GEOLOGICAL SURVEY CIRCULAR 268

PRELIMINARY REPORT ON THE GEOLOGY AND GROUND-WATER RESOURCES OF THE MATANUSKA VALLEY AGRICULTURAL AREA ALASKA

UNITED STATES DEPARTMENT OF THE INTERIOR
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GEOLOGICAL SURVEY
W. E. Wrather, Director

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By Frank W. Trainer

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PRELIMINARY REPORT ON THE GEOLOGY AND GROUND-WATER RESOURCES OF THE MATANUSKA VALLEY AGRICULTURAL AREA, ALASKA

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ABSTRACT

This report describes the geology and ground-water resources of an area of present and potential agricultural development in south-central Alaska. The agricultural area lies on a wide valley floor, most of which is formed by glacial deposits. Nonglacial unconsolidated deposits include windblown material distributed generally over the agricultural area and slope deposits along the valley walls. Small bodies of perennially frozen ground (permafrost) are present in some bogs.

Till ("hardpan"), possibly of late Wisconsin (Mankato) age, occurs at the surface or beneath surficial outwash gravel deposits in a large part of the valley floor. In several widely separated localities the till is known to be underlain by older glacial gravel, and the presence of an older till beneath this gravel is suspected. Several types of outwash deposits, most of them formed during glacial recession in this area, are differentiated on the geologic map which accompanies the report. Associated with glaciofluvial deposits of existing streams are estuarine deposits of glacial silt. The topography developed on the unconsolidated deposits is due chiefly to glacial deposition, large-scale stagnation of ice, and trenching of glacial deposits by outwash streams.

Most wells in the agricultural area obtain water from gravel. Supplies sufficient for domestic and farm use are generally available wherever the gravel is saturated. Only a little is known of the quantities of water available. Till in this area is relatively impermeable; most wells in till obtain water from included thin or gravel layers. Bedrock here appears to be a relatively poor water-bearing material.

The area is divided into six physiographic units to facilitate description of the occurrence of ground water.

Recharge of ground water is chiefly from precipitation, but parts of the area receive drainage from adjacent mountain slopes. Fluctuations of the water table as much as several feet were observed during the period 1949-51.

Chemical analyses show that the ground water ranges from moderately hard to very hard but is suitable for general domestic and farm uses.

A table giving records of 333 wells is included in this report. The locations of the wells are shown on the geologic map.

INTRODUCTION

Location and Extent of Area

The Matanuska Valley is a part of the lowland lying north of the Coast Range in south-central Alaska. The valley of the Matanuska River and the lowland extending westward from it to the Susitna River are in the Matanuska and Wasilla districts as defined by P. S. Smith (1939, pl. 3).[1] The area described by the present report, hereafter termed the Matanuska Valley agricultural area, is best known as including the site of agricultural colonization undertaken by the Federal Government in 1939. It lies between the Talkeetna Mountains on the north and the Chugach Range on the south (fig. 2). It is bounded on the north by the Talkeetna Mountains and the Little Susitna River, and on the south by the Knik River and Knik Arm. It lies between Eska Creek on the northeast and Goose Bay on the southwest. As thus defined, the area lies approximately between 148°55' and 149°50' west longitude and between 61°25' and 61°45' north latitude; it covers about 350 square miles. (See fig. 1.)

Purpose and Scope of Investigation

Studies in the Matanuska Valley agricultural area were made by the writer during the 1949 and 1950 field seasons and part of the 1951 season, as a part of the investigation of ground-water resources of Alaska begun by the U. S. Geological Survey in 1947. The purpose of the studies in the area was to map the water-bearing materials and to determine the occurrence, availability, and quality of ground water in the area. The need for the compilation and interpretation of geologic and hydrologic data became increasingly important after colonization in 1935, and this need has increased during the postwar period of continuing settlement. Many homes and farms are completely dependent upon wells for their water supply, and homesteaders taking up new land in undeveloped areas have lacked data on the availability of ground water. More extensive utilization of ground water, possibly including irrigation, undoubtedly will come in the future.

1/ See page 31 for list of references.

During the 1949 field season a well inventory and a water-level observation program were begun. Locations and descriptions of existing wells were recorded. The altitude of the land surface at each well was determined with an altimeter from benchmark control. Depths to water levels in wells were measured wherever possible with a steel tape, and periodic measurement of water levels in selected wells was begun. This program is being continued as of the date of writing of this report (spring 1952). In addition to the well inventory, preliminary geologic field work was done in 1949; the geology was mapped on areal photographs during 1950 and 1951. Data were transferred from the photographs to a base map with a vertical sketchmaster. The base used for the surficial-geology map (pl. 1) was taken from parts of the Sutton, Matanuska, Eklutna, Houston, and Knik quadrangles of the Corps of Engineers of the U. S. Army.

Three test wells were drilled by the Geological Survey, using the jet-percussion method.

Samples of unconsolidated materials exposed in the area were collected for laboratory study. Mechanical analyses were made by the writer, using sieves for the coarser fractions, and the hydrometer or the pipette method for the finer fractions. (For a description of methods in general use for mechanical analysis of granular materials, see Am. Soc. Testing Materials, 1950.) The permeability of small undisturbed samples was determined in the field with a variable-head permeameter (Wenzel, 1942, p. 64).

