MULLICAN 1992

Milestone Report

SUMMARY OF BUREAU OF ECONOMIC GEOLOGY PANTEX PLANT 1992 DRILLING PROGRAM

PRELIMINARY RESULTS

INTRODUCTION

Two stratigraphic/hydrologic test wells were recently drilled on the Pantex plant by Fugro Geosciences, Inc., under contract to the Bureau of Economic Geology (BEG). This work, which is described in Task 9 of Appendix C--Annual Supplement to Scope of Work (1991-1992), was completed April 13, 1992. These wells were completed as a perched aquifer observation well and as an Ogallala aquifer observation well. The following is a summary of the drilling program, the hydrologic and geologic findings, and the engineering problems encountered during drilling.

DRILLING SUMMARY

Both observation wells were drilled with hollow-stem augers down to auger refusal (the depth at which no further penetration is possible) using a CME-75 drilling rig. At auger refusal, drilling was converted to continuous coring with a fresh-water-based mud-circulation system using a Failing 1500 drilling rig. The boreholes were reamed from a nominal 3.9- to 8.5-inch diameter from ground surface to total depth, logged with an extensive suite of geophysical tools, subjected to a vertical seismic profiling, and completed as a perched and as an Ogallala monitor well.

Drilling of the first observation well, BEG-PTX No. 1, started February 10, 1992 (Fig. 1). After removing the 5-ft core barrel from the sampled interval from 33 to 38 ft, routine atmospheric monitoring using a combustible gas indicator and oxygen meter in and around the borehole indicated a Lower Explosive Limit (LEL) of >5 percent and an oxygen level of <19.5 percent. Because both of these levels meet or exceed BEG action levels, the drilling rig was evacuated and Mason Hanger/Battelle (MHB) personnel were contacted. Mason Hanger/Battelle and BEG supervisors returned to the drilling rig and secured the borehole for the day. After monitoring by MHB industrial hygienists on the morning of February 11 recorded only background levels in and around the borehole, drilling was resumed. After drilling the interval from 53 to 58 ft, monitoring again indicated unknown gases in the borehole with a maximum LEL of 20 percent and oxygen readings of 18 percent. After evacuating the rig, MHB industrial hygienists returned to the rig and confirmed BEG monitor levels. Samples were collected and analyzed, but gas levels were too low for reliable determination of the gas source. After air monitor readings returned to background levels, drilling proceeded as planned. The auger method of drilling in this borehole was terminated at a depth of 81.6 ft.

Auger refusal in BEG-PTX No. 1 was reached as the result of difficulty encountered while penetrating basically continuous, dry clays of the Blackwater Draw Formation from ground surface to 81 ft. From a drilling perspective, dry clays such as those encountered in this borehole create two significant problems. First, the dry nature of the clays tends to restrict upward movement of cuttings on the auger flights, and second, friction buildup between auger flights and the walls of the borehole may reach levels sufficiently high to damage drill bits and auger flights. These two factors resulted in a shallower than anticipated depth for auger refusal. One additional problem encountered while augering this borehole occurred when a $CaCo_3$ nodule was apparently plucked from the borehole wall at a depth of 60 ft while drilling at 81 ft. This $CaCo_3$ nodule wedged between the auger flights and borehole wall in such a manner that approximately 3 ft of auger flight was separated from the auger stem and left in the borehole (see fig. 2 for photo of destroyed auger flights). All attempts to remove this metal with magnets or by displacing the metal into the side of the formation wall proved unsuccessful. Therefore, this borehole was abandoned and grouted from total depth to ground surface (see fig. 3 for schematic of BEG-PTX No. 1). Recovery rates accomplished while augering BEG-PTX No. 1 were excellent, with an overall recovery rate of 99.37 percent. Recovery rates at specific depths are illustrated in figure 4.

