CEMENTING

PermSeal Solution Stops Artesian Water, Geopressured Sand Flows

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Operators drilling in deep water off the continental shelf can use PermSeal, an acrylate monomer solution (AMS), to prevent artesian water flows and geopressured sand flows from entering the wellbore. Unchecked water flows can wash cement away from casing, making cementation of conductor pipe expensive and sometimes impossible.

PermSeal is effective in downhole temperatures ranging from 50° to 200°F. The solution is pumped into a well as a water-thin liquid that soon becomes a highly gelled, rubber-like solid that serves as an impermeable barrier against overpressured waterflows. Based on the temperature of the formation, PermSeal can be mixed to provide variable gel times. After PermSeal has formed a barrier, the operator can drill through the PermSeal mass and later cement conductor pipe in place without artesian water influx ruining the cement job.

PermSeal helps significantly reduce the permeability of a porous formation while simultaneously consolidating the formation's structure into a cohesive mass. PermSeal can be formulated with fluid densities up to 17 lb/gal. The PermSeal technique helps stabilize large areas and stop any crossflow of artesian water between wells. The solution may be especially attractive to operators drilling well templates where seismic tests and other data have shown the presence of artesian water sands.

Background

In 30 to 40% of deepwater drilling operations in the Gulf of Mexico, operators encounter artesian water flows in formations less than 2,000 ft below the mudline (BML). These geologically young formations are the result of sands and silts eroding from the continental shelf and settling over older deepwater formations (Figure 1). These younger formations are often highly permeable and can act as conduits for overpressured water.[1]

In addition to high permeability and large size, numerous overpressured zones may exist, having extremely low fracture gradients. A cement slurry that is dense enough to control artesian water might be too dense to be supported by the formation. PermSeal can help increase the fracture gradient, but the solution does not do this as effectively as Statalock™ . Thus, PermSeal is generally more useful for reducing formation permeability.

The Importance of State-of-the-Art Cementing

One successful approach applied to stopping artesian water flows has been to cement conductor casings with combinations of lightweight, foamed slurries, such as Flo-Stop 4000 or Flo-Stop 5000, and settable spotting fluids. Flo-Stop slurries used for this purpose must have good compressive strengths. The compressible nature of the Flo-Stop slurries helps control water flow, yet it is not so dense that it causes formation fracturing. The settable spotting fluid provides high mud displacement during the cementing process. Because this fluid is formulated with hydraulic material, any fluid that is not completely displaced by cement will solidify.

When using state-of-the-art cementing techniques to control water flow, operators must consider the following:

- Proper hole preparation. Properties of wellbore fluids are critical. When operators plan the formulation of wellbore fluid, they must improve the likelihood that cement slurry will displace wellbore fluid and seal the conductor-wellbore annulus. Operators have successfully lowered the gel-strength profile and fluid loss of the spotting fluid with a starch fluid-loss control agent. To improve annulus sealing even more, operators often add a hydraulic material to the spotting fluid that remains liquid for 7 to 10 days but sets within hours after the cement slurry is placed. Any filter cake or fluid not removed by the cementing process will solidify, providing better annulus sealing.
- Cement slurry design (Flo-Stop 4000 and Flo-Stop 5000). The lightweight, foamed cement slurry must be dense enough to control formation influx, but it must not contribute to the possibility of a formation fracture. Typical ranges of slurry density should fall within the gradient window between formation pore and fracture pressure. In addition to hydrostatic pressure for well control, incremental hydrostatic pressure must be designed into the slurry to compensate for the pressure reduction that will occur during slurry hydration.

While state-of-the-art cementing has effectively shut off artesian waterflows into individual wellbores, it has not been an effective approach to site stabilization. In some cases, mud channeling in cement sheaths has compromised the seal of the annulus, resulting in water crossflowing into shallower sands or breaching previous casing shoes. Wells drilled in a template have been compromised by crossflows of water from one cemented well to another. When these crossflows occur, the stability of an entire site can be compromised, and operator losses can easily run into millions of dollars. An effective way to ensure the isolation of water and geopressured sand in a high-permeability sandstone is to pump PermSeal into the formation and follow the treatment with state-of-the-art cementing techniques.

