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7. Abstract

This document presents the revised groundwater monitoring plan for two Resource Conservation and Recovery Act sites in the 100-N Area: the 1301-N and 1325-N Liquid Waste Disposal Facilities. Detection monitoring will be reinstated at the 1301-N facility; its monitoring program will essentially start over with four quarters of baseline monitoring. The 1325-N program will continue under detection monitoring with semiannual sampling. The network will be modified and one additional well will be installed downgradient of the 1325-N facility to replace wells that have gone dry.

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GROUNDWATER MONITORING PLAN FOR THE 1301-N AND 1325-N LIQUID WASTE DISPOSAL FACILITIES

1.0 INTRODUCTION

This document presents groundwater monitoring plans for two *Resource Conservation and Recovery Act of 1976* (RCRA) hazardous waste sites: the 1301-N Liquid Waste Disposal Facility (LWDF) and the 1325-N LWDF. This monitoring plan is based on requirements for interim-status units, as defined by the RCRA and amended by the Hazardous and Solid Waste Amendments of 1984. These regulations are promulgated by the U.S. Environmental Protection Agency (EPA) in 40 CFR 265, Subpart F, as implemented by the Washington State Department of Ecology (Ecology) in WAC 173-303-400.

Groundwater monitoring was begun at the 1301-N and 1325-N LWDFs in December 1987. The 1325-N LWDF is currently monitored under an indicator evaluation program (40 CFR 265.92). After the first year of groundwater monitoring at the 1301-N LWDF and the nearby 1324-N/NA sites, specific conductance in some downgradient wells was found to be elevated above background (i.e., upgradient) levels. Groundwater quality assessment programs were initiated at these two sites (Gilmore and Jensen 1989; Gilmore 1989). The assessment programs found no evidence that hazardous waste or hazardous waste constituents from the 1301-N or 1324-N/NA sites have entered the groundwater (Hartman 1992b). The groundwater monitoring program at the 1301-N site will revert to an indicator parameter monitoring program, as described in 40 CFR 265.93(d)(6). The monitoring program for the 1324-N/NA site will be described in a separate document, to be released in 1993.

The purpose of this plan is to present indicator evaluation groundwater monitoring programs that will detect adverse impacts of the 1301-N or 1325-N LWDF on the quality of the groundwater in the uppermost aquifer beneath the site [40 CFR 265.93(d)]. This plan describes the methods that will be used to perform the following:

- Further characterize site hydrogeology
- Determine whether any hazardous constituents are detectible in the groundwater beneath the site
- Modify existing networks to improve monitoring efficiency, including installing one new well.

2.0 BACKGROUND INFORMATION

This section describes the 1301-N and 1325-N LWDFs, waste characteristics, and hydrogeology of the region and the site. References for further information include the following:

- Closure/Postclosure Plan for the 1301-N LWDF (DOE 1987b)
- Closure/Postclosure Plan for the 1325-N LWDF (DOE 1987c)
- Preliminary safety analysis report for a proposed power plant near the 100-N Area (WPPSS 1974)
- Waste Stream Characterization Report (WHC 1989) and N Reactor Stream-Specific Report (WHC 1990)
- RCRA quarterly progress reports (e.g., Smith et al. 1990)
- RCRA annual progress reports (e.g., Smith and Gorst 1990)
- Groundwater quality assessment plans for the 1301-N and 1324-N/NA sites (Gilmore and Jensen 1989; Gilmore 1989)
- Results of groundwater quality assessment monitoring at the 1301-N and 1324-N/NA sites (Hartman 1992b).

2.1 PHYSICAL DESCRIPTION AND WASTE CHARACTERISTICS

The 1301-N and 1325-N sites are located in the 100-N Area of the Hanford Site in southeastern Washington (Figure 2-1). This section describes the LWDFs and the characteristics of the waste discharged to them. Waste streams are described in more detail in WHC (1989) and WHC (1990).

2.1.1 1301-N Liquid Waste Disposal Facility

The 1301-N LWDF consists of an unlined, concrete basin connected to a long, zig-zagged trench covered with concrete slabs. The basin is 290 ft long and 125 ft wide. The trench is 1,600 ft long, 50 ft wide, and 12 ft deep. The LWDF was used to dispose of radioactive waste water generated in the N Reactor from 1963 until 1985. Discharge volume averaged 1,700 gal/min. From 1983 until August 1985, waste was split between the 1301-N LWDF and the newer 1325-N LWDF. In 1985, all of the waste was routed to the 1325-N LWDF, and the 1301-N LWDF was taken out of use. The 1301-N LWDF is described more fully in DOE (1987b).

Wastes discharged to the 1301-N LWDF primarily were radioactive fission and activation products, including cobalt-60, strontium-90, and cesium-137. Small quantities of nonradioactive hazardous wastes were also discharged to the units. Constituents discharged to the 1301-N LWDF included hydrazine, ammonium hydroxide, diethylthiourea, sodium dichromate, morpholine, phosphoric

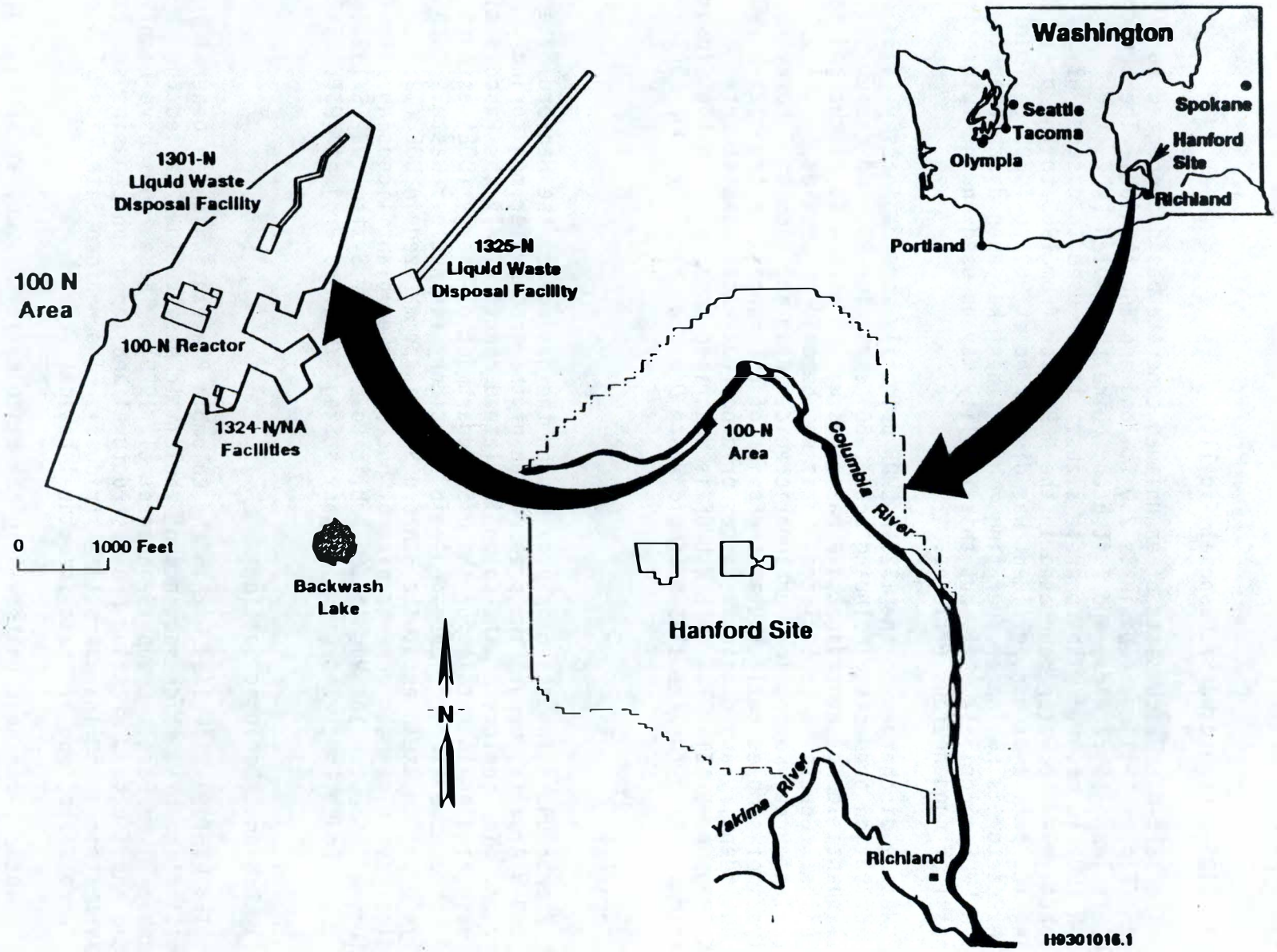

Figure 2-1. Location of the 100-N Area and the Hanford Site, Washington.

acid, lead, and cadmium. However, analyses of samples collected at the point of discharge into the 1301-N LWDF did not identify any dangerous wastes (DOE 1987b, p. 3-1).

2.1.2 1325-N Liquid Waste Disposal Facility

The 1325-N LWDF consists of an unlined concrete basin connected to a long trench (Figure 2-1). The basin is 250 ft long and 240 ft wide. The trench is 3,000 ft long, 55 ft wide, and 7 ft deep. Like the 1301-N LWDF, the 1325-N LWDF is covered with concrete slabs. It was used to dispose of radioactive waste water generated in the N Reactor from 1983 to the present. During its period of use, effluent was discharged at 900 to 1,600 gal/min. The N Reactor is no longer operating. No effluent has been discharged to the 1325-N LWDF since late 1991, but this facility may be used in the future for disposal of nondangerous effluent.

Wastes discharged to the 1325-N LWDF primarily were radioactive fission and activation products, including cobalt-60, strontium-90, and cesium-137. Small quantities of nonradioactive hazardous wastes were also discharged to the units. Constituents included hydrazine, ammonium hydroxide, diethylthiourea, morpholine, phosphoric acid, lead, and cadmium. However, analyses of samples collected at the point of discharge into the 1325-N LWDF did not identify any dangerous wastes or dangerous waste constituents (WHC 1990, p. 5-15). The 1325-N LWDF is described more fully in the *Closure/Postclosure Plan for the 1325-N Liquid Waste Disposal Facility* (DOE 1987c).

2.2 GEOLOGY

Background information is provided on the geology of the Hanford Site and the 100-N Area to support the preparation of the groundwater monitoring programs. The geology of the Columbia Plateau, particularly the Pasco Basin, has been studied in detail for the U.S. Department of Energy (DOE) as part of the siting studies for a deep geologic repository for nuclear waste. Much of the information known about the Hanford Site is summarized in DOE (1988). Studies have also been done as part of nuclear power plant licensing efforts, including those for the Washington Public Power Supply System (WPPSS 1981) and the Puget Sound Power and Light Company's Skagit/Hanford Project (PSPL 1982).

2.2.1 Regional Geologic Setting

The Hanford Site lies within the Columbia Plateau, which is generally characterized by a thick sequence of tholeiitic basalt flows called the Columbia River Basalt Group (Swanson et al. 1979). These flows have been folded and faulted, creating broad structural and topographic basins separated by asymmetric anticlinal structures (ridges). The Hanford Site lies within the Pasco Basin, one of these structural basins.

Principal geologic units within the Pasco Basin include, in ascending order, the Columbia River Basalt Group and interbedded sediments of the Ellensburg Formation (Miocene), the Ringold Formation (Miocene-Pliocene), the Plio-Pleistocene unit (pedogenic calcrete and alluvial deposits), the early

"Palouse" soil (windblown sand and silt), and the Hanford formation (Pleistocene). A regionally discontinuous veneer of recent alluvium, colluvium, and/or eolian sediments overlies the principal geologic units.

2.2.2 Geology of the 100-N Area

Details of the geology beneath the individual waste sites in the 100-N Area are limited because the wells in the area are shallow, and most borehole logs, completed by the drillers, are very general. Therefore, it is more appropriate to discuss the geology of the 100-N Area as a whole rather than the individual RCRA sites. Summary lithologic logs for selected wells are presented in Appendix A.

The geologic interpretations contained in this plan are primarily based on data collected prior to 1990. The main sources of information are borehole records from DOE activities around the 100-N Area and nuclear power plant siting activities conducted by the Washington Public Power Supply System (Supply System) for the initial location of Nuclear Power Plant #1 at the 100-N Area (WPPSS 1974). Borehole data include drillers' logs and geologists' logs based on drill cuttings from shallow boreholes drilled by the cable-tool method, and data obtained from deep, cored boreholes located near the 100-N Area during the Supply System nuclear power plant siting. Core samples from two of the Supply Systems' boreholes were re-examined by Dr. Kevin Lindsey of Westinghouse Hanford Company Geosciences. Dr. Lindsey's interpretations of those boreholes are used in this plan.

2.2.2.1 Data Coverage. Most of the approximately 70 boreholes in the 100-N Area penetrate less than the upper 100 ft of the stratigraphic section. Five boreholes near the 100-N Area penetrate the entire suprabasalt sediment package (Figure 2-2). One of these boreholes, 699-86-60, was drilled using a cable-tool rig; the driller's log is complete to the top of the Columbia River Basalt Group. The other four deep boreholes were drilled by the Supply System and are documented in WPPSS (1974). Three of the boreholes, 699-84-59 (called BH-16 in the Supply System report), 699-81-62 (BH-17), and 699-86-64 (BH-18) were cored through the suprabasalt sequence and into the Asotin Member of the Saddle Mountains Basalt. The other deep borehole, 699-84-62A (BH-1), is a rotary-drilled hole to the top of basalt.

2.2.2.2 Site Stratigraphy. Principal stratigraphic units of the 100-N Area are described below, oldest to youngest.

2.2.2.2.1 Columbia River Basalt Group. The cored boreholes that penetrate the Columbia River Basalt Group near the 100-N Area encountered the following members of the Saddle Mountains Basalt: the Elephant Mountain Member, the Pomona Member, the Wilbur Creek Member, and the Asotin Member. The entire basalt stratigraphy of the area is known from a borehole east of the site and another borehole north of the site in the Saddle Mountains. It is estimated that more than 12,000 ft of Columbia River basalt exists beneath the 100-N Area (Reidel et al. 1989).

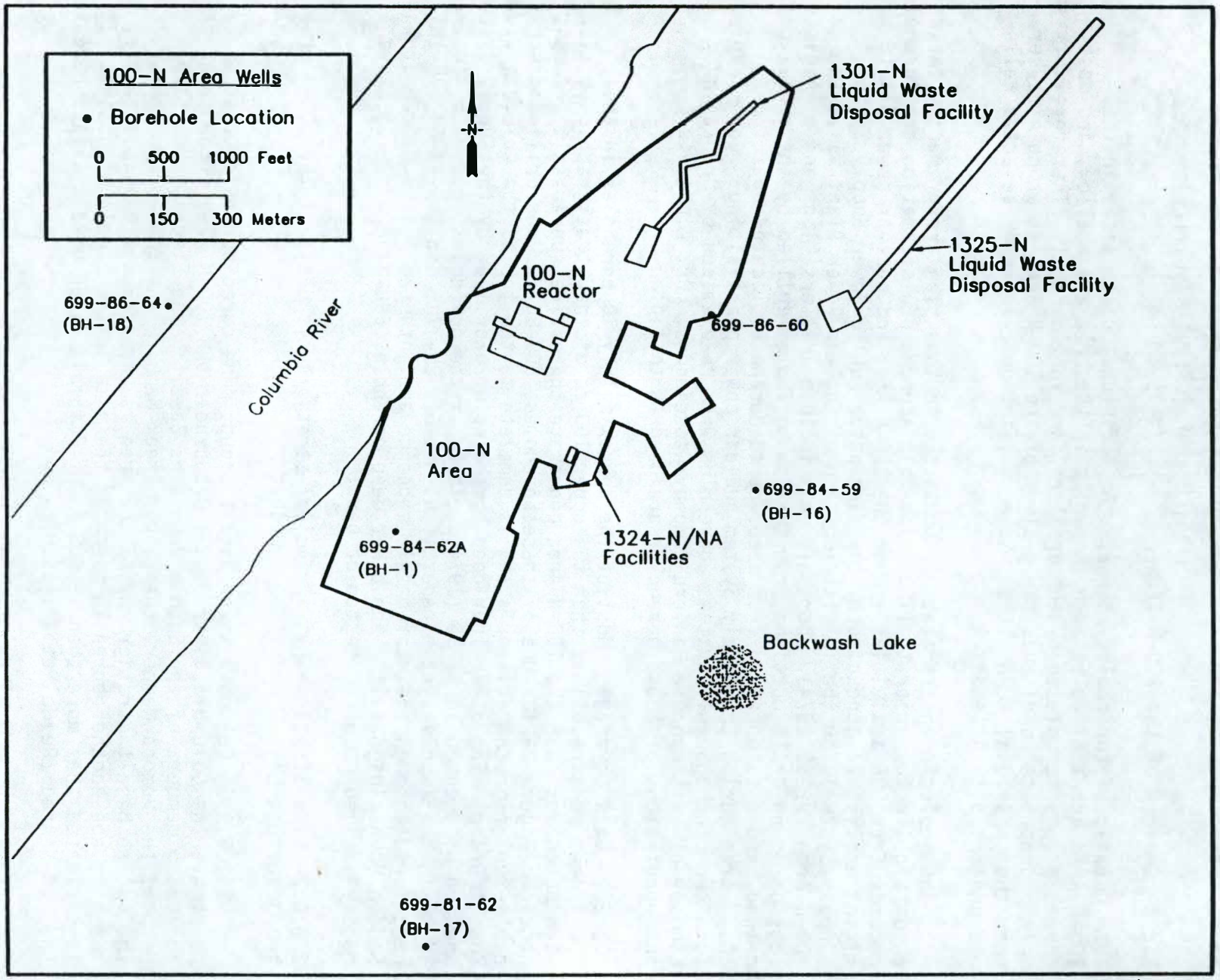

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Figure 2-2. Locations of Washington Public Power Supply System Boreholes Near the 100-N Area.

The 100-N Area lies above a buried course of the ancestral Clearwater-Snake River that existed during the Saddle Mountains time (Reidel and Fecht 1981). This channel developed along flow margins that controlled the river channel and the path of several basalt flows as well.

2.2.2.2.2 Ellensburg Formation. In the 100-N Area, very little is known about the nature of the Ellensburg Formation. The three cored boreholes near the 100-N Area that penetrate the Ellensburg Formation indicate the principal lithologies are sandstones, siltstones, and claystones, with minor conglomerates throughout the section. These deposits probably represent channel deposits and overbank deposits related to the ancestral Clearwater-Snake River system. The uppermost unit of the Ellensburg Formation at the 100-N Area is the Rattlesnake Ridge Interbed.

2.2.2.2.3 Ringold Formation. The fluvial-lacustrine Ringold Formation was deposited in the basins and generally east-west-trending valleys by the ancestral Columbia River and its tributaries in response to development of the Yakima Fold Belt. Although exposures of the Ringold Formation are limited to the White Bluffs east of the 100-N Area and to Smyrna and Taunton Benches north of the Saddle Mountains, data on the Ringold Formation are available from the three cored boreholes and two rotary boreholes near the 100-N Area (Figure 2-2).

The Ringold stratigraphy is best described in the 100-N Area in terms of facies types. At the 100-N Area, the Ringold Formation consists predominantly of interstratified clays, silts, sands, and paleosols. Thin gravels occur near the top and bottom of the Ringold section.

A cross section through the 100 Areas (Figure 2-3), developed from three cored boreholes and two rotary holes, illustrates the distribution of sediment types in the subsurface. The Ringold Formation is approximately 450 ft thick at the 100-N Area but thins to 422 ft across the Columbia River to the west (at borehole 699-86-64). This may reflect erosion caused by the Columbia River, perhaps prior to the Pleistocene catastrophic flooding.

Geologic data for the Ringold Formation in the 100-N Area are sparse, and in many cases available data have not been evaluated in detail. The following is a general summary of Ringold characteristics that appear to be consistent across the 100-N site. The units are discussed oldest to youngest.

- Pebbly conglomerate or gravel--This unit overlies the Elephant Mountain Member of the Saddle Mountains Basalt of the Columbia River Basalt Group. The gravel is cemented and is generally less than 20 ft thick.

- Laminated deposits of clay and silt--This unit is approximately 130 ft thick and appears to be relatively uniform across the 100 Areas.

- Silty to clayey sands--This unit is approximately 80 to 100 ft thick. Some tuffaceous ash beds can be locally correlated from borehole to borehole with the present data. A few fine- to medium-grained sandstones are present in this unit.

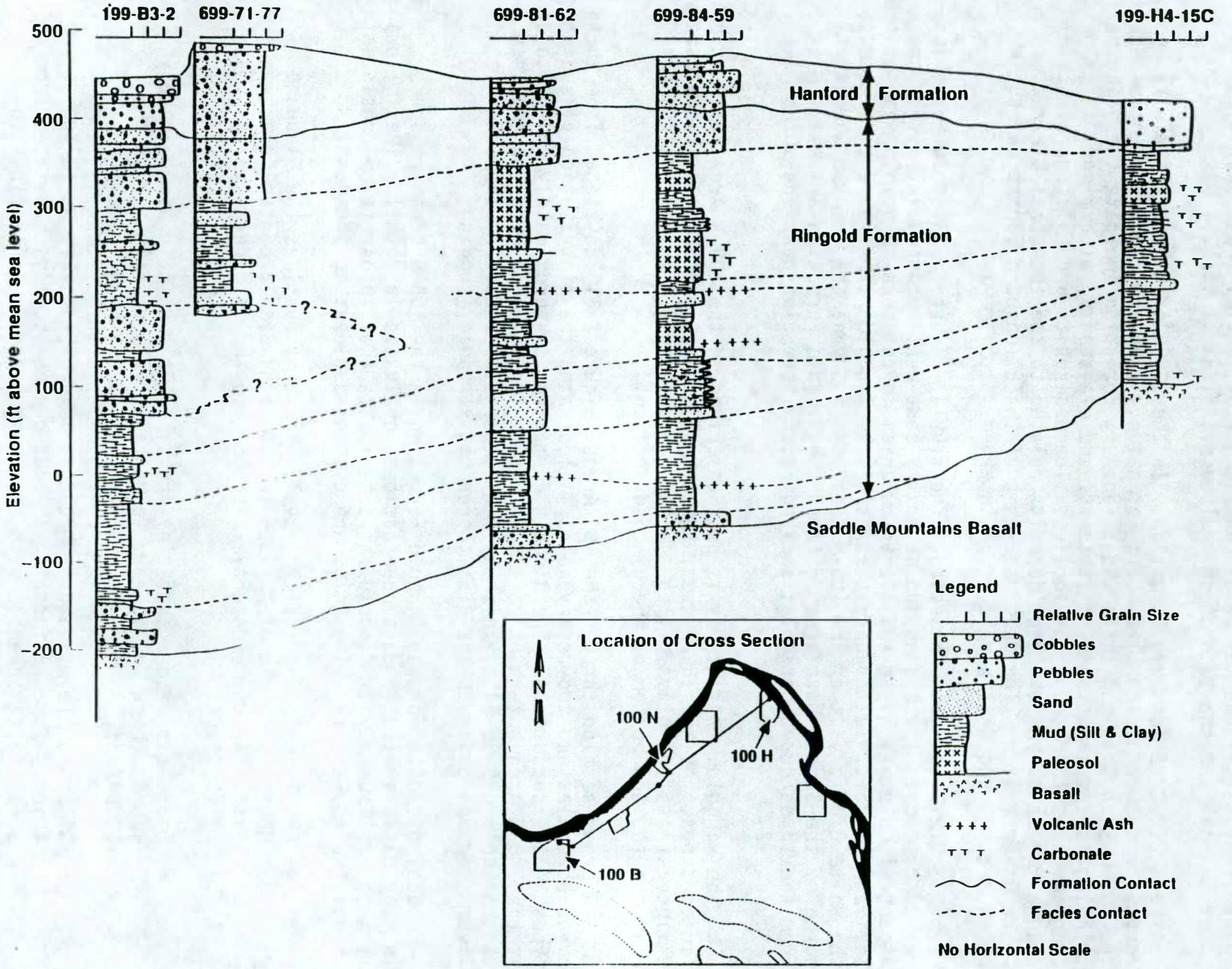

Figure 2-3. Geologic Cross Section through the 100 Areas. (Geologic Interpretation by Dr. K. A. Lindsey)

- Interstratified clays, silts, sands, and paleosols--This sequence is approximately 200 ft thick and is laterally and vertically variable. The lower two-thirds of this unit generally contains more sand than the upper third. Tuffaceous ash beds are present. The most distinctive units within this sequence are a series of paleosols. The paleosols are commonly distinguished by an increase in calcium carbonate content.

- Sandy gravel--This unit is approximately 50 to 60 ft thick and is relatively uniform across the site.

The contact between the Ringold Formation and the overlying Hanford formation is normally distinguished on the Hanford Site using two criteria: the well-indurated nature of the Ringold Formation compared to the Hanford formation, and the dominance of quartzo-feldspathic material in the Ringold Formation compared to basaltic material in the Hanford formation. At the 100-N Area, the top of the Ringold Formation is not much more indurated than the Hanford formation. However, the composition of the sands and gravels is different in the two units. The Hanford/Ringold contact is recognizable in the field as a color change (the Hanford formation is black or grey; the Ringold Formation is tan or brown).

2.2.2.2.4 Post-Ringold Pre-Pleistocene. In the 100-N Area, no paleosols are preserved at the top of the Ringold Formation, but exposures along the Columbia River near the site attest to the significant amount of erosion that occurred in post-Ringold pre-Pleistocene time. The entire upper Ringold Formation that forms the "White Bluffs" along the Columbia River has been removed from the 100-N Area. Total amount of erosion of the Ringold Formation at the 100-N Area may be up to 400 ft.

2.2.2.2.5 Quaternary Deposits. Quaternary deposits on the Hanford Site include the Hanford formation (informal name), and alluvium. The Hanford formation represents proglacial flood deposits, primarily from the late Pleistocene. Alluvial deposits include river deposits, landslides, and wind-blown loess and sand.

The Hanford formation in the 100-N Area comprises mainly sands and gravels, termed the Pasco gravels. There appears to be a general coarsening downward, but no detailed work has been done in the area. The unit is approximately 40 to 60 ft thick. Northeast of the 100-N Area are mounds consisting of poorly sorted gravels, which represent megaripples (10 to 20 ft in amplitude) resulting from the catastrophic floods.

Other Quaternary deposits in the 100-N Area comprise Holocene sediments and minor amounts of wind-blown silt and sand.

The elevation of the Hanford-Ringold contact and, where known, the base of the uppermost aquifer, are listed in Table 2-1.

Table 2-1. Elevation of Geologic Units at 100-N Area RCRA Sites.

Site	Elevation of surface (ft msl)	Elevation Hanford/Ringold contact (ft msl)	Elevation top of fine-grained unit (ft msl) and no. of wells
1301-N	450 to 460	394 to 417	350 to 360 (4)
1325-N	450 to 460	406 to 415	350 (1)

2.2.2.3 **Structural Geology and Seismicity.** Very little information is available on the structure of the 100-N Area, resulting primarily from the lack of surface exposures and the sparsity of deep borehole information. The 100-N Area is located on the south-dipping limb of the south side of the Saddle Mountains anticline, just north of the axis of the Wahluke syncline. No data are available to indicate folding of the Ringold Formation at the site. There is no evidence to indicate that any boreholes around the 100-N Area penetrate a fault.

No significant seismic activity has been recorded at the 100-N Area. An area of shallow micro-earthquake activity, the Coyote Rapids swarm area, is located west of the area. The area has been the site of several swarms since 1969, when instrumental monitoring of this area began.

2.3 HYDROGEOLOGY

This section provides background information on the hydrogeology of the Hanford Site and the 100-N Area. Detailed descriptions of the Hanford Site hydrogeology are available in reports by DOE (1988) and Gephart et al. (1979).

2.3.1 Regional Setting

The Hanford Site lies within a semiarid climatic zone that commonly has warm, dry summers and cool winters. Mean precipitation is 6.3 in. (DOE 1988). Climate, evapotranspiration, and natural recharge were studied by Stone et al. (1983), Wallace (1977), Gee (1987), and Routson et al. (1988).

Groundwater beneath the Hanford Site occurs under unconfined and confined conditions. The unconfined aquifer is contained primarily within the lower portion of the Hanford formation and in the Ringold Formation. Figure 2-4 illustrates the water table in the northern portion of the Hanford Site. The base of the regional unconfined aquifer is the basalt surface. In some locations fine-grained sediments in the Ringold Formation act as confining layers for underlying coarse-grained sediments. Deeper confined aquifers beneath the Hanford Site include sedimentary interbeds and interflow zones that occur between dense basalt flows of the Columbia River Basalt Group.

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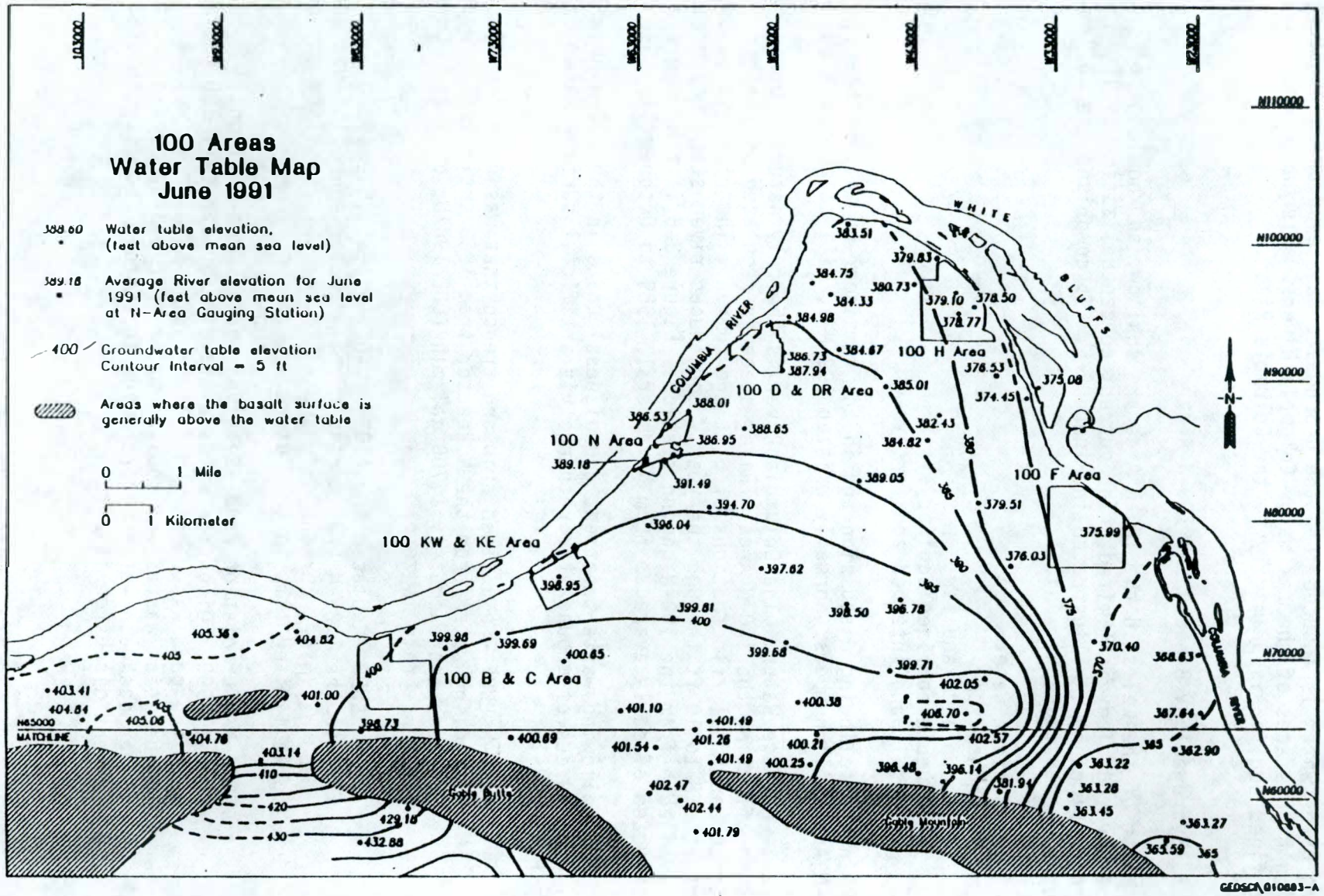
Figure 2-4. Water Table in the Northern Portion of the Hanford Site, June 1991.



The major sources of natural recharge to the unconfined aquifer are rainfall and runoff from areas of high relief bordering the Hanford Site, ephemeral streams in the Cold Creek and Dry Creek valleys, and localized areas where river water is induced into the groundwater as temporary bank storage during high stages of the Yakima or Columbia Rivers. Discharge from the unconfined aquifer is primarily to the Columbia River.

2.3.2 Hydrogeology Beneath the 100-N Area

Most of the wells in the 100-N Area are shallow, so knowledge of the deeper hydrogeology is limited. The current conceptualization of 100-N Area hydrostratigraphy is illustrated in Figure 2-5. It comprises the following major hydrostratigraphic units:

- Surface water
- Vadose zone
- Unconfined aquifer
- Ringold confined aquifer system
- Basalt and interbed aquifer system.

In the following discussion and in the remainder of this document, 100-N Area well numbers, normally written 199-N-#, will be abbreviated N-#.

2.3.2.1 Surface Water. The Columbia River is the only natural surface water feature affecting the 100-N Area. River stage is regulated by the dams upstream, and daily fluctuations of 6 ft are common. The river stage usually fluctuates 8 to 10 ft through the year. Continuous river stage measurements are available from the 100-N gaging station. Figure 2-6 is a hydrograph constructed of daily averages from November 1, 1989 to October 31, 1990.

The following waste treatment and disposal units in the 100-N Area have provided sources of groundwater recharge via artificial surface-water bodies (see Figure 2-1):

- 1301-N LWDF--An unlined crib and trench that was used for disposal of cooling water from the N Reactor from 1963 until 1985. Discharge rate was approximately 1,700 gal/min (DOE 1987b, p. 3-1). Current discharge rate is zero.

- 1325-N LWDF--Replaced the 1301-N LWDF in 1985 (DOE 1987c). Total flow to the 1325-N LWDF during normal reactor operation was 900 to 1,600 gal/min. Current discharge is zero; this facility may be used for a limited time in the future.

- 1324-NA Percolation Pond--Received wastes from 1977 until August 1990. Discharge rates averaged approximately 300 gal/min when the pond was receiving filter backwash water as well as regeneration wastes and cooling water (DOE 1987a, p. 4-4). The filter backwash water was rerouted to another facility in 1983. Current discharge is zero.

Figure 2-5. Conceptual Drawing of Hydrogeologic Units in the 100-N Area.

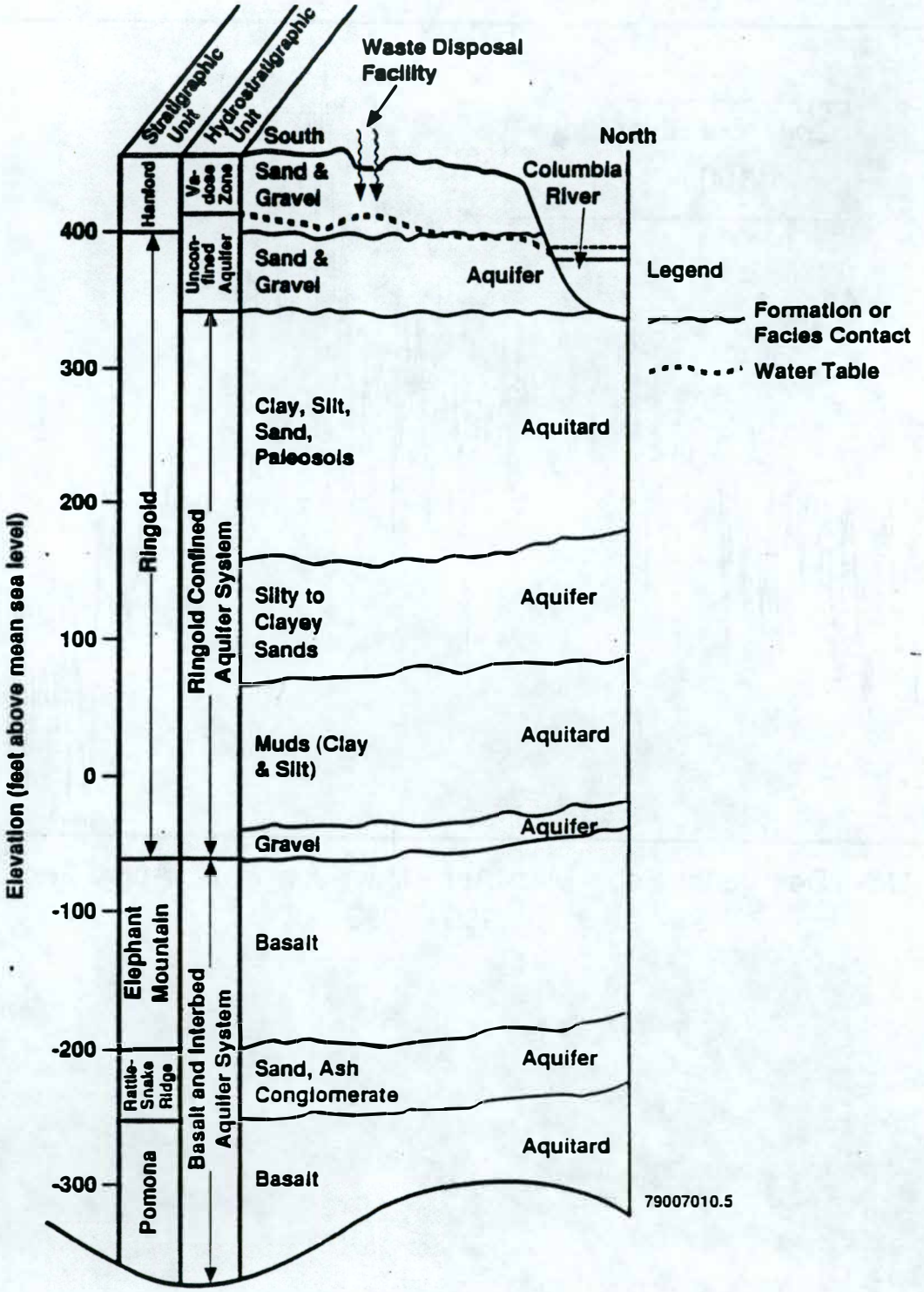
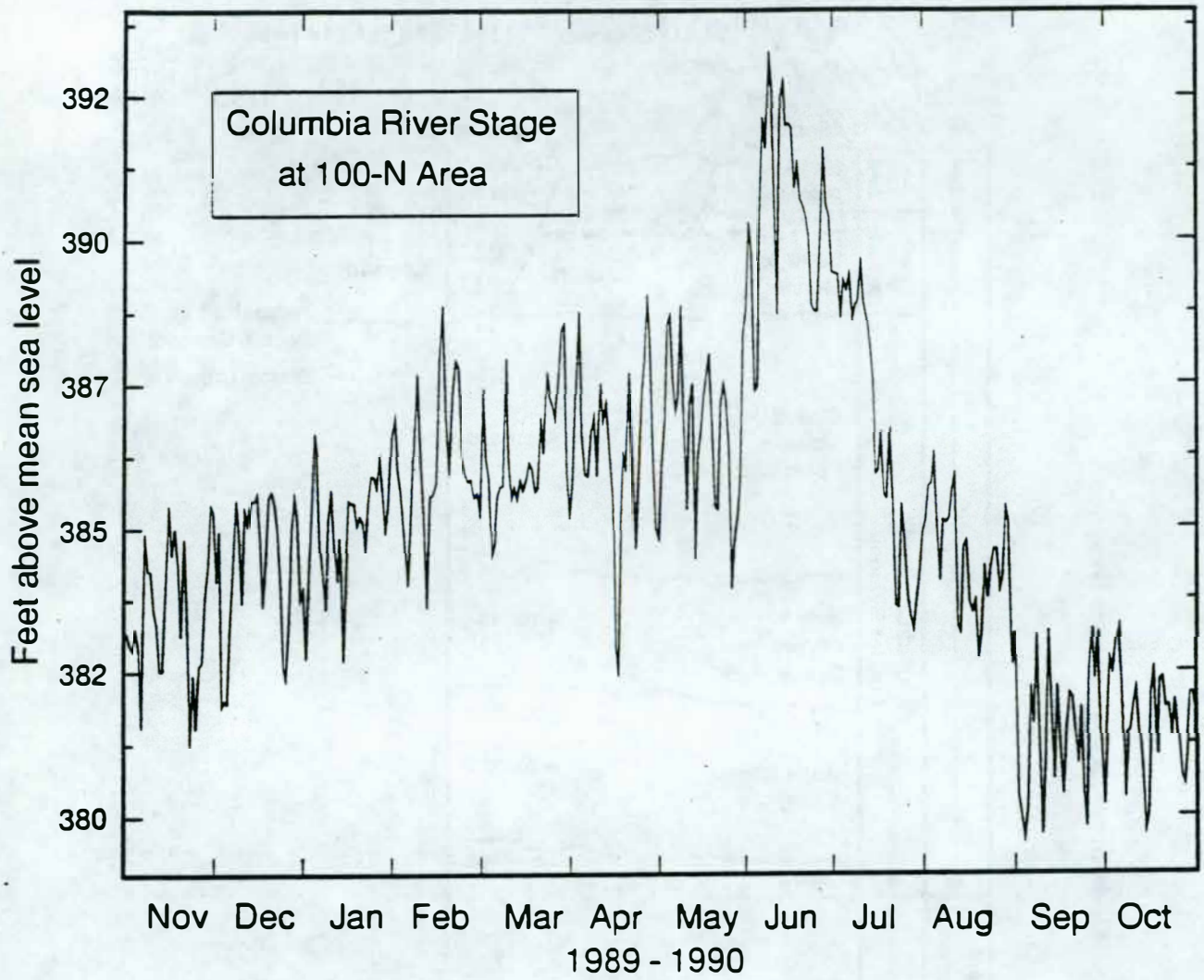


Figure 2-6. Hydrograph of the Columbia River at the 100-N Gaging Station, November 1989 through October 1990 (daily averages of 1- to 2-hour measurements).



- Backwash Lake--Disposal site for nonregulated waste from the 183-N Filtered Water Plant. Has received influent since 1983. Estimated volume of discharge averaged 300,000 gal/day (DOE 1987b, p. 4-4). Current and expected future discharge rate averages approximately 11 gal/min.

These water bodies recharged the uppermost aquifer, forming mounds in the water table at various locations in the 100-N Area in the past.

When groundwater mounds are not present in the 100-N Area, water flows from the unconfined aquifer into the river. At times of high river stage, however, water may flow from the river into the aquifer. This reversed gradient occasionally extends as far inland as the 1301-N LWDF.

Groundwater enters the Columbia River in the 100-N Area via a series of seeps, known collectively as "N-Springs." They are located along the right bank of the Columbia River adjacent to the 1301-N LWDF and extend approximately 1.7 mi downstream. These seeps, particularly those located nearest the 100-N Area, appear to be related to increased groundwater levels resulting from effluent discharge to the ground. Now that effluent discharge has virtually ceased, there are fewer seeps, and they flow at a lower rate. Bank storage discharging back to the river also contributes to N-Springs. Water samples from N-Springs are analyzed annually. Perkins (1989) describes the results of 1988 sampling of N-Springs. The prominent radionuclides included tritium, cobalt-60, strontium-90, and antimony-125. Recent sampling of N-Springs occurred during September and October 1991 (DOE 1992b).

2.3.2.2 Vadose Zone. The vadose zone beneath the 100-N Area comprises primarily unconsolidated sediments of the Hanford formation. This highly permeable unit is composed mainly of cobbles, boulders, gravel, and coarse sand. Drilling data indicate that isolated lenses of silty sand and gravel are also present. The vadose zone also includes the top few feet of the Ringold Formation in some parts of the 100-N Area. These sediments are similar to the Hanford formation: sands, gravels, and cobbles, with varying fractions of silt.

Some perched water was noted during drilling of well N-35 at a depth of approximately 30 ft. Well N-35, located immediately adjacent to the 1325-N crib, was installed after effluent disposal to that unit had begun.

The vadose zone in the 100-N Area ranges in thickness from 0 ft at the Columbia River to approximately 70 ft in the eastern part of the site. The thickness of the vadose zone beneath the 100-N Area RCRA sites is 60 to 70 ft. Soil moisture data for the 100-N Area are limited and range from 1 to 3% (Hartman 1992a).

2.3.2.3 Unconfined Aquifer. The unconfined aquifer in the 100-N Area comprises primarily the upper part of the Ringold Formation. In some locations the bottom portion of the Hanford formation was also saturated when groundwater mounds were present. The base of the aquifer is believed to be a laterally continuous clay-rich unit containing a series of paleosols. Lithologies in this unit are believed to range from clay and silt to sand. Most of the wells in the 100-N Area were completed at the water table; therefore, the thickness of the clay-rich unit is not known precisely at all

locations. It is not known whether the clay unit fully isolates the shallow aquifer from the underlying units. There may be hydraulic communication between water-bearing units in the Ringold Formation.

The unconfined aquifer is approximately 40 to 50 ft thick. Information on the 100-N Area hydrogeology is summarized from well log data, aquifer test results, water table maps, and various published reports.

2.3.2.3.1 Hydraulic Properties. Data on hydraulic properties of the unconfined aquifer in the 100-N Area are limited, and most of the available data are concentrated around the 1325-N LWDF. Aquifer test results are summarized in Table 2-2 and are discussed below (Figure 2-7 for well locations).

Three 24-hour, constant-rate pumping tests were conducted in wells N-27, N-30, and N-32. These wells are all completed in sandy gravel at the top of the Ringold Formation. Analysis of the data indicates there are apparently boundary effects in some of the wells. Calculated transmissivities are summarized in Table 2-2, and additional information is presented in Appendix B.

