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7. Abstract

This document presents ground water monitoring plans for three Resource Conservation and Recovery Act (RCRA) hazardous waste sites: (1) the 1301-N Liquid Waste Disposal Facility (LWDF), (2) the 1324-N Surface Impoundment and 1324-NA Percolation Pond, and (3) the 1325-N LWDF. This monitoring plan is based on requirements for interim-status facilities. Ground water has been monitored under RCTA at the three sites since December 1987. Monitoring will continue in the existing wells and additional wells will be installed.

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GROUND WATER MONITORING PLAN FOR THE 1301-N, 1324-N/NA, AND 1325-N FACILITIES

1.0 INTRODUCTION

This document presents ground water monitoring plans for three *Resource Conservation and Recovery Act* of 1976 (RCRA) hazardous waste sites: (1) the 1301-N Liquid Waste Disposal Facility (LWDF); (2) the 1324-N Surface Impoundment and 1324-NA Percolation Pond (1324-N/NA facilities); and (3) the 1325-N LWDF. These plans are described in a single document because of their proximity to one another and because their influence on local ground water movement and quality is interrelated. This monitoring plan is based on requirements for interim-status facilities, 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 in WAC 173-303-400.

Ground water monitoring was begun at the three RCRA sites in December 1987. The monitoring program was described in draft plans and RCRA quarterly reports, but there were no approved plans for the three sites at that time. The 1325-N LWDF currently remains in an indicator evaluation monitoring program (40 CFR 265.92). After the first year of ground water monitoring, specific conductance in wells in the monitoring networks for the 1301-N LWDF and the 1324-N/NA facilities was found to be elevated above background (i.e., upgradient) levels. Ground water quality assessment programs were initiated at these two facilities (described in Gilmore and Jensen 1989, and Gilmore 1989). The assessment programs found no evidence that hazardous waste or hazardous waste constituents from the 1301-N or 1324-N/NA facilities have entered the ground water (Hartman 1990). It has been proposed that ground water monitoring at the 1301-N and 1324-N/NA sites revert to an indicator parameter monitoring program, as described in 40 CFR 265.93(d)(6).

The purpose of this plan is to present indicator evaluation ground water monitoring programs that will detect adverse impacts of the 1301-N, 1324-N/NA, and 1325-N facilities on the quality of the ground water in the uppermost aquifer beneath the facilities [40 CFR 265.93(d)]. This plan describes the methods that will be used to:

- Further characterize site hydrogeology
- Identify potential pathways for contaminant migration
- Determine whether any hazardous constituents have migrated from the sites to the ground water

- Install monitoring wells to supplement the existing monitoring networks.

Seven new wells are proposed for installation in 1991 and 1992. Four will be constructed in 1991 in support of Tri-Party Agreement milestone M-24-17.

2.0 BACKGROUND INFORMATION

This section describes the 1301-N, 1324-N/NA, and 1325-N facilities, waste characteristics, and hydrogeology of the region and site. References for further information include:

- Closure/Postclosure Plan for the 1301-N LWDF (DOE 1987a)
- Closure Plan for the 1324-NA Percolation Pond (DOE 1987b)
- Part B Permit Application for 1324-N Surface Impoundment (DOE 1986)
- 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 stream-specific reports (WHC 1990a,b)
- RCRA Quarterly Progress Reports (e.g., Smith et al. 1990)
- RCRA Annual Progress Reports (e.g., Smith and Gorst 1990)
- Ground water quality assessment plans for the 1301-N and 1324-N/NA facilities (Gilmore and Jensen 1989; Gilmore 1989)
- Results of ground water quality assessment monitoring at the 1301-N and 1324-N/NA facilities (Hartman 1990).

2.1 FACILITY DESCRIPTION AND WASTE CHARACTERISTICS

The 1301-N, 1324-N/NA, and 1325-N facilities are all located in the 100-N Area of the Hanford Site in southeastern Washington (Figure 2-1). This section describes each of the 100-N Area RCRA facilities and the characteristics of the waste discharged to the facilities.

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 facility was used to dispose of radioactive waste water generated in the N Reactor from 1963 until 1985. From 1983 until August 1985, waste was split between the 1301-N LWDF and the new 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 (1987a).

Wastes discharged to the 1301-N LWDF were primarily radioactive fission and activation products, including cobalt-60, strontium-90, and cesium-137. Small quantities of nonradioactive hazardous wastes were also discharged to the facilities. Constituents discharged to the 1301-N LWDF included

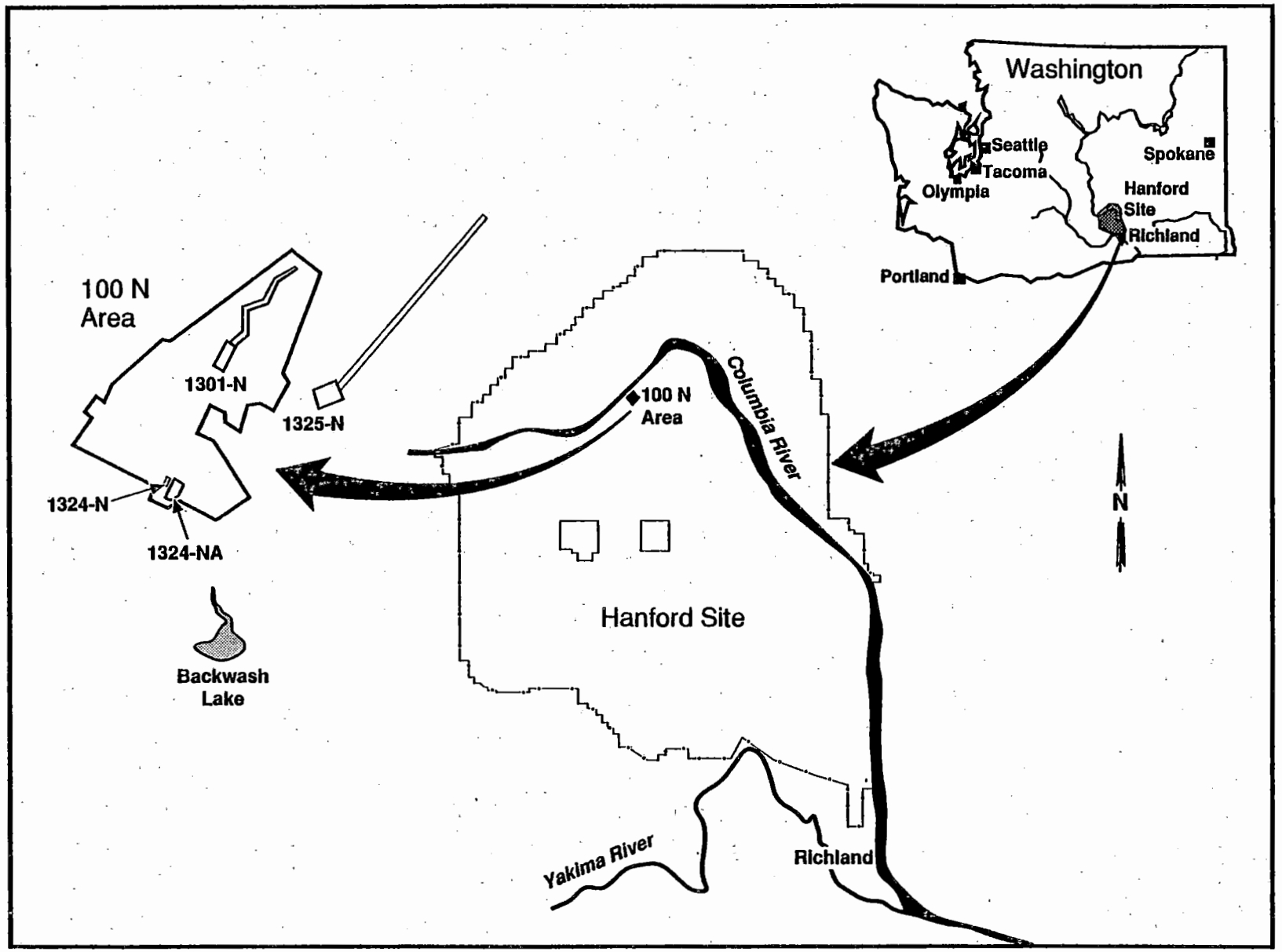

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Figure 2-1. Location of the 100-N Area and the Hanford Site, Washington.

hydrazine, ammonium hydroxide, diethylthiourea, sodium dichromate, morpholine, phosphoric 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 1987a, 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 (see Figure 2-1). Like the 1301-N LWDF, 1325-N is covered with concrete slabs. It was used to dispose of radioactive waste water generated in the N Reactor from 1983 to the present. The N Reactor is no longer operating, so discharges to the 1325-N LWDF are currently minimal and intermittent. Routine discharges to the facility are expected to remain minimal in the future.

Wastes discharged to the 1325-N LWDF were primarily radioactive fission and activation products, including cobalt-60, strontium-90, and cesium-137. Small quantities of nonradioactive hazardous wastes were also discharged to the facilities. Constituents discharged to the various waste streams 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 1990a, p. 5-15).

The 1325-N LWDF is described more fully in the closure-postclosure plan for that facility (DOE 1987c). Waste characteristics are described in the *Waste Stream Characterization Report* (WHC 1989) and stream-specific report for the 163-N demineralization plant (WHC 1990a).

2.1.3 1324-N/NA Facilities

The 1324-NA Percolation Pond is an unlined pond that was historically used to treat corrosive hazardous wastes and, later, to dispose of treated effluent. It was put into service in 1977 and has been in use until the present. Current discharge to the 1324-NA Percolation Pond is zero.

The 1324-N Surface Impoundment was a treatment facility that was in service from May 1986 to November 1988, when it was replaced with an elementary neutralization unit. This facility is a doubly lined pond with a leachate collection system that was used to neutralize the wastes. It is currently not in use.

Table 2-1 presents a summary of discharges to the 1324-N and 1324-NA facilities throughout their periods of use. Wastes treated in the 1324-N Surface Impoundment and, before 1986, in the 1324-NA Percolation Pond, had pH ranging from 1 to 14 (DOE 1987b). These wastes contained sulfuric acid and sodium hydroxide and were designated hazardous because of the characteristic of corrosivity. No corrosive waste has been discharged to the 1324-NA Percolation Pond since May 1986 (DOE 1987b, p. 1-1); no effluent has been discharged to the 1324-N Surface Impoundment since November 1988 (Smith et al. 1989, p. 7.1). No listed dangerous wastes (WAC 173-303) were discharged to either facility at any time (DOE 1987b, p. 3-2).

Table 2-1. Summary of Wastes Discharged to the 1324-N/NA Facilities.

Dates	Waste type and source	T/S/D[a]	Waste category
1324-NA Percolation Pond			
Aug 1977 - 1983	Filter Backwash water (183-N filtered water plant)	D	nonhazardous, nonradioactive
	Regeneration waste (163-N demineralizer)	T & D	corrosive (hazardous); nonradioactive
1983 - May 1986	Regeneration waste (163-N demineralizer)	T & D	corrosive (hazardous); nonradioactive
May 1986 - Nov 1988	Treated wastes (1324-N surface impoundment)	D	nonhazardous; nonradioactive
Nov 1988 - Aug 1990	Treated wastes (elementary neutralization unit)	D	nonhazardous; nonradioactive
Aug 1990 - present	Inactive		
1324-N Surface Impoundment			
May 1986 - Nov 1988	Corrosive Waste (163-N demineralizer)	T	Corrosive (hazardous); non-radioactive
Nov 1988 - present	Inactive		

[a]Type of hazardous waste facility as defined in 40 CFR 265.1: T = treatment; S = storage; D = disposal.

The 1324-N/NA facilities are described more fully in the *Closure Plan for the 1324-NA Percolation Pond* and the Part B Permit Application for the 1324-N Surface Impoundment (DOE 1987b and DOE 1986, respectively). The *Waste Stream Characterization Report* (WHC 1989) and stream-specific report for 163-N demineralizer effluent (WHC 1990b) contain more information on the waste streams discharged to these facilities.

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 ground water monitoring programs. The geology of the Columbia Plateau, and particularly the Pasco Basin, has been studied in detail for 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 by 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 (i.e., 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 were completed by the driller and 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 based on data collected prior to 1990. The primary 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 (WPPSS) for the initial location of Nuclear Power Plant #1 at 100-N Area (WPPSS 1974). Borehole data include driller's logs and geologist's 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 WPPSS nuclear power plant siting. Core samples from two of the WPPSS boreholes were reexamined by Dr. Kevin Lindsey, a NORCUS post-doctoral fellow with the Geosciences Group at Westinghouse Hanford Company. 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 WPPSS and documented in WPPSS (1974). Three of the boreholes, 699-84-59 (called BH-16 in the WPPSS 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 chip hole drilled 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.

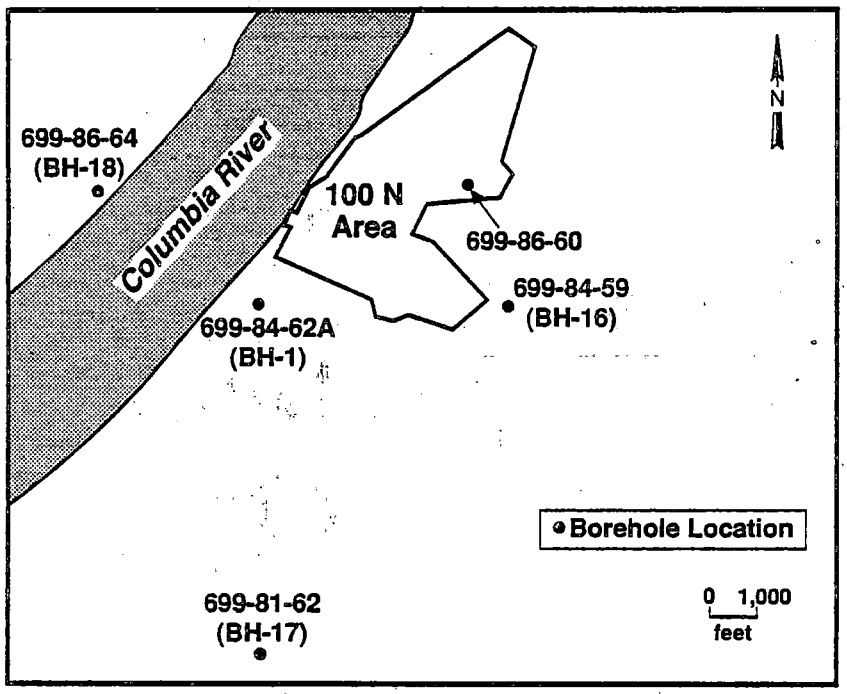
2.2.2.2.1 Columbia River Basalt Group. The cored boreholes that penetrate the Columbia River Basalt Group near the 100-N Area encountered the following members of the Saddle Mountains Basalt: the Elephant Mountain Member, the Pomona Member, the Wilbur Creek Member, and the Asotin Member. The entire basalt 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 there is over 12,000 ft of Columbia River basalt beneath the 100-N Area (Reidel et al. 1989).

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. While exposures of the Ringold Formation are limited to the White Bluffs east of 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 100-N (see Figure 2-2).

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



The Ringold stratigraphy is best described in the 100-N Area in terms of facies types. At 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.

- 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 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 (Hanford formation is black or grey; Ringold is tan or brown).

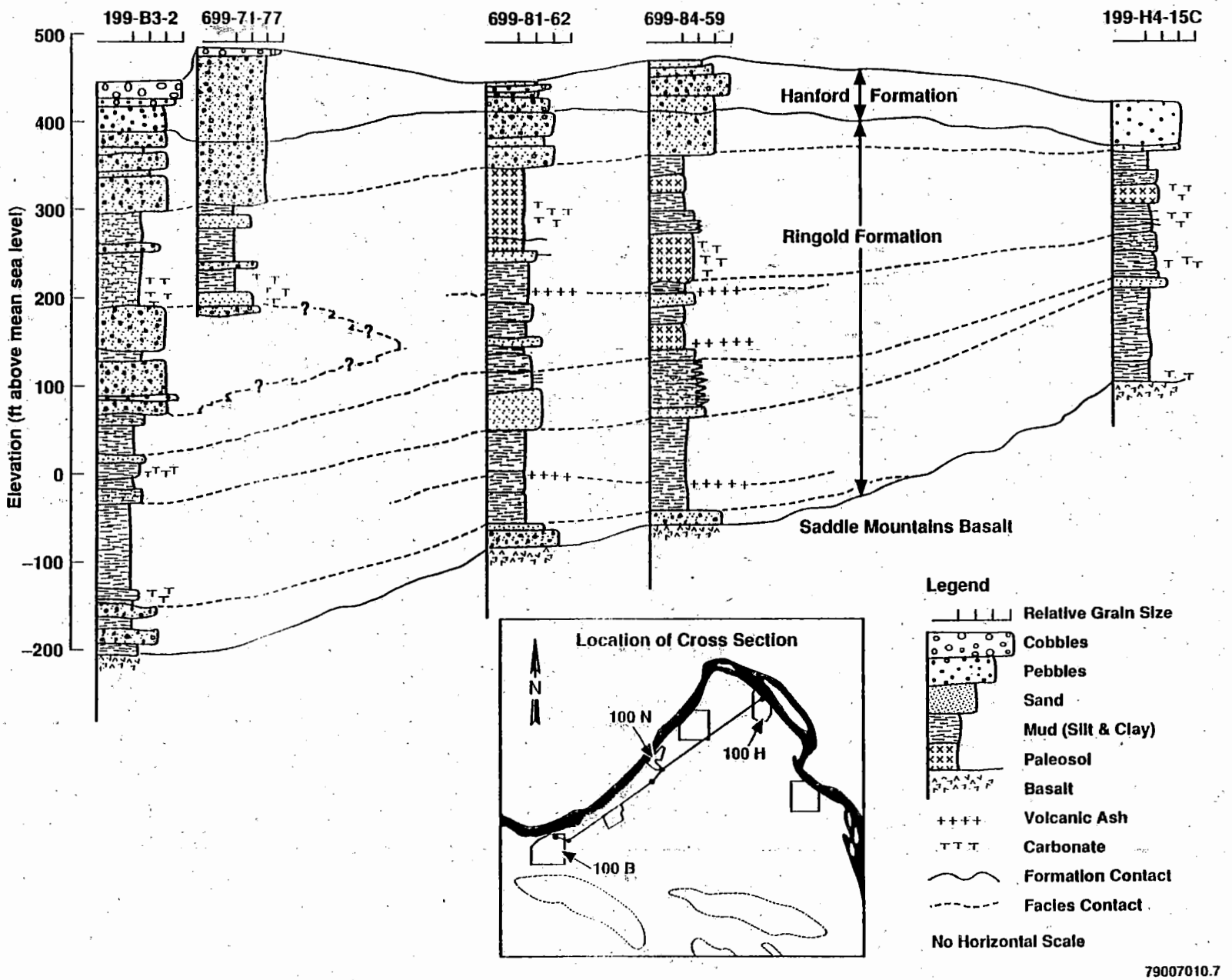


Figure 2-3. Geologic Cross Section Through the 100 Areas (Geologic Interpretation by Dr. K.A. Lindsey).

2.2.2.2.4 Post-Ringold Pre-Pleistocene. In the 100-N Area, no paleosols are preserved at the top of the Ringold 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 at 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. To the 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 2-2.

2.2.2.3 Structural Geology and Seismicity. Very little information is available on the structure of the 100-N Area, primarily due to 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 seismic activity has been recorded at the 100-N Area. An area of shallow swarm activity, the Coyote Rapids swarm area, is located west of the area. The Coyote Rapids swarm area has been the site of several swarms since 1969, when instrumental monitoring of this area began.

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

Site	Elevation of Surface (ft msl)	Elevation of Hanford/Ringold Contact (ft msl)	Elevation top of fine-grained unit (ft msl) and # wells
1301-N	450 to 460	394 to 417	355 to 360 (3)
1325-N	450 to 460	406 to 415	350 (1)
1324-N/NA	450 to 460	396 to 406	no data

2.3 HYDROGEOLOGY

This section provides background information on the hydrogeology of the Hanford Site and the 100-N Area to support preparation of the ground water monitoring programs. 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).

Ground water 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.

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 ground water 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

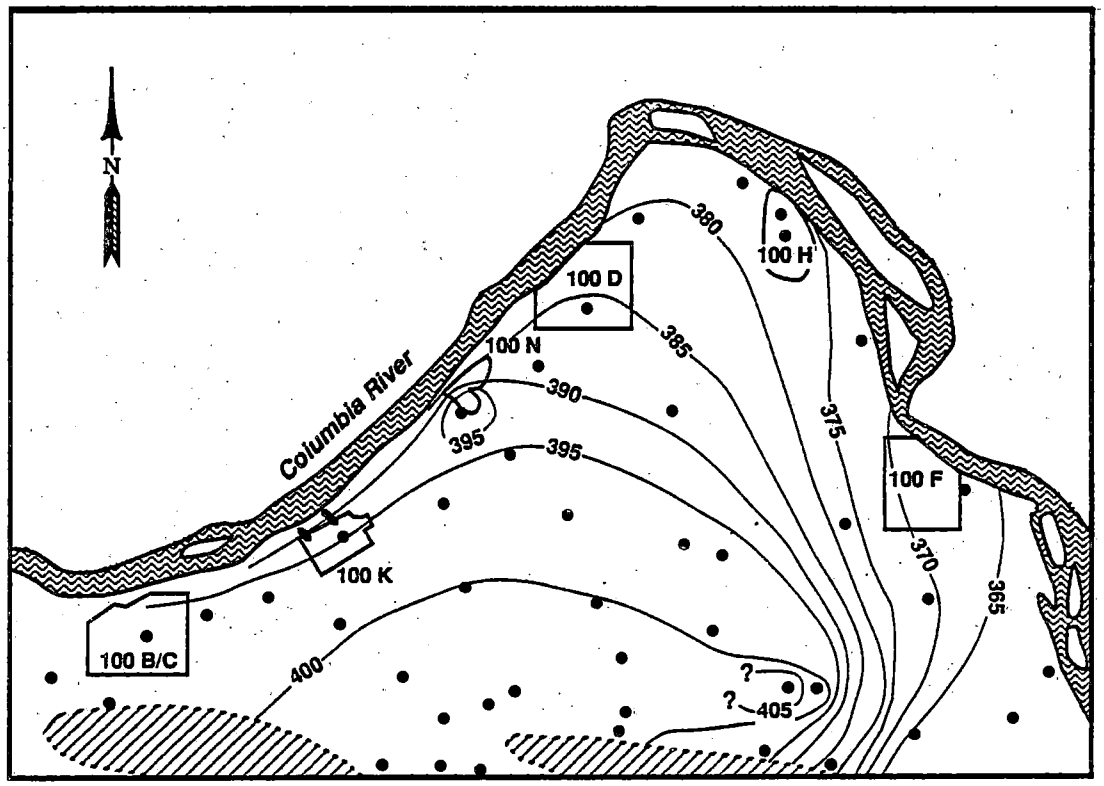
Most of the wells in the 100-N Area are shallow, so knowledge of the deeper hydrogeology is limited. The current conceptualization of 100-N Area hydrostratigraphy is illustrated in Figure 2-5. It comprises the following major hydrostratigraphic units:

- 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

Figure 2-4. Water Table in the Northern Portion of the Hanford Site, December 1989.



Legend

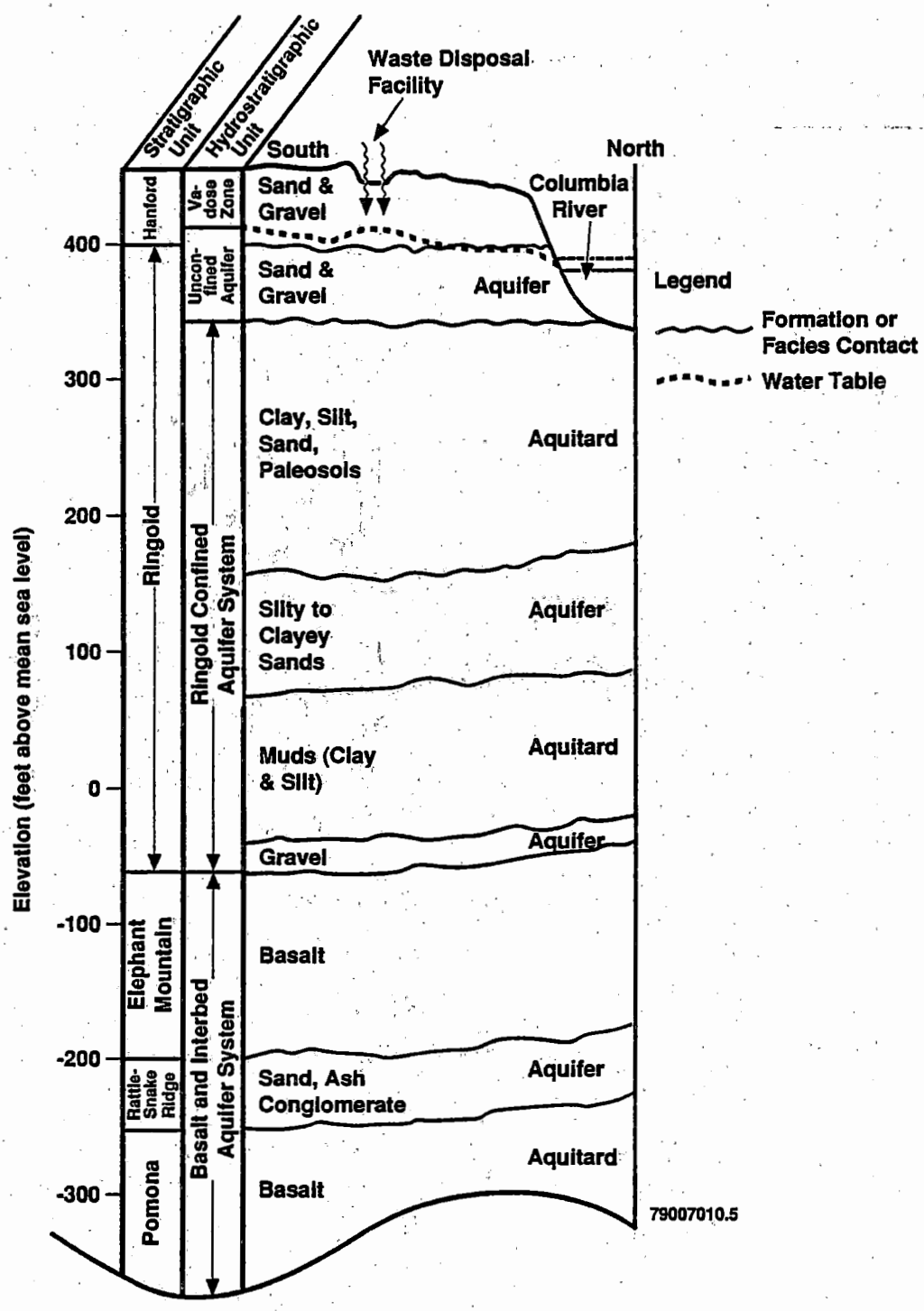
- ● Well used in creating water table map
- Basalt above water table
- 390 Water table contour in feet above mean sea level December 1989

Note:
Data used to create this water table map are from wells completed in the unconsolidated sediments and are believed to be representative of the uppermost aquifer. Some wells are completed below the water table.

0 10,000
Scale in Feet

79007010.6

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



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.

Water flows from the unconfined aquifer in the 100-N Area into the river. Elsewhere on the Hanford Site (e.g., the 100-H Area), high river levels locally reverse the gradient from the river into the unconfined aquifer. In the 100-N Area, however, this effect has been much less pronounced. Data presented in Newcomer (1988, Appendix A) show that water levels in piezometers located less than 50 ft of the high-water river bank were greater than river stage, even when river stage was relatively high. These changes in river stage caused a pressure response in the aquifer, which altered the magnitude of the ground water gradient, though not the direction. Another recent study observed locally reversed gradients near the river and water level responses in the aquifer several hundred feet away from the river (Gilmore et al. 1990, p. 29). River stage changes do not appear to affect the wells beneath the 100-N RCRA facilities significantly. The lack of a significant river stage effect in the aquifer beneath the 100-N Area was probably due to the presence of a steep gradient toward the river, caused by artificial recharge. As the ground water mounds dissipate, reversed gradients from river stage changes may become more prominent.

Ground water enters the Columbia River in the 100-N Area via a series of seeps (discharging underwater) and springs (discharging above the water line). These features are known collectively as "N-Springs." The springs are located along the south bank of the Columbia River adjacent to the 1301-N LWDF and extend approximately 1.7 mi downstream. These springs, particularly those located nearest the 100-N Area, appear to be related to increased ground water levels due to effluent discharge to the ground. 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.

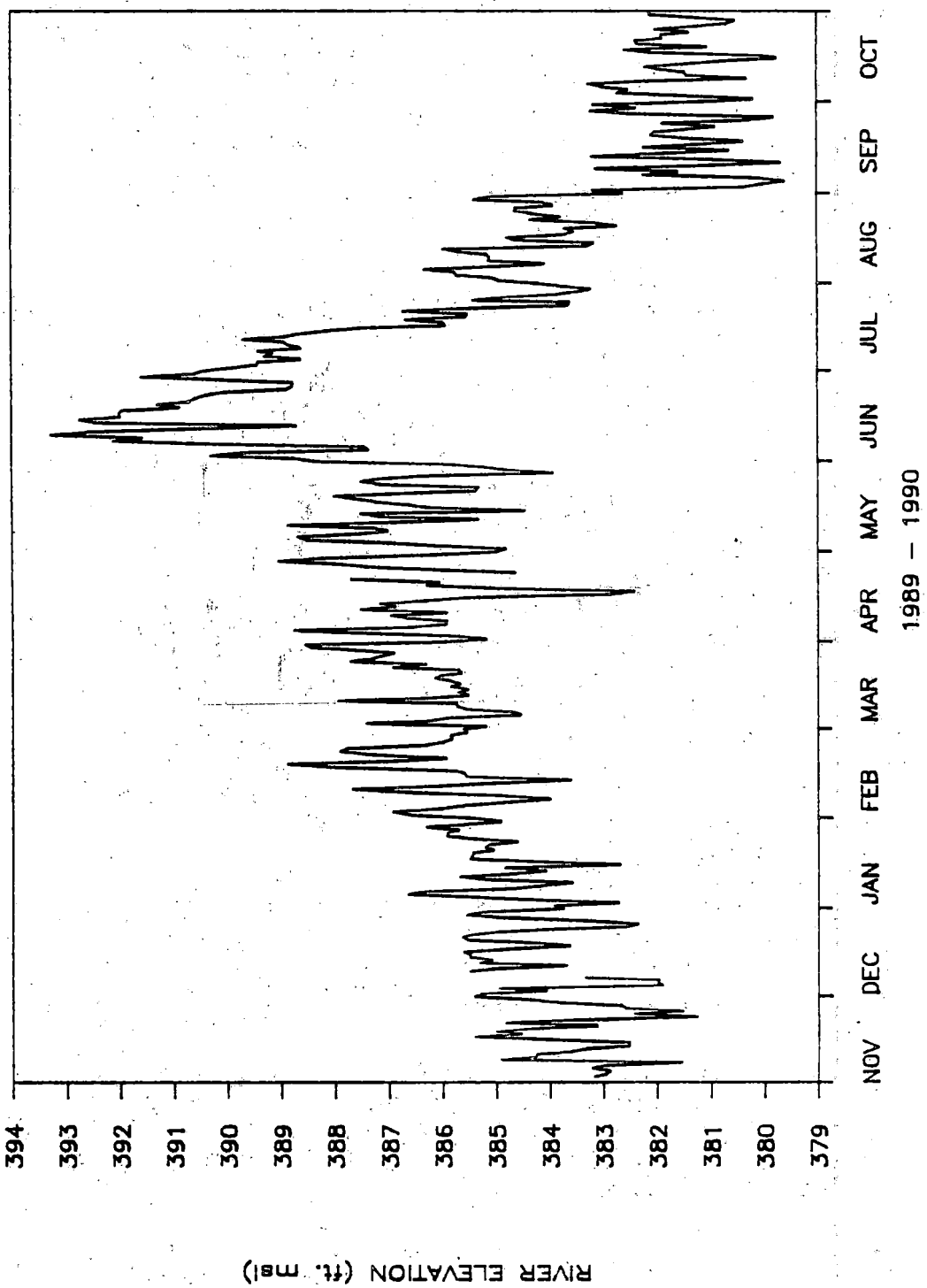
Waste treatment and disposal facilities in the 100-N Area have provided sources of ground water recharge (see Figure 2-1). These artificial surface-water bodies are:

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

- 1325-N LWDF: Replaced the 1301-N facility 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 minimal and intermittent.

- 1324-NA Percolation Pond: Received wastes from 1977 until August 1990. Discharge rates averaged approximately 450,000 gal/day when it was receiving filter backwash water as well as regeneration wastes and cooling water (DOE 1987b, p. 4-4). The filter backwash water was rerouted to another facility in 1983. Current discharge is zero.

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 1987a, p. 4-4). Current and expected future discharge rate is approximately 42,000 gal/day.

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 of mainly 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 is located immediately adjacent to the 1325-N crib, and it was installed after effluent disposal to that facility had begun.

The vadose zone in the 100-N area ranges in thickness from 0 ft at the river to approximately 70 ft in the eastern part of the site. The thickness of the vadose zone beneath each of the 100-N RCRA facilities is 60 to 70 ft. Soil moisture data for the 100-N Area are unavailable.

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 ground water mounds were present. The base of the aquifer is believed to be a laterally continuous clay-rich unit containing a series of paleosols. 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. 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 2-3 and are discussed below (see Figure 2-7 for well locations).

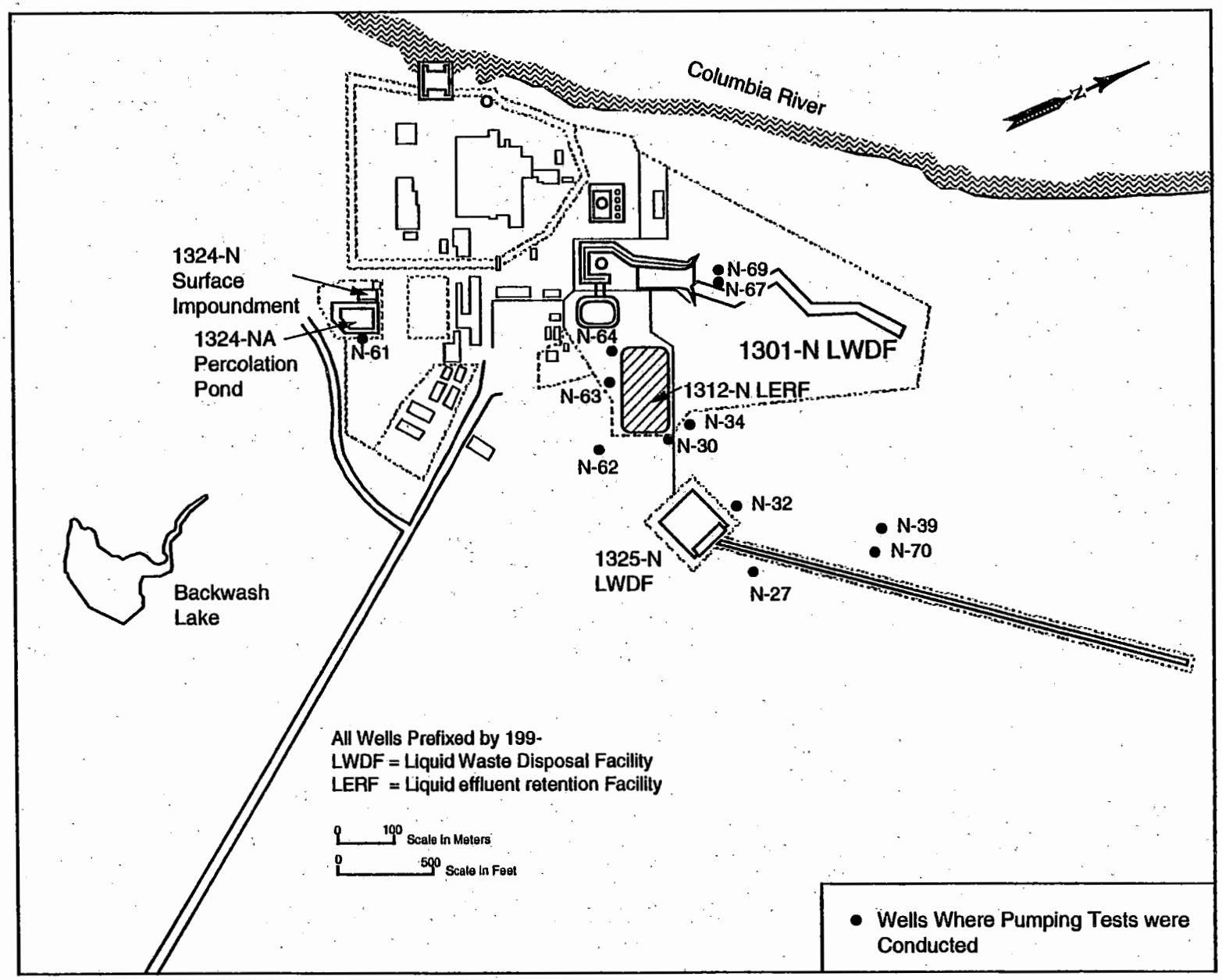
Three 24-h, constant-rate pumping tests were conducted in wells N-27, N-30, and N-32. These wells are all completed in sandy gravel at the top of the Ringold Formation. Analysis of the data indicated there are apparently boundary effects in some of the wells. Calculated transmissivities are summarized in Table 2-3, 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 were documented in unpublished reports and are summarized below. Data sheets and/or plots from those reports are presented in Appendix B.

Table 2-3. 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)	27,000 ft^2/d for time less than 80 minutes;	66 - 78.5	test conducted on August 16, 1988 by PNL for WHC.
drawdown data	11,000 ft^2/d for time greater than 80 minutes		
recovery data	20,000 ft^2/d		
N-39 (observation well)		N-70: 89 - 99 N-39: 54 - 73	pumped well was N-70; test conducted in June, 1988 by PNL for WHC.
drawdown data	5,200 ft^2/d		
recovery data	5,700 ft^2/d		
N-67 (observation well)		N-69: 90 - 100 N-67: 65 - 76	pumped well was N-69; test conducted in June, 1988 by PNL for WHC.
drawdown data	8,200 ft^2/d		
recovery data	10,000 ft^2/d		

Figure 2-7. Aquifer Test Well Locations.



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Wells N-61, N-62, N-63, and N-64 were tested in May and June 1988, during installation of a monitoring system at the 1312-Liquid Effluent Retention Facility (see 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-h 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*; transmissivities are listed in Table 2-3.

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 2-3.

2.3.2.3.2 Ground Water Levels. Ground water 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 ground water 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 ground water flow direction was probably to the north and northwest, toward the river. At various times in the history of waste disposal at the 100-N Area, ground water mounds formed beneath the 1301-N, 1325-N, and 1324-N/NA facilities. Locally, ground water 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 ground water flow in the 100-N Area during active disposal of liquid wastes. The active facility shown in the figure is an area of ground water recharge; therefore, there is a downward gradient beneath the facility. On a local scale ground water flows radially outward from the ground water mound. The overall direction of ground water flow in the uppermost aquifer is toward the Columbia River. There is an upward gradient near the river, which is characteristic of areas of ground water discharge.

Water table maps of the 100-N Area for December 1988, June 1989, and May 1990, 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 facility was low. Ground water flowed radially outward from this mound. Discharge to the 1325-N facility increased markedly through the spring of 1989, causing the mound beneath that facility to eclipse the 1324-NA mound.

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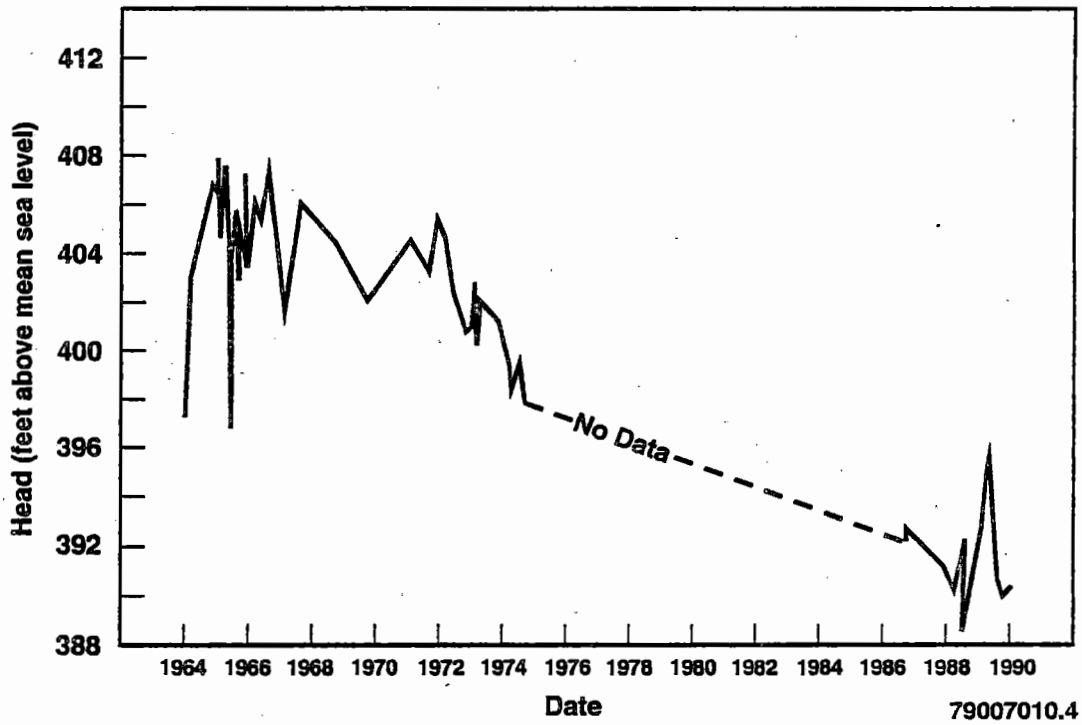
*Results of the pumping test in well N-64 were cited in PNL (1988), giving a transmissivity value of 7751 ft^2/d. However, drawdown and recovery data for this test were very erratic. Results of the aquifer tests in wells N-62, N-63, and N-65 were not summarized in any of the quarterly reports.

