The Nebraska Grout Study

The surprising findings from this study are predicted to spark "a wave of regulatory changes across the industry." What is the Nebraska Grout Study? What were its discoveries and what could this mean to the future of your business?

By Jill Ross

When it comes to the use of grouts, the water well industry's involvement can be summed up in a few words: We've come a long way, baby.

"It wasn't too long ago that people were completely uneducated about grouts," recalls Lee Orton, executive director of the Nebraska Well Drillers Association. "Back in 1988 or '89, when we would conduct grouting workshops, we would have attendees who had never used grouts at all. There were definitely some skeptics."

Since the late 1980s, it's clear that the industry has undergone a major transformation in its use and perceptions of grouting (helped along the way by new state regulations, of course). Now, a new tide of changes could be on the horizon. The main reason? Because of the Nebraska Grout Study, which was started in 2001 and is still ongoing.

How Did the Study Get Started?

In 1999, representatives from the Nebraska Well Drillers Association, the Nebraska Department of Health and

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Figure 1. Diagram of grout observation well

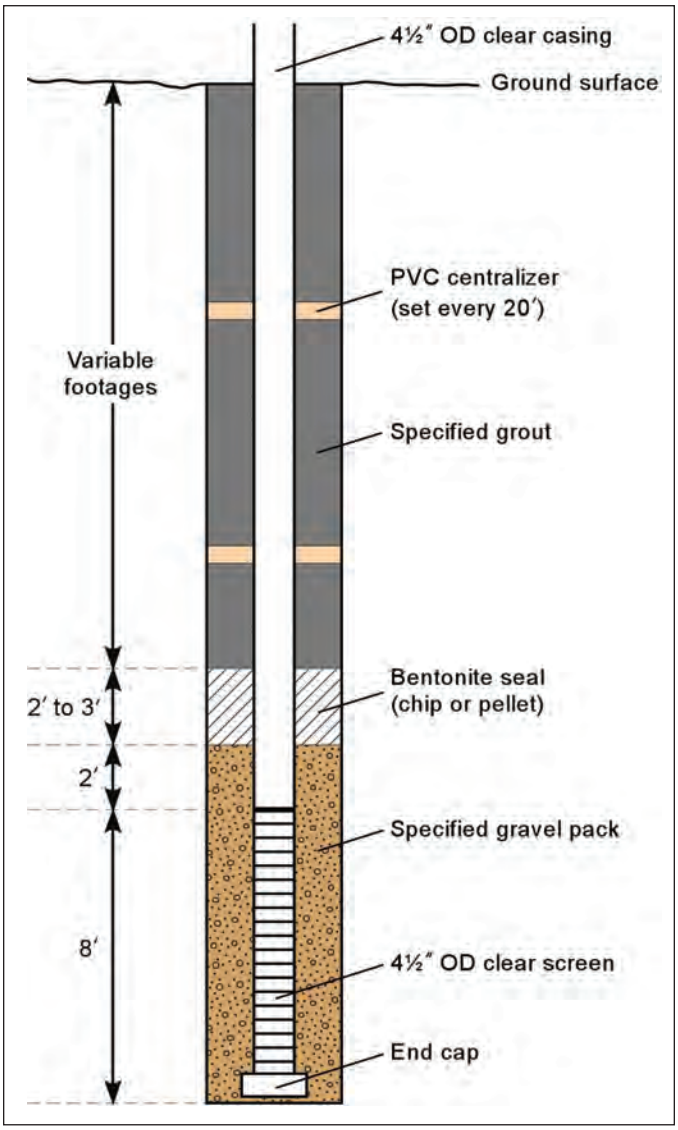
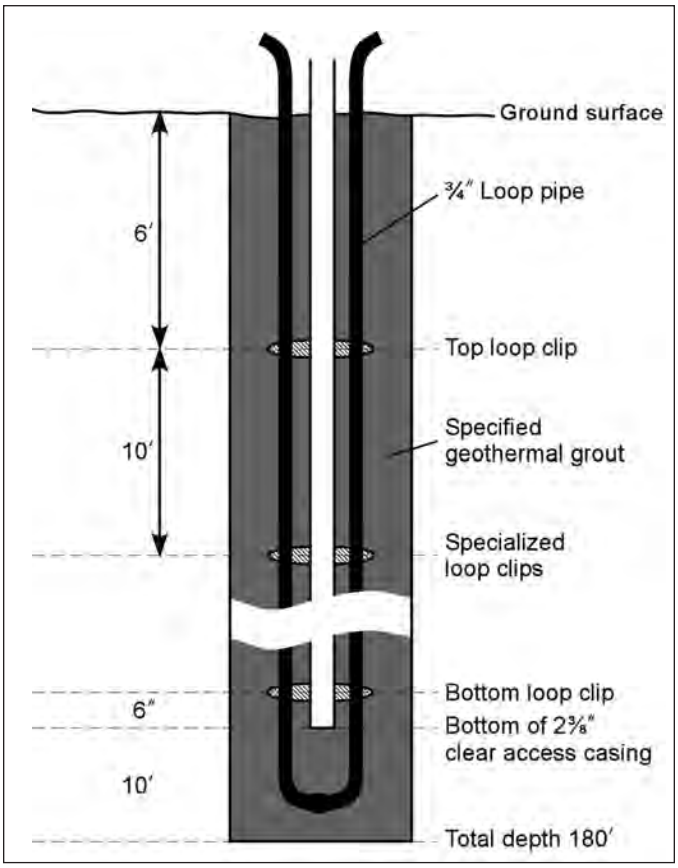