A series of constant discharge pumping tests were conducted on several wells in the 100-N Area in 1988. These tests were conducted for Westinghouse Hanford Company by Pacific Northwest Laboratory. The results are summarized below. Data sheets and/or plots are presented in Appendix B.

Wells N-62, N-63, N-64, and N-65 were tested in May and June 1988 during installation of a monitoring system at the 1312 Liquid Effluent Retention Facility (Figure 2-7). Most of the tests were fraught with variations in pumping rates, causing most of the data to be erratic and uninterpretable. However, a 6-hour test in well N-62 was somewhat more successful. The test was conducted in a gravelly sand of the Ringold Formation. Data from this test are presented in Appendix B[1]; transmissivities are listed in Table 2-2.

Aquifer tests were also conducted in wells N-69 and N-70 in June 1988. Well N-67 was used as an observation well for well N-69; well N-39 served as the observation well for well N-70. It is important to note that the pumping wells are deeper than the observation wells. Thus, the results may not represent true horizontal transmissivity. A discussion of the tests is included in Appendix B. Results are summarized in Table 2-2.

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[1]Results of the pumping test in well N-64 were cited in PNL (1988), which gives a transmissivity value of 7,751 ft^2/d. However, drawdown and recovery data for this test were very erratic. Results of the aquifer tests in wells N-62, N-63, and N-65 were not summarized in any of the quarterly reports.

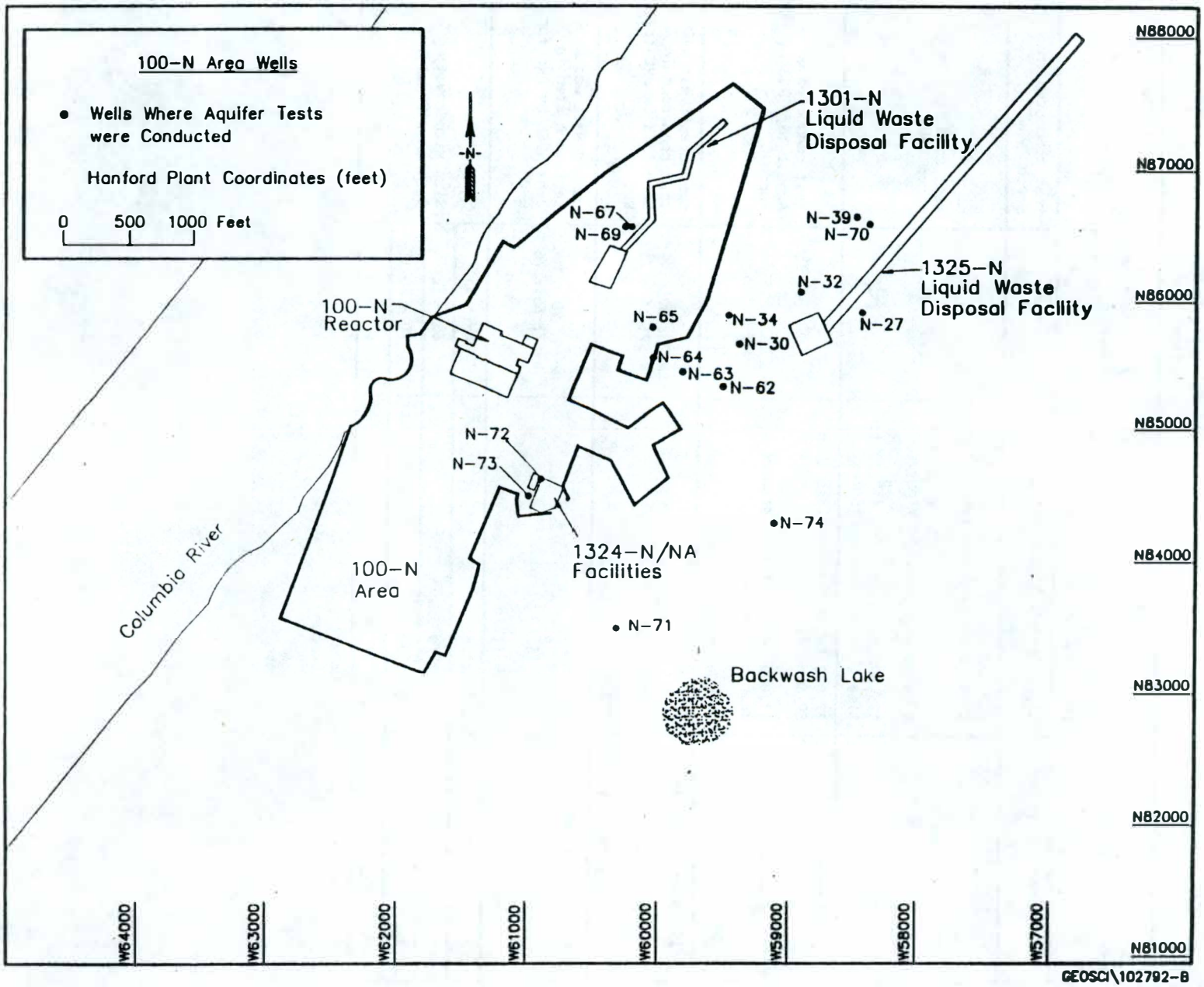


Figure 2-7. Aquifer Test Well Locations.

Table 2-2. Summary of Transmissivity Data for the 100-N Area.

Well number	Transmissivity	Depth of tested zone (ft below surface)	Comments
N-34 (observation well)	196,216 gpd/ft (26,000 ft^2/d) for time between 200 and 600 minutes 111,692 gpd/ft (15,000 ft^2/d) for time greater than 600 minutes	N-30: 58 - 78 N-34: 58 - 78	pumped well was N-30 test conducted in March 1984.
N-32 (pumped well) recovery data	43,278 gpd/ft (5,800 ft^2/d)	60 - 80	test conducted in March 1984.
N-27 (pumped well) recovery data	132,000 gpd/ft (18,000 ft^2/d) for time less than 5 minutes 85,411 gpd/ft (11,000 ft^2/d) for time between 5 and 50 minutes; 193,600 gpd/ft (26,000 ft^2/d) for time greater than 50 minutes.	49 - 69	test conducted in March 1984.
N-62 (pumped well) drawdown data recovery data	27,000 ft^2/d for time less than 80 minutes 11,000 ft^2/d for time greater than 80 minutes 20,000 ft^2/d	66 - 78.5	test conducted on August 16, 1988 by PNL for WHC
N-39 (observation well) drawdown data recovery data	5,200 ft^2/d 5,700 ft^2/d	N-70: 89 - 99 N-39: 54 - 73	pumped well was N-70; test conducted in June 1988 by PNL for WHC
N-67 (observation well) drawdown data recovery data	8,200 ft^2/d 10,000 ft^2/d	N-69: 90 - 100 N-67: 65 - 76	pumped well was N-69; test conducted in June 1988 by PNL for WHC
N-71	380 ft^2/d	69 - 85	Slug withdrawal; Hartman (1992a)
N-72	430 ft^2/d	65 - 82	
N-73	170 ft^2/d	70 - 86	
N-74	1,700 ft^2/d	62 - 80	

PNL = Pacific Northwest Laboratory.
WHC = Westinghouse Hanford Company.

Water levels were measured during development and subsequent recovery of wells N-71 through N-74. Slug injection and withdrawal tests were also performed. Data were analyzed by Hartman (1992a). Values of transmissivity are one to two orders of magnitude less than those estimated in previous tests (see Table 2-2). It is not known whether these differences represent aquifer heterogeneity or are an artifact of the smaller scale of the recent tests.

2.3.2.3.2 Groundwater Levels. Groundwater levels in the 100-N Area and across the Hanford Site have varied through time because of artificial recharge from liquid waste disposal operations. Figure 2-8 is a hydrograph from well N-2 for the years 1964 to present. Waste disposal to the 1301-N LWDF began in 1963, just before this well was installed.

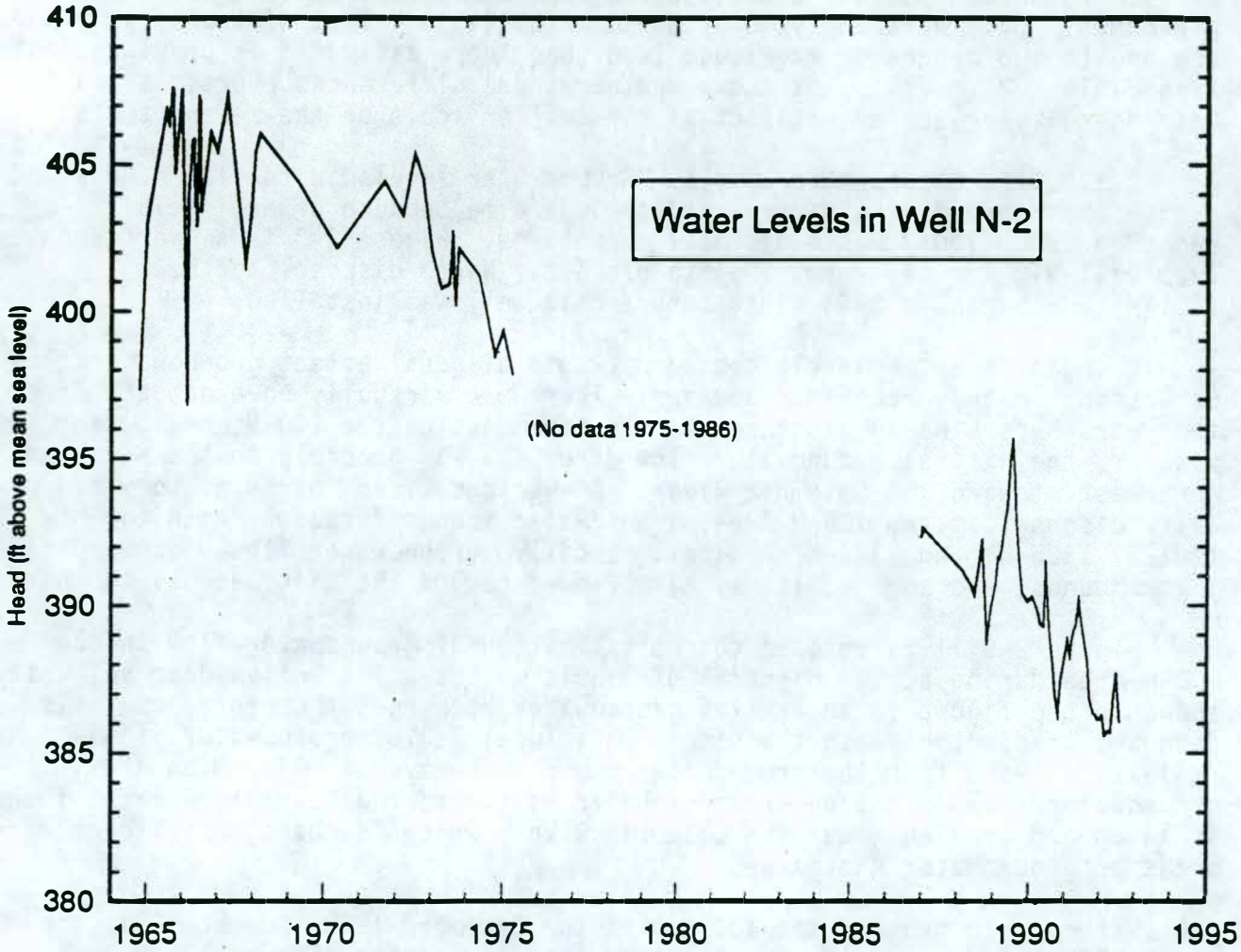
Changes in water levels caused by waste disposal affect groundwater flow directions in the unconfined aquifer. There are virtually no head data from the years before waste discharge to the sediments at the 100-N Area began; however, the natural groundwater flow direction was probably to the north and northwest, toward the Columbia River. At various times in the history of waste disposal at the 100-N Area, groundwater mounds formed beneath the 1301-N, 1325-N, and 1324-N/NA sites. Locally, groundwater flowed outward from these mounds, and some of it may have flowed toward the east, across the horn.

Figure 2-9 illustrates a conceptualization of groundwater flow in the 100-N Area during active disposal of liquid wastes. The active disposal unit shown in the figure is an area of groundwater recharge; therefore, there is a downward gradient beneath the site. On a local scale, groundwater flows radially outward from the groundwater mound. The overall direction of groundwater flow in the uppermost aquifer is toward the Columbia River. There is an upward gradient near the Columbia River, which is characteristic of areas of groundwater discharge.

Water table maps of the 100-N Area for December 1988, August 1989, and March 1992 illustrate recent changes in the flow regime (Figures 2-10 through 2-12). The mound caused by artificial recharge from the 1324-NA Percolation Pond was evident in late 1988 when discharge to the 1325-N LWDF was low. Groundwater flowed radially outward from this mound. Discharge to the 1325-N LWDF increased markedly through the spring of 1989, causing the mound beneath that site to eclipse the 1324-NA mound. Groundwater flowed to the west beneath the 1324-NA pond during this time. Discharge to the 1325-N LWDF decreased again after July 1989, and the 1325-N mound began to dissipate rapidly. The water table map for March 1992 indicates that the primary flow direction is toward the north beneath the 1325-N LWDF and toward the northwest beneath the 1301-N LWDF.

The vertical groundwater gradients are not well defined in the 100-N Area. Two wells are completed at the base of the uppermost aquifer and are located near wells completed at the top of the aquifer. Wells N-67 and N-69 are a shallow/deep pair near the 1301-N LWDF; wells N-39 and N-70 are a shallow/deep pair near the 1325-N LWDF. Data from these two well pairs are inconclusive regarding vertical gradients.

Figure 2-8. Hydrograph of Well N-2, 1964 to 1992.



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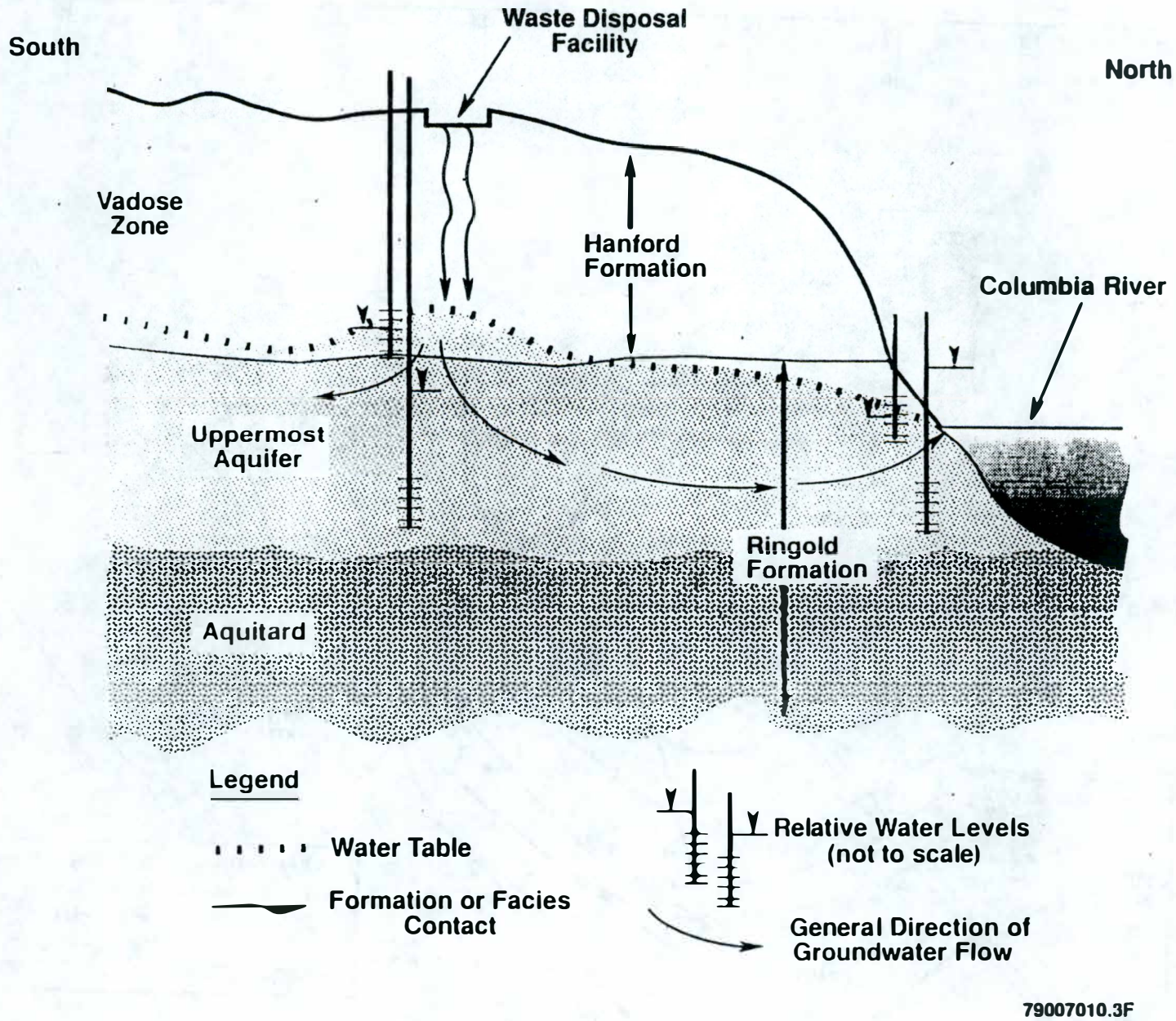


Figure 2-9. Conceptual Drawing of Groundwater Flow in the Uppermost Aquifer at the 100-N Area.

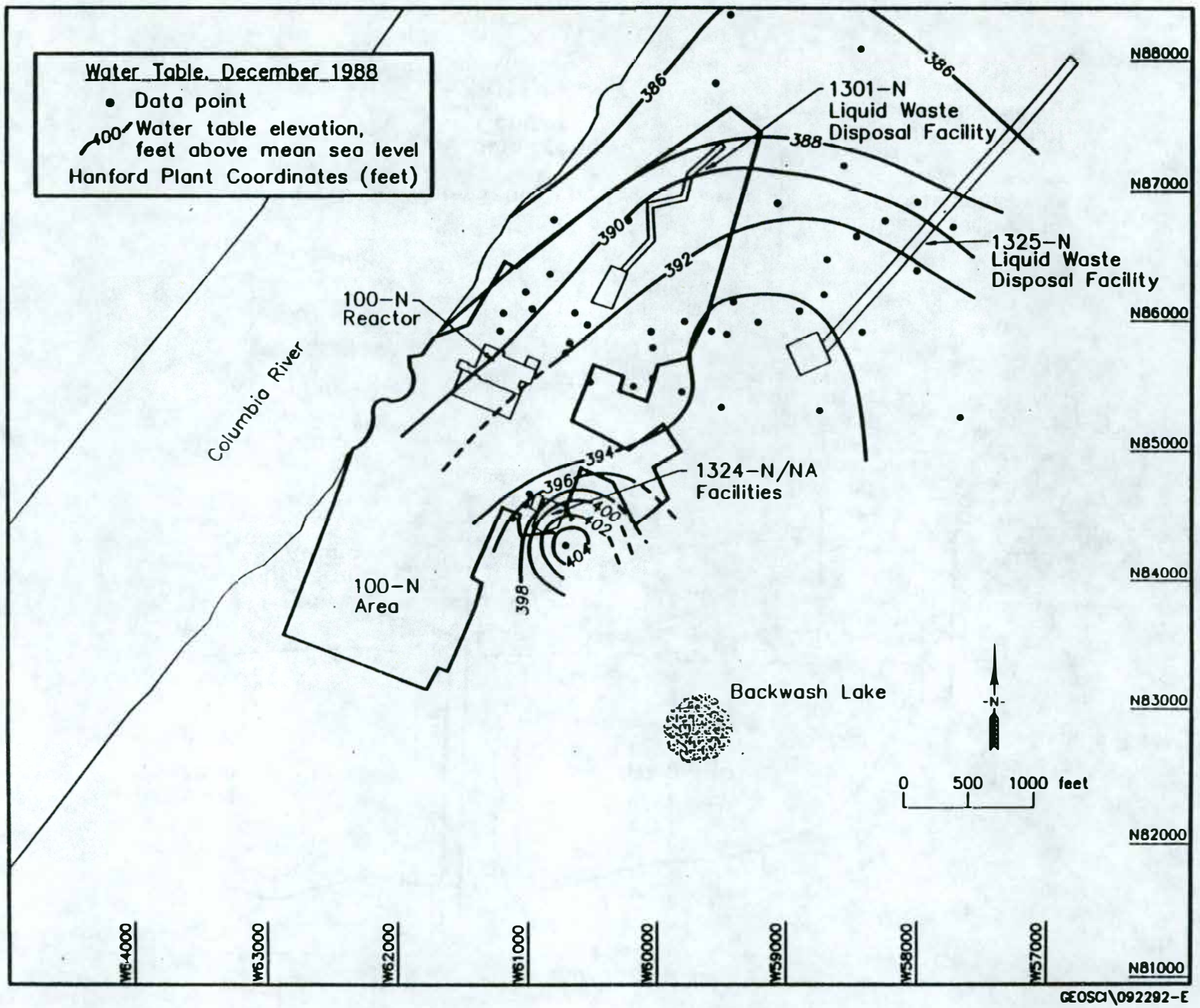


Figure 2-10. Water Table in the 100-N Area, December 1988 (Hartman 1992b).

9613493.0126

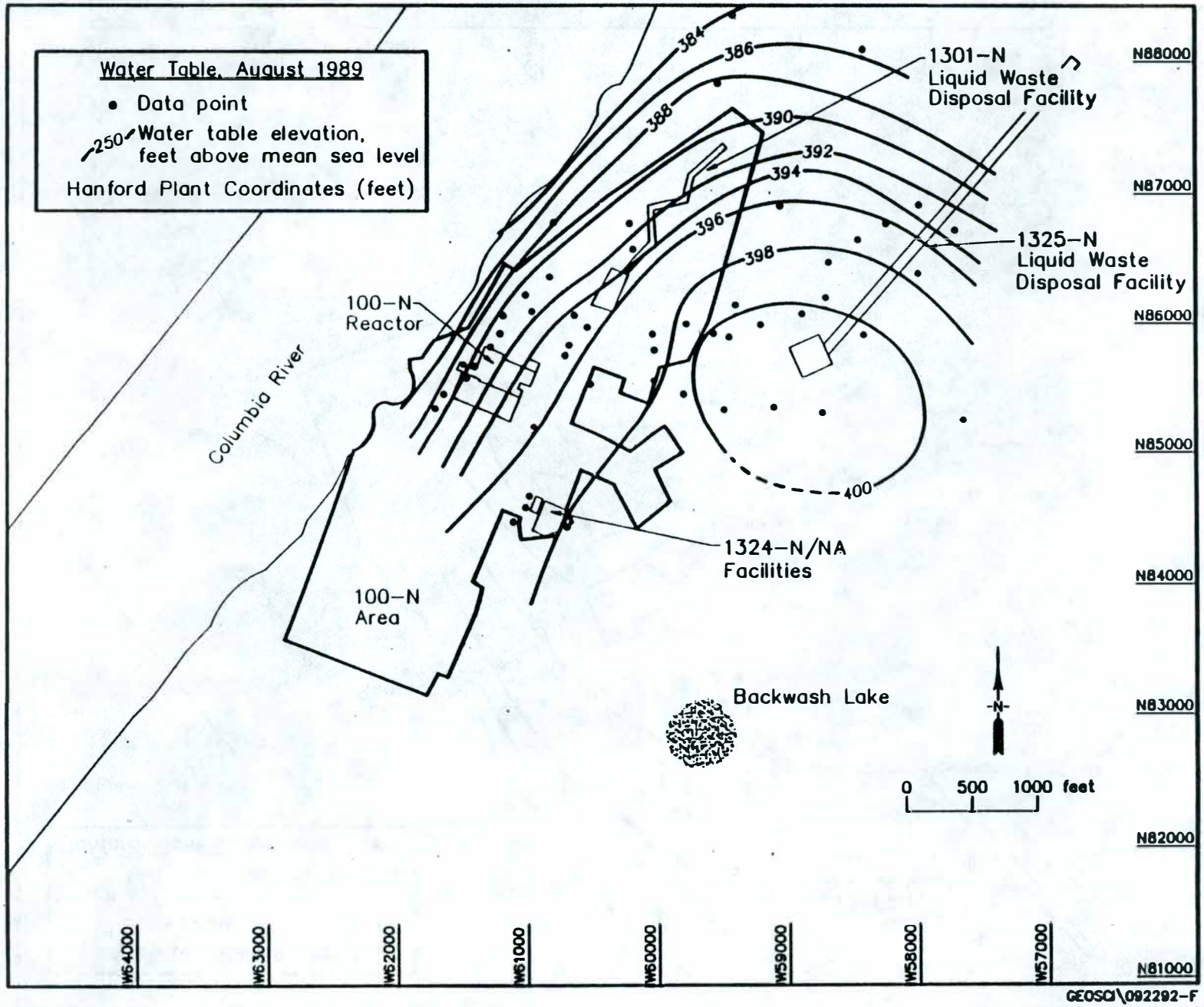


Figure 2-11. Water Table in the 100-N Area, August 1989 (Hartman 1992b).

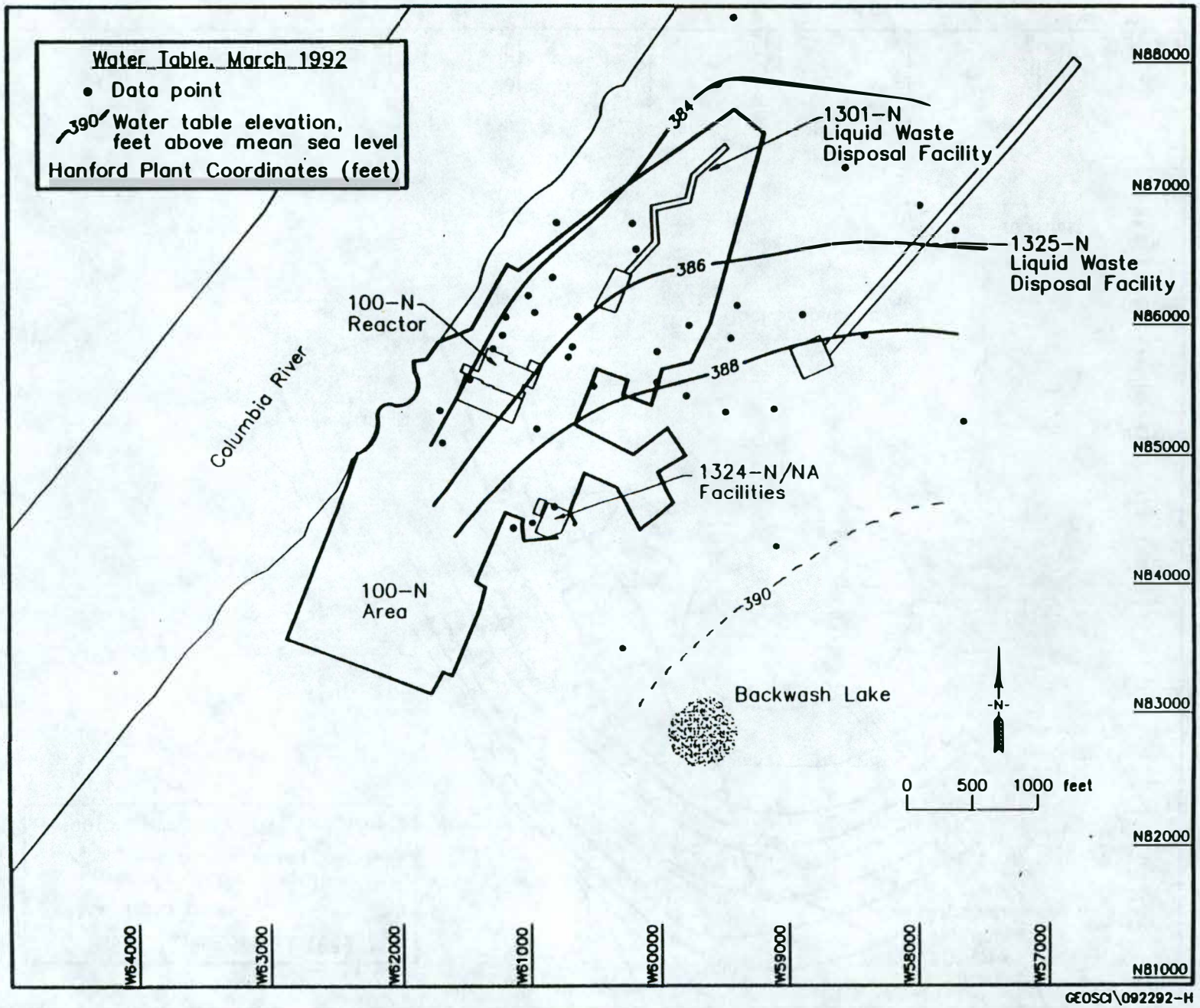


Figure 2-12. Water Table in the 100-N Area, March 1992 (Hartman 1992b).

2.3.2.3.3 Groundwater Chemistry in the Unconfined Aquifer. Groundwater quality in the unconfined aquifer beneath the 100-N Area has been affected by the 1301-N LWDF, the 1325-N LWDF, and the 1324-NA Percolation Pond. In addition, various leaks and spills may have affected soil or groundwater chemistry (DOE 1991b).

Data from RCRA sampling and analysis are presented in quarterly reports (e.g., DOE 1992a). Interpretation of the data are included in annual reports (e.g., DOE 1991a).

The primary contaminants in groundwater associated with the 1301-N and 1325-N LWDF are strontium-90 and tritium (DOE 1991a). Constituents associated with the 1324-N/NA include sulfate and sodium. Strontium-90, tritium, and sulfate distribution in the unconfined aquifer are shown in Figures 2-13 through 2-15.

2.3.2.4 Ringold Confined Aquifer System. The existence of the Ringold confined aquifer system beneath the 100-N Area is inferred on the basis of geologic interpretation and limited borehole data from the surrounding area. Lithologic and stratigraphic data (see Section 2.2) suggest that a system of confined aquifers and aquitards underlies the unconfined aquifer. The members of this aquifer system are listed below, shallowest to deepest (see Figure 2-5):

- Continuous interbedded silt and clay-rich paleosols, approximately 200 ft thick--This unit is believed to be an aquitard, forming the base of the unconfined aquifer; however, thin sand aquifers are present, as observed at well N-80 (see Appendix A).

- Silty to clayey sands, approximately 80 to 100 ft thick--This unit may act as an aquifer.

- Laminated deposits of clay and silt, 130 ft thick--These sediments probably have very low permeability and are thought to act as an aquitard.

- Gravel (indurated), approximately 20 ft thick--This unit lies over the Columbia River Basalt and may act as an aquifer.

Well N-80 was installed in 1992. It penetrates 16 ft of clay and is completed in a 5-ft-thick layer of sand (see Appendix A). The borehole encountered another clay unit beneath the sand. Groundwater elevations are not available for well N-80 at this time.

2.3.2.5 Basalt and Interbed Aquifer System. Little site-specific information is available regarding the basalt and interbed aquifer system beneath the 100-N Area. The uppermost member of the aquifer system is the Elephant Mountain member of the Saddle Mountains Basalt, which is considered an aquitard elsewhere on the Hanford Site. This aquitard comprises two basalt flows about 115 ft thick. Beneath the Elephant Mountain member is the Rattlesnake Ridge interbed of the Ellensburg Formation (see Section 2.2). It is approximately 50 ft thick, comprising tuffaceous siltstones and clayey silts and sands. Beneath the Rattlesnake Ridge interbed is the Pomona basalt flow, which acts as an aquitard.

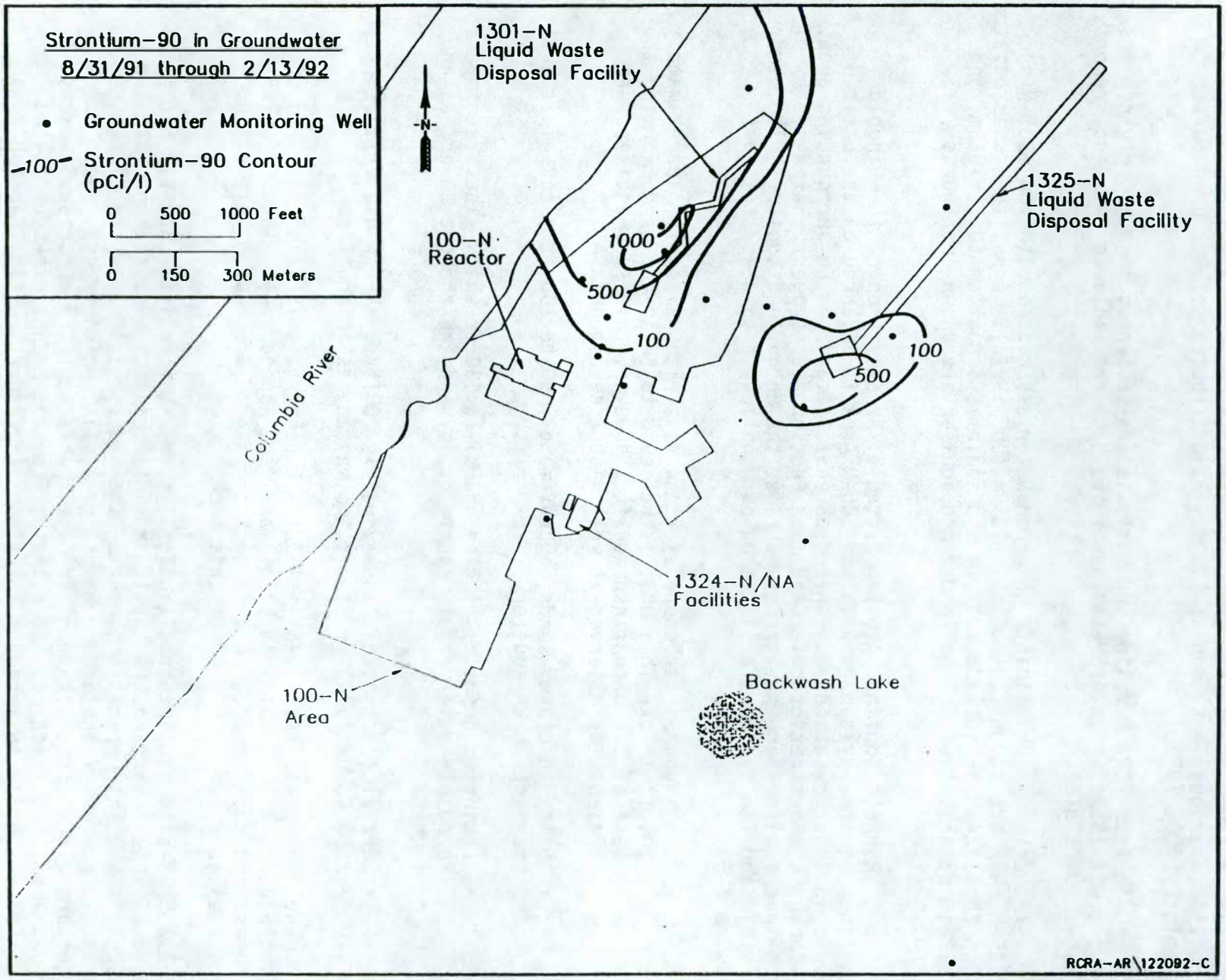


Figure 2-13. Distribution of Strontium-90 in the Unconfined Aquifer in the 100-N Area (data from 8/31/91 through 2/13/92).

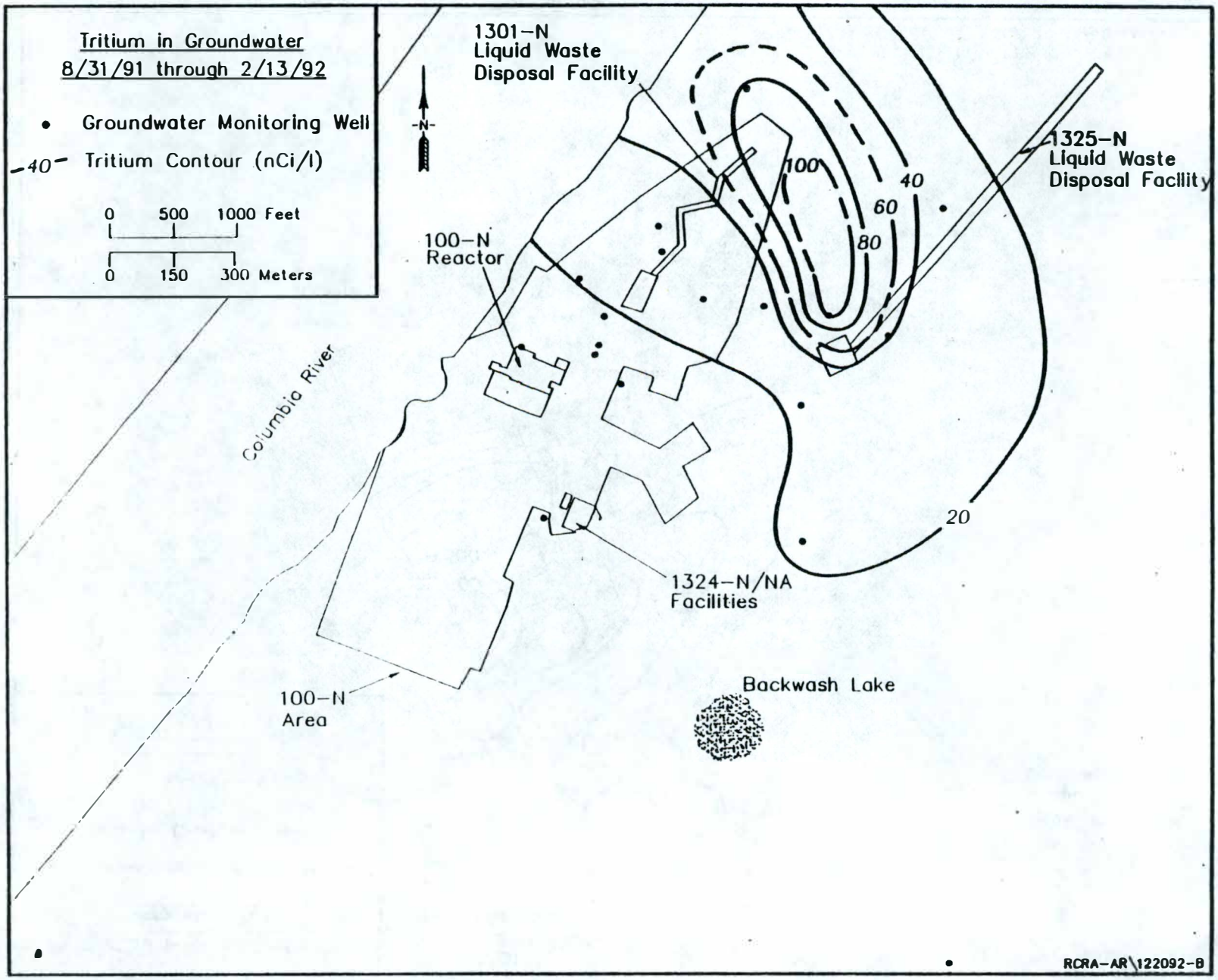


Figure 2-14. Distribution of Tritium in the Unconfined Aquifer in the 100-N Area (data from 8/31/91 through 2/13/92).

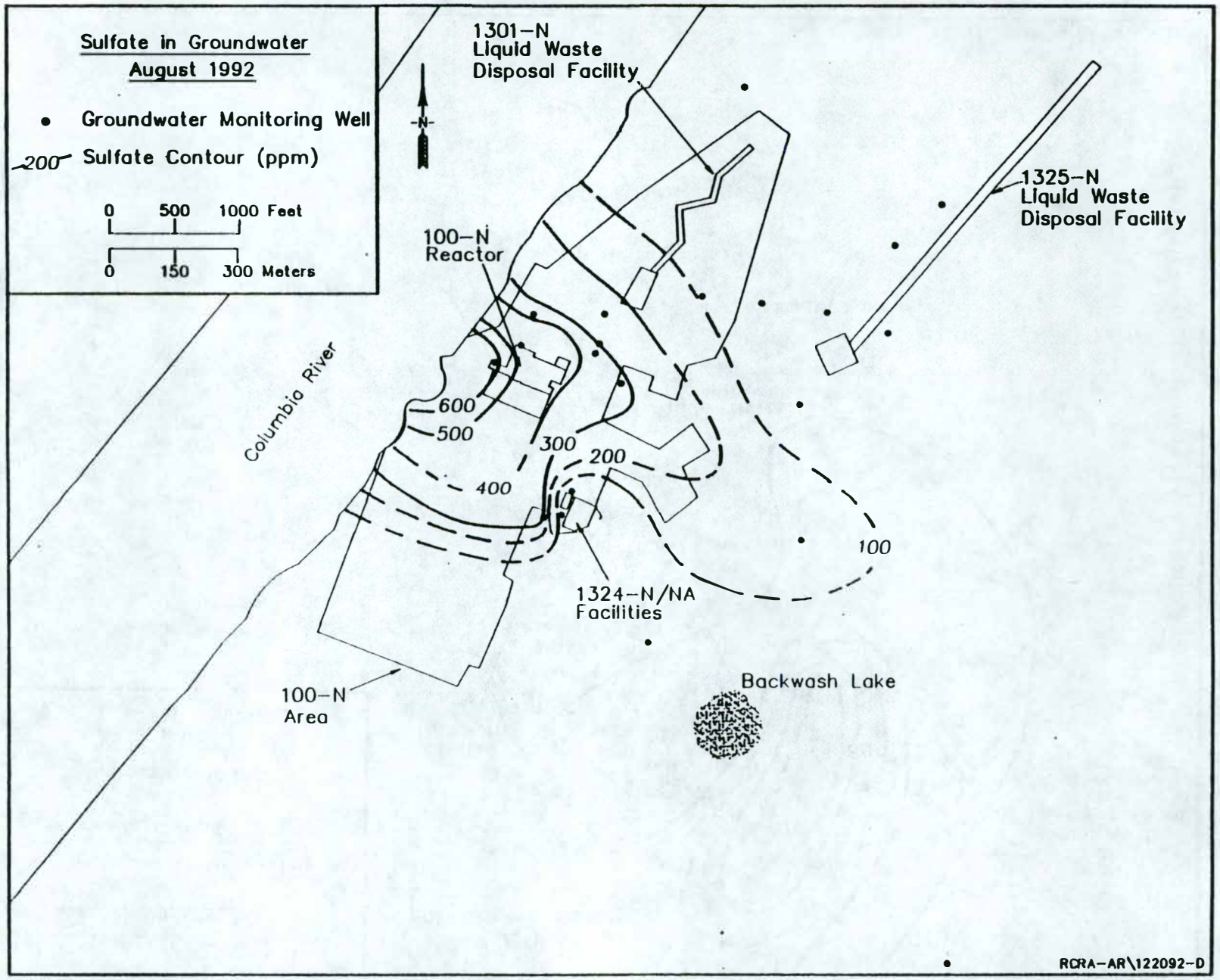


Figure 2-15. Distribution of Sulfate in the Unconfined Aquifer in the 100-N Area (data from 8/31/91 through 2/13/92).

3.0 GROUNDWATER MONITORING PROGRAM

This plan has been developed in accordance with RCRA, as described in 40 CFR 265, Subpart F, to describe interim-status indicator-evaluation groundwater monitoring programs for the 1301-N and 1325-N LWDF. Monitoring programs were previously described by Gilmore and Jensen (1989) and Hartman (1990).

3.1 OBJECTIVES

Following are objectives of the indicator evaluation groundwater monitoring program described in this plan:

- Determine background (upgradient) groundwater quality for the 1301-N and 1325-N RCRA sites
- Determine if hazardous waste constituents are present in the groundwater downgradient of the sites at concentrations significantly above upgradient levels.

The design of the groundwater monitoring program presented in this plan depends on the hydrogeology of the site. This plan also describes hydrogeologic characterization studies to identify and characterize the uppermost aquifer and potential contaminant pathways beneath the sites. Information from these studies may be used for RCRA monitoring and for *Comprehensive Response, Compensation, and Liability Act of 1980* (CERCLA) investigations (100-NR-2 operable unit).

3.2 APPROACH

This section presents an overview of the proposed groundwater monitoring program. Details of the program are in the following sections. Groundwater has been monitored for RCRA at the 1301-N and 1325-N LWDFs since December 1987. These data will be supplemented with data from installation of one additional well.

Subsurface soil samples will be collected during drilling at the new well location. These samples will be described and classified in the field. Selected samples may be submitted to the laboratory for analyses to determine various physical and chemical parameters.

Groundwater samples will be collected after reaching the water table if these samples are necessary for determining how to dispose purge water during aquifer testing and well development. These samples may be analyzed for contamination indicator parameters (noted later in this section) before aquifer testing or well development. Aquifer tests may be conducted to provide estimates of hydraulic properties of materials beneath the site.

Groundwater samples from the well networks will be analyzed for a variety of chemical and radiological constituents, continuing the monitoring programs that have been under way since December 1987. Radiological constituents are

not regulated under RCRA, but they are the primary constituents of interest at the 1301-N and 1325-N LWDFs, and their concentration and distribution aid in defining groundwater flow beneath the 100-N Area. Radionuclides will be investigated under RCRA past practice operable unit studies (Ecology, EPA, and DOE 1989, Section 6.3).

Groundwater levels will be measured before each sampling event. Additional water-level measurements will be made in most of the 100-N Area wells monthly, at least until groundwater levels stabilize.

3.2.1 1301-N Approach

Indicator parameter monitoring will be reinstated at the 1301-N site. Different wells will be monitored for upgradient groundwater quality. Four quarters of background data will be collected to re-establish upgradient critical mean values. There is a significant gap in downgradient well data, so downgradient groundwater quality also will be monitored quarterly for the first year.

