Assessment of the Water Resources of the Grand Ronde Area, Oregon

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 97–4040

Prepared in cooperation with the
CONFEDERATED TRIBES OF THE GRAND RONDE COMMUNITY OF OREGON

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By Kathleen A. McCarthy, John C. Risley,
Rodney R. Caldwell, and William D. McFarland

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Portland, Oregon
1997

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in)	2.54	centimeter
inch (in)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
acre	0.4047	hectare
section (640 acres or 1 square mile)	259.0	hectare
square mile (mi^2)	259.0	hectare
square mile (mi^2)	2.590	square kilometer
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

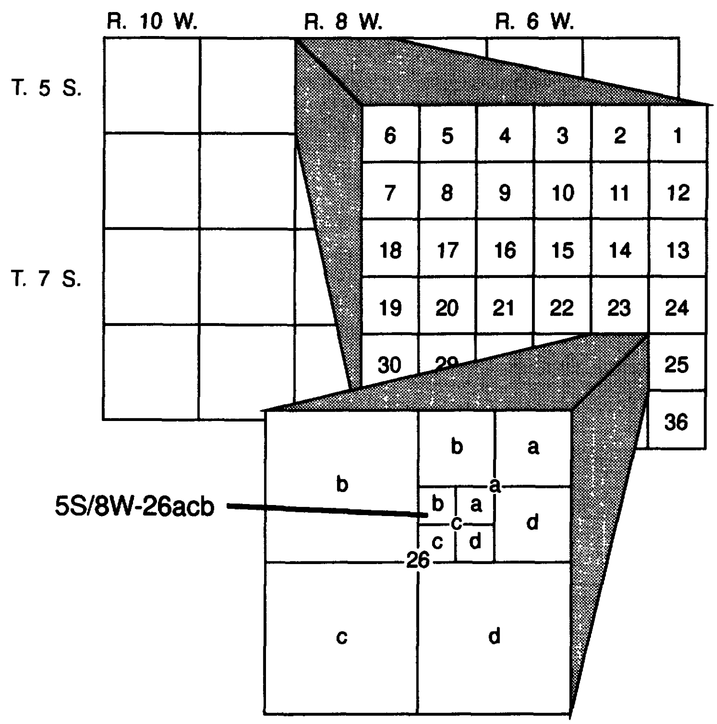
Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8\ °C) + 32$$

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.

LOCATION-NUMBERING SYSTEM

The location-numbering system used in this report is based on the rectangular system for subdivision of land. Each number-letter designation indicates the location of the site with respect to township, range, and section. Townships and ranges in the study area are numbered south and west of the Willamette Baseline and Meridian. The letters after the section indicate the location within the section; the first letter indicates the quarter section (160 acres), the second letter indicates the quarter-quarter section (40 acres), and the third letter indicates the quarter-quarter-quarter section (10 acres). For example, site 5S/8W-26acb is in the NW quarter of the SW quarter of the NE quarter of section 26, township 5 south, range 8 west:



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Abstract

Stream hydrographs show that throughout the Grand Ronde area most precipitation follows surface or shallow subsurface pathways to streams, resulting in rapid runoff and little natural water storage within the basin. Limited storage and low aquifer permeability restrict base flow to streams, and streamflows therefore decline rapidly once precipitation ceases. Shallow ground water and springs occur throughout the area, but because of the low permeability of aquifer materials, nearly all wells and springs have low yields. Water quality in streams, wells, and springs is generally good, but saline ground water has been reported on a number of drillers' logs for the study area and in several previous investigations of nearby areas. Further development of water resources in the Grand Ronde area is likely to be constrained by existing downstream water rights, the low permeability of geologic materials throughout the area, and possibly the intrusion of saline water. However, construction of facilities to store available water and thus compensate for low yields could provide a reliable, sustainable water supply for the Grand Ronde area.

INTRODUCTION

The Tribal headquarters of the Confederated Tribes of the Grand Ronde Community of Oregon (the Tribe) is located in the unincorporated community of Grand Ronde in northwestern Oregon (fig. 1). The Tribe consists of an estimated 3,000 registered Tribal members, of which over 400 reside within the community of Grand Ronde. It is expected that during the next 20 years, as the Tribe becomes more established in the community and as Tribal economic development proceeds, Tribal members will be drawn back to the Grand Ronde Community. Such economic development began in 1995 when the Tribe opened the Spirit Mountain Casino, a multimillion dollar gaming facility that has become a very successful business. As a result of this success, the Tribe is planning further development, including construction of a hotel facility to accommodate visitors to the Grand Ronde area.

The primary source of water for the community is a group of springs approximately 5 miles southwest of Grand Ronde (site 63, fig. 1). Water from these springs, which yield approximately 1.3 cubic feet per second, is delivered through a single pipeline to the distribution system in the community. The Grand Ronde Community Water Association, a private, nonprofit organization, owns and operates the community water system. Although numerous domestic wells are in use in the area, no wells are being used for municipal supply.

The Tribal community does not have its own water-supply system and uses water from the community system. Although a member of the Grand Ronde Community Water Association, the Tribe is concerned about the vulnerability of this water supply and whether it will be adequate to sustain Tribal economic development and growing domestic needs resulting from Tribal members returning to the community. Additionally, the Tribe has little in the way of irrigation water rights and will likely need irrigation at several development sites in the future.

To determine if adequate water supplies are available to meet the growing needs of the Tribe, an understanding of the quantity and quality of the water resources in the Grand Ronde vicinity is necessary. In 1995, the U.S. Geological Survey entered into a cooperative agreement with the Tribe to assess the water resources of the area.

Purpose and Scope

This report describes a hydrogeologic assessment of water resources in the Grand Ronde area designed to

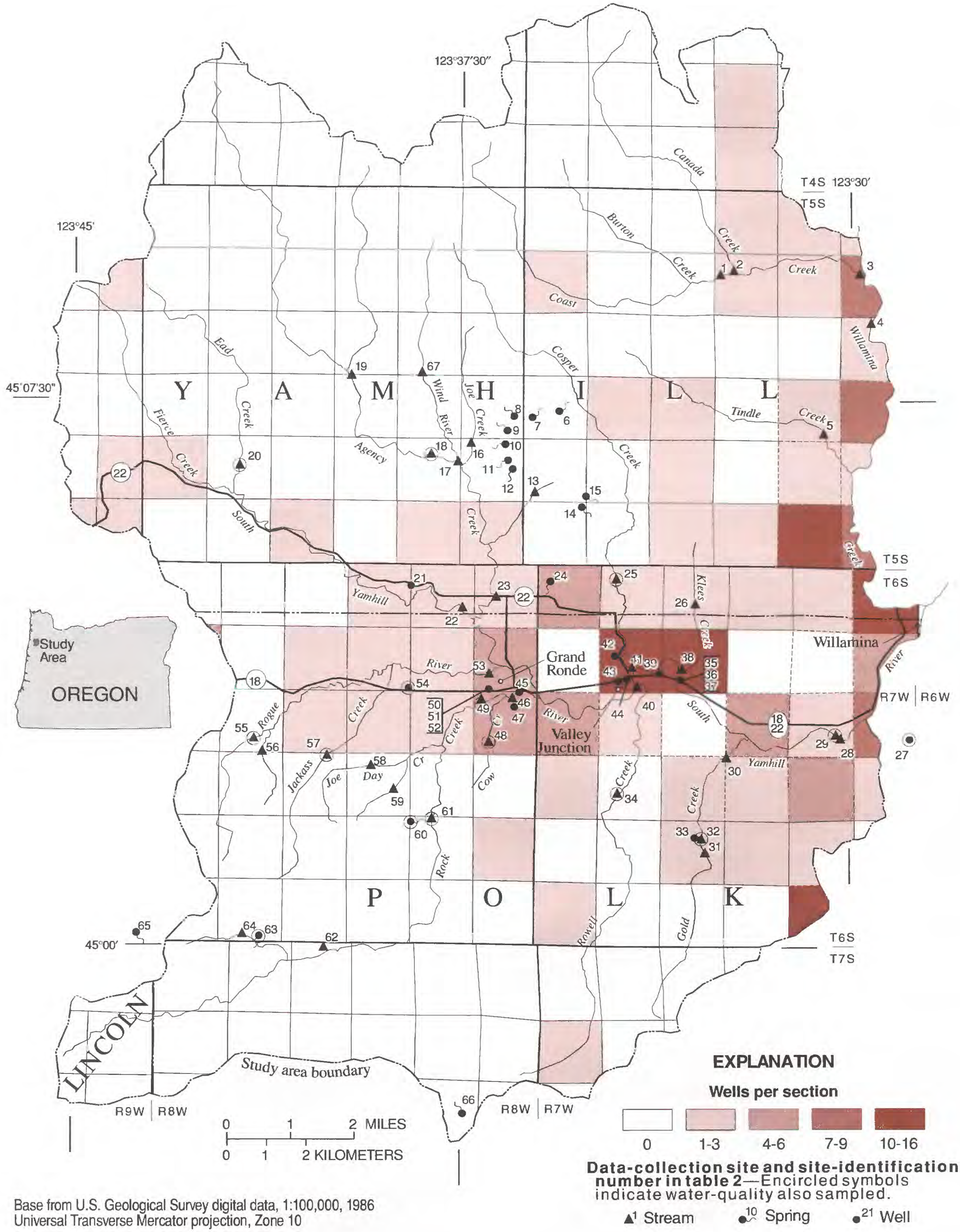


Figure 1. Study area location, data-collection sites, and distribution of documented wells within the study area.

(1) provide a better understanding of the hydrology and water resources of the area, (2) identify potential alternative sources of water in the Grand Ronde area, and (3) define supplementary data that would be necessary to further understand and quantify potential alternative sources of water. The assessment is based on a compilation of existing geologic, hydrologic, and water-quality information on the Grand Ronde and surrounding areas; hydrologic reconnaissance of the study area; measurement of surface-water and spring discharge data; measurement of ground-water levels; and collection of water-quality data.

The study was conducted by the U.S. Geological Survey (USGS) under a cooperative agreement with the Confederated Tribes of the Grand Ronde Community.

