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City of San José Uses Creativity to Keep a Critical Link from Becoming a "Missing Link"

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ABSTRACT: In the late 1970's, City of San José converted the former Alviso Sewer Treatment Plant into a transmission pump station. The Spreckles Pump Station conveys approximately 1 MGD of wastewater from Alviso to the Regional Wastewater Facility through a 10-inch AC force main. Since the 1970's, no significant improvements were performed to the mechanical and electrical systems at the Spreckles pump station. Concurrently, the 10-inch AC force main had experienced pipe ruptures due to the age and pipe material type. Due to its close proximity to an environmentally sensitive habitat, the City initiated a project to upgrade the pump station and install a supplemental force main.

The paper evaluates multiple design and construction methodologies for the force main based on site specific conditions. Also, the implementation of an alternate bid approach for trenchless technologies helped control construction costs and reduced permit requirements and project schedule by 1-2 years. Significant consideration was given to pre-qualifying trenchless contractors, but a performance-based approach was utilized. Other project challenges included potential presence of asbestos waste; pipe material, mechanical and electrical equipment selection; special trench details; minimizing O&M requirements; value engineering of trenchless shafts; and construction sequencing to maintain sanitary service during construction.

1. INTRODUCTION

In the mid 1970's, a report was prepared by Consoer, Townsend and Associates Consulting Engineer, recommending consolidation of various wastewater treatment plants within the San Jose area. In 1977 the former Alviso Wastewater Treatment plant, later known as Spreckles Pump Station, was converted into a 1 MGD transmission pump station and approximately 6,900 linear foot of a 10-inch diameter asbestos cement (AC) forcemain was installed to connect directly to the current Regional Wastewater Facility. During this modification process, additional features were added to convert into a pump station which included two pumps in a dry well, and modifications of the Administration Building to add electrical controls and a 230 kw standby generator. Currently, this pump station and forcemain are the only means of transporting wastewater for the residents in the Alviso area to the Regional Wastewater Facility (RWF).

Massive flooding occurred in the Alviso area during the 1980's (see Figure 1). The flood inundated the Spreckles Pump Station site. The Administration Building had been built on piers above grade, which protected most of the electrical facilities (see Figure 2). However, the pumps located in the dry well were damaged. A new wet well structure with two submersible pumps was constructed in 1992. New pump control panels were installed near the wet well and new electrical cables were installed in new conduits between the wet well and the Administration Building. Since then no major improvements were performed at the pump station. As the pump station aged, the City's Operations and Maintenance staff were dealing with problems maintaining the pumps due to age and lack of parts, the pumps were not properly drawing down the wetwell.

Figure 1 - Flooding in the Alviso Area caused extensive damage in 1982 and again in 1983.

Figure 2 - The Spreckles Pump Station Administration Building was constructed on piers to protect the electrical equipment from flooding.

Concurrently, the 10-inch AC forcemain experienced increasing maintenance issues due to its age and material type. These issues and the resulting increased risk of sanitary sewer overflows (SSOs) heightened the need to either rehabilitate the existing 10-inch AC pipeline or install a supplemental line to allow for a redundant, more reliable system.

City staff investigated the feasibility of rehabilitating the existing forcemain using the cured-in-place pipe (CIPP) lining method. Due to several factors, not the least of which involved the substantial cost to divert 1 MGD of sewage for more than a mile, rehabiltating the existing pipe was cost prohibitive. It was more cost effective to install a new supplemental pipeline to provide the desired redundancy and also allow subsequent rehabilitation of the existing Spreckles Pump Station. Essentially, the City decided that it would be most cost effective to install a new supplemental pipe line and upgrade the mechanical and electical components at the Spreckles Pump Station.

Constructing a new forcemain was not without its own challenges. One of the key challenges with installing the new 10-inch pipeline was to determine an alignment that avoided the several endangered vegetation and animal species living within an environmentally sensitive area , several City of San Jose and City of Santa Clara owned facilites, and the future installation of underground infrastucture for nearby development. Selecting applicable materials for the pipe and appurtenances, choosing appropriate construction methods, and coordinating the hydraulic conditions of the new and existing forcemains were additional challenges.

