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PROJECT COMPLETION REPORT FOR THE PIPE SLIP LINING AT ALPHA DELTA PIERS

NS MAYPORT FL

3/1/1995

BECHTEL ENVIRONMENTAL

PROJECT COMPLETION REPORT

FOR THE

PIPE SLIP LINING AT THE ALPHA DELTA PIERS

NAVAL STATION MAYPORT, FLORIDA

Prepared for

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

Under Contract No. N62467-93-D-0936

Prepared by

BECHTEL ENVIRONMENTAL, INC.
OAK RIDGE, TENNESSEE

MARCH 1995

Bechtel Job No. 22567

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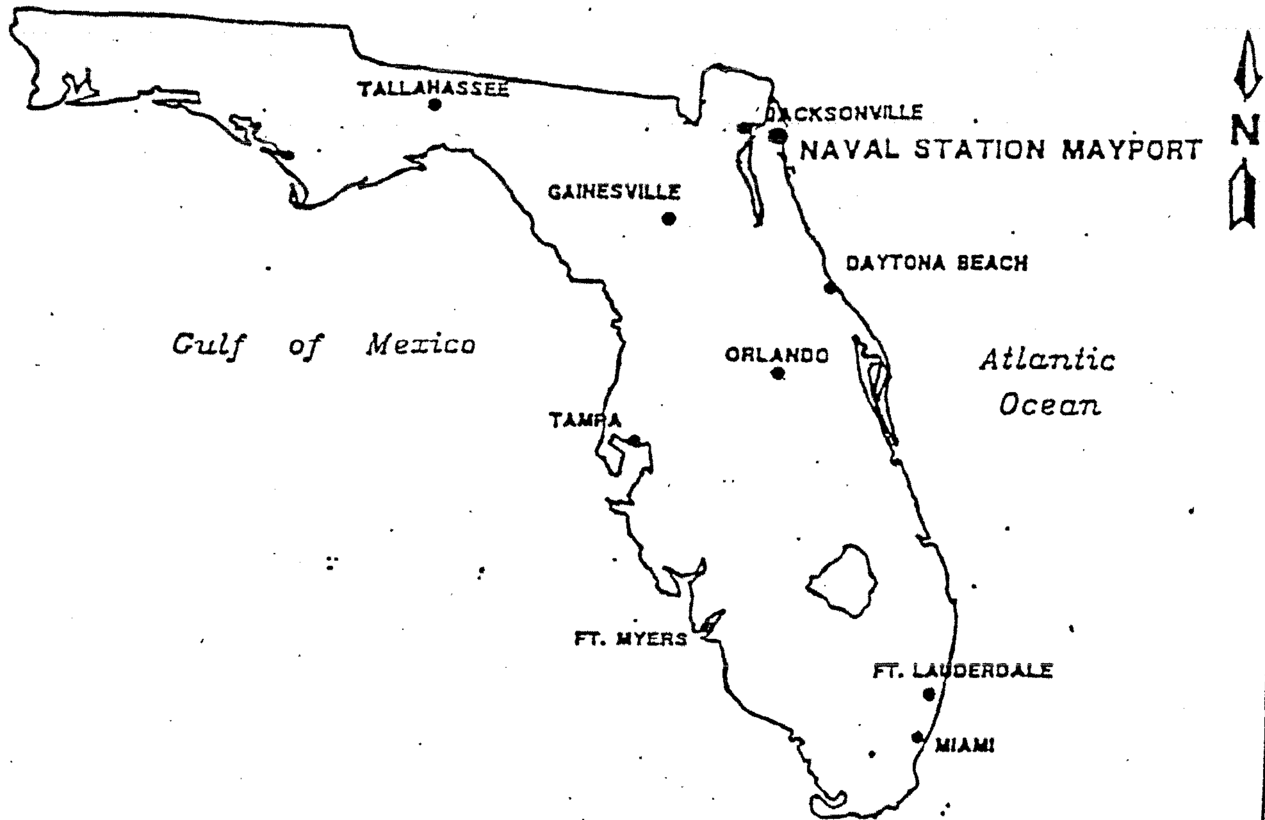
EXECUTIVE SUMMARY

Bechtel Environmental, Inc. (BEI) conducted remedial actions at the Alpha Delta Piers located at the U.S. Naval Station in Mayport, Florida (NS Mayport). This work was performed under Task No. 5 of Delivery Order No. 0010. NS Mayport location is shown in Figures 1 and 2. The objective of this project was to rehabilitate drainage pipes to prevent uncontrolled releases of contaminants from infiltration and percolation into sections of the existing storm sewer drainage system. The system discharges to the Mayport turning basin. To accomplish this objective, 644 linear feet of storm water sewer pipe was cleaned, lined, and video inspected.

BEI subcontracted this work with Enviroq InSituform, Inc. (Jacksonville, Florida) to perform the rehabilitation operations. The storm sewer was lined with InSitutube (liner) manufactured by InSitu Form. InSitutube is a dry resin saturated polyester sleeve that is placed within the existing sewers and then heated by circulating 180 degree water within the liner. An endothermic reaction occurs which cures the resin to form a rigid structural internal pipe.

All water and sediment generated during the cleaning operations was contained and stored in an on site 20,000 gallon storage tank. After sediment settled, water from the tank was decanted and discharged to the NS Mayport oily water treatment plant. All remaining sediment and associated debris was placed in 55 gallon DOT 17H drums. The drums were sealed, appropriately labeled and staged by Bechtel at the Jacksonville Shipyards, Inc. (JSI), Facility, NS Mayport. Contract required submittals are located in Appendix A.

This project was completed on schedule and within the forecasted budget.



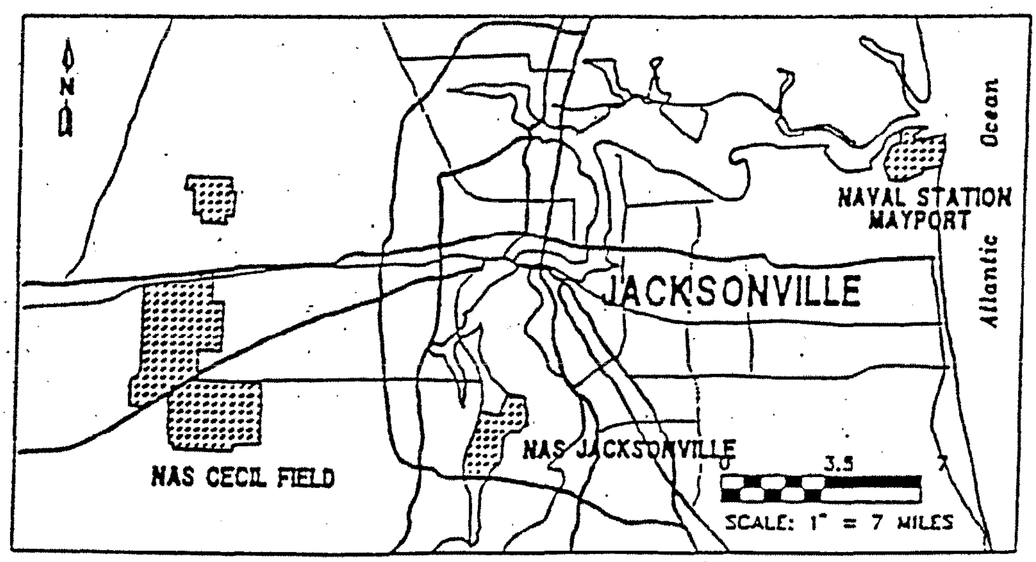


FIGURE 1
FACILITY LOCATION MAP

U.S. Naval Station
Mayport, Florida

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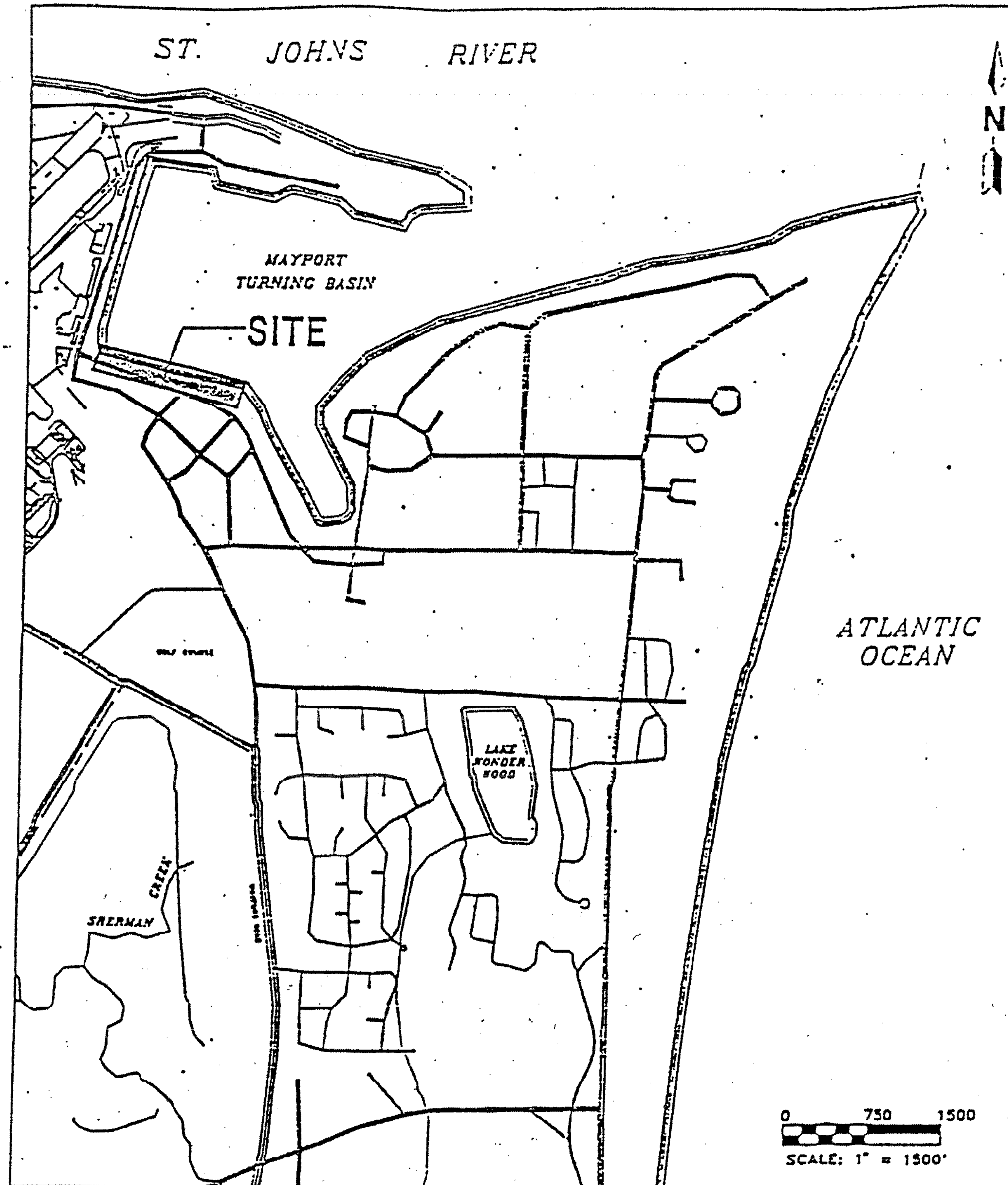


FIGURE 2
SITE LOCATION MAP

U.S. Naval Station
Mayport, Florida

1.0 SCOPE OF WORK

The remedial action conducted at the NS Mayport for the Alpha Delta Piers was rehabilitation of 310 linear ft of 15-in. diameter, 274 linear ft of 24-in. diameter, and 60 linear ft of 30-in. diameter storm sewer pipe at the Alpha Pier and Delta Pier, respectively. To accomplish this scope, the following services were performed:

- Mobilization
- Asphalt Demolition and Soil Excavation
- Cleaning of Storm Water Sewer Pipe
- Video Inspection of Storm Water Sewer Pipe
- Liner installation
- Site Restoration
- Demobilization

1.1 MOBILIZATION

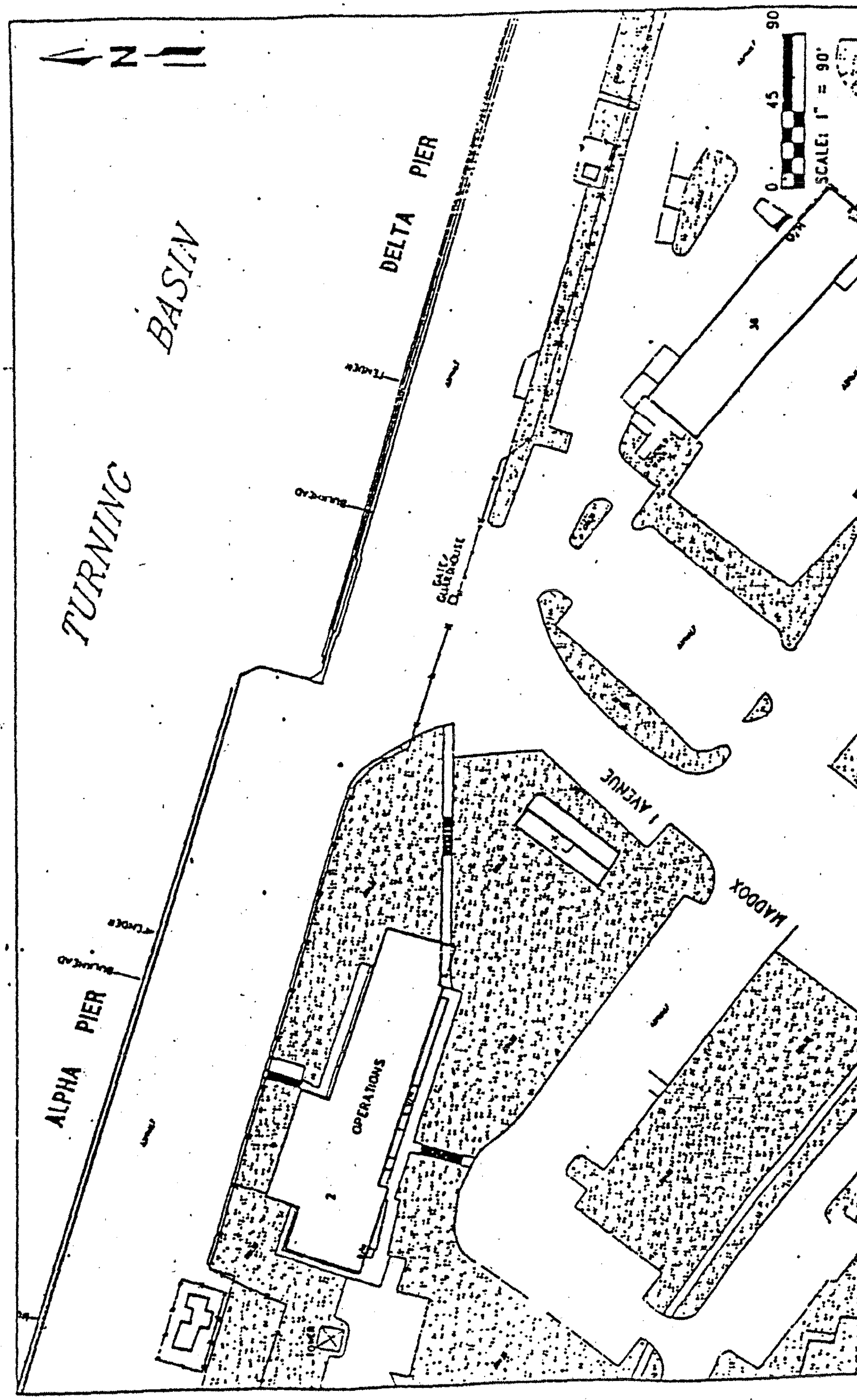
Mobilization activities were initiated on January 16, 1995. These activities included delivery to the job site and work areas all construction equipment, tools, materials, supplies and miscellaneous articles; establishing a workforce sufficient to commence and sustain construction activities, designating laydown and material storage areas; and securing necessary permits for performance of this project. Permits included:

- Hot Work Permit
- Oily Waste/Oily Water Transfer Permit

1.2 ASPHALT DEMOLITION AND SOIL EXCAVATION

Asphalt demolition and soil excavation was required to provide access to a junction at a storm sewer transition (24- to 30-in.) located at the Alpha Pier (Figure 3). Prior to excavation, BEI personnel visually surveyed for potential excavation interferences. The area was visually inspected to verify locations of manholes, transitions, overhead obstructions, and existing building foundations. BEI consulted with the NS Mayport Staff Civil Engineering department and jointly reviewed relevant utility drawings. To further reduce possible subsurface interference damage, all soil was excavated by hand, using shovels.

