GROUND-WATER PUMPAGE FROM THE COLUMBIA PLATEAU REGIONAL AQUIFER SYSTEM, WASHINGTON, 1984

By D. R. Cline and M. E. Knadle

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Contents

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For the convenience of readers who may prefer to use metric units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound units	by	to obtain SI units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1,233.	cubic meter (m^3)

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ABSTRACT

An inventory of ground-water pumpage from large-capacity wells on the Columbia Plateau in eastern Washington was started in 1981 in conjunction with a regional aquifer study of the plateau. Irrigation accounts for most of the pumpage. The area is underlain by extensive basalt flows of Miocene age that are nearly flat-lying except in the western part, where they are folded into ridges. Water is withdrawn from four water-yielding units (three basalt and one unconsolidated deposits). Pumpage from the Grande Ronde unit (oldest basalt) totaled 205,000 acre-feet; the Wanapum unit, 270,000 acre-feet; the Saddle Mountains unit, 24,000 acre-feet; and the locally occurring overburden (unconsolidated water-yielding sediments), 180,000 acre-feet, for a total of 680,000 acre-feet in 1984. Most of the pumpage from the overburden occurs in only two counties, Grant and Franklin. These two counties plus Adams and Lincoln Counties (the core area) accounted for three-fourths of the total pumpage on the plateau. Of the core-area pumpage, three-quarters was from three subareas: Odessa subarea, 212,000 acre-feet; Black Sands area, 96,000 acre-feet; and southern Franklin County, 75,000 acre-feet. In the core area the only significant lowering of ground-water levels occurs in the Odessa subarea, where declines locally exceeded 100 feet.

INTRODUCTION

Background

In 1981 the U. S. Geological Survey, in cooperation with the State of Washington Department of Ecology, started an inventory of ground water pumpage in the Columbia Plateau, Washington, (fig. 1) in anticipation of a 1982 study of the Columbia Plateau regional aquifer system, one of many undertaken by the U. S. Geological Survey as part of the Regional Aquifer System Analysis (RASA) program. The Columbia River Basalt Group and overlying water-yielding unconsolidated sediments make up the regional aquifer system in the Columbia Plateau, which covers southeastern Washington, northeastern Oregon, and small parts of northwestern Idaho.

The Columbia River Basalt Group underlies an area of 25,000 square miles in Washington and is the major source of ground water for irrigation and municipal, industrial, and domestic uses. In some areas unconsolidated sediments are the major source of ground water. Concurrent with ground-water usage, surface water is used for irrigation in several areas of the plateau. Surface water is almost fully appropriated, and the demand for more irrigation water is increasing. Ground-water levels have risen in some areas because of surface-water irrigation, and water-levels have declined locally in areas of ground-water pumpage. In some places, declines considerably exceed 100 feet. Changes in the chemical quality of the ground water have also occurred locally in irrigated areas.

Purpose and Scope

The Columbia Plateau pumpage project and the subsequent RASA project were originated to aid in the effective management of the important ground-water resources by providing information on the geohydrology and geochemistry of the regional aquifer system. The objective of this report is to present ground-water pumpage data in the Columbia Plateau in Washington. These data help determine the area's water budget, and are critical to the RASA study.

This report describes the quantities and distribution of ground-water pumpage in 1984 from the four water-yielding units in the Washington part of the Columbia Plateau. Three units yield water from the Yakima Basalt Subgroup of the Columbia River Basalt Group and the fourth yields water from the overlying unconsolidated sediments. Along the eastern border of Washington there is a small amount of pumpage in Idaho which is included in this report also. The plateau, regional aquifer system, and study area have the same pumpage and nearly the same boundaries, so the terms are used interchangeably in this report. A companion report presents the 1984 ground-water pumpage in the Oregon part of the Columbia Plateau (Collins, 1987).

Pumpage data for the central part of the project area (see core area, fig. 2), where the largest quantities of ground water are pumped, were obtained by using power company records. Other methods, such as crop application rates, water rights, and reported values were used to estimate pumpage for the rest of the area.

Acknowledgments

The authors thank the various power companies and many individuals for their permission and assistance in obtaining these data. In particular, we thank Douglas Burk and Grant County PUD, Bonnie Hickman and Franklin County PUD, Jack Kercheval and Washington Water Power, and the staffs of Big Bend Electric Cooperative and Lincoln Electric Cooperative. Thanks are also given to Terry Henderson, Umatilla, Oregon, for his special help with the acoustic flowmeter and pump efficiency testing.

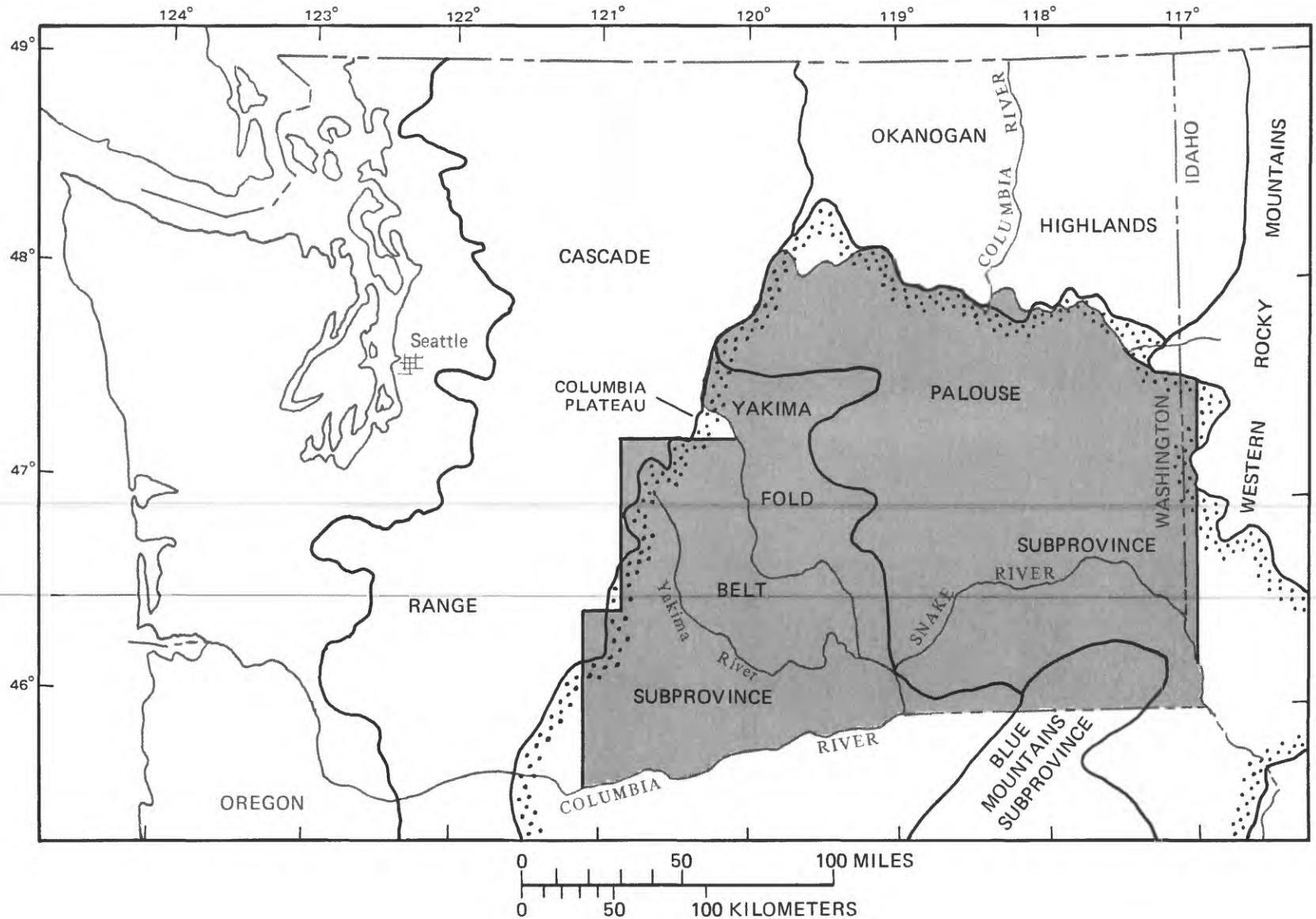

FIGURE 1.--Northern part of the Columbia Plateau, showing study area (shaded) and physiographic provinces.

