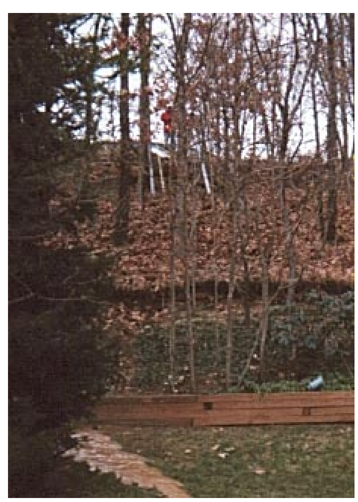
Left: *The data in the graph above was generated by our state-of-the-art, self-contained force measuring computer capable of measuring both tensile and compressive loads. It is protected by a steel cylinder and mounted on swivels at both ends. Data was sampled 10 times per second. This leading-edge technology has enabled engineers to determine the actual loading on the pipe as it is being pulled through the ground. This is the first known application of such high technology to the development and application of pipe for boring applications.*

Bore-Gard® Installation - 220 ft.
Long Island, NY

Distance of Installation:	220 feet
Maximum Pulling Force on Pipe:	1,560 pounds
Reamer Diameter:	6 inch
Soil Conditions:	Clay and Rock

This was a challenging bore because of the significant elevation change. From the road level the pipe had to transition up a 50 ft. high hill at 45 degrees. The bore first went beneath the street, then beside and behind the residence. The varied elevations proved how convenient the short lengths of Bore-Gard are to transport and assemble. The 1,560 lbs maximum load on the pipe was measured by our leading edge on-board computer. This used using only 18% of Bore-Gard's capacity.

Above Left: *Bore-Gard PVC pipe being installed down a 45 degree slope behind a residence. The elevation change was 50 feet from the residence yard below.* ***Above Right:*** *View from the drill rig. The bore path went under the street, beside the residence and up the hill behind the home - a total of 220 ft.*



Far Left: *Bore-Gard 20 ft. pipes being installed down a steep slope. HDPE on a reel was not an option due to the steep terrain. Convenient Bore-Gard pipes can be held in any position required.* ***Left:*** *A view from the residence yard looking up the hill where the pipe was being installed. There was no disruption to the landscape of the residence.*

Bore-Gard® Installation - 200 ft.

Indianapolis State Museum Expansion

Distance of Installation:	200 feet
Maximum Pulling Force on Pipe:	Approx. 22,000 pounds
Reamer Diameter:	36” Backreamer
Soil Conditions:	Wet Clay

This was a $65 million project, which entailed constructing a new state-of–the-art administration building for Indianapolis’ State Museum. Miles of conduit and cables where needed to connect the two facilities, and because the two buildings were separated by a 200 ft. canal and roadway, the networking connection posed several challenges to the construction crew. However, despite the severe angle of the bore and the extreme stress placed on the conduit, 30 sticks of Schedule 40 Bore-Gard, each 200 ft. long, was successfully pulled through the bore at one time.

Above Left: A 200 ft. bore under a canal and roadway was needed to connect the Indiana State Museum with the new Administration Building. **Above Right:** Prime Conduit Bore-Gard has a 65 degree bend radius making it flexible enough to be pulled around a building.

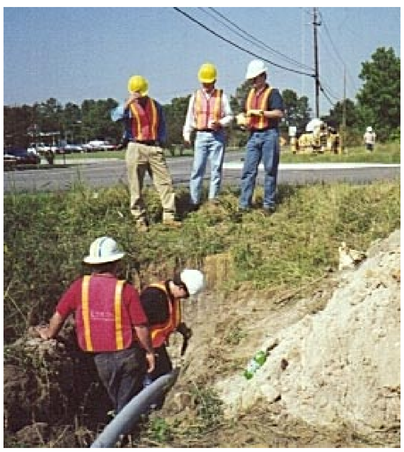
Above Left: A 36” backreamer was used to pull the 30 sticks of Bore-Gard through the bore.

Above Right: Twenty-Six 4” Bore-Gard conduits and four 4” Boreable Multi-Gard ducts, each 200 ft. long, are being pulled through a 200 ft. long bore.

