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

By C. A. Collins

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[Plate is in pocket]

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CONVERSION FACTORS

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

Factors for converting English units to metric units are shown to four significant figures.

Multiply inch-pound unit	By	To obtain metric unit
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	.001233	cubic hectometer (hm^3)
foot (ft)	.3048	meter (m)
inch (in.)	25.40	millimeter (mm)
square mile (mi^2)	2.590	square kilometer (km^2)

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ABSTRACT

Ground-water pumpage was estimated for 1984 for an area of about 8,000 square miles in north-central Oregon. Pumpage data were collected from irrigation, industrial and public supply users and analyzed as part of the Columbia Plateau Regional Aquifer System Analysis (RASA) study. Ground water is pumped from Tertiary basalts and interflow material of the Columbia River Basalt Group and the overlying Tertiary-Quaternary sedimentary material. Pumpage was estimated from flowmeter data for about two-thirds of the area. For wells without flowmeters, pumpage was estimated from power-consumption data, if available, or from irrigated acreage data, using an areally adjusted application rate. The total amount of water pumped during 1984 was estimated to be about 148,000 acre-feet.

INTRODUCTION

This report is one of a series examining the effects of ground-water pumpage on the regional aquifer system of a large part of the Columbia Plateau. The Columbia Plateau extends across central and eastern Washington, north-central and northeastern Oregon, and a small part of western Idaho (fig. 1). The Columbia Plateau regional aquifer system consists of a sequence of Miocene basalt flows, minor interbeds, and undifferentiated overlying sediments. This aquifer system supplies ground water for irrigation, municipal, industrial, and domestic uses.

The Columbia Plateau regional aquifer system is 1 of 29 aquifer systems being studied by the U.S. Geological Survey's RASA (Regional Aquifer System Analysis) program. The general objectives of the RASA program are to: (1) describe the geologic framework, (2) describe the hydraulic characteristics, (3) describe the area's water budget, (4) describe the ground-water flow system, (5) describe the water-quality characteristics of the regional aquifer system, and (6) construct a numerical ground-water model for simulation and projection of the ground-water flow system. With this information on the geohydrology and geochemistry of regional aquifer systems, the RASA program provides the analytical capabilities necessary to effectively manage the Nation's ground-water resources.

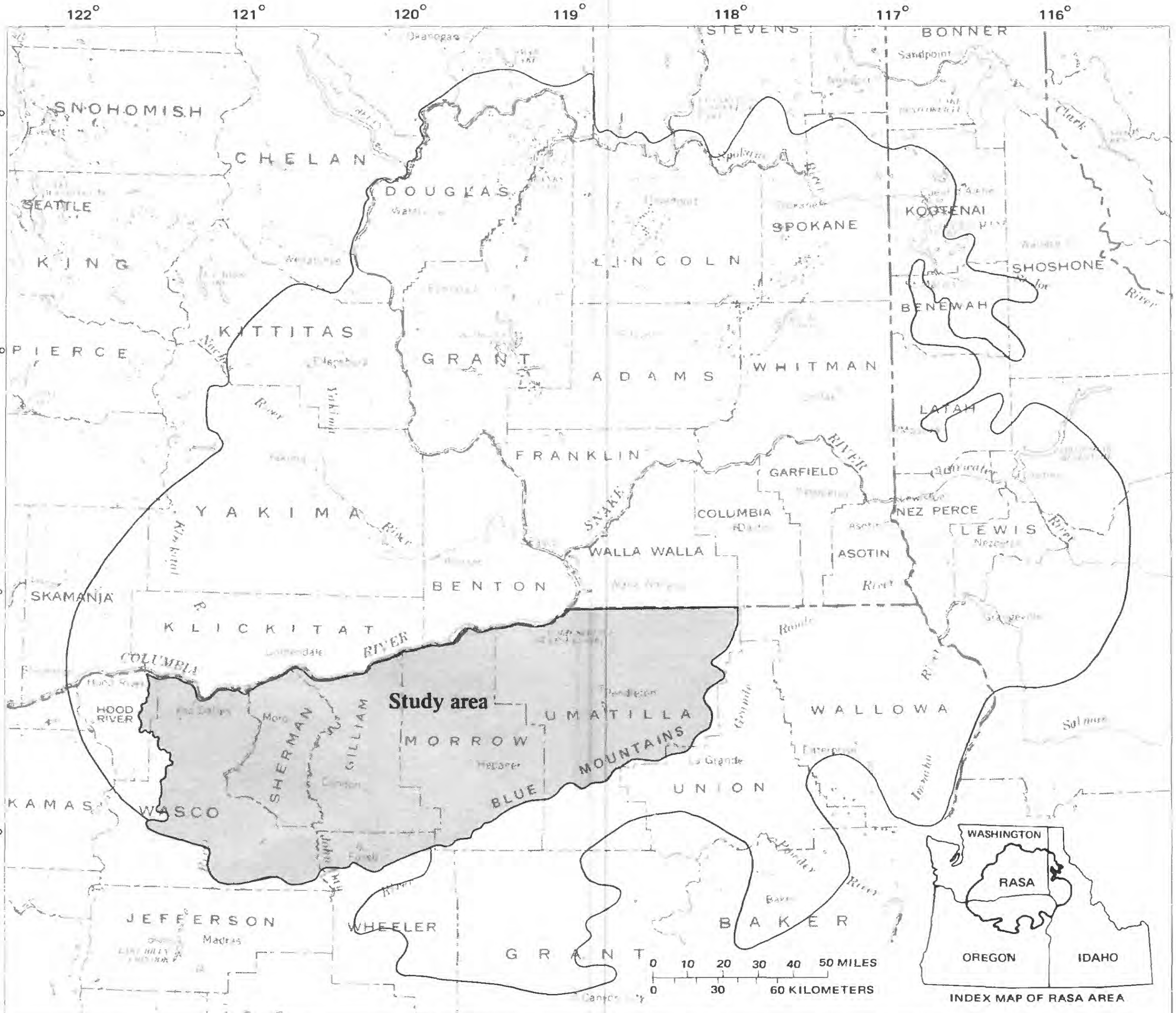

FIGURE 1.--Location of study area.

Agriculture forms a large part of the local economy, and information on availability and use of water is of prime importance to local and regional water users and managers. Surface and ground water are heavily used in this region, and, while surface-water resources have been fully appropriated for many years, ground-water use has increased dramatically in the past two decades. Ground-water withdrawals in part of the study area have resulted in ground-water level declines of as much as 200 feet. The OWRD (Oregon Water Resources Department) has taken steps to limit ground-water pumpage for some of these areas and may expand the area of regulation in the future.

