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Horizontal Directional Drilling Experience in Difficult Conditions

Case Studies for Directed Technologies Drilling, Inc.

Each horizontal drilling project is unique, with its own set of challenges. Sometimes these challenges relate to logistics, such as site layout or accessibility. Other sites may present challenges related to a difficult bore profile or infrastructure that complicates navigation. Still others required careful planning and preparation to work within strict administrative rules or regulations. Finally, and generally most significantly, some sites pose challenges imposed by the geology or lithology of the formations to be drilled. Each site has the potential to present a combination of these challenges, particularly those associated with geological conditions.

Directed Technologies Drilling Inc. (DTD) has successfully completed numerous projects in difficult-to-drill soil and rock formations, and is confident of our abilities to surmount the challenges posed by difficult drilling conditions. This document presents brief descriptions of several projects completed by DTD, with drilling conditions that required ingenuity, skill, and experience to overcome.

The following projects are discussed:

- Hanford utility conduit, Richland, WA
- Slope drain, Metaline Falls, WA
- Water supply project, Palomar, CA
- Blind injection wells, Camp Bullis (San Antonio), TX
- Wetlands mitigation water supply, Logan Town Center, Altoona, PA
- CO^2 injection well, Montana State University, Bozeman, MT

Hanford Utility Conduit, Richland, WA

In 2008, DTD completed a project to install two utility conduits under a road, across a graded area and beneath a cobble-filled containment berm at the Department of Energy's Hanford Reservation in eastern Washington.

As seen from the photographs, the project presented a significant drilling challenge, due to the high percentage of large gravel to cobble sized material, in a sparsely supported sand matrix. The borehole path penetrated through the densely imbricate cobble formation seen in the lower half of the photo left. DTD used our Vermeer 24x40 drill rig with a drill head designed for directional drilling in gravel and cobble. As expected, the cobbly soil presented difficulties in steering, borehole advancement, and borehole stability. Despite these challenges, the DTD crew completed the borehole on schedule, surprising client representatives who did not anticipate a rapid project completion.

Successful completion of this project demonstrated that high-energy alluvial deposits (Missoula Flood) at Hanford can be drilled using horizontal directional drilling technologies, a concept that was previously in doubt. As a result, Directed Technologies Drilling has been invited to several technology demonstrations at the site, and HDD technologies are being strongly considered for several high-profile projects for site remediation at contaminated areas at Hanford.

Slope Drain, Metaline Falls, WA

DTD was contracted to provide drilling consultation and management for the installation of a slope drain at Metaline Falls, Washington for a Portland cement manufacturing plant. The project required installation of a 780 foot drain in alluvial sands and gravels. DTD teamed with another HDD company, who supplied a drill crew and a larger drill rig than DTD had in inventory, while DTD managed the drilling operations and well installation. Since then, DTD has hired the project driller and acquired an upgraded version of the same drill rig.

The drilling challenge for this project stemmed from the extreme heterogeneity of the alluvial deposits. The first several hundred feet of the bore were in soft sand – so soft, in fact, that the weight of the drill rods initially caused the drillhead to dive below the bore profile. By changing to a drill head designed for these extreme soft conditions, the borehole was advanced to the next soil material, a dense cobble zone. In order to penetrate this zone, the drillhead had to be changed again. This required that the soft sand zone be cased prior to withdrawing the drill string, to ensure that the borehole could be reoccupied when the new bit was advanced to the cobble zone. This was accomplished by washing the casing in over the drill rods (photo left). After advancing the casing and changing the drill bit, the cobble zone was then drilled without incident, and the boring continued through firmer sand and silt to completion. The drain was then cased with a slotted screen to complete the installation.

This project demonstrated the necessity to deal with changing conditions in the field, and have the knowledge and experience to employ appropriate tooling and techniques when conditions dictate.

Water Supply Project, Palomar, CA

Except in the oil and gas industry, horizontal directional drilling is not often considered as a technique compatible with bedrock drilling. However, with the appropriate equipment, tooling, and techniques, horizontal wells can be installed in hard rock.

