Sliplining Provides the Perfect Trenchless Solution for the City of Del Mar, California

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1. ABSTRACT

The City of Del Mar, California is a well-known enclave within San Diego County. With only 4,000 residents, the cost of maintaining and replacing aging infrastructure is challenging. A recent concern was the reliability of a 20-inch steel water main feeding the city from the north end of town. Replacing the pipeline using open-cut, dig and replace construction would have been expensive and highly disruptive with the existing pipeline located directly under busy Jimmy Durante Boulevard which is the primary artery between the famous Del Mar Fairgrounds and the downtown area.

As part of a larger streetscape upgrade, the City engaged Nasland Engineering of San Diego, California to consider options for replacing or rehabilitating the 20-inch water line. In the end, two alternate construction methods were bid on the project. The first was to install a new pipeline with traditional dig and replace methods. The second was to install a new pipeline using slipline methodology.

In the end, sliplining was the most cost effective option, while it also worked to resolve specific project challenges including cost, traffic congestion, and the requirement to complete the project before the busy summer season. The project was constructed with a single 2,015-foot insertion using the fuse and pull method, where pipe is joined together at grade and then inserted immediately into the existing pipeline.

This paper will discuss the evaluation process and bid setup for the project, as well as construction results for the unique way in which sliplining methodology was employed.

2. INTRODUCTION

The City of Del Mar lies along the west coast of California between La Jolla and Solana Beach with a total area of two square miles and a population of only 4,000 people. The area was first encountered by an engineer on the Southern California Railroad as a route was built from San Diego to San Bernardino in 1882. Finding it “the most attractive place on the entire coast,” he purchased land, built a home, and established a tent city on the beach. His wife named the area Del Mar after a poem titled “The Fight on Paseo Del Mar.” Soon after, Colonel Jacob Taylor came to the area with his family and purchased 338.11 acres in 1885, officially founding the City of Del Mar.

Taylor created a resort called Casa Del Mar intended to attract the rich and famous. It initially succeeded only to fall from bankruptcy, flood, and then a fire which burned the establishment to the ground in 1889. After this loss, the area became inactive until the early 1900s when the South Coast Land Company started developing San Diego County. Among San Diego developments, the company built the Stratford Inn in Del Mar in 1910, which quickly...
became the main attraction of the town, drawing Hollywood stars to the area. Rapid development of residential areas began in the 1920s when Del Mar received electricity from San Diego Gas and Electric.

In 1936, the San Diego County Fair found its permanent home in Del Mar with the construction of the fairgrounds in the San Dieguito Valley. The first fair opened October 8, 1936 and welcomed 50,000 visitors. Part of the fairgrounds included a mile-long oval racetrack where Bing Crosby established the Del Mar Turf Club, opening the first races on July 3, 1937. Bing recorded the renowned “Where the Turf Meets the Surf” song in 1938; intended to open and close the races each day, the song now rings the start of summer to San Diegans. Racing season attracted large crowds and enticed many Hollywood celebrities to purchase homes in Del Mar including famous entertainer Jimmy Durante after which the street leading to the fairgrounds was named.

Jimmy Durante Boulevard is the primary artery from the Del Mar Fairgrounds to downtown Del Mar. Although the city’s population is small, the fairgrounds and beaches attract visitors year round peaking in the summer season with the San Diego County Fair opening in early June each year. In recent years, fair attendance has reached 1.5 million averaging 60,000 guests a day. With the closing of the fair in July, racing season begins, prohibiting any major construction work on the main roads through the end of the summer. These factors posed an issue for the Public Works Department in the City of Del Mar when they considered rehabilitating Jimmy Durante Boulevard and the 20-inch steel water line that runs beneath it.

3. PROJECT BACKGROUND

The existing line supplies potable water to the City of Del Mar, running from the fairgrounds to the north, down Jimmy Durante Boulevard, ending in the downtown area of Del Mar. The line dates back to the initial development of the fairgrounds. Decades later, the line is corroded and leaking (see Figure 1) causing a concern over the reliability of the water main and motivating the City to consider replacement of the line as part of other renovations in the area. Whenever a leak needed to be patched, the busy boulevard would have to be shut down to cut into the road and fix the line. Jimmy Durante Boulevard not only connects north and south Del Mar, but houses many businesses along the length of the route making it imperative to maintain traffic access.