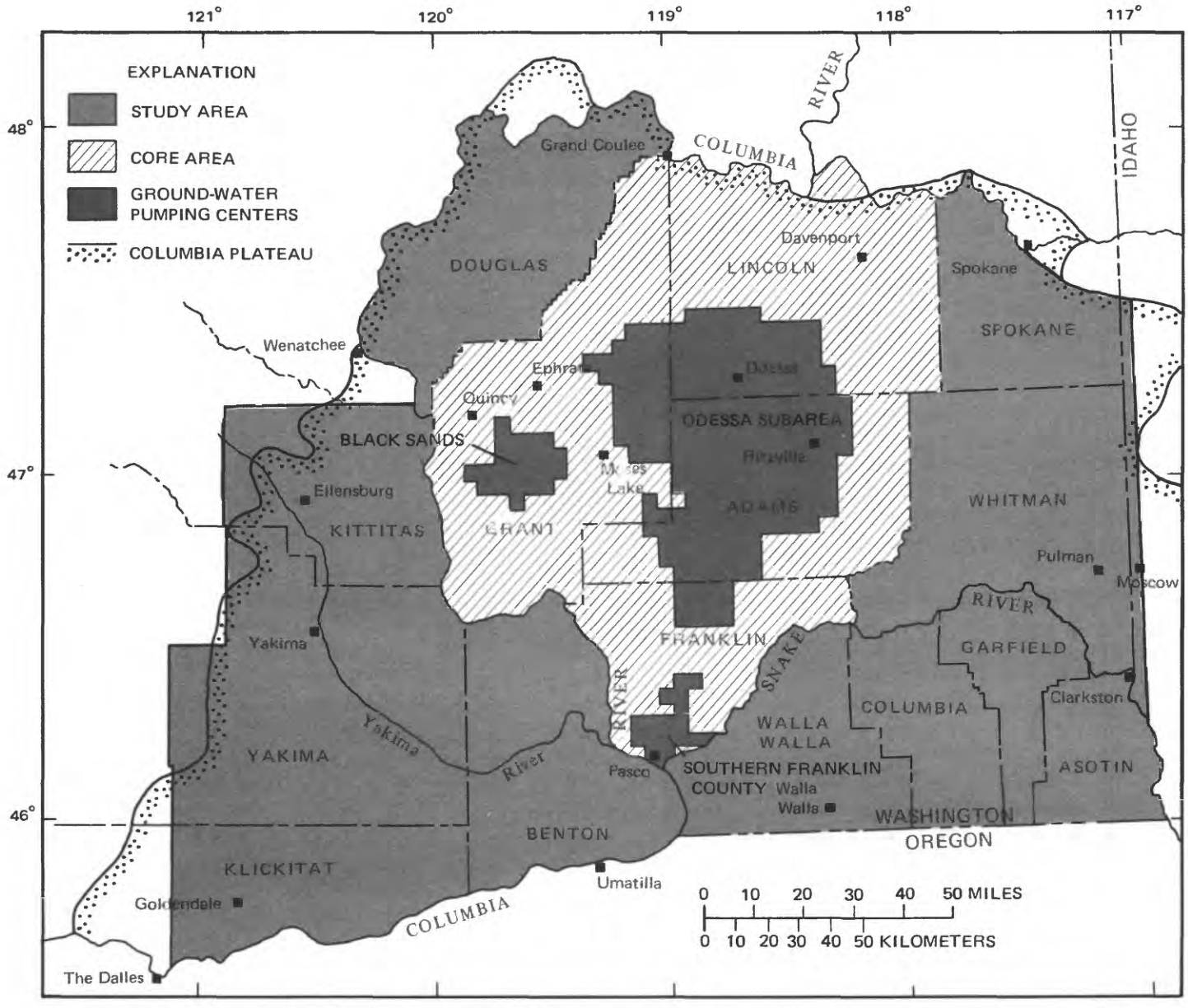

FIGURE 2.--Study area, Columbia Plateau, Washington, showing ground-water pumping centers in the core area. (see figure 1. location map.)

DESCRIPTION OF THE STUDY AREA

The Columbia Plateau aquifer system underlies the Columbia Plateau, which is in the Columbia Basin Subprovince of the Columbia Intermontane physiographic province (Freeman and others, 1945). The plateau is bordered by the Blue Mountains on the south, the Cascade Range on the west, the Okanogan Highlands on the north, and the western ranges of the Rocky Mountains on the east (fig. 1). The plateau has been divided into three informal subprovinces, the Yakima Fold Belt, the Blue Mountains, and the Palouse Subprovinces. Together these subprovinces form a large, complex structural basin containing smaller structural basins that tend to be partly filled with unconsolidated sediments. The Yakima Fold Belt, located in the western part of the study area, has large east-west-trending anticlinal ridges with intervening broad to narrow synclinal valleys. Most development is in the valleys. The Palouse Subprovince has a rolling topography underlain by gently southwest-dipping, nearly undeformed basalts. Little of the Blue Mountains Subprovince is in Washington, and there is little or no ground-water pumpage from it; thus it is excluded from this report.

The study area is completely within the drainage of the Columbia River, and major tributaries that drain the area are the Snake and Yakima Rivers. These rivers and their associated tributaries drain the bordering mountainous areas, which receive 30 to 50 inches of precipitation a year, increasing to more than 100 inches along much of the crest of the Cascade Range. Forest lands predominate where precipitation is greatest, and smaller dissected perennial streams are common. The central part of the plateau is lower in elevation, and precipitation there ranges from 7 to 15 inches a year. The lower precipitation results in an arid environment over much of the plateau, characterized by sage and grasslands with few perennial streams. At intermediate elevations, precipitation ranges from 15 to 25 inches; the vegetation of both grasslands and forest there is more typical of semiarid climates.

The predominant economic activity on the plateau is agriculture and its associated services. In 1982 there were 1,453,000 acres (2,270 square miles) of irrigated croplands on the plateau in Washington, of which about 70 percent were irrigated by surface water and 30 percent by ground water (U. S. Department of Commerce, 1982). The major source of the surface water is the Columbia River, with the Yakima River providing the next largest amount.

Geohydrologic Setting

Basalt Units

The Columbia Plateau is underlain by rocks of the Columbia River Basalt Group, and is a structural basin with its lowest point near Pasco, Washington (fig. 2). The Columbia River Basalt Group underlies about 51,000 square miles of the plateau; 25,000 square miles are in Washington. Rocks underlying the plateau are primarily extensive Miocene basalt flows with relatively minor amounts of interbedded sediments and overlying sediments of Miocene to Holocene age. Along the borders of the plateau, the basalts lap onto

Precambrian to lower Tertiary "basement" rocks of mostly granitic, volcanic, and metamorphic origin. In the central part of the basin the basalts overlie older, deeply buried, fine-grained sedimentary rocks. None of the underlying rocks are significant aquifers.

Individual basalt flows range in thickness from a few inches to more than 200 feet and average about 100 feet. The extrusion and cooling of individual flows under different physical conditions resulted in the formation of permeable zones, such as columnar joints, pillow lavas, and brecciated flow tops. A flow top combined with an overlying lava flow base is called an interflow zone. Interflow zones generally consist of vesicular basalt and clinkers, weathered in many places, and average about 5 to 10 percent of the total thickness of a single flow. Most ground water is withdrawn from interflow zones. Wells tapping these zones vary in yield because the zones vary in size and permeability. Well yields also vary depending on the number of zones that are tapped.

The Columbia River Basalt Group in Washington consists primarily of the Yakima Basalt Subgroup, which consists in ascending order of the Grande Ronde, Wanapum, and Saddle Mountains Basalts. In this report, the terms Grande Ronde, Wanapum, and Saddle Mountains units as used include any sedimentary interbeds, if present, down to the top of the next basalt formation except for the Grande Ronde unit, which excludes the basement rocks. Older basalt flows are excluded because they occur only in the extreme southeast part of the study area. Little is known about them, and probably little ground water is withdrawn from them. Geologic maps of the Grande Ronde, Wanapum, and Saddle Mountains Basalts (Swanson and others, 1979) were modified for Washington by Drost and Whiteman (1986). The modifications included the generation of structure maps of the basalts, which were used to determine the contributions of water from each formation to wells. The areal extent of each formation is shown on the pumpage maps, which are discussed in the pumpage section (see plate 1).

The Grande Ronde unit underlies virtually all of the study area. It is exposed only along the northern margin and southeastern corner and in a few deeply incised stream channels in the central part. Its thickness ranges from a few feet along the northern margin, where it pinches out against basement rocks, to more than 4,000 feet in the central and southwestern parts of the study area. The Grande Ronde unit is composed of at least 30 and perhaps as many as several hundred individual basalt flows. Sedimentary interbeds in the Grande Ronde unit are extremely rare and generally are only a few feet thick.

A sedimentary interbed between the Grande Ronde unit and the overlying Wanapum Basalt occurs in places, and generally is a good stratigraphic marker bed. Where present, this interbed is as much as 100 feet thick and averages about 25 feet; it is thin or missing in much of the central and southern parts of the study area. Water obtained from the this interbed is considered part of the Wanapum unit pumpage.

The Wanapum unit crops out or is covered by a veneer of sediments throughout most of the northern half of the study area. In the southern half, the Wanapum unit is generally covered by thick sequences of sediments or by the Saddle Mountains unit. The Wanapum unit underlies most of the study area (see pl. 1) and averages about 600 feet in thickness, ranging from a few feet

where it pinches out against exposures of the Grande Ronde unit to more than 1,600 feet in the southwestern part of the study area. The Wanapum unit generally contains about 10 flows. Sedimentary interbeds are more common in the Wanapum unit than in the Grande Ronde unit but are still relatively rare, and most are only a few feet thick.

A sedimentary interbed lying between the Wanapum and the overlying Saddle Mountains Basalt unit occurs in the southwestern part of the area. This interbed is as much as 150 feet thick and averages about 50 feet. Water obtained from the interbed is considered part of the Saddle Mountains unit pumpage.

The Saddle Mountains unit underlies only the southwestern part of the study area and a small area in the southeastern corner (see pl. 1). It has a maximum thickness of more than 800 feet and averages about 600 feet. Individual basalt flows in the Saddle Mountains unit vary greatly in texture and composition. Sedimentary interbeds are common and relatively thick, many being 50 feet or more; one is areally extensive and hydrologically important in parts of the Yakima Fold Belt.

Overburden Unit

Unconsolidated sediments, called overburden, compose a major aquifer in parts of the Columbia Plateau in Washington (see pl. 1). The term overburden unit is used here to include water-yielding sediments overlying the Columbia River Basalt Group, and the unit includes Pliocene to Holocene fluvial, glaciofluvial, and volcaniclastic sediments. A windblown silt, called loess, which occurs throughout much of the Columbia Plateau, is excluded because it yields little water. The areal extent of the overburden unit that is more than 50 feet thick is limited mostly to the Quincy Basin (centered on the Black Sands area), the Pasco and Walla Walla Basins, and the Yakima Valley. The extent of overburden shown in plate 1, however, is based on the work of Drost and Whiteman (1986), who included all materials overlying the Columbia River Basalt Group and only generally followed the 50-foot thickness criterion. Thicknesses can exceed several hundred feet, especially in the Yakima Valley and the Pasco Basin. Sands and gravels in the unit yield the most water.

