3RD TIME'S THE CHARM: SOUTH TAHOE HDD SUCCESS SOFTENS BAD MEMORIES OF PREVIOUS FAILURES

Jack Burnam P.E., Project Manager – Carollo Engineers
Kimberlie Staheli P.E., Principal – Bennett/Staheli Engineers
Richard Solbrig Assistant Manager/Engineer – South Tahoe Public Utility District
Jim Hoggatt Construction Manager – South Tahoe Public Utility District

ABSTRACT

The South Tahoe Public Utility District (District) owns and operates a mechanically complex, high-pressure, wastewater reclamation system in one of the most environmentally sensitive and highly regulated regions in the world. A new pipeline traversing an environmentally sensitive meadow and Trout Creek was needed. Horizontal directional drilling (HDD) was chosen as the best method to install the 1,200 feet of 30-inch ID steel force main. However, making the District comfortable with trenchless technology was challenging because they experienced significant problems with the use of HDD on two previous projects.

This paper details the proactive steps that were taken to ease the utility's concerns and ensure the success of horizontal directional drilling. These steps included the use of a specialty sub-consultant, pre-qualification of HDD contractors, strategically planned geotechnical investigations, and monitoring drilling fluid pressures to prevent inadvertent returns. The single 1,200-foot HDD bore was successfully completed during the summer of 2000.

Keywords: horizontal directional drilling, inadvertent returns, HDD design, HDD construction management, HDD monitoring, downhole pressure.

INTRODUCTION

The South Tahoe Public Utility District owns and operates a mechanically complex, high-pressure, wastewater reclamation system in one of the most environmentally sensitive and highly regulated regions in the world. A new pipeline traversing an environmentally sensitive meadow and associated Trout Creek was needed. Horizontal Directional Drilling (HDD) was chosen as the best method to install the 1,200 feet of 30-incyh ID steel force main. However, this decision was not made lightly. The District had experienced significant problems with the use of HDD to install much smaller force mains on two previous projects. Problems included hydrofracture under a busy highway, leaving slick drilling mud on the asphalt surface, freezing a pipe during pullback under a creek and, poor contractor drilling methods that extending projects well beyond anticipated completion.

PROJECT DEVELOPMENT

Through project development was the key factor in the success of the horizontal directional drilling in South Lake Tahoe. The following steps were taken during the development of the project to provide the District with a successful project**.**

Specialty Sub-consultant

One of the key factors to completing a successful project is “doing your homework.” Not completing this vital first step results in:

1. Project specifications that don’t accurately reflect the work to be done,
2. Inexperienced HDD contractors bidding on the project, and
3. Experienced contractors not bidding the project, due to a lack of information or vague project requirements.

The District felt that many of the problems experienced on their past HDD projects were due to this aspect of project development. Thus, it was decided to include a specialty subconsultant on the project team to assist in the development of project specific HDD plans and specifications. In this case, Bennett/Staheli Engineers was hired to work with Carollo Engineers to compete the design of the project. Corollo Engineers was intimately familiar with the needs and sensitivities of the District; Bennett/Staheli brought large-diameter HDD experience to the team. This project was to occur under the “fishbowl” eye of every regulatory agency with authority in the Tahoe Basin. The formation of a specialty team increased the likelihood of a successful project.

Pipe Materials

The first decision to be made was the identification of the required pipe material. The choice of pipe affected the following:

1. Minimum curve radius,
2. Internal pressure ratings,
3. Load ratings,
4. Pull strength (or pull forces that could be safely applied to the pipe), and
5. Requirements for lining and coating the new pipe being installed.

In this case, the internal working pressure of 250 pounds per square inch (psi) essentially dictated the choice of steel. However, it was pull forces that dictated the

Figure 1 Welded and Coated Pipe String on Barbara Avenue

required thickness of the steel pipe walls not the internal working pressures. A 3/8-inch wall thickness was needed to accommodate an internal 250 psi working pressure. However, anticipated pulling forces required a wall thickness of 1/2 inch. Lining and coating was also an important consideration. The type of lining and coating had to be flexible and well bonded to the steel pipe to withstand the bending and flexing of the pipe as it was pulled into place. In this case, fusion- bonded epoxy was used to line and coat the steel pipe. The pipe was delivered to the site lined and coated with fusion- bonded epoxy to within 6 inches of each end. After the ends of each pipe section were squared and welded together, the inside and outside were sandblasted to remove weld slag and the exposed pipe brought back to “near white” condition prior to field applying the fusion bonded epoxy at the joints.

