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HDD Through Difficult Soils in the High Desert of California for the Upper Narrows Project

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1. ABSTRACT

An unprecedented storm event overwhelmed the high desert of CA in the winter of 2010 and the Victor Valley Wastewater Reclamation Authority (VVWRA) sustained damage to several of its interceptors. High flows in the Mojave River caused a blockage which resulted in an overflow event for the system. The VVWRA set about to repair the damaged pipeline by taking it out of the river and tunneling through the Upper Narrows.

As part of this reestablishment of the gravity interceptor system, the new alignment required installation of a siphon section crossing under the Mojave River. This section was designed to be installed via horizontal directional drilling. The 1,600 LF installation was to include two pipelines, both 16-inch nominal lines, installed at the same time in a bundle configuration.

There were several aspects of this project that made it very difficult. The project required full-time environmental monitoring and Native American cultural monitoring. The HDD alignment and lay down area for the pipe staging operation was directly adjacent to a school which required limited access and security measures. Most importantly, the geology for the alignment was characterized by running sands, cobbles, and a very dense bedrock formation at depth.

This paper will summarize the difficult drilling requirements encountered, how the project approach was changed to address the site conditions, and the outcome of the construction process for the siphon installation.

2. INTRODUCTION

The City of Victorville was incorporated into the State of California on September 21, 1962. The area had been settled for quite a long period of time prior to its incorporation – around 1885, a community was developed known as Victor. Named after one of the construction superintendents of the California Southern Railroad, Jacob Nash Victor, it was established a mile south east of a railroad station built in the narrows of the Mojave River. The area was rich in water and agriculturally viable land which made it ideal for settlement. In 1901, the US Post Office changed the name of the budding town to Victorville after there was confusion with the Colorado settlement which had the same name.

World War II changed the residential nature of the community. Post World War II, a number of new emigrants and immigrants settled on the land and began a real town. At the time of incorporation the population was approximately 8,110 people and the town covered 9.7 square miles. Since then, the city has grown substantially in both population and land. As of the 2010 census, there were 115,921 residents in the city and the city occupied 73.18 square miles.

During World War II, the area was used by the Army to develop the Victorville Army Airfield which was completed on May 18, 1943. Later, the base changed hands and it was renamed the George Air Force Base. It was home to two Tactical Fighter Wings of the Tactical Air Command and employed approximately 6000 people between civilians and military personnel. The base was closed under the Base Closure and Realignment Act on December 15, 1992. It has since been annexed by the City of Victorville and is currently being developed into a "global access" freight transportation hub which is planned to include the Southern California Logistics Airport (SCLA) and Centre and the Southern California Rail Complex.

Victorville is the largest of the cities in the Victor Valley area. It is currently undergoing an industrial and retail expansion based on its establishment as a cost effective location with access to major transportation routes, and high yield investments into its public infrastructure. This boom in industry has brought many new companies, residents, and visitors to the area, which has increased the demand on public utilities. Though corporate entities are supported by a waste water treatment plant located on the SCLA's owned land, residential needs are met by a different source.

In 1972, the Clean Water Act was passed by congress in order to regulate the discharging of pollutants into water sources as well as to establish the quality standards for surface waters. In response to this Act, the Mojave Water Authority formed the Victor Valley Wastewater Reclamation Authority (VVWRA) in 1976 to provide wastewater treatment services for the Victor Valley Community. The VVWRA began operations in 1981at its main treatment facility in Victorville. That facility is now considered to be one of the largest publicly owned pieces of infrastructure in the High Desert of California.

Today, the VVWRA operates as both a Joint Powers Authority and a public agency within California. It provides wastewater treatment services to four member agencies – San Bernardino County Service Areas 42 (Oro Grande) and 64 (Spring Valley Lake), the Cities of Hesperia and Victorville, and the Town of Apple Valley. These four agencies each provide an elected or appointed leader to make up the VVWRA's Board of Commissioners. In total, the VVWRA covers a service area of 216 square miles with service extended to over 200,000 people. The main facility is located in Oro Grande, approximately 94 miles from Los Angeles.

At the start of its operational capabilities, the plant could provide tertiary treatment for up to 4.5 million gallons per day. Expansions to the plant over time have increased processing ability to 18 million gallons per day. In 2014, two new sub regional water recycling plants were approved for construction in Hesperia and Apple Valley. Each of these plants is designed to process one million gallons per day with the intended goal of freeing up potable water for consumption by making recycled water available for landscaping, irrigation, and construction.