Figure 2-8. Hydrograph of Well N-2, 1964 to 1990.



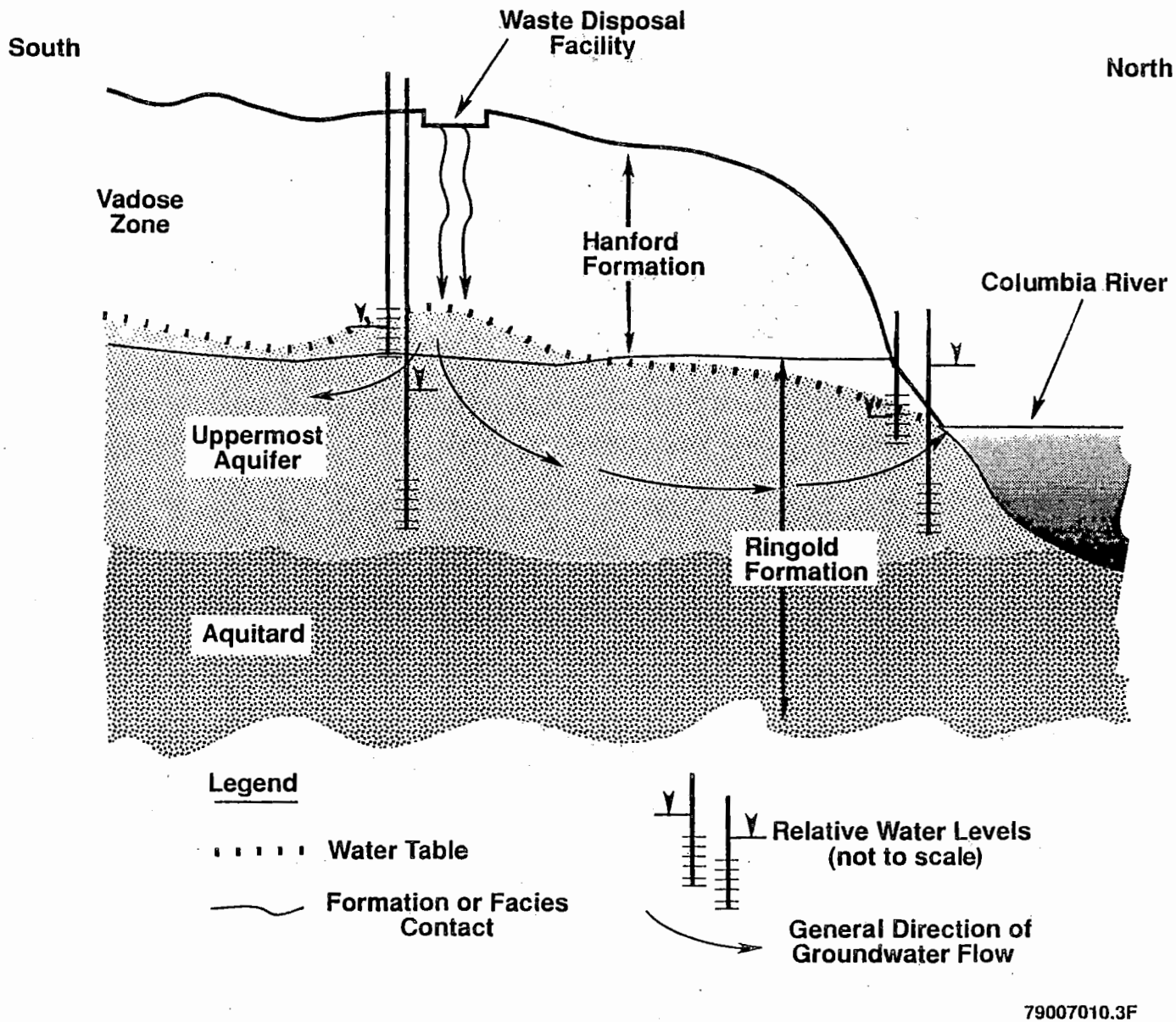


Figure 2-9. Conceptual Drawing of Ground Water Flow in the Uppermost Aquifer at the 100-N Area.

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Figure 2-10. Water Table in the 100-N Area, December 1988.

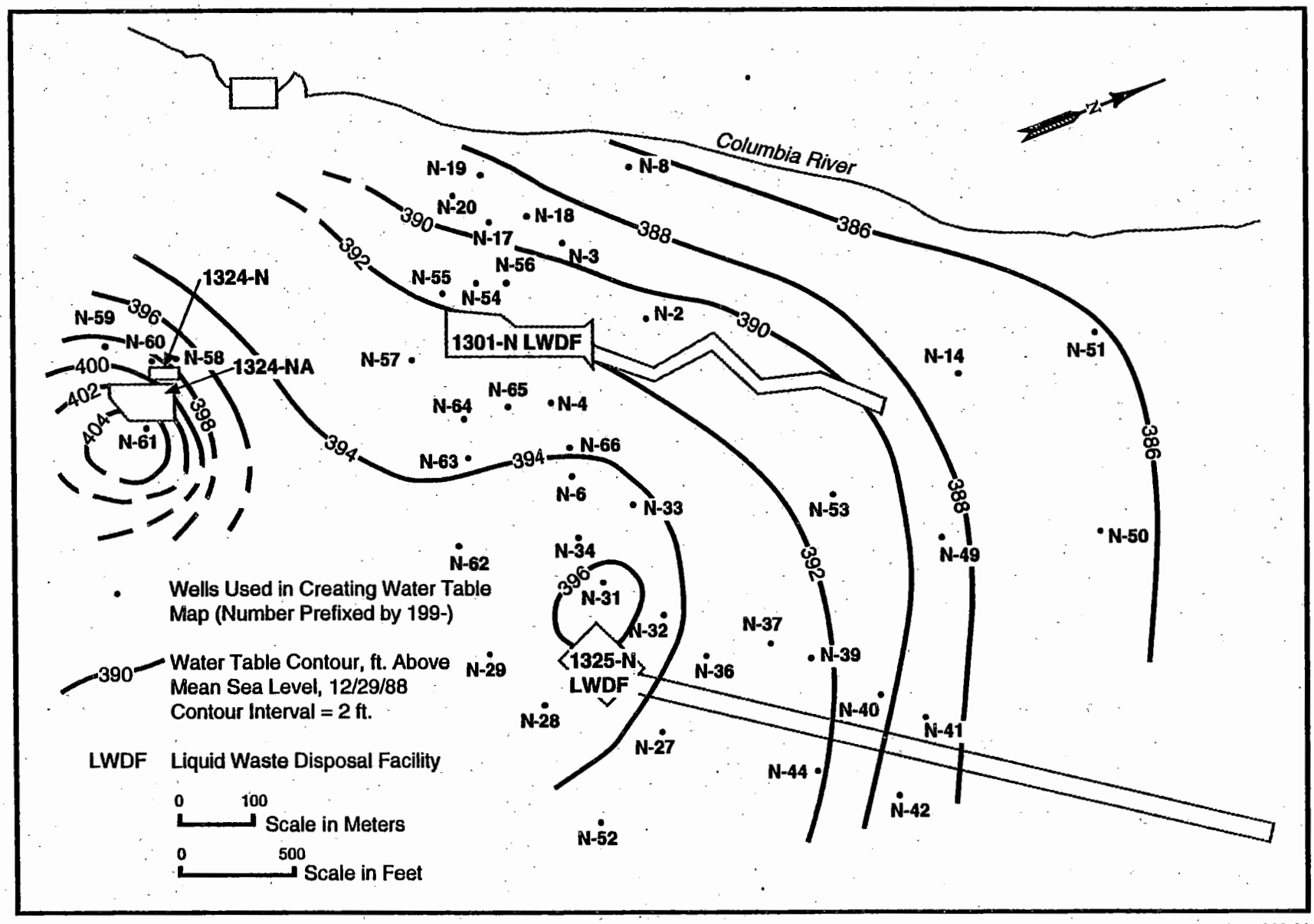

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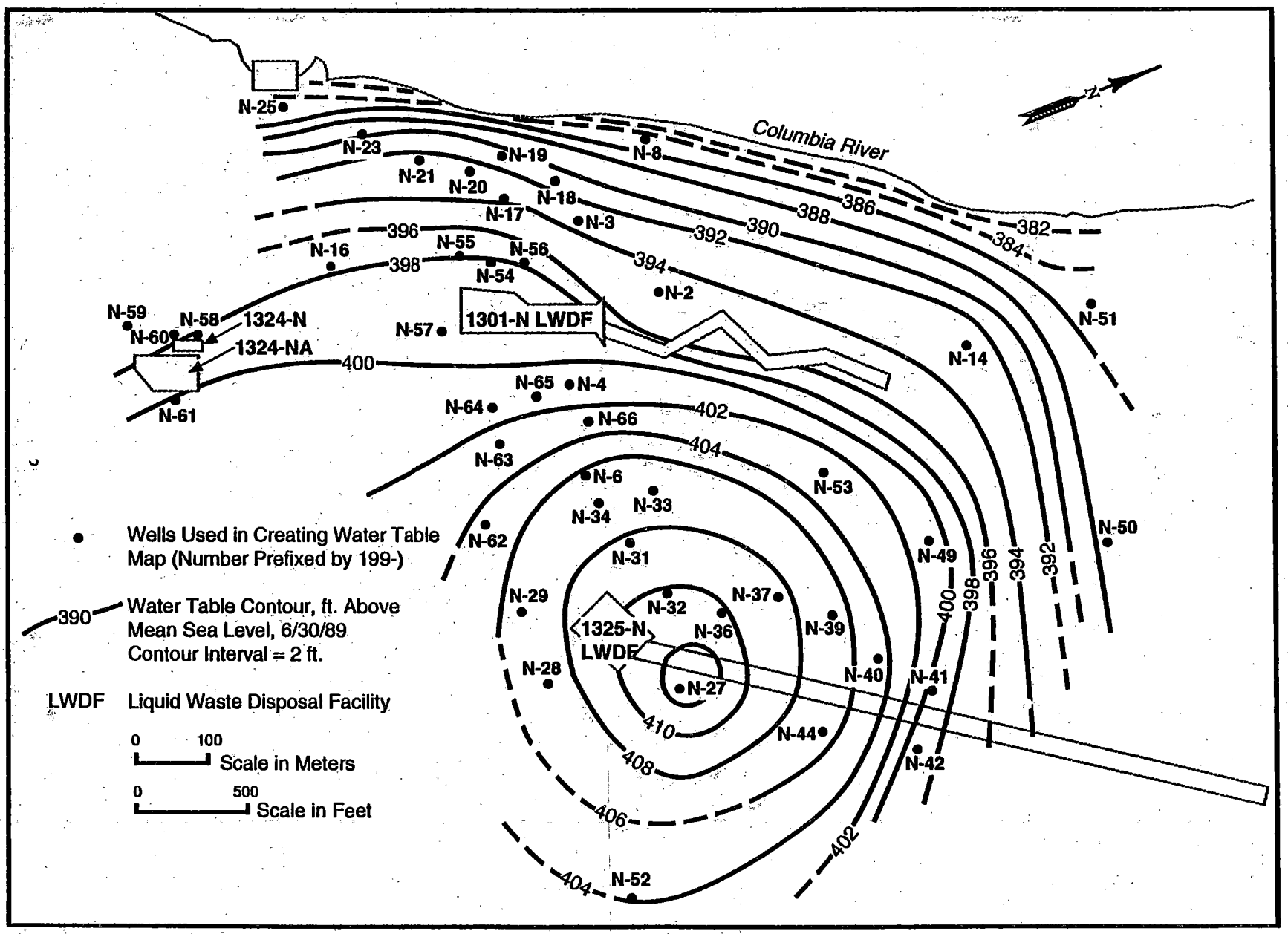
Figure 2-11. Water Table in the 100-N Area, June 1989.



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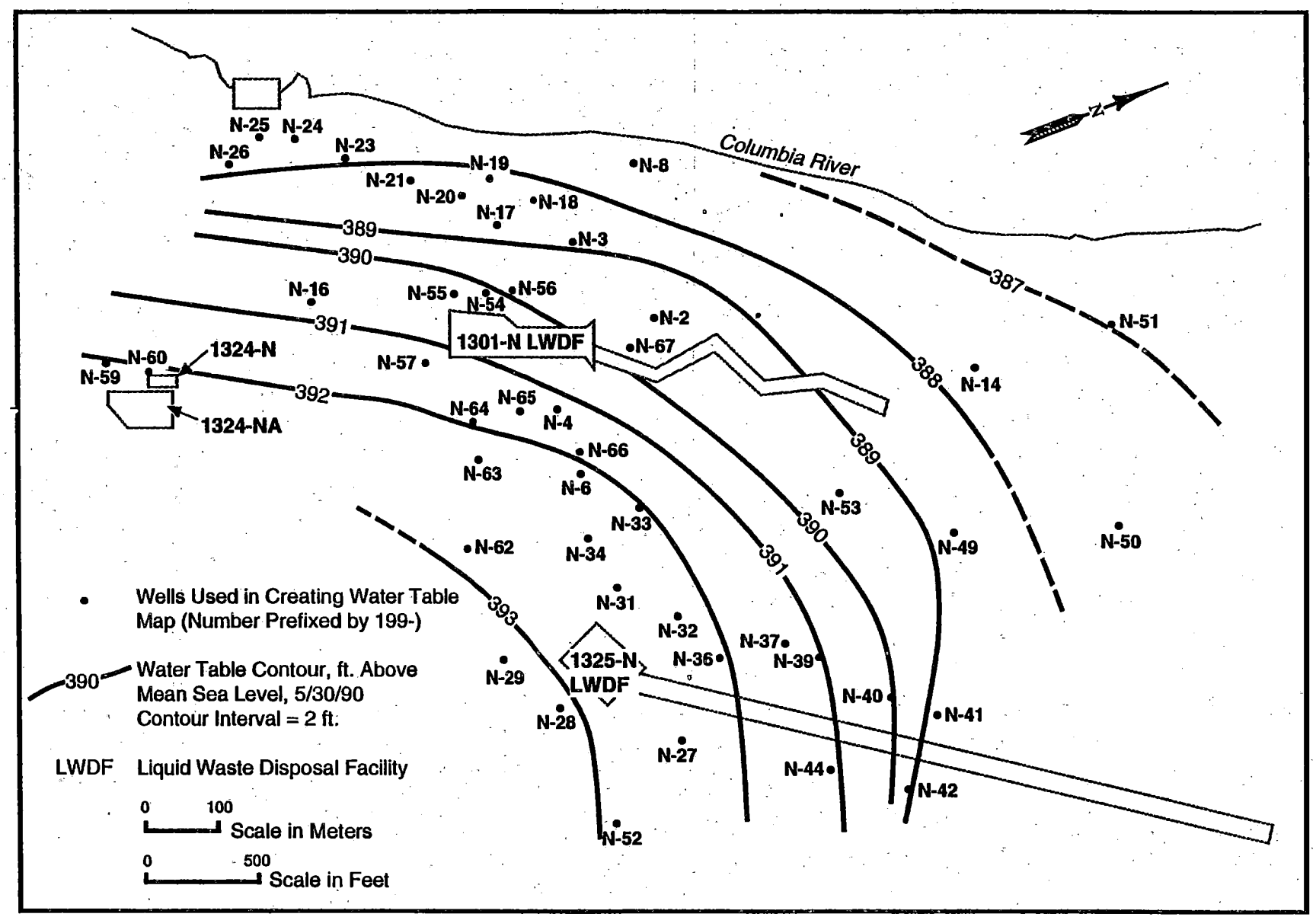

79007010.12

Figure 2-12. Water Table in the 100-N Area, May 1990.

Ground water flowed to the west beneath the 1324-NA facility during this time. Discharge to the 1325-N facility decreased again after July 1989 and the 1325-N mound began to dissipate rapidly. The water table map for May 1990, indicates that the primary flow direction beneath the 1324-NA Percolation Pond is toward the west and northwest. Ground water levels beneath the facility will decrease in the future, because no waste is being discharged there. A small amount of recharge from the backwash lake will continue.

The vertical ground water 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.

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 or semiconfined aquifers and aquitards underlies the unconfined aquifer. There are no wells completed in these units near the 100-N Area, so there are no data on hydrologic properties or water levels. 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.
- 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.

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.

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3.0 GROUND WATER 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 ground water monitoring programs for the 1301-N, 1325-N, and 1324-N/NA facilities.

3.1 OBJECTIVES

The objectives of the ground water monitoring program described in this plan are to:

- Determine background (upgradient) ground water quality for each of the 100-N Area RCRA sites.
- Determine if hazardous waste constituents that originate from any of the 100-N Area RCRA facilities are present in the ground water above background levels.

The design of the ground water 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 facilities.

3.2 APPROACH

This section presents an overview of the proposed ground water monitoring program. Details of the program are in the following sections. Ground water has been monitored for RCRA at the 1301-N, 1325-N, and 1324-N/NA facilities since December 1987. These data will be supplemented with data from installation of several additional wells.

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

Ground water 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.

Ground water 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 facilities, and their concentration and distribution aid in defining ground water flow beneath the 100-N Area. Radionuclides will be investigated under RCRA past practice operable unit studies (Tri-Party Agreement, Section 6.3).

round water levels will be measured before each sampling event. onal water-level measurements will be made in most of the 100-N Area monthly, at least until ground water levels stabilize.

1301-N Approach

efore the initiation of assessment monitoring at 1301-N (April 1989), twork consisted of seven wells. Two new wells will be installed to fill ap in the down-gradient network. The network will be sampled nually under an indicator evaluation program.

1325-N Approach

he 1325-N monitoring network originally included 12 wells. This network dified based on new data and because of changes in the ground water flow in the 100-N Area, and currently includes 10 wells. The current ient well for the 1325-N network is well 699-81-58, which is shared with 24-N/NA network. A new upgradient well will be installed to replace 99-81-58, which is an older well with a 55-ft-long perforated interval. tor parameter monitoring will continue semiannually at the site to adverse impacts of the facility on the ground water.

1324-N/NA Approach

he initial monitoring network for the 1324-N/NA facilities comprised one ient well and four downgradient wells. The upgradient well is shared he 1325-N site. A new upgradient well will be installed. Water levels ropped to the extent that three of the four existing downgradient wells y or virtually dry. Two new wells will be installed, but the dry wells ot be abandoned, in case water levels rise again. One additional down- nt well also will be installed, completed at the base of the uppermost r. The monitoring network will be sampled semiannually in an indicator tion program.

ROUND WATER MONITORING NETWORK

his section describes the aquifer that will be monitored, the existing water monitoring wells, the location and justification of the proposed onal monitoring wells, how the proposed wells will be installed, the ncy of sampling, and ground water constituents to be analyzed. ng, well construction, aquifer testing, and associated activities will ducted according to applicable Westinghouse Hanford Company procedures. ic Environmental Investigation Instructions (EII) are cited in the ing sections of this plan (WHC 1988). Additional EII may also apply.

Definition of the Uppermost Aquifer

s discussed in Section 2.3, nearly all of the uppermost aquifer beneath 0-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 ground water flow characteristics for the uppermost aquifer.

3.3.2 Existing Monitoring Network

This section describes the current monitoring networks for the 1301-N, 1325-N, and 1324-N/NA facilities.

3.3.2.1 Current Monitoring Network for 1301-N. Prior to initiation of ground water 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). All of these wells are completed at the top of the aquifer except N-69, which is completed above a clay layer that is believed to form 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.

Chemical data from four quarters of monitoring the upgradient well were analyzed statistically per 40 CFR 265.93(b) to determine background ground water quality. Data from the downgradient wells were compared to the background values of pH, total organic carbon (TOC), total organic halogen (TOX), and specific conductance. Specific conductance in well N-3 was elevated above background in December 1988. A ground water quality assessment program was initiated to determine the source of the elevated specific conductance and to assess the extent and rate of ground water contamination from the facilities (Gilmore and Jensen 1989).

Early monitoring data indicated that the elevated specific conductance may have been caused by influence of the 1324-N/NA facilities rather than the 1301-N LWDF. The 1324-N/NA facilities went into ground water quality assessment monitoring based on results of March 1989 samples. The assessment programs for the two sites were combined; 13 additional wells in the vicinity of the sites were put into use for assessment sampling, and the frequency of sampling was increased. The assessment networks are illustrated in Figure 3-1. As-built diagrams and lithologic logs are included in Appendix A.

Results of the assessment program indicated that there was no evidence that hazardous constituents from the 1301-N LWDF had entered the ground water (Hartman 1990). The assessment network for the 1301-N LWDF was pared back to a total of 15 wells and quarterly monitoring continues, pending the approval of this indicator evaluation ground water monitoring plan.

As ground water levels in the 100-N Area decline, some of the 1301-N monitoring wells may contain too little water to sample, especially during extended periods of low river stage. Well N-66 is the most likely to go dry; wells N-57 and N-67 also are relatively shallow. If any of these wells go dry, the network will be reevaluated for adequacy. It may be possible to monitor additional existing wells, or new wells may need to be installed.

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

Well number	Hanford coords.	Elev. T.O.C.	Drill date	Depth to bottom	Casing/ screen	Screened or perf'd depth	Head 5/30/90	Sampling device
N-2	W 60306 N 86577	459.83	6/64	95	cs/pc	35-95	389.27	submersible pump
N-3	W 60828 N 86365	459.45	6/64	86	cs/pc	34-86	388.85	submersible pump
N-4	W 60042 N 85921	458.73	6/64	73	cs/pc	50-60	391.13	submersible pump
N-6	W 59572 N 85925	460.97	5/65	70	cs/pc	36-65	392.94	submersible pump
N-14	W 59535 N 87834	453.15	4/69	78	cs/pc	45-78	387.49	submersible pump
N-16	W 60950 N 85208	456.70	2/81	78	cs/screen inside pc	12-78	390.46	submersible pump
N-17	W 60963 N 86098	461.20	1/81	84	cs/pc	12-83	388.75	submersible pump
N-18	W 61012 N 86226	458.50	2/81	78	cs/screen inside pc	12/78	388.08	submersible pump
N-21	W 61285 N 85823	457.00	1/81	79	cs/pc	12-78	388.67	submersible pump
N-23	W 61469 N 85586	456.30	1/81	80	cs/pc	12-78	387.88	bailer
N-24	W 61640 N 85460	432.50	1/81	55	cs/pc	12-54	387.25	bailer
N-25	W 61706 N 85351	425.80	1/81	48	cs/screen inside pc	12-47	387.37	bailer
N-26	W 61687 N 85105	455.80	1/81	79	cs/screen inside pc	12-77	387.86	bailer
N-27	W 58417 N 85915	449.08	8/83	69	cs/ss & packer	32-69	392.44	submersible pump
N-29	W 59112 N 85358	465.25	8/83	84	cs/ss & packer	47-84	393.11	submersible pump
N-31	W 59211 N 85993	462.63	9/83	81	cs/ss & packer	44-81	392.1	submersible pump
N-32	W 58893 N 86077	462.08	9/83	80	cs/ss & packer	44-80	392.41	submersible pump

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

Well number	Hanford coords.	Elev. T.O.C.	Drill date	Depth to bottom	Casing/ screen	Screened or perf'd depth	Head 5/30/90	Sampling device
N-33	W 59403 N 86148	459.87	9/83	75	cs/ss & packer	38-75	392.07	submersible pump
N-36	W 58710 N 86204	458.97	4/84	74	cs/ss & packer	54/74	391.98	submersible pump
N-39	W 58461 N 86651	454.31	4/84	78	cs/ss & packer	53-73	390.86	submersible pump
N-41	W 57989 N 86916	457.59	4/84	78	cs/ss & packer	53-73	388.36	submersible pump
N-42	W 57716 N 86724	455.14	4/84	72	cs/ss & packer	52-72	388.87	submersible pump
N-47	not surveyed	443.53	11/84	73	cs/ss & packer	53-73	Not avail-able	submersible pump
N-54	W 60678 N 85836	457.51	6/87	73	ss/ss	58-73	390.48	HydroStar pump
N-55	W 60710 N 85758	457.85	6/87	73	ss/ss	58-73	390.5	HydroStar pump
N-56	W 60637 N 86066	458.09	6/87	74	ss/ss	59-74	389.63	HydroStar pump
N-57	W 60517 N 85535	457.76	6/87	73	ss/ss	58-73	391.42	HydroStar pump
N-58	W 60939 N 84487	462.88	11/87	70	ss/ss	55-70	392.05	HydroStar pump
N-59	W 61029 N 84252	459.53	11/87	72	ss/ss	57-72	392	HydroStar pump
N-60	W 60969 N 84416	461.94	11/87	70	ss/ss	55-70	392.1	HydroStar pump
N-61	W 60708 N 84272	462.02	11/87	67	ss/ss	52-67	DRY	HydroStar pump
N-66	W 59827 N 84992	456.25	11/87	78	ss/ss	67-78	391.75	HydroStar pump
N-67	W 60248 N 86377	458.46	3/88	76	ss/ss	60-76	389.16	HydroStar pump
N-69	W 60282 N 86397	458.84	6/88	100	ss/ss	90-100	389.02	HydroStar pump

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

Well number	Hanford coords.	Elev. T.O.C.	Drill date	Depth to bottom	Casing/ screen	Screened or perf'd depth	Head 5/30/90	Sampling device
N-70	W 85360 N 86600	454.21	6/88	99	ss/ss	89-99	390.97	HydroStar pump
6-81-58	W 57993 N 81004	439.55	10/62	90	cs/pc	35-90	396.37	submersible pump

All depths in feet below land surface; elevations in feet above mean sea level. Depths are rounded to the nearest foot.

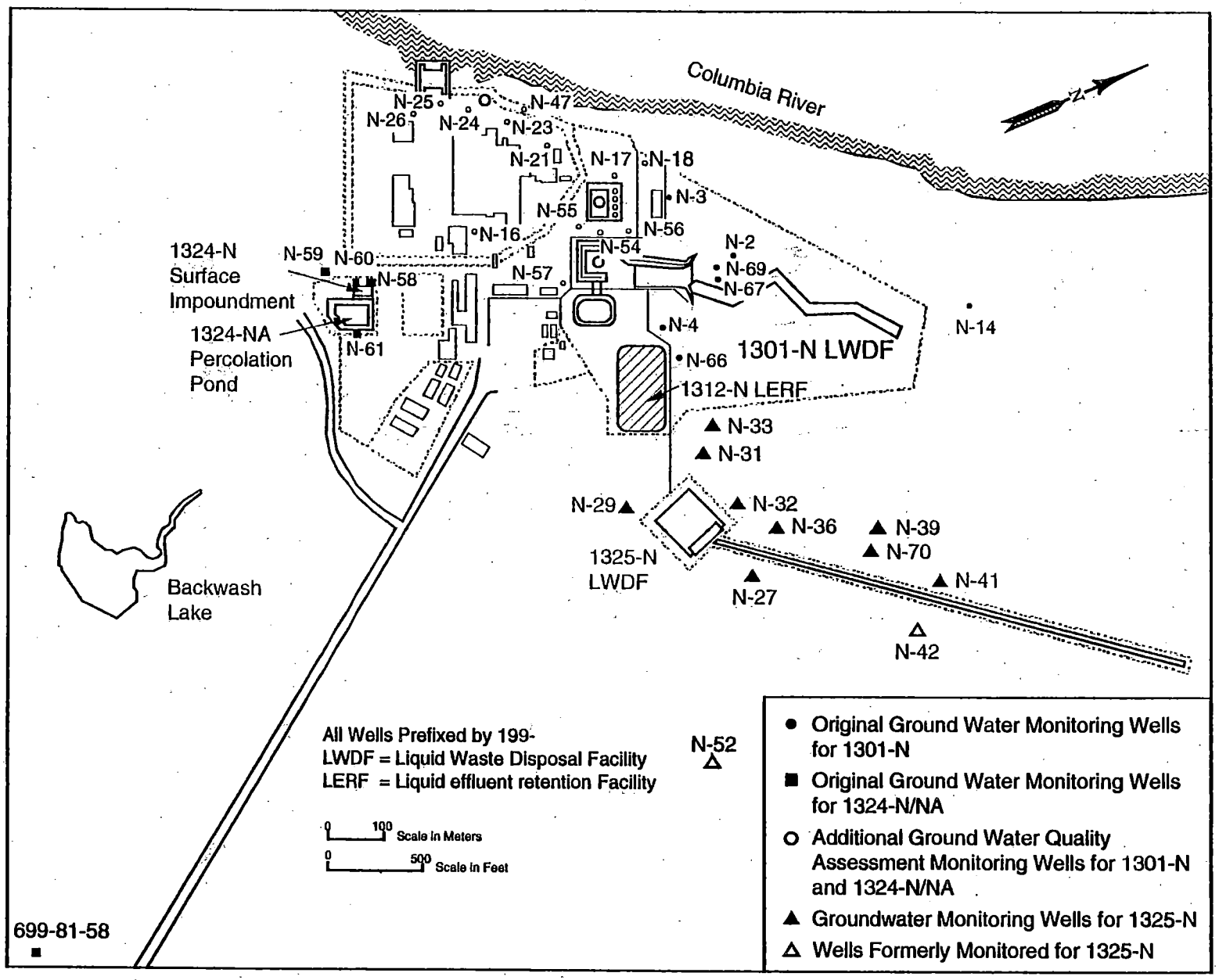
For wells with sand or cement plugs, the plugged depth and elevation are given.

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), driller's logs, and geologist's logs.

Figure 3-1. Ground Water Monitoring Networks for 1301-N, 1324-N/NA, and 1325-N Facilities.



79007010.13

3.3.2.2 Current Monitoring Network for 1325-N. The original ground water 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 indicated 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. Construction details for the wells are summarized in Table 3-1. As-built diagrams and lithologic logs are presented in Appendix A.

Chemical data from four quarters of monitoring the upgradient well were analyzed statistically per 40 CFR 265.93(b). After the first year, data from the downgradient wells were compared to the background values of pH, TOC, TOX, and specific conductance. None of the downgradient wells has shown significantly elevated values for the indicator parameters, so the 1325-N site is monitored as an indicator evaluation program.

Declining ground water levels may cause wells N-36, N-39, and N-41 to go dry. These wells are not critical to the monitoring network, and probably will not need to be replaced (see Section 3.3.4.2).

3.3.2.3 Current Monitoring Network for 1324-N/NA. The original RCRA ground water monitoring network for the 1324-N/NA facilities included four wells installed at locations based on presumed ground water flow directions. After installation of these wells in 1987, it was discovered that all four wells were located downgradient of the facilities because of the ground water mound associated with the 1324-NA Percolation Pond. An older well, located approximately one mile southeast of the site, was added to the network to monitor background ground water quality (see Figure 3-1). All of the wells are completed at the top of the unconfined aquifer. As-built diagrams for the wells are included in Appendix A. Table 3-1 is a summary of construction details.

Chemical data from four quarters of monitoring the upgradient well were analyzed statistically per 40 CFR 265.92. After the first year, data from the other four wells were compared to the background values of pH, TOC, TOX, and specific conductance. All four wells were significantly above background specific conductance. This trend had been observed throughout the first year of monitoring. A ground water quality assessment program was initiated to determine the source of the elevated specific conductance and to assess the extent and rate of ground water contamination from the facilities (Gilmore 1989). The assessment program was conducted in conjunction with 1301-N, as discussed above.

Results of the ground water quality assessment program indicated that sulfate was the primary ion responsible for the elevated specific conductance (Hartman 1990). No hazardous wastes or hazardous waste constituents were present in the ground water. The assessment network for the 1324-N/NA facilities was pared back to a total of 12 wells and quarterly monitoring continues, pending the approval of this indicator evaluation ground water monitoring plan.

Two of the original downgradient wells for the 1324-N/NA facilities went dry during 1990, and another is expected to have too little water to sample. These wells will be replaced (see Section 3.3.3.3).

3.3.3 Proposed Additional Monitoring Wells

This section describes the wells proposed to be added to the monitoring networks for the 100-N RCRA sites. A total of seven new wells will be installed for the 100-N RCRA sites. Their locations are shown in Figure 3-2 and the approximate Hanford coordinates are listed in Table 3-2. The final well locations will depend on field conditions and will be determined by the project scientist.

3.3.3.1 Additional Wells for the 1301-N LWDF. Three wells will be added to the monitoring network for the 1301-N LWDF. One existing well, N-57, will be monitored as an upgradient well instead of N-4. Well N-57 has been used in the assessment program for 1301-N and 1324-N/NA. It is completed at the top of the uppermost aquifer. Construction details are summarized in Table 3-1. An as-built diagram is included in Appendix A.

Two new wells (NR-5 and NR-6) will be installed downgradient of the 1301-N LWDF to fill in a gap in the network. These wells will be completed at the top of the uppermost aquifer.

3.3.3.2 Additional Wells for the 1325-N LWDF. The current upgradient well for the 1325-N LWDF (699-81-58) was drilled in 1962 and is constructed of carbon steel casing with 55 ft of perforations. The construction of this well may not be suitable for RCRA monitoring. A new upgradient well (NR-4) will be installed. The well will be completed at the top of the uppermost aquifer.

3.3.3.3 Additional Wells for the 1324-N/NA Facilities. The four downgradient wells in the 1324-N/NA network were installed when there was a large ground water mound beneath the facility. Since waste discharges nearly ceased in early 1990, the mound has been declining. Wells N-58 and N-61 went dry in 1990; well N-60 was also nearly dry as of December 1990. Two new wells (NR-2, NR-3) will be installed to monitor the top of the aquifer. The wells will be completed at a depth of approximately 80 ft to intercept the lower water table. Another new well (NR-7), completed at the base of the uppermost aquifer, will be installed next to one of the shallow downgradient wells. The current upgradient well for the 1324-N/NA facilities (699-81-58) will be replaced with a new well (NR-1).

3.3.4 Justification for Locations of New Wells

The objective of ground water monitoring is to detect adverse impacts to ground water quality caused by the facilities. This involves monitoring background ground water quality in upgradient wells and downgradient water quality to detect potential impacts. Upgradient wells should be located out of the influence of the facility but in the path of ground water flow beneath the facility. Downgradient wells should be placed close enough to the facility and to each other to monitor the aquifer adequately.

Figure 3-2. Proposed Revised Monitoring Networks for the 1301-N, 1324-N/NA, and 1325-N Facilities.

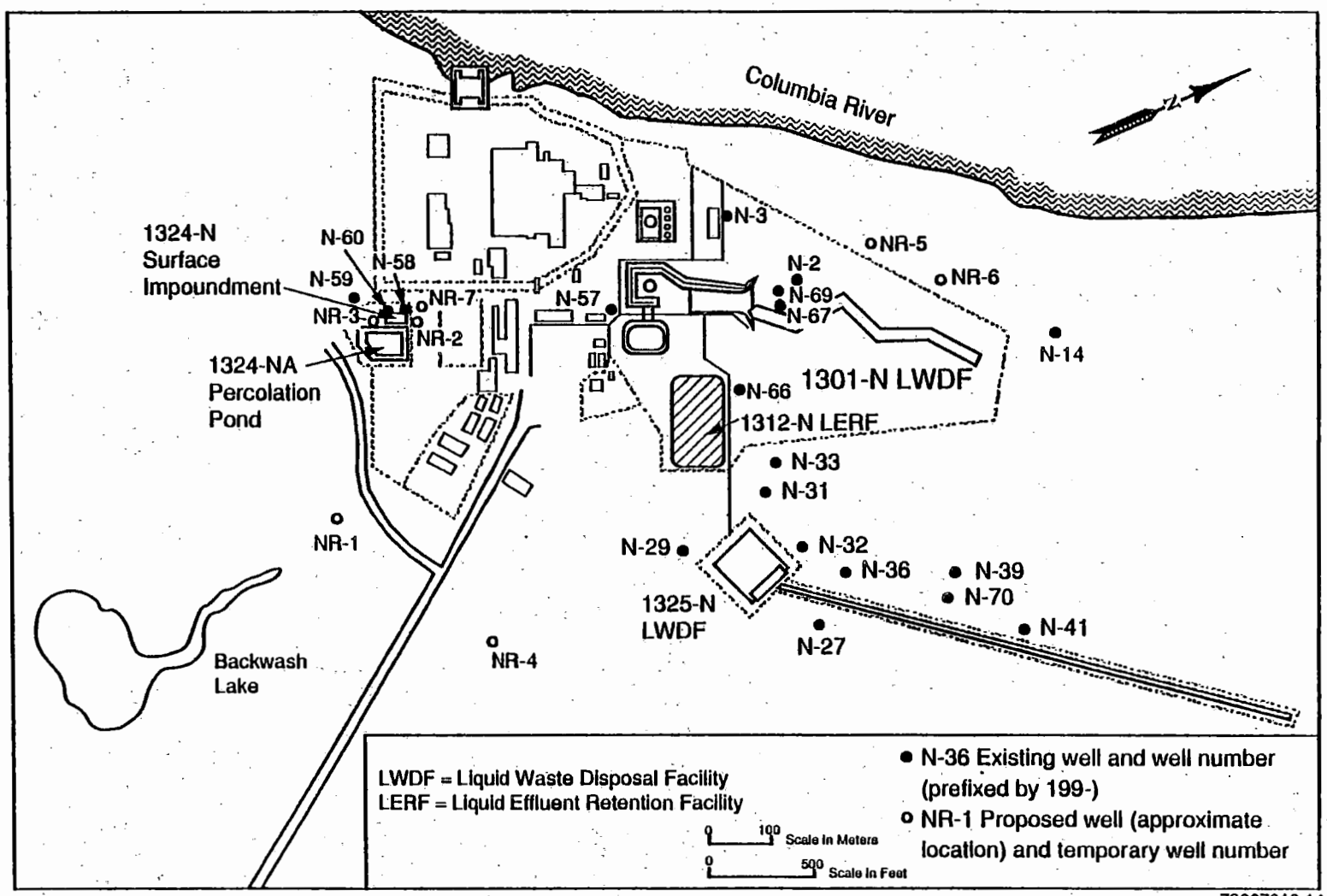


Table 3-2. Proposed RCRA Wells in the 100-N Area.

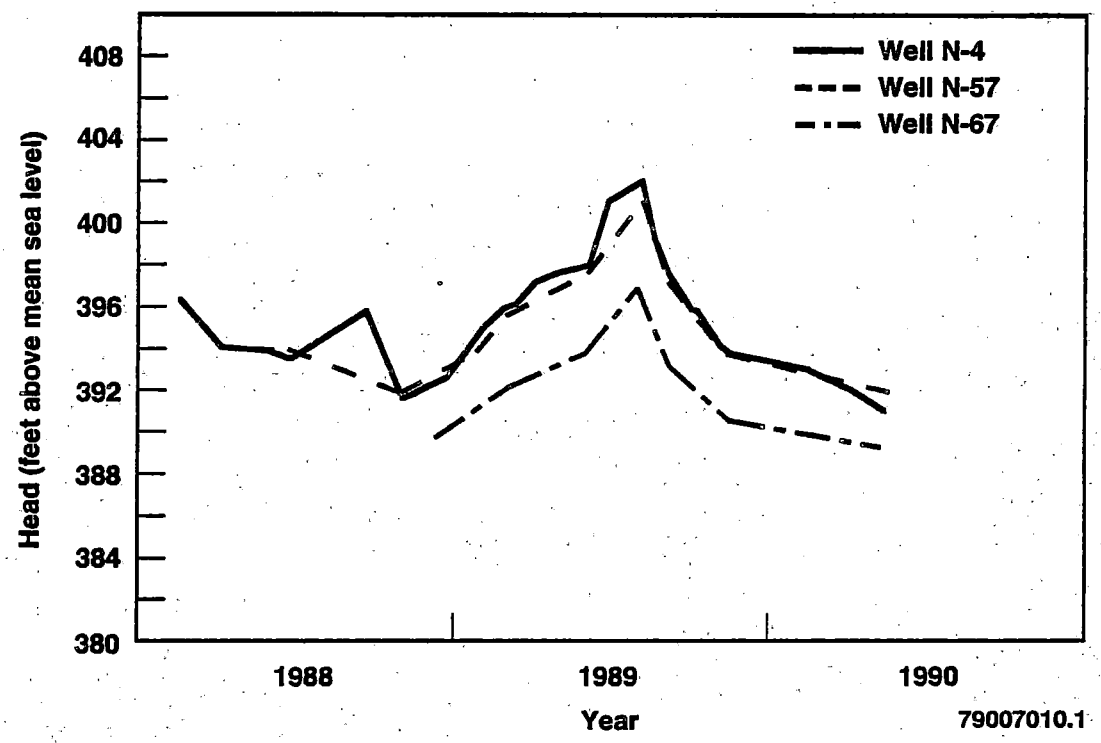
Well	Year	Facility	Approximate Hanford coordinates		Screened interval[a]
NR-1[b]	1991	1324-N/NA	60,300 W;	83,500 N	top 10-20 ft of aquifer
NR-2	1991	1324-N/NA	59,800 W;	87,200 N	top 10-20 ft of aquifer
NR-3	1991	1324-N/NA	60,900 W;	84,400 N	top 10-20 ft of aquifer
NR-4[b]	1991	1325-N	59,100 W;	84,300 N	top 10-20 ft of aquifer
NR-5	1992	1301-N	60,200 W;	87,000 N	top 10-20 ft of aquifer
NR-6	1992	1301-N	59,800 W;	87,200 N	top 10-20 ft of aquifer
NR-7	1992	1324-N/NA	59,800 W;	87,200 N	bottom 10 ft of aquifer

[a]Screened interval will chosen by the project scientist and well site geologist.
[b]Upgradient well.

