

WATER-SUPPLY AQUIFERS AT EAGLE RIVER, ALASKA

By James A. Munter and Roger D. Allely



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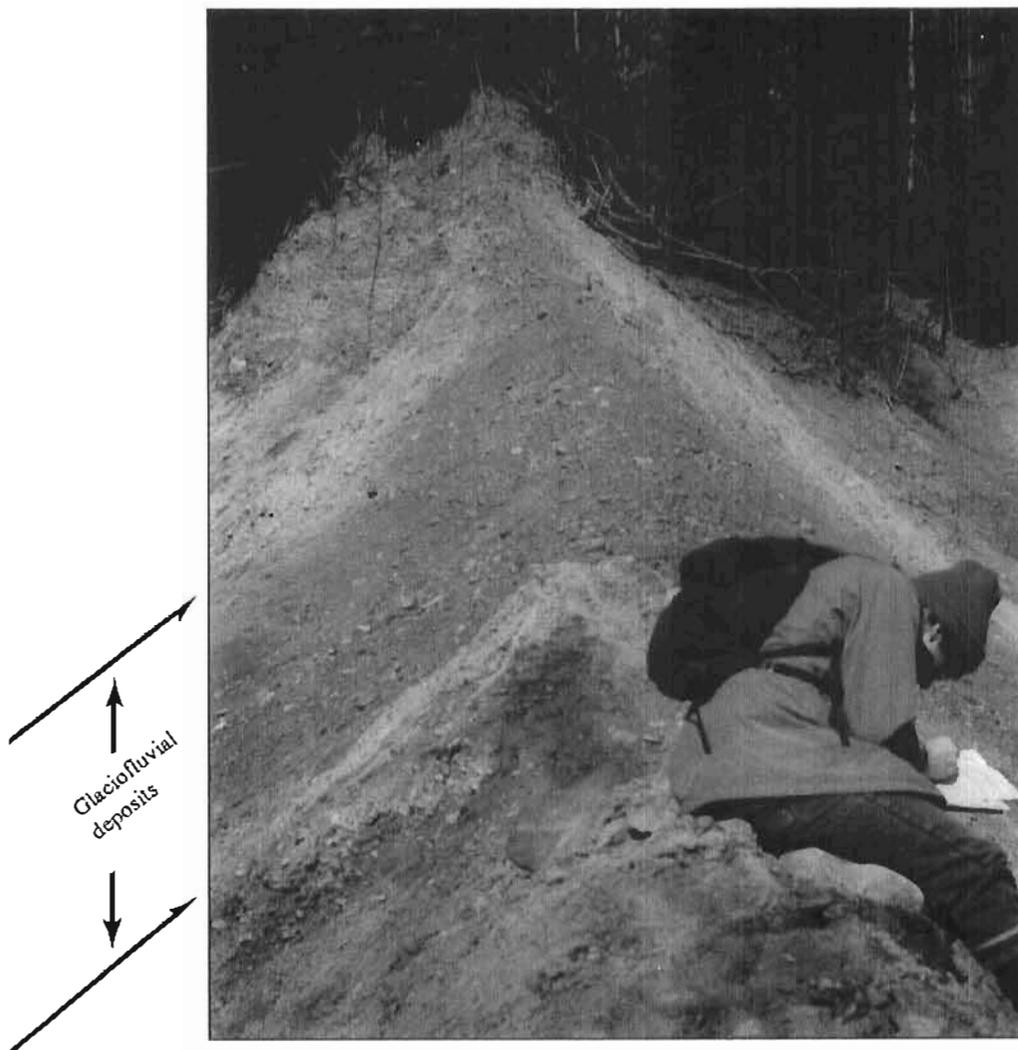
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
In cooperation with the Division of Water

Winter 1992



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Glaciofluvial deposits of Eagleridge aquifer, overlain by till and underlain by confining unit of silty diamicton. Photo taken at measured-section location (sheet 1) by Jim Munter.

Cover: Eagle River Midvalley area, Glenn Highway in foreground, Meadow Creek in background. Photo by Stan Carrick

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By

James A. Munter¹ and Roger D. Allely¹

ABSTRACT

Ground water for domestic and commercial use in Eagle River, Alaska, is obtained from both bedrock and nonlithified aquifers. Most of it is obtained from confined sand-and-gravel aquifers occurring within glacial, glaciostuvial, and glaciolacustrine sediments up to 700 ft thick. Ground water is also obtained from a shallow glacioalluvial aquifer and sedimentary and metamorphic bedrock aquifers. As a result of rapid population growth during the early 1980's, the community of Eagle River experienced an increase in ground-water use, synchronous water-level declines in two confined aquifers, and failure of private domestic wells. The water-level declines and well failures were restricted to an area within a 1-mi radius of primary production wells tapping the confined aquifers. Although water is currently imported to the most densely developed area of Eagle River from a remote surface water source (Eklutna Lake), most of the Eagle River area continues to rely on local ground water for residential water supply. In most of these areas, ground-water resources are likely to remain adequate for local water-supply requirements.

INTRODUCTION

The community of Eagle River, Alaska (fig. 1) grew rapidly during the early 1980's, primarily through residential and light commercial expansion. Growth was initially facilitated by an increased reliance on local ground-water supplies obtained from unconfined and confined sand and gravel aquifers, and bedrock aquifers (Munter, 1984). From 1982 to 1987, ground-water resources in parts of Eagle River were significantly stressed by pumpage, resulting in conflicts over limited water supplies (Munter and Prokosch, 1985) and well failures (Munter, 1989). During the same period, numerous small independent water systems were consolidated under ownership of the Anchorage Water and Wastewater Utility (AWWU) to improve water service, and surface-water supplies were piped from Ship Creek in Anchorage to Eagle River to supplement local ground-water supplies. Presently (1990), most developed areas in the Eagle River valley rely on local ground water either from individual domestic wells or from a few privately owned public-supply wells. This report describes aquifers at Eagle River used for ground-water supplies. Information for the report was obtained from stratigraphic test drilling, examining available well records and aquifer test information, collecting water-level data, interviewing well owners, and reviewing relevant historic data.

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For this report, the community of Eagle River is divided into the upper-valley, midvalley, and lower-valley areas (fig. 1). The upper-valley area, including South Fork Eagle River valley, had a population of 2,323 in 1988 (Municipality of Anchorage, 1989); water supplies here are almost exclusively obtained from individual domestic wells. The midvalley area (1988 population of 14,106) is where most ground-water problems have occurred; fortunately, it also has the most ground-water data available. The commercial district and some residential neighborhoods in the midvalley area are connected to public water and sewer systems. The lower valley area is largely unpopulated and consists mostly of Fort Richardson Military Reservation property.

Zenone and others (1974) presented a variety of geologic and ground-water information for the Eagle River area, including numerous chemical analyses of ground water. Natural concentrations of common inorganic constituents were consistently found to be acceptable for domestic use. Natural-water chemistry is not further addressed in this report.

PHYSICAL SETTING

The 30-mi-long Eagle River valley is one of the largest valleys in the western Chugach Mountains (fig. 1). Eagle Glacier is the source of Eagle River. The glacier covers 7 percent of the river's 232-mi² drainage area, and numerous small side-valley glaciers cover an additional 5 percent of the basin. The river flows through a 0.5- to 2-mi-wide, U-shaped glacial valley for about 20 mi, then emerges to flow for about 6 mi through glaciated lowlands before entering Knik Arm of Cook Inlet (fig. 2). The largest tributary of Eagle River is South Fork Eagle River, which enters the main stem 9 mi upstream from Knik Arm. Two small glaciers feed South Fork Eagle River. Meadow Creek, the second largest tributary, is a nonglacier-fed stream that enters Eagle River from the north, near the Glenn Highway.

BEDROCK GEOLOGY

Both sedimentary and metamorphic rocks are exposed in the Eagle River area. These rocks are overlain by a mantle of nonlithified deposits that is thin to absent in mountainous areas and some lowland localities but up to 700 ft thick in the Eagle River valley. Both sedimentary and metamorphic rocks are termed "bedrock" in this report.