3.2.2 1325-N Approach

Indicator parameter monitoring will continue semiannually at the 1325-N site to detect adverse impacts of the unit on the groundwater. Several downgradient wells have become dry in recent years, and flow directions beneath the 1325-N LWDF have changed. Two former downgradient wells will be removed from the network. One existing well will be added to monitor the northern portion of the 1325-N trench. A new well will be installed to replace a well that has gone dry because of declining water levels.

3.3 GROUNDWATER MONITORING NETWORK

This section describes the aquifer that will be monitored, the existing groundwater monitoring wells, proposed changes in monitoring networks, how one proposed well will be installed, the frequency of sampling, and groundwater constituents to be analyzed. Drilling, well construction, aquifer testing, and associated activities will be conducted according to applicable Westinghouse Hanford Company procedures. Specific Environmental Investigation Instructions (EII) are cited in the following sections of this plan (WHC 1988). Additional EII may also apply.

3.3.1 Definition of the Uppermost Aquifer

As discussed in Section 2.3, nearly all of the uppermost aquifer beneath the 100-N Area is contained within the Ringold Formation. The uppermost aquifer extends from the water table to the top of a fine-grained unit (see Figure 2-9). Hydrogeologic characterization activities are designed to obtain information on hydraulic and groundwater flow characteristics for the uppermost aquifer.

3.3.2 Existing Monitoring Network

This section describes the current monitoring networks for the 1301-N and 1325-N LWDFs.

3.3.2.1 Current Monitoring Network for 1301-N. Prior to initiation of groundwater quality assessment monitoring at the 1301-N LWDF, the monitoring network comprised two upgradient wells (N-4 and N-66) and five downgradient wells (N-2, N-3, N-67, N-69, and N-14). Thirteen additional wells were added to the network under the assessment program in 1989. The network later was modified by substituting another upgradient well (N-57) for well N-4. Two downgradient wells (N-75 and N-76) were installed in 1992 to fill a gap in the network. All of the wells are completed at the top of the aquifer except N-69, which is completed above a clay layer that forms the base of the uppermost aquifer. Construction materials and depths are presented in Table 3-1. Locations of wells in the current network are illustrated in Figure 3-1. As-built diagrams and lithologic logs are included in Appendix A.

3.3.2.2 Current Monitoring Network for 1325-N. The original groundwater monitoring network for the 1325-N LWDF comprised 12 wells (see Figure 3-1). Well N-70 is completed at the base of the uppermost aquifer; the other wells are completed at the top of the aquifer. Data indicate that the well originally thought to be upgradient (N-52) was in fact influenced by the 1325-N LWDF. Well 699-81-58 was subsequently used as an upgradient well, and well N-52 was monitored as a downgradient well. As water levels changed with changing waste disposal practices in 1989 and 1990, the network was modified somewhat. Wells N-42 and N-52 are no longer downgradient of the 1325-N LWDF and have been dropped from the sampling schedule. A new upgradient well (N-74) was installed in 1991. Several downgradient wells have become dry because of a dropping water table. Construction details for the wells are summarized in Table 3-1. As-built diagrams and lithologic logs are presented in Appendix A.

3.3.3 Proposed Monitoring Networks

Two downgradient wells that do not add to the effectiveness of 1325-N monitoring will be taken out of the network. One existing well will be added to the network to monitor groundwater flowing toward the north near the 1325-N trench. One new well will be installed downgradient of the 1325-N LWDF to replace a dry well. Well locations are shown in Figure 3-2 and Hanford coordinates are listed in Table 3-1. The precise location of the new well will depend on field conditions and will be determined by the project scientist.

3.3.4 Justification for Well Locations

This section discusses the rationale for modifications made in the monitoring networks for the 1301-N and 1325-N LWDF.

Table 3-1. Well Construction Information for 100-N Area.
(sheet 1 of 2)

Well number	Proposed network	Hanford coordinates	Elev. top of casing	Drill date	Depth to bottom	Casing/ screen	Screened or perforated depth	Head 8/92	Sampling device
N-2	1301-N	W 60306 N 86577	459.83	6/64	95	cs/pc	35-95	385.50	submersible pump
N-3	1301-N	W 60828 N 86365	459.45	6/64	86	cs/pc	34-86	384.91	submersible pump
N-4	--	W 60042 N 85921	458.73	6/64	73	cs/pc	50-60	dry	submersible pump
N-14	1301-N	W 59535 N 87834	453.15	4/69	78	cs/pc	45-78	383.85	submersible pump
N-16	--	W 60950 N 85208	456.70	2/81	78	cs/screen inside pc	12-78	386.74	submersible pump
N-17	--	W 60963 N 86098	461.20	1/81	84	cs/pc	12-83	384.62	submersible pump
N-18	--	W 61012 N 86226	458.50	2/81	78	cs/screen inside pc	12-78	383.98	submersible pump
N-21	--	W 61285 N 85823	457.00	1/81	79	cs/pc	12-78	384.51	submersible pump
N-23	--	W 61469 N 85586	456.30	1/81	80	cs/pc	12-78	384.24	bailer
N-24	--	W 61640 N 85460	432.50	1/81	55	cs/pc	12-54	dry	bailer
N-25	--	W 61706 N 85351	425.80	1/81	48	cs/screen inside pc	12-47	382.56	bailer
N-26	--	W 61687 N 85105	455.80	1/81	79	cs/screen inside pc	12-77	383.75	bailer
N-27	1325-N	W 58417 N 85915	449.08	8/83	69	cs/ss & packer	32-69	387.95	submersible pump
N-29	1325-N 1301-N	W 59112 N 85358	465.25	8/83	84	cs/ss & packer	47-84	388.46	submersible pump
N-31	--	W 59211 N 85993	462.63	9/83	81	cs/ss & packer	44-81	387.35	submersible pump
N-32	1325-N	W 58893 N 86077	462.08	9/83	80	cs/ss & packer	44-80	387.49	submersible pump
N-33	--	W 59403 N 86148	459.87	9/83	75	cs/ss & packer	38-75	387.17	submersible pump
N-34	1301-N	W 59452 N 85899	459.63	9/83	78	cs/ss & packer	34-78	387.66	submersible pump
N-36	--	W 58710 N 86204	458.97	4/84	74	cs/ss & packer	54/74	dry	submersible pump
N-39	--	W 58461 N 86651	454.31	4/84	78	cs/ss & packer	53-73	dry	submersible pump
N-41	1325-N	W 57989 N 86916	457.59	4/84	78	cs/ss & packer	53-73	385.09	submersible pump
N-42	--	W 57716 N 86724	455.14	4/84	72	cs/ss & packer	52-72	385.67	submersible pump
N-43	1325-N	W 57384 N 87488	449.01	4/84	71	cs/ss & packer	51-71	N/A	to be installed

Table 3-1. Well Construction Information for 100-N Area.
(sheet 2 of 2)

Well number	Proposed network	Hanford coordinates	Elev. top of casing	Drill date	Depth to bottom	Casing/ screen	Screened or perforated depth	Head 8/92	Sampling device
N-47	--	not surveyed	443.53	11/84	73	cs/ss & packer	53-73	N/A	submersible pump
N-54	--	W 60678 N 85836	457.51	6/87	73	ss/ss	58-73	386.17	HydroStar pump
N-55	--	W 60710 N 85758	457.85	6/87	73	ss/ss	58-73	386.25	HydroStar pump
N-56	--	W 60637 N 86066	458.09	6/87	74	ss/ss	59-74	385.59	HydroStar pump
N-57	1301-N	W 60517 N 85535	457.76	6/87	73	ss/ss	58-73	387.56	HydroStar pump
N-66	--	W 59827 N 84992	456.25	11/87	78	ss/ss	67-78	386.65	HydroStar pump
N-67	1301-N	W 60248 N 86377	458.46	3/88	76	ss/ss	60-76	385.44	HydroStar pump
N-69	1301-N	W 60282 N 86397	458.84	6/88	100	ss/ss	90-100	385.32	HydroStar pump
N-70	1325-N	W 58360 N 86600	454.21	6/88	99	ss/ss	89-99	386.48	HydroStar pump
N-74	1325-N	W 58264 N 84264	457.13	8/91	80	ss/ss	59-80	389.57	HydroStar pump
N-75	1301-N	W 60150[a] N 87235	456.24	4/92	85	ss/ss	64-85	N/A	HydroStar pump
N-76	1301-N	W 60029 N 87437	451.58	4/92	81	ss/ss	61-81	N/A	HydroStar pump
6-81-58	--	W 57993 N 81004	439.55	10/62	90	cs/pc	35-90	393.52	submersible pump
N-81[b]	1325-N	W ~58450 N ~86500	N/A	1993	~90	ss/ss	N/A	N/A	to be installed

NOTES: All depths in feet below land surface; elevations in feet above mean sea level. Depths are rounded to the nearest foot. For wells with sand or cement plugs, the plugged depth and elevation are given.

Shaded wells are included in a proposed network. Others have been included in past or current networks.

HydroStar is a registered trade name of Instrumentation Northwest, Redmond, Washington.

N/A = not available.
cs = carbon steel casing.
pc = perforated casing.
ss = stainless steel casing/screen.

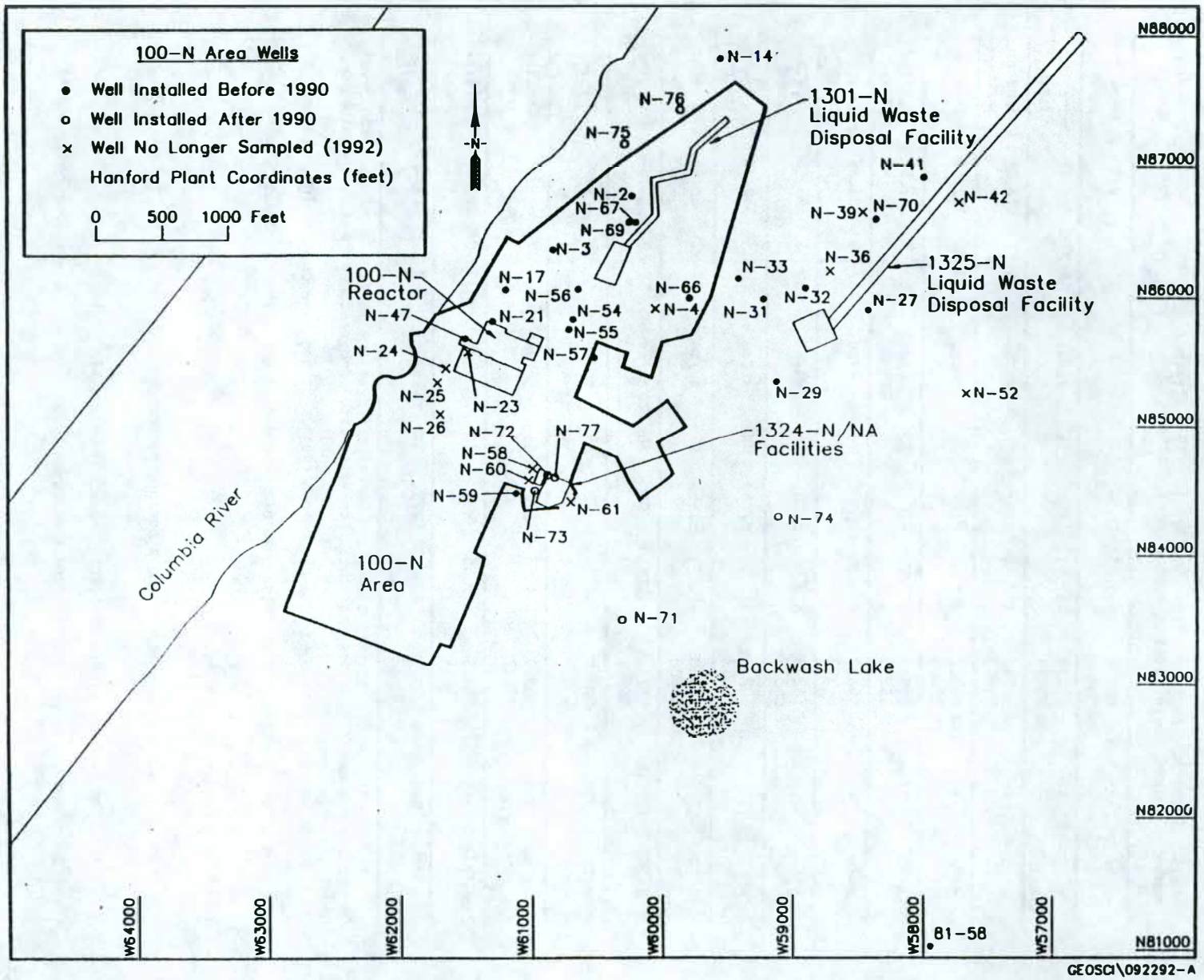
For wells with both a screen and a perforated interval, the perforated interval is given.

Data from McGhan (1989), drillers' logs, and geologists' logs.

[a]Coordinates converted to Hanford from Lambert coordinates. Elevations converted to 100-N Area datum from NVGD'29.

[b]Proposed well to be installed in 1993.

Figure 3-1. Former Groundwater Monitoring Networks for 1301-N and 1325-N Sites.



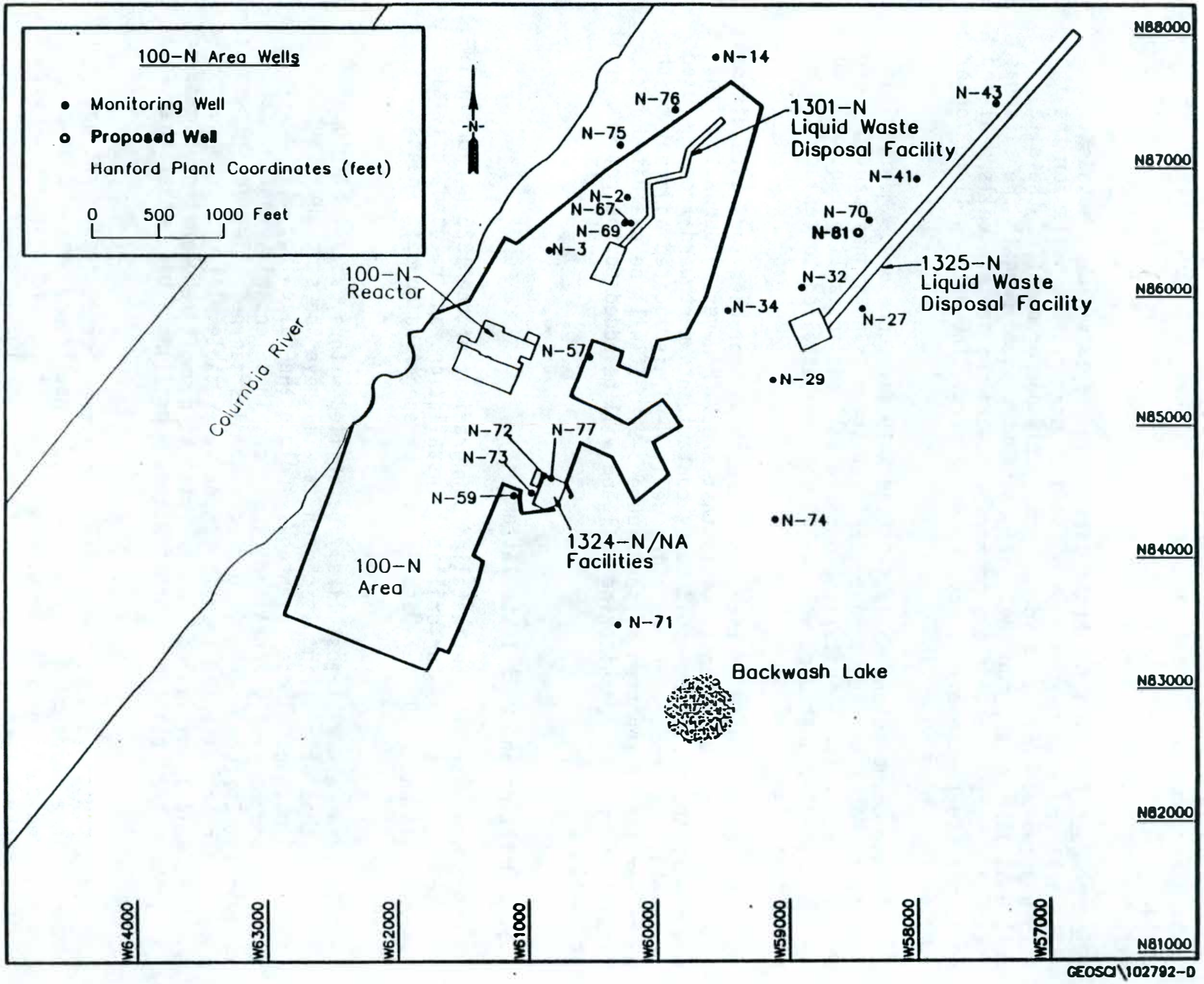


Figure 3-2. Proposed Revised Monitoring Networks for the 1301-N and 1325-N Sites.

3.3.4.1 Justification for Modifications in the 1301-N LWDF Network. The current upgradient wells for the 1301-N LWDF are N-66 and N-57. These wells are located in positions where they can detect possible impacts on the groundwater from the 1325-N and 1324-N/NA sites. Declining water levels have caused well N-66 to nearly go dry. An existing well, either N-34 or N-29, will be substituted for well N-66 as an upgradient well.

3.3.4.2 Justification for Modifications in the 1325-N LWDF Network. Wells N-31 and N-33 have been monitored as downgradient wells for the 1325-N network. They were formerly directly downgradient of the site. Well N-31 is dry, and now that the groundwater mound beneath the site has dissipated, groundwater flows primarily toward the north. Wells N-31 and N-33 no longer add to the efficiency of the network. The wells will no longer be sampled for the RCRA program.

Former downgradient wells N-36 and N-39 have gone dry. Monitoring Efficiency Modeling (MEMO) indicates that there is no significant difference in efficiency between installing one new well and installing two. A single new well (N-81), near deep well N-70, will be installed to replace the dry wells (see Figure 3-2).

The northern half of the 1325-N trench was not used for waste disposal, so no wells have been monitored in that area. However, groundwater flow is now toward the north and could carry contaminants northward from the used portion of the trench. An existing well, N-43, is located adjacent to the north portion of the trench (see Figure 3-2). It will be evaluated for fitness for use as a monitoring well and will be added to the network if it is suitable.

3.3.5 Drilling and Well Installation

One new well will be installed downgradient of the 1325-N LWDF in 1993. Generic specifications for drilling, installation, and related activities are described in WHC (1992a). Details will be specified on data sheets (Figure 3-3).

The new well will most likely be drilled with a cable tool rig. If another method of drilling is chosen it will have the same advantages as the cable tool method. These advantages include the following: (1) drill cuttings can be easily contained (important in potentially contaminated material); (2) representative geologic samples can be collected; (3) moisture samples can be collected from above the water table; (4) disturbance to the borehole wall is minimized; (5) a straight, plumb borehole is produced; and (6) groundwater quality is not affected by drilling fluids other than water or air.

Drill cuttings will be routinely monitored for radiation and hazardous material in accordance with a site-specific health and safety plan. Contaminated cuttings will be handled, transported, and disposed of according to Westinghouse Hanford Company procedures. If the level of contamination is significant enough to require changes in well design or well location, Ecology will be notified before the changes are made.

Figure 3-3. Example Groundwater Monitoring Well Data Sheet.

DATA SHEET FOR GROUND WATER MONITORING WELLS
AT THE (UNIT)
Milestone M-XX-XX

1. LOCATION:

2. TEMPORARY CASING SIZE AND SCHEDULE:

3. APPROXIMATE WELL DEPTH:

4. SPECIAL INSTRUCTIONS: (Include details such as well specification, desired order of well drilling, expected perched water zones, estimated number of split-spoon samples, critical start and completion dates, and any other pertinent information that may impact drilling.)

5. APPLICABLE DOCUMENTS: (Include groundwater monitoring plans and work plans)

6. WELL NUMBERS, LOCATIONS, PROPOSED DEPTH, TYPE, AND SCREEN LENGTHS:

Well Number	Coordinates	Depth, ft	Design Type	Screen Length, ft

The drill rig and peripheral equipment (such as drill tools, cables, and temporary casing) will be steam cleaned before arriving on site. During drilling in the zone to be sampled, the addition of water to the borehole will be minimized or avoided, thus reducing well development pumping after wells are completed and minimizing the chances of driving any vadose zone contaminants into the groundwater.

Temporary carbon steel casing will be driven to total depth as the borehole is advanced. After the borehole has been drilled to its total depth, the final well casing and screen will be installed, and the temporary carbon steel casing will be removed as the filter pack and annular seal materials are placed in the annular space. The wells will be drilled 10 to 20 ft into the saturated sediments.

3.3.6 Well Construction

Figure 3-4 shows a schematic diagram of the proposed well. Well specifications are described in WHC (1992a). Well drilling will be governed by EII 6.7. Guidance concerning geologic sampling and inspection of well construction is given in EII 5.2 and EII 6.7, respectively. The WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," is used as required for well design and construction materials. Quality assurance requirements of the Tri-Party Agreement and WHC (1992b) also apply.

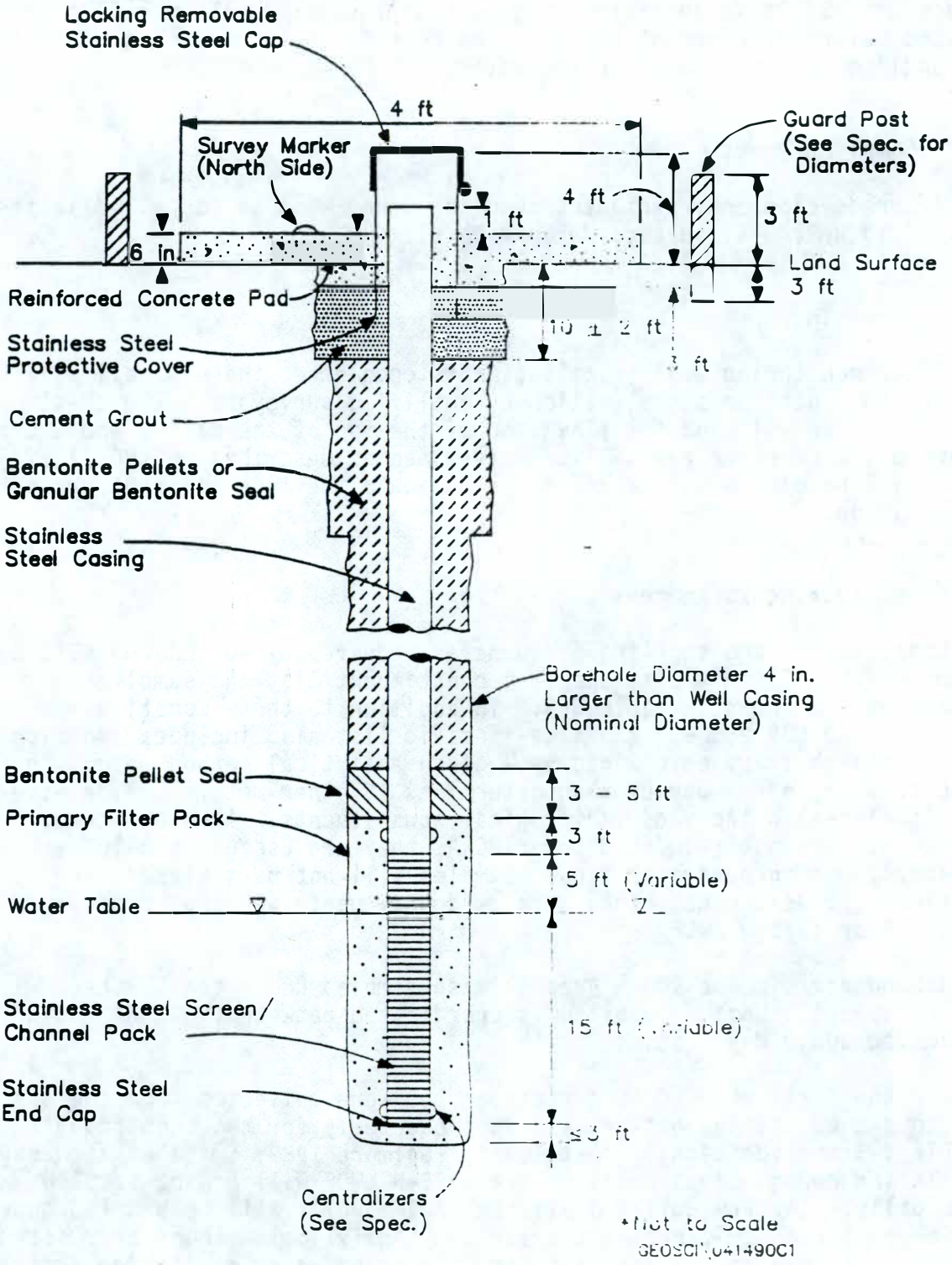
The new well will be constructed of stainless steel, fiberglass, or other inert material. The screen will be placed with approximately 15 ft below the water table and 5 ft above. A channel-pack screen will be used, or the site geologist will determine the filter pack size and screen slot size based on guidelines outlined in EII 6.8. The sand filter pack will be placed from approximately 1 to 3 ft below to 3 to 5 ft above the top of the screen.

A 3- to 5-ft-thick bentonite pellet seal will be placed on top of the sand pack. The annulus above the bentonite pellet seal to 10±2 ft below ground surface will be filled with dry granular bentonite. Cement grout will then be installed to within 3 ft of the ground surface. The well casing will extend 1 to 2 ft above ground surface and will be protected by an outer steel casing and a locking cap. The protective casing will be set into the ground and cemented in place with a concrete pad 4 ft by 4 ft by 6 in. A brass survey marker will be placed in the concrete pad, and all protective casings will be permanently marked with well identification numbers.

3.3.7 Well Development

Following completion, the well will be developed as described in WHC (1992a), using the procedures in EII 10.4. The well will be developed until discharge water has a turbidity of less than 5 NTU, or the sediment content is less than 8 mg/L.

Figure 3-4. Schematic Diagram of Shallow Monitoring Well Construction.



All groundwater discharged from the well during development will be disposed in accordance with Westinghouse Hanford Company guidelines and procedures. If it is necessary, a groundwater sample will be collected and analyzed before development begins. The results could be used to determine the handling and disposal of purge water.

3.3.8 Sampling Pumps

After development, permanent sampling pumps will be installed in the new well and in well N-43 in accordance with EII 6.8.

3.3.9 Surveying

After monitoring well installation is completed, the new well will be surveyed for location and elevation by qualified surveyors. The areal location of the well and the elevation of the top of the casing and a brass marker in the concrete pad will be determined as described in WHC (1992a). A mark will be placed on the casing to indicate the location that was surveyed for elevation.

3.3.10 Monitoring Parameters

Constituents and sampling frequencies required by 40 CFR 265.93 are listed in Table 3-2. A site-specific constituent list and sampling frequencies are shown in Table 3-3. In addition to those constituents required by 40 CFR 265.93, the site-specific list also includes additional constituents that are determined by a given analytical method (e.g., the method to analyze for barium also determines 18 other metals). The site-specific list also includes radiological constituents. Although these constituents are not regulated under RCRA, they are useful to help determine the direction of groundwater flow. Samples will not be analyzed for pesticides and herbicides because these constituents were not discharged to the 1301-N or 1325-N LWDF.

Groundwater in the 100-N Area is also sampled under the CERCLA 100-NR-1 Operable Unit. Sampling is coordinated between the RCRA and CERCLA programs to avoid duplication.

For the first year, groundwater samples were collected from the existing wells in the monitoring network at least quarterly for the constituents listed in Table 3-3 and additional constituents (Gilmore 1989; Smith et al. 1990). The existing downgradient wells at the 1325-N LWDF will now be sampled semiannually. The new well and all the 1301-N wells will be sampled quarterly for one year, and semiannually thereafter. Analytical methods are listed in the *Quality Assurance Project Plan for RCRA Groundwater Monitoring Activities* (WHC 1992b).

Table 3-2. Groundwater Sampling Parameters and Frequency of Analysis Required by 40 CFR 265.

Constituent	Maximum level[a]
Interim Primary Drinking Water Standards 40 CFR 265, Appendix III[b]	
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Fluoride	1.4 to 2.4
Lead	0.05
Mercury	0.002
Nitrate (as NO_3^-)	45
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP Silvex	0.01
Radium	5 pCi/L
Gross alpha	15 pCi/L
Gross beta	4 mrem/yr
Coliform bacteria	1/100 mL
Groundwater Quality Parameters 40 CFR 265.92(b)(2)[c]	
Chloride	
Iron	
Manganese	
Phenols	
Sodium	
Sulfate	
Groundwater Contamination Indicator Parameters 40 CFR 265.92(b)(3)[d]	
pH	
Specific conductance	
Total organic carbon	
Total organic halogen	

NOTE: Regulatory requirements for sampling parameters are subject to change because of federal regulations.

[a]Unless otherwise noted, levels are in mg/L.

[b]These constituents sampled quarterly for first year.

[c]These constituents sampled quarterly for first year; annually thereafter.

[d]These constituents sampled quarterly for first year; semi-annually thereafter.

Table 3-3. Groundwater Analyses and Frequency of Analysis for 1301-N and 1325-N RCRA Projects. (sheet 1 of 2)

Analysis	Frequency[a]	
	Well N93-1 and 1301-N wells: first 4 quarters	Other wells
pH (field and laboratory)	Q	SA
specific conductance (field and lab)	Q	SA
total organic carbon	Q	SA
total organic halogen (low detection limit)	Q	SA
phenols	Q	A
turbidity	Q	SA
temperature (field)	Q	SA
Metals by the inductively coupled plasma method (filtered, unfiltered)	Q	SA
antimony		
barium		
beryllium		
cadmium		
calcium		
chromium		
cobalt		
copper		
iron		
magnesium		
manganese		
nickel		
potassium		
silver		
sodium		
tin		
vanadium		
zinc		
Other metals (filtered, unfiltered)	Q	SA
arsenic		
lead		
mercury		
selenium		

Table 3-3. Groundwater Analyses and Frequency of Analysis for 1301-N and 1325-N RCRA Projects. (sheet 2 of 2)

Analysis	Frequency[a]	
	Well N93-1 and 1301-N wells: first 4 quarters	Other wells
Anions by ion chromatography	Q	SA
bromide		
chloride		
fluoride		
nitrate		
nitrite		
phosphate		
sulfate		
Coliform bacteria	Q	--
Radiological	Q	SA
radium		
gross alpha		
gross beta		
strontium-90		
tritium		
gamma scan		
Hydrazine	Q	SA

[a]Q = quarterly; A = annually; SA = semiannually; -- = not analyzed.

3.4 HYDROGEOLOGIC CHARACTERIZATION

Hydrogeologic characterization of the 100-N Area has been conducted as part of the existing RCRA monitoring program and for numerous environmental and engineering studies through the past 30 yr. These data will be supplemented with data gathered during drilling of the new well. Work performed will follow approved procedures, in accordance with WHC (1992b).

Data collection and interpretation will focus on geology, geochemistry, hydrogeology, hydrochemistry, and groundwater monitoring. The characterization will be performed during and after construction of the planned well. Information obtained from the existing wells will also be integrated into the characterization and interpretation effort. Characterization of this site is a discovery process, and data collection in these areas may expand or decrease depending on the information obtained.

3.4.1 Geologic Characterization

This section describes the activities that will be conducted in support of geologic characterization.

As the new well is drilled, geologic samples will be collected at 5-ft intervals, at changes in lithology, and when significant changes in moisture content are observed (EPA 1986). Sampling will be conducted in accordance with EII 5.2. A general description of the borehole cuttings between sampling intervals will be recorded by the well site geologist to obtain a continuous lithologic record. Samples will be archived for possible future analyses. No drilling fluids (including water) will be added to the borehole unless necessary and approved by the well site geologist. This will aid detection of perched water zones, allow collection of representative moisture samples, and have minimal impact on groundwater chemistry. Samples will be collected for moisture content determinations in the unsaturated sediments at 5-ft intervals and at moist or wet zones.

The well site geologist will describe the samples in the field and document the descriptions on borehole logs in accordance with EII 9.1. Every sample will be recorded on borehole logs as it is collected at the drill site. The detailed lithologic descriptions of geologic samples will include color, texture, sorting, mineralogy, roundness, relative calcium carbonate concentration, consolidation, and cementation. In addition, the drilling and well construction information, along with the various sample collection depths, will be documented on the borehole logs.

Guided by the criteria listed in Table 3-4, the site geologist may select geologic samples to be analyzed in the laboratory.

Table 3-4. Laboratory Analyses for Sediment Samples and Criteria for Selection.

Analysis	Criteria
Sieve particle size	At changes in lithology
Pipette and/or hydrometer analyses	Samples with 50% or more mud-sized particles, as determined by sieve analyses
Calcium carbonate content	Same as sieve particle size
Moisture content	Every 5 ft above the water table when no water is added during drilling

3.4.2 Chemical and Radiological Analysis of Sediments

Sediment samples will be monitored for volatile and radioactive contaminants with field screening instruments, as stated in Section 3.3.5. If contamination is detected, samples will be sent to a laboratory and analyzed.

3.4.3 Borehole Geophysical Logging

The primary purpose of geophysical logging will be to correlate and interpret subsurface stratigraphy between boreholes. Another use will be to identify stratigraphic zones that may have been contaminated by gamma-ray-emitting radionuclides.

The new monitoring well will be logged during construction with a gross gamma-ray system, and may also be logged with the spectral gamma-ray logging sound. After the well is completed, the project scientist may elect to have the new well viewed with a downhole video camera to ensure it is clean and undamaged. In addition, wells may be relogged with the spectral gamma system to provide a baseline for any future applicable radionuclide monitoring.

3.4.4 Aquifer Testing

The purpose of aquifer testing is to determine the hydraulic characteristics of in situ geologic materials in the uppermost aquifer underlying the 100-N Area. However, the primary purpose of installing the wells in the 100-N Area RCRA monitoring networks is to monitor the groundwater chemistry, so the wells are not designed for aquifer testing. Aquifer tests may be influenced by well design, and results should be considered in this perspective.

Aquifer testing that involves pumping groundwater out of the well will be conducted only if adequate means exist for disposing of the purge water at the time the wells are ready for testing. Slug testing is an alternative that has been used at other sites at the Hanford Site because it does not produce any purge water. However, slug tests are often not very useful in highly permeable sediments, are representative of only very small parts of the aquifer, and may be affected by well construction. The procedures for constant discharge tests and slug tests are included in EII 10.1.

Slug tests will be attempted in the new wells after completion and development to obtain estimates of transmissivity of the monitored unit. During the slug tests, the hydraulic head will be changed by suddenly introducing or removing a cylinder of known volume. The water-level recovery response will then be observed over time.

Water levels and discharge rate will be monitored during well development. If possible, these data will be used to estimate aquifer properties.

3.4.5 Determination of Groundwater Flow Paths

Water levels will be measured in all the wells of the monitoring network and in additional wells in the 100-N Area to determine the hydraulic head distribution used in identifying groundwater flow paths. Measurements will also be made over time to evaluate temporal changes in flow paths and dynamics of the aquifer system. Groundwater levels are measured each time a well is sampled. Currently, groundwater levels are also measured in most of the wells in the 100-N Area monthly, usually all in a single day. These monthly measurements will continue at least until the water table in the vicinity of the 100-N Area stabilizes. Distribution of chemical and radioactive constituents in the groundwater also will be used to determine flow paths.

3.4.6 Data Interpretation and Presentation

A data package will be prepared after the new well is completed. This package will include borehole stratigraphy, geophysical logs, details of well completion, aquifer test results, well development, and survey data.

After additional data are gathered (i.e., groundwater chemistry and water levels), a site characterization report will be prepared. Specifically, this report will include (1) descriptions of hydrostratigraphic units; (2) water-level data and water table maps; (3) test data and results of analyses; (4) as-built diagrams of wells; and (5) hydrochemical data.

The hydrogeologic data will be integrated to refine the current conceptual model of the groundwater flow system(s) in the vicinity of the 100-N Area. The data will also be used to evaluate whether the characterization was adequate and if the groundwater monitoring system is appropriately designed. Recommendations will be provided for additional characterization activities or construction of additional groundwater monitoring wells, if necessary.

3.5 SAMPLING AND ANALYSIS

The new well and the 1301-N wells will be sampled quarterly for 1 yr and semiannually thereafter. Other wells will be sampled twice per year. The depth to water will be measured before samples are collected. The wells will be purged, and samples will be collected after at least three borehole volumes have been removed and when specific conductance, temperature, and pH have stabilized. In the case of wells that pump dry because of very low-permeability materials, the sample will be collected after recharge.

Sample analysis, preservation, and chain-of-custody procedures in accordance with 40 CFR 265.92 are discussed in WHC (1992b), which is updated annually. The quality assurance/control protocol is also given in WHC (1992b). The purpose of the quality control activities is to determine and document that samples were carefully collected and transferred to an analytical laboratory, that the quality of the analytical results being produced by the laboratory are defensible, and that corrective actions will be taken as necessary.

Under the indicator-evaluation monitoring program, groundwater surface elevation data must be evaluated at least annually to determine if the monitoring wells are appropriately located (see Section 3.4.6). If the evaluation indicates that existing wells are no longer adequately located, the groundwater monitoring system will be modified to bring it into compliance with 40 CFR 265.91(a).

3.6 STATISTICAL ANALYSIS OF GROUNDWATER MONITORING DATA

The following discussion summarizes methods for establishing baseline water quality, evaluating water chemistry data, and reporting monitoring results. Statistical methods are described in greater detail by Chou (1991).

3.6.1 Establishing Baseline Groundwater Quality

For the purposes of 1301-N and 1325-N RCRA groundwater monitoring, "baseline groundwater quality" refers to the chemical makeup of groundwater unaffected by the 1301-N and 1325-N LWDF. This water may have been affected by contamination from other Hanford Site activities.

The upgradient wells for the 1301-N LWDF have been changed since the baseline concentrations of indicator parameters were originally established. Therefore, four quarters of quadruplicate samples will be collected from the upgradient wells, and new background concentrations will be established using the new data.

After the last quarter of 1992, four quarters of data will be available from 1325-N upgradient well N-74. Upgradient data will be analyzed to determine new baseline values.

3.6.2 Evaluation of Data

A minimum of four replicate measurements of each indicator parameter will be obtained each time a well is sampled. To determine trends in the data, plots of the indicator parameters and other key constituents may be maintained for each well.

Summary statistics (mean, standard deviation, and coefficient of variation) will be calculated from four quarters of replicate averages for the indicator parameters from the upgradient well for each site. The upgradient data will be reviewed regularly, and the background statistics and/or statistical methodology may be modified if required, to address trends or seasonal variations.

After the baseline concentrations have been established, downgradient groundwater chemistry will be compared to baseline values. At least four replicate measurements will be obtained from each downgradient well for each of the indicator parameters, and the arithmetic mean and variance will be calculated for the indicator parameters for each sample.

An averaged replicate t-test will be used to determine statistically significant changes in the concentration of indicator parameters in downgradient wells relative to initial baseline concentrations. For specific conductance, total organic halogen, and total organic carbon, a one-tailed t-test will be used to test for significant increase over baseline values at the 0.01 level of significance. The test for pH will be a two-tailed t-test at the overall 0.01 level of significance.

If a large percentage (i.e., over 50%) of the total organic carbon and total organic halogen values from the upgradient well are below the contractually established detection limits, a limit of quantitation (LOQ) will be calculated from the analytical laboratory's blank data. The LOQ is defined as the blank mean plus 10 blank standard deviations (EPA 1989). For cases where the calculated critical mean is below the limit of quantitation, the LOQ will be used as the comparison value between upgradient and downgradient wells, following the guidance in EPA (1986). This approach makes use of laboratory quality control data to target the limits of quantifiable data and provides a realistic approach for upgradient-downgradient well comparison.

3.7 NOTIFICATION AND REPORTS

A summary of the reports required for compliance with 40 CFR 265, Subpart F, is given in Table 3-5.

Table 3-5. Reports Required for Compliance with 40 CFR 265, Subpart F, for Groundwater Monitoring.

Submittal	Submittal period	Reference
First year of sampling only: Concentrations of interim primary drinking water constituents, identifying those exceeding the limits of 40 CFR 265, Appendix III.	Quarterly	40 CFR 265.94(a)(2)(i)
Concentration and statistical analyses of groundwater contamination indicator parameters, noting significant differences in upgradient wells.	Annually, by March 1 of following year	40 CFR 265.94(a)(2)(ii)
Results of groundwater surface elevation evaluation and description of response if appropriate.	Annually, by March 1 of following year	40 CFR 265.94(a)(2)(iii)

4.0 PHASE II--INITIATION OF GROUNDWATER QUALITY ASSESSMENT PROGRAM

This chapter discusses the criteria that would again require notification of regulatory agencies and initiation of a groundwater quality assessment program. The notifications for compliance with 40 CFR 265, Subpart F, are presented, and the contents of the groundwater quality assessment program are outlined.

Groundwater samples from all monitoring wells will be tested semiannually for contamination indicator parameters, and annually for interim primary drinking water constituents, secondary groundwater quality parameters, and site-specific parameters (see Table 3-4). The indicator parameters for the downgradient wells will be statistically compared to the established background values to determine if there is a significant difference (see Section 3.6.2). If a parameter is significantly elevated and indicates that the unit may be affecting groundwater, the well(s) with the elevated values will be resampled. If the results are verified by the second sampling, Ecology will be notified in writing within 7 days of verification.
A groundwater quality assessment plan will be developed and sent to Ecology within 15 days following the notification. An outline of this plan is presented below.

- Introduction
- Existing Data and Evaluation
- Overview of Site Hydrogeology
- Groundwater Quality Assessment Program
  - Investigatory Approach
  - Assessment Monitoring Network
  - Water Level Monitoring
  - Constituents
  - Schedule
- Sampling and Analysis
  - Methods
  - Quality Assurance
  - Quality Control
- References

The groundwater quality assessment program will include (1) number, location, and depth of wells in the monitoring network; (2) sampling and analytical methods used; (3) evaluation procedures; and (4) a schedule of implementation. The assessment program will also provide an investigative approach to determine rate and extent of migration of hazardous waste or hazardous constituents in the groundwater and their concentrations. As soon as technically feasible, these determinations will be made, and a report of the findings will be sent to Ecology. Table 4-1 provides a schedule for reports and notifications.

Table 4-1. Reports and Notifications.

Submittal	Submittal period	Reference
Reports required whether or not the unit might be affecting groundwater		
First year of sampling only: Concentrations of interim primary drinking water standards, identifying those exceeding the limits of 40 CFR 265, Appendix III	Quarterly	40 CFR 265.94(a)(2)(i)
Concentrations and statistical analyses of groundwater contamination indicator parameters, noting significant differences in upgradient wells	Annually, by March 1 of following year	40 CFR 265.94(a)(2)(ii)
Results of groundwater surface elevation and description of response, if appropriate	Annually, by March 1 of following year	40 CFR 265.94(a)(2)(iii)
Reports required if the unit might be affecting groundwater		
Notification that the unit might be affecting groundwater	Within 7 days of confirmation of a statistically significant difference over background	40 CFR 265.93(d)(1)
Groundwater quality assessment plan	Within 7 days of the above notification	40 CFR 265.93(d)(2)
Report on assessment of groundwater quality, including concentrations of hazardous waste constituents and their rate and extent of migration	Within 15 days of first determination (as soon as technically feasible)	40 CFR 265.93(d)(5)
Results of the groundwater quality assessment program	Annually, by March 1 of following year, until closure of unit	40 CFR 265.94(b)(2)

5.0 REFERENCES

40 CFR 265, Subpart F, 1987, U.S. Environmental Protection Agency, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Code of Federal Regulations, Washington, D.C.

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APPENDIX A

GEOLOGIC AND WELL CONSTRUCTION DIAGRAMS FOR SELECTED 100 N AREA WELLS

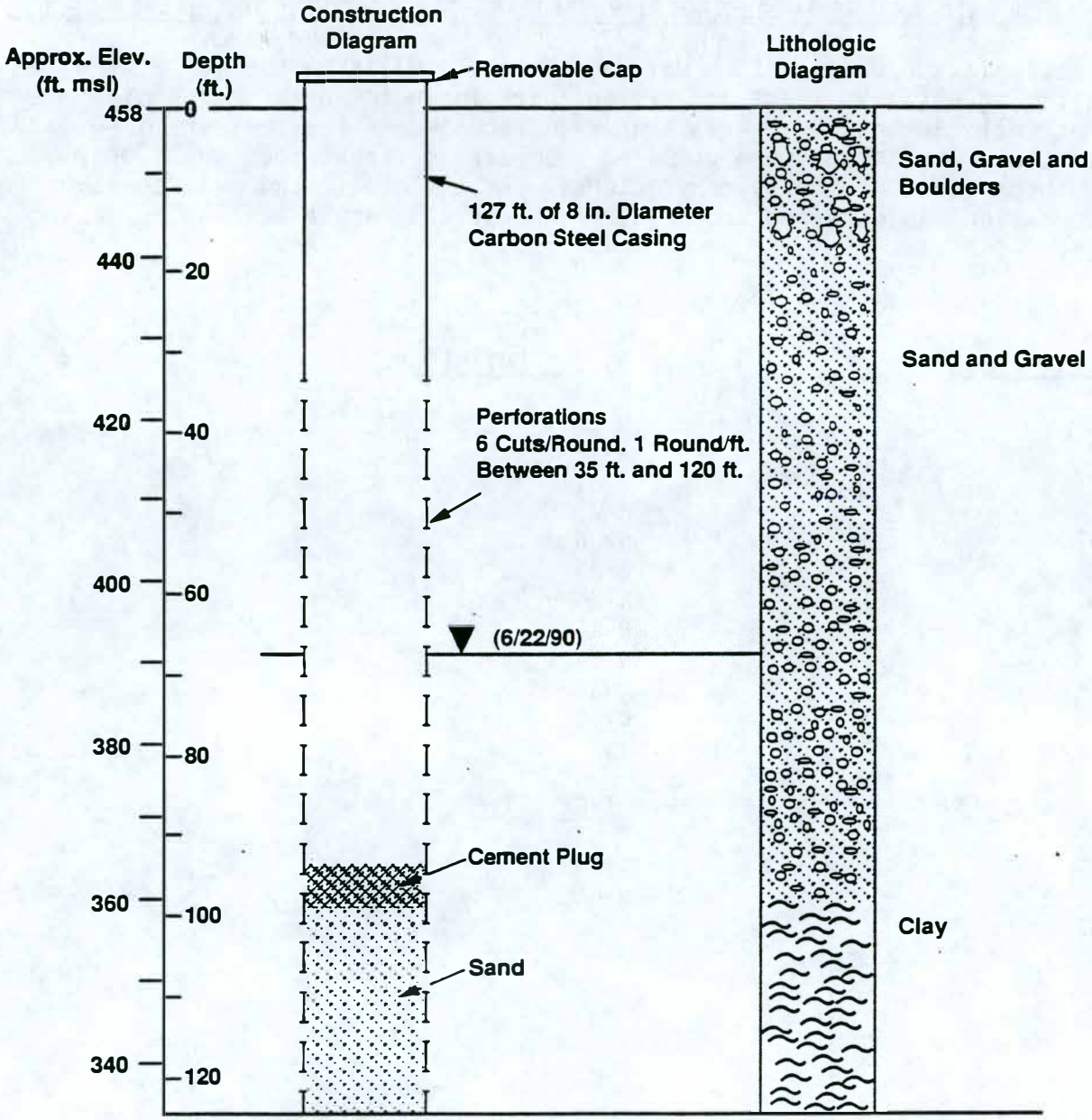
Geologic and construction diagrams from the wells in the 100 N Area RCRA monitoring networks (past and present) are included in this appendix. Several other wells in the 100 N Area that are discussed in the text are also included. These logs were compiled from data obtained from wells drilled by U.S. Department of Energy contractors. The lithologic and well construction information was obtained from drillers' logs and, where available, geologist's logs.

