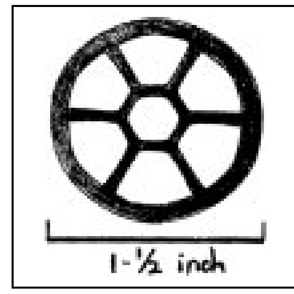
FEATURE

Installing Continuous Multi-Chamber Tubing Using Sonic Drilling

Attention, geologists and environmental drillers: This innovation can provide up to seven isolated screen intervals for ground water sampling.

by Michael Lewis, R.G.



Continuous multi-chamber tubing.

As a geologist, core is the first thing that comes to mind when talking about sonic drilling—continuous, near complete core recovery through almost any lithology. Sand to silt transitions can be logged on a centimeter scale if desired. Geologic contacts can be mapped with accuracy of less than one foot. In an environmental ground water assessment, it seems an awful shame to collect (and pay for) all of that detailed lithologic information, only to slam a continuous length of PVC screen through the saturated interval. Hours and hours of logging, discerning grain size, grading, clast type, etc., only to lump it all into one ground water sample.

Unlike continuous coring with hollow-stem auger, the core recovery is relatively undeformed and rarely incomplete.

Continuous Multi-Chamber Tubing™ (CMT, patent pending) complements sonic drilling by providing up to seven isolated screen intervals for ground water sampling. Not only can seven ground water zones be screened for sampling, but the geologist also can select the perforations after the geologic log is complete. I recently had an opportunity to observe ResonantSonic® International drill a 200-foot boring using a truck-mounted, sonic drilling rig and install a CMT well. The CMT monitoring well was drilled as part of an MTBE (methyl *tert*-butyl ether) investigation ongoing in Orange County, California.

Why CMT?

The need for multiple well completions in a single borehole usually occurs in a layer-cake scenario where a shallow, unconfined aquifer may be separated from an underlying confined aquifer by a competent clay layer. A nested well may be completed with a casing for the upper unit and a separate casing for the lower water-bearing unit. A conduit must be installed or a drive casing drilling method used to minimize the potential cross contamination between ground water units.

Pathways for contaminant migration are now being considered more complicated than simple layer-cake, laminar flow, which can be represented by arrows which point down-gradient on a map. Some contaminants are denser than water—for example, perchloroethylene (PCE)—and may move laterally within the ground water body along homogeneous fine-grained contacts until a pinch-out provides an opportunity for the mass to "sink" to a lower stratigraphic layer. Wells must be designed to monitor vertical migration and lateral migration.

In the case of MTBE (less dense than water), the contaminant dissolves so readily in water that it is thought to flow with ground water through paths of least resistance, particularly when the plume has entered a production well capture zone. In such a case it is suspected that a mass of dissolved-phase MTBE released into a heterogeneous sandy/gravelly aquifer may preferentially move through the zones of highest flow potential—for instance, the gravel. The best way to confirm or refute this hypothesis under the site-specific conditions was to obtain a detailed geologic log of the aquifer and subsequently design a monitoring well that would allow sampling of the primary suspected migratory pathways. What better scenario for sonic drilling and CMT wells could there be?

Placing the tubing. Note the screen interval above.

Sonic drilling rig with a bundle of CMT.

In this application, the objective was to install a CMT well next to a shut-in ground water production well known to have detectable concentrations of MTBE. Sonic drilling would give team geologists an opportunity to improve upon the driller's log from 1967. With detailed knowledge of the aquifer lithologies, the CMT could be appropriately designed to best monitor the path of MTBE transport.

Sonic Drilling

Fundamentally, sonic drilling is simple. Core is collected by drilling 20 feet ahead and then following up with a drive casing to maintain the borehole. The core drilling pipe is made of 1-inch-thick steel and has an outside diameter of 4 inches. The drill bit is slightly bell-shaped to fit snugly within the 5¾-inch inside diameter of the drive casing. Sonic bits vary in type, but a high-carbide steel button bit worked best in the sand and gravel present in this environment. As the sonic head vibrates the core drilling string and pushes it down into the hole, you can feel a small vibration through your boots at a distance of 15 feet. The combined noise from the diesel engine and sonic head is naturally loud, but it is like a hum and is less irritating to me than the noise associated with air-rotary methods of comparable size and power.

