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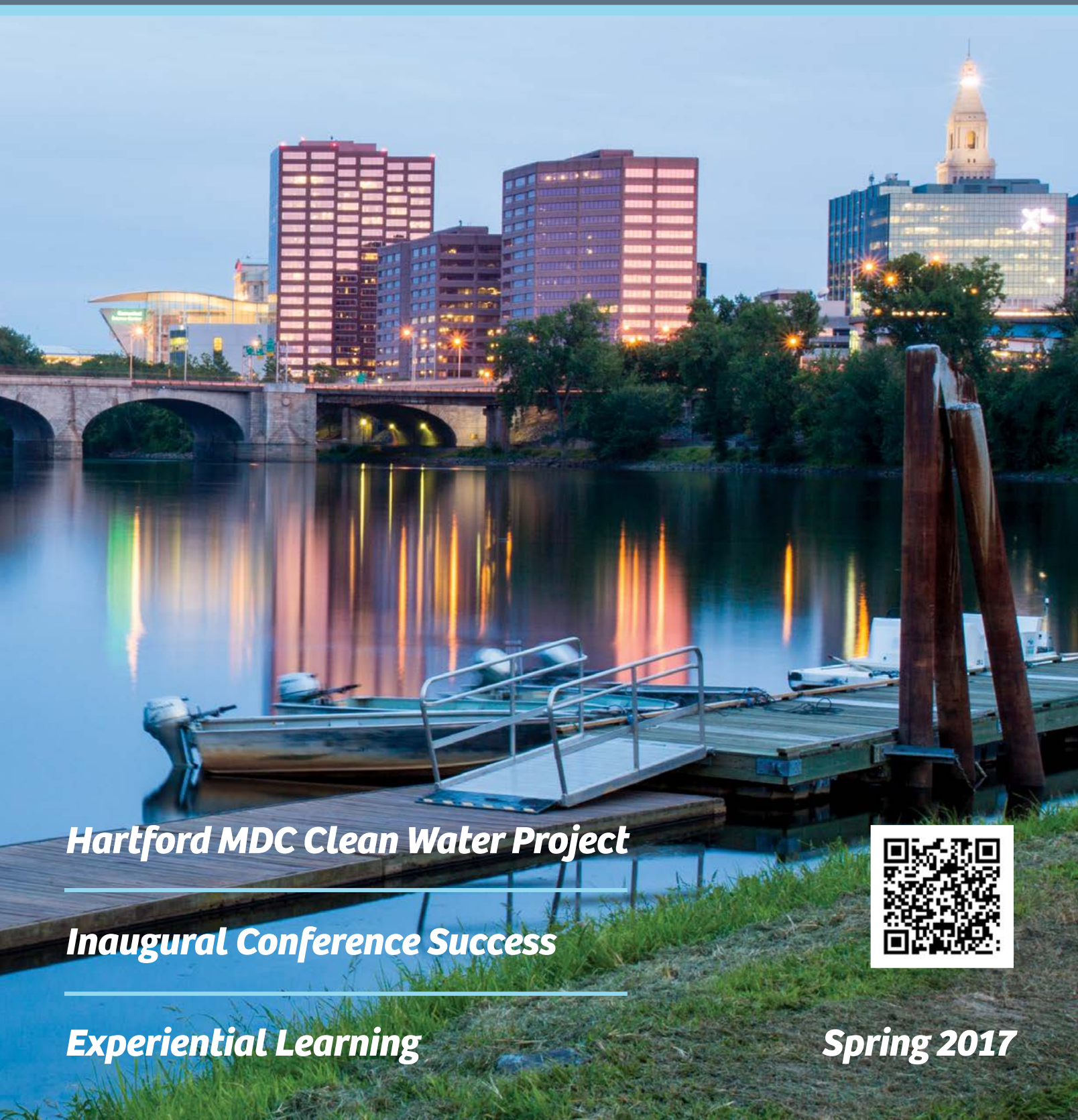

Hartford MDC Clean Water Project

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LARGE-SCALE REHABILITATION IN MULTIPLE TOWNS:

The Metropolitan District Implementation of SSES Recommendations and SSES Pilot Study Program