After all efforts to remove the metal from BEG-PTX No. 1 proved unsuccessful, the rig was moved approximately 5 ft to the west, and a new borehole, identified as BEG-PTX No. 3, was started (fig. 1). This borehole was cored using a fresh-water-based mud-circulation system from 10 ft to a total depth of 504 ft. The nature of Ogallala sediments in this borehole below 100 ft significantly affected recovery rates, borehole conditions, and the eventual termination of drilling in this borehole. Core recovered below 100 ft documented that the Ogallala Formation, for the most part, is loose, uncemented, unconsolidated, fine to coarse sands. With increasing depth, caving and collapse of the borehole increased. Eventually, clean out of caving and collapse that occurred when the rig was shut down at the end of the day consumed a full day's effort. As this pattern became clear, drilling was increased from 12 to 24 hours a day. This change in drilling procedures greatly increased production rates and prevented further deterioration of borehole conditions.

At a drilled depth of 504 ft, while recovering a 10-ft core, the borehole, from 440 to 504 ft, collapsed on the drill pipe, core barrel, and core bit. All attempts to loosen and retrieve the stuck pipe were unsuccessful. To complete the well as a perched monitor well, Haliburton Well Services of Pampa, Texas, was contracted to cut the pipe at approximately 440 ft using directional explosives. This was successful on the first attempt, and the remaining pipe was removed. The borehole was then reamed to total depth of 434 ft.

Recovery rates achieved while coring BEG-PTX No. 3 dropped dramatically below 100 ft. The overall recovery rate for the cored interval from 10 to 504 ft was 58.1 percent. Recovery rates at specific depths achieved while drilling BEG-PTX No. 3 are illustrated in figure 5.

Borehole testing of BEG-PTX No. 3 proceeded using the following geophysical logs: spontaneous potential, gamma ray, compensated neutron, litho-density, sonic, caliper, and dual induction. Although a complete evaluation of these logs has not been completed, it was clearly illustrated from the combined litho-density compensated neutron log that a perched interval was encountered from approximately 250 to 282 ft. A well completion was designed on the basis of this information, and BEG-PTX No. 3 was completed as a perched observation well (see fig. 6 for well schematic). The well was bailed down to static water level and developed to the point where a Bennett Pump could be installed for further testing.

The southern observation well (BEG-PTX No. 2) was augered from ground surface to auger refusal at a depth of 73 ft. Dry clays in the Blackwater Draw Formation again prevented returning cuttings to the surface because elevated friction levels in the clays were sufficient to terminate rotation of the augers. On the basis of experience gained from BEG-PTX No. 1, augering was terminated and continuous coring initiated.

Two significant differences in the overall geology of the Ogallala Formation were observed in BEG-PTX No. 2 compared with BEG-PTX No. 3. First, an overall increase in the clay content allowed for a much more stabilized borehole. Second, a thick, very coarse gravel section was encountered from 246 to 312 ft where only a very thin (<2-ft-thick) zone of gravel had been observed in BEG-PTX No. 3. Attempts to core through this gravel section became impractical because of the severe wear on diamond bits, and the drilling method was changed temporarily to simple rotary drilling with an 8.5-inch tricone rotary bit. After the major gravel section had been penetrated, coring was resumed. Triassic red beds were penetrated at a depth of 410 ft, and drilling was terminated at 420 ft. Recovery rates achieved while drilling this well from ground surface to 420 ft were 77 percent (this does not include the gravel section described where only drill cuttings were collected). Recovery rates at specific depths are illustrated in figure 7.

This observation well (BEG-PTX No. 2) was also logged with the same suite of geophysical logs as used in BEG-PTX No. 3. In addition, a detailed vertical seismic profile was conducted in this well. A Litton LRS-315 vibrator truck was used as the source of seismic energy, and a three-component geophone tool was used to acquire downhole seismic data. Seismic data were collected at 10-ft intervals from approximately total depth (420 ft) to 10 ft below ground surface. Following collection of vibrator data, the BEG seismic source (accelerated weight drop) was used to collect seismic data at 100-ft intervals from the bottom of the borehole to ground surface. Both data sets will be processed and used to calibrate surface seismic velocity data, verify reflections evident in surface seismic data, and assign depths to reflectors.