Geohydrology

Nearly all of the Columbia Plateau is underlain by Miocene basalts of the Columbia River Basalt Group. The basalts cover much of eastern Oregon and Washington and extend into parts of western Idaho. The Oregon part of this area forms the south side of a large basin that is filled with layer upon layer of basalt flows and minor sedimentary interbeds that dip and thicken to the north. Wells drilled within the Plateau have penetrated as much as 4,000 feet of basalt. The basalt and the interbeds are folded and faulted and are cut by erosion in many areas. Overlying the basalt in several areas are deposits of overburden consisting mainly of sedimentary and volcanic materials. The overburden may be as much as 150 feet thick near Hermiston, but it is reported to be as much as 800 feet thick in parts of the Walla Walla River basin. Three basalt units and the overburden are the main sources of ground-water in the study area. Rocks older than the Columbia River Basalt Group crop out around the periphery of the study area and are not considered as significant sources of ground water.

The RASA study has subdivided the Columbia Plateau regional aquifer system by stratigraphic boundaries into four major hydrogeologic units. Three of the units consist mainly of basalt but also include minor sedimentary interbeds. These basalt units, from oldest to youngest, are the Grande Ronde, the Wanapum, and the Saddle Mountain units. The fourth and youngest unit is the overburden unit, which includes all sediments that overlie the Grande Ronde, Wanapum, and Saddle Mountain Basalts belonging to the Columbia River Basalt Group. The term "unit" is used instead of the term "aquifer" because some of the lithologic material within the unit cannot strictly be classified as water bearing.

Generalized geologic contacts are shown on maps for the individual units in the section Ground-Water Pumpage and indicate the general distribution of each unit. The contacts represent the zone where a unit pinches out at the margin of the basin or where isolated areas remain after erosion. Generally the basalt units thicken to the north and may be overlain in some areas by younger basalts or overburden. The areal extent of these units does not necessarily imply sufficient thickness to provide a source of ground water, but rather the maximum geologic extent of the unit.

Most of the basalt wells in the study area penetrate several basalt flows belonging to one or more hydrogeologic units; this well construction allows water from several zones to mingle in the well bore. It is difficult to determine the quantity of water yielded by each unit. Some assumptions were made to estimate the yield of each unit. The total depth of the well was adjusted to include only that length of well bore that was below the well casing or the static water level, whichever was deeper. The percentage of the total adjusted depth was determined for each basalt unit. These values were used to estimate the yield or contribution of individual basalt units to the total well yield. Overburden wells have been developed for irrigation and industrial use only in areas of adequate saturated thickness and water-yielding characteristics. Overburden wells are considered single aquifer wells.

Location of Area

For purposes of this report, the term "study area" refers to the Oregon part of the Columbia Plateau regional aquifer system study area (see fig. 1). The boundary of the study area is formed by the Columbia River on the north, the Oregon-Washington State line on the northeast, the crest of the Blue Mountains on the northeast, east, and south to the Deschutes River; the boundary then extends from the vicinity of Madras to The Dalles. This area covers about 8,000 square miles. Pumpage data were not collected for areas outside these boundaries.

The study area lies in the rain shadow of the Oregon-Washington Cascade Range and much of it receives only 10 to 15 inches of precipitation per year. Dry land farming is practiced over much of the area, but irrigated farming is concentrated in only a few areas. Most of the irrigated land is in Umatilla and Morrow Counties near the communities of Hermiston and Boardman. Smaller areas of irrigated land are found near Pendleton, Athena, Adams, Milton-Freewater, and The Dalles. Limited amounts of ground water are used for irrigation in areas along some of the major streams--the middle reach of the Umatilla River, Butter Creek, Rock Creek, and Willow Creek.

Purpose and Scope

The purpose of this report is to provide information on the amount and distribution of ground-water pumpage for 1984 in the Oregon part of the RASA study area. Detailed pumpage information from major ground-water users is required for the construction and calibration of a ground-water flow model. A calibrated ground-water flow model provides information so that local and regional water users and managers can estimate the effect of various development scenarios on the area's ground-water system and thus can more effectively manage the resource.

Previous Studies in Area

Estimates of annual pumpage for selected wells or small areas within the study area were made in two early reports (Hogenson, 1964 and Gonthier and Harris, 1977). Two modeling studies estimated pumpage in the Walla Walla River basin, part of which lies in Oregon (MacNish and Barker, 1976 and Barker and MacNish, 1976). Estimates have been made of pumpage in the immediate area of The Dalles (Foxworthy and Bryant, 1967 and Grady, 1983). Data from these earlier reports were updated for this study.

Acknowledgments

The author would like to express appreciation to the municipal officials and local well owners for access to their equipment and records. Appreciation also is extended to the staffs of the Pendleton Watermaster's Office and the ground-water section of the OWRD for the many hours spent collecting and verifying information on water rights, flowmeters, and other associated well data that were so important during the compilation of data for this report.

Another report in the series presents more detailed interpretation of the hydrogeologic units (Gonthier, 1986).

METHODS USED TO ESTIMATE GROUND-WATER PUMPAGE

Annual pumpage for 1984 was computed from field data collected in February 1984 and February 1985, a period which spans one irrigation pumping season. Data were collected during the pumping season for selected sites. These data were collected by personnel from The Dalles and Pendleton watermasters' offices, from OWRD, and the Geological Survey. Flowmeters have been installed at basalt wells (wells completed in basalt) that supply water for the major ground-water users in much of the eastern two-thirds of the study area and for an area near The Dalles. Overburden wells (wells completed in sedimentary deposits overlying the basalt) in a small area southwest of Hermiston also are equipped with flowmeters. Data collected from wells with functional flowmeters were used to directly estimate annual pumpage and to develop a relation between annual pumpage and annual power consumption. This relation can then be used to estimate pumpage from power-consumption data. Annual power consumption was computed from electric meter readings collected at the time of the field visits. In wells without flowmeters or power-consumption data, pumpage was estimated from information on irrigated acreage and an areally adjusted water application rate.

