The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington

By B.E. Thomas, J.M. Wilkinson, and S.S. Embrey

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.18943	meter per kilometer
square foot (ft^2)	0.0929	square meter
acre	0.4047	hectare
	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second per mile ($ft^3/s/mi$)	0.0176	cubic meter per second per kilometer
cubic foot per second per square mile ($ft^3/s/mi^2$)	0.01093	cubic meter per second per square kilometer
cubic foot per day (ft^3/d)	0.472	liter per day
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
gallon per minute (gal/min)	0.06309	liter per second
gallon per day (gal/d)	0.2642	liter per day
million gallons per day (Mgal/d)	0.04381	cubic meters per second

Temperature: To convert temperature given in this report in degrees Fahrenheit (°F) to degrees Celsius (°C), use the following equation: °C = 5/9(°F-32).

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Altitude: In this report, "altitude" is measured in feet above sea level.

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ABSTRACT

This study was undertaken to improve the understanding of the ground-water resources of western Snohomish County, which is located in the Puget Sound area of northwestern Washington. The population has been rapidly increasing in the past decade and is projected to continue this rapid growth. Thus, there is concern about the quantity and quality of the ground-water resources that support the population.

The geohydrologic framework and ground-water system of the study area were described using data collected during a field inventory of 1,330 wells, along with the lithologic logs and pumpage data for those wells. The ground-water quality was described using the results of the analyses of water samples that were collected from 297 wells during 1993-94. Analyses were made of general chemical characteristics, nutrients, bacteria, trace elements, septage-related compounds, and a few synthetic organic compounds.

Western Snohomish County is underlain by as much as 1,200 feet of Quaternary unconsolidated deposits that are mostly of glacial origin. Interpretation of 27 geohydrologic sections and about 1,100 lithologic logs of wells led to the delineation of six geohydrologic units in the unconsolidated deposits. Two upper units, the alluvium and Vashon recessional outwash, were defined as aquifers. Underlying the Vashon recessional outwash is an extensive confining bed, the Vashon till. Underlying the till is the principal aquifer in terms of use and areal extent, the Vashon advance outwash. Between the Vashon advance outwash and bedrock are at least one confining bed and one aquifer that are not well defined because of meager data.

Average annual precipitation ranges from about 30 to 90 inches across the study area, and the overall average is 46 inches. Estimates of recharge indicate that the ground-water system receives an average of about 24 inches per year. Ground-water flow generally follows the land-surface gradient and moves toward the major streams and lowlands. In most areas there is also a downward component of ground-water flow. Areas of upward flow are in the Marysville Trough and near the Puget Sound shoreline. Ground water discharges to streams, springs, lakes, seepage faces on bluffs, as underflow out of the study area and to Puget Sound, by evapotranspiration, and by withdrawals through wells. No estimates were made of the individual components of natural discharge because the needed data were unavailable. Mostly used for public supply, approximately 19,630 acre-feet of water was withdrawn from the ground-water system through wells in 1992.

The relative sensitivity of the ground-water system to contamination was assessed. The areal distribution of sensitivities for the water table of the outcrop areas of geohydrologic units was 41 percent with low sensitivity, 28 percent with moderate, and 31 percent with high.

The water quality of the ground-water system was generally good, and 94 percent of the water samples were classified as soft or moderately hard. Dissolved-solids concentrations ranged from 36 to 1,040 milligrams per liter, had a median of 133 milligrams per liter, and tended to be higher in the stratigraphically lower units.

The ground-water system in the study area had no appreciable widespread ground-water contamination. Constituents that are associated with seawater intrusion, agricultural activities, and septic systems were investi-

gated; elevated concentrations of nitrate and ammonia were found in isolated areas, but no regional patterns of contamination were discernible. The overall concentrations were low, with a median for nitrate of less than (<) 0.05 milligrams per liter and a median for ammonia of 0.04 milligrams per liter. Chloride, phosphorus, bacteria, and septage-related compounds, which are sometimes indicators of contamination, had generally low concentrations and no correlation with seawater intrusion, agricultural activities, or septic systems. Twelve water samples were analyzed for pesticides and nine samples were analyzed for volatile organic compounds. No pesticides and two volatile organic compounds were detected, but this small sample is not adequate to assess possible contamination by these constituents.

The most common and widespread water-quality problems resulted from natural causes. High iron and manganese concentrations were fairly common; 20 percent of the water samples exceeded 300 micrograms per liter of iron, and 41 percent of the samples exceeded 50 micrograms per liter of manganese. These concentrations are mostly a nuisance and they are typical of western Washington ground waters. Arsenic was detected in 63 percent of the samples, and 18 percent had concentrations of 10 micrograms per liter or higher.

INTRODUCTION

This report describes an investigation of the ground-water resources of western Snohomish County, which is located in the northwestern part of the State of Washington (fig. 1). Bounded by the Cascade Range of mountains on the east and Puget Sound on the west, western Snohomish County has a climate of abundant rainfall and moderate temperatures, abundant and diverse vegetation, and gently rolling topography of plateaus and river valleys. The County is located in the Puget Sound region, where most of the population of the State of Washington resides.

The population of Snohomish County increased by more than one-third from 1980 to 1990, and the growth in population is projected to continue at nearly the same rate from 1990 to 2000. There is concern that this growth in population may have a detrimental effect on the ground-water resources. In 1990, about one quarter of the population of the County relied on ground water for drinking-water supplies. Ground-water quantity may decline if withdrawals of ground water increase and exceed the rate of natural or induced replenishment. Ground-water quality may be degraded by increases in the amount of sewage disposed through septic systems; by increases in the use of chemicals for agricultural, commercial, and industrial activities; or by seawater intrusion in coastal areas where withdrawals of ground water may be increased beyond the natural balance between volumes of fresh water and salt water.

In 1990 the State of Washington passed the Growth Management Act, which was a response to the concerns about recent and projected population growth and its effect on the quality of the environment. As part of that act, a ground-water management area was established for western Snohomish County. Under the act, the County is required to develop and implement a management plan that will protect and manage its ground-water resources. To assess the current condition of the ground-water resources and to help the County develop an informed and well-balanced plan for the future use of such resources, the U.S. Geological Survey (USGS), in cooperation with Snohomish County, conducted a ground-water study of the ground-water management area.

Purpose and Scope

This report describes the results of a study that was undertaken to describe the ground-water resources of western Snohomish County. During 1992-94, data were collected and analyzed to improve the understanding of the existing conditions. Specific objectives of the study were to:

1. Describe and quantify the ground-water system;
2. Evaluate the general potential for ground-water development in terms of aquifer characteristics, interaction with surface-water bodies, and ground-water recharge;
3. Describe the general water chemistry of the significant aquifers, and describe any regional patterns of human-caused ground-water contamination that may be a result of agricultural activities, sewage disposal from septic systems, or other regional sources;
4. Prepare a ground-water budget of the study area for 1992;
5. Describe the relative sensitivity of the ground-water system to contamination from human activities on the land surface; and
6. Evaluate deficiencies in the current state of knowledge about the ground-water resources to determine what additional data or studies might be needed.

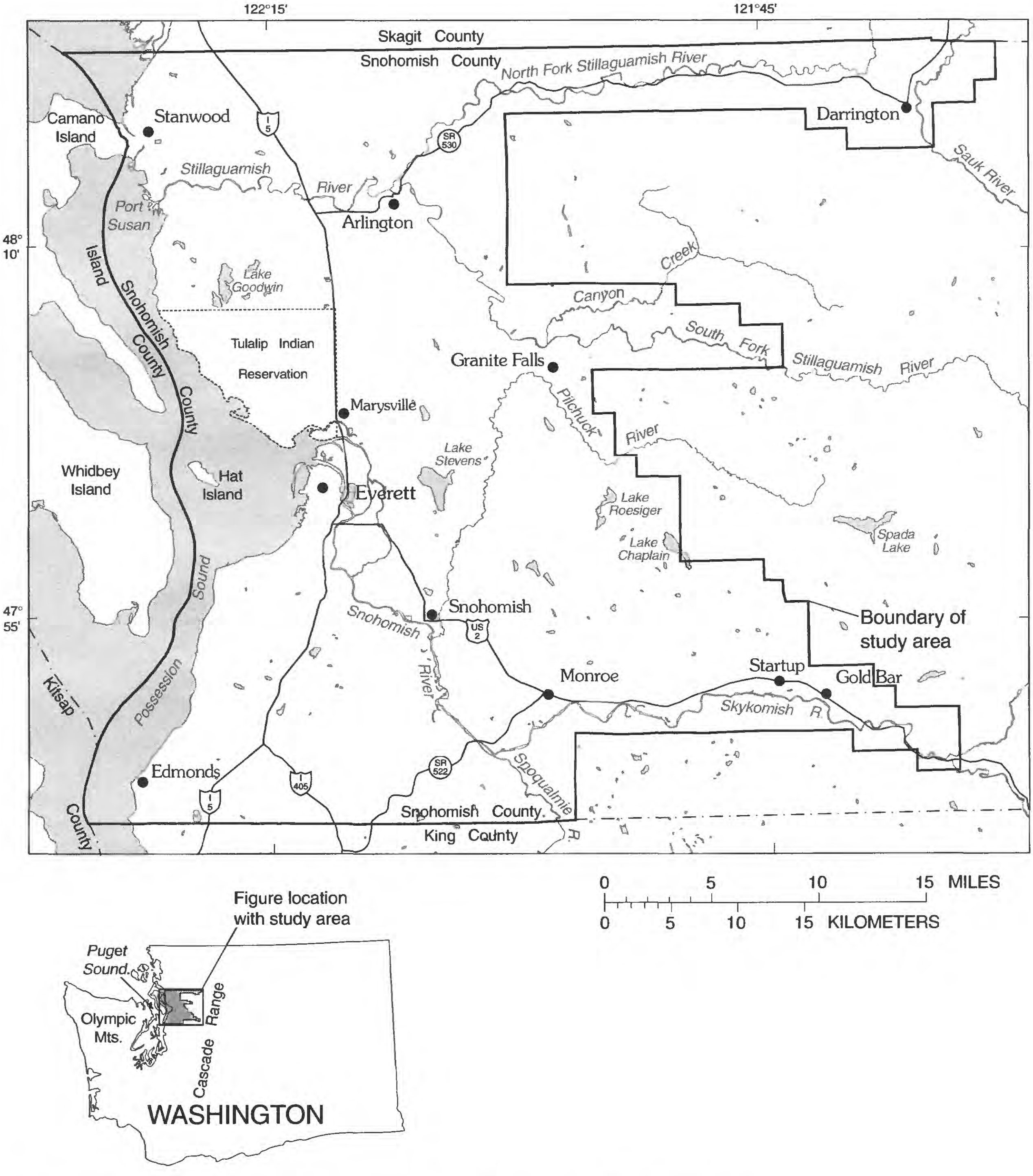


Figure 1. Location of study area, western Snohomish County, Washington.

Physical and Cultural Setting

Location and Extent of Study Area

Western Snohomish County is in the northwestern part of the State of Washington (fig. 1). Most of the 850-mi^2 study area is underlain by unconsolidated geologic deposits. Altitudes range from sea level to about 3,000 ft, and about 90 percent of the study area is below 800 ft. The boundaries are Possession Sound and Port Susan on the west, the border of Skagit County on the north, the eastern limit of unconsolidated deposits on the east, and the border of King County on the south. The eastern boundary was drawn largely along township and section lines; therefore, it does not exactly follow the boundary between bedrock and unconsolidated deposits.

Climate and Vegetation

Western Snohomish County has a temperate marine climate with cool, wet winters and warm, dry summers. Temperatures are moderated by the Pacific Ocean and Puget Sound, and these bodies of water provide a vast supply of moisture for storms that typically move from west to east across the County. The average annual precipitation varies according to distance from Puget Sound and altitude (fig. 2). It ranges from about 30 in. near Puget Sound to 90 in. at the eastern boundary of the study area. The average annual precipitation for the entire study area is about 46 in. or 2,090,000 acre-ft.

The annual precipitation from 1921-94 at four sites in western Snohomish County was moderately variable, and no long-term trends are apparent in the records (fig. 3). Precipitation at Everett during the 2 years of data collection for this study was 32.9 in. in 1992 and 30.4 in. in 1993. These amounts are 91 and 84 percent of the long-term average, respectively.

The distribution of precipitation is variable throughout a year (fig. 4). Summers (June-August) are typically dry throughout the study area; the average precipitation is about 6 in. Winters are wetter than summers, and the amount of winter (December-February) precipitation increases with increased distance from Puget Sound. Average winter precipitation ranges from about 14 in. at Everett (near Puget Sound) to about 36 in. at Darrington (near the eastern edge of the study area).

Temperatures are moderate throughout the year and do not change appreciably according to location within the study area. Temperatures in Everett and Darrington are similar, with Darrington having a slightly larger spread in minimum and maximum temperatures (fig. 4). For both sites, the average monthly maximum temperature is about 75°F in July, and the average monthly minimum temperature is about 30°F in January (fig. 4).

Evapotranspiration is the combination of evaporation from water surfaces and soils and transpiration by plants. Several estimates of average evapotranspiration have been made for the study area. A Palmer-Haven application of Thornthwaite's method with an average soil waterholding capacity of 6 in. resulted in a range of 20 to 24 in. of evapotranspiration per year (Washington State University Cooperative Extension Service, 1966, table 23). An application of a deterministic rainfall-runoff model to the watersheds of Quilceda, North, and Swamp Creeks in western Snohomish County resulted in a range of 16 to 19 inches per year (in/yr) (J.J. Vaccarro., U.S. Geological Survey, Tacoma, Wash., written commun., 1994). Estimated average monthly evapotranspiration increases in the summer during the period of highest temperatures and decreases to nearly zero during the winter (fig. 4).

Natural vegetation in western Snohomish County is verdant and diverse because of the abundant rainfall and moderate temperatures. The type and location of vegetation is mostly related to topography and soil drainage. On plateaus and hillsides, soils are usually well drained, and on valley floors and other depressional areas, soils are usually moderately or poorly drained. In well-drained areas, the forest overstory commonly consists of Douglas fir, western red cedar, western hemlock, Sitka spruce, red alder, and bigleaf maple. Common understory plants are salal, western swordfern, evergreen huckleberry, brackenfern, Oregon grape, common rose, and vine maple. In poorly drained areas, the forest overstory consists largely of red alder, but also includes bigleaf maple, western hemlock, western red ceder, and Douglas fir. The understory includes plants such as trailing blackberry, western swordfern, thimbleberry, salmonberry, huckleberry, vine maple, willow, and deer fern.

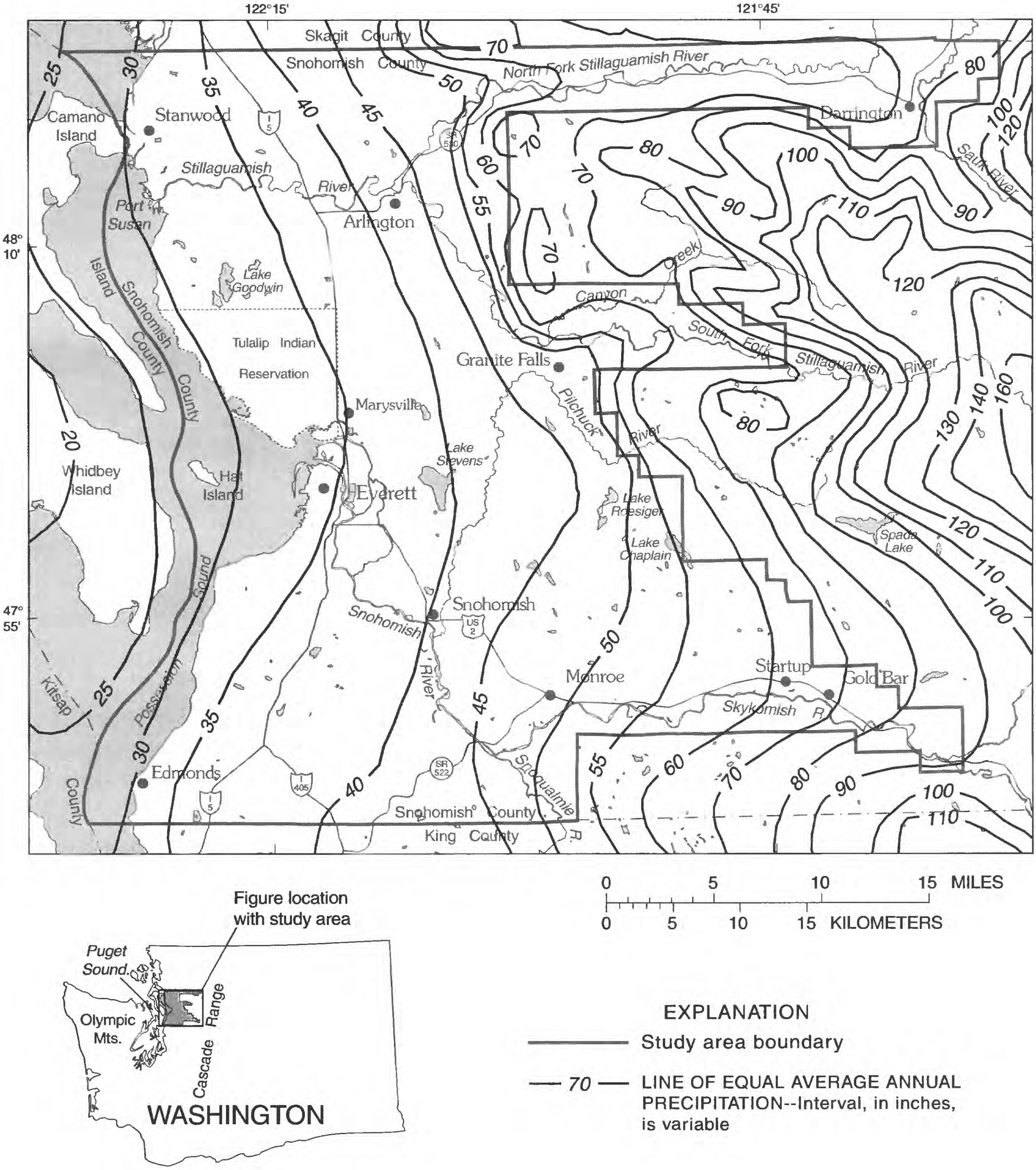


Figure 2. Average annual precipitation (U.S. Weather Bureau, 1965).

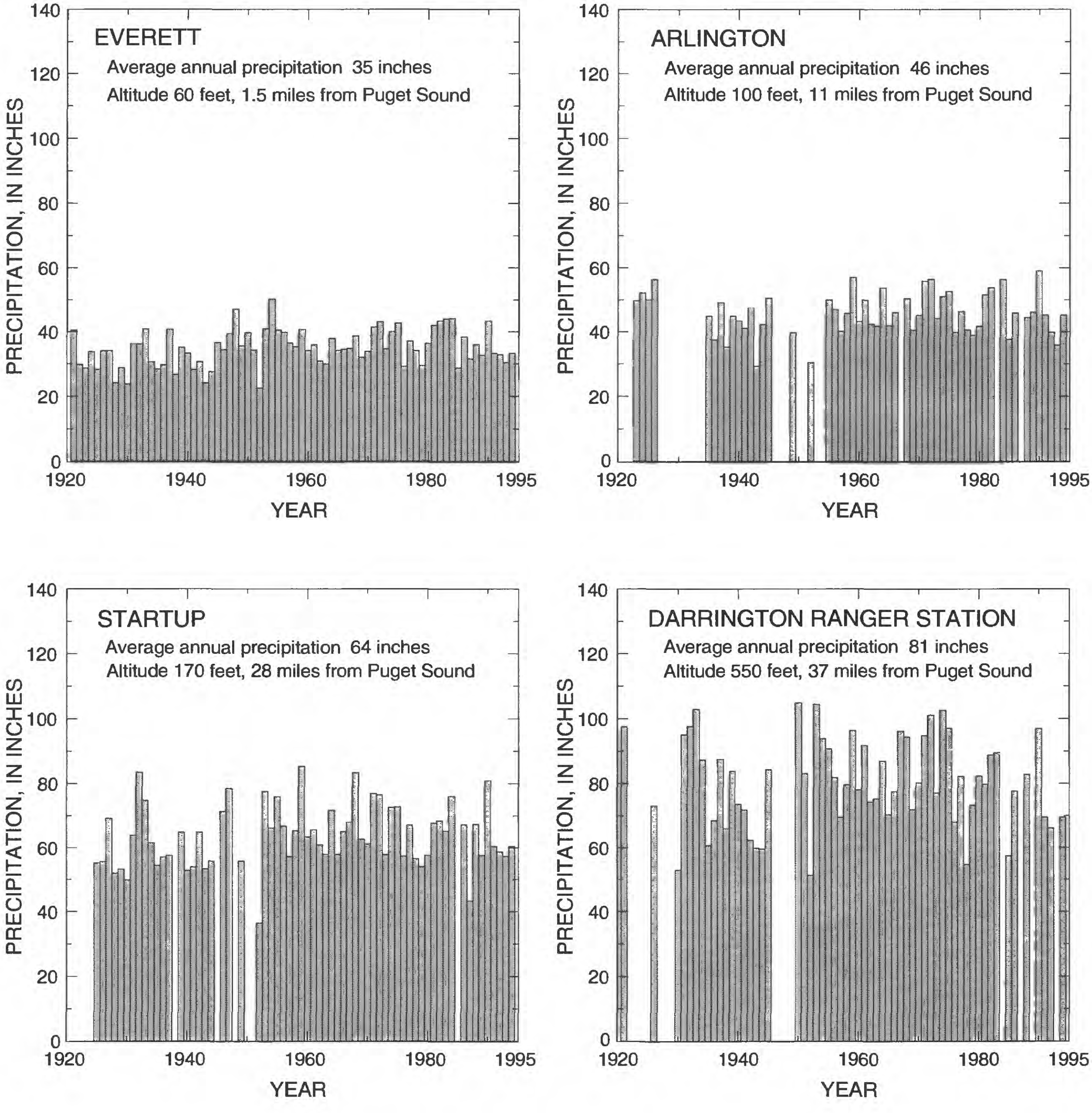
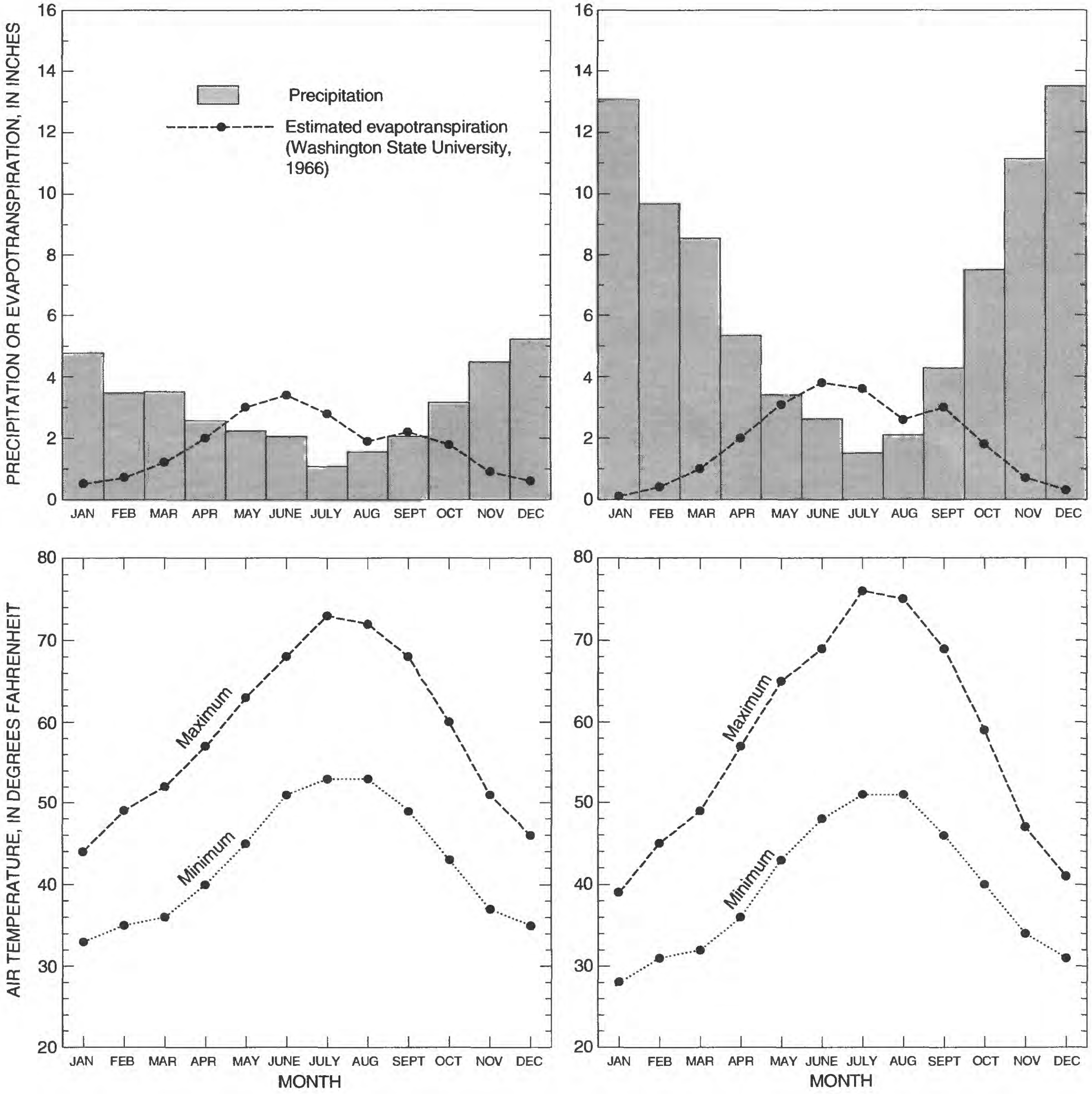


Figure 3. Annual precipitation at National Weather Service stations in Everett, Arlington, Startup, and Darrington, Washington



EVERETT, WASHINGTON
National Weather Service Station
(1951-80)

DARRINGTON RANGER STATION, WASHINGTON
National Weather Service Station
(1951-80)

Figure 4. Average monthly precipitation and air temperature, and estimated average monthly evapotranspiration for Everett and Darrington, Washington.

Topography and Surface-Water Flow

Western Snohomish County contains several large plateaus separated by river valleys. This topography is largely a result of the glacial and fluvial activity of the past tens of thousands of years. The plateaus are mostly disconnected and are largely mantled by glacial till that is resistant to erosion. Most plateaus are generally smooth and gently rolling, but some have steep escarpments. The valleys and lowlands were carved by moving glaciers and by erosion from associated streams, and they are mostly covered with alluvium or glacial outwash.

The topographic features are assigned names in this report for reference and convenience (fig. 5). The names of the lowlands or valleys generally correspond to their respective streams, and the names of the plateaus are adapted from names used by Newcomb (1952) and Economic and Engineering Services, Inc. (1991).

The Snohomish River occupies a large river valley in the south-central part of the study area. Three other large river valleys traverse the study area in an east-west direction and extend eastward into the Cascade Range; the valley of the North Fork Stillaguamish River is along the northern boundary, the valley of the South Fork Stillaguamish River is near the center of the study area, and the valley of the Skykomish River is along the southern boundary. Another major lowland area in the north-central part of the study area is the Marysville Trough, which has several streams draining mostly southward.

The six major upland parts of the study area are the East Stanwood Plateau, the upland surface extending north from the Stillaguamish River to the study-area boundary; the Arlington Heights Plateau, the area extending east from Arlington to the study-area boundary; the Tulalip Plateau, the area extending westward from the Marysville Trough to Port Susan and Possession Sound; the Getchell Plateau, the upland area that extends south from Arlington to Snohomish; the Lakes Plateau, the upland area north of the Skykomish River and east of the Pilchuck River; and the Intercity Plateau, the upland plain between Puget Sound and the Snohomish River.

The Intercity, Tulalip, and Getchell Plateaus have steep escarpments on many sides and generally flat surfaces that are mostly above 300 ft in altitude. Surface-water drainage is mostly southward on the Intercity and Getchell Plateaus and radially outward from the center of the Tulalip Plateau.

The East Stanwood, Arlington Heights, and Lakes Plateaus adjoin the outside boundary of the study area where there are many outcrops of bedrock. These plateaus have sloping surfaces that rise from near sea level in the river valleys up to altitudes of over 1,000 ft near the mountains. The terrain is diverse and dissected, with the surface water flowing generally from mountains to river valleys.

Most of the larger streams or rivers originate outside the study area. Only in the Tulalip Plateau, Getchell Plateau, and Marysville Trough do all the streams originate and flow entirely within the study area. Along the northern, eastern, and southeastern boundaries, most streams flow into the study area, and along the southwestern boundary, the streams flow southward out of the study area.

The average annual flows of five streams with drainage areas within the study area ranged from about 50 to 65 percent of the average annual precipitation, with an average of about 55 percent (Williams and others, 1985). These streams (North Creek and Swamp Creek in the Intercity Plateau, Little Pilchuck River in the Getchell Plateau, Quilceda Creek in the Marysville Trough, and Armstrong Creek in the East Stanwood Plateau) are probably representative of average flow conditions for the other streams with drainage areas within the study area. Their drainage areas range from 7 to 25 mi^2, with average annual precipitation from 37 to 45 in. and average annual flow of 20 to 29 in. (1.4 to 2.2 $ft^3/s/mi^2$). The streams or rivers originating in the mountains outside the study area have much larger amounts of flow because of much larger amounts of precipitation falling on their drainage areas. The drainage areas of the North Fork Stillaguamish River, South Fork Stillaguamish River, and Skykomish River range from 200 to 535 mi^2, with average annual flow of 98 to 108 in. (7.3 to 8.0 $ft^3/s/mi^2$); most of their basins receive more than 100 in. of average annual precipitation (fig. 2). The average annual flow for these streams is typically more than 80 percent of the average annual precipitation (Williams and others, 1985).

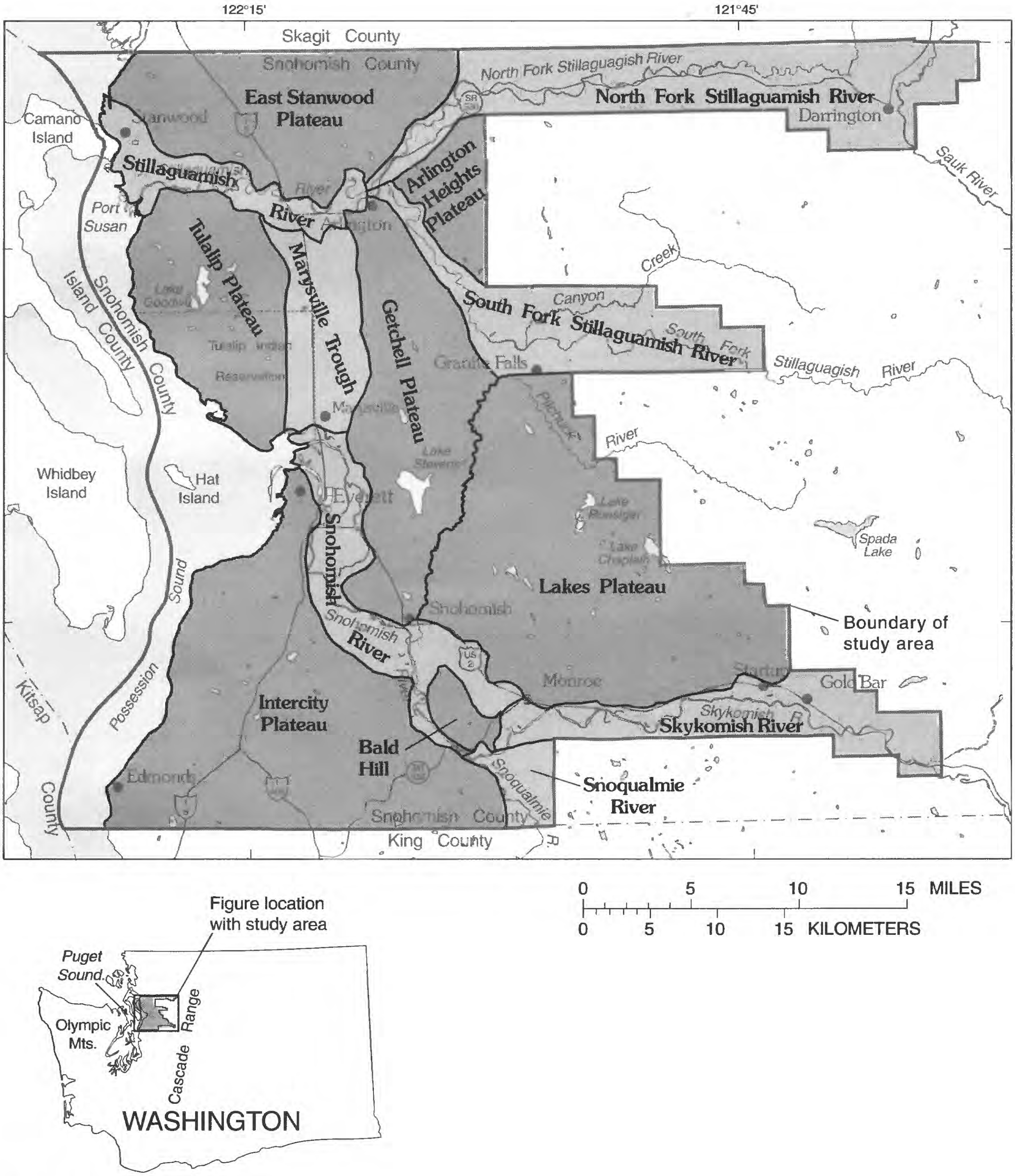


Figure 5. Topographic features.

Population and Human Activities

The population of Snohomish County was about 494,300 in 1992. From 1980-90, the population increased by 38 percent, and the rate of growth from 1990 to 2000 is projected to be about 27 percent (Snohomish County Planning Commission, 1994). Most of the population in 1992 was concentrated in the Intercity Plateau in the southwestern part of the County (fig. 6). Other areas of moderate density are near Lake Stevens, and near the cities of Marysville, Arlington, and Monroe.

Population growth can affect the quantity of the water resources; an increased population requires more withdrawals of ground water or surface water. Another result of an increasing population and the corresponding development of land for houses, roads, shopping malls, and businesses is an increase in impervious surfaces. Most of the ground-water recharge in the study area is from infiltration and percolation of precipitation. Impervious surfaces prevent infiltration and thereby decrease recharge. As would be expected, the density of impervious surfaces (fig. 7) matches the population density (fig. 6).

A larger population may also result in degradation of the quality of water resources because of contamination from increased septic-system effluent; increased use of fertilizers and pesticides on private gardens and lawns; and increased agricultural, industrial, or commercial activity, which may have associated hazardous chemicals.

Some human activities that may affect the ground-water resources of western Snohomish County are disposing sewage through septic systems; producing agricultural products; growing of lawns and gardens; and operating businesses that produce waste products. These activities may affect the ground-water resources by consuming water or by discharging potential contaminants such as petroleum products, some chemicals, or some waste products. Discharged petroleum products, chemicals, or waste products can cause contamination of ground water if they are not handled properly and are allowed to infiltrate the land surface. The potential regional effects of septic systems and agricultural activities are evaluated in this study. However, as the purpose of this study was to investigate the general condition of the ground-water system, point sources of contamination, such as most industrial and commercial activity, were not evaluated.

Previous Studies

There have been many studies of the geology and ground water of western Snohomish County. However, most studies focused only on small, local areas within the County. Only two studies have investigated the regional ground-water system for the County; Newcomb (1952) described the ground-water system using data collected in the 1940's, and Economic and Engineering Services, Inc. (1991) described the ground-water resources using existing data in 1990.

The principal geologic studies of the study area produced four maps showing the surficial geology at a scale of 1:100,000: Tabor and others (1982), Tabor and others (1988), Pessl and others (1989), and Yount and others (1993). Many other geologic studies focusing on smaller areas are provided in the "Selected References" section at the end of the report.

Well-Numbering System

The well-numbering system used by the USGS in the State of Washington is based on the rectangular subdivision of public land, and indicates township, range, section, and 40-acre tract within the section. For example, in well number 30N/05E-12H05 (fig. 8), the part preceding the hyphen indicates the township and range (T. 30 N., R. 05 E.) north and east of the Willamette base line and meridian, respectively. The first number following the hyphen (12) indicates the section, and the letter (H) gives the 40-acre tract within that section. The last number (05) is the sequence number of the well in that 40-acre tract, and it indicates that the well was the fifth one inventoried by USGS personnel.

Acknowledgments

The authors acknowledge the cooperation of the many well owners and tenants who supplied information and access to their wells and land during the field work, and the owners and managers of various water systems and companies who supplied well and water-use data.

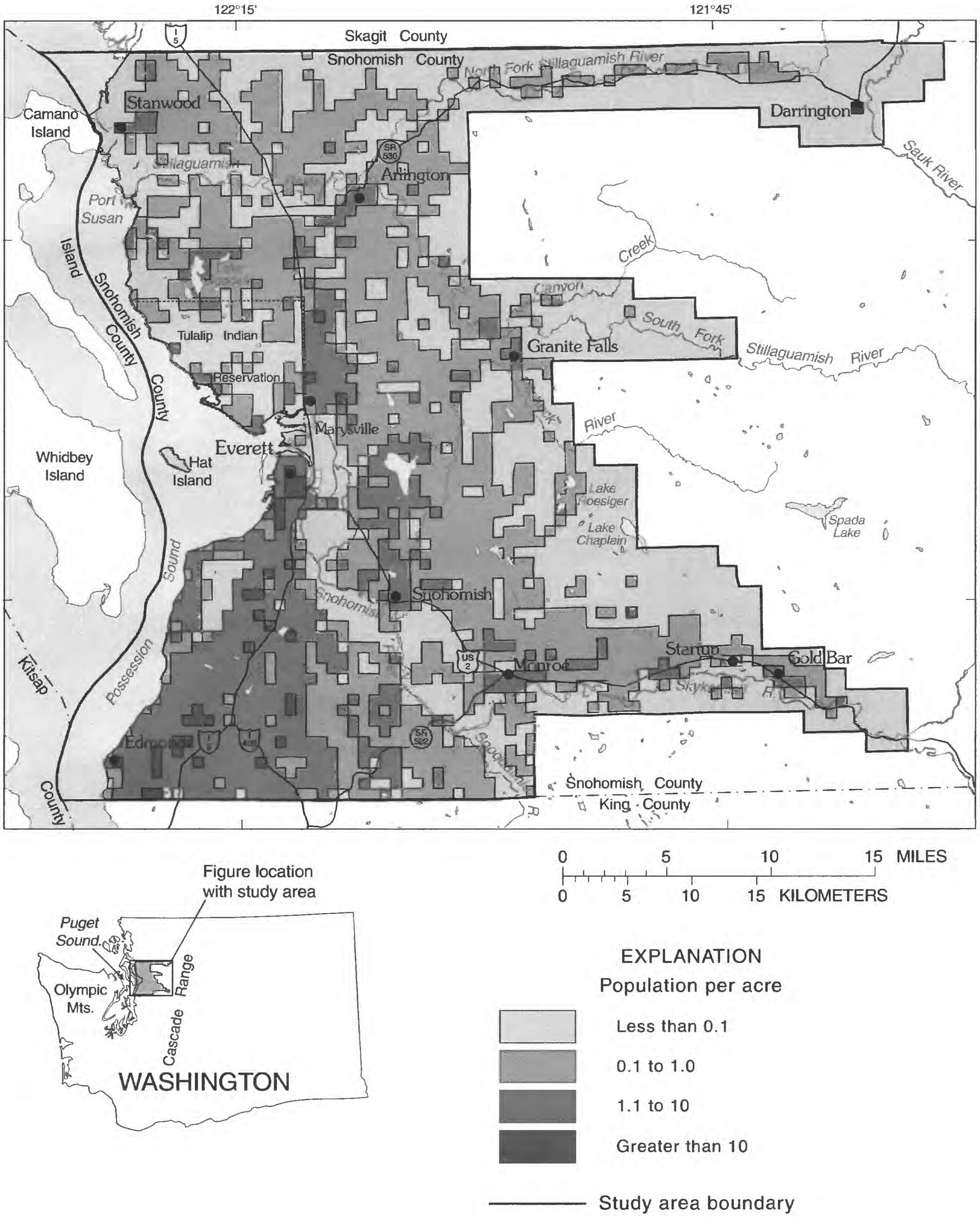


Figure 6. Density in 1992 (Phil Beilin, Snohomish County, written communication,1994).

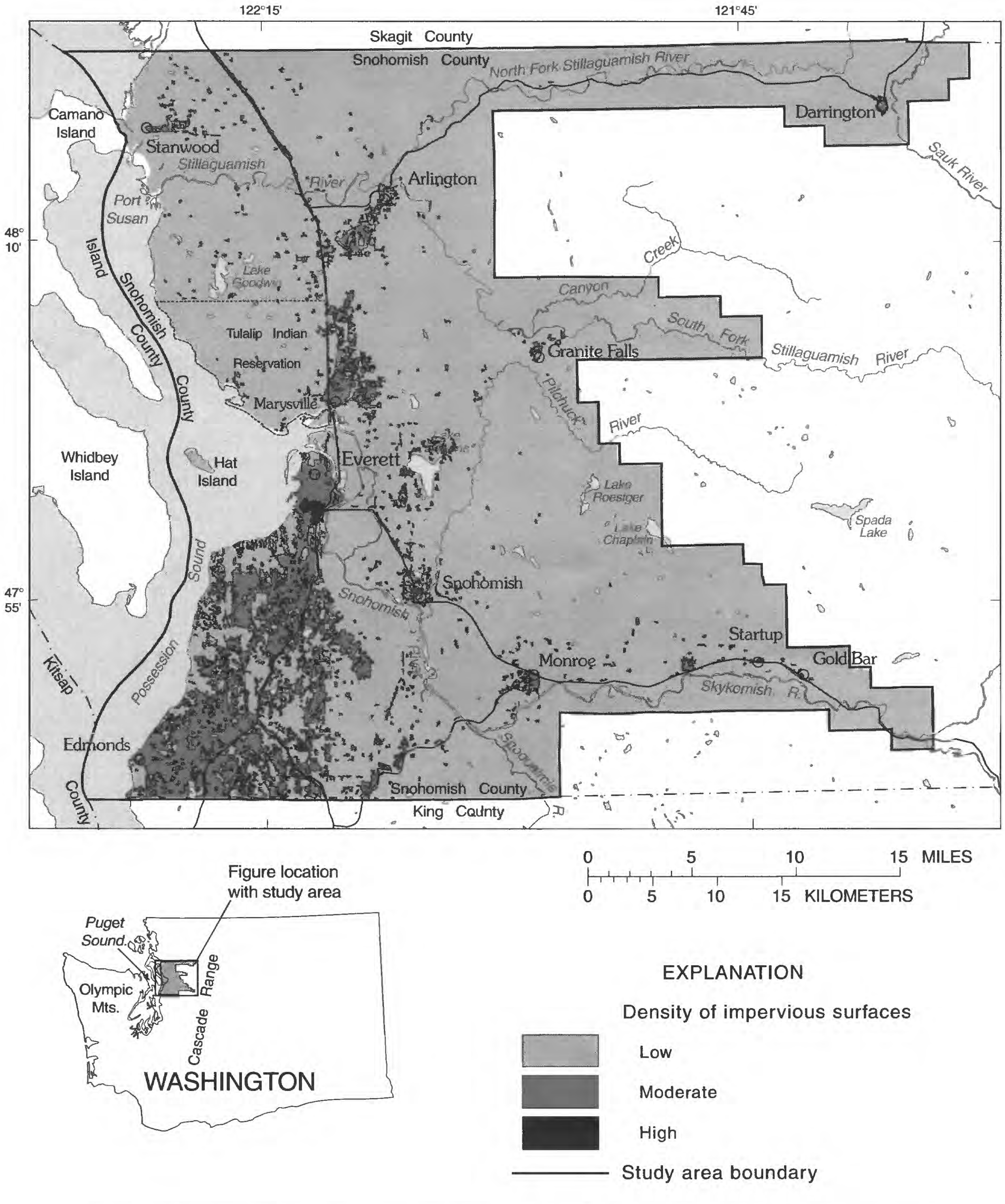


Figure 7. Density of impervious surfaces in 1992 (Phil Beilin, Snohomish County, written communication, 1994).

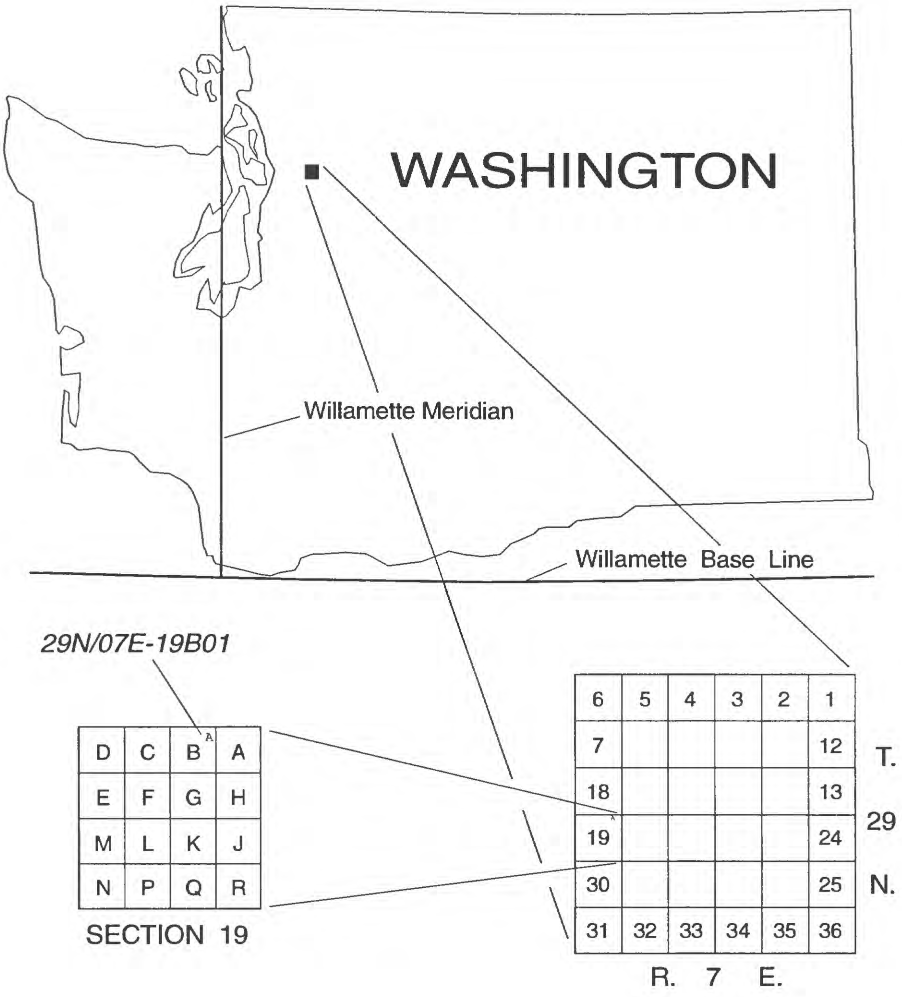


Figure 8. Well- and spring-numbering system used in Washington.

GENERAL CONCEPTS AND DEFINITIONS OF GROUND-WATER HYDROLOGY

A general description of ground-water hydrology is provided in this section to help the reader understand the information in this report. Hydrologic processes are briefly described, and common hydrologic terms are defined. For a detailed description of ground-water hydrology, refer to Heath (1989).

Hydrologic Cycle

The hydrologic cycle describes the ways in which water moves around the earth (fig. 9). During its continual circulation from ocean to atmosphere to ground and back to ocean, water is temporarily stored in streams, lakes, the soil, or under ground.

Although the hydrologic cycle has no beginning or end, it is convenient to begin a description with the movement of water from the land surface or ocean to the atmosphere. Water moves by transpiration from plants and by evaporation from the ocean, lakes, streams, bare soil, and plant surfaces. The combination of these processes is called evapotranspiration. Once the moisture is in the atmosphere, winds carry it, clouds form, and then the moisture returns to the land surface or the ocean as precipitation.

Precipitation has several forms, including rain, snow, or hail, but only rain is considered in this discussion. Before reaching the land surface, most rain is intercepted by vegetation. Some of this intercepted water is returned to the atmosphere by evaporation, and the remainder falls to the ground. The water then infiltrates into the soil at varying rates, depending on the condition of the soil surface and the character and moisture content of the soil. If the rainfall intensity exceeds the rate of infiltration, the water will move as surface runoff into nearby streams or lakes. Some of the infiltrated water is stored in the soil, but if enough infiltration occurs and the soil water content is raised sufficiently, water will percolate downward to the water table and will recharge the ground-water system. Ground water moves downward or laterally to sites of ground-water discharge such as springs, streams, lakes, or the ocean. Water that reaches streams, both by surface runoff and from ground-water discharge, moves to the ocean where it evaporates again to perpetuate the cycle.

The hydrologic cycle can also be represented in the form of a water-balance equation. This equation is useful to evaluate how changes in one component will affect the other components of the water balance. The effects of land-use activities or natural changes in a component can thus be evaluated. A simple form of the water balance for a small drainage basin underlain by impervious rock can be expressed as follows:

$$P = SR + ET + GWR \ , \tag{1}$$

where

P = precipitation;

SR = surface runoff (including surface runoff of water and shallow subsurface flow);

ET = evapotranspiration (including evaporation of intercepted precipitation, evaporation from water surface and bare soil, and transpiration from plants); and

GWR = ground-water recharge.

Assumptions in this equation are that (1) there are no changes in storage, (2) ground-water recharge equals ground-water discharge, and (3) the surface runoff component is a combination of surface runoff of water and shallow subsurface flow, which can be substantial in steep hillside areas. Most hydrologic systems approximate conditions (1) and (2) over a single year. Also, streamflow is not shown in the equation, but it is a combination of parts or all of surface runoff and ground-water discharge. Precipitation, P, is the source of all water in the equation, and for any given value of P, a decrease in one right-side component must be balanced by an increase in one of the other right-side components. For example, if surface runoff is increased because of urbanization and paving of part of the watershed, one of the other components, such as ground-water recharge or evapotranspiration will be decreased.

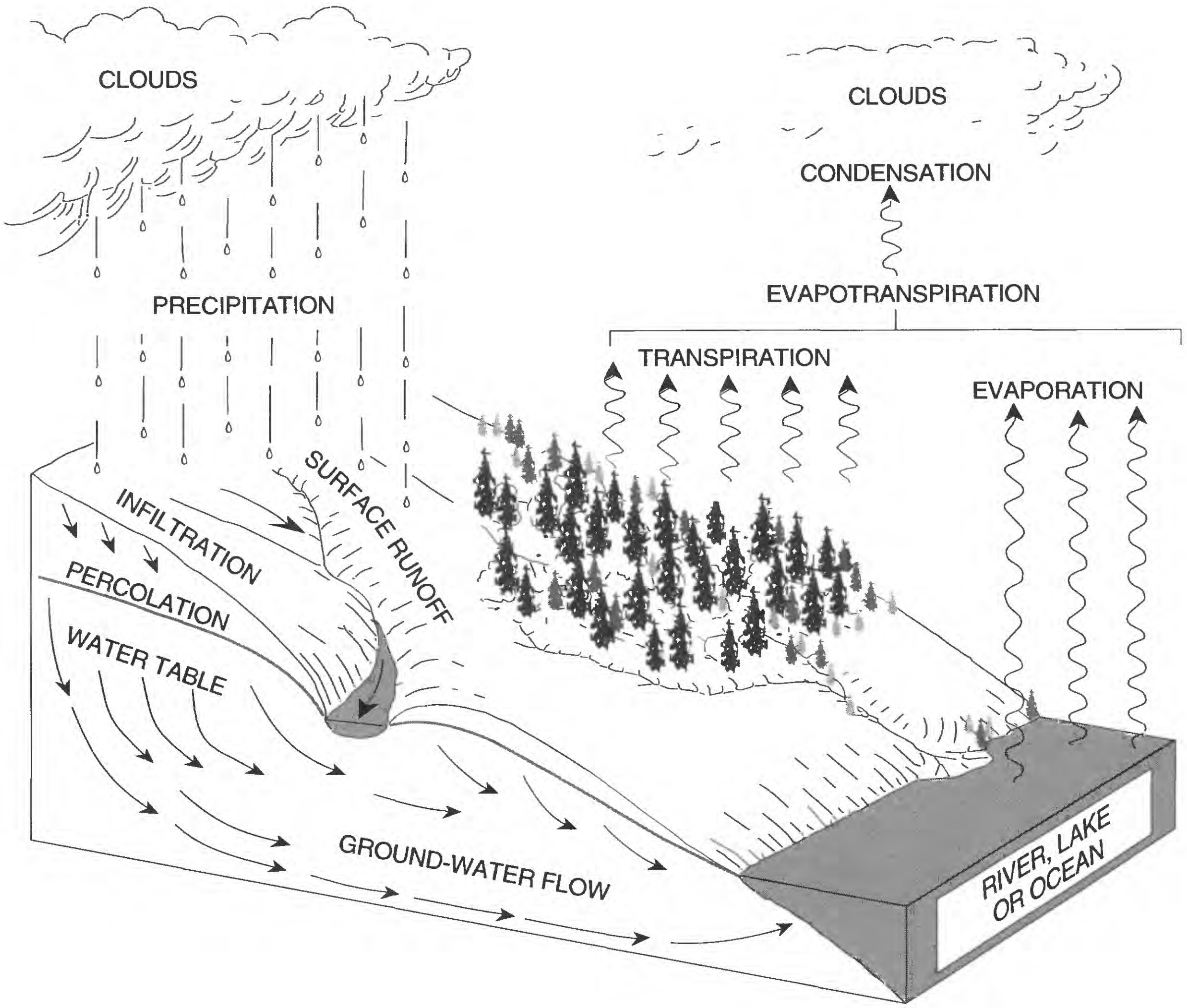


Figure 9. The hydrologic cycle.

Ground-Water Systems

A ground-water system is a body of porous material that is saturated with ground water. The body of porous material can be fractured rock or the weathered products of rock such as gravel, sand, or silt. A general definition of a ground-water system includes a description of the: (1) boundaries of the system, (2) inflow and outflow of water through the boundaries (recharge and discharge), (3) directions and rates of ground-water flow, and (4) hydraulic properties of the porous material.

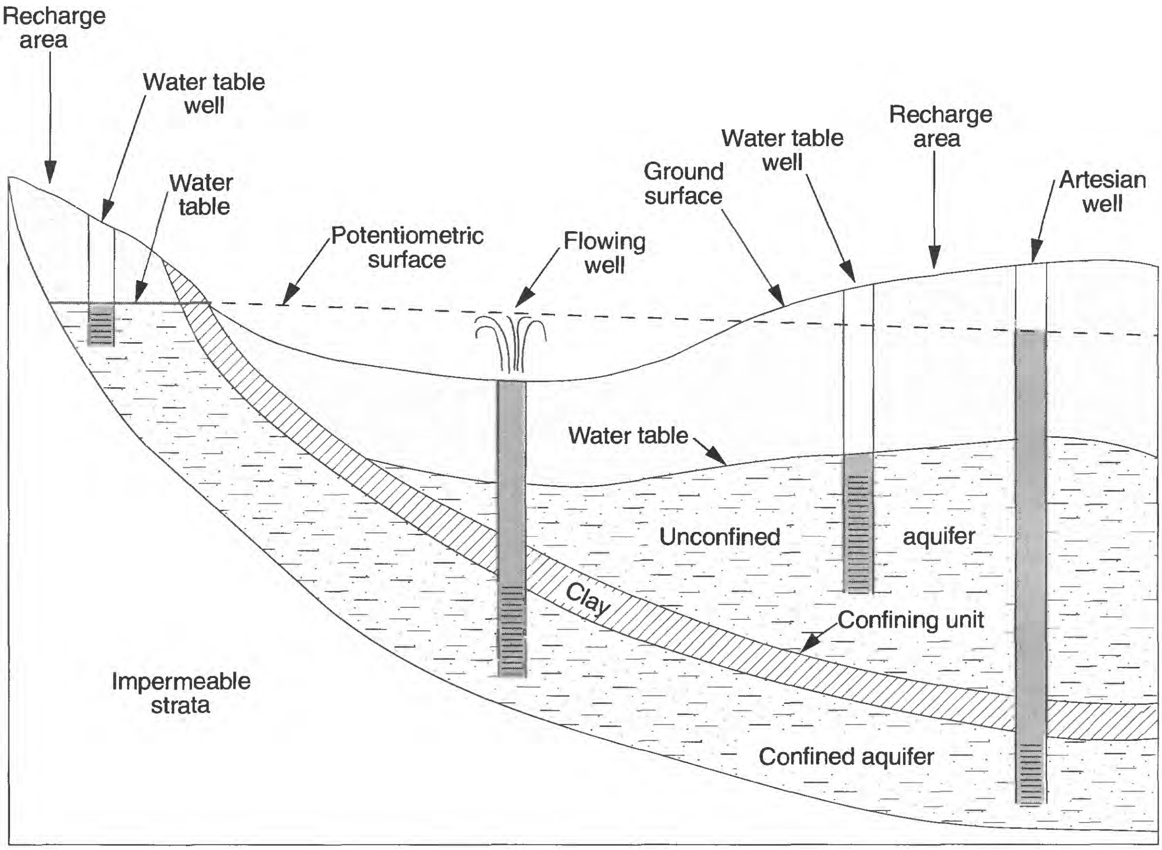


Figure 10. Features of unconfined and confined ground-water systems. (Modified from Todd, 1980.)

A ground-water system consists of a single aquifer or multiple aquifers and confining beds. An aquifer is a body of porous material that will yield water in a usable quantity to a well or spring. A confining bed is a body of porous material having very low hydraulic conductivity that restricts the movement of ground water either into or out of adjacent aquifers.

The boundaries of a ground-water system define a three-dimensional surface that encloses the aquifers and confining beds. Examples of boundaries are (1) the water table, which is a plane marking the upper limit of the ground-water system, (2) the plane marking the lower limit of the system where an aquifer abuts against relatively impermeable bedrock, (3) the zone of contact between an aquifer and a river or lake, or (4) the zone of contact between an aquifer and a saline water body such as the ocean.

Ground water is under either unconfined or confined conditions (fig. 10). Unconfined ground water only partly fills an aquifer, and the surface of ground water is the water table. A water level measured in a well screened in an unconfined aquifer will stand at the same level as the water table. Confined ground water is under pressure appreciably greater than atmospheric, and its upper limit is the bottom surface of an overlying confining bed. A water level measured in a well that is screened in a confined aquifer will stand above the top of the confined aquifer. “Artesian” is a commonly used term and is synonymous with confined. An artesian well is a well deriving its water from an artesian or confined aquifer. If the water level in an artesian well stands above land surface, the well is a flowing artesian well. Water will naturally flow out of such wells because of the positive pressure in the confined ground water.

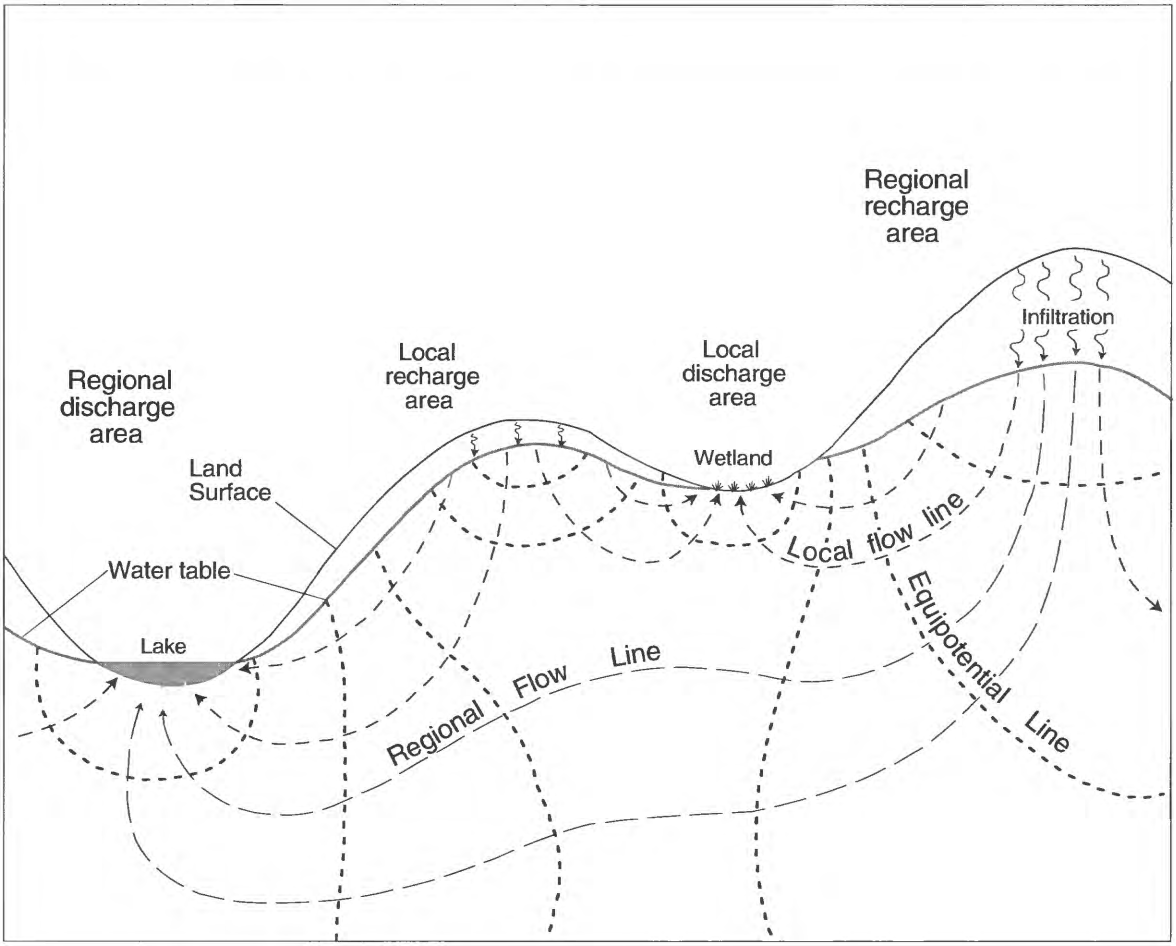


Figure 11. Idealized flow directions beneath an area of uniformly permeable material. (Modified from Hubbert, 1940.)

A ground-water boundary can have three flow conditions; no flow, inflow (recharge), or outflow (discharge). The flow condition depends on the relation between the heads or fluid density on either side of the boundary and the permeability of the material on either side of the boundary.

The direction of ground-water flow into, out of, or within a ground-water system is determined by comparing hydraulic heads. Ground water moves from higher to lower head. Heads are determined by measuring the position of the water level in a well and relating the measurement to a datum plane. A datum that is common to all wells in an area is used for comparisons. Sea level is used for the datum in this report (Heath, 1989, p. 6 and 10), and measured water levels are reported as an altitude, in feet above sea level. A potentiometric surface is an areal representation of the hydraulic head in an aquifer. Thus, comparing two heads can be used to determine direction of flow between the two points, but the potentiometric surface shows direction of flow for an area. The term "water table" is defined as the potentiometric surface at which the water pressure is the same as atmospheric pressure.

Ground-water systems can be described as local or regional in scale (fig. 11). The residence time of ground water in local systems typically can be months or years, and in regional systems it can be hundreds or thousands of years. The difference between local and regional systems is mostly related to depth and distance of flow of the ground water. In local or shallow systems, recharge is typically at the water table; ground water flows short distances and then discharges to springs, seeps, streams, or lakes. In regional or deep systems, recharge and discharge are typically in the same areas as local systems, but ground water flows much greater distances.

The general characteristics of a particular type of boundary, one between a freshwater aquifer and a saline water body, merits discussion because the ground-water system in western Snohomish County has this type of boundary along Puget Sound. The relation between fresh ground water and saline ground water can be described by some physical principles. Freshwater will float on salt water because the density of freshwater (1.00) is slightly less than the density of seawater (1.025). The Ghyben-Herzberg principle states that at any particular location, for every 1 ft of altitude of the water table above sea level, fresh ground water will extend 40 ft below sea level. For example, if the water table at a given site is 5 ft above sea level, the freshwater-salt water boundary is theoretically 200 ft below sea level. The boundary is not sharp, but rather is a diffusion zone in which the salt concentration of the freshwater gradually increases with distance from the freshwater body until it reaches the concentration of the saltwater body. In addition to the relative densities of the freshwater and seawater, the position of the boundary is also affected by tides, the seasonal position of the water table, the hydraulic characteristics of the aquifer, and recharge-discharge relations within the aquifer.

In natural conditions of equilibrium, the altitude of the potentiometric surface of an aquifer is higher than sea level and decreases toward the shoreline, and the boundary (zone of diffusion) is maintained in a relatively constant position (fig. 12). Stresses to aquifers, such as a large amount of pumping can cause a decline in ground-water levels and seawater intrusion, which is the landward or upward movement of the boundary between freshwater and salt water.

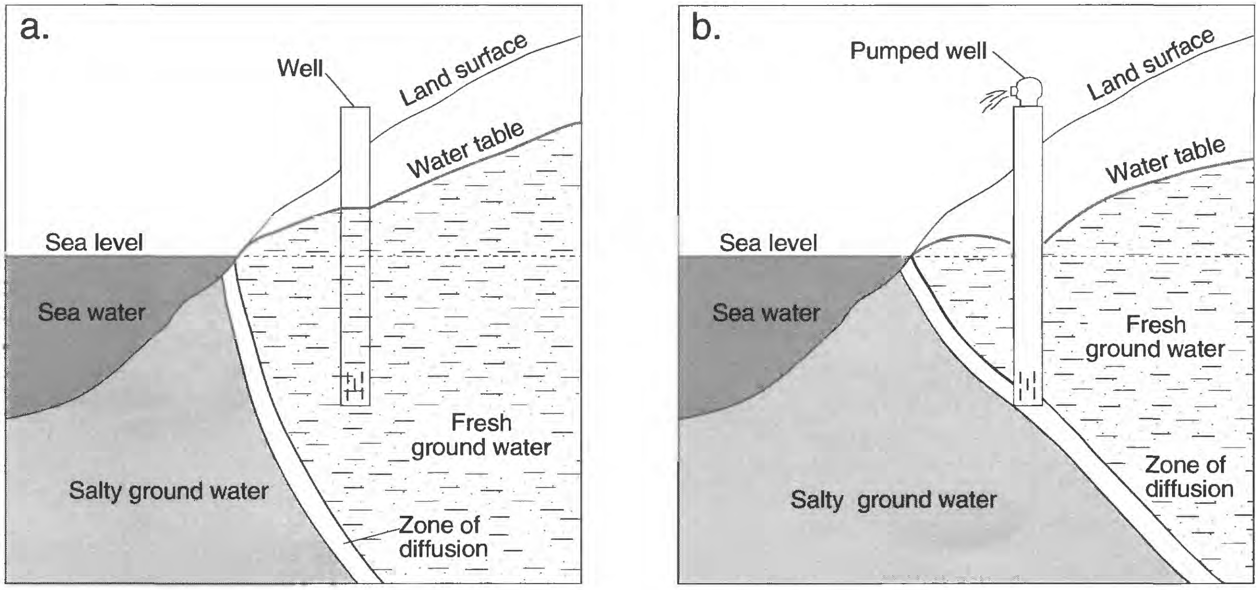
The hydraulic properties of an aquifer or confining bed can be described by the hydraulic conductivity, transmissivity, and storage capacity. Hydraulic conductivity is a measure of the relative ease with which a body of porous material can transmit a liquid under a potential gradient. The rate of movement of ground water, therefore, is proportional to the magnitude of the conductivity. The shape, size, and interconnections of the pores of the material are the major factors controlling the magnitude of hydraulic conductivity. Transmissivity is a measure of the productivity of an aquifer and is equal to the hydraulic conductivity multiplied by the thickness of the aquifer.

The storage capacity of an aquifer influences the amount of water that is available for withdrawal. In an unconfined aquifer, specific yield is a measure of the storage capacity. Specific yield of a rock or soil is the ratio of (1) the volume of water that the rock or soil, after being saturated, will yield by gravity to (2) the total volume of the rock or soil. Typical values of specific yield range from 0.1 to 0.3. In a confined aquifer, storage coefficient is the measure of storage capacity and it is the volume of water that an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. Typical values of storage coefficient range from 0.00001 to 0.001 (Heath, 1989).

A ground-water system may be in a steady-state or transient-state condition in relation to time. In a steady-state system the quantity of inflow is balanced by the quantity of outflow. Under such conditions, water levels may fluctuate seasonally in response to variations in precipitation; however, the long-term average of water levels remains constant. In contrast, a system in a transient-state condition will have long-term changes in water levels.

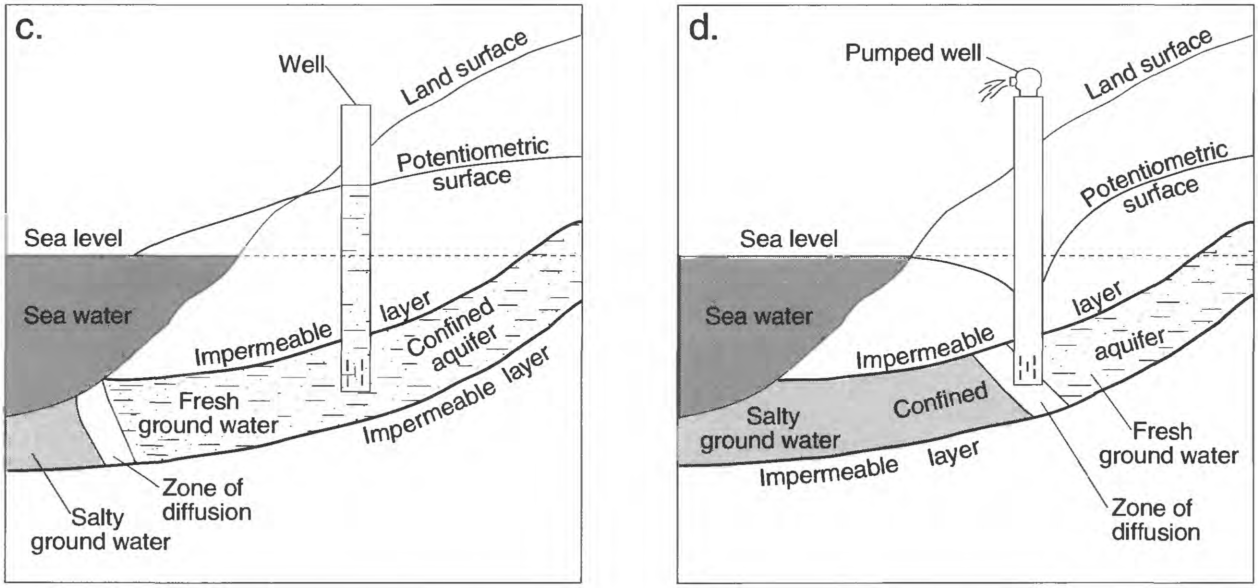
Ground-Water Quality

Ground-water quality is largely determined by the types and amounts of constituents dissolved in the water and by characteristics or properties that these substances give to the water. The types of constituents and their concentrations in the ground water depend on several conditions, including the mineral composition of aquifer materials and confining beds through which the water moves; the composition of precipitation; and biological and chemical reactions at the land surface and in the soil horizon (Heath, 1989). The composition of ground water can also be affected by the introduction of inorganic and synthetic organic chemicals from domestic, urban, industrial, and agricultural activities. Because of their effect on water use, the characteristics of ground water and concentrations of chemical constituents are commonly measured or analytically determined to evaluate the water as a resource. The chemistry and composition of ground and other natural waters are discussed in detail by Freeze and Cherry (1979), Stumm and Morgan (1981), and Hem (1992).



Well tapping an unconfined (water-table) aquifer under conditions of equilibrium--no intrusion has occurred.

The same well under conditions of intensive pumping--intrusion has reached the well.



Well tapping confined (artesian) aquifer under conditions of equilibrium--no intrusion has occurred.

The same well under conditions of intensive pumping--intrusion has reached the well.

Figure 12. Hypothetical hydrologic boundary conditions for coastal aquifers before (a, c) and after seawater intrusion (b,d).

One method of assessing the quality of ground water is to compare the water chemistry to established standards for drinking water, irrigation, and livestock watering (table 1). The U.S. Environmental Protection Agency (USEPA) has established drinking water regulations under the Public Health Service Act, as amended by the Safe Drinking Water Act of 1986. These regulations are categorized as primary and secondary. Primary drinking water regulations were established to control contaminants that affect human health. The maximum allowable concentration determined for a constituent is referred to as a maximum contaminant level, or MCL, and is enforceable by regulatory agencies. Secondary drinking water regulations were established to provide guidelines for the control of contaminants that affect the aesthetic qualities of drinking water. The secondary maximum contaminant level, or SMCL, is not enforceable by regulatory agencies. Both sets of regulations apply only to public systems, but can also be used to help assess the quality of private systems. The State of Washington has generally the same or more stringent drinking-water standards as those specified by the USEPA (table 1). Water standards for irrigation and livestock watering have been established by USEPA (1986) and by National Academy of Sciences and National Academy of Engineering (1973).

Water-quality characteristics and related constituents determined in this study include pH, specific conductance, dissolved-solids content, hardness, alkalinity (and its major components of bicarbonate and carbonate ions), dissolved-oxygen content, and sodium adsorption ratio. The pH of a substance is a measure of the hydrogen-ion activity and is gaged on a logarithmic scale from 0 to 14. In natural waters, pH is a function of the chemical equilibrium reactions between atmospheric carbon dioxide and the aqueous forms of carbon dioxide—carbonic acid (H_2CO_3), bicarbonate (HCO_3^-) ions, and carbonate (CO_3^{2-}) ions. The dissociation of carbonic acid and bicarbonate ions generates the hydrogen ions. A pH of 7 is considered neutral. Because the scale is logarithmic, a pH of 6 indicates that a water has 10 times the activity of hydrogen ions than a water with a pH of 7. Water with low values of pH, particularly below 4 pH units, can be corrosive and tends to dissolve metals such as copper, lead, zinc, and cadmium. Water with a high pH can adversely affect the drinking-water chlorination process and can cause carbonate to deposit in pipes. The USEPA (1993a) recommends a range of pH from 6.5 to 8.5 for drinking water and a range from 4.5 to 9.0 to protect crops (U.S. Environmental Protection Agency, 1986) (table 1).

Most substances that easily dissolve in water tend to dissociate into ions, which results in a water's ability to carry an electrical current. Specific conductance is a measure of the electrical conductivity of water at a standard water temperature of 25°C. Specific conductance is a good indicator of the amount of dissolved minerals in the water, or what commonly is referred to as the dissolved-solids concentration. The larger the specific conductance, the larger is the dissolved-solids concentration.

The major components of dissolved solids usually include calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and silica. Other constituents, such as carbonate and fluoride or metals such as iron and manganese are rarely present in substantial concentrations. Water with an excessively high concentration of dissolved solids can corrode some materials, impart an unpleasant taste to drinking water, and have adverse physiological effects on humans. The USEPA (1993a) recommends a SMCL for dissolved solids in drinking water of 500 mg/L (table 1). In irrigation water, the magnitude of dissolved-solids content and the proportions of the different cations can affect osmotic processes of plants and certain characteristics of soils. Concentrations above 500 to 1,000 mg/L can have detrimental effects on certain crops (U.S. Environmental Protection Agency, 1976).

Water hardness is calculated using calcium and magnesium concentrations and is expressed in milligrams per liter of $CaCO_3$ (calcium carbonate). The most familiar effect of increased hardness is a decreased production of lather from a given amount of soap. Hard water also causes scale deposits on the inside of plumbing pipes and boilers. Water hardness can be classified from soft to very hard in the following manner (Hem, 1992):

Description	Hardness Range (mg/L of $CaCO_3$)
Soft	0 - 60
Moderately hard	61 - 120
Hard	121 - 180
Very Hard	Greater than 180

Table 1.--*Drinking water standards for selected constituents, and properties and criteria for the purposes of irrigation and livestock watering*

[Concentrations in micrograms per liter unless specified; MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; mg/L, milligrams per liter; --, no criterion or standard available]

	USEPA Drinking Water Standards[1]		Washington State Primary Contaminant Criterion[2]		
Constituent or property	MCL	SMCL		Irrigation	Livestock watering[4]
pH (units)	--	6.5 to 8.5	--	[3]4.5 to 9.0	--
Dissolved solids (mg/L)	--	500	--	[3a]500	--
Sulfate (mg/L)	--	250	--	--	--
Chloride (mg/L)	--	250	--	--	--
Fluoride (mg/L)	4	2	4	--	--
Nitrate (mg/L as nitrogen)	10	--	10	--	--
Nitrite (mg/L as nitrogen)	1	--	--	--	--
Nitrite plus nitrate (mg/L, as nitrogen)	10	--	10	--	--
Arsenic	50	--	--	[4]100	200
Barium	2,000	--	1,000	--	--
Boron	--	--	--	[3a]750	5,000
Cadmium	5	--	10	[4]10	50
Chromium	100	--	50	[4]100	1,000
Copper	[1a]1,300	1,000	--	[4]200	500
Iron	--	300	--	--	--
Lead	[1b]b15	--	50	[4]5,000	100
Manganese	--	50	--	[3]200	--
Mercury	2	--	2	--	10
Selenium	50	--	10	[4]20	50
Silver	--	100	50	--	--
Zinc	--	5,000	--	[4]2,000	25,000

[1] U.S. Environmental Protection Agency (1993a)
[a] Maximum contaminant level goal
[b] Action level under treatment technology.

[2] Washington State Department of Ecology (1990).

[3] U.S. Environmental Protection Agency (1986)
[a] Criterion for long-term irrigation of sensitive crop.

[4] National Academy of Sciences and National Academy of Engineering (1973).

Alkalinity is a measure of a water's capacity to neutralize acid. Alkalinity is important because it buffers pH changes in water. The carbonate and bicarbonate ion components of alkalinity can form complexes with certain metals and reduce their toxicity to freshwater organisms. The bicarbonates of calcium and magnesium decompose in steam boilers and water heaters to form scale and release corrosive carbon dioxide gas (Heath, 1989). Large concentrations of bicarbonate in irrigation water can precipitate calcium and magnesium ions in soil water.

Water that contains high concentrations of sodium can also affect the structure and permeability of soils and can be toxic to some plants. Sodium concentrations in water for irrigation can be evaluated with the sodium adsorption ratio (SAR), which is calculated with the following equation (Hem, 1992):

$$SAR = \frac{(Na^+)}{\sqrt{1/2\,[\,(Ca^{2+}) + (Mg^{2+})\,]}} \quad , \qquad (2)$$

where Na^{+} (sodium), Ca^{2+} (calcium), and Mg^{2+} (magnesium) are concentrations expressed in milliequivalents per liter. High values for SAR imply a hazard of sodium replacing adsorbed calcium and magnesium in soil. SAR hazards are classified into the following ranges (Hem, 1992, fig. 51):

Sodium hazard	SAR value
Low	Less than 10
Medium	10 - 18
High	19 - 26
Very High	Greater than 26

For sensitive fruits, the sodium tolerance is a SAR of no more than about 4. For less-sensitive crops and forages, the tolerance is a range of SAR's from about 8 to 18, depending on local soil conditions (U.S. Environmental Protection Agency, 1976).

The presence or absence of dissolved-oxygen influences some of the chemical reactions in water. Low dissolved-oxygen concentrations indicate that a chemically reducing reaction is possible, whereas high concentrations indicate that a chemically oxidizing reaction is possible. The solubilities of iron and manganese are two examples of how a low dissolved-oxygen concentration and a low oxidation-reduction potential affect the solubility of certain chemicals.

By quantifying the various dissolved inorganic and organic chemical constituents present in water samples, the composition of ground water and its quality can be described. Most of the dissolved inorganic constituents are ions. Cations are positively charged and include calcium, magnesium, sodium, potassium, and most metals. Anions are negatively charged and include bicarbonate, carbonate, sulfate, chloride, fluoride, and nitrate. Silica is a major dissolved component that is not an electrically charged ion. Most of these constituents are abundant in natural waters—those constituents that are usually present in concentrations greater than 1.0 mg/L are referred to as the major ions (Hem, 1992). Of the anions, sulfate, chloride, and fluoride can affect the suitability of water for drinking. In addition to imparting unpleasant taste to the water, excessive concentrations of sulfate can have a laxative effect on humans. High fluoride concentrations can also have adverse physiological effects, such as tooth-enamel discoloration; however, moderate concentrations protect the teeth against decay. The USEPA (1993a) recommends SMCL's of 250 mg/L for sulfate and chloride, a SMCL of 2 mg/L for fluoride, and a MCL of 4 mg/L for fluoride in drinking water (table 1).

Major ions are sometimes used to describe, in a general way, the water type or composition of natural water on the basis of percentages of dominant ions. The first step in determining water type is to convert major ion concentrations from milligrams per liter to milliequivalents per liter. A milliequivalent is based on the number of molecules and electrical charge of a compound and is the amount of the compound that either furnishes or reacts with a given amount of H^{+} or OH^{-}. When expressed as milliequivalents, all cations or anions are equivalent for the purpose of balancing chemical equations. The second step in determining water type is to add the milliequivalents of the cations and of the anions. Because water is electrically neutral, the cation sum value should nearly equal the anion sum value. Finally, the contribution of each ion to its respective sum is calculated as a percentage. The cation and anion that contributes the most to their respective sums defines the water type. For example, the water type of seawater is sodium/chloride.

A trilinear (Piper) diagram is a tool to determine water types. The percentages of cations and anions for a given sample are plotted on the diagram. The water type is determined from the zone of the diagram in which the sample values are plotted and is named for the dominant cation and anion. Combined water types, in which more than one cation or anion dominate, are possible and quite common. To qualify as the sole dominant ion, an ion must make up at least 60 percent of the cation or anion sum, and the analysis must be plotted near one of the corners of the diagram (see plate 9). An ion that makes up less than 20 percent of the sum will not be part of the water type. For a combined water type, the ions are listed in order of dominance. For example, a calcium-magnesium/bicarbonate type has more calcium than magnesium, and a magnesium-calcium/bicarbonate type has more magnesium than calcium, but both are plotted in the same zone of the diagram. The diagram is based only on percentages and does not show actual concentrations.

Nitrogen and phosphorus are two major components of sewage, and because they are nutrients required for plant growth, they are major components of fertilizers. Nitrogen can be present in water as nitrite or nitrate anions, as ammonium cations, as ammonia, and at intermediate oxidation states as a part of organic solutes (Hem, 1992). The extent to which these forms are found in water depends on their different chemical properties. The nitrite ion, ammonium ion, and some organic forms are unstable in water with dissolved oxygen present. In drinking water, large concentrations of nitrate can be harmful to infants less than three months old. Because of the potential risk to bottle-fed infants, the USEPA (1993a) designated a MCL of 10 mg/L nitrate nitrogen for domestic water supplies (table 1).

Inorganic phosphorus is typically present in water in its oxidized form of phosphate. The low solubility of phosphorus and its use by biota as a nutrient usually limit the concentrations of phosphorus in water to less than a few tenths of a milligram per liter. Because the organic form of phosphorus is a component of sewage, detergents, and some insecticides, the organic forms can sometimes constitute a significant fraction of the dissolved and particulate phosphorus in natural waters (Hem, 1992).

Excessive amounts of nitrogen and phosphorus in ground water might be of concern if the ground water discharges into a surface-water body, such as a lake, where these nutrients behave as aquatic plant fertilizers. To prevent excessive plant growth, the USEPA (1986) recommends a maximum total phosphorus concentration of 0.05 mg/L in streams near the points where they discharge into a lake or reservoir.

Dissolved iron and manganese can be present in high concentrations in ground water, largely due to natural processes. These processes depend closely on ambient geochemical conditions, especially the concentration of dissolved oxygen. Water depleted of oxygen can dissolve iron or manganese from the surrounding minerals as chemically reduced forms. If the water is reoxygenated, the iron or manganese is oxidized to a less soluble form than the reduced form and will precipitate as an oxide or a carbonate. Because of these oxygen-sensitive reactions, dissolved iron and manganese concentrations in a given area can vary considerably, depending on dissolved oxygen concentrations. In addition, the iron and manganese content of the aquifer material can be highly variable. Iron and manganese in excessive amounts makes drinking water taste unpleasant and stains plumbing fixtures and laundry. The USEPA (1993a) drinking water SMCL's are 300 micrograms per liter (μg/L) for iron and 50 μg/L for manganese (table 1).

The trace elements analyzed for in this study include boron, metals such as barium, cadmium, chromium, copper, lead, mercury, silver, and zinc, and nonmetallic elements such as arsenic and selenium. If present in natural water systems, trace elements are usually found in low concentrations in quantities of micrograms per liter.

Boron is found in nature as a sodium- or calcium-borate salt and as the mineral tourmaline in igneous and granitic rocks (Hem, 1992). Small amounts of boron are essential for plant growth, but concentrations greater than 750 μg/L in irrigation water can harm certain crops (U.S. Environmental Protection Agency, 1986). Because boron is sometimes used in cleansing products, it can be present in sewage and industrial wastes.

Barium is one of the alkaline-earth metals, along with the common elements magnesium and calcium. Most barium in natural water is likely from barite. The USEPA (1993a) MCL for barium is 2,000 μg/L and the State's primary contaminant criterion is 1,000 μg/L (Washington State Department of Ecology, 1990).

Cadmium is present in zinc ore minerals and copper ore. It is used for electroplating, paint pigments, plastics, batteries, and fluorescent tubes. Because many products contain cadmium, there are many opportunities for leaching of cadmium into ground water as the buried wastes of these products come into contact with water. The USEPA (1993a) MCL for cadmium is 5 μg/L.

Chromium is present in air, soil, and living organisms (Hem, 1992). Although chromium is common in the Earth's crust, it is usually absent from natural waters. Chromium is an essential micronutrient for human beings, but is toxic in high concentrations; the hexavalent form (Cr^{6+}) is more harmful to humans and aquatic animals than the trivalent form (Cr^{3+}). The USEPA (1993a) MCL for chromium in drinking water is 100 μg/L. The Washington State water quality standards for ground water (Washington State Department of Ecology, 1990) lists a primary contaminant criterion of 50 μg/L for chromium, a level that is the same as a previous USEPA MCL for chromium (U.S. Environmental Protection Agency, 1988).

Copper exists in nature as a native metal and as a component of various minerals. In addition to copper's importance in industry and manufacturing, the oxides and sulfates of copper are used in pesticides and are incorporated into paints and wood preservatives to inhibit biological growth. Copper is also an essential micronutrient for plants and animals. Concentrations of copper greater than USEPA (1993a) SMCL of 1,000 μg/L impart an unpleasant taste to drinking water.

Lead and mercury concentrations in natural waters are typically low because these elements tend to form complexes with other inorganic and organic substances. Sources of lead and mercury are usually industrial, particularly ore smelting and fossil-fuel burning (Hem, 1992).

Both metals tend to accumulate in animal and human tissues and are highly toxic. The USEPA (1993a) MCL for lead in drinking water supplies is governed by best available treatment technology with an action level of 15 µg/L; the State's primary contaminant criterion for ground waters is 50 µg/L (Washington State Department of Ecology, 1990). The USEPA (1993a) MCL for mercury in drinking water is 2 µg/L.

Silver is a rare element in crustal rocks, but is used extensively by humans, especially in photography. Silver is also used in the seeding of clouds and has been proposed as a disinfectant for water. The State's primary contaminant criterion for silver is 50 µg/L.

