Session 2B-3

Dade County, Florida - A No-Dig Success Story for Sewer Rehabilitation

Written by

Luis Aguiar
Miami-Dade Water & Sewer Department
4200 Salzedo Street
Coral Gables, FL 33146 USA

James T. Cowgill
Hazen & Sawyer, P.C.
4000 Hollywood Boulevard, 7th Fl.
Hollywood, FL 33021 USA

Thomas G. Scheller
Rust Environment & Infrastructure
2600 Douglas Road, Suite 800
Coral Gables, FL 33134 USA

Iqbal Noor
Hazen & Sawyer, P.C.
2600 Douglas Road, Suite 800
Coral Gables, FL 33134 USA

Presented by
Thomas G. Scheller

DADE COUNTY, FLORIDA- A NO DIG SUCCESS STORY FOR SEWER REHABILITATION

Luis Aguiar, Miami-Dade Water and Sewer Department, Assistant Director
Thomas G. Scheller, P.E., Rust Environment and Infrastructure, Program Manager
James T. Cowgill, P.E., Hazen and Sawyer, P.C., Vice-President
Iqbal Noor, Ph.D., Hazen and Sawyer, P.C., Project Engineer

Introduction

The Miami-Dade Water and Sewer Department (MDWASD), the regional wastewater utility of Metropolitan Dade County, is currently undertaking one of the Country's largest Infiltration/Inflow (I/I) reduction programs. Under this program, MDWASD intends to evaluate the condition of its gravity sewer collection system by performing manhole inspections, smoke testing and closed circuit television inspection. The entire system has 57,211 manholes and 2,483 miles of gravity sewers, which make up 889 collection basins. Approximately 90% of the gravity sewers are made of 8-inch diameter vitreous clay pipes (VCP).

Sewer repairs are performed by MDWASD forces and contractors. Point repairs which require excavations are performed by both MDWASD and contractors. Line replacement and trenchless repairs are performed primarily by contractors. Trenchless repairs include the use of fold and form and cured-in-place liners, sectional cured-in-place liners, joint grouting and robotic point repairs. There are a number of factors which determine the repair method chosen for a defective line segment. These factors range from the severity of the defect, the depth of the sewer, the number of defects in the line segment, whether the surface overlying the sewer is paved or unpaved, the presence of roots and the number of service connections in the line segment. All of these factors have an impact on repair costs. In essence, a trade off between the effectiveness of a repair method and the costs involved must be made. This paper outlines the methodology used to identify the different types of sewer repairs in MDWASD's I/I Reduction Program.

Detection of Sewer Line Defects

The field investigation phase of the program identifies defects in the gravity collection system. Work on this phase is primarily done by MDWASD forces. Smoke testing is used mainly to identify sources of inflow. Closed circuit television inspection is used to provide detailed information about the line segments structural integrity and sources of infiltration. In addition, information on the depth of the sewer, its size, its location (e.g. under paved roadway, backyard or building), the number of service connections and its material is also confirmed and documented during the television inspection process. The information gathered during television inspection is recorded on video log sheets. Video log sheets, along with videotapes, are submitted to the Rust Environment & Infrastructure/Hazen and Sawyer I/I Reduction Program Control Center (PCC). The PCC is responsible for providing overall I/E/I Reduction Program management, as well as engineering and construction management support to the I/I reduction program.

Engineering Evaluation

The engineering evaluation team at the PCC validates and reviews the television inspection data. The first step in this process involves a check to ensure that all of the line segments in a collection basin have been televised. This check is made by comparing line segments on the MDWASD sewer atlas maps with those in the video logs. Line segments without video logs or videotapes are issued to the television inspection crews for inspection.

During the engineering review of a line segment, each defect is noted by the reviewer. Information on the location of the defect (i.e. distance from either the upstream or the downstream manhole) is noted. The type of defect (for example, cracked pipe, open joint, etc.) and the clock reference position of the defect is also noted. In addition, an approximate I/I quantity associated with the defect is recorded. The estimated I/I quantity is determined by comparing the infiltration observed on the video tape, to a set of photographs which shows documented rates of infiltration simulated in a laboratory environment.

The entire line segment is reviewed before any repair call is made. This procedure allows for more economical and effective repairs to be made. For example, instead of requesting two separate point repairs and a sectional liner to repair three separate defects, it may be more cost effective to replace the entire line segment. The most cost effective repair is determined by analyzing available cost data, site conditions, and constructability issues.

Repair Cost Data

Historical data from previously completed projects and bid prices from ongoing contracts are used to develop the costs for the different repair options. In choosing a repair method, repair costs are considered in conjunction with the severity of a defect and potential constructability problems. A description of the methodology used to identify the various types of repairs and their associated costs are presented in the following sections.

