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FORCE MAIN CIPP CHALLENGES

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ABSTRACT: The City of Burlingame has been aggressively upgrading its wastewater collection system for the past 12 years. The Airport Force Main Rehabilitation Project covered a portion of the collection system in the 2015 sewer capital improvement plan that includes a pump station and a 47-year-old, 3,100-foot, 8-inch-diameter asbestos cement (ACP) force main directly adjacent to the San Francisco Bay. The collection system serves a commercial area including five San Francisco International Airport hotels, an off-airport parking lot, five restaurants and several other businesses.

The City of Burlingame (City) had observed severe deterioration and compromised structural integrity of ACP installed within bay muds on other projects in the area, and in recent years the force main required numerous emergency repairs due to degradation of the pipe. Replacement plans had been deferred in expectation of the construction of a major commercial/retail development project that would have required pump station upsizing and replacement of the problematic force main. However, in 2014 the City decided to proceed with a fast-track project to stabilize the ACP main due to continuing uncertainty with the timing of the development project.

A fiberglass-reinforced cured-in-place-pipe (CIPP) liner was selected for interim force main strengthening. This paper presents the considerations and challenges from the fast-track project, including liner type selection, inclusion of permanent force main maintenance and bypass facilities, an extensive bypass pumping system, traffic control, and access pit/manhole excavation within a landfill area.

1. INTRODUCTION

Airport Boulevard runs through a commercial area in the City of Burlingame, CA, east of the US-101 freeway and immediately adjacent to the San Francisco Bay. Most of the land in that section of the municipality was at one time estuarine sloughs that have since been filled with highly variable material, including precast concrete debris from a former area manufacturer of concrete products, to allow for development. The northerly section of the project area served for years as a municipal landfill prior to its being capped and closed.

The segment of Airport Boulevard within the project area is minutes south of San Francisco International Airport. Multiple hotels, restaurants and an off-airport parking lot are located along the busy roadway. A

church, several businesses, a municipal golf center constructed on the capped landfill, municipal recreation fields, the City's wastewater treatment plant and a scenic pedestrian walkway along the Bay bracket the section of Airport Boulevard in the project area. The wastewater generated from these businesses, hotels and restaurants is all routed to a sewage pumping station located in the roadway median at 710 Airport Boulevard. Twin constant speed pumps discharge the sewage through an 8-inch asbestos-cement (ACP) force main directly to the headworks of the wastewater treatment plant, more than a half-mile north of the pumping station. The force main is located in the landscaped median of the roadway for approximately half its length and then in pavement, along the southbound lane of the roadway to the wastewater treatment plant.



Figure 1. Project site map and force main alignment.

With the expectation that a major commercial/residential development project in the area would require upsizing of both the pump station and the force main, the City had planned to address rehabilitation of the system in conjunction with the development project. However, in 2014, following several emergency repairs to the 47-year-old force main, continued doubt surrounding the timing of the development project, and the penalties and adverse publicity resulting from sewer system overflows, the City decided to move forward with a rehabilitation project to repair the force main. This paper will detail the design considerations, construction challenges and lessons learned on this fast-track project.

2. DESIGN CONSIDERATIONS

Project Concept Development

The following project-specific factors were the basis for an alternatives analysis workshop completed by the City of Burlingame Department of Public Works (DPW) operations and engineering staff, and Mott MacDonald:

- 1) With the thriving Bay Area economy, a major development project in the area would likely be constructed in the future. The additional wastewater flows generated from the development project would necessitate an upgrade to the pumping station and likely upsizing and replacement of the existing force main. The developer would be responsible for a significant portion of the upgrade costs.
- 2) The 8-inch nominal diameter of the existing force main was adequate for the current pumping rates and could accommodate interim increases in pumping rates if necessary, until the major development project was completed.