Bore-Gard® Installation - 100 ft.
Florence, SC

Distance of Installation:	100 feet
Maximum Pulling Force on Pipe:	Estimated 800 pounds
Reamer Diameter:	6 inch
Soil Conditions:	Sandy

This was a short bore in sandy soil conditions. Done beneath an active 3-lane street, it proved how convenient the short lengths of Bore-Gard are to transport and assemble. Twenty foot lengths were installed for this major telephone company. The top executive and many other managers were on hand to see first hand how cost effective and tough Bore-Gard really is.



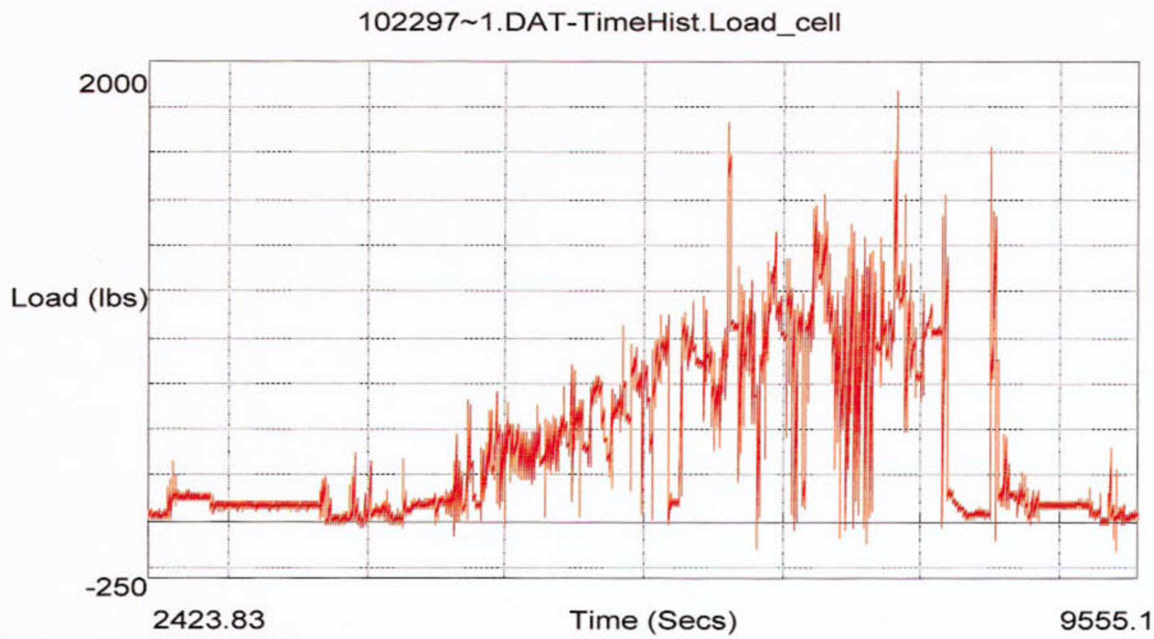
Above Left: *Bore-Gard PVC pipe at a depth of 6 feet is being pulled beneath the active roadway. The tight transition and resultant bend radius was no problem for the strong joint design.* ***Above Right:*** *The entire Telco company crew was impressed with the simplicity, fast assembly, and strength of Bore-Gard. The entire 100 feet of pipe was laid out in a few minutes for before the installation.*

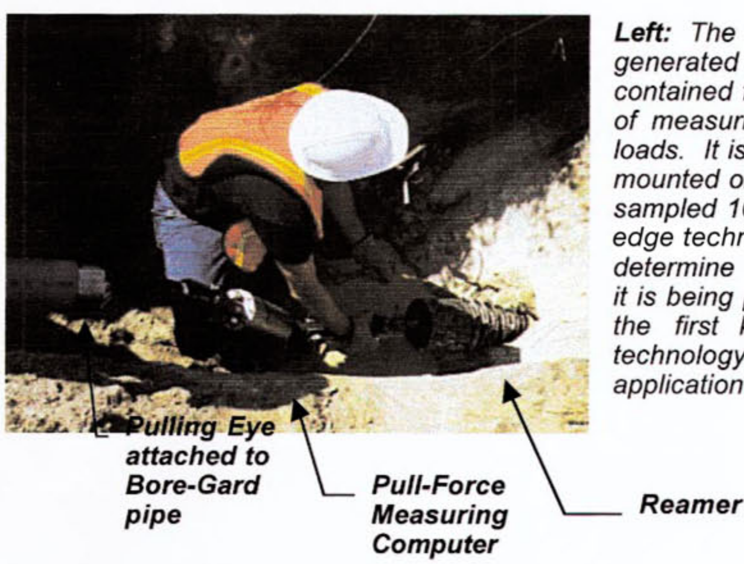
Above Left: *In the foreground is the drill entrance location of the straight bore under the street for a total of 100 feet.* ***Above Right:*** *A close-up look at the pulling eye (left), swivels, on-board computer and 6 inch reamer (right) attached to the lead end of the Bore-Gard pipe (left) as it enters the ground.*

