ABSTRACT: This paper will outline the process undertaken and learning garnered from a potable water pipe rehabilitation project completed by the Oswego Water Department in the city of Oswego, NY. The project utilized a rapid setting, trenchless, spin cast, polyurea technology and took place in September, 2011. Workscoope included the cleaning and rehabilitation of 2,265 feet of heavily tuberculated 6 inch diameter cast iron main installed in the early 1920’s, which had undergone three emergency repairs and repeated service outages over the previous two years. In addition, the rehabilitated section had seen significant water quality issues including coloration and turbidity. The use of the selected polyurea technology enabled a Same Day Return to Service (SDSR) rehabilitation technique that eliminated the need for the use of temporary bypass piping. Localized boil order notices were put in place during the lining project to facilitate bacterial testing requirements. The project was completed in five sections over five days. Each of the 5 sections was cleaned, lined and reinstated within the same day. The following paper will cover the benefits of eliminating by-pass piping from the project workscoope, the preplanning process that was followed, and the project sequence and application process utilized to accomplish the SDSR project. In addition, the paper will discuss project savings, rehabilitation results and customer feedback.

1. INTRODUCTION

One of the most important operational or maintenance aspects of any water supply system is the relationship that develops between the utility and its customers; in part through efforts to maintain continuous water service. To ensure continuous and reliable service during a water pipe rehabilitation project, temporary bypass piping is commonplace on drinking water rehabilitation projects in the United States. The use of bypass piping can also be considered a major impediment to the wider adoption of trenchless rehabilitation in the drinking water market, where many cities choose instead to dig and replace aging water pipe. This is due to the fact that the use of bypass piping can add significant man-hours, cost, and customer dissatisfaction to a project. To the extent that these costs can be mitigated or eliminated through innovative rehabilitation techniques and project planning, there exists an opportunity to expand the use of trenchless technology in this market and extend municipal water utility budgets. Technologies that eliminate the need for using temporary bypass piping are a big step in reducing costs and project time out of a pipe rehabilitation project.

Bypass piping is installed ahead of the rehabilitation process, after bacteriological testing on the bypass line confirms no e. coli or coliform presence in the bypass pipe water. The bypass pipe stays in place throughout the water main rehabilitation, reinstatement and required post-rehabilitation bacteriological test results. Two Federal regulations under the Save Drinking Water Act (SDWA) set the maximum contaminants levels (MCLs) and monitoring requirements for drinking water. Under the Total Coliform Rule, approved test methods must be able to detect presence or absence of e. coli and total coliform. In practice, this means 1 culture forming unit (CFU) in a 100
mL sample of water. Approved test methods like membrane filtration and Colilert® typically take 18-24 hours to get results back. Waiting for these testing results can be a barrier to rapid reinstatement of the pipe.

There are a number of common trenchless technologies that are used to rehabilitate drinking water pipes including epoxy lining, cement mortar lining (CML), and cured-in-place pipe (CIPP). These rehabilitation methods utilize products with cure times that range from 1 hour, in the case of steam cure with CIPP, to 24 hours or longer with some epoxy and CML lining products. These long cure times are a barrier to rapid reinstatement of the pipe.

The use of bypass piping can be especially challenging for a city, when one takes into account the high cost of installation of temporary bypass piping. Bypass piping can add significant man-hours to a project. The results of an AWWA Research Foundation study of 9 projects in the United States shows the average man-hours required for installation, disinfection and removal of temporary bypass piping was 135 hours when normalized for 1000 feet of pipe.

The study also concludes that up to 41% of manhours of the cleaning and lining portion of a pipe lining project can be attributed to temporary bypass pipe tasks (Figure 1).

![Figure 1 – Distribution of manpower for lining tasks and temporary pipe tasks as a percent of the total man hours. Adapted from “Guidelines to Minimize Downtime during Pipe Lining Operations” by T. D. Rockaway and R. T. Ball, 2007, Denver, CO: AWWA Research Foundation. Copyright 2007 by the Water Research Foundation.](image)

2. SAME DAY RETURN TO SERVICE: PROJECT PLANNING

The Oswego Water Department had a section of distribution pipe with a history of main breaks and emergency repairs, in addition to water quality issues. Specifically, the pipe had severe tuberculation and corrosion and had been repaired on an emergency basis three times in two years, resulting in repeated service disruptions. The Oswego Water Department did a thorough analysis of rehabilitation technologies that could address water quality issues as well as provide a structural solution to limit the amount of future repair done to the pipe. They were interested in a project that could be done without the use of temporary bypass piping. They selected a rapid setting
polyurea spray lining rehabilitation technology (3M™ Scotchkote™ Pipe Renewal Liner 2400). The test was completed on 2,265 feet of 6 inch cast iron pipe that had been installed in 1923.

