

Hydrogeology of the Unconsolidated Sediments, Water Quality, and Ground-Water/Surface-Water Exchanges in the Methow River Basin, Okanogan County, Washington

Water-Resources Investigations Report 03-4244

Prepared in cooperation with
OKANOGAN COUNTY



Photograph of the Methow River flowing through a forested floodplain in June 2002 near Fawn Creek, Mazama, Washington.
Photograph taken by Christopher Konrad, U.S. Geological Survey.

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By Christopher P. Konrad, Brian W. Drost, *and* Richard J. Wagner

U.S. GEOLOGICAL SURVEY

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OKANOGAN COUNTY

Tacoma, Washington
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CONVERSION FACTORS AND DATUMS

CONVERSION FACTORS

	Multiply	By	To obtain
acre-foot (acre-ft)		1,233	cubic meter
cubic foot per second (ft ³ /s)		0.02832	cubic meter per second
cubic foot per second per square mile [(ft ³ /s)/mi]		0.01093	cubic meter per second per square kilometer
foot (ft)		0.3048	meter
foot per day (ft/d)		0.3048	meter per day
foot per year (ft/yr)		0.3048	meter per year
gallon per minute (gal/min)		0.06309	liter per second
inch (in.)		2.54	centimeter
inch (in.)		25.4	millimeter
mile (mi)		1.609	kilometer
square mile (mi ²)		2.590	square kilometer

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

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8.$$

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

DATUMS

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Hydrogeology of the Unconsolidated Sediments, Water Quality, and Ground-Water/Surface-Water Exchanges in the Methow River Basin, Okanogan County, Washington

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ABSTRACT

The U.S. Geological Survey, in cooperation with Okanogan County, investigated the hydrogeology of the unconsolidated sedimentary deposits in the Methow River Basin, the quality of surface and ground waters, and the exchanges between ground water and surface water. Alluvium (Qa) and glaciofluvial sediments (Qga) deposited during the Quaternary period constitute the primary aquifer in the Methow River Basin, which is used as a source of water for domestic and public-water supplies and for maintaining streamflow during seasonal dry periods. The sediments form a nearly continuous unit along the valley bottom from above the Lost River to the confluence of the Methow and Columbia Rivers, covering more than 45 square miles of the basin's surface. There are no distinct units within the deposit that can be identified across or along the valley except for fragments of a possible lake bed near the town of Twisp. Ground-water levels in the unconsolidated aquifer are highest during the summer and lowest in the winter and early spring.

Ground water and surface water, sampled during June and September 2001, generally were of high quality. Only two samples from domestic and municipal wells indicated the possibility of ground-water contamination from nitrate and arsenic concentrations. In both cases, potential contamination was isolated to an individual well. No trends in water quality were apparent when comparing the results of this investigation with previous studies.

The flow of water between rivers and aquifers is important for regulating the availability of water resources for in-stream and out-of-stream uses in the

Methow River Basin. Ground-water discharge from the unconsolidated aquifer to the Methow River from Lost River to Pateros ranged from an estimated 153,000 acre-ft in water year 2001 to 157,000 acre-ft in water year 2002. In contrast, ground-water discharge to the lower Twisp River from Newby Creek to near Twisp ranged from 4,700 acre-ft in water year 2001 to 9,200 acre-ft in water year 2002. The Methow and Twisp Rivers, among others in the basin, are major sources of recharge for the unconsolidated aquifer, particularly during high-flow periods in May and June. Aquifer recharge by both rivers increased with streamflow in water year 2002 compared to water year 2001 as indicated by daily losses of streamflow. Aquifer recharge by the Methow River from Lost River to Pateros was estimated to be 82,000 acre-ft in water year 2001 and 137,000 acre-ft in water year 2002. Aquifer recharge by the Twisp River from Newby Creek to near Twisp was estimated to be 2,000 acre-ft in water year 2001 and 6,400 acre-ft in water year 2002.

Seepage from unlined irrigation canals also recharges the unconsolidated aquifer during the late spring and summer and may contribute as much 38,000 acre-ft annually to aquifer recharge in the basin. Some portion of this ground water returns to rivers as indicated by a seasonal increase in ground-water discharge in the Methow River from Winthrop to Twisp and in the lower Twisp River during late summer and early autumn. Although the increase is likely due primarily to irrigation canal seepage, however, fluvial recharge during the summer also may have contributed to the increase. The increased rate of ground-water discharge decays by January in both reaches.

INTRODUCTION

Water is an important resource to people and aquatic ecosystems in the Methow River Basin in north-central Washington State (fig. 1). Effective water-resources management for societal and ecological objectives begins with an understanding of the availability and quality of water, which varies by season and location in the basin. In 2000, the U.S. Geological Survey (USGS), in cooperation with Okanogan County and with support from the USGS Ground-Water Resources Program, began a study of three aspects of water resources in the Methow River Basin: the hydrogeology of unconsolidated sedimentary deposits, which serve as the primary ground-water resource for human uses and as the source of baseflow in rivers and streams; the quality of surface and ground waters; and the exchanges between ground water and surface water, which influence the availability of water for in-stream and out-of-stream uses. The three components of this investigation address recommendations developed by the Methow Valley Ground Water Management Advisory Committee (1994) for the development of water information in the basin. Moreover, the information will contribute to the scientific basis for water-resources management by the Methow Basin Planning Unit, established under the authority of Washington State Engrossed Substitute House Bill 2514.

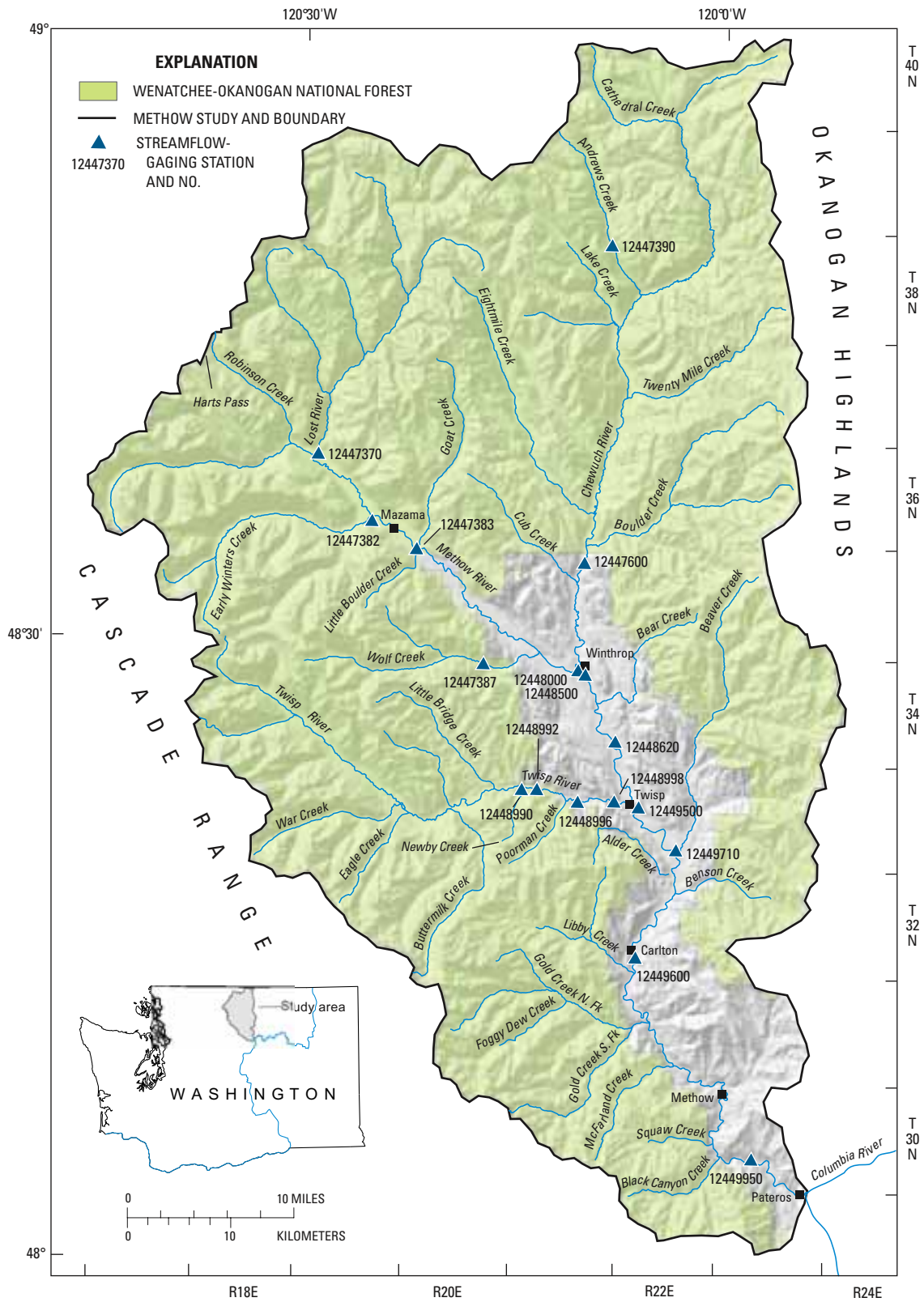
Hydrologic processes in the Methow River Basin reflect the distinct seasons in the region's climate, characterized by cold winters with abundant snowfall at higher altitudes and warm, dry summers. During the spring and early summer, snowmelt recharges shallow aquifers and raises streamflow. By late summer, however, snow has melted from most of the basin and precipitation (either snow or rain) generally is scarce until autumn or winter. As a result, the availability of water resources is limited from late summer through winter. The limited availability of water resources in the Methow River Basin is most evident for rivers and streams in the late summer and early autumn, when surface water continues to be appropriated for

agricultural and domestic uses but also provides habitat for spawning and rearing of endangered salmon (upper Columbia River Basin spring chinook).

The availability of ground-water resources is controlled by the occurrence of geologic formations that can store water (aquifers) and the flow of water into those formations (recharge). The availability of surface-water resources is controlled by the location of river and stream channels in the landscape, runoff of snowmelt and rainfall from hillslopes, and ground-water discharge from aquifers into the channels. Ground-water and surface-water resources are linked by the flow of water between rivers and aquifers such that both the quantity and quality of these resources depend on each other.

Purpose and Scope

This report describes the hydrogeology of unconsolidated sediments that fill the Methow River valley, the quality of ground and surface waters, and exchanges between ground and surface waters. The description of hydrogeologic units of the unconsolidated sediments is based on a review of well logs and other geologic investigations. The description of the unconsolidated units includes their extent and thickness, a discussion of confining material, and estimates of hydraulic conductivity. A map of ground-water levels in the unconsolidated sediments and seasonal fluctuations was constructed from water-level measurements made between November 2000 and July 2001. Water quality in the basin was assessed using ground-water and surface-water samples collected throughout the basin in June and September 2001 and analyzed for various constituents. Spatial and temporal patterns in exchanges between rivers and shallow unconsolidated aquifers were analyzed using streamflow measurements made in September 2001, February 2002, and September 2002, and surface-water discharge balances for water years 2001 and 2002. A water year begins on October 1 of the previous calendar year and ends on September 30.



Base from U.S. Geological Survey Digital Data, 1:100,000, 1985
 Universal Transverse Mercator projection,
 Zone 10, Datum NAD 83

Figure 1. Location of study area and streamflow-gaging stations in the Methow River Basin, Okanogan County, Washington.

Aquifer recharge due to seepage from irrigation canals in the basin was estimated from surface-water discharge balances for selected canals. Continuous monitoring of ground-water levels and a surface-water discharge balance were used to analyze the influence of aquifer recharge due to irrigation-canal seepage on streamflow in the lower Twisp River. The Modular Modeling System (MMS) was used to develop a water budget for the Methow River Basin for water years 1992-2001.

Acknowledgments

Many organizations contributed to and participated in the investigation including the Okanogan County Department of Water Resources, the Methow Basin Planning Unit, the Washington State Department of Ecology, the Washington Department of Fish and Wildlife, the U.S. Forest Service, and the U.S. Bureau of Reclamation. Their assistance is appreciated. The Twisp Valley Power and Irrigation Company (TVPI) allowed the U.S. Geological Survey to conduct detailed monitoring of their irrigation system and helped to get the involvement of landowners in the investigation. Marty Williams, manager of the TVPI Canal, contributed much of his time to help with the investigation. His willingness to participate in the investigation and his diligence to canal operations and reporting were invaluable. The participation of other irrigation companies and districts that provided access to their canals for discharge measurements also is greatly appreciated. Finally, this project could not have been possible without the support of hundreds of private landowners in the Methow River Basin who gave the U.S. Geological Survey access to their land and wells.

Description of Study Area

The Methow River drains 1,810 mi² in north-central Washington and is a tributary to the Columbia River (fig. 1). The Cascade Range forms the western boundary of the basin and the Okanogan Highlands form the eastern boundary. Land-surface altitudes range from 8,950 ft above NAVD 88 in the Cascade Range to 775 ft at the Methow River's confluence with the Columbia River. Major tributaries include the Lost River, Early Winters Creek, Wolf Creek, the Chewuch River, and the Twisp River. The population in the Methow River Basin was about 4,700 in 2000 (Washington State Office of Financial Management, 2002), with most people living in the valley. The largest towns are Twisp and Winthrop.

Most of the Methow River Basin and all its headwaters are in the Wenatchee-Okanogan National Forest. Land uses in the National Forest include recreation, grazing, and timber harvesting. Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), and ponderosa pine (*Pinus ponderosa*) forests cover mid-altitude (2,000 to 5,000 ft) areas of the basin. Shrub-steppe communities with bitter brush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), and bunchgrasses (such as *Agropyron inermi*) are common at altitudes less than 4,000 ft, and subalpine fir (*Abies lasiocarpa*), Pacific silver fir (*Abies amabilis*), mountain hemlock (*Tsuga mertensiana*), whitebark pine (*Pinus albicaulis*), and subalpine larch (*Larix lylli*) are common at altitudes greater than 3,000 ft. Deciduous trees including black cottonwood (*Populus trichocarpa*) and aspen (*Populus tremuloides*) occupy valley bottoms and riparian areas. Historically, fire was the dominant landscape process influencing the structure, composition, and extent of vegetation communities in the Methow River Basin (Knott and others, 1998).

There is a steep precipitation gradient across the basin, with high-altitude areas on the western side of the basin receiving about 80 in. annually and areas in the lower river valley receiving 12 in. For water years 1984 to 2002, mean annual precipitation was 54 in. at Harts Pass, 22 in. at Mazama, and 14 in. at Winthrop. The basin receives most of its precipitation as snow during winter. Precipitation during November through February accounted for 57 percent of the total precipitation at Harts Pass, 60 percent of the total precipitation at Mazama, and 53 percent of the total precipitation at Winthrop (Natural Resource Conservation Service, 2003; Western Regional Climate Center, 2003a and 2003b).

A drought persisted over much of the Pacific Northwest during water year 2001, with below normal snowpack and streamflow throughout the region. Annual precipitation at Harts Pass, which generally represents snowpack conditions producing most of the runoff in the Methow River Basin, was 32 in. in water year 2001, compared to 65 in. in water year 2002 (National Resource Conservation Service, 2003). Likewise, annual precipitation at Mazama was 12 in. in water year 2001 compared to 22 in. in water year 2002 (Western Regional Climate Center, 2003a). Precipitation was less affected by the drought in the more arid parts of the basin. For example, annual precipitation at Winthrop was 8 in. in water year 2001 compared to 10 in. in water year 2002 (Western Regional Climate Center, 2003b).

Streamflow records from the Methow River near Pateros (12449950, [fig. 1](#)) for water years 1960-2002 illustrate seasonal hydrologic patterns in the basin. Mean annual discharge of the Methow River near Pateros was 1,550 ft³/s, which is equivalent to annual runoff of 1.1 million acre-ft. Streamflow is unevenly distributed during the year, with high flows in late spring and early summer and low flows in late summer and winter. For example, the mean monthly discharge of the Methow River near Pateros was 4,932 ft³/s for May and 5,915 ft³/s for June, which, combined, account for nearly 60 percent of the mean annual

discharge of the river. Mean monthly discharge of the Methow River near Pateros was 423 ft³/s for January and 420 ft³/s for February, although streamflow also is low in September, when the mean monthly discharge was 444 ft³/s.

Geology

The Methow River Basin is underlain by bedrock that is exposed at the surface or only thinly covered by sediments almost everywhere except beneath the floors of the major valleys. The bedrock is of many different rock types of a wide range of ages. These rocks have been folded and faulted into a complex pattern (Walters and Nassar, 1974). Starting just south of Twisp and extending up the Methow River, the bedrock consists of sedimentary and volcanic rocks that have been downfaulted between large blocks of intrusive igneous and metamorphic rocks. The sedimentary and volcanic bedrock is exposed over a 15- to 20-mile-wide expanse that extends about 35 to 40 mi northwest to southeast ([fig. 2](#)). Downriver of the sedimentary and volcanic rocks, the bedrock underlying the river is primarily intrusive igneous and metamorphic. The basin has been described as a graben (Barksdale, 1975) or a rift-block valley (Waitt, 1972). Shales, siltstones, sandstones, conglomerates, breccias, and tuffs are the major sedimentary and volcanic rocks present in the basin. Both sedimentary and volcanic rocks span a range of ages from the Cretaceous Period (or possibly Jurassic) to the Tertiary Sub-Era (Barksdale, 1975). Most of the intrusive igneous and metamorphic rocks are granite, gneiss, marble, and schist. Intrusive igneous rocks range in age from the Cretaceous to the Oligocene Epoch, but the age of metamorphic rocks is not well known (Barksdale, 1975). The unconsolidated sediments that overlie the bedrock are mostly sands and gravels of glaciofluvial origin. Glacial till and glaciolacustrine silts and clays also are present, but are much less extensive than the sands and gravels. The unconsolidated sediments were deposited during the Pleistocene and Holocene Epochs.

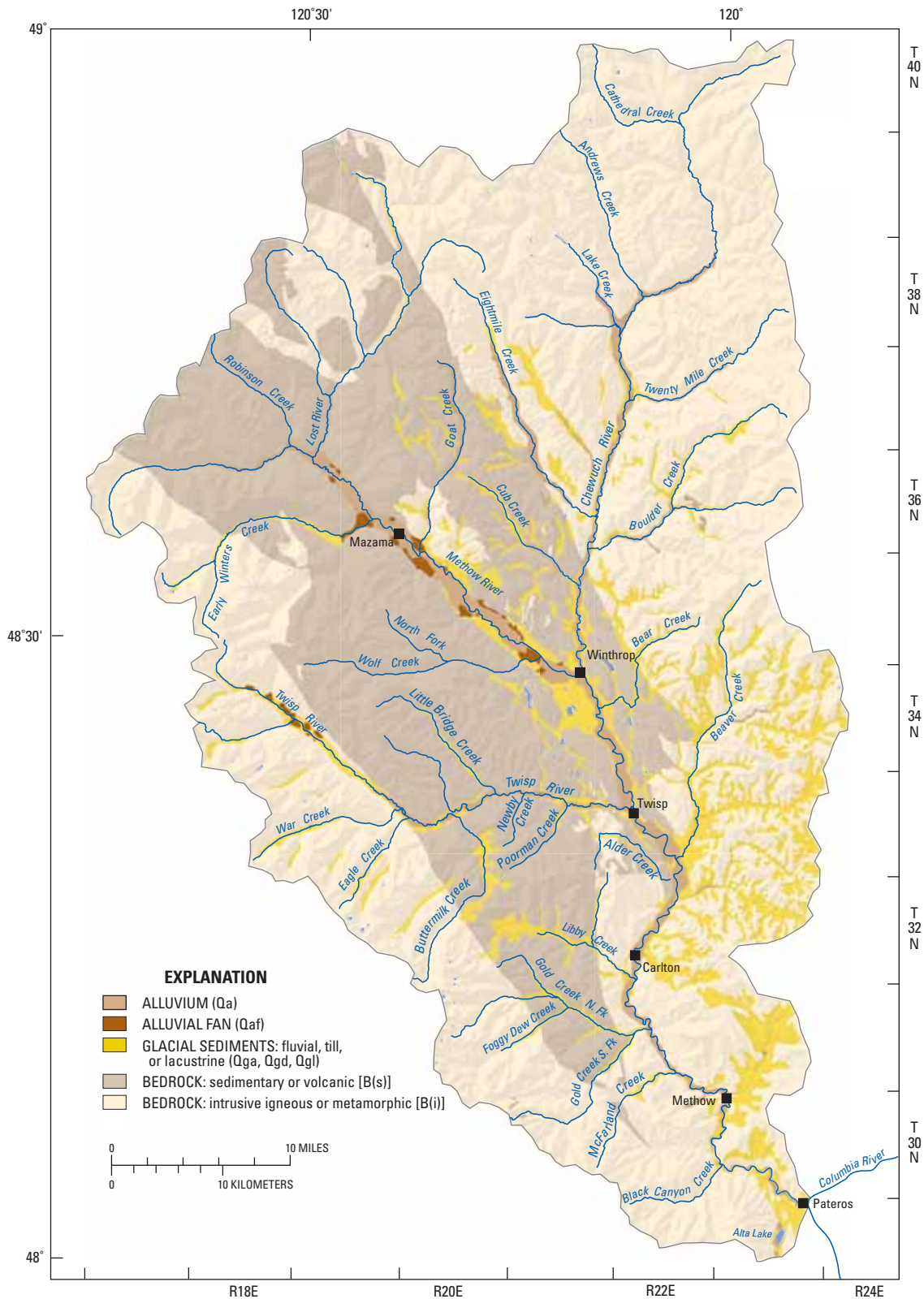


Figure 2. Surficial geology of the Methow River Basin, Okanogan County, Washington. Geology was modified from Harris and Shuster (2000).

The basin was almost entirely covered by ice several times during the Pleistocene glaciations. Upland areas were eroded and ultimately mantled with relatively thin glacial deposits, while thick accumulations of sand and gravel, along with some tills, silts, and clays, were deposited along the lower slopes and bottoms of the major valleys (Walters and Nassar, 1974). Although the glacial deposits at the surface originated from the recent ice-sheet glaciation that covered most of the basin, there is clear erosional evidence of significant alpine glaciation prior to the ice sheets (Waite, 1972). Alpine glaciation is responsible for the wide U-shaped cross-valley profiles of the Methow River valley upriver of Carlton and of the Twisp River valley upriver of Little Bridge Creek (Waite, 1972). Beneath parts of these U-shaped valleys, alpine glaciation apparently eroded the bedrock many hundreds of feet below the level of the bedrock immediately downriver. Alluvial and alpine and ice-sheet glacial sediments later filled these deep sections.

HYDROGEOLOGY OF UNCONSOLIDATED SEDIMENTS

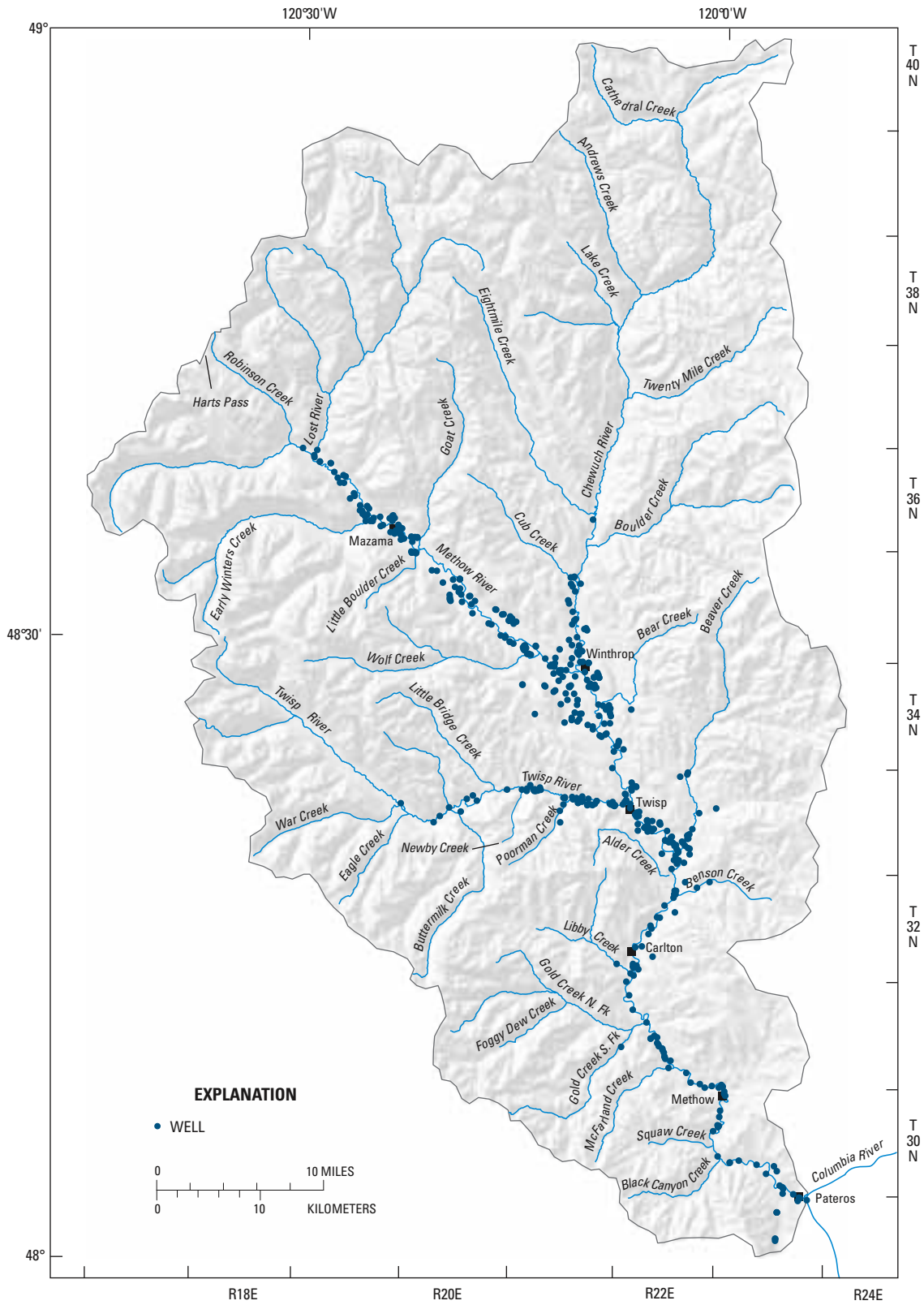
The spatial extent, depth, and lithology of the unconsolidated sediments form the hydrogeologic framework for the shallow ground-water system, which represents the primary ground-water resource in the Methow River Basin. The hydrogeologic framework was defined in the main river valley from Lost River to Pateros and in major tributary valleys based primarily on information from water-well reports filed with the Washington State Department of Ecology (Ecology). Ground-water levels in the unconsolidated sediments were measured in November 2000, March to April 2001, and June to August 2002.

Methods

Ground-water wells were the primary source of information used to define the hydrogeologic framework and the ground-water system of the unconsolidated sediments in the Methow River Basin. Geophysical data from previous investigations (Artim, 1975; EMCON Northwest, unpub. data, 1993) supplemented the data from the ground-water wells.

Well Inventory and Water-Level Measurements

Data from 488 wells were used to study the hydrogeology of the Methow River Basin ([table 10. at back of report](#)). Water-well reports for several thousand wells in the Methow River Basin were obtained from Ecology. These reports were reviewed and 463 wells were selected for a field inventory. Most of these wells were inventoried during late October through early December 2000. Data from an additional 25 wells used in previous studies (EMCON Northwest, unpub. data, 1993, and Montgomery Water Group, Inc., 2001) or in current (Okanogan County) or discontinued (Verne Donnet, written commun., 2002) water-level networks were incorporated into the database for this study. The selected wells are broadly distributed in the major river valleys ([fig. 3](#)) and open to both shallow and deep aquifers in both the unconsolidated sediments and in bedrock. A high priority was placed on locating wells that penetrated the bedrock surface, so that the thickness of the unconsolidated sediments in the study area could be determined.



Base from U.S. Geological Survey Digital Data, 1:100,000, 1985
 Universal Transverse Mercator projection,
 Zone 10, Datum NAD 83

Figure 3. Location of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington.

Wells in Washington are assigned a local number that identifies the township, range, section, and 40-acre tract. For example, 33N/21E-09C01 (fig. 4) indicates that the well is in township 33 north (N) and Range 21 east (E) of the Willamette base line and meridian. The numbers immediately following the hyphen indicate the section (09) within the township; the letter following the section identifies the 40-acre tract within the section. The two-digit sequence number following the letter (01) indicates that the well was the first one inventoried by the USGS in that tract. The letter D and a number following a sequence number indicate that the well has been deepened and how many times; for instance, D1 indicates the well has been deepened once. The letters A or B after the sequence number indicates that piezometers are nested in the well, with successive numbers or letters assigned to each piezometer in the well.

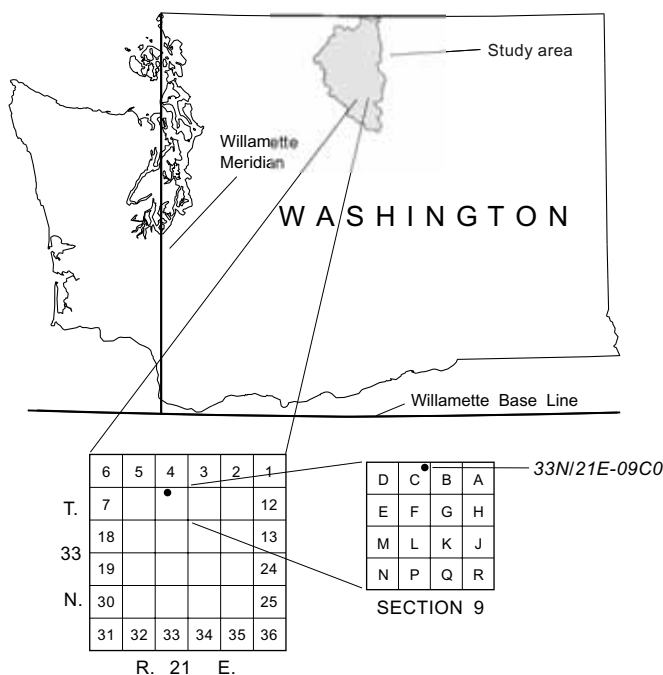


Figure 4. Well-numbering system used in Washington.

The field inventory consisted of locating wells for which lithologic logs and well-construction information were available. After a well was located in the field and permission given by the owner, the water level in the well was measured and the coordinates (latitude, longitude) of its location were determined. Water levels were measured as depth below land surface using either a graduated steel tape or a calibrated electric tape accurate to the nearest 0.01 ft. Water levels were measured at least twice, several minutes apart, to verify the measurement and determine if the water level was static or was affected by recent pumping or pumping of a nearby well. After the initial field inventory, many of the wells were revisited, either for additional water-level measurements or to collect samples for water-quality analysis.

Latitude and longitude of a well were determined using hand-held Global Positioning System (GPS) receivers. The accuracy of these latitudes and longitudes probably is within 0.5 second. Land-surface altitudes were determined by plotting the wells, using the latitude/longitudes from the GPS receivers, on 1:24,000-scale topographic maps and interpolating the altitudes from the contours (generally to within one-half the contour interval). The contour interval in most of the study area was 40 ft, and some areas had supplemental 20-foot contours.

More precise latitudes, longitudes, and land-surface altitudes (NAVD 88) were determined for a subset of 133 wells using a differential GPS from June 18 to June 21, 2001. Two GPS receivers (reference stations) were placed at fixed locations for at least 8 hours each day. Four other GPS receivers were placed at wells within 6 mi of a reference station for at least 20 minutes per well. The transient deviations in the base station coordinates for any given period were used to correct the coordinates of wells. The accuracy of these latitudes and longitudes is within 0.1 second. The accuracy of the land-surface altitudes is within 1 ft, and probably within 0.2 ft in most instances.

Water-surface altitude was calculated for each water-level measurement as the difference between the land-surface altitude at the well and the depth to the water surface. The water surface in an open well is referred to as the potentiometric surface of the aquifer. The altitude of the potentiometric surface is equal to the sum of the altitude of water at the open interval of the well casing and the pressure of the water at the open interval divided by its specific weight (the pressure head). If an aquifer is confined (above) by a low-permeability layer, water may be under higher pressure than the atmosphere and the potentiometric surface altitude of water measured in an open well would be higher than the altitude of the top of the saturated aquifer.

Static water-surface altitudes (NAVD 88) with a precision within 1 ft, measured from June through August 2001, were used to construct a map of the potentiometric surface of ground water in the unconsolidated deposits of the Methow River Basin. Construction of the map generally followed procedures outlined by Technical Memorandum No. 2002.06 (U.S. Geological Survey, Office of Information, written commun., accessed November 1, 2002, at URL http://water.usgs.gov/publishing/Memos/memo2002_06.html). Along rivers and streams, the altitude of the ground-water surface was assumed to be equal to the land-surface altitude. A digital elevation model (DEM) of the land surface (U.S. Geological Survey, 2003) was used to locate points where the potentiometric contours cross rivers and streams. Surface-water levels were known to within 1 ft at 14 locations that have continuous stage records. Mean surface-water levels at these sites for June 2001 confirmed that the DEM generally was representative of summer water-surface levels for the Methow River. After the initial potentiometric contours were digitized, they were checked for consistency with water levels from wells where altitudes were less precise than 1 ft.

Hydrogeologic Interpretation

The hydrogeologic units in the Methow River Basin were determined using a variety of geologic data, including surficial geologic maps (Artim, 1975; Harris and Schuster, 2000), the lithologic logs from water-well reports and geophysical logs (seismic reflection and vertical electric resistivity) from previous investigations (Artim, 1975; EMCON Northwest, unpub. data, 1993).

The surficial geologic map by Harris and Schuster (2000) is a composite of many different mapping investigations by numerous investigators. The nature and extent of the mapping of the unconsolidated sediments varied widely among these investigations. Some of the composite maps indicate unconsolidated sediments only where these sediments are thick and areally extensive, and indicate bedrock at the surface where the sediments are thin or of minor areal extent. On some maps, the unconsolidated sediments were divided into several units (for example, “glacial drift” and “alluvium”), and on others they were lumped into a single unit (“sedimentary deposits”). The unconsolidated sediments were mapped by Harris and Schuster (2000) in some detail east of Twisp and Winthrop ([fig. 2](#)), but were mapped in much less detail in other areas of the basin. Additional areas of unconsolidated sediments were added to [figure 2](#) based on additional information from lithologic logs, field observations, topography, and descriptions of depositional features by Waitt (1972).

Hydrogeologic interpretations were made for all study wells with available lithologic logs ([table 11, at back of report](#)). Well-construction information supplied by well drillers and water levels measured during the inventory were used to determine the nature of the water-bearing units in each well and label the well as confined or unconfined ([table 12, at back of report](#)).

Hydraulic Conductivity

Water production from a well is often tested at the time of drilling. The pumping rate, drawdown of water level, and pumping time of a specific-capacity test can be used to calculate hydraulic conductivity. Of all the wells inventoried for this investigation, only 36 had adequate test results for analysis. The test results were analyzed using the modified Theis equation for drawdown of a confined aquifer (Jacob, 1947) and were corrected for wells that partially penetrate the aquifer (Jacob, 1950). Assumptions underlying the analysis include horizontal ground-water flow; an infinite, homogeneous, and isotropic aquifer; and constant transmissivity. The analysis used a storage coefficient of 0.1 for the 26 wells in unconfined aquifers, and the analysis used two values of the storage coefficient (0.01 and 0.001) for the 10 wells in confined aquifers to test the sensitivity of the results for the likely range of values for the storage coefficient.

Hydrogeologic Units

The most significant part of the ground-water reservoir, in terms of volume and proximity to rivers and the human population in the Methow River Basin, is in the unconsolidated sediments along the bottoms and lower slopes of the major valleys. These unconsolidated sediments are composed mostly of sand and gravel and range in thickness from a few feet to more than a thousand feet. Wells open to these materials typically will yield more than 100 gal/min. Layers of silt, clay, or glacial till are present within the sands and gravels and act locally as confining beds. The bedrock underlying the unconsolidated sediments or exposed at the land surface typically is a poor producer of ground water. Single-home domestic supplies can be obtained from the bedrock in some locations, but often require wells that penetrate and are open to several hundred feet of the bedrock.

Geologic identification and mapping of the unconsolidated sediments in the Methow River valley have not been done in any detail. Given the state of mapping and the nature of the available data (primarily water-well reports), it is not possible to identify and correlate individual layers over any great distance.

Therefore, identification of the unconsolidated sediments was done primarily on a lithologic basis, resulting in the following set of units.

- **Recent alluvium (Qa).** Mostly sand or sand and gravel with minor amounts of silt and clay, deposited by alluvial processes. Primarily forms aquifers. Probably of Holocene age.
- **Alluvial fan (Qaf).** Mostly sand and gravel, some boulders, with minor amounts of silt and clay, deposited by alluvial and colluvial (landslide) processes. Primarily forms aquifers. Probably of Pleistocene-Holocene age.
- **Glaciofluvial sediments (Qga).** Mostly sand and gravel, some coarse sands, some cobbles, deposited by glaciofluvial processes. Primarily forms aquifers. Probably of Pleistocene age.
- **Glacial till (Qgd).** Unsorted, unstratified mixture of fine- to coarse-grained sediments, compacted or uncompact, deposited by glacial processes. Primarily forms confining units. Probably of Pleistocene age.
- **Glaciolacustrine sediments (Qgl).** Mostly silt and clay, with minor amounts of fine sand, deposited by glaciofluvial processes. Primarily forms confining units. Probably of Pleistocene age.

The glacially derived units (Qga, Qgd, and Qgl) are often repeated several times in the lithologic logs, and three or four different Qga, Qgd, or Qgl units may appear in the same log ([table 11](#)).

The thickest unconsolidated sediments are found in the Methow River valley upstream of Winthrop (pl. 1). Most of this part of the valley is underlain by at least 500 ft of unconsolidated sediments and in some locations by more than 1,000 ft. The interpretation of unconsolidated sediment thickness in this study differs from an earlier interpretation (EMCON Northwest, unpub. data, 1993) that proposed the existence of a bedrock “barrier” extending across the entire valley, based on a seismic profile between wells E-1, with bedrock at a depth of 550 ft, and E-2, with bedrock at a depth of 1,050 ft (pl. 1). Bedrock is more likely shallower at well E-1 because that well is closer to the valley wall than well E-2, rather than because a shallow bedrock surface extends across the valley.

Downstream of well E-1, the bedrock surface is at greater depth, for example greater than 820 ft at well E-14, which is not consistent with an upstream bedrock barrier.

Downstream of Winthrop, the unconsolidated sediments beneath the Methow River generally are less than 200 ft thick, except in the reach from Twisp to Benson Creek, where thicknesses can approach 300 ft. In a buried valley segment near the mouth of the Methow River beneath Alta Lake (Waite, 1972), thickness of the unconsolidated sediments is estimated to exceed 500 ft.

The unconsolidated sediments beneath the main Methow River valley are dominated by coarse-grained materials, mostly sand and gravel. These coarse-grained materials are highly transmissive and, where saturated, are the most productive aquifers in the basin. These materials include Quaternary alluvium (Qa) deposited recently (Holocene) by rivers or glaciofluvial sediments (Qga) deposited earlier by glaciers and rivers.

Relatively minor amounts of silts and clays (Qgl) and till (Qgd) occur within the mass of coarse-grained unconsolidated deposits. The fine-grained deposits are relatively poorly transmissive and locally act as confining units. Beneath some parts of the main Methow River valley, these confining units are nearly nonexistent: during the drilling of a 527-foot test well near Mazama (36N/19E-25J02A), only 20 ft of confining materials was encountered, from a depth of 222 to 242 ft.

In the Twin Lakes area just south of Winthrop, where a kame moraine (unstratified drift deposited by glacial meltwater) occupies most of the river valley (Waite, 1972), a relatively large percentage of the sediments is confining material. Many of the wells on the kame moraine were drilled through thick silts, clays, and tills that frequently make up 50 percent or more of the materials encountered.

The existing data indicate that the confining units are of limited lateral extent, although originally they may have been more continuous. The remnants of what may have been a continuous glaciolacustrine deposit

from a possible glacial lake can be seen as blue or gray clays in logs from a few of the wells between Twisp and Carlton (fig. 5).

The unconsolidated sediments directly beneath the main Methow River valley form the most productive aquifers where the ground water is closely connected to the flow in the Methow River. Additional unconsolidated sediments occur along the main valley side slopes, in tributary valleys, and in some upland areas. These sediments differ from the main valley sediments, generally containing much larger percentages of non-aquifer materials, typically finer grained and compacted sediments. An example is at well 35N/20E-24N01, which is located along the southwestern slope of the Methow River valley upriver from Winthrop. This well was drilled through 365 ft of glacial deposits, 338 ft of which were silts, clays, and tills.

Hydraulic conductivities were calculated from specific-capacity tests from 36 wells with open intervals in glaciofluvial deposits (Qga). The storage coefficient, which must be specified to calculate hydraulic conductivity from a specific-capacity test, was not known for Qga, so a storage coefficient of 0.1 was used to calculate hydraulic conductivity where the unit is unconfined. Hydraulic conductivity calculated from the specific-capacity tests from 26 wells completed in the unconfined unit ranged from 20 to 3,500 ft/d with a median of 430 ft/d. The storage coefficient may vary over a few orders of magnitude for a confined aquifer. Hydraulic conductivity calculated from the specific-capacity tests from 10 wells completed in the confined unit ranged from 50 to 2,600 ft/d with a median of 460 ft/d, assuming the storage coefficient was 0.01. When the storage coefficient was changed to 0.0001, the hydraulic conductivity of the unit ranged from 70 to 3,500 ft/d with a median of 620 ft/d. The calculated hydraulic conductivities are consistent with published values for clean sand and fine gravel (Freeze and Cherry, 1979). Hydraulic conductivities were not calculated for other units because there were no specific-capacity tests for wells in those units.

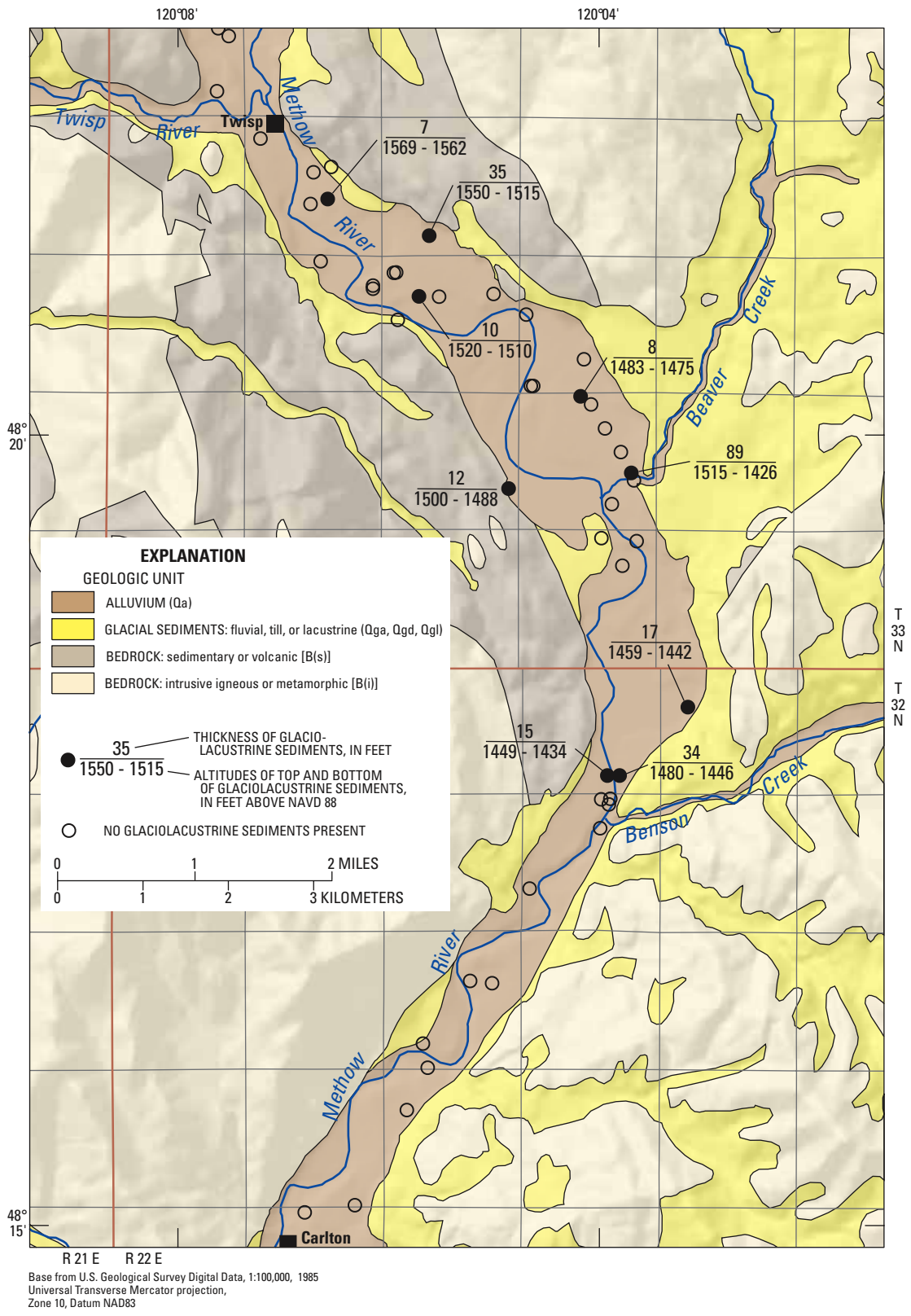


Figure 5. Thickness and altitude of the top and bottom of glaciolacustrine deposits in selected wells between Twisp and Carlton in the Methow River Basin, Okanogan County, Washington. The deposits may be remnants of a once-continuous deposit.

Water Levels in the Unconsolidated Aquifer

Unconsolidated sedimentary deposits in the Methow River valley extend continuously from above Lost River to around Black Canyon Creek, where bedrock is exposed along the river channel. Alluvial and glaciofluvial deposits (Qa and Qga) along the Lost, Chewuch, and Twisp Rivers and Beaver, Benson, and Libby Creeks are contiguous with alluvial and glaciofluvial deposits along the mainstem of the Methow River. These deposits form an unconsolidated aquifer, which exchanges water with the Methow River and its tributaries.

Ground-water levels were measured during a regional drought in water year 2001. Ground water generally was close to the land surface in the unconsolidated aquifer from November 2000 through August 2001 ([table 13, at back of report](#)). The median value for static depth to ground water in 184 wells from June through August 2001 was 27 ft below land surface, with a range from 1.2 to 218 ft. Generalized altitudes of the potentiometric surface for the unconsolidated aquifer (Qa and Qga) and, in some cases, alluvial fans (Qaf) during the summer of 2001 are shown on plate 1.

Ground-water levels generally are even across the valley, with higher levels along the valley walls. For an aquifer where the hydraulic conductivity is isotropic (equal in all directions), the direction of ground-water flow is perpendicular to the potentiometric contours. Assuming isotropic conditions, ground-water flow generally is oriented down valley with some inflow from the surrounding terraces and alluvial fans. Ground water flows into the Methow River where potentiometric contours are concave downstream and the river recharges the aquifer where potentiometric contours are convex downstream. Ground water discharges to the Methow River upstream of Wolf Creek, at the Twin Lakes terrace, and at some tributary junctions, particularly Beaver Creek.

The steepest hydraulic gradient in the main valley was 0.9 percent, from the Lost River to Early Winters Creek. The hydraulic gradient decreased downstream to Winthrop, where it was 0.5 percent and

remained fairly constant to Beaver Creek. The lowest hydraulic gradient was 0.3 percent, from Beaver Creek to Libby Creek. Downstream of Libby Creek, the hydraulic gradient of ground water increased, reaching a maximum of 0.6 percent in the narrow canyon upstream of Pateros.

The altitudes of the potentiometric surface on plate 1 generally are consistent with Artim (1975), who mapped ground-water levels from Mazama to Winthrop, although the potentiometric contours on plate 1 are convergent from Weeman Bridge to Wolf Creek rather than straight across the valley as in Artim (1975).

The vertical component of ground-water flow is not known because wells in the unconsolidated aquifer generally were shallow and neighboring wells typically penetrated to similar depths. Vertical hydraulic gradients were inferred from water levels in neighboring shallow and deep wells north of Twin Lakes, where ground water may flow upward from a deep bedrock aquifer into the overlying unconsolidated glacial terrace. Assuming ground water is in equilibrium with the altitude of Beaver Creek, ground water in the alluvial deposits may flow downward into older unconsolidated material. In highly permeable material such as alluvium, vertical ground-water flow is likely to be greatest at sources of active recharge, at seepage faces, and at discontinuities in impermeable layers that allow ground water to flow vertically between regions with different potentiometric heads. Ground-water flow also is likely to have a large vertical component where the altitude of the underlying confining bed varies in the direction of horizontal flow. For example, the altitude of the bottom of the unconsolidated sediments appears to increase from Mazama to Winthrop. As a result, ground-water flow in this region is likely to have a large vertical (upward) component.

Seasonal fluctuations were analyzed using ground-water levels from 93 wells in which static water levels had been measured in autumn (November 2000), spring (March-April 2001), and summer (June-August 2001). Of the three seasons in water year 2001 when ground-water levels were measured, water levels

generally were lowest in the spring (March and April 2001) and highest in the summer (June-August 2001), although there were many wells that deviated from this pattern. Water levels generally declined from autumn to spring, with a median change in water level of -0.4 ft (range of -17 to 31 ft) from autumn to spring. Water levels generally rose from spring to summer, with a median change of 1.0 ft (range of -23 to 27 ft). The seasonal fluctuations in ground-water levels were locally consistent among neighboring wells but varied along the valley ([table 1](#), pl. 1). The largest rises in water levels from spring to summer were in the upper valley, upstream of Weeman Bridge. Other areas with large rises include around Bear Creek on the east side of the Methow River, the large terrace north of the Twisp River, and the northeast side of the Methow River from Twisp to Beaver Creek. Wells with declining water levels from spring to summer were isolated and generally were located on terraces above rivers.

Table 1. Changes in static water levels and number of wells in the unconsolidated sediments of the Methow River Basin, Okanogan County, Washington, spring to summer 2001

Change in water level	Number of wells
Decline greater than 1.0 foot	8
Decline of 1.0 foot to rise of 1.0 foot	37
Rise of 1.0 to 2.0 feet	18
Rise of 2.0 to 10 feet	21
Rise greater than 10 feet	9

WATER QUALITY

The quality of surface and ground waters in the Methow River Basin was assessed by synoptic (one-time) sampling during 2001 from 19 surface-water sites and 89 ground-water wells. The samples were analyzed for common water-quality parameters (temperature, pH, specific conductance, dissolved oxygen), nitrate, chloride, arsenic, and lead as indicators of

anthropogenic contamination, and common ions to characterize the source of water. Previous studies were reviewed to provide information on water quality in the basins at other times.

Previous Studies

Water-quality studies in the Methow River Basin have been limited mostly to synoptic water-quality sampling of one or more surface- or ground-water sites (Raforth and others, 2000; HWA Geosciences, 2001; Raforth and others, 2002). The USGS and the Washington State Department of Ecology (Ecology) have sampled surface-water quality periodically at seven sites ([table 2](#)). Andrews Creek near Mazama is one of 50 stations in the USGS Hydrologic Benchmark Network (HBN) chosen to provide long-term measurements of streamflow and water quality in areas that are minimally affected by human activities. The Andrews Creek HBN station data set of 168 samples collected from December 1971 through August 1991 is described and analyzed by Mast and Clow (2000). Mast and Clow concluded that apparent trends in calcium, magnesium, sulfate, and alkalinity were more than likely artifacts of analytical bias (due to changes in analytical methods or equipment) rather than indications of environmental change.

The Methow River near Pateros has been a long-term monitoring station for both the USGS and Ecology. Samples from the Methow River at Pateros historically have exceeded State water-quality criteria for pH and temperature (Washington State Department of Ecology, 2002). The Methow River also has been sampled from 1976 to date at two sites near Twisp ([table 2](#)). Site 48A130 was abandoned in 1989 in favor of site 48A140, which is sampled from the bridge in Twisp and which was sampled during this study and also by Ecology. The Methow River below Gate Creek was sampled periodically from 1976 to 1980. The Chewuch River at Winthrop and the Methow River at Weeman Bridge, near Mazama were sampled twice monthly during 1976.

Table 2. Long-term surface-water-quality sampling sites in the Methow River Basin, Okanogan County, Washington

[Site No.: Location of surface-water sampling sites are shown on [figure 6](#). **Sampling agency:** USGS, U.S. Geological Survey; Ecology, Washington State Department of Ecology. **Years sampled:** Water years (October through September). **Number of samples:** Period of record through September 2000]

Site name	Sampling agency	Site No.	Years sampled	Number of samples
Andrews Creek near Mazama	USGS	12447390	1972-91	168
	Ecology	48C070	1972-81	99
Chewuch River at Winthrop	USGS	12448000	1976-96	23
	Ecology	48B070	1976	22
Methow River near Pateros	USGS	12449950	1960-70, 1972	98
	Ecology	48A070	1959-66, 1972; 1975-current	386
Methow River near Twisp	USGS	12449510	1976-80	67
	Ecology	48A130	1976-1988	139
Methow River at Twisp	Ecology	48A140	1982-current	131
Methow River at Weeman Bridge, near Mazama	USGS	12447385	1976	24
	Ecology	48A170	1976	24
Methow River below Gate Creek, near Mazama	USGS	12447374	1976-80	43
	Ecology	48A190	1976-80	43

From 1997 through 2001, Ecology investigated mining districts throughout the State to characterize water and sediment quality in streams that drain mining districts in Washington. Ecology collected and analyzed samples of surface water and sediment from the Twisp mining district in June and October 1997 (Raforth and others, 2000). Samples were collected from Alder Creek ([fig. 1](#)) at locations upstream and downstream of Alder Mine, the primary mine in the district. Comparisons show downstream increases in all measured field properties except pH, alkalinity, and hardness. The high-flow pH measurement of 4.91 at the middle site, about 0.5 mi below the upstream site, exceeds the State water-quality standard of 6.5 (Washington State Department of Ecology, 1997). Concentrations of lead in samples ranged from 0.022 to 0.17 $\mu\text{g/L}$; concentrations of arsenic were less than the limit of detection during high flow, but ranged from 1.0 to 1.3 $\mu\text{g/L}$ during low flow at the downstream and upstream sites, respectively. Nearly all metals analyzed at the Alder Creek site were lower in concentration during low-flow conditions, except for arsenic. The higher arsenic concentrations during low flow indicate that ground water may be transporting arsenic. In most cases, concentrations of metals were lower at the

upstream site; the highest concentrations were at the middle site, which is directly below the discharge from one of the adits (entrances) at Alder mine, and for which Raforth and others (2000) observed that the water-quality results correspond to the mineralogy of the ore produced from the mine. Concentrations of several metals in samples from Alder Creek exceeded State water-quality standards, but concentrations of lead and arsenic exceeded State water-quality standards only in samples from the adit discharge.

Samples of surface water and sediment from Goat Creek in the Mazama mining district were collected and analyzed by Ecology in October 2000 and April 2001 (Raforth and others, 2002). Comparison of concentrations between samples collected at low and high flow showed differences in pH and concentrations of dissolved solids and sulfate. Concentrations of lead in all samples were less than the detection limit (0.08 $\mu\text{g/L}$); concentrations of arsenic were less than the detection limit during low flow, and ranged from 0.62 to 0.94 $\mu\text{g/L}$ during high flow at the upstream and downstream sites, respectively. None of the concentrations of metals in samples of surface water from the Mazama mining district exceeded State water-quality standards.

Samples of surface water and sediment also were collected and analyzed by Ecology in the Gold Creek mining district from Gold Creek and Foggy Dew Creek in October 2000 and April 2001 (Raforth and others, 2002). Raforth and others compared concentrations between samples from Foggy Dew Creek and samples collected downstream of the confluence of Foggy Dew Creek and Gold Creek, and observed few differences in measurements of specific conductance. Concentrations of lead in all samples were less than the detection limit. Concentrations of arsenic were higher at the downstream site, during low and high flows, ranging from less than the detection limit to 1.36 µg/L. Concentrations of arsenic also were greater during high flow, ranging from 0.3 to 1.6 µg/L at the upstream and downstream sites, respectively. None of the concentrations of metals in samples of surface water from the Gold Creek mining district exceeded State water-quality standards.

Sampling and Analytical Procedures

Nineteen surface-water sites ([fig. 6](#)) and 89 ground-water sites ([fig. 7](#)) were selected for sampling water quality in the Methow River Basin. Sites were selected to represent the variation of water quality in the surface and ground water throughout the basin. Ground-water samples were collected from domestic- or municipal-supply wells during June 2001. Surface-water samples were collected from rivers and streams during September 2001. Ground-water samples were analyzed for concentrations of nitrite plus nitrate, to assess possible leaching of fertilizer into the ground water, and for concentrations of chloride, to assess possible leaching of effluent from septic systems into the ground water or from other anthropogenic sources. In addition to nitrite plus nitrate and chloride, a subset of about 25 percent of the samples also was analyzed for major ions, lead, and arsenic.

Clean sampling protocols, as described by Wilde and others (1998), were used to collect samples. Teams of two persons coordinated to measure physical properties of ground or surface water and to collect

samples of ground or surface water for shipment to the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colo., for analysis. Samples for the analysis of major ions and trace metals were filtered and preserved as described by Pritt and Raese (1995) and USGS Office of Water Quality Technical Memorandum 98.06 (U.S. Geological Survey, 1998a). Samples for the analysis of total ammonia plus organic nitrogen and total phosphorus were collected and preserved as described by USGS Office of Water Quality Technical Memorandum 99.04 (U.S. Geological Survey, 1998b).