Techniques for the estimation of pumpage are commonly based on the relation between short-term pump discharge, total pumping lift, instantaneous power consumption, and annual (seasonal) power consumption (Sandberg, 1966; Luzier, written commun., 1981). Annual power-consumption data for 1984 were not available for many of the wells in the study area. Some field data collected were missing values for one or more of the parameters required for estimating pumpage. Trial computations with these data suggested that estimation of the missing factors would introduce unacceptably large errors into the estimates of pumpage. Because of these factors, it was decided to use the methods discussed in this report to estimate pumpage. Pumpage data were calculated directly from flowmeter readings in 1984 for about 500 wells. Power-consumption data generally were available for this sites. In order to check the proper functioning of the flowmeter, the ratio of power consumed to water pumped was calculated for each site. If the ratio was outside the expected range of values, the pumpage was estimated from the power-consumption data.

A relation between power consumption and pumpage measured from flowmeters was derived from data for irrigation, municipal, and industrial wells. Data from 182 wells pumping water from the basalt units were used in one comparison and data from 32 wells pumping from the overburden unit were used in a similar comparison. All data were screened for validity prior to use, and outlying points were rechecked after correlation. Where possible, data were compared with records from other years for the site to indicate any significant deviation from the historic record.

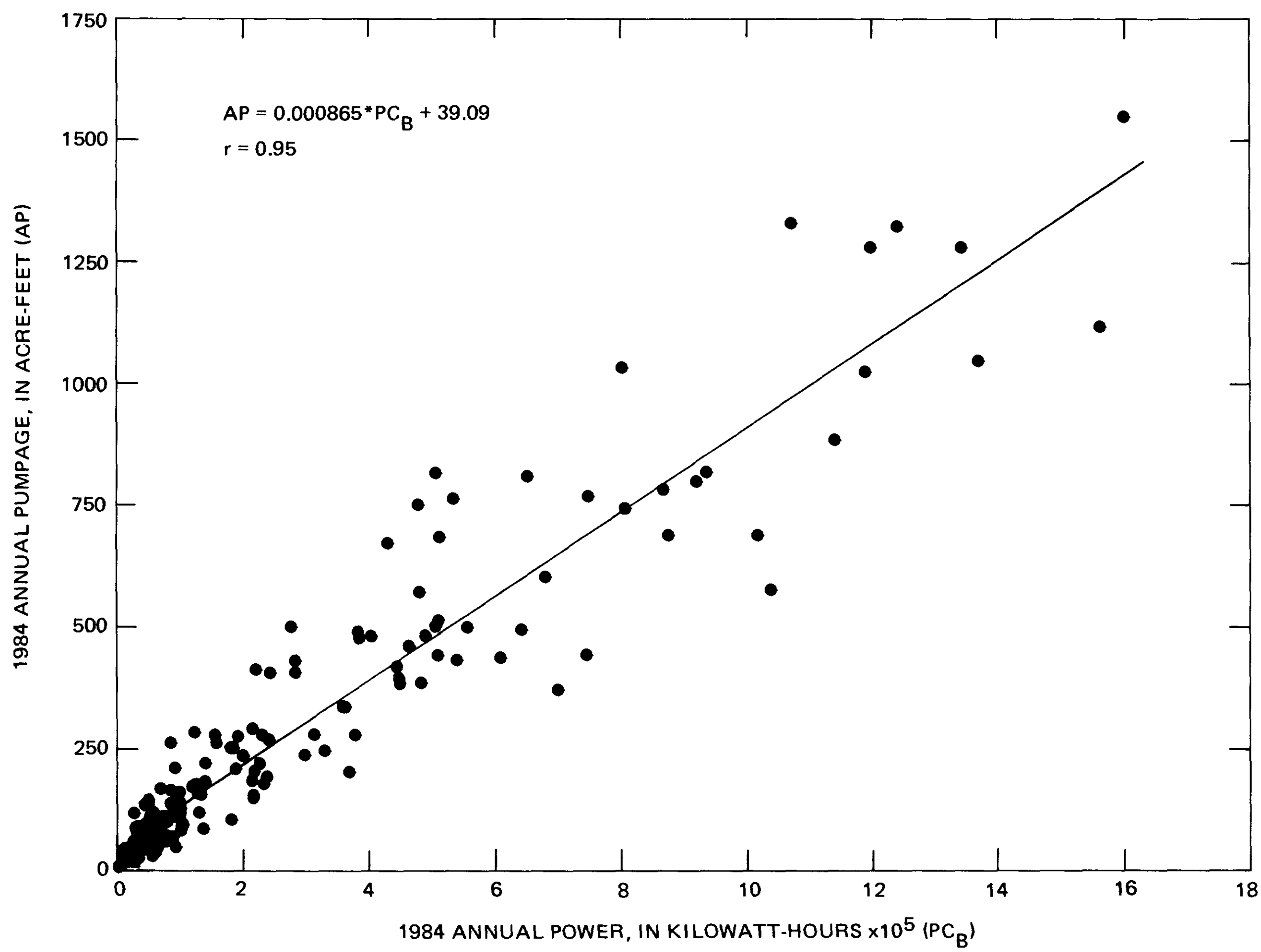

FIGURE 2.--Relation between annual power consumption and pumpage for basalt wells.

The data used to develop the relation between 1984 power consumption and pumpage for basalt wells is shown in figure 2. The equation of the line of best-fit through the plotted points on the graph was derived by the least-squares technique in linear regression analysis. The equation of the line is

$$AP = 0.000865\ PC_B + 39.09 \qquad (1)$$

where AP = annual pumpage, in acre-ft, and PC_B = annual power consumption from basalt wells, in kilowatt hours.

The relation between annual power consumption and pumpage from overburden wells is shown in figure 3. The equation of the line of best-fit is

$$AP = 0.00193\ PC_O + 66.88 \qquad (2)$$

where PC_O = annual power consumption from overburden wells, in kilowatt hours.