The City selected HDR Engineering, Inc. to provide design and construction support services for a supplemental force main and rehabilitation of the pump station. Upgrades to the pump station were to include larger submersible pumps; replacement of deteriorated piping and valves; correction of concrete corrosion in the wet well and valve vault; replacement of electrical conduits, cables and components to meet the standards of the 2008 National Electric Code (NEC); and improvements to the instrumentation system. This paper and presentation will focus on the design and construction of the forcemain.

2. PROJECT OBJECTIVES

When the project began, the City's main goals were:

1. Provide a redundant and reliable forcemain system that would maintain sewer service at all times for the residents of Alviso
2. Reduce pipeline failures that result in sanitary sewer overflows (SSOs)
3. Minimize the need for O&M requirements.

The importance of minimal O&M requirements became very important. In the mid 1990's, the City added nine access manholes with tees and valves to the existing forcemain. However, it was discovered during this project that these valves were not been exercised and did not function properly. In addition, each of the manholes had significant infiltration and were not accessible.

3. FORCEMAIN DESIGN

Considerations

When designing supplemental or parallel forcemains it is important to understand the hydraulic performance of the existing pumping system and how the existing forcemain will operate in the revised system. Otherwise you could wind up with a pumping system that has very different characteristics depending on which forcemain is being used. The new forcemain could provide adequate capacity, but the existing forcemain may not; this situation could limit system reliability. It could also occur that the new forcemain could have significantly different Total Dynamic Head (TDH) than the existing forcemain. This situation commonly occurs when the alignment of the new forcemain is drastically different than the existing forcemain. When this happens, the electrical costs when one forcemain is in use can be substantially less than the other, creating a situation where the O&M staff prefers to use one pipeline over the other. Differences in TDH can also have a pronounced effect when dual forcemains are used in parallel. The pumping system will automatically balance itself until the TDH of the two forcemains matches by pushing more flow to one pipeline. This imbalanced flow split may not be acceptable.

For the Spreckles Pumping System, a detailed hydraulic analysis was completed to understand pumping system performance under a variety of conditions. First of all, AC pipe is ID-controlled. The ID of a 10-inch forcemain is 10.0 inches (subject to manufacturing tolerances). HDPE pipe is OD-controlled in the smaller diameters, with the ID of a 10-inch DR17 HDPE pipe being 9.4 inches (6% smaller). The recommended design coefficients of friction of the two pipe materials is also different. It is well understood that the C-values of forcemains decreases with time as pipe wears and solids deposit in the pipeline, decreasing the effective cross section diameter of the pipe. The existing AC pipe had been installed 35 years ago. The City was understandably reluctant to stress test the existing force main that is the only means of wastewater conveyance from Alviso to the RWF – with its fragile condition and history of failures – to measure current C-values. Another important consideration was the City's future plans to rehabilitate the existing AC forcemain, likely by cured-in-place pipe lining (CIPP) that will reduce the pipe's ID by 1.6 inches or more. The goal was not to design a system that will work on the first day of its existence, but to design a pumping system that meets design criteria throughout its anticipated lifetime.

HDR completed a detailed hydraulic analysis that considered each of these factors. In addition, a sensitivity analysis was performed to understand the impacts of changing C-values. This sensitivity analysis was partly to verify that the selected combination of pumps, pipe material, and pipe size will provide the required capacity throughout the life of the system, but also to illustrate for the City's O&M crews the importance of regular pipeline pigging (to control the C-values). The results of the hydraulic analysis are summarized in Figure 3.

