SWIMMING IN SUCCESS, NOT I/I – WHAT MADE IT WORK – CLEVELAND, TENNESSEE'S SCOPE 10 PROGRAM

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ABSTRACT

The purpose of a sanitary sewer rehabilitation project is to eliminate inflow and infiltration and improve system infrastructure including mainlines, manholes, and service lateral connections. A successful project is based upon adaptability, continuous oversight during the construction phase, planning, and proper budgeting. The planning must include system prioritization by strategically utilizing flow monitoring and sanitary sewer evaluation survey data. Leveraging technological advances in GIS when conducting sanitary sewer evaluation studies allows maximum flexibility during the design process of rehabilitation projects. Continuous oversight and supervision throughout the construction phase is key to ensure the design is properly carried out and all repairs are made according to specifications.

KEYWORDS:

Collection system, trenchless rehabilitation, cured-in-place-pipe rehabilitation, service lateral reinstatement, flow monitoring, system prioritization, long-term planning

INTRODUCTION

Each utility responsible for maintaining a sanitary sewer system is charged with providing protection to the environment by keeping waterways free from contaminants and ensuring public safety. Cleveland Utilities formed the SCOPE-10 program (**S**trategic **CO**mmitment to **P**rotect the **E**nvironment – A Ten Year Commitment to Improving Water Quality) to do just that. As part of this program, Cleveland Utilities has committed the resources necessary to take steps in pro-actively protecting not only the environment, but also the public's investment in wastewater infrastructure.

Maintaining aging infrastructure as well as providing newly constructed facilities to serve the community requires a comprehensive asset management strategy. Through the SCOPE-10 program, Cleveland Utilities formed a new department (Wastewater Collections and Rehabilitation) to implement, manage, and oversee rehabilitation and daily operation of the sanitary sewer collection system. Balancing the needs of the collection system with those of the rate payers is achieved by prioritizing repairs, relying upon internal knowledge and efforts of key staff members, and procuring funding from the Tennessee State Revolving Fund (SRF) Program.

PROJECT APPROACH

Since inception in 2011, SCOPE-10 has changed the way rehabilitation and maintenance are addressed internally and how information is managed. One of the major challenges utilities face with underground infrastructure is knowing when to evaluate in order to maintain proper care, knowing how to locate issues within the varying types of underground structures, and more specifically, knowing where to begin looking such that thinly stretched budgets aren't depleted by merely gathering data that has historically sat on bookshelves or on video media in a closet rarely used.

Recently, common "buzz words" of the industry have been "systematic approach," "strategic planning," or "prioritization" but what do those words actually look like "in the field" to help produce needed results. With the advancements in technology over the last decade, there are many tools available to aid in the collection and storage of data gathered in the field resulting in a more user friendly way of reviewing and using the volumes of data collected.

The methods of "finding" extraneous flow (I/I) have not changed much over the years; however, the order and to the extent they are utilized can greatly affect the budget used. For most utilities, fixed budgets are a given, and are based on the revenue stream produced by the number of rate payers within a system. The SCOPE-10 program was developed to be a pro-active approach to "find and fix" defective infrastructure and reduce sanitary sewer overflows (SSOs). With a renewed commitment, Cleveland Utilities employed an experienced engineering firm (S&ME, Inc.) to aid in the planning, design, and implementation of the program.

"Where to start" was the first question to be answered. Cleveland Utilities had previously installed (in early 2011) nine (9) temporary flow monitors in parts of the system to provide a baseline for conditions during both dry and wet weather. Based on knowledge from Cleveland staff, the meters were installed in areas of the system believed to have significant issues. The analysis of this data provided a starting point by identifying portions of the system with high volumes of I/I. Although this was not a "bells and whistles" type flow monitoring study with the recommended coverage throughout the system, the information provided Cleveland Utilities and S&ME staff a focus area (See Figure -1) in which to concentrate funds to locate and perform repairs over the next several years. (See system specifics below).

- 17,900 wastewater accounts
- 360 miles of gravity sewer (ranging from 6-inch to 54-inch diameter pipe)
- 7100 manholes
- 17 lift stations
- 19 miles of force main
- 1 wastewater treatment plant

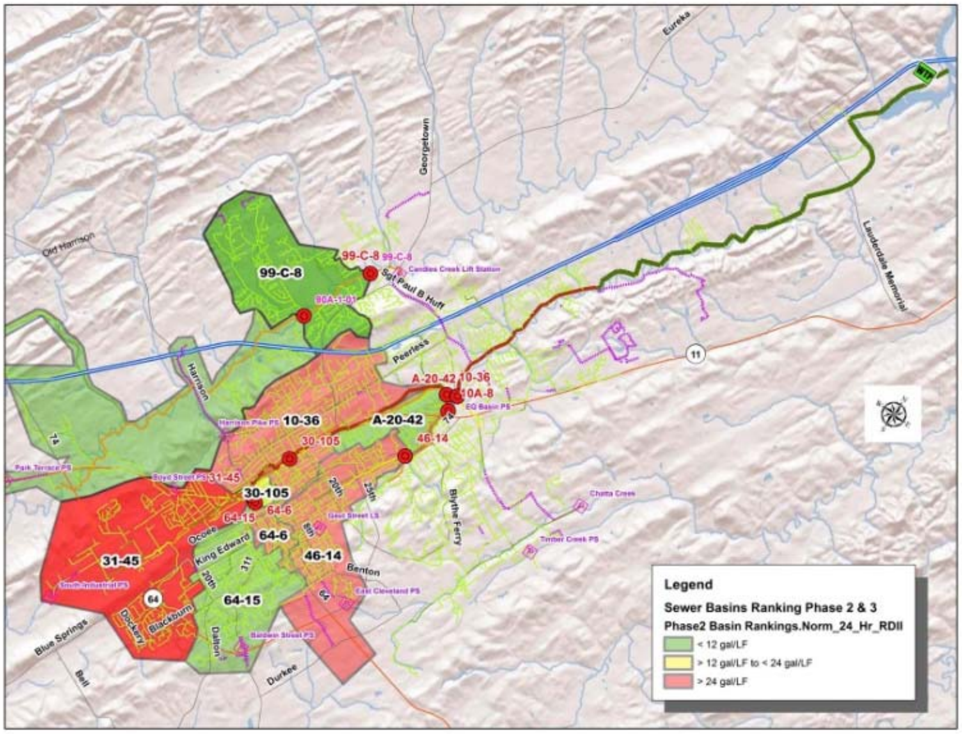

Figure 1 – System Priority Map

The results from the 2011 study indicated that approximately 53% (11.3 MG during the initial 24-hour storm period) of the rain-dependent inflow and infiltration (RDII) volume was observed within approximately 27% (360,000 LF) of the monitored area. These areas were identified as Basins 31-45 and 10-36. Both metering locations indicated significant inflow and infiltration signatures in the data with sustained peaks of 22 MGD, a 120% increase from average daily flow.