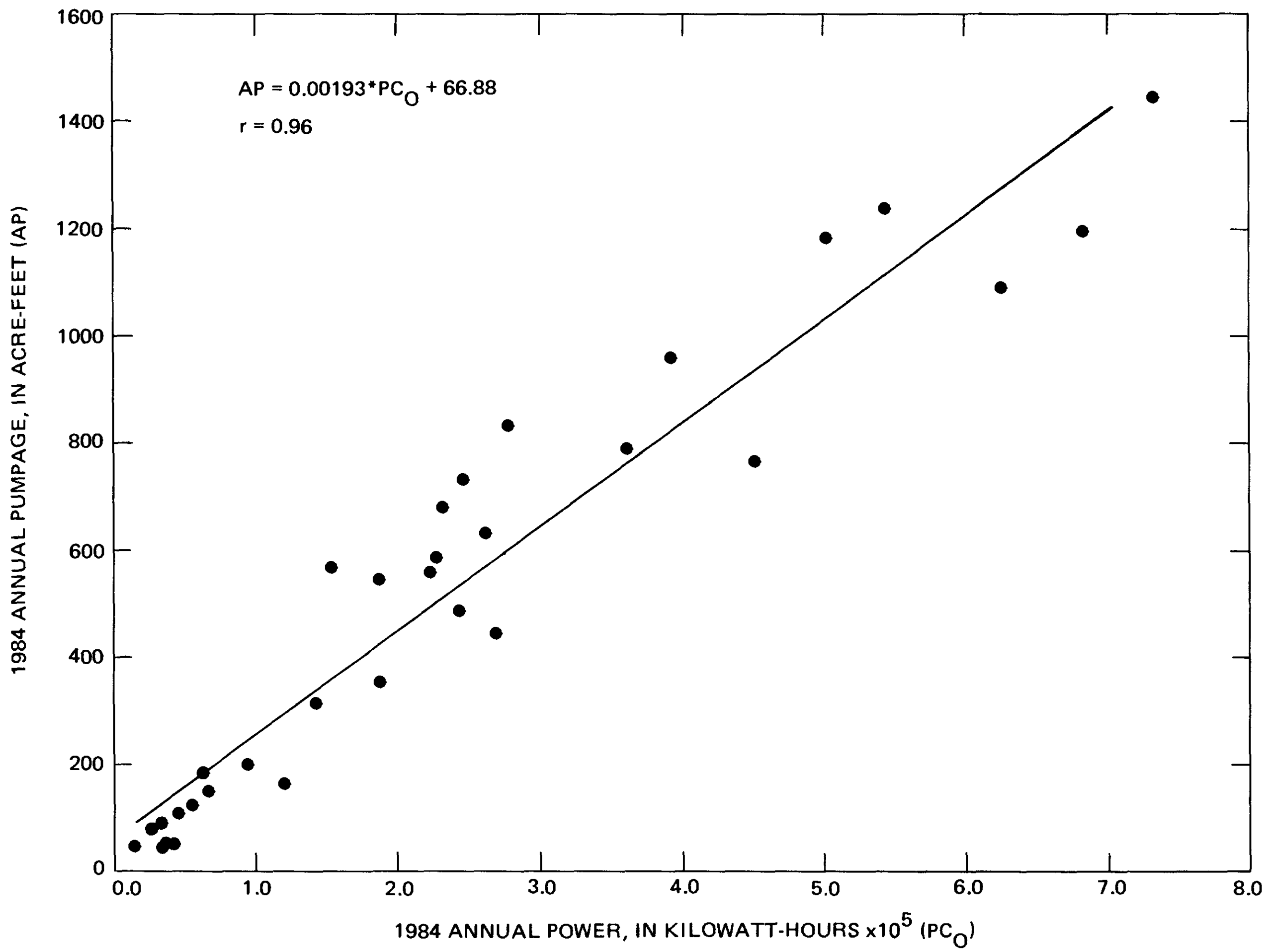

FIGURE 3.--Relation between annual power consumption and pumpage for overburden wells.

The coefficient of correlation (r) indicates how well the regression equation explains the relation between annual power consumption and annual pumpage. A value of 0 (zero) indicates no correlation and a value of ±1 indicates all points lie on the regression line. The coefficient of correlation for equation 1 is 0.95 and for equation 2 is 0.96; both are significant at the 99 percent confidence level.

Total dynamic head or total pumping lift for 23 basalt wells was calculated and used to improve the estimate of pumpage from power-consumption data. Total lift is the sum of pumping lift within the well and the additional lift due to the resistance of the distribution system. Pumping lift is the height, in feet, the water is lifted within the well from the pumping level to land surface. Additional lift is converted to feet of lift with a factor applied to the water-line pressure measured at the discharge point of the pump.