When using sonic drilling, the cuttings are the core. The 20-foot core is recovered in four 5-foot flush-threaded sections of drill pipe which are brought to the surface and then "shaken" out. As the driller applies sonic vibration, a section of core slides out and is captured into a long plastic bag. The recovery in this alluvial basin was wonderful. The geologic detail that can be mapped using this method completely impressed me because, unlike continuous coring with hollow-stem auger, the core recovery is relatively undeformed and rarely incomplete. Gravel to sand to silt sequences could be logged to the half foot at worst and to the inch at best.

The key requirement for this drilling application was water. First, ground water was encountered at approximately 40 feet and the target depth was 200 feet. In order to keep the borehole clear of heaving alluvium, water was continuously added during drilling. The driller took water from a nearby fire hydrant and added it through the injection assembly at the top of the sonic head. A totalizer at the hydrant recorded more than 3000 gallons of water used during the drilling operation.

Continuous Multi-Port Tubing Well Installation

After the geologists had their opportunity to describe, analyze, debate, and disagree, a well completion with perforation intervals was decided. The well construction information was passed onto Resonant-Sonic's CMT well assembly team. The objective on this particular well was to perforate 1-foot sections at approximately 198, 178, 158, 121, 101, 71, and 45 feet below grade. The overall well installation approach is conventional. First, install the perforated CMT and then pull back the drive casing while adding sand to pack the screen intervals and complete the blank sections with time-release bentonite chips.

The CMT is semi-rigid, 1½ -inch-diameter Teflon tubing with a "honeycomb" inner structure. The honeycomb consists of an inner chamber surrounded by six outer chambers. Each of the outer chambers of the honeycomb is perforated to provide for depth-discrete sampling. Resonant-Sonic has constructed a spool-to-spool workshop complete with special tubing clamps that double as perforation templates. Nine perforations are drilled per foot using a conventional power drill and 7⁄16-inch drill bit modified with a welded guide to prevent drilling through the inner chamber. The perforated interval is then wrapped with doubled-over screen mesh, which is secured with hose clamps. Hot glue is used to seal the bottom of each chamber just below the perforated interval. This prevents ground water from entering the sample interval from below. The inner chamber serves as the bottom-most sampling port and is simply screened at the bottom. In order to track and distinguish the individual chambers, the tubing is manufactured with a slight groove running lengthwise on the outer surface. Chambers and associated perforation intervals can be noted clockwise from the groove. Careful note-taking and attention to detail are a must.

With the perforations drilled and the screen wrap fixed in place, the CMT is ready for installation. The inner diameter of the flush-threaded drive casing is 5¾ inches. The outside diameter and resulting annulus is just over 6 inches. Remember, the tubing is flexible and is packaged in a spool. As it is placed downhole it wants to coil and snake around inside the drive casing. It is also relatively buoyant and wants to float. To reduce the buoyancy, air vents were drilled into the chambers just below the bottom glue seal. This allows air to escape as the CMT is plunged into borehole water. Even so, the tubing is placed slowly to prevent kinking.

Since the tubing is light and naturally wants to coil, hanging the well by wireline does not help it to straighten in the borehole. As a fix, Resonant-Sonic uses insertion tubing to keep the CMT well straight during installation. The insertion tubing is 2-inch-diameter (O.D.), flush-threaded, aluminum casing that is slipped over the CMT to act as a rigid stabilizer. They have also constructed centralizers by adding "wings" to 5-foot sections of the aluminum insertion tube. The centralizers are placed 5 feet and 20 feet from the bottom. Sand or chips are slowly added as the drive casing and insertion tube are retracted. The rigid aluminum insertion tube and centralizers work well to keep the CMT straight and centered within the annulus.

Special Concerns

With every well drilled, the driller, the crew, and the geologist should learn and take note of successes and problems. This well, the first of many to be installed on the project, was a success with two special concerns. First, a piece of insertion tubing was lost during the well installation. This was attributed to the sonic vibration unthreading a connection. The driller has corrected this problem by ordering flush-threaded tubing with more threads per inch. Second, in accordance with the regulatory agency–approved work plan, the amount of water added during drilling should be removed during development. All of the purging and sampling conducted with small-chambered CMT wells is done with low-flow peristaltic pumps or thin bailers. Recovering 3000 gallons of water is almost unimaginable. The consulting company has argued that by allowing natural mixing and by analyzing purge water for native elements, it can ensure that ground water samples collected for contaminant analysis are representative of ground water, not injected water.

After this scope of continuous multi-chamber tubing well installation work is complete and the ground water sampling conducted, I will revisit this CMT project with a description of development and sampling procedures, monitoring tools and methods, and provide an insight to overall project effectiveness. WWJ

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