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REHABILITATION OF TCE-CONTAMINATED UNDERGROUND STORM WATER SYSTEM USING TRENCHLESS TECHNOLOGY

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ABSTRACT

The Naval Air Warfare Center (NAWC) at Trenton, NJ is a gas turbine engine testing facility. Trichloroethene (TCE) is used as a heat exchange medium during engine testing. As part of an on-going environmental investigation program, TCE was found in groundwater and in water discharging from the outfalls of the facility's storm water collection system. Because of high groundwater levels, it was unclear whether the TCE in the outfall discharge was entering the storm sewers via pipe connections and/or from impacted groundwater infiltrating deteriorated sewer lines.

The main storm sewer lines associated with two of the facility's four outfalls, i.e., in the areas of highest TCE concentrations in groundwater, were video inspected. Structural deficiencies ranging from cracked pipe and failed joints to total collapse were found. The rehabilitation of these lines was deemed to be an important part of the facility's remediation plans. Due to the disadvantages associated with conventional pipe excavation and replacement techniques at this site, in-situ rehabilitation alternatives were considered. Cured-in-place pipe (CIPP) technology was selected as the best alternative. This technology involves the formation of a new CIPP inside an existing pipe using a novel "inversion" process.

The disadvantages of excavating contaminated soil to repair the deteriorated storm sewer lines were avoided. Approximately 1,900 lineal feet of pipe, ranging from 8 inches to 27 inches in diameter, were repaired using the CIPP method. A reduction in the infiltration of groundwater into the storm sewer system, and a corresponding reduction in the TCE at the outfall, was observed as a result of the repair work.

1. INTRODUCTION

As part of an on-going remedial investigation (RI) at NAWC Trenton, groundwater and storm water samples were collected in July, 1992. Trichloroethene (TCE) and its degradation products were found in the groundwater and in portions of the storm sewer system. (See Table 1).

Brown & Root Environmental (B&RE) was tasked to investigate the sources and levels of TCE in the storm sewer system and, in subsequent tasks, to inspect and make repairs to portions of the system.

TABLE 1. MAXIMUM CONCENTRATIONS OF TCE DETECTED AT OUTFALLS DURING RI

Outfall No.	TCE Concentration, μg/l
001	1,200
002	270
003	14
004	17

μg/l = micrograms per liter (parts per billion)

A field survey and sampling were conducted of all four areas of the site that drain through Outfalls 001 through 004. Inspection of all accessible manholes and inlets identified inconsistencies from the existing sewer drawings and the presence of flow from system connections. Sampling confirmed the presence of TCE in the storm sewer at locations identified during the remedial investigation, predominantly around Bldgs. 40, 41 and 42 that are situated in areas which drain toward Outfalls 001 and 002. In addition, flow of water was observed in the storm sewer during periods of no rain. Infiltration of TCE-containing groundwater to the storm sewers and/or exfiltration of TCE-containing process waters from the storm sewers was indicated. In light of these findings, B&RE's field efforts were focused on the storm sewer lines leading to Outfalls 001 and 002. (See Figure 1).

An illicit-discharge investigation, which included records review, in-field inspection and line tracing, and smoke and dye testing was also conducted to ensure that the storm sewer system was not being compromised by process waters or illicit discharges. Approximately 2,900 lineal feet of pipe in the Outfall 001 and 002 systems were cleaned and inspected. Almost 5 cubic yards of debris were removed. Sections of cracked and collapsed pipe were found. Ninety-five percent of the joints in the uncollapsed piping failed pressure testing and required grouting. Previously unknown connections to the sewer system were found. The illicit-discharge investigation revealed that several process drains and other unidentified lines were connected to the sewer lines. (See Table 2). At this point, B&RE's scope of work was increased to include sewer reconstruction and repair.

TABLE 2 . RESULTS OF CLEANING AND INSPECTION - OUTFALLS 001 & 002 NETWORK

- 2,900 Lineal Feet Cleaned and Video Inspected - Obstructions, Offset Joints, Collapsed Pipe Prevented Complete Inspection
- 4.8 Cubic Yards of Debris Removed
- Joints Grouted in 1,512 Lineal Feet of Pipe - 95% of Joints Failed Pressure Test (324 of 342)
- 7 Illicit Connections Found - Rerouted, Plugged or Removed
- 1,900 Lineal Feet Repaired by CIPP Technique

Two subcontractors were procured. One was tasked to perform conventional pipe repair and manhole replacement, and to reroute illicit drain lines and service connections away from the sewer system. Plugging of out-of-service manhole connections and pipe removal were also performed.

A second subcontractor was procured to perform the reconstruction of severely deteriorated sewer lines within the Outfall 001 and 002 systems. To avoid the disadvantages associated with conventional pipe excavation and replacement, in-situ rehabilitation alternatives were considered. A cured-in-place pipe (CIPP) trenchless technology was selected. This rehabilitation proved successful in isolating the sections of the storm water system where it was applied.

