North American Society for Trenchless Technology (NASTT)
NO-DIG 2005

Orlando, Florida
April 24-27, 2005

TRENCHLESS REHABILITATION OF THE INDIAN ROCKS BEACH FORCE MAIN REPLACEMENT

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ABSTRACT : The Indian Rocks Beach (Florida) force main, a 12-inch-diameter cast iron pipe that carries wastewater from the Cities of Indian Rocks Beach and Belleair Beach eastward to Pinellas County's McKay Creek booster pumping station facility, was constructed in 1964. The force main runs for approximately one-half mile from the Indian Rocks Pumping Station, passes under the Intracoastal Waterway, and continues to the booster pumping station facility via easements through a condominium complex.

Over the last ten years, the force main, which is owned by Pinellas County, has experienced numerous breaks. One break occurred near-shore within the Intracoastal Waterway and the others have occurred along the eastern land portion of the force main. Concerned over the frequency of these pipeline failures and the possible environmental impacts associated with these sanitary sewer overflows (SSO), the County contracted with TBE to investigate and assess the pipe's condition, identify rehabilitation options to achieve needed improvements, make recommendations, and provide design, permitting and construction related services for the rehabilitation.

This paper discusses several of the issues unique to trenchless rehabilitation of pressure pipe in a populated and environmentally sensitive beach community including permit issues relevant to this project. The specific use of subsurface utility engineering (SUE) to locate existing utilities on-shore, and the use of radio detection and ultrasonic thickness measurement equipment in the underwater investigation will also be discussed.

INTRODUCTION

Pinellas County is an urban county located along the west coast of Florida on a penisula separating Tampa Bay from the Gulf of Mexico. In land area, the County is small, only 280 square miles in size, yet its population of approximately 921,000 permanent residents at the beginning of the twenty-first century makes it the fifth most populous county in Florida and the 41st in the nation.

Within the County are several beach communities which are separated from the mainland by the Intracoastal Waterway, a Class III Outstanding Florida Waterway, located within the Pinellas County Aquatic Preserve.

Indian Rocks Beach and Belleair Beach are two beach communities which are connected to the mainland by Walsingham Road on the south and Belleair Causeway on the north. Wastewater from both communities is pumped through the Indian Rocks Beach 12-inch cast iron force main to Pinellas County's McKay Creek Facilities.

The force main was constructed in 1964. It originates at the Indian Rocks Pumping Station located near Miami Avenue and 2nd Street North, crosses the Intracoastal Waterway subaqueously, and continues to the McKay Creek facilities via easements through the Shipwatch Condominium Complex. The subaqueous crossing was constructed by dredging and direct burial. The cast iron pipe was constructed with push-on joints on the upland sides and with the subaqueous crossing the pipe joint-type is unknown.

In 1995, Pinellas County took over ownership of the subaqueous force main, including easements from Indian Rocks Beach. The County subsequently entered into two separate interlocal agreements, one with Belleair Beach and the other with indian Rocks Beach. These interlocal agreements restructured the wholesale sewer service agreements between the County and the two municipalities.

Over the last ten years, and more recently, the force main has experienced a number of breaks, most often occurring on the easterly side of the Intracoastal Waterway in the Shipwatch Condominium Complex and the McKay Creek Wastewater Treatment Plant (WWTP) site. Probable causes of pipeline failures are due to corrosive soils, possible stray electric currents, and hydraulic surges in the pipeline.

TBE was contracted by Pinellas County Utilities (PCU) to provide professional engineering services in connection with the Indian Rocks Force Main. The work was completed in two phases.

Phase I of the investigation evaluated the eastern, upland portion of the force main, from the condo's seawall to the booster pumping station facility. Immediate replacement using trenchless technology rehabilitation was recommended. Construction included both horizontal directional drilling (HDD) and sliplining techniques. The replacement pipe which is a 16-inch high density polyethylene (HDPE) pipe is now operating successfully.

In Phase II, an underwater investigation was conducted to locate and assess the condition of the subaqueous force main. Replacement, using HDD, was recommended based on the results of the underwater investigation. The design and permitting are complete. Construction is expected to be completed in Juneof 2005.