GROUND-WATER PUMPAGE

Ground-water pumpage from the Columbia Plateau in Washington (including a very small amount in Idaho) is mostly from irrigation wells; lesser quantities are withdrawn from municipal and industrial wells. Irrigation is by sprinkler systems, most of them center pivots. Nearly all large-capacity pumps installed in wells are electric deep-well turbines. Many wells also have centrifugal booster pumps to help push the water into the system. Pumping systems range from about 7.5 to 900 horsepower. Estimates of pumpage from domestic and other small-capacity wells were not made in this study. The boundary of the study area excludes parts of some counties, so only part of the pumpage from those counties, notably Spokane County, is included in this report.

Most of the pumpage on the plateau was from the so-called "core area" of Grant, Adams, Franklin, and Lincoln Counties (fig. 2), and most of that was from three pumping centers in the core area. The largest pumping center is the Odessa subarea, so designated by the Washington State Department of Ecology because of declining ground-water levels (fig. 1). More ground-water is pumped from that area than from any other on the plateau. Another major ground-water pumping center is the Black Sands area in central Grant County, west of Moses Lake (fig. 2). This area was excluded from the U. S. Bureau of Reclamation surface-water irrigation blocks (tracts) in the Columbia Basin Irrigation Project because the area was originally thought to be unsuitable for irrigation. The third area of heavy ground-water pumping is that part of the Pasco Basin in southern Franklin County which encompasses townships 9, 10, and 11 north (fig. 2).

Methods Used to Determine Pumpage

Pumpage data for 1984 in Washington were obtained and determined in a number of ways. Electrical power consumption data were used for estimating pumpage for the core area, where most of the pumpage in the plateau occurs. Pumpage in the noncore area was estimated by using various existing data, such as published reports, unpublished project data, flowmeter data, field visits, population data, 1975 water-use data, 1982 Landsat imagery, water rights, inventory of water suppliers, and well data, such as use, diameter, depth, and horsepower. Some telephone surveys also were conducted to obtain information. Data for 1984 were also obtained for two areas from on-going and recent studies by the U. S. Geological Survey: the Pullman-Moscow area (W. E. Lum, II, U. S. Geological Survey, written commun., 1985) and the Horse Heaven Hills area (A. J. Hansen, Jr., U. S. Geological Survey, written commun., 1985) (fig. 2). Ground-water pumpage on the plateau is also discussed in many published reports, such as those by Prych (1983), Mac Nish, Myers, and Barker (1973), and Cline (1984).

Pumpage can be computed from the quantity of electricity used by a pump to do the work of lifting water out of a well and distributing it. Pumpage was calculated from power consumption data using the equation:

$$A = \frac{K \times E}{1.024 \times T}$$

where A = pumpage in acre-feet of water,
K = kilowatt-hours of electricity used during the year,
E = efficiency of the pumping system, in percent, and
T = total operating head, in feet.

Efficiency is the ratio of water pumped to electricity used. Pumping system efficiencies were measured for nearly 300 wells, including most of the largest producers. The U. S. Geological Survey did most of the measurements, but some measurements were made by Agri-Water Control, Hermiston, Oregon; Bonneville Power Administration, Spokane, Washington; and Lincoln Electric Co-op, Davenport, Washington. Flow measurements by the U. S. Geological Survey for the efficiency tests were made with a recently developed acoustic velocity flowmeter that has a tested accuracy of 1 percent under ideal conditions. A thickness meter was used to measure pipe-wall thickness to obtain an accurate internal cross-sectional area of the pipe. Test data were compared to pump performance curves where possible to cross check results. For the remaining 1,000 wells that were not tested, an average efficiency of 60 percent was used for wells in Grant and Lincoln Counties and 65 percent for wells in Adams and Franklin Counties. These were average values of the efficiency tests in each area.

Total operating head is equal to the depth to the pumping water level, plus discharge-line pressure, plus friction loss between the pump intake and the point where line pressure is measured. For wells with no line pressure information, an average of 200 feet of head for line pressure was generally assumed. For wells without pumping water levels, old water levels plus drawdown data or water levels in nearby wells were used to estimate pumping water levels. Friction losses calculated for efficiency tests generally were small, less than 20 feet for shallow pumping levels and less than 40 feet for deeper levels. Pumping water levels in wells tapping the overburden unit are generally less than 200 feet below land surface, whereas pumping water levels in the basalt are commonly several hundred feet, with a few as much as 800 feet or more. Total heads of a few systems are 1,000 feet or more.

A number of factors other than using average values, such as changing water levels and line pressures, and pump wear, affect the accuracy of calculating pumpage from power records. Water levels and line pressures can vary for several reasons, such as lowering of the water table, hilly land where water is pumped uphill at times and downhill at others as the boom arm moves, and whether or not a booster pump is running. Sometimes the irrigation system has been changed, especially from a high-pressure sprinkler system to a low-pressure one.

Some problems encountered were not related directly to computing from kilowatt-hours used: (1) determining whether an electrical account is for a well or for something else (for example, a surface-water pump, booster pump, circle drive motors, etc.), (2) matching accounts to wells (locations and names may be different, no well record exists, or a well is unused or destroyed), (3) determining which power company serves a well, and (4) confidentiality requirements that restricted working with the records (the calculations had to be done at the power companies). Even though the accuracy of computations for a particular well may not be good, the authors believe that the estimates of pumpage given for quarter-townships (discussed below) are still reasonably accurate.

Pumpage for each well was assigned to the water-yielding units tapped by that well. Where a well tapped more than one unit, the pumpage was divided proportionally according to the saturated thickness of each unit open to the well (uncased). Pumpage was then aggregated by quarter-township blocks so that an individual owner's pumpage could not be identified; some blocks had to be aggregated with other blocks and an average given for them in order to keep ownership confidential. Locations of blocks that were grouped are shown on plate 1. In a few places minor amounts of pumpage were omitted because it wasn't feasible to aggregate them. Also, a small amount of pumpage was not included along the Columbia River in western Grant County because it was from limited sand and gravel deposits next to the river in a bedrock canyon, thus hydraulically connected to the river. Wells that tapped sand and gravel deposits next to the Columbia River outside of the core area were also excluded.

Another method, used for estimating pumpage outside the core area, was to inventory irrigated cropland using Landsat images. The inventory was done by hand, using visual identification of cropland. Plants that are growing vigorously because plenty of water is available, generally from irrigation in arid to semiarid country, reflect strongly in the infrared band, and thus can be identified by sensors in satellites such as Landsat. Pumpage was estimated from the 1982 color composite Landsat images by locating irrigated fields, estimating their size and crop type, and multiplying the acres times a crop water-use requirement. Crop types were divided into two groups, high and low water use. High water-use crops included potatoes, corn, alfalfa, hay, and pasture for which a requirement of 2.8 acre-feet per acre was used. Low water-use crops included wheat, barley, and various vegetables with a requirement from north to south of 1.1 to 1.6 acre-feet per acre used.

Errors inherent in the Landsat interpretation method include misidentifying the source of water for irrigated land, using wrong crop water-use requirements, and not correctly identifying irrigated land. Errors can also occur because plants that tap shallow ground water or have received rain recently can look similar to irrigated plants on Landsat scenes. A crop that is not growing vigorously because it is mature and waiting for harvest, or a field that has been recently harvested can look like it has not been irrigated and thus can be misidentified. In particular, crops such as alfalfa and hay are cut several times during the irrigation season, making them difficult to identify at these times.

Quantities and Distribution

The total pumpage of ground water from the Columbia Plateau regional aquifer system in Washington for 1984 was about 680,000 acre-feet, of which 205,000 acre-feet (30 percent) was from the Grande Ronde unit; 270,000 acre-feet (40 percent) was from the Wanapum unit; 24,000 acre-feet (3 percent) was from the Saddle Mountains unit; and 180,000 acre-feet (27 percent) was from the overburden unit. The quantities and areal distribution of the pumpage are shown in plate 1 as specified ranges of pumpage by quarter-township. Actual quantities are listed in table 1 at the end of the report. Pumpage of less than 50 acre-feet of water is not shown on the maps because most small quantities were not inventoried.

Nine-tenths (89 percent) of the total pumpage of the plateau in Washington was from the core area plus Yakima and Walla Walla Counties. Pumpage in the core area (Adams, Franklin, Grant, and Lincoln Counties) was about 500,000 acre-feet, or three-fourths of the total (74 percent) for the plateau in 1984 (table 2). Lincoln County had the smallest total pumpage in the core area. In the rest of the study area, Yakima County has more pumpage than Lincoln County, but nearly one-third of it is from municipal and industrial wells. Municipal and industrial pumpage accounts for less than one-tenth of the totals in the core counties. Walla Walla County has somewhat less pumpage than Lincoln County, and the remaining counties have considerably less pumpage (table 2).

TABLE 2.--Ground-water pumpage in 1984 from the Columbia Plateau, Washington and Idaho, by county and water-yielding unit

		Pumpage, in acre-feet						
		Basalt units						
County	State	Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Overburden unit	Total	Percentage of core area	Percentage of Columbia Plateau
Adams	WA	81,050	51,700	100	0	132,850	26	[1] 20
Asotin	WA	4,400	0	0	0	4,400	--	1
Benton	WA	0	8,330	7,340	0	15,670	--	2
Columbia	WA	590	0	0	0	590	--	0
Douglas	WA	2,840	0	0	0	2,840	--	0
Franklin	WA	5,810	22,940	3,800	62,950	95,500	19	[1] 14
Garfield	WA	550	0	0	0	550	--	0
Grant	WA	50,610	100,360	0	74,940	225,910	45	[1] 33
Kittitas	WA	340	0	0	5,100	5,440	--	1
Klickitat	WA	2,200	25,320	0	0	27,520	--	4
Lincoln	WA	33,470	16,230	0	0	49,700	10	[1] 7
Spokane	WA	7,200	3,030	0	0	10,230	--	2
Walla Walla	WA	1,070	20,420	130	15,560	37,180	--	6
Whitman	WA	6,550	730	0	0	7,280	--	1
Yakima	WA	5,710	22,320	12,350	21,790	62,170	--	9
Latah	ID	2,900	100	0	0	3,000	--	0
Nez Perce	ID	100	0	0	0	100	--	0
Total		205,390	271,480	23,720	180,340	680,930	100	100

[1] Core area totals 503,960 acre-feet, or 74 percent of Columbia Plateau.