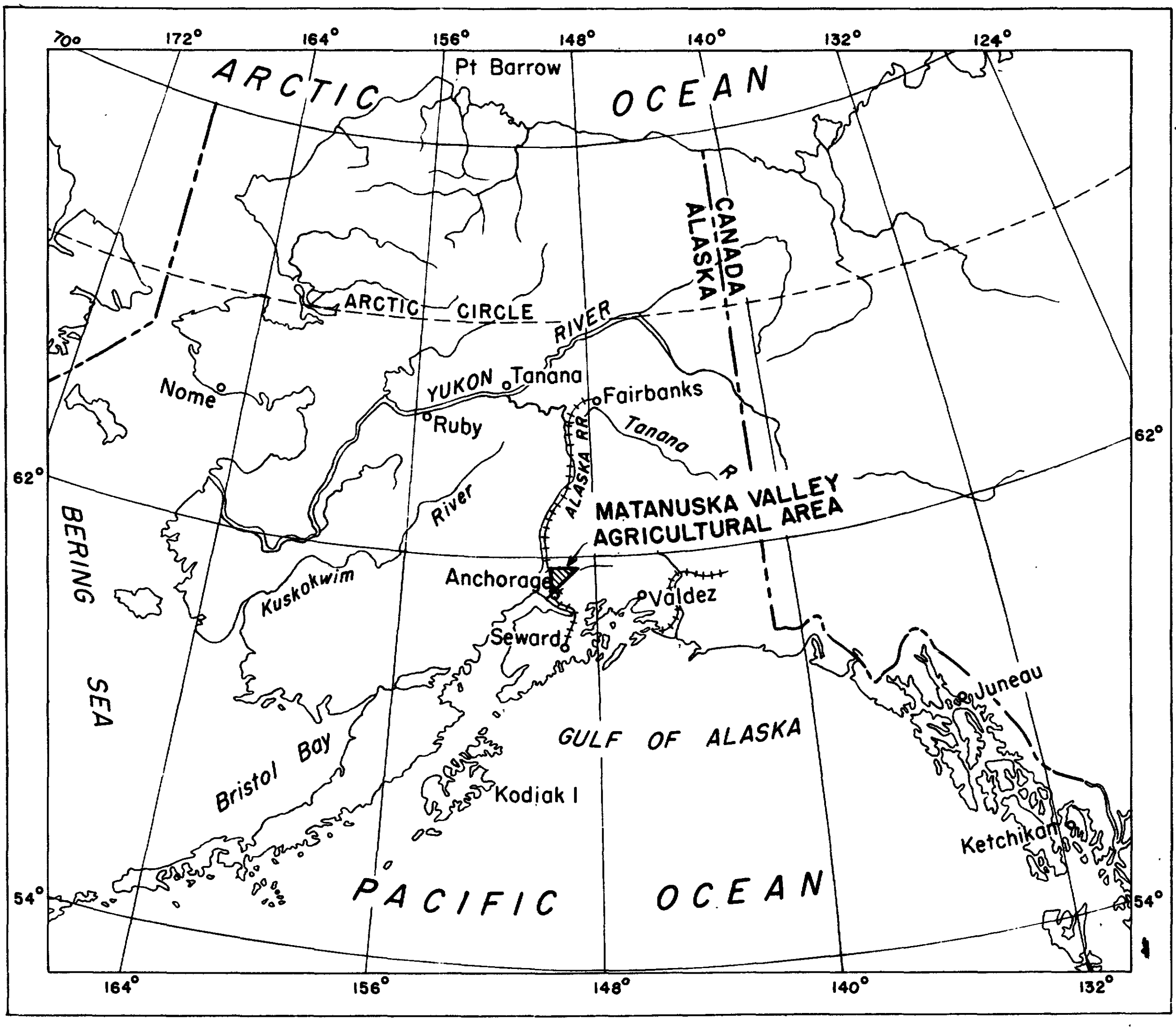

Figure 1. Index map showing the location of the Matanuska Valley agricultural area.

Data representing 333 wells are tabulated in the well records which are part of this report. Included are the locations and a brief description of the topographic situation of each well, and such information as is available on the depth of the well, the water level, the yield of the well, and the type of water-bearing material. The locations of wells are shown on plate 1.

The ground-water investigation was made under the general direction of A. N. Sayre, chief of the Ground Water Branch of the Water Resources Division of the Geological Survey. The field work was supervised by D. J. Cederstrom, district geologist of the Ground Water Branch. M. J. Slaughter, G. W. Whetstone, and Mrs. Arline Day, of the Water Resources Division at Palmer did much to facilitate the field work. E. C. Casey, D. C. Phillips, Clifford Shaw, Mr. Slaughter, and Mr. Whetstone made a number of water-level measurements.