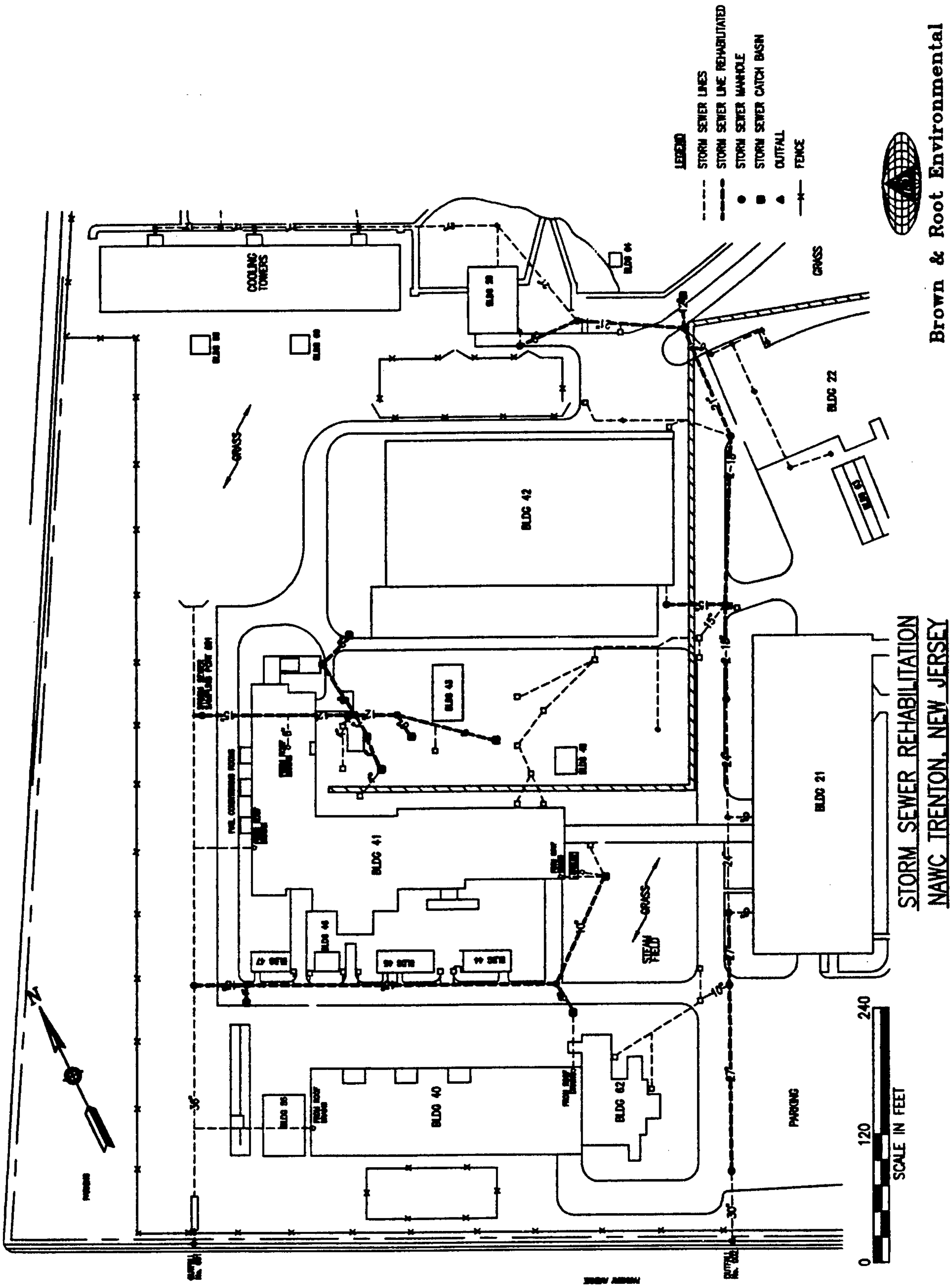

Figure 1. Site Plan of Outfalls 001 and 002 Storm Drainage Area - NAWC Trenton. Heavy dashed lines indicate sewer lines rehabilitated by CIPP technology.

2. CURED-IN-PLACE-PIPE INSTALLATION

The CIPP technology selected for the NAWC Trenton storm water system rehabilitation was provided by Insituform® of North America. The set up and installation is depicted in Figures 2 an 3. A plastic-coated, needled felt tube is custom engineered and prefabricated to the desired length and diameter that is required to fit the deteriorated line(s). It is impregnated with a liquid thermosetting resin and shipped to the installation site. A support scaffold with an inversion tube and elbow is set up over a manway leading to the damaged pipe. One end of the prefabricated tube is banded to the lower end of the inversion tube elbow. The inversion tube is then filled with water. The weight of the water inverts the felt tube and forces it to expand inside the damaged pipe. The tube turns inside out and is pressed by the water against the inside walls of the old pipe. The smooth, coated side of the felt tube becomes the new interior surface of the pipe. (Figure 2).