A comparison of the pumpage by quarter-township and by water-yielding unit (table 1 and pl. 1) and pumpage totals by county (table 2) shows that there is considerable areal variation in the amounts and sources of water withdrawn. Three-fourths of the quarter-townships on the map in plate 1 that shows total pumpage have less than 2,000 acre-feet of pumpage, and 36 percent have less than 500 acre-feet of pumpage. A breakdown that shows the number of quarter-townships in each range of pumpage, and the spread of each range in acre-feet is shown in figure 3. The number of blocks in the larger ranges would be even less if each range covered only 500 acre-feet. A breakdown by water-yielding units of the number of blocks in each pumpage range (fig. 4) shows a pattern similar to the distribution of blocks for total pumpage. The number of blocks in figures 3 and 4 is different because the quarter-townships represented by many blocks obtain water from more than one water-yielding unit. Although the number of blocks representing the overburden unit is small, the average pumpage per block is roughly double that of the other water-yielding units.

Pumpage from the four water-yielding units is unevenly distributed areally between the units. Nearly all of the pumpage from the overburden unit occurs in only four counties, Grant, Franklin, Yakima, and Walla Walla, three-fourths (76 percent) of it in the first two counties (pl. 1). In Franklin County, the overburden unit is by far the dominant aquifer (table 2), and in the quarter-township with the greatest pumpage, 19N/25E-SE in the Black Sands area in Grant County, all 10,500 acre-feet are withdrawn from the overburden unit. In the basalt units, most of the pumpage in the southern part of the study area is from the Wanapum unit and pumpage in the northern and eastern part is from the Grand Ronde unit (pl. 1; tables 1 and 2). Of the pumpage in the core area, which was three-fourths of the pumpage in the study area (table 2), 34 percent was from the Grande Ronde unit, 38 percent from the Wanapum unit, 27 percent from the overburden unit, and only 1 percent from the Saddle Mountains unit.

The three pumping centers in the core area, Odessa subarea, Black Sands, and southern Franklin County, accounted for three-fourths (76 percent) of the core area pumpage in 1984 and 56 percent of the total from the study area (fig. 2; pl. 1; table 3). More ground-water was pumped from the Odessa subarea than from any other area on the plateau, about 212,000 acre-feet or 31 percent of the total. Most is from Adams County; the remainder is from Grant, Lincoln, and Franklin Counties (table 4). The subarea accounts for 42 percent of the pumpage in the core area, with 63 percent pumped from the Grande Ronde unit and 37 percent from the Wanapum unit. Ground-water levels have declined in places in the Odessa subarea, and locally have been considerably more than 100 feet (Cline, 1984).

Pumpage from the Black Sands area in 1984 was about 96,000 acre-feet, or 14 percent of the total from the plateau, 19 percent of the core area total, and 43 percent of the county total. Pumpage in the Black Sands area was 44 percent from the Wanapum unit, 55 percent from the overburden unit, and only 1 percent from the Grande Ronde unit. Because the area is surrounded and recharged by surface-water irrigation, it has not had significant water-level declines despite heavy pumping.

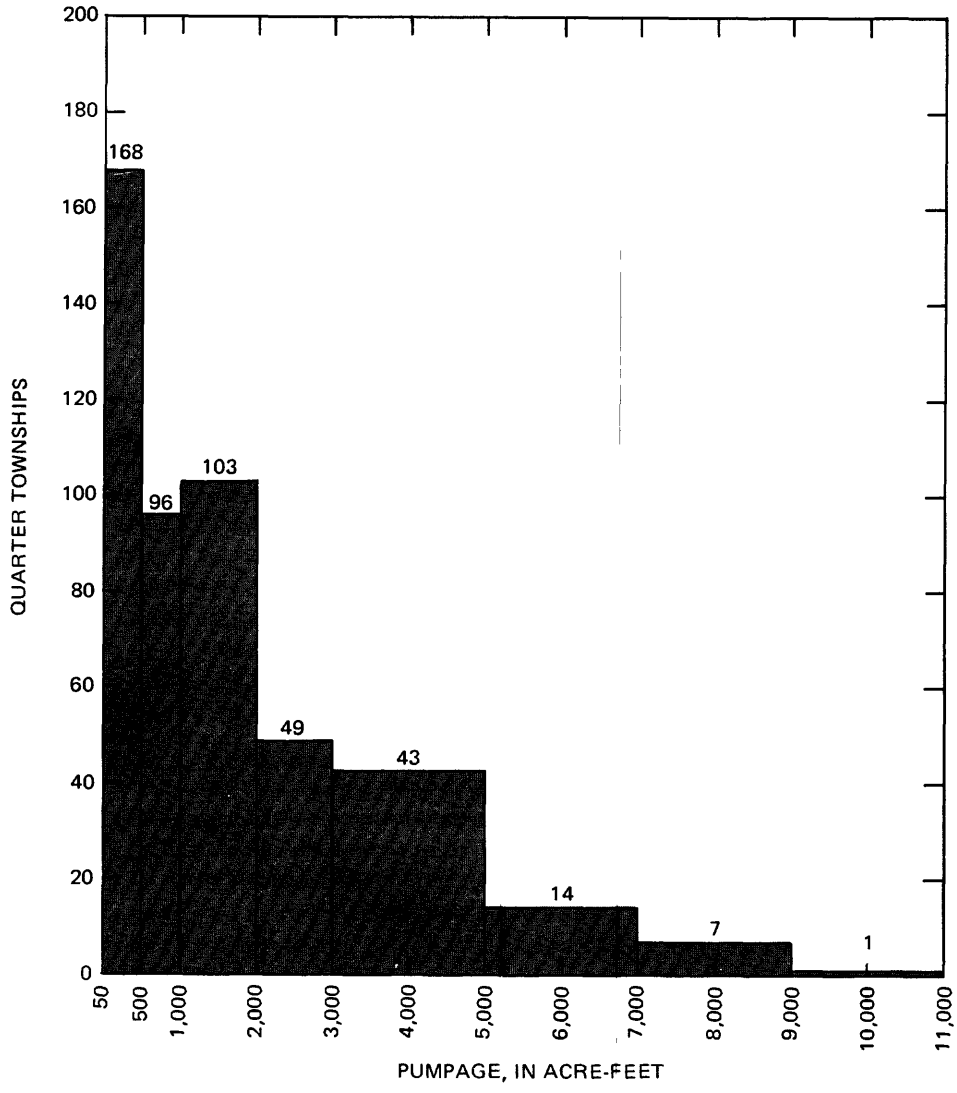

FIGURE 3.--Number of quarter townships in specified ranges of total ground-water pumpage, 1984.

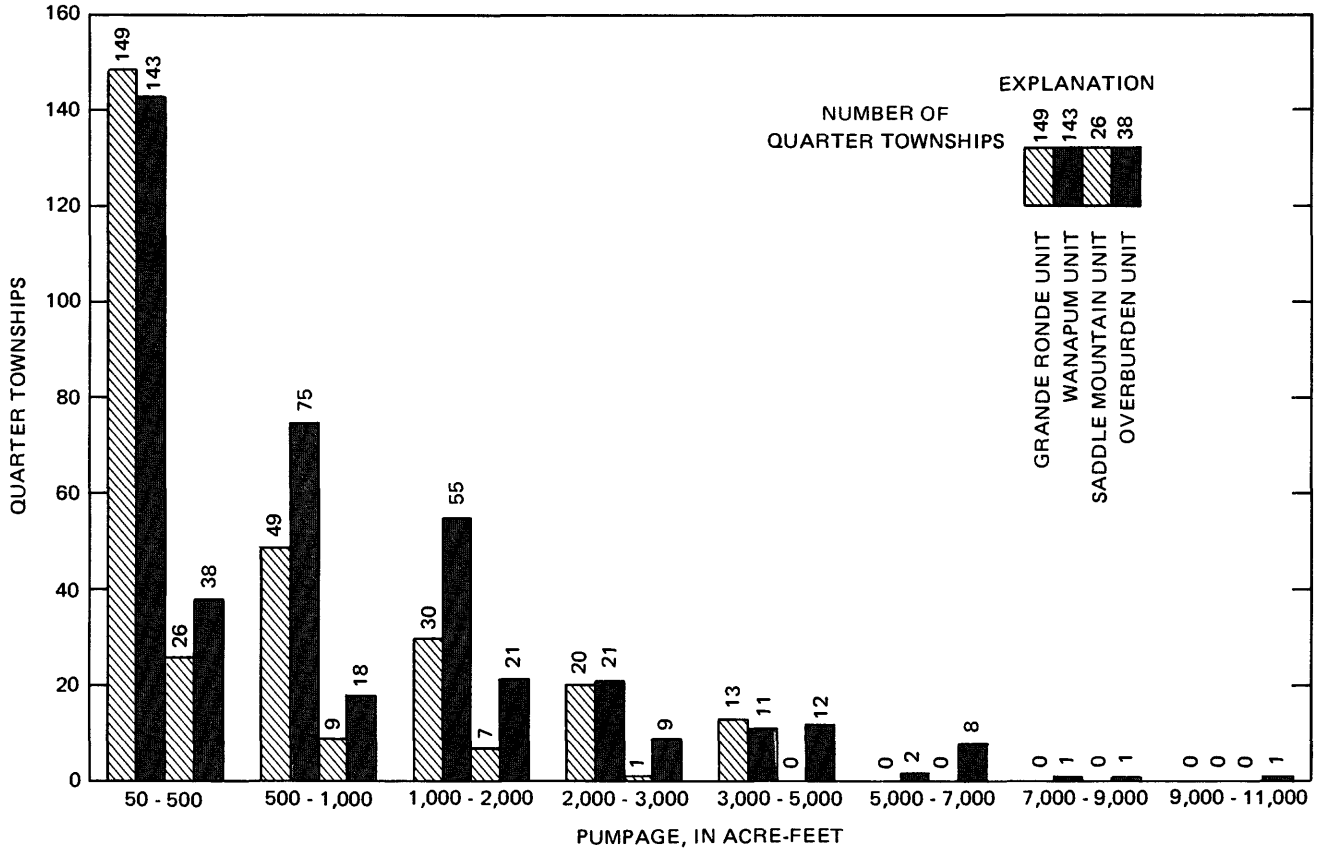

FIGURE 4.-- Number of quarter townships in specified ranges of ground-water pumpage from water-yielding units, 1984.