Description of the Study Area

The study area, which encompasses approximately 160 square miles, is located on the eastern flank of the Oregon Coast Range and is within the South Yamhill River drainage basin (fig. 1; pl. 1). The South Yamhill River is a tributary of the Willamette River to the east. The South Yamhill River Valley is surrounded by the mountains and hills of the Coast Range, and the river has deposited a thin layer of sediments derived from these highlands along the valley floor. The surrounding mountains generally are forested except where timber has been recently harvested. Tributary streams have dissected the mountains, creating smaller valleys with varying degrees of slope depending on tributary size and local geology. Geologic units in the area include basalts, marine and nonmarine shales and sandstones, intrusive rocks, and alluvium (Brownfield, 1982a, 1982b). Several faults have been mapped in the area (Baldwin and Roberts, 1952; Baldwin and others, 1955; Brownfield, 1982a, 1982b).

Most of the population is concentrated on the valley floor. Average annual precipitation in the study area ranges from more than 160 inches in the southwestern uplands to approximately 50 inches on the eastern valley floor. Elevation ranges from approximately 3,000 feet above sea level in the uplands to the southwest to a few hundred feet above sea level on the valley floor.

Forest products and agriculture have been the primary industries in the area for many years. However, with the recent completion and success of the Spirit Mountain Casino, gaming is now a major industry in the area.

Approach

This study consisted of three primary tasks—

- a literature and data search to locate information from previous investigations,
- hydrologic reconnaissance with collection of supporting data, and
- interpretation of the data.

The study began in March 1995, and data were collected through August 1996. The three tasks were conducted as follows:

Literature and data search.—A literature search was conducted to locate all geologic maps and hydrogeologic reports covering the vicinity of Grand Ronde and adjacent areas. In addition, all well, spring, and stream-discharge records were compiled and reviewed.

Hydrologic reconnaissance and data collection.—A preliminary survey of the surface- and ground-water resources in the Grand Ronde vicinity was conducted. During this survey, the hydrogeology of the area was reviewed in the field and compared to existing geologic maps. Through this reconnaissance, the current use of water resources in the area was assessed and deficiencies in the available data were identified. Additional data were then collected to provide a more complete understanding of the water resources in the area. Discharges were measured at selected streams and springs, and water levels were measured in selected wells. In addition, water samples collected from streams, springs, and wells were analyzed for a variety of chemical properties, including major-ion and nutrient concentrations. These water-quality data were used to determine the general chemical characteristics of water in the area.

Interpretation of data.—The data compiled and collected were analyzed to identify relationships, trends, and anomalies in discharge rates and water-quality constituents. On the basis of these data, a general understanding of water resources in the area was developed.

GEOLOGIC SETTING

The geologic units of the Grand Ronde area consist of Tertiary marine sedimentary and volcanic bedrock units, which are locally overlain by unconsolidated sedimentary deposits along the South Yamhill River and its tributaries. The generalized surficial geology compiled from previous investigations is shown on plate 1 (Baldwin and Roberts, 1952; Baldwin, 1964; Macleod, 1969; Brownfield, 1982a, 1982b; and Wells and others, 1983). Conflicts among overlapping maps were resolved using the more recent and (or) more detailed mapping.

The active continental margin of Oregon and Washington was the locus of tectonic and volcanic activity and sediment accumulation during much of Cenozoic time. A thorough review of the regional geologic history of the continental margin, including the Grand Ronde area, is included in reports by Niem and Niem (1984), Snavely (1987), and Snavely and Wells (1991). The Cenozoic tectonic activity resulted in the deformation of Tertiary bedrock in the Grand Ronde area. The most predominant structural feature is the east-west-trending Yamhill River fault in the southern part of the study area, which is downthrust on the north side and has an estimated displacement of about 1,000 feet (Baldwin and others, 1955). For most of the faults in the area, it is suggested that displacement occurred prior to the late Eocene (Baldwin, 1964; MacLeod, 1969; Brownfield, 1982b).

Tertiary Bedrock

The bedrock in the Grand Ronde study area consists of Tertiary marine and volcanic units. The lower- to middle-Eocene Siletz River Volcanics (Tsr, pl. 1), originally named the Siletz River Volcanics Series by Snavely and Baldwin (1948), are the oldest rocks in the central Oregon Coast Range. The Siletz River Volcanics are the basement rocks in the Grand Ronde area and are exposed in the southeastern part of the study area. The unit consists of a sequence of basalt flows, pillow basalt, flow breccia, basaltic fragmental debris, and volcaniclastic marine sedimentary rocks that may be over 12,000 feet thick in the central Coast Range (Brownfield, 1982b). The petrography and petrochemistry of the Siletz River Volcanics are described by Snavely and others (1968) and by MacLeod (1969). The presence of zeolites in joints, fractures, and interstices (Keith and Staples, 1985) reduce the fracture permeability of the unit. Well information indicates that the Siletz River Volcanics rocks are generally of low permeability (Frank, 1974; Gonthier, 1983), but typically yield enough water for domestic use. The Kings Valley Siltstone Member, a tuffaceous sedimentary unit present at some places within the Siletz River Volcanics, is the principal aquifer in the Kings Valley area (Penoyer and Niem, 1975), which is located about 25 miles southeast of the Grand Ronde study area.

The middle-Eocene bedrock exposed to the south of the Yamhill River fault in the southern part of the study area is mapped as the Yamhill and Tyee Formations, undivided (Tyt, pl. 1) (MacLeod, 1969; Brownfield, 1982b; Wells and others, 1983). The upper part of the unit consists of siltstone, shale, and sandstone of the lower Yamhill Formation and the lower part consists of siltstone and sandstone of the Tyee Formation. The Yamhill and Tyee Formations have not been differentiated on the map because of limited exposure and interfingering lithologies (Brownfield, 1982b). The undivided Yamhill and Tyee Formations unit unconformably overlies the Siletz River Volcanics and may be about 2,000 to 3,000 feet thick in the area (Brownfield, 1982b).

The middle- to upper-Eocene Yamhill Formation (Ty, pl. 1) is mapped as a separate unit to the north of the Yamhill River fault (Brownfield, 1982b; Wells and others, 1983). The type section, located east of the study area along Mill Creek near Buell, Oregon, consists of a thinly bedded 500-foot basal unit of dark-gray shale and siltstone with occasional beds of lime-cemented sandstone, 500 feet of massive to thick-bedded gray to greenish-gray sandstone, and approximately 4,000 feet of massive to faintly bedded micaceous siltstone and mudstone (Baldwin and others, 1955). Within the study area, the Yamhill Formation is as much as 5,000 feet thick (Brownfield, 1982b).

The upper-Eocene Nestucca Formation (Tn, pl. 1), originally described by Snavely and Vokes (1949), is the predominant marine bedrock unit exposed in the central and northern parts of the study area. The Nestucca Formation consists of tuffaceous siltstone and shale; tuffaceous, felspathic sandstone; and interbedded basaltic flows, pillows, pillow-breccia, breccia, and tuff (Brownfield, 1982b). It unconformably overlies the Yamhill Formation and is at least 2,000 feet thick in the study area (Brownfield, 1982b).

The marine sedimentary bedrock units (Tyt, Ty, Tn) in the Grand Ronde area are the same or lithologically similar to the marine sedimentary bedrock units that have been investigated in the Willamette Valley (Price, 1967; Frank, 1973, 1974, 1976; Helm and Leonard, 1977; Frank and Collins, 1978; Gonthier, 1983). The units are generally fine grained, cemented, and have low permeability. The majority of the wells completed in the sedimentary bedrock within the Willamette Valley are of low yield.

Several Eocene to Miocene mafic dikes and sills intrude the marine sedimentary rocks in the study area. The Tertiary intrusives (Ti, pl. 1) consist primarily of amphibole camptonite, basalt, diabase, diorite, and granophyric gabbro (Baldwin and Roberts, 1952; Baldwin, 1964; Brownfield, 1982a, 1982b; MacLeod, 1969, 1981). The intrusive rocks vary in thickness and lateral extent, with a section exposed in the Saddleback Mountain area that is as much as 2,000 feet thick (Baldwin and Roberts, 1952). Hydrologic information is limited for the intrusive rocks in the Coast Range, but well information indicates that these rocks have low permeability (Frank, 1974; Frank and Collins, 1978).

Quaternary Sediments

Recent alluvium and terrace deposits (Qal, pl. 1) overlie the Tertiary bedrock units along the South Yamhill River and its tributaries. These unconsolidated sediments consist mostly of poorly sorted deposits of clay, silt, sand, and fine to very coarse gravel (Brownfield, 1982a, 1982b). Water-well data in the area indicate that the unconsolidated sediments are thin and of limited extent, with a maximum thickness of less than 60 feet, but commonly less than 20 feet. Quaternary landslide material is mapped to the north (Baldwin and Roberts, 1952), east (Brownfield, 1982a), and south (MacLeod, 1969) of the study area in the marine sedimentary bedrock units and may exist in the study area. Because of the limited thickness and extent of the unconsolidated sediments, it is unlikely that the unconsolidated material would support sustained high well yields.

HYDROLOGY

The hydrology of the Grand Ronde area is typical of that of many forested basins in western Oregon. Abundant annual precipitation falls on the land surface and is diverted through various flow pathways. These pathways include evaporation and transpiration, direct surface runoff, subsurface runoff through the soil zone, and recharge to the ground-water system. Complex geologic formations have created springs and seeps at some locations where subsurface flowpaths intersect the land surface.

The study area includes the South Yamhill River drainage basin upstream of Willamina and the eastern part of the Willamina Creek drainage basin (fig. 1, pl. 1). Except for the northeastern boundary, which is defined by Willamina Creek, the study area boundary coincides with the South Yamhill River drainage-basin boundary. Because the boundary is defined by these surface drainage divides, no flow from streams enters the study area, and water leaves the area primarily via the South Yamhill River, Willamina Creek, and evapotranspiration. Ground-water flow generally coincides with surface drainage, and ground-water flow across most of the study area boundary is therefore not likely to be significant. Along Willamina Creek, however, water from the western part of the Willamina Creek Basin (which is outside the study area) may enter the stream as base flow; conversely, water from Willamina Creek may discharge to ground water in the western part of the basin.