Past Uses of PermSeal

In the past, PermSeal has most often been used in conformance operations to reduce or plug water flow into hydrocarbon-producing wells or injection wells with bottomhole injection temperatures (BHITs) between 65° and 200°F (18° and 93°C). PermSeal usually contains 15% monomer (optionally up to 20%) pumped into a formation at matrix rates. The solution can be batch-mixed or blended on the fly. Temperature-activated initiators cause PermSeal to transform from a liquid to a solid at predictable times and known BHITs. PermSeal can be formulated in seawater and a variety of brines. With heavyweight brines, final PermSeal density can be as high as 17.0 lb/gal. In conformance applications, PermSeal can be used to do the following:

- Minimize waterflood channeling and CO_2 channeling; seal pinhole casing leaks, and seal channels behind pipe
- Seal high-pressure zones and control gas migration and lost circulation at the kickoff point in deviated wells
- stabilize subsiding zones and fault zones

Before using PermSeal for conformance, operators must perform tests to determine the presence of natural or induced fractures, vugs, or high-permeability streaks. A BHIT profile of the well is critical. Operators must have accurate BHITs for correctly formulating a PermSeal treatment for volume and placement rate.

PermSeal has been used in weighted and slurried forms to aid conformance. Operators can choose the concentration of initiator used in a PermSeal treatment to initiate in-situ polymerization throughout the entire treatment soon after pumping has been completed. Operators can also formulate the PermSeal solution so that the leading edge of the treatment will begin polymerizing shortly before pumping is complete, allowing for squeeze pressure and diversion of the solution into less permeable zones.

PermSeal Used During Drilling of New Wells

In a typical riserless operation in the Gulf of Mexico, operators jet in a 30-in drivepipe to a depth of about 300 ft BML. As the hole is deepened, seawater used as drilling fluid is circulated through the annulus between the drivepipe and the wellbore back to the ocean floor (Figure 2) . After a target depth has been reached, the drivepipe is held in place by silts washed away from the sides of the wellbore and by a mud mat set in place at the mudline (Figure 3). Drivepipe is not usually cemented. Drilling is continued with a conventional drillpipe below 300 ft. Lengths of 26-in conductor casing are set below the drivepipe with state-of-the-art cementing procedures. Seawater, cuttings, and other fluids are forced out of the wellbore through the annulus between the conductor casing and drivepipe (Figure 4).

In typical Gulf of Mexico deepwater drilling operations, high-permeability sand zones and artesian water flows can be expected at depths of approximately >600 ft BML. Operators working with seismic data or data collected from offset wells will often know in advance of drilling where such zones are located. Ideally, operators would stop drilling just before reaching a high-permeability zone. Then, they would run casing and cement the 26-in. conductor pipe into place (Figure 5). With the artesian sand exposed by the drilling process, operators would proceed with a Perm Seal treatment (Figure 6). After the PermSeal solution gels, operators would continue to drill the wellbore through the PermSeal barrier. Then, they would cement the casing string through the treated sand (Figure 7). In a riserless system, overbalanced placement techniques would be used to spot PermSeal into the problem reservoir. In other applications, packers would be set on the drillpipe, isolating the wellbore and artesian water sand. PermSeal pumped through the drillpipe would essentially influx into the reservoir, assisted by hydrostatic pressure created by surface pumps. The PermSeal solution, formulated to gel at the appropriate BHIT, would form an impermeable mass over a matter of hours. After drilling the conductor hole to about 1,500 ft, operators would use state-of-the-art techniques to complete cementing the 20-in conductor casing.

An effective PermSeal treatment requires the following:

- Good penetration of the treating fluid into the sandy reservoir
- Uniform or nearly uniform radial penetration away from the wellbore
- Sufficient penetration of the formation to withstand the pressures of any crossflowing water and sand
- Adequate strength, adhesion, and elasticity of the treating fluid to form and maintain an effective seal in the formation

Conclusion

Artesian water flows and flows of geopressured sands threaten the stability of deepwater wells being drilled in poorly consolidated formations. In many cases, state-of-the-art cementing techniques have been effective in preventing damage. However, PermSeal can better guarantee the results of good cementing and site stabilization. PermSeal is effective in downhole temperatures between 50° and 200°F, temperatures typical of depths where high-permeability sand zones are routinely encountered. The solution is mixed on-the-fly at the site and is easily pumped as a water-thin liquid that forms into an impermeable barrier within hours after penetrating a sand formation. After it has gelled, sealing off water sand, operators can drill through the PermSeal, which will eventually supplement the stability of the cemented well casing and of a well template site.