Bore-Gard® Installation - 180 ft.
Columbia, SC

Pipe Pull Force Data
Maximum 1,870 lbs.

Note: Pull force data generated from self-contained on-board strain gauge and data gathering computer mounted between pipe lead end and reamer. Data samples taken at a rate of 10 per second. See picture below.





Left: *The data in the graph above was generated by our state-of-the-art, self-contained force measuring computer capable of measuring both tensile and compressive loads. It is protected by a steel cylinder and mounted on swivels at both ends. Data was sampled 10 times per second. This leading-edge technology has enabled engineers to determine the actual loading on the pipe as it is being pulled through the ground. This is the first known application of such high technology to the development and application of pipe for boring applications.*

Bore-Gard® Installation - 180 ft.
Columbia, SC

Distance of Installation:	180 feet
Maximum Pulling Force on Pipe:	1,870 pounds
Reamer Diameter:	6 inch
Soil Conditions:	Rock, Roots, Sand, Clay

This bore required drilling 16 feet deep under a creek, which proved Bore-Gard is able to withstand challenging boring conditions. Roots, rock, and clay were encountered by the crew of a major Telco (see photos below). As is the case with many bores, a small pit was created for the product entry requiring the Bore-Gard pipe to bend at a tight radius. The strong joint has been designed and tested to handle the toughest conditions in trenchless construction. This installation was proof of its performance.

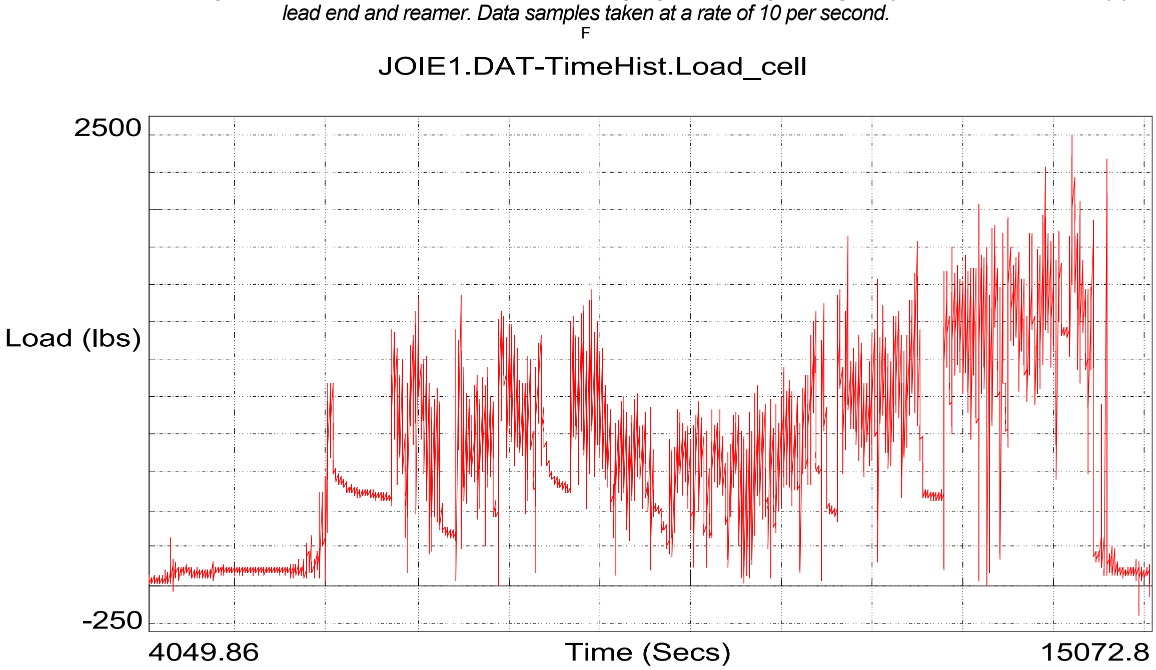
Far Left: *At the entrance pit, Bore-Gard PVC pipe is being pulled into the 6 inch reamed hole through challenging tree roots, rock, clay and sandy soil.* ***Left:*** *Facing the entrance pit overlooking a creek 6 ft. below road level. Maximum depth of 16 ft. was reached below the creek bed. Space restrictions required the pipe to be added every 20 feet of the bore. The simple joint design enabled quick assembly to easily keep pace with pulling of the reamer.*