The inversion process results in no relative movement between the felt tube and the old pipe, minimizing damage to the flexible tube material. Also, any incoming or standing water is forced ahead of the inverting tube and out of the pipe. No water that could inhibit proper curing of the resin or alter the shape of the finished pipe is trapped behind the new tube.

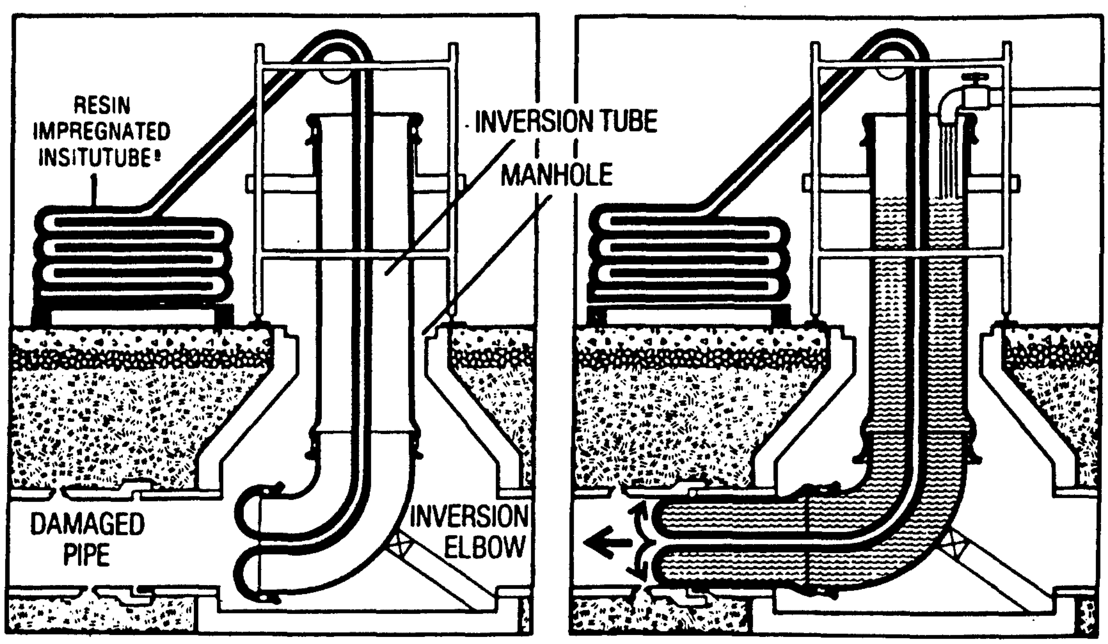

Figure 2. Set Up and Placement of Insituform® CIPP

After the tube is fully inverted through the old pipe, the water used for inversion is circulated (via a hose attached to and drawn into the tube while it is inverting) through a heater to a temperature of approximately 160° F. The hot water causes the thermosetting resin to cure within a few hours. This changes the the pliable felt tube into a hard pipe-within-a-pipe. (Figure 3). The latter has no joints or seams and should be as strong or stronger than the pipe it replaces. The ends of the hardened pipe are cut off and sealed. The inversion tube and scaffolding are removed. Lateral connections to the pipe are restored by a camera-equipped, remotely controlled cutting device.