References

1. Griffith, J.E. and Faul, R.: "Cementing the Conductor Casing Annulus in an Overpressured Water Formation," paper OTC 8304 presented at the 1997 Offshore Technology Conference, Houston, May 5-8.

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Figure 1: Drilling in "young" formation off the Continental shelf.

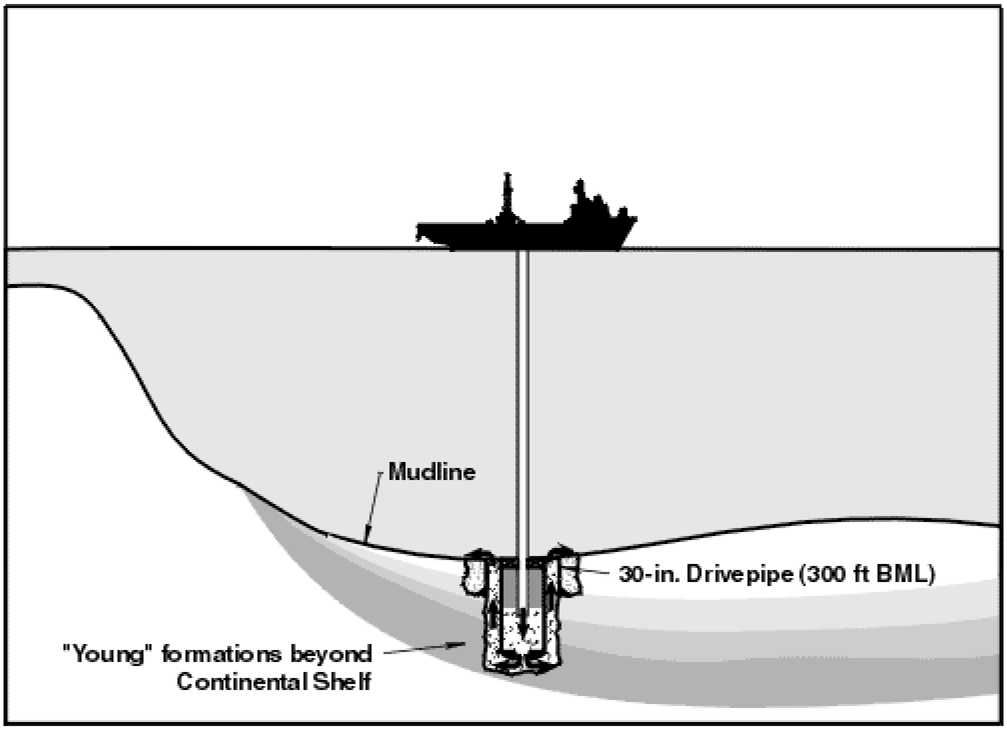


Figure 2: A jet-in drilling operation to a depth of 300 ft BML.