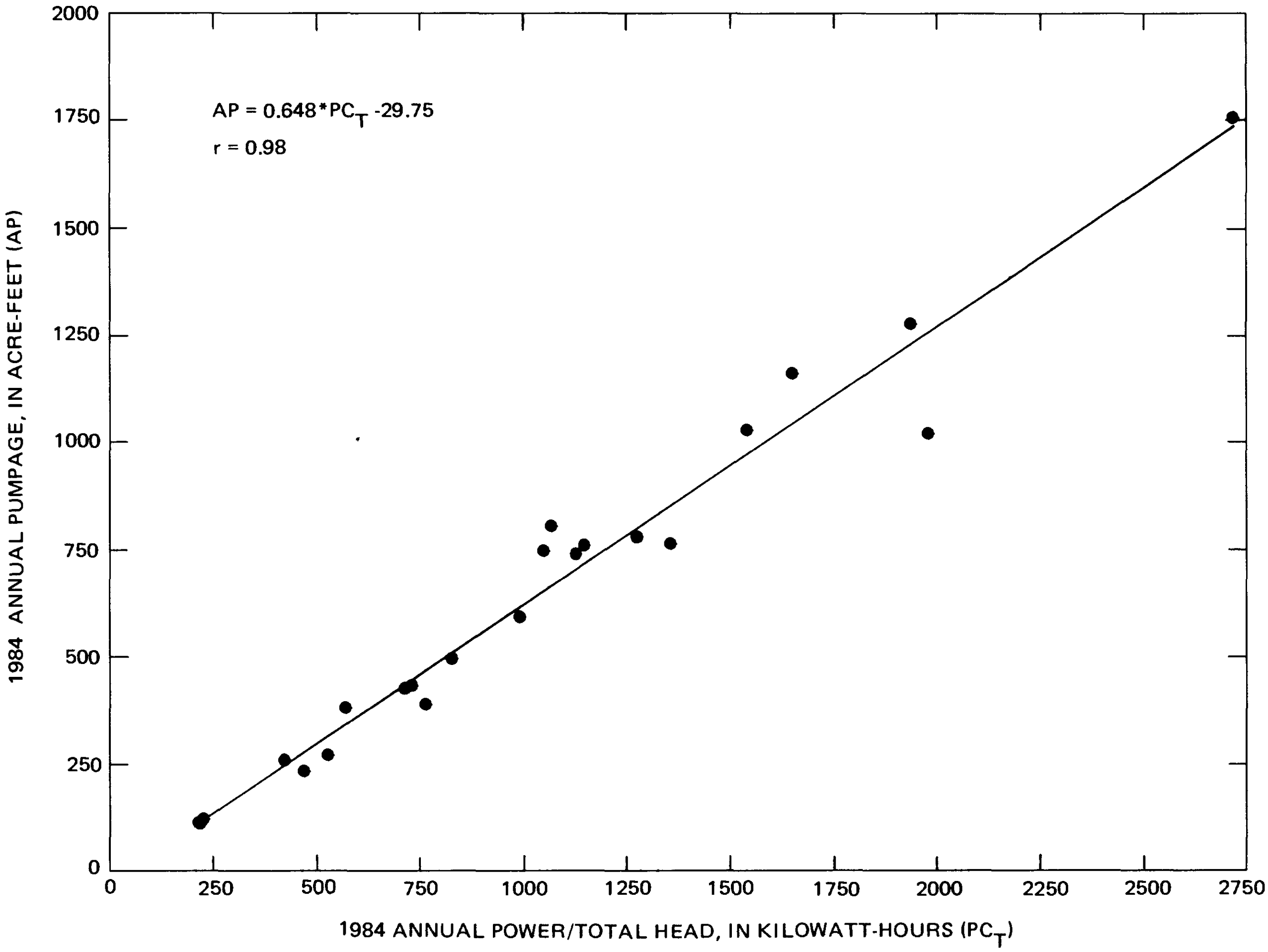

FIGURE 4.--Relation between ratio of annual power consumption divided by total lift, and pumpage for basalt wells.

Another regression analysis was done on the ratio of power consumption divided by total pumping lift versus pumpage for 23 basalt wells (fig. 4). The correlation coefficient for these 23 wells was 0.91, when PC (power consumption) was defined as annual power consumption (equation 1). However, the coefficient increased to 0.98 when PC was divided by total pumping lift (equation 3). Several values of 1983 total pumping lift were used when 1984 data were not available; no significant changes are believed to have occurred for these sites during the two years. The equation of the line of best-fit for these basalt wells is

$$AP = 0.648\ PC_T - 29.75 \qquad (3)$$

where PC_T = annual power consumption/total pumping lift (fig. 4). Data were inadequate to determine a similar relation for overburden wells. This correlation suggests that, if total pumping lift data were available for all wells, estimates of pumpage would be improved.

To maintain comparability between the sample data and the total group of major wells, it was important to maintain a similar distribution of pumping characteristics. Pump horsepower was chosen as the characteristic used to relate the sample wells (shown in fig. 2) with all major wells in the study area. The distribution of pump horsepower of the 1984 basalt sample group versus that of all major basalt wells is shown in figure 5. For each horsepower range, the number of wells in the total group and the sample data group form a reasonably constant ratio. Pumpage for 1984 was estimated from power-consumption data for about 150 sites using the previously mentioned equations.

Flowmeter and power-consumption data were not available for an area of about 2,500 mi^2 on the west end of the study area. However, this part of the area has about 10 percent of the large capacity wells (100 wells) and has a smaller percentage of water use. Ideally, estimates of pumpage from wells lacking flowmeter and power-consumption data would be based on information on total irrigated acreage, crop type, soil type, precipitation, soil moisture, and optimum water application rates. Changes in the economic and climatic factors also affect the use of ground water. However, only irrigated acreage data were available for wells in this area, and an areally adjusted application rate, based on generalized crop water requirements, was used to estimate pumpage. Ground-water pumpage for this area was estimated to be about 12,000 acre-feet for 1984.

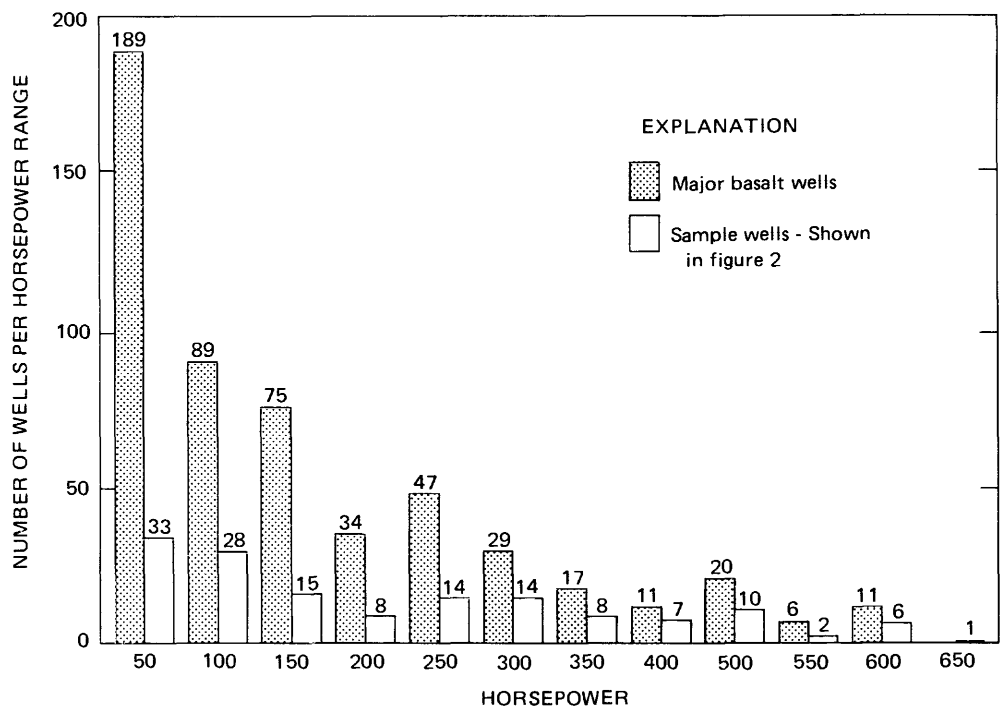

FIGURE 5.--Distribution of pump horsepower of major basalt wells.

The most accurate estimates of ground-water pumpage come from wells with accurate flowmeters. Estimates based solely on annual power-consumption data are less accurate. Use of the power consumption versus flowmeter-pumpage relation assumes that the pumping efficiencies of sites used fall within a normal range and that their respective flowmeters were accurate during the 1984 pumping season. Least reliable are the estimates based on irrigated acreage and application rates.

GROUND-WATER PUMPAGE

In 1984, annual ground-water pumpage was estimated for about 1,000 wells supplying major ground-water users in the study area. Irrigation, public supply, and industrial uses are considered the major use of ground water; rural domestic and stock use are considered minor uses. Annual pumpage was not computed for these minor uses.