3. FAILURE EVENT

In December of 2010, a series of storms battered southern California, southern Nevada, and more of the Southwest. Beginning on December 16th and continuing throughout the following week, heavy rains fell almost continuously while the Sierra Nevada Mountains sustained heavy snowfall. Between ten and twenty five inches of precipitation were estimated to have fallen in Southern California; Santa Barbara sustained 47% of its yearly average of precipitation. The following warm rain that fell in the mountains caused significant amounts of runoff water to also enter the Santa Margarita, San Diego, and Mojave Rivers. This water also caused mass flooding, a large amount of debris to be washed into the roads and water intake pipes, and severe property damage, prompting the Governor to call a state of emergency.

For the VVWRA, the damage sustained was severe. Several interceptors were damaged and sufficient amounts of sand debris were forced into the pipes causing blockage which snowballed into an overflow event. In total, an estimated 42 million gallons of wastewater was spilled into the Mojave River over a period of fifteen days. During testing to determine water quality for public consumption, two offline wells consistently tested positive for fecal coliform. Thirty-nine private wells were under threat of contamination as well; their owners were advised to have the water tested prior to consuming. The fecal bacteria were found more than five miles from the failure event. A temporary bypass line was set up while contractors worked to remove the damaged portion of the pipe and stem the flow of wastewater into the sand bed. Repairs were estimated to cost $15 million.

In 2012, the state of California and the VVWRA were able to come to an agreement about how much the fines for the spills would be. Originally, the state levied a $433 million fine on the plant for the seriousness of the spill and its extensive effect on the surrounding area. This amount, however, would have effectively shut the plant down as a private operator. After explanations of just how much effort the VVWRA's Board was putting into having the problem dealt within in as quick a time frame as possible and ensuring that such an event would not occur again in the future, as well as the thoroughness of their clean-up efforts, the final fine amount was significantly lowered. The fee would be paid to two separate entities – the State Water Resources Control Board's Cleanup and Abatement Account and a Supplement Environmental Project. Reserve funds were used by the VVWRA to make the payments.

4. DESIGN PROCESS

In June of 2013, the VVWRA adopted the 2013-14 budget, which included the approval for the Upper Narrows Pipeline Realignment project. This project intended to shift the location of the main interceptor from the Mojave River to a drilled line through Old Town Victorville. $16 million in funding was approved for the undertaking, the majority of which came from a Public Assistance Grant through the Federal Emergency Management Agency. The California Emergency Management Agency also contributed a considerable amount to the project, leaving the VVWRA to self-fund approximately 6.25% of the budget. In total, the project was expected to cost approximately $38 million.