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INTRODUCTION

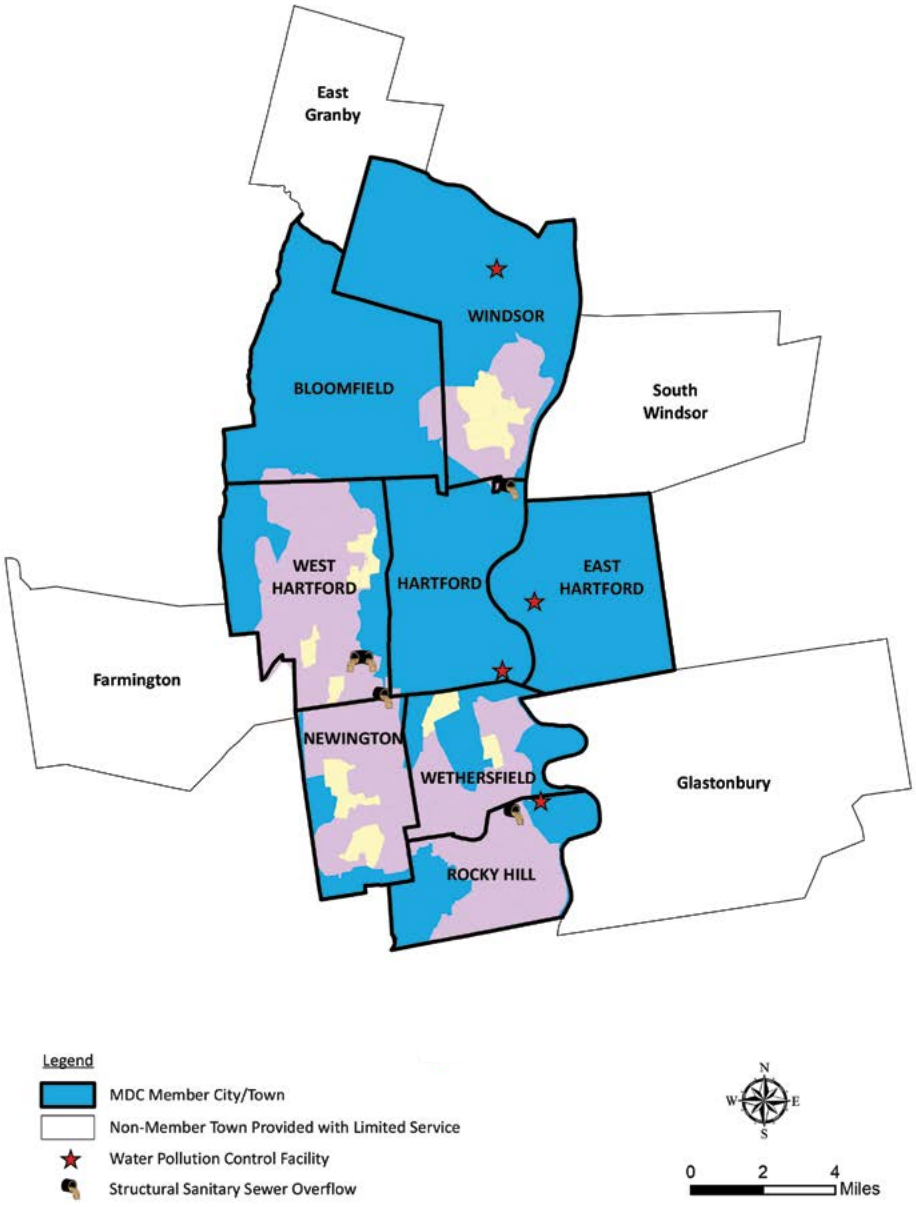
The Metropolitan District (District) owns and operates a sanitary sewer collection system in the towns of Newington, Rocky Hill, West Hartford, Wethersfield and Windsor in central Connecticut. The system experiences occasional weather related sanitary sewer overflows (SSOs) due to excessive inflow and infiltration that enters during or after storm events and during periods of high groundwater. In 2006, the District was issued a Consent Decree by the USEPA and Consent Order by the Connecticut Department of Energy and Environmental Protection. The Consent Decree/Order established remedial measures necessary to fulfill the objectives of the Clean Water Act by eliminating SSOs from its sanitary sewer collection system.