- 3) Minimizing disruption to traffic patterns and access to hotels, restaurants and recreational facilities weighed strongly in favor of rehabilitation/replacement alternatives that required minimal excavation and backfilling. Conventional trenching and backfilling to install a replacement force main would have required either: 1) shutting down half the roadway to install the new force main in one of the travel lanes, or 2) replacing the force main in its current alignment and restoring the landscaped median and curbing.
- 4) The City has used numerous pipe rehabilitation techniques during its wastewater collection system upgrade program. Pipe bursting and cured-in-place pipe (CIPP) installation had been successfully employed on gravity pipelines on numerous projects.
- 5) The existing force main is constructed of asbestos cement pipe. National Emission Standards for Hazardous Air Pollutants (NESHAP) limit pipeline construction methods that create friable Regulated Asbestos Containing Material (RACM), to 261 lineal feet per year in most states in the country (US Environmental Protection Agency, 2016). In California, the Bay Area Air Quality Management District imposes more stringent regulations, limiting pipe bursting to 50 linear feet per year (Wee, 2006). Consequently, the City of Burlingame does not employ pipe bursting as a replacement method for asbestos cement pipelines.
- 6) Installation of a CIPP liner would result in an approximate half-inch decrease in internal force main diameter. The velocity in the existing force main is low and therefore results in an increase in velocity but minimal increase in the total dynamic head that the existing sewage pumps would operate against. A hydraulic analysis confirmed the resultant decrease in pumping rate was minimal.

Liner Type Selection

Based upon the above factors, it was determined that a cured-in-place liner would be installed within the existing ACP force main. AWWA Manual M28 categorizes liners based upon their structural properties. Class 3 semi-structural and Class 4 structural liners utilize the host pipe only as a form during installation and curing but rely on it minimally or not at all for structural integrity to resist internal and external pipeline loads (American Water Works Association, 2014). Recognizing the continuing uncertainty with the timing of the future development project that would necessitate the replacement of the force main, and the cost of responding to force main breaks and sewer system overflows, it was determined that a structural liner system, which assumes a fully deteriorated host pipe, would be specified for the rehabilitation of the Airport Boulevard Pump Station force main.

Force Main Access Manholes

The length of the Airport Boulevard Pump Station force main is nearly 4,000 linear feet. Approximately 3,100 linear feet of the total length force main length is located within Airport Boulevard, directly adjoining San Francisco Bay as previously described.

The existing force main was constructed with four wye type fittings intended to provide pipeline access for cleaning and maintenance purposes. The wyes were installed in manholes where the force main was deeper and in small precast utility boxes where the force main was shallower. The wyes were spaced at approximate 800-foot intervals. Unfortunately, the access wyes did not include bracketing force main isolation valves and therefore force main shutdown and implementation of sewage bypassing measures was required if the access wyes were to be utilized. Set-up of bypass pumping facilities for any incident that required accessing the force main through the wyes, whether planned or unplanned, was impractical and consequently the wyes were soon found to be of very limited value and not utilized. When significant force main downtime was necessary, mobilization of vacuum-trucks to remove and haul sewage from the pump station wet well to a suitable discharge point was practiced.

The City DPW desired a more practical means to perform cleaning, inspection and, if necessary, repairs to the force main. Recognizing that installation of the CIPP liner would require accessing the force main at approximate 400-foot intervals, it was determined that four permanent force main access manholes would be installed on the rehabilitated main. Each force main manhole would be equipped with an upward facing tee and plug valves on each branch of the tee. Together with an existing above-grade pump station bypass located adjacent to the station wet well, the manholes provide a readily accessible means to isolate and bypass 800-foot sections of the force main with the City's portable pump and hosing equipment.

3. CONSTRUCTION CHALLENGES

The construction phase of this project posed several interesting challenges. Among them were traffic control and public safety, roadway excavation within a landfill area, construction adjacent to the San Francisco Bay, construction of the force main maintenance manholes, and difficulties with the CIPP liner installation.

Traffic control is a common challenge on construction projects, and it ties directly into public safety. As with any project, the safety of both the public and construction workers is paramount. Traffic control proved to be particularly difficult on this project due to the high volume of hotel-related traffic and a tight working area.