A total of about 148,000 acre-ft of ground water was pumped from wells in the study area in 1984. Of that amount, about 116,000 acre-ft was pumped from the basalt units and about 32,000 acre-ft was pumped from the overburden unit (table 1). Of the total pumpage, approximately 84 percent was for irrigation use, 9 percent for public supply use, and 7 percent for industrial use. The ground-water pumpage for 1984 is summarized by county in table 2.

The areal distribution of 1984 pumpage is shown on the maps (pl. 1) as blocks that each represent one quarter of a township (9 square miles). Shading patterns are used to show the range of annual pumpage. Blocks without shading indicate areas with no pumpage or with less than 20 acre-ft of pumpage. The distribution of 1984 pumpage, combining all units, is shown on plate 1. Table 1 lists detailed information on pumpage for each block. The amount of pumpage for a block represents the total pumpage from all major wells located within that block. These wells are not uniformly distributed within the block and the pumpage may appear to be spread over a larger area. In blocks that extend into Washington, pumpage was estimated only for wells in the Oregon part of the block (table 1). The Grande Ronde unit underlies nearly all of the study area. Thirty-eight percent of the total pumpage for 1984 came from the Grande Ronde unit, as shown on plate 1 and table 1. The Wanapum unit, which is intermediate in areal extent between the Saddle Mountain unit and the Grande Ronde unit, produced about 37 percent of the 1984 total pumpage (plate 1, table 1). The 1984 annual pumpage from the Saddle Mountain unit is shown on plate 1. About 3 percent of the total 1984 pumpage comes from the Saddle Mountain unit (table 1).

The distribution of 1984 pumpage from the overburden unit is shown on plate 1. Although this unit is unsaturated in much of the area, it accounts for about 22 percent of the combined annual pumpage. The largest volume of water pumped per quarter township (about 9,500 acre-ft) was pumped from the overburden unit in the southwest quarter of T.4 N., R.27 E. (table 1).

Areas of Significant Pumpage

The greatest concentration of pumpage in the study area occurs near Hermiston. Pumpage in 1984 in several quarter-township blocks was in the 3,000 to 5,000 acre-ft range and, in one block, exceeds 9,500 acre-ft. Other areas with large amounts of pumpage are near Pendleton, Milton-Freewater, and The Dalles (see plate 1).

Pumpage in these areas has probably resulted in water-level declines in either the overburden or the basalt units. For example, water levels in a basalt well (fig. 6) near Hermiston show a decline beginning in about 1960 and continuing through 1984. However, water levels in the overburden well (fig. 6) in the same area show a decline until 1975, but have recovered since that time. This recovery may be due to recharge of the overburden unit in the area. The primary source of recharge is surface water diverted from the Umatilla River. Some of these areas have been declared "critical ground-water areas" and OWRD has taken action either to restrict the amount of annual pumpage or to allow artificial recharge to conserve the ground-water supply.

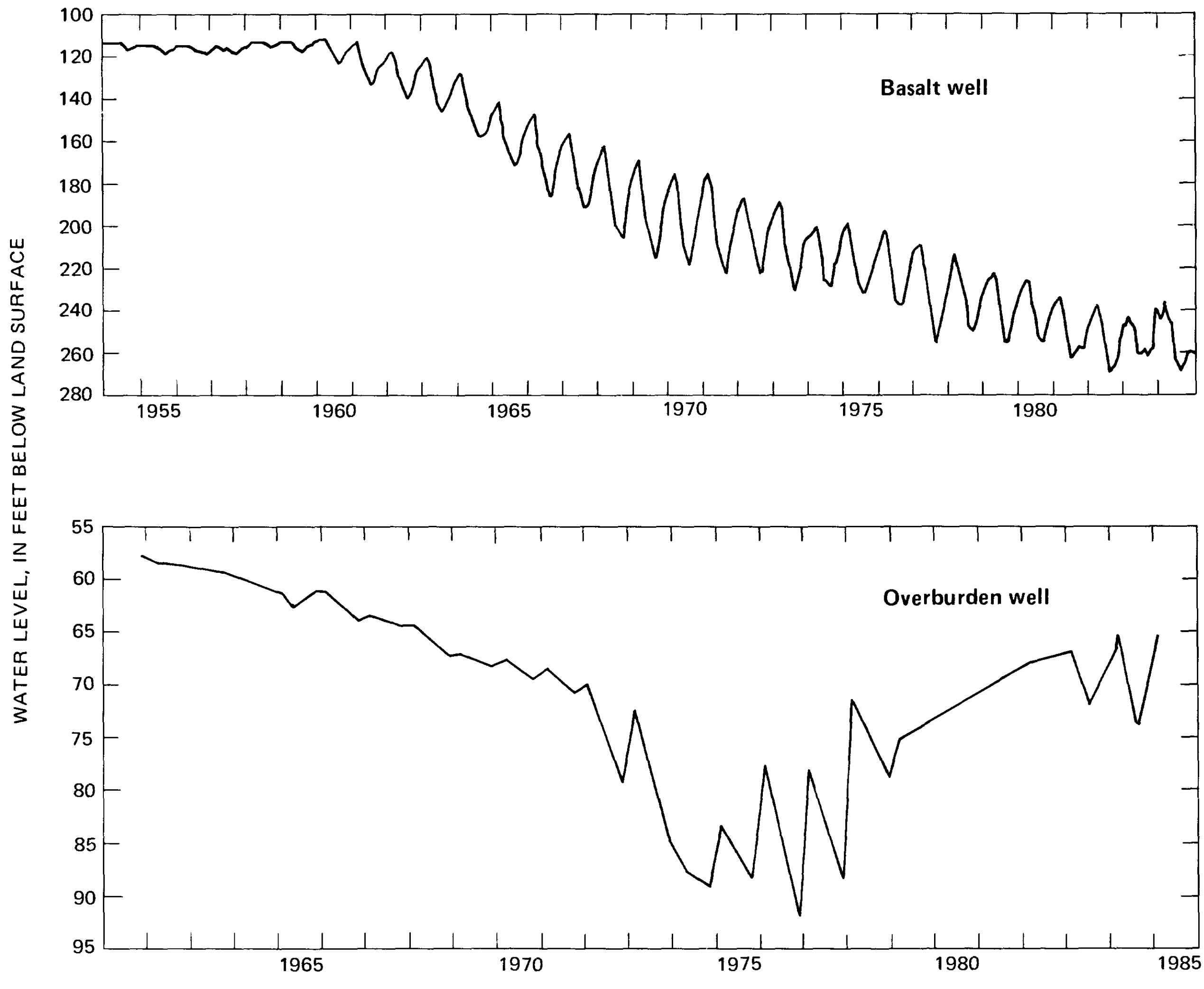

FIGURE 6.--Ground-water levels in basalt and overburden units.