![Figure 1. Existing 20-inch steel line removed during construction.](image)

With such a small population of permanent residents in the City of Del Mar, large construction projects such as this have to be voter approved and completed in the most cost effective manner possible since most funding will come from taxes on the residents themselves. With funding by TransNet, larger citywide improvements are possible by incurring a half-cent countywide sales tax that helps fund regional transportation projects. This provided the necessary backing for a multi-year, multi-segment improvement project for the City of Del Mar. The Jimmy Durante Boulevard and Camino Del Mar 2015 Street and Drainage Capital Project was one key segment of these improvements. As part of the larger streetscape upgrade to the route from the fairgrounds to downtown, the City engaged Nasland Engineering to consider options for replacing or rehabilitating the 20-inch water line under Jimmy Durante Boulevard.
4. PROJECT DESIGN

The segment of water line to be replaced runs under the southbound lane of Jimmy Durante Boulevard from the intersection with San Dieguito Drive to the Camino Del Mar overpass. This boulevard consists of two lanes that enable travel from the race track to downtown. With only about a mile from the fairgrounds to the downtown area, many people walk the distance along the side of the road. This originally meant braving a walk along the shoulder of a busy street. This project intended to improve those conditions by installing sidewalks along the route together with other street improvements. Since the surface was being upgraded, it only made sense to upgrade the water line below to prevent having to repave the street if improvements were done at a later date. Key factors in the execution of this installation included minimizing the construction zone along the two-lane thoroughfare and ensuring completion before the start of summer.

The City of Del Mar sought the most cost effective installation method for this extensive water line upgrade. The initial design by Nasland only considered open-cut installation along the southbound lane of the road. This method is a standard practice for utility projects in Del Mar. Specifications and plans were drawn up with the intention of excavating and installing a new pipeline to the side of the existing steel pipe down the center of the southbound lane of Jimmy Durante Boulevard. Upon completion of preliminary design, the City requested a constructability review to be performed by Dudek Engineering + Environmental. During the review it was determined that it would have a lesser impact to the City and its residents to perform slilining as opposed to open-cut excavation. Slilining was then added to the bid package as an alternate water line rehabilitation method. A full design was not created; the option was only added to the project specifications. The final plans provided horizontal and vertical alignment information for the open-cut construction method only with just an approximate horizontal alignment of the existing steel line shown. The slilining option would be like a design-build project if the method was selected.

The length of water line to be rehabilitated or replaced was determined from the existing locations of key water mains and valves in the proximity of the street upgrades to be completed in the project. The northern extent of the planned roadway improvements ended near the intersection of Jimmy Durante Boulevard with San Dieguito Drive. Although the existing steel line continued north, past that intersection, towards the fairgrounds, the extent of the water line replacement in the project was only as far as that of the street upgrades. South of the intersection there is an existing 3-way valve package and that portion of the existing line feeds approximately one third of Del Mar so it could not be shut down for any extended time period. Therefore, the new water line would start from the south end of the valve package, just after the intersection. The existing 20-inch steel line continues south along Jimmy Durante Boulevard until the Camino Del Mar overpass, at which point the steel line connects to 12-inch polyvinyl chloride (PVC) water line. The new water line would thus end at the connection to existing 12-inch PVC just before the Camino Del Mar overpass. These start and end points give a total pipe length of 2,015 linear feet (see Figure 2).
The original 20-inch steel water line was installed back when the City of Del Mar was just starting to develop. At that point, the potential population of the area was unknown, so larger pipelines were preferred to anticipate increased growth. Now fully developed, the design engineer recognized that a 12-inch line would easily meet the capacity necessary to feed the City of Del Mar. This size was determined to provide sufficient flow dynamics in the initial open cut design. The size reduction from a 20-inch diameter was not for the purpose of fitting the new line into the existing line in the slipline application. The existing line could fit pipes up to 16 inches in diameter if sliplined, but a 12-inch diameter would give the desired hydraulics. Too large of a pipe wouldn’t have given proper water pressure and velocity. Additionally, the new line would connect to existing 12-inch PVC at the end of the installation, so the line would now be consistently sized and have the benefit of saving the City money over using larger pipe.