EMERGENCY RESPONSE

Phase I – Immediate Replacement

Phase I evaluated the condition of the easterly upland side of the force main from the seawall in the Shipwatch Condominium Complex easterly to the McKay Creek Facilities. Based on the history of breaks, the condition of a failed section of pipe removed from the force main, and discussions with PCU staff, it was agreed that this portion of the force main required immediate replacement. TBE provided design assistance and worked closely with PCU staff and its contractor, Kamminga & Roodvoets. Approximately 1,100 linear feet of the 12-inch cast iron force main was replaced with 16-inch (O.D.) DR11, high density polyethelyene (HDPE) pipe. Construction methods included horizontal directional drilling (HDD) and sliplining of an abandoned 48-inch treatment plant outfall concrete pipeline.

HDD was selected due to the extent of existing underground utilities and limited working area. Test borings using the standard penetration test (SPT) method of sampling indicated that the drilling operations would encounter soft to very stiff clays. During final reaming and pull-back operation, the drill rig's on-board drilling fluid pumps failed which resulted in the ultimate failure of the drill pipe and loss of the reamer and pulling head. A second HDD attempt proved successful and included the following characteristics:

entry/exit angle.....15 degrees
bore length .....510 feet
maximum depth.....24 feet

Once the new HDPE pipe sections were constructed and tested, connections to the existing force main took place. At the downstream end, the connection was made to a relatively new section of polyvinylchloride (PVC) pipe using a pressure tap fitting and valve including a line stop. At the sea wall location, the connection was made by a wet tie-in to the existing cast iron pipeline. The cast iron pipe was found to be severely encrusted with marine growth and its overall integrity questioned raising concerns over risk of imminent rupture. A special reinforced concrete encasement was designed and constructed to accomplish the connection. The pipe was initially excavated to the spring line. The pipe was then hand excavated in short segments and was supported from overhead cross beams spanning the trench. At the hanger locations, wood blocking was used to avoid point hanger loads on the pipe. The work was scheduled during periods of low flow between midnight and 5:00 AM. During this time, the pump station was shut down and vactor trucks were used to assist with the draining of the 12-inch cast iron force main and to provide emergency back-up at the pump station, if necessary.

Due to the poor foundation conditions the concrete encasement was supported on screw piles. To improve the water tightness of the encasement in the event a leak developed, the pipe was wrapped with perforated PVC tubing that would permit the injection at the pipe/concrete interface with a hydrophilic compound to stop potential leaks.

The replacement pipe on the easterly upland side of the Intracoastal Waterway is on-line and is operating successfully.

Phase II - Underwater Investigation

In Phase II, the subaqueous force main under the Intracoastal Waterway was located and its condition evaluated. TBE's subsurface utility engineering (SUE) services were used to locate and flag the existing 12-inch cast iron force main located on the easterly and westerly shorelines.

Dive-Tech International, Inc. (DTI) performed the underwater inspection and was assisted by Suncoast Land Surveyors, Inc. The underwater pipeline was located using the Radiodetection Corporation RD-400 Utility Locator. An 8 kHz tone was inducted into the pipeline and tracked by the diver with an underwater receiver. At eight locations the pipeline was excavated using a combination of a jet pump and a 4-inch hydraulic dredge system.

The underwater locations exposed by the diver were surveyed. Positioning on the "x", "y", and "z" axis were taken on the top of pipeline. The natural bottom was taken only on the "z" axis to show the amount of cover over the pipeline. Except for two locations, the pipeline had between 1.8 feet and 5.2 feet of

cover. On the eastern shoreline, the pipeline was approximately 50-percent exposed for 25 linear feet from the seawall. Near the western shoreline, the pipeline extended beneath a boat fueling dock. On the South side of the fueling dock, the pipeline was approximately 50% exposed for 20 linear feet.

Ultrasonic thickness readings were taken at four locations, ten shots per location. The thickness readings were taken with a Cygnus Ultrasonic Thickness Gauge. The results of the ultrasonic thickness readings taken at the four locations are summarized as follows:

Table 1

Pipe Location Number	Average Actual Thickness
#2	0.105-inches
#4	0.105-inches
#5	0.120-inches
#8	0.093-inches

To confirm the field data collected, the ultrasonic thickness instrument was brought to PCU's office to determine the thickness of the section of damaged cast iron pipe which was previously removed from the eastern land portion of the existing 12-inch Indian Rocks Beach force main. The ultrasonic thickness instrument was only able to capture one reading which was 0.326-inches. Due to the lack of conductive media between the instrument and the pipe, the instrument was unable to lock in on all other attempted readings.

The results of the ultrasonic thickness measurements obtained were considered unreliable due to the composition and present condition of the cast iron material.