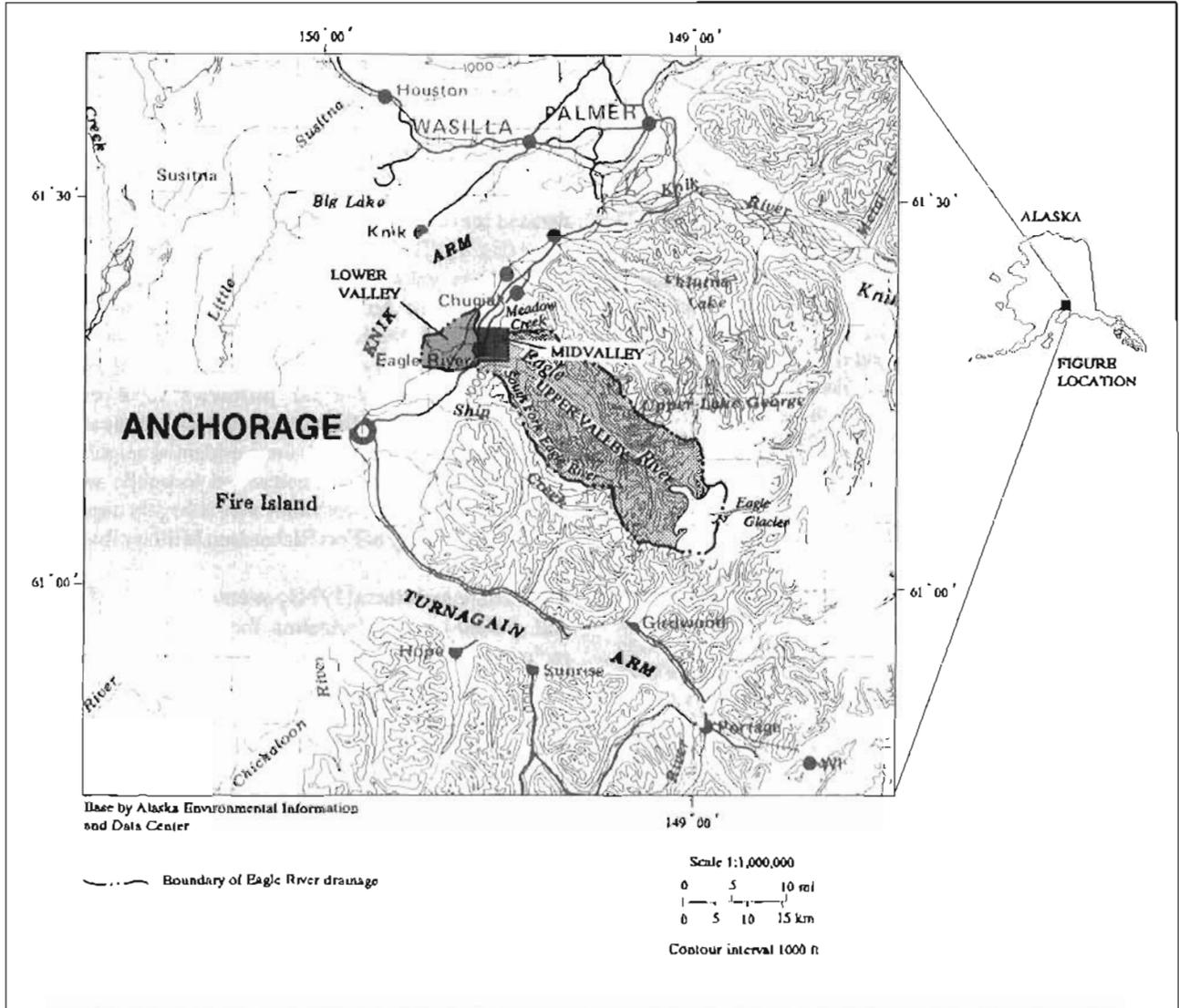


Figure 1. Location map of the community of Eagle River and the Eagle River drainage area.

Rocks of the Chugach Mountains near Eagle River (fig. 3) are metamorphic and consist mostly of the McHugh Complex and the Valdez Group of Mesozoic age (Clark, 1972a; Tysdal and Plafker, 1978). The McHugh Complex consists of a deformed metaclastic sequence (siltstone, graywacke, arkose, conglomeratic sandstone) that is chaotically juxtaposed with a metavolcanic sequence (greenstones, metachert, cherty argillite, argillite) (Clarke, 1973). The Valdez Group in this area consists mostly of metagraywacke, siltite, and argillite (Clark, 1972a). These Mesozoic rocks at Eagle River are bounded on the northwest by the Border Ranges fault zone (MacKevett and Plafker, 1974), which is locally called Knik fault (Clark, 1972a). Plafker and Campbell (1978) describe the Border Ranges fault zone as "a major tectonic boundary in southern Alaska that defines the landward margin of an oceanic accretionary

terrane of Mesozoic age." The Mesozoic rocks have been accreted to an assemblage of Permian to Jurassic rocks that are part of the lithologically diverse Peninsular tectonostratigraphic terrane (Jones and Silberling, 1979; Plafker and others, 1989). Locally, the Permian to Jurassic rocks are named the Thunderbird Complex and are described by Updike and Ulery (1983). These rocks are exposed only at a few locations in a narrow band along the base of the Chugach Mountains north of Meadow Creek (map unit JPU, fig. 3).

The lowlands near Knik Arm are underlain by Tertiary sedimentary rocks, chiefly siltstone, sandstone, and lignite. Wolfe and others (1966) correlated leaf fossils from exposures in the lower Eagle River valley with the Oligocene to Miocene Tyonek Formation of the Kenai Group. The lithology, structure, and juxtaposition of local exposures

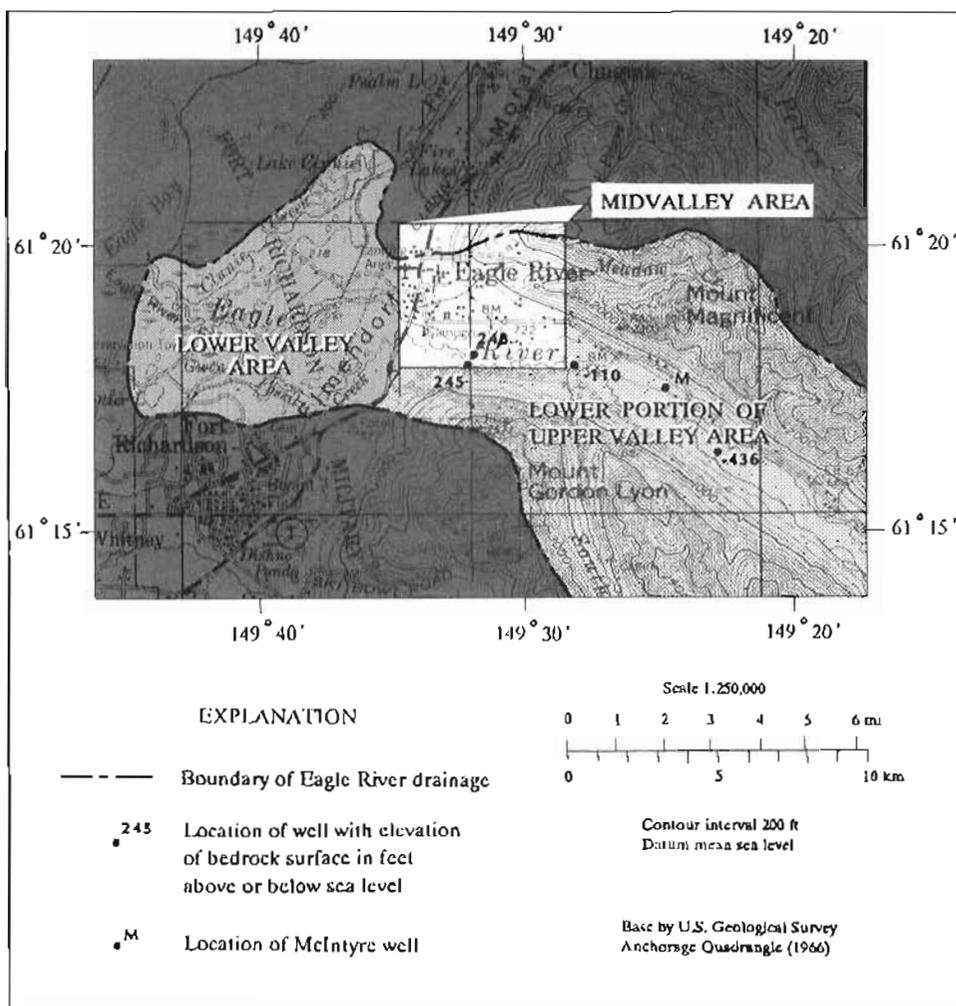


Figure 2. Location map of the Eagle River mid-valley area with elevations of the top of the bedrock surface in selected deep wells.

suggest that the Kenai Group rocks may be faulted against pre-Tertiary rocks, possibly by Tertiary activity of the Border Ranges fault zone.

GLACIAL GEOLOGY

The Cook Inlet area has been glaciated numerous times during the Pleistocene (Karlstrom, 1964; Schmoll and Yehle, 1986) and possibly during the late Tertiary (Schmoll and others, 1984). Low mountain flanks near Eagle River are typically mantled with moraines and colluvial deposits, and lowlands are covered with moraines, alluvium, glacioalluvium, lake-bed deposits, and other types of drift (Schmoll and others, 1980; Yehle and Schmoll, 1989). The occurrence of several different levels of lake-bed erosional features in Eagle River valley (Schmoll and others, 1980; Yehle and Schmoll, 1988; 1989; Yehle and others, 1990) provides evidence that glacier-dammed lakes have formed repeatedly during the Quaternary history of the valley. Yehle and Schmoll (1989) and Yehle and others (1990) provide additional details of the geologic history of the

Eagle River area. Comparisons of geologic and hydrogeologic units in Eagle River are shown in figure 4.

The stratigraphy of Quaternary deposits in the midvalley area is significant because numerous public and individual-domestic water-supply wells occur in that area. Cross sections through the midvalley area show major hydrostratigraphic units and water-level data (see sheet 1). The cross sections are based on interpretation of well drillers' logs, measurements of static water levels, stratigraphic test drilling, and examination of natural exposures. The following discussion of geologic deposits at Eagle River is presented to provide a framework for the description of aquifers in subsequent sections of the report.