The approximate dimensions of the excavation were 4.5' wide x 5.0' long x 4.0' deep. The excavated soil was monitored for organic vapors using a Foxboro OVA 128 during excavation. Results of the monitoring were all non-detect (see copy of results in Appendix A). There was no visual or olfactory evidence of contamination. The soil was stored in 55 gallon DOT 17H drums, appropriately labeled and stored at the JSI Facility, NS Mayport.



Alpha Delta Piers
U.S. Naval Station
Mayport, Florida

FIGURE 3
SITE MAP

1.3 CLEANING OF STORM WATER SEWER PIPE

Prior to the installation of the liner, the storm sewer pipes were cleaned of vegetation, sediment, rocks and other debris. All water and materials generated were contained and stored onsite in a 20,000-gal storage tank. Cleaning operations were performed during low tide when the storm sewer discharge pipe invert elevation was above sea level. The discharge points were sealed by air inflated packers to prevent discharge of water and debris during cleaning.

1.4 VIDEO INSPECTION OF STORM WATER SEWER PIPES

Video inspection was required to verify storm sewer pipe had been sufficiently cleaned of materials and obstructions; to verify the layout and design of pipes (diameters, transitions, radii, junctions, etc.); and, after installation, to verify the liner had been properly installed.

1.5 LINER INSTALLATION

Installation included: determining liner diameters, diameters and locations of transitions, service inlet diameters and locations, and lengths of liner required; installing the liner according to manufacturer's instructions and specifications; restoring service inlet drainage; and cutting and removing excess liner material.

1.6 BACKFILL

Backfill consisted of soil previously excavated.

1.7 SITE RESTORATION

Asphalt repair was required after the excavation had been properly backfilled. Asphalt repair required placement and compaction of crushed lime rock. All work areas were routinely "policed" and kept free of trash, debris and obstructions.

1.8 WASTE MANAGEMENT

Water, vegetation, sediment, rocks and other debris were contained onsite in a 20,000-gal storage tank. Decanted water was discharged to the NS Mayport Oily Water Treatment Plant. Sediment and other debris cleaned from the storage tank were placed in 55 gallon DOT 17H drums, sealed, appropriately labeled, and staged at the JSI Facility, NS Mayport.

1.9 DEMOBILIZATION

Demobilization included decontamination of equipment, cleaning work areas, removing equipment from the work site, and removing and staging drummed materials.

2.0 APPROACH AND TECHNIQUES

The following section discusses the methodologies used to accomplish the objective of remediating the storm sewer pipes located at the Alpha Delta Piers. The storm sewer pipe rehabilitation was performed to preclude the spread of contamination into the NS Mayport turning basin via outfall discharge. Rehabilitation did not involve removal of contaminated materials. The scope of this rehabilitation project involved only the lateral extent of pipe sections lined. This did not include other additional sections of pipe nor junction structures encountered.

2.1 OBJECTIVES

The remedial action objective at NS Mayport was to line 310 linear ft of 15-in. diameter, 274 linear ft of 24-in. diameter, and 60 linear ft of 30-in. diameter storm sewer pipe located at Alpha Pier and Delta Pier, respectively. Lining was required to provide a barrier or seal to prevent infiltration and percolation of contaminants into the pipe through cracks, void spaces and other possible migration pathways. The pipe was lined with soft, flexible InSitu Form dry resin saturated polyester InSitutube (referred to as liner).

2.2 LINER INSTALLATION

Table 2-1 provides information regarding specific storm sewer pipe lined, including diameters, lengths of pipe linings, and dates of installation.

2.2.1 Cleaning

Prior to installation of the liner, the existing storm sewer pipe was cleaned. To prevent water and dislodged sediment from being discharged into the turning basin, the outfall of the pipes were plugged with an inflated packer.

The storm sewer pipes were cleaned by inserting a high pressure water jet with a peripherally ported head. The water jet was operated from the point of pipe entry and advanced to the terminus of each individual storm sewer pipe to be lined. The water jet was also operated during retraction. All water and associated sediment, rock and other debris generated was simultaneously vacuumed into a vacuum truck from a location at the pipe entry. The water and materials were then transported, discharged, and stored in a 20,000-gal storage tank located on the pier.

2.2.2 Video Inspection

After cleaning, storm sewer pipe lines were video inspected with a remote self-propelled video camera. All video inspections indicated pipes were sufficiently cleaned for lining. The video camera system featured a calibrated odometer. The odometer reading was used to indicate relative diameter transitions and inlet locations.

2.2.3 Liner Emplacement

The liner supplier pre-manufactured the liner with appropriate diameters, diameter transition locations, and lengths. The liners were delivered to the site and readied for installation. To reduce

Table 2-1
Storm Sewer Pipe Cleaned and Lined

Pier	Storm Sewer Pipe Diameter	Length	Date Cleaned	Date Liner Inspected
Alpha	15"	310'	01/12/95	01/24/95
	24"	67'	01/12/95	01/25/95
Delta	24"	207'	01/18/95	01/25/95
	30"	60'	01/24/95	01/25/95

friction between the liner and the storm sewer pipe interior walls, a 4-ml polyurethane tube was installed before liner installation.

The liner was installed in the existing pipe through access points (manholes or drainage inlets) via an inversion standpipe and inversion elbow. The liner material was "cuffed back" and mechanically strap-banded to the inversion standpipe, creating a closed system. Potable water from hydrants was used to fill the inversion standpipe. The force of the column of water (head pressure) turned the liner inside out and into the pipe. As the liner traveled through the pipe, water was continually added to maintain a constant pressure. Water pressure kept the liner pressed tightly against the walls of the existing storm sewer.

2.3.4 Curing

After the liner reached the termination point, water in the line was circulated through a heat exchanger where it was heated and returned to the liner. The heated water accelerated an endothermic reaction to harden the resin and form a structurally sound, jointless, internal pipe.

Once the liner had hardened and cooled, water pressure was released and the liner ends were trimmed with a pneumatic cutter. One service inlet (Delta Pier) was reinstated using a remote control cutting device.

3.0 MAJOR PROBLEMS ENCOUNTERED AND SOLUTIONS ADOPTED

Contingencies had not been planned for unforeseen situations encountered. The unforeseen situations included: (1) no access point at the designed terminating end of the 15-in. storm sewer pipe, Alpha Pier; and (2) the presence of a large junction box at the storm sewer transition, Delta Pier.

3.1 INSTALLATION ACCESS

During site mobilization, it was noted that there was no access point at the location of the terminal's west lateral, Alpha Pier. The original required installation of the liner was to terminate at the midpoint of the lateral (half-way between the manhole and the inlet drain). However, installation of the liner required open access at both ends of the pipe being lined. To rectify the situation, Navy approval was granted to extend the liner operation an additional 75 linear ft, thereby terminating at the existing drain inlet.

3.2 JUNCTION BOX OBSTRUCTION

During the cleaning operation of the 24-in. storm sewer pipe (Delta Pier), an obstruction was encountered. Video inspection revealed a 24- to 30-in. junction box at the storm sewer. Orientation of the 24- and 3-in. storm sewer pipe created a deflection of approximately 20°. The junction box dimensions were approximately 4.5 ft wide by 5.0 ft long by 3.0 ft high. The combination of the 5.0-ft transition span and a 20° angle prevented line cleaning equipment from negotiating the deflection. Therefore, to properly clean and install the liner, access to the transition junction box was required. The surface asphalt and approximately 3 ft of backfill was excavated to expose the transition junction top. The concrete top was opened using an air-powered jackhammer. After lining was completed, the transition junction box was backfilled. A 3/8-in. thick steel plate was placed to cover the hole created on the top of the transition junction box. Crushed limestone was compacted to the base of the adjacent undisturbed asphalt. Asphalt was then placed to the original elevation.

4.0 COSTS INCURRED AND DEVIATIONS FROM THE BUDGET

Deviations from the budget included the extension of the liner operation an additional 75 ft.

APPENDIX A

AIR MONITORING

Date:
Page: 1 of 2
ATTACHMENT: E

(DIRECT READING)

AIR MONITORING DATA SHEET

SITE: A/D Piers NS Mayport	WEATHER CONDITION: Sunny, windy	DATE: 1-25-95
PERSON PERFORMING MONITORING: Trent J Rogers		

EMPLOYEES PRESENT:	HRS PRESENT	EMPLOYEE'S COMPANY	INSTRUMENT TYPE	INFORMATION SERIAL NO.
Ensco - See Safety Meeting in Sub file	0830 ↓ until		OVA 128	

INSTRUMENTS CALIBRATION	PPE IN USE	PROCESS
NA ☒ YES ☐ NO ☐	CSE - wear tyvek for cleanliness	Slip forming A/D Piers

MONITORING DATA

LOCATION: REMARKS	TIME	OV (PPM)	LEL (%)	O_2 (%)	RAD	OTHER
Dd - top of Pier Liner Feed	0926	Ø				
JB - Surface - Chest high	0926	Ø				
D2 - top of Grate	0927	Ø				
D1 - Surface	0928	Ø				
D1 - Surface	0931	Ø				
D2 - ~~Surface~~ Top of Grate	0932	Ø				
JB - Surface	0933	Ø				
Dd - Top of Pier	0933	Ø				
JB - Surface H2O Input	1100	Ø				
A3 - Surface CSE Reading on Surface	1101	Ø				
A3 - At top of hole CSE - burn is cutting the line	1103	0.3-0.5 [illegible]				
A2 - Surface Liner Feed	1104	Ø				
A1 - Surface	1106	Ø-0.5				
A2 - Surface	1110	Ø				
A3 - Surface	1353	Ø				
A2 - Surface - Liner Head	1354	Ø				
A1 - Surface	1355	Ø				
Ad - Top of Pier	1356	Ø				
Outside of [illegible] on my truck (Verification)	1400	97				

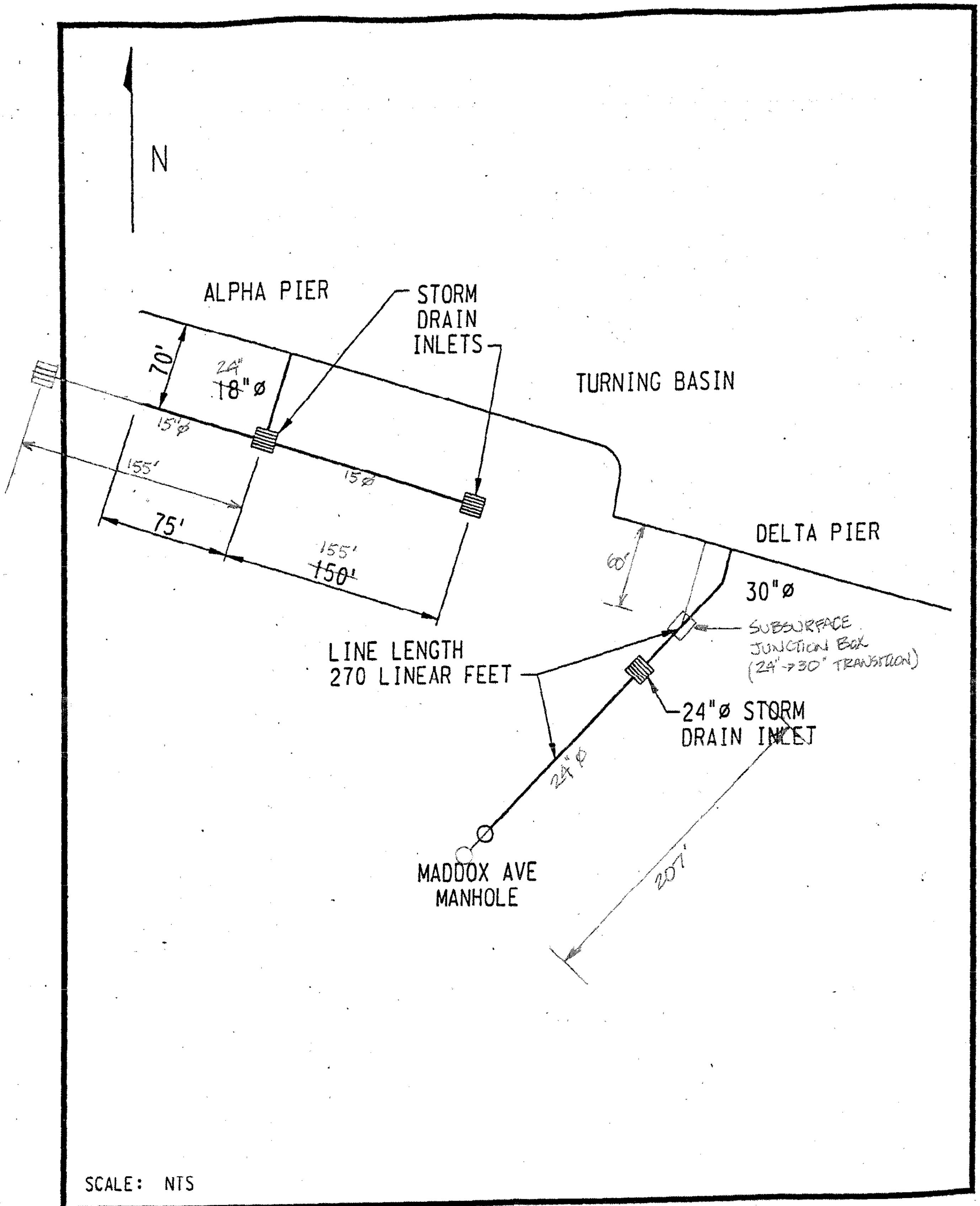
Date:
Page: 2 of 2
ATTACHMENT: E

AIR MONITORING DATA SHEET
ADDITIONAL COMMENTS/OBSERVATIONS/CALCULATIONS

Except for short duration CSE - all work is completed outside w/ optimal ventilation.

APPENDIX B

AS-BUILT AND MANUFACTURER'S PRODUCT DATA



22567 FIG 1-4 SVS
02/10/95

Figure 1-4
ALPHA DELTA PIER
PIPE SLIP LINING AS-BUILT

SUBMITTAL CHECKLIST

DO/TASK NO. 0010/5

PREPARED BY [signature] for V. McCain

DATE 3/27/95

Submittal Type	Required	Previously Submitted	N/A
Manufacturer's product data	✓		
As-built records	✓		
Drawings			✓
Test reports			✓
Construction samples			✓
Environmental Sampling Database			✓
Administrative submittals		✓	
Operation and maintenance manuals			✓
Quality control inspections	✓		
Manifests for hazardous waste disposal			✓
Certificate of Completion			✓
Final Release of Claims			✓
Administrative Record File documents		✓	

INSITUFORM®
SOUTHEAST, INC. An ENVIROQ Company

February 27, 1995

VIA FACSIMILE NO.: 904-779-8999
Mr. Steve Santa Maria
BECHTEL
Quarters E, G Avenue
P.O. Box 171
NAS Cecil Field
Jacksonville, FL 32215

RE: Liner of Storm Drain Pipes at Alpha Delta Piers,
U.S. Naval Station, Mayport, Florida

Dear Sir:

This is to confirm that all lines were cleaned in accordance to Insituform technology specs. In addition, the Insituform was installed in accordance to manufacturer's specifications, along with ASTM F1216.

Insituform Southeast had no problems with the installation of any of the Insitupipes. The end product was found to be in excellent condition, as evidenced in the video tapes already provided to you.

If we can be of any further assistance please feel free to call.

Sincerely,

Richard T. Howton

Richard T. Howton
Project Manager

RTH/pm

RECEIVED
MAR 0 1 1995
V. HERMANN BAUER

P.O. Box 41629 • 11511 Phillips Highway South • Jacksonville, Florida 32203
(904) 262-5802 • WATS 1-800-633-8362 • In Florida 1-800-342-1907

ENHANSCO
9 EAST MADISON STREET
BALTIMORE, MD 21202
(410) 332-8044

CERTIFICATE OF COMPLIANCE

Date: January 6, 1995

Customer Name: Insituform Southeast, Inc

Proposal Number: 22567-241-SC-0057

Job Name: Pipe Slip Lining Services

Location: NS Mayport, Florida

Client: Bechtel Environmental Inc

Method of Shipment: Bulk

This certifies that the Insituform resin (Polyester Resin 7-5810PM) was manufactured in accordance with specifications of Insituform Technologies, Inc., and requirements of manufacture by Enhansco.