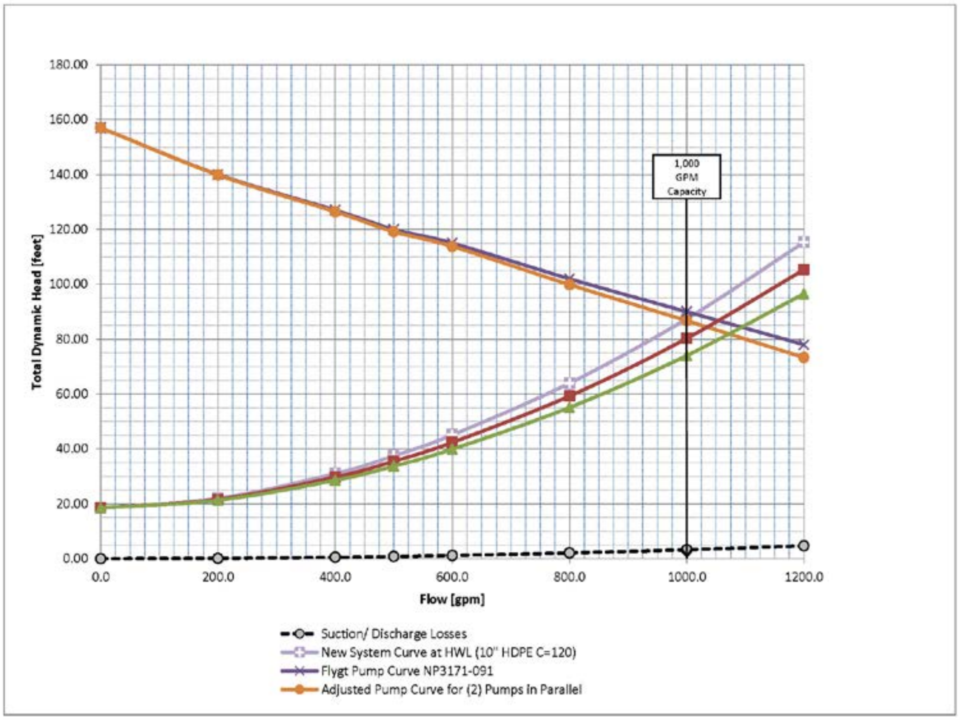

Figure 3 - Understanding how the complete pumping system will function throughout the anticipated lifetime is key to selecting the right combination of pumps and forcemains.

Alignment Selection and Access Manholes

Available alignment options between the Spreckles Pump Station and the RWF were generally limited to the same series of public roads that the existing forcemain follows. However, finding a corridor among the existing utilities presented a challenge. As is common, the density of utilities increased significantly near the wastewater treatment plant. A preliminary alignment was selected based on available utility information obtained. A comprehensive subsurface utility engineering program was then developed and implemented and a final alignment identified.

The final alignment passed through the environmentally sensitive area, using the previously disturbed roadway sections where possible. However, several “Special Status” species – both plant and animal – had to be accounted for. Wetlands areas had to be identified and avoided. Numerous utilities were accounted for avoided. What could not be avoided, however, were two crossings that required trenchless construction methods.

In an effort to minimize the number of access manholes along the new force main, it was decided during the design phase to utilize one of the shafts for the trenchless crossing and build an access manhole. The location of the access manholes were coordinated with City’s O&M staff to meet the needs they may have for future maintenance efforts required. The profile of the proposed alignment was designed to create high points at the access manholes to install gate valves and air relief valves. In addition, a custom insert was incorporated so that the City’s O&M staff can clean approximate 1500 feet sections of the pipe for pigging use. Also, a 6” HDPE riser was installed below the rim of the manhole cover to minimize the need for confined space entry and ease in access to connect a vactor truck during the cleaning process.

Evaluation of Trenchless Crossing Methods

The two trenchless crossings that had to be considered included a single track Union Pacific Railroad (UPRR) crossing and a slough culvert crossing. Neither crossing was particularly long (90 linear feet and 45 linear feet, respectively) nor deep (9 feet and 13 feet, respectively). However, successful completion of these crossings was critical.

To provide assistance in evaluating potential trenchless crossing methods, we relied upon the experts at Bennett Trenchless Engineering (BTE). Their expertise was valuable in identifying applicable construction techniques, determining risks and methods to mange those risks, and in evaluating the constructability and costs of each approach. Trenchless construction methods considered included auger bore/jack (bore/jack), horizontal direction drilling (HDD), pilot-tube microtunneling/guided boring (PTMT), and pipe ramming.