Sheets 1 and 2 present locations and descriptions of measured stratigraphic sections at a bluff along the Eagle River and results of stratigraphic test drilling about 600 ft to the north-northeast. Test drilling was done with an air-rotary rig equipped with a drive-through hammer, which allowed 6-in.-diam steel casing to be advanced with the boreholes. The first hole drilled at the site, test hole ER3,

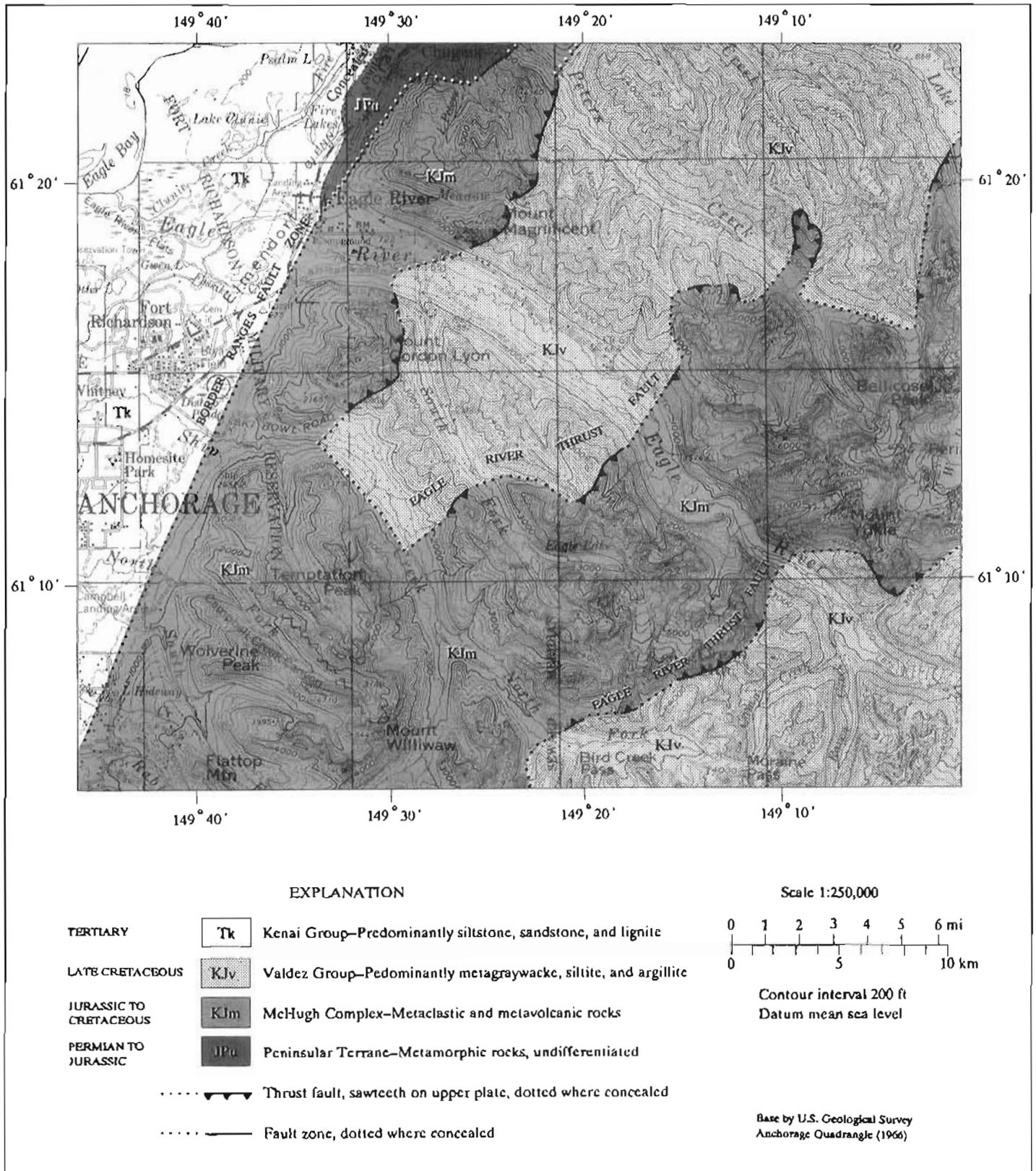


Figure 3. Generalized bedrock geology of the Eagle River area (after Clark, 1972a; and Jones and Silberling, 1979).

Erathem	System	Series	Stratigraphic unit	Thickness (feet)	Lithology	Aquifer	
CENOZOIC	QUATERNARY	Holocene	Unnamed alluvial, colluvial and bog deposits	0-20(?)	Sand and gravel, diamicton, peat and silt, with some cobbles and boulders		
		Pleistocene	Clunie Creek glaciofluvial deposits and kame-channel deposits of the Elmendorf moraine	40-130	Sand and gravel with cobbles and boulders	Clunie Creek aquifer	
			Till (including Elmendorf moraine), glaciofluvial, alluvial fan, colluvial, and lacustrine or marine deposits	0-700	Diamicton, sand and gravel, sand and gravel with boulders, silt cobbles and silty clay	Ravenwood aquifer Hylen Crest aquifer Eagle Ridge aquifer Midvalley aquifer	
		TERTIARY	Miocene	Kenai Group (Tyonek Formation)	Unknown	Siltstone, sandstone, lignite and conglomerate	Unconformity
			Oligocene				
	MESOZOIC	CRETACEOUS	Valdez Group and McHugh complex	Unknown	Metaclastic and metavolcanic rocks	Unconformity	Bedrock aquifer
		JURASSIC					
		TRIASSIC	Peninsular terrane	Unknown	Undifferentiated metamorphic rocks		
	PALEOZOIC	PERMIAN					

Figure 4. Comparisons of geologic and hydrogeologic units at Eagle River.

was logged by visual examination of cutting returns and with borehole geophysical instruments (sheet 2). Attempts to set a screen in the hole failed and the hole was subsequently abandoned. Wells ER4S and ER4D, drilled 11 ft northwest of well ER3, were drilled and completed as a dual-completion installation with open intervals from 126 ft to 129 ft below land surface and at 219 ft below land surface, respectively. Well ER5, drilled 10 ft west of well ER3 and 8 ft south of wells ER4S and ER4D, was completed as an observation well with an open interval at a depth of 263 to 268 ft below land surface.

The measured section shown in sheet 2 is divided into three distinct geologic units (youngest to oldest): till, glaciofluvial deposits, and undifferentiated drift.

Much of the lowland of the midvalley area is mantled with ground moraines (map unit Qmg, shown by Schmoll and others, 1980) that correlate with the till observed in the measured section (sheet 2). Reger and Updike (1983) assigned an age of late Wisconsinan to surficial deposits of this area, and this age is consistent with the conclusion of Schmoll and others (1980) that the upper part of map unit Qmg correlates with deposits in the Elmendorf moraine southwest of Eagle River. The Elmendorf moraine is an end moraine caused by the advance of the Knik-Matanuska glacial lobe (Schmoll and others, 1984) during the late stage of the Naptowne Glaciation, which ended approximately 10,000 to 11,000 yr ago (Reger and Updike, 1983). Sheet 1 shows the thickness of nonlithified deposits in the midvalley area. Nonlithified deposits are up to 700 ft thick where the Elmendorf moraine deposits (and older nonlithified deposits) overlie a bedrock low in the eastern part of the midvalley area.

The glaciofluvial deposits lying immediately beneath the till at the measured section (sheet 2) are interpreted to be advance outwash deposits of the glaciation that produced the Elmendorf moraine. The unit does not correlate with any surficial map units of Schmoll and others (1980) or Yehle and Schmoll (1989), but it does correlate with an advance outwash deposit shown in map and cross-section views by Miller and Dobrovolsky (1959) and by Yehle and others (1990) near the mouth of the Eagle River and with an advance outwash unit mentioned by Reger and Updike (1983) near the Glenn Highway bridge over the Eagle River. Karlstrom (1964) also notes the existence of an advance outwash unit under the Elmendorf moraine on the west side of Knik Arm. The till and glaciofluvial deposits observed in the bluff exposure are correlated with sediments observed in the upper 132 ft of test hole ER3. The glaciofluvial deposits are interpreted to be of late Wisconsinan age.

The undifferentiated drift observed at the measured section (sheet 2) consists of sand and sandy gravel units below a silty diamicton. Nearby subsurface data indicate that multiple sand and gravel units occur within a sequence of sandy and gravelly silt units. In places, the sand and

gravel units are 20 ft or more thick. Schmoll and others (1980) mapped this outcrop of drift and a similar exposure located 1 mi northwest as interglacial pond deposits. Sediments from that exposure, which may correlate with the drift observed in the measured section, were radiocarbon-dated as older than 38,000 yr B.P. (Marsters and others, 1969), which is older than the overlying Elmendorf moraine and advance outwash deposits. The thickness, lithology, and extent of the undifferentiated drift deposits described in this report indicate that at least part or possibly all of the unit results from lacustrine or marine deposition and subaqueous proglacial delta or outwash deposition. In the absence of more detailed information, the undifferentiated drift is assigned an age of pre-late Wisconsinan for this report.

The undifferentiated drift unit described in sheet 2 may correlate with thick accumulations of silty sediment observed in the subsurface east of the measured section (Dearborn, 1977; CH2M Hill, 1981; Deeter and George, 1982). The sediments at the measured section differ significantly from their eastern counterparts by showing a much greater proportion of sands and gravels. The higher percentage of sands and gravels in the midvalley areas compared to the upper-valley areas may be attributable to active sedimentation occurring near the confluence of four glacial valleys (Knik Arm, Eagle River, Meadow Creek, South Fork Eagle River) in the midvalley area, rather than quiet-water lacustrine or marine deposition farther upvalley.

GROUND-WATER RESOURCES OF THE UPPER EAGLE RIVER VALLEY

A series of water-resource investigations have used geophysics, low-flow investigations, and test drilling to characterize ground-water supply potential in the upper Eagle River valley (Dearborn, 1977; R&M Consultants, 1979; Dearborn and Schaefer, 1981; CH2M Hill, 1981; Deeter and George, 1982; Smith and Robertson & Associates, 1983). Although the metamorphic bedrock surface is well below present-day sea level in the upper valley, most of the valley-fill sediments are silty, and no prolific valleywide aquifers have been discovered. Most residents of the area obtain water from metamorphic bedrock aquifers or sand-and-gravel aquifers located on the flanks of the Eagle River or South Fork Eagle River valleys. These aquifers have not been studied. L.L. Dearborn (U.S. Geological Survey, written commun., 1980) observed that most of the upper valley sediments apparently consist of silty lacustrine or marine sediments, but that valley-marginal alluvial fans could be significant aquifers.