TABLE 3.--Ground-water pumpage in 1984 from the three pumping centers in the core area, Columbia Plateau, Washington, by water-yielding unit

	1984 pumpage, in acre-feet				
	Basalt units				
	Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
Odessa subarea	133,850	78,270	0	370	212,490
Black Sands area	870	42,510	0	52,920	96,300
Southern Franklin Co.	200	10,000	3,000	61,800	75,000
TOTAL	134,920	130,780	3,000	115,090	383,790

TABLE 4.--Ground-water pumpage in 1984 from the Odessa subarea, Columbia Plateau, Washington, by county and water yielding unit

	Pumpage, in acre-feet						
	Basalt units						
County	Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total	Percentage of subarea	Percentage of county pumpage in subarea to county total
Adams	78,590	42,920	0	0	121,510	57	91
Franklin	3,970	8,730	0	0	12,700	6	13
Grant	26,350	17,970	0	370	44,690	21	20
Lincoln	24,940	8,650	0	0	33,590	16	68
Total	133,850	78,270	0	370	212,490	100	42

In southern Franklin County, pumpage in 1984 totaled 75,000 acre-feet, of which 82 percent was from the overburden unit, 13 percent from the Wanapum unit, and 4 percent from the Saddle Mountains unit. Pumpage from this area was 11 percent of the total from the plateau in Washington, 15 percent of the core area total, and 79 percent of the county total. This area has not had significant water-level declines, also due to recharge from the surface-water irrigation in bordering areas.

In two small areas outside the core area that had only a moderate amount of pumpage, water-levels declined significantly. One area is in the Horse Heaven Hills, at the eastern end of Klickitat County, where water levels have declined about 100 feet (A. J. Hansen, Jr., U. S. Geological Survey, oral commun., 1986). The other area is the Pullman-Moscow Basin, which has experienced water-level declines approaching 100 feet (W. E. Lum, II, U. S. Geological Survey, oral commun., 1986).

SUMMARY

Pumpage of ground water from the regional aquifer system underlying the Columbia Plateau in Washington is mostly from the core area (Adams, Franklin, Grant, and Lincoln Counties), mostly from the basalt, and mostly used for irrigation. The Columbia River Basalt Group is composed of extensive basalt flows of Miocene age that are nearly flat-lying except in the western part, where they are folded into ridges. They are divided into three water-yielding basalt units which are from the oldest to the youngest, the Grande Ronde unit, the Wanapum unit, and the Saddle Mountains unit. Overlying the basalt in structural basins are unconsolidated water-yielding sediments called overburden, which is composed of fluvial, glaciofluvial, and volcaniclastic materials. Three-fourths (500,000 acre-feet) of the ground water pumped from the Columbia Plateau in Washington in 1984 was from the basalt units; over one-half (270,000 acre-feet) of that was from the Wanapum unit and most of the remainder was from the Grande Ronde unit. Of the one-fourth (180,000 acre-feet) of the total pumpage withdrawn from the overburden unit, about three-fourths is withdrawn from only two counties, Grant and Franklin.

Ground-water pumpage in 1984 from the plateau in Washington totaled about 680,000 acre-feet (including a very small amount in Idaho), three-fourths (about 500,000 acre-feet) of which was withdrawn in the core area. Three-fourths of the core area pumpage (56 percent of the total pumpage) was in three heavily pumped areas: Odessa subarea (212,000 acre-feet), Black Sands (96,000 acre-feet), and southern Franklin County (75,000 acre-feet). The Odessa subarea had the largest amount of pumpage, which was 42 percent of the core area and about one-third of the total from the plateau. The Odessa subarea is the only one of the three that has had significant lowering of water levels, locally more than 100 feet. In the other two areas water is obtained predominantly from the overburden, which is recharged by adjacent surface-water irrigation, whereas pumpage in the Odessa subarea is from the basalt.

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TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township

[Agg Num: Aggregation number. 0, pumpage not aggregated with another quarter-township block; numbers indicate blocks for which pumpage was aggregated with other blocks with the same number (see plate 1). County: AD, Adams; AS, Asotin; BE, Benton; CO, Columbia; DO, Douglas; FR, Franklin; GA, Garfield; GR, Grant; KI, Kittitas; KL, Klickitat; LI, Lincoln; SP, Spokane; WA, Walla Walla; WH, Whitman; YA, Yakima; LA, Latah (Idaho); NE, Nez Perce (Idaho). A, Average.]

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
3N/15E-NE	0	KL	0	200	0	0	200
3N/15E-SE	0	KL	300	300	0	0	600
3N/15E-SW	0	KL	600	200	0	0	800
3N/16E-NW	0	KL	900	900	0	0	1,800
3N/17E-NW	0	KL	0	700	0	0	700
3N/20E-SW	0	KL	0	700	0	0	700
4N/15E-NE	0	KL	0	300	0	0	300
4N/15E-NW	0	KL	0	500	0	0	500
4N/16E-NE	0	KL	400	900	0	0	1,300
4N/16E-SE	0	KL	0	1,000	0	0	1,000
4N/16E-SW	0	KL	0	500	0	0	500
4N/17E-SW	0	KL	0	1,500	0	0	1,500
4N/20E-NE	0	KL	0	220	0	0	220
5N/15E-SE	0	KL	0	300	0	0	300
5N/16E-NW	0	KL	0	1,000	0	0	1,000
5N/22E-SE	0	KL	0	2,400	0	0	2,400
5N/23E-NE	0	KL	0	2,100	0	0	2,100
5N/23E-SW	0	KL	0	4,500	0	0	4,500
5N/26E-NW	0	BE	0	780	320	0	1,100
6N/23E-NE	0	KL	0	1,800	0	0	1,800
6N/23E-NW	0	KL	0	2,100	0	0	2,100
6N/23E-SE	0	KL	0	3,200	0	0	3,200
6N/33E-NE	0	WA	0	400	0	1,400	1,800
6N/33E-NW	0	WA	0	900	0	700	1,600
6N/34E-NE	0	WA	0	0	0	3,000	3,000
6N/34E-NW	0	WA	0	500	0	2,000	2,500
6N/35E-NE	0	WA	0	900	0	1,200	2,100
6N/35E-NW	0	WA	0	0	0	2,300	2,300
6N/36E-NE	0	WA	0	200	0	0	200
6N/36E-NW	0	WA	300	2,700	0	400	3,400
6N/37E-NW	0	WA	40	0	0	0	40
7N/21E-SW	0	YA	0	20	20	0	40
7N/25E-SE	0	BE	0	3,300	200	0	3,500
7N/31E-NE	0	WA	0	0	50	0	50
7N/33E-SE	0	WA	0	1,400	0	700	2,100

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
7N/33E-SW	0	WA	0	2,000	0	200	2,200
7N/34E-SE	0	WA	0	380	0	260	640
7N/34E-SW	0	WA	0	1,800	0	400	2,200
7N/35E-NE	0	WA	0	280	0	0	280
7N/35E-NW	0	WA	20	160	0	0	180
7N/35E-SE	0	WA	0	2,200	0	1,300	3,500
7N/35E-SW	0	WA	0	400	0	900	1,300
7N/36E-NE	0	WA	0	2,700	0	0	2,700
7N/36E-SE	0	WA	0	2,000	0	200	2,200
7N/36E-SW	0	WA	0	1,000	0	600	1,600
7N/37E-NW	0	WA	250	370	0	0	620
8N/22E-NE	0	YA	0	440	200	0	640
8N/22E-SE	0	YA	0	500	200	0	700
8N/23E-NE	0	YA	0	0	40	0	40
8N/24E-NE	0	BE	0	600	1,500	0	2,100
8N/28E-NE	0	BE	0	0	70	0	70
8N/30E-NE	0	WA	0	0	80	0	80
8N/30E-SE	0	BE	0	0	50	0	50
8N/36E-SW	0	WA	0	130	0	0	130
9N/21E-NE	0	YA	0	0	0	270	270
9N/21E-SE	0	YA	0	0	0	3,200	3,200
9N/22E-SW	0	YA	0	0	0	950	950
9N/23E-NE	0	YA	0	0	160	0	160
9N/23E-SE	0	YA	0	400	800	0	1,200
9N/23E-SW	0	YA	0	300	300	0	600
9N/27E-NE	0	BE	0	150	950	0	1,100
9N/27E-NW	0	BE	0	0	1,700	0	1,700
9N/27E-SE	0	BE	0	0	250	0	250
9N/28E-NW	0	BE	0	0	1,100	0	1,100
9N/29E-NE	0	FR	0	0	0	6,900	6,900
9N/30E-NE	0	FR	0	0	0	8,300	8,300
9N/30E-NW	0	FR	0	0	0	6,200	6,200
9N/30E-SE	0	FR	0	0	0	5,900	5,900
9N/30E-SW	0	FR	0	0	0	1,000	1,000
9N/31E-NE	1	FR	0	0	600 A	3,300 A	3,900 A
9N/32E-NW	1	FR	0	0	600 A	3,300 A	3,900 A
9N/37E-NE	0	WA	340	0	0	0	340
10N/17E-SE	0	YA	700	1,600	700	400	3,400
10N/17E-SW	0	YA	200	400	0	0	600
10N/18E-SW	0	YA	0	600	0	0	600
10N/20E-NE	0	YA	0	0	0	1,100	1,100