Zinc is commonly associated with the sulfides of such metals as lead, copper, cadmium, and iron, and is important in many industrial applications. Zinc is also an important micronutrient for human metabolism. The USEPA (1993a) SMCL for zinc in drinking water is 5,000 µg/L.

Arsenic is ubiquitous in nature. Arsenic has a complex chemistry in water, where it can exist in trivalent (As^{3+}) or pentavalent (As^{5+}) states. Most forms of arsenic are toxic to mammals, but the trivalent compounds tend to be more toxic than the pentavalent compounds. The USEPA (1993a) MCL for arsenic is 50 µg/L in drinking water (table 1), but the value is being reviewed and might be lowered to 3 µg/L or less (Turney and others, 1995).

Selenium is a rare element that is an essential micronutrient for animals, but is toxic in high concentrations. In many western states, selenium has been found in the soils and drainage water in irrigated areas. The USEPA (1993a) MCL for selenium is 50 µg/L, and the State's primary contaminant criterion is 10 µg/L.

The fecal coliform bacteria group is a subset of a large group of indicator bacteria known as the total-coliform bacteria. Fecal coliform bacteria typically inhabit the intestines of warm-blooded animals and are therefore present in feces and sewage. Because they are easier to collect, artificially grow, and quantify than most pathogenic organisms, the fecal-coliform bacteria are used to indicate the potential presence of pathogenic organisms in water contaminated by human or animal wastes. With the exception of a few strains or varieties of certain species, the indicator bacteria are not typically pathogens. Drinking water standards governing coliform bacteria are complex and usually based on statistical measures that are obtained by some type of regular monitoring program. The USEPA (1993a) MCL for bacteria is based on the presence or absence of total coliform bacteria in a sample rather than on an estimate of coliform concentration. In addition, the USEPA requires that if a sample is positive for total coliforms, the sample is analyzed further to determine if fecal coliforms are present. If fecal coliforms are detected, then the MCL for total coliform is violated. Although total coliforms were not analyzed for in this study, the presence of fecal coliforms in a water sample implies that the MCL for bacteria is exceeded.

Septage refers to the mixture of sludge, fatty materials, and wastewater that accumulates in a septic tank (Canter and Knox, 1985). Major components of septage are dissolved and suspended solids, organic nitrogen, ammonia, phosphorus, chloride, some metals, and bacteria. In addition, septage can contain detergents and various other cleaning agents, including synthetic organic compounds. Methylene-blue-active substances (MBAS) are common additives in detergents and are one of a trio of constituents referred to in this study as septage-related constituents. The other two septage-related constituents are boron and dissolved organic carbon (DOC). Boron is often a detergent residue, and high concentrations of DOC may indicate the presence of some organic septage compounds. When evaluated as a group, the presence of MBAS, boron, and DOC might indicate ground-water contamination by septic systems.

Synthetic organic compounds are organized into one of several groups on the basis of similar chemical and physical properties. One property, aqueous solubility, determines to a large extent which compounds are found in water (Smith and others, 1988). Nonionic compounds, such as the organochlorine insecticides, are nearly insoluble and are usually not detectable in water samples. These compounds tend to sorb to soils by partitioning into organic matter, where they can persist for several years (Smith and others, 1988). Compared with chlorinated insecticides, the carbamate insecticides (such as carbaryl) and organophosphorus insecticides (such as diazinon and malathion) are more soluble in water and less environmentally persistent (Smith and others, 1988). Ionic compounds, such as herbicides and phenolic compounds, typically are soluble in water, but their solubilities vary with pH. Herbicides tend not to partition into organic matter, and are generally nonpersistent in the environment, and many are rapidly degraded by microbial action or by photolytic and hydrolytic reactions (Smith and others, 1988). The types of synthetic organic compounds of interest to this study are volatile organic compounds (VOC's) typically associated with manufacturing and industrial activities, and pesticides. The VOC's compose groups such as the halogenated aliphatic and monocyclic aromatic hydrocarbons, such as carbon tetrachloride and benzene; and the polycyclic aromatic hydrocarbons, such as naphthalene and benzo(a)pyrene. The pesticides include the organochlorine, carbamate, and organophosphorus insecticides, and the organonitrogen and organochlorine herbicides.

METHODS OF INVESTIGATION

To define the ground-water resources of western Snohomish County, previous studies of this and similar areas were examined, pertinent data were collected, and new and existing data were analyzed.

General Information

Ground-water wells are the primary source of information used to define the geohydrologic framework, ground-water system, and ground-water quality. The boundaries of aquifers and confining units (geohydrologic units) were defined by evaluating and correlating the lithology described in drillers' logs of wells. To define the ground-water system, wells were used for measuring water levels (heads) and for estimating hydraulic properties of the aquifers. Ground-water quality was described by analyzing water samples collected from wells.

A field inventory of 1,330 wells was conducted to determine accurate locations, to determine land-surface altitudes, to measure ground-water levels, to determine water use, to verify information on ownership and characteristics of construction and plumbing, to determine suitability for water-quality sampling, and to determine suitability as part of a water-level observation network. Location and land-surface altitude were estimated using 7.5-minute topographic maps. Water levels were measured in 876 wells, 297 wells were selected for water-quality sampling, and 40 wells were selected for the water-level observation network. The data describing the inventoried wells are shown in appendix A.

Two goals of the field inventory were to obtain an even areal distribution of wells and a uniform distribution of depth of wells. The approach was to select two wells, one shallow (less than 100 ft) and one deep (more than 100 ft) in each section or square mile of the study area. The first goal was mostly achieved with a fairly even areal distribution throughout the study area (plate 1). Some areas had smaller or larger densities of wells because some areas had no available wells, or in some areas the well owners could not be found or contacted. The distribution of depths of wells is biased toward more shallow wells because most wells in the County are less than 200 ft deep (fig. 13).

The inventoried wells are evenly distributed over a range of land-surface altitudes (fig. 13). Nearly all the wells are used for domestic water supply, and most are steel-cased and were drilled using air-rotary or cable-tool methods. The distributions of well depth, land-surface altitude, water use, and method of construction shown on figure 13 apply to the inventoried wells, but probably are a reasonable representation of all the wells in western Snohomish County.

Geohydrologic Framework

The geohydrologic framework describes the boundaries and lithology of the geohydrologic units (aquifers and confining beds) in the study area. The three-dimensional locations of these boundaries were defined in a map of the surficial geohydrology, in geohydrologic cross sections, and in maps of areal extent and altitude of the upper surface of each unit (plates 2-5). Drillers' logs of wells containing lithology were the principal source of information. In addition, many large-scale geologic maps and geophysical information in geologic consultant reports were used to help define the framework. Much of the geohydrologic analysis was performed using a geographic information system (GIS) that included locations and lithologic information for 1,281 wells, surficial geology from four maps, (Tabor and others (1982), Tabor and others (1988), Pessl and others (1989), and Yount and others (1993)), and digital land-surface altitudes (30-meter cell size) obtained from topographic maps of 1:24,000 scale.

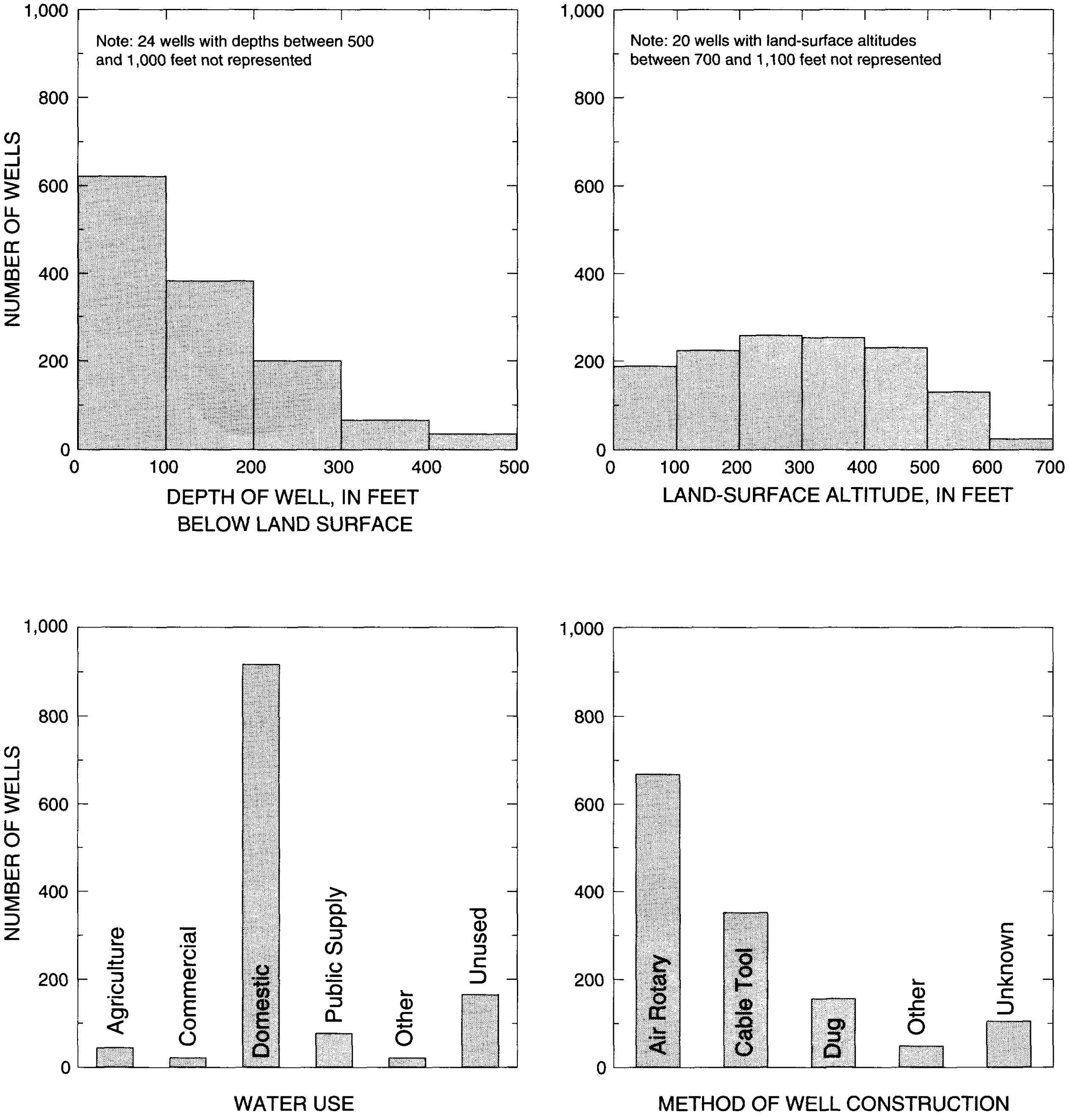


Figure 13. Frequency distributions for selected characteristics of inventoried wells in western Snohomish County, Washington

The boundaries of the geohydrologic units were defined in several steps by analyzing and correlating surficial geology, land-surface altitudes, and lithologic information from wells. The first step in the analysis was to define the geohydrologic units on the basis of the lithologic and hydraulic properties of the geologic units mapped in the study area. Then top and bottom surfaces of geohydrologic units in 1,143 well logs were defined by analyzing the driller's lithologic descriptions. The next step was to construct 12 east-west and 15 north-south cross sections using lithologic information from 338 wells (eight of those cross sections are shown on plates 3 and 4 of this report). The 27 cross sections are spaced about 3 mi apart and cover about 460 mi in length. The next step was to define the areal extent of geohydrologic units using the information in the 27 cross sections, outcrop locations, and lithologic information from the other 805 wells. To construct the top surface of a unit, contours of equal altitude were drawn on the basis of cross-section data and the altitude of the unit at a well.

Ground-Water System

Hydraulic Properties

To estimate the horizontal hydraulic conductivity of the geohydrologic units, specific-capacity data obtained from drillers' logs were converted to hydraulic conductivity using either of two equations, depending on the method of construction of each well. Only data from wells with complete specific-capacity information (discharge rate, discharge time, drawdown, well-construction data, and lithologic log) were used, and all wells had been pumped a minimum of 1 hr.

For wells that had a screened, perforated, or open-hole interval (a section of a well in bedrock with no casing or screen), the modified Theis equation (Ferris and others, 1962) was used to estimate transmissivity values. This equation, solved for transmissivity using Newton's iterative method (Carnahan and others, 1969), is

$$T = \frac{Q}{4\pi s}\ln\frac{2.25Tt}{r^2S}, \qquad (3)$$

where

T = transmissivity of the geohydrologic unit, in square feet per day;

Q = discharge, or pumping rate, of the well, in cubic feet per day;

s = drawdown in the well, in feet;

t = length of time the well was pumped, in days;

r = radius of the well, in feet; and

S = storage coefficient, dimensionless.

The storage coefficient used in equation 3 was estimated as 0.10 for all unconfined geohydrologic units and 0.001 for all confined units. These typical values (Heath, 1989) were used because sufficient detailed hydraulic information was not available to separately define storage coefficients for the different geohydrologic units.

Horizontal hydraulic conductivity was computed using the transmissivity from equation 3 and the following equation:

$$K_h = \frac{T}{b}, \qquad (4)$$

where

K_h = horizontal hydraulic conductivity of the geohydrologic unit, in feet per day;

T = transmissivity, as calculated above; and

b = thickness of the geohydrologic unit, in feet, approximated by the length of the open interval as described in the driller's water well report.

The use of the open interval to approximate the thickness of a geohydrologic unit assumes that the wells are open through the entire thickness of the unit, which was never the case. Nevertheless, this assumption is necessary because the equations as derived assume only horizontal flow; in a homogeneous geohydrologic unit, horizontal flow can be measured only if a well penetrates the entire unit thickness. However, in heterogeneous and anisotropic glacial geohydrologic units, such as those in western Snohomish County, vertical flow is likely to be much smaller than horizontal flow because the layering of the geologic materials leads to horizontal hydraulic conductivities that are generally much larger than vertical hydraulic conductivities. Thus, the assumption that the open interval represents unit thickness is considered reasonable.

A second equation was used to estimate hydraulic conductivity for wells having only an open end, and thus no vertical dimension to the opening. Bear (1979) provides an equation for hemispherical flow to an open-ended well that just penetrates the upper part of an aquifer. When modified for spherical flow to an open-ended well within an aquifer, the equation becomes

$$K_h = \frac{Q}{4\pi s r}\,, \qquad (5)$$

where

K_h = horizontal hydraulic conductivity of the geohydrologic unit, in feet per day;

Q = discharge, or pumping rate of the well, in cubic feet per day;

s = drawdown in the well, in feet; and

r = radius of the well, in feet.

Equation 5 is based on the assumption that ground water can flow at the same rate in all directions, and specifically that horizontal and vertical hydraulic conductivities are equal. As discussed above, this is not likely to be true for glacial material. However, the errors associated with violating this assumption are likely to be less than those resulting from using equations 3 and 4 for open-ended wells (Turney and others, 1995, p. 11).

The average or median hydraulic conductivities estimated for geohydrologic units in this study are biased toward higher values because of the nature of the statistical sample of inventoried wells. The ideal statistical sample of wells would represent all the horizontal and vertical variations of lithology and pore-size structure in the geohydrologic units. The wells used in this study represent only the more productive parts of the units because they are primarily domestic wells that were drilled for water-supply purposes. When a driller installs a well, the depth, location, and construction of the well are determined to maximize the amount of water that can be pumped. Thus, the less productive fine-grained parts of the geohydrologic units are bypassed until a coarse-grained productive part is found. The bias toward higher values of hydraulic conductivity is more acute for the confining beds than for the aquifers. The overall hydraulic conductivity of the confining units is low, but the sample of inventoried wells is mostly located in the discontinuous coarse-grained lenses that have higher conductivities. The overall hydraulic conductivity of the aquifers is high because most parts of the aquifers are coarse-grained, and the sample of inventoried wells is likely to be located in the widespread coarse material.

Recharge and Directions of Flow

The estimates of ground-water recharge from precipitation were based on the results of precipitation-runoff studies in King County. Because the methods used in making the estimates are complex and involve much interpretation, they are described in the section on recharge (p. 50-52).

The directions of ground-water flow in each aquifer were defined using potentiometric maps that were constructed from water levels measured in wells. During the field inventory, water levels were measured in 876 wells. Water levels were not measured at the remaining inventoried wells because either the wells were destroyed, physical access was not possible, or the owner's permission was not given. For 319 wells in which water levels were not measured during the inventory, water levels measured by drillers or measured previously by the USGS were used to help define potentiometric surfaces in areas of insufficient data.

Potentiometric maps were constructed by plotting the water levels at well locations and fitting contours of equal water levels through the point data. Contours were not fit to some anomalous water levels (about 6 percent of the water levels) because (1) there may be possible errors in the estimates of land-surface altitudes at the wells, which would lead to errors in the water-level altitudes, or (2) in some areas, nearby wells were completed in upper and lower parts of an aquifer that may have large vertical head differences.

Discharge

The amount of natural ground-water discharge going to surface-water bodies, springs, seepage faces on cliffs, Puget Sound, and evapotranspiration was not estimated because no data were collected, nor were any data available that could be used for that purpose.

The amount of ground-water withdrawals by wells for 1992 was estimated for five categories of use: public supply, domestic self-supplied, irrigation, livestock, and mining. The commercial and industrial activities in western Snohomish County obtain water largely from public-supply sources, primarily the City of Everett, which obtains its water from Spada Lake.

The Washington State Department of Health (WDOH) has grouped public-supply systems into either class A or class B. Class A systems have 15 or more residential service connections, or serve 25 or more people. In addition, class A includes non-residential systems with similar criteria as for residential systems, such as schools, businesses, motels, restaurants, campgrounds, county parks, and churches. Class B systems are all public-supply systems that do not meet the criteria for class A.

Public-supply data obtained from the WDOH included location and depth of wells, number of connections, owner, and address. Fifty-nine class A system owners were contacted directly by phone or mail to verify the WDOH data and to collect actual pumpage data. Those 59 systems included about 90 percent of the total class A connections in the study area.

In 1992, there were 141 class A systems, with about 30,000 residential connections serving about 75,000 people, and 611 class B systems, with about 1,960 residential connections serving about 4,900 people. The populations for most systems were estimated using an average of 2.5 people per connection. These public-supply systems provide water primarily for drinking or other domestic uses, but small quantities were also used for irrigation, raising livestock, and commercial activities.

To estimate water used by the class A public-supply systems, pumpage data from the contacted class A systems were combined with estimated pumpage for the remaining systems. An average use per residential connection of 300 gal/d was obtained by using pumpage data from 20,000 connections in 12 of the largest systems. This average value was applied to systems with no pumpage data to obtain the estimated values. For the class A systems with non-residential connections, such as restaurants, schools, campgrounds, churches, and stores, average values computed for each category using data from contacted systems were applied to the remaining systems. Total water use in 1992 for class A systems was estimated as 3,151,000,000 gal or 9,670 acre-ft. All water use for class B systems was estimated using the same average water use per connection as class A systems, and its total was 215,000,000 gal or 660 acre-ft.

Domestic self-supplied water is pumped from privately owned wells for domestic purposes such as drinking, flushing toilets, bathing, and irrigation of lawns, gardens, and landscaping. To estimate the amount of this water use, an average water use per capita was applied to the population of users, estimated as 36,400. This number came from the total population of the study area (494,300), minus the population served by public-supplied ground water (79,900), minus the population served by public-supplied surface water (378,000). The population served by public-supplied surface water was estimated using information from the City of Everett, WDOH, and the mail and telephone survey conducted in this study. An average value of 120 gal/d per person was used, which is the public-supply average of 300 gal/d per connection divided by 2.5 people per connection. The estimated domestic self-supplied water use is 1,590,000,000 gal or 4,880 acre-ft.

Irrigation in Snohomish County includes water for crops such as alfalfa, vegetables, fruits, and berries; nurseries and greenhouses; and golf courses. Water for irrigation of crops was estimated on the basis of 6,300 acres of irrigated land in the study area (U.S. Bureau of the Census, 1994), the assumption that one-half of the irrigated land is supplied by ground water (U.S. Bureau of the Census, 1984), and 0.5 ft of irrigation per year (Matt Brady, U.S. Department of Agriculture, Natural Resources Conservation Service, oral commun., 1995). The resulting amount is 513,000,000 gal. Water used for nurseries was estimated by contacting most of the nurseries in the study area. Of the 23 nurseries contacted, 12 had wells and 11 purchased water from public-supply sources. Three of the 12 nurseries with wells had actual pumpage volumes. An average use of 21 gallons per square foot (gal/ft^2) of growing area was computed and applied to the areas of 5 nurseries with more than 1,000 ft^2 of growing area. The resulting total water use for nurseries was estimated as 18,000,000 gal. Water for irrigating golf courses was estimated by contacting 18 courses and obtaining pumpage volumes; only 6 courses use wells, and total water use was 78,000,000 gal. Total water use for irrigation, therefore, was estimated as 609,000,000 gal or 1,870 acre-ft.

Livestock water use in western Snohomish County includes water for dairies (milk cows), beef cows, hogs and pigs, sheep and lambs, and chickens. The amount of water used in the activities associated with livestock was estimated using the number of a particular type of animal, multiplied by the average water use per animal per unit time. The number of animals was obtained from the 1992 Census of Agriculture (U.S. Bureau of the Census, 1994) and the average water use per animal was estimated by Matt Brady (U.S. Department of Agriculture, Natural Resources Conservation Service, oral commun., 1995). The following table shows the results of the estimates of water use by the different kinds of livestock in the study area. Total water use for livestock was estimated as 807,000,000 gal or 2,480 acre-ft.

Type of animal	Number of animals	Average water use per animal (gal/d)	Total water use in 1992 (gallons)
Milk cows	23,700	60	519,000,000
Beef cows	29,350	12	129,000,000
Hogs and pigs	1,620	1.5	887,000
Sheep and lambs	1,580	1.5	865,000
Chickens	860,000	0.5	157,000,000
All			806,752,000

Mining in western Snohomish County is primarily for sand and gravel. Ten of the largest sand and gravel companies were contacted by phone. Most companies use on-site surface water or water purchased from public-supply systems. Ground-water withdrawals by the few companies that had wells was estimated as 70 acre-ft.

Ground-Water Quality

Methods used to collect and analyze water-quality samples followed guidelines presented in several U.S Geological Survey Techniques of Water-Resources Investigations Reports (TWRI) (Wood, 1981; Friedman and Erdmann, 1982; Wershaw and others, 1987; Britton and Greeson, 1988; Fishman and Friedman, 1989; and Fishman, 1993) and, where applicable, guidelines for GWMA studies as presented by Carey (1986). In addition, the field procedures outlined by M.A. Sylvester, L.R. Kister, and W.B. Garrett, eds. (U.S. Geological Survey, written commun., 1990) supplemented the TWRI guidelines.

Water samples were collected from 297 wells and 13 springs during July 1993 to March 1994 to describe the general chemical character of the geohydrologic units and to identify any regional ground-water contamination. The wells selected for water-quality sampling had all been inventoried as part of this study. Most of the selected wells are used for domestic purposes, but some are used for public supply, livestock, and irrigation purposes. The wells were selected to uniformly cover the study area and to be representative of the identified geohydrologic units. Because of the regional nature of this study, samples were not collected from wells known to be affected by point-source contamination problems. However, land use and potential contamination sources were considered in selecting wells for the analyses of certain trace elements, organic compounds, and septage-related compounds, particularly if the potential contamination might be widespread. All selected wells were open to only one geohydrologic unit. All selected wells had an existing pump for water-quality sampling; a submersible-type pump was preferred over a jet, centrifugal, or turbine type. However, in some parts of the study area, a few wells equipped with jet pumps were selected because wells with submersible pumps were not available.

Water samples were collected from a faucet as near to the wellhead as possible and ahead of any water treatment such as disinfection, softening, or filtration. Samples were also collected after a small (less than 50 gal) storage/pressure tank if a faucet was not present near the wellhead or in the water distribution system ahead of the tank. Nylon or polyethylene tubing connected the faucet to a stainless-steel manifold mounted in a mobile water-quality laboratory. The manifold allowed the sample water to be fed directly either to a flow chamber, whole-water line, or filtration unit (fig. 14). At the flow chamber, temperature, pH, specific conductance values, and dissolved-oxygen (DO) concentrations were monitored continuously while purging several casing volumes of water from the well (and the volume of any storage/pressure tank if necessary).

When the flow-chamber measurements were stable for about 10 minutes (indicating that water was being drawn from the aquifer), whole- and filtered-water samples were collected from the appropriate manifold outlets. Stable measurements for 10 minutes were defined as less than a 5 percent change in specific conductance, temperature, and DO, and less than 0.2 pH units. Sample bottles for analyses of organic compounds and for enumeration of fecal-coliform bacteria were filled directly from the faucet. Water for inorganic analyses was filtered through a 0.10-micron membrane filter. The 0.10-micron filter was used because other similar GWMA studies in western Washington (Dion and others, 1994; and Turney and others, 1995) used that size filter, which is better for ground water with high iron and manganese concentrations (Wood, 1981). Water for DOC was filtered through a 0.45-micron silver membrane filter. All other types of analyses, including those for organic compounds, were made with whole water. In this report, concentrations determined from filtered-water samples are referred to as dissolved, and concentrations determined from whole-water samples are referred to as total concentrations.

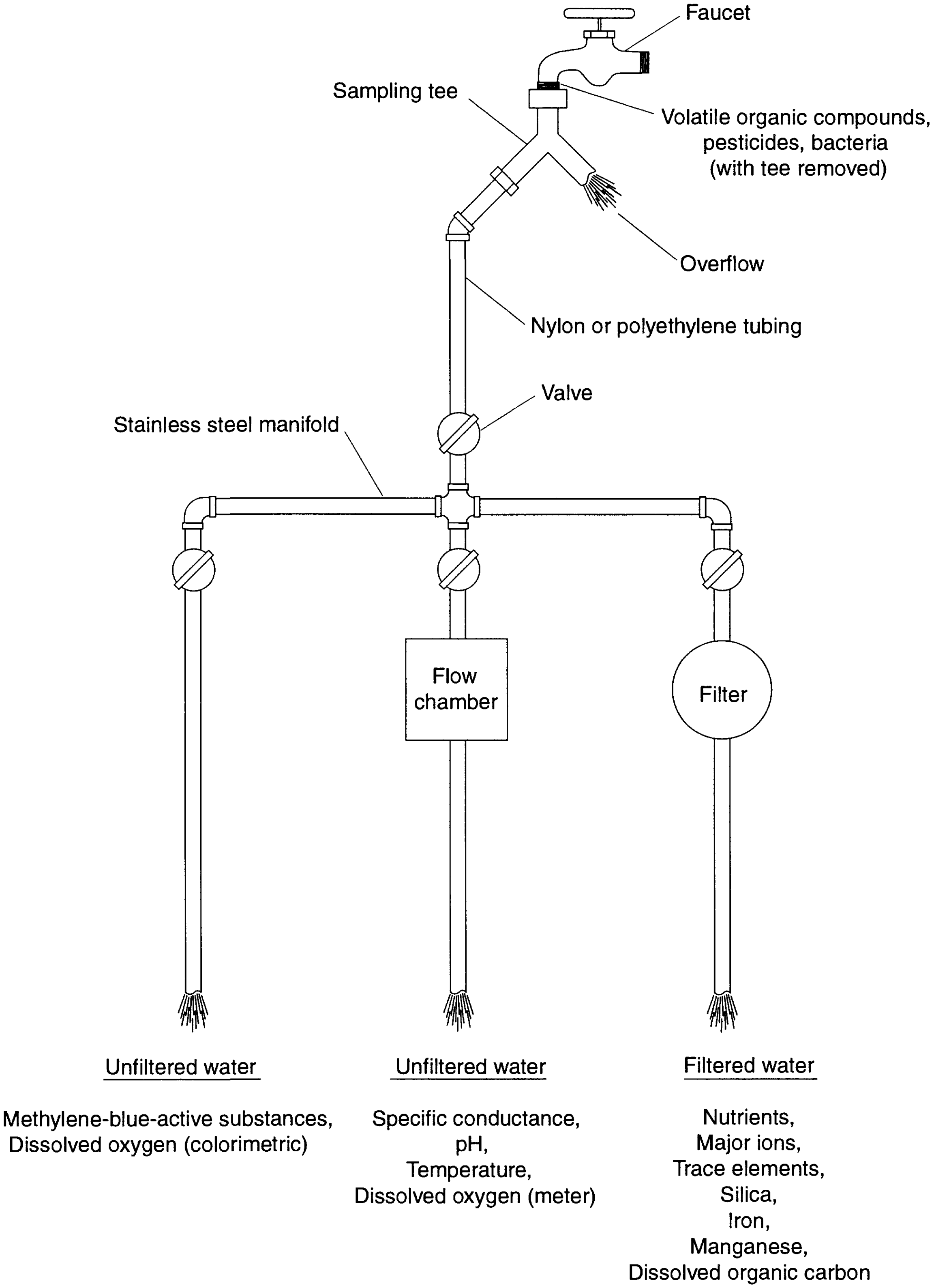


Figure 14. Ground-water sampling system for domestic wells.

After collection, the samples were preserved and chilled, if required, according to standard USGS procedures (Britton and Greeson, 1988; C.A. Watterson and A.T. Kashuba, U.S. Geological Survey, written commun., 1993). Samples to be analyzed by the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo., were sent by first-class mail the next day. Analytical procedures used at the NWQL are described by Wershaw and others (1987), Fishman and Friedman (1989), and Fishman (1993).

All well and spring samples were analyzed for concentrations of major ions, alkalinity, silica, nutrients, iron, manganese, and arsenic (table 2). In addition, fecal-coliform bacteria concentration, water temperature, pH, specific conductance, and DO concentration were measured in the field at all sites. For 68 wells and all 13 springs, samples were analyzed for concentrations of the trace elements barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc. For 95 wells and all 13 springs, samples were analyzed for concentrations of septage-related compounds (boron, DOC, and methylene-blue-active substances (MBAS). Finally, for 18 wells and 1 spring, samples were analyzed for concentrations of selected organic compounds that included one or more of the following classes: volatile organic compounds (VOC's), chlorophenoxy-acid herbicides, triazine herbicides, organophosphorus insecticides, and organochlorine insecticides and related organochlorine compounds.

Concentrations of fecal-coliform bacteria were determined by the membrane-filtration method outlined by Britton and Greeson (1988). Field determinations of temperature, pH, and specific conductance were made on-site with meters, using standard USGS methods (Wood, 1981; M.A. Sylvester, L.R. Kister, and W.B. Garrett, eds., U.S. Geological Survey, written commun., 1990). Dissolved-oxygen concentrations also were determined on-site with a meter if concentrations were greater than 1.0 mg/L. If meter readings were 1.0 mg/L or less, dissolved-oxygen concentrations were verified with a Rhodazine-D colorimetric method (White and others, 1990) developed by Chemetrics, Inc.

All water samples were analyzed for alkalinity at the USGS NWQL. In addition, 91 samples were analyzed for alkalinity in the field. Previous studies of ground-water quality in western Washington have shown that the difference between field and laboratory alkalinity values was insignificant in most cases (Turney and others, 1995, appendix C). The case in which the difference may be significant is ground water with low dissolved-oxygen concentration and high iron concentration. Therefore, using criteria recommended by Turney and others (1995, appendix C) field alkalinity values were determined for any sample with a dissolved-oxygen concentration of 1.0 mg/L or less and an iron concentration of 800 µg/L or more. The iron concentration was estimated in the field at all sites with a colorimetric method also developed by Chemetrics, Inc.

Table 2.--*Number of wells and springs sampled for water-quality analyses, July 1993 to March 1994, western Snohomish County, Washington*

Type of analysis	Wells	Springs
Field measurements (temperature, pH, dissolved oxygen, specific conductance, fecal-coliform bacteria)	297	13
Field alkalinity	91	0
Major ions, silica, laboratory alkalinity	297	13
Nutrients	297	13
Iron, manganese, arsenic	297	13
Trace elements	68	13
Septage-related compounds	95	13
Organic compounds		
Volatile organic compounds	9	0
Chlorophenoxy-acid herbicides	12	1
Triazine herbicides	1	0
Organophosphorus insecticides	4	1
Organochlorine insecticides	1	0

The study's quality assurance program for water-quality data collected in the field included meter calibration, duplicate samples, and field-blank samples. To ensure the accuracy of field pH and specific-conductance measurements, meters were calibrated daily with known standards. Dissolved-oxygen meters were also calibrated daily using the water-saturated air technique. Ten duplicate water samples from nine wells finished in the various aquifers and from 1 spring were collected and analyzed for selected constituents. Eighteen field-blank samples were prepared for selected constituent analyses using either laboratory-supplied inorganic-free or organic-free deionized water. Duplicates and field blanks were processed, treated, and submitted to the NWQL in the same manner as the regular field ground-water or spring-water samples.

Because of the quality assurance program at the NWQL for inorganic and organic constituents, no standard reference water samples (SRWS) or spiked samples were submitted from the field to the NWQL. For internal quality control on most inorganic analyses at the NWQL, standard reference materials (SRM), such as SRWS, are analyzed immediately after each instrument calibration and after about twenty sample determinations (Jones, 1987). The SRWS values must meet specified precision and accuracy criteria, which are 1.5 interlaboratory standard deviations from the interlaboratory mean for each constituent (Jones, 1987). Standardized check samples are also inserted after every 20 determinations to monitor the instrument for drift in the calibration. In addition, the NWQL and the USGS Branch of Quality Assurance regularly submit blind reference samples into the sets of sample analyses. The NWQL inserts SRWS blind samples on a daily schedule and the results are reviewed monthly; the Branch of Quality Assurance submits blind reference samples on the average of one per day and the results are compiled and circulated in semiannual reports (Jones, 1987). For quality control of organic analyses, appropriate standards are spiked into each sample for all gas-chromatographic determinations and a spiked distilled-water sample is added to every set of 10 or fewer samples to determine the percent recovery of various organic compounds.

After review and acceptance of the sample analyses by the NWQL, the resulting analytical data were released to the USGS district office in Tacoma, Wash., by electronic transfer. District and project personnel further reviewed the data for quality and accuracy using various statistical and computational techniques (see appendix C). The project quality-assurance plan by B.E. Thomas and S.S. Embrey (U.S. Geological Survey, written commun., March 25, 1993), a general plan by Friedman and Erdmann (1982), and a quality-control manual by Jones (1987) provide additional details concerning field and laboratory quality-assurance procedures and data review. The results of the quality assurance practices and the analytical data for the samples collected and processed in the field are discussed in appendix C at the end of the report.

Statistical Data Analysis

Several statistical methods were used in this report to help analyze and interpret the hydrologic data. Hydrologic data are usually quite variable, and relations among the data are difficult to determine. Statistical methods are useful for describing characteristics of the data, and they provide support and objective criteria for making decisions about the data. Descriptive statistics, correlation analysis, and hypothesis testing were used in this study.

Descriptive statistics provide a summary of a sample of data. The mean of a sample of observations is the most common statistic, and it describes the location or most representative value. In most samples of hydrologic data, however, the median is used as the most representative value instead of the mean because the median is not affected by extreme values that are common in hydrologic samples. The median is the central value of a sample when the data are ranked in order of magnitude; half the data exceed it and half the data are less than it. In addition to the most representative value of a sample, the dispersion of the sample also needs to be described. The minimum and maximum values provide the range of values in the sample. The 25th and 75th percentiles describe in more detail the shape of the dispersion. The 25th percentile is the value that is exceeded by 75 percent of the data and the 75th percentile is the value that is exceeded by 25 percent of the data.

Correlation analyses are made to determine the strength of association between two variables. A dimensionless correlation coefficient is computed that ranges from -1.0 to 1.0. When there is no correlation between two variables, the coefficient equals zero. The coefficient is positive when one variable increases as the second increases; the coefficient is negative when the variables vary in opposite directions. As the coefficient gets closer to -1.0 or 1.0, the strength of association (correlation) increases. In this study, the nonparametric Spearman's correlation coefficient (ρ) is used because the typical extreme values in hydrologic data invalidate the use of the more common parametric statistics, such as the Pearson's correlation coefficient (Helsel and Hirsch, 1992, p. 207-220).

Hypothesis testing is a powerful statistical method that is useful in making objective decisions about relations between data. Hypotheses are ideas or concepts that describe systems or populations. In order to test a hypothesis, data are collected to provide a sample that represents a population. Statistical tests are then applied to such data, and the results of the tests can be used to substantiate a hypothesis or to determine if a hypothesis must be modified or rejected.

Most of the hypothesis testing in this report was done to evaluate and compare groups of data. An example is a hypothesis that says two groups are from the same population. The two groups may be nitrate concentrations in ground-water samples collected from agricultural areas and in samples collected from non-agricultural areas. The hypothesis is that the nitrate concentrations from both groups are from the same population, and therefore agricultural activity has no effect on nitrate concentrations. If this hypothesis is rejected, then nitrate concentrations are significantly related to agricultural activity.

An important feature of the statistical methods used to test hypotheses is the computed probability or p-value, which is a measure of the strength of evidence (data) for supporting or rejecting the hypothesis. For example, a p-value of 0.03 means that there is a 0.03 probability (or a 3 percent chance) that the conclusion of the statistical test is incorrect. Before the test is made, a threshold significance level (α-level) is usually selected at which the hypothesis is rejected or not rejected. For this report, the threshold level is a α-level of 0.05; a computed p-value of less than 0.05 is significant and a p-value of more than 0.05 is not significant. Thus, using the example in the previous paragraph, if a test computes a p-value of less than 0.05; the hypothesis (that two groups are from the same population) is rejected, and we say that the two groups are significantly different and nitrate concentrations are significantly related to agricultural activity.

GEOHYDROLOGIC FRAMEWORK

This section describes the geohydrologic framework, which defines the physical boundaries and lithology of the geohydrologic units that compose the ground-water system in the study area. Geohydrologic units are a composite of the unconsolidated geologic units in the study area. To understand the framework, it is also helpful to discuss the geologic history, which describes how the geologic units were formed.

Geologic History

Many studies have contributed to our current understanding of the geohydrologic framework of the study area. The geology in this area is a complex combination of continental and alpine glacial deposits and marine and nonmarine interglacial deposits that have been influenced by subsequent forces, such as volcanism, faulting, and erosion. Detailed descriptions of geologic conditions in western Snohomish County and the Puget Sound Lowland are provided by Willis (1898), Bretz (1910, 1911, 1913), Newcomb (1952), Crandell (1965), Crandell and others (1965), Hall and Othberg (1974), Thorson (1980), Tabor and others (1982 and 1988), Booth (1987 and 1990b), Pessl and others (1989), and Yount and others (1993). The brief discussion that follows summarizes information from Newcomb (1952), Booth (1987 and 1990b), and Booth and Goldstein (1994).

Continental glaciers advanced into Snohomish County several times during the Pleistocene Epoch (between 2 million and 10,000 years ago). This ice, part of the Cordilleran ice sheet, is known as the Puget Lobe. The most recent period of glaciation, the Vashon Stade, began about 15,000 years ago. As the climate cooled during the Vashon Stade, the continental ice sheet in Canada expanded, and the Puget Lobe slowly advanced southward into western Snohomish County and beyond. The ice of this Vashon Glacier blanketed the entire Puget Sound Basin before halting and retreating.

As the Vashon Glacier advanced southward, streams and melting ice in front of the glacier deposited sediments throughout the Puget Sound Lowland. As the glacier continued its advance, it overrode these advance outwash deposits and covered them with glacial till. This till, also known as hardpan, consists of reworked older deposits and rocks scoured by the bottom and sides of the advancing glacier. Because of the pressure of thousands of feet of overlying ice, the till is very compact and cemented in some areas, with a texture much like concrete. However, there also are areas where the till was subjected to the influence of subglacial water during deposition, resulting in local deposits of fine- and coarse-grained sediments. About 13,500 years ago, the climate began to warm, and the Vashon Glacier started to retreat. During this retreat, recessional outwash sediments were deposited, filling in discontinuous depressions and channels in front of the glacier.

The typical progression of glacial deposits, from advance outwash to till to recessional outwash, is well preserved at the surface and at depth in most of western Snohomish County. Areas that do not appear to have this typical sequence are the Snohomish River Valley, the Marysville Trough, and the Stillaguamish River Valley west of Arlington (fig. 5). Although there is a good areal distribution of wells throughout the study area, most penetrate to a depth of less than 300 ft below land surface. Among the deeper wells, four are within these areas: wells 31N/04E-03F02, 30N/05E-08L04, 30N/05E-17G01, and 28N/05E-05B01 (appendix A). The till unit was not identified in the lithologic logs of these four wells, nor in any other well in these areas. On the basis of these data, it appears that the till unit is not present at depth in these areas. This may be the result of pre-existing drainages that established coincident subglacial drainage patterns, thus inhibiting deposition of the till. Sediments deposited in these areas appear to be fluvial and correlative in age with the advance or recessional outwash units.

In addition to the continental glacial deposits, sediments in the eastern part of the study area were deposited by alpine glaciers moving out of the Cascade Range. These alpine glaciers are responsible for most of the glacial sediments found in the valleys of the North and South Fork Stillaguamish and Skykomish Rivers. Near the mouths of these valleys, alpine and continental glacial deposits are mixed.

Subsequent to the deposition of glacial sediments, alluvial sediments of Holocene age (10,000 years ago to the present) were deposited. These are predominantly fluvial deposits of sand and gravel in stream and river valleys. During the same time, bog, marsh, and peat deposits were formed in small low-lying and poorly drained areas.

As a result of the glacial and fluvial activity and erosion during the Pleistocene Epoch, the study area is underlain by unconsolidated sediments of both glacial and nonglacial origin. Beneath these deposits are consolidated Tertiary rocks. The thickness of the entire assemblage of unconsolidated deposits varies considerably, but averages about 500 ft thick, with a maximum thickness of more than 1,200 ft (fig. 15). The deposits are thickest in the western part of the study area and are thinner to the east where the Tertiary bedrock is at or near land surface.

Geohydrologic Units

Geohydrologic units are the aquifers and confining beds that compose the ground-water system in the study area. A composite of the unconsolidated geologic units, they were defined on the basis of lithology of the units and stratigraphic and hydrologic relations between adjacent units. In general, the aquifers are the coarse-grained deposits, and the confining beds are the fine-grained deposits.

The unconsolidated geologic deposits of Pleistocene and Holocene age were classified into four aquifers and two confining beds (table 3 and plates 2-5); the bedrock unit at the base of the system was classified as a confining bed. The two upper aquifers are alluvium (Qal) and Vashon recessional outwash (Qvr). In some areas, these aquifers function as one aquifer because they are vertically contiguous and hydrologically connected. In other areas, they are physically separated and function as independent aquifers. The confining bed underlying Qvr is the Vashon till (Qvt). Underlying Qvt is Vashon advance outwash (Qva), the principal aquifer in the study area in terms of amount of use and areal extent. The transitional beds (Qtb) form a confining bed that underlies Qva. The thick undifferentiated sediments (Qu) below Qtb are heterogeneous and not well defined because of meager data, but they are generally coarse grained and have been lumped into a single aquifer. Finally, the base of the ground-water system is bedrock (Tb).

Contours depicting the top of four selected geohydrologic units (plate 5) show varying levels of detail, generally decreasing with depth of the unit. The number of wells penetrating each unit decreases with depth, so the contours become more generalized with each successively deeper unit. During the formation of each unit, a combination of depositional and erosional environments coexisted, resulting in a landscape that was probably similar to that of the present. Therefore, it is likely that many gullies and hills exist in the top surfaces, but they are not shown in the generalized contours on plate 5.

In addition to the seven defined geohydrologic units (Qal through Tb), bog, marsh, and peat deposits (Qm) also cover a small part of the study area. These deposits are composed of peat interbedded with organic rich mud. The typical thickness is about 3 ft with a maximum thickness of about 10 ft. They cover about 6 mi^2 and are located in depressions in the till surface or in low-lying areas of alluvium or outwash. Because they are thin, discontinuous, and have a small areal extent, they have little influence on the regional hydrologic system and they were not classified as a geohydrologic unit for this study.

The youngest geohydrologic unit is the alluvium (Qal) aquifer. This unit is primarily fluvial in origin, and it includes geologic units mapped as younger and older alluvium, beach, and modified land. It consists primarily of sand with some small gravel, but also includes lenses of fine-grained overbank deposits, coarse gravel, and cobbles. The typical thickness is about 40 ft, with a maximum of about 120 ft in the Snohomish River Valley (table 3). It covers about 140 mi^2, and the entire unit is exposed in outcrop (plate 2 and fig. 16). The most areally extensive deposits are in the Stillaguamish, Skykomish, and Snohomish River Valleys, although many stream valleys throughout the study area also contain localized alluvial deposits.

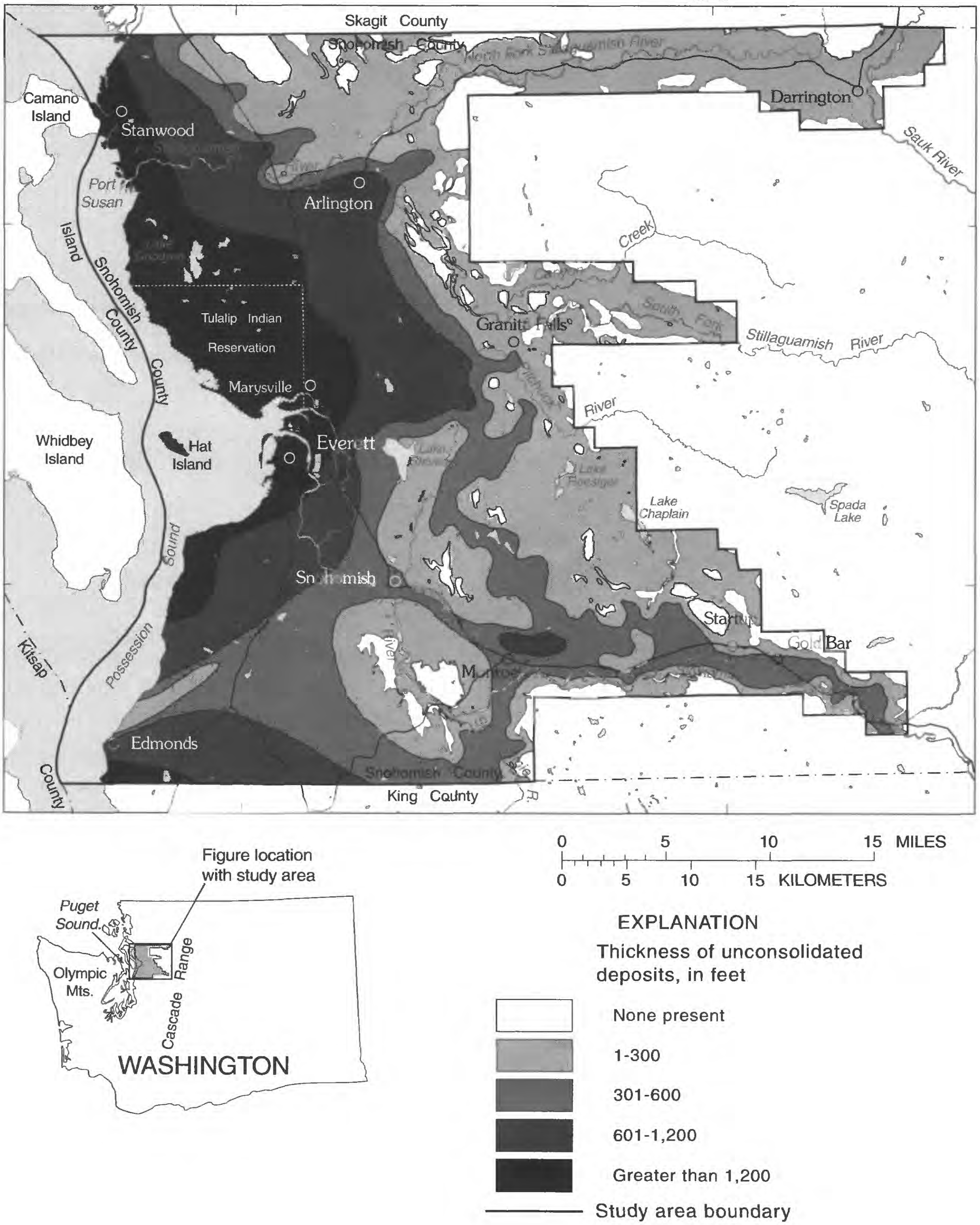
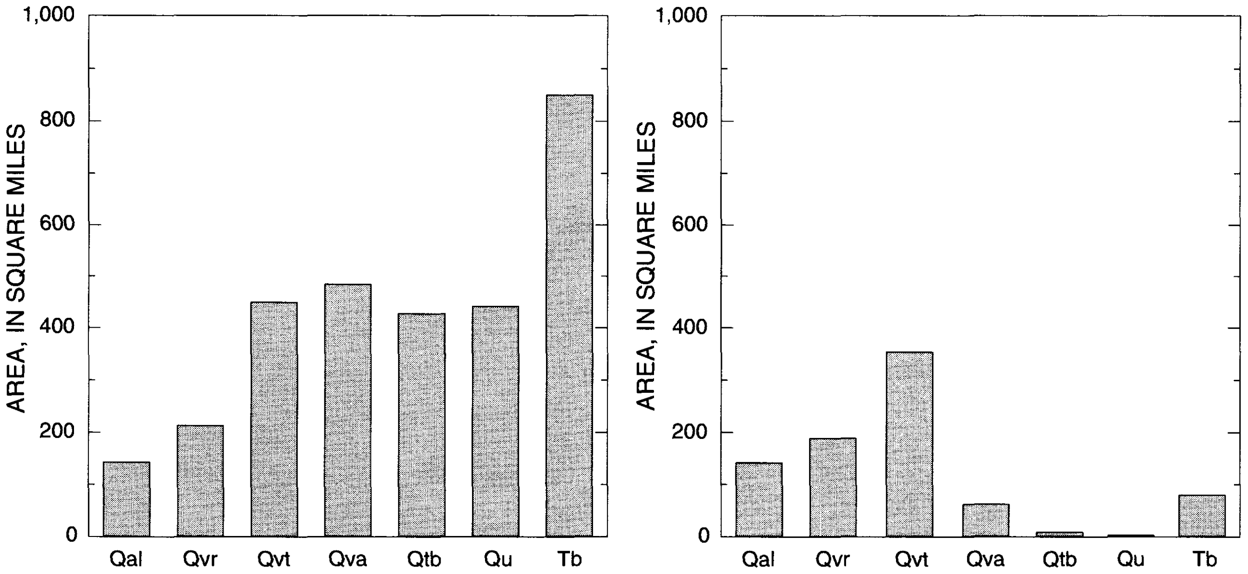


Figure 15. Thickness of unconsolidated deposits (Jones, 1996).

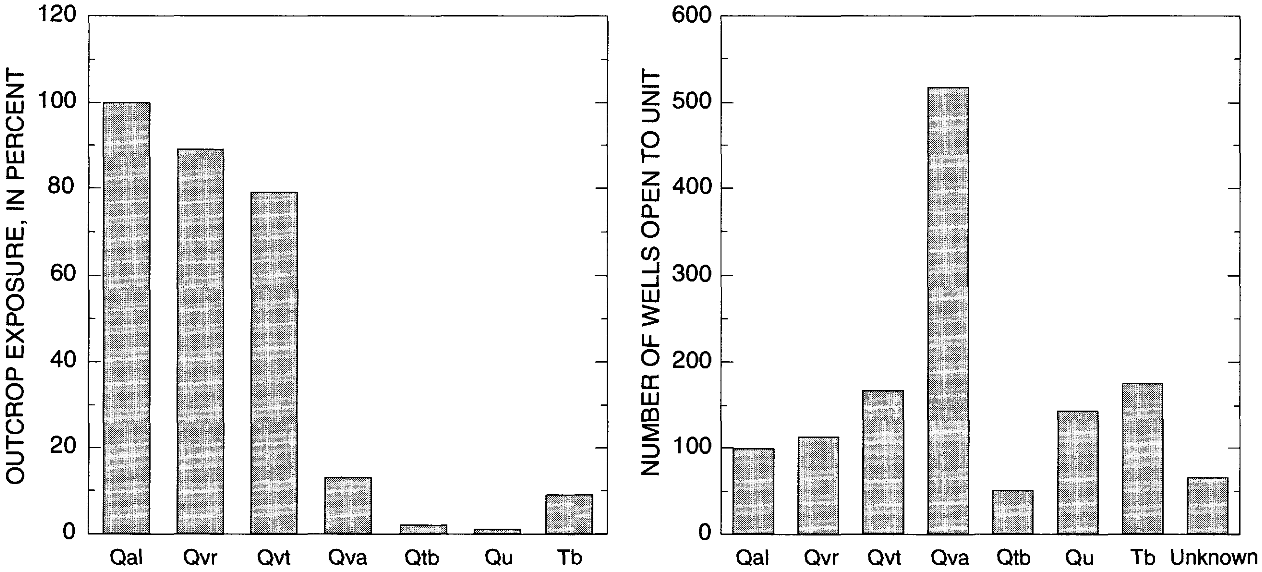
Table 3.--*Lithologic and hydrologic characteristics of geohydrologic units in western Snohomish County, Washington*

Period	Epoch	Geohydrologic unit		Geohy-drologic unit label	Typical thickness (feet)	Maximum thickness (feet)	Lithologic characteristics	Hydrologic characteristics
Quaternary	Holocene	Bog, marsh, and peat deposits		Qm	3	10	Fibrous and woody peat layers interbedded with organic-rich mud	Not an aquifer or a confining bed. Too thin and discontinuous.
		Alluvium		Qal	40	120	Fluvial and beach deposits. Fine to coarse sand with lenses of silt and gravel.	Aquifer. Ground water is unconfined.
	Pleistocene	Vashon Drift of the Fraser Glaciation	Recessional outwash	Qvr	40	250	Moderate to well sorted sand and gravel. Grades to silt. conditions occur locally.	Aquifer. Ground water is unconfined and perched
			Till	Qvt	70	250	Compact, unsorted sand, gravel, and boulders, in a matrix of silt and clay. Some lenses of sand and gravel.	Confining bed, but can yield usable amounts of water. Some thin lenses of sand and gravel.
			Advance outwash	Qva	120	350	Well bedded fine sand. Grades to sand and gravel. Some lenses of silt.	Principal aquifer in terms of use. Most water is unconfined.
		Transitional beds		Qtb	100	400	Laminated sand to silty clay with lenses of sand and gravel.	Confining bed, but can yield usable amounts of water.
		Undifferentiated sediments		Qu	500	1,000	Glacial drift and interglacial deposits. Mostly sand and gravel. Some beds of laminated marine silts.	Mostly an aquifer, but includes some confining beds. Most water is confined.
Tertiary	Eocene	Bedrock		Tb	Unknown	Unknown	Volcanic rocks, conglomerate, sandstone, shale, limestone, etc.	Confining bed, but can yield usable amounts of water. Water contained in fractures and joints. Well yields are small.



AREAL EXTENT OF GEOHYDROLOGIC UNITS

AREA OF OUTCROP OF GEOHYDROLOGIC UNITS



PERCENTAGE OF GEOHYDROLOGIC UNIT THAT IS EXPOSED IN OUTCROP

RELATION BETWEEN NUMBER OF WELLS AND GEOHYDROLOGIC UNITS

Figure 16. Areal distributions of geohydrologic units and number of inventoried wells open to each geohydrologic unit, western Snohomish County, Washington.

The Vashon recessional outwash (Qvr) aquifer is the second youngest geohydrologic unit in the study area with 90 percent of it exposed in outcrop (plate 2 and fig. 16). The aquifer contains primarily the Vashon recessional outwash geologic unit, but it also includes small areas of landslide deposits of recessional outwash. The recessional outwash geologic unit typically has coarse, gravelly sediments at the base that grade upward into fine-grained deposits, a result of a depositional environment that progressed from high to low energy as the glacier retreated. The geologic unit also has been subdivided in previous studies into several members, including the Marysville Sand, Arlington Gravel, and Stillaguamish Sand members (Newcomb, 1952). The lithology of the Qvr aquifer in this study is moderately to well-sorted sand and gravel grading to silt.

The typical thickness of the Qvr aquifer is about 40 ft, with a maximum of about 250 ft in the upper valleys of the North Fork and South Fork Stillaguamish Rivers (table 3). Covering about 210 mi^2, extensive deposits of the Qvr aquifer are found in the Marysville Trough, valleys of the Stillaguamish and Skykomish Rivers, Arlington Heights Plateau, and the western part of the East Stanwood Plateau (plate 2 and fig. 16). Other isolated deposits, which are filled-in depressions in the glacial till, are found in most of the plateaus. The Qvr aquifer pinches out at the periphery except where rivers have incised it to form terraces and bluffs, such as the northern part of the Arlington Heights Plateau (cross section G-G', plate 4). The altitude of the top of the aquifer ranges from 0 to 1,000 ft, indicating that it was deposited on a topographic surface of considerable relief.

The Vashon till (Qvt) confining bed underlies the Qvr aquifer, but about 80 percent of Qvt is exposed in outcrop (plate 5 and fig. 16). The Vashon till confining bed contains the Vashon till geologic unit, but it also includes small areas of fine-grained lahar deposits in the North Fork Stillaguamish River Valley and other fine-grained landslide deposits in the other major river valleys. The Vashon till geologic unit, commonly referred to as hardpan, is generally an unsorted combination of fine- and coarse-grained sediments. It typically consists of some gravel in a clay matrix that is quite compacted and concrete-like in most areas. The Vashon till confining bed in this study has generally the same lithology as described for the Vashon till geologic unit.

The typical thickness of the Qvt confining bed is about 70 ft, with a maximum thickness of about 250 ft in the Lakes Plateau (table 3). It covers about 450 mi^2 and forms the top surface of much of the Intercity, Tulalip, East Stanwood, Getchell, and Lakes Plateaus (plate 5 and fig. 16). The deposits on these plateaus are somewhat discontinuous because of erosion by streams. The altitude of the top of the confining bed ranges from 0 to 800 ft and mostly matches the land-surface topography (plate 5).

The Vashon advance outwash (Qva) aquifer underlies the Qvt confining bed. The aquifer in this study is the Vashon advance outwash geologic unit. The Qva aquifer typically has fine-grained sediments at the base that grade upward into coarse-grained deposits, a result of a depositional environment that progressed from low to high energy as the glacier advanced. The Vashon advance outwash geologic unit has been subdivided in previous studies into several members, including the Esperance Sand, Lawton Clay, and Pilchuck Clay members (Pessl and others, 1989). The lithology of the Qva aquifer is predominantly sand or sand and gravel, with some scattered lenses of fine-grained sediments.

Typical thickness of the Qva aquifer is about 120 ft, with a maximum thickness of about 350 ft in the Tulalip Plateau (table 3). This unit generally does not pinch out, but terminates abruptly in bluffs as a result of erosion by rivers and streams. The Qva aquifer covers about 485 mi^2 with only about 10 percent exposed in outcrop (plate 5 and fig. 16). The aquifer is in several discrete parts of the study area and it is absent near Lake Stevens and in the valleys of the Stillaguamish, Snohomish, Snoqualmie, Skykomish, and Pilchuck Rivers. Possible explanations for these absences are that either the aquifer material may not have been deposited in these areas, it was eroded by subglacial drainage during the glaciation, or it was eroded by rivers after the glaciers departed. The altitude of the top surface is variable, ranging from about -50 to 700 ft, and it generally matches the existing surface topography with gentle slopes under most of the plateaus except the Lakes Plateau, which has several steep mounds with radial slopes.

The transitional beds (Qtb) confining bed underlies Qva. The Qtb confining bed contains the transitional beds geologic unit, and in some local areas, it may contain the basal part of the early Vashon advance outwash deposits, such as the Lawton Clay and Pilchuck Clay members, and the Kitsap Formation (Pessl and others, 1989). The Qtb confining bed is generally considered an interglacial unit deposited in a low energy environment. It is fine-grained, consisting of sandy to silty blue to gray clay with lenses of sand and some gravel.

Typical thickness of the Qtb confining bed is about 100 ft, with a maximum thickness of about 400 ft in the Stillaguamish River Valley (table 3). The Qtb confining bed covers about 430 mi^2, with only about 2 percent exposed in outcrop (plate 5 and fig. 16). It extends throughout the western, or lowland, portion of the study area and fills in a depression in the Skykomish River Valley. In the lowland area, it is absent in the Snohomish River Valley, where the river probably eroded it. The altitude of the top surface ranges from about -100 in the Marysville Trough to about 300 ft under the Lakes Plateau. The top surface forms mounds under the plateaus, with a depression in the Marysville Trough and Snohomish River Valley. In the Skykomish River Valley, a well (27N/09E-05N01) near Gold Bar was drilled to a depth of 690 ft below land surface but did not contact bedrock, indicating a trough feature in this valley. The lithologic log for this well indicates that the sediments are almost entirely fine-grained blue clay and silt, which were classified as Qtb for this report.

The undifferentiated sediments (Qu) aquifer underlies Qtb. This composite aquifer consists of glacial and interglacial deposits that have a wide range of lithologies from coarse-grained sands and gravels to stratified clays and silts. Defined geologic units that are included in Qu are Olympia nonglacial deposits, Possession Drift, Whidbey Formation, and Double Bluff Drift (Pessl and others, 1989). There are probably several individual aquifers and confining beds in Qu, but meager data prevented any differentiation. For this study, Qu was defined as an aquifer because most of its sediments are coarse grained.

Typical thickness of the Qu aquifer is about 500 ft, with a maximum thickness of about 1,000 ft in several parts of the western side of the study area (table 3). It covers about 440 mi^2, with only about 1 percent exposed in outcrop (plate 5 and fig. 16). Similar to Qtb, this unit is regionally extensive throughout the western, or lowland part of the study area and into the Skykomish River Valley. The unit pinches out against the bedrock periphery in the foothills to the east and north (plate 5). The altitude of the top surface ranges from about -300 to 300 ft. A trough extends along the Snohomish River Valley at 100 ft below sea level, through the Marysville Trough, and into the lower Stillaguamish River Valley to 400 ft below sea level.

The basal unit is the bedrock (Tb) confining bed. It consists of a variety of consolidated rocks including volcanic, conglomerate, sandstone, limestone, and others. It underlies the entire study area, with 9 percent exposed in outcrop, mostly along the foothills to the east (plate 2 and fig. 16). The cross sections in plates 3 and 4 show that the surface of Tb drops off rapidly to the west, with a depression below the Everett area. The altitude of the top surface varies considerably from less than 1,200 ft below sea level to more than 2,400 ft above sea level.

Definition of geohydrologic units in the North and South Fork Stillaguamish and Skykomish River Valleys was difficult because the unconsolidated deposits in those valleys are considerably more variable than deposits in the remainder of the study area. The North Fork Stillaguamish River Valley has a mixture of advance and recessional deposits from the Vashon glacier, lahar deposits, alpine glacial deposits, and alluvial deposits. In the South Fork Stillaguamish and Skykomish River Valleys, the advance of the Vashon glacier was limited, resulting in predominantly recessional deposits mixed with alpine glacial, fluvial, and other alluvial deposits. Also notable in the Skykomish River Valley are fine-grained lacustrine sediments, which are a result of ice dams from the Vashon glacier. Ideally, the study area would be divided into lowland and mountain valley regions with separately defined geohydrologic units. However, the scope and scale of this study did not allow this level of detail, and the aforementioned alpine glacial, lacustrine, and other mountain deposits of the large river valleys were lumped into the classification scheme used for the lowland areas to the west.

Two composite aquifers were defined in this study, based on geographic area and the relation between the geohydrologic units. They are the North Fork Stillaguamish River Valley aquifer and the Skykomish River Valley aquifer. In the North Fork Stillaguamish River Valley, Qal, Qvr, and Qva are hydraulically connected, and ground water can flow freely between these units. The till (Qvt) confining bed does exist in the valley, but most of it is on land surface; its primary effect on the flow system is to limit recharge by infiltration and percolation of precipitation. Therefore, the North Fork Stillaguamish River Valley aquifer is a composite of Qal, Qvr, Qvt, and Qva. In the Skykomish River Valley, Qal and Qvr are hydraulically connected, and Qvt and Qva do not extend into the valley. Therefore, the Skykomish River Valley aquifer is a composite of Qal and Qvr. Typical thickness is about 200 ft for the North Fork Stillaguamish River Valley aquifer and 80 ft for the Skykomish River Valley aquifer.

GROUND-WATER SYSTEM

The ground-water system in western Snohomish County consists of multiple aquifers and confining beds in the unconsolidated geologic deposits that lie above bedrock. Some wells in the study area withdraw water from bedrock, but bedrock aquifers have small productivity. This study focused on the aquifers in the unconsolidated material.

The aquifers and confining beds have variable boundaries and hydraulic properties. Because of the large study area of 850 mi^2 and the thick sequence of several hundred feet of heterogeneous deposits, considerable simplification is needed to describe this ground-water system. The defined aquifers are generally composed of coarse-grained material, but local lenses of fine-grained clays or silts may affect the permeability and flow characteristics of the aquifers in those areas. The defined confining beds are generally composed of fine-grained material, but local lenses of coarse-grained sands or gravels can yield moderate amounts of water from individual wells.

Despite the simplifications and uncertainty of the ground-water system described in this report, the description nonetheless provides a useful generalized regional framework. A quantitative assessment of the errors in the estimates of boundaries, hydraulic properties, and recharge was not made because of the difficulty and uncertainty in such an assessment; the density of data, however, is a good indication of the relative accuracy and reliability of the estimates.

Location and Flow Boundaries

Regional System

Ground water is found throughout the study area in all the geohydrologic units in a complex sequence of conditions such as perched, unconfined, and confined. Some parts of the geohydrologic units may be unsaturated at their periphery or where they are thin, but most parts contain at least some ground water.

The boundaries of the regional ground-water system are bedrock, the water table, streams, lakes, and Puget Sound (a saline water body). The lower boundary, the top of the bedrock surface, is considered to be relatively impermeable, with little or no flow crossing that boundary. The upper boundary is the water table, which is not static but rises and falls throughout the year. The water table can be an inflow, outflow, or no-flow boundary, depending on its closeness to land surface, the time of year, and nearby directions of ground-water flow. Water flows into the water table in most areas during the winter as a large amount of precipitation infiltrates land surface and percolates down to the water table. Water can flow out of the water table if it is close to land surface and water can move upward by capillary action to evaporate at land surface or is withdrawn by roots and transpired by plants. At certain times in some areas, ground-water flow is entirely parallel to the water table; in such areas, the water table is a no-flow boundary.

The ground-water system abuts the bedrock along most of the northern, eastern, and southeastern sides of the study area (plate 2). Because of the relatively impermeable bedrock, these sides of the study area are considered to be boundaries of no flow or small inflow. The ground-water system extends across the other sides of the study area, and ground water may flow across these study-area boundaries. Inflow boundaries are (1) along the northwestern side of the study area at the East Stanwood Plateau and (2) at the valley of the Snoqualmie River. Outflow boundaries are (1) along the southwestern side of the study area at the Intercity Plateau and (2) along the entire western side where fresh ground water flows into the saline water of Puget Sound.

Streams and lakes form many ground-water-system boundaries inside the study area. These boundaries may have either inflow or outflow, depending on the gradient between the heads in the adjacent ground water and in the surface-water body. Ground water is discharged when ground-water heads are higher than surface-water heads, and ground water is recharged when the gradient is reversed. Only a few data were available to determine gradients between ground and surface water; those data are discussed in the following section titled "Discharge."

Individual Aquifers

The principal aquifers in the study area are alluvium (Qal), Vashon recessional outwash (Qvr), Vashon advance outwash (Qva), undifferentiated sediments (Qu), North Fork Stillaguamish River Valley aquifer, and Skykomish River Valley aquifer. The Qva aquifer is the most areally extensive and the most used, followed by Qvr, Qal, and Qu.

Ground water in the alluvium (Qal) aquifer is under unconfined conditions in the major river valleys and in many of the moderate-size stream valleys. Flow conditions at the lower boundary of Qal are variable because in different areas the boundary is the top of Qvr, Qvt, Qva, Qtb, or Qu. Where the boundary is with an aquifer (Qvr, Qva, or Qu), some flow may move upward or downward, but where the boundary is with a confining bed (Qvt or Qtb) a smaller amount of vertical flow is likely. The upper boundary of Qal is the water table, with variable flow conditions. Because Qal is in stream or river valleys, the streams or rivers in those valleys are important inflow or outflow boundaries for the aquifer. Water-level data in Qal and available surface-water-level data were not sufficiently accurate to define specific areas of inflow or outflow.

The Vashon recessional outwash (Qvr) aquifer is scattered throughout the study area, with substantial areas in the East Stanwood Plateau, Arlington Heights Plateau, Marysville Trough, and the upper parts of the Stillaguamish and Skykomish River Valleys. The lower boundary of Qvr is usually the top surface of Qvt. This surface forms a relatively impervious boundary that causes most water in Qvr to move laterally and to discharge at springs along plateau edges or into streams. In a few areas such as the Marysville Trough and parts of the major river valleys, Qvt is absent and Qvr lies directly on top of Qva. In these areas, downward movement from Qvr to Qva is probable. The upper boundary of Qvr is the water table. About 90 percent of the aquifer is exposed in outcrop, and all streams that flow through the outcrop area probably form inflow or outflow boundaries with the aquifer.

The Vashon advance outwash (Qva) aquifer is in about one-half of the study area and in several discrete parts that form separate and isolated flow systems (plate 5). The Qva aquifer is absent under the Stillaguamish River Valley, the Snohomish River Valley, and part of the Pilchuck River Valley; and isolated flow systems are under the East Stanwood, Getchell, Lakes, and Intercity Plateaus. In addition, Qva under the Getchell Plateau is split into separate northern and southern flow systems.

The lower boundary of the Qva aquifer is the top surface of the transitional beds (Qtb) confining bed. Because Qtb is a confining bed, it inhibits vertical flow; most ground water in Qva flows horizontally from recharge to discharge areas. The upper boundary of Qva is the water table in unconfined areas and the top surface of Qva in confined areas. Only 10 percent of the aquifer is exposed in outcrop, therefore only a few streams can connect to form boundaries with the aquifer. Such streams include Tulalip and Mission Creeks in the Tulalip Plateau, Panther and Woods Creeks in the Lakes Plateau, and Swamp, North, and Bear Creeks in the Intercity Plateau. Puget Sound is an outflow boundary along the western side of the study area.

The undifferentiated sediments (Qu) aquifer is in about one-half of the study area and is much more continuous than Qva. The lower boundary of Qu is the top surface of the bedrock (Tb) confining bed, and little or no flow crosses this boundary. The upper boundary is the water table in unconfined areas and the top surface of Qu in confined areas. Less than 1 percent of the aquifer is exposed in outcrop, thus streams can connect with the aquifer in only a small area. Such streams are part of West Fork Woods Creek in the Lakes Plateau and small reaches of some streams along the bluffs of the Intercity Plateau. Puget Sound is an outflow boundary along the entire western side of the study area.

The lower boundary of the North Fork Stillaguamish River Valley aquifer is the top surface of bedrock with little or no flow crossing it. The lower boundary of the Skykomish River Valley aquifer is the top surface of the Qu in the lower third of the valley, Qtb in the middle third, and bedrock in the upper third. Most ground water in the Skykomish River Valley aquifer flows horizontally and does not cross this lower boundary with highly variable permeability. The upper boundary of both river-valley aquifers is the water table. The North Fork Stillaguamish River and Skykomish River are important inflow or outflow boundaries; however, water-level data for the aquifers and for the surface water were not sufficiently accurate to define specific areas of inflow or outflow.

Hydraulic Properties

The horizontal hydraulic conductivity of each geohydrologic unit was estimated using specific-capacity data from wells. These specific-capacity data are biased toward higher values because the wells were drilled for water-supply purposes. The bias problem is more pronounced in the confining beds because they have more heterogeneous hydraulic properties than the aquifers. Nevertheless, the estimates of hydraulic conductivity are useful for general comparisons, especially among the aquifers.

The two upper aquifers (Qal and Qvr) have the highest values of horizontal hydraulic conductivity, with medians of 88 feet per day (ft/d) for Qal and 180 ft/d for Qvr (table 4). The two lower aquifers have lower values; Qva has a median of 40 ft/d and Qu has a median of 31 ft/d. The confining beds have a large variability of median values, ranging from 0.82 ft/d for Tb to 53 ft/d for Qvt.

The geographic variation of horizontal hydraulic conductivity was analyzed for Qvr and Qva. The other units did not have sufficient density of data for such an analysis. Unit Qvr has a median conductivity of 280 ft/d in the Arlington Heights Plateau; thus, it appears that area has higher conductivities than the other areas of Qvr (table 4). Most areas of Qva have similar median conductivities of about 40 ft/d, except that the median conductivity under the Tulalip Plateau is 70 ft/d.

Table 4.--*Summary of horizontal hydraulic conductivity for geohydrologic units, estimated from specific-capacity values of wells, western Snohomish County, Washington*

Geohydrologic unit	Area	Number of wells	Horizontal hydraulic conductivity, in feet per day				
			Minimum	25th percentile	Median	75th percentile	Maximum
Qal	Entire unit	30	3.6	40	88	980	3,200
Qvr	Entire unit	48	0.080	18	180	300	1,800
	Arlington Heights Plateau	11	4.7	60	280	400	770
	Marysville Trough	14	0.13	74	210	310	460
Qvt	Entire unit	60	0.040	9.3	53	160	1,000
Qva	Entire unit	215	0.18	14	40	130	2,800
	East Stanwood Plateau	23	2.6	11	36	82	430
	Tulalip Plateau	41	0.23	20	70	140	1,400
	Getchell Plateau	40	1.0	11	36	150	890
	Lakes Plateau	34	0.18	9.1	43	85	660
	Intercity Plateau	49	3.4	20	42	100	310
Qtb	Entire unit	16	0.025	7.6	20	58	280
Qu	Entire unit	54	0.22	12	31	110	1,800
Tb	Entire unit	47	0.0023	0.047	0.82	6.3	310

Recharge

Recharge to the ground-water system is primarily by infiltration and percolation of precipitation. Other minor sources of recharge are seepage from streams, lakes, and marshes; lateral subsurface inflow in unconsolidated material along parts of the study-area boundary; lateral and upward flow from adjacent bedrock units; and seepage from excess irrigation water and septic-system effluent. Recharge from precipitation is everywhere except in (1) areas covered by impervious materials, such as asphalt and concrete; (2) areas of ground-water discharge, such as the lower reaches of the Snohomish or Stillaguamish Rivers; and (3) areas covered by water.

In addition to this recharge to the ground-water system, ground water flows vertically between aquifers within the system. Thus, ground water will recharge one aquifer as it discharges from a nearby aquifer. Over a long period of time, however, this vertical flow within a closed ground-water system tends to balance out so that the amount of downward flow equals the amount of upward flow.

Average annual recharge by infiltration and percolation of precipitation is estimated to be about 24 in. or 1,090,000 acre-ft for the entire study area (plate 6). Recharge from surface-water seepage, lateral inflow from outside the study area, or lateral or upward inflow from bedrock was not estimated, but is assumed to be minimal. Two steps were used to estimate recharge. Regression relations between recharge, mean annual precipitation, and surficial geohydrology were first used to estimate recharge in areas that are largely undisturbed by human activities. Those estimates of recharge were then modified according to the amount of impervious surfaces in urbanized areas.

The regression relations used to estimate recharge in this study are based on methods used by Woodward and others (1995) to estimate recharge in southwestern King County in western Washington. These methods are applicable to this study because southwestern King County and western Snohomish County have similar climate, vegetation, and geohydrologic units.

A regression analysis was made by Woodward and others (1995) with ground-water recharge as the response variable and mean annual precipitation, surficial geology, land cover (vegetation), and soil characteristics as explanatory variables. Recharge data used in the regression analysis were from a deep percolation recharge model (Bauer and Vaccaro, 1987) applied to eight drainage basins with precipitation and streamflow data. Mean annual precipitation and surficial geology were the most significant explanatory variables in the regression analysis. To develop a more widely applicable and simpler method for estimating recharge, the recharge data from Woodward and others (1995) were used to derive two regression relations, one relating recharge to precipitation in glacial outwash areas and one relating recharge to precipitation in till areas (fig. 17) (S.S. Sumioka, U.S. Geological Survey, written commun., 1989; Dion and others, 1994). These relations for outwash and till areas were used in this study; however, no relations were developed using data from Woodward and others (1995) for other surficial deposits that exist in the study area. To estimate recharge for areas with those deposits, an examination was made of the permeabilities of soil types derived from the surficial geologic deposits in the study area. Soils are important factors influencing the amount of recharge from infiltration and percolation of precipitation; comparisons of their permeabilities, therefore, can be used to indicate relative amounts of recharge. Based on their parent material, 40 soil series found in western Snohomish County (Soil Conversation Service, 1983) were placed into five groups of surficial geologic deposits: 9 soils from outwash, 7 soils from till, 5 soils from bedrock, 17 soils from alluvium, and 2 soils from organic matter.

The following method was used to estimate the relative amounts of ground-water recharge expected according to soil characteristics. Each soil series has several layers, with usually different permeabilities estimated for each layer (Soil Conservation Service, 1983, table 14). To compare relative amounts of ground-water recharge, the lowest permeability of all layers for each soil was selected. Then an average minimum permeability was computed for the soils in the five geologic groups. The average values were 0.6 inch per hour (in/hr) for organic deposits, 1.1 in/hr for alluvium, 1.3 in/hr for outwash, 0.7 in/hr for till, and 0.6 in/hr for bedrock. A distinct grouping is apparent in the average permeability values; soils derived from outwash and alluvium have similar permeabilities, and soils derived from till, bedrock, and organic deposits have similar permeabilities. Therefore, the existing outwash-recharge relation (fig. 17) was also applied to areas with surficial geology of alluvium, and the existing till-recharge relation was also applied to areas with surficial geology of bedrock or organic deposits. Because units Qtb and Qu had no associated soils, their predominant lithologies were used to place outcrop areas of Qtb in the till group and outcrop areas of Qu in the outwash group.

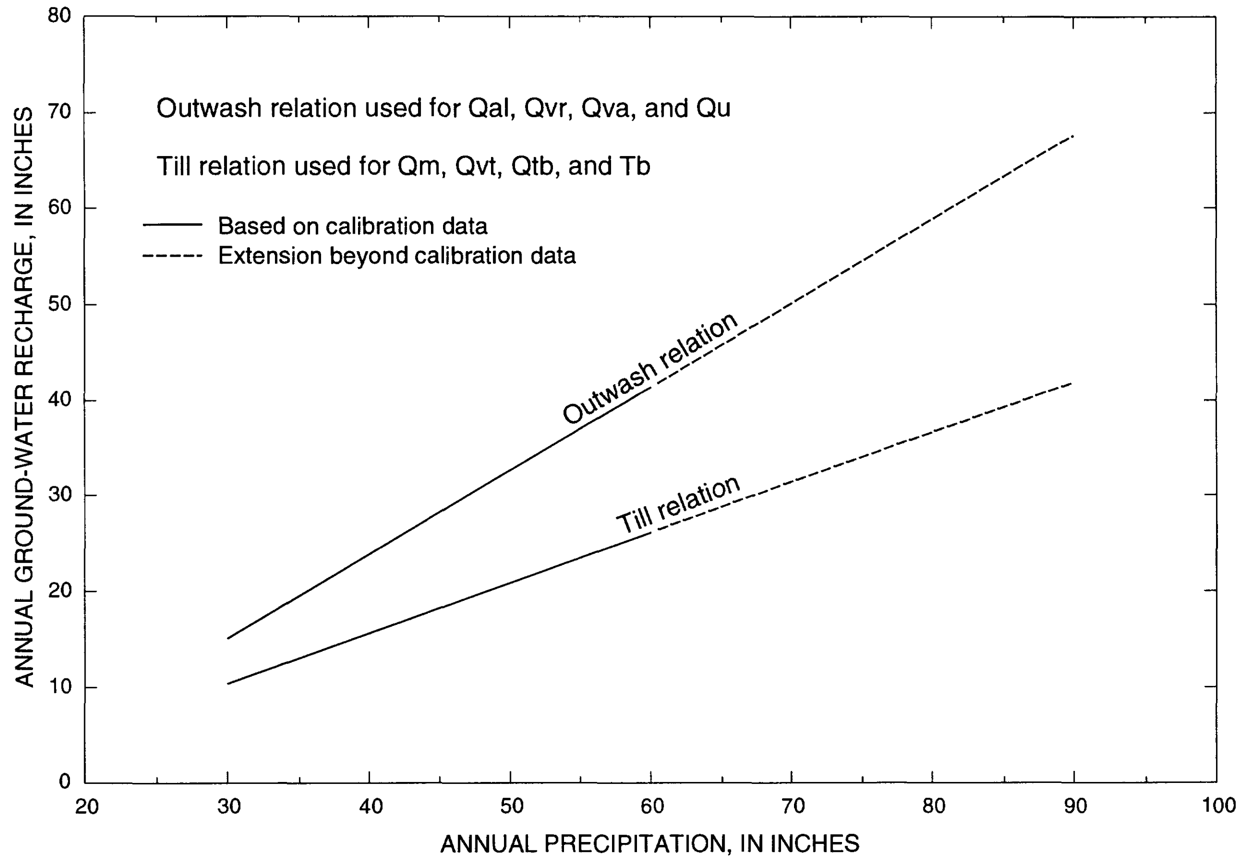


Figure 17. Precipitation-recharge relations used to estimate average annual ground-water recharge in western Snohomish County, Washington.

The data used to develop the relations between recharge, mean annual precipitation, and surficial geology had a range of mean annual precipitation of 30 to 60 in. (Woodward and others, 1995). Mean annual precipitation in this study area is as high as 90 in.; therefore, the relations were extended between 60 and 90 in. using the same slope as was derived for 30 to 60 in. (fig. 17).

The second major step in the estimation of recharge by infiltration and percolation of precipitation was to account for the extent of impervious surfaces in the study area. Using land-cover characteristics of the study area derived from a satellite image made in 1992 (Phil Beilin, Snohomish County, written commun., 1994), the study area was divided into three groups of density of impervious surfaces; low, moderate, and high (fig. 7). Areas with a low density of impervious surfaces have largely a natural land cover, and no adjustment was made to the estimated natural recharge in those areas. Only a small part of the downtown area of Everett was classified as high density. That area was estimated to have 90 percent impervious surfaces, and therefore recharge was decreased by 90 percent. The areas classified as moderate density are mostly in the Intercity Plateau, but most of the larger cities such as Arlington, Marysville, and Monroe have areas that are also in this group. The land in this group is mostly residential, with some shopping malls, strip malls, and commercial and industrial areas. The moderate density area was estimated to have 30 percent impervious surfaces, and therefore the undisturbed recharge was decreased by

30 percent in those areas. This 30-percent value was estimated using the average amount of effective impervious surfaces in three urban catchments in Bellevue, Wash. (Prych and Ebbert, 1986). Those three urban catchments were assumed to have density characteristics similar to the moderate density area in western Snohomish County. Effective impervious surfaces in those areas are some roofs, streets, parking lots, and other paved areas that eventually drain to storm drains or established stream channels. The effective impervious surface does not include roofs that drain onto lawns. Examples of pervious surfaces in urban areas are lawns, gardens, and areas of natural plant cover.

To estimate the areal distribution of ground-water recharge, areas of incremental values of average annual precipitation (fig. 2) were overlaid on the map of surficial geohydrology (plate 2) and the recharge relations (fig. 17) were applied to the intersecting characteristics. Then the computed recharge was adjusted according to density of impervious areas shown on figure 7; the adjustment resulted in an overall decrease in recharge across the study area of about 2 percent. The distribution of recharge (plate 6) reflects the diverse surficial geohydrology, the increasing precipitation from west to east, and the urban areas mostly in the Intercity Plateau. This estimated recharge is the amount of water that reaches the water table for the outcrop areas of the geohydrologic units. No attempt was made to determine the fate of this recharge in quantitative terms once it becomes part of the ground-water system. In areas with steep hillsides, some recently recharged ground water may move short distances and quickly discharge to nearby streams. However, in other areas, ground water may move vertically and enter a regional flow system where it may not discharge for many years.

Directions of Flow

The direction of ground-water movement can be determined from maps of potentiometric or water-level contours. Ground water flows in the direction of decreasing potentiometric levels and at right angles to the contours. Most ground-water movement is horizontal, but some ground water moves downward in recharge areas and upward in discharge areas (fig. 11).

Determining directions of ground-water flow in the alluvium (Qal) aquifer is difficult because the water-level surface in Qal is fairly flat in most areas (plate 6). The Qal aquifer is in stream or river valleys, where ground-water levels are usually close to the water-level surface of the adjacent stream or river. Available data are not accurate enough to determine differences between the levels of surface and ground water and, therefore, the directions of flow between the two bodies. Downward flow from Qal to aquifers below Qal in the Stillaguamish and Snohomish River Valleys is unlikely, because ground-water levels in Qal are near sea level, and aquifers beneath Qal probably have water levels at or above sea level.

Ground water in the North Fork Stillaguamish River Valley aquifer flows from east to west, following the same direction as flow in the river (plate 6). As the ground water flows down the river valley, water flows in some areas from the aquifer to the river; in other areas, water flows from the river to the aquifer. Data are not of sufficient density or accuracy to define these areas. This aquifer includes all unconsolidated material above bedrock, so downward flow into the bedrock is highly unlikely because of the low permeability of the bedrock.

Ground water in the Skykomish River Valley aquifer has flow patterns similar to ground water in the North Fork Stillaguamish River Valley aquifer: a general east-to-west flow, with an interchange with the river. Downward flow to unconsolidated materials below the aquifer is unlikely because available ground-water levels indicate either no vertical gradient or an upward gradient.

Ground-water flow in the Vashon recessional outwash (Qvr) aquifer generally follows the land-surface gradient; water moves from high-altitude areas toward stream valleys. Potentiometric surfaces were constructed for the two areas that had sufficient water-level data (plate 6). In the Marysville Trough, a ground-water divide is in the north-central part at about the same location as the surface-water divide for Quilceda Creek. From this divide, ground water flows northward toward Portage Creek and the Stillaguamish River and southward toward Marysville and the Snohomish River. Under the Arlington Heights Plateau, ground water flows in west and northwest directions. Most water in Qvr flows horizontally because of the low permeability of the underlying till unit (Qvt). Some water, however, flows downward through the till and into Qva in most of the area where Qvr is present. The one exception to downward flow is in the Marysville Trough, where ground water flows upward from Qva to Qvr.

Ground-water flow in the Vashon advance outwash (Qva) aquifer generally follows the land-surface gradient and moves from high altitude areas toward plateau edges or stream valleys. Most water in Qva flows horizontally because of the low permeability of the underlying Qtb unit. Mounds of ground water are under the Tulalip, Getchell, and Lakes Plateaus, and ground water flows radially away from the centers of these mounds (plate 6). Two separate flow systems exist under the East Stanwood Plateau, with water flowing westward and southward in the western part, and southward in the eastern part.

Potentiometric contours for Qva in the central and eastern parts of the Intercity Plateau were drawn where the density of water-level data is sufficient (plate 6). The contours show that ground water generally flows southward and discharges to North and Bear Creeks. A water-level map of Qva shown in Newcomb (1952) has data for the central and western parts of the Intercity Plateau. Although the water levels of Newcomb (1952) were measured in the 1940's, general ground-water flow directions in the 1990's are most likely the same. The Newcomb (1952) map shows the same pattern of flow as on plate 6 under the central part of the Plateau. In addition, it shows ground-water mounds and radial flow in the northeast corners of T.28N.-R.4E, and T.27N.-R.4E, and it shows ground-water discharge to Swamp Creek. Therefore, the general pattern of flow under the Intercity Plateau is radially from the center toward the edges, but with some interruptions caused by ground-water discharge to Swamp, North, and Bear Creeks.