Surface-Water Sampling

Surface-water sites in the Methow River Basin were sampled September 17-21, 2001, during low flow near the end of the irrigation season to assess basin-wide variations in nutrients, major ions, and, to a limited extent, concentrations of arsenic and lead in surface water ([fig. 6](#) and [table 14, at back of report](#)). Sites were selected along the mainstems and tributaries of the Methow, Twisp, and Chewuch Rivers to provide a distribution of samples in and around the major valleys. The Methow River was sampled from the tributaries in the headwaters on Lost River, Early Winters Creek, and Goat Creek and from the mainstem of the upper Methow River at Goat Creek to near the mouth at Pateros, Washington. Surface-water sites along the Twisp River were sampled from above Buttermilk Creek to near Twisp. Sites in the Chewuch River Basin were sampled from Andrews Creek in the headwaters to the mouth at Winthrop, as well as the Eightmile Creek.

Water samples representative of the flow in the stream cross section were obtained by collecting depth- and width-integrated sub-samples at equally spaced intervals across the stream using a US DH-81 sampler, as described by Edwards and Glysson (1999). The sampler holds a 1-liter or 3-liter Teflon bottle, and all parts of the sampler coming in contact with the water sample are made of Teflon. Sub-samples were composited and split using a polyethylene churn splitter, as described by Wilde and others (1999a).

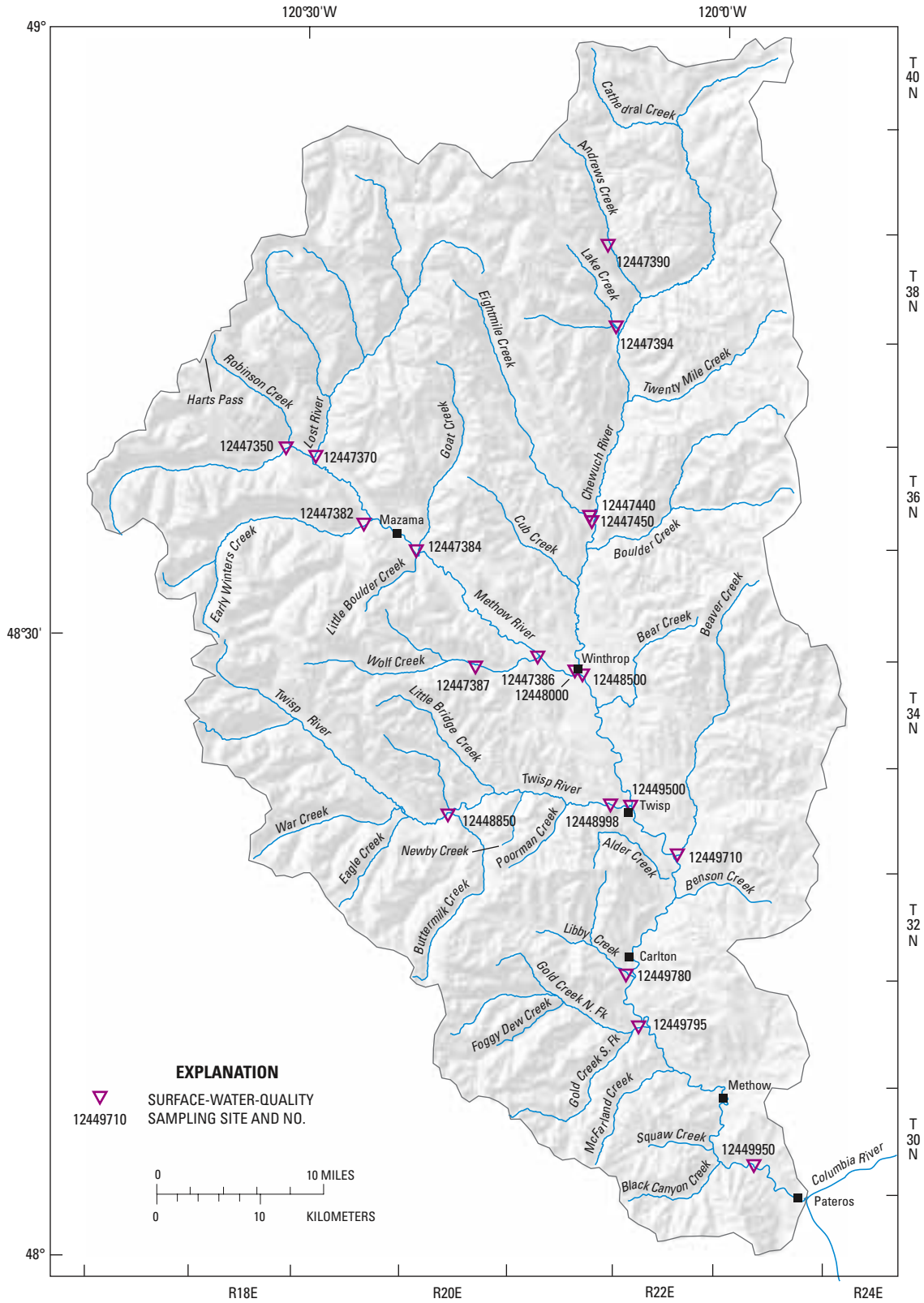
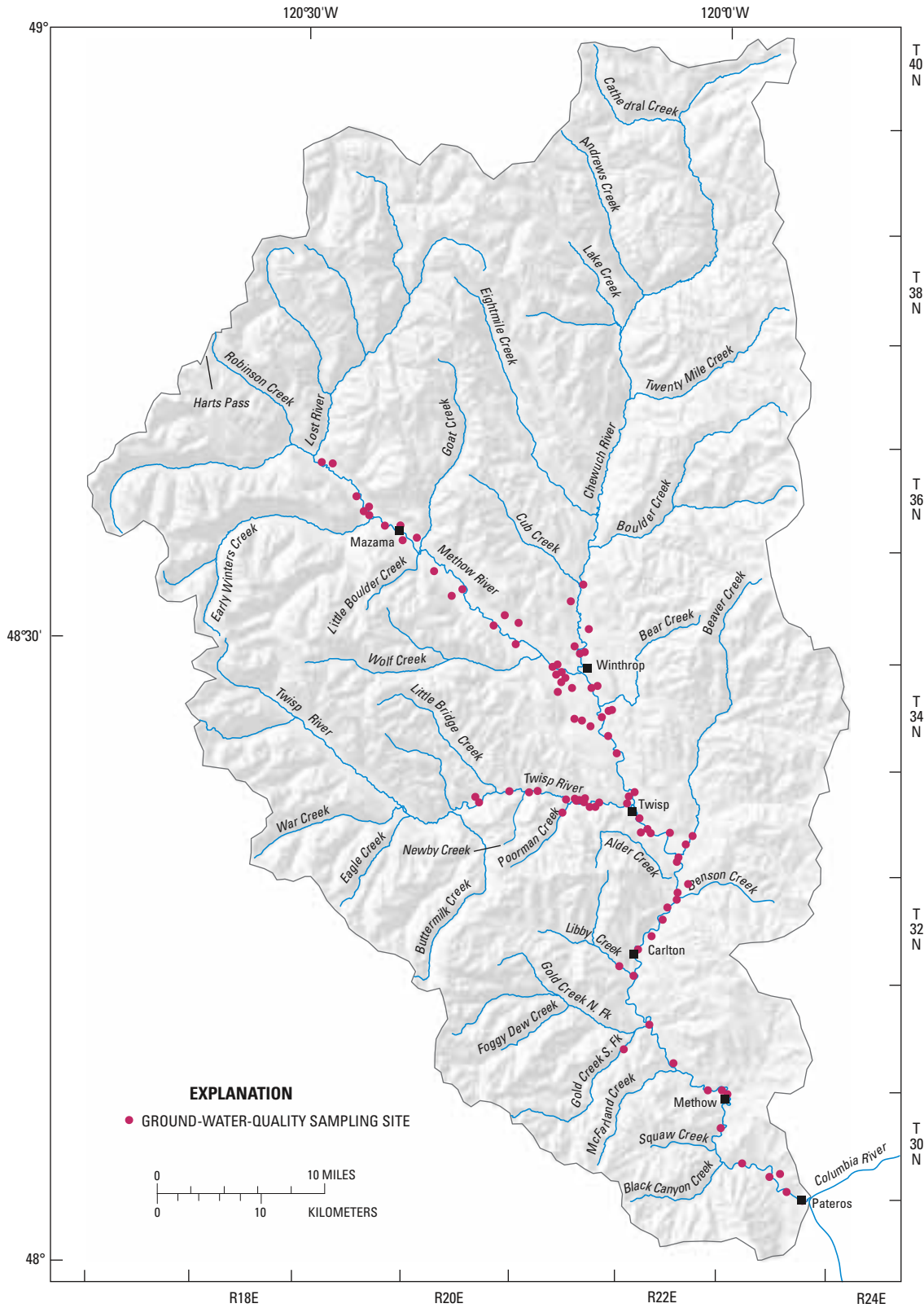


Figure 6. Location of surface-water-quality sampling sites in the Methow River Basin, Okanogan County, Washington.



Base from U.S. Geological Survey Digital Data, 1:100,000, 1985
 Universal Transverse Mercator projection,
 Zone 10, Datum NAD 83

Figure 7. Location of ground-water-quality sampling sites in the Methow River Basin, Okanogan County, Washington.

Samples for major ions, nutrients, lead, and arsenic were drawn from the churn splitter and filtered or preserved if necessary. Sub-samples for analysis of filtered nutrients were pumped through a disposable 0.45- μm filter cartridge into opaque polyethylene bottles and chilled to less than 4 °C. Samples for analysis of unfiltered nutrients were collected in translucent polyethylene bottles and preserved with 1 mL of 4.5 Normal sulfuric acid. Samples for analysis of major ions, lead, and arsenic were filtered through the same 0.45- μm filter cartridge, and the samples for analysis of cations, iron, manganese, lead, and arsenic were acidified with nitric acid to a pH less than 2. All samples were shipped on ice to the NWQL for analysis. All equipment used to collect and process samples was cleaned with a 0.2-percent non-phosphate detergent, rinsed with deionized water, soaked for 30 minutes in a 5-percent solution of hydrochloric acid, rinsed with deionized water, and stored in a dust-free environment prior to sampling.

Ground-Water Sampling

Ground-water sites were distributed in the major valleys of the Methow River Basin and included wells in the glaciofluvial sediments and bedrock ([fig. 7](#) and [table 15, at back of report](#)).

All ground-water samples were collected following protocols described by Wilde and others (1999a) in order to ensure representative samples of ground water. Sampling equipment consisted of Teflon or polyethylene tubing with stainless steel fittings that was attached to a faucet at the wellhead or at a point before pressure tanks or treatment. The tubing was then connected directly to a mobile water-quality laboratory and water was pumped through the tubing to a flow chamber to monitor physical properties (temperature, pH, specific conductance, and concentrations of dissolved oxygen) and through a splitter to provide either raw or filtered water samples.

Water levels were measured before pumping, if possible, and the water level was used to calculate the volume of standing water in the well casing. Wells then were purged to remove at least three casing volumes of water, and samples were collected and processed after values of monitored field properties were within the allowable differences specified by Wilde and others

(1999a). If a well was in use or an equivalent volume of purge water had already been pumped during the last 24 hours, the sampling equipment was flushed with ground water and samples were collected after ensuring the stability of physical properties. All pump lines and processing equipment that came in contact with the sample water after the point of collection were composed of Teflon, polyethylene, or stainless steel. Ground-water samples were pumped directly through a splitter or a filtration cartridge into sample bottles, and samples were preserved or stored on ice and shipped for analysis to the NWQL. All lines and processing equipment used to collect and process samples were cleaned with a 0.2-percent non-phosphate detergent, rinsed with deionized water, and stored in a dust-free environment prior to sampling.

Laboratory Methods

Water samples for the analysis of nitrate and other nutrients were received at the NWQL and stored at less than 4°C prior to analysis, as described by Pritt and Raese (1995). All samples were analyzed for nitrite plus nitrate and chloride and a subset of samples were analyzed for major ions, lead, and arsenic ([table 3](#)). Nutrient samples were analyzed for nitrite plus nitrate using a cadmium reduction-diazotization colorimetric method, for ammonia using a salicylate-hypochlorite colorimetric method, and for orthophosphate using a phosphomolybdate colorimetric method; all as described by Fishman (1993). Samples were analyzed for phosphorus as well as for ammonia plus organic nitrogen using microkjeldahl digestion and colorimetry, as described by Patton and Truitt (1992; 2000). Samples were analyzed for chloride and sulfate using ion chromatography, as described by Fishman and Friedman (1989); calcium, magnesium, sodium, and iron were analyzed using inductively coupled plasma, as described by Fishman (1993); and potassium was analyzed using flame atomic absorption, as described by Fishman and Friedman (1989). Arsenic, lead, and manganese were analyzed using inductively coupled plasma detected with a mass spectrometer (ICP/MS), as described by Garbarino (1999) for arsenic and by Faires (1993) for lead and manganese.

Table 3. Inorganic and organic analytes, analytical methods, reporting limits, and references for analysis of water quality in the Methow River Basin, Okanogan County, Washington

[**Analytical method:** AA, atomic absorption flame; ASF, automated-segment flow; IC, ion chromatography; ICP, inductively coupled plasma; ICP-AES, inductively coupled plasma with atomic emission spectrometry; ICP/MS, inductively coupled plasma/mass spectrometry; ISE, ion-selective electrode. **Laboratory reporting limit:** All concentrations are in milligrams per liter unless otherwise indicated. **Reference:** USEPA, U.S. Environmental Protection Agency. **Abbreviations:** µg/L, micrograms per liter]

Analytes	Analytical method	Laboratory reporting limit ¹	Reference
Nutrients			
Nitrogen, ammonia, filtered as N	Colorimetry, salicylate-hypochlorite	0.041	Fishman, 1993
Ammonia plus organic nitrogen, filtered, as N	Colorimetry, microkjeldahl digestion	.10	Patton and Truitt, 2000
Ammonia plus organic nitrogen, unfiltered, as N	Colorimetry, microkjeldahl digestion	.08	Patton and Truitt, 2000
Nitrogen, nitrite, filtered, as N	Colorimetry, diazotization	.006	Fishman, 1993
Nitrite plus nitrate, filtered, as N	Colorimetry, cadmium reduction-diazotization	.047	Fishman, 1993
Phosphorus, orthophosphate, filtered, as P	Colorimetry, phosphomolybdate	.018	Fishman, 1993
Phosphorus, filtered, as P	Colorimetry, phosphomolybdate	.006	USEPA, 1993
Phosphorus, unfiltered, as P	Colorimetry, phosphomolybdate	.0037	USEPA, 1993
Major ions and metals			
Arsenic, filtered (µg/L)	ICP/MS	0.18	Garbarino, 1999
Bromide, filtered	Colorimetry, fluorescein	² 0.1	Fishman and Friedman, 1989
Calcium, filtered	ICP-AES	.011	Fishman, 1993
Chloride, filtered	IC	.08	Fishman and Friedman, 1989
Fluoride, filtered	Colorimetry, ASF/ISE	.16	Fishman and Friedman, 1989
Iron, filtered (µg/L)	ICP-AES	10	Fishman, 1993
Lead, filtered (µg/L)	ICP/MS	.08	Faires, 1993
Magnesium, filtered	ICP-AES	.008	Fishman, 1993
Manganese, filtered (µg/L)	ICP/MS	3.2	Faires, 1993
Potassium, filtered	AA, flame	.09	Fishman and Friedman, 1989
Residue, filtered (180 degrees Celsius)	Gravimetric, residue on evaporation	³ 10	Fishman and Friedman, 1989
Silica, filtered	Colorimetry, ASF, molybdate blue	.48	Fishman and Friedman, 1989
Sodium, filtered	ICP-AES	.06	Fishman, 1993
Sulfate, filtered	IC	.11	Fishman and Friedman, 1989

¹The Laboratory Reporting Level (LRL) generally is equal to twice the yearly determined long-term method detection level (LT-M DL). The LRL controls false negative error. The probability of falsely reporting a non-detection for a sample that contained an analyte at a concentration equal to or greater than the LRL is predicted to be less than or equal to 1 percent. The value of the LRL will be reported with a "less than" remark code for samples in which the analyte was not detected. The U.S. Geological Survey National Water Quality Laboratory collects quality-control data from selected analytical methods on a continuing basis to determine LT-MDLs and establish LRLs. These values are re-evaluated annually based on the most current quality-control data and may change.

²Reporting limit is the U.S. Environmental Protection Agency method detection limit (MDL), described as the minimum concentration of a substance that can be measured and reported with a 99-percent confidence that the analyte is greater than zero.

³Reporting limit is the minimum reporting level (MRL), described by Timme (1995) as the smallest measured concentration of a constituent that may be reliably reported by using a given analytical method.

Quality Assurance

About 15 percent of all samples submitted to the laboratory for analysis were quality-control samples, which included field blanks and equipment blanks to measure possible contamination and bias and replicate samples to measure variability. The quality-control techniques for sample processing are described by Wilde and others (1999b). Additionally, quality-control samples were routinely analyzed as part of the NWQL quality-assurance plan described by Pritt and Raese (1995).

Field- and equipment-blank samples for surface water were free of compounds of interest, except for low-level detections of phosphorus, chloride, and sulfate in the equipment blank and a low-level detection of ammonia plus organic nitrogen in one field blank. Field- and equipment-blank samples for ground water were free of compounds of interest, except for low-level detections of calcium and dissolved solids in one of the equipment blanks and a detection of chloride in one of the field blanks. Concentrations of the analytes detected in blanks were all at or near detection levels and generally were much lower than ambient concentrations in ground and surface water; thus, there is little chance that the environmental concentrations for these constituents are biased.

The combined precision of sample collection and laboratory analysis is shown by the relative percentage of difference between replicate analyses that were collected in the field and submitted to the laboratory for analysis ([table 16, at back of report](#)). Relative percentage of differences ranged from 0.0 to 69.7 percent, with a median of 2.3 percent. There were 15 of a total of 122 replicate pairs submitted with a percentage of difference greater than 10 percent, ranging in concentration from differences of 0.01 mg/L between replicates submitted for analysis of bromide and nitrite plus nitrate to a difference of 2 µg/L between replicates submitted for analysis of iron. These quality-control results for analyses of replicates generally are an indication of good precision for field collection and laboratory analytical techniques and present no problems for interpretation of data.

The quality of data collection and analysis also may be measured by the calculation of ion balances of a chemical water analysis. Ion balances for 43 ground- and surface-water quality samples that have complete major-ion balances ranged from -3.00 to 3.69 percent, indicating that analytical measurements were of good quality and that data-collection and analysis techniques for major ions generally were free from bias.

Results of Water-Quality Analyses

Surface and ground water generally was of high quality in the Methow River Basin. Concentrations of constituents in surface water ([table 17, at back of report](#)) did not exceed any Federal drinking-water standards or health advisories (U.S. Environmental Protection Agency, 2002). Water temperature measured at all surface-water sites at the time of sampling was within the criteria for class AA (extraordinary) streams (Washington State Department of Ecology, 1997). Values of pH measured for all sites except for Beaver Creek also meet the criteria for class AA streams; the pH at Beaver Creek (8.8) meets the criteria for a class C (fair) stream. Concentrations of constituents in ground water ([table 17](#)) exceeded Federal drinking-water standards only for arsenic in one well, which is discussed below. Statistical summaries of data collected for samples of surface water are shown in [table 4](#) and for samples of ground water in [table 5](#).

Specific conductance of ground water ranged from 95 to 1,550 µS/cm with a median of 293 µS/cm, whereas specific conductance of streams was much lower, ranging from 60 to 373 µS/cm with a median of 163 µS/cm. Concentrations of dissolved oxygen in samples of ground water ranged from 0 to 11.0 mg/L with a median of 6.8 mg/L, and dissolved oxygen in samples of surface water generally were higher, ranging from 9.20 to 11.1 mg/L, with a median of 10.2 mg/L. pH in ground-water samples ranged from 7.0 to 9.4 with a median of 7.62, and pH in surface-water samples ranged from 7.6 to 8.8, with a median of 8.2. Ground-water temperature ranged from 6.1 to 13.8 °C with a median of 10.7 °C, and surface-water temperature ranged from 6.5 to 14.7 °C with a median of 11.3 °C.

Table 4. Statistical summary of selected surface-water quality data collected in the Methow River Basin, Okanogan County, Washington, September 2001

[**Descriptive statistics: Minimum:** E, estimated. Identification is confirmed, but the concentration is estimated because the calculated concentration is less than the laboratory reporting level (LRL, less than the lowest calibration standard, or because the compound was detected in instrument blanks). **Mean, Median:** Asterisk (*) indicates that concentration is estimated by using a log-probability regression to predict the values of data less than the detection limit. **Abbreviations:** NWIS, U.S. Geological Survey National Water Information System; ft³/s, cubic feet per second; mg/L, milligrams per liter; μS/cm, microsiemens per centimeter at 25 degrees Celsius; μg/L, micrograms per liter. <, less than; –, insufficient data for statistical calculation]

NWIS parameter code	Physical property or water-quality constituent	Sample size	Descriptive statistics			Median
			Minimum	Maximum	Mean	
00061	Discharge, instantaneous (ft ³ /s)	17	0.44	220	6.97	13.0
00300	Dissolved oxygen, filtered (mg/L)	19	9.20	11.1	10.1	10.2
00400	pH, field (standard units)	19	7.6	8.8	8.2	8.2
00095	Specific conductance (μS/cm)	19	60	373	168	163
00020	Air temperature (degrees Celsius)	19	8.2	27.7	17.6	17.0
00010	Water temperature (degrees Celsius)	19	6.5	14.7	11.0	11.3
00915	Calcium, filtered (mg/L)	19	7.5	53.7	23.7	21.6
00925	Magnesium, filtered (mg/L)	19	1.06	11.4	4.28	3.76
00935	Potassium, filtered (mg/L)	19	.25	.45	.75	.60
00930	Sodium, filtered (mg/L)	19	1.7	11.9	3.78	3.40
39086	Alkalinity, filtered (mg/L as CaCO ₃)	19	28	165	74.2	64.0
00453	Bicarbonate, filtered (mg/L as HCO ₃)	19	34	202	89.6	78.0
00452	Carbonate, filtered (mg/L as CO ₃)	19	0	4	.325	.0
00940	Chloride, filtered (mg/L)	19	.1	3.3	.821	.60
00950	Fluoride, filtered (mg/L)	19	.1E	.3	.147*	.127*
00955	Silica, filtered (mg/L)	19	7.1	21.1	11.1	10.5
00945	Sulfate, filtered (mg/L)	19	.5	30.5	7.72	5.50
00608	Nitrogen ammonia, filtered (mg/L as N)	19	.023E	.07	–	<.04
00623	Ammonia plus organic nitrogen, filtered (mg/L as N)	19	.05E	.230	.082*	.073*
00625	Ammonia plus organic nitrogen, unfiltered (mg/L as N)	19	.04E	.320	.085*	.066*
00631	Nitrite plus nitrate, filtered (mg/L as N)	19	.023E	.259	.079*	.047*
00613	Nitrogen, nitrite, filtered (mg/L as N)	19	.003E	.048	–	<.006
00666	Phosphorus, filtered (mg/L as P)	19	.003E	.016	–	<.006
00671	Phosphorus, orthophosphate, filtered (mg/L as P)	19	<.02	.077	–	<.02
00665	Phosphorus, unfiltered (mg/L as P)	19	.002E	.025	.004*	.003*
01000	Arsenic, filtered (μg/L)	5	<.2	.5	(¹)	.2
01046	Iron, filtered (μg/L)	19	6E	21	(¹)	<10
01049	Lead, filtered (μg/L)	5	.07E	.14	(¹)	<.08
01056	Manganese, filtered (μg/L)	19	1.06E	6.1	2.47*	2.23*

¹Constituent was not detected in majority of samples.

Table 5. Statistical summary of selected ground-water quality data collected in the Methow River Basin, Okanogan County, Washington, June 2001

[**Descriptive statistics: Minimum:** E, estimated. Identification is confirmed, but the concentration is estimated because the calculated concentration is less than the laboratory reporting level (LRL, less than the lowest calibration standard, or because the compound was detected in instrument blanks).

Mean, Median, Asterisk (*) indicates that concentration is estimated by using a log-probability regression to predict the values of data less than the detection limit. **Abbreviations:** NWIS, U.S. Geological Survey National Water Information System; ft, feet; NGVD of 1929, National Geodetic Vertical Datum of 1929; mm, millimeters; mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; μ g/L, micrograms per liter; –, insufficient data for statistical calculation]

NWIS parameter code	Physical property or water-quality constituent	Sample size	Descriptive statistics			Median
			Minimum	Maximum	Mean	
72008	Depth of well (feet below land surface)	89	24.0	450.0	105	74.5
72000	Altitude of land surface (ft above NGVD of 1929)	89	790	2,350	1,740	1,800
00025	Air pressure (mm of mercury)	86	696	745	715	713
00300	Dissolved oxygen, filtered (mg/L)	89	0	11.0	5.79	6.8
00400	pH, field (standard units)	89	7.0	9.4	7.62	7.6
00095	Specific conductance (μ S/cm)	89	95	1,550	323	293
00020	Air temperature (degrees Celsius)	85	7.6	31.5	20.1	20.4
00010	Water temperature (degrees Celsius)	84	6.1	13.8	10.4	10.7
00915	Calcium, filtered (mg/L)	24	.13	111.0	33.3	27.8
00925	Magnesium, filtered (mg/L)	24	.019	36.7	6.88	5.25
00935	Potassium, filtered (mg/L)	24	.14	2.73	.783*	.62*
00930	Sodium, filtered (mg/L)	24	2.0	85.0	15.4	4.40
39086	Alkalinity, filtered (mg/L as CaCO ₃)	24	41	203	111	98.0
00453	Bicarbonate, filtered (mg/L as HCO ₃)	24	49	247	133	120
00452	Carbonate, filtered (mg/L as CO ₃)	22	0	10	.455	0
71870	Bromide, filtered (mg/L)	24	<.01	.02	.007*	.005*
00940	Chloride, filtered (mg/L)	89	.2	14.9	1.22	.90
00950	Fluoride, filtered (mg/L)	24	.1E	1.9	.267*	.20*
00955	Silica, filtered (mg/L)	24	7.6	20.7	13.2	12.2
00945	Sulfate, filtered (mg/L)	24	3.6	473	31.5	10.8
70300	Residue, filtered (180 degrees Celsius, mg/L)	24	64	884	178	127
00631	Nitrite plus nitrate, filtered (mg/L as N)	89	.025E	6.28	.722*	.19*
01000	Arsenic, filtered (μ g/L)	24	.10E	25.4	1.48	.30
01046	Iron, filtered (μ g/L)	24	<10	120	–	<10
01049	Lead, filtered (μ g/L)	24	.06E	2.01	.423*	.175*
01056	Manganese, filtered (μ g/L)	24	1.8E	21.0	4.29*	2.32*

Nitrate and Chloride as Contaminant Indicators

Nitrite, nitrate, and chloride concentrations serve as indicators of potential contamination of ground and surface waters from leaking septic tanks, agricultural fertilizer runoff, or other anthropogenic causes. Most nitrite concentrations in both surface water and ground water were less than the detection limit; thus nitrite plus nitrate is referred to hereafter simply as nitrate. Concentrations of nitrate in surface-water samples ranged from less than the detection limit to a maximum of 0.259 mg/L with a median of 0.047 mg/L and concentrations of chloride ranged from 0.1 to 3.3 mg/L with a median of 0.60 mg/L. Concentrations of nitrate in ground-water samples ranged from less than the detection limit to a maximum of 6.28 mg/L, with a median of 0.19 mg/L (fig. 8). Concentrations of chloride in ground-water samples ranged from 0.2 to 14.9 mg/L, with a median of 0.90 mg/L (fig. 8). Nitrate concentrations were greater than 3 mg/L in five ground-water samples and may be an indicator of anthropogenic sources of contaminations (Madison and Brunett, 1985), although natural sources also can contribute to this level of nitrate concentration. The

concentration of nitrate in all samples was less than the Federal Primary Drinking Water Standard maximum contaminant level of 10 mg/L (U.S. Environmental Protection Agency, 2002). Overall, the concentrations of chloride were very low in ground-water and surface-water samples, however, one ground-water sample was more than 10 times the median. Overall, the concentrations of nitrate and chloride in samples of ground and surface water were relatively low and indicate little likelihood of contamination from leaking septic tanks or excess nitrate fertilizer.

Lead and Arsenic as Contaminant Indicators

Lead and arsenic also may serve as indicators of potential contamination of ground and surface waters. Both lead and arsenic were used historically as pesticides in orchards. Runoff from historical mining sites in the Methow River Basin also may contribute to elevated concentrations of lead and arsenic in the ground or surface water (Peplow and Edmonds, 2002). Lead and arsenic also occur naturally in rocks and can dissolve into the surrounding ground and surface waters.

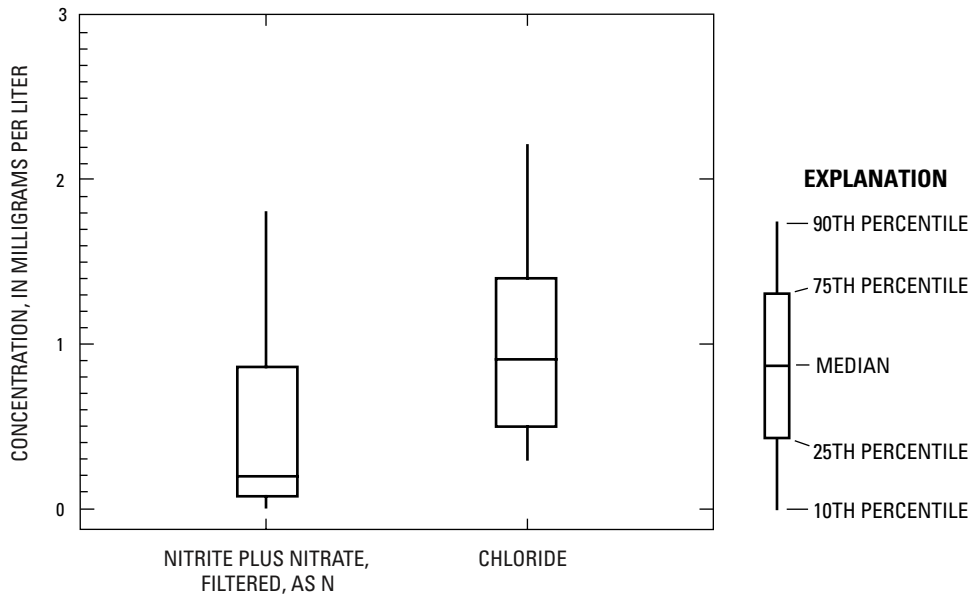


Figure 8. Distributions of nitrate and chloride concentrations in ground- and surface-water-quality samples from the Methow River Basin, Okanogan County, Washington.

Concentrations of lead in surface water ranged from a minimum estimated value of 0.07 $\mu\text{g/L}$ in a sample from Andrews Creek to a maximum of 0.14 $\mu\text{g/L}$ in a sample from the Chewuch River at Winthrop. Concentrations from the remaining sites (Early Winters Creek, Eightmile Creek and Twisp River near Twisp) were 0.08 $\mu\text{g/L}$. Concentrations of arsenic ranged from less than 0.2 to 0.5 $\mu\text{g/L}$. Concentrations were less than 0.2 $\mu\text{g/L}$ in samples from Andrews Creek, Chewuch River at Winthrop, and Eightmile Creek. Concentrations of arsenic were 0.5 $\mu\text{g/L}$ in samples from Early Winters Creek and Twisp River near Twisp.

Concentrations of lead in samples of ground water ranged from a minimum estimated value of 0.06 to 2.01 $\mu\text{g/L}$, with a median of 0.175 $\mu\text{g/L}$ (fig. 9). All 24 detections of lead in samples of ground water, which range in concentration from 0.06 to 2.01 $\mu\text{g/L}$, are less than the “action level” of 15 $\mu\text{g/L}$, which triggers treatment or other requirements for water-supply systems but not for domestic wells (U.S. Environmental Protection Agency, 2002).

Concentrations of arsenic in samples from ground water ranged from 0.1 to 25.4 $\mu\text{g/L}$ (fig. 10). Only the sample with an arsenic concentration of 25.4 $\mu\text{g/L}$ exceeded the Federal drinking water standard maximum contaminant level (MCL) for drinking water of 10 $\mu\text{g/L}$ for arsenic (U.S. Environmental Protection Agency, 2002). The well (33N/22E-20G01) with the highest concentration of arsenic also had the second highest concentration of lead.

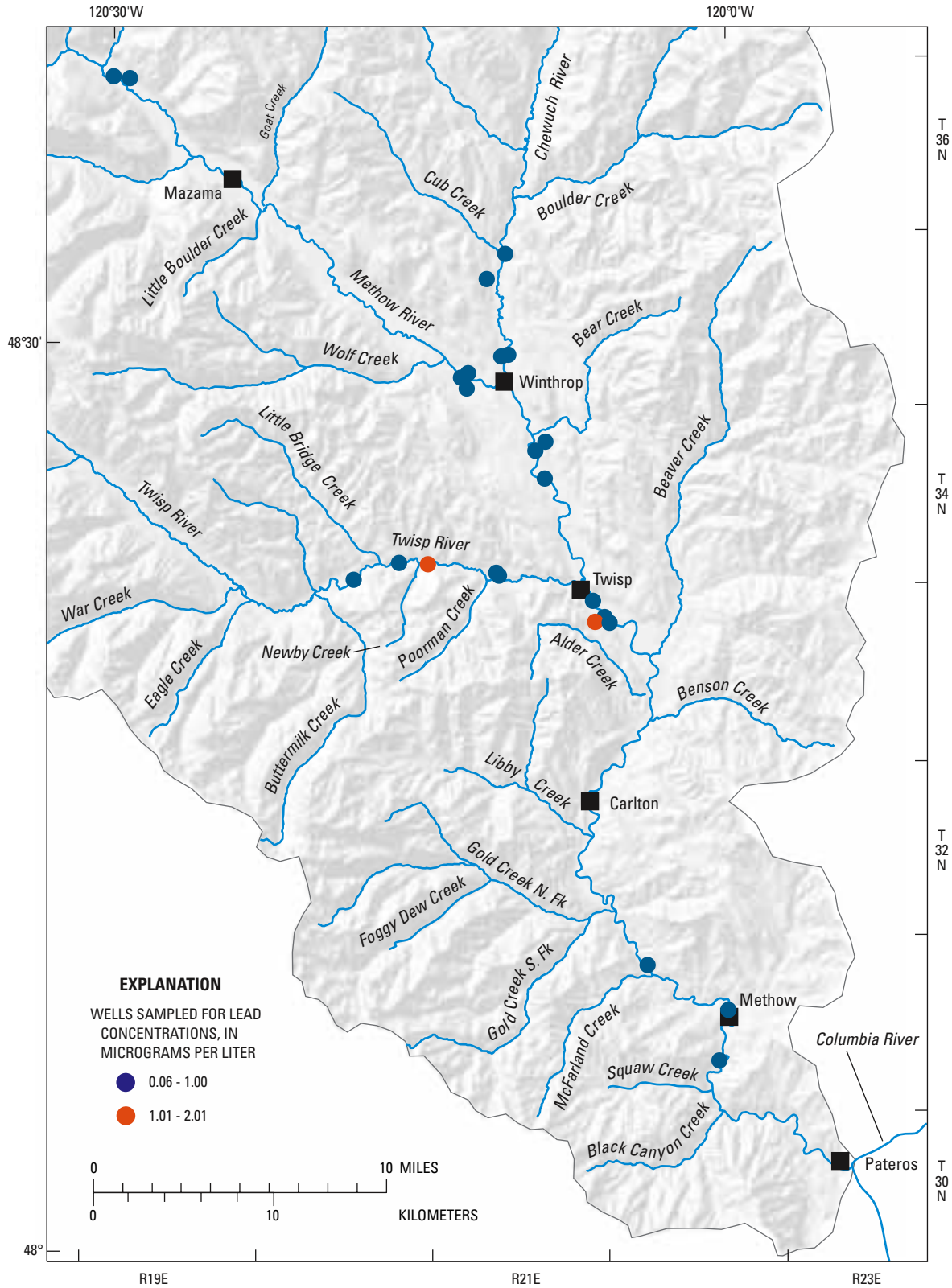
Concentrations in three nearby wells that also were sampled (33N/22E-21E01, 33N/22E-17L01, and 33N/22E-20A04) ranged from 0.1 to 0.9 $\mu\text{g/L}$ of arsenic and 0.10 to 0.19 $\mu\text{g/L}$ of lead, which were very close to the basin-wide medians of 0.30 $\mu\text{g/L}$ arsenic and 0.175 $\mu\text{g/L}$ lead. The large difference in arsenic concentrations between relatively nearby wells may be natural or anthropogenic. The three wells are located on the opposite side of the river from well 33N/22E-20G01, and a river typically divides ground-water flow. The wells are constructed in different hydrogeologic units. Whereas 33N/22E-20G01 was drilled 450 ft in sedimentary bedrock and is only cased in the upper 40 ft, the three nearby wells are constructed in glaciofluvial deposits (Qga; table 12). Thus, the arsenic may be leaching from the bedrock. Alternatively, the

high concentration of arsenic in well 33N/22E-20G01 may be due to arsenic leaching from the abandoned mines on the hillside above the well.

Ionic Composition of Surface and Ground Water

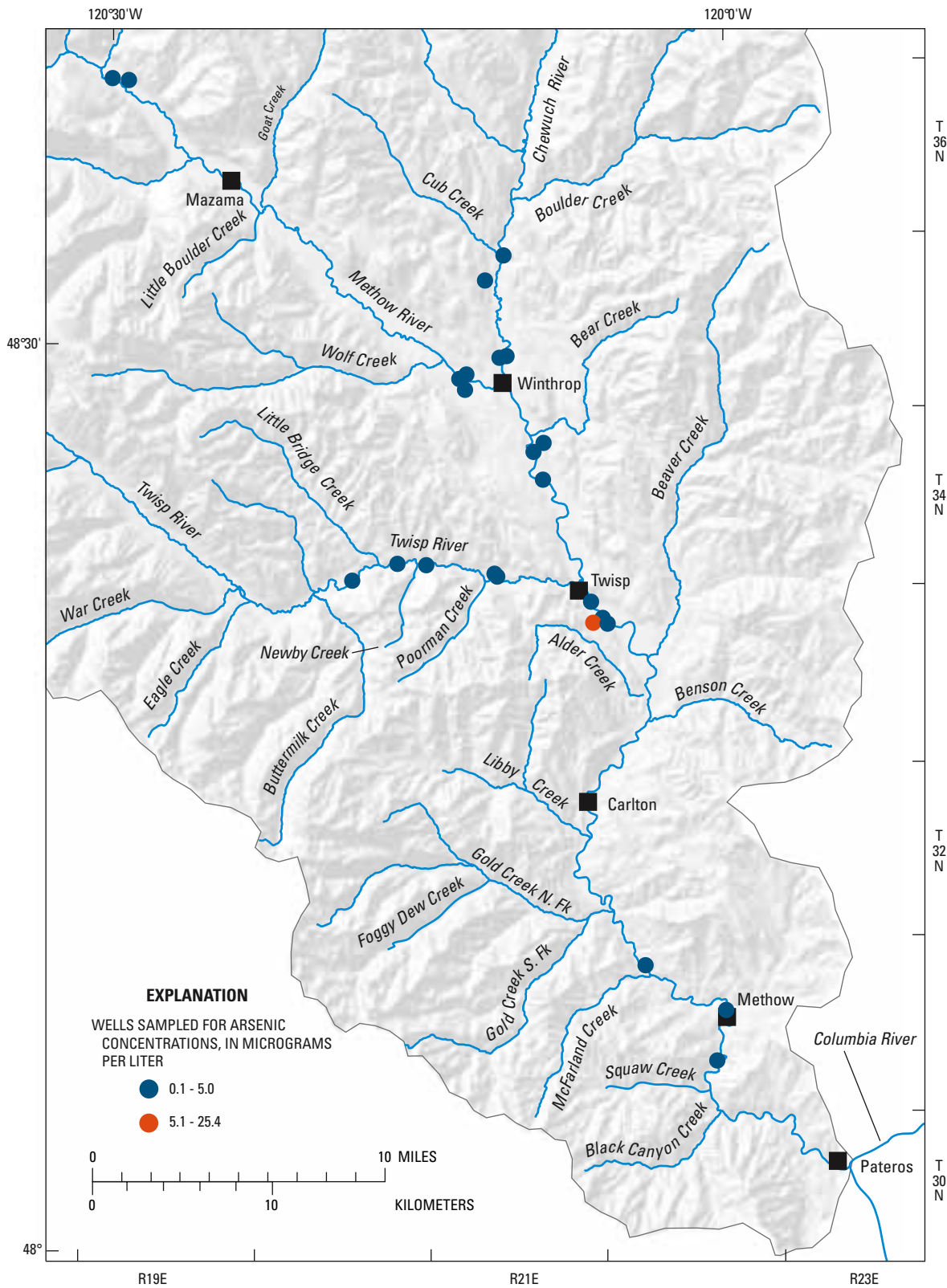
Water chemistry can be characterized generally by the relative percentage of major ions, which are depicted using a trilinear diagram as described by Hem (1985). Water types are described by the combination of dominant cations (calcium, magnesium, sodium, and potassium) and anions (sulfate, chloride, carbonate, bicarbonate, fluoride, and nitrite plus nitrate). Surface water in samples from the Methow River Basin generally was of the same ionic composition: predominantly calcium bicarbonate (fig. 11) and varied only in strength of ionic composition. Samples from the headwaters (Andrews Creek, Lake Creek, Early Winters Creek, Lost River, and Chewuch River at Eightmile Ranch) consisted of water of relatively low ionic strength, as measured by specific conductance that was less than 100 $\mu\text{S/cm}$. Specific conductance ranged from 60 $\mu\text{S/cm}$ at Andrews Creek to 98 $\mu\text{S/cm}$ at the Lost River.

The ionic strength of surface-water samples from the Methow River increased downstream, ranging from 113 $\mu\text{S/cm}$ in a sample from above Robinson Creek to 205 $\mu\text{S/cm}$ in a sample from the Methow River at Pateros. Input from tributaries may account for some of the increase. For example, a sample from Goat Creek measured 227 $\mu\text{S/cm}$, a sample from Beaver Creek measured 322 $\mu\text{S/cm}$, and a maximum of 373 $\mu\text{S/cm}$ was measured in a sample from Libby Creek. The downstream increase in ionic strength also is likely due to ground-water inflow to the river. The ionic strength of samples from the tributaries also increased downstream, which may reflect ground-water inflow: specific conductance in the Twisp River increased from 113 $\mu\text{S/cm}$ above Buttermilk Creek to 213 $\mu\text{S/cm}$ near Twisp, and specific conductance in the Chewuch River increased from 97 $\mu\text{S/cm}$ above Eightmile Creek to 163 $\mu\text{S/cm}$ at Winthrop. The concentrations of major ions in samples of surface water also varied in proportion to the changes observed in specific conductance, but concentrations of the limited number of trace-element samples (lead and arsenic) did not show any relation to streamflow or location.



Base from U.S. Geological Survey Digital Data, 1:100,000, 1985
 Universal Transverse Mercator projection,
 Zone 10, Datum NAD 83

Figure 9. Concentrations of lead in selected wells in the Methow River Basin, Okanogan County, Washington, June 2001.



Base from U.S. Geological Survey Digital Data, 1:100,000, 1985
 Universal Transverse Mercator projection,
 Zone 10, Datum NAD 83

Figure 10. Concentrations of arsenic in selected wells in the Methow River Basin, Okanogan County, Washington, June 2001.

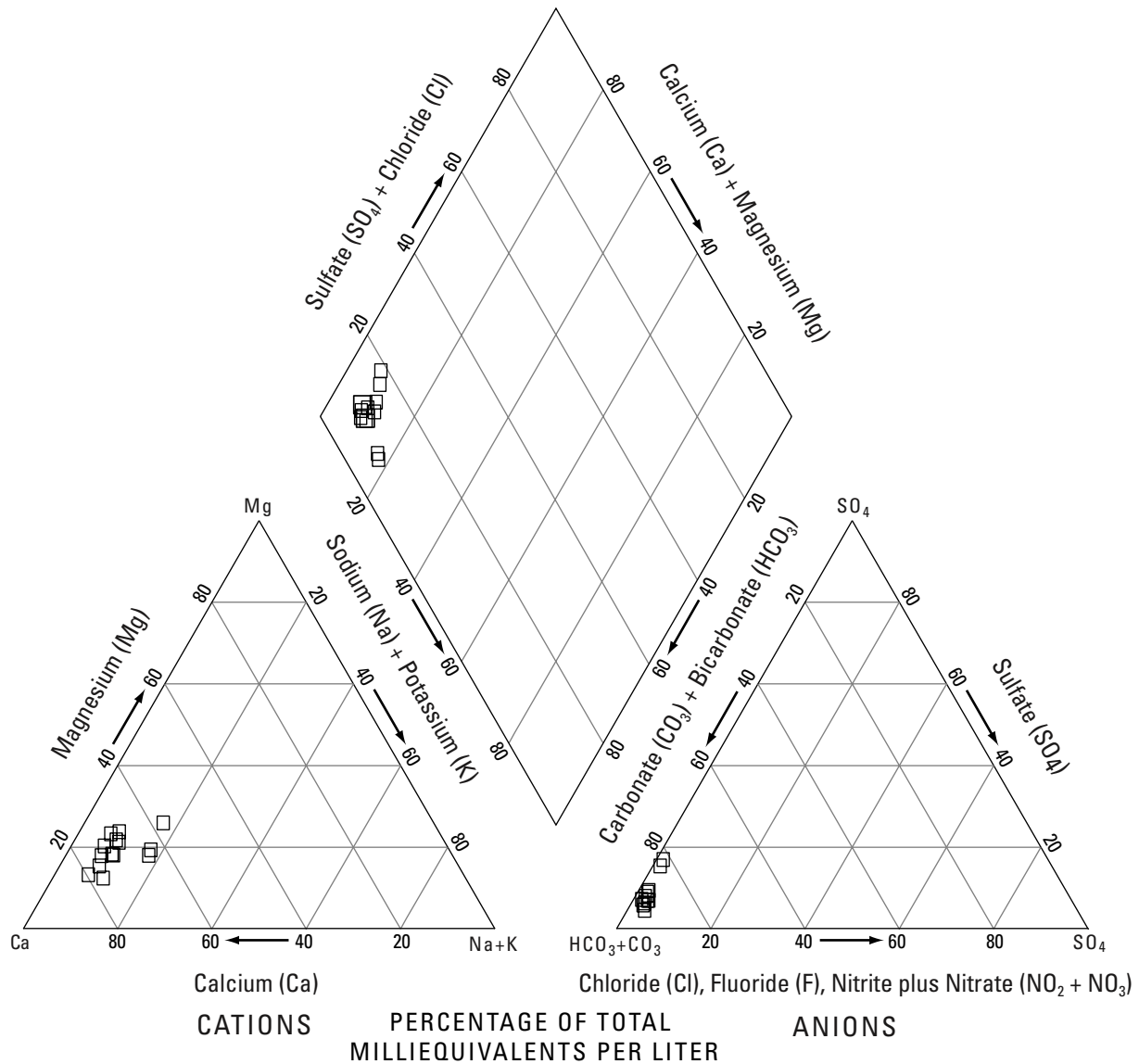


Figure 11. Major ions in surface-water samples from the Methow River Basin, Okanogan County, Washington, September 2001.

Three types of water chemistry were evident from the ionic composition of ground-water samples (fig. 12). Twenty of the samples were calcium-bicarbonate water types, representative of waters from wells that are open to aquifers in Pleistocene glacial drift, or glaciofluvial lithology (Qga). Samples from three wells were sodium-bicarbonate water. Two of these samples are from wells (34N/21E-13K01 and 35N/21E-15K01) that draw water from sedimentary bedrock. The third sample of sodium-bicarbonate water

is somewhat anomalous because the well (35N/21E-11M01) draws water from older Pleistocene glaciofluvial deposits (Qga), which are usually associated with calcium-bicarbonate types of water. Water from this site also is the lowest in ionic strength, which may indicate mixing of the water from a different source. Water from well 33N/22E-20G01 represents a third type of water sampled: primarily calcium and sulfate. This well also is open to water from sedimentary bedrock.

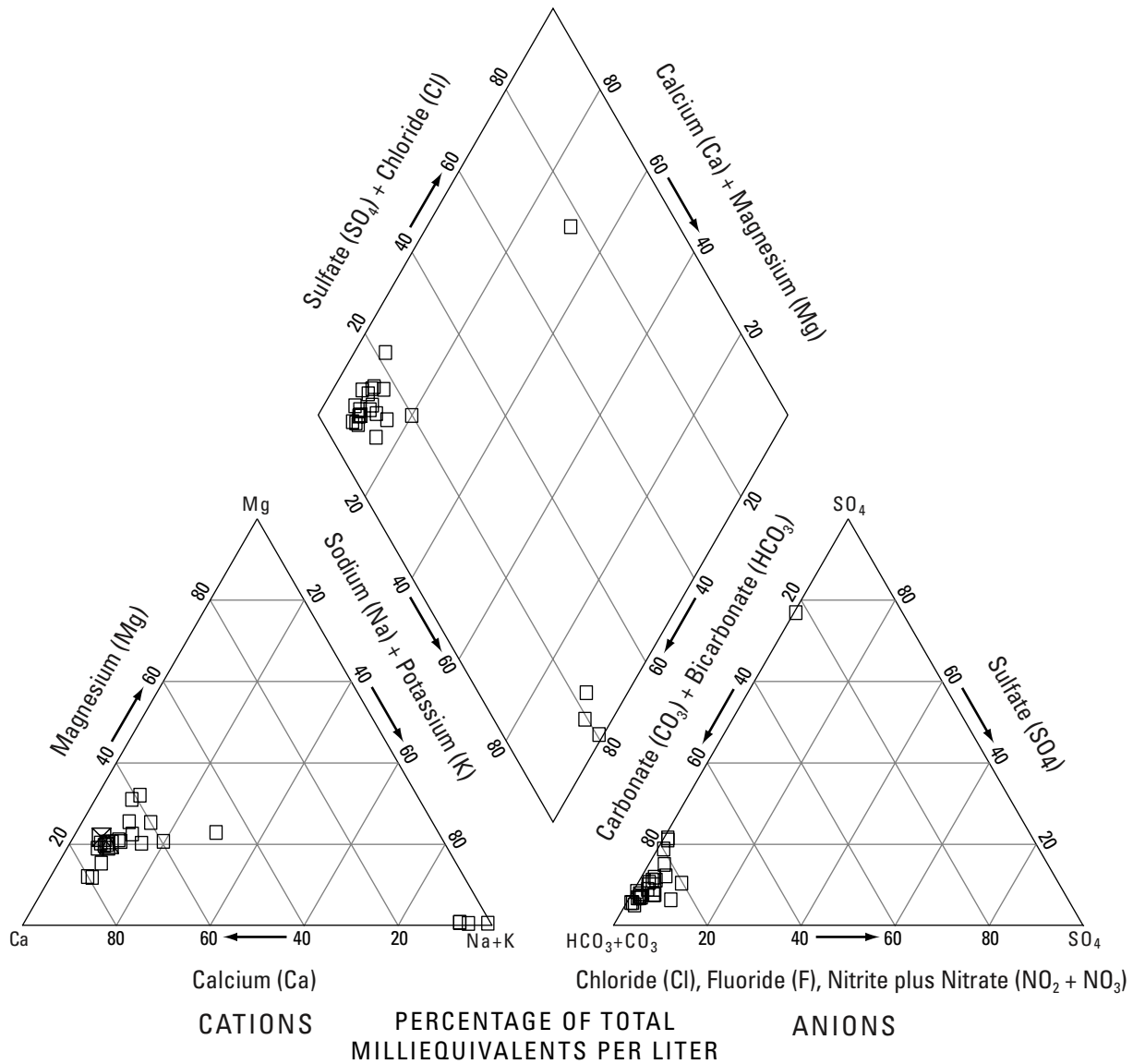


Figure 12. Major ions in ground-water samples from the Methow River Basin, Okanogan County, Washington, June 2001.

Comparison of Water-Quality Results with Historical Records

The quality of surface water in the Methow River Basin as indicated in this study generally is consistent with longer term monitoring results. Physical properties and analytical measurements made at Andrews Creek compared well with the median values for the period from December 1971 to August 1995 described by Mast and Clow (2000). Percentage of

differences between the concentrations of cations measured during this study and the median concentration of cations historically measured ranged from 7 to 11 percent (except for a difference of 27 percent for potassium, because of the small range of concentrations of potassium). Percentage of differences between anions and specific conductance measured during this study and historical measurements also compared well, ranging from -17 to 7 percent.

Water temperature and specific conductance exceeded values measured in 1976 for the Chewuch River at Winthrop, but streamflow was lower during sampling in 2001 for this study than in 1976. Although pH and water temperature in the Methow River near Pateros historically have exceeded State water-quality criteria, values in samples collected for this study in September 2001 did not exceed those criteria and compare favorably with samples also collected by Ecology during September (Hallock, 2002). Walters and Nassar (1974) describe the water from the Methow River at Pateros as a calcium magnesium bicarbonate type, suitable for most common uses. Results from analysis of water-quality samples collected from the Methow River at Twisp during this study are within the range of historical values for samples collected by Ecology from the Methow River near Twisp and at Twisp except for streamflow, which was less than the minimum measured during previous sample collections.

EXCHANGES BETWEEN GROUND AND SURFACE WATER IN THE METHOW RIVER VALLEY AND LOWER TWISP RIVER VALLEY

Ground-water discharge from unconsolidated sedimentary deposits in the Methow River Basin is a primary source of baseflow in the Methow and Twisp Rivers. Unconsolidated aquifers, in turn, are recharged by infiltration of snowmelt and rainfall, ground-water flow from adjacent unconsolidated or bedrock aquifers, and seepage from rivers and irrigation canals. The location, rate, and seasonal patterns of exchanges between ground water and surface water were investigated in the Methow and lower Twisp River valleys using streamflow records and ground-water monitoring wells.

Previous Studies

Surface water has been the historical focus of most water-resources investigations in the Methow River Basin, largely because of its uses as water supply in agriculture and for power generation. The USGS first collected continuous records of streamflow in the Methow River beginning in 1904 at Pateros

(12450500). Measurements of irrigation diversions in the Methow River Basin were made as early as 1912 (Walters and Nassar, 1974). In an assessment of streamflow depletion from irrigation in the Columbia River Basin, Simons (1953) calculated total consumptive water use in the Methow River Basin of 22,450 acre-ft in 1946, based on an annual consumptive use rate of 1.75 ft per acre applied over 12,830 acres of crops.

The availability and use of ground-water and surface-water resources in the Methow River Basin were first described by Walters and Nassar (1974). Walters and Nassar developed an annual water budget with estimated precipitation of 3 million acre-ft, which is equivalent to 32 in., discharge to the Columbia River of 1.2 million acre-ft, ground-water discharge out of the basin of 0.7 million acre-ft, and evapotranspiration of 1.2 million acre-ft. They noted, however, that ground-water discharge from the basin likely was lower, given ground-water hydraulic conditions at the basin outlet. If ground-water discharge was indeed lower, then either precipitation was lower or evapotranspiration was higher than their estimates.

Walters and Nassar (1974) estimated that annual water use in the basin was 114,500 acre-ft, which is equivalent to a mean annual rate of 158 ft³/s, with irrigation accounting for 95 percent of the total. Because irrigation generally is practiced only 5 months of the year, total diversions in the basin during the peak irrigation season from May through August may have been more than 300 ft³/s. Walter and Nassar estimated that more than 95 percent of the water used for irrigation came from rivers and streams. They noted that the high rate of water use per irrigated acre, which was more than 8 ft/yr, was due in part to seepage from irrigation canals. Walter and Nassar cited a study by the Pacific Northwest River Basins Commission (1971) that estimated seepage from canals was 36,000 acre-ft and accounted for 45 percent of the water used for irrigation in the Methow River Basin.

Milhous and others (1976) also comprehensively assessed water resources in the Methow River Basin. They revised estimates of water use in the basin, updated the water budget accordingly, and compiled streamflow records to calculate gains and losses along the Methow River from Robinson Creek to the Weeman Bridge (Washington State Highway 20),

between Mazama and Winthrop. They estimated that annual water use in the basin was 88,000 acre-ft (mean annual rate of 120 ft³/s), again with irrigation accounting for 95 percent and surface-water diversions providing more than 95 percent of the water for irrigation. They estimated that 1.6 million acre-ft (mean annual rate of 2,240 ft³/s) was lost to the atmosphere by evapotranspiration, with crops accounting for an annual loss of 27,000 acre-ft (mean annual rate of 37 ft³/s). Ground-water discharge from the basin was estimated as 62,000 acre-ft (85 ft³/s). Their review of estimates of irrigated acreage in the basin showed a wide range, from 3,200 to 13,400 acres.

Milhous and others (1976) calculated gains and losses for the Methow River above Weeman Bridge from their compilation of streamflow measurements. The river gained 7.4 ft³/s from Early Winters Creek to Weeman Bridge (31 percent of outflow from the reach) in January 1944. The river lost 45 ft³/s (24 percent of inflow to the reach) from Robinson Creek to the Mazama Bridge, downstream of Early Winters Creek, in August 1971. In late summer and early autumn of 1972, the river lost flow from Mazama to Fawn Creek, with a mean loss of 36 ft³/s for 4 days from mid-September to October when streamflow at Mazama ranged from 135 to 63.5 ft³/s. Losses from Mazama to Fawn Creek were not significantly greater than measurement uncertainty earlier in the summer when streamflow was greater than 159 ft³/s. Gains in streamflow from Fawn Creek to the Weeman Bridge were documented from August to October 1972, with a mean loss rate of 44 ft³/s for 7 days. Streamflow at the Weeman Bridge ranged from 576 to 88 ft³/s during this period.

Kauffman and Bucknell (1977) established policies on water-resources management in the Methow River Basin for Ecology with regard to protection of existing water rights, baseflows intended to preserve instream uses, closures of certain surface waters to further consumptive appropriation, and quantities of water available for additional appropriation in the basin. They noted the importance of the unconsolidated aquifer for domestic and irrigation use and public concern for aquifer recharge

from irrigation-canal seepage among their other findings. The policies described by Kauffman and Bucknell (1977) were codified in Chapter 173-548 of the Washington State Administrative Code (1991), which describes the water-resources program for the Methow River Basin.