Staging Areas

The locations of staging areas for pipe layout (“stringing”), preparation (welding, lining and coating), and HDD machine setup were identified early in development. These items contributed to the choice of the alignment for the new pipe. For this project, 1,400 lineal feet of layout room was needed in an area that could be isolated for approximately 8 weeks. This allowed for pipe delivery, layout, face up, welding, lining, coating and pull back. An area of approximately 200 feet square (for HDD setup and operation at the other end of the directional drilling operation) was needed for the same period. These requirements were accomplished by working with the City of South Lake Tahoe to close Barbara Avenue for the duration of the installation project. This provided the required room for pipe layout and provided some additional room for overall project staging. The main access road into the District’s Wastewater Treatment Plant was also closed for HDD equipment set up and operation. A secondary road was opened to allow the public access to the District offices for paying bills, etc.

Geotechnical Exploration

Trout Creek and the associated meadow are environmentally sensitive, making the task of obtaining geological information in this highly regulated area difficult. Several meetings were held with regulating agencies to obtain permits for test borings. Negotiations with the regulatory agencies resulted in permission for four borings in the meadow. The District, the geologist, the regulating agency, and Carollo Engineers strategically located the borings to obtain the maximum amount of subsurface information at key points along the alignment. A special drill rig was used with oversized tires to maximize weight distribution on the meadow. In addition, ground mats were laid ahead of the drill rig for traveling in the meadow. Bores were extended at least 20 feet below the anticipated depth of the HDD to allow for some flexibility in choosing the final alignment, in the event that unexpected obstacles were encountered. The results of the geotechnical exploration showed subsurface soils to be extremely dense glaciated sand, overlain by loose to medium-dense silt and sand.

Plan Development

Contract drawings were developed showing the proposed path of the HDD pipeline in plan and profile views. Geotechnical boring data was overlaid on the profile view to provide the HDD contractor with a geotechnical interpretation of the soil layers that would be encountered during drilling. (Figure 3, Plan Sheet showing reach of HDD project)

Specifications

Detailed HDD specifications were developed for this project that identified the requirements of the project and the minimum qualifications of the HDD contractor. This was a complex project that involved unusual risks. The project required a HDD contractor with experience in pulling large diameter (30 inch diameter) steel pipe approximately 1,200 lineal feet in a single pull. The specifications also required:

1. the use of downhole pressure sensors to monitor drilling pressures at the drill head,
2. piezometers located along the drill path to monitor elevated groundwater pressures due to the drilling process,
3. Contingency plans for handling hydrofracture (should it occur) or other common problems,
4. HDD pipe to be used in the project (pipe materials, lining and coating),
5. Required drilling monitoring procedures, and
6. Calculations performed by the Contractor identifying maximum and minimum drilling fluid pressures and pipe stresses anticipated during the installation.

Prequalification of HDD Contractors

Work within the Tahoe Basin is under close scrutiny by many regulatory agencies. The District had experienced two previous HDD projects that were problematic and were very concerned about the HDD contractor that would be used on this project. Therefore, it was decided to develop and complete a process to prequalify HDD contractors. The prequalification package included the HDD specifications and soils report developed for this project and was advertised in trenchless trade magazines and sent directly to HDD contractors known to the District or specialty subconsultant. The most emphasis was placed on the HDD contractor's experience in installation of large diameter pipelines for distances comparable to the project length. Approximately 30 prequalification packages were sent to HDD contractors. Six HDD contractors were chosen for inclusion in this project including: ARB, Inc.; Horizontal Drilling International, Inc.; Michaels Pipeline Construction, Inc.; Cherrington Corporation; Smit Land & Marine, Inc.; and Piute Directional Drilling. These HDD contractors were listed in the bid package for this project as the only acceptable HDD contractors that could be used for this part of the project.

CONSTRUCTION OF THE PIPELINE

Cherrington corporation was the HDD sub-contractor for the construction of the pipeline. They used a drilling rig manufactured by Cherrington with a 200,000 pound pull back capacity. A TruTracker downhole tracking system was used to determine the location of the drill head during drilling. The TruTracker coil was laid on the surface on both sides of Trout Creek and the position of the coil was surveyed and entered into the computerized tracking system. The construction of the pipeline began on July 29, 2000 and was completed on August 17, 2000.

Specialty Monitoring

Prior to the commencement of HDD operations, two standpipe peizometers were installed in the meadow along the proposed alignment. The screened sections of the peizometers were located 5 to 10 feet above the planned bore and were located on the drill rig side of Trout Creek. The function of the peizometers was to provide an early indication of elevated down-hole drilling fluid pressures that could result in hydrofracture. As the drill passed beneath each peizometers, careful, continuous readings were taken to evaluate the effect of the down-hole mud pressure on the water table. If the water table were to raise a significant amount, drilling operations and fluid pressures could be adjusted prior to allowing drilling mud to escape in the meadow.