Airport Boulevard is a two-lane road through approximately half the project site. The alignment of the force main was generally either in the roadway shoulder or the median except for an approximate 300-foot segment where it transitioned across the southbound lane. This alignment was advantageous in that it allowed the contractor to limit the lane closures to only one lane. Providing sufficient clearance for the large buses and shuttles running between the San Francisco International Airport and the hotels and parking services down Airport Boulevard proved challenging. Multiple flaggers were needed on most occasions and the work areas had to be made as small as possible to allow the high volumes of vehicle and bicycle traffic to pass safely through the work zones. While excavating across intersections and perpendicularly across Airport Boulevard for bypass piping installation, the work areas were small and constantly shifting in order to allow traffic to pass. These constraints played a significant role in reducing the size of the equipment the contractor could use during certain operations because larger equipment would not fit. Additionally, the only construction storage yard was located at the northerly end of the project. With a narrow shoulder limiting staging areas for large equipment along the roadway, slower pieces of machinery, such as large excavators, were used only when absolutely necessary due to the time and flagging needed to transport them to and from the storage yard to the active work sites.



Figure 2. Traffic control setup on Airport Blvd.

Another challenge resulted from the 2015 San Francisco Bay Diva Race half-marathon and 5k courses passing directly through the project working area. This race attracts several thousand volunteers, spectators and athletes to the area each October and brings a significant amount of business to local shops, restaurants and hotels. This created several concerns related to public safety. The City, Mott MacDonald and the contractor worked together to ensure the site was secure and safe for race day. Prior to race day, the City extended the daily working hours, allowing the lining contractor to complete the liner installation ahead of schedule. This provided the prime contractor sufficient time to install and backfill the force main manholes prior to the race. The City and race sponsors were extremely concerned about providing as safe a roadway surface as possible for both runners and spectators. Consequently, all excavations used for CIPP access points were backfilled and paved over, eliminating the temporary trench plates previously covering excavation points. The contractor removed and secured all the construction equipment possible from the site for the race weekend and ensured all traffic lanes were open. The temporary bypass piping did have to remain in place during the race but was secured using rebar dowels, sandbags and barricades.



Figure 3. Diva Race course map adapted to show project limits (Home of Divas, 2016).

As previously mentioned, the project area was once part of the Bay and had been filled in to allow for development. Additionally, a portion of the land adjacent to the project site was previously a landfill, which was later capped and converted to the Burlingame Golf Center. Due to this history, several issues were encountered during construction excavation. There were five separate instances of manmade buried debris found in the nine excavations required for project construction. Four of the five objects were buried concrete, and the fifth object was a three-by-six-foot tree stump. These unforeseen conditions led to some minor delays and extra costs. In one of the excavations adjacent to the Burlingame Golf Center, when the excavator operator dislodged the buried tree stump, a surge of water came rushing up from beneath the ground. It was unclear where the water was coming from, but it did not appear to be coming from the Bay. The water was tested and determined to be groundwater. The contractor mobilized bypass pumping setup to dewater the excavated pit and facilitate installation of the force main manhole at that location. The groundwater was pumped into a settling tank and then to the City wastewater treatment plant approximately 800 feet away. It was later theorized that the source of the groundwater was runoff from the clay cap installed over the landfill directly west of Airport Boulevard, which had then percolated into the ground and built up at the toe of the landfill slope.



Figure 4. Tree stump encountered during excavation.

Whenever a project involves excavations and work on a sanitary sewage force main in such close proximity to an environmentally sensitive area, precautions are required. For this project, approximately 3,000 feet of 10-inch self-restrained, spline joint pipe was installed as the backbone of the bypass system. The contractor elected to use this pipe due to their familiarity with it and the ease of assembling and dismantling the pipe. Additionally, they were able to rent and return the pipe and fittings to their supplier rather than having to store and find use for the pipe afterward, such as with fused HDPE. The majority of the bypass piping was installed within 50 to 100 yards of the Bay and several of the excavations took place no more than 20 yards away. All storm drain catch basins in the area drain directly to the Bay. This proximity to an environmentally sensitive area provides very little recovery time in the event of an accident or spill. Therefore, the contractor was required to implement special precautions in addition to the typical stormwater best management practices.