In this well, the combination of compensated neutron litho-density geophysical logs again illustrated a saturated perched zone. This zone, however, was much thinner than the saturated perched zone in well BEG-PTX No. 3, the total saturated interval having a thickness of approximately 2 to 4 ft from 306 to 310 ft. Because of the extreme difficulty in completing such a thin zone with open borehole below, it was decided to complete this well as an Ogallala observation well. The completion design for BEG-PTX No. 2 is illustrated in figure 8. After extensive well development, the static water level in this well was measured at 372.5 ft below ground surface.

DRILLING PROBLEMS

As with any drilling program designed for an area where little or no background drilling or coring information is available, unforeseen problems were encountered. The following is a brief description of these problems and possible solutions to be considered.

Augering to any depth below the cap rock, at the Pantex Plant at approximately 80 ft, may always be difficult. The drilling rig used must have a high rotary torque capacity if friction inherent in the clays of the Blackwater Draw Formation is to be successfully overcome. The drilling rig used in this program had a rotary torque capacity of 13,000 ft-lb, which was insufficient to auger through the cap rock. A drilling rig with a minimum of 20,000 ft-lb of torque would have a much greater chance of success. The diameter of the augers may also impact the drilling capabilities. The larger the auger diameter, the greater the torque required to turn the augers. During this program, 4.25-inch-internal-diameter (I.D.) augers were used. A greater depth to auger refusal may have been achieved if 3.25-inch-I.D. augers had been used. Continuous efforts to work drill cuttings to the surface should be attempted as an additional drilling procedure to enhance auger capabilities. This procedure may involve pulling the entire string of auger flights out of the borehole on a regular basis to remove the buildup of cuttings. When possible, only heavy-duty auger flights should be used while augering through the clays overlying the cap rock. Standard augers in this drilling environment appear to be subject to damage and loss in the borehole.

Continuous coring while maintaining a high recovery rate using a mud-circulation system is also difficult to achieve successfully. The primary problem occurs when the drilling string is removed from the borehole for any extended period of time, overnight for example. Drilling on a 24-hour schedule, thereby continuously maintaining the borehole, may partly correct this problem. Another partial solution to the problem of caving and collapse is to core short intervals and then ream out the cored interval (core 30 ft then ream the same 30 ft, for example). Mud/formation conditioners might also assist in coring through the very loose sands of the Ogallala Formation.