Prior to making the decision to pursue a Same Day Return to Service project, several key success factors were identified by Oswego:

- Buy-in from key water utility and city officials
- Adequate pre-project planning to eliminate downtime during the actual pipe rehabilitation projects
- Selection of a rapid pipe lining rehabilitation product
- Effective resident communication
- Effective project management during the actual pipe rehabilitation project

Both the cleaning contractor (Mainlining Services Inc) and lining contractor (3M Company) worked closely with the Oswego Water Department on project specifics including: lengths of pipe to line each day, project sequencing, reinstatement process at the end of each shift, resources required on site during each aspect of the project, resident communications, and special permits or approvals that were needed for the project. In addition, precise pit locations were pre-determined (Figure 2) along with which valves would be used to reinstate service to residents each evening.

![Figure 2 – Arial view of Hillside Avenue, Oswego, NY with access pit locations marked](image)

3. SAME DAY RETURN TO SERVICE: RAPID SETTING POLYUREA TECHNOLOGY AND APPLICATION PROCESS

Rapid setting polyurea spray technology was initially developed in Europe for the use in non-structural linings to mitigate water quality issues. Eventually the technology was developed into a solution that could obtain a higher build and advanced material properties and therefore structural enhancement to the host pipe. Different thicknesses and/or formulations of polyurea linings need to be utilized depending on which pipe problems and AWWA classifications are being addressed (Figure 3).
Figure 3. Spray in Place Pipe rehabilitation solutions for varying pipe issues

The rapid setting polyurea spray lining process that was selected for the Oswego project uses a similar trenchless rehabilitation process to cement mortar or epoxy lining. This involves excavation of access pits at each end of the section to be lined. After excavation, the upstream valve is closed, a 4-6 foot section of the exposed pipe is removed and the pipe is dewatered. After dewatering, the pipe is cleaned with one of a variety of mechanical cleaning methods such as rack feed bore, drag scraping or hydrojetting. In the case of Same Day Return to Service, it is critical that the variability in cleaning time associated with the various methods be carefully scrutinized. The choice of cleaning method should match the pipe diameter, length and severity of tuberculation. Hard and/or soft swabs are used to remove remaining debris and any standing water from the pipe. After cleaning the pipe, it is inspected using closed circuit television (CCTV). It is critical at this point in the project that any service connections blocked by debris are blown back and any ground water intrusion or leaking service connections are addressed. Additional swabbing may be necessary. After the pipe is satisfactorily cleaned, the lining process can be initiated. The lining team utilizes a properly calibrated application rig which monitors and controls the lining process. After lining, the section is re-inspected with CCTV and any blocked service connections are opened with a robotic cutter/camera system. The pipe may then be reinstated. Most rapid set polyurea lining solutions require a minimal one-hour cure before water may be introduced for disinfection and reinstatement but this should be validated with the lining manufacturer and the product’s NSF/ANSI 61 (or country-specific regulatory approval) listing should be referenced.

Project sequencing and crew experience are critical aspects to a successful Same Day Return to Service project. An illustrative example of a typical 600 foot (180 meter) section of 6 in (150 mm) diameter pipe is shown in Table 1 to demonstrate the variability one may see in this type of project. One of the key success factors in Oswego was separate excavation, cleaning and lining teams. This enabled the excavation crew to work ahead of the cleaning and lining crews and the access pits for each section were completed a day ahead of the cleaning and lining and road plated to allow traffic to flow uninterrupted. The excavations, disinfection and reinstatement tasks were done by the Oswego Water Department. This enabled the cleaning and lining crews to get an early start each morning and enough time to complete the work by 5pm. Out of the 5 lining sections, all were completed by 5pm with the exception of one section which was completed by 6pm due to camera/cutter issues.
Table 1. Time breakdown (in hours) for typical Same Day Return to Service polyurea pipe rehabilitation based on project variability