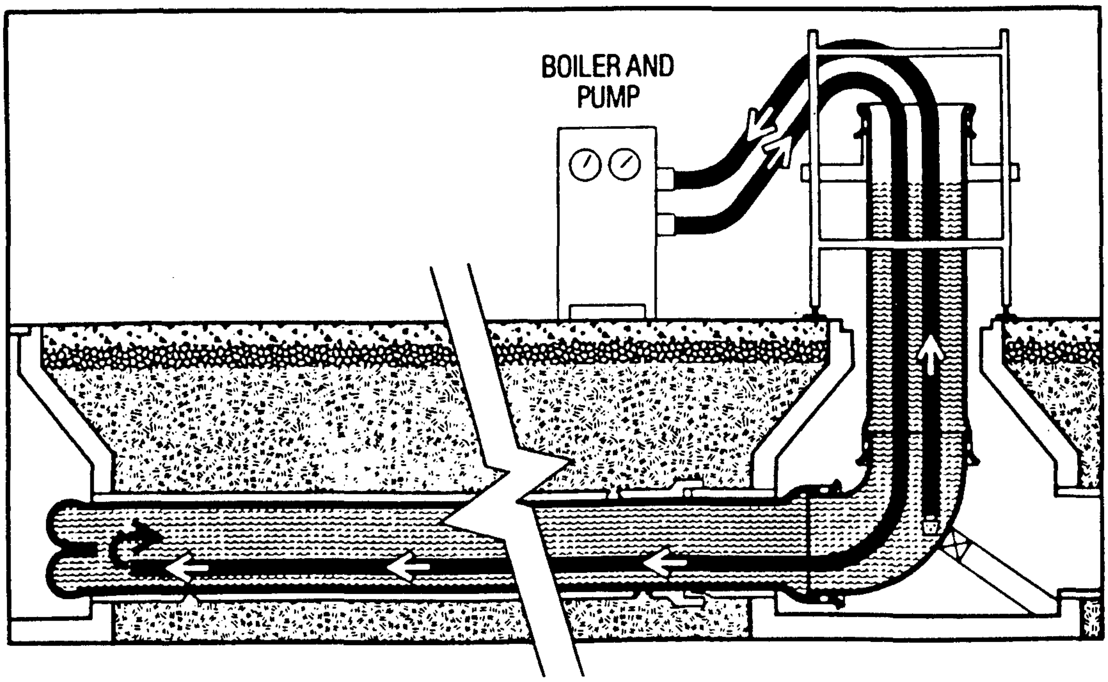

Figure 3. Curing of Insituform® CIPP

Other in situ technologies were considered but were rejected. Hard sleeve liners were not applicable. They would not have eliminated the problem of infiltration of groundwater into the sewer lines, as an annular space would have remained between the liner and the old pipe, nor would they have been able to negotiate the offsets in the deteriorated pipe as had the Insituform CIPP. Expandable PVC pipe, while more flexible than a hard liner, would also not have assured an annular seal nor allowed customization of the resin compound for compatibility with chlorinated solvents, as did the Insituform.

3. ADVANTAGES OF TRENCHLESS TECHNOLOGY

The use of the selected trenchless technology afforded some significant advantages over traditional excavation and repair methods. These are summarized in Table 3.

TABLE 3. ADVANTAGES OF TRENCHLESS TECHNOLOGY
STORM SEWER REPAIR - NAWC TRENTON

- No Pavement or Roadway Excavation
- No Traffic Disruption
- No Excavation, Stockpiling, Sampling and Analyses, Loading, Transport or Disposal of Contaminated Soil
- No Exposure of Construction Workers to Affected Soils or Groundwater
- No Confined Space Considerations
- No Treatment of Groundwater during Installation
- No Joints
- Improved Flow Characteristics

While roadway excavation and traffic disruption were avoided, at this site the advantages gained from a safety and environmental standpoint were even more significant. Costly efforts to maintain environmental and regulatory compliance were unnecessary. Where the trenchless technology was employed, the risks associated with the handling and disposal of contaminated soils and groundwater were avoided. No elaborate environmental safety and health plans were needed. The problems associated with stockpiling ,containing, sampling, transporting and disposing of contaminated soils were avoided. Each of these activities involve added cost, and the risk of spills and the exposure of workers and the environment to contaminants. Digging and working in trenches to replace underground piping requires safety measures such as sidewall shoring and, possibly, following confined space entry procedures. The latter were also unnecessary. Further, due to the high groundwater level at this site, it would have been necessary to pump groundwater from the excavations during the pipe replacement. Due to the presence of chlorinated solvents like TCE, the water would have needed treatment prior to discharge, another inconvenience and added expense. Finally, the new pipe eliminates the irregularities in the old pipe's flow path and possesses a lower friction factor, so flow conditions were improved.

4. RESULTS OF SEWER LINE REPAIR

The success of the trenchless technology in repairing and isolating the storm sewer system was observed. While the scope of work did not allow the complete rehabilitation of the 001 outfall system, the 002 outfall system was nearly completely rehabilitated. Measurements of the TCE in the two storm water outfalls from sampling events before and after the pipe repair is shown in Table 4.

TABLE 4. TCE CONCENTRATIONS AT STORM WATER OUTFALLS - NAWC TRENTON

	Before CIPP Repair, µg/l 7/93	After CIPP Repair, µg/l 12/94
Outfall 001	140	130
Outfall 002	90	4(J)

(J) = Concentration below the analytical method detection limit

CONCLUSIONS

Inspection and field tracing studies of the storm sewer lines at NAWC Trenton were carried out. Illicit connections were rerouted or disconnected. Sewer line reconstruction within two of the facility's four outfall systems was done, in part by conventional means and, more significantly, by the application of a CIPP trenchless technology. Those lines repaired using the trenchless technology were successfully isolated from contaminated groundwater as indicated by the reduction in TCE concentration measured at the storm water outfall. Significant advantages from environmental, safety and cost perspectives were realized through the application of the trenchless technology.

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