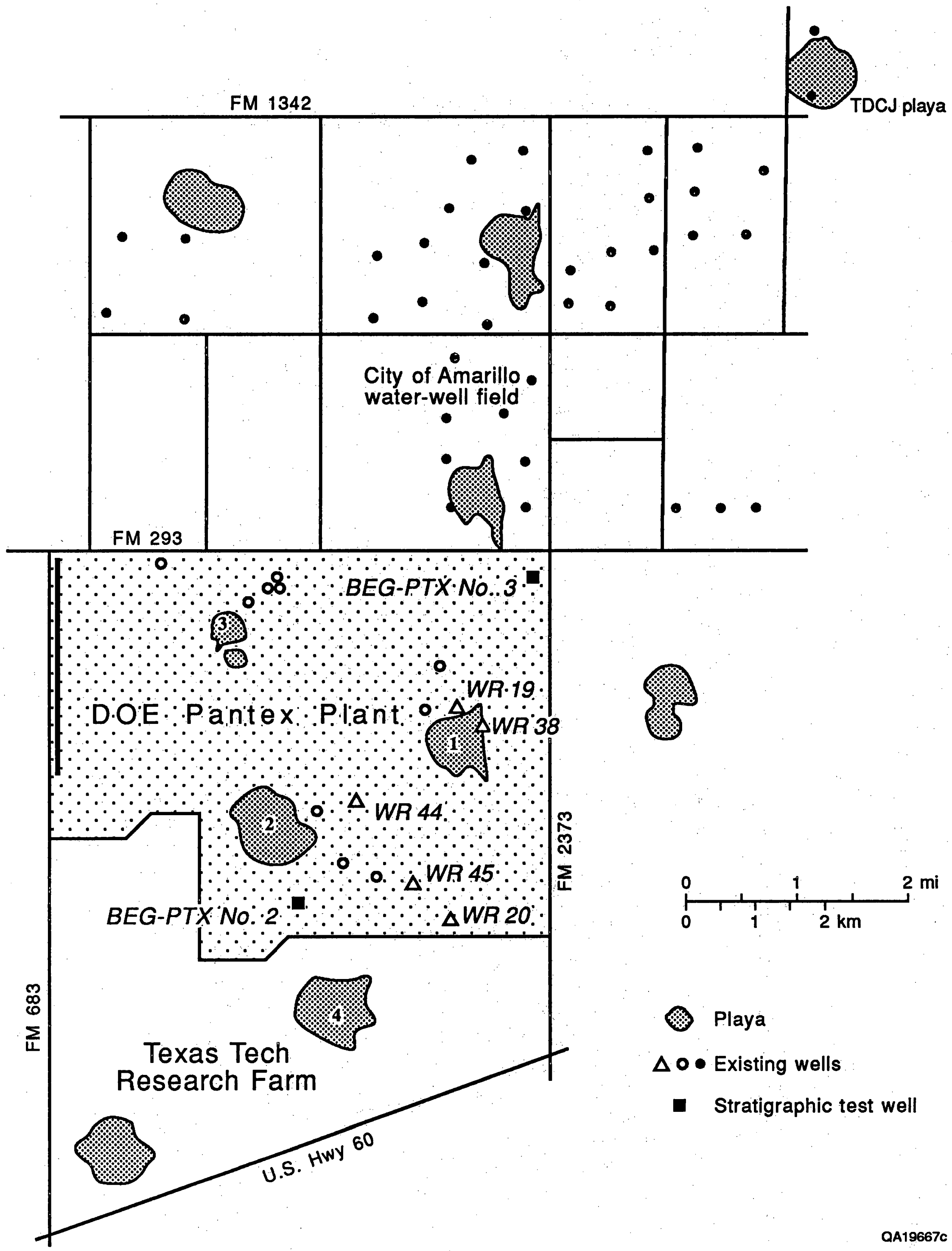

Figure 1. Location map of observation wells completed as a part of this drilling program.