Supporting site specific information for the crossings was provided by GeoEngineers, who completed a geotechnical investigation that included borings at each anticipated pit location. BTE used the information provided by GeoEngineers and supplemented that data with information contained in two previous geotechnical reports covering the same alignment. Soil conditions at the two crossings were found to consist of approximately 10 to 12 feet (Below Ground Surface, bgs) of stiff to very stiff silty clays, underlain by a layer of loose to medium dense sand and silty sand extending to depths of 14 to 24 feet bgs. Groundwater levels were measured as varying from 1 to 8 feet bgs.

Based on the site conditions, it was determined that bore/jack would not be an appropriate method if the grounwater level was at the higher end of the range during installation, especially if the pipeline profile was within the loose sands. If conditions came together at the tome of construction – a long dry period prior to construction, soils in the tunnel profile that were closer to the “medium dense” range throughout – then bore/jack could work. However, since these risks were difficult to manage, bore/jack was eliminated from further consideration.

The short crossing reaches actually worked against one construction technique: HDD. Further complicating HDD was the probable requirement to install the forcemain in a steel casing under the railroad, and numerous utilities near the intersection of Spreckles Avenue and Grand Boulevard near the slough crossing.

Geotechnical Investigation

An extensive geotechnical investigation was performed by GeoEngineers (now Jacobs Associates). Key elements of the investigation included 12 soils borings ranging from 16.5 to 53 feet in depth, 2 trench pits to evaluate shoring needs, 3 piezometers to measure groundwater fluctuations, and 29 reference borings, with associated laboratory analyses. The geotechnical plan is shown in Figure 4.

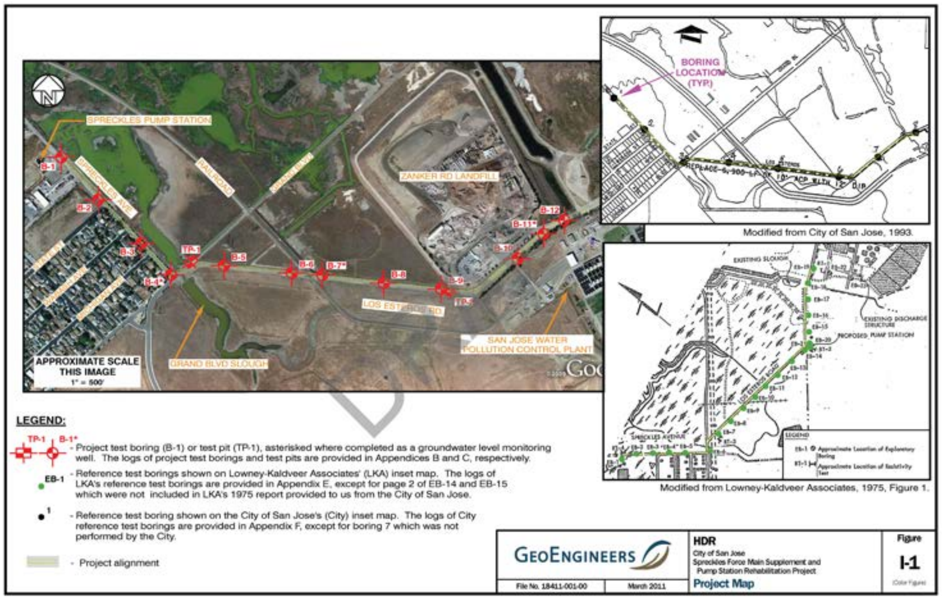

Figure 4 - Geotechnical information obtained for the Spreckles supplemental forcemain was based on 42 test sites to characterize soil and groundwater conditions.

Generally, the soils in the project alignment were found to consist primarily of alluvial deposits with areas of Bay mud. A layer of fill approximately 5 feet in depth covered the whole area. Figure 5 shows the borings profile along the pipe alignment. These findings were not surprising based on an historical understanding of recurrent flooding in the area (producing the alluvial layers), location on the fringes of San Francisco Bay (where Bay mud is common), and attempts to reduce flooding (fill). The groundwater levels were found to range between about 3-5 feet bgs. The soils were also found to be very aggressive, with areas of high sulfates and chlorides, and with fairly high alkalinity (pH=8.1 to 8.2).