<table>
<thead>
<tr>
<th>Pipe Section: 1</th>
<th>Total Access Pits: 2</th>
<th>Lining Crew Size: 3 (does not include cleaning/excavation crew)</th>
<th>Assumes No Bypass Piping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Timeline – weeks prior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boil Order Notice Plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Prior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First two access pits may be dug ahead of time (no pipe cutting)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>Experienced Lining Crew</td>
<td>Inexperienced Lining Crew or Cleaning Issues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Task Start</td>
<td>Task Finish</td>
<td>Task Start</td>
</tr>
<tr>
<td>Remove pipe section (measure length) – 1 hr</td>
<td>8am</td>
<td>8am</td>
<td></td>
</tr>
<tr>
<td>First pipe section is cleaned – 2 to 5 hr</td>
<td>9am</td>
<td>11am</td>
<td>9am</td>
</tr>
<tr>
<td>Pre-lining CCTV inspection – 1 hr</td>
<td>11am</td>
<td>12pm</td>
<td>2pm</td>
</tr>
<tr>
<td>Lining – 1 hr</td>
<td>12pm</td>
<td>1pm</td>
<td>3pm</td>
</tr>
<tr>
<td>Post-lining CCTV inspection – 1 hr</td>
<td>1pm</td>
<td>2pm</td>
<td>4pm</td>
</tr>
<tr>
<td>Cut any blocked service connections – 1-2 hr</td>
<td>2pm</td>
<td>3pm</td>
<td>5pm</td>
</tr>
<tr>
<td>Install splice section – 1 hr</td>
<td>3pm</td>
<td>4pm</td>
<td>7pm</td>
</tr>
<tr>
<td>Return to service</td>
<td>4pm</td>
<td>8pm</td>
<td></td>
</tr>
<tr>
<td>Subsequent Days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacteria tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lift boil notice advisory</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. **SAME DAY RETURN TO SERVICE: RESIDENT COMMUNICATION STEPS**

The Oswego Water Department implemented this Same Day Return project knowing that proper communication to the affected residents was required. The city met multiple times to determine the number and timing of the voluntary boil order notices that were going to be the most effective. It was determined that the following resident communications were required:

1. Communication 14 days before the project
2. Communication 7 days before the project
3. Communication the day of the project
4. Communication when the bacteria testing had been completed

In addition to these resident communications, two articles were published in the local paper. The first article ran before the first resident communication and described the need for the project and process. A second ran a couple of days before the project commenced to announce the work and alert the City to the potential traffic issues. Notices shown in Figure 4 described the nature of the work being performed, the schedule, how residents’ service would be affected, information on the boil water advisory and contact information for questions or concerns. Figure 5 show the actual boil water notice and the safe to consume notice. In retrospective evaluation of the project, it was determined that this communication approach was very effective.
Figure 4. Resident notices for work to be performed and boil water advisory

Figure 5. Boil water notice and the safe to consume notice
5. SAME DAY RETURN TO SERVICE: PROJECT MANAGEMENT CONSIDERATIONS

One key to effective same-day return to service is the reduction of downtime. The goal is to have water reinstated to customers at the end of each shift (5pm). It is key for the municipality to work with contractors ahead of the project to identify ways to reduce downtime upfront. Efficiencies in these areas can assist in the successful delivery of a Same Day Return to Service project. Oswego Water Department considered the following factors:

- Approval of rapid pipe cleaning techniques like drag scrapping, rack feed boring or hydrojetting.
- Consider each block as a separate pipe rehabilitation project. The objective is to isolate, clean and line a single city block, returning it to service in a single day. Depending on the type of polyurea lining and experience level of the contractor, a typical Same Day Return to Service project may include the rehabilitation of up to 600 feet per day. Performing this operation will require more attention to scheduling, work progression and customer education than working with bypass piping.
- Based on blueprints and site visits the city worked with the contractors and the road authorities to agree to the overall location of the access pits. This helps to plan individual resident dates of outages.
- Identify pit locations and location of isolations/hydrants. Pits typically were located at valve or fire hydrant locations to minimize excavations and valve/hydrant work was done in parallel.
- Develop lining schedules in advance of the rehabilitation project.
- City Water Department should consider publishing two newspaper articles, one published prior to first resident work notice to describe need for project and intent and second article published a day or two before work commences to remind all of the work and to alert City residents to potential traffic issues.
- City Water Department sends out general work notice to residents 1–2 weeks in advance of the project.
- The City should have already notified the residents that they may need to enter their house to complete a “blow-back” in the event a service connection is blocked during the cleaning or lining process.
- Implement any contingency planning that was required by the key stakeholders.
- Provide final pit digging plan and dig them at least one day in advance of the specific section being completed.
- Contractor should inspect excavation, cleaning, lining, disinfection equipment in advance of the job to ensure it is operational and that critical duplicate parts are available for things that may break or not work properly.
- Ensure all crew members are properly trained to complete pipe rehabilitation steps. Ensure that lining rigs are properly calibrated for the material being applied.
- City Water Department sends out water shut off notice to residents at least one day in advance of the work.