Figure 2

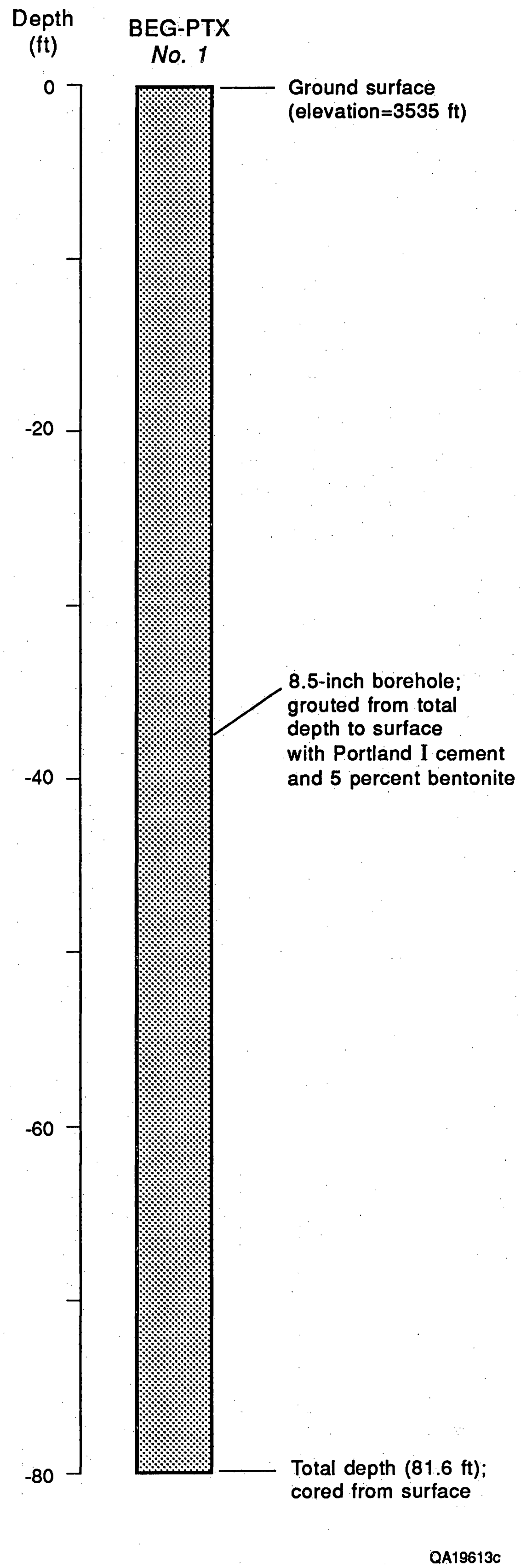

Figure 3. Schematic diagram of BEG-PTX No. 1.

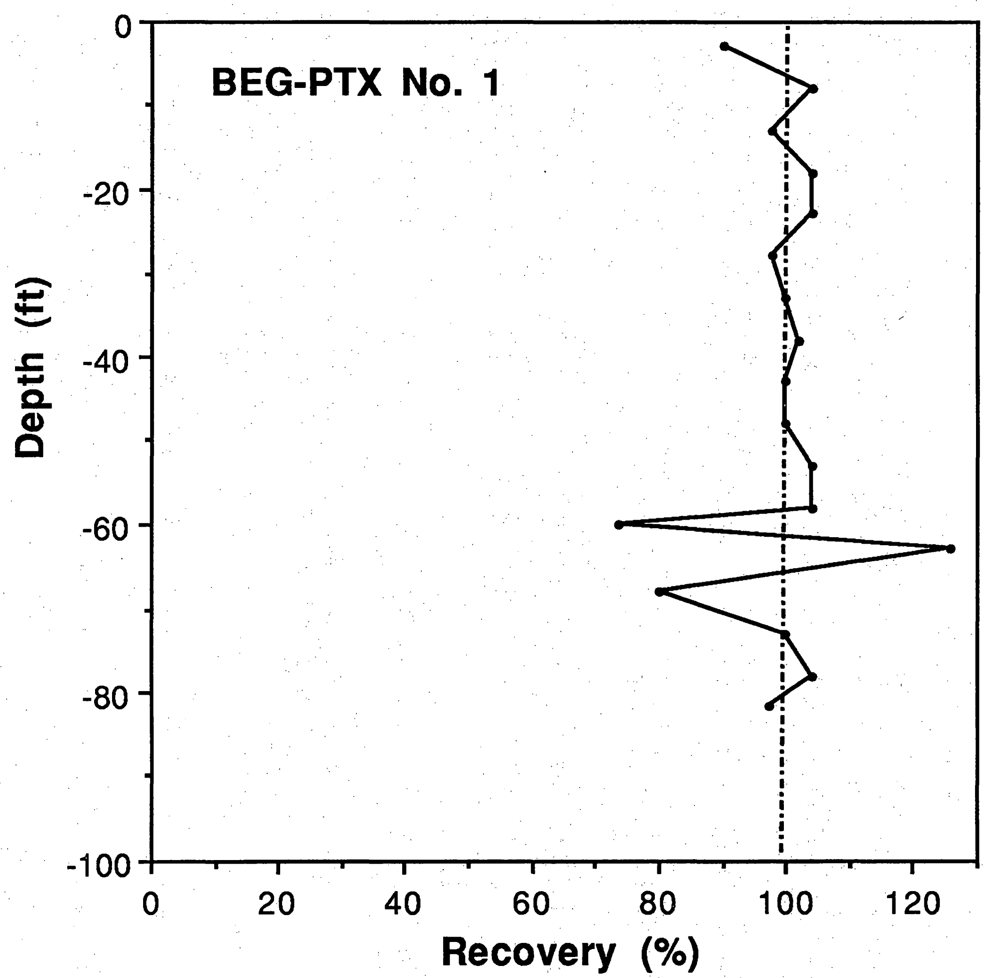

Figure 4. Recovery rates achieved while drilling BEG-PTX No. 1.