Due to changes in waste disposal in the 100-N Area, ground water flow directions have changed since monitoring began in December 1987. The original ground water monitoring networks have been modified in response to those changes. Some additional wells are needed to correct deficiencies in the current networks. This section presents justification for the location of the new wells and, in some cases, for removing old wells from the network.

3.3.4.1 Justification for 1301-N Well Locations. The current monitoring network for the 1301-N network does not adequately monitor upgradient water quality. Ground water has flowed in various directions through time, depending on the relative sizes of ground water mounds beneath the 1325-N and 1324-N/NA facilities. The two wells currently used as upgradient wells (N-4 and N-66) do not reflect the influence of the 1324-N/NA facilities on ground water quality. This resulted in a false indication that the 1301-N LWDF was affecting ground water quality. Well N-57 may be a suitable substitute for well N-4. It is located upgradient of the facility as interpreted from recent water table maps and hydrographs (Figure 3-3). It is possible that well N-57 is located too close to the facility to provide representative background data. When the 1301-N LWDF was in operation, well N-57 was most likely downgradient because of a ground water mound at the site. Data from this well will be examined to see if it appears to be affected by the 1301-N LWDF. If not, indicator parameter data from N-57 and N-66 will be used to determine background ground water quality. If N-57 is influenced by the 1301-N LWDF, a new up-gradient well will be installed. A change to this ground water monitoring plan would then be issued.

Figure 3-3. Water Levels in Wells N-4, N-57, and N-67, January 1988 to April 1990.



Two new wells will be installed to monitor the 1301-N trench (NR-5 and NR-6; see Figure 3-2). Several alternatives were considered for the locations of wells NR-5 and NR-6:

1. Adjacent to the trench
2. Just inside the fence surrounding the 1301-N LWDF
3. Outside the 1301-N fence.

The first alternative is precluded by the presence of a large mound of gravel and earth, which would not allow drill rig access. The difference in distance between alternatives 2 and 3 is 100 to 200 ft. The 1301-N LWDF has not been used since 1985. If dangerous waste constituents from the facility entered the ground water, it is likely that they have migrated beyond the immediate vicinity of the trench, and could be detected by the wells outside the fence. Drilling in this location has the added advantage of being outside a radiation zone, thus limiting the exposure of the drilling and sampling crews to radioactive contamination.

3.3.4.2 Justification for 1325-N Well Locations. The direction of ground water flow in the 100 N Area has varied with waste disposal practices. Ground water mounds have existed beneath the 1324-N/NA and 1325-N facilities at times, causing water to flow radially outward from the mounds. At times the height of these mounds have been greater than the water level in the "upgradient" well [699-81-58 (Figure 3-4)]. However, a water table map of the larger area suggests that well 699-81-58 is outside the area of influence of 1324-N/NA and 1325-N (see Figure 2-4). This conclusion is backed up by the chemical data from well 699-81-58. The constituents associated with 1324-N/NA (primarily sulfate) or 1325-N (primarily strontium-90) are not elevated in well 699-81-58.

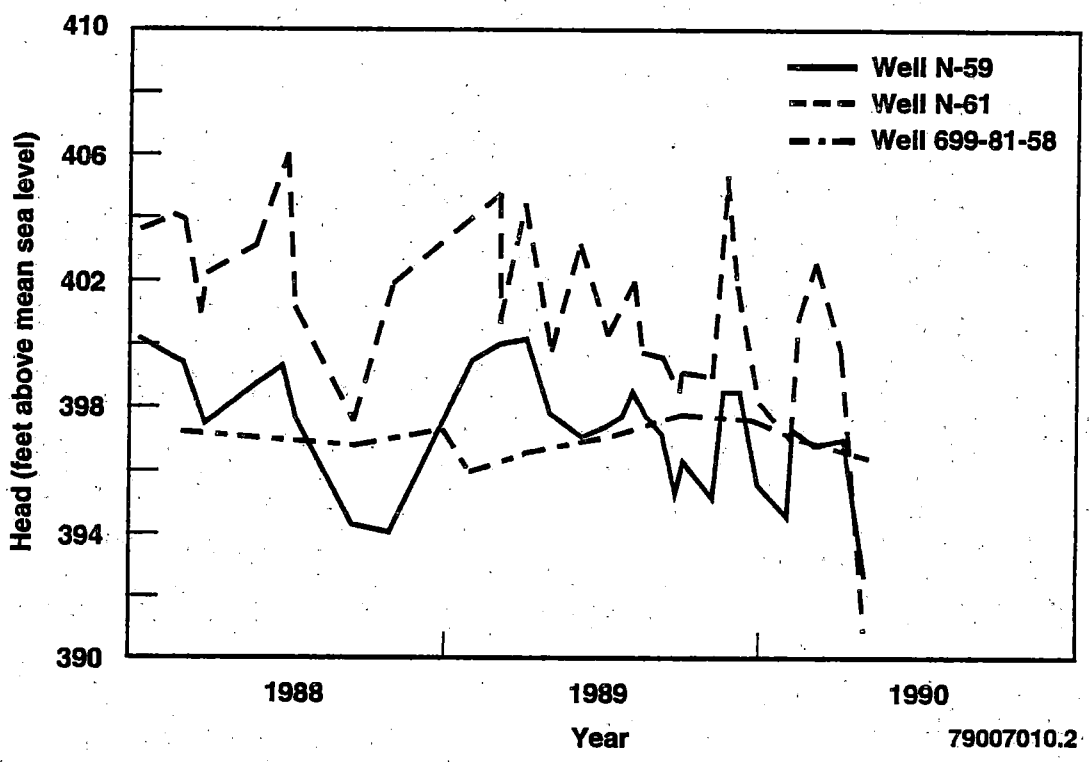
The 100-N ground water mounds have largely dissipated, so a new upgradient well (NR-4) will be installed closer to the 1325-N facility. This location is believed to be directly upgradient of the facility under current and expected ground water flow conditions. Well NR-4 is at the same location as a monitoring well proposed in DOE-RL (1990). Well construction and sampling will be coordinated between the two programs.

Ground water in the vicinity of proposed well NR-4 may have been affected by effluent disposal to the 1325-N LWDF in the past, and there is some risk that the aquifer or vadose zone still contains contaminants. If sampling of well NR-4 indicates contamination from the 1325-N LWDF, a new upgradient well will be installed further from the facility.

Several wells monitored in the original, downgradient monitoring network for the 1325-N LWDF are no longer useful in monitoring the site. Wells N-42 and N-52 are not downgradient of the facility under current or expected water table conditions, and were removed from the network in 1990.

Wells N-36, N-39, and N-41 may go dry, due to the declining water table in the 100-N Area. No new wells are proposed to replace these wells, for the following reasons: wells N-39 and N-41 are located at the middle or far end of the 1325-N trench, where no effluent was discharged; none of these wells has shown trends in chemical data different from the other downgradient wells;

Figure 3-4. Water Levels in Wells N-59, N-61, and 699-81-58, January 1988 to April 1990.



hazardous constituents are not evident in any of the downgradient wells for the 1325-N LWDF; the LWDF currently does not receive any hazardous effluent, and even the discharge of non-hazardous, low-level radioactive effluent has virtually ceased. It is unlikely that new chemical contamination will be observed.

3.3.4.3 Justification for 1324-N/NA Well Locations. Because the mounds beneath the 1324-N/NA and 1325-N facilities are dissipating, a new upgradient well (NR-1) will be installed. The proposed location is believed to be directly upgradient of the 1324-N/NA facilities, and is closer to the facilities than is the existing upgradient well. The proposed location is also better than the existing well because it will monitor impacts of the backwash lake. Ground water in the vicinity of proposed well NR-1 may have been affected by effluent disposal to the 1324-N/NA facilities in the past, and there is some risk that the ground water or sediments still contains contaminants. If sampling of well NR-1 shows contamination from the 1324-N/NA facilities, a new upgradient well will be installed.

As discussed above, three of the four current downgradient wells for the 1324-N/NA facilities are dry or virtually dry and will not consistently provide ground water samples or water levels measurements, assuming the water table does not rise significantly. Two new wells will be installed (NR-2 and NR-3) so there will be at least three downgradient wells monitoring the facility.

A new well will be installed adjacent to one of the shallow downgradient wells. This new well (NR-7) will be completed at the bottom of the unconfined unit, just above the clay-rich layer that is believed to act as the base of the aquifer. This deeper well is designed to detect any contaminants that are heavier than water (not anticipated at the 1324-N/NA site). It will also provide geologic and hydrologic data on the base of the aquifer beneath the 1324-N/NA site. Finally, the shallow/deep well pair will provide information on the vertical ground water gradient in the vicinity of 1324-N/NA.

3.3.5 Drilling and Well Installation

Four wells will be installed in 1991, and three in 1992. The first wells to be installed will be the shallow, downgradient wells for the 1324-N/NA facilities and the new upgradient wells. The downgradient wells for the 1301-N LWDF and the deep well for the 1324-N/NA facilities will be installed during 1992. Generic specifications for drilling, installation, and related activities are described in WHC (1990c). Details will be specified on data sheets (Figure 3-5).

The new wells 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: (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) ground water quality is not affected by drilling fluids other than water or air.

Figure 3-5. Example Ground Water Monitoring Well Data Sheet.

DATA SHEET FOR GROUND WATER MONITORING WELLS
AT THE (FACILITY)
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 that wells are to be drilled, 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 ground water 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

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, the Washington State Department of Ecology will be notified by Westinghouse Hanford Company prior to making the changes.

Drill rigs and peripheral equipment (such as drill tools, cables, and temporary casing) will be steam cleaned before arriving on site, moving to a new site, and beginning construction of the next well. During drilling in the zone to be sampled, the addition of water to the borehole will be kept to a minimum or avoided. This will minimize well development pumping after wells are completed and minimize the chances of driving any vadose zone contaminants into the ground water.

Temporary carbon steel casing with a minimum diameter of 8 in. will be driven to total depth as each borehole is advanced. A temporary, 8-in.-diameter telescoping screen may be installed for aquifer testing, if necessary. 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. If a temporary screen is used, it will be left in place.

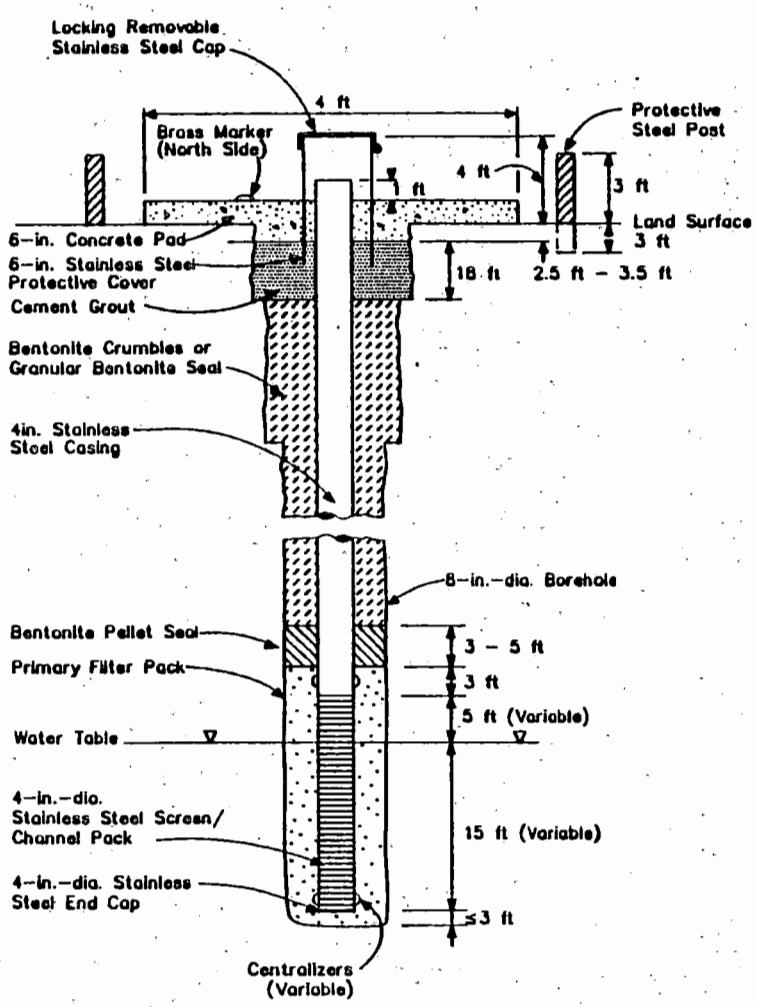
The shallow wells will be drilled 10 to 20 ft into the saturated sediments. The deep well will be drilled 10 ft into the fine-grained unit that forms the base of the aquifer (expected depth is approximately 100 ft). Laboratory and aquifer testing of the fine-grained unit will be conducted if possible.

3.3.6 Well Construction

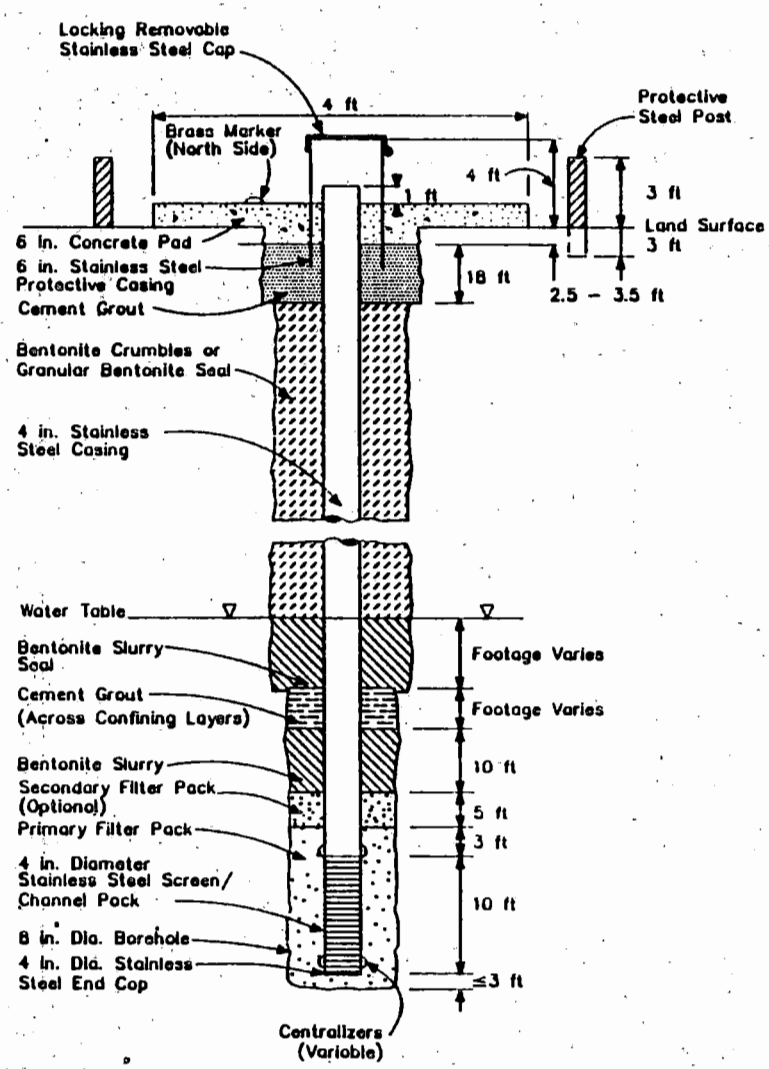
This ground water monitoring plan proposes seven new wells: six completed at the water table and one completed at the base of the aquifer. Figure 3-6 shows schematic diagrams of the shallow and deep wells. Well drilling will be governed by EII 6.7. Guidance concerning geologic sampling and inspection 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 (QAPP) WHC (1990d) also apply.

Declining ground water levels and river stage fluctuations are two variables to be considered in picking screened intervals. The water table in the 100-N Area is expected to stabilize at no less than 385 ft msl. Water levels in some of the wells near the river may occasionally be lower than 385 ft during times of low river stage. Screened intervals will be chosen to span the expected high and low water table conditions; screen lengths may range from 10 to 20 ft beneath the water table. Screened intervals will be chosen by the site geologist and project manager at the time of construction.

Figure 3-6. Schematic Diagram of Deep and Shallow Monitoring Well Construction (WHC 1990) (WHC-S-014 rev. 5).



Schematic Diagram of a Typical Shallow Groundwater Monitoring Well Completion



Schematic Diagram of a Typical Deep Groundwater Monitoring Well Completion

*Not to Scale
GEOSCI\022291-A

The top of the screens in the new shallow wells at the 1324-N/NA site will be placed at elevations that are above the bottom of the screens of the existing wells. This will allow monitoring the top of the aquifer under a variety of water levels. For example, the bottom of well N-61 is at 395 ft msl. A nearby new well will be screened from 10 to 20 ft below the water table up to 400 ft msl.

For the deep well, the borehole will be plugged to within 3 ft of the top of the fine-grained unit. The well screen will be 10 ft in length, placed at the base of the aquifer.

The new wells will be constructed of stainless steel, fiberglass, or other inert material. Channel-pack screens 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. If a sand filter pack is used, it will be placed in the annulus between the 8-in. telescoping screen (if used) or the temporary 8-in.-diameter casing and the permanent 4-in.-diameter casing and screen as the temporary casing is withdrawn. If a telescoping screen is used during tests, it will be left in the hole. 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 20 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 4-ft by 4-ft by 6-in. concrete pad. 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, wells will be developed using the procedures described in EII 10.4. If the water cannot be developed to a turbidity of less than 5 NTU, an explanation will be provided and documented by the site hydrogeologist.

All ground water discharged from the wells during development will be disposed in accordance with Westinghouse Hanford Company guidelines and procedures. If it is necessary, a ground water 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 each well in accordance with EII 6.8. Hydrostar pumps will be used.

3.3.9 Surveying

After monitoring well installation is completed, all wells in the 100-N networks will be surveyed for location and elevation by qualified surveyors. The elevation of the top of the casing and a brass marker in the concrete pad will be determined within 0.04 ft. A mark will be placed on the casing to indicate the location that was surveyed. The areal location will be determined to the nearest 0.5 ft. All measurements will be referenced to a common datum.

3.3.10 Monitoring Parameters

Constituents and sampling frequencies required by 40 CFR 265.93 are listed in Table 3-3. A site-specific constituent list and sampling frequencies are shown in Table 3-4. Ground water samples were collected from the existing wells in the monitoring network at least quarterly for the constituents listed in Table 3-4 and additional constituents (see Gilmore 1989 and Smith et al. 1990). These wells will now be sampled semiannually, as indicated in the table. The new wells will be sampled quarterly for the first year, and semiannually thereafter. Analytical methods are listed in the *Sampling and Analysis Plan* (Appendix C).

3.4 HYDROGEOLOGIC CHARACTERIZATION

Hydrogeologic characterization of the 100-N Area has been conducted as part of the existing RCRA monitoring program as well as for numerous environmental and engineering studies through the past 30 yr. These data will be supplemented with data gathered in drilling of the new wells. Work performed will follow approved procedures, in accordance with WHC (1990d) (i.e., the QAPP).

Data collection and interpretation will focus on geology, geochemistry, hydrogeology, hydrochemistry, and ground water monitoring. The characterization will be performed during and after construction of the planned wells. 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

The activities that will be conducted in support of geologic characterization are described in the following section.

As the new wells are 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 in order to obtain a continuous lithologic record. Samples will be archived for

Table 3-3. Ground Water Sampling Parameters and Frequency of Analysis Required by 40 CFR 265.

Interim Primary Drinking Water Standards	Maximum Level[b]
(40 CFR 265, Appendix III) Sampled quarterly for first year:	
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
<u>Ground-water Quality Parameters</u>	
[40 CFR 265.93(b)(2)] Sampled quarterly for first year; annually thereafter:	
Chloride	
Iron	
Manganese	
Phenols	
Sodium	
Sulfate	
<u>Ground-water Contamination Indicator Parameters</u>	
[40 CFR 265.93(b)(3)] Sampled quarterly for first year; semi-annually thereafter:	
pH	
Specific conductance	
Total organic carbon	
Total organic halogen	

[a]Regulatory requirements for sampling parameters are subject to change because of federal regulations.
[b]Unless otherwise noted, levels are in mg/L.

Table 3-4. Ground Water Analyses and Frequency of Analysis for 1301-N, 1324-N, and 1325-N RCRA Projects (sheet 1 of 2).

Analysis	Frequency[a]	
	New wells first year	Older wells and new wells after first year
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	SA
turbidity	Q	SA
temperature (field)	Q	SA
Metals by the inductively coupled plasma method (filtered, unfiltered)	Q	SA
aluminum		
antimony		
barium		
beryllium		
boron		
cadmium		
calcium		
chromium		
cobalt		
copper		
iron		
lithium		
magnesium		
manganese		
molybdenum		
nickel		
potassium		
silicon		
silver		
sodium		
strontium		
tin		
titanium		
vanadium		
zinc		
zirconium		
Other metals (filtered, unfiltered)	Q	SA
arsenic		
lead		
mercury		
selenium		

Table 3-4. Ground Water Analyses and Frequency of Analysis for 1301-N, 1324-N, and 1325-N RCRA Projects (sheet 2 of 2).

Analysis	Frequency[a]	
	New wells first year	Older wells and new wells after first year
Anions by ion chromatography bromide chloride fluoride nitrate nitrite phosphate sulfate	Q	SA
Pesticides endrin methoxychlor toxaphene lindane (four isomers)	Q	--
Herbicides 2,4-D 2,4,5-TP silvex 2,4,5-T	Q	--
Coliform bacteria	Q	SA
Radiological radium gross alpha gross beta strontium-90 tritium gamma scan	Q	SA[b]
Hydrazine	Q	SA[b]

[a]Q = quarterly; A = annual; SA = semi-annual; -- = not analyzed.
[b]These constituents will be analyzed for 1301-N and 1325-N wells only.

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 ground water 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, per EII 9.1. Every sample will be recorded on borehole logs as they are 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, plus the depths where various samples were collected, will be documented on the borehole logs.

The site geologist will select geologic samples to be analyzed in the laboratory, guided by the criteria listed in Table 3-5.

Table 3-5. 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 for some or all of the constituents list in Table 3-6.

3.4.3 Borehole Geophysical Logging

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

Table 3-6. Method and Constituent List for Soil Sample Analysis.

Constituent	Method
Uranium	EPA 908.0
Chromium	SW-846 6010
Lead	SW-846 7421
Selenium	SW-846 7740
Major elements	SW-846 6010
Total organic carbon	SW-846 9060
Volatile organic constituents	SW-846 8240
Cation exchange	SW-846 9080 or 9081
Anions	EPA 300.0
Gross alpha	SW-846 9310
Gross beta	SW-846 9310
Gamma scan	EPA 901.1

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

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 ground water chemistry, so the wells are not designed for aquifer testing. Results of aquifer tests may be influenced by well design and should be considered in this perspective.

Aquifer testing that involves pumping ground water 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 Hanford 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 before completion to obtain estimates of transmissivity of various units. The drive casing will be pulled back a few feet to expose the formation to the open hole. If heaving or caving formations are expected, a section of telescoping screen will be set in the well before testing. The borehole will be bailed to remove drilling fluids and debris before conducting the test. During the slug test, 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.

Constant-discharge tests could be conducted for up to 24 h in those cases where at least one observation well is available and drawdown is large enough (greater than 0.2 ft) to allow a quantitative analysis of the data. When available, data from the observation wells can be analyzed to yield estimates of transmissivity, storativity, and sometimes, hydraulic conductivity anisotropy. Single well constant-discharge tests can normally be conducted for up to 8 h, and can be used to estimate transmissivity.

Multiple-well constant discharge tests will be attempted in one of the 1324-N/NA wells where other monitoring wells are located near enough to be used as observation wells. Constant-discharge tests will also be attempted in the new 1301-N wells.

A temporary screen will be installed in the pumping well prior to well completion. The well will be pumped prior to the test to develop the formation and to determine the best pumping rate for the test. After water levels have recovered to static, the well will be pumped at a constant rate and water levels monitored. The duration and design of the tests will be described in an aquifer test plan.

3.4.5 Determination of Ground Water 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 ground water flow paths. Measurements will also be made over time to evaluate temporal changes in flow paths and dynamics of the aquifer system. Ground water levels are measured each time a well is sampled. Currently, ground water levels are also measured in most of the wells in the 100-N Area monthly, usually all in a single day, because water levels in the 100-N Area change considerably with time, due to waste discharges. 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 ground water also will be used to determine flow paths.

3.4.6 Data Interpretation and Presentation

A data package will be prepared after the wells are 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., ground water 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 ground water 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 ground water monitoring system is appropriately designed. Recommendations will be provided for additional characterization activities or construction of additional ground water monitoring wells, if necessary.

3.5 SAMPLING AND ANALYSIS

The new wells will be sampled quarterly for 1 yr and semiannually thereafter. 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 Appendix C. The quality assurance/control protocol is also given in Appendix C. 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 to see that corrective actions will be taken as necessary.

Under the indicator-evaluation monitoring program, ground water 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 ground water monitoring system will be modified to bring it into compliance with 40 CFR 265.91(a).

3.6 STATISTICAL ANALYSIS OF GROUND WATER MONITORING DATA

The methods for establishing background values of water quality and evaluating water-chemistry data, and the reporting requirements, are discussed below.

3.6.1 Establishing Background Ground Water Quality

Quarterly samples were collected for 1 yr from the ground water monitoring wells in compliance with 40 CFR 265.92. The samples were analyzed for the constituents listed in Table 3-4 and additional constituents (see quarterly reports). Data from the first year of quarterly monitoring of the upgradient wells were analyzed to determine background values for indicator parameters, using methods described in the following section. Indicator parameters for downgradient and upgradient wells are compared to background values each time these wells are sampled.

This plan proposes changes in the upgradient wells for the 1301-N, 1324-N/NA, and 1325-N sites, so background values will again be recalculated after four quarters of data are available from the new upgradient wells.

3.6.2 Evaluation of Data

Plots of the indicator parameters will be maintained for each well to look for trends in the data. Plots of additional parameters that are of particular interest for individual sites will also be maintained (e.g., strontium-90 for 1301-N and 1324-N/NA; sulfate for 1324-N/NA).

The new downgradient wells will be sampled and analyzed quarterly for the first year. A minimum of four independent samples will be obtained for each well and for each monitoring parameter or constituent. Analytical data from all the downgradient wells will be compared with the background well data to determine whether there is a statistically significant increase (or in the case of pH, difference) in the mean or median values over the background populations. Alternative methods are provided to handle data that are below the analytical detection limit(s). A flow chart depicting the process of selecting a method of analysis is presented in Figure 3-7. Statistical analysis methods include analysis of variance (ANOVA), test of proportions, and other methods deemed appropriate (EPA 1989). The methods selected are based on knowledge of present conditions, and may be changed as new information is obtained and/or ground water flow patterns change.

For each constituent, the downgradient data will be compared with background statistics collected over a period of one year. This approach is preferred over same-point-in-time comparisons because it provides a larger data set for establishing background. The background data will be regularly reviewed and the background statistics and/or statistical methodology may be modified if required to address trends or seasonal variations. The following discussion provides an approach to be used initially, and assumes no significant trends or seasonal variations.

3.6.2.1 ANOVA. One-way ANOVA procedures will be used to test with a 99% level of confidence whether the compliance data are drawn from the same population as the background data. A parametric ANOVA procedure assumes that the data consist of random samples drawn from normal population(s) with a common variance. If the data are shown to be normally or log-normally

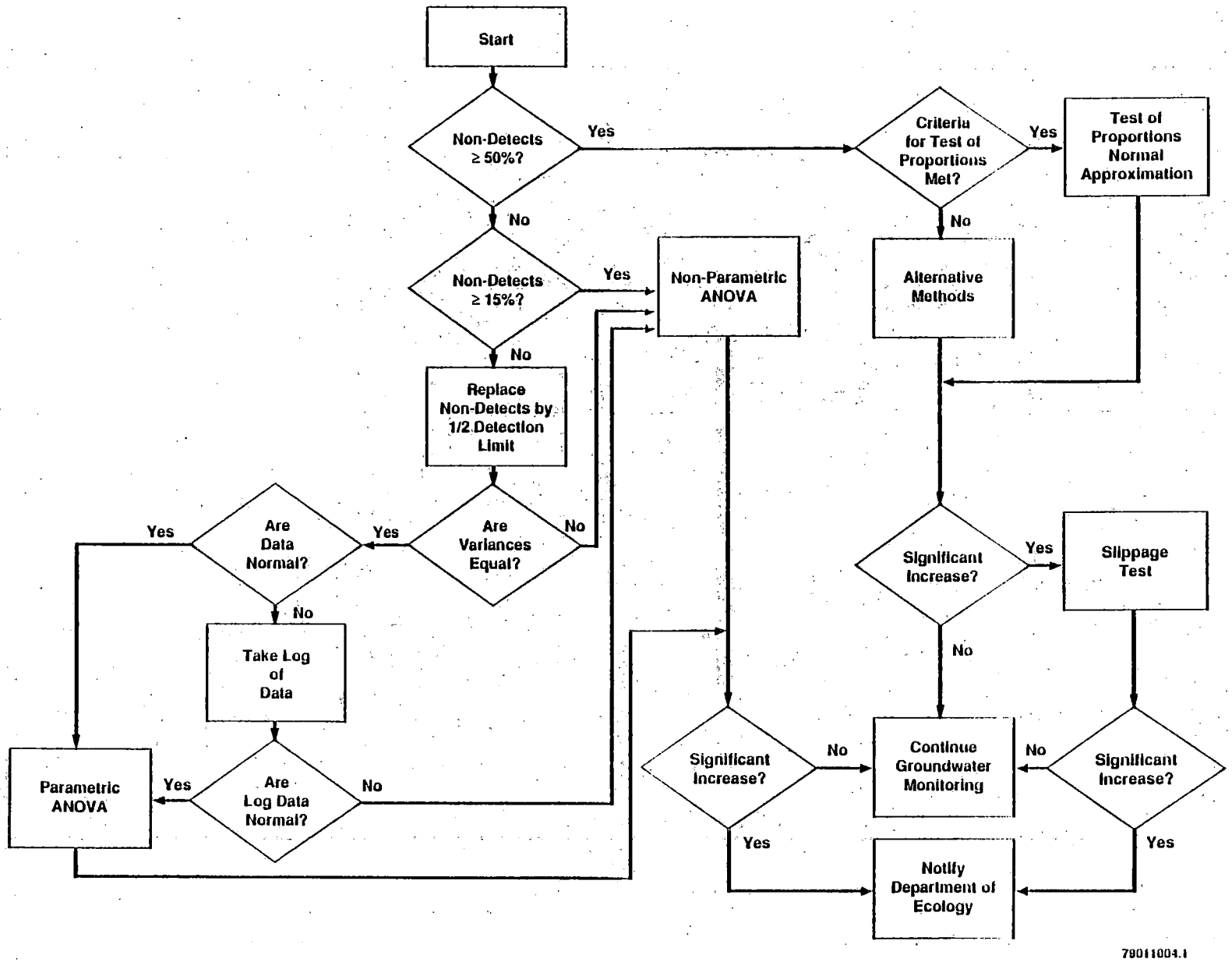


Figure 3-7. Flow Chart for Selecting Method of Analysis for Ground Water Data.

distributed with a common variance, and if less than 15% of the samples from each population are below the detection limit, the non-detects will be assigned a value equal to one-half of the detection limit and parametric ANOVA will be used.

A non-parametric procedure such as the Kruskal-Wallis one-way ANOVA may be used if the data do not meet the parametric ANOVA requirements or if the proportions of non-detects from each population are less than 50% but more than 15%.

If parametric or non-parametric ANOVA is significant at 1% level, multiple comparison procedures will be used to evaluate which well may be contaminated (EPA 1989).

3.6.2.2 Test of Proportions. This procedure uses the normal distribution approximation to the binomial distribution. This assumes that the sample size is reasonably large. If more than 50% of the data are below the detection limit and the conditions for applying the normal approximation to the binomial are satisfied (EPA 1989), a test of proportions may be used to compare the background well data with the downgradient well data.

If very few quantified values are found, an exact test procedure for the equality for two binomial proportions as described by Nelson (1982) may be used. Alternative methods such as tolerance limits or a quantile test (Johnson et al. 1987) or a slippage test (Rosenbaum 1954) may also be considered. These alternatives would be appropriate when the number of detected compounds is quite small relative to the number of compounds analyzed.

The test of proportions compares the proportions of detects rather than the magnitude of the actual concentrations of the constituents of concern and could therefore, indicate a significant difference when the downgradient well concentrations were in fact lower than the background concentrations or vice versa. To protect against such possibilities, a significant difference in proportions will not be considered as an indicator of contamination unless the maximum background concentration is exceeded by that allowed by the slippage test (Rosenbaum 1954). For purpose of the statistical analysis, the practical quantitation limit is considered to be the maximum background concentration in case when all the background samples are non-detects.

3.7 NOTIFICATION AND REPORTS

A summary of the reports required for compliance with 40 CFR 265, Subpart F, is given in Table 3-7.

Table 3-7. Reports Required for Compliance with 40 CFR 265, Subpart F, for Ground Water Monitoring.

Submittal	Submittal Period	Reference
First year of sampling only: Concentrations of interim primary drinking water constituents, identifying those that exceed the limits of 40 CFR 265, Appendix III.	Quarterly	40 CFR 265.94(a)(2)(i)
Concentration and statistical analyses of ground water 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 ground water surface elevation evaluation and description of response if appropriate.	Annually, by March 1 of following year	40 CFR 265.94(a)(2)(iii)

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4.0 PHASE II--INITIATION OF GROUND WATER QUALITY ASSESSMENT PROGRAM

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

Ground water samples from all monitoring wells will be tested semiannually for contamination indicator parameters, and annually for interim primary drinking water constituents, secondary ground water 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 facility may be affecting ground water, 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 ground water 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
- Ground Water Quality Assessment Program
  - Investigatory Approach
  - Assessment Monitoring Network
  - Water Level Monitoring
  - Constituents
  - Schedule
- Sampling and Analysis
  - Methods
  - Quality Assurance
  - Quality Control
- References
- Appendix A--As-Built Diagrams for Monitoring Wells
- Appendix B--Water Table Elevation Maps for the Surrounding Area

The ground water 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 ground water and their concentrations. As soon as technically feasible, these determinations will be made and a report of the findings sent to Ecology. Table 4-1 provides a schedule for reports and notifications.

Table 4-1. Reports and Notifications.

Submittal	Submittal Period	Reference
Required whether or not the facility might be affecting ground water:		
First year of sampling only: Concentrations of interim primary drinking water standards, identifying those that exceed the limits of 40 CFR 265, Appendix III.	Quarterly	40 CFR 265.94(a)(2)(i)
Concentrations and statistical analyses of ground water 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 ground water surface elevation and description of response, if appropriate.	Annually, by March 1 of following year	40 CFR 265.94(a)(2)(iii)
Required if the facility might be affecting ground water:		
Notification that the facility might be affecting ground water.	Within 7 days of confirmation of a statistically significant difference over background	40 CFR 265.94(d)(1)
Ground water quality assessment plan.	Within 7 days of the above notification	40 CFR 265.94(d)(2)
Report on assessment of ground water 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 265.94(d)(5)
Results of the ground water quality assessment program.	Annually, by March 1 of following year, until closure of facility	40 CFR 265.94(b)(2)

It is likely that specific conductance will remain elevated in the wells downgradient of the 1324-N/NA facilities for some time. This elevated specific conductance is due primarily to sulfate and sodium, which are not hazardous waste constituents (Hartman 1990). Each time the indicator parameters are compared to background for the 1324-N/NA wells, metals and anion data will be evaluated to determine what ions are causing it. If the elevated specific conductance is still due to the nonregulated constituents, this information will be noted in the quarterly reports, and assessment monitoring will not be reinstated.

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5.0 REFERENCES

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APPENDIX A

GEOLOGIC AND WELL CONSTRUCTION DIAGRAMS FOR SELECTED 100-N AREA WELLS

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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 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, geologists' logs.