The Qva aquifer receives downward flow from Qvr in most of its area. Ground water also flows downward from Qva into Qu in most of the area of Qva. As in Qvr, the Marysville Trough is an area of generally upward flow, where water from Qu flows upward into Qva.

Water-level gradients are typically 100 ft/mi in most of Qva (plate 5). However, the flow system under the northern part of the Getchell Plateau has a smaller gradient of less than 50 ft/mi in much of its area, and two mounds of ground water under the Lakes Plateau have steeper gradients of 150 to 200 ft/mi. These areas of different water-level gradients do not appear to be related to different hydraulic conductivities; the conductivities were fairly uniform throughout Qva except for under the Tulalip Plateau where the conductivity was higher.

Ground water generally flows from east to west in the undifferentiated sediments (Qu) aquifer. Water-level data are too meager to draw potentiometric maps or to discern any more detail in flow directions. Most areas of Qu receive downward flow of ground water from Qva. The general pattern of upward flow in the Marysville Trough, described earlier, is also found in Qu, where water flows upward from Qu into Qva.

Discharge

Natural

Ground water discharges to surface-water bodies such as streams, lakes, and marshes, to springs, to seepage faces on cliffs, to the saltwater body of Puget Sound, and to the atmosphere by evapotranspiration. The quantity of ground water discharging by these means was not estimated because no data were collected nor were any data available that could be used for that purpose.

Ground-water discharge to several streams is indicated by the potentiometric contours of the North Fork Stillaguamish River Valley aquifer, the Qvr aquifer, and the Qva aquifer (plate 6). The North Fork Stillaguamish River appears to be receiving ground water from the aquifer. Ground water in Qvr discharges to Quilceda Creek in the Marysville Trough, and ground water in Qva discharges to North and Bear Creeks in the Intercity Plateau and to Mission Creek in the Tulalip Plateau. In addition, many other streams in the study area receive ground-water discharge, but the potentiometric contours (plate 6) are not of sufficient detail to show this.

Another method used to estimate areas of ground-water discharge to streams was to compare water levels at 17 streamflow gaging stations to nearby ground-water levels. The average annual water-level altitude at each gaging station was compared with ground-water altitudes at wells within 2,000 ft of the gaging station. Potential ground-water discharge was assumed if the ground-water level was appreciably higher than the surface-water level. The water-level differences indicated that ground water discharges at eight sites and is recharged at one site; the differences were too small to indicate a direction of flow at eight sites. There were eight sites (areas near gaging stations) with indicated ground-water discharge: Skykomish River near Gold Bar, Sultan River near its mouth, Pilchuck River near Snohomish, Quilceda Creek near Marysville, South Fork Stillaguamish River near Granite Falls and near Arlington, and North Fork Stillaguamish River near Darrington and near Arlington.

Ground-water discharge to all springs in the study area was not quantified, but discharge was measured at 13 springs (table 5). Discharges ranged from 2 to 900 gal/min, had a median of 20 gal/min, and totaled 2,570 gal/min. Twenty-one of the larger springs in the study area were inventoried by Newcomb (1952, table 6). Discharges at those springs, five of which were also measured in this study, ranged from 5 to 5,600 gal/min, had a median of 75 gal/min, and totaled 10,530 gal/min. Many small- to moderate-size springs that are scattered throughout the study area undoubtedly have a combined discharge that is much larger than the discharge of these two samples.

Well Withdrawals

In addition to the natural ground-water discharge, ground water is withdrawn from wells. Ground-water withdrawals during 1992 for western Snohomish County were estimated for the following water-use categories: public supply, domestic self-supplied, irrigation, livestock, and mining (table 6). Water for commercial or industrial activities comes largely from surface-water sources.

Total ground-water withdrawals for 1992 were estimated to be 19,630 acre-ft. This quantity represents gross withdrawal and does not take into account the quantity of water that is returned to the ground-water system through septic systems, the excessive application of irrigation water, or the return of water used in sand and gravel mining.

Table 5.--*Selected springs in western Snohomish County, Washington*

[H, domestic; P, public supply; S, stock; U, unused; Gal/m, gallons per minute; --, no name]

Spring number	Name	Geohydrologic unit	Altitude (feet)	Use	Discharge	
					Date	Gal/m
27N/03E-25F01S	South Edmonds/Yost Spring	Qva	220	U	02-14-47	[1]55
					09-29-93	20
27N/03E-35A01S	Deer Creek Spring	Qva	230	P	09-29-93	690
27N/06E-21A01S	--	Qvt	150	P	09-28-93	30
27N/07E-19J01S	Heathercrest-Rimrock Spring	Tb	800	P	09-29-93	6
28N/07E-28K01S	--	Qal	150	U	09-28-93	5
28N/08E-16D01S	Lake Sixteen Spring	Qvr	560	P	12-11-46	[1]5,600
					09-28-93	540
30N/05E-14Q01S	--	Qva	130	S	08-12-93	9
30N/06E-13A01S	--	Qvt	320	S	08-12-93	3
30N/07E-05K01S	--	Tb	610	U	09-30-93	4
31N/04E-04K01S	--	Qvr	170	H	08-13-93	2
31N/04E-05F01S	Hat Slough Spring	Qva	50	P	12-12-46	[1]500
					09-30-93	325
31N/04E-24N03S	Edwards Spring	Qva	240	P	08-01-44	[1]950
					09-30-93	900
32N/03E-12J01S	Detting Crossing Spring	Qva	15	S	12-12-46	[1]100
					09-30-93	33

[1] Measurements from Newcomb (1952, table 6).

Table 6.--*Summary of ground-water use in 1992, western Snohomish County, Washington*

Use category	Withdrawals, in acre-feet
Public supply, class A	9,670
Public supply, class B	660
Domestic self-supplied	4,880
Irrigation	1,870
Livestock	2,480
Mining	70
Total	19,630

About three-quarters of the total ground-water withdrawal was used for public supply or self-supplied domestic purposes. About one-quarter of the ground-water withdrawal was used for irrigation, livestock, or mining.

Ground-water withdrawn for class A and B public-supply systems was estimated to be 10,330 acre-ft. The areal distribution of class A withdrawals is shown by township on figure 18. Three areas with large class A withdrawals are the western part of the East Stanwood Plateau, near Arlington, and the eastern part of the Intercity Plateau. Based on a population of 36,400 that relies on privately-owned wells, the withdrawals for domestic self-supplied users was estimated to be 4,880 acre-ft. Ground-water for irrigation of crops, nurseries, and golf courses was estimated to be 1,870 acre-ft. The estimated 2,480 acre-ft of ground water used for the livestock category includes water used in dairies, and in the raising of beef cows, hogs and pigs, sheep and lambs, and chickens. Ground water for the mining of sand and gravel was estimated to be 70 acre-ft.

Water-Level Fluctuations

Ground-water levels fluctuate over time in response to changes in recharge and discharge through the boundaries of the ground-water system. These water-level fluctuations reflect changes in the amount of water that is stored in the system. As water levels rise, more water is stored in the system, and as water levels drop, water is removed from the system.

Seasonal

Ground-water levels fluctuate seasonally because of the variation in recharge and discharge during a year. During typical winters with large amounts of precipitation, ground-water recharge exceeds discharge, and water levels rise. During typical summers with small amounts of precipitation, ground-water discharge exceeds recharge, and water levels decline. The close relation between ground-water levels and monthly precipitation for selected wells in the study area is shown on figures 19-21.

The magnitude of seasonal water-level fluctuations and the timing of the response to precipitation are related to amount of ground-water recharge, depth to ground water, depth of well, whether the aquifer is exposed in outcrop or buried beneath other geohydrologic units, whether the aquifer is confined or unconfined, the hydraulic characteristics of the aquifer and the geohydrologic units overlying the aquifer, and the nearby geohydrologic boundaries such as a stream.

Aquifers that are exposed in outcrop and that have a shallow water table have relatively large water-level fluctuations and the water levels respond quickly to precipitation (fig. 19). Seasonal fluctuations in three shallow wells were 4 ft in Qal (in the Stillaguamish River Valley), 6 ft in Qvr (in the Marysville Trough), and 10 ft in Qva (in the Lakes Plateau).

For aquifers that are buried, the magnitude of water-level fluctuations is dampened and the response to precipitation is delayed (fig. 20). Water-level fluctuations in three moderate-depth wells in a buried Qva aquifer ranged from 3 to 4 ft. Fluctuations for a well site (zone surrounding a well opening) with confined conditions in the Getchell Plateau (well 30N/06E-22N04) were larger and responded more quickly to precipitation than for a well site with confined conditions in the Tulalip Plateau (well 31N/04E-15N03), probably because depth to water was near land surface for the well site in the Getchell Plateau, but depth to water was about 70 ft for the well site in the Tulalip Plateau (fig. 20).

Water-level fluctuations in two deep wells in buried aquifers with deep ground-water levels in the Intercity Plateau were extremely small and had almost no response to precipitation (fig. 21). Depth to water was about 175 ft for a 220-ft well open to an unconfined Qva aquifer (well 27N/05E-02Q01) and depth to water was 135 ft for a

160-ft well open to a confined Qu aquifer (well 27N/04E-05B01). The primary reasons for these small fluctuations are probably the deep wells and deep ground-water levels. The aquifers at both sites are overlain by confining beds that inhibit the recharge at land surface from reaching the aquifers. But, two sites in the Qva aquifer shown on figure 20, (wells 31N/04E-15N03 and 30N/06E-22N04), also have overlying confining beds, and they had fluctuations of 3 to 4 ft. The differences between the two sites with appreciable fluctuations and the two sites with small fluctuations are well depth and depth to ground water.

A well site in a confined Qu aquifer in the Arlington Heights Plateau (well 31N/06E-06Q02) had unexpectedly moderate magnitude water-level fluctuations and a quick response to precipitation (fig. 21). The site has several characteristics that would lead one to expect small water-level fluctuations: well depth is 295 ft, depth to water is 180 ft, and the aquifer is buried by Qvr, Qvt, Qva, and Qtb. A possible reason for the unexpected fluctuation is that recharge to Qu near this well may have a much shorter route than moving downward through all the units directly overlying Qu at that well. The well is located at an altitude of 260 ft on top of a plateau, only 2,000 ft from the South Fork Stillaguamish River. The altitude of the nearby river valley is about 70 ft, and recharge that enters the ground-water system in the river valley only has to move through Qva and Qtb to reach Qu.

Long-Term

Ground-water levels may fluctuate or change over a long period of time (over several years) because of variations in the ground-water recharge and discharge over that period. Natural recharge and discharge fluctuate with changes in precipitation; however, precipitation and recharge-discharge relations tend to even out over many years, and long-term water levels tend to remain relatively constant. Withdrawals of ground water through wells, however, can cause long-term declines in the water table if the amount of withdrawals exceeds the ability of the system to replenish itself by increased recharge or decreased discharge.

Ground-water levels do not appear to have appreciably declined in any widespread areas of western Snohomish County. Long-term water-level data were available for three wells (fig. 22); two of the wells are in the Qvr and Qu aquifers in the Marysville Trough, and one well is in the Qva aquifer under the Tulalip Plateau. Water levels in two of these wells did decline, but only by a small amount of less than 5 ft.

Historical water-level differences were compared in 208 wells with more than 10 years between measurements of the water levels (table 7). The water levels measured by the USGS at the time of well inventory in 1992-93 were compared with the water levels reported by the drillers at the time of construction. The median water-level differences for each geohydrologic unit ranged from -2 to 2 ft, with a positive value indicating a rise. Data were sufficient to compare geographic areas within the Qva aquifer, and no areas were found with appreciable declines in water levels.

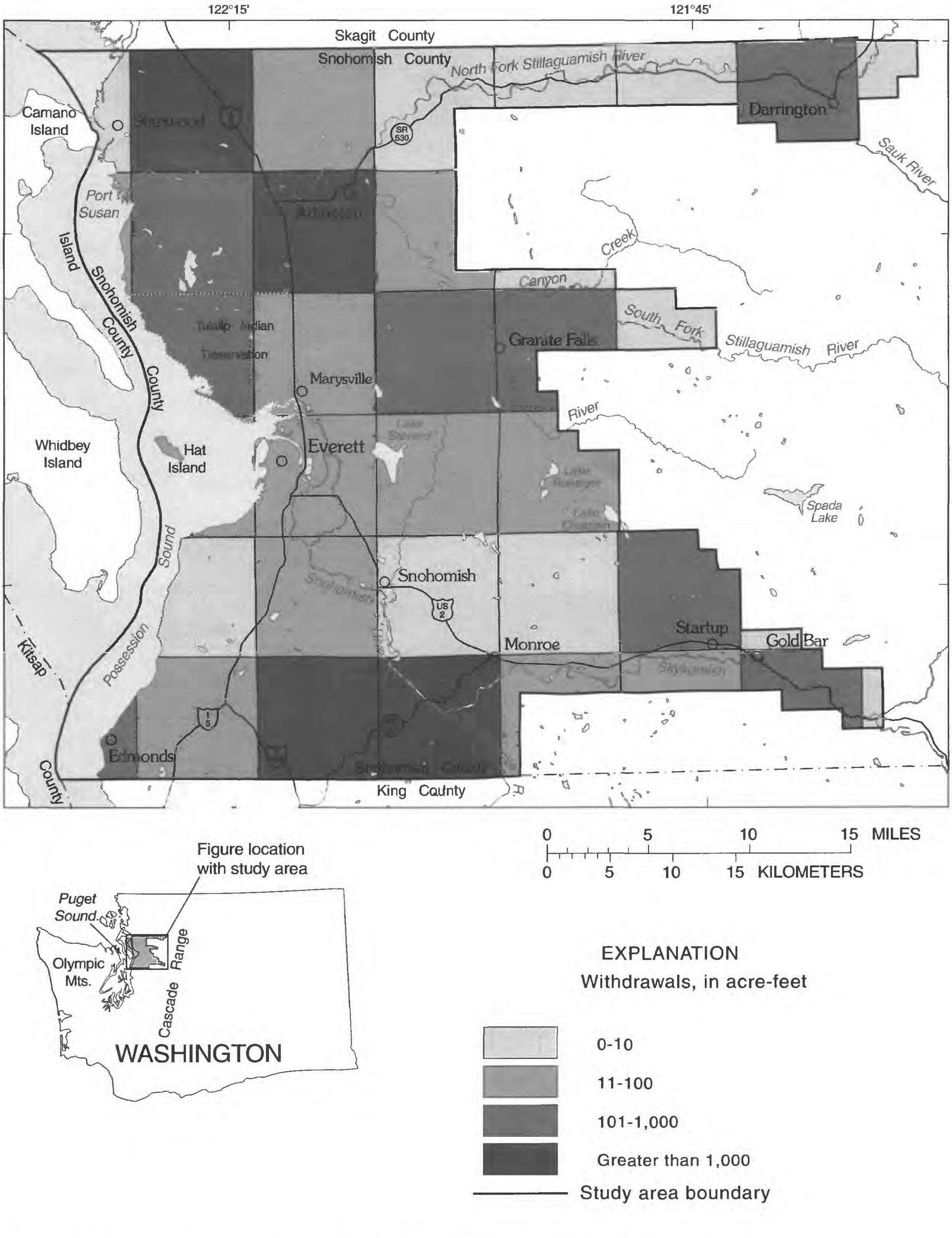


Figure 18. Ground-water withdrawals in 1992 for class A public-supply systems.

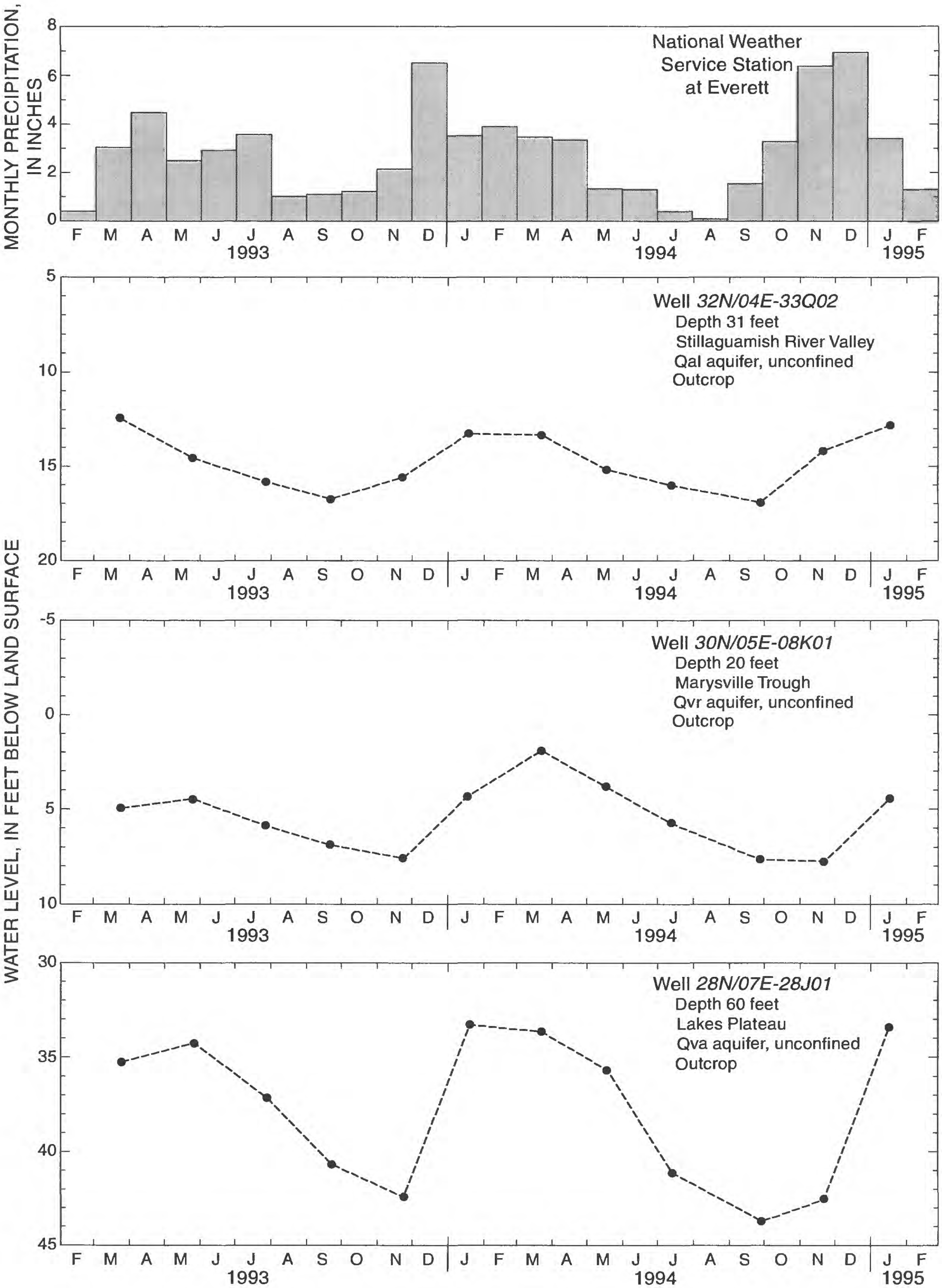


Figure 19. Relation between monthly precipitation and water levels in selected wells in Qal, Qvr, and Qva aquifers, western Snohomish County, Washington.

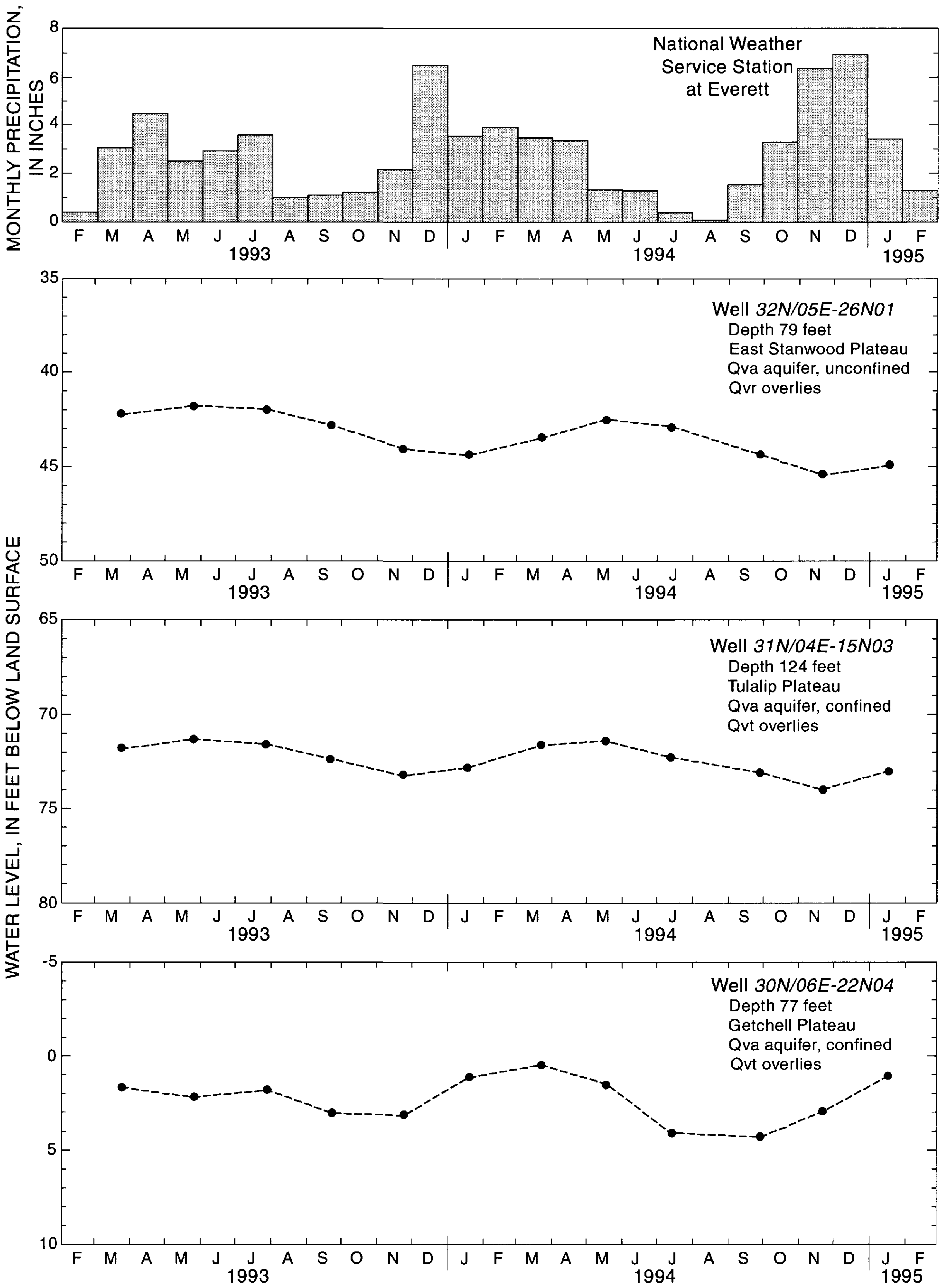


Figure 20. Relation between monthly precipitation and water levels in selected wells in Qva aquifer, western Snohomish County, Washington.

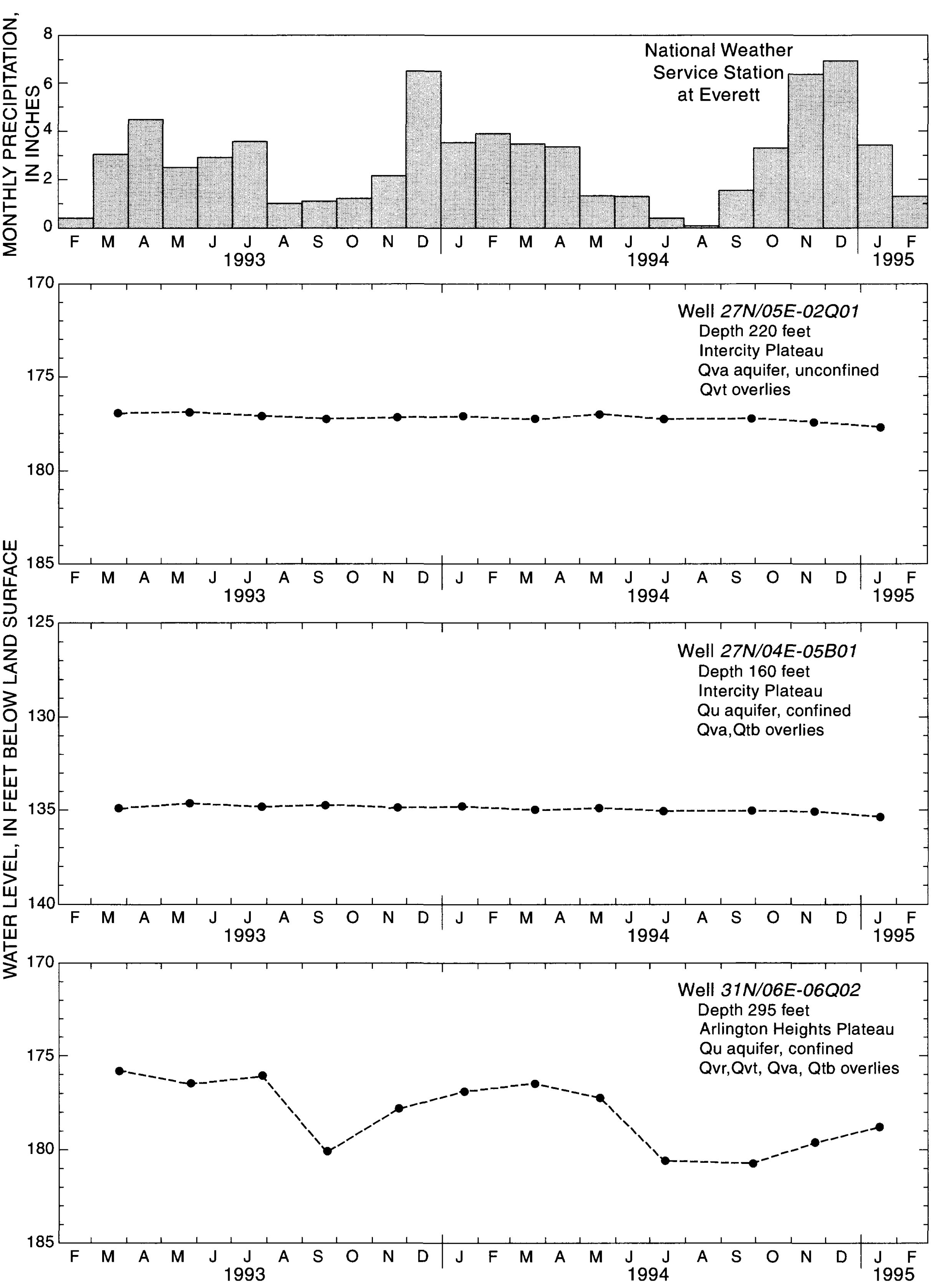


Figure 21. Relation between monthly precipitation and water levels in selected wells in Qva and Qu aquifers, western Snohomish County, Washington.

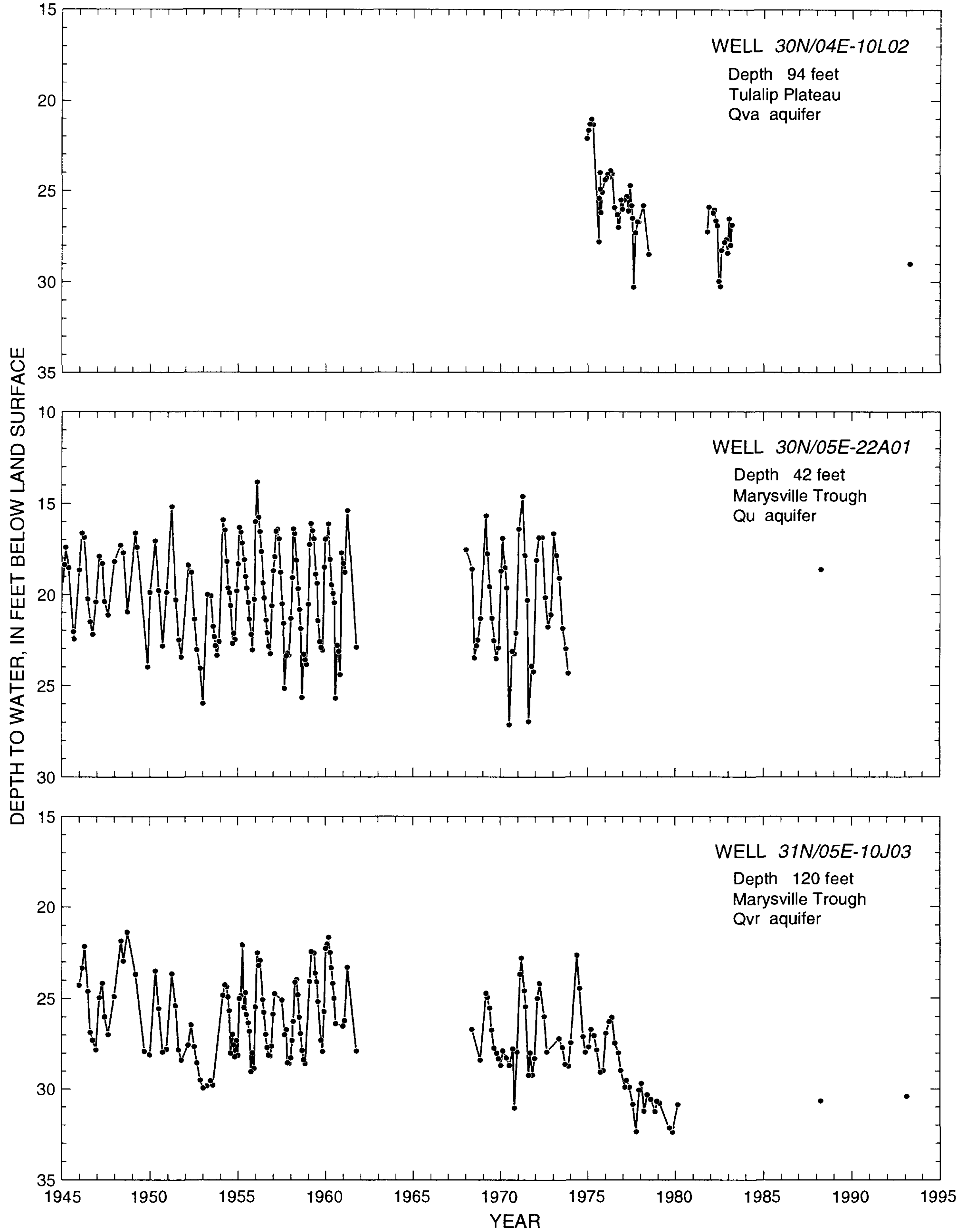


Figure 22. Long-term water-level fluctuations in selected wells, western Snohomish County, Washington.

Table 7.--*Summary of historical water-level differences in wells with more than 10 years between measurements, western Snohomish County, Washington*

[Water-level difference: Difference between driller's older water level and more recent inventoried water level; positive value is rise and negative value is decline in water level.]

Geohydrologic unit	Area	Number of wells	Water-level difference, in feet: 25th percentile	Water-level difference, in feet: Median	Water-level difference, in feet: 75th percentile	Time between water-level measurements, in years: Median	Time between water-level measurements, in years: 75th percentile
Qal	Entire unit	21	-3	-1	2	24	38
Qvr	Entire unit	16	-2	2	5	34	48
Qvt	Entire unit	29	-2	0	2	14	17
Qva	Entire unit	93	-3	1	5	14	17
	Tulalip Plateau	10	-18	-2	1	13	23
	Getchell Plateau	16	-3	1	9	14	18
	Lakes Plateau	21	-8	-1	3	13	14
	Intercity Plateau	36	-3	0	6	14	20
Qtb	Entire unit	10	-26	0	4	14	31
Qu	Entire unit	23	0	2	8	19	31
Tb	Entire unit	16	-18	0	24	14	18

WATER BUDGET OF THE STUDY AREA

On a long-term basis under natural conditions, a hydrologic system is usually in a state of dynamic equilibrium; that is, inflow to the system is equal to outflow from the system, and there is little or no change in the amount of water stored within the system. An approximate water budget for an average year of precipitation in the 850-mi^2 study area is presented in the following table.

Hydrologic factor	Quantity: Inches per year	Quantity: Acre-feet per year	Percent
Precipitation	46	2,090,000	100
Fate of precipitation:			
Surface runoff	4	180,000	9
Evapotranspiration	18	820,000	39
Ground-water recharge	24	1,090,000	52
Total	46	2,090,000	100
Fate of recharge:			
Discharge to streams	21	950,000	88
Other natural discharge	2.6	120,000	10
Withdrawals by wells	0.4	20,000	2
Total	24	1,090,000	100

Detailed explanations of the methods used to estimate the compounds of the water budget are given in previous sections of this report. The value for evapotranspiration (18 in.) is an average value from deterministic rainfall-runoff models used in the study area. The value for runoff (4 in.) is a residual; that is, it represents the quantity that remains after recharge (24 in.) plus evapotranspiration (18 in.) is subtracted from precipitation (46 in.). Discharge to streams was estimated by assuming that 55 percent of precipitation in the study area becomes streamflow (25 in.) and that 4 in. of that streamflow comes from surface runoff; therefore, the ground-water discharge is the difference of 21 in. Other natural discharge, most of which is discharge to springs or subsurface flow out of the study area, is the residual (2.6 in.).

As mentioned previously, the value for ground-water withdrawals by wells (0.4 in.) represents gross withdrawal. If the quantity of water that is returned to the ground-water system through septic systems or irrigation return flows were calculated and accounted for, the resulting value (net withdrawal) would be substantially smaller.

The amount of gross ground-water withdrawals in 1992 was only about 2 percent of the total ground-water recharge. In addition, there was no evidence of widespread large declines in ground-water levels in the past few decades (table 6 and fig. 22). So, it appears that historical withdrawals did not have an appreciable effect on the ground-water system in the study area. This minimal historical effect, however, does not mean that additional water can be withdrawn with little or no effect on the system.

A simple comparison between ground-water recharge and withdrawals (historical and projected) is not a good indicator of the amount of water that is potentially available for ground-water development. Any additional withdrawal superimposed on a previously stable system must be balanced by an increase in recharge, a decrease in discharge, a loss of storage in the system (reflected by lower water levels), or a combination of these factors (Bredehoeft and others, 1982). Considering the ground-water system of western Snohomish County in particular, the possibility of increased natural recharge on a long-term basis appears remote. In fact, the trend of increased residential development and centralized sewers will most likely result in decreased recharge. Additional withdrawals, therefore, would probably result in a loss of storage (with an attendant decline in water levels) or a decrease in natural discharge. The magnitude of sustainable ground-water development, therefore, depends on the acceptable amount of water-level declines or decreased natural discharge. A small decline in water levels is probably acceptable, but as the decline becomes larger, pumps would have to be lowered, and more wells would go dry. Some beneficial uses of ground-water discharge that would have to be considered include maintenance of streamflow during low flow periods, public water supply from springs and streams, prevention of salt-water intrusion near the coast, recreation, and so forth.

It is beyond the scope of this study to quantify the effects of future withdrawals, but the possible relative effects and the problems with using a simple water budget to make inferences about water supply are noted here. A reliable assessment of the effects of development needs to consider the combined effects of geohydrologic boundaries, hydraulic properties of aquifers, and the water budget; and the present or projected uses of the ground-water discharge that would probably be decreased by the withdrawals.

RELATIVE SENSITIVITY OF THE GROUND-WATER SYSTEM TO CONTAMINATION

A ground-water system can become contaminated by chemicals or other substances that are not natural to the system and that may be harmful to the health of humans, animals, or plants. The potential for such contamination in a particular area is an important aspect of land-use planning and a simplified assessment of part of that potential was made in this study.

In many previous investigations, the potential for ground-water contamination was divided into two parts: sensitivity and vulnerability (U.S. Environmental Protection Agency, 1993b). Ground-water sensitivity, as defined by USEPA, is the relative ease with which a contaminant applied at or near land surface can migrate to ground water. Sensitivity accounts only for intrinsic geohydrologic variables such as ground-water recharge, aquifer permeability, soil characteristics, and depth to water. Ground-water vulnerability accounts for sensitivity and human activities, which determine the source, quantity, and type of contaminants. Sensitivity and vulnerability are not necessarily correlated. An area with high sensitivity may have low vulnerability if there are no sources of contaminants in the area. Conversely, an area with low sensitivity may have high vulnerability if large amounts of contaminants are applied to the area.

For this study, the relative sensitivity of the ground-water system to contamination was evaluated. Many simplifications and assumptions were made in the evaluation. The estimated sensitivities are not based on deterministic models; therefore, no specific probabilities of contamination or absolute rates of movement of contaminants are estimated. The sensitivities are relative; areas with a high rating are more sensitive to contamination than areas with a low rating, but the absolute difference in sensitivity is not known. No evaluation was made of the behaviors of different potential contaminants. The assumption about contaminant behavior for this evaluation is that a contaminant is conservative (nonreactive) and mobile, and will be carried by and travel at the same rate as percolating water. This is an important assumption because relative sensitivity can vary widely depending on the behavior of the contaminant of interest.

The evaluation of sensitivity in this study was made on the upper boundary of the entire ground-water system, the water table for the outcrop areas of geohydrologic units. This water table is the plane through which contaminants are most likely to enter the ground-water system.

A first step in an evaluation of ground-water sensitivity is to determine the pathways for transport of contaminants to the ground-water system. Pathways in the study area include transport with the infiltration and percolation of precipitation, transport with downward seepage of water from streams or lakes, and transport by human-caused disturbances such as water flowing down poorly constructed well bore-holes or exposure of the water table of an aquifer by road construction or gravel mining. In addition, a contaminant may be liquid and of sufficient volume that it could infiltrate the land surface and move to the water table by itself, without having to travel with percolating water. Transport with infiltration and percolation of precipitation is the most common pathway for chemicals applied at or near the land surface such as spills of liquid or solid chemicals, sewage effluent from septic systems, fertilizers and pesticides, and animal-waste material. This transport mechanism, therefore, was examined in this study.

The method used in this study to estimate relative sensitivity was similar to the DRASTIC method developed for the USEPA (Aller and others, 1985). In the DRASTIC method, relative pollution potential is evaluated using seven hydrogeologic variables: (1) depth to water table, (2) net recharge, (3) aquifer media, (4) soil media, (5) topography, (6) impact of the unsaturated zone, and (7) hydraulic conductivity of the aquifer. Two of the variables in DRASTIC were used in this study to assess the relative sensitivity of the ground-water system. These variables were represented by (1) average annual ground-water recharge by infiltration and percolation of precipitation and (2) depth to water below land surface. Data for other variables that can affect sensitivity (including those not used in DRASTIC) were not available in a form that could be used in this assessment. However, aquifer media and hydraulic conductivity are partly incorporated into the estimate of ground-water recharge used in this study.

It was assumed that sensitivity increases with increased amounts of the average annual ground-water recharge estimated in this study (plate 6). The areal distribution of recharge affects sensitivity because as the annual volume of percolating water increases, more water is available to carry contaminants downward to the water table. The temporal distribution of recharge also affects sensitivity. The probability of a contaminant reaching the water table increases with more days of recharge. During a given period of time (such as a year), areas with larger annual recharge rates will likely have more days with sufficient precipitation to produce recharge than areas with smaller recharge rates; therefore as annual recharge rates increase, a contaminant introduced at or near land surface will have more opportunities to be carried with recharge down to the water table.

The second variable used in the estimation of sensitivity is depth to water from land surface. As depth increases, sensitivity decreases. Because the percolating water that carries contaminants takes longer to reach the water table, there is more likelihood that attenuation of the contaminant will take place.

Four steps were used in the method to estimate relative ground-water sensitivity: (1) determine relative importance of recharge and depth to water; (2) assign weighting factors to ranges of recharge and depth to water; (3) compute rating scores by multiplying the weighting factors; and (4) divide the rating scores into groups of low, moderate, and high sensitivity.

Annual recharge and depth to water were assumed to be of equal importance in influencing ground-water sensitivity because the DRASTIC method assigns these two variables nearly equal importance (a weight of 5 for depth to water and 4 for net recharge).

Weighting factors of 1 to 6 were assigned to intervals of annual recharge and depth to water (table 8 and fig. 23). Ground-water sensitivity increases with increased magnitude of the weighting factors. Except for the upper ranges of recharge and depth to water, sensitivity was assumed to increase linearly as recharge increased and as depth to water decreased. The linear relations were assumed for simplicity and convenience, and no known specific studies of the study area had evaluated the linearity of the relations between recharge, depth to water, and ground-water sensitivity. The linear relations were determined by dividing recharge rates and depth to water into five groups with intervals of equal magnitude and assigning the weighting factors in increments of one. The slope of the weighting-factor relations change for the highest recharge rates and for deep water levels. The sensitivity was assumed to be equal for all areas with recharge of greater than 50 in. and for all areas with depths to water of greater than 100 ft. Therefore, a weighting factor of 6 was applied to all areas with recharge greater than 50 in., and a weighting factor of 1 was applied to all areas with depths to water of greater than 100 ft.

The weighting factors for recharge for specific parts of the study area were determined by dividing the study area into six parts with each part having a specified range in recharge (plate 6 and fig. 23). Then the six weighting factors from table 8 were assigned to the specified areas. For example, about 260 mi^2 of the study area have recharge between 20 and 29 in. and were assigned a weighting factor of 3 (fig. 23).

The weighting factors for depth to water for specific parts of the study area were determined by grouping measured depths to water according to the outcrop areas of geohydrologic units (table 9). In addition, if the density of water-level measurements in a particular unit was at least 0.5 measurements per square mile, weighting factors were also determined for geographic subareas identified on the basis of topographic features (fig. 5). By accounting for geographic subareas in the method, more detail is provided for areal variation in depths to water.

Because depth to water varies within a geohydrologic unit or geographic subarea, a method was designed to determine the most representative weighting factor for each unit or subarea. The median and 75th percentile of the water-level data were computed for each unit or subarea and compared with the weighting-factor thresholds shown in table 8. The data must fit both ranges for median and 75th percentile to be assigned the specified weighting factor. If the 75th percentile of the data is larger than the indicated threshold in table 8, the next smallest weighting factor is assigned. The median represented the typical depth to water and the 75th percentile represented the spread in the deeper water-level data. An area with most water levels close to the median of a particular group was assumed to have a higher sensitivity than an area with a considerable spread in water levels that were deeper than the median.

Two examples of assigning a weighting factor for depth to water are: (1) if the water-level data for an outcrop area have a median depth of 50 ft and a 75th percentile of 65 ft, the area is assigned a factor of 4, and (2) if the water-level data for an outcrop area have a median depth of 50 ft and a 75th percentile of 90 ft, the area is assigned a factor of 3.

Table 8.--*Group thresholds of ground-water recharge and depth to water used for assignment of weighting factors in the assessment of relative ground-water sensitivity, western Snohomish County, Washington*

[<, less than]

Ground-water recharge (inches)	Depth to water, in feet below land surface		Weighting factor
	Median	75th percentile	
0 - 9	101 - 290	--	1
10 - 19	81 - 100	<125	2
20 - 29	61 - 80	<100	3
30 - 39	41 - 60	<75	4
40 - 49	21 - 40	<50	5
50 - 72	0 - 20	<25	6

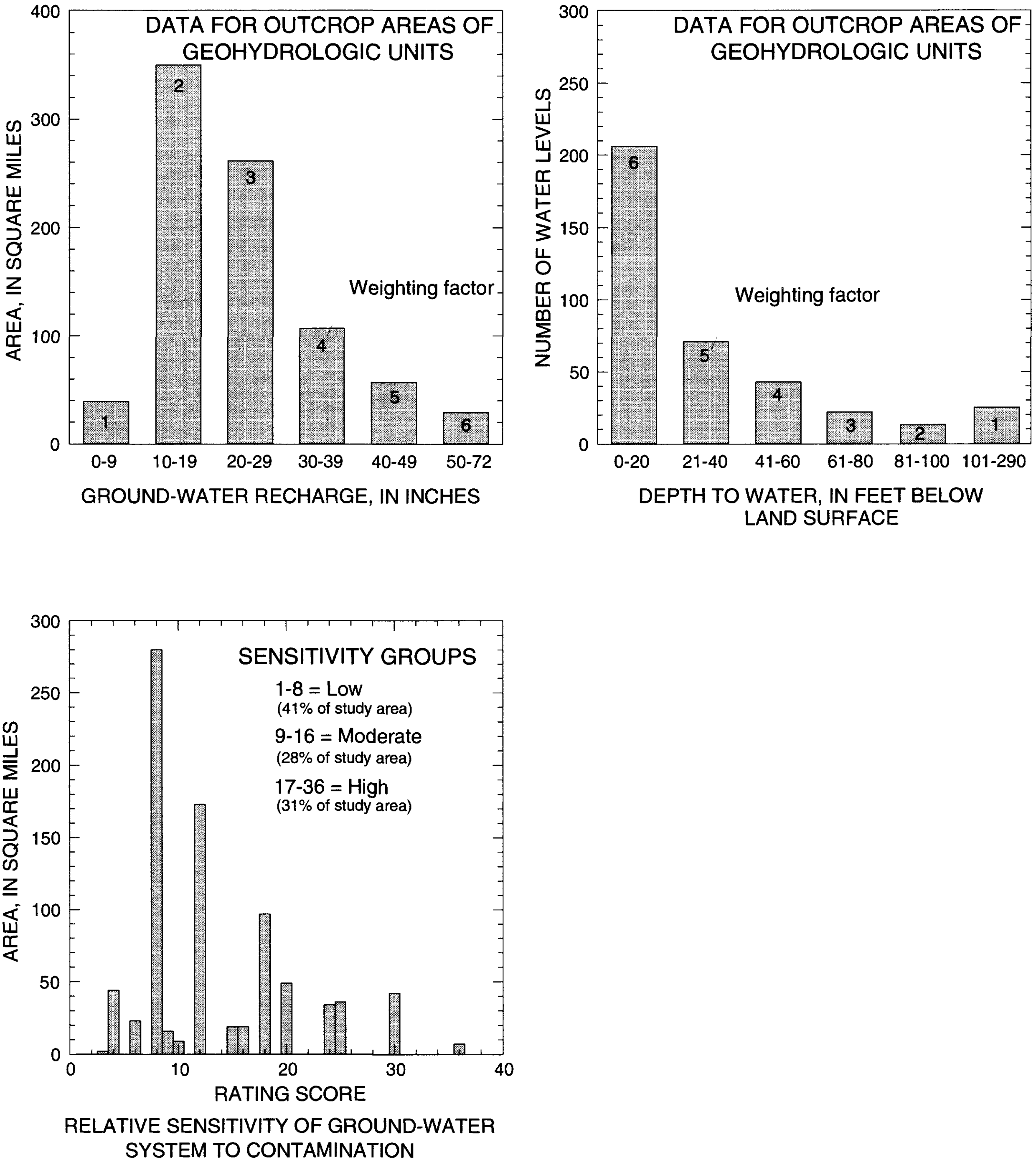


Figure 23. Distributions of data used for assessment of relative ground-water sensitivity and resulting rating scores of sensitivity, western Snohomish County, Washington.

Table 9.--*Depth-to-water data for assessment of relative ground-water sensitivity in western Snohomish County, Washington*

[--, not applicable]

Geohydrologic unit	Outcrop area	Number of water levels	Depth to water, in feet below land surface: 25th percentile	Median	75th percentile	Weighting factor
Qal	Entire unit	89	7	11	16	6
Qvr	Entire unit	93	8	16	32	5
	East Stanwood Plateau	13	6	9	16	6
	Arlington Heights Plateau	22	12	20	32	5
	Marysville Trough	25	6	10	20	6
Qvt	Entire unit	114	11	25	56	4
Qva	Entire unit	50	16	48	76	3
	Tulalip Plateau	14	50	63	94	3
	Lakes Plateau	12	40	48	78	3
	Intercity Plateau	23	11	19	57	4
Qtb	Entire unit	3	--	--	--	3
Qu	Entire unit	5	--	--	--	3
Tb	Entire unit	34	16	44	70	4

To compute rating scores, the weighting factors for recharge and depth to water were multiplied by each other, resulting in the distribution of rating scores shown on figure 23. Dividing the rating scores into three groups (1-8, 9-16, and 17-36), resulted in 41 percent of the study area classified as having a low sensitivity, 28 percent as moderate, and 31 percent as high. The group limits of the rating scores were selected by dividing the scores as evenly as possible to classify one-third of the study area as low, one-third as moderate, and one-third as high sensitivity. This rationale of equal proportions was used to ensure objectivity and replicability of results. It was also used because the results of the method are relative ground-water sensitivities; that is, areas with a high rating are more sensitive to contamination than areas with a low rating, but the absolute difference in sensitivity is not known. No specific probabilities of contamination are estimated.

The result of the method, the relative sensitivity of the ground-water system to contamination, is shown on plate 7. This map represents the relative sensitivity for the water table of the outcrop areas of geohydrologic units. For convenience, subsets of this map are also shown on plate 7 for individual aquifers that are exposed at land surface—the alluvium (Qal) aquifer, the North Fork Stillaguamish River Valley aquifer, the Skykomish River Valley aquifer, and the Vashon recessional outwash (Qvr) aquifer.

The areal variation of the relative sensitivity of the ground-water system to contamination reflects the variation in the two variables used in the method—annual ground-water recharge and depth to water. The influence of lower recharge rates in outcrop areas of till (Qvt) is shown in the low sensitivities where till is exposed in the Tulalip Plateau and in the Intercity Plateau (plates 2 and 7). The generally high sensitivities in the lowlands of river valleys and the Marysville Trough reflect the shallow depths to water and the higher recharge rates through the coarse surficial material in those areas. The overall influence of recharge is shown by the generally increasing sensitivities from west to east in the direction of increasing recharge.

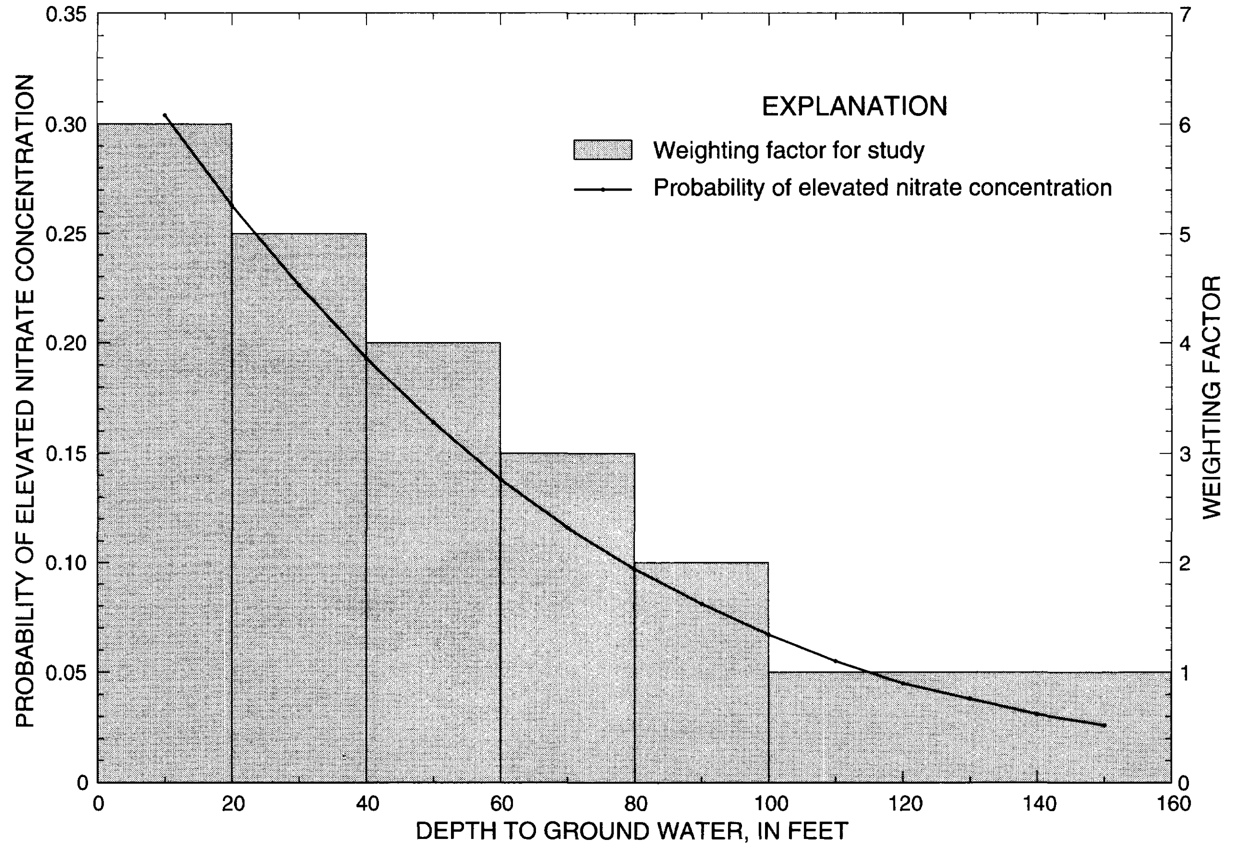


Figure 24. Relation between the weighting factor for depth to ground water used in the ground-water-sensitivity analysis and an independently estimated probability of elevated nitrate concentration for ground water in coarse-grained glacial deposits in western Washington. Probability analysis by A.J. Tesoriero, U.S. Geological Survey, written communication, 1995.

A thorough assessment of the accuracy and reliability of the ground-water sensitivity ratings could not be made with readily available data. However, independent methods based on nitrate and dissolved-oxygen concentrations in ground water were used to make partial assessments of the validity of one part of the method and the sensitivity ratings.

The validity of the slope of the weighting-factor relation used for depth to water was assessed by comparing the slope of the relation with results of an independent assessment of ground-water sensitivity in western Washington (A.J. Tesoriero, U.S. Geological Survey, Tacoma, Wash., written commun., 1995). That assessment analyzed nitrate-concentration and depth-to-water data collected during 1986-94 from 1,967 wells in western Washington. Regression analyses were made with the probability of elevated nitrate concentration as the response variable and depth to water as the explanatory variable. The threshold for elevated nitrate concentration was assumed to be 2.0 mg/L. Separate regression relations were developed for wells located in three major surficial geology types: coarse-grained glacial deposits, fine-grained glacial deposits, and alluvial deposits. Of the three computed regression relations, only the one for coarse-grained deposits was statistically significant. This relation was compared with the weighting-factor relation for depth-to-water (fig. 24). This comparison validates the slope of the weighting-factor relation used in this study; the weighting-factor relation and the probability-of-elevated-nitrate relation have similar slopes between depths of 0 and 100 ft and a flattening of the slopes for depths greater than 100 ft (fig. 24).

The validity of the ground-water sensitivity ratings was independently assessed by statistically comparing the sensitivity ratings with nitrate and dissolved-oxygen concentrations in shallow ground-water samples collected in this study. The hypothesis of the nitrate comparison is that nitrate concentrations would increase as the sensitivity increased. An assumption of this assessment is that the sources of nitrate are equivalent in volume and distribution throughout the areas defined for the three sensitivity groups.

The hypothesis of the dissolved-oxygen comparison is that concentrations would increase as the sensitivity increased. Shallow ground water with high dissolved-oxygen concentrations is expected to have higher sensitivity than ground water with low concentrations, because the high concentrations indicate a larger degree of contact with the atmosphere and therefore greater likelihood that contaminants would be carried to the water table by infiltration and percolation of precipitation.

To conduct the independent assessment of the validity of the ground-water sensitivity ratings, well locations were intersected with the maps of sensitivity, and nitrate and dissolved-oxygen concentrations in samples from the wells were placed into the three groups of sensitivity. Because the ratings measure the sensitivity of the water table of outcrop areas of geohydrologic units, the wells selected for analysis are shallow (less than 100 ft deep), and they are open only to a geohydrologic unit that is exposed at land surface (outcrop area). A nonparametric rank-sum test (one-sided) (Helsel and Hirsch, 1992, p. 117-134) was used to determine if the nitrate and dissolved-oxygen concentrations significantly increased from (1) the low to moderate sensitivity group, (2) the moderate to high group, and (3) the low to high group.

Nitrate concentrations in shallow ground water roughly agree with the ground-water sensitivity ratings (table 10); the median nitrate concentrations in samples from wells increased from low to high sensitivity, but the rank-sum tests between adjacent groups (low versus moderate and moderate versus high) showed no significant increase (at $\alpha = 0.05$) in concentrations between these groups. There is a significant increase ($p = 0.05$), however, from the low to high sensitivity group.

There is a good agreement between the sensitivity ratings and dissolved-oxygen concentrations in shallow ground water (table 10). Median dissolved-oxygen concentrations increased in each of the three sensitivity groups, and the increase is significant from the moderate to high sensitivity group ($p = 0.01$) and from the low to high group ($p < 0.01$).

Table 10.--*Validation assessment of relative ground-water sensitivity using nitrate and dissolved-oxygen concentrations of water samples withdrawn from shallow wells, western Snohomish County, Washington*

[<, less than]

Ground-water sensitivity	Constituent	Number of samples[1]	Concentration, in milligrams per liter: 25th percentile	Concentration, in milligrams per liter: Median	Concentration, in milligrams per liter: 75th percentile	P-value[2]	
Low	Nitrate	18	<0.05	0.18	1.2	0.24	0.05
Moderate	Nitrate	23	<0.05	0.27	2.5	0.21	
High	Nitrate	21	0.22	0.85	1.4		
Low	Dissolved oxygen	18	0.1	0.7	2.9	0.30	<0.01
Moderate	Dissolved oxygen	22	0.1	1.2	6.9	0.01	
High	Dissolved oxygen	21	2.4	5.7	8.0		

[1] Water samples withdrawn from wells less than 100 feet deep in outcrop areas of geohydrologic units.

[2] A rank-sum test (one-sided) was used to test the hypothesis that two groups of samples are from the same population. The p-value is the computed probability that the conclusion of the statistical test is incorrect.

The statistical comparisons of the ground-water sensitivity ratings with nitrate and dissolved-oxygen concentrations provide moderate evidence for a validation of the sensitivity ratings, but they do not provide conclusive evidence. The statistical tests showed significant increases in concentrations between some, but not all, of the three sensitivity groups. The dissolved-oxygen concentrations had a stronger agreement with the sensitivity ratings than did the nitrate concentrations. The weaker agreement between the nitrate concentrations and the ratings might be caused by a violation of the assumption of equivalent sources and distribution of nitrate throughout the areas defined for the three sensitivity groups.

The ground-water sensitivity ratings shown on plate 7 have many limitations, which are a function of the method and the available data. The principal limitations, which need to be considered by a user of the sensitivity maps, are listed below.

1.) Relative ratings—The ratings are relative and are only applicable to western Snohomish County. No absolute sensitivities, such as a specific probability of contamination or an absolute rate of contaminant movement, were estimated.

2.) Regional scale—The ratings are regional in scale; they are not valid for site-specific studies and are applicable only for areas larger than about 1 mi^2.

3.) Unknown accuracy—The accuracy of the ratings is not known.

4.) Some artificial boundaries in maps—Because the estimates of ground-water recharge were based on contours of average annual precipitation, some seemingly artificial lines or boundaries appear in the sensitivity maps. Two notable examples of these artificial boundaries are the change from moderate to high sensitivity in the southwestern part of the Marysville Trough and the change from low to moderate sensitivity in the till unit in the Lakes Plateau (plate 7). These abrupt changes are computed because the recharge weighting factor increases along that recharge contour, which causes the rating score to increase from a lower to higher sensitivity group. In fact, actual sensitivities do not change abruptly according to a contour of recharge. The sensitivities should gradually change near these boundaries.

5.) Sensitivity, not vulnerability—The maps show the sensitivity of the ground-water system to contamination; therefore, they do not account for the influence of human activities;

6.) Effects of variables not used in the method—Many variables that affect the sensitivity of a ground-water system to contamination were not considered in the method. The following unused variables are the more important ones:

    a.) Differences in individual contaminant behavior—No evaluation was made of the different behaviors of potential contaminants. The assumption about contaminant behavior for this evaluation is that a contaminant is mobile and will be carried with and travel at the same rate as percolating water.

    b.) Temporal changes in sensitivity—The method used average annual recharge as one variable in computing sensitivity; therefore, the computed sensitivities reflect average conditions for a year. The sensitivity, however, can vary during a year according to changes in soil-moisture content and precipitation intensity; both variables can affect the rate of transport of contaminants from land surface to the water table.

    c.) Land-surface slope—The ratings are applicable only in areas of low or moderate land-surface slopes (less than about 20 percent). The depth-to-water data used in the analysis are not representative of areas with steep land-surface slopes.

    d.) Soil characteristics—The texture, structure, organic-material content, and depth of a soil were not considered in the method and all these characteristics can affect contaminant transport.

GROUND-WATER QUALITY

The quality of the ground water in the study area is described on the basis of chemical analyses of water samples collected during 1993-94. Chemical concentrations and characteristics are discussed and related to area and geohydrologic unit. The concentrations are compared with applicable USEPA (1993a) drinking water regulations. Possible sources of any widespread or common water-quality problems are also identified.

General Chemistry

Most of the data that describe the general chemistry of the ground water are presented statistically in summary tables. Table 11 presents the minimum, median, and maximum values of common properties and constituents, trace elements, and septage-related compounds; table 12 presents the median values of the constituents by geohydrologic unit. All supporting basic data are presented in appendix B. Patterns in constituent concentrations are described using a nonparametric Spearman's correlation coefficient (Helsel and Hirsch, 1992, p. 217-218)

For many constituents, some concentrations are reported as less than (<) a certain value, where the value provided is the laboratory's reporting limit for an analytical method. For example, the concentrations of many trace elements are reported at <1 µg/L, where 1 µg/L is determined by the laboratory to represent a limit of detection for the analytical method. Below 1 µg/L, a constituent could be present at a lower concentration, or not be present at all, but the value is not reported because of statistical constraints developed to minimize the chance of reporting false positive results.

pH, Dissolved Oxygen, and Specific Conductance

The pH values of the samples collected as part of this study ranged from 5.6 to 9.6 and the median was 7.7 (table 11). Sixty-three samples had pH values that did not meet the USEPA (1993a) SMCL for drinking water. Of the 63, 26 samples had pH values greater than 8.5 and they were mostly from wells open to bedrock (unit Tb); 37 samples had pH values less than 6.5 and they were mostly from wells open to Qvr. Median pH values by geohydrologic unit ranged from 6.6 in Qal to 8.5 in Tb (table 12). Natural variability in aquifer materials, chemical reactions with those materials, and different residence times of water in the geohydrologic units all affect a water's chemical composition, and probably account for the observed ranges of pH values.

Throughout the study area, dissolved-oxygen concentrations typically were low; the overall median concentration was only 0.3 mg/L and the range was from <0.1 to 10.7 mg/L. The median dissolved-oxygen concentration of 5.2 mg/L for samples from wells in Qvr was the highest of the seven units. Median concentrations were less than 1 mg/L in the remaining 6 units and, in the lower three units (Qtb, Qu, and Tb), median concentrations were 0.1 mg/L or less. Similar to the variation observed by Dion and others (1994) in northern Thurston County and by Turney and others (1995) in eastern King County, Washington, dissolved-oxygen concentrations varied greatly within individual units; in each of the upper 4 units (Qal, Qvr, Qvt, and Qva), the maximum value was at least 8.0 mg/L, and the minimum value was <0.1 mg/L.

Specific conductance is an accurate indicator of the concentrations of those dissolved minerals typically referred to as dissolved solids. Because dissolved-solids data are discussed below, specific conductance values are presented here and in the tables only for general information. Specific conductance values ranged from 35 to 2,100 µS/cm (microsiemens per centimeter at 25°C), and the overall median was 197 µS/cm. The median values by geohydrologic unit ranged from 121 µS/cm in Qal to 399 µS/cm in Tb.

Dissolved Solids

The dissolved-solids concentrations for this study were calculated from the analytically determined concentrations of several constituents, including the major ions, silica, nitrate, iron, and manganese. In western Snohomish County ground water, the primary contributors to the dissolved-solids concentrations were calcium, sodium, bicarbonate, and silica. The concentrations ranged from 36 to 1,040 mg/L, and the median was 133 mg/L. Concentrations of dissolved-solids exceeded the USEPA (1993a) SMCL of 500 mg/L in only three samples (table B1). One sample was from a well in Qva, and two were from wells in Tb. Median concentrations by geohydrologic unit consistently increased from 80 mg/L in the youngest unit (Qal) to 257 mg/L in the oldest unit (Tb). Some of this variation is likely caused by different rock types in the units, but some of the variation is probably a result of the water's longer residence time in the older and deeper units. Water that has been in the ground for a longer time has had the opportunity to dissolve more minerals than water with a shorter residence time.

No definite pattern was apparent in the geographic distribution of dissolved-solids concentrations (plate 8). Ninety-three percent of the sample concentrations were less than 300 mg/L, and these samples were found in wells throughout the study area. There were two areas with a cluster of similar concentrations: an area east of Monroe, with most samples having concentrations of less than 100 mg/L; and an area northwest of Arlington, with many samples having concentrations of greater than 300 mg/L.

Major Ions

In western Snohomish County ground water, calcium was the primary cation, with a median concentration of 15 mg/L (table 11). The remaining cations were mostly accounted for by sodium, with a median concentration of 7.1 mg/L, and magnesium, with a median concentration of 7.0 mg/L. Median concentrations of the other cations were 1.8 mg/L for potassium, 38 µg/L for iron, and 31 µg/L for manganese.

The concentrations of calcium and magnesium were used to calculate the hardness of water, which can affect the aesthetic quality of the water and can deposit scale on plumbing fixtures. Most of the water samples were classified as either soft or moderately hard, according to the following scheme (Hem, 1992):

Description	Hardness range (mg/L of $CaCO_3$)	Number of samples	Percentage of samples
Soft	0 - 60	106	36
Moderately hard	61 - 120	172	58
Hard	121 - 180	15	5
Very hard	Greater than 180	4	1
		297	100

The concentrations of sodium are used to calculate the sodium hazard of ground water used for irrigation. Most of the water samples were classified as a low hazard on the basis of the sodium adsorption ratio (SAR) shown in the following table (Hem, 1992). Ten of the 12 water samples with a very high hazard were from wells in the Tb unit. There appears to be a geographic pattern in these 10 Tb samples; 6 of the 10 samples are from wells in the East Stanwood Plateau.

Sodium hazard	SAR value	Number of samples	Percentage of samples
Low	Less than 10	275	92
Medium	10 - 18	5	2
High	19 - 26	5	2
Very high	Greater than 26	12	4
		297	100

The primary anion in the ground water was bicarbonate, as indicated by the median laboratory alkalinity concentration of 85 mg/L (table 11). Although alkalinity consists mostly of bicarbonate, carbonate, and hydroxide, the concentrations of each are dependent on pH. At all the pH values measured during the study, bicarbonate was the major component of the alkalinity. The highest alkalinity concentration was 510 mg/L in a sample collected from a well in Qva. Concentrations of the other anions were much lower than alkalinity; median values were 4.8 mg/L for sulfate, 3.2 mg/L for chloride, 0.1 mg/L for fluoride, and <0.05 mg/L for nitrate. No sulfate concentrations in the samples exceeded the USEPA (1993a) SMCL of 250 mg/L. One sample exceeded the USEPA (1993a) MCL of 4 mg/L for fluoride; this sample contained the study's maximum concentration of 6 mg/L and was collected from well 28N/06E-24Q02, which is completed in Tb. The sample collected from well 27N/09E-05C01, also completed in Tb, had a fluoride concentration of 2 mg/L, which is equal to the USEPA (1993a) SMCL. High concentrations of chloride and nitrate are important to local water-quality conditions, and both are discussed below in separate sections.

Comparisons of median concentrations of the major ions by geohydrologic unit indicate that concentrations generally increased from the shallow unit Qal to the deep unit Qu (table 12). In unit Tb, however, the median concentrations of calcium, magnesium, and potassium were the lowest of the seven geohydrologic units. Sodium and alkalinity concentrations were highly correlated (ρ greater than 0.85) with dissolved-solids concentration, and sodium and alkalinity appear to account for most of the variation in the dissolved-solids concentrations of the different geohydrologic units. Concentrations of calcium, magnesium, potassium, sulfate, fluoride, and silica had weak correlations with dissolved-solids concentrations ($\rho < 0.4$); chloride concentration was moderately correlated with dissolved-solids concentration ($\rho = 0.59$).

Water Types

A common practice in water-quality analysis is to determine the water type, or dominant cation and anion, of a particular ground water. These classifications are derived by plotting the analytical results, expressed in percent milliequivalents, on trilinear diagrams. For this study, a trilinear diagram was constructed for each of the seven geohydrologic units (plate 9). Calcium and magnesium as the dominant cations, and bicarbonate as the dominant anion, are typical water types in the glacial deposits of western Washington (Van Denburgh and Santos, 1965).

Table 11. --*Summary of field measurements and constituent concentrations in ground-water samples, July 1993 to March 1994, western Snohomish County, Washington*

[Concentrations are dissolved; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; cols/100 mL, colonies per 100 milliliters; $CaCO_3$, calcium carbonate; HCO_3, bicarbonate; CO_3, carbonate; N, nitrogen; <, less than; --, no applicable standard; USEPA, U.S. Environmental Protection Agency. See table 1 for primary maximum contaminant and secondary maximum contaminant levels for drinking water.]

Constituent or property	Number of samples	Values			Number of samples exceeding USEPA (1993a) drinking-water standards
		Minimum	Median	Maximum	
Field-measured property:					
pH (standard units)	297	5.6	7.7	9.6	63
Dissolved oxygen (mg/L)	293	<0.1	0.3	10.7	--
Specific conductance (µS/cm)	297	35	197	2,100	--
Temperature (°C)	296	7.5	11.5	19.5	--
Field-measured bacteria:					
Fecal coliform (cols/100 mL)	297	<1	<1	40	6
Common constituent:					
Hardness (mg/L as $CaCO_3$)	297	0	70	200	--
Calcium (mg/L)	297	.08	15	59	--
Magnesium (mg/L)	297	.01	7.0	27	--
Sodium (mg/L)	297	1.6	7.1	460	--
Potassium (mg/L)	297	<.1	1.8	11	--
Bicarbonate (mg/L as HCO_3)	89	21	140	620	--
Carbonate (mg/L as CO_3)	89	0	1	60	--
Alkalinity, field (mg/L as $CaCO_3$)	91	28	120	510	--
Alkalinity, laboratory (mg/L as $CaCO_3$)	297	10	85	510	--
Sulfate (mg/L)	297	<.1	4.8	60	0
Chloride (mg/L)	297	.8	3.2	400	2
Fluoride (mg/L)	297	<.1	.1	6	[1]1,1
Silica (mg/L)	297	7	27	57	--
Dissolved solids (mg/L)	275	36	133	1,040	3
Nitrite (mg/L as N)	297	<.01	<.01	.07	0
Nitrate (mg/L as N)	297	<.05	<.05	23	4
Ammonia (mg/L as N)	297	<.01	.04	12	--
Phosphorus (mg/L)	297	<.01	.07	2.9	--
Iron (µg/L)	297	<3	38	26,000	58
Manganese (µg/L)	297	<1	31	910	123
Trace element:					
Arsenic (µg/L)	295	<1	2	280	5
Barium (µg/L)	68	<2	18	2,000	[2]0
Cadmium (µg/L)	68	<1	<1	<1	0
Chromium (µg/L)	68	<1	<1	10	0
Copper (µg/L)	68	<1	<1	96	0
Lead (µg/L)	68	<1	<1	1	0
Mercury (µg/L)	68	<.1	<.1	2.4	1
Selenium (µg/L)	68	<1	<1	<1	0
Silver (µg/L)	68	<1	<1	<1	0
Zinc (µg/L)	68	<3	18	490	0
Septage-related compound:					
Boron (µg/L)	94	<10	20	500	--
Dissolved organic carbon (mg/L)	97	<.1	.4	9.9	--
Methylene-blue-active substances (mg/L)	96	<.02	<.02	.03	--

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[1] One sample exceeded maximum contaminant level and another sample exceeded the secondary maximum contaminant level.

[2] One sample was equal to the maximum contaminant level.

Calcium-magnesium/bicarbonate water types result from the slow dissolution of carbonate minerals such as calcite and dolomite by dilute, slightly acidic water (Freeze and Cherry, 1979). Most of the samples collected from throughout the study area, particularly from units Qal, Qvt, and Qva, were a calcium/bicarbonate or a calcium-magnesium/bicarbonate water type.

The water types that were considerably different from the typical water type for an individual unit were considered anomalies. The most notable anomalies were the sodium/chloride and sodium/bicarbonate water types; many samples from Qu and Tb had these water types. Fifteen samples that appear to have chloride as the dominant anion actually had high nitrate concentrations, which increased the apparent chloride contribution. Most of these high-nitrate samples were from shallow wells completed in the outcrop areas of Qvr and Qva.

High sodium concentrations in 93 samples (31 percent) from units Qvr, Qtb, Qu, and Tb resulted in mixed water types consisting of varying proportions of calcium, magnesium, and sodium. In 29 of the 297 samples, high sodium concentrations contributed to a sodium/bicarbonate water type (plate 9). Turney and others (1995) discuss the high proportions of sodium found in geohydrologic units in eastern King County that are equivalent to units Qu and Tb in western Snohomish County. In Tb, they indicate that andesite and basalt of the Tb are likely sources of sodium to the ground water. As water infiltrates and interacts with rocks containing calcium, magnesium and sodium, hydrolysis produces hydroxyl ions (OH^-) that raise the ground-water pH. Because of the higher pH, calcium carbonate and magnesium carbonate solubilities are exceeded, and those compounds are precipitated. But at the same pH, the solubilities of sodium minerals are not exceeded, resulting in sodium-enriched water. For water in Qu, the source of sodium is uncertain; one possibility might be the presence of more sodium-rich minerals than in other units, and another might be upward flow of sodium-rich water from the underlying Tb (Dion and others, 1994; Turney and others, 1995).

Twenty-four water samples from units Qvr, Qva, and Tb contained sufficient chloride for that element to be either the sole dominant anion or codominant anion with the bicarbonate anion. However, for wells sampled along the Puget Sound shoreline during this study, chloride concentrations, water types, and other water-quality characteristics did not indicate any appreciable seawater intrusion. In samples from wells away from marine shorelines, water types having chloride as the dominant anion could be due to the presence of connate seawater, which is seawater trapped in a geohydrologic unit during its deposition (Dion and others, 1994; Turney and others, 1995).

Chloride

Concentrations of chloride in the water samples are discussed in relation to overall variability, variation between geohydrologic units, and geographic patterns. Specific instances of elevated or unusual concentrations are also discussed. Possible regional or study-wide relations between chloride and seawater intrusion or septic systems are discussed in the sections "Seawater Intrusion" and "Septic Systems".

Chloride concentrations in the 297 samples ranged from 0.8 to 400 mg/L, with a median concentration of 3.2 mg/L. Similar to ground-water studies in northern Thurston County (Dion and others, 1994) and eastern King County (Turney and others, 1995), median chloride concentrations in the study area were not related to geohydrologic unit, ranging from 2.3 mg/L in samples from Qal to 5.4 mg/L in samples from Qu (table 12). However, most of the higher concentrations of chloride were found in samples from Tb; eight of the 13 samples with chloride concentrations greater than 50 mg/L were from wells completed in Tb. Connate seawater seeping from marine rocks of Tertiary age is the likely source of chloride for these wells (Dion and others, 1994). Samples from two wells, both completed in Tb, had chloride concentrations exceeding the USEPA (1993a) SMCL of 250 mg/L (table B1); one sample with 400 mg/L, was from well 30N/06E-11A05, and one with 350 mg/L, was from well 31N/06E-20R02.

Some geographic patterns are apparent in the concentrations of chloride (plate 8). Generally low values are found in the central and east-central parts of the study area. Four areas that have values consistently higher than the median include a small area north of Monroe, the northwestern part of the study area, along the South Fork of the Stillaguamish River, and near the town of Snohomish.

Table 12.--*Median values of field measurements and constituent concentrations, by geohydrologic unit, western Snohomish County, Washington*

[Concentrations are dissolved; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; $CaCO_3$, calcium carbonate; N, nitrogen; <, less than; --, no value; Qal, alluvium; Qvr, Vashon recessional outwash; Qvt, Vashon till; Qva, Vashon advance outwash; Qtb, transitional beds; Qu, undifferentiated sediments; Tb, bedrock]

	Geohydrologic unit (number of samples)						
Common constituent or property	Qal (13)	Qvr (26)	Qvt (39)	Qva (139)	Qtb (13)	Qu (31)	Tb (36)
pH, field (standard units)	6.6	6.2	7.5	7.7	8.0	8.0	8.5
Dissolved oxygen, field (mg/L)	1.4	5.2	0.6	[1]0.8	<0.1	[2]0.1	0.1
Specific conductance, field (µS/cm)	121	160	197	185	231	250	399
Temperature, field (°C)	12	12	12	11	10.5	11.5	11.2
Fecal coliform, field (cols/100 mL)	<1	<1	<1	<1	<1	<1	<1
Hardness (mg/L as $CaCO_3$)	51	48	70	71	70	81	21
Calcium (mg/L)	11	12	17	15	15	16	6.0
Magnesium (mg/L)	5.5	3.6	7.1	7.4	6.9	9.6	2.0
Sodium (mg/L)	3.6	4.7	5.9	6.3	10	14	61
Potassium (mg/L)	1.6	1.4	1.7	1.9	3.0	2.3	.7
Alkalinity, laboratory (mg/L as $CaCO_3$)	56	40	77	77	107	113	164
Sulfate (mg/L)	3.1	4.2	6.0	5.0	1.2	4.4	4.5
Chloride (mg/L)	2.3	3.1	2.9	3.3	3.2	5.4	3.3
Fluoride (mg/L)	.1	<0.1	.1	.1	.2	.1	.2
Silica (mg/L)	19	20	27	30	31	36	16
Dissolved solids (mg/L)	80	103	[3]123	[4]124	[5]156	[6]158	[7]257
Nitrite (mg/L as N)	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Nitrate (mg/L as N)	.27	.59	<.05	.10	<.05	<.05	<.05
Ammonia (mg/L as N)	.03	<.03	.04	.04	.21	.28	.08
Phosphorus (mg/L)	.03	.01	.06	.08	.28	.23	.09
Arsenic (µg/L)	<1	<1	[3]2	3	6	2	<1
Iron (µg/L)	43	14	40	38	130	220	26
Manganese (µg/L)	31	3	43	31	79	70	5.5

Trace element	Qal (1)	Qvr (5)	Qvt (8)	Qva (23)	Qtb (5)	Qu (12)	Tb (14)
Barium (µg/L)	--	22	16	14	20	22	26
Cadmium (µg/L)	--	<1	<1	<1	<1	<1	<1
Chromium (µg/L)	--	<1	<1	<1	2	<1	<1
Copper (µg/L)	--	<1	<1	<1	<1	<1	<1
Lead (µg/L)	--	<1	<1	<1	<1	<1	<1
Mercury (µg/L)	--	<.1	<.1	<.1	<.1	<.1	<.1
Selenium (µg/L)	--	<1	<1	<1	<1	<1	<1
Silver (µg/L)	--	<1	<1	<1	<1	<1	<1
Zinc (µg/L)	--	6	9.5	20	7	74.5	4.5

Septage-related compound	Qal (7)	Qvr (12)	Qvt (18)	Qva (44)	Qtb (3)	Qu (4)	Tb (6)
Boron (µg/L)	20	10	10	10	40	25	280
Dissolved organic carbon (mg/L)	.7	.6	.4	[8].3	--	1.3	[9].5
Methylene-blue-active substances (mg/L)	<.02	<.02	[10]<.02	[11]<.02	--	<.02	<.02

n = number of samples:

[1]n=138; [2]n=29; [3]n=38; [4]n=135; [5]n=10; [6]n=24; [7]n=30; [8]n=47; [9]n=7; [10]n=19 [11]n=46.

Nitrogen

Concentrations of nitrogen in the water samples are discussed in relation to overall variability, variation between geohydrologic units, and geographic patterns. Specific instances of elevated or unusual concentrations are also discussed. Water samples were analyzed for two forms of nitrogen, nitrate and ammonia, and the characteristics of each form are discussed. Possible regional or study-wide relations between nitrogen and agricultural activities or septic systems are discussed in the sections "Agricultural Activities" and "Septic Systems".

In the full set of 297 water samples collected during this study, three forms of dissolved nitrogen were analyzed for—ammonia, nitrite, and nitrite plus nitrate. The reported nitrite-plus-nitrate concentrations can generally be considered entirely nitrate because nitrite concentrations are usually negligibly small. The nitrite concentrations in this study confirmed this assumption (table B1). Ninety-four percent of the samples had nitrite concentrations below the detection limit of 0.01 mg/L. Of the remaining 6 percent, one sample had a concentration of 0.07 mg/L, and the others had concentrations of less than 0.04 mg/L. In the text and summary tables (tables 10-13) of this report, all the nitrite plus nitrate concentrations are reported as a nitrate concentration. In the data tables (B1 and B3), however, the nitrite plus nitrate designation is reported, as well as some other supplemental nitrogen analyses on a subset of samples.

Throughout most of the study area, concentrations of nitrate were low, with a median concentration at the analytical reporting limit of <0.05 mg/L (table 11 and plate 8). Seventy-five percent of the samples had concentrations less than 1.0 mg/L. A concentration of greater than 1.0 mg/L was a level used by Dion and others (1994) and Turney and others (1995) to indicate possible nitrate contamination of ground water in western Washington. The 75 samples with nitrate concentrations greater than 1.0 mg/L were from wells distributed mostly evenly throughout the study area. Two areas appear to have a pattern of slightly elevated concentrations: an area near Lake Goodwin and the Tulalip Indian Reservation, and an area near and southwest of Monroe. Slightly more than half the samples in these areas have concentrations greater than 1.0 mg/L. The sources of nitrate in these areas are probably isolated and not regional in nature.

The maximum nitrate concentration for the study area was 23 mg/L (table 11) in the sample from well 31N/04E-03L05, a dug well that is only 25 ft deep. Nearby agricultural activities are probably responsible for the high concentration of nitrate. Samples from three other dug wells, all less than 30 ft deep, had concentrations exceeding the USEPA (1993a) MCL of 10 mg/L (wells 30N/05E-29F07, 31N/05E-28A01, and 32N/05E-36R04).

Nitrate concentrations were usually highest in samples from the shallow geohydrologic units; this is to be expected because nitrate sources are usually at or near the land surface (table 12). The median concentrations were 0.27 mg/L in Qal and 0.59 mg/L in Qvr. With the exception of unit Qva, which had a median concentration of 0.12 mg/L, the median concentrations were at the reporting limit of <0.05 mg/L in all the deeper units. Nitrate concentrations at individual wells, however, were not strongly correlated with well depth ($\rho = -0.30$).

Ammonia nitrogen was detected in 239 samples (80 percent). The concentrations ranged from <0.01 to 12 mg/L, with a median concentration of 0.04 mg/L. Although detections of ammonia at low concentrations of 0.04 mg/L or less should be interpreted cautiously (see appendix C), concentrations above 0.2 mg/L are probably accurate. The sample with the maximum ammonia concentration (12 mg/L) was from well 31N/04E-18E01, which is 210 ft deep and completed in unit Qu. The shallow wells with samples having ammonia concentrations higher than 0.2 mg/L were located in some of the same general areas where nitrate concentrations exceeded 1.0 mg/L. Areas with high ammonia concentrations were the Stillaguamish River Valley, between North and Bear Creeks (Intercity Plateau), and the agricultural areas near the towns of Snohomish and Monroe. Water from geohydrologic units Qal, Qvr, Qvt, Qva, and Tb had similar median concentrations of ammonia, ranging from <0.03 to 0.08 mg/L; Qtb and Qu water samples had much higher median concentrations (0.21 mg/L for Qtb and 0.28 mg/L for Qu) probably because of the generally low dissolved-oxygen concentrations in water from those units (table 12).

In addition to nitrate, ammonia appears to be an important form of nitrogen for evaluating the quality of ground water in western Snohomish County. However, there are probably some natural sources of ammonia in the study area. Evidence for these natural sources are generally low concentrations (median of 0.04 mg/L) are widespread, and the fact that ammonia was found in many samples from deep wells. Of the 33 samples with ammonia concentrations of greater than 0.5 mg/L, 22 were from wells more than 100 ft deep. Human-caused contamination by ammonia would most likely be found in samples from shallow wells.

Iron and Manganese

Iron concentrations ranged from the analytical reporting limit of <3 µg/L to 26,000 µg/L, with a median of 38 µg/L (table 11). Median concentrations for the geohydrologic units ranged from 14 µg/L for Qvr to 220 µg/L for Qu (table 12). Fifty-eight samples had iron concentrations that exceeded the USEPA (1993a) SMCL of 300 µg/L. Units Qvr, Qvt, Qva, and Tb had less than 20 percent of their samples with iron concentrations greater than 300 µg/L, and units Qal, Qtb, and Qu had more than 30 percent of their samples with iron concentrations greater than 300 µg/L. The geographic distribution of iron concentrations was variable (plate 8), as has been observed in other studies in western Washington (Dion and others, 1994; and Turney and others, 1995). Two areas had generally low concentrations: near Lake Goodwin, and between Monroe and Startup.

Manganese concentrations ranged from the analytical reporting limit of <1 µg/L to 910 µg/L, with a median of 31 µg/L. Median concentrations for the geohydrologic units ranged from 3 µg/L for Qvr to 79 µg/L for Qtb. One hundred and twenty three samples exceeded the USEPA (1993a) SMCL of 50 µg/L. Thus, the number of samples with elevated manganese concentrations was about twice the number for iron concentrations. The relation between geohydrologic units was similar to that for iron. Units Qtb and Qu had more than 55 percent of their samples with manganese concentrations greater than 50 µg/L; units Qal, Qvt, and Qva had between 40 and 50 percent; and units Qvr and Tb had the lowest number with less than 25 percent. Like iron, manganese concentrations showed no strong geographic pattern. However, where iron concentrations were high, manganese concentrations also tended to be high; the correlation coefficient between iron and manganese concentrations was 0.76.

Trace Elements

Sixty-eight ground-water samples were analyzed for the trace elements of barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc; and 295 samples were analyzed for arsenic. The concentrations of all these elements were generally low. The median concentrations were less than 20 µg/L for arsenic, barium, and zinc, and all other elements had median concentrations of less than 1 µg/L (table 11). A few samples had elevated trace-element concentrations that might indicate contamination or might be a health concern; five samples exceeded the USEPA (1993a) MCL for arsenic, one sample equaled the MCL for barium, and one sample exceeded the MCL for mercury.

Arsenic is the trace element of most concern in western Snohomish County. High arsenic concentrations that exceed the USEPA drinking water standard are a regional water-quality problem in the Granite Falls area. Exceptionally high concentrations of arsenic—as much as 15,000 µg/L—were found in that area by Ficklen and others (1989). In addition, a recent study of ground water in eastern King County, just south of Snohomish County, found that 64 percent of the samples had arsenic detected (Turney and others, 1995). The concentrations of the eastern King County samples were not high; the upper 15 percent of the samples had concentrations between 20 and 77 µg/L. But the concentrations were high enough to warrant some concern because of current research into the relation between arsenic and human health and a possible lowering of the USEPA MCL (Turney and others, 1995, p. 46).