The District was chartered by the Connecticut General Assembly in 1929 to provide potable water supply and sewerage services on a regional basis. The District mission is to provide its customers with safe, pure drinking water, environmentally protective wastewater collection and treatment, and other services that benefit the member towns. The District is responsible for integrated sewer systems within all member towns, including the core combined sewer systems that were constructed in the City of Hartford between 1850 and the early 1900's. Every time it rains a quarter of an inch or more, storm water can overwhelm the District's combined sewer system. Storm water connections like sump pumps, foundation drains and downspouts, as well as cracks and open joints in the sewer pipes, allow storm water to enter the system. This extraneous flow mixes with raw sewage, filling the pipes beyond their capacity and activating sewer overflows or releases at various points within the sewer system. These overflows can cause raw sewage to back up into basements, spill out into neighborhood streets and flow into local waterways. Not only is this pollution unhealthy, but due to regulatory changes after the construction of the sewer system, these overflows violate the Clean Water Act.

"THE BENEFITS OF THESE PROJECTS INCLUDE I/I REDUCTION AND REDUCED MAINTENANCE THROUGH THE STRUCTURAL INFRASTRUCTURE IMPROVEMENTS MADE UNDER THE SSES AND PILOT STUDY REHABILITATION PROJECTS"

In response to the Consent Decree/Order, the District developed the Clean Water Project (CWP). The main goals of the CWP are to eliminate SSOs, reduce the amount of combined sewage and reduce the amount of nitrogen that is released into the Connecticut River. The main components of the $2.4 billion CWP

FIGURE 1. METROPOLITAN DISTRICT SERVICE AREA



includes wastewater treatment plant improvements, storage and conveyance tunnels, relief pipe, consolidation pipe and I/I reduction. The primary approach in the District's SSO communities to remove extraneous flow from the sanitary sewer systems has been I/I reduction through pipe and manhole rehabilitation. In addition to the sewer rehabilitation program, the District initiated a pilot study in 2010 to examine additional approaches to rehabilitation for sewer service laterals and private I/I sources. The main goal of the pilot study was to establish a 'toolbox' of rehabilitation techniques that can address a variety of system defects to achieve additional levels of I/I reduction. Figure 1 shows the member towns, non-member towns, areas, the Sewer System Evaluation Survey (SSES) implementation areas and sewer rehabilitation pilot study project areas.

SANITARY SEWER OVERFLOW (SSO) ELIMINATION PROGRAM

The initial steps of the SSO elimination program began with the development of Phase I SSES reports that date back to 2005. In this program, the collection systems in each SSO community were subdivided into areas with similar pipe lengths ranging between 20,000 and 30,000 linear feet. Flow data was then collected and analyzed from each of these sub-systems to estimate base sanitary sewer flows, groundwater infiltration and rainfall derived inflow and infiltration (RDII) entering the collection system. The flow data showed that during wet weather, extraneous storm water entering the sanitary collection systems can exceed the capacity of the sewer pipes in certain locations, resulting in SSOs, manhole surcharging or basement backups.

Phase II field investigations were then performed in areas that were found to be excessively high in inflow, infiltration or RDII. Recommendations to reduce extraneous flows were made in multiple Phase II reports submitted in 2008. Additional sewer system capacity assessments were then completed to incorporate the recommendations and completed work into the calibrated hydraulic models. These assessments included analysis to determine what additional work is necessary to abate SSO discharges under baseline and future conditions. Most recently, this process has led to the development of EPA approved SSO Elimination Plans which include recommendations to close the structural SSOs and relieve system surcharging at the following levels of service:

- Eliminate basement backups from sewer services during a 5-year storm event
- Eliminate SSOs from manholes during a 10-year storm event
- Eliminate structural SSOs during a 25-year storm event

An extensive flow monitoring program was completed between 2009 and 2014 to determine the estimated overall I/I reduction in each sewershed. The key goals of this metering program were to collect pre-construction and post-construction

TABLE 1. REHABILITATION TOTALS BY TOWN

Town	Sewer Main Lining (lf)	% Total Pipe Lined	Sewer Pipe Replacement (lf)	Sewer Point Repairs (ea)	Sewer Manhole Lining (ea)	Sewer Manhole Sealing (ea)	Frame and Cover Replacement (ea)
Newington	161,419	29%	1,396	1	142	39	763
West Hartford	503,112	50%	16,469	169	403	21	1,617
Windsor	117,999	31%	1,616	10	369	50	389
Wethersfield	169,122	35%	2,522	15	361	43	453
Rocky Hill	22,031	8%	0	2	90	0	142
Totals	**973,683**	**36%**	**22,003**	**197**	**1,365**	**153**	**3,364**