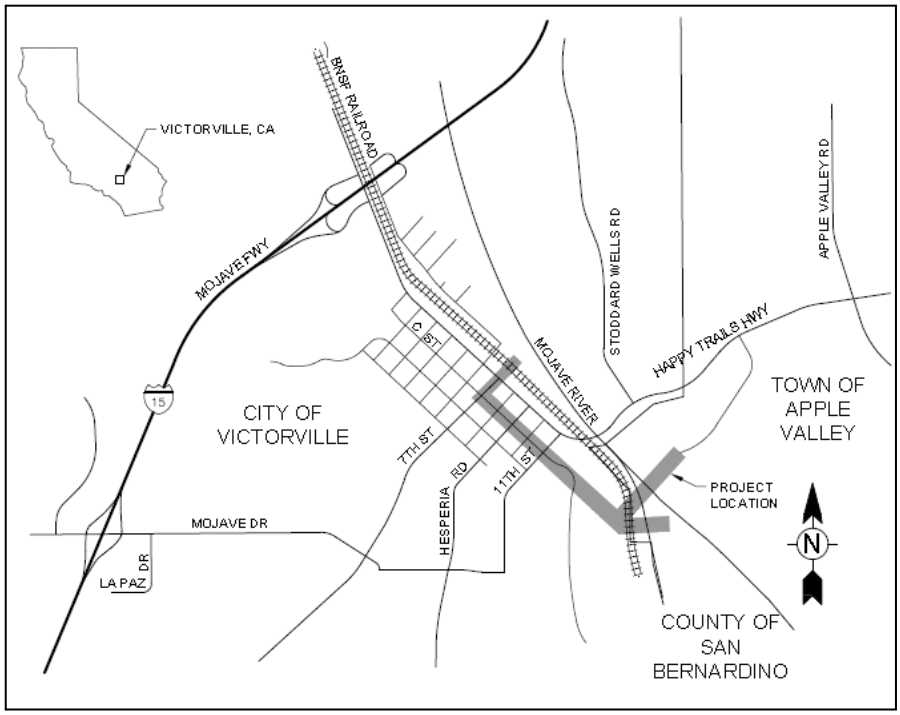

Figure 1. Map of the anticipated layout of the Upper Narrows Pipeline Replacement Project.

The Tetra Tech office of Irvine, CA was contracted to develop the plans for the wastewater main replacement. Tetra Tech was also instrumental in the VVWRA acquisition of additional FEMA funding for the project.

The design process for this project was extensive. Design production began in March of 2011 and it remained in the design phase until December of 2013. Over this period of time, a number of changes had to be made to the initial alignment of the pipe as more information on the geology of the project site was discovered. A geotechnical report was developed by Leighton Consulting, Inc. (LCI). Its findings made substantial alterations to the design of the project. During LCI's test bores, they located significant quantities of hydrocarbons present in the area that had originally been designated for the pipe's alignment. Their presence was accounted for through an ongoing fuel-

hydrocarbon remediation project. To prevent the contamination that these ground pollutants may have caused the alignment was altered to avoid the worst of the hydrocarbons.

This discovery did raise an interesting question of how to develop the project around the various locations of hydrocarbons found within the area. Their presence had been detected throughout most of the Narrows, and a top priority became finding ways to limit the public's exposure to them. It was from this hurdle that Tetra Tech was able to determine that a significant amount of the project was going to be installed by utilizing trenchless technologies.

By using drilling equipment at depths beyond what would be easily accessible by open trenching, the contractors would be able to install pipe in a manner that better minimized the release of ground contaminants and avoided such materials. It would also provide a more limited impact means of installation through the rock deposits found throughout the project that can make conventional excavation difficult. To lessen that difficulty, engineers began to design in horizontal directional drilling, microtunneling, and bore and jack portions of the project while limiting the amount of open trench installation to what was absolutely necessary.

In terms of the expectations of the owner, the VVWRA was open to piping material options, as long as they were suitable for the installation methods, met the standards of the Authority, and accounted for the potential growth of the area. They were, however, adamant that the piping had to be free from mechanical joints. This choice was made for both for the ease of installation that a smooth exterior allows and also so that waste material would not hang on or accumulate at joints or pipe discontinuities. For the portion of the project designated for horizontal directional drilling, some sort of fusible piping would be required.

In the design, both fusible polyvinylchloride pipe (FPVCP) and high density polyethylene (HDPE) pipe were allowed for the bundled horizontal directional drill section that was to extend approximately 1,750 within the south western corner of the Town of Apple, across the Mojave River. To offer an equivalent degree of load resistance, internal pressure capability, and flow area, both 16-inch FPVCP DR-18 and 20-inch HDPE DR-9 were included in the Bid Form as equals (See Figure 1). Contractors were required to designate which type of pipe they would be bidding at the time of submittal to ensure that the supplied pricing was definite and that there would not be any post-bid day substitutions.