Point Repairs

Point repairs are normally called for under the following conditions:

- There exists a collapsed pipe or broken pipe with jagged edges
- Roots exist in a lateral
- Only a portion, (up to 15 feet) of a line segment requires replacement

This type of repair requires excavation work to be performed so the defective section of the line segment can be removed and replaced with a new section of pipe. In some cases, point repairs are required so that other trenchless repair methods (cured-in-place and fold and form liners) can be performed. In these situations, the costs of both the point repair and liner is compared to the costs of replacing the entire line. A rule of thumb in the current I/I Reduction Program is that line replacement is selected instead of another repair method if the costs of both repair methods are within 20% of each other and accessibility problems do not preclude line replacement. The

engineering staff at the PC have found that whenever there is need for more than one dig and replace point repair per 100 feet of sewer, cost considerations usually rule in favor of line replacement.

Point repair costs for sewers at different depths and diameters are presented in Table 1. If the point repair is performed in a paved area, an additional $400 is added to the cost obtained in Table 1. This additional cost is based on restoring a 3 to 4 foot wide area over the length of the excavation.

Sewer Depth (ft)	Diameter of Sewer (inch)					
	8	10	12	15	18	24
1	$2,000	$1,600	$1,700	$3,800	$10,000	$13,000
2	$2,000	$1,600	$1,700	$3,800	$10,000	$13,000
3	$2,000	$1,600	$1,700	$3,800	$10,000	$13,000
4	$2,000	$1,600	$1,700	$3,800	$10,000	$13,000
5	$3,500	$3,600	$3,700	$3,800	$10,000	$13,000
6	$3,500	$3,600	$3,700	$3,800	$10,000	$13,000
7	$3,500	$3,600	$3,700	$3,800	$10,000	$13,000
8	$5,300	$5,500	$5,600	$5,700	$10,000	$13,000
9	$5,300	$5,500	$5,600	$5,700	$10,000	$13,000
10	$5,300	$5,500	$5,600	$5,700	$10,000	$13,000
11	$5,300	$5,500	$5,600	$5,700	$10,000	$13,000
12	$7,500	$10,000	$10,100	$9,700	$14,000	$17,000
13	$7,500	$10,000	$10,100	$9,700	$14,000	$17,000
14	$7,500	$10,000	$10,100	$9,700	$14,000	$17,000
15	$7,500	$10,000	$10,100	$9,700	$14,000	$17,000
16	$7,500	$10,000	$10,100	$9,700	$14,000	$17,000
17	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
18	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
19	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
20	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
21	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
22	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
23	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000
24	$10,000	$15,000	$15,000	$12,000	$17,000	$20,000

Table 1: Dig and Replace Point Repair Costs

Sectional Cured-In-Place Liners

Sectional cured-in-place liners are used to repair a variety of defects. They are used to repair sewers with joint to joint axial cracks and full circumference radial cracks. These liners can also be used to repair multiple cracks located in one section (spider web type) or repair cracks which show signs of active infiltration or exhibit stains caused by leaks. They are limited in their application, as they can only repair up to nine feet of damaged sewer. Although multiple sectional cured-in-place liners may be used, cost considerations normally rule in favor of either a full line segment liner or line replacement. Typical sectional liner costs are presented in Table 2.

Pipe Diameter (inch)	Costs (up to 6 feet)	Costs per foot over 6 ft (up to 9 ft)
8	$1,310	$26
10	$1,395	$35
12	$1,450	$40
15	$1,620	$60
18	$2,200	$75
21	$2,400	$100
24	$4,160	$120

Table 2: Sectional Liner Costs

Robotic Repairs

Robotic point repairs are performed on protruding and recessed laterals as well as on axial and radial dry cracks which do not extend from joint to joint or the full circumference of the pipe. If there is a crack in the main-line which is located within 1 foot of a wye, a robotic repair is used even though the crack exhibits no sign of infiltration. In this case a robotic repair is chosen in lieu of the usual sectional liner due to the added difficulty and costs associated with reinstating the wye once the sectional liner is installed. Robotic repairs of recessed and protruding service laterals cost about $1,500 and $1,000 respectively. Axial and radial cracks cost approximately $800 each to repair. Robotic point repairs to cracks across joints cost about $1,000 each.