Arsenic was detected in 63 percent of the water samples in this study; concentrations ranged from <1 to 280 µg/L and the median was 2 µg/L (table 11). The five samples exceeding the USEPA (1993a) MCL of 50 µg/L were collected from wells in the Cascade Range foothills between Arlington and Granite Falls (fig. 25). Two of the five wells (30N/06E-36E01 and 31N/06E-27K01) are completed in bedrock, which is probably the principal source of the arsenic (Snohomish County Health District and Washington State Department of Health, 1991). Well 32N/06E-32G01 is 256 ft deep and completed in unit Qtb; water from the bedrock might influence the arsenic concentration in this unit. The remaining two wells are shallow: 30N/06E-23C01 is 33 ft deep and is completed in Qvr, and well 31N/06E-09K01 is 16 ft deep and is completed in Qal. Bedrock-derived material in the unconsolidated units could be a source of the arsenic to these shallow wells. During this study, concentrations of arsenic greater than 10 µg/L were found in samples from 52 wells representing all seven geohydrologic units and located throughout the study area. Arsenic concentrations did not strongly correlate with geohydrologic units or with any of the other chemical constituents measured.

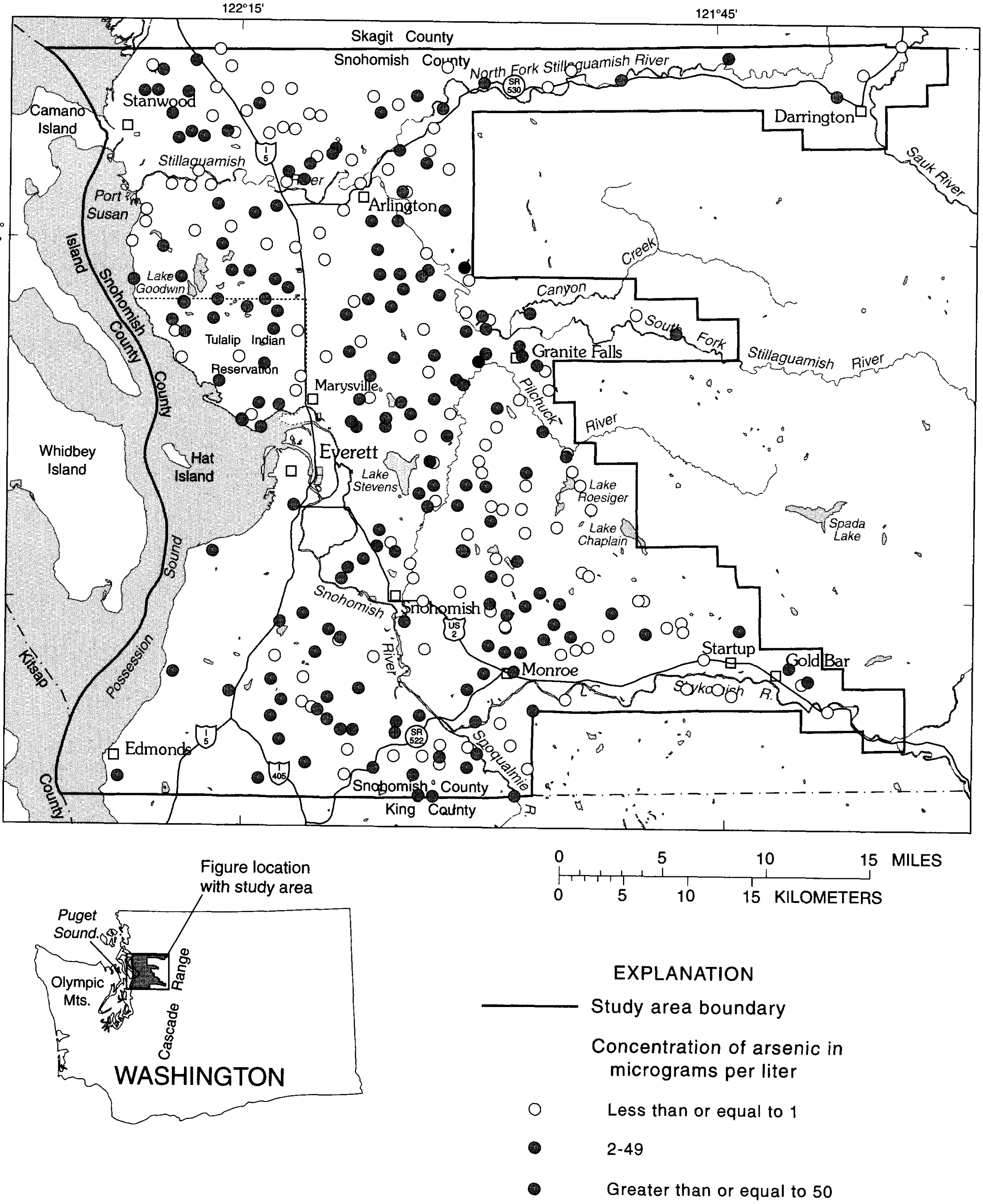

Figure 25. Concentrations of arsenic in ground water, 1993.

In addition to the variability among geohydrologic units and across the study area, the Snohomish County Health District and Washington Department of Health (1991) found considerable seasonal variation in arsenic concentrations, and concluded that a one-time testing of well water could be insufficient to identify an arsenic-contaminated well. That study resulted in recommendations for additional sampling on the basis of the following criteria:

1) If a sample has a concentration higher than 10 µg/L, a confirmation sample should be collected and analyzed;
2) If either the first or the confirmation sample contains between 20 and 50 µg/L, a seasonal set of samples should be analyzed to determine if arsenic concentrations exceed the MCL during a year's time; and
3) If either the first or the confirmation sample has an arsenic concentration higher than 50 µg/L, the well water can be considered to exceed the MCL for a part of the year. Monthly samples might be collected to better define seasonal variation and to determine if arsenic concentrations are exceptionally high during certain times.

Barium was detected in 81 percent of the water samples; concentrations ranged from <2 µg/L to 2,000 µg/L, and the median was 18 µg/L (table 11). The maximum sample concentration for the study, collected from well 32N/06E-17C01, is equal to the USEPA (1993a) MCL of 2,000 µg/L. Concentrations in the remaining samples were less than 250 µg/L, much below the MCL (table B1). Barium in the ground water is probably from a natural source. However, for well 32N/06E-17C01, the high sample concentration may indicate a human source, although no human sources are readily apparent from available information.

Chromium was detected in 31 percent of the samples from wells in all geohydrologic units except Qal and Qvr; concentrations ranged from <1 to 10 µg/L, with a median of <1 µg/L (table 11). The maximum concentration of 10 µg/L was far below the USEPA (1993a) MCL of 100 µg/L.

Copper was detected in 24 percent of the samples from wells in all geohydrologic units except Qal and Qtb; concentrations ranged from <1 to 96 µg/L, with a median of <1 µg/L. Zinc was detected in 84 percent of the samples from wells in all units, and concentrations ranged from <3 to 490 µg/L, with a median of 18 µg/L (table 11). By geohydrologic unit, concentrations of copper and zinc were variable, but the median concentrations of zinc were higher in Qva and Qu than in the other units. The presence of copper and zinc in many of the samples might not be solely from natural sources. Copper and zinc are present in pipes used in wells and in home plumbing systems. The metals can be leached from the pipes if the water is slightly acidic and low in dissolved-solids concentration, as is much of the water in western Snohomish County.

Mercury was detected in five samples—well 27N/09E-05C01 with 0.1 µg/L, well 32N/04E-04K01 with 0.2 µg/L, well 32N/04E-07R02 with 0.6 µg/L, well 32N/08E-02L01 with 1.5 µg/L, and well 30N/04E-05P02 with 2.4 µg/L. The USEPA (1993a) MCL for mercury is 2 µg/L. The source of the mercury in these samples is unknown. Although the presence of mercury might be due to isolated instances of sample contamination from the mercuric chloride used for preserving nutrient samples, mercury was not detected in any of the quality-assurance samples. Similarly, Turney and others (1995) also found mercury in water samples from eight wells in eastern King County but did not detect any mercury in the quality-assurance samples.

The remaining trace elements analyzed for were either not detected in the samples or were present in concentrations that were mostly unimportant when compared with water-quality criteria. Two samples had a detection of lead at the analytical reporting limit of 1 µg/L. Like copper and zinc, lead in ground-water samples might be from plumbing systems, particularly the lead-based solder used in some older homes. None of the samples contained any cadmium, selenium, or silver. The fact that no selenium was detected is in contrast with the 1991 arsenic study (Snohomish County Health District and Washington State Department of Health, 1991) that found selenium concentrations between 2 and 6 µg/L in 10 of 26 well samples in the Granite Falls area.

Synthetic Organic Compounds

The synthetic organic compounds analyzed for in this study were volatile organic compounds (VOC), chlorophenoxy-acid and triazine herbicides, and organophosphorus and organochlorine insecticides. Of the nine samples collected from the wells (table 2), no volatile organic compounds were found except for two detections of dichlorodifluoromethane (Freon 12) (table B2). This compound was found at a concentration of 0.7 µg/L in the sample from well 28N/06E-12J01, and at a concentration of 51 µg/L in the sample from well 29N/05E-20P02. Well

28N/06E-12J01 is located in a rural area; the source of the dichlorodifluoromethane to the water sample is unknown. This well is completed in unit Tb and obtains water from about 200 ft below land surface. Water from well 29N/05E-20P02 is used for heating and cooling in an industrial- urban area and the well is completed in unit Qu at 303 ft below land surface. The source of the dichlorodifluoromethane is unknown.

Twelve wells were sampled for chlorophenoxy-acid herbicides; one of these wells was also sampled for the triazine herbicides (table B2). None of the chlorophenoxy-acid herbicides, the group which includes the widely used 2,4-D, and none of the triazine herbicides were detected in the samples (table B2).

Four wells were sampled for organochlorine insecticides (such as DDT) and other organochlorine compounds (such as PCB's), and one well was sampled for organophosphorus insecticides (such as diazinon). None of the insecticides, insecticide degradation products, or other chlorinated compounds were detected in the samples (table B2).

Septage-Related Compounds

The purpose of sampling for septage-related compounds (boron, DOC, and methylene-blue-active substances (MBAS)) in the water was to determine if effluent from septic systems has caused ground-water contamination. The results are discussed in relation to overall variability, geographic patterns, and relation to other possible contaminants from septic systems. A summary of this discussion is also provided later in the section "Septic Systems."

Threshold concentrations of the septage-related compounds, above which might indicate contamination from septic systems, have been established only for MBAS. Hughes (1975) stated that MBAS concentrations above 0.02 mg/L can be considered as evidence of ground-water degradation. There are no natural sources of MBAS in ground water; therefore, just a detection of MBAS is an indication of contamination. Such contamination, however, is not necessarily from septic systems because activities such as dairy farming also use detergents that may contain MBAS. There are natural sources of boron and DOC in ground water. Because their concentrations can vary considerably, it is difficult to establish a contamination threshold for these constituents. Some natural concentrations reported in the literature are in excess of 100 µg/L for boron (Hem, 1992) and a median value for DOC of 0.7 mg/L for ground waters throughout the United States (Thurman, 1985). Because of these limitations, concentrations of boron and DOC were interpreted cautiously, and more emphasis was placed on evaluating the relations between concentrations of boron, DOC, and MBAS as well as the relations between concentrations of other constituents commonly associated with septic systems, such as nitrate and ammonia.

About 95 water samples were analyzed for the septage-related compounds. MBAS were detected in only five samples; two had a concentration of 0.02 mg/L and three had a concentration of 0.03 mg/L (table B1). Concentrations of boron ranged from <10 to 500 µg/L, with a median concentration of 20 µg/L (table 11). Concentrations of DOC ranged from <0.1 to 9.9 mg/L, with a median concentration of 0.4 mg/L.

The concentrations of septage-related compounds were evaluated two different ways. In addition to boron, DOC, and MBAS, which have been defined as septage related, nitrate and ammonia were also added to the evaluation because they are commonly associated with septic-system effluent. The strength of association between boron, DOC, nitrate, and ammonia was evaluated by computing Spearman's correlation coefficients for the concentrations of those constituents. A strong correlation between concentrations of two or more constituents might indicate contamination from septic systems. Correlations were not computed for MBAS because only 5 out of 96 samples had detections of MBAS; and this distribution of concentrations would provide no meaningful correlations with concentrations of other constituents.

The second method used to evaluate septage-related compounds was to determine possible relations between water samples with relatively high concentrations of those constituents and factors such as well depth, geohydrologic unit, and geographic area. Ideally, samples that contained septage-contaminated water would have been used for this evaluation instead of the relatively high concentrations, but it was not possible to confidently specify concentrations, except for MBAS, that could be classified as contaminated. Any detection of MBAS can be considered evidence of contamination because MBAS is not a natural substance. Threshold concentrations were therefore selected for boron, DOC, nitrate, and ammonia, above which the constituents were considered to have relatively high concentrations. The threshold was chosen at the 90th percentile of the distribution of sample concentrations for each constituent. The 97 samples with analyses for septage-related compounds were evaluated, and all samples that had concentrations equal to or exceeding two or more of the thresholds were selected (table 13). The hypothesis of this evaluation is that samples with more than one relatively high concentration of these constituents are more likely to be contaminated than the samples that do not meet this criterion.

The magnitudes of the Spearman's correlation coefficients between concentrations of boron, DOC, nitrate, and ammonia do not indicate regional ground-water contamination by septic systems. The coefficients ranged from -0.66 to 0.61. Correlation coefficients for the same constituents in samples from wells less than 100 ft deep also were not large, with a range of -0.57 to 0.48.

Table 13.--*Water samples containing relatively high concentrations of septage-related compounds and nitrogen compounds, western Snohomish County, Washington*

[Wells shown had samples with concentrations equal to or exceeding two or more of the indicated "threshold" concentrations; MBAS, methylene blue active substance; mg/L, milligrams per liter; ug/L, micrograms per liter; <, less than; --, not determined or not applicable]

Local well number	Date	Depth of well (feet)	Boron, dissolved (µg/L as B)	Organic carbon, dissolved (mg/L as C)	MBAS (mg/L)	Nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)
--	--	--	[1]60	[1]1.8	[1]0.02	[1]2.5	[1]0.54
27N/05E-19B03	09-01-93	49	20	2.5	<.02	<.05	1.1
27N/06E-01A01	09-15-93	115	30	5.9	<.02	<.05	7.4
27N/06E-03Q01	09-14-93	42	40	2.8	<.02	<.05	2.8
27N/07E-31N02	08-31-93	505	30	2.2	<.02	<.05	.88
28N/05E-22N01	09-16-93	140	50	2.1	<.02	<.05	.91
28N/05E-33C01	08-17-93	100	60	0.2	<.02	5.9	.02
29N/07E-27A02	08-11-93	100	60	1.4	<.02	<.05	.64
30N/04E-08G01	08-02-93	55	--	.6	.03	5.3	.02
30N/04E-36L06	08-03-93	300	20	2.7	<.02	<.05	3.6
30N/06E-02Q02	08-05-93	100	210	.4	.03	<.05	.29
30N/07E-18P06	08-24-93	171	180	.5	.02	<.05	.21
31N/06E-09K01	07-29-93	16	280	2.8	<.02	<.05	.79
31N/06E-20R02	07-29-93	200	320	4.4	<.02	<.05	.30
32N/04E-33Q02	07-19-93	31	30	1.8	<.02	.27	.69
32N/05E-24C02	07-21-93	100	250	9.9	<.02	<.05	8.2
32N/06E-04R01	07-23-93	110	500	.5	.03	<.05	.05
32N/06E-16P01	07-28-93	18	60	.7	<.02	8.8	.10
32N/06E-29R01	07-20-93	99	10	.2	.02	2.2	.03

[1] Threshold concentration, above which the septage-related compounds or nitrogen compounds were considered to have relatively high concentrations. This value was selected at the 90th percentile of the distribution of concentrations for the samples of each constituent.

The evaluation of samples with relatively high concentrations of septage-related and nitrogen compounds found no relation between such samples and well depth or geohydrologic unit, but there appeared to be some relation to geographic area. Eighteen of the 97 samples with analyses for septage-related compounds had two or more relatively high concentrations of boron, DOC, nitrate, or ammonia, or a detection of MBAS (table 13). The depths of the 18 wells with samples of relatively high concentrations were not appreciably different from the depths of the other 79 wells. At least one of the 18 samples was found in each of the geohydrologic units, and no unit had a proportionately larger number of the 18 samples. A pattern is apparent in the geographic distribution of the samples with relatively high concentrations (fig. 26). About one half the samples are located in an area from Granite Falls, along the South Fork Stillaguamish River, and northward to the study-area boundary. One cannot conclude that there is contamination from septic systems in this area, but the evidence indicates a possibility of contamination, and any future studies of ground-water quality in that area need to consider this possibility.

Bacteria

Fecal-coliform bacteria were present in water samples from 6 of the 297 sampled wells (table B1). The median concentration was <1 col/100 mL (colony per 100 milliliters) and the maximum was 40 col/100 mL (table 11). The wells with samples that contained bacteria were 27N/06E-17C01, 30N/04E-04D01, 31N/05E-28A01, 31N/06E-09K01, 32N/05E-21B01, and 32N/07E-09B01. Two of the wells, 31N/05E-28A01 and 32N/07E-09B01, are located on farms where animals could be the source of the bacteria. All wells except well 30N/04E-04D901 were 60 ft or less in depth. Samples from two of the wells also had elevated nitrogen compounds; well 32N/05E-21B01 had a sample with 1.5 mg/L of nitrate, and well 31N/06E-09K01 had a sample with 0.79 mg/L of ammonia.

Fecal coliform bacteria were present in water samples from nine of the 13 springs that were sampled (table B3). These 13 springs are only a small fraction of the hundreds of springs throughout the study area, and their water quality cannot be used to represent the quality of all the other springs. Only three of the nine samples with bacteria were collected directly from the emergence point of the spring; the other six samples were collected from stream channels, collection boxes, or ponds that were several feet to tens of feet away from the emergence point. No human sources of bacteria were apparent near these wells, but water that is exposed to the air can be contaminated with bacteria that are associated with the waste products from many different types of animals.

Sources of Potential Water-Quality Problems

Several constituents in ground water can cause a water-quality problem when their concentrations are particularly high or occasionally when their concentrations are low. Sometimes a water-quality problem can be a health concern; at other times it may only affect the aesthetic qualities of the water. The principal sources of potential water-quality problems in western Snohomish County are seawater intrusion, agricultural activities, septic systems, commercial and industrial activities, and natural conditions. Although identifying the source of a particular problem is difficult because of insufficient data and the complexities of ground-water systems, in general there was no regional contamination from these principal sources.

Seawater Intrusion

Seawater intrusion, which is the movement of salt water into a freshwater aquifer, can be a water-quality problem. In addition to raising the concentrations of sodium and chloride, intrusion can also lead to increased concentrations of calcium, magnesium, potassium, sulfate, barium, and some other trace elements. Seawater intrusion can be caused by decreased ground-water recharge or increased ground-water discharge. Lower-than-average precipitation over several years could decrease recharge, but the most common cause of seawater intrusion is from increased discharge by human-induced stresses such as ground-water withdrawals (fig. 12).

The extent of seawater intrusion can be determined by measuring the chloride concentration of the ground water. Chemically stable, chloride moves through an aquifer at virtually the same rate as the intruding seawater. The typical chloride concentration of seawater is about 19,000 mg/L (Hem, 1992, p. 7). Chloride concentrations above 50 mg/L in ground waters of western Washington are a general indication that some seawater has intruded (Walters, 1971, p. 13).

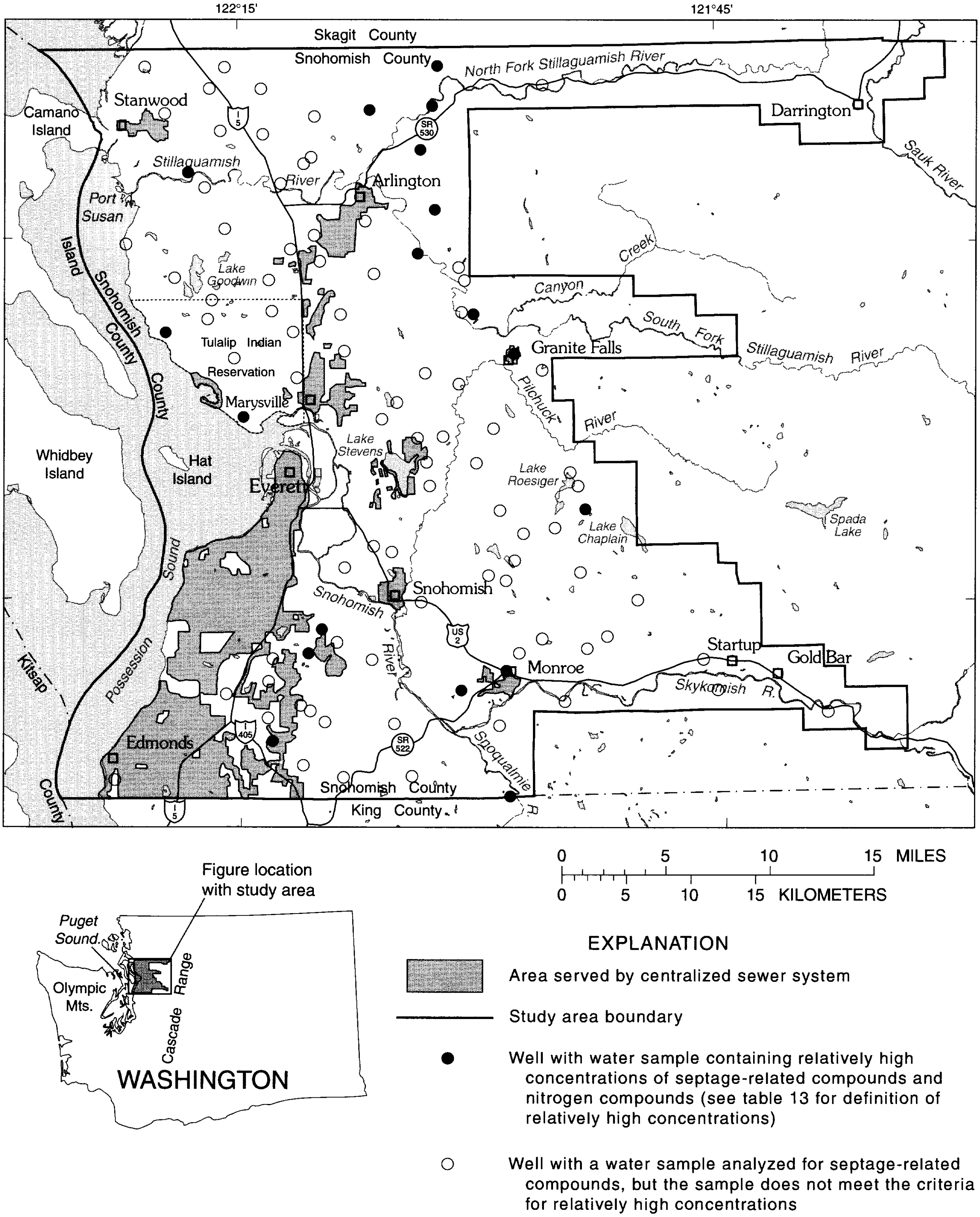

Figure 26. Wells with relatively high concentrations of septage-related compounds and nitrogen compounds, 1993. Sewer-system data from Tom Niemann, Snohomish County, written communication, 1993.

There was no appreciable seawater intrusion in the ground-water system in western Snohomish County. Water samples were collected from 17 wells located within 1 mi of the Puget Sound shoreline; only one of those samples had a chloride concentration greater than 50 mg/L. The sample from well 29N/04E-01A03, which is open to unit Qu at 26 ft below sea level, had a chloride concentration of 60 mg/L. That concentration barely exceeds 50 mg/L, so it is not considered a water-quality problem. The USEPA (1993a) SMCL for chloride is 250 mg/L. Although there was no evidence of widespread seawater intrusion, small isolated areas that were not sampled may have some intrusion.

The historical evidence of seawater intrusion in western Snohomish County is isolated and inconsistent (Walters, 1971; Drost, 1983; and Dion and Sumioka, 1984). Small areas along the Puget Sound shoreline were found with some intrusion, but the areas appeared to be isolated and have not spread landward over time. Walters (1971, p. 39-40) sampled 37 wells in 1966-68 within about 1 mi of the Puget Sound shoreline. He reported that two public-supply wells, one at the southern tip of the Tulalip Plateau and one at the mouth of the Stillaguamish River, had to be abandoned because of excessive chloride concentrations. Walters (1971, p. 40) also mentioned the Hat Island public-supply wells that tap a small aquifer with water levels near sea level, where the balance between freshwater and salt water is fragile and overpumping will always be of concern. Dion and Sumioka (1984) sampled 23 wells in 1978 within about 1 mi of the shoreline and found no chloride concentrations greater than 50 mg/L. Drost (1983) analyzed available water-quality data, including those of Walters (1971) and Dion and Sumioka (1984) and concluded that there was no seawater intrusion along most of the shoreline of the Tulalip Indian Reservation. The southern tip of the Tulalip Plateau (named Priest Point), however, was cited by Drost (1983, p. 45) as having the potential for intrusion.

Agricultural Activities

Agricultural activities in the study area include crop production, dairy farming, livestock production, and forestry. These activities can result in several types of water-quality problems, most typically elevated concentrations of various nitrogen species, the presence of pesticides and associated compounds, and the presence of bacteria. Most problems are related to fertilizer or pesticide application, or animal wastes.

Virtually all fertilizers contain some type of nitrogen. The applied nitrogen is usually converted by bacteria in the soil to nitrite and then to nitrate during the process of nitrification. Some nitrate is then taken up by crops. Any remaining nitrate can be transported down through the soil and the unsaturated zone to the water table. Nitrate generally does not sorb, or attach, to the aquifer material, so it is transported at a rate similar to that of the ground water. In some instances, unconverted nitrogen can be transported to the ground water, either as ammonia or as part of an organic compound. Ammonia tends to sorb to soil particles, so it might not be transported as quickly as nitrate. Usually, any ammonia or ammonia compound reaching the ground water ultimately will be converted to nitrate. Fertilizers also contain other chemicals that can be introduced into the ground water, such as potassium and phosphorous, but the resulting effects on natural concentrations of those chemicals are usually minimal.

Animal wastes, including that from dairies, feedlots, and poultry operations, contain urea, chloride, and bacteria, along with other constituents in smaller quantities. Urea is eventually converted to nitrate, which is transported to the aquifer in a manner similar to nitrate from fertilizers. Chloride is generally unreactive and can also be transported to the water table. Many different types of bacteria are present in animal wastes, including the indicator bacteria (fecal coliform) analyzed for in this study. The transport of bacteria to and within the ground water depends on such factors as depth to water and water temperature, which greatly affect bacterial survival.

The transport of pesticides and their associated compounds to the ground water is complex. Most pesticides undergo chemical and biological transformations as part of one or more of the following processes: biodegradation, photolysis, hydrolysis, or oxidation. The products of these reactions may be as great a contamination problem as the original pesticide. Also, solvents and carriers, such as toluene, are applied with pesticides to assure an even application of the pesticide, and can themselves become contaminants. The transport of all these pesticide-related compounds is affected by physical processes such as dissolution in the water, sorption to aquifer material, and volatilization to the atmosphere as soil gas. Because of all of these variables, the concentrations of pesticides in ground water can vary widely over space and time.

One group of agricultural activities not included in the above description is hobby farming. Hobby farming consists of agricultural activities similar to those already discussed, but on a smaller scale and for private rather than commercial use. Most hobby farms are in suburban or urban areas, and examples include backyard gardens, pet pens or corrals, and lawns. Pesticides and fertilizers are used extensively in hobby farming and they are commonly overapplied because of a lack of knowledge, experience, or motive for cost effectiveness. Little documentation has been done on hobby farming, but researchers have reported that urban lawn fertilizers might contribute as much nitrate to ground water as septic systems (Porter, 1980).

Agricultural activities that use fertilizers or that produce animal wastes do not appear to have caused any widespread ground-water contamination in western Snohomish County. Concentrations of nitrate and ammonia were generally low throughout the study area, and bacteria were present in only 6 of 297 water samples. No pesticides or associated compounds were found in the water-quality samples. However, only 12 samples were analyzed for pesticides, and no conclusions can be made about the effects on ground water from pesticide use in commercial agricultural activities or hobby farms.

The 297 water samples that were analyzed for nitrate and ammonia are a representative regional sample of the ground-water conditions in the study area. The low overall nitrate concentrations indicate there are probably no large inputs from fertilizers used in crop production, nor from animal wastes. Overall ammonia concentrations were slightly higher than might be expected, but there was no pattern or apparent relation to agricultural activities; therefore, most of the ammonia concentrations are probably natural. Some isolated elevated nitrate and ammonia concentrations, however, probably were caused by animal wastes.

The possible contamination of ground water by agricultural activities was statistically tested by comparing concentrations of selected constituents in ground water to areas of agricultural activity. Because actual areas of agricultural activity were not available, areas zoned for such activity were used as a surrogate (fig. 27). These zoned areas were not necessarily being used for crop production or dairy farming in 1993, but there probably had been such activity in the past, and the areas are a reasonable representation of agricultural activity in the study area. To perform the statistical tests, sampled wells were placed into two groups: wells located in the zoned areas, and wells not located in the zoned areas. The concentrations of nitrate, ammonia, chloride, potassium, and phosphorus in the two groups of samples were then statistically compared using a nonparametric rank-sum test (one-sided) (Helsel and Hirsch, 1992, p. 118-124). The concentrations were also compared for samples from wells with depths of less than 100 ft. In the complete group of wells and in the shallow group of wells (depth < 100 ft), none of the constituents had significantly higher (at $\alpha = 0.05$) concentrations in the areas zoned for agriculture. The samples in these tests were not evenly distributed; for the complete group of wells, 25 wells were located in the agricultural areas and 272 wells were located in non-agricultural areas. Nevertheless, the tests are another indication that agricultural activity has not caused any regional ground-water contamination from fertilizers or animal wastes.

Septic Systems

A septic system, consisting of a septic tank and drainfield, can be a source of several constituents in ground water. The most familiar of these is nitrate, but others are sodium, potassium, sulfate, chloride, phosphorous, ammonia, DOC, boron, MBAS, and bacteria (Canter and Knox, 1985, p. 45-49). Because they are used virtually everywhere that central sewer systems are not available, septic systems can be a widespread source of these constituents and remain so for some time after they are abandoned.

In the operation of a septic system, household sewage is piped into a tank. Solids settle to the bottom of the tank and liquids discharge to a drainfield, which consists of perforated pipe in one or several subsurface trenches filled with permeable material such as sand or gravel. The effluent from the drainfield infiltrates the natural soil or geologic formation and flows down through the unsaturated zone. If the volume of effluent is large and the water table is shallow, the effluent may reach the water table. Where individual septic systems are used in densely populated areas, their combined discharge may contribute a substantial amount to the total ground-water recharge.

Once in the unsaturated zone, the individual constituents in the effluent are susceptible to physical, chemical, and biological transformations. Nitrate and chloride usually do not react with other constituents, and they flow through the unsaturated material at virtually the same rate as water. Sodium, potassium, sulfate, MBAS, and other constituents, however, can undergo sorption, ion exchange, or degradation reactions in the unsaturated zone that hinder their transport to the water table.

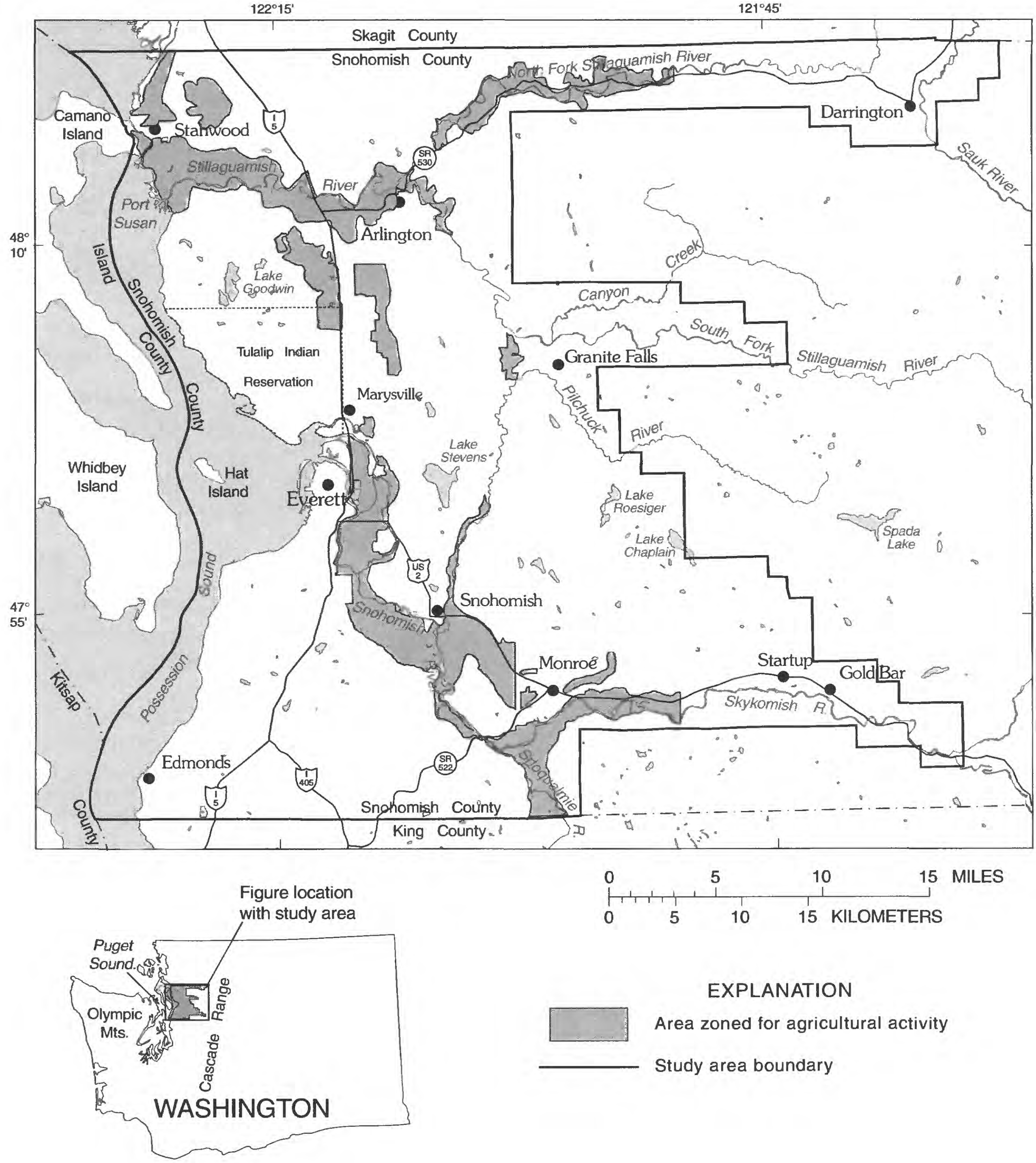

Figure 27. Areas zoned for agricultural activity (Tom Niemann, Snohomish County, written communication, 1993).

Septic systems have not caused any appreciable widespread ground-water contamination in the study area. Nitrate and ammonia concentrations were generally low throughout the study area, and there were no areas with consistently high concentrations. The low concentrations of septage-related compounds (MBAS, boron, and DOC), and lack of correlation among them and nitrate and ammonia concentrations support this conclusion. Some isolated high concentrations of nitrate, ammonia, boron, DOC, or MBAS might be instances of local contamination by septic systems. One area was identified as having possible contamination because several samples had two or more relatively high concentrations of septage-related or nitrogen compounds (see page 76). The evidence is not conclusive in this area, which extends from Granite Falls, along the South Fork Stillaguamish River, and northward to the study-area boundary; but future studies need to consider this possible contamination.

The possible contamination of ground water by septic-system effluent was statistically tested by comparing concentrations of selected constituents in ground water to population density in areas with septic systems. The areas with septic systems were assumed to be all areas not served by centralized sewer systems (fig. 26). Population density was used as a surrogate for septic-system density in the tests. Water samples from 289 wells were placed into three groups of population density: less than 0.1 person per acre (63 wells), 0.1 to 1.0 person per acre (192 wells), and greater than 1.0 person per acre (34 wells) (fig. 6). A nonparametric rank-sum test (one-sided) (Helsel and Hirsch, 1992, p. 117-124) was used to determine if concentrations of sodium, potassium, sulfate, chloride, nitrate, ammonia, phosphorus, boron, and DOC significantly increased from (1) the low to moderate density group, (2) the moderate to high group, and (3) the low to high group. Almost all the constituent concentrations did not significantly increase (at $\alpha = 0.05$) as the population density increased. Only the concentrations of ammonia and phosphorus had significant relations, and those were between the low and moderate density groups. The tests were repeated for the same constituents, but with groups of wells of less than 100 ft deep (136 wells). Only one test was significant for these shallow wells; the phosphorus concentration significantly increased from the low to moderate density group. Therefore, the tests are another indication that septic systems have not caused any appreciable widespread ground-water contamination.

Commercial and Industrial Activities

Commercial and industrial activities are substantial in the southwestern part of the study area (Intercity Plateau), have been increasing in the Marysville Trough, and are minimal in other parts of the study area. Some of the chemicals used in these activities are potential ground-water contaminants. Service stations are sources of benzene and benzene-related compounds from fuels and oils. Dry cleaners and paint shops are potential sources of solvents such as 1,1,1-trichloroethane and trichloroethene. Solvents, along with metals such as chromium, copper, zinc, and lead, can come from electronic, machine, and automotive-repair shops. Parking lots and roads may also be sources of many of these chemicals. In general, most of the chemicals are volatile organic compounds or trace elements. Industrial activities such as shipping, manufacturing, and food processing can also be sources of these chemicals. Roadside spraying to inhibit the growth of vegetation along road shoulders is a possible source of pesticides in the ground water, but this practice is diminishing in the study area.

Chemicals are sometimes spilled or dumped onto the ground where they can dissolve or otherwise be incorporated into the recharge water. Also, runoff water from impervious areas, such as roads and parking lots, can carry chemicals laterally to permeable areas and into the ground. In the case of large spills of liquids such as fuels or oils, the chemicals can travel into the unsaturated zone unaltered. In other instances, the chemicals reach the ground water only after being subjected to physical or chemical transformation processes, such as volatilization, sorption, biodegradation, hydrolysis, or oxidation. As a result, the contaminants in ground water can include any of the compounds initially spilled or their transformation products.

The possible contamination of ground water by commercial or industrial activity could not be evaluated in this regional study; the number of samples analyzed for contaminants associated with such activity was too small. Only nine water samples were analyzed for volatile organic compounds (VOC's). Trace elements are also commonly associated with these activities, but only 11 wells were analyzed for trace elements in the area of most commercial or industrial activity, the Intercity Plateau. Commercial and industrial sources are usually isolated, and areas contaminated by those sources are usually small; therefore, a dense network of sample wells and a specific targeting of wells toward possible sources would be needed to reliably assess contamination by commercial or industrial sources.

Natural Conditions

Most of the regional water-quality problems in the study area were a result of natural conditions. As discussed previously, elevated concentrations of arsenic, iron, and manganese are the most widespread problems. Values of pH outside of the accepted range were found in 21 percent of the samples; these acidic or basic conditions were also a result of natural causes.

NEED FOR MONITORING AND ADDITIONAL STUDIES

The current state of knowledge about the ground-water resources of western Snohomish County was assessed and improved during this investigation. The data collected for this study provide a solid baseline of information that presents a picture of the ground-water system and ground-water quality in 1992-93. The density of data, however, is regional in nature; changes in hydrologic boundaries, ground-water flow, recharge, discharge, or water quality within 1 or 2 mi^2 would not be detected by the data in this report. Therefore, it must be kept in mind that this study provides an accurate regional picture of the ground-water resources, but the local or small-scale variability is unknown.

Future assessments of the ground-water resources for areas of less than a few square miles might need more hydrologic information, depending on the purpose of the assessment. A particular land-use activity, whether proposed or current, needs to be evaluated according to its potential impacts on the ground-water resource and according to the unique hydrologic characteristics of the site. It is beyond the scope of this report to discuss data needs for small-scale activity. The following discussion relates to the data or study needs for the regional ground-water system.

The regional definition of the geohydrologic framework is reliable for the geohydrologic units above the transitional beds (Qtb). More data are needed to define the areal extents and the top and bottom surfaces of Qtb and the units beneath Qtb. The undifferentiated sediments (Qu) aquifer of this study is a mixture of many different lithologies, and with more data, it probably could be separated into additional aquifers and confining beds. Wells drilled into these sediments or geophysical studies could provide these data. All areas of western Snohomish County are in need of this kind of information.

The regional description of ground-water flow is reliable in most areas for the upper aquifers, Qal, Qvr, and Qva. Ground-water flow in Qvr is defined in the Marysville Trough and Arlington Heights Plateau, but more water-level data are needed in its other areas. In the western part of the Intercity Plateau, more water-level data are needed to define flow in the Qva aquifer. Flow is undefined in the Qu aquifer, and more water-level data are needed for all of its area.

The water budget of the ground-water system was only roughly defined in this study. An approximate value for recharge to the entire system was defined, but the quantity of recharge that reaches the buried aquifers is not known. Likewise the amount of ground-water discharge to streams, springs, and as underflow out of the study area is not known. The interaction between ground water and surface water was not defined in this study. The potential effects of ground-water development (pumping) were not specifically investigated in this study; the estimates of recharge and hydraulic conductivity made in this study can provide initial approximations for some of the data needed for such an investigation.

The water budget, which includes recharge, discharge, and possible withdrawals, is complex and difficult to define. Many of the components are interrelated, and a change in one component will affect another component. Digital ground-water models are useful tools that can be used to help define the water-budget components and the effects of ground-water development. Models account for all the boundaries and interrelated components of the system. Sometimes, for small areas, simpler analytical equations can be used instead of the digital models for the same purposes.

Data are needed to help define the water budget, the interaction between ground water and surface water, and the effects of development. Measurements of streamflow during baseflow periods could help define flow between ground and surface waters. Measurements of springflow could help define discharge by that means. Ground water that moves as subsurface flow out of the study area could be estimated with more water-level data and more accurate estimates of hydraulic properties. The estimates of hydraulic conductivity made in this study are approximate; refinement of these values could be made with aquifer tests, which also can be used to define storage properties. An evaluation of the effects of development could be based on all the types of data mentioned in this paragraph.

The historical trends in water levels were reliably assessed on a regional basis in this study. No areas of long-term water-level declines were found. A study of future trends in water levels could be based on the data from this study.

In this study, a simplified assessment was made of the relative sensitivity of the ground-water system to contamination. Some of the limitations of this assessment include relative ratings, regional scale, unknown accuracy, some artificial boundaries, human activities not considered, and effects of variables not included in the method (see page 64). Future studies of ground-water sensitivity or vulnerability would need to address these limitations. In particular, the more important limitations are (1) the effects of variables not included in the method, such as contaminant behavior and soil characteristics, and (2) the effects of human activities.

Water quality was defined regionally; however, there could be many small areas of contamination that were not found with the 297 water samples in this large study area. That represents only about one well for every 3 mi^2.

This study did not conduct an assessment of potential contamination from synthetic organic compounds such as pesticides or volatile organic compounds. Only about a dozen samples were analyzed for those constituents. If such contamination is a concern, samples would need to be collected and analyzed for target constituents from areas of suspected contamination.

The long-term effects of various ground-water management alternatives and of changing land-use conditions in western Snohomish County could be monitored by the establishment of a water-level measurement and water-quality sampling network. Water-level declines beyond those expected for seasonal or climatic reasons could provide an early warning of ground-water overdrafts; water-quality degradation could indicate the need to revise land-use controls.

As a long-term, minimum level of effort to monitor water quantity, water levels could be measured in selected wells every 2 to 3 years in spring and autumn, corresponding to times when water levels in shallow wells are at their seasonal highs and lows, respectively. The aquifers of greatest concern would be those that are the most heavily relied on for ground-water supplies. Observation wells could be selected to provide broad geographic coverage of the aquifers of concern, with emphasis on the areas of greatest ground-water withdrawal.

A minimum water-quality monitoring program would be the periodic collection of samples for the analyses of nitrate, chloride, and bacteria. An expanded program could include analyses for concentrations of major ions, trace elements, and synthetic organic compounds (including pesticides). Samples would be collected from the areas of potential contamination from various activities.

Although no appreciable seawater intrusion was found, a monitoring program of the collection of water samples from wells within 1 mi of the Puget Sound shoreline, and particularly wells that are open to near or below sea level, could detect early intrusion problems.

The monitoring program discussed above would be reviewed annually to evaluate the number and locations of wells, and the frequency of their measurement and sampling. This evaluation would reflect changing cultural, managerial, and hydrologic conditions. Modifications could be made, but should be kept to a minimum because the long-term success of a monitoring program depends in part on continuity.

SUMMARY AND CONCLUSIONS

This study was undertaken to improve the understanding of the ground-water resources of western Snohomish County, which is located in the Puget Sound area of northwestern Washington. The population has been rapidly increasing in the past decade and is projected to continue this rapid growth. Thus, there is concern about the quantity and quality of the ground-water resources that support the population.

The geohydrologic framework and ground-water system of the study area were described using data collected during a field inventory of 1,330 wells during 1992-94, along with the lithologic logs and pumpage data for those wells. Information obtained from the field inventory included location, depth to ground water, land-surface altitude, water use, and physical characteristics of the site and well. The ground-water quality was described using water samples that were collected from 297 wells during 1993-94. Analyses were made of general chemical characteristics, nutrients, bacteria, trace elements, septage-related compounds, and a few synthetic organic compounds.

Western Snohomish County is underlain by as much as 1,200 ft of Quaternary unconsolidated deposits that are mostly of glacial origin. Beneath these unconsolidated deposits is bedrock, which is composed of consolidated rocks, mostly of Tertiary Age. Interpretation of 27 geohydrologic sections and about 1,100 lithologic logs of wells led to the delineation of six geohydrologic units in the unconsolidated deposits. Four aquifers were defined, and these units consist mostly of coarse-grained material. Two fine-grained confining beds separate the aquifers, and the bedrock unit, at the base of the ground-water system, was also defined as a confining bed.

Two upper units, the alluvium (Qal) and Vashon recessional outwash (Qvr), were defined as aquifers. They each have a typical thickness of about 40 feet and limited areal extents of about 20 percent of the study area. The principal aquifer in terms of use and areal extent is the Vashon advance outwash (Qva). It has a typical thickness of about 120 feet and it covers about 60 percent of the study area. The Vashon till (Qvt), which is between the Vashon recessional outwash and Vashon advance outwash, is an important confining bed that restricts movement between those two aquifers. Directly beneath the Vashon advance outwash aquifer is a confining bed (transitional beds (Qtb)), and beneath that is another aquifer (undifferentiated sediments (Qu)), but they are not well defined because of meager data.

Water can be obtained from all the geohydrologic units in the study area. The most consistent and reliable sources are the aquifers, but usable quantities of water can sometimes be obtained from the confining beds. The two confining beds in unconsolidated material, Vashon till and transitional beds, are mostly fine-grained, but wells can produce water from local lenses of sand and gravel. Water obtained from bedrock comes from fractures and joints, but bedrock is the least productive and least reliable unit.

Average annual precipitation ranges from about 30 to 90 inches across the study area and the overall average is 46 inches. Estimates of recharge indicate that the ground-water system receives an average of about 24 inches per year. Ground water generally follows the land-surface gradient and moves toward the major streams and lowlands. In most areas there is also a downward component of ground-water flow. The only areas of regional upward flow are in the Marysville Trough and near the Puget Sound shoreline. Ground water discharges to streams, springs, lakes, seepage faces on bluffs, as underflow out of the study area and to Puget Sound, by evapotranspiration, and by withdrawals through wells. No estimates were made of the individual components of natural discharge because the needed data were unavailable. Approximately 19,630 acre-feet of water was withdrawn from the ground-water system through wells in 1992, and the largest use of that water was for public supply.

The relative sensitivity of the ground-water system to contamination was assessed. The areal distribution of sensitivities for the water table of the outcrop areas of geohydrologic units was 41 percent with low sensitivity, 28 percent with moderate, and 31 percent with high.

The water quality of the ground-water system was generally good. Ninety-four percent of the water samples were classified as soft or moderately hard. Dissolved-solids concentrations ranged from 36 to 1,040 milligrams per liter (mg/L), had a median of 133 mg/L, and tended to be higher in the lower units. The major cations were calcium and magnesium; the major anion was bicarbonate. Calcium/bicarbonate and calcium-magnesium/bicarbonate were the most common water types, typical of glacial deposits in western Washington.

The ground-water system in the study area has no appreciable widespread ground-water contamination. Constituents that are associated with seawater intrusion, agricultural activities, and septic systems were investigated; elevated concentrations of nitrate and ammonia were found in isolated areas, but no regional patterns of contamination were found. The most common and widespread existing water-quality problems are from natural causes. High iron and manganese concentrations were fairly common; 20 percent of the water samples exceeded 300 micrograms per liter (μg/L) of iron and 41 percent of the samples exceeded 50 μg/L of manganese. These concentrations are not a major health concern, but are mostly a nuisance because they impart an objectionable odor and can stain laundry and plumbing fixtures. High iron and manganese concentrations are common throughout western Washington.

Another natural water-quality problem in western Snohomish County is the presence of arsenic in ground water throughout much of the area. Arsenic concentrations ranged from less than 1 to 280 μg/L, with a median of 2 μg/L. Arsenic was detected in samples from 186 wells (63 percent) and 52 samples (18 percent) had concentrations of 10 μg/L or higher. Most of the higher concentrations were from wells between Granite Falls and Arlington.

There was no appreciable seawater intrusion in the ground-water system in western Snohomish County. Only one of 17 sampled wells located within 1 mile of the Puget Sound shoreline had a chloride concentration greater than 50 mg/L. The historical evidence of seawater intrusion in the study area is isolated and inconsistent. Small areas have been found with some intrusion, but the areas appeared to be isolated and have not spread landward over time.

Agricultural activities that use fertilizers or that produce animal-waste material do not appear to have caused any widespread ground-water contamination. Concentrations of nitrate and ammonia were generally low throughout the study area and bacteria were present in only 6 of 297 water samples. A few isolated samples had elevated nitrate or ammonia concentrations, but the source was probably local and not regional in extent. No pesticides or associated compounds were found in the water-quality samples. However, only 12 samples were analyzed for pesticides, and no conclusions can be made about the effects on ground water from pesticide use in commercial agricultural activities or hobby farms.

Septic systems have not caused any appreciable widespread ground-water contamination. Nitrate and ammonia concentrations were generally low throughout the study area, and there were no areas with consistently high concentrations. The low concentrations of septage-related compounds (methylene-blue-active substances, boron, and dissolved organic carbon), and lack of correlation among them and nitrate and ammonia concentrations, support this conclusion. A few high concentrations of nitrate or ammonia were found in conjunction with the presence of boron, dissolved organic carbon, and phosphorus, but those cases are isolated and were not caused by a regional source.

Concentrations of selected constituents were compared with maximum contaminant levels (MCL's) and with secondary maximum contaminant levels (SMCL's) from applicable USEPA drinking water regulations. The MCL's were exceeded in four samples for nitrate, five samples for arsenic, one sample for fluoride, and one sample for mercury. The presence of fecal-coliform bacteria in six water samples indicates the MCL for total coliform was exceeded. Manganese had the highest SMCL exceedance percentage of all applicable drinking water regulations. Forty-one percent of the samples exceeded the manganese SMCL of 50 µg/L. The SMCL's for iron and pH also were not met in many samples; 20 percent of the samples exceeded the SMCL of 300 µg/L for iron and 21 percent of the samples were outside the SMCL range of 6.5 to 8.5 for pH. About 1 percent of the samples exceeded the SMCL's for dissolved solids and chloride.

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Appendix A.--*Physical and hydrologic data for the study wells*

EXPLANATION

Geohydrologic unit:	Qal, alluvium aquifer; Qvr, Vashon recessional outwash aquifer; Qvt, Vashon till confining bed; Qva, Vashon advance outwash aquifer; Qtb, transitional beds confining bed; Qu, undifferentiated sediments aquifer; Tb, bedrock confining bed; --, not determined
Land-surface altitude:	Feet above sea level
Well depth:	Depth of casing and screen, in feet below land surface
Casing diameter:	--, not applicable
Water use:	C, commercial; F, fire; H, domestic; I, irrigation; J, industrial-cooling; K, mining; N, industrial; P, public supply; Q, aquaculture; R, recreation; S, stock; T, institutional; U, unused; Z, other
Construction method:	--, not known; A, air rotary; B, bored or augered; C, cable tool; D, dug; H, hydraulic rotary; R, reverse rotary; V, driven; Z, other
Water level:	Feet, feet below land surface; Date, month-day-year, 00, month or day not known; Source, GS, U.S. Geological Survey; DR, driller; --, not determined
Ground-water condition:	C, confined; F, flows at least part of the time; U, unconfined; --, not determined
Yield:	--, not determined
Drawdown:	--, not determined
Hydraulic conductivity:	--, not determined
Remarks:	G, used in construction of geohydrologic section; L, driller's (lithologic) log available; Q, sampled for water quality; W, project observation well for water levels; --, no remarks

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/03E-23R01	Qu	10	49	--	6	U	A	1	01-29-88	DR	U	--	--	--	L
27N/03E-26B01	Qu	30	55	--	8	Q	A	14.5	06-10-92	GS	U	--	--	--	L
27N/03E-26L01	Qva	220	256	--	6	H	C	232	02-19-92	DR	U	12	11	25	L
27N/03E-35A01	Qva	240	42	--	6	H	A	15.5	06-09-92	GS	U	25	10	36	L,Q
27N/03E-35B01	--	185	986	--	6	U	A	--	--	--	-	--	--	--	L
27N/03E-35G02	Qvt	320	135	6	10	H	A	79.4	06-09-92	GS	U	42	3	200	L
27N/04E-02N01	Qva	360	123	8	12	P	C	-25	11-07-56	DR	C	--	--	--	L,Q
27N/04E-05B01	Qu	260	160	--	6	H	A	134	06-02-92	GS	C	--	--	--	L,Q,W
27N/04E-05C02	Qu	260	358	--	6	S	A	317	04-15-93	GS	U	--	--	--	L
27N/04E-10N01	Qva	500	176	12	20	P	C	90	10-14-58	DR	U	530	33	82	L
27N/04E-10P01	Qva	510	122	--	5	U	C	--	--	--	-	--	--	--	--
27N/04E-12G01	Qva	440	220	14	20	P	C	119	03-00-58	DR	U	--	--	--	L
27N/04E-14M01	Qva	400	197	--	18	P	A	47	11-29-60	DR	U	--	--	--	L
27N/04E-15F02	Qva	540	276	14	20	P	A	137	06-03-92	GS	U	--	--	--	L,W
27N/04E-16E01	Qu	410	535	8	12	P	A	266	11-29-55	DR	C	300	126	17	L
27N/04E-16Q01	Qva	390	137	12	16	P	-	6	01-15-60	DR	U	--	--	--	L
27N/04E-20A01	--	360	43	--	4	U	B	--	--	--	-	--	--	--	L
27N/04E-20D04	Qva	430	198	--	8	I	A	149	06-04-92	GS	U	--	--	--	L
27N/04E-21F01	Qva	350	225	12	16	T	C	64.5	06-04-92	GS	C	393	37	150	L
27N/04E-21N01	Qu	345	342	8	12	P	-	169	02-01-58	DR	C	--	--	--	L
27N/04E-21N02	Qu	345	341	8	12	P	-	100	08-27-53	DR	C	--	--	--	L
27N/04E-23D01	Qvt	410	50	--	4	U	-	22.9	08-19-93	GS	U	--	--	--	L
27N/04E-24L01	--	480	485	--	-	P	-	--	--	--	-	--	--	--	L
27N/04E-27P01	Qva	360	139	8	24	P	-	22	08-00-56	DR	U	--	--	--	L
27N/04E-28P01	Qva	490	109	--	6	U	C	106	03-20-45	DR	U	--	--	--	--
27N/04E-29M02	Qvt	350	35	--	4	U	B	--	--	--	-	--	--	--	L
27N/04E-30A01	Qva	410	198	--	5	U	C	144	03-13-45	DR	U	--	--	--	--
27N/04E-31B01	Qu	450	590	6	8	P	A	449	04-28-88	DR	U	155	33	17	L
27N/04E-31B02	Qu	360	612	6	24	P	C	456	08-13-90	DR	U	570	53	44	L
27N/04E-32K01	Qva	320	150	--	-	U	-	--	--	--	-	--	--	--	--
27N/04E-36B01	Qtb	434	436	8	24	T	C	283	06-11-92	GS	U	280	46	47	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches) Minimum	Casing diameter (inches) Maximum	Water use	Construc-tion method	Water level (Feet)	Water level Date	Water level Source	Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
27N/05E-01B01	Tb	260	374	--	12	U	-	10	05-08-60	DR	U	--	--	--	L
27N/05E-02M01	Qtb	590	300	--	6	U	A	--	--	--	-	--	--	--	L
27N/05E-02N02	Qvt	590	90	--	6	U	A	--	--	--	U	--	--	--	L
27N/05E-02Q01	Qva	590	220	--	6	H	A	177	06-18-92	GS	U	20	25	18	L,Q,W
27N/05E-03E01	Qva	420	56	--	6	H	-	17.2	03-18-93	GS	U	15	18	23	L
27N/05E-04D03	Qva	410	58	--	6	H	-	38.8	06-16-92	GS	U	12	9	82	L
27N/05E-04D04	Qva	410	59	--	6	H	-	42	05-27-79	DR	U	10	3	98	L
27N/05E-04K02	--	450	132	4.5	6	H	A	73.6	06-17-92	GS	-	--	--	--	L
27N/05E-04P01	Qva	450	178	--	6	U	A	95	02-28-79	DR	U	12	15	3.4	L
27N/05E-05H01	Qva	430	191	--	6	H	A	72.7	06-17-92	GS	U	--	--	--	L,Q,G
27N/05E-06F02	Qva	310	74	--	6	P	-	--	--	--	F	--	--	--	L,Q
27N/05E-06J01	Qva	450	271	--	8	I	A	72	06-15-79	DR	U	325	170	21	L
27N/05E-07G01	Qva	300	138	--	4.5	H	A	18	05-04-88	DR	U	--	--	--	L
27N/05E-07H01	Qva	390	178	--	6	H	A	110	07-07-92	GS	U	30	50	37	L,Q,G
27N/05E-07K01	Qva	270	26	--	6	H	-	2.6	06-19-92	GS	U	20	4	150	L
27N/05E-08J02	Qva	370	37	--	6	H	A	13.3	07-07-92	GS	U	30	10	180	L,Q
27N/05E-08N01	Qtb	270	96	--	6	U	C	5	11-09-74	DR	U	20	50	25	L
27N/05E-08R02	Qva	370	44	--	6	H	-	4.6	06-16-92	GS	U	7	5	37	L
27N/05E-09K02	Qva	400	156	--	6	H	A	91.6	06-17-92	GS	U	--	--	--	L
27N/05E-09P01	Qva	370	50	--	6	H	-	30.5	06-18-92	GS	U	20	2	310	L
27N/05E-09P02	Qva	360	85	--	6	H	C	27.4	07-09-92	GS	C	10	25	25	L,Q
27N/05E-09Q02	Qva	410	160	--	6	H	A	91.6	06-17-92	GS	U	--	--	--	L,Q
27N/05E-10A01	Qva	550	181	--	6	H	C	--	--	--	-	--	--	--	L
27N/05E-10B01	Qva	500	148	--	6	H	C	123	06-04-92	GS	U	10	7	34	L
27N/05E-10D02	Qva	370	52	--	6	H	C	0	06-18-92	GS	U	45	32	25	L,Q
27N/05E-10F02	Qva	370	50	--	6	H	A	19.6	06-16-92	GS	U	7	33	3.6	L
27N/05E-12J01	Qva	360	70	--	6	U	-	6.1	07-07-92	GS	U	--	--	--	L
27N/05E-13C01	Tb	500	129	--	6	U	C	--	--	--	-	--	--	--	L
27N/05E-13F02D1	Qva	540	230	--	6	H	C	206	06-04-92	GS	U	8	16	11	L
27N/05E-13P01	Qva	410	100	--	6	H	A	86.1	06-16-92	GS	U	10	10	61	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohydrologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construction method	Water level			Ground-water condition	Yield (gallons per minute)	Drawdown (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/05E-14A01	Qva	610	262	--	8	U	-	230	07-08-92	GS	U	--	--	--	L
27N/05E-14L01	Qva	440	105	--	6	H	C	67	06-02-92	GS	C	8	30	12	L,Q
27N/05E-14P02	Qva	470	180	--	6	H	C	156	06-02-92	GS	U	15	5	80	L
27N/05E-15E03	Qva	330	58	--	6	H	A	12.1	06-04-92	GS	C	30	6	310	L,Q,W
27N/05E-15K01	Qva	450	159	--	6	H	C	124	06-05-92	GS	U	18	11	42	L,Q
27N/05E-15K02	Qva	480	100	--	6	H	A	77.5	06-19-92	GS	U	8	30	5.5	L
27N/05E-16A01	Qva	320	250	--	6	U	C	40	03-29-91	DR	U	--	--	--	L
27N/05E-16M01	Qva	380	127	--	8	H	-	110	08-20-50	DR	U	--	--	--	L
27N/05E-18C01	Qva	220	58	--	6	H	A	18.5	07-08-92	GS	U	--	--	--	L,Q
27N/05E-19B03	Qva	170	49	--	6	H	A	1.2	07-08-92	GS	U	--	--	--	L,Q
27N/05E-20H01	--	430	560	--	8	U	A	--	--	--	-	--	--	--	L
27N/05E-20J01	--	430	560	--	8	U	A	--	--	--	-	--	--	--	L
27N/05E-21M02	--	430	500	--	8	U	A	--	--	--	-	--	--	--	L
27N/05E-22B01	Qu	380	198	--	6	H	C	147	05-20-92	GS	C	--	--	--	L
27N/05E-22N02	Qvt	350	56	--	6	H	C	-4.6	11-05-84	DR	U	--	--	--	L
27N/05E-23M01	Qva	280	92	--	6	H	C	74	06-27-79	DR	U	20	3	200	L,Q
27N/05E-23N01	Qva	290	70	--	6	H	C	1.5	05-22-92	GS	C	10	25	7.8	L
27N/05E-24B01	Qva	400	120	--	6	U	A	79.6	05-20-92	GS	U	--	--	--	L
27N/05E-24M02	Qva	440	225	--	6	H	C	147	07-07-92	GS	U	27	12	120	L
27N/05E-25L01	Qtb	400	160	--	6	P	A	76.2	05-21-92	GS	U	--	--	--	L,Q
27N/05E-26C01	Qva	240	49	--	6	H	C	-7	02-05-90	DR	F	20	31	40	L
27N/05E-26K02	Qva	350	67	--	6	U	C	2.5	05-21-92	GS	C	24	15	80	L
27N/05E-26R03	Qva	440	151	--	6	H	C	139	06-03-92	GS	U	--	--	--	L
27N/05E-27E01	Qva	380	220	--	6	H	A	167	04-06-84	DR	U	--	--	--	L
27N/05E-27R02	Qva	150	70	--	6	H	-	--	--	--	-	--	--	--	L,Q
27N/05E-28E01	Qva	320	79	--	6	H	C	54.1	06-03-92	GS	U	18	5	98	L
27N/05E-29H01	Qva	320	79	--	6	H	C	62.2	06-02-92	GS	U	15	4	100	L,Q
27N/05E-30A01	Qtb	80	35	--	6	H	C	5.3	05-22-92	GS	U	--	--	--	L
27N/05E-31H01	Qva	120	69	--	6	U	C	17.1	07-09-92	GS	C	12	20	28	L
27N/05E-31R01	Qva	270	208	--	6	U	-	--	--	--	-	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/05E-32R01	--	80	498	--	8	U	-	--	--	--	-	--	--	--	L
27N/05E-33M01	Qva	60	55	--	14	Q	C	3	06-03-92	GS	U	40	30	3.9	L
27N/05E-34G01	Qva	150	78	--	8	H	A	12.4	05-21-92	GS	C	--	--	--	L
27N/05E-35F01	--	330	115	--	6	P	C	1.2	08-18-93	GS	-	--	--	--	L
27N/05E-35L02	Qva	320	55	--	6	H	C	13.4	05-21-92	GS	C	7	32	9.5	L
27N/05E-35P03	Qva	480	182	--	6	H	-	172	05-21-92	GS	U	--	--	--	L
27N/05E-36Q01	Qva	350	101	--	10	P	C	17.6	06-03-92	GS	U	--	--	--	L
27N/05E-36R01	Qva	360	66	--	4.5	U	C	--	--	--	-	--	--	--	L
27N/06E-01A01	Qva	120	115	--	8	N	C	33	07-22-68	DR	U	210	55	58	L,Q
27N/06E-02B01	Qal	30	30	--	6	H	C	5.2	08-17-93	GS	U	10	14	44	L,Q
27N/06E-02L01	Qal	35	27	--	6	H	A	6.0	08-18-93	DR	U	--	--	--	L
27N/06E-03F01	--	35	100	--	6	U	A	--	--	--	-	--	--	--	L
27N/06E-03F02	Tb	40	140	4.5	6	H	-	13.5	09-21-93	GS	U	--	--	--	L
27N/06E-03Q01	Qtb	45	41.5	--	6	S	-	5.9	04-16-92	GS	C	--	--	--	L,Q
27N/06E-05C01	Tb	420	165	--	6	U	-	125	04-15-92	GS	U	--	--	--	L
27N/06E-05E01	Qvt	50	110	--	6	H	-	--	--	--	-	--	--	--	L,G
27N/06E-06N01	Tb	100	280	4.5	6	U	A	88.6	04-16-92	GS	U	--	--	--	L
27N/06E-06Q02	--	20	86	--	-	U	Z	--	--	--	-	--	--	--	L
27N/06E-06R01	Qal	20	68	--	-	U	Z	4	12-16-63	DR	U	--	--	--	L
27N/06E-07C01	Qal	20	57	--	-	U	Z	7.5	12-03-63	DR	U	--	--	--	L
27N/06E-07D01	--	200	180	--	6	H	-	11.7	04-16-92	GS	-	--	--	--	--
27N/06E-07E01	Tb	170	214	--	6	U	C	38.8	04-17-92	GS	U	1.5	160	0.0023	L
27N/06E-08D01	Qal	20	35	--	-	U	Z	--	--	--	U	--	--	--	L,G
27N/06E-10R01	Qvt	150	18	--	48	U	D	2.0	02-19-93	GS	U	--	--	--	--
27N/06E-11K01	Qal	35	52	10	13	T	-	10	04-15-92	GS	U	700	7	990	L
27N/06E-12L01	Qal	40	30	--	6	H	C	13.6	04-15-92	GS	U	30	1	1,800	L
27N/06E-12N01	Qal	55	35	--	6	H	C	18.4	04-15-92	GS	U	20	2	610	L
27N/06E-13L02	Qva	40	50	--	6	H	-	14.5	04-15-92	GS	C	--	--	--	L,Q,W

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/06E-14B01	Qal	35	19	--	36	U	D	8.9	05-19-92	GS	U	240	5	1,100	L
27N/06E-14E03	Qva	60	160	--	6	H	A	120	04-29-92	GS	U	--	--	--	L,Q
27N/06E-15A01	Qvt	50	385	--	6	U	C	9.5	04-29-92	GS	U	--	--	--	L
27N/06E-15B01	Qva	60	38	--	6	U	C	13	08-18-88	DR	C	7.5	10	18	L
27N/06E-16E02	Tb	140	14.6	--	36	H	D	3.5	04-30-92	GS	U	--	--	--	L
27N/06E-16Q01	Tb	150	300	--	6	U	A	37.1	04-30-92	GS	U	--	--	--	L
27N/06E-17A01	Tb	70	254	--	6	U	C	6	02-14-45	DR	U	--	--	--	L
27N/06E-17A02	Qvt	50	20	--	36	H	D	12	12-09-87	DR	U	20	5	98	L
27N/06E-17C01	Tb	65	60	4.5	6	H	A	12.8	04-29-92	GS	U	--	--	--	L,Q
27N/06E-18F01	Qva	260	70	--	6	H	C	10.2	04-28-92	GS	U	14	33	10	L,Q
27N/06E-18P02	Qva	340	155	--	6	H	A	61.2	04-28-92	GS	U	--	--	--	L,Q
27N/06E-19D02	Qva	420	156	--	6	H	C	122	05-04-92	GS	U	22	10	56	L
27N/06E-19G01	Qva	290	78	--	6	H	A	15	07-16-86	DR	C	--	--	--	L
27N/06E-20E04	Qva	320	70	--	6	U	C	37	03-29-90	DR	C	--	--	--	L
27N/06E-20F01	Qvt	320	80	--	6	U	A	54	08-24-90	DR	U	--	--	--	L,G
27N/06E-20G01	Tb	470	220	--	8	U	A	91.2	04-29-92	GS	C	30	10	9.1	L
27N/06E-20M01	Tb	330	80	--	8	U	A	--	--	--	-	--	--	--	L
27N/06E-20R01	Qvt	480	111	--	6	H	C	97.1	04-30-92	GS	U	10	2	240	L
27N/06E-21L03	Tb	500	240	4	6	H	A	80.7	04-29-92	GS	U	20	110	0.28	L,Q
27N/06E-21P01	Qvt	520	74	--	6	H	C	61.4	04-29-92	GS	U	5	1	310	L,W
27N/06E-22G02	Qu	310	283	--	6	H	C	181	04-30-92	GS	C	3	14	4.2	L
27N/06E-22J01	Qva	300	76	--	6	H	C	26.5	05-19-92	GS	C	--	--	--	L,Q
27N/06E-23N01	Qu	220	210	--	6	H	C	157	04-17-92	GS	U	4	30	2.1	L,Q
27N/06E-23N02	Qtb	250	73	--	6	H	C	40	08-27-88	DR	U	7.5	2	100	L
27N/06E-23N02D1	Qtb	250	303	--	6.6	H	C	206	04-30-92	GS	U	2	60	0.025	L
27N/06E-24J01	Qvt	240	42	--	6	H	A	30.1	05-14-92	GS	U	--	--	--	L,Q
27N/06E-24K04	Qtb	170	253	5	10	H	C	104	05-14-92	GS	U	20	120	0.77	L
27N/06E-25A01	Qvt	260	39	--	6	H	A	11.6	05-14-92	GS	U	35	16	70	L
27N/06E-26K01	Qu	110	131	5	6	H	-	74.2	05-19-92	GS	U	8	12	49	L
27N/06E-26M01	Qva	300	92	--	6	H	C	77.8	05-14-92	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/06E-26N01	Qu	420	335	5	6	P	A	185	06-07-92	GS	C	15	40	9.4	L
27N/06E-27K02	Qva	480	153	--	6	H	C	142	05-13-92	GS	U	5	4	29	L,Q
27N/06E-27N07	Tb	420	50	--	4	H	-	6	09-20-90	DR	U	1	42	0.054	L
27N/06E-28C01	Qvt	480	69	5	6	H	C	50.3	05-13-92	GS	U	10	1	310	L,Q
27N/06E-28F02	Qva	540	260	--	6	H	A	234	05-12-92	GS	U	--	--	--	L,Q
27N/06E-28Q02	Qva	530	176	--	6	U	A	--	--	--	-	--	--	--	L
27N/06E-29B01	Qva	460	101	--	6	H	C	85.7	05-13-92	GS	U	6	10	14	L
27N/06E-29B02	Qva	460	103	--	6	H	C	76.5	05-15-92	GS	C	25	23	88	L,Q,G
27N/06E-29N01	Qva	280	88	--	6	H	A	--	--	--	-	--	--	--	L,Q
27N/06E-29P01	Qva	290	47	--	6	H	C	--	--	--	-	--	--	--	L
27N/06E-30D01	Qva	400	145	--	6	H	A	103	05-11-92	GS	U	--	--	--	L,Q
27N/06E-32C02	Qva	360	80	--	6	H	C	72.2	05-19-92	GS	U	--	--	--	L,G
27N/06E-32F01	Qva	340	41	--	6	H	A	7	08-21-87	DR	C	25	10	150	L
27N/06E-32K04	--	450	110	--	6	U	A	--	--	--	-	--	--	--	L
27N/06E-32P01	Qu	270	252	--	6	H	-	32.2	05-11-92	GS	C	12	1	740	L,Q,G
27N/06E-33B01	Qva	460	240	--	6	H	A	174	07-01-80	DR	U	--	--	--	L
27N/06E-33H01	Qva	540	270	--	6	H	C	239	03-28-75	DR	U	20	3	200	L
27N/06E-33N02	Qtb	440	89	--	6	H	C	64.2	05-12-92	GS	C	6	15	15	L,Q
27N/06E-34D01	Qva	400	101	--	6	H	C	56.5	05-13-92	GS	U	--	--	--	L
27N/06E-34F01	Qva	470	186	--	6	H	A	136	05-13-92	GS	U	--	--	--	L
27N/06E-35B01	Qvt	10	208	--	6	-	C	--	--	--	U	--	--	--	L
27N/06E-35G02	Qu	100	177	--	8	H	-	110	02-04-69	DR	C	20	10	50	L
27N/07E-01N01	Qal	100	74	--	6	H	A	29.3	04-10-92	GS	U	--	--	--	L,W
27N/07E-01N02	Qal	100	109	--	6	I	C	-3	07-09-82	DR	U	190	12	970	L
27N/07E-02G02	Qal	90	100	--	6	H	C	30	08-08-88	DR	U	10	10	31	L
27N/07E-03D03	Qva	300	162	--	6	U	C	140	11-22-83	DR	U	10	3	9.1	L
27N/07E-03K01	Qu	100	96	--	6	H	A	21	04-10-92	GS	C	--	--	--	L
27N/07E-04M02	Qal	80	39	--	6	U	C	17	09-03-76	DR	U	15	8	47	L,G
27N/07E-05J01	Qal	70	18	--	10	U	-	5.4	04-10-92	GS	U	--	--	--	L,G
27N/07E-05J03	--	65	378	--	6	U	C	--	--	--	-	--	--	--	L
27N/07E-06L01	Qal	50	21	--	216	U	D	17.8	07-31-44	DR	U	--	--	--	--

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/07E-06L02	Qal	50	21	--	300	U	D	9.6	03-02-93	GS	U	--	--	--	--
27N/07E-07H02	Qva	60	22	--	6	H	C	18.8	06-08-92	GS	U	20	3	410	L
27N/07E-07R01	Tb	270	300	4	6	P	A	23.6	04-14-92	GS	U	--	--	--	L
27N/07E-07R02	Qvt	270	107	--	8	P	C	58	06-11-80	DR	U	--	--	--	L,Q
27N/07E-09G01	Qu	90	51	--	6	H	A	32.1	04-13-92	GS	C	--	--	--	L,Q,G
27N/07E-10F01	Qal	90	48	--	6	H	A	17.4	03-02-93	GS	U	--	--	--	L
27N/07E-11D01	Qal	100	30	--	6	H	C	11.3	04-14-92	GS	U	10	7	88	L
27N/07E-12R01	Qvr	160	79	--	6	H	C	25.8	03-02-93	GS	U	20	30	14	L
27N/07E-18G01	Qu	280	153	--	6	H	A	43.2	03-02-93	GS	C	5	130	2.4	L
27N/07E-19K01	Tb	600	496	6	8	P	A	113	03-17-93	GS	U	25	408	0.015	L
27N/07E-30K02	Tb	820	260	4	6	H	A	45.9	04-09-92	GS	U	8	55	0.25	L,Q
27N/07E-30Q01	Tb	860	160	4	6	H	A	51.7	04-09-92	GS	U	--	--	--	L
27N/07E-31L01	Tb	130	30	4.5	6	H	C	7.1	08-18-93	GS	U	15	15	25	L
27N/07E-31N02	Qu	30	505	6	8	H	A	--	--	--	-	--	--	--	L,Q
27N/07E-31Q01	Tb	260	134	4.5	6	H	C	98	07-18-84	DR	U	--	--	--	L
27N/08E-01A01	Qva	170	18	--	6	H	-	6.9	04-14-92	GS	C	--	--	--	L
27N/08E-02J01	Qva	160	140	--	6	H	A	10.3	04-15-92	GS	C	--	--	--	L
27N/08E-03R01	Qvt	140	35	--	6	H	C	18.4	04-15-92	GS	U	30	4	300	L
27N/08E-04N01	Qal	110	30	--	6	H	A	9.2	04-15-92	GS	U	--	--	--	L
27N/08E-04P01	Qal	130	48	--	6	H	A	29.6	04-17-92	GS	U	--	--	--	L,Q,W
27N/08E-04Q01	Qvr	110	32	--	6.6	H	C	7.8	06-10-92	GS	U	20	6	88	L
27N/08E-06C01	Qvt	180	95	--	6	H	-	52.9	03-17-93	GS	U	10	1	350	L
27N/08E-07E01	Tb	200	152	--	6	H	C	35.7	03-16-93	GS	U	4	119	0.022	L
27N/08E-10A01	Qal	150	32	--	6	H	C	13.1	06-09-92	GS	U	10	7	88	L,Q
27N/08E-10B01	Qal	150	35	--	6	H	A	29.3	06-11-92	GS	U	15	8	51	L
27N/08E-11D01	Qal	180	40	--	6	H	A	13.7	04-15-92	GS	U	--	--	--	L
27N/08E-11D02	Qal	170	34	--	6	H	C	14.5	03-16-93	GS	U	10	7	47	L
27N/08E-11G02	Qal	240	81	--	6	H	C	68.4	04-15-92	GS	U	8	10	20	L,Q
27N/09E-04L01	Qva	270	310	4.5	6	S	A	31	02-22-91	DR	C	3	74	0.48	L,Q
27N/09E-05A01	Qvr	492	42	--	8	P	C	5.6	02-23-94	GS	U	30	18	38	L
27N/09E-05C01	Tb	230	200	4	6	H	A	8.0	03-03-94	GS	U	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
27N/09E-05N01	--	205	690	8	16	P	C	-60	02-28-94	GS	F	--	--	--	L
27N/09E-05Q01	--	230	140	--	-	U	-	--	--	--	-	--	--	--	L
27N/09E-05Q02	Qvr	230	39	--	6	H	C	14.9	02-23-94	GS	U	3	12	4.4	L,Q
27N/09E-08E01	Qtb	210	340	--	6	H	A	41.5	02-25-94	GS	U	--	--	--	L
27N/09E-15D03	Qal	290	48	--	6	H	A	29	03-03-94	GS	U	--	--	--	L,Q
28N/04E-03C01	Qu	210	259	--	6	H	C	115	05-06-92	GS	C	--	--	--	L,Q,W
28N/04E-10B01	--	430	30	--	2	U	B	16	06-24-93	GS	-	--	--	--	L
28N/04E-11A01	Qu	440	545	10	12	U	-	310	03-28-61	DR	C	--	--	--	L
28N/04E-11J01	Qva	600	230	--	10	C	C	198	07-01-92	GS	C	138	19	200	L
28N/04E-14E01	Qva	580	239	--	8	U	A	--	--	--	-	--	--	--	L,G
28N/04E-15A01	Qvt	566	36	--	2	U	B	5.7	06-24-93	GS	U	--	--	--	L
28N/04E-15L01	Qvt	550	25	--	2	U	C	10.0	06-24-93	GS	U	--	--	--	L
28N/04E-17H01	Qu	150	185	--	6	H	C	167	05-21-92	GS	U	12	10	31	L,G
28N/04E-18M01	Qva	510	201	--	6	U	A	--	--	--	-	--	--	--	L
28N/04E-22J01	Qvt	590	25	--	4	U	B	9.8	06-23-93	GS	U	--	--	--	L
28N/04E-24G01	Qvt	530	15	--	2	U	B	7.8	06-24-93	GS	U	--	--	--	L
28N/04E-26L01	Qvt	490	27	--	4	U	B	7.0	04-15-93	GS	U	--	--	--	L
28N/04E-26L02	Qvt	490	25	--	4	U	B	8.1	04-15-93	GS	U	--	--	--	L
28N/04E-27K01	Qvt	590	20	--	2	U	B	4.2	06-22-93	GS	U	--	--	--	L
28N/04E-27K02	Qvt	590	20	--	2	U	B	3.6	06-22-93	GS	U	--	--	--	L
28N/04E-28B01	Qu	500	571	6	8	U	A	278	12-09-92	GS	C	--	--	--	L
28N/04E-28C01	Qu	500	552	6	8	U	-	361	04-16-93	GS	C	--	--	--	L
28N/04E-36C01	Qva	480	240	--	10	C	C	162	05-06-77	DR	U	--	--	--	L
28N/05E-02G04	Qu	245	232	--	8	H	C	188	04-09-92	GS	C	10	8	57	L,Q
28N/05E-03R01	Qva	80	96	--	6	H	A	59.5	05-20-92	GS	U	--	--	--	L,Q,W
28N/05E-04H01	Qal	10	113	--	8	J	-	14.6	04-10-92	GS	U	--	--	--	L
28N/05E-05B01	--	10	776	--	18	U	-	--	--	--	-	--	--	--	L,G
28N/05E-06P01	--	430	53	--	-	U	B	--	--	--	-	--	--	--	L
28N/05E-10G01	Qtb	105	153	--	6	H	-	121	05-20-92	GS	C	10	2	280	L,Q
28N/05E-11G02	Qva	280	97	--	6	U	-	--	--	--	-	--	--	--	L
28N/05E-12R01	Qva	97	150	--	10	U	-	73	07-00-49	DR	U	380	13	190	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
28N/05E-12R02	Qva	97	150	--	10	U	D	73	01-29-57	DR	U	--	--	--	L
28N/05E-12R03	Qva	97	235	--	10	U	D	72	04-08-52	DR	U	230	8	380	L
28N/05E-17L01	Qva	485	242	12	16	U	-	147	06-01-56	DR	U	--	--	--	L
28N/05E-18D01	Qva	565	246	--	5	U	-	214	05-07-92	GS	U	--	--	--	L
28N/05E-19K01	Qva	470	149	--	6	Z	C	123	09-00-64	DR	U	18	5	110	L,Q,G
28N/05E-20A01	Qva	380	252	--	6	R	A	173	04-22-93	GS	U	20	24	14	L,Q
28N/05E-21D01	Qva	350	100	--	3	U	D	97	02-13-45	DR	U	--	--	--	L
28N/05E-22N01	Qva	260	140	--	6	H	C	--	--	--	-	--	--	--	L,Q
28N/05E-22P01	Qtb	180	240	--	6	H	-	167	05-08-92	GS	U	--	--	--	L,G
28N/05E-24L01	Qal	15	93	--	8	S	C	11	08-17-93	GS	U	240	5	290	L
28N/05E-25M02	Qal	10	31	--	36	U	D	6	09-01-56	DR	U	--	--	--	L
28N/05E-27G01	Qva	250	116	--	6	T	C	47.1	05-07-92	GS	C	89	12	210	L,Q,W
28N/05E-27H02	Qva	220	165	--	6	H	C	73.6	04-09-92	GS	U	15	18	51	L
28N/05E-27K01	Qva	300	35	--	6	H	C	16.8	05-07-92	GS	U	6.5	5	31	L,Q
28N/05E-28N01	--	410	71	--	6	U	-	--	--	--	-	--	--	--	L
28N/05E-29N02	Qva	460	96	--	6	U	-	93.5	02-13-45	DR	U	--	--	--	L
28N/05E-31F01	Qva	400	60	--	6	H	A	24.8	04-15-93	GS	U	--	--	--	L,Q
28N/05E-33C01	Qva	440	100	--	6	H	C	70	10-17-78	DR	C	13	15	49	L,Q
28N/05E-36F01	Tb	290	150	--	6	H	C	36	07-16-82	DR	U	4.5	114	0.027	L,Q
28N/06E-01M01	Qvt	580	67	--	6	H	C	23.5	05-05-92	GS	U	4	40	0.23	L,Q
28N/06E-03B01	Qva	520	145	--	6	H	A	91	05-06-92	GS	U	4	90	0.69	L,Q
28N/06E-03C01	Qva	530	80	--	6	H	A	25.1	05-05-92	GS	U	40	10	280	L,Q
28N/06E-03C02	Qva	510	78	--	6	H	-	35	06-08-87	DR	U	15	7	58	L
28N/06E-04M01	Qtb	210	320	--	6	U	A	--	--	--	-	--	--	--	L
28N/06E-05C01	Qva	90	95	--	6	H	A	50.1	05-12-92	GS	C	--	--	--	L
28N/06E-05M01	Qvt	65	100	--	6	H	A	25.4	05-06-92	GS	U	--	--	--	L,G
28N/06E-05M02	Qu	70	218	--	6	H	-	28	06-25-92	GS	C	20	32	38	L,Q,G
28N/06E-06C01	Qva	230	70	--	6	H	A	47.5	05-20-92	GS	U	--	--	--	L,Q
28N/06E-06J01	Qvt	60	60.5	--	6	H	A	3.0	01-12-93	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches) Minimum	Casing diameter (inches) Maximum	Water use	Construc-tion method	Water level (Feet)	Water level Date	Water level Source	Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
28N/06E-08E01	Qva	45	37	--	6	H	A	11.3	05-06-92	GS	C	--	--	--	L,Q,G
28N/06E-08N02	Qal	70	220	--	6	H	A	10.9	08-10-92	GS	U	--	--	--	L
28N/06E-09F01	Tb	150	155	--	6	U	C	--	--	--	F	--	--	--	L
28N/06E-11H02	Qvt	520	56	--	6	H	C	-1.0	05-08-92	GS	U	15	5	94	L,Q
28N/06E-12J01	Tb	460	225	--	6	H	C	98.4	08-17-92	GS	C	3	181	0.084	L,Q
28N/06E-12Q01	Qvt	500	42	4.5	6	H	A	6	09-28-91	DR	U	--	--	--	L
28N/06E-13J01	Qvt	540	80	--	6	H	A	18.9	08-10-92	GS	U	30	6	310	L
28N/06E-13J02	Qva	530	188	--	6	H	A	--	--	--	-	--	--	--	L,G
28N/06E-14J01	Qva	375	230	--	6	H	C	87.9	05-07-92	GS	C	10	54	7.9	L,Q
28N/06E-14J02	Qva	390	208	--	6	U	C	115	06-19-75	DR	U	10	10	16	L,G
28N/06E-14J03	Qvt	390	57	--	6	U	A	46	10-16-79	DR	U	1.5	3	17	L
28N/06E-15C03	Qvr	280	60	--	6	H	A	18	08-23-85	DR	U	--	--	--	L,Q,G
28N/06E-15C04	Tb	280	300	--	6	H	-	--	--	--	F	--	--	--	L
28N/06E-15F01	--	380	26	--	6	H	A	17	08-23-88	DR	-	--	--	--	L
28N/06E-16R02	Qva	140	75	--	6	H	C	47	08-21-80	DR	U	7	20	21	L
28N/06E-16R02D1	Qvt	140	125	--	6	H	-	67	06-30-92	GS	U	--	--	--	L
28N/06E-17K01	Qal	50	39	--	6	U	A	26.5	05-12-92	GS	U	--	--	--	L
28N/06E-17K02	Qu	50	102	--	6	S	-	32	06-01-88	DR	C	--	--	--	L,G
28N/06E-17K03	Qu	45	96	--	6	S	A	41.1	05-12-92	GS	C	--	--	--	L
28N/06E-17K04	Qtb	30	84	--	6	S	A	8.7	05-12-92	GS	U	--	--	--	L,Q
28N/06E-17M01	Qva	15	50	--	6	I	C	6.3	05-12-92	GS	C	--	--	--	L
28N/06E-18F03	Qva	70	100	--	8	U	-	51	05-10-60	DR	U	--	--	--	L,G
28N/06E-18G01	Qal	20	30.5	--	36	K	D	9.4	05-06-92	GS	U	--	--	--	L
28N/06E-19G01	Qu	15	48	--	6	H	C	12	01-06-83	DR	C	30	1	1,800	L
28N/06E-19K01	Qal	15	64	--	6	H	C	12	01-12-93	GS	U	14	50	5.1	L,Q,W
28N/06E-19N01	Qal	15	40	--	6	H	C	11	06-16-90	DR	U	--	--	--	L
28N/06E-22A01	Tb	210	494	4.5	6	U	-	46.3	05-21-92	GS	U	--	--	--	L
28N/06E-22J01	Qal	55	126	--	6	H	-	--	--	--	U	--	--	--	L
28N/06E-22M01	Qtb	50	92	--	6	U	A	35	03-03-82	DR	U	--	--	--	L
28N/06E-23A01	Qva	280	150	5	6	H	A	18.4	05-19-92	GS	C	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohydrologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construction method	Water level			Ground-water condition	Yield (gallons per minute)	Drawdown (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
28N/06E-23M01	Qtb	145	271	--	6	H	C	130	10-23-78	DR	U	--	--	--	L
28N/06E-24B01	Tb	480	170	--	6	H	A	51.5	05-13-92	GS	C	5	80	0.82	L,Q
28N/06E-24Q01	Qvt	450	60	--	6	H	A	39.9	05-13-92	GS	U	15	11	84	L,Q
28N/06E-24Q02	Tb	450	216	--	6	H	C	13.6	05-13-92	GS	U	4	200	0.012	L,Q
28N/06E-24R01	Qva	450	97	--	6	H	A	67.1	05-13-92	GS	U	--	--	--	L
28N/06E-24R02	Qva	470	87	--	6	H	C	71.4	05-13-92	GS	U	8	1	240	L
28N/06E-25B01	Qva	450	202	--	6	H	A	86.5	03-26-93	GS	U	10	85	2.1	L,W
28N/06E-25B02	Qva	450	300	--	6	H	A	86.9	07-14-92	GS	U	--	--	--	L
28N/06E-25R01	Qvt	460	50	--	6	H	C	31.5	05-19-92	GS	U	5	13	9.0	L,W
28N/06E-26D01	Qal	30	32	--	8	U	B	-5	01-01-44	DR	U	10	30	15	--
28N/06E-26J01	Qva	220	113	--	6	H	C	102	04-14-93	GS	C	--	--	--	L,Q
28N/06E-28M01	Qva	80	152	--	6	H	-	62.6	08-19-93	GS	U	--	--	--	L
28N/06E-29E01	Qal	10	38	--	36	I	-	4.2	05-11-92	GS	U	--	--	--	L
28N/06E-29H01	Qtb	30	138	--	6	S	-	12.5	03-09-93	GS	U	--	--	--	L
28N/06E-29R01	Qva	140	160	--	6	H	A	137	05-11-92	GS	U	--	--	--	L,Q,G
28N/06E-30M01	Qu	15	35	--	6	U	-	14	06-00-41	DR	C	--	--	--	L
28N/06E-32A02	Qva	160	215	--	6	U	A	155	07-26-87	DR	U	7	60	2.1	L,G
28N/06E-34A01	Qva	30	160	--	8	U	-	5	10-01-57	DR	U	--	--	--	L
28N/06E-34A02	Qal	30	55	--	8	U	-	6	04-21-62	DR	U	--	--	--	L
28N/06E-34H01	--	25	224	--	6	U	A	--	--	--	-	--	--	--	L
28N/06E-35E02	Qvt	25	300	10	12	N	-	8	03-21-45	DR	U	300	110	7.8	L
28N/06E-35E03	Qvt	25	180	--	12	U	-	22.2	05-19-92	GS	U	500	137	6.8	L
28N/06E-36B01	Qva	390	278	--	6	H	A	250	08-19-92	GS	U	10	6	68	L,Q
28N/07E-06M01	Qva	530	60	--	6	H	A	17.7	06-18-92	GS	C	--	--	--	L,Q
28N/07E-06P02	Qvt	510	180	--	6	H	A	11.2	08-25-92	GS	U	--	--	--	L,G
28N/07E-07N01	Qvt	570	80	--	6	H	C	19.9	08-26-92	GS	U	2	40	2.1	L
28N/07E-08E02	Qva	550	80	--	6	H	A	55	06-28-88	DR	C	--	--	--	L
28N/07E-08M01	Qvt	690	210	--	6	H	A	185	06-18-92	GS	U	--	--	--	L,G
28N/07E-10F01	Qva	410	44	--	6.6	H	C	10.1	06-16-92	GS	C	80	5	870	L,Q
28N/07E-10F02	Qvt	500	114	--	6	H	C	70	06-16-92	GS	U	--	--	--	L
28N/07E-10G01	Tb	590	57	--	6	U	A	--	--	--	-	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
28N/07E-10G02	Tb	530	200	--	6	U	A	10	06-17-92	GS	U	--	--	--	L
28N/07E-10G03	Tb	530	90	--	6	H	A	12.1	06-17-92	GS	U	--	--	--	L,Q
28N/07E-12R01	Tb	630	70	--	6	H	A	6.5	06-23-92	GS	U	--	--	--	L
28N/07E-15D01	Tb	445	350	--	6	U	A	4.6	04-13-93	GS	-	--	--	--	L
28N/07E-16L01	Qvt	430	200	--	6	H	A	59.6	06-17-92	GS	-	--	--	--	L,G
28N/07E-16L02	Qvt	460	60	--	6	H	A	16	04-21-90	DR	U	--	--	--	L,Q
28N/07E-17C01	Qva	530	261	--	6	H	A	31.8	06-05-92	GS	C	--	--	--	L,Q
28N/07E-17C02	Qva	520	125	--	6	U	A	30.6	08-25-92	GS	C	--	--	--	L
28N/07E-17D03	Qva	660	165	--	6	H	C	140	08-24-77	DR	C	10	15	41	L,G
28N/07E-17M02	Qva	570	97.5	--	6	H	A	57.1	08-26-92	GS	U	--	--	--	L
28N/07E-18Q01	Qva	590	80	--	6	U	C	21.2	08-27-92	GS	C	5	30	10	L
28N/07E-18Q02	Qva	590	140	--	6	H	A	74.4	08-27-92	GS	C	--	--	--	L,Q,G
28N/07E-19N01	Qvt	490	75	--	6	H	C	38.1	06-23-92	GS	U	6	23	5.1	L
28N/07E-20D02	Qvt	460	300	4.5	6	H	A	51.6	06-18-92	GS	U	--	--	--	L,G
28N/07E-20J01	Tb	480	188	4.5	6	H	A	31.1	06-03-92	GS	C	--	--	--	L,Q
28N/07E-20L01	Tb	520	183	5	6	U	C	128	04-13-93	GS	-	--	--	--	L
28N/07E-21A01	Qva	365	170	--	6	H	A	139	06-02-92	GS	U	--	--	--	L,G
28N/07E-21M01	--	510	146	--	-	U	-	--	--	--	-	--	--	--	--
28N/07E-21M01D1	--	510	206	--	6	H	A	--	--	--	-	--	--	--	L
28N/07E-23A01	Qvr	450	110	--	6	H	C	38.6	07-16-92	GS	U	30	1	1,800	L,Q,G
28N/07E-25M04	Qva	320	104	--	6	H	C	78.7	05-21-92	GS	C	--	--	--	L
28N/07E-26A01	Qva	390	325	4.5	6	U	A	148	05-22-92	GS	U	--	--	--	L
28N/07E-26B01	Qva	270	69	--	8	H	C	49	10-25-76	DR	U	20	3	200	L,Q
28N/07E-26H02	Qva	280	118	--	6	H	C	56.7	05-22-92	GS	U	18	18	61	L
28N/07E-27Q01	Qvt	340	62	--	6	H	C	34.6	03-10-93	GS	U	5	21	4.2	L,Q
28N/07E-28F01	Qva	150	39	--	6	H	A	15	08-15-90	DR	U	--	--	--	L
28N/07E-28H01	Tb	230	246	4	6	H	A	79.4	06-02-92	GS	U	--	--	--	L,Q,W
28N/07E-28J01	Qva	230	60	--	6	H	A	39.9	06-01-92	GS	U	--	--	--	L,W
28N/07E-29B01	Qva	470	134	--	6	H	C	114	03-20-81	DR	U	20	1	660	L
28N/07E-29F01	Qva	370	75	--	6	H	A	18.3	06-02-92	GS	C	11	8	84	L,G

