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WATER DISTRIBUTION SYSTEM REPLACEMENT UTILIZING PRE-CHLORINATED PIPE BURSTING TECHNOLOGY TO PROTECT SENSITIVE ENVIRONMENTAL AREAS

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Abstract: Compact static pull pipe bursting systems have been used in the United Kingdom for decades to replace deteriorated gas and water mains. A natural evolution of the process was to migrate toward the installation of new pre-chlorinated water mains.

The installation of pre-chlorinated pipe reduces or eliminates the time and cost associated with providing temporary water service over an extended period of time and the labor and cost associated with cleaning and chlorinating a newly installed water main post installation.

This paper will review the history and current methods of bursting and replacing water mains with pre-chlorinated pipe in the United Kingdom.

Additionally, a case study of pipe bursting AC cement water mains in the Everglades National Park and replacing them with pre-chlorinated pipe will be presented. The State of Florida was one of, if not the first, to recognize the value of this procedure and approve its use as a means of water main replacement.

The National Park Service (NPS) engaged CDM to design and construct improvements to its Flamingo water system, including the complete replacement of its water distribution system. The Flamingo area is the largest developed area within Everglades National Park (Park) and includes a visitor's center, restaurant facilities, and housing to accommodate visitors from all over the world. The existing water distribution system consists of 25,000 linear feet of 6-, 4-, and 2-inch asbestos concrete and polyvinyl chloride water mains. The majority of the distribution system was constructed in 1947.

The plan for the distribution system replacement utilized almost entirely trenchless construction, making Minimizing impacts to valuable environmentally sensitive and irreplaceable natural resources, the main distribution lines were replaced using high-density polyethylene (HDPE) pipeline (Figures 1 and 2) by the pipe bursting method. The polyethylene pipelines were pre-chlorinated (Figure 3) to disinfect and cleared of bacteria above ground prior to installation. This allowed the new lines to be placed into service immediately with minimal disruption to the visitors and residents at the Park. This project is the largest application to date in total linear footage of this technology in North America.

This paper will document the installation of the new pipelines with a special focus on the use of pipe bursting and pre-chlorination techniques. This project was designed and the Notice to Proceed for construction was issued on November 4, 2002. The final completion inspection was completed on June 17, 2003.

Water Pipe Replacement by Pipe Bursting

Pipe bursting is a process that has become popular with the rehabilitation of clay sewer lines. The process typically utilizes a Hydraulic system to crack the brittle pipe while a replacement line, usually HDPE, is pulled through the “host” pipe. To replace these types of lines, a hydraulic system is used that employs a system of rods and a cutting head to split the host pipe while an expander opens an annular space for the replacement pipe. This system was developed by British Gas to replace failing ductile gas lines with HDPE.

Pre-Chlorination

The technology proved to be so successful in the replacement of gas mains in the congested underground environment of England’s cities that water utilities began to capitalize on this technology to replace aging ductile iron water mains. These replacement lines could be installed with minimal disturbance to the existing neighboring infrastructure. However, they required the customers that were served by the line to be subjected to service downtime while the new line was either cleared of bacteria or to a boil water restriction.

A major breakthrough occurred when the properties of HDPE were capitalized upon to allow the replacement lines to be disinfected and pressure tested prior to their installation. During the pipe bursting process, a sealed puling eye or a welded polyethylene puller is utilized to keep the interior of the pipe free from contamination. The properties of HDPE allow it to be fused together into long sections. The fusion welds have strength greater than the walls of the pipe itself. This allows the entire length of the pipe to be fused and assembled in a continuous section or delivered to the jobsite in a continuous coil. Once the pipe is in place, the pipe can be disinfected using a standard practices and pressure tested (Figure 4) to ensure the fusion welds are sound.

The concept of pre-chlorination was brought to Florida through the efforts of the Florida Section of the American Water Works Association (FSAWWA). The Florida Department of Environmental Protection accepted this method in November, 2000.