Submitted by

James A. McCormick
James A. McCormick
General Manager

Phyllis T. Hensley
Notary
PHYLLIS T. HENSLEY
NOTARY PUBLIC STATE OF MARYLAND
My Commission Expires February 1, 1997

RECEIVED
JAN 1 0 1995
BECHTEL 22567

Insituform Technologies, Inc.
1770 Kirby Parkway, Suite 300
Memphis, TN 38138
901-759-7473, Fax 901-759-7500

Insituform Technologies.

CERTIFICATE OF COMPLIANCE

Date: January 6, 1995

Customer Name: Insituform Southeast, Inc.

Customer Reference: Bechtel Environmental, Inc.
Project: NC Mayport
Job No.: 22567

Description: 18", 24" and 30" Diameter Insitutubes

This is to certify that Insitutubes furnished under the above customer reference will be manufactured in accordance with specifications of Insituform Technologies, Inc.

Lynn E. Osborn
Product Manager

STATE OF TENNESSEE
COUNTY OF SHELBY

Notary
My Commission Expires Nov. 3, 1997

My Commission Expires

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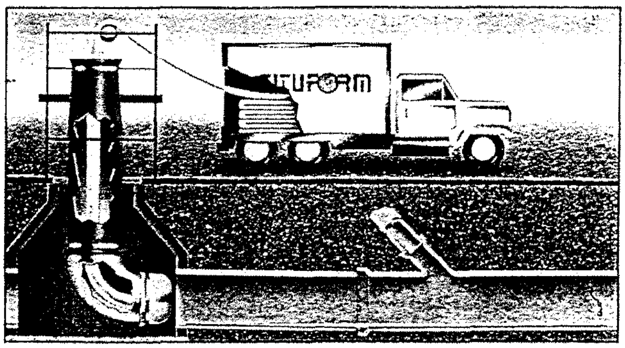
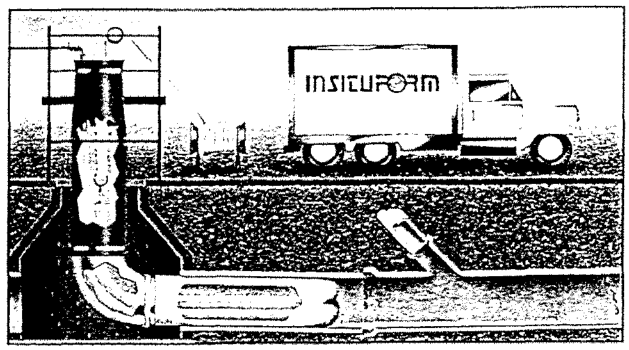
BECHTEL 22567

How Insituform® Is Installed

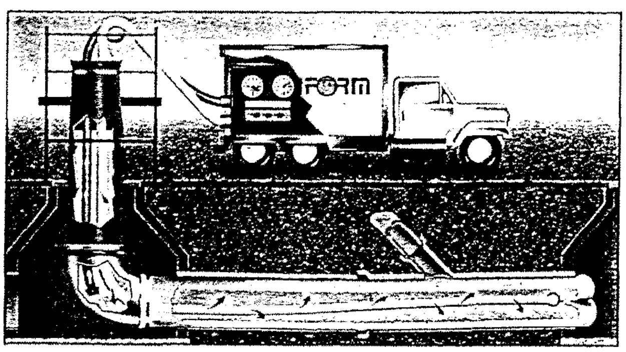
Insituform is a proven process for reconstructing damaged pipeline systems in municipal and industrial applications without digging. A flexible, resin absorbent, fabric Insitutube*, coated on the outside with an elastomeric material, is custom engineered and manufactured to fit the cross-section, length and required design thickness for the damaged pipe. The Insitutube is saturated (wet-out) with a liquid thermosetting resin. Resin selection is determined by the effluent characteristics and type of service (gravity vs. pressure). Insituform is installed using an inversion technique which allows the material to negotiate bends, accommodate changes in pipe alignment and size, and span missing pipe segments. A new Cured-in-Place Pipe (CIPP), or Insitupipe*, is formed inside of the existing conduit as follows (other inversion techniques can be used for several applications):



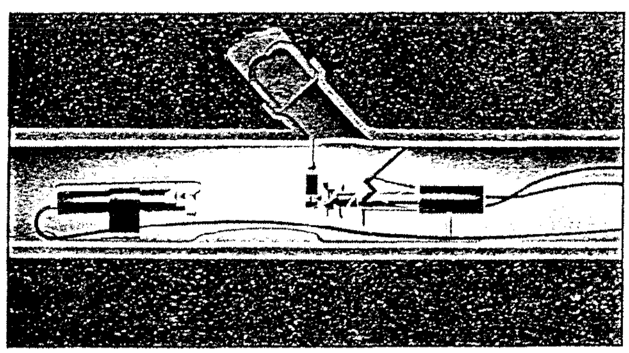
STAGE 1 The resin saturated material is installed in the existing pipe through a manhole or other access point via an inversion standpipe and inversion elbow. The Insitutube is cuffed back and banded to the inversion elbow, creating a closed system that allows the water inversion process to take place.



STAGE 2 Water from nearby hydrants, or other convenient source, is used to fill the inversion standpipe. The force of the column of water turns the wet-out Insitutube inside-out and into the pipe being reconstructed. As the Insitutube travels through the pipe, water is continually added to maintain a constant pressure. The water pressure keeps the Insitutube pressed tightly against the walls of the old pipe.



STAGE 3 After the Insitutube reaches the termination point, the water in the line is circulated through a heat exchanger where it is heated and returned to the Insitutube. The hot water cures the thermosetting resin, causing it to harden into a structurally sound, jointless "pipe-within-a-pipe," an Insitupipe*.



STAGE 4 Once the Insitupipe has hardened and cooled, the water pressure is released and the ends are trimmed. Service connections are reinstated internally with a remote control cutting device or by man-entry techniques. The Insituform operation is then completed, and the newly installed pipe is ready for immediate use. All this is accomplished without excavation.

INSITUFORM®

1-800-234-2992

Key# AB1099 1/93

Insituform[*] Specification

1. INTENT

1.1 It is the intent of this specification to provide for the reconstruction of pipelines and conduits by the installation of a resin-impregnated flexible tube (Insitutube®) which is inverted into the original conduit by use of a hydrostatic head. The resin is cured by circulating hot water within the tube. When cured, the finished pipe (Insitupipe®) will be continuous and formed to the original conduit. This reconstruction process can be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and ventilation systems.

1.2 This is a standard specification and may require modification for specific job conditions.

2. REFERENCED DOCUMENTS

2.1 This specification references ASTM F1216 which is made a part hereof by such references and shall be the latest edition and revision thereof. ASTM F1216 shall govern when this specification does not address installation methods and materials. If there is a conflict between ASTM F1216 and this specification, this specification will govern.

3. PREQUALIFICATION

3.1 Only bids from prequalified products and contractors will be read. Bids submitted on products or from contractors that have not been prequalified will be returned unopened. The contractor and the proposed method of reconstruction shall be clearly and legibly identified on the bid envelope.

4. MATERIALS

4.1 Tube – The Insitutube material shall meet the rquirements of ASTM F1216.

4.1.1 The Insitutube shall be fabricated to a size that when installed will form to the internal circumference and length of the original pipe. Allowance should be made for circumferential stretching during inversion.

4.1.2 The outside layer of the Insitutube (before inversion) shall be plastic coated with a transparent flexible material that is compatible with the resin system used. The plastic coating shall not be subject to delamination after cure of the Insitutube.

4.1.3 The Insitutube shall contain no intermediate or encapsulated elastomeric layers. No materials shall be included in the tube that are subject to delamination in the cured Insitupipe.

4.2 Resin – The resin system shall meet the requirements of ASTM F1216.

4.3 The wall color of the interior pipe surface of the Insitupipe after installation shall not be of a dark or non-reflective nature that could inhibit proper closed circuit television inspection.

5. STRUCTURAL REQUIREMENTS

5.1 The Insitupipe shall be designed as per ASTM F1216, with the following additional requirements:

5.1.1 The Insituform design shall assume no bonding to the original pipe wall.

5.1.2 External Hydrostatic Design – Acceptable third party testing and verification of the enhancement factor, K, shall be submitted.

5.1.3 External Buckling Design – Where the Insitupipe is designed as a stand alone pipe, a fully deteriorated condition, acceptable third party testing and verification of design analysis techniques shall be submitted. This testing requirement can be accomplished with soil box testing.

5.2 The bond between Insitupipe layers shall be strong and uniform. All layers, after cure, must form one homogeneous structural pipe wall with no part of the tube left unsaturated by resin.

6. TESTING REQUIREMENTS

6.1 Chemical Resistance – The Insitupipe shall meet the chemical resistance requirements of ASTM F1216. Samples for testing shall be of tube and resin system similar to that proposed for actual construction. It is required that Insitupipe samples with and without plastic coating meet these chemical testing requirements.

6.2 Hydraulic Capacity – Calculations must support that the finished Insitupipe shall have at least 100% of the full flow capacity of the original pipe before rehabilitation. Calculated capacities may be derived using a commonly accepted roughness coefficient for the original pipe material. A typical roughness coefficient for the Insitupipe shall be as verified by third party test data.

6.3 Field Samples – To verify past performance, the manufacturer shall submit a minimum of 15 test results from previous field installations of the same resin system and tube material as proposed for the actual installation. These test results must verify that the physical properties specified in section 4.2 of this specification have been achieved in previous field applications.

7. INSTALLATION

7.1 Insituform installation shall be in accordance with ASTM F1216 with the following additional requirements:

7.1.1 Resin Impregnation – The quantity of resin used for tube impregnation shall be sufficient to fill the volume of air voids in the tube with additional allowances for polymerization shrinkage and the loss of resin through cracks and irregularities in the original pipe wall. A vacuum impregnation process shall be used. A roller system shall be used to uniformly distribute the resin throughout the tube.

7.1.2 Service Reconnections – No more than one excavation will be allowed for service reconnections in any ten reconnections. Any costs related to additional excavations will be entirely at the installer's expense.

8. INSPECTION

8.1 For each inversion length designated by the owner of the contract documents or purchase order, one Insitupipe sample shall be prepared using one of the following methods.

8.1.1 The sample shall be cut from a section of the cured Insitupipe at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample shall be fabricated from material taken from the Insitutube and the resin/catalyst system used and cured in a clamped mold placed in the downtube.

8.2 The Insitupipe samples shall be tested in accordance with ASTM F1216.

8.3 Leakage testing of the Insitupipe shall be accomplished during cure while under a positive head.

8.4 Visual inspection of the finished Insitupipe shall be in accordance with ASTM F1216.

9. CLEAN-UP

9.1 Upon acceptance of the installation work and testing, the Installer shall reinstate the project area affected by the operations.

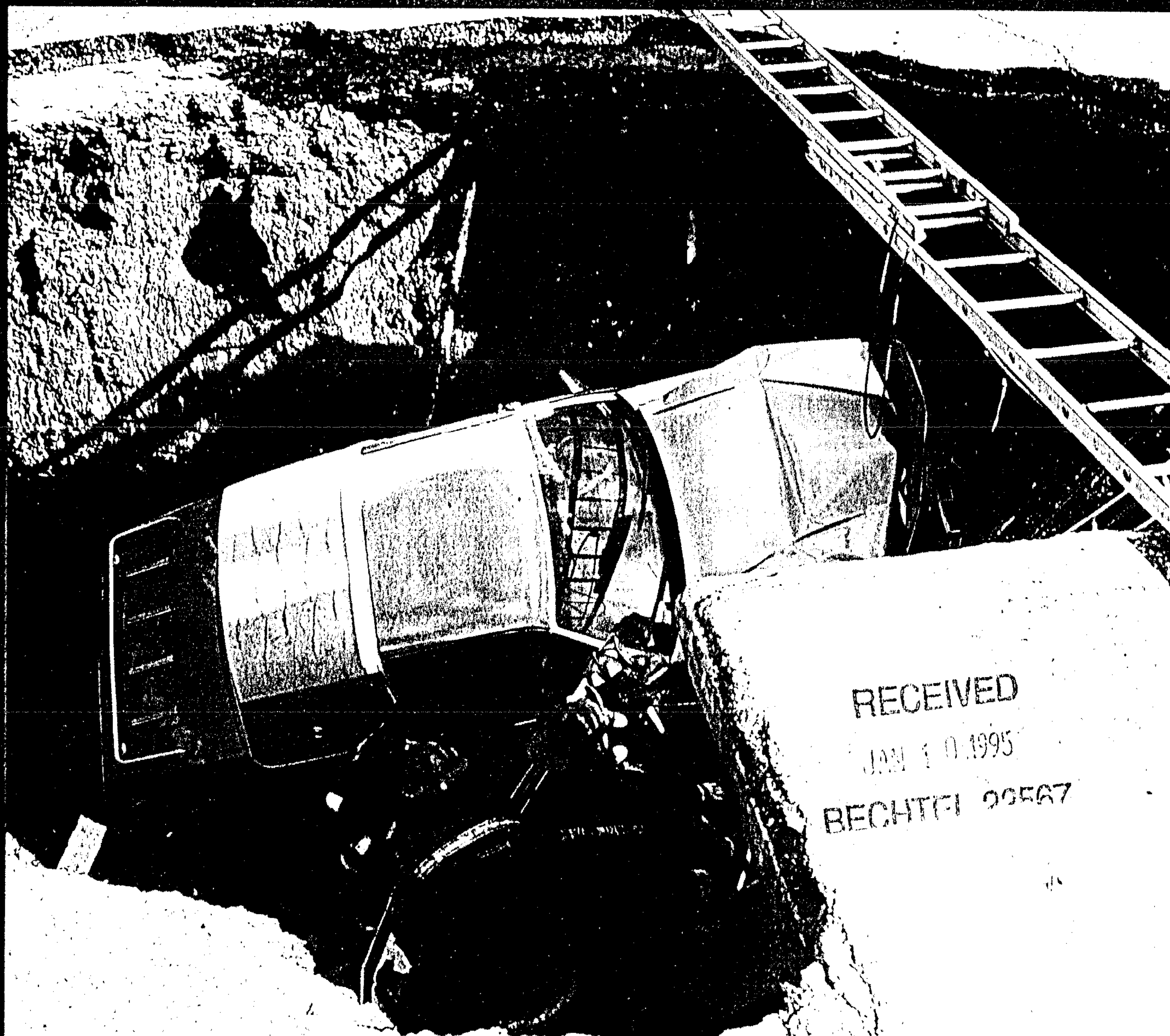
10. PAYMENT

10.1 Payment for the work included in this section will be in accordance with the prices set forth in the proposal for the quantity of work performed. Progress payments will be made monthly based on the work performed during that period.

NOTE:

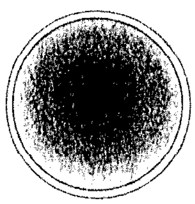
The Specification for Insituform is written to cover typical Insituform installations. Unusual job conditions may require modification to the specification.

America's sewers are collapsing.

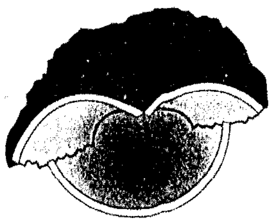


Buried pipes fail because they leak and lose soil support

When pipes are completely surrounded by well-packed soil, it is almost impossible for them to collapse.