SUMMARY

Ground-water pumpage was estimated for the Oregon part of the Columbia Plateau regional aquifer system. About three-fourths of the ground-water pumpage comes from the basalt units, with the remaining one-fourth from the overlying overburden unit. Estimates of pumpage from basalt or overburden units were made by one of three methods: (1) directly from flowmeter readings, (2) from equations that relate annual power-consumption data with flowmeter-pumpage data, or (3) from irrigated acreage and areally adjusted water application rates. Data for these estimates were collected during the 1984 irrigation season. Additional historical data, available for a small number of wells, were used to verify ranges of the power-pumpage ratio. The sample group of wells used in developing the regression equations for 1984 are considered representative of the total group of wells.

Pumpage was estimated for irrigation, public supply, and industrial uses; about 84 percent of the water was pumped for irrigation, 9 percent for public supply, and 7 percent for industrial use. Of the 148,000 acre-ft of ground water pumped in 1984 from all units, about 38 percent was pumped from the Grande Ronde unit, 37 percent from the Wanapum unit, about 3 percent from the Saddle Mountain unit, and about 22 percent from the overburden unit. The largest volume of ground-water pumpage for a quarter-township block was pumped from the overburden aquifer in T.4 N., R.27 E.

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SUPPLEMENTAL DATA TABLES

Table 1.--1984 ground-water pumpage from the Columbia River Plateau aquifer system, Oregon

[* Due to rounding, total of units may not equal block total]

Location township/range-quarter township	Pumpage, in acre-feet*				
	Quarter township total	Overburden unit	Saddle Mountain unit	Wanapum unit	Grande Ronde unit
01N/12E-NE	540	100	0	450	0
01N/12E-SW	30	30	0	0	0
01N/12E-SE	60	0	0	60	0
01N/13E-NE	520	10	0	510	0
01N/13E-NW	500	30	0	470	0
01N/13E-SW	2200	0	0	1400	830
01N/13E-SE	1400	0	0	1200	150
01N/14E-SW	330	0	0	330	0
01N/14E-SE	920	0	0	920	0
01N/15E-SW	50	0	0	30	20
01N/17E-NW	240	0	0	60	180
01N/21E-NE	1500	0	30	1300	150
01N/21E-SW	1200	0	0	720	500
01N/21E-SE	740	0	0	660	70
01N/22E-NW	210	0	60	160	0
01N/23E-SE	140	0	0	0	140
01N/26E-NW	1500	0	0	10	1500
01N/26E-SE	1900	0	0	0	1900
01N/27E-NE	160	0	0	0	160
01N/27E-NW	1200	0	0	0	1200
01N/27E-SW	120	0	0	0	120
01N/27E-SE	290	0	0	0	290
01N/28E-SW	130	0	0	0	130
01N/32E-NE	460	0	0	0	460
01N/32E-NW	250	0	0	0	250
01N/32E-SW	500	0	0	0	500
01N/32E-SE	770	0	0	0	770
01N/33E-NE	90	0	0	0	90
01S/13E-NE	490	0	0	490	0
01S/13E-SW	880	0	0	340	540
01S/13E-SE	2000	0	0	2000	0
01S/14E-NE	200	0	0	60	140
01S/14E-NW	240	0	0	240	0
01S/14E-SW	470	0	0	470	0
01S/16E-SE	50	0	0	20	30
01S/17E-NW	130	0	0	0	130
01S/18E-NW	90	0	0	0	90

Table 1.--1984 ground-water pumpage from the Columbia River Plateau aquifer system, Oregon--Continued

Location township/range-quarter township	Pumpage, in acre-feet*				
	Quarter township total	Overburden unit	Saddle Mountain unit	Wanapum unit	Grande Ronde unit
01S/20E-SE	630	0	0	0	630
01S/22E-NE	1300	0	0	0	1300
01S/22E-SW	190	0	0	0	190
01S/23E-NE	180	0	0	0	180
01S/24E-NE	280	0	0	0	280
01S/24E-NW	80	0	0	0	80
01S/24E-SE	30	0	0	0	30
01S/25E-SW	80	0	0	0	80
01S/25E-SE	670	0	0	0	670
01S/26E-NE	80	0	0	0	80
01S/27E-SW	170	0	0	0	170
01S/32E-NE	80	0	0	0	80
01S/32E-NW	2700	0	0	0	2700
01S/32E-SW	430	0	0	0	430
01S/32E-SE	30	0	0	0	30
02N/12E-NW	940	80	310	560	0
02N/12E-SW	160	0	0	160	0
02N/12E-SE	300	170	0	130	0
02N/13E-NW	80	10	0	60	10
02N/13E-SW	3300	150	0	3200	0
02N/14E-SW	40	0	0	40	0
02N/14E-SE	120	0	0	120	0
02N/15E-SW	320	0	0	320	0
02N/16E-NE	270	0	0	140	130
02N/17E-NW	410	0	0	200	210
02N/18E-SW	430	0	0	430	0
02N/20E-NW	200	0	0	200	0
02N/20E-SW	1000	0	0	850	150
02N/21E-NE	90	0	0	0	90
02N/21E-SW	300	0	0	260	40
02N/22E-SW	140	0	0	140	0
02N/23E-NW	620	0	160	450	0
02N/23E-SW	80	0	0	70	0
02N/24E-SW	440	0	0	100	340
02N/24E-SE	600	0	0	220	380
02N/26E-NE	1800	0	0	1200	560
02N/26E-NW	710	0	0	370	330
02N/26E-SW	760	0	0	380	380
02N/26E-SE	200	0	0	100	100

Table 1.--1984 ground-water pumpage from the Columbia River Plateau aquifer system, Oregon--Continued