This appendix includes information for the following wells:

1301-N WELLS	ASSESSMENT WELLS
N-2	N-16
N-3	N-17
N-4	N-18
N-34	N-21
N-14	N-23
N-57	N-24
N-66	N-25
N-67	N-26
N-69	N-47
N-75	N-54
N-76	N-55
	N-56

1325-N WELLS	OTHER WELLS
N-27	N-63
N-29	N-64
N-31	N-65
N-32	N-80
N-33	
N-36	
N-39	
N-41	
N-42	
N-43	
N-52	
N-70	
N-74	
699-81-58	

Well 199-N-2



Drilled Depth: 125 ft.
Completion Date: 6/64
Plug Installed 5/78
Elevation Top of Casing: 459.53 ft. msl

Logged by Driller

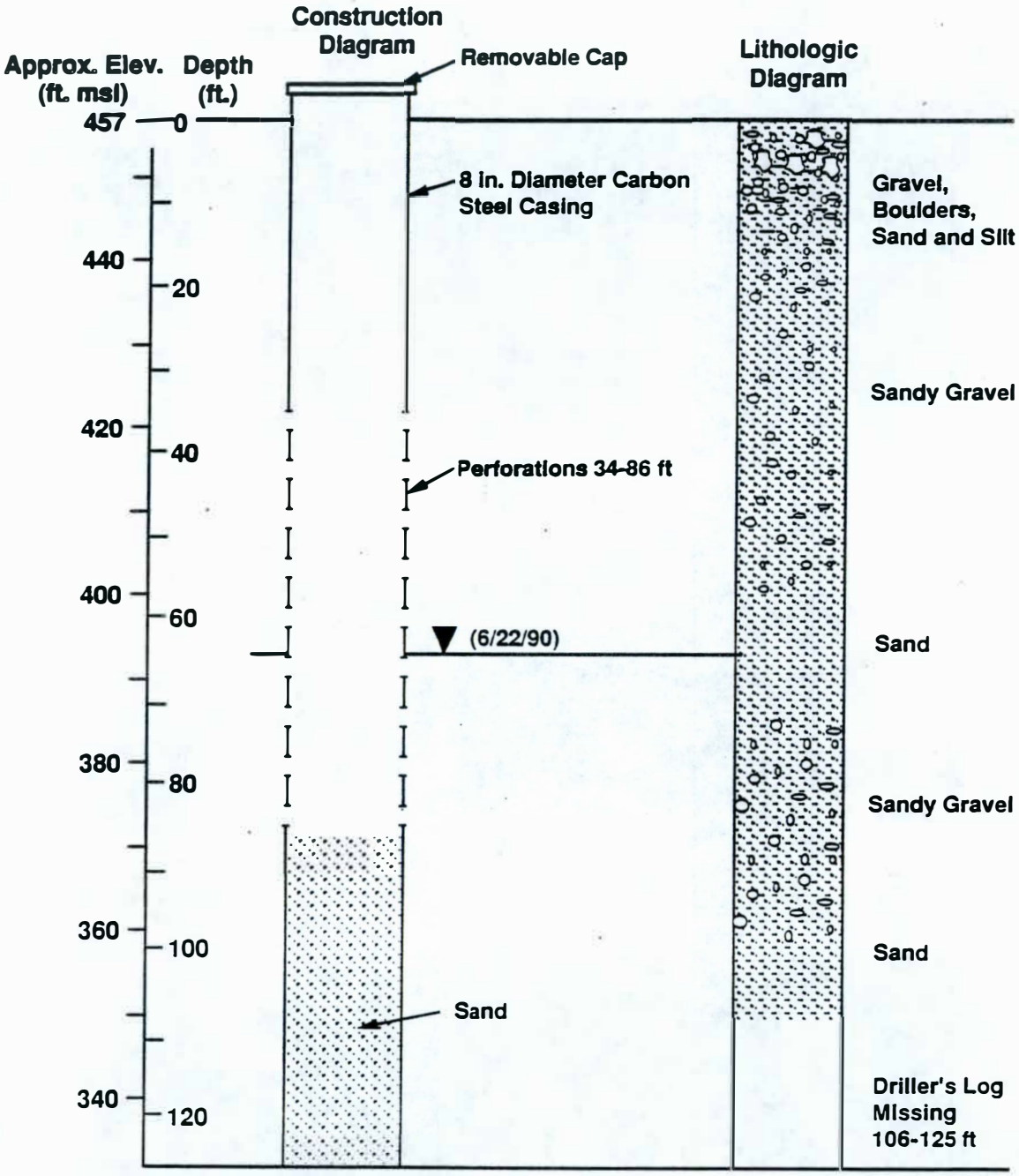
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.40

Well 199-N-3



Drilled Depth: 125 ft
Completion Date: 6/64
Elevation Top of Casing: 459.45 ft. msl

Logged by Driller

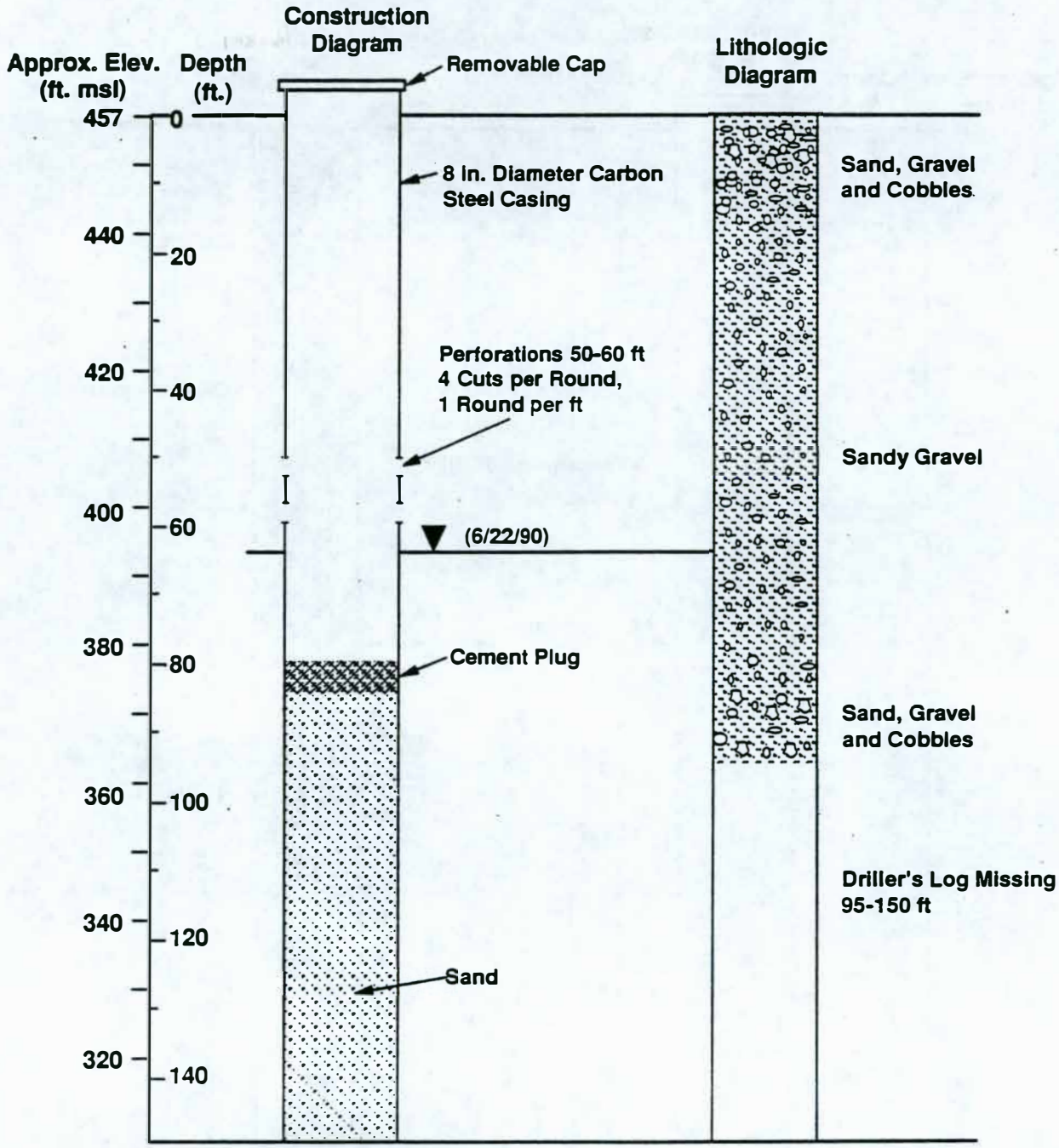
(6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.39

Well 199-N-4



Drilled Depth: 150 ft
Completion Date: 6/64
Plug Installed: 6/74
Elevation Top of Casing: 458.73 ft. msl

Logged by Driller

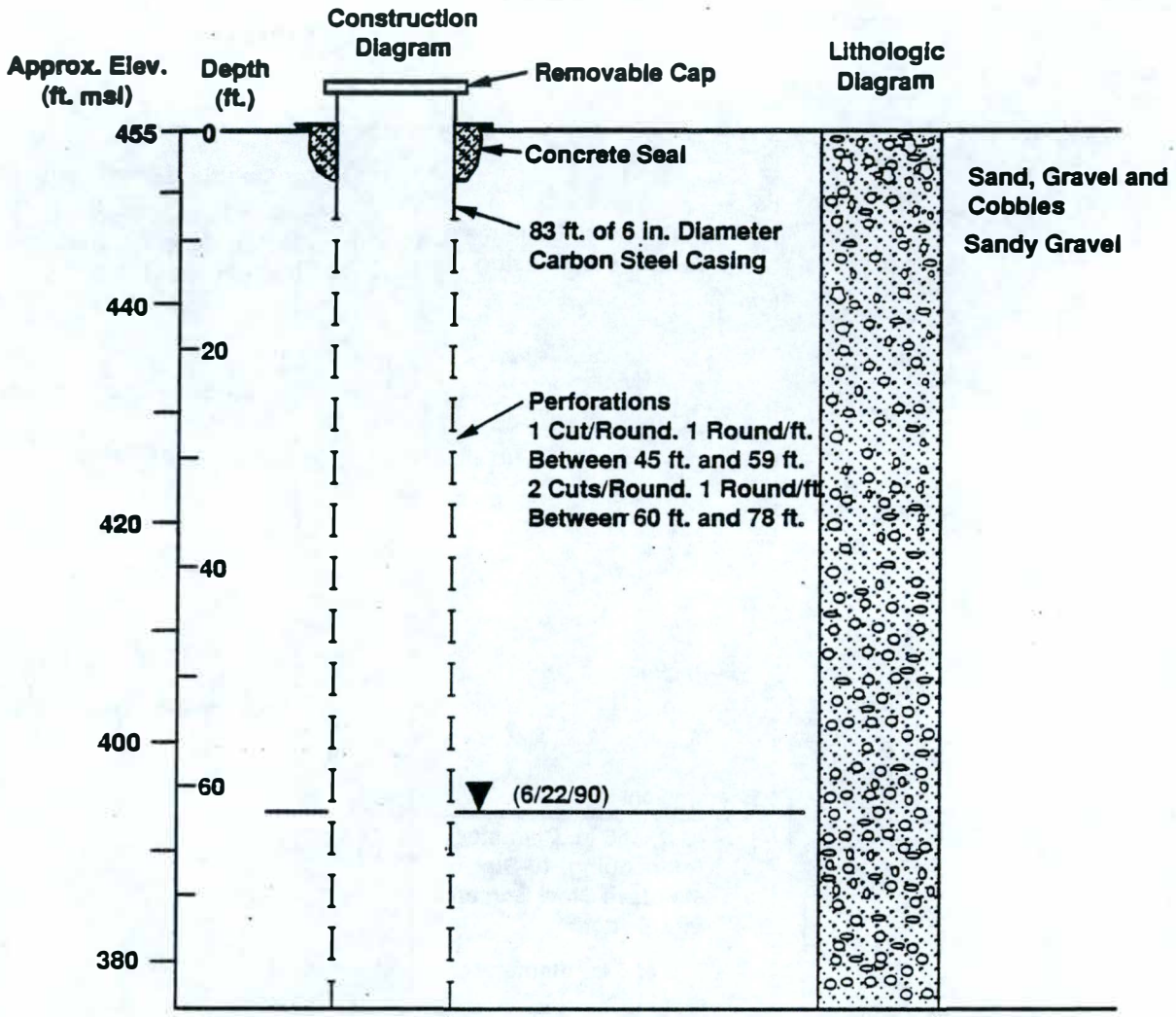
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.38

Well 199-N-14



Drilled Depth: 80 ft.
Completion Date: 4/69
Elevation Top of Casing: 453.15 ft. msl

Logged by Driller

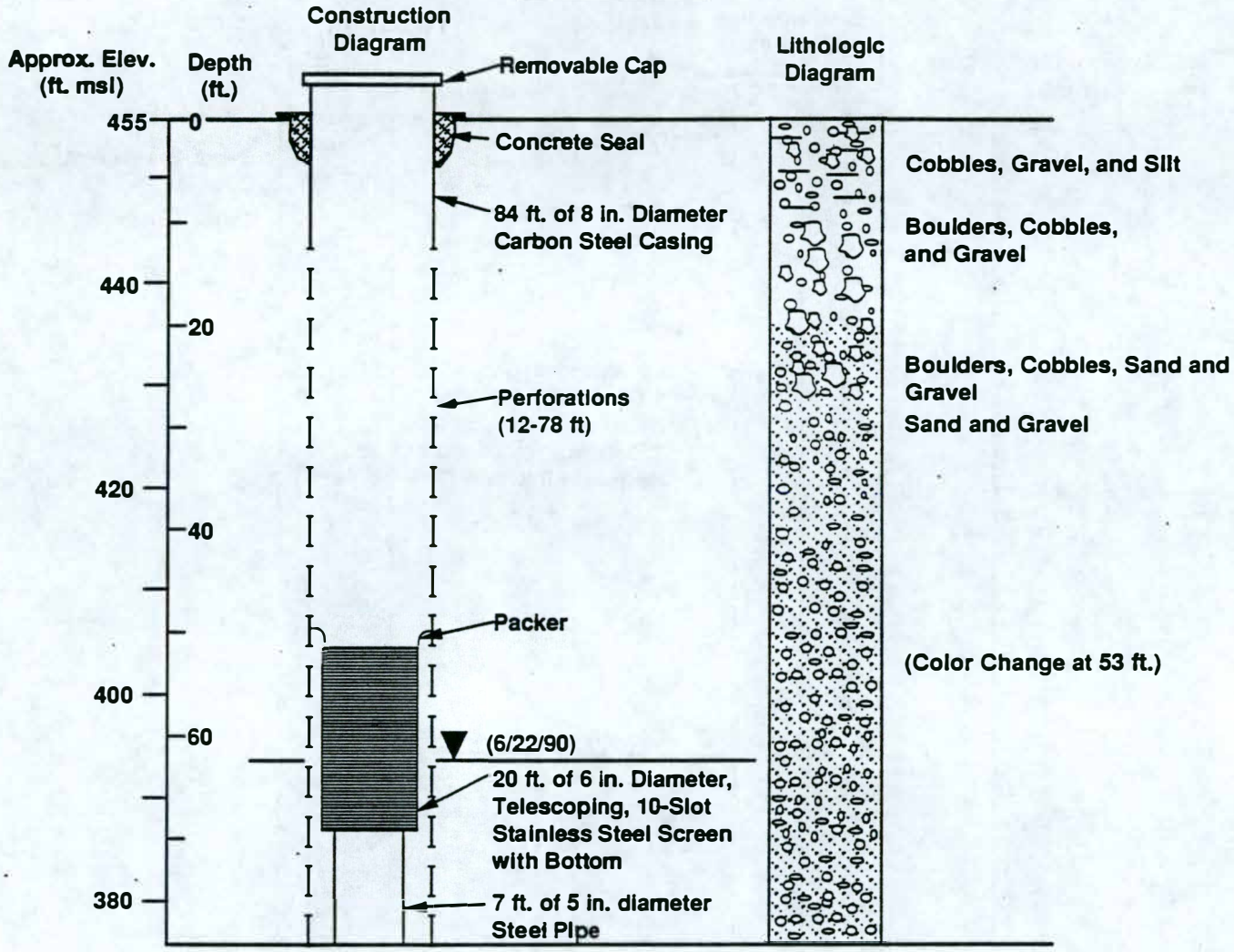
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.37

Well 199-N-16



Drilled Depth: 80 ft.
Completion Date: 2/81
Elevation Top of Casing: 456.70 ft. msl

Logged by Driller

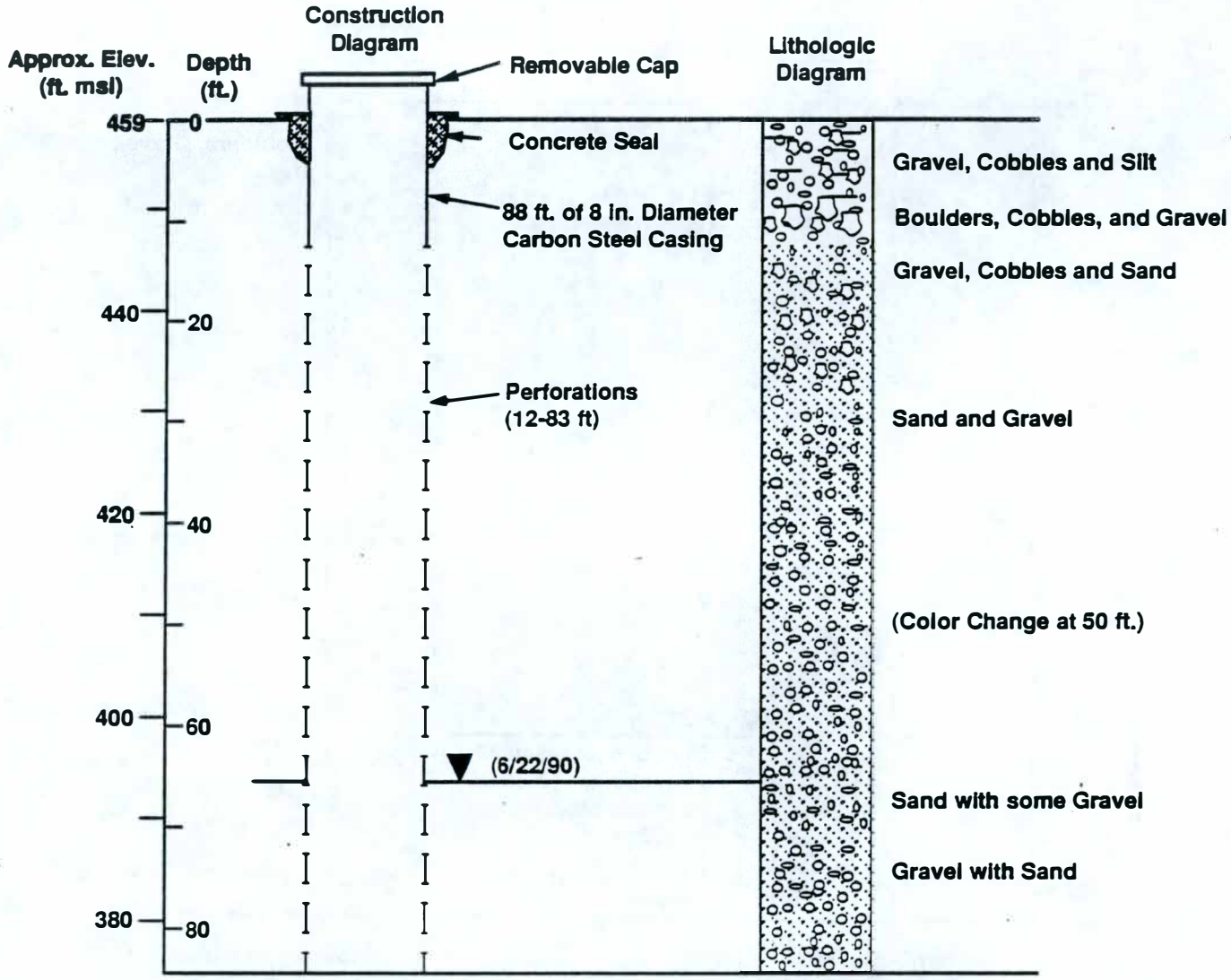
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.36

Well 199-N-17



Drilled Depth: 84.5 ft.
Completion Date: 1/81
Elevation Top of Casing: 461.20 ft. msl

Logged by Driller

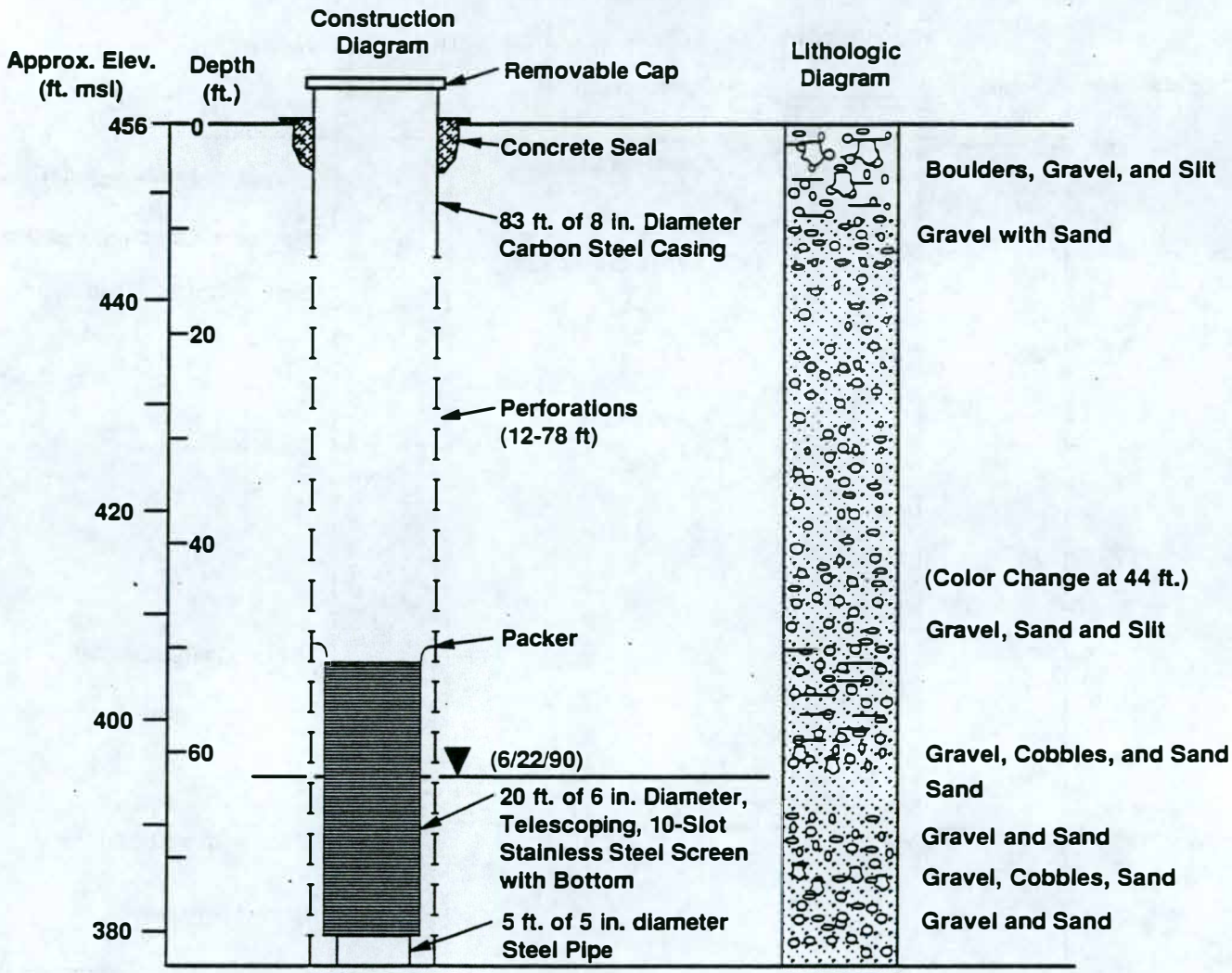
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.35

Well 199-N-18



Drilled Depth: 80 ft.
Completion Date: 2/81
Elevation Top of Casing: 458.50 ft. msl

Logged by Driller

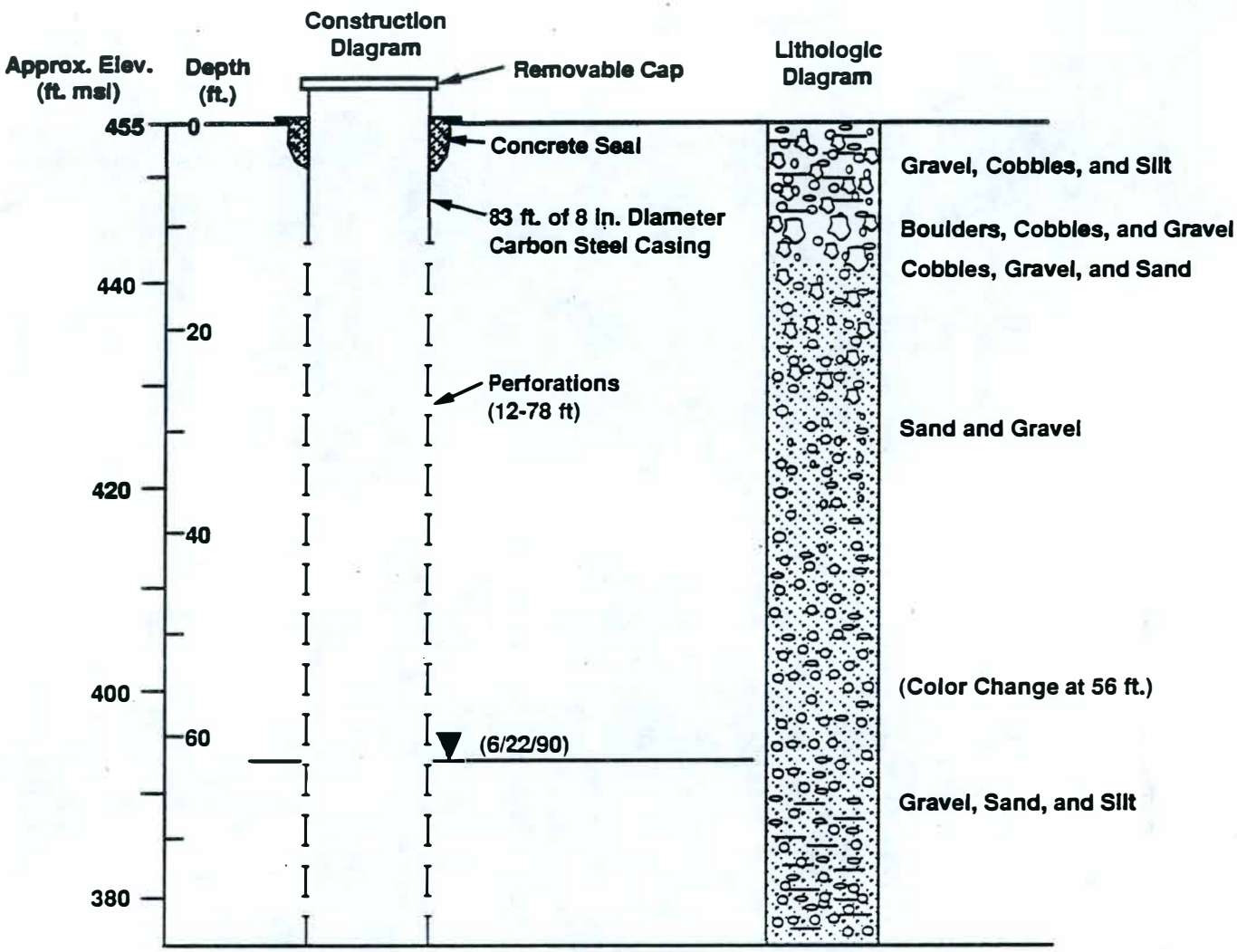
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.34

Well 199-N-21



Drilled Depth: 80 ft.
Completion Date: 1/81
Elevation Top of Casing: 457.00 ft. msl

Logged by Driller

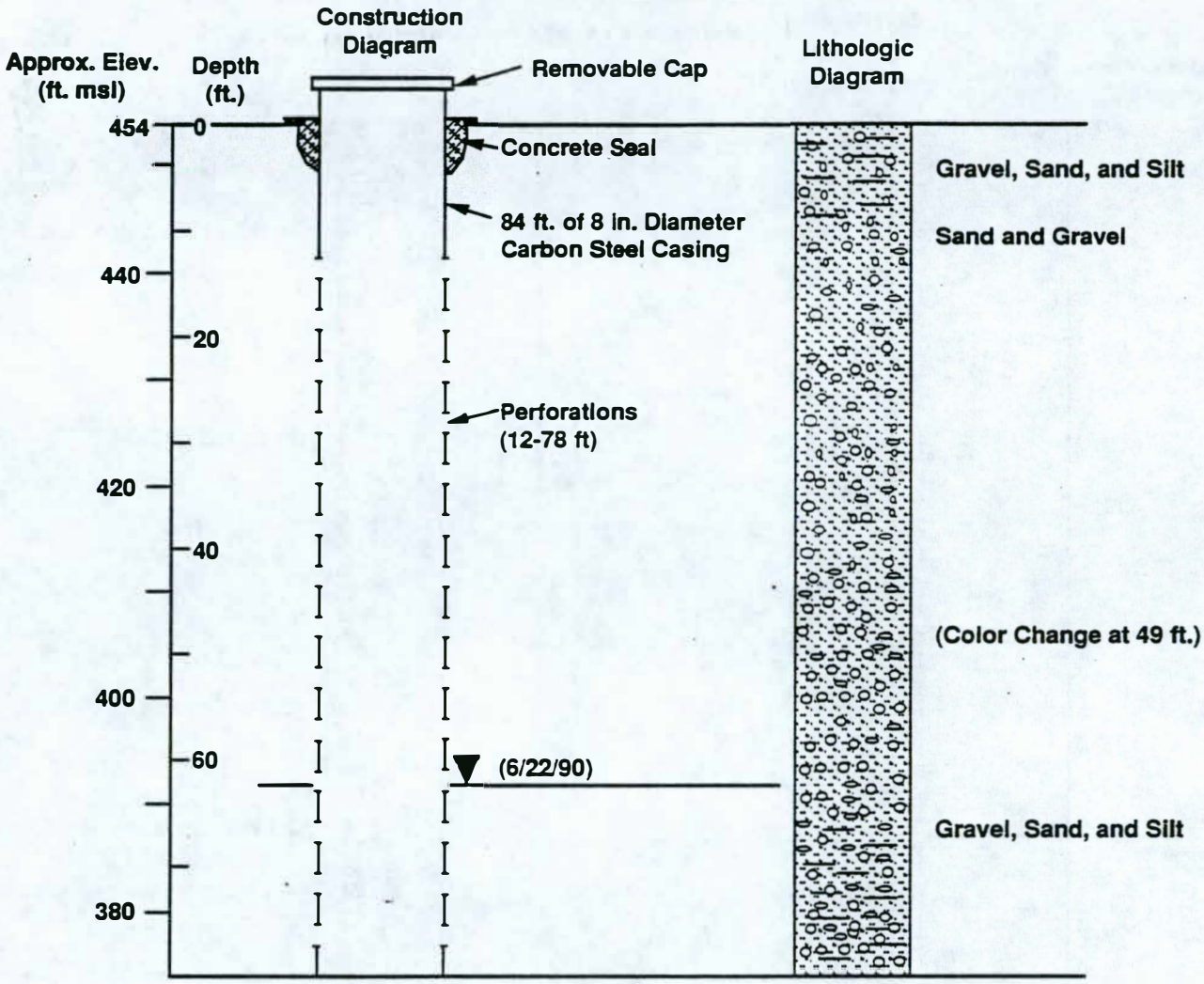
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.33

Well 199-N-23



Drilled Depth: 80 ft.
Completion Date: 1/81
Elevation Top of Casing: 456.30 ft. msl

Logged by Driller

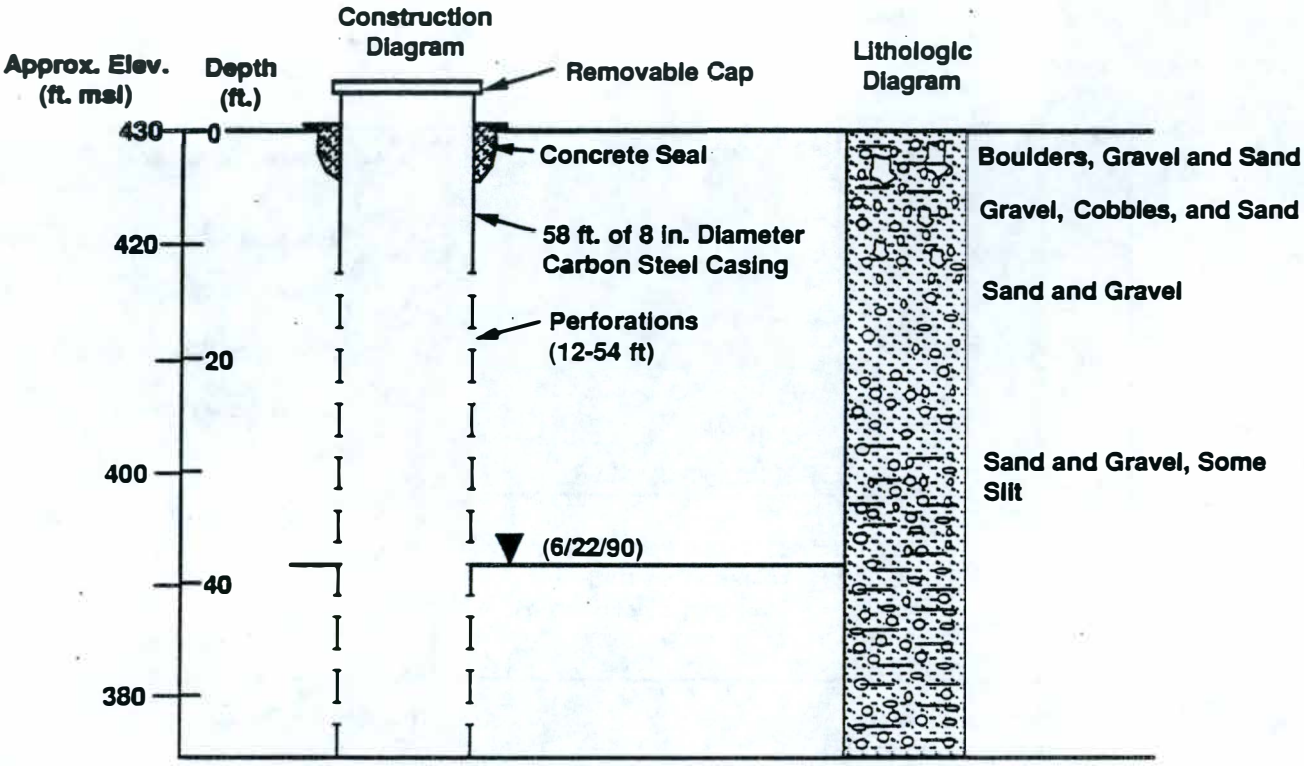
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.32

Well 199-N-24



Drilled Depth: 55 ft.
Completion Date: 1/81
Elevation Top of Casing: 432.50 ft. msl

Logged by Driller

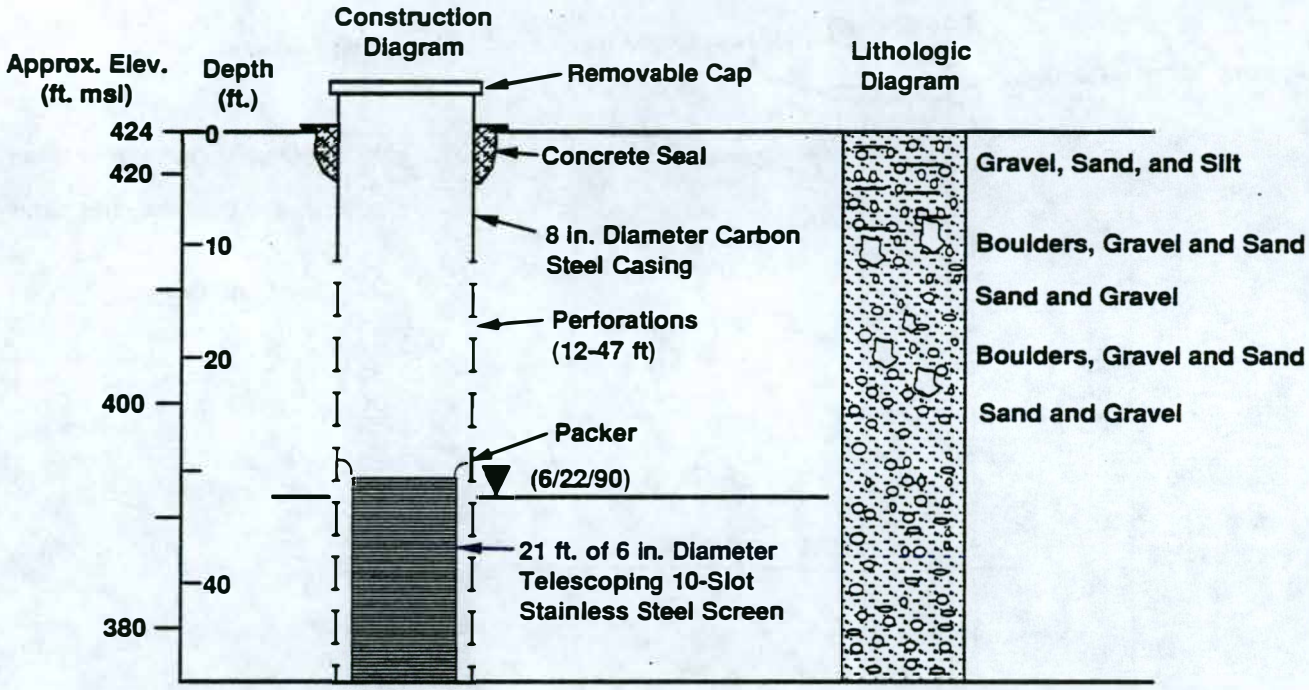
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.31

Well 199-N-25



Drilled Depth: 49 ft.
Completion Date: 1/81
Elevation Top of Casing: 425.80 ft. msl

Logged by Driller

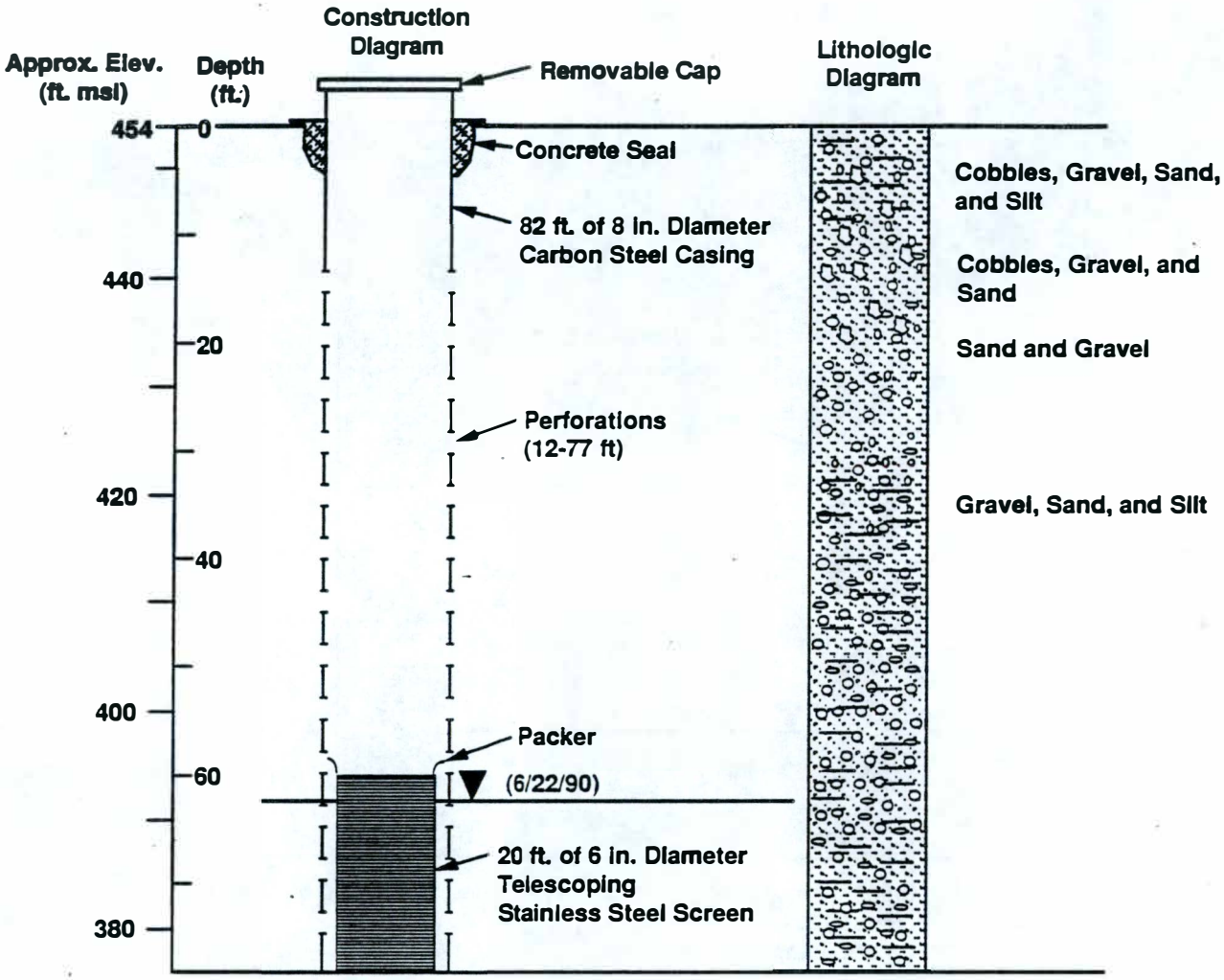
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.30

Well 199-N-26



Drilled Depth: 79 ft.
Completion Date: 1/81
Elevation Top of Casing: 455.80 ft. msl

Logged by Driller

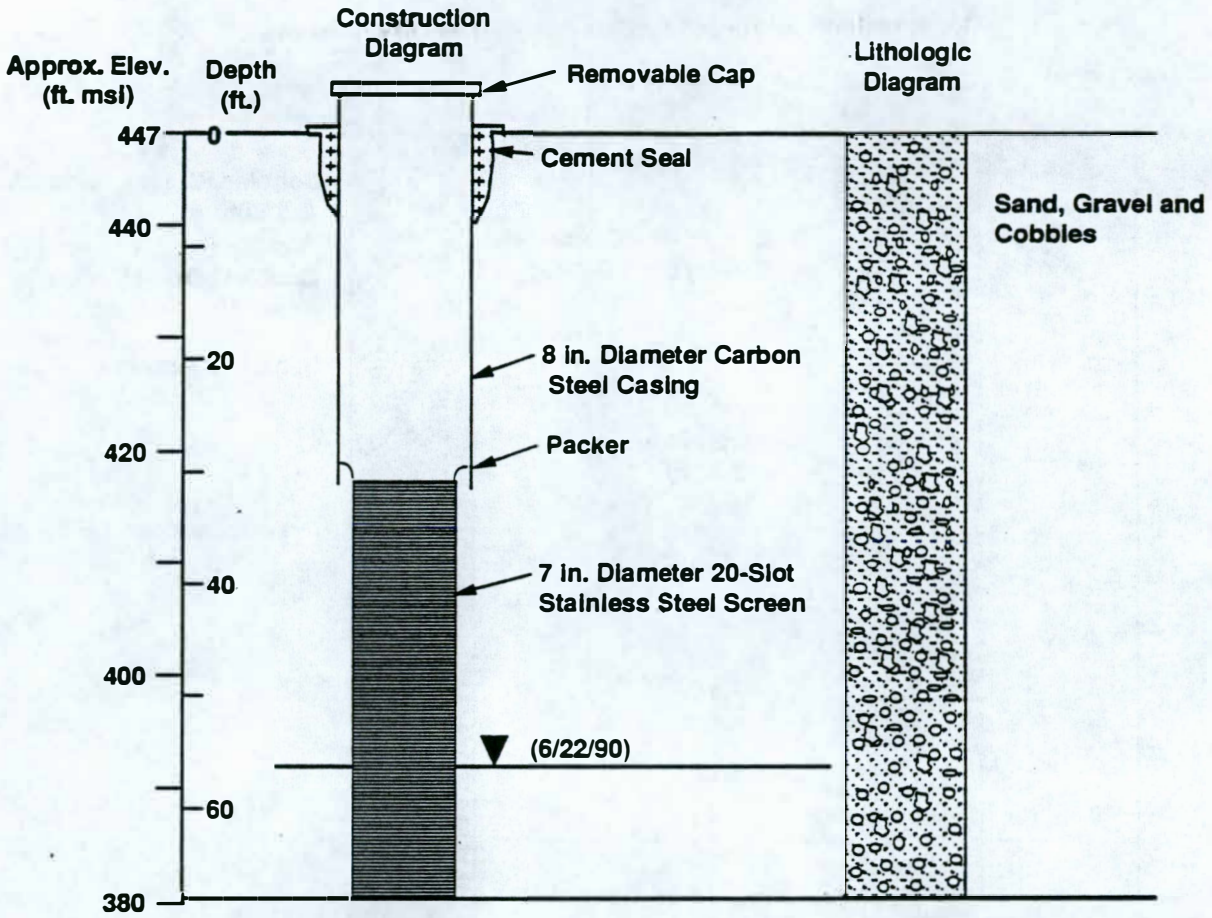
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.29

Well 199-N-27



Drilled Depth: 69 ft.
Completion Date: 8/83
Elevation Top of Casing: 449.08 ft. msl

Logged by Driller.