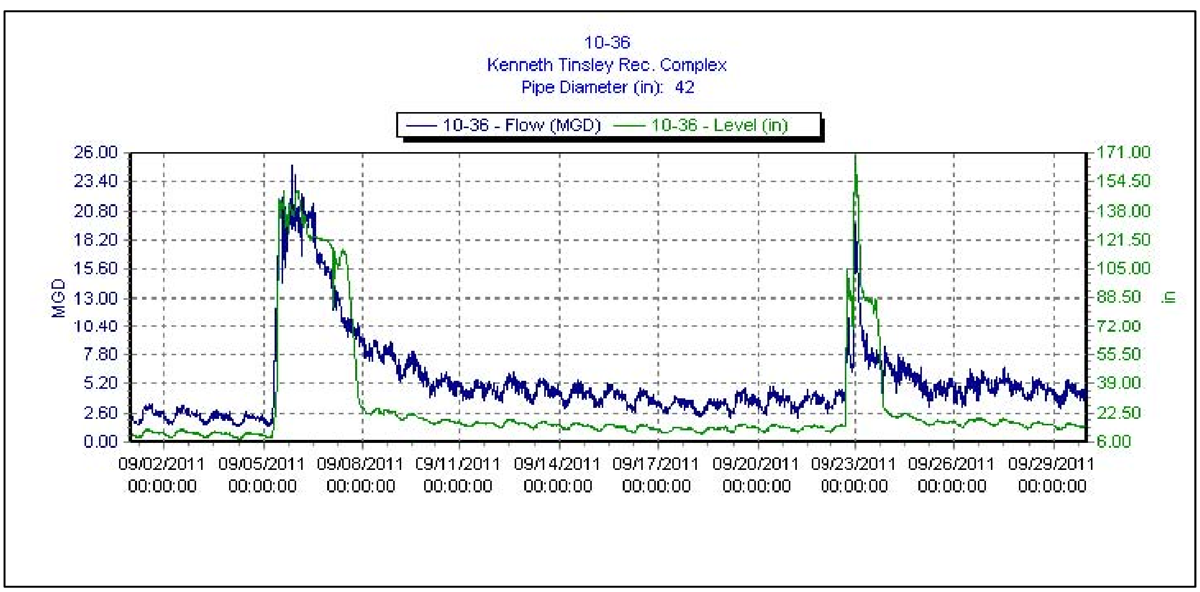

Figure 2 – Depth-Flow Hydrograph – Basin 10-36

With the identification of the focus area, planning and budgeting would determine how much and how quickly work could be completed. As part of the SCOPE-10 initiative, annual budget funding was increased from $400,000 annually to $3 million annually. Additionally, the Tennessee State Revolving Fund (SRF) program was utilized to procure additional funds to be used in conjunction with the annual budget. Cleveland Utilities' staff provided a 10-year outlook plan to spend $30 million dollars in rehabilitation and inspection of the sanitary sewer collection system over a 10-year period with a portion of the funding including $451,000 in principal forgiveness along with very modest interest rates, both of which translate to lower sewer rates. To meet the payoff schedule, Cleveland Utilities would be required to implement a series of rate increases of 4%-5% over the next ten years. In order to educate the public about the program, the rate increases, and the work to be accomplished, Cleveland Utilities incorporated a public outreach arm within the SCOPE-10 program to provide information to the public. Information was included in the local paper and on local radio on a regular basis.

METHODOLOGY

With funding in place and the focus area identified, decisions needed to be made regarding the most efficient and cost-effective use of time and money. Due to the overall size of the areas identified as priority, it was determined to establish project areas that coincided with the funding. Basin 31-45 was the worst area and was slated to be completed first followed by Basin 10-36. Additionally, a moratorium had been issued in a small basin to the west of town (Wildwood & Inman) which would also require additional attention in conjunction with those areas identified by the flow study. Figure 3 provides a breakdown of the project areas and how they were funded.

Project Area	Funding	Summary of Project	Year
Basin 31-45	Cleveland Utilities Annual Budget	1000 Manhole inspections, 217,475 LF Smoke Testing, 44 Flow Isolations, 121,000 LF CCTV	2011-2012
Basin 10-36	SRF Funding and Annual Budget	892 Manhole inspections, 190,134 LF Smoke Testing, 50 Flow Isolations, 209,514 LF CCTV	2012-2013
Wildwood-Inman	SRF Funding	444 Manhole inspections, 104,950 LF Smoke Testing, 27 Flow Isolations, 67,500 LF CCTV	2013-2014
Basin 10A-8	SRF Funding	1256 Manhole Inspections, 265,962 LF Smoke Testing, 76 Flow Isolations, 185,115 LF CCTV	2016-2017

Figure 3 – SSES Project Summary Table

With the goal of eliminating I/I, defective mainlines, manholes, and service lateral connections would need to be identified and prioritized for repair. Additionally, because a comprehensive inspection program had not previously been implemented, base data for what inventory existed in the system was not correct. Cleveland Utilities had bolstered GIS mapping capabilities with the onset of the program, but had limited mapping capabilities initially. As part of the SCOPE-10 initiative, an inventory of the system would be collected, manholes would be located and GPS (survey grade) points would be taken in order to update and create an accurate sewer GIS layer, including pertinent information that would be useful during regular, daily O&M activities.

Timing of the sanitary sewer evaluation survey (SSES) activities was crucial to the program. In order to find the most significant I/I sources, most activities would need to occur during wet weather periods. A strategic schedule was formulated for the program as follows in Figure 4:

SSES Activity	Optimum Seasonal Period	Comments
Smoke Testing	Summer/Fall	Needed to be performed during the driest periods
Manhole Inspections	Winter/Spring	Needed to be performed under high ground water or wet weather periods
Manhole GPS	Anytime	To be completed once manholes were located/marked
Flow Isolation	Winter	Needed to be completed during storm events (at night) prior to CCTV inspection
Dyed-water Testing	Winter/Spring	Performed in conjunction with CCTV inspections
CCTV Inspections	Winter/Spring	Needed to be performed during high ground water or wet weather periods
Service Lateral Inspections	Anytime	Performed in conjunction with CCTV inspections but was not dependant upon wet weather

Figure 4 – SSES Project Schedule Table

Because of the seasonal timing, it was imperative that the SSES activities stayed on schedule; otherwise, the entire program could be set back for a year or more. The following descriptions provide a summary of each activity.

Smoke Testing - As indicated in the table, smoke testing was performed in the driest season of the year and typically completed prior to the manhole inspections. This allowed for the location of manholes along heavily vegetative easement areas. Smoke testing was also a quick and efficient means to locate potential cross-connection leaks that allow high volumes of I/I into the sewer system. Typically, because smoke testing is an economical means to locate defects, all pipeline segments with diameters 6-inch to 15-inch are completed. In Figure 5, a sewer mainline pipe was found defective running through a storm catch basin during smoke testing.