More recently, Larson (1991) described continuity between ground water and surface water in the Methow River Basin, based on a compilation of information from other, unpublished reports. Larson used 10 ft/d as the lateral velocity for ground water in the upper basin (near Mazama) to estimate a travel time of 200 to 300 days for ground-water recharged from the river flow to wells within 0.5 mi of the river. Downvalley ground-water flow was estimated to be 56 ft³/s near Mazama and aquifer recharge from the river and its tributaries was 30 ft³/s during autumn storms and 170 ft³/s during peak runoff. Downvalley ground-water flow was estimated to be 13 ft³/s near Winthrop.

Irrigation-canal seepage was documented by Klohn Leonoff, Inc. (1990) for the Methow Valley Irrigation District (MVID). Losses of flow were calculated for both the MVID East Canal (total length of 13.8 mi) and West Canal (total length of 9.8 mi) in August 1989 and September 1989. The mean seepage rates were 2.1 (ft³/s)/mi for the East Canal and 2.3 (ft³/s)/mi for the West Canal in August. The mean seepage rates decreased in September to 0.8 (ft³/s)/mi for the East Canal and 1.5 (ft³/s)/mi for the West Canal.

Methods for Analyzing Ground-Water and Surface-Water Exchanges

Two types of ground-water and surface-water exchanges were analyzed in the Methow River Basin: flow between rivers and aquifers and aquifer recharge from irrigation-canal seepage. River-aquifer exchanges were analyzed using gains and losses in streamflow calculated from a surface-water discharge balance. Irrigation-canal seepage was estimated from measured losses in discharge for canals, but also was assessed by observing seasonal changes in ground-water levels in the Twisp River valley.

Surface-Water Discharge Balance

Exchanges between the Methow and Twisp Rivers and the adjacent unconsolidated aquifers were calculated using a surface-water discharge balance wherein the exchange rate is equal to the difference between inflows to and outflows from a reach. Gains in streamflow (outflows greater than inflows) were attributed to ground-water discharge, and losses (inflows greater than outflows) were attributed to ground-water recharge. Exchanges between rivers and aquifers were calculated for nine reaches of the Methow River and three reaches of the Twisp River during three low-flow periods. Exchanges were calculated on a daily basis for water years 2001 and 2002 in four reaches of the Methow River and one reach of the Twisp River where continuous records of major inflows and outflows were available. Streamflow was measured using vertical-axis current meters in accordance with Rantz and others (1982) or were calculated from stage-discharge curves at gaging stations. Surface-water measurement sites are listed in [table 18 \(at back of report\)](#).

Exchanges During Low-Flow Conditions

Gains and losses of streamflow in the Methow and Twisp River were calculated for three low-flow periods (September 11-14, 2001, February 11-14, 2002, and September 17-19, 2002). Records of continuous discharge demonstrate that streamflow throughout the basin was steady during these periods ([fig. 13](#)). Discharge in the mainstem of the Methow River, its major tributaries, and one surface-water diversion were measured to calculate gains and losses for nine reaches of the Methow River from Lost River to near Pateros ([table 19, at back of report](#)). The diversion to the Foghorn Canal was estimated from measurements made earlier in the year.

Tributaries contributing unmeasured inflow to the Methow River included Little Boulder Creek, tributary to the Methow River above Goat Creek, and Benson Creek, tributary to the Methow River above Carlton ([fig. 1](#)). The inflow from these tributaries was likely to be less than 1 percent of discharge in the respective reaches of the Methow River, based on measurements of larger tributaries, and was neglected in the surface-water discharge balance for low-flow conditions. Inflow from McFarland Creek, Squaw Creek, and Black Canyon Creek, tributaries to the

Methow River above Pateros, was measured on October 24, 2000. The combined inflow contributed by these tributaries was 4.0 ft³/s, compared to 363 ft³/s for the Methow River near Pateros. Inflow from the unmeasured tributaries was estimated to be 3 ft³/s for low-flow conditions.

Flow in the mainstem of the Twisp River and two surface-water diversions were measured to calculate gains and losses for three reaches of the Twisp River from Newby Creek to near Twisp. Daily inflow to the Twisp River returned by the Twisp Valley Power and Irrigation (TVPI) Canal was estimated from stage measurements at a rectangular metal weir at the end of the canal (M. Williams, TVPI Co., written commun., 2002). Tributaries contributing unmeasured inflow included Newby and Poorman Creeks. Based on measurements during higher flow periods ([table 18](#)) and observations during low-flow conditions, inflow from these tributaries was estimated to be less than 0.1 ft³/s each and was neglected in the surface-water discharge balance for low-flow conditions.

Daily Gains and Losses in Streamflow

Daily exchanges between ground water and four reaches of the Methow River from Lost River to near Pateros were estimated with a surface-water discharge balance using continuous records for water years 2001 and 2002 from streamflow-gaging stations in the basin ([table 6](#)). The four reaches are from the Lost River to Goat Creek, from Goat Creek to the Chewuch River, from the Chewuch River to Twisp River, and from the Twisp River to Pateros ([fig. 1](#)). Discharge records for water year 2001 were rated as good except for Early Winters Creek (12447382), Wolf Creek (12447387), Twisp River near Twisp (12448998), and Beaver Creek (12449710), which were rated as fair. The main ungaged inflow or tributaries to the Methow includes the Methow River above Lost River and Little Boulder Creek (inflows from the Lost River to Goat Creek); Goat and Little Boulder Creeks (from Goat Creek to the Chewuch River); and Benson Creek, Gold Creek, Libby Creek, and McFarland Creek (from the Twisp River to Pateros). Unmeasured inflows to each reach were estimated using a hydrologic simulation model for the Methow River Basin (Ely, 2003). The calculated difference between outflow and inflow on some days may have an upward bias, indicating a larger gain or smaller loss than the actual exchange, because of unmeasured tributary inflow.

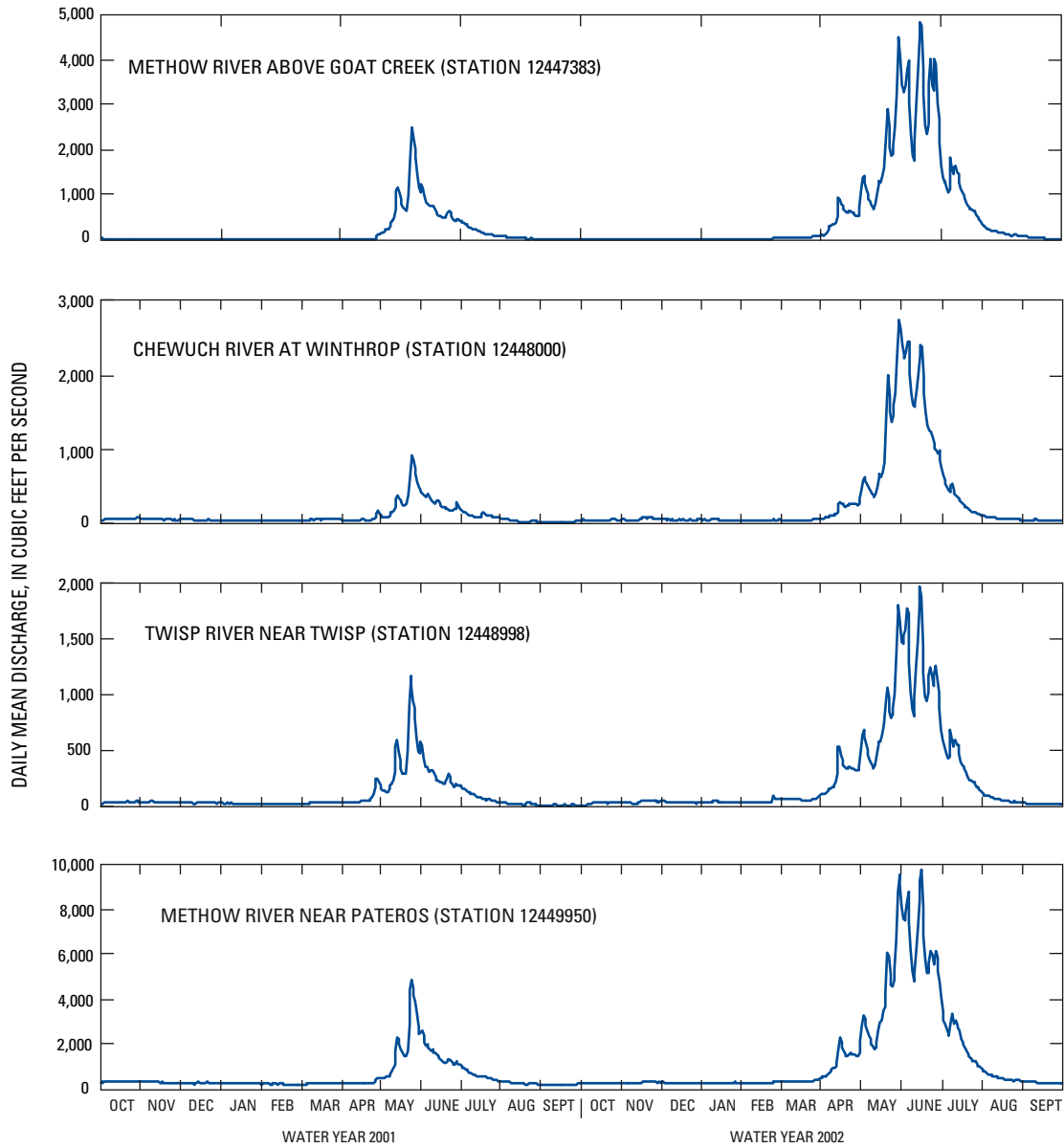


Figure 13. Daily mean discharge in the Chewuch, Methow, and Twisp Rivers in the Methow River Basin, Okanogan County, Washington, during water years 2001 and 2002.

Table 6. Streamflow-gaging stations with continuous streamflow records used to calculate daily exchanges in the Methow and Twisp Rivers and mean discharge in the Methow River Basin, Okanogan County, Washington, water years 2001 and 2002

[Station No: Location of gaging stations are shown on [figure 1](#). –, no data available]

Station No.	Station name	Drainage area (square mile)	Mean discharge (cubic feet per second)	
			Water year 2001	Water year 2002
Methow River				
12447370	Lost River near Mazama	146	88	268
12447382	Early Winters Creek near Mazama	80	68	179
12447383	Methow River above Goat Creek	373	153	581
12447387	Wolf Creek below diversion	33	13	40
12448000	Chewuch River at Winthrop	525	101	315
12448500	Methow River at Winthrop	1,007	430	1,143
12448998	Twisp River near Twisp	245	100	264
12448620	Methow Valley Irrigation District - East Diversion	–	¹ 8	¹ 8
12449500	Methow River at Twisp	1,301	508	1,352
12449710	Beaver Creek near mouth	110	6	–
12449950	Methow River near Pateros	1,772	576	1,420
Twisp River				
12448990	Twisp River above Newby Creek	207	108	276
12448998	Twisp River near Twisp	245	100	262
12448996	Methow Valley Irrigation District - West Diversion	–	¹ 8	¹ 8
12448992	Twisp Valley Power and Irrigation Company Diversion	–	¹ 4	¹ 4

¹Annual mean diversion.

A daily discharge balance from November 1, 2000 through September 30, 2002 for the lower Twisp River from Newby Creek to near Twisp was calculated from continuous-streamflow records collected at streamflow-gaging stations ([table 6](#)). Inflow was measured continuously in the Twisp River above Newby Creek (12448990). Outflows were measured continuously in the Twisp River near Twisp (12448998), the TVPI Canal (12448992) and the MVID West Canal (12448996). The irrigation canals divert water from late April to early October. Discharge records were rated good for the Twisp River above Newby and MVID West Canal and fair for the TVPI Canal and Twisp River near Twisp. At its downstream end, the TVPI Canal returned water back to the river

about 1 mi upstream of station 12448998. The return-flow rate from the canal to the Twisp River was estimated on the basis of daily observations of stage at a rectangular metal weir at the end of the canal (M. Williams, TVPI Co., written commun., 2002). Although inflows to the reach from Newby and Poorman Creeks were not measured continuously, the combined tributary discharge of Newby and Poorman Creeks was 1.6 ft³/s on May 9-10, 2001 (0.7 percent of daily inflow to the reach) and 0.6 ft³/s on June 5-6, 2001 (0.2 percent of daily inflow). Streamflow in both of these creeks continued to decrease through the summer of 2001. Because of their small contribution to total inflow to the lower Twisp River, these creeks were neglected in the daily discharge balance.

Uncertainty of Calculated Daily Gains and Losses in Streamflow

The gains and losses calculated from daily streamflow records have errors associated with unsteady flow and the accuracy of the record. Rapidly rising or falling streamflow, which does not occur simultaneously along a river, may produce a difference in streamflow between two gaging stations. Daily discharges at stations throughout the Methow River Basin, however, rise and fall synchronously, even during high flows, so errors associated with unsteady flow are assumed to be negligible.

The uncertainty of the exchanges calculated from the streamflow records was estimated using a first-order analysis of measurement accuracy (Benjamin and Cornell, 1970) based on the accuracy rating of the records. The accuracy rating of the streamflow records was determined, in part, by the interval around a stage-discharge curve that spans 95 percent of the manual streamflow measurements made during the record period. Streamflow records used to calculate exchanges had accuracy ratings of good or fair. A good rating indicates that about 95 percent of the daily streamflow values are expected to be plus or minus (\pm) 5 percent of the actual streamflow. In practice, streamflow records were rated as good if 95 percent of the discharge measurements were within 5 percent of the discharge indicated by the rating curve for the gaging station. If discharge measurements are assumed to be normally distributed and unbiased (their mean value is the actual discharge), then the standard error (σ_Q) of good measurements is 2.5 percent of the measured value. A fair rating indicates that about 95 percent of discharge measurements are expected to be within ± 7.5 percent of the actual discharge, in which case $\sigma_Q = 3.8$ percent of the measured value.

For normally distributed and unbiased measurements, 95 percent of the calculated exchanges are expected to be within two standard errors of the actual exchange, where the standard error of the calculated exchange ($\sigma_{\Delta Q}$) is given by

$$\sigma_{\Delta Q} = \sqrt{\sum_i (\sigma_{Q_i})^2} \quad (1)$$

where

Q_i is the i^{th} discharge measurement used to calculate a gain or loss along a given reach.

The uncertainty of a calculated exchange, then, depends on the number of discharge measurements used for the calculation and the relative value of each measurement. The 95-percent confidence interval for an exchange calculated from two good measurements with similar values is about ± 7 percent of measured discharge. The confidence interval (uncertainty) of an exchange expands with the number of measurements used to calculate the exchange and with lower quality ratings. For example, the 95-percent confidence interval for an exchange calculated from four fair measurements with equal values (a reach starting at the confluence of two tributaries with a large diversion where all inflow and outflow rates are approximately equal) is ± 15 percent of any one of the measurements.

The standard error of daily (continuous) exchanges ($\sigma_{\Delta Q}$) was estimated using equation 1, where σ_{Q_i} was specified as 0.025 or 0.038 of each daily discharge value used to calculate the exchange, depending on whether the record was rated as good or fair, respectively, and as 0.1 for estimated discharges. The 95-percent confidence interval around each calculated exchange corresponds to $\pm 2 \sigma_{\Delta Q}$.

Exchanges during low-flow periods generally were calculated from two good measurements, so calculated gains greater than 7 percent of outflow from a reach, and calculated losses greater than 7 percent of inflow to a reach, are likely to indicate actual gains or losses of flow rather than only measurement error.

Continuous Ground-Water Levels in the Lower Twisp River Valley

Ground water occurs in alluvial, glaciofluvial, and glaciolacustrine deposits as well as bedrock in the Twisp River valley. Alluvial and glaciofluvial deposits (Qa and Qga) form the primary aquifer in the lower Twisp River. The width (cross-valley) of the deposit ranges from 300 to 1,600 ft. The thickness of the deposit is not known precisely except at wells that have penetrated through the alluvium into bedrock, but it ranges from 30 ft to more than 170 ft. The potentiometric surface of ground water in the alluvium slopes down-valley, with a gradient of 1.4 percent from Newby Creek to Twisp (pl. 1). Other deposits of unconsolidated sediments include terraces along the valley walls and fill in tributary valleys, particularly in the lower part of the valley.

Ground-water levels and river stage were monitored at three sites on the north side of the Twisp River (fig. 14), beginning in May 2001, to evaluate the ground-water response to irrigation-canal seepage and to assess the relation between river-aquifer exchanges and ground-water levels. Each site has two ground-water monitoring wells (table 7) and one river stage station (see fig. 14).

The upstream site is located in Elbow Coulee at Twisp, river mile (RM) 6.5, where an unconsolidated deposit forms a terrace more than 20 ft above the Twisp River and extends north, filling the dry valley (fig. 14). Waitt (1972) identified Elbow Coulee as an ice-marginal channel formed through a combination of fluvial and glacial erosion. The wells at the upstream site are located north of the river and straddle the TVPI Canal. Both wells penetrate a confined aquifer formed by an unconsolidated glacial deposit (sand, gravel, cobbles, and clay). The north well (33N/21E-09D02, or TW1N) is located 1,300 ft north of the river and extends 61 ft below the land surface into a fractured shale unit with a top altitude of 27 ft above the riverbed altitude. The lower 8 ft of the well is open (no casing). The south well (33N/21E-09D03, or TW1S) is located 660 ft north of the river and extends 38 ft below the land surface, all of which is cased. The lower 5 ft of the well casing is perforated. The bottom of the hole is 6.2 ft above the riverbed altitude but does not extend to bedrock.

The middle site is located at the southwestern margin of a large glacial terrace north of the Twisp River at RM 4.9. The wells are located north of the

river on a hillslope forming the southern edge of the large terrace. The TVPI Canal is about 1,300 ft north of the river at the northern margin of the terrace. The wells penetrate a confined aquifer formed by an unconsolidated glacial deposit (sand, gravel, cobble, and clay). The north well (33N/21E-10L02, or TW2N) is located 390 ft north of the river and extends 80 ft below the land surface to a shale unit that is 40 ft below the altitude of the river. The lower 2 ft of the well is open. The south well (33N/21E-10L03, or TW2S) is located 260 ft north of the river and extends 38 ft below the land surface. The casing extends to the entire length of the hole and is open at its bottom, which is 21 ft below the altitude of the river.

The downstream site is located at the southern margin of the large terrace at RM 3.5. The TVPI Canal is about 0.5 mi north of the river at the northern edge of the terrace. The north well (33N/21E-11P03, or TW3N) is located near the top of the terrace and is 525 ft north and 80 ft above the river. TW3N penetrates through the unconsolidated material forming the terrace into a confined aquifer formed by an igneous unit. The well is cased for 100 ft to the top of the igneous unit, which is 15 ft below the altitude of the river in this area; the bottom of the well is 75 ft below the riverbed. The south well (33N/21E-11P04, or TW3S) is located 260 ft north of the river on a floodplain and extends 30 ft below the land surface. The entire well is cased and the lower 5 ft of the casing is perforated. The well is open to a confined aquifer in unconsolidated material. The bottom of the hole is 22 ft below the riverbed altitude.

Ground-water levels in all wells were measured and recorded hourly from May 2001 through October 2002 using a non-submersible pressure transducer with an integrated data logger. Water levels were measured manually with an electric-contact tape measure about every 2 months. Water levels from the pressure transducer were within 0.1 ft of all manual measurements with no bias (drift) over the period of record. The land-surface altitude at one well at each site was measured to within 1 ft using differential GPS (see section "Well Inventory and Water-Level Measurements"). Land-surface altitudes for the other wells were surveyed with a level (theodolite) using the land-surface altitude from the differential GPS as a reference.

Table 7. Continuous monitoring wells in the lower Twisp River Valley in the Methow River Basin, Okanogan County, Washington

[Monitoring site No.: Location of wells are shown on figure 14]

Monitoring site No.	Site No.	Well No.
TW1N	482252120134501	33N/21E-09D02
TW1S	482246120134101	33N/21E-09D03
TW2N	482224120115401	33N/21E-10L02
TW2S	482221120115601	33N/21E-10L03
TW3N	482213120103601	33N/21E-11P03
TW3S	482212120104001	33N/21E-11P04

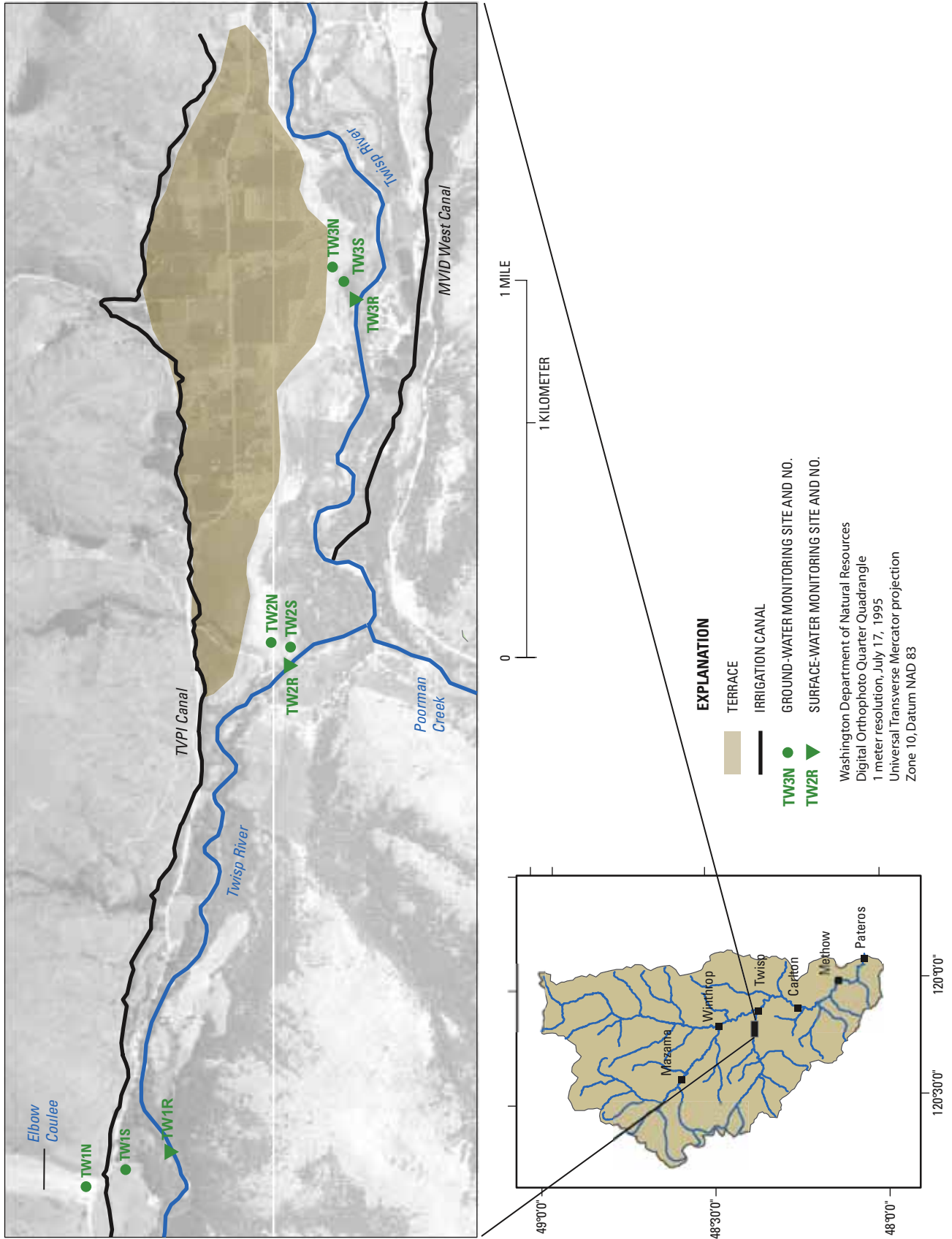


Figure 14. Location of ground-water and surface-water monitoring sites in the Lower Twisp River valley in the Methow River Basin, Okanogan County, Washington.

River stage at the middle and downstream sites also was recorded continuously using non-submersible pressure transducers with integrated data loggers. There were gaps in the stage record when the instruments were inundated by high flows. The stage record for the middle site was terminated in April 2002 when the instrument was washed away by high flows. The stage record for the lower site was discontinued in August 2002 after high flows. Stage at the upstream site was measured manually relative to a reference mark on a boulder along the channel bank on five occasions. A synthetic time-series of stage at each site was developed for gaps in the records based on a logarithmic regression of stage measured at each site and stage measured at the Twisp River near Twisp (12448998). The relation between stage measured at a site and stage measured near Twisp had a correlation coefficient r^2 greater than 0.99 for each site. The altitude of the stage datum at each site was determined by surveying with a level at each site using the altitude of the wells as references.

Estimates of Aquifer Recharge from Irrigation Canals Using a Surface-Water Discharge Balance

Aquifer recharge from irrigation-canal seepage in the Methow River Basin was calculated using a surface-water discharge balance and discharge measurements made in 13 irrigation systems. Discharge was measured at the upstream and downstream ends of 45 canal reaches totaling 29.8 mi, which was about one-half of the total length of unlined irrigation canals (not including lateral canals) operating in the Methow River Basin during water year 2001. Measurement locations were chosen to exclude large water users and spills from the canals; however, there may have been some small users in some of the reaches and, as a result, a small upward bias in the estimates of recharge. The mean seepage rate for each canal was calculated as the sum of the measured losses for each reach divided by the sum of canal-reach lengths. Reach lengths were calculated from digital raster graphics of

7.5-minute quadrangle maps (1:24,000 scale) using a geographic information system. The mean seepage rate for all canals was calculated as the sum of measured losses for all canals divided by the total length of canals over which measurements were made, rather than the average of seepage rates of each canal.

Methods for Developing a Water Budget

A simple water budget for the Methow River Basin was developed using the Modular Modeling System (MMS) (Ely, 2003). MMS integrates individual programs that simulate spatially distributed hydrologic processes including interception, evaporation, transpiration, infiltration, ground-water flow, and runoff. Runoff from the Methow River Basin was calculated in MMS using the USGS Precipitation-Runoff Modeling Systems (PRMS). Model inputs include time series of precipitation, temperature, and surface-water diversions, land-surface altitudes, and land cover (vegetation). The model was calibrated for the period from 1992 to 2001 based on streamflow records from six USGS streamflow-gaging stations.

The water budget has four terms: precipitation, evapotranspiration, ground-water recharge, and runoff (or streamflow). Ground-water flow into and out of the basin was assumed to be zero. Changes in ground-water storage over the 11-year period are not known and were not constrained in the simulations. Ground-water recharge due to infiltration of precipitation, irrigation-canal seepage, and over-application of water to crops was simulated by the model. Fluvial recharge is not simulated by the model and consequently, is included as streamflow in the water budget. Consumptive domestic uses were not accounted for in the model, but are likely to be small relative to basin-wide evapotranspiration. Consumptive domestic use was estimated based on the per capita water use in Twisp and estimates of percentage of water consumed by domestic use and irrigation in Solley and others (1993).

Gains and Losses in Streamflow Along the Methow River

The annual mean discharge of the Methow River near Pateros was 576 ft³/s for water year 2001 and was the second lowest annual value for the period from water years 1960 to 2002. Streamflow returned to near normal conditions in water year 2002, when annual mean discharge at Pateros was 1,420 ft³/s, compared to a mean discharge of 1,550 ft³/s for water years 1960 to 2002. The difference in annual mean discharge between 2001 and 2002 can be attributed largely to higher flows from May through July in 2002 (fig. 13): maximum daily mean discharge near Pateros was 4,870 ft³/s on May 25, 2001, for water year 2001 and 9,780 ft³/s on June 16, 2002, for water year 2002. Baseflow in the Methow River near Pateros during September, which is representative of baseflow conditions with diversions of surface water for irrigation, also was

lower in water year 2001 than water year 2002, with a monthly mean discharge of 238 ft³/s for September 2001 compared to 322 ft³/s for September 2002.

Spatial Patterns During Low-Flow Conditions

Gains and losses of streamflow along the Methow River were calculated during three low-flow periods: September 2001, February 2002, and September 2002 (table 19, fig. 15). The lowest flows of the three periods were measured on September 12 and 13, 2001, when daily mean discharge near Pateros was 239 and 240 ft³/s, respectively. Streamflow was higher at most locations on February 12 and 13, 2002, when daily mean discharge at Pateros was 288 and 282 ft³/s, respectively. The highest flows of the three periods were on September 17 and 19, 2002, when daily mean discharge at Pateros was 302 and 297 ft³/s, respectively.

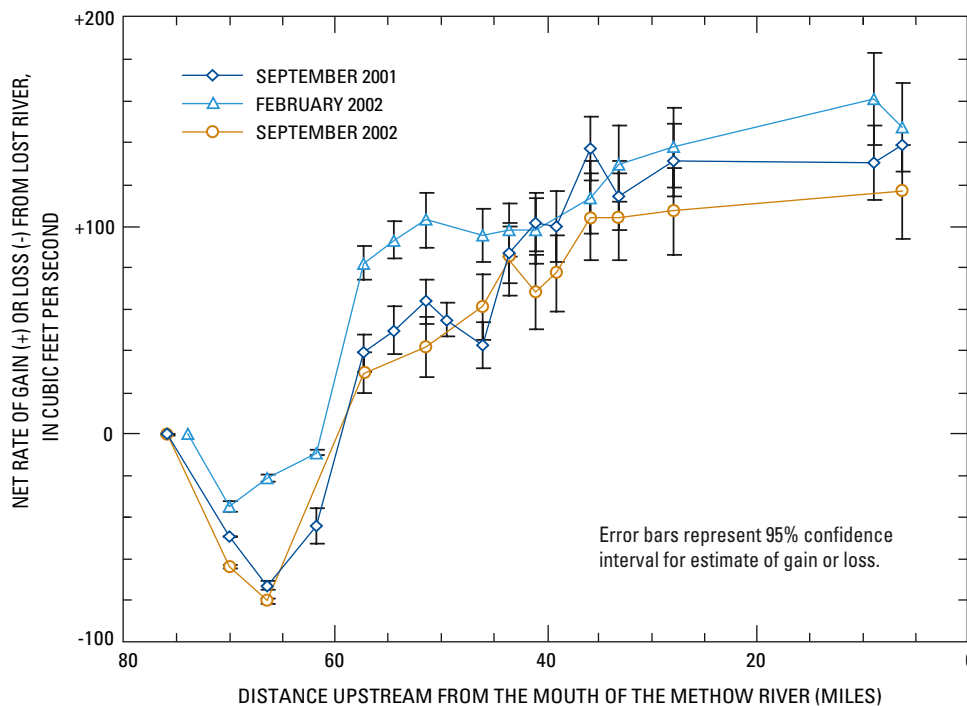


Figure 15. Cumulative gains and losses along the Methow River from Lost River to Pateros under low-flow conditions, Methow River Basin, Okanogan County, Washington.

The Methow River had a net gain of 135.6 ft³/s in September 2001, which was 57 percent of daily mean discharge near Pateros on September 12, 2001. The net gain decreased slightly in February 2002 to 109.7 ft³/s, which was 39 percent of daily mean discharge near Pateros on February 13, 2002. In September 2002, the Methow River had a net gain of 113.2 ft³/s, which was 37 percent of daily mean discharge near Pateros on September 17, 2001. The net gain was inversely related to streamflow, with the largest gains during the lowest flows.

Generalized patterns of gains and losses for eight reaches of the Methow River during low-flow conditions are shown in [figure 16](#). Two reaches consistently gained flow: Goat Creek to Winthrop (reach B) and Twisp River to Beaver Creek (reach E). One reach consistently lost flow: Lost River to Goat Creek (reach A). Reach I from Burma Road to Pateros was neutral (no significant gains or losses). The directions of exchanges were not consistent during low flow in the other reaches, which are labeled “transient” in [figure 16](#). Exchanges in individual reaches of the Methow River are described below.

Reach A of the Methow River (from Lost River to Goat Creek) lost 72.6, 55.3, and 80.0 ft³/s in September 2001, February 2002, and September 2002, respectively. The large losses are characteristic of the Methow River above Goat Creek, which has had periods of no flow in 8 of 12 years from water years 1991 to 2002, despite perennial flow in the Methow River above Lost River, in the Lost River, and in Early Winters Creek. The Methow River above Lost River and its tributaries flow out of surrounding mountains, where they have steep channels confined by narrow valleys with only thin alluvial deposits over bedrock. Downstream of Lost River, the thickness of alluvial deposits in the Methow River valley increases to as much as 1,000 ft and its width increases from less than 1,000 ft to as much as 1.2 mi. As a result of the

increased width and thickness of the deposit, ground-water levels are likely to be lower than the river surface, promoting recharge of the unconsolidated aquifer by the river.

Ground water consistently discharged to the Methow River along reach B (from Goat Creek to Winthrop) during low-flow conditions, producing a gain in streamflow of 136.4 ft³/s in September 2001, 123.8 ft³/s in February 2002, and 122.2 ft³/s in September 2002. Most of the gain for each period was concentrated between Goat Creek and RM 56. The consistent gain in this location may depend on a number of factors, but the downstream decrease in the thickness of the unconsolidated basin-fill sediments from Mazama to Winthrop is likely to be the primary reason (pl. 1).

Downstream of Winthrop, the relative and absolute magnitudes of exchanges were smaller and were less consistent over time. In reach C (from Winthrop to RM 45), there was a loss of 21.0 ft³/s in September 2001, a loss of 7.0 ft³/s in February 2002, and a gain of 19.0 ft³/s in September 2002. Reach D (from RM 45 to RM 43), gained 59.0 ft³/s in September 2001 but 2.0 ft³/s in February 2002 and 7.0 ft³/s in September 2002. Reach E (from Twisp to Beaver Creek) gained 35.6 ft³/s in September 2001, 15.9 ft³/s in February 2002, and 36.0 ft³/s in September 2002. Reach F (from Beaver Creek to Benson Creek) lost 23.0 ft³/s in September 2001, gained 16.0 ft³/s in February 2002, but had no measurable gain or loss in September 2002. Reach G (from Benson Creek to Carlton) gained 17.0 ft³/s in September 2001 but gained only 8.0 ft³/s in February 2002 and 2.7 ft³/s in September 2002. There were no significant exchanges downstream of Carlton other than a gain of 23.3 ft³/s in reach H (from Carlton to Burma Road) and a loss of 17.0 ft³/s in reach I in February 2002. These exchanges, however, may have been artifacts of measurement error.

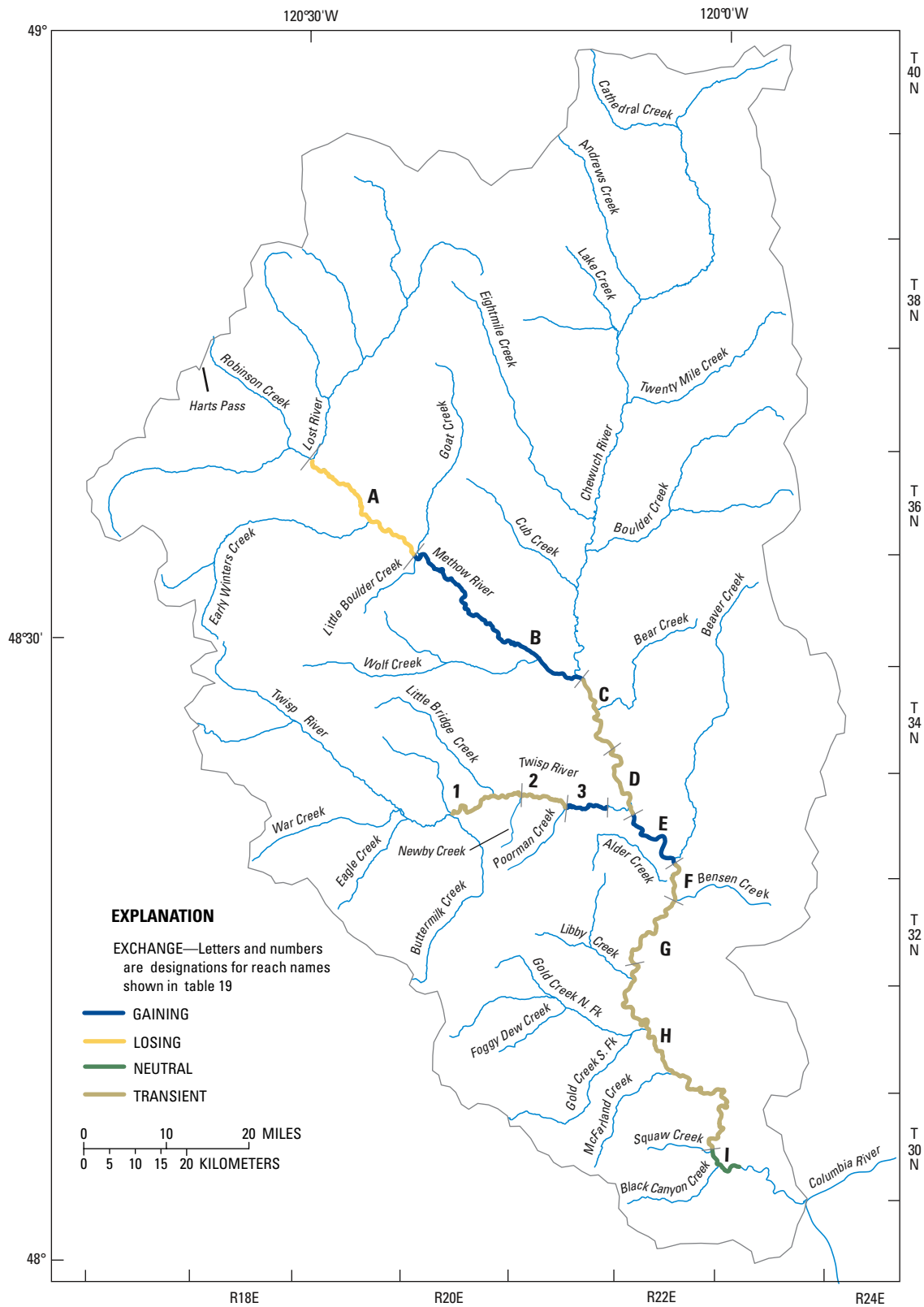


Figure 16. Location of gaining and losing reaches of the Methow and Twisp Rivers in the Methow River Basin, Okanogan County, Washington.

Annual and Seasonal Patterns

The Methow River from the Lost River to Pateros had an annual mean gain of 97 ft³/s in water year 2001 and 27 ft³/s in water year 2002. Total daily gains for the four reaches where daily exchanges between the river and aquifer were calculated equaled 153,000 acre-ft in water year 2001 and 157,000 acre-ft in water year 2002 (table 8). The total daily losses, however, increased from 82,000 acre-ft in water year 2001 to 137,000 acre-ft in water year 2002. The higher losses during water year 2002 represent increased recharge of the unconsolidated aquifer by the river that may have been a consequence of both low ground-water levels brought about by the drought during water year 2001 and near-average streamflow, particularly during the middle to late summer when aquifer recharge by the river is at its highest levels.

In both years, there were three distinct seasonal patterns in river-aquifer exchanges at the reach scale: consistent losses from Lost River to Goat Creek (fig. 17A), consistent gains from Goat Creek to Winthrop (fig. 17B), and seasonally dependent gains and losses from Winthrop to Twisp (fig. 17C) and Twisp to Pateros (fig. 17D). Gains in streamflow were

relatively steady between water years 2001 and 2002 in all reaches except from Lost River to Goat Creek, which had smaller gains during water year 2001, the drier year, than water year 2002 (table 8). Similarly, all of the reaches had greater losses during water year 2002 than water year 2001.

The Methow River consistently loses flow to aquifer recharge above Goat Creek, with the exception of high-flow periods during May and June (fig. 17A). The annual mean loss of streamflow from Lost River to Goat Creek was 81 ft³/s in water year 2001 and 53 ft³/s in water year 2002. Cumulative daily losses were 60,000 acre-ft in water year 2001 and 58,000 acre-ft in water year 2002 (table 8). The seasonal pattern of losses in streamflow from Lost River to Goat Creek was similar in both water years 2001 and 2002, with losses generally varying directly with inflow to the reach. After the onset of high flows in the spring, however, the reach gained flow for periods in both years (fig. 17A). After high flows receded, the reach returned to a losing condition. This reach accounted for 73 and 42 percent of the total losses of streamflow in the Methow River between Lost River and Pateros in water years 2001 and 2002, respectively.

Table 8. Summary of cumulative gains and losses for four reaches of the Methow River Basin from Lost River to Pateros and for the Twisp River, Methow River Basin, Okanogan County, Washington, water years 2001–2002

[Annual net exchange: Values in parentheses () represent the 95-percent confidence interval around the annual net exchange. Because of rounding, totals may not equal the sum of the reaches gains and losses]

Water year	Cumulative daily gains (+) and losses (-) in reach, in thousands of acre-feet					
	Methow River reaches					Lower Twisp River
	Lost River to Goat Creek ¹	Goat Creek to Winthrop	Winthrop to Twisp	Twisp to Pateros ¹	Total	
2001						
Cumulative daily gains	+2	+115	+5	+31	+153	+4.7
Cumulative daily losses	-60	+0	-15	-7	-82	-2.0
Annual net exchange	-58 (±50.9)	+115 (±1.8)	-10 (±2.2)	24 (±2.4)	+71 (±3.8)	+2.7 (±0.65)
2002						
Cumulative daily gains	+20	+104	5	+28	+157	+9.2
Cumulative daily losses	-58	-11	-38	-30	-137	-6.4
Annual net exchange	-38 (±2.7)	+94 (±5.5)	-34 (±6.3)	-2 (±6.7)	-20 (±11)	+2.8 (±1.7)

¹Some inflow estimated.

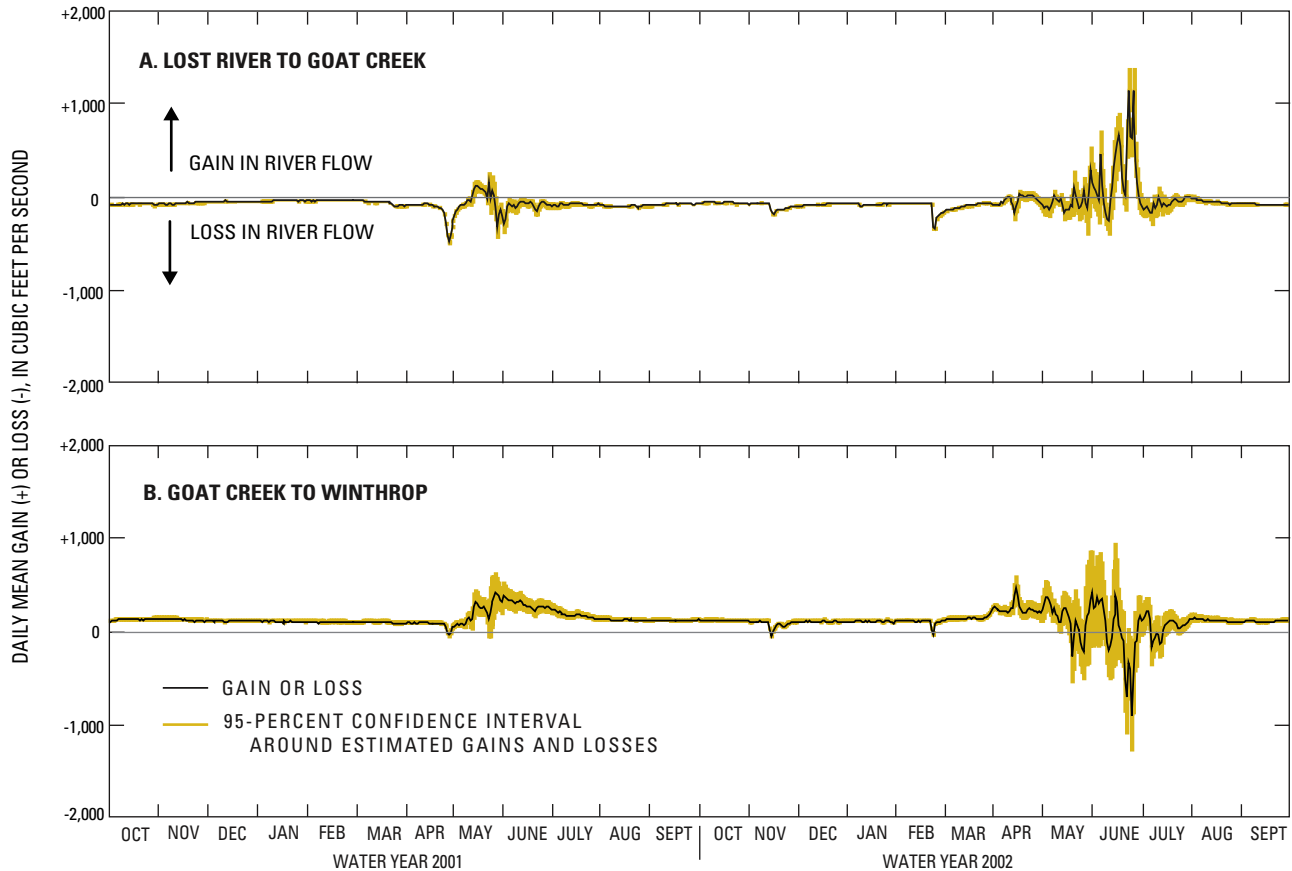


Figure 17. Daily gains and losses for four reaches of the Methow River in the Methow River Basin, Okanogan County, Washington, water years 2001 and 2002.

The Methow River from Goat Creek to Winthrop consistently gained flow from ground-water discharge throughout the year, except for a brief period during high flows in June 2002 (fig. 17B). The annual mean gain in streamflow from Goat Creek to Winthrop was 159 ft³/s in water year 2001 and 115 ft³/s in water year 2002. Total daily gains were 115,000 acre-ft in water year 2001 and 104,000 acre-ft in water year 2002 (table 8). Daily ground-water discharge along this reach was relatively consistent much of the time (fig. 17B), with more variation during high flows. The reach appears to have lost streamflow during high flow in water year 2002. Most of the ground water that discharges to the Methow River occurs along this reach, which accounted for 75 and 67 percent of the annual ground-water inflow between the Lost River and Pateros in water years 2001 and 2002, respectively.

River-aquifer exchanges in the Methow River from Winthrop to Twisp is relatively neutral during much of the year (fig. 17C). The reach had annual

mean losses of 14 ft³/s in water year 2001 and 47 ft³/s in water year 2002. Losses during high flows account for most of the annual exchange volume of water in this reach, although the river gained about 30 ft³/s during August and September in both 2001 and 2002. Cumulative daily gains, which mostly occurred during late summer in the reach, were consistent in 2001 and 2002 and were estimated to be 5,000 acre-ft annually.

The Methow River from Twisp to Pateros generally gained flow except in high-flow periods (fig. 17D). The reach had an annual mean gain of 34 ft³/s in water year 2001 but an annual mean loss of 2 ft³/s in water year 2002, although the loss was not significantly greater than the uncertainty of the record. Gains from Twisp to Pateros were consistent in 2001 and 2002 (31,000 and 28,000 acre-ft, respectively, but losses were higher in 2002 (30,000 acre-ft) than in 2001 (7,000 acre-ft).

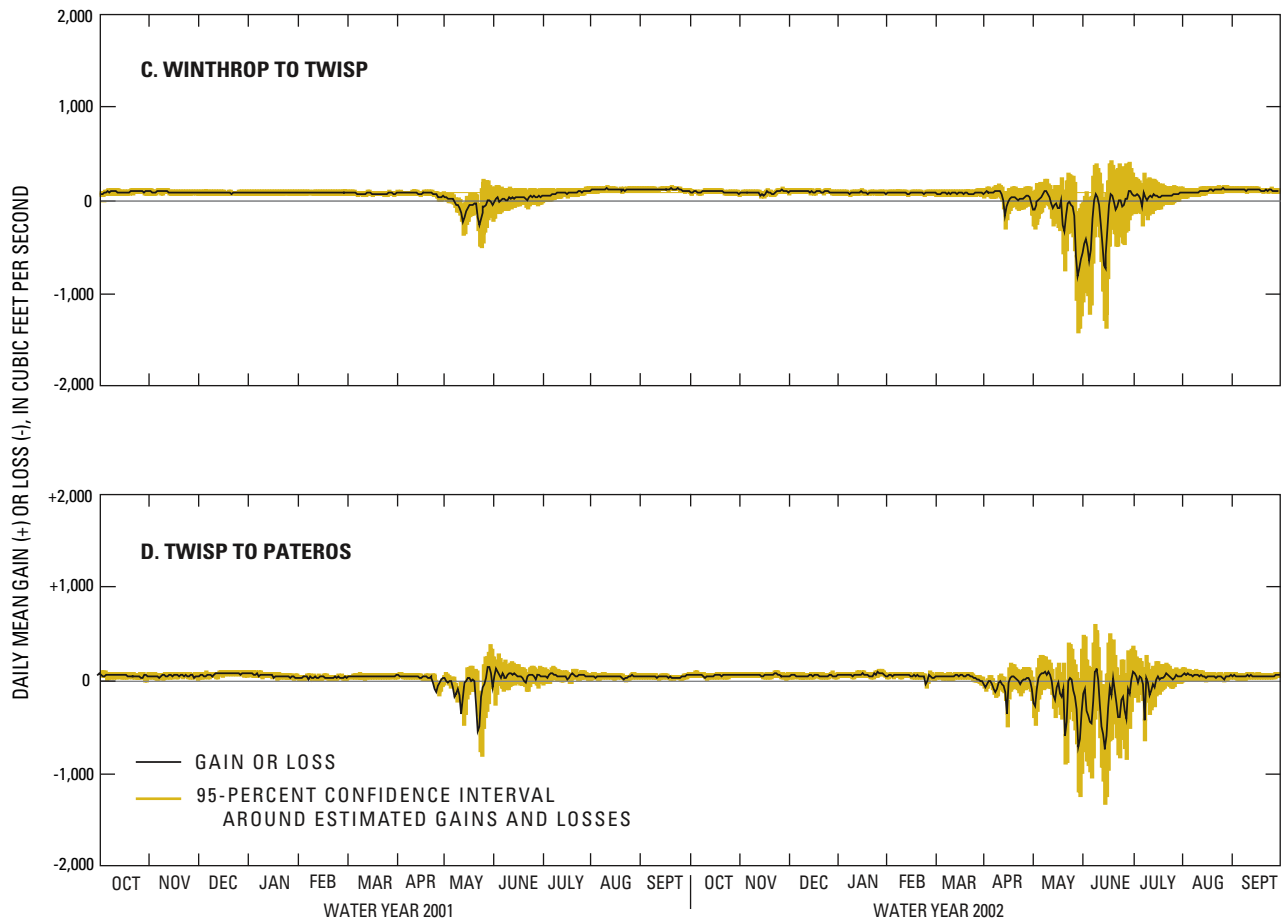


Figure 17. — Continued.

Gains and Losses in Streamflow Along the Lower Twisp River

The mean annual discharge of the Twisp River near Twisp was 262 ft³/s for the 17-year period from water years 1976-79 and 1990-2002. Streamflow in the Twisp River was well below average in water year 2001 but returned to near average during water year 2002, as in the Methow River. Annual mean discharge of the Twisp River in water year 2001 was 108 ft³/s above Newby Creek and 100 ft³/s near Twisp. In contrast, annual mean discharge of the Twisp River in water year 2002 was 272 ft³/s above Newby Creek and 264 ft³/s near Twisp.

Maximum daily mean discharge for the Twisp River in water year 2001 was 1,110 ft³/s above Newby Creek and 1,180 ft³/s near Twisp on May 24, 2001. Maximum daily mean discharge for the Twisp River in 2002 was 2,061 ft³/s above Newby Creek and 1,970 ft³/s near Twisp on June 16, 2002. Baseflow in the Twisp River was lower in water year 2001, with a monthly mean discharge of 19 ft³/s for September 2001 compared to 33 ft³/s for September 2002. The minimum daily mean discharge for the Twisp River near Twisp was 15 ft³/s on several days in September 2001 and equaled the lowest recorded daily mean discharge for the 17-year streamflow record.

The TVPI and MVID West Canals diverted water from the Twisp River at a mean combined rate of 29 ft³/s from April 29 to October 15, 2001. Diversions were highest during the early summer, with a monthly mean rate of 33 ft³/s in July, which was equal to 21 percent of monthly mean discharge of the Twisp River above Newby Creek. Combined diversions decreased to a monthly mean rate of 21 ft³/s in September, which was equal to 79 percent of the monthly mean discharge of the Twisp River above Newby Creek. Diversions to the MVID West Canal were stopped on four occasions (for 1 to 3 days each) from August 21 to September 25, 2001. The combined diversions of the TVPI and MVID West Canals were 26 ft³/s from April 29, 2002 to September 30, 2002 and decreased to a monthly mean rate of 23 ft³/s in September 2002, which was 53 percent of monthly mean discharge of the Twisp River above Newby Creek. Mean (estimated) return flow from the TVPI Canal was 1.3 ft³/s for the 2001 irrigation season and 1.4 ft³/s for the 2002 irrigation season.

Spatial Patterns During Low-Flow Conditions

Gains and losses along the lower Twisp River, from Buttermilk Creek to near Twisp, were calculated for a series of three reaches during three low-flow periods in September 2001, February 2002, and September 2002 (table 19, fig. 18). The lowest flows of the three periods were measured on September 11, 2001, when daily mean discharge above Newby Creek was 27 ft³/s. Streamflow was higher on February 11, 12, and 14, 2002, when daily mean discharge above Newby Creek was 39, 36, and 45 ft³/s. Although streamflow varied during the February seepage run, the daily net gain from above Newby Creek to near Twisp ranged only between 2 and 3 ft³/s for the 3 days. Daily mean discharge above Newby Creek was 39 ft³/s on September 18, 2002.

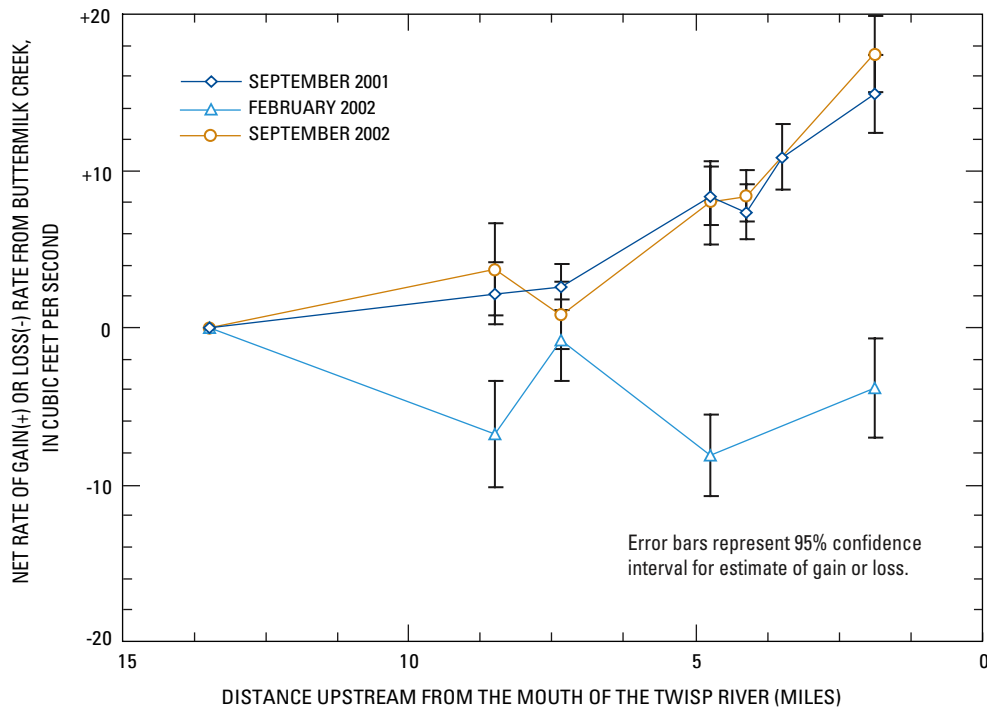


Figure 18. Cumulative gains and losses along the lower Twisp River from Buttermilk Creek to near Twisp under low-flow conditions, Methow River Basin, Okanogan County, Washington.

The lower Twisp River from Buttermilk Creek to near Twisp had a net gain of 14.9 ft³/s on September 11, 2001, which was 45 percent of daily mean discharge near Twisp, a net loss of 3.8 ft³/s in February 2002, which was 7 percent of the Twisp River discharge measured below Buttermilk Creek on February 14, 2002, and a net gain of 16.8 ft³/s on September 18, 2002, which was 52 percent of daily mean discharge near Twisp. Reach 1 (from Buttermilk Creek to Newby Creek) had net gains during September 2001 and 2002 (2.2 and 3.7 ft³/s, respectively), but a net loss of 6.8 ft³/s on February 14, 2002. Similarly, reach 2 (from Newby Creek to Poorman Creek) had net gains in September 2001 and 2002 (6.2 and 7.2 ft³/s, respectively), but lost 1.3 ft³/s in February 2002. The Twisp River from Poorman Creek to the gaging station near Twisp (reach 3) gained 6.5 ft³/s on September 11, 2001, and 8.4 ft³/s on September 18, 2002, but gained only 4.3 ft³/s on February 12, 2002.

During low-flow conditions, river-aquifer exchanges in the lower Twisp River exhibit a seasonal pattern of large gains (about 16 ft³/s) during late summer and losses (about 4 ft³/s) or small gains during winter. High flows in the river and ground-water flow from glacial terraces and unconsolidated sediments filling side valleys such as Elbow Coulee are likely to recharge the unconsolidated aquifer in the lower valley, which then discharges to the river during summer. As the unconsolidated aquifer drains and recharge of unconsolidated sediments from irrigation-canal seepage ceases in early autumn, ground-water inflow to the river decreases.

The gains in reach 1 during September 2001 and 2002 likely represent the discharge of ground water that had been recharged by the river and its tributaries during high flows earlier in the summer. As the unconsolidated aquifer drained, declining ground-water levels are likely to have caused the transition to a losing condition in reach 1 during February 2002. The seasonal gains along reach 2 likely represent the same mechanism, but also ground-water flow from Elbow Coulee, which includes seepage from the TVPI Canal. The seasonal gains in reach 3 are likely due to ground-water flow from the glacial terrace north of the river, which would include seepage from the TVPI Canal, ground-water flow from Elbow Canyon south of the river, and seepage from the MVID Canal. As with reach 1, however, aquifer recharge by the river and its tributaries during high flows may also contribute to

increased ground-water discharge back to the river later in the summer in reaches 2 and 3. Thus, irrigation-canal seepage may account for only a portion of the seasonal difference of about 18 ft³/s between the streamflow gains in September and loss in February in reaches 2 and 3.