Data-Collection Methods

Stream-discharge data were collected from three gaging stations located in the study area. These gages include the South Yamhill River near Willamina (USGS station number 14192500), Willamina Creek near Willamina (14193000), and the Wind River near Grand Ronde (14192450). The South Yamhill River and the Willamina Creek gages were operated by the USGS from 1934 through 1993 and 1934 through 1991, respectively, and are currently operated by the Oregon Water Resources Department (OWRD). The Wind River gage was operated by the Bureau of Land Management (BLM) from 1984 to 1988 and is no longer in use. It should be noted that streamflow and precipitation during the study were generally greater than the long-term averages (table 1). For example, during the 1995 water year, streamflow in the South Yamhill River near Willamina, streamflow in Willamina Creek near Willamina, and precipitation at Willamina were approximately 18, 25, and 14 percent greater, respectively, than long-term averages (table 1).

To quantify the base-flow characteristics of the geologic formations in the study area, stream discharge was measured at a number of ungaged locations during low-flow periods (June to September 1995 and August 1996). Standard USGS methods were used for these measurements (Rantz, 1982). Depending on the magnitude of the discharge, either a Price AA meter, pygmy

Table 1. Comparisons between the 1995 water year and the long-term average stream discharge and precipitation in the Grand Ronde area

[Source: Precipitation data provided by the Oregon Climate Service, Oregon State University; ft^3/s, cubic feet per second; in, inches]

	Stream discharge (ft^3/s)					
	South Yamhill River near Willamina (14192500)		Willamina Creek near Willamina (14193000)		Precipitation at Willamina (in)	
Month	1995	1935 to 1995	1995	1935 to 1995	1995	1935 to 1995
October	219	170	62	58	3.4	3.9
November	1,245	853	487	306	11	7.5
December	2,067	1,412	932	560	9.3	9.3
January	1,576	1,442	715	592	10	8.4
February	1,444	1,301	622	549	4.8	6.8
March	1,120	979	463	440	7.7	6.0
April	559	582	291	270	5.0	3.4
May	203	274	133	134	1.1	2.0
June	98	131	64	68	2.0	1.3
July	39	49	31	33	.1	.4
August	27	24	18	20	.9	.6
September	30	38	18	21	2.2	1.5
Mean	716	605	318	254	58	51

meter, portable flume, or bucket and stopwatch was used for the measurement.

To gain an understanding of ground water throughout the study area, data were compiled from drillers' logs of all documented wells in the study area for which yield data were available. In addition, 15 wells and 15 springs were field located. The depth to ground water in wells was measured using standard USGS methods (Kazmann, 1965). Spring yields were measured using either a portable flume or a bucket and stopwatch, depending on the magnitude of the discharge (Rantz, 1982).

The locations of all sites from which data were collected during this study are shown on plate 1 and figure 1. Further site-identification information is provided in table 2.

Surface Water

The South Yamhill River is the principal stream in the study area. Secondary streams in the area include Agency Creek, Rogue River, Rock Creek, Rowell Creek, Cosper Creek, Klees Creek, Gold Creek, and Willamina Creek, which are tributaries of the South Yamhill River; and Coast Creek and Tindle Creek, which flow into Willamina Creek. All of these streams are perennial. The gradient of the South Yamhill River is slight and its flow follows a slow, meandering course. The river is incised in the alluvial material, and there are no wetlands along its course. The upland subbasins are well drained due to steep stream gradients, loamy soils, and the limited storage capacity of the geologic formations. However, some small ponds and wetlands exist adjacent to the tributary creeks. Some of these wetlands are associated with seeps located at the contact between the Nestucca Formation and the underlying Yamhill Formation. The Nestucca Formation is composed of more permeable sediments than the Yamhill Formation, and this contrast in permeability creates lateral ground-water flow at the contact, resulting in discharge where the contact between the two formations intersects land surface.

Hydrographs for the South Yamhill River and Willamina Creek (fig. 2) reveal the quick, "flashy" response to runoff in these two basins. Flow in both streams increases rapidly in response to precipitation, and peak discharges dissipate quickly once rainfall stops. This response is typical of basins characterized by relatively impermeable geologic materials. Because infiltration to ground water does not occur readily through such materials, storm runoff tends to follow rapid, direct surface or shallow subsurface routes to stream channels. In more permeable basins, where more of the precipitation infiltrates and reaches the ground-water system before discharging to streams, storm-related discharge peaks are delayed and attenuated.

Stream base-flow results from water stored in the stream's drainage area, often in wetlands or the ground-water system. This stored water is released slowly over time and sustains streamflow during periods of low precipitation. Past records from the gaging stations show that summer is typically a low-flow period for the streams throughout the study area. In addition, field observations showed that stream discharge generally increased downgradient, indicating inflow from ground water along most stream reaches.

Base flows in the South Yamhill River and Willamina Creek, particularly in the summer, are only a small fraction of the higher flows that occur during the winter months (fig. 2). This large contrast between summer and winter base flow is further evidence of the low permeability of geologic materials in the study area. Because most precipitation runs off by way of surface or shallow subsurface pathways, recharge to the ground-water system is limited; furthermore, low aquifer permeability restricts the ground-water flux that sustains streamflow during periods of low precipitation.

To better understand the base-flow characteristics of the area, stream discharge measurements were made during the summer months near the mouths of the major tributary streams in the study area (table 3). Except for the June 7–8, 1995, measurements, which were influenced by recent precipitation, streamflow during these measurements was primarily base flow. The base flow at the outlet of the measured subbasins, expressed as a percentage of total basin outflow (table 3), shows that surface runoff throughout the study area is generally diffuse, distributed as moderate or low flows in a large number of streams.

In Oregon, withdrawal of water from streams is governed by a water-rights system administered by the OWRD. Because of the large amount of water withdrawn under existing water rights, streamflow at the mouth of the South Yamhill River—and hence, all points upstream—is fully appropriated for the months of July through October (Oregon Water Resources Department, 1997), and additional water is not available for withdrawal during these months. Furthermore,

Table 2. Data-collection sites in the Grand Ronde area, 1995–96

[Site-identification number corresponds to the site-identification number on figure 1; Location number, see explanation on page V]

Site-identification number	Site name	Location number	Latitude	Longitude	Water-quality sampling site
		Surface-Water Sites			
1	Coast Creek below Burton Creek	5S/7W-10bcb	45° 09' 14"	123° 32' 32"	
2	Canada Creek above Coast Creek	5S/7W-10bdb	45° 09' 18"	123° 32' 16"	
3	Coast Creek (mouth)	5S/7W-12bdb	45° 09' 15"	123° 29' 49"	
4	Willamina Creek (gage)	5S/7W-13baa	45° 08' 34"	123° 29'37"	
5	Tindle Creek (mouth)	5S/7W-23dcd	45° 07' 03"	123° 30' 31"	
13	Tributary of Agency Creek	5S/7W-30cca	45° 06' 15"	123° 36' 06"	
16	Joe Creek	5S/8W-25bba	45° 06' 55"	123° 37' 21"	
17	Agency Creek below Wind River	5S/8W-26add	45° 06' 39"	123° 37' 35"	
18	Agency Creek near Grand Ronde	5S/8W-26acb	45° 06' 46"	123° 38' 07"	X
19	Agency Creek below Yoncalla Creek	5S/8W-22bab	45° 07' 50"	123° 39' 40"	
20	Ead Creek	5S/8W-29acc	45° 06' 36"	123° 41' 48"	X
22	South Yamhill	6S/8W-02dac	45° 04' 39"	123° 37' 29"	
23	Agency Creek (near mouth)	6S/8W-01bdc	45° 04' 48"	123° 36' 50"	
25	Cosper Creek	6S/7W-05bac	45° 05' 03"	123° 34' 31"	X
26	Klees Creek	6S/7W-04cad	45° 04' 42"	123° 32' 59"	
28	South Yamhill River (gage)	6S/7W-14dac	45° 02' 52"	123° 30' 11"	
29	South Yamhill River	6S/7W-14dbd	45° 02' 55"	123° 30' 16"	X
30	Gold Creek (near mouth)	6S/7W-22bbb	45° 02' 35"	123° 32' 22"	
31	Gold Creek	6S/7W-28dba	45° 01' 17"	123° 32'47"	
32	Gold Creek	6S/7W-28acb01	45° 01' 30"	123° 32' 52"	X
34	Rowell Creek	6S/7W-20cab	45° 02' 06"	123° 34' 29"	X
38	Klees Creek (mouth)	6S/7W-09cac	45° 03' 49"	123° 33' 15"	
40	Rowell Creek (mouth)	6S/7W-08dcc	45° 03' 35"	123° 34' 06"	
41	Cosper Creek (mouth)	6S/7W-08dbb	45° 03'50"	123° 34'13"	
46	Rock Creek (mouth)	6S/8W-13abb	45° 03' 25"	123° 36' 31"	
48	Cow Creek	6S/8W-13cca	45° 02' 48"	123° 36' 58"	X
49	Rock Creek	6S/8W-13bbb	45° 03' 24"	123° 37' 07"	
53	Rogue River (mouth)	6S/8W-12cbd	45° 03' 45"	123° 36' 57"	
55	Rogue River (west)	6S/8W-17dcb	45° 02' 51"	123° 41' 30"	X
56	Tributary of Rogue River (east)	6S/8W-17dcd	45° 02' 40"	123° 41' 20"	
57	Jackass Creek	6S/8W-21aba	45° 02' 37"	123° 40' 06"	X
58	Joe Day Creek	6S/8W-22bad	45° 02' 28"	123° 39' 14"	
59	Tributary of Joe Day Creek	6S/8W-22dba	45° 02' 09"	123° 38' 48"	
61	Rock Creek	6S/8W-26bab	45° 01'45"	123° 38' 03"	X
62	Tributary of Rock Creek	7S/8W-04abb	44° 59' 59"	123° 40' 09"	
64	Tributary of Rock Creek	6S/8W-32cda	45° 00' 09"	123° 41' 43"	
67	Wind River (gage)	5S/8W-14cdd	45° 08' 00"	123° 38' 30"	