"A KEY TAKEAWAY OF THIS STUDY IS THE INHERENT VARIABILITY FOUND IN EACH PROJECT AREA DUE TO THE AGE OF THE SUBSYSTEM, SUBSURFACE CHARACTERISTICS AND ANTECEDENT CONDITIONS DURING THE FLOW METERING PERIODS"

flow data in the sewer rehabilitation pilot study areas and in locations where other capacity improvements projects were completed in the collection system upstream of structural SSOs. Prior SSO elimination reports estimated that I/I would be reduced by 10 percent upon completion of the SSES implementation in each sewershed. Determining if this benchmark was being met would help determine the future direction and goals of the SSO elimination program. For the pilot study areas, the goal was to determine the additional levels of reduction that may be achieved through implementation of additional rehabilitation techniques, and to confirm the 10 per cent I/I reduction estimate for SSES implementation.

SSES IMPLEMENTATION

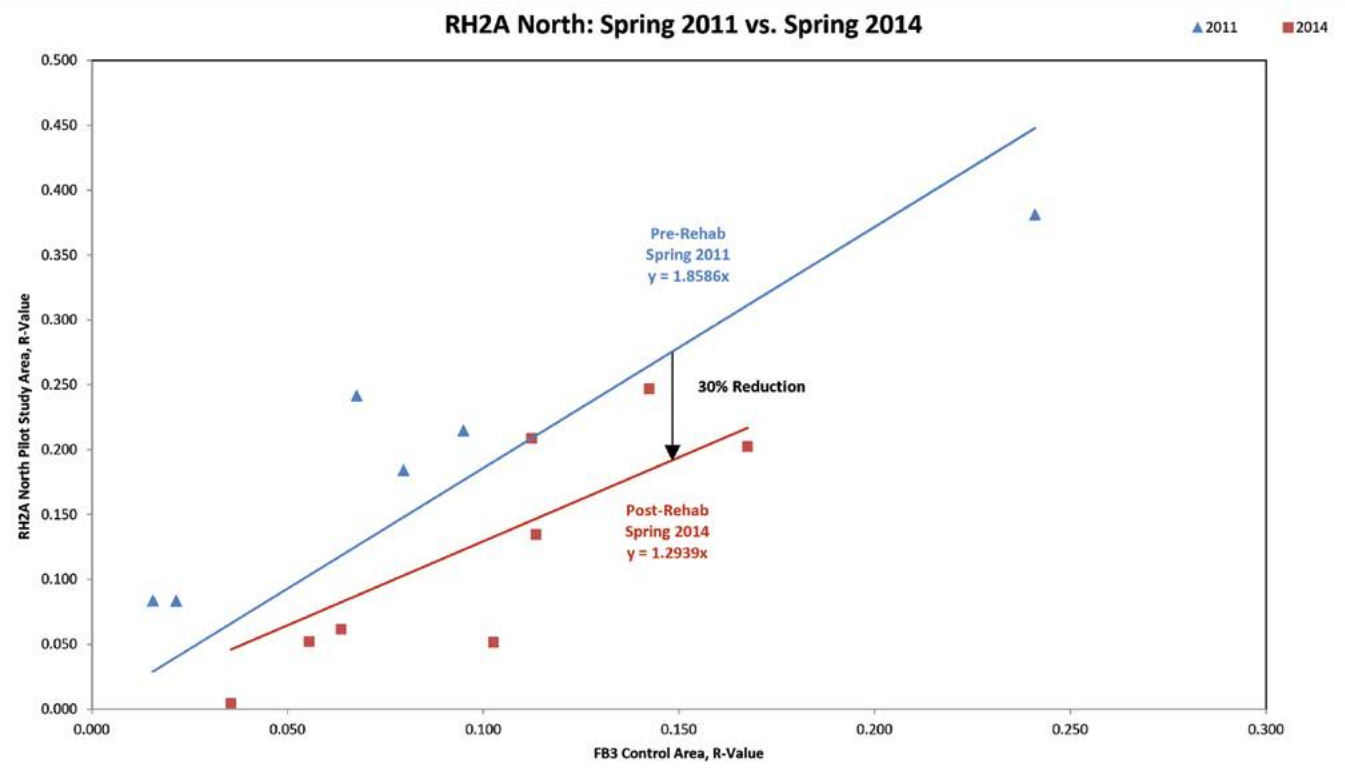
The District initiated smaller scale sewer rehabilitation through multiple construction contracts prior to the development of the SSES reports (before 2005), with additional larger scale contracts completed during and after the sewer rehabilitation pilot study performed between 2010 and 2017. These contracts have included trenchless rehabilitation and excavation work, including sewer main point repairs, cured-in-place pipe lining, segment replacement, manhole frame and cover replacement, manhole monolithic lining and manhole sealing. Table 1 lists the rehabilitation totals that are expected upon the completion of the program in each SSO community.