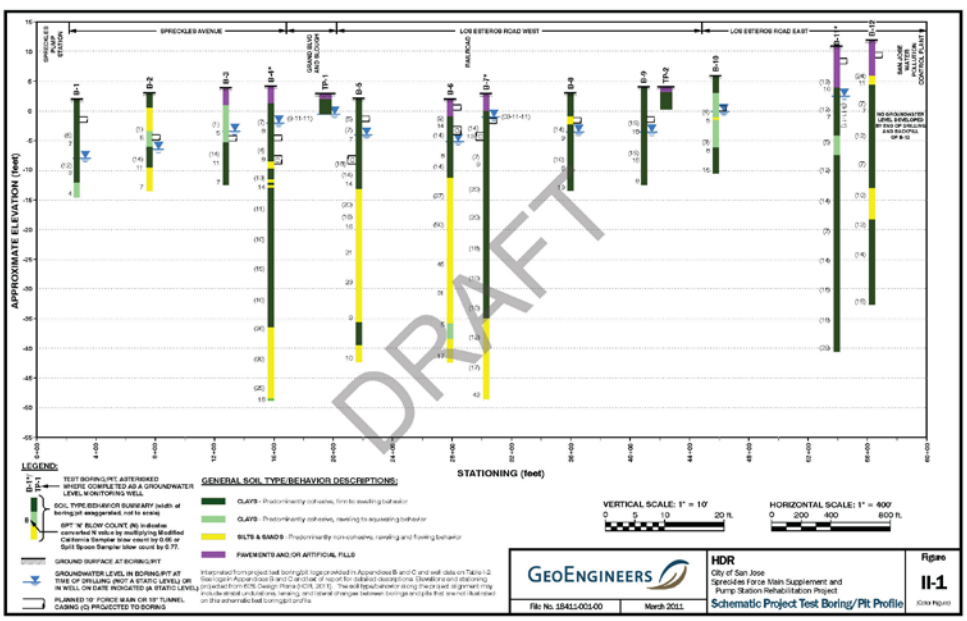

Figure 5 - The borings profile map was used to guide the design elevations of the Spreckles supplemental forcemain.

This information was used by the design team to plan the best profile for the forcemain, make material selections, and recommend trench backfill. Pertinent information was also available to the bidders/contractor to plan their operations and determine their costs, such as for appropriate shoring requirements.

During the field work, the geotechnical engineer watched for identifiable signs of petroliferous soils or other potentially contaminated soils. No obvious signs of questionable materials (either color changes or odors) were observed. One of the soil contaminants that cannot be identified in this process is the presence of asbestos. Subsequent to the geotechnical field work it was discovered that much of the fill that had been used to raise the elevation of the surrounding land had come from waste material provided by local AC pipe plants that had operated in the area. The City implemented a comprehensive testing program to collect and analyze soil samples along the forcemain alignment to determine whether the fill material contained asbestos waste. Fortunately, no asbestos was found. However, in the Specifications the contractor was alerted to the possible presence of asbestos, and a requirement for testing the soil and provisions for proceeding in case asbestos was encountered were included to minimize the risk of project delays.

Pipe Material

Soils that are high in sulfate and chloride are known to be particularly aggressive to steel and concrete. Even stainless steel hardware components of piping systems have been observed to fail in less than five years under these conditions. Bay mud is a very soft, cohesionless material that is prone to settling; within the reach of the forcemain alignment near the Pump Station and along Spreckles Avenue, standard blow counts of five or less were found in the planned pipe zone.

The pipe material selected for the supplemental forcemain needed to be able to withstand the aggressive soils and accommodate possible differential settlement. In addition, selection of a pipe material with a low friction coefficient would help control pumping costs. Pipe materials evaluated included ductile iron (DI) pipe, polyvinyl chloride (PVC) pipe, and high-density polyethylene (HDPE) pipe.