Table 2. Data-collection sites in the Grand Ronde area, 1995–96—Continued

Site-identification number	Site name	Location number	Latitude	Longitude	Water-quality sampling site
		Ground-Water Sites			
21		6S/8W-03ada	45° 04' 57"	123° 38' 29"	
27		6S/7W-13dac	45° 02' 52"	123° 28' 50"	X
33		6S/7W-28acb02	45° 01' 29"	123° 32' 57"	
35		6S/7W-09cbd02	45° 03' 39"	123° 33' 16"	
36		6S/7W-09cbd01	45° 03' 40"	123° 33' 16"	
37		6S/7W-09cbd03	45° 03' 40"	123° 33' 17"	
39		6S/7W-08dad	45° 03' 45"	123° 33' 40"	
43		6S/7W-08cdb	45° 03' 39"	123° 34' 28"	X
44		6S/7W-08cda	45° 03' 41"	123° 34' 18"	
45		6S/8W-13aba	45° 03' 30"	123° 36' 22"	
47		6S/8W-13abd	45° 03' 18"	123° 36' 28"	
50		6S/8W-12ccd03	45° 03' 32"	123° 36' 58"	
51		6S/8W-12ccd02	45° 03' 33"	123° 36' 59"	
52		6S/8W-12ccd01	45° 03' 34"	123° 37' 00"	
54		6S/8W-10ddd	45° 03' 33"	123° 38' 32"	X
		Spring Sites			
6		5S/7W-19dbb	45° 07' 22"	123° 35' 38"	
7		5S/7W-19cbd	45° 07' 16"	123° 36' 10"	
8		5S/8W-24dac	45° 07' 17"	123° 36' 31"	
9		5S/8W-24ddc	45° 07' 05"	123° 36' 38"	
10		5S/8W-25aba	45° 06' 54"	123° 36' 40"	
11		5S/8W-25adb	45° 06' 41"	123° 36' 37"	
12		5S/8W-25adc	45° 06' 34"	123° 36' 32"	
14		5S/7W-31aaa	45° 06' 03"	123° 35' 11"	
15		5S/7W-30ddd	45° 06' 12"	123° 35' 07"	
24		6S/7W-06bca	45° 05' 01"	123° 35' 47"	
42		6S/7W-08bcd	45° 04' 00"	123° 34' 32"	
60		6S/8W-26bbb	45° 01' 43"	123° 38' 28"	X
63		6S/8W-32dcd	45° 00' 07"	123° 41' 23"	X
65		6S/9W-36ddc	45° 00' 10"	123° 43' 45"	
66		7S/8W-14caa	44° 57' 42"	123° 37' 27"	

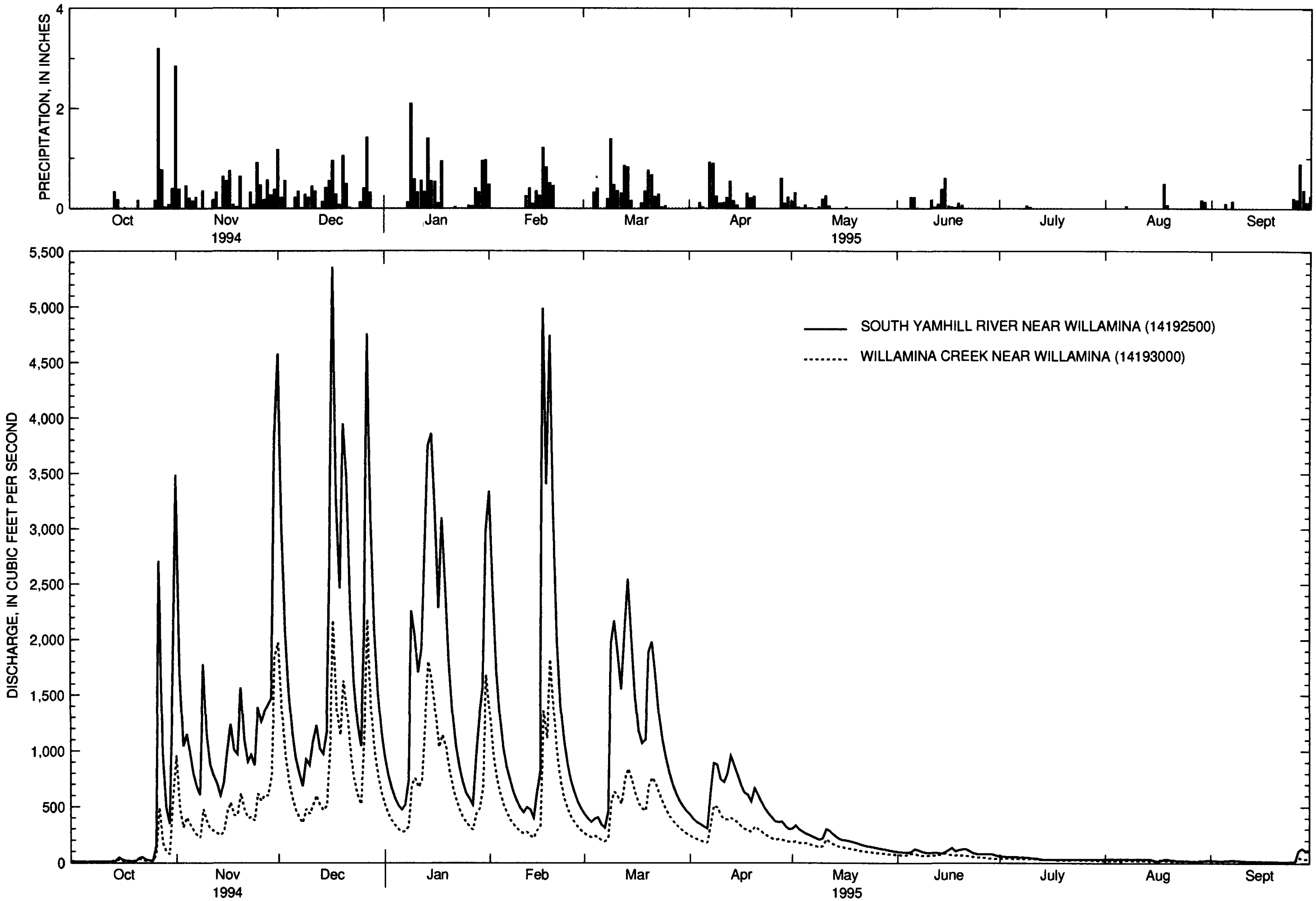


Figure 2. Daily mean discharge for the South Yamhill River near Willamina (14192500) and Willamina Creek near Willamina (14193000), and daily precipitation at Willamina, water year 1995.

Table 3. Miscellaneous discharge measurements in the Grand Ronde area, 1995–96

[Site-identification number corresponds to the site-identification number in table 2 and on figure 1; ft^3/s, cubic feet per second; Percent of basin outflow, the miscellaneous discharge measurement as a percent of the concurrent daily mean discharge in the South Yamhill River near Willamina (14192500) or *, Willamina Creek Willamina Creek near Willamina (14193000)]

Site-identification number	Stream	Date	Discharge (ft^3/s)	Percent of basin outflow
1	Coast Creek below Burton Creek	06–08–95	6.8	11
2	Canada Creek above Coast Creek	06–08–95	8.8	14
3	Coast Creek (mouth)	08–26–96	5.5	30*
4	Willamina Creek (gage)	08–26–96	18	---
4	Willamina Creek (gage)	08–27–96	20	---
5	Tindle Creek (mouth)	08–27–96	.1	.7*
13	Tributary of Agency Creek	06–30–95	<.1	<.1
16	Joe Creek	08–01–95	.3	.8
17	Agency Creek below Wind River	06–07–95	18	16
18	Agency Creek near Grand Ronde	08–01–95	5.2	16
19	Agency Creek below Yoncalla Creek	06–07–95	16	14
20	Ead Creek	08–02–95	2.1	6.4
22	South Yamhill River	08–26–96	6.1	34
23	Agency Creek (near mouth)	08–27–96	4.2	21
25	Cosper Creek	07–28–95	1.2	3.8
26	Klees Creek	07–27–95	<.1	.3
28	South Yamhill River (gage)	08–26–96	18	---
28	South Yamhill River (gage)	08–27–96	19	---
30	Gold Creek (mouth)	06–07–95	4.7	4.1
30	Gold Creek (mouth)	08–26–96	.7	3.9
31	Gold Creek	07–27–95	.8	2.4
32	Gold Creek	07–27–95	.9	2.9
32	Gold Creek	09–26–95	.7	3.9
34	Rowell Creek	07–27–95	3.2	10
34	Rowell Creek	08–29–95	3.8	27
38	Klees Creek (mouth)	08–27–96	<.1	.3
40	Rowell Creek (mouth)	06–07–95	10	8.9
40	Rowell Creek (mouth)	08–26–96	2.0	11
41	Cosper Creek (mouth)	06–07–95	5.7	5.0
41	Cosper Creek (mouth)	08–26–96	.6	3.2
46	Rock Creek (mouth)	08–27–96	5.8	30
48	Cow Creek	07–28–95	.5	1.5
49	Rock Creek	06–07–95	30	26
53	Rogue River (mouth)	08–26–96	1.1	6.1
55	Rogue River (west)	08–22–95	1.0	4.9
56	Rogue River (east)	08–22–95	.2	.7
57	Jackass Creek	08–23–95	.5	2.5
58	Joe Day Creek	08–23–95	<.1	.2
59	Joe Day Creek	08–23–95	.1	.6
61	Rock Creek	08–23–95	6.5	34
62	Tributary of Rock Creek	07–12–95	.2	.2
64	Tributary of Rock Creek	07–12–95	<.1	<.1

water-management strategies outlined in the OWRD's Willamette Basin Plan may dictate additional restrictions on new withdrawals. As a result, surface water is not a satisfactory alternative source of water for users in the Grand Ronde area.

Ground Water and Springs

According to records obtained from the OWRD, more than 200 water wells have been drilled in the study area. The areal distribution of these wells is shown in figure 1. Most of the wells have been drilled along the floors of the South Yamhill River and Willamina Creek Valleys, where they tap the alluvial gravel and terrace deposits. Ground-water level measurements in the 15 field-located wells indicate that the water table is very shallow along the valley floors (table 4). Although the field-located wells ranged in depth from 10 to 251 feet, and in altitude from 280 to 430 feet, most water levels measured during this study were less than 10 feet below land surface, and the deepest was less than 18 feet below land surface. However, despite shallow ground-water levels, low well yields and large drawdowns limit the utility of the resource.