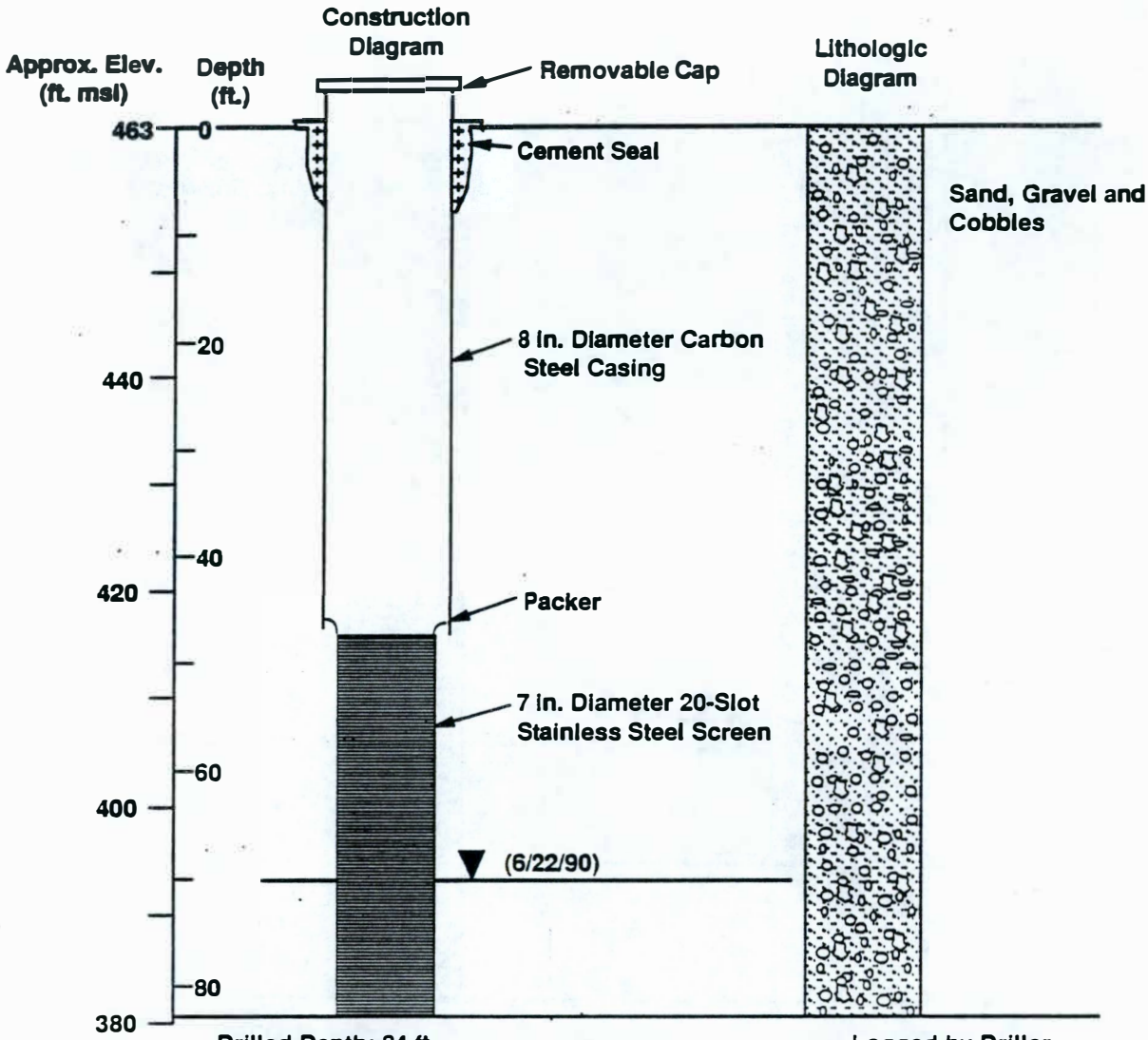
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.28

Well 199-N-29



Drilled Depth: 84 ft.
Completion Depth: 84 ft.
Completion Date: 8/83
Elevation Top of Casing: 465.25 ft. msl

Logged by Driller

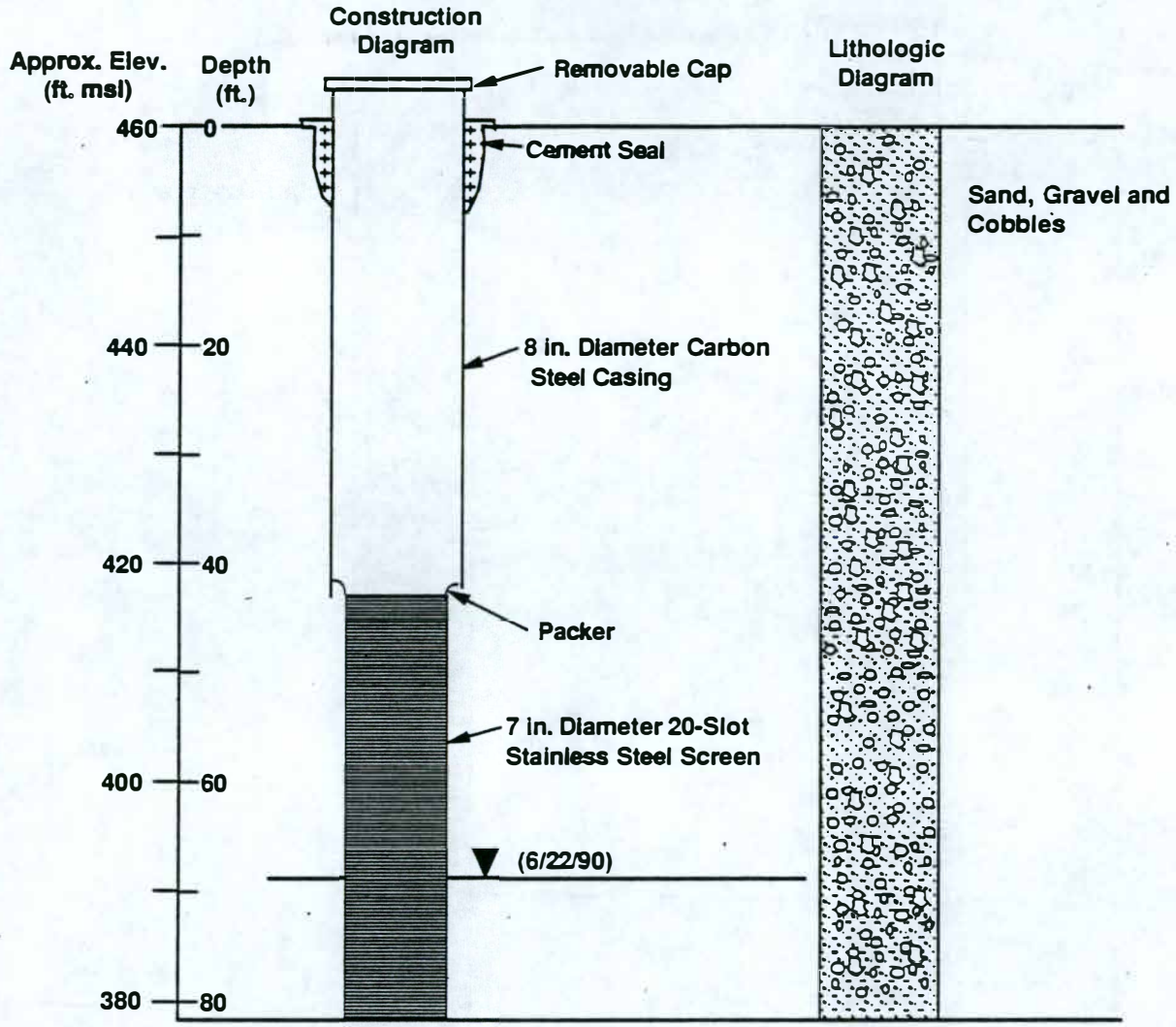
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.27

Well 199-N-31



Drilled Depth: 81 ft.
Completion Depth: 81 ft.
Completion Date: 9/83
Elevation Top of Casing: 462.63 ft. msl

Logged by Driller

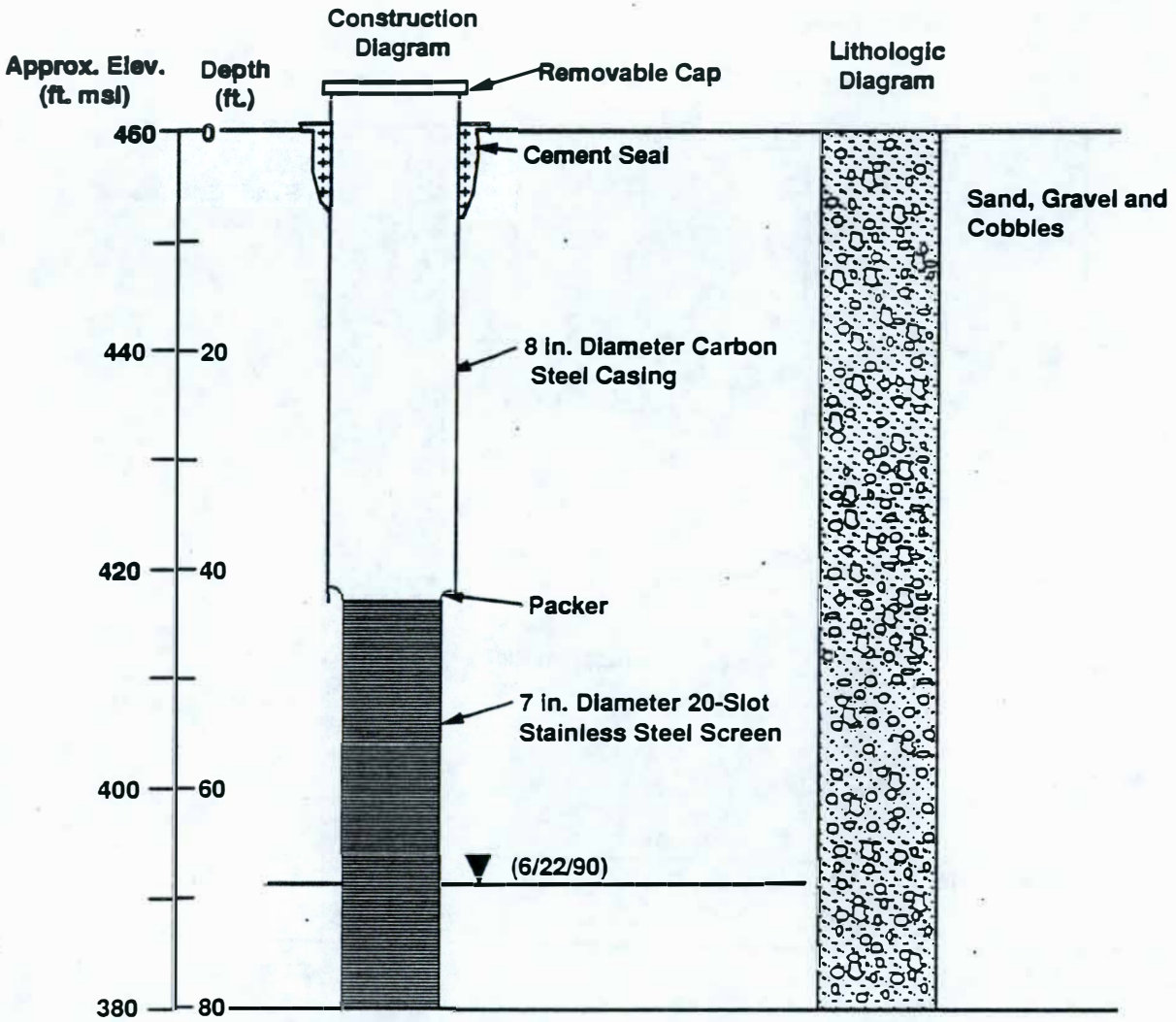
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.26

Well 199-N-32



Drilled Depth: 80 ft.
Completion Depth: 80 ft.
Completion Date: 9/83
Elevation Top of Casing: 462.08 ft. msl

Logged by Driller

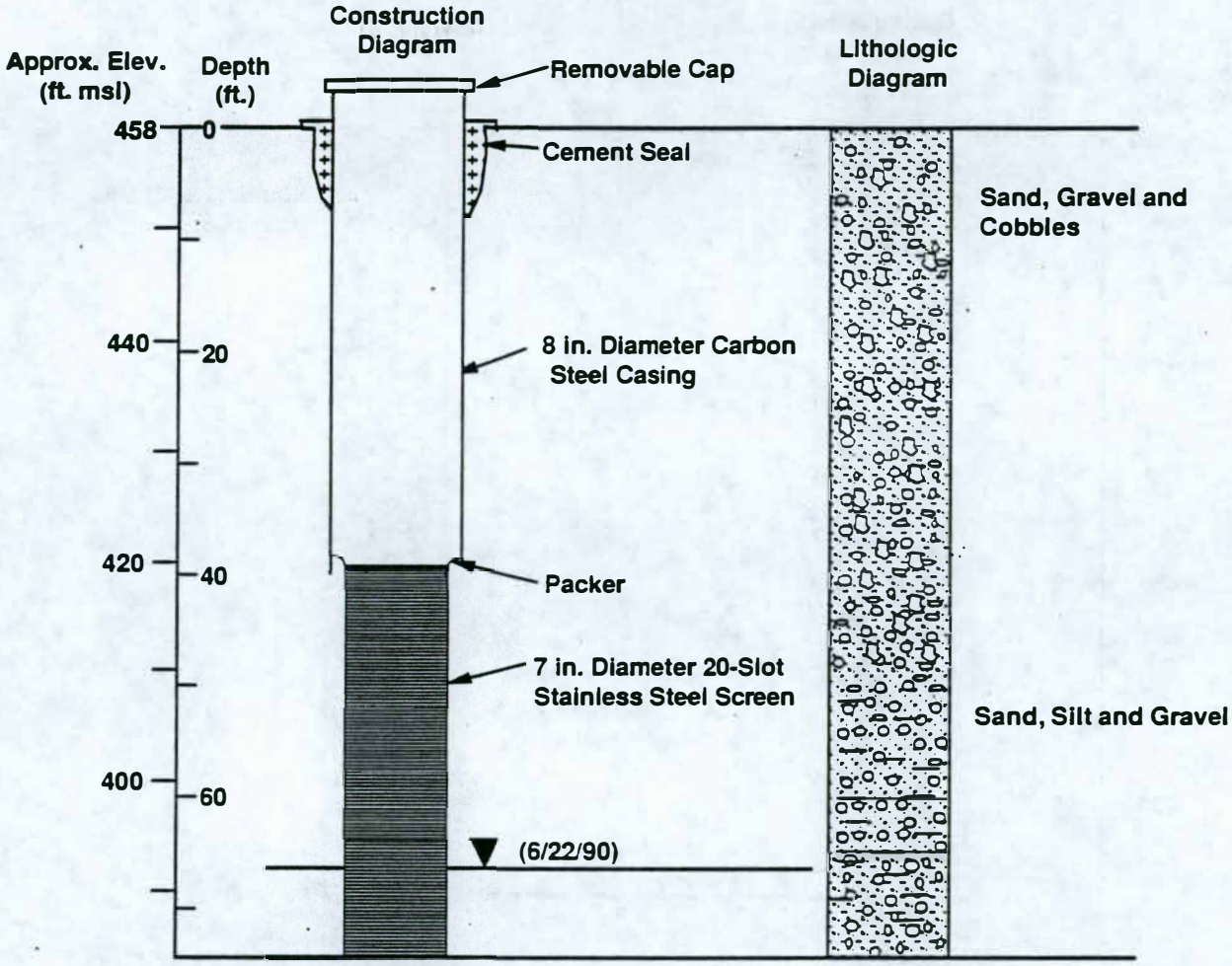
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.25

Well 199-N-33



Drilled Depth: 75 ft.
Completion Depth: 75 ft.
Completion Date: 8/83
Elevation Top of Casing: 459.87 ft. msl

Logged by Driller

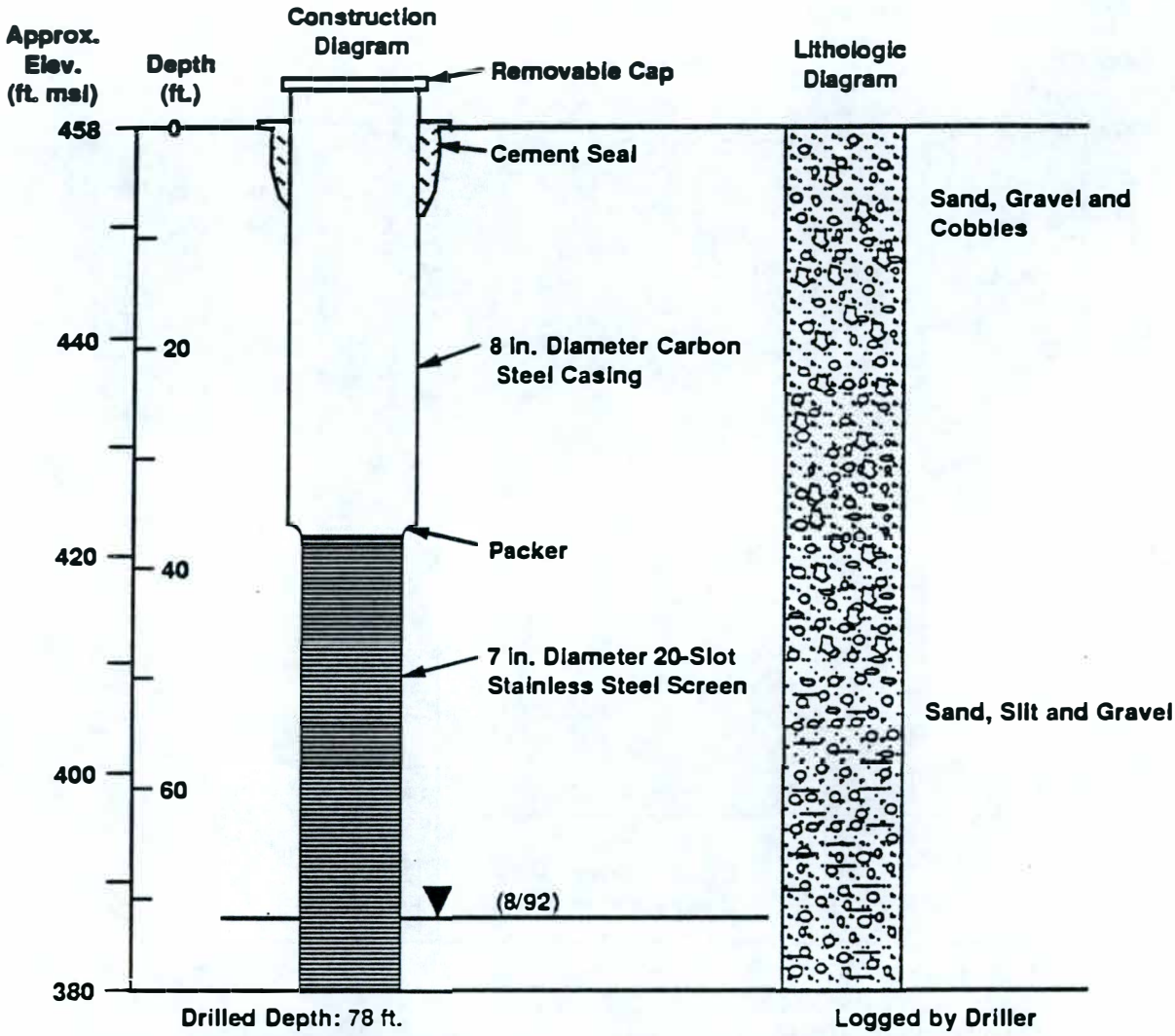
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.24

Well 199-N-34



Drilled Depth: 78 ft.
Completion Depth: 78 ft.
Completion Date: 9/83
Elevation Top of Casing: 459.63 ft. msl

Logged by Driller

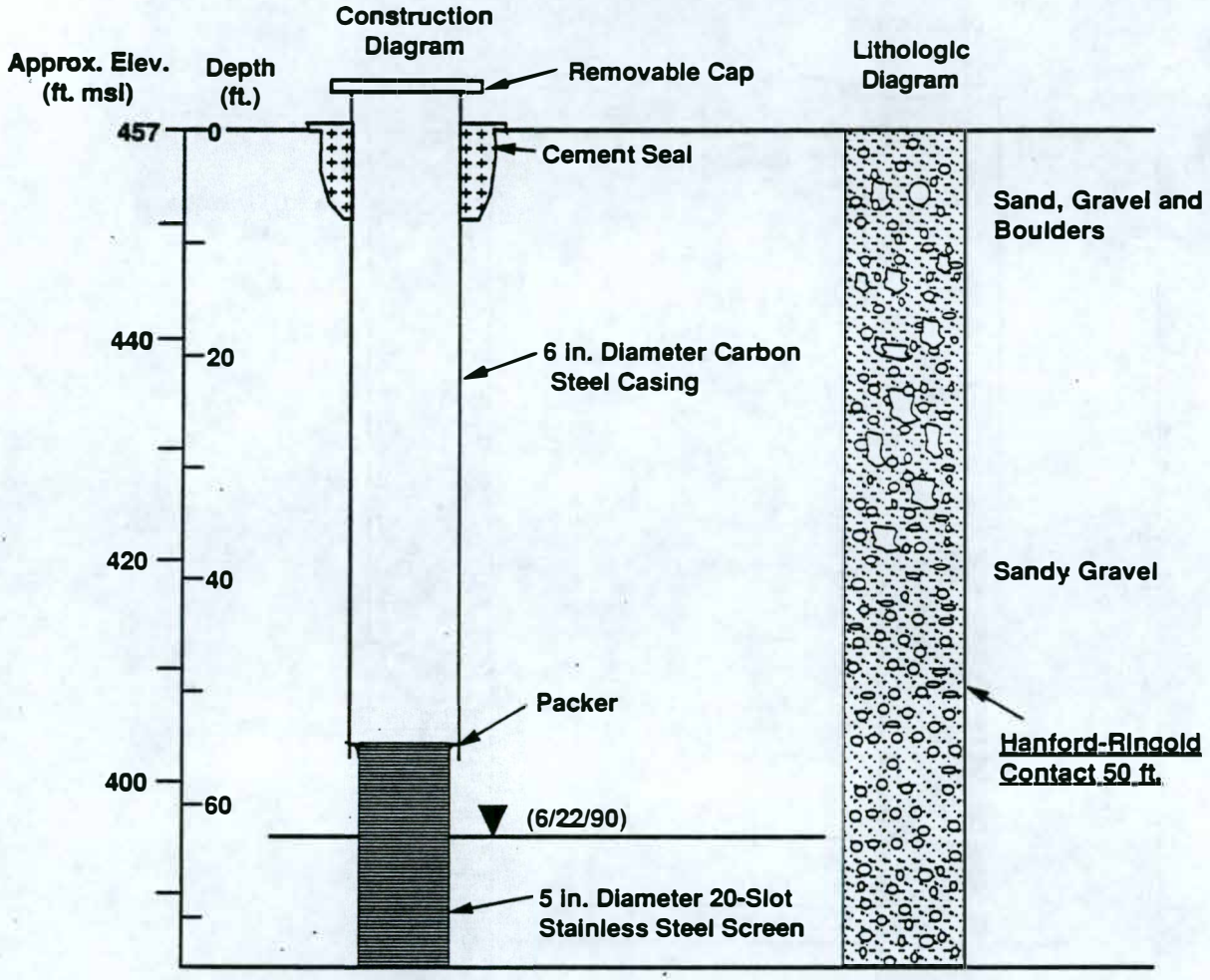
▼ (8/92) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

H9301032.1

Well 199-N-36



Drilled Depth: 75 ft.
Completion Depth: 74 ft.
Completion Date: 4/84
Elevation Top of Casing: 458.97 ft. msl

Logged by Geologist

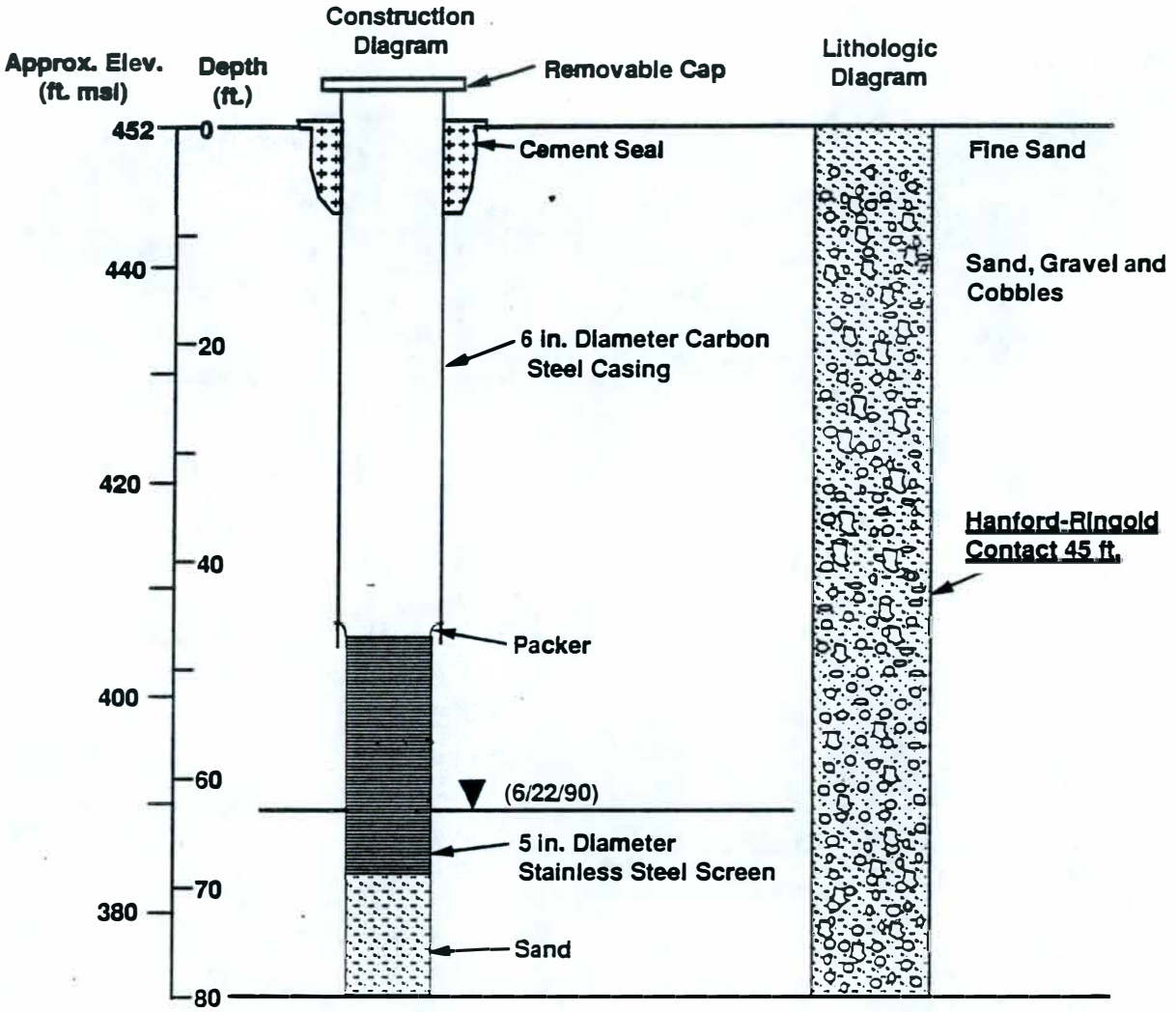
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.23

Well 199-N-39



Drilled Depth: 80 ft.
Completion Date: 4/84
Screen Installed: 6/85
Elevation Top of Casing: 454.31 ft. msl

Logged by Geologist

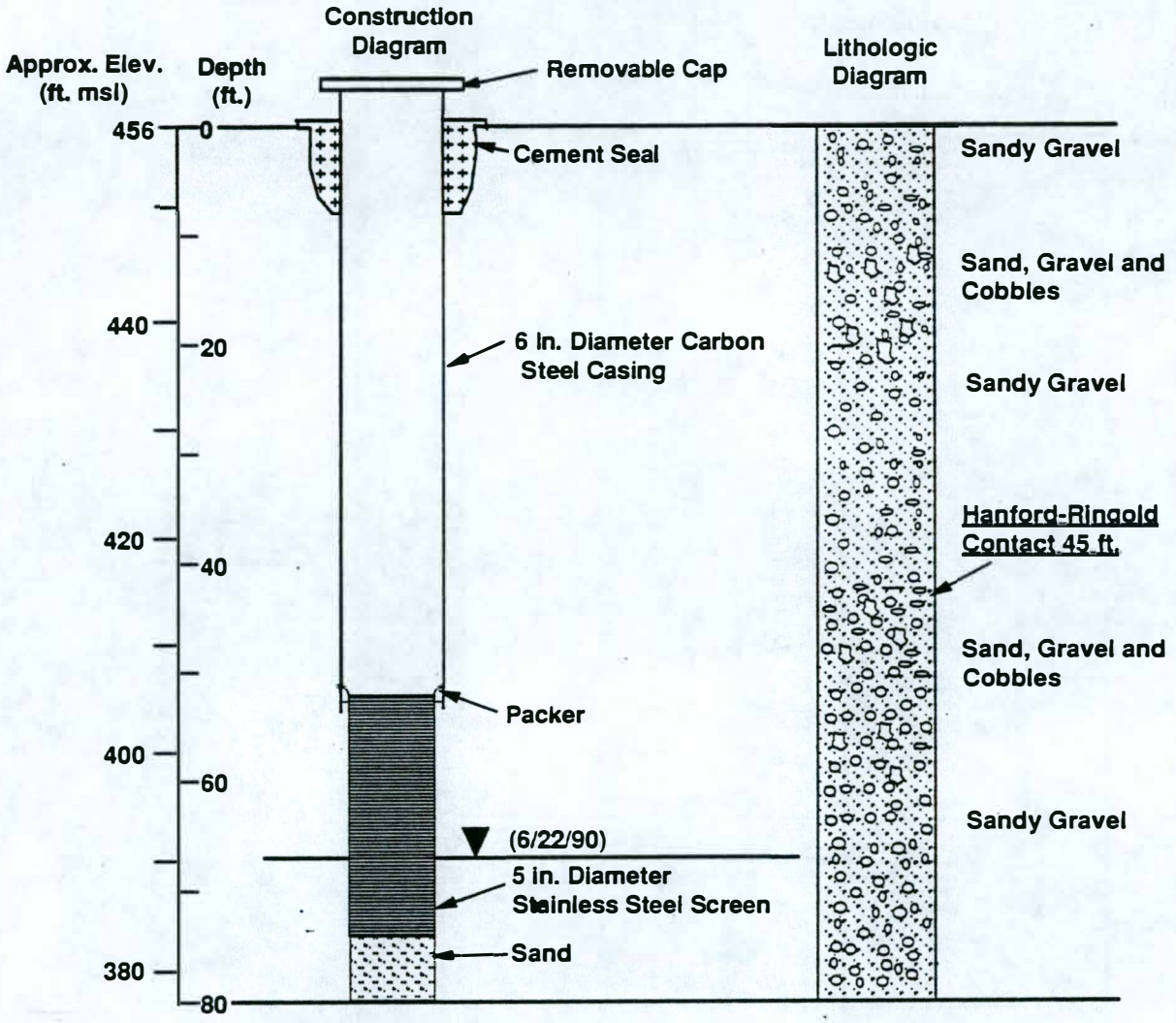
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.22

Well 199-N-41



Drilled Depth: 80 ft.
Completion Date: 4/84
Screen Installed: 6/85
Elevation Top of Casing: 457.59 ft. msl

Logged by Geologist

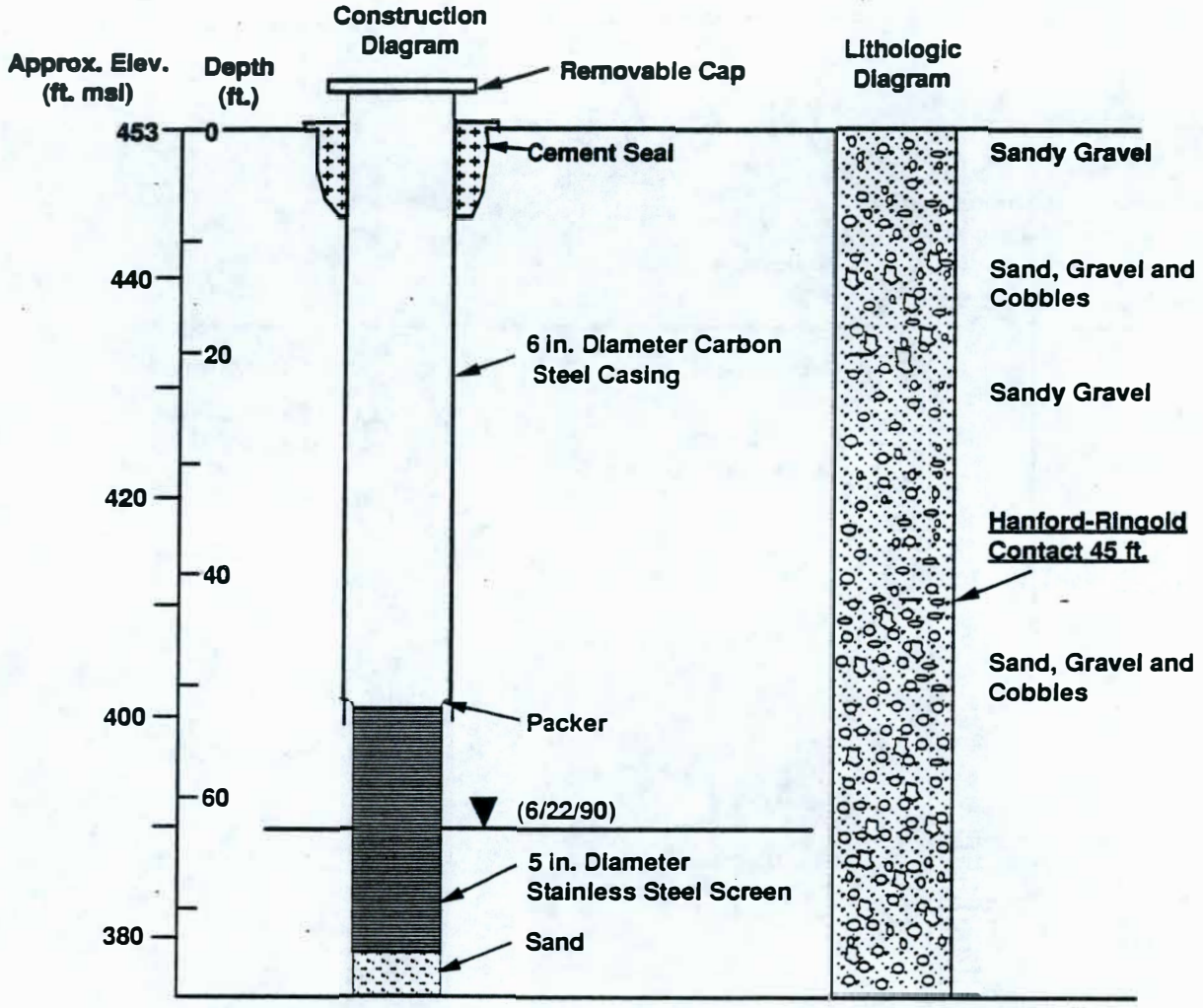
(6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.21

Well 199-N-42



Drilled Depth: 78 ft.
Completion Date: 4/84
Screen Installed: 7/85
Elevation Top of Casing: 455.14 ft. msl

Logged by Geologist

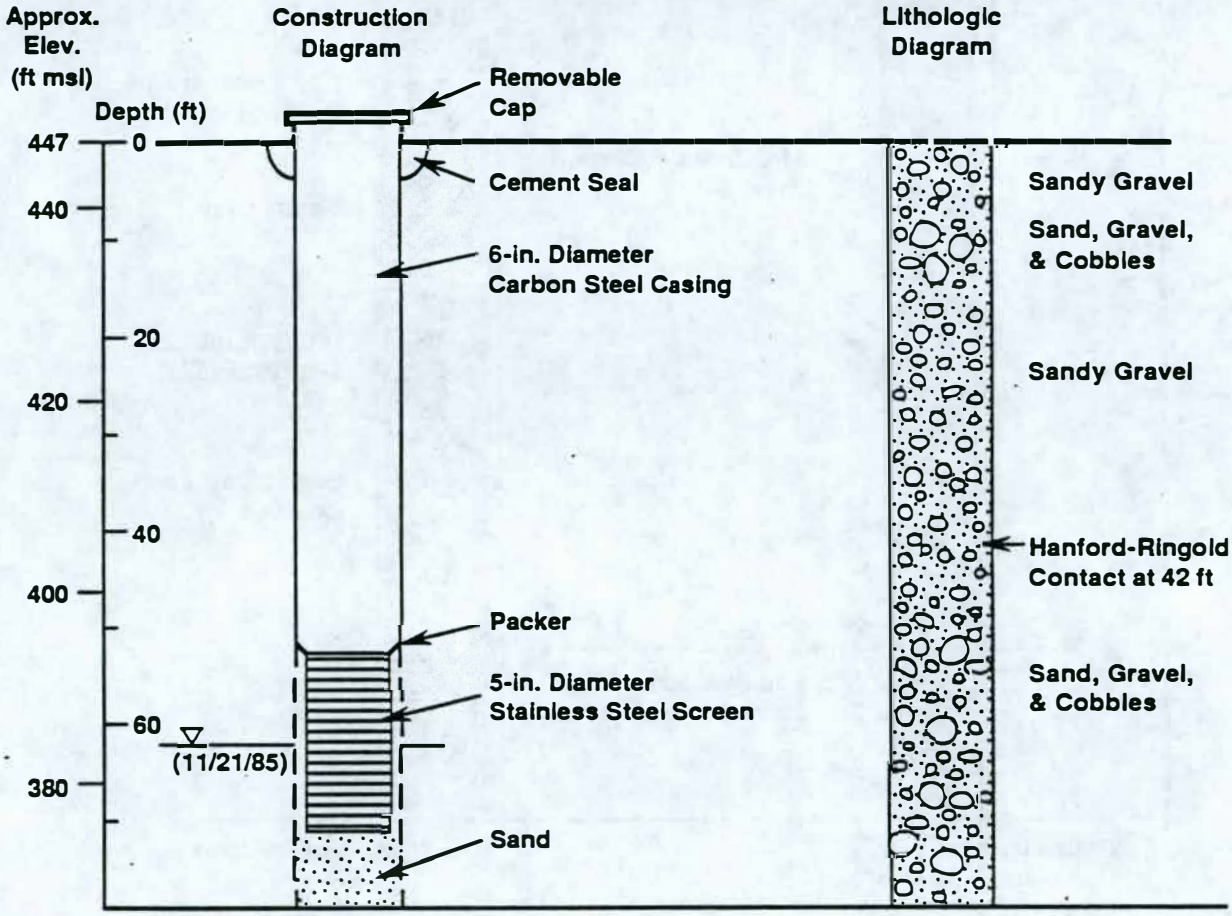
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.20

Well 199-N-43

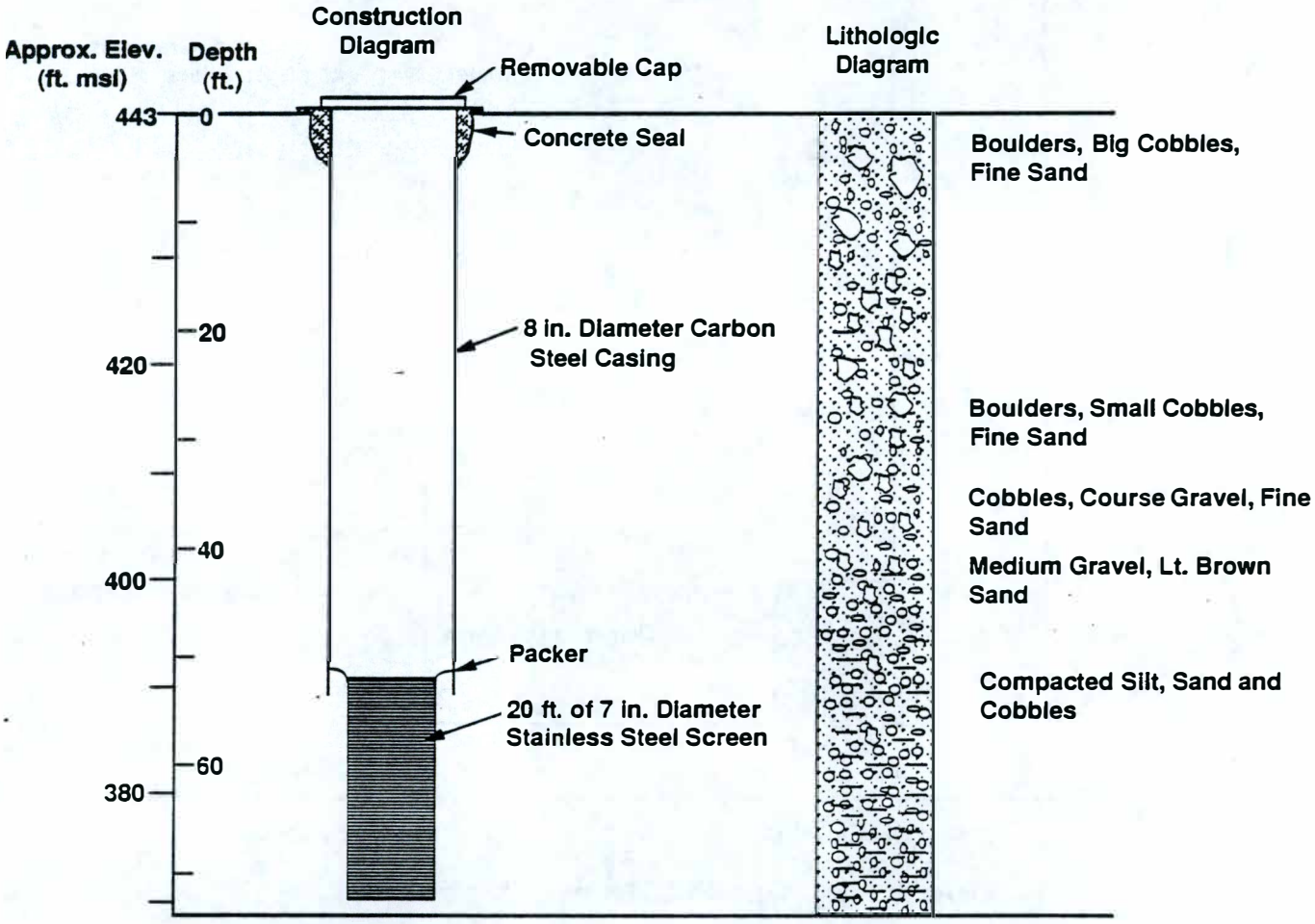


Logged by Geologist

Drilled Depth: 78 ft
Completion Depth: 71 ft
Completion Date: 4/84
Elevation Top of Casing: 449.01
▽ (11/21/85) Water Table and Date Measured
ft msl = Feet above mean sea level
All depths are in reference to land surface.