Figure 5 – Broken 8-inch Sewer Mainline in Storm Catch Basin

Manhole Inspections – The completion of manhole inspections is crucial in obtaining an inventory of the system, verifying connectivity, and identifying inflow sources. Each manhole is located and inspected as part of this process. In order to maximize funding, inspections are scheduled during wet weather periods or periods of high ground water such that defects might be observed, logged, and prioritized for repair. Figure 6 is an example of a significant defect found during wet weather manhole inspections.

Figure 6 – Active Infiltration at Manhole/Line Connection

Manhole GPS – Obtaining Global Positioning System (GPS) points for each manhole is a critical part of building an accurate GIS map. Cleveland Utilities and S&ME staff decided on survey grade accuracy in order to aid in the building of a hydraulic model thus eliminating the need for additional data. The GPS points are obtained by separate crews than the manhole inspection crews and are dispatched to perform work subsequent to the location/inspection of each manhole. This process provides a more efficient flow of data and is supervised by a registered licensed surveyor (RLS) to ensure accuracy.

Flow Isolations – In order to minimize the footage to CCTV inspect, flow isolations are utilized to determine micro areas where high volumes of I/I are present immediately following a minimum size storm event (as indicated by the flow monitoring data). Micro areas are usually 3,000 LF to 5,000 LF in size. Readings from a volumetric weir are typically taken during times when wastewater production is at the lowest (10 PM to 5 AM), thus identifying segments requiring further investigation. Figure 7 illustrates the results of a portion of basin 31-45 as it shows the priority of each line segment. Those line segments with no priority were found to have negligible I/I volumes and were thus omitted from the CCTV priority listing.

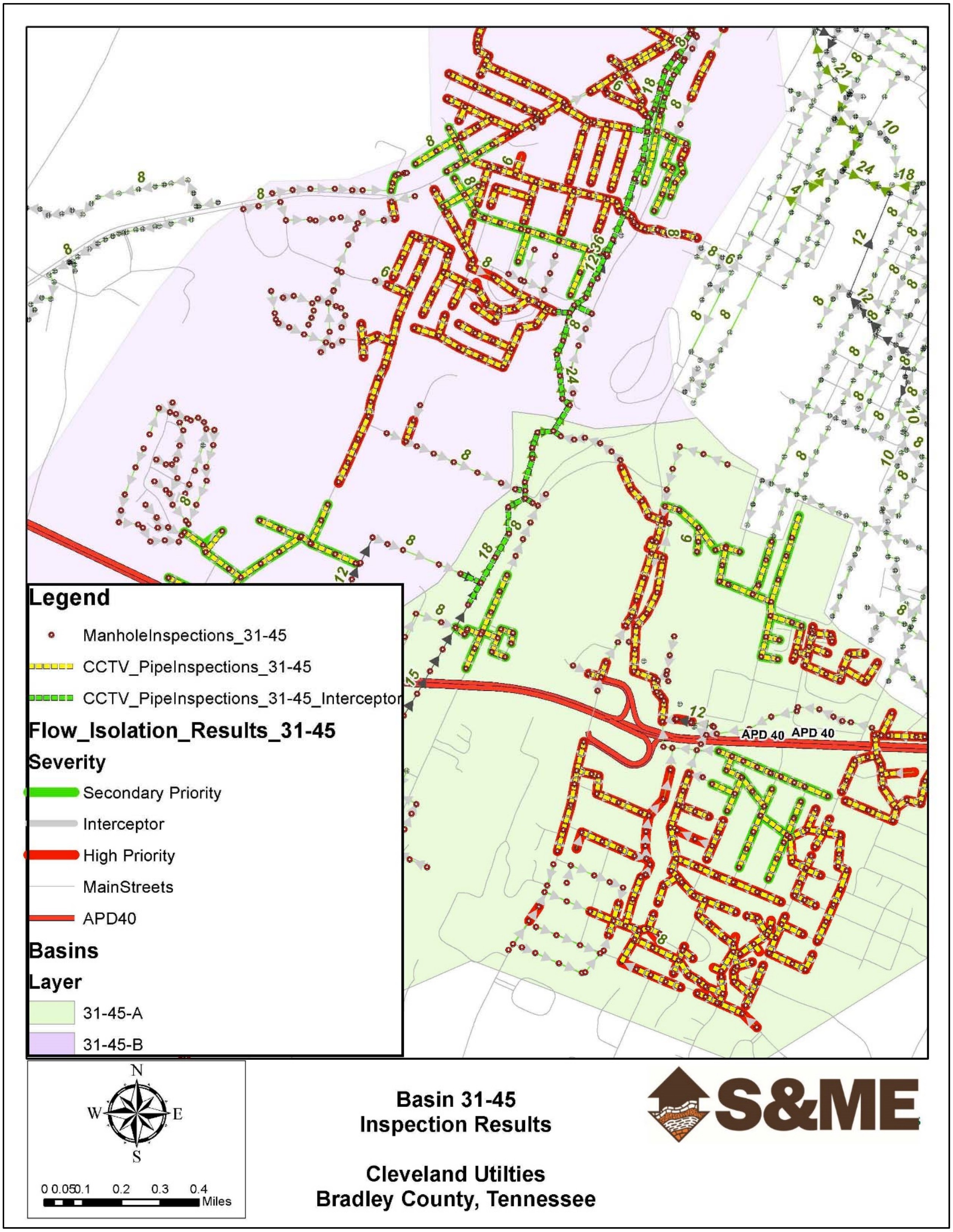

Figure 7 – Flow Isolation Results- Basin 31-45

Dyed-Water Testing – Used in conjunction with CCTV inspections, dyed-water testing is a means to verify the cross-connection leaks identified during the smoke testing phase of the project.

CCTV Inspection – By utilizing flow isolations to identify segments to include for CCTV inspection, a significant cost savings is realized. Depending on the age and condition of the system being evaluated, CCTV inspection totals could be cut in half be eliminating pipes that show little or no I/I. As part of the SCOPE-10 program, Cleveland Utilities ensured that their CCTV operators were PACP (Pipeline Assessment and Certification Program) certified through the NASSCO (National Association of Sewer Service Companies) organization. Having in-house staff properly trained provided a means for the remaining segments to be televised at scheduled times to complete the inspection of the entire basin, but at a much lower cost. CCTV inspections must also be performed during wet weather conditions or periods of high ground water in order to observe I/I through defects that might not be apparent during drier seasons of the year.