This appendix includes information for the following wells:

<u>1301-N WELLS</u>
N-2
N-3
N-4
N-14
N-57
N-66
N-67
N-69

<u>1324-N/NA WELLS</u>
N-58
N-59
N-60
N-61
699-81-58

<u>1325-N WELLS</u>
N-27
N-29
N-31
N-32
N-33
N-36
N-41
N-42
N-52
N-39
N-70

<u>ASSESSMENT WELLS</u>
N-16
N-17
N-18
N-21
N-23
N-24
N-25
N-26
N-47
N-54
N-55
N-56

<u>OTHER WELLS</u>
N-62
N-63
N-64
N-65

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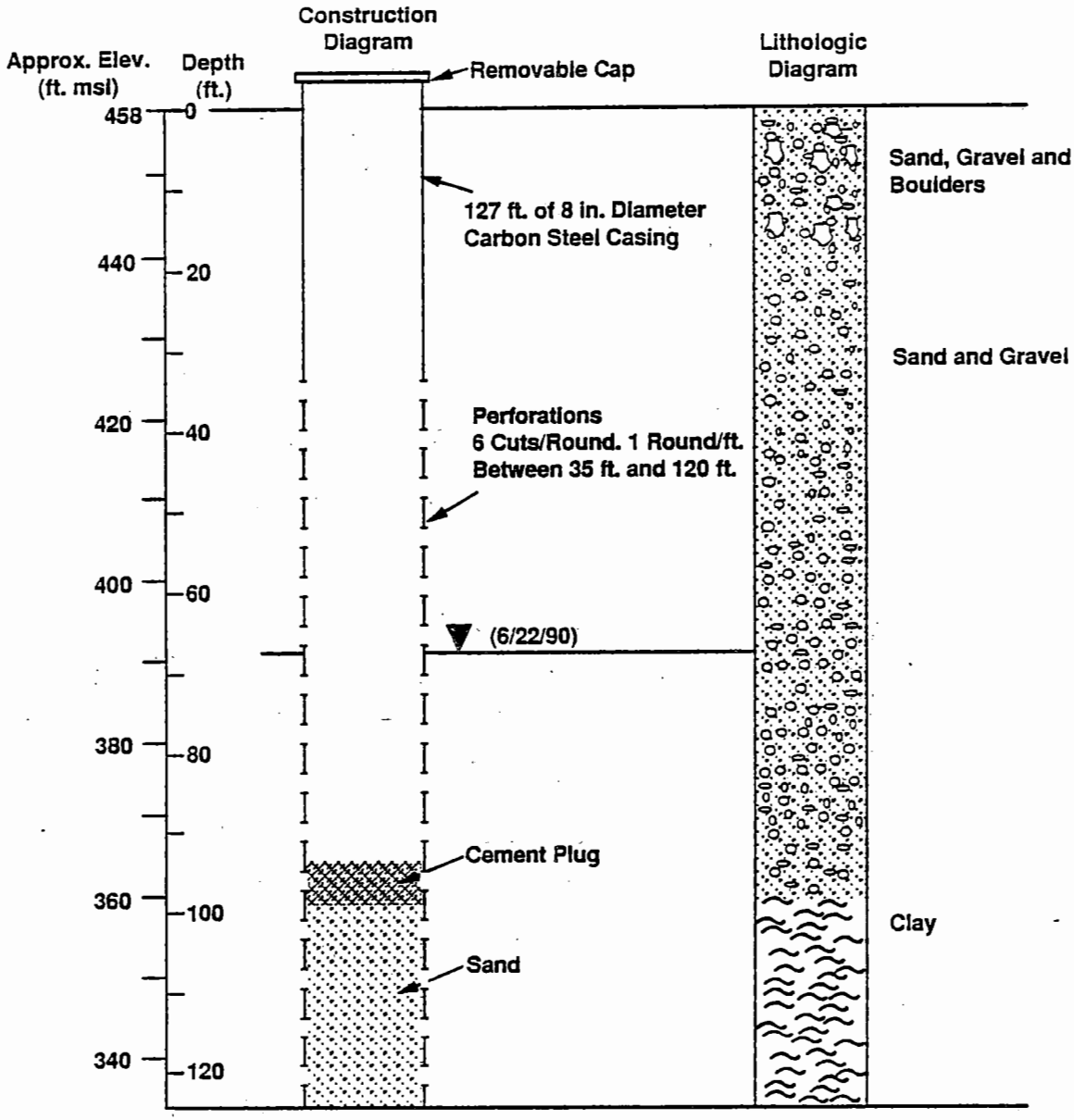
Well 199-N-2



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

Logged by Driller

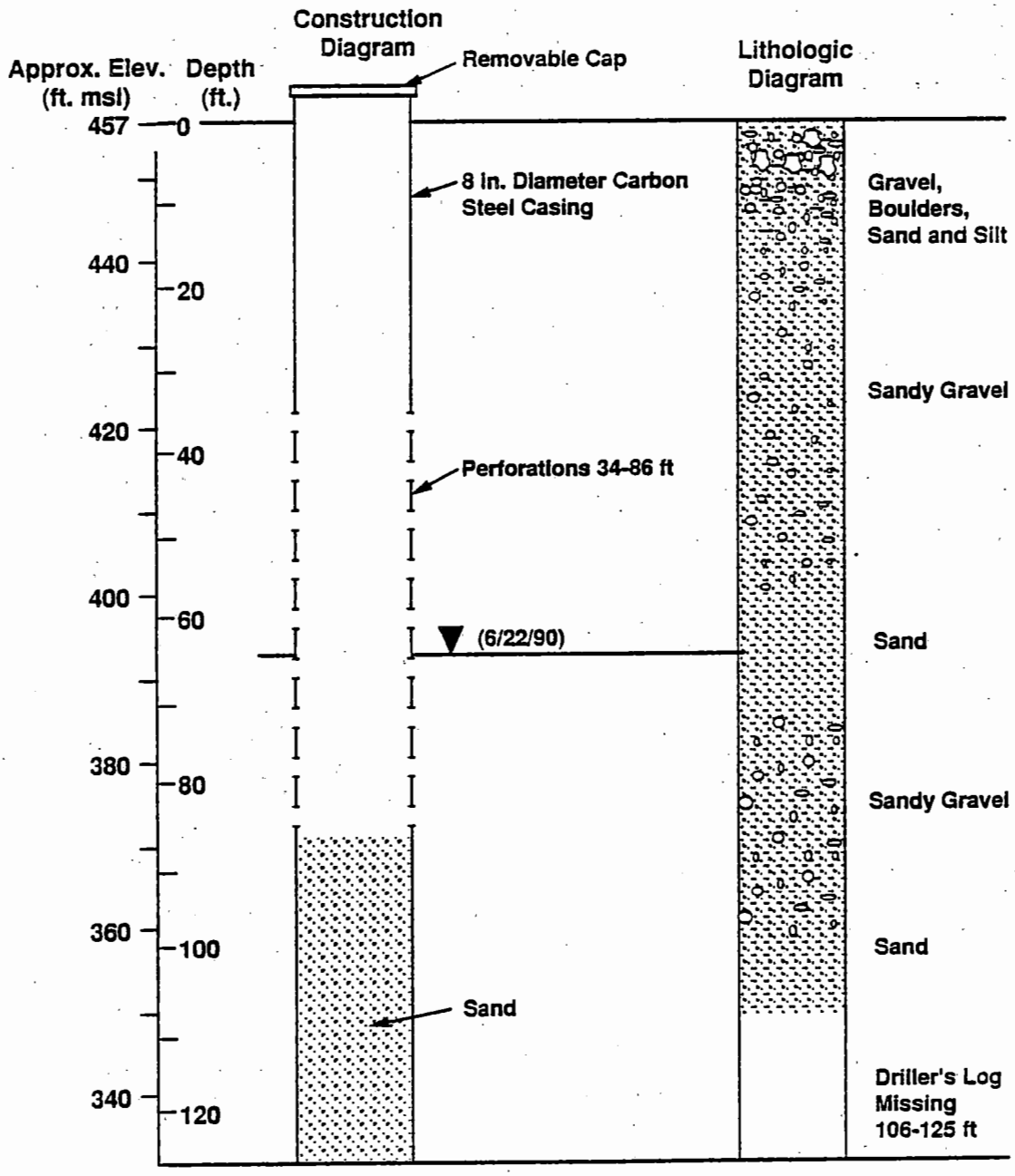
(6/22/90) = Water table and date measured

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

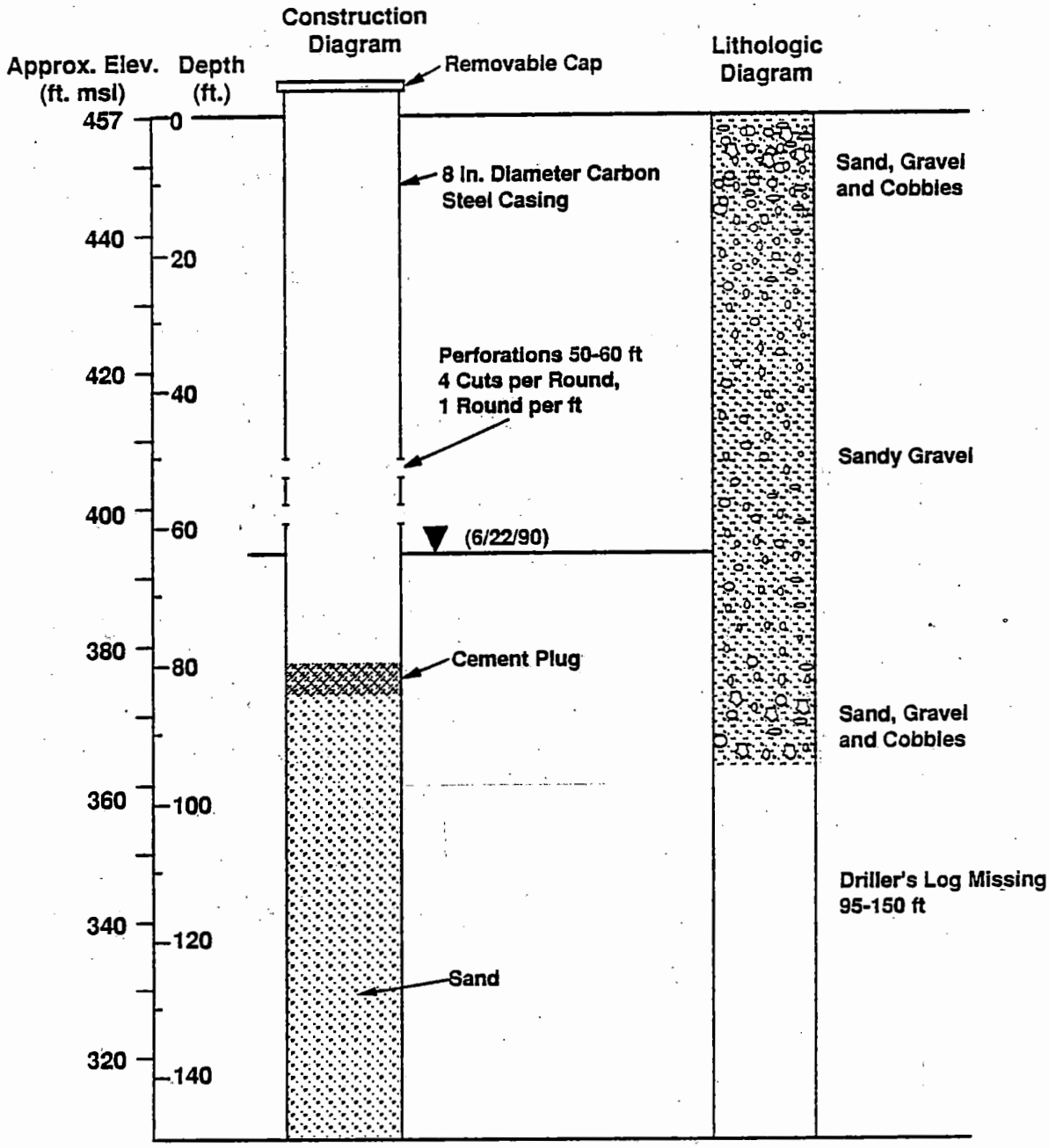
(6/22/90) = Water table and date measured

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

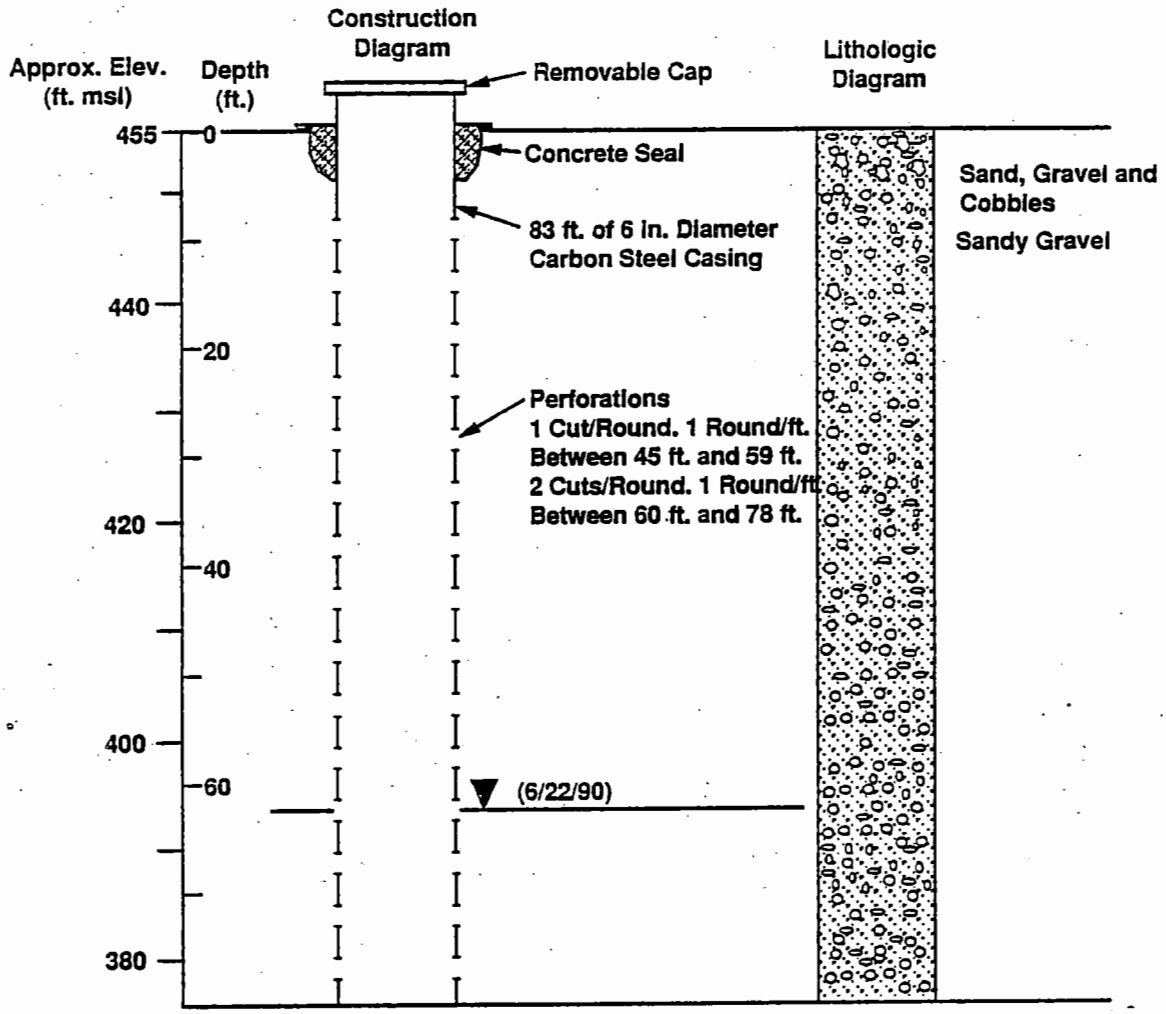
▼ (6/22/90) = Water table and date measured

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

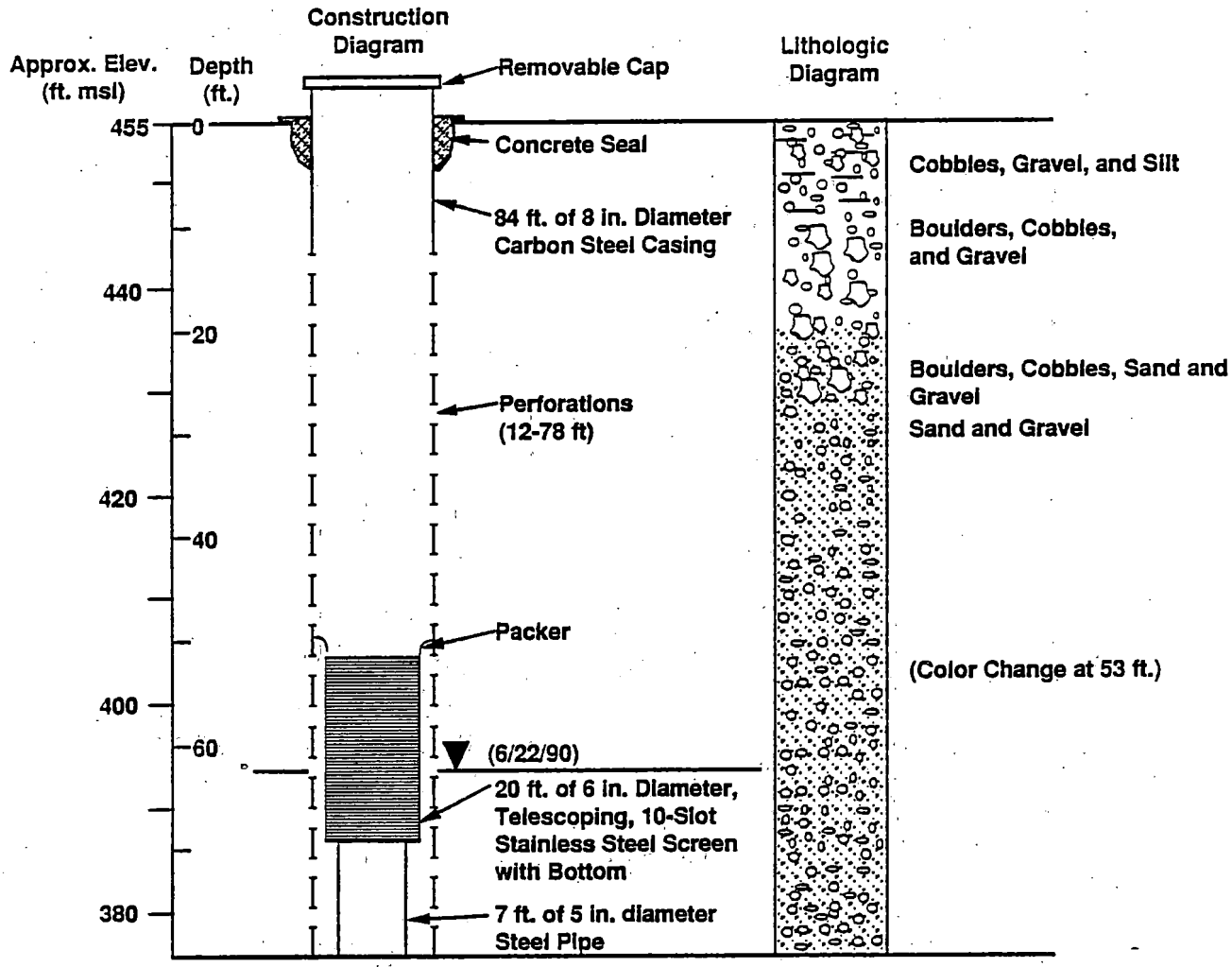
▼ (6/22/90) = Water table and date measured

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

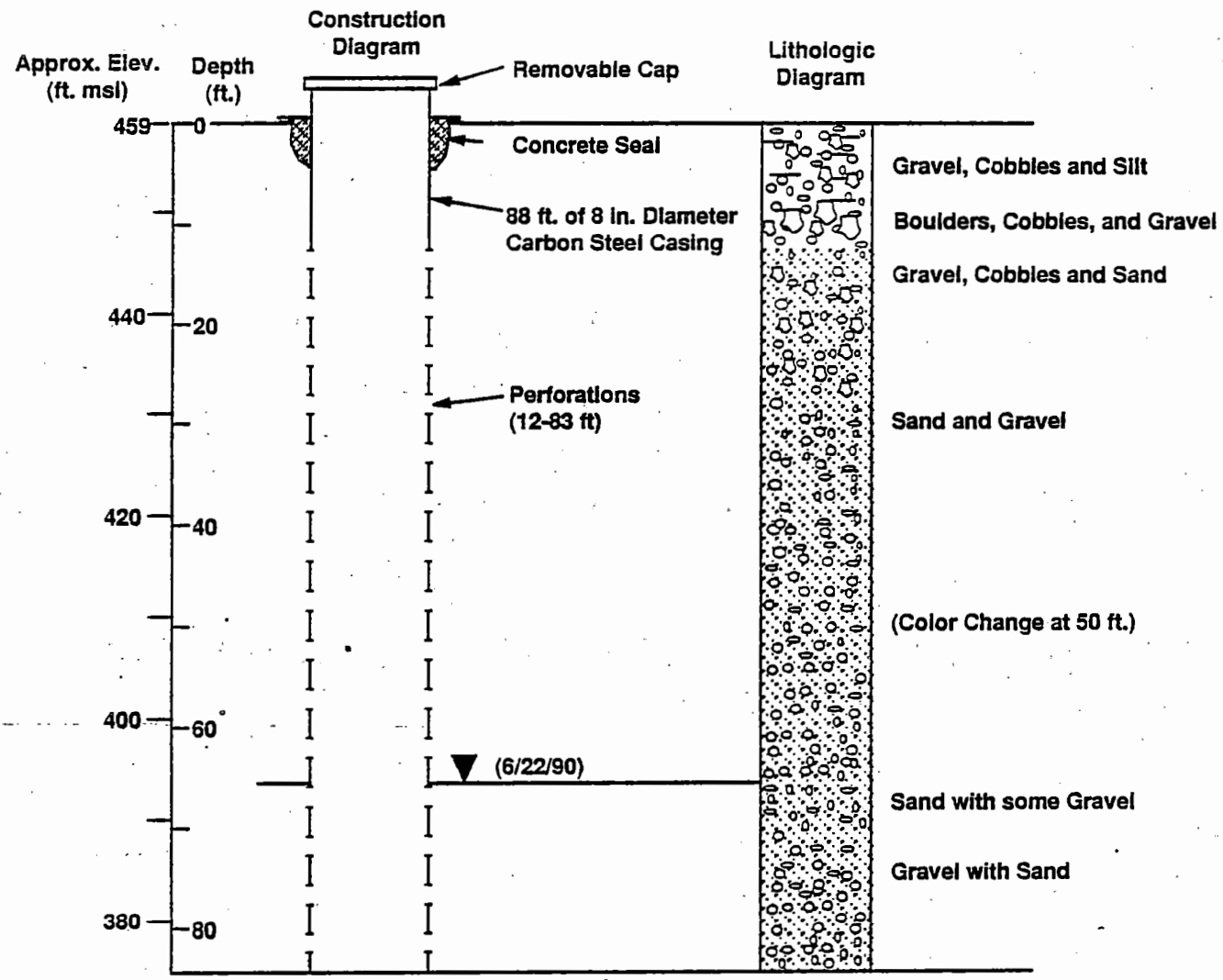
▼ (6/22/90) = Water table and date measured

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

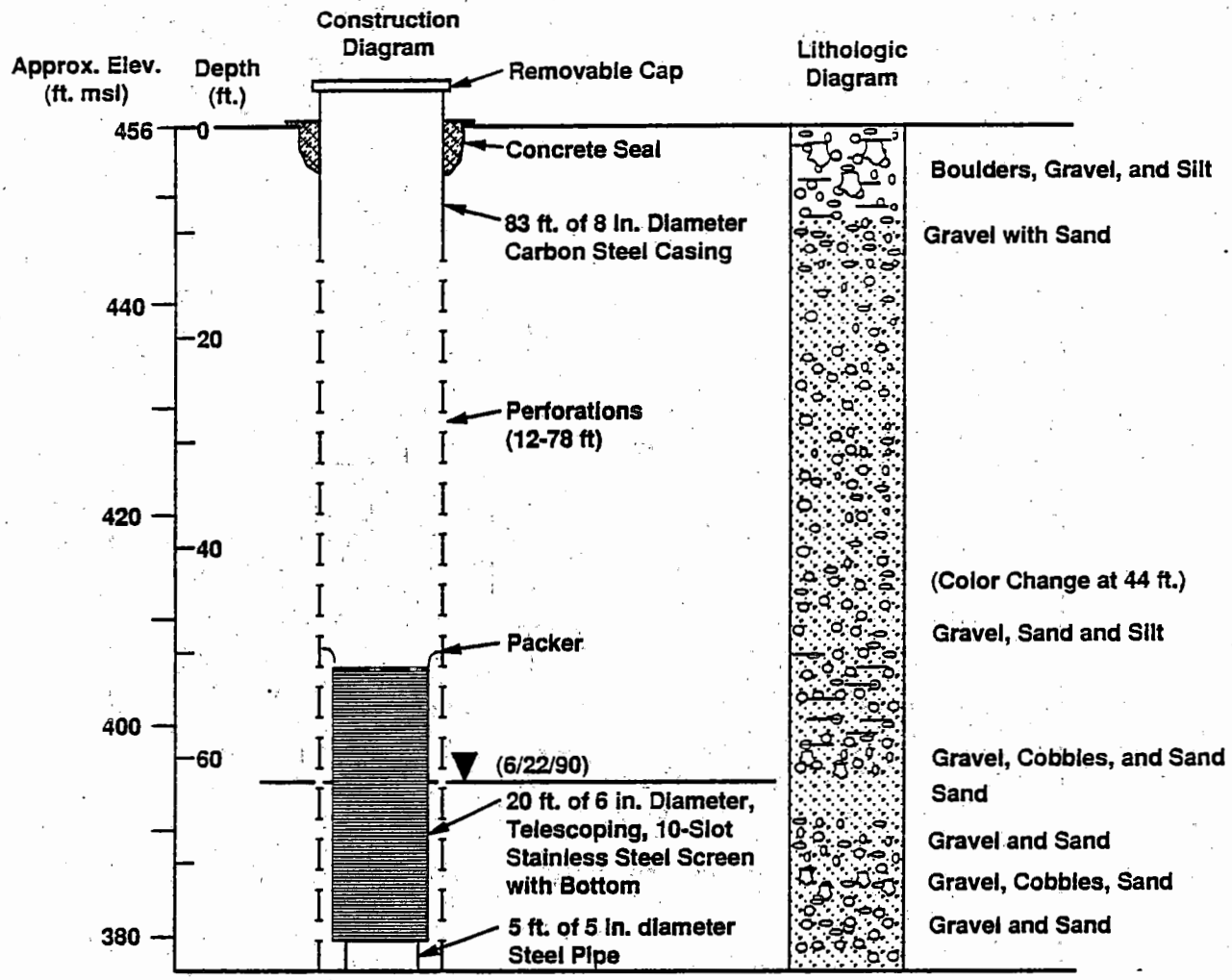
▼ (6/22/90) = Water table and date measured

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

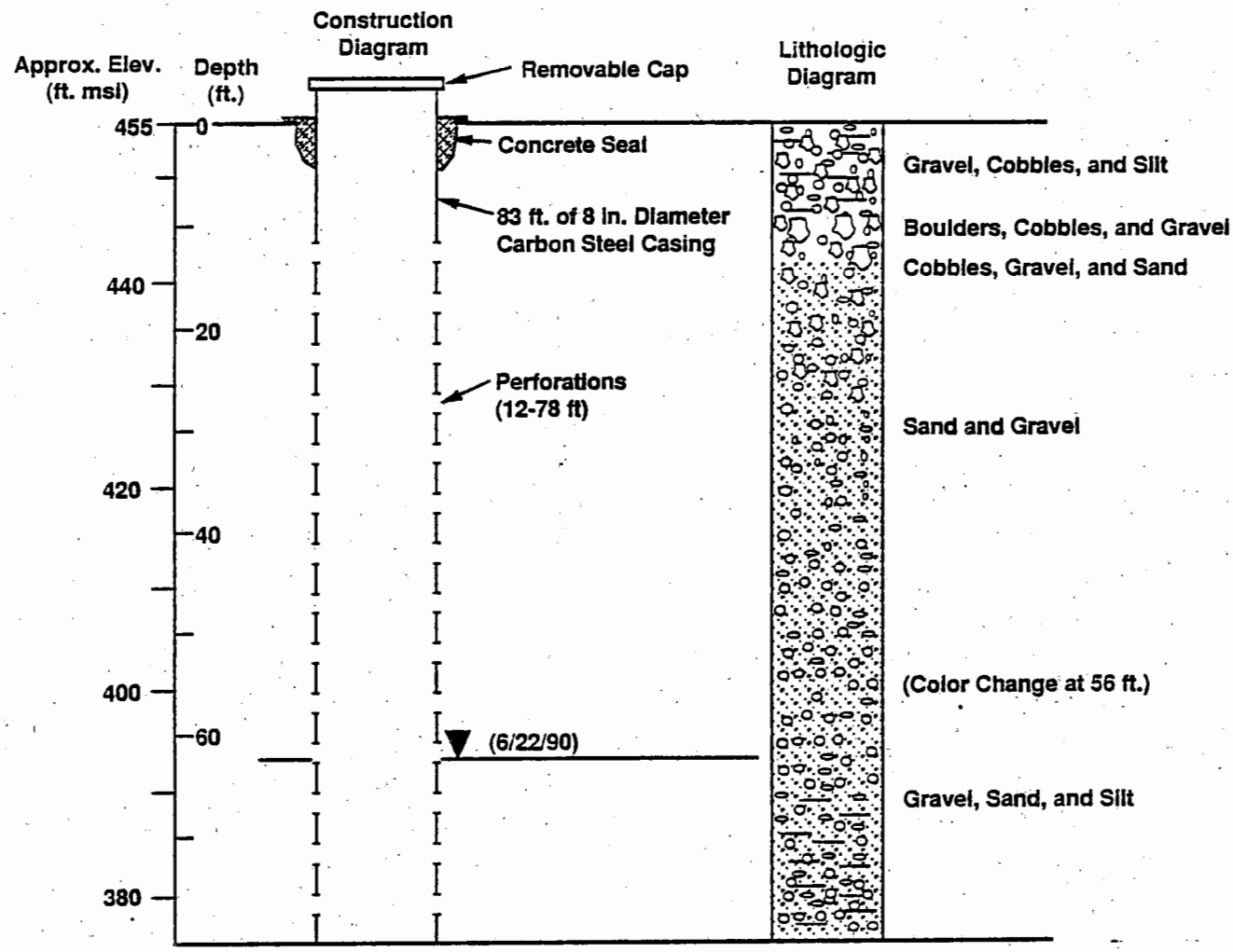
▼ (6/22/90) = Water table and date measured

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

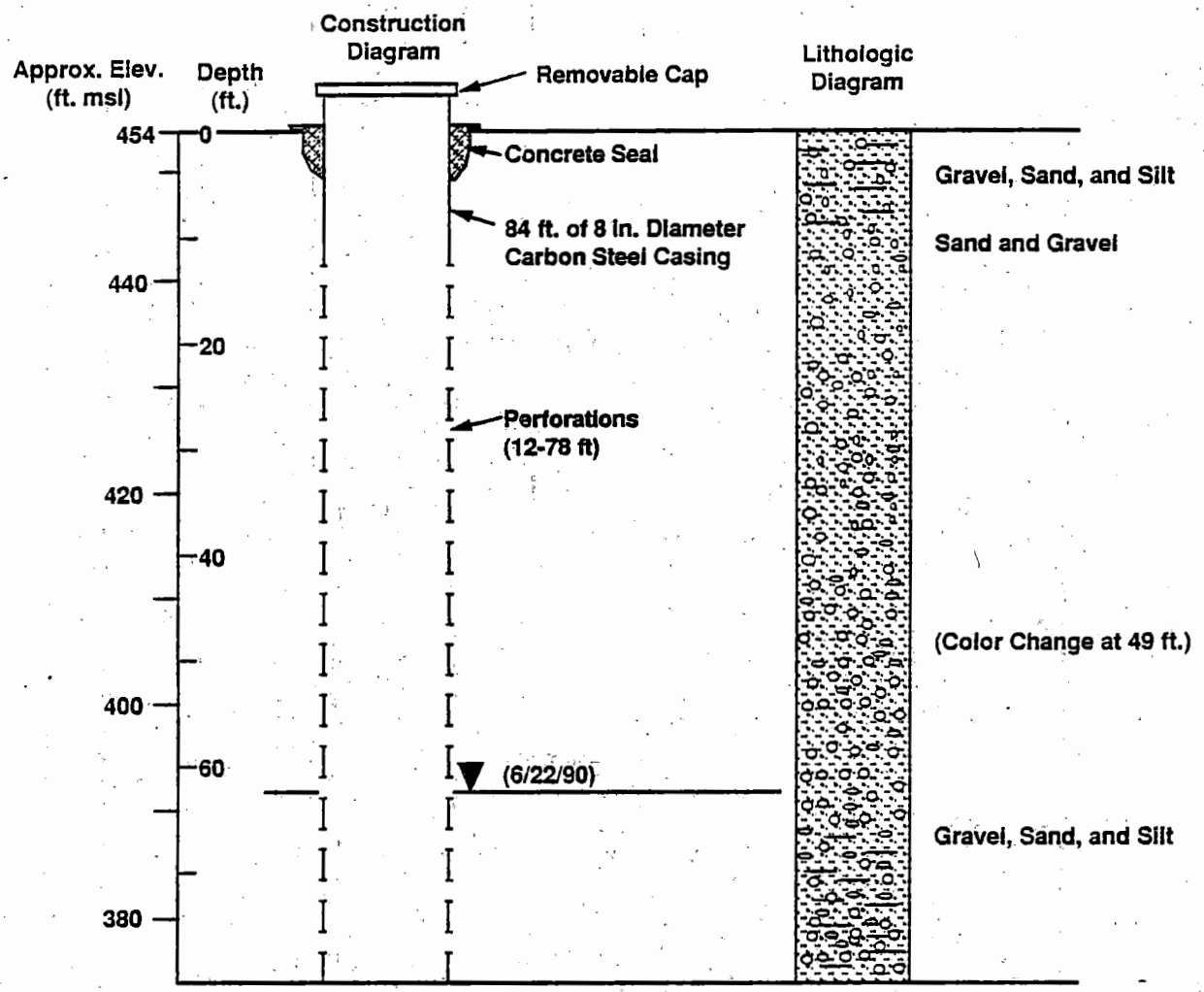
▼ (6/22/90) = Water table and date measured

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

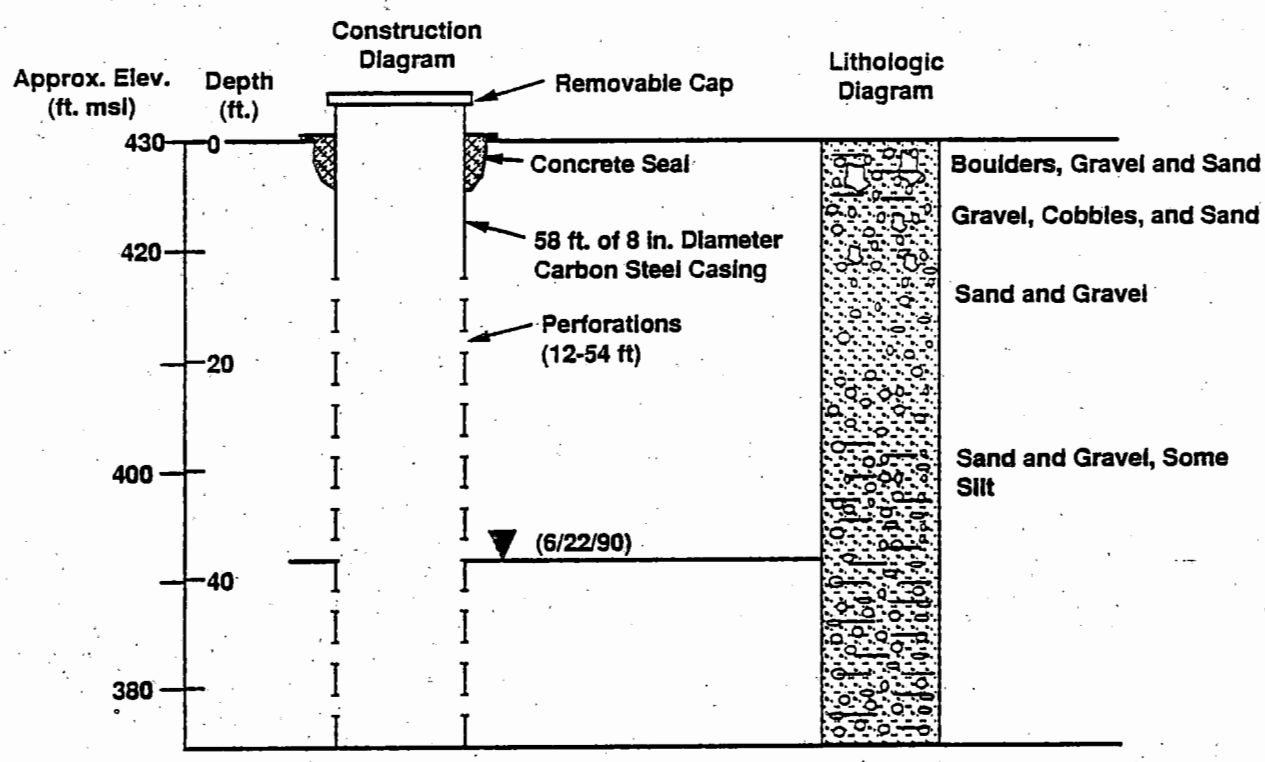
▼ (6/22/90) = Water table and date measured

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

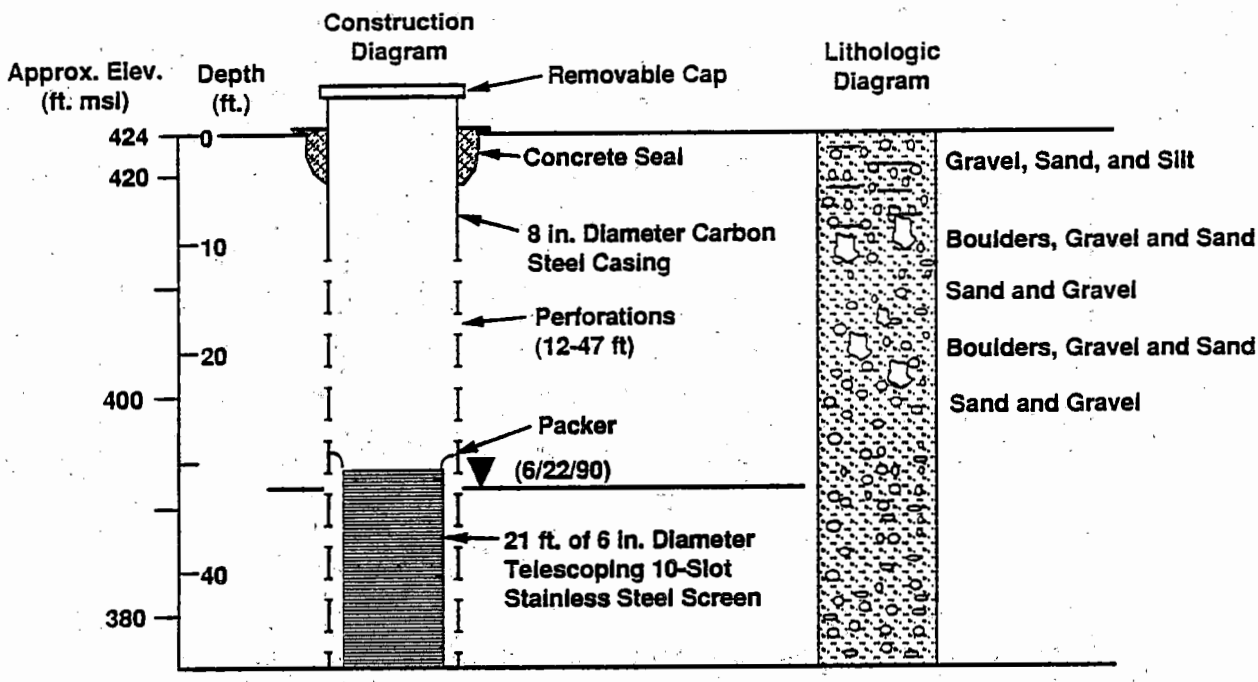
▼ (6/22/90) = Water table and date measured

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

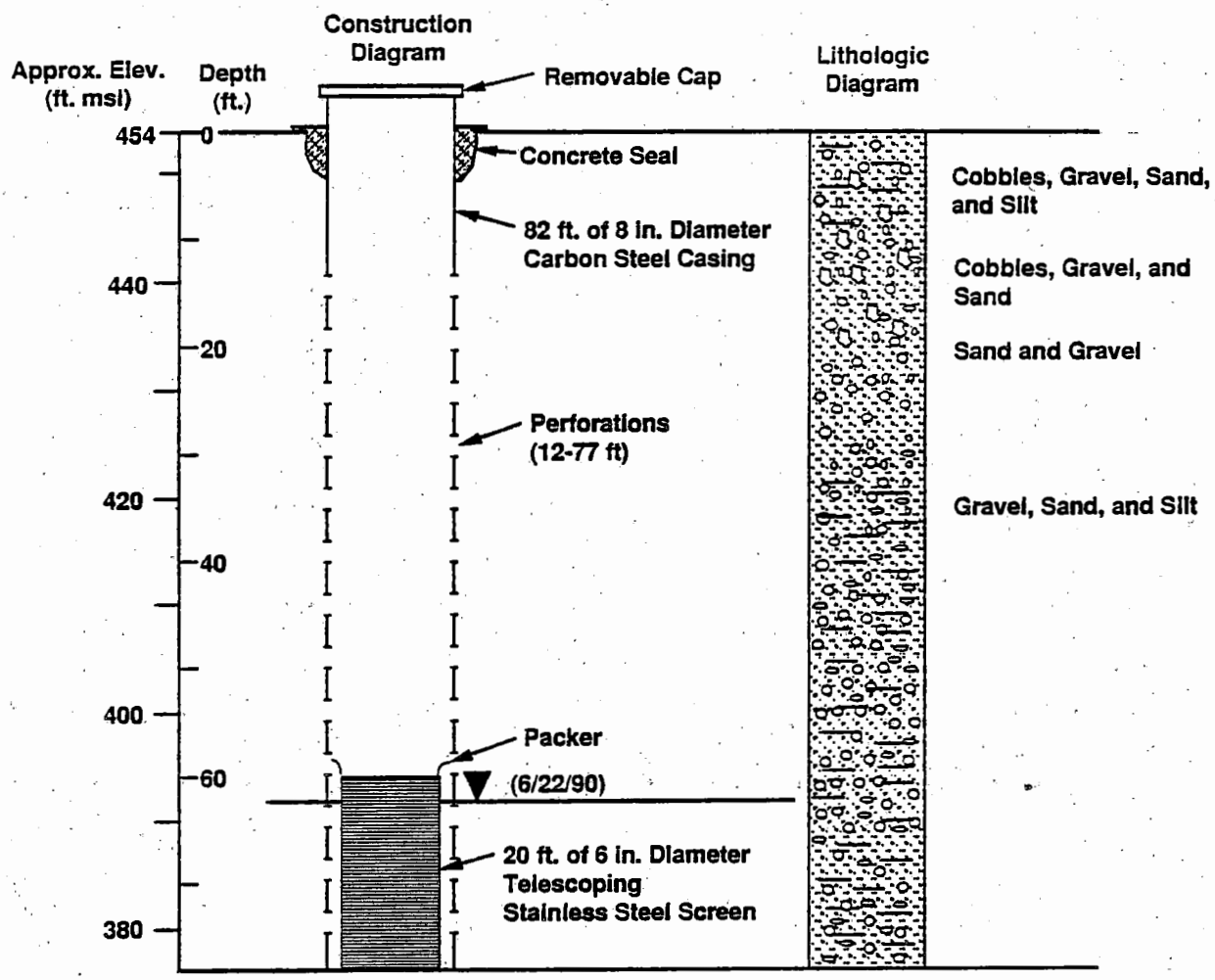
▼ (6/22/90) = Water table and date measured