Annual and Seasonal Patterns

The lower Twisp River from Newby Creek to near Twisp had an annual mean gain of 4.1 ft³/s in water year 2001 and 3.9 ft³/s in water year 2002. Exchanges calculated for water year 2001 do not include October 2000. Magnitudes of daily exchanges were larger in 2002 than in 2001, despite the similar annual mean gains. Total daily gains for the reach were equal to 4,700 acre-ft in water year 2001 and 9,200 acre-ft in water year 2002 ([table 8](#)). Total daily losses for the reach were equal to 2,000 acre-ft in 2001 and 6,400 acre-ft in 2002.

Exchanges had a seasonal pattern characterized by three distinct regimes: ground-water discharge to the river decreasing from late summer to early spring; fluctuating ground-water discharge and recharge as river rose during the late spring; and ground-water recharge in early summer ([fig. 19](#)). The seasonal patterns in river-aquifer exchanges were similar between water years 2001 and 2002, with the exception of the earlier onset of initial streamflow losses in 2002. The rate of streamflow gains during the winter and late summer also were similar. During low flows from November 1, 2000, through April 23, 2001 (regime 1), the river had a consistent daily gain with a mean of 4.5 ft³/s and a standard deviation of 1.3 ft³/s. During this period, ground-water discharge accounted for as much as 21 percent of the daily mean discharge in the Twisp River near Twisp.

The first regime of steady ground-water discharge to the river was disrupted by the onset of higher flows in spring. From April 24 to July 24, 2001, the river alternated between gaining and losing conditions (regime 2), with the largest magnitude of exchanges for the year. A high daily loss of 35 ft³/s on May 12, 2001, was followed by a brief (2-day) gaining period that coincided with a peak in streamflow on May 14, 2001. After another week of losing flow, the lower river gained flow at rates as high as 110 ft³/s during the period of maximum runoff from the basin (May 23 to June 14).

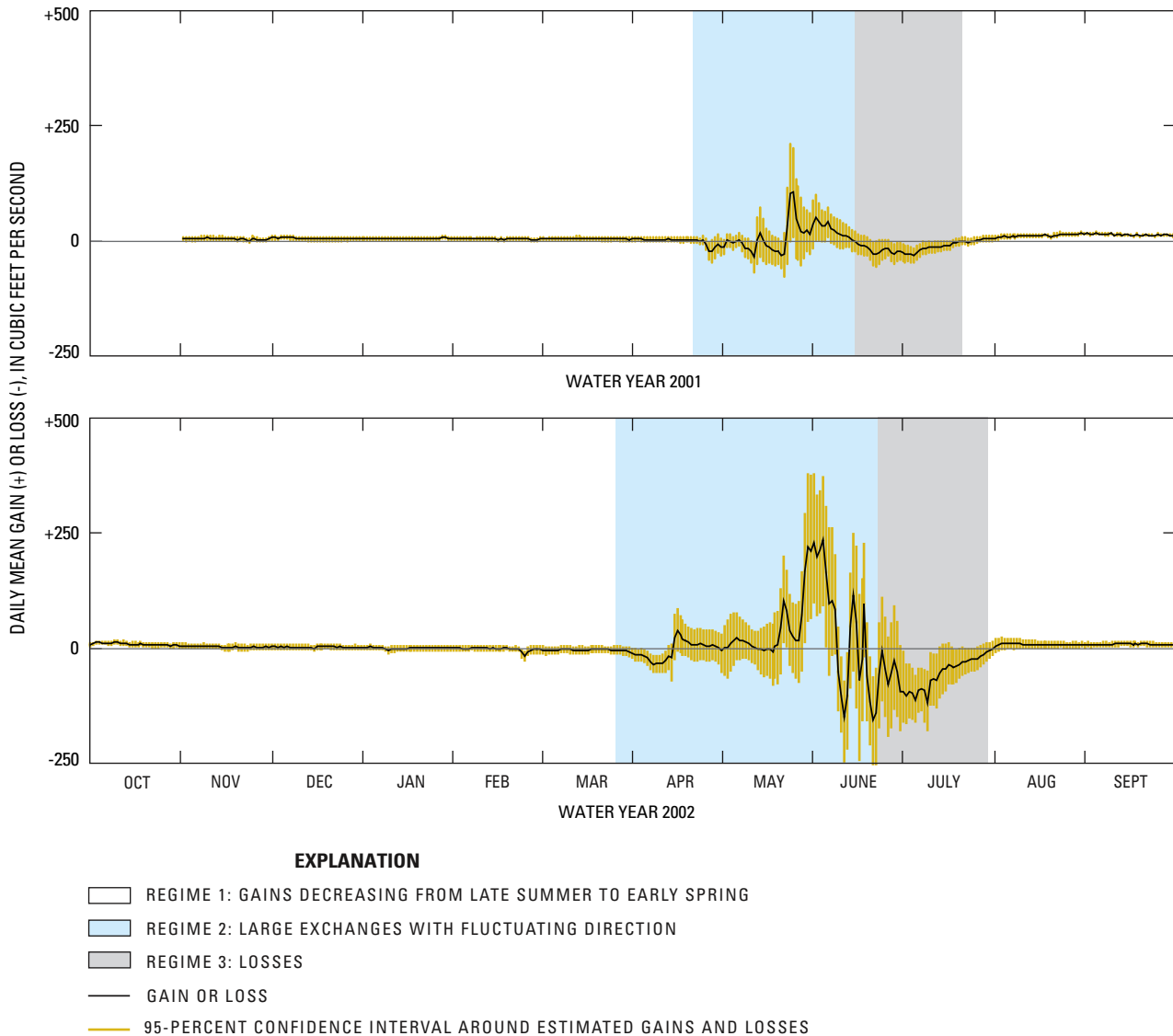


Figure 19. Daily gains and losses for the lower Twisp River in the Methow River Basin, Okanogan County, Washington, water years 2001 and 2002.

This gaining period was followed by the longest losing period for the river, from June 15 to July 25 (regime 3). Losses during high flows were likely a result of bank storage, whereas gains were likely produced by a combination of increased ground-water inflow to the study area from the main valley (upstream) and tributary valleys and release of bank storage during recessional periods. Unaccounted surface-water inflow from tributaries was likely to be only a small component of the calculated gains.

The river returned to a consistently gaining condition (regime 1) on July 26, 2001, but the rate of ground-water inflow to the river was higher than during

the previous autumn and winter. Mean daily net ground-water inflow to the Twisp River was 12 ft³/s, with a standard deviation of 3.1 ft³/s for July 26 through October 20, 2001. The largest gain in streamflow for any month occurred during September 2001, when the mean ground-water inflow was 13 ft³/s and accounted for 71 percent of the discharge of the Twisp River near Twisp. Ground-water inflow to the lower reach accounted for as much as 90 percent of the daily mean discharge (on September 9, 2001) for the Twisp River near Twisp during this period.

The gain along the lower Twisp River steadily decreased from autumn to winter with a mean gain of 1 ft³/s for February 2002. When streamflow rose briefly in February and again in April, the Twisp River lost flow between Newby Creek and Twisp, which represented a transition to the second regime of river-aquifer exchanges. The river changed back to a gaining condition in the spring with the highest gains of the year. By mid-June, the river was losing flow (regime 3). The losing condition persisted until July 30, 2002, when there was an abrupt transition back to a gaining condition (regime 1). The mean rate of gain increased to 11.2 ft³/s for September 2002.

Ground-Water Levels and Timing of Aquifer Recharge in the Lower Twisp River Valley

The monitoring wells were installed and instrumented at the three sites in the lower Twisp River valley (fig. 14) as ground-water levels increased during the spring of 2001. Ground-water levels in the lower Twisp River valley generally declined from late spring and summer 2001 to late autumn 2001 and winter 2002, when they were at minimum annual levels. Ground-water levels rose in spring 2002 and attained maximum levels in summer 2002. This pattern is consistent with the smaller gains in streamflow (lower rate of aquifer discharge) observed during winter and larger gains in streamflow (higher rate aquifer of discharge) observed during summer. The specific timing of changes and minimums and maximums, however, varied from well to well and likely reflected differences in geology and sources of recharge.

Ground-water levels in wells at the upstream site at Elbow Coulee (TW1N and TW1S in fig. 14) were relatively steady day-to-day, although seasonal patterns in ground-water levels were evident. In water year 2001, ground-water levels at the site rose during May, reaching maximum altitudes of 1,962.8 ft in TW1N on May 27, 2001, and 1,942.8 ft in TW1S on May 25, 2001 (fig. 20). Water levels declined steadily through the summer and autumn, with a mean rate of 0.007 ft/d in TW1N and 0.02 ft/d in TW1S from June 15 to October 15, 2001. Water levels declined more rapidly in TW1S from October 15 to 31, 2001, at a mean rate of 0.08 ft/d, while the rate of decline increased only slightly in the north well to 0.01 ft/d.

Water levels continued to decline through the rest of autumn 2001 and winter 2002, reaching minimum altitudes on February 16, 2002, of 1,961.2 ft in TW1N and 1,937.8 ft in TW1S. Water levels rose slowly from mid-February 2002 to the end of April 2002, and then rose more rapidly during May 2002 to annual maximum altitudes of 1,962.7 ft in TW1N on May 25, 2002, and 1,942.4 ft in TW1S on May 28, 2002.

The maximum water levels in TW1N and TW1S were within 0.6 ft during late spring 2001 (partial record only) and 2002, despite drought conditions in water year 2001. The similar levels indicate that seasonal recharge may not be sensitive to annual fluctuations in precipitation. Moreover, most of the water-level rise in both wells occurred during May, indicating that the source of recharge is relatively close to the wells (or recharge would likely be more gradual over time) and varies seasonally. Recharge also has a larger effect on water levels in the south well than in the north well. All these characteristics are consistent with aquifer recharge from the TVPI Canal, which is located between the two wells. Because ground-water flow generally is from the north well toward the south well, canal seepage disproportionately affects ground-water levels in the south well. The timing of the fluctuations in May and October coincides with the seasonal operation of the canal.

Ground water at the upstream site at Elbow Coulee had a high cross-valley hydraulic gradient sloping toward the river: the gradient between the TW1N and TW1S was 3 percent in May 2002 (annual maximum water level) and 4 percent in February 2002 (annual minimum water level); the gradient between the TW1S and the river was 2 percent during both periods. Because of the steep hydraulic gradient between the wells and the river, there was little response in ground-water levels to fluctuations in river stage (fig. 20).

Ground-water levels in wells at the middle site (wells TW2N and TW2S in fig. 14) varied much more through the year than those at the upstream site (fig. 20). Water levels in the two wells fluctuated synchronously, with no more than 0.2 ft difference between their altitudes at any time, and generally they coincided with changes in river stage. Water levels for this site are discussed in terms of the mean water altitudes for the two wells.

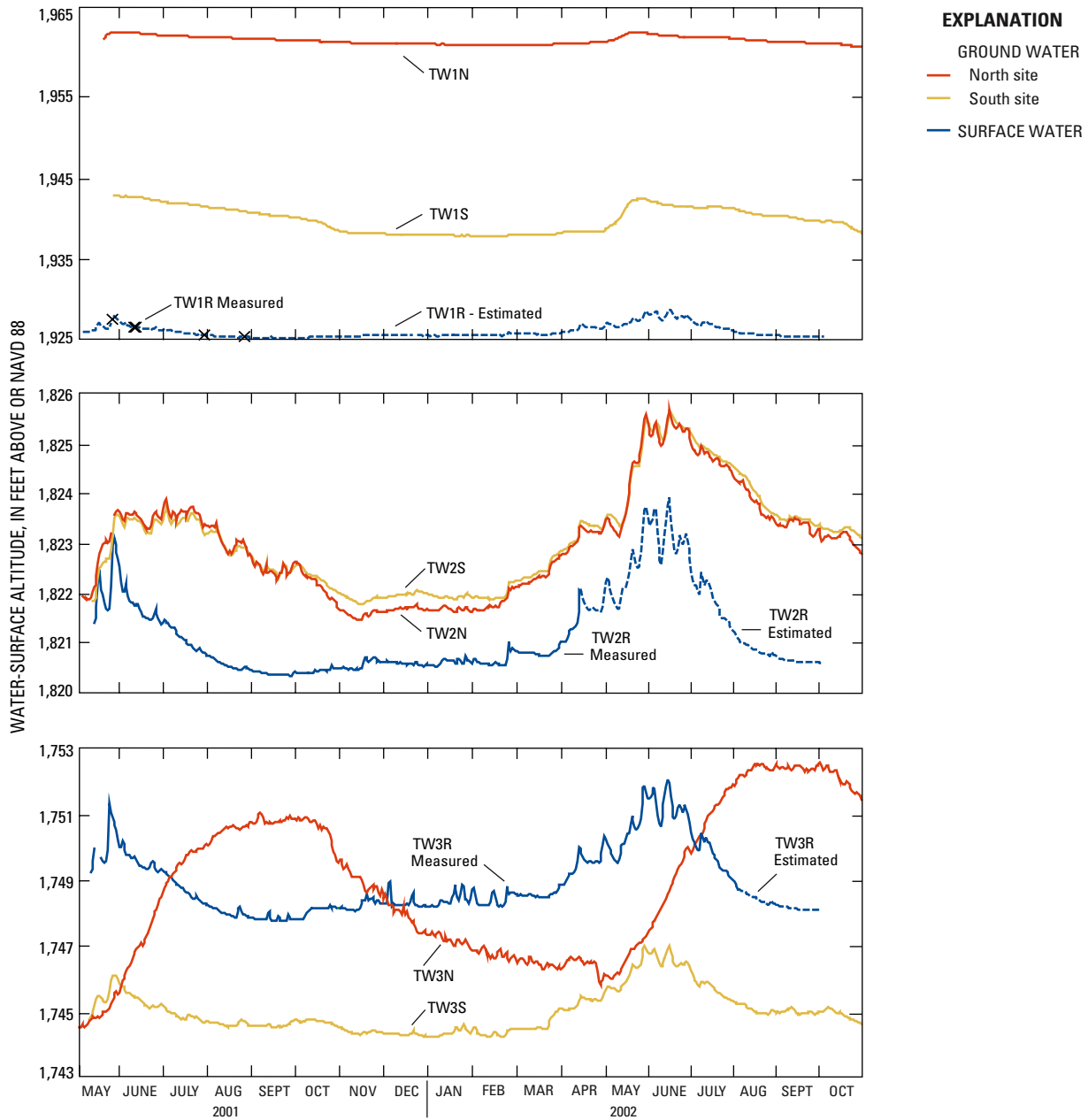


Figure 20. Ground-water and surface-water levels in the lower Twisp River valley, Methow River Basin, Okanogan County, Washington, water years 2001 and 2002.

Water levels rose abruptly in May 2001, reached maximum altitude of 1,823.8 ft, and remained high until the middle of July 2001. Water levels declined during summer and autumn, falling to a minimum altitude of 1,821.6 ft on November 13, 2001. They remained relatively steady until March 2002, when they rose in conjunction with spring snowmelt at lower

altitudes. The initial rise in ground-water levels in early spring preceded a faster increase during April, May, and June that coincided with high river stages, driven by snowmelt from higher altitudes, and the beginning of the irrigation season. Ground water reached a maximum altitude of 1,825.7 ft on June 16, 2002, and was higher than in water year 2001.

The relative contribution to recharge from snowmelt, the river, irrigation-canal seepage, and water applied to crops is difficult to distinguish at the middle site. The increase in water levels during March 2002 likely was due to recharge from melting snow that infiltrated into the ground. The increase in water levels during April 2002 also may reflect recharge from the Twisp River. Irrigation-canal seepage and infiltration of water applied to crops likely contributed to increasing water levels during May 2001 and 2002, and then sustained high water levels during both summers while streamflow was receding. The seasonal effect of recharge from irrigation-canal seepage and applied water may persist until mid-November, when ground-water levels generally stop declining and only appear to change in response to river stage.

Ground water at the middle site had a lower and more variable cross-valley hydraulic gradient than at the upstream site. The gradient between TW2S and the river ranged from 0.4 percent in June 2002 to 1 percent in November 2001. The gradient between TW2N and TW2S was essentially flat, indicating that ground water had at most only a small component of flow across valley. Ground water at the downstream site sloped down toward the river during late summer and autumn, with a maximum gradient of 0.9 percent in September 2002, indicating ground-water flow toward the river. Ground-water levels sloped away from the river in other seasons, with a minimum gradient of -0.5 percent in June 2002, indicating flow from the river into the aquifer. These patterns are consistent with the seasonal increase in ground-water inflow to the river during late summer and autumn compared with winter and spring.

Ground-water levels in wells at the downstream site (TW3N and TW3S in [fig. 14](#)) had the most complex spatial and temporal patterns of all the sites ([fig. 20](#)). Water levels in TW3S, located on the floodplain north of the river, fluctuated synchronously with river stage. The water-surface altitude in TW3S was consistently lower, on average 3.6 ft, than the water-surface level of the river. Maximum ground-water altitudes in the south well were 1,746.1 ft on May 27, 2001, and 1,747.0 on June 16, 2002, and lagged peak river stage by 4 and 3 days, respectively. Although the lowest stage of the Twisp River for the monitoring period was in late September 2001, the

minimum altitude in well TW3S was 1,744.2 ft on January 4, 2002. The seasonal patterns of water-level changes in TW3N were the most consistent of any of the wells with the three regimes of river-aquifer exchanges for the lower Twisp River. Water levels in well TW3N initially were lower than the water-surface level of the river in May 2001, but rose above river stage by early July and reached a maximum altitude of 1,751.0 ft on September 5, 2001. Water levels declined during the autumn, winter, and early spring to a minimum altitude of 1,745.9 ft on April 30, 2002. Water levels rose quickly and steadily in the spring and summer to a maximum of 1,752.6 ft on September 29, 2002. Water levels in TW3S were consistently lower than the Twisp River at all times. In contrast, the hydraulic gradient between TW3N and the river was positive during the summer and early autumn (indicating flow toward the river), but negative the rest of the year.

The differences between water levels in wells at the downstream site are likely a result of differences in the hydrogeology of the aquifers and their seasonal recharge. The volume of water released from a unit volume of an aquifer under a unit decline in hydraulic head, which is specific storage, generally is smaller for bedrock than for unconsolidated alluvium. As a result, the larger changes in potentiometric surface in TW3N, which is open to a bedrock aquifer, in comparison to the changes in TW3S, which is open to the alluvial aquifer, do not necessarily represent differences in the volume of water stored in and released from these aquifers. The seasonal patterns in recharge, however, are distinctly different for the two aquifers: the alluvial aquifer responds primarily to increases in river stage; in contrast, the water level in the bedrock aquifer shows little relation to river stage. Irrigation-canal seepage and infiltration of water applied to crops are likely the primary source of seasonal variation in recharge of the bedrock aquifer because (1) the timing of water-level changes coincides with the irrigation season; and (2) aquifer recharge from other sources (snowmelt, streamflow, or ground-water flow from tributary basins) is unlikely to sustain ground-water levels at a steady high level during summer only to decrease in autumn.

Estimates of Aquifer Recharge by Rivers and Irrigation Canals in the Methow River Basin

Annual fluvial recharge of the unconsolidated aquifer in the Methow River valley from Lost River to Pateros by the Methow and Twisp Rivers is equal to the total daily losses in streamflow described in the section on gains and losses of streamflow. For the four reaches of the Methow River from Lost River to Pateros, total daily streamflow losses in the Methow River, which represents annual recharge of the unconsolidated aquifer by the river, were estimated to be 82,000 acre-ft in water year 2001 and 137,000 acre-ft in water year 2002 ([table 8](#)). Much of the annual recharge (between 60 and 73 percent) by the river occurs between Lost River and Goat Creek. Annual fluvial recharge of the unconsolidated aquifer in the lower Twisp River valley was estimated to be 2,000 acre-ft in water year 2001 and 6,400 acre-ft in water year 2002. Combined, fluvial recharge by the Methow and Twisp Rivers ranged from 84,000 acre-ft in 2001 to 143,000 acre-ft in 2002. During high flows, the river likely recharges the aquifer in many places; however, some of this recharge may be shallow bank storage that returns quickly to the river.

The 2001 drought influenced the results of this investigation. Ground-water levels and streamflow generally were lower than they would have been in most years. Ground-water discharge from the unconsolidated aquifer was a larger component of streamflow during the drought. For example, the net discharge from the unconsolidated aquifer to the Methow River from the Lost River to Pateros was 135.6 ft³/s (57 percent of the discharge near Pateros) in September 2001, 109.7 ft³/s (39 percent) in February 2002, and 113.2 ft³/s (39 percent) in September 2002. This difference was a result of higher streamflow but also smaller gains in September 2002. The unconsolidated aquifer appears to have acted as a buffer against annual variation in low flow by discharging at higher rates to the river during lower flows in September 2001 than in February 2002 or September 2002.

Upstream of Winthrop, however, cumulative daily ground-water discharge was higher in water year 2002. In contrast, cumulative daily ground-water recharge from Winthrop to Pateros was higher in 2002 than in 2001. Thus, the effect of the drought varied

depending on the period: streamflow gains during low-flow periods were higher in the drought, but cumulative exchanges over the year (both gains and losses) were lower.

Regardless of its annual variation, ground-water discharge from the unconsolidated aquifer provides a large component of streamflow during low-flow periods in the Methow and Twisp Rivers. The rates of river-aquifer exchanges in the Methow and Twisp River were relatively steady during most of the year, with the exception of high-flow periods when the magnitude of exchanges are high and their direction may fluctuate from recharge (streamflow loss) to discharge (streamflow gain) and vice versa. The lower Twisp River and the Methow River from Winthrop to Twisp, however, demonstrated a seasonal pattern distinct from the other reaches of the Methow River: both reaches has relatively high, steady gains of streamflow during late summer and early autumn but lower rate exchanges (gains and losses) during winter. For example, the Methow River from Winthrop to Twisp on average gained 35 ft³/s for September 2001 and 29 ft³/s for September 2002, but lost 1 ft³/s in February 2001 and lost 4 ft³/s in January 2002. Likewise, the lower Twisp River from Newby Creek to near Twisp on average gained 13 ft³/s for September 2001 and 11 ft³/s for September 2002, but gained only 3 ft³/s for February 2001 and 1 ft³/s for February 2002.

The contribution of irrigation-canal seepage to aquifer recharge was calculated from discharge measurements spanning 29.8 mi of 13 canals in the Methow River Basin ([table 20, at back of report](#)). The mean seepage rate from unlined irrigation canals, calculated from the total losses divided by the total length of canals that were measured, was 1.8 (ft³/s)/mi. Seepage estimates for individual irrigation canals ranged from 1.0 to 10.7 (ft³/s)/mi from May through August ([table 21, at back of report](#)). Seepage rates also vary along individual canals. The large range in seepage rates reflects, in part, canal maintenance, which can disturb the surface of the canal bottom and increase the seepage rate. Differences in seepage rates also reflect the material forming the canal, which in the Methow River Basin includes unconsolidated glaciofluvial deposits, colluvium (landslide deposits), clay placed artificially to line canals in places, and fractured bedrock.

Seepage rates decrease during the late summer because of the combined effects of subsurface saturation, reduction in the infiltration capacity of the canal beds from the accumulation of fine materials, and lower diversion rates. The average decrease for two canals (TVPI and MVID West) between early (May through August) and late (September) seasons was 35 percent, compared to a 50-percent decrease observed by Klohn Leonhoff, Inc. (1990) for the MVID East and West Canals.

Annual aquifer recharge from irrigation canals for seven subbasins (table 9) assuming a seepage rate of 1.8 (ft³/s)/mi for May through August and a lower rate of 1.2 (ft³/s)/mi for September. If the calculated seepage rate from a canal exceeded its maximum measured diversion rate, then the seepage rate was assumed to equal 50 percent of the diversion rate. The length of unlined irrigation canals and their period of operation are not known precisely, but were estimated to be at most 72.9 mi in water years 2001 and 2002. For the specific seepage rate and estimate length of unlined irrigation canals, the maximum total annual recharge from irrigation canal seepage is estimated to be 37,800 acre-ft in the Methow River Basin (table 9). This corresponds to an instantaneous rate of 124 ft³/s from May to September, however, ground-water discharge to rivers as a result of irrigation-canal seepage would be lower because the ground water would return to the rivers over a longer period of time. In the lower Twisp River valley, irrigation-canal seepage may have contributed up to 4,900 acre-ft annually to aquifer recharge.

Table 9. Estimates of annual aquifer recharge from irrigation-canal seepage in the Methow River Basin, Okanogan County, Washington

Subbasin	Length of unlined irrigation canal (miles)	Annual seepage from canals (thousands of acre-feet)
Beaver	3.9	1.8
Chewuch	10.5	5.5
Lower Methow (below Twisp)	14.5	7.4
Middle Methow (Winthrop to Twisp)	25.2	13.2
Upper Methow (Goat Creek to Winthrop)	6.1	3.2
Headwaters Methow	3.4	1.8
Twisp	9.3	4.9
Total	72.9	37.8

The calculation of recharge from irrigation canals has two primary sources of uncertainty. First, the estimated length of unlined irrigation canals neglects lateral canals, which convey water from main canals to the field where the water is applied for irrigation. Second, some irrigation canals may not be used currently or are operated for less than the May to October period, and seepage rates are likely to be less than 1.8 (ft³/s)/mi in small canals. The negative bias introduced by neglecting lateral canals may offset the positive bias introduced by assuming continuous operation and uniform seepage from all canals; however, some error is likely to remain in the estimate.

If all seepage from irrigation canals returned to the river as steady ground-water flow with no seasonal variation, irrigation-canal seepage would at most account for a steady (year round) gain of about 20 ft³/s in the Methow River from Winthrop to Twisp and 7 ft³/s in the lower Twisp River. Alternatively, if irrigation-canal seepage returned to the rivers at the rate it seeped out of the canals, it would account for a 43 ft³/s gain in the Methow River from Winthrop to Twisp and a 16 ft³/s gain in the lower Twisp River. In this case, however, the gains in streamflow due to irrigation-canal seepage would cease at the end of the irrigation season. The seasonal differences in river-aquifer exchanges in both reaches likely represent a transient increase in ground-water discharge to rivers during late summer and early autumn as a result of irrigation canal seepage: the Methow River from Winthrop to Twisp gained about 30 ft³/s more streamflow in late summer (September) compared to mid-winter (February); the Twisp River gained about 10 ft³/s more streamflow in late summer compared to mid-winter. Based on fluctuations of ground-water levels with the operations of the irrigation canals in the lower Twisp River valley, the seasonal increase in ground-water discharge to these rivers likely was due primarily to irrigation-canal seepage rather than fluvial recharge. Consequently, most of the water recharged by irrigation canals was likely to have drained back to the rivers by February and any component of ground-water discharge in February that could be attributed to irrigation canal seepage is likely to be negligible in the Methow River and at most 2 ft³/s in the Twisp River.

The Twisp River from Buttermilk Creek to Newby Creek, however, also had seasonally high gains in streamflow in September 2001 and 2002 compared to February 2002, even though there is likely to be little irrigation-canal seepage along this reach. In this case, natural recharge also may contribute to increased ground-water discharge during late summer to some rivers in the Methow River Basin.

The seasonal increase in streamflow gains along the Methow River from Winthrop to Twisp and the lower Twisp River during late summer and autumn may be due in part to the hydraulic effect of irrigation-canal seepage: ground water mounds underneath canals in response to recharge rather than rising uniformly across the aquifer. Ground-water flow would increase in response to the higher hydraulic gradient between the mound and the regional ground-water system and the increased saturated thickness of the aquifer at the mound. As a result, ground-water flow from irrigation-canal seepage would not return to the river steadily throughout the year, but instead would be greatest in late summer and decrease as diversions decrease in the autumn. The transient rise in ground-water levels is supported further by the continuous water-level data from the lower Twisp River valley (fig. 20). The seasonal effect of canal recharge on ground-water discharge to both the lower Twisp River and the Methow River from Winthrop to Twisp appears to dissipate by January at which point the lower Twisp has a steady gain of about 4 ft³/s and the Methow River from Winthrop to Twisp has no significant gain or loss of streamflow during the winter.

Water Budget for the Methow River Basin

Mean annual precipitation in the Methow River Basin for 1991 to 2001 was estimated to be 32.6 in. (3.15 million acre-ft). Simulated runoff from the basin was 1,570 ft³/s (or 36 percent of precipitation) compared to 1,529 ft³/s for mean discharge of the Methow River near Pateros. Evapotranspiration accounted for 19 in. (or 58 percent of precipitation). The residual between precipitation less evapotranspiration and runoff was the change in ground-water storage for the simulation period, but is

not a physically based measure of the change in ground-water storage. Mean annual ground-water recharge due to the infiltration of precipitation and irrigation canal seepage (but not fluvial recharge) was estimated to be 4.2 in. or 410,000 acre-ft over the whole basin, not just the unconsolidated aquifer. Annual recharge due to irrigation-canal seepage and over application of water to crops was simulated to be 35,000 acre-ft based on an efficiency of 50 percent in the delivery of water for 16 surface-water diversions in the basin. The simulated recharge from irrigation-canal seepage of water is about 3,000 acre-ft less than the estimate based on a seepage rate of 1.8 (ft³/s)/mi and a maximum of 73 mi of unlined irrigation canal. The difference between the estimates is not significant compared to the uncertainty of either estimate.

Domestic use of water was not explicitly simulated in the hydrologic model for the Methow River Basin. Annual domestic use of water, including irrigation of lawns, other landscaping, and non-commercial gardens, is estimated to be 2,100 acre-ft based on an estimated municipal use of 400 gallons per person per day for the City of Twisp (R. Lane, U.S. Geological Survey, written commun., September 16, 2003) and a population of 4,669 in 2000 for the Methow River Basin (Washington State Office of Financial Management, 2002). A portion of domestically used water is discharged to the Methow River as treated wastewater or to the soil column as effluent from onsite septic systems. The remaining portion of water that is consumed by domestic uses is uncertain. A USGS study of water use in the United States in 1990 estimated that 17 percent of domestic use was consumptive while 56 percent of irrigation use was consumptive (Solley and others, 1993). Depending on the extent to which domestic users irrigate landscaping and gardens, annual consumptive domestic use of water is estimated to range between 360 to 1,170 acre-ft. The estimate of consumptive domestic water use does not account for water used by non-residents. Water use by non-residents particularly irrigation of landscaping or gardens on rental or intermittently occupied properties represents an additional but unknown component of consumptive domestic water use in the Methow River Basin.

SUMMARY

An understanding of the availability and quality of water is an important aspect of managing the water resources in the Methow River Basin. The U.S. Geological Survey, in cooperation with Okanogan County and with support from the U.S. Congress, studied the hydrogeology of the unconsolidated sediments, the quality of surface and ground waters, and the exchanges between surface water and ground waters during water years 2001 and 2002.

Unconsolidated sediments were deposited by fluvial and glacial processes along the bottoms and lower slopes of valleys in the Methow River Basin. The sediments are largely coarse-grained materials (sands and gravels). Alluvium and glaciofluvial sediments deposited during the Quaternary period constitutes the primary aquifer in the Methow River Basin for maintaining streamflow during seasonal dry periods and for domestic and public-water supplies. It forms a nearly continuous deposit along the valley bottom from above Lost River to the confluence of the Methow and Columbia Rivers, covering over 45 square miles of the basin's surface. The deposit is 0.5 mile wide and more than 1,000 ft thick at its upper end near Mazama, decreases to less than 100 ft thick near Winthrop, and increases again south of Twisp to 200 ft thick or more in places. Ground-water levels in the unconsolidated aquifer are highest during the summer and lowest in the late winter and early spring.

Both surface and ground water generally are of high quality. Water-quality results from wells indicated the possibility of ground-water contamination from nitrate and arsenic concentrations at only two locations in the basin. In both cases, potential contamination was isolated to a single well. No major differences in water quality were apparent when comparing the results of this investigation with previous studies.

The flow of water between rivers and aquifers is important for regulating the availability of water resources for in-stream and out-of-stream uses in the Methow River Basin. Ground-water discharge from the unconsolidated aquifer to the Methow River from Lost River to Pateros was determined from daily gains in streamflow and was relatively steady both years of study, ranging from an estimated 153,000 acre-ft in water year 2001 to 157,000 acre-ft in water year 2002. Ground-water discharge to the Methow River contributed 37 to 57 percent of the streamflow near

Pateros during low-flow conditions in September 2001, February 2002, and September 2002. The Methow River gained most of the flow between Goat Creek and Winthrop. Ground-water discharge to the lower Twisp River from Newby Creek to near Twisp ranged from 4,700 acre-ft in water year 2001 to 9,200 acre-ft in water year 2002. Ground-water discharge to the lower Twisp River contributed 45 to 52 percent of streamflow near Twisp during September 2001 and 2002, respectively, but was negligible during February 2001.

The Methow and Twisp Rivers, among others in the basin, are major sources of recharge for the unconsolidated aquifer, particularly during high-flow periods in May and June. Aquifer recharge by both rivers increased with streamflow in water year 2002 compared to water year 2001 as indicated by daily losses of streamflow. Aquifer recharge by the Methow River from Lost River to Pateros was estimated to be 82,000 acre-ft in water year 2001 and 137,000 acre-ft in water year 2002. Aquifer recharge by the Twisp River from Newby Creek to near Twisp was estimated to be 2,000 acre-ft in water year 2001 and 6,400 acre-ft in water year 2002. Combined, mean annual recharge of the unconsolidated aquifer by the Methow and Twisp Rivers for water years 2001 and 2002 was equal to 28 percent of annual recharge by all nonfluvial sources of all aquifers in the basin as calculated by a hydrologic simulation model for water years 1992 to 2001.

Seepage from unlined irrigation canals also recharges the unconsolidated aquifer during the late spring and summer and may contribute as much 38,000 acre-ft annually to aquifer recharge in the basin. In this case, irrigation-canal seepage would represent about 9 percent of annual non-fluvial ground-water recharge in the basin as simulated by the model for water years 1992 to 2001. Seepage from the canals is likely to have the greatest effect on streamflow in September and October, when streamflow and diversions are relatively low but ground-water flow from the seepage is still relatively high. A transient increase in ground-water discharge of about 30 ft³/s to the Methow River from Winthrop to Twisp and of about 10 ft³/s to the lower Twisp River was observed in late summer and early autumn correspond to winter. The increased rate of ground-water discharge to these reaches likely is due primarily to irrigation canal seepage, however, fluvial recharge during the summer may also contributed to the increase. The increased rate of ground-water discharge decays by February in both reaches.

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Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
29N/23E-01D01	480246119541001	480245.9	1195409.7	G	900	M	120	112	D
29N/23E-02A01	480250119543101	480251.7	1195438.8	G	780	M	53	53	D
29N/23E-02B02	480250119544502	480252.8	1195444.3	D	786.3	D	34	24	D
29N/23E-02B04	480242119545001	480243.0	1195450.3	G	800	M	75	55	D
29N/23E-03P01	480210119562001	480209.9	1195620.9	G	1,240	M	–	–	–
29N/23E-03P02	480210119562101	480209.4	1195621.0	G	1,240	M	175	155	D
29N/23E-03P03	480209119562101	480209.7	1195621.0	G	1,240	M	146	141	D
29N/23E-15F01D1	480050119562702	480047.0	1195628.9	G	1,180	M	405	385	D
29N/23E-15F02D1	480052119562702	480052	1195629	M	1,200	M	350	337	D
30N/22E-13H02	480608120010101	480607.2	1200101.1	D	1,121.1	D	133	133	D
30N/23E-06C01	480804120001201	480804.0	1200012.0	D	1,113.5	D	42	42	D
30N/23E-06C02	480757120001201	480756.8	1200012.2	D	1,111.1	D	38	38	D
30N/23E-06G02	480751120000701	480750.9	1200006.8	G	1,120	M	39.5	39.5	D
30N/23E-07D02	480707120002901	480707.1	1200029.3	G	1,140	M	92	92	D
30N/23E-07M02	480650120003401	480649.4	1200033.6	D	1,069.6	D	54	53	D
30N/23E-07N01	480626120004001	480624.8	1200040.2	G	1,140	M	126	126	D
30N/23E-07N04	480623120003601	480623.4	1200036.3	G	1,140	M	128	126	D
30N/23E-18D02	480619120003801	480619.4	1200038.4	G	1,140	M	128	128	D
30N/23E-19M01	480453120004001	480453.9	1200040.2	G	1,000	M	–	–	–
30N/23E-20P01	480442119590701	480441.6	1195906.8	D	920.7	D	46	46	D
30N/23E-27F01	480425119563401	480425.1	1195633.7	G	1,240	M	101	100	D
30N/23E-27L01	480411119562101	480410.9	1195621.4	G	1,140	M	305	305	D
30N/23E-28C02	480429119575001	480429.4	1195749.6	G	900	M	45	45	D
30N/23E-28J03	480403119570801	480402.4	1195708.0	D	866.8	D	100	78	D
30N/23E-30A01	480435119594601	480435.7	1195946.5	G	960	M	–	46	–
30N/23E-30A02	480435119594602	480435.1	1195946.2	G	960	M	–	–	–
30N/23E-34G03	480324119555701	480323.9	1195557.4	G	800	M	39	39	D
30N/23E-34G04	480424120000001	480328.1	1195610.4	G	820	M	–	18	D
30N/23E-34J02	480318119555301	480318.4	1195552.8	G	820	M	65	65	D
30N/23E-34R01	480305119555601	480305.2	1195555.6	G	920	M	137	137	D
30N/23E-35P03	480303119550901	480303.1	1195509.2	G	800	M	65	65	D
31N/22E-05M01	481245120071101	481244.8	1200711.0	G	1,360	M	82	82	D
31N/22E-08L01	481202120065401	481202.3	1200653.9	G	1,340	M	–	45	–
31N/22E-16D01	481126120055301	481125.8	1200553.3	D	1,306.8	D	45	43	D
31N/22E-16Q01	481046120051801	481045.9	1200517.6	D	1,256.8	D	46	35	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. —, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
31N/22E-16Q01D1	481046120051802	481045.9	1200517.6	D	1,256.8	D	105	105	D
31N/22E-19K01	481014120074401	481013.6	1200744.0	G	1,800	M	260	260	D
31N/22E-21B01	481005120051201	481041	1200508	M	1,280	M	60	60	D
31N/22E-21C01	481039120053402	481038.6	1200534.0	G	1,380	M	58	45	D
31N/22E-21C01D1	481039120053401	481038.6	1200534.0	G	1,380	M	150	150	D
31N/22E-21G02	481025120050701	481025.2	1200506.7	D	1,265.1	D	60	60	D
31N/22E-21G03	481022120050201	481021.4	1200501.6	D	1,245.6	D	144	143	D
31N/22E-21J01	481010120044501	481009.5	1200444.9	G	1,260	M	60	60	D
31N/22E-21J02	480957120043701	481016.4	1200459.3	G	1,280	M	70	70	D
31N/22E-21R01	481006120044301	481005.3	1200442.5	G	1,260	M	82	82	D
31N/22E-22N01	480958120043701	480957.6	1200437.1	G	1,260	M	52	52	D
31N/22E-27D01	480944120043401	480945.3	1200433.8	G	1,240	M	40	40	D
31N/22E-27D02	480946120043401	480945.6	1200433.9	G	1,240	M	40	40	D
31N/22E-27E01	480940120043101	480939.5	1200431.3	G	1,240	M	40	40	D
31N/22E-27F01	480933120040801	480933.5	1200407.7	G	1,300	M	178	178	D
31N/22E-27P01	480912120041701	480912.7	1200416.9	G	1,400	M	135	135	D
31N/22E-35C01	480858120025701	480858.1	1200258.2	G	1,220	M	82	82	D
31N/22E-35K01	480830120023801	480829.7	1200238.5	G	1,180	M	43	43	D
31N/22E-36M01	480826120015801	480825.6	1200157.9	G	1,200	M	70	70	D
31N/22E-36P01	480826120013601	480815.1	1200136.5	G	1,180	M	54	54	D
31N/22E-36R01	480819120010801	480819.6	1200107.6	G	1,200	M	102	100	D
31N/23E-31L01	480822120002401	480822.5	1200023.5	G	1,180	M	74	73	D
31N/23E-31N01	480815120003601	480814.8	1200035.7	G	1,180	M	140	140	D
31N/23E-31P02	480818120001801	480817.4	1200017.7	D	1,162.7	D	80	80	D
32N/22E-01G01	481801120004501	481817	1200118	M	1,940	M	185	180	D
32N/22E-02E01	481817120030501	481816.9	1200304.9	G	1,480	M	40	40	D
32N/22E-02J01	481601120021501	481800.7	1200214.6	G	1,780	M	85	84	D
32N/22E-03Q01	481752120034501	481751.8	1200344.7	G	1,500	M	253	253	D
32N/22E-03Q02	481752120035201	481751.5	1200351.6	D	1,493.5	D	80	80	D
32N/22E-10B01	481731120035501	481730.8	1200355.5	G	1,480	M	60	60	D
32N/22E-10B02	481741120035301	481741	1200353	M	1,500	M	80	78	D
32N/22E-10B03	481740120035001	481740	1200350	M	1,500	M	140	140	G
32N/22E-10B04	481742120034901	481742	1200349	M	1,500	M	160	135	D
32N/22E-10M02	481709120043601	481708.5	1200435.7	D	1,484.0	D	73	73	D
32N/22E-15B01	481648120035001	481648.2	1200350.4	G	1,740	M	185	185	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. —, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
32N/22E-16G02	481634120050901	481633.6	1200509.0	D	1,442.6	D	56	56	D
32N/22E-16H01	481633120045601	481632.5	1200456.1	D	1,469.6	D	80	80	D
32N/22E-16P01	481600120053401	481600.5	1200533.6	D	1,429.4	D	50	50	D
32N/22E-16P02	481609120053701	481608.9	1200536.6	G	1,460	M	80	80	D
32N/22E-20R01	481512120061601	481508.2	1200615.6	G	1,460	M	140	140	D
32N/22E-21E01	481544120054501	481544.2	1200545.0	D	1,471.8	D	103	103	D
32N/22E-28L01	481439120052701	481438.6	1200527.2	G	1,700	M	108	108	D
32N/22E-29C02D1	481506120064302	481505.5	1200643.2	G	1,440	M	74.5	74.5	D
32N/22E-29P01	481417120065301	481416.9	1200653.1	G	1,400	M	59	59	D
32N/22E-30P01	481416120080601	481416.8	1200806.0	G	1,600	M	109	105	D
32N/22E-31R01	481326120072401	481325.1	1200723.5	D	14,18.6	D	103	101	D
32N/22E-32B01	481412120063601	481412.2	1200636.9	G	1,420	M	—	—	—
32N/22E-32C01	481406120065201	481405.6	1200651.7	D	1,381.8	D	40	—	D
32N/22E-32C02	481409120065301	481409.0	1200653.1	G	1,380	M	—	41.4	—
32N/22E-32E01	481341120070401	481348.6	1200703.4	D	1,405.7	D	60	60	D
32N/22E-32G01	481401120063001	481401.1	1200630.0	D	1,548.4	D	120	120	D
32N/22E-32L01	481343120065001	481343.2	1200649.7	G	1,380	M	56	55	D
33N/20E-07N01	482204120235801	482204.5	1202357.5	G	2,420	M	125	125	D
33N/20E-10J01	482218120190701	482217.9	1201906.4	D	2,233.3	D	148	148	D
33N/20E-11L01D1	482228120184002	482228.4	1201839.4	D	2,305.7	D	—	190	D
33N/20E-11P01	482213120182301	482212.8	1201822.6	D	2,184.7	D	166	166	D
33N/20E-15G01	482141120193301	482140.9	1201933.4	G	2,380	M	118	118	D
33N/20E-16A01	482153120202501	482153.2	1202024.7	D	2,345.5	D	185	185	D
33N/20E-16L01	482128120210501	482127.5	1202105.4	G	2,340	M	48	46	D
33N/20E-21D01	482110120213101	482109.3	1202131.5	D	2,328.0	D	40	40	D
33N/21E-05P01	482300120142801	482259.5	1201428.1	G	2,220	M	345	345	D
33N/21E-07D01	482246120161001	482245.9	1201609.9	G	2,100	M	48	46	D
33N/21E-08A03	482244120135401	482244.1	1201354.9	G	1,940	M	40	40	D
33N/21E-08A04	482247120140701	482247.0	1201406.8	D	1,979.8	D	48	46	D
33N/21E-08A05	482244120140401	482242.4	1201404.1	G	1,960	M	48	46	D
33N/21E-08B01	482240120141401	482246	1201414	M	1,960	M	47	45	D
33N/21E-08B02	482243120141001	482242.8	1201410.2	G	1,960	M	—	—	—
33N/21E-08C01	482249120144201	482248.9	1201441.6	G	2,000	M	45	30	D
33N/21E-08C02	482243120144401	482242.6	1201443.9	D	2,041.6	D	66	65	D
33N/21E-08D03	482246120150501	482245.9	1201504.7	G	2,020	M	40	40	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. —, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
33N/21E-09D01	482246120134401	482246.7	1201344.8	G	1,980	M	40	40	D
33N/21E-09D02	482252120134501	482252.2	1201345.4	G	2,000.42	L	61	61	D
33N/21E-09D03	482246120134101	482246.2	1201341.0	D	1,964.8	D	39	38	D
33N/21E-10J01	482225120112301	482224.9	1201122.7	D	1,878	D	158	158	D
33N/21E-10J02	482219120112001	482218.8	1201119.4	D	1,788	D	64	60	D
33N/21E-10J03	482220120111701	482220.0	1201116.9	D	1,791.3	D	—	6.1	—
33N/21E-10J04	482220120111601	482219.3	1201115.7	D	1,789.5	D	53	50	D
33N/21E-10L01	482223120120201	482222.7	1201202.0	D	1,826.5	D	42	42	D
33N/21E-10L02	482224120115401	482224.3	1201154.9	G	1,851.10	L	80	80	D
33N/21E-10L03	482221120115601	482222.1	1201155.8	D	1,830.1	D	40	38	D
33N/21E-10P01	482203120120101	482203.3	1201200.8	G	1,880	M	65	65	D
33N/21E-11J01	482220120101201	482220.2	1201012.0	D	1,850.1	D	153	150	D
33N/21E-11L01	482227120103801	482226.5	1201038.3	D	1,877.0	D	300	300	D
33N/21E-11M01	482225120111001	482221.3	1201103.6	G	1,800	M	25	25	D
33N/21E-11M02	482227120110401	482221.3	1201103.7	G	1,800	M	73	73	D
33N/21E-11M03	482221120110401	482221.2	1201103.8	G	1,800	M	90	90	D
33N/21E-11N01	482208120105701	482208	1201057	M	1,760	M	—	—	—
33N/21E-11N02	482208120105702	482208	1201057	M	1,760	M	—	—	—
33N/21E-11P01	482211120105201	482211.4	1201052.4	G	17,60	M	60	60	D
33N/21E-11P02	482215120104301	482215.2	1201043.1	D	1,837.9	D	209	209	D
33N/21E-11P03	482213120103601	482213.2	1201036.7	D	1,825.6	D	160	160	D
33N/21E-11P04	482212120104001	482212.0	1201040.0	G	1,748.92	L	32	30	D
33N/21E-11Q01	482203120101901	482204.0	1201013.1	G	1,740	M	40	40	D
33N/21E-11R01	482145120102901	482203.6	1201002.9	G	1,760	M	75	75	D
33N/21E-12N01	482214120093702	482213.7	1200936.6	D	1,695.5	D	52	50	D
33N/21E-12N02	482214120093701	482213.7	1200936.6	D	1,695.5	D	47	45	D
33N/21E-12N03	482206120094401	482205.9	1200943.8	G	1,740	M	62	62	D
33N/21E-12R01	482206120083601	482205.9	1200835.7	G	1,660	M	108	106	D
33N/21E-12R02	482206120083701	482206.1	1200837.6	D	1,663.2	D	—	—	—
33N/21E-13D01	482202120095301	482201.4	1200953.4	D	1,747.5	D	70	70	D
33N/21E-14B01	482202120101701	482201.2	1201017.1	D	1,758.4	D	105	105	D
33N/21E-15E01	482145120121801	482144.6	1201217.7	D	1,961.4	D	40	34.5	D
33N/21E-15N01	482111120121601	482110.6	1201215.6	G	2,300	M	92	90	D
33N/22E-02C01	482333120025801	482332.7	1200257.7	G	2,140	M	95	85	D
33N/22E-02C02	482337120025401	482337.7	1200254.0	G	2,160	M	145	145	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
33N/22E-03H01	482326120033001	482325.7	1200329.7	G	2,280	M	245	245	D
33N/22E-05M01	482308120070101	482308.3	1200701.4	G	1,660	M	–	–	–
33N/22E-05P01	482255120064201	482255.1	1200642.0	G	1,880	M	265	265	D
33N/22E-05P02	482257120064301	482256.6	1200643.4	G	1,880	M	225	225	D
33N/22E-05P03	482259120065301	482258.7	1200653.2	G	1,840	M	280	260	D
33N/22E-07H01	482233120072601	482232.6	1200726.4	G	1,600	M	74	74	D
33N/22E-07H02	482235120073201	482235.0	1200732.0	D	1,595.5	D	40	40	D
33N/22E-07J01	482204120072401	482216.5	1200725.5	G	1,600	M	15	14.6	D
33N/22E-07N01	482205120083301	482202.0	1200832.0	G	1,660	M	42	37	D
33N/22E-07N02	482204120083401	482204.1	1200833.8	G	1,680	M	160	160	D
33N/22E-07N03	482211120082701	482211.4	1200826.6	G	1,660	M	75.5	75.5	D
33N/22E-07N04	482327120071801	482206.9	1200823.7	G	1,640	M	70	70	D
33N/22E-07N05	482204120082001	482204.4	1200820.6	D	1,631.6	D	84	84	D
33N/22E-07N06	482201120082101	482201.9	1200821.9	G	1,620	M	–	30	–
33N/22E-07Q01	482204120074101	482203.8	1200741.0	G	1,620	M	20	20	D
33N/22E-07R01	482212120073401	482211.7	1200733.6	D	1,620.9	D	71	71	D
33N/22E-08D02	482245120070101	482245.0	1200701.2	G	1,620	M	60	60	D
33N/22E-08D03	482252120070301	482252	1200703	M	1,620	M	–	35	–
33N/22E-08N02	482205120070901	482205.4	1200709.0	G	1,600	M	–	52	–
33N/22E-13A02	481253120004901	482153.1	1200049.3	G	2,140	M	120	120	D
33N/22E-14H01	482139120020501	482139	1200205	M	1,900	M	36.1	–	G
33N/22E-16N01	482117120055701	482116.8	1200555.4	G	1,560	M	23	23	D
33N/22E-16N02	482117120055301	482117	1200553	M	1,560	M	–	23	D
33N/22E-16P01	482116120053201	482115.8	1200532.0	G	1,580	M	82	80	D
33N/22E-16R03	482112120045801	482111.7	1200457.8	G	1,680	M	–	–	–
33N/22E-17D01	482154120070701	482153.8	1200708.2	G	1,608	M	100	100	D
33N/22E-17F01	482137120064401	482140.4	1200638.1	G	1,580	M	–	32	D
33N/22E-17G01	482143120062801	482142.9	1200628.1	G	1,620	M	140	140	D
33N/22E-17K01	482130120063001	482130.0	1200630.0	G	1,580	M	35	35	D
33N/22E-17L01	482128120064001	482128.2	1200638.9	G	1,570.67	L	83	83	D
33N/22E-17L03	482134120064601	482134.5	1200646.4	G	1,580	M	–	–	–
33N/22E-18C01	482201120081301	482201.4	1200813.8	D	1,627.4	D	170	170	D
33N/22E-18D01	482202120082301	482201.7	1200822.7	G	1,640	M	60	60	D
33N/22E-18D02	482200120082001	482200.4	1200819.8	G	1,640	M	21	15	D
33N/22E-18D03	482159120081801	482159.4	1200818.4	G	1,640	M	21	20	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
33N/22E-20A02	482057120060401	482056.9	1200604.3	G	1,600	M	83	83	D
33N/22E-20A03	482056120060401	482056.0	1200604.8	G	1,600	M	–	–	–
33N/22E-20A04	482057120060501	482056.7	1200604.7	G	1,600	M	83	83	D
33N/22E-20B01	482106120063501	482106.3	1200634.5	G	1,580	M	40	40	D
33N/22E-20G01	482047120063301	482047.3	1200633.1	G	1,720	M	450	450	D
33N/22E-21A01	482106120045501	482105.9	1200455.0	G	1,680	M	–	6	–
33N/22E-21A02	482108120045901	482108.1	1200458.7	G	1,660	M	–	–	–
33N/22E-21D01	482103120055201	482102.9	1200552.1	G	1,600	M	200	195	D,G
33N/22E-21D02	482103120055101	482102.6	1200551.4	G	1,600	M	192	191	D
33N/22E-21E01	482045120055001	482044.8	1200550.4	G	1,560	M	73.5	73.5	D
33N/22E-21F01	482053120052601	482052.8	1200525.9	G	1,540	M	40	40	D
33N/22E-21F02	482054120053801	482053.6	1200538.6	G	1,540	M	240	240	D
33N/22E-21F03	482053120052501	482052.8	1200525.9	G	1,540	M	80	80	D
33N/22E-21F04	482046120053101	482046.0	1200531.5	G	1,540	M	–	–	–
33N/22E-21H02	482054120045501	482054	1200455	G	1,590	M	83	80	D
33N/22E-21H03	482054120045502	482054	1200455	G	1,590	M	83	83	D
33N/22E-22E01	482046120042601	482046.5	1200425.8	G	1,560	M	87	78	D
33N/22E-22N02	482019120043401	482019.1	1200433.8	G	1,520	M	197	145	D,G
33N/22E-22N03	482019120043402	482018.9	1200434.4	G	1,520	M	156	141	D
33N/22E-22P03	482026120041101	482026.3	1200410.8	G	1,520	M	39	35	D
33N/22E-22P04	482029120040401	482029	1200404	M	1,530	M	340	340	D
33N/22E-23G01	482052120023401	482052	1200234	M	1,740	M	37.5	–	G
33N/22E-23L01	482033120025401	482033.2	1200254.0	G	1,680	M	–	5.6	–
33N/22E-23L02	482034120025501	482033.8	1200254.8	G	1,700	M	–	–	–
33N/22E-23L03	482033120025501	482033.0	1200255.5	G	1,680	M	–	56.7	–
33N/22E-23L04	482037120024701	482036.9	1200246.9	G	1,700	M	84	83	D
33N/22E-23P01	482024120025501	482024	1200255	G	1,660	M	32	31	D
33N/22E-23P02	482023120025501	482023.8	1200255.8	G	1,660	M	–	5.73	–
33N/22E-23P03	482025120025201	482025.1	1200251.6	G	1,720	M	128	120	D
33N/22E-26D01	482004120030601	482003.8	1200305.9	G	1,640	M	141	141	D
33N/22E-26D02	482012120031601	482012.3	1200316.1	G	1,680	M	197	197	D
33N/22E-26D03	482015120031901	482015.2	1200319.1	G	1,680	M	197	192	D
33N/22E-26F01	481954120024501	481954.8	1200245.8	G	1,680	M	–	–	–
33N/22E-26F02	481956120025401	481956.7	1200254.9	G	1,660	M	–	123	–
33N/22E-26L01	481938120024601	481938.5	1200246.3	G	1,640	M	200	198	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
33N/22E-27B02	482011120035901	482011	1200359	M	1,530	M	55	44	D
33N/22E-27B03	482005120034601	482005	1200346	M	1,530	M	–	50	–
33N/22E-27C02	482014120041901	482013.9	1200419	G	1,520	M	18	18	D
33N/22E-27C03	482014120042101	482014	1200407	G	1,520	M	73	73	D
33N/22E-27G01	481954120034301	481954.1	1200343.0	G	1,520	M	43	39	D
33N/22E-27G02	482003120035301	482003.0	1200352.5	G	1,520	M	272	272	D
33N/22E-27H01	481950120033901	481950.6	1200339.7	G	1,520	M	–	138	–
33N/22E-27J01	482142120033701	481946	1200337	G	1,520	M	210	210	D
33N/22E-27J03	481943120033601	481943	1200336	M	1,520	M	57.5	–	G
33N/22E-27Q01	481934120034801	481934.2	1200348.1	G	1,500	M	60	60	D
33N/22E-28J01	481940120044801	481939.8	1200447.7	G	1,520	M	40	38	D
33N/22E-34A01	481920120033401	481920.4	1200334.0	G	1,520	M	64	64	D
33N/22E-34B02	481921120035501	481921.3	1200354.8	G	1,560	M	114	114	D
33N/22E-34G01	481911120034201	481910.8	1200341.8	G	1,500	M	60	60	D
33N/22E-34L01	481855120040401	481855.2	1200404.8	G	1,500	M	–	64	–
33N/22E-35D01	481913120031201	481913	1200312	M	1,540	M	–	46	--
34N/21E-01L01	482823120093101	482823.0	1200931.1	G	2,500	M	–	–	–
34N/21E-01M01	482829120093301	482829.4	1200933.7	G	2,500	M	–	–	–
34N/21E-01N01	482816120095001	482815.5	1200950.2	G	2,060	M	240	240	D
34N/21E-01N02	482816120094901	482816.4	1200949.4	G	2,060	M	180	180	D
34N/21E-01P01	482815120092601	482815.2	1200926.1	G	2,500	M	124	122	D
34N/21E-01P02	482815120092602	482815.2	1200926.1	G	2,500	M	–	–	–
34N/21E-02B01	482858120101303	482858.0	1201012.9	G	2,180	M	412	410	D
34N/21E-02B03	482858120101302	482858.2	1201013.2	G	2,180	M	192	192	D
34N/21E-02B03D1	482858120101301	482858.2	1201013.2	G	2,180	M	282	282	D
34N/21E-02L01	482831120103001	482831	1201030	M	1,820	M	–	–	–
34N/21E-02Q01	482813120101901	482808.7	1201019.8	G	1,760	M	18	18	D
34N/21E-03B01	482854120113301	482853.9	1201133.1	D	1,831.0	D	220	220	D
34N/21E-03E01	482834120122101	482834.7	1201221.1	G	1,780	M	140	140	D
34N/21E-03E02	482835120122101	482834.5	1201220.9	D	1,783.5	D	110	110	D
34N/21E-03E03	482834120121901	482833.6	1201218.9	G	1,780	M	145	145	D
34N/21E-03E04	482836120121701	482836.0	1201217.5	G	1,780	M	–	–	–
34N/21E-03E05	482836120121702	482836.9	1201217.0	G	1,780	M	–	–	–
34N/21E-03F01	482837120115301	482837.1	1201152.6	D	1,766.7	D	41	40	D
34N/21E-03M02	482834120122401	482834.4	1201223.6	G	1,780	M	46	44.5	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. —, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
34N/21E-03M03	482832120122101	482832.4	1201220.9	G	1,780	M	125	122	D
34N/21E-03M04	482830120122101	482829.6	1201220.9	G	1,780	M	150	147	D
34N/21E-03M05	482833120121701	482832.6	1201217.3	D	1,784.3	D	72	70	D
34N/21E-03M06	482834120122001	482833.8	1201219.4	D	1,783.5	D	110	110	D
34N/21E-03P01	482818120120701	482817.4	1201207.2	D	1,781.6	D	43	38	D
34N/21E-03R01	482818120111201	482818.4	1201112.1	G	1,820	M	120	120	D
34N/21E-04A01	482857120124201	482856.6	1201242.3	G	1,780	M	40	40	D
34N/21E-04B01	482849120125301	482849.2	1201252.9	G	1,780	M	40	40	D
34N/21E-04B02	482849120125201	482848.9	1201251.5	G	1,780	M	60	60	D
34N/21E-04B03	482851120125801	482851.8	1201258.4	G	1,780	M	40	40	—
34N/21E-04B04	482848120130301	482848.5	1201303.0	G	1,800	M	70	70	D
34N/21E-04H01	482847120124501	482847.3	1201245.0	G	1,780	M	40	40	D
34N/21E-04H02	482847120124401	482847.3	1201244.4	G	1,780	M	40	40	D
34N/21E-04J01	482847120124701	482826.9	1201246.8	D	1,795.7	D	60	60	D
34N/21E-08E01	482753120150501	482753	1201505	M	2,400	M	96	96	D
34N/21E-08E02	482753120150401	482753	1201504	M	2,400	M	65	46	D
34N/21E-09F01	482749120132401	482749.1	1201323.8	G	2,640	M	185	180	D
34N/21E-09F02	482751120132701	482751.2	1201326.8	G	2,640	M	100	100	D
34N/21E-09J01	482737120124001	482736.8	1201240.3	G	2,020	M	287	287	D
34N/21E-09J02	482733120124601	482733.0	1201245.7	G	2,080	M	180	180	D
34N/21E-10D01	482806120122501	482805.1	1201224.4	D	1,837.2	D	87	86	D
34N/21E-10G01	482748120113701	482748.3	1201136.9	D	1,873.8	D	200	200	D
34N/21E-10G02	482747120113601	482747.1	1201135.9	G	1,880	M	330	330	D
34N/21E-10G03	482748120113801	482748.2	1201138.2	G	1,880	M	330	328	D
34N/21E-10G04	482752120113101	482751.9	1201131.0	D	1,872.3	D	330	330	D
34N/21E-10P02	482728120115401	482728.0	1201153.7	G	1,900	M	140	140	D
34N/21E-10R02	482728120111601	482727.8	1201116.0	G	1,880	M	106	106	D
34N/21E-11A01	482757120100601	482756.9	1201005.5	G	1,740	M	50	50	D
34N/21E-11A02	482757120100501	482756.8	1201005.5	G	1,740	M	50	50	D
34N/21E-11G01	482748120101201	482748.2	1201012.4	G	1,760	M	57	54	D
34N/21E-11H01	482754120100301	482753.7	1201003.5	G	1,740	M	50	50	D
34N/21E-11H02	482754120100401	482753.8	1201003.5	G	1,740	M	50	50	D
34N/21E-11H03	482750120100101	482749.5	1201001.0	G	1,740	M	40	40	D
34N/21E-11H04	482751120095201	482750.8	1200951.9	G	1,760	M	70	70	D
34N/21E-12E02	482755120094601	482754.1	1200945.9	D	1,839.2	D	245	245	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
34N/21E-12E04	482744120094701	482743.5	1200946.7	G	1,760	M	40	34.5	D
34N/21E-12E05	482745120094001	482745.3	1200940.2	G	1,800	M	–	–	–
34N/21E-13F01	482656120092901	482656.3	1200929.2	G	1,720	M	40	40	D
34N/21E-13G01	482652120090801	482652.1	1200908.2	G	1,780	M	62	62	D
34N/21E-13H01	482654120084301	482654.5	1200842.6	G	1,820	M	60	60	D
34N/21E-13J01	482644120084101	482644.2	1200841.1	G	1,800	M	60	55	D
34N/21E-13J02	482638120083901	482638.0	1200839.2	G	1,800	M	46	40	D
34N/21E-13J03	482645120083701	482645	1200837	M	1,800	M	–	35.4	–
34N/21E-13K01	482642120085601	482641.5	1200856.0	D	1,794.6	D	343	343	D
34N/21E-13R01	482629120083801	482629	1200838	M	1,780	M	41	40	D
34N/21E-14D01	482709120110101	482709.3	1201101.7	G	1,840	M	94	94	D
34N/21E-14D02	482709120110102	482709.3	1201101.7	G	1,840	M	–	–	–
34N/21E-14E01	482656120110301	482655.3	1201103.2	D	1,848.6	D	75	75	D
34N/21E-14N01	482629120105101	482628.9	1201050.8	G	1,860	M	95	95	D
34N/21E-14P01	482629120104501	482629.1	1201045.3	G	1,860	M	80	80	D
34N/21E-15B01	482710120114601	482709.7	1201145.6	G	1,900	M	160	160	D
34N/21E-15E01	482657120121401	482657.2	1201214.5	G	1,960	M	230	224	D
34N/21E-15R01	482633120111301	482632.6	1201113.2	D	1,882.1	D	164	164	D
34N/21E-17Q01	482627120140901	482627.7	1201409.2	G	2,400	M	47	45	D
34N/21E-22A01	482617120112701	482617.2	1201126.5	D	1,893.5	D	124	124	D
34N/21E-22A02	482610120112701	482610.5	1201127.2	D	1,925.1	D	150	150	D
34N/21E-22F01	482603120115801	482603.2	1201157.9	G	1,960	M	40	40	D
34N/21E-23D01	482613120105401	482612.9	1201053.7	D	1,865.6	D	94	92	D
34N/21E-23E01	482606120110201	482606.5	1201101.3	G	1,940	M	140	140	D
34N/21E-23G01	482557120101601	482556.6	1201015.8	D	1,818.7	D	66	66	D
34N/21E-23J01	482552120095501	482551.7	1200955.4	G	1,800	M	80	80	D
34N/21E-23R01	482544120095401	482543.5	1200954.0	G	1,780	M	285	285	D
34N/21E-24A01	482623120083501	482622.9	1200835.3	G	1,800	M	60	60	D
34N/21E-24C01	482623120092601	482623.0	1200926.0	D	1,701.1	D	40	40	D
34N/21E-24G01	482601120090201	482600.5	1200902.3	G	1,720	M	60	60	D
34N/21E-24H01	482601120083901	482600.5	1200838.4	D	1,758.7	D	60	60	D
34N/21E-25B01	482530120085501	482530.5	1200855.0	G	1,700	M	62	62	D
34N/21E-25B02	482529120085801	482528.7	1200858.4	D	1,691.2	D	60	60	D
34N/21E-25C01	482526120092301	482526.1	1200923.1	G	1,700	M	–	81	–
34N/21E-25C02	482522120091401	482522.4	1200914.2	G	1,700	M	68	68	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
34N/22E-17M01	482642120070301	482642.0	1200703.7	G	2,260	M	135	135	D
34N/22E-30F02	482505120080001	482505	1200800	G	1,700	M	81	74	D
34N/22E-30F03	482510120075801	482509.9	1200758.4	G	1,720	M	165	160	D
34N/22E-30L01	482455120080901	482455.1	1200809.7	D	1,676.9	D	63	63	D
34N/22E-30L02	482456120080301	482456.4	1200802.8	G	1,700	M	63	63	D
34N/22E-30N01	482438120082101	482438.0	1200820.6	D	1,653.5	D	40	40	D
34N/22E-30Q01	482445120074001	482445	1200740	M	1,700	M	–	186	–
34N/22E-31N01	482351120012601	482350.7	1200826.2	G	1,660	M	80	80	D
35N/20E-04N01	483326120212501	483326.2	1202125.0	D	2,006	D	47	45	D
35N/20E-05R01	483327120214701	483326.9	1202147.1	G	2,020	M	76	76	D
35N/20E-09L01	483252120205801	483251.6	1202057.6	G	2,000	M	60	60	D
35N/20E-10E01	483301120211201	483300.5	1202013.0	D	1,970.1	D	40	40	D
35N/20E-10F01D1	483302120194402	483301.8	1201943.5	G	2,050	M	119	119	D
35N/20E-10F02	483302120194301	483301.8	1201943.6	D	2,027.5	D	120	120	D
35N/20E-10F03	483301120194201	483301.6	1201942.9	G	2,020	M	–	–	–
35N/20E-10N02	483239120200501	483238.6	1202004.9	G	1,960	M	40	40	D
35N/20E-10P01	483234120194201	483234.5	1201942.0	G	1,950	M	47	45	D
35N/20E-14E02	483212120185701	483212.5	1201856.8	G	1,940	M	40	40	D
35N/20E-14L01	483158120183501	483158.0	1201835.3	G	1,920	M	43	43	D
35N/20E-14N01	483149120185101	483149.0	1201851.3	G	1,920	M	40	40	D
35N/20E-15C01	483224120194801	483224.2	1201947.7	G	1,950	M	40	40	D
35N/20E-15C02	MW13 483216120193701	483216.9	1201937.2	G	1,946	L	–	–	–
35N/20E-15H01	483213120185701	483212.0	1201900.7	D	1,936.8	D	40	40	D
35N/20E-15K01	481356120193301	483155.5	1201933.3	D	1,941.5	D	40	40	D
35N/20E-16H01	483207120202801	483206.9	1202027.3	G	2,020	M	80	80	D
35N/20E-16H02	483204120202701	483204.3	1202027.1	G	2,020	M	80	80	D
35N/20E-16H05	483216120202801	483215.7	1202027.8	D	1,961.7	D	40	40	D
35N/20E-16J01	483201120202601	483201.4	1202025.8	G	2,000	M	100	100	D
35N/20E-16J02	483158120202401	483158.3	1202024.0	G	2,000	M	80	80	D
35N/20E-23E01	483122120184601	483122.3	1201846.0	G	2,040	M	210	210	D
35N/20E-24C01	483135120170601	483134.2	1201705.6	D	1,900.2	D	45	39	D
35N/20E-24C02	483133120170201	483133.2	1201701.6	G	1,900	M	47	46	D
35N/20E-24H01	483119120162901	483119.4	1201629.2	G	1,900	M	48	43.8	D
35N/20E-24H02	483119120163501	483119.2	1201635.0	D	1,882.9	D	47	45	D
35N/20E-24N01	483050120172301	483049.8	1201723.3	G	2,100	M	460	420	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available	
		Latitude	Longitude	Method derived			Hole	Well		
35N/20E-24N02		483053120173501	483052.6	1201735.0	G	2,080	M	265	260	D
35N/20E-25J01	MW14	483011120162301	483011.7	1201623.0	G	1,855	L	39	27	G
35N/20E-25K01		483017120164201	483017	1201642	M	1,860	M	40	40	D
35N/21E-10A01		483311120111701	483310.8	1201117.2	G	2,060	M	85	85	D
35N/21E-10A02		483309120111901	483309.5	1201119.0	D	2,059.7	D	85	85	D
35N/21E-10A03		483310120111901	483309.5	1201119.2	G	2,060	M	105	105	D
35N/21E-10B01		483308120113401	483308	1201134	G	2,060	M	38	38	D
35N/21E-10J01		483242120112601	483242.4	1201125.5	G	2,020	M	450	450	D
35N/21E-10K01		483250120113201	483249.6	1201131.8	G	2,040	M	145	145	D
35N/21E-11M01		483248120104901	483250.1	1201050.1	G	1,960	M	108	108	D
35N/21E-15A01		483228120113401	483228.0	1201113.7	G	2,020	M	305	305	D
35N/21E-15K01		483201120114501	483201	1201145	G	2,240	M	117	115	D
35N/21E-15K02		483152120114001	483152	1201140	G	2,200	M	205	205	D
35N/21E-19E01		483114120155901	483113.6	1201559.5	D	2,207.4	D	265	265	D
35N/21E-19L01		483108120155101	483107.7	1201551.2	G	2,160	M	205	205	D
35N/21E-19M01		483102120160601	483101.9	1201605.9	G	1,906	D	62	60.5	D
35N/21E-19M02		483102120160501	483101.5	1201605.8	D	1,906.2	D	61	59	D
35N/21E-19M03		483101120160501	483101.9	1201605.9	G	1,906	D	62	59.5	D
35N/21E-19M04		483101120160601	483101.9	1201605.9	G	1,906	D	61	59	D
35N/21E-19P01		483052120154501	483052.1	1201545.4	G	1,920	M	127	–	D
35N/21E-19Q01		483058120153301	483057.5	1201533.2	G	2,040	M	65	65	D
35N/21E-22A02		483128120112401	483128.1	1201124.2	G	1,960	M	47	45	D
35N/21E-22J01		483121120111601	483102.4	1201116.9	G	1,880	M	26	26	–
35N/21E-22J02		483102120111701	483101.7	1201116.7	G	1,880	M	66	66	D
35N/21E-22J03		483107120111001	483106.5	1201111.0	G	1,860	M	26	26	D
35N/21E-22R01		483051120112601	483050.8	1201126.5	G	1,880	M	–	60	–
35N/21E-26B01		483033120102101	483033	1201021	M	1,960	M	–	–	–
35N/21E-26B02		483040120102501	483039.8	1201025.0	G	1,980	M	190	190	D
35N/21E-26C01		483037120103201	483037.8	1201032.0	G	2,000	M	–	200	–
35N/21E-26M01		483013120110601	483013.2	1201105.1	G	1,860	M	140	140	D
35N/21E-27Q01		483005120113901	483005.0	1201139.3	G	2,120	M	305	305	D
35N/21E-30M01		483014120162101	483013.4	1201620.5	G	1,840	M	67	65	D
35N/21E-30P01		482959120160101	482959.1	1201601.4	G	1,840	M	61	58	D
35N/21E-30P01D1		482959120160102	482959.1	1201601.4	G	1,840	M	81	80	D
35N/21E-30P02		482954120154601	482954.4	1201545.5	D	1,836.9	D	34	32	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available
		Latitude	Longitude	Method derived			Hole	Well	
35N/21E-32A01	482945120140701	482947.2	1201406.6	G	2,020	M	540	540	D
35N/21E-32A02	482945120140501	482945.7	1201405.1	G	2,000	M	–	225	–
35N/21E-32D01	482948120145801	482947.9	1201458.0	D	1,844.2	D	80	80	D
35N/21E-32D02	482949120145401	482948.9	1201453.8	D	1,840.4	D	80	80	D
35N/21E-32D03	482941120145001	482941.2	1201449.8	G	1,860	M	97	97	D
35N/21E-32D04	482943120150301	482942.8	1201502.8	D	1,857.4	D	80	80	D
35N/21E-32E01	482946120140501	482934.6	1201457.2	G	1,880	M	100	100	D
35N/21E-32E02	482935120150101	482938.4	1201501.1	G	1,880	M	80	80	D
35N/21E-32L01	482924120144401	482923.7	1201444.4	G	1,900	M	100	100	D
35N/21E-32L02	482924120143801	482924.4	1201437.7	G	1,880	M	80	80	D
35N/21E-32L03	482922120142801	482921.8	1201428.5	G	1,860	M	86	86	D
35N/21E-33P01	482910120132401	482910.0	1201324.1	G	1,780	M	80	76	D
35N/21E-33R01	482913120123901	482912.8	1201239.3	G	1,980	M	200	200	D
35N/21E-34A01	482950120112701	482949.9	1201127.0	D	1,972.8	D	–	–	–
35N/21E-34E01	482938120122101	482937.5	1201221.2	G	2,000	M	340	340	D
35N/21E-34R01	482912120112701	482911.5	1201126.8	G	1,900	M	56	56	D
35N/21E-35D01	482945120105601	482945.2	1201055.5	G	1,860	M	105	105	D
35N/21E-35D02	482943120105501	482949.4	1201054.6	G	1,860	M	305	305	D
35N/21E-35E01	482929120110401	482928.8	1201103.6	G	1,820	M	101	100	D
35N/21E-35E02	482927120110201	482927.0	1201101.5	G	1,820	M	290	290	D
35N/21E-35F01	482933120104201	482932.9	1201042.5	G	1,880	M	26	26	D
35N/21E-35F02	482932120104101	482932.6	1201041.8	G	1,880	M	–	15.6	–
35N/21E-35M02	482923120105701	482922.5	1201056.4	G	1,820	M	100	100	D
35N/21E-35P01	482901120105001	482901.1	1201050.1	G	1,780	M	43	43	D
35N/21E-35P03	482901120103901	482901	1201039	M	1,860	M	–	230	–
36N/19E-04N01	483839120291701	483839.4	1202916.9	G	2,346.0	D	80	80	D
36N/19E-04N01D1	483839120291702	483839.1	1202916.6	D	2,346.0	D	135	135	D
36N/19E-05C01	MW02 483917120301601	483917.4	1203016.8	G	2,380	M	40	34	G
36N/19E-05E02	EW12 483902120303101	483902	1203031	M	2,362	L	–	39	–
36N/19E-05M01	483856120302901	483856.0	1203029.4	G	2,360	M	43.5	41	D
36N/19E-05P01	483843120300501	483843.5	1203004.8	D	2,332.2	D	85	85	D
36N/19E-05P02	483843120300502	483843.4	1203005.2	G	2,332	D	–	–	–
36N/19E-06B01	MW01 483922120312101	483922.6	1203121.9	G	2,420	M	47.5	43	G
36N/19E-09F01	MW03 483813120290001	483813.2	1202900.5	G	2,288	L	–	43.1	–
36N/19E-09J01	EW13 483757120282101	483804	1202821	M	2,288.4	L	–	–	–