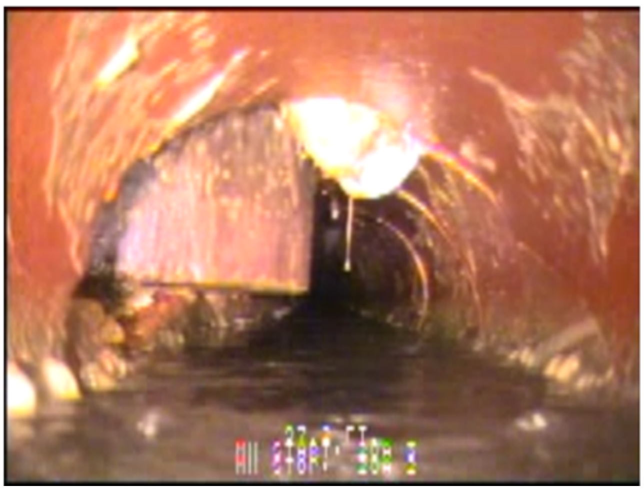

Figure 8 – Telephone Pole through Sewer Pipe

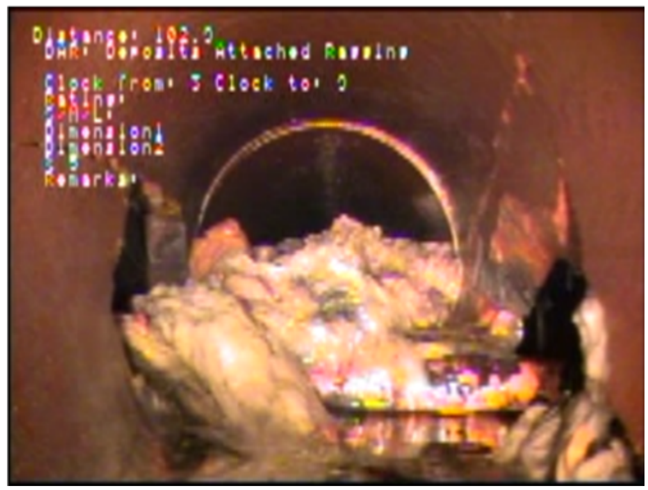

Figure 9 – Water Line through Sewer Pipe

Upon completion of the inspection in the first area (Basin 31-45), a rehabilitation project was designed for the priority defects identified within the allowable rehabilitation budget. The process of inspect, prioritize, design, and construct was followed to complete work within the three basin areas (31-45, 10-36, & Wildwood-Inman). Project totals with associated costs are illustrated in Figure 10.

Approximately 25% of the priority (90,000 LF of the 360,000 LF) area has been included in rehabilitation projects for a construction cost of approximately $10 million dollars which equates to an average of $116 per foot to construct. This cost includes mainlines, manholes, and services lateral connections (up to the property line) with any associated costs such as paving and concrete work.

Project Area	Funding	Summary of Project Repairs	Project Cost	Year
Basin 31-45	Cleveland Utilities Annual Budget	12,647 LF of Mainline, 574 VF of Manhole, 98 Service Laterals	$ 1,187,403.75	2012
Basin 10-36 Phase 0	SRF Funding	48,414 LF of Mainline, 2,271 VF of Manhole, 509 Service Laterals	$ 4,164,700.00	2014
Wildwood-Inman	SRF Funding with Subsidized Funding	8,566 LF of Mainline, 523 VF of Manhole, 185 Service Laterals	$ 1,202,847.04	2015
Basin 10-36-Phase 1	SRF Funding	10,045 LF of Mainline, 939 VF of Manhole, 165 Service Laterals	$ 2,112,971.00	2017
Basin 10-36-Phase 2	SRF Funding	8,122 LF of Mainline, 340 VF of Manhole, 143 Service Laterals	$ 1,544,518.00	2017

Figure 10 – Rehabilitation Project Summary

Where possible, trenchless rehabilitation methods were recommended to minimize public disturbance as much of the work was located under the pavement of City streets. Cured-in-place pipe (CIPP) was installed to repair defective mainlines (See Figure 11) along with pipe bursting techniques; however, some open-cut-replacement was necessary in certain applications. In lieu of replacement, manholes were rehabilitated utilizing a spray on coating to provide both structural and corrosion resistant protection (see Figure 12).

Figure 11 – CIPP Mainline Repair

Figure 12 – Manhole Rehabilitation

A key component of these projects was the comprehensive repair methodology utilized. On all mainline repairs utilizing CIPP technology, each lateral along that line was also repaired either by installing a CIPP lateral liner or by open-cut-replacement methods (i.e., installing a saddle at the connection and new PVC pipe back to the property line). The manholes on either side of the line segment were also repaired by spraying a polyurea or epoxy based liner to prevent corrosion and seal the manhole walls and manhole/line connection, thus preventing I/I from migrating through the pipe trench to the manhole.

RESULTS

The results of the pre and post flow monitoring along with the SSO reports indicate significant improvements in specific focus areas of the system. A number of SSO locations have been eliminated and/or volumes significantly reduced, especially those in the upper portions of the study area. Figure 13 illustrates historical chronic SSO points along with rehabilitation completed.