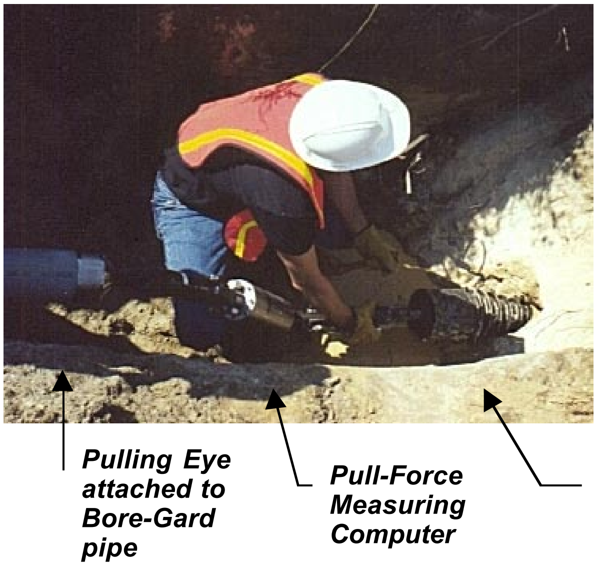
Left: *Facing the drilling rig (top left) overlooking the creek. Directional drilling and Bore-Gard pipe was the least cost option for this varied-terrain 180 ft. bore. Trenching was not an option.* ***Above Right:*** *A look at the 180 ft. span of the bore from far left to far right (drill rig) of the picture.*

Bore-Gard® Installation - 2x 220 ft.
Cleveland, OH

Pipe Pull Force Data
Maximum 2,395 lbs.

Note: Pull force data generated from self-contained on-board strain gauge and data gathering computer mounted between pipe lead end and reamer. Data samples taken at a rate of 10 per second.





Left: *The data in the graph above was generated by our state-of-the-art, self-contained force-measuring computer, which is capable of measuring both tensile and compressive loads. It is protected by a steel cylinder and mounted on swivels at both ends. Data was sampled 10 times per second. This leading-edge technology has enabled engineers to determine the actual loading on the pipe as it is being pulled through the ground. This is the first known application of such high technology to the development and application of pipe for boring applications.*

Bore-Gard® Installation - 2x 220 ft.
Cleveland, Ohio

Distance of Installation:	Two 220 ft. runs (440 ft. total)
Maximum Pulling Force on Pipe:	2,395 pounds
Reamer Diameter:	8 inch
Soil Conditions:	Clay, Gravel, and Rock Fill

As seen in the pictures below, the steep terrain of this installation would have made it nearly impossible for a reel of HDPE to be installed. However, the convenient 20 ft. lengths of Bore-Gard PVC pipe were able to be carried to the bottom of the hill before installation. With a maximum pull rating of 8,700 pounds, the pipe easily withstood a maximum pulling force of 2,395 pounds, using only 27% of its maximum rated load.

Above: *Bore-Gard PVC pipe is being installed on a 45 degree slope near the intersection of Ohio Interstate 271 and Route 480 near Cleveland. Two 220 ft. installations were made about 20 feet apart under the active highway. In spite of the challenging terrain, the pipes were easily assembled and locked together before being installed.*

Above Left: *The 8 inch diameter reamer is seen here along with the strain gauge and on-board computer used to measure the pull force on the pipe. An expandable pulling eye was used to grip the leading end of the pipe.* ***Above Right:*** *The directional boring machine and a 1,200 gallon water tank.*

Corbitt & Sons Construction took on a seemingly impossible project and successfully placed thirty 4-in. (100-mm) PVC conduits in a single directional bore. But that wasn't the original plan.

Conduit Holds Key to Project Success

By Bob Greene

The White River Park, located in central Indianapolis, Ind., is surrounded by attractions that pull visitors in from all over the world.

