Complex dewatering project at mixed-use development

Digging deeper to accommodate underground parking in a large, mixed-use development project in Boulder, Colorado, United States (US), requires the use of deepwell dewatering wells, portable sump wells, and groundwater treatment. TerraFirma Earth Technologies' President David Giles explains how the construction dewatering and groundwater control project was carried out.

TerraFirma Earth Technologies completed the installation of temporary dewatering and groundwater treatment systems for Revé – a highly anticipated mixed-use development community in Boulder, Colorado. Located across from the new Google complex, the project was started in 2015 with projected occupancy in January and February 2021.

Southern Land Company's first development in the Boulder market, the Revé community will offer multiple home sizes and styles including micro, studio, efficiency, as well as one-, two-, and three-bedroom, town home, and live/work residences. The plan contains 244 residences, approximately 7,470 square meters (m^2) (24,500 square feet) of retail space, 33,130 m^2 (108,700 square feet) of office space, and ample green space and bike paths.

With the dewatering system up and running, the excavation of both the north and south parcels successfully reached its target subgrade of 8 m or 26 feet (ft). below ground surface, despite having to perform the work throughout Boulder's swinter months.

The estimated eight-month-long maintenance and operation phase of the dewatering was completed in Summer 2019; however, TerraFirma's groundwater treatment/filtration equipment will remain in place through November 2019, at which time the permanent filtration equipment is anticipated to be brought online.

Winter temperatures required constant monitoring of the deepwells. TerraFirma provided a technician who monitored the wells 24/7, either remotely with camera images every 15 minutes, or on the site for the winter months to be certain the low nighttime temperatures didn't freeze the pipes and disable the pumps. According to Southern Land Project Manager Jonathan Harel, TerraFirma crews also kept concrete blankets over the main that connected the wells and added heat trace to be sure nothing froze.

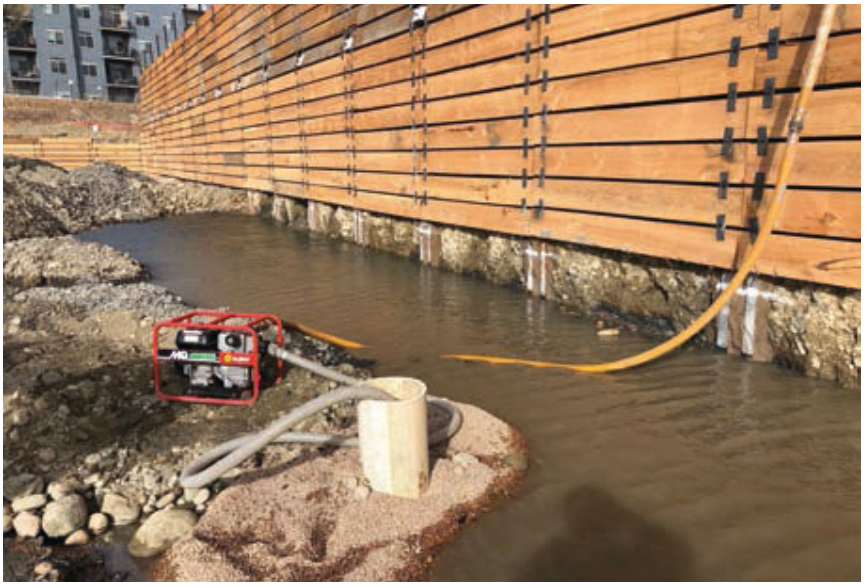
Why so deep?

As available lands become scarcer, underground parking becomes more and more appealing, especially in growing urban areas like Boulder. Additionally, city planners and developers desire to maintain views and not block sunlight, which are more advantages of underground parking. For these reasons, Southern Land Company chose to build two levels of subterranean parking beneath the entire development.

Digging deeper, however, can be a difficult and costly task if not properly planned out. One of the most important considerations, especially for excavations extending below the groundwater table, is effective control and lowering of the groundwater prior to excavation. This process is known in the construction industry as dewatering. For site dewatering, Southern Land turned to the US company TerraFirma Earth Technologies, a Houston-based dewatering company with offices in Denver.

The high water table, located just 3 m (10 ft) below ground surface, along with complex geological conditions at the Revé site, created special challenges for TerraFirma, with important cost considerations for the developer.

"The site of Revé is situated over 2 to 11 ft (0.6 to 3.4 m) of man-placed fill, underlain by water bearing, naturally occurring sand, gravel, cobbles, and even some boulders," says TerraFirma Superintendent Bairn Leonard. "Making dewatering even more of a challenge, bedrock was encountered between 12 to 28 ft (3.7 to 8.6 m) below ground surface. With a planned excavation extending to approximately 26 ft (8 m) below ground surface – well below the top of bedrock – meant lowering the water table to the top of the confining layer. Committed to having the two parking levels below ground, we proposed multiple possible dewatering methods for the developer to deliberate over. These were supported by the geotechnical engineering report conducted by Terracon and the Groundwater Characterization Study by Ayres Associates."