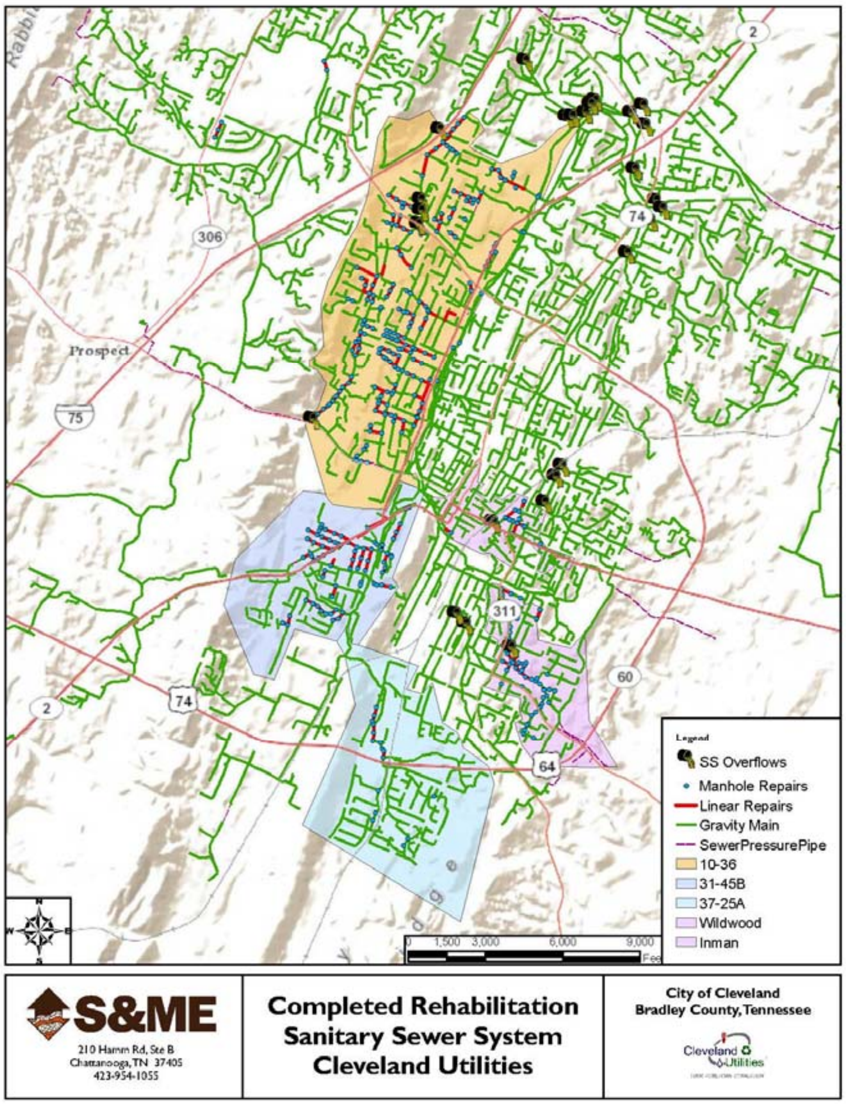

Figure 13 – Study Area & Historical SSO Map

In the Wildwood Basin, the project was aimed at eliminating or significantly reducing the two historical chronic SSO points (as shown in Figure 14) along with mitigating significant volumes of I/I which were observed and/or identified throughout the basin during the SSES phase of the project. One of the most significant issues identified were leaking service connections. Over a decade ago, a number of mainlines were repaired via CIPP but the PVC service lateral connections were not addressed, they were only cored and brushed subsequent to the installation of the mainline CIPP. One of the objectives of this project was to utilize trenchless methods of repair by installing CIPP lateral liners from the mainline to the property line cleanout to prevent digging in busy City streets, even on those that were PVC. Where this technology was not feasible, the connection was repaired by dig-and-replace methods which included the installation of a new saddle at the connection of the CIPP material. Additionally, there were a number of manholes with significant I/I issues that were rehabilitated using trenchless techniques as shown in Figure 12. In conjunction with these repairs, CIPP was installed along severely defective mainline pipe. Figure 14 illustrates all work completed.

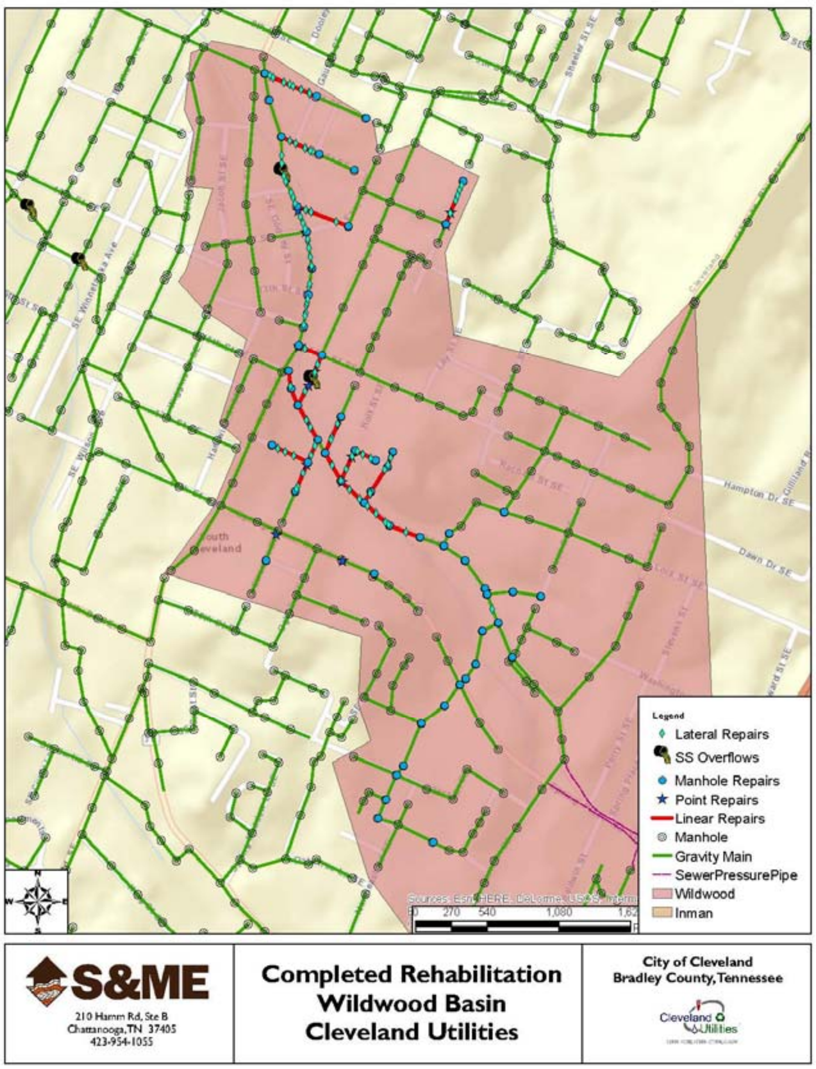

Figure 14 – Wildwood Basin – Completed Rehabilitation

As illustrated in Figure 15, a 48% decrease in wet weather rain dependent I/I (RDII) volume was observed as a result of the rehabilitation work completed. Pre-rehabilitation wet weather volume for a 3-inch rain event resulted in approximately 21,000 gallons of RDII during the initial 24-hour storm period. Post rehabilitation wet weather RDII volume was reduced to approximately 11,000 gallons of RDII. Additionally, during pre-rehabilitation conditions, only a trace of rainfall resulted in an increase of flow, while post rehabilitation results indicated 0.50-inches of rainfall was required to produce any type of reaction within the system. The result was achieved by primarily addressing lateral connection of previously lined mainlines and the rehabilitation of leaking manholes.