Previous Investigations

No published reports describe in detail the geology of the Matanuska Valley agricultural area, although parts of the area are discussed in several publications. Martin and Katz (1912) describe that part of the area in the vicinity of Moose and Eska Creeks, and Landes (1927) describes the district between the Knik and Matanuska Rivers, including part of the Chugach Range. The geology of the general region is discussed briefly by Capps (1940) and the physiography by Martin (1942). Rockie (1946) gives the most complete description of the physical geography of the agricultural area. Karlstrom (1950) includes the area discussed in the present

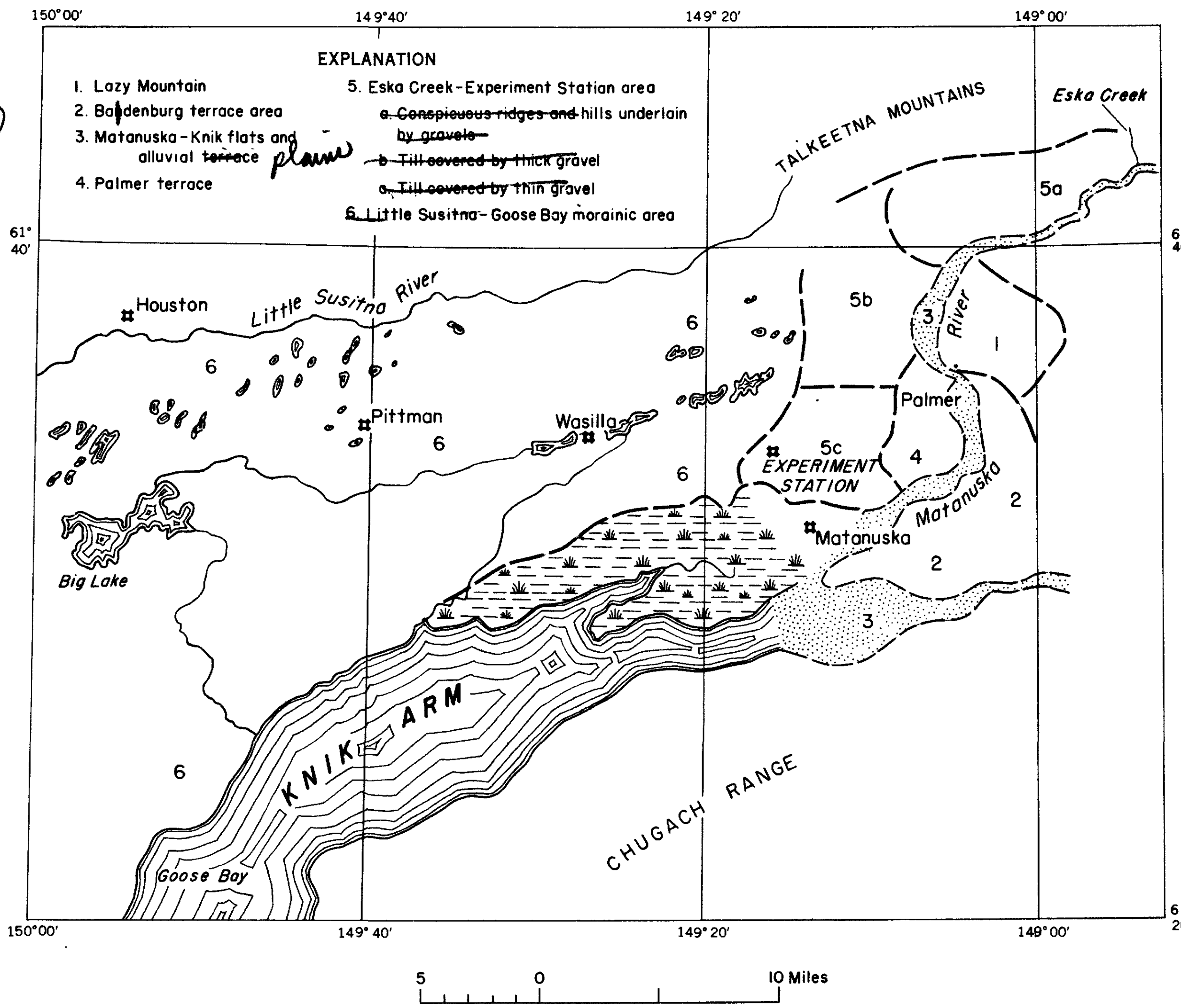

Figure 2. Physiographic units in the Matanuska Valley agricultural area.

report in a map of the larger area bordering Cook Inlet. Other papers, including those by Black (1951), Rockie (1942), and Tuck (1938), treat of special problems of the geology of the area.

Method of Well Numbering

Wells described in this report are designated by simple consecutive numbers; blank numbers have been left to accomodate wells that may be constructed in the future. In sequence the well numbers follow approximately the physiographic units or subareas described in this report. (See p. 20.) The first wells listed are on the lower slope of Lazy Mountain (pl. 1). Wells east of the Matanuska River and north of the Knik River are listed next. Then follow, in order, wells on the terrace at and south of Palmer, wells between Eska Creek, Four Corners, and the vicinity of the Matanuska Agricultural Experiment Station, and wells located in the remainder of the agricultural area to the west and southwest.

Acknowledgments

For many courtesies the writer is indebted to W. A. Rickie, Soil Conservation Service, Portland, Oreg., to C. W. Wilson and T. H. Day, Soil Conservation Service, Palmer, and to D. L. Irwin and A. H. Mick, Alaska Agricultural Experiment Station, Palmer. James Hurley made available copies of well logs from the files of the Alaska Rural Rehabilitation Corp. The Matanuska Valley Fair Association permitted the use of storage space.

Special thanks are due the late Kirk Bryan, and M. P. Billings, K. F. Mather, H. C. Stetson, and C. E. Stearns, of Harvard University, for their discussion of and many suggestions regarding the writer's work.