One such valley-marginal alluvial fan, at the McIntyre location (fig. 2), may have significant potential ground-water resources. A well drilled May 21, 1982, reportedly

penetrated "blue clay" from 52 to 121 ft below land surface and yielded 500 gal/min of water from "sand, gravel, and water" that occurs at a depth of 125 ft to 134 ft. The original static water level was reported to be more than 21 ft above land surface (C.J. McIntyre, oral commun., 1982). During a field visit by DGGs on June 2, 1982, several springs were noted near the well, some of which may have been created as a result of well drilling. An attempt to set a screen in the well failed, and the soil within a 30-ft radius around the casing suddenly collapsed, causing the drilling rig to tip into the resulting hole. The rig and well casing were removed and the hole was filled with 700 yd³ of gravelly fill (C.J. McIntyre, oral commun., 1985). A second well was drilled to a depth of 134 ft at the same location (possibly in the same borehole) during January and February 1983 and had a reported artesian flow rate of 160 gal/min and an estimated well yield of 450 gal/min. As of 1989, no aquifer testing had been performed at the McIntyre location to assess the developable capacity of this alluvial fan aquifer (D. Tubbs, Eklutna, Inc., oral commun., 1989).

GROUND-WATER RESOURCES OF THE EAGLE RIVER MIDVALLEY AREA

A 10.5-mi² area near the confluence of Meadow Creek and the Eagle River, herein termed the "midvalley" area, has been the focus of population and light commercial growth in Eagle River. The estimated population of the area nearly doubled (from 7,536 to 13,687) between 1981 and 1985 (A. Van Domelen, the Municipality of Anchorage, written commun., 1983, 1984, 1988) and increased to 14,106 in 1988 (Municipality of Anchorage, 1989). Development of new subdivisions was accompanied by construction and expansion of numerous public water supply systems that relied completely on local ground-water sources. About 1,000 to 1,500 single-family residential wells were in use in the midvalley area in 1983 (Munter, 1984).

Johnson (1979) listed 361 wells located within the midvalley area and gave well locations resolved to the fourth-order aliquot parcel (2.5 acres) of the occupied section of land. However, many assigned locations were incorrect because most wells had not been field located or had been field located before detailed maps of the area became available. Many additional well logs were acquired from other agencies, drillers, and the public during this investigation. An extensive field- and office-location and verification effort was conducted for both previously listed wells and those for which new records were acquired. As of June 9, 1988, the U.S. Geological Survey's WATSTORE database, managed cooperatively in Alaska with DGGs, contained 957 sites with ground-water data. The vast majority of data are from water-well logs, which usually contain the driller's descriptions of geologic materials

penetrated, a static water level, well yield, and well construction information. Numerous unpublished engineering reports describing local well and water-supply systems were also reviewed for this study. Land-surface elevations at most wells were obtained from Municipality of Anchorage 1:2,400-scale maps with 4-ft contour intervals.

BEDROCK AQUIFERS

Bedrock in the midvalley area consists of Tertiary sedimentary rocks and pre-Tertiary metamorphic rocks. The distribution of these two rock types and contours of the bedrock surface are shown in sheet 3. Sheet 3 also shows areas where most wells obtain water from bedrock. Some wells in these areas obtain water from thin sand and gravel deposits overlying bedrock. In the northwest part of the area, near-surface sedimentary bedrock is not widely used as an aquifer because public water supplies are available; also, wells drilled in the area commonly had low reported yields (less than 3 gal/min).

Bedrock is used extensively as an aquifer north of Meadow Creek and Eagle River Loop Road and east of gravel pits on Eagle River Loop Road (sheet 3). In a study of this area, Petrik (1986) found numerous low-yield wells and local water-shortage problems caused by the low primary and secondary permeability of the fractured metamorphic-rock aquifer. Reported yields of wells varied from 0.1 to 21 gal/min. The median well depth was 277 ft and the median reported well yield was 2 gal/min, the same yield as reported by Johnson (1979) for all wells obtaining water from bedrock in the Chugiak-Eagle River area. Public water supplies have not been extended to Petrik's (1986) study area.

Eighteen of 53 wells studied by Petrik (1986) had reported yields of 1 gal/min or less. A 1-gal/min yield can supply up to 1,400 gal/day, which is two to five times the amount of water used by most families. However, water-supply problems can occur in these wells when short-term demand-(household pumps may deliver about 7 gal/min)-exhausts the water available in storage. Under static conditions, the 18 wells described above held 40 to 400 ft (60 to 600 gal) of water in their well bores. Some houses may also have had supplemental storage tanks, commonly holding 500 gal. Individual water-shortage problems were most commonly addressed by conserving water, distributing water-use activities throughout the day, deepening wells, drilling new wells, installing supplemental storage tanks, or fracturing aquifers by use of explosives or high hydraulic pressures to enhance well yields. These practices are necessitated by the naturally low permeability of the bedrock aquifer encountered at many well sites. Three separate areas totalling 28 acres were identified where reported well yields were less than 1 gal/min (sheet 3). The well data collected also showed an inverse relationship between well depth and well yield.

Deeper wells, for example, typically had lower yields. This suggests that attempts to increase water yield by deepening a well might be less effective than redrilling at another location. Large differences in the altitude of measured water levels in closely spaced wells prevented identification of an areawide flow system in the bedrock aquifer. This was interpreted to be the result of low hydraulic connectivity of the fractures in the bedrock aquifer.

NONLITHIFIED AQUIFERS

Most ground water in the midvalley area is obtained from glacial and glaciofluvial deposits of Quaternary age that mantle most of the low-altitude areas of Eagle River. Available data from test drilling and well logs, stratigraphic exposures along the Eagle River, and surficial geologic maps (Schmoll and others, 1971; Schmoll and others, 1980; and Yehle and Schmoll, 1989) are detailed enough to allow delineation of: (1) a shallow glacioalluvial aquifer; (2) undifferentiated glacial or glaciofluvial aquifers; and (3) confined sand and gravel aquifers (sheet 3).

CLUNIE CREEK AQUIFER

The Clunie Creek aquifer ranges in thickness from about 40 to about 130 ft and consists mainly of sand and gravel in glacioalluvial channels deposited during the waning phase of the last glaciation. The Clunie Creek aquifer is named after the Clunie Creek glacioalluvial deposits described by Yehle and Schmoll (1989). Areas where most wells obtain water from the Clunie Creek aquifer are shown in sheet 3. Although glacioalluvial and alluvial deposits occur at land surface more widely than is shown in sheet 3, they are commonly too thin to be useful as water-supply aquifers. Three calculated transmissivity values for this aquifer range from 11,000 to 110,000 ft²/day (table 1). Table 2 lists six public water supply systems that tap this aquifer. As a result of inefficiencies associated with keeping numerous small-capacity (up to a few hundred gallons per minute) wells functioning and concerns about contamination of the shallow aquifer, the Municipality of Anchorage has largely replaced local ground-water production from the Clunie Creek aquifer with imported surface water (Anchorage Water and Wastewater Utility, written commun., 1984-89). Although additional water supplies could probably be developed from shallow aquifers in the area (Munter, 1984), well locations would require careful selection to avoid ground-water contamination by nitrates and fecal coliform bacteria. Shallow ground-water contamination has been documented on Juanita Street and just north of Farm Avenue (Munter and Maynard, 1987; Municipality of Anchorage, written commun., 1987).

UNDIFFERENTIATED GLACIAL AND GLACIOFLUVIAL AQUIFERS

Ground water in the midvalley area is also obtained from undifferentiated glacial or glaciofluvial aquifers. These aquifers occur throughout the glaciated lowland where the Clunie Creek aquifer or confined sand and gravel aquifers are not separately mapped and where the mapped depth to bedrock is greater than 50 ft. The sand and gravel aquifers are typically small and discontinuous and are commonly confined by till or bedrock or both. Aquifer depths range from about 40 ft to several hundred feet. Although reported well yields are commonly low (below 10 gal/min), an exceptionally productive glaciofluvial aquifer occurs south of the Eagle River (well 1-14 in sec. 13, T. 14 N., R. 2 W.), where an aquifer estimated to be able to produce more than 180 gal/min has been reported (H4M Corp., 1986). The top of the sand-and-gravel aquifer occurs at a depth of 254 ft and it is at least 78 ft thick. Drilling stopped before the bottom of the aquifer was penetrated. Two calculated transmissivity values for the undifferentiated glacial and glaciofluvial aquifers are 68 and 2,500 ft²/day (table 1), which illustrates the wide variability of aquifer potential. Table 2 lists three public water supply systems obtaining water from the undifferentiated glacial and glaciofluvial aquifer.

CONFINED AQUIFERS

Lithologic data from about 390 logs of wells tapping confined sand-and-gravel aquifers in the midvalley area are available. Most of these wells tap one of four mappable aquifers ranging in area from 0.26 to 2.27 mi² (sheet 4). Physical characteristics of each of these confined aquifers are described below.

Midvalley Aquifer

The midvalley aquifer is informally named for its central location in the Eagle River valley and consists of multiple sandy and gravelly units of varying lateral continuity. The units are confined above and below by silty sediments of the undifferentiated drift (sheet 2) and its lateral equivalents or by bedrock. Both the "middle" and "lower" aquifers discussed by Munter (1984) are included in the midvalley aquifer of this report because water-level data from wells ER5 ("lower" aquifer) and ER4D ("middle" aquifer) have shown that these aquifers respond almost identically to nearby pumping stresses.