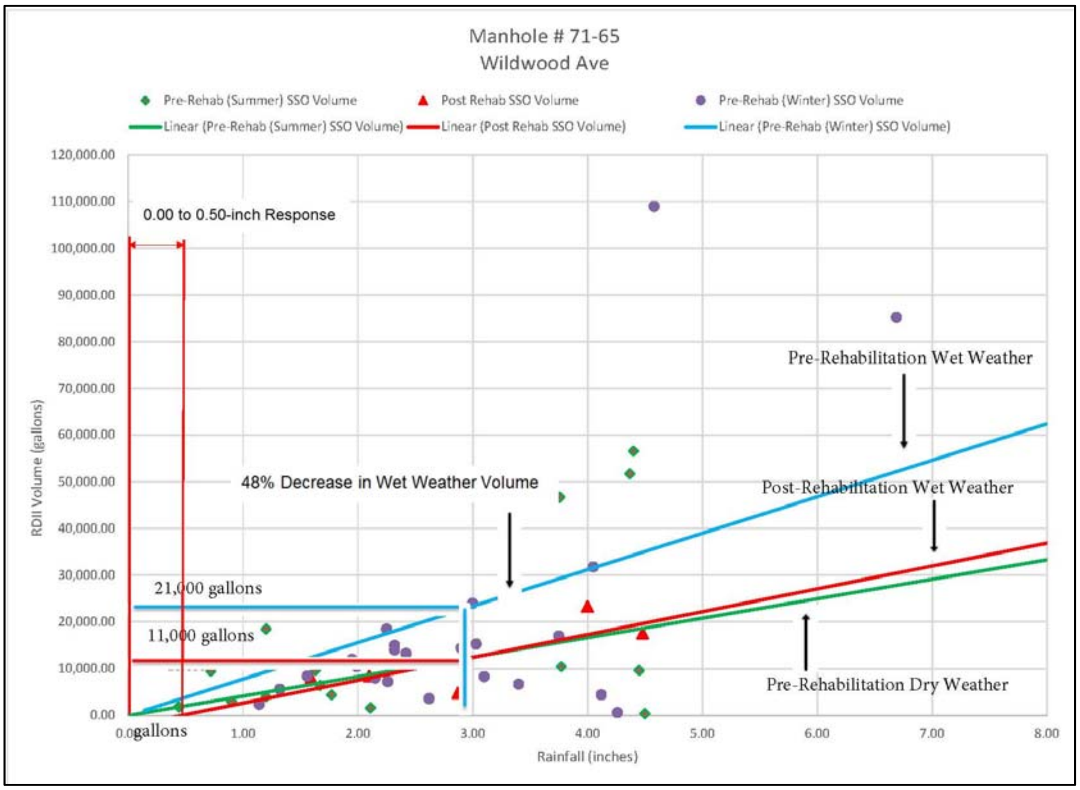

Figure 15 – Q vs i Comparison – Pre/Post Rehabilitation_Wildwood Ave

Similar results were observed within the Inman Street area (see Figure 16) with an 83% reduction in RDII volume as illustrated in Figure 17. In this basin, flows would respond immediately to a trace of rainfall prior to rehabilitation; however, once repairs were made, the system showed virtually no response to storms under an inch of rainfall. Additionally, as shown in Figure 17, post rehabilitation responses to winter-time rainfall storm events were found to be equivalent to that observed during summer-time rainfall storm events or those events occurring under typical dry weather periods during pre-rehabilitation conditions.

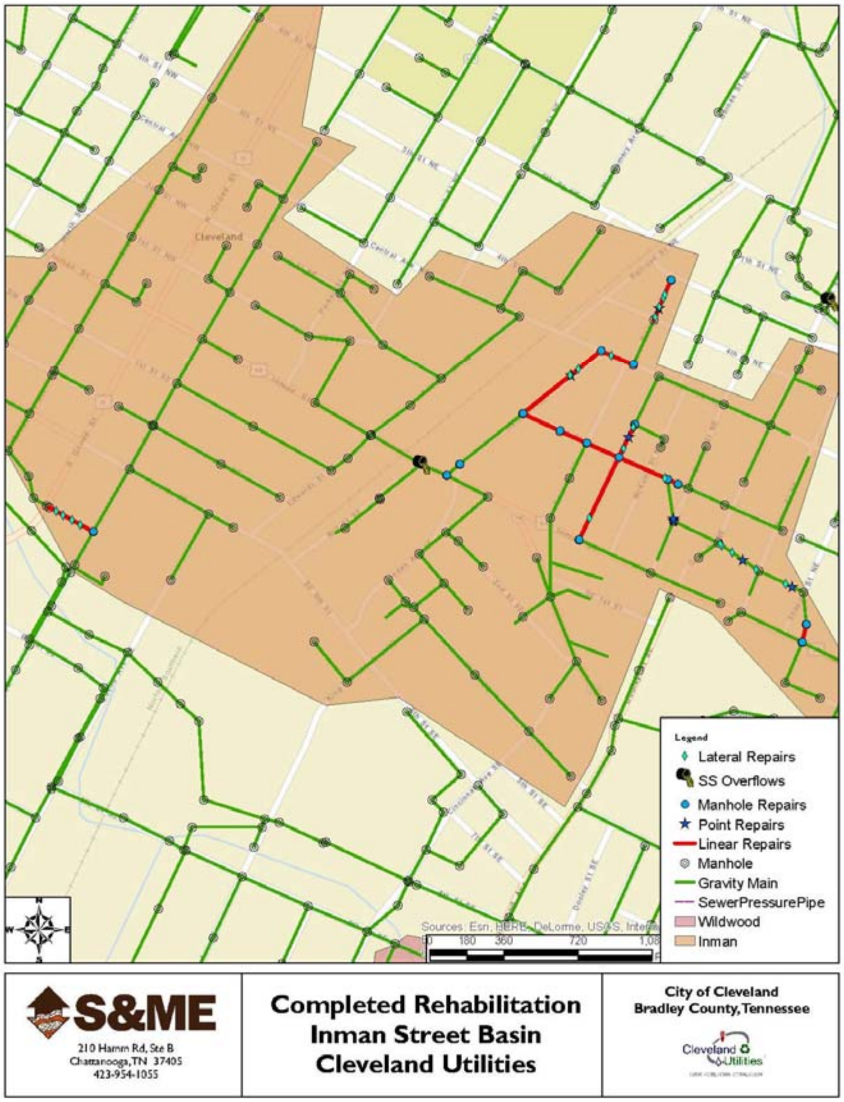

Figure 16 – Inman Street Basin – Completed Rehabilitation

The SSOs in these areas were also positively affected by the rehabilitation completed. Although they are not totally eliminated, they are not present during the smaller and medium sized rain events and the volume and/or overflow time is drastically reduced during the larger storm events. Figure 18 summarizes both the SSO time reduction (time in hours that each SSO point overflowed) and the estimated SSO volume reduction. It was observed that the Inman Street basin had a 62% reduction in the time of overflow for 1-inch of rainfall from 3.4 hours to 1.3 hours. Similarly, the Wildwood Ave basin was reduced from 9.5 hours to 5.1 hours. The associated SSO volume reduction observed is 85% and 48%, from the Inman and Wildwood areas, respectively. Figures 19 & 20 provide a graphical illustration of the SSOs observed during post rehab conditions and how they associate with the pre-rehabilitation conditions.