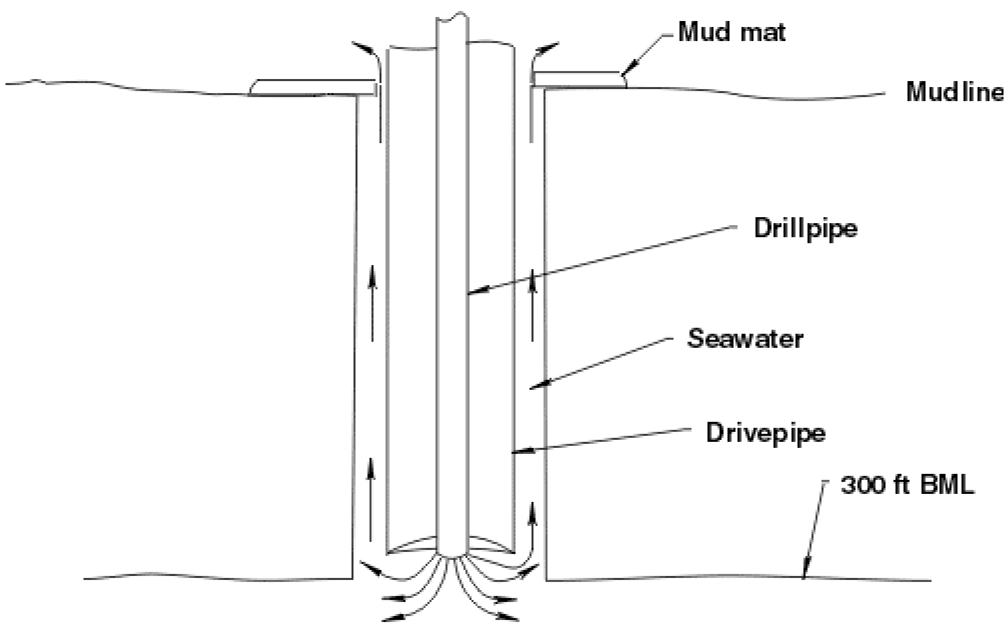


Figure 3: 30-in drivepipe held by slits.

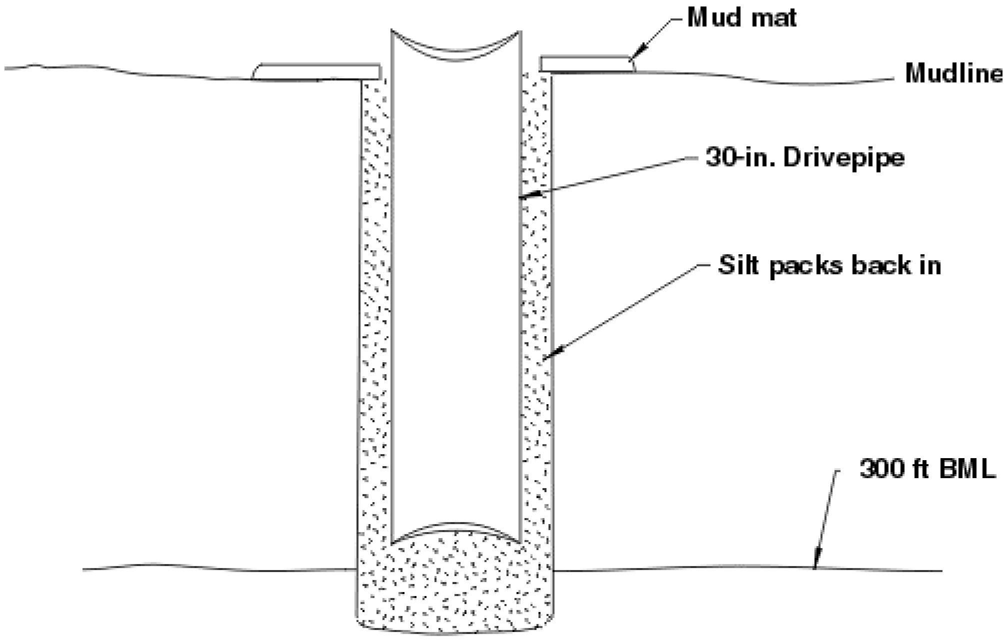


Figure 4: 26-in conductor casing set below the drivepipe as the hole in drilled deeper.

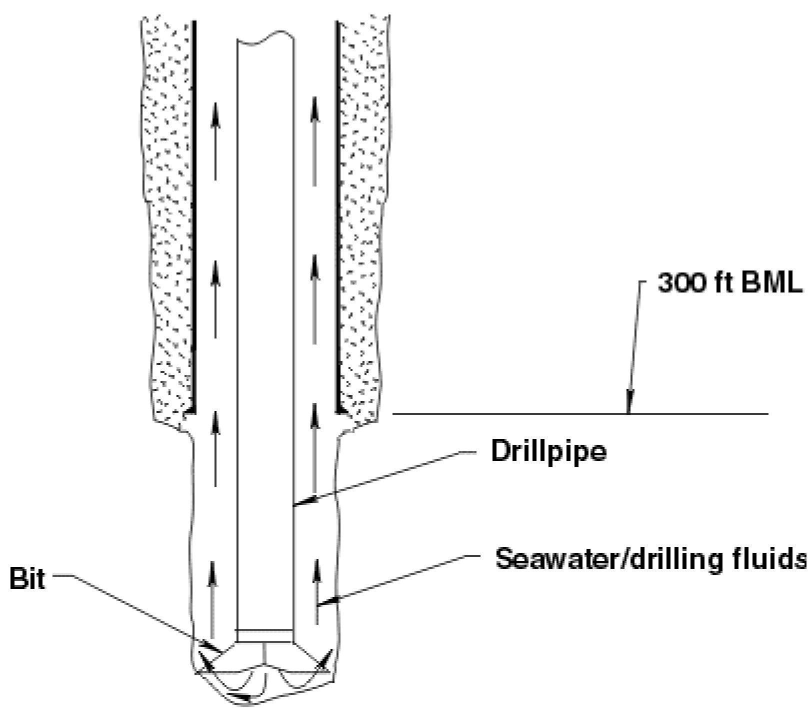


Figure 5: After the high-permeability zone is encountered, drilling is stopped, and conductor casing is cemented into place.