6. SAME DAY RETURN TO SERVICE: PROJECT SUMMARY AND SAVINGS

Full price cost comparisons of pipe rehabilitation projects and techniques vary widely. Contributing cost factors include local labor rates, pipe bury depth, material selection, project specifications and competition. The Oswego Water Department project was completed at subsidized rates to demonstrate the Same Day Return to Service technique. However, full cost pricing comparisons are possible through a critical review of competitively bid projects. For example, a competitively bid open-cut replacement project of 2,400 linear feet of 8” ductile iron water main was completed in the Northeastern U.S. in 2011 for a total installed cost of $504,000 or $210/ft. Comparatively, this same project using the polyurea pipe rehabilitation technique applied at a 3.5mm, AWWA Class IV manufacturer specified lining thickness, would be roughly $286,000 or $119/ft. Table 2 summarizes the open-cut replacement pricing relative to alternative trenchless techniques including CIPP, CML and Polyurea SIPP from a competitively bid project of similar pipe diameter and length also located in the Northeastern U.S. in 2011.
Table 2. Full cost of pipe rehabilitation techniques based on competitive bid data (2,400 ft of 8” ductile iron)\textsuperscript{viii}

<table>
<thead>
<tr>
<th>REHAB OPTIONS</th>
<th>8” PIPE BIDS</th>
<th>$/FT</th>
<th>% REPLACEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement (w/ bypass)</td>
<td>$504K</td>
<td>$210/ft</td>
<td>100%</td>
</tr>
<tr>
<td>CIPP (w/ bypass)</td>
<td>$374K</td>
<td>$156/ft</td>
<td>74%</td>
</tr>
<tr>
<td>Polyurea SIPP (w/ bypass)</td>
<td>$286K</td>
<td>$119/ft</td>
<td>57%</td>
</tr>
<tr>
<td>CML (w/ bypass)</td>
<td>$215K</td>
<td>$90/ft</td>
<td>43%</td>
</tr>
<tr>
<td>Polyurea SIPP (w/o bypass)</td>
<td>$190K</td>
<td>$79/ft</td>
<td>38%</td>
</tr>
</tbody>
</table>

In Table 2, the first listed Polyurea SIPP project pricing includes the cost of bypass piping and shows an installed cost of $119/ft, a savings of 43% when compared to open-cut replacement of a similar size, length and pipe type. If a same-day return to service method is utilized in concert with Polyurea SIPP, the bypass piping may be eliminated which lowers the overall Polyurea SIPP rehabilitation method to an installed cost of $79/foot, a savings of 62% when compared to open-cut dig and replacement. When this option is then added to Table 2, the savings relative to open cut pipe replacement and alternative rehabilitation methods becomes very apparent. Figure 6 shows the Polyurea SIPP project costs from our example above relative to open-cut replacement with a break-down of typical construction costs for each process step (excavation, cleaning and lining, bypass, etc).

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{Open Cut Replacement vs. Polyurea SIPP project cost breakdown}
\end{figure}

7. CONCLUSIONS

The City of Oswego, NY was able to complete a Same Day Return to Service project while rehabilitating 2,265 feet of 1920’s 6” cast iron pipe. The project was broken up into five smaller linings that were completed over the course of five days. Each pipe section was cleaned, lined and reinstated within the same day. Combining rapid rehabilitation techniques through quick-cure polyurea type linings, effective project management and proactive resident communication through boil order advisories eliminated the need for bypass piping. The Oswego Water Department was pleased with the overall impact and success of this lining project and has not experienced
subsequent main breaks or service disruptions on the rehabilitated section since the project was completed in September 2011. The overall project and time savings were significant for the Oswego Water Department and the residents remained happy during the pipe rehabilitation project.

This project illustrated the need for the city to be actively involved in the project management considerations and to plan and coordinate with all contractors involved in the project. The efficiencies and cost savings achieved by the elimination of temporary bypass piping during potable water pipe rehabilitation projects may be leveraged with other cities and help to extend municipal budgets and expand the adoption of trenchless water pipe rehabilitation techniques.

8. REFERENCES


iii USEPA. 1985. Test methods for Escherichia coli and enterococci in water by the membrane filter procedure (Method #1103.1). EPA 600/4-85-076. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH.


viii 3M Company, Infrastructure Protection Division