Fold and Form Liners

Fold and form liners are generally used to repair defects in line segments which are no deeper than 8 feet and show only water infiltration (no sand). This form of repair is not used on line segments which have jagged edges from broken or collapsed sections. This precaution is taken to avoid potential damage to the liner as it is pulled through the sewer. For this same reason, fold and form liners are also not used to repair sewers containing tuberculated and encrusted sections. Once the fold and form liner has been installed, all the service laterals in the line segment are reinstated and

grouting is performed to seal the annular space between the wye and liner at each lateral. The cost

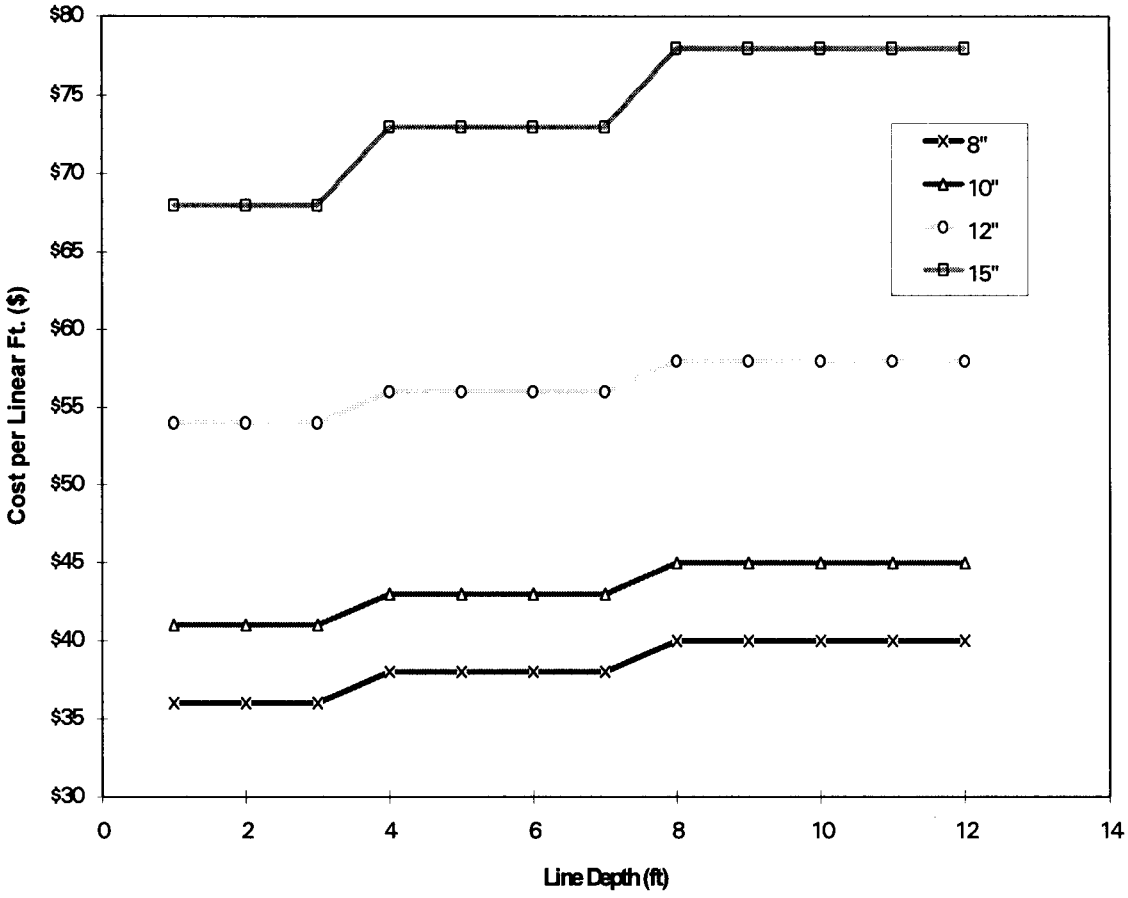

Figure 1: Fold and Form Liner Costs

of fold and form liners are shown in Figure 1.

Cured-In-Place Liners

The cured-in-place installation process makes this form of rehabilitation more applicable when line segments have tuberculated sections, jagged edges, or are at depths greater than 8 feet. During the installation process, the cured-in-place liner is rolled inside-out, through the damaged pipe, utilizing constant water pressure from a nearby source -- usually a fire hydrant. As with the fold and form liner, all service laterals are reinstated once the cured-in-place liner is installed.

The cost of cured-in-place liners are shown in Figure 2. It should be noted that for sewers with tuberculated sections, descaling costs have to be added to the costs obtained from Figure 2.

Descaling costs for a 8 inch diameter sewer are about $20 per linear foot. The price per linear foot increases by $5 as the sewer diameter increases in size from 8 inches to 10, 12, 15 and 18 inches.