PVC was the preferred pipe material for both methods of water line construction. The City of Del Mar was familiar with the material, already using it in other parts of their water system. This is a potable water line so HDPE was not considered due to its vulnerability to oxidative degradation when exposed to chlorine-based water disinfectants. PVC pipe, on the other hand, has no record of oxidation induced failure due to the material formula’s resistance to oxidation. The open-cut design could be installed with standard bell-and-spigot (B&S) PVC. The same could not be used for the slipline installation as the water line pipe would need to be pulled in one continuous length and B&S PVC pipe would pull apart at the joints. Fusible polyvinyl chloride pipe’s (FPVCP) fused joints are intrinsically restrained, allowing the pipe to withstand long pulls and preventing the joints from pulling apart. There would also be no risk of over-belling as may be possible in other restrained joint PVC pipe products, should the pipe be pushed. FPVCP would provide the City with a familiar material, requiring no further training of City repair crews should additions need to be made to the line at a later date, while enabling trenchless repair of the existing line. After sliplining was added to the bid package as a result of the constructability review, Dudek suggested the product to the city engineer who quickly approved FPVCP as a slipline material.

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12-inch FPVCP by Slipline in Existing 20-inch Steel Line

Approximate Open-Cut 12-inch B&S PVC Cross Section

Figure 3. Comparison of installation methods and respective pipe materials.

Both installation methods had their own set of advantages and disadvantages. The originally designed method of open-cut replacement is a common practice that would allow the water supply to continue in the existing line while construction of the new line progressed to the side of it. This differs from the slipline installation which would require a temporary water service system during construction unless the original system could be looped to serve residents affected by the shut off of this segment of the line. The open-cut method, however, presented many concerns in terms of traffic control, a main factor in the construction of this water line. The method would
necessitate the excavation of a trench down the center of the southbound lane down Jimmy Durante Boulevard, requiring the lane to be shut down for extended periods during installation. The two-lane road has multiple islands between the north and southbound lanes, broken up only by left turn lanes into side roads or driveways. These islands further hinder traffic flow during construction as in order to shut down one lane, traffic would need to be diverted to the other side of these islands and then back once the construction area had been passed. In order to avoid such a disruption in a high traffic area much major work would be forced to be completed at night to lessen traffic control issues. The slipline method had the advantage of eliminating excessive excavation, only requiring trenches where connections need to be made to the new line, considerably lessening the impact on traffic. Figure 3 highlights the significant difference in excavation and required road repair of open-cut installation when compared to the suggested trenchless method. Slipping would also have the innate benefit of utilizing the existing steel line, rather than having it capped off and abandoned in place should open-cut methods be employed. It also avoids filling additional underground space with pipe that could potentially obstruct further utility improvements down the line.

5. PROJECT BIDDING

Once the project had been designed, reviewed, and revised, the Jimmy Durante Boulevard and Camino Del Mar 2015 Street and Drainage Capital Project advertised to bidders on January 7, 2015. The bid form was set up to have a bid schedule “A,” bid schedule “B,” and bid schedule “B-1.” Bid schedule “A” covered items related to the street improvements, while bid schedules “B” and “B-1” covered utility improvements. Bid schedules “B” and “B-1” differed only in the installation of the new 2,015 linear foot 12-inch water main. Bid schedule “B,” considered the base bid, contained a bid item for open-cut construction of a 12-inch PVC water main along with related bid items to cut, plug, and abandon the existing 20-inch steel water main and to resurface the trench that resulted from the open-cut excavation. Bid schedule “B-1,” considered the alternate base bid, contained a bid item to slipline the existing 20-inch steel water line with 12-inch FPVCP water main and grout fill the annular space along with related bid items to cut out the existing steel line where connections would be made and provide temporary water services to all residents, businesses, and fire hydrants during construction. The lowest bidder would be determined from the total of schedules “A plus B” or “A plus B-1,” whichever was lower. There was no preference in the installation method; the City just wanted the most cost effective option. The project bid on January 29, 2015 and, after receiving only two bids, was awarded to lowest responsible bidder, PAL General Engineering, Inc. who based their bid on sliplining.

6. CONSTRUCTION

Construction began in February of 2015 when PAL Engineering started preparation for the slip line installation. The contractor drained and isolated the section of pipe to be sliplined and completed other utility improvements using open-cut methods along side streets. The lines that connected into the existing steel pipe were cut off and isolated and had valves installed at the ends. There were enough loops in place in the existing water system that a bypass line was not needed when flow to the existing steel line was shut off. The contractor was instead able to reroute the lines so that the shut off did not affect the residents.