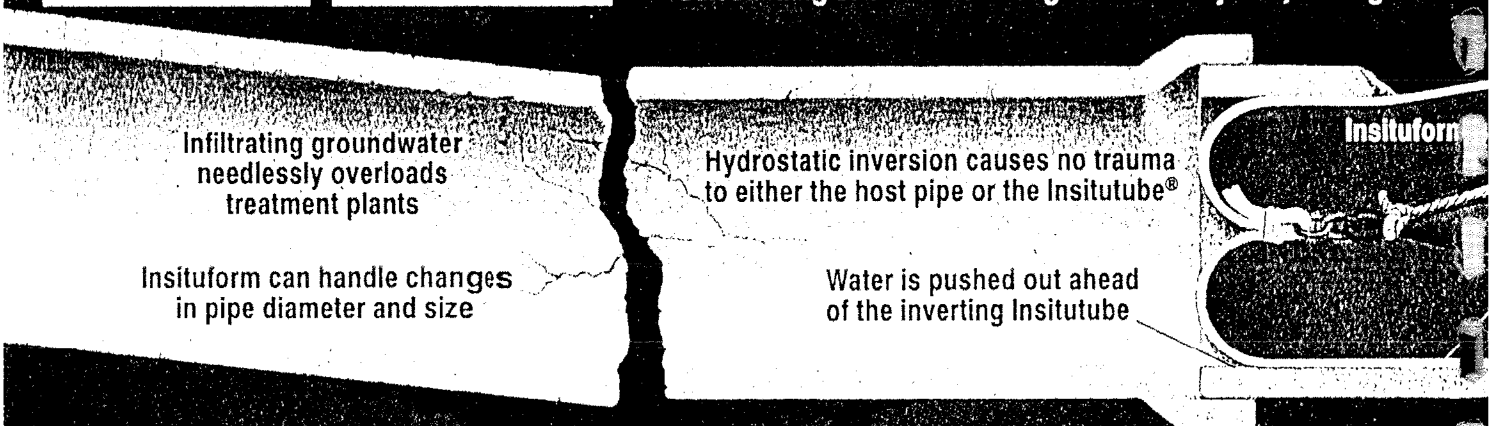


Without soil support, loads can push the walls outward, allowing the pipe to collapse.



Insituform® stops the leaks that lead to collapse

Surrounding soil washes through cracks and joints, leaving voids.



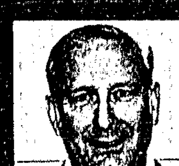
Leaking pipes are dangerous and expensive. They're dangerous when chemical wastes and raw sewage leak into the environment *and* they're expensive when groundwater leaks *into* your wastewater collection system. Infiltration erodes soil from around pipelines, creating underground voids. Soil voids seriously weaken pipelines by removing critical sidefill support, and they lead to depressions, potholes, and even street collapse. Plus, groundwater leaking into your collection system creates an extra burden on your city's treatment plant.

Leaks usually occur at joints, cracks, and in sections of pipe destroyed by sulfide gases. Insituform stops these leaks because it is jointless and spans missing sections, cracks and offset joints. Insituform also adds strength, stops root intrusion, and leaves no annular space. In addition, it is resistant to corrosion and abrasion and normally increases flow capacity.

When your pipelines have been reconstructed with Insituform, your streets and buildings will be on solid ground. Sewage will be kept in, and groundwater will be kept out.

"We simply can't afford to dig up and replace our crumbling sewers."

John Koeper
Director of Operations
Metro St. Louis District



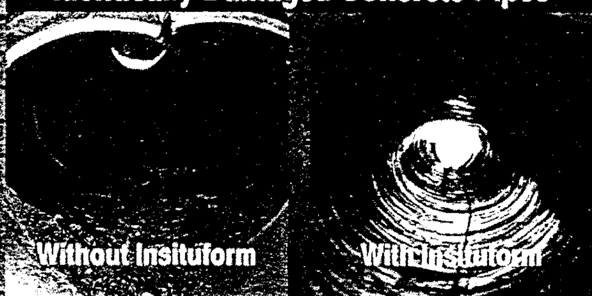
"With only four miles of reconstruction Insituform reduced flow at our treatment plant by a half million gallons a day."

Gene Tewalt
Director of Public Works
Front Royal, Virginia

Independent tests prove Insituform® restores structural integrity to damaged pipe

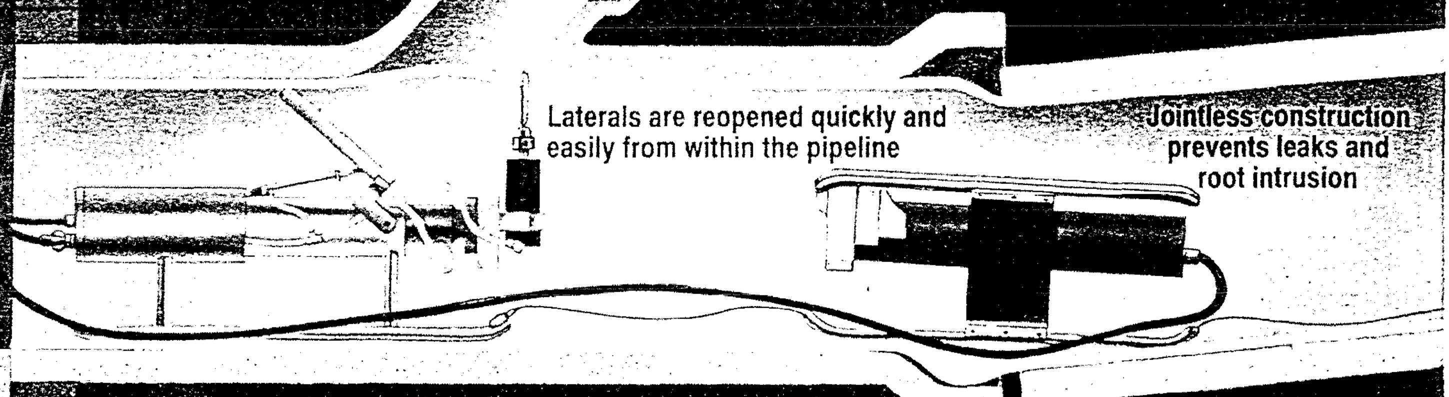
Insituform® is a structural pipe that resists corrosion and abrasion

Identically Damaged Concrete Pipes



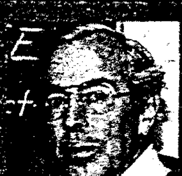
Sulfuric acid in sewers can destroy concrete pipes

Insitupipe is unaffected by sulfide gases



The structural performance of the Insitupipe tested by Dr. Reynold K. Watkins at Utah State University exceeded design projections. Two identically-damaged concrete pipes were buried in a test cell, and one was reconstructed by Insituform. Then, both pipes were simultaneously subjected to pressure equivalent to a burial depth of 72 feet. When the test ended, the unrepaired pipe had deflected significantly more than had the Insituform-repaired pipe. In fact, the unrepaired pipe was completely shattered. The Insituform-repaired pipe was still completely serviceable because no breaks had developed. Contact your local Insituform licensee for a complete copy of the test report.

Hydrogen sulfide (H_2S) is a flammable, poisonous gas formed by the bacteria in the slime layer of sewage. When this gas escapes from the sewage, it frequently merges with condensation in the crown of pipelines and changes into sulfuric acid (H_2SO_4) which can destroy concrete very quickly. Insitupipe is very resistant to sulfide gases. In fact, samples of Insitupipe have been submerged in 10% sulfuric acid at our research laboratory for more than a year without suffering any damage. Insituform also has the ability to enhance resin formulations and make your pipeline resistant to the effects of almost any chemical or material it must carry.



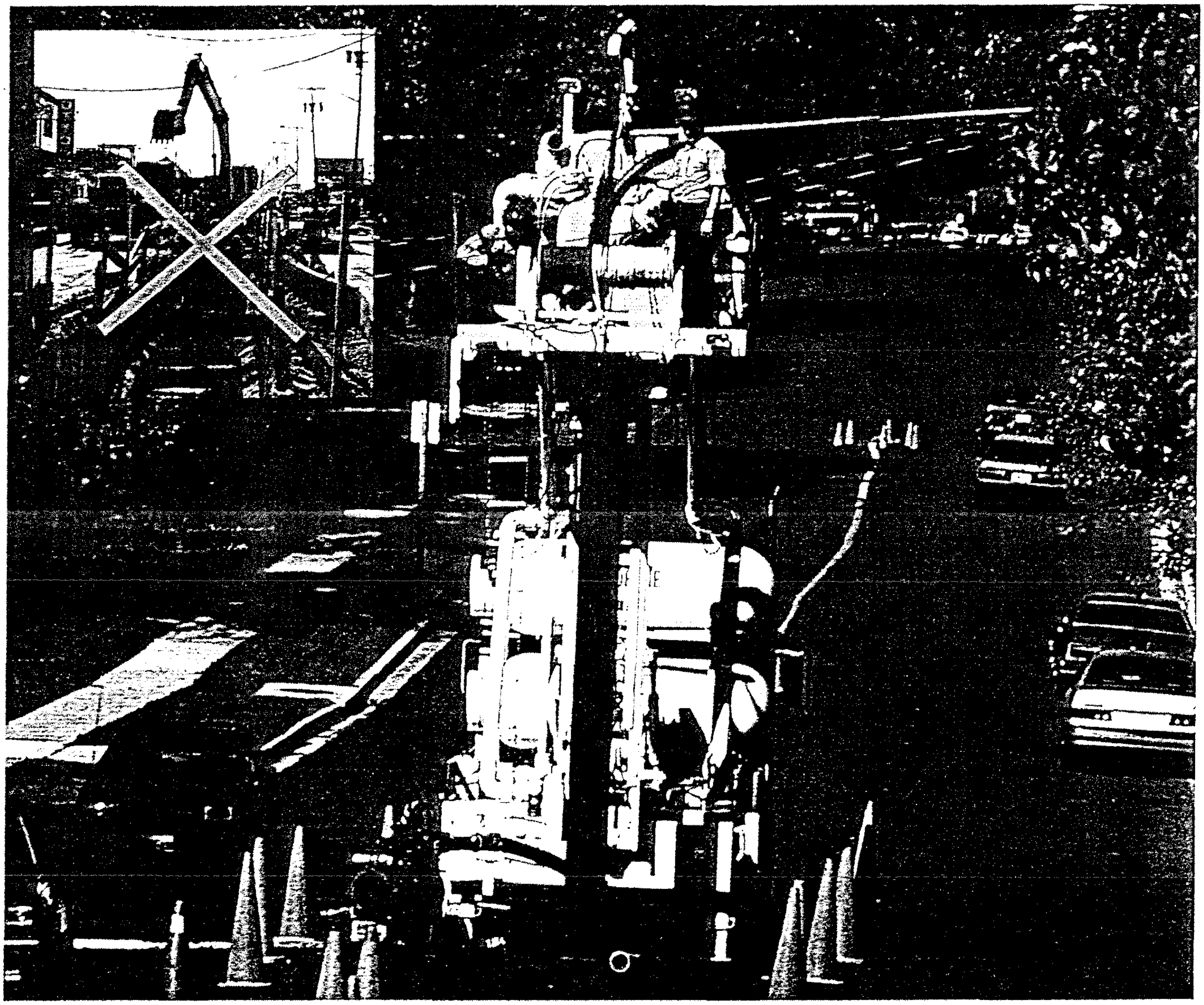
"Insituform added at least 50% to the strength of the test pipe."

Dr. Reynold K. Watkins
Professor of Engineering
Utah State University

"Insituform that we specified over ten years ago has held up beautifully."

Jack Dillard
Senior Project Engineer
Briley, Wild and Associates
Ormond Beach, Florida

Insituform has reconstructed over 10 million feet of pipeline without digging, danger or disruption.



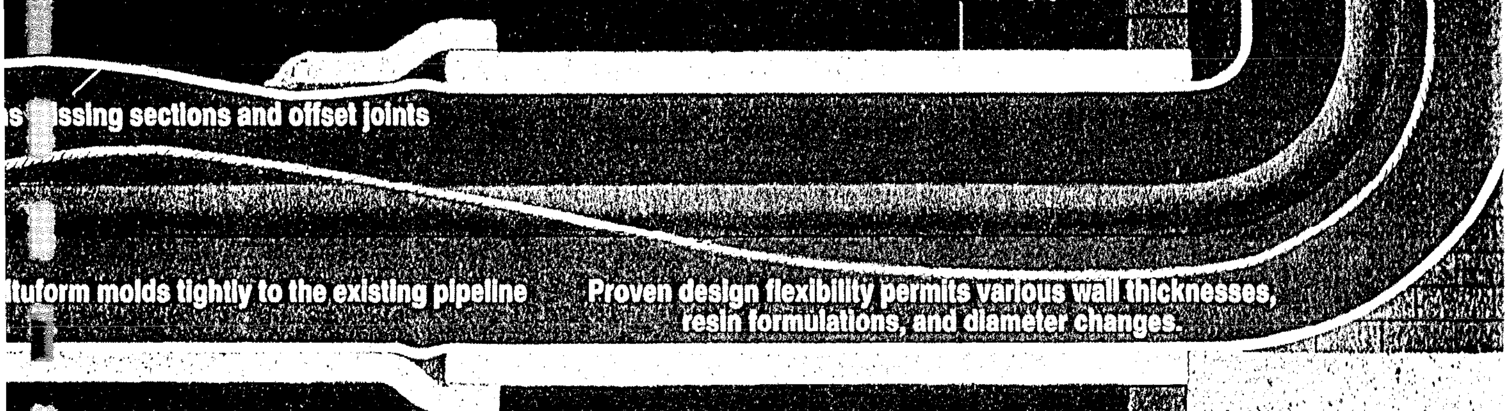
With 20 years of proven experience and over 10 million feet of pipeline installed, Insituform has distinguished itself as the proven leader of trenchless pipeline reconstruction. As a result, you don't have to put up with leaking pipes, cave-ins, pollution, potholes, and overtaxed treatment plants. And you can avoid plant shutdowns, loss of sales from blocked businesses, and all the detours, dirt, danger, delays and disruption digging can cause.

Insituform® gives you more for your money than you get with other methods

Insituform works through existing manholes to hydrostatically invert a soft, flexible Insitutube® that is impregnated with a thermosetting resin.

After the Insitutube is in place, the water used to invert it is heated to cure the resin and form a tight-fitting, structural Insitupipe™.

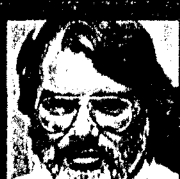
Recent flow studies by Sverdrup Corporation/SESI found in-service Insitupipe sewers to have 33% lower roughness (Manning "*n*") than in-service clay and concrete sewers. The results indicate potentially significant flow improvement when existing sewers are reconstructed with Insitupipe.



It's not unusual for 25% of a reconstruction budget to be used to restore property damaged by digging. Even then, property owners are seldom satisfied with the result. Insituform can reconstruct hundreds of feet of pipe in a day working through existing manholes without blocking streets or crossing private property. And, Insituform is practically maintenance-free. Its smooth, jointless inner surface resists slime and sediment buildup so it seldom needs cleaning. Installation and supervision costs are much less than when digging is involved, and subsequent repairs will be unnecessary because an Insitupipe is structural and resistant to abrasives and chemicals, including H_2SO_4.

Municipalities can't afford the time, expense and disruption caused by dig-and-replace reconstruction methods. Insituform installers can rebuild hundreds of feet of pipe in only a few hours. Meanwhile, city services and commerce are undisturbed. With Insituform there are no dangerous open trenches, mounds of dirt or congested traffic that can interrupt business and interfere with services.

Beyond its short-term advantages, Insituform is made to last. The 10 million feet of Insitupipe already installed in the United States will remain a cost-effective solution to the problem of crumbling underground infrastructure well into the 21st century.



"So far, WSSC has saved $35 million with Insituform."

Richard Thomasson
Systems Maintenance Division Head
Washingtom Suburban
Sanitary Commission

"A sound infrastructure is vital to our community's growth."

Mayor Paul Helmke
Fort Wayne, Indiana

Stop leaks, add strength, and increase flow. Without digging.

MADE IN AMERICA ★ AND PROUD OF IT

It may sound impossible, but it's true. Insituform has been reconstructing municipal and industrial pipelines for over 20 years. In fact, there are now over 10 million feet of Insitupipe™ in service worldwide.

You don't have to put up with leaking pipes, cave-ins, pollution, potholes, and overtaxed treatment plants. Insituform can reconstruct your pipelines in a matter of hours without digging. And you can avoid plant shutdowns, loss of sales (and tax revenues) from interrupted businesses, and all the detours, dirt, danger, delays, and disruption digging can cause.

To find out more about what the proven leader in trenchless pipeline reconstruction can do for you, call or write today.