Figure 2. Diagram of geothermal heat loop



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Human Services, the University of Nebraska-Lincoln Conservation and Survey Division, Baroid Industrial Drilling Products, and Design Water Technologies constructed a water well with transparent casing and screen to use in an educational program (called the East Campus well).

"It was designed to be the 'ultimate well'," says Tom Christopherson, program manager for the water well standards and contractors' licensing program for the Nebraska Department of Health and Human Services. "It was the very first time anyone had ever used clear PVC casing."

The goal of the program was to provide state and regulatory personnel with a working knowledge of well design, construction, and development. To that end everything went as expected.

The big surprise came when the well was revisited 16 months later and a new video log was recorded.

"The ultimate well turned out to have problems," Christopherson recalls. The video showed big voids and cracks in the grout column that could potentially allow surface contaminants to move through the grout and into the groundwater supply.

Says Orton, "We were flabbergasted. We didn't know this was happening before we saw it."

"We conducted lots of testing after this discovery," Christopherson adds. "We came up with no answers, but a lot of questions. Clearly, we needed to verify the existing grouting standards."

At this point, in June 2001, the Nebraska Grout Task Force was formally organized and included representatives from the Nebraska Well Drillers Association, the Nebraska Department of Health and Human Services, the Conservation and Survey Division, the Nebraska Department of Environmental Quality, and industry grout suppliers Baroid, CETCO, and Wyo-Ben.

The task force originally developed this project to study in-situ bentonite grouts over a two-year period to assess state regulations related to minimum percent solids requirements (how 16% solids grout performed versus 20%), and to observe the grout material under varying geologic and hydrologic conditions.

"Initially, we thought we were just going to drill some more wells and show what happened at the East Campus well was an anomaly," says Stewart Krause, senior sales engineer for Wyo-Ben. "It wasn't."

For the study, wells were constructed with different bentonite slurry grouts containing less than 20%, equal to 20%, and greater than 20% solids. The first wells were constructed

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Table 1. Overall Visual Ratings

Grout type	Visual rating (All installations)
Bentonite chip	1.3
Neat cement with 6 gallons of water	1.4
Cement with bentonite	1.6
Cement with sand	1.6
Bentonite slurry >20%	1.8
Neat cement with 7 gallons of water	1.8
Bentonite slurry =20%	2.0
Concrete	2.0
Bentonite slurry <20%	2.3
Bentonite geothermal-sand ~60%	2.7
Bentonite geothermal ~20%	2.8

Table 2. Overall Average Percentage of Unsaturated Zone Penetrated by Dye

Grout type	Average percentage
Cement with sand*	24
Neat cement with 7 gallons of water*	37
Concrete*	40
Bentonite chip (Pilger & Trenton wells)	40
Neat cement with 6 gallons of water*	44
Cement with bentonite*	48
Bentonite slurry >20%	65
Bentonite geothermal-sand ~60%**	67
Bentonite slurry =20%	75
Bentonite geothermal ~20%**	86
Bentonite slurry <20%	87

* Based on maximum depth of dye in one- and 24-hour videos.
** Water level estimated from water table well

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in three different geological environments in Nebraska. The wells were designed to replicate domestic well installations typical for Nebraska, with the exception that full-length grout was specified (Figure 1).