A summary of well tests conducted and reported by drillers shows that well yields are typically low throughout the area; most wells yielding less than 10 gallons per minute (fig. 1; table 5). Two wells in township 6S, range 7W, section 35 were reported to yield 300 gallons per minute, but nearly complete drawdown resulted in both wells from this pumping rate. Such large drawdowns generally indicate that high yields may not be sustainable over the long term, and discussion with the owner of one of these wells confirmed that the high pumping rate could not be maintained.

Previous studies in nearby areas found similarly low average yields for the same geologic formations that occur within the study area (Gonthier, 1983; Caldwell, 1993). These studies also report a small number of relatively high-yield wells, but such wells are scarce throughout the region, and their locations do not reveal a clear pattern. It is likely that such wells are associated with local anomalous geologic features such as fracture zones or faults.

Specific capacities for wells in the Grand Ronde area were calculated from drillers' tests (table 5). The specific capacity of a well is defined as the rate of discharge of the well divided by the resulting drawdown (Driscoll, 1986). Because drawdown in a well generally increases over the duration of a pumping test—especially in low-permeability aquifers—specific capacity typically decreases over the duration of the test. Although most driller's tests are of short duration and, therefore, may tend to overestimate specific capacity, the values do provide a rough indication of aquifer productivity. It is clear that specific capacities throughout the study area are low—typically less than 0.2 gallons per minute per foot of drawdown. Even for the few wells with high yields, drawdowns were high, resulting in low specific capacities.

More permeable unconsolidated sediments that overlie older Tertiary bedrock units generally occur adjacent to and beneath the South Yamhill River and its tributaries. But as indicated previously, these sediments are generally less than 20 feet thick and, in some areas, are not fully saturated. Therefore, these materials are not a major water-bearing unit. Where these sediments are saturated, they are probably hydraulically connected to streams. However, as is evident from the low summer flows in the South Yamhill River and Willamina Creek and the rapid response of these streams to rainfall (fig. 2), these sediments do not store substantial quantities of water within the drainage basin.

Many springs are located throughout the study area. However, data collected from springs during this study show that, except for the large spring currently used as a water supply by the Grand Ronde Community Water Association (spring 63), discharges are low (table 6). Spring yields, like well yields, are limited by the low permeability of aquifer materials throughout the area.

Relationships among Surface Water, Ground Water, and Precipitation

A statewide map of mean annual precipitation (1961–90) was developed by the Oregon State Climatologist (Taylor, 1993; Daly and Neilson, 1994); the part of the map covering the study area is shown in figure 3. Annual precipitation within the area averages 85 inches (table 7), but varies considerably with elevation, ranging from less than 60 inches in the lowlands to more than 160 inches in the uplands.

For each of the subbasin base-flow measurements made in August 1996, the subbasin base-flow yield (subbasin discharge per square mile) and the normalized subbasin base-flow yield (subbasin yield per inch of precipitation) were calculated (table 7). Mean annual precipitation values used in these calculations were computed from the isohyetal map (fig. 3).

Table 4. Data for field-located wells in the Grand Ronde area

[Site-identification number corresponds to the site-identification number in table 2 and on figure 1; --, no data available; ft BLS, feet below land surface
Use—D, domestic; M, monitoring; U, unused
Driller's well test—M, method (A, air; B, bailer); Y, yield in gallons per minute; D, drawdown in feet; P, period of duration in hours
Water level date, (D) indicates measurement by driller]

Site-identification number	State ID number	Owner	Date drilled	Use	Altitude (ft)	Depth (ft)	Diameter (in)	Depth to open interval (ft BLS)		Driller's well test				Depth to water (ft BLS)	Water level date
								Top	Bottom	M	Y	D	P		
21	YAMH7837	Mercier, Pat	09–12–70	U	390	51	6	20	50	B	7	40	1	10.00	09–12–70 (D)
														6.94	06–27–95
														7.04	09–29–95
27	POLK452	Hamel, John	05–08–92	D	400	251	4	90	250	A	5	238	1	12.00	05–08–92 (D)
														5.26	06–29–95
														9.77	09–01–95
33	--	Smith, Jack and Louise	--	D	420	58	--	--	--	--	--	--	--	16.66	07–27–95
														17.55	09–29–95
35	POLK450	Jenne, Cliff	04–29–92	M	285	15	2	5	15	--	--	--	--	8.50	04–30–92 (D)
														9.26	06–28–95
36	POLK451	Jenne, Cliff	04–29–92	M	285	15	2	5	15	--	--	--	--	5.00	04–30–92 (D)
														6.59	06–28–95
37	POLK499	Jenne, Cliff	04–29–92	M	285	15	2	5	15	--	--	--	--	4.50	04–30–92 (D)
														6.42	06–28–95
39	--	Marner, Vaughn	--	D	280	12	36	--	--	--	--	--	--	10.03	07–12–95
														9.17	09–29–95
43	--	Grand Ronde Water Association	--	D	290	10	8	--	--	--	--	--	--	5.98	06–30–95
														6.03	08–29–95
														5.92	09–27–95

Table 4. Data for field-located wells in the Grand Ronde area—Continued

Site-identification number	State ID number	Owner	Date drilled	Use	Altitude (ft)	Depth (ft)	Diameter (in)	Depth to open interval (ft BLS)		Driller's well test				Depth to water (ft BLS)	Water level date
								Top	Bottom	M	Y	D	P		
44	POLK440	Werth, Elmer	04–02–92	M	280	14	2	4	14	--	--	--	--	5.50	04–02–92 (D)
														0.60	06–22–95
														2.09	09–29–95
45	POLK1554	Soules, Bernice	08–17–60	U	325	90	6	12	90	B	1	60	5	10.00	08–17–60 (D)
														11.53	06–23–95
														11.61	09–27–95
47	POLK1558	Fry, Scott and Selene	12–04–65	U	360	242	6	180	242	B	1	200	3	30.00	01–08–65 (D)
														6.62	06–22–95
50	POLK339	Oregon Department of Transportation	08–05–91	M	350	9	2	4	9	--	--	--	--	7.20	08–05–91 (D)
														6.44	06–23–95
51	POLK338	Oregon Department of Transportation	08–05–91	M	350	9	2	4	9	--	--	--	--	7.30	08–05–91 (D)
														5.19	06–23–95
52	POLK337	Oregon Department of Transportation	08–05–91	M	350	8	2	3	8	--	--	--	--	7.30	08–05–91 (D)
														5.74	06–23–95
54	POLK1547	Jahn, Alvin	06–24–67	I	430	47	6	20	47	B	7	29	1	6.00	06–22–67 (D)
														5.02	06–23–95
														6.32	09–01–95
														6.03	09–26–95

Table 5. Summary of yield data for wells in the Grand Ronde area

[Well yield, Specific capacity, and Well depth data are provided only for wells with a documented driller's test; data for wells bearing unusable water are excluded; number in parentheses is number of wells from which median was determined; gpm, gallons per minute; gpm/ft, gallons per minute per foot; ft, feet; n/a, not applicable; --, data not available]

Section	Total number of wells	Well yield (gpm)			Specific capacity (gpm/ft)			Well depth (ft)			Comments
		Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	
Township 4S, Range 7W											
27	2	n/a	5 (1)	n/a	n/a	0.04 (1)	n/a	n/a	178 (1)	n/a	
34	1	n/a	12 (1)	n/a	n/a	--	n/a	n/a	222 (1)	n/a	
Township 5S, Range 7W											
1	2	3	4 (2)	5	n/a	.08 (1)	n/a	85	123 (2)	160	
2	1	n/a	10 (1)	n/a	n/a	.10 (1)	n/a	n/a	110 (1)	n/a	
3	1	n/a	1 (1)	n/a	n/a	2.00 (1)	n/a	n/a	73 (1)	n/a	
7	1	n/a	15 (1)	n/a	n/a	--	n/a	n/a	122 (1)	n/a	
10	1	n/a	3 (1)	n/a	n/a	.20 (1)	n/a	n/a	60 (1)	n/a	
11	2	2	11 (2)	20	.01	.27 (2)	.53	60	129 (2)	198	
12	9	2	7 (8)	30	.01	.03 (3)	.05	140	174 (8)	335	1 well unusable due to salt
13	3	3	7 (3)	7	.03	.08 (3)	.19	60	155 (3)	155	
20	1	n/a	6 (1)	n/a	n/a	.12 (1)	n/a	n/a	160 (1)	n/a	
21	2	5	7 (2)	9	.05	.18 (2)	.30	42	84 (2)	125	
23	1	n/a	3 (1)	n/a	n/a	.10 (1)	n/a	n/a	70 (1)	n/a	
24	8	1	5 (7)	14	.04	.12 (6)	.28	55	120 (7)	155	1 well unusable due to salt
25	1	n/a	4 (1)	n/a	n/a	.05 (1)	n/a	n/a	83 (1)	n/a	
26	3	< 1	< 1 (3)	1	n/a	.02 (1)	n/a	n/a	68 (3)	n/a	
28	2	1	4 (2)	8	n/a	.01 (1)	n/a	180	183 (2)	185	
33	2	6	9 (2)	12	.14	.19 (2)	.24	80	102 (2)	124	
34	2	2	6 (2)	10	.01	.51 (2)	1.00	26	158 (2)	290	
35	16	< 1	5 (16)	50	<.01	.05 (15)	1.20	52	102 (16)	198	
36	7	< 1	2 (7)	6	.01	.03 (6)	.09	44	98 (7)	300	
Township 5S, Range 8W											
30	1	n/a	10 (1)	n/a	n/a	--	n/a	n/a	270 (1)	n/a	
33	1	n/a	6 (1)	n/a	n/a	.20 (1)	n/a	n/a	66 (1)	n/a	
35	1	n/a	13 (1)	n/a	n/a	.33 (1)	n/a	n/a	60 (1)	n/a	
36	3	3	5 (2)	6	.06	.18 (2)	.30	42	52 (2)	62	

