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DEPARTMENT **OF NATURAL RESOURCES**

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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November 1992

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GROUND-WATER RESOURCES OF THE PALMER AREA, ALASKA

By
D.M. LaSage
Division of Water

STATE OF ALASKA
Department of Natural Resources
DMSION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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GROUND-WATER RESOURCES OF THE PALMER AREA, ALASKA

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INTRODUCTION

The City of Palmer, Alaska, and its immediate surroundings represents an important agricultural center in southcentral Alaska since its settlement in the 1930's. In the early-to-mid 1980's the area experienced significant population growth as a result of its proximity to Anchorage, Alaska's largest urban center (fig. 1). This growth resulted in an increase in the use of ground-water for domestic, light commercial, and industrial water supply, in addition to established agricultural use.

This report summarizes the results of a ground-water resources investigation in the Palmer area. The study was initiated as part of the Alaska Water Resources Evaluation (AWARE) program, a joint effort of the State of Alaska Department of Natural Resources (DNR) and the U.S. Geological Survey-Water Resources Division (USGS). It is the third in a series of reports describing the ground-water resources of the Matanuska-Susitna Borough. Earlier reports described the Big Lake (Dearborn and Allely, 1983) and Houston (Maynard, 1987) areas.

The investigation was conducted primarily to improve and expand the publicly available database of well logs for the Palmer area; to produce a map showing locations for which well logs are available; to summarize the information contained in the database pertaining to water wells in the area; and to provide information on ground-water occurrence, usage, and quality in the Palmer vicinity. The data included in the report are intended to be useful for conducting preliminary hydrogeologic assessments associated with contamination investigations, water-supply evaluations, aquifer protection programs, and land-use planning. Fieldwork for this study was conducted intermittently from 1986-88.

Well log data for the report were obtained from DNR Division of Water (DOW), Alaska Hydrologic Survey (AI-IS) (formerly the Water Resources Section of the Division of Geological & Geophysical Surveys [DGGS]); USGS; and the Alaska Department of Environment Conservation @EC). In addition to summarizing data from historic information, 25 wells were visited to obtain water-level measurements and characterize ground-water quality.

Sheet 1 depicts the area included in the report (Anchorage [C-6] SW, Alaska USGS topographic quadrangle). The boundaries are approximately defined on the south by the Knik River, on the north by the southern three-quarters of secs. 27-30 T. 18 N., R. 2 E. and secs. 25-26 T. 18 N., R. 1 E., on the east by the Matanuska River and Clark-Wolverine Road, and on the west by Trunk Road.

RELATED REPORTS

Trainer (1953, 1960) provided early discussions of the geology and ground-water resources of the agricultural area in the Matanuska Valley, including the Palmer area. His work provided much of the historical data referenced here. Reger and Updike (1983) describe the surficial geology along the Glenn Highway and the glacial history of the Palmer area. Earlier reports that summarize water well data within other portions of the Matanuska-Susitna Borough include Dearborn and Allely (1983) and Maynard (1987). Generalized hydrologic information pertaining to the Palmer area is included in Feulner (1971) and Freethey and Scully (1980). Jokela and others, (1990) provided a conceptual model of ground-water occurrence, a regional water-table map, and a discussion of surface-water/ground-water interactions in the Matanuska-Susitna Borough.

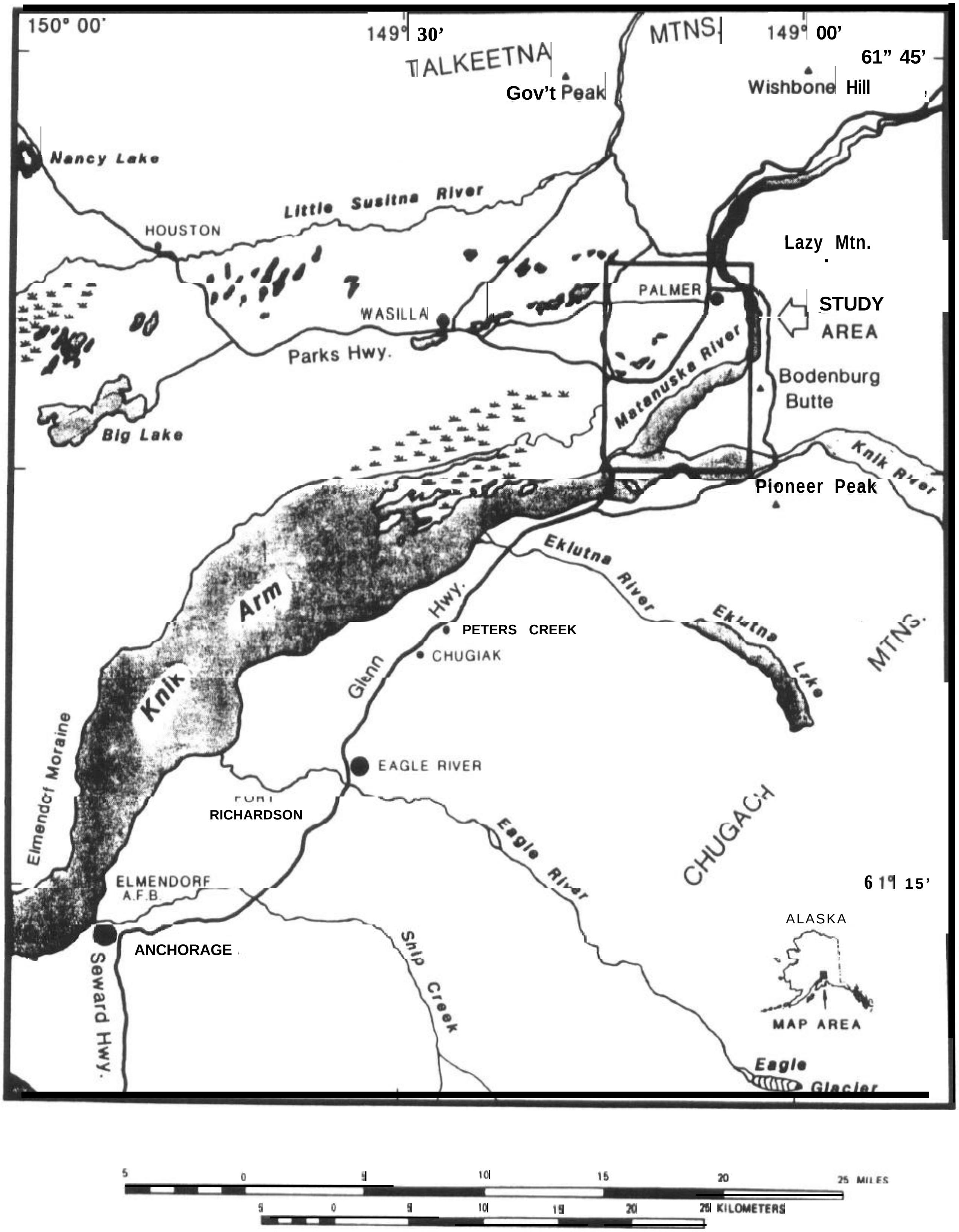

Figure 1. *Map showing location of rhe Palmer study area.*

CLIMATE

Selkregg's (1974) summary of climatic data place Palmer in the transition zone between the Maritime and Continental climatic zones. Average high and low temperatures in Palmer range from 7°C (44°F) to 19°C (67°F) in summer, and -14°C (6°F) to 6°C (42°F) in winter, respectively. Seasonal temperature extremes range from -37°C (-35°F) to 32°C (90°F). The 30-yr normal precipitation average for the area is between 39.4 cm (15.5 in.) and 40.6 cm (16.0 in.) per year (Arctic Environmental Information and Data Center, University of Alaska-Anchorage), including 163 cm (64 in.) as snowfall (Selkregg, 1974). The highest monthly averages from the area occur in July, August, and September, when 5.6 to 6.6 cm (2.2 to 2.6 in.) of precipitation are recorded (National Oceanic and Atmospheric Administration, 1978). Wind speed averages 7.0 kph (4.3 mph), and may be as high as 161 kph (100 mph) (Selkregg, 1974). Two winds predominate locally: the Matanuska wind, coming from the northeast in the colder months, and the Knik wind from the southeast in the warmer months.

GEOLOGY

The Palmer study area lies within the Matanuska Valley, a structural trough formed during repeated periods of glaciation. Cretaceous- and Tertiary-age granitic intrusives and sedimentary rocks of the Talkeetna Mountains form the northern boundary of the trough; to the south are the Chugach Mountains, composed of Cretaceous-Jurassic metasedimentary and metaigneous rocks. The various rock types present are referred to collectively as "bedrock" in this report. The bedrock surface within the area is irregular, and is mostly obscured by a covering of Quaternary-age unconsolidated deposits ranging in thickness from less than 3 m (10 ft) in parts of the Bodenburg Butte area to an unknown thickness greater than 200 m (650 ft) in the Scott Road area of Palmer.

Many of these younger deposits are the result of the last major ice expansion. Glacial drift, including till, was first deposited over scoured bedrock. As the ice receded, ice-contact deposits, including kames, eskers, and crevasse fills produced the uneven terrain west of the Glenn Highway (Reger and Updike, 1983). Outwash alluvium from the Matanuska River formed an alluvial fan near the present townsite of Palmer (fig. 2). As the sediment load of the river decreased, it began downcutting the fan, dissecting it into the Palmer and Bodenburg terraces observable today. Wind-blown sand and silt (loess) from the unvegetated, exposed portions of the river bed formed a thin [25 to 76 cm (10 to 30 in.)] veneer over the entire area, with sandy bluffs up to 15 m (50 ft) thick near the Matanuska and Knik Rivers (Schoephorster, 1968). These process continue to be active today (Reger and Updike, 1983). Tidal silts and clays, present in the flood plains and estuarine flats in the southeast portion of the area, are greater than 61 m (200 ft) thick (Trainer, 1960).

Drillers' logs are available for 42 water wells within the study area which reportedly encountered bedrock. Eleven of these logs specify that the bedrock encountered was sedimentary • either shale, siltstone, sandstone, or limestone. With one exception (well number 12 in T. 17 N., R. 1 E., sec. 24, sheet 1), these wells are located in the southern half of the study area. Three wells in T. 17 N., R. 2 E., sec. 5 (wells numbered 2, 14, and 15, sheet 1) are described by the driller as being finished in an igneous rock type. Additionally, four wells in the southeast quarter of the study area and one in the southwest quarter are described by the driller as encountering "greenstone," a term once commonly used to describe certain types of altered igneous rock. The remainder of the well logs give no indication of the type of bedrock penetrated.

Although approximately the same distance as Anchorage from the epicenter of the 1964 earthquake, the Palmer area received little damage beyond local ground fractures and ice cracks. High tides inundated the Alaska Railroad tracks south of Matanuska (Hansen and others, 1966), and artesian wells experienced pressure losses (Waller, 1966). Water levels in unconfined systems were not noticeably changed. Plafker and others (1969) attributed the lack of damage to the relative stability of the sand and gravel deposits underlying the area, and the fact that the water table is ten to several tens of feet below land surface.

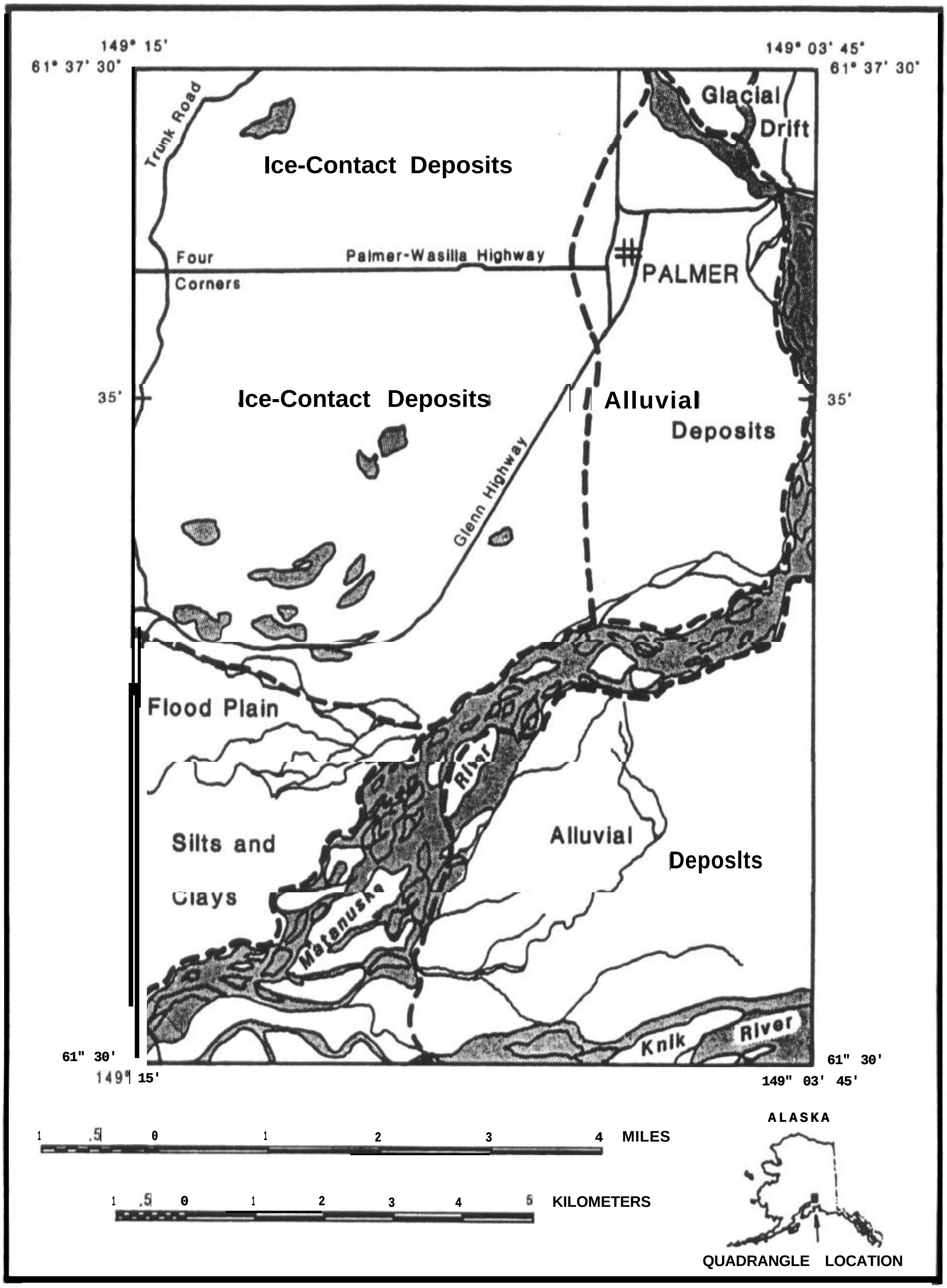

Figure 2. *Map showing surficial geology of the Palmer area.*

GROUND-WATER OCCURRENCE

Ground-water in the Palmer area is obtained primarily from saturated sand-and-gravel deposits within 46 m (150 ft) of the surface. The most productive aquifers are clean sands and gravels such as alluvial or glacial outwash deposits. Bedrock aquifers and sand-and-gravel stringers in till are secondary, less productive sources of ground-water.