Without exception, residents of the area willingly permitted access to wells on their property or provided information regarding them. Henry LaRose, A. R. and Thomas Moffitt, and James and Albert Frey, drillers, described their experience in the Matanuska Valley and gave the writer much valuable information. T. B. Bourne and Associates, Inc., consulting engineers, provided data obtained during construction of a test well for the city of Palmer. The owners of the observation wells listed in the well records permitted use of their wells for this purpose, and J. C. Baldwin, Henry LaRose, F. B. Linn, Loren McKechnie, G. E. Murphy, Oscar Tryck, and Noel Woods made periodic water-level measurement.

GEOGRAPHY

Climate

The climate of the eastern part of the Cook Inlet lowland, which includes the Matanuska Valley agricultural area, is the result of a combination of marine and continental influences. The lowland lacks both the high rainfall of coastal areas and the temperature extremes of the interior of Alaska.

Although climatic data have been collected at several localities in the agricultural area in recent years, the only extended record is that for the Alaska Agricultural Experiment Station near Matanuska. Selected data for this locality are presented in table 1.

The departure from the mean annual precipitation and the seasonal distribution of precipitation are significant. In a given year the total precipitation may be about one-third greater or less than the mean. The mean total annual snowfall is about 3½ feet, but the annual departure from the mean may be as great as half this amount. In most

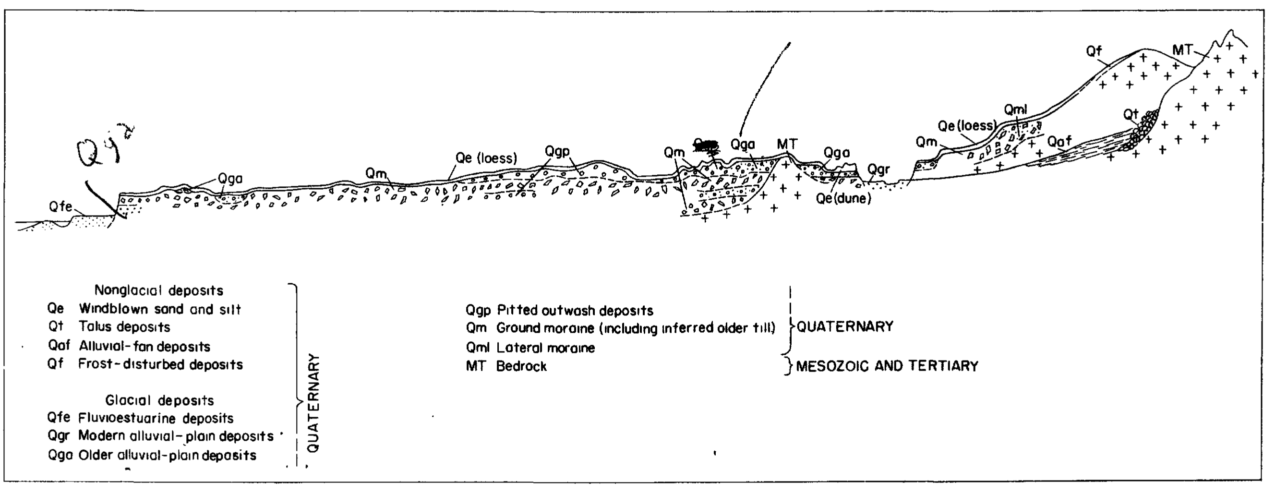

Figure 3. Generalized section of the Matanuska Valley agricultural area showing stratigraphic units.

Table 1.--Climatological data for Alaska Agricultural Experiment Station, near Matanuska, Alaska 1/

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Seasonal 2/
Precipitation in inches:														
Mean, 1920-48	0.87	0.73	0.56	0.42	0.68	1.13	1.96	2.86	2.66	1.76	0.94	0.97	15.54	
Maximum, 1939-48	.20	1.20	1.04	.88	1.71	2.10	3.75	6.37	4.81	3.48	2.33	1.74	21.13	
Minimum, 1939-48	.26	.07	.14	.02	.17	.16	.09	.45	.51	.39	.10	.05	11.07	
Snowfall (unmelted snow), in inches:														
Mean, 1936-46	7.5	5.3	6.8	2.9	.5	0	0	0	0	5.0	8.1	8.0	44.0	43.3
Maximum, 1936-46	21.4	10.3	13.8	17.5	5.3	....	....	....	3/Tr.	18.0	15.7	27.5	20.3	77.4
Minimum, 1936-46	.6	0	0	0	0	....	....	....	0	0	1.5	.4	29.5	36.0
Temperature, in degrees Fahrenheit:														
Mean, 1939-48	10.6	23.3	24.8	37.2	47.0	55.3	57.2	54.6	47.2	35.5	20.1	12.8	35.5	
Maximum, 1939-48	25.7	30.2	33.5	44.4	51.4	57.6	59.4	59.0	52.0	39.6	31.8	26.6	38.7	
Minimum, 1939-48	-4.0	13.2	15.8	33.0	43.8	52.5	56.0	52.6	44.8	29.6	13.2	1.2	32.8	

1/ Data from U. S. Department of Agriculture (1941) and U. S. Weather Bureau (1936-48). Data for 1949-51 are incomplete.
2/ Seasonal snowfall is that recorded between July 1 of one year and June 30 of the following year.
3/ Tr., less than 0.1 inch.

years the winter and spring are relatively dry. On the average about two-thirds of the annual precipitation occurs during the 5-month period June-October.