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
28N/07E-29F02	Qva	335	52	--	6	H	C	24.2	06-02-92	GS	C	10	9	54	L,Q,G
28N/07E-29H01	Qva	410	260	5	6	H	A	98.4	06-03-92	GS	U	--	--	--	L
28N/07E-30F01	Qva	450	209	--	6	H	C	111	06-03-92	GS	U	1.5	75	0.18	L
28N/07E-30P01	Qva	380	100	--	6	H	C	83.9	06-04-92	GS	U	10	2	310	L
28N/07E-30Q01	Qva	390	140	--	6	I	Z	100	05-15-53	DR	U	12	2	84	L
28N/07E-31A01	Qu	270	232	8	10	U	Z	174	01-01-37	DR	U	--	--	--	L
28N/07E-31A02	Qu	270	226	10	12	U	Z	179	01-01-37	DR	U	--	--	--	L
28N/07E-31C02	Qva	330	68	--	6	H	C	57.3	06-16-92	GS	U	10	6	45	L
28N/07E-31C03	Qva	320	112	--	6	H	C	94	03-20-78	DR	U	10	2	150	L
28N/07E-31C04	Qva	355	99	--	6	H	C	74.4	04-14-93	GS	U	10	4	150	L,Q
28N/07E-31D01	Qva	370	160	--	6	H	A	60	08-05-86	DR	C	--	--	--	L
28N/07E-31D02	Qu	380	228	--	6	H	C	207	06-16-92	GS	C	--	--	--	L
28N/07E-31H06	--	270	716	8	18	U	Z	--	--	--	-	--	--	--	L
28N/07E-32A03	Qva	310	98	--	6	H	A	57.4	06-23-92	GS	U	--	--	--	L
28N/07E-32F01	Qu	210	184	--	6	H	C	134	06-04-92	GS	U	8	37	4.3	L,G
28N/07E-32K01	Qva	90	57	4.5	6	U	A	--	--	--	-	--	--	--	L,G
28N/07E-33A01	Qva	290	60	--	6	H	C	47	11-12-87	DR	C	--	--	--	L
28N/07E-33F01	Qva	170	118	--	6	H	D	100	06-01-92	GS	U	10	5	55	L,Q
28N/07E-34D02	Qva	330	100	--	6	H	A	84.5	06-17-92	GS	U	10	5	50	L,Q
28N/07E-34E01	Qu	230	80	--	6	H	A	94	06-05-79	DR	C	--	--	--	L
28N/07E-35E02	Qva	370	176	--	6	H	-	153	04-14-93	GS	U	8	8	0.64	L
28N/07E-35G01	Qva	400	92	--	6	U	C	--	--	--	-	--	--	--	L
28N/07E-36P01	--	370	110	--	6	H	-	100	01-01-25	DR	-	--	--	--	L
28N/08E-18L01	Tb	660	400	4.5	6	H	A	19.3	04-14-93	GS	U	--	--	--	L,Q
28N/08E-18L02	Tb	725	400	--	6	H	A	90.9	04-14-93	GS	U	--	--	--	L
28N/08E-18M01	Qvt	765	50	--	6	H	A	26.7	04-16-93	GS	U	--	--	--	L,Q
28N/08E-20Q03	Qvt	540	119	--	6	H	-	109	06-04-92	GS	U	11	15	19	L
28N/08E-21F02	Tb	680	500	--	6	U	A	150	06-03-92	GS	U	--	--	--	L,G
28N/08E-21H01	Tb	760	101	4.5	6	H	A	50	06-03-92	GS	U	--	--	--	L,G
28N/08E-21N01	Tb	660	250	--	4.5	H	A	162	06-03-92	GS	U	4	36	0.36	L,Q
28N/08E-21P01	Tb	710	353	4.5	6	H	A	160	12-04-88	DR	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
28N/08E-25N01	Tb	680	45	--	6	H	C	10.4	06-02-92	GS	U	2	38	0.12	L
28N/08E-26A01	Qvr	620	100	--	6	H	A	36.4	06-02-92	GS	U	--	--	--	L,Q,G
28N/08E-26A02	Qvt	880	82	--	6	H	-	62.2	06-02-92	GS	U	5	5	25	L
28N/08E-26R02	Qvt	440	265	--	4.5	H	A	100	06-02-92	GS	U	2	38	0.22	L
28N/08E-28C01	Qva	520	150	--	6	H	A	124	06-03-92	GS	C	--	--	--	L,Q
28N/08E-28G01	Qvt	480	80	--	6	H	C	65.2	06-03-92	GS	U	20	16	77	L
28N/08E-29A02	Tb	540	160	--	6	H	A	108	06-04-92	GS	U	8.5	15	1.6	L
28N/08E-29B01	Qva	490	100	--	6	H	A	50.3	06-04-92	GS	U	--	--	--	L,Q
28N/08E-30C01	Qva	160	128	--	6	H	C	10.1	06-10-92	GS	C	7	12	27	L,Q
28N/08E-30F02	Qvr	150	60	--	6	H	C	8.4	06-10-92	GS	U	20	2	330	L
28N/08E-31G01	Qu	240	177	--	6	U	-	146	05-27-75	DR	U	--	--	--	L
28N/08E-31G02	Qu	240	245	--	6	H	C	150	04-20-79	DR	U	12	3	240	L
28N/08E-31J01	--	120	54	--	-	P	-	--	--	--	-	--	--	--	--
28N/08E-33H01	Qvr	220	30	--	36	U	D	10.5	06-04-92	GS	U	--	--	--	L
28N/08E-34L01	Qvr	200	13	--	36	H	D	4.0	06-01-92	GS	U	--	--	--	L,Q
28N/08E-35A02	Qvt	400	135	--	4.5	U	A	107	06-02-92	GS	U	--	--	--	L
28N/08E-36R02	Qal	140	24	--	8	U	C	8.9	06-02-92	GS	U	600	8	1,600	L
28N/08E-36R03	Qal	180	26	--	6	H	C	8	03-06-79	DR	U	--	--	--	L
28N/09E-31P01	Qal	180	40	--	4.5	H	A	9	03-17-90	DR	U	16	4	64	L
28N/09E-32E01	Tb	420	204	--	6	H	A	47.1	02-23-94	GS	U	--	--	--	L
29N/04E-01A01	Qva	120	174	6	8	U	C	121	04-01-41	DR	U	--	--	--	L
29N/04E-01A02	Qva	120	146	--	8	P	C	119	05-21-92	GS	U	40	5	260	L
29N/04E-01A03	Qu	120	146	--	8	P	C	118	05-21-92	GS	C	30	3	520	L,Q
29N/04E-01B02	Qu	105	160	--	6	P	C	105	05-21-92	GS	C	50	6	240	L
29N/04E-01B03	--	120	172	--	6	P	C	116	05-21-92	GS	-	--	--	--	L
29N/04E-01C02	Qu	125	160	--	6	P	C	120	05-21-92	GS	C	--	--	--	L
29N/04E-08F01	Qu	152	172	--	8	P	C	150	06-30-93	GS	U	--	--	--	L
29N/04E-08F02	Qu	168	192	--	6	P	C	--	--	--	-	--	--	--	L
29N/04E-08F03	Qu	155	169	--	6	P	C	137	06-30-93	GS	U	63	9	110	L
29N/04E-08F04	Qu	150	169	--	6	P	C	135	09-15-88	DR	U	60	4	250	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
29N/04E-08K01	Qu	221	236	--	6	P	-	--	--	--	-	--	--	--	L,G
29N/04E-08K02	Qu	220	233	--	6	P	C	207	06-30-93	GS	U	30	7	75	L
29N/05E-01A02	Qva	320	100	--	6	H	A	21.1	05-05-92	GS	U	--	--	--	L,Q
29N/05E-02C02	Qu	280	338	--	16	P	C	132	01-14-65	DR	C	1,220	39	430	L,Q
29N/05E-02C03	Qtb	280	267	10	12	U	-	130	11-20-58	DR	U	--	--	--	L
29N/05E-02F01	Qva	270	115	--	48	U	D	112	03-24-93	GS	U	--	--	--	L
29N/05E-04D01	Qal	10	20	--	2	Z	-	--	--	--	U	--	--	--	L
29N/05E-05H01	Qal	200	15	--	2	Z	-	4.6	08-17-93	GS	U	--	--	--	L
29N/05E-05R01	Qal	10	12	--	2	U	B	5.4	06-23-93	GS	U	--	--	--	L
29N/05E-08G01	Qal	10	18	--	2	U	B	5.0	06-23-93	GS	U	--	--	--	L
29N/05E-09N01	Qal	10	9.5	--	2	U	B	8.2	06-23-93	GS	U	--	--	--	L
29N/05E-09N02	Qal	10	25	--	2	U	B	8.4	06-23-93	GS	U	--	--	--	L
29N/05E-10B01	Qal	10	99	--	12	U	C	0.8	03-24-93	GS	U	--	--	--	--
29N/05E-11F01	Qtb	60	63	--	48	U	D	--	--	--	-	--	--	--	--
29N/05E-13L01	Qva	360	66	--	30	H	D	58.8	05-05-92	GS	U	7.5	1.5	66	L
29N/05E-16D01	Qal	8	9	--	2	U	B	4.9	06-23-93	GS	U	--	--	--	L
29N/05E-16D02	Qal	9	26.5	--	2	U	B	6.9	06-23-93	GS	U	--	--	--	L
29N/05E-17C01	Qvt	80	30	--	4	Z	-	12.7	08-18-93	GS	U	--	--	--	L
29N/05E-18G01	Qal	5	16	--	2	Z	-	4.2	08-18-93	GS	U	--	--	--	L
29N/05E-19K02	Qu	10	73.8	--	12	U	C	3	00-00-41	DR	U	--	--	--	L
29N/05E-19K03	Qu	10	75	8	12	U	C	8	00-00-41	DR	U	--	--	--	L
29N/05E-19K04	Qu	10	109	--	10	C	V	7	05-19-67	DR	U	600	19	210	L
29N/05E-19K05	Qu	10	119	--	10	C	V	4	02-09-68	DR	U	630	29	130	L
29N/05E-19K07	Qu	10	100	10	12	N	C	2	06-16-53	DR	U	300	20	89	L
29N/05E-20P01	Qu	70	277	8	12	U	-	61.6	03-26-92	GS	C	--	--	--	L
29N/05E-20P02	Qu	70	303	8	12	J	C	62	12-03-53	DR	C	--	--	--	L,Q
29N/05E-23R01	Qva	260	20	--	36	U	D	0.8	03-25-93	GS	U	40	10	150	L
29N/05E-25N02	Qva	180	150	--	6	H	Z	--	--	--	-	--	--	--	L
29N/05E-26G01	Qva	240	130	--	6	U	-	57	09-13-74	DR	U	4	53	1.0	L
29N/05E-29K01	Qal	15	65	--	2	U	B	17.5	06-21-93	GS	U	--	--	--	L
29N/05E-29Q01	Qal	10	60	--	2	U	B	23.7	06-21-93	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
29N/05E-31A01	--	180	237	12	18	U	-	--	--	--	-	--	--	--	L
29N/05E-31A02	Qva	200	35	--	2	U	B	27	09-29-88	DR	U	--	--	--	L
29N/05E-32B01	Qal	15	30	--	2	U	B	10.7	06-21-93	GS	U	--	--	--	L
29N/05E-32B02	Qal	15	30	--	2	U	B	7.8	06-21-93	GS	U	--	--	--	L
29N/05E-35J01	Qu	80	143	--	6	H	C	47.2	03-25-93	GS	C	15	30	23	L
29N/05E-36B01	Qva	200	120	--	6	H	A	1.9	05-07-92	GS	C	15	30	24	L
29N/05E-36B02	Qva	180	112	--	6	H	A	-11.5	03-25-93	GS	F	--	--	--	L,Q,W
29N/05E-36P02	Qva	220	80	--	6	P	A	32.2	03-25-93	GS	C	--	--	--	L,Q
29N/06E-01B01	Tb	730	245	--	6	H	C	120	04-10-92	GS	U	12	6	8.4	L
29N/06E-01D01	Tb	660	100	--	6	H	A	10	11-08-89	DR	C	15	40	4.2	L
29N/06E-01E03	--	670	151	4.5	6	H	C	32.8	04-10-92	GS	-	--	--	--	L,Q
29N/06E-02K01	Qva	490	116	--	6	H	A	10	02-25-77	DR	C	--	--	--	L
29N/06E-02K02	Qva	470	315	--	6	H	A	-23	06-04-80	DR	F	--	--	--	L
29N/06E-03J01	Tb	410	324	4.5	6	H	A	208	04-10-84	DR	U	10	40	1.4	L
29N/06E-03M01	Qva	280	93	4.5	6	H	A	51.6	04-09-92	GS	U	--	--	--	L
29N/06E-03M02	Qu	230	210	--	6	H	H	--	--	--	F	--	--	--	L
29N/06E-04A03	Qu	375	243	--	6	H	A	183	05-05-92	GS	C	--	--	--	L
29N/06E-04K01	Qtb	310	320	--	6	H	A	144	04-09-92	GS	C	--	--	--	L,Q
29N/06E-04M01	Qva	300	96	--	6	H	-	81	12-15-75	DR	U	--	--	--	L
29N/06E-05E02	Qva	300	59	--	6	H	A	1.5	03-23-93	GS	C	--	--	--	L,W
29N/06E-05J01	Qva	255	101	--	6	H	C	62	05-05-92	GS	C	30	1	890	L
29N/06E-05L02	Qva	270	57	--	6	H	-	4	01-06-79	DR	C	--	--	--	L,Q,G
29N/06E-06C01	Qva	360	109	--	6	H	A	50	08-22-88	DR	U	--	--	--	L
29N/06E-06F02	Qva	365	159	--	6	H	A	11.1	05-05-92	GS	C	29	17	100	L
29N/06E-06J03	Qvt	420	60	--	6	H	A	23.7	05-05-92	GS	U	--	--	--	L
29N/06E-07D01	--	230	40	--	48	U	D	--	--	--	-	--	--	--	--
29N/06E-07D02	Qu	230	100	--	6	H	Z	7	07-00-45	DR	C	9	2	280	--
29N/06E-08F03	Qu	220	120	--	6	U	Z	-2	06-00-45	DR	F	--	--	--	--
29N/06E-08R01	Qvt	250	69	--	6	H	-	36.5	05-07-92	GS	U	8	16	6.3	L,Q
29N/06E-09N01	Qva	190	48	--	6	H	A	--	--	--	-	--	--	--	L
29N/06E-09N02	Qu	220	248	--	6	H	C	126	05-07-92	GS	C	20	20	61	L,Q,G,W

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
29N/06E-10E01	Qu	170	199	--	6	H	-	-2	10-17-91	DR	F	20	60	15	L
29N/06E-10Q01	Qva	430	260	--	6	H	A	241	05-07-92	GS	U	8	20	25	L
29N/06E-11A01	--	610	440	4	6	H	A	--	--	--	-	--	--	--	L
29N/06E-11A02	--	590	230	--	-	U	A	--	--	--	-	--	--	--	L
29N/06E-11B02	Tb	480	336	--	6	H	A	208	07-29-92	GS	C	--	--	--	L,Q
29N/06E-11H01	Qva	585	99	--	6	H	C	72.6	07-29-92	GS	U	8	18	9.9	L
29N/06E-11H03	Qvt	580	30	--	36	I	D	260	03-14-90	DR	U	--	--	--	L
29N/06E-11J01	Qvt	575	137	--	6	H	A	122	07-29-92	GS	U	--	--	--	L
29N/06E-11M01	Qtb	530	325	--	6	H	A	265	00-00-92	DR	U	--	--	--	L
29N/06E-11P01	Qva	470	165	--	6	H	A	128	05-07-92	GS	U	--	--	--	L
29N/06E-11P02	Qvt	590	60	--	6	H	A	15.8	07-29-92	GS	U	--	--	--	L,Q
29N/06E-12J01	Qva	560	116	--	6	H	A	86.4	04-14-93	GS	C	--	--	--	L
29N/06E-13D01	Qva	530	103	--	6	H	A	53.4	04-13-93	GS	C	--	--	--	L
29N/06E-14F01	Qva	460	251	--	6	H	A	228	12-30-87	DR	U	--	--	--	L
29N/06E-14F03	Qu	480	418	--	6	H	A	230	08-25-92	GS	C	--	--	--	L,Q
29N/06E-14Q01	Qva	390	140	--	6	H	A	115	04-15-87	DR	U	20	15	82	L
29N/06E-14Q02	Qvt	380	58	--	6	H	A	15.9	08-26-92	GS	U	--	--	--	L,Q
29N/06E-14R01	Qu	380	300	--	6	H	A	27	04-13-93	GS	C	--	--	--	L
29N/06E-15C01	Tb	270	338	--	6	H	A	107	04-17-87	DR	C	25	15	100	L
29N/06E-15P01	Qva	220	60	--	6	H	A	44.5	08-24-92	GS	C	--	--	--	L
29N/06E-15Q01	Qtb	210	87	--	6	H	C	36.2	08-03-92	GS	U	14	14	21	L,Q
29N/06E-16N01	Qva	240	88	--	6	H	A	19.5	08-11-92	GS	C	--	--	--	L,Q
29N/06E-16N02	Tb	200	210	--	6	U	A	112	07-19-91	DR	C	--	--	--	L
29N/06E-17R01	Qtb	240	126	--	6	U	A	31.5	04-13-93	GS	U	25	70	22	L,G
29N/06E-20F01	Qva	300	137	--	6	U	A	115	03-16-87	DR	U	--	--	--	L
29N/06E-20F02	Qva	270	55	--	6	H	A	37.1	08-04-92	GS	C	15	5	150	L,Q
29N/06E-20R01	Tb	120	211	--	6	H	C	12	05-22-79	DR	C	--	--	--	L,Q,G
29N/06E-21E05	Qu	190	206	--	6	H	A	105	07-12-78	DR	C	--	--	--	L
29N/06E-21M01	Qva	115	58	--	6	H	A	8.7	08-05-92	GS	C	--	--	--	L,Q,W
29N/06E-22F01	Qu	260	130	--	6	H	A	53	10-11-91	DR	C	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
29N/06E-22K02	Qtb	300	200	--	6	H	A	120	08-17-88	DR	U	--	--	--	L
29N/06E-22N01	Qu	280	234	--	6	H	A	197	08-05-92	GS	C	--	--	--	L,Q
29N/06E-23R01	--	500	110	--	6	H	A	75.3	08-10-92	GS	-	--	--	--	L
29N/06E-23R02	Qtb	520	300	--	6	H	A	190	12-11-87	DR	C	--	--	--	L,Q
29N/06E-23R03	Qva	380	97.5	--	6	H	A	56	04-13-93	GS	U	--	--	--	L
29N/06E-24R01	Qva	460	173	--	6	H	A	33.6	08-06-92	GS	U	--	--	--	L
29N/06E-25C01	Qva	310	80	--	6	S	A	9.8	08-27-92	GS	C	20	30	30	L,Q
29N/06E-25E01	Qvt	465	234	--	6	H	A	198	09-03-87	DR	U	--	--	--	L
29N/06E-25N01	Qva	450	84	--	6	H	A	33	07-08-90	DR	C	--	--	--	L
29N/06E-25N02	Tb	450	97	--	6	U	C	5.0	08-26-92	GS	U	20	20	23	L
29N/06E-25P01	Tb	435	117	--	6	H	C	44	08-06-92	GS	U	26	24	66	L
29N/06E-26B01	Qva	560	220	--	6	H	A	100	04-18-86	DR	U	--	--	--	L
29N/06E-26J01	Tb	540	247	4.5	6	H	C	196	05-17-89	DR	U	10	3	32	L,Q
29N/06E-29C02	Qva	400	120	4.5	10	I	A	39	06-29-89	DR	C	14	15	12	L
29N/06E-29P01	Qtb	70	260	--	8	S	A	--	--	--	-	--	--	--	L,G
29N/06E-31K01	Qvt	260	80	--	6	H	A	--	--	--	U	--	--	--	L
29N/06E-31M01	Qva	280	138	--	6	H	A	101	05-06-92	GS	U	--	--	--	L,Q
29N/06E-32L02	Tb	80	62	4.5	6	H	C	11.3	08-12-92	GS	U	4.8	35	1.7	L
29N/06E-32M01	Tb	100	280	4.5	6	H	C	67.3	08-12-92	GS	U	6	180	0.13	L,G
29N/06E-33R01	Qva	410	115	--	6	H	A	73.7	08-26-92	GS	U	10	25	8.8	L
29N/06E-34G01	Tb	420	215	--	6	H	C	138	08-13-92	GS	C	10	13	47	L,Q
29N/06E-35A01	Qva	480	150	--	6	H	C	100	01-25-88	DR	U	--	--	--	L
29N/06E-36J01	Tb	460	111	--	6	H	C	78.2	06-24-92	GS	C	--	--	--	L
29N/07E-05F01	Qvt	430	68	--	6	H	A	43.2	03-11-93	GS	U	--	--	--	L,Q,G
29N/07E-09K03	Tb	470	18	--	36	U	D	--	--	--	-	--	--	--	L,Q
29N/07E-09K04	Tb	490	131	4.5	6	H	C	14	08-18-92	GS	U	10	80	1.1	L,Q
29N/07E-15M01	Qva	760	260	--	6	H	A	--	--	--	-	--	--	--	L
29N/07E-16H03	Qvt	750	98	--	6	H	A	80.2	06-25-92	GS	U	--	--	--	L,Q
29N/07E-18G01	Qva	370	100	--	6	H	A	41	06-15-89	DR	U	--	--	--	L,G
29N/07E-18G02	Qva	390	80	--	6	H	A	47.1	06-30-92	GS	U	--	--	--	L,Q,G
29N/07E-19B01	Qva	440	210	4.5	6	H	C	118	03-16-93	GS	U	20	5	30	L,Q,G

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
29N/07E-21A01	Qva	610	38	--	6	H	A	6	04-06-87	DR	C	--	--	--	L
29N/07E-21C02	Qva	600	198	--	6	H	A	160	04-20-89	DR	U	--	--	--	L
29N/07E-21E01	Qva	610	225	--	6	H	A	78.9	06-30-92	GS	C	--	--	--	L
29N/07E-21Q01	Qvt	630	52	8	10	R	C	0.7	06-25-92	GS	U	--	--	--	L
29N/07E-22D01	Qvt	750	212	--	6	H	A	192	07-15-92	GS	U	--	--	--	L,Q
29N/07E-27A02	Qva	670	100	--	6	R	A	--	--	--	-	--	--	--	L,Q
29N/07E-27L01	Qvt	550	107	--	6	R	C	--	--	--	U	--	--	--	L
29N/07E-28B03	Qva	680	64	--	6	H	A	40	08-08-86	DR	U	--	--	--	L
29N/07E-28B04	Qva	610	95	--	6	U	C	42	10-01-92	DR	C	8	40	9.1	L
29N/07E-28E01	Qvt	570	95	--	6.6	H	C	19.9	03-11-93	GS	U	1.5	90	0.040	L
29N/07E-28L02	Qvt	690	54.5	--	6	H	A	29	08-18-92	GS	U	--	--	--	L,W
29N/07E-30C01	Qvt	530	254	--	6	H	C	135	03-17-93	GS	U	15	69	13	L,Q,G
29N/07E-31C01	Qtb	340	200	--	6	H	C	--	--	--	-	--	--	--	L,G
29N/07E-31G01	Qvt	340	54	--	6	H	A	--	--	--	U	--	--	--	L
29N/07E-31G02	Qvt	320	47.5	--	6	H	A	16.5	08-10-92	GS	U	--	--	--	L,Q
29N/07E-31N01	Qva	530	132	--	6	H	C	94.7	06-24-92	GS	C	--	--	--	L
29N/07E-32G01	Qva	580	86	--	6	H	A	30	06-03-86	DR	C	--	--	--	L
29N/07E-32M01	Tb	390	300	4.5	6	U	A	71.1	08-17-92	GS	U	--	--	--	L
29N/07E-32M02	Tb	390	145	--	6	H	C	--	--	--	-	--	--	--	L
29N/07E-32M03	Qvt	370	75	--	6	H	C	20.4	08-19-92	GS	U	12	30	25	L,W
29N/07E-33D01	Qva	540	94	--	6	H	A	5.6	03-11-93	GS	C	--	--	--	L,Q
30N/04E-01A05	Qva	440	155	--	6	H	A	121	06-02-92	GS	U	--	--	--	L
30N/04E-01E01	Qva	560	277	--	6	H	C	244	06-04-92	GS	U	11	1	370	L,Q
30N/04E-01N01	Qva	520	257	--	8	P	C	199	11-14-74	DR	U	--	--	--	L
30N/04E-02G01	Qva	510	218	--	6	H	A	192	06-03-92	GS	U	4	4	38	L,G
30N/04E-02H02	Qva	550	260	--	6	H	A	217	06-02-92	GS	U	--	--	--	L
30N/04E-03D03	Qva	440	179	--	6	H	A	135	06-03-92	GS	U	--	--	--	L
30N/04E-03P01	Qva	320	108	--	6	H	A	72.5	06-03-92	GS	U	--	--	--	L,Q
30N/04E-04D01	Qva	340	340	--	6	H	A	286	06-05-92	GS	U	--	--	--	L,Q
30N/04E-05P01	Qtb	440	480	--	6	H	A	392	01-11-86	DR	U	15	28	11	L
30N/04E-05P02	Qu	420	429	--	6	H	A	377	06-08-92	GS	C	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/04E-06L02	Qu	340	480	--	6	H	A	373	06-04-92	GS	C	--	--	--	L,G
30N/04E-06Q03	Qu	400	520	--	6	H	A	--	--	--	-	--	--	--	L
30N/04E-07G02	Qva	60	60	--	8	P	C	27.4	06-09-92	GS	U	--	--	--	L
30N/04E-07G03	Qva	60	45	--	42	P	D	20.1	06-09-92	GS	U	--	--	--	--
30N/04E-07H02	--	450	80	4.5	8	H	A	31.9	06-11-92	GS	-	--	--	--	L
30N/04E-08G01	Qvt	390	55	--	6	H	A	32.4	08-04-92	GS	U	--	--	--	L,Q
30N/04E-08H01	Qva	455	365	--	6	H	C	339	03-14-91	DR	U	9	18	10	L
30N/04E-09M01	Qva	410	363	--	6	H	A	335	04-15-93	GS	U	--	--	--	L,Q
30N/04E-10A01	Qu	310	439	--	8	P	A	--	--	--	-	--	--	--	L,G
30N/04E-10L01	Qva	210	65	--	8	U	C	-7.1	12-12-74	DR	F	--	--	--	L
30N/04E-10L02	Qva	210	94	--	8	P	-	29	04-14-93	GS	C	--	--	--	L
30N/04E-10L03	Qva	210	102	--	8	P	C	20.2	04-14-93	GS	C	280	46	97	L
30N/04E-13Q02	Qva	340	287	--	6	H	C	181	08-03-92	GS	U	5	2	180	L
30N/04E-14J02	Qva	250	133	--	5	H	-	96.3	07-30-92	GS	U	--	--	--	L,G
30N/04E-14K02	Qva	250	178	--	6	H	A	111	07-30-92	GS	U	--	--	--	L,Q
30N/04E-14R01	Qva	170	100	--	6	H	A	11.2	08-05-92	GS	U	--	--	--	L
30N/04E-15J01	Qu	120	131	--	6	H	A	--	--	--	-	--	--	--	L
30N/04E-15R02	Qu	100	120	--	6	H	A	--	--	--	-	--	--	--	L
30N/04E-17B19	Qu	110	134	--	6	P	C	97.1	08-06-92	GS	C	16	23	17	L
30N/04E-17K03	Qva	170	138	--	6	P	A	104	08-03-92	GS	U	--	--	--	L
30N/04E-17R02	Qva	290	230	--	6	H	A	195	07-29-92	GS	U	2	67	0.23	L,Q,W
30N/04E-21G01	Qu	170	375	--	6	P	C	152	07-28-92	GS	C	30	30	25	L
30N/04E-21Q01	Qu	20	20	--	36	H	D	11.6	07-29-92	GS	C	10	7	15	L
30N/04E-22H01	Qu	120	98	--	6	H	A	25.6	07-28-92	GS	C	--	--	--	L
30N/04E-22J05	Qu	100	220	--	6	H	A	120	04-24-91	DR	U	--	--	--	L
30N/04E-22Q01	Qu	95	311	--	8	P	C	51.8	08-04-92	GS	C	315	165	30	L,Q
30N/04E-23F01	Qva	260	99	--	6	H	C	63.7	07-28-92	GS	U	--	--	--	L,G
30N/04E-23F02	Qva	260	173	--	6	H	C	117	07-29-92	GS	U	10	3	98	L
30N/04E-24A01	Qtb	460	293	--	6	H	A	261	08-17-92	GS	U	--	--	--	L,Q
30N/04E-24F01	Qva	220	93	--	6	H	A	61.8	08-06-92	GS	C	--	--	--	L,W

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/04E-25Q01	Qva	210	137	--	6	H	C	77.2	04-15-93	GS	U	43	35	11	L,Q
30N/04E-25R01	Qvt	230	160	--	8	I	C	94.1	04-15-93	GS	U	40	8	39	L
30N/04E-26E01	Qva	50	140	--	6	H	A	-2.2	07-29-92	GS	F	55	70	48	L,G
30N/04E-28A01	Qu	60	163	--	6	P	C	40.5	08-05-92	GS	C	--	--	--	L
30N/04E-35R01	Qu	110	171	--	6	P	C	128	04-14-93	GS	U	--	--	--	L
30N/04E-35R04	Qva	150	178	--	6	H	A	137	10-10-85	DR	U	20	17	28	L,Q,G
30N/04E-36L06	Qu	200	300	--	6	H	A	201	07-27-92	GS	C	--	--	--	L,Q,G
30N/04E-36P14	Qu	130	146	--	6	H	A	119	07-27-92	GS	C	--	--	--	L
30N/05E-01D03	Qva	385	125	--	6	H	A	85.9	06-16-92	GS	C	--	--	--	L
30N/05E-01G01	Qva	420	60	--	6	H	A	38.9	06-16-92	GS	C	--	--	--	L
30N/05E-02B02	Qu	310	237	--	6	H	A	124	06-16-92	GS	C	--	--	--	L
30N/05E-02C01	Qvt	360	21	--	36	U	D	8.3	09-02-92	GS	U	--	--	--	--
30N/05E-02C02	Qva	360	100	--	6	H	A	21.3	09-02-92	GS	C	--	--	--	L,Q
30N/05E-02H01	Qva	370	127	--	6	H	C	80	06-17-92	GS	C	10	26	17	L
30N/05E-02P01	Qva	370	200	--	6	H	A	134	06-16-92	GS	U	--	--	--	L
30N/05E-03J01	Qu	90	322	--	6	C	A	43	06-17-92	GS	C	6	261	0.22	L
30N/05E-03J02	Qal	90	30	--	6	I	A	3	05-19-88	DR	U	--	--	--	L,Q
30N/05E-03J03	Qvr	90	27	--	6	I	A	--	--	--	U	--	--	--	L
30N/05E-04L02	Qvr	90	30	--	36	I	D	4.4	03-10-93	GS	U	100	3	340	L
30N/05E-05C02	Qvr	90	29	--	36	U	D	1.4	03-10-93	GS	U	--	--	--	L
30N/05E-05E02	Qvr	93	26	--	36	U	D	6.1	10-18-74	DR	U	56	8	150	L
30N/05E-06G04	Qva	175	78	--	6	H	C	46.7	06-18-92	GS	C	12	4	180	L,Q
30N/05E-06L06	Qva	260	125	--	6	H	A	58	06-18-92	GS	U	10	54	3.1	L
30N/05E-07F08	Qva	320	210	--	6	H	A	179	06-18-92	GS	C	--	--	--	L,Q
30N/05E-07G02	Qvt	130	26.5	--	36	H	D	15.5	03-03-93	GS	U	--	--	--	--
30N/05E-07H02	Qu	80	105	--	6	H	A	--	--	--	F	--	--	--	L
30N/05E-08J02	Qu	65	537	--	6	C	A	--	--	--	-	--	--	--	L
30N/05E-08K01	Qvr	75	20	--	36	H	D	5.6	06-29-92	GS	U	50	5	450	L,Q,W
30N/05E-08L01	Qvr	75	12	--	36	H	D	4.2	03-03-93	GS	U	--	--	--	--
30N/05E-08L04	Qu	75	374	--	6	H	A	-13.6	09-27-86	DR	F	--	--	--	L
30N/05E-09K01	Qvr	70	32	--	36	H	D	18.1	06-30-92	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/05E-10E03	Qtb	80	27	--	36	H	D	10.7	06-30-92	GS	U	30	6	130	L
30N/05E-10F03	Qu	80	260	--	8	P	A	-1	05-28-86	DR	F	125	159	13	L
30N/05E-11Q02	Qu	180	251	--	6	H	A	56.6	07-07-92	GS	C	--	--	--	L
30N/05E-11Q03	Qu	180	211	--	6	H	A	66.5	06-30-92	GS	C	--	--	--	L,Q
30N/05E-12L01	Qva	380	80	--	6	H	A	47.6	07-01-92	GS	C	--	--	--	L
30N/05E-12N01	Qva	380	82	--	6	H	A	49.2	07-06-92	GS	C	--	--	--	L
30N/05E-12R01	Qva	425	55	--	6	H	A	27.3	07-06-92	GS	C	--	--	--	L
30N/05E-13C01	Qva	400	120	--	6	H	A	83.3	07-07-92	GS	C	--	--	--	L
30N/05E-13C02	Qva	405	65	--	6	H	A	35.4	07-07-92	GS	C	--	--	--	L
30N/05E-14B01	Qtb	180	250	--	6	H	C	66.5	07-08-92	GS	U	30	30	61	L
30N/05E-14M01	Qu	105	120	--	6	H	A	60.4	07-08-92	GS	C	--	--	--	L
30N/05E-15B01	Qva	105	76	5	6	H	A	30	07-08-92	GS	C	5	32	7.5	L
30N/05E-15H01	Qva	105	103	--	6	H	A	34.4	07-08-92	GS	C	--	--	--	L,Q
30N/05E-15H02	Qva	105	99	--	6	H	A	22	06-15-89	DR	C	15	2	400	L
30N/05E-16J01	Qvr	60	36	--	36	H	D	17.3	03-04-93	GS	U	--	--	--	L,Q
30N/05E-16M01	Qvr	50	37	--	36	H	D	20	07-11-79	DR	U	--	--	--	L
30N/05E-17G01	Qu	60	640	5	6	C	A	--	--	--	-	--	--	--	L
30N/05E-20K05	Qva	30	38	--	6	H	A	20.7	07-10-92	GS	U	5	10	13	L,Q
30N/05E-21D02	Qvr	45	37.5	--	36	H	D	28.9	07-09-92	GS	U	40	5	230	L
30N/05E-22A01	Qu	60	42	--	36	Z	D	21	07-06-44	DR	C	--	--	--	--
30N/05E-22D01	Qvr	50	16.5	--	42	H	D	12.6	03-04-93	GS	U	--	--	--	--
30N/05E-23J02	Qu	320	320	--	6	H	A	135	07-13-92	GS	C	--	--	--	L
30N/05E-24M01	Qva	350	303	--	6	H	C	140	07-14-92	GS	C	10	40	11	L,Q
30N/05E-25D01	Qva	420	172	--	6	H	C	135	07-14-92	GS	C	10	20	27	L
30N/05E-25E01	Qva	400	160	--	6	H	A	86.1	07-15-92	GS	C	--	--	--	L
30N/05E-25M01	Qva	380	183	--	6	H	A	106	07-14-92	GS	C	8	70	7.0	L
30N/05E-25M02	Qva	380	125	--	6	H	A	91.3	07-15-92	GS	C	--	--	--	L,Q
30N/05E-26P01	Qu	220	146	--	6	H	C	118	07-17-92	GS	C	15	22	42	L,Q
30N/05E-27L01	Qu	50	97	--	36	U	D	1.6	03-03-93	GS	C	--	--	--	--
30N/05E-28H01	Qal	40	30	--	36	U	D	28	08-00-44	DR	U	8	20	3.6	--

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/05E-29B03	Qal	25	23.7	--	35	U	D	11.8	03-04-93	GS	U	--	--	--	L
30N/05E-29F07	Qvr	25	25	--	36	H	D	12.4	07-10-92	GS	U	20	7	96	L,Q
30N/05E-31B10	Qva	60	89	--	6	H	C	48.1	07-13-92	GS	U	24	9	70	Q
30N/05E-31B11	Qtb	15	140	--	4	H	A	12.2	07-14-92	GS	C	--	--	--	L,G
30N/05E-34F01	Qal	15	16.8	--	36	U	D	1.8	03-18-93	GS	U	--	--	--	--
30N/05E-35H02	Qva	380	100	--	6	H	A	74.9	07-16-92	GS	C	--	--	--	L
30N/05E-35J01	Qva	370	175	--	6	H	A	83.8	07-16-92	GS	C	10	41	11	L,G
30N/05E-35N02	Qu	260	240	--	6	H	A	142	07-16-92	GS	C	--	--	--	L,Q,G
30N/05E-36D01	Qva	415	160	--	6	H	A	131	07-01-92	GS	C	--	--	--	L
30N/05E-36E04	Qva	425	190	--	6	H	A	131	07-15-92	GS	C	--	--	--	L,G
30N/05E-36J01	Qvt	360	58	--	6	H	A	29.6	07-16-92	GS	U	--	--	--	L,Q
30N/05E-36Q01	Qva	400	156	--	6	H	C	113	07-15-92	GS	C	15	30	31	L
30N/06E-01F01	Qvr	380	60	--	6	H	A	31.6	03-03-93	GS	U	--	--	--	L
30N/06E-02D01	Qvr	285	70	--	6	H	A	4	08-28-89	DR	U	--	--	--	L
30N/06E-02G01	Qva	310	102	--	6	H	C	42	09-02-87	DR	C	5	50	6.1	L
30N/06E-02L01	Tb	295	15	--	36	H	D	10.4	06-30-92	GS	U	--	--	--	L,G
30N/06E-02N01	Tb	325	143	4	6	H	C	18.3	07-10-92	GS	U	0.5	127	0.010	L
30N/06E-02Q02	Qvr	305	100	--	4.5	H	A	52.7	07-06-92	GS	U	11	10	15	L,Q,G
30N/06E-03B01	Tb	265	120	--	6	H	A	51	07-01-92	GS	U	--	--	--	L,G
30N/06E-03K01	Qvr	250	13	--	6	H	B	10.2	07-09-92	GS	U	--	--	--	L,Q
30N/06E-03N01	Qvt	375	62	--	6	H	A	28.2	07-09-92	GS	U	--	--	--	L
30N/06E-03N02	Tb	375	200	--	6	H	A	20	08-18-88	DR	C	--	--	--	L
30N/06E-04A01	Qvt	450	28	--	36	H	D	7.1	02-19-93	GS	U	--	--	--	--
30N/06E-06E02	Qva	425	79	--	6	H	C	45.3	07-16-92	GS	C	16	6	160	L,Q
30N/06E-07D01	Qva	450	82	--	6	H	A	41	07-03-90	DR	C	--	--	--	L
30N/06E-08G01	Qva	460	64	--	6	H	C	42.6	03-10-93	GS	C	20	5	200	L,Q,G
30N/06E-10D01	Tb	350	112	--	6	H	A	38.5	07-08-92	GS	U	--	--	--	L
30N/06E-10K01	Qvt	300	120	--	6	H	A	43.7	07-15-92	GS	U	--	--	--	L,Q
30N/06E-10M02	Qva	420	54	--	6	H	A	15	07-15-92	GS	C	8	20	18	L
30N/06E-11A05	Tb	300	300	--	6	H	A	90	08-28-86	DR	U	--	--	--	L,Q,G
30N/06E-11G01	Qvt	220	80	--	6	H	A	53.1	07-06-92	GS	U	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/06E-12R01	Qvt	260	17.5	--	36	H	D	10.2	07-09-92	GS	U	--	--	--	L
30N/06E-13C03	Qva	275	156	--	6	H	A	127	07-08-92	GS	U	--	--	--	L
30N/06E-13P01	Qvr	340	38	--	6	H	C	14.3	07-28-92	GS	U	4	16	5.1	L
30N/06E-14J02	Tb	260	58	--	6	U	C	39.6	07-07-92	GS	U	10	1	310	L
30N/06E-14K02	--	340	200	--	6	H	C	27	07-28-92	GS	-	--	--	--	L
30N/06E-14K06	Qva	340	76	--	6	H	C	38	11-21-78	DR	C	20	10	120	L,Q
30N/06E-15D01	Qvt	370	21	--	60	H	D	1.3	03-09-93	GS	U	--	--	--	--
30N/06E-16M01	Qvt	450	82	--	6	H	C	58	05-14-87	DR	U	10	4	150	L,Q
30N/06E-16N01	Qva	365	98	--	6	H	A	71	07-10-90	DR	C	--	--	--	L
30N/06E-17C02	Qva	430	40	--	6	H	A	13.5	07-17-92	GS	C	--	--	--	L
30N/06E-17L01	Qva	410	108	--	6	H	C	76	05-30-88	DR	C	18	14	79	L,G
30N/06E-17N01	Qva	420	120	--	6	H	A	88	07-12-90	DR	C	--	--	--	L
30N/06E-17P04	Qva	405	86	--	6	H	A	72	05-18-88	DR	C	--	--	--	L
30N/06E-17P05	Qva	405	88	--	6	H	A	70.4	07-27-92	GS	C	--	--	--	L,G
30N/06E-18E02	Qvr	390	35	--	6	H	A	5.3	07-15-92	GS	U	--	--	--	L
30N/06E-18N02	Qva	390	80	--	6	H	A	54	05-10-93	DR	U	--	--	--	L,Q
30N/06E-19A02	Qva	410	119	--	6	H	A	76	06-15-83	DR	C	--	--	--	L
30N/06E-19D01	Qva	380	60	--	6	H	C	35.8	07-14-92	GS	C	12	6	120	L
30N/06E-20E01	Qva	400	100	--	6	H	A	64.1	07-29-92	GS	C	--	--	--	L,G
30N/06E-20J01	Qva	350	60	--	6	H	A	14.9	07-30-92	GS	C	--	--	--	L,Q
30N/06E-20K02	Qva	375	87	--	6	H	C	58	05-24-89	DR	C	--	--	--	L
30N/06E-20M01	Qvt	410	24	--	24	U	D	--	--	--	U	--	--	--	--
30N/06E-21D01	Qva	405	80	--	6	H	A	59.7	07-28-92	GS	U	--	--	--	L
30N/06E-21F01	Qva	370	139	--	6	H	A	70.8	08-25-92	GS	C	--	--	--	L
30N/06E-21H01	Qva	300	86	--	6	H	A	3.0	08-24-92	GS	C	--	--	--	L
30N/06E-21K01	Qva	345	159	--	6	H	C	62	07-08-86	DR	C	10	67	9.1	L
30N/06E-22N04	Qva	250	77	--	6	H	C	3.6	08-04-92	GS	C	30	10	160	L,Q,W
30N/06E-22N05	Qva	270	123	--	6	H	C	6.9	03-14-88	DR	C	--	--	--	L
30N/06E-23C01	Qvr	290	33	--	6	H	C	15	03-30-90	DR	U	--	--	--	L,Q
30N/06E-23E01	Qvr	285	20	--	36	H	D	11.1	07-29-92	GS	U	12	4	31	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/06E-23E02	Qvr	250	42	--	36	C	D	11	02-20-89	DR	U	--	--	--	L
30N/06E-24C01	Qal	340	26	--	36	H	D	19	12-07-78	DR	U	--	--	--	L
30N/06E-25A01	Qvt	360	100	--	6	H	A	3	06-21-90	DR	U	--	--	--	L
30N/06E-27B01	Qal	240	14	--	36	H	D	13.5	08-03-92	GS	U	--	--	--	L
30N/06E-27C01	Qva	250	40	--	6	H	A	9.9	07-28-92	GS	U	--	--	--	L,Q
30N/06E-28B02	Qva	310	163	--	6	H	C	50.4	07-30-92	GS	C	12	68	7.5	L
30N/06E-28B03	Qva	310	164	--	6	H	C	48.2	07-27-92	GS	C	20	8	150	L
30N/06E-28J07	Qvr	235	20	--	6	H	A	7.6	07-19-92	GS	U	--	--	--	L
30N/06E-28J08	Qal	235	40	--	6	H	A	6.8	07-29-92	GS	U	--	--	--	L
30N/06E-28K01	Qvt	255	102	--	6	H	C	20.1	07-17-92	GS	U	4	82	0.70	L
30N/06E-28N01	Qva	260	112	--	6	H	A	8.3	07-28-92	GS	C	--	--	--	L,Q
30N/06E-29E01	Qva	350	78.5	--	6	H	A	52	11-27-89	DR	U	--	--	--	L,G
30N/06E-29G01	Qva	330	45	--	6	H	A	8	07-01-86	DR	C	--	--	--	L
30N/06E-30J01	Qva	390	120	--	6	H	A	59.9	08-25-92	GS	C	--	--	--	L
30N/06E-30Q01	Qva	350	58	--	6	H	A	5.5	07-29-92	GS	C	--	--	--	L,Q
30N/06E-31B02	Qvt	365	60	--	4.5	H	A	25.9	07-16-92	GS	U	12	3	64	L
30N/06E-31F01	Qva	325	65	--	6	H	-	7	06-04-76	DR	C	20	10	120	L
30N/06E-31J01	Qva	340	190	--	6	H	C	50	03-27-80	DR	C	10	75	8.2	L,Q
30N/06E-31J02	Qva	330	226	--	6	H	A	73.4	07-14-92	GS	C	--	--	--	L
30N/06E-31J03	Qva	330	207	--	6	H	A	37	04-27-79	DR	C	--	--	--	L,G
30N/06E-31J04	Qva	330	114	--	6	H	A	33.4	07-15-92	GS	C	7	80	5.4	L
30N/06E-32D02	Qva	375	76	--	6	H	C	40	06-14-77	DR	C	10	12	51	L,G
30N/06E-32E02	Qva	355	50	--	6	H	A	22.9	07-09-92	GS	C	--	--	--	L
30N/06E-32G01	Qva	300	140	--	6	H	A	24.1	07-16-92	GS	C	--	--	--	L,G
30N/06E-32P03	Qva	305	82	--	6	H	-	11	08-22-81	DR	C	16	39	31	L,G
30N/06E-33A02	Qvr	220	18	--	36	H	D	8.4	07-07-92	GS	U	17	4	43	L
30N/06E-33J01	Qva	330	88	--	6	H	A	55	07-08-92	GS	U	--	--	--	L,Q
30N/06E-33Q01	Qvt	330	116	--	6	H	A	67.9	07-08-92	GS	U	--	--	--	L
30N/06E-33R01	Qva	375	131	--	6	H	A	94	06-28-74	DR	C	10	20	31	L
30N/06E-34D02	Qvr	240	12	--	36	H	D	7	11-14-74	DR	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/06E-34N02	Qva	350	131	--	6	H	A	95	01-18-81	DR	C	--	--	--	L
30N/06E-34N03	Qva	370	190	--	6	H	A	129	07-06-92	GS	C	--	--	--	L
30N/06E-34N04	Qva	370	195	--	6	H	A	124	07-19-92	GS	U	--	--	--	L,G
30N/06E-36A01	Tb	645	245	--	6	H	A	210	10-17-84	DR	U	2	10	0.98	L
30N/06E-36A02	Tb	580	234	--	6	I	-	210	07-16-92	GS	U	--	--	--	L
30N/06E-36A03	Qvt	580	42	--	36	H	D	36	03-01-90	DR	U	--	--	--	L
30N/06E-36B01	Tb	600	358	4	6	U	A	108	06-30-92	GS	C	--	--	--	L,G
30N/06E-36E01	Tb	710	298	5	6	H	C	143	07-01-92	GS	U	--	--	--	L,Q,G
30N/06E-36J01	Qvt	560	34	--	6	H	A	2	05-02-91	DR	U	--	--	--	L
30N/06E-36N03	Tb	725	160	--	4.5	H	A	26	07-07-92	DR	C	12	2	170	L
30N/07E-01L01	Qvr	1040	186	--	6	H	A	138	07-10-92	GS	U	--	--	--	L,G
30N/07E-01R02	Qal	940	40	--	6	H	A	22.9	07-10-92	GS	U	--	--	--	L,Q,G
30N/07E-04D01	Qal	490	26	--	6	H	C	6.8	07-14-92	GS	U	--	--	--	L
30N/07E-04F02	Qal	510	40	--	6	H	A	13.5	07-13-92	GS	U	--	--	--	L
30N/07E-05G01	--	530	297	4.5	6	H	A	53.7	07-13-92	GS	-	--	--	--	L,G
30N/07E-05H01	Tb	530	300	--	6	U	C	258	09-11-86	DR	U	1	42	0.0066	L,G
30N/07E-05H02	Qvr	530	60	--	6	H	C	32.3	07-13-92	GS	U	5	15	7.1	L
30N/07E-06H03	Tb	420	95	--	6	H	C	--	--	--	F	--	--	--	L,G
30N/07E-06J02	Qva	570	246	--	6	P	A	129	07-17-92	GS	C	--	--	--	L,Q,G
30N/07E-06N01	Tb	350	90	--	6	H	A	7.0	06-30-92	GS	U	--	--	--	L,G
30N/07E-06P01	--	440	120	--	6	U	A	23.4	07-14-92	GS	-	--	--	--	L
30N/07E-06R01	Tb	520	186	--	6	H	A	100	07-14-92	GS	U	--	--	--	L
30N/07E-06R02	--	520	45.5	--	-	U	D	--	--	--	-	--	--	--	L
30N/07E-06R03	Qvr	510	37	30	36	H	D	26.6	07-15-92	GS	U	--	--	--	L
30N/07E-07A01	Tb	540	145	--	6	U	A	44	09-01-87	DR	U	--	--	--	L,G
30N/07E-07P01	Qvr	450	80	--	6	H	A	52.9	07-15-92	GS	U	--	--	--	L
30N/07E-08E01	Tb	420	300	6	8	U	A	--	--	--	-	--	--	--	L,G
30N/07E-08P01	Qvt	450	180	--	8	N	A	136	07-16-92	GS	U	--	--	--	L,G
30N/07E-17R01	Tb	550	290	4.5	6	H	A	180	11-29-90	DR	U	--	--	--	L
30N/07E-18C03	Qvr	470	70	--	6	H	A	43	07-15-92	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohydrologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construction method	Water level			Ground-water condition	Yield (gallons per minute)	Drawdown (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
30N/07E-18C04	Qvr	470	70	--	6	H	A	40	02-08-83	DR	U	--	--	--	L
30N/07E-18F01	Qva	430	115	--	6	H	A	66.2	07-17-92	GS	C	--	--	--	L,Q
30N/07E-18H01	Qvr	480	112	--	6	U	A	85	07-08-89	DR	U	--	--	--	L
30N/07E-18P04	Qva	410	163	--	10	P	C	42.5	07-16-92	GS	C	180	70	52	L
30N/07E-18P06	--	410	171	8	12	P	-	43	09-23-92	DR	-	--	--	--	L,Q
30N/07E-19A02	Qvt	460	102	--	6	H	A	10.5	07-29-92	GS	U	--	--	--	L
30N/07E-19F01	Qvr	390	37.5	18	36	H	D	21.1	07-28-92	GS	U	--	--	--	L
30N/07E-19L02	Qvr	390	39	--	6	H	A	29	06-07-79	DR	U	10	10	61	L
30N/07E-20C01	Qvt	530	100	--	6	H	C	60.1	07-30-92	GS	U	10	12	21	L
30N/07E-20D02	Tb	550	237	4.5	6	H	A	59.3	07-29-92	GS	U	--	--	--	L,Q,G,W
30N/07E-20D03	--	650	110	4	6	H	C	75.3	07-29-92	GS	-	--	--	--	L,G
30N/07E-20K01	Tb	620	480	4.5	6	H	A	17.8	02-18-92	GS	U	--	--	--	L
30N/07E-20K02	Qvt	520	15	--	36	H	D	7.9	02-18-92	GS	U	20	3	190	L,Q
30N/07E-20K03	Tb	550	100	--	6	U	A	34	07-28-92	GS	U	--	--	--	L
30N/07E-28E02	Tb	510	89	--	6	U	C	2	03-31-86	DR	U	4	77	3.2	L
30N/07E-28E03	Tb	530	31	--	6	U	C	10	10-28-85	DR	U	3	10	6.3	L
30N/07E-28M01	Tb	510	131	--	6	U	C	30	09-15-85	DR	U	--	--	--	L
30N/07E-29G01	Tb	550	227	4	6	H	A	220	10-11-89	DR	U	--	--	--	L,G
30N/07E-29G02	Tb	550	295	4.5	6	H	A	96.1	07-29-92	GS	U	--	--	--	L,Q
30N/07E-30F01	Qvt	390	61	--	6	H	C	28.6	07-30-92	GS	U	30	10	180	L
30N/07E-30M01	Qva	350	53	--	6	H	A	9.4	07-16-92	GS	C	--	--	--	L
30N/07E-30P01	Tb	540	170	4.5	6	H	A	119	06-20-90	DR	U	--	--	--	L
30N/07E-30P01D1	Tb	540	360	4.5	6	H	A	84.5	07-30-92	GS	U	--	--	--	L,Q,G
30N/07E-31C02	Qva	550	75	--	67	P	A	55.4	07-30-92	GS	U	15	11	7.5	L
30N/07E-31F03	Qva	570	210	--	6	H	A	185	08-03-92	GS	C	--	--	--	L
30N/07E-32E01	Qvt	510	147	--	6	H	A	124	07-30-92	GS	U	--	--	--	L,G
30N/07E-32L01	Qvt	470	98	--	6	H	A	77.3	07-30-92	GS	U	--	--	--	L,G
30N/07E-32L02	Qvt	470	100	--	6	U	A	78	08-17-90	DR	U	--	--	--	L
30N/08E-08J03	Qal	935	20	--	6	P	C	9	07-09-74	DR	U	--	--	--	L
30N/08E-08J04	Qvr	940	204	--	6	P	A	--	--	--	U	--	--	--	L,Q,G

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/03E-13J01	Qu	160	198	--	6	P	A	--	--	--	-	--	--	--	L
31N/03E-13R01	Qu	170	186	--	6	P	A	150	08-20-92	GS	C	--	--	--	L
31N/03E-24G01	Qva	120	115	--	6	H	C	87.2	08-21-92	GS	U	15	4	100	L,Q
31N/03E-24H01	Qu	170	210	--	6	H	C	153	08-20-92	GS	C	10	10	31	L
31N/03E-24H02	Qu	180	195	--	6	H	C	157	08-20-92	GS	C	12	5	120	L
31N/03E-24R01	Qu	190	236	--	6	H	C	191	08-20-92	GS	C	28	10	140	L,W
31N/03E-25A03	Qu	290	598	--	6	P	A	268	04-17-91	DR	C	--	--	--	L
31N/03E-25H01	Qu	205	540	--	6	U	A	207	08-21-92	GS	C	35	75	13	L
31N/03E-25H02	Qu	205	560	--	6	P	A	205	08-21-92	GS	C	35	270	3.2	L
31N/03E-25H03	Qu	160	230	--	6	H	A	149	08-21-92	GS	C	40	28	74	L
31N/03E-25H04	Qu	190	235	--	6	H	A	182	08-21-92	GS	C	2.5	40	1.6	L
31N/03E-36B01	Qu	10	75	--	8	P	C	0.5	02-18-92	GS	C	--	--	--	--
31N/03E-36B04	Qu	10	82	--	6	I	-	0.5	02-18-92	GS	C	--	--	--	Q
31N/04E-01L01	--	30	23	--	1.25	U	V	--	--	--	-	--	--	--	--
31N/04E-02M01	Qu	110	540	--	6	S	A	116	08-03-92	GS	U	--	--	--	L,G
31N/04E-02N02	Qva	170	76	--	6	H	C	49.5	08-11-92	GS	U	12	9	32	L
31N/04E-03F01	Qu	90	125	--	6	S	A	72	09-19-83	DR	C	--	--	--	L
31N/04E-03F02	Qu	90	398	--	6	U	A	--	--	--	-	--	--	--	L
31N/04E-03K01	Qu	110	295	--	6	U	A	33.8	08-04-92	GS	C	10	40	0.92	L
31N/04E-03L04	Qvr	110	25	--	36	H	D	11.5	08-05-92	GS	U	80	4	300	L
31N/04E-03L05	Qvr	110	25	--	36	S	D	15.7	08-04-92	GS	U	40	6	190	L,Q
31N/04E-03P02	Qva	170	128	--	6	H	A	17.1	08-03-92	GS	C	--	--	--	L
31N/04E-04L02	Qva	210	68	--	36	H	D	55.5	08-03-92	GS	C	40	5	820	L
31N/04E-04L03	Qva	270	79	--	6	H	A	52.8	08-03-92	GS	U	--	--	--	L,Q
31N/04E-04M01	Qva	320	153	--	6	H	A	113	08-05-92	GS	U	--	--	--	L
31N/04E-05H01	Qal	30	27.5	36	48	H	C	22	01-13-93	GS	U	8	6	41	L
31N/04E-05K01	Qu	330	325	--	4.5	H	A	146	09-17-90	DR	C	--	--	--	L
31N/04E-05L01	Qu	310	283	--	6	H	A	248	08-05-92	GS	U	--	--	--	L,Q
31N/04E-05M01	Qu	190	157	--	6	H	A	126	08-05-92	GS	C	--	--	--	L
31N/04E-06R01	Qva	160	85	--	6	H	A	57	04-00-85	DR	U	20	15	16	L
31N/04E-07H03	Qva	160	119	--	6	H	A	94	08-06-92	GS	U	15	3	140	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/04E-07L02	Qu	170	240	--	6	P	C	163	07-05-78	DR	U	35	21	16	L
31N/04E-07L02D1	Qu	170	349	6	6.6	P	A	146	05-12-83	DR	U	50	5	57	L
31N/04E-07N01	Qtb	170	322	--	6	P	A	152	08-05-92	GS	U	--	--	--	L
31N/04E-07N02	Qu	170	337	--	6.6	P	A	135	04-26-83	DR	C	--	--	--	L,Q
31N/04E-08B01	Qva	370	317	--	6	H	A	256	08-10-92	GS	U	--	--	--	L
31N/04E-08E02	Qva	230	144	--	6	H	A	95.2	08-06-92	GS	U	--	--	--	L,W
31N/04E-09C01	Qva	330	199	--	6	H	C	143	02-28-91	DR	U	15	10	40	L
31N/04E-09E01	Qu	390	333	--	6	H	A	270	08-10-92	GS	C	--	--	--	L
31N/04E-09K02	Qva	370	260	--	6	H	A	185	03-17-91	DR	U	--	--	--	L
31N/04E-10G04	Qva	170	38	--	36	H	D	9.2	08-10-92	GS	C	50	15	320	L,Q
31N/04E-10K01	Qva	170	107	--	6	H	A	11.1	08-10-92	GS	C	--	--	--	L
31N/04E-10Q01	Qva	240	80	--	6	H	A	-1.6	08-13-92	GS	F	--	--	--	L
31N/04E-11D01	Qu	240	275	--	6	U	A	216	08-14-92	DR	C	--	--	--	L,G
31N/04E-11E04	Qva	230	88	--	6	H	A	70.7	08-11-92	GS	C	--	--	--	L
31N/04E-11L01	Qu	250	472	--	6	H	A	218	05-02-89	DR	C	--	--	--	L,G
31N/04E-12P01	--	150	150	--	6	H	A	105	08-12-92	GS	-	--	--	--	L
31N/04E-12P02	Qva	150	120	--	6	H	A	87.2	08-11-92	GS	U	--	--	--	L,Q
31N/04E-13C03	Qva	180	160	--	6	H	A	132	08-11-92	GS	U	--	--	--	L
31N/04E-13F01	Qu	210	213	--	6	U	C	150	08-11-92	GS	C	19	7	130	L
31N/04E-14K02	Qtb	170	160	4.5	6	H	A	--	--	--	F	--	--	--	L,G
31N/04E-14L01	Qvt	190	9	--	36	H	D	3.4	08-12-92	GS	U	3	4	7.7	L,Q
31N/04E-14M03	Qva	260	98	--	6	H	A	5.4	08-12-92	GS	C	25	1	1,400	L
31N/04E-15B01	Qva	300	82	--	6	H	A	11.1	08-13-92	GS	C	--	--	--	L
31N/04E-15K01	Qva	360	64	--	6	H	A	18.6	09-29-92	GS	C	--	--	--	L
31N/04E-15N03	Qva	470	124	--	6	H	A	70.9	08-12-92	GS	C	--	--	--	L,W
31N/04E-15P02	Qva	450	105	--	6	H	A	74.8	08-13-92	GS	U	--	--	--	L
31N/04E-15P03	Qva	450	98	--	6	H	A	73	09-04-92	DR	C	--	--	--	L
31N/04E-15Q04	Qva	450	55	--	6	H	C	29.4	08-17-92	GS	C	20	7	140	L
31N/04E-16P01	Qva	350	150	--	6	H	C	120	08-17-92	GS	U	7	20	7.5	L
31N/04E-16Q02	Qva	390	60	--	6	H	A	26.6	08-17-92	GS	U	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/04E-16R03	Qva	440	120	--	6	H	C	67.9	08-17-92	GS	C	10	20	22	L
31N/04E-17E01	Qva	250	156	--	6	H	C	136	08-18-92	GS	U	10	3	90	L
31N/04E-18E01	Qu	180	210	--	6	P	A	136	08-18-92	GS	C	30	56	13	L,Q
31N/04E-18G01	Qu	240	453	--	6	H	A	231	08-18-92	GS	U	6	20	2.8	L
31N/04E-19F02	Qvt	190	19.5	--	36	U	D	12	09-25-91	DR	U	10	6	46	L
31N/04E-19P01	Qu	290	414	--	6	H	C	279	10-27-91	DR	C	10	60	10	L
31N/04E-19P01D1	Qu	290	573	--	6	H	C	248	08-18-92	GS	C	5	200	0.86	L
31N/04E-20E01	Qu	310	315	--	6	H	C	243	08-19-92	GS	C	10	20	22	L,Q
31N/04E-20N01	Qu	310	252	--	6	H	A	213	09-29-92	GS	C	--	--	--	L
31N/04E-20P01	Qva	230	15	--	36	U	D	3.9	08-19-92	GS	U	20	10	20	L
31N/04E-21A02	Qva	410	83	--	6	H	A	21	11-28-91	DR	C	--	--	--	L
31N/04E-21A03	Qva	450	124	--	6	H	A	72.4	08-19-92	GS	C	20	11	87	L
31N/04E-21A04	Qva	450	120	--	6	H	A	67	06-09-90	DR	C	--	--	--	L
31N/04E-21L01	Qvr	390	14	--	-	U	D	3.6	02-17-93	GS	U	--	--	--	--
31N/04E-21Q01	Qva	370	180	--	10	P	-	135	09-30-92	GS	U	165	9	130	L
31N/04E-22H01	Qva	450	160	--	6	H	A	112	08-19-92	GS	U	--	--	--	L,G
31N/04E-22H02	Qva	470	160	--	6	H	A	122	08-20-92	GS	U	--	--	--	L,Q
31N/04E-22L02	Qvt	420	180	6	8	P	C	95.6	09-30-92	GS	U	218	24	65	L
31N/04E-23N01	Qva	430	157	--	6	P	A	115	02-17-93	GS	U	15	25	6.3	L
31N/04E-24M02	Qva	300	70	--	6	H	C	22	08-20-92	GS	C	--	--	--	L
31N/04E-25G01	Qva	280	120	--	6	H	C	27.3	09-29-92	GS	C	20	43	20	L
31N/04E-25K01	Qva	330	81	--	6	H	C	46.1	09-29-92	GS	U	20	15	32	L
31N/04E-25M04	Qva	430	200	--	6	H	A	144	09-29-92	GS	U	--	--	--	L,Q
31N/04E-26L01	Qva	550	330	--	12	P	C	225	09-30-92	GS	U	300	51	100	L,Q,G
31N/04E-27K01	Qva	500	256	--	6	H	A	193	03-10-93	GS	U	--	--	--	L
31N/04E-28P02	Qva	410	79	--	6	H	D	46.7	08-20-92	GS	C	10	2	130	L
31N/04E-29D01	Qu	300	402	--	6	H	A	328	10-31-90	DR	C	--	--	--	L
31N/04E-29D02	Qu	290	460	--	6	U	A	297	09-30-92	GS	C	--	--	--	L
31N/04E-29J03	Qva	450	191	--	6	H	A	174	09-30-92	GS	U	--	--	--	L
31N/04E-29R01	Qva	410	63	--	6	H	A	23.9	10-01-92	GS	C	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/04E-31B01	Qva	240	70	--	8	U	A	35.5	03-09-93	GS	U	90	12	140	L
31N/04E-33N01	Qva	390	322	--	6	H	A	285	10-06-92	GS	U	4	20	3.4	L,G
31N/04E-33N02	Qva	390	310	--	6	H	C	289	10-06-92	GS	U	9	15	17	L
31N/04E-34B01	Qva	460	252	--	8	P	C	173	08-11-82	DR	U	145	7	190	L
31N/04E-34C03	Qva	360	85	--	6	H	A	57.4	10-07-92	GS	U	--	--	--	L
31N/04E-34Q02	Qva	450	182	--	6	H	A	135	10-06-92	GS	U	--	--	--	L,Q
31N/04E-34Q03	Qva	450	180	--	6	H	A	151	10-06-92	GS	U	--	--	--	L,G
31N/04E-35R01	Qva	530	240	--	6	H	A	211	10-06-92	GS	U	4	20	3.4	L,G
31N/04E-36R02	Qva	300	140	--	6	H	A	99.1	10-06-92	GS	U	--	--	--	L,Q
31N/05E-01G01	Qva	70	160	--	6	U	A	7.1	04-09-93	GS	U	--	--	--	L
31N/05E-01H01	Qvt	190	140	--	6	U	A	56.8	04-22-93	GS	U	--	--	--	L
31N/05E-01H02	Qvt	160	40	--	36	H	D	27.5	04-09-93	GS	U	--	--	--	--
31N/05E-02B02	Qvr	60	62	--	8	N	A	--	--	--	U	--	--	--	L
31N/05E-02F01	Qal	60	36	--	36	P	D	21.3	07-27-92	GS	U	1,200	5	3,200	L,Q
31N/05E-02F02	Qal	60	36	--	36	P	D	21.3	07-27-92	GS	U	1,200	5	3,200	L
31N/05E-02F03	Qal	60	36	--	36	P	D	21.3	07-27-92	GS	U	--	--	--	--
31N/05E-03A01	Qal	42	29	--	156	Z	D	0.6	01-15-78	DR	U	--	--	--	L
31N/05E-03Q03	Qal	55	17.5	--	36	U	D	14	08-26-90	DR	U	40	3	430	L
31N/05E-03Q04	Qva	55	57	--	6	H	C	11.7	04-14-93	GS	C	24	4	310	L
31N/05E-05B01	Qva	210	508	4.5	6	H	A	34.4	07-27-92	GS	C	--	--	--	L
31N/05E-05H01	Qva	310	120	--	6	H	A	91.7	07-28-92	GS	U	--	--	--	L,Q
31N/05E-06H01	Qva	140	28.5	--	36	H	D	19	04-30-88	DR	U	--	--	--	L,Q
31N/05E-06K01	Qtb	150	160	--	6	U	A	124	07-29-92	GS	U	--	--	--	L
31N/05E-06K02	Qu	150	222	--	6	H	A	138	07-29-92	GS	C	--	--	--	L
31N/05E-07D03	Qva	35	35	--	6	S	A	15.5	07-28-92	GS	C	--	--	--	L
31N/05E-07F04	Qu	35	60	--	6	H	A	23	10-09-92	DR	U	--	--	--	L,Q
31N/05E-07G01	Qu	35	148	--	6	U	-	11.9	02-10-93	GS	C	--	--	--	L
31N/05E-07G02	--	35	40.5	--	8	U	-	--	--	--	-	--	--	--	--
31N/05E-07G03	Qal	35	40	--	36	I	-	10.1	02-10-93	GS	U	--	--	--	--

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/05E-07L03	Qva	35	40	--	6	S	A	11.9	07-30-92	GS	C	--	--	--	L
31N/05E-08B02	Qal	50	37.5	--	6	H	A	15.3	07-28-92	GS	U	--	--	--	L
31N/05E-08L03	--	45	20	--	4	U	B	--	--	--	-	--	--	--	L
31N/05E-09G01	Qva	40	37.5	--	8	P	A	21.8	07-30-92	GS	U	--	--	--	L
31N/05E-09G02	Qva	40	23	--	8	U	C	11	01-30-80	DR	C	--	--	--	L
31N/05E-10G01	Qvr	65	30	5	6	H	A	8	05-03-88	DR	U	--	--	--	L
31N/05E-10J03	Qvr	90	120	--	6	H	C	30.4	02-10-93	GS	U	10	60	5.9	--
31N/05E-10J04	Qvr	65	73	--	6	H	A	9	06-03-80	DR	U	13	63	3.5	L
31N/05E-10Q01	Qva	90	79	--	6	H	C	30	11-22-83	DR	U	45	13	210	L,Q
31N/05E-10R01	Qvr	90	35	--	36	H	D	20	03-30-84	DR	U	50	8	260	L
31N/05E-13A01	--	410	435	--	4.5	U	A	270	08-25-92	GS	-	--	--	--	L
31N/05E-13B01	Qtb	430	397	--	6	U	A	--	--	--	-	--	--	--	L
31N/05E-13B02	Qtb	410	385	--	6	U	A	--	--	--	-	--	--	--	L
31N/05E-13D02	Qvt	370	25	--	36	H	D	16	06-06-89	DR	U	--	--	--	L,Q
31N/05E-13K04	Qva	410	260	--	6	H	A	199	08-14-92	GS	U	--	--	--	L
31N/05E-13L03	Qvt	430	28	--	36	H	D	12	03-15-86	DR	U	--	--	--	L
31N/05E-14P02	Qtb	230	162	--	6	H	A	99.2	08-14-92	GS	U	--	--	--	L
31N/05E-15A02	Qvr	125	77	--	36	I	D	47.7	02-12-93	GS	U	--	--	--	L
31N/05E-15R02	Qva	140	167	--	-	P	A	45	12-00-43	DR	C	--	--	--	L
31N/05E-16Q01	Qvr	130	50	--	36	H	D	35	06-18-86	DR	U	50	8	170	L
31N/05E-16Q02	Qvr	125	48	--	36	H	D	37	10-05-85	DR	U	40	4	300	L,Q
31N/05E-17M02	Qvr	75	94	--	6	H	C	9.0	04-08-93	GS	U	2	70	0.13	L
31N/05E-17P01	Qva	125	191	--	6	H	C	49.6	02-12-93	GS	C	5	140	0.37	L
31N/05E-18C01	Qva	65	140	--	6	H	D	12.5	08-19-92	GS	C	30	84	17	L
31N/05E-18C02	Qvr	50	12	--	36	H	D	4.9	08-19-92	GS	U	40	7	190	L
31N/05E-18C03	Qal	50	12.5	--	36	U	D	5.7	08-19-92	GS	U	20	7	15	L
31N/05E-18N04	Qva	130	80	--	6	H	A	23	11-20-88	DR	C	--	--	--	L
31N/05E-18P02	Qva	110	151	--	6	H	C	--	--	--	-	--	--	--	L
31N/05E-19D02	Qva	130	135	--	6	H	C	20	01-20-88	DR	C	20	2	560	L
31N/05E-19E02	Qva	110	110	--	6	H	-	10.4	07-30-92	GS	C	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches) Minimum	Casing diameter (inches) Maximum	Water use	Construc-tion method	Water level (Feet)	Water level Date	Water level Source	Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
31N/05E-19J01	--	115	23	--	42	H	D	--	--	--	-	--	--	--	--
31N/05E-19J02	Qva	115	87	--	6	H	C	15	08-13-72	DR	C	15	5	160	L
31N/05E-20H02	Qvr	125	154	--	6	H	A	19.7	08-17-92	GS	U	--	--	--	L,W
31N/05E-20L01	Qvr	125	19	--	36	H	D	7.5	08-18-92	GS	U	--	--	--	L
31N/05E-20L02	Qvr	125	18	--	36	H	D	10	11-20-89	DR	U	20	2	450	L,Q
31N/05E-21N01	--	121	115	--	36	U	-	--	--	--	-	--	--	--	--
31N/05E-22F02	Qva	132	185	10	12	P	H	33	05-00-71	DR	C	408	15	250	L
31N/05E-23N01	Qvr	135	40	--	6	H	A	--	--	--	U	--	--	--	L
31N/05E-23P01	Qva	260	200	--	6	H	C	161	08-20-92	GS	U	15	10	36	L
31N/05E-24A01	Qvt	470	68	--	6	H	A	52.2	08-18-92	GS	U	--	--	--	L
31N/05E-24F01	Qva	420	220	--	6	H	C	184	08-19-92	GS	U	11	8	33	L
31N/05E-24L01	Qu	445	391	--	6	H	A	317	07-08-80	DR	C	8	64	4.9	L,Q
31N/05E-24N01	Qva	380	157	--	6	H	C	121	08-19-92	GS	U	15	2	110	L
31N/05E-24R01	Qva	510	266	--	6	H	C	249	08-18-92	GS	U	10	3	150	L
31N/05E-25B01	Qvt	470	30	--	36	H	D	17.8	08-19-92	GS	U	--	--	--	L
31N/05E-25B02	Qtb	475	480	--	6	H	A	212	08-24-92	GS	U	25	189	8.1	L
31N/05E-25F01	Qva	460	260	--	6	H	A	186	08-19-92	GS	U	--	--	--	L
31N/05E-25L01	Qvt	460	79	--	6	H	A	41.6	08-19-92	GS	U	--	--	--	L,Q
31N/05E-25Q01	Qva	450	265	--	6	H	C	207	08-24-92	GS	U	15	10	36	L,G
31N/05E-26A01	Qva	390	181	--	6	H	A	150	08-24-92	GS	U	--	--	--	L
31N/05E-26C01	Qva	240	118	--	6	H	A	98.2	08-20-92	GS	U	20	2	550	L
31N/05E-26D02	Qtb	140	35	--	6	H	A	1.6	08-20-92	GS	U	--	--	--	L
31N/05E-27R01	Qvr	115	40	--	6	H	A	1.4	02-12-93	GS	U	--	--	--	L
31N/05E-28A01	Qvr	115	16.5	--	36	C	D	8.0	08-25-92	GS	U	70	7	300	L,Q
31N/05E-29M02	Qva	105	43	--	6	P	C	2.6	08-25-92	GS	U	80	1	2,800	L
31N/05E-30K02	Qva	170	130	--	6	H	A	51.1	08-25-92	GS	C	10	35	13	L
31N/05E-30P01	Qva	200	25	--	6	H	C	--	--	--	-	--	--	--	L,Q
31N/05E-30P02	Qva	190	80	--	6	H	A	44.3	08-25-92	GS	C	--	--	--	L
31N/05E-31E04	Qva	290	157	--	6	H	A	135	08-27-92	GS	C	--	--	--	L
31N/05E-31F02	Qva	250	197	--	6	H	A	113	08-26-92	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohydrologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construction method	Water level			Ground-water condition	Yield (gallons per minute)	Drawdown (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/05E-31L01	Qva	260	80	--	6	H	A	39.1	10-08-92	GS	C	--	--	--	L
31N/05E-31P01	Qva	260	80	--	6	P	A	41.7	08-27-92	GS	U	42	31	19	L,G
31N/05E-32E01	Qvt	115	76	--	6	H	A	8.6	08-26-92	GS	U	--	--	--	L,Q
31N/05E-32J01	Qtb	95	187	--	6	I	C	7	07-15-82	DR	U	25	80	19	L,G
31N/05E-33A01	Qvr	105	30	--	36	U	D	2.6	04-13-93	GS	U	--	--	--	L
31N/05E-34H02	Qtb	110	68	--	6	H	C	1.2	04-07-93	GS	U	10	32	7.4	L,G
31N/05E-35R01	Qva	375	60	--	6	H	A	32.6	04-13-93	GS	C	--	--	--	L,Q
31N/06E-03D02	Qvr	240	48	--	6	H	A	-0.8	11-05-92	GS	U	--	--	--	L
31N/06E-04B01	Qvr	310	36	--	36	H	D	20	12-17-91	DR	U	40	6	280	L
31N/06E-04C01	Qvr	310	14	--	3	H	V	12	07-00-44	DR	U	--	--	--	--
31N/06E-04D01	Qvr	310	36	--	36	I	D	12.6	08-02-92	GS	U	200	8	400	L
31N/06E-04M01	Qvr	305	13.8	--	48	H	D	0.1	01-29-93	GS	U	--	--	--	--
31N/06E-05B01	Qvr	310	35	--	36	H	D	22	12-01-86	DR	U	--	--	--	L
31N/06E-05L02	Qvr	305	26	--	36	H	D	15.6	04-14-93	GS	U	40	5	230	L
31N/06E-06D01	Qvr	195	20	--	36	I	D	1.1	02-11-93	GS	U	--	--	--	L
31N/06E-06M01	Qal	110	176	--	6	H	A	3.5	08-03-92	GS	U	--	--	--	L
31N/06E-06Q01	Qtb	285	340	--	6	H	A	175	11-12-88	DR	U	2	75	0.074	L
31N/06E-06Q02	Qu	265	295	--	6	H	A	177	08-03-92	GS	C	--	--	--	L,Q,W
31N/06E-06R01	Qvr	270	25	--	36	H	D	10.1	12-21-92	GS	U	--	--	--	L,Q
31N/06E-07P01	Tb	95	140	--	8	U	Z	--	--	--	-	--	--	--	L
31N/06E-08B01	Qvr	275	32	--	36	H	D	20	04-16-83	DR	U	10	5	60	L
31N/06E-08G01	Qva	280	130	--	6	U	A	23.7	08-05-92	GS	C	15	50	13	L,G
31N/06E-08J01	Qva	270	71	--	6	H	C	12	03-09-89	DR	C	30	20	92	L,G
31N/06E-08J02	Qva	260	97	--	6	H	A	14.7	08-12-92	GS	C	15	40	18	L,G
31N/06E-09K01	Qal	180	16	24	36	I	D	8	08-23-88	DR	U	20	6	51	L,Q
31N/06E-16M01	Qvt	170	53	--	6	H	C	8	02-08-92	DR	U	10	34	5.4	L,G
31N/06E-17D01	Tb	205	22.5	--	42	H	D	15	09-04-82	DR	U	--	--	--	L
31N/06E-17E02	Qvt	160	20	--	36	H	D	2.9	12-21-92	GS	U	4.5	2	23	L
31N/06E-18A01	Tb	155	346	4	6.6	U	A	50	04-16-80	DR	U	3.5	276	0.047	L
31N/06E-18B02	Qal	95	37	--	8	U	Z	--	--	--	U	--	--	--	L
31N/06E-18C01	Qva	300	270	--	6	H	A	215	02-16-92	DR	U	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/06E-18C04	Qal	95	39	--	8	I	Z	--	--	--	U	--	--	--	L
31N/06E-18E01	Qvt	350	42	--	36	H	D	25	02-13-90	DR	U	--	--	--	L
31N/06E-18H03	Qal	105	37	--	8	U	Z	--	--	--	U	--	--	--	L
31N/06E-19D01	Tb	490	250	--	6	U	A	187	08-04-92	GS	U	--	--	--	L
31N/06E-19E02	Qvt	510	54	--	30	U	D	30	02-10-93	GS	U	--	--	--	--
31N/06E-19N01	Qvt	510	50	--	36	H	D	22	07-26-88	DR	U	--	--	--	L
31N/06E-20A01	Qvr	290	45	--	36	H	D	32	10-07-87	DR	U	10	7	25	L
31N/06E-20F01	Qal	160	16	--	36	H	D	12	06-05-91	DR	U	50	0.5	1,000	L
31N/06E-20H01	Tb	245	140	4	6	H	A	107	12-23-92	GS	U	--	--	--	L,G
31N/06E-20R02	Tb	120	200	--	6	H	A	--	--	--	-	--	--	--	L,Q,G
31N/06E-21A01	Qvr	290	98	--	6	H	A	4.6	04-08-93	GS	U	--	--	--	L
31N/06E-21D01	Tb	250	90	--	6	H	A	22.5	04-09-93	GS	U	--	--	--	L
31N/06E-27E01	Tb	300	200	--	6	H	A	40	07-22-88	DR	U	--	--	--	L
31N/06E-27J01	Tb	400	60	--	6	I	A	60	08-16-80	DR	U	--	--	--	L
31N/06E-27J02	Tb	330	100	--	6	U	C	--	--	--	-	--	--	--	L
31N/06E-27J03	Tb	400	242	4	6	H	A	8	07-24-85	DR	U	--	--	--	L
31N/06E-27K01	Tb	390	145	--	6	H	A	85	05-08-89	DR	U	--	--	--	L,Q
31N/06E-27N01	--	300	120	--	6	H	A	53.8	12-22-92	GS	-	--	--	--	L
31N/06E-27P01	Tb	320	200	4.5	6	U	A	19.8	09-02-92	GS	U	--	--	--	L
31N/06E-27R01	Tb	300	300	--	6	U	A	40	12-10-86	DR	U	--	--	--	L
31N/06E-27R02	Tb	310	300	4	6	I	A	10	05-23-85	DR	U	--	--	--	L
31N/06E-28G01	Tb	160	455	5	8	U	C	25	03-09-89	DR	U	10	200	0.046	L
31N/06E-28M01	Tb	425	156	5	6	H	C	43.3	08-31-92	GS	U	20	60	4.2	L
31N/06E-29B01	Tb	475	140	4.5	6	H	A	49.8	08-31-92	GS	U	--	--	--	L
31N/06E-29B02	Tb	450	160	4.5	6	H	A	8.8	09-02-92	GS	U	--	--	--	L
31N/06E-29J01	Tb	420	136	5	6	H	C	35.8	08-20-92	GS	U	10	60	1.2	L,Q,G
31N/06E-29J02	Tb	425	22	--	48	H	D	1.4	12-23-92	GS	U	--	--	--	L
31N/06E-29K01	Tb	440	22.5	--	36	H	D	6.6	08-12-92	GS	U	--	--	--	L
31N/06E-29Q01	Qvt	480	41	--	36	H	D	22	07-30-89	DR	U	--	--	--	L,Q
31N/06E-29Q02	--	475	230	--	6	H	-	20	02-00-82	DR	-	--	--	--	