H9210027.4

Well 199-N-47

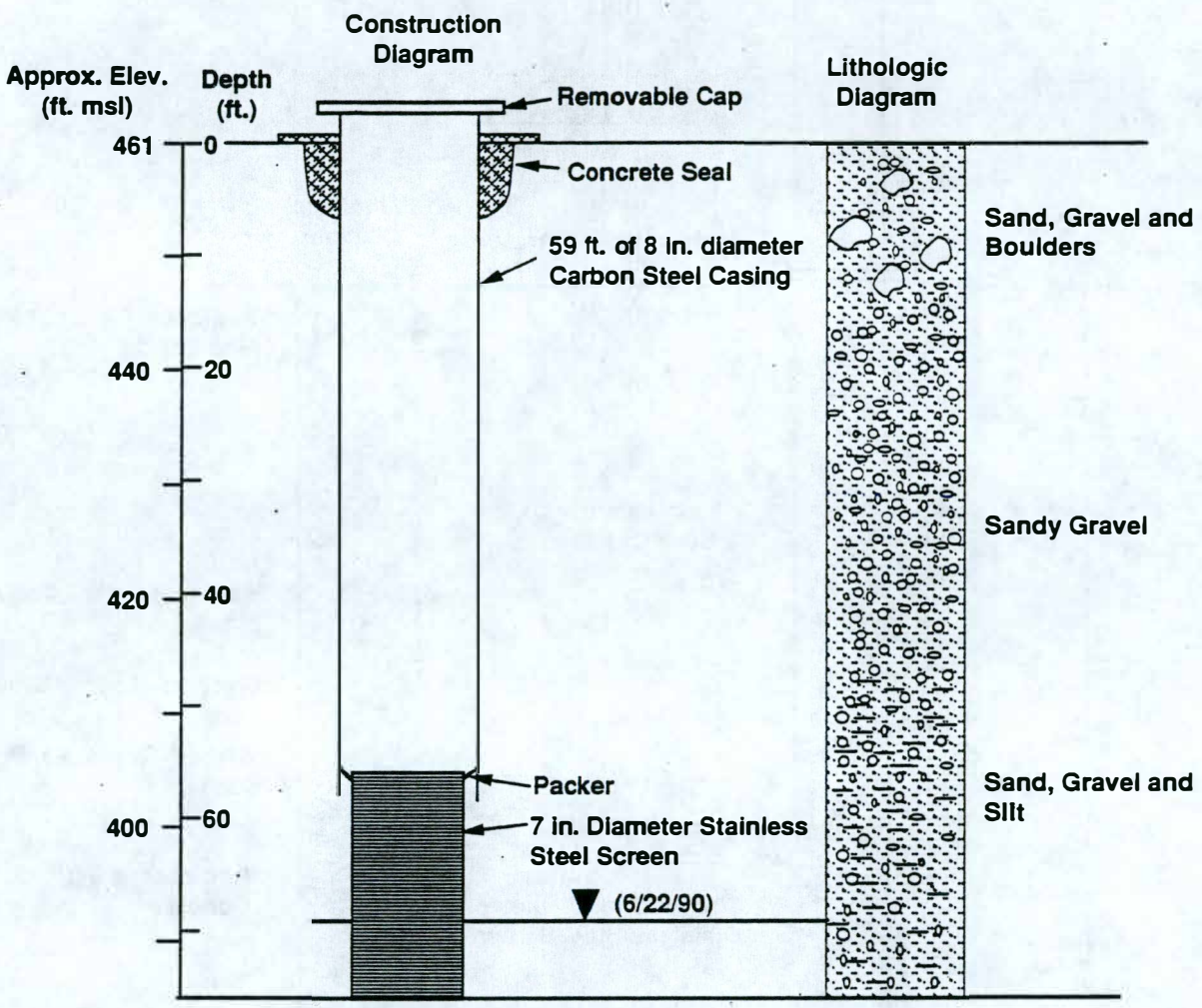


Drilled Depth: 73 ft.
Completion Date: 7/85
Elevation Top of Casing: 443.53 ft. msl
No Water Level Data
ft. msl = Feet above mean sea level
All depths are in reference to land surface

Logged by Driller

39008007.19

Well 199-N-52



Drilled Depth: 76 ft.
Completion Date: 7/85
Elevation Top of Casing: 463.70 ft. msl

Logged by Driller

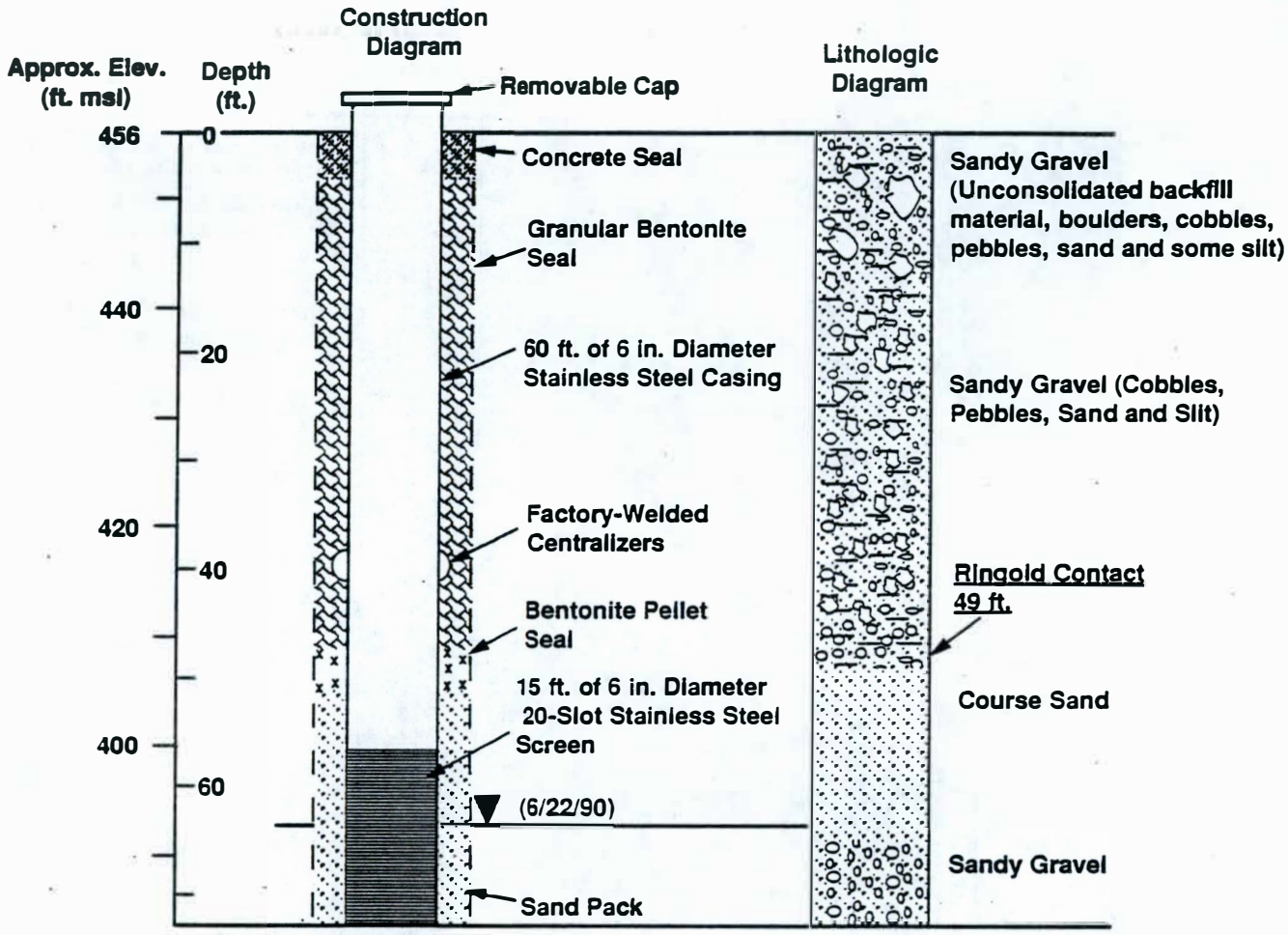
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.18

Well 199-N-54



Drilled Depth: 73 ft.
Completion Depth: 73 ft
Completion Date: 6/87
Elevation Top of Casing: 457.51 ft. msl

Logged by Geologist

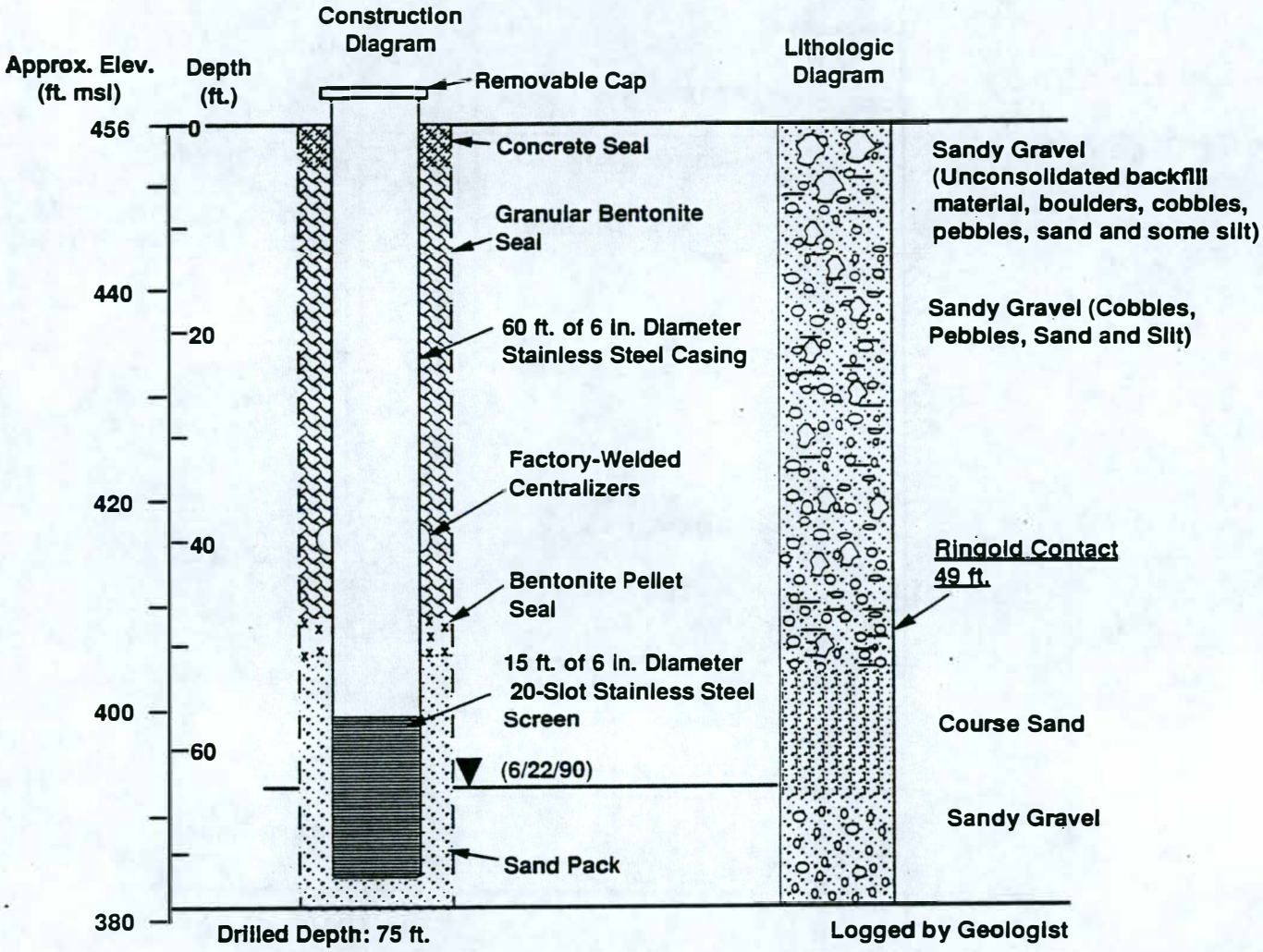
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.17

Well 199-N-55



Drilled Depth: 75 ft.
Completion Depth: 73 ft
Completion Date: 6/87
Elevation Top of Casing: 457.85 ft. msl

Logged by Geologist

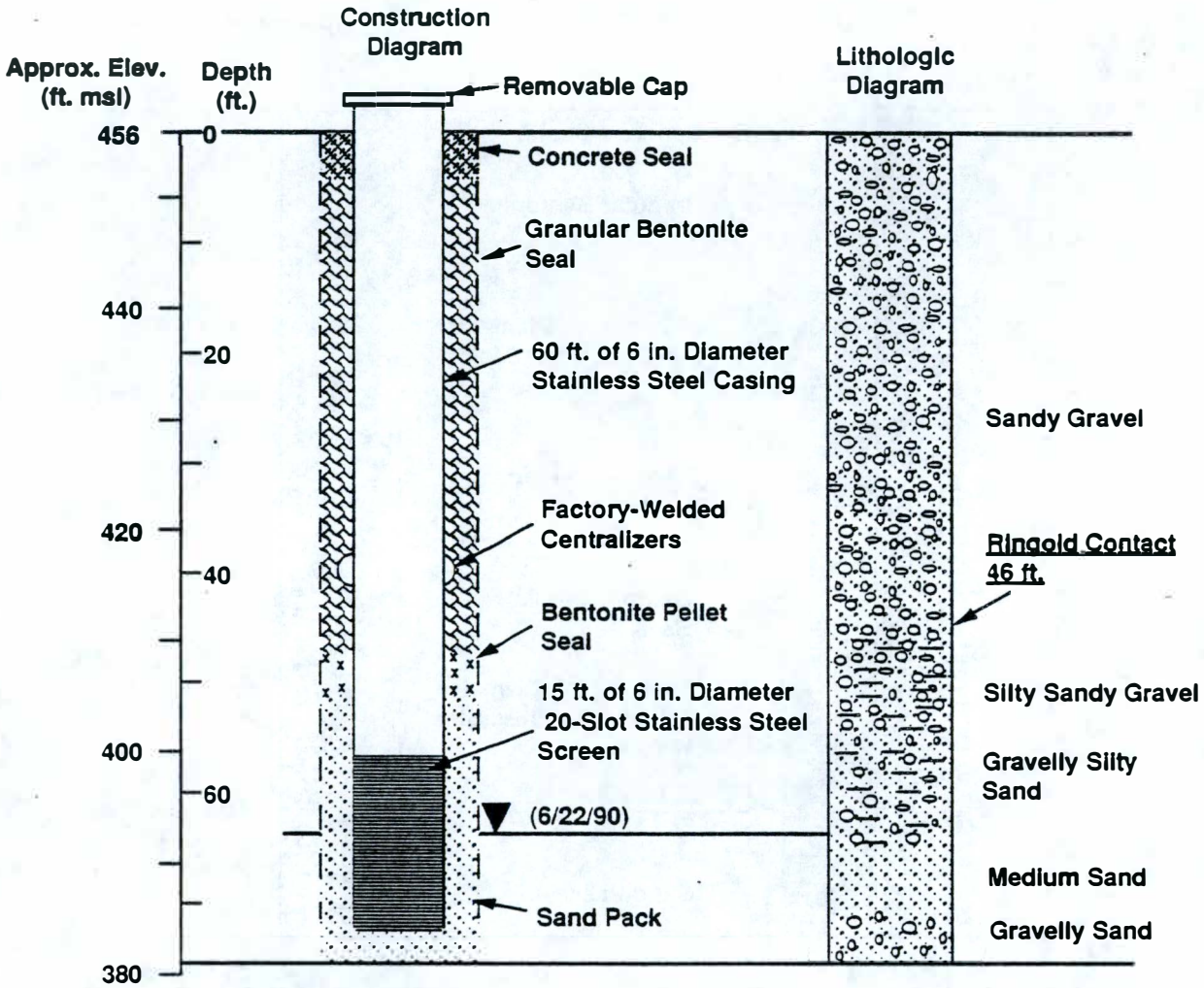
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.16

Well 199-N-56



Drilled Depth: 75 ft.
Completion Depth: 74 ft
Completion Date: 6/87
Elevation Top of Casing: 458.09 ft. msl

Logged by Geologist

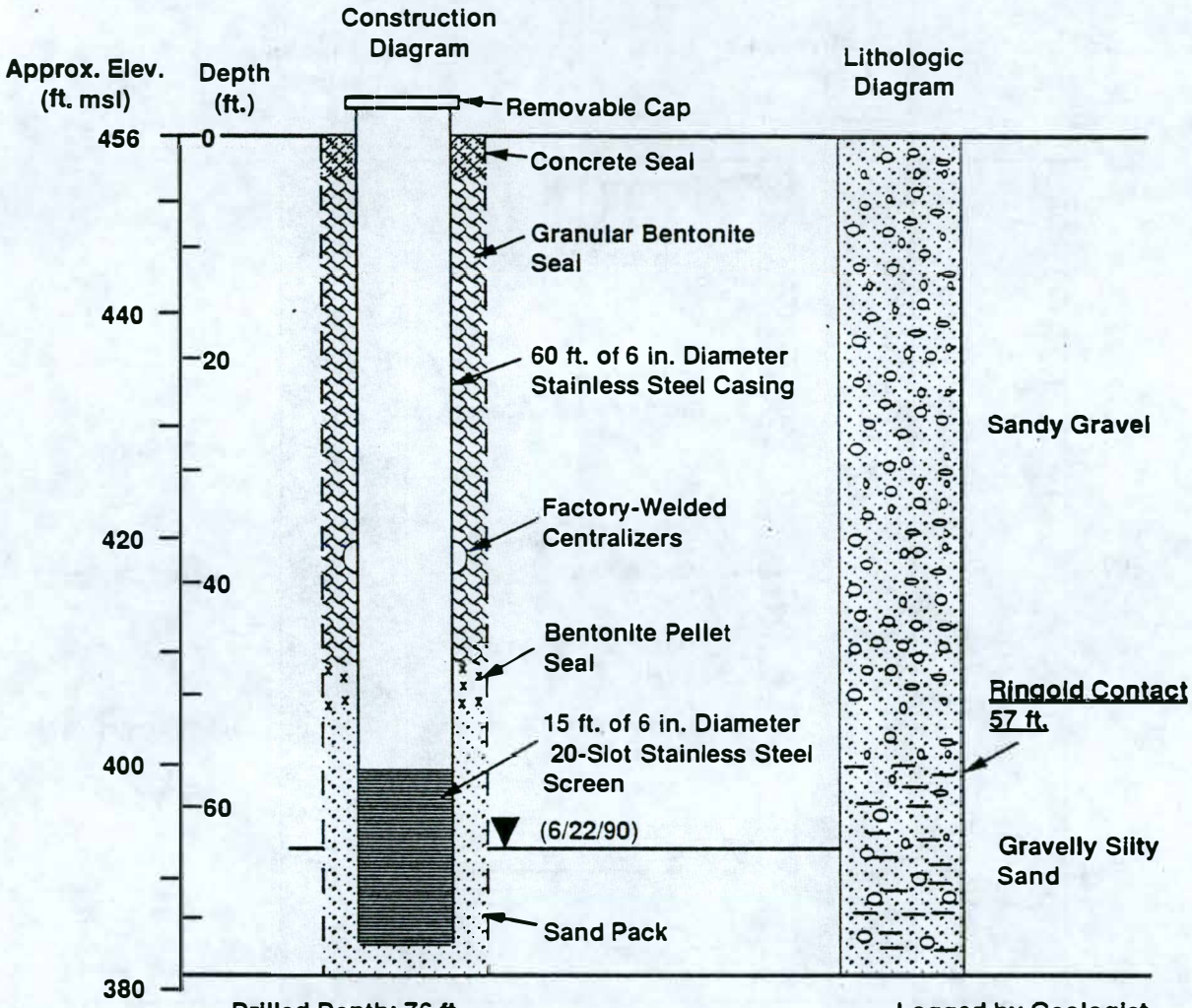
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.15

Well 199-N-57



Drilled Depth: 76 ft.
Completion Depth: 73 ft
Completion Date: 6/87
Elevation Top of Casing: 457.76 ft. msl

Logged by Geologist

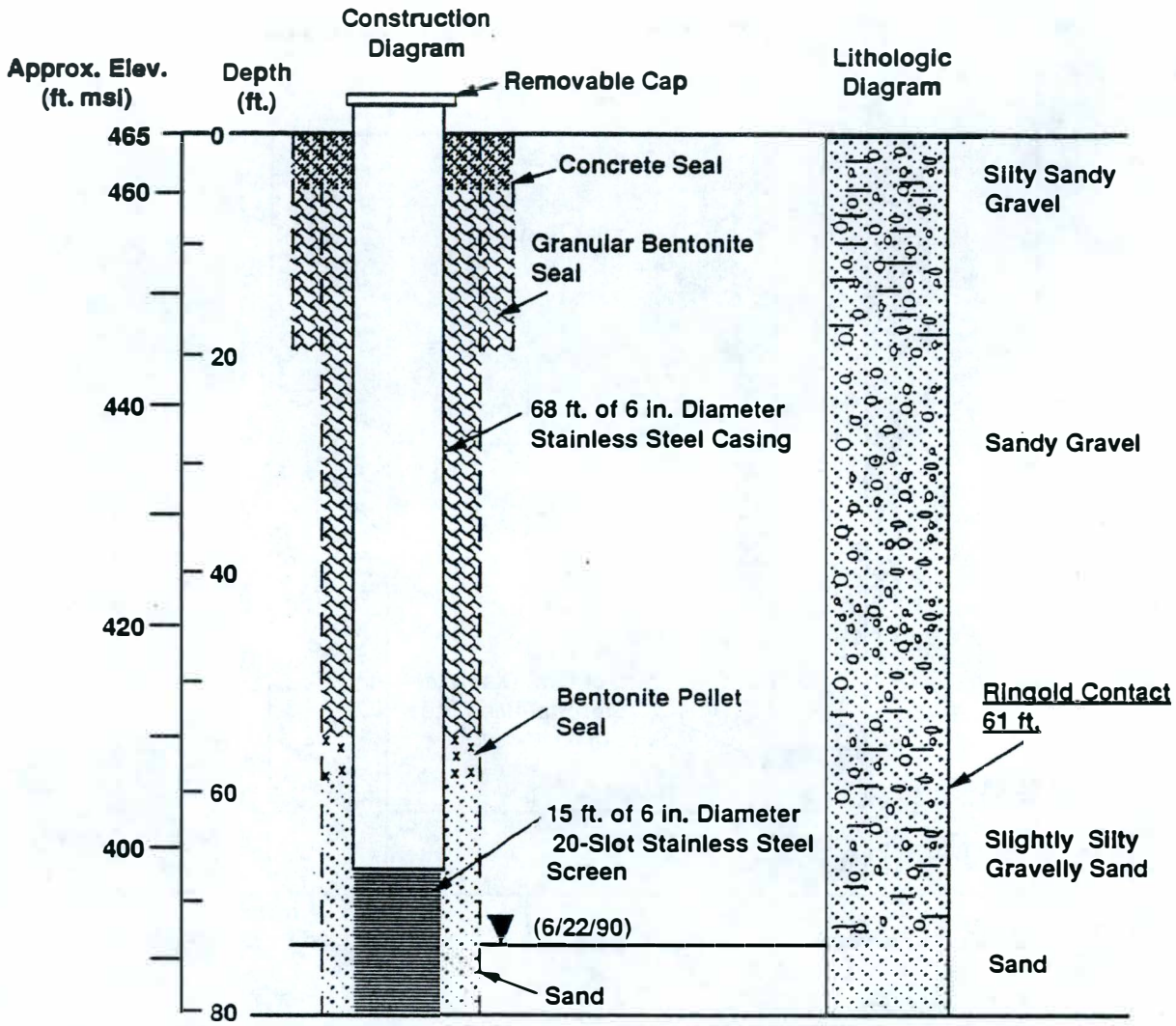
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

39008007.14

All depths are in reference to land surface

Well 199-N-63



Drilled Depth: 81 ft.
Completion Depth: 81 ft
Completion Date: 11/30/87
Elevation Top of Casing: 466.70 ft. msl

Logged by Geologist

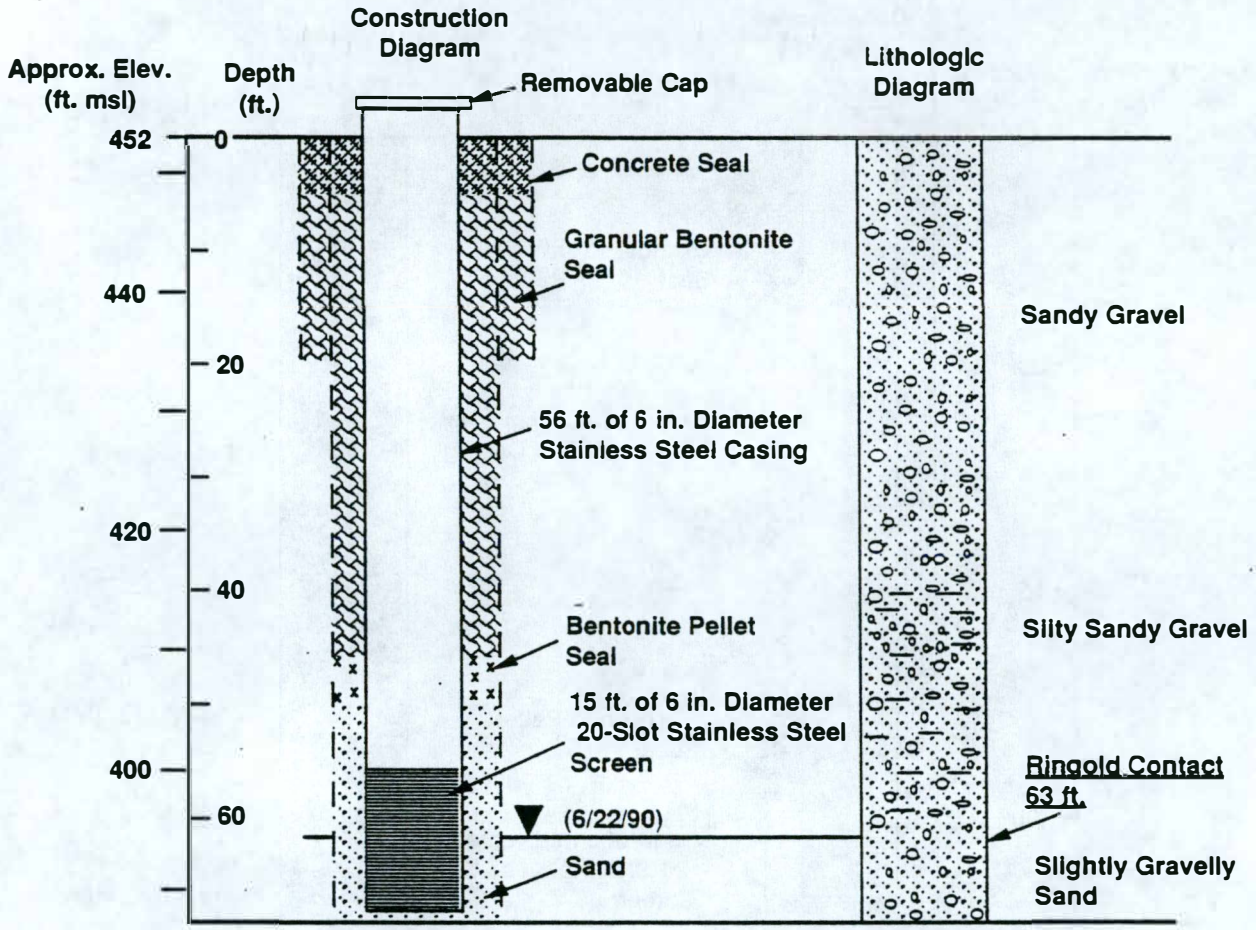
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.8

Well 199-N-64



Drilled Depth: 69.5 ft.
Completion Depth: 69 ft
Completion Date: 11/30/87
Elevation Top of Casing: 454.63 ft. msl

Logged by Geologist

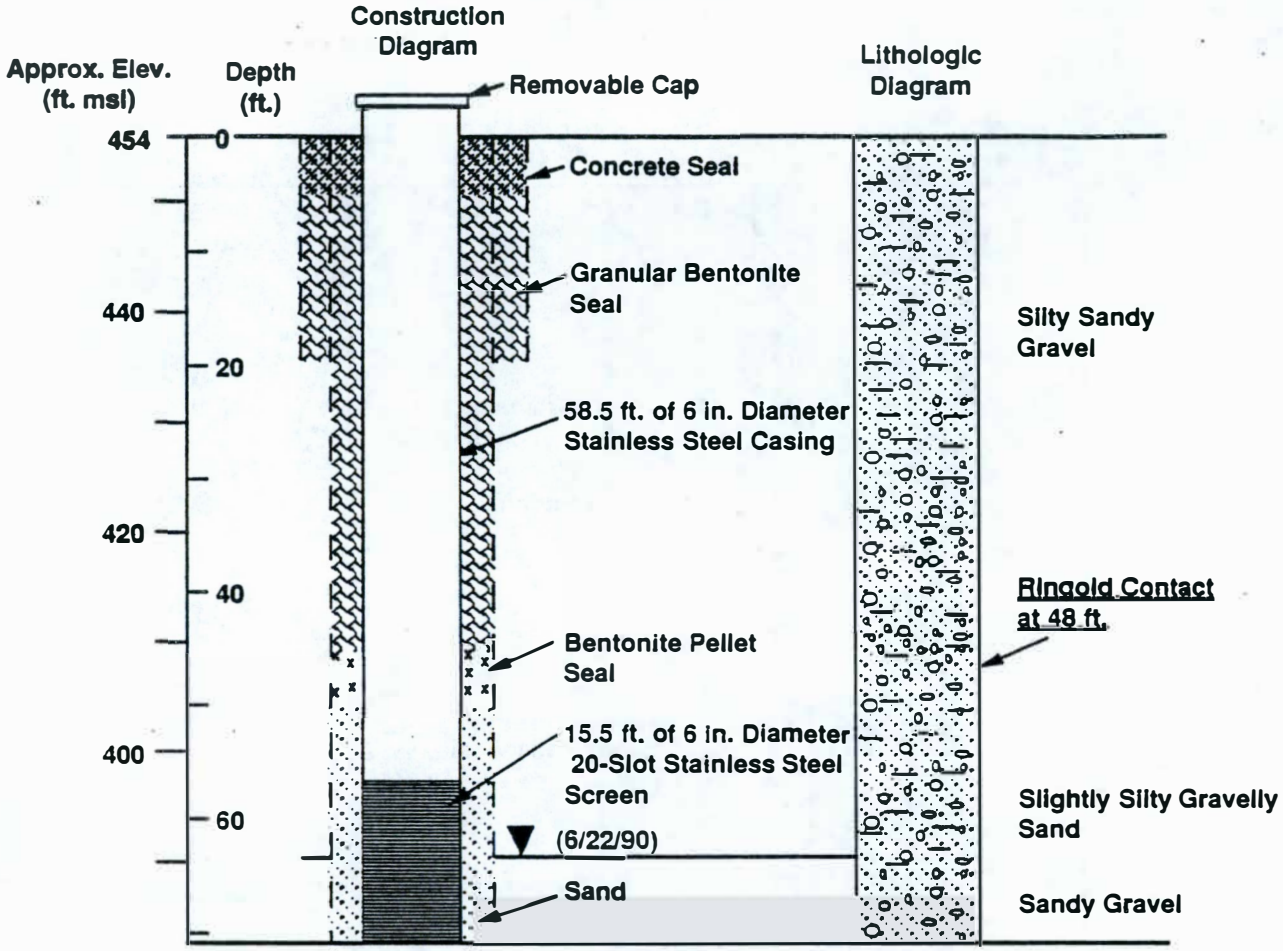
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.7

Well 199-N-65



Drilled Depth: 71 ft.
Completion Depth: 71 ft
Completion Date: 11/30/87
Elevation Top of Casing: 456.44 ft. msl

Logged by Geologist

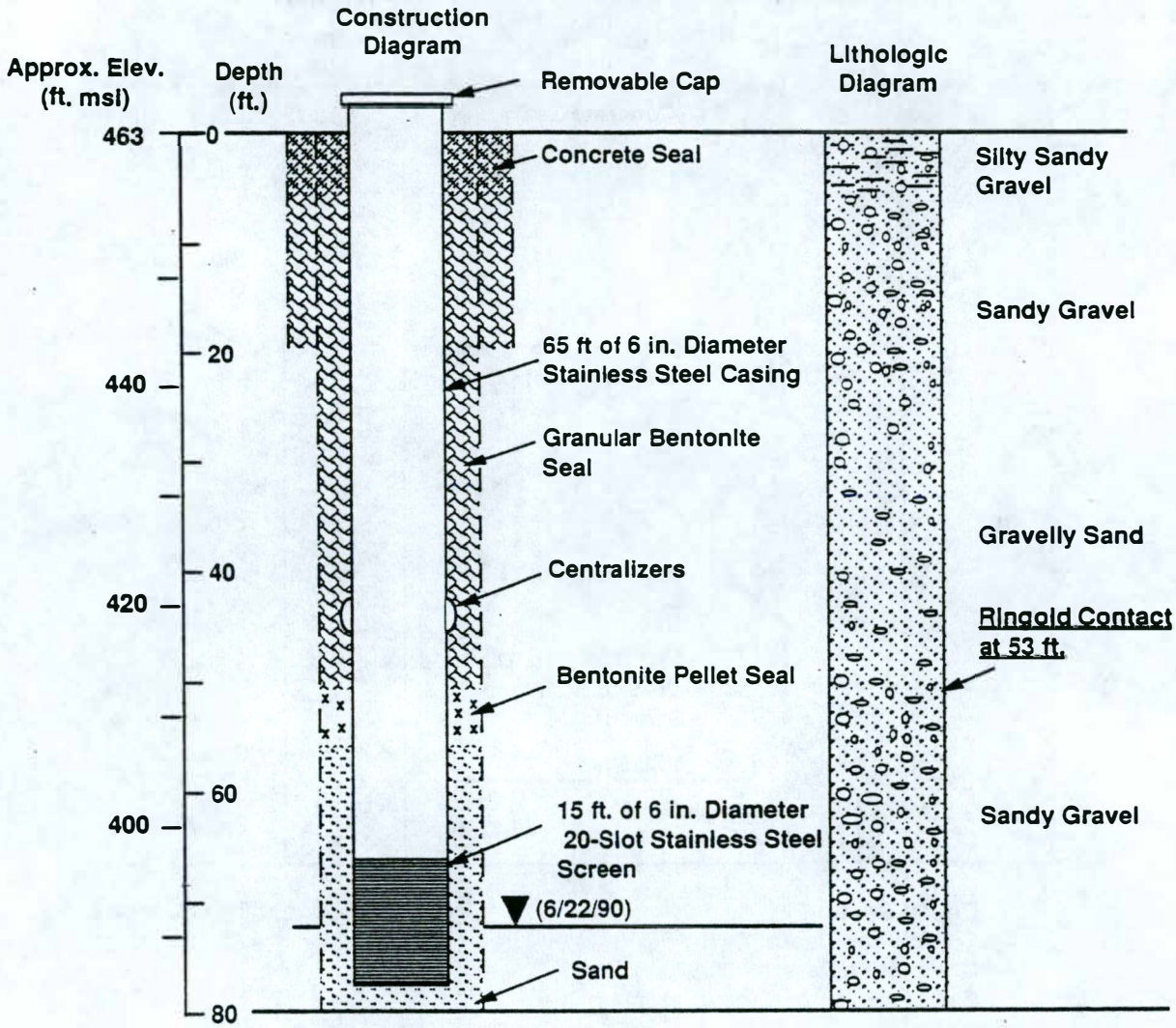
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.6

Well 199-N-66



Drilled Depth: 80 ft.
Completion Depth: 78 ft
Completion Date: 11/30/87
Elevation Top of Casing: 465.25 ft. msl

Logged by Geologist

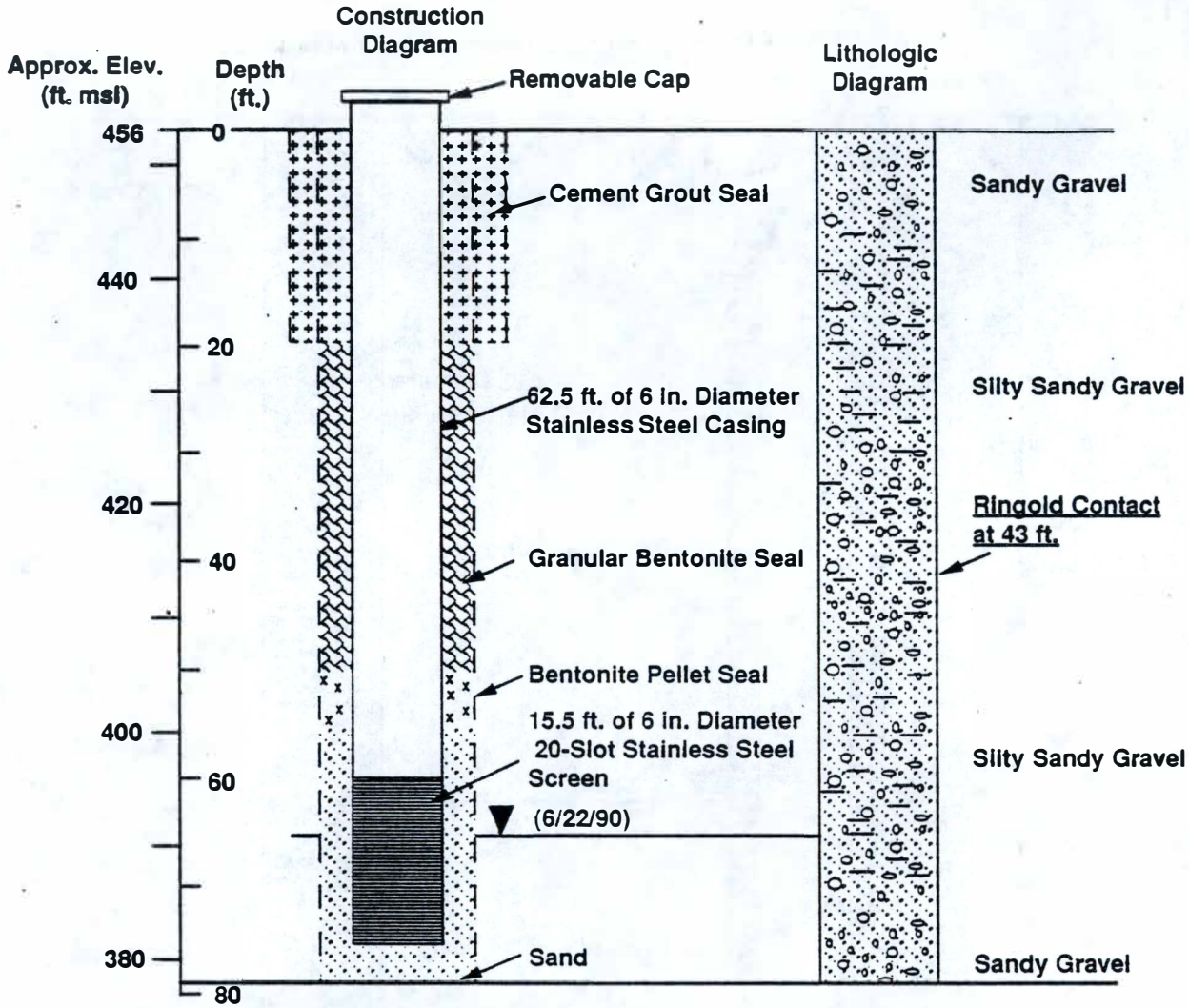
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.5

Well 199-N-67



Drilled Depth: 79 ft.
Completion Depth: 76 ft
Completion Date: 3/9/88
Elevation Top of Casing: 458.46 ft. msl

Logged by Geologist

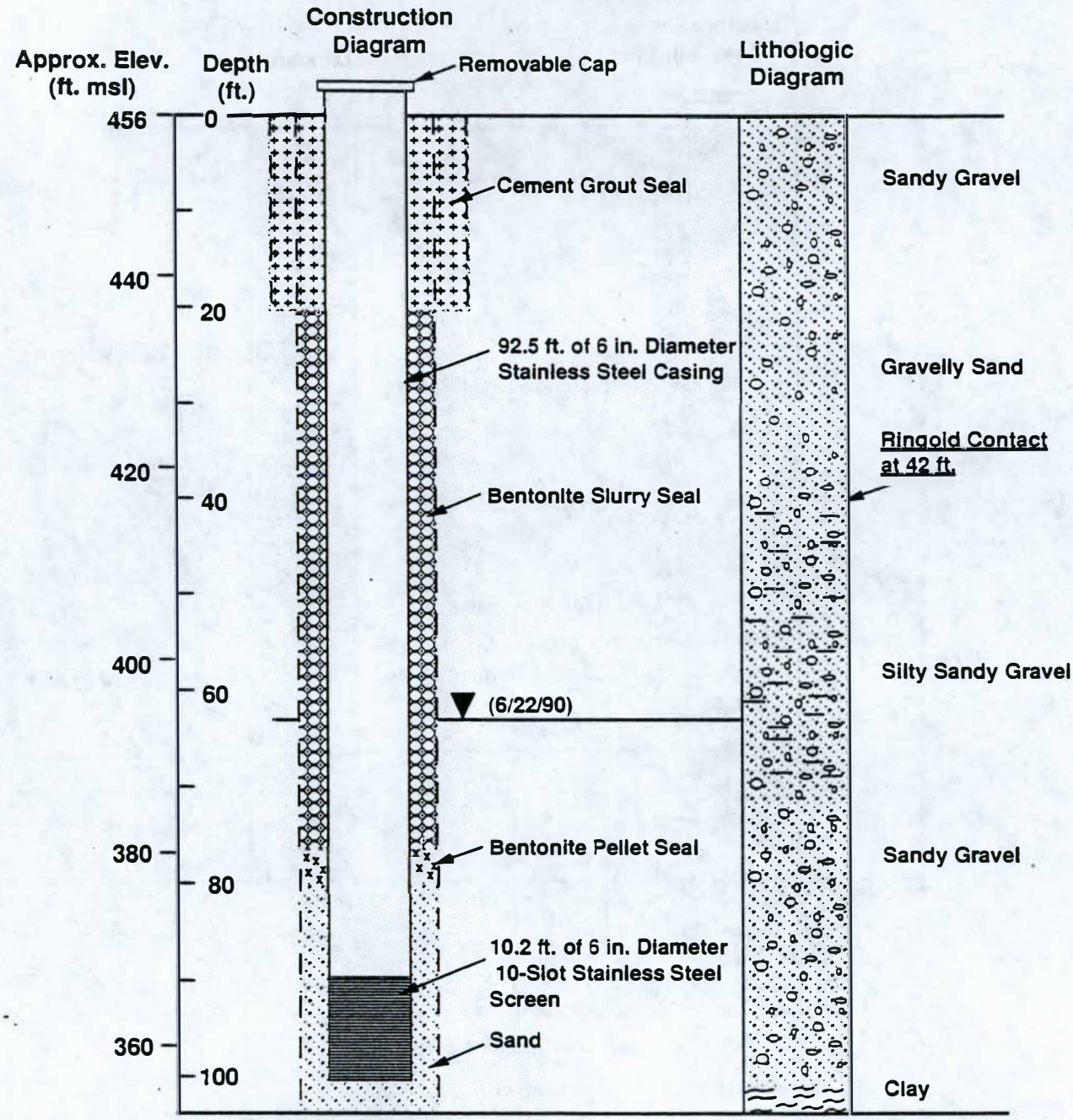
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.4

Well 199-N-69



Drilled Depth: 104 ft.
Completion Depth: 100 ft
Completion Date: 7/13/88
Elevation Top of Casing: 458.84 ft. msl

Logged by Geologist

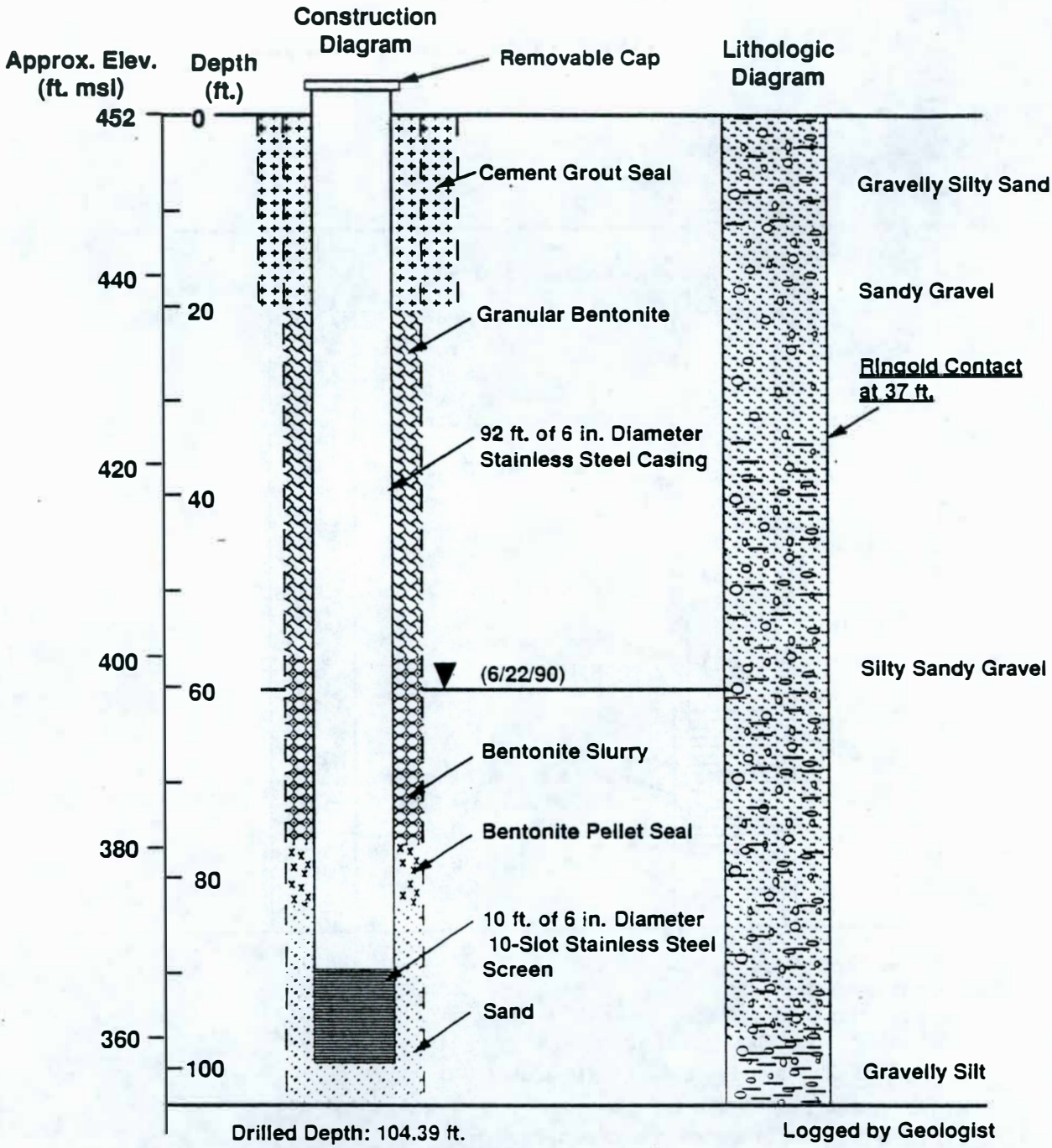
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