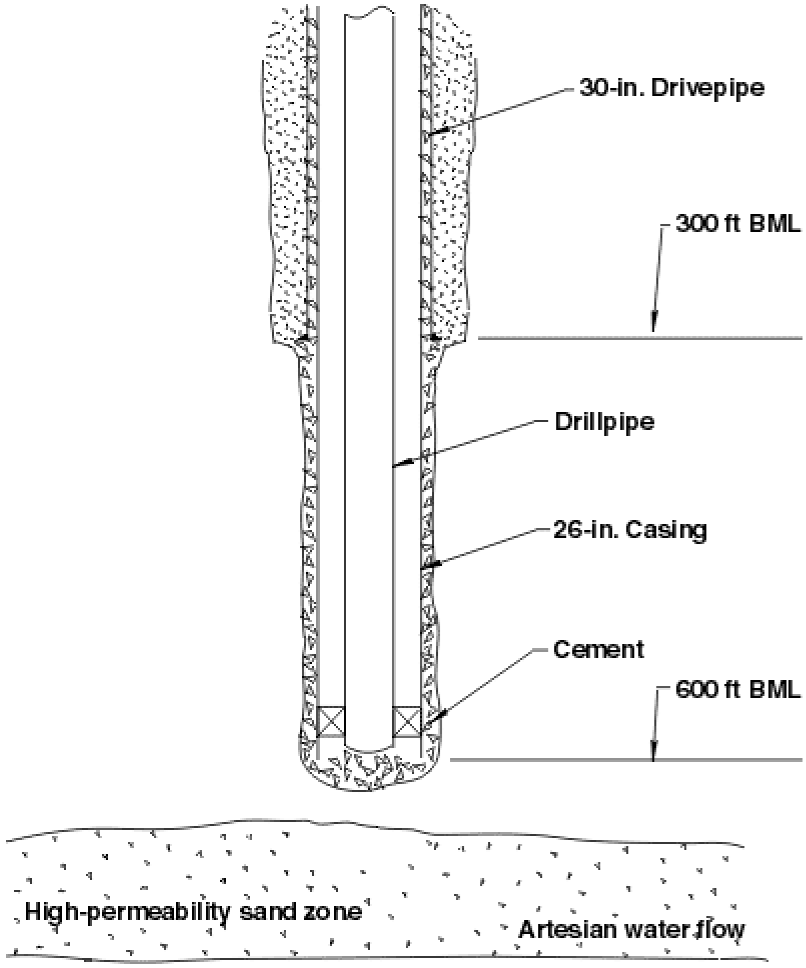


Figure 6: PermSeal is added through the drillpipe to penetrate the formation. Formulated to gel at the BHIT, the PermSeal becomes and impermeable mass over a matter of hours.