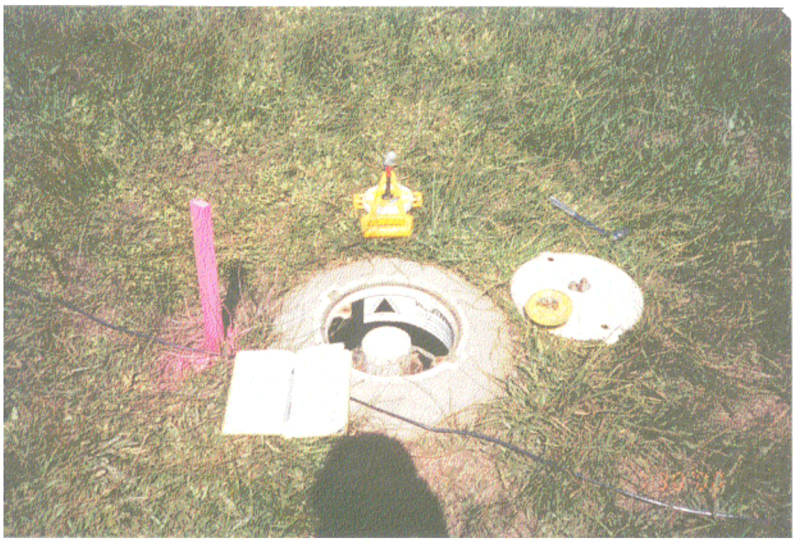

Figure 2 Peizometers for measuring groundwater levels as the drill passes below

Pilot Bore—The First Time

The pilot bore began on July 29, 2000. An 8-1/2 inch tri-cone bit with 2 jet nozzles was used as the cutting tool. On the first day of drilling, the contractor installed 6 drill pipes or approximately 180 feet of the 1,200 foot pilot bore. During drilling of the 6th drill pipe, the drill head encountered the hard, dense sand layer and had difficulty penetrating the formation. On July 30th, Cherrington installed drill pipe 7 through 17; however, the hard ground resulted in steering problems and the contractor had to re-drill each pipe for position. Some drill

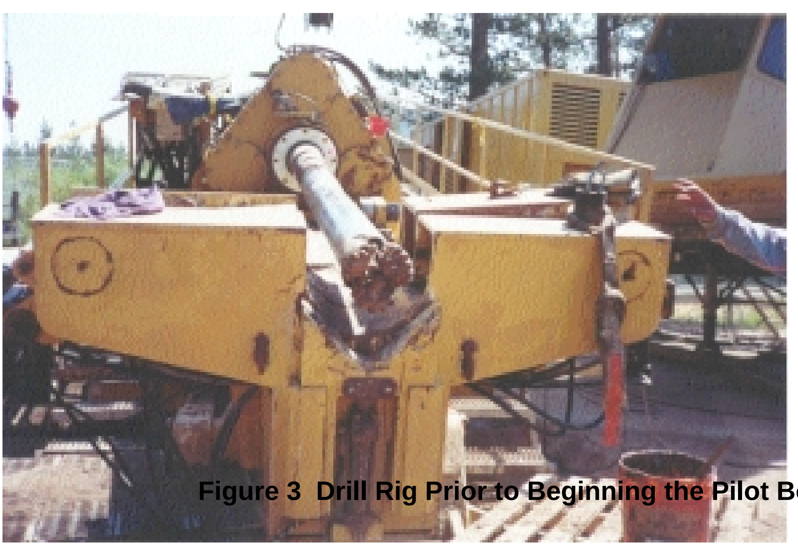

Figure 3 Drill Rig Prior to Beginning the Pilot Bore

pipes were re-drilled as many as seven times before the next pipe was attached in the string. The water table did not increase as the pilot bore passed beneath the peizometers, indicating that the down-hole mud pressure was not in danger of causing hydro-fracture. As a result, the District was comfortable with letting the contractor pass beneath Trout Creek without modifying any drilling practices.

On July 31st Cherrington decided to remove the drill rods from the excavated pilot bore and change the cutter bit to improve steering reaction. The 8-1/2 inch, 2 nozzle tri-cone cutter was replaced with a 7-7/8 inch tri-cone bit with only one nozzle for fluid assisted cutting.

Pilot Bore – The Second Time

The contractor resumed drilling by noon on the 31st, after tripping out the drill pipes and changing the cutting tool. They began drilling in native soil and drilled through pipe 18 or approximately 540 feet into the bore.