Ground-water in the area is obtain+ from both water-table and confined aquifers. Water table aquifers generally occur where permeable deposits are near the land surface and confined aquifers occur where permeable materials are overlain by a relatively impermeable material such as till. Both types of aquifer occur throughout the area. Freethey and Scully (1980) observe that, while a wider range of well yields have been recorded in confined aquifers, the highest yields-in excess of 250 liters per second (l/s) (4,000 gallons per minute [gpm])-have been obtained from wells extracting water from unconfined aquifers in alluvium adjacent to present-day rivers.

In areas where bedrock lie-s near the surface, fractures in the rock may contribute small amounts of water. Of 42 wells in the area encountering bedrock, however, only 15 extract water primarily from the rock. The others are recorded as dry holes, or derive water from saturated sand-and-gravel deposits immediately overlying the bedrock.

SURFACE WATER - GROUND-WATER RELATIONSHIPS

Fresh water is plentiful in the Palmer area as both surface water and ground-water. The primary sources of fresh water are precipitation and snowmelt. The water may be stored in bogs or lakes or may occur as runoff in streams. Water which percolates through the soil and rock is available as ground-water. Some precipitation in the area evaporates or is used by plants in the process of transpiration. Ground-water, surface water, and atmospheric water are closely interconnected. Lakes and streams, for example, may undergo leakage which recharges the ground-water supply, or may themselves be recharged by ground-water.

Streams in the Palmer area may be either glacial or nonglacial in origin. Glacial streams include the Matanuska and Knik Rivers. Smaller, nonglacial streams include Wasilla Creek, Spring Creek, and Rabbit Slough. Ground-water gradients are commonly towards the streams; however, east and southeast of Palmer the gradient reverses allowing the Matanuska River to recharge ground-water (Trainer, 1960). The ground-water flow direction near the Knik River has been known to reverse temporarily during and after flooding associated with the Lake George breakout in the Knik River valley (Trainer, 1960).

Lakes are important for surface-water storage, and for recreational and aesthetic purposes. Lakes in the vicinity of Echo and Kepler Lakes were formerly occupied by stagnant-ice masses separated by meltwater streams (Reger and Updike, 1983). Modern lakes formed in the depressions left by the melting ice are probably spring-fed (Jokela and others, 1990).

Waterquality data are available for 12 lakes in the study area through the USGS or the Alaska Department of Fish and Game (Maurer and Woods, 1984). Conductivity values for these lakes suggest a significant ground-water contribution (M. Maurer, DGGS, oral commun., 1989).

GROUND-WATER RECHARGE AND DISCHARGE

Precipitation, snowmelt, and surface-water leakage are the principal sources of ground-water recharge in unconfined aquifers. USGS water level records for a well in T. 17 N., R. 2 E., sec. 9 indicate water levels in wells in that area are usually highest following summer rainfall. On-site wastewater disposal systems provide additional recharge to unconfined aquifers.

Confined aquifers receive recharge from leakage through overlying confining units, or through upgradient, unconfined portions of the aquifer. Ground-water discharges from aquifers naturally through springs, surface-water bodies, and communication with other aquifers. Pumping wells provide another means of discharge.

WELL CHARACTERISTICS

Appendix A contains records of 694 wells in the study area dug, driven, or drilled during the period from 1914 to 1988. Sixty percent of these wells were drilled between 1980 and 1984, illustrating the rapid growth of the area during that period. The wells are typically 15 cm (6 in.) diameter, open-ended wells intended for single-family domestic supply or light commercial use. A few larger wells exist which were installed as public water-supply or irrigation wells. These wells yield greater amounts of water due to differences in construction techniques, such as the use of larger-diameter casings and well screens. They may also be considerably deeper.

Considering all 694 wells, depths range from less than 3 m (10 ft) to more than 200 m (650 ft) deep (fig. 3). Eighty-two percent of these (569) are 46 m (150 ft) or less deep. One-quarter (181) were drilled between 18 and 27 m (60 and 90 ft) deep. Only three wells, all of which are public water-supply wells for the City of Palmer (T. 18 N., R. 2 E., sec. 31, map number 16, sec. 32, map number 1, see appendix A), were drilled to a depth greater than 183 m (600 ft). Estimated well yields (fig. 4), as recorded on well logs or reported by homeowners (494), range from 0.03 l/s (0.50 g-pm) in single-family domestic wells to 76 l/s (1,200 gpm) from a well owned

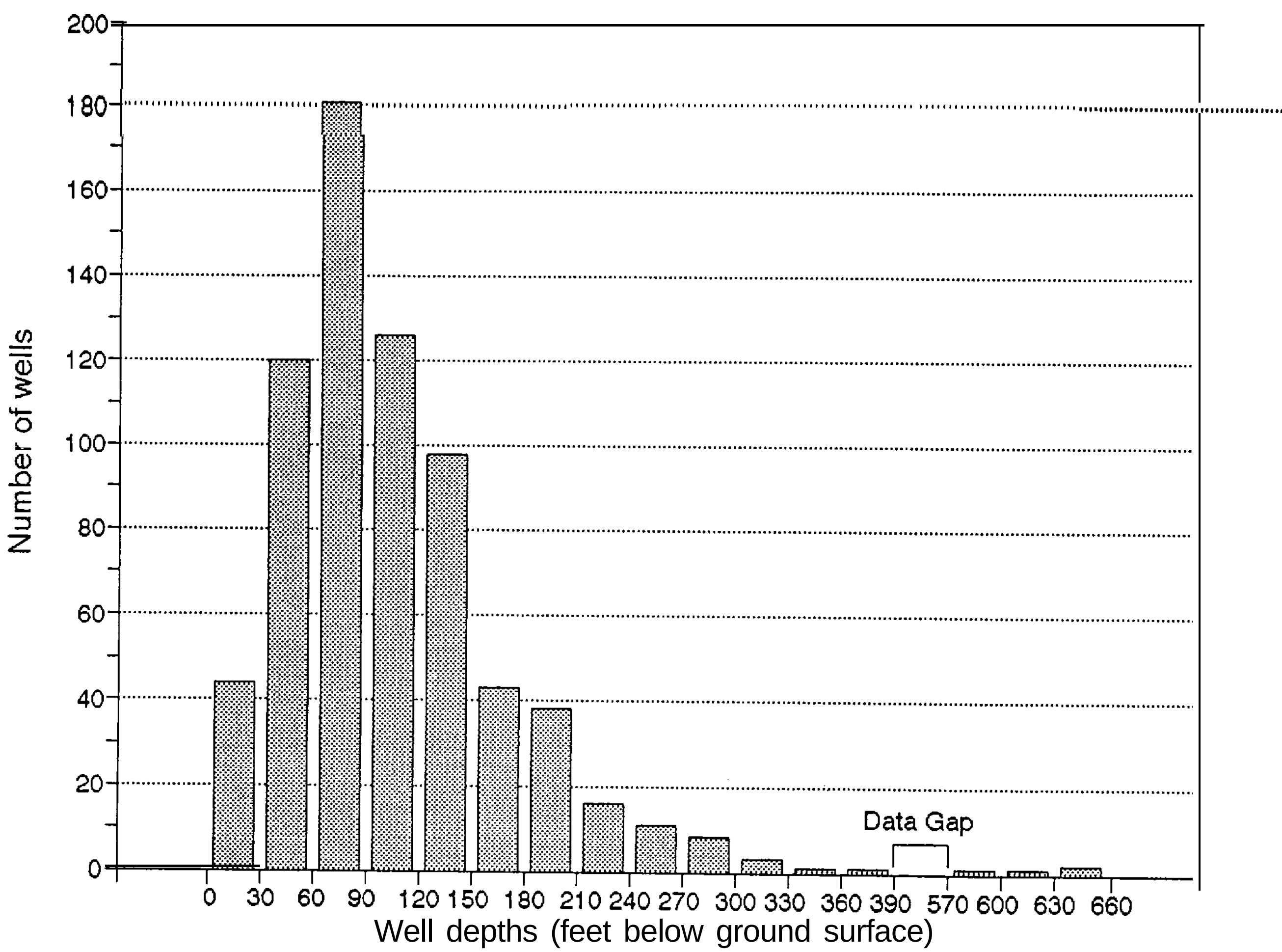

Figure 3. Histogram showing distribution of well depths in the study area.

by the City of Palmer, located in T. 17 N., R. 2 E., sec. 4, map number 12. The yield of single-family domestic wells in the area is most often reported as 0.6 l/s (10 gpm) on drillers' logs. Ninety percent (435) of the well logs containing information about well yield record a value of 1.9 l/s (30 gpm) or less.

GROUND-WATER USAGE

The majority of the wells at Palmer serve as private domestic wells. Some public, industrial, and irrigation wells do exist, however. DEC lists 17 Class A public water systems (serving at least 25 people at least 60 days each year) in the Palmer area, all of which use ground-water supplies, Numerous smaller systems also exist, and these use ground-water sources also.

The DNR DOW is the state agency responsible for issuing water-use permits and certificates. These are required when more than 1,900 liters per day (lpd) (500 gallons per day [gpd]) is pumped. Table 1 summarizes DOW permitted and certificated water use in the study area.

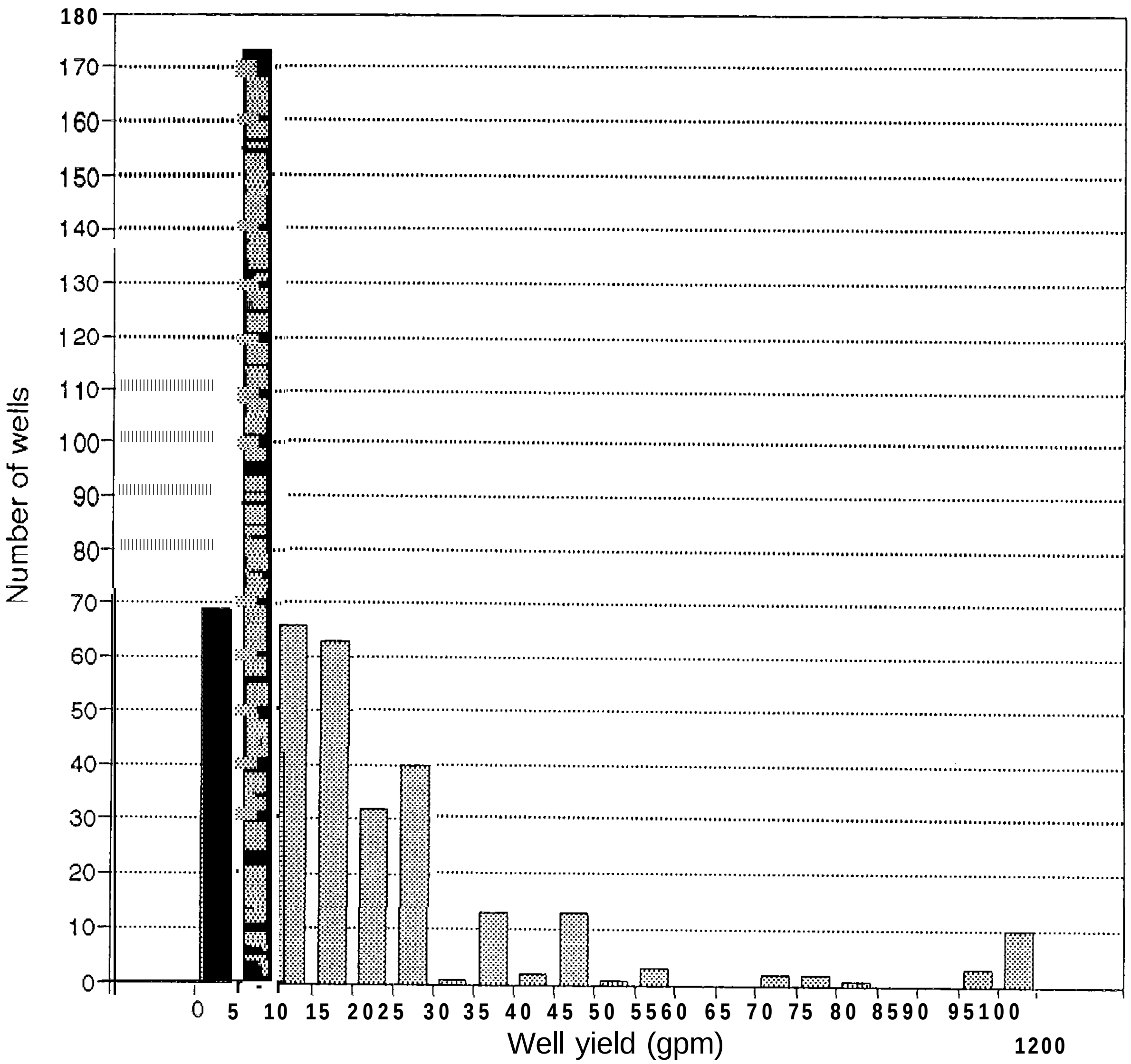

Figure 4. *Histogram showing distribution of well yields within the study area.*

Table 1. *Water usage for which Division of Water has issued permits or certificates*