When the task force technical team checked the wells, it became apparent that the slurry grouts did not perform as expected in the unsaturated zone.

"The good news was that the 16 percent grout was as good as the 20 percent grout," Christopherson says. "The bad news is that they all had problems."

The task force decided to expand the project and test all the grouts approved by the State of Nebraska (including bentonite chip and cement-based grouts), which increased the number of observation wells. The study was also expanded to include functioning geothermal heat loop installations (Figure 2). Soon, there were 63 observation wells located at five sites.

Monitoring the Wells

According to the report *Nebraska Grout Task Force: In-Situ Study of Grout Materials 2001-2006 and 2007 Dye Tests*, three elements were included in the site monitoring—water level measurements, video surveys, and dye tests. Video surveys were conducted 24 hours after the placement of the grout, then 30 days after, and then about 90 days after. Subsequent videos were taken on a semiannual basis. The dye tests were conducted two years after the well construction. For the dye tests, special dye reservoirs were built (shown in Figures 1 and 2). This allowed the techinial team to create a "worse case scenario" to allow for comparison of grout mixtures. Figure 1 is the surface completion diagram for grout observation wells and Figure 2 is surface completion diagram for geothermal grout loops.

Early analyses showed that all grout materials showed voids above the water table and were mainly intact below the water

Table 3. Overall Average Results

Grout type	Performance ranking	Visual ranking	Ranking variation
Cement-sand *	1	3.5	+2.5
Bentonite chip (All 3 wells)	2	1	-1
Neat cement -7 gallons H_2O *	3	5.5	+2.5
Concrete *	4	8	+4
Neat cement - 6 gallons H_2O *	5	2	-3
Cement-bentonite *	6	3.5	-2.5
Bentonite slurry >20%	7	5.5	-1.5
Geothermal-sand ~60%**	8	10	+2
Bentonite slurry =20%	9	7	-2
Geothermal ~20%**	10	11	+1
Bentonite slurry <20%	11	9	-2

* Based on maximum depth of dye in one- and 24-hour videos.
** Water level estimated from water table well

table. Therefore, the visual assessments were performed only for the portion of the grout column in the unsaturated zone.

"This was all because we could see," says Christopherson, emphasizing the importance of the clear casings used in the study. "Previous grout studies didn't allow this."

Not to say that it was easy. The study involved looking at "hours and hours" of downhole video logs that had to be interpreted. The use of different cameras, varied camera views, excessive condensation, and some discoloration of the casing were some factors that presented challenges to interpretation.

"The biggest surprise to me was how quickly the grouts were affected in the vadose zone," Krause says. "Most of the time, it was within the first month."

Another element that factored into the study was the fact that Nebraska was in a drought cycle while the wells were being observed—a factor that may have contributed to the shrinking and cracking that took place in some of the grouts.

"One of the most surprising findings to us was the effect that the drought conditions had on the high solids slurry grouts in the unsaturated zone," says Bob Oliver, northwest regional manager at CETCO Drilling Products Group. "We were expecting some shrinking and cracking, but were surprised at the extent of it in some of the grouts."

In the end, the task force assigned "visual ratings" for the different grouts (shown in Table 1), which showed the bentonite chip grout performed the best out of all recipes in the study. After the dye tests were conducted, a "performance ranking" was established for the grouts (shown in Table 2). The percentage of the unsaturated zone penetrated by dye was used to rate the performance of each grout, with the lowest percentage indicating the best performance. The results indicate sand-cement and bentonite chip grouts performed the best. Table 3 shows the overall average results. These data suggest that bentonite slurry with less than 20% solids and geothermal grout without sand performed the worst in the observation wells.

"Some of the findings of the study were news, some were not," sums up Ed Anderson, manager of the Eurasia, Middle East, and Africa region for Halliburton/Baroid Industrial Drilling Products.

One positive finding of the study was the fact that, in general, the grouts performed as expected below the water table.

"Another very pleasant surprise was finding out how much better the bentonite chip well grouts performed in the unsaturated zone," Oliver says.