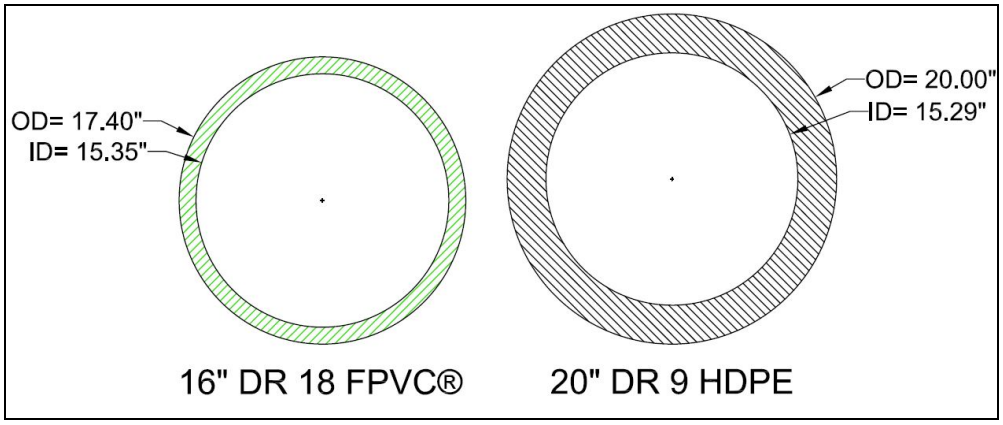

Figure 2. Comparison of 16-inch DR-18 FPVCP and 20-inch DR-9 HDPE IPS cross-sections.

In consideration of the challenging ground conditions, it was determined that steel casings would be required to provide stability to the entry and exit alignments for HDD. 80 foot lengths of steel piping were installed in both the entrance and exit pits. This was to ensure that the ground surrounding the drill would be adequately restrained from the installation, preventing any potential cave-ins or other such blockages during the installation process.

Also included in the design were short sections of open trench installed FPVCP to be used at each end of the drill to connect the new siphons to inlet and outlet manholes. (See Figure 3) These distances were not long enough to qualify for separate drills on their own, but the connections required too sharp a curve for the existing drill to safely negotiate, so it was decided that a short section of open cut would be used to connect to the siphon and allow for the necessary concrete encasement for the manhole.

Sections of the project were also determined encounter large rock deposits. For this reason, microtunneling was chosen for a nearly 2,700 foot installation that would involve crossing below a mountainous area. This was the longest single portion of the Upper Narrows Pipeline Replacement project and would require the most time and care to accomplish. For the section of the tunnel that was to go under the mountain, a Rock Tunnel Boring Machine was to be used. This machine is intended for use in areas that are continuous stretches of solid rock. The tunnel it created was to intercept another microtunnel from the other side of the formation.

The location of the project site, specifically the exit pit for the horizontal directional drilling portion and accompanying open trench connection to an existing interceptor and manhole, caused some alarm within the community. The trench was located in close proximity to the Academy of Academic Excellence/Lewis Center while the exit pit would need to be located on school grounds, which concerned some parents. In order to assuage the fears of the parents and general community, the school hosted a parent night with officials from the VVWRA also in attendance. During the meeting, the officials offered assurance that the distance between where the pumps and machinery would be and where the children were during the school day was far enough to ensure that they would be safe. Additionally, fencing and other such safety materials were used in the area to ensure that the work space was blocked off from public access.

Construction Method	Approximate Length of Sewer Line Interceptor Pipe (LF)	Description
Reach I-A – Underneath the Mojave River commencing at the Lewis Learning Center		
Open Trench	120	To connect to existing sewer at MH 4
HDD	1744	Reach I-A
Open Trench	53	To connect to Reach I-B and Reach II
Reach I-B – Underneath the BNSF Railroad at the Kemper Campbell Ranch		
Open Trench	159	To connect to Reach I-A and Reach II
Bore & Jack	106	Reach I-B
Open Trench	41	To connect to existing sewer between existing MH VV 5-8 and VV 5-9
Reach II – Through the Upper Narrows Formation from the Kemper Campbell Ranch to Downtown Victorville		
Tunnel	2664	Reach II
Open Trench	138	To connect to Reach I-A and Reach I-B
Reach III – Through Downtown Victorville, C St, 7th St, and D St.		
Open Trench	1066	Reach III
Reach IV – Underneath the BNSF Railroad		
Bore & Jack	143	Reach IV
Reach V – Through Private Lands		
Open Trench	195	To connect to existing sewer between existing MH 4-26 & 4-25

Figure 3. Summary of installations to be completed in the Upper Narrows Pipeline Replacement Project

As a quality control item, the full length of the pipe was required to pass a mandrel test. A mandrel test is conducted by pulling a mandrel – a circular piece of rigid material historically used for shaping glass and metal pipes into smooth, hollow curves – through the entire length of the pipe after installation and backfilling, but prior to pressure testing and paving (when necessary). For this particular project, deflection within the pipe was required to be at or below 3%. The test was required to ensure that the less-than-ideal ground conditions were not causing unexpected deflections in the pipe that may cause problems during use.