During the course of the SSES implementation program, several lessons were learned that have helped shape the underlying approach towards completing the scope of work. Early in the program, the approach focused more on individual pipe segments that exceeded an infiltration threshold of 4,000 gallons per day per inch-diameter mile. These segments were packaged into CIPP lining contracts, with separate contracts to address dig repairs that were necessary before the pipe could be CIPP lined. Individual manholes with repair recommendations were also targeted under separate contracts. Initially, this approach made sense due to the high number of pipe segments that were recommended for CIPP lining, with better pricing achieved through competitive bidding of contracts that focused on only CIPP lining work. However, as more segments were lined in each SSO community, additional improvements were often identified, such as point repairs that were necessary before the CIPP lining could be completed.

Subsequent discussions with the District and review of these early contracts led to changes in how the SSES rehabilitation work was implemented. To increase efficiency and minimize construction duration, contracts were developed with all rehabilitation work included in the same contract on a subarea basis. This put the responsibility on one contractor to complete all pipe and manhole rehabilitation in each subarea under the same contract. This strategy was well received by municipalities, residents and business owners because it helped streamline the construction process and minimize construction duration.

Previously, the CIPP mainline contractor would CCTV a segment in advance of CIPP lining and determine that the segment needed a point repair that was not previously identified. The point repair would need to be completed under a different contract and then the pipe would be CIPP lined at a later date. Today, the majority of point repairs have been identified during the design process and completed under the same contract as the CIPP lining. Manhole rehabilitation is also included to allow for streamlined coordination between mainline and manhole

FIGURE 2. WETHERSFIELD RH2A CONTROL AREA R-VALUE CORRELATION CHART



work. Combining dig rehabilitation work like frame and cover replacements along with point repairs and segment replacements helps the District strategically plan with municipality paving schedules. This shift in the implementation approach was a valuable lesson learned on how to complete the SSES projects more efficiently.