Structure contours of the top of the midvalley aquifer show that the surface generally slopes from north to south, southwest, and southeast (sheet 4). Logs of seven wells that fully penetrate the aquifer show that the cumulative thickness

Table 1. Summary of aquifer-test data in Eagle River (see sheet 1 for well locations)

Pumped-well identifier	Test dates	Duration of pumping (hrs)	Average pumping rate (gal/min)	Observation wells	Aquifer tapped	Calculated transmissivity (ft ² /day)	Calculated storativity	Analytical method used	Source of data	Aquifer thickness penetrated (ft)	Thickness screened or perforated (ft)
2-75	11/20/71	12.0	50	0	Midvalley	80	-	Cooper & Jacob (1946)	Jones & Young Drilling Co.	17	8
1-76	10/4/78-10/7/78	72	165	0	Midvalley	3,600 ¹	-	Cooper & Jacob (1946)	R & M Consultants (1979)	61	26
2-15	11/15/78-11/18/78	72	475	1	Midvalley	2,200	4x10 ⁻³	Cooper & Jacob (1946)	W.C. Ellis, Los Altos, CA; written commun., 1978	36	28
2-4	8/19/82-8/20/82	24	295	0	Midvalley	680	-	Cooper & Jacob (1946)	CH2M Hill, Anchorage, AK	18	16
2-76	10/12/83-10/13/83	36	125	2	Midvalley	330 ¹	1x10 ⁻¹	Cooper & Jacob (1946)	Smith, Robertson and Assoc. (1983)	129	63
1-14	6/11/86-6/14/86	72.5	180	3	Undifferentiated glaciofluvial	2,500	1.5x10 ⁻⁴	Theis (1935)	H4M Corporation (1986)	88	15
1-4	7/7/81-7/8/81	21.6	104	0	Eagle Ridge	800	-	Cooper & Jacob (1946)	CH2M Hill	10.5	-
1-5	8/10/81-8/11/81	24	240	1	Eagle Ridge	2,600	6x10 ⁻⁵	Cooper & Jacob (1946)	CH2M Hill	19	14
1-6	12/1/82-12/2/82	24	31	0	Eagle Ridge	200	-	Cooper & Jacob (1946)	CH2M Hill	23	21
1-29	3/9/83-3/10/83	24	20	0	Hysten Crest	47	-	Cooper & Jacob (1946)	Dowl Engineers, Anchorage, AK	14	10.5
RAV	3/26/83	3.1	15	0	Ravenwood	40	-	Cooper & Jacob (1946)	Dowl Engineers, Anchorage, AK	22	10
2-65	6/27/83	1	110	0	Clunie Creek	19,000	-	Cooper & Jacob (1946)	Anchorage Water & Wastewater Utility	16	10.5
2-41	6/11/82-6/13/82	58.5	474	1	Clunie Creek	110,000 ¹	-	Theis (1935), Neuman (1974)	Munter & Dearborn (1984)	50	15
2-83	8/23/82	8.3	50	2	Clunie Creek	11,000	-	Theis (1935)	DGGS	49	35
4-25	8/4/83	12	29	0	Undifferentiated glaciofluvial	68	-	Cooper & Jacob (1946)	Dowl Engineers, Anchorage, AK	12	10

¹Aquifer productivity is considered to be affected by nearby low permeability boundaries.

Table 2. List of active class A and class B public water systems using wells in the midvalley area as extracted from Alaska's Public Water System Inventory (K.L. Lindley, Alaska Department of Environmental Conservation, written commun., 1989). See sheet 3 for locations of well map numbers

Map no.	T-R-S*	System name	Class	Aquifer tapped
1-65	14-1-7	Colonial Park Subd	A	Midvalley
2-8, 3-8	14-2-14	Eagle River Correctional Center	A	Undifferentiated glaciofluvial
1-9	14-2-12	Eagle River Mobile Home Park	A	Midvalley
3-45	14-2-2	Eagle River West Condominiums	A	Clunie Creek
ECM	14-2-1	Eaglecrest Manor Apts	A	Unknown
1-4,1-5,1-6	14-2-13	Eklutna, Inc.	A	Eagleridge
2-4	14-2-13	Eklutna, Inc.	A	Midvalley
3-63	14-2-12	G.A. Phillips Subd	A	Midvalley
1-24,2-24	14-1-8	Hylen Crest Subd	A	Hylen Crest
12-139,12-239	14-2-12	Lazy Mountain Trailer Park	A	Midvalley
MOA-AWWU ^b				
1-39,2-39	14-2-2	1-Eagle Glenn West ^c	A	Clunie Creek
1-41,2-41	14-2-2	2-Eagle Glenn East ^c	A	Clunie Creek
MOA-3	14-2-11	3-Regional Park ^c	A	Clunie Creek
2-83	14-2-12	4-Eagle River Hts N	A	Undifferentiated glaciofluvial
5-83	14-2-12	4-Eagle River Hts N	A	Midvalley
1-56,2-56	14-2-12	5-Eagle River Hts S ^c	A	Midvalley
2-65	14-2-1	6-McAlpine ^c	A	Clunie Creek
1-36,2-36	14-2-12	7-Sunny Slopes ^c	A	Midvalley
1-75,2-75	14-2-12	8-Palos Verdes ^c	A	Midvalley
1-69,2-69	14-1-7	9-Eagle Crest	A	Midvalley
1-15,2-15	14-1-7	Norfolk Utilities	A	Midvalley
2-16	14-2-1	Pipple Subd L2 B6	A	Midvalley
4-14	14-2-1	Pipple Subd L6 B5	A	Midvalley
TV	14-2-1	Taiga Vista Apts	A	Midvalley
Anchorage School District				
1-29	14-1-17	Ravenwood School	B	Hylen Crest
GD	14-2-11	Golden Donut - Johnson Tire	B	Undifferentiated glaciofluvial
1-60	14-1-7	Joy Lutheran Church	B	Eagleridge

*Township-Range-Section.

^bMunicipality of Anchorage - Anchorage Water and Wastewater Utility.

^cWells permanently deactivated, 1986-88.

of dominantly sand and gravel units in the aquifer ranges from 21 to 117 ft and averages 61 ft. Comparison of sheet 4 to sheet 3 shows that the total aquifer thickness (including interbedded fine-grained materials) is commonly 100 to 200 ft.

The midvalley aquifer is one of the most prolific and widely used aquifers in Eagle River. Aquifer test data and well production records (Petrik, 1990, 1991a, 1991b) show that sustainable well yields of 100 to 500 gal/min are possible in some areas. Most domestic wells completed in this aquifer are open-ended 6-in.-diam casings and have reported yields of 5 to 30 gal/min. The median reported yield of all wells tapping the midvalley aquifer is 17 gal/min. Five calculated transmissivity values for the aquifer range

from 80 to 3,600 ft²/day (table 1). Fourteen public water supply systems (table 2) obtain water from the midvalley aquifer.

Continuous water-level data have been collected from a well completed in the midvalley aquifer (well ER5, sheets 1 and 3; table 3) since 1983. The hydrograph (fig. 5) shows that water levels declined 22 ft from early 1983 to mid-1986 and increased about 19 ft from mid-1986 to late 1989. The well exhibited large (7-9 ft) short-term (hours to days) fluctuations of water levels after October 1, 1985, when a 208-ft-deep public-supply well (well 2-4, sheet 3) located 0.25 mi to the west began operation (Craig Walker, Eklutna Utilities, Inc., oral commun., 1985).

Table 3. *Information regarding three water-level observation wells in Eagle River*Well RAV (Ravenwood School well 1)

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 17, T. 14 N., R. 1 W., Seward Meridian
 Aquifer tapped: Ravenwood aquifer (Quaternary)
 Owner: Anchorage School District
 Well characteristics: Diameter 6 in.; depth 44 ft; open from 43 to 44 ft
 Land surface altitude: 666 ft (determined from 1:2,400-scale topographic map).

Well ER4S

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 13, T. 14 N. R. 2 W., Seward Meridian
 Aquifer tapped: Eagle Ridge aquifer (Quaternary)
 Owner: State of Alaska
 Well characteristics: Annulus between 3-in.-diam PVC casing and 6-in.-diam steel casing; depth 200 ft, open from 126 to 129 ft
 Land surface altitude: 516 ft (determined from 1:2,400-scale topographic map).

Well ER5

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 13, T. 14 N. R. 2 W., Seward Meridian
 Aquifer tapped: midvalley aquifer (Quaternary)
 Owner: State of Alaska
 Well characteristics: Diameter 6 in.; depth 268 ft; open from 263 to 268 ft
 Land surface altitude: 516 ft (determined from 1:2,400-scale topographic map).

Water-level data collected from closely spaced wells constructed at different depths in the midvalley aquifer have shown that water-level differences within the aquifer are typically small (less than a few feet) with both upward and downward hydraulic gradients. Thus, the potentiometric surface of the aquifer (sheet 4) was constructed by using data collected from a February-June 1983 survey of water levels in local wells and elevation information where the aquifer crops out. Water-level data reported by drillers at the time of well construction were also used, but only to guide contour drawing in areas of sparse 1983 data. Examination of figure 5 and sheet 4 shows that water-level changes that occurred in the aquifer during the 1983 water-level survey were small compared to the scale and contour interval of the potentiometric surface map.