Within easy walking distance are the city's convention complex, a huge sports dome, a zoo and historical attractions such as the old canal that runs through the park. The state recently decided to build a new facility for the Indiana State Museum in the park. According to Jeff Myers, museum assistant director, the $65 million project more than triples the amount of the museum's current space. The museum will occupy two buildings separated by the canal and the old national road beside it.

To connect the two buildings, museum officials decided to have a contractor either auger or directionally bore under the canal and the road. The contractor would then pull in a 36-in. (900-mm) steel casing to accommodate thirty 4-in. (100-mm) PVC conduits. Only one contractor would respond. After taking a closer look at the project, Corbitt & Sons Construction informed F.A. Wilhelm, the general contractor, that it couldn't be done the way they wanted.

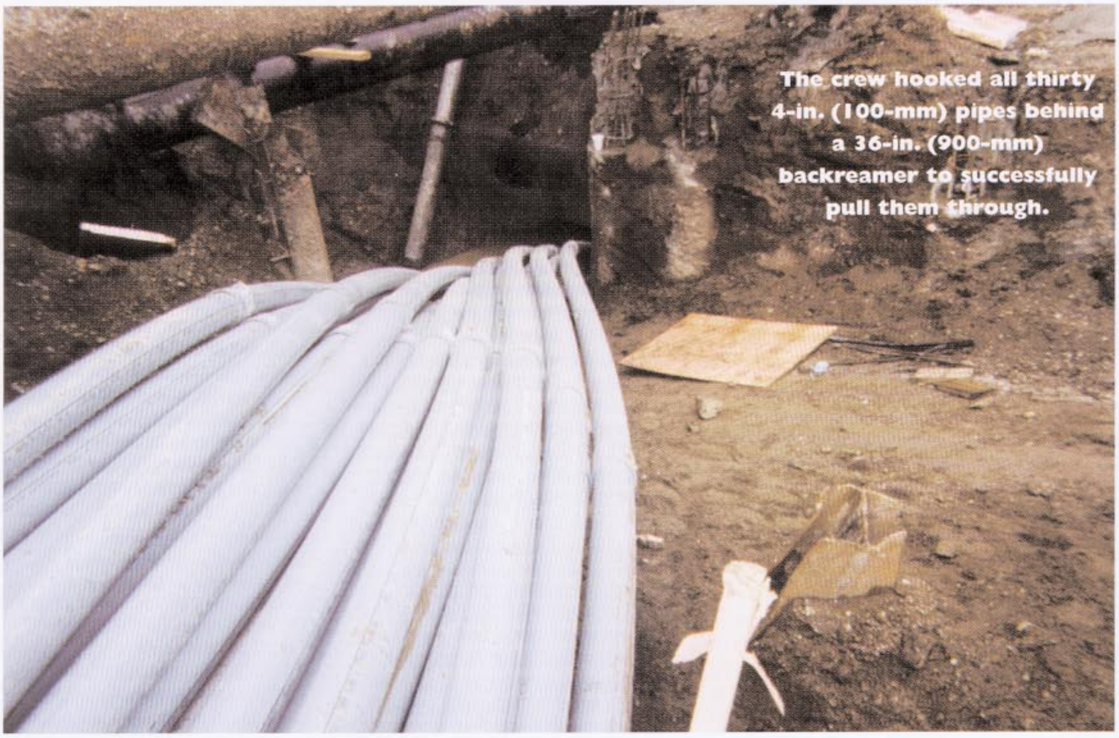
The original plan was to excavate to a depth beneath the canal to set up the boring rig. They would also excavate down to the basement level on the other side of the road. The problem was that even at that depth there were other utilities running under the canal and road that would have to be avoided. They would have to dip down and then come back up at too severe of an angle.

It was questionable whether even the drilling rods would take the stress of such an angle, let alone pull a 36-in. (900-mm) casing into it. The casing was out of the question.

As another option to get 30 pipes

under that canal, William Sears, Corbitt's project coordinator, proposed that they would do three directional drills, hooking onto 10 conduits after each drill and pulling them in behind a backreamer.

That compromise was accepted, but the pipe they used had to be approved by the state and also had to be Underwriters Laboratories (UL) listed. This eliminated the HDPE pipe Corbitt typically used. The rigid plastic electrical conduit would not hold up to the stresses sure to be experienced in such an extreme pull. It looked like another dead-end.