Township	Range	Section	Year-round withdrawals (gpd)	Additional summer withdrawals (gpd)	Maximum total withdrawals (gpd)
16N	2E	5	500	0	500
17N	1E	1	3,575	0	1,500
		2	11,900	4,618	16,518
		3	15,300	0	15,300
		10	74,100	3,205	77,305
		11	1,545	2,089	3,634
		12	0	0	0
		13	3,300	358	3,658
		14	600	4,297	4,897
		15	14,432	213,711	228,143
		22	901	0	901
		23	7,130	1,243	8,373
		24	10,000	11,210	21,210
17N	2E	3	1,000	106,256	107,256
		4	1,506,700	0	1,502,000
		5	4,525	119,956	124,481
		6	4,860	240,000	244,860
		7	14,230	89	14,319
		8	7,530	14,962	22,492
		9	23,050	1,271,072	1,294,122
		10	4,490	555,521	560,011
		15	8,185	0	8,185
		16	9,723	358	10,081
		17	10,801	614,058	624,859
		18	1,395,613	337,841	1,733,454
		20	450	0	450
		21	1,500	0	1,500
		22	24,036	60,873	84,909
		27	31,370	651,926	683,296
		29	9,000	0	9,000
		33	0	1,181,657	1,181,657
		34	2,000	1,718,775	1,720,775
18N	1E	25	7,000	0	7,000
		26	4,050	286,586	290,636
		27	9,804	463,108	472,912
		34	153,199	31,546	184,745
		35	310,315	307,767	618,082
		36	8,062	0	8,062
18N	2E	27	1,500	0	1,500
		28	4,100	0	4,100
		29	3,605	2,479	6,084
		30	31,663	17,471	49,134
		31	1,021,700	4,190	1,025,890
		32	16,050	6,623	22,673
		34	4,692	250	4,942

Ground-water withdrawals are highest during the growing season, when total irrigation use may exceed 23.0 million lpd (6.0 million gpd). Irrigation is therefore a major use of ground-water during the warmer months. During the winter months, when water is not needed for irrigation, the primary permitted or certificated water user is the City of Palmer. Approximately 700 residential and 150 commercial or industrial users are connected to the public water system (D. Soulak, Palmer City Manager, oral commun., 1989). Although the city wells are certificated for over 7.6 million lpd (2.0 million gpd), the actual use for the period from November 1988 through August 1989 ranges from 1.7 to 2.2 million lpd (0.5 to 0.6 million gpd) (S. Ingalls, Palmer City Hall, oral commun., 1989; see also Petrik, 1989), corresponding to an average use of 171,000 to 223,000 lpd (46,000 to 59,000 gpd). Table 2 de-scribes water use in the six sections which potentially use 3.8 million lpd (1.0 million gpd) or more for at least part of the year.

WATER LEVELS

Ground-water usage in the area is considerably less than what is potentially available. Since 1949, USGS has maintained an observation well on Outer Springer Loop Road (T. 17 N., R. 2 E., sec. 17, map number 4). The well, finished in the Palmer terrace alluvial deposits, is in an area which may use large quantities of water during the summer growing season. Water-level records for the well from 1949 to 1989 (the last year for which records area available) show no significant long-term trend (fig. 5), suggesting that ground-water pumpage during that period did not noticeably stress the aquifer system in the area. The extreme water-level readings for the period of record for this well range from 21 to 23 m (70 to 77 ft) below land surface (Still and Brunett, 1987).

The water levels in wells measured during the course of this study were compared to water levels in the same wells reported immediately after drilling, to identify any change-s over time in the position of the water surface. No overall trends were apparent, although this may be due in part to the small number of wells involved (11). Comparison of water-level measurements was complicated by possible differences in height of the measuring point (top of casing vs. ground level); natural seasonal or cyclical variation in water levels; and inconsistency in the use of the term “static water level.” Static water level is generally used to indicate the depth to water below a permanent measuring point such as the top of the protective well casing, but is occasionally used by drillers to indicate the height of the water column in the well.

GROUND-WATER OUALITY

Water quality in the Palmer area is generally good. Homeowner’s reports and water quality analyses indicate the ground-water usually requires little or no treatment. Water softening systems are used by some homeowners to lower hardness and reduce iron content.

Isolated instances of poor quality water have occurred in the area. High iron (greater than 10 mg/L) was measured in a well in the southeast quarter of T. 18 N., R. 1 E., sec. 34 (well number 4). In at least one instance (T. 18 N., R. 2 E., sec. 34, well number 2), the presence of gas was reported in the well when it was first drilled.

Twenty-three sites were visited during this investigation and sampled for water quality (table 3). All tests were done at the site using portable field instrumentation. The hardness and iron content of the water samples were measured using Hach test kits. The temperature, Ph, conductivity, and dissolved oxygen were measured using a Hydrolab Digital Model 4041. Total alkalinity was determined by titration to a pH of 4.5 with sulfuric acid.

Measurable iron values in the study area ranged from 0.2 to 3.2 mg/L. Much higher values may exist, as evidenced by the single well previously mentioned, which contained levels of iron beyond the limits of the test kit (10 mg/L).

State of Alaska water quality standards (18 AAC 80.050) (DEC 1982) recommend a limit of 0.3 mg/L iron in public water supplies. This standard is not normally achieved in many wells without using water-conditioning

Table *2. Summary of water use for sections with withdrawals totalling 1 MGD or greater for at least part of the year (as of October 1988)*

	Maximum quantity (gallons per day)					
	T. 17 N., R. 2 E.					T. 18 N., R. 2 E.
Type of use	Section 4	Section 9	Section 18	Section 33	Section 34	Section 31
Single family dwelling	500	5,450	3,700	--	2,000	5,500
Public supply	1,500,000	--	--	--	--	1,012,000
Agriculture*	--	1,286,172	1,439,819	1,181,657	1,718,775	7,190
Aggregate wash	--	--	291,000	--	--	--
Other[b]	6.200	2.500		--		700
TOTAL	1,506,700	1,294,122	1,734,519	1,181,657	1,720,775	1,025,390

*Year-round use for noncommercial animals, dairy farms, crop planting, crop preparation, and potato farming; plus seasonal use for general farms, lawn and garden, field crops, and commercial greenhouses.

[b]Includes multi-unit housing, ready mixed concrete, building construction, and recreational services.

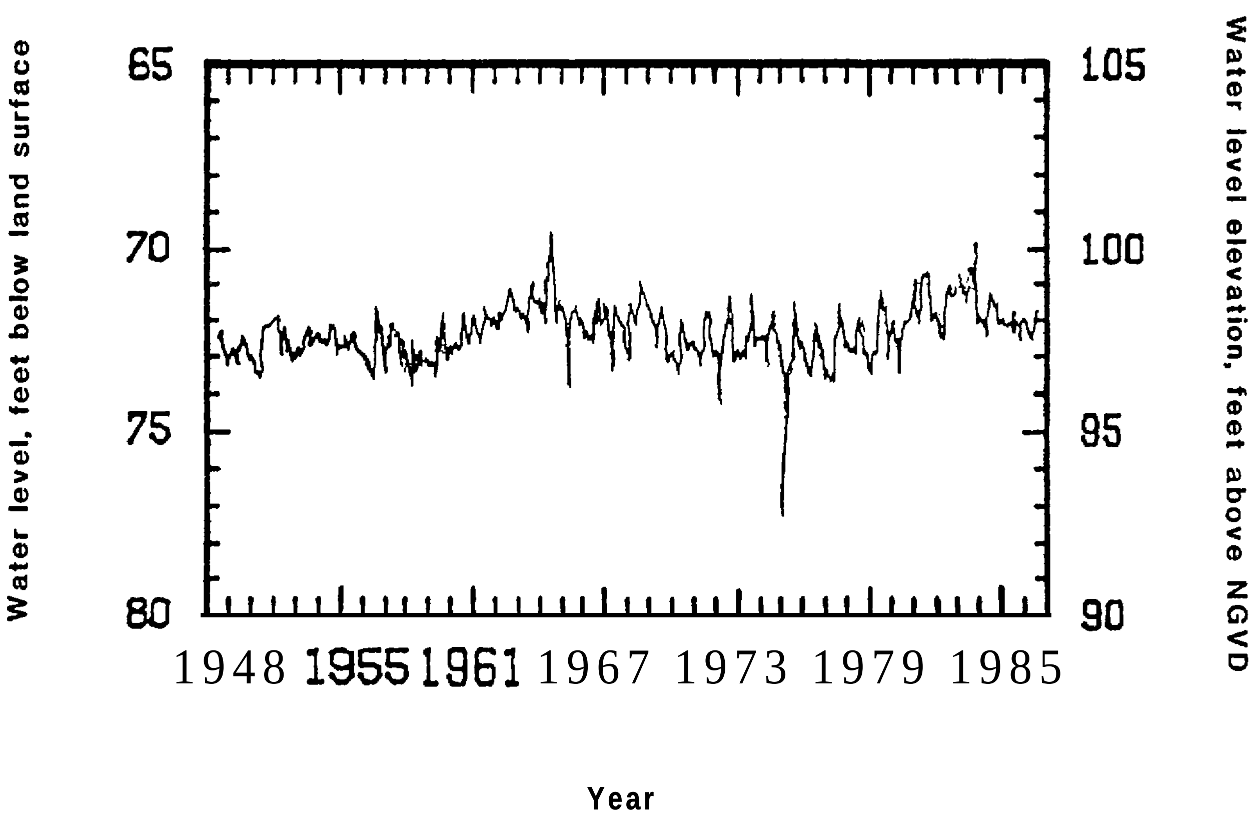

Figure *5. Hydrograph of water levels in a well in T. 17 N., R. 2 E., sec. 9.*

Table 3. *Water-quality data for the Palmer area*

Well Location T	R	S	Map No	Sample Date	Depth to water (ft)*	Sample Temp. (°C)	pH	Specific Conductance (uS/cm)	Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L)	Total Iron (mg/L)	Oxygen, dissolved (mg/L)
17N	1E	3	15	08-09-88	27	4.0	8.5	304	145		1.4	2.5
		11	3	08-09-88	74	4.2	8.8	228	95		0.8	3.0
		13	9	09-15-86			7.1	471	248	201	0.4	3.6
		24	1	09-15-86		7.0	7.0	419	175	192	1.6	1.5
17N	2E	5	19	08-28-86		4.5	7.4	295	172	150	0.8	1.7
		6	8	08-28-86		4.5	6.8	438	250	190	0.2	1.1
		8	12	08-14-86		4.3	7.2	688	335		0.3	
		8	14	08-01-86		4.7	6.6	777	420	225	0.2	5.4
		9	2	08-14-86	97	4.3	7.6	301	180		0.6	
		10	8	08-27-86	70	4.5	7.5	269	169	89	1.4	5.2
		16	5	08-14-86	58	4.7	7.8	316	166		0.2	
		17	18	08-01-86	41	4.5	6.9	336	173	109	0.6	5.7
		18	2	09-08-86	28	4.5	7.5	331	169	151	1.0	4.5
		21	2	08-09-88	31	4.5	7.5	251	180	94	0.6	3.3
18N	1E	25	2	09-15-86	47	4.5	6.8	281	409	235	3.2	4.5
		27	1	09-16-86		4.5	7.0	379	190	164	0.5	4.5
		34	26	08-09-88		4.0	8.4	786	202	90	0.6	2.8
		34	4	08-09-88		6.8	6.7	991		246	10+	
		36	20	09-16-86		4.0	8.0	247		154	0.8	1.6
18N	2E	29	5	08-28-86		4.0	7.6	272	200	120	0.2	2.0
		31	13	09-16-86	75	3.5	7.2	231	132	126	1.2	1.6
		32	20	08-28-86	14	4.0	7.1	473	239	174	3.2	4.7
		34	14	09-16-86		4.5	8.3	284	137	140	0.6	0.06

* Measured from the top of the protective well casing, commonly 1.5 to 2 ft above land surface.

equipment. Iron levels above 0.3 mg/L may result in staining of plumbing fixtures; iron levels many times higher than the recommended maximum may result in other complaints, such as staining of clothes when the water is used for laundering, or undesirable taste. Two wells sampled showed evidence of reddish-brown biofilm characteristic of iron-precipitating bacteria. Iron-precipitating bacteria tend to reduce the amount of dissolved iron in the water, but are considered undesirable in water-supply wells because the slime and ocher precipitated tend to clog aquifers and well screens or perforations, thereby reducing well yield. In addition, the presence of large bacteria colonies is considered undesirable in drinking water supplies, Iron-precipitating bacteria are often introduced in water wells when equipment is lowered into the well, but can be controlled by periodic well disinfection.