The Palomar project provides an example of how DTD applies a variety of technologies to accomplish the project. The project required installation of three, 300 foot water supply wells in a fractured granite bedrock formation. Conventional, utilitiy-focused drilling tools would not penetrate this hard rock, so DTD selected pneumatic percussion drilling tools with a downhole hammer to advance the borehole.

When the drilling air was lost in the formation at a depth of 100 feet, DTD grouted the hole to seal off the fractures responsible for the air loss to restore air circulation and drill cuttings removal. The crew then continued to finish the borehole and install the well screen within the non-grouted interval.

Key lessons from this project were the adaptation of non-standard HDD drilling methods to complete a horizontal boring, and successfully selecting and applying proven methods to regain circulation. The project confirmed another important point for drilling in unstable formations – when the drilling tools failed to advance at one point, the team was forced to drill in reverse to back their way out of the borehole. Had they selected tooling that could be trapped in the hole, due to shifting rock (or, in an alluvial material, a shifting boulder) the only recourse would have been to abandon the tooling in the hole and start a new one.

Blind Injection Wells, Camp Bullis (San Antonio), TX

DTD installed five horizontal fluid injection wells, ranging from 240 to 350 feet in length at Camp Bullis, TX. The wells were installed beneath disposal trenches at a munitions landfill, in the Glen Rose Limestone. Drilling was complicated by the fact that the limestone was fractured, with loss of circulation being a potential issue.

Since the drilling conditions were not well-known, DTD mobilized to the site with a several types of equipment available to advance the borehole, from conventional boring bits to a down-hole mud motor. The drilling was accomplished with a geologic boring bit to advance each bore through the curved entry profile; the straight sections of the well after the entry were bored with a tri cone bit mounted on a bent (2 degree) sub. Drilling rates through the limestone were slow, but sustainable. During the drilling process, the crew kept close attention on drilling fluid consumption and return, to assure that cuttings were removed from the bore and that no excessive mud loss was occurring.

The wells were completed with 2 inch diameter fiberglass reinforced epoxy casings and screens. This material was selected for its overall strength, resistance to chemicals, and value (compared to stainless steel). The wells were successfully put into operation for the injection of reducing chemicals beneath the landfill to reduce chemicals that had been applied at the surface to neutralize chemical weapons in the landfill.

Wetland Mitigation Water Supply, Logan Town Center, Altoona, PA

One of the more difficult drilling projects completed by DTD, on the basis of geological challenge, was the installation of two wells, of only 100 foot length each, in Pennsylvania. The drilling was completed in what was essentially a talus slope of extremely hard quartzite cobbles and boulders with a compressive strength in the vicinity of 40,000 psi. The wells supply water to maintain a wetland, required for mitigation in the development of the shopping center.

The drilling was accomplished with traditional horizontal/rotary drilling methods, with particular attention focused on the drill tooling. A Tri-Hawk drill head was selected and used for the drilling operation. Due to the unstable, difficult drilling conditions presented by the cobbles, it was necessary to drive steel casing to an intermediate depth of approximately 30 feet and then continue the boring to the total depth. PVC pipe was then inserted to the total depth of each well.

CO^2 Injection Well, Montana State University, Bozeman, MT

DTD was contracted to install a well for CO^2 injection for a sequestering test facility at an MSU site in Bozeman, MT. The project presented challenges from both a geological standpoint and a logistical/operational perspective. The formation drilled contained 4-10” cobbles at the target depth of eight feet (see test pit photo, right) The drilling was performed in the winter, with daytime temperatures around -15°F, which presented additional needs to prevent pumps and water lines from freezing, and other arctic engine operational issues.

DTD managed the drilling and well installation, with a drill rig and crew provided by a subcontractor. Since the time of this project, DTD has acquired several large drill rigs of our own, and would complete the work with in-house equipment. The bore was drilled to a length of approximately 320 feet. At this shallow depth, the combination of cobbles and lack of confining pressure tended to push the drill head upwards from the design profile. This is a fairly common occurrence in drilling conditions of this sort, and should be anticipated when designing the bore profile and choosing drilling tools, drilling rates, and downthrust and mud pressures.

The well was successfully completed with approximately 220 feet of 4-inch diameter stainless steel screen.