There were not any as-built plans available for the existing steel line. The contractor only had a rough idea of where existing utilities were located and had an idea of the depth of the line based on the standards of the area, typically a minimum three feet of cover and up to six feet of cover. Because the slipline option was added later, no CCTV inspection of the existing steel line was completed prior to bidding. Under the assumption that the alignment shown in the project plans was correct, crews began to dig down to the steel line at sections where valves and service connections were to be made. The contractor quickly determined that the actual alignment of the steel line was not as anticipated when crews dug down to prepare for a valve installation and there was no steel line to be found. At this point the project truly became a design-build. The contractor needed to first determine the actual alignment of the steel line and then adapt his plan for the slipline installation accordingly. The contractor traced the alignment by adding an electrical charge to a hydrant off of the existing line. This added conductivity to the steel line that could then be followed with a utility locator. He found two horizontal alignment offsets in the steel line starting a few hundred feet from the north end of the alignment. The contractor also performed a CCTV inspection himself along the line to ensure there were no further hiccups in the pipe alignment. The vertical depths were as expected in the range of three to six feet of cover.

Initially when the existing alignment was assumed to be relatively straight, the steel line would have only needed to be excavated and cut at the start and end of the alignment with very small trenches and cuts in locations where
services would be connected to the new line. Upon finding the two bends in existing alignment, the contractor had to consider breaking the slipline into three runs since FPVCP could not slip through that drastic of a deflection; one run from the start of the alignment to the first bend, one from the first bend to the second bend, and one from the second bend to the connection at the Camino Del Mar overpass. PAL Engineering worked with the construction management team at Underground Solutions Inc. (UGSI), the FPVCP supplier, to evaluate the existing layout of the fittings and come up with an alternative solution. Instead of dividing the installation into multiple runs, the contractor would cut out the two horizontal offsets as well as additional steel pipe in each direction of the bend to allow the FPVCP to curve through the offset with its inherent bend radius (see Figure 4). This would require removal of approximately 60 feet of the steel line for each offset, 30 feet from either side of the existing bend. The slipline subcontractor was fine with this approach as it would enable a single pull-in through the entire length of the alignment and eliminate the need to install short pipe segments and dig additional insertion pits that would only further impede traffic along the road. This approach would also allow the pipe staging and fusion area to remain in the same position, not having to move to multiple insertion pits. The 60-foot by 3-foot trenches at each offset would be treated just as the other open-cut sections for service reconnections and tie-ins. All sections would be covered with steel plates to allow traffic to continue along the roadway. The plates would only be removed from a particular trench for short periods when the new 12-inch line was being pulled through that trenched segment.

![Figure 4. Open-cut excavation for alignment offset in existing steel line.](image)

Due to the constrained nature of the project, with the goal of eliminating traffic disruptions wherever possible, typical fusion and laydown of the entire 2,015 linear foot FPVCP string prior to pull-in was simply not feasible. The slipline subcontractor consulted with UGSI’s construction manager to determine the least invasive means of installing such a long length of pipe in a small, traffic heavy area. They settled on a far less intrusive process of pipe fusing and staging known as a “fuse-and-pull” operation. The set up allows the pipe to be sliplined into the existing steel line as 45 foot lengths of FPVCP are fused together. After a joint is fused, the pipe is pulled into the existing line and out of the fusion machine until the end of the last stick of pipe is set at the center of the fusion machine, ready to be fused to the next stick. This method allows fusion, staging, and installation to occur simultaneously and avoids having to stage long sections of fused pipe above ground. Upon assessment of the work area along the alignment, a dirt lot was discovered on the north end of the alignment on the shoulder of the southbound lane that was ideal for setting up this operation. As well as providing plenty of room to stage, fuse, and pull the pipe into place, the lot happened to coincide with the start of the water line replacement. The lot was actually a city-owned property that the City of Del Mar willingly allowed the contractor to use to stage and install the pipe. This staging location and condensed fusion and installation set up were beneficial for public perception of the project (see Figure
5). The entire pipe string did not have to be staged in public view nor did it have to be placed in an area that wouldn’t be conducive to working.