The project portion titled Upper Narrows Pipeline Replacement Project was advertised for bid on September 23, 2013. A mandatory pre-bid meeting was held on October 2nd and bids were initially intended to open on October

30th. However, over the following three months, questions and requests for clarifications from interested contractors, subcontractors, and vendors continued to help the development of the project which in turn continued to extend the bid date. In total, eight addenda were released to complete the adjustments needed to the project. The final documentation was released in December in preparation for a January, 2014 bid date.

5. CONSTRUCTION

The contract for the project was won by J.W. Fowler of Dalles, Oregon. The entirety of the horizontal directional drilling portion of the project was subcontracted out to The HDD Company out of Cameron Park, CA. During the bidding process, J.W. Fowler had designated FPVCP as their choice for the horizontal directional drill, a choice that The HDD Company was in agreement with. It was felt that the FPVCP would offer a better resistance to the hydrocarbons present in the area of construction as well as a more stable pulling option in such rocky and difficult terrain.

Figure 4. FPVCP lay down next to Lewis Center school grounds in preparation for pull back.

In the early stages of preparing the project for the initiation of directional drilling, The HDD Company requested permission to alter the project design by completing the boring process through two separate drills rather than one large bore hole and a bundled insertion. This request was made in an effort to decrease the difficulty and risk of keeping the bore hole open in the varying ground conditions. There were fears that the ground conditions would be too unstable to hold open such a large hole for the entire distance of the drill. Tetra Tech acquiesced to the request and the HDD design was modified into two parallel drills of 16-inch FPVCP and 24-inch bore holes rather than a bundled pull of two 16-inch pipe strings in a single 54-inch to 60-inch bore hole. Both drills required their own steel conductor casings to ensure that the entrance and exit holes would be suitable for the pulls; beyond that small alteration, there was nothing really changed by the decision to divide the drills.

Given the ground conditions that were found during the geotechnical report, the two drills went very well. There were no additional project delays faced by The HDD Company; they were able to follow the Tetra Tech design without any serious complications during either of the bores. The initial start date of the drill, however, did have to be moved from its planned commencement because the Mojave River is a resting place during an annual bird migration.

The bores were accomplished with an American Augers 440 drill rig. Prior to installing each pipe, the 80 foot lengths of steel casing pipe were positioned at the entrance and exits pits. The casings were hammered into place prior to drilling commencement. The pullback of the first pipe string was accomplished on October 21st and passed pressure testing on October 24th. The second pull back took place a month later; it was completed on Novermber 23rd and was successfully pressure tested on November 25th. The month long gap was caused by the need to move all of the machinery to the site of the second bore and to excavate and stabilize the new bore bits. During both pullbacks, the pipes were fully ballasted in order to lower expected pullback forces on the pipelines.

Since fusible piping develops an internal bead during the fusion process, the fusion technician used an internal debeading device to remove the internal bead. It is not possible to fully remove the evidence of the fusion from the pipe, so the inner diameter used for calculating the Mandrel testing requirements had to be adjusted slightly to compensate.

Once both pipes had passed pressure and Mandrel testing, the pipes were grouted into their steel casings to seal the ends of the installation.

6. CONCLUSION

Though the geology of the project was difficult, the design by Tetra Tech yielded a horizontal directional drilling project well suited to the ground conditions of the area and the driller encountered next to no problems during the HDD installation process. By splitting the drill plan into two separate sections rather than force one very large drill, a considerable amount of money and risk was saved on the project. This installation should allow VVWRA and the area a much greater degree of peace of mind over their wastewater infrastructure.

Horizontal Directional Drilling can be an excellent tool in the arsenal of a designer or owner. It can be used for the installation of very long pipe strings, such as that required by the Upper Narrows Pipeline Replacement Project, while also being used for much shorter shots, such as for creek or street crossings. By nature, the majority of the installation occurs below the surface, so the impacts to residents are minimized. It also allows for a less destructive installation in areas that have a delicate ecosystem; the Mojave River, already having been disrupted by the failure event during the storm four years earlier, was not affected by this installation.

The VVWRA is hopeful that the Upper Narrows Pipeline Replacement Project will be completed in December of 2015. The microtunneling portion, expected to be the most difficult due to the need to tunnel through rock deposits, has been completed, along with the HDD siphon installation.