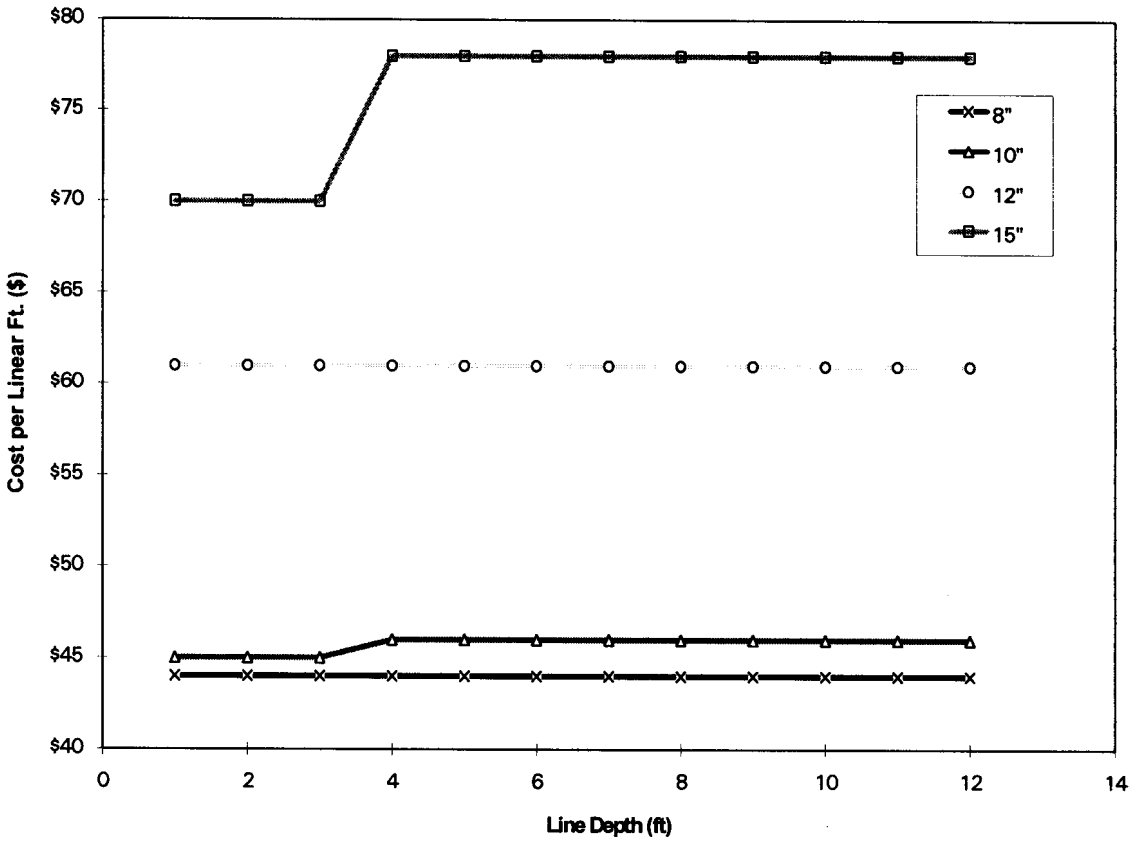

Figure 2: Cured-In-Place Liner Costs

Thus the cost to descale an 18 inch diameter sewer would be $40 per linear foot.

A comparison of the graphs presented in Figures 1 and 2 shows that for a given diameter and depth of a sewer, cured in place liner costs are generally higher than that for fold and form liners. However, in certain scenarios, the potential for defective liners caused by line segments with jagged edges, sand/debris and tuberculated sections make the use of cured-in-place liners the rehabilitation method of choice.

Pressure Grouting

Pressure chemical grouting is used to seal defective joints where groundwater leakage (usually less than 3 gpm) is occurring and the sewer is in sound structural condition. Previously mentioned repair methods are normally used to repair joints having leaks greater than 3 gpm. This decision is based

on cost considerations and the effectiveness of the other repair methods. During pressure grouting operations, every joint in a line segment is pressure tested. If a joint fails the pressure test, a grout packer is expanded and grout is applied to the defective joint. This is done for every joint in a line segment. This approach has been adopted in an effort to prevent the migration of a leak from one joint to another.

In the current I/I Reduction Program, line grouting is not used to repair leaking joints in line segments which contain cracks and other defects. This decision is based on the fact that when joints are pressure tested during line grouting, the applied pressure has the potential of propagating existing cracks. This situation is prevalent in the clay pipes which comprise 90% of MDWASD's gravity collection system.

Line grouting costs are approximately $10 per linear foot for sewers of diameters 10 inches and less. Grouting costs increase to $12.50/LF for 12 and 15 inch diameter sewers and $15.30/LF for 18 and 20 inch diameter sewers.