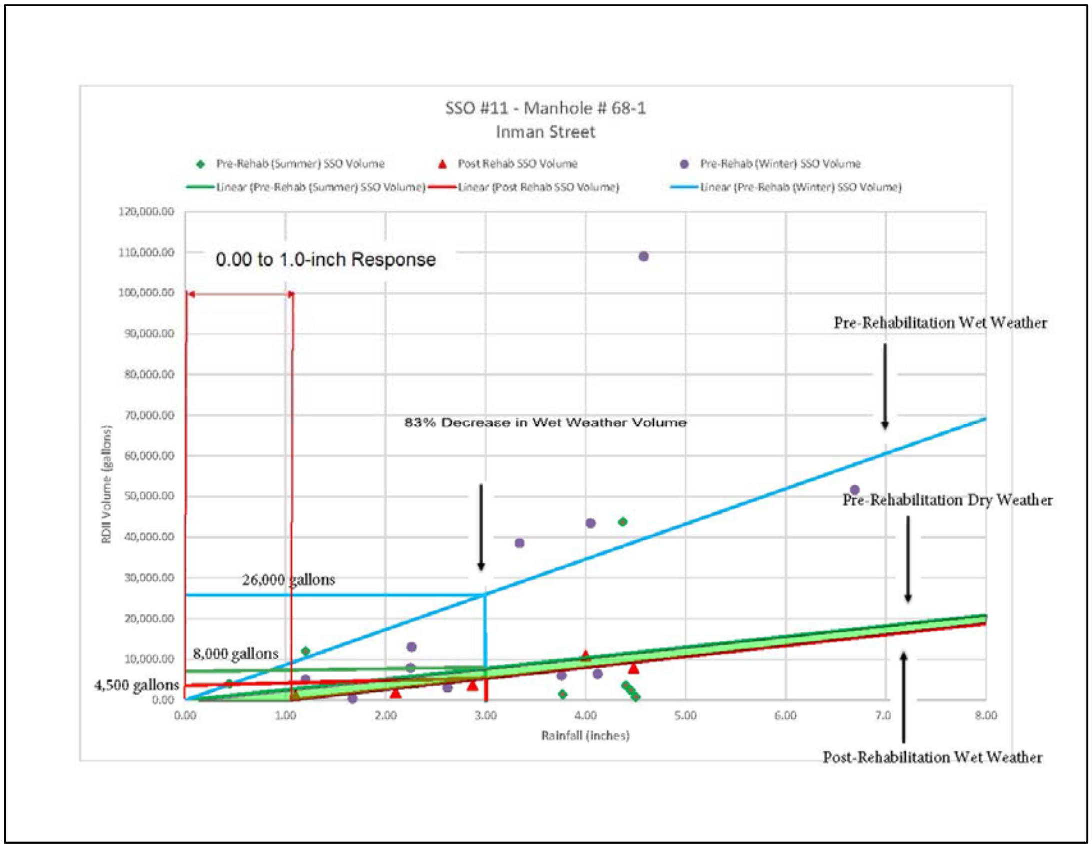

Figure 17 – Q vs i Comparison – Pre/Post Rehabilitation_Inman Street

	SSO Time Reduction			SSO Volume Reduction	
	Inman Street	Wildwood Ave		Inman Street	Wildwood Ave
	Hours/Inch	Hours/Inch		Gallons	Gallons
Pre-Rehabilitation Conditions	3.4	9.5		26,000	21,000
Post-Rehabilitation Conditions	1.3	5.1		4,000	11,000
Percent Decrease	62%	46%		85%	48%