1-800-633-8362

(In Florida, call 1-800-342-1907)

YOU GET ALL THESE BENEFITS WITH INSITUFORM

- ○ Installs without digging
- ○ Adds structural strength
- ○ Increases flow capacity
- ○ Fits most shapes and sizes
- ○ Fast installation
- ○ Leaves no annular space
- ○ Jointless construction
- ○ Negotiates 90° bends
- ○ Custom wall thickness
- ○ Handles transitions in size and shape
- ○ Stops leaks and root intrusion
- ○ Resists corrosion and abrasion
- ○ No digging to reconnect laterals

- ○ A network of highly-trained installers
- ○ Quick response to emergencies
- ○ On-time delivery and installation
- ○ Custom designed by highly-trained engineers
- ○ Ongoing research and development
- ○ Quality assurance

- ○ National technical support
- ○ Made in the USA

INSITUFORM®

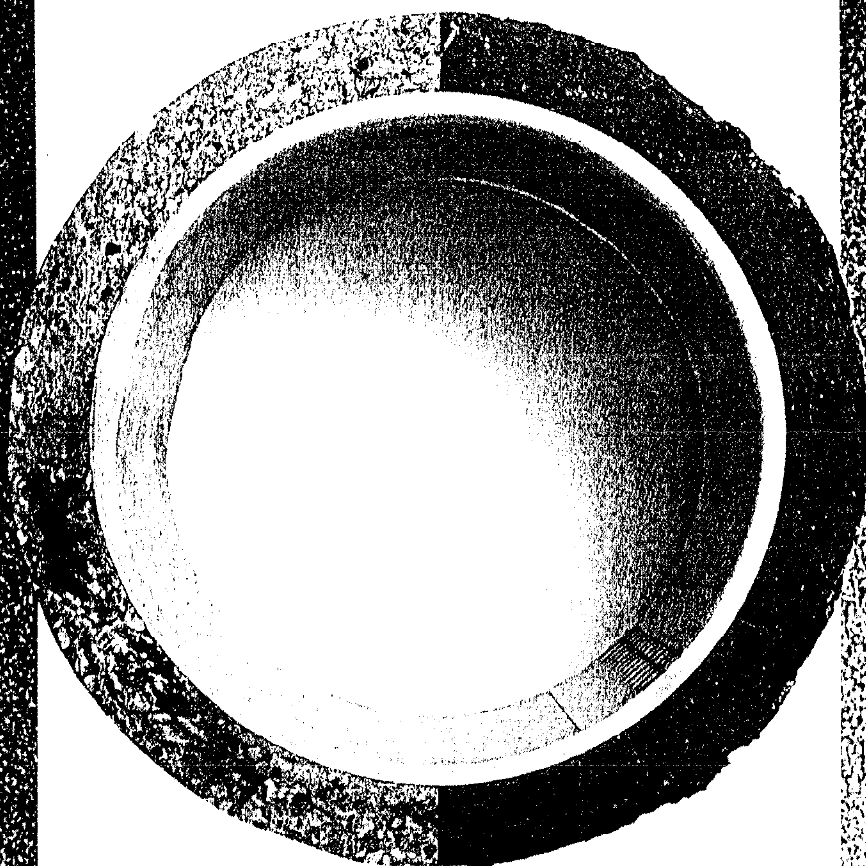
The Proven Leader In Trenchless Pipeline Reconstruction

CHARTER MEMBER NASTT

AB1076/60M/5-91

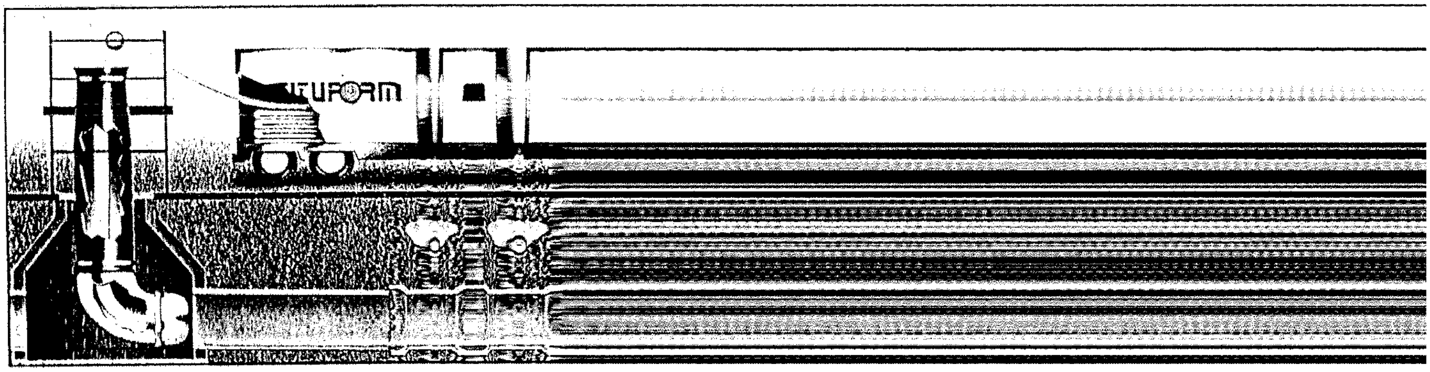
INSITUFORM SOUTHEAST, INC. • P.O. BOX 41629 • 11511 PHILLIPS HIGHWAY SOUTH • JACKSONVILLE, FL 32256 • (904) 262-5802 • FAX (904) 262-6994

Design Guide for Trenchless Pipeline Reconstruction

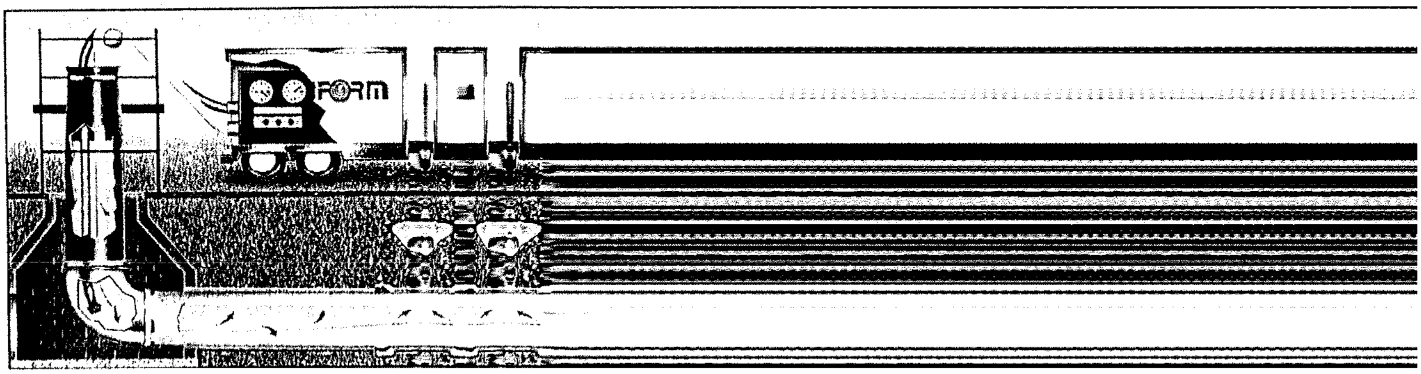


INSITUFORM®

How Insitu



STAGE 1 The resin saturated mate
existing pipe through a manhole or
an inversion standpipe and inversion
material is cuffed back and banded to
creating a closed system that allows
process to take place.



STAGE 3 After the Insitutube reache
the water in the line is circulated thr
where it is heated and returned to th
water cures the thermosetting resin
into a structurally sound, jointless
an Insitupipe® cured-in-place pipe

Insituform®, Insitu

Other Design Conditions

In partially deteriorated applications, special design techniques are available to evaluate localized conditions involving missing segments of pipe at the crown and flat portions of the pipe circumference where deposits cannot be removed.

Insituform can be designed to withstand all live loads and dead loads in the case where the existing pipe is fully deteriorated. Please refer to the Insituform Engineering Design Guide and/or the Utah State University Structural Tests.

Insituform is also available for internal pressure pipeline applications. Contact an Insituform representative for assistance.

Flow Characteristics

Insituform usually improves flow capacity, as demonstrated in an independent study by Sverdrup Corporation, due to smooth transitions at offsets and protrusions, no joints between manholes, and a smoother surface. The traditional Manning equation can be used to determine specific flowrates by substituting appropriate before and after conditions. An average Manning coefficient (n) value of 0.010 can be expected in Insitupipes that have been in service long enough to develop any slime layers. For rough-walled or corrugated Insitupipes, a higher n value can be expected.

For circular pipes, before and after Insituform flowrates can be compared as follows:

Gravity Pipes

$$\%\ \text{New Flow Capacity} = \frac{n_{existing}}{n_{Insituform}} \left[\frac{D_{Insituform}}{D_{existing}}\right]^{8/3} \times 100$$

Where n = Manning coefficient
D = inside pipe diameter, inches

Table 3 illustrates the increased flow capacity after Insituform installation with respect to pipe material and various dimension ratios (DRs). Existing pipe flow equals 100 percent.

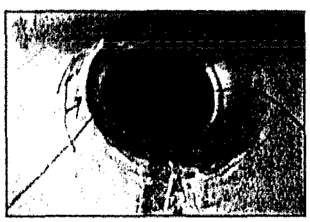
TABLE 3

Pipe Material and 'n' Value		Insitupipe DR*			
		30	40	50	60
Clay Pipe	n = 0.013	108%	114%	117%	119%
Concrete Pipe	n = 0.015	125%	131%	135%	137%

*Assumes Insitupipe 'n' = 0.010
Existing pipe flow = 100%

Stop leaks, add strength, and increase flow; Without digging.


Before

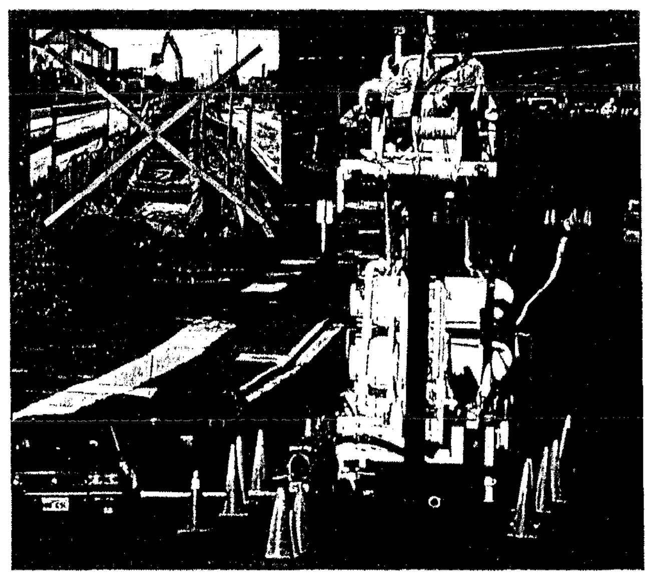

After

Insituform's patented process is being used all across America by thousands of municipalities and industrial plants to restore crumbling sewers and other pipeline systems to better than new condition. Without excavation.

With more than 20 years experience and over 22 million feet of successful reconstruction, Insituform is a proven leader of the trenchless pipeline reconstruction industry.

Insituform can reconstruct hundreds of feet of pipeline in a day working through existing manholes without blocking streets or disturbing private property. And, Insituform creates a structural pipe with proven design flexibility which permits various wall thicknesses, resin formulations, and changes in shape and diameter. Jointless Insituform stops leaks and root intrusion and independent tests found that Insituform increases flow capacity.

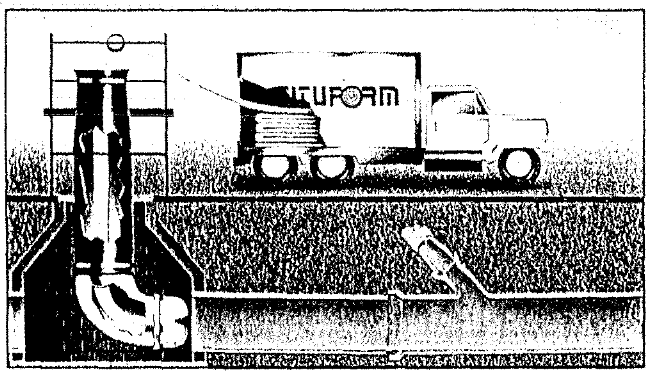
Insituform is less complicated and usually less expensive than dig-and-replace projects. It eliminates extensive surveys, material specifications, easements, change orders, delays, and cost overruns.



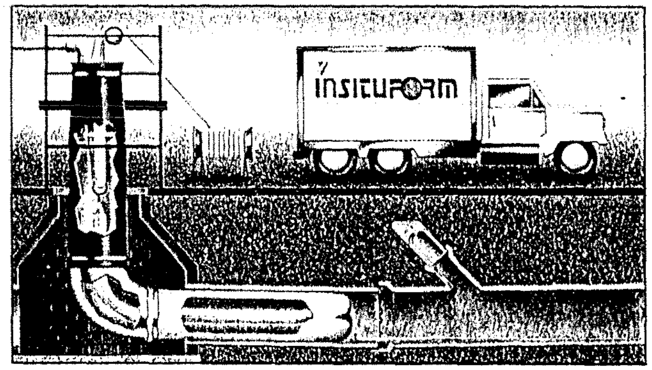
Any way you shape it, Insituform is the sensible solution to pipeline restoration.

Note: The information presented in this guide is condensed from a more comprehensive work entitled *Insituform Engineering Design Guide*, which is available upon request. The design information is based on tests performed in the United States and Great Britain, standard engineering formulae, and extensive experience in the installation of the Insituform product. This information is proprietary to Insituform, a licensed process, and can only be used in connection with Insituform design applications. The use of this guide should be incorporated along with good engineering practices and judgement.

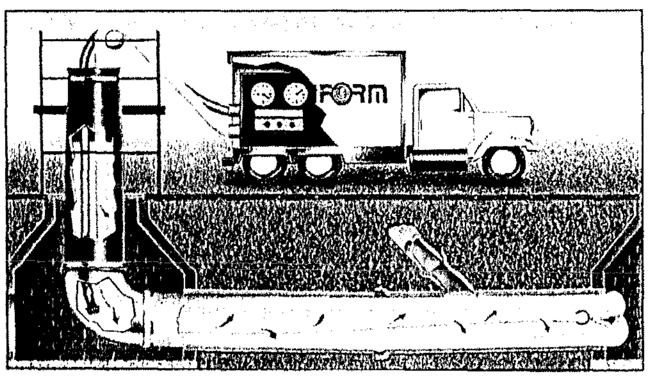
How Insituform Is Installed



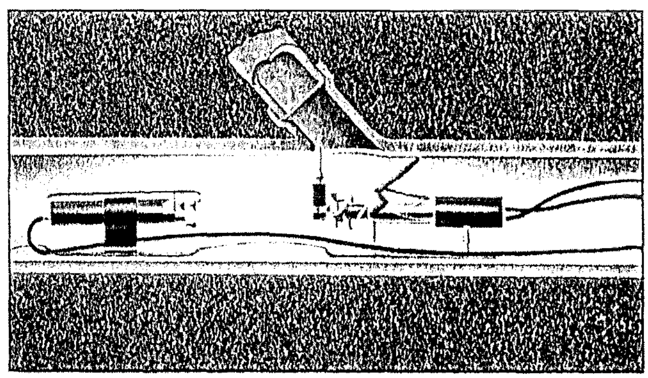
STAGE 1 The resin saturated material is installed in the existing pipe through a manhole or other access point via an inversion standpipe and inversion elbow. The Insitutube material is cuffed back and banded to the inversion elbow, creating a closed system that allows the water inversion process to take place.



STAGE 2 Water from nearby hydrants, or other convenient source, is used to fill the inversion standpipe. The force of the column of water turns the wet-out Insitutube inside-out and into the pipe being reconstructed. As the Insitutube travels through the pipe, water is continually added to maintain a constant pressure. The water pressure keeps the Insitutube pressed tightly against the walls of the old pipe.



STAGE 3 After the Insitutube reaches the termination point, the water in the line is circulated through a heat exchanger where it is heated and returned to the Insitutube. The hot water cures the thermosetting resin, causing it to harden into a structurally sound, jointless "pipe-within-a-pipe," an Insitupipe® cured-in-place pipe.



STAGE 4 Once the Insitupipe has hardened and cooled, the water pressure is released and the ends are trimmed. Service connections are reinstated internally with a remote control cutting device or by man-entry techniques. The Insituform operation is then completed, and the newly installed pipe is ready for immediate use. All this is accomplished without excavation.