Figure 5. Excavation near the San Francisco Bay.

All the rubber gaskets on the bypass pipe couplings were replaced with new ones for the project, and the contractor performed a hydrostatic pressure test on the bypass system to check for leaks prior to diverting the sewage flow from the permanent force main into the bypass piping system. When the rehabilitation work was complete, the bypass line was flushed with chlorinated water and then potable water to remove solids and disinfect the pipeline. The contractor used a vacuum trailer and plastic tubs to dewater the bypass lines and contain leakage during the dismantling process.



Figure 6. Temporary bypass pipe in Airport Boulevard median.

As noted earlier, Mott MacDonald designed four 60-inch-diameter manholes along the force main alignment. These manholes contain an 8-inch x 8-inch x 8-inch tee with three 8-inch plug valves attached. The branch ends of the tees were faced upward toward the ground surface. A blind flange with a

threaded nipple was installed on the top using a 6-inch stainless steel cam and groove coupling and cap to seal it off. The design enables City maintenance crews to isolate any side of the tee and connect hoses and pumps to bypass a section of the force main for repairs. The City's preferred structure was a 60-inch precast manhole and a 32-inch hinged manhole cover.

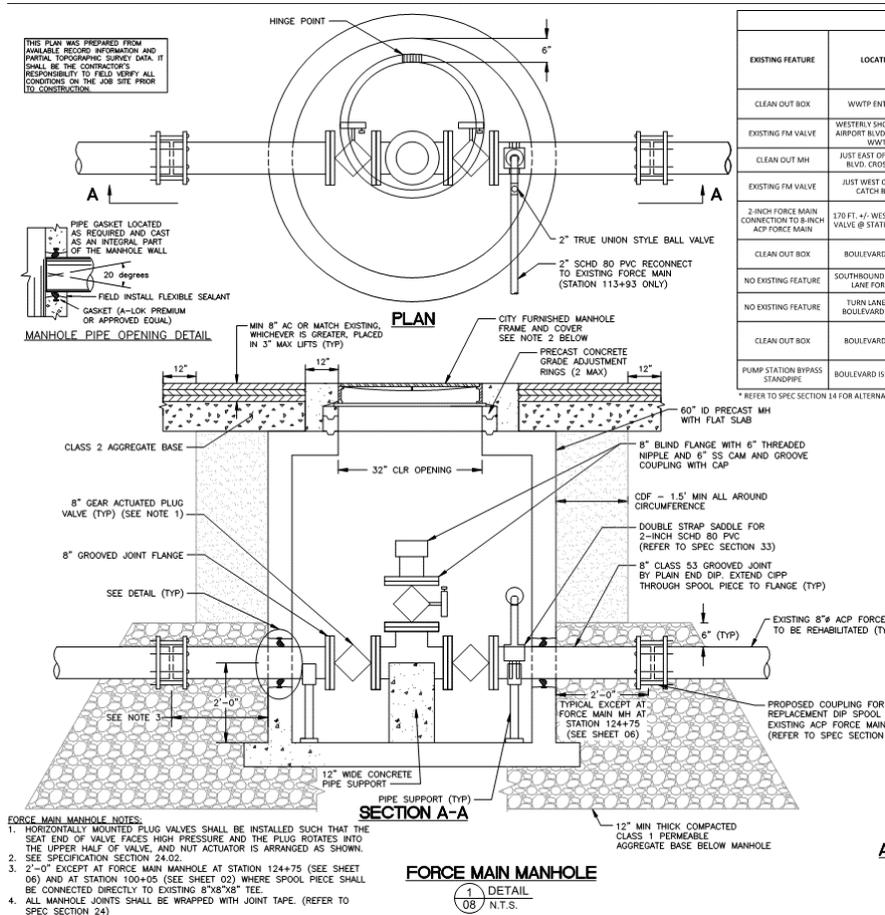


Figure 7. Force main manhole detail

During construction, the contractor experienced some difficulty fitting the equipment into the manholes. Rather than using flange-to-flange connections, the contractor proposed the use of restrained flange adapters to provide greater clearance for fitting equipment in the field. Additionally, for the shallower manholes especially, it was difficult to fit all three of the valve operating nuts below the manhole cover to allow operation from the ground surface above. Some modifications to the shallowest manhole were made in the field. Upon project completion, all plug valves in all four manholes were operable from the surface.



Figure 8. Completed plug valve assembly inside one of the force main manholes.

The installation of the CIPP liner was arguably the most critical operation of this project. During the installation of the liner, several complications arose. The lining contractor kept the sections of liner runs to a maximum of 400 feet to minimize issues during the liner inversion process. Due to the fiberglass reinforcement, the liner was thicker than a typical felt liner used for gravity sewer line rehabilitation, which led to difficulty during inversion. The contractor primarily used pressurized air to invert the liner but periodically used water as well when the liner became stuck. However, in one instance the air pressure got too high and an unrestrained section of the liner standpipe split open. The installation crew had to manually pull the liner back out of the host pipe, refold it, cut out the ruptured section, and start the installation process over. After installation was complete, post-construction CCTV video showed some minor damage and blistering to the polyurethane layer on the interior of the liner as well as some circumferential wrinkling of the liner. These issues will be discussed further in the “Lessons Learned” section of this paper. Ultimately, it was determined no repairs needed to be made to the liner. The force main was placed back into service and no issues have been reported to date.