Specific conductance values of sampled waters ranged from 228 microsiemens per centimeter (μS/cm) to 991 μS/cm. Specific conductance is a measure of the capacity of water to transmit an electric current, and may be used to estimate the total dissolved solids (TDS) content of water. The State of Alaska recommends a maximum of 500 mg/L TDS in public water supplies; depending upon the ground-water chemistry, this may correspond to a specific conductance of 665 to 900 μS/cm (Hem, 1985). This report follows the common convention that

500 mg/L TDS is approximately equal to 750 μS/cm . Three specific conductance values greater than 750 μS/cm occurred (table 3), and may represent instances of water somewhat high in dissolved solids.

Twenty-one samples were tested for hardness, a measure of the effects of calcium and magnesium (and to a lesser extent, strontium, iron, and manganese). Water with a high degree of hardness may chemically combine with soap, which prevents foaming and forms an insoluble residue. Hem (1965) uses the following classification to define water hardness:

Hardness range (mg/L as $CaCO_3$)	Description
0 - 60	soft
61 - 120	moderately hard
121 - 180	hard
greater than 180	very hard

Using Hem's classification, one sample (5 percent) would be considered moderately hard, 11 samples (52 percent) would be classified as hard, and nine samples (43 percent) would be considered very hard. No samples were taken which would be classified as soft water.

The State of Alaska DEC requires periodic testing of Class A public water systems to determine compliance with drinking water standards. Results of these tests (table 4) indicate low levels of inorganic constituents and physical parameters for which primary (enforceable) maximum permissible concentrations exist. Primary organic and radioactive contaminant levels were not determined.

WATER QUALITY EFFECTS ON AGRICULTURE

The effects of irrigation water on crops and soils is an important consideration in agricultural communities such as Palmer. The suitability of ground-water for irrigation depends largely on salinity and sodium content, as expressed by specific conductance and sodium adsorption ratio (SAR) values, respectively.

Ground-water high in salinity may adversely affect crops by reducing the availability of moisture and nutrients. Also, if the rate of salt accumulation exceeds the rate of leaching near the ground surface, the permeability of the soil may be reduced, making it more difficult for the water to reach crop roots (Driscoll, 1986).

If the sodium content of the water is high relative to the amount of calcium and magnesium, expressed by a high SAR, base exchange may occur. This process, in which calcium and magnesium in clay particles in the soil are replaced by sodium from the irrigation water, reduces the permeability and tilth of the soil (Tchobanoglous and Schroeder, 1985).

Irrigation water may be classified based on specific conductance and SAR values. An SAR less than 3 is considered low risk (Tchobanoglous and Schroeder, 1985); higher values may be acceptable, depending on the specific conductance (fig. 6).

Certain crops may be sensitive to levels of various elements in the soil. To avoid this specific ion toxicity, recommended limits have been developed for several trace elements. These are summarized in table 5.

Additionally, DEC has developed certain water quality criteria for irrigation water. Those criteria applicable to ground-waters are listed in table 6.

Using data from Trainer (1960), analyses of ground-water samples collected from seven wells in the study area were examined for specific conductance and SAR values (appendix B). Six of the samples were classified as low-sodium, medium-salinity waters appropriate for plants with moderate salt tolerances (fig. 6). One sample

Table 4. ***Water-quality data from*** Class A Public-Water ***Systems (from DEC files)***

		System name								
		Equestrian Acres	Iris Circle	Matanuska Research Farm	Matanuska Research Farm	Meadow Valley	Mountain View Estates	Palmer Water System	Roses Apartments	Violet Circle
		Sampling date								
		04-09-85	05-09-84	02-13-87	02-13-87	01-23-85	07-21-79	01-28-83	01-25-79	01-14-86
Primary contaminants	Enforceable MCL[a] (mg/L)									
Arsenic	0.05	< 0.005	<0.005	0.009	0.003	0.018	<0.05	<0.01	0.014	<0.005
Barium	1.0	<0.2	0.025	<0.05	0.12	<0.2	<0.1	<0.5	ND[b]	<0.2
Cadnium	0.010	<0.002	< 0.005	<0.002	<0.002	<0.002	<0.01	<0.010	ND	< 0.002
Chromium	0.05	<0.005	<0.007	<0.01	<0.01	<0.005	0.05	0.05	ND	0.005
Fluoride	2.4	<0.2	--	<0.01	<0.01	--	0.1	0.54	ND	co.2
Lead	0.02	<0.005	<0.005	<0.01	<0.01	<0.005	co.05	<0.05	ND	<0.005
Mercury	0.002	<0.001	<0.001	<0.0002	<0.0002	<0.001	<0.002	<0.001	ND	<0.001
Nitrate	10.0	<0.5	2.2	<0.10	<0.10	<0.5	0.5	<0.01	6.4	3.6
Selenium	0.01	<0.002	<0.002	<0.001	<0.001	<0.002	<0.01	<0.01	ND	<0.002
silver	0.05	<0.002	0.011	<0.01	<0.01	<0.002	<0.05	<0.05	ND	<0.002
Physical	(NTU)									
Turbidity	1	0.12	--	0.30	0.27	--	--	0.46	--	0.30
Other impurities	Recommended MCL (mg/L)									
Manganese	0.05	0.005	<0.005	--	--	0.038	<0.05	<0.05	ND	--
Iron	0.3	<0.2	0.03	--	--	<0.2	<0.3	<0.05	0.095	--
Zinc	5.0	--	--	--	--	< 0.005	--	--	--	--
Sodium	250	6.3	8.9	--	--	4.0	5.4	55	11.2	--
Color	15 units	15	--	--	--	--	--	10	--	5
Alkalinity	--	--	209	--	--	--	--	--	--	--
Nickel	--	--	--	--	--	<0.01	--	--	--	--

[a]MCL = Maximum contaminant limit @EC)
[b]ND = Not detected.

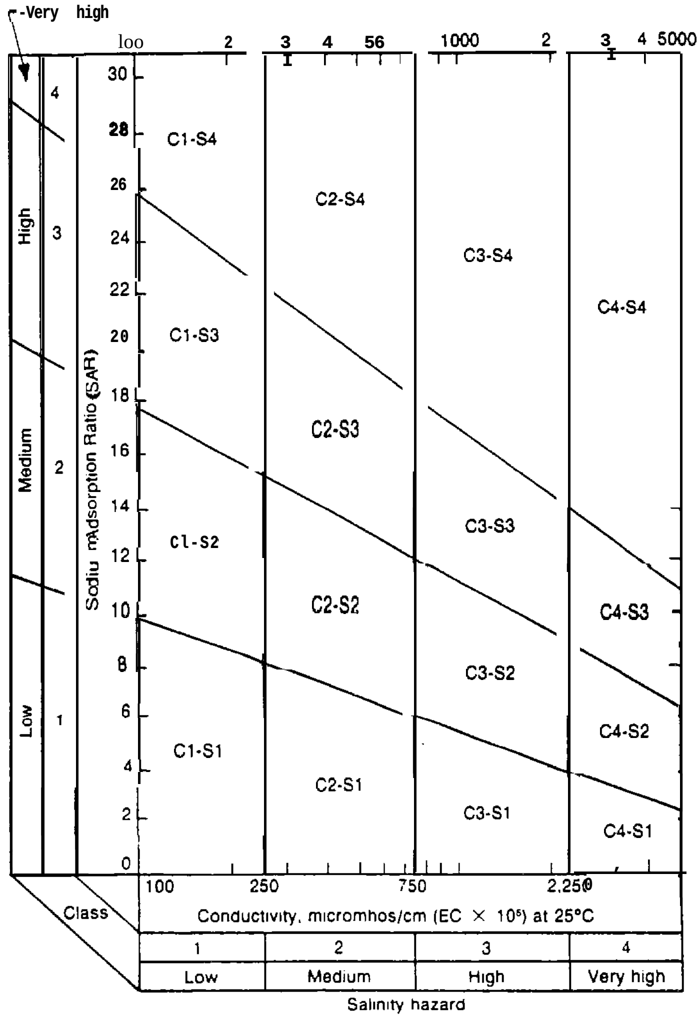

Figure 6. *Classification of irrigation waters based on SAR and conductivity. Interpretation of quality-class ratings of water for irrigation purpose.9 is as follows:*

Conductivity (Salinity)

***Low-salinity water* (Cl)** can be used for most crops and soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation on all but the tightest of soils.

***Medium-salinity water* (C2)** can be used where a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-salinity water (C3) cannot be used on soils that have restricted drainage. With adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very-high-dinky water (C4) is not suitable for irrigation under ordinary conditions. If used, the soils must be permeable, drainage must be adequate, considerable excess irrigation water must be applied, and very tolerant crops should be selected.

Sodium Adsorption Patio

***Low-sodium water* (S1)** can be used with little danger on nearly all soils. Sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

Medium-sodium *water* (S2) is hazardous for use on fine-textured soils that have high cation-exchange capacity. This water may be used on coarse-textured or organic soils with good permeability.

High-sodium water (S3) may be harmful to most soils and thus requires special soil management: good drainage, high leaching, and addition of organic matter. Chemical amendments may be necessary except for gypsiferous soils.

Very-high-sodium water (S4) is generally unsatisfactory for irrigation purposes, except at low salinity and where calcium from the soil or use of gypsum or other mineral additions may make these waters usable. (U.S. Department of Agriculture)

(from Groundwater **and** Wells; reprinted with permission)

Table 5. *Recommended maximum concentrations of certain elements in irrigation waters (afier Driscoll, 1986)*

Element	Recommended limit (mg/L)
Aluminum	5.0
Arsenic	0.1
Beryllium	0.1
Boron	0.75
Cadmium	0.01
Chromium	0.1
Cobalt	0.05
Copper	0.2
Fluoride	1.0
Iron	5.0
Lead	5.0
Lithium	2.5
Manganese	0.2
Molybdenum	0.01
Nickel	0.2
Selenium	0.02
Vanadium	0.1
zinc	2.0

(located at T. 17 N., R. 2 E., sec. 5, well number 1, sheet 1) from an 8-m (27-ft) deep dug well is classified as low-sodium high-salinity water, requiring special management for salinity control. A nearby drilled well, 45-m (146-ft) deep at the same location, yielded one of the samples classified as low-sodium, medium salinity. In this instance, the SAR value of that sample (4.1) exceeded the limit of less than 2.5 included in DEC (1979).

Trainer's (1960) data, which pertain to elements commonly found in relative abundance in ground-water, did not include analyses for elements associated with specific ion toxicity (with the exception of iron and manganese). The data from table 4 does contain information about several of the elements of concern, and was compared

Table 6. *State of Alaska Department of Environmental Conservation water quality criteria for irrigation waters (DEC, 1979)*

Parameter	Criteria
Fecal coliform	200 FC/100 ml[a] 20 FC/100 ml[b]
pH	5.0 - 9.0
Temperature	30°C
Total dissolved solids (TDS)	1,000 mg/L
Sodium absorption ratio (SAR)	2.5
Boron	0.3 mg/L

[a]For use with products normally cooked; mean value of five samples over a period of 30 days.
[b]For use with products not normally cooked; mean value of five samples over a period of 30 days.

against the recommended limits for those elements in irrigation water (table 5). In this comparison, none of the eight impurities present in both table-s exceeded the recommended limits. Values for iron were included in tables 3 and 4 in this report and in Trainer (1960). Only one sample, from a well located at T. 18 N., R. 1 E., sec. 34 well number 4 (sheet 1), exceeded the recommended limit (table 3). Feulner (1971) notes the presence of "excessive" concentrations of boron in wells in the Palmer area, which may be harmful to certain crops.

Based on the available data included here, water quality adequate for irrigation is generally available; however, individual supplies should be sampled and analyzed.

WELL INFORMATION

Appendix A contains information from well logs on file at AHS offices as of February 1989. For further hydrogeologic information, please contact either AHS (phone: 907-696-0070; P.O. Box 772116, Eagle River, AK 99577-2116) or the U.S. Geological Survey (phone: 907-786-7100; 4230 University Drive, Suite 201, Anchorage, AK 99508-4664).

SUMMARY AND CONCLUSIONS

Ground-water is the primary water-supply source for the city of Palmer and the surrounding area. Both confined and unconfined aquifers are tapped. Most of the water is withdrawn from sand and gravel alluvial deposits, or sand and gravel lenses within less permeable glacial deposits; bedrock is only occasionally used as a water-supply source. The aquifers are recharged by precipitation and snowmelt, leakage from surface-water lakes or streams, and flow from adjacent aquifers. Discharge occurs through springs, surface-water bodies, other aquifer-s, and pumpage.

Water-supply wells in Palmer are relatively shallow, generally less than 46 m (150 ft) deep, and are almost always adequate for single-family domestic or light commercial use, with reported yields of 0.6 to 1.9 l/s (10-30 gpm). Seasonally, the major use of water is agricultural, including irrigation. During the winter months, public water supply and single-family domestic supply account for most of the water use. Water-level records for the area do not indicate stress upon ares aquifers due to pumpage, suggesting that potential supply significantly exceeds actual usage.

Ground-water quality in the area is generally acceptable for most uses. Levels of iron commonly exceed the recommended limit of 0.3 mg/L for public water systems; additionally, water-softening treatments may be considered desirable. Occasional instances of poor quality water occur in which total dissolved solids exceed 500 mg/L, the maximum recommended by DEC for public water systems.