INSITUFORM®
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If not listed in the current combined Index, will appear in the next edition.

Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube[1,2,3]

This standard is issued under the fixed designation F 1216; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes the procedures for the reconstruction of pipelines and conduits (4 to 96 in. diameter) by the installation of a resin-impregnated, flexible tube which is inverted into the existing conduit by use of a hydrostatic head or air pressure. The resin is cured by circulating hot water or introducing controlled steam within the tube. When cured, the finished pipe will be continuous and tight-fitting. This reconstruction process can be used in a variety of gravity and pressure applications such as sanitary sewers, storm sewers, process piping, electrical conduits, and ventilation systems.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for informational purposes only.

1.3 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.4.2.

2. Referenced Documents

2.1 *ASTM Standards:*

D 543 Test Method for Resistance of Plastics to Chemical Reagents[4]

D 638 Test Method for Tensile Properties of Plastics[4]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[4]

D 883 Definitions of Terms Relating to Plastics[4]

D 903 Test Method for Peel or Stripping Strength of Adhesive Bonds[5]

D 1600 Terminology Relating to Abbreviations, Acronyms and Codes for Terms Relating to Plastics[4]

D 3839 Practice for Underground Installation of Fiberglass (Glass-Fiber-Reinforced Thermosetting Resin) Pipe[6]

F 412 Terminology Relating to Plastic Piping Systems[6]

2.2 *AWWA Standard:*

Manual on Cleaning and Lining Water Mains, M28[7]

2.3 *NASSCO Standard:*

Recommended Specifications for Sewer Collection System Rehabilitation[8]

NOTE 1—An ASTM Specification for Cured-In-Place Pipe materials appropriate for use in this standard is under preparation and will be referenced in this practice when published.

3. Terminology

3.1 *General*—Definitions are in accordance with Definitions D 883 and F 412. Abbreviations are in accordance with Terminology D 1600, unless otherwise indicated.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *cured-in-place pipe (CIPP)*—a hollow cylinder containing a non-woven or a woven material, or a combination of non-woven and woven material surrounded by a cured thermosetting resin. Plastic coatings may be included. This pipe is formed within an existing pipe. Therefore, it takes the shape of and fits tightly to the existing pipe.

3.2.2 *inversion*—the process of turning the resin-impregnated tube inside out by the use of water pressure or air pressure.

3.2.3 *lift*—a portion of the CIPP that has cured in a position such that it has pulled away from the existing pipe wall.

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations who are involved in the rehabilitation of conduits through the use of a resin-impregnated tube inverted through the existing conduit. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 *Tube*—The tube should consist of one or more layers of flexible needled felt or an equivalent nonwoven or woven material, or a combination of nonwoven and woven materials, capable of carrying resin, withstanding installation

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[1] This practice is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.62 on Sewer.
Current edition approved July 15, 1991. Published November 1991. Originally published as F 1216 – 89. Last previous edition F 1216 – 89.

[2] The rehabilitation of existing pipelines and conduits by the inversion and curing of a resin-impregnated tube is covered by patents. (Insituform Pipes and Structures Ltd., Horsley Road, Kingsthorpe Northampton, England and Ashimori Industry Co. Ltd., Osaka, Japan.) Interested parties are invited to submit information regarding the identification of acceptable alternatives to this patented item to the Committee on Standards, ASTM Headquarters, 1916 Race Street, Philadelphia, PA 19103. Your comments will receive careful consideration at a meeting of the responsible technical committee which you may attend.

[3] The following report has been published on one of the processes: Driver, F. T., and Olson, M. R., "Demonstration of Sewer Relining by the Insituform Process, Northbrook, Illinois," EPA-600/2-83-064, Environmental Protection Agency, 1983. Interested parties can obtain copies from the Environmental Protection Agency or from a local technical library.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 15.06.

[6] *Annual Book of ASTM Standards*, Vol 08.04.

[7] Available from the American Water Works Association, 6666 W. Quincey Ave, Denver, CO 80235.

[8] Available from the National Association of Sewer Service Companies, 101 Wymore Rd., Suite 501, Altamonte, FL 32714.

TABLE 1 CIPP Initial Structural Properties[A]

Property	Test Method	Minimum Value psi	Minimum Value (MPa)
Flexural strength	D 790	4 500	(31)
Flexural modulus	D 790	250 000	(1 724)
Tensile strength (for pressure pipes only)	D 638	3 000	(21)

[A] The values in Table 1 are for field inspection. The purchaser should consult the manufacturer for the long-term structural properties.

pressures and curing temperatures. The tube should be compatible with the resin system used. The material should be able to stretch to fit irregular pipe sections and negotiate bends. The outside layer of the tube should be plastic coated with a material that is compatible with the resin system used. The tube should be fabricated to a size that, when installed, will tightly fit the internal circumference and the length of the original conduit. Allowance should be made for circumferential stretching during inversion.

5.2 *Resin*—A general purpose, unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process should be used. The resin must be able to cure in the presence of water and the initiation temperature for cure should be less than 180°F (82.2°C). The CIPP system can be expected to have as a minimum the initial structural properties given in Table 1. These physical strength properties should be determined in accordance with Section 8.

6. Design Considerations

6.1 *General Guidelines*—The design thickness of the CIPP is largely a function of the condition of the existing pipe. Design equations and details are given in Appendix X1.

7. Installation

7.1 *Cleaning and Inspection:*

7.1.1 Prior to entering access areas such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations.

7.1.2 *Cleaning of Pipeline*—All internal debris should be removed from the original pipeline. Gravity pipes should be cleaned with hydraulically-powered equipment, high-velocity jet cleaners, or mechanically-powered equipment (see NASSCO Recommended Specifications for Sewer Collection System Rehabilitation). Pressure pipelines should be cleaned with cable attached devices or fluid propelled devices as shown in AWWA Manual on Cleaning and Lining Water Mains, M28.

7.1.3 *Inspection of Pipelines*—Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television or man entry. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent proper installation of the impregnated tube, such as protruding service taps, collapsed or crushed pipe, and reductions in the cross-sectional area of more than 40 %. These conditions should be noted so that they can be corrected.

7.1.4 *Line Obstructions*—The original pipeline should be clear of obstructions such as solids, dropped joints, protruding service connections, crushed or collapsed pipe, and reductions in the cross-sectional area of more than 40 % that will prevent the insertion of the resin-impregnated tube. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then a point repair excavation should be made to uncover and remove or repair the obstruction.

7.2 *Resin Impregnation*—The tube should be vacuum-impregnated with resin (wet-out) under controlled conditions. The volume of resin used should be sufficient to fill all voids in the tube material at nominal thickness and diameter. The volume should be adjusted by adding 5 to 10 % excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe.

7.3 *Bypassing*—If bypassing of the flow is required around the sections of pipe designated for reconstruction, the bypass should be made by plugging the line at a point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. The pump and bypass lines should be of adequate capacity and size to handle the flow. Services within this reach will be temporarily out of service.

7.3.1 Public advisory services will be required to notify all parties whose service laterals will be out of commission and to advise against water usage until the mainline is back in service.

7.4 *Inversion:*

7.4.1 *Using Hydrostatic Head*—The wet-out tube should be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube should be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube should be turned inside out and attached to the standpipe so that a leakproof seal is created. The inversion head should be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to over-stress the felt fiber.

7.4.1.1 An alternative method of installation is a top inversion. In this case, the tube is attached to a top ring and is inverted to form a standpipe from the tube itself or another method accepted by the engineer.

NOTE 2—The tube manufacturer should provide information on the maximum allowable tensile stress for the tube.

7.4.2 *Using Air Pressure*—The wet-out tube should be inserted through an existing manhole or other approved access by means of an inversion process and the application of air pressure sufficient to fully extend it to the next designated manhole or termination point. The tube should be connected by an attachment at the upper end of the guide chute so that a leakproof seal is created and with the impermeable plastic membranes side out. As the tube enters the guide chute, the tube should be turned inside out. The inversion air pressure should be adjusted to be of sufficient pressure to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to overstress the woven and non-woven materials.

NOTE 3: Warning—Suitable precautions should be taken to eliminate hazards to personnel in the proximity of the construction when pressurized air is being use.

7.4.3 *Required Pressures*—Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressures until the inversion has been completed. Should the pressure deviate from within the range of the minimum and maximum pressures, the installed tube shall be removed from the existing conduit.

7.5 *Lubricant*—The use of a lubricant during inversion is recommended to reduce friction during inversion. This lubricant should be poured into the inversion water in the downtube or applied directly to the tube. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

7.6 *Curing:*

7.6.1 *Using Circulating Heated Water*—After inversion is completed, a suitable heat source and water recirculation equipment are required to circulate heated water throughout the pipe. The equipment should be capable of delivering hot water throughout the section to uniformly raise the water temperature above the temperature required to effect a cure of the resin. Water temperature in the line during the cure period should be as recommended by the resin manufacturer.

7.6.1.1 The heat source should be fitted with suitable monitors to gage the temperature of the incoming and outgoing water supply. Another such gage should be placed between the impregnated tube and the pipe invert at the termination to determine the temperatures during cure.

7.6.1.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post cure temperature recommended by the resin manufacturer. The post cure temperature should be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the boiler to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of soil).

7.6.2 *Using Steam*—After inversion is completed, suitable steam generating equipment is required to distribute steam throughout the pipe. The equipment should be capable of delivering steam throughout the section to uniformly raise the temperature within the pipe above the temperature required to effect a cure of the resin. The temperature in the line during the cure period should be as recommended by the resin manufacturer.

7.6.2.1 The steam generating equipment should be fitted with a suitable monitor to gage the temperature of the outgoing steam. The temperature of the resin being cured should be monitored by placing gages between the impregnated tube and the existing pipe at both ends to determine the temperature during cure.

7.6.2.2 Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to post-cure temperatures recommended by the resin manufacturer. The post-cure temperature should be held for a period as recommended by the resin manufacturer, during which time the distribution and control of steam to maintain the temperature continues. The curing of the CIPP must take into account the existing pipe material, the resin system and ground conditions (temperature, moisture level and thermal conductivity of soil).

7.6.3 *Required Pressures*—Before the curing begins, the pressure required to hold the flexible tube tight against the existing conduit shall be provided by the tube manufacturer. Once the cure has started and dimpling for laterals is completed, the required pressure shall be maintained until the cure has been completed. Should the pressure deviate more than 2.3 ft of water (1 psi) from the required pressure, the installed tube shall be removed from the existing conduit. If required by the owner, a continuous log of pressure during cure shall be maintained.

7.7 *Cool-Down:*

7.7.1 *Using Cool Water After Heated Water Cure*—The new pipe should be cooled to a temperature below 100°F (38°C) before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care should be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

7.7.2 *Using Cool Water After Steam Cure*—The new pipe should be cooled to a temperature below 113°F (45°C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care should be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed pipe.

7.8 *Workmanship*—The finished pipe should be continuous over the entire length of an inversion run and be free of dry spots, lifts, and delaminations. If these conditions are present, remove and replace the CIPP in these areas.

7.8.1 If the CIPP does not fit tightly against the original pipe at its termination point(s), the space between the pipes should be sealed by filling with a resin mixture compatible with the CIPP.

7.9 *Service Connections*—After the new pipe has been cured in place, the existing active service connections should be reconnected. This should generally be done without excavation, and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a remote control cutting device.

8. Inspection Practices

8.1 For each inversion length designated by the owner in the contract documents or purchase order, the preparation of two CIPP samples is required, one from each of the following two methods:

8.1.1 The sample should be cut from a section of cured CIPP at an intermediate manhole or at the termination point that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.

8.1.2 The sample should be fabricated from material taken from the tube and the resin/catalyst system used and cured in a clamped mold placed in the downtube when circulating heated water is used and in the silencer when steam is used.

8.1.3 The samples for each of these cases should be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and also for tensile testing, if applicable. The following test procedures should be followed after the sample is cured and removed.

8.1.3.1 *Short-Term Flexural (Bending) Properties*—The initial tangent flexural modulus of elasticity and flexural stress should be measured for gravity and pressure pipe applications in accordance with Test Methods D 790 and should meet the requirements of Table 1.

8.1.3.2 *Tensile Properties*—The tensile strength should be measured for pressure pipe applications in accordance with Test Method D 638 and must meet the requirements of Table 1.

8.2 *Gravity Pipe Leakage Testing*—If required by the owner in the contract documents or purchase order, gravity pipes should be tested using an exfiltration test method where the CIPP is plugged at both ends and filled with water. This test should take place after the CIPP has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals and diameters of 36 in. or less. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3.0 m) of water or 4.3 psi (29.7 kPA) and the water level inside of the inversion standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. The test should be conducted for a minimum of one hour.

NOTE 4—It is impractical to test pipes above 36 in. diameter for leakage due to the technology available in the pipe rehabilitation industry. Post inspection of larger pipes will detect major leaks or blockages.

8.3 *Pressure Pipe Testing*—If required by the owner in the contract documents or purchase order, pressure pipes should be subjected to a hydrostatic pressure test. A recommended pressure and leakage test would be at twice the known working pressure or at the working pressure plus 50 psi, whichever is less. Hold this pressure for a period of two to three hours to allow for stabilization of the CIPP. After this period, the pressure test will begin for a minimum of one hour. The allowable leakage during the pressure test should be 20 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been evacuated from the line prior to testing and the CIPP has cooled down to ambient temperature.

NOTE 5—The allowable leakage for gravity and pressure pipe testing is a function of water loss at the end seals and trapped air in the pipe.

8.4 Delamination Test—If required by the owner in the contract documents or purchase order, a delamination test should be performed on each inversion length specified. CIPP samples should be prepared in accordance with 8.1.2, except that a portion of the tube material in the sample should be dry and isolated from the resin in order to separate tube layers for testing. (Consult the tube manufacturer for further information.) Delamination testing shall be in accordance with Test Method D 903, with the following exceptions:

8.4.1 The rate of travel of the power-actuated grip shall be 1 in. (25 mm)/min.

8.4.2 Five test specimens shall be tested for each inversion specified.

8.4.3 The thickness of the test specimen shall be minimized, but should be sufficient to adequately test delamination of non-homogeneous CIPP layers.

8.5 The peel or stripping strength between any non-homogeneous layers of the CIPP laminate should be a minimum of 10 lb/in. (178.60 g/mm) of width for typical CIPP applications.

NOTE 6—The purchaser may designate the dissimilar layers between which the delamination test will be conducted.

NOTE 7—For additional details on conducting the delamination test, contact the CIPP contractor.

8.6 *Inspection and Acceptance*—The installation may be inspected visually if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater should be observed. All service entrances should be accounted for and be unobstructed.

APPENDIXES

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 *Terminology:*

X1.1.1 *partially deteriorated pipe*—the original pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10.0 % distortion of the diameter. If the distortion of the diameter is greater than 10.0 %, alternative design methods are required (see Note 2).

X1.1.2 *fully deteriorated pipe*—the original pipe is not structurally sound and cannot support soil and live loads nor is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the original pipe are missing, the pipe has lost its original shape, or the pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.2 *Gravity Pipe:*

X1.2.1 *Partially Deteriorated Gravity Pipe Condition*—The CIPP is designed to support the hydraulic loads due to groundwater, since the soil and surcharge loads can be supported by the original pipe. The groundwater level should be determined by the purchaser and the thickness of the CIPP should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(SDR-1)^3} \cdot \frac{C}{N} \quad \text{(X1.1)}$$

where:

P = groundwater load, psi (MPa),
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a minimum value of 7.0 is recommended where there is full support of the existing pipe),
E_L = long-term (time corrected) modulus of elasticity for CIPP, psi (MPa) (see Note X1.1),
ν = Poisson's ratio (0.3 average),
SDR = standard dimension ratio of CIPP,
C = ovality reduction factor = $\left(\left[1-\frac{q}{100}\right] \Big/ \left[1+\frac{q}{100}\right]^2\right)^3$
q = percentage ovality of original pipe =
$100 \times \frac{\text{(Mean Inside Diameter} - \text{Minimum Inside Diameter)}}{\text{Mean Inside Diameter}}$
or
$100 \times \frac{\text{(Maximum Inside Diameter} - \text{Mean Inside Diameter)}}{\text{Mean Inside Diameter}}$,
and
N = factor of safety.

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value for E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—If there is no groundwater above the pipe invert, the CIPP should typically have a maximum SDR of 100, dependent upon design conditions.