The crew hooked all thirty 4-in. (100-mm) pipes behind a 36-in. (900-mm) backreamer to successfully pull them through.

A Solution

Carlon, a plastics extruder based out of Cleveland, Ohio, had recently developed a UL-listed Schedule 40 plastic pipe that was designed for boring applications. Wilhelm suggested that Corbitt use the Carlon® Bore-Gard®.

Jason Smith, Corbitt's HDPE fusion technician, was skeptical. He thought there was no way the PVC would make it through that bore. Even if it did not crack to pieces under the stress, it wouldn't hold together. It came in 10- to 20-ft (3- to 6-m) sticks and was joined together with a thin nylon strap — no fusion, no glue, no screws. Corbitt refused to accept liability if the pipe failed. Wilhelm agreed to it.

Using a Vermeer D80 rig, 15-ft (4.5-m) rods, and a 6-in. (150-mm) pilot bit, the first shot at the 180-ft (55-m) bore was attempted. They lost the signal, so they had to pull it back. A combination of depth and interference from the other utilities really made it tough.

On two other attempts, they broke drill rods and lost expensive heads.

Many contractors would have given up before then, but Steve Corbitt, owner of Corbitt & Sons Construction, was quite tenacious. His crew even attempted several bores at night to see if there would be less signal interference.

By their sixth attempt, they had lost more than $15,000 in equipment. Everybody unhappily agreed this would have to be their last shot . . . it was successful! Due to the difficulties and cost, it would be unfeasible to attempt two more bores.

Going For Broke

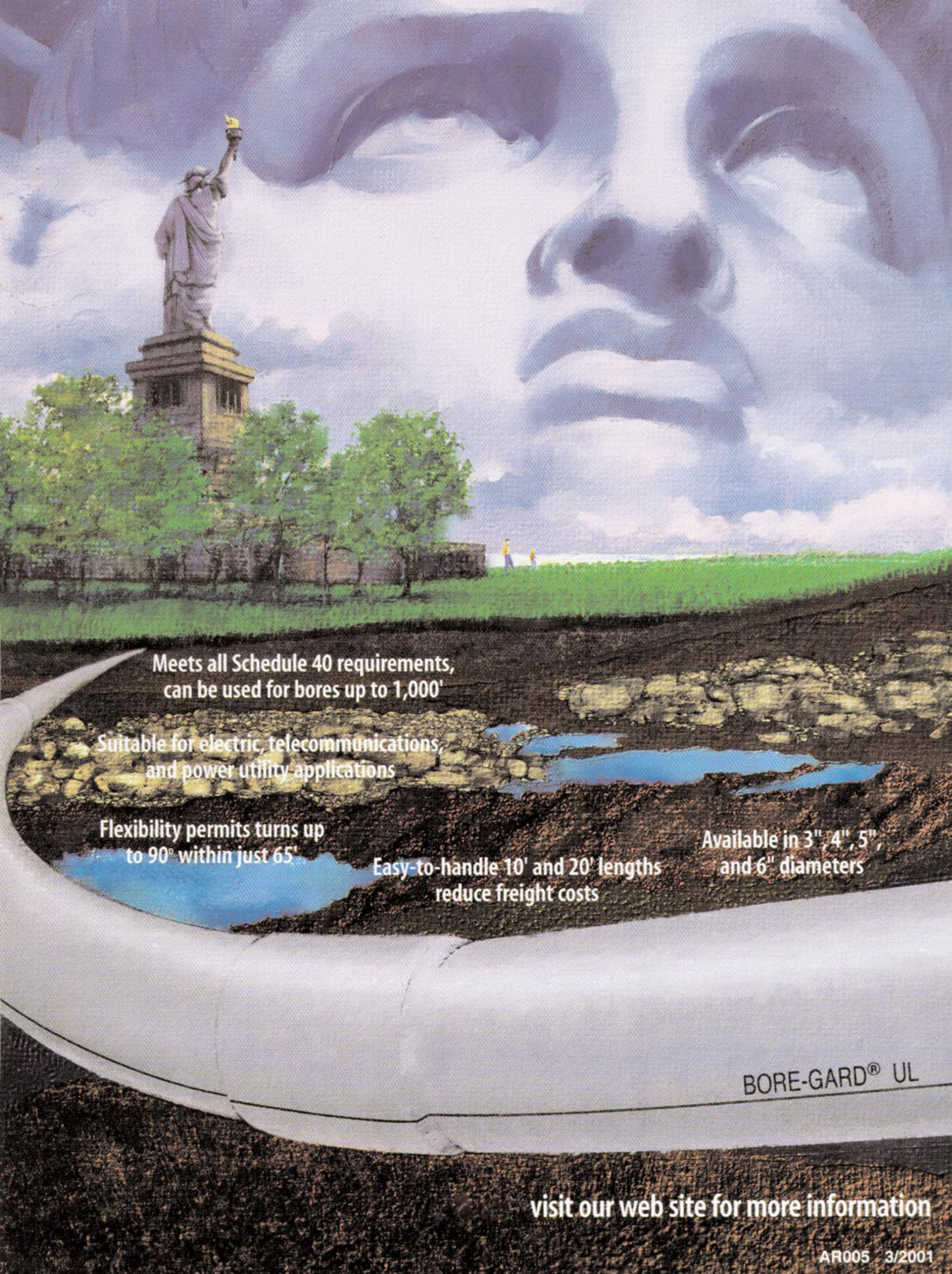
The decision was made. They would back ream with 16-, 26- and 30-in. (400-, 650 and 750-mm) reamers and then hook onto all 30 pipes behind a 36-in. (900-mm) backreamer. It was quite a risk, but any other options would have cost much more than the plastic pipe they might lose in this attempt.