Table 5. Summary of yield data for wells in the Grand Ronde area—Continued

Section	Total number of wells	Well yield (gpm)			Specific capacity (gpm/ft)			Well depth (ft)			Comments
		Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	
Township 5S, Range 9W											
12	1	n/a	6 (1)	n/a	n/a	0.05 (1)	n/a	n/a	150 (1)	n/a	
25	2	< 1	1(2)	2	n/a	<.01 (1)	n/a	110	119 (2)	127	
35	1	n/a	7 (1)	n/a	n/a	.06 (1)	n/a	n/a	120 (1)	n/a	
36	1	n/a	17 (1)	n/a	n/a	.12 (1)	n/a	n/a	298 (1)	n/a	
Township 6S, Range 7W											
1	10	4	7 (5)	10	.05	.10 (5)	.48	80	92 (5)	138	1 well unusable due to salt
2	2	n/a	10 (1)	n/a	n/a	.18 (1)	n/a	n/a	72 (1)	n/a	1 well unusable due to salt
3	1	n/a	16 (1)	n/a	n/a	--	n/a	n/a	140(1)	n/a	
4	1	n/a	5 (1)	n/a	n/a	.03 (1)	n/a	n/a	200 (1)	n/a	
5	2	< 1	2 (2)	5	n/a	.06 (1)	n/a	75	90 (2)	105	
6	6	2	5 (5)	7	.07	.13 (3)	.35	57	65 (5)	80	1 well unusable due to salt
8	11	< 1	4 (4)	12	.01	.05 (4)	.33	65	73 (4)	185	2 wells unusable due to salt
9	10	2	7 (4)	8	.01	.12 (4)	.36	50	105 (4)	195	
12	6	1	4 (6)	8	.01	.05 (4)	.06	62	154 (6)	300	
13	9	0	5 (9)	6	.02	.05 (6)	.17	50	150 (9)	360	
14	1	n/a	0 (1)	n/a	n/a	.00 (1)	n/a	n/a	155 (1)	n/a	
15	4	1	3 (4)	15	.02	.16 (4)	.88	35	63 (4)	110	
17	1	n/a	1 (1)	n/a	n/a	.01 (1)	n/a	n/a	200 (1)	n/a	
18	4	3	5 (3)	5	.14	.32 (2)	.50	40	70 (3)	120	1 well unusable due to salt
19	1	n/a	6 (1)	n/a	n/a	.08 (1)	n/a	n/a	224 (1)	n/a	
21	3	2	2 (3)	9	.01	.13 (3)	.23	37	51 (3)	200	
22	2	2	4 (2)	6	.01	.02 (2)	.02	250	282 (2)	314	
23	6	< 1	8 (6)	16	.01	.01 (3)	.32	70	152 (6)	302	

Table 5. Summary of yield data for wells in the Grand Ronde area—Continued

Section	Total number of wells	Well yield (gpm)			Specific capacity (gpm/ft)			Well depth (ft)			Comments
		Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	
Township 6S, Range 7W—Continued											
24	3	8	15 (3)	15	0.33	0.33 (3)	0.36	62	113 (3)	180	
26	1	n/a	10 (1)	n/a	n/a	.19 (1)	n/a	n/a	72 (1)	n/a	
27	1	n/a	0 (1)	n/a	n/a	.00 (1)	n/a	n/a	149 (1)	n/a	
28	1	--	--	--	--	--	--	--	--	--	
31	2	0	0 (2)	0	.00	.00 (2)	.00	79	190 (2)	300	
35	13	1	10 (12)	300	.01	.48 (10)	5.00	35	138 (12)	540	1 well unusable due to salt
36	5	0	4 (5)	12	.00	.02 (4)	.14	47	155 (5)	400	
Township 6S, Range 8W											
1	3	0	<1 (3)	10	.00	.25 (2)	.50	46	120 (3)	220	
2	3	1	3 (3)	3	.02	.02 (2)	.02	80	140 (3)	212	
3	3	7	13 (3)	14	.18	.32 (3)	.43	51	58 (3)	158	
7	4	3	8 (3)	16	n/a	--	n/a	60	98 (3)	232	1 well unusable due to salt
9	1	n/a	3 (1)	n/a	n/a	.04 (1)	n/a	n/a	160 (1)	n/a	
10	3	< 1	3 (3)	7	.01	.03 (3)	.24	47	89 (3)	138	
11	1	n/a	5 (1)	n/a	n/a	.08 (1)	n/a	n/a	130 (1)	n/a	
12	4	n/a	14 (1)	n/a	n/a	.44 (1)	n/a	n/a	63 (1)	n/a	
13	5	1	3 (4)	8	.01	.08 (4)	.27	60	78 (4)	242	1 well unusable due to sulphur
14	3	2	3 (3)	5	.02	.05 (2)	.07	46	138 (3)	220	
15	2	2	5 (2)	7	n/a	.02 (1)	n/a	100	110 (2)	120	
16	1	n/a	2 (1)	n/a	n/a	.03 (1)	n/a	n/a	78 (1)	n/a	
25	1	n/a	30 (1)	n/a	n/a	1.20 (1)	n/a	n/a	54 (1)	n/a	
Township 7S, Range 7W											
7	1	n/a	11 (1)	n/a	n/a	--	n/a	n/a	280 (1)	n/a	

Table 6. Data for field-located springs in the Grand Ronde area

[Site-identification number corresponds to the site-identification number in table 2 and on figure 1; ft, feet; ft^3/s, cubic feet per second; U, unused; D, domestic; P, public supply; --, not available; e, estimated]

Site-identification number	Owner	Use	Altitude (ft)	Discharge: Yield (ft^3/s)	Discharge: Measurement Date	Tributary to
6	--	U	860	0.06	06–29–95	Cosper Creek
7	--	U	1,010	.04	06–29–95	Cosper Creek
8	--	U	900	--	06–29–95	Agency Creek
9	--	U	805	--	06–29–95	Agency Creek
10	--	U	800	.08	06–29–95	Agency Creek
11	--	U	800	.02	06–29–95	Agency Creek
12	--	U	860	--	06–29–95	Agency Creek
14	--	U	940	.02	07–11–95	Cosper Creek. tributary
15	--	U	1,020	e .08	07–11–95	Cosper Creek. tributary
24	Grand Ronde Forestry Division	U	445	--	06–20–95	--
42	Werth	D	350	--	06–23–95	--
60	Rock Creek Hideout	P	880	.09	08–23–95	--
63	Grand Ronde Water Association	P	2,010	1.3	08–30–95	Rock Creek
65	--	--	2,100	.16	08–02–95	Salmon River
66	--	U	2,840	.06	09–29–95	Rock Creek

Although subbasin base-flow yields and precipitation both vary across the basin, the relationship between these two parameters is ambiguous. Subbasin base-flow yields normalized by precipitation are small and range over only one order of magnitude. These numbers indicate that the study area as a whole lacks substantial sources of naturally stored water (such as ground water or wetlands), which could sustain higher streamflows during periods of low precipitation.

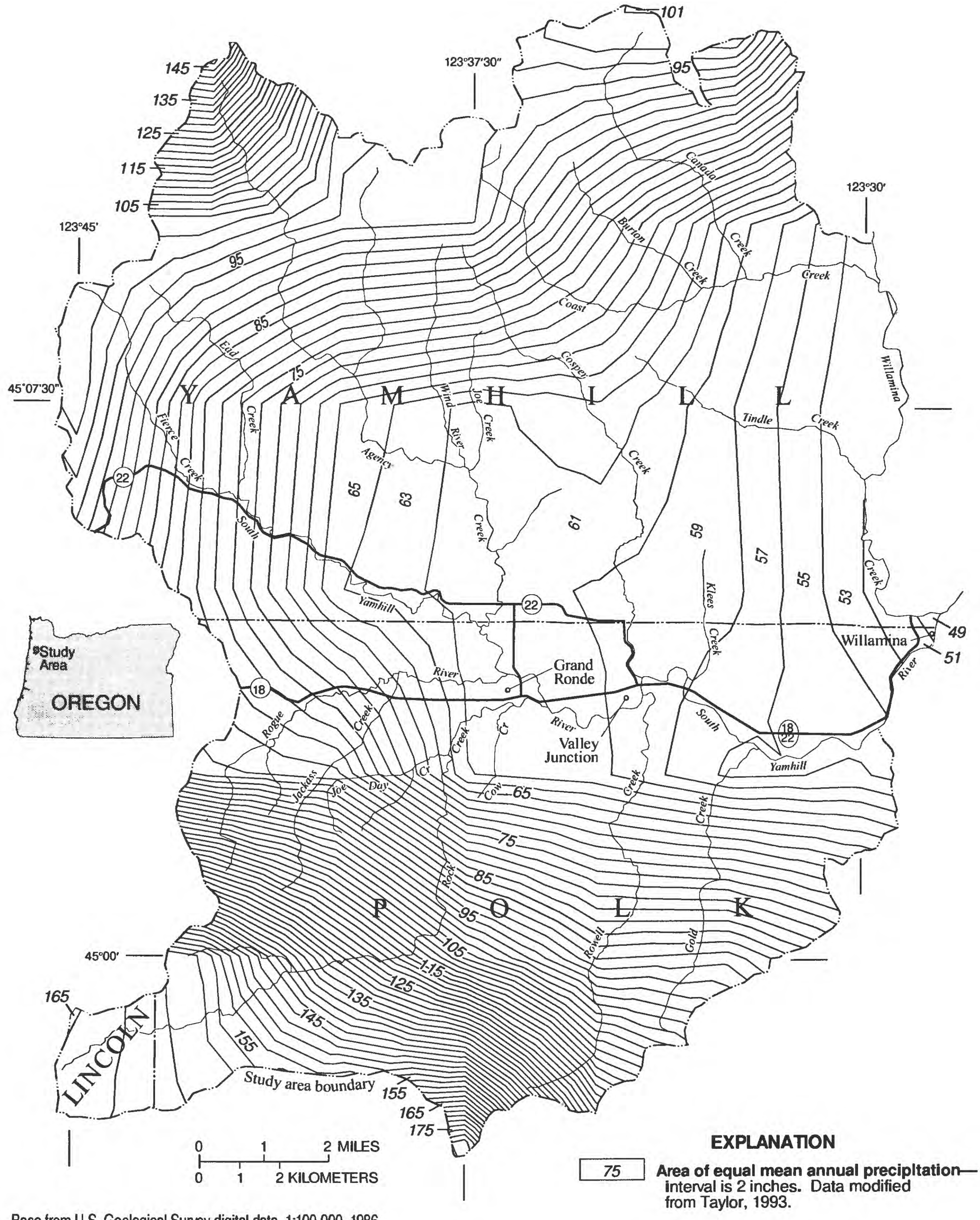
Daily mean discharge of the Wind River, which drains a 2.35-square-mile subbasin in the north central part of the study area and drains into Agency Creek, is compared with discharges of the South Yamhill River and Willamina Creek in figure 4. The striking similarity in the shape of the three hydrographs illustrates that the temporal distribution of runoff is similar throughout the study area, and indicates that effects on runoff response from variations in the geology and soils of the basin are small. In fact, no clear relationship between subbasin yield and the geologic material of the subbasin was noted throughout the area.