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APPENDIX A

Water well information for the Palmer area
(T = township, R = range, Sec. = section)

Appendix A. *Water well information for the Palmer area. (Map numbers are arbitrarily assigned to wells within a given section of land to facilitate location of the well on sheet 1; asterisk (*) indicates well encountered bedrock)*

T	R	Sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
16N	1E	3	1	1963	150			ADH	
			2	1963	28			ADH	
17N	1E	1	1	1979	211	125	20	M-W Drilling	Summer-woods Sub L15 B6
			1	1981	209	123	20	M-W Drilling	Summenvoods Sub L15 B6
			2	1982	252		25	Moon Drilling	Summerwoods Sub L10 B5B
			3	1982	62		8	Moon Drilling	Summer-woods Sub L9 B5A
			4	1981	143	105	10	McKay Well Drilling	Summerwoods Sub L17 B2
			5	1983	312	197	96	B & B Drilling	Summerwoods Sub L7B B5
			6	1983	118	91	6	Frontier Drilling	Summerwoods Sub L26 B1
			7	1983	55		16	B & B Drilling	Summerwoods Sub L6 B3
			8	1983	100	58	12	B & B Drilling	Summerwoods Sub L6 AB5
			9	1983	93	47	10	B & B Drilling	Summer-woods Sub L8 B1
			9	1983	62	47	10	McKay Well Drilling	Summer-woods Sub L9 B1
			10	1986	93	64	1	Hefty Drilling	Central Landfill
			11	1986	97			Hefty Drilling	Central Landfill
			12	1986	109	58		Unknown	Central Landfill
			13	1986	158			Hefty Drilling	Central Landfill
			13	1988	97			Hefty Drilling	Central Landfill
			14	1983	77	40	15	Wheaton Water Wells	Summerwoods Sub L16 B3
			15	1981	95		8	McKay Well Drilling	Summerwoods Sub L13 B3
			16	1984	60	40	5	Durbin Drilling	Summerwoods Sub L4 B3
			17	1982	80	50	15	Wheaton Water Wells	Summerwoods Sub L21 B3
			17	1983	81		30	Moon Drilling	Summerwoods Sub L3 B1
			18	1982	121	55	5	Wheaton Water Wells	Summerwoods Sub L20 B3
			19	1983	60	32	7	Wheaton Water Wells	Summerwoods Sub L25 B3
			20	1981	80	50	15	Wheaton Water Wells	Summerwoods Sub L24 B3
			21	1983	80	35	15	Wheaton Water Wells	Summerwoods Sub L23 B3
			22	1983	220		3	Moon Drilling	Summerwoods Sub L11 B3
			23	1984	181	90	4	Wheaton Water Wells	Summerwoods Sub L12 B3
			24	1981	85	43	12	McKay Well Drilling	Summerwoods Sub L14 B6
			24	1984	80	32	10	Wheaton Water Wells	Summerwoods Sub L13 B6
			25	1984	208		40	Moon Drilling	Summerwoods Sub L9 B3
			26	1984	60	40	5	Wheaton Water Wells	Summer-woods Sub L9 B6
			27	1983	143		40	Moon Drilling	Summerwoods Sub L6 B5A
			27	1983	122		12	Moon Drilling	Summerwoods Sub L7 B5A
			28	1982	141		25	Moon Drilling	Summerwoods Sub L6 B6
			29	1983	118	73	50	Frontier Drilling	Summer-woods Sub 3 L11 B5A
			30	1984	298	244		Moore Drilling	Summerwoods Sub 2 L4 B5B

			31	1982	242	85	12	Wheaton Water Wells	Summerwoods Sub 2 L5 B5B
			32	1983	242		15	Moon Drilling	Summerwoods Sub 2 L8 B5B
			32	1982	235		50	Moon Drilling	Summerwoods Sub 2 L9 B5B
			33	1984	120	84	20	Durbin Drilling	Summerwoods Sub L23 B1
			34	1983	98	81	7	Durbin Drilling	Summerwoods Sub L21 B1
			35	1980	238		15	CB Drilling	Summerwoods Sub L18 B1
			35	1985	58	48	10	Gee & Son's Wtr Wells	Summerwoods Sub L17 Bl
			36	1983	126	94	12	McKay Well Drilling	Summerwoods Sub L6 B2
			37	1982	161	95	12	Wheaton Water Wells	Summerwoods Sub L9 B2
			37	1983	144		15	McKay Well Drilling	Summerwoods Sub L7 B2
			38	1985	150	65	6	Gee's Water Wells	Summerwoods Sub L24 Bl
			39	1985	63	50	10	Gee's Water Wells	Summerwoods Sub L16 B1
			40	1983	121	96	10	Wheaton Water Wells	Summerwoods Sub L28 B1 '
			41	1982	80	45	15	Wheaton Water Wells	Summerwoods Sub L21 B2
			42	1982	98		12	Moon Drilling	Summerwoods Sub Ll 1 B1
			43	1983	60	32	10	Wheaton Water Wells	Summerwoods Sub L24 B2
			44	1982	141	107	25	Sullivan Water Wells	Summcrwoods Sub L1 1 B2
			45	1983	161	90	25	Wheaton Water Wells	Summerwoods Sub L12 B2
			46	1984	156	112	6	Moore Drilling	Summerwoods Sub L10 B2
			47	1982	143		20	Moon Drilling	Summerwoods Sub L15 B2
			48	1982	150	98	10	Valley Drilling	Summerwoods Sub L5 B5A
			49	1988	39	20	3	Hefty Drilling	Central Landfill
			50	1988	97			Hefty Drilling	Central Landfill
			51	1984	121	60	7	Wheaton Water Wells	Summerwoods Sub 3 L2B B5A
17N	1E	2	1		22		-	Pearson	
			2		40			Owner	
			3	1982	181	80	20	Wheaton Water Wells	Golden Hills Estates L5 B2
			4	1983	180	132	20	M-W Drilling	Section 2 L-D16
			5	1983	161	80	7	Wheaton Water Wells	Bit 0' Erin Sub L3 B2
			6	1984	156	75	6	Gee & Son's Wtr Wells	Bit 0' Erin Sub L20 B2
			7	1984	136	76	3	Gee & Son's Wtr Wells	Bit 0' Erin Sub L13 B2
			7	1985	112	75	15	WN White Drilling	Bit 0' Erin Sub L16 B2
			8	1984	186	76	3	WN White Drilling	Bit 0' Erin Sub L15A B2
			9	1983	167	100	8	Bill's Water Wells	Bit O' Erin Sub L6 B2
			9	1984	101	68	30	Wheaton Water Wells	Bit 0' Erin Sub L5 B2
			10	1983	110	70	5	Jay Williams Drilling	Golden Hills Estates L3 B4
			11	1983	280	81	3	Wheaton Water Wells	Bit 0' Erin Sub L2 B2
			11	1983	161	96	15	Wheaton Water Wells	Bit 0' Erin Sub L1 B2
			12	1982	205	90	20	McKay Well Drilling	Golden Hills Estates L2 B1
			13	1984	60	20	20	Wheaton Water Wells	Golden Hills Estates L3 B3
			14	1979	196	96	12	Blue Bear Drilling	Golden Hills Estates L4 B2
			14	1982	220	90	6	Wheaton Water Wells	Golden Hills Estates L4 B1
			15	1984	40		40	Moon Drilling	Golden Hills Estates L7 B1
			16	1982	166	90	8	Swanson Drilling	Golden Hills Estates L11 B3
			17	1982	180	85	10	Wheaton Water Wells	Golden Hills Estates L10 B3
			18	1982	171	90	9	Penn Jersey Drilling	Golden Hills Estates L20 B3
			19	1984	53	35	20	Friesen Drilling	Golden Hills Estates L18 B3

Appendix A. *Water* well information for *the Palmer area*-Continued

T	R	Sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			20	1984	178	90	30	Durbin Drilling	Golden Hills Estates L15 B1
			20	1984	175	135	10	Joe Gielarowski Drilling	Golden Hills Estates L16 B1
			21	1984	155	85	4	Rock Ridge	EntsSection 2 L-D7
			22	1984	178	90	25	Durbin Drilling	Golden Hills Estates L13 B1
			23	1978	202		7	Moon Drilling	Moffitt Acres L9
			24	1986	117		20	Moon Drilling	Section 2 L-B6
			25	1984	270*	78	5	Valley Drilling	Bit 0' Erin Sub L12 B2
			26	1981	96	83	9	Swanson Drilling	Golden Hills Estates L1 1 B1
			27	1984	225	131	10	Swanson Drilling	Section 2 L-D18
			28	1985	123	75	10	Bill's Water Welts	Golden Hills Estates L16 B3
			29	1978	125			unknown	Moffitt Acres L11
			30	1985	202	165	7	Durbin Drilling	Section 2 L-D19
17N	1E	3	1		14			Owner	
			2	1978	50	20	25	Ken's Company	
			3	1982	299*	58	2	U-W Drilling	Winding Brook Est L16 B1
			4	1982	81		7	Moon Drilling	Shellywoods Sub L3 B2
			4	1982	104		7	Moon Drilling	Shellywoods Sub L4 B2
			4	1982	60	25	7	Wheaton Water Wells	Shellywoods Sub L5 B2
			10	1982	60	10	25	Wheaton Water Wells	Shellywoods Sub L16 B1
			10	1983	60	15	30	Wheaton Water Wells	
			11	1984	60	32	10	Wheaton Water Wells	Shellywoods Sub L13 B1
			11	1984	80	40	10	Wheaton Water Wells	Shellywoods Sub L14 B1
			11	1983	60	10		Wheaton Water Wells	Shellywoods Sub L15 B1
			12	1982	56	15	20	Wheaton Water Wells	Shellywoods Sub L1 B1
			13	1982	51	20	8	Wheaton Water Wells	Shellywoods Sub L2 B1
			13	1982	53	20	7	Wheaton Water Wells	Shellywoods Sub L3 B1
			14	1983	50	25	8	Wheaton Water Wells	Shellywoods Sub L4 B1
			15	1982	60	38	15	H & H Drilling	Shellywoods Sub L8 B1
			15	1982	60	20	6	Wheaton Water Wells	Shellywoods Sub L5 B1
			16	1983	141	40	10	Wheaton Water Wells	Shellywoods Sub L10 B1
			16	1983	101	35	30	Wheaton Water Wells	Shellywoods Sub L11 B1
			16	1982	60	20	8	Wheaton Water Wells	Shellywoods Sub L12 B1
			17	1982	60		5	Magnuson Drilling	Shellywoods Sub L9 B1
			17	1983	80	35	20	Wheaton Water Wells	Shellywoods Sub L10 B2
			17	1983	101	30	30	Wheaton Water Wells	Shellywoods Sub L11 B2
			18	1982	70	47	20	H & H Drilling	Shellywoods Sub L6 B1
			18	1983	80	40	10	Wheaton Water Wells	Shellywoods Sub L7 B1
			19	1982	60	12	25	Wheaton Water Wells	Shellywoods Sub L1 B2
			19	1982	80	20	20	H & H Drilling	Shellywoods Sub L2 B2
			20	1983	100	65	25	Friesen Drilling	Shellywoods Sub Tr B
			21	1982	104		50	Moon Drilling	Shellywoods Sub L6 B2

			21	1982	63	40	10	Wheaton Water Wells	Shellywoods Sub L7 B2
			21	1982	60	30	5	Wheaton Water Wells	Shellywoods Sub L8 B2
			22	1982	60	30	20	H & H Drilling	Shellywoods Sub L9 B2
			23	1983	80	35	25	Wheaton Water Wells	Shellywoods Sub L12 B2
			23	1983	78	50	20	Wheaton Water Wells	Shellywoods Sub L13 B2
			24	1982	105		10	Moon Drilling	Shellywoods Sub L15 B2
			25	1982	60	25	8	Wheaton Water Wells	Shellywoods Sub L14 B2
			26	1979	50	30	20	H & H Drilling	Winding Brook Est L1 B1
			27	1982	83		4	Moon Drilling	Widiig Brook Est L1 8 B1
			29	1978	50	20	25	Ken's Company	Wmding Brook Est L4 B1
			43	1983	60	25	50	Wheaton Water Wells	Section 3 L-C2
17N	1E	10	1	1922	57			Peter Johnson	
			4		107	86	16	L & M Drilling	Campus by Cottrell Sub L7 B3
			6	1983	161	50	80	Wheaton Water Wells	Matanuska Heights Sub L1
			7	1978	235	118	30	McKay Well Drilling	Cottrcll Park Sub L2A B2
			7	1983	234	124	6	Gee's Water Wells	Cottrell Park Sub L2B B2
			8	1971	200			unknown	Cottrell Park Sub L5 B1
			9	1980	188	30	10	H & H Drilling	Campus by Cottrell Sub L9 B3
			10	1976	135	10	10	H & H Drilling	Campus by Cottrell Sub L2 B1
			11	1976	138			Unknown	Campus by Cottrell Sub L3 B1
			12	1977	289		10	unknown	Campus by Cottrcll Sub L3 B2
			12	1977	150			Moon Drilling	Campus by Cottrell Sub L4 B2
			14	1980	99	85	7	Valley Drilling	Cottrell Park Sub L2 B3
			15	1982	100	80	10	Valley Drilling	Section 10 L-A2
			17	1974	159	54	11	H & H Drilling	Matanuska Heights L7
			18	1975	133		25	H & H Drilling	Matanuska Heights L4
17N	1E	11	1	1981	208	90	15	Wheaton Water Wells	Campus by Cottrell Sub L10 B2
			2	1983	330	111	20	Durbin Drilling	Campus by Cottrell Sub L17 B2
			3	1984	242	80	30	Wheaton Water Wells	Campus by Cottrell Sub L21 B2
			4	1984	127	89	20	Moon Drilling	Campus by Cottrcll Sub L23 B2
			5	1981	157			unknown	Campus by Cottrcll Sub L7 B2
			5	1981	160	90	25	McKay Well Drilling	Campus by Cottrell Sub L6 B2
			6	1984	222	80	10	Wheaton Water Wells	Campus by Cottrell Sub L19 B2
			6	1984	222	80	10	Wheaton Water Wells	Campus by Cottrell Sub L20 B2
			7	1979	226	126	10	Valley Drilling	Campus by Cottrcll Sub L15 B2
			7	1979	230	135	30	Wheaton Water Wells	Campus by Cottrcll Sub L13 B2
17N	1E	13	1	1974	201	9s	50	M-W Drilling	Canoe Lake Sub L5 B2
			2	1974	204*		6	M-W Drilling	Canoe Lake Sub L10 B2
			2	1985	103	95	15	Gee's Water Wells	Canoe Lake Sub L2 B3
			3	1976	64	56	8	McKay Well	DrillingIrene Lake
			4	1979	99	85	10	M-W Drilling	Canoe Lake Sub 2 L9
			5	1980	197	95	7	Sullivan Water Wells	Canoe Lake Sub L14 B1
			5	1985	159	85	15	Gee's Water Wells	Canoe Lake Sub L15 B1
			6	1985	90	85	10	Bill's Water Wells	Canoe Lake Sub 2 L8
			7	1976	198*		10	Moffitt Drilling	Canoe Lake Sub L13 B1