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

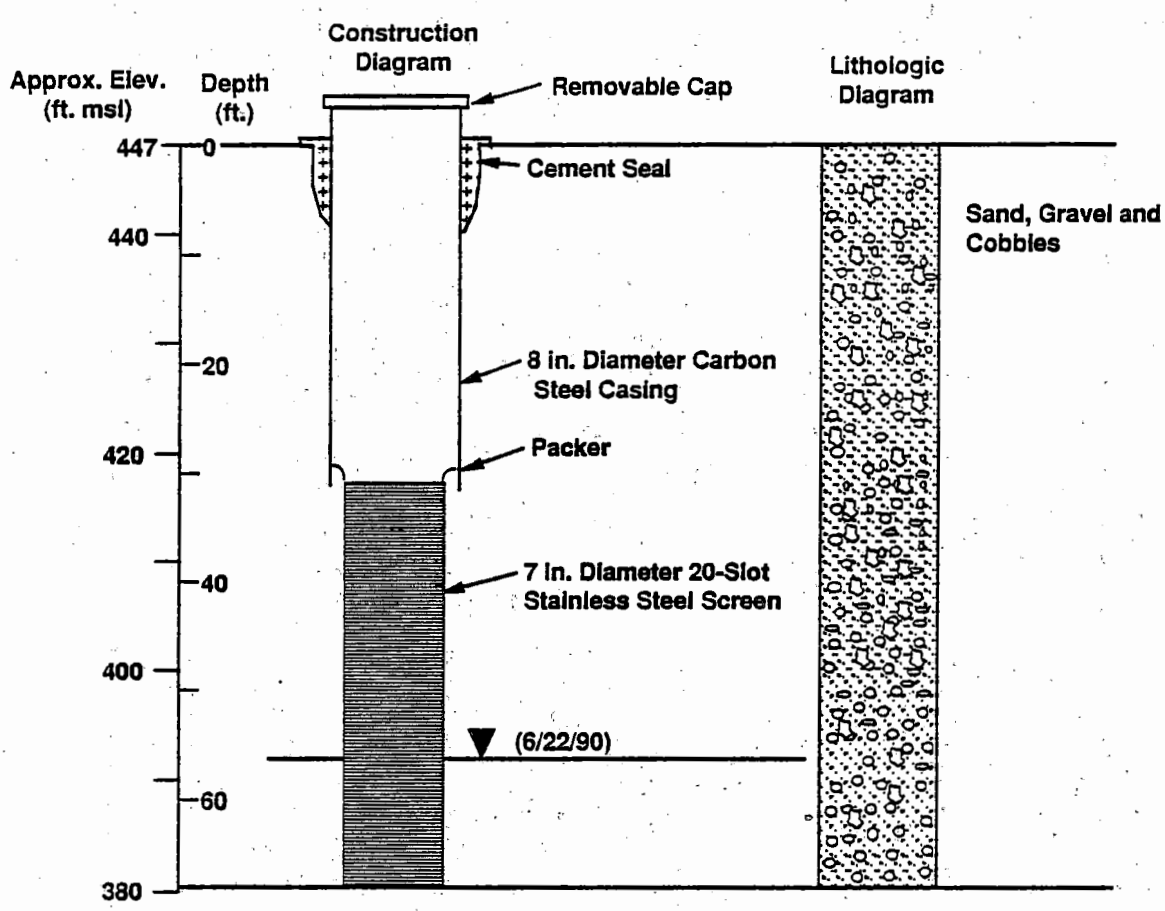
▼ (6/22/90) = Water table and date measured

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

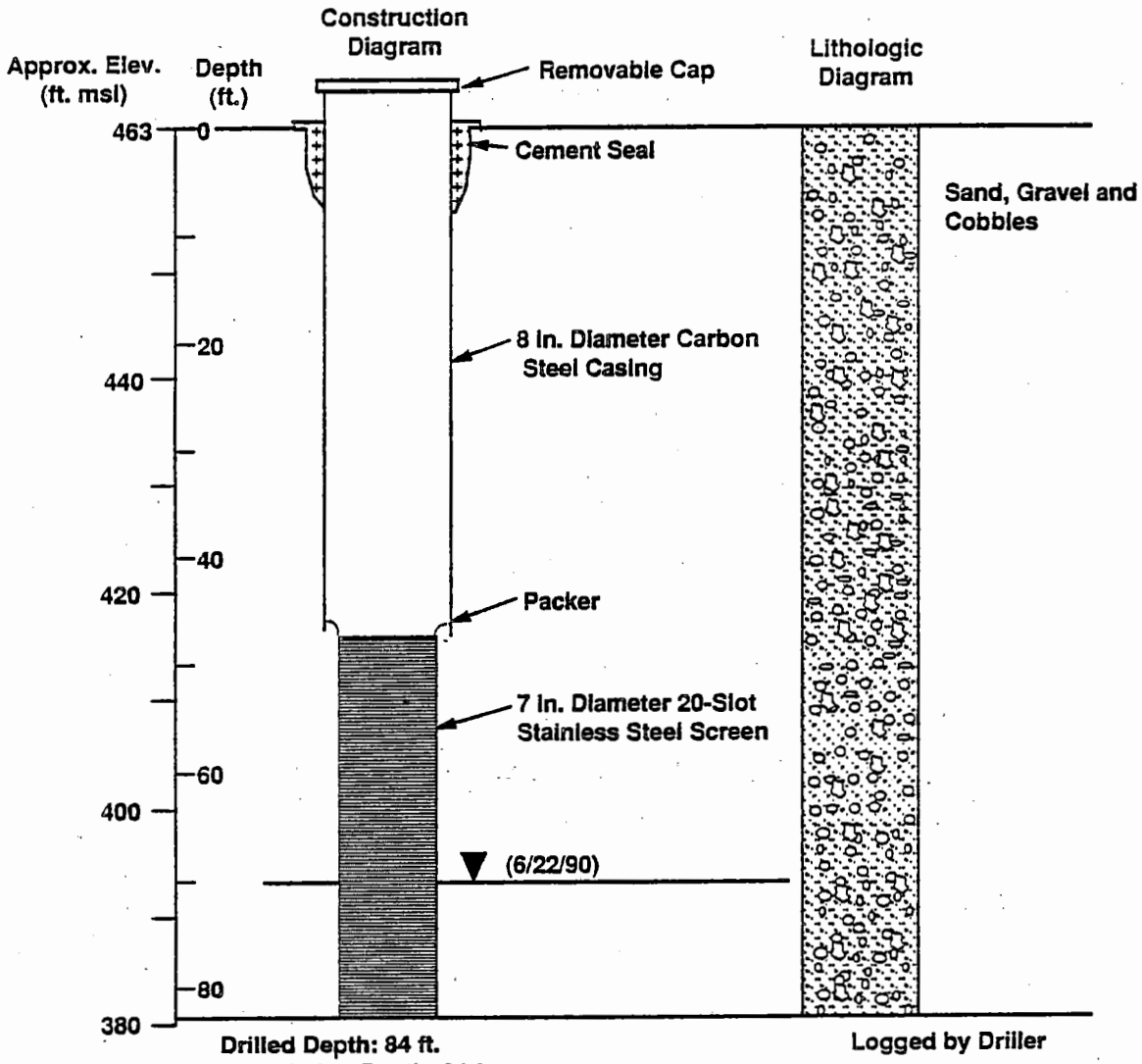
▼ (6/22/90) = Water table and date measured

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

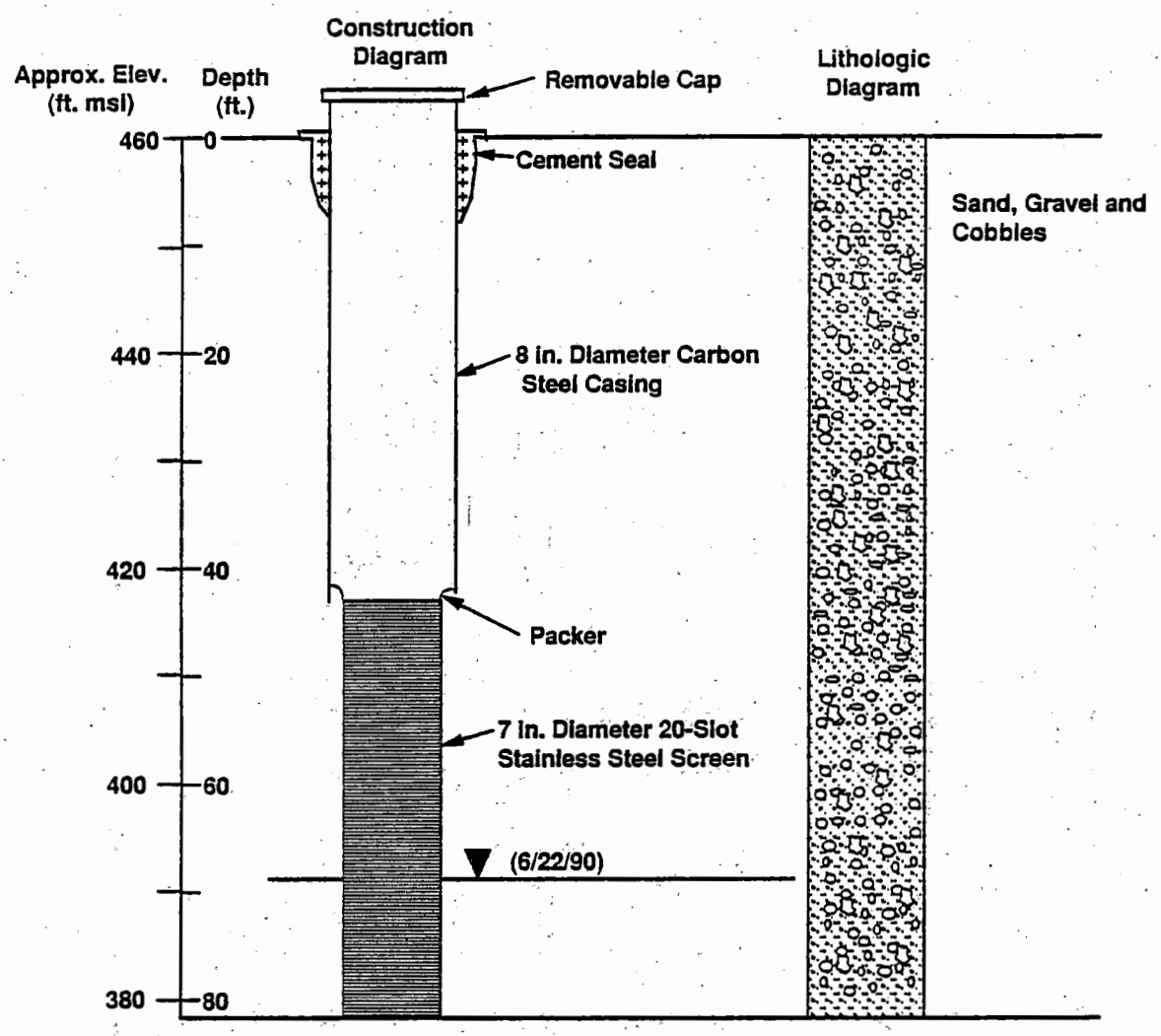
▼ (6/22/90) = Water table and date measured

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

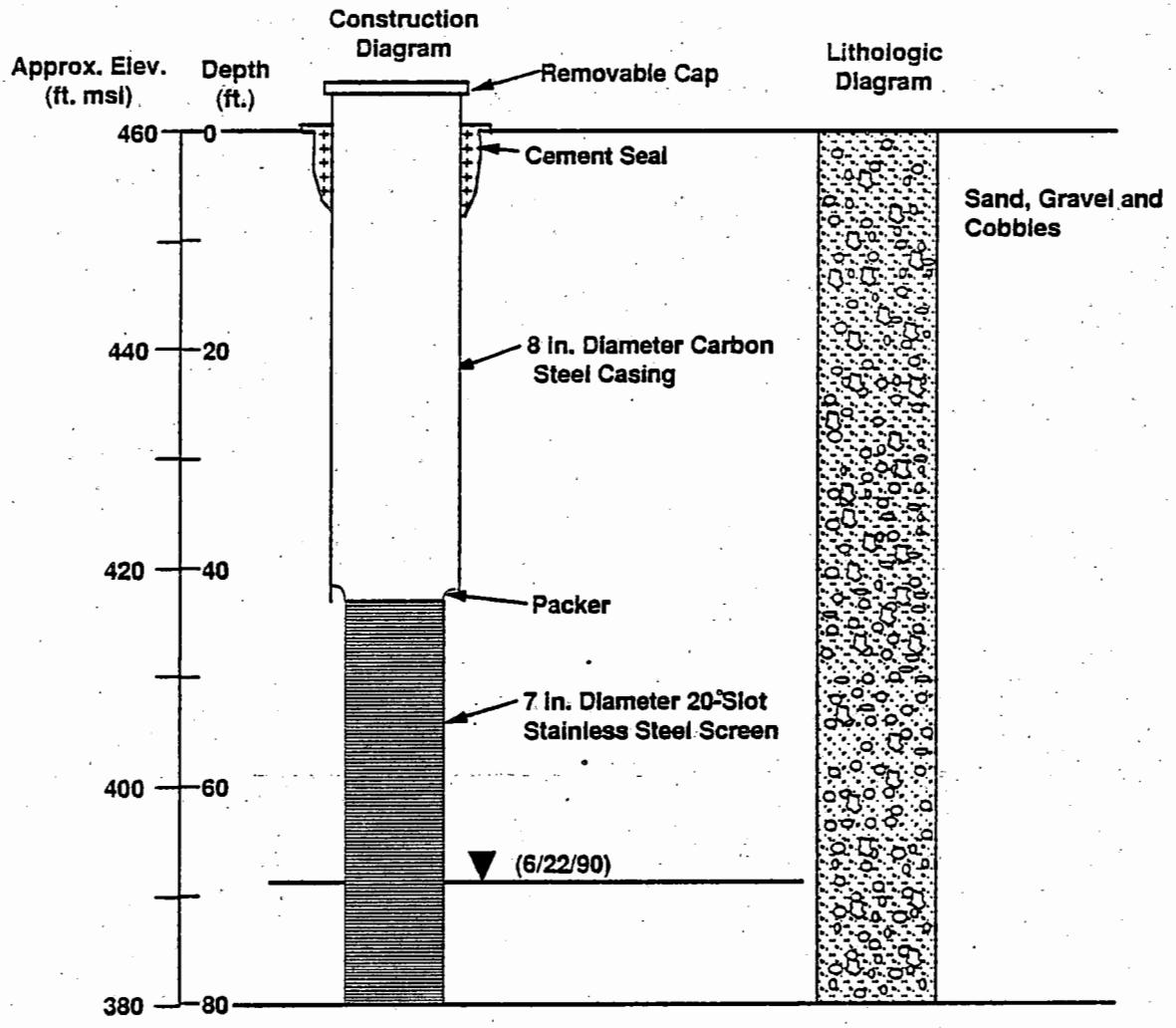
▼ (6/22/90) = Water table and date measured

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. msi

Logged by Driller

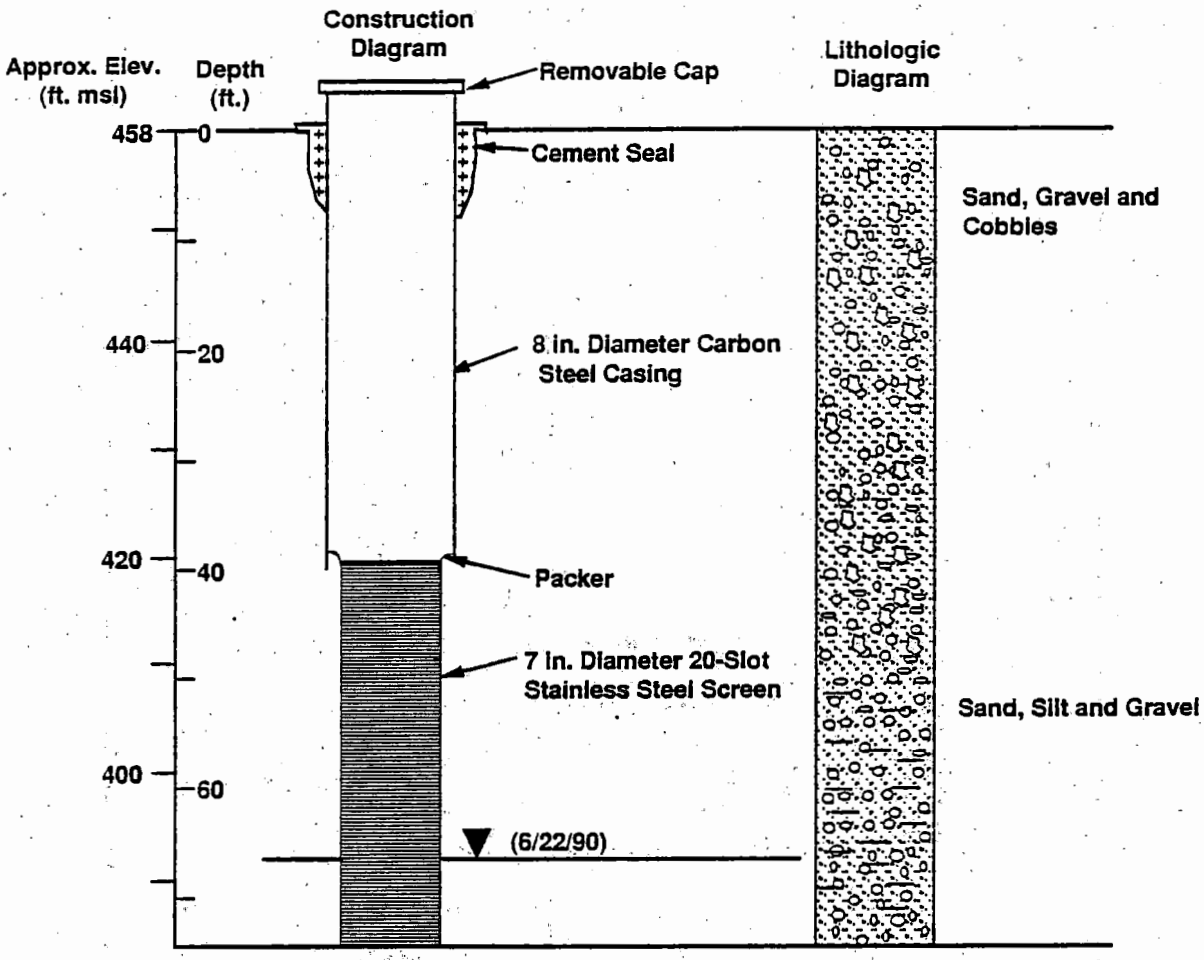
▼ (6/22/90) = Water table and date measured

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

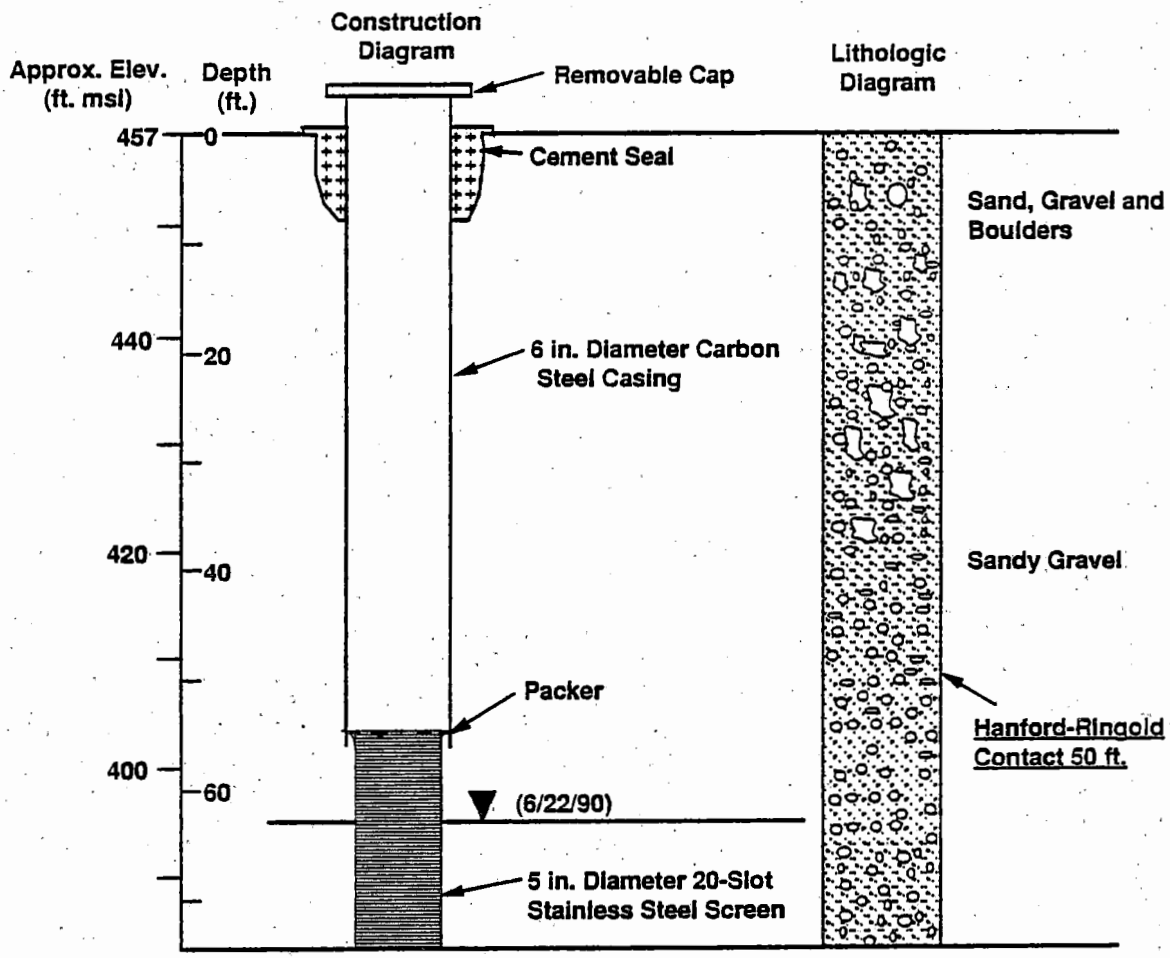
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.24

Well 199-N-36



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

Logged by Geologist

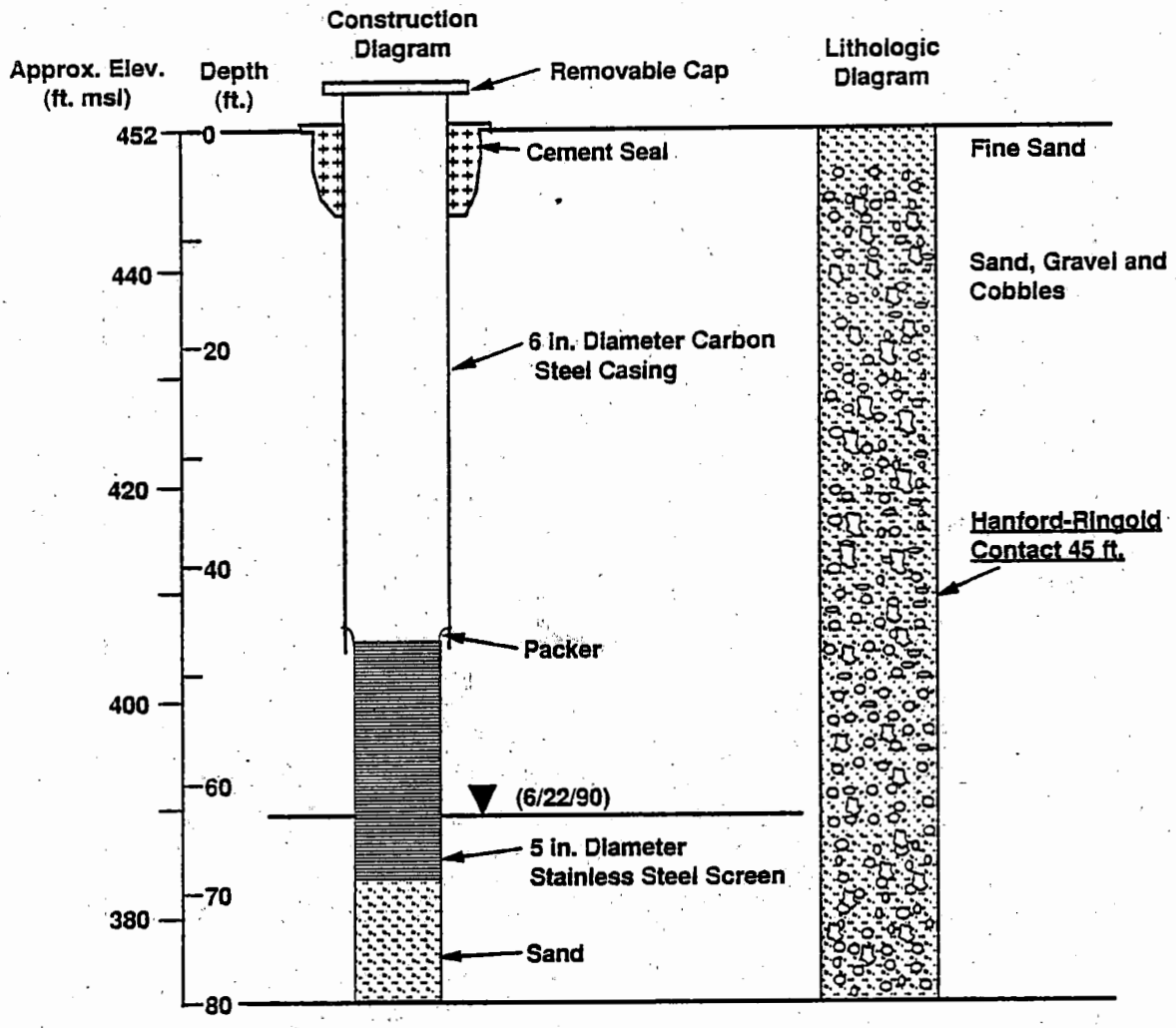
▼ (6/22/90) = Water table and date measured

ft. msi = 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

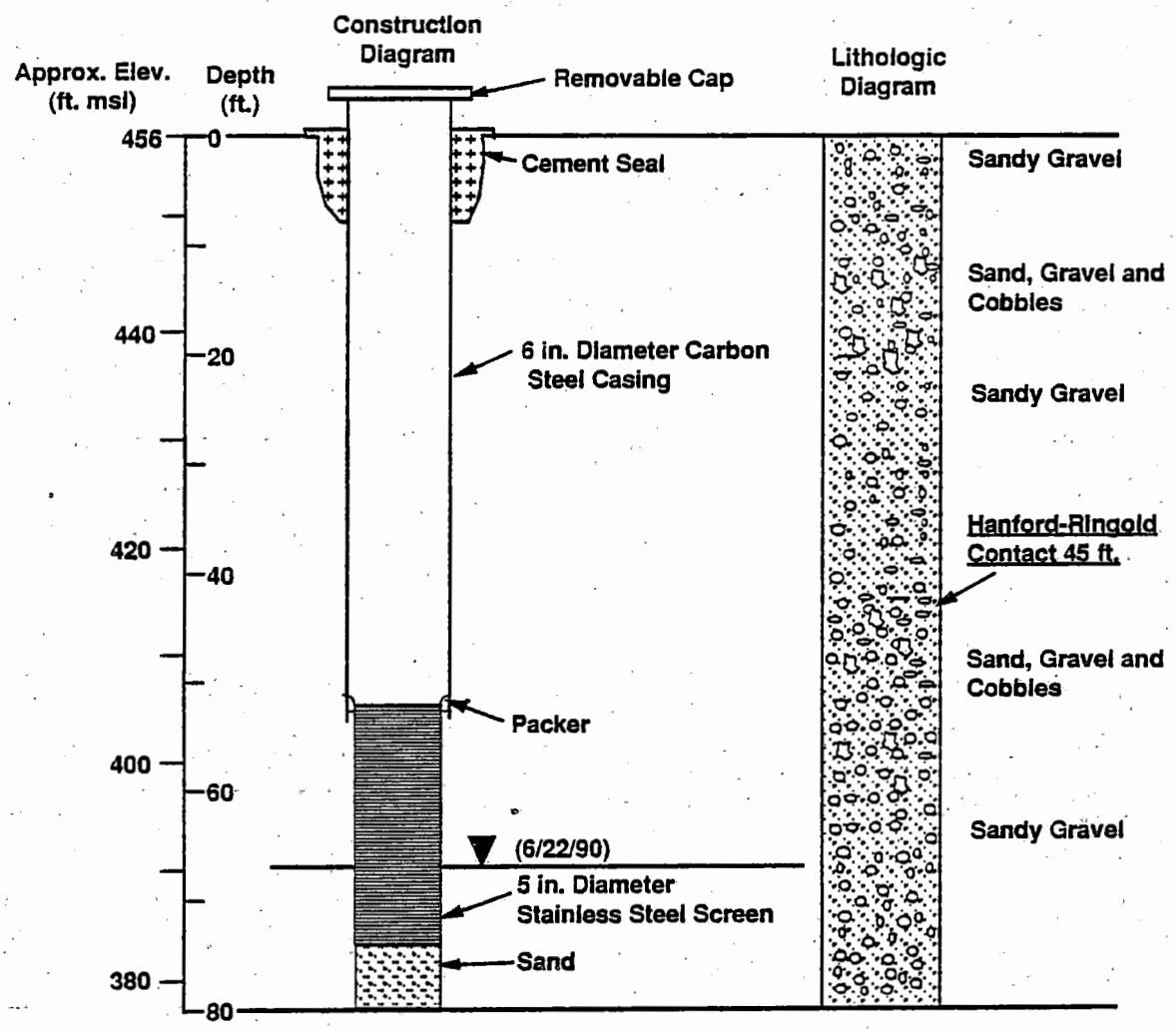
▼ (6/22/90) = Water table and date measured

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. msi

Logged by Geologist

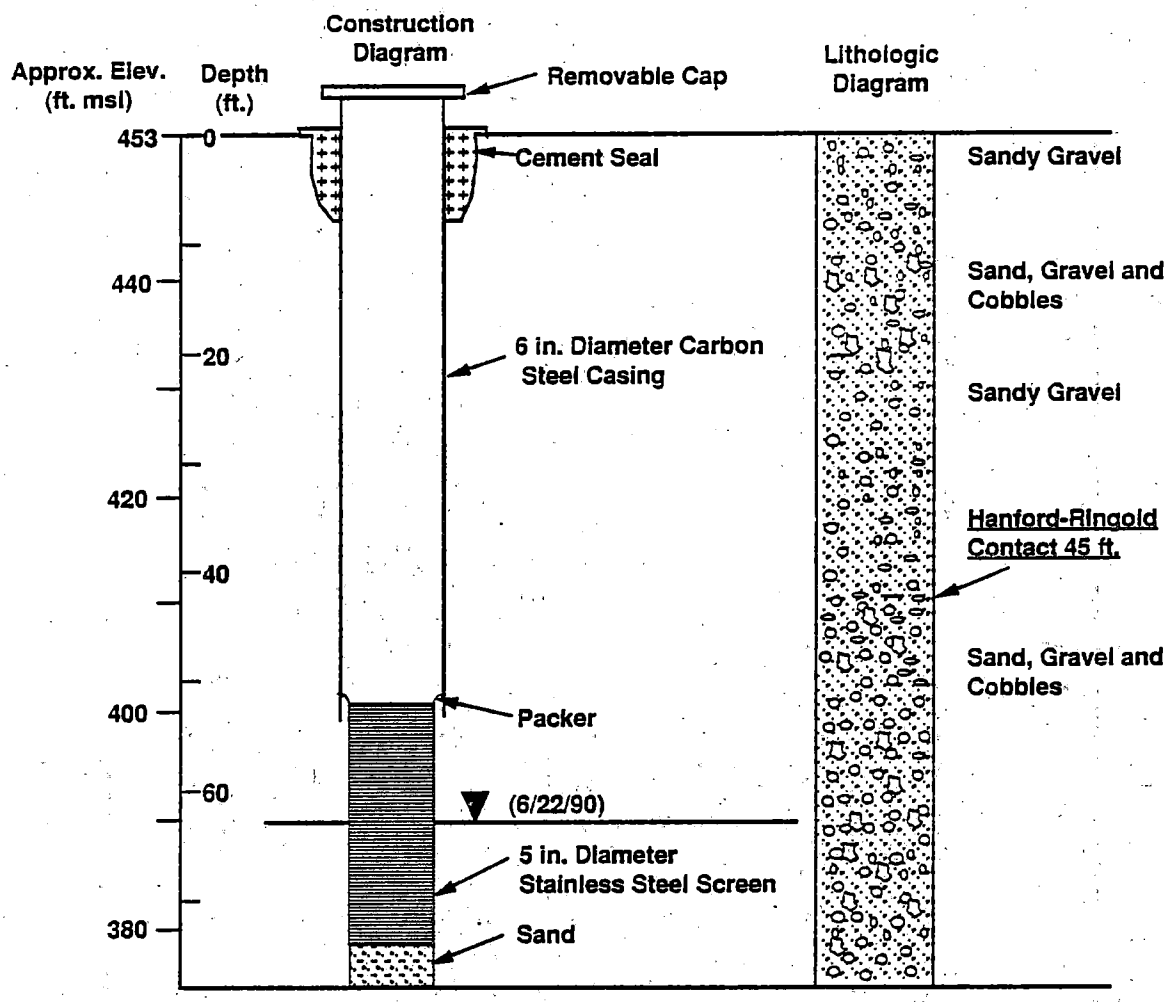
▼ (6/22/90) = Water table and date measured

ft. msi = 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

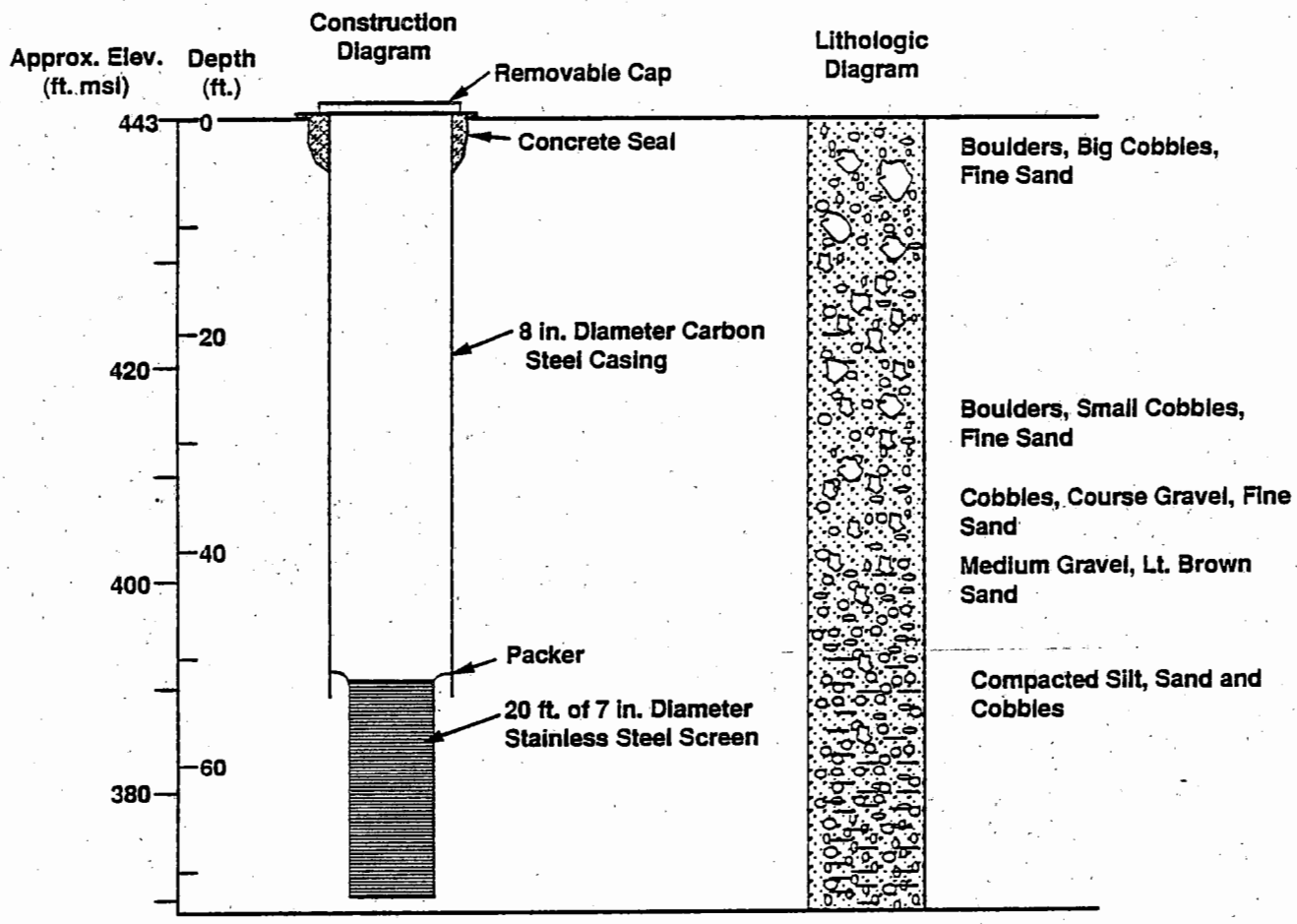
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.20

Well 199-N-47

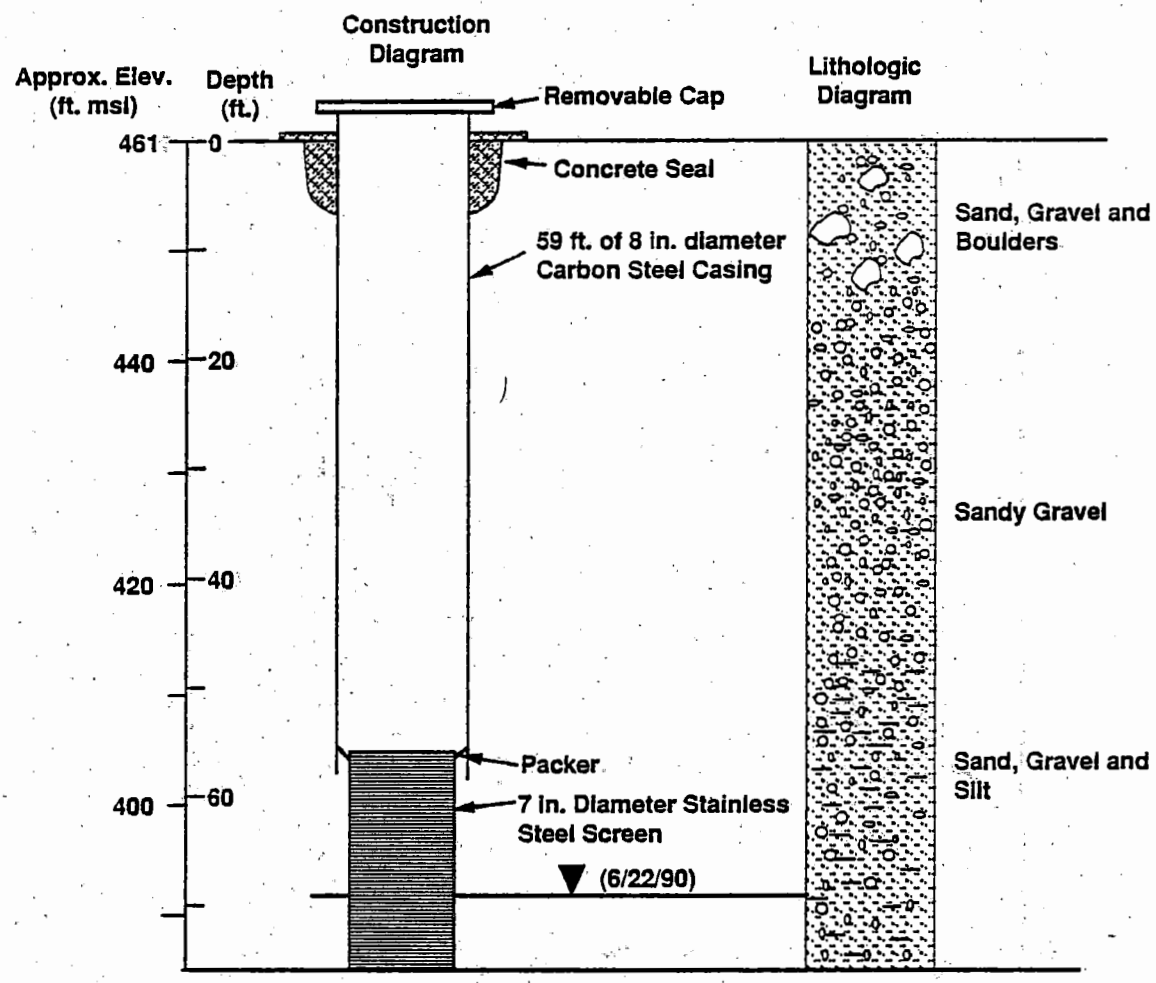


Drilled Depth: 73 ft.
Completion Date: 7/85
Elevation Top of Casing: 443.53 ft. msl
No Water Level Data
ft. msl = Feet above mean sea level
All depths are in reference to land surface