RECOMMENDATIONS

After careful review of the results of the underwater investigation and discussion with PCU staff, TBE recommended that the subaqueous portion of the force main be replaced for the following reasons:

- the age of the pipe (i.e., 40 years old and reaching its expected service life)
- the pipeline is exposed in several locations
- pipeline has minimum or less than minimum, cover at several locations and therefore, does not meet regulatory standards
- there have been past failures of the pipeline in the water crossing (i.e., the easterly shoreline near the seawall)
- corrosive soils were noted on the easterly land side which were degrading the exterior of the pipeline and these soils may also be present in the Intracoastal Waterway
- since the pipeline on the easterly land side has been replaced, the portion under the Intracoastal Waterway may become the "weak link" and may be subject to future failures

TBE further recommend that the subaqueous pipeline be replaced with a new 16-inch O.D. HDPE pipe constructed by horizontal directional drilling.

Subaqueous Replacement Design

ISSUES AND CONCERNS

Successful horizontal bores are the result of careful planning and skillful execution. The more complex the bore, the more significant the planning stage becomes. During the planning stages of this project, the following issues were addressed:

- alternative alignments
- permits
- easements
- environmental considerations
- geotechnical investigation
- tracking system
- down hole monitoring

ALTERNATIVE ALIGNMENTS

Several alternative pipeline alignments for the proposed HDD crossing were considered and evaluated. In general, the alignments followed the existing pipeline with the drilling and pull-back operations being positioned on either side of the Intracoastal Waterway. The recommended alignment, which did not follow the existing pipeline, has the drilling and pull-back operations located on the west side of the Intracoastal Waterway and the pipeline layout and fabrication site on the County's McKay Creek property. See Figure 1.

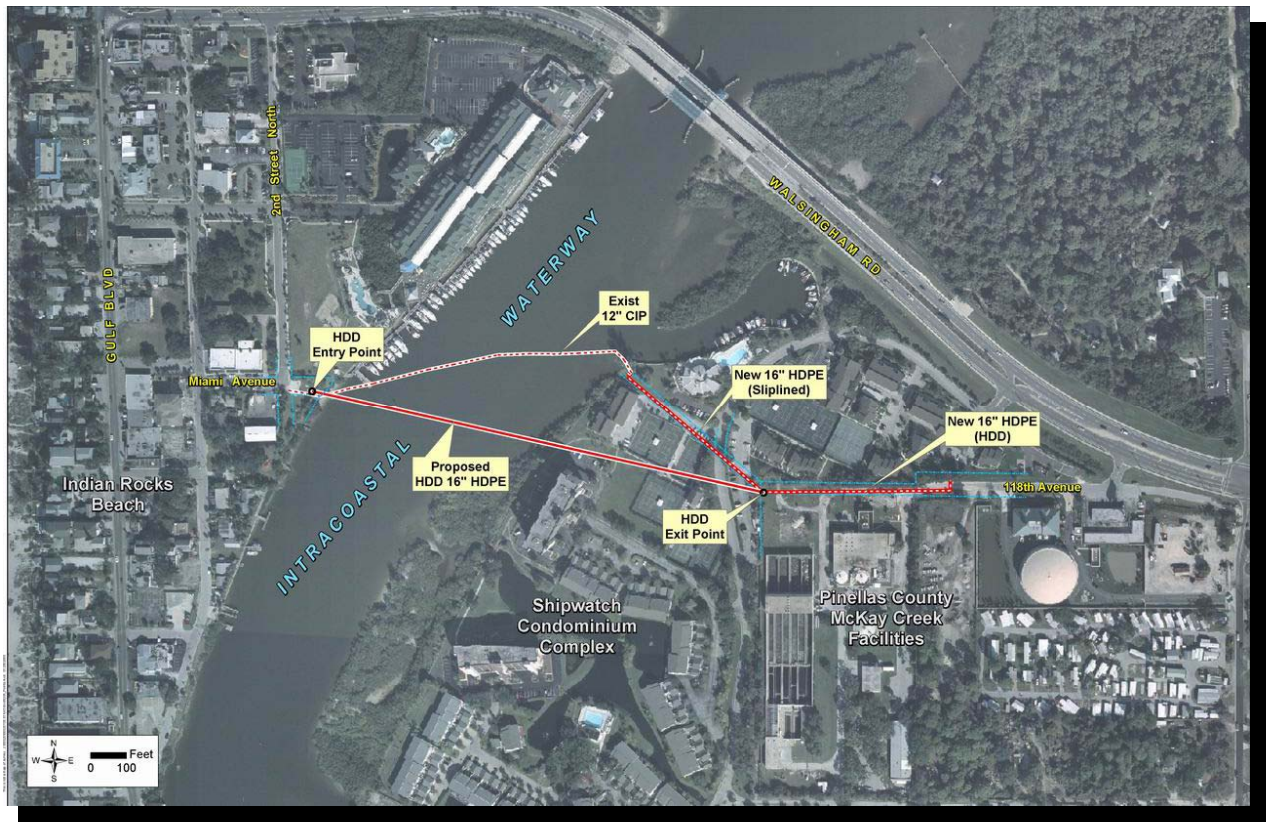

Figure 1

The recommended alignment has the following advantages and disadvantages:

Advantages:

- drill and pullback from same location
- very good pipeline fabrication site on County's property
- reduced disruption to residents and traffic
- less surface restoration
- shorter overall force main route

- straight alignment
- avoids seawall

Disadvantages:
- longest bore
- approximately 500 feet of new HDPE replacement abandoned
- require conductor barrel at entry side
- require permanent easement through Shipwatch Condominimum Association
- higher construction cost

PERMITS

Permits for the project were obtained from the Florida Department of Environmental Protection (FDEP), the United States Army Corps of Engineers (USACOE) and from the City of Indian Rocks Beach.

EASEMENTS

Since no platted public right-of-way existed at the proposed crossing of the Intracoastal Waterway, a sovereign lands permit was considered to be required. Accordingly, a 50-foot wide easement was requested from the FDEP. The 50-foot wide easement was requested to allow for minor deviations in the pipeline construction.

FDEP adivised that the project is considered to occur on state-owned, sovereign submerged lands and therefore, would normally require a public easement from FDEP for the use of those lands, pursuant to Florida Statutes. However, as a county government entity, pursuant to Florida Statutes, no authorization to use sovereign submerged lands will be required for the referenced crossing.

The permit application and associated drawings documenting the proposed construction was forwarded to FDEP's Title and Land Records Section for placement in their archives. A permanent 25-foot wide easement across a portion of property owned by Shipwatch Yacht and Tennis Club was negotiated and secured from the Shipwatch Condominium Homeowners Association.

ENVIRONMENTAL CONSIDERATIONS

Based on the geotechnical investigation, steering response may be poor in the upper loose sands and soft clay and at the interface of the soil/limestone. Bore tracking and guidance are less accurate beneath water than beneath land. In addition, filled or open cavities could be encountered that could adversely impact steering and circulation. The potential for encountering solution cavities and hard rock increased the risk of the bore. If the bore encounters open solution cavities, circulation could be lost and the drill pipe or product pipe may seize. If the bore encounters hard rock, line and grade control would be difficult to maintain, especially near the interface of the rock with the sand and clay soils. These factors increased the risks of the HDD operation.

Because of the environmentally sensitive location and required permitting, the Contract Documents requires the selected contractor to submit the following documentation for review:

- Noise reduction program
- Solids control and drilling procedures
- Pipe fusion, hydrostatic testing and pigging procedures
- HDD work plan
- Qualifications of superintendent and key personnel
- Shop drawings
- Construction activity schedule
- Procedure and data records of downhole survey tool and tracking system and Tru-

Tracker or equal energized surface grid

- Safety plan
- Details for monitoring and protecting adjacent utilities, structures and facilities
- Contingency plan including contractor's proposed response(s) to the following potential occurrences:
    - loss of returns/loss of circulation of drilling fluid
    - hydrofracture
    - obstruction encountered during drilling
    - broken drill pipe
    - product pipe collapse
    - drill pipe or product pipe cannot be advanced
    - excessive ground settlement or heave
    - utility strike