There is also a wide range in departure from mean temperature. This is best illustrated by the length of the growing season. The last spring frost commonly occurs in late May, the earliest autumn frost in late August or September. During the 10-year period 1939-48, however, the length of the growing season ranged from 67 to 151 days.

Midsummer temperatures in the agricultural area range from 45 to 70 F; temperatures as high as 80° F are unusual. The winters are moderately cold; periods during which the temperature reaches -20 to -30 F are usually short. The freezeup in autumn comes in October or November. Seasonal frost commonly reaches depths of 6 feet or more. The ground begins to thaw in April or May, but seasonal frost may persist beneath the surface in protected spots as late as July.

The distribution of rainfall and the danger of late spring and early autumn frost are responsible for a measure of uncertainty of crop yields in the Matanuska Valley agricultural area.

The dominant wind of the agricultural area, known locally as the "Matanuska wind," is from the northeast. It is an autumn and winter wind. During storms it may blow more or less continuously for periods of several days; Weather Bureau records indicate that gusts reaching velocities of 50 miles per hour or more occur during the more severe storms. The "Knik wind," oceanic air from the south moving down the Knik Valley, is relatively warm. During late winter and spring it brings mild weather and, together with rain, may remove much of the snow cover from the agricultural area before the ground begins to thaw.

Topography and Drainage

The Matanuska Valley agricultural area lies in a wide, flat-floored valley formed by the merging of the Matanuska and Knik Valleys at the eastern end of Knik Arm. Figure 2 shows the principal physiographic units. The valley is bounded by rugged mountains which rise abruptly above its floor. In the Chugach Range, at the southern edge of the valley, Pioneer Peak rises to an altitude greater than 6,300 feet; several other peaks surpass 4,000 feet, and altitudes of 3,000 feet are common. Along the northern edge of the valley, peaks in the Talkeetna Mountains reach altitudes of 3,000 to 5,000 feet.

Although the altitude of the valley floor ranges from tide level on Knik Arm to 1,000 feet at the base of Wishbone Hill (pl. 1), the local relief is generally not more than 100 to 200 feet. Features providing greater local relief include Bodenburg Butte, which is almost 800 feet higher than the surrounding lowland, and several similar hills of rock. The bluffs along the Matanuska River north of Palmer rise 200 to 300 feet above the river channel.

Most of the valley floor, extending westward from the Matanuska River north of Palmer, is a gently rolling surface. In much of it, the hills and valleys have a southwest trend; this orientation is shown most conspicuously by the series of lakes whose axis passes south of Wasilla and less strikingly by a second series of lakes to the northeast. In the northwestern part of the agricultural area, west and northwest of Pittman, the hills and valleys trend south-southwest. Two tracts, one between Eska and Moose Creeks and extending 2 to 3 miles west of Moose Creek, and the other between Palmer and the Agricultural Experiment Station, are characterized by irregular hills and swales and conspicuous ridges. The local relief in these tracts is as much as 150 feet. The ridges are most conspicuous near the experiment station, where they are continuous and parallel.

A conspicuous belt of hills which rise 50 to 150 feet above the surrounding country extends southwestward past Pittman. A chain of similar hills borders Big Lake on the south and extends southwestward out of the area described in this report, beyond which it curves to the south and then to the southeast, ending at Goose Bay.

Palmer is on a wide, flat-topped bench. Similar benches lie east of the Matanuska River south of Wolverine Creek, between the Knik and Matanuska Rivers, and along part of the top of the bluff overlooking Knik Arm. Smaller benches north of Palmer and throughout the rolling country to the west are less conspicuous. The rolling country and benches north of Knik Arm are separated from it, and from the low-lying flat ground near it, by a conspicuous bluff 50 feet or more high which extends from Goose Bay eastward and grades into the bluff of the Matanuska River near Matanuska.

Most of the area drains into the Matanuska and Knik Rivers, but several small streams flow directly into Knik Arm. The Little Susitna River drains part of the northern section of the area. The drainage in many interstream tracts is poor because of the irregular topography and the vegetative cover. There are large areas of swampy ground, and shallow lakes occupy many of the hollows. The oriented lakes west of Pittman and the two southwestward-trending series of lakes near Wasilla are among the prominent features of the valley floor.

The Knik River floods annually in July or August when Lake George, impounded by Knik Glacier, is drained as a result of its overflow and the resulting erosion of the ice along one edge of the glacier.

Vegetation

In its natural state most of the area discussed in this report was forested. White spruce, aspen, cottonwood, and birch are characteristic of the better drained soils. Willow is found on all types of deposits. Black spruce is common only in bogs. Alder is common both in moist spots on the lowland and with willows on the mountain slopes bordering the valley. The altitude of tree line depends upon exposure; locally it is above 2,000 feet. Trees in this area are shallow rooted and are easily blown down. Windfalls are common in forests composed of older trees.

Fire, probably in part natural but largely accompanying settlement and railroad construction, has burned over many parts of the valley floor. Extensive burned areas have become reforested.

The ground cover in the forest consists of various shrubs, herbs, grasses, and other small plants. Mosses and grasses are characteristic of poorly drained areas. Fireweed is the commonest plant on newly burned land. Fireweed and grass may persist for long periods on burned land near the tree line.