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

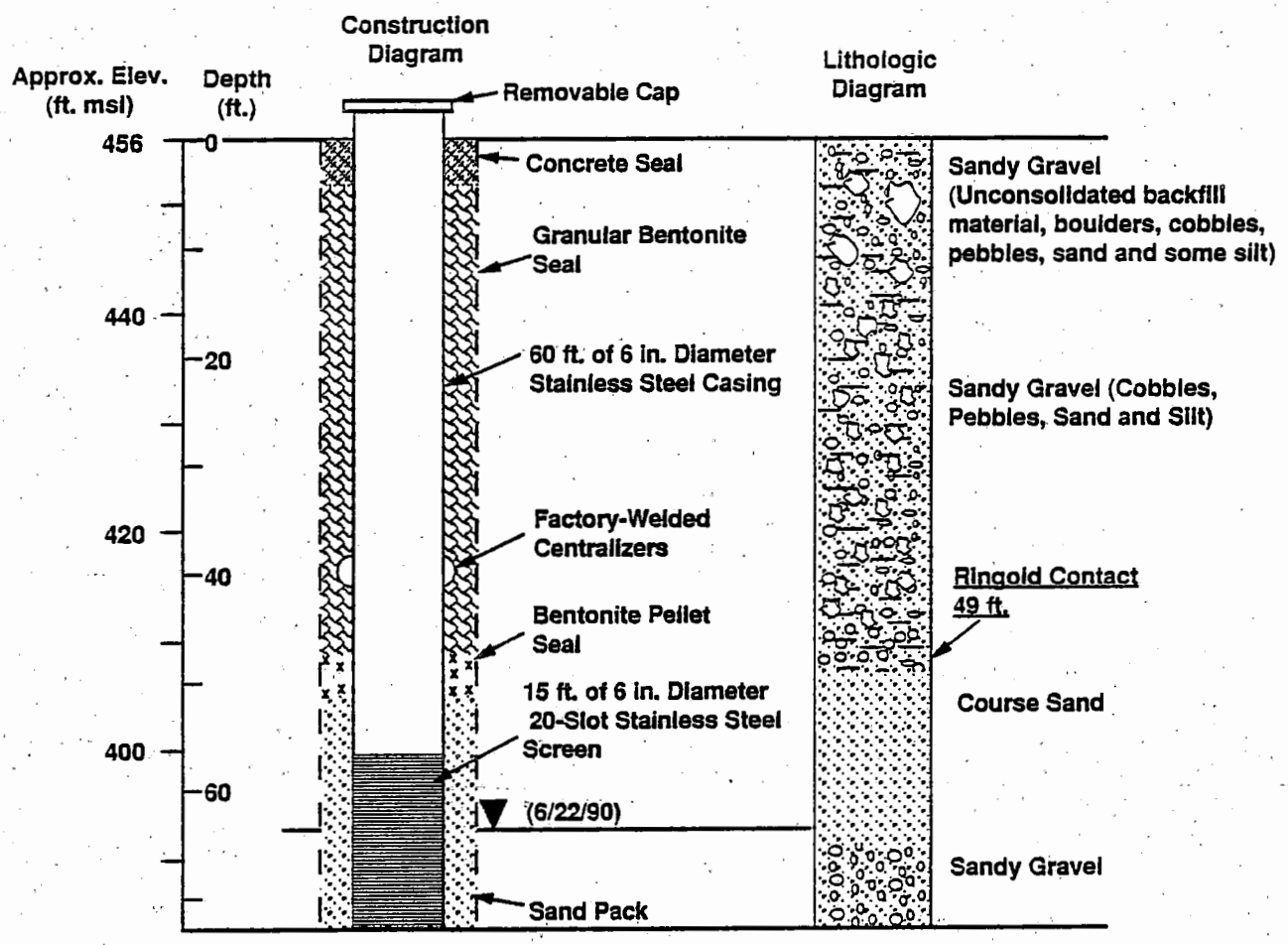
▼ (6/22/90) = Water table and date measured

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

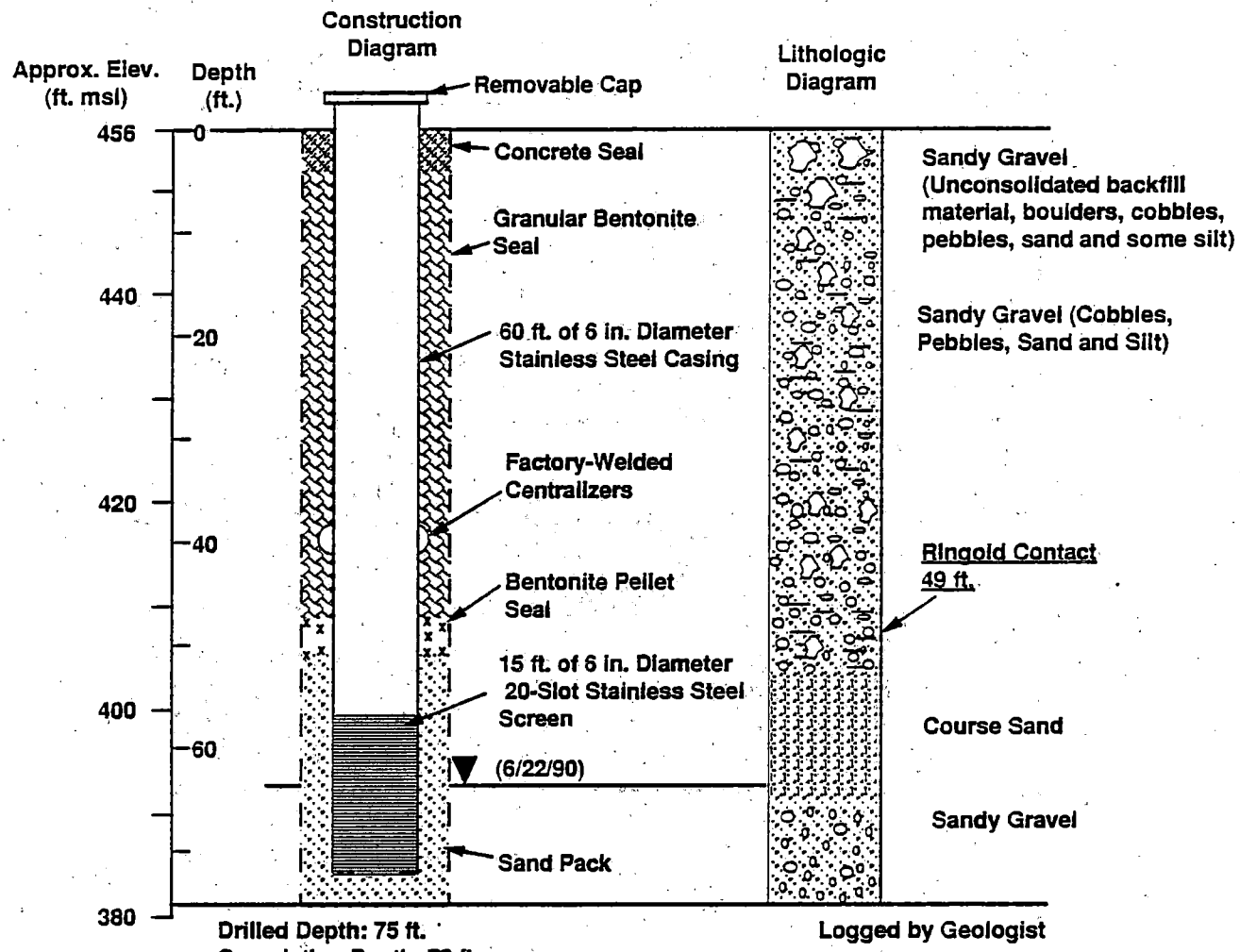
▼ (6/22/90) = Water table and date measured

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

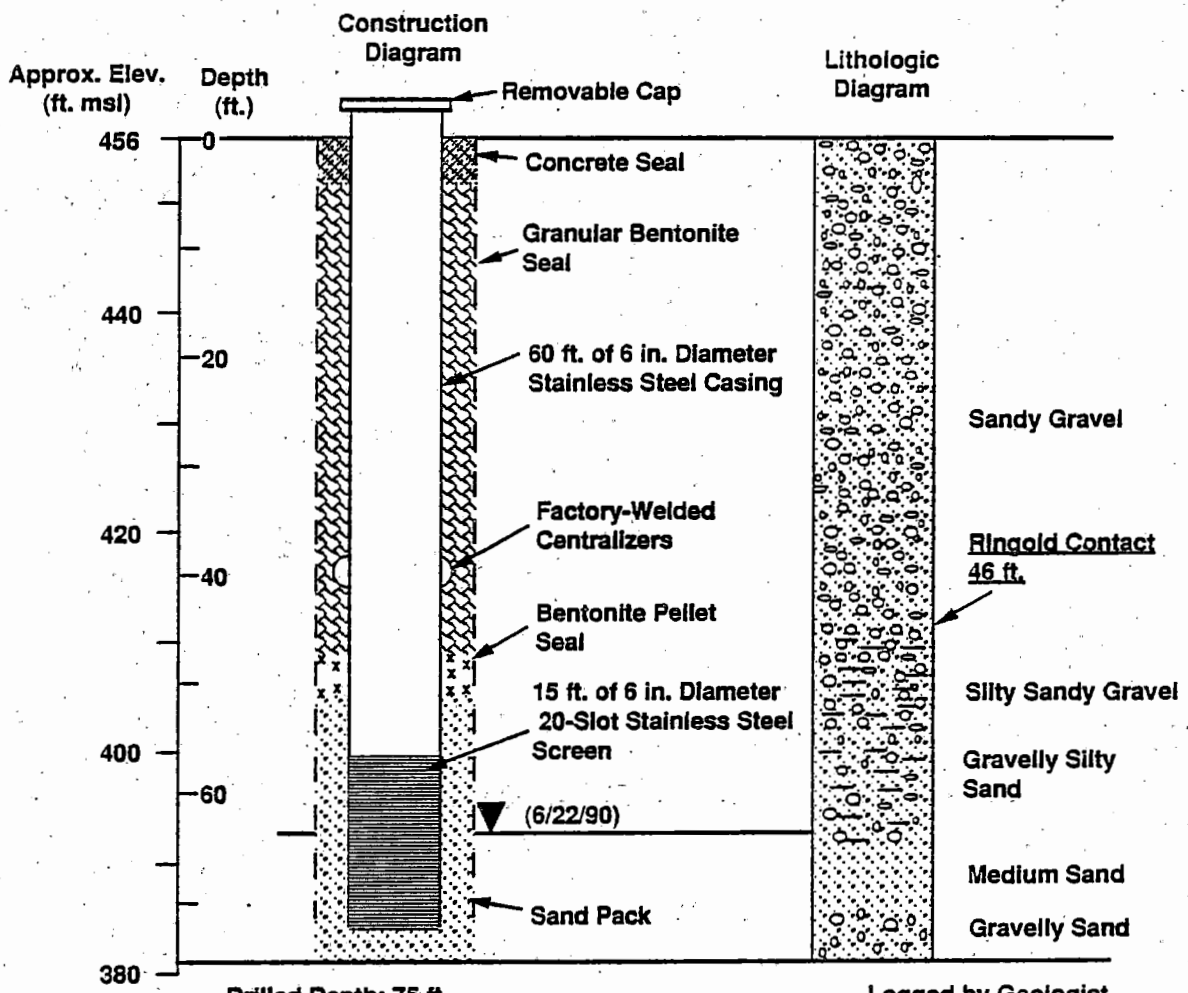
▼ (6/22/90) = Water table and date measured

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

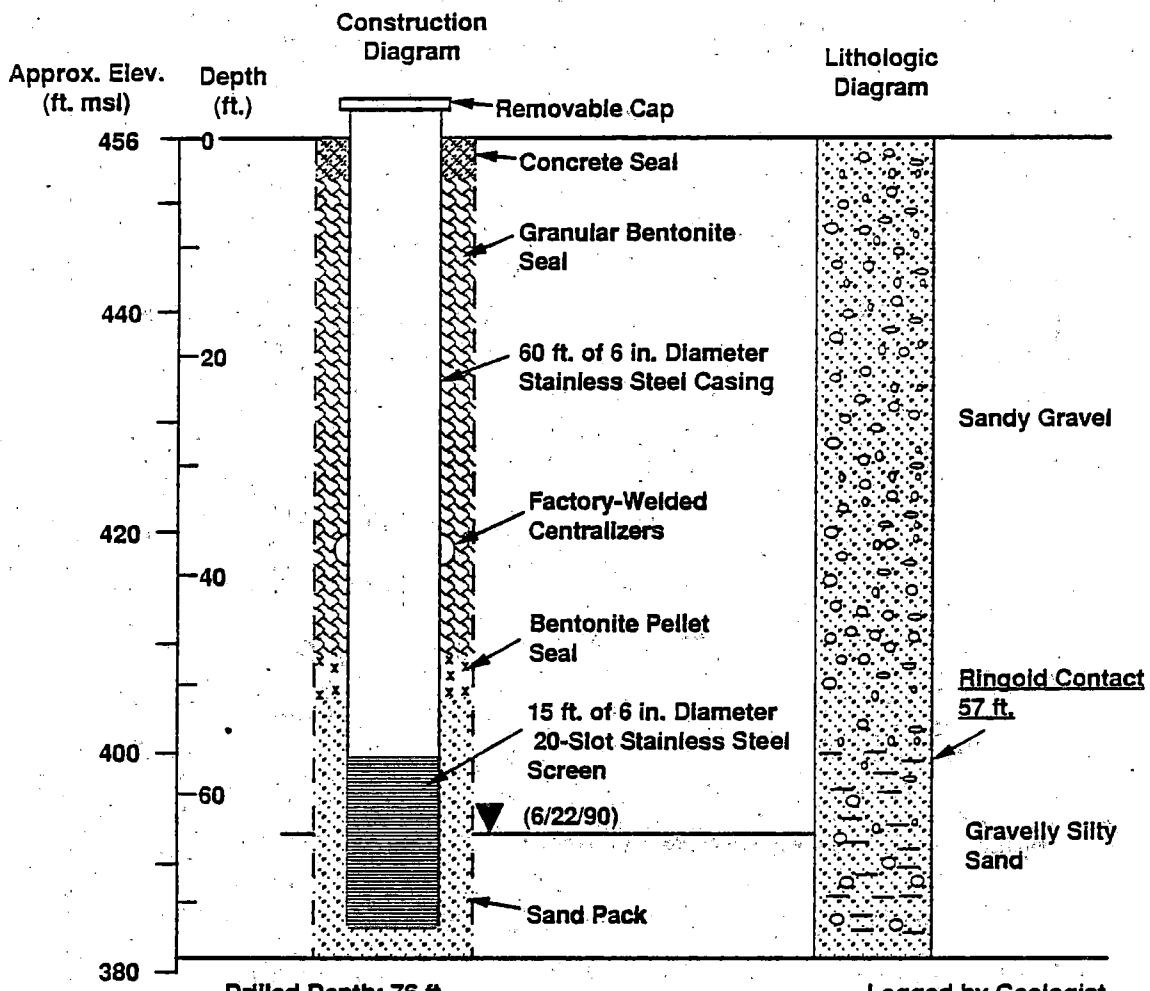
▼ (6/22/90) = Water table and date measured

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

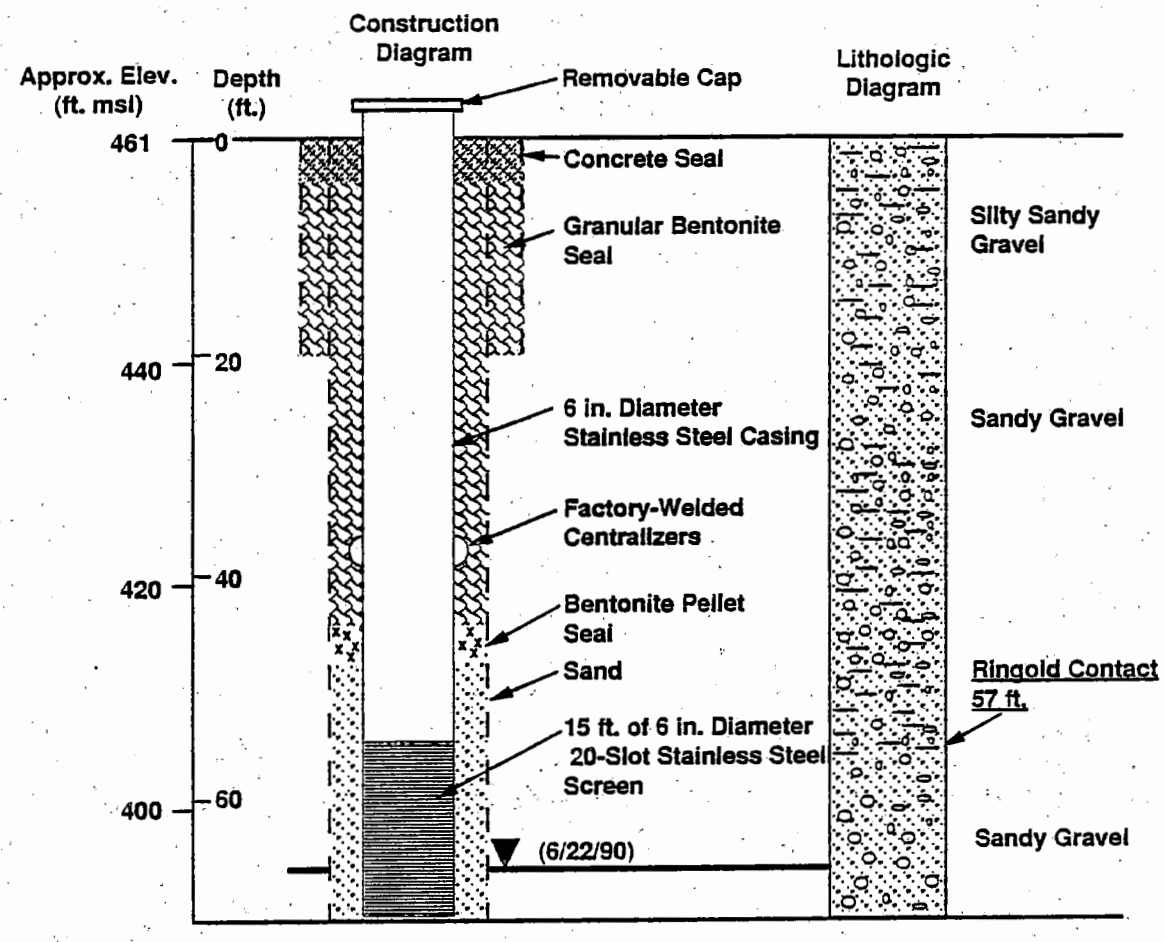
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

39008007.14

All depths are in reference to land surface

Well 199-N-58



Drilled Depth: 71 ft.
Completion Depth: 70 ft
Completion Date: 11/87
Elevation Top of Casing: 462.88 ft. msl

Logged by Geologist

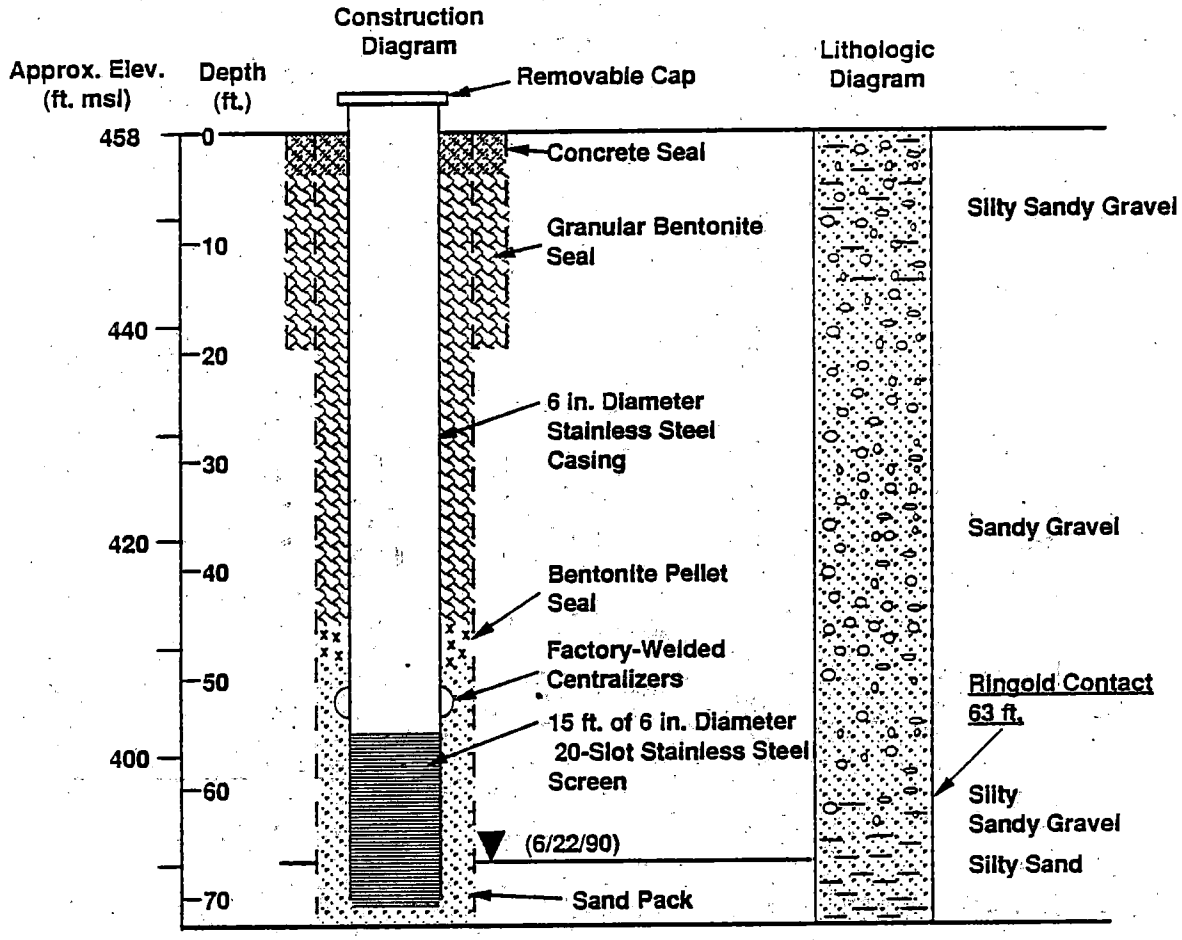
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.13

Well 199-N-59



Drilled Depth: 73 ft.
Completion Depth: 72 ft
Completion Date: 11/87
Elevation Top of Casing: 459.53 ft. msl

Logged by Geologist

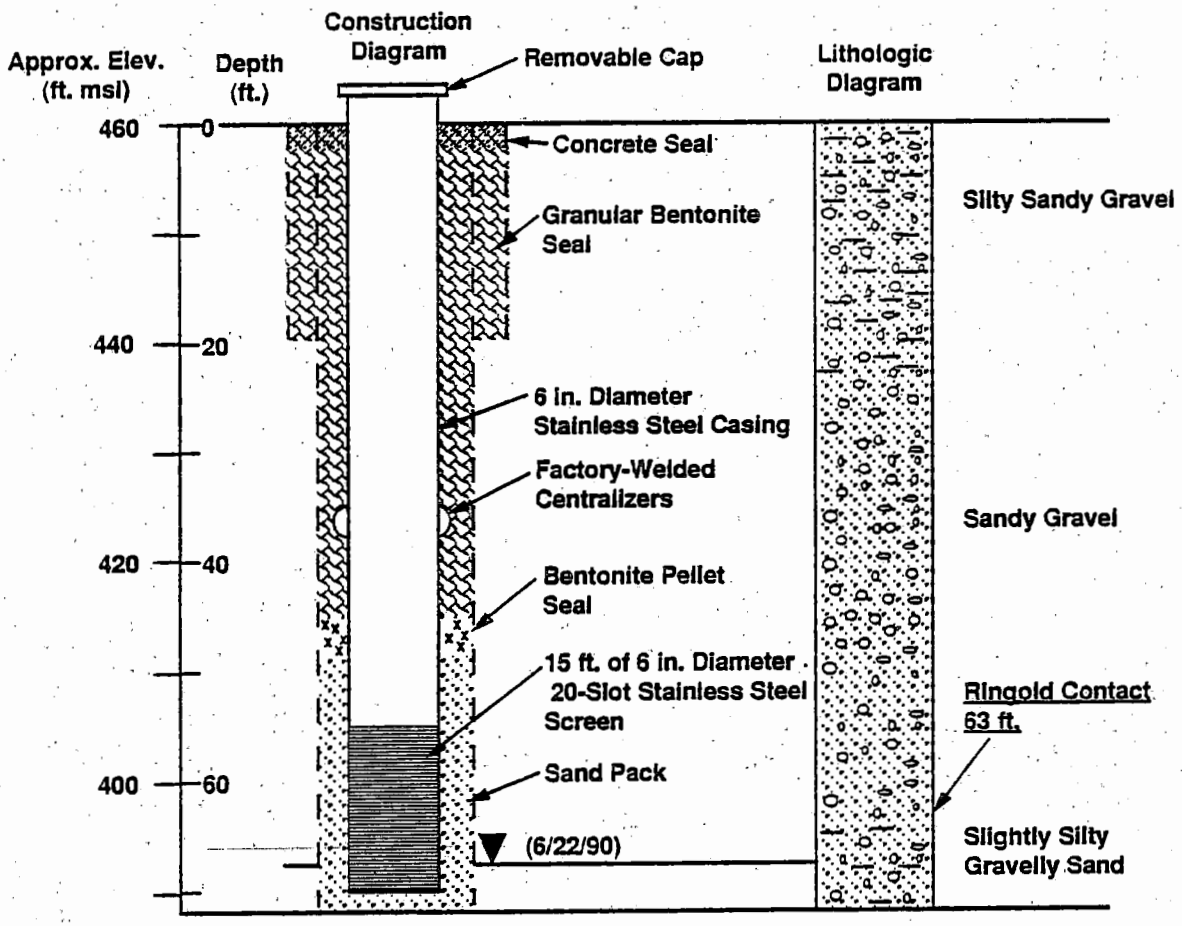
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.12

Well 199-N-60



Drilled Depth: 72 ft.
Completion Depth: 70 ft
Completion Date: 11/87
Elevation Top of Casing: 461.94 ft. msl

Logged by Geologist

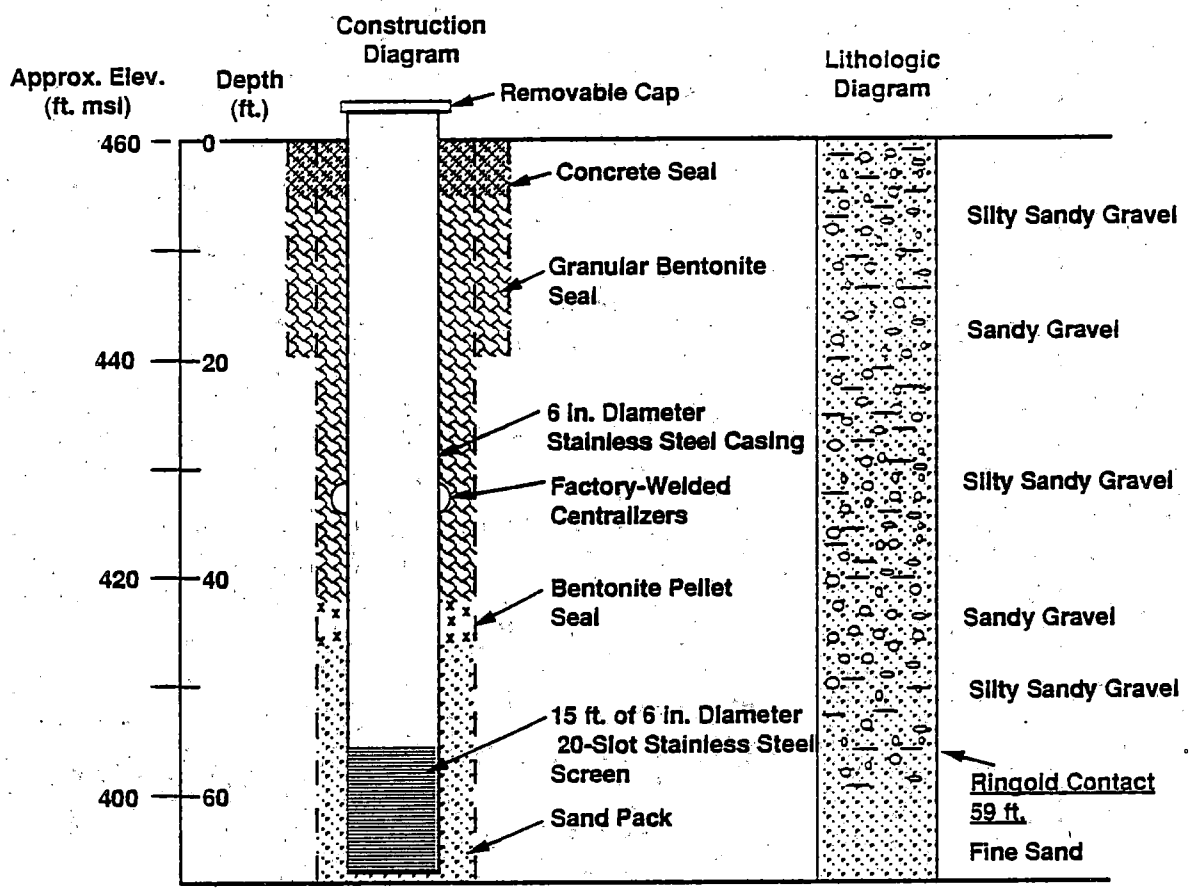
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.11

Well 199-N-61

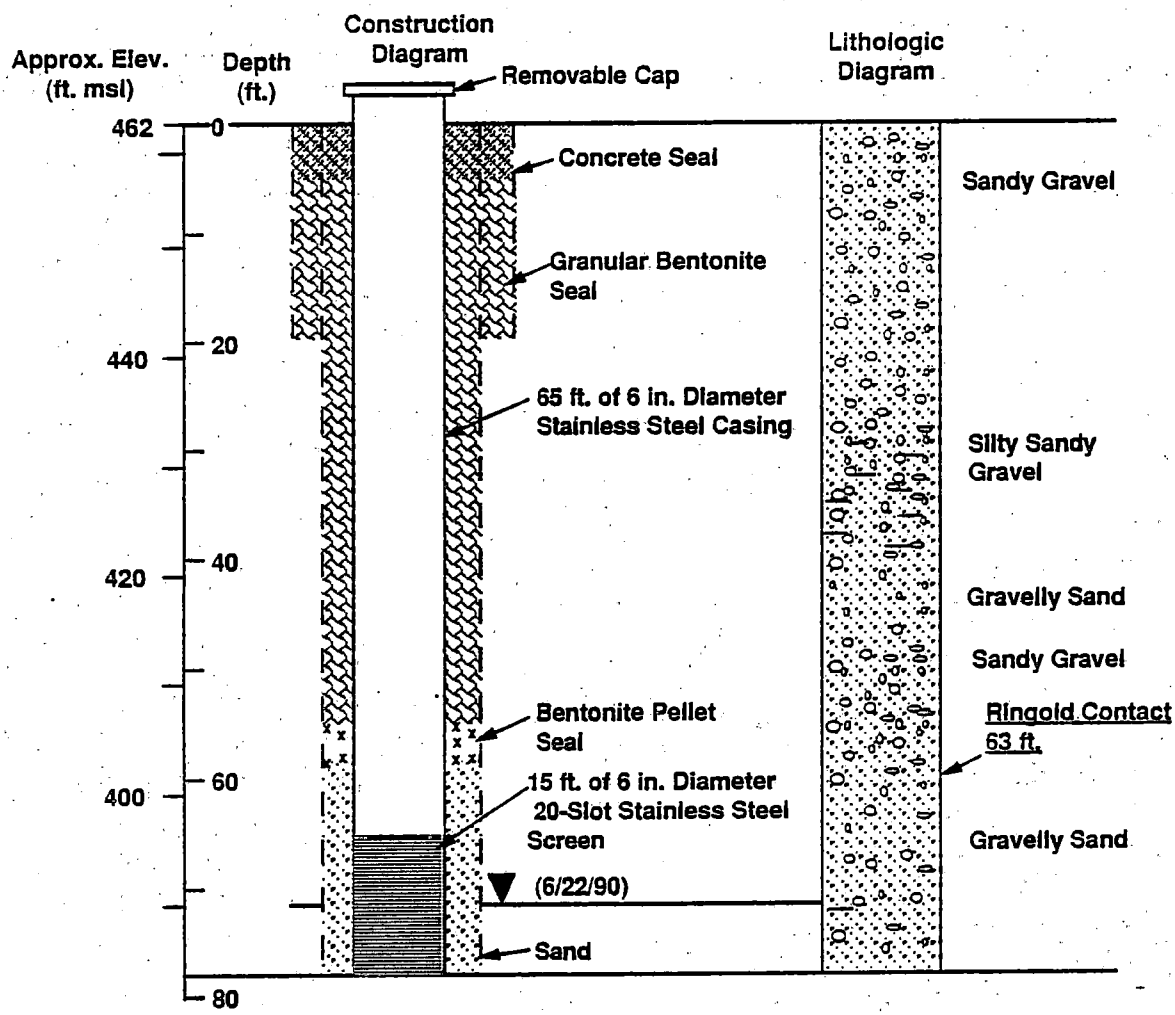


Drilled Depth: 68 ft.
Completion Depth: 67 ft
Completion Date: 11/87
Elevation Top of Casing: 462.02 ft. msl
Dry Well 6/22/90
ft. msl = Feet above mean sea level
All depths are in reference to land surface

Logged by Geologist

39008007.10

Well 199-N-62



Drilled Depth: 78.5 ft.
Completion Depth: 78.5 ft
Completion Date: 10/87
Elevation Top of Casing: 463.59 ft. msl

Logged by Geologist

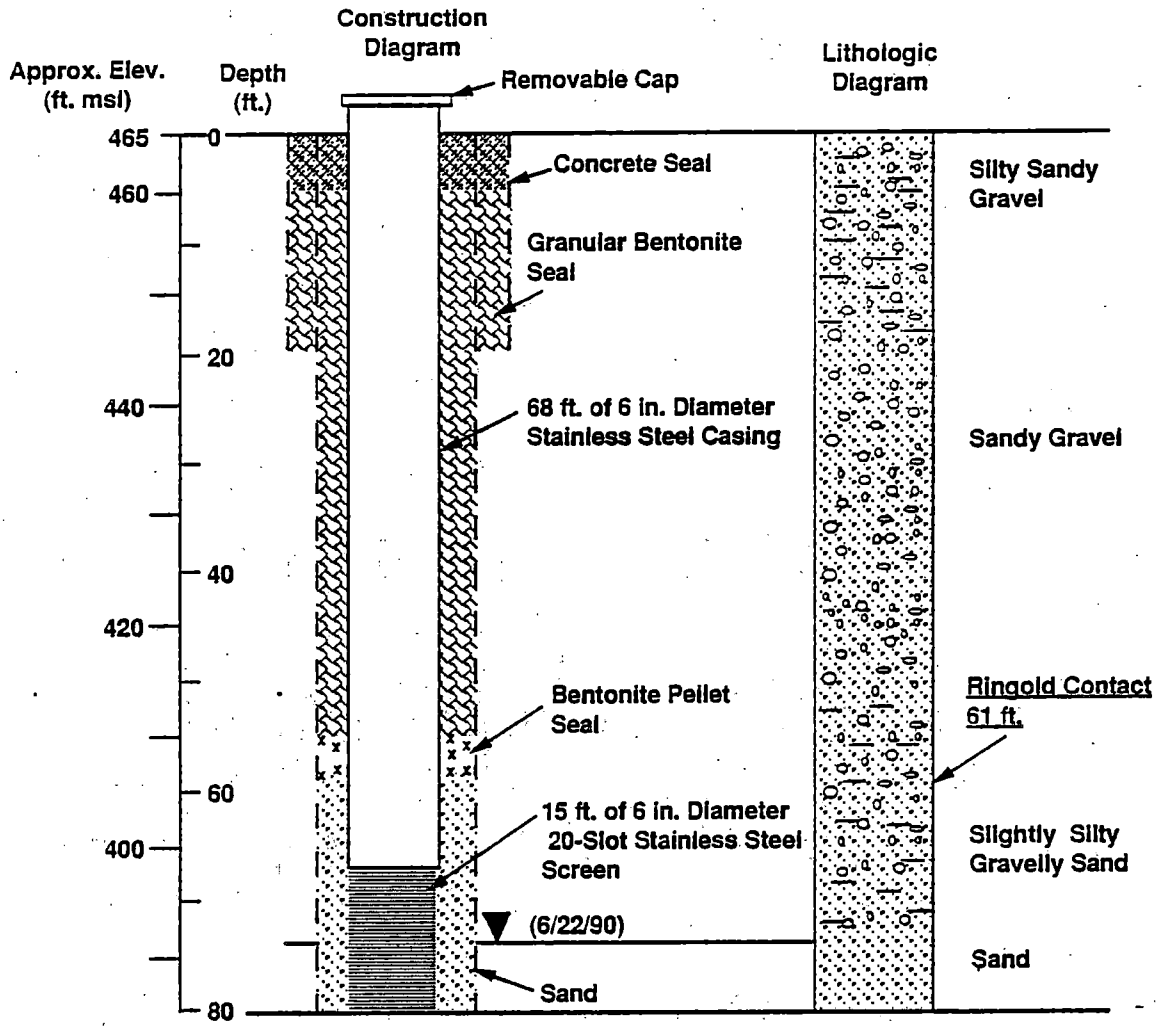
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.9

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

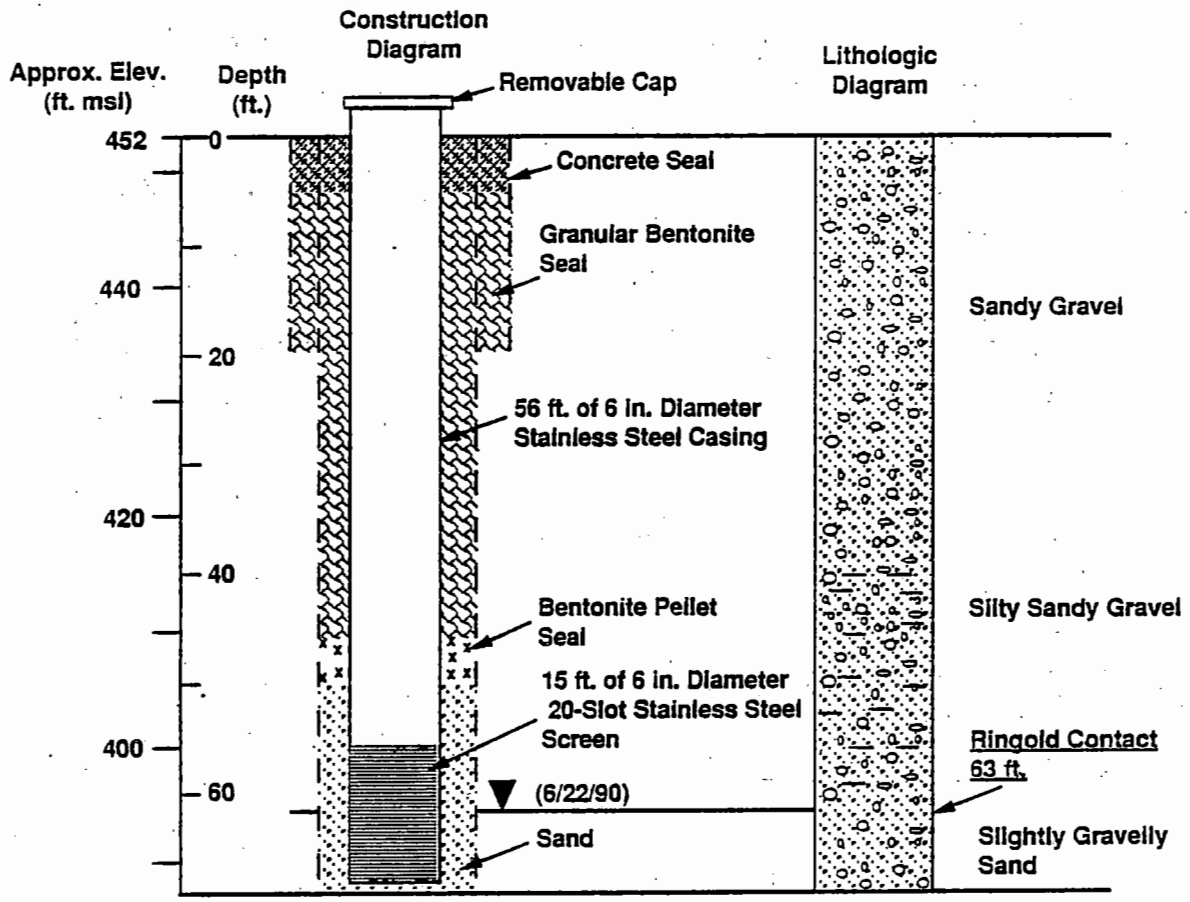
▼ (6/22/90) = Water table and date measured