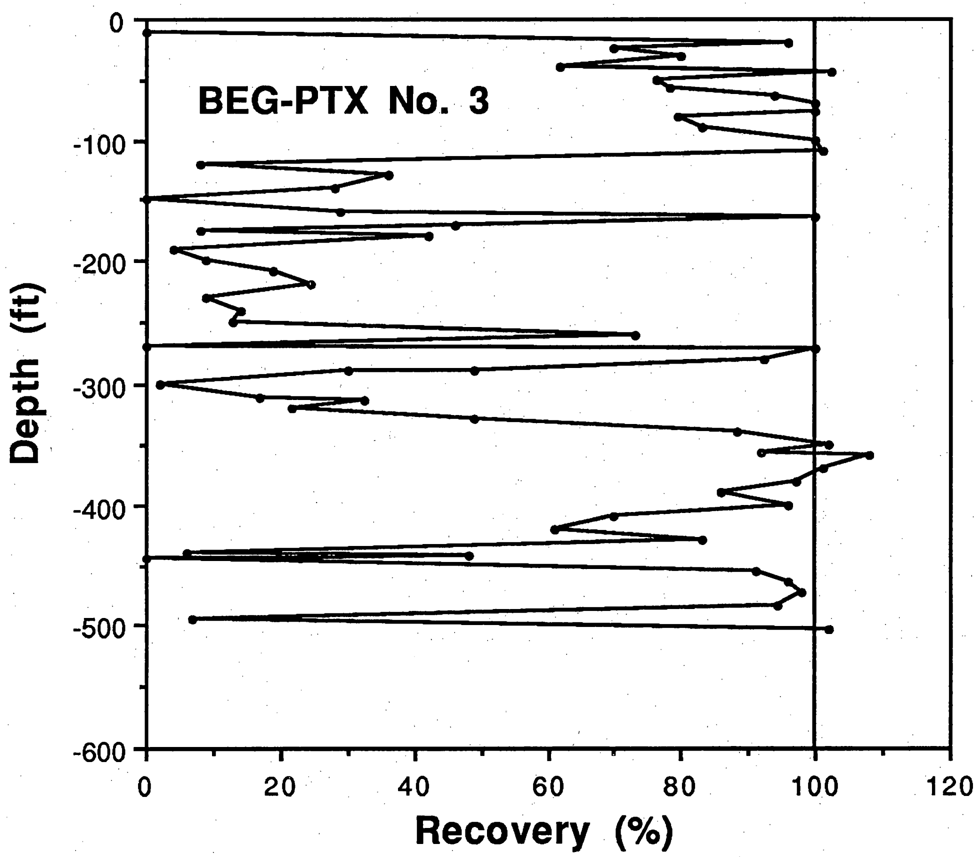

Figure 5. Recovery rates achieved while drilling BEG-PTX No. 3.