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
10N/20E-NW	0	YA	0	0	0	2,600	2,600
10N/21E-NW	0	YA	0	0	0	50	50
10N/21E-SE	0	YA	0	0	0	180	180
10N/22E-SE	0	YA	0	300	1,400	1,200	2,900
10N/25E-SE	0	BE	0	0	1,200	0	1,200
10N/29E-SE	0	FR	0	0	0	4,100	4,100
10N/30E-SE	0	FR	0	0	0	3,200	3,200
10N/30E-SW	0	FR	0	0	0	2,700	2,700
10N/31E-NW	2	FR	0	1,300 A	900 A	6,000 A	8,200 A
10N/36E-SW	0	WA	120	0	0	0	120
10N/39E-SW	0	CO	400	0	0	0	400
10N/46E-NW	0	AS	1,000	0	0	0	1,000
11N/17E-NE	0	YA	280	970	350	0	1,600
11N/17E-NW	0	YA	300	1,300	300	0	1,900
11N/17E-SW	0	YA	0	0	1,300	0	1,300
11N/18E-SE	0	YA	0	0	0	60	60
11N/19E-NE	0	YA	0	0	0	1,000	1,000
11N/20E-SE	0	YA	0	0	0	1,400	1,400
11N/20E-SW	0	YA	0	0	0	100	100
11N/30E-SE	0	FR	0	0	0	4,900	4,900
11N/31E-NE	3	FR	100 A	3,700 A	0	0	3,800 A
11N/31E-NW	3	FR	100 A	3,700 A	0	0	3,800 A
11N/31E-SW	2	FR	0	1,300 A	900 A	6,000 A	8,200 A
11N/42E-NW	0	GA	300	0	0	0	300
11N/46E-SW	0	AS	3,400	0	0	0	3,400
12N/16E-SE	0	YA	800	0	0	0	800
12N/17E-NE	0	YA	0	500	600	300	1,400
12N/17E-NW	0	YA	680	420	400	0	1,500
12N/18E-NE	0	YA	0	0	0	200	200
12N/18E-NW	0	YA	0	0	0	800	800
12N/18E-SE	0	YA	0	930	670	0	1,600
12N/18E-SW	0	YA	500	900	0	0	1,400
12N/19E-NE	0	YA	0	0	0	150	150
12N/19E-NW	0	YA	0	0	0	1,200	1,200
12N/20E-NE	0	YA	0	200	100	0	300
12N/21E-NW	0	YA	0	3,500	60	140	3,700
12N/21E-SE	0	YA	0	1,200	2,600	0	3,800
12N/21E-SW	0	YA	0	100	1,100	0	1,200
12N/22E-NE	0	YA	550	180	0	0	730
12N/22E-SE	0	YA	0	900	0	0	900
12N/22E-SW	0	YA	0	900	0	0	900

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
12N/24E-NW	0	BE	0	500	0	0	500
12N/24E-SW	0	BE	0	1,800	0	0	1,800
12N/37E-NE	0	CO	40	0	0	0	40
12N/39E-NE	0	CO	150	0	0	0	150
12N/42E-SW	0	GA	250	0	0	0	250
12N/46E-NW	0	WH	0	100	0	0	100
13N/16E-SE	0	YA	300	0	0	0	300
13N/17E-NE	0	YA	0	200	80	0	280
13N/17E-NW	0	YA	0	650	0	0	650
13N/17E-SW	0	YA	300	0	0	300	600
13N/18E-NE	0	YA	0	0	0	500	500
13N/18E-NW	0	YA	800	0	0	0	800
13N/18E-SE	0	YA	0	0	0	300	300
13N/18E-SW	0	YA	0	1,800	400	0	2,200
13N/19E-NW	0	YA	0	0	0	650	650
13N/19E-SE	0	YA	0	0	0	350	350
13N/19E-SW	0	YA	0	0	0	50	50
13N/20E-SE	0	YA	0	0	50	0	50
13N/24E-SE	0	BE	0	1,200	0	0	1,200
13N/31E-NE	4	FR	570 A	930 A	0	0	1,500 A
13N/31E-SE	4	FR	570 A	930 A	0	0	1,500 A
13N/31E-SW	4	FR	570 A	930 A	0	0	1,500 A
13N/32E-NE	5	FR	0	1,100 A	0	0	1,100 A
13N/32E-NW	5	FR	0	1,100 A	0	0	1,100 A
13N/34E-NW	0	FR	500	150	0	150	800
13N/45E-SE	0	WH	0	70	0	0	70
14N/16E-NE	0	YA	100	0	0	0	100
14N/17E-NW	0	YA	0	60	70	70	200
14N/17E-SE	0	YA	0	250	150	0	400
14N/17E-SW	0	YA	0	0	200	360	560
14N/18E-NE	0	YA	0	0	100	750	850
14N/18E-NW	0	YA	0	0	0	160	160
14N/18E-SE	0	YA	200	0	0	1,500	1,700
14N/18E-SW	0	YA	0	2,800	0	0	2,800
14N/23E-NE	0	GR	0	2,500	0	5,100	7,600
14N/29E-NW	6	FR	0	1,100 A	400 A	0	1,500 A
14N/29E-SW	6	FR	0	1,100 A	400 A	0	1,500 A
14N/31E-NW	0	FR	500	1,700	0	0	2,200
14N/31E-SE	0	FR	2,900	2,000	0	0	4,900
14N/32E-SW	0	FR	0	1,900	0	0	1,900
14N/34E-SE	7	FR	0	0	0	500 A	500 A

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
14N/35E-SW	7	FR	0	0	0	500 A	500 A
14N/45E-NW	0	WH	3,000	0	0	0	3,000
15N/18E-SE	0	YA	0	0	0	300	300
15N/18E-SW	0	YA	0	0	0	1,200	1,200
15N/23E-SE	0	GR	0	500	0	1,100	1,600
15N/29E-NE	0	AD	0	530	0	0	530
15N/29E-NW	0	AD	200	1,900	100	0	2,200
15N/30E-NE	8	AD	300 A	1,200 A	0	0	1,500 A
15N/31E-NE	9	AD	220 A	650 A	0	0	870 A
15N/31E-NW	0	AD	2,300	1,800	0	0	4,100
15N/31E-SE	9	AD	220 A	650 A	0	0	870 A
15N/31E-SW	8	AD	300 A	1,200 A	0	0	1,500 A
15N/32E-NW	0	AD	2,200	0	0	0	2,200
15N/32E-SW	0	AD	0	620	0	0	620
15N/34E-SE	10	AD	240 A	520 A	0	0	760 A
15N/36E-SW	11	AD	630 A	20 A	0	0	650 A
15N/39E-NE	0	WH	0	70	0	0	70
15N/43E-NW	0	WH	120	0	0	0	120
15N/44E-NE	0	WH	100	0	0	0	100
15N/45E-SE	0	WH	20	0	0	0	20
15N/45E-SW	0	WH	1,200	0	0	0	1,200
16N/20E-NW	0	KI	40	0	0	0	40
16N/23E-NE	12	GR	410 A	390 A	0	0	800 A
16N/24E-NW	12	GR	410 A	390 A	0	0	800 A
16N/25E-NE	0	GR	220	30	0	0	250
16N/25E-SE	0	GR	0	0	0	800	800
16N/26E-SE	0	GR	0	0	0	320 A	320 A
16N/26E-SW	0	GR	0	0	0	360 A	360 A
16N/29E-SE	0	AD	100	2,700	0	0	2,800
16N/30E-NW	0	AD	0	1,900	0	0	1,900
16N/30E-SE	0	AD	0	3,700	0	0	3,700
16N/31E-NE	14	AD	1,600 A	800 A	0	0	2,400 A
16N/31E-NW	14	AD	1,600 A	800 A	0	0	2,400 A
16N/31E-SE	15	AD	450 A	520 A	0	0	970 A
16N/31E-SW	15	AD	450 A	520 A	0	0	970 A
16N/32E-NE	16	AD	4,000 A	800 A	0	0	4,800 A
16N/32E-SE	16	AD	4,000 A	800 A	0	0	4,800 A
16N/32E-SW	0	AD	2,900	1,700	0	0	4,600
16N/33E-SW	16	AD	4,000 A	800 A	0	0	4,800 A
16N/35E-SW	10	AD	240 A	520 A	0	0	760 A
16N/36E-NE	17	AD	0	140 A	0	0	140 A