SEWER REHABILITATION PILOT STUDY

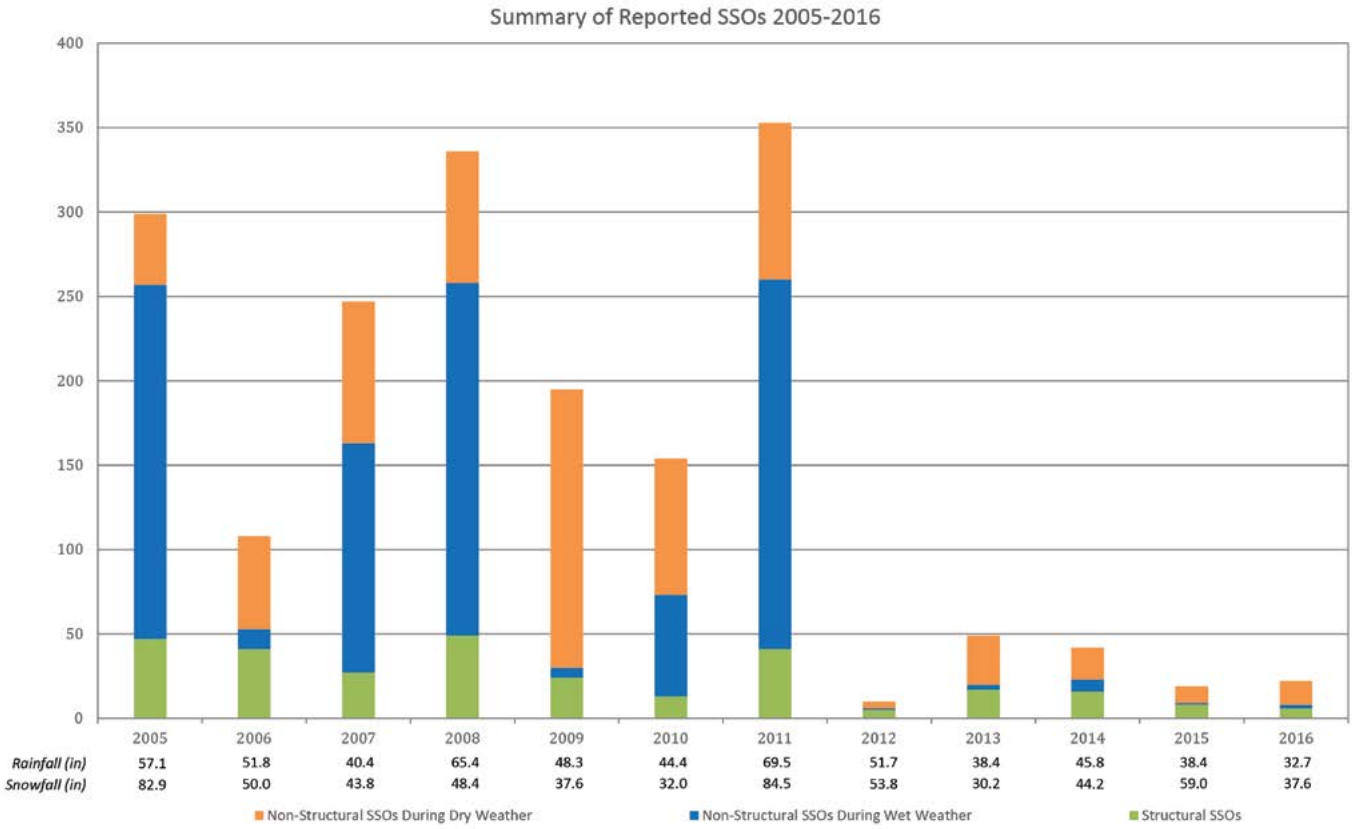
The main goal of the sewer rehabilitation pilot study was determining the potential I/I reductions that may be achievable through the implementation of SSES recommendations and additional rehabilitation techniques for sewer service laterals and the removal of private I/I sources. This included testing the assumption made during the SSO elimination reports that a 10 percent level of I/I reduction was achievable with the completion of SSES recommendations only. During consideration of the approach for each area, it was determined that any remaining SSES rehabilitation recommendations should also be completed as part of the study. This included any sewer main repairs, cured-in-place pipe lining, cementitious monolithic manhole lining and sewer manhole frame and cover replacement in addition to implementation of the more specific pilot study approach, where applicable. Rehabilitation approaches utilized for the pilot study subareas included:

- Removal of private I/I connections to the sanitary sewer via new sump pumps to storm drain
- Service lateral replacement to the property line
- Partial service lateral CIPP lining without cleanouts
- Full service lateral CIPP lining with cleanouts
- Comprehensive subarea cementitious manhole lining
- Comprehensive subarea mainline sewer rehabilitation including CIPP lining of sewer mains, cementitious manhole lining and service connection liners (top hats)

Combining the SSES and pilot study work minimized construction related disruptions and provided another level of comparison for analysis. Additional subareas where only SSES recommendations were implemented were analyzed to provide a baseline comparison to the pilot study specific areas and determine if the 10 percent I/I reduction goal was being achieved. The study included design and construction phases in Newington, West Hartford, Wethersfield and Windsor to provide a diverse approach and to gain valuable experience addressing problems within each community. The work was divided into five construction contracts which were completed between 2011 and 2014 at a total overall cost of approximately $19.5 million.

In order to document the effectiveness of the various sewer rehabilitation techniques implemented, all relevant flow monitoring data was collected, reviewed and analyzed throughout the course of the pilot study. This included historical data before the study began, data that was collected during the study period and post-rehabilitation data collected after construction. Data from flow meters, groundwater wells and rain gauges were compared with temperature records, snowfall records, Connecticut

FIGURE 3. SUMMARY OF REPORTED SSOS, 2005-2016



River elevations, and treatment plant flow records to better understand collection system performance before and after rehabilitation. Analysis for this study included common period comparisons, R-value calculations, control area R-value correlations, and linear regression of rainfall versus RDII volume. Figure 2 shows an example chart developed for the control area R-value correlation analysis.