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

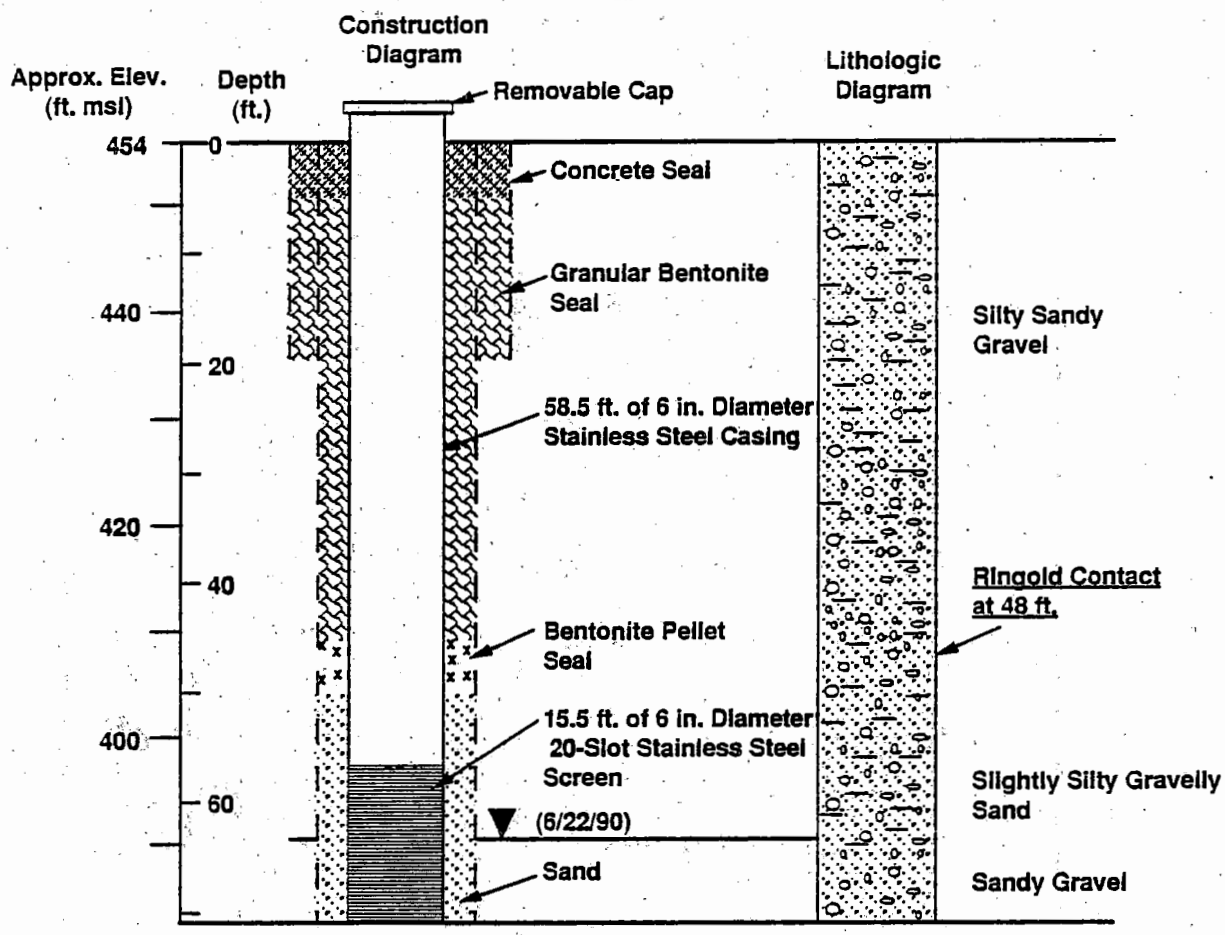
▼ (6/22/90) = Water table and date measured

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

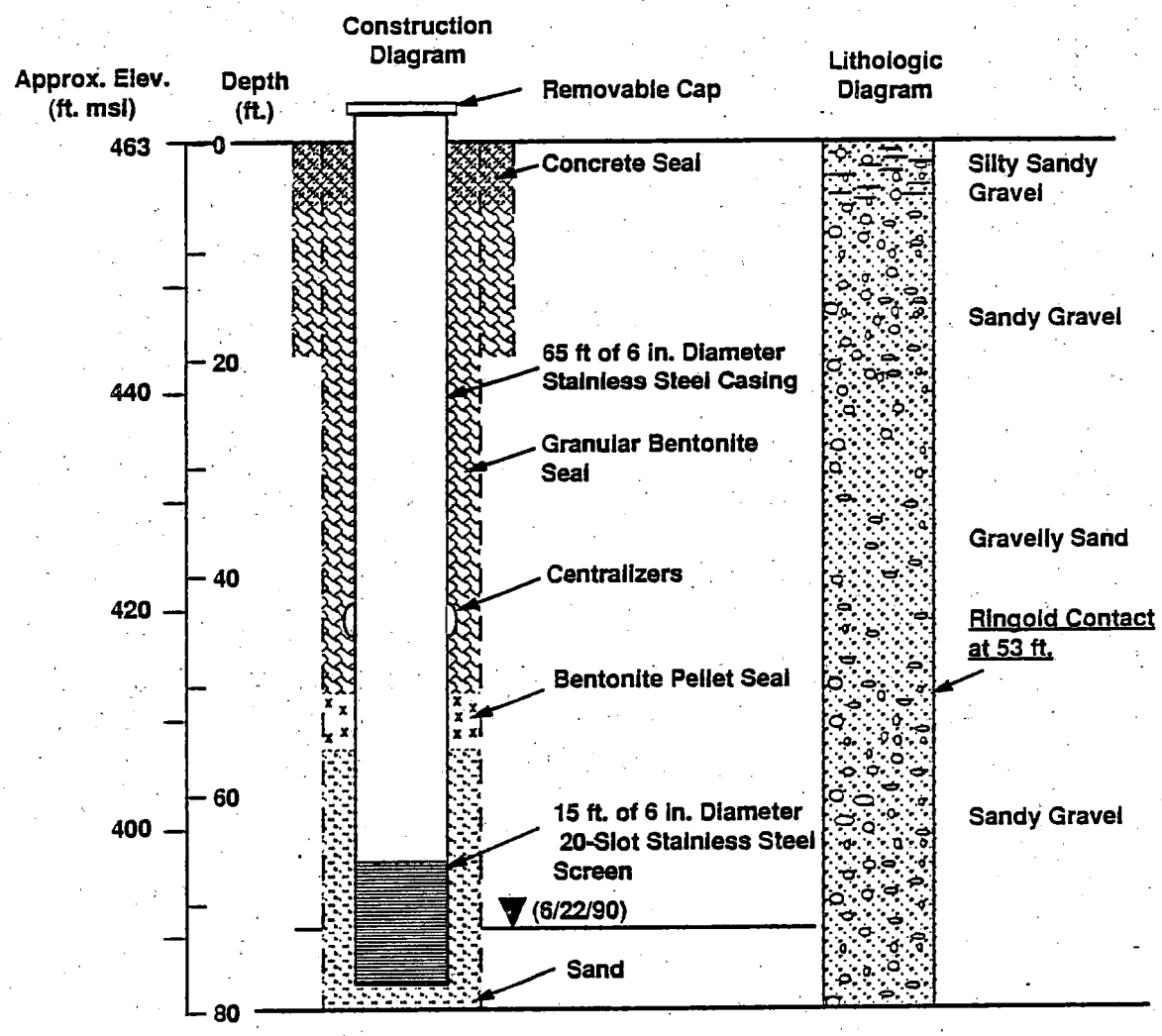
▼ (6/22/90) = Water table and date measured

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

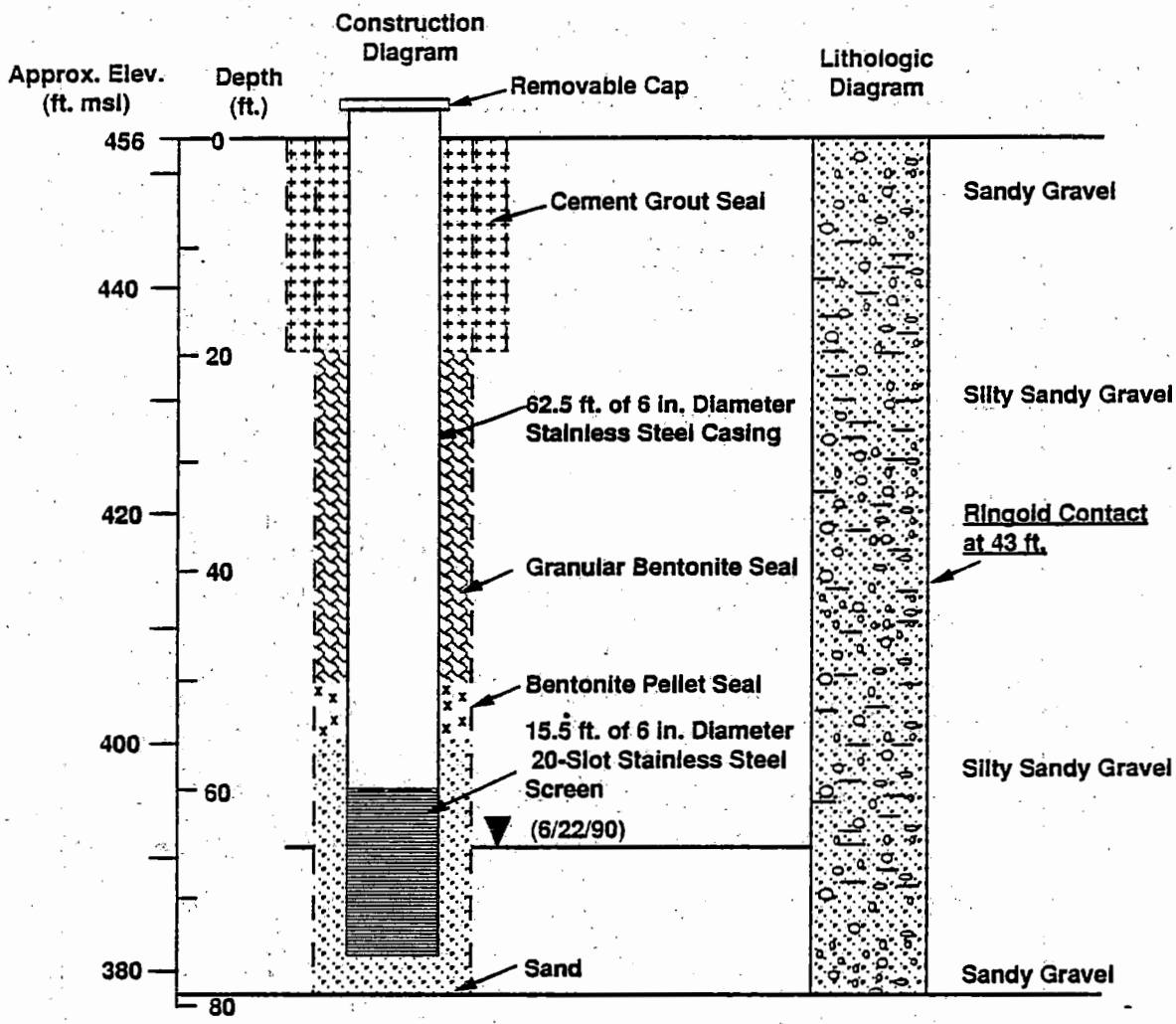
▼ (6/22/90) = Water table and date measured

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

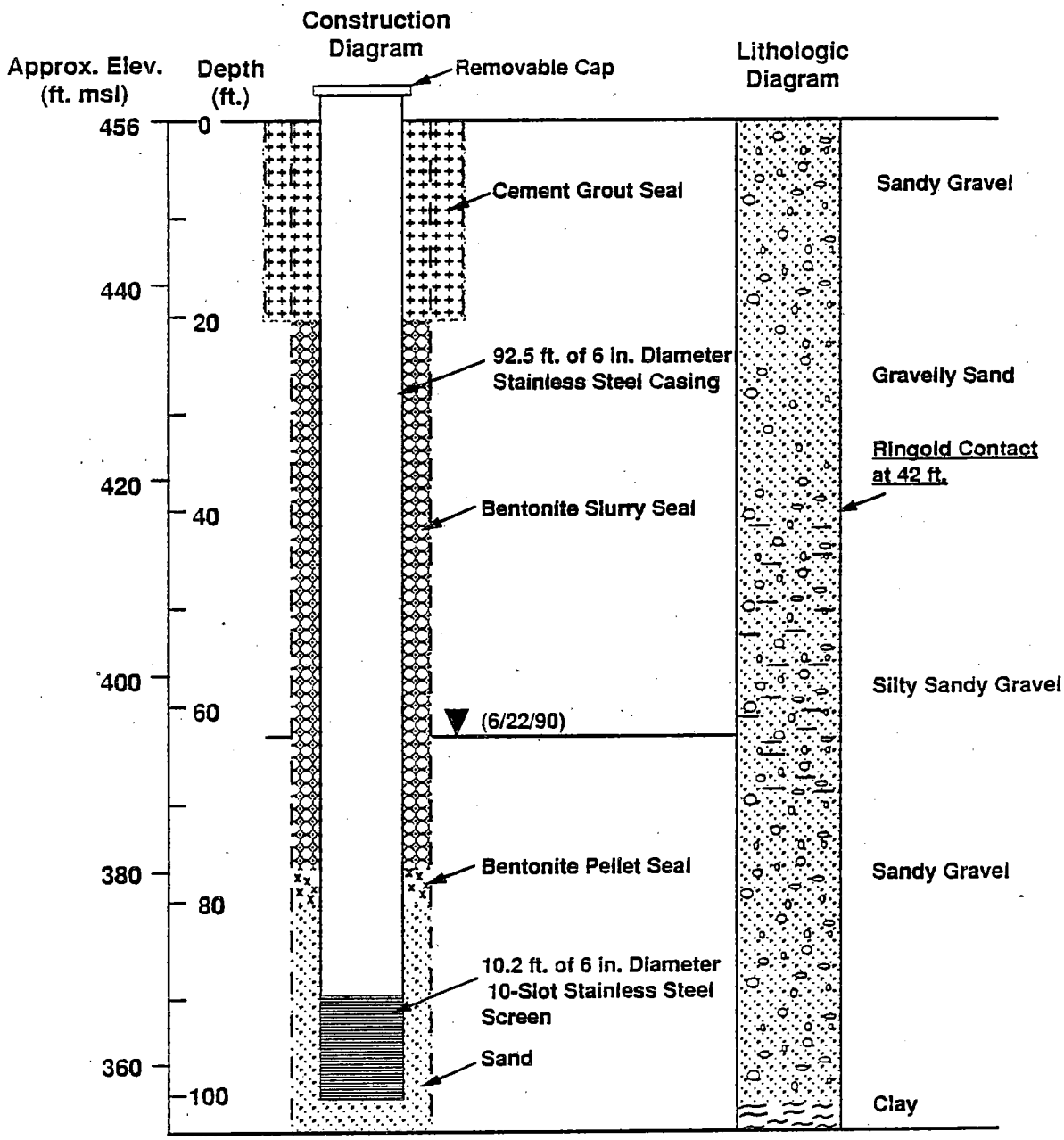
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.4

Well 199-N-69



Logged by Geologist

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

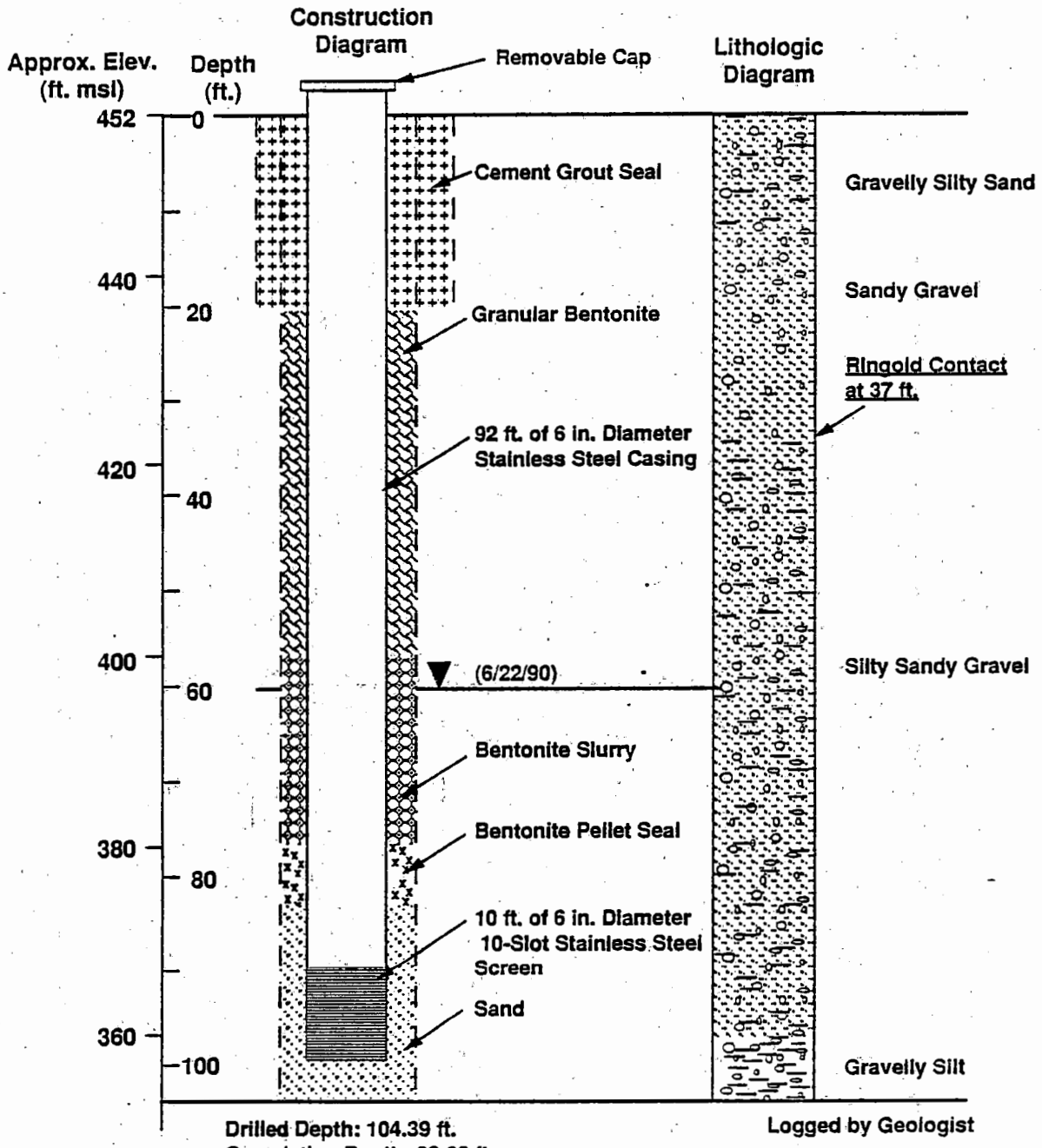
▼ (6/22/90) = Water table and date measured

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

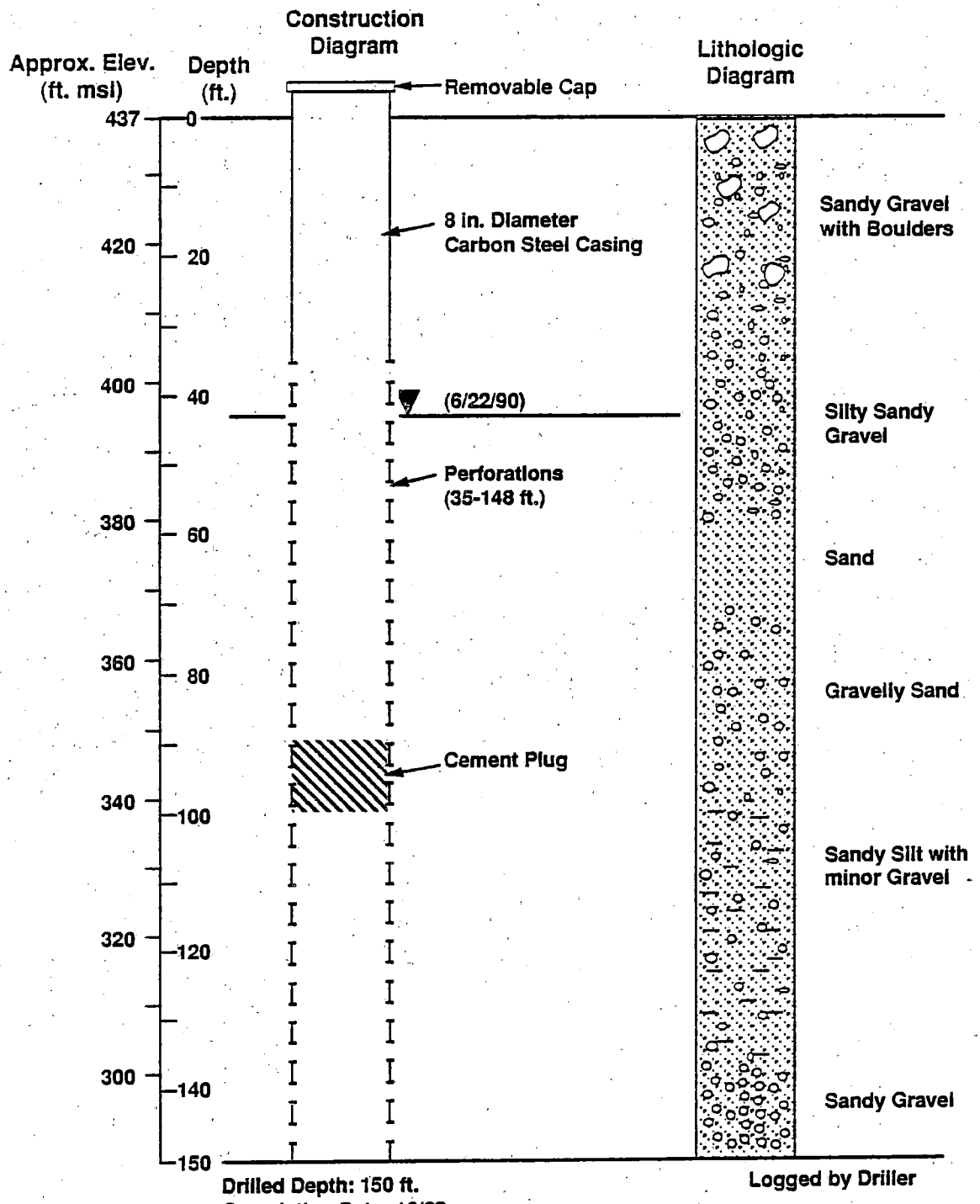
▼ (6/22/90) = Water table and date measured

ft. msl = Feet above mean sea level

All depths are in reference to land surface

39008007.2

Well 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

9613493.0061

APPENDIX B

100-N AREA AQUIFER TESTS

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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). Aquifer testing of wells N-30, N-32, and N-27 was 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.

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.

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.

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 analyzed 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.

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).

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.

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 gpm. 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.

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 screen in 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.

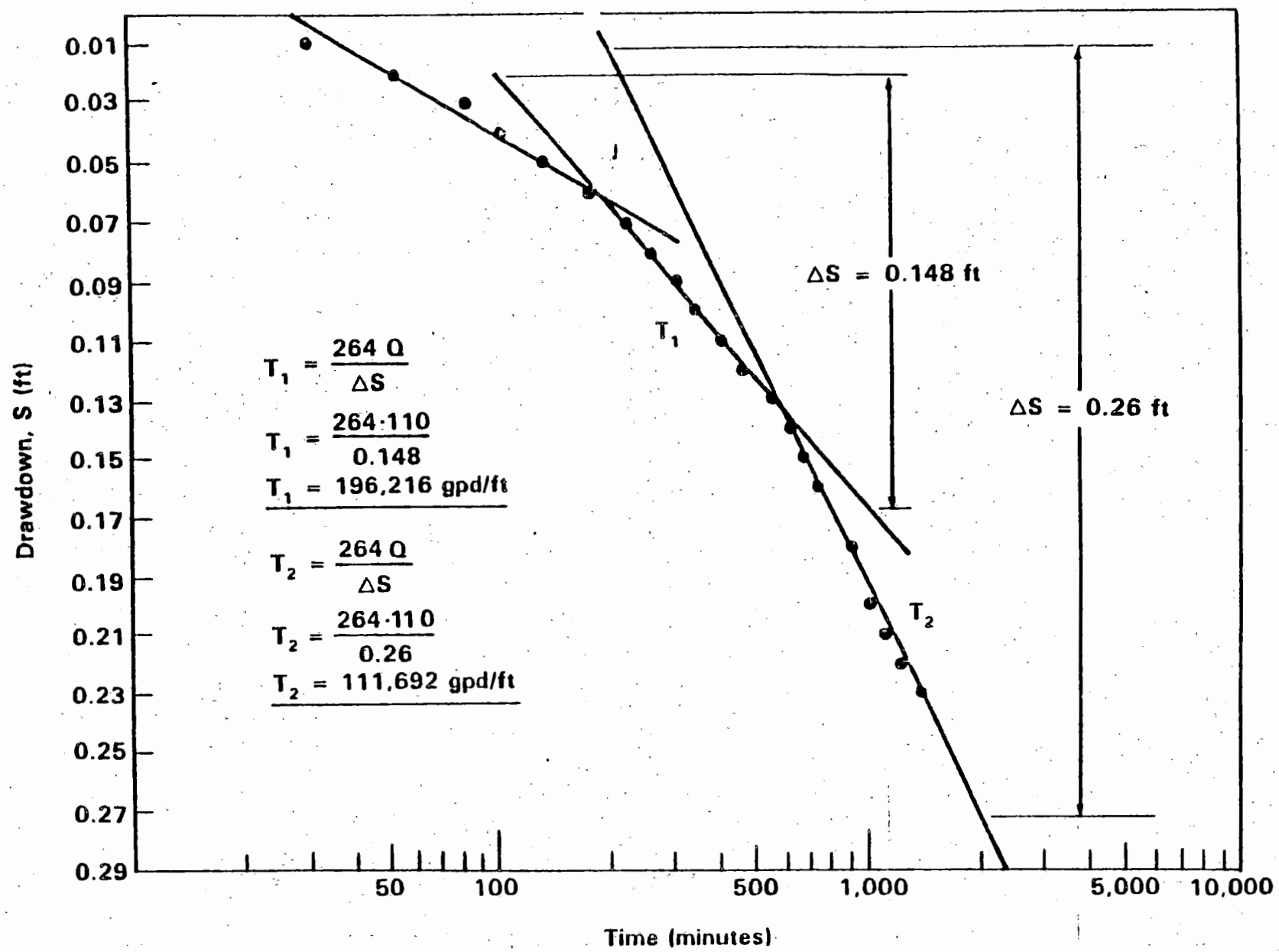


Figure B-1. N-34 Drawdown Data.

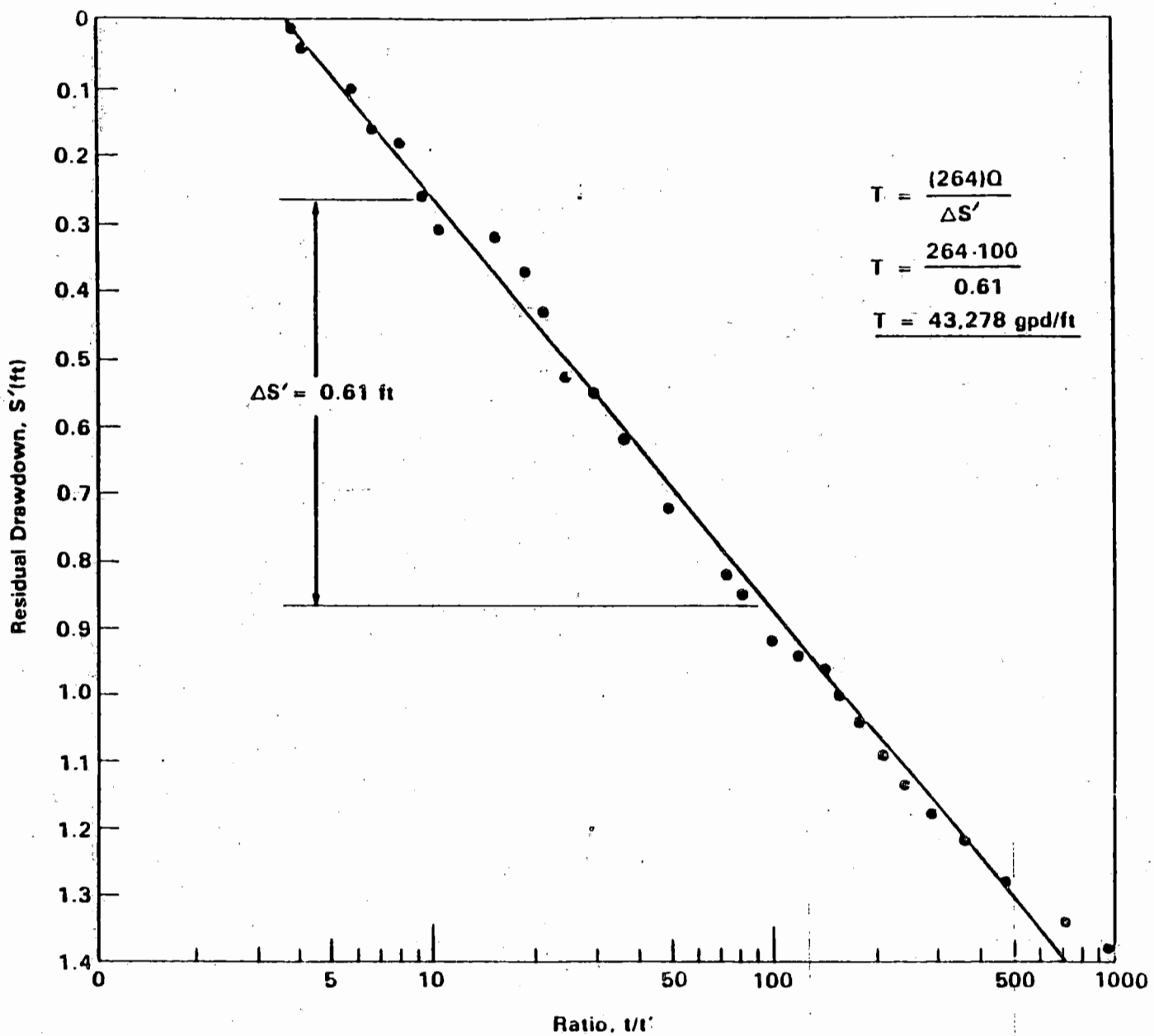


Figure B-2. N-32 Recovery Data.

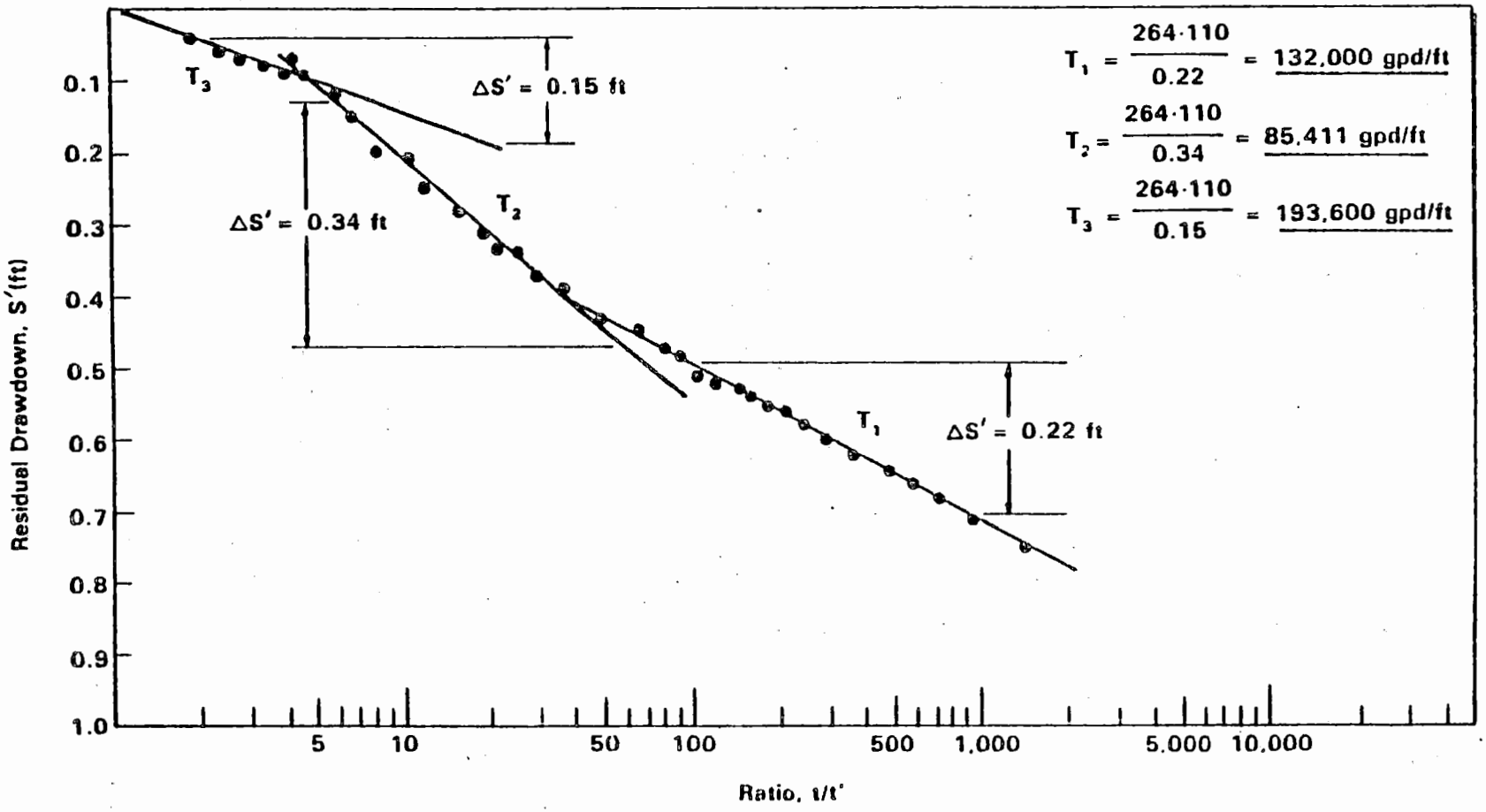


Figure B-3. N-27 Recovery Data.

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 900T (Data Industrial)
How W.L.'s Measured E-tape (Slope Indicator) S.N. 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 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 10psi xD. Began baseline data on Terra @ approx. 0830hrs.
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		96511(00)		DRN	approximately 2.5'
		1			–		DRN 8:55	–				DRN	of water in bottom
1		1.5			–	* tremie top of tremie				pipe is		DRN	of well @ 0810 hrs.
		2			70.69'	0.26' from top of casing		1.33				DRN	76.3 gpm @ 9:30:30
		2.5			–			–				DRN	Air in line during
		3			70.71			1.35				DRN	first min. of pumping
		4.5			70.73			1.37				DRN	77.6 gpm @ 9:33:30
		5			70.74			1.38				DRN	± 0.1 gpm
		6			70.74			1.38				DRN	77.3 ± 0.2 gpm @
		7			70.75			1.39				DRN	0939 hrs.
1		8			70.76			1.40				DRN	
		9			–			–				DRN	
		10			70.77			1.41				DRN	discharge varies from
		16			70.79			1.43				DRN	76.8 to 77.5 gpm.
										96650(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
												Digitizer turned over	@ 0956 hrs
										96740(00)		@ 0959 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 96911(00) gal hrs @ 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 @ 1040 hrs.
		100			70.89			1.53	turned to	97330(00)		DRN	76.7 ± 0.1 gpm @ 1041 hrs.
		120			70.90			1.54		@ 11:15:20		DRN	76.7 ± 0.1 gpm @ 11:16 hrs.
	1200	150			70.92	All E-tape		1.56	turned	97690(00)		DRN	76.9 to 77.3 gpm @ 1201 hrs.
		180			70.94'	measurements made from		1.58		@ 12:42:55		DRN	
		210			70.95'	70' mark		1.59		98150	@ 1301:25	DRN	77.0 ± 0.1 gpm @ 1301 hrs.
		240			70.97'			1.61				DRN	
	1400	270			70.99'			1.63		98620	@ 1401:17	DRN	~77.0 gpm @ 1401 hrs
		300			71.00			1.64				DRN	
		330			71.015'			1.655		99030	@ 1501:50	DRN	77.2 gpm @ 1501 hrs.
✓	1530	358			71.02'			1.66	final	99290		DRN	Shut pump off @ 1530 hrs.
										1540 hrs			Flow rate has fluctuated
													between 76.4 and 77.6 gpm
													during pump test

Q_{AVG} = 77.2 gpm

Aquifer Test Data

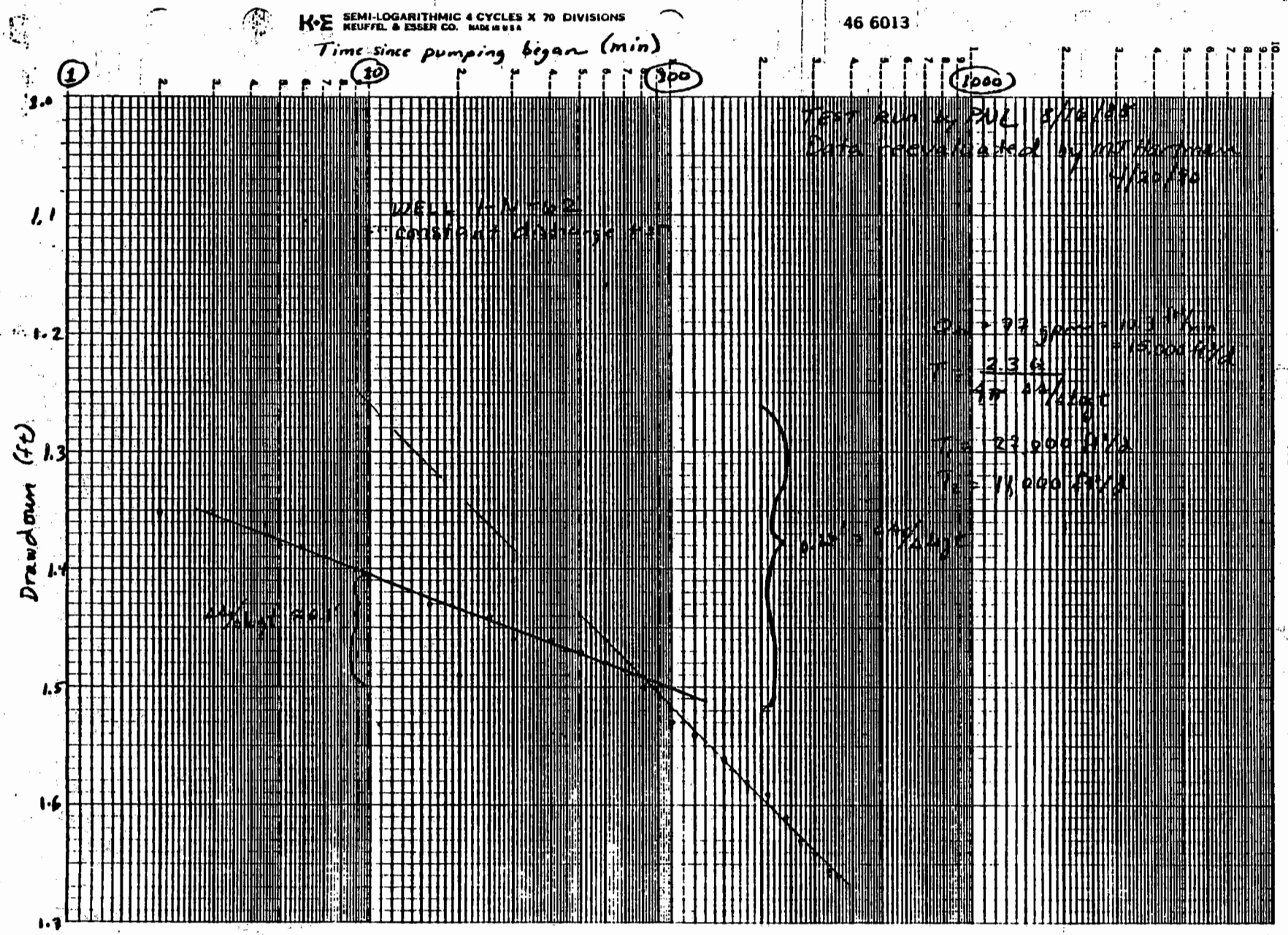
page 2 of 2

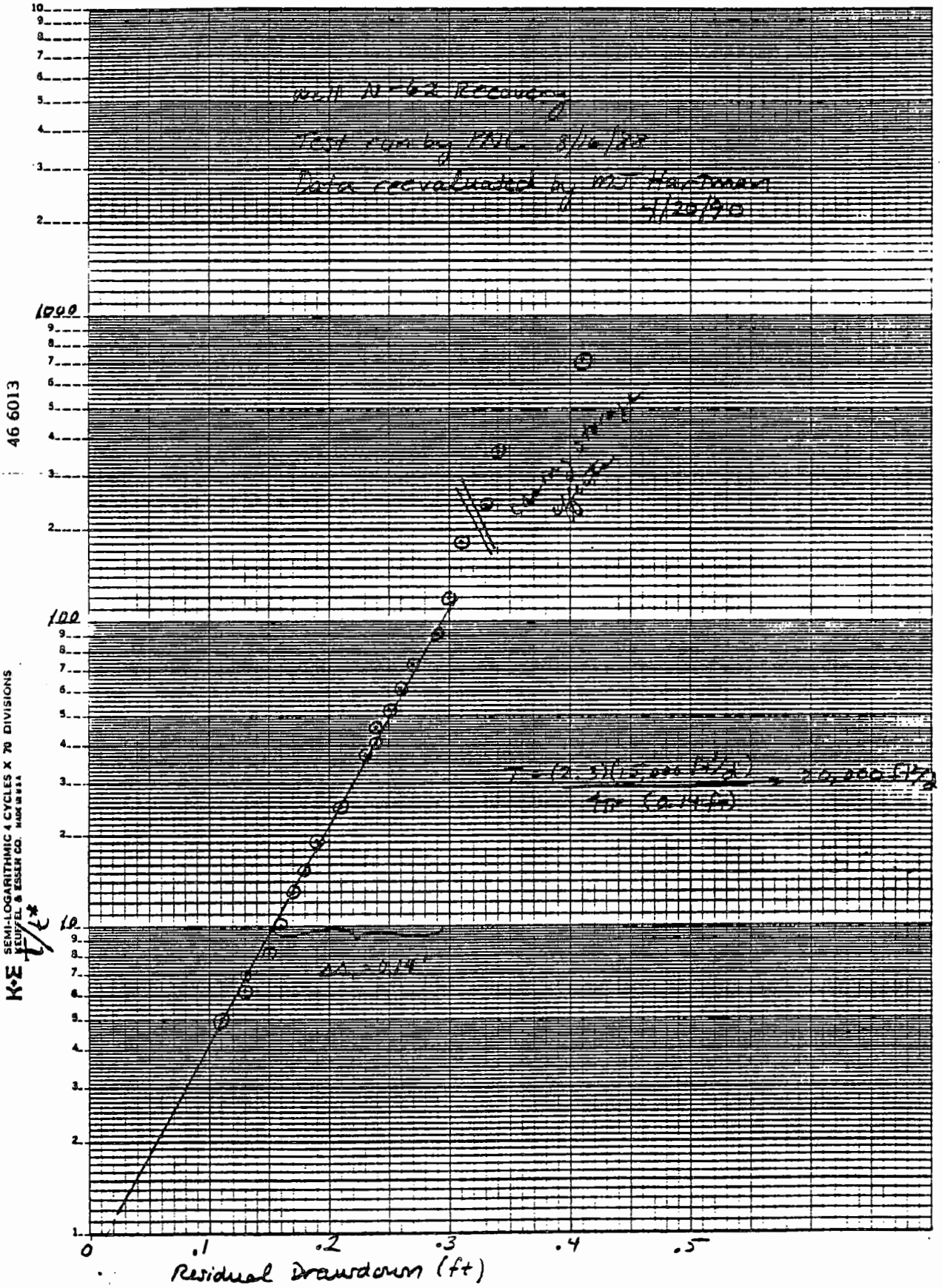
Data for Well 199-N-62
Pumping Well 199-N-62
Observation Wells None

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) S.N. 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	Began baseline data on Terra @ approx 15N hrs. Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
recovery test 8/16	1530	360	0	–	~~69~~ DRN 8-16-88			~~0.44~~ DRN 8-16-88				DRN	pump shut off
		3695	0.5	721	69.77			0.41				DRN	@ 1530 hrs.
		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	~~1500~~ 450	90	5	69.47			0.11				DRN	
		DRN 8-16-88											Stopped logging data on Terra datalogger @ 1701 hrs


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 1-N-02
constant discharge
TEST RUN by PNL
Data reevaluated by
4/20/90


Well N-62 Recovery
Test run by PNL 8/16/88
Data reevaluated by MJT Hartman 4/20/90
T = (2.3)(15,000 gal/d) / 4π (0.14 ft) = 20,000 GPD/ft
Δs = 0.14'
t/t*
Residual Drawdown (ft)
0
.1
.2
.3
.4
.5
1
10
100
1000
K+E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
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.