Appendix A. ***Water well information for the*** Palmer area-Continued

T	R	Sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			8	1983	63		60	Moon Drilling	Tara Dells Sub L7 B3
			9	1978	98	87	10	Valley Drilling	Tara Dells Sub L9 B3
			10	1978	96	88	8	McKay Well Drilling	Tara Wells Sub L1 B2 Tr.C
			11	1985	62	53	8	Moore Drilling	Tara Wells Sub L4 B3
			12	1977	72			Unknown	Tara Dells Sub L1 B3
			12	1982	81		30	Moon Drilling	Tara Dells Sub L2 B3
			13	1977	69	60	15	McKay Well Drilling	Tara Dells Sub L3 B1
17N	1E	15	5		96			ARRC	-
			6	1937	105*	55		ARRC	
			8	1972	288	62	47	M-W Drilling	UAF Dairy Research Facility
17N	1E	23	1		21	9		ARRC	
			2		90	76		ARRC	
			3	1963	70			unknown	
			3	1975	125	83	30	M-W Drilling	Section 23 L-B1
			4	1973	124	80	15	G & G Drilling	AA Cobb Subdivision L21
			5	1986	101	50	40	Wheaton Water Wells	Kepler-Bradley Lake
17N	1E	24	1		108	90	18	Cotten Drilling	
			2	1978	190*		20	CB Drilling	Bradley Lake Sub L3B B3
			3	1979	164		50	Moon Drilling	Bradley Lake Resub L3A
			4	1978	60	15	12	H & H Drilling	Bradley Lake Sub L1 B1
			5	1984	144	68	40	Durbin Drilling	Bradley Lake Sub L5 B1
			6	1977	215*			Delta Drilling	Bradley Lake Sub L4 B1
			7	1984	141		100	Moon Drilling	Bradley Lake Sub L2A B2
			8	1970	219	83		Unknown	Kepler Sub 2 Parcel A
			9	1988	69		10	Moffiu Drilling	
			10	1981	77	12	30	Swanson Drilling	Grandview Sub Tr.3
			10	1979	55	39	20	Swanson Drilling	Grandview Sub Tr.4
			11	1977	113	81	10	Swanson Drilling	Grandview Sub L2 B 1
			12	1972	172*	81	10	Cotten Drilling	
17N	2E	3	1		109*	61		ARCC	Palmer airport
			2	1949	80	77		Owner	Palmer airport
			3	1952	118	100	12	Penn-Jersey Drilling	
			4		117	80		Unknown	
17N	2E	4	1		155*			ARRC	Old hospital
			2		47			ARRC	
			3	1949	72	64		Moffitt Drilling	Palmer airport

			4	1936	300*	75		ARRC	Government tract 68
			5	1937	97			ARRC	Government tract 67
			6	1936	590*			ARRC	Old slaughterhouse well
			7	1936	113	107	5	ARRC	Government tract 70
			8	1937	i14			ARRC	Government tract 69
			9	1949	105	103		unlcnown	
			10	1962	120			Moffitt Drilling	
			11	1963	112	62		Knik Drilling Company	Experimental Station
			12	1987	186	103	1200	M-W Drilling	Section 4 L-D9
			12	1986	190	105	300	M-W Drilling	Section 4 L-D9
17N	2E	5	1	1955	27	25		F. Bailey	
			1	1956	48*	29	S	Cotten Drilling	
			i	1956	146*	49	1/4	Cotten Drilling	
			1		24	22		unknown	
			2	1949	34*	15	4	ARRC	
			3	1949	86			Moffitt Drilling	
			3	1967	210*	65		G & G Drilling	
			4	1949	64*	44	7	G & G Drilling	Section 5 L-Al5
			4	1965	180			unknown	
			5	1953	64	5s	7	Hamilton & Cotten Drl	
			6	1937	74	67		ARRC	Government tract 17
			7		90			Moftitt Drilling	
			S	1949	44	42		Owner	
			9	1954	139	59	6	Sam Cotten Drilling	
			10	1970	114	41		Sam Cotten Drilling	Section 5 L-B6
			11	1973	150			G & G Drilling	
			11	1975	300			G & G Drilling	
			12	1976	96	65	2	Vcm's Drilling	Timbered Acres Sub L3 B1
			13	1976	85	64	1	Vem's Drilling	Timbered Acres Sub L4 B1
			13	1978	76	57	25	Swanson Drilling Co.	Timbered Acres Sub L5 B1
			14	1982	185*	43	2	WN White Drilling	Section 5 L-Cl9
			15	1983	210*			WN White Drilling	Fairside Est L3
			16		96	81	15	Swanson Drilling Co.	Bollen Sub L7B
			17	1978	75	60	15	Swanson Drilling Co.	Timbered Acres Sub L6 Bl
			1s	197s	80	35	2	H & H Drilling	Timbered Acres Sub L1 B2
			19	1976	86*			Moftitt Drilling	Section 5 L-Al6
			19	1984	145*	70	2	unknown	Section 5 L-A16
			20	1984	166*			Moon Drilling	Section 5 L-Al5
			21	1986	118*	60	5	Martin's Water Wells	Section 5 L-C10
17N	2E	6	1		144	104		ARRC	Government tract 16
			2	1947	30	27		Owner	
			3	1953	126			Hamilton & Cotten	
			3	1968	85	47	10	G & G Drilling	
			4		63	55		ARRC	
			5	197s	76*			Gee's Water Wells	Palmer West Sub L8 B2
			6	1982	225		15	Wheaton Water Wells	Silvers Sub Phase I L5
			7	1983	100	77	4	Gee's Water Wells	Palmer West Sub L22 B1

Appendix A. *Water well information for the Palmer area*-Continued

T	R	Sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			8	1984	43*			M-W Drilling	Palmer West Sub L23 B1
			8	1984	79	65	15	M-W Drilling	Palmer West Sub L23 B1
			8	1984	97*	78	3	Gee's Water Wells	Palmer West Sub L25 B1
			9	1984	78	74	10	Gee's Water Wells	Palmer West Sub L6 B2
			10	1984	86	79	8	Gee's Water Wells	Palmer West Sub L12 B1
			10	1986	90	78	15	Martin's Water Wells	Palmer West Sub L11 B1
			11	1984	78*			Gee's Water Wells	Palmer West Sub L9 B1
			11	1984	73*			Gee's Water Wells	Palmer West Sub L9 B1
			11	1984	86	79	2	Gee's Water Wells	Palmer West Sub L9 B1
			12	1983	86	74	10	Gee's Water Wells	Section 6 L-D2
			13	1985	84	70	112	Durbin Drilling	Palmer West Sub L3 B2
			14	1959	106		12	Cotten Drilling	Section 6 L-B6
			15	1982	82		10	Swanson Drilling	Palmer West Sub L16 B1
			16	1979	98*	87	10	Gee's Water Wells	Palmer West Sub L13 B1
17N	2E	7	1	1975	148	65	75	M-W Drilling	Green Valley Sub Tr-D
			2	1983	119	69	155	M-W Drilling	Green Valley Sub Tr-E
			3	1984	175	116	10	Valley Drilling	Green Valley Sub 1 L2 B7
			4	1985	73	52	10	Durbin Drilling	Green Valley Sub 1 L5 B7
			5	1979	98	65	30	M-W Drilling	Green Valley Sub Tr-G
			6	1982	197	133	2	Wheaton Water Wells	Section 7 L-A9
			7	1987	77	56	10	L & M Drilling	Section 7 L-D3
17N	2E	8	1		89			ARRC	Section 8 L-D1
			2		78	72		ARRC	Government tract 54
			3		70			unknown	
			4	1936	93	68		ARRC	Government tract 49
			5	1953	113	97	10	Moffitt Drilling	
			6	1953	129*	103	5	Moffitt Drilling	
			7		125	119		ARRC	Government tract 48
			8		84	59	20	G & G Drilling	Section 8 L-B6
			9	1962	14			ADH	
			10	1940	88			ARRC	
			11	1935	72			ARRC	Section 8 L-D1
			12	1982	80	65	5	M-W Drilling	Hodson Sub L2
			12	1972	91	70	7	G & G Drilling	Section 8 L-B17
			13	1983	105	90	25	Bill's Water Wells	Wild Rose Estates Sub L10
			14		132			Unknown	Wild Rose Estates Sub L7
			15	1972	91	70	7	G & G Drilling	Section 8 L-B17

17N	2E	9	1	-	106	80		Unknown	
			2	1950	109	99		Northern Drilling Co	
			2	1981	124		25	Moon Drilling	Willis Sub Tr-A
			3	1936	121			ARRC	Government tract 207
			4	1952	92	67		Kozloski	
			5	-	84	78		ARRC	Section 9 L-D3
			6	1935	112	70		ARRC	Section 9 L-Cl
			7	1952	91	80		Moffitt Drilling	
			8	1949	94	81		ARRC	Government tract 71
			9	1949	83	73		ARRC	section 9 L-C17
			10	1966	124	84	350	Sam Cotten Drilling	
			11	1974	120	104	30	B.A. Drilling Co	Section 9 L-A13
			12	1978	180	-	10	H & H Drilling	Pope Sub L1
17N	2E	10	1	1987	86			Owner	Section 10 L-A2
			2	1936	83	81		ARRC	Section 10 L-B5
			3	1935	105	87		ARRC	Section 10 L-B3
			4	1935	174	81		ARRC	Section 10 L-C7
			4	-	200	110		unknown	Section 10 L-C7
			5	-	76	72	12	ARRC	Suction 10 L-C1 1
			5	1949	147	70			
			6	1970	118	72	500	L & M Drilling	Section IO L-B3
			7	1982	96	73	25	Valley Drilling	Lepak Sub I L6 B3
			8	1982	90	67	10	Valley Drilling	Greater Springer Est L14 B1
			8	1981	84		10	Moon Drilling	Greater Springer Est L15 B1
			9	1983	81		25	Moon Drilling	Greater Springer Est L5 B1
			10	1977	97	71	15	Wilson Well Drilling	Gunnysack Acres L2
			11	1983	80	64	5	Wheaton Water Wells	Greater Springer Est L20 B1
			12	1981	85		10	Moon Drilling	Greater Springer Est L16 B1
			12	1980	85		20	Moon Drilling	Greater Springer Est L17 B1
			13	1977	80	72	12	Hartner Drilling	Greater Springer Est L2 B1
			14	1980	81		20	Moon Drilling	Greater Springer Est L9 B1
			15	1978	157	69	30	A & L Drilling	Greater Springer Est L11 B1
			15	1988	187	67	30	Archibald Drilling	Greater Springer Est L13 B1
			16	1977	83	62	30	Hartner Drilling	Greater Springer Est L8 B1
			18	1985	80	70	20	Gee's Water Wells	Greater Springer Est L23 B1
17N	2E	15	1	1936	80	35		ARRC	Section 15 L-D4
			2	1949	77		2	ARRC	
			2	1984	67	53	30	Gee's Water Wells	Colony East Sub L1 B5
			3	1983	84		15	Moon Drilling	Glen View Sub L2 B1
			5	1982	80		30	Moon Drilling	Glen View Sub L6 B1
			5	1981	78		34	Moon Drilling	Glen View Sub L7 B1
			6	1982	81		30	Moon Drilling	Glen View Sub L9 B1
			6	1982	81		30	Moon Drilling	Glen View Sub L10 B1
			6	1982	80		30	Moon Drilling	Glen View Sub L8 B1

T	R	sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			7	1984	65	53	30	Gee's Water Wells	Colony East Sub L5 B3
			7	1985	60	43	20	Gee's Water Wells	Colony East Sub L5 B3
			9	1984	65	53	20	Gee's Water Wells	Colony East Sub L5 B4
			10	1984	67	53	30	Gee's Water Wells	Colony East Sub L1 B4
			11	1984	64	52	30	Gee's Water Wells	Colony East Sub L7 B4
			12	1982	82		30	Moon Drilling	Glen View Sub L5 B1
			12	1982	80		30	Moon Drilling	Glen View Sub L4 B1
			12	1982	80		30	Moon Drilling	Glen View Sub L3 B1
			14	1984	70	60	20	Gee's Water Wells	Colony East Sub L1 B2
			14	1984	74	60	36	Gee's Water Wells	Colony East Sub L2 B2
			15	1985	71	56	20	Gee & Son's Water Wells	Colony East Sub L4 Bl
			16	1984	73	49	36	Gee's Water Wells	Colony East Sub L2 B6
17N	2E	16	1	1936	63	56		ARRC	Section 16 L-AI
			2	1936	80	75		ARRC	Fremont Meadows Tr-E
			3		92	62	7	ARRC	Section 16 L-A5
			4	1937	72	67	3	ARRC	Liebing Sub Tr-1
			5	1935	63	57		ARRC	
			5	1984	87	60	20	Bullock's Well Drilling	Springer View Est L1 B4
			6	1984	80	68	10	Bullock's Well Drilling	Springer View Est L7 B1
			6	1984	80		25	Bullock's Well Drilling	Springer View Est L6 B1
			7	1984	80	62	25	Bullock's Well Drilling	Springer View Est L8 B4
			8	1984	80	60	10	Bullock's Well Drilling	Springer View Est L6 B4
			8	1984	80	57	25	Bullock's Well Drilling	Springer View Est L5 B4
			9	1984	90	55	45	Bullock's Well Drilling	Springer View Est L7 B2
			9	1985	80	57	20	Bullock's Well Drilling	Springer View Est L4 B4
			10	1984	80	68	10	Bullock's Well Drilling	Springer View Est L12 B3
			11	1984	80	62	25	Bullock's Well Drilling	Springer View Est L9 B3
			12	1984	80	57	20	Bullock's Well Drilling	Springer View Est L6 B2
			13	1984	80	57	25	Bullock's Well Drilling	Springer View Est L3 B2
			14	1984	73	54	10	Gee's Water Wells	Springer View Est L5 B1
			14	1984	80	55	25	Bullock's Well Drilling	Springer View Est L3 B1
			14	1984	70	60	8	Gee & Son's Water Wells	Springer View Est L4 B1
			15	1985	80	57	20	Bullock's Well Drilling	Springer View Est L12 B2
			16	1984	70	57	20	Gee's Water Wells	Springer View Est L2 B3
17N	2E	17	1	1936	75			ARRC	Section 17 L-Al
			2	1937	85			ARRC	Section 17 L-A7
			3	1936	74	71		ARRC	Section 17 L-B4
			4	1955	114*	64	53	Ramsey	Section 17 L-Al