Location township/range-quarter township	Pumpage, in acre-feet* Quarter township total	Overburden unit	Saddle Mountain unit	Wanapum unit	Grande Ronde unit
02N/27E-NE	470	0	0	0	470
02N/27E-NW	1800	0	0	1100	650
02N/27E-SW	2600	0	0	160	2400
02N/27E-SE	550	0	0	0	550
02N/28E-NE	2800	0	0	340	2500
02N/28E-NW	680	0	0	90	600
02N/30E-NE	100	0	0	0	100
02N/30E-NW	140	0	0	0	140
02N/32E-NE	3000	0	0	0	3000
02N/32E-NW	1200	0	0	0	1200
02N/32E-SW	530	0	0	10	520
02N/32E-SE	220	0	0	0	220
02N/33E-NE	650	0	0	320	330
02N/33E-NW	110	0	0	0	110
02N/33E-SW	480	0	0	0	480
02N/33E-SE	40	0	0	0	40
02N/34E-NW	80	0	0	0	80
02S/12E-NE	50	0	0	0	50
02S/13E-NW	600	0	0	0	600
02S/16E-SE	440	0	0	50	390
02S/22E-NE	60	0	0	0	60
02S/22E-NW	140	0	0	0	140
02S/22E-SE	170	0	0	0	170
02S/24E-SE	340	0	0	0	340
02S/25E-NE	450	0	0	210	240
02S/26E-NW	540	0	0	0	540
02S/26E-SW	220	0	0	0	220
02S/26E-SE	30	0	0	0	30
02S/27E-SW	140	0	0	0	140
02S/28E-NE	40	0	0	0	40
02S/29E-NW	40	0	0	0	40
02S/30E-NW	40	0	0	0	40
03N/17E-SW	80	0	0	0	80
03N/21E-SW	170	0	0	170	0
03N/21E-SE	260	0	0	260	0
03N/24E-SW	20	0	0	20	0
03N/26E-NE	850	20	210	270	340
03N/26E-NW	1800	0	0	1800	0
03N/27E-NW	460	60	0	170	230
03N/27E-SE	110	0	0	110	0

Table 1.--1984 ground-water pumpage from the Columbia River Plateau aquifer system, Oregon--Continued

Location township/range-quarter township	Pumpage, in acre-feet* Quarter township total	Overburden unit	Saddle Mountain unit	Wanapum unit	Grande Ronde unit
03N/28E-NE	190	10	0	180	0
03N/28E-SW	560	0	0	80	480
03N/28E-SE	3800	0	0	730	3100
03N/29E-NE	2800	0	0	540	2200
03N/29E-NW	560	0	0	200	360
03N/29E-SW	3300	0	0	540	2700
03N/29E-SE	720	0	0	410	310
03N/30E-NE	400	0	0	330	70
03N/30E-NW	1800	0	0	500	1300
03N/30E-SW	1100	0	0	460	610
03N/30E-SE	390	0	0	120	280
03N/31E-SW	200	0	0	0	200
03N/33E-SW	40	0	0	30	10
03N/33E-SE	20	0	0	20	0
03N/34E-NE	420	0	0	300	120
03N/34E-NW	400	0	0	40	360
03N/34E-SE	160	0	0	10	140
03N/35E-NW	240	0	0	0	240
03S/16E-NE	20	0	0	0	20
03S/16E-NW	30	0	0	0	30
03S/16E-SW	20	0	0	20	0
03S/21E-SW	220	0	0	0	220
03S/25E-SE	20	0	0	0	20
03S/26E-NE	30	0	0	0	30
03S/27E-NE	70	0	0	0	70
03S/27E-NW	190	0	0	0	190
03S/28E-NW	120	0	0	0	120
03S/28E-SW	310	0	0	0	310
04N/24E-NE	210	0	210	0	0
04N/25E-NE	3800	10	880	2900	0
04N/25E-NW	250	0	250	0	0
04N/26E-NW	300	300	0	0	0
04N/27E-NE	250	250	0	0	0
04N/27E-SW	9500	9500	0	30	0
04N/27E-SE	4400	2800	160	1400	0
04N/28E-NE	2000	290	130	1400	120
04N/28E-NW	1400	1400	0	0	0
04N/28E-SW	3800	3600	50	210	0
04N/28E-SE	4500	160	440	3600	280
04N/29E-NE	1000	200	100	550	190

Table 1.--1984 ground-water pumpage from the Columbia River Plateau aquifer system, Oregon--Continued

Location township/range-quarter township	Pumpage, in acre-feet*				
	Quarter township total	Overburden unit	Saddle Mountain unit	Wanapum unit	Grande Ronde unit
04N/29E-NW	920	280	320	270	50
04N/29E-SW	1600	80	50	1100	310
04N/29E-SE	1400	0	0	1000	350
04N/30E-SW	4400	0	0	3400	1100
04N/30E-SE	180	0	0	180	0
04N/33E-NE	50	0	0	50	0
04N/34E-SW	510	0	0	260	250
04N/34E-SE	680	0	50	230	400
04N/35E-NE	660	0	0	0	660
04N/35E-SW	450	0	70	70	310
04N/35E-SE	840	0	0	0	840
04S/25E-NW	230	0	0	0	230
04S/26E-NE	90	0	0	0	90
05N/26E-SW	1500	1500	0	0	0
05N/26E-SE	3200	3200	0	0	0
05N/27E-SW	190	0	190	0	0
05N/28E-NE	600	0	0	600	0
05N/28E-NW	530	0	0	510	20
05N/28E-SE	210	0	210	0	0
05N/29E-SW	400	0	220	180	0
05N/29E-SE	60	0	30	30	0
05N/34E-NE	410	0	410	0	0
05N/35E-NE	2800	140	0	2600	0
05N/35E-NW	40	0	0	40	0
05N/36E-NW	90	0	0	0	90
06N/33E-SE	290	0	0	290	0
06N/34E-SW	2000	1300	0	710	0
06N/34E-SE	1400	580	0	860	0
06N/35E-SW	2200	2000	30	150	0
06N/35E-SE	3100	3000	10	40	40
06N/36E-SW	1400	630	0	760	0
06N/36E-SE	310	0	0	310	0
	147,520	31,910	4,630	54,870	55,870

Table 2.--1984 ground-water pumpage by county from the Columbia River Plateau aquifer system, Oregon

[* Due to rounding, total of units may not equal county total]

County	Pumpage, in acre-feet*				
	Total	Overburden unit	Saddle Mountain unit	Wanapum unit	Grande Ronde unit
Wasco	16,740	580	310	13,560	2,340
Sherman	2,210	0	0	920	1,290
Gilliam	8,520	0	90	4,720	3,710
Morrow	41,560	14,590	1,900	9,560	15,370
Umatilla	78,490	16,740	2,330	26,110	33,160