On August 1st, drill pipes 19 through 23 were installed. Drilling was slow as because the contractor would stop at 10-foot intervals to check the TruTracker for the location of the drill head. On August 2nd, drill pipes 24 through 27 were drilled when the TruTracker was showing an error. The contractor decided to shut down operations to re-survey the location of the TruTracker cable on the surface. Approximately one full day was spent re-surveying the cable and entering the new location data into the TruTracker system.

Drilling resumed on August 3rd when drill pipes 28 through 30 were installed, taking the pilot bore to approximately 900 feet. On August 4th pipes 30 through 32 were drilled when a powerful thunderstorm entered the Tahoe Basin. The storm included torrential down-pours, heavy hail, and powerful lightning strikes. Lightning hit the ground in close proximity to the bore and the electrical current burned up the down-hole steering tool. By the end of the day Cherrington decided to trip out all of the drilling pipes and replace the damaged steering tool. Commendably, the contractor had a new steering tool flown to Reno, allowing replacement of the tool, re-threading the pilot bore, and resumed drilling within a 24-hour period.

Pilot Bore – The Final Time

On August 5th, drilling resumed by 3 pm and the pilot bore was completed on drill pipe 38. Circulation was lost during drill pipe 33. Drilling fluid had escaped to the surface when the drill head was within 10 feet of the surface, five drill pipes from the hole-out location. The contractor was able to quickly contain the frac-out and built a small pit from which the drilling mud was pumped to a tanker truck and hauled back to the mud plant.

The drill missed the exit location by approximately 40 feet from the planned exit location. This exit location was not acceptable to the District and they made the contractor take the necessary steps to exit at the proper location. The contractor elected to pull back 8 drill pipes or 240 feet and re-drill. On the second attempt, the contractor hit the exit location within a foot and the pilot bore was completed.

Reaming

Cherrington chose to enlarge the pilot bore to the full 42-inch diameter in a single reaming pass. They chose to forward ream from the rig to the exit location with a fluid assisted fly-cutter reamer. The reaming was completed in 7 working days. The mud handling capabilities of the mud plant limited the progress of the reaming operations. Due to the large volume of silt and extremely fine sand, the under-sized mud plant was not able to efficiently clean the spoils from the drilling mud. It was common practice to drill for 15 minutes and then stop drilling to clean mud for well over an hour.

Figure 4 Fly cutter prior to the forward reaming

During the forward reaming pass, the down-hole mud pressures were higher than during the drilling of the pilot bore, as indicated by the increase in pressure noted at the peizometers locations. The water table rose 6 inches when the reamer was over 100 feet away from the peizometers along the bore path. As a result the contractor slowed the drilling operations and lowered the overall drilling mud pressure as they were crossing Trout Creek to guard against the possibility of drilling mud escaping into the creek.

After the forward reaming pass, a barrel reamer was used to back-ream and swab the borehole.
The barrel reamer's main function was to compact the soil on the periphery of the borehole to stabilize the hole prior to pull-back of the product pipe. Barrel reaming took place in a single day and was completed on August 16, 2000.

Figure 5 Beginning the barrel ream

Pull-Back

Pull-back operations began on August 17^{th}. Large capacity cranes were mobilized to the site to lift the 30-inch pipe to facilitate pulling the pipe into the hole without overstressing the pipe string. Pull-back operations were started at 1:40 pm and the full 1,200-foot pull was completed at 6:10 pm. Pull-back forces peaked at 168,000 pounds. Interestingly, on the last pull, the contractor had difficulty removing the reaming assembly from the pipe string. This was largely due to the high torque that was applied to the string during the pullback operations. It took the contractor 45 minutes to remove the reamer. After removing the reamer, they attempted to pull the pipe string the final 40 feet. However, due to the delay, the pipe froze in the ground. Although they applied the full 200,000 pounds of available force, the contractor was not able to move the pipe again. As a result the tie-in location was adjusted at the completion of the project.

Figure 6 Pipe pull-back

CONCLUSION

The pressure pipeline was installed without a serious incident of hydrofracture and the alignment was maintained within acceptable limits. While each project is specific to the individual installation to be undertaken, the methods used on this project and the lessons learned can be used to increase the success rate of future projects. The lessons include:

1. Beginning the pre-design of the HDD work early in the planning process, including horizontal and vertical alignment layout is invaluable.
2. Prequalification of HDD contractors for difficult projects provides the client with some assurance that the project will be constructed properly and sets the stage for a successful project.
3. Closely monitoring drilling performance and operating drilling fluid pressures can reduce the risk of hydrofracture/inadvertent fluid returns.
4. Full time inspection by experienced HDD personnel can help to avoid problems and claim situations.
5. Problems can be detected at an early stage of drilling if the inspector has a relative idea of the expected construction parameters. For example, the inspector should

know expected pull forces, mud volumes, pumping capacities, etc., prior to the commencement of drilling.