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available	
		Latitude	Longitude	Method derived			Hole	Well		
36N/19E-09J02	EW14	483755120281401	483800	1202812	M	2,281.61	L	–	–	–
36N/19E-09L01		483756120284701	483756.3	1202846.9	G	2,310	M	80	80	D
36N/19E-09Q01	EW09	483742120283601	483742.1	1202835.9	G	2,287.7	L	62	62	D
36N/19E-09R01		483742120281801	483742.3	1202818.0	G	2,300	M	–	–	–
36N/19E-15L01		482707120273201	483706.6	1202731.8	G	2,220	M	46	46	D
36N/19E-15L02		483704120273001	483703.7	1202730.5	G	2,210	M	80	80	D
36N/19E-15L03	EW08	483729120275101	483711	1202734	M	2,221.6	L	–	–	–
36N/19E-15L04	EW06	483721120274301	483705	1202731	M	2,215.3	L	–	–	–
36N/19E-15N01	EW05	483709120281001	483656	1202752	M	2,237.9	L	–	47	–
36N/19E-22G01	EW04	483730120275101	483636	1202707	M	2,213.5	L	–	46	–
36N/19E-22J01		483616120265401	483615.7	1202653.9	G	2,180	M	60	60	D
36N/19E-22J02		483620120265801	483620.4	1202658.1	G	2,180	M	60	60	D
36N/19E-22J03		483611120265401	483611.3	1202654.5	G	2,180	M	–	–	–
36N/19E-22K01		483621120270801	483621.3	1202707.7	G	2,200	M	–	–	–
36N/19E-23E02	EW19	483604120254701	483634.2	1202635.6	G	2,192.48	L	50	50	D
36N/19E-23E03	EW19A	483635120263601	483634.1	1202635.0	D	2,192.4	D	86	84.5	D
36N/19E-23F01		483628120262601	483627.2	1202626.6	D	2,182.3	D	60	60	D
36N/19E-23N01		483609120263401	483609.4	1202633.7	G	2,170	M	60	60	D
36N/19E-23N02	EW03A	483615120270001	483604	1202643	M	2,181.0	L	–	–	–
36N/19E-23N03	EW03B	483615120270002	483604	1202643.2	M	2,183.8	L	–	46	–
36N/19E-23Q01	EW02	483603120261201	483559	1202606	M	2,160.8	L	50	50	D
36N/19E-23R01		483603120253701	483602.9	1202537.2	G	2,140	M	60	60	D
36N/19E-24Q01		483607120244001	483607.1	1202439.6	G	2,240	M	160	160	D
36N/19E-24Q02		483605120244301	483604.9	1202443.3	G	2,220	M	120	120	D
36N/19E-24Q03		483609120243901	483600.7	1202436.2	D	2,183.9	D	100	100	D
36N/19E-24Q04		483609120243601	483559.8	1202433.8	G	2,200	M	100	100	D
36N/19E-25B03		483551120244201	483550.9	1202442.3	D	2,135.4	D	63	63	D
36N/19E-25C01		483559120245501	483558.7	1202455.3	G	2,150	M	61	61	D
36N/19E-25E01		483540120252401	483539.1	1202524.3	D	2,136.3	D	60	60	D
36N/19E-25H02		483540120241601	483539.8	1202416.5	D	2,117.7	D	46	44.5	D
36N/19E-25J01	EW10	483531120241401	483531	1202414	M	2,108.87	L	–	–	–
36N/19E-25J02A		483522120242601	483522.3	1202425.5	D	2,111.3	D	527	180	D
36N/19E-25J02B		483522120242602	483522.3	1202425.5	D	2,111.3	D	527	205	D
36N/19E-25J02C		483522120242603	483522.3	1202425.5	D	2,111.3	D	527	–	D
36N/19E-25J02D		483522120242604	483522.3	1202425.5	D	2,111.3	D	527	–	D

Table 10. Descriptions of wells used to study the hydrogeology, quality of water, and ground-water/surface-water exchange in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Latitude and longitude:** Latitude and longitude at well, in degrees, minutes, and seconds referenced to NAD 27. **Method derived:** D, differential global positioning system (accurate to within 0.1 second); G, global positioning system (accurate to within about 0.5 second); M, topographic map (accurate to within about 1 second). **Altitude method derived:** D, differential global position system (accurate to within about 1 foot); L, level (accurate to within about 0.1 foot); M, topographic map (accurate to within about 20 feet). **Type of log available:** D, driller’s log; G, geologist’s log. –, no data available]

Well No.	Site No.	Coordinates			Land-surface altitude (feet above NGVD 29)	Altitude method derived	Depth, in feet below land surface		Type of log available	
		Latitude	Longitude	Method derived			Hole	Well		
36N/19E-25J02E		483522120242605	483522.3	1202425.5	D	2,111.3	D	527	–	D
36N/19E-25J03	MW09	483523120242601	483522.8	1202426.0	G	2,111.3	D	–	123	–
36N/19E-25J04	MW06	483533120241101	483532.8	1202411.7	G	2,108	L	–	43	–
36N/19E-25J05	MW07	483533120241201	483532.8	1202411.8	G	2,108	L	–	120	–
36N/19E-25J06	MW08	483523120242701	483522.7	1202426.5	G	2,110	L	–	47	–
36N/19E-25J07		483522120252601	483522.4	1202425.6	G	2,111	D	143	120	D
36N/19E-25P01		483518120245101	483518.4	1202451.2	G	2,130	M	–	–	–
36N/19E-25Q01	MW10	483514120243201	483514.6	1202432.6	G	2,121	L	–	49	–
36N/19E-25Q02	MW11	483514120243202	483514.7	1202432.6	G	2,121	L	–	120	–
36N/19E-26C01		483551120261201	483550.8	1202611.5	G	2,170	M	85	85	D
36N/19E-26C02		483551120262201	483550.7	1202621.8	G	2,180	M	60	60	D
36N/19E-26D03	MW05	483551120264001	483550.4	1202640.2	G	2,195	L	210	210	D
36N/19E-26H01		483535120253401	483535.6	1202534.0	G	2,150	M	–	–	–
36N/20E-30M01		483529120235901	483529.2	1202359.1	D	2,098.3	D	60	60	D
36N/20E-30N01		483512120240801	483512	1202408	M	2,096.6	L	–	–	–
36N/20E-30N02		483510120240401	483510	1202404	M	2,096.6	L	–	–	–
36N/20E-31A01		483505120230401	483504.7	1202303.7	G	2,100	M	75	75	D
36N/20E-31B01		483505120231901	483505	1202319	M	2,097.9	L	–	–	–
36N/20E-31C01		483459120235101	483459.4	1202350.7	G	2,090	M	60	60	D
36N/20E-31D01		483457120240601	483456.9	1202406.3	G	2,100	M	40	40	D
36N/20E-31D02D1		483457120240602	483500.8	1202354.8	G	2,090	M	–	79	D
36N/20E-31G01		483451120231401	483450.8	1202313.6	D	2,075.7	D	40	40	D
36N/20E-31Q01		483422120231801	483421.9	1202318.0	G	2,060	M	60	60	D
36N/20E-31Q02		483418120231601	483418.4	1202315.6	G	2,060	M	60	60	D
36N/20E-31Q03		483418120231501	483418.3	1202315.4	G	2,060	M	60	60	D
36N/20E-31R01	EW01B	482419120230301	483417	1202258	M	2,052.8	L	–	20	–
36N/20E-31R01D1	EW01A	483419120230302	483417	1202258	M	2,052.8	L	50	50	–
36N/20E-31R02		483420120230101	483420.9	1202300.8	G	2,050	M	40	40	D
36N/20E-32D01		483604120225301	483503.8	1202252.5	D	2,113.4	D	100	100	D
36N/20E-32D02		483502120225201	483502	1202252	G	2,120	M	100	100	D
36N/20E-32D03		483503120225501	483503	1202255	G	2,120	M	100	100	D
36N/20E-32D04		483503120225401	483503	1202254	G	2,110	M	100	100	D
36N/21E-23R01		483558120095501	483557.9	1200955.4	G	2,120	M	66	65	D

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial-fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
29N/23E-01D01	0	>120	Qgd	900	<780	30N/23E-07D02	0	28	Qga	1,130	1,102
29N/23E-02A01	0	2	Qa	785	783		28	44	Qgl	1,102	1,086
	2	>53	Qga	783	<732		44	48	Qga	1,086	1,082
29N/23E-02B02	0	17	Qa	786	769		48	54	Qgd	1,082	1,076
	17	>34	Qga	769	<752		54	>92	Qga	1,076	<1,038
29N/23E-02B04	0	8	Qa	795	787	30N/23E-07M02	0	12	Qa	1,070	1,058
	8	65	Qga	787	730		12	24	Qga	1,058	1,046
	65	73	Qgd	730	722		24	28	Qgd	1,046	1,041
	73	>75	B(i)	722	<720		28	35	Qgl	1,042	1,034
29N/23E-03P02	0	115	Qga	1,230	1,115		35	>54	Qga	1,035	<1,016
	115	121	Qgl	1,115	1,109	30N/23E-07N01	0	>126	Qga	1,140	<1,014
	121	>175	Qga	1,109	<1,055	30N/23E-07N04	0	18	Qgd	1,140	1,122
29N/23E-03P03	0	>146	Qga	1,230	<1,084		18	>126	Qga	1,122	<1,014
29N/23E-15F01D1	0	5	Qgd	1,180	1,175	30N/23E-18D02	0	>128	Qga	1,130	<1,002
	5	41	Qgl	1,175	1,139	30N/23E-20P01	0	4	Qa	921	917
	41	73	Qga	1,139	1,107		4	9	Qga	917	912
	73	259	Qgl	1,107	921		9	21	Qgl	912	900
	259	277	Qga	921	903		21	>46	Qga	900	<875
	277	370	Qgl	903	810	30N/23E-27F01	0	62	Qga	1,240	1,178
	370	>405	Qga	810	<775		62	90	Qgd	1,178	1,150
29N/23E-15F02D1	0	23	Qgd	1,200	1,177		90	>101	Qga	1,150	<1,139
	23	85	Qgl	1,177	1,115	30N/23E-27L01	0	16	Qga	1,140	1,124
	85	280	Qgl	1,115	920		16	>305	B(i)	1,124	<835
	280	307	Qga	920	893	30N/23E-28C02	0	35	Qa	890	855
	307	>350	Qgl	893	<850		35	>45	Qga	855	<845
30N/22E-13H02	0	112	Qga	1,121	1,009	30N/23E-28J03	0	14	Qgl	867	853
	112	125	Qgd	1,009	996		14	27	Qga	853	840
	125	>133	Qga	996	<988		27	59	Qgl	840	808
30N/23E-06C01	0	21	Qa	1,114	1,092		59	66	Qgd	808	801
	21	>42	Qga	1,092	<1,072		66	76	Qga	801	791
30N/23E-06C02	0	9	Qa	1,111	1,102		76	97	Qgd	791	770
	9	>38	Qga	1,102	<1,073		97	>100	B	770	<767
30N/23E-06G02	0	14	Qa	1,115	1,101	30N/23E-34G03	0	4	Qa	790	786
	14	>39	Qga	1,101	<1,076		4	>39	Qga	786	<751

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; —, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom	
30N/23E-34G04	0	8	Qa	810	802	31N/22E-21G03	0	14	Qa	1,246	1,232	
	8	17	Qga	802	793		14	28	Qga	1,232	1,218	
	17	>18	B	793	<792		28	33	Qgd	1,218	1,213	
30N/23E-34J02	0	2	Qa	820	818	31N/22E-21J01	33	144	Qga	1,213	1,102	
	2	>65	Qga	818	<755		144	>144	B	1,102	<1,102	
30N/23E-34R01	0	132	Qga	920	788	31N/22E-21J01	0	13	Qga	1,260	1,247	
	132	>137	B(i)	788	<783		13	28	Qgd	1,247	1,232	
30N/23E-35P03	0	15	Qa	800	785	31N/22E-21J02	28	>60	Qga	1,232	<1,200	
	15	30	Qga	785	770		0	6	Qa	1,280	1,274	
	30	>65	B(i)	770	<735		6	12	Qga	1,274	1,268	
31N/22E-05M01	0	22	Qa	1,360	1,338	31N/22E-21R01	12	24	Qgl	1,268	1,256	
	22	>82	Qga	1,338	<1,278		24	>70	Qga	1,256	<1,210	
31N/22E-16D01	0	26	Qgd	1,307	1,281	31N/22E-21R01	0	15	Qa	1,260	1,245	
	26	32	Qgl	1,281	1,275		15	>82	Qga	1,245	<1,178	
	32	43	Qga	1,275	1,264		31N/22E-22N01	0	5	Qa	1,250	1,245
	43	>45	Qgl	1,264	<1,262			5	11	Qga	1,245	1,239
31N/22E-16Q01	0	18	Qa	1,257	1,239	31N/22E-22N01	11	28	Qgl	1,239	1,222	
	18	>46	Qga	1,239	<1,211		28	>52	Qga	1,222	<1,198	
31N/22E-19K01	0	12	Qga	1,800	1,788	31N/22E-27D01	0	5	Qa	1,240	1,235	
	12	55	Qgl	1,788	1,745		5	10	Qga	1,235	1,230	
	55	90	Qgd	1,745	1,710		10	21	Qgl	1,230	1,219	
	90	160	Qgl	1,710	1,640		21	>40	Qga	1,219	<1,200	
	160	195	Qgd	1,640	1,605	31N/22E-27D02	0	6	Qa	1,240	1,234	
	195	210	Qgl	1,605	1,590		6	12	Qga	1,234	1,228	
	210	215	Qgd	1,590	1,585		12	25	Qgd	1,228	1,215	
	215	>260	B(i)	1,585	<1,540		25	>40	Qga	1,215	<1,200	
31N/22E-21B01	0	18	Qa	1,280	1,262	31N/22E-27E01	0	6	Qa	1,240	1,234	
	18	22	Qgl	1,262	1,258		6	12	Qga	1,234	1,228	
	22	>60	Qga	1,258	<1,220		12	25	Qgl	1,228	1,215	
31N/22E-21C01	0	23	Qa	1,380	1,357	31N/22E-27F01	25	>40	Qga	1,215	1,200	
	23	46	Qga	1,357	1,334		0	4	Qa	1,290	1,286	
	46	58	Qgl	1,334	1,322		4	77	Qga	1,286	1,213	
	58	>58	B(i)	1,322	<1,322		77	>177	Qga	1,213	<1,112	
31N/22E-21G02	0	18	Qa	1,265	1,247	31N/22E-27P01	0	87	Qgl	1,400	1,313	
	18	37	Qga	1,247	1,228		87	127	Qga	1,313	1,273	
	37	45	Qgd	1,228	1,220		127	>135	B(i)	1,273	<1,265	
	45	>60	Qga	1,220	<1,205							

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
31N/22E-35C01	0	27	Qa	1,220	1,193	32N/22E-02J01	0	14	Qa	1,780	1,766
	27	>82	Qga	1,193	<1,138		14	46	Qga	1,766	1,734
31N/22E-35K01	0	3	Qa	1,180	1,177	32N/22E-03Q01	46	76	Qgd	1,734	1,704
	3	7	Qga	1,177	1,173		76	>85	Qga	1,704	<1,695
	7	26	Qgd	1,173	1,154	0	2	Qa	1,490	1,488	
31N/22E-36M01	26	>43	Qga	1,154	<1,137	2	10	Qgd	1,488	1,480	
	0	6	Qa	1,190	1,184	10	44	Qgl	1,480	1,446	
	6	12	Qga	1,184	1,178	44	161	Qga	1,446	1,329	
	12	19	Qgd	1,178	1,171	161	188	Qgl	1,329	1,302	
31N/22E-36P01	19	36	Qga	1,171	1,154	188	>253	Qga	1,302	<1,237	
	36	48	Qgd	1,154	1,142	32N/22E-03Q02	0	10	Qa	1,494	1,484
	48	>70	Qga	1,142	<1,120		10	45	Qga	1,484	1,448
	0	9	Qa	1,180	1,171	45	60	Qgl	1,449	1,434	
	9	18	Qga	1,171	1,162	60	>80	Qga	1,434	<1,414	
18	24	Qgd	1,162	1,156	32N/22E-10B01	0	7	Qa	1,470	1,463	
24	>54	Qga	1,156	<1,126		7	>60	Qga	1,463	<1,410	
31N/22E-36R01	0	14	Qa	1,200	1,186	32N/22E-10B02	0	7	Qa	1,500	1,493
	14	100	Qga	1,186	1,100		7	15	Qga	1,493	1,485
	100	>102	B(i)	1,100	<1,098	15	17	Qgd	1,485	1,483	
31N/23E-31L01	0	27	Qa	1,170	1,143	32N/22E-10B03	17	>80	Qga	1,483	<1,420
	27	>74	Qga	1,143	<1,096		0	12	Qa	1,500	1,488
31N/23E-31N01	0	20	Qa	1,180	1,160	32N/22E-10B04	12	>139	Qga	1,488	<1,361
	20	40	Qga	1,160	1,140		0	12	Qa	1,500	1,488
	40	63	Qgd	1,140	1,117	12	>160	Qga	1,488	<1,340	
	63	>140	B(i)	1,117	<1,040	32N/22E-10M02	0	14	Qa	1,484	1,470
0	28	Qa	1,163	1,135	14		>73	Qga	1,470	<1,411	
31N/23E-31P02	28	32	Qgl	1,135	1,131	32N/22E-15B01	0	40	Qgd	1,740	1,700
	32	>80	Qga	1,131	<1,083		40	60	B(i)	1,700	1,680
	0	18	Qa	1,940	1,922	60	>185	B(s)	1,680	<1,555	
32N/22E-01G01	18	85	Qga	1,922	1,855	32N/22E-16G02	0	6	Qa	1,443	1,437
	85	146	Qgd	1,855	1,794		6	14	Qga	1,437	1,429
	146	>185	Qga	1,794	<1,755		14	23	Qgd	1,429	1,420
	0	8	Qa	1,475	1,467		23	>56	Qga	1,420	<1,387
32N/22E-02E01	8	16	Qga	1,467	1,459	32N/22E-16H01	0	13	Qa	1,470	1,457
	16	33	Qgl	1,459	1,442		13	>80	Qga	1,457	<1,390
	33	>40	Qga	1,442	<1,435						

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
32N/22E-16P01	0	5	Qa	1,429	1,424	32N/22E-32E01	0	8	Qa	1,406	1,398
	5	14	Qgl	1,424	1,415		8	16	Qga	1,398	1,390
	14	21	Qgd	1,415	1,408		16	23	Qgl	1,390	1,383
	21	>50	Qga	1,408	<1,379		23	50	Qgd	1,383	1,356
32N/22E-16P02	0	3	Qa	1,460	1,457	32N/22E-32G01	50	>60	Qga	1,356	<1,346
	3	14	Qgl	1,457	1,446		0	8	Qga	1,548	1,540
	14	28	Qgd	1,446	1,432		8	26	Qgl	1,540	1,522
	28	>80	Qga	1,432	<1,380		26	49	Qgd	1,522	1,499
32N/22E-20R01	0	8	Qa	1,460	1,452	32N/22E-32L01	49	66	Qga	1,499	1,482
	8	23	Qga	1,452	1,437		66	97	Qgd	1,482	1,451
	23	40	Qgd	1,437	1,420		97	>120	B(i)	1,451	<1,428
	40	139	Qga	1,420	1,321		0	14	Qa	1,370	1,356
32N/22E-20R01	139	>140	B(i)	1,321	<1,320	32N/22E-32L01	14	>56	Qga	1,356	<1,314
	0	6	Qa	1,472	1,466		33N/20E-07N01	0	7	Qa	2,420
32N/22E-21E01	6	>100	Qgd	1,466	<1,372	33N/20E-07N01	7	15	Qga	2,413	2,405
	0	17	Qga	1,700	1,683		15	98	Qgd	2,405	2,322
32N/22E-28L01	17	98	Qgl	1,683	1,602	33N/20E-07N01	98	113	Qga	2,322	2,307
	98	>108	B(i)	1,602	<1,592		113	>125	B(s)	2,307	<2,295
	0	40	No data	1,435	1,395		33N/20E-10J01	0	22	Qga	2,233
32N/22E-29C02D1	40	65	Qgd	1,395	1,370	33N/20E-10J01	22	50	Qgd	2,211	2,183
	65	>74	Qga	1,370	<1,360		50	>148	B(s)	2,183	<2,085
	0	7	Qa	1,390	1,383		33N/20E-11L01D1	0	9	Qa	2,306
32N/22E-29P01	7	>59	Qga	1,383	<1,331	33N/20E-11L01D1	9	18	Qga	2,297	2,288
	0	10	Qa	1,590	1,580		18	38	Qgd	2,288	2,268
	10	20	Qga	1,580	1,570		38	149	Qgl	2,268	2,157
	20	78	Qgl	1,570	1,512		149	>163	Qga	2,157	<2,143
	78	>105	Qga	1,512	<1,485		33N/20E-11P01	0	4	Qa	2,185
32N/22E-31R01	0	6	Qa	1,419	1,413	33N/20E-11P01	4	8	Qga	2,181	2,177
	6	18	Qga	1,413	1,401		8	30	Qgl	2,178	2,155
	18	83	Qgd	1,401	1,336		30	112	Qga	2,155	2,073
	83	>103	Qga	1,336	<1,316		112	148	Qgl	2,073	2,037
32N/22E-32C01	0	7	Qa	1,382	1,375	33N/20E-15G01	148	>166	Qgd	2,037	<2,019
	7	>40	Qga	1,375	<1,342		0	13	Qgl	2,370	2,357
						13	72	Qgd	2,357	2,298	
						72	114	Qga	2,298	2,256	
						114	>118	B(s)	2,256	<2,252	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—Continued

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
33N/20E-16A01	0	78	Qgd	2,346	2,268	33N/21E-08D03	0	11	Qa	2,020	2,009
	78	>185	B(i)	2,268	<2,161		11	22	Qgd	2,009	1,998
33N/20E-16L01	0	24	Qgd	2,330	2,306	33N/21E-09D01	22	28	Qga	1,998	1,992
	24	>48	Qga	2,306	<2,282		28	34	Qgd	1,992	1,986
33N/20E-21D01	0	20	Qgl	2,328	2,308	33N/21E-09D02	34	>40	Qga	1,986	<1,980
	20	31	Qgd	2,308	2,297		0	12	Qaf	1,970	1,958
	31	>40	Qga	2,297	<2,288		12	22	Qgl	1,958	1,948
33N/21E-05P01	0	10	Qga	2,220	2,210	33N/21E-09D03	22	>40	Qgd	1,948	<1,930
	10	120	Qgl	2,210	2,100		0	22	Qga	2,000	1,978
	120	135	Qgd	2,100	2,085		22	30	Qgd	1,978	1,970
	135	>345	B(s)	2,085	<1,875		30	53	Qgd	1,970	1,947
33N/21E-07D01	0	4	Qa	2,100	2,096	33N/21E-09D03	53	>61	B(s)	1,947	<1,939
	4	20	Qgd	2,096	2,080		0	15	Qaf	1,965	1,950
	20	>48	Qga	2,080	<2,052		15	30	Qga	1,950	1,935
33N/21E-08A03	0	2	Qa	1,940	1,938	33N/21E-10J01	30	34	Qgd	1,935	1,931
	2	25	Qgl	1,938	1,915		34	>39	Qga	1,931	<1,926
	25	>40	Qga	1,915	<1,900		0	19	Qga	1,878	1,859
33N/21E-08A04	0	16	Qa	1,980	1,964	33N/21E-10J02	19	34	Qgl	1,859	1,844
	16	24	Qga	1,964	1,956		34	45	Qga	1,844	1,833
	24	41	Qgd	1,956	1,939		45	92	Qgl	1,833	1,786
	41	>48	Qga	1,939	<1,932		92	102	Qga	1,786	1,776
33N/21E-08A05	0	16	Qa	1,950	1,934	33N/21E-10J04	102	134	Qgl	1,776	1,744
	16	>48	Qga	1,934	<1,902		134	>158	B(s)	1,744	<1,720
33N/21E-08B01	0	10	Qa	1,960	1,950	33N/21E-10J02	0	10	Qa	1,788	1,778
	10	>45	Qgd	1,950	<1,915		10	21	Qgl	1,778	1,767
33N/21E-08C01	0	6	Qa	1,990	1,984	33N/21E-10J04	21	34	Qgd	1,767	1,754
	6	21	Qgd	1,984	1,969		34	61	Qga	1,754	1,727
	21	30	Qga	1,969	1,960		61	>64	Qgl	1,727	<1,724
	30	35	Qgd	1,960	1,955		0	24	Qa	1,790	1,766
	35	>45	Qgl	1,955	<1,945		24	36	Qgl	1,766	1,754
33N/21E-08C02	0	43	Qa	2,042	1,999	33N/21E-10J04	36	43	Qgd	1,754	1,746
	43	>66	Qga	1,999	<1,976		43	>50	Qga	1,746	<1,740

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[**Well or site No.:** See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
33N/21E-10L01	0	9	Qa	1,826	1,818	33N/21E-11P01	0	10	Qa	1,760	1,750
	9	18	Qgl	1,818	1,808		10	24	Qga	1,750	1,736
	18	26	Qgd	1,808	1,800		24	30	Qgl	1,736	1,730
	26	34	Qgl	1,800	1,792		30	>60	B(i)	1,730	<1,700
	34	>42	Qga	1,792	<1,784		33N/21E-11P02	0	13	Qga	1,838
33N/21E-10L02	0	>45	Qga	1,851	<1,806	13	63	Qgd	1,825	1,775	
	45	58	Qgd	1,806	1,793	63	97	Qga	1,775	1,741	
	58	70	Qgl	1,793	1,781	97	106	Qgl	1,741	1,732	
	70	78	Qga	1,781	1,773	106	117	Qgd	1,732	1,721	
	78	>80	B(s)	1,773	<1,771	117	>209	B(s)	1,721	<1,629	
33N/21E-10L03	0	25	Qga	1,830	1,805	33N/21E-11P03	0	21	Qgl	1,826	1,805
	25	30	Qgl	1,805	1,800	21	61	Qga	1,805	1,765	
	30	35	Qgd	1,800	1,795	61	98	Qgd	1,765	1,728	
	35	>38	Qga	1,795	<1,792	98	>160	B(i)	1,728	<1,666	
33N/21E-10P01	0	11	Qga	1,880	1,869	33N/21E-11P04	0	10	Qa	1,749	1,739
	11	40	Qgd	1,869	1,840	10	27	Qgd	1,739	1,722	
	40	>65	B(s)	1,840	<1,815	27	>30	Qga	1,722	<1,719	
33N/21E-11J01	0	43	Qga	1,850	1,807	33N/21E-11Q01	0	13	Qa	1,740	1,727
	43	56	Qgd	1,807	1,794	13	31	Qgd	1,727	1,709	
	56	150	Qga	1,794	1,700	31	>40	Qga	1,709	<1,700	
33N/21E-11L01	150	>153	B(s)	1,700	<1,697	33N/21E-11R01	0	8	Qa	1,750	1,742
	0	60	Qga	1,877	1,817	8	16	Qga	1,742	1,734	
	60	85	Qgl	1,817	1,792	16	>75	Qgd	1,734	<1,675	
	85	160	Qgd	1,792	1,717	33N/21E-12N01	0	15	Qa	1,696	1,680
33N/21E-11M01	160	>300	B(s)	1,717	<1,577	15	35	Qgl	1,680	1,660	
	0	25	Qa	1,800	1,775	35	45	Qgd	1,660	1,650	
33N/21E-11M02	0	14	Qa	1,800	1,786	45	50	Qga	1,650	1,646	
	14	27	Qgl	1,786	1,773	50	>52	B(s)	1,646	<1,644	
	27	67	Qgd	1,773	1,733	33N/21E-12N02	0	15	Qa	1,696	1,680
	67	>73	Qga	1,733	<1,727	15	35	Qgl	1,680	1,660	
33N/21E-11M03	0	90	No data	1,800	1,710	35	45	Qgd	1,660	1,650	
	90	>90	B	1,710	<1,710	45	>47	Qga	1,650	<1,648	
33N/21E-12N03	0	45	Qgd	1,740	1,695	0	45	Qgd	1,740	1,695	
	45	>62	Qga	1,695	<1,678	45	>62	Qga	1,695	<1,678	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
33N/21E-12R01	0	35	Qga	1,660	1,625	33N/22E-07H02	0	4	Qa	1,596	1,592
	35	76	Qgl	1,625	1,584		4	32	Qgd	1,592	1,564
	76	>108	Qga	1,584	1,552		32	>40	Qga	1,564	<1,556
33N/21E-13D01	0	8	Qa	1,748	1,740	33N/22E-07J01	0	7	Qa	1,600	1,593
	8	36	Qga	1,740	1,712		7	15	Qga	1,593	1,585
	36	42	Qgl	1,712	1,705		33N/22E-07N01	0	21	Qga	1,660
42	>70	Qga	1,705	<1,678	21	35		Qgd	1,639	1,625	
33N/21E-14B01	0	23	Qga	1,758	1,735	33N/22E-07N02		35	36	Qga	1,625
	23	47	Qgd	1,735	1,711		36	>42	B(s)	1,624	<1,618
	47	58	Qgl	1,711	1,700		0	93	Qga	1,680	1,587
33N/21E-15E01	0	20	Qgd	1,961	1,941	33N/22E-07N03	93	>160	B	1,587	<1,520
	20	34	Qga	1,941	1,927		0	7	Qa	1,660	1,653
	34	>40	Qgd	1,927	<1,921		7	14	Qga	1,653	1,646
33N/21E-15N01	0	60	Qgd	2,290	2,230	33N/22E-07N04	14	62	Qgl	1,646	1,598
	60	87	Qgl	2,230	2,203		62	>76	Qga	1,598	1,584
	87	>92	Qgd	2,203	<2,198		0	6	Qa	1,630	1,624
33N/22E-02C01	0	10	Qga	2,140	2,130	33N/22E-07N05	6	19	Qga	1,624	1,611
	10	45	Qgl	2,130	2,095		19	23	Qgd	1,611	1,607
	45	>95	B(s)	2,095	<2,045		23	68	Qga	1,607	1,562
33N/22E-02C02	0	10	Qga	2,160	2,150	33N/22E-07N05	68	>70	B(s)	1,562	<1,560
	10	45	Qgl	2,150	2,115		0	4	Qa	1,632	1,628
	45	>145	B(s)	2,115	<2,015		4	8	Qga	1,628	1,624
33N/22E-03H01	0	35	Qgd	2,270	2,235	33N/22E-07Q01	8	18	Qgd	1,624	1,614
	35	>245	B(i)	2,235	<2,025		18	>84	Qga	1,614	<1,548
	33N/22E-05P01	0	58	Qgd	1,870		1,812	0	10	Qa	1,610
58		>265	B(s)	1,812	<1,605	10	>20	Qga	1,600	<1,590	
33N/22E-05P02		0	12	Qgd	1,870	1,858	33N/22E-07R01	0	8	Qa	1,621
	12	38	Qgl	1,858	1,832	8		15	Qga	1,613	1,606
	38	>225	B(i)	1,832	<1,645	15		30	Qgd	1,606	1,591
33N/22E-05P03	0	12	Qgl	1,830	1,818	33N/22E-08D02	30	>71	Qga	1,591	<1,550
	12	215	Qgd	1,818	1,615		0	16	Qa	1,610	1,594
	215	>280	B	1,615	<1,550		16	28	Qga	1,594	1,582
33N/22E-07H01	0	8	Qa	1,595	1,587	33N/22E-08D02	28	41	Qgd	1,582	1,569
	8	>74	Qga	1,587	<1,521		41	>60	Qga	1,569	<1,550

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
33N/22E-13A02	0	19	Qga	2,130	2,111	33N/22E-18D01	0	17	Qga	1,640	1,623
	19	38	Qgl	2,111	2,092		17	58	Qgl	1,623	1,582
	38	79	Qgd	2,092	2,051		58	>60	B(i)	1,582	<1,580
	79	96	Qga	2,051	2,034	33N/22E-18D02	0	11	Qgd	1,640	1,629
	96	>120	B(s)	2,034	<2,010		11	17	Qga	1,629	1,623
33N/22E-14H01	0	8	Qa	1,900	1,892	33N/22E-18D03	17	>21	Qgd	1,623	<1,619
	8	>36	Qga	1,892	<1,864		0	10	Qgd	1,640	1,630
33N/22E-16N01	0	5	Qa	1,550	1,545	33N/22E-20A02	10	15	Qga	1,630	1,625
	5	>23	Qga	1,545	<1,527		15	>20	Qgd	1,625	<1,620
33N/22E-16N02	0	13	Qa	1,550	1,537	33N/22E-20A04	0	4	Qa	1,590	1,586
	13	>23	Qga	1,537	<1,527		4	8	Qga	1,586	1,582
33N/22E-16P01	0	10	Qa	1,580	1,570	33N/22E-20B01	8	20	Qgd	1,582	1,570
	10	30	Qga	1,570	1,550		20	>83	Qga	1,570	<1,507
	30	65	Qgl	1,550	1,515		0	3	Qa	1,590	1,587
33N/22E-17D01	65	>82	Qga	1,515	<1,498	33N/22E-20G01	3	7	Qga	1,587	1,583
	0	8	Qa	1,620	1,612		7	22	Qgd	1,583	1,568
	8	18	Qga	1,612	1,602		22	>83	Qga	1,568	<1,507
	18	24	Qgd	1,602	1,596		0	4	Qa	1,570	1,566
33N/22E-17D01	24	>100	Qga	1,596	<1,520	33N/22E-21D01	4	8	Qga	1,566	1,562
	0	16	Qa	1,580	1,564		8	16	Qgl	1,562	1,554
	16	>32	Qga	1,564	<1,548		16	22	Qgd	1,554	1,548
33N/22E-17G01	0	38	Qgl	1,620	1,582	33N/22E-20G01	22	>40	Qga	1,548	<1,530
	38	65	Qgd	1,582	1,555		0	37	Qgd	1,720	1,683
	65	>140	Qga	1,555	<1,480		37	>450	B(s)	1,683	<1,270
33N/22E-17K01	0	5	Qa	1,580	1,575	33N/22E-21D02	0	12	Qa	1,590	1,578
	5	11	Qga	1,575	1,569		12	>200	Qga	1,578	<1,390
	11	18	Qgl	1,569	1,562		0	12	Qa	1,590	1,578
	18	>35	Qga	1,562	<1,545		12	>192	Qga	1,578	<1,398
33N/22E-17L01	0	15	Qa	1,570	1,556	33N/22E-21E01	0	5	Qga	1,560	1,555
	15	>83	Qga	1,556	<1,488		5	71	Qgd	1,555	1,489
33N/22E-18C01	0	3	Qa	1,627	1,624	33N/22E-21F01	71	>73	B(s)	1,489	<1,487
	3	61	Qga	1,624	1,566		0	14	Qa	1,540	1,526
	61	98	Qgl	1,566	1,529		14	>40	Qga	1,526	<1,500
	98	>170	Qga	1,529	<1,457						

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
33N/22E-21F02	0	20	Qa	1,540	1,520	33N/22E-23P01	0	16	Qa	1,660	1,644
	20	30	Qgl	1,520	1,510		16	>32	Qga	1,644	<1,628
	30	58	Qgd	1,510	1,482	33N/22E-23P03	0	25	Qgd	1,710	1,685
	58	>240	B(s)	1,482	<1,300		25	80	Qga	1,685	1,630
33N/22E-21F03	0	13	Qgd	1,540	1,527	80	100	Qgd	1,630	1,610	
	13	22	Qga	1,527	1,518	100	>128	Qga	1,610	<1,582	
	22	34	Qgd	1,518	1,506	33N/22E-26D01	0	>141	Qga	1,630	<1,489
	34	>80	Qga	1,506	<1,460		33N/22E-26D02	0	59	Qga	1,670
33N/22E-21H02	0	3	Qa	1,590	1,587	59		181	Qgl	1,611	1,489
	3	14	Qga	1,587	1,576	181	>197	Qga	1,489	<1,473	
	14	23	Qgd	1,576	1,567	33N/22E-26D03	0	141	Qga	1,680	1,539
	23	75	Qga	1,567	1,515		141	186	Qgl	1,539	1,494
	75	>83	B(s)	1,515	<1,507		186	>196	B(s)	1,494	<1,484
33N/22E-21H03	0	3	Qa	1,590	1,587	33N/22E-26L01	0	9	Qga	1,640	1,631
	3	14	Qga	1,587	1,576		9	22	Qgd	1,631	1,618
	14	23	Qgd	1,576	1,567		22	38	Qga	1,618	1,602
	23	75	Qga	1,567	1,515		38	64	Qgd	1,602	1,576
	75	>83	B(s)	1,515	<1,507		64	>200	B(i)	1,576	<1,440
33N/22E-22E01	0	18	Qa	1,550	1,532	33N/22E-27B02	0	6	Qa	1,525	1,519
	18	80	Qga	1,532	1,470		6	>55	Qga	1,519	<1,470
	80	>87	B(i)	1,470	<1,463	33N/22E-27C02	0	9	Qa	1,525	1,516
33N/22E-22N02	0	12	Qa	1,525	1,513		9	>18	Qga	1,516	<1,507
	12	>200	Qga	1,513	<1,325	33N/22E-27C03	0	8	Qa	1,525	1,517
33N/22E-22N03	0	15	Qa	1,525	1,510		8	42	Qga	1,517	1,483
	15	>146	Qga	1,510	<1,379	42	50	Qgl	1,483	1,475	
33N/22E-22P04	0	18	Qa	1,525	1,507	33N/22E-27G01	0	8	Qa	1,525	1,517
	18	>39	Qga	1,507	<1,486		8	41	Qga	1,517	1,484
	0	10	Qa	1,525	1,515		41	>43	Qgd	1,484	<1,482
33N/22E-23G01	0	3	Qa	1,740	1,737	33N/22E-27G02	0	12	Qa	1,525	1,513
	3	6	Qga	1,737	1,734		12	130	Qga	1,513	1,395
	6	16	Qgl	1,734	1,724		130	138	Qgl	1,395	1,387
	16	>32	Qga	1,724	<1,708		138	180	Qga	1,387	1,345
	0	>84	Qga	1,700	<1,616		180	196	Qgl	1,345	1,329
33N/22E-23L04	0	>84	Qga	1,700	<1,616	196	>272	Qga	1,329	<1,253	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
33N/22E-27J01	0	5	Qa	1,525	1,520	34N/21E-03B01	0	35	Qga	1,831	1,796
	5	10	Qga	1,520	1,515		35	97	Qgd	1,796	1,734
	10	99	Qgl	1,515	1,426		97	>220	B(s)	1,734	<1,611
	99	>100	Qga	1,426	<1,425		34N/21E-03E01	0	2	Qa	1,780
33N/22E-27J03	0	10	Qa	1,525	1,515		2	>140	Qga	1,778	<1,640
	10	>55	Qga	1,515	<1,470	34N/21E-03E02	0	3	Qa	1,784	1,780
33N/22E-27Q01	0	9	Qa	1,500	1,491		3	12	Qgd	1,780	1,772
	9	>60	Qga	1,491	<1,440		12	>110	Qga	1,772	<1,674
33N/22E-28J01	0	5	Qa	1,520	1,515	34N/21E-03E03	0	5	Qa	1,785	1,780
	5	20	Qga	1,515	1,500		5	29	Qgd	1,780	1,756
	20	32	Qgl	1,500	1,488		29	>145	Qga	1,756	<1,640
	32	>38	Qga	1,488	<1,482	34N/21E-03F01	0	21	Qa	1,767	1,746
33N/22E-34A01	0	8	Qa	1,520	1,512		21	>40	Qga	1,746	<1,727
	8	>63	Qga	1,512	<1,457	34N/21E-03M02	0	1	Qa	1,780	1,779
33N/22E-34B02	0	24	Qga	1,560	1,536		1	46	Qga	1,779	1,734
	24	37	Qgd	1,536	1,523	34N/21E-03M03	0	59	Qga	1,780	1,721
	37	>114	Qga	1,523	<1,446		59	>125	Qga	1,721	<1,655
33N/22E-34G01	0	11	Qa	1,490	1,479	34N/21E-03M04	0	2	Qa	1,780	1,778
	11	23	Qga	1,479	1,467		2	70	Qga	1,778	1,710
	23	34	Qgl	1,467	1,456		70	>150	Qga	1,710	<1,630
	34	>60	Qga	1,456	<1,430	34N/21E-03M05	0	3	Qa	1,784	1,781
34N/21E-01N01	0	8	Qga	2,060	2,052		3	>72	Qga	1,781	<1,712
	8	21	Qgd	2,052	2,039	34N/21E-03M06	0	3	Qa	1,784	1,780
	21	38	Qgl	2,039	2,022		3	20	Qgd	1,780	1,764
	38	60	Qgd	2,022	2,000		20	>110	Qga	1,764	<1,674
	60	>240	B(s)	2,000	<1,820	34N/21E-03P01	0	20	Qa	1,782	1,762
34N/21E-01N02	0	15	Qgd	2,060	2,045		20	>43	Qga	1,762	<1,739
	15	25	Qgl	2,045	2,035	34N/21E-03R01	0	15	Qga	1,820	1,805
	25	>180	B(s)	2,035	<1,880		15	80	Qgl	1,805	1,740
34N/21E-01P01	0	46	Qga	2,490	2,444		80	95	Qga	1,740	1,725
	46	72	Qgd	2,444	2,418		95	>120	Qgd	1,725	<1,700
	72	>124	B(s)	2,418	<2,366	34N/21E-04A01	0	16	Qa	1,780	1,764
34N/21E-02B01	0	>412	B(s)	2,180	<1,768		16	>40	Qga	1,764	<1,740
34N/21E-02B03D1	0	>282	B(s)	2,180	<1,898	34N/21E-04B01	0	19	Qa	1,780	1,761
34N/21E-02Q01	0	18	Qa	1,755	1,737		19	>40	Qga	1,761	<1,740