Figure 9. Installation of cured-in-place-pipe (CIPP) liner on Airport Blvd.

4. LESSONS LEARNED

The lessons learned on this project can be applied to many other projects, whether they involve trenchless methods, conventional methods or both.

It is important to remember that trenchless methods minimize the construction phase impacts associated with traditional pipeline excavation methods; however, impacts are not eliminated entirely. It is still critical to consider traffic control, public safety, pedestrian/bicycle access and similar issues on trenchless projects, particularly when a large, temporary bypass line similar to the bypass required on this project is used.

Any time work is being performed underground there is the potential for unknowns to arise. In this case, the fact that the project site was predominantly situated in a fill area and adjacent to a closed landfill increased the likelihood for encountering unanticipated debris. The fast-track nature of the design schedule reduced the feasibility of performing extensive potholing. Although no amount of potholing or soil boring can eliminate all unknowns, this project illustrates some of the benefits of a comprehensive pre-construction subsurface investigation. Also, a general understanding of the history of the project area is recommended to enable the design team as well as the contractor to anticipate some of the types of issues that may arise and be prepared to adjust if they do. For example, during construction an old record drawing of the project area was found; it included the name of a former area cement company on one of the land parcels. Had the map been discovered during the design phase, the project team could have anticipated the possibility of encountering buried concrete debris, and the contractor could have arranged to have pneumatic breaker attachments on-site to speed up the process of concrete removal.

As previously mentioned, the force main manholes included plug valve assemblies to allow for bypass pumping of segments of the force main. Force mains are typically shallow and in order to fit all the equipment into a 60-inch precast manhole, the tolerances and clearances in those manholes were very tight. In hindsight, a larger precast structure would have allowed for more space to bolt up and install the plug valve assemblies. Also, at the shallowest manhole, fitting the plug valve operating nuts below the manhole opening at the ground surface was difficult. One alternative to address this would be to install a larger structure below ground, space out the two valves installed along the force main axis and place a conventional small valve box above them. A standard 24-inch manhole cover would then be installed over the upward-facing center valve equipped with quick-connect cam-lock coupling for attachment of the DPW's bypass hosing. This would enable the operation of all three valve nuts from the road surface with a valve key through either the manhole cover or the valve covers, as well as man-entry through the manhole cover when necessary. A second option would be to install a larger manhole cover, such as a 48-inch, with a 24-inch concentric inner lid. This would allow easy access through the smaller cover and full access through the larger cover when necessary. The disadvantage to this approach is that all valve actuators would not be operable from the surface.