The flats along Knik Arm are, or recently have been, subject to tidal flooding; over most of their area they bear only small salt-tolerant plants. The wide alluvial flood plains of the Matanuska and Knik Rivers are practically bare of vegetation because at some time during every season or two the gravel bars either are submerged or are removed and rebuilt during the channel shifting that accompanies flooding. The middle slopes of the mountains flanking the valley bear a cover of moss and low or prostrate shrubs; near the summits there is no vegetative cover.

Culture

As a result of the finding of gold in the Talkeetna Mountains, the settlement at Knik was established in 1898 on the site of an Indian Village and Russian mission. In 1916 the Alaska Railroad was extended through the Matanuska Valley, and where it crossed the trail between Knik and the Talkeetna Mountains the community of Wasilla was established. Matanuska grew at the junction of the main line and the spur line leading to the Matanuska Valley coalfields. After the establishment of the agricultural colony in 1935 the center of population of the valley shifted toward the community of Palmer.

The population of Palmer is estimated at about 800. Wasilla is much smaller, and only a few families remain in Matanuska and Knik. The farm population of the area is 2,000 to 3,000; it is distributed chiefly around Palmer and, to a lesser extent, around Wasilla.

The agricultural area is traversed by the main line of the Alaska Railroad, which passes through Matanuska and Wasilla northward to Fairbanks. A branch of the railroad extends from Matanuska through Palmer to Jonesville, on Eska Creek. The Glenn Highway begins at Anchorage, 48 miles southwest of Palmer, and extends through Palmer and into the interior of Alaska. Daily bus service is maintained between Wasilla, Palmer, and Anchorage. All the settled sections of the valley lie on a road net maintained by the Alaska Road Commission. Air travel has long been popular in this area, as elsewhere in Alaska. Several small local fields have been used, and a new airport was completed at Palmer in 1950.

Development of agriculture in the area has continued since establishment of the agricultural colony; dairying and vegetable growing are the most important types of farming. The history of the agricultural colony is the subject of a recent study by Stone (1950).

GEOLOGY

Mesozoic and Tertiary Rocks

The character of the rocks underlying the greater part of the Matanuska Valley agricultural area is unknown. The writer estimates that bedrock is exposed at the surface in less than 1 percent of the area; elsewhere the bedrock is covered by unconsolidated deposits whose thickness is known at relatively few places. Exposures of bedrock in the area are indicated on plate 1.

The bedrocks exposed in and adjacent to the agricultural area have been described by Martin and Katz (1912), Capps (1940), and Landes (1927). The Talkeetna Mountains to the north, are composed mostly of igneous rocks, predominantly granitic intrusives (Mesozoic?) and to a lesser extent lava and tuff. A belt of Cretaceous and Tertiary sedimentary rocks forms the south flank of the mountains. Mesozoic rocks in the Chugach Range, to the south, include granitic intrusives, metamorphosed sedimentary rocks (chiefly slate and argillite), and greenstone.

Cretaceous sedimentary rocks extend down the Matanuska Valley to Moose Creek; they are sandstone (including graywacke) and shale. Conglomerate and sandstone (graywacke) exposed in small hills south of Palmer may be the southwestward extension of these rocks. Conglomerate, sandstone, shale, and coal of Tertiary age are exposed in the Eska Creek-Wishbone Hill-Moose Creek area. Tertiary coal-bearing rocks also occur at Houston, just beyond the northwestern corner of the area described in this report.

Wishbone Hill, at the northeastern corner of the agricultural area, is a synclinal hill held up by the Tertiary Eska conglomerate. Martin and Katz (1912, p. 72-75, pls. 15, 16) describe the straight front of the Talkeetna Mountains as representing a zone of faulting; they believe that the course of the Little Susitna River is approximately along the fault downstream from the point where the stream emerges from the mountains. Recent work by F. F. Barnes, of the U. S. Geological Survey, shows the presence of coal-bearing Tertiary rocks north of the Little Susitna River; these Tertiary rocks, with other evidence, suggest that the mountain front rather than the stream coarse marks the western extension of the fault (Barnes, F. F., personal communication, 1952). Martin and Katz (1912, p. 74) suggest also that the relatively straight front of the Chugach Range, to the south, also may be due to faulting, but they do not find enough evidence to form a definite conclusion. Exposures along the Matanuska River and Moose and Wolverine Creeks show that the folded sedimentary rocks strike northeastward and are faulted. The available data are insufficient to justify conclusions regarding the structure of the sedimentary rocks underlying most of the valley floor to the west or their depth of burial beneath the overlying unconsolidated deposits.

Quaternary Deposits

Unconsolidated deposits of both glacial and nonglacial origin cover the bedrock of the valley floor in most of the area described in this report. The glacial deposits consist of till, or outwash sand and gravel, and fluvioestuarine deposits in and along Knik Arm. The existing Matanuska and Knik Glaciers lie beyond the limits of this area; but, because the Matanuska and Knik Rivers derive much of their water and sediment from these glaciers, the modern deposits of these streams are considered glaciofluvial. The nonglacial deposits include windblown material, which mantles most of the agricultural area, and alluvial fans, talus, and frost-disturbed deposits chiefly along the walls of the valley. (See fig. 3.)

It has not been shown whether the existing glaciers are remnants of the more extensive Pleistocene Matanuska and Knik glaciers, from which most of the glacial deposits in this area originated. Separation of the Pleistocene and Recent in epochs in this area is therefore difficult. In this report all unconsolidated materials overlying Tertiary or older rocks are designated simply <u>Quaternary deposits</u>.