Sporadic water-level data collected at two wells tapping the midvalley aquifer (sheet 3; table 4) indicate that water-level declines of about 10 ft occurred in the north-central part of the aquifer before 1983. A comparison of water-level measurements made in 12 wells during 1983 with levels reported at the time of well construction (which ranged from 1962 to 1978) showed that the median apparent water-level change was -1.1 ft (1983 water levels were lower). Most of these water-level measurements were made in the southwest part of the aquifer.

The midvalley aquifer is recharged from local precipitation and snowmelt through overlying aquifers and leaky confining units. Also, Meadow Creek is a probable source of recharge for aquifers in the area.

On July 2, 1974 the U.S. Geological Survey (Scully and others, 1978, p. 102) made two streamflow measurements on the lower reaches of Meadow Creek. They observed discharges of 6.87 cfs 200 ft upstream from the mouth of Meadow Creek, and 8.75 cfs 1.5 miles above the mouth near the apex of the Meadow Creek alluvial fan. This suggests a net loss of 1.88 cfs or 1.2 mgd by the stream along its lower reaches.

Eagleridge Aquifer

The Eagleridge aquifer is informally named for the overlying Eagleridge Subdivision (sheet 4) and consists of glaciofluvial deposits shown in sheet 2, and sandy and gravelly sediments that are laterally equivalent (unit Qaler, sheet 1). The Eagleridge aquifer was described as the "upper" aquifer by Munter (1984). Structure contours of the top of the Eagleridge aquifer (sheet 4) shows that it has a fan-like upper surface near Meadow Creek and a relatively flat profile over much of the midvalley area, suggesting that sediments composing the aquifer were derived

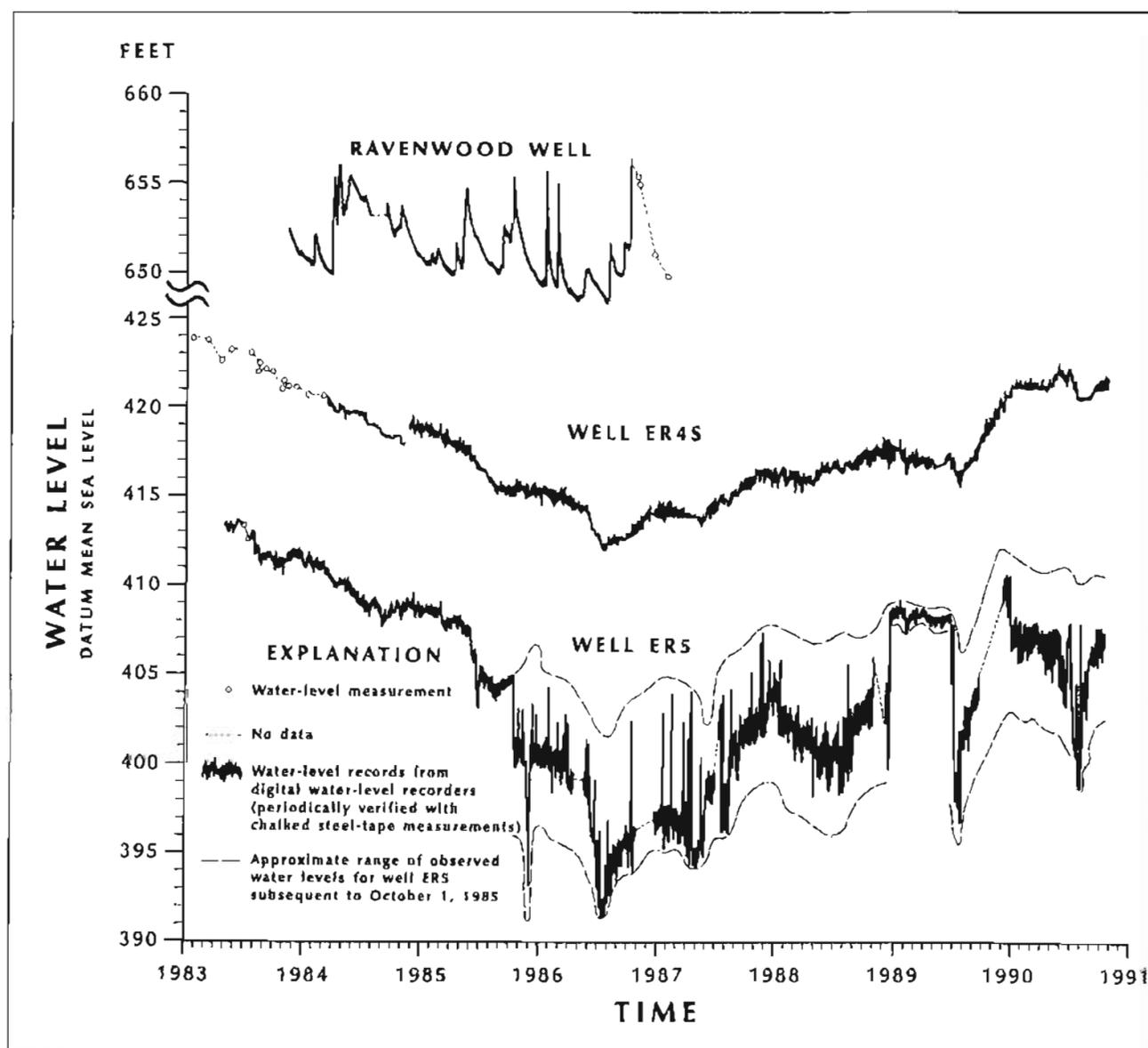


Figure 5. Water-level data collected at three wells in Eagle River.

from a source area north of the aquifer. Possible channel-like erosional features are evident on the upper surface of the aquifer. Along its western and southern edges, the aquifer is near land surface and is erosionally truncated. Although most wells that tap the Eagleridge aquifer are not drilled to the bottom of the aquifer, available data suggest that the aquifer is 10 to 43 ft thick in most places. In the northcentral part of the aquifer near Meadow Creek, the sand and gravel deposits thicken to about 80 ft but the upper parts are unsaturated. Reported yields of wells tapping the Eagleridge aquifer range from 2 to 240 gal/min, with a median and mode of 10 gal/min. Three calculated transmissivity values for the aquifer range from 200 to 2,600 ft²/day (table 1). Two public water-supply systems obtain water from the Eagleridge aquifer (table 2).

The potentiometric surface of the Eagleridge aquifer was defined measuring static-water levels in 58 domestic wells in 1983 (sheet 4). Data reported by drillers were used to guide the drawing of contours in areas of sparse data. The potentiometric surface illustrates that ground-water flow in the aquifer is toward the southwest.

An observation well (well ER4S, sheets 1 and 3; table 3) tapping the Eagleridge aquifer installed in late 1982 serves to identify recent water-level trends. The hydrograph (fig. 5) shows that water levels declined in a pattern similar to well ER5, although the magnitude of declines was less and water levels did not exhibit large daily fluctuations. Water levels declined about 11 ft from early 1983 to mid-1986, and increased about 11 ft from mid-1986 to late 1990. A comparison of 53 water-level

Table 4. *Water-level data collected at two wells tapping the midvalley aquifer, Eagle River. Wells are located near Eagle River Loop Road (see sheet 3)*

Well identifier	Date of measurement	Static water level* (ft)	Well opening interval(s)* (ft)	Source
2-15	03/09/70	176.2	240-268	R.W. Kranich, written commun., 1970
2-15	11/15/78	178.0	240-268	W.C. Ellis, written commun., 1978
2-15	03/31/83	186.6	240-268	R.D. Allely, DGGs
1-76	10/04/78	215.3	263-283, 336-342	R & M (1979); Smith and Robertson (1983)
1-76	09/28/83	224.9	263-283	
1-76	10/18/83	225.0	263-283	Smith and Robertson (1983)

*Below land surface datum.

measurements made during 1983 with those reported at the time of well construction (1957 to 1981) shows that the median increase of water levels was 7.3 ft. Most water-level measurements were made in the eastern part of the Eagleridge aquifer (sheet 4).

Hylen Crest Aquifer

The Hylen Crest aquifer, identified solely by using subsurface data, occurs east of Eagle River Lane in the midvalley area (sheets 1 and 3). This aquifer is informally named for Hylen Crest subdivision (sheet 4) which partially overlies it and is served by a public water system that relies on two wells tapping the aquifer. These are well 2-24 (346 ft deep), which has a reported yield of 182 gal/min, and well 1-24 (308 ft deep), which has a reported yield of 61 gal/min. A single calculated transmissivity value for the aquifer is 47 ft²/day (table 1). Two public water-supply systems obtain water from the Hylen Crest aquifer (table 2).

The top of Hylen Crest aquifer occurs 200-300 ft below land surface in most places. The aquifer is locally up to 30 ft thick, but silty zones are common. Reported yields range from 3 to 182 gal/min, with a median of 7 gal/min. The shape and position of the aquifer suggest that sediments composing the aquifer may have been deposited as a proglacial fan or delta from westerly or easterly glacial sources. As described later, a westerly glacial source is most likely.

The general configuration of the potentiometric surface of the Hylen Crest aquifer (sheet 4) is described by using relatively few water-level data. Ground water is recharged to the aquifer through overlying glacial drift and is discharged to wells, deeper deposits, and wetland areas near the Eagle River. A comparison of six water-level measurements made during 1983 and 1984 with

measurements made at the time of well construction (1972 to 1983) showed that the median increase of water levels was 5.8 ft. Examination of geologic and water-level data indicates that the Hylen Crest aquifer is separated from overlying and underlying aquifers by 60 to 120 ft of low-permeability fine-grained glacial sediment.