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohydrologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construction method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
31N/06E-29R01	Tb	475	300	--	6	H	A	100	08-24-92	GS	U	--	--	--	L
31N/06E-30C01	Qvt	490	300	--	6	H	A	149	12-18-89	DR	U	--	--	--	L
31N/06E-30K01	Qvt	560	40	--	36	H	D	15.8	08-06-92	GS	U	50	25	60	L
31N/06E-30L02	Qva	520	50	--	6	H	A	17.8	08-10-92	GS	C	--	--	--	L,Q
31N/06E-30P01	Qva	510	160	--	6	H	A	73.9	08-26-92	GS	C	--	--	--	L
31N/06E-30Q01	Qva	525	130	--	6	H	A	99.6	08-31-92	GS	C	--	--	--	L
31N/06E-31C01	--	530	130	--	6	H	C	106	03-09-93	GS	-	--	--	--	--
31N/06E-31G01	Qva	525	140	--	6	H	A	--	--	--	-	--	--	--	L,Q,G
31N/06E-31G02	Qva	530	137	--	6	C	A	106	04-07-93	GS	U	--	--	--	L,G
31N/06E-31N03	Qva	460	124	5	6	U	C	69.9	12-22-92	GS	C	9	44	4.3	L
31N/06E-32D01	Qvt	545	96	--	6	U	C	86	05-04-90	DR	U	1	10	0.48	L
31N/06E-32D02	Qva	550	158	--	6	H	A	129	08-26-92	GS	U	--	--	--	L
31N/06E-32H01	Qva	595	131	--	6	H	A	51.5	07-16-92	GS	C	--	--	--	L,G
31N/06E-33N01	Qva	510	99	--	6	H	A	32.7	09-02-92	GS	C	--	--	--	L,G
31N/06E-33P01	Qva	500	43	--	36	H	D	10.1	07-16-92	GS	C	50	17	280	L,Q
31N/06E-33P02	Tb	500	360	--	6	H	A	20	05-09-88	DR	C	--	--	--	L,G
31N/06E-34A01	Qvt	300	59	--	6	H	-	19.9	09-01-92	GS	U	33	2	540	L,Q
31N/06E-34B01	Tb	270	51	--	6	H	C	0.9	12-22-92	GS	U	4.5	45	6.1	L
31N/06E-34P01	Qvt	240	70	--	6	H	C	43.4	12-23-92	GS	U	20	2	270	L,G
31N/06E-35E01	Tb	320	26	--	6	H	C	6	03-22-90	DR	U	3	20	2.4	L
31N/06E-35N01	Qvr	130	123	--	6	H	C	39.3	09-03-92	GS	U	1.2	77	0.080	L
32N/03E-13G01	Qva	100	307	--	6	H	C	68.6	01-13-93	GS	U	4	22	11	L,G
32N/04E-02L01	Tb	640	165	--	6	H	A	36	01-18-85	DR	U	20	35	0.41	L,G
32N/04E-02M01	Qvt	460	24.5	--	36	H	D	12	05-15-89	DR	U	--	--	--	L
32N/04E-02P01	Qvt	530	18	--	48	H	D	12.4	10-13-92	GS	U	--	--	--	L,Q
32N/04E-02Q01	Tb	600	160	--	6	H	C	117	10-26-87	DR	U	5	30	0.13	L
32N/04E-03A01	Tb	430	420	--	6	H	A	69.9	10-07-92	GS	U	--	--	--	L,Q,G
32N/04E-03K01	Tb	370	160	4.5	6	H	A	29.8	10-07-92	GS	U	--	--	--	L
32N/04E-03K03	Qvt	350	24	--	36	H	D	5.2	10-07-92	GS	U	--	--	--	L
32N/04E-03R01	Tb	420	300	4.5	6	H	A	73.9	10-07-92	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/04E-04A02	Qva	350	125	--	6.6	H	C	78.1	10-08-92	GS	C	20	25	36	L
32N/04E-04H01	Qva	330	80	--	6	H	A	59.8	10-13-92	GS	C	--	--	--	L
32N/04E-04K01	Qva	310	106	--	6	H	A	49.8	10-21-92	GS	C	--	--	--	L,Q
32N/04E-04N04	Qu	290	264	--	6	H	C	173	10-13-92	GS	C	10	15	30	L
32N/04E-05A01	Qva	270	218	--	6	H	A	153	10-14-92	GS	C	--	--	--	L
32N/04E-05N01	Qva	250	178	--	6.6	H	A	146	10-13-92	GS	U	--	--	--	L,Q
32N/04E-05Q02	Qva	230	152	--	6	H	C	127	10-13-92	GS	U	--	--	--	L
32N/04E-06F01	Qva	300	187	--	6	H	C	133	10-14-92	GS	U	15	15	23	L
32N/04E-06K01	Qva	220	151	--	8	P	A	111	10-14-92	GS	C	215	17	360	L
32N/04E-06K02	Qva	220	145	--	8	P	C	114	10-14-92	GS	U	--	--	--	L
32N/04E-06N01	Qva	170	360	--	6	U	A	159	10-14-92	GS	U	--	--	--	L
32N/04E-06N02	Qva	170	235	--	6	H	C	158	10-14-92	GS	U	10	30	7.1	L
32N/04E-06P01	Qvt	300	40	--	6	U	A	25.2	10-20-92	GS	U	--	--	--	L
32N/04E-06Q04	Qva	230	220	--	6	H	A	150	10-15-92	GS	C	--	--	--	L
32N/04E-06Q05	Qvr	340	47.5	--	36	H	D	34.7	10-14-92	GS	U	40	10	98	L,Q
32N/04E-07A03	Qtb	210	200	--	6	Z	A	--	--	--	-	--	--	--	L
32N/04E-07B03	Qva	210	150	--	6	H	A	98	05-17-91	DR	U	--	--	--	L
32N/04E-07C05	Qu	190	214	--	6	H	A	129	10-15-92	GS	C	--	--	--	L
32N/04E-07N03	Qva	120	86	--	6	H	C	45.6	10-15-92	GS	C	12	12	51	L,Q
32N/04E-07R02	Qu	240	295	--	6	H	A	169	10-21-92	GS	C	--	--	--	L,Q
32N/04E-08E03	Qva	250	202	--	6	H	A	150	10-20-92	GS	U	--	--	--	L
32N/04E-08E04	Qva	250	195	--	6	H	A	149	10-20-92	GS	U	--	--	--	L
32N/04E-08J01	Qvr	220	21	--	36	U	D	6.1	10-20-92	GS	U	--	--	--	L,W
32N/04E-08J02	Qva	220	154	--	6	H	A	94.3	10-20-92	GS	C	12	40	16	L
32N/04E-09E01	Qvr	250	25	--	36	H	D	0.4	10-22-92	GS	U	50	5	300	L
32N/04E-09F01	Qva	290	86	--	6	H	A	39.7	10-21-92	GS	C	--	--	--	L
32N/04E-09F03	Qva	270	136	--	6	H	C	106	10-20-92	GS	C	10	13	47	L
32N/04E-09R03	Qvt	310	242	--	6	H	A	178	11-04-92	GS	U	--	--	--	L
32N/04E-10P01	Qva	350	73	--	6	H	A	48	02-25-79	DR	C	15	11	110	L
32N/04E-10Q04	Qva	330	55	--	6	H	C	12.5	10-22-92	GS	C	12	20	27	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/04E-10R01	Tb	350	61.5	--	48	U	D	5.1	02-17-93	GS	-	--	--	--	--
32N/04E-10R02	Tb	360	200	--	6	H	A	43	10-20-92	GS	U	--	--	--	L
32N/04E-11B02	Tb	600	224	--	6	H	A	65.8	10-21-92	GS	U	--	--	--	L,G
32N/04E-12N02	Tb	540	245	4.5	6	H	A	46.8	10-21-92	GS	U	--	--	--	L,G
32N/04E-12Q01	Tb	540	300	--	4.5	H	A	18.1	10-22-92	GS	U	3	155	0.0075	L
32N/04E-13B01	Tb	500	105	--	6	H	C	19.6	11-03-92	GS	C	12	72	12	L
32N/04E-13K01	Qvt	460	140	--	6	H	A	21.6	11-03-92	GS	U	--	--	--	L,Q
32N/04E-13N01	Tb	460	435	4	6	H	C	143	11-03-92	GS	C	4	260	0.092	L,Q
32N/04E-13Q03	Qvt	400	32	--	36	U	D	4	10-01-90	DR	U	--	--	--	L,G
32N/04E-13Q04	Qvt	420	30	--	36	H	D	4.0	11-04-92	GS	U	--	--	--	L
32N/04E-14P01	--	370	27	--	36	H	D	--	--	--	-	--	--	--	L
32N/04E-14R02	--	420	515	4	8	H	C	114	11-03-92	GS	-	--	--	--	L,G
32N/04E-15H02	Tb	400	298	--	3	H	A	-1.5	11-04-92	GS	F	--	--	--	L
32N/04E-15L01	Qvt	290	64	--	6	H	C	49	11-04-92	GS	U	15	10	50	L
32N/04E-16A01	Qva	270	215	--	6	H	C	130	05-09-89	DR	C	10	15	31	L
32N/04E-16D01	Qva	210	146	--	6	H	A	81.7	11-04-92	GS	C	--	--	--	L,Q
32N/04E-17N01	Qva	240	199	--	6	H	C	157	11-05-92	GS	U	7.5	10	8.2	L,G
32N/04E-18A01	--	250	320	--	6	U	A	--	--	--	-	--	--	--	L
32N/04E-18A02	Qu	250	245	--	6	H	A	166	11-05-92	GS	C	--	--	--	L
32N/04E-18B02	Qvt	240	215	--	6	H	C	165	09-09-82	DR	U	7	2	34	L
32N/04E-18B04	Qva	240	200	--	6	H	A	151	11-06-92	GS	U	--	--	--	L
32N/04E-20C01	Qva	180	73	--	6	P	C	--	--	--	-	--	--	--	Q
32N/04E-21E01	Qva	200	93	--	6	H	A	62.9	11-05-92	GS	U	--	--	--	L
32N/04E-21K01	Qva	270	180	--	6	H	A	122	11-05-92	GS	U	--	--	--	L
32N/04E-22A02	Qvt	350	58	--	36	H	D	55.5	11-06-92	GS	U	30	3	450	L,G
32N/04E-22A03	--	340	395	5	6	U	C	90	12-14-88	DR	-	--	--	--	L
32N/04E-22F01	Qvt	340	209	--	6	H	C	191	11-06-92	GS	U	9	2	160	L,Q,G
32N/04E-23J01	--	280	163	5	6	H	C	--	--	--	F	--	--	--	L,G
32N/04E-23N02	Qvt	360	61	--	6	H	A	38.4	12-09-92	GS	U	--	--	--	L,Q
32N/04E-24E01	Qva	350	302	--	6	H	A	--	--	--	-	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/04E-24E02	Qvt	390	46.5	--	36	H	D	26.3	11-03-92	GS	U	--	--	--	L
32N/04E-25A02	Qva	240	518	--	6	H	A	107	12-11-92	GS	U	--	--	--	L
32N/04E-25G02	Qva	250	80	--	6	H	A	66.5	12-10-92	GS	C	--	--	--	L
32N/04E-26B03	Tb	290	300	--	6	Z	A	240	12-11-92	GS	U	--	--	--	L
32N/04E-26C01	Qtb	350	440	--	6	H	A	301	12-09-92	GS	C	--	--	--	L,Q,G
32N/04E-26J01	Qva	220	202	--	6	H	C	176	12-10-92	GS	U	12	10	14	L,G
32N/04E-26R02	Qva	220	198	--	6	U	C	164	12-17-74	DR	U	5	30	4.5	L
32N/04E-27D02	Qvt	330	37	--	6	H	C	20	07-10-90	DR	U	3.5	12	10	L
32N/04E-27D02D1	Qva	330	267	--	4	H	C	249	12-10-92	GS	U	10	4	78	L
32N/04E-28A01	Qva	290	284	--	6	H	A	226	01-12-93	GS	U	--	--	--	L,Q
32N/04E-28C01	Qva	240	104	--	6	H	A	71.1	12-11-92	GS	U	--	--	--	L,Q
32N/04E-29A01	Qva	130	132	--	6	H	C	44.6	01-12-93	GS	C	7	10	43	L
32N/04E-29H01	Qtb	100	94	--	6	H	A	77.8	01-12-93	GS	U	--	--	--	L,Q
32N/04E-30L01	Qal	15	145	12	20	U	-	6	09-00-47	DR	U	--	--	--	L
32N/04E-33Q02	Qal	30	31	--	36	S	D	15.3	01-12-93	GS	U	--	--	--	L,Q,W
32N/04E-35K01	Qal	20	43.9	--	36	S	D	15.6	01-13-93	GS	U	100	5	200	L,G
32N/04E-35P01	Qal	20	33	--	36	U	D	12	04-30-76	DR	U	--	--	--	L,G
32N/04E-36C01	Qva	220	170	--	6	H	C	127	01-13-93	GS	U	10	28	7.7	L,G
32N/04E-36K01	Qva	190	139	--	6	H	A	80.5	01-13-93	GS	U	--	--	--	L
32N/05E-04E02	Tb	570	440	5	6	H	A	290	03-26-91	DR	U	--	--	--	L
32N/05E-04F01	Qvt	500	20	--	36	H	D	6.8	01-14-93	GS	U	--	--	--	L
32N/05E-04L01	Tb	500	236	4	6	H	A	74.6	01-14-93	GS	U	--	--	--	L
32N/05E-05F01	Tb	230	130	--	8	U	A	1.8	12-17-92	GS	U	--	--	--	L
32N/05E-05F02	Qvt	220	76	--	6	U	A	2.2	12-17-92	GS	U	--	--	--	L
32N/05E-05M01	Qvt	210	99	--	6	S	A	--	--	--	U	--	--	--	L
32N/05E-06N01	Tb	845	425	--	8	H	C	80	09-23-70	DR	U	--	--	--	L
32N/05E-07L01	Tb	500	480	--	6	U	C	--	--	--	F	1	150	0.0030	L
32N/05E-07N01	Tb	500	200	--	6	H	A	--	--	--	-	--	--	--	L,Q
32N/05E-08N01	Tb	490	380	4	6	H	A	46.4	04-15-93	GS	U	--	--	--	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/05E-09E02	Qvt	240	18	--	36	H	D	0.5	04-14-93	GS	U	--	--	--	L
32N/05E-09G01	Qvt	380	20	--	36	H	D	10	06-26-90	DR	U	40	10	98	L
32N/05E-11R01	Tb	560	335	4	8	H	C	95.9	01-27-93	GS	U	1	282	0.0033	L
32N/05E-12F01	Qvt	740	27	--	36	H	D	19.4	04-07-93	GS	U	10	5	60	L
32N/05E-12G01	Qvt	700	25	--	36	H	D	6.6	01-27-93	GS	U	--	--	--	L
32N/05E-13E01	Qva	460	98	--	6	H	A	61	01-27-93	GS	U	20	2	310	L,Q,G
32N/05E-14L01	Tb	260	237	--	6	H	A	33.3	10-08-92	GS	U	--	--	--	L,G
32N/05E-15L01	Qvt	450	100	--	6	H	C	78.9	01-27-93	GS	U	6	10	13	L,G
32N/05E-16Q01	Tb	180	200	5	6	H	A	-2.2	01-27-93	GS	F	--	--	--	L,G
32N/05E-18M01	--	420	372	--	6	H	C	42.4	12-18-92	GS	-	--	--	--	L,G
32N/05E-18R01	Tb	340	350	--	6	U	A	61.8	01-13-93	GS	U	--	--	--	L,G
32N/05E-19A01	Tb	345	100	--	6	U	A	3.4	01-13-93	GS	C	--	--	--	L
32N/05E-19A02	Tb	340	400	--	6	H	A	24.4	01-13-93	GS	U	--	--	--	L
32N/05E-19B01	Tb	370	175	--	6	H	C	33.5	01-13-93	GS	C	10	55	0.39	L,G
32N/05E-19L01	Tb	220	500	--	6	H	A	26.3	01-13-93	GS	C	--	--	--	L
32N/05E-19R01	Qva	225	164	--	6	H	A	154	01-12-93	GS	U	12	4	80	L,Q
32N/05E-20K01	Tb	100	200	4	6	H	A	27	03-28-91	DR	U	--	--	--	L
32N/05E-20P01	Tb	80	320	--	6	H	A	34.5	10-14-92	GS	C	--	--	--	Q
32N/05E-20R02	Qvr	130	30	--	36	H	D	16	01-07-88	DR	U	--	--	--	--
32N/05E-21B01	Qvr	190	18	--	36	H	D	14.9	10-09-92	GS	U	--	--	--	L,Q
32N/05E-21D01	Tb	190	203	--	6	H	A	49.5	10-14-92	GS	U	--	--	--	L,Q,G
32N/05E-21N01	Tb	150	117	--	6	U	A	--	--	--	-	--	--	--	L
32N/05E-21N02	Qva	150	50	--	6	H	A	11.2	10-14-92	GS	U	--	--	--	L
32N/05E-22A01	Qvt	240	30	--	36	H	D	8.3	10-08-92	GS	U	--	--	--	L
32N/05E-22D01	--	240	203	--	6	U	A	--	--	--	-	--	--	--	L
32N/05E-22D02	Qvr	220	76	4.5	6	H	A	8.3	05-19-92	DR	U	--	--	--	L
32N/05E-22J01	Qvt	250	136	--	6	H	C	80	12-27-78	DR	U	--	--	--	L
32N/05E-22L02	Qva	275	320	--	6	H	A	42.5	10-08-92	GS	U	--	--	--	L
32N/05E-22N01	Tb	170	100	--	6	Z	A	--	--	--	-	--	--	--	L
32N/05E-23C01	Tb	245	275	--	6	H	-	122	10-07-92	GS	U	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/05E-23F01	Qvr	180	25	--	36	H	D	8.0	10-08-92	GS	U	--	--	--	L
32N/05E-23M01	Qvt	200	103	--	6	H	A	-4.0	08-17-90	DR	U	--	--	--	L
32N/05E-24C01	Qvr	330	12.5	--	36	H	D	5.2	12-16-92	GS	U	15	1.5	300	L
32N/05E-24C02	Qva	340	100	--	6	H	A	32.2	01-12-93	GS	C	--	--	--	L,Q
32N/05E-26N01	Qva	145	79	--	6	H	A	43.7	12-17-92	GS	U	--	--	--	L,W
32N/05E-26N02	Qva	140	220	--	6	U	A	67.2	01-13-93	GS	U	12	130	2.6	L
32N/05E-26P01	Qva	120	108	--	4.5	H	A	49	09-02-91	DR	U	--	--	--	L
32N/05E-27L02	Qva	150	83	--	6	P	A	26.8	10-15-92	GS	C	30	24	82	L,Q
32N/05E-27N03	Qu	155	215	--	6	P	A	66.6	10-15-92	GS	C	--	--	--	L,Q
32N/05E-27Q03	Qvr	130	17	--	42	H	D	4.9	10-29-92	GS	U	100	15	260	L
32N/05E-28C01	Qvr	135	15	--	36	H	D	6	04-10-91	DR	U	--	--	--	L
32N/05E-28M01	Qtb	135	118	--	6	U	A	9.3	10-29-92	GS	U	--	--	--	L
32N/05E-28N01	Qva	130	94	--	6	H	A	--	--	--	F	38	11	430	L
32N/05E-28P01	Qva	135	57	--	6	H	A	7.2	10-29-92	GS	C	--	--	--	L
32N/05E-29K01	Tb	180	440	--	66	H	A	20.7	10-30-92	GS	U	--	--	--	L
32N/05E-29K02	Tb	190	180	4	6	H	A	8.7	10-30-92	GS	U	--	--	--	L
32N/05E-29Q01	Qva	175	21.5	--	36	H	D	8	09-17-80	DR	U	--	--	--	L
32N/05E-30D01	Qvr	210	14	--	36	I	D	8	10-25-78	DR	U	--	--	--	L,Q
32N/05E-30E01	Qva	160	63	--	6	H	A	35	11-15-89	DR	U	--	--	--	L
32N/05E-30E02	--	160	260	--	6	H	A	41.4	01-11-93	GS	-	--	--	--	L
32N/05E-31H01	Qva	180	200	--	6	P	A	57.8	12-09-92	GS	C	--	--	--	L
32N/05E-31H02	Qva	180	100	--	6	P	A	39.8	12-09-92	GS	C	--	--	--	L
32N/05E-31H03	Qvr	180	21	15	36	P	D	15.8	12-10-92	GS	U	80	4	690	L
32N/05E-32D01	Qvr	150	25	--	36	H	D	14.1	12-10-92	GS	U	--	--	--	L
32N/05E-32N01	Qva	170	96	--	6	H	A	55.8	12-10-92	GS	C	--	--	--	L,Q
32N/05E-32P01	Tb	190	300	--	6	H	A	155	12-10-92	GS	U	--	--	--	L
32N/05E-32P02	Tb	190	364	--	6	U	A	--	--	--	-	--	--	--	L
32N/05E-32P03	Tb	190	280	--	6	U	A	40	04-06-88	DR	U	--	--	--	L
32N/05E-33C02	Qvt	145	12.5	--	36	H	D	3.1	12-11-92	GS	U	60	5	380	L,Q
32N/05E-33E02	Qvt	260	105	--	6	H	C	40.4	12-11-92	GS	U	10	30	6.3	L,Q

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/05E-33N02	Tb	300	287	--	6	H	A	23.1	12-11-92	GS	C	--	--	--	L
32N/05E-34E02	Qvt	140	34	--	36	H	D	23	02-17-92	DR	U	40	10	150	L
32N/05E-34E03	Tb	140	180	--	6	U	A	49.5	12-16-92	GS	C	--	--	--	L
32N/05E-35E01	Qva	120	100	--	6	H	A	70.2	12-16-92	GS	U	--	--	--	L,Q
32N/05E-35L01	Qva	70	77	--	6	H	C	-0.1	01-12-93	GS	C	30	6	260	L
32N/05E-36N01	--	120	198	--	6	H	A	68.5	12-16-92	GS	-	--	--	--	L
32N/05E-36R03	Qvr	190	17.5	--	36	U	D	9	06-02-86	DR	U	50	5	300	L
32N/05E-36R03	Qva	190	150	--	6	H	A	92.9	07-30-92	GS	U	--	--	--	L
32N/05E-36R04	Qvt	170	30	--	36	H	D	14.5	01-13-93	GS	U	40	2	1,000	L,Q
32N/06E-04R01	Tb	--	110	4.5	6	H	R	--	--	--	-	--	--	--	L,Q
32N/06E-04R02	Tb	600	185	4.5	6	H	A	24	10-07-91	DR	U	--	--	--	L
32N/06E-09H01	Tb	345	460	--	6	H	A	99.5	10-07-92	GS	U	--	--	--	L,G
32N/06E-09H02	Tb	250	306	--	6	H	C	--	--	--	-	--	--	--	L
32N/06E-10C01	Qvr	340	45	--	6	H	-	35.9	10-07-92	GS	U	--	--	--	L
32N/06E-10Q01	Qal	125	20	--	6	H	A	--	--	--	-	--	--	--	L
32N/06E-11C01	Qal	190	22.5	--	36	H	D	15	08-20-90	DR	U	40	6	190	L
32N/06E-11K01	Qvr	140	165	--	6	H	C	4.3	10-09-92	GS	U	10	116	1.2	L,Q,G
32N/06E-15E01	Qal	140	17.5	--	36	H	D	8.5	11-05-92	GS	U	--	--	--	L
32N/06E-15L01	Qvt	200	74	--	6	U	A	41.5	11-04-92	GS	U	26	13	55	L
32N/06E-15M01	Qvt	140	60	--	6	U	A	9.7	08-28-92	GS	U	--	--	--	L
32N/06E-16P01	Qal	115	17.5	--	36	H	D	--	--	--	-	--	--	--	L,Q
32N/06E-17C01	--	450	100	--	6	H	A	9.3	10-29-92	GS	-	--	--	--	L,Q
32N/06E-17M01	Tb	495	484	--	6	H	A	--	--	--	-	--	--	--	L,G
32N/06E-18J01	Tb	430	115	--	6	U	A	--	--	--	-	--	--	--	L,G
32N/06E-18J02	Tb	415	420	--	6	H	A	--	--	--	-	--	--	--	L
32N/06E-18L01	Qvr	380	60	--	6	H	A	36.2	11-05-92	GS	U	--	--	--	L,Q,G
32N/06E-18R01	Tb	395	200	4	6	U	A	22.6	11-05-92	GS	U	--	--	--	L,G
32N/06E-20C01	Tb	340	85	--	6	H	A	--	--	--	-	--	--	--	L
32N/06E-20J01	Qtb	100	145	--	6	H	A	5.4	10-30-92	GS	C	--	--	--	L,G,W

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/06E-20J02	Qva	110	147	--	6	I	A	9.6	11-05-92	GS	U	--	--	--	L
32N/06E-21N01	Qvr	205	33	--	36	H	D	18	10-00-89	DR	U	--	--	--	L
32N/06E-21N02	Qvr	200	37	--	36	H	D	27.1	11-04-92	GS	U	--	--	--	L,Q
32N/06E-21Q01	Qvr	245	88	--	6	H	C	44.8	11-05-92	GS	U	12	20	6.3	L
32N/06E-28K02	Qvt	390	40	--	6	H	A	36.7	10-29-92	GS	U	--	--	--	L
32N/06E-28L01	Qvr	345	94	--	6	H	A	73.6	10-08-92	GS	U	--	--	--	L
32N/06E-28L02	Qvr	345	205	--	6	U	A	86.1	11-06-92	GS	U	--	--	--	L
32N/06E-29A02	Qvr	200	82	--	6	C	C	19.5	10-29-92	GS	U	15	28	4.7	L,G
32N/06E-29D01	Qvr	180	26	--	6	H	A	23.2	11-05-92	GS	U	10	1	770	L
32N/06E-29R01	Qvr	320	99	--	6	H	A	68.4	11-06-92	GS	U	--	--	--	L,Q
32N/06E-30A01	Qvt	140	19.5	--	36	H	D	12	03-22-91	DR	U	--	--	--	L
32N/06E-30K01	Qvt	190	44.5	--	6	H	A	25.1	10-09-92	GS	U	--	--	--	L
32N/06E-30N01	Tb	200	420	--	6	H	A	116	11-06-92	GS	U	--	--	--	L
32N/06E-30P02	Qvt	190	100	--	6	H	A	10.8	10-08-92	GS	U	--	--	--	L,Q
32N/06E-31A01	Qvr	300	50	--	36	H	D	45.3	11-17-92	GS	U	20	4	190	L
32N/06E-31H01	Qvt	250	169	--	6	H	C	101	11-04-92	GS	U	8	6	36	L
32N/06E-32E03	Qvr	310	60	--	6	H	A	--	--	--	U	--	--	--	L
32N/06E-32F01	Tb	320	240	--	6	U	A	--	--	--	-	--	--	--	L
32N/06E-32G01	Qtb	320	256	--	6	H	A	125	10-29-92	GS	U	--	--	--	L,Q,G
32N/06E-32M01	Qvr	305	38	--	6	H	D	24.5	10-08-92	GS	U	40	5	600	L
32N/06E-33H02	Qvt	360	132	--	6	H	A	81.8	10-30-92	GS	U	--	--	--	L
32N/06E-33J01	Tb	360	464	--	6.6	H	A	74.7	10-30-92	GS	C	--	--	--	L
32N/06E-33R01	Qvr	315	30	--	36	H	D	22.1	11-17-92	GS	U	50	5	300	L,Q
32N/06E-34J01	Qvr	335	20	--	36	R	D	6.3	11-19-92	GS	U	--	--	--	L
32N/06E-34L02	Qvr	280	30	--	6	H	-	--	--	--	U	--	--	--	L
32N/06E-34N01	Qvr	265	77.5	--	6	H	A	--	--	--	U	--	--	--	L
32N/06E-35E01	--	400	102	--	6	H	A	83.7	11-04-92	GS	-	--	--	--	L
32N/06E-36A01	--	420	30	4.5	6	H	A	4.0	11-06-92	GS	-	--	--	--	L
32N/06E-36F01	--	420	34	--	36	H	D	15	01-29-91	DR	-	--	--	--	L
32N/06E-36F02	--	410	119	--	6	H	A	45	10-21-80	DR	-	--	--	--	L

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/07E-07R01	Qal	180	77	--	6	H	A	--	--	--	U	--	--	--	L
32N/07E-08J01	Qal	215	60	--	6	H	A	--	--	--	U	--	--	--	L
32N/07E-08P02	Qal	200	64	--	6	F	-	12	01-12-79	DR	U	70	50	37	L
32N/07E-08Q02	Qal	200	39	--	6	H	A	15.6	11-19-92	GS	U	--	--	--	L,Q,G,W
32N/07E-09B01	Qvr	240	58	--	6	H	A	30	01-22-89	DR	U	60	25	150	L,Q
32N/07E-09H01	Qvr	220	97	--	6	H	A	--	--	--	U	--	--	--	L,G
32N/07E-10E01	Qvt	230	78	--	6	U	A	29.9	11-18-92	GS	U	--	--	--	L
32N/07E-10E02	Qvt	220	61	--	6	H	A	8	05-13-88	DR	U	--	--	--	L,G
32N/07E-10R01	Qva	245	121	--	6	H	A	20	06-20-91	DR	U	10	10	23	L
32N/07E-11M01	Qva	270	87.5	--	6	H	A	54.2	11-18-92	GS	U	10	20	10	L,G
32N/07E-12M01	Qva	280	95	--	6	H	A	56.4	11-18-92	GS	C	--	--	--	L,Q,G
32N/07E-12M02	Qvr	280	38	--	6	H	A	22	01-30-90	DR	U	--	--	--	L,G
32N/07E-16E01	Qal	205	57.5	--	6	H	A	10	11-15-91	DR	U	--	--	--	L
32N/07E-17M01	Qal	200	28	--	6	H	A	2	09-27-90	DR	U	--	--	--	L
32N/08E-02J01	Qva	445	107	--	6	H	A	76.5	03-02-94	GS	U	--	--	--	L,G
32N/08E-02L01	Qva	470	240	--	6	H	-	159	03-02-94	GS	U	--	--	--	L,Q,G
32N/09E-06N01	Qal	420	60	--	6	H	A	0.8	03-02-94	GS	U	--	--	--	L,G
32N/09E-06Q01	Qvt	430	116	--	6	H	A	24.8	02-18-94	GS	U	--	--	--	L
32N/09E-07A01	Qva	520	210	--	6	H	A	109	02-17-94	GS	U	--	--	--	L,G
32N/09E-08D01	Qva	520	143	--	6	H	A	60	10-15-91	DR	U	--	--	--	L
32N/09E-11J02	Qvt	515	64	--	6	H	A	27.5	02-16-94	GS	U	25	35	15	L,Q
32N/09E-12M01	Qvt	510	50	--	6	H	C	20.6	02-16-94	GS	U	10	5	69	L
32N/09E-14Q01	Qva	545	208	--	8	U	A	66.4	02-16-94	GS	C	110	111	24	L
32N/09E-15G03	Qva	530	203	--	6	H	C	46.7	02-17-94	GS	U	15	15	23	L,Q,G
32N/09E-17D01	Qva	460	57	--	6	H	A	11.4	02-17-94	GS	C	--	--	--	L
32N/09E-23J01	Qva	580	243	6	8	I	C	--	--	--	-	--	--	--	L
32N/10E-04F01	Qva	545	180	--	6	H	A	113	02-15-94	GS	C	--	--	--	L,G
32N/10E-05J01	Qvt	430	50	--	6	H	A	7.3	02-15-94	GS	U	20	4	170	L
32N/10E-06A01	Qva	450	100	--	6	H	A	22.7	02-16-94	GS	C	--	--	--	L,Q
32N/10E-07P01	Qal	470	84	--	10	H	C	11.4	02-15-94	GS	U	45	4	310	L,G
32N/10E-08H01	Qva	500	140	--	6	H	A	74.1	02-16-94	GS	C	--	--	--	L,G

Appendix B.--Water Quality Data Tables

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994*

[Qal, alluvium aquifer; Qvr, Vashon recessional outwash aquifer; Qvt, Vashon till confining bed; Qva, Vashon advance outwash aquifer; Qtb, transitional beds confining bed; Qu, undifferentiated sediments aquifer; Tb, bedrock confining bed; --, no data; <, less than]

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conductance, field (microsiemens per centimeter)	Specific conductance, laboratory (microsiemens per centimeter)	pH, field (standard units)	pH, laboratory (standard units)
27N/03E-35A01	Qva	09-01-93	1030	42	240	335	329	7.4	8.4
27N/04E-02N01	Qva	09-14-93	1000	123	360	153	152	7.5	7.2
27N/04E-05B01	Qu	08-25-93	1745	160	260	244	236	7.4	7.4
27N/04E-36B01	Qtb	09-15-93	1200	436	434	208	214	7.8	7.3
27N/05E-02Q01	Qva	08-27-93	0835	220	590	156	156	7.5	7.7
27N/05E-05H01	Qva	08-30-93	1710	191	430	129	128	8.3	7.9
27N/05E-06F02	Qva	09-15-93	1615	74	310	115	115	7.5	7.5
27N/05E-07H01	Qva	09-02-93	1655	178	390	111	107	7.8	7.6
27N/05E-08J02	Qva	08-26-93	1115	37	370	116	114	6.7	7.0
27N/05E-09P02	Qva	09-16-93	0940	85	360	343	340	7.1	7.3
27N/05E-09Q02	Qva	08-27-93	1000	160	410	119	118	7.1	7.4
27N/05E-10D02	Qva	09-14-93	1100	52	370	157	156	7.8	8.0
27N/05E-14L01	Qva	09-16-93	1120	105	440	143	143	7.7	7.6
27N/05E-15E03	Qva	09-13-93	1615	58	330	136	138	7.9	7.3
27N/05E-15K01	Qva	08-18-93	1335	159	450	160	160	7.4	7.5
27N/05E-18C01	Qva	09-16-93	1700	58	220	165	164	8.3	7.5
27N/05E-19B03	Qva	09-01-93	1815	49	170	171	161	7.2	7.0
27N/05E-23M01	Qva	08-26-93	1410	92	280	107	104	7.7	7.5
27N/05E-25L01	Qtb	08-17-93	1350	160	400	190	189	7.5	7.5
27N/05E-27R02	Qva	09-01-93	1550	70	150	160	157	8.3	7.4
27N/05E-29H01	Qva	08-26-93	1550	79	320	187	173	7.2	7.5
27N/06E-01A01	Qva	09-15-93	1530	115	120	267	227	6.9	6.7
27N/06E-02B01	Qal	09-16-93	0930	30	30	181	184	8.2	7.9
27N/06E-03Q01	Qtb	09-14-93	1415	41	45	249	220	7.0	6.8
27N/06E-13L02	Qva	09-13-93	1530	50	40	153	151	6.2	6.5
27N/06E-14E03	Qva	08-30-93	1400	160	60	310	307	7.5	7.8
27N/06E-17C01	Tb	08-30-93	1535	60	65	547	542	7.7	7.7
27N/06E-18F01	Qva	09-02-93	1130	70	260	174	177	7.7	7.5
27N/06E-18P02	Qva	08-27-93	1015	155	340	166	165	6.9	7.1
27N/06E-21L03	Tb	09-13-93	1710	240	500	388	389	9.4	9.4
27N/06E-22J01	Qva	09-17-93	1040	76	300	185	190	7.4	7.5
27N/06E-23N01	Qu	09-14-93	1630	210	220	342	340	8.4	7.9
27N/06E-24J01[1]	Qvt	08-25-93	0910	42	240	118	117	6.7	6.9
27N/06E-27K02	Qva	08-26-93	1455	153	480	161	160	7.8	7.2
27N/06E-28C01	Qvt	08-18-93	1830	69	480	184	185	7.3	7.5
27N/06E-28F02	Qva	08-27-93	1130	260	540	115	115	7.5	7.3
27N/06E-29B02	Qva	08-26-93	1325	103	460	101	99	6.6	7.0

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
27N/03E-35A01	11.0	<0.1	<1	150	14	27	10	13	0.4
27N/04E-02N01	9.5	3.3	<1	61	12	7.6	6.0	17	.3
27N/04E-05B01	10.0	<0.1	<1	100	19	13	8.0	14	.3
27N/04E-36B01	10.5	0.1	<1	60	13	6.8	22	43	1
27N/05E-02Q01	12.0	1.1	<1	61	10	8.8	5.6	16	.3
27N/05E-05H01	11.0	.1	<1	48	7.3	7.2	5.6	20	.4
27N/05E-06F02	12.5	<0.1	<1	47	8.0	6.6	5.0	18	.3
27N/05E-07H01	11.0	.2	<1	43	6.7	6.4	4.5	18	.3
27N/05E-08J02	11.5	8.6	<1	42	9.3	4.6	5.0	20	.3
27N/05E-09P02	10.0	6.2	<1	140	26	18	9.0	12	.3
27N/05E-09Q02	10.5	2.7	<1	42	6.6	6.3	4.9	19	.3
27N/05E-10D02	9.0	.2	<1	66	12	8.8	6.3	16	.3
27N/05E-14L01	10.5	.3	<1	57	11	7.2	4.7	15	.3
27N/05E-15E03	10.5	.1	<1	57	13	5.9	4.8	15	.3
27N/05E-15K01	12.0	3.7	<1	62	11	8.5	5.6	16	.3
27N/05E-18C01	11.0	<0.1	<1	67	15	7.2	5.2	14	.3
27N/05E-19B03	12.5	1.3	<1	61	13	7.0	7.7	21	.4
27N/05E-23M01	10.5	<0.1	<1	38	7.6	4.6	4.5	20	.3
27N/05E-25L01	10.0	<0.1	<1	78	13	11	6.0	14	.3
27N/05E-27R02	11.0	1.6	<1	58	12	6.7	8.3	23	.5
27N/05E-29H01	10.5	4.4	<1	78	13	11	6.4	15	.3
27N/06E-01A01	10.0	--	<1	86	21	8.2	7.0	14	.3
27N/06E-02B01	12.5	.1	<1	85	20	8.5	4.5	10	.2
27N/06E-03Q01	12.0	<0.1	<1	85	20	8.5	10	20	.5
27N/06E-13L02	11.0	2.4	<1	55	14	4.9	5.5	17	.3
27N/06E-14E03	13.0	2.1	<1	92	21	9.7	24	35	1
27N/06E-17C01	12.5	<0.1	[2]2	7	2.5	0.3	120	97	19
27N/06E-18F01	10.5	.2	<1	71	19	5.8	5.6	14	.3
27N/06E-18P02	11.0	6.3	<1	66	12	8.8	5.8	16	.3
27N/06E-21L03	11.0	.1	<1	2	0.58	0.03	83	--	29
27N/06E-22J01	10.0	5.1	<1	83	15	11	5.7	13	.3
27N/06E-23N01	11.5	.1	<1	83	21	7.5	33	44	2
27N/06E-24J01[1]	11.0	5.4	<1	48	9.0	6.2	3.7	14	.2
27N/06E-27K02	11.0	10.7	<1	67	16	6.5	5.3	14	.3
27N/06E-28C01	12.0	2.8	<1	77	9.2	13	5.6	13	.3
27N/06E-28F02	10.0	5.4	<1	46	11	4.4	4.5	17	.3
27N/06E-29B02	11.5	9.7	<1	33	9.1	2.5	5.4	26	.4

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field, (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
27N/03E-35A01	3.8	--	--	--	137	29	8.2	<0.1
27N/04E-02N01	2.3	--	--	--	64	8.1	2.9	.2
27N/04E-05B01	3.2	130	0	106	104	9.6	5.4	<.1
27N/04E-36B01	3.0	--	--	--	107	0.1	2.1	.2
27N/05E-02Q01	2.2	--	--	--	62	12	2.4	.1
27N/05E-05H01	1.9	--	--	--	61	2.4	2.6	.1
27N/05E-06F02	1.6	--	--	--	53	3.6	2.3	.1
27N/05E-07H01	1.7	63	0	52	52	1.5	2.0	.1
27N/05E-08J02	0.6	--	--	--	42	4.8	3.3	.1
27N/05E-09P02	2.1	--	--	--	96	11	16	<.1
27N/05E-09Q02	1.7	--	--	--	37	12	3.6	.1
27N/05E-10D02	2.6	--	--	--	78	1.9	2.2	.2
27N/05E-14L01	1.8	--	--	--	57	11	2.6	.1
27N/05E-15E03	1.9	--	--	--	61	5.8	2.7	.1
27N/05E-15K01	1.2	--	--	--	69	5.8	3.4	<.1
27N/05E-18C01	3.0	--	--	--	81	1.3	1.7	.1
27N/05E-19B03	2.3	--	--	--	82	.8	2.4	.2
27N/05E-23M01	1.4	47	0	39	38	9.2	2.2	.1
27N/05E-25L01	2.3	--	--	--	85	9.6	2.8	.1
27N/05E-27R02	3.5	--	--	--	76	2.1	1.7	.2
27N/05E-29H01	1.4	--	--	--	64	9.7	4.8	.1
27N/06E-01A01	3.4	--	--	--	113	.2	2.0	.2
27N/06E-02B01	1.3	--	--	--	93	1.0	2.3	.1
27N/06E-03Q01	2.1	143	0	117	106	<.1	6.2	.2
27N/06E-13L02	1.3	--	--	--	38	7.0	5.6	.1
27N/06E-14E03	2.1	--	--	--	92	5.0	21	.1
27N/06E-17C01	.8	--	--	--	204	14	39	.1
27N/06E-18F01	2.7	--	--	--	72	13	2.5	.1
27N/06E-18P02	1.9	--	--	--	62	5.0	4.3	.1
27N/06E-21L03	<.1	168	24	178	180	16	3.1	<.1
27N/06E-22J01	1.0	--	--	--	89	4.2	1.6	.1
27N/06E-23N01	6.2	--	--	--	125	<.1	29	.1
27N/06E-24J01[1]	.8	--	--	--	38	7.1	1.9	.1
27N/06E-27K02	1.4	--	--	--	75	8.4	1.8	.1
27N/06E-28C01	1.5	--	--	--	72	13	3.0	<.1
27N/06E-28F02	.8	--	--	--	42	6.5	2.3	.1
27N/06E-29B02	.6	--	--	--	30	4.4	2.9	.1

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milli-grams per liter as SiO_2)	Solids, sum of consti-tuents, dissolved (milli-grams per liter)	Total nitrate nitrogen (milli-grams per liter as N)	Nitrate nitrogen, dissolved (milli-grams per liter as N)	Nitrite nitrogen, dissolved (milli-grams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as NH_4)
27N/03E-35A01	39	214	--	--	<0.01	<0.05	0.02	0.03
27N/04E-02N01	40	118	0.07	--	<.01	.07	.02	.03
27N/04E-05B01	37	162	--	--	<.01	<.05	.30	.39
27N/04E-36B01	46	162	--	--	<.01	<.05	1.3	1.7
27N/05E-02Q01	30	110	.21	--	<.01	.21	.01	.01
27N/05E-05H01	38	103	--	--	.02	<.05	.13	.17
27N/05E-06F02	33	92	--	--	<.01	<.05	.03	.04
27N/05E-07H01	30	85	--	--	<.01	<.05	.07	.09
27N/05E-08J02	24	83	1.3	--	<.01	1.3	.01	.01
27N/05E-09P02	35	219	10	--	<.01	10	.02	.03
27N/05E-09Q02	29	90	.84	--	<.01	.84	.01	.01
27N/05E-10D02	42	124	--	--	<.01	<.05	.22	.28
27N/05E-14L01	31	105	.26	--	<.01	.26	.04	.05
27N/05E-15E03	30	101	--	--	<.01	<.05	.09	.12
27N/05E-15K01	27	108	.90	--	<.01	.90	.02	.03
27N/05E-18C01	37	121	--	--	<.01	<.05	.48	.62
27N/05E-19B03	42	131	--	--	<.01	<.05	1.1	1.4
27N/05E-23M01	19	73	--	--	<.01	<.05	.05	.06
27N/05E-25L01	33	129	--	--	<.01	<.05	.03	.04
27N/05E-27R02	37	119	--	--	<.01	<.05	.53	.68
27N/05E-29H01	25	118	1.9	--	<.01	1.9	.01	.01
27N/06E-01A01	47	179	--	--	<.01	<.05	7.4	9.5
27N/06E-02B01	20	114	--	--	<.01	<.05	.04	.05
27N/06E-03Q01	41	--	--	--	<.01	<.05	2.8	3.6
27N/06E-13L02	17	102	5.3	--	<.01	5.3	.02	.03
27N/06E-14E03	28	182	3.5	3.5	.03	3.5	.08	.10
27N/06E-17C01	16	316	.07	0.07	.03	.10	.12	.15
27N/06E-18F01	28	121	.10	--	<.01	.10	.05	.06
27N/06E-18P02	30	111	1.2	--	<.01	1.2	.01	.01
27N/06E-21L03	17	--	--	--	<.01	<.05	.11	.14
27N/06E-22J01	27	124	1.1	--	<.01	1.1	.02	.03
27N/06E-23N01	39	--	--	--	<.01	<.05	.45	.58
27N/06E-24J01[1]	22	79	--	--	<.01	<.05	2.4	3.1
27N/06E-27K02	19	107	.70	--	<.01	.70	.01	.01
27N/06E-28C01	23	118	1.5	--	<.01	1.5	.02	.03
27N/06E-28F02	21	82	1.5	--	<.01	1.5	.01	.01
27N/06E-29B02	26	80	2.4	--	<.01	2.4	.01	.01

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phosphorus, ortho, dissolved (milligrams per liter as P)	Phosphate, ortho, dissolved (milligrams per liter as PO_4)	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (micrograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (micrograms per liter as Cu)	Iron, dissolved (micrograms per liter as Fe)
27N/03E-35A01	0.04	0.12	2	--	<10	--	--	--	330
27N/04E-02N01	.16	.49	6	5	10	<1.0	2	<1	3
27N/04E-05B01	.32	.98	2	--	--	--	--	--	1,600
27N/04E-36B01	.64	2.0	3	17	--	<1.0	<1	<1	510
27N/05E-02Q01	.22	.67	3	--	--	--	--	--	5
27N/05E-05H01	.12	.37	<1	--	--	--	--	--	180
27N/05E-06F02	.08	.25	7	--	<10	--	--	--	99
27N/05E-07H01	.05	.15	3	--	--	--	--	--	860
27N/05E-08J02	<.01	--	<1	4	<10	<1.0	<1	10	100
27N/05E-09P02	.02	.06	1	--	<10	--	--	--	<3
27N/05E-09Q02	.02	.06	2	--	--	--	--	--	6
27N/05E-10D02	.32	.98	7	--	--	--	--	--	160
27N/05E-14L01	.11	.34	3	--	--	--	--	--	10
27N/05E-15E03	.09	.28	4	--	<10	--	--	--	130
27N/05E-15K01	.02	.06	2	--	--	--	--	--	7
27N/05E-18C01	.32	.98	2	--	<10	--	--	--	120
27N/05E-19B03	.90	2.8	9	--	20	--	--	--	2,200
27N/05E-23M01	.06	.18	1	--	--	--	--	--	920
27N/05E-25L01	.08	.25	7	--	--	--	--	--	260
27N/05E-27R02	.21	.64	<1	8	30	<1.0	<1	<1	62
27N/05E-29H01	.03	.09	2	--	10	--	--	--	5
27N/06E-01A01	1.6	4.9	11	51	30	<1.0	<1	<1	7,400
27N/06E-02B01	.06	.18	7	--	--	--	--	--	24
27N/06E-03Q01	.22	.67	2	--	40	--	--	--	8,900
27N/06E-13L02	<.01	--	<1	--	<10	--	--	--	4
27N/06E-14E03	.22	.67	14	12	--	<1.0	1	3	<3
27N/06E-17C01	.02	.06	27	--	--	--	--	--	31
27N/06E-18F01	.17	.52	10	--	10	--	--	--	54
27N/06E-18P02	.08	.25	3	--	--	--	--	--	7
27N/06E-21L03	.13	.40	1	--	--	--	--	--	12
27N/06E-22J01	.01	.03	<1	--	--	--	--	--	9
27N/06E-23N01	.23	.71	4	31	--	<1.0	<1	<1	93
27N/06E-24J01[1]	.76	2.3	1	--	--	--	--	--	<3
27N/06E-27K02	.02	.06	4	--	--	--	--	--	12
27N/06E-28C01	.02	.06	4	--	--	--	--	--	<3
27N/06E-28F02	.01	.03	<1	--	--	--	--	--	<3
27N/06E-29B02	<.01	--	<1	--	--	--	--	--	8

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dis-solved (micro-grams per liter as Pb)	Manga-nese, dis-solved (micro-grams per liter as Mn)	Mercury, dis-solved (micro-grams per liter as Hg)	Selenium, dis-solved (micro-grams per liter as Se)	Silver, dis-solved (micro-grams per liter as Ag)	Zinc, dis-solved (micro-grams per liter as Zn)	Carbon, organic, dissolved (milli-grams per liter as C)	Methylene-blue-active substances (milligrams per liter)
27N/03E-35A01	--	78	--	--	--	--	0.4	--
27N/04E-02N01	<1	<1	<0.1	<1	<1.0	5	.2	<0.02
27N/04E-05B01	--	310	--	--	--	--	--	--
27N/04E-36B01	<1	79	<.1	<1	<1.0	7	--	--
27N/05E-02Q01	--	1	--	--	--	--	--	--
27N/05E-05H01	--	93	--	--	--	--	--	--
27N/05E-06F02	--	11	--	--	--	--	.1	<.02
27N/05E-07H01	--	100	--	--	--	--	--	--
27N/05E-08J02	<1	8	<.1	<1	<1.0	100	.2	<.02
27N/05E-09P02	--	<1	--	--	--	--	.3	<.02
27N/05E-09Q02	--	4	--	--	--	--	--	--
27N/05E-10D02	--	140	--	--	--	--	--	--
27N/05E-14L01	--	17	--	--	--	--	--	--
27N/05E-15E03	--	44	--	--	--	--	.2	<.02
27N/05E-15K01	--	10	--	--	--	--	--	--
27N/05E-18C01	--	72	--	--	--	--	1.3	<.02
27N/05E-19B03	--	140	--	--	--	--	2.5	<.02
27N/05E-23M01	--	32	--	--	--	--	--	--
27N/05E-25L01	--	15	--	--	--	--	--	--
27N/05E-27R02	<1	49	<.1	<1	<1.0	6	.5	<.02
27N/05E-29H01	--	<1	--	--	--	--	.2	<.02
27N/06E-01A01	<1	290	<.1	<1	<1.0	24	5.9	<.02
27N/06E-02B01	--	59	--	--	--	--	--	--
27N/06E-03Q01	--	300	--	--	--	--	2.8	<.02
27N/06E-13L02	--	<1	--	--	--	--	.2	<.02
27N/06E-14E03	<1	77	<.1	<1	<1.0	24	--	--
27N/06E-17C01	--	14	--	--	--	--	--	--
27N/06E-18F01	--	130	--	--	--	--	.4	<.02
27N/06E-18P02	--	<1	--	--	--	--	--	--
27N/06E-21L03	--	2	--	--	--	--	--	--
27N/06E-22J01	--	3	--	--	--	--	--	--
27N/06E-23N01	<1	55	<.1	<1	<1.0	83	--	--
27N/06E-24J01[1]	--	<1	--	--	--	--	--	--
27N/06E-27K02	--	<1	--	--	--	--	--	--
27N/06E-28C01	--	<1	--	--	--	--	--	--
27N/06E-28F02	--	1	--	--	--	--	--	--
27N/06E-29B02	--	2	--	--	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conductance, field (microsiemens per centimeter)	Specific conductance, laboratory (microsiemens per centimeter)	pH, field (standard units)	pH, laboratory (standard units)
27N/06E-29N01	Qva	09-16-93	1125	88	280	125	125	7.7	7.8
27N/06E-30D01	Qva	09-15-93	1410	145	400	105	104	6.8	7.3
27N/06E-32P01	Qu	08-19-93	1340	252	270	349	343	7.5	7.5
27N/06E-33N02	Qtb	08-25-93	1515	89	440	154	152	7.6	7.5
27N/07E-07R02	Qvt	09-14-93	1735	107	270	513	534	6.9	7.2
27N/07E-09G01	Qu	08-31-93	1840	51	90	194	231	7.6	7.7
27N/07E-30K02	Tb	08-25-93	1300	260	820	348	346	6.8	7.1
27N/07E-31N02	Qu	08-31-93	1455	505	30	1,010	983	8.1	7.8
27N/08E-04P01	Qal	08-26-93	1130	48	130	92	90	6.0	6.2
27N/08E-10A01	Qal	09-01-93	1245	32	150	57	57	6.0	8.0
27N/08E-11G02	Qal	08-25-93	1100	81	240	62	62	6.2	6.7
27N/09E-04L01	Qva	03-23-94	1605	310	270	625	618	8.2	7.9
27N/09E-05C01	Tb	03-23-94	1340	200	230	1,010	998	8.2	7.3
27N/09E-05Q02	Qvr	03-24-94	1045	39	230	67	66	7.7	7.0
27N/09E-15D03	Qal	03-23-94	1500	48	290	45	46	6.4	6.9
28N/04E-03C01	Qu	08-19-93	0945	259	210	196	195	8.0	7.8
28N/05E-02G04	Qu	09-01-93	1500	232	245	233	224	7.3	7.2
28N/05E-03R01	Qva	08-16-93	1645	96	80	188	185	7.7	7.5
28N/05E-10G01	Qtb	08-19-93	1105	153	105	284	284	7.5	7.5
28N/05E-19K01	Qva	08-25-93	1500	149	470	142	141	7.8	7.4
28N/05E-20A01	Qva	08-25-93	0910	252	380	230	218	7.0	7.2
28N/05E-22N01	Qva	09-16-93	1415	140	260	211	213	8.1	7.9
28N/05E-27G01	Qva	08-17-93	1045	116	250	178	170	7.3	7.2
28N/05E-27K01	Qva	08-17-93	0910	35	300	102	102	6.3	6.8
28N/05E-31F01	Qva	08-17-93	1530	60	400	104	104	6.4	6.8
28N/05E-33C01	Qva	08-17-93	1400	100	440	247	246	7.4	7.3
28N/05E-36F01	Tb	08-18-93	1055	150	290	470	468	8.9	8.9
28N/06E-01M01	Qvt	08-20-93	1105	67	580	155	156	6.8	7.1
28N/06E-03B01	Qva	09-16-93	1645	145	520	218	222	8.5	8.3
28N/06E-03C01	Qva	08-18-93	1510	80	530	202	203	8.0	8.0
28N/06E-05M02	Qu	08-18-93	1310	218	70	151	151	8.4	7.9
28N/06E-06C01	Qva	08-18-93	1005	70	230	276	277	7.4	7.5
28N/06E-08E01	Qva	09-01-93	1715	37	45	196	195	6.3	6.6
28N/06E-11H02	Qvt	08-19-93	1645	56	520	307	305	8.1	8.0
28N/06E-12J01	Tb	08-19-93	1045	225	460	634	627	9.0	8.8
28N/06E-14J01	Qva	08-19-93	1400	230	375	234	232	8.0	7.8
28N/06E-15C03	Qvr	09-14-93	1015	60	280	718	648	9.6	9.4
28N/06E-17K04	Qu	08-18-93	1600	84	30	279	277	7.2	7.3
28N/06E-19K01[1]	Qal	08-19-93	1030	64	15	219	169	6.6	6.6
28N/06E-23A01	Qva	08-18-93	1740	150	280	1,300	1,280	8.5	8.4

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
27N/06E-29N01	12.0	<0.1	<1	21	4.9	2.2	19	64	2
27N/06E-30D01	10.5	8.0	<1	41	9.8	4.0	4.8	20	.3
27N/06E-32P01	12.0	.1	<1	17	4.0	1.7	72	89	8
27N/06E-33N02	10.5	.6	<1	63	14	6.9	5.3	15	0.3
27N/07E-07R02	14.5	5.8	<1	21	5.2	1.9	110	92	10
27N/07E-09G01	15.5	.1	<1	100	22	11	8.7	16	.4
27N/07E-30K02	11.0	7.0	<1	130	41	7.6	25	29	.9
27N/07E-31N02	13.0	<0.1	<1	200	57	13	120	56	4
27N/08E-04P01	9.5	6.9	<1	25	6.2	2.3	3.6	19	.3
27N/08E-10A01	10.5	4.9	<1	21	6.4	1.2	2.3	19	.2
27N/08E-11G02	11.5	8.3	<1	23	8.0	0.80	2.0	15	.2
27N/09E-04L01	11.0	<0.1	<1	190	57	11	64	41	2
27N/09E-05C01	10.0	<0.1	<1	69	19	5.2	170	83	9
27N/09E-05Q02	9.5	.4	<1	24	5.8	2.4	2.3	16	.2
27N/09E-15D03	9.0	7.8	<1	17	5.3	.83	1.6	13	.2
28N/04E-03C01	10.0	<0.1	<1	76	15	9.3	10	22	.5
28N/05E-02G04	12.0	<0.1	<1	85	20	8.4	10	20	.5
28N/05E-03R01	12.0	.2	<1	73	16	7.9	6.4	16	.3
28N/05E-10G01	13.5	<0.1	<1	120	28	11	8.1	13	.3
28N/05E-19K01	11.0	8.0	<1	57	11	7.1	4.8	15	.3
28N/05E-20A01	10.0	<0.1	<1	91	20	10	6.4	13	.3
28N/05E-22N01	12.5	.1	<1	78	21	6.1	11	22	.5
28N/05E-27G01	10.5	<0.1	<1	70	16	7.4	5.4	14	.3
28N/05E-27K01	11.5	6.9	<1	36	7.0	4.6	4.5	21	.3
28N/05E-31F01	12.0	7.3	<1	35	7.6	3.9	4.7	22	.3
28N/05E-33C01	11.0	5.6	<1	96	17	13	7.6	14	.3
28N/05E-36F01	17.0	1.7	<1	1	0.48	.03	110	99	42
28N/06E-01M01	15.0	.8	<1	61	14	6.2	5.0	15	.3
28N/06E-03B01	11.5	.3	<1	69	21	4.0	21	39	1
28N/06E-03C01	11.0	<0.1	<1	80	21	6.7	6.7	15	.3
28N/06E-05M02	11.5	.1	<1	61	15	5.8	4.8	14	.3
28N/06E-06C01	11.5	2.4	<1	120	25	14	6.9	11	.3
28N/06E-08E01	11.0	1.2	<1	78	17	8.7	7.5	17	.4
28N/06E-11H02	11.0	.1	<1	130	29	13	6.3	10	.2
28N/06E-12J01	11.5	<0.1	<1	7	2.7	.10	140	98	23
28N/06E-14J01	12.5	.2	<1	94	18	12	11	20	.5
28N/06E-15C03	11.5	<0.1	<1	11	4.0	.21	130	96	17
28N/06E-17K04	14.5	.3	<1	100	19	13	14	23	.6
28N/06E-19K01[1]	13.0	.7	<1	65	14	7.3	6.2	17	.3
28N/06E-23A01	11.5	<0.1	<1	26	10	.18	260	96	22

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field, (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
27N/06E-29N01	1.5	--	--	--	61	2.5	1.6	0.2
27N/06E-30D01	.8	--	--	--	35	5.3	3.3	.1
27N/06E-32P01	2.1	--	--	--	164	.1	7.9	.3
27N/06E-33N02	0.8	--	--	--	55	18	1.6	.1
27N/07E-07R02	.7	--	--	--	239	6.0	24	.3
27N/07E-09G01	1.7	--	--	--	103	14	2.3	<.1
27N/07E-30K02	.7	--	--	--	172	5.4	2.4	<.1
27N/07E-31N02	10	283	0	232	232	<.1	180	.2
27N/08E-04P01	5.8	--	--	--	26	3.1	1.0	.1
27N/08E-10A01	.4	--	--	--	20	2.9	1.4	.1
27N/08E-11G02	.4	--	--	--	21	3.6	1.1	<.1
27N/09E-04L01	8.3	367	0	301	303	31	6.9	.4
27N/09E-05C01	3.7	--	--	--	144	.9	210	2.0
27N/09E-05Q02	.8	--	--	--	33	3.4	0.9	<.1
27N/09E-15D03	5.2	--	--	--	20	2.2	1.2	<.1
28N/04E-03C01	2.3	--	--	--	100	.2	2.7	.2
28N/05E-02G04	.2	142	0	116	116	<.1	2.1	.2
28N/05E-03R01	2.5	112	0	91	91	.3	4.0	.2
28N/05E-10G01	4.2	174	0	143	145	<.1	3.8	.2
28N/05E-19K01	1.7	--	--	--	66	.2	4.1	.1
28N/05E-20A01	2.4	138	0	113	112	.2	1.8	.2
28N/05E-22N01	3.9	--	--	--	104	<.1	1.7	.2
28N/05E-27G01	1.9	109	0	89	87	<.1	2.1	.1
28N/05E-27K01	1.2	--	--	--	33	5.3	2.6	<.1
28N/05E-31F01	.7	--	--	--	30	5.3	4.3	<.1
28N/05E-33C01	2.4	--	--	--	82	12	6.2	<.1
28N/05E-36F01	.1	214	16	201	199	38	2.7	.3
28N/06E-01M01	1.4	--	--	--	63	9.4	2.9	.1
28N/06E-03B01	2.4	122	5	108	106	3.9	4.0	.1
28N/06E-03C01	3.0	--	--	--	95	7.1	2.0	.1
28N/06E-05M02	1.4	80	1	67	68	5.5	3.1	.1
28N/06E-06C01	1.4	--	--	--	109	20	6.2	<.1
28N/06E-08E01	1.0	--	--	--	69	10	6.3	.1
28N/06E-11H02	1.5	--	--	--	94	13	27	<.1
28N/06E-12J01	.4	202	18	196	198	.2	86	.3
28N/06E-14J01	2.3	146	0	120	122	.4	1.5	.2
28N/06E-15C03	.2	116	32	149	150	7.5	110	.4
28N/06E-17K04	1.8	150	0	123	121	7.2	8.9	<.1
28N/06E-19K01[1]	1.6	123	0	101	78	1.9	5.0	.1
28N/06E-23A01	.6	--	--	231	233	.4	250	.1

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milli-grams per liter as SiO_2)	Solids, sum of consti-tuents, dissolved (milli-grams per liter)	Total nitrate nitrogen (milli-grams per liter as N)	Nitrate nitrogen, dissolved (milli-grams per liter as N)	Nitrite nitrogen, dissolved (milli-grams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as NH_4)
27N/06E-29N01	21	91	--	--	<0.01	<0.05	0.17	0.22
27N/06E-30D01	26	81	1.4	--	<.01	1.4	.02	.03
27N/06E-32P01	23	220	--	--	<.01	<.05	.50	.64
27N/06E-33N02	28	109	--	--	<.01	<.05	.04	.05
27N/07E-07R02	22	319	1.2	--	<.01	1.2	.02	.03
27N/07E-09G01	22	144	--	--	<.01	<.05	.06	.08
27N/07E-30K02	21	213	1.5	--	<.01	1.5	.02	.03
27N/07E-31N02	43	--	--	--	<.01	<.05	.88	1.1
27N/08E-04P01	12	63	3.1	--	<.01	3.1	.01	.01
27N/08E-10A01	13	46	1.3	--	<.01	1.3	.02	.03
27N/08E-11G02	10	43	.92	--	<.01	.92	.01	.01
27N/09E-04L01	20	381	--	--	.03	<.05	.19	.24
27N/09E-05C01	11	507	--	--	.02	<.05	.53	.68
27N/09E-05Q02	13	49	--	--	.01	<.05	<.01	--
27N/09E-15D03	10	41	.60	0.6	.01	.61	<.01	--
28N/04E-03C01	46	149	--	--	<.01	<.05	.62	.80
28N/05E-02G04	34	--	--	--	<.01	<.05	2.1	2.7
28N/05E-03R01	39	134	--	--	<.01	<.05	.75	.97
28N/05E-10G01	41	--	--	--	<.01	<.05	1.3	1.7
28N/05E-19K01	39	109	--	--	<.01	<.05	.40	.52
28N/05E-20A01	39	162	2.4	--	<.01	2.4	.01	.01
28N/05E-22N01	30	--	--	--	<.01	<.05	.91	1.2
28N/05E-27G01	37	--	--	--	<.01	<.05	.98	1.3
28N/05E-27K01	30	86	2.5	--	<.01	2.5	.05	.06
28N/05E-31F01	21	78	2.7	--	<.01	2.7	.03	.04
28N/05E-33C01	35	169	5.9	--	<.01	5.9	.02	.03
28N/05E-36F01	23	297	.10	--	<.01	.10	.02	.03
28N/06E-01M01	23	104	.77	--	<.01	.77	.03	.04
28N/06E-03B01	17	140	.07	--	<.01	.07	.17	.22
28N/06E-03C01	23	127	--	--	<.01	<.05	.06	.08
28N/06E-05M02	18	94	--	--	<.01	<.05	.04	.05
28N/06E-06C01	27	170	1.0	--	<.01	1.0	<.01	--
28N/06E-08E01	20	124	2.8	--	<.01	2.8	.01	.01
28N/06E-11H02	20	167	--	--	<.01	<.05	.07	.09
28N/06E-12J01	8.5	356	--	--	<.01	<.05	.12	.15
28N/06E-14J01	30	153	--	--	<.01	<.05	.36	.46
28N/06E-15C03	23	365	--	--	<.01	<.05	<.01	--
28N/06E-17K04	31	171	--	--	<.01	<.05	.28	.36
28N/06E-19K01[1]	28	142	--	--	<.01	<.05	.36	.46
28N/06E-23A01	9.6	671	--	--	<.01	<.05	.23	.30

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phos-phorus, ortho, dissolved milli-grams per liter as P)	Phos-phate, ortho, dissolved (milli-grams per liter as PO_4)	Arsenic, dissolved (micro-grams per liter as As)	Barium, dissolved (mirco-grams per liter as Ba)	Boron, dissolved (micro-grams per liter as B)	Cadmium, dissolved (micro-grams per liter as Cd)	Chromium, dissolved (micro-grams per liter as Cr)	Copper, dissolved (micro-grams per liter as Cu)	Iron, dissolved (micro-grams per liter as Fe)
27N/06E-29N01	0.25	0.77	4	--	<10	--	--	--	360
27N/06E-30D01	.03	.09	<1	--	--	--	--	--	14
27N/06E-32P01	2.9	8.9	15	--	--	--	--	--	640
27N/06E-33N02	.23	0.71	2	--	--	--	--	--	230
27N/07E-07R02	.02	.06	2	--	--	--	--	--	6
27N/07E-09G01	.03	.09	1	--	40	--	--	--	220
27N/07E-30K02	<.01	--	<1	--	--	--	--	--	4
27N/07E-31N02	.60	1.8	45	85	30	<1.0	<1	<1	1,800
27N/08E-04P01	<.01	--	<1	--	--	--	--	--	<3
27N/08E-10A01	.01	.03	<1	--	<10	--	--	--	25
27N/08E-11G02	<.01	--	<1	--	--	--	--	--	12
27N/09E-04L01	.16	.49	21	--	--	--	--	--	770
27N/09E-05C01	.03	.09	2	230	--	<1.0	<1	<1	25
27N/09E-05Q02	<.01	--	<1	4	--	<1.0	<1	<1	230
27N/09E-15D03	<.01	--	<1	--	<10	--	--	--	27
28N/04E-03C01	.63	1.9	2	--	--	--	--	--	430
28N/05E-02G04	.61	1.9	19	--	--	--	--	--	3,500
28N/05E-03R01	.31	.95	7	21	20	<1.0	<1	<1	880
28N/05E-10G01	.40	1.2	20	--	--	--	--	--	1,400
28N/05E-19K01	.05	.15	3	--	--	--	--	--	59
28N/05E-20A01	.04	.12	12	--	--	--	--	--	3,600
28N/05E-22N01	1.0	3.1	49	--	50	--	--	--	180
28N/05E-27G01	.32	.98	13	--	--	--	--	--	2,000
28N/05E-27K01	.01	.03	<1	5	20	<1.0	<1	13	42
28N/05E-31F01	.02	.06	<1	--	--	--	--	--	3
28N/05E-33C01	.02	.06	2	--	60	--	--	--	25
28N/05E-36F01	.10	.31	<1	<2	30	<1.0	2	4	11
28N/06E-01M01	.09	.28	1	--	--	--	--	--	11
28N/06E-03B01	.31	.95	15	28	--	<1.0	<1	<1	23
28N/06E-03C01	.19	.58	10	--	--	--	--	--	100
28N/06E-05M02	.04	.12	1	--	--	--	--	--	110
28N/06E-06C01	.02	.06	2	--	20	--	--	--	25
28N/06E-08E01	<.01	--	<1	--	--	--	--	--	7
28N/06E-11H02	.06	.18	5	--	20	--	--	--	130
28N/06E-12J01	.01	.03	<1	26	--	<1.0	<1	<1	80
28N/06E-14J01	1.4	4.3	27	--	--	--	--	--	660
28N/06E-15C03	.07	.21	<1	<2	--	<1.0	<1	<1	8
28N/06E-17K04	.04	.12	1	--	20	--	--	--	1,400
28N/06E-19K01[1]	<.01	--	7	--	--	--	--	--	16,000
28N/06E-23A01	<.01	--	<1	--	--	--	--	--	250

Table B1 .--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dis-solved (micro-grams per liter as Pb)	Manga-nese, dis-solved (micro-grams per liter as Mn	Mercury, dis-solved (micro-grams per liter as Hg)	Selenium, dis-solved (micro-grams per liter as Se)	Silver, dis-solved (micro-grams per liter as Ag)	Zinc, dis-solved (micro-grams per liter as Zn)	Carbon, organic, dissolved (milli-grams per liter as C)	Methylene blue active substances (milligrams per liter)
27N/06E-29N01	--	32	--	--	--	--	0.5	<.02
27N/06E-30D01	--	4	--	--	--	--	--	--
27N/06E-32P01	--	26	--	--	--	--	--	--
27N/06E-33N02	--	340	--	--	--	--	--	--
27N/07E-07R02	--	2	--	--	--	--	--	--
27N/07E-09G01	--	140	--	--	--	--	0.3	<0.02
27N/07E-30K02	--	2	--	--	--	--	--	--
27N/07E-31N02	<1	340	<0.1	<1	<1.0	6	2.2	<.02
27N/08E-04P01	--	1	--	--	--	--	--	--
27N/08E-10A01	--	2	--	--	--	--	.3	<.02
27N/08E-11G02	--	1	--	--	--	--	--	--
27N/09E-04L01	--	86	--	--	--	--	--	--
27N/09E-05C01	<1	17	.1	<1	<1.0	57	--	--
27N/09E-05Q02	<1	85	<.1	<1	<1.0	490	--	--
27N/09E-15D03	--	6	--	--	--	--	.2	<.02
28N/04E-03C01	--	220	--	--	--	--	--	--
28N/05E-02G04	--	210	--	--	--	--	--	--
28N/05E-03R01	<1	170	<.1	<1	<1.0	86	1.1	<.02
28N/05E-10G01	--	290	--	--	--	--	--	--
28N/05E-19K01	--	570	--	--	--	--	--	--
28N/05E-20A01	--	250	--	--	--	--	--	--
28N/05E-22N01	--	150	--	--	--	--	2.1	<.02
28N/05E-27G01	--	380	--	--	--	--	--	--
28N/05E-27K01	<1	4	<.1	<1	<1.0	19	.2	<.02
28N/05E-31F01	--	1	--	--	--	--	.2	<.02
28N/05E-33C01	--	1	--	--	--	--	.2	<.02
28N/05E-36F01	<1	1	<.1	<1	<1.0	4	.5	<.02
28N/06E-01M01	--	12	--	--	--	--	--	--
28N/06E-03B01	<1	25	<.1	<1	<1.0	8	--	--
28N/06E-03C01	--	89	--	--	--	--	--	--
28N/06E-05M02	--	140	--	--	--	--	--	--
28N/06E-06C01	--	<1	--	--	--	--	.2	<.02
28N/06E-08E01	--	3	--	--	--	--	--	--
28N/06E-11H02	--	280	--	--	--	--	.3	<.02
28N/06E-12J01	<1	6	<.1	<1	<1.0	<3	1.5	--
28N/06E-14J01	--	180	--	--	--	--	--	--
28N/06E-15C03	<1	2	<.1	<1	<1.0	6	--	--
28N/06E-17K04	--	170	--	--	--	--	.4	<.02
28N/06E-19K01[1]	--	910	--	--	--	--	--	--
28N/06E-23A01	--	14	--	--	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conductance, field (microsiemens per centimeter)	Specific conductance, laboratory (microsiemens per centimeter)	pH, field (standard units)	pH, laboratory (standard units)
28N/06E-24B01	Tb	09-03-93	1015	170	480	182	179	8.3	7.9
28N/06E-24Q01	Qvt	08-20-93	1350	60	450	83	84	6.6	7.3
28N/06E-24Q02	Tb	09-03-93	1210	216	450	934	909	9.4	9.1
28N/06E-26J01	Qva	08-25-93	1655	113	220	190	188	7.9	7.2
28N/06E-29R01	Qva	08-24-93	0945	160	140	158	158	7.0	7.0
28N/06E-36B01	Qva	08-26-93	1525	278	390	123	122	7.8	7.9
28N/07E-06M01	Qva	08-23-93	1125	60	530	164	163	8.1	7.9
28N/07E-10F01	Qva	09-03-93	1430	44	410	99	99	6.7	7.2
28N/07E-10G03	Tb	09-14-93	1315	90	530	197	196	6.1	6.3
28N/07E-16L02	Qvt	08-31-93	1210	60	460	158	151	8.5	7.6
28N/07E-17C01	Tb	08-23-93	1335	261	530	191	191	8.4	8.1
28N/07E-18Q02	Qva	09-03-93	1035	140	590	172	169	8.3	7.8
28N/07E-20J01	Tb	08-25-93	1030	188	480	181	180	8.4	8.2
28N/07E-23A01	Qvr	08-24-93	1405	110	450	178	177	8.6	8.2
28N/07E-26B01	Qva	08-26-93	1230	69	270	120	118	6.2	6.5
28N/07E-27Q01	Qvt	08-24-93	1645	62	340	116	115	6.4	6.5
28N/07E-28H01	Tb	09-14-93	1545	246	230	222	221	8.7	8.4
28N/07E-29F02	Qva	08-23-93	1605	52	335	191	190	7.8	7.8
28N/07E-31C04	Qva	08-24-93	1155	99	355	172	172	7.9	7.3
28N/07E-33F01	Qva	09-03-93	1145	118	170	169	167	7.7	7.4
28N/07E-34D02	Qva	09-16-93	1400	100	330	113	139	7.0	7.8
28N/08E-18L01	Tb	08-25-93	1425	400	660	131	130	9.6	9.4
28N/08E-18M01	Qvt	08-26-93	0930	50	765	197	194	8.0	7.9
28N/08E-21N01	Tb	08-27-93	0900	250	660	516	509	7.7	7.6
28N/08E-26A01	Qvr	08-26-93	0920	100	620	183	182	8.4	7.6
28N/08E-28C01	Qva	09-15-93	1300	150	520	110	110	7.2	7.0
28N/08E-29B01	Qva	08-24-93	0915	100	490	113	111	7.6	7.6
28N/08E-30C01	Qva	08-24-93	1135	128	160	229	224	7.6	7.4
28N/08E-34L01	Qvr	08-24-93	1610	13	200	98	95	5.9	6.2
29N/04E-01A03	Qu	08-12-93	1500	146	120	490	487	7.8	7.9
29N/05E-01A02	Qva	08-05-93	1610	100	320	221	220	8.4	8.2
29N/05E-02C02	Qu	08-25-93	1110	338	280	80	80	8.2	8.2
29N/05E-20P02	Qu	08-11-93	0930	303	70	404	387	7.9	7.2
29N/05E-36B02	Qva	08-06-93	1215	112	180	169	167	7.2	7.8
29N/05E-36P02	Qva	08-05-93	1345	80	220	207	206	8.0	7.8
29N/06E-01E03	Tb	08-09-93	1450	151	670	222	218	8.2	8.1
29N/06E-04K01	Qtb	08-18-93	1200	320	310	277	277	8.6	8.3
29N/06E-05L02	Qva	09-02-93	1230	57	270	190	191	8.1	8.0
29N/06E-08R01	Qvt	08-10-93	1700	69	250	174	173	8.3	8.0
29N/06E-09N02	Qu	08-10-93	1525	248	220	295	292	8.4	8.0

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
28N/06E-24B01	11.0	<0.1	<1	75	21	5.5	7.7	18	0.4
28N/06E-24Q01	10.0	7.7	<1	30	6.1	3.6	4.3	23	.3
28N/06E-24Q02	11.0	1.7	<1	15	5.9	.04	170	96	19
28N/06E-26J01	16.0	6.7	<1	90	18	11	4.4	9	0.2
28N/06E-29R01	11.0	1.8	<1	65	12	8.5	5.7	16	.3
28N/06E-36B01	12.5	4.3	<1	47	9.5	5.7	4.2	16	.3
28N/07E-06M01	13.0	0.2	<1	71	19	5.7	5.3	14	.3
28N/07E-10F01	10.5	.4	<1	42	7.7	5.6	3.0	13	.2
28N/07E-10G03	11.0	2.1	<1	85	25	5.4	7.2	15	.3
28N/07E-16L02	12.0	.1	<1	67	15	7.1	4.8	13	.3
28N/07E-17C01	10.0	<0.1	<1	76	20	6.3	9.0	20	.4
28N/07E-18Q02	11.0	<0.1	<1	70	20	4.8	5.7	15	.3
28N/07E-20J01	12.5	.1	<1	75	16	8.6	7.4	17	.4
28N/07E-23A01	10.0	.1	<1	58	17	3.8	14	34	.8
28N/07E-26B01	11.0	1.6	<1	48	10	5.5	4.4	17	.3
28N/07E-27Q01	11.0	7.1	<1	45	8.8	5.5	4.9	19	.3
28N/07E-28H01	12.0	<0.1	<1	79	20	7.1	19	33	.9
28N/07E-29F02	11.0	.4	<1	82	23	6.0	5.1	12	.2
28N/07E-31C04	12.0	.4	<1	78	17	8.6	5.3	13	.3
28N/07E-33F01	12.5	.8	<1	70	16	7.4	5.8	15	.3
28N/07E-34D02	11.0	7.4	<1	44	7.5	6.2	3.8	16	.2
28N/08E-18L01	13.5	.6	<1	6	2.2	0.03	26	--	5
28N/08E-18M01	10.0	.2	<1	81	22	6.3	6.7	15	.3
28N/08E-21N01	12.5	.2	<1	200	59	13	29	24	.9
28N/08E-26A01	11.0	.9	<1	83	21	7.3	4.8	11	.2
28N/08E-28C01	11.0	9.5	<1	46	9.4	5.5	2.8	12	.2
28N/08E-29B01	10.0	7.4	<1	49	14	3.5	2.4	9	.1
28N/08E-30C01	11.5	.8	<1	92	27	5.9	10	19	.5
28N/08E-34L01	15.0	3.9	<1	34	11	1.6	2.7	14	.2
29N/04E-01A03	--	--	--	130	29	14	47	43	2
29N/05E-01A02	12.0	<0.1	<1	80	18	8.6	11	21	.5
29N/05E-02C02	11.0	--	<1	24	6.4	1.9	6.6	37	.6
29N/05E-20P02	9.0	<0.1	<1	120	20	17	25	30	1
29N/05E-36B02	10.5	<0.1	<1	69	18	5.9	5.7	15	.3
29N/05E-36P02	17.5	.1	<1	85	20	8.6	7.2	15	.3
29N/06E-01E03	10.0	.2	<1	81	18	8.8	15	28	.7
29N/06E-04K01	12.0	.2	<1	54	15	3.9	43	63	3
29N/06E-05L02	13.5	8.8	<1	75	17	7.9	8.4	19	.4
29N/06E-08R01	13.5	.1	<1	73	18	6.7	5.3	13	.3
29N/06E-09N02	11.0	.3	<1	61	15	5.7	42	59	2

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field, (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
28N/06E-24B01	3.0	--	--	--	85	<.1	1.9	0.2
28N/06E-24Q01	.4	--	--	--	33	3.1	1.8	.1
28N/06E-24Q02	.2	21	20	51	49	.3	220	6.0
28N/06E-26J01	1.0	--	--	--	75	5.1	3.3	.1
28N/06E-29R01	2.0	--	--	--	59	7.3	4.0	<.1
28N/06E-36B01	0.9	--	--	--	49	3.2	2.1	.1
28N/07E-06M01	1.3	--	--	--	80	3.5	1.4	.1
28N/07E-10F01	.4	--	--	--	40	3.6	1.9	<.1
28N/07E-10G03	.7	--	--	--	67	8.3	5.2	.1
28N/07E-16L02	.9	79	2	68	66	8.5	2.1	.1
28N/07E-17C01	1.7	102	1	86	87	1.2	7.3	.1
28N/07E-18Q02	2.3	--	--	--	75	2.4	2.1	.1
28N/07E-20J01	2.1	104	2	89	89	2.5	2.4	.2
28N/07E-23A01	1.8	106	1	89	89	<0.1	2.2	.1
28N/07E-26B01	.6	--	--	--	48	3.8	2.2	.1
28N/07E-27Q01	.7	--	--	--	39	2.3	2.5	<.1
28N/07E-28H01	2.5	128	4	111	112	.7	2.1	.2
28N/07E-29F02	1.8	--	--	--	82	7.8	3.6	<.1
28N/07E-31C04	1.5	--	--	--	80	5.8	1.9	<.1
28N/07E-33F01	1.7	--	--	--	67	10	4.0	.1
28N/07E-34D02	.5	--	--	--	52	3.3	1.9	.1
28N/08E-18L01	<.1	40	13	54	54	8.8	1.2	.1
28N/08E-18M01	1.9	116	0	95	96	3.8	0.9	.2
28N/08E-21N01	.9	--	--	--	217	60	1.0	.1
28N/08E-26A01	1.1	100	1	84	86	7.5	.9	.1
28N/08E-28C01	.4	--	--	--	44	2.2	1.8	.1
28N/08E-29B01	.6	--	--	--	44	4.9	1.7	<.1
28N/08E-30C01	2.7	138	0	113	114	<.1	2.3	.2
28N/08E-34L01	2.1	--	--	--	39	6.2	.8	<.1
29N/04E-01A03	3.5	--	--	--	113	26	60	.2
29N/05E-01A02	6.0	128	1	107	105	4.8	2.3	.2
29N/05E-02C02	.5	34	0	28	29	4.4	4.9	.8
29N/05E-20P02	4.2	151	0	124	109	6.2	48	.1
29N/05E-36B02	2.3	--	--	--	82	<.1	3.1	.1
29N/05E-36P02	2.0	--	--	--	86	12	4.4	<.1
29N/06E-01E03	2.9	--	--	--	109	3.0	1.7	<.1
29N/06E-04K01	.7	--	--	136	145	.3	2.3	<.1
29N/06E-05L02	3.0	--	--	--	96	.4	2.0	.2
29N/06E-08R01	2.3	--	--	--	82	2.5	2.6	.2
29N/06E-09N02	1.5	187	2	157	153	<.1	1.9	<.1