The geologic map (pl. 1) shows the distribution of bedrock exposures and unconsolidated deposits exclusive of swamp deposits and the mantle of windblown material. Data obtained by the mechanical analysis of samples of the unconsolidated sediments are given in table 4.

Glacial Deposits

Till ("hardpan")

Till is a clastic unconsolidated rock deposited directly by or from glacial ice with little or no modification by running water. It is dominantly unsorted, consisting of rock fragments ranging from clay to large boulders. The distinction between a till slightly sorted during deposition and a poorly sorted gravel is in many instances arbitrary. Till is one end member of a continuous series of materials; the other end member is well-sorted outwash sand and gravel (Flint, 1947, p. 103).

Till at the surface in the agricultural area is in the form of ground moraine, a glacial deposit which usually occurs as a relatively thin mantle on the underlying material. Ground moraine may consist of material deposited beneath glacial ice, or of debris derived, upon melting, from the glacial load within or upon the ice. Though the ground moraine is predominantly till, layers of washed material are present in it, and thin sand and gravel deposits locally mantle its surface. Over much of the area mapped by the writer as ground moraine (pl. 1) the till presents the original surface of glacial deposition, modified little or not at all by erosion.

Till in this area is commonly gray or blue gray. It is composed mainly of subangular to rounded stones in a matrix of mixed sand and silt. Table 4 shows the grain-size distribution of the fragments smaller than 2 millimeters in diameter, in two samples of till. Very little clay is present in these samples. Poor sorting is shown by the distribution of material over a wide range of grain sizes (as compared, for example, with the lesser range of sizes in windblown sand). Stones in the till range from granules to boulders; they consist of the greenstone, slate, schist, and felsic intrusive rocks characteristic of the adjacent mountains and of the sedimentary rocks exposed in the Matanuska Valley.

Silt-rich till is compact and tough. It is difficult to excavate and is known locally as "hardpan."

Irregular roughly horizontal streaks and layers containing more stones or more silt than the underlying and overlying till can be observed in some exposures. They are commonly a few feet thick and may extend laterally a hundred feet or more in well-exposed sections. Fractures which may be faults cut the till in some exposures. In the bluff above the river 1 mile north of Palmer the walls of several such fractures are separated by a few inches of silt and sand laminated parallel to the walls. These fractures are most reasonably explained as tension fractures filled with sorted sediment by water. The fractures and the irregular layers consisting of sandy till may be recognized in dry weather because they remain more damp than adjacent silty till. Because of the limited exposures of till, it is not possible to draw conclusions regarding the occurrence of fractures and irregular sandy layers in the agricultural area as a whole.

In some exposures layers of sand or gravel occur within massive till. The layers are commonly a few inches to a few feet thick. Most of those the writer has seen are composed of medium to coarse sand or sandy pebble gravel; they appear to form relatively narrow stringers enclosed in compact till. Some of these show sharp changes in grain size and thickness within short distances.

Similar thin sandy and gravelly streaks in till have also been found in many wells in the area. These layers seem to be similar to lenses and stringers of imperfectly sorted material found in till in the United States (Meinzer, 1923, p. 285). The writer believes that these deposits were laid down by small subglacial streams which flowed temporarily upon till beneath the ice before being covered by additional till from the overlying ice. The sorting of sand in these layers, which is better than that in most other sediments analyzed, is shown by the analyses of two samples in table 4. The better sorting may be due to deposition from a confined stream flowing under hydrostatic pressure. Evidence available from outcrops and from wells suggests that these layers are of limited and irregular areal extent.

In a few exposures slightly sorted material which resembles till may be observed resting upon massive till. The till-like material shows neither the bedding nor the sorting of outwash gravel. The best exposure seen by the writer is in a gravel pit on the lower slope of Lazy Mountain, about half a mile northeast of the Matanuska River bridge. There the slightly sorted material rests upon the underlying massive till along an irregular but distinct surface. This slightly sorted material is best explained as superglacial till: it is probably composed of debris which lay upon the surface of the ice and became slightly sorted before being let down upon the massive till beneath as the ice melted. Exposures of till in the agricultural area are not sufficiently numerous or extensive to show the areal importance of superglacial till.

The till of the Matanuska Valley agricultural area is relatively impermeable. Only the layers of sorted material yield water freely, and these in small quantities. Poor surface drainage is characteristic of tracts underlain by till; marshes are common, even on high ground. Some lakes, including Wasilla Lake, appear to be perched on till. Contact springs are present along hillsides in localities where saturated gravel lies on till.

Many of the depressions on the ground moraine in the western part of the agricultural area, or on ground moraine covered by thin gravel, are bordered by high-level deposits of horizontally bedded gravel. Such beds, three-eighths of a mile west of Wasilla, are 40 feet above the level of Wasilla Lake. The ground moraine north of Lake Lucile and northwest of Wasilla is marked by entrenched stream-cut channels which stand above the level of the lake. The high-level bedded gravel and stream channels are most reasonably explained by the assumption that the basins of Lake Lucile and Wasilla Lake were occupied by blocks of stagnant ice. Streams flowing along the boundary between the ice and the adjacent ground moraine deposited gravel; where they locally flowed across the moraine, they cut channels. Melting of the last ice left the lake basins in much their present form, with bedded gravel and channels perched upon the surrounding hillsides. The pattern of gravel islands and spits in the lakes east and northeast of Wasilla is best explained by this ice-block hypothesis; an alternative explanation of the lake basins and accompanying features as having been formed by erosion alone is unsatisfactory. All the other basins in the two southwest-trending series of lakes near Wasilla (see pl. 1) are probably ice-block holes.