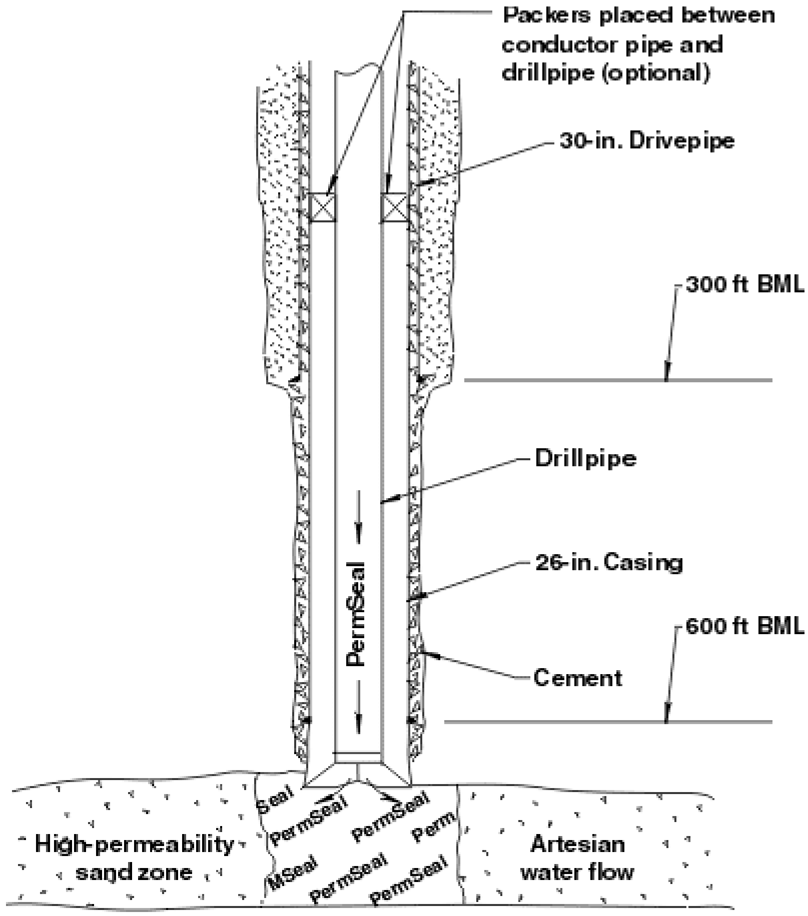
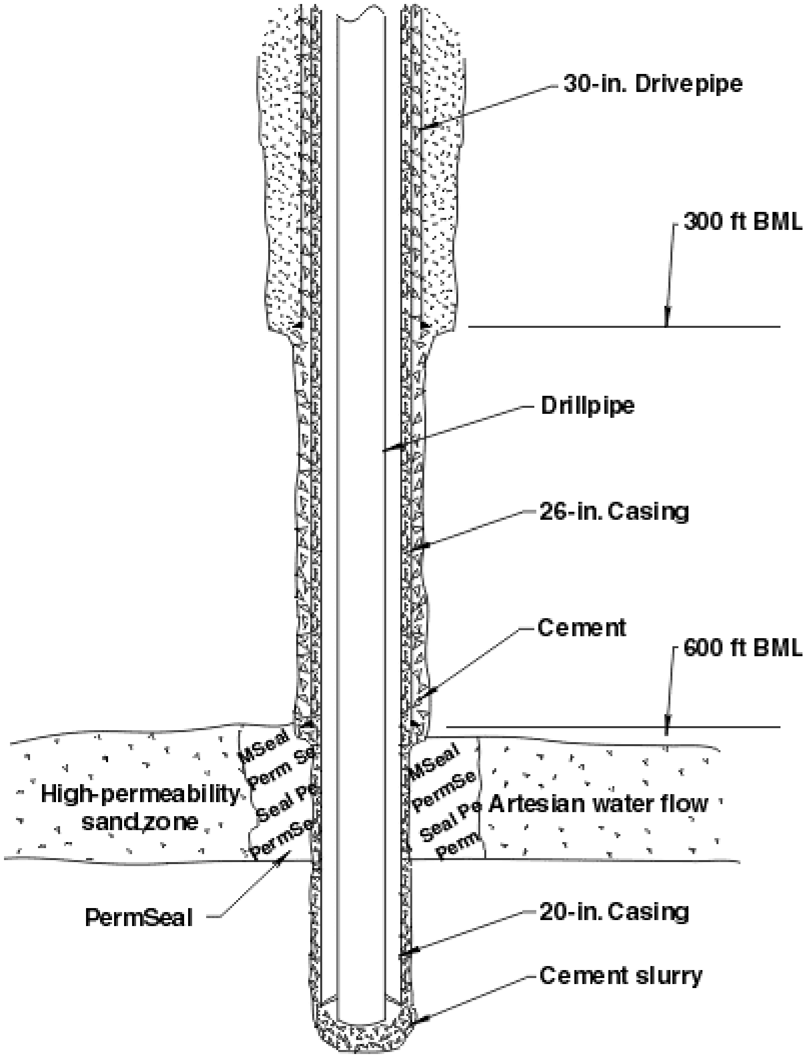


Figure 7: After the PermSeal has gelled, drilling of the wellbore continues through the PermSeal mass. State-of-the-art techniques are later used for cementing 20-in. conductor casing into place.



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