With the completion of construction preparations and trenches at all tie-in, reconnection, and horizontal offset locations, fusion and slipline installation of 12-inch DR 18 FPVCP began in mid-March of 2015. Typically in slipline installations, a winch and cable assembly is set up at the end of the installation opposite from the pipe staging area. The cable is then fed up the existing line to connect to a pull head on the front end of the new pipeline and then the cable is pulled back with the winch, pulling the pipe along with it through the existing line. However, in this project, the smooth condition of the existing line and the relatively level grade allowed for a less invasive approach. A pull head was attached to the front of the pipe length just in case the pipe needed to be pulled by this more conventional method but instead the pipe was fused and simultaneously pulled out of the fusion machine and pushed into the 20-inch steel line (see Figure 6). The “fuse-and-pull” operation became a “fuse-and-push” operation due to the low friction resistance between the new pipe and existing steel line. Because a winch was not required, there was no extra equipment at the south end of the alignment, further eliminating potential obstructions to traffic. The entire process of fusing the pipe and sliplining it into the existing line took only four days.
Traffic control was the primary concern during installation. Permitted work hours required that construction not begin before 8:00 AM and that all equipment be completely packed up by 5:00 PM each work day. Between 8:00 AM and 5:00 PM the contractor needed to make as many provisions as necessary to facilitate traffic flow in construction zones. All of the larger open trenches for radius alignments and tie-ins and small trench sections to connect services, water lines, existing fire hydrants, as well as blow off assemblies were steel plated the moment the trench was fully excavated to permit vehicle commute. Once sliplining began, traffic was only stopped when the head of the pipe string was pushed through any open-cut portion. When the 12-inch line reached a trench section, the steel plate was removed, the crew watched the pull head to make sure it did not drop and was properly guided to the next section of steel line (see Figure 7), and then the steel plate was replaced to allow traffic to pass again. Traffic was only be impacted for approximately 15 minutes at a time (see Figure 8).

Once the new 12-inch water line was fully sliplined through the existing 20-inch steel line, all tees and service lines were installed and connected in the previously excavated trenches. The City of Del Mar does not use many restrained connections in general practice. UGSI approached the contractor to suggest using restrainer glands on the tees and any other connections off of the new 12-inch line in order to restrain fittings to the new line. Mechanical restraints were needed to ensure a solid connection to lines running off this transmission main, especially since the line would be pressure tested inside the existing steel pipe prior to grouting, so the 12-inch pipe would undoubtedly move and have the potential of disconnecting from tie-ins. Dudek, in its role as inspector and construction manager, agreed that this was a necessary item so the City of Del Mar approved this change order (see Figure 9).
On April 20, 2015, after all water and service connections were made to the new line, the 12-inch FPVCP water line passed pressure testing of 160 psi, holding pressure without a drop for two hours. The slipline subcontractor grouted the line in place the following week. The pressure grouting was successful but required multiple attempts due to issues with mixing time and the flowability of the grout. Chlorination and dechlorination of the pipe and final tie-ins followed the successful grouting attempt. The project was fully completed and operational with the new line in service by late May, about three weeks prior to the opening of the San Diego County Fair at the Del Mar Fairgrounds.

7. CONCLUSIONS

Despite the constraining traffic requirements of the jobsite, the project was successfully completed with a week to spare from the desired completion date of May 25, 2015. There was a big push to complete the project before the start of the summer season and the county fair. The fair brings in substantial income to the City so if construction impeded visitation to the fairgrounds, the fair and the City would have suffered. The City of Del Mar, UGSI, Dudek, and PAL Engineering teamed together to make sure the project was done on time.

The slipline method made it possible to meet the deadline and lessen the impact on traffic. It limited excavation to four main pits with only small open trench sections for tie-ins, greatly reducing the amount of traffic control and diversion required during construction. Had open-cut been the chosen method, installation would have taken at least twice the time, possibly longer depending on the number of existing lines encountered during excavation. Sliplining also had the added benefit of reduced trucking for the import and export of excavated material and lower paving requirements. The trenchless method produced an overall project savings exceeding $70,000 compared with the open-cut option.

The City of Del Mar was very happy with the procedure and how fast and smooth it went compared to open trench replacement. The efforts to create the most cost-effective, time-saving, and commuter-friendly plan were greatly appreciated. The new water line now provides the system with better flow dynamics, increased volume, and lessens the work required of the pumps in the system due to the increased coefficient of the pipeline when compared to the existing 20-inch steel line. The results opened the City up to potentially using similar methods in future projects in the area.

8. REFERENCES

The Official Website of Del Mar, California. Retrieved from http://www.delmar.ca.us/