Line Replacement

An entire line segment is replaced when it contains sections of collapsed pipe, misaligned joints or excessive sagging. When a line segment is replaced, all service laterals have to be reinstated and surface restoration has to be performed. In some instances, line replacement may not be possible due to accessability problems caused by congested work spaces (e.g. rear easements) or permanent structures (buildings and historic sites).

Line replacement costs are presented in Table 3. In addition to the costs presented in Table 3, an amount of $1,000 is added for reconnecting the new line segment to the upstream and downstream manholes. The cost of reinstating each service lateral is approximately $750. If the overlying surface is paved, a paving rehabilitation cost of approximately $17.50 per linear foot has to be included in the total line replacement costs. This estimated cost of $17.50/LF is based upon a 15 foot wide average excavation width.

Effectiveness of Repairs

Since the onset of the I/I reduction program, dig and replace point repairs and line replacement have accounted for 18.3% and 4.4% of all repairs respectively. Trenchless repairs have accounted for approximately 55% of all repairs. The repair and replacement of service laterals account for the remainder of repairs. The trenchless repairs, representing 55% of all repairs, is distributed as follows:

- Robotic repairs 9.1%
- Cured-in-place liners 9.6%
- Pressure grouting 9.7%
- Fold and form liners 10.5%
- Sectional liners 16.1%

Depth of Sewer (ft)	Diameter of Sewer (inch)		
	8	10	12
1	$34	$34	$34
2	$34	$34	$34
3	$34	$34	$34
4	$34	$34	$34
5	$34	$34	$34
6	$41	$41	$57
7	$41	$41	$57
8	$46	$46	$64
9	$46	$46	$64
10	$60	$60	$65
11	$60	$60	$65
12	$70	$70	$90
13	$70	$70	$90
14	$70	$70	$90

Table 3: Line Replacement Costs Per Linear Foot

From a construction management perspective, this diverse nature of repairs helps to distribute the repair workload equitably among the various contractors and suppliers. However, the efforts required to coordinate and manage the various contractors increases. To help manage the rehabilitation program, the PCC utilizes critical path method (CPM) scheduling techniques. To date, all repairs have been performed on schedule and within stipulated budgets.

One of the methods to judge the effectiveness of the repair program is the tracking of the monthly I/I removed from the sewer collection system. The amount of I/I removed per month is obtained from a pre- and post-rehabilitation seven day flow monitoring program conducted by MDWASD forces. This program utilizes portable flow meters which are installed in a collection basin before and after rehabilitation activities occur. The I/I removed in a basin is computed as the difference in the average flow before and after repairs. Rain and groundwater conditions are also documented for reference.

In its five year I/I reduction program, MDWASD aims to reduce 1 million gallons per day (MGD) per month of I/I from its sewer collection system. Thus far, MDWASD's I/I reduction program has been able to achieve this goal.

The New Technology Evaluation Committee

Repair techniques for sewer rehabilitation continues to be developed and introduced at a rapid rate. In order to keep abreast with new technologies, and to ensure that the most cost effective, long-term repairs are being made, a New Technology Evaluation Committee was formed to examine and evaluate new repair products/technologies. The Committee undertakes a close scrutiny of all products/technologies before granting its approval for their use in the I/I reduction program.

In accordance with the by-laws of the New Technology Evaluation Committee, a number of steps are involved in the approval process for a new repair technique/material. The first step involves the completion of a detailed questionnaire outlining a case history of the product usage, any warranties which may be applicable, references and technical data. This information is submitted to a sub-committee for initial screening of the product and further evaluation. Before granting its final approval, the New Technology Evaluation Committee may request a limited demonstration of the product/repair technique.

Conclusions

The current I/I reduction program undertaken by MDWASD has been very successful. It has satisfied all regulatory requirements and is on target to meet MDWASD's self imposed goal of removing 60 MGD of I/I from its sewer collection system. It has been able to rehabilitate its sewer system by using cost effective sewer repair methods. This objective has been met by adhering to stringent guidelines which yields the most cost effective, long term repair solutions.

Throughout the rehabilitation phase of its program, MDWASD has consistently sought a trade off between repair costs, constructability and the effectiveness of a repair method. This philosophy has resulted in 55% of all repairs being trenchless repairs.

The I/I reduction program in Dade County, Florida can certainly bare a claim of being a true no-dig success story. Based on engineering and economic guidelines more than half of all the repairs performed to date have been no-dig or trenchless repairs. These repairs have not only assisted in meeting construction targets but have also kept repair costs within budget.