What a difference a day makes. Dewatering Revé's south excavation using filtered portable sump well installation. Photo by David Giles, TerraFirma Earth Technologies, February 2019.

Deepwell dewatering wells

With the excavation extending well beyond the limits of a traditional vacuum wellpoint dewatering system, and the anticipated flow rates exceeding that of an ejector-well dewatering system, TerraFirma chose to rely on closely spaced, large-diameter deepwell dewatering wells as the primary means of controlling the groundwater. The deepwell dewatering wells were installed from ground surface, just outside the excavation's h-pile (a structural beam usually made of steel) and wood-lagging support system. With the perimeter of both the south and north parcel excavations exceeding 610 m (2,000 linear ft), a total of 52 deepwell dewatering wells were installed.

To install the wells, TerraFirma used a Soilmec 312 hydraulic drilling rig to advance the 9.15 m (30 ft) diameter borehole to the designed termination depth of 9.75 m (32 ft), easily excavating the extensive layer of sand, gravel, cobbles, and boulders.

"Additionally, by utilizing the powerful Solimec 312, we were able to easily penetrate nearly 10 ft (3 m) into the underlaying bedrock, creating a sump- effect along the entire excavation footprint, which allowed us to draw down the water further – closer to the bedrock-alluvial interface," explains Leonard.

Portable sump wells supplement traditional deepwell dewatering wells

TerraFirma's dewater plan also included the installation of strategically placed portable sump wells within the excavation to supplement the deepwell dewatering wells. These were a very necessary component due to the excavation extending below the bedrock-alluvium interface, according to Leonard. The portable sump wells were used to handle perched and trapped groundwater within the excavation, as the excavation encroached upon the bedrock-alluvial interface. Each portable sump can consisted of a 3.7-m (12-ft) diameter by 3.1 m (10 ft) long, SCH 40 polyvinyl chloride (PVC), factory slotted well screen. Each sump can was fitted with an electrically driven, submersible, dewatering pump assembly. The sump wells were drilled in from the top of bedrock, extending approximately 3.1 m (10 ft) deep. The sump well was then surrounded with a select filterial material.

Leonard explains, "Selecting the proper filter material and placement method was very important. By pre-filtering the groundwater prior to collecting it in the common discharge manifold and ultimately through groundwater treatment-filtration equipment installed at ground surface, additional costly treatment measures were avoided by preventing premature clogging and fouling of the treatment equipment. Each sump pump was also fitted with a liquid-level control device that turned the pump on and off, based on the water level within the sump – preventing the pumps from running dry and causing premature pump failure."

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According to Harel, during constant monitoring of the water contaminant filtration, the limits were occasionally exceeded and TerraFirma always presented multiple options for resolving the issue, which ultimately created trust among all stakeholders involved.

Water treated prior to discharge

From the deepwells, the groundwater was directed to Boulder's left-hand ditch, directly adjacent to the site. However, as is true of many construction sites along Denver's front range, the preliminary geotechnical and environmental sampling reports revealed groundwater that was contaminated.

"To deal with the contaminated groundwater, we teamed up with United Rentals Fluid Solutions Group," says Leonard. "Their extensive experience in the Boulder area and knowledge of its groundwater chemistry, as well as their working relationship with the various regulatory agencies involved, has proven invaluable."

Following the approval of the Remedial Discharging Permit Surface Water Permit from the Colorado Department of Public Health and Environment (CDPHE), United Rentals Fluid SolutionsCorp, in close conjunction with TerraFirma, developed a Remedial Activities Management Plan to reduce the pollutants of concern to below the limits set forth in the permit issued by the CDPHE.

James Weeks, filtration productline manager for United Rentals Fluid Solutions Corp. said, "The variety of hydrogeologic and environmental conditions in the Denver area and associated Rocky Mountain Front Range offer a number of groundwater treatment challenges to meet strict Colorado surface water discharge requirements."

Their groundwater treatment plan included the introduction of a of sodium hypochlorite into the dewatering influent water to oxidize the metals Iron (Fe), and Manganese (Mg). Caustic acid was also dripped into the tanks as a means of controlling pH, and further promoting the oxidation of the metals. These reactions took place in two 79,500-liter (21,000-gallon) flocculation tanks. From the flocculation tank, the water was pumped through two 12-unit bag filtration pods to capture the flocculated metals. Granular activated carbon was added to the treatment train to remove any

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