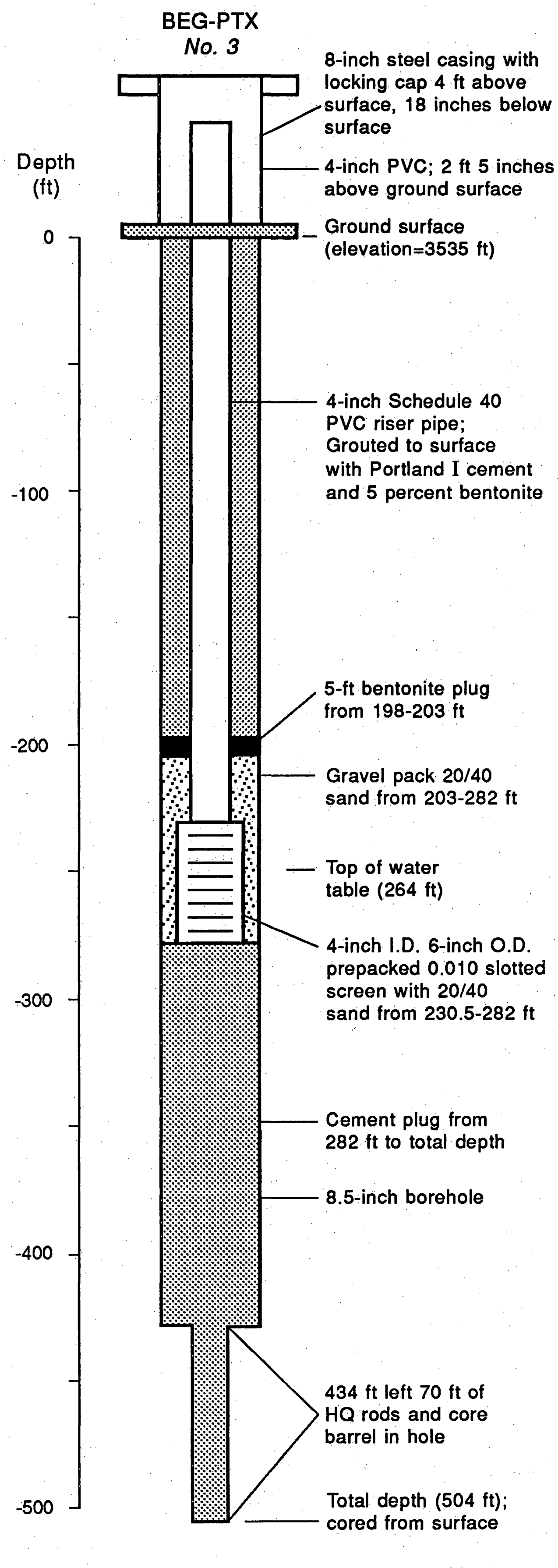

Figure 6. Schematic diagram of BEG-PTX No. 3.

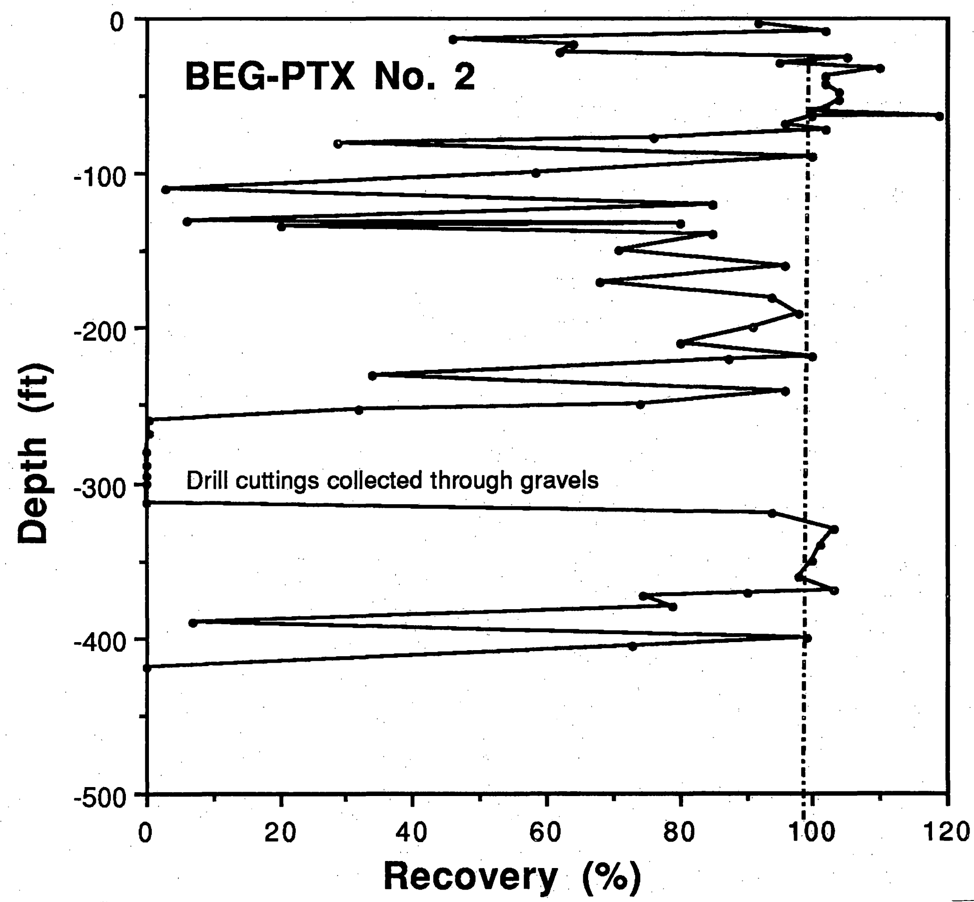

Figure 7. Recovery rates achieved while drilling BEG-PTX No. 2.

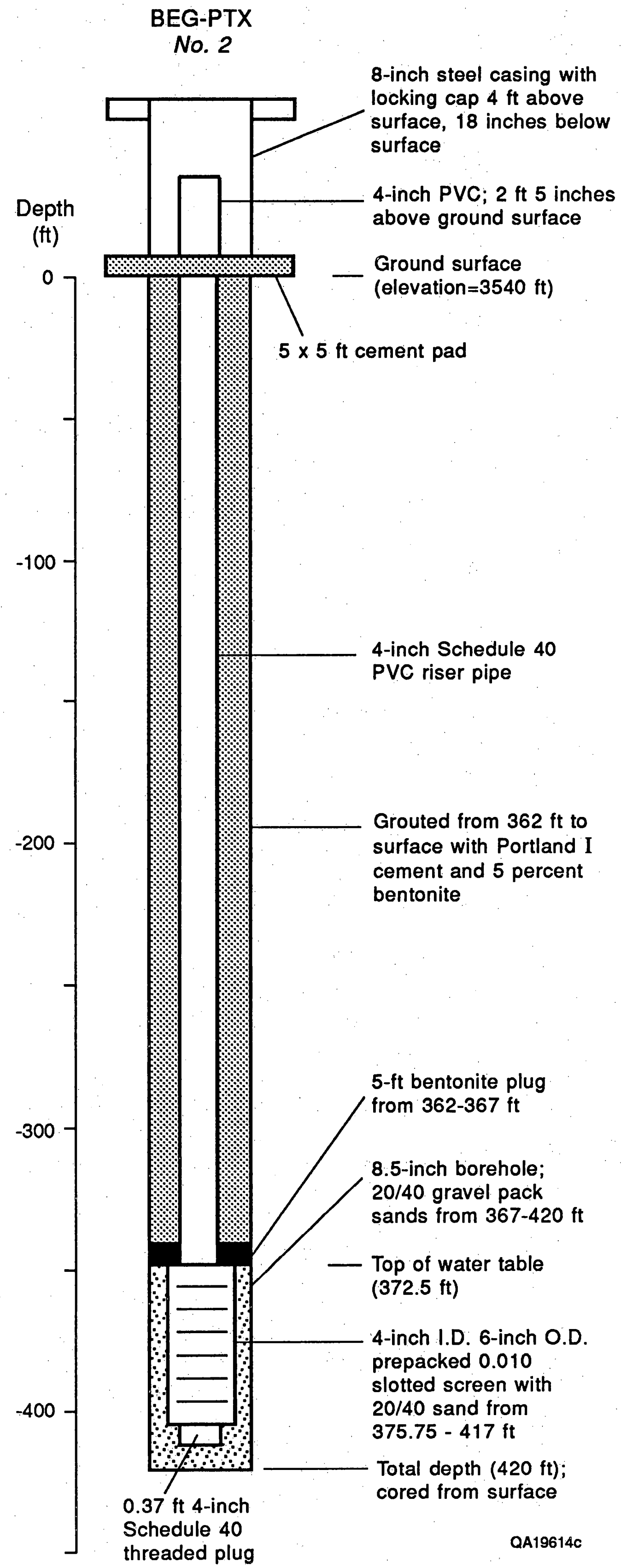

Figure 8. Schematic diagram of BEG-PTX No. 2.