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
34N/21E-04B02	0	18	Qa	1,780	1,762	34N/21E-10D01	0	33	Qgl	1,837	1,804
	18	>60	Qga	1,762	<1,720		33	51	Qga	1,804	1,786
34N/21E-04B04	0	9	Qa	1,790	1,781	34N/21E-10G01	51	57	Qgl	1,786	1,780
	9	24	Qgl	1,781	1,766		57	>87	Qga	1,780	<1,750
	24	32	Qga	1,766	1,758	0	20	Qga	1,874	1,853	
	32	54	Qgl	1,758	1,736	20	36	Qgl	1,854	1,837	
	54	>70	Qga	1,736	<1,720	36	110	B(i)	1,838	1,764	
34N/21E-04H01	0	17	Qa	1,780	1,763	34N/21E-10G02	110	>200	B(s)	1,764	<1,674
	17	>40	Qga	1,763	<1,740		0	40	Qga	1,870	1,830
34N/21E-04H02	0	22	Qa	1,780	1,758	34N/21E-10G03	40	48	Qgd	1,830	1,822
	22	>40	Qga	1,758	<1,740		48	>330	B(s)	1,822	<1,540
34N/21E-04J01	0	18	Qa	1,796	1,778	34N/21E-10G04	0	15	Qga	1,875	1,860
	18	29	Qga	1,778	1,767		15	29	Qgd	1,860	1,846
	29	37	Qgd	1,767	1,759		29	35	Qga	1,846	1,840
	37	>60	Qga	1,759	<1,736		35	50	Qgd	1,840	1,825
34N/21E-08E01	0	88	Qga	2,400	2,312	34N/21E-10P02	50	58	Qga	1,825	1,817
	88	91	Qgd	2,312	2,309		58	130	B(i)	1,817	1,745
	91	>96	B(s)	2,309	<2,304		130	>330	B(s)	1,745	<1,545
34N/21E-08E02	0	21	Qga	2,390	2,369	34N/21E-10G04	0	38	Qga	1,872	1,834
	21	47	Qgd	2,369	2,343		38	>330	B(s)	1,834	<1,542
	47	59	Qga	2,343	2,331	34N/21E-10P02	0	12	Qga	1,900	1,888
	59	>65	Qgd	2,331	<2,325		12	28	Qgl	1,888	1,872
34N/21E-09F01	0	16	Qga	2,630	2,614	34N/21E-10R02	28	52	Qgd	1,872	1,848
	16	>185	B(s)	2,614	<2,445		52	75	Qgl	1,848	1,825
34N/21E-09F02	0	13	Qgl	2,640	2,627	34N/21E-11A01	75	122	Qgd	1,825	1,778
	13	>100	B(s)	2,627	<2,540		122	>140	Qga	1,778	<1,760
34N/21E-09J01	0	69	Qgd	2,010	1,941	34N/21E-11A02	0	12	Qa	1,740	1,728
	69	140	Qga	1,941	1,870		12	>50	Qga	1,728	<1,690
	140	>287	B(s)	1,870	<1,723		0	13	Qa	1,740	1,727
34N/21E-09J02	0	41	Qgd	2,080	2,039	34N/21E-11A02	13	>50	Qga	1,727	<1,690
	41	118	Qga	2,039	1,962						
	118	134	Qgd	1,962	1,946						
	134	>180	B(s)	1,946	<1,900						

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
34N/21E-11G01	0	10	Qa	1,750	1,740	34N/21E-14D01	0	94	Qga	1,840	1,746
	10	56	Qga	1,740	1,694		94	>96	B(s)	1,746	<1,744
	56	>57	B(s)	1,694	<1,693	34N/21E-14E01	0	>75	Qga	1,849	<1,774
34N/21E-11H01	0	11	Qa	1,740	1,729	34N/21E-14N01	0	23	Qgl	1,860	1,837
	11	>50	Qga	1,729	<1,690	23	42	Qga	1,837	1,818	
34N/21E-11H02	0	11	Qa	1,740	1,729	42	89	Qgl	1,818	1,771	
	11	>50	Qga	1,729	<1,690	89	93	Qga	1,771	1,767	
34N/21E-11H03	0	10	Qa	1,740	1,730	93	>95	B(s)	1,767	<1,765	
	10	>40	Qga	1,730	<1,700	34N/21E-14P01	0	23	Qgl	1,860	1,837
34N/21E-11H04	0	11	Qgd	1,760	1,749	23	39	Qga	1,837	1,821	
	11	>70	B(s)	1,749	<1,690	39	>80	B(s)	1,821	<1,780	
34N/21E-12E02	0	26	Qgd	1,839	1,813	34N/21E-15B01	0	69	Qga	1,890	1,821
	26	65	Qga	1,813	1,774	69	110	Qgl	1,821	1,780	
	65	>245	B(s)	1,774	<1,594	110	>160	Qga	1,780	<1,730	
34N/21E-12E04	0	9	Qgd	1,760	1,751	34N/21E-15E01	0	16	Qgd	1,950	1,934
	9	>40	Qga	1,751	<1,720	16	31	Qgl	1,934	1,919	
34N/21E-13F01	0	7	Qa	1,720	1,713	31	115	Qgd	1,919	1,835	
	7	18	Qgd	1,713	1,702	115	>230	B(s)	1,835	<1,720	
	18	>40	Qga	1,702	<1,680	34N/21E-15R01	0	15	Qgd	1,882	1,867
34N/21E-13G01	0	34	Qga	1,770	1,736	15	136	Qga	1,867	1,746	
	34	>62	B(s)	1,736	<1,708	136	160	Qgl	1,746	1,722	
34N/21E-13H01	0	8	Qgl	1,820	1,812	160	>164	Qga	1,722	<1,718	
	8	24	Qga	1,812	1,796	34N/21E-17Q01	0	30	Qgd	2,390	2,360
	24	38	Qgl	1,796	1,782	30	45	Qga	2,360	2,345	
	38	>60	Qga	1,782	<1,760	45	>47	Qgl	2,345	<2,343	
34N/21E-13J01	0	10	Qga	1,800	1,790	34N/21E-22A01	0	14	Qga	1,894	1,880
	10	31	Qgl	1,790	1,769	14	120	Qgd	1,880	1,774	
	31	>60	Qga	1,769	<1,740	120	>124	Qga	1,774	<1,770	
34N/21E-13J02	0	10	Qgl	1,800	1,790	34N/21E-22A02	0	32	Qga	1,925	1,893
	10	15	Qgd	1,790	1,785	32	51	Qgl	1,893	1,874	
	15	>46	Qga	1,785	<1,754	51	>150	Qga	1,874	<1,775	
34N/21E-13K01	0	37	Qga	1,795	175	34N/21E-22F01	0	12	Qgl	1,960	1,948
	37	>343	B(s)	1,758	<1,452	12	21	Qgd	1,948	1,939	
34N/21E-13R01	0	37	Qga	1,780	1,743	21	34	Qga	1,939	1,926	
	37	>41	B(s)	1,743	<1,739	34	>40	Qgd	1,926	<1,920	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
34N/21E-23D01	0	28	Qga	1,866	1,838	34N/21E-25C02	0	6	Qa	1,690	1,684
	28	40	Qgl	1,838	1,826		6	>68	B(s)	1,684	<1,622
	40	45	Qgd	1,826	1,821	34N/22E-17M01	0	30	Qgd	2,260	2,230
	45	>94	Qga	1,821	<1,772		30	>135	B(s)	2,230	<2,125
34N/21E-23E01	0	8	Qga	1,930	1,922	34N/22E-30F02	0	8	Qa	1,690	1,682
	8	100	Qgd	1,922	1,830		8	>81	Qga	1,682	<1,609
	100	>140	Qga	1,830	<1,790	34N/22E-30F03	0	23	Qgl	1,720	1,697
34N/21E-23G01	0	66	Qga	1,819	1,753		23	49	Qgd	1,697	1,671
34N/21E-23J01	0	10	Qga	1,800	1,790		49	>165	B(s)	1,671	<1,555
	10	60	Qgd	1,790	1,740	34N/22E-30L01	0	7	Qa	1,677	1,670
	60	71	Qga	1,740	1,729		7	12	Qgd	1,670	1,665
	71	>80	B(s)	1,729	<1,720		12	>63	Qga	1,665	<1,614
34N/21E-23R01	0	15	Qga	1,780	1,765	34N/22E-30L02	0	5	Qa	1,690	1,685
	15	55	Qgd	1,765	1,725		5	20	Qgd	1,685	1,670
	55	>285	B(s)	1,725	<1,495	20	>63	Qga	1,670	<1,627	
34N/21E-24A01	0	11	Qga	1,800	1,789	34N/22E-30N01	0	15	Qa	1,654	1,638
	11	29	Qgd	1,789	1,771		15	21	Qgd	1,638	1,632
	29	56	Qga	1,771	1,744		21	>40	Qga	1,632	<1,614
	56	>60	B(s)	1,744	<1,740	34N/22E-31N01	0	14	Qgd	1,660	1,646
34N/21E-24C01	0	36	Qa	1,701	1,665		14	38	Qga	1,646	1,622
	36	>40	Qga	1,665	<1,661		38	>80	B(s)	1,622	<1,580
34N/21E-24G01	0	13	Qa	1,710	1,697	35N/20E-04N01	0	9	Qa	2,006	1,997
	13	24	Qgl	1,697	1,686		9	>47	Qga	1,997	<1,959
	24	>60	Qga	1,686	<1,650	35N/20E-05R01	0	10	Qaf	2,015	2,005
34N/21E-24H01	0	4	Qa	1,759	1,755		10	48	Qgl	2,005	1,967
	4	10	Qga	1,755	1,749	48	>76	Qga	1,967	<1,939	
	10	25	Qgl	1,749	1,734	35N/20E-09L01	0	9	Qa	1,995	1,986
	25	36	Qga	1,734	1,723		9	18	Qga	1,986	1,977
36	>60	B(s)	1,723	<1,699	18	32	Qgd	1,977	1,963		
34N/21E-25B01	0	16	Qa	1,700	1,684	32	>60	Qga	1,963	<1,935	
	16	28	Qgd	1,684	1,672	35N/20E-10E01	0	6	Qa	1,970	1,964
	28	>62	Qga	1,672	<1,638		6	19	Qgl	1,964	1,951
34N/21E-25B02	0	16	Qa	1,691	1,675	19	>40	Qga	1,951	<1,930	
	16	27	Qgd	1,675	1,664						
	27	>60	Qga	1,664	<1,631						

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
35N/20E-10F01D1	0	24	Qga	2,025	2,001	35N/20E-16H02	0	2	Qa	2,010	2,008
	24	47	Qgd	2,001	1,978		0	26	Qgl	2,010	1,984
	47	>119	Qga	1,978	<1,906		26	41	Qgd	1,984	1,969
35N/20E-10F02	0	6	Qa	2,028	2,022	35N/20E-16H05	41	70	Qgl	1,969	1,940
	6	115	Qgd	2,022	1,912		70	>80	Qga	1,940	<1,930
	115	>120	Qga	1,912	<1,908		0	3	Qa	1,962	1,959
35N/20E-10N02	0	8	Qa	1,955	1,947	35N/20E-16J01	3	17	Qgl	1,959	1,945
	8	21	Qgd	1,947	1,934		17	23	Qgd	1,945	1,939
	21	>40	Qga	1,934	<1,915		23	23	Qga	1,939	1,938
35N/20E-10P01	0	25	Qa	1,950	1,925	35N/20E-16J02	0	24	Qgl	2,000	1,976
	25	>45	Qga	1,925	<1,905		24	91	Qgd	1,976	1,909
35N/20E-14E02	0	9	Qa	1,935	1,926	35N/20E-16J02	59	91	Qgl	1,941	1,909
	9	>40	Qga	1,926	<1,895		91	>100	Qga	1,909	<1,900
35N/20E-14L01	0	5	Qa	1,920	1,915	35N/20E-23E01	0	6	Qa	2,000	1,994
	5	10	Qga	1,915	1,910		0	28	Qgl	1,994	1,972
	10	36	Qgd	1,910	1,884		28	44	Qgd	1,972	1,956
	36	>43	Qga	1,884	1,877		44	73	Qgl	1,956	1,927
35N/20E-14N01	0	9	Qa	1,920	1,911	35N/20E-24C01	73	>80	Qga	1,927	<1,920
	9	23	Qgd	1,911	1,897		0	75	Qgd	2,030	1,955
	23	>40	Qga	1,897	<1,880		75	165	Qgl	1,955	1,865
35N/20E-15C01	0	20	Qa	1,945	1,925	35N/20E-24C02	165	204	Qgd	1,865	1,826
	20	>40	Qga	1,925	<1,905		204	>210	Qga	1,826	<1,820
35N/20E-15H01	0	25	Qa	1,937	1,912	35N/20E-24H01	0	35	Qaf	1,900	1,865
	25	>40	Qga	1,912	<1,897		35	>45	Qgd	1,865	<1,855
35N/20E-15K01	0	6	Qa	1,942	1,936	35N/20E-24H02	0	30	Qaf	1,900	1,870
	6	23	Qgl	1,936	1,918		30	>47	Qga	1,870	<1,853
	23	34	Qgd	1,918	1,908		0	21	Qaf	1,900	1,879
	34	>40	Qga	1,908	<1,902		21	32	Qgl	1,879	1,868
35N/20E-16H01	0	4	Qa	2,010	2,006	35N/20E-24H02	32	>48	Qga	1,868	<1,852
	4	28	Qgl	2,006	1,982		0	12	Qaf	1,883	1,871
	28	40	Qgd	1,982	1,970		12	23	Qgd	1,871	1,860
	40	68	Qgl	1,970	1,942		23	>47	Qga	1,860	<1,836
	68	>80	Qga	1,942	<1,930						

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom	
35N/20E-24N01	0	28	Qga	2,090	2,062	35N/21E-10J01	0	12	Qgd	2,020	2,008	
	28	53	Qgd	2,062	2,037		12	41	Qgl	2,008	1,979	
	53	101	Qgl	2,037	1,989		41	72	Qga	1,979	1,948	
	101	185	Qgd	1,989	1,905		72	95	Qgl	1,948	1,925	
	185	320	Qgl	1,905	1,770		95	105	Qga	1,925	1,915	
	320	325	Qga	1,770	1,765		105	>450	B(s)	1,915	<1,570	
	325	361	Qgl	1,765	1,729		35N/21E-10K01	0	22	Qgl	2,030	2,008
	361	>365	Qga	1,729	<1,725			22	24	Qgd	2,008	2,006
35N/20E-24N02	0	10	Qga	2,080	2,070	24	26	Qga	2,006	2,004		
	10	39	Qgd	2,070	2,041	26	>145	B(s)	2,004	<1,885		
	39	70	Qgl	2,041	2,010	35N/21E-11M01	0	50	Qa	1,950	1,900	
	70	130	Qgd	2,010	1,950		50	100	Qgl	1,900	1,850	
	130	190	Qgl	1,950	1,890		100	>108	Qga	1,850	<1,842	
	190	220	Qgd	1,890	1,860	35N/21E-15A01	0	8	Qgd	2,020	2,012	
220	>265	Qga	1,860	<1,815	8		>305	B(s)	2,012	<1,715		
35N/20E-25J01 MW14	0	9	Qa	1,855	1,846	35N/21E-15K01	0	22	Qgd	2,240	2,218	
	9	39	Qga	1,846	1,816		22	>117	B(s)	2,218	<2,123	
35N/20E-25K01	0	13	Qga	1,860	1,847	35N/21E-15K02	0	18	Qgl	2,190	2,172	
	13	26	Qgd	1,847	1,834		18	>200	B	2,172	<1,990	
	26	>40	Qga	1,834	<1,820	35N/21E-19E01	0	16	Qga	2,207	2,191	
35N/21E-10A01	0	12	Qga	2,060	2,048		16	31	Qgd	2,191	2,176	
	12	28	Qgd	2,048	2,032	31	>265	B(s)	2,176	<1,942		
	28	>85	B(s)	2,032	<1,975	35N/21E-19L01	0	>205	B(s)	2,160	<1,955	
35N/21E-10A02	0	8	Qga	2,060	2,052		35N/21E-19M01	0	7	Qaf	1,906	1,899
	8	20	Qgd	2,052	2,040	7		52	Qgd	1,899	1,854	
	20	>85	B(s)	2,040	<1,975	52		61	Qga	1,854	1,845	
35N/21E-10A03	0	8	Qga	2,060	2,052	35N/21E-19M02	61	>61	B(s)	1,845	<1,845	
	8	20	Qgd	2,052	2,040		0	4	Qaf	1,906	1,902	
	20	>105	B(s)	2,040	<1,955		4	35	Qgd	1,902	1,871	
35N/21E-10B01	0	>38	Qga	2,060	<2,022	35	60	Qga	1,871	1,846		
						60	>61	B(s)	1,846	<1,845		

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
35N/21E-19M03	0	4	Qaf	1,906	1,902	35N/21E-30P01D1	0	21	Qa	1,835	1,814
	4	35	Qgd	1,902	1,871		21	77	Qga	1,814	1,758
	35	45	Qga	1,871	1,861		77	>81	Qgl	1,758	<1,754
	45	60	Qga	1,861	1,846	35N/21E-30P02	0	11	Qa	1,837	1,826
	60	>62	B(s)	1,846	<1,844		11	19	Qgd	1,826	1,818
35N/21E-19M04	0	4	Qaf	1,906	1,902	19	32	Qga	1,818	1,805	
	4	35	Qgd	1,902	1,871	32	>34	Qgl	1,805	<1,803	
	35	45	Qga	1,871	1,861	35N/21E-32A01	0	216	Qga	2,020	1,804
	45	58	Qgd	1,861	1,848		216	310	Qgd	1,804	1,710
	58	60	Qga	1,848	1,846		310	330	Qgl	1,710	1,690
60	>61	B(s)	1,846	<1,845	330	440	Qgd	1,690	1,580		
35N/21E-19P01	0	9	Qaf	1,910	1,901	440	>540	B(s)	1,580	1,680	
	9	34	Qgd	1,901	1,876	35N/21E-32D01	0	1	Qaf	1,844	1,843
	34	78	Qga	1,876	1,832		1	22	Qgd	1,843	1,822
	78	>127	B(s)	1,832	<1,783		22	>80	Qga	1,822	<1,764
35N/21E-19Q01	0	12	Qgl	2,040	2,028	35N/21E-32D02	0	10	Qaf	1,840	1,830
	12	32	Qgd	2,028	2,008		0	22	Qgl	1,840	1,818
	32	50	Qgl	2,008	1,990		22	31	Qgd	1,818	1,809
	50	>65	Qga	1,990	<1,975		31	>80	Qga	1,809	<1,760
35N/21E-22A02	0	8	Qgl	1,950	1,942	35N/21E-32D03	0	16	Qaf	1,860	1,844
	8	>45	Qga	1,942	<1,905		16	38	Qgd	1,844	1,822
35N/21E-22J02	0	6	Qa	1,870	1,864	38	>97	Qga	1,822	<1,763	
	6	12	Qgd	1,864	1,858	35N/21E-32D04	0	12	Qa	1,857	1,845
	12	>66	Qga	1,858	<1,804		12	26	Qgd	1,845	1,832
35N/21E-22J03	0	14	Qa	1,860	1,846	26	>80	Qga	1,831	<1,777	
	14	26	Qga	1,846	1,834	35N/21E-32E01	0	12	Qaf	1,880	1,868
35N/21E-26B02	0	180	Qgd	1,980	1,800		12	30	Qgd	1,868	1,850
180	>190	Qga	1,800	<1,790	30		55	Qga	1,850	1,825	
35N/21E-26M01	0	14	Qa	1,860	1,846	55	70	Qgd	1,825	1,810	
	14	>140	B(s)	1,846	<1,720	70	90	Qgl	1,810	1,790	
35N/21E-27Q01	0	>305	B(s)	2,110	<1,805	90	>100	Qga	1,790	<1,780	
35N/21E-30M01	0	11	Qa	1,830	1,819	35N/21E-32E02	0	8	Qaf	1,870	1,862
	11	>67	Qga	1,819	<1,763		8	30	Qgd	1,862	1,840
35N/21E-30P01	0	16	Qa	1,835	1,819	30	45	Qga	1,840	1,825	
	16	59	Qga	1,819	1,776	45	70	Qgd	1,825	1,800	
	59	>61	Qgl	1,776	<1,774	70	>80	Qga	1,800	<1,790	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; —, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
35N/21E-32L01	0	8	Qaf	1,890	1,882	35N/21E-35E01	0	6	Qa	1,820	1,814
	8	16	Qgl	1,882	1,874		6	20	Qgd	1,814	1,800
	16	26	Qgd	1,874	1,864		20	>101	Qga	1,800	<1,719
	26	39	Qga	1,864	1,851	35N/21E-35E02	0	16	Qa	1,820	1,804
	39	61	Qgl	1,851	1,829		16	42	Qga	1,804	1,778
	61	>100	Qgd	1,829	<1,790		42	61	Qgl	1,778	1,759
35N/21E-32L02	0	13	Qaf	1,870	1,857	61	75	Qga	1,759	1,745	
	13	28	Qgd	1,857	1,842	75	90	Qgl	1,745	1,730	
	28	>80	Qga	1,842	<1,790	90	>290	B(s)	1,730	<1,530	
35N/21E-32L03	0	26	Qaf	1,860	1,834	35N/21E-35F01	0	12	Qgd	1,880	1,868
	26	31	Qgl	1,834	1,829		12	>26	Qga	1,868	<1,854
	31	52	Qga	1,829	1,808	35N/21E-35M02	0	13	Qa	1,820	1,807
	52	56	Qgl	1,808	1,804		13	26	Qgd	1,807	1,794
	56	>86	Qga	1,804	<1,774		26	99	Qga	1,794	1,721
35N/21E-33P01	0	19	Qa	1,780	1,761	99	>101	B(s)	1,721	<1,719	
	19	37	Qgl	1,761	1,743	35N/21E-35P01	0	14	Qa	1,780	1,766
	37	52	Qgd	1,743	1,728		14	>43	Qga	1,766	<1,737
	52	>80	Qga	1,728	<1,700	35N/21E-35P03	0	36	Qga	1,860	1,824
35N/21E-33R01	0	21	Qgl	1,970	1,949		36	200	B(s)	1,824	1,660
	21	85	Qgd	1,949	1,885		200	>365	B(i)	1,660	<1,495
	85	130	Qgl	1,885	1,840	36N/19E-04N01D1	0	31	Qaf	2,346	2,315
	130	142	Qga	1,840	1,828		31	68	Qgd	2,315	2,278
	142	170	Qgl	1,828	1,800		68	>80	Qga	2,278	<2,266
170	>200	Qga	1,800	<1,770	36N/19E-05C01 MW02	0	10	Qa	2,380	2,370	
35N/21E-34E01	0	22	Qga	2,000		1,978	10	25	Qga	2,370	2,355
	22	31	Qgd	1,978		1,969	25	>40	B(s)	2,355	<2,340
	31	46	Qgl	1,969	1,954	36N/19E-05M01	0	15	Qa	2,350	2,335
	46	60	Qgd	1,954	1,940		15	<44	Qga	2,335	<2,306
	60	>340	B(s)	1,940	<1,660		36N/19E-05P01	0	2	Qa	2,332
35N/21E-34R01	0	>36	Qga	1,890	<1,854	2		>85	Qga	2,330	<2,247
35N/21E-35D01	0	30	Qa	1,850	1,820	36N/19E-06B01 MW01	0	6	Qa	2,410	2,404
	30	55	Qga	1,820	1,795		6	>47	Qga	2,404	<2,363
	55	>105	B(s)	1,795	<1,745	36N/19E-09L01	0	14	Qa	2,310	2,296
35N/21E-35D02	0	20	Qa	1,850	1,830		14	28	Qgd	2,296	2,282
	20	>305	B(s)	1,830	<1,545		28	>80	Qga	2,282	<2,230

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –. no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
36N/19E-09Q01 EW09	0	20	Qa	2,288	2,268	36N/19E-24Q02	0	31	Qaf	2,220	2,189
	20	>62	Qga	2,268	<2,226		31	66	Qgd	2,189	2,154
36N/19E-15L01	0	8	Qa	2,215	2,207	36N/19E-24Q03	66	102	Qgl	2,154	2,118
	8	>46	Qga	2,207	<2,169		102	>120	Qga	2,118	<2,100
36N/19E-15L02	0	14	Qa	2,210	2,196	36N/19E-24Q04	0	44	Qaf	2,184	2,140
	14	23	Qgl	2,196	2,187		44	60	Qgl	2,140	2,124
	23	62	Qgd	2,187	2,148		60	86	Qgd	2,124	2,098
	62	>80	Qga	2,148	<2,130		86	>100	Qga	2,098	<2,084
36N/19E-22J01	0	9	Qaf	2,175	2,166	36N/19E-25B03	0	44	Qaf	2,190	2,146
	9	19	Qga	2,166	2,156		44	60	Qgl	2,146	2,130
	19	45	Qgd	2,156	2,130		60	86	Qgd	2,130	2,104
	45	>60	Qga	2,130	<2,115		86	>100	Qga	2,104	<2,090
36N/19E-22J02	0	10	Qaf	2,175	2,165	36N/19E-25C01	0	18	Qa	2,135	2,117
	10	21	Qga	2,165	2,154		18	30	Qgd	2,117	2,105
	21	43	Qgd	2,154	2,132		30	>63	Qga	2,105	<2,072
	43	>60	Qga	2,132	<2,115		0	14	Qa	2,145	2,131
36N/19E-23E02 EW19	0	10	Qa	2,192	2,182	36N/19E-25E01	14	>61	Qga	2,131	<2,084
	10	>50	Qga	2,182	<2,142		0	20	Qa	2,136	2,116
36N/19E-23E03 EW19A	0	12	Qa	2,192	2,180	36N/19E-25H02	20	>60	Qga	2,116	<2,076
	12	>86	Qga	2,180	<2,106		0	24	Qa	2,118	2,094
36N/19E-23F01	0	17	Qa	2,182	2,165	36N/19E-25J02A	24	36	Qgd	2,094	2,082
	17	>60	Qga	2,165	<2,122		36	>46	Qga	2,082	<2,072
36N/19E-23N01	0	11	Qaf	2,170	2,159	36N/19E-25J02B	0	70	Qa	2,111	2,041
	11	>60	Qga	2,159	<2,110		70	222	Qga	2,041	1,889
36N/19E-23Q01 EW02	0	12	Qa	2,161	2,149		222	242	Qgd	1,889	1,869
	12	25	Qgd	2,149	2,136		242	>527	Qga	1,869	<1,584
	25	>50	Qga	2,136	<2,111	0	70	Qa	2,111	2,041	
36N/19E-23R01	0	10	Qa	2,140	2,130	36N/19E-25J07	70	222	Qga	2,041	1,889
	10	18	Qga	2,130	2,122		222	242	Qgd	1,889	1,869
	18	32	Qgd	2,122	2,108		242	>527	Qga	1,869	<1,584
	32	>60	Qga	2,108	<2,080		0	10	Qa	2,111	2,101
36N/19E-24Q01	0	37	Qaf	2,240	2,203	36N/19E-26C01	10	>134	Qga	2,101	<1,977
	37	148	Qgd	2,203	2,092		0	8	Qaf	2,165	2,157
	148	>160	Qga	2,092	<2,080		8	14	Qgl	2,157	2,151
						14	>85	Qga	2,151	<2,080	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
36N/19E-26C02	0	13	Qaf	2,180	2,167	36N/20E-31Q03	0	10	Qa	2,060	2,050
	13	>60	Qga	2,167	<2,120		10	24	Qgl	2,050	2,036
36N/19E-26D03	0	6	Qaf	2,195	2,189	36N/20E-31R02	24	40	Qgd	2,036	2,020
	6	25	Qgl	2,189	2,170		40	>60	Qga	2,020	<2,000
	25	30	Qgd	2,170	2,165	0	4	Qa	2,050	2,046	
	30	45	Qga	2,165	2,150	4	17	Qgd	2,046	2,033	
36N/20E-30M01	45	>210	B(s)	2,150	<1,985	36N/20E-32D01	17	>40	Qga	2,033	<2,010
	0	1	Qa	2,098	2,097		0	15	Qaf	2,113	2,098
	1	12	Qgd	2,097	2,086	15	65	Qgd	2,098	2,048	
	12	23	Qgl	2,086	2,075	65	>100	Qga	2,048	<2,013	
36N/20E-31A01	23	>60	Qga	2,075	<2,038	36N/20E-32D02	0	20	Qaf	2,110	2,090
	0	16	Qaf	2,100	2,084		20	60	Qgd	2,090	2,050
	16	32	Qga	2,084	2,068	60	>100	Qga	2,050	<2,010	
	32	37	Qgd	2,068	2,063	36N/20E-32D03	0	20	Qaf	2,110	2,090
37	>75	Qga	2,063	<2,025	20		45	Qgd	2,090	2,065	
36N/20E-31C01	0	10	Qa	2,090	2,080	36N/20E-32D04	45	>100	Qga	2,065	<2,010
	10	28	Qga	2,080	2,062		0	18	Qaf	2,110	2,092
	28	36	Qgd	2,062	2,054	18	70	Qgd	2,092	2,040	
	36	>60	Qga	2,054	<2,030	70	>100	Qga	2,040	<2,010	
36N/20E-31D01	0	5	Qa	2,100	2,095	36N/21E-23R01	0	18	Qa	2,110	2,092
	5	21	Qgd	2,095	2,079		18	28	Qgd	2,092	2,082
36N/20E-31D02D1	21	>40	Qga	2,079	<2,060	28	35	Qga	2,082	2,075	
	0	7	Qa	2,090	2,083	35	45	Qgd	2,075	2,065	
	7	14	Qga	2,083	2,076	45	>66	Qga	2,065	<2,044	
	14	27	Qgd	2,076	2,063	E-1	0	550	Uncs	1,925	1,375
36N/20E-31G01	27	>40	Qga	2,063	<2,050	550	–	B	1,375	–	
	0	8	Qa	2,076	2,068	E-2	0	1,050	Uncs	1,925	875
36N/20E-31Q01	8	>40	Qga	2,068	<2,036	1,050	–	B	875	–	
	0	7	Qa	2,060	2,053	E-3	0	580	Uncs	2,185	1,605
	7	22	Qgl	2,053	2,038	580	–	B	1,605	–	
	22	38	Qgd	2,038	2,022	E-4	0	940	Uncs	2,160	1,220
36N/20E-31Q02	38	>60	Qga	2,022	<2,000	940	–	B	1,220	–	
	0	9	Qa	2,060	2,051	E-5	0	1,020	Uncs	2,120	1,100
	9	20	Qgl	2,051	2,040	1,020	–	B	1,100	–	
	20	36	Qgd	2,040	2,024	E-6	0	1,000	Uncs	2,090	1,090
	36	>60	Qga	2,024	<2,000	1,000	–	B	1,090	–	

Table 11. Hydrogeologic units and thicknesses at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letters following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks; E-#, vertical electrical resistivity sites (EMCON Northwest, unpub. data, 1993). T-#1, seismic refraction sites (Artim, 1975). **Hydrogeologic unit:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qaf, alluvial fan deposits; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits; Uncs, undifferentiated unconsolidated sediments. >, greater than; <, less than; –, no data available]

Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29		Well or site No.	Depth, in feet below land surface		Hydrogeologic unit	Altitude, in feet above NGVD 29	
	To unit top	To unit bottom		Unit top	Unit bottom		To unit top	To unit bottom		Unit top	Unit bottom
E-7	0	940	Uncs	2,030	1,090	T-2	0	>5	Qa	2,088	<2,083
	940	–	B	1,090	–	T-3	0	>55	Qa	2,087	<2,032
E-8	0	690	Uncs	1,965	1,275	T-4	0	>100	Qaf	2,118	<2,018
	690	–	B	1,275	–	T-5	0	30	Qa	2,008	1,978
E-9	0	190	Uncs	1,930	1,740		30	>30	Qgd	1,978	<1,978
	190	–	B	1,740	–	T-6	0	47	Qaf	2,108	2,061
E-10	0	860	Uncs	1,995	1,135		47	>47	Qgd	2,061	<2,061
	860	–	B	1,135	–	T-7	0	56	Qa	2,068	2,012
E-11	0	750	Uncs	1,950	1,200		56	–	B	2,012	–
	750	–	B	1,200	–	T-8	0	58	Qaf	2,103	2,045
E-12	0	850	Uncs	2,200	1,350		58	–	B	2,045	–
	0	1,150	Uncs	1,950	800	T-17	0	68	Qaf	1,957	1,889
E-13	1,150	–	B	800	–		68	–	B	1,889	–
	0	820	Uncs	1,790	970	T-21	0	47	Qaf	1,893	1,846
E-14	0	510	Uncs	2,120	1,610		47	>47	Qgd	1,846	<1,846
	510	–	B	1,610	–	T-22	0	29	Qaf	1,882	1,853
E-15	0	1,200	Uncs	2,085	885		29	>29	Qgd	1,853	<1,853
	1,200	–	B	885	–	T-23	0	30	Qaf	1,885	1,855
E-16	0	1,450	Uncs	2,110	660		30	>30	Qgd	1,855	<1,855
	1,450	–	B	660	–						

Table 12. Hydrologic unit and aquifer type at selected wells in the Methow River Basin, Okanogan County, Washington

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Hydrogeologic unit at open interval:** B, undifferentiated bedrock; B(i), intrusive igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits. **Ground-water condition at open interval:** C, confined; E, unit is sometimes confined and sometimes unconfined; M, well open to multiple units, both confined and unconfined; U, unconfined. –, no data available]

Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval	Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval
29N/23E-01D01	Qgd	U	31N/22E-27P01 ¹	Qgl+B(i)	C
29N/23E-02A01	Qga	U	31N/22E-35C01	Qga	U
29N/23E-02B02	Qga	U	31N/22E-35K01	Qga	C
29N/23E-02B04	Qga	U	31N/22E-36M01	Qga	C
29N/23E-03P02	Qga	U	31N/22E-36P01	Qga	U
29N/23E-03P03	Qga	U	31N/22E-36R01 ¹	Qga	U
29N/23E-15F01D1	Qga	C	31N/23E-31L01	Qga	U
29N/23E-15F02D1	Qgl	C	31N/23E-31N01	B(i)	C
30N/22E-13H02	Qga	C	31N/23E-31P02	Qga	U
30N/23E-06C01	Qga	U	32N/22E-01G01	Qga	U
30N/23E-06C02	Qga	U	32N/22E-02E01	Qga	C
30N/23E-06G02	Qga	U	32N/22E-02J01	Qga	C
30N/23E-07D02	Qga	U	32N/22E-03Q01	Qga	C
30N/23E-07M02	Qga	C	32N/22E-03Q02	Qga	C
30N/23E-07N01	Qga	U	32N/22E-10B01	Qga	U
30N/23E-07N04	Qga	U	32N/22E-10B02	Qga	U
30N/23E-18D02	Qga	U	32N/22E-10B03	Qga	U
30N/23E-20P01	Qga	C	32N/22E-10B04	Qga	U
30N/23E-27F01	Qga	C	32N/22E-10M02	Qga	U
30N/23E-27L01	B(i)	U	32N/22E-15B01	B(i)+B(s)	C
30N/23E-28C02	Qga	U	32N/22E-16G02	Qga	C
30N/23E-28J03	Qga+Qgd	C	32N/22E-16H01	Qga	U
30N/23E-34G03	Qga	U	32N/22E-16P01	Qga	C
30N/23E-34G04	Qga	U	32N/22E-16P02	Qga	U
30N/23E-34J02	Qga	U	32N/22E-20R01	Qga	U
30N/23E-34R01 ¹	Qga+B(i)	M	32N/22E-21E01	Qga	U
30N/23E-35P03	Qga+B(i)	M	32N/22E-28L01 ¹	B(i)	C
31N/22E-05M01	Qga	U	32N/22E-29C02D1	Qga	C
31N/22E-16D01 ¹	Qga	E	32N/22E-29P01	Qga	U
31N/22E-16Q01	Qga	U	32N/22E-30P01	Qga	C
31N/22E-19K01	B(i)	C	32N/22E-31R01	Qga	C
31N/22E-21B01	Qga	C	32N/22E-32C01	Qga	U
31N/22E-21C01	Qga	U	32N/22E-32E01	Qga	C
31N/22E-21G02	Qga	C	32N/22E-32G01	B(i)+Qgd	U
31N/22E-21G03	Qga	C	32N/22E-32L01	Qga	U
31N/22E-21J02	Qga	U	33N/20E-07N01 ³	B(s)	C
31N/22E-21R01	Qga	U	33N/20E-10J01	B(s)	C
31N/22E-22N01	Qga	C	33N/20E-11L01D1	Qga	C
31N/22E-27D01	Qga	E	33N/20E-11P01	Qgd	C
31N/22E-27D02	Qga	C	33N/20E-15G01 ¹	Qga+B(s)	M
31N/22E-27E01	Qga	E	33N/20E-16A01	B(i)	C
31N/22E-27F01 ²	Qga	U	33N/20E-16L01	Qga	U

Table 12. Hydrologic unit and aquifer type at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: D, well that has been deepened or otherwise reconstructed; MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, 1993). **Hydrogeologic unit at open interval:** B, undifferentiated bedrock; B(i), igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits. **Ground-water condition at open interval:** C, confined; E, unit is sometimes confined and sometimes unconfined; M, well open to multiple units, both confined and unconfined; U, unconfined. –, no data available]

Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval	Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval
33N/20E-21D01	Qga	C	33N/22E-05P03	B+Qgd	M
33N/21E-05P01	B(s)	C	33N/22E-07H01	Qga	U
33N/21E-07D01	Qga	U	33N/22E-07H02	Qga	C
33N/21E-08A03	Qga	C	33N/22E-07J01	Qga	U
33N/21E-08A04	Qga	C	33N/22E-07N01	Qga	C
33N/21E-08A05	Qga	U	33N/22E-07N02	Qga+B	M
33N/21E-08B01	Qgd	U	33N/22E-07N03	Qga	C
33N/21E-08C01	Qga	C	33N/22E-07N04	Qga	C
33N/21E-08C02	Qga	U	33N/22E-07Q01	Qga	U
33N/21E-08D03	Qga	C	33N/22E-07R01	Qga	U
33N/21E-09D01	Qgd	C	33N/22E-08D02	Qga	C
33N/21E-09D02	Qgd+B(s)	M	33N/22E-13A02	B(s)	C
33N/21E-09D03	Qga+Qgd	C	33N/22E-16N01	Qga	U
33N/21E-10J01	B(s)	C	33N/22E-16N02	Qga	U
33N/21E-10J02	Qga	C	33N/22E-16P01	Qga	C
33N/21E-10J04	Qga	C	33N/22E-17D01	Qga	U
33N/21E-10L01	Qga	C	33N/22E-17F01	Qga	U
33N/21E-10L02	Qga+B(s)	C	33N/22E-17G01	Qga	C
33N/21E-10L03	Qga	C	33N/22E-17K01	Qga	U
33N/21E-10P01	B(s)	C	33N/22E-17L01	Qga	U
33N/21E-11J01 ¹	Qga	U	33N/22E-18D01	Qgl+B(i)	C
33N/21E-11L01	B(s)	C	33N/22E-18D02	Qga	C
33N/21E-11M01	Qa	U	33N/22E-18D03	Qgdo	–
33N/21E-11M02	Qga	C	33N/22E-20A02	Qga	U
33N/21E-11P01	Qga+B(i)	M	33N/22E-20A04	Qga	U
33N/21E-11P02	B(s)	C	33N/22E-20B01	Qga	C
33N/21E-11P03	B(i)	C	33N/22E-20G01	B(s)	E
33N/21E-11P04	Qga+Qgd	C	33N/22E-21D01	Qga	U
33N/21E-11Q01	Qga	C	33N/22E-21D02	Qga	U
33N/21E-11R01	Qgd	U	33N/22E-21E01 ⁴	Qga	U
33N/21E-12N01	Qga	C	33N/22E-21F01	Qga	U
33N/21E-12N02	Qga	C	33N/22E-21F02	B(s)	C
33N/21E-12N03	Qga	C	33N/22E-21H02 ¹	B(s)	C
33N/21E-12R01	Qga	C	33N/22E-21H03 ¹	B(s)	C
33N/21E-13D01	Qga	C	33N/22E-22E01	Qga	U
33N/21E-14B01	B(i)	C	33N/22E-22N02	Qga	U
33N/21E-15E01	Qga	C	33N/22E-22N03	Qga	U
33N/21E-15N01	Qgd	C	33N/22E-22P03	Qga	U
33N/22E-02C01	B(s)	C	33N/22E-23L04	Qga	U
33N/22E-02C02	B(s)	E	33N/22E-23P01	Qga	U
33N/22E-03H01	B(i)	U	33N/22E-23P03	Qga	C
33N/22E-05P01	B(s)	U	33N/22E-26D01	Qga	U
33N/22E-05P02	B(i)	U	33N/22E-26D02	Qga	C

Table 12. Hydrologic unit and aquifer type at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: D, well that has been deepened or otherwise reconstructed; MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, 1993). **Hydrogeologic unit at open interval:** B, undifferentiated bedrock; B(i), igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits. **Ground-water condition at open interval:** C, confined; E, unit is sometimes confined and sometimes unconfined; M, well open to multiple units, both confined and unconfined; U, unconfined. –, no data available]

Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval	Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval
33N/22E-26D03	Qgl+B(s)	M	34N/21E-09J02	B(s)	C
33N/22E-26L01	B(i)	C	34N/21E-10D01	Qga	U
33N/22E-27B02	Qga	U	34N/21E-10G01	B(s)+B(i)	M
33N/22E-27C02	Qga	U	34N/21E-10G02	B(s)	U
33N/22E-27C03	Qga	C	34N/21E-10G03	B(s)+B(i)	M
33N/22E-27G01	Qga	U	34N/21E-10G04	B(s)	C
33N/22E-27G02	Qga	C	34N/21E-10P02	Qga	C
33N/22E-27Q01	Qga	U	34N/21E-10R02	Qga	C
33N/22E-28J01	Qga	C	34N/21E-11A01	Qga	U
33N/22E-34A01	Qga	U	34N/21E-11A02	Qga	U
33N/22E-34B02	Qga	U	34N/21E-11G01 ¹	Qga	U
33N/22E-34G01	Qga	C	34N/21E-11H01	Qga	U
34N/21E-01N01	B(s)	U	34N/21E-11H02	Qga	U
34N/21E-01N02	B(s)	U	34N/21E-11H03	Qga	U
34N/21E-01P01	B(s)	C	34N/21E-11H04	B(s)	U
34N/21E-02B01	B(s)	U	34N/21E-12E02	B(s)	C
34N/21E-02B03	B(s)	U	34N/21E-12E04	Qga	U
34N/21E-02B03D1	B(s)	U	34N/21E-13F01	Qga	C
34N/21E-02Q01	Qa	U	34N/21E-13G01	B(s)	C
34N/21E-03B01	B(s)	C	34N/21E-13H01	Qga	C
34N/21E-03E01	Qga	U	34N/21E-13J01	Qga	C
34N/21E-03E02	Qga	U	34N/21E-13J02	Qga	E
34N/21E-03E03	Qga	C	34N/21E-13K01	B(s)	U
34N/21E-03F01	Qga	U	34N/21E-13R01	Qga+B(s)	M
34N/21E-03M02	Qga	U	34N/21E-14D01	Qga	U
34N/21E-03M03	Qga	U	34N/21E-14E01	Qga	U
34N/21E-03M04	Qga	U	34N/21E-14N01 ¹	Qga	C
34N/21E-03M05	Qga	U	34N/21E-14P01	B(s)	E
34N/21E-03M06	Qga	C	34N/21E-15B01	Qga	U
34N/21E-03P01	Qga	U	34N/21E-15E01	B(s)	U
34N/21E-03R01	Qga+Qgd	C	34N/21E-15R01	Qga	C
34N/21E-04A01	Qga	U	34N/21E-17Q01	Qga	C
34N/21E-04B01	Qga	U	34N/21E-22A01	Qga	C
34N/21E-04B02	Qga	U	34N/21E-22A02	Qga	U
34N/21E-04B04	Qga	C	34N/21E-22F01	Qga+Qgd	M
34N/21E-04H01	Qga	U	34N/21E-23D01	Qga	U
34N/21E-04H02	Qga	U	34N/21E-23E01	Qga	U
34N/21E-04J01	Qga	C	34N/21E-23G01	Qga	U
34N/21E-08E01	Qgd+B(s)	M	34N/21E-23J01	Qga+B(s)	–
34N/21E-08E02	Qgd	U	34N/21E-23R01	B(s)	C
34N/21E-09F01	B(s)	U	34N/21E-24A01 ¹	B(s)	C
34N/21E-09F02	B(s)	U	34N/21E-24C01	Qga	U
34N/21E-09J01	B(s)	U	34N/21E-24G01	Qga	U

Table 12. Hydrologic unit and aquifer type at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: D, well that has been deepened or otherwise reconstructed; MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, 1993). **Hydrogeologic unit at open interval:** B, undifferentiated bedrock; B(i), igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits. **Ground-water condition at open interval:** C, confined; E, unit is sometimes confined and sometimes unconfined; M, well open to multiple units, both confined and unconfined; U, unconfined. –, no data available]

Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval	Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval
34N/21E-24H01	B(s)	C	35N/21E-10J01	B(s)	C
34N/21E-25B01	Qga	U	35N/21E-10K01	Qga+B(s)	C
34N/21E-25B02	Qga	U	35N/21E-11M01 ⁵	Qga	C
34N/21E-25C02	B(s)	U	35N/21E-15A01	B(s)	U
34N/22E-17M01	B(s)	U	35N/21E-15K01	B(s)	U
34N/22E-30F02	Qga	U	35N/21E-15K02	B	U
34N/22E-30F03	B(s)	C	35N/21E-19E01	B(s)	C
34N/22E-30L01	Qga	U	35N/21E-19L01	B(s)	U
34N/22E-30L02	Qga	U	35N/21E-19M01	Qga	C
34N/22E-30N01	Qga	C	35N/21E-19M02	Qga	U
34N/22E-31N01	B(s)	U	35N/21E-19M03	Qga	C
35N/20E-04N01	Qga	U	35N/21E-19M04	Qga	C
35N/20E-05R01	Qga	C	35N/21E-19P01	Qga	U
35N/20E-09L01	Qga	C	35N/21E-19Q01	Qga	C
35N/20E-10E01	Qga	C	35N/21E-22A02	Qga	U
35N/20E-10F01D1	Qga	U	35N/21E-22J02	Qga	E
35N/20E-10F02	Qgd+Qga	M	35N/21E-22J03	Qga	U
35N/20E-10N02	Qga	C	35N/21E-26B02 ¹	Qga+Qgd	M
35N/20E-10P01	Qga	U	35N/21E-26M01	B(s)	U
35N/20E-14E02	Qga	U	35N/21E-27Q01	B(s)	U
35N/20E-14L01	Qga	C	35N/21E-30M01	Qga	U
35N/20E-14N01	Qga	C	35N/21E-30P01	Qga	U
35N/20E-15C01	Qga	U	35N/21E-30P01D1	Qga+Qgl	M
35N/20E-15H01	Qga	U	35N/21E-30P02 ¹	Qga	C
35N/20E-15K01	Qga	C	35N/21E-32A01	Qgd+B(s)	C
35N/20E-16H01	Qga	C	35N/21E-32D01	Qga	U
35N/20E-16H02	Qga	C	35N/21E-32D02	Qga	U
35N/20E-16H05	Qga	C	35N/21E-32D03	Qga	U
35N/20E-16J01	Qga	C	35N/21E-32D04	Qga	U
35N/20E-16J02	Qga	C	35N/21E-32E01	Qga	C
35N/20E-23E01	Qga	C	35N/21E-32E02	Qga	C
35N/20E-24C01	Qaf	U	35N/21E-32L01	Qgd	U
35N/20E-24C02	Qga	U	35N/21E-32L02	Qga	U
35N/20E-24H01	Qga	C	35N/21E-32L03	Qga	C
35N/20E-24H02	Qga	C	35N/21E-33P01	Qga	C
35N/20E-24N01	Qga	C	35N/21E-33R01	Qga	U
35N/20E-24N02	Qga	C	35N/21E-34E01	B(s)	C
35N/20E-25J01 MW14	Qa+Qga	U	35N/21E-34R01	Qga	U
35N/20E-25K01	Qga	C	35N/21E-35D01	B(s)	C
35N/21E-10A01	B(s)	C	35N/21E-35D02	B(s)	U
35N/21E-10A02	B(s)	C	35N/21E-35E01	Qga	U
35N/21E-10A03	B(s)	C	35N/21E-35E02	B(s)	U
35N/21E-10B01	Qga	U	35N/21E-35F01	Qga	C

Table 12. Hydrologic unit and aquifer type at selected wells in the Methow River Basin, Okanogan County, Washington—*Continued*

[Well No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: D, well that has been deepened or otherwise reconstructed; MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, 1993). **Hydrogeologic unit at open interval:** B, undifferentiated bedrock; B(i), igneous or metamorphic bedrock; B(s), sedimentary or volcanic bedrock; Qa, alluvium; Qga, glaciofluvial deposits; Qgd, till; Qgl, glaciolacustrine deposits. **Ground-water condition at open interval:** C, confined; E, unit is sometimes confined and sometimes unconfined; M, well open to multiple units, both confined and unconfined; U, unconfined. –, no data available]

Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval	Well No.	Hydrogeologic unit at open interval	Ground-water condition at open interval
35N/21E-35M02	B(s)+Qga	M	36N/19E-25H02	Qga	C
35N/21E-35P01	Qga	U	36N/19E-25J02A	Qga	U
35N/21E-35P03	B(s)+B(i)	C	36N/19E-25J02B	Qga	U
36N/19E-04N01	Qga	C	36N/19E-25J02C	Qgd	U
36N/19E-05C01 MW02	Qga+B(s)	M	36N/19E-25J02D	Qga	C
36N/19E-05M01	Qga	U	36N/19E-25J02E	Qga	C
36N/19E-05P01	Qga	U	36N/19E-25J07	Qga	U
36N/19E-06B01 MW01	Qga	U	36N/19E-26C01	Qga	U
36N/19E-09L01	Qga	E	36N/19E-26C02	Qga	C
36N/19E-09Q01 EW09	Qga	U	36N/19E-26D03 MW05	Qga+B(s)	E
36N/19E-15L01	Qga	U	36N/20E-30M01	Qga	C
36N/19E-15L02	Qga	C	36N/20E-31A01	Qga	U
36N/19E-22J01	Qga	C	36N/20E-31C01	Qga	C
36N/19E-22J02	Qga	C	36N/20E-31D01	Qga	U
36N/19E-23E02 EW19	Qga	U	36N/20E-31D02D1	Qga	U
36N/19E-23E03 EW19A	Qga	U	36N/20E-31G01	Qga	U
36N/19E-23F01	Qga	U	36N/20E-31Q01	Qga	C
36N/19E-23N01	Qga	U	36N/20E-31Q02	Qga	E
36N/19E-23Q01 EW02	Qga	E	36N/20E-31Q03	Qga	C
36N/19E-23R01	Qga	C	36N/20E-31R02	Qga	U
36N/19E-24Q01	Qga	C	36N/20E-32D01	Qga	E
36N/19E-24Q02	Qga	C	36N/20E-32D02	Qga	U
36N/19E-24Q03	Qga	C	36N/20E-32D03	Qga	U
36N/19E-24Q04	Qga	C	36N/20E-32D04	Qga	E
36N/19E-25B03	Qga	E	36N/21E-23R01	Qga	C
36N/19E-25C01	Qga	U			
36N/19E-25E01	Qga	U			

¹Construction interpretation uncertain.

²Construction information indicates igneous or metamorphic bedrock.

³Also open to Qgl.

⁴100 feet of decomposed basalt?

⁵Water-quality data indicates possible bedrock source.