WATER QUALITY

To provide insight into the general quality of water in the basin, water samples were collected from 10 streams, 2 springs, and 3 wells within the study area (pl. 1, table 2, fig. 1). The water-quality constituents measured included nitrogen and phosphorus compounds, commonly referred to as nutrients (table 8); major ions (table 9); and total dissolved solids, specific conductance, alkalinity, sodium adsorption ratio, dissolved residue, and hardness (table 10).

Data-Collection Methods

Stream samples were collected using either the equal-width increment method (Edwards and Glysson, 1988) or a grab method; spring samples were collected using a grab method; well samples were collected from the tap prior to any storage, filtration, or chlorination. Sample processing was conducted according to the methods of M.A. Sylvester, L.R. Kister, and W.B. Garrett (U.S. Geological Survey, written commun., 1990). Specific conductance and temperature were determined in the field using standard USGS procedures (M.A. Sylvester, L.R. Kister, and W.B. Garrett, U.S. Geological Survey, written commun., 1990). All other analyses were performed by the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado. Fishman and Friedman (1989)



Base from U.S. Geological Survey digital data, 1:100,000, 1986
Universal Transverse Mercator projection, Zone 10

Figure 3. Mean annual precipitation for the Grand Ronde area.

Table 7. Subbasin base-flow yield and precipitation data for the Grand Ronde area, August 1996

[Source: Precipitation data provided by the Oregon Climate Service, Oregon State University; Site-identification number corresponds to the site-identification number in table 2 and on figure 1; Subbasin base-flow yield, subbasin base-flow discharge divided by the drainage area of the subbasin; Normalized subbasin base-flow yield, subbasin base-flow yield divided by the mean annual precipitation of the subbasin; ft^3/s, cubic feet per second; mi^2, square miles; $ft^3/s/mi^2$, cubic feet per second per square mile; in, inch; $ft^3/s/mi^2/in$, cubic feet per second per square mile per inch]

Site-identification number	Stream	Date	Base-flow discharge (ft^3/s)	Drainage area (mi^2)	Subbasin base-flow yield ($ft^3/s/mi^2$)	Mean annual precipitation (in)	Normalized subbasin base-flow yield ($ft^3/s/mi^2/in$)
3	Coast Creek	08–26–96	5.5	23	0.24	79	3×10^{-3}
5	Tindle Creek	08–27–96	.1	6.1	.02	59	3×10^{-4}
22	South Yamhill	08–26–96	6.1	23	.27	79	3×10^{-3}
23	Agency Creek	08–27–96	4.2	27	.15	84	2×10^{-3}
30	Gold Creek	08–26–96	.7	7.8	.09	78	1×10^{-3}
38	Klees Creek[1]	08–27–96	<.1	2.5	.02	59	3×10^{-4}
40	Rowell Creek	08–26–96	2.0	13	.16	94	2×10^{-3}
41	Cosper Creek	08–26–96	.6	11	.05	65	8×10^{-4}
46	Rock Creek[2]	08–27–96	6.5	25	.26	122	2×10^{-3}
53	Rogue River	08–26–96	1.1	10	.11	86	1×10^{-3}
TOTAL STUDY AREA						85	

[1] Estimated discharge.

[2] Measured discharge was 5.75 cubic feet per second. 0.75 cubic feet per second was added to that value to account for mean annual withdrawals from the subbasin for Grand Ronde domestic water supply.

provide a description of the analytical procedures used at the NWQL.

Quality Assurance

Procedures used in the field to assure the quality of data included processing of blank samples and frequent calibration of meters. Blank samples were prepared by processing deionized water in the same manner as environmental samples. Specific conductance meters were calibrated once each day. In addition to the procedures used in the field, standard quality-assurance procedures were used at the NWQL (Pritt and Raese, 1995).

The results of blank sample analyses are shown along with the environmental data in tables 8, 9, and 10. Concentrations of phosphorus of the same order of magnitude as environmental samples were detected in two blanks, but the very low concentrations of phosphorus in all environmental samples indicate that sample contamination with phosphorus compounds was not a significant problem. Calcium and silica were detected in blanks, but generally at concentrations more than two orders of magnitude lower than the environmental samples. Specific conductance measured in one blank suggested that the sample may have been contaminated, but the value was substantially lower than those measured in the environmental samples and, therefore, did not impair the qualitative interpretation of the data.

Discussion of Water-Quality Characteristics

Stream water sampled throughout the study area had very similar characteristics, with relatively low concentrations of solutes. The two springs had water-quality characteristics very similar to surface water, suggesting that this water follows fairly shallow, short subsurface flow paths. Ground water from well 43 was similar in quality to spring water, probably because this well is only 10 feet deep. Relative to surface water and shallow ground water, ground water from well 27 (251 feet deep) and well 54 (47 feet deep) had higher total dissolved solids and specific conductance, probably due at least partially to the longer subsurface flow paths followed by deeper ground water and the normal dissolution of aquifer material as ground water flows through the subsurface.

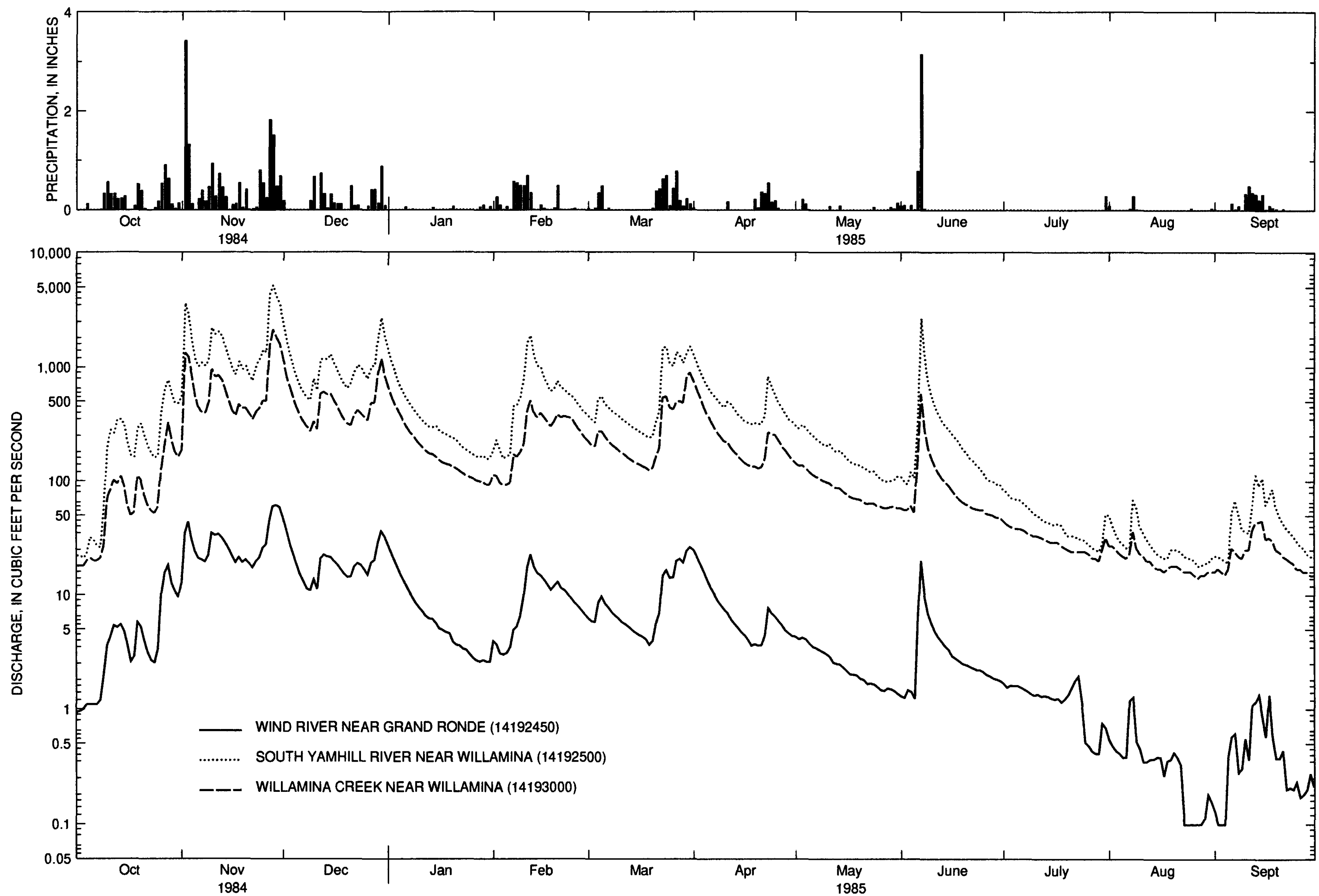


Figure 4. Daily mean discharge for the Wind River near Grand Ronde (14192450), the South Yamhill River near Willamina (14192500) and Willamina Creek near Willamina (14193000), water year 1985. (Note that discharge is logarithmic.)