X1.2.1.1 If the original pipe is oval, the CIPP design from Eq X1.1 shall have a minimum thickness as calculated by the following formula:

$$1.5\frac{q}{100}\left(1+\frac{q}{100}\right)SDR^2 - 0.5\left(1+\frac{q}{100}\right)SDR = \frac{\sigma_L}{PN} \quad \text{(X1.2)}$$

where:

σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5).

X1.2.1.2 See Table X1.1 for typical design calculations.

X1.2.2 *Fully Deteriorated Gravity Pipe Condition*—The CIPP is designed to support hydraulic, soil, and live loads. The groundwater level, soil type and depth, and live load should be determined by the purchaser, and the following equation should be used to calculate the CIPP thickness required to withstand these loads without collapsing:

$$q_t = \frac{C}{N}[32R_w B' E'_s (E_L I/D^3)]^{1/2} \quad \text{(X1.3)}$$

where:

q_t = total external pressure on pipe, psi (MPa),
R_w = water buoyancy factor (0.67 min) = $1 - 0.33\,(H_w/H)$,
H_w = height of water above top of pipe, ft (m),
H = height of soil above top of pipe, ft (m),
B' = coefficient of elastic support = $1/(1+4e^{-0.065H})$ inch-pound units, $(1/(1+4e^{-0.213H})$ SI units),
I = moment of inertia of CIPP, in.^{4}/in. (mm^4/mm) = $t^3/12$,
t = thickness of CIPP, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety,
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.4),
E_L = long term modulus of elasticity for CIPP, psi (MPa), and
D = mean inside diameter of original pipe, in. (mm).

X1.2.2.1 The CIPP design from Eq X1.3 should have a minimum thickness as calculated by the following formula:

$$\frac{EI}{D^3} = \frac{E}{12(SDR)^3} \geq 0.093 \text{ (inch-pound units)},$$

or (X1.4)

$$\frac{E}{12(SDR)^3} \geq 0.00064 \text{ (SI units)}$$

where:

E = initial modulus of elasticity, psi (MPa).

NOTE X1.3—Finite element analysis is an alternative design method for noncircular pipes.

NOTE X1.4—For definition of modulus of soil reaction, see Practice D 3839.

X1.2.2.2 The minimum CIPP design thickness for a fully deteriorated condition should also meet the requirements of Eqs X1.1 and X1.2.

X1.3 *Pressure Pipe:*

X1.3.1 *Partially Deteriorated Pressure Condition*—A CIPP installed in an existing underground pipe is designed to support external hydrostatic loads due to groundwater as well as withstand the internal pressure in spanning across any holes in the original pipe wall. The results of Eq X1.1 are compared to those from Eqs X1.6 or X1.7, as directed by Eq X1.5 and the largest of the thicknesses is selected. In an above-ground design condition, the CIPP is designed to withstand the internal pressure only by using Eqs X1.5, X1.6, and X1.7 as applicable.

X1.3.1.1 If the ratio of the hole in the original pipe wall to the pipe diameter does not exceed the quantity shown in Eq X1.5, then the CIPP is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only. In this case, Eq X1.6 is used for design. For holes larger than the d/D value in Eq X1.5, the liner cannot be considered in flat plate loading, but rather in ring tension or hoop stress, and Eq X1.7 is used.

$$\frac{d}{D} \leq 1.83\left(\frac{t}{D}\right)^{1/2} \quad \text{(X1.5)}$$

where:

d = diameter of hole or opening in original pipe wall, in. (mm),
D = mean inside diameter of original pipe, in. (mm), and
t = thickness of CIPP, in. (mm).

$$P = \frac{5.33}{(SDR - 1)^2}\left(\frac{D}{d}\right)^2 \frac{\sigma_L}{N} \quad (X1.6)$$

where:

SDR = standard dimension ratio of CIPP,
D = mean inside diameter of original pipe, in. (mm),
d = diameter of hole or opening in original pipe wall, in. (mm),
σ_L = long-term (time corrected) flexural strength for CIPP, psi (MPa) (see Note X1.5), and
N = factor of safety.

NOTE X1.5—The choice of value (from manufacturer's literature) of σ_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.3.2 *Fully Deteriorated Pressure Pipe Condition*—A CIPP to be installed in an underground condition is designed to withstand all external loads and the full internal pressure. The design thicknesses are calculated from Eqs X1.1, X1.3, X1.4, and X1.7 and the largest thickness is selected. If the pipe is above ground, the CIPP is designed to withstand internal pressure only by using Eq X1.7.

$$P = \frac{2\sigma_{TL}}{(SDR - 2)\,N} \quad (X1.7)$$

where:

P = internal pressure, psi (MPa),
σ_{TL} = long-term (time corrected) tensile strength for CIPP, psi (MPa) (see Note 12),
SDR = standard dimension ratio of CIPP, and
N = factor of safety.

NOTE X1.6—The choice of value (from manufacturer's literature) of σ_{TL} will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of σ_{TL} will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

X1.4 *Negative Pressure*—Where the pipe is subject to a vacuum, the CIPP should be designed as a gravity pipe with the external hydrostatic pressure increased by an amount equal to the negative pressure.

NOTE X1.7—Table X1.1 presents maximum groundwater loads for partially deteriorated pipes for selected typical nominal pipe sizes. CIPP is custom made to fit the original pipe and can be fabricated to a variety of sizes from 4 to 96 in. diameter which would be impractical to list here.

TABLE X1.1 Maximum Groundwater Loads for Partially Deteriorated Gravity Pipe Condition

Diameter in. (I.D. of Original Pipe)	Nominal CIPP Thickness, mm	CIPP Thickness, t, in.	Maximum Allowable Ground-water Load[A] (above invert) ft	m
8	6	0.236	40.0	12.2
10	6	0.236	20.1	6.1
12	6	0.236	11.5	3.5
15	9	0.354	20.1	6.1
18	9	0.354	11.5	3.5
18	12	0.472	27.8	8.5
24	12	0.472	11.5	3.5
24	15	0.591	22.8	6.9
30	15	0.591	11.5	3.5
30	18	0.709	20.1	6.1

[A] Assumes $K = 7.0$, $E = 125\,000$ psi (862 MPa) (50 yr strength), $\nu = 0.30$, $C = 0.64$ (5 % ovality), and $N = 2.0$

X2. CHEMICAL RESISTANCE TESTS

X2.1 *Scope:*

X2.1.1 This appendix covers the test procedures for chemical resistance properties of CIPP. Minimum standards are presented for standard domestic sewer applications.

X2.2 *Procedure for Chemical Resistance Testing:*

X2.2.1 Chemical resistance tests should be completed in accordance with Test Method D 543. Exposure should be for a minimum of one month at 73.4°F (23°C). During this period, the CIPP test specimens should lose no more than 20 % of their initial flexural strength and flexural modulus when tested in accordance with Section 8 of this standard.

X2.2.2 Table X2.1 presents a list of chemical solutions that serve as a recommended minimum requirement for the chemical resistant properties of CIPP in standard domestic sanitary sewer applications.

TABLE X2.1 Minimum Chemical Resistance Requirements for Domestic Sanitary Sewer Applications

Chemical Solution	Concentration, %
Tap water (pH 6–9)	100
Nitric acid	5
Phosphoric acid	10
Sulfuric acid	10
Gasoline	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

X2.2.3 For applications other than standard domestic sewage, it is recommended that chemical resistance tests be conducted with actual samples of the fluid flowing in the pipe. These tests can also be accomplished by depositing CIPP test specimens in the active pipe.

APPENDIX C

CONSTRUCTION PHOTOGRAPHS

PHOTOGRAPH LOG
NAVY RAC - SOUTHERN DIVISION
ROLL NO. 40

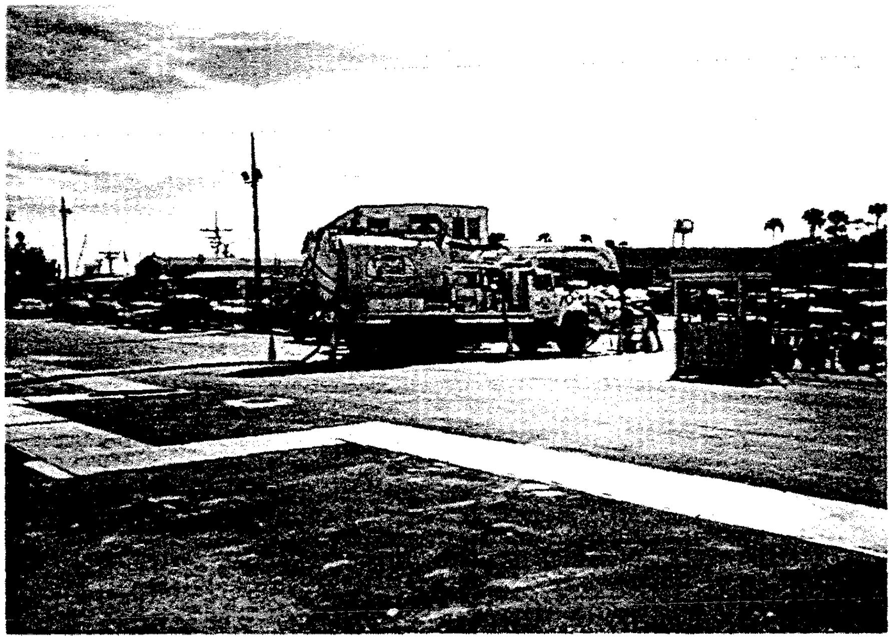
PHOTOGRAPHER'S NAME: Steve SantaMaria

Negatives - NONE

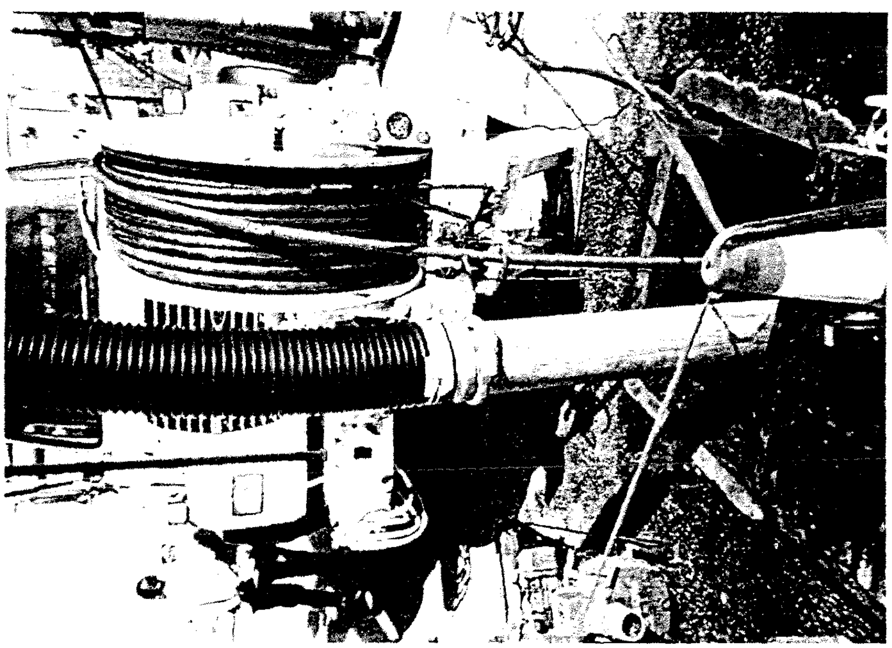
NEG/PRT #	DATE	DESCRIPTION	SITE LOCATION/DESIGNATION
1	2/8/95	Storm water drainage, pipe cleaning and vacuuming equipment adjacent to Delta Pier. Access provided through an existing manhole.	AD Piers, NS Mayport
2	2/8/95	Close-up of vacuum line (Aluminum 8" dia) and water jet (Rod 1 1/2" dia) at Alpha Pier.	AD Piers, NS Mayport
3	2/8/95	21,000 gallon water storage tank. Water generated during cleaning operations (Alpha Pier).	AD Piers, NS Mayport
4	2/8/95	Remote Video Camera	AD Piers, NS Mayport
5	2/8/95	Soil and debris generated during cleaning operations.	AD Piers, NS Mayport
6	2/8/95	Drummed soil and debris staged at the JSI Facility at Mayport NS.	AD Piers, NS Mayport
7	2/8/95	Installation of polyethelene "sleeve" at Delta Pier.	AD Piers, NS Mayport
8	2/8/95	Insitutube (Liner) cuffed back and banded to the inversion stand pipe.	AD Piers, NS Mayport
9	2/8/95	Potable water added to the inversion. The force of head pressure turns the liner inside out and into the existing storm water drainage pipe.	AD Piers, NS Mayport
10	2/8/95	Liner in place.	AD Piers, NS Mayport
11	2/8/95	Water in liner is heated and circulated to cure the liner.	AD Piers, NS Mayport
12	2/6/95	Same as #11.	AD Piers, NS Mayport
13	2/8/95	Cured liner seen at excavated access point - Delta Pier.	AD Piers, NS Mayport
14	2/8/95	Pneumatic cutter used to trim cured liner.	AD Piers, NS Mayport

PIPE SLIPLINING AT ALPHA-DELTA PIERS

Photograph Log

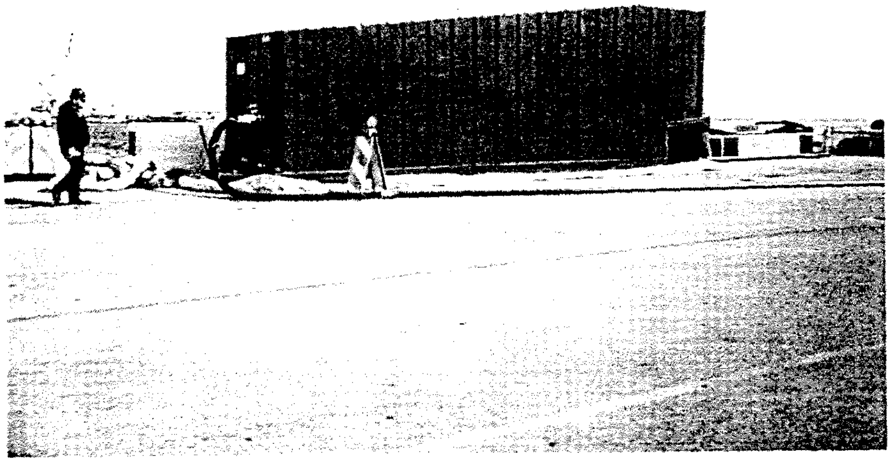


# 1	2/8/95	Storm water drainage, pipe cleaning and vacuuming equipment adjacent to Delta Pier. Access provided through an existing manhole.	AD Piers, NS Mayport



# 2	2/8/95	Close-up of vacuum line (Aluminum 8"dia) and water jet (Rod 1 1/2" dia) at Alpha Pier.	AD Piers, NS Mayport

PIPE SLIPLINING AT ALPHA-DELTA PIERS
Photograph Log

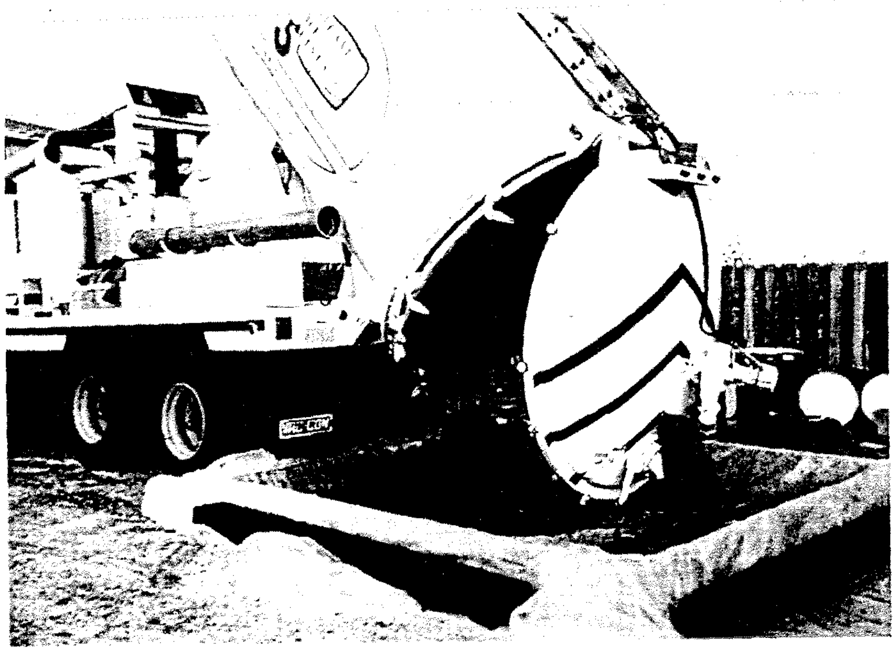


# 3	2/8/95	21,000 Gallon water storage tank. Water generated during cleaning operations (Alpha Pier).	AD Piers, NS Mayport