Ravenwood Aquifer

The Ravenwood aquifer, located near Eagle River Lane in the eastern part of the midvalley area, is informally named for Ravenwood Elementary School (sheet 4). The aquifer is identified solely with subsurface data, although seeps and a spring occur at the south edge of the aquifer, where it is inferred to discharge through a thin soil and vegetative mantle. Well RAV (sheets 1 and 3), also known as Ravenwood School well 1, taps the aquifer and has a depth of 44 ft. The well was never used as a public supply well because of insufficient yield, but was used as a water-level observation well (fig. 5; table 3). Analysis of well-log data indicates that the aquifer is composed principally of sand and gravel and is confined both above and below by less permeable till. Most well logs show an aquifer thickness of 2 to 12 ft. Reported well yields range from 1.5 to 30 gal/min, with a median of 7 gal/min. A single calculated transmissivity value for the aquifer is 40 ft²/day (table 1). The depth to the top of the aquifer varies from about 130 ft in the north to near zero feet in the south, where the aquifer appears to be erosionally truncated. The aquifer is recharged by percolation of precipitation and snowmelt through the overlying confining unit. The shape and location of the aquifer suggest that the aquifer materials were deposited as an eastward prograding alluvial fan from a westerly glacial source.

The potentiometric surface of the Ravenwood aquifer (sheet 4) is about 100 to 300 ft higher than that of the Hylen

Crest aquifer, and 220 to 250 ft higher than that of the Eagleridge aquifer. Ground water in the Ravenwood aquifer flows generally to the south through the aquifer and seeps vertically downward to the underlying Hylen Crest and Eagleridge aquifers through leaky confining units. Water-level records from an observation well tapping the Ravenwood aquifer (fig. 5) show a fluctuation range of about 8.5 ft, but no significant trend over the 3-yr period. Mid- to late-winter increases in water level correlate with brief mid-winter thaw periods accompanied by precipitation events (Munter, 1986). This indicates that relatively rapid recharge to the Ravenwood aquifer occurs, even through surficially frozen soils.

A comparison of 20 water-level measurements made during 1983 with measurements reported at the time of well construction (1965 to 1983) shows the median increase in water level to be 9.0 ft.

ORIGIN OF GLACIAL DEPOSITS IN THE MIDVALLEY AREA

As previously described, the Eagleridge aquifer is considered to be composed of advance outwash deposited during the late stage of the Naptowne Glaciation of Late Wisconsinan age. Comparison of sheet 4 shows that the aquifer extends north and east from its outcrops to areas where the Ravenwood and Hylen Crest aquifers and intervening deposits overlie it. These upper two aquifers and the overlying and underlying till are therefore inferred to be part of the Elmendorf moraine deposits that lie directly over the Eagleridge aquifer. The total thickness of sediment overlying the Eagleridge aquifer ranges up to about 400 ft.

Schmoll and others (1980) mapped the eastern extent of Elmendorf-equivalent ground moraine (unit Qmg) to the eastern limit of the Eagleridge aquifer (sec. 17, T. 14 N., R. 1 W., SM). Confirmation that deposits from the Knik-Matanuska glacial lobe extended to that location was provided by identification of a cobble-sized clast of pyroxenite in an exposure of glaciofluvial materials located near Eagle River Lane. Pyroxenite is not known to occur farther up the Eagle River Valley (R.G. Updike, Alaska Division of Geological & Geophysical Surveys, oral commun., 1985), but does occur in the Knik Arm drainage (Clark, 1972b; Rose, 1966).

The deposits comprising the Ravenwood and Hylen Crest aquifers are interpreted to have been deposited as a result of minor fluctuations in the position of the glacial ice front during the late stage of the Naptowne Glaciation that produced the Elmendorf moraine. Deposition of aquifer materials in alluvial fans or fan-delta complexes is attributed to the discharge of ice-marginal streams flowing along the Chugach Mountain front from the north into the ice-free Eagle River valley. The existence of ice-marginal streams has previously been postulated to explain the

modern presence of large channels along the Chugach Mountain front near Eagle River (Yehle and Schmoll, 1989).

The interpreted geologic history presented in this report is based in part on geologic mapping by Schmoll and others (1980) rather than on recently revised mapping (Yehle and Schmoll, 1989) that shows Dishno Pond moraine deposits overlying the Ravenwood, Hylen Crest, and Eagleridge aquifers. The Dishno Pond moraine is inferred (Schmoll and Yehle, 1986) to have been deposited as a result of a glacial advance of the Knik-Matanuska ice lobe that preceded the advance that produced the Elmendorf moraine. The Dishno Pond moraine interpretation of Yehle and Schmoll (1989) is not used in this report because it is not consistent with the stratigraphic correlations described herein.

INTERPRETATION OF WATER-LEVEL TRENDS IN THE MIDVALLEY AREA

Water levels in confined aquifers in the midvalley area are influenced mainly by ground water pumpage and variations in natural recharge. The midvalley and Eagleridge aquifers, for example, exhibit a limited amount of hydraulic communication as evidenced by a 24-hr aquifer test performed in the midvalley aquifer. Well 2-4 (sheet 3, table 1) was pumped at 295 gal/min, and 2 ft of drawdown was observed in wells 1-4 and 1-5 (sheet 3, table 1), which were completed in the Eagleridge aquifer nearby (F. Damron, CH2M Hill, written commun., 1983). The water-level record at well ER5, as previously described, exhibits short-term fluctuations in response to pumping at well 2-4. Long-term changes in pumping are also related to changes in water levels. Ground-water pumpage patterns have changed in recent years as a result of population increases and importation of surface-water supplies from Ship Creek and Eklutna Lake. Examination of water-use patterns is necessary to obtain an understanding of the causes of long-term ground-water level changes.

WATER-USE DATA

Munter (1984) estimated an average 1983 Eagle River per-capita water use value of 120 gal per person per day, primarily based on water use data from residential neighborhoods. Light commercial development in part of the study area may increase the estimate of areawide per-capita use to 130 to 140 gal/day and is comparable to Municipality of Anchorage values of 150 gal/person/day used for planning (Municipality of Anchorage, 1983). Using an average per-capita figure of 135 gal/day and a 1988 population figure of 14,106 in the midvalley area (Municipality of Anchorage, 1989), total water use is estimated to be 1.9 million gal/day.

About 46 percent of midvalley's total water demand is supplied by AWWU, 17 percent by Norfolk and Eklutna Utilities, and 37 percent by individual residential wells and a variety of small to midsized privately owned public water-supply systems using wells (fig. 6). Locations of all known active class A and class B public-water-supply wells are shown in sheet 3. Definitions of class A, class B and class C systems are given by Alaska Department of Environmental Conservation (1982).

Until 1986, four of the most heavily pumped public water-supply systems in the midvalley area (Norfolk Utilities, Eagle River Heights North-AWWU, Eklutna Utilities, and Eagle Crest-AWWU), were located in the central part of the region underlain by confined aquifers. Most of the water pumped was extracted from the midvalley and Eagleridge aquifers.

Before 1983, almost no water-use data were collected in Eagle River. Data collected between 1983 and 1987 from these four systems are shown in figure 7. Figure 7 illustrates the rapid increase in water use that occurred between 1983 and 1986, and the decrease in pumpage that occurred as a result of AWWU's switch to surface-water sources between 1986 and 1988.

PRECIPITATION TRENDS

The only long-term precipitation data available near Eagle River are collected at Anchorage International Airport, 17 mi southwest of the study area. Although local variations in precipitation occur as a result of orographic and geographic differences, long-term trends observed at the airport are probably similar to trends at Eagle River. Precipitation data (fig. 8) show that the years 1968 to 1978 had average or below-average precipitation and that 1979 to 1982 were substantially above average. A record amount of precipitation fell in Anchorage in 1989.

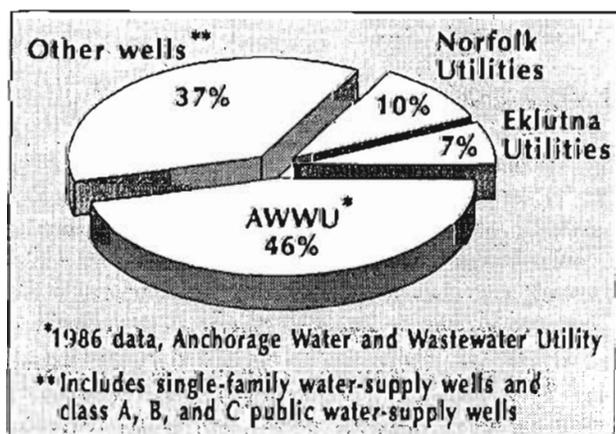


Figure 6. Estimated and reported water use in the midvalley area, 1988. Total estimate, 1.9 mil/gal/day.

CORRELATION OF WATER-LEVEL, WATER-USE, AND PRECIPITATION DATA

About two-thirds of the private domestic wells whose water levels were measured during 1983 were drilled between 1975 and 1978. Water levels reported by drillers at the time these wells were constructed were probably near or below average as a result of several years of average or below-average precipitation prior to their construction. Measurements made during 1983 closely followed 4 yr of above-average precipitation, resulting in higher measured water levels except where influenced by pumping from public-supply wells. Water levels observed in the Ravenwood, Hyleen Crest, and Eagleridge aquifers during 1983 were generally higher than those reported by well drillers. Ravenwood aquifer, the shallowest, showed the largest median increase in water levels. In the midvalley aquifer, which is more heavily pumped than the other three, increases in water-level elevations that could be expected as a result of increased precipitation appear to have been offset by drawdowns caused by pumping; this resulted in an apparent minor average drop (1.1 ft) in midvalley pre-1983 water levels. Pumping of ground water does not appear to have had any significant effect on water levels in the Ravenwood aquifer.