The study included five construction contracts featuring Sewer System Evaluation Survey (SSES) implementation work combined with additional rehabilitation techniques to address sewer service lateral defects and private I/I sources. Pre- and post-rehabilitation flow monitoring was performed to estimate reductions and determine the most cost effective approach. Review of the 2014 post-rehabilitation data shows that R-values have been reduced between 10 percent and 40 percent in the pilot study subareas.

CONCLUSIONS

The benefits of these projects include I/I reduction and reduced maintenance through the structural infrastructure improvements made under the SSES and pilot study rehabilitation projects. Since the start of the program in 2005, there has been a significant reduction in the number of SSOs reported through 2016. This includes structural SSOs that have been reduced through rehabilitation and relief sewer projects, as well as non-structural dry weather and wet weather SSOs that have been reduced through improved system cleaning and maintenance programs. Figure 3 shows the number of reported SSOs between 2005 and 2016 in the District's sanitary sewer overflow system. The annual rainfall and snowfall for each year is also listed. The highest rainfall (69.5 inches) and snowfall (84.5 inches) totals during this reporting period were in 2011, which was also the year with highest total of reported SSOs (353).

Prior to the pilot study, sewer rehabilitation efforts have focused on CIPP lining of sewer mains and addressing issues related to the mainline sewer system. In most cases, these improvements can be implemented before the pipe becomes severely deteriorated, avoiding emergency digs repairs or segment replacements which carry greater financial construction cost and increased disruptions to the public. As a higher percentage of sewer mains are lined in a particular area, other sources of I/I may become more apparent, particularly when post-rehabilitation metering shows that R-values or groundwater infiltration rates have not been reduced.

In problematic areas of the system, each individual potential source should be documented and prioritized to develop a cost effective rehabilitation approach that maximizes the reduction of extraneous

flow. This includes the most effective combination of sewer main CIPP lining, sewer main replacement, lateral CIPP lining, lateral replacement, manhole rehabilitation, manhole frame and cover replacement, and removal of private I/I sources. In certain locations, it will be more beneficial to rehabilitate the entire manhole-to-manhole segment, including the manholes and laterals that connect to that segment. Removal of private I/I sources should also be completed in the most problematic areas as part of a comprehensive rehabilitation approach.

A key takeaway of this study is the inherent variability found in each project area due to the age of the subsystem, subsurface characteristics and antecedent conditions during the flow metering periods. Despite some commonalities in each town, each area has its own unique set of characteristics that help put each reduction value into perspective. Once problems areas are identified, all potential sources of extraneous flow should be investigated and prioritized to establish the best possible approach in each area. Flows should be monitored before and after construction to help guide future aspects of the overall program. This process of flow monitoring, investigation and prioritization can play an important role in maximizing I/I reduction and minimizing the overall costs of each project area, while providing justification for capital expenditures.

ABOUT THE AUTHOR:

Katelyn Biedron, P.E. *is a project manager with CDM Smith and has 12 years of experience working as a design engineer, project manager and construction coordinator. Her experience includes multiple phases of collection systems projects, ranging from trenchless rehabilitation, design, and construction of wastewater pipelines and pump stations to sewer system evaluation surveys (SSES) and I/I analysis. She earned her BSCE from the University of Massachusetts Lowell and is an active member of NEWEA.*

John A. Harper, P.E. *is a senior project manager with CDM Smith with over 16 years of experience working as a project engineer and project manager. His experience includes a wide variety of collection systems projects, ranging from combined sewer system separation, sewer design, drainage design, trenchless rehabilitation, I/I reduction analysis, wastewater treatment plant improvements, sanitary sewer overflow long-term planning and combined sewer overflow long-term planning.*

Jason Waterbury, P.E. *is Project Manager/Team Leader with over 15 years of experience in the water and wastewater field for the Technical Services at The Metropolitan District. Among other duties at the District, he currently oversees the CMOM compliance component of the District's Consent Decree and is managing the drafting of the District's CSO LTCP Update as required by the District's Consent Order.*