Table 8. Concentrations of nitrogen and phosphorus compounds in surface water and ground water of the Grand Ronde area, 1995

[Site-identification number corresponds to the site-identification number in table 2 and on figure 1; number in parentheses is laboratory parameter code; mg/L, milligrams per liter; --, no data available; n/a, not applicable]

Site-identification number	Date	Ammonia, dissolved (00608) (mg/L as N)	Nitrite, dissolved (00613) (mg/L as N)	Ammonia plus organic nitrogen, dissolved (00623) (mg/L as N)	Ammonia plus organic nitrogen, total (00625) (mg/L as N)	Nitrite plus nitrate, dissolved (00631) (mg/L as N)	Phosphorus, total (00665) (mg/L as P)	Phosphorus, dissolved (00666) (mg/L as P)	Orthophosphate, dissolved (00671) (mg/L as P)
Streams									
18	08–30–95	<0.015	<0.01	<0.2	<0.2	0.11	<0.01	<0.01	<0.01
20	08–30–95	.020	<.01	<.2	<.2	.22	<.01	<.01	<.01
25	08–29–95	<.015	<.01	<.2	<.2	<.05	<.01	<.01	<.01
29	09–01–95	<.015	<.01	<.2	<.2	<.05	<.01	<.01	<.01
32	08–30–95	<.015	<.01	<.2	<.2	.13	.02	<.01	.02
34	08–29–95	<.015	<.01	<.2	<.2	.14	.05	.02	.01
48	08–31–95	<.015	<.01	<.2	<.2	.10	.05	<.01	.02
55	08–31–95	<.015	<.01	<.2	<.2	.06	<.01	<.01	<.01
57	08–31–95	<.015	<.01	<.2	<.2	.14	<.01	<.01	<.01
61	08–31–95	<.015	<.01	<.2	<.2	<.05	<.01	<.01	<.01
Springs									
60	08–31–95	<.015	<.01	<.2	--	.18	--	<.01	.02
63	08–30–95	.020	<.01	<.2	--	.07	--	<.01	.02
Wells									
27	09–01–95	.48	<.01	.4	--	<.05	--	<.01	<.01
43	08–29–95	<.015	<.01	<.2	--	.26	--	.02	.01
54	09–01–95	.62	<.01	.6	--	<.05	--	.11	.12
Blanks									
n/a	08–29–95	<.015	<.01	<.2	<.2	<.05	.07	.03	.03
n/a	08–31–95	<.015	<.01	<.2	<.2	<.05	<.01	<.01	<.01
n/a	09–05–95	<.015	<.01	<.2	<.2	<.05	.03	<.01	<.01

Table 9. Concentrations of dissolved major ions in surface water and ground water of the Grand Ronde Area, 1995

[Site-identification number corresponds to the site-identification number in table 2 and on figure 1; number in parentheses is laboratory parameter code; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data available; n/a, not applicable]

Site-identification number	Date	Calcium (00915) (mg/L)	Magnesium (00925) (mg/L)	Sodium (00930) (mg/L)	Potassium (00935 (mg/L))	Chloride (00940) (mg/L)	Sulfate (00945) (mg/L)	Fluoride (00950) (mg/L)	Silica (00955) (mg/L as SiO_2)	Iron (01046) (µg/L)	Manganese (01056) (µg/L)	Arsenic (01000) (µg/L)	Boron (01020) (µg/L)	Bromide (71870) (mg/L)
						Streams								
18	08–30–95	5.5	1.6	5.5	0.4	4.4	5.5	<0.1	13	95	4	--	--	--
20	08–30–95	6.8	2.3	6.8	.4	5.2	2.4	<.1	17	97	2	--	--	--
25	08–29–95	11	3.6	8.3	1.0	6.0	2.6	<.1	16	640	22	--	--	--
29	09–01–95	7.5	2.1	7.0	.6	8.6	4.3	<.1	13	140	6	--	--	--
32	08–30–95	12	5.6	7.4	.3	5.1	1.5	<.1	19	77	3	--	--	--
34	08–29–95	6.5	2.2	5.0	.4	3.6	2.6	<.1	16	42	1	--	--	--
48	08–31–95	7.1	2.2	6.8	.6	5.0	3.3	<.1	15	280	3	--	--	--
55	08–31–95	6.5	2.2	5.5	.4	4.3	3.6	<.1	14	76	3	--	--	--
57	08–31–95	5.6	2.0	5.6	.3	3.8	3.9	<.1	14	19	<1	--	--	--
61	08–31–95	4.2	1.4	3.8	.3	2.9	2.8	<.1	11	100	1	--	--	--
						Springs								
60	08–31–95	12	4.1	7.9	.2	4.5	2.7	<.1	24	<3	<1	<1	<10	<0.01
63	08–30–95	7.2	3.0	4.1	.2	3.3	.8	<.1	23	<3	<1	<1	<10	.02
						Wells								
27	09–01–95	38	3.4	75	.6	8.4	150	.3	19	30	32	<1	560	.04
43	08–29–95	13	1.8	7.9	.9	3.8	14	<.1	15	81	27	<1	20	.03
54	09–01–95	1.2	.2	120	.5	22	3	.3	12	12	2	<1	450	.10
						Blanks								
n/a	08–29–95	<.02	<.01	<.2	<.1	<.1	<.1	<.1	.01	<3	<1	--	--	--
n/a	08–31–95	.02	<.01	<.2	<.1	<.1	<.1	<.1	.04	<3	<1	--	--	--
n/a	09–05–95	.03	<.01	<.2	<.1	<.1	<.1	<.1	<.01	<3	<1	--	--	--

Table 10. Miscellaneous water-quality data for the Grand Ronde area, 1995

[Site-identification number corresponds to the site-identification number in table 2 and on figure 1; number in parentheses is laboratory parameter code; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; --, no data available; n/a, not applicable]

Site-identification number	Date	Dissolved solids (70301) (mg/L)	Specific conductance (90095) (µS/cm)	Alkalinity (90410) (mg/L as $CaCO_3$)	Sodium adsorption ratio (00931)	Temperature (00010) (°C)	pH, Lab (00403) (standard pH units)	Dissolved residue at 180°C (70300) (mg/L)	Hardness (00900) (mg/L as $CaCO_3$)
Streams									
18	08–30–95	50	71	22	0.5	14.4	7.3	53	20
20	08–30–95	61	85	32	.6	13.8	7.3	64	26
25	08–29–95	79	120	50	.6	--	7.3	82	42
29	09–01–95	60	91	28	.6	19.8	7.1	62	27
32	08–30–95	87	134	59	.4	--	7.5	89	53
34	08–29–95	55	75	30	.4	--	7.0	58	25
48	08–31–95	61	88	33	.6	11.7	7.5	64	27
55	08–31–95	54	77	29	.5	14.5	7.3	57	25
57	08–31–95	51	70	26	.5	14.5	7.2	54	22
61	08–31–95	38	52	19	.4	14.8	7.7	40	16
Springs									
60	08–31–95	89	122	55	.5	9.2	7.3	88	47
63	08–30–95	63	78	35	.3	7.6	7.0	63	30
Wells									
27	09–01–95	352	529	93	3	12.3	8.1	360	110
43	08–29–95	81	119	38	.5	14.3	7.0	81	40
54	09–01–95	301	511	233	27	11.9	9.0	305	4
Blanks									
n/a	08–29–95	--	2	1.4	0	--	7.6	3	0
n/a	08–31–95	--	2	1.5	0	--	7.7	2	0
n/a	09–05–95	--	21	1.3	0	--	7.8	<1	0

The elevated ammonia concentrations in wells 27 and 54 were probably due largely to sources such as animal or domestic waste, but may also have resulted partially from the biodegradation of naturally occurring organic matter, or the microbial reduction of nitrate from waste or fertilizer. Elevated sulfate and boron in well 27 and elevated orthophosphate and boron in well 54 also may have been due to normal mineralization of aquifer material, or may have resulted from a nearby source of domestic waste. Elevated chloride in well 54 likely was due to mixing with naturally occurring saline ground water, but may have resulted partially from a waste source, also. Although these data suggest that shallow ground-water quality in the populated valley floors may be slightly influenced by animal or domestic wastes, any impact is slight at this time.

A distinctive odor associated with water from well 54, along with reduced sulfate and elevated alkalinity relative to other wells, indicate that sulfate reduction of organic matter is occurring in this water. A similar odor was associated with well 45, and comments on the driller's log for another well in this same section (63 feet deep) indicated that the well was unusable due to the presence of sulfur (table 5).

Surface water and ground water sampled throughout the study area were generally of good quality. However, as indicated in table 5, water with a high enough salt content to render it unusable was reported on 10 of the 206 available drillers' logs for wells in the vicinity of the study area. The occurrence of saline ground water has been previously documented in numerous investigations of the western Willamette Valley and foothills of the Coast Range (Piper, 1942; Baldwin, 1964; Newton, 1969; Gonthier, 1983; Caldwell, 1993; and Woodward and Gannett, in press). Such saline waters are generally associated with marine sediments and are reported to occur most commonly in valleys or other relatively flat topographic settings (Gonthier, 1983; Caldwell, 1993); Woodward and Gannett (in press) suggest that such saline water may migrate upward along faults and tight folds. However, the distribution of subsurface saltwater in the area does not follow an obvious, consistent pattern and its occurrence is not possible to predict.

SUMMARY AND CONCLUSIONS

Data collected during this study and results of earlier studies in the general area indicate that further development of water resources in the Grand Ronde area will be limited by existing surface-water rights, which fully appropriate streamflow at the mouth of the basin during the months of July through October, and the low permeability of the geologic formations that underlie the region, which restricts aquifer yields. Although more permeable sediments typically occur adjacent to and beneath streams, their limited extent restricts their value as a water source. Furthermore, such alluvial aquifers are typically hydraulically connected to the adjacent streams, and pumping from them would likely deplete the adjacent streamflow and adversely affect downstream water users.

Although precipitation throughout the study area is generally ample, there is little natural storage of water within the basin because of the low permeability of subsurface materials and the lack of wetlands. As a result, sharply decreasing streamflows during periods of low precipitation are a further impediment to the development of the area's water resources. Even though streamflow and precipitation were much greater during the study period than long-term averages, the limited natural storage capacity of the basin was still apparent.

Stream water sampled throughout the study area was of good quality. The water quality of sampled springs and wells was also generally good, but saline ground water has been reported on a number of drillers' logs for the study area and in several previous investigations of nearby areas.

Because of the uneven seasonal distribution of runoff in the basin, development of artificial storage capacity to capture available water from streams or springs may be the most feasible approach to developing a reliable, sustainable water supply for the Grand Ronde area. Monthly discharge measurements to quantify the water available from springs in the area and determine the magnitude of seasonal fluctuations in discharge would provide information necessary for optimal development of water resources for users in the Grand Ronde area.

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