The rise in water levels observed in the Eagleridge and midvalley aquifers from 1986 to 1988 (fig. 5) is probably the results of a major reduction in ground-water pumpage that occurred during that period (sheet 1). The rise in water levels observed during 1989 is likely a result, in part at least, of the unusually large amount of precipitation that fell in 1989.

WELL FAILURES IN THE MIDVALLEY AREA

Aside from well problems associated with the low-permeability bedrock aquifer described previously, six wells tapping confined sand-and-gravel aquifers in the southwest part of section 12 of T. 12 N., R. 2 W. were reported to have failed during March and April 1986 (Munter, 1986). These wells had original reported yields of 5 to 10 gal/min and failed when static-water levels dropped to within a few feet of the well bottoms and exposed the submersible pumps. This lowering of static-water levels was caused by an areawide lowering of potentiometric surfaces of the Eagleridge and midvalley aquifers (fig. 5), which in turn was primarily attributed to pumping from those confined aquifers by private and public water-supply wells. Five of the six wells originally tapped the Eagleridge aquifer, and one tapped the upper part of the midvalley aquifer. All six wells were deepened or redrilled into the midvalley aquifer and obtained reported yields of 10 to 25 gal/min. The new wells are an

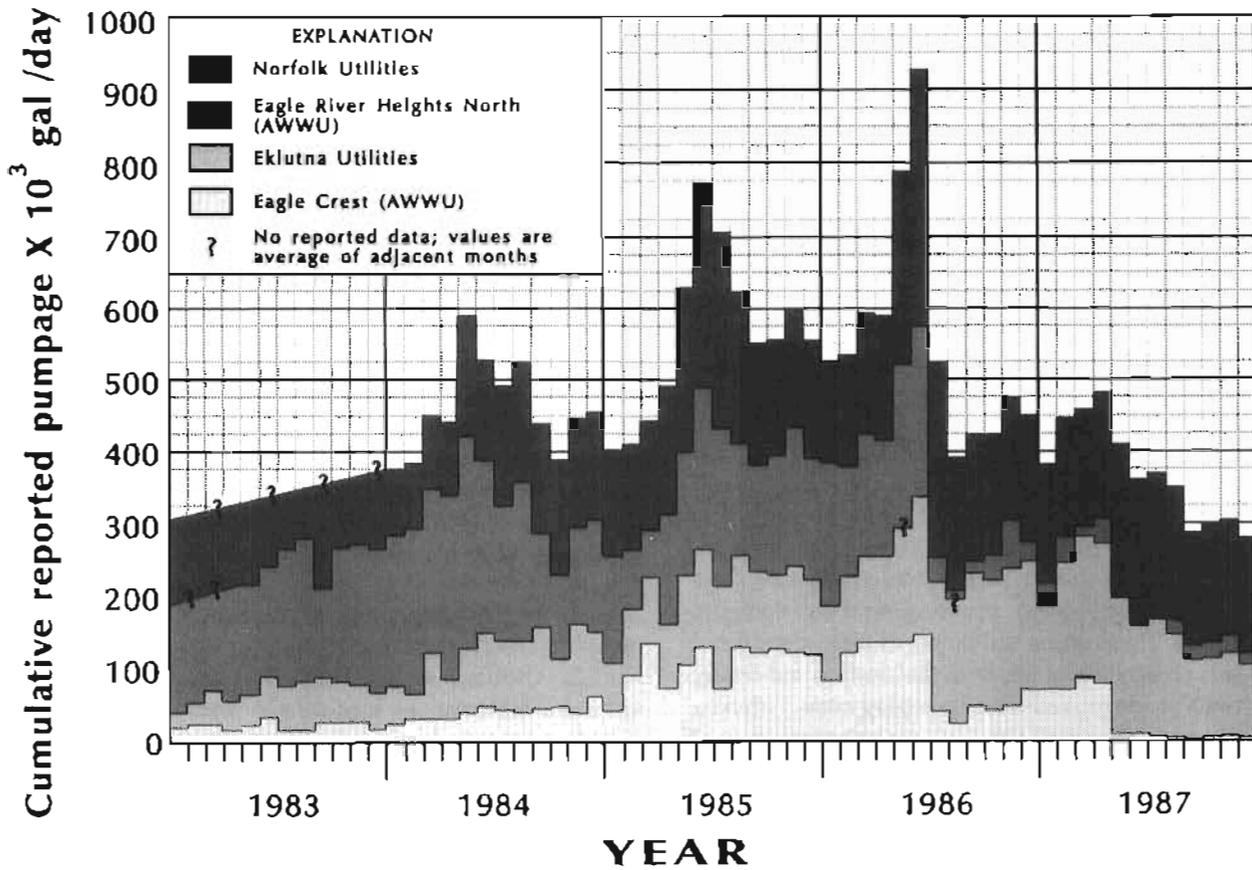


Figure 7. Water-use data for four major users of confined aquifers in Eagle River, 1983-87.

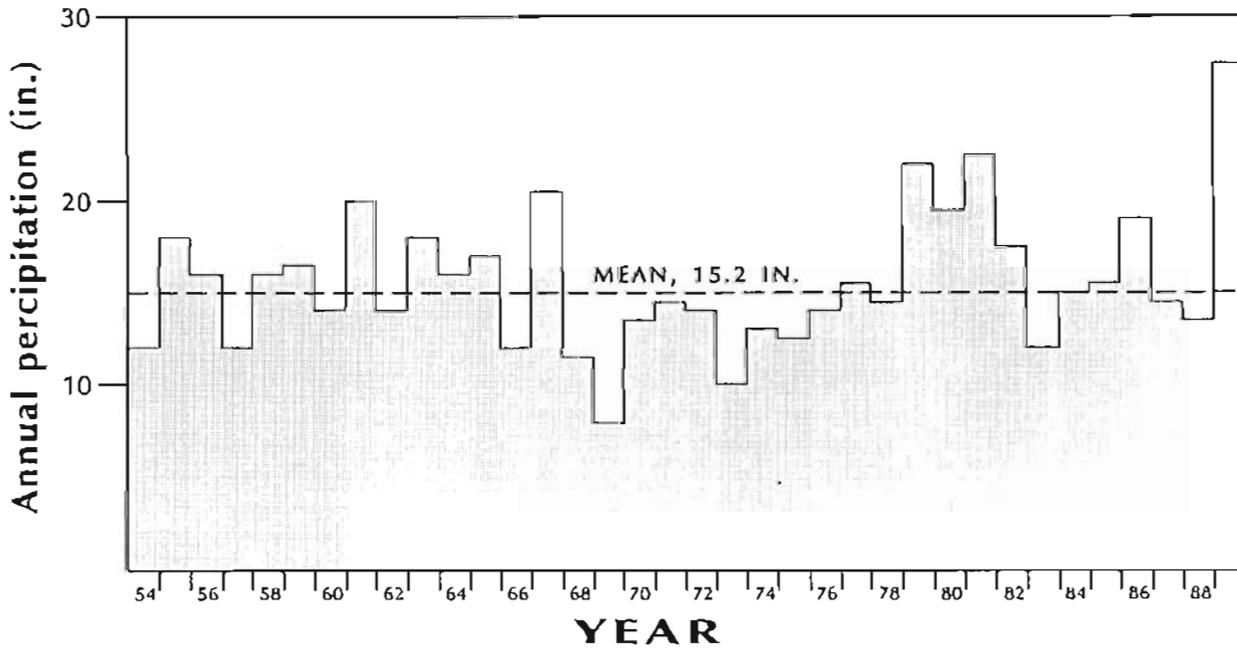


Figure 8. Annual precipitation at Anchorage Weather Service Meteorological Office - Airport.

average of 62 ft deeper than the old wells. The potentiometric surface of the midvalley and Eagleridge aquifers reached their historic lows in early to mid-1986, coincident with the occurrence of the well failures (fig. 5). No new failures of wells tapping these aquifers are known to have occurred since mid-1986.

SUMMARY AND CONCLUSIONS

Ground-water supplies are available throughout the Eagle River area from nonlithified and sedimentary- and metamorphic-rock aquifers. In the upper Eagle River valley, large well yields may be available only from side-valley alluvial deposits. In the midvalley area, ground water is obtained from shallow glacioalluvial, undifferentiated glacial and glaciofluvial, bedrock, and confined sand-and-gravel aquifers. Water levels declined before July 1986 in western parts of two confined aquifers (midvalley and Eagleridge), resulting in several domestic well failures. The location and timing of these water-level declines is closely associated with the location and timing of highest historic ground-water pumping rates. Pumping by private and public well owners is the principal cause of failure of wells tapping confined aquifers. Well-yield problems in the bedrock aquifer are caused by the low permeability of the aquifer. Since 1986, total well-water use has decreased, water levels in the two largest confined aquifers (midvalley and Eagleridge) have risen, and no new well failures are known to have occurred in the area where confined aquifers are used. Significant water-level declines and well failures have not been observed in wells tapping the Ravenwood or Hylén Crest confined aquifers, where large-scale public-supply well development has not occurred. Water levels in these aquifers appear to be relatively unaffected by pumping from existing residential and public-supply wells in the area.

Although surface water supplies from outside the Eagle River area have replaced and augmented local ground water in areas served by AWWU to a large extent, substantial areas

of residential development continue to be served by single-family and small public-water systems. In most of these areas, ground-water resources are likely to remain adequate for local water-supply requirements. However, local water-supply problems caused by the low-permeability bedrock aquifer may persist in some areas.

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