Not only would there be unbelievable forces at work on the pipes, but most of the worst forces would be on the conduits on the outside of the bundle. For the next few hours, everybody was anxious. Smith said the cakewall started breaking down part way through and the pull was hitting about 22,000 lbs (98 kN). He cringed to think about what was happening to the pipe.

When the backreamer came through, Smith expected to see a bunch of busted up plastic following it. Amazingly, every duct was intact. When tested, every piece of the Bore-Gard pipe proved that it had made it through the tortuous trial unscathed and ready for many years of service to the museum. They were able to use standard PVC couplings, bends and adapters to finish out the job.

***Bob Green** is a freelance writer, based in South Bloomingville, Ohio.*


We Know
How To Treat A Lady.
Bore-Gard® trenchless raceway — why was it the hands-down choice when Liberty Island needed new conduit? Because it's the fastest, easiest, least disruptive, lowest cost solution there is. Plus Bore-Gard is the only conduit UL Listed for directional drilling, and it's suitable for electric, telecommunications, and power utility applications. All good reasons why it's the right choice for you.
Positive stop automatically aligns strap grooves
Matching grooves and plastic locking strap allow fast, cement-free assembly
Triple-lobed gasket forms a water-tight seal
Heavy walls and deep insertion make joints immune to effects of normal bending
AND CSA LISTED. PATENT PENDING


Meets all Schedule 40 requirements,
can be used for bores up to 1,000'
Suitable for electric, telecommunications,
and power utility applications
Flexibility permits turns up
to 90° within just 65'
Easy-to-handle 10' and 20' lengths
reduce freight costs
Available in 3", 4", 5",
and 6" diameters
BORE-GARD® UL
visit our web site for more information
AR005 3/2001

Bore-Gard® Installation – 150 ft.,190 ft. & 240 ft.
Liberty Island, New York

Distance of Installation:	150 feet,190 feet and 240 feet
Maximum Pulling Force on Pipe:	Approx. 1000 pounds
Reamer Diameter:	16” Backreamer
Soil Conditions:	Granite wall, rock fill, dirt and water

The Liberty Island was needed to provide future utility and cable needs. Horizontal Directional Drilling was the preferred method of installation because it minimized any disruption to the islands pristine environment and tourist activities and Bore-Gard’s convenient 10 and 20 foot lengths were ideal for limited space. Three bores were needed on the island, the first was 150 ft. under a bricked walkway to the corner of the gift shop, the second was 190 ft near a row of oak trees, and the third was 240 ft. under a recessed walkway near the base of the statue.

Left: Limited spaces and minimizing disruption to the pristine environment and daily tourist activities made Horizontal Directional Drilling and Bore-Gard the ideal solution.

Above: Bore-Gard was transported to the island, after visiting hours, on a 10,000 s. ft barge pushed by a tugboat.

Left: Using a 16” backreamer, two 6 inch Bore-Gard ducts are being pulled into the 190 ft. bore