			5	1937	79	56	3	ARRC	Section 17 L-A5
			6	1935	64	56		ARRC	Section 17 L-D9
			7		60			ARCC	Section 17 L-D2
			8	1953	60			Moffitt Drilling	
			9	1936	133	50		ARRC	section I7 L-C2
			10	1945	187	47		ARRC	
			11	1953	83	46	2	Sam Cotten Drilling	Section 17 L-B1
			12		72	50	10	G & G Drilling	Section 17 L-B1
			13	1983	50	43	15	Frontier Drilling	Outer Springer Wds Sub L6 B1
			14	1976	60		40	Moon Drilling	Outer Springer Wds Sub L2 BP
			15	1981	61	-	43	Moon Drilling	Outer Springer Wds Sub L4 B1
			16	1981	50	-	20	Swanson Drilling	Mountain View Est L8 B2
			17	1978	139		10	Moon Drilling	Mountain View Est L13 B4
			18	1986	55	41		Gee & Son's Water Wells	Outer Springer Wds Sub L5 B2
			19	1978	70	60	7	Gee's Water Wells	
			19	1979	78	58	10	Gee's Water Wells	Kalwies Sub L2
			20	1983	90	59	200	Swanson Drilling	Section 17 L-A6
			21	1965	58	43	9	OK Drilling	Springer Sub 2 Tr-1
17N	2E	18	1	1937	41	35	5	ARRC	Section 18 L-Al 1
			2	1937	36	22		ARRC	Seetion 18 L-D3
			3	1950	32	22		Frey Brothers Drilling	Section 18 L-D2
			4	1937	50	47		ARRC	Scetion 18 L-B4
			5	1937	39			ARRC	Scetion 18 L-A4
			6	1935	42	39		ARRC	Section 18 L-A3
			7	1962	34		-	ADH	Section 18 LA3
			7	1962	32			ADH	Seetion 18 L-A3
			8	1970	65	37	17	G & G Drilling	
17N	2E	19	1	1937	43	39	-	ARRC	Section 19 L-AI
17N	2E	20	1	1936	55	51		ARRC	Section 20 L-A6
17N	2E	21	1	1980	38		15	Gee's Water Wells	Circle View Sub L7 B2
			2	1982	90	65	20	Magnuson Drilling	Circle View Sub L2 B3
			2	1983	55	33	2.5	Hefty Drilling	Circle View Sub Ll B3
			3	1983	40	17	10	Bill's Water Wells	Circle View Sub L6 B3
			4	1983	90	30	10	Bill's Water Wells	Circle View Sub L15 B1
			5	1984	50	44	10	Gee's Water Wells	Circle View Sub L4 B3
			6	1983	90	40	10	Bill's Water Wells	Circle View Sub L3 B3
			7	1982	60	25	8	H & H Drilling	Circle View Sub L11 B2
17N	2E	22	1	1954	144*	39	13	Conboy	Section 22 L-C11
			1	1949	52	38		ARRC	Section 22 L-Cl 1
			2		18			Owner	Section 22 L-C6
			2	1965	171*	42	1/2	A & L Drilling	Section 22 L-C6
			3		44	34		ARRC	Butte Meadows Sub L6

Appendix A. *Water well information for the Palmer* area-Continued

T	R	sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			3		51	31	7	G & G Drilling	Butte Meadows Sub L6
			4		38	29		ARRC	-
			5		44	30	10	G & G Drilling	Section 22 L-D6
			6	1960	35	6	40	G & G Drilling	Section 22 L3
			7		78*	22	3	G & G Drilling	Section 22 L-D4
			8	1982	130			Bill's Water Wells	Circle View Sub L8 B1
			9	1982	76		7	Magnuson Drilling	Circle View Sub L9 B1
			10	1983	120	20	15	Wheaton Water Wells	Circle View Sub L2 B2
			11	1982	235			Magnuson Drilling	Circle View Sub L4 B1
			12	1982	33	26	10	Biis Water Wells	Circle View Sub L5 B1
			13	1984	68	28	20	Bill's Water Wells	Circle View Sub L13 B1
			14	1984	62	30	5	Bill's Water Wells	Circle View Sub L5 B4
			15	1985	41	13	10	Jay Williams Drilling	Circle View Sub L5 B5
			16	1985	37	28	10	Gee & Son's Water Wells	Circle View Sub L1 B4
			17	1985	43		50	Moon Drilling	Stampede Est L4 Bl
17N	2E	27	1	1937	55			ARRC	Section 27 L-B2
			1		63	52	10	G & G Drilling	Section 27 L-B2
			2	1937	56			ARRC	Section 27 LB 1
			3	1937	22			ARRC	Section 27 L-B6
			4	1937	19	13		ARRC	Section 27 L-C3
			5		23	12		ARRC	Section 22 L-C4
			7	1937	35			ARRC	Section 27 Lots
			8	1937	32			ARRC	Section 27 Lots
			8	1982	78	29	230	M-W Drilling	Section 27 L-A2
			10		40			unknown	
			11	1983	62		60	Moon Drilling	King Sub I L1
			11	1986	50	16	40	Martin's Water Wells	King Sub I L2
			12	1984	41	20	20	Gee's Water Wells	King Sub II L18
			13	1984	40	20	20	Wheaton Water Wells	King Sub II L19
			14	1981	40	25	4	Jay Williams Drilling	King Sub I L24
			14	1981	39	18	12	Bill's Water Wells	King Sub I L23
			15	1981	60	30	30	Jay Williams Drilling	King Sub I L11
17N	2E	34	1	1937	21			ARRC	Section 34 L-D5
			2		22			Moffitt Drilling	
			3		21	16		ARRC	Section 34 Lots
			4	1937	27	7		ARRC	Section 34 Lots
			4	1969	30	18	10	G & G Drilling	Section 34 Lots
			4	1962	30	17	7	G & G Drilling	Section 34 Lots
			8	1956	27	19	8	G & G Drilling	Section 34 Lots

18N	1E	25	1	1982	65	37	10	Valley Drilling	Eagle Est L27 B3
			2	1982	134	57	5	Valley Drilling	Eagle Est L43 B3
			2	1982	68	46	P0	Valley Drilling	Eagle Est L44 B3
			3	1982	99	52	5	Valley Drilling	Eagle Est L42 B3
			3	1982	74	52	10	Valley Drilling	Eagle Est L41 B3
			3	1982	150	52	10	Valley Drilling	Eagle Est L40 B3
			4	1982	100	50	20	Valley Drilling	Eagle Est L26 B3
			4	1983	78	51	10	Valley Drilling	Eagle Est L25 B3
			5	1982	147	53	10	Valley DrilIing	Eagle Est L37 B3
			5	1982	137	56	5	Valley Drilling	Eagle Est L39 B3
			6	1983	112	37	10	Valley DrilIing	Eagle Est L24 B3
			6	1983	132	50	10	Valley Drilling	Eagle Est L23 B3
			7	1983	70	55	10	Valley Drilling	Eagle Est L48 B3
			7	1985	62	55	P0	Gee's Water Wells	Eagle Est L7 B6
			8	1983	110	56	10	Valley Drilling	Eagle Est L51 B3
			8	1983	131	65	8	Valley Drilling	Eagle Est L49 B3
			9	1983	68	50	10	Valley Drilling	Eagle Est L45 B3
			10	1983	125	41	10	Valley Drilling	Eagle Est L22 B3
			10	1983	114	31		Valley Drilling	Eagle Est L21 B3
			11	1983	122	49	8	Valley Drilling	Eagle Est L19 B3
			11	1983	112	40	10	Valley DrilIing	Eagle Est L20 B3
			12	1984	72	54	15	Gee's Water Wells	Eagle Est L14 B6
			13	1984	78	57	20	Gee's Water Wells	Eagle Est L8 B6
			13	1984	118	45	20	Gee & Son's Water Wells	Eagle Est L10 B6
			13	1983	40	31	10	Downey Inc.	Eagle Est L10 B6
			14	1985	60	35	10	Gene Skyles Well Drilling	Eagle Est L7 B1
			15	1983	129	46	10	Valley Drilling	Eagle Est L30 B3
			15	1984	121	65	12	Valley Drilling	Eagle Est L29 B3
			16	1983	146	51	8	Valley Drilling	Eagle Est L32 B3
			17	1983	138	59	8	Valley Drilling	Eagle Est L17 B3
			17	1983	141	64	50	Wheaton Water Wells	Eagle Est L16 B3
			18	1984	81		20	Moon DrilIing	Eagle Est L53 B3
			19	1983	61		15	Moon Drilling	Eagle Est L61 B3
			20	1983	141	64	30	Wheaton Water Wells	Eagle Est L13 B3
			21	1983	136	51	20	Valley Drilling	Eagle Est L56 B3
			21	1983	116	37	7	Valley Drilling	Eagle Est L57 B3
18N	1E	26	1	1942	16	14	-	Owner	Section 26 L-Cl
			1	1936	59		-	ARRC	Section 26 L-Cl
			2	1985	123*	+3	5	Gene Skyles Well Drilling	Eagle Est L8 B2
			2	1984	83*	3	5	Gene Skyles Well Drilling	Eagle Est L10 B2
			2	1985	75	20	10	Gene Skyles Well Drilling	Eagle Est L9 B2
			3	1985	38	2	50	Gene Skyles Well Drilling	Eagle Est L6 B2
			4	1985	86	25	12	Gene Skyles Well Drilling	Eagle Est L5 B2
			5	1985	33	11	15	Durbin DrilIing	Eagle Est L49 B1
			6	19x5	49	15	30	Gee's Water Wells	Eagle Est L38 B1
			7	1984	56	24	40	Durbin Drilling	Eagle Est L28 B1
			8	1983	60	40	20	Wheaton Water WelIs	Eagle Est L19 B1

Appendix A. *Water well information for the Palmer area*-Continued

T	R	sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
18N	1E	27	1	1936	23	19		ARRC	Section 22 L-D2
18N	1E	34	1	1961	33			unknown	
			3		42	22	10	G & G Drilling	Section 34 L-D14
			4	1973	29	10	15	Foss Drilling	Section 34 L-D14
			26	1976	38	20	12	Wallace Drilling	Section 34 L-D3
18N	1E	35	1	1949	58	56		Owner	
			2		79	17	5	G & G Drilling	Section 35 L-D1
			3	1985	35	6		Pioneer Drilling	Midtown Est 2 Tr-5
			4	1984	112	20	80	Wheaton Water Wells	Suction 35 L-Cl
			5	1984	100	15	100	Whcaton Water Wells	Midtown Est Tr-D
			6	1965	200	24		Gohr Drilling	Section 35 L-C8
			7	1975	69		5	Moffitt DriUing	Section 35 L-C2
18N	1E	36	1	1935	142	82		ARRC	Section 36 L-Al
			2		100	95		ARRC	Section 36 L-Al
			3	1936	108	50		ARRC	Section 36 L-C5
			4		86	61		unknown	
			5	1970	202	139	10	G & G Drilling	Arabian Acres Sub L1 B1
			6	1976	50	23	9	D & E Drilling	Arabian Acres Sub L5 B3
			7	1982	117		30	Muon Drilling	Laurel Est 2 L10 B3
			7	1982	100	38	5	McKay Well Drilling	Laurel Est 2 L1 1 B3
			8	1982	125	25	8	Jay Williams Drilling	Arabii Acres Sub L3 B5
			9	1986	141		30	Moon DriUing	Arabian Acres Sub L2 B5
			10	1983	156	15	50	Durbin DriUing	Arabian Acres Sub L2 B4
			10	1980	146			H & H Drilling	Arabian Acres Sub L3 B4
			11	1981	181	60	20	Wheaton Water Wells	Laurel Est 1 L4 B3
			12	1983	141	40	30	Sullivan Water Wells	Laurel Est 1 L5 B3
			13	1981	140	100	25	Jay Williams Drilling	Laurel Est 1 L6 B3
			14	1984	142		30	Muon Drilling	Laurel Est 1 L1 B2
			14	1981	126		12	Moon Drilling	Laurel Est 1 L5 B2
			15	1986	142		40	Moon Drilling	Laurel Est 1 L3 B2
			16	1983	120	80	10	Jay Williams Drilling	Laurel Est 1 L2 B1
			17	1981	40		8	Moon Drilling	Laurel Est 2 L8 B3
			18	1984	315	150	20	Wheaton Water Wells	Arabian Acres Sub L2 B1
			19	1981	100	85	30	H & H Drilling	Arabian Acres Sub L5 B4
			20	1981	140	50	10	H & H Drilling	Arabian Acres Sub L1 B4
			21	1983	130	35	20	Bill's Water Wells	Arabian Acres Sub L7 B3
			22	1981	244			CB DriUing	Arabian Acres Sub L6 B1
			23	1983	201		20	Moon Drilling	Arabian Acre-s Sub L4 B1