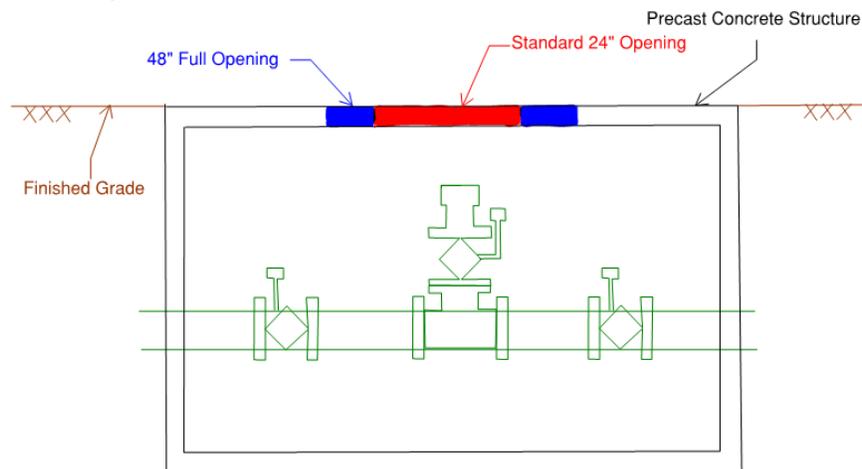


Figure 10. Schematic of 48-inch cover with 24-inch inner cover.

Post-construction CCTV video of the CIPP liner showed several instances of circumferential wrinkling of the liner and scuffs on the polyurethane coating. The scuffs to the interior coating are believed to have occurred when the crew had to pull out and reinstall the liner section where the blowout occurred. The contractor's liner supplier provided the City and Mott MacDonald with a written explanation stating the polyurethane coating's primary purpose was to contain the resin during transportation, installation and curing and was not a key structural element. No remedial action was taken regarding the scuffs. The circumferential wrinkles were of more concern as they appeared to be greater than the five percent of the cross-sectional diameter of the host pipe allowed per the project specifications. It was agreed that the lining contractor would provide an additional maintenance bond for a period of six months, after which they would return to the site and perform a CCTV re-examination of the liner. If no issues were reported with the pipe and the CCTV inspection showed no excessive accumulation of solids or grease at the wrinkles, the City would release the bond. Is it suspected that the issues during liner inversion caused the wrinkle formation.

5. CONCLUSION

This Airport Boulevard Force Main rehabilitation project was completed on-time and under budget with no significant complaints or issues from the public, no contractor claims and no workplace injuries. The force main has operated with no reported issues since its rehabilitation, and the City of Burlingame considers the project a success. As with most unique projects, valuable lessons were learned that can be applied to future projects, particularly those involving CIPP or other trenchless methods.

6. REFERENCES

American Water Works Association. (2014) – Manual of Water Supply Practices M28, Rehabilitation of Water Mains, Third Edition.

Home of Divas. (2016) – Half Marathon and 5K in San Francisco Bay. Retrieved from http://www.runlikeadiva.com/events/divas_half_marathon_5k_-_san_francisco_bay_ca.htm

United States Environmental Protection Agency. (2016, November 1) - Asbestos National Emission Standards for Hazardous Air Pollutants. Retrieved from <https://www.epa.gov/asbestos/asbestos-neshap#main-content>

Wee, Kelly. J. (2006, June 21) - Asbestos Control Requirements for Pipe Bursting and Pipe Reaming. Retrieved from http://www.baaqmd.gov/~media/files/compliance-and-enforcement/advisories/asbestos-renovation/adv_062006_asbestos_pipe_reaming.pdf?la=en