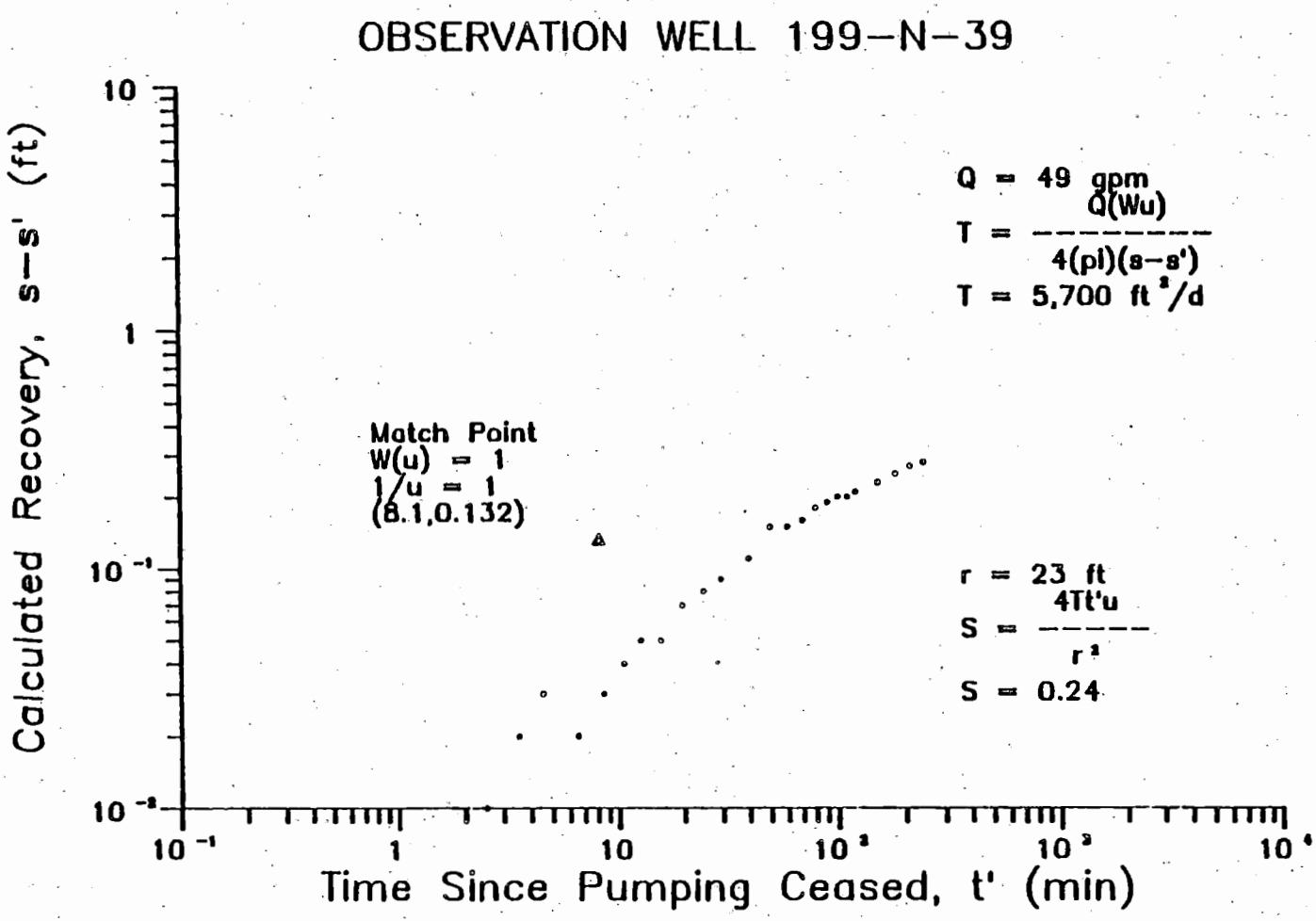
SUMMARY

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
Calculated Recovery, s-s' (ft)
Time Since Pumping Ceased, t' (min)
10
1
10 -1
10 -2
10 -1
1
10
10 2
10 3
10 4
Q = 49 gpm
T = Q(Wu) / 4(pi)(s-s')
T = 5,700 ft 2/d
Match Point
W(u) = 1
1/u = 1
(8.1,0.132)
r = 23 ft
S = 4Tt'u / r 2
S = 0.24

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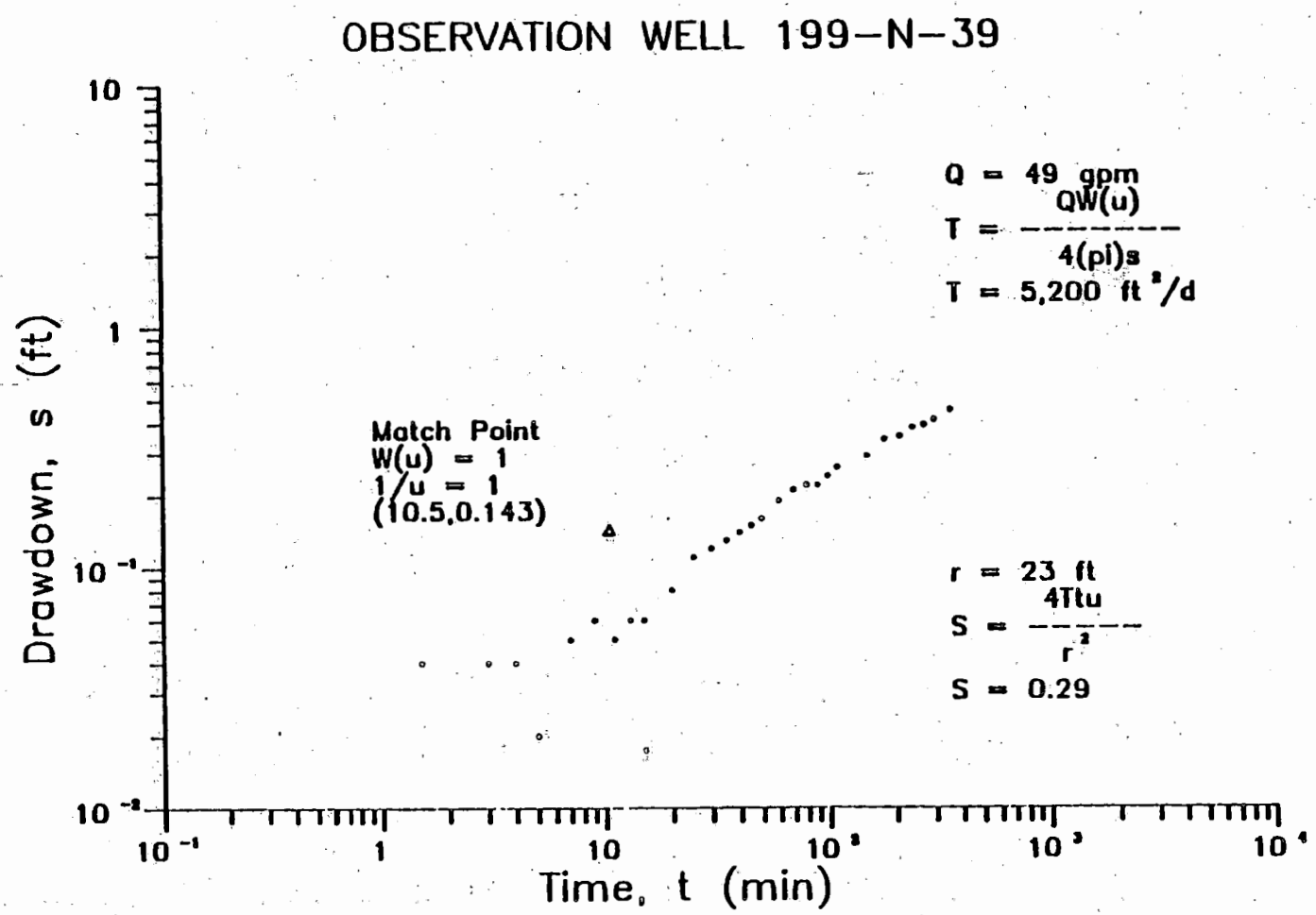
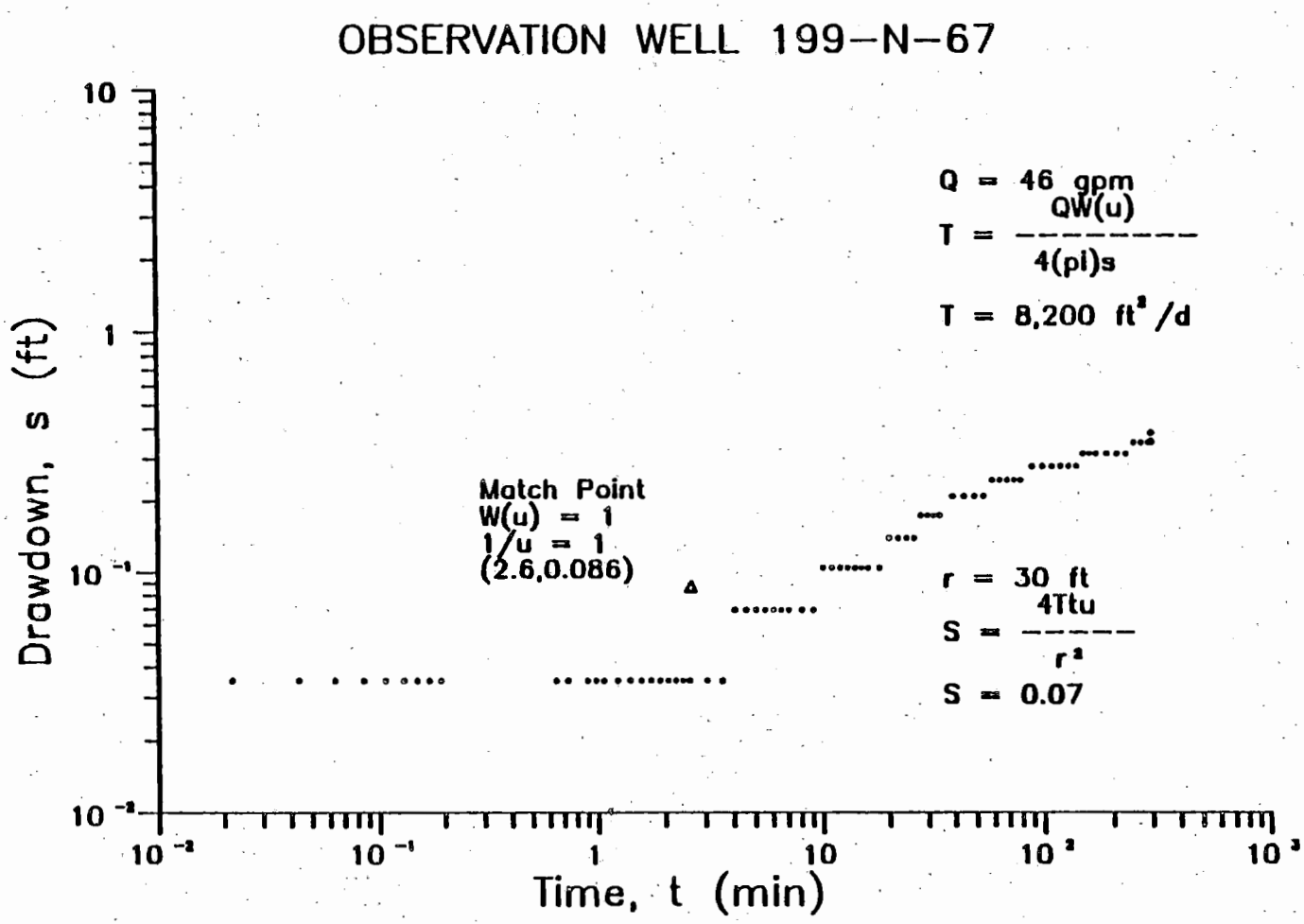
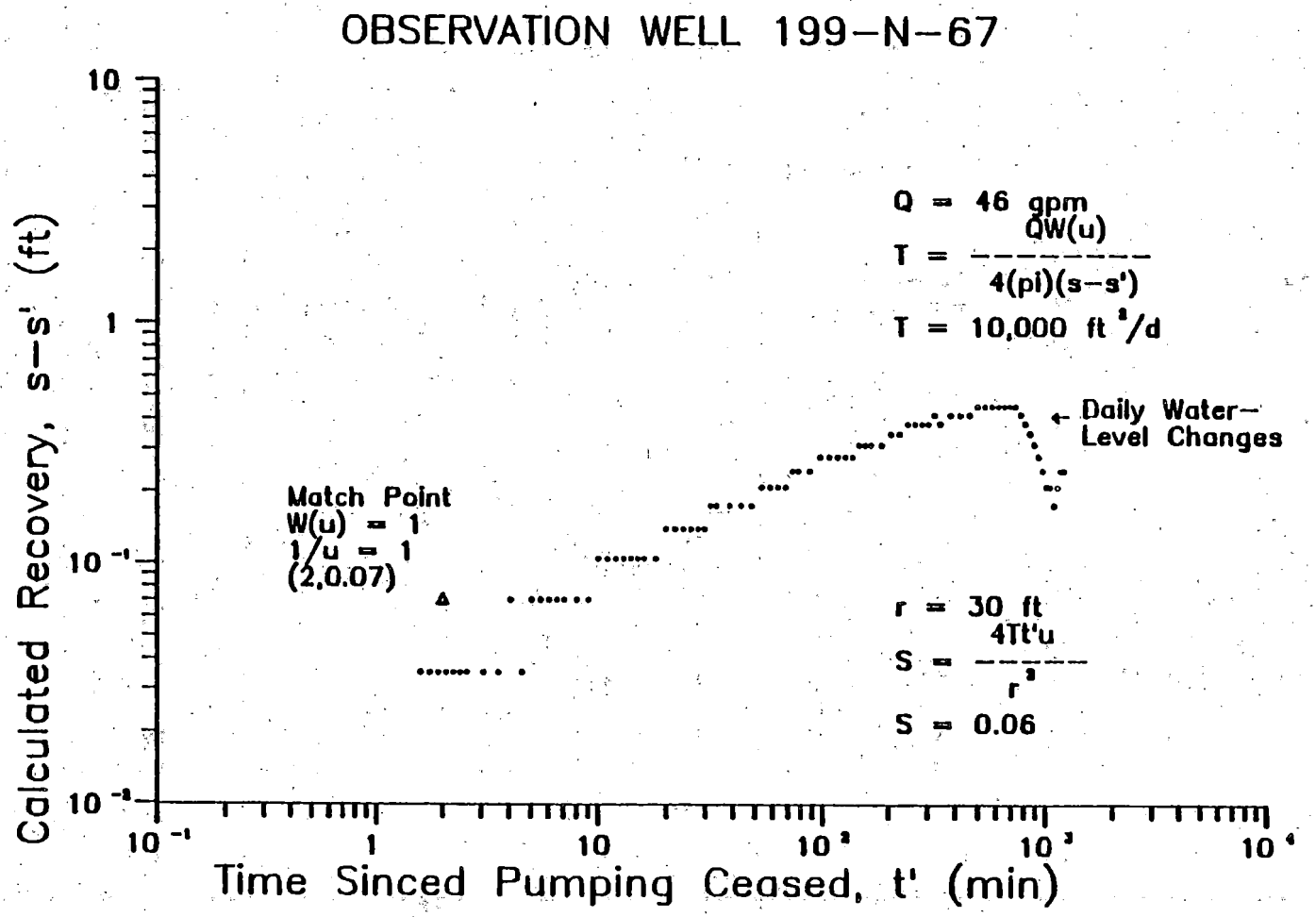



OBSERVATION WELL 199-N-67
Q = 46 gpm
T = QW(u) / 4(pi)s
T = 8,200 ft²/d
Match Point
W(u) = 1
1/u = 1
(2.6,0.086)
r = 30 ft
S = 4Ttu / r²
S = 0.07
Drawdown, s (ft)
Time, t (min)
10
1
10⁻¹
10⁻²
10⁻²
10⁻¹
1
10
10²
10³



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Aquifer Test Data

page 1 of 3

Data for Well 199-N-69

Pumping Well "

Observation Wells 199-N-67

Location 199-N-69

Type of Aquifer Test Step 2D / Development

How Q Measured Digital Flowmeter

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

Depth of Pump/Airpipe ~90' / well depth ~100

Rad./Dist. of/From Pumping Well

Pump On: date 6/9/88 time 0915 step 2:

Meas. Point for W.L.'s T/C 1.43' 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/ brass marker

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			—							CSC	Turn Kuney & [illegible]
1	0945	30			86.37	only doing					47		Dump
1	0953	98			86.87	one step					46.5		0-10 psi trans. in
1						point where to							well 199-N-67
1						DD below pump							0-15 psi trans. in
1													well 199-N-69
1													value is open
1													only 1 line
1	1026	130			86.87								
1	1030	135	0							92.1200			Recovery from
1		135.5	.50		71.30								Development
1		136	1		68.99								1st composite sample
1		137	2		68.06								at 1015 hr
1		138	3		67.94								
1		139	4		67.99								Transducer in
1		140	5		68.00								Observation well
1		143	8		67.99								199-N-67 not
1		144	9										working correctly
1		146	11		68.08								
1		149	13										
1		150	15		68.09								
1		155	20		68.08								Are flows over
1		160	25		68.15								effects of
1	1102	167	32		68.20								pumps cycle [illegible]
1	1115	180	45		68.30								
1	1125	190	50		68.32								
1	1135	200	60		68.31								Also [illegible]
1	1145	210	70		68.35								shut off valve [illegible]
1	1150	215	80		68.34								[illegible]
1	1200	225	90		68.33								
1	1210	235	100		68.30								
1	1220	245	110		68.30								
1	1230	255	120		68.30								
1	1300	225	150		68.29								

Aquifer Test Data

page 2 of 2

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 / TRANSDUCER
Rad./Dist. of/From Pumping Well
Meas. Point for W.L.'s T/C 1.43' Above Lsd
Elevation of Meas. Point

Depth of Pump/Airpipe ~90' / well depth ~190'
Pump On: date 6/9/88 time 1315 hr
Pump Off: date 6/9/88 time 1815 hr
Duration of Aquifer Test 300 min

Obs. stick, 67.74' 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	Conversions or Corrections	Water Level	s or s'		Reading	Q		
6/9	1315	0								921200		CSC	PLACED 0-15 psi
		:30									47		TRANSDUCER in
		1											Obs well ~30 +
		2											DID NOT
		3											START EXACTLY
		4											AT 1315 hr
		5			86.85						46.8		
		7											SLIGHT TO RAIN
		9			86.76						46.7		
		11			86.85								
		13			86.85								
		15											
		20			86.84						46.6		
		25			86.86						46.7		
		30			86.83						46.7		
		35			86.85						46.9		
		40			86.85						46.7		
													Tried to get 4.0 l/sec
					Discharge dropped								
					off slightly						45.6		
					opened valve								
					further back						46.7		
6/6	1815	300	0							935100			RECOVERY
			:30							Avg flow rate = 46.8 lpm			
			1		68.84								
			2		68.72								
			3		68.48								
			4		68.47								
			5		68.49								
			7		68.45								
			9		68.46								
			11		68.46								
			13		68.46								
			15		68.47								
	1835	320	20		68.46								

OBSERVATION WELL

Aquifer Test Data

199-N-67

Data for Well 199-N-67
Pumping Well 199-N-49
Observation Wells 199-N-67

Location 199-N-49
Type of Aquifer Test CONSTANT DISCH RECOVERY
How Q Measured DIGITAL FLOWMETER
How W.L.'s Measured E-TAPE / TRANS
Rad./Dist. of/From Pumping Well
Meas. Point for W.L.'s T/C 1.30' ABOVE LSD
Elevation of Meas. Point
LSD CEMENT PAD W/ BRASS PLATE

Depth of Pump/Airpipe ~90' / 100' 3/4" PA
Pump On: date 06/09/89 time 1515 hr
Pump Off: date 6/10/89 time 1915 hr
Duration of Aquifer Test 5 hr (300 min)

Time t = 300 at t' = 0					Water Level Data Static Water Level 67.76 STEEL TAPE				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
6/9	1040	325	25	13	67.96	(E-tape end		0.23			CSC	E-TAPE MOVED TO
1	1345	330	30	11	67.92	steel tape		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				Check tape = 67.91
1	1915	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 ≈ 5660

page 1 of 2

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-DISCH - STEP TO DEVELOPMENT
How Q Measured DIGITAL FLOW METER
How W.L.'s Measured E-TAPE / TRANSDUCER
Rad./Dist. of/From Pumping Well NA
Meas. Point for W.L.'s T/C 2.32' ABV LD
Elevation of Meas.-Point
LD = SEMENT TOP

Depth of Pump/Airpipe ~96' SCREENED 90-100'
Pump On: date 6/14/98 time 9:45
Pump Off: date 6/14/98 time 11:45
Duration of Aquifer Test 120 min.

Time t = ____ at t' = 0					Water Level Data 61.42' Static Water Level 61.61					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 PROBE
		5											STUCK - SEPARATED
		7											FROM CABLE
		9									43.4		USE ONLY TRANSDUCER
		11									43.5		
		13									49.2		
		15									49.9		
		20									44.9		Increase rate (2 turns)
		21									50.6		
		22									50.9		
		23									49.7		
		25									49.5		
		27									49.5		
		30									49.2		
		35									49.6		
		40									49.5		Increase Rate (2 turns)
		41									49.9		
		45									49.5		
		50									49.8		
		60									49.7		
		90									49.7		
	1145	120	0							Average	3		Pump off start recovery [illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]
													[illegible]

Aquifer Test Data

Total Gallons = 16,900

page 2 of 2

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 DIGITAL FLOW METER
How W.L.'s Measured E-TAPE / PRESSURE
Rad./Dist. of/From Pumping Well NA
Meas. Point for W.L.'s T/C 2.32' Abv LSD
Elevation of Meas. Point
LSD = CEMENT PAD

Depth of Pump/Airpipe ~96 - SUCCEED
Pump On: date 6/15/88 time 0945
Pump Off: date 6/15/88 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		
6/15	0915				61.67					94000			E-TAPE
	0930				61.68								
	0945	0			61.68								
		:30			74.92						50.3		
		1											
		1:30											
		2											
		3									49.5		
		4											E TAPE HUNG-UP
		5											in well
		7			~~77~~						49.6		
		9											
		11									49.7		
		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									49.1		Opened valve 2 turns
		85									49.4		
		90									48.8		Opened valve 2 turns
	1125	100									48.6		Opened valve 2 turns
	1130	105									48.7		Valve wide open
	1145	120									49.1		Grab-bottle sample
	1218	158									49.3		1st taken 1 [illegible]
	1245	180									49.0		development
	1315	210									49.2		
	1345	240									49.7		3rd Sample taken
	1415	270									49.0		
	1445	300									49.0		
	1515	330									48.8		
	1530	345								95700			FLOWMETER GOES [illegible]
	1545	360											QU: [illegible] STOPPED PUMP

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WHC-SD-EN-AP-038
Rev. 0

OBSERVATION WELL

Aquifer Test Data

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Data for Well 199-N-30
Pumping Well 199-N-70
Observation Wells 199-N-32

Location 199-N-70 (100N Area)
Type of Aquifer Test STEP DD - CONSTANT DSCH.
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 ~96' SCREENED 50-100'
Pump On: date 6/15/98 time 0945
Pump Off: date 6/15/98 time 1545
Duration of Aquifer Test 360 min.

Time t = ____ at t' = 0					Water Level Data Static Water Level 61.79					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
6/14		0		2 hours									TRANSDUCER
		20											0-10 PSI
		30		4									.0 W&M
		40		6									
		60											
							63.00						Steel tape
			67				62.79						
6/15	0900	-			60.55								E-TAPE
	0930				60.86								
	0945	0			—			—					TRANSDUCER
		30			60.86			0				SIT	
		1.00			60.86			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				[illegible]	
	11:45	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 9:45
Pump Off: date 6-15-88 time 1545
Duration of Aquifer Test 360 min (Const.-disch.)

Time: t = 360 at t' = 0
Water Level Data: Static Water Level ~~61.24~~ 60.56' E-Tape

Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Discharge Reading	Discharge Q	Recorded By	Comments
6/15	12:45	150			61.15			0.29				SST	
1	12:45	180			61.29			0.34				SST	
1	1315	210			61.31			0.35					
1	1345	240			61.34			0.38					
1	1415	270			61.35			0.39					
1	1445	300			61.37			0.41					
1	1515	330			61.40			0.44					
1	1541	355			61.41			0.45					
1	1545	360	0	—	—			—s'					Begin Recovery Test
1	1545:30	360.5	30	721	61.30			0.44					
1	1546	361	1:00	361	61.30			0.44					
1	1546:30	361.5	1:30	241	61.30			0.44					
1	1547	362	2:00	181	61.30			0.44					
1	1548	363	3	121	61.29			0.43					
1	1549	364	4	91	61.28			0.42					
1	1550	365	5	73	61.27			0.41					
1	1552	367	7	52.4	61.28			0.42					
1	1554	369	9	41	61.27			0.41					
1		371	11	33.7	61.26			0.40					
1		373	13	28.7	61.25			0.39					
1		376	16	23.5	61.25			0.39					
		380	20	19	61.23			0.37					
1		385	25	15.4	61.22			0.36					
		390	30	13	61.21			0.35					
1		400	40	10	61.19			0.33					
		410	50	8.2	61.15			0.29					
1	1645	420	60	7	61.15			0.29					
1		430	70	6.14	61.14			0.28					
1		440	80	5.5	61.12			0.26					
1		450	90	5	61.11			0.25					
1		460	100	4.6	61.10			0.24					
1		470	110	4.27	61.10			0.24					
1		480	120	4	61.09			0.23					
1			~~130~~		~~61~~								
1			~~140~~										
1		510	150	3.4	61.07			0.21					
1	1745	540	180	3	61.05			0.19					
1		570	210	2.7	~~61.04~~ 61.03 ST.			0.17					
✓	17:45	600	240	2.5	61.02			0.16				CSC	End of recovery

measurements

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.

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

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.

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APPENDIX C

SAMPLING AND ANALYSIS PLAN

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APPENDIX C

SAMPLING AND ANALYSIS PLAN

This appendix introduces the procedures that will be used for ground water sample collection (including well evacuation and sample withdrawal methods), chain of custody, analytical methods, and quality assurance/ quality control.

All sampling activities are performed under contract by Pacific Northwest Laboratory (PNL). U.S. Testing Company, Inc., (UST) has, until June 1990, conducted sample analyses for most constituents. Future testing will be carried out by other contract laboratories, to be determined, under contract to PNL or Westinghouse Hanford Company. This sampling and analysis plan reflects the requirements in the PNL statement of work for the new contract laboratory.

SAMPLE COLLECTION PROCEDURES

The procedures for ground water sample collection, water-level measurements, and field measurements are contained in Procedures for Ground-Water Investigations (PNL 1989). Specific applicable procedures include the following:

- GC-1 - Ground-Water Sample Collection Procedure
- GC-2 - In-Line Sample Filtration Procedure
- GC-3 - Disposal of Purge Water from Monitoring Wells
- FA-1 - Temperature Measurement Procedure
- FA-2 - Calibration of Conductivity Meter and Measurement of Field Conductivity
- FA-3 - Calibration of pH Meter and Measurement of Field pH
- WL-1 - Water-Level Measurement Procedure
- WL-2 - Procedure for Standardizing Steel Tapes.
- AD-1 - Change Control Procedure
- AD-2 - Ground-Water Sample Chain of Custody
- AD-4 - Sediment Sample Chain of Custody
- DO-1 - Collection and Documentation of Borehole Samples and Well Construction Data
- DO-2 - Split-Barrel Auger Sediment Sampling

Analytical methods are listed in Tables C-1 through C-11.

CHAIN-OF-CUSTODY PROCEDURES

Chain-of-custody procedures are contained in Procedures for Groundwater Investigations (PNL 1989). The specific applicable procedure is AD-2, "Groundwater Sample Chain-of-Custody Procedure." The history of the custody of each sample will be documented according to this procedure.

Table C-1. Metals by Inductively Coupled Plasma Spectrometry Using Method 6010 of SW-846.

Constituent	CRQL* (ppb)
ANTIMONY	200
BARIUM	20
BERYLLIUM	3
CADMIUM	10
CALCIUM	100
CHROMIUM	20
COBALT	20
COPPER	20
IRON	20
MAGNESIUM	100
MANGANESE	10
NICKEL	30
POTASSIUM	300
SILVER	20
SODIUM	300
TIN	100
VANADIUM	30
ZINC	10

*Contract required quantitation limit.

Table C-2. Metals by Atomic Absorption.

Constituent	CRQL (ppb)	Method
ARSENIC	5	7060 (SW-846)
LEAD	5	7421 (SW-846)
MERCURY	0.2	7470 (SW-846)
SELENIUM	10	7740 (SW-846)
THALLIUM	5	7841 (SW-846)

Table C-3. Anions by Ion Chromatography Using Either Method 300.0, EPA-600/4-84-017, Mar. 1984 or ASTM Method D4327-84.

Constituent	CRQL (ppb)
CHLORIDE[a]	2000
NITRATE[a]	2000
NITRATE[a]	2000
PHOSPHATE[a]	4000
CHLORIDE[b]	200
NITRATE[b]	200
NITRATE[b]	200
PHOSPHATE[b]	400
BROMIDE[c]	500
CHLORIDE[c]	200
FLUORIDE[c]	100
PHOSPHATE[c]	400
SULFATE[c]	500

[a]Preserved sample, diluted ten fold; chloride may be analyzed from a preserved sample.
[b]Preserved sample, undiluted.
[c]Unpreserved, undiluted sample.

Table C-4. Individual Inorganic Analytical Procedures.

Constituent	CRQL (ppb)	Method
AMMONIUM ION	100	ASTM D1426-D or D1426-C
CYANIDE	20	9010 (SW-846)
SULFIDE	10000	9030 (SW-846)
HYDRAZINE	30	ASTM D2579 A or B

Table C-5. Miscellaneous Parameters and Bacteriological Tests.

Constituent	CRQL	Method
ALKALINITY	50 ppb	ASTM D1067 A or B
TURBIDITY	0.1[a]	APHA #214A
COLIFORM (FERMENTATION)	2.2[b]	9131 (SW-846)
COLIFORM (FILTER)	1[c]	9132 (SW-846)
TOTAL DISSOLVED SOLIDS	0.5 ppb	APHA #209B
TOTAL CARBON	2000	ASTM D2579 A or B

[a]Nephelometric Turbidity Units.
[b]Most Probable Number.
[c]Minimum Colony Count.

Table C-6. Chlorinated Herbicides by Gas Chromatography Using Method 8150 of SW-846.

Constituent	CRQL (ppb)
2,4-D	10
DINOSEB; DNBP	1
SILVEX; 2,4,5-TP	2
2,4,5-T	2

Table C-7. Pesticides and PCB's by Gas Chromatography Using Method 8080 of SW-846.

Constituent	CRQL (ppb)
ALDRIN	0.05
ALPHA-BHC	0.05
BETA-BHC	0.05
DELTA-BHC	0.1
GAMMA-BHC (LINDANE)	0.05
CHLORDANE	0.1
4,4'-DDD	0.1
4,4'-DDE	0.05
4,4'-DDT	0.1
DIELDRIN	0.05
ENDOSULFAN I	0.1
ENDOSULFAN II	0.05
ENDOSULFAN SULFATE	0.5
ENDRIN	0.1
ENDRIN ALDEHYDE	0.2
HEPTACHLOR	0.05
HEPTACHLOR EPOXIDE	1
METHOXYCHLOR	2
TOXAPHENE	2
POLYCHLORINATED BIPHENYLS; PCBs	1
Aroclor 1016	
Aroclor 1221	
Aroclor 1232	
Aroclor 1242	
Aroclor 1248	
Aroclor 1254	
Aroclor 1260	

Table C-8. Volatile Organics to be Analyzed for by Method 8240 of SW-846.

Constituent	CRQL(ppb)
ACETONE	100
BENZENE	5
CARBON TETRACHLORIDE	5
CHLOROFORM	5
CHLOROPRENE (2-CHLORO-1,3-BUTADIENE)	5
p-DICHLOROBENZENE	5
1,1-DICHLOROETHANE	5
1,2-DICHLOROETHANE	5
trans-1,2-DICHLOROETHYLENE (cis + trans)	5
METHYLENE BROMIDE	5
METHYLENE CHLORIDE	5
METHYL ETHYL KETONE	100
METHYL IODIDE	5
METHYL METHACRYLATE	5
4-METHYL-2-PENTANONE	50
(METHYL ISOBUTYL KETONE)	5
2-PICOLINE (2-METHYLPYRIDINE)	5
TETRACHLOROETHYLENE	10
TETRAHYDROFURAN	5
TOLUENE	5
1,1,1-TRICHLOROETHANE	5
1,1,2-TRICHLOROETHANE	5
TRICHLOROETHYLENE	10
VINYL CHLORIDE	5
XYLENE (m)	5
XYLENE (o,p)	

Table C-9. Phenols by Gas Chromatography Using Method 8040 of SW-846.

Constituent	CRQL (ppb)
PHENOL	20

Table C-10. Radiological Parameters.

Constituent	CRQL (pCi/L)	Method
RADIUM	1	SW-846, #9315*
GAMMA SCAN		Krieger and Whittaker (1980)
Co-60	22.5	
Cs-137	20	
Ru-106	172.5	
GROSS ALPHA	4	SW-846, #9310
GROSS BETA	8	SW-846, #9310
TRITIUM	500	ASTM D2476-81
STRONTIUM-90	5	Krieger and Whittaker (1980), #905

*The method also references ASTM (1988) and Krieger and Whittaker (1980).

Table C-11. Indicator Parameters.

Constituent	CRQL (ppb)	Method
CONDUCTIVITY	N/A	ASTM D1125-A
pH	±0.05*	ASTM D1293
TOTAL ORGANIC CARBON (TOC)	1000	Method 9060 (SW-846)
TOTAL ORGANIC HALIDES (TOX)	10	Method 9020 (SW-846)

*pH units.

QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance

Quality assurance (QA) will be conducted in accordance with the Quality Assurance Project Plan for RCRA Ground Water Monitoring Activities (WHC 1990), which is supported by the Westinghouse Hanford Environmental Investigations and Site Characterization Manual (WHC 1989).

Quality Control

The purpose of quality control (QC) is to determine and document the quality of the analytical results being produced by the laboratory and to bring potential problems with analyses to light for corrective actions as needed. The QC effort has two main components: (1) routine internal checks performed by the laboratory, and (2) external checks conducted by PNL to evaluate laboratory performance independently. The scope of these efforts is described in the following sections.

Internal Quality Control. Internal quality control at the subcontracted laboratory will include general practices applicable to a wide range of analyses, as well as specific procedures stipulated for particular analyses. The quality control and quality assurance programs will be documented in a quality control manual and a quality assurance manual. The laboratory will produce a quarterly quality control report to PNL, which includes blank, matrix, spike, and surrogate data.

External Quality Control. Pacific Northwest Laboratory will use interlaboratory comparisons, replicate, blank, and blind samples to evaluate the accuracy of results from the subcontracted laboratory. The purpose and scope of each of these is as follows.

Interlaboratory comparisons using field samples are conducted to determine if the results obtained by the primary laboratory are comparable to those obtained from other laboratories. Comparisons are currently being conducted for anions, selected volatile organic constituents, metals, cyanide, gross alpha, gross beta, and tritium. Each month, replicate samples from selected wells are delivered to PNL laboratories. The results from these PNL laboratories are then compared with the results from the subcontracted laboratory. Samples sent to PNL laboratories are from the same sampling set as those to be analyzed in duplicate by the subcontracted laboratory.

Replicate analyses of field samples are conducted to establish how much variability might be expected in the laboratory measurements performed on nearly identical samples and as a check for gross errors. Blanks for a wide range of analyses are submitted to the laboratory monthly to check for container or laboratory contamination.

Trip (transport) blanks and transfer blanks are submitted to the laboratory to determine whether environmental conditions encountered during collection and transportation of samples have affected the results obtained by analysis. One set of trip blanks and transfer blanks are submitted each sample period per sample area at the rate of at least one for 1 to 20 wells. These blanks are analyzed for volatile organic constituents.

Blind samples are submitted to the laboratory to estimate the bias of analytical laboratory procedures and to determine when this bias exceeds control limits. Blind standard samples prepared by PNL containing metals, anions, herbicides, pesticides, and volatile organic compounds have been submitted quarterly since January 1986. Most blind samples are now prepared with materials supplied by the U.S. Environmental Protection Agency (EPA), including the previous list of analytes plus ammonium ion, cyanide, semivolatile compounds, PCBs, and an expanded number of pesticides and volatile organic compounds. Samples containing constituents not available in EPA performance samples are prepared from high-quality chemicals. These include constituents from the enhanced thiourea and phosphorous pesticides group analyses, plus ethylene glycol, sulfide, perchlorate, and hydrazine dioxin (TCDD).

APPENDIX C REFERENCES

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