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. –, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
29N/23E-03P02	480210119562101	03-05-01	70.24	30N/23E-07N01	480626120004001	11-14-00	98.03
		04-23-01	71.43 S			04-27-01	98.96
		07-30-01	96.01 P			06-19-01	96.71
29N/23E-03P03	480209119562101	03-05-01	71.66 R	30N/23E-07M02	480650120003401	07-30-01	97.87
		04-23-01	79.34 P			11-16-00	26.13
		07-30-01	84.36 P			04-27-01	26.7
29N/23E-02B04	480242119545001	11-28-00	15.97	30N/23E-07D02	480707120002901	07-30-01	29.63 P
		04-27-01	16.27			11-16-00	58.5
		07-30-01	16.36			07-30-01	58.48
29N/23E-02B02	480250119544502	11-14-00	5.43	30N/23E-06C02	480757120001201	11-29-00	15.27
		04-23-01	5.36 X	30N/23E-06C01	480804120001201	11-29-00	13.4
		06-20-01	4.81 X			04-28-01	13.68 P
		07-30-01	4.82			06-19-01	13.09 P
30N/23E-34R01	480305119555601	11-15-00	84.65			06-21-01	12.32
		04-23-01	100.55 P			07-30-01	14.36 P
30N/23E-34J02	480318119555301	11-15-00	38.35	31N/23E-31N01	480815120003601	11-30-00	61.98
		04-23-01	42.39 P			07-31-01	62.05
		06-20-01	40.66	31N/22E-36P01	480826120013601	11-15-00	26.7
30N/23E-28J03	480403119570801	07-30-01	41.92			04-27-01	26.29
		11-16-00	45.81			06-19-01	29.92 P
		04-23-01	48.55 R	31N/23E-31P02	480818120001801	07-31-01	28.98 P
		06-20-01	48.3			11-27-00	51.46
30N/23E-27L01	480411119562101	07-30-01	48.26			04-28-01	51.1
		11-16-00	30.4	31N/22E-36R01	480819120010801	07-30-01	51.15
		04-23-01	31.7			11-15-00	71.74
		06-20-01	52.9 R	31N/22E-36M01	480826120015801	04-28-01	71.84
30N/23E-27F01	480425119563401	07-30-01	33.08			11-15-00	35.94
		11-15-00	75.5			04-28-01	35.42
		04-23-01	68.48	31N/22E-27P01	480912120041701	06-21-01	33.89
		07-30-01	75			07-31-01	35.44
30N/23E-30A02	480435119594602	11-28-00	12.42			11-14-00	119.33
30N/23E-30A01	480435119594601	11-28-00	15.69			04-27-01	119.81
30N/23E-20P01	480442119590701	11-28-00	14.77			07-31-01	120.12
		04-23-01	16.25 R	31N/22E-27F01	480933120040801	11-17-00	75.22
		07-30-01	P			04-27-01	75.18
30N/22E-13H02	480608120010101	11-15-00	110.16			06-18-01	73.66
		04-27-01	110.31 R			07-31-01	74.94
		06-21-01	109.57	31N/22E-27E01	480940120043101	11-17-00	25.58
		07-30-01	109.46	31N/22E-27D01	480944120043401	11-17-00	17.89
						04-27-01	17.64
						07-31-01	17.56

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. –, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
31N/22E-27D02	480946120043401	11-07-00	17.41	32N/22E-32E01	481341120070401	11-28-00	33.48
		04-27-01	17.14			04-26-01	34.8 R
		07-31-01	17.08			06-19-01	32.11
31N/22E-22N01	480958120043701	11-16-00	21.06	32N/22E-32G01	481401120063001	06-21-01	32.78
		04-27-01	20.85			07-31-01	34.15 R
		07-31-01	20.73			04-26-01	99.22
31N/22E-21R01	481006120044301	11-17-00	33.04	32N/22E-32C01	481406120065201	06-21-01	99.86
		04-27-01	32.9			07-31-01	100.28
		07-31-01	32.87			04-26-01	19.07
31N/22E-19K01	481014120074401	11-18-00	173.1	32N/22E-32C02	481409120065301	06-21-01	17.53
		04-27-01	168.9			07-31-01	18.7
		06-20-01	169.96			04-26-01	11.76
31N/22E-21J02	480957120043701	11-17-00	45.85	32N/22E-30P01	481416120080601	07-31-01	11.59
		04-27-01	45.98			11-16-00	48.95
		07-31-01	45.5			04-28-01	49.27 R
31N/22E-21G03	481022120050201	11-16-00	10.51	32N/22E-29P01	481417120065301	06-18-01	65.91 R
		04-27-01	15.52 S			07-31-01	77.32 P
		07-31-01	15.15 S			11-16-00	4.37
31N/22E-21G02	481025120050701	11-16-00	26.86	32N/22E-28L01	481439120052701	11-13-00	25.97
		04-28-01	26.85 R			04-26-01	25.52
		06-21-01	25.59 S			07-31-01	29.06 R
31N/22E-21C01D1	481039120053401	11-15-00	14.49	32N/22E-29C02D1	481506120064302	11-10-00	39.2
		04-27-01	13.42 R			04-26-01	39.37
		07-31-01	18.43			06-19-01	37.84
31N/22E-21B01	481005120051201	11-16-00	15.81	32N/22E-20R01	481512120061601	04-26-01	61.18
31N/22E-16Q01D1	481046120051802	11-15-00	9.07	32N/22E-21E01	481544120054501	08-01-01	61.03
		04-27-01	8.54			11-13-00	68.46
		06-21-01	7.37			04-26-01	68.71
31N/22E-16D01	481126120055301	07-31-01	8.3	32N/22E-16P01	481600120053401	06-21-01	68.81 P
		06-18-01	34.73 P			08-01-01	68.24 P
		07-31-01	26.25			11-10-00	19.57
31N/22E-05M01	481245120071101	11-13-00	29.9	32N/22E-16H01	481633120045601	04-26-01	19.8
		04-27-01	29.94			06-21-01	18.19
		07-31-01	29.58			08-01-01	19.38
32N/22E-31R01	481326120072401	11-27-00	72.35			11-09-00	46.05
		04-26-01	72.4			04-26-01	46.27 R
		07-31-01	72.15			06-16-01	44.33 P
						06-21-01	44.9 P
						08-01-01	46.53 P

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Well or site No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#1, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
32N/22E-16G02	481634120050901	11-09-00	19.83	33N/22E-34B02	481921120035501	11-06-00	65.34
		04-26-01	19.96			04-26-01	68.15
		06-21-01	18.3			06-14-01	75.12 P
		08-01-01	19.56			08-01-01	68.59 R
32N/22E-10M02	481709120043601	11-09-00	45.15	33N/22E-27Q01	481934120034801	11-01-00	13.88
		04-26-01	45.58			04-25-01	14.38
		06-16-01	43.18			06-15-01	14.2 P
		06-21-01	43.25			08-02-01	14.9 P
32N/22E-10B01	481731120035501	08-01-01	44.55	33N/22E-26L01	481938120024601	11-02-00	59.35
		11-09-00	27.5			04-25-01	60.07
		04-25-01	27.91	33N/22E-28J01	481940120044801	08-02-01	61.34
		06-16-01	25.66			03-06-01	13.07
32N/22E-10B03	481740120035001	08-01-01	27.02	33N/22E-27H01	481950120033901	04-25-01	13.02
		01-01-01	33			08-01-01	11.72
32N/22E-03Q02	481752120035201	11-08-00	42.1	33N/22E-26F02	481956120025401	11-14-00	24.06
		04-26-01	42.35			11-14-00	24.06
		06-18-01	40.68			04-25-01	25.68
		06-21-01	40.78 R			08-01-01	24.14
32N/22E-03Q01	481752120034501	08-01-01	41.72 R	33N/22E-27G02	482003120035301	11-02-00	48.9
		11-09-00	43.35			04-25-01	49.58
		04-25-01	43.06			08-02-01	49.74
		08-01-01	43.3			03-06-01	16.04
32N/22E-02J01	481601120021501	11-08-00	37.79	33N/22E-26D01	482004120030601	04-24-01	16.38
		04-26-01	38.74			08-02-01	14.68
		08-01-01	41.22			11-01-00	110.56
32N/22E-02E01	481817120030501	11-08-00	9.41	33N/22E-27B03	482005120034601	11-14-00	9.8
		04-26-01	9.37	33N/22E-27B02	482011120035901	11-22-00	15.26
		06-16-01	9.08	33N/22E-26D02	482012120031601	03-06-01	132.05
		08-01-01	9.98	33N/22E-26D03	482015120031901	04-24-01	133.03
11-13-00	16.59	08-02-01	130.48				
33N/22E-34L01	481855120040401	04-25-01	16.84	33N/22E-22N02	482019120043401	03-06-01	142.6
		08-01-01	14.86			04-24-01	143.88
		04-25-01	9.67			11-01-00	13.94
33N/22E-34G01	481911120034201	08-01-01	9.04	33N/22E-23P02	482023120025501	04-24-01	14.32
		11-14-00	40.56			08-01-01	14
33N/22E-35D01	481913120031201	11-14-00	40.56	33N/22E-22P04	482029120040401	04-24-01	4
		11-08-00	33.25			08-02-01	4.1
		04-25-01	33.79			11-17-00	27.16
33N/22E-34A01	481920120033401	08-02-01	33.06				

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
33N/22E-23L03	482033120025501	04-24-01	6.38	33N/22E-16N02	482117120055301	11-17-00	17.93
		08-02-01	6.94	33N/20E-16L01		482128120210501	11-16-00
33N/22E-23L01	482033120025401	03-06-01	3.4			04-25-01	27.68
		04-24-01	3.3			07-31-01	27.78
		08-02-01	3.7	33N/22E-17L01	482128120064001	10-30-00	19.47
33N/22E-23L02	482034120025501	03-06-01	12.06 R			04-24-01	20.26
		08-02-01	12.65 R			08-02-01	18.77
33N/22E-23L04	482037120024701	04-25-01	15.4	33N/22E-17K01	482130120063001	10-31-00	18.04
		06-15-01	15.44				04-24-01
33N/22E-21E01	482045120055001	04-25-01	30.02			08-02-01	17
		06-14-01	28.16	33N/22E-17F01	482137120064401	11-01-00	W
		08-01-01	29.4	33N/22E-17G01	482143120062801	10-30-00	62.06
33N/22E-22E01	482046120042601	11-14-00	31.06			04-24-01	62.78
		04-25-01	32.46			08-02-01	60.5
		06-15-01	24.96	33N/21E-15E01	482145120121801	11-30-00	12.18 R
		08-01-01	25.58			04-23-01	11.6 R
33N/22E-20G01	482047120063301	11-03-00	36.84 R			06-15-01	15.61 P
		04-25-01	75.83 R			06-20-01	13.02 R
		06-14-01	27.97 R			08-01-01	16.94 R
		08-01-01	39.67 R	33N/22E-13A02	481253120004901	11-02-00	72.94 R
33N/22E-21F01	482053120052601	11-01-00	17.48			08-02-01	74.05 P
		04-24-01	18.4	33N/20E-16A01	482153120202501	11-16-00	30.99 R
		08-01-01	16.42			04-27-01	31.1 R
33N/22E-21F02	482054120053801	04-24-01	21.5			06-18-01	29.71
33N/22E-20A03	482056120060401	11-30-00	53.56			06-20-01	29.65
		04-24-01	53.8			08-02-01	30.64 R
33N/22E-20A04	482057120060501	04-24-01	51.93	33N/22E-17D01	482154120070701	04-24-01	44.96
		06-11-01	49.24			08-02-01	44.88 P
33N/22E-20A02	482057120060401	04-24-01	52.1	33N/21E-14B01	482202120101701	03-06-01	27.82
		06-11-01	49.48			04-27-01	28.34
		08-01-01	50.58			06-15-01	22.93
33N/22E-21D02	482103120055101	10-31-00	50.18			06-20-01	22.96
		04-24-01	51.5			08-01-01	22.1
		08-01-01	48.5	33N/21E-13D01	482202120095301	11-28-00	38.66
33N/22E-20B01	482106120063501	11-03-00	11.46			06-15-01	24.56
		04-25-01	12.18			06-20-01	24.96
		08-01-01	10.42			08-02-01	26.97
33N/20E-21D01	482110120213101	11-16-00	18.29	33N/22E-18C01	482201120081301	10-12-00	15
		06-20-01	17.5			04-24-01	4.93
		07-31-01	18.14			06-20-01	4.62
33N/21E-15N01	482111120121601	11-30-00	19.66			07-31-01	5.32
		04-23-01	19.74				
		08-01-01	39.11 P				

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#1, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
33N/21E-10P01	482203120120101	11-17-00	13.42	33N/21E-12N02	482214120093701	11-28-00	10.47
		04-23-01	13.18			04-25-01	10.52
		08-01-01	15.49			06-15-01	10.62
33N/22E-07N05	482204120082001	10-23-00	10	33N/21E-11P02	482215120104301	06-20-01	9.63
		04-24-01	4.88			08-01-01	9.59
		08-02-01	5.28			03-06-01	97.52
33N/22E-08N02	482205120070901	10-30-00	11.66 V			04-24-01	98.08
		04-24-01	11.42			06-14-01	96.3
		08-02-01	11.08			06-20-01	95.36
33N/21E-12R01	482206120083601	08-01-01	20.28 R	33N/22E-07J01	482204120072401	08-01-01	92.93
33N/21E-12R02	482206120083701	11-18-00	24.96			11-28-00	12.64
		04-24-01	26.28			04-24-01	12.5
		06-20-01	21.1	33N/20E-10J01	482218120190701	08-01-01	11.98
		08-01-01	21.7			11-15-00	2.91
						04-25-01	5.24
33N/22E-07N04	482327120071801	04-25-01	6.03			06-20-01	5.98
33N/21E-11P01	482211120105201	03-06-01	14.99			07-31-01	5.99
		04-24-01	14.48	33N/21E-10J02	482219120112001	11-30-00	7.69
		08-01-01	8.45			04-24-01	7.9
11-29-00	26.12	06-20-01	5.35				
33N/22E-07N03	482211120082701	08-02-01	26.06	33N/21E-10J04	482220120111601	08-01-01	6.04
		11-27-00	42.59			03-08-01	10.42
		04-24-01	42.48			04-24-01	10.46
33N/22E-07R01	482212120073401	06-14-01	39.39			06-14-01	8.58
		06-20-01	39.84 R			06-20-01	7.58
		07-31-01	41.42			08-01-01	8.85 R
						03-08-01	3.77
						04-24-01	3.67
33N/21E-11P04	482212120104001	05-03-01	9.9	33N/21E-10J03	482220120111701	06-20-01	3.18
		05-09-01	8.08			08-01-01	3.24
		05-22-01	7.53			11-18-00	126.02
		07-26-01	8.23			06-20-01	123.45
		08-23-01	7.19			08-02-01	119.6
33N/20E-11P01	482213120182301	11-17-00	1.94	33N/21E-11J01	482220120101201	11-30-00	16.7 R
		04-25-01	6 R			04-24-01	17
		06-18-01	1.22			06-14-01	12.48 R
		06-20-01	4.26 R			08-01-01	13.05 R
		07-31-01	1.61			11-30-00	17.63
33N/21E-11P03	482213120103601	04-27-01	84.12	33N/21E-11M02	482227120110401	04-24-01	18.27
		05-17-01	84.07				
		07-26-01	79.4				
		08-23-01	78.91				

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
		08-01-01	14.4 T	33N/21E-08C02	482243120144401	11-30-00	42.47
33N/21E-11M01	482225120111001	11-30-00	19.4			04-27-01	42.14
		04-24-01	20.65			06-18-01	41.41
		08-01-01	16.6			06-20-01	41.35
33N/21E-10L03	482221120115601	04-30-01	13.8			08-02-01	42.2
		05-09-01	12.06	33N/21E-08A03	482244120135401	08-02-01	15.8 R
		05-22-01	11.11	33N/22E-08D02	482245120070101	11-10-00	27
		07-26-01	10.78			04-28-01	27.05
		08-23-01	11.1			06-18-01	25.37
33N/21E-10L01	482223120120201	03-09-01	4.61			07-30-01	26.37
		04-23-01	4.8	33N/21E-07D01	482246120161001	11-16-00	34.2
		06-15-01	3.43 R			04-25-01	37.16
		06-20-01	3.06			06-18-01	14.4 P
		08-01-01	2.89			07-31-01	12.63 P
33N/21E-10L02	482224120115401	04-26-01	34.5	33N/21E-09D03	482246120134101	05-17-01	25.91
		04-27-01	33.3			05-18-01	28.2
		05-09-01	33.2			07-26-01	27.36
		05-22-01	32.01			08-23-01	27.95
		07-26-01	31.8	33N/21E-09D01	482246120134401	04-28-01	31.49
		08-23-01	32.09			08-02-01	28.85
33N/21E-10J01	482225120112301	11-28-00	68.18	33N/21E-08A04	482247120140701	04-28-01	24.92
		04-24-01	68.97			06-18-01	21.32
		06-14-01	61.21			06-20-01	21.39
		06-20-01	61.73			08-02-01	22.78 R
		08-01-01	63.13 R	33N/21E-08C01	482249120144201	11-28-00	7.06
33N/21E-11L01	482227120103801	11-17-00	133.32			04-27-01	6.48
		04-24-01	135.5			08-02-01	6.81
		06-14-01	125.88	33N/22E-08D03	482252120070301	11-10-00	11.41
33N/20E-11L01D1	482228120184002	03-06-01	18.66 R	33N/21E-09D02	482252120134501	05-16-01	43.7
		04-27-01	14.3			05-17-01	41.57
		06-18-01	18.68 R			05-22-01	41.37
		06-20-01	17.01			07-26-01	42.19
		07-31-01	19.21 R			08-23-01	42.43
33N/22E-07H01	482233120072601	11-30-00	11.13 R	33N/22E-05P02	482257120064301	07-30-01	41.56
		04-25-01	13.03 R	33N/21E-05P01	482300120142801	11-17-00	-1.8
		06-20-01	16.44 P	33N/22E-03H01	482326120033001	11-09-00	107.34
		07-31-01	17.11 P	33N/22E-02C02	482337120025401	10-23-00	70
33N/22E-07H02	482235120073201	11-29-00	7.45 Z			04-28-01	48.06
		04-27-01	9.8 Z	34N/22E-30N01	482438120082101	11-30-00	16.75
		06-20-01	7.62			04-27-01	16.94
		08-02-01	8.89			06-19-01	14.42

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
34N/22E-30Q01	482445120074001	11-10-00	31.92	34N/21E-22A01	482617120112701	11-08-00	98.29
34N/22E-30L01	482455120080901	11-27-00	33.46			04-26-01	102.11
		04-27-01	33.78			06-19-01	103.32 P
		06-20-01	30.41			08-01-01	103.34 R
		08-03-01	31.42	34N/21E-24A01	482623120083501	11-09-00	10.64
34N/22E-30L02	482456120080301	11-27-00	36.94			08-02-01	8.75
		08-02-01	34.33	34N/21E-24C01	482623120092601	11-10-00	15.18
34N/22E-30F02	482505120080001	11-27-00	33.14			04-27-01	15.28
		08-02-01	28.17			06-19-01	14.3
34N/22E-30F03	482510120075801	11-18-00	30			08-02-01	15.02
34N/21E-25C01	482526120092301	11-27-00	20.79	34N/21E-17Q01	482627120140901	04-26-01	18.97
34N/21E-25B02	482529120085801	11-15-00	29.9			08-02-01	7.64
		04-27-01	30.2	34N/21E-13R01	482629120083801	11-03-00	8.34
		06-18-01	27.91	34N/21E-15R01	482633120111301	11-08-00	86.28
		06-20-01	28.4			04-26-01	89.68 R
		08-02-01	29.02			06-19-01	90.26
34N/21E-25B01	482530120085501	11-11-00	28.85			08-02-01	91.14
		08-02-01	27.63	34N/21E-13J02	482638120083901	11-28-00	15.64
34N/21E-23G01	482557120101601	11-08-00	36.73	34N/21E-13K01	482642120085601	11-07-00	39.55
		04-26-01	39.21			04-27-01	48.83
		06-19-01	39.66			06-16-01	84.02 R
		08-02-01	40.48			06-19-01	117.59 R
34N/21E-24H01	482601120083901	11-09-00	8.72			08-02-01	67.22 R
		04-26-01	15.63	34N/22E-17M01	482642120070301	11-14-00	41.43
		06-19-01	11.2			04-28-01	43.07
34N/21E-24G01	482601120090201	11-28-00	35.22			07-30-01	58.98 R
		04-26-01	36.12	34N/21E-13J01	482644120084101	11-28-00	14.37
		08-02-01	31.02			04-24-01	21.41
34N/21E-22F01	482603120115801	11-08-00	25.74			06-13-01	15.02
		04-26-01	26.97			08-01-01	11.54
		08-02-01	27.61	34N/21E-13J03	482645120083701	11-07-00	14.99
34N/21E-23E01	482606120110201	08-02-01	126.52 R	34N/21E-13G01	482652120090801	11-14-00	24.84
34N/21E-22A02	482610120112701	04-26-01	134.41			04-26-01	29.04
		06-19-01	134.82			07-31-01	26.8
		08-02-01	135.78 R	34N/21E-13H01	482654120084301	11-07-00	22.08
34N/21E-23D01	482613120105401	11-09-00	74.1			04-24-01	32.36
		04-26-01	77.07	34N/21E-14E01	482656120110301	11-08-00	52.29
		06-16-01	77.68			04-26-01	54.91
		08-02-01	78.81 P			06-19-01	56.31
						08-02-01	57.08 R

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. –, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
34N/21E-13F01	482656120092901	11-28-00	15.12	34N/21E-12E02	482755120094601	11-07-00	62.18
		04-24-01	15.32			04-24-01	67.39 R
		08-01-01	13.84			06-12-01	59.91
34N/21E-15E01	482657120121401	11-10-00	133.36			06-19-01	75.6 P
34N/21E-14D01	482709120110101	11-10-00	26.64			08-01-01	60.81
		08-02-01	28.4	34N/21E-11A01	482757120100601	04-26-01	22.8
34N/21E-14D02	482709120110102	11-10-00	29.16 R	34N/21E-10D01	482806120122501	11-14-00	60
34N/21E-15B01	482710120114601	11-09-00	120.48			04-24-01	61.1 R
34N/21E-10P02	482728120115401	04-26-01	68.91			06-12-01	60.56
34N/21E-09J02	482733120124601	08-01-01	109.5			06-19-01	60.49
34N/21E-09J01	482737120124001	11-01-00	209			07-31-01	61.45
		04-24-01	215.94	34N/21E-01P01	482815120092601	04-23-01	67.79
		06-12-01	216.91			08-01-01	85.11 R
34N/21E-12E04	482744120094701	11-07-00	19.3	34N/21E-03P01	482818120120701	11-16-00	10.55
		04-26-01	18.38			04-24-01	10.48
		08-01-01	15.4			06-11-01	10.01
34N/21E-12E05	482745120094001	11-29-00	86.42			06-19-01	10.24
34N/21E-10G02	482747120113601	11-02-00	52	34N/21E-03R01	482818120111201	11-02-00	72.84
34N/21E-11G01	482748120101201	10-31-00	24.63			04-24-01	73.54
		04-24-01	24.72			07-31-01	71.86
		06-13-01	22.6	34N/21E-04J01	482847120124701	11-03-00	21.2
34N/21E-10G01	482748120113701	07-31-01	29.3 R			04-24-01	21.17
		11-02-00	69.76 R			06-11-01	19.81
		04-24-01	67.95			06-19-01	20.28
34N/21E-09F01	482749120132401	06-12-01	63.59	34N/21E-02L01	482831120103001	10-04-00	11.25
		06-19-01	62.65			11-22-00	10.84
		07-31-01	63.65	34N/21E-03M03	482832120122101	11-03-00	P
34N/21E-11H04	482751120095201	11-06-00	102.2	34N/21E-03M05	482833120121701	11-03-00	16
		04-25-01	101.19			04-24-01	14.92 S
		08-01-01	124.04			06-19-01	15.4
34N/21E-09F02	482751120132701	11-03-00	13.86			07-31-01	16.18
		11-07-00	12.59	34N/21E-03M06	482834120122001	11-03-00	17.35
		11-16-00	37.2			04-24-01	16.26
34N/21E-10G04	482752120113101	04-25-01	38.36			06-19-01	16.53
		08-01-01	40.62			07-31-01	16.98
		11-14-00	33	34N/21E-03M02	482834120122401	04-24-01	13.47 P
34N/21E-11H01	482754120100301	04-24-01	33.4			06-11-01	13.6
		06-19-01	34.29			07-31-01	15.12 R
		07-31-01	34.86				
		04-26-01	22.09				

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. –, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
34N/21E-03E02	482835120122101	11-03-00	16.82 S	35N/21E-35F02	482932120104101	12-01-00	11.28
		04-24-01	15.87	35N/21E-35F01	482933120104201	12-01-00	9.68
		06-19-01	16.24			04-26-01	10.12
		07-31-01	16.63			06-14-01	3.25 R
34N/21E-03E04	482836120121701	11-03-00	13.6			07-31-01	4.18
34N/21E-03F01	482837120115301	11-14-00	10.73	35N/21E-32E01	482946120140501	11-29-00	75.25
		04-24-01	10.89 R	35N/21E-34E01	482938120122101	04-25-01	F
		06-19-01	9.71			08-01-01	F
34N/21E-04B04	482848120130301	07-31-01	10.38	35N/21E-32E02	482935120150101	11-29-00	64.64
		11-01-00	29.78			04-25-01	63.71
		04-26-01	29.82			07-31-01	63.1
		06-12-01	28.19	35N/21E-32D03	482941120145001	12-01-00	53.61
34N/21E-04B03	482851120125801	07-31-01	29.33			04-27-01	53.89
		04-25-01	10.65			08-02-01	53.43
34N/21E-03B01	482854120113301	11-01-00	56.51	35N/21E-32D04	482943120150301	04-25-01	48.29
		04-24-01	57.78			06-18-01	46.44
		06-19-01	59.1 R	35N/21E-32A02	482945120140501	11-28-00	D
		07-31-01	60.12 R	35N/21E-32A01	482945120140701	11-28-00	196.36
34N/21E-04A01	482857120124201	04-25-01	9.48			04-24-01	197.22
		06-12-01	7.73			07-31-01	197.39
		07-31-01	9.07	35N/21E-32D01	482948120145801	12-01-00	34.8
34N/21E-02B01	482858120101303	10-31-00	29.12			04-25-01	34.95
		04-23-01	20.94			06-19-01	33.13
34N/21E-02B03D1	482858120101301	10-31-00	27.13			07-31-01	34.36
		04-23-01	19.06	35N/21E-32D02	482949120145401	12-01-00	31.12
		06-12-01	49.7 P			04-25-01	31.41
		07-31-01	64.42			06-19-01	29.59
35N/21E-35P03	482901120103901	11-22-00	37.96			07-31-01	30.84
35N/21E-35P01	482901120105001	04-26-01	20.16	35N/21E-34A01	482950120112701	04-25-01	22.18
35N/21E-33P01	482910120132401	11-30-00	16.68			06-14-01	17.98
		04-24-01	16.76			06-19-01	18.01
		07-31-01	16.41	35N/21E-30P02	482954120154601	11-30-00	7.31
35N/21E-35M02	482923120105701	04-26-01	64.06			04-25-01	7.33
		07-31-01	58.62 R			06-13-01	6.49 R
35N/21E-32L01	482924120144401	12-01-00	80			06-18-01	6.63 P
		04-26-01	79.88			08-02-01	8.24 R
35N/21E-32L02	482924120143801	12-01-00	71.1	35N/21E-30P01D1	482959120160102	11-30-00	6.48
		04-26-01	71.13	35N/21E-27Q01	483005120113901	03-07-01	14.03 R
35N/21E-35E01	482929120110401	04-26-01	70.11			06-14-01	107.35 R
		06-13-01	68.66			08-01-01	87.85 R
		07-31-01	67.72				

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level
35N/21E-26M01	483013120110601	12-01-00	25.99	35N/20E-24H02	483119120163501	03-08-01	11.36
		08-01-01	31.42 R			04-25-01	11.42
35N/21E-30M01	483014120162101	11-29-00	8.65			06-11-01	9.38
		04-25-01	8.7			06-18-01	9.44
		08-02-01	8.29			08-02-01	10.91
35N/21E-26B01	483033120102101	11-29-00	23.6	35N/20E-24H01	483119120162901	03-07-01	26.65
35N/21E-26C01	483037120103201	11-29-00	50.16	35N/20E-23E01	483122120184601	04-25-01	130.48
35N/21E-26B02	483040120102501	11-29-00	32.74	35N/20E-24C02	483133120170201	04-24-01	15.82
		04-26-01	33.23	35N/20E-24C01	483135120170601	03-08-01	19.6
		06-13-01	50.49			06-22-01	14.88
		07-30-01	52.53			08-02-01	18.06
35N/20E-24N01	483050120172301	03-08-01	223.27	35N/20E-14L01	483158120183501	11-10-00	8
		06-13-01	225.1 R			04-27-01	8.26
		08-02-01	222.91			08-03-01	7.33
35N/21E-22R01	483051120112601	03-09-01	10.99	35N/20E-16J02	483158120202401	11-30-00	58.19
		04-25-01	11.07	35N/21E-15K01	483201120114501	11-27-00	26.3 R
		08-01-01	10.98			04-25-01	47.23
35N/21E-19P01	483052120154501	03-08-01	61.47			06-13-01	33.38 R
		04-25-01	61.44			07-30-01	38.97 R
		08-02-01	61.26	35N/20E-16J01	483201120202601	11-30-00	50.77
35N/20E-24N02	483053120173501	03-08-01	201.43	35N/20E-16H02	483204120202701	11-30-00	56.52
		04-25-01	201.52	35N/20E-16H01	483207120202801	11-30-00	60.29
		08-02-01	201.1			04-24-01	61.22
35N/21E-19Q01	483058120153301	04-25-01	11.76			08-02-01	60.14
		06-13-01	13.66	35N/20E-15H01	483213120185701	11-10-00	10.55
		08-02-01	15.38			04-24-01	11.58
35N/21E-22J02	483102120111701	10-27-00	7			06-18-01	8.24
		04-25-01	11.9			08-01-01	10.42
		08-01-01	12.02	35N/20E-16H05	483216120202801	11-09-00	11.69
35N/21E-19M01	483102120160601	03-07-01	47.82			04-24-01	13.26
		04-24-01	47.86			06-11-01	10.35
		06-18-01	46.68			06-18-01	10.76
		08-02-01	47.15			08-01-01	11.42
35N/21E-22J01	483121120111601	04-25-01	11.21	35N/20E-15C01	483224120194801	11-10-00	4.45
		08-01-01	11.31	35N/21E-15A01	483228120113401	04-25-01	60.1
35N/21E-22J03	483107120111001	04-25-01	3.93			07-30-01	57.68
35N/21E-19L01	483108120155101	03-08-01	41.21	35N/20E-10P01	483234120194201	11-09-00	6.98
		04-25-01	28.39			04-25-01	8.05
		08-02-01	41.2			06-13-01	5.44
35N/21E-19E01	483114120155901	06-18-01	28.34			08-02-01	6.6
		08-02-01	29.94				

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#1, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. –, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level		
35N/21E-10J01	483242120112601	12-06-00	120	36N/20E-31D01	483457120240601	11-07-00	29.4		
		04-25-01	89.28			04-27-01	39.46		
		07-30-01	85.6			11-07-00	20.24		
35N/21E-10K01	483250120113201	03-09-01	21.26	36N/20E-31C01	483459120235101	04-27-01	31.16		
		04-25-01	19.6			08-01-01	16.96		
		07-30-01	18.7 R			04-27-01	31.98		
35N/20E-09L01	483252120205801	04-27-01	23.81	36N/20E-31D02D1	483457120240602	06-16-01	16.38		
		06-18-01	18.17			08-01-01	18.26		
		08-02-01	19.22			36N/20E-32D02	483502120225201	08-01-01	67.61
35N/20E-10E01	483301120211201	11-09-00	7.2	36N/20E-32D01	483604120225301	11-07-00	70.32		
		04-24-01	9.49			06-22-01	63.56		
		06-18-01	5.8			36N/20E-31A01	483505120230401	11-10-00	50.53
		08-01-01	6.71					04-26-01	64.88 R
35N/20E-10F03	483301120194201	11-10-00	70.7			06-12-01	43.44		
35N/20E-10F02	483302120194301	11-10-00	76.58			08-01-01	46.33		
		06-18-01	68.73	36N/19E-25P01	483518120245101	11-01-00	20.84		
35N/21E-10B01	483308120113401	11-27-00	6	36N/19E-25J02A	483522120242601	03-07-01	30.87		
		04-25-01	5.79			06-18-01	15.8		
		07-30-01	6.62			08-03-01	17.12		
35N/21E-10A02	483309120111901	12-01-00	17.6	36N/19E-25J02B	483522120242602	03-07-01	31.45		
		04-25-01	16.84			07-31-01	17.86		
		06-19-01	28.85 S			08-03-01	17.38		
35N/21E-10A03	483310120111901	12-01-00	18.43	36N/19E-25J07	483522120252601	03-07-01	32.56		
		07-30-01	32.4	36N/20E-30M01	483529120235901	11-07-00	15.6		
35N/21E-10A01	483311120111701	12-01-00	17.5			04-26-01	25.13		
35N/20E-04N01	483326120212501	11-09-00	9.78			06-18-01	12.3		
		04-25-01	17.61			08-01-01	13.82		
		06-18-01	7.39	36N/19E-26H01	483535120253401	11-01-00	20.27		
		08-01-01	8.59	36N/19E-25E01	483540120252401	11-10-00	18.3		
35N/20E-05R01	483327120214701	11-08-00	36.74			04-26-01	21.62		
		04-25-01	45.47			06-12-01	15.26		
		06-12-01	33.84			06-22-01	15.26		
36N/20E-31R02	483420120230101	10-31-00	18			07-31-01	16.68		
		11-02-00	17.67	36N/19E-25H02	483540120241601	10-31-00	19.24 P		
		04-27-01	29.44			10-31-00	18.96 R		
		08-01-01	13.37			11-28-00	19.91		
36N/20E-31Q01	483422120231801	11-07-00	20.08			04-27-01	25.65		
		04-27-01	31.79			06-12-01	15.83		
36N/20E-31G01	483451120231401	11-07-00	21.2			06-18-01	16.17		
		04-26-01	36.2			07-31-01	17.56		
		06-22-01	13.77	36N/19E-26C02	483551120262201	11-01-00	30.44		

Table 13. Water levels measured in wells in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Well or site No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks, E-#, vertical electrical resistivity sites (EMCON Northwest, 1993). T-#, seismic refraction sites (Artim, 1975). **Water level:** D, site was dry (no water level recorded); F, site was flowing, but the head could not be measured without additional equipment; P, site was being pumped; R, site had been pumped recently; S, a nearby site that taps the same aquifer was being pumped; T, a nearby site that taps the same aquifer had been pumped recently; X, water level was affected by stage in nearby surface-water site; W, well was destroyed (no water level is recorded); Z, other conditions existed that would affect the measured water level. —, no data available]

Well No.	Site No.	Date	Water level	Well No.	Site No.	Date	Water level	
36N/19E-26C01	483551120261201	11-01-00	22.88	36N/19E-23F01	483628120262601	11-28-00	16.41	
		11-28-00	23.73			06-18-01	20.06	
		04-26-01	28.04 R			07-31-01	20.89	
		08-01-01	20.51			10-31-00	28.78	
36N/19E-25B03	483551120244201	10-31-00	26.7	36N/19E-23E03 EW19A	483635120263601	10-31-00	28.78	
		04-27-01	32			04-26-01	40.16	
		06-18-01	24.16			06-12-01	22.82	
		07-31-01	25.32			06-18-01	22.99	
36N/21E-23R01	483558120095501	11-03-00	22.86	36N/19E-23E02 EW19	483604120254701	07-31-01	23.94	
		04-26-01	23.17			10-31-00	27.83	
		07-30-01	22.54			06-18-01	21.81	
36N/19E-25C01	483559120245501	11-06-00	29.21	36N/19E-15L02	483704120273001	07-31-01	22.72	
		07-31-01	27.7			11-01-00	21.18	
36N/19E-24Q04	483609120243601	07-31-01	65.16	36N/19E-15L01	482707120273201	04-26-01	37.58	
36N/19E-24Q03	483609120243901	04-27-01	80.88			06-13-01	10.24	
		06-18-01	72.77			08-01-01	11.44	
36N/19E-23R01	483603120253701	07-31-01	73.92	11-01-00	22.08	36N/19E-09Q01 EW09	04-26-01	38.62
		10-31-00	24	08-01-01	11.9			
		04-27-01	26.96	11-02-00	54.61			
36N/19E-24Q01	483607120244001	07-31-01	22.56	36N/19E-09R01	483742120283601	08-01-01	41.94	
		11-08-00	138.16			11-02-00	63.04	
		04-27-01	144			11-01-00	59.38	
36N/19E-23N01	483609120263401	08-02-01	136.84	36N/19E-09L01	483756120284701	04-26-01	69.19	
		11-01-00	16.12			08-01-01	46.41	
		04-26-01	24.9			04-28-01	45.46	
		06-13-01	12.05			06-12-01	41.66	
36N/19E-22J03	483611120265401	08-01-01	13.44	36N/19E-04N01D1	483839120291702	08-01-01	38.95	
		04-26-01	30.78			11-03-00	51.73	
36N/19E-22J01	483616120265401	11-01-00	22.18	36N/19E-05P02	483843120300502	11-03-00	13.07 R	
		08-01-01	18.49			04-28-01	10.44 R	
36N/19E-22J02	483620120265801	11-01-00	21.52	36N/19E-05P01	483843120300501	04-28-01	11.22 R	
		04-26-01	33.44			06-12-01	8.18	
		06-13-01	15.9			06-18-01	9.65 R	
36N/19E-22K01	483621120270801	08-01-01	17.3			08-01-01	9.36	
		11-01-00	26.64					

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Table 14. Location and description of sites sampled for surface-water quality in the Methow River Basin, Okanogan County, Washington, September 2001

[Station No.: Locations of station Nos. are shown in figure 6. **Latitude and longitude:** Latitude and longitude at station, in degrees, minutes, and seconds referenced to NAD 27. –, no data available]

Station No.	Station name	Latitude	Longitude	Altitude (feet above NGVD29)	Drainage area (square miles)	Streamflow (cubic feet per second)
12447350	Methow River above Robinson Creek, near Mazama	483934	1203223	2,500	–	13
12447370	Lost River near Mazama	483919	1203018	2,370	146	32
12447382	Early Winters Creek near Mazama	483555	1202631	2,180	80.2	26
12447384	Goat Creek near Mazama	483431	1202243	2,040	–	.44
12447386	Methow River above Wolf Creek, near Winthrop	482929	1201349	1,800	–	103
12447387	Wolf Creek below Diversion, near Winthrop	482900	1201824	2,660	32.5	2.2
12447390	Andrews Creek near Mazama	484923	1200841	4,300	22.1	2.8
12447394	Lake Creek near Winthrop	484525	1200809	2,700	–	6.1
12447440	Eightmile Creek near Winthrop	483618	1201001	2,140	–	12
12447450	Chewuch River at Eightmile Ranch, near Winthrop	483602	1200950	2,100	–	35
12448000	Chewuch River at Winthrop	482838	1201107	1,736	525	22
12448500	Methow River at Winthrop	482825	1201034	1,718	1,007	147
12448850	Twisp River above Buttermilk Creek, near Twisp	482142	1202024	2,280	–	15
12448998	Twisp River near Twisp	482212	1200851	1,640	245	16
12449500	Methow River at Twisp	482155	1200654	1,580	1,301	184
12449710	Beaver Creek near mouth, near Twisp	481943	1200329	1,540	110	.63
12449780	Libby Creek near Carlton	481355	1200717	1,430	–	2.2
12449795	Gold Creek near Carlton	481121	1200613	1,340	–	4.1
12449950	Methow River near Pateros	480439	1205902	900	1,772	229

Table 15. Location and description of wells sampled for ground-water quality in the Methow River Basin, Okanogan County, Washington, June 2001

[Well No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Type of Opening:** P, perforated or slotted; S, screen; X, open hole. –, no data available]

Well No.	Site No.	Altitude (feet above NAVD88)	Depth of open interval (feet below land surface)		Type of opening
			Top	Bottom	
Intrusive Igneous or Metamorphic Bedrock [B(i)]					
30N/23E-27L01	480411119562101	1,144	20	305	X
31N/22E-19K01	481014120074401	1,804	220	260	X
31N/23E-31N01	480815120003601	1,184	70	140	X
33N/21E-14B01	482202120101701	1,762.5	60	105	X
Sedimentary or Volcanic Bedrock [B(s)]					
33N/21E-10J01	482225120112301	1,882.1	138	158	X
33N/21E-11L01	482227120103801	1,881.1	167	172	P
			172	300	X
33N/21E-11P02	482215120104301	1,842	120	209	X
33N/22E-20G01	482047120063301	1,724	40	450	X
34N/21E-09J01	482737120124001	2,014	247	287	X
34N/21E-10G01 ¹	482748120113701	1,877.8	40	200	X
34N/21E-12E02	482755120094601	1,843.2	65	245	X
34N/21E-13K01	482642120085601	1,798.6	42	343	X
35N/21E-15K01	483201120114501	2,244	25	115	X
35N/21E-27Q01	483005120113901	2,114	20	305	X
Pleistocene glaciofluvial deposits (Qga, mostly sand and gravel, frequently boulders)					
29N/23E-02B02	480250119544502	790.3	–	–	–
30N/23E-06C01	480804120001201	1,117.5	–	–	–
30N/23E-07N01	480626120004001	1,144	–	–	–
30N/23E-20P01	480442119590701	924.8	26	46	P
30N/23E-28J03 ²	480403119570801	870.8	68	78	S
30N/23E-34J02	480318119555301	824	–	–	–
31N/22E-16D01	481126120055301	1,310.8	–	–	–
31N/22E-27F01	480933120040801	1,294	172.5	177.5	S
31N/22E-36P01	480826120013601	1,184	44	54	P
32N/22E-02E01	481817120030501	1,479	–	–	–
32N/22E-03Q02	481752120035201	1,497.5	75	80	S
32N/22E-10B01	481731120035501	1,474	55	60	P
32N/22E-10M02	481709120043601	1,488.5	–	–	–
32N/22E-16H01	481633120045601	1,474	75	80	S
32N/22E-21E01	481544120054501	1,475.8	99	103	S

Table 15. Location and description of wells sampled for ground-water quality in the Methow River Basin, Okanogan County, Washington, June 2001—*Continued*

[**Well No.:** See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Type of Opening:** P, perforated or slotted; S, screen; X, open hole. —, no data available]

Well No.	Site No.	Altitude (feet above NAVD88)	Depth of open interval (feet below land surface)		Type of opening
			Top	Bottom	
Pleistocene glaciofluvial deposits (Qga, mostly sand and gravel, frequently boulders)—<i>Continued</i>					
32N/22E-29C02D1	481506120064302	1,439	—	—	—
32N/22E-30P01	481416120080601	1,594	—	—	—
32N/22E-32E01	481341120070401	1,409.7	—	—	—
33N/20E-11L01D1	482228120184002	2,309.8	180	190	S
33N/21E-07D01	482246120161001	2,104	45	46	P
33N/21E-08A04	482247120140701	1,983.9	—	—	—
33N/21E-08C02	482243120144401	2,045.7	—	—	—
33N/21E-10J04	482220120111601	1,793.6	48	50	P
33N/21E-10L01	482223120120201	1,830.6	—	—	—
33N/21E-12N02	482214120093701	1,699.6	44	45	P
33N/21E-13D01	482202120095301	1,751.6	55	70	P
33N/21E-15E01	482145120121801	1,965.5	—	—	—
33N/22E-07H01	482233120072601	1,599	—	—	—
33N/22E-07R01	482212120073401	1,625	—	—	—
33N/22E-08D02	482245120070101	1,614	—	—	—
33N/22E-17L01	482128120064001	1,574.72	62	80	P
33N/22E-20A04	482057120060501	1,594	—	—	—
33N/22E-21E01	482045120055001	1,564	—	—	—
33N/22E-22E01	482046120042601	1,554	73	78	S
33N/22E-23L04	482037120024701	1,704	80	83	P
33N/22E-26D02	482012120031601	1,674	189	197	P
33N/22E-27Q01	481934120034801	1,504	—	—	—
33N/22E-34B02	481921120035501	1,564	—	—	—
34N/21E-03M02	482834120122401	1,784	43.5	44.5	P
34N/21E-03P01	482818120120701	1,785.6	—	—	—
34N/21E-04A01	482857120124201	1,784	—	—	—
34N/21E-04B04	482848120130301	1,794	—	—	—
34N/21E-04J01	482847120124701	1,799.7	—	—	—
34N/21E-10D01	482806120122501	1,841.2	—	—	—
34N/21E-11G01	482748120101201	1,754	—	—	—
34N/21E-13J01	482644120084101	1,804	—	—	—
34N/21E-22A01	482617120112701	1,897.5	—	—	—
34N/21E-23D01	482613120105401	1,869.6	—	—	—
34N/21E-23G01	482557120101601	1,822.7	—	—	—
34N/21E-24C01	482623120092601	1,705.1	—	—	—

Table 15. Location and description of wells sampled for ground-water quality in the Methow River Basin, Okanogan County, Washington, June 2001—*Continued*

[Well No.: See figure 4 for explanation of well-numbering system. Letter following sequence number: MW and EW, “monitoring well” or “existing well” designation from earlier study (EMCON Northwest, unpub. data, 1993) or from Washington Department of Ecology or from Okanogan County water-level networks. **Type of Opening:** P, perforated or slotted; S, screen; X, open hole. —, no data available]

Well No.	Site No.	Altitude (feet above NAVD88)	Depth of open interval (feet below land surface)		Type of opening
			Top	Bottom	
Pleistocene glaciofluvial deposits (Qga, mostly sand and gravel, frequently boulders)—Continued					
34N/21E-25B02	482529120085801	1,695.2	—	—	—
34N/22E-30N01	482438120082101	1,657.5	—	—	—
35N/20E-05R01	483327120214701	2,019	62	76	S
35N/20E-10P01	483234120194201	1,954	—	—	—
35N/20E-16H05	483216120202801	1,965.8	—	—	—
35N/20E-24H02	483119120163501	1,887	—	—	—
35N/20E-24N01	483050120172301	2,094	320	325	P
			361	365	P
			375	379	P
35N/21E-11M01	483248120104901	1,954	100	108	P
35N/21E-19Q01	483058120153301	2,044	50	60	P
35N/21E-26B02 ²	483040120102501	1,984	20	190	X
35N/21E-30P02	482954120154601	1,840.9	—	—	—
35N/21E-35E01	482929120110401	1,824	—	—	—
35N/21E-35F01	482933120104201	1,884	—	—	—
36N/19E-05P01	483843120300501	2,336.4	—	—	—
36N/19E-15L02	483704120273001	2,214	70	80	P
36N/19E-22J02	483620120265801	2,179	—	—	—
36N/19E-23E03 EW19A	483635120263601	2,196.6	—	—	—
36N/19E-23N01	483609120263401	2,174	—	—	—
36N/19E-25E01	483540120252401	2,140.4	—	—	—
36N/19E-25H02	483540120241601	2,121.8	—	—	—
36N/20E-31A01	483505120230401	2,104	—	—	—
36N/20E-31D02D1	483457120240602	2,094	—	—	—
Pleistocene glacial drift (Qgd, mostly till)					
33N/20E-11P01	482213120182301	2,188.8	154	160	P
Insufficient information for lithologic interpretation					
33N/21E-11M03	482221120110401	1,804	80	90	P
36N/19E-04N01D1	483839120291702	2,350.2	—	—	—

¹Also open to intrusive igneous bedrock.

²Also open to Pleistocene glacial drift.

Table 16. Concentrations and precision data for replicate samples for water-quality analysis in the Methow River Basin, Okanogan County, Washington

[Concentrations: In milligrams per liter unless otherwise indicated; E, estimated. Identification is confirmed, but the concentration is estimated because the calculated concentration is less than the laboratory reporting level (LRL), less than the lowest calibration standard, or because the compound was detected in instrument. —, no data available]

Analyte	Concentration in replicates	Difference (percent)	Analyte	Concentration in replicates	Difference (percent)
Nutrients			Nutrients—Continued		
Nitrogen, ammonia, filtered, as N	<.04	—	Phosphorus, unfiltered, as P	0.002E	—
	<.04			<.004	
	<.04	—		.003E	0
	<.04			.003E	
Ammonia plus organic nitrogen, filtered, as N	<.10	—	Major ions and Metals		
	<.10		Arsenic, filtered (µg/L)	0.2	0
	<.10	—		.2	
	.05E			.9	0
Ammonia plus organic nitrogen, unfiltered as N	.05E	0		.9	
	.05E			.1E	0
	<.08	—		.1E	
	<.08			.3	0
Nitrogen, nitrite, filtered, as N	<.006	—		.3	
	<.006			.2E	0
	<.006	—		.2E	
	<.006		Bromide, filtered	<.01	—
Nitrite plus nitrate, filtered, as N	.05	0		<.01	
	.05			.02	66.7
	<.050	—		.01	
	<.050			<.01	—
	.67	0		<.01	
	.67			<.01	—
	.04E	0		<.01	
	.04E		Calcium, filtered	<.01	
	.77	1.3		14.9	.7
	.78			14.8	
	1.53	0		33.3	.3
	1.53			33.2	
	.28	0		28.6	.0
	.28			28.6	
	.07	0		38.9	2.6
	.07			37.9	
	.17	5.7		26.4	4.1
	.18			27.5	
	.05	0		38.3	1.6
	.05			38.9	
	.06	0		.13	7.4
	.06			.14	
	.07	15.4	Chloride, filtered	.60	1.7
	.06			.59	
Phosphorus, filtered, as P	<.006	—		.56	1.8
	<.006			.55	
	<.006	—		.49	24.6
	<.006			.73	
Phosphorus, orthophosphate, as P	<.02	—		1.43	47.5
	<.02			2.32	
	<.02	—		1.10	2.8
	<.02			1.07	

Table 16. Concentrations and precision data for replicate samples for water-quality analysis in the Methow River Basin, Washington—*Continued*

[**Concentrations:** In milligrams per liter unless otherwise indicated; Superscript E remark code, identification is confirmed, but the concentration is estimated because the calculated concentration is less than the laboratory reporting level (LRL), less than the lowest calibration standard, or because the compound was detected in instrument. —, no data available]

Analyte	Concentration in replicates	Difference (percent)	Analyte	Concentration in replicates	Difference (percent)
Major ions and Metals—Continued			Major ions and Metals—Continued		
Chloride, filtered— <i>Continued</i>	0.66	15.4	Lead, filtered (µg/L)— <i>Continued</i>	0.16	11.8
	.77			.18	
	1.10	2.8		.14	40.0
	1.07			.21	
	2.30	3.5		.60	69.7
	2.22			.29	
	1.13	34.2		.06E	0
	.80			.06E	
	.86	2.4	Magnesium, filtered	1.42	0
	.84			1.42	
	1.27	.8		5.51	.2
	1.28			5.52	
	.87	8.4		4.81	.4
	.80			4.83	
	.23	19.6		8.07	2.3
	.28			7.89	
	.33	21.6		4.40	4.2
	.41			4.59	
	.53	1.9		9.30	1.6
	.54			9.45	
Fluoride, filtered	.3	0		.019	0
	.3			.019	
	<.2	—	Manganese, filtered (µg/L)	<3.0	—
	<.2			<3.0	
	<.2	—		<3.0	—
	<.2			<3.0	
	.2	0		<3.0	—
	.2			<3.0	
	.1E	0		<3.0	—
	.1E			<3.0	
	.1E	66.6		3.6	8.0
	.2			3.9	
	.1E	—		<3.0	—
	<.2			<3.0	
Iron, filtered (µg/L)	<10	—		<3.0	—
	<10			<3.0	
	<10	—	Potassium, filtered	.36	0
	<10			.36	
	<10	—		.67	1.5
	<10			.68	
	<10	—		.52	15.9
	<10			.61	
	17	12.5		1.41	4.2
	15			1.47	
	<10	—		.57	29.9
	6E			.77	
	<10	—		<.09	—
	<10			<.09	
Lead, filtered (µg/L)	<.08	—		<.09	—
	<.08			<.09	

Table 16. Concentrations and precision data for replicate samples for water-quality analysis in the Methow River Basin, Washington—*Continued*

[Concentrations: In milligrams per liter unless otherwise indicated; Superscript E remark code, identification is confirmed, but the concentration is estimated because the calculated concentration is less than the laboratory reporting level (LRL), less than the lowest calibration standard, or because the compound was detected in instrument. –, no data available]

Analyte	Concentration in replicates	Difference (percent)	Analyte	Concentration in replicates	Difference (percent)
<i>Major ions and Metals—Continued</i>			<i>Major ions and Metals—Continued</i>		
Residue, filtered (180 degrees Celsius)	183	0	Sodium, filtered – <i>Continued</i>	3.56	
	183			3.54	2.3
	110	.9		3.46	
	111			7.47	1.2
	172	.6		7.38	
	171			3.10	2.5
	68	0		3.18	
Silica, filtered	68		6.57	.2	
	7.8	5.0	6.58		
	8.2		22.7	1.3	
	10.9	.9	23.4		
	10.8		4.1	2.5	
	10.9	5.4	4.0		
	11.5		19.6	1.5	
	18.7	1.6	19.9		
	18.4		7.7	6.3	
	10.8	2.7	8.2		
	11.1		11.9	0	
	15.8	1.3	11.9		
	16.0		11.0	.9	
13.8	.7	11.1			
13.7		11.0	.9		
Sodium, filtered	2.29	.4	11.1		
	2.30		8.9	2.3	
	3.54	.6	8.7		

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001

[Abbreviations: °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; -, no data available; E, estimated; M, presence of material verified but not quantified]

Station or site No.	Date	Temperature, water (°C)	Temperature, air (°C)	Barometric pressure (mm of mercury)	Specific conductance, unfiltered (µS/cm at 25 °C)	Dissolved oxygen, unfiltered (mg/L)	pH, unfiltered, field (standard units)	pH, unfiltered, laboratory (standard units)	Carbonate, filtered, incremental titration, field (mg/L)	Bicarbonate, filtered, incremental titration, field (mg/L)
SURFACE WATER										
12449950	09-21-01	13.7	10.9	736	205	9.8	8.2	8.1	0	113
12449795	09-21-01	9.8	8.2	726	248	10.8	8.3	8.2	0	138
12449780	09-20-01	12.2	27.2	723	373	10	8.4	8.3	0	202
12449710	09-20-01	13.9	20.2	720	322	10.1	8.8	8.7	4	178
12448850	09-20-01	8.2	10.1	696	113	10.4	7.9	8.1	0	61
12449500	09-20-01	13.2	27.7	724	164	10.3	8.4	8.3	0	91
12448998	09-20-01	12.5	15.8	717	213	10.2	8.3	7.9	0	120
12448500	09-20-01	10.4	9.1	715	147	10.3	7.9	8.1	0	78
12448000	09-19-01	14.7	25.1	716	163	9.8	8.5	8.1	2	89
12447387	09-19-01	9.6	21.2	691	183	9.8	8.3	8	0	102
12447386	09-19-01	13	23.8	714	134	9.8	8.2	7.8	0	74
12447384	09-18-01	11.3	14.4	704	227	9.8	8.3	8.2	0	115
12447382	09-18-01	11.3	26	701	86	10.2	8	8.1	0	46
12447450	09-19-01	9.4	11.1	705	97	10.2	7.9	7.9	0	54
12447440	09-19-01	6.5	9.1	705	195	11.1	8.3	8.1	0	112
12447370	09-18-01	9.7	20.1	697	98	10.5	8	8	0	52
12447350	09-18-01	10.1	25.5	694	113	10.3	8.2	8.1	0	58
12447394	09-17-01	13.2	17	688	64	9.2	8	7.8	0	38
12447390	09-17-01	7.8	12.2	655	60	10.2	7.6	7.4	0	34

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Abbreviations: °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; –, no data available; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Ammonia,	Nitrite,	Ammonia +	Ammonia	Nitrite plus	Phosphorus,	Phosphorus,	Orthophosphate,	Calcium,
		filtered	filtered	organic	plus organic	nitrate,	unfiltered	filtered	filtered (mg/L as	filtered
		mg/L as N					(mg/L)	(mg/L)	phosphorus)	(mg/L)
SURFACE WATER— <i>Continued</i>										
12449950	09-21-01	<0 .040	< 0.006	0.08E	0.11	0.221	0.004	< 0.006	<0 .020	28.6
12449795	09-21-01	< .040	< .006	< .10	< .08	< .050	.003E	< .006	< .020	34.8
12449780	09-20-01	< .040	< .006	.05E	.12	.030E	.01	< .006	< .020	53.7
12449710	09-20-01	.07	.048	.23	.32	.149	.025	.016	.077	39.6
12448850	09-20-01	< .040	< .006	< .10	< .08	.030E	< .004	.003E	< .020	16.7
12449500	09-20-01	< .040	< .006	< .10	.1	.217	.002E	< .006	< .020	24
12448998	09-20-01	< .040	< .006	.06E	.07E	.259	.002E	< .006	< .020	30.1
12448500	09-20-01	< .040	< .006	< .10	.06E	.075	< .004	< .006	< .020	21.2
12448000	09-19-01	< .040	.004E	.09E	.11	.095	.002E	< .006	< .020	21.6
12447387	09-19-01	< .040	< .006	< .10	< .08	.026E	.002E	< .006	< .020	25.9
12447386	09-19-01	.031E	.003E	< .10	.06E	.049	< .004	< .006	< .020	20.4
12447384	09-18-01	< .040	< .006	< .10	< .08	< .050	.003E	< .006	< .020	33.3
12447382	09-18-01	< .040	< .006	< .10	.05E	.032E	< .004	< .006	< .020	12.4
12447450	09-19-01	< .040	.003E	< .10	.07E	.023E	.002E	< .006	< .020	12.3
12447440	09-19-01	.023E	< .006	< .10	.1	.053	.003E	< .006	< .020	28.6
12447370	09-18-01	< .040	< .006	< .10	.05E	.047	.002E	< .006	< .020	14.9
12447350	09-18-01	< .040	< .006	< .10	.06E	.041E	< .004	< .006	< .020	17.9
12447394	09-17-01	< .040	< .006	< .10	.04E	< .050	< .004	< .006	< .020	8.05
12447390	09-17-01	< .040	< .006	< .10	.06E	< .050	< .004	< .006	< .020	7.58

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; **mm**, millimeters; **cm**, centimeters; **mg**, milligrams; **mg/L**, milligrams per liter; **mg/L as N**, milligrams per liter as nitrogen; **µg/L**, micrograms per liter; +, plus; –, no data available; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Magnesium, filtered (mg/L)	Sodium, filtered (mg/L)	Potassium, filtered (mg/L)	Chloride, filtered (mg/L)	Sulfate, filtered (mg/L)	Fluoride, filtered (mg/L)	Silica, filtered (mg/L)	Arsenic, filtered (µg/L)	Iron, filtered (µg/L)
SURFACE WATER—Continued										
12449950	09-21-01	5.21	4.4	0.9	3.3	9.7	0.2	9.9	–	< 10
12449795	09-21-01	6.63	4.6	1.13	1	12.5	.1E	14	–	< 10
12449780	09-20-01	11.4	7.5	1.13	1.1	30.5	.1E	14.4	–	M
12449710	09-20-01	10.8	11.9	2.45	1.7	9.6	.2E	21.1	–	20
12448850	09-20-01	2.41	1.7	.59	.2	4.4	< .2	8.5	–	< 10
12449500	09-20-01	3.76	3.5	.6	1	5.8	.2	10.5	–	< 10
12448998	09-20-01	6.18	3.9	.88	1.1	10	< .2	11.5	0.5	< 10
12448500	09-20-01	3.21	3.2	.58	1	4.9	.2	11	–	M
12448000	09-19-01	4.29	4.4	1.14	1	5.5	< .2	13.4	.2	10
12447387	09-19-01	5.17	3	.34	.1	6.7	< .2	7.5	–	< 10
12447386	09-19-01	2.46	2.5	.46	.6	4.1	.2	9.3	–	< 10
12447384	09-18-01	5.51	3.5	.67	.6	19.6	< .2	10.9	–	< 10
12447382	09-18-01	1.79	2	.33	.2	3.7	.1E	8.3	.5	< 10
12447450	09-19-01	2.06	3.4	.9	.7	2	< .2	13.9	–	10
12447440	09-19-01	4.81	3.5	.52	.5	7.7	< .2	10.9	.2	< 10
12447370	09-18-01	1.42	2.3	.36	.6	4.1	.3	7.8	–	< 10
12447350	09-18-01	1.77	1.9	.25	.3	4.6	.2	7.1	–	< 10
12447394	09-17-01	1.47	2.3	.41	.4	.5	< .2	10.2	–	< 10
12447390	09-17-01	1.06	2.4	.63	.2	.8	< .2	10.5	< .2	< 10

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; **mm**, millimeters; **cm**, centimeters; **mg**, milligrams; **mg/L**, milligrams per liter; **mg/L as N**, milligrams per liter as nitrogen; **µg/L**, micrograms per liter; +, plus; –, no data available; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Lead, filtered (µg/L)	Manganese, filtered (µg/L)	Alkalinity, filtered, incremental titration, field (mg/L as calcium carbonate)	Residue on evaporation, dried at 180 °C, filtered (mg/L)	Bromide, filtered (mg/L)	Sample purpose (code)	Depth to water level (feet below land surface)	Specific conductance, unfiltered, laboratory (µS/cm at 25 °C)	Acid neutralizing capacity, unfiltered, fixed endpoint (pH 4.5) titration, laboratory (mg/L as calcium carbonate)
SURFACE WATER—Continued										
12449950	09-21-01	–	< 3.0	92	–	–	60	–	204	94
12449795	09-21-01	–	< 3.0	114	–	–	60	–	247	117
12449780	09-20-01	–	4.9	165	–	–	60	–	369	162
12449710	09-20-01	–	1.6E	153	–	–	60	–	322	159
12448850	09-20-01	–	< 3.0	50	–	–	60	–	115	53
12449500	09-20-01	–	< 3.0	74	–	–	60	–	165	78
12448998	09-20-01	< 0.08	6.1	98	–	–	60	–	212	99
12448500	09-20-01	–	1.6E	64	–	–	60	–	147	69
12448000	09-19-01	.14	2.3E	77	–	–	60	–	165	78
12447387	09-19-01	–	< 3.0	84	–	–	60	–	184	89
12447386	09-19-01	–	< 3.0	60	–	–	60	–	133	64
12447384	09-18-01	–	< 3.0	94	–	–	60	–	229	96
12447382	09-18-01	< .08	< 3.0	38	–	–	60	–	89	40
12447450	09-19-01	–	2.6E	44	–	–	60	–	97	47
12447440	09-19-01	< .08	< 3.0	92	–	–	60	–	197	94
12447370	09-18-01	–	< 3.0	43	–	–	60	–	98	45
12447350	09-18-01	–	< 3.0	48	–	–	60	–	113	52
12447394	09-17-01	–	< 3.0	31	–	–	60	–	65	33
12447390	09-17-01	.07E	< 3.0	28	–	–	60	–	61	30