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milligrams per liter as SiO_2)	Solids, sum of constituents, dissolved (milligrams per liter)	Total nitrate nitrogen (milligrams per liter as N)	Nitrate nitrogen, dissolved (milligrams per liter as N)	Nitrite nitrogen, dissolved (milligrams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as NH_4)
28N/06E-24B01	30	--	--	--	<0.01	<0.05	0.40	0.52
28N/06E-24Q01	24	69	1.3	--	<.01	1.3	.02	.03
28N/06E-24Q02	7.8	441	--	--	<.01	<.05	.04	.05
28N/06E-26J01	23	124	3.0	--	<.01	3.0	<.01	--
28N/06E-29R01	24	105	1.4	--	<.01	1.4	.02	.03
28N/06E-36B01	24	87	1.8	--	<.01	1.8	.02	.03
28N/07E-06M01	19	104	--	--	<.01	<.05	.09	.12
28N/07E-10F01	20	70	0.88	--	<.01	.88	.02	.03
28N/07E-10G03	12	121	3.7	--	<.01	3.7	.02	.03
28N/07E-16L02	18	98	--	--	<.01	<.05	.03	.04
28N/07E-17C01	23	121	--	--	<.01	<.05	.10	.13
28N/07E-18Q02	21	105	--	--	<.01	<.05	.23	.30
28N/07E-20J01	33	126	--	--	<.01	<.05	.03	.04
28N/07E-23A01	16	--	--	--	<.01	<.05	.10	.13
28N/07E-26B01	20	80	1.1	--	<.01	1.1	<.01	--
28N/07E-27Q01	23	88	3.8	--	<.01	3.8	.01	.01
28N/07E-28H01	21	140	--	--	<.01	<.05	.10	.13
28N/07E-29F02	23	124	.82	--	<.01	.82	.03	.04
28N/07E-31C04	24	114	.38	--	<.01	.38	.03	.04
28N/07E-33F01	21	112	1.2	--	<.01	1.2	.07	.09
28N/07E-34D02	19	89	3.4	--	<.01	3.4	.01	.01
28N/08E-18L01	11	--	--	--	<.01	<.05	<.01	--
28N/08E-18M01	16	116	--	--	<.01	<.05	.16	.21
28N/08E-21N01	16	309	--	--	<.01	<.05	.04	.05
28N/08E-26A01	13	106	--	--	<.01	<.05	.03	.04
28N/08E-28C01	22	76	1.3	--	<.01	1.3	.02	.03
28N/08E-29B01	15	75	1.4	--	<.01	1.4	.03	.04
28N/08E-30C01	26	--	--	--	<.01	<.05	1.3	1.7
28N/08E-34L01	11	61	.46	--	<.01	.46	.03	.04
29N/04E-01A03	33	291	2.4	--	<.01	2.4	<.01	--
29N/05E-01A02	39	155	--	--	<.01	<.05	.18	.23
29N/05E-02C02	7.2	50	.08	--	<.01	.08	.01	.01
29N/05E-20P02	36	239	--	--	<.01	<.05	1.1	1.4
29N/05E-36B02	40	--	--	--	<.01	<.05	.94	1.2
29N/05E-36P02	27	134	--	--	<.01	<.05	.23	.30
29N/06E-01E03	19	136	--	--	<.01	<.05	.24	.31
29N/06E-04K01	12	165	--	--	<.01	<.05	.09	.12
29N/06E-05L02	34	132	.05	--	<.01	.05	.17	.22
29N/06E-08R01	36	124	--	--	<.01	<.05	.24	.31
29N/06E-09N02	15	--	--	--	<.01	<.05	.43	.55

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phos-phorus, ortho, dissolved milli-grams per liter as P)	Phos-phate, ortho, dissolved (milli-grams per liter as PO_4)	Arsenic, dissolved (micro-grams per liter as As)	Barium, dissolved (mirco-grams per liter as Ba)	Boron, dissolved (micro-grams per liter as B)	Cadmium, dissolved (micro-grams per liter as Cd)	Chromium, dissolved (micro-grams per liter as Cr)	Copper, dissolved (micro-grams per liter as Cu)	Iron, dissolved (micro-grams per liter as Fe)
28N/06E-24B01	0.38	1.2	4	26	--	<1.0	<1	<1	140
28N/06E-24Q01	.01	.03	<1	--	--	--	--	--	3
28N/06E-24Q02	.01	.03	<1	--	--	--	--	--	<3
28N/06E-26J01	.02	.06	2	--	--	--	--	--	6
28N/06E-29R01	.03	.09	<1	--	--	--	--	--	20
28N/06E-36B01	.04	.12	2	<2	--	<1.0	3	16	9
28N/07E-06M01	.15	.46	20	--	<10	--	--	--	190
28N/07E-10F01	<.01	--	<1	--	<10	--	--	--	27
28N/07E-10G03	<.01	--	<1	--	--	--	--	--	21
28N/07E-16L02	.03	.09	3	--	--	--	--	--	270
28N/07E-17C01	.35	1.1	4	--	--	--	--	--	35
28N/07E-18Q02	.39	1.2	11	--	--	--	--	--	390
28N/07E-20J01	.07	.21	3	8	--	<1.0	<1	<1	34
28N/07E-23A01	.22	.67	3	--	--	--	--	--	23
28N/07E-26B01	<.01	--	<1	--	<10	--	--	--	7
28N/07E-27Q01	.01	.03	<1	<100	10	<1.0	1	96	<3
28N/07E-28H01	.10	.31	5	--	--	--	--	--	29
28N/07E-29F02	.14	.43	6	--	<10	--	--	--	4
28N/07E-31C04	.17	.52	7	--	10	--	--	--	5
28N/07E-33F01	.09	.28	<1	--	--	--	--	--	44
28N/07E-34D02	.01	.03	<1	--	--	--	--	--	5
28N/08E-18L01	.01	.03	<1	<2	--	<1.0	<1	1	13
28N/08E-18M01	.07	.21	<1	12	30	<1.0	<1	<1	270
28N/08E-21N01	<.01	--	<1	--	--	--	--	--	5
28N/08E-26A01	.10	.31	7	--	--	--	--	--	22
28N/08E-28C01	.01	.03	<1	--	--	--	--	--	4
28N/08E-29B01	.03	.09	<1	--	--	--	--	--	13
28N/08E-30C01	.70	2.1	16	--	--	--	--	--	790
28N/08E-34L01	<.01	--	<1	--	20	--	--	--	18
29N/04E-01A03	.06	.18	6	--	--	--	--	--	10
29N/05E-01A02	.37	1.1	19	--	--	--	--	--	64
29N/05E-02C02	.06	.18	2	3	--	<1.0	<1	<1	9
29N/05E-20P02	.16	.49	2	14	--	<1.0	1	<1	5,500
29N/05E-36B02	.33	1.0	7	24	--	<1.0	<1	<1	270
29N/05E-36P02	.22	.67	6	--	20	--	--	--	7
29N/06E-01E03	.47	1.4	1	--	<10	--	--	--	330
29N/06E-04K01	.30	.92	6	89	20	<1.0	2	<1	35
29N/06E-05L02	.33	1.0	<1	--	30	--	--	--	52
29N/06E-08R01	.25	.77	3	--	10	--	--	--	49
29N/06E-09N02	.30	.92	<1	--	--	--	--	--	160

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dis-solved (micro-grams per liter as Pb)	Manga-nese, dis-solved (micro-grams per liter as Mn	Mercury, dis-solved (micro-grams per liter as Hg)	Selenium, dis-solved (micro-grams per liter as Se)	Silver, dis-solved (micro-grams per liter as Ag)	Zinc, dis-solved (micro-grams per liter as Zn)	Carbon, organic, dissolved (milli-grams per liter as C)	Methylene blue active substances (milligrams per liter)
28N/06E-24B01	<1	99	<0.1	<1	<1.0	4	--	--
28N/06E-24Q01	--	4	--	--	--	--	--	--
28N/06E-24Q02	--	2	--	--	--	--	--	--
28N/06E-26J01	--	4	--	--	--	--	--	--
28N/06E-29R01	--	6	--	--	--	--	--	--
28N/06E-36B01	<1	2	<.1	<1	<1.0	230	--	--
28N/07E-06M01	--	130	--	--	--	--	0.3	<0.02
28N/07E-10F01	--	7	--	--	--	--	.2	<.02
28N/07E-10G03	--	7	--	--	--	--	--	--
28N/07E-16L02	--	140	--	--	--	--	--	--
28N/07E-17C01	--	100	--	--	--	--	--	--
28N/07E-18Q02	--	91	--	--	--	--	--	--
28N/07E-20J01	<1	75	<.1	<1	<1.0	45	--	--
28N/07E-23A01	--	28	--	--	--	--	--	--
28N/07E-26B01	--	1	--	--	--	--	.2	<.02
28N/07E-27Q01	<1	<1	<.1	<1	<1.0	<10	.2	<.02
28N/07E-28H01	--	32	--	--	--	--	--	--
28N/07E-29F02	--	110	--	--	--	--	.2	<.02
28N/07E-31C04	--	120	--	--	--	--	.4	<.02
28N/07E-33F01	--	120	--	--	--	--	--	--
28N/07E-34D02	--	<1	--	--	--	--	--	--
28N/08E-18L01	<1	2	<.1	<1	<1.0	20	--	--
28N/08E-18M01	<1	55	<.1	<1	<1.0	<3	.3	<.02
28N/08E-21N01	--	140	--	--	--	--	--	--
28N/08E-26A01	--	45	--	--	--	--	--	--
28N/08E-28C01	--	1	--	--	--	--	--	--
28N/08E-29B01	--	2	--	--	--	--	--	--
28N/08E-30C01	--	220	--	--	--	--	--	--
28N/08E-34L01	--	5	--	--	--	--	.4	<.02
29N/04E-01A03	--	31	--	--	--	--	--	--
29N/05E-01A02	--	38	--	--	--	--	--	--
29N/05E-02C02	<1	1	<.1	<1	<1.0	<3	--	--
29N/05E-20P02	<1	340	<.1	<1	<1.0	<3	--	--
29N/05E-36B02	<1	210	<.1	<1	<1.0	26	--	--
29N/05E-36P02	--	100	--	--	--	--	.7	<.02
29N/06E-01E03	--	65	--	--	--	--	.5	<.02
29N/06E-04K01	<1	26	<.1	<1	<1.0	9	--	--
29N/06E-05L02	--	44	--	--	--	--	.8	<.02
29N/06E-08R01	--	81	--	--	--	--	.6	<.02
29N/06E-09N02	--	25	--	--	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conduc-tance, field (micro-siemens per centi-meter)	Specific conduc-tance, laboratory (micro-siemens per centi-meter)	pH, field (stan-dard units)	pH, labora-tory (stan-dard units)
29N/06E-11B02	Tb	08-09-93	1630	336	480	291	285	8.5	8.3
29N/06E-11P02	Qvt	08-09-93	1825	60	590	123	123	7.5	7.9
29N/06E-14F03	Qu	08-09-93	1755	418	480	404	391	8.3	8.2
29N/06E-14Q02	Qvt	09-17-93	1015	58	380	151	151	8.3	8.0
29N/06E-15Q01	Qtb	08-10-93	1420	87	210	187	187	7.6	8.0
29N/06E-16N01	Qva	08-10-93	1640	88	240	179	177	8.3	8.1
29N/06E-20F02	Qva	08-11-93	1550	55	270	188	187	7.1	7.3
29N/06E-20R01	Tb	08-13-93	1350	211	120	308	304	8.4	8.3
29N/06E-21M01	Qva	08-12-93	1810	58	115	152	150	6.7	7.0
29N/06E-22N01	Qu	08-10-93	1625	234	280	202	201	8.2	8.4
29N/06E-23R02[1]	Qtb	08-12-93	1255	300	520	231	359	8.4	8.3
29N/06E-25C01	Qva	08-12-93	1440	80	310	254	250	8.4	7.8
29N/06E-26J01	Tb	08-13-93	0935	247	540	256	253	7.9	7.7
29N/06E-31M01	Qva	08-13-93	1245	138	280	164	163	8.1	8.0
29N/06E-34G01	Tb	08-12-93	1650	215	420	274	271	8.2	8.1
29N/07E-05F01	Qvt	09-02-93	1510	68	430	238	238	8.2	7.9
29N/07E-09K03	Tb	08-11-93	1140	18	470	53	53	5.7	6.1
29N/07E-09K04	Tb	08-12-93	0945	131	490	230	230	8.2	8.3
29N/07E-16H03	Qvt	08-27-93	1155	98	750	108	95	7.1	7.0
29N/07E-18G02	Qva	08-11-93	1545	80	390	188	186	8.2	8.0
29N/07E-19B01	Qva	09-02-93	1730	210	440	195	197	8.4	8.2
29N/07E-22D01	Qvt	08-17-93	1035	212	750	344	344	7.8	7.8
29N/07E-27A02	Qva	08-11-93	1355	100	670	210	206	7.9	7.7
29N/07E-30C01	Qvt	08-11-93	0935	254	530	159	153	8.3	7.8
29N/07E-31G02	Qvt	08-13-93	1045	47.5	320	181	180	8.1	8.0
29N/07E-33D01	Qva	08-12-93	1135	94	540	216	214	6.4	6.6
30N/04E-01E01	Qva	08-05-93	1005	277	560	93	92	8.0	7.7
30N/04E-03P01	Qva	08-04-93	1000	108	320	129	127	7.7	7.4
30N/04E-04D01	Qva	08-13-93	0930	340	340	185	183	7.6	8.1
30N/04E-04D01	Qva	08-19-93	1545	340	340	--	--	--	--
30N/04E-05P02	Qu	08-03-93	1210	429	420	184	182	7.8	7.8
30N/04E-08G01	Qvt	08-02-93	1325	55	390	209	207	6.4	6.8
30N/04E-09M01	Qva	09-15-93	1125	363	410	243	240	7.4	7.1
30N/04E-14K02	Qva	08-05-93	1450	178	250	143	137	7.2	7.1
30N/04E-17R02	Qva	08-05-93	1630	230	290	286	283	7.4	7.4
30N/04E-22Q01[1]	Qu	08-06-93	0950	311	95	143	134	7.0	7.6
30N/04E-24A01	Qtb	08-03-93	0950	293	460	199	207	8.0	7.9
30N/04E-25Q01	Qva	08-06-93	1130	137	210	178	177	7.2	7.8
30N/04E-35R04	Qva	08-03-93	1715	178	150	382	381	7.8	8.4
30N/04E-35R04	Qva	08-12-93	1605	178	150	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
29N/06E-11B02	13.0	0.1	<1	81	23	5.8	32	46	2
29N/06E-11P02	12.5	2.7	<1	44	11	4.1	5.0	18	.3
29N/06E-14F03	13.0	.1	<1	120	32	10	42	42	2
29N/06E-14Q02	11.5	.1	<1	63	15	6.3	4.9	14	0.3
29N/06E-15Q01	11.0	.1	<1	79	17	8.9	6.8	15	.3
29N/06E-16N01	12.0	.1	<1	76	19	6.9	6.4	15	.3
29N/06E-20F02	16.5	2.4	<1	81	11	13	5.8	13	.3
29N/06E-20R01	10.5	<0.1	<1	25	6.1	2.3	59	83	5
29N/06E-21M01	11.0	2.8	<1	61	13	7.0	4.9	15	.3
29N/06E-22N01	12.5	.5	<1	48	12	4.4	24	51	2
29N/06E-23R02[1]	10.5	<0.1	<1	1	0.20	0.03	87	99	48
29N/06E-25C01	10.5	1.3	<1	92	27	6.0	16	27	.7
29N/06E-26J01	10.5	<0.1	<1	95	24	8.4	14	--	.6
29N/06E-31M01	10.5	<0.1	<1	65	14	7.2	6.8	19	.4
29N/06E-34G01	13.5	2.0	<1	93	31	3.7	22	--	1
29N/07E-05F01	11.5	<0.1	<1	110	29	9.0	3.8	7	.2
29N/07E-09K03	12.0	5.0	<1	18	4.5	1.6	2.3	21	.2
29N/07E-09K04	11.5	.1	<1	110	16	17	6.1	11	.3
29N/07E-16H03	12.0	.8	<1	35	8.1	3.6	4.7	22	.3
29N/07E-18G02	11.5	<0.1	<1	80	22	6.1	5.9	14	.3
29N/07E-19B01	10.5	<0.1	<1	85	26	4.9	6.6	14	.3
29N/07E-22D01	11.0	1.3	<1	170	48	12	8.3	10	.3
29N/07E-27A02	12.5	.1	<1	78	24	4.4	11	23	.5
29N/07E-30C01	10.5	<0.1	<1	63	17	5.0	6.5	18	.4
29N/07E-31G02	13.0	.1	<1	70	23	3.1	8.5	20	.4
29N/07E-33D01	13.0	1.9	<1	88	17	11	6.8	14	.3
30N/04E-01E01	11.5	5.7	<1	31	4.9	4.6	4.4	23	.3
30N/04E-03P01	10.0	7.9	<1	48	8.0	6.8	5.9	20	.4
30N/04E-04D01	10.5	5.5	8[b]	71	14	8.8	7.1	17	.4
30N/04E-04D01	--	--	<1	--	--	--	--	--	--
30N/04E-05P02	12.5	<0.1	<1	75	14	9.6	8.1	18	.4
30N/04E-08G01	14.5	5.2	<1	75	14	9.6	10	22	.5
30N/04E-09M01	11.0	8.4	<1	93	14	14	10	18	.5
30N/04E-14K02	10.5	1.7	<1	46	9.6	5.4	6.2	22	.4
30N/04E-17R02	13.0	10.1	<1	100	15	16	11	18	.5
30N/04E-22Q01[1]	9.5	2.2	<1	49	8.4	6.8	33	58	2
30N/04E-24A01	13.0	<0.1	<1	81	17	9.3	7.5	15	.4
30N/04E-25Q01	11.5	2.9	<1	66	9.9	10	7.8	20	.4
30N/04E-35R04	13.5	<0.1	--	170	36	19	12	13	.4
30N/04E-35R04	--	--	<1	--	--	--	--	--	--

Table B1 .--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field, (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
29N/06E-11B02	1.0	181	2	152	151	1.8	1.5	<0.1
29N/06E-11P02	4.5	--	--	--	54	5.4	2.1	<.1
29N/06E-14F03	2.2	266	0	218	218	.2	1.8	<.1
29N/06E-14Q02	1.6	--	--	--	64	3.9	1.6	.1
29N/06E-15Q01	1.4	--	--	--	90	4.2	2.2	.1
29N/06E-16N01	3.9	--	--	--	82	5.8	1.8	.2
29N/06E-20F02	2.2	--	--	--	86	7.2	2.4	.1
29N/06E-20R01	1.8	195	3	164	164	0.2	1.4	.2
29N/06E-21M01	1.2	--	--	--	58	10	3.8	<.1
29N/06E-22N01	0.9	--	--	--	98	4.5	1.7	.1
29N/06E-23R02[1]	.8	137	2	116	160	.2	19	<.1
29N/06E-25C01	.7	159	2	134	132	.2	1.9	<.1
29N/06E-26J01	<.1	--	--	--	117	12	1.8	<.1
29N/06E-31M01	.2	--	--	--	81	.5	2.4	.2
29N/06E-34G01	<.1	--	--	--	139	3.2	2.3	<.1
29N/07E-05F01	2.1	--	--	--	117	12	2.7	<.1
29N/07E-09K03	.6	--	--	--	16	3.4	1.5	<.1
29N/07E-09K04	.1	--	--	--	117	5.5	1.2	.2
29N/07E-16H03	.9	61	0	50	44	2.8	1.4	.2
29N/07E-18G02	1.6	--	--	--	88	4.8	1.6	.1
29N/07E-19B01	.5	115	1	96	97	3.6	1.4	.1
29N/07E-22D01	.5	--	--	--	176	6.5	1.0	<.1
29N/07E-27A02	1.7	--	--	--	106	.2	1.2	.1
29N/07E-30C01	.8	92	0	76	77	2.9	1.5	.1
29N/07E-31G02	1.4	--	--	--	91	2.0	1.2	<.1
29N/07E-33D01	.9	--	--	--	69	32	2.0	.1
30N/04E-01E01	1.4	--	--	--	27	5.3	3.2	<.1
30N/04E-03P01	1.5	--	--	--	47	4.1	4.5	<.1
30N/04E-04D01	2.5	--	--	--	67	13	5.5	.1
30N/04E-04D01	--	--	--	--	--	--	--	--
30N/04E-05P02	2.5	--	--	--	73	8.2	6.9	<.1
30N/04E-08G01	1.0	--	--	--	61	13	6.1	<.1
30N/04E-09M01	2.7	--	--	--	72	14	9.7	.1
30N/04E-14K02	2.0	--	--	--	62	1.9	4.1	.1
30N/04E-17R02	3.4	--	--	--	71	18	17	.1
30N/04E-22Q01[1]	1.8	--	--	--	54	5.2	17	.2
30N/04E-24A01	9.8	--	--	--	96	<.1	3.2	.1
30N/04E-25Q01	2.4	--	--	--	71	7.9	4.8	.1
30N/04E-35R04	2.7	207	0	169	168	15	9.6	.2
30N/04E-35R04	--	--	--	--	--	--	--	--

Table B1 .--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milli-grams per liter as SiO_2)	Solids, sum of consti-tuents, dissolved (milli-grams per liter)	Total nitrate nitrogen (milli-grams per liter as N)	Nitrate nitrogen, dissolved (milli-grams per liter as N)	Nitrite nitrogen, dissolved (milli-grams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as NH_4)
29N/06E-11B02	14	171	--	--	<0.01	<0.05	0.19	0.24
29N/06E-11P02	53	118	--	--	<.01	<.05	.04	.05
29N/06E-14F03	17	237	--	--	<.01	<.05	.35	.45
29N/06E-14Q02	23	96	--	--	<.01	<.05	.17	.22
29N/06E-15Q01	23	118	--	--	<.01	<.05	.08	.10
29N/06E-16N01	34	128	--	--	<.01	<.05	.07	.09
29N/06E-20F02	32	126	0.24	--	<.01	.24	<.01	--
29N/06E-20R01	12	184	--	--	<.01	<.05	.10	.13
29N/06E-21M01	21	97	.29	--	<.01	.29	<.01	--
29N/06E-22N01	14	122	--	--	<.01	<.05	.18	.23
29N/06E-23R02[1]	14	191	--	--	<.01	<.05	.02	.03
29N/06E-25C01	17	150	--	--	<.01	<.05	.19	.24
29N/06E-26J01	21	--	--	--	<.01	<.05	.27	.35
29N/06E-31M01	36	117	--	--	<.01	<.05	.11	.14
29N/06E-34G01	16	--	--	--	<.01	<.05	.22	.28
29N/07E-05F01	15	145	.13	0.13	.03	.16	.03	.04
29N/07E-09K03	11	39	.91	--	<.01	.91	<.01	--
29N/07E-09K04	16	133	--	--	<.01	<.05	<.01	--
29N/07E-16H03	32	87	--	--	<.01	<.05	.06	.08
29N/07E-18G02	14	110	--	--	<.01	<.05	.20	.26
29N/07E-19B01	19	120	--	--	<.01	<.05	.10	.13
29N/07E-22D01	31	214	--	--	<.01	<.05	.08	.10
29N/07E-27A02	23	132	--	--	<.01	<.05	.64	.82
29N/07E-30C01	30	111	--	--	<.01	<.05	.10	.13
29N/07E-31G02	19	113	--	--	<.01	<.05	.04	.05
29N/07E-33D01	22	139	1.2	--	<.01	1.2	<.01	--
30N/04E-01E01	33	83	2.3	--	<.01	2.3	<.01	--
30N/04E-03P01	35	102	1.8	--	<.01	1.8	.01	.01
30N/04E-04D01	40	134	.56	--	<.01	.56	<.01	--
30N/04E-04D01	--	--	--	--	--	--	--	--
30N/04E-05P02	43	137	--	--	<.01	<.05	.04	.05
30N/04E-08G01	35	149	5.3	--	<.01	5.3	.02	.03
30N/04E-09M01	46	176	4.9	--	<.01	4.9	.03	.04
30N/04E-14K02	54	125	--	--	<.01	<.05	1.5	1.9
30N/04E-17R02	52	201	5.7	--	<.01	5.7	.01	.01
30N/04E-22Q01[1]	45	153	.62	--	<.01	.62	<.01	--
30N/04E-24A01	54	--	--	--	<.01	<.05	1.0	1.3
30N/04E-25Q01	50	141	1.2	--	<.01	1.2	.02	.03
30N/04E-35R04	33	231	--	--	<.01	<.05	.27	.35
30N/04E-35R04	--	--	--	--	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phosphorus, ortho, dissolved milligrams per liter as P)	Phosphate, ortho, dissolved (milligrams per liter as PO_4)	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (mircograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (micrograms per liter as Cu)	Iron, dissolved (micrograms per liter as Fe)
29N/06E-11B02	0.17	0.52	<1	--	--	--	--	--	320
29N/06E-11P02	<.01	--	--	--	<10	--	--	--	8
29N/06E-14F03	.12	.37	<1	--	--	--	--	--	500
29N/06E-14Q02	.22	.67	4	--	--	--	--	--	140
29N/06E-15Q01	.06	.18	4	--	--	--	--	--	130
29N/06E-16N01	.19	.58	8	14	20	<1.0	<1	<1	130
29N/06E-20F02	.04	.12	2	--	--	--	--	--	9
29N/06E-20R01	.63	1.9	11	--	--	--	--	--	55
29N/06E-21M01	.02	.06	<1	--	--	--	--	--	14
29N/06E-22N01	.25	.77	20	--	--	--	--	--	110
29N/06E-23R02[1]	.03	.09	<1	<2	--	<1.0	<1	<1	27
29N/06E-25C01	.10	.31	<1	--	40	--	--	--	260
29N/06E-26J01	.29	.89	3	--	--	--	--	--	250
29N/06E-31M01	.28	.86	<1	--	--	--	--	--	140
29N/06E-34G01	.03	.09	<1	--	--	--	--	--	130
29N/07E-05F01	.08	.25	12	--	--	--	--	--	30
29N/07E-09K03	.01	.03	<1	--	--	--	--	--	6
29N/07E-09K04	.01	.03	8	38	--	<1.0	<1	<1	170
29N/07E-16H03	.09	.28	<1	--	<10	--	--	--	2,800
29N/07E-18G02	.14	.43	16	--	--	--	--	--	260
29N/07E-19B01	.09	.28	<1	--	--	--	--	--	23
29N/07E-22D01	.02	.06	<1	15	20	<1.0	<1	<1	350
29N/07E-27A02	.56	1.7	--	--	60	--	--	--	420
29N/07E-30C01	.11	.34	<1	29	--	<1.0	<1	<1	1,600
29N/07E-31G02	.08	.25	<1	--	20	--	--	--	60
29N/07E-33D01	.01	.03	<1	--	10	--	--	--	66
30N/04E-01E01	.04	.12	4	--	--	--	--	--	8
30N/04E-03P01	.05	.15	3	--	<10	--	--	--	6
30N/04E-04D01	.10	.31	6	--	--	--	--	--	6
30N/04E-04D01	--	--	--	--	--	--	--	--	--
30N/04E-05P02	.06	.18	6	38	--	<1.0	<1	<1	44
30N/04E-08G01	.02	.06	<1	--	--	--	--	--	24
30N/04E-09M01	.05	.15	2	--	--	--	--	--	17
30N/04E-14K02	.29	.89	<1	--	20	--	--	--	1,500
30N/04E-17R02	.07	.21	1	--	--	--	--	--	7
30N/04E-22Q01[1]	.06	.18	2	--	--	--	--	--	54
30N/04E-24A01	1.6	4.9	26	--	--	--	--	--	70
30N/04E-25Q01	.18	.55	5	--	--	--	--	--	<3
30N/04E-35R04	.07	.21	4	--	--	--	--	--	720
30N/04E-35R04	--	--	--	--	--	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dissolved (micrograms per liter as Pb)	Manganese, dissolved (micrograms per liter as Mn	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene blue active substances (milligrams per liter)
29N/06E-11B02	--	47	--	--	--	--	--	--
29N/06E-11P02	--	99	--	--	--	--	0.2	<0.02
29N/06E-14F03	--	70	--	--	--	--	--	--
29N/06E-14Q02	--	170	--	--	--	--	--	--
29N/06E-15Q01	--	210	--	--	--	--	--	--
29N/06E-16N01	<1	55	<0.1	<1	<1.0	<3	0.3	<.02
29N/06E-20F02	--	4	--	--	--	--	--	--
29N/06E-20R01	--	10	--	--	--	--	--	--
29N/06E-21M01	--	11	--	--	--	--	--	--
29N/06E-22N01	--	14	--	--	--	--	--	--
29N/06E-23R02[1]	<1	<1	<.1	<1	<1.0	4	--	--
29N/06E-25C01	--	61	--	--	--	--	.8	<.02
29N/06E-26J01	--	56	--	--	--	--	--	--
29N/06E-31M01	--	200	--	--	--	--	--	--
29N/06E-34G01	--	44	--	--	--	--	--	--
29N/07E-05F01	--	78	--	--	--	--	--	--
29N/07E-09K03	--	1	--	--	--	--	--	--
29N/07E-09K04	<1	6	<.1	<1	<1.0	<3	--	--
29N/07E-16H03	--	180	--	--	--	--	.2	<.02
29N/07E-18G02	--	140	--	--	--	--	--	--
29N/07E-19B01	--	42	--	--	--	--	--	--
29N/07E-22D01	<1	190	<.1	<1	<1.0	250	1.2	<.02
29N/07E-27A02	--	170	--	--	--	--	1.4	<.02
29N/07E-30C01	<1	72	<.1	<1	<1.0	220	--	--
29N/07E-31G02	--	43	--	--	--	--	<.1	<.02
29N/07E-33D01	--	15	--	--	--	--	.6	<.02
30N/04E-01E01	--	2	--	--	--	--	--	--
30N/04E-03P01	--	2	--	--	--	--	.2	<.02
30N/04E-04D01	--	12	--	--	--	--	--	--
30N/04E-04D01	--	--	--	--	--	--	--	--
30N/04E-05P02	<1	200	2.4	<1	<1.0	150	--	--
30N/04E-08G01	--	9	--	--	--	--	.6	.03
30N/04E-09M01	--	10	--	--	--	--	--	--
30N/04E-14K02	--	150	--	--	--	--	1.5	<.02
30N/04E-17R02	--	6	--	--	--	--	--	--
30N/04E-22Q01[1]	--	17	--	--	--	--	--	--
30N/04E-24A01	--	320	--	--	--	--	--	--
30N/04E-25Q01	--	<1	--	--	--	--	--	--
30N/04E-35R04	--	340	--	--	--	--	--	--
30N/04E-35R04	--	--	--	--	--	--	--	--

Table B1 .--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conduc-tance, field (micro-siemens per centi-meter)	Specific conduc-tance, laboratory (micro-siemens per centi-meter)	pH, field (stan-dard units)	pH, labora-tory (stan-dard units)
30N/04E-36L06	Qu	08-03-93	1505	300	200	250	232	6.9	6.9
30N/05E-02C02	Qva	08-03-93	1000	100	360	154	153	8.0	7.9
30N/05E-03J02[1]	Qal	08-12-93	1850	30	90	233	218	6.6	6.7
30N/05E-06G04	Qva	08-03-93	1405	78	175	156	156	7.2	8.4
30N/05E-07F08	Qva	08-03-93	1245	210	320	122	120	7.5	7.8
30N/05E-08K01	Qvr	08-04-93	1600	20	75	150	148	6.0	6.0
30N/05E-11Q03	Qu	08-03-93	1540	211	180	195	193	7.5	8.2
30N/05E-15H01	Qva	08-24-93	1515	103	105	263	264	8.6	8.5
30N/05E-16J01	Qvr	08-04-93	1335	36	60	91	91	6.6	6.7
30N/05E-20K05	Qva	08-04-93	1140	38	30	138	136	6.6	7.1
30N/05E-24M01	Qva	08-05-93	1300	303	350	218	216	8.2	7.9
30N/05E-25M02	Qva	08-11-93	1715	125	380	213	212	8.0	8.1
30N/05E-26P01	Qu	08-06-93	1015	146	220	258	256	7.7	7.4
30N/05E-29F07	Qvr	08-04-93	0950	25	25	262	256	6.2	6.5
30N/05E-31B10	Qva	08-05-93	1550	89	60	328	321	6.7	7.2
30N/05E-35N02	Qu	08-05-93	1100	240	260	176	173	7.9	7.8
30N/05E-36J01	Qvt	08-04-93	0905	58	360	273	271	7.3	7.5
30N/06E-02Q02	Qvr	08-05-93	0920	100	305	302	298	8.0	8.2
30N/06E-03K01	Qvr	08-05-93	1320	13	250	182	174	6.1	6.5
30N/06E-06E02	Qva	08-11-93	1510	79	425	231	230	7.8	7.7
30N/06E-08G01	Qva	08-24-93	0945	64	460	136	138	6.7	7.1
30N/06E-10K01	Qvt	08-20-93	1250	120	300	321	323	8.2	8.2
30N/06E-11A05	Tb	09-16-93	1345	300	300	1,980	1,990	8.1	8.0
30N/06E-11G01	Qvt	08-04-93	1437	80	220	232	232	7.5	8.0
30N/06E-14K06	Qva	08-05-93	1115	76	340	252	248	8.0	8.0
30N/06E-16M01	Qvt	08-11-93	1345	82	450	215	215	8.1	7.9
30N/06E-18N02	Qva	08-11-93	1955	80	390	117	115	7.1	7.4
30N/06E-20J01	Qva	08-11-93	1420	60	350	169	168	7.4	7.7
30N/06E-22N04	Qva	08-09-93	1650	77	250	231	226	8.3	8.2
30N/06E-23C01	Qvr	08-10-93	1200	33	290	294	290	8.4	8.6
30N/06E-27C01	Qva	08-19-93	1700	40	250	259	257	6.4	6.8
30N/06E-28N01	Qva	08-13-93	1210	112	260	148	147	7.9	7.5
30N/06E-30Q01	Qva	08-19-93	1835	58	350	122	119	9.3	9.1
30N/06E-31J01	Qva	09-15-93	0945	190	340	341	340	8.1	8.1
30N/06E-33J01	Qva	08-16-93	1735	88	330	155	156	6.6	7.4
30N/06E-36E01	Tb	08-16-93	1500	298	710	262	267	7.9	7.9
30N/07E-01R02	Qal	08-04-93	1335	40	940	121	120	6.7	7.0
30N/07E-06J02	Qva	08-04-93	1120	246	570	312	306	7.6	7.6
30N/07E-18F01	Qva	09-14-93	1345	115	430	191	191	8.6	8.2
30N/07E-18P06	Qtb	08-24-93	1130	171	410	244	244	8.3	8.3

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Tempe-rature, water (degrees Celsius)	Oxygen, dis-solved (milli-grams per liter)	Fecal-coliform bacteria (colonies per 100 milli-liters)	Hard-ness, total (milli-grams per liter as $CaCO_3$)	Calcium, dis-solved (milli-grams per liter as Ca)	Magne-sium, dis-, solved (milli-grams per liter as Mg)	Sodium, dissolved (milli-grams per liter as Na)	Sodium, percent	Sodium adsorp-tion ratio
30N/04E-36L06	13.0	0.5	<1	86	18	10	8.7	18	0.4
30N/05E-02C02	12.0	<0.1	<1	67	15	7.2	5.4	15	.3
30N/05E-03J02[1]	16.5	2.1	<1	93	19	11	7.4	14	.3
30N/05E-06G04	10.5	3.1	<1	61	10	8.8	5.8	16	.3
30N/05E-07F08	12.0	2.8	<1	46	6.3	7.3	5.5	20	.4
30N/05E-08K01	13.5	6.2	<1	34	8.9	2.8	6.2	22	.5
30N/05E-11Q03	13.0	<0.1	<1	30	5.3	4.1	31	67	2
30N/05E-15H01	13.0	<0.1	<1	110	20	14	12	18	.5
30N/05E-16J01	13.0	7.8	<1	31	7.3	3.1	4.6	24	.4
30N/05E-20K05	12.5	9.0	<1	48	9.0	6.2	6.6	22	.4
30N/05E-24M01	11.0	<0.1	<1	93	19	11	6.7	13	.3
30N/05E-25M02	12.0	<0.1	<1	87	20	9.1	7.8	16	.4
30N/05E-26P01	11.5	<0.1	<1	110	28	9.2	11	18	.5
30N/05E-29F07	12.5	7.9	<1	63	14	6.9	21	41	1
30N/05E-31B10	14.5	0.3	<1	140	23	19	11	15	.4
30N/05E-35N02	11.5	<0.1	<1	75	14	9.6	6.5	16	.3
30N/05E-36J01	13.5	.6	<1	120	24	14	7.6	12	.3
30N/06E-02Q02	12.5	.6	<1	78	22	5.7	33	46	2
30N/06E-03K01	15.0	8.8	<1	87	30	2.9	3.6	8	.2
30N/06E-06E02	12.5	1.9	<1	99	15	15	7.5	14	.3
30N/06E-08G01	11.0	6.4	<1	61	11	8.1	4.2	13	.2
30N/06E-10K01	19.5	1.8	<1	73	17	7.4	39	52	2
30N/06E-11A05	12.5	2.8	<1	23	8.0	0.73	400	97	36
30N/06E-11G01	12.5	<0.1	<1	76	18	7.6	15	29	.7
30N/06E-14K06	10.5	.6	<1	88	26	5.6	12	22	.6
30N/06E-16M01	10.0	3.3	<1	94	21	10	5.4	11	.2
30N/06E-18N02	10.5	2.0	<1	45	7.8	6.2	4.6	18	.3
30N/06E-20J01	11.0	.1	<1	70	16	7.2	6.0	16	.3
30N/06E-22N04	10.5	.3	<1	100	26	9.7	7.2	13	.3
30N/06E-23C01	12.0	<0.1	<1	63	22	2.0	37	55	2
30N/06E-27C01	14.5	3.6	<1	90	21	9.2	14	25	.6
30N/06E-28N01	12.5	<0.1	<1	58	15	5.0	6.2	18	.4
0N/06E-30Q01	12.0	<0.1	<1	48	7.5	7.1	4.5	17	.3
30N/06E-31J01	11.0	<0.1	<1	56	11	7.0	53	65	3
30N/06E-33J01	11.0	7.2	<1	62	12	7.7	5.1	15	.3
30N/06E-36E01	10.5	<0.1	<1	110	38	3.0	11	18	.5
30N/07E-01R02	10.5	3.1	<1	50	11	5.5	2.5	10	.2
30N/07E-06J02	13.5	.1	<1	99	28	7.0	24	34	1
30N/07E-18F01	11.5	.1	<1	77	17	8.5	7.6	17	.4
30N/07E-18P06	10.0	<0.1	<1	83	24	5.6	18	31	.9

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milli-grams per liter as K)	Bicar-bonate, whole water, field, (milli-grams per liter as HCO_3)	Carbo-nate, whole water, field (milli-grams per liter as CO_3)	Alka-linity, whole water, field (milli-grams per liter as $CaCO_3$)	Alka-linity, whole water, laboratory (milli-grams per liter as $CaCO_3$)	Sulfate, dissolved (milli-grams per liter as SO_4)	Chloride, dissolved (milli-grams per liter as Cl)	Fluo-ride, dis-solved (milli-grams per liter as F)
30N/04E-36L06	2.1	149	0	122	113	<0.1	4.4	0.2
30N/05E-02C02	1.7	--	--	--	75	.5	2.2	.1
30N/05E-03J02[1]	2.3	--	--	--	100	9.1	2.5	.1
30N/05E-06G04	3.8	--	--	--	59	4.3	3.1	<0.1
30N/05E-07F08	1.6	--	--	--	45	4.5	3.1	<.1
30N/05E-08K01	10	--	--	--	10	12	6.4	.1
30N/05E-11Q03	3.0	--	--	--	93	<0.1	2.0	<.1
30N/05E-15H01	6.6	144	4	124	127	7.0	2.8	.3
30N/05E-16J01	0.3	--	--	--	24	12	3.4	<.1
30N/05E-20K05	1.2	--	--	--	36	9.7	7.4	<.1
30N/05E-24M01	2.1	--	--	--	111	1.4	2.0	.2
30N/05E-25M02	2.1	--	--	--	106	.8	2.3	.3
30N/05E-26P01	2.9	159	0	130	131	<.1	2.4	.3
30N/05E-29F07	1.7	--	--	--	35	14	17	<.1
30N/05E-31B10	3.5	--	--	--	126	12	8.5	<.1
30N/05E-35N02	1.2	--	--	--	83	4.8	2.5	.2
30N/05E-36J01	3.0	--	--	--	118	17	4.6	.1
30N/06E-02Q02	3.5	--	--	--	110	4.4	22	.2
30N/06E-03K01	.5	--	--	--	82	1.9	1.5	<.1
30N/06E-06E02	1.7	--	--	--	103	5.5	4.0	<.1
30N/06E-08G01	.9	--	--	--	66	2.1	1.7	<.1
30N/06E-10K01	5.3	--	--	--	156	6.0	5.3	.2
30N/06E-11A05	1.5	--	--	--	341	12	400	.4
30N/06E-11G01	2.9	--	--	--	96	7.2	8.6	.2
30N/06E-14K06	2.2	--	--	--	70	11	25	.1
30N/06E-16M01	1.7	--	--	--	103	5.6	2.0	<.1
30N/06E-18N02	1.2	--	--	--	50	3.4	2.6	.1
30N/06E-20J01	.9	--	--	--	74	4.4	4.4	.1
30N/06E-22N04	1.9	--	--	--	101	14	3.0	<.1
30N/06E-23C01	2.3	125	2	105	105	6.8	22	.3
30N/06E-27C01	1.1	--	--	--	60	11	25	<.1
30N/06E-28N01	1.9	--	--	--	67	4.2	1.8	.2
30N/06E-30Q01	.9	49	7	52	57	4.6	2.1	.1
30N/06E-31J01	4.5	--	--	--	175	.2	2.8	<.1
30N/06E-33J01	.9	--	--	--	44	4.8	4.5	<.1
30N/06E-36E01	.6	--	--	--	117	16	1.3	<.1
30N/07E-01R02	.6	--	--	--	56	3.7	1.5	<.1
30N/07E-06J02	1.7	189	0	155	149	1.9	5.7	.3
30N/07E-18F01	1.9	84	2	73	72	12	6.9	.1
30N/07E-18P06	3.8	--	--	--	113	5.8	5.4	.3

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milli-grams per liter as SiO_2)	Solids, sum of constituents, dissolved (milli-grams per liter)	Total nitrate nitrogen (milli-grams per liter as N)	Nitrate nitrogen, dissolved (milli-grams per liter as N)	Nitrite nitrogen, dissolved (milli-grams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as NH_4)
30N/04E-36L06	56	--	--	--	<0.01	<0.05	3.6	4.6
30N/05E-02C02	34	113	--	--	<.01	<.05	.24	.31
30N/05E-03J02[1]	35	153	--	--	<.01	<.05	.20	.26
30N/05E-06G04	41	125	2.7	--	<.01	2.7	.01	.01
30N/05E-07F08	45	108	1.7	--	<.01	1.7	.02	.03
30N/05E-08K01	17	103	7.6	--	<.01	7.6	.01	.01
30N/05E-11Q03	32	--	--	--	<.01	<.05	.66	.85
30N/05E-15H01	39	178	--	--	<.01	<.05	.08	.10
30N/05E-16J01	20	68	.71	--	<.01	.71	.01	.01
30N/05E-20K05	26	98	2.4	--	<.01	2.4	.03	.04
30N/05E-24M01	38	148	--	--	<.01	<.05	.14	.18
30N/05E-25M02	22	128	--	--	<.01	<.05	.14	.18
30N/05E-26P01	34	--	--	--	<.01	<.05	.85	1.1
30N/05E-29F07	25	174	12	--	<.01	12	.03	.04
30N/05E-31B10	47	220	4.5	--	<.01	4.5	.04	.05
30N/05E-35N02	22	112	--	--	<.01	<.05	.06	.08
30N/05E-36J01	38	181	.46	--	<.01	.46	.02	.03
30N/06E-02Q02	24	183	--	--	<.01	<.05	.29	.37
30N/06E-03K01	13	106	.85	--	<.01	.85	.06	.08
30N/06E-06E02	34	151	1.4	--	<.01	1.4	.01	.01
30N/06E-08G01	23	92	.39	--	<.01	.39	.02	.03
30N/06E-10K01	27	203	.12	0.12	.01	.13	.04	.05
30N/06E-11A05	9.5	1,040	.38	--	<.01	.38	.03	.04
30N/06E-11G01	23	141	--	--	<.01	<.05	.14	.18
30N/06E-14K06	19	144	--	--	<.01	<.05	.08	.10
30N/06E-16M01	32	141	.42	--	<.01	.42	.03	.04
30N/06E-18N02	29	88	.57	--	<.01	.57	.01	.01
30N/06E-20J01	22	107	.25	.25	.07	.32	<.01	--
30N/06E-22N04	23	146	--	--	<.01	<.05	.04	.05
30N/06E-23C01	30	187	--	--	<.01	<.05	.15	.19
30N/06E-27C01	25	161	4.3	--	<.01	4.3	.02	.03
30N/06E-28N01	21	96	--	--	<.01	<.05	<.01	--
30N/06E-30Q01	18	76	--	--	<.01	<.05	<.01	--
30N/06E-31J01	34	221	--	--	<.01	<.05	.68	.88
30N/06E-33J01	26	109	4.9	--	<.01	4.9	.02	.03
30N/06E-36E01	25	166	--	--	<.01	<.05	.20	.26
30N/07E-01R02	20	80	.37	--	<.01	.37	.02	.03
30N/07E-06J02	19	184	--	--	<.01	<.05	1.1	1.4
30N/07E-18F01	24	122	--	--	<.01	<.05	.04	.05
30N/07E-18P06	17	149	--	--	<.01	<.05	.21	.27

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phosphorus, ortho, dissolved milligrams per liter as P)	Phosphate, ortho, dissolved (milligrams per liter as PO_4)	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (mircograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (micrograms per liter as Cu)	Iron, dissolved (micrograms per liter as Fe)
30N/04E-36L06	0.40	1.2	<1	--	20	--	--	--	4,600
30N/05E-02C02	.31	.95	<1	14	--	<1.0	1	<1	190
30N/05E-03J02[1]	.14	.43	5	--	20	--	--	--	5,200
30N/05E-06G04	.17	.52	6	--	<10	--	--	--	<3
30N/05E-07F08	.09	.28	6	<2	--	<1.0	9	<1	<3
30N/05E-08K01	<.01	--	<1	--	20	--	--	--	4
30N/05E-11Q03	1.1	3.4	1	28	--	<1.0	<1	<1	360
30N/05E-15H01	.32	.98	3	--	50	--	--	--	31
30N/05E-16J01	<.01	--	<1	--	--	--	--	--	15
30N/05E-20K05	.01	.03	<1	--	--	--	--	--	19
30N/05E-24M01	.17	.52	7	--	--	--	--	--	500
30N/05E-25M02	.03	.09	<1	--	--	--	--	--	68
30N/05E-26P01	.86	2.6	16	20	--	<1.0	<1	<1	890
30N/05E-29F07	.02	.06	<1	--	--	--	--	--	9
30N/05E-31B10	.04	.12	2	--	--	--	--	--	21
30N/05E-35N02	.07	.21	2	3	--	<1.0	<1	<1	720
30N/05E-36J01	.05	.15	3	--	<10	--	--	--	7
30N/06E-02Q02	.35	1.1	32	32	210	<1.0	<1	<1	97
30N/06E-03K01	<.01	--	<1	--	<10	--	--	--	4
30N/06E-06E02	.04	.12	2	--	--	--	--	--	7
30N/06E-08G01	.01	.03	<1	--	--	--	--	--	8
30N/06E-10K01	.46	1.4	27	--	--	--	--	--	3
30N/06E-11A05	.13	.40	1	--	--	--	--	--	4
30N/06E-11G01	.20	.61	11	--	--	--	--	--	27
30N/06E-14K06	.20	.61	15	--	--	--	--	--	56
30N/06E-16M01	.04	.12	4	--	--	--	--	--	7
30N/06E-18N02	.07	.21	2	--	--	--	--	--	8
30N/06E-20J01	.09	.28	1	--	10	--	--	--	16
30N/06E-22N04	.05	.15	5	11	--	<1.0	<1	<1	38
30N/06E-23C01	.25	.77	280	--	--	--	--	--	27
30N/06E-27C01	<.01	--	11	--	40	--	--	--	11
30N/06E-28N01	.19	.58	8	--	--	--	--	--	100
30N/06E-30Q01	.02	.06	2	--	20	--	--	--	4
30N/06E-31J01	.73	2.2	2	61	--	<1.0	<1	<1	190
30N/06E-33J01	<.01	--	<1	--	--	--	--	--	13
30N/06E-36E01	.10	.31	95	90	--	<1.0	<1	<1	50
30N/07E-01R02	.03	.09	<1	5	--	<1.0	<1	<1	43
30N/07E-06J02	.11	.34	2	--	--	--	--	--	960
30N/07E-18F01	.05	.15	7	11	--	<1.0	<1	<1	13
30N/07E-18P06	.28	.86	38	--	180	--	--	--	11

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dissolved (micrograms per liter as Pb)	Manganese, dissolved (micrograms per liter as Mn	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene blue active substances (milligrams per liter)
30N/04E-36L06	--	360	--	--	--	--	2.7	<0.02
30N/05E-02C02	<1	110	<0.1	<1	<1.0	4	--	--
30N/05E-03J02[1]	--	620	--	--	--	--	4.7	<.02
30N/05E-06G04	--	<1	--	--	--	--	<0.1	<.02
30N/05E-07F08	<1	<1	<0.1	<1	<1.0	150	--	--
30N/05E-08K01	--	12	--	--	--	--	.7	<.02
30N/05E-11Q03	<1	36	<.1	<1	<1.0	110	--	--
30N/05E-15H01	--	82	--	--	--	--	.6	<.02
30N/05E-16J01	--	1	--	--	--	--	--	--
30N/05E-20K05	--	5	--	--	--	--	.2	<.02
30N/05E-24M01	--	220	--	--	--	--	--	--
30N/05E-25M02	--	150	--	--	--	--	--	--
30N/05E-26P01	<1	530	<.1	<1	<1.0	58	--	--
30N/05E-29F07	--	<1	--	--	--	--	--	--
30N/05E-31B10	--	11	--	--	--	--	--	--
30N/05E-35N02	<1	65	<.1	<1	<1.0	66	--	--
30N/05E-36J01	--	1	--	--	--	--	.2	<.02
30N/06E-02Q02	<1	91	<.1	<1	<1.0	4	.4	.03
30N/06E-03K01	--	66	--	--	--	--	.2	<.02
30N/06E-06E02	--	1	--	--	--	--	--	--
30N/06E-08G01		--	3	--	--	--	--	-- --
30N/06E-10K01	--	22	--	--	--	--	--	--
30N/06E-11A05	--	4	--	--	--	--	--	--
30N/06E-11G01	--	89	--	--	--	--	--	--
30N/06E-14K06	--	61	--	--	--	--	--	--
30N/06E-16M01	--	1	--	--	--	--	--	--
30N/06E-18N02	--	12	--	--	--	--	--	--
30N/06E-20J01	--	160	--	--	--	--	.1	<.02
30N/06E-22N04	<1	94	<.1	<1	<1.0	20	--	--
30N/06E-23C01	--	36	--	--	--	--	--	--
30N/06E-27C01	--	1	--	--	--	--	.2	<.02
30N/06E-28N01	--	220	--	--	--	--	--	--
30N/06E-30Q01	--	19	--	--	--	--	.2	<.02
30N/06E-31J01	<1	72	<.1	<1	<1.0	34	--	--
30N/06E-33J01	--	2	--	--	--	--	--	--
30N/06E-36E01	<1	230	<.1	<1	<1.0	<3	--	--
30N/07E-01R02	<1	3	<.1	<1	<1.0	120	--	--
30N/07E-06J02	--	410	--	--	--	--	--	--
30N/07E-18F01	<1	57	<.1	<1	<1.0	18	--	--
30N/07E-18P06	--	42	--	--	--	--	.5	.02

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conductance, field (micro-siemens per centi-meter)	Specific conductance, laboratory (micro-siemens per centi-meter)	pH, field (standard units)	pH, laboratory (standard units)
30N/07E-20D02	Tb	08-04-93	1545	237	550	454	455	9.1	8.8
30N/07E-20K02	Qvt	08-06-93	0930	15	520	51	51	5.7	7.3
30N/07E-29G02	Tb	09-15-93	1530	295	550	670	643	8.9	8.4
30N/07E-30P01D1	Tb	08-23-93	1730	360	540	455	456	9.0	8.8
30N/08E-08J04	Qvr	03-24-94	0840	204	940	216	218	8.1	7.4
31N/03E-24G01	Qva	07-29-93	1615	115	120	188	186	7.0	7.1
31N/03E-36B04	Qu	07-26-93	1530	82	10	216	216	8.0	7.9
31N/04E-03L05	Qvr	07-28-93	1750	25	110	299	293	5.8	6.0
31N/04E-04L03	Qva	07-30-93	1315	79	270	156	153	6.8	7.0
31N/04E-05L01	Qu	08-02-93	1710	283	310	153	152	7.5	7.5
31N/04E-07N02	Qu	07-29-93	1135	337	170	197	196	8.5	8.3
31N/04E-10G04	Qva	07-28-93	1500	38	170	228	226	8.4	8.2
31N/04E-12P02	Qva	08-10-93	0935	120	150	255	251	7.9	8.5
31N/04E-14L01	Qvt	07-28-93	1310	9	190	204	203	7.2	7.3
31N/04E-16Q02	Qva	08-10-93	1140	60	390	200	199	6.8	7.0
31N/04E-18E01[1]	Qu	07-30-93	1035	210	180	611	590	9.2	8.9
31N/04E-20E01	Qu	08-02-93	1530	315	310	190	187	8.3	8.2
31N/04E-22H02	Qva	07-28-93	1020	160	470	136	135	7.7	7.2
31N/04E-25M04	Qva	07-28-93	1215	200	430	161	160	8.4	8.1
31N/04E-26L01	Qva	07-28-93	1430	330	550	150	149	8.1	7.9
31N/04E-29R01	Qva	07-28-93	0925	63	410	207	205	7.1	7.2
31N/04E-34Q02	Qva	07-29-93	0930	182	450	138	137	8.2	8.1
31N/04E-36R02	Qva	07-29-93	1040	140	300	126	124	7.7	7.5
31N/05E-02F01	Qal	07-27-93	1350	36	60	74	74	6.6	7.1
31N/05E-05H01	Qva	07-27-93	1730	120	310	269	266	8.2	8.2
31N/05E-06H01	Qva	07-27-93	1530	28.5	140	210	207	6.3	6.8
31N/05E-07F04	Qu	07-28-93	1750	60	35	435	379	6.6	7.1
31N/05E-10Q01	Qva	07-27-93	1210	79	90	141	140	6.5	7.0
31N/05E-13D02	Qvt	07-27-93	1015	25	370	225	224	7.3	7.5
31N/05E-16Q02	Qvr	07-30-93	1015	48	125	101	101	6.8	7.0
31N/05E-19E02	Qva	07-28-93	0930	110	110	179	177	8.2	7.9
31N/05E-20L02	Qvr	07-29-93	1800	18	125	69	68	6.0	6.5
31N/05E-24L01	Qu	07-28-93	1135	391	445	283	278	8.0	8.2
31N/05E-25L01	Qvt	07-27-93	1015	79	460	164	165	8.0	7.7
31N/05E-28A01	Qvr	08-11-93	0740	16.5	115	254	248	6.1	6.5
31N/05E-30P01	Qva	07-27-93	1440	25	200	225	225	8.5	8.1
31N/05E-32E01	Qvt	07-27-93	1615	76	115	205	204	8.6	8.3
31N/05E-35R01	Qva	07-27-93	1215	60	375	235	237	7.9	7.6
31N/06E-06Q02	Qu	08-10-93	1200	295	265	510	502	8.6	8.7
31N/06E-06R01	Qvr	08-12-93	0945	25	270	80	78	5.6	6.2

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
30N/07E-20D02	13.5	2.5	<1	150	26	21	21	23	0.7
30N/07E-20K02	15.0	2.4	<1	17	4.0	1.7	2.2	22	.2
30N/07E-29G02	10.5	.1	<1	17	2.6	2.6	140	94	15
30N/07E-30P01D1	10.5	<0.1	<1	9	3.3	0.17	100	96	15
30N/08E-08J04	7.5	0.1	<1	82	23	6.0	8.9	18	0.4
31N/03E-24G01	14.5	.4	<1	69	11	10	7.5	19	.4
31N/03E-36B04	11.5	.3	<1	90	18	11	8.2	16	.4
31N/04E-03L05	16.0	6.2	<1	100	18	14	9.3	16	.4
31N/04E-04L03	10.0	9.4	<1	51	10	6.2	7.9	25	.5
31N/04E-05L01	13.5	2.9	<1	60	7.9	9.7	6.2	18	.3
31N/04E-07N02	14.0	<0.1	<1	81	16	10	8.2	18	.4
31N/04E-10G04	12.5	.2	<1	93	19	11	7.5	15	.3
31N/04E-12P02	13.5	.1	<1	110	25	12	6.6	11	.3
31N/04E-14L01	13.0	.2	<1	80	18	8.5	7.7	17	.4
31N/04E-16Q02	12.0	7.2	<1	79	12	12	7.1	16	.3
31N/04E-18E01[1]	11.5	6.6	<1	130	22	18	76	55	3
31N/04E-20E01	10.5	<0.1	<1	79	16	9.6	7.0	15	.3
31N/04E-22H02	10.0	8.2	<1	49	7.7	7.3	6.1	20	.4
31N/04E-25M04	10.5	2.8	<1	64	14	7.0	6.3	17	.3
31N/04E-26L01	9.0	6.4	<1	57	13	5.9	5.8	18	.3
31N/04E-29R01	11.0	1.6	<1	82	13	12	8.4	18	.4
31N/04E-34Q02	10.0	7.7	<1	52	10	6.6	5.9	19	.4
31N/04E-36R02	11.0	7.0	<1	47	8.3	6.3	5.5	20	.4
31N/05E-02F01	13.0	--	<1	31	8.4	2.5	2.0	12	.2
31N/05E-05H01	10.5	.1	<1	120	33	9.3	6.4	10	.3
31N/05E-06H01	11.5	5.6	<1	76	14	10	8.0	18	.4
31N/05E-07F04	11.5	<0.1	<1	160	23	24	10	12	.3
31N/05E-10Q01	11.5	5.0	<1	55	10	7.3	4.1	14	.2
31N/05E-13D02	12.5	5.5	<1	94	23	8.8	5.7	11	.3
31N/05E-16Q02	11.0	9.6	<1	40	6.0	6.1	3.6	16	.2
31N/05E-19E02	11.0	.1	<1	72	16	7.8	6.3	16	.3
31N/05E-20L02	11.5	4.6	<1	21	5.6	1.7	4.2	30	.4
31N/05E-24L01	11.5	<0.1	<1	62	14	6.6	34	53	2
31N/05E-25L01	11.5	<0.1	<1	66	10	10	5.9	16	.3
31N/05E-28A01	12.5	5.9	[2]1	98	25	8.6	3.6	7	.2
31N/05E-30P01	12.0	<0.1	<1	99	23	10	5.9	11	.3
31N/05E-32E01	14.0	<0.1	<1	79	18	8.2	8.6	18	.4
31N/05E-35R01	11.5	3.0	<1	110	24	11	6.3	11	.3
31N/06E-06Q02	12.5	.1	<1	35	5.7	5.0	96	83	7
31N/06E-06R01	12.0	1.1	<1	28	7.8	2.0	3.7	22	.3

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field, (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
30N/07E-20D02	2.9	87	5	79	76	4.6	89	0.1
30N/07E-20K02	.2	--	--	--	17	3.1	2.0	<.1
30N/07E-29G02	1.1	305	16	276	276	1.2	47	1.1
30N/07E-30P01D1	.4	217	12	197	202	0.2	26	<.1
30N/08E-08J04	4.2	--	--	--	110	3.1	2.0	.2
31N/03E-24G01	1.3	--	--	--	66	13	7.5	<.1
31N/03E-36B04	2.3	--	--	--	91	9.3	7.0	<.1
31N/04E-03L05	2.0	--	--	--	24	10	12	<.1
31N/04E-04L03	1.5	--	--	--	43	4.8	4.4	<.1
31N/04E-05L01	1.9	--	--	--	59	7.3	5.1	<.1
31N/04E-07N02	.4	109	3	95	93	1.8	4.5	.1
31N/04E-10G04	2.2	119	3	102	100	12	4.0	<.1
31N/04E-12P02	2.0	--	--	--	116	11	3.4	.1
31N/04E-14L01	2.2	--	--	--	85	5.1	7.0	.1
31N/04E-16Q02	1.4	--	--	--	80	3.6	6.5	<.1
31N/04E-18E01[1]	3.4	346	23	322	334	.1	11	.4
31N/04E-20E01	3.1	--	--	--	88	4.3	4.4	.1
31N/04E-22H02	1.8	--	--	--	47	3.4	4.9	<.1
31N/04E-25M04	1.7	70	1	60	63	5.6	4.9	<.1
31N/04E-26L01	1.5	--	--	--	57	3.7	3.9	<.1
31N/04E-29R01	2.1	--	--	--	85	12	4.8	<.1
31N/04E-34Q02	1.7	--	--	--	55	4.5	3.4	<.1
31N/04E-36R02	1.4	--	--	--	49	3	3.4	<.1
31N/05E-02F01	.7	--	--	--	32	3.3	1.4	<.1
31N/05E-05H01	2.5	--	--	--	120	16	4.0	<.1
31N/05E-06H01	2.1	--	--	--	55	7.6	9.4	<.1
31N/05E-07F04	1.3	209	0	171	141	12	28	<.1
31N/05E-10Q01	.9	--	--	--	41	15	3.5	<.1
31N/05E-13D02	1.9	--	--	--	83	14	4.1	<.1
31N/05E-16Q02	.9	--	--	--	39	4.3	3.3	<.1
31N/05E-19E02	1.9	--	--	--	78	3.0	5.5	<.1
31N/05E-20L02	.3	--	--	--	20	6.0	4.3	<.1
31N/05E-24L01	2.9	--	--	--	138	.2	7.1	.2
31N/05E-25L01	2.0	--	--	--	71	9.4	3.2	.1
31N/05E-28A01	3.1	--	--	--	39	16	10	<.1
31N/05E-30P01	2.1	111	1	92	95	16	3.9	<.1
31N/05E-32E01	3.9	116	2	98	97	6.3	2.6	.2
31N/05E-35R01	2.3	--	--	--	105	5.9	5.1	<.1
31N/06E-06Q02	6.0	220	8	194	191	10	38	.2
31N/06E-06R01	.7	--	--	--	30	3	2.5	<.1

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milligrams per liter as SiO_2)	Solids, sum of constituents, dissolved (milligrams per liter)	Total nitrate nitrogen (milligrams per liter as N)	Nitrate nitrogen, dissolved (milligrams per liter as N)	Nitrite nitrogen, dissolved (milligrams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as NH_4)
30N/07E-20D02	9.8	223	0.07	--	<0.01	0.07	0.04	0.05
30N/07E-20K02	11	37	.58	--	<.01	.58	.01	.01
30N/07E-29G02	8.0	370	.05	--	<.01	.05	.01	.01
30N/07E-30P01D1	10	259	--	--	<.01	<.05	.08	.10
30N/08E-08J04	29	145	.11	0.11	.02	.13	.10	.13
31N/03E-24G01	25	119	.98	--	<.01	.98	.02	.03
31N/03E-36B04	38	149	--	--	<.01	<.05	.03	.04
31N/04E-03L05	18	200	23	--	<.01	23	.03	.04
31N/04E-04L03	34	121	5.9	--	<.01	5.9	.02	.03
31N/04E-05L01	43	120	.68	--	<.01	.68	.02	.03
31N/04E-07N02	39	137	--	--	<.01	<.05	.25	.32
31N/04E-10G04	34	152	--	--	<.01	<.05	.12	.15
31N/04E-12P02	26	157	--	--	<.01	<.05	.06	.08
31N/04E-14L01	42	144	.31	--	<.01	.31	.41	.53
31N/04E-16Q02	36	136	2.1	--	<.01	2.1	.02	.03
31N/04E-18E01[1]	54	398	--	--	<.01	<.05	12	15
31N/04E-20E01	42	140	--	--	<.01	<.05	.12	.15
31N/04E-22H02	36	109	3.0	--	<.01	3.0	.02	.03
31N/04E-25M04	35	117	1.5	--	<.01	1.5	.02	.03
31N/04E-26L01	32	112	2.6	2.6	.02	2.6	.04	.05
31N/04E-29R01	36	142	.46	--	<.01	.46	.02	.03
31N/04E-34Q02	35	107	1.5	--	<.01	1.5	.02	.03
31N/04E-36R02	29	95	1.9	--	<.01	1.9	.02	.03
31N/05E-02F01	8.3	46	.11	--	<.01	.11	.03	.04
31N/05E-05H01	23	166	--	--	<.01	<.05	.03	.04
31N/05E-06H01	34	151	7.4	--	<.01	7.4	.03	.04
31N/05E-07F04	31	250	--	--	<.01	<.05	.32	.41
31N/05E-10Q01	21	96	2.2	--	<.01	2.2	.01	.01
31N/05E-13D02	26	146	2.8	--	<.01	2.8	.02	.03
31N/05E-16Q02	26	79	1.1	--	<.01	1.1	.03	.04
31N/05E-19E02	34	123	--	--	<.01	<.05	.35	.45
31N/05E-20L02	14	50	.47	--	<.01	.47	<.01	--
31N/05E-24L01	43	195	.12	--	<.01	.12	.93	1.2
31N/05E-25L01	38	122	--	--	<.01	<.05	.03	.04
31N/05E-28A01	20	159	11	--	<.01	11	.01	.01
31N/05E-30P01	33	150	--	--	<.01	<.05	.05	.06
31N/05E-32E01	25	133	--	--	<.01	<.05	.09	.12
31N/05E-35R01	33	158	1.6	--	<.01	1.6	.03	.04
31N/06E-06Q02	22	300	--	--	<.01	<.05	.16	.21
31N/06E-06R01	22	61	.34	--	<.01	.34	.01	.01

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phos-phorus, ortho, dissolved milli-grams per liter as P)	Phos-phate, ortho, dissolved (milli-grams per liter as PO_4)	Arsenic, dissolved (micro-grams per liter as As)	Barium, dissolved (mirco-grams per liter as Ba)	Boron, dissolved (micro-grams per liter as B)	Cadmium, dissolved (micro-grams per liter as Cd)	Chromium, dissolved (micro-grams per liter as Cr)	Copper, dissolved (micro-grams per liter as Cu)	Iron, dissolved (micro-grams per liter as Fe)
30N/07E-20D02	0.02	0.06	2	30	--	<1.0	<1	2	3
30N/07E-20K02	<.01	--	<1	--	10	--	--	--	32
30N/07E-29G02	.01	.03	<1	27	--	<1.0	<1	<1	20
30N/07E-30P01D1	.15	.46	<1	--	--	--	--	--	47
30N/08E-08J04	.49	1.5	31	22	--	<1.0	<1	<1	34
31N/03E-24G01	<.01	--	<1	--	--	--	--	--	140
31N/03E-36B04	.08	.25	14	--	--	--	--	--	7
31N/04E-03L05	<.01	--	<1	--	10	--	--	--	5
31N/04E-04L03	.03	.09	<1	--	--	--	--	--	40
31N/04E-05L01	.06	.18	<1	<2	--	<1.0	3	5	34
31N/04E-07N02	.14	.43	<1	--	--	--	--	--	7
31N/04E-10G04	.09	.28	2	19	--	<1.0	<1	1	90
31N/04E-12P02	.14	.43	3	--	--	--	--	--	370
31N/04E-14L01	.19	.58	1	--	<10	--	--	--	140
31N/04E-16Q02	.02	.06	<1	--	--	--	--	--	5
31N/04E-18E01[1]	1.3	4.0	<1	21	--	<1.0	<1	<1	290
31N/04E-20E01	.16	.49	4	--	--	--	--	--	70
31N/04E-22H02	.03	.09	3	--	--	--	--	--	5
31N/04E-25M04	.09	.28	6	--	--	--	--	--	5
31N/04E-26L01	.05	.15	5	--	--	--	--	--	<3
31N/04E-29R01	.05	.15	3	16	10	<1.0	1	<1	18
31N/04E-34Q02	.09	.28	5	--	<10	--	--	--	8
31N/04E-36R02	.04	.12	2	--	--	--	--	--	7
31N/05E-02F01	<.01	--	<1	--	--	--	--	--	80
31N/05E-05H01	<.01	--	9	--	--	--	--	--	140
31N/05E-06H01	<.01	--	<1	--	<10	--	--	--	14
31N/05E-07F04	<.01	--	3	--	--	--	--	--	17,000
31N/05E-10Q01	<.01	--	<1	--	--	--	--	--	10
31N/05E-13D02	<.01	--	2	10	10	<1.0	5	50	7
31N/05E-16Q02	.03	.09	<1	--	<10	--	--	--	<3
31N/05E-19E02	.20	.61	<1	--	--	--	--	--	200
31N/05E-20L02	<.01	--	<1	--	<10	--	--	--	6
31N/05E-24L01	.47	1.4	11	23	--	<1.0	<1	3	490
31N/05E-25L01	.06	.18	4	--	<10	--	--	--	230
31N/05E-28A01	<.01	--	<1	66	10	<1.0	<1	2	62
31N/05E-30P01	.03	.09	8	--	<10	--	--	--	75
31N/05E-32E01	.14	.43	8	17	--	<1.0	<1	<1	40
31N/05E-35R01	.02	.06	3	--	--	--	--	--	6
31N/06E-06Q02	.32	.98	7	--	--	--	--	--	23
31N/06E-06R01	<.01	--	<1	--	--	--	--	--	170

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dissolved (micrograms per liter as Pb)	Manganese, dissolved (micrograms per liter as Mn	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene blue active substances (milligrams per liter)
30N/07E-20D02	<1	<1	<0.1	<1	<1.0	160	--	--
30N/07E-20K02	--	7	--	--	--	--	0.6	<0.02
30N/07E-29G02	<1	4	<.1	<1	<1.0	4	--	--
30N/07E-30P01D1	--	11	--	--	--	--	--	--
30N/08E-08J04	<1	54	<.1	<1	<1.0	45	--	--
31N/03E-24G01	--	17	--	--	--	--	0.4	<.02
31N/03E-36B04	--	230	--	--	--	--	--	--
31N/04E-03L05	--	2	--	--	--	--	.6	<.02
31N/04E-04L03	--	10	--	--	--	--	--	--
31N/04E-05L01	<1	6	<.1	<1	<1.0	360	--	--
31N/04E-07N02	--	36	--	--	--	--	--	--
31N/04E-10G04	<1	270	<.1	<1	<1.0	12	--	--
31N/04E-12P02	--	27	--	--	--	--	--	--
31N/04E-14L01	--	170	--	--	--	--	1.0	<.02
31N/04E-16Q02	--	1	--	--	--	--	--	--
31N/04E-18E01[1]	<1	160	<.1	<1	<1.0	4	--	--
31N/04E-20E01	--	160	--	--	--	--	--	--
31N/04E-22H02	--	<1	--	--	--	--	--	--
31N/04E-25M04	--	<1	--	--	--	--	--	--
31N/04E-26L01	--	2	--	--	--	--	--	--
31N/04E-29R01	<1	7	<.1	<1	<1.0	11	.4	<.02
31N/04E-34Q02	--	<1	--	--	--	--	.2	<.02
31N/04E-36R02	--	2	--	--	--	--	--	--
31N/05E-02F01	--	21	--	--	--	--	--	--
31N/05E-05H01	--	31	--	--	--	--	--	--
31N/05E-06H01	--	3	--	--	--	--	.4	<.02
31N/05E-07F04	--	460	--	--	--	--	--	--
31N/05E-10Q01	--	3	--	--	--	--	--	--
31N/05E-13D02	<1	2	<.1	<1	<1.0	6	.5	<.02
31N/05E-16Q02	--	<1	--	--	--	--	.2	<.02
31N/05E-19E02	--	72	--	--	--	--	--	--
31N/05E-20L02	--	2	--	--	--	--	.6	<.02
31N/05E-24L01	1	44	<.1	<1	<1.0	250	--	--
31N/05E-25L01	--	84	--	--	--	--	.2	<.02
31N/05E-28A01	<1	2	<.1	<1	<1.0	<3	.5	<.02
31N/05E-30P01	--	87	--	--	--	--	.3	<.02
31N/05E-32E01	<1	32	<.1	<1	<1.0	21	--	--
31N/05E-35R01	--	2	--	--	--	--	--	--
31N/06E-06Q02	--	12	--	--	--	--	--	--
31N/06E-06R01	--	72	--	--	--	--	--	--

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conduc-tance, field (micro-siemens per centi-meter)	Specific conduc-tance, laboratory (micro-siemens per centi-meter)	pH, field (stan-dard units)	pH, labora-tory (stan-dard units)
31N/06E-09K01	Qal	07-29-93	1425	16	180	331	323	7.9	7.7
31N/06E-18C01	Qva	07-29-93	0930	270	300	221	222	7.6	7.7
31N/06E-20R02	Tb	07-29-93	1115	200	120	2,100	2,030	8.5	8.4
31N/06E-27K01	Tb	09-17-93	1205	145	390	410	406	7.5	7.6
31N/06E-29J01	Tb	07-29-93	1240	136	420	425	474	9.4	9.4
31N/06E-29Q01	Qvt	07-29-93	1630	41	480	313	309	8.2	8.2
31N/06E-30L02	Qva	07-30-93	1050	50	520	175	170	7.6	7.3
31N/06E-31G01	Qva	07-29-93	1525	140	525	162	161	8.0	7.9
31N/06E-33P01	Qva	07-30-93	0920	43	500	334	323	7.6	7.6
31N/06E-34A01	Qvt	08-20-93	1125	59	300	151	156	6.5	7.0
32N/04E-02P01	Qvt	07-27-93	1020	18	530	99	98	6.1	6.5
32N/04E-03A01	Tb	07-27-93	1215	420	430	659	656	9.4	9.3
32N/04E-04K01	Qva	07-27-93	1430	106	310	245	242	7.9	7.8
32N/04E-05N01	Qva	07-26-93	1640	178	250	252	252	7.9	8.0
32N/04E-06Q05	Qvr	07-27-93	1600	47.5	340	252	250	6.6	6.7
32N/04E-07N03	Qva	07-23-93	1050	86	120	295	292	8.0	8.0
32N/04E-07R02	Qu	07-28-93	1625	295	240	328	325	8.5	8.3
32N/04E-10Q04	Qva	07-22-93	1550	55	330	220	218	7.2	7.5
32N/04E-13K01	Qvt	07-22-93	1050	140	460	447	464	7.7	7.7
32N/04E-13N01	Tb	07-22-93	1730	435	460	521	488	9.4	9.5
32N/04E-16D01	Qva	07-22-93	1400	146	210	270	271	8.3	8.2
32N/04E-20C01	Qva	07-21-93	1745	73	180	291	290	7.6	7.7
32N/04E-22F01	Qvt	07-21-93	1345	209	340	144	145	7.9	7.9
32N/04E-23N02	Qvt	07-21-93	1550	61	360	232	233	8.3	8.1
32N/04E-26C01	Qtb	07-21-93	1045	440	350	355	354	9.0	8.8
32N/04E-28A01	Qva	07-20-93	1645	284	290	221	221	7.8	7.8
32N/04E-28C01	Qva	07-20-93	1445	104	240	191	191	8.0	7.6
32N/04E-29H01	Qtb	07-20-93	1145	94	100	266	267	8.2	8.0
32N/04E-33Q02[1]	Qal	07-19-93	1800	31	30	422	341	6.5	6.4
32N/05E-07N01	Tb	07-26-93	1740	200	500	381	380	9.2	9.7
32N/05E-08N01	Tb	09-13-93	1315	380	490	411	406	9.3	9.1
32N/05E-13E01	Qva	08-10-93	1000	98	460	195	192	7.8	7.9
32N/05E-19R01	Qva	07-22-93	1720	164	225	248	243	7.5	7.5
32N/05E-20P01	Tb	09-16-93	1155	320	80	608	597	9.1	9.0
32N/05E-21B01	Qvr	07-22-93	1530	18	190	169	166	5.9	6.1
32N/05E-21D01	Tb	09-17-93	1045	203	190	765	774	8.5	8.0
32N/05E-24C02	Qva	07-21-93	1350	100	340	590	554	7.2	7.6
32N/05E-27L02	Qva	09-16-93	1030	83	150	272	271	8.2	8.1
32N/05E-27N03	Qu	09-16-93	0945	215	155	578	570	8.3	8.2
32N/05E-30D01	Qvr	07-28-93	1520	14	210	132	130	6.1	6.3

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
31N/06E-09K01	12.0	0.3	40	61	17	4.4	45	58	3
31N/06E-18C01	11.0	7.4	<1	59	14	5.9	17	34	1
31N/06E-20R02	11.5	.1	<1	19	5.5	1.3	460	98	46
31N/06E-27K01	11.0	0.1	<1	96	22	10	50	52	2
31N/06E-29J01	11.0	1.5	<1	4	1.4	.04	100	98	23
31N/06E-29Q01	10.0	2.4	<1	140	29	16	7.9	11	0.3
31N/06E-30L02	10.0	.2	<1	77	16	8.9	4.9	12	.2
31N/06E-31G01	10.5	<0.1	<1	66	14	7.5	4.7	13	.3
31N/06E-33P01	11.0	<0.1	<1	130	34	10	17	22	.7
31N/06E-34A01	12.0	3.9	<1	62	12	7.7	4.6	14	.3
32N/04E-02P01	11.5	8.2	<1	27	7.3	2.1	9.5	42	.8
32N/04E-03A01	12.0	1.8	<1	3	.78	.15	160	99	43
32N/04E-04K01	12.0	<0.1	<1	99	23	10	8.5	15	.4
32N/04E-05N01	11.5	.1	<1	100	21	12	12	20	.5
32N/04E-06Q05	11.5	8.0	<1	97	19	12	13	22	.6
32N/04E-07N03	11.5	<0.1	<1	120	23	15	12	17	.5
32N/04E-07R02	11.5	<0.1	<1	110	10	21	23	29	.9
32N/04E-10Q04	11.0	1.2	<1	89	16	12	8.3	16	.4
32N/04E-13K01	10.0	<0.1	<1	81	20	7.5	67	63	3
32N/04E-13N01	12.0	.1	<1	2	.92	.03	120	99	34
32N/04E-16D01	12.0	.2	<1	110	24	12	10	16	.4
32N/04E-20C01	11.5	4.9	<1	120	21	17	9.9	15	.4
32N/04E-22F01	13.5	<0.1	<1	58	14	5.7	5.6	17	.3
32N/04E-23N02	11.0	1.4	<1	98	21	11	7.9	14	.3
32N/04E-26C01	10.0	.3	<1	20	4.5	2.1	74	87	7
32N/04E-28A01	11.5	.3	<1	93	14	14	9.3	17	.4
32N/04E-28C01	11.5	2.0	<1	82	18	9.0	6.9	15	.3
32N/04E-29H01	13.0	<0.1	<1	70	13	9.0	26	42	1
32N/04E-33Q02[1]	12.0	.1	<1	150	21	23	12	15	.4
32N/05E-07N01	14.5	<0.1	<1	1	.52	.01	88	99	33
32N/05E-08N01	10.5	.9	<1	1	.39	.04	92	99	38
32N/05E-13E01	10.5	<0.1	<1	75	16	8.4	11	24	.6
32N/05E-19R01	10.5	1.2	<1	100	25	10	5.5	10	.2
32N/05E-20P01	10.0	.2	<1	3	1.3	.04	120	99	28
32N/05E-21B01	12.5	2.8	3[b]	68	21	3.8	5.2	14	.3
32N/05E-21D01	12.0	.1	<1	3	1.2	.11	160	99	37
32N/05E-24C02	10.5	<0.1	<1	170	43	16	38	31	1
32N/05E-27L02	11.5	.1	<1	120	29	12	6.4	10	.3
32N/05E-27N03	12.0	5.4	<1	64	17	5.3	89	72	5
32N/05E-30D01	13.5	5.7	<1	51	15	3.4	4.5	16	.3

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field, (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
31N/06E-09K01	7.2	--	--	--	147	0.3	10	0.6
31N/06E-18C01	11	--	--	--	52	6.1	28	<.1
31N/06E-20R02	1.5	617	2	509	510	<.1	350	.7
31N/06E-27K01	2.3	--	--	--	178	33	2.7	0.2
31N/06E-29J01	0.3	140	30	165	164	6.3	45	.2
31N/06E-29Q01	3.6	--	--	--	154	9.6	3.1	<.1
31N/06E-30L02	1.7	94	0	77	77	7.4	2.2	<.1
31N/06E-31G01	2.2	--	--	--	68	9.8	2.7	<.1
31N/06E-33P01	4.3	206	0	169	164	3.5	3.1	.2
31N/06E-34A01	.9	--	--	--	61	5.8	2.7	<.1
32N/04E-02P01	1.4	--	--	--	35	7.4	3.6	<.1
32N/04E-03A01	.5	325	42	336	341	6.3	3.9	.3
32N/04E-04K01	3.7	--	--	--	115	5.0	5.3	.2
32N/04E-05N01	3.2	--	--	--	126	0.2	4.4	.3
32N/04E-06Q05	1.7	--	--	--	78	18	8.2	<.1
32N/04E-07N03	4.3	173	0	142	140	5.4	6.7	.3
32N/04E-07R02	8.0	183	10	167	166	2.3	5.9	.3
32N/04E-10Q04	2.4	--	--	--	83	12	6.0	<.1
32N/04E-13K01	4.9	283	0	232	224	.9	13	.5
32N/04E-13N01	1.0	167	60	237	238	2.1	9.7	1.1
32N/04E-16D01	4.3	158	0	130	127	5.1	6.3	.2
32N/04E-20C01	3.3	--	--	--	116	15	10	.2
32N/04E-22F01	2.2	81	0	66	69	2.5	2.6	<.1
32N/04E-23N02	3.9	--	--	--	100	13	4.5	.2
32N/04E-26C01	3.4	191	11	174	172	1.2	9.0	.3
32N/04E-28A01	2.5	--	--	--	107	3.8	4.2	.2
32N/04E-28C01	1.8	--	--	--	79	9.6	5.6	.1
32N/04E-29H01	6.1	151	0	124	122	8.3	5.5	.2
32N/04E-33Q02[1]	4.9	234	0	192	141	.8	21	.1
32N/05E-07N01	.4	120	46	174	173	9.1	5.5	.5
32N/05E-08N01	1.0	176	18	174	179	25	3.5	.2
32N/05E-13E01	2.6	--	--	--	96	.6	2.2	.2
32N/05E-19R01	2.8	--	--	--	94	22	5.3	.1
32N/05E-20P01	.2	170	15	164	166	5.3	84	.2
32N/05E-21B01	.7	--	--	--	72	3.8	2.9	<.1
32N/05E-21D01	.4	310	10	270	241	4.4	97	.4
32N/05E-24C02	7.6	386	0	316	291	.1	2.2	.4
32N/05E-27L02	2.3	--	--	--	123	7.3	8.4	<.1
32N/05E-27N03	8.0	--	--	--	179	9.9	67	.2
32N/05E-30D01	.8	--	--	--	51	3.2	5.6	<.1

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milligrams per liter as SiO_2)	Solids, sum of constituents, dissolved (milligrams per liter)	Total nitrate nitrogen (milligrams per liter as N)	Nitrate nitrogen, dissolved (milligrams per liter as N)	Nitrite nitrogen, dissolved (milligrams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as NH_4)
31N/06E-09K01	39	220	--	--	<0.01	<0.05	0.79	1.0
31N/06E-18C01	26	150	2.5	--	<.01	2.5	.01	.01
31N/06E-20R02	7.0	--	--	--	<.01	<.05	.30	.39
31N/06E-27K01	15	243	.19	--	<.01	.19	.08	.10
31N/06E-29J01	14	266	--	--	<.01	<.05	.09	.12
31N/06E-29Q01	24	186	.05	--	<.01	.05	.02	.03
31N/06E-30L02	21	110	--	--	<.01	<.05	.54	.70
31N/06E-31G01	27	109	--	--	<.01	<.05	.05	.06
31N/06E-33P01	37	214	--	--	<.01	<.05	.42	.54
31N/06E-34A01	27	105	1.7	--	<.01	1.7	.01	.01
32N/04E-02P01	29	86	1.1	--	<.01	1.1	.04	.05
32N/04E-03A01	17	393	.12	--	<.01	.12	.02	.03
32N/04E-04K01	39	165	--	--	<.01	<.05	.15	.19
32N/04E-05N01	44	175	--	--	<.01	<.05	.43	.55
32N/04E-06Q05	35	172	4.2	--	<.01	4.2	.04	.05
32N/04E-07N03	36	190	--	--	<.01	<.05	.17	.22
32N/04E-07R02	37	209	--	--	<.01	<.05	.170	.22
32N/04E-10Q04	35	149	1.5	--	<.01	1.5	.10	.13
32N/04E-13K01	42	304	.04	0.04	.02	.06	1.3	1.7
32N/04E-13N01	53	331	--	--	.03	<.05	.07	.09
32N/04E-16D01	35	176	--	--	<.01	<.05	.16	.21
32N/04E-20C01	41	189	.48	--	<.01	.48	.01	.01
32N/04E-22F01	42	115	--	--	<.01	<.05	.11	.14
32N/04E-23N02	30	152	--	--	<.01	<.05	.08	.10
32N/04E-26C01	31	232	--	--	<.01	<.05	.10	.13
32N/04E-28A01	45	158	--	--	<.01	<.05	.04	.05
32N/04E-28C01	36	135	.15	--	<.01	.15	<.01	--
32N/04E-29H01	33	178	--	--	<.01	<.05	.32	.41
32N/04E-33Q02[1]	25	252	.26	.26	.01	.27	.69	.89
32N/05E-07N01	45	255	--	--	<.01	<.05	.06	.08
32N/05E-08N01	40	269	.18	.18	.01	.19	.03	.04
32N/05E-13E01	35	136	--	--	<.01	<.05	.26	.33
32N/05E-19R01	20	150	--	--	<.01	<.05	.12	.15
32N/05E-20P01	32	342	--	--	<.01	<.05	.06	.08
32N/05E-21B01	20	107	1.5	--	<.01	1.5	<.01	--
32N/05E-21D01	19	446	--	--	<.01	<.05	.08	.10
32N/05E-24C02	44	362	--	--	<.01	<.05	8.2	11
32N/05E-27L02	33	173	--	--	<.01	<.05	.05	.06
32N/05E-27N03	36	342	.22	.22	.03	.25	.08	.10
32N/05E-30D01	27	95	1.1	--	<.01	1.1	.04	.05