GEOTECHNICAL INVESTIGATION

A geotechnical investigation was undertaken to examine subsurface soil and ground water conditions for use in design and construction. Marine test borings were conducted utilizing a drilling rig supported by portable barges along the general alignment and off the proposed centerline of the directional drilling beneath the Intracoastal Waterway. The test borings were offset from the proposed center line to prevent the loss of drilling fluid during the crossing installation. The project surveyors provided the position of these borings and also surveyed the mud-line elevation at the time of the test borings. Results of the geotechnical borings indicate that the soil profile can be grouped into two zones for the purposes of HDD design. The upper zone from ground surface to approximately 18 feet deep, or elevation -14 is predominantly medium dense to very dense sand and clayey sand and stiff to very stiff clay. The lower zone from approximately 18 feet deep to bottom of borings is predominantly stiff to hard clay and limestone layers. One of the borings indicated a 100-percent loss of fluid circulation at elevation -20 feet. The geotechnical investigation also indicated the presence of unfilled dissolution features at varying depths which is common for the region. The presence of these solution features creates the potential for preferential seepage paths for the migration of drilling fluids to the surface during the pilot bore and reaming operations. To mitigate the potential for inadvertent surface returns or frac-outs, the contractor will be required to install a conductior casing at least 125-feet long at the drill rig entry side. The conductor casing should be approximately 36-inch diameter steel pipe with a minimum wall thickness of ½ inch or thicker, if necessary to support installation loads. The conductor casing is needed to prevent drilling fluid from leaving the borehole by hydrofracturing the soil formation or through unfilled solution features. The conductor casing will be installed to a depth at or below the transition into the hard clay and limestone region. Below this region, the formation strength and confining pressure will be sufficient to prevent hydraulic fracturing of the soil strata and the potential of solution features providing a seepage path to the surface is greatly reduced. Near the exit location, hydraulic fracturing may occur when the soil confining pressure is exceeded by the downhole fluid pressure. The HDD contractor will be required to have cleanup and containment supplies on site (including a vac-truck, hay bales, silt fence, straw wattles, etc.) and a contingency plan in place to quickly contain drilling fluids.

A relief well will be installed by the contractor near the exit location of the proposed HDD bore. The relief well will be designed to intercept and relieve excessive formation pressures created by the pressurized drilling fluid that could cause hydrofracture as the soil cover decreases. The relief well will be located between the tennis courts and Shipwatch Drive. The relief well will be installed with a 10-foot long screened/perforated interval and with the tip elevations five feet above the crown of the proposed HDD

bore. The relief well will be abandoned after construction is completed, following acceptable industry practices for well abandonment.

TRACKING SYSTEM

The primary HDD guidance system for the project will be a downhole wireline tracking system. A Tru-Tracker surface grid tracking system will be required to ensure the accuracy of the pilot bore. The Tru-Tracker system consists of a surface wire grid with surveyed coordinates and elevations that encompass the planned bore alignment. The grid is energized using a DC welder to induce an electromagnetic field. The energized core improves accuracy by locating the position of the drill head relative to the known position of the surface grid system. Since the pilot hole entry vertical curve is located entirely under the Intracoastal Waterway, the contractor will be required to install and survey the location of a Tru-Tracker guidance system completely across the waterway channel bottom. Alternatively, the contractor may install the Tru-Tracker system on a floating grid of PVC pipe that can be moved as necessary to avoid disrupting boat traffic. If the Tru-Tracker coil is attached to a floating grid of PVC pipe, the contractor will coordinate with the Tru-Tracker subcontractor to ensure that the grid covers the necessary area above the bore, it is securely anchored during operations, and that surveyed coordinates are documented before and after each relocation of the grid as the bore progresses.

DOWNHOLE MONITORING

The risks and potential consequences associated with inadvertent fluid returns or frac-outs can be reduced by following HDD good practices. A conductor casing will be installed on the drill rig entry side to prevent hydraulic fracturing or loss of drilling fluid to the surface or formation through solution features. The contractor will be required to provide a downhole pressure monitoring device to allow monitoring of drilling fluid pressures throughout the pilot bore. Monitoring of downhole drilling fluid pressures will allow the contractor to closely monitor fluid pressures on the exit side where frac-out potential is high. The contractor will be required to carefully monitor mud weights and drilling penetration rates vs. drilling fluid pump rates to avoid high pressures and out-running the pump which increase the potential for frac-outs.

PIPE DESIGN

Alternative profiles were evaluated by TBE Group during pipe design. The final profile is shown in Figure 2.