DI pipe, even with external tape wraps or double-polyethylene bagging, would be subject to corrosion based on the aggressive soils. Any imperfections or installation-related damage to the coatings could result in accelerated corrosion at the point(s) of exposure. It was felt that the only way to fully protect the pipeline would be to install bonding joints and a cathodic protection system for the entire pipeline length. DI pipe is also much heavier than either HDPE or PVC pipe. Ten-inch DI ANSI53 pipe has a unit weight that is 4.44 times the weight of HDPE pipe. Heavier pipe would have a greater tendency to settle in the Bay mud reaches of the project, so special handling methods would be required. These special handling methods could include deeper excavation to reach beyond the bottom of the Bay mud layer or modified trench backfill. Due to the potential for differential settlement, restrained joints would also be necessary. Each of these additions would add cost to the project. If more suitable alternatives did not exist then the design could accommodate the use of DI pipe, but in this case that was not a necessary expense.

PVC pipe could provide a reasonable corrosion-resistant product. However, all of the fittings for a PVC piping system are commonly DI. Each of the DI fittings would need to be individually protected against corrosion. Fabricated fittings are available in PVC, but are significantly more expensive. For example, a 10-inch x 8-inch DI tee is approximately $1,100, whereas a 10-inch x 8-inch fabricated DR18 PVC tee is about $2,400. Fusible PVC was considered as a means to accommodate the potential settlement anticipated in the Bay mud, but the City does not have much experience with fusible PVC and did not feel that this project was a good one to learn on.

HDPE was determined to be the most appropriate pipe material for the Spreckles supplemental forcemain. The inherent flexibility, lightweight, corrosion resistance, and restrained butt-fusion joints of HDPE piping systems were ideally suited to the aggressive soil and potential for differential settlement.

One issue with HDPE pipe that needs to be addressed, however, is the requirement commonly written into Specifications that all fittings must provide the same or greater pressure rating as the pipe they are connected to. Fabricated HDPE fittings are significantly derated due to stresses caused by the geometry of the fitting. For example, a PE4710, DR17 three-segment 90-degree elbow is rated for 71 psi, as compared to a pressure rating of 126 psi for the same size straight pipe. In order to maintain the same pressure rating as the straight pipe, it is necessary to go to a DR11 90-degree elbow. The problem with that transition is the pipe wall increases and the ID reduces from 9.409 inches to 8.678 inches, a reduction of nearly 8%. For many piping applications, this transition may be acceptable. However, the City wants to be able to clean the Spreckles supplemental forcemain by pigging the line. If the fittings are smaller, then the pig that can be inserted into the pipeline has to be smaller or there is a risk of getting the pig stuck in the pipe. That means reduced cleaning efficiency for more than 99% of the forcemain (the portion of the pipe that is full diameter).

During design, we took advantage of the short bending radius of HDPE pipe to eliminate as many fittings as possible. For the fittings that could not be eliminated, molded fittings were specified. Molded fittings are not derated, so there is no need to use thicker-walled pipe. During construction, we worked with the contractor to use molded fittings where necessary to maintain piggability, but allowed the use of thicker pipes for tees and other branches where the pig would not travel.

One impact this approach had was on the placement of the access manholes on either side of each trenchless crossing. To avoid the use of fittings, the contractor was allowed to bend the HDPE pipe rising from the depth of the trenchless crossing to the higher profile of the open-cut sections. This transition could not be accomplished as designed, and the access manholes had to be moved further away from the trenchless crossings. This change was accommodated with only minor modifications.

Mechanical and Electrial Equipment

Although this paper focuses on the forcemain and not the pump station, there was one component of the pump station design we wanted to mention. The existing generator at the Spreckles Pump Station had apparently served the entire wastewater treatment plant originally. This assumption was based on both the age of the generator and the size. The generator, which filled approximately half of the Administration Building, was significantly over-sized to efficiently run the pumps at the pump station. Initially the plan was to replace the generator with a smaller, properly sized generator.