"The most important point of the study is the emphasis and need for full interval grouting—from the top of the production zone up," Anderson adds. "The most critical point is the segment right above the production zone."

One negative finding was that cement grouts did not bond with the plastic well casing.

"The cement cures and shrinks," Christopherson says. "The cement pulls away from the casing and becomes a direct conduit."

What's Next?

Although it's been almost 10 years since the task force was established, Christopherson says they are not finished yet. Another phase of the study will start next year and is intended to address some "lingering questions" from the study of the vadose zone.

"There are some additional products we want to test," he says. "In the initial study, we tested three basic recipes. There are 18 different recipes being tested now, including nine new products."

And speaking of new products, all three grout suppliers almost immediately got busy reworking their existing product lines to address some of the problems identified in the study.

"You've got to give the industry credit," Christopherson says. "They reacted very swiftly to address some of these issues."

Baroid, CETCO, and Wyo-Ben all say they have plans for new products, as well as reformulations to existing products and revamped placement recommendations and procedures.

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"All of us have found stuff to tweak in existing formulas," Krause says.

One of the industry's concerns is cost. While it's almost certain that new products will cost more, all the manufacturers are concerned about keeping products affordable.

"It's like a three-legged stool," says Krause. "One, you need to be able to place the grout. Two, it has to work. And three, you have to be able to afford it."

Orton says there are already new products on the market that are being used by drillers in Nebraska—not because they are required, but because it's better technology. He says he doesn't see that cost is going to be that much of a factor. "We're not talking about an exorbitant cost here."

"Groundwater protection is a necessity, not a luxury,"
Anderson says. "We have to be willing to put forth the money to protect it, or we all will suffer as a result."

Some Cautions

Since the first report was made public last November, many in the industry are left wondering what this all means for the groundwater drilling industry. Although those interviewed for this article agree that changes are certainly on the horizon, it's not so clear at this point what those changes will end up being.

"This study will have an impact on the groundwater industry for many years to come. It is the most comprehensive study of grouting that has been conducted to date to the best of my knowledge," Oliver says.

"We're still trying to educate people about it," Orton adds. "Right now, (changes) are more voluntary."

No doubt, future changes will be regulatory-driven. However, there is a clear concern among study participants that new regulations not be written too hastily.

"The key fact that we have to keep in mind is that the study is not complete. All the questions have not been answered, and some new ones have popped up as a result of the study. We need to continue this research in order to provide the best grout for every grouting application," Oliver says.

"One of my fears is that people only hear what they want to hear," Anderson says. "There is a lot of information yet to come. So far, this is only one piece of the entire puzzle. There are more components of the study that are yet to be published."

That said, some revisions have occurred already in Nebraska for public water wells, based on this study. New regulations specify that seals be moved down to the water level and bentonite chip grout is specified.

Christopherson says regulations for drilling private water wells in Nebraska have not yet changed, but proposed revisions may include:

- requiring an increased percentage of solids in grout
- requiring a high-solids seal on top of the water table to protect groundwater
- requiring a combination of high-solids fill to surface seal
- not to allow slurry bentonite for grouting closed-loop systems.

He says he is also recommending that a steel riser be required in the top 10 to 20 feet of wells where a cement grout is used, so the cement will bond to the steel.

Christopherson, who earned a living as a well driller for 20 years, says he understands the urgency of "getting to the pay zone," but says that now drillers need to pay more attention than ever to "what's in between."

Anderson concurs. "There will come to be a broader realization of the importance of geologic influences on annular seals," he says. "Mother Nature has a lot of influence. It's essential that drillers understand the subsurface geology and geochemistry of the soil before they drill.

"Everyone wants a one-size-fits-all solution, but that's not going to happen. I think we will find that we need to use more than one component in grouting. It's not all about the composition of the grout. The environment and the efficiency of the placement procedures also play a big part."

Krause recalls when the first grouting rules were written back in the 1980s and 1990s.

"The findings from this study will probably be just as significant, the natural next step," he says. "We'll just keep getting better and keep pushing ahead." *WWJ*

A copy of the report *Nebraska Grout Task Force: In-Situ Study of Grout Materials 2001-2006 and 2007 Dye Tests* is available for purchase from the Nebraska Maps and More store for $30. Go to *http://nebraskamaps.unl.edu* for ordering information.