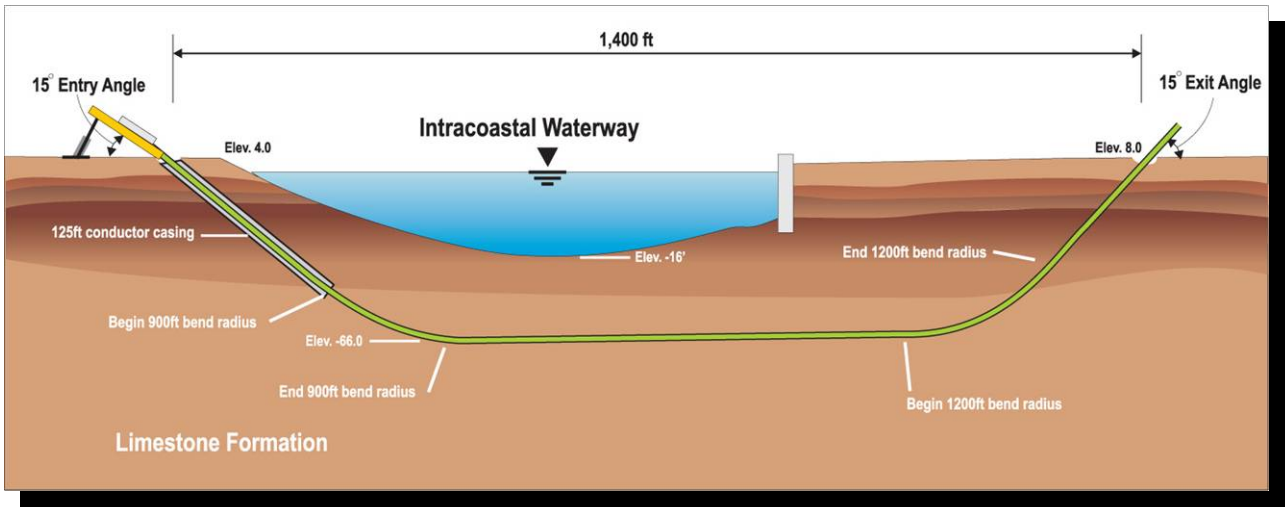

Figure 2

The final profile was chosen based on the feasible entry and exit angles, establishing the depth to keep the majority of the steering operations in reasonably uniform soils, and maintaining the original entry and exit points.

Selection of pipe for the HDD portion of this project must account for service loads as well as installation loads. The 16-inch HDPE pipe was analyzed to determine the required DR to withstand tensile (pull back), bending, and external hoop stress (hydrostatic buckling). The recommended DR 11 meets the required installation loading capacities and will be specified in the contract documents.

Bennett/Staheli Engineers performed a series of pipe stress calculations for the 16-inch HDPE pipe to determine the required DR to withstand tensile (pull back), bending and external hoop stress (Hydrostatic buckling). The results of this work indicate that 16-inch DR 11 HDPE pipe is adequate to satisfy design criteria, installation, and in-place loading conditions. They recommended that the HDPE pipe be filled with water during installation. Analysis of long term unconstrained buckling resistance determined that a DR 11 pipe provides a factor of safety of five against long term buckling when filled with water and when empty the pipe is at the critical point of geometric instability and unconstrained collapse. The borehole slurry will eventually set up and provide some confinement of the pipe, but the extent of the confinement is unknown and was not assumed for these calculations. Following is a detailed description of the assumptions used and results of the pullback stress calculations.

Table 2

Pullback Stress Calculations for 16-Inch DR 11 HDPE Pipe	
OD	17.4
SDR	11
Unit Weight of Pipe	34.29 lb/ft
Yield Strength	3200 psi
Elastic Modulus	110,000 psi
Poisson Ratio	0.30
Pipe Full of Water During Installation	Yes

Table 3

Soil	
General Soil Conditions	Clayey Sand/Clay/Limestone
Soil to Pipe Friction Coefficient	0.3
Mud to Pipe Drag Coefficient	0.05
Mud Weight	10.5 lb/gal
Height of Mud Column/Max. Depth	73 ft

Table 4

Bore Geometry	
Horizontal Length of Bore	1390 feet
Entry Angle	15 degrees
Exit Angle	15 degrees
Entry Vertical Curve Radius	900 feet
Exit Veritical Curve Radius	1200 feet
Maximum depth Beneath Ground Surface	73 feet

RESULTS

Table 5

Pullback Loads		
Estimated Pullback Load	61,600 lb	30.8 tons
Stress Analyses		
	Calculated	**FS**
Tensile Stress	783 psi	3.38
Bending Stress	88.6 psi	27.1
Hoop Stress	45.0	11.9

CONCLUSION

The existing Indian Rocks Beach 12-inch cast iron force main was replaced on the eastern upland side of the Intracoastal Waterway. Replacement included the construction of 16-inch HDPE pipe by sliplining an existing 48-inch concrete pipe located in the Shipwatch Condominium Complex and the construction of 16-inch HDPE pipe by HDD in the County's McKay Creek property. The replacement pipe is on-line and operating successfully.

Based on the results of the underwater investigation the subaqueous 12-inch cast iron pipe was recommended to be replaced using HDD. Replacement pipe will be 16-inch HDPE pipe. The design and permitting are completed. The project will be advertised in February 2005, with construction to be completed in June 2005.

REFERENCES

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