Design

The Flamingo area functions as a destination for visitors to the Parkland. The NPS maintains facilities which include the visitor’s center restaurant, hotel, visitor cottages, camping facilities, and living quarters for park service staff and concessionaires. The replacement of the distribution system was required to be accomplished with minimal disruption to park operations. An additional consideration was the need to minimize impacts to wildlife in the park. Open trenches would be of particular concern for the eastern indigo snake and could present a problem to crocodiles during their nesting season. Pre-chlorinated pipe bursting was selected to replace the distribution system at Flamingo. This was primarily due to the ability to restore service immediately after installation and the limited amount of excavation and disruption to wildlife habitat.

As part of the improvements to the distribution system, CDM created a hydraulic model of the distribution system. Based on the results of the modeling analysis, CDM recommended increasing the size of the main trunk line from the water plant to the visitors center from 6-inch to 8-inch in diameter. Additionally, several mains that served fire hydrants were upsized from 4-inch to 6-inch. Upsizing the line was possible using the pipe bursting technology. Typically, it is feasible to increase the line size by one to two pipe sizes utilizing this technology.

Plans for the work were based on the existing record drawings the park service staff provided to CDM. Because the replacement pipe was installed using the existing pipe as a guide for the bursting rig, conflicts with existing utilities were eliminated. Unlike pneumatic bursting equipment, the hydraulic cutting head causes minimal disruption to the surrounding soil. The only condition which causes concern during the bursting process is the additional soil displacement caused by upsizing the host pipe or inadequate cover on the host pipe (usually 2 foot or less), which can cause the pavement above the pipe to heave and crack. The pipe bursting subcontractor, Murphy Pipelines, was able to layout the work using the existing drawings. Notes and line sizes were added to the record drawings to create the design drawings.

Construction

The following sequence of pictures (Figures 5 through 11) depicts the typical construction sequence that occurs to install HDPE water mains utilizing pipe bursting.

Conclusions

Pipe bursting potable water mains utilizing pre-chlorination is an effective method for the replacement of aging distribution systems. Advantages include minimal disruption of service to customers, limited potential to disturb existing utilities, limited excavation required, and the ability to upsize lines. The utilization of this technology allowed CDM to complete this project for the NPS within a short time frame and with limited disturbance to the existing customers.

Figure 1: HDPE was delivered to the job site in 4- and 6-inch coils. Each coil contained a continuous piece of pipe.

Figure 2: The 8-inch lines were delivered in standard 40-foot sections and butt-fused and assembled in the staging area.

Figure 3: The various lines were capped and disinfected with a hypochlorite solution. The lines were then flushed and 2 consecutive days of samples were drawn from the lines and tested for bacteriological clearance. The lines were then capped again. If the lines passed the bacteriological clearance, the line was prepared for pressure testing.

Figure 4: The lines were pressure tested above grade to ensure they contained no leaks.

Figure 5: At the entrance pit, a pipe splitter and pipe expander were attached to the threaded rod assembly. The pipe cleared of bacteria and pressure tested, is attached to the end of the splitter, expander train and prepared for insertion behind the bursting tool.

Figure 6: Entry and exit pits were excavated on either side of the line to be replaced. Using a hydraulic ram, a system of threaded rods were inserted into the host pipe from the exit pit side of the host pipe. This process continued until the threaded rods appeared in the entrance pit.

Figure 7: A copper wire was attached to the HDPE pipeline. This tracer wire would be used to locate the line after installation.

Figure 8: If necessary, the entrance pit was expanded to allow for the HDPE pipe to make a smooth transition into the host pipe.

Figure 9: From the exit pit, the hydraulic ram was switched from push to pull. The system of rods was then pulled back through the host pipe. This in turn drew the splitter, expander, and new HDPE back through the host pipe. This pull caused the host pipe first to be split. The pieces of the host pipe would then be pushed into the surrounding soil by the expander. Finally, the new pipe would be pulled through the annular space created by the expander.

Figure 10: At the exit pit, the sections of threaded rod were removed.

Figure 11: Finally, the new HDPE appeared at the exit pit. The line was connected at the entrance pit and the water services tied into the new line. The process could then continue. The entrance pit was restored and the exit pit became the new entrance pit for the next burst.