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
16N/36E-SE	11	AD	630 A	20 A	0	0	650 A
16N/37E-NE	17	AD	0	140 A	0	0	140 A
16N/39E-SE	0	WH	0	100	0	0	100
16N/41E-SE	0	WH	60	0	0	0	60
16N/42E-SW	0	WH	50	0	0	0	50
16N/43E-NE	0	WH	200	0	0	0	200
16N/46E-NW	0	WH	330	0	0	0	330
17N/18E-NE	0	KI	0	0	0	2,200	2,200
17N/19E-NE	0	KI	0	0	0	400	400
17N/19E-SW	0	KI	300	0	0	0	300
17N/24E-NE	0	GR	0	0	0	1,000	1,000
17N/25E-NE	0	GR	570 A	560 A	0	570 A	1,700
17N/26E-SW	0	GR	0	1,600	0	0	1,600
17N/27E-NE	18	GR	0	90 A	0	0	90 A
17N/27E-SE	18	GR	0	90 A	0	0	90 A
17N/27E-SW	18	GR	0	90 A	0	0	90 A
17N/28E-NW	0	GR	0	60	0	0	60
17N/29E-SE	0	GR	0	150	0	0	150
17N/30E-NE	0	GR	0	340	0	0	340
17N/30E-NW	0	GR	0	1,300	0	0	1,300
17N/30E-SE	19	GR	430 A	530 A	0	0	960 A
17N/30E-SW	19	GR	430 A	530 A	0	0	960 A
17N/31E-NE	20	AD	2,800 A	800 A	0	0	3,600 A
17N/31E-SE	20	AD	2,800 A	800 A	0	0	3,600 A
17N/32E-NW	21	AD	3,900 A	1,500 A	0	0	5,400 A
17N/33E-NE	0	AD	300	0	0	0	300
17N/33E-NW	0	AD	1,800	200	0	0	2,000
17N/34E-NW	22	AD	70 A	190 A	0	0	260 A
17N/34E-SE	22	AD	70 A	190 A	0	0	260 A
17N/34E-SW	22	AD	70 A	190 A	0	0	260 A
17N/35E-NE	0	AD	0	950	0	0	950
17N/36E-SW	17	AD	0	140 A	0	0	140 A
17N/37E-SW	17	AD	0	140 A	0	0	140 A
17N/41E-SW	0	WH	0	70	0	0	70
17N/44E-SW	0	WH	570	0	0	0	570
18N/17E-NE	0	KI	0	0	0	1,000	1,000
18N/18E-SE	0	KI	0	0	0	1,500	1,500
18N/23E-NW	0	GR	0	450	0	0	450
18N/24E-NE	0	GR	0	300	0	3,700	4,000
18N/24E-NW	23	GR	0	940 A	0	0	940 A
18N/24E-SE	0	GR	0	2,600	0	3,200	5,800

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
18N/25E-NE	0	GR	0	0	0	4,100	4,100
18N/25E-NW	0	GR	0	1,200	0	5,400	6,600
18N/25E-SE	0	GR	300	7,000	0	0	7,300
18N/25E-SW	0	GR	0	1,300	0	0	1,300
18N/26E-NE	0	GR	0	1,300	0	1,400	2,700
18N/26E-NW	0	GR	0	0	0	2,300	2,300
18N/26E-SE	0	GR	0	3,100	0	600	3,700
18N/26E-SW	0	GR	0	2,700	0	4,800	7,500
18N/27E-NW	0	GR	0	3,200	0	1,400	4,600
18N/28E-NE	0	GR	0	120	0	0	120
18N/28E-SE	0	GR	0	1,900	0	0	1,900
18N/29E-NE	24	GR	0	2,900 A	0	0	2,900 A
18N/29E-NW	0	GR	0	1,600	0	0	1,600
18N/29E-SE	0	GR	0	5,000	0	0	5,000
18N/29E-SW	24	GR	0	2,900 A	0	0	2,900 A
18N/31E-NE	0	AD	3,300	1,700	0	0	5,000
18N/31E-NW	0	AD	2,900	2,600	0	0	5,500
18N/31E-SW	0	AD	4,000	1,200	0	0	5,200
18N/32E-SW	21	AD	3,900 A	1,500 A	0	0	5,400 A
18N/34E-SW	0	AD	60	100	0	0	160
18N/37E-NW	25	AD	200 A	1,200 A	0	0	1,400 A
18N/38E-NW	0	AD	0	770	0	0	770
18N/41E-NW	0	WH	50	50	0	0	100
18N/45E-SW	0	WH	70	0	0	0	70
18N/46E-NW	0	WH	30	0	0	0	30
19N/23E-SE	0	GR	0	1,200	0	0	1,200
19N/24E-SW	23	GR	0	940 A	0	0	940 A
19N/25E-NE	0	GR	0	1,100	0	0	1,100
19N/25E-NW	0	GR	0	5,800	0	500	6,300
19N/25E-SE	0	GR	0	0	0	10,500	10,500
19N/25E-SW		GR	0	2,900	0	3,900	6,800
19N/26E-NE	26	GR	0	210 A	0	350 A	560 A
19N/26E-NW	0	GR	0	0	0	2,300	2,300
19N/26E-SE	0	GR	0	3,500	0	800	4,300
19N/26E-SW	0	GR	0	2,100	0	5,000	7,100
19N/27E-NE	0	GR	0	400	0	1,000	1,400
19N/27E-NW	26	GR	0	210 A	0	350 A	560 A
19N/27E-SE	0	GR	0	100	0	2,600	2,700
19N/27E-SW	0	GR	0	1,300	0	300	1,600
19N/28E-NE	0	GR	400	1,600	0	800	2,800
19N/28E-NW	0	GR	0	600	0	2,700	3,300

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
19N/28E-SE	0	GR	400	1,600	0	0	2,000
19N/28E-SW	0	GR	150	120	0	730	1,000
19N/29E-NE	0	GR	1,000	4,400	0	0	5,400
19N/29E-NW	0	GR	0	640	0	0	640
19N/29E-SE	0	GR	0	1,900	0	0	1,900
19N/30E-NE	0	GR	2,000	900	0	0	2,900
19N/30E-NW	0	GR	1,700	1,300	0	0	3,000
19N/30E-SE	0	GR	2,000	2,300	0	0	4,300
19N/30E-SW	0	GR	190	270	0	0	460
19N/31E-NE	27	AD	2,100 A	500 A	0	0	2,600 A
19N/31E-NW	0	AD	580	120	0	0	700
19N/31E-SE	27	AD	2,100 A	500 A	0	0	2,600 A
19N/31E-SW	0	AD	1,600	200	0	0	1,800
19N/32E-NW	0	AD	2,000	600	0	0	2,600
19N/32E-SE	28	AD	2,200 A	400 A	0	0	2,600 A
19N/32E-SW	28	AD	2,200 A	400 A	0	0	2,600 A
19N/33E-NW	0	AD	4,200	200	0	0	4,400
19N/34E-NW	29	AD	350 A	0	0	0	350 A
19N/34E-SW	29	AD	350 A	0	0	0	350 A
19N/35E-NE	0	AD	270	330	0	0	600
19N/35E-SE	0	AD	110	490	0	0	600
19N/36E-NE	0	AD	600	600	0	0	1,200
19N/36E-SE	25	AD	200 A	1,200 A	0	0	1,400 A
19N/36E-SW	0	AD	1,700	300	0	0	2,000
19N/40E-SE	0	WH	150	0	0	0	150
19N/41E-SE	0	WH	110	40	0	0	150
19N/44E-SE	0	WH	60	40	0	0	100
20N/23E-NE	30	GR	0	70 A	0	0	70 A
20N/23E-SW	30	GR	0	70 A	0	0	70 A
20N/24E-NE	0	GR	0	980	0	0	980
20N/24E-NW	0	GR	3,000	1,100	0	0	4,100
20N/24E-SW	0	GR	0	170	0	0	170
20N/25E-NE	0	GR	0	340	0	0	340
20N/25E-NW	0	GR	0	2,400	0	0	2,400
20N/25E-SW	0	GR	0	1,400	0	2,800	3,200
20N/26E-SE	0	GR	0	720	0	0	720
20N/27E-SE	0	GR	0	0	0	2,100	1,100
20N/28E-SE	0	GR	0	0	0	20	20
20N/28E-SW	0	GR	250	950	0	0	1,200
20N/29E-NE	31	GR	610 A	350 A	0	0	960 A
20N/29E-NW	31	GR	610 A	350 A	0	0	960 A

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
20N/29E-SE	31	GR	610 A	350 A	0	0	960 A
20N/30E-NE	32	GR	850 A	550 A	0	0	1,400 A
20N/30E-SE	0	GR	2,800	200	0	0	3,000
20N/30E-SW	0	GR	1,500	200	0	0	1,700
20N/31E-NE	0	AD	260	530	0	0	790
20N/31E-NW	0	AD	1,600	700	0	0	2,300
20N/32E-NE	33	AD	400 A	400 A	0	0	800 A
20N/32E-NW	34	AD	70 A	640 A	0	0	710 A
20N/32E-SW	34	AD	70 A	640 A	0	0	710 A
20N/33E-NE	33	AD	400 A	400 A	0	0	800 A
20N/33E-NW	33	AD	400 A	400 A	0	0	800 A
20N/34E-NE	35	AD	830 A	0	0	0	830 A
20N/34E-NW	35	AD	830 A	0	0	0	830 A
20N/35E-NE	36	AD	340 A	160 A	0	0	500 A
20N/35E-NW	36	AD	340 A	160 A	0	0	500 A
20N/35E-SE	0	AD	900	600	0	0	1,500
20N/35E-SW	35	AD	830 A	0	0	0	830 A
20N/36E-NE	0	AD	50	230	0	0	280
20N/36E-NW	0	AD	200	1,700	0	0	1,900
20N/37E-NE	37	AD	110 A	90 A	0	0	200 A
20N/38E-NW	37	AD	110 A	90 A	0	0	200 A
20N/39E-SE	0	WH	0	180	0	0	180
20N/39E-SW	0	WH	30	10	0	0	40
20N/42E-NE	0	WH	60	0	0	0	60
20N/43E-NE	0	WH	120	0	0	0	120
20N/45E-SE	0	WH	220	0	0	0	220
21N/22E-NE	0	DO	350	0	0	0	350
21N/24E-SE	38	GR	310 A	0	0	0	310 A
21N/24E-SW	38	GR	310 A	0	0	0	310 A
21N/26E-NE	0	GR	520	20	0	0	540
21N/26E-NW	0	GR	1,200	0	0	0	1,200
21N/26E-SE	39	GR	0	0	0	160 A	160 A
21N/26E-SW	39	GR	300	740	0	160 A	1,200 A
21N/27E-NW	40	GR	0	0	0	350 A	350 A
21N/28E-NE	41	GR	370 A	360 A	0	370 A	1,100 A
21N/28E-NW	0	GR	480	490	0	0	970
21N/28E-SE	41	GR	370 A	360 A	0	370 A	1,100 A
21N/30E-NE	42	GR	1,600 A	0	0	0	1,600 A
21N/30E-NW	0	GR	470	0	0	0	470
21N/30E-SE	32	GR	850 A	550 A	0	0	1,400 A
21N/31E-NE	43	LI	1,100 A	300 A	0	0	1,400 A