**Note: Hours/inch represents the hours of estimated time the SSO overflowed per inch of rainfall.*

Figure 18 – SSO Time & Volume Summary Table

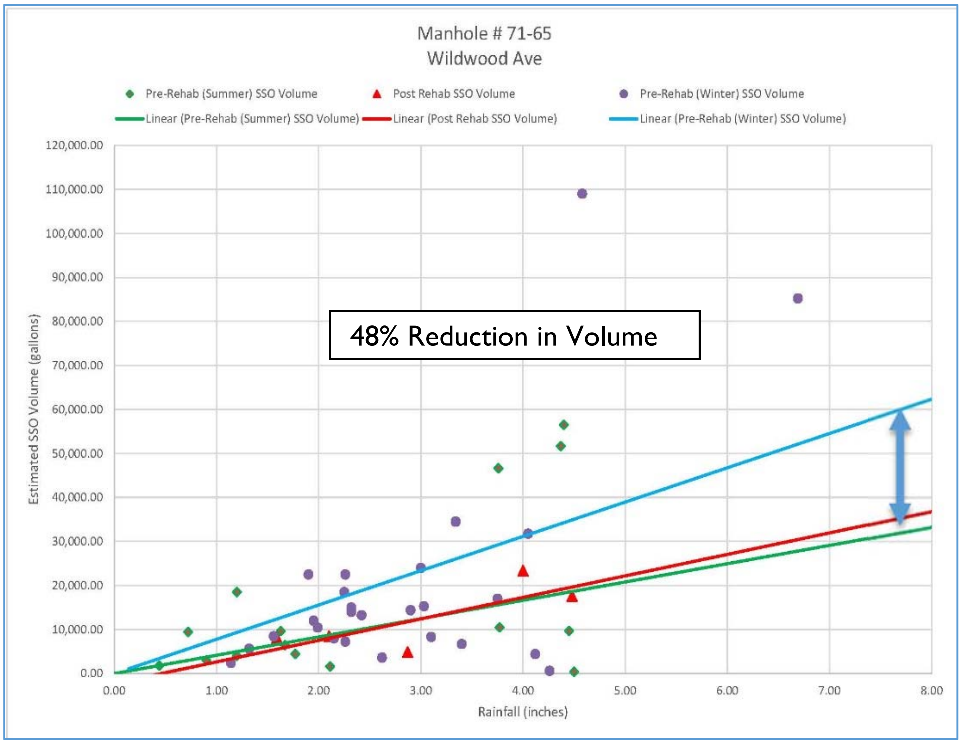

Figure 19 – Q vs i Comparison – Pre/Post Rehabilitation_Wildwood Street

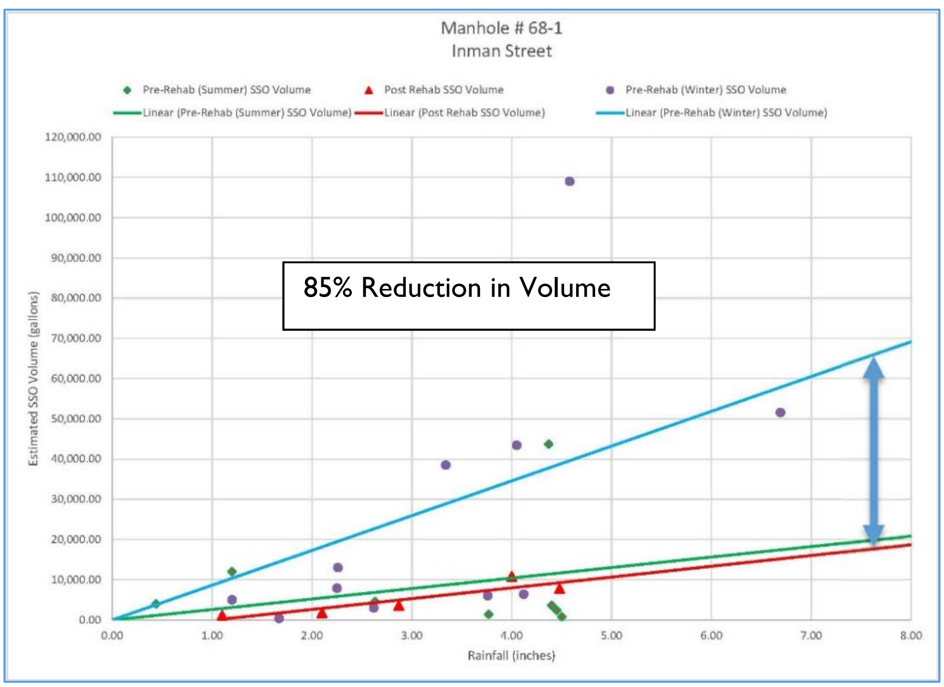

Figure 20 – Q vs i Comparison – Pre/Post Rehabilitation_Inman Street

CONCLUSIONS

With the work completed to-date, there have been great successes measured both on a large scale and on a small scale in more localized areas. There are some key factors to which the successes are greatly attributed, with the most important being **adaptability**. Although a plan was formulated prior to the initial project, Cleveland Utilities and S&ME staff worked closely throughout the process to evaluate each step of the project, both during and after completion, to determine what worked well and what needed to be revised. For example, in the initial project, on mainlines where CIPP was installed, only those service lateral connections that were observed (from the mainline) to be defective were repaired. Those connections that were PVC saddles were only cored and brushed. However, as illustrated in Figure 21, I/I migrated to the service connections that had only been cored and brushed, entering the mainline between the CIPP and host pipe material. Although the original PVC saddle connection may have been in satisfactory condition, this did not provide a complete seal.

Additionally, on earlier projects, no laterals were televised unless they were being rehabilitated via CIPP liner; however, this resulted in a significant number of contract changes due to the unknown condition of the laterals, including the ability to be rehabilitated via trenchless methods. On current SSES projects, all laterals along priority mainlines (as determined through the flow isolation process) are being televised. The advantage is that an early assessment of each lateral can be made during the design of the rehabilitation project, and not on-the-fly during the construction process. This provides more stability during the construction phase. Consequently, pricing for the lateral CCTV inspection is approximately 3.5-4.0 times cheaper when performed in bulk during the SSES phase.

Figure 21 – Leaking Service Connection – Core & Brushed Only

Another key contributing factor in the success of the rehabilitation program is the **continuous oversight during the construction phase**. The best designs are only successful with proper construction. With so many varying types of repairs and as many different sub-contractors on one project, continuous oversight to ensure the specifications are being followed is crucial to success. Trenchless rehabilitation repairs are typically considered specialized work with a limited number of contractors available. With project requirements changing in each City a contractor performs works, it is imperative to hold meetings throughout the construction phase discussing details of the project. Cleveland Utilities provided trained resident project representatives (RPR) throughout each project with assistance from S&ME. Having trained representatives on site continuously facilitates a smooth flow of work as they are able to answer questions, address concerns, and oversee the product going into the ground. In order to help with organization of documentation coming in from the field, on current projects, RPRs are using ArcGIS products on iPads to document all work performed. This includes photos, comments, and sign-off sheets, all which provide a means to track the project in real-time through ArcGIS (see Figure 22).

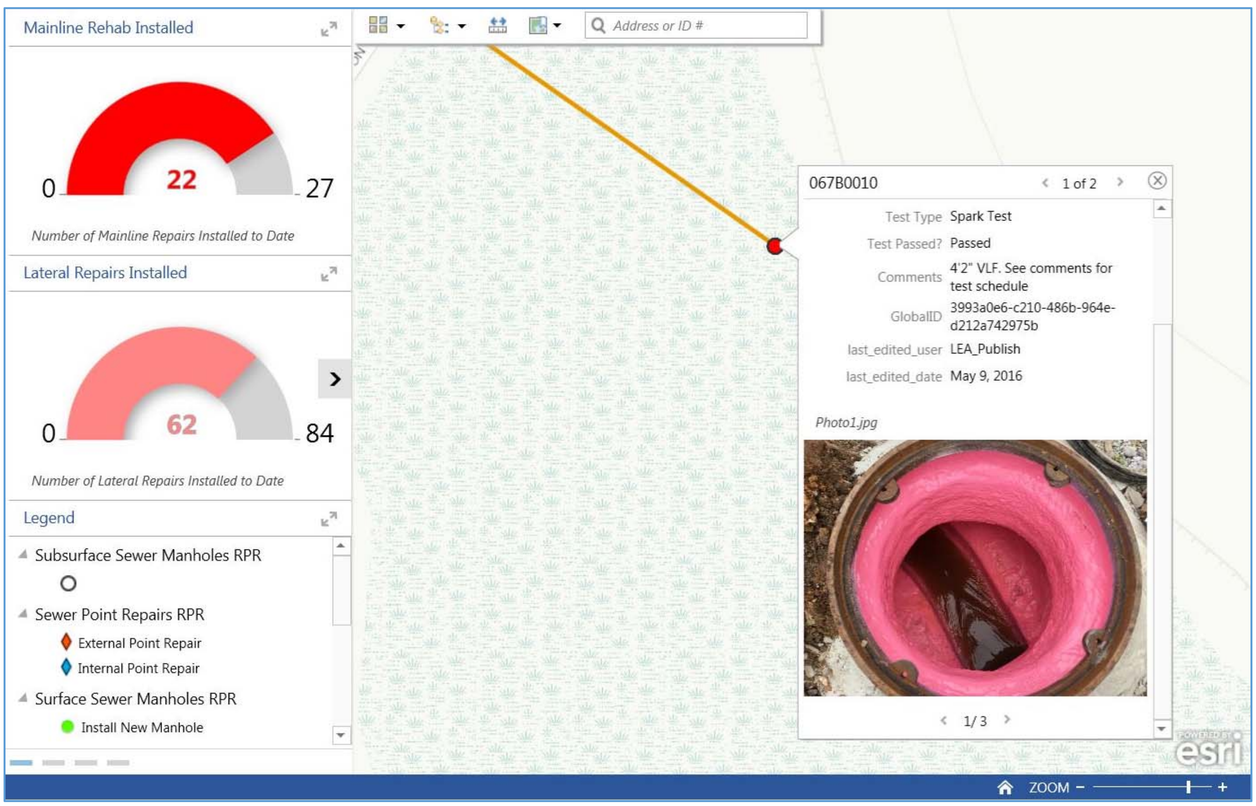

Figure 22 – RPR Construction Application

The final key component to the success of the program is the **long-term planning and budgeting** as identified and brought about by the SCOPE-10 effort of Cleveland Utilities. Cleveland Utilities and S&ME staff were able to plan and budget to both a 5-year and 10-year schedule for SSES and construction projects which enabled the most efficient flow of work. Project timelines were annually updated as projects were completed and new ones began. Being able to procure funding from the Tennessee State Revolving Fund program has allowed Cleveland Utilities to fund these projects with a very attractive interest rate thus resulting in minimal rate increases spread over a 10-year period as opposed to randomly applying significant rate increases to fund last minute project requests.

Cleveland Utilities has committed to stay on course with the SCOPE-10 program, providing customers with superior service while protecting the environment and ensuring public safety. With continuous planning and associated budgeting, Cleveland Utilities has a goal to work through the remainder of the collection system, prioritizing and systematically addressing the needs observed within the sanitary sewer infrastructure.