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; –, no data available; E, estimated; M, presence of material verified but not quantified]

Station or site No.	Date	Temperature, water (°C)	Temperature, air (°C)	Barometric pressure (mm of mercury)	Specific conductance, unfiltered (µS/cm at 25 °C)	Dissolved oxygen, unfiltered (mg/L)	pH, unfiltered, field (standard units)	pH, unfiltered, laboratory (standard units)	Carbonate, filtered, incremental titration, field (mg/L)	Bicarbonate, filtered, incremental titration, field (mg/L)
GROUND WATER										
480250119544502	06-20-01	13	26	745	644	0.6	7.4	–	–	–
480318119555301	06-20-01	13.1	31.5	742	486	1.1	8	–	–	–
480403119570801	06-20-01	–	17.5	–	396	6.4	7.5	–	–	–
480411119562101	06-20-01	–	25.5	734	372	6.8	7.8	–	–	–
480442119590701	06-19-01	11.5	28.2	740	324	5.3	7.7	–	–	–
480626120004001	06-19-01	11.5	26.8	735	379	7.9	7.6	7.5	0	213
480804120001201	06-19-01	10.3	25.8	737	278	6.4	7.5	7.3	0	147
480815120003601	06-19-01	12.2	29.6	733	302	8.1	8	–	–	–
480826120013601	06-19-01	10.5	27	725	236	7.5	7.8	–	–	–
480933120040801	06-18-01	12.3	24.9	731	405	6.3	7.8	7.6	0	247
481014120074401	06-20-01	12.6	24.5	715	130	.1	7	–	–	–
481126120055301	06-18-01	10.6	20.7	731	384	5.7	8	–	–	–
481341120070401	06-19-01	8.5	19.6	730	293	5.8	7.8	–	–	–
481416120080601	06-18-01	12.5	20.4	724	524	2.8	7.6	–	–	–
481506120064302	06-19-01	9	18.7	730	182	8.2	8.3	–	–	–
481544120054501	06-16-01	10.8	22.3	723	361	8.7	8	–	–	–
481633120045601	06-16-01	11.3	19.7	723	383	7.2	7.8	–	–	–
481709120043601	06-16-01	12.1	24.8	722	567	4.7	7.7	–	–	–
481731120035501	06-16-01	10	18.5	723	135	4.3	7.6	–	–	–
481752120035201	06-18-01	11.5	17.6	727	394	0	7.8	–	–	–
481817120030501	06-16-01	11.4	15	724	390	1.2	7.6	–	–	–
481921120035501	06-14-01	10.4	23.9	719	219	.4	7.4	–	–	–
481934120034801	06-15-01	10	23.9	–	220	1.8	7.5	–	–	–
482012120031601	06-15-01	11.3	22.4	719	426	5.7	7.9	–	–	–
482037120024701	06-15-01	10.8	–	719	392	7.1	7.6	–	–	–
482045120055001	06-14-01	13.1	20.7	718	262	8.5	7.7	7.6	0	154
482046120042601	06-15-01	13.5	–	722	382	2.6	7.9	–	–	–
482047120063301	06-14-01	12.5	20.5	715	1,310	4.2	7.7	7.6	0	180
482057120060501	06-11-01	9	10.5	716	190	4.3	7.3	7.4	0	101
482128120064001	06-15-01	9.3	22.7	721	199	6.1	7.9	7.6	0	110
482145120121801	06-15-01	7.1	19	708	487	8.9	7.3	–	–	–
482202120101701	06-15-01	8	21.7	714	224	8.5	7.6	–	–	–
482202120095301	06-15-01	10.2	23.7	713	380	11	7.7	–	–	–
482212120073401	06-14-01	10.5	21.3	713	532	4.8	7.5	–	–	–
482213120182301	06-18-01	9.1	25.1	705	230	1	8.3	8	0	122
482214120093701	06-15-01	11	23.2	715	618	.1	7.5	–	–	–
482215120104301	06-14-01	12.4	23.4	708	1,550	.1	7.8	–	–	–
482220120111601	06-14-01	11	22.7	709	365	8	7.3	7.5	0	200
482221120110401	06-14-01	12.2	14.6	709	359	.1	7.7	–	–	–
482223120120201	06-15-01	9.8	17.8	711	209	7.2	7.2	–	–	–
482225120112301	06-14-01	11.6	16.1	708	388	.1	7.5	7.6	0	195
482227120103801	06-14-01	11.4	24.7	707	429	5.1	7.6	–	–	–
482228120184002	06-18-01	10.9	25.3	701	490	.6	7.8	–	–	–

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; -, no data available; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Ammonia,	Nitrite,	Ammonia +	Ammonia	Nitrite plus	Phosphorus,	Phosphorus,	Orthophosphate,	Calcium,
		filtered	filtered	organic nitrogen, filtered	plus organic nitrogen, unfiltered	nitrate, filtered	unfiltered (mg/L)	filtered (mg/L)	filtered (mg/L as phosphorus)	filtered (mg/L)
mg/L as N										
GROUND WATER—Continued										
480250119544502	06-20-01	—	—	—	—	1.75	—	—	—	—
480318119555301	06-20-01	—	—	—	—	.306	—	—	—	—
480403119570801	06-20-01	—	—	—	—	1.84	—	—	—	—
480411119562101	06-20-01	—	—	—	—	.862	—	—	—	—
480442119590701	06-19-01	—	—	—	—	.561	—	—	—	—
480626120004001	06-19-01	—	—	—	—	4.32	—	—	—	62.7
480804120001201	06-19-01	—	—	—	—	.668	—	—	—	38.9
480815120003601	06-19-01	—	—	—	—	1.5	—	—	—	—
480826120013601	06-19-01	—	—	—	—	.604	—	—	—	—
480933120040801	06-18-01	—	—	—	—	1.13	—	—	—	52.2
481014120074401	06-20-01	—	—	—	—	< .050	—	—	—	—
481126120055301	06-18-01	—	—	—	—	6.28	—	—	—	—
481341120070401	06-19-01	—	—	—	—	.19	—	—	—	—
481416120080601	06-18-01	—	—	—	—	.06	—	—	—	—
481506120064302	06-19-01	—	—	—	—	.251	—	—	—	—
481544120054501	06-16-01	—	—	—	—	.913	—	—	—	—
481633120045601	06-16-01	—	—	—	—	1.74	—	—	—	—
481709120043601	06-16-01	—	—	—	—	1.43	—	—	—	—
481731120035501	06-16-01	—	—	—	—	.108	—	—	—	—
481752120035201	06-18-01	—	—	—	—	< .050	—	—	—	—
481817120030501	06-16-01	—	—	—	—	.422	—	—	—	—
481921120035501	06-14-01	—	—	—	—	.044E	—	—	—	—
481934120034801	06-15-01	—	—	—	—	.774	—	—	—	—
482012120031601	06-15-01	—	—	—	—	2.3	—	—	—	—
482037120024701	06-15-01	—	—	—	—	1.53	—	—	—	—
482045120055001	06-14-01	—	—	—	—	.152	—	—	—	41.5
482046120042601	06-15-01	—	—	—	—	.282	—	—	—	—
482047120063301	06-14-01	—	—	—	—	.064	—	—	—	111
482057120060501	06-11-01	—	—	—	—	.285	—	—	—	26.4
482128120064001	06-15-01	—	—	—	—	.337	—	—	—	29.3
482145120121801	06-15-01	—	—	—	—	.159	—	—	—	—
482202120101701	06-15-01	—	—	—	—	.035E	—	—	—	—
482202120095301	06-15-01	—	—	—	—	.072	—	—	—	—
482212120073401	06-14-01	—	—	—	—	6.1	—	—	—	—
482213120182301	06-18-01	—	—	—	—	.025E	—	—	—	30.7
482214120093701	06-15-01	—	—	—	—	< .050	—	—	—	—
482215120104301	06-14-01	—	—	—	—	.028E	—	—	—	—
482220120111601	06-14-01	—	—	—	—	2.09	—	—	—	56.3
482221120110401	06-14-01	—	—	—	—	< .050	—	—	—	—
482223120120201	06-15-01	—	—	—	—	.249	—	—	—	—
482225120112301	06-14-01	—	—	—	—	.143	—	—	—	61.4
482227120103801	06-14-01	—	—	—	—	.759	—	—	—	—
482228120184002	06-18-01	—	—	—	—	.054	—	—	—	—
482233120072601	06-20-01	—	—	—	—	.176	—	—	—	—

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; **mm**, millimeters; **cm**, centimeters; **mg**, milligrams; **mg/L**, milligrams per liter; **mg/L as N**, milligrams per liter as nitrogen; **µg/L**, micrograms per liter; +, plus; –, No data; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Magnesium, filtered (mg/L)	Sodium, filtered (mg/L)	Potassium, filtered (mg/L)	Chloride, filtered (mg/L)	Sulfate, filtered (mg/L)	Fluoride, filtered (mg/L)	Silica, filtered (mg/L)	Arsenic, filtered (µg/L)	Iron, filtered (µg/L)
GROUND WATER—Continued										
480250119544502	06-20-01	–	–	–	5.6	–	–	–	–	–
480318119555301	06-20-01	–	–	–	1.6	–	–	–	–	–
480403119570801	06-20-01	–	–	–	2.2	–	–	–	–	–
480411119562101	06-20-01	–	–	–	2.2	–	–	–	–	–
480442119590701	06-19-01	–	–	–	1.6	–	–	–	–	–
480626120004001	06-19-01	10.9	7.2	1.61	2.5	11.3	0.1E	20.7	0.9	M
480804120001201	06-19-01	8.07	7.5	1.41	1.4	11.9	.2	18.7	.9	< 10
480815120003601	06-19-01	–	–	–	1	–	–	–	–	–
480826120013601	06-19-01	–	–	–	1.1	–	–	–	–	–
480933120040801	06-18-01	13.5	13.4	1.94	1.4	14.9	.2E	18.5	.5	< 10
481014120074401	06-20-01	–	–	–	.5	–	–	–	–	–
481126120055301	06-18-01	–	–	–	2.1	–	–	–	–	–
481341120070401	06-19-01	–	–	–	.5	–	–	–	–	–
481416120080601	06-18-01	–	–	–	1	–	–	–	–	–
481506120064302	06-19-01	–	–	–	.5	–	–	–	–	–
481544120054501	06-16-01	–	–	–	1.4	–	–	–	–	–
481633120045601	06-16-01	–	–	–	1.8	–	–	–	–	–
481709120043601	06-16-01	–	–	–	1.7	–	–	–	–	–
481731120035501	06-16-01	–	–	–	.5	–	–	–	–	–
481752120035201	06-18-01	–	–	–	1.9	–	–	–	–	–
481817120030501	06-16-01	–	–	–	1.8	–	–	–	–	–
481921120035501	06-14-01	–	–	–	.7	–	–	–	–	–
481934120034801	06-15-01	–	–	–	1.1	–	–	–	–	–
482012120031601	06-15-01	–	–	–	2	–	–	–	–	–
482037120024701	06-15-01	–	–	–	2.3	–	–	–	–	–
482045120055001	06-14-01	6.93	3.8	.67	.3	10.6	.1E	13.1	.9	< 10
482046120042601	06-15-01	–	–	–	1.9	–	–	–	–	–
482047120063301	06-14-01	36.7	85	2.73	.9	473	.8	17.1	25.4	< 10
482057120060501	06-11-01	4.4	3.1	.57	1.1	11	.1E	10.8	.1E	20
482128120064001	06-15-01	4.68	3.1	.77	1	10	.1E	10.7	.3	< 10
482145120121801	06-15-01	–	–	–	1	–	–	–	–	–
482202120101701	06-15-01	–	–	–	.3	–	–	–	–	–
482202120095301	06-15-01	–	–	–	.6	–	–	–	–	–
482212120073401	06-14-01	–	–	–	2.8	–	–	–	–	–
482213120182301	06-18-01	5.82	7.2	1.89	2	12.4	.1E	11.5	2.4	120
482214120093701	06-15-01	–	–	–	1.3	–	–	–	–	–
482215120104301	06-14-01	–	–	–	14.9	–	–	–	–	–
482220120111601	06-14-01	10.1	4.7	.97	1.1	12.6	.2	15.7	.4	< 10
482221120110401	06-14-01	–	–	–	1	–	–	–	–	–
482223120120201	06-15-01	–	–	–	.7	–	–	–	–	–
482225120112301	06-14-01	9.21	6	.35	1	39.5	.3	13.4	.7	10
482227120103801	06-14-01	–	–	–	1.1	–	–	–	–	–
482228120184002	06-18-01	–	–	–	.6	–	–	–	–	–
482233120072601	06-20-01	–	–	–	.8	–	–	–	–	–

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Abbreviations: °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; -, No data; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Lead, filtered (µg/L)	Manganese, filtered (µg/L)	Alkalinity, filtered, incremental titration, field (mg/L as calcium carbonate)	Residue on evaporation, dried at 180 °C, filtered (mg/L)	Bromide, filtered (mg/L)	Sample purpose (code)	Depth to water level (feet below land surface)	Specific conductance, unfiltered, laboratory (µS/cm at 25 °C)	Acid neutralizing capacity, unfiltered, fixed endpoint (pH 4.5) titration, laboratory (mg/L as calcium carbonate)
GROUND WATER—Continued										
480250119544502	06-20-01	—	—	—	—	—	—	—	—	—
480318119555301	06-20-01	—	—	—	—	—	—	40.66	—	—
480403119570801	06-20-01	—	—	—	—	—	—	48.3	—	—
480411119562101	06-20-01	—	—	—	—	—	—	—	—	—
480442119590701	06-19-01	—	—	—	—	—	—	—	—	—
480626120004001	06-19-01	0.78	< 3.0	190	266	< 0.01	—	96.71	421	—
480804120001201	06-19-01	.16	< 3.0	132	183	< .01	—	12.32	289	—
480815120003601	06-19-01	—	—	—	—	—	—	—	352	—
480826120013601	06-19-01	—	—	—	—	—	—	—	—	—
480933120040801	06-18-01	.94	< 3.0	203	237	.02	—	73.66	405	—
481014120074401	06-20-01	—	—	—	—	—	—	169.96	—	—
481126120055301	06-18-01	—	—	—	—	—	—	—	374	—
48134120070401	06-19-01	—	—	—	—	—	—	32.11	—	—
481416120080601	06-18-01	—	—	—	—	—	—	—	—	—
481506120064302	06-19-01	—	—	—	—	—	—	37.84	—	—
481544120054501	06-16-01	—	—	—	—	—	—	—	362	—
481633120045601	06-16-01	—	—	—	—	—	—	—	—	—
481709120043601	06-16-01	—	—	—	—	—	—	43.25	559	—
481731120035501	06-16-01	—	—	—	—	—	—	25.66	138	—
481752120035201	06-18-01	—	—	—	—	—	—	40.68	388	—
481817120030501	06-16-01	—	—	—	—	—	—	9.08	389	—
481921120035501	06-14-01	—	—	—	—	—	—	—	220	—
481934120034801	06-15-01	—	—	—	—	—	—	—	220	—
482012120031601	06-15-01	—	—	—	—	—	—	—	426	—
482037120024701	06-15-01	—	—	—	—	—	—	15.44	—	—
482045120055001	06-14-01	.1	< 3.0	126	157	< .01	—	28.16	269	—
482046120042601	06-15-01	—	—	—	—	—	—	24.96	381	—
482047120063301	06-14-01	1.2	19.3	148	884	< .01	—	—	1,290	—
482057120060501	06-11-01	.14	3.6	83	110	.02	—	—	189	—
482128120064001	06-15-01	.19	< 3.0	90	119	< .01	—	—	200	—
482145120121801	06-15-01	—	—	—	—	—	—	—	—	—
482202120101701	06-15-01	—	—	—	—	—	—	22.93	—	—
482202120095301	06-15-01	—	—	—	—	—	—	24.56	—	—
482212120073401	06-14-01	—	—	—	—	—	—	39.39	525	—
482213120182301	06-18-01	< .08	14.8	100	135	.01	—	1.22	229	—
482214120093701	06-15-01	—	—	—	—	—	—	10.62	—	—
482215120104301	06-14-01	—	—	—	—	—	—	96.3	1,540	—
482220120111601	06-14-01	.91	< 3.0	164	214	< .01	—	8.58	365	—
482221120110401	06-14-01	—	—	—	—	—	—	—	—	—
482223120120201	06-15-01	—	—	—	—	—	—	—	—	—
482225120112301	06-14-01	<.08	21	160	235	< .01	—	61.21	388	—
482227120103801	06-14-01	—	—	—	—	—	—	—	—	—
482228120184002	06-18-01	—	—	—	—	—	—	—	—	—
482233120072601	06-20-01	—	—	—	—	—	—	—	—	—

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; –, no data available; E, estimated; M, presence of material verified but not quantified]

Station or site No.	Date	Temperature, water (°C)	Temperature, air (°C)	Barometric pressure (mm of mercury)	Specific conductance, unfiltered (µS/cm at 25 °C)	Dissolved oxygen, unfiltered (mg/L)	pH, unfiltered, field (standard units)	pH, unfiltered, laboratory (standard units)	Carbonate, filtered, incremental titration, field (mg/L)	Bicarbonate, filtered, incremental titration, field (mg/L)
GROUND WATER—Continued										
482233120072601	06-20-01	9.7	18.1	722	216	2.2	8.1	–	–	–
482243120144401	06-18-01	7.5	22.3	710	200	8.5	7.5	7.4	0	116
482245120070101	06-18-01	11.7	18.5	722	335	5.7	7.8	–	–	–
482246120161001	06-18-01	7.9	22.9	708	165	9.9	7.4	7.3	0	96
482247120140701	06-18-01	7.2	22.5	712	155	7.6	7.4	–	–	–
482438120082101	06-19-01	11	17.5	721	95	5.8	7.4	–	–	–
482529120085801	06-18-01	9.6	13.4	719	288	7.1	7.3	7.3	0	158
482557120101601	06-19-01	–	25.7	714	453	6.7	7.6	–	–	–
482613120105401	06-16-01	–	20.6	710	364	7.2	7.7	–	–	–
482617120112701	06-19-01	9.7	27.3	713	366	8	7.4	–	–	–
482623120092601	06-19-01	–	20.3	719	167	7	7.3	7.2	0	91
482642120085601	06-16-01	12.8	22.8	711	346	.1	9.2	9	10	156
482644120084101	06-13-01	11.6	17	716	507	8.7	7.5	–	–	–
482737120124001	06-12-01	13.8	15.5	707	360	5.4	7.8	–	–	–
482748120101201	06-13-01	11.3	11.7	719	164	8.8	7.1	–	–	–
482748120113701	06-12-01	11.8	14.4	709	401	.2	7.9	–	–	–
482755120094601	06-12-01	13.5	16.8	714	454	2.7	9.4	–	–	–
482806120122501	06-12-01	11.7	12.1	713	427	8.7	7.6	–	–	–
482818120120701	06-11-01	9.3	18.6	709	196	7.6	7.4	–	–	–
482847120124701	06-11-01	8.8	15.3	708	150	8.1	7.4	7.4	0	87
482834120122401	06-11-01	9.3	–	709	154	8.7	7.2	–	–	–
482848120130301	06-12-01	8.6	–	713	135	8.5	7	7.1	0	77
482857120124201	06-12-01	9.4	16.1	714	180	7.6	7.4	7.3	0	91
482929120110401	06-13-01	12.3	24.4	711	320	7.6	7.7	7.4	0	161
482933120104201	06-14-01	11.4	18.6	710	194	5.5	7.4	7.5	–	117
482954120154601	06-13-01	8.6	12.9	712	145	6.9	7.2	–	–	–
483005120113901	06-14-01	13.4	19.1	–	693	1.9	7.9	–	–	–
483040120102501	06-13-01	11.3	20.2	710	565	1.3	7.9	–	–	–
483050120172301	06-13-01	11.4	13.5	705	279	3.1	8.2	–	–	–
483058120153301	06-13-01	11.5	25.4	705	644	3.6	7.4	–	–	–
483119120163501	06-11-01	9.7	16.5	703	194	5.8	7	–	–	–
483201120114501	06-13-01	11.3	23.6	701	386	.4	8.8	8.5	0	188
483216120202801	06-11-01	10.3	15.5	700	139	7.3	7.2	–	–	–
483234120194201	06-13-01	9.3	16.9	708	116	7.7	7.2	–	–	–
483248120104901	06-13-01	11.7	22.7	710	99	6.9	7.6	7.3	0	49
483327120214701	06-12-01	7.4	7.6	742	114	9.6	7.3	–	–	–
483457120240602	06-16-01	8.2	16	705	103	10	7.4	–	–	–
483505120230401	06-12-01	7.8	16.5	704	120	10.1	7.1	–	–	–
483540120252401	06-12-01	7.2	12.3	701	124	8.7	7.5	–	–	–
483540120241601	06-12-01	8.5	13	701	104	10.4	7.1	–	–	–
483609120263401	06-13-01	7.3	20.4	701	127	9.2	7.5	–	–	–
483620120265801	06-13-01	6.9	20.5	701	127	9.3	7.4	–	–	–
483635120263601	06-12-01	7.9	18.6	700	126	9.4	7.6	–	–	–
483704120273001	06-13-01	7.8	23.7	700	107	9.6	7.2	–	–	–
483839120291702	06-12-01	7.2	18.1	696	118	9.1	7.5	7.5	0	66
483843120300501	06-12-01	6.1	15.7	696	113	10	7.4	7.3	–	64

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[Abbreviations: °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; -, no data available; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Ammonia, filtered	Nitrite, filtered	Ammonia +	Ammonia	Nitrite plus nitrate, filtered	Phosphorus, unfiltered (mg/L)	Phosphorus, filtered (mg/L)	Orthophosphate, filtered (mg/L as phosphorus)	Calcium, filtered (mg/L)
				organic nitrogen, filtered	plus organic nitrogen, unfiltered					
GROUND WATER—Continued										
482243120144401	06-18-01	—	—	—	—	0.097	—	—	—	25.5
482245120070101	06-18-01	—	—	—	—	1.7	—	—	—	—
482246120161001	06-18-01	—	—	—	—	.163	—	—	—	20.4
482247120140701	06-18-01	—	—	—	—	.248	—	—	—	—
482438120082101	06-19-01	—	—	—	—	.116	—	—	—	—
482529120085801	06-18-01	—	—	—	—	1.69	—	—	—	38.3
482557120101601	06-19-01	—	—	—	—	1.81	—	—	—	—
482613120105401	06-16-01	—	—	—	—	4.03	—	—	—	—
482617120112701	06-19-01	—	—	—	—	1.4	—	—	—	—
482623120092601	06-19-01	—	—	—	—	.429	—	—	—	22.5
482642120085601	06-16-01	—	—	—	—	.036E	—	—	—	4.39
482644120084101	06-13-01	—	—	—	—	.895	—	—	—	—
482737120124001	06-12-01	—	—	—	—	.197	—	—	—	—
482748120101201	06-13-01	—	—	—	—	.351	—	—	—	—
482748120113701	06-12-01	—	—	—	—	< .050	—	—	—	—
482755120094601	06-12-01	—	—	—	—	.07	—	—	—	—
482806120122501	06-12-01	—	—	—	—	2.13	—	—	—	—
482818120120701	06-11-01	—	—	—	—	.312	—	—	—	—
482847120124701	06-11-01	—	—	—	—	.178	—	—	—	21.1
482834120122401	06-11-01	—	—	—	—	.257	—	—	—	—
482848120130301	06-12-01	—	—	—	—	.148	—	—	—	19.7
482857120124201	06-12-01	—	—	—	—	.96	—	—	—	24.9
482929120110401	06-13-01	—	—	—	—	3.71	—	—	—	38.1
482933120104201	06-14-01	—	—	—	—	.108	—	—	—	30.4
482954120154601	06-13-01	—	—	—	—	.128	—	—	—	—
483005120113901	06-14-01	—	—	—	—	.168	—	—	—	—
483040120102501	06-13-01	—	—	—	—	.028E	—	—	—	—
483050120172301	06-13-01	—	—	—	—	.048	—	—	—	—
483058120153301	06-13-01	—	—	—	—	.461	—	—	—	—
483119120163501	06-11-01	—	—	—	—	.299	—	—	—	—
483201120114501	06-13-01	—	—	—	—	.036E	—	—	—	7.1
483216120202801	06-11-01	—	—	—	—	.077	—	—	—	—
483234120194201	06-13-01	—	—	—	—	.088	—	—	—	—
483248120104901	06-13-01	—	—	—	—	.052	—	—	—	.13
483327120214701	06-12-01	—	—	—	—	.136	—	—	—	—
483457120240602	06-16-01	—	—	—	—	.131	—	—	—	—
483505120230401	06-12-01	—	—	—	—	.222	—	—	—	—
483540120252401	06-12-01	—	—	—	—	.064	—	—	—	—
483540120241601	06-12-01	—	—	—	—	.083	—	—	—	—
483609120263401	06-13-01	—	—	—	—	.065	—	—	—	—
483620120265801	06-13-01	—	—	—	—	.093	—	—	—	—
483635120263601	06-12-01	—	—	—	—	.09	—	—	—	—
483704120273001	06-13-01	—	—	—	—	.08	—	—	—	—
483839120291702	06-12-01	—	—	—	—	.068	—	—	—	18.8
483843120300501	06-12-01	—	—	—	—	.081	—	—	—	18.5

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; **mm**, millimeters; **cm**, centimeters; **mg**, milligrams; **mg/L**, milligrams per liter; **mg/L as N**, milligrams per liter as nitrogen; **µg/L**, micrograms per liter; +, plus; –, No data; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Magnesium, filtered (mg/L)	Sodium, filtered (mg/L)	Potassium, filtered (mg/L)	Chloride, filtered (mg/L)	Sulfate, filtered (mg/L)	Fluoride, filtered (mg/L)	Silica, filtered (mg/L)	Arsenic, filtered (µg/L)	Iron, filtered (µg/L)
GROUND WATER—Continued										
482243120144401	06-18-01	7.8	3.8	<0 .09	0.3	5	<0 .2	10.9	0.1E	< 10
482245120070101	06-18-01	–	–	–	1.4	–	–	–	–	–
482246120161001	06-18-01	6.76	3.1	.77	.3	4	< .2	11.3	.2E	< 10
482247120140701	06-18-01	–	–	–	.4	–	–	–	–	–
482438120082101	06-19-01	–	–	–	.2	–	–	–	–	–
482529120085801	06-18-01	9.3	6.6	< .09	.9	11	.1E	15.8	.3	< 10
482557120101601	06-19-01	–	–	–	1.5	–	–	–	–	–
482613120105401	06-16-01	–	–	–	1.8	–	–	–	–	–
482617120112701	06-19-01	–	–	–	1.3	–	–	–	–	–
482623120092601	06-19-01	4.13	3.4	.76	.5	6.9	.1E	12.5	.2	< 10
482642120085601	06-16-01	.2	73.1	.06E	.8	24.8	1.9	10.9	.1E	< 10
482644120084101	06-13-01	–	–	–	1.3	–	–	–	–	–
482737120124001	06-12-01	–	–	–	.6	–	–	–	–	–
482748120101201	06-13-01	–	–	–	.8	–	–	–	–	–
482748120113701	06-12-01	–	–	–	.4	–	–	–	–	–
482755120094601	06-12-01	–	–	–	1.3	–	–	–	–	–
482806120122501	06-12-01	–	–	–	1.3	–	–	–	–	–
482818120120701	06-11-01	–	–	–	.5	–	–	–	–	–
482847120124701	06-11-01	3.51	2.6	.41	.4	4.8	.2	10.4	.2	M
482834120122401	06-11-01	–	–	–	.4	–	–	–	–	–
482848120130301	06-12-01	3.06	2.6	.44	.3	4.5	.2	10.7	.2	< 10
482857120124201	06-12-01	4.48	4.1	.57	.4	10.2	.3	11.9	–	< 10
482929120110401	06-13-01	7.88	13.9	1.01	1.5	15.4	.2E	17.4	.2E	< 10
482933120104201	06-14-01	3.78	3.7	.73	.8	5.1	< .2	12.5	.3	< 10
482954120154601	06-13-01	–	–	–	.4	–	–	–	–	–
483005120113901	06-14-01	–	–	–	.9	–	–	–	–	–
483040120102501	06-13-01	–	–	–	1.1	–	–	–	–	–
483050120172301	06-13-01	–	–	–	4.6	–	–	–	–	–
483058120153301	06-13-01	–	–	–	.9	–	–	–	–	–
483119120163501	06-11-01	–	–	–	.6	–	–	–	–	–
483201120114501	06-13-01	.556	84.2	.14	.7	40	.3	11	.1E	< 10
483216120202801	06-11-01	–	–	–	.3	–	–	–	–	–
483234120194201	06-13-01	–	–	–	.3	–	–	–	–	–
483248120104901	06-13-01	.019	22.7	< .09	.2	8.9	.1E	13.8	.2E	< 10
483327120214701	06-12-01	–	–	–	.5	–	–	–	–	–
483457120240602	06-16-01	–	–	–	.6	–	–	–	–	–
483505120230401	06-12-01	–	–	–	.3	–	–	–	–	–
483540120252401	06-12-01	–	–	–	.3	–	–	–	–	–
483540120241601	06-12-01	–	–	–	.3	–	–	–	–	–
483609120263401	06-13-01	–	–	–	.5	–	–	–	–	–
483620120265801	06-13-01	–	–	–	.5	–	–	–	–	–
483635120263601	06-12-01	–	–	–	.4	–	–	–	–	–
483704120273001	06-13-01	–	–	–	.5	–	–	–	–	–
483839120291702	06-12-01	1.69	2.2	.32	.3	3.6	.3	8.6	.3	M
483843120300501	06-12-01	1.66	2	.33	.3	4	.2	7.6	.4	< 10

Table 17. Water-quality data for samples collected in the Methow River Basin, Okanogan County, Washington, water year 2001—*Continued*

[**Abbreviations:** °C, degrees Celsius; mm, millimeters; cm, centimeters; mg, milligrams; mg/L, milligrams per liter; mg/L as N, milligrams per liter as nitrogen; µg/L, micrograms per liter; +, plus; –, No data; E, estimated; M, presence of material verified but not quantified]

Site No.	Date	Lead, filtered (µg/L)	Manganese, filtered (µg/L)	Alkalinity, filtered, incremental titration, field (mg/L as calcium carbonate)	Residue on evaporation, dried at 180 °C, filtered (mg/L)	Bromide, filtered (mg/L)	Sample purpose (code)	Depth to water level (feet below land surface)	Specific conductance, unfiltered, laboratory (µS/cm at 25 °C)	Acid neutralizing capacity, unfiltered, fixed endpoint (pH 4.5) titration, laboratory (mg/L as calcium carbonate)
GROUND WATER—Continued										
482243120144401	06-18-01	2.01	< 3.0	95	116	<0 .01	–	41.41	200	–
482245120070101	06-18-01	–	–	–	–	–	–	25.37	–	–
482246120161001	06-18-01	.65	< 3.0	79	98	< .01	–	–	167	–
482247120140701	06-18-01	–	–	–	–	–	–	21.32	158	–
482438120082101	06-19-01	–	–	–	–	–	–	14.42	–	–
482529120085801	06-18-01	.6	< 3.0	130	172	< .01	–	27.91	287	–
482557120101601	06-19-01	–	–	–	–	–	–	–	454	–
482613120105401	06-16-01	–	–	–	–	–	–	77.68	–	–
482617120112701	06-19-01	–	–	–	–	–	–	–	–	–
482623120092601	06-19-01	.28	< 3.0	75	108	< .01	–	14.3	166	–
482642120085601	06-16-01	.23	3.2E	144	210	.01	–	84.02	345	–
482644120084101	06-13-01	–	–	–	–	–	–	15.02	508	–
482737120124001	06-12-01	–	–	–	–	–	–	216.91	–	–
482748120101201	06-13-01	–	–	–	–	–	–	22.6	–	–
482748120113701	06-12-01	–	–	–	–	–	–	63.59	–	–
482755120094601	06-12-01	–	–	–	–	–	–	59.91	–	–
482806120122501	06-12-01	–	–	–	–	–	–	60.56	–	–
482818120120701	06-11-01	–	–	–	–	–	–	10.01	–	–
482847120124701	06-11-01	.69	< 3.0	72	88	.02	–	19.81	149	–
482834120122401	06-11-01	–	–	–	–	–	–	13.6	–	–
482848120130301	06-12-01	.09	< 3.0	63	81	< .01	–	28.19	135	–
482857120124201	06-12-01	.1	< 3.0	74	110	< .01	–	7.73	180	–
482929120110401	06-13-01	.59	2.3E	132	197	< .01	–	68.66	319	–
482933120104201	06-14-01	.12	1.8E	96	116	< .01	–	–	195	–
482954120154601	06-13-01	–	–	–	–	–	–	–	146	–
483005120113901	06-14-01	–	–	–	–	–	–	–	692	–
483040120102501	06-13-01	–	–	–	–	–	–	50.49	566	–
483050120172301	06-13-01	–	–	–	–	–	–	–	275	–
483058120153301	06-13-01	–	–	–	–	–	–	13.66	–	–
483119120163501	06-11-01	–	–	–	–	–	–	9.38	–	–
483201120114501	06-13-01	< .08	< 3.0	154	233	< .01	–	–	383	–
483216120202801	06-11-01	–	–	–	–	–	–	10.35	–	–
483234120194201	06-13-01	–	–	–	–	–	–	5.44	118	–
483248120104901	06-13-01	.06E	< 3.0	41	68	< .01	–	–	101	–
483327120214701	06-12-01	–	–	–	–	–	–	33.84	–	–
483457120240602	06-16-01	–	–	–	–	–	–	16.38	–	–
483505120230401	06-12-01	–	–	–	–	–	–	43.44	119	–
483540120252401	06-12-01	–	–	–	–	–	–	15.26	–	–
483540120241601	06-12-01	–	–	–	–	–	–	15.83	103	–
483609120263401	06-13-01	–	–	–	–	–	–	12.05	128	–
483620120265801	06-13-01	–	–	–	–	–	–	15.9	–	–
483635120263601	06-12-01	–	–	–	–	–	–	22.82	127	–
483704120273001	06-13-01	–	–	–	–	–	–	10.24	–	–
483839120291702	06-12-01	.09	5.6	55	71	< .01	–	41.66	119	–
483843120300501	06-12-01	.1	< 3.0	52	64	< .01	–	10.48	109	–

Table 18. Discharge measurements at miscellaneous surface-water sites in the Methow River Basin, Okanogan County, Washington

[Latitude and longitude: Latitude and longitude at station, in degrees, minutes, and seconds referenced to NAD 27]

Site name	Latitude	Longitude	Date	Discharge (cubic feet per second)
	(degrees, minutes, seconds)			
Methow River and Tributaries				
Methow River above Robinson Creek (12447350)	48 39 30.1	120 32 36.8	09-13-01	16.6
Robinson Creek	48 39 42.4	120 32 22.2	09-13-01	6
Methow River below Robinson Creek			09-19-02	25
Methow River above Early Winters	48 36 04.3	120 26 18.8	09-13-01	3.5
Goat Creek (12447384)	48 34 53	120 22 42	09-18-01	.4
			04-16-02	94
			09-19-02	1.5
Methow River at Weeman Bridge (12447385)	48 32 39.8	120 19 21.7	09-12-01	29
			02-12-02	16
Methow River at Big Valley Wildlife Area	48 30 20.3	120 16 39.9	09-12-01	112
			02-12-02	107
			09-19-02	128
Methow River above Wolf Creek (12447386)	48 29 26.5	120 13 50.2	09-12-01	123
Methow River at river mile 48	48 27 01.5	120 09 44.3	09-12-01	140
Methow River above MVID East Diversion			09-17-02	211
Methow River below MVID East Diversion	48 25 06.8	120 08 29.9	09-12-01	107
			02-12-02	169
Methow River at river mile 43	48 23 45.4	120 08 16.9	09-12-01	151
			02-12-02	171
			04-15-02	1,566
			09-17-02	221
Methow River near Twisp Airport	48 20 44.3	120 05 45.7	09-12-01	188
			09-19-02	246
Methow River below Beaver Creek	48 19 21.7	120 03 46.0	09-12-01	226
			02-13-02	230
			09-17-02	280
Methow River below Benson Creek	48 17 30.4	120 04 01.6	09-02-01	256
			09-12-01	203
			02-13-02	246
			09-17-02	280
Methow River at Carlton	48 14 44.4	120 07 02.6	10-25-00	390
			02-02-01	241
			06-08-01	1,960
			07-18-01	678
			08-17-01	239
			09-12-01	220
Methow River below Burma Road	48 05 42.2	120 01 12.2	09-12-01	231
Libby Creek	48 15 07.0	120 09 28.0	10-24-01	5.6
			02-13-02	4.9
			09-17-02	3.2
Gold Creek	48 11 03.0	120 07 03.0	10-24-01	18
			02-13-02	14
			04-15-02	57
			09-17-02	6.7

Table 18. Discharge measurements at miscellaneous surface-water sites in the Methow River Basin, Okanogan County, Washington—*Continued*

[Latitude and longitude: Latitude and longitude at station, in degrees, minutes, and seconds referenced to NAD 27]

Site name	Latitude	Longitude	Date	Discharge (cubic feet per second)
	(degrees, minutes, seconds)			
Methow River and Tributaries—Continued				
Methow River above McFarland Creek	48 09 57.0	120 04 44.0	10-25-01	350
McFarland Creek	48 08 33.0	120 05 14.0	10-24-01	1.8
			09-17-02	3
Methow River below McFarland Creek	48 09 10.0	120 03 39.0	10-25-01	403
Methow River at Burma Road	48 06 02.0	120 01 16.0	10-25-01	377
			02-13-02	296
Squaw Creek	48 05 21.0	120 01 32.0	10-24-01	.83
Methow River above Black Canyon	48 05 03.0	120 00 50.0	10-25-01	369
			10-26-01	365
Methow River at Black Canyon	48 04 45.0	120 00 34.0	10-26-01	353
Black Canyon Creek	48 04 11.0	120 01 11.0	10-24-01	1.2
Twisp River and Tributaries				
Twisp River below Buttermilk Creek	48 21 51.0	120 20 06.6	09-11-01	25
			02-14-02	52
			09-18-02	35
Twisp River below TVPI Diversion	48 22 47.3	120 14 36.7	06-06-01	366
			07-16-01	110
			08-16-01	40
			09-11-01	19
			02-11-02	45
			04-15-02	473
Twisp River above Poorman Creek	48 22 20.5	120 12 00.8	09-18-02	29
			07-17-01	116
			07-26-01	77.3
			08-16-01	37.7
			09-11-01	25
			02-12-02	35
Poorman Creek	48 22 09.7	120 11 55.8	09-18-02	22
			05-10-01	1.01
Twisp River below MVID West Diversion	48 22 14.1	120 11 15.3	06-06-01	.32
			08-16-01	16.8
Twisp River near Elbow Canyon	48 22 07.3	120 10 32.8	09-11-01	24
			09-11-01	27.5

Table 19. Gains and losses under low-flow conditions for the Methow and Twisp Rivers in the Methow River Basin, Okanogan County, Washington, September 2001 and February and September 2002

[Sites listed in bold face are continuous-record streamflow-gaging stations; all others are miscellaneous sites]

Reach	Site name	River mile	September 2001					February 2002					September 2002						
			Mainstem flow (ft ³ /s)	Inflow (ft ³ /s)	Outflow (ft ³ /s)	Gain or loss from previous station (ft ³ /s)	Gain or loss as percent of streamflow	Mainstem flow (ft ³ /s)	Inflow (ft ³ /s)	Outflow (ft ³ /s)	Gain or loss from previous station (ft ³ /s)	Gain or loss as percent of streamflow	Mainstem flow (ft ³ /s)	Inflow (ft ³ /s)	Outflow (ft ³ /s)	Gain or loss from previous station (ft ³ /s)	Gain or loss as percent of streamflow		
A	Methow River above Robinson Creek	76	16.6																
	Robinson Creek	75		6.0															
	Methow River below Robinson Creek	74				15.5 E													
	Lost River	73		30.0				18.8											
	Methow above Early Winters Creek	70	3.5			0.0													
	Early Winters Creek	70		20.0					21										
Methow River above Goat Creek	66	0.0			0.0														
			Subtotal for Reach A =			-72.6													
B	Goat Creek			0.4				4.0E											
	Methow River at Weeman Bridge	62	29.0			16.1													
	Methow River at river mile 56	56	112.0			107.0													
	Methow River above Wolf Creek	54	123.0			118.0													
	Wolf Creek			3.2					4.2										
	Foghorn Diversion																15.0E		
Chewuch River			24.0					44.0									45.3		
Methow River at Winthrop	51	149.0			176.0												192.0		
			Subtotal for Reach B =			136.4												12.9	
C	Methow River at river mile 48	48	140.0															122.2	
	Methow River above MVID East Diversion	45																19.0	
	MVID East Diversion	45		21.0														12.0	
	Methow River below MVID East Diversion	45	107.0			169.0													
				Subtotal for Reach C =			-21.0												19.0
				Subtotal for Reach D =			59.0												22.0
D	Methow River at river mile 43	43	151.0			171.0												22.0	
	Twisp River	42		24.0														31.0	
	Methow River at Twisp	41	190.0			210.0												237.0	
				Subtotal for Reach D =			-2.0												7.0
E	Methow River at river mile 38 (Twisp Airport)	38	188.0			230.0												9.0	
	Beaver Creek			0.4														7.0	
	Methow River below Beaver Creek	36	226.0			230.0												27.0	
F			Subtotal for Reach E =			35.6												36.0	
	Methow River below Benson Creek	33	203.0			246.0												0.0	
			Subtotal for Reach F =			-23.0													0.0

Table 19. Gains and losses under low-flow conditions for the Methow and Twisp Rivers in the Methow River Basin, Okanogan County, Washington, September 2001 and February and September 2002—
Continued

Reach	Site name	River mile	September 2001				February 2002				September 2002						
			Mainstem stream-flow (ft ³ /s)	Inflow (ft ³ /s)	Outflow (ft ³ /s)	Gain or loss from previous station (ft ³ /s)	Gain or loss as percent- tage of streamflow	Mainstem stream-flow (ft ³ /s)	Inflow (ft ³ /s)	Outflow (ft ³ /s)	Gain or loss from previous station (ft ³ /s)	Gain or loss as percent- age of streamflow	Mainstem stream-flow (ft ³ /s)	Inflow (ft ³ /s)	Outflow (ft ³ /s)	Gain or loss from previous station (ft ³ /s)	Gain or loss as percent- age of streamflow
Methow River — Continued																	
G	Methow River at Carlton	28	220.0		17.0	17.0	8	254.0		8.0	8.0	3	282.7		2.7	2.7	1
			Subtotal for Reach G =				17.0			8.0					2.7		
H	Libby Creek			3.0 E													
	Gold Creek			8.8 E										3.2			
	Methow River below Burma Road	9	231.0		-0.8	-0.8	-0.3	296.0		23.3	23.3	8.5		6.7			
			Subtotal for Reach H =				-0.8			23.3							
I	Methow River near Pateros	6	239.0		5.0	5.0	2	282.0	3.0 E	-17.0	-17.0	-6	302.0	3.0 E	6.4	6.4	2
			Subtotal for Reach I =				5.0			-17.0					6.4		
	Net exchange				135.6	135.6	57			109.7	109.7	39			113.2	113.2	37
Twisp River																	
1	Twisp River below Buttermilk Creek	13.5	24.8		2.2	2.2	8	39.1	36.0	51.8	51.8		35.3				
	Twisp River above Newby	8.5	27.0		2.2	2.2			45.0	45.0		-13	39.0		3.7	3.7	9
			Subtotal for Reach 1 =				8.2			-6.8					3.7		
2	TVPI Diversion																
	Twisp River at fish weir	7.4	19.2		0.4	0.4	1	45.0				13	28.6		7.5		-7
	Twisp River above Poorman Creek	4.8	25.0		5.8	5.8	23		34.7			-0.2	35.8		7.2	7.2	20
			Subtotal for Reach 2 =				6.2								4.3		
3	MVID West Diversion																
	Twisp River below MVID West Diversion	4.1	24.0		-1.0	-1.0	-4						22.0		0.4	0.4	2
	Twisp River near Elbow Canyon (ponds on left floodplain)	3.5	27.5		3.5	3.5	13										
	TVPI return flow			1.5													
	Twisp River near Twisp	1.9	33.0		4.0	4.0	12	39.0				11	32.0	1.6	8.4	8.4	26
			Subtotal for Reach 3 =				6.5			4.3					8.8		
	Net exchange				14.9	14.9	45			-3.8	-3.8	-7			16.8	16.8	52

Table 20. Measurements of discharge from irrigation canals in the Methow River Basin, Okanogan County, Washington, June 2001 and May-July 2002

[Latitude and longitude: Latitude and longitude at station, in degrees, minutes, and seconds referenced to NAD27]

Description of discharge measurement location	Latitude	Longitude	Township Range	Section	Quarter-quarter section	Date	Discharge (ft ³ /s)						
Batie Canal													
50 feet downstream from fish screen, 4.2 miles northeast of Twisp	48 23 49.0	120 02 38.0	T34N R22E	35	SW SE	05-09-02	3.1						
0.35 mile downstream from diversion	48 23 38.0	120 02 42.5	T33N R22E	2	NW NE	05-09-02	2.9						
0.4 mile downstream from diversion	48 23 54.4	120 02 44.8	T33N R22E	2	NW NE	05-09-02	2.3						
0.8 mile downstream from diversion	48 23 19.3	120 02 40.7	T33N R22E	2	NW NE	05-09-02	2.6						
30 feet downstream from #4	48 23 17.6	120 02 40.8	T33N R22E	2	NW NE	05-09-02	1.9						
1.05 miles downstream from diversion	48 23 01.8	120 02 39.1	T33N R22E	2	SE SW	05-09-02	1.8						
150 feet downstream from # 6	48 23 00.9	120 02 40.0	T33N R22E	2	SE SW	05-09-02	1.5						
End of diversion, 850 feet downstream of # 7	48 22 54.0	120 02 33.5	T33N R22E	2	SE SW	05-09-02	1.2						
Chewuch Canal													
50 feet downstream from headgate, 6.2 miles north of Winthrop	48 34 0.6	120 10 36.8	T35N R21E	2	NW NE	06-20-01	41.9						
						05-08-02	25.3						
						07-16-02	27.9						
0.3 mile upstream from Ramsey Creek, on East Chewuch Road	48 33 39.6	120 10 31.7	T35N R21E	2	SE SW	06-20-01	41.0						
						05-08-02	24.7						
						07-16-02	29.6						
0.2 mile downstream from Ramsey Creek, on East Chewuch Road	48 33 13.3	120 10 46.4	T35N R21E	11	NW NW	06-14-01	36.4						
						05-08-02	22.0						
						07-16-02	26.0						
Downstream from culvert on East Chewuch Road, 3.6 miles north of Winthrop	48 31 43.7	120 10 45	T35N R21E	14	SW SE	06-20-01	31.7						
						05-08-02	20.0						
						07-16-02	23.8						
On Red Dog Road, 10 feet upstream from siphons	48 30 56.3	120 10 50.4	T35N R21E	23	SW SW	06-20-01	28.7						
						05-08-02	21.7						
						07-16-02	21.8						
On Red Dog Road, 10 feet downstream from siphons	48 30 55.1	120 10 49.3	T35N R21E	23	SW SW	05-08-02	19.9						
						Dempsey Drop, 1.7 miles north of Winthrop	48 30 5.4	120 10 28.5	T35N R21E	26	SE SW	05-08-02	20.4
												07-16-02	20.1
0.1 mile downstream from Lake Creek	48 29 38.8	120 10 36.4	T35N R21E	35	NW NE	06-20-01	22.2						
						05-10-02	12.8						
						07-16-02	16.8						
Downstream from Pearrygin Lake, above Winthrop	48 29 00	120 10 38	T35N R21E	35	SW SE	06-20-01	17.4						
						05-10-02	11.8						
						07-16-02	15.0						
On Eastside Road, 1.0 mile southeast of Winthrop	48 28 00	120 09 50.6	T34N R21E	12	NW NW	06-20-01	14.5						
						05-10-02	11.5						
						07-16-02	12.8						
Upstream from Bear Creek spillway at Boesel Farm, 2.4 miles southeast of Winthrop	48 27 16.7	120 8 40.8	T34N R22E	18	NW NW	05-10-02	8.6						
						07-16-02	8.7						
Downstream from Bear Creek spillway at Boesel Farm, 2.4 miles southeast of Winthrop	48 27 16.4	120 8 39.7	T34N R22E	18	NW NW	06-20-01	10.1						
						05-10-02	4.8						
						07-16-02	8.1						
0.6 mile downstream from Bear Creek, on Eastside Road	48 26 33.3	120 8 38.4	T34N R21E	13	SE SE	06-20-01	8.6						
						05-10-02	3.6						
						07-16-02	6.7						
End of diversion, 1.4 miles downstream from Bear Creek	48 25 53.9	120 08 20.8	T34N R22E	19	NW SW	06-20-01	4.3						
						05-10-02	2.0						

Table 20. Measurements of discharge from irrigation canals in the Methow River Basin, Okanogan County, Washington, June 2001 and May-July 2002–*Continued*

Description of discharge measurement location	Latitude	Longitude	Township Range	Section	Quarter-quarter section	Date	Discharge (ft ³ /s)
Foghorn Canal							
20 feet downstream from headgate, at National Fish Hatchery	48 28 22.2	120 11 24.4	T34N R21E	3	SE NE	05-07-02	24.4
						07-17-02	19.9
0.2 mile downstream from headgate at end of hatchery	48 28 19.5	120 11 11.3	T34N R21E	2	SW SW	07-17-02	18.6
Side lateral off Foghorn Ditch, 0.4 mile downstream from headgate	48 28 12.6	120 10 40.9	T34N R21E	2	SW SE	05-07-02	.6
						07-17-02	1.2
5 feet upstream from siphon, 1.0 mile downstream from headgate on Highway 20, 0.9 mile southeast of Winthrop	48 27 54.0	120 10 23.1	T34N R21E	11	NE NW	05-07-02	20.2
						07-17-02	15.2
5 feet downstream from siphon, 1.0 mile downstream from headgate on Highway 20, 0.9 mile southeast of Winthrop	48 27 53.1	120 10 22.5	T34N R21E	11	NE NW	05-07-02	16.9
						07-17-02	13.3
20 feet upstream from spillway on Highway 20, 0.3 mile upstream from Bear Creek	48 27 07.4	120 09 50.7	T34N R21E	13	NW NW	05-07-02	13.1
						07-17-02	11.1
20 feet downstream from spillway on Highway 20, 0.3 mile upstream from Bear Creek	48 27 03.6	120 09 48.6	T34N R21E	13	NW NW	05-07-02	10.6
						07-17-02	7.9
20 feet upstream from siphon at Twin Lakes Road and Highway 20	48 26 19.6	120 09 49.0	T34N R21E	24	NW NW	05-07-02	8.1
						07-17-02	5.9
20 feet downstream from siphon at Twin Lakes Road and Highway 20	48 26 18.2	120 09 48.7	T34N R21E	24	NW NW	05-07-02	6.3
10 feet upstream from second siphon, 1.0 mile downstream from Bear Creek	48 26 02.3	120 09 46.9	T34N R21E	24	NW SW	05-07-02	4.7
						07-17-02	5.1
20 feet downstream from second siphon, 1.0 mile downstream from Bear Creek	48 26 03.3	120 09 47.8	T34N R21E	24	NW SW	07-05-02	4.0
						07-17-02	4.2
End of diversion at Methodist Church	48 25 18.0	120 09 13.9	T34N R21E	25	NW NE	07-05-02	1.5
						07-17-02	1.4
Fulton Canal							
30 feet downstream from headgate, 0.4 mile north of Winthrop	48 28 58.6	120 10 54.6	T34N R21E	2	NW NW	06-19-01	16.2
						05-09-02	15.3
						07-18-02	17.5
0.21 mile downstream from headgate, upstream from siphon	48 28 57.5	120 11 10.5	T34N R21E	2	NW NW	06-19-01	14.5
						05-09-02	15.7
						07-18-02	17.3
Duck Brand Inn at Winthrop	48 28 38.3	120 10 56.5	T34N R21E	2	NW SW	06-19-01	13.6
						05-09-02	11.4
						07-18-02	12.7
At intersection of Washington Street and Castle Avenue in Winthrop	48 28 20.6	120 10 24.4	T34N R21E	2	SE SW	06-19-01	13.9
						05-09-02	11.8
						07-18-02	10.9
On Eastside Road, 1.0 mile southeast of Winthrop	48 27 51	120 09 50	T34N R21E	12	NW NW	06-19-01	11.2
						05-09-02	11.3
						07-18-02	11.4
0.4 mile upstream from Bear Creek	48 27 18.4	120 09 17.9	T34N R21E	12	SW SE	07-18-02	9.0
Upstream from spillway at Bear Creek Road	48 27 10.0	120 9 18.6	T34N R21E	13	NW NE	05-09-02	8.7
						07-18-02	6.3
Downstream from spillway at Bear Creek Road	48 27 10.0	120 9 18.6	T34N R21E	13	NW NE	06-19-01	5.9
						05-09-02	6.8
						07-18-02	4.6
At downstream weir, 0.5 mile downstream of Bear Creek	48 26 31.5	120 09 08.4	T34N R21E	13	SE SW	06-19-01	4.4
						05-09-02	5.9
						07-18-02	2.3

Table 20. Measurements of discharge from irrigation canals in the Methow River Basin, Okanogan County, Washington, June 2001 and May-July 2002–
Continued

Description of discharge measurement location	Latitude	Longitude	Township Range	Section	Quarter-quarter section	Date	Discharge (ft ³ /s)
Red Shirt Canal							
300 feet downstream from headgate, 3.6 miles northeast of Twisp	48 22 53.9	120 02 48.7	T33N R22E	2	SW SE	05-09-02	1.0
Upstream from Beaver Creek Road	48 22 42.8	120 02 36.3	T33N R22E	11	NE NW	05-09-02	.4
End of ditch	48 22 26.9	120 02 16.8	T33N R22E	11	NE SE	05-09-02	.5
Skyline Canal							
50 feet downstream from pipe, 3.4 miles north of Winthrop	48 31 37.8	120 11 26.6	T35N R21E	15	SE SW	05-10-02	5.8
						07-15-02	4.7
0.64 mile downstream from pipe	48 31 03.0	120 11 29.7	T35N R21E	22	SE NW	05-10-02	3.9
						07-15-02	3.0
End of unlined section, 0.9 mile downstream from pipe	48 28 22.2	120 11 24.4	T35N R21E	22	SE SW	05-10-02	2.8
						07-15-02	2.1
Stokes Canal							
Downstream from headgate, 3.7 miles northeast of Twisp	48 22 48.1	120 02 50.0	T33N R22E	2	SW SE	05-09-02	1.6
0.3 mile downstream of headgate	48 22 36.7	120 02 49.3	T33N R22E	11	NW SE	05-09-02	1.3
30 feet upstream from pipe	48 22 29.0	120 02 43.6	T33N R22E	11	NW SE	05-09-02	.9
Eight Mile Canal							
110 feet downstream of culvert	48 36 16	120 10 09	T36N R21E	23	SE NW	06-18-01	4.1
Upstream of 8 Mile Ranch turn-in	48 35 55	120 10 02	T36N R21E	26	NE NE	06-18-01	2.3
Foster Canal							
20 feet downstream of flume	48 35 09	120 22 30	T36N R20E	29	SW SE	06-18-01	4.8
200 feet -250 feet upstream of lake	48 35 02	120 23 13	T36N R20E	31	NE NW	06-18-01	3.7
McKinney Mtn Canal							
Below screen	48 33 16	120 20 51	T35N R20E	9	NE NW	06-21-01	2.3
End of dredged section	48 33 15	120 20 48	T35N R20E	9	NE NW	06-21-01	1.0
Near Highway 20	48 33 10	120 20 47	T35N R20E	9	SE SW	06-21-01	.7
Rockview Canal							
Below screen	48 32 22	120 19 03	T35N R20E	14	NW NW	06-20-01	9.0
Above turnout	48 32 15	120 18 47	T35N R20E	14	NW NW	06-20-01	7.6
Below turnout	48 31 58	120 18 19	T35N R20E	14	SE NW	06-20-01	5.4
Downstream point in hay field	48 31 46	120 17 45	T35N R20E	14	SE SE	06-20-01	5.4

Table 21. Measured seepage rates from irrigation canals in the Methow River Basin, Okanogan County, Washington

[Total measured loss rate: Mean values in bold for canals where multiple seepage runs were made]

Irrigation canal	Length of canal (miles)	Total measured loss rate (cubic feet per second)		Seepage rate (cubic feet per second per mile)	
		May to August	September to October	May to August	September to October
Twisp Valley Power and Irrigation Company	3.17	4.6	2.5	1.4	0.8
Methow Valley Irrigation District, west	3.13	3.3	1.8	1.0	.6
Eightmile	.44	1.8		4.1	
Foster	.56	1.1		2.0	
McKinney Mountain	.15	1.6		10.7	
Rockview	1.25	3.6		2.9	
Chewuch	10.0	16.2		1.6	
Fulton	3.23	4.9		1.5	
Skyline	1.03	2.8		2.7	
Foghorn	4.78	12.4		2.6	
Red Shirt	.48	.5		1.0	
Stokes	.62	.7		1.1	
Batie	1.12	1.6		1.4	
Totals	30.0	55.1			
Mean seepage rates				1.8	0.7



Konrad and others

Hydrogeology of the Unconsolidated Sediments, Water Quality, and Ground-Water/Surface-Water
Exchanges in the Methow River Basin, Okanogan County, Washington

WRIIR 03-4244