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
21N/31E-NW	43	LI	1,100 A	300 A	0	0	1,400 A
21N/31E-SE	0	LI	3,300	1,100	0	0	4,400
21N/31E-SW	0	LI	2,100	500	0	0	2,600
21N/32E-NW	44	LI	330 A	0	0	0	330 A
21N/32E-SE	45	LI	500 A	600 A	0	0	1,100 A
21N/32E-SW	0	LI	2,000	400	0	0	2,400
21N/33E-NE	46	LI	800 A	600 A	0	0	1,400 A
21N/33E-NW	0	LI	1,000	100	0	0	1,100
21N/33E-SW	45	LI	500 A	600 A	0	0	1,100 A
21N/34E-SE	47	LI	250 A	100 A	0	0	350 A
21N/34E-SW	46	LI	800 A	600 A	0	0	1,400 A
21N/35E-NW	47	LI	250 A	100 A	0	0	350 A
21N/38E-SE	37	LI	110 A	90 A	0	0	200 A
21N/40E-SE	0	SP	200	150	0	0	350
21N/41E-SW	0	SP	0	100	0	0	100
21N/45E-SW	0	SP	0	40	0	0	40
22N/23E-NE	0	DO	530	0	0	0	530
22N/23E-SW	0	DO	430	0	0	0	430
22N/26E-SE	0	GR	1,100	600	0	0	1,700
22N/27E-SE	40	GR	0	0	0	350 A	350 A
22N/27E-SW	0	GR	600	600	0	0	1,200
22N/28E-NE	0	GR	0	0	0	380	380
22N/28E-NW	0	GR	0	0	0	1,500	1,500
22N/28E-SE	0	GR	1,600	600	0	0	2,200
22N/28E-SW	0	GR	380	390	0	0	770
22N/29E-NE	0	GR	1,500	0	0	0	1,500
22N/29E-NW	48	GR	1,400 A	0	0	0	1,400 A
22N/30E-NE	0	GR	400	0	0	0	400
22N/30E-NW	0	GR	360	0	0	0	360
22N/30E-SE	42	GR	1,600 A	0	0	0	1,600 A
22N/31E-NE	44	LI	330 A	0	0	0	330 A
22N/31E-SE	44	LI	330 A	0	0	0	330 A
22N/32E-NE	49	LI	280 A	180 A	0	0	460 A
22N/32E-SW	44	LI	330 A	0	0	0	330 A
22N/33E-NW	49	LI	280 A	180 A	0	0	460 A
22N/33E-SE	0	LI	530	360	0	0	890
22N/33E-SW	0	LI	810	180	0	0	990
22N/34E-SE	0	LI	200	300	0	0	500
22N/42E-NE	0	SP	100	0	0	0	100
22N/43E-NW	0	SP	80	0	0	0	80
22N/45E-SW	0	SP	30	70	0	0	100

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
23N/24E-SW	0	DO	230	0	0	0	230
23N/25E-SW	0	DO	470	0	0	0	470
23N/27E-SE	50	GR	290 A	0	0	0	290 A
23N/27E-SW	50	GR	290 A	0	0	0	290 A
23N/28E-SE	48	GR	1,400 A	0	0	0	1,400 A
23N/29E-NE	51	GR	440 A	0	0	0	440 A
23N/29E-NW	51	GR	440 A	0	0	0	440 A
23N/29E-SE	51	GR	440 A	0	0	0	440 A
23N/30E-NE	52	GR	650 A	0	0	0	650 A
23N/30E-SE	52	GR	650 A	0	0	0	650 A
23N/30E-SW	0	GR	1,400	0	0	0	1,400
23N/31E-NE	0	LI	730	0	0	0	730
23N/31E-SE	53	LI	680 A	0	0	0	680 A
23N/31E-SW	53	LI	680 A	0	0	0	680 A
23N/32E-NE	0	LI	1,100	800	0	0	1,900
23N/32E-NW	0	LI	2,400	300	0	0	2,700
23N/32E-SW	49	LI	280 A	180 A	0	0	460 A
23N/33E-NE	54	LI	900 A	400 A	0	0	1,300 A
23N/33E-NW	54	LI	900 A	400 A	0	0	1,300 A
23N/34E-NW	55	LI	150 A	70 A	0	0	220 A
23N/34E-SW	55	LI	150 A	70 A	0	0	220 A
23N/36E-NE	56	LI	0	250 A	0	0	250 A
23N/36E-SE	56	LI	0	250 A	0	0	250 A
23N/40E-NE	0	SP	250	50	0	0	300
23N/40E-NW	0	SP	0	50	0	0	50
23N/41E-NE	0	SP	1,500	0	0	0	1,500
23N/41E-NW	0	SP	80	40	0	0	120
23N/41E-SE	0	SP	50	20	0	0	70
23N/41E-SW	0	SP	30	20	0	0	50
23N/42E-NE	0	SP	100	0	0	0	100
23N/42E-NW	0	SP	200	0	0	0	200
23N/43E-NW	0	SP	150	0	0	0	150
23N/43E-SW	0	SP	200	0	0	0	200
23N/45E-SW	0	SP	0	90	0	0	90
24N/22E-NE	0	DO	300	0	0	0	300
24N/28E-NE	57	GR	230 A	0	0	0	230 A
24N/29E-NE	0	GR	2,800	0	0	0	2,800
24N/29E-SW	57	GR	230 A	0	0	0	230 A
24N/31E-SE	58	LI	800 A	0	0	0	800 A
24N/32E-NE	0	LI	1,200	200	0	0	1,400
24N/32E-SE	0	LI	1,300	400	0	0	1,700

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
24N/32E-SW	58	LI	800 A	0	0	0	800 A
24N/33E-SE	59	LI	410 A	380 A	0	0	790 A
24N/34E-SW	59	LI	410 A	380 A	0	0	790 A
24N/36E-NE	0	LI	180	70	0	0	250
24N/40E-NE	0	SP	3,100	0	0	0	3,100
24N/40E-SW	0	SP	0	200	0	0	200
24N/41E-NE	0	SP	300	1,000	0	0	1,300
24N/42E-NW	0	SP	30	0	0	0	30
25N/22E-SW	0	DO	230	0	0	0	230
25N/28E-NE	59	GR	1,000 A	1,100 A	0	0	2,100 A
25N/28E-SE	59	GR	1,000 A	1,100 A	0	0	2,100 A
25N/29E-NE	0	GR	60	0	0	0	60
25N/29E-NW	61	GR	80 A	100 A	0	0	180 A
25N/29E-SE	0	GR	1,600	0	0	0	1,600
25N/30E-NW	0	GR	870	0	0	0	870
25N/31E-NW	62	LI	30 A	160 A	0	0	190 A
25N/32E-SE	0	LI	850	250	0	0	1,100
25N/33E-NW	63	LI	150 A	440 A	0	0	590 A
25N/33E-SE	64	LI	420 A	290 A	0	0	710 A
25N/33E-SW	64	LI	420 A	290 A	0	0	710 A
25N/34E-NE	65	LI	50 A	280 A	0	0	330 A
25N/34E-SW	65	LI	50 A	280 A	0	0	330 A
25N/35E-SW	65	LI	50 A	280 A	0	0	330 A
25N/36E-SE	66	LI	0	290 A	0	0	290 A
25N/36E-SW	66	LI	0	290 A	0	0	290 A
25N/37E-SW	0	LI	500	0	0	0	500
25N/39E-NE	0	LI	80	90	0	0	170
25N/40E-SE	0	SP	50	0	0	0	50
25N/41E-SE	0	SP	400	1,200	0	0	1,600
25N/41E-SW	0	SP	100	0	0	0	100
26N/29E-NW	61	GR	80 A	100 A	0	0	180 A
26N/31E-SW	62	LI	30 A	160 A	0	0	190 A
26N/32E-NE	67	LI	40 A	150 A	0	0	190 A
26N/32E-NW	67	LI	40 A	150 A	0	0	190 A
26N/33E-NW	0	LI	240	490	0	0	730
26N/33E-SE	63	LI	150 A	440 A	0	0	590 A
26N/33E-SW	0	LI	0	940	0	0	940
26N/34E-NE	0	LI	30	70	0	0	100
26N/41E-SW	0	SP	250	0	0	0	250
27N/25E-SE	0	DO	70	0	0	0	70
27N/28E-NW	0	DO	130	0	0	0	130

TABLE 1.--Ground-water pumpage in 1984 by water-yielding unit from the Columbia Plateau, Washington, by quarter-township--continued

Quarter-Township	AGG NUM	County	Pumpage, in acre-feet				
			Basalt units				
			Grande Ronde unit	Wanapum unit	Saddle Mountains unit	Over-burden unit	Total
27N/28E-SE	0	DO	100	0	0	0	100
27N/32E-SW	67	LI	40 A	150 A	0	0	190 A
28N/30E-NE	0	GR	100	0	0	0	100
28N/30E-NW[1]	0	GR	0	0	0	400	400
35N/ 5W-NW[1]	0	NE	100	0	0	0	100
39N/ 5W-NW[1]	0	LA	2,900	100	0	0	3,000
			205,390	271,480	23,720	180,340	680,930

[1] Idaho