Early in the design phase, however, the City staff came up with a better idea to use a trailer-mounted, diesel driven pump as a concurrent backup for the submersible pumps and as a source of standby power. The self-contained, automatic Godwin centrifugal pump provides more than enough capacity. The pump-generator was designed to sit on a concrete pad such that the important components of the equipment were located above the flood level, and was plumbed into the wet well and the discharge piping and connected to the SCADA system. In the event of pump failure, either due to mechanical breakdown or loss of power, the pump-generator will automatically start and take over pumping duties until the submersible pumps are once again ready. In addition, one spare submersible pump was provided as part of the project, to be stored at the City's main warehouse. In the event of a pump failure, the SCADA system will alert the O&M staff, who will respond and determine whether the spare pump needs to be installed. The pump-generator helps to manage the risk of failure-related SSOs and also mitigates the sense of urgency associated with failure alarms.

Special Trench Details

A great deal of effort went into developing an appropriate trench detail that would meet the project recommendations of the geotechnical engineer, satisfy both the City's Materials and Testing Lab (MTL) and Construction Management departments, and allow the contractor to maintain reasonable rates of installation. The City's standard trench detail utilizes a modified Class I backfill material in the pipe zone – essentially drainrock. This backfill material is "self-compacting," which alleviates trench compaction testing during installation. However, the project team was very concerned that the native soils in the forcemain alignment plus the high groundwater conditions were not amenable to the use of this material.

The concerns included the lack of fine materials in the backfill to provide interlocking, the potential for backfill migration, and the risk of groundwater travelling along the trench, disturbing the backfill and causing voids. These issues could be partially mitigated by wrapping the pipe zone backfill in geotextile fabric. However, adding the geotextile fabric would negatively impact the contractor's installation rate.

Furthermore, if future contractors were to cut into the envelope of Class I wrapped in geotextile fabric, the risk of the backfill raveling out of the trench uncontrollably could lead to improper recompaction around the forcemain, especially if the contractor who cut into the trench was not being watched closely by a City inspector at the time. This loss of foundation support could be detrimental to the HDPE forcemain.

A special trench detail was developed that replaced the Class I with a specific mix of controlled-density fill (CDF) familiar to the City's MTL. Use of the pre-approved CDF mixture streamlined acceptance, provided a trench structure that the project team was happy with, and would allow the contractor to maintain their production rates. In a concession to the MTL and the construction inspector, a layer of geotextile fabric was required at the interface between the CDF and the Class 2 AB material in the backfill zone.

Controlling Permits through Trenchless Construction

At one time during the design phase, the City expressed an interest in replacing the slough culvert crossing on Grand Boulevard. The theory was that the culvert was very old and in poor condition. By replacing the culvert at the same time as the forcemain, the forcemain could be installed by open-cut construction at a presumably lower cost. A check with the permitting agencies quickly dashed those hopes.

The sloughs were connected to San Francisco Bay, giving the U.S. Army Corps of Engineers (COE) jurisdiction. However, the California Department of Fish and Wildlife (CA F&W) and U.S. Fish and Wildlife (US F&W) also had regulatory authority. Both CA F&W and US F&W told us that they would follow the lead of the COE. If COE required a permit, then they would each also require a permit. This was particularly concerning because the US F&W permit process would have to begin with a Section 7 consultation followed by issuance of a Biological Opinion. This permitting process was estimated to take between 12 and 24 months. However, the COE reviewed our preliminary permit application with supporting documentation and decided that as long as we used trenchless construction methods to cross the slough they would not require a permit.

The approach to crossing the slough became quite apparent at that point. This was the first time the design team had experienced the COE make a jurisductional ruling based on use of trenchless technology, and it is seen as an encouraging sign for the future.

Bid Strategy for Controlling Trenchless Construction Costs

Through the evaluation of applicable trenchless construction methods it was determined that either PTMT or pipe ramming could be used to install the forcemain beneath the slough and beneath the railroad. Rather than locking in on one method or the other based on perceived relative construction costs, the project team decided to implement a strategy that allowed bidders to select either construction method as a part of their bid. This approach increased the number of subcontractors that could bid on the job significantly.