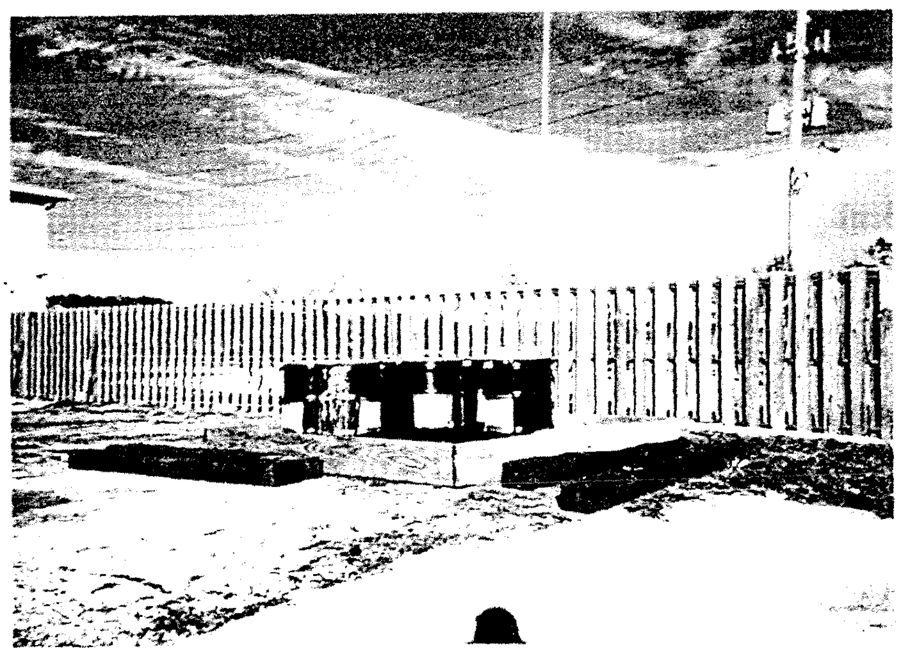
# 4	2/8/95	Remote Video Camera	AD Piers, NS Mayport

PIPE SLIPLINING AT ALPHA-DELTA PIERS

Photograph Log

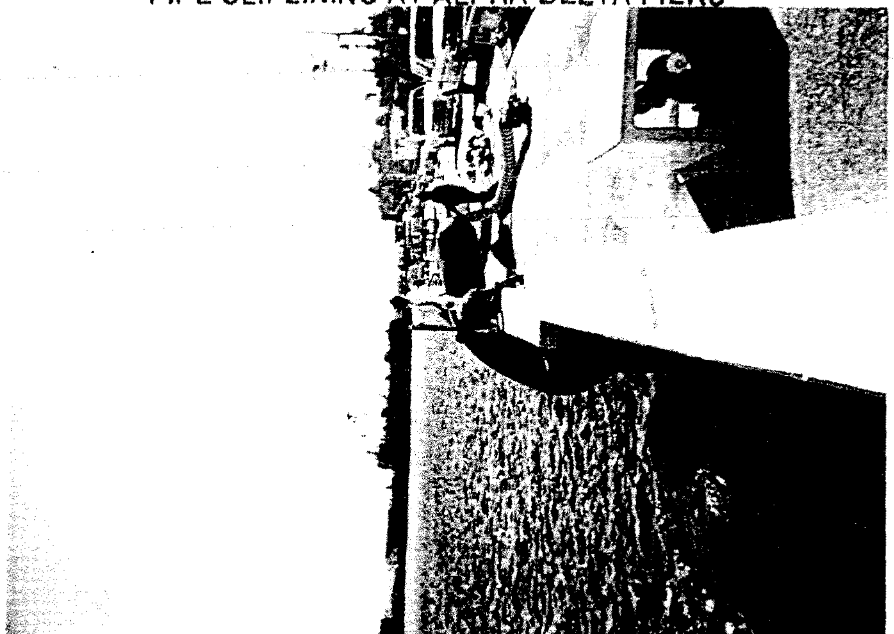


# 5	2/8/95	Soil and debris generated during cleaning operations	AD Piers, NS Mayport



# 6	2/8/95	Drummed soil and debris staged at the JSI Facility at Mayport NS	AD Piers, NS Mayport

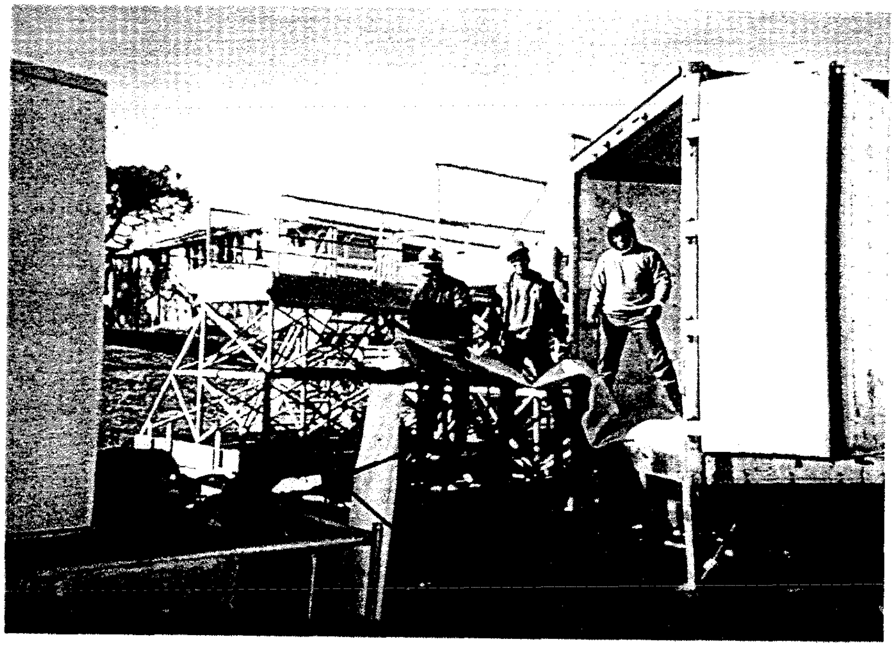
PIPE SLIPLINING AT ALPHA-DELTA PIERS



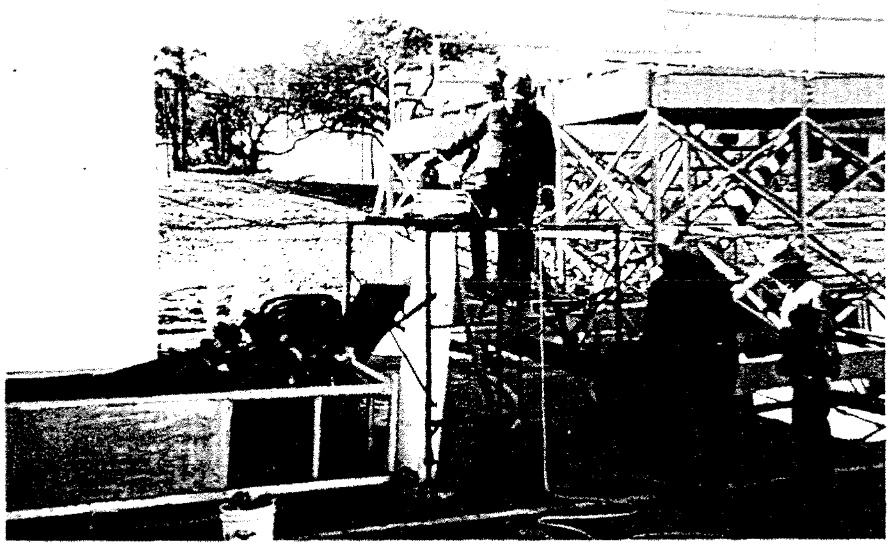
# 7	2/8/95	Installation of polyethelene "sleeve" at Delta Pier	AD Piers NS Mayport

# 8	2/8/95	Insitutube (Liner) cuffed back and banded to the inversion stand pipe.	AD Piers, NS Mayport

PIPE SLIPLINING AT ALPHA-DELTA PIERS
Photograph Log



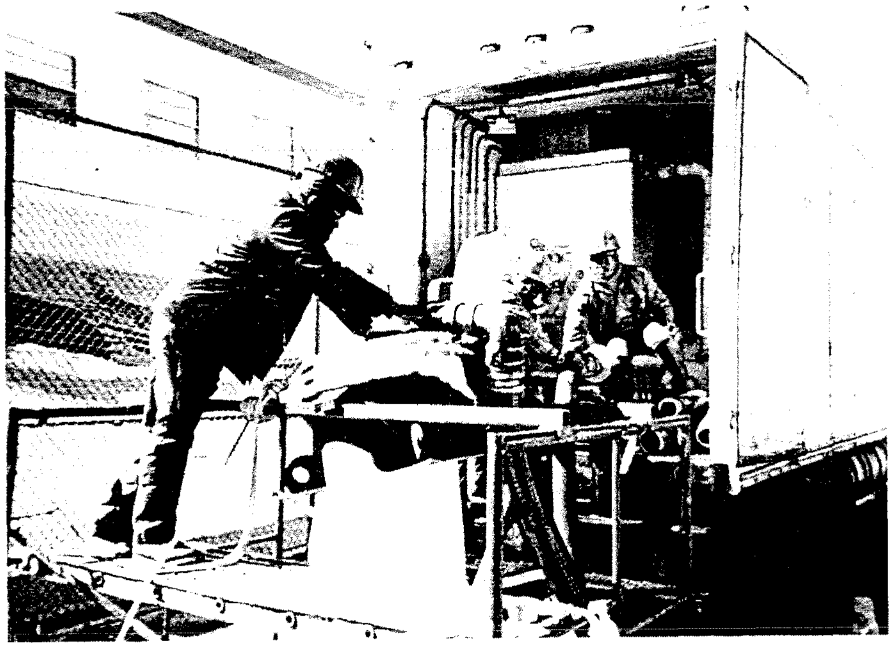
# 9	2/8/95	Potable water added to the inversion. The force of head pressure turns the liner inside out and into the existing storm water drainage pipe.	NS Mayport



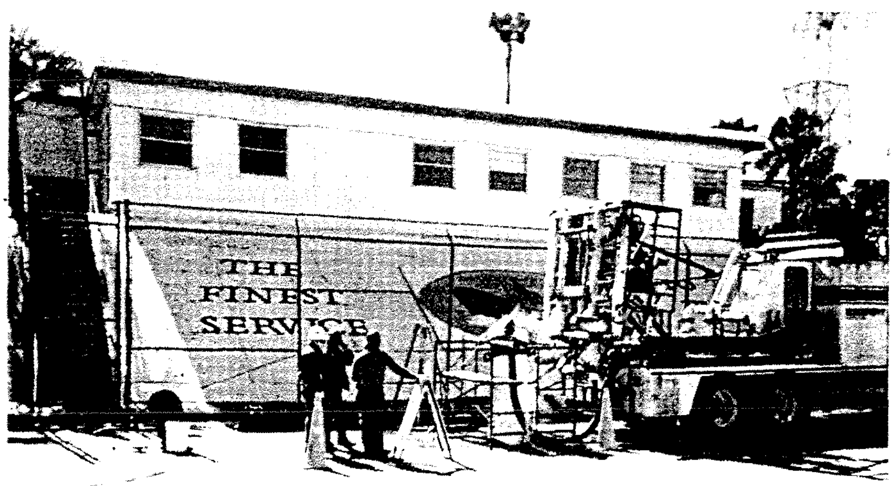
# 10	2/8/95	Potable water added to the inversion. The force of head pressure turns the liner inside out and into the existing storm water drainage pipe.	NS Mayport

PIPE SLIPLINING AT ALPHA-DELTA PIERS

Photograph Log

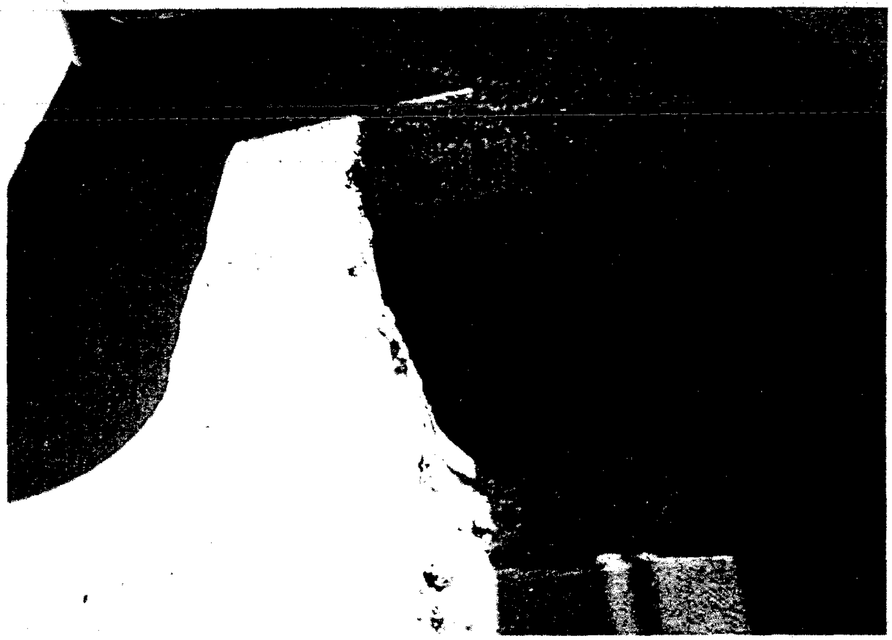


# 11	2/8/95	Water in liner is heated and circulated to cure the liner.	NS Mayport

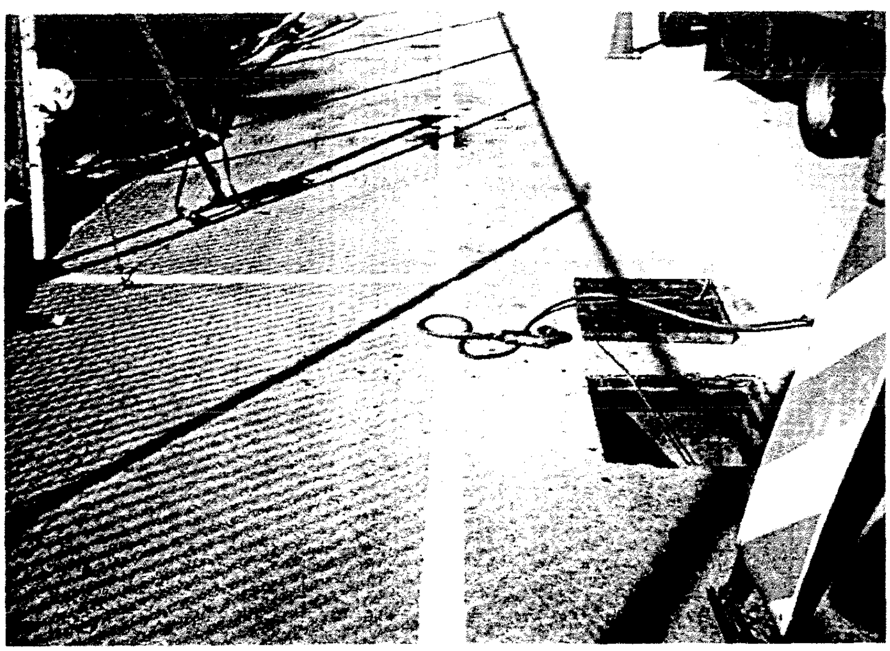


# 12	2/8/95	Same as #11	NS Mayport

PIPE SLIPLINING AT ALPHA-DELTA PIERS
Photograph Log



# 13	2/8/95	Cured liner seen at excavated access point-Delta Pier	NS Mayport



# 14	2/8/95	Pneumatic cutter used to trim cured liner.	NS Mayport

APPENDIX D

VIDEO