The ground moraine in the tract north and west of Pittman is characterized by north-northeastward-trending parallel, elongate hills and valleys; most of the valleys are now occupied by lakes or marshes (pl. 1). Horizontally bedded gravel deposits mantle the hillsides above some of the lakes. Discontinuous eskerlike ridges of till, as much as 20 feet high and several hundred feet long, lie upon the ground moraine in this tract. Many of these ridges are covered by several feet of gravel; locally, as at the gravel pit 1½ miles west of Pittman, gravel has been deposited between the till ridges and has partly or completely covered them. Till ridges at the lake north of the railroad and 3 miles southeast of Houston extend into the lake. The ridges are interpreted as fillings formed in short crevasses in stagnant ice. Their presence over most of the tract under discussion shows that the form of the morainal surface is due to glacial deposition and that the surface has been modified only slightly by erosion. The extension of ridges, into one lake and the presence of high-level bedded gravel beside others are taken as evidence that the elongate valleys are ice-block holes. The orientation of the elongate parallel hills of ground moraine is attributed to the presence in the ice of elongate alternating zones of debris-laden and relatively clean ice. Debris from dirty ice formed hills; the last remaining clear ice between bands of dirty ice separated into blocks around which gravel deposits were laid down. Final melting of the last blocks left the existing lake basins.

Over the remainder of the ground moraine in the western part of the agricultural area the orientation of hills and valleys is much less regular and conspicuous than that near Pittman. The valleys, most of which are interpreted as ice-block holes, show a southwestward trend like that of the large glacial drainage channels west of Wasilla. The ice-block holes have the form of dimples in the ground moraine; they are most reasonably explained as cavities formed by the melting of relatively clean ice, whereas the adjacent higher moraine is the result of deposition from ice having a heavier load of debris.

The writer concludes that the form of the ground moraine in the western part of the agricultural area is due to widespread stagnation of ice, and that the distribution of debris in the ice may have controlled the position and form of hills and valleys on the moraine. The elongate, parallel zones of dirty ice inferred to have formed the parallel hills northwest of Pittman may have been folded medial moraines such as may be seen on the Malaspina (Washburn, 1935) and Bering Glaciers along the Gulf of Alaska. If similar zones of debris were present in ice over the remainder of the western part of the agricultural area, they left no conspicuous topographic expression; any that were present may have been broken by renewed movement of part of the terminal zone of the nearly stagnant glacier.

Till is present also in a hilly belt which extends southwestward through Pittman toward Big Lake and in hills south of Big Lake. Near Pittman the till is overlain by pitted gravel deposits. This hilly belt may represent a medial moraine in the ice, or, if part of the terminal ice moved past stagnant ice lying northwest of Pittman, the hills may mark the juncture of the two ice masses. Hills of till south of Big Lake are continuous to the west with the band of hills mentioned on page 6, which is arcuate toward the west and which extends from the vicinity of Willow and Nancy, northwest of Houston, to Knik Arm near Goose Bay. On the basis of study of aerial photographs, T. N. V. Karlstrom (personal communication, 1949), of the Geological Survey, interpreted this arcuate belt of hills as the end moraine of the last glacier which lay over the agricultural area. The writer believes this interpretation to be correct.

Over most of the agricultural area east of Wasilla and west and north of the Màtanuska River the till is covered by gravel. The thickness of the gravel ranges from a featheredge to about 100 feet; in general the deposits are thicker toward the east.

The till deposits described in preceding paragraphs are considered to form a single sedimentary unit deposited during one glaciation. Several natural exposures and about 35 wells show older glacial deposits lying beneath this till. The older deposits are mainly glaciofluvial but in 1 well such deposits rest upon what may be still older till.

In the bluff along Knik Arm east of Goose Bay the surface till rests upon gravel. (See section 1.) In several exposures along the Matanuska River north of Palmer the till lies beneath surficial gravel but rests upon older gravel. (See section 2.) Most of the wells that pass through the near-surface till into older deposits are in an area lying within a few miles west, northwest, or north of Palmer, but others are near the Agricultural Experiment Station and about 3 miles east of Wasilla. Table 2 presents logs of three such wells. The first of these is about three-eighths of a mile west of the Matanuska bluff and 2½ miles north of Palmer; the "blue mud and gravel" 63 to 101 feet beneath the surface (table 2) is correlated with the buried till in the Matanuska bluff (section 2). The older gravel shown by the drillers' log may represent the advance outwash of the glacier which deposited the overlying till, the outwash associated with the retreat of an earlier glacier, or both. Several of the logs, including the second in table 2, record red or brown gravel in which the color may represent the effects of weathering; in addition, the gravel locally is slightly consolidated. The gravel may therefore have been exposed for some time after its deposition before it was covered by the overlying till. Thus it is reasonably considered to represent an earlier glaciation. The blue mud from 198 feet to bedrock at about 226 feet in the first log in table 2 may be till deposited during this earlier glaciation. The gravel at Goose Bay, as shown in the section, may represent the recessional outwash of the earlier glaciation and the advance outwash of the glacier which deposited the