Once the decision was made to allow both construction methods in the Contract Documents, the challenge now became how to provide a level playing field for all bidders while concurrently protecting the City to avoid bid protests and, ultimately, obtain a properly installed forcemain. Since the City maintains a contract with the prime contractor only, the trenchless subcontractor would not be directly obligated to the City. Therefore, it was imperative to ensure that the contractor had the necessary experience and qualifications necessary to do a good job.

Initially, it was intended to pre-qualify suitable PTMT and pipe ramming contractors. However, as the pre-qualification documents involved the subcontractor to provide a significant amount of information about its role, it was recommended by City's legal staff to implement a performance-based experience requirement for the subcontractors, and the bidders had to assume the responsibilty to include a suitably qualified subcontractor on their team. Defining clear requirements that was expected of the contractor with regards to performance avoided any potential bid protests and allowed for very good competitive bids.

Bid Results
Bids were received and opened on March 21, 2013. Six bids were received, ranging from an apparent low bid of $2,744,444 to a high of $3,415,643 compared to an engineer's estimate of $3,227,000. After the bids, it was discovered that the low bidder had made a mathematical error in their bid and an adjustment was made to $2,774,444, but this did not change the bid order.

In their bids, each contractor was required to indicate whether they planned to use PTMT or pipe ramming, identify the subcontractor, provide the required experience information, and include a unit cost. Each of the bidders selected PTMT as their trenchless contruction method. The unit costs for PTMT ranged from $400/linear foot to $500/linear foot. Fortunately, no bidders where excluded because they failed to handle these requirements properly. Additionally, all bidders used a subcontractor.

4. FORCEMAIN CONSTRUCTION

During the design phase, it was imperative to create a design that will incorporate continuous sewer service for the Alviso residents during construction. Once the alignment was proposed, the phasing of work was simplified for the Contractor to construct the new force main while the existing 10-inch AC force main maintained service. A temporary bypass pump can be installed on the Spreckles Pump Station site to divert the sewage entering through the 18-inch gravity pipe into the wet well structure at the Spreckles Pump Station and directly connect it to the newly constructed 10-inch HDPE force main. City O&M Staff emphasized that the Spreckles Pump Station can only be shut down for two hours, so the location of the temporary bypass pumps was included in the design plans to help simplify the need for a contractor to determine diversion. The temporary bypass pumps are required to handle a minimum of 1 MGD and also account for any redundancy in case of power or equipment failure.

During the bidding period, it was required for all bidders to bid on a shoring system that the contractor would use during construction. Shortly after the Notice-to-Proceed was issued, the contractor submitted a value engineering request for the shoring methods for the shafts associated with the trenchless construction work. The same contractor had recently completed work for a local developer in the area installing an 18 inch water main. Auger jack and bore was used at the same two crossings that this project would cross – under the Alviso Slough and the UPPR railroad crossing. The lowest bidder requested to utilize the same shoring methods they had used for the previous work since the water table was not as high when the log of borings were taken in 2011. The team reviewed the submittal and required the contractor to increase the thickness of the shields, add steel backing plates, and properly coordinate the depths of the trench boxes they planned to use.

Also, the lowest bidder requested the width of the trench be reduced to save some additional money on the use of CDF. The team evaluated the proposal and requested the contractor to maintain the top thickness, but the sides of the pipe could be reduced to six inches all around.

The Contractor started the forcemain work in mid September and completed the work by early December.

5. CONCLUSION

The importance of understanding a design that will utilimately help the City staff who operate and maintain the facility helped simplify the design of the new facilities. Training was imbedded into the contract to allow City Staff to understand how the new equipment will be used.

The level of detail that was shown on the plans and specifications was very clear and concise for the contractor to bid with ease. In addition, the construction sequencing for the project made it easier for the contractor to expedite the work because they were allowed to close the streets.

A lesson learned regarding the soil conditions is that it is important for the design team to be accommodating to suggestions by the contractor if soils do not reflect conditions when log of borings were done. Having a working relationship with the contractor will help the project operate more efficiently and help reduce costs further.