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phosphorus, ortho, dissolved milligrams per liter as P)	Phosphate, ortho, dissolved (milligrams per liter as PO_4)	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (mircograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (micrograms per liter as Cu)	Iron, dissolved (micrograms per liter as Fe)
31N/06E-09K01	2.0	6.1	130	--	280	--	--	--	310
31N/06E-18C01	.02	.06	2	--	--	--	--	--	17
31N/06E-20R02	.10	.31	<1	<100	320	<1.0	2	<1	120
31N/06E-27K01	<.01	--	98	--	290	--	--	--	11
31N/06E-29J01	.08	0.25	2	--	--	--	--	--	9
31N/06E-29Q01	.11	.34	11	--	--	--	--	--	<3
31N/06E-30L02	.03	.09	3	--	--	--	--	--	640
31N/06E-31G01	<.01	--	6	--	--	--	--	--	150
31N/06E-33P01	.48	1.5	9	--	--	--	--	--	1,500
31N/06E-34A01	.01	.03	<1	--	20	--	--	--	<3
32N/04E-02P01	<.01	--	<1	--	40	--	--	--	44
32N/04E-03A01	.43	1.3	<1	--	--	--	--	--	5
32N/04E-04K01	.23	.71	11	26	--	<1.0	6	<1	450
32N/04E-05N01	.49	1.5	3	--	--	--	--	--	170
32N/04E-06Q05	<.01	--	<1	--	50	--	--	--	5
32N/04E-07N03	.40	1.2	6	--	--	--	--	--	280
32N/04E-07R02	.34	1.0	10	42	--	<1.0	2	<1	130
32N/04E-10Q04	.10	.31	1	--	10	--	--	--	31
32N/04E-13K01	1.7	5.2	4	--	--	--	--	--	1,400
32N/04E-13N01	.32	.98	<1	<2	--	<1.0	<1	<1	19
32N/04E-16D01	.22	.67	14	--	--	--	--	--	54
32N/04E-20C01	.06	.18	7	--	20	--	--	--	3
32N/04E-22F01	.15	.46	<1	--	--	--	--	--	270
32N/04E-23N02	.19	.58	14	--	20	--	--	--	20
32N/04E-26C01	.28	.86	<1	--	--	--	--	--	95
32N/04E-28A01	.17	.52	7	--	--	--	--	--	170
32N/04E-28C01	.14	.43	9	--	--	--	--	--	15
32N/04E-29H01	.27	.83	31	20	--	<1.0	10	<1	1,100
32N/04E-33Q02[1]	.03	.09	1	--	30	--	--	--	26,000
32N/05E-07N01	.29	.89	<1	<2	280	<1.0	5	1	23
32N/05E-08N01	.48	1.5	<1	--	--	--	--	--	38
32N/05E-13E01	.48	1.5	<1	--	--	--	--	--	320
32N/05E-19R01	.72	2.2	<1	--	--	--	--	--	710
32N/05E-20P01	.08	.25	<1	--	--	--	--	--	27
32N/05E-21B01	<.01	--	<1	--	10	--	--	--	64
32N/05E-21D01	.17	.52	<1	10	--	<1.0	<1	<1	28
32N/05E-24C02	.39	1.2	10	--	250	--	--	--	8,700
32N/05E-27L02	.04	.12	3	--	--	--	--	--	69
32N/05E-27N03	.30	.92	25	--	--	--	--	--	14
32N/05E-30D01	.01	.03	<1	--	20	--	--	--	8

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dissolved (micrograms per liter as Pb)	Manganese, dissolved (micrograms per liter as Mn	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene blue active substances (milligrams per liter)
31N/06E-09K01	--	180	--	--	--	--	2.8	<0.02
31N/06E-18C01	--	1	--	--	--	--	--	--
31N/06E-20R02	1	<10	<0.1	<1	<1.0	220	4.4	<.02
31N/06E-27K01	--	33	--	--	--	--	0.3	<0.02
31N/06E-29J01	--	2	--	--	--	--	--	--
31N/06E-29Q01	--	<1	--	--	--	--	--	--
31N/06E-30L02	--	230	--	--	--	--	--	--
31N/06E-31G01	--	92	--	--	--	--	--	--
31N/06E-33P01	--	390	--	--	--	--	--	--
31N/06E-34A01	--	<1	--	--	--	--	.2	<.02
32N/04E-02P01	--	2	--	--	--	--	1.5	<.02
32N/04E-03A01	--	3	--	--	--	--	--	--
32N/04E-04K01	<1	150	.2	<1	<1.0	96	--	--
32N/04E-05N01	--	230	--	--	--	--	--	--
32N/04E-06Q05	--	<1	--	--	--	--	.8	<.02
32N/04E-07N03	--	100	--	--	--	--	--	--
32N/04E-07R02	<1	22	.6	<1	<1.0	170	--	--
32N/04E-10Q04	--	40	--	--	--	--	.4	<.02
32N/04E-13K01	--	530	--	--	--	--	--	--
32N/04E-13N01	<1	1	<.1	<1	<1.0	5	--	--
32N/04E-16D01	--	24	--	--	--	--	--	--
32N/04E-20C01	--	2	--	--	--	--	.5	<.02
32N/04E-22F01	--	57	--	--	--	--	--	--
32N/04E-23N02	--	36	--	--	--	--	.5	<.02
32N/04E-26C01	--	12	--	--	--	--	--	--
32N/04E-28A01	--	160	--	--	--	--	--	--
32N/04E-28C01	--	2	--	--	--	--	--	--
32N/04E-29H01	<1	170	<.1	<1	<1.0	<3	--	--
32N/04E-33Q02[1]	--	890	--	--	--	--	1.8	<.02
32N/05E-07N01	<1	1	<.1	<1	<1.0	<3	1.5	<.02
32N/05E-08N01	--	3	--	--	--	--	--	--
32N/05E-13E01	--	82	--	--	--	--	--	--
32N/05E-19R01	--	61	--	--	--	--	--	--
32N/05E-20P01	--	2	--	--	--	--	--	--
32N/05E-21B01	--	18	--	--	--	--	.6	<.02
32N/05E-21D01	<1	5	<.1	<1	<1.0	11	--	--
32N/05E-24C02	--	670	--	--	--	--	9.9	<.02
32N/05E-27L02	--	160	--	--	--	--	--	--
32N/05E-27N03	--	33	--	--	--	--	--	--
32N/05E-30D01	--	1	--	--	--	--	.9	<.02

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Geo-hydro-logic unit	Date	Time	Depth of well (feet)	Land-surface altitude (feet above sea level)	Specific conductance, field (micro-siemens per centimeter)	Specific conductance, laboratory (micro-siemens per centimeter)	pH, field (standard units)	pH, laboratory (standard units)
32N/05E-32N01	Qva	07-22-93	1410	96	170	193	192	8.5	7.8
32N/05E-33C02	Qvt	07-28-93	1625	12.5	145	67	66	6.1	6.5
32N/05E-33E02	Qvt	07-22-93	1240	105	260	229	227	8.5	8.2
32N/05E-35E01	Qva	07-22-93	1040	100	120	212	211	7.2	7.5
32N/05E-36R04[1]	Qvt	08-11-93	1025	30	170	273	261	6.1	6.4
32N/06E-04R01	Tb	07-23-93	1445	110	540	280	279	9.3	9.4
32N/06E-11K01	Qvr	07-20-93	1345	165	140	214	211	8.4	8.2
32N/06E-16P01	Qal	07-28-93	1325	17.5	115	322	327	6.4	6.4
32N/06E-17C01	Qvt	07-21-93	1155	100	450	875	820	7.1	7.1
32N/06E-18L01	Qvr	07-21-93	1020	60	380	75	75	5.9	6.3
32N/06E-21N02	Qvr	07-19-93	1405	37	200	102	98	6.3	6.6
32N/06E-29R01	Qvr	07-20-93	1030	99	320	102	101	7.0	7.4
32N/06E-30P02	Qvt	07-19-93	1730	100	190	227	224	6.3	6.7
32N/06E-32G01	Qtb	07-20-93	1215	256	320	200	199	8.3	8.2
32N/06E-33R01	Qvr	07-29-93	1555	30	315	35	35	6.1	6.4
32N/07E-08Q02	Qal	07-20-93	1725	39	200	112	109	7.1	7.3
32N/07E-09B01	Qvr	08-09-93	1405	58	240	101	100	6.2	6.4
32N/07E-09B01	Qvr	08-11-93	1300	58	240	--	--	--	--
32N/07E-12M01	Qva	07-20-93	1530	95	280	198	195	8.1	7.9
32N/08E-02L01	Qva	03-22-94	1315	240	470	189	189	8.4	7.8
32N/09E-11J02	Qal	03-22-94	1655	64	515	104	93	7.1	7.1
32N/09E-15G03	Qva	03-22-94	1530	203	530	174	173	8.5	7.9
32N/10E-06A01	Qva	03-23-94	0900	100	450	45	43	6.1	6.6

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dis-, solved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent	Sodium adsorption ratio
32N/05E-32N01	10.5	0.3	<1	70	18	6.0	8.1	19	0.4
32N/05E-33C02	13.0	.4	<1	20	5.1	1.7	2.2	17	.2
32N/05E-33E02	11.0	<0.1	<1	91	23	8.1	6.5	13	.3
32N/05E-35E01	12.0	2.3	<1	90	18	11	6.4	13	0.3
32N/05E-36R04[1]	12.0	3.8	<1	67	17	6.0	4.7	13	.2
32N/06E-04R01	10.0	0.1	<1	3	1.2	0.03	63	98	16
32N/06E-11K01	12.0	.3	<1	79	17	8.8	11	22	.5
32N/06E-16P01	12.0	.5	<1	110	18	16	17	24	.7
32N/06E-17C01	10.5	<0.1	<1	200	46	20	99	52	3
32N/06E-18L01	12.5	8.9	<1	27	5.8	3.1	3.2	20	.3
32N/06E-21N02	11.0	7.8	<1	39	10	3.5	3.6	16	.2
32N/06E-29R01	10.0	7.5	<1	36	6.4	4.8	4.8	21	.3
32N/06E-30P02	11.0	.4	<1	0	0.08	.02	51	100	42
32N/06E-32G01	10.5	.2	<1	70	18	6.1	10	21	.5
32N/06E-33R01	10.0	9.9	<1	10	3.0	.68	2.5	31	.3
32N/07E-08Q02	12.5	<0.1	<1	51	10	6.2	1.9	7	.1
32N/07E-09B01	16.5	2.3	[2]7	46	9.0	5.7	2.3	10	.1
32N/07E-09B01	--	--	[2]4	--	--	--	--	--	--
32N/07E-12M01	11.0	.2	<1	84	26	4.7	5.9	13	.3
32N/08E-02L01	9.0	.1	<1	83	25	5.1	4.0	9	.2
32N/09E-11J02	8.5	<0.1	<1	34	7.5	3.6	4.6	22	.3
32N/09E-15G03	8.0	<0.1	<1	75	22	4.8	5.7	14	.3
32N/10E-06A01	8.5	6.9	<1	14	4.5	.77	1.7	20	.2

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Potassium, dissolved (milli-grams per liter as K)	Bicar-bonate, whole water, field, (milli-grams per liter as HCO_3)	Carbo-nate, whole water, field (milli-grams per liter as CO_3)	Alka-linity, whole water, field (milli-grams per liter as $CaCO_3$)	Alka-linity, whole water, laboratory (milli-grams per liter as $CaCO_3$)	Sulfate, dissolved (milli-grams per liter as SO_4)	Chloride, dissolved (milli-grams per liter as Cl)	Fluo-ride, dis-solved (milli-grams per liter as F)
32N/05E-32N01	5.0	106	1	89	89	5.9	3.4	0.1
32N/05E-33C02	2.7	--	--	--	19	5.2	2.9	<.1
32N/05E-33E02	2.6	88	0	72	71	33	6.5	.1
32N/05E-35E01	1.8	--	--	--	89	8.3	6.1	<0.1
32N/05E-36R04[1]	1.9	--	--	--	43	12	9.1	<.1
32N/06E-04R01	0.2	129	20	140	140	2.7	2.1	.2
32N/06E-11K01	3.7	120	0	98	98	4.1	5.7	.2
32N/06E-16P01	3.3	--	--	--	89	13	25	.1
32N/06E-17C01	4.4	585	0	480	445	<0.1	[3]38	.4
32N/06E-18L01	.5	--	--	--	30	1.7	1.6	<.1
32N/06E-21N02	1.3	--	--	--	41	3.2	1.6	<.1
32N/06E-29R01	2.0	--	--	--	35	3.3	2.2	<.1
32N/06E-30P02	.2	102	0	84	85	13	9.9	<.1
32N/06E-32G01	7.9	--	--	--	99	1.5	2.0	.2
32N/06E-33R01	1.6	--	--	--	12	2.5	2.3	<.1
32N/07E-08Q02	.6	--	--	--	50	4.4	2.4	<.1
32N/07E-09B01	.9	--	--	--	46	1.9	1.3	<.1
32N/07E-09B01	--	--	--	--	--	--	--	--
32N/07E-12M01	2.3	118	0	97	98	.8	2.4	.1
32N/08E-02L01	.8	--	--	--	92	7.5	1.9	<.1
32N/09E-11J02	1.7	65	0	53	50	.6	1.9	<.1
32N/09E-15G03	1.6	100	5	90	92	2.5	2.4	.1
32N/10E-06A01	.5	--	--	--	19	1.8	0.9	<.1

Table B1.--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Silica, dissolved (milli-grams per liter as SiO_2)	Solids, sum of consti-tuents, dissolved (milli-grams per liter)	Total nitrate nitrogen (milli-grams per liter as N)	Nitrate nitrogen, dissolved (milli-grams per liter as N)	Nitrite nitrogen, dissolved (milli-grams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as N)	Ammonia nitrogen, dissolved (milli-grams per liter as NH_4)
32N/05E-32N01	28	129	--	--	<0.01	<0.05	0.23	0.30
32N/05E-33C02	13	49	1.1	--	<.01	1.1	.03	.04
32N/05E-33E02	32	155	--	--	<.01	<.05	.02	.03
32N/05E-35E01	29	137	.71	--	<.01	.71	.01	.01
32N/05E-36R04[1]	21	151	12	--	<.01	12	<.01	--
32N/06E-04R01	13	166	--	--	<.01	<.05	.05	.06
32N/06E-11K01	27	138	--	--	<.01	<.05	.11	.14
32N/06E-16P01	19	204	8.8	--	<.01	8.8	.10	.13
32N/06E-17C01	37	--	--	--	<.01	<.05	9.3	12
32N/06E-18L01	17	57	1.4	--	<.01	1.4	.01	.01
32N/06E-21N02	27	80	1.1	--	<.01	1.1	.03	.04
32N/06E-29R01	40	94	2.2	--	<.01	2.2	.03	.04
32N/06E-30P02	54	179	--	--	<.01	<.05	.02	.03
32N/06E-32G01	30	139	--	--	<.01	<.05	.42	.54
32N/06E-33R01	14	36	.42	--	<.01	.42	.02	.03
32N/07E-08Q02	9.4	66	.06	--	<.01	.06	.02	.03
32N/07E-09B01	15	65	.39	--	<.01	.39	<.01	--
32N/07E-09B01	--	--	--	--	--	--	--	--
32N/07E-12M01	28	130	--	--	<.01	<.05	.22	.28
32N/08E-02L01	13	113	--	--	<.01	<.05	.01	.01
32N/09E-11J02	57	114	--	--	<.01	<.05	.20	.26
32N/09E-15G03	44	138	--	--	<.01	<.05	.24	.31
32N/10E-06A01	13	38	.45	0.45	.02	.47	.01	.01

Table B1 .--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Phosphorus, ortho, dissolved milligrams per liter as P)	Phosphate, ortho, dissolved (milligrams per liter as PO_4)	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (mircograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (micrograms per liter as Cu)	Iron, dissolved (micrograms per liter as Fe)
32N/05E-32N01	0.20	0.61	9	--	--	--	--	--	22
32N/05E-33C02	<.01	--	<1	--	10	--	--	--	130
32N/05E-33E02	.04	.12	3	--	30	--	--	--	75
32N/05E-35E01	<.01	--	<1	12	--	<1.0	3	2	7
32N/05E-36R04[1]	<.01	--	<1	--	--	--	--	--	<3
32N/06E-04R01	<.01	--	<1	--	500	--	--	--	10
32N/06E-11K01	.31	.95	18	--	--	--	--	--	73
32N/06E-16P01	.06	.18	7	--	60	--	--	--	34
32N/06E-17C01	.03	.09	10	2,000	--	<1.0	<1	<1	13,000
32N/06E-18L01	<.01	--	<1	--	--	--	--	--	9
32N/06E-21N02	.05	.15	<1	--	--	--	--	--	6
32N/06E-29R01	.05	.15	1	--	10	--	--	--	37
32N/06E-30P02	.18	.55	15	<2	--	<1.0	10	<1	89
32N/06E-32G01	1.0	3.1	80	33	--	<1.0	10	<1	97
32N/06E-33R01	.01	.03	<1	--	--	--	--	--	13
32N/07E-08Q02	.03	.09	<1	--	<10	--	--	--	410
32N/07E-09B01	<.01	--	<1	--	--	--	--	--	11
32N/07E-09B01	--	--	--	--	--	--	--	--	--
32N/07E-12M01	.18	.55	15	42	--	<1.0	1	<1	670
32N/08E-02L01	<.01	--	2	29	--	<1.0	<1	<1	150
32N/09E-11J02	.11	.34	1	--	--	--	--	--	4,200
32N/09E-15G03	.11	.34	13	--	--	--	--	--	170
32N/10E-06A01	<.01	--	<1	<2	--	<1.0	<1	1	780

Table B1 .--*Field measurements and concentrations of inorganic constituents and septage compounds in ground-water samples, July 1993 to March 1994--Continued*

Local well number	Lead, dis-solved (micro-grams per liter as Pb)	Manga-nese, dis-solved (micro-grams per liter as Mn	Mercury, dis-solved (micro-grams per liter as Hg)	Selenium, dis-solved (micro-grams per liter as Se)	Silver, dis-solved (micro-grams per liter as Ag)	Zinc, dis-solved (micro-grams per liter as Zn)	Carbon, organic, dissolved (milli-grams per liter as C)	Methylene blue active substances (milligrams per liter)
32N/05E-32N01	--	18	--	--	--	--	--	--
32N/05E-33C02	--	58	--	--	--	--	1.3	<0.02
32N/05E-33E02	--	120	--	--	--	--	--	<.02
32N/05E-35E01	<1	<1	<0.1	<1	<1.0	230	--	--
32N/05E-36R04[1]	--	7	--	--	--	--	--	--
32N/06E-04R01	--	2	--	--	--	--	0.5	.03
32N/06E-11K01	--	62	--	--	--	--	--	--
32N/06E-16P01	--	31	--	--	--	--	.7	<.02
32N/06E-17C01	<1	380	<.1	<1	<1.0	6	--	--
32N/06E-18L01	--	3	--	--	--	--	--	--
32N/06E-21N02	--	2	--	--	--	--	--	--
32N/06E-29R01	--	1	--	--	--	--	.2	.02
32N/06E-30P02	<1	5	<.1	<1	<1.0	13	--	--
32N/06E-32G01	<1	56	<.1	<1	<1.0	100	--	--
32N/06E-33R01	--	2	--	--	--	--	--	--
32N/07E-08Q02	--	36	--	--	--	--	.6	<.02
32N/07E-09B01	--	3	--	--	--	--	--	--
32N/07E-09B01	--	--	--	--	--	--	--	--
32N/07E-12M01	<1	220	<.1	<1	<1.0	79	--	--
32N/08E-02L01	<1	61	1.5	<1	<1.0	19	--	--
32N/09E-11J02	--	190	--	--	--	--	--	--
32N/09E-15G03	--	110	--	--	--	--	--	--
32N/10E-06A01	<1	48	<.1	<1	<1.0	18	--	--

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[1] Cation/anion balance exceeds quality-control percent-difference curve.

[2] Estimate based on non-ideal count.

[3] Laboratory estimate.

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994*

[Concentrations are total recoverable unless otherwise indicated; µg/L micrograms per liter; Qal, alluvium aquifer; Qvr, Vashon recessional outwash aquifer; Qvt, Vashon till confining bed; Qva, Vashon advance outwash aquifer; Qtb, transitional beds confining bed; Qu, undifferentiated sediments aquifer; Tb, bedrock confining bed; DDD, dichloro diphenyl dichloroethane; DDE, dichloro diphenyldichloro ethylene; DDT, dichloro diphenyl trichloroethane; DEF, SSS-tributylphosphorotrithioate; --, not determined; <, less than]

Local well number	Geo-hydro-logic unit	Date	Time	Poly-chlor-inated bi-phenyls (µg/L)	Poly-chlor-inated naptha-lenes (µg/L)	Aldrin (µg/L)	Chlor-dane (µg/L)	DDD (µg/L)	DDE (µg/L)	DDT (µg/L)
27N/05E-09P02	Qva	09-16-93	0940	--	--	--	--	--	--	--
27N/05E-19B03	Qva	09-01-93	1815	--	--	--	--	--	--	--
27N/05E-25L01	Qtb	08-17-93	1350	--	--	--	--	--	--	--
27N/06E-01A01	Qva	09-15-93	1530	--	--	--	--	--	--	--
27N/06E-02B01	Qal	09-16-93	0930	--	--	--	--	--	--	--
27N/06E-13L02	Qva	09-13-93	1530	--	--	--	--	--	--	--
27N/08E-11G02	Qal	08-25-93	1100	--	--	--	--	--	--	--
28N/05E-33C01	Qva	08-17-93	1400	--	--	--	--	--	--	--
28N/05E-36F01	Tb	08-18-93	1055	<0.1	<0.1	<0.01	<0.1	<0.01	<0.01	<0.01
28N/06E-12J01	Tb	08-19-93	1045	--	--	--	--	--	--	--
28N/06E-19K01	Qal	08-19-93	1030	--	--	--	--	--	--	--
28N/07E-10G03	Tb	09-14-93	1315	--	--	--	--	--	--	--
28N/07E-27Q01	Qvt	08-24-93	1645	--	--	--	--	--	--	--
29N/05E-20P02	Qu	08-11-93	0930	--	--	--	--	--	--	--
29N/06E-16N01	Qva	08-10-93	1640	--	--	--	--	--	--	--
30N/05E-02C02	Qva	08-03-93	1000	--	--	--	--	--	--	--
30N/05E-03J02	Qal	08-12-93	1850	--	--	--	--	--	--	--
30N/05E-36J01	Qvt	08-04-93	0905	--	--	--	--	--	--	--
31N/05E-07F04	Qu	07-30-93	0920	--	--	--	--	--	--	--
31N/05E-28A01	Qvr	08-11-93	0740	--	--	--	--	--	--	--
30N/05E-14Q01S	Qva	10-01-93	0930	--	--	--	--	--	--	--
Field blank	--	08-19-93	1032	--	--	--	--	--	--	--
Field blank	--	10-01-93	0932	--	--	--	--	--	--	--

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	Dieldrin (µg/L)	Endosulfan (µg/L)	Endrin (µg/L)	Heptachlor (µg/L)	Heptachlor expoxide (µg/L)	Lindane (µg/L)	Methoxychlor (µg/L)	Mirex (µg/L)	Perthane (µg/L)	Toxaphene (µg/L)
27N/05E-09P02	--	--	--	--	--	--	--	--	--	--
27N/05E-19B03	--	--	--	--	--	--	--	--	--	--
27N/05E-25L01	--	--	--	--	--	--	--	--	--	--
27N/06E-01A01	--	--	--	--	--	--	--	--	--	--
27N/06E-02B01	--	--	--	--	--	--	--	--	--	--
27N/06E-13L02	--	--	--	--	--	--	--	--	--	--
27N/08E-11G02	--	--	--	--	--	--	--	--	--	--
28N/05E-33C01	--	--	--	--	--	--	--	--	--	--
28N/05E-36F01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<1
28N/06E-12J01	--	--	--	--	--	--	--	--	--	--
28N/06E-19K01	--	--	--	--	--	--	--	--	--	--
28N/07E-10G03	--	--	--	--	--	--	--	--	--	--
28N/07E-27Q01	--	--	--	--	--	--	--	--	--	--
29N/05E-20P02	--	--	--	--	--	--	--	--	--	--
29N/06E-16N01	--	--	--	--	--	--	--	--	--	--
30N/05E-02C02	--	--	--	--	--	--	--	--	--	--
30N/05E-03J02	--	--	--	--	--	--	--	--	--	--
30N/05E-36J01	--	--	--	--	--	--	--	--	--	--
31N/05E-07F04	--	--	--	--	--	--	--	--	--	--
31N/05E-28A01	--	--	--	--	--	--	--	--	--	--
30N/05E-14Q01S	--	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--	--

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	Chlor-pyrifox (µg/L)	DEF (µg/L)	Di-azinon (µg/L)	Di-syston (µg/L)	Ethion (µg/L)	Fono-fox (µg/L)	Mala-thion (µg/L)	Methyl para-thion (µg/L)	Para-thion (µg/L)	Phorate (µg/L)
27N/05E-09P02	--	--	--	--	--	--	--	--	--	--
27N/05E-19B03	--	--	--	--	--	--	--	--	--	--
27N/05E-25L01	--	--	--	--	--	--	--	--	--	--
27N/06E-01A01	--	--	--	--	--	--	--	--	--	--
27N/06E-02B01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27N/06E-13L02	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
27N/08E-11G02	--	--	--	--	--	--	--	--	--	--
28N/05E-33C01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
28N/05E-36F01	--	--	--	--	--	--	--	--	--	--
28N/06E-12J01	--	--	--	--	--	--	--	--	--	--
28N/06E-19K01	--	--	--	--	--	--	--	--	--	--
28N/07E-10G03	--	--	--	--	--	--	--	--	--	--
28N/07E-27Q01	--	--	--	--	--	--	--	--	--	--
29N/05E-20P02	--	--	--	--	--	--	--	--	--	--
29N/06E-16N01	--	--	--	--	--	--	--	--	--	--
30N/05E-02C02	--	--	--	--	--	--	--	--	--	--
30N/05E-03J02	--	--	--	--	--	--	--	--	--	--
30N/05E-36J01	--	--	--	--	--	--	--	--	--	--
31N/05E-07F04	--	--	--	--	--	--	--	--	--	--
31N/05E-28A01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
30N/05E-14Q01S	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Field blank	--	--	--	--	--	--	--	--	--	--
Field blank	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	Trithion (µg/L)	2,4-D (µg/L)	2,4,5-T (µg/L)	2,4-DP (µg/L)	Dicamba (µg/L)	Picloram (µg/L)	Silvex (µg/L)	Alachlor, dissolved (µg/L)	Ametryn, dissolved (µg/L)	Atrazine, dissolved (µg/L)
27N/05E-09P02	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	--	--
27N/05E-19B03	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
27N/05E-25L01	--	--	--	--	--	--	--	--	--	--
27N/06E-01A01	--	--	--	--	--	--	--	--	--	--
27N/06E-02B01	<0.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
27N/06E-13L02	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
27N/08E-11G02	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
28N/05E-33C01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
28N/05E-36F01	--	--	--	--	--	--	--	--	--	--
28N/06E-12J01	--	--	--	--	--	--	--	--	--	--
28N/06E-19K01	--	<.01	<.01	<.01	<.01	<.01	<.01	<0.05	<0.05	<0.05
28N/07E-10G03	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
28N/07E-27Q01	--	--	--	--	--	--	--	--	--	--
29N/05E-20P02	--	--	--	--	--	--	--	--	--	--
29N/06E-16N01	--	--	--	--	--	--	--	--	--	--
30N/05E-02C02	--	--	--	--	--	--	--	--	--	--
30N/05E-03J02	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
30N/05E-36J01	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
31N/05E-07F04	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
31N/05E-28A01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
30N/05E-14Q01S	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
Field blank	--	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--
Field blank	<.01	<.01	<.01	<.01	<.01	<.01	<.01	--	--	--

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	Cyanazine, dissolved (µg/L)	Deethyl atrazine, dissolved (µg/L)	Deisopropyl atrazine, dissolved (µg/L)	Metolachlor, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Propazine, dissolved (µg/L)	Simazine, dissolved (µg/L)	Prometon, dissolved (µg/L)	Prometryn, dissolved (µg/L)
27N/05E-09P02	--	--	--	--	--	--	--	--	--
27N/05E-19B03	--	--	--	--	--	--	--	--	--
27N/05E-25L01	--	--	--	--	--	--	--	--	--
27N/06E-01A01	--	--	--	--	--	--	--	--	--
27N/06E-02B01	--	--	--	--	--	--	--	--	--
27N/06E-13L02	--	--	--	--	--	--	--	--	--
27N/08E-11G02	--	--	--	--	--	--	--	--	--
28N/05E-33C01	--	--	--	--	--	--	--	--	--
28N/05E-36F01	--	--	--	--	--	--	--	--	--
28N/06E-12J01	--	--	--	--	--	--	--	--	--
28N/06E-19K01	<0.20	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
28N/07E-10G03	--	--	--	--	--	--	--	--	--
28N/07E-27Q01	--	--	--	--	--	--	--	--	--
29N/05E-20P02	--	--	--	--	--	--	--	--	--
29N/06E-16N01	--	--	--	--	--	--	--	--	--
30N/05E-02C02	--	--	--	--	--	--	--	--	--
30N/05E-03J02	--	--	--	--	--	--	--	--	--
30N/05E-36J01	--	--	--	--	--	--	--	--	--
31N/05E-07F04	--	--	--	--	--	--	--	--	--
31N/05E-28A01	--	--	--	--	--	--	--	--	--
30N/05E-14Q01S	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	Benzene (µg/L)	Bromoform (µg/L)	Carbon tetra chloride (µg/L)	Chlorobenzene (µg/L)	Dibromochloromethane (µg/L)	Chloroform (µg/L)	Dibromochloromethane (µg/L)	Dichlorodifluoromethane (µg/L)	1,1-Dichloroethane (µg/L)	1,2,-Dichloroethane (µg/L)
27N/05E-19B03	--	--	--	--	--	--	--	--	--	--
27N/05E-25L01	<0.2	<0.2	<0.2	<0.20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
27N/06E-01A01	<.2	<.2	<.2	<.20	<.2	<.2	<.2	<.2	<.2	<.2
27N/06E-02B01	--	--	--	--	--	--	--	--	--	--
27N/06E-13L02	--	--	--	--	--	--	--	--	--	--
27N/08E-11G02	--	--	--	--	--	--	--	--	--	--
28N/05E-33C01	--	--	--	--	--	--	--	--	--	--
28N/05E-36F01	<.2	<.2	<.2	<.20	<.2	<.2	<.2	<.2	<.2	<.2
28N/06E-12J01	<.2	<.2	<.2	<.20	<.2	<.2	<.2	.7	<.2	<.2
28N/06E-19K01	--	--	--	--	--	--	--	--	--	--
28N/07E-10G03	--	--	--	--	--	--	--	--	--	--
28N/07E-27Q01	<.2	<.2	<.2	<.20	<.2	<.2	<.2	<.2	<.2	<.2
29N/05E-20P02	<.2	<.2	<.2	<.20	<.2	<.2	<.2	51	<.2	<.2
29N/06E-16N01	<.2	<.2	<.2	<.20	<.2	<.2	<.2	<.2	<.2	<.2
30N/05E-02C02	<.2	<.2	<.2	<.20	<.2	<.2	<.2	<.2	<.2	<.2
30N/05E-03J02	--	--	--	--	--	--	--	--	--	--
30N/05E-36J01	--	--	--	--	--	--	--	--	--	--
31N/05E-07F04	--	--	--	--	--	--	--	--	--	--
31N/05E-28A01	<.2	<.2	<.2	<.20	<.2	<.2	<.2	<.2	<.2	<.2
30N/05E-14Q01S	--	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--	--

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	*cis*-1,2-Dichloroethene (µg/L)	1,1-Dichloroethylene (µg/L)	1,2-Dichloropropane (µg/L)	1,2-Dichlorobenzene (µg/L)	1,3-Dichlorobenzene (µg/L)	1,4-Dichlorobenzene (µg/L)	Ethylbenzene (µg/L)	Methylene chloride (µg/L)	*trans*, 1,2-Dichloroethene (µg/L)
27N/05E-09P02	--	--	--	--	--	--	--	--	--
27N/05E-19B03	--	--	--	--	--	--	--	--	--
27N/05E-25L01	<0.2	<0.2	<0.2	<0.20	<0.20	<0.20	<0.2	<0.2	<0.2
27N/06E-01A01	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
27N/06E-02B01	--	--	--	--	--	--	--	--	--
27N/06E-13L02	--	--	--	--	--	--	--	--	--
27N/08E-11G02	--	--	--	--	--	--	--	--	--
28N/05E-33C01	--	--	--	--	--	--	--	--	--
28N/05E-36F01	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
28N/06E-12J01	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
28N/06E-19K01	--	--	--	--	--	--	--	--	--
28N/07E-10G03	--	--	--	--	--	--	--	--	--
28N/07E-27Q01	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
29N/05E-20P02	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
29N/06E-16N01	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
30N/05E-02C02	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
30N/05E-03J02	--	--	--	--	--	--	--	--	--
30N/05E-36J01	--	--	--	--	--	--	--	--	--
31N/05E-07F04	--	--	--	--	--	--	--	--	--
31N/05E-28A01	<.2	<.2	<.2	<.20	<.20	<.20	<.2	<.2	<.2
30N/05E-14Q01S	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--

Table B2.--*Concentrations of synthetic organic compounds in well, spring, and field-blank samples, July 1993 to March 1994--Continued*

Local well number	1,1-Tri-chloro-ethene (µg/L)	Styrene (µg/L)	Tetra-chloro-ethyl-ene (µg/L)	Toluene (µg/L)	Tri-chloro-ethyl-ene (µg/L)	Tri-chloro-fluoro-methane (µg/L)	Tri-chloro-tri-fluoro-ethane (µg/L)	Vinyl chloride (µg/L)	Xylene (µg/L)
27N/05E-09P02	--	--	--	--	--	--	--	--	--
27N/05E-19B03	--	--	--	--	--	--	--	--	--
27N/05E-25L01	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.20
27N/06E-01A01	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
27N/06E-02B01	--	--	--	--	--	--	--	--	--
27N/06E-13L02	--	--	--	--	--	--	--	--	--
27N/08E-11G02	--	--	--	--	--	--	--	--	--
28N/05E-33C01	--	--	--	--	--	--	--	--	--
28N/05E-36F01	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
28N/06E-12J01	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
28N/06E-19K01	--	--	--	--	--	--	--	--	--
28N/07E-10G03	--	--	--	--	--	--	--	--	--
28N/07E-27Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
29N/05E-20P02	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
29N/06E-16N01	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
30N/05E-02C02	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
30N/05E-03J02	--	--	--	--	--	--	--	--	--
30N/05E-36J01	--	--	--	--	--	--	--	--	--
31N/05E-07F04	--	--	--	--	--	--	--	--	--
31N/05E-28A01	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.20
30N/05E-14Q01S	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--
Field blank	--	--	--	--	--	--	--	--	--

Table B3.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in water samples from springs, September 1993 to October 1993*

[>, greater than; <, less than; --, not determined]

Local spring number	Date	Time	Land-surface altitude (feet above sea level)	Specific conductance, field (micro-siemens per centimeter)	Specific conductance, laboratory (micro-siemens per centimeter)	pH, field (standard units)	pH, laboratory (standard units)
27N/03E-25F01S	09-29-93	1900	220	299	298	8.1	7.9
27N/03E-35A01S	09-29-93	1700	230	298	298	7.1	7.3
27N/06E-21A01S	09-28-93	1630	150	134	134	7.8	7.9
27N/07E-19J01S	09-29-93	1330	800	74	75	7.2	7.1
28N/07E-28K01S	09-28-93	1020	150	71	70	6.1	7.0
28N/08E-16D01S	09-28-93	1310	560	81	82	7.3	7.6
30N/05E-14Q01S	10-01-93	0930	130	123	123	7.6	7.8
30N/06E-13A01S	09-30-93	1815	320	167	168	7.9	7.7
30N/07E-05K01S	09-30-93	1600	610	77	77	7.3	7.5
31N/04E-04K01S	10-01-93	1150	170	235	236	8.0	8.0
31N/04E-05F01S	09-30-93	0915	50	165	167	7.3	8.0
31N/04E-24N03S	09-30-93	1330	240	167	167	7.4	7.7
32N/03E-12J01S	09-30-93	1100	15	258	259	7.4	7.6

Local spring number	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dissolved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Sodium, percent
27N/03E-25F01S	12.5	8.8	>200	130	23	18	9.2	13
27N/03E-35A01S	11.5	8.7	[1]1	130	21	18	9.4	14
27N/06E-21A01S	12.5	8.9	40	53	12	5.5	6.6	21
27N/07E-19J01S	9.0	10.9	[1]1	25	6.9	2.0	4.3	27
28N/07E-28K01S	9.5	9.6	<1	22	5.0	2.3	3.4	25
28N/08E-16D01S	11.0	8.2	[1]4	35	7.4	4.0	2.1	11
30N/05E-14Q01S	9.5	10.0	67	49	8.9	6.4	5.2	18
30N/06E-13A01S	12.0	10.1	[1]8	75	16	8.6	4.4	11
30N/07E-05K01S	9.5	8.9	[1]180	34	10	2.2	2.0	11
31N/04E-04K01S	11.5	10.2	740	110	13	18	6.5	12
31N/04E-05F01S	8.5	6.1	<1	61	7.9	10	6.3	18
31N/04E-24N03S	9.0	10.2	<1	68	11	9.8	5.9	16
32N/03E-12J01S	10.0	2.6	<1	110	24	11	10	17

Table B3.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in water samples from springs, September 1993 to October 1993--Continued*

Local spring number	Sodium adsorption ratio	Potassium, dissolved (milligrams per liter as K)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)	Silica, dissolved (milligrams per liter as SiO_2)	Solids, sum of constituents, dissolved (milligrams per liter)
27N/03E-25F01S	0.3	4.1	131	14	6.5	<0.1	36	193
27N/03E-35A01S	.4	3.1	109	20	7.9	<.1	38	197
27N/06E-21A01S	.4	0.9	57	5.4	2.1	.1	25	98
27N/07E-19J01S	.4	.3	32	4.6	2.1	.1	13	54
28N/07E-28K01S	.3	.5	17	3.1	2.8	.1	12	53
28N/08E-16D01S	.2	.4	38	3.1	1.1	.1	16	57
30N/05E-14Q01S	.3	1.8	54	4.1	2.7	.2	34	98
30N/06E-13A01S	.2	2.5	71	11	2.7	.1	27	116
30N/07E-05K01S	.1	.3	32	3.8	4.9	.1	13	57
31N/04E-04K01S	.3	1.7	102	6.8	5.8	<.1	43	165
31N/04E-05F01S	.4	2.1	62	8.9	5.7	.1	44	129
31N/04E-24N03S	.3	1.7	61	4.4	4.5	.1	32	122
32N/03E-12J01S	.4	3.1	112	6.9	6.5	.2	33	170

Local spring number	Total nitrate nitrogen (milligrams per liter as N)	Nitrate nitrogen, dissolved (milligrams per liter as N)	Nitrite nitrogen, dissolved (milligrams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as NH_4)	Phosphorus, ortho, dissolved (milligrams per liter as P)	Phosphate, ortho, dissolved (milligrams per liter as PO_4)
27N/03E-25F01S	0.67	--	<0.01	0.67	0.04	0.05	0.06	0.18
27N/03E-35A01S	3.2	--	<.01	3.2	.01	.01	.02	.06
27N/06E-21A01S	1.4	--	<.01	1.4	.02	.03	<.01	--
27N/07E-19J01S	.25	--	<.01	.25	.01	.01	<.01	--
28N/07E-28K01S	3.1	--	<.01	3.1	.01	.01	<.01	--
28N/08E-16D01S	--	--	<.01	<.05	.02	.03	<.01	--
30N/05E-14Q01S	.41	--	<.01	.41	.02	.03	.03	.09
30N/06E-13A01S	.22	--	<.01	.22	.02	.03	.10	.31
30N/07E-05K01S	.27	--	<.01	.27	.01	.01	<.01	--
31N/04E-04K01S	1.9	--	<.01	1.9	.02	.03	.04	.12
31N/04E-05F01S	1.4	--	<.01	1.4	<.01	--	.07	.21
31N/04E-24N03S	3.6	--	<.01	3.6	.01	.01	.03	.09
32N/03E-12J01S	1.6	--	<.01	1.6	.02	.03	.30	.92

Table B3.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in water samples from springs, September 1993 to October 1993--Continued*

Local spring number	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (micrograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (micrograms per liter as Cu)	Iron, dissolved (micrograms per liter as Fe)	Lead, dissolved (micrograms per liter as Pb)
27N/03E-25F01S	2	24	50	<1.0	<1	<1	100	<1
27N/03E-35A01S	2	24	30	<1.0	<1	<1	4	<1
27N/06E-21A01S	1	15	<10	<1.0	3	1	70	<1
27N/07E-19J01S	<1	12	<10	<1.0	<1	<1	<3	<1
28N/07E-28K01S	<1	2	30	<1.0	<1	<1	<3	<1
28N/08E-16D01S	1	11	<10	<1.0	2	<1	13	<1
30N/05E-14Q01S	1	11	10	<1.0	<1	<1	87	<1
30N/06E-13A01S	5	18	10	<1.0	<1	<1	16	<1
30N/07E-05K01S	<1	5	<10	<1.0	<1	<1	10	<1
31N/04E-04K01S	2	6	<10	<1.0	6	<1	30	<1
31N/04E-05F01S	3	11	10	<1.0	4	<1	6	<1
31N/04E-24N03S	1	14	<10	<1.0	4	<1	<3	<1
32N/03E-12J01S	5	18	30	<1.0	<1	<1	35	<1

Local spring number	Manganese, dissolved (micrograms per liter as Mn)	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene-blue-active substances (milligrams per liter)
27N/03E-25F01S	120	<0.1	<1	<1.0	14	2.3	<0.02
27N/03E-35A01S	2	<.1	<1	<1.0	<3	0.6	<.02
27N/06E-21A01S	6	<.1	<1	<1.0	9	3.6	<.02
27N/07E-19J01S	<1	<.1	<1	<1.0	<3	.7	<.02
28N/07E-28K01S	<1	<.1	<1	<1.0	<3	.5	<.02
28N/08E-16D01S	1	<.1	<1	<1.0	4	1.1	<.02
30N/05E-14Q01S	30	<.1	<1	<1.0	<3	3.5	<.02
30N/06E-13A01S	2	<.1	<1	<1.0	<3	3.5	<.02
30N/07E-05K01S	<1	<.1	<1	<1.0	<3	.7	<.02
31N/04E-04K01S	10	<.1	<1	<1.0	<3	3.5	<.02
31N/04E-05F01S	<1	<.1	<1	<1.0	<3	.5	<.02
31N/04E-24N03S	<1	<.1	<1	<1.0	<3	.4	<.02
32N/03E-12J01S	6	<.1	<1	<1.0	<3	.7	<.02

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[1] Estimate based on non-ideal count.

Appendix C.--Quality-Assurance Assessment of Water-Quality Data

APPENDIX C.--QUALITY-ASSURANCE ASSESSMENT OF WATER-QUALITY DATA

To ensure that the water-quality data were of sufficient quality to meet study objectives, the quality-assurance plan for this study (B.E. Thomas and S.S. Embrey, U.S. Geological Survey, written commun., March 1993) outlined quality-control procedures for data collection and analysis. Whereas many of the procedures address only methodology, some procedures required the collection and analysis of quality-control samples. The resulting data were reviewed to determine the quality of the project water-quality data.

The majority of the water-quality data for this study appeared to be of good quality by all measures used in this quality-assurance assessment. All water-quality data are, therefore, shown in this report and were used in the interpretations of ground-water quality. Errors associated with most of the duplicate samples were within project criteria for most constituents. Some exceptions were a few samples with large percent differences between the cations and anions; however, the large percentage errors were mostly from constituent concentrations near detection limits with otherwise small absolute errors. Concentrations of most constituents in the blank samples, various internal sample checks, and comparisons of field and laboratory determinations indicated that the water-quality data collected during the study were within acceptable limits for most constituents and samples. The only consistent and widespread problem was the low concentrations of ammonia nitrogen present in most of the blank samples. Low concentrations of ammonia were therefore interpreted cautiously.

The following sections discuss some anomalous sampling procedures and conditions, as well as the results of assessments of duplicate samples, blank samples, cation-anion balances, field and laboratory alkalinities, and checks on field values. These data and associated error analyses are summarized in tables C1, C2, and C3; the field and laboratory results for the duplicate and blank samples are listed in tables C4 and C5 at the end of appendix C.

Anomalous Sampling Procedures and Conditions

At 6 percent of the 297 sampled wells, a deviation from standard sampling procedures occurred or the pump and plumbing characteristics did not meet the standards specified in the study quality-assurance plan. A deviation from standard sampling procedures occurred at six wells where water was obtained directly from the water faucet instead of the ground-water sampling system shown on figure 14. It was not possible to attach the sampling system to wells 27N/04E-02N01, 27N/06E-01A01, 28N/05E-20A01, 29N/04E-01A03, 29N/05E-02C02, and 29N/05E-20P02. At four of the 297 wells, characteristics of the pumps or water-distribution systems might have aerated the samples: these wells were 27N/05E-27R02 (a flowing well equipped with a jet pump), 30N/04E-17R02 (sample was obtainable only after filling a large storage tank), 31N/05E-02F01 (fluctuations in dissolved oxygen concentrations possibly caused by the pump cycling on and off), and 31N/05E-28A01 (a 16.5-foot well equipped with a centrifugal pump). At two wells the characteristics of the water-distribution system prevented an optimum flow to be maintained through the flow chamber; these wells were 29N/05E-36B02 and 30N/05E-03J02. Degassing (effervescence or bubble-formation on flow-chamber wall) of some water samples as water moved through the flow chamber was noted by field personnel at wells 27N/09E-05C01, 28N/06E-23A01, 28N/06E-24Q02, 31N/06E-20R02, 32N/05E-27N03, and 32N/06E-17C01. The degassing was likely due to a combination of chemical and physical characteristics of the aquifer, and the process of removing the water from the ground. In all of the above samples, some alteration of the water chemistry might have occurred, such as in the dissolved concentrations of redox-sensitive constituents like iron and manganese. However, applicable quality-assurance evaluations of the analytical data with respect to various parameters, including well-construction, well depth, and field measurements, did not indicate major problems with the resulting chemical-concentration data.

Duplicate Samples

Duplicate pairs of samples were collected for all types of analyses performed except for synthetic organic compounds. Quality-assurance goals for this study called for an error of 10 percent or less for cations, anions, and nutrients, and an error of 20 percent or less for ammonia nitrogen, phosphorus, metals, trace elements, dissolved organic carbon, and methylene blue active substances. To evaluate these errors, the percent differences between the concentrations of the sample pairs were determined for each constituent and an average percent difference was calculated. These average differences and the number of sample pairs exceeding the percent-difference goals are listed in table C1.

For most constituents, the average percent difference was well within the 10-percent-difference criterion for major constituents and the 20-percent-difference criterion for trace constituents. None of the average differences for the major constituents exceeded the 10-percent difference criterion. Only ammonia nitrogen with an average difference of 36 percent, iron with an average difference of 21 percent, and boron with an average difference of 21 percent exceeded the 20-percent difference criterion, although the average error for zinc of 16 percent was also large. In almost all cases, the larger percent errors were a result of small absolute differences between low concentrations near analytical reporting limits, so the analyses and the percent differences were considered acceptable. One exception was iron, for which a pair of samples from well 29N/06E-16N01 had concentrations of 100 and 130 µg/L, well above the detection limit of 3 µg/L. This disparity between the concentrations could reflect sampling or analytical problems, but because the overall difference for iron was 21 percent, this sample was not excluded from the data set or data interpretation.

Blank Samples

Blanks of deionized water were processed in the same manner as field water samples and sent to the NWQL for analysis (see pages 30 to 33); the resulting data are summarized in table C2. Although no criteria were set for constituent concentrations in blanks, the importance of any constituent present in a blank was based on (1) how close the constituent concentration was to the reporting limit, (2) how close the median blank concentration was to the median sample concentration, and (3) the number of times the constituent was detected in blank samples. When compared with these three factors, the concentrations in blanks were unimportant for all constituents except alkalinity, ammonia nitrogen, chloride, iron, and boron.

Alkalinity and ammonia nitrogen were present in nearly all the blank samples. Even though the maximum concentration of alkalinity in a blank sample was 50 mg/L, the median concentration for alkalinity in the blanks was 2.8 mg/L, which is considered acceptable. The median ammonia nitrogen concentration for the blank samples was 0.02 mg/L and the maximum concentration was 0.04 mg/L. Because the median concentration of ammonia nitrogen for all the ground-water samples was only 0.04 mg/L, the number of occurrences and the magnitude of ammonia present in the blanks indicates that in ground-water samples, ammonia concentrations of about 0.04 mg/L or less should probably be interpreted with caution. Chloride was detected in 9 of 16 blanks with a maximum concentration of 2.5 mg/L and a median concentration of 0.10 mg/L. Iron was also detected in nine of 16 blanks with a maximum iron concentration of 9 µg/L and a median concentration of 3 µg/L. The chloride and iron data collected during the study were all considered acceptable because the concentrations of those constituents in the blanks were much lower than the ground-water sample concentrations. Although the maximum boron concentration was 30 µg/L, boron was not detected in any of the other five blank samples, so the results for boron are also considered acceptable.

Cation-Anion Balance

Various sums, differences, and ratios based on the principles of aquatic chemistry were computed for each sample. These computations check the consistency between constituent concentrations in a sample, and provide a gross check in the accuracy and completeness of the analysis. One of the most useful computations is the cation-anion balance, which is discussed in the following paragraphs. The cation-anion balance was calculated as a percent difference, using the following equation:

$$Percent\ difference = \frac{\Sigma\ cations - \Sigma\ anions}{\Sigma\ cations + \Sigma\ anions} \times 100\ , \quad (1)$$

where

$\Sigma\ cations$ = the sum of the concentrations of cations, in milliequivalents, and

$\Sigma\ anions$ = the sum of the concentrations of anions, in milliequivalents.

Although the ideal percent difference is zero, nonzero values are typical and can be large if a cation or anion concentration is in error or if an ion not analyzed for is present in high concentrations. The acceptable percent difference varies with the total sum of cations and anions as shown on figure C1.

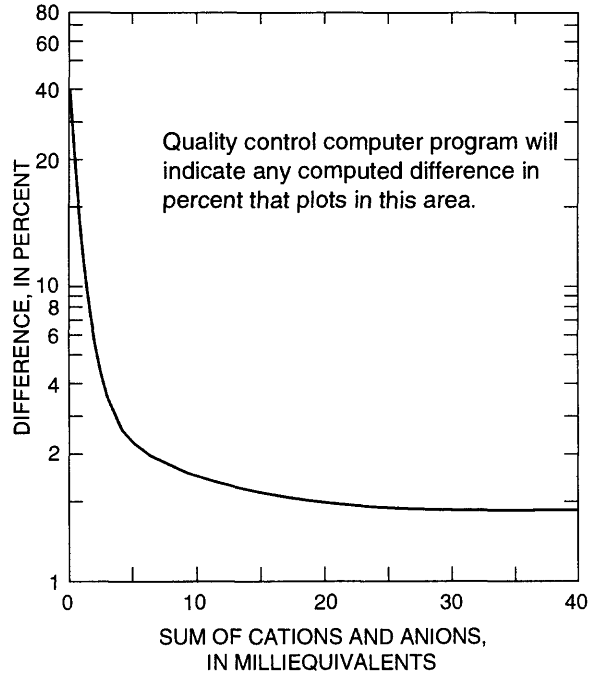

Figure C1. Cation and anion percent difference curve (Friedman and Erdmann, 1982).

For most of the samples collected in western Snohomish County, the cation-anion balance was acceptable; only nine analyses exceeded the allowable percent difference. Of these, six had cation-anion balances within 5 percent of the allowable percent difference. Of the nine analyses exceeding the allowable percent difference, five had high concentrations (greater than about 200 µg/L) of iron or manganese, and two others had concentrations of sodium or chloride as much as 10 times the study's median concentration of 7.1 mg/L for sodium and 3.2 mg/L for chloride. The cation-anion balances for one of the analyses with high iron or manganese might have been improved if field alkalinity had been measured and used in the percent difference calculation instead of the laboratory alkalinity. But a field titration of alkalinity was not needed according to the study's screening procedures that used field concentrations of dissolved oxygen and iron as guidelines (described below in this section). Three of the nine analyses exceeded the allowable percent difference by more than 10 percent, which this study considers to be a substantial error. The three wells for which analyses resulted in such poor cation-ion balances were 29N/06E-23R02, 30N/04E-22Q01, and 32N/05E-36R04. The reasons for the large percent error in these three analyses are unknown, but could be due to laboratory sample-handling errors, laboratory analytical error, or to field sample collection and processing errors. With a total of 297 wells in the study, the nine analyses did not affect the overall median values or the range of values, therefore none was removed from the study's data sets. However, the nine wells are noted in table B1 as having poor cation-anion balances.

Field Alkalinity

In most natural ground-water systems, alkalinity primarily consists of bicarbonate and a minor amount of carbonate and hydroxide. Alkalinity can be determined by titration either in the laboratory or in the field, but there are drawbacks with each procedure. Field alkalinity analyses are time-consuming and are performed on-site in a field vehicle where there are opportunities for contamination from the environment. Although the laboratory procedure is performed in a clean environment, the samples are not preserved, so any changes in sample chemistry prior to analysis, particularly mineral precipitation or dissolution, can affect the alkalinity. A good indicator of the accuracy of an alkalinity value is the cation-anion balance—if field and laboratory alkalinity values differ greatly, the one that provides the better cation-anion balance is likely more accurate. This study used the approach taken by Turney and others (1995) of not titrating all samples for a field alkalinity. They established this approach on the basis of the following general observations. In studies where field alkalinities were determined for every sample (Turney, 1986a, 1986b, 1986c, 1990), the difference in field and laboratory alkalinities was unimportant in most cases. Furthermore, when differences were important, the laboratory value was almost always more accurate, as judged by the cation-anion balance. Turney and others (1995) stated that most differences were therefore attributable to error in the field analysis. The most notable exceptions occurred when dissolved-oxygen values were less than 1.0 mg/L and iron concentrations were greater than 1,000 µg/L. In these cases, the laboratory alkalinity was usually substantially smaller than the field alkalinity because the unpreserved sample can become oxygenated, resulting in the precipitation of iron carbonate, thereby decreasing the total alkalinity. Because the iron concentration is determined in the laboratory from an acid-preserved sample, a corresponding decrease in the iron concentration typically is not observed (Turney and others, 1995).

For this study, field alkalinities were determined for a total of 91 samples. Twenty-six of the 91 samples met the basic screening criteria established by Turney and others (1995) of dissolved-oxygen concentrations less than 1.0 mg/L and iron concentrations greater than 800 µg/L. In addition, field personnel of this study titrated alkalinities for 57 samples that had dissolved oxygen concentrations less than 1.0 mg/L, but with iron concentrations less than 800 µg/L. Finally, because field-screening chemical supplies for the colorimetric determinations of dissolved oxygen were occasionally depleted, eight samples were titrated for field alkalinities even though subsequent laboratory analyses showed the dissolved-oxygen concentrations to be higher than 1.0 mg/L and iron concentrations to be low. Seventy-eight of the 91 field and laboratory alkalinity values differed by 5 percent or less (table C3), and only three alkalinity values differed by more than 20 percent. Two of the samples with large percent differences had poor cation-anion balances and iron concentrations greater than 10,000 µg/L; also, the laboratory alkalinity values were less than the field values, which probably indicates some precipitation and loss of alkalinity. For the third sample with a large percent difference, well 29N/06E-23R02, the cation-anion balance was poor and the laboratory specific conductance did not match the field specific conductance, it therefore appears that some alkalinity might have been lost even before the field alkalinity could be determined. Given the overall good cation-anion balances observed for the western Snohomish County samples and the results of the field alkalinities, the approach taken in this study for deciding when to determine field alkalinities seems reasonable.

Checks on Field Values

The accuracy of field values of pH, specific conductance, dissolved oxygen, and temperature primarily depends on proper instrument calibration and field procedures. Values of pH and specific conductance are also determined in the laboratory as standard procedure in various analyses. For 79 of 297 samples, laboratory and field pH values differed by more than 0.3 units; 28 of these 79 differed by more than 0.5 units. For 21 of 297 samples, laboratory and field specific conductance values differed by 5 percent or more; 12 of the 21 samples differed by 10 percent or more. Because pH and specific conductance values can change during the time between the field and laboratory determinations, these comparisons must be considered approximations at best, but the comparisons indicate the field values to be reasonable.

Table C1.--*Average absolute differences in constituent concentrations determined for duplicate samples*

Constituent	Number of duplicate pairs	Average absolute difference, in percent	Number of pairs exceeding difference criteria[1]
Calcium	10	0.8	0
Magnesium	10	0.5	0
Sodium	10	0.6	0
Potassium	10	2.1	0
Alkalinity (laboratory)	10	1.8	0
Sulfate	10	7.6	1
Chloride	10	1.5	0
Fluoride	10	.1	2
Silica	10	.3	0
Dissolved solids	9	.8	0
Nitrite+nitrate nitrogen	10	3.4	1
Ammonia nitrogen	10	36	6
Phosphorus	10	4.2	1
Iron	10	21	3
Manganese	10	1.8	0
Arsenic	10	2.2	0
Barium	5	3.0	0
Cadmium	5	.0	0
Chromium	5	8.0	1
Copper	5	.0	0
Lead	5	.0	0
Mercury	5	.0	0
Selenium	5	.0	0
Silver	5	.0	0
Zinc	5	16	0
Boron	4	21	1
Dissolved organic carbon	5	12	2
Methylene-blue-active substances	5	.0	0

[1] Difference criterion is 10 percent for cations, anions, silica, dissolved solids, and nitrite plus nitrate nitrogen. Percent-difference criterion is 20 percent for all metals, trace elements, ammonia nitrogen, phosphorus, dissolved organic carbon, and methylene blue active substances. No percent-difference criterion was established for bacteria or synthetic organic compounds.

Table C2.--*Summary of constituent concentrations determined for blank samples*

[Concentrations in milligrams per liter unless otherwise noted; µg/L, micrograms per liter; --, not applicable]

Constituent	Number of blanks	Reporting limit	Number of blanks equal to or exceeding detection limit	Median blank concentration	Maximum blank concentration	Median field sample concentration
Calcium	16	0.02	8	0.02	0.07	15
Magnesium	16	.01	3	<.01	.04	7.0
Sodium	16	.2	0	<.2	<.2	7.1
Potassium	16	.1	1	<.1	.9	1.8
Alkalinity, laboratory	16	1	15	2.8	50	85
Sulfate	16	.1	6	<.1	.2	4.8
Chloride	16	.1	9	.1	2.5	3.2
Fluoride	16	.1	4	<.1	.1	0.1
Silica	16	.1	3	<.1	.1	27
Nitrite plus nitrate nitrogen	17	.05	0	<.05	<.05	<.05
Ammonia nitrogen	17	.01	14	.02	.04	.04
Phosphorus	17	.01	4	<.01	.03	.07
Iron (µg/L)	16	3	9	3	9	38
Manganese (µg/L)	16	1	1	<1	2	31
Arsenic (µg/L)	16	1	0	<1	<1	2
Barium (µg/L)	5	2	1	<2	9	18
Cadmium (µg/L)	5	1	0	<1	<1	<1
Chromium (µg/L)	5	1	1	<1	1	<1
Copper (µg/L)	5	1	0	<1	<1	<1
Lead (µg/L)	5	1	0	<1	<1	<1
Mercury (µg/L)	5	.1	0	<.1	<.1	<.1
Selenium (µg/L)	5	1	0	<1	<1	<1
Silver (µg/L)	5	1	0	<1	<1	<1
Zinc (µg/L)	5	3	1	<3	8	18.5
Boron (µg/L)	6	10	1	<10	30	20
Dissolved organic carbon	6	.1	3	<.1	.2	.4
Methylene-blue-active substance	6	.02	1	<.02	.03	<.02
Organochlorine insecticides (µg/L)	1	.01	0	--	<.01	<.01
Organophosphorus insecticides (µg/L)	1	.01	0	--	<.01	<.01
Chlorophenoxy acid herbicides (µg/L)	2	.01	0	--	<.01	<.01

Table C3.--*Field alkalinity, laboratory alkalinity, and concentrations of dissolved oxygen and iron*

[mg/L, milligrams per liter; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; <, less than; --, not applicable]

Local well number	Field alkalinity (mg/l, as as $CaCO_3$)	Laboratory alkalinity (mg/L as as $CaCO_3$)	Percent difference between field and laboratory alkalinity	Oxygen, dissolved (mg/L)	Iron, dissolved (µg/L)
27N/04E-05B01	106	104	2	0	1,600
27N/05E-07H01	52	52	0	0.2	860
27N/05E-23M01	39	38	3	0	920
27N/06E-03Q01	117	106	10	0	8,900
27N/06E-21L03	178	180	1	0.1	12
27N/07E-31N02	232	232	0	0	1,800
27N/09E-04L01	301	303	<1	0	770
28N/05E-02G04	116	116	0	0	3,500
28N/05E-03R01	91	91	0	0.2	880
28N/05E-10G01	143	145	1	0	1,400
28N/05E-20A01	113	112	<1	0	3,600
28N/05E-27G01	89	87	2	0	2,000
28N/05E-36F01	201	199	1	1.7	11
28N/06E-03B01	108	106	2	0.3	23
28N/06E-05M02	67	68	1	0.1	110
28N/06E-12J01	196	198	1	0	80
28N/06E-14J01	120	122	2	0.2	660
28N/06E-15C03	149	150	<1	0	8
28N/06E-17K04	123	121	2	0.3	1,400
28N/06E-19K01	101	78	26	0.7	16,000
28N/06E-23A01	231	233	<1	0	250
28N/06E-24Q02	51	49	4	1.7	<3
28N/07E-16L02	68	66	3	0.1	270
28N/07E-17C01	86	87	1	0	35
28N/07E-20J01	89	89	0	0.1	34
28N/07E-23A01	89	89	0	0.1	23
28N/07E-28H01	111	112	<1	0	29
28N/08E-18L01	54	54	0	0.6	13
28N/08E-18M01	95	96	1	0.2	270
28N/08E-26A01	84	86	2	0.9	22
28N/08E-30C01	113	114	<1	0.8	790
29N/05E-01A02	107	105	2	0	64
29N/05E-02C02	28	29	4	--	9
29N/05E-20P02	124	109	13	0	5,500
29N/06E-04K01	136	145	6	0.2	35

Table C3.--*Field alkalinity, laboratory alkalinity, and concentrations of dissolved oxygen and iron--Continued*

Local well number	Field alkalinity (mg/l, as as CaCO$_3$)	Laboratory alkalinity (mg/L as as CaCO$_3$)	Percent difference between field and laboratory alkalinity	Oxygen, dissolved (mg/L)	Iron, dissolved (µg/L)
29N/06E-09N02	157	153	3	0.3	160
29N/06E-11B02	152	151	<1	0.1	320
29N/06E-14F03	218	218	0	0.1	500
29N/06E-20R01	164	164	0	0	55
29N/06E-23R02	116	160	32	0	27
29N/06E-25C01	134	132	2	1.3	260
29N/07E-16H03	50	44	13	0.8	2,800
29N/07E-19B01	96	97	1	0	23
29N/07E-30C01	76	77	1	0	1,600
30N/04E-35R04	169	168	<1	0	720
30N/04E-36L06	122	113	8	0.5	4,600
30N/05E-15H01	124	127	2	0	31
30N/05E-26P01	130	131	<1	0	890
30N/06E-23C01	105	105	0	0	27
30N/06E-30Q01	52	57	10	0	4
30N/07E-06J02	155	149	4	0.1	960
30N/07E-18F01	73	72	1	0.1	13
30N/07E-20D02	79	76	4	2.5	3
30N/07E-29G02	276	276	0	0.1	20
30N/07E-30P01D1	197	202	2	0	47
31N/04E-07N02	95	93	2	0	7
31N/04E-10G04	102	100	2	0.2	90
31N/04E-18E01	322	334	4	6.6	290
31N/04E-25M04	60	63	5	2.8	5
31N/05E-07F04	171	141	19	0	17,000
31N/05E-30P01	92	95	3	0	75
31N/05E-32E01	98	97	1	0	40
31N/06E-06Q02	194	191	2	0.1	23
31N/06E-20R02	509	510	<1	0.1	120
31N/06E-29J01	165	164	<1	1.5	9
31N/06E-30L02	77	77	0	0.2	640
31N/06E-33P01	169	164	3	0	1,500
32N/04E-03A01	336	341	1	1.8	5
32N/04E-07N03	142	140	1	0	280
32N/04E-07R02	167	166	<1	0	130

Table C3.--*Field alkalinity, laboratory alkalinity, and concentrations of dissolved oxygen and iron--Continued*

Local well number	Field alkalinity (mg/l, as as $CaCO_3$)	Laboratory alkalinity (mg/L as as $CaCO_3$)	Percent difference between field and laboratory alkalinity	Oxygen, dissolved (mg/L)	Iron, dissolved (µg/L)
32N/04E-13K01	232	224	4	0	1,400
32N/04E-13N01	237	238	<1	0.1	19
32N/04E-16D01	130	127	2	0.2	54
32N/04E-22F01	66	69	4	0	270
32N/04E-26C01	174	172	1	0.3	95
32N/04E-29H01	124	122	2	0	1,100
32N/04E-33Q02	192	141	31	0.1	26,000
32N/05E-07N01	174	173	<1	0	23
32N/05E-08N01	174	179	3	0.9	38
32N/05E-20P01	164	166	1	0.2	27
32N/05E-21D01	270	241	11	0.1	28
32N/05E-24C02	316	291	8	0	8,700
32N/05E-32N01	89	89	0	0.3	22
32N/05E-33E02	72	71	1	0	75
32N/06E-04R01	140	140	0	0.1	10
32N/06E-11K01	98	98	0	0.3	73
32N/06E-17C01	480	445	8	0	13,000
32N/06E-30P02	84	85	1	0.4	89
32N/07E-12M01	97	98	1	0.2	670
32N/09E-11J02	53	50	6	0	4,200
32N/09E-15G03	2	90	92	0	170

Table C4.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance duplicate samples, July 1993 to March 1994*

[Qal, alluvium aquifer; Qvr, Vashon recessional outwash aquifer; Qvt, Vashon till confining bed; Qva, Vashon advance outwash aquifer; Qtb, transitional beds confining bed; Qu, undifferentiated sediments aquifer; Tb, bedrock confining bed; --, not determined; <, less than; K in front of value indicates non-ideal count of bacteria.]

Geohydrologic unit	Local well number	Date	Time	Depth of well (feet)	Land-surface-altitude (feet above sea level)	Specific conductance, field (microsiemens per centimeter)	Specific conductance, laboratory (microsiemens per centimeter)	pH, field (standard units)
Qva	27N/05E-27R02	09-01-93	1550	70	150	160	157	8.3
Qva	27N/05E-27R02	09-01-93	1551	70	150	160	157	8.3
Qva	27N/06E-18F01	09-02-93	1130	70	260	174	177	7.7
Qva	27N/06E-18F01	09-02-93	1131	70	260	180	181	7.5
Qva	28N/05E-19K01	08-25-93	1500	149	470	142	141	7.8
Qva	28N/05E-19K01	08-25-93	1501	149	470	142	140	7.8
Qva	28N/05E-22N01	09-16-93	1415	140	260	211	213	8.1
Qva	28N/05E-22N01	09-16-93	1416	140	260	211	--	8.1
Tb	28N/07E-20J01	08-25-93	1030	188	480	181	180	8.4
Tb	28N/07E-20J01	08-25-93	1031	188	480	181	180	8.4
Qva	29N/06E-16N01	08-10-93	1640	88	240	179	177	8.3
Qva	29N/06E-16N01	08-10-93	1641	88	240	179	177	8.3
Qvr	30N/05E-08K01	08-04-93	1600	20	75	150	148	6.0
Qvr	30N/05E-08K01	08-04-93	1601	20	75	150	162	6.0
Qu	31N/06E-06Q02	08-10-93	1200	295	265	510	502	8.6
Qu	31N/06E-06Q02	08-10-93	1201	295	265	510	501	8.6
Qvr	32N/04E-06Q05	07-27-93	1600	47.5	340	252	250	6.6
Qvr	32N/04E-06Q05	07-27-93	1601	47.5	340	253	250	6.6
Qva	32N/05E-35E01	07-22-93	1040	100	120	212	211	7.2
Qva	32N/05E-35E01	07-22-93	1041	100	120	212	212	7.2
--	27N/07E-19J01S	09-29-93	1330	--	800	74	75	7.2
--	27N/07E-19J01S	09-29-93	1331	--	800	75	75	7.2

Table C4.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance duplicate samples, July 1993 to March 1994--Continued*

Local well number	pH, laboratory (standard units)	Temperature, water (degrees Celsius)	Oxygen, dissolved (milligrams per liter)	Fecal-coliform bacteria (colonies per 100 milliliters)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)	Magnesium, dissolved, (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)
27N/05E-27R02	7.4	11.0	1.6	<1	58	12	6.7	8.3
27N/05E-27R02	7.6	11.0	1.6	--	57	12	6.6	8.3
27N/06E-18F01	7.5	10.5	0.2	<1	71	19	5.8	5.6
27N/06E-18F01	7.6	10.5	.6	--	72	19	5.9	5.5
28N/05E-19K01	7.4	11.0	8.0	<1	57	11	7.1	4.8
28N/05E-19K01	7.4	11.0	8.0	<1	57	11	7.2	4.9
28N/05E-22N01	7.9	12.5	.1	<1	78	21	6.1	11
28N/05E-22N01	--	12.5	.1	--	--	--	--	--
28N/07E-20J01	8.2	12.5	.1	<1	75	16	8.6	7.4
28N/07E-20J01	8.0	12.5	.6	<1	75	16	8.6	7.4
29N/06E-16N01	8.1	12.0	.1	<1	76	19	6.9	6.4
29N/06E-16N01	8.0	12.0	.1	--	73	18	6.9	6.4
30N/05E-08K01	6.0	13.5	6.2	<1	34	8.9	2.8	6.2
30N/05E-08K01	6.8	13.5	6.2	<1	34	8.8	2.8	6.2
31N/06E-06Q02	8.7	12.5	.1	<1	35	5.7	5.0	96
31N/06E-06Q02	8.7	12.5	.1	<1	35	5.7	5.0	96
32N/04E-06Q05	6.7	11.5	8.0	<1	97	19	12	13
32N/04E-06Q05	7.3	11.5	7.7	<1	97	19	12	13
32N/05E-35E01	7.5	12.0	2.3	<1	90	18	11	6.4
32N/05E-35E01	7.4	12.0	2.3	--	90	18	11	6.4
27N/07E-19J01S	7.1	9.0	10.9	K1	25	6.9	2.0	4.3
27N/07E-19J01S	7.0	9.0	10.9	--	26	7.0	2.0	4.4

Table C4.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance duplicate samples, July 1993 to March 1994*

Local well number	Sodium (percent)	Sodium adsorption ratio	Potassium, dissolved (milligrams per liter as K)	Bicarbonate, whole water, field (milligrams per liter as HCO_3)	Carbonate, whole water, field (milligrams per liter as CO_3)	Alkalinity, whole water, field (milligrams per liter as $CaCO_3$)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)
27N/05E-27R02	23	0.5	3.5	--	--	--	76	2.1	1.7
27N/05E-27R02	23	.5	3.6	--	--	--	76	2.1	1.7
27N/06E-18F01	14	.3	2.7	--	--	--	72	13	2.5
27N/06E-18F01	14	.3	2.7	--	--	--	78	13	2.6
28N/05E-19K01	15	.3	1.7	--	--	--	66	0.2	4.1
28N/05E-19K01	15	.3	1.8	--	--	--	66	<.1	4.1
28N/05E-22N01	22	.5	3.9	--	--	--	104	<.1	1.7
28N/05E-22N01	--	--	--	--	--	--	--	--	--
28N/07E-20J01	17	.4	2.1	104	2	89	89	2.5	2.4
28N/07E-20J01	17	.4	2.1	--	--	--	89	2.5	2.5
29N/06E-16N01	15	.3	3.9	--	--	--	82	5.8	1.8
29N/06E-16N01	15	.3	3.7	--	--	--	82	5.7	1.8
30N/05E-08K01	22	.5	10	--	--	--	10	12	6.4
30N/05E-08K01	23	.5	10	--	--	--	11	13	6.7
31N/06E-06Q02	83	7	6.0	220	8	194	191	10	38
31N/06E-06Q02	83	7	6.1	220	7	192	191	10	39
32N/04E-06Q05	22	.6	1.7	--	--	--	78	18	8.2
32N/04E-06Q05	22	.6	1.8	--	--	--	78	18	8.2
32N/05E-35E01	13	.3	1.8	--	--	--	89	8.3	6.1
32N/05E-35E01	13	.3	1.8	--	--	--	89	8.3	6.1
27N/07E-19J01S	27	.4	0.3	--	--	--	32	4.6	2.1
27N/07E-19J01S	27	.4	.3	--	--	--	32	4.6	2.1

Table C4.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance duplicate samples, July 1993 to March 1994*

Local well number	Fluoride, dissolved (milligrams per liter as F)	Silica, dissolved (milligrams per liter as SiO_2)	Solids, sum of constituents, dissolved (milligrams per liter)	Total nitrate nitrogen (milligrams per liter as N)	Nitrite nitrogen, dissolved (milligrams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as N)	Ammonia nitrogen, dissolved (milligrams per liter as NH_4)	Phosphorus, ortho, dissolved (milligrams per liter as P)
27N/05E-27R02	0.2	37	119	--	<0.01	<0.05	0.53	0.68	0.21
27N/05E-27R02	.2	37	119	--	<.01	<.05	.53	.68	.21
27N/06E-18F01	.1	28	121	0.10	<.01	.10	.05	.06	.17
27N/06E-18F01	.2	28	125	.13	<.01	.13	.04	.05	.15
28N/05E-19K01	.1	39	109	--	<.01	<.05	.40	.52	.05
28N/05E-19K01	.1	39	--	--	<.01	<.05	.40	.52	.05
28N/05E-22N01	.2	30	--	--	<.01	<.05	.91	1.2	1.0
28N/05E-22N01	--	--	--	--	--	--	--	--	--
28N/07E-20J01	.2	33	126	--	<.01	<.05	.03	.04	.07
28N/07E-20J01	.2	33	126	--	<.01	<.05	.05	.06	.07
29N/06E-16N01	.2	34	128	--	<.01	<.05	.07	.09	.19
29N/06E-16N01	.1	34	127	--	<.01	<.05	.08	.10	.20
30N/05E-08K01	.1	17	103	7.6	<.01	7.6	.01	.01	<.01
30N/05E-08K01	<.1	17	106	7.9	<.01	7.9	.02	.03	<.01
31N/06E-06Q02	.2	22	300	--	<.01	<.05	.16	.21	.32
31N/06E-06Q02	.2	22	300	--	<.01	<.05	.07	.09	.25
32N/04E-06Q05	<.1	35	172	4.2	<.01	4.2	.04	.05	<.01
32N/04E-06Q05	<.1	35	172	4.2	<.01	4.2	.02	.03	<.01
32N/05E-35E01	<.1	29	137	.71	<.01	.71	.01	.01	<.01
32N/05E-35E01	<.1	30	138	.71	<.01	.71	.01	.01	<.01
27N/07E-19J01S	.1	13	54	.25	<.01	.25	.01	.01	<.01
27N/07E-19J01S	.1	13	54	.24	<.01	.24	.02	.03	<.01

Table C4.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance duplicate samples, July 1993 to March 1994*

Local well number	Phosphate, ortho, dissolved (milligrams per liter as PO_4)	Arsenic, dissolved (micrograms per liter as As)	Barium, dissolved (micrograms per liter as Ba)	Boron, dissolved (micrograms per liter as B)	Cadmium, dissolved (micrograms per liter as Cd)	Chromium, dissolved (micrograms per liter as Cr)	Copper, dissolved (milligrams per liter as Cu)	Iron, dissolved (milligrams per liter as Fe)	Lead, dissolved (milligrams per liter as Pb)
27N/05E-27R02	0.64	<1	8	30	<1.0	<1	<1	62	<1
27N/05E-27R02	.64	<1	8	--	<1.0	<1	<1	58	<1
27N/06E-18F01	.52	10	--	10	--	--	--	54	--
27N/06E-18F01	.46	9	--	20	--	--	--	59	--
28N/05E-19K01	.15	3	--	--	--	--	--	59	--
28N/05E-19K01	.15	3	--	--	--	--	--	60	--
28N/05E-22N01	3.1	49	--	50	--	--	--	180	--
28N/05E-22N01	--	--	--	--	--	--	--	--	--
28N/07E-20J01	.21	3	8	--	<1.0	<1	<1	34	<1
28N/07E-20J01	.21	3	8	--	<1.0	<1	<1	39	<1
29N/06E-16N01	.58	8	14	20	<1.0	<1	<1	130	<1
29N/06E-16N01	.61	9	15	--	<1.0	<1	<1	100	<1
30N/05E-08K01	--	<1	--	20	--	--	--	4	--
30N/05E-08K01	--	<1	--	20	--	--	--	8	--
31N/06E-06Q02	.98	7	--	--	--	--	--	23	--
31N/06E-06Q02	.77	7	--	--	--	--	--	22	--
32N/04E-06Q05	--	<1	--	50	--	--	--	5	--
32N/04E-06Q05	--	<1	--	60	--	--	--	5	--
32N/05E-35E01	--	<1	12	--	<1.0	3	2	7	<1
32N/05E-35E01	--	<1	12	--	<1.0	2	2	<3	<1
27N/07E-19J01S	--	<1	12	<10	<1.0	<1	<1	<3	<1
27N/07E-19J01S	--	<1	13	<10	<1.0	<1	<1	<3	<1

Table C4.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance duplicate samples, July 1993 to March 1994*

Local well number	Manganese, dissolved (micrograms per liter as Mn)	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene-blue-active substances (milligrams per liter)	Sample code[1]
27N/05E-27R02	49	<0.1	<1	<1.0	6	0.5	<0.02	E
27N/05E-27R02	48	<.1	<1	<1.0	<3	--	--	D
27N/06E-18F01	130	--	--	--	--	.4	<.02	E
27N/06E-18F01	130	--	--	--	--	.3	<.02	D
28N/05E-19K01	570	--	--	--	--	--	--	E
28N/05E-19K01	570	--	--	--	--	--	--	D
28N/05E-22N01	150	--	--	--	--	2.1	<.02	E
28N/05E-22N01	--	--	--	--	--	2.1	<.02	D
28N/07E-20J01	75	<.1	<1	<1.0	45	--	--	E
28N/07E-20J01	75	<.1	<1	<1.0	48	--	--	D
29N/06E-16N01	55	<.1	<1	<1.0	<3	.3	<.02	E
29N/06E-16N01	55	<.1	<1	<1.0	<3	--	--	D
30N/05E-08K01	12	--	--	--	--	.7	<.02	E
30N/05E-08K01	13	--	--	--	--	.7	<.02	D
31N/06E-06Q02	12	--	--	--	--	--	--	E
31N/06E-06Q02	13	--	--	--	--	--	--	D
32N/04E-06Q05	<1	--	--	--	--	.8	<.02	E
32N/04E-06Q05	<1	--	--	--	--	.8	<.02	D
32N/05E-35E01	<1	<.1	<1	<1.0	230	--	--	E
32N/05E-35E01	<1	<.1	<1	<1.0	220	--	--	D
27N/07E-19J01S	<1	<.1	<1	<1.0	<3	.7	<.02	E
27N/07E-19J01S	<1	<.1	<1	<1.0	<3	.5	<.02	D

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[1] Sample code of E designates the primary or environmental sample; sample code of D designates the duplicate, quality-assurance sample.

Table C5.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance field-blank samples, July 1993 to March 1994*

[--, not determined; <less than]

Date	Time	Specific conductance, field (microsiemens per centimeter)	Specific conductance laboratory (microsiemens per centimeter)	pH, field (standard units)	pH, laboratory (standard units)	Temperature, water (degrees Celsius)	Hardness, total (milligrams per liter as $CaCO_3$)	Calcium, dissolved (milligrams per liter as Ca)
07-22-93	1042	--	4	--	6.2	--	0	0.07
07-23-93	1447	--	2	--	7.5	--	--	.04
07-27-93	1602	--	3	--	6.2	--	--	.03
07-28-93	1302	--	--	--	--	--	--	--
07-29-93	1802	3	2	5.8	5.6	--	--	<.02
08-04-93	1602	5	3	7.3	5.7	--	--	<.02
08-10-93	0937	1	2	7.1	8.0	19.5	--	<.02
08-10-93	1642	2	2	6.5	7.8	--	--	.02
08-11-93	1957	2	2	5.8	7.8	--	--	<.02
08-19-93	1032	1	2	6.2	7.1	--	--	<.02
08-31-93	1842	2	2	6.0	8.0	21.5	0	.05
09-02-93	1512	2	1	6.5	7.9	24.5	0	.04
09-15-93	1202	1	1	6.1	7.9	16.5	--	<.02
09-15-93	1302	4	1	6.0	8.2	13.5	--	.03
09-29-93	1332	2	2	5.7	8.5	19.0	--	<.02
10-01-93	0932	--	--	--	--	--	--	--
03-23-94	0902	2	2	5.6	7.7	5.5	--	<.02
03-23-94	1607	7	2	7.2	7.9	19.5	--	.05

Table C5.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance field-blank samples, July 1993 to March 1994--Continued*

Date	Time	Magnesium, dissolved (milligrams per liter as Mg)	Sodium, dissolved (milligrams per liter as Na)	Potassium, dissolved (milligrams per liter as K)	Alkalinity, whole water, laboratory (milligrams per liter as $CaCO_3$)	Sulfate, dissolved (milligrams per liter as SO_4)	Chloride, dissolved (milligrams per liter as Cl)	Fluoride, dissolved (milligrams per liter as F)
07-22-93	1042	0.04	<0.2	<0.1	3.7	0.2	0.1	<0.1
07-23-93	1447	<.01	<.2	<.1	4.0	.1	2.5	<.1
07-27-93	1602	<.01	<.2	<.1	3.3	.1	.2	<.1
07-28-93	1302	--	--	--	--	--	--	--
07-29-93	1802	<.01	<.2	<.1	2.7	<.1	.1	<.1
08-04-93	1602	<.01	<.2	<.1	1.6	<.1	<.1	<.1
08-10-93	0937	<.01	<.2	<.1	1.1	<.1	.1	<.1.
08-10-93	1642	<.01	<.2	<.1	1.1	.2	<.1	<.1
08-11-93	1957	<.01	<.2	.9	1.5	<.1	<.1	<.1
08-19-93	1032	<.01	<.2	<.1	4.5	<.1	<.1	<.1
08-31-93	1842	.01	<.2	<.1	1.4	.1	.2	<.1
09-02-93	1512	.01	<.2	<.1	1.0	.1	.2	.1
09-15-93	1202	<.01	<.2	<.1	2.8	<.1	<.1	.1
09-15-93	1302	<.01	<.2	<.1	2.9	<.1	.2	.1
09-29-93	1332	<.01	<.2	<.1	4.1	<.1	<.1	.1
10-01-93	0932	--	--	--	--	--	--	--
03-23-94	0902	<.01	<.2	<.1	50	<.1	<.1	<.1
03-23-94	1607	<.01	<.2	<.1	<1.0	<.1	.8	<.1

Table C5.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance field-blank samples, July 1993 to March 1994--Continued*

Date	Time	Silica, dissolved (milli- grams per liter as SiO_2)	Nitrite nitrogen, dissolved (milli- grams per liter as N)	Nitrite plus nitrate nitrogen, dissolved (milli- grams per liter as N)	Ammonia nitrogen, dissolved (milli- grams per liter as N)	Ammonia nitrogen, dissolved (milli- grams per liter as NH_4)	Phos- phorus, ortho, dissolved (milli- grams per liter as P)	Phos- phate, ortho, dissolved (milli- grams per liter as PO_4)
07-22-93	1042	<0.1	<0.01	<0.05	0.01	0.01	<0.01	--
07-23-93	1447	<.1	<.01	<.05	.02	.03	<.01	--
07-27-93	1602	<.1	<.01	<.05	.04	.05	<.01	--
07-28-93	1302	--	<.01	<.05	.02	.03	.01	0.03
07-29-93	1802	<.1	<.01	<.05	.02	.03	<.01	--
08-04-93	1602	<.1	<.01	<.05	.03	.04	<.01	--
08-10-93	0937	.1	<.01	<.05	.03	.04	<.01	--
08-10-93	1642	.1	<.01	<.05	.03	.04	<.01	--
08-11-93	1957	<.1	<.01	<.05	<.01	--	<.01	--
08-19-93	1032	<.1	<.01	<.05	.02	.03	<.01	--
08-31-93	1842	<.1	<.01	<.05	.02	.03	.03	.09
09-02-93	1512	.1	<.01	<.05	.03	.04	.01	.03
09-15-93	1202	<.1	<.01	<.05	.04	.05	.01	.03
09-15-93	1302	<.1	<.01	<.05	.02	.03	<.01	--
09-29-93	1332	<.1	<.01	<.05	.02	.03	<.01	--
10-01-93	0932	--	--	--	--	--	--	--
03-23-94	0902	<.1	.02	<.05	<.01	--	<.01	--
03-23-94	1607	<.1	.02	<.05	<.01	--	<.01	--

Table C5.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance field-blank samples, July 1993 to March 1994--Continued*

Date	Time	Arsenic, dissolved (micro-grams per liter as As)	Barium, dissolved (micro-grams per liter as Ba)	Boron, dissolved (micro-grams per liter as B)	Cadmium, dissolved (micro-grams per liter as Cd)	Chromium, dissolved (micro-grams per liter as Cr)	Copper, dissolved (micro-grams per liter as Cu)	Iron, dissolved (micro-grams per liter as Fe)	Lead, dissolved (micro-grams per liter as Pb)
07-22-93	1042	<1	<2	--	<1.0	1	<1	<3	<1
07-23-93	1447	<1	--	<10	--	--	--	9	--
07-27-93	1602	<1	--	30	--	-	--	7	--
07-28-93	1302	--	--	--	--	--	--	--	--
07-29-93	1802	<1	--	<10	--	--	--	3	--
08-04-93	1602	<1	--	<10	--	--	--	<3	--
08-10-93	0937	<1	--	--	--	--	--	3	--
08-10-93	1642	<1	<2	--	<1.0	<1	<1	4	<1
08-11-93	1957	<1	--	--	--	--	--	<3	--
08-19-93	1032	<1	--	--	--	--	--	5	--
08-31-93	1842	<1	--	<10	--	--	--	4	--
09-02-93	1512	<1	--	--	--	--	--	<3	--
09-15-93	1202	<1	<2	--	<1.0	<1	<1	6	<1
09-15-93	1302	<1	--	--	--	--	--	<3	--
09-29-93	1332	<1	9	<10	<1.0	<1	<1	<3	<1
10-01-93	0932	--	--	--	--	--	--	--	--
03-23-94	0902	<1	<2	--	<1.0	<1	<1	<3	<1
03-23-94	1607	<1	--	--	--	--	--	9	--

Table C5.--*Field measurements and concentrations of inorganic constituents and septage-related compounds in quality-assurance field-blank samples, July 1993 to March 1994--Continued*

Date	Time	Manganese, dissolved (micrograms per liter as Mn)	Mercury, dissolved (micrograms per liter as Hg)	Selenium, dissolved (micrograms per liter as Se)	Silver, dissolved (micrograms per liter as Ag)	Zinc, dissolved (micrograms per liter as Zn)	Carbon, organic, dissolved (milligrams per liter as C)	Methylene-blue-active substances (milligrams per liter)
07-22-93	1042	<1	<0.1	<1	<1.0	<3	--	--
07-23-93	1447	<1	--	--	--	--	<0.1	<0.02
07-27-93	1602	<1	--	--	--	--	<.1	<.02
07-28-93	1302	--	--	--	--	--	--	--
07-29-93	1802	<1	--	--	--	--	.1	<.02
08-04-93	1602	<1	--	--	--	--	<.1	<.02
08-10-93	0937	<1	--	--	--	--	--	--
08-10-93	1642	<1	<.1	<1	<1.0	<3	--	--
08-11-93	1957	<1	--	--	--	--	--	--
08-19-93	1032	<1	--	--	--	--	--	--
08-31-93	1842	<1	--	--	--	--	.2	.03
09-02-93	1512	<1	--	--	--	--	--	--
09-15-93	1202	<1	<.1	<1	<1.0	8	--	--
09-15-93	1302	2	--	--	--	--	--	--
09-29-93	1332	<1	<.1	<1	<1.0	<3	.2	<.02
10-01-93	0932	--	--	--	--	--	--	--
03-23-94	0902	<1	<.1	<1	<1.0	<3	--	--
03-23-94	1607	<1	--	--	--	--	--	--

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