39008007.1

All depths are in reference to land surface

Well 199-N-70



Drilled Depth: 104.39 ft.
Completion Depth: 99.08 ft
Completion Date: 7/13/88
Elevation Top of Casing: 454.21 ft. msl

Logged by Geologist

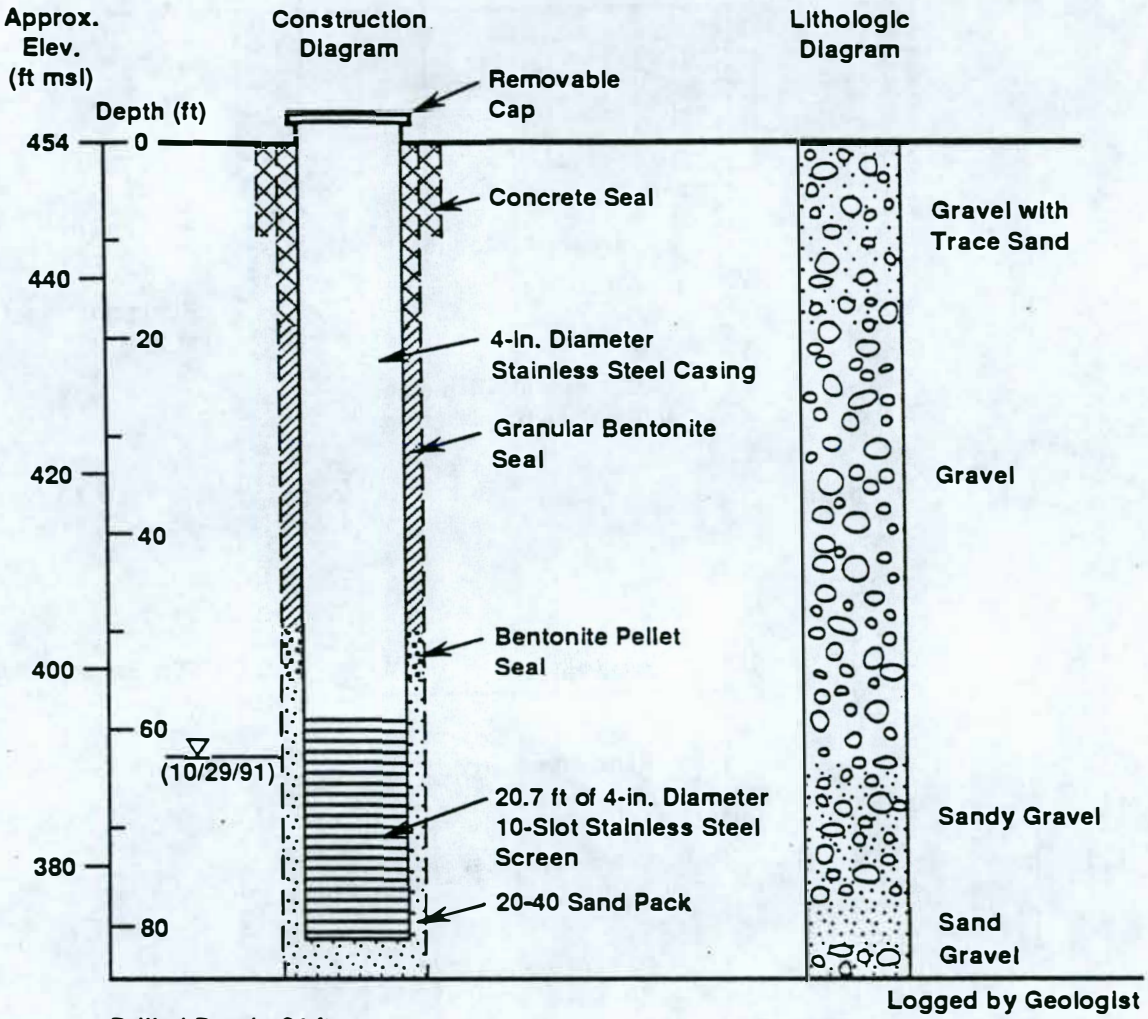
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.2

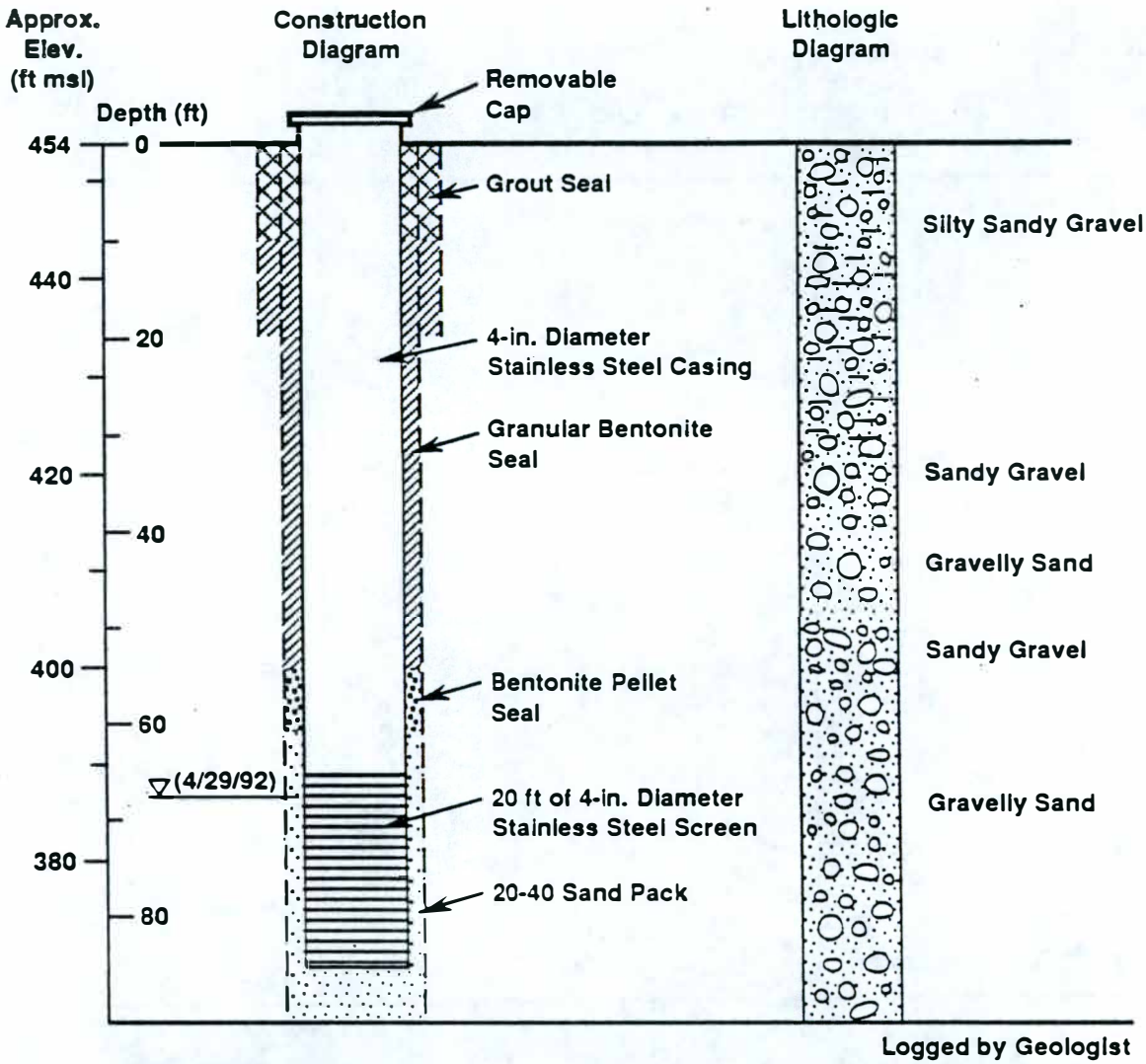
Well 199-N-74



Drilled Depth: 84 ft
Completion Depth: 80 ft
Completion Date: 11/7/91
Elevation Top of Casing: 457.13
▽ (10/29/92) Water Table and Date Measured
ft msl = Feet above mean sea level
All depths are in reference to land surface.

H9210027.3

Well 199-N-75



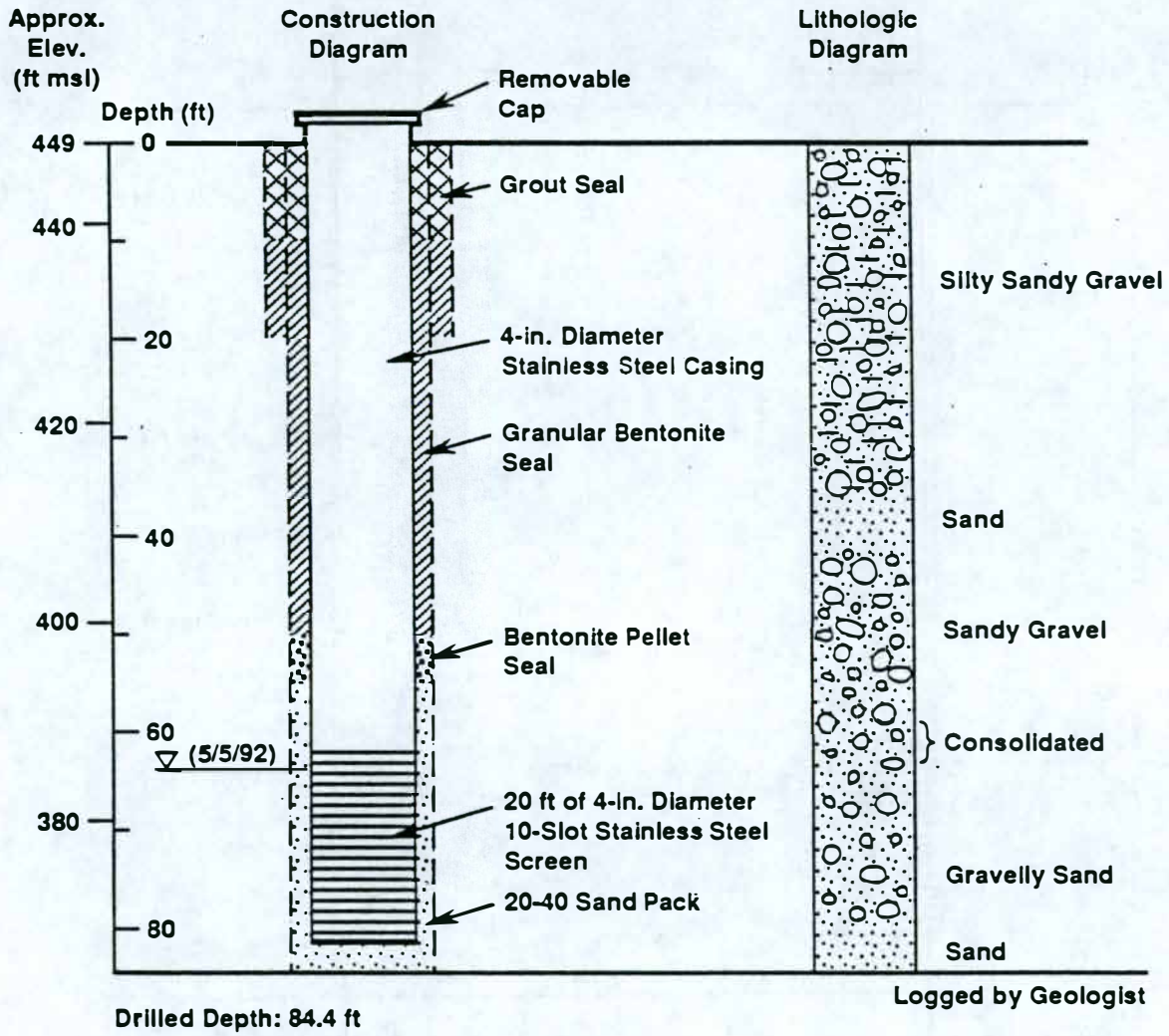
Drilled Depth: 89.6 ft
Completion Depth: 85 ft
Completion Date: 7/92
Elevation Top of Casing: 456.24 (converted to 100-N datum)

▽(4/29/92) Water Table and Date Measured

ft msl = Feet above mean sea level
All depths are in reference to land surface.

H9210027.1

Well 199-N-76



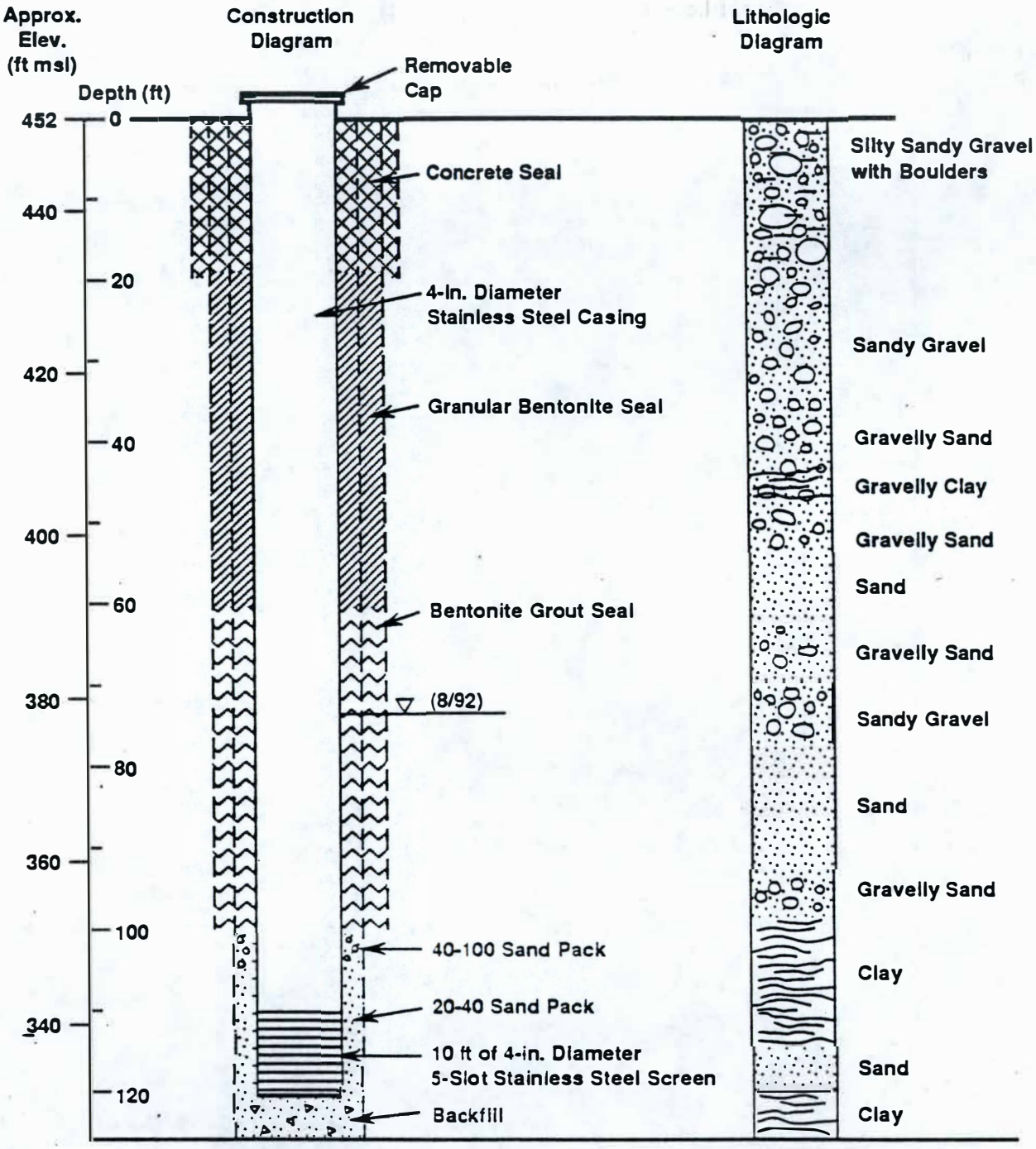
Drilled Depth: 84.4 ft
Completion Depth: 81 ft
Completion Date: 7/92
Elevation Top of Casing: 451.58 (converted to 100-N datum)

▽ (5/5/92) Water Table and Date Measured

ft msl = Feet above mean sea level
All depths are in reference to land surface.

H9210027.2

Well 199-N-80



Logged by Geologist

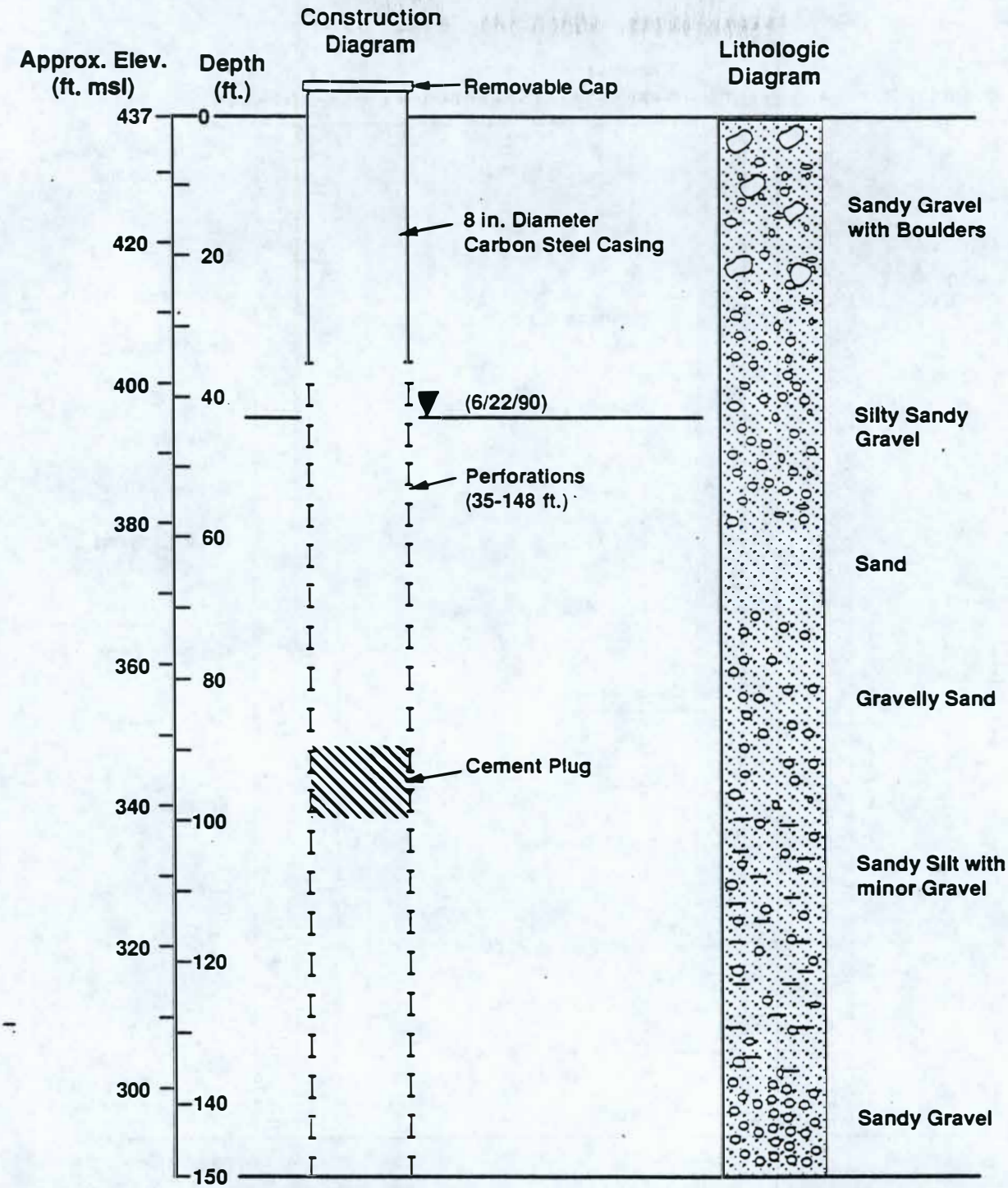
Drilled Depth: 126 ft
Completion Depth: 121 ft
Completion Date: 8/92

▽ (8/92) Piezometric level and date measured

ft msl = Feet above mean sea level
All depths are in reference to land surface.

H9210027.5

Well 699-81-58



Drilled Depth: 150 ft.
Completion Date: 10/62
Plug Installed: 4/80
Elevation Top of Casing: 439.55 ft. msl

Logged by Driller

▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.3

APPENDIX B: 100 N Area Aquifer Tests

This appendix includes data plots and discussion of several pumping tests conducted in wells in the 100 N Area by Pacific Northwest Laboratory (PNL). These data have not been previously published. Aquifer testing of wells N-30, N-32, and N-27 were conducted in 1984. Results and data plots are summarized below. Well N-62 was tested in 1988, along with a number of other newly-installed wells. The other aquifer tests did not yield useful data. The N-62 test is discussed below. Aquifer tests in wells N-69 and N-70 were conducted by PNL after well installation in 1988. PNL's analysis and discussion of those aquifer tests is also presented in this appendix.

An interpretation of limited aquifer testing in wells N-71 through N-74 is presented by Hartman (1992).

The analyses discussed below share the following assumptions:

1) the aquifer has a seemingly infinite areal extent
2) the aquifer is homogeneous, isotropic, and of uniform thickness.
3) The well is pumped at a constant discharge rate.
4) Flow to the pumping well is horizontal and laminar.
5) The well diameter is infinitesimal (storage in the well can be neglected).
6) The well penetrates the entire thickness of the aquifer.

The most significant violation of these assumptions is that the wells do not penetrate the entire aquifer. Partially penetrating wells can result in a low estimate of transmissivity.

B.1. AQUIFER TESTS IN THE VICINITY OF THE 1325-N CRIB

A series of pumping tests were conducted in wells near the 1325-N LWDF in 1984. Results appeared in an unpublished report by L.S. Prater of PNL.

B.1.1. N-30 Aquifer Test

On March 20, 1984, well N-30 was pumped for 24 hours at approximately 110 gpm with a total drawdown of 6.09 feet. Well N-34, located 240 feet from the pumping well, was used as an observation well. Both wells are completed at the top of the aquifer in gravelly material of the Ringold Formation; neither well penetrates the entire aquifer. The drawdown data from the observation wells were anlayzed using the Jacob modified non-equilibrium formula (Johnson Division, 1975). A semilog plot of these data is shown in figure B.1. Results suggest the presence of boundary effects that cause the slope of the plot to change. Two transmissivities were calculated from the plot: 196,216 gpd/ft (26,000 ft^2/d) near the pumping well and 111,692 gpd/ft (15,000 ft^2/d) further from the pumping well.

B.1.2. N-32 Aquifer Test

A 24-hour constant discharge test was conducted in well N-32 on March 26, 1984. The well was pumped at approximately 100 gpm with 8.88 ft total drawdown. Well N-32 is completed at the top of the aquifer in gravelly material of the Ringold Formation; it does not penetrate the entire aquifer.

Recovery data from the well were analyzed (Figure B.2). The calculated transmissivity is 43,278 gpd/ft (5,800 ft^2/d).

B.1.3. N-27 Aquifer Test

A 24-hour constant discharge test was conducted in well N-27 on March 29, 1984. The well was pumped at approximately 110 gpm with 13.83 ft total drawdown. Well N-27 is completed at the top of the aquifer in gravelly sediments of the Ringold Formation; it does not penetrate the entire aquifer. Recovery data from the well (Figure B.3) suggest an apparent boundary effect and a recharge effect. The calculated transmissivities were 132,000 gpd/ft (18,000 ft^2/d) for time less than 5 minutes, 85,411 gpd/ft (11,000 ft^2/d) for time between 5 and approximately 50 minutes, and 193,600 gpd/ft (26,000 ft^2/d) for time greater than 50 minutes.

B.2. N-62 AQUIFER TEST

On August 16, 1988, well N-62 was developed for 2 hours, beginning at a flow rate of approximately 20 gpm and successively increasing the rate in steps to a maximum of 60 gpm. The water level was allowed to recover to static. A constant discharge test was then conducted for 6 hours at a rate averaging 77 gallons per minute. Maximum drawdown was 1.6 feet. After pumping ceased, residual drawdown was measured for 1.5 hours, until the water level had nearly returned to its pre-test level.

Drawdown data from the constant discharge test were plotted on semilog paper (attached). There appear to be two straight-line trends. Analysis of the data with the Cooper and Jacob (1946) straight-line method yields an estimate of transmissivity of 27,000 ft^2/d for time less that 80 minutes and 11,000 ft^2/d for time greater than 80 minutes. This could be due to a less transmissive zone within the radius of influence of the well.

The Cooper and Jacob (1946) analysis applied to a semilog plot of residual drawdown versus t/t′ (time since pumping began divided by time since pumping ceased) yields an estimate of transmissivity of 20,000 ft^2/d. The change in transmissivity observed in analysis of drawdown data was not evident in the recovery data.

B.3. N-69 AND N-70 AQUIFER TESTS

On June 9, 1988, a constant-discharge pumping test was conducted in well N-69. Well N-69 is completed with 10 feet of screen in a sandy gravel on top of a clay-rich unit, believed to be the base of the uppermost aquifer. Well N-67, located approximately 30 ft from the pumping well, was used as an observation well. It is completed in a sandy gravel at the top of the uppermost aquifer. The base of the screened interval at well N-67 is approximately 15 feet higher in elevation than the top of the screened interval at well N-69.

On June 14, 1988, a constant-discharge pumping test was conducted in well N-70. Well N-70 is completed with 10 feet of screenin a silty sandy gravel, on top of a finer-grained unit believed to be the base of the uppermost aquifer. Well N-39, located approximately 23 feet from the pumping well, was used as an observation well. It is completed at the top of the aquifer. The

base of the screened interval at well N-39 is approximately 25 feet higher than the top of the screened interval at well N-70.

Additional details and results of the N-69 and N-70 pumping tests are presented in the attached excerpt from an unpublished borehole completion report provided to WHC from PNL. The authors are T.J. Gilmore, S.M. Goodwin, and D.R. Newcomer.

APPENDIX B REFERENCES

Cooper, H. H., and C. E. Jacob. 1946. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History." Transactions of the American Geophysical Union 27(iv):526-534.

Hartman, M.J., 1992, *Borehole Completion Data Package for Wells 199-N-71, 199-N-72, 199-N-73, and 199-N-74*, WHC-SD-EN-DP-040, Westinghouse Hanford Company, Richland, Washington.

Johnson Division, UOP Inc., 1975, Ground Water and Wells, Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Prater, L.S., 1984, Results of a Hydrogeologic Study and Aquifer Testing Near the 1325-N Crib at the 100-N Area, Pacific Northwest Laboratory, Richland, Washington.

Theis, C.V., 1935, "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-water Storage," in American Geophysical Union Transactions, v.16, p. 519-524.

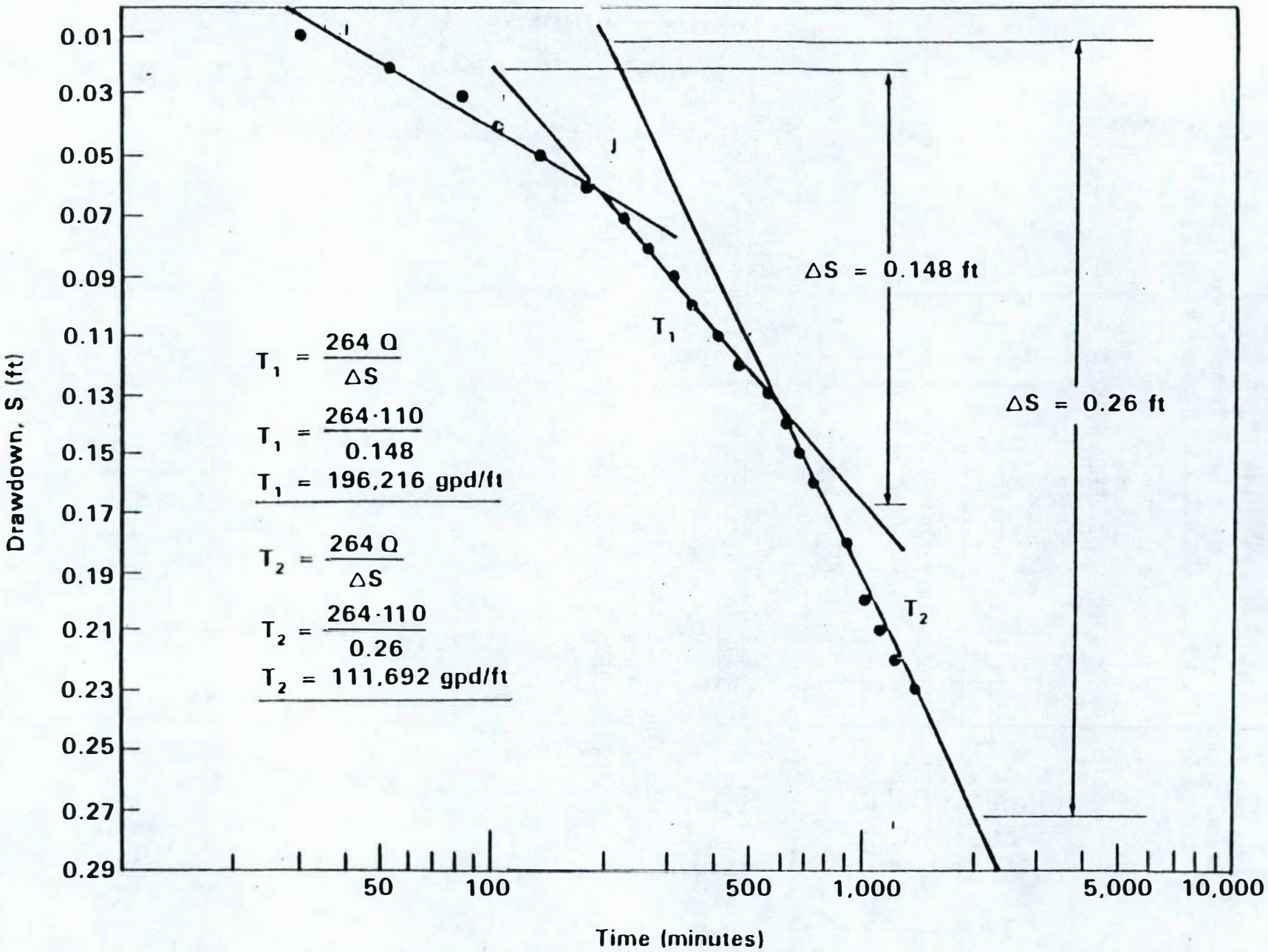


Figure B-1. N-34 Drawdown Data.

9613493.0165

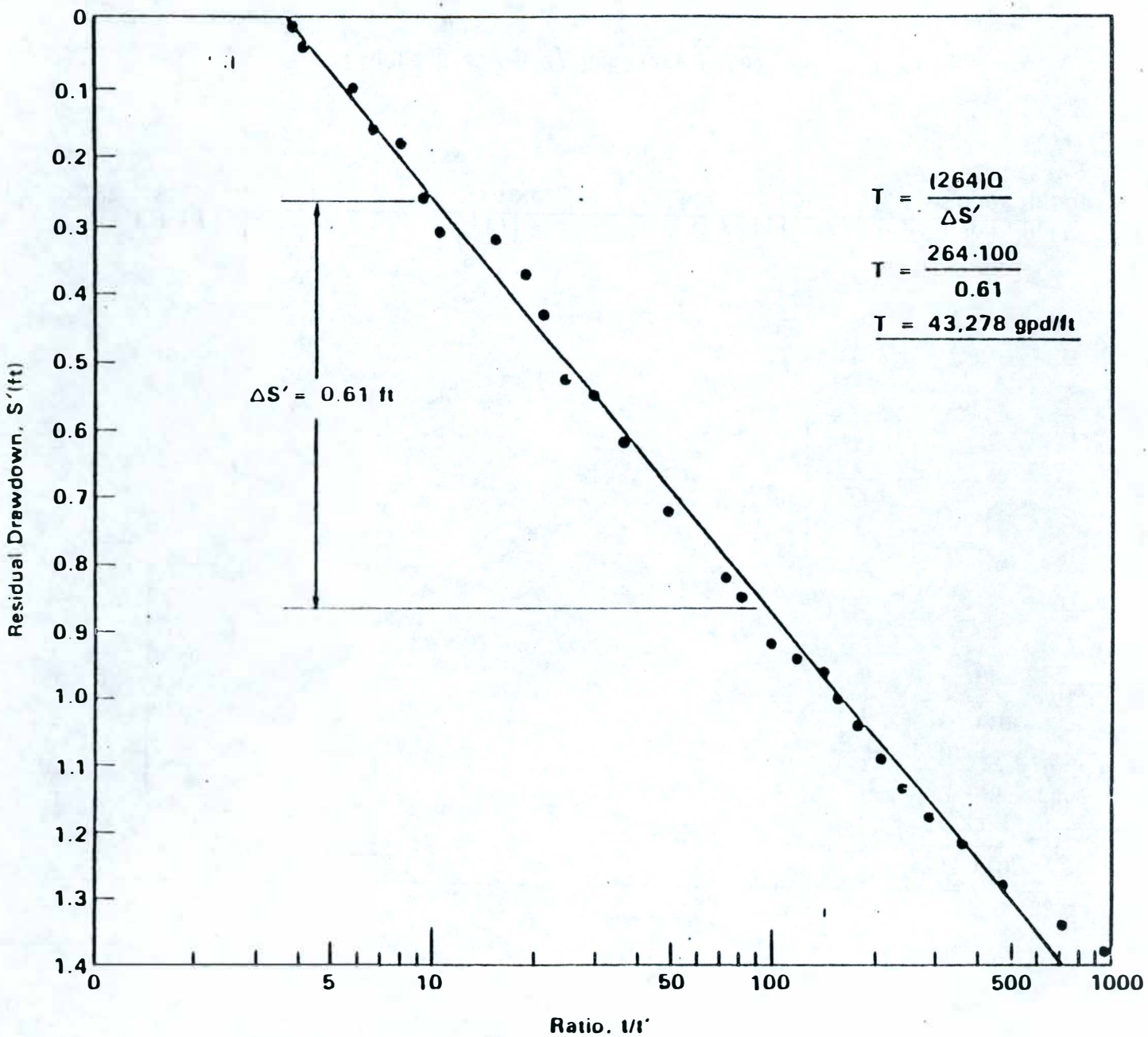


Figure B-2. N-32 Recovery Data.

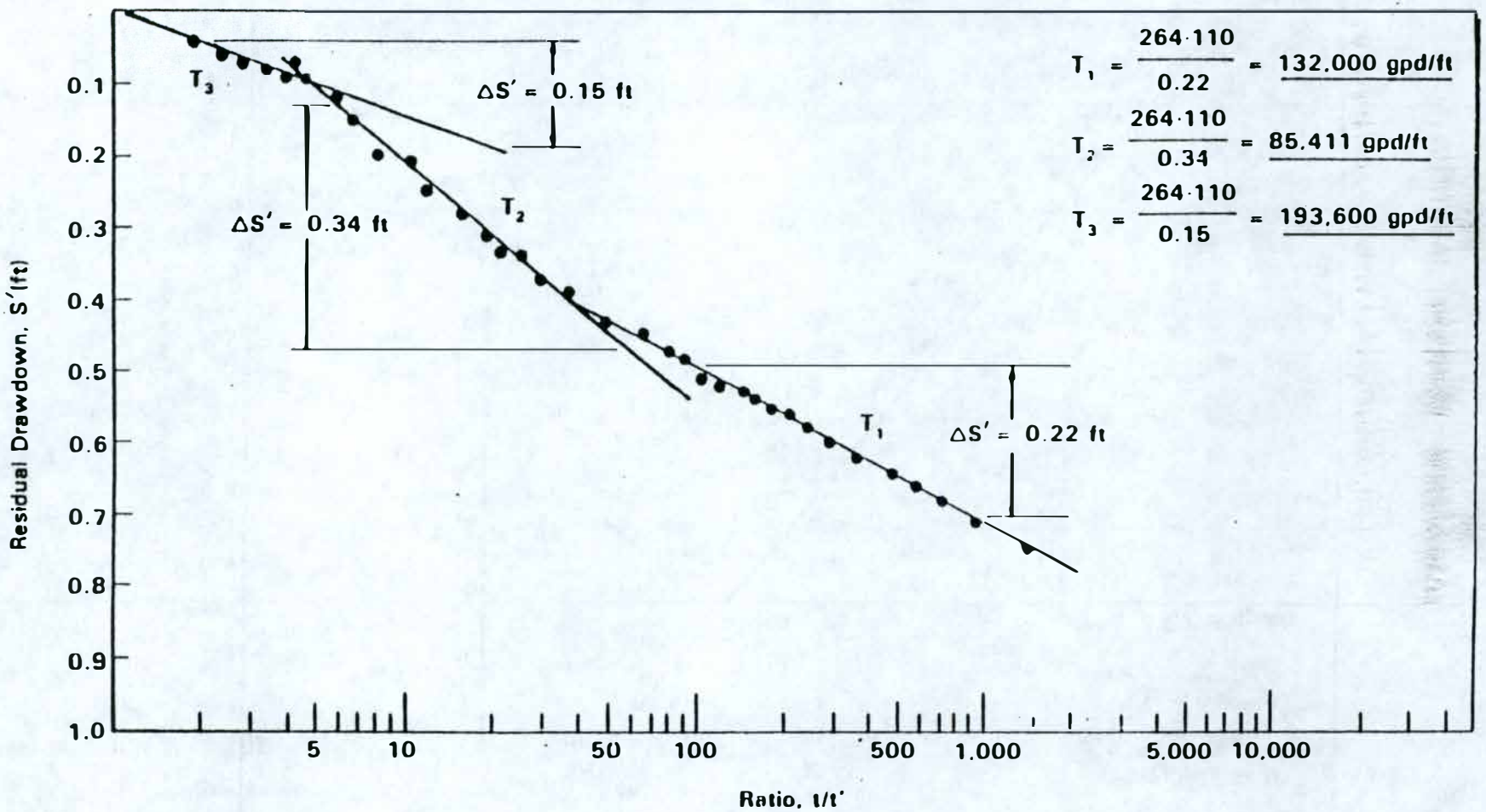


Figure B-3. N-27 Recovery Data.

Aquifer Test Data

page 2 of 2

Data for Well 199-N-62
Pumping Well 199-N-62
Observation Wells None

Location 100-N
Type of Aquifer Test Constant Discharge Recovery
How Q Measured In-Line Data Flow Monitor Model 900T (Data Industrial)
How W.L.'s Measured E-tape (Slope Indicator) SN. 12174
Rad./Dist. of/From Pumping Well
Meas. Point for W.L.'s Top of tremie pipe
Elevation of Meas. Point

Depth of Pump/Airpipe
Pump On: date 8-16-88 time 09:30:00
Pump Off: date 8-16-88 time 15:30:00
Duration of Aquifer Test 6 hours

Time t = 1530 at t' = 0					Water Level Data Static Water Level 69.36'					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
8/16	1530	360	0	–								DRN	Begin shut off @ 1530 hrs.
		360.5	0.5	721	69.77			0.41				DRN	
		361	1	361	69.70			0.34				DRN	
		361.5	1.5	241	69.69			0.33				DRN	
		362	2	181	69.67			0.31				DRN	
		363	3	121	69.66			0.30				DRN	
		364	4	91	69.65			0.29				DRN	
		365	5	73	69.63			0.27				DRN	
		366	6	61	69.62			0.26				DRN	
		367	7	52.4	69.61			0.25				DRN	
		368	8	46	69.60			0.24				DRN	
		369	9	41	69.60			0.24				DRN	
		370	10	37	69.59			0.23				DRN	
		375	15	25	69.57			0.21				DRN	
	1550	380	20	19	69.55			0.19				DRN	
		385	25	15.4	69.54			0.18				DRN	
		390	30	13	69.53			0.17				DRN	
		400	40	10	69.52			0.16				DRN	
		410	50	8.2	69.51			0.15				DRN	
		420	60	7	69.49			0.13				DRN	
		430	70	6.14	69.49			0.13				DRN	
	1700	450	90	5	69.47			0.11				DRN	
													Stopped logging data on Terra datalogger @ 1701 hrs

recovery test

Aquifer Test Data

page 1 of 2

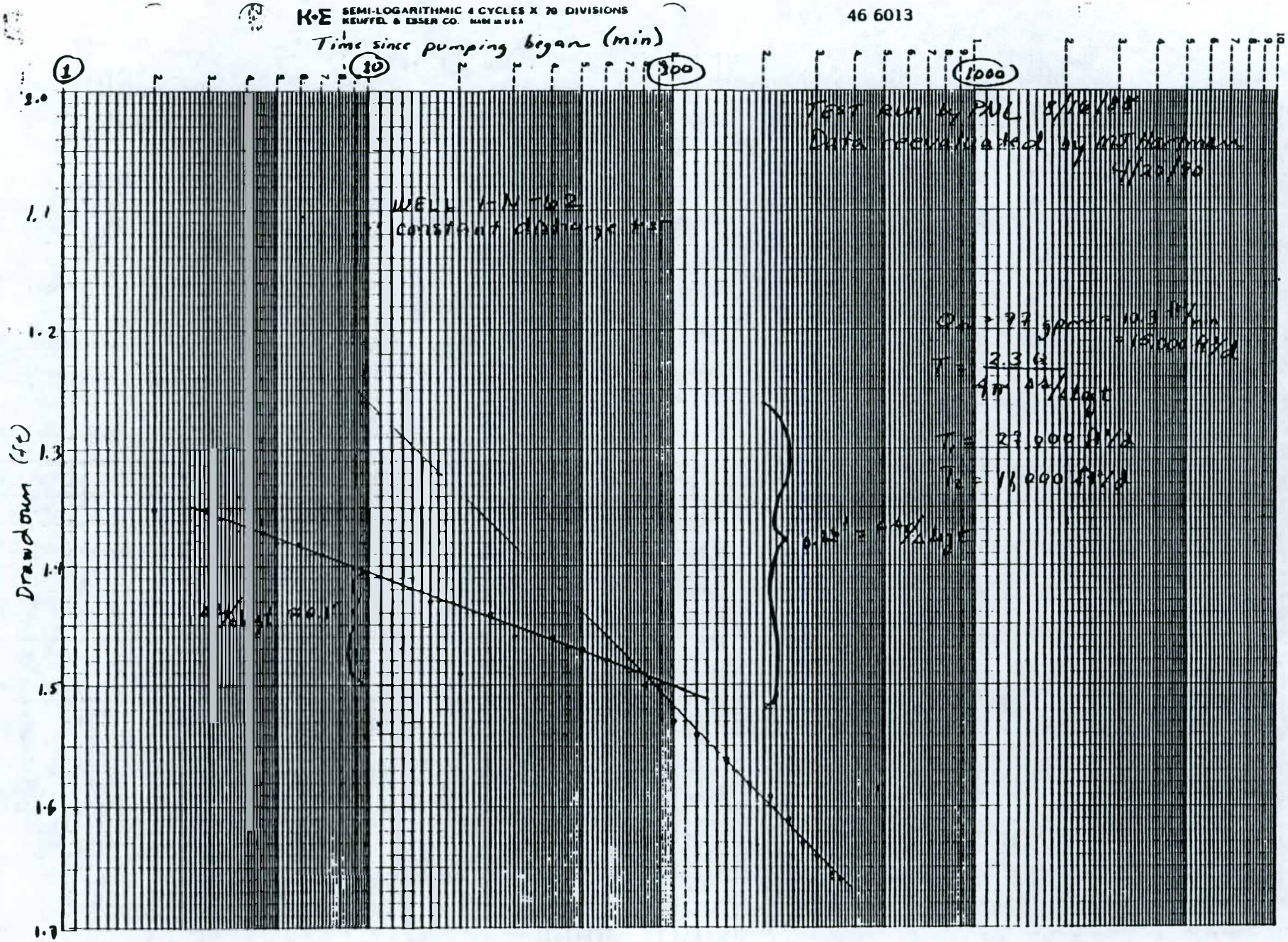
Data for Well 199-N-62
Pumping Well 199-N-62
Observation Wells None

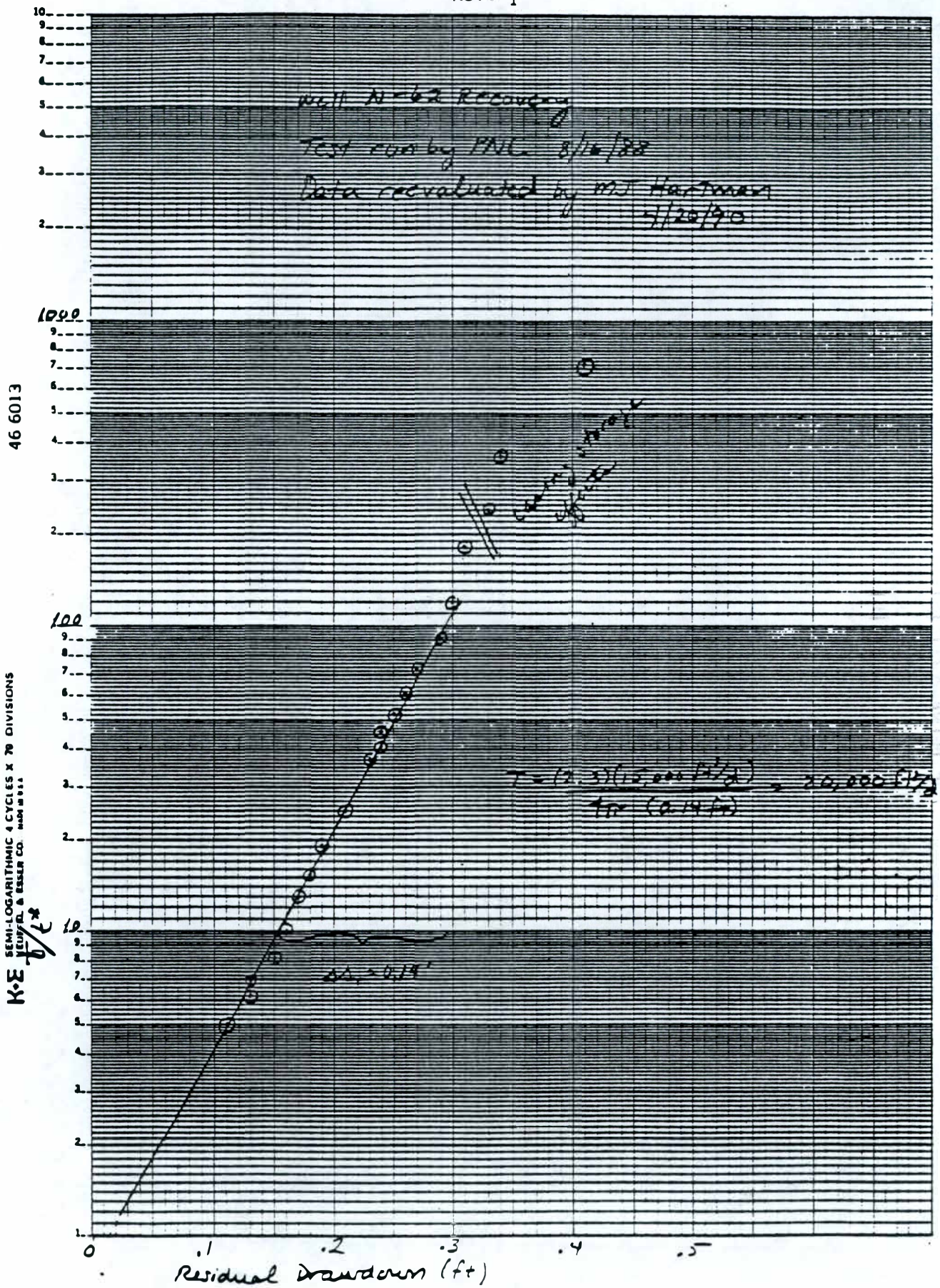
Location 100-N
Type of Aquifer Test Constant Discharge
How Q Measured In-Line Data Flow Monitor Model 930T (Data Industrial)
How W.L.'s Measured E-tape (Slope Indicator)
Rad./Dist. of/From Pumping Well S.W. 12 74
Meas. Point for W.L.'s Top of tremie pipe *
Elevation of Meas. Point

Depth of Pump/Airpipe Intake is approx. 73.6' from TOC
Pump On: date 8/16/88 time 09:30:00
Pump Off: date 8/16/88 time 15:30:00
Duration of Aquifer Test 6 hours.