			24	1979	248	161	15	Arctic Drilling Co	Arabian Acres Sub L5 B1
			25	1983	127			Moon Drilling	Section 36 L-B4
			26	1984	220		1	Wheaton Water Wells	Ortner Sub L8
			27	1980	120	40	10	H & H Drilling	Arabian Acres Sub L2 B3
			28	1983	161			Moon Drilling	Arabii Acres Sub Cl B3
18N	2E	27	i		295		10	G & G Drilling	
			2	1965	163	108	3	G & G Drilling	
18N	2E	28	1		45		-	Moffitt Drilling	
			2	1949	70	58		Owner	Section 28 LB4
			3	1948	58	46	-	Owner	Section 28 L-C6
			4	1950	27	25	-	F. Bailey	Section 28 L-C6
			5	1950	25	24		F. Bailey	Bailey Hts Sub
			6	1950	31			F. Bailey	
			6	1977	241	15	10	H & H Drilling	Bailey Hts Sub L7 B2
			7		28	25		F. Bailey	Bailey Hts Sub
			7	1950	15	12	25	F. Bailey	Bailey Hts Sub
			8	1952	126	96		S. Kozloski	Alaska Rockhound Sub
			9	1947	35			Moffitt Drilling	
			10		60	15	10	G & G Drilling	Bailey Hts Sub
			11		23			Owner	
			11		30	-		Owner	
			11	1951	96			Frey Brothers Drilling	
			11	1959	122	98	10	G & G Drilling	Bailey Hill
			12	1961	128			unknown	
			13	1940	60			Unknown	
			13		98	21	1/2	G & G Drilling	Bailey Hts Sub L27 B3
			14		114	75	20	G & G Drilling	Palmer
			15	1963	40			Owner	
			16		27			Unknown	
			16		49	16	10	G & G Drilling	Bailey Hts Sub L35 B3
			17	1985	294	244	17	J. Gielarowski Drilling	Bailey Heights Sub L10 B2
18N	2E	29	4	1949	30	28		Unknown	
			5	1935	61	48	-	ARRC	Section 29 L-D6
			6	1936	61		-	ARRC	Section 29 L-C5
			6	1964	97	32	25	Moffitt Drilling	Section 29 L-C5
			7	1936	79	53	-	ARRC	Section 29 L-C5
			8	1935	118	90	-	ARRC	Section 29 L-D4
			9	1977	37	18	4	Gee's Water Wells	Section 29 L-D5
			11	1965	62		-	Moffitt Drilling	Section 29 L-B4
			12	1977	112	59		Moffitt Drilling	Section 29 L-C6
			14	1977	100		-	Moffitt Drilling	Section 29 L-C6
18N	2E	30	3		54			Owner	Section 30 L-B23
			3	1953	75	43		Moffitt Drilling	Section 30 L-B23
			4		9	0		Owner	

Appendix **A.** *Water well information for the Palmer area-Continued*

T	R	Sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			4	1967	36	19	30	G & G Drilling	Section 30 L-C6
			6	1936	51	46		ARRC	Section 30 L-A4
			7	1955	70	4s	12	Moffitt Drilling	Section 30 L-A4
			8		120	63		ARRC	Section 30 L-CS
			8	1978	189	100	10	M-W Drilling	Section 30 L-C5
			9	1968	130	71	10	G & G Drilling	Section 30 L-B20
			11	1982	114	48	10	Valley Drilling	Eve's Eye Sub L1 B1
			13	1979	49	38	S	Gee's Water Wells	Section 30 L-B15
			14	1983	161		50	Moon Drilling	Eve's Eye Sub L10 B1
			14	1979	125	50	1/2	Valley Drilling	Eve's Eye Sub L10 B1
			1s	1983	131	48	40	M-W Drilling	Forest Hills Sub L3 B2
			16	1983	127	58	25	M-W Drilling	Forest Hills Sub L6 B2
			17	1983	119	52	25	M-W Drilling	Forest Hills Sub L4 B2
			18	1983	100	28	12	McKay Well Drilling	Eve's Eye Sub L10 B2
			19	1981	100		13	Moon Drilling	Eve's Eye Sub L7 B2
			20	1983	161		60	Moon Drilling	Eve's Eye Sub L5 B1
			21	1984	171	70	7	Wheaton Water Wells	Eve's Eye Sub L3 B1
			22	1983	90	40	12	Gee's Water Wells	Eve's Eye Sub L4 B2
			22	1983	117		7	Moon Drilling	Eve's Eye Sub L5 B2
			22	1981	138	60	3	Valley Drilling	Eve's Eye Sub L6 B2
			23	1986	72	23	25	L & M Drilling	Eve's Eye Sub L12 B2
			24	1983	90	37	10	Valley Drilling	Eve's Eye Sub L2 B2
			28	1984	81		20	Moon Drilling	Forest Hills Sub L1 B4
			29	1984	146	90	15	Durbin Drilling	Forest Hills Sub L9 B3
			29	1984	71	40	S	Bill's Water Wells	Forest Hills Sub L8 B3
			30	1985	146	85	10	Durbin Drilling	Forest Hills Sub L7 B3
			30	1984	147	80	12	Downey, Inc.	Forest Hills Sub L6 B3
			31	1983	138	75	30	M-W Drilling	Forest Hills Sub L1 B3
			31	1983	79	53	5	M-W Drilling	Forest Hills Sub L3 B3
			32	1983	148	75	20	M-W Drilling	Forest Hills Sub L4 B3
			33	1983	121		15	Moon Drilling	Forest Hills Sub L1 B1
			33	1984	126	60	15	Magnuson Drilling	Forest Hills Sub L1 B1
			34	1986	122		50	Moon Drilling	Forest Hills Sub L2 BS
			34	1983	81		2	Moon Drilling	Forest Hills Sub L3 B5
18N	2E	31	1		170			Cotten Drilling	
			2		18	12		Owner	
			2	1953	128	16	10	Conboy	Section 31 L-A4
			3	1947	110	50		ARRC	Section 3 1 L-A2
			4	1949	31	27		Owner	Section 3 1 lots

			4	1982	119	50	12	Wheaton Water Wells	Monte Vista Sub L1 B3
			5		92	18	10	G & G Drilling	Section 31 lots
			6	1972	118	53	20	G & G Drilling	Section 31 L-D7
			7	1984	122		25	Moon Drilling	Monte Vista Sub L6 B3
			8	1984	120	0	30	Jay Williams Drilling	Monte Vista Sub L15 B1
			8	1984	140	80	20	Jay Williams Drilling	Monte Vista Sub L14 B1
			9	i984	120	80	15	Jay Williams Drilling	Monte Vista Sub L12 Bl
			10	1984	145	54	20	Delta Drilling	Monte Vista Sub L5 B3
			11	1984	133	88	15	Jay Williams Drilling	Monte Vista Sub L10 Bl
			11	1984	140	95	10	Jay Williams Drilling	Monte Vista Sub L9 B1
			12	1984	380	60	5	Jay Williams Drilling	Monte Vista Sub L6 B1
			13	1983	120	9	20	McKay Well Drilling	Monte Vista Sub L3 B2
			13	1982	267		8	Moon Drilling	Monte Vista Sub L4 B1
			14	1984	200	140	6	Hefty Drilling	Monte Vista Sub L3 B1
			15	1983	167	115	150	Sullivan Water Wells	Equestrian Acres L18 B5
			15	1984	164	117	85	sullivan water wells	Equestrian Acres L18 B5
			16	1980	651	210		Len Melton	Section 31 L-A5
			17	1985	114	0	30	Durbin Drilling	Monte Vista 2 L2 B4
18N	2E	32	1	1958	624	163	200	Cotten Drilling	Section 32 L-B6
			1	1952	170	30		Cotten Drilling	
			1	1952	165	20	75	Kozloski	
			i	1980	651	210	1000	Len Melton	Section 32 LB6
			2	1936	8	27		ARRC	Valley Trails Subdivision
			3		35	33		J Bugge	
			4	1915	30*	29		Owner	Section 32 lots
			5	1936	86	20		ARRC	Section 32 L-B5
			6		67	30		ARRC	
			7	1936	72	50		ARRC	Section 32 L-A3
			8	1936	15	14		unknown	Section 32 L-A3
			8	1965	108	37	10	G & G Drilling	Section 32 L-A2
			9		24	22		ARRC	Section 32 L-Al 1
			9	1954	152	82	5	Moffitt Drilling	Section 32 L-Al 1
			9	1956	44	21	15	G & G Drilling	Section 32 LA1 1
			10		18	16		ARRC	Section 32 lots
			10	1968	118	51	8	G & G Drilling	Section 32 lots
			11		25	15	-	unknowll	Section 32 lots
			12	1954	100*	60	3	Cotten Drilling	Section 32 lots
			12	1947	100	55	8	LaRose-Ekert	Section 32 lots
			13		14	11		McKechnie	Section 32 lots
			13	1914	14	13		Unknown	
			14		82			unknown	Hanscenic Est L9
			15	1936	61	11	5	ARRC	Section 32 L-C22
			16	1980	118	18	12	Valley Drilling	Hanscenic Sub L2B B1
			17	1971	101	19	8	G & G Drilling	Chalet Sub L7 B1
			18		86	62	3	Valley Drilling	Section 32 L-D3
			19	1982	59	25	20	Valley Drilling	Section 32 L-A26

Appendix A. ***Water well information for the Palmer area-Continued***

T	R	Sec.	Map no.	Year drilled	Well depth (ft)	Depth to water (ft)	Yield (gpm)	Driller	Property Description
			20	1975	120	60	-	Unknown	Chalet Sub L4 B1
			21	1973	55	-	-	Mitchell Drilling	Chalet Sub L1 B1
			22	1985	62	39	7	Hood & Son's Drilling	The Highlands Sub L5 B1
			23	1983	108	40	20	Wheaton Water Wells	Section 32 L-A3 1
			1		17*			Owner	Section 33 lots
			2		31			Owner	
			3		27	24		Owner	Section 33 lot3
18N	2E	33	4	1949	37*	31		Moffitt Drilling	Section 33 lots
			5		21			unknown	
			6	1965	150			unknown	
			7		200*	100	1/3	G & G Drilling	Smith Sub
			8		28			Owner	
			9		95			ARRC	Section 33 lots
18N	2E	34	1	1951	23	6		Owner	Section 34 lots
			2	1956	111*	-		Cotten Drilling	Section 34 lots
			8	1971	103*	21	4	A & L Drilling	Section 34 L-C2
			9		124	102	14	Ron Palmer	Lazy Mtn Acres L6 B2
			9	1974	135		10	Swafford Drilling	Lazy Mtn Acres L6 B2
			12	1983	183	145	8	Valley Drilling	Lazy Mtn Acres L7 B1
			13	1983	192	157	10	Gee's Water Wells	Lazy Mtn Acres L6 B1
			14	1983	204		10	Swanson Drilling	Lazy Mtn Acres L4 B1
			14	1983	338	179	8	Durbin Drilling	Lazy Mtn Acres L4 B1
			14	1984	195	180	8	Bill's Water Wells	Lazy Mtn Acres L5 B1
			15	1982	261			Moon Drilling	Lazy Mtn Acres L4 B2
			16	1983	98		5	Moon Drilling	Lazy Mtn Acres L1 B2
			17	1983	99		6	Moon Drilling	Lazy Mtn Acres L3 B2

APPENDIX B

Calculated SAR values using Trainer's (1960) data [Sodium adsorption ratio (SAR)]

Appendix B
Calculated SAR values using data from Trainer (1960)

Well number	Location: Township	Location: Range	Location: Section	Map number	(Na^{+}) mg/L	(Na^{+}) epm	(Ca^{+2}) mg/L	(Ca^{+2}) epm	(Mg^{+2}) mg/L	(Mg^{+2}) epm	Y	SAR	Specific conductance (µS/cm @ 25°C)
80	17N	2E	22	1	6.0	0.26	56	2.8	5.9	0.48	1.28	0.2	327
123	18N	2E	33	4	34	1.5	75	3.7	20	1.6	1.64	0.9	657
145	17N	2E	5	1	33	1.4	147	7.34	30	2.5	2.21	0.6	1,050
147	17N	2E	5	1	62	2.7	14	0.70	1.8	0.15	0.65	4.1	327
195	17N	2E	17	4	6.3	0.27	39	2.0	4.2	0.34	1.07	0.2	255
347	18N	2E	28	9	11	0.48	55	2.7	20	1.6	1.48	0.3	444
363	18N	2E	32	1	6.2	0.27	34	1.7	9.1	0.75	1.10	0.2	261

Explanation of headings:

Well number - from Trainer (1960).

Location - township, range. and section (TRS) plus map number from sheet 1.

Na^{+} - Concentration of sodium ion, in milligrams per liter (mg/L), and in equivalents per million (cpm).

Ca^{+2} - Concentration of calcium ion, in milligrams per liter (mg/L), and in equivalents per million (epm).

Mg^{+2} - Concentration of magnesium ion, in milligrams per liter (mg/L), and in equivalents per million (epm).

$y = (Ca^{+2}) + (Mg^{+2})/2)^{1/2}$.

$SAR = (Na^{+})/y$.

Specific conductance - Ability of the water sample to conduct an electric current, expressed in microsiemens per cm (µm/S) at 25°C.