Time t = ____ at t' = 0					Water Level Data Static Water Level 69.36'					Discharge		Recorded By	Comments Used Terra Datalogger and a 10 psi. xD. Began baseline data ... Terra @ approx. 0800 hrs.
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
8/16	09:30	0			69.36'			0		9651(00)		DRN	approximately 2.5' of water in bottom
		1			-		DRN	-				DRN	
1		1.5			-	* top of tremie pipe is						DRN	of well @ 0800 hrs.
		2			70.69'	0.26' from top of casing		1.33				DRN	76.3 gpm @ 9:30:30
1		2.5			-			-				DRN	Air in line during
1		3			70.71			1.35				DRN	first min. of pumping
1		4.5			70.73			1.37				DRN	77.6 gpm @ 9:33:30
1		5			70.74			1.38				DRN	± 0.1 gpm
1		6			70.74			1.38				DRN	77.3 ± 0.2 gpm @ 0939 hrs.
1		7			70.75			1.39				DRN	
1		8			70.76			1.40				DRN	
		9			—			-				DRN	
1		10			70.77			1.41				DRN	discharge varies from
1		16			70.79			1.43				DRN	76.8 to 77.5 gpm.
1										9665(00)		@ 0948 hrs.	
		20			70.85			1.49				DRN	
	0955	25			70.80			1.44				DRN	
		30			70.82			1.46				DRN	76.6 to 76.8 gpm
													@ 0956 hrs
										9674(00)		@ 0958 hrs	77.2 ± 0.1 gpm @ 10:01:30
		40			70.82			1.46				DRN	
	1020	50			70.83			1.47				DRN	
									Digitizer turned over to 9674(00) @ 10:20:55				
		60			70.84			1.48				DRN	76.8 gpm. @ 1001 hrs
		80			70.86			1.50				DRN	77.2 ± 0.3 gpm @ 1041 hrs.
		100			70.89			1.53	turned 1	9733(00)		DRN	76.7 ± 0.1 gpm @ 1141 hrs.
		120			70.90			1.54		@ 11:35:20		DRN	76.7 ± 0.1 gpm @ 11:16 hrs.
	1200	150			70.92	All E-tape measurements made from 0' mark		1.56	turned	9769(00)		DRN	76.9 to 77.3 gpm @ 1201 hrs.
		180			70.94'			1.58		@ 12:00:30		DRN	
		210			70.95'			1.59		9815 @	1304:20	DRN	77.3 ± 0.1 gpm @ 1304 hrs.
		240			70.97'			1.61				DRN	
	1400	270			70.99'			1.63		9862 @	1401:20	DRN	~77.0 gpm @ 1401 hrs
1		300			71.00			1.64				DRN	
1		330			71.015			1.655		9908 @	1501:55	DRN	77.2 gpm @ 1501 hrs.
V	1520	359			71.02'			1.66	final	9929 @ 1530 hrs		DRN	Shut pump off @ 1530 hrs. Flow rate has fluctuated between 76.4 and 77.6 gpm during pump test

Q_{AVG} = 77.2 gpm


K•E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6013
Time since pumping began (min)
1
10
100
1000
Drawdown (ft)
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
WELL HN-102
constant discharge test
TEST RUN by PNL 5/16/85
Data revalidated by MT Hartman 4/20/90
Q = 97 gpm = 10.3 ft³/min = 15,000 ft³/d
T = 2.3 Q / 4π Δs/Δlog t
T₁ = 27,000 ft²/d
T₂ = 18,000 ft²/d
Δs/Δlog t = 0.25


Well N-62 Recovery
Test run by PNL 8/16/88
Data recalculated by MJ Hartman 3/20/90
1000
100
10
1
0
.1
.2
.3
.4
.5
Residual Drawdown (ft)
K·E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
46 6013

N-69 and N-70

HYDROLOGIC TESTING AT 100-N AREA

INTRODUCTION

Hydrologic tests (aquifer pumping tests) were conducted in two wells located in the 100-N Area in June of 1988. The wells are designed to monitor the ground water in the uppermost aquifer beneath the 1301-N and 1325-N liquid waste disposal facilities as required by Resource Conservation and Recovery Act (RCRA) standards. The tests are considered to be opportunistic in that the wells were not designed for aquifer testing. Therefore, the results obtained from the tests must be considered in this perspective.

Purpose of the Aquifer Tests

The purpose of the aquifer pumping tests was to determine the transmissivity, hydraulic conductivity and, if possible, the storativity of the uppermost, unconfined aquifer beneath the 1301-N and 1325-N liquid waste disposal facilities.

Estimates of transmissivity and hydraulic conductivity are determined from data collected from constant-discharge and recovery tests conducted in wells 199-N-69 and 199-N-70. Data collected from observation wells 199-N-39 (while pumping Well 199-N-70) and 199-N-67 (while pumping Well 199-N-69) also are to be used to determine estimates of transmissivity and hydraulic conductivity and, if possible, storativity.

Well Locations

The location of the pumping wells (199-N-69 and 199-N-70) and the observation wells (199-N-39 and 199-N-67) are shown in Figure 1.

METHODS OF ANALYSIS

The Theis (1935) curve-fitting method was used to analyze the drawdown and recovery data. The underlying assumptions in using this method include the following:

- The aquifer is of infinite areal extent.
- The aquifer is homogeneous, isotropic, and of uniform thickness within the radius of influence of the pump test.
- The pumped well penetrates, and receives water from, the full thickness of the aquifer by horizontal flow.
- The well is pumped at a constant discharge rate.
- The static level of the piezometric surface is horizontal within the radius of influence of the well.
- the well diameter is infinitesimal (storage in the well is neglected).
- the water removed from storage is discharged instantaneously with decline of head.
- Laminar flow

General Limitations

An important condition that is not satisfied in the Theis analysis is that the pumping wells do not fully penetrate the aquifer. Partial penetration creates vertical flow gradients in the vicinity of the well during pumping, affecting the drawdown data. Analysis of the data affected by partial penetration tends to underestimate transmissivity near the well.

WELL 199-N-69 AQUIFER TEST

The stratigraphy, well construction, development, test performance, and data analysis of the test at Well 199-N-69 are presented below.

Stratigraphy and Well Construction

A schematic diagram of the lithology and well construction for Well 199-N-69 is shown in the As-Built Diagrams. The textural classifications of the aquifer sediments at Well 199-N-69 are silty sandy gravel, gravelly silty sand, slightly gravelly sand, and sandy gravel. The unconfined aquifer lies within the Middle Ringold Unit between 67 and 100 feet below land surface and is bounded below by a well-defined layer of clay.

The well was completed with a 10-foot section of 6-inch diameter 10-slot continuous-wound stainless steel screen at the bottom of the aquifer between 90 and 100 feet below land surface. A 20-40 mesh sand pack was placed in the annular space around the screen.

The textural classifications of the aquifer sediments at well observation 199-N-67 are sandy gravel and silty sandy gravel. The aquifer also lies within the Middle Ringold Unit at this well.

Well 199-N-67 was completed in the uppermost part of the aquifer with a 15.5-foot section of 6-inch diameter 20-slot continuous-wound stainless steel screen. The screen extends 11 feet below the water table, which is approximately 65 feet below land surface.

Pre-test Well Development

Development of Well 199-N-69 was conducted on June 9, 1988 for a period of 135 minutes. The discharge rate was approximately 46 gpm. After the pump was shut off, the water level was measured and recorded while it returned to its pre-test level.

Test Performance

The constant-discharge test, conducted on June 9, 1988, was a multiple-well test. The observation well, 199-N-67, is located approximately 30 feet from the pumping well.

The test was conducted for a period of 5 hours. The discharge rate was stable, averaging 46 gpm. The water was pumped from the well with a 25-horsepower submersible pump and discharged to the 1325-N liquid waste disposal facility.

The water level was measured with an electric water-level indicator (E-tape) in the pumping well. After 40 minutes of pumping, drawdown could not be measured because of problems in getting the E-tape probe past the wiring and pump column. After the first 20 minutes of the recovery test, the E-tape was removed from the pumping well and placed in the observation well. A data logger and pressure transducer system was used to measure and record drawdown and recovery in the observation well. The discharge rate was measured with an in-line digital flowmeter. Field data were recorded on aquifer test data sheets, which are attached to this report.

Discussion of Data

Well entrance losses occurred in the pumping well as indicated by 18.5 feet of drawdown after 5 minutes of pumping. The water level stabilized during the remainder of the constant-discharge test. The recovery test yielded a water-level response which regained its pre-test level within 3 minutes after the pump was shut off.

A steady drawdown trend occurred in the observation well after approximately 5 minutes of pumping. The maximum drawdown (as measured with a pressure transducer) was approximately 0.35 feet. A semi-logarithmic plot of the recovery data versus time since the pump stopped indicates that the water levels may have been influenced by daily water-level changes after approximately 60 minutes of recovery.

Data Analysis

Application of the Theis curve-fitting technique to a full logarithmic plot of the drawdown data from the observation well (Figure) yields an estimate of transmissivity of 8200 ft^2/d and a storage coefficient of 0.07. The Theis method applied to the recovery data (Figure), for $t' < 60$ minutes, yields an estimate of transmissivity of 10,000 ft^2/d and a storage coefficient of 0.06. The transmissivities divided by the aquifer thickness yield estimates of hydraulic conductivity of 250 ft/d and 300 ft/d, respectively. This assumes that the aquifer thickness (33 feet) is constant within the radius of influence.

WELL 199-N-70 AQUIFER TEST

The stratigraphy, well construction, development, test performance, and data analysis of the test at Well 199-N-70 are presented below.

Stratigraphy and Well Construction

A schematic diagram of the lithology and well construction for Well 199-N-70 is shown in the As-Built Diagrams. The textural classifications of the aquifer sediments at Well 199-N-70 are silty sandy gravel and gravelly silty sand. The aquifer lies within the Middle Ringold Unit between 59 and 100 feet below land surface and is bounded below by a layer of gravelly silt (clay).

The well was completed with a 10-foot section of 6-inch diameter 10-slot continuous-wound stainless steel screen at the bottom of the aquifer between 90 and 100 feet below land surface. A 20-40 mesh sand pack was placed in the annular space around the screen.

The aquifer sediments at Well 199-N-39 cannot be classified accurately based on the information available; however, the lithology is similar to that of the pumping well. The well was drilled to a total depth of 78 feet and was completed with a screen in the upper part of the aquifer. The water table is approximately 59 feet below land surface.

Pre-test Well Development

Development of Well 199-N-70 was conducted on June 14, 1988 for a period of 120 minutes. The discharge rate was adjusted to 43 gpm at the beginning of the test and stepped up to approximately 50 gpm after 20 minutes of pumping. After the pump was shut off, the water level returned to its pre-test level.

Test Performance

The constant-discharge aquifer test, conducted on June 15, 1988, was a multiple-well test. The observation well, 199-N-39, is located approximately 23 feet from the pumping well.

The well was pumped for a period of 6 hours at maximum discharge. The discharge rate was stable, averaging 49 gpm. The water was pumped with a 25-horsepower submersible pump and discharged to the 1325-N liquid waste disposal facility.

Drawdown and recovery were measured in the observation well with an E-tape. The E-tape in the pumping well became "hung up" during the constant-discharge test and therefore, could not be used to measure drawdown. A data logger and pressure transducer system was used to measure and record pressure head in both wells, however the transducer in the observation well was not working correctly. The discharge rate was measured with an in-line digital flowmeter. The flowmeter generator stopped approximately 15 minutes before the pump was shut off and could not be restarted. Field data were recorded on aquifer test data sheets, which are attached to this report.

Discussion of Data

Well entrance losses occurred in the pumping well as indicated by approximately 13 feet of drawdown within one minute of pumping. The water level stabilized during the remainder of the constant-discharge test. The recovery test yielded a recovery response of nearly 13 feet one minute after the pump was shut off before gradually recovering to the pre-test level.

Examination of the drawdown data from the observation well indicate that a distinct trend in the data occurs after approximately 10 minutes of pumping. The maximum drawdown (as measured with the E-tape) was 0.45 feet. The recovery data, plotted as calculated recovery versus time after pumping ceased, show a similar trend as the drawdown data.

Data Analysis

The Theis curve-fitting analysis applied to a full logarithmic plot of drawdown in the observation well versus time (Figure) yields an estimate of transmissivity of 5,200 ft^2/d and a storage coefficient of 0.29. This technique applied to a logarithmic plot of calculated recovery in the observation well versus time (Figure) yields an estimate of transmissivity of 5,700 ft_2/d and

a storage coefficient of 0.24. The transmissivities divided by the thickness of the aquifer (41 feet) yield estimates of hydraulic conductivity of 130 ft/d and 140 ft/d, respectively.

SUMMARY

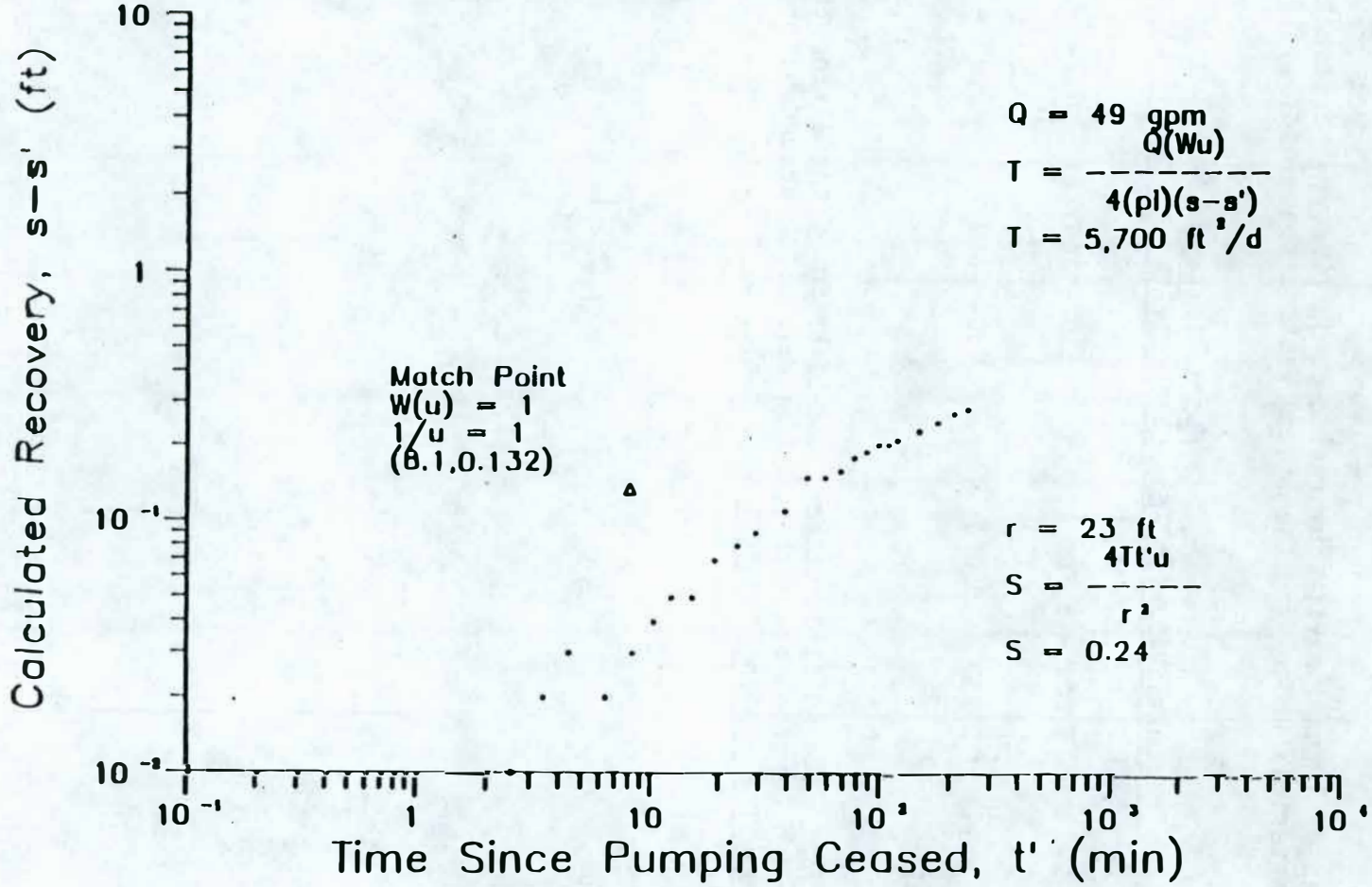
Estimates of transmissivity, hydraulic conductivity, and storativity of the aquifer materials underlying the liquid waste disposal facilities are indicated as follows:

Well Number	Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d)	Storativity
199-N-39 (Observation Well)	5,200 - 5,700	130 - 140	0.24 - 0.29
199-N-67 (Observation Well)	8,200 - 10,000	250 - 300	0.06 - 0.07

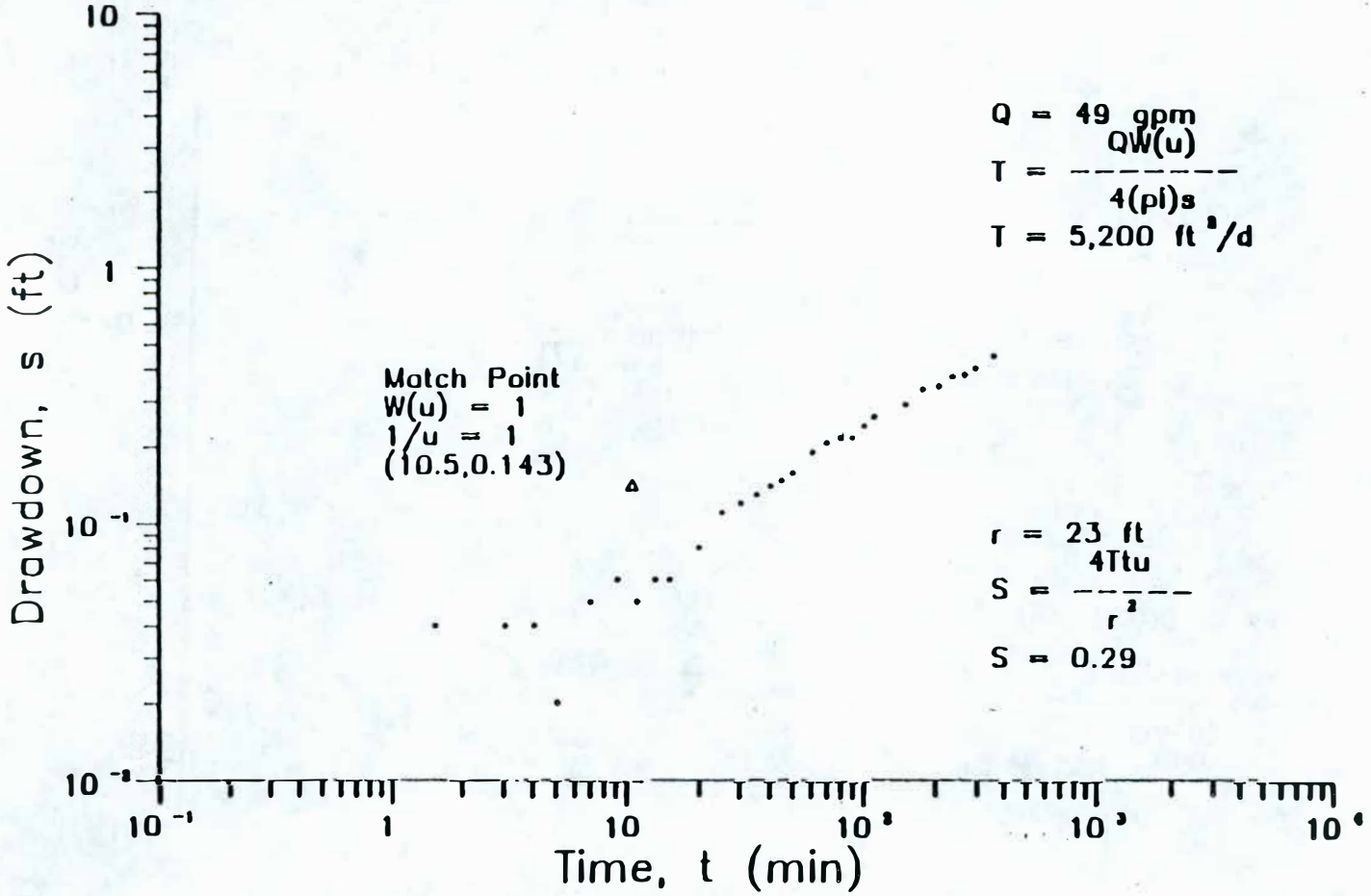
REFERENCES

Theis C V. 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-water Storage. American Geophysical Union Transactions., v. 16, p. 519-524.

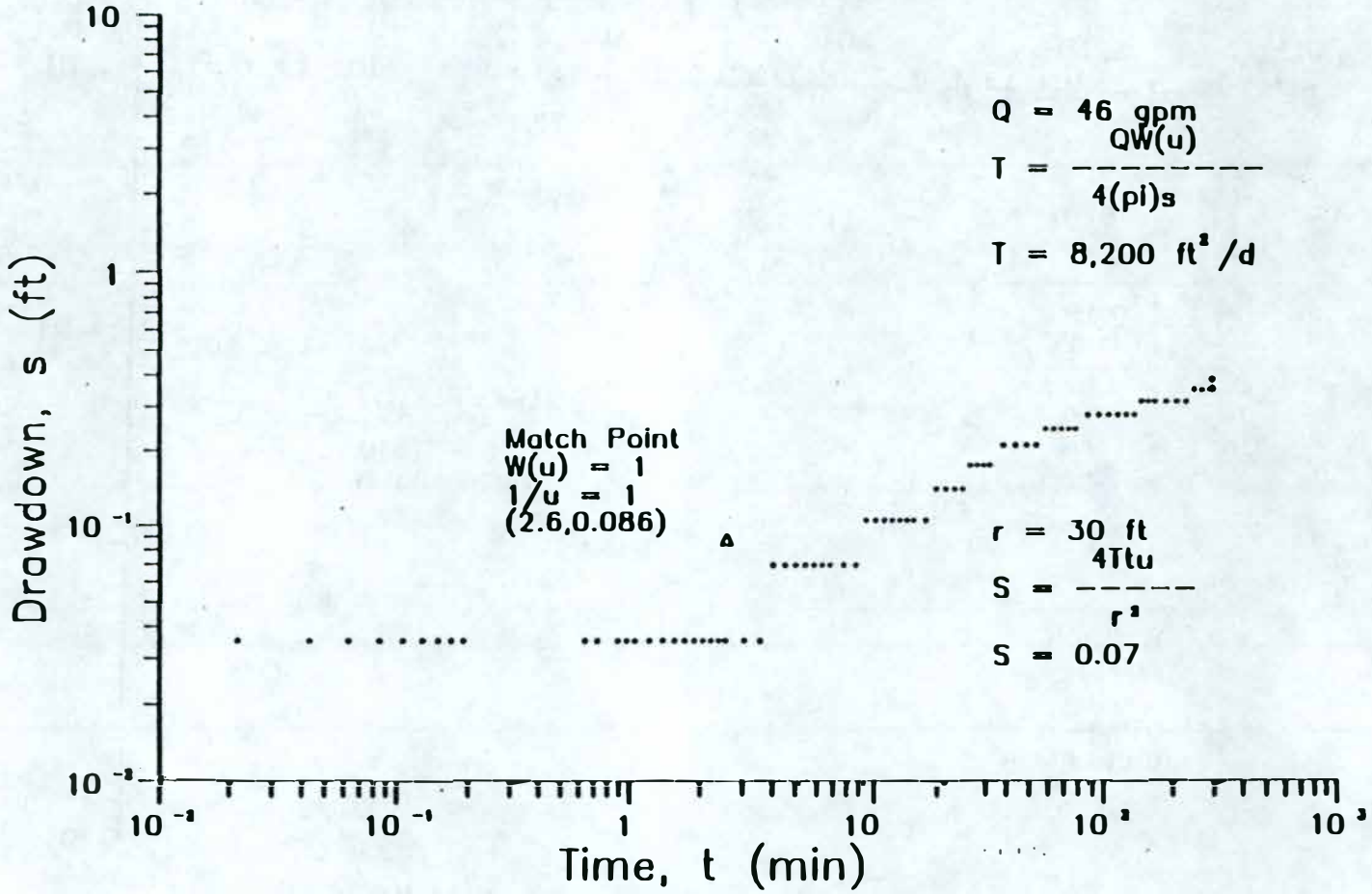
OBSERVATION WELL 199-N-39

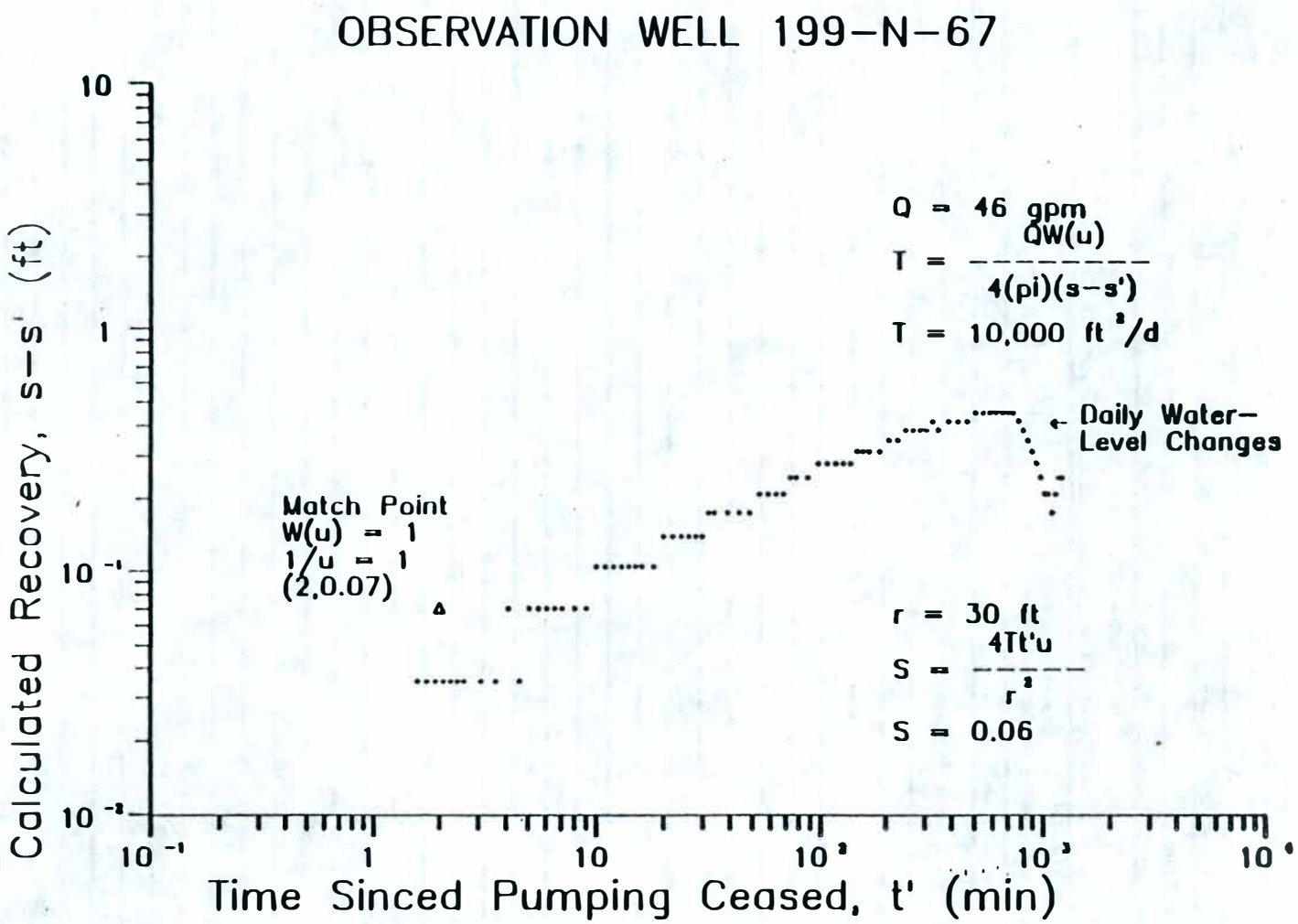


OBSERVATION WELL 199-N-39



OBSERVATION WELL 199-N-67




OBSERVATION WELL 199-N-67
Q = 46 gpm
T = QW(u) / 4(pi)(s-s')
T = 10,000 ft²/d
Daily Water-Level Changes
Match Point
W(u) = 1
1/u = 1
(2,0.07)
r = 30 ft
S = 4Tt'u / r²
S = 0.06
Calculated Recovery, s-s' (ft)
Time Sinced Pumping Ceased, t' (min)
10
1
10⁻¹
10⁻²
10⁻¹
1
10
10²
10³
10⁴

Aquifer Test Data

page 1 of 3

Data for Well 00-N-69

Pumping Well "

Observation Wells 199-N-67

Location 199-N-66

Type of Aquifer Test [illegible] / Development

How Q Measured Digital Flowmeter

How W.L.'s Measured E-Tape Transducer

Depth of Pump/Airline ~90' / well depth ~135

Rad./Dist. of/From Pumping Well

Pump On: date 6/9/88 time 0915 hr

Meas. Point for W.L.'s T/C 1.83' abv LSD

Pump Off: date 6/9/88 time 1030 hr

Elevation of Meas.-Point

Duration of Aquifer Test 135 min

LSD cement pad w/ large manhole

Time t = ____ at t' = 0					Water Level Data Static Water Level ____					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
6/9	0915	0			—							CEP	Tank [illegible]
	[illegible]	30			86.37	only daily					[illegible]		Dump
	0955	93			86.87	[illegible]					[illegible]		[illegible]
						[illegible]							well 00-N-67
						DD							[illegible]
													well 00-N-69
													[illegible]
	1025	130			86.87								[illegible]
	1030	135	0							92/200			Re-[illegible]
		135.5	.5		21.20								Dump [illegible]
		136	1		68.29								1st [illegible]
		137	2		68.06								[illegible] 1015 hr
		138	3		67.94								
		139	4		67.98								[illegible]
		140	5		68.00								[illegible]
		143	8		67.99								199-N-67 [illegible]
		144	9										[illegible]
		146	11		68.08								
		148	13										
		150	15		68.09								
		155	20		68.08								[illegible]
		160	25		68.15								[illegible]
	1102	167	32		68.20								[illegible]
	1115	180	45		68.30								
	1125	190	50		68.32								
	1135	200	60		68.31								[illegible]
	1145	210	70		68.35								[illegible]
	1150	215	80		68.34								[illegible]
	1200	225	90		68.33								
	1210	235	100		68.30								
	1220	245	110		68.30								
	1230	255	120		68.30								
	1300	225	150		68.29								

Aquifer Test Data

page [illegible] of [illegible]

Data for Well 199-N-66

Pumping Well 199-N-69

Observation Wells 199-N-67

Location 199-N-69

Type of Aquifer Test Constant Discharge

How Q Measured Digital Flowmeter

How W.L.'s Measured E-Tape / Tape Sounder

Rad./Dist. of/From Pumping Well

Meas. Point for W.L.'s T/C 1.43' Above Grd

Elevation of Meas. Point

Depth of Pump/Airline -90' / [illegible]

Pump On: date 6/9/89 time [illegible]

Pump Off: date 6/9/89 time 1815 hrs

Duration of Aquifer Test 300 min

Obs [illegible] 67.34' Below T/C Steel Tape

Time t = 300 at t' = 0					Water Level Data Static Water Level 68.30					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Corrections or Corrections	Water Level	s or s'		Reading	Q		
6/9	[illegible]	0								821200		CSC	Placed 0-15 psi
		:30									67		Transducer
		1											Obs [illegible]
		2											[illegible]
		3											[illegible]
		4											at 1315 hrs
		5			86.95						46.8		
		7											Switched to E.T.
		9			86.76						46.7		
		11			86.85								
		13			86.95								
		15											
		20			86.94						46.6		
		25			86.96						46.7		
		30			86.931						46.7		
		35			86.95						46.9		
		40			86.95						46.91		
													[illegible]
													[illegible]
											45.6		[illegible]
													[illegible]
											46.7		[illegible]
6/9	1815	300	0							825100			Recovery
			:30							No flow measured			
			1		67.29								[illegible]
			2		68.22								[illegible]
			3		68.48								[illegible]
			4		68.47								[illegible]
			5		68.49								
			7		68.45								
			9		68.46								
			11		68.46								
			13		68.46								
			15		68.47								
	1835	320	20		68.46								Removed E-Tape
													[illegible]
													[illegible]

OBSERVATION WELL

Aquifer Test Data

199-N-67

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Data for Well 199-N-67
Pumping Well 199-N-69
Observation Wells 199-N-67

Location 199-N-69
Type of Aquifer Test CONSTANT RATE RECOVERY
How Q Measured DIGITAL FLOWMETER
How W.L.'s Measured E-TAPE / TAPES
Rad./Dist. of/From Pumping Well
Meas. Point for W.L.'s T/C 1.70' ABOVE LSD
Elevation of Meas. Point
LSD CONCRETE W/ BROKEN TOP

Depth of Pump/Airpipe ~90' / 100' TOTAL
Pump On: date 06/09/89 time 1315 hr
Pump Off: date 6/10/89 time 1815 hr
Duration of Aquifer Test 5 hr (300 min)

Time: t = 300 at t' = 0					Water Level Data: Static Water Level 67.70 STEEL TAPE				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Corrections or Corrections	Water Level	s or s'	Reading	Q		
6/9	1040	325	25	13	67.96	(E-TAPE and		0.23			CSC	E-TAPE MOVED TO
1	1945	330	30	11	67.92	WELLTAPE		0.19				OBS WELL
1		335	35	9.57	67.92	differ by 0.01 ft)		0.19				
1		340	40	8.5	67.91			0.18				
1		345	45	7.67	67.91			0.18				
1		350	50	7	67.90			0.17				SWITCH TAPE: 67.91
1	1955	360	60	6	67.89			0.16				
1		370	70	5.29	67.88			0.15				
1		380	80	4.75	67.87			0.14				
1		390	90	4.33	67.86			0.13				
1		400	100	4	67.85			0.12				
1		410	110	3.73	67.84			0.11				
V	2015	420	120	3.5	67.83			0.10				

Aquifer Test Data

Total gallons ≈ 5860

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Data for Well 199-N-70
Pumping Well 199-N-70
Observation Wells 199-N-39

Location 199-N-70 (100N Area)
Type of Aquifer Test CONSTANT-RATE - STEP 30 DEVELOPMENT
How Q Measured DIGITAL FLOW METER
How W.L.'s Measured E-TAPE / TRANSDUCER
Rad./Dist. of/From Pumping Well 23 NA
Meas. Point for W.L.'s T/C 2.32' ABV LSD
Elevation of Meas.-Point
Depth of Pump/Airline 96' SCREENED 90-100'
Pump On: date 6-1-99 time 9:45
Pump Off: date 6/14/99 time 11:45
Duration of Aquifer Test 120 min.

Time t = ____ at t' = 0					Water Level Data Static Water Level 61.42'					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
6/14	0945	0									49	CC	
		:30											
		1											
		1:30											
		2											
		3									43		
		4											E. TAPE PLUGS
		5											SOUND - REFINITE
		7											FROM CABLE
		9									43.4		LIGHT ONLY TRANSDUCER
		11									43.5		
		13									49.2		
		15									49.9		
		20									49.9		Increase rate (2 turns)
		21									50.6		
		22									50.2		
		23									50.7		
		25									50.5		
		27									49.5		
		30									49.2		
		35									49.6		
		40									50.5		Increase rate (2 turns)
		41									49.9		
		45									49.3		
		50									49.8		
		60									49.4		
		90									49.6		
✓	1145	120	0							Suggested			Turn off [illegible]

Aquifer Test Data

Total Gallons = 16,900

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Data for Well 199-N-70

Pumping Well 199-N-70

Observation Wells 199-N-39

Location 199-N-70 (100 N Area)

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured DIRECT-FLOW METER

How W.L.'s Measured E-TAPE / AIRLINE

Rad./Dist. of/From Pumping Well NA

Meas. Point for W.L.'s T/C 2.32' above LSD

Elevation of Meas. Point

LSD = CONCRETE PAD

Depth of Pump/Airline ~96 - SUCCEED SCOPE

Pump On: date 06/15/98 time 0045

Pump Off: date 6/15/98 time 1545

Duration of Aquifer Test 360 min

Time: t = 360 at t' = 0					Water Level Data: Static Water Level					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
6/5	0915				61.63					94460			E. TAPE
	0930				61.68								
	0945	0			61.68								
		1:30			74.92						50.3		
		1											
		1:30											
		2											
		3									49.5		
		4											E TAPE HUNG-UP
		5											in 49.68
		7									49.6		
		9											
		11									49.3		
		13											
		15											
		20											
		25									49.4		
		30									49.4		
		35									49.3		
		40									49.4		
		45									49.6		
		50									49.2		
		60									49.1		
		70									49.1		
		80									90.1		Opened valve 2 turns
		85									89.4		
		90									88.8		Opened valve 2 turns
	1125	180									48.6		Opened valve 2 turns
	1130	185									48.7		Valve wide open
	1145	120									49.1		Sampled sample
	1218	158									49.3		16' below [illegible]
	1245	180									49.0		[illegible]
	1345	210									49.2		
	1345	240									49.2		3rd Sample taken
	1415	270									49.0		
	1445	300									49.0		
	1515	330									48.8		
	1530	345								9700			FLOWMETER GOOD
	1545	360											[illegible]

STOPPED PUMP

OBSERVATION WELL

Aquifer Test Data

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Data for Well 199-N-70
Pumping Well 199-N-70
Observation Wells 199-N-70

Location 199-N-70 (100N Area)
Type of Aquifer Test STEP DD - CONSTANT DISCH.
How Q Measured DIGITAL FLOWMETER
How W.L's Measured E-TAPE / TRANSDUCER
Rad./Dist. of/From Pumping Well 23'
Meas. Point for W.L's T/C 3.21' abv LSD
Elevation of Meas. Point LSD = CEMENT PAD

Depth of Pump/Airpipe ~76' SCREENED 58-108'
Pump On: date 6/15/98 time 0905
Pump Off: date 6/15/98 time 1505
Duration of Aquifer Test 360 min.

Time: t = _____ at t' = 0
Water Level Data: Static Water Level 61.79

Day	Clock Time	t	t'	1/t'	Reading	Corrections or Corrections	Water Level	s or s'		Discharge Reading	Q	Recorded By	Comments
6/14		0	7		[illegible]								TRANSDUCER
		20	5		[illegible]								0-10 PSI [illegible]
		30	7		[illegible]								[illegible]
		60	7	4	[illegible]								
		90	7	6	[illegible]								
		160	7										[illegible]
													[illegible]
		[illegible]					63.00						Steel tape [illegible]
			67				62.79						
6/15	0900	-			60.55								ETAPE
	0930				60.96								[illegible]
	0945	0			—			—					TRANSDUCER
		30			60.26			0				SIT	[illegible]
		1.00			60.26			0				"	
		1.30			60.90			0.04				"	
		2			60.85			-0.01				"	
		3			60.90			0.04				"	
		4			60.90			0.04				"	
		5			60.88			0.02				"	
		7			60.91			0.05				"	
		9			60.92			0.06				"	
		11			60.91			0.05				"	
		13			60.92			0.06					
		15			60.92			0.06					
		20			60.94			0.08					
		25			60.97			0.11					
		30			60.98			0.12					
		35			60.99			0.13					
		40			61.00			0.14					
		45			61.01			0.15					
		50			61.02			0.16					
		60			61.05			0.19					
		70			61.07			0.21					
		80			61.08			0.22					
		90			61.08			0.22					
		100			61.10			0.24					
		110			61.12			0.26					
	1045	120			—			—					

Aquifer Test Data

OBSERVATION WELL

page 2 of 2

Data for Well 199-N-39
Pumping Well 199-N-70
Observation Wells 199-N-39

Location 199-N-70 (100 N Area)
Type of Aquifer Test Constant Discharge / Recovery
How Q Measured Digital Flowmeter
How W.L.'s Measured E-tape / Transducer
Rad./Dist. of/From Pumping Well 23'
Meas. Point for W.L.'s T/C 2.21' Above L.S.
Elevation of Meas. Point
L.S. = Concrete Pad

Depth of Pump/Airpipe ~96' Screened 90-100'
Pump On: date 6-15-88 time 0:45
Pump Off: date 6-15-88 time 1545
Duration of Aquifer Test 360 min (Constant-discharge)

Time t = 360 at t' = 0					Water Level Data Static Water Level ~~61.60~~ 60.56 E-Tape				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Corrections or Corrections	Water Level	s or s'	Reading	Q		
6/15	12:45	150			61.15			0.29			SST	
	12:45	180			61.29			0.34				
	1315	210			61.31			0.35				
	1345	240			61.34			0.38				
	1415	270			61.35			0.39				
	1445	300			61.37			0.41				
	1515	330			61.40			0.44				
	1541	355			61.41			0.45				
	1545	360	0	–	–			–5'				Begin Recovery Test
	1545:41	360.5	30	721	61.40			0.44				
	1546	361	1:00	361	61.40			0.44				
	1546:30	361.5	1:30	241	61.40			0.44				
	1547	362	2:00	181	61.40			0.44				
	1548	363	3	121	61.39			0.43				
	1549	364	4	91	61.38			0.42				
	1550	365	5	73	61.37			0.41				
	1552	367	7	52.4	61.38			0.42				
	1554	369	9	41	61.37			0.41				
		371	11	33.7	61.36			0.40				
		373	13	28.7	61.35			0.39				
		376	16	23.5	61.35			0.39				
		380	20	19	61.33			0.37				
		385	25	15.4	61.32			0.36				
		390	30	13	61.31			0.35				
		400	40	10	61.29			0.33				
		410	50	8.2	61.15			0.29				
	1645	420	60	7	61.15			0.29				
		430	70	6.14	61.14			0.28				
		440	80	5.5	61.12			0.26				
		450	90	5	61.11			0.25				
		460	100	4.6	61.10			0.24				
		470	110	4.3	61.10			0.24				
		480	120	4	61.08			0.23				
			~~130~~		~~[illegible]~~							
			~~140~~									
		510	150	3.4	61.07			0.21				
	1645	540	180	3	61.05			0.19				
		570	210	2.7	~~[illegible]~~ 61.03			0.17				
	17:45	600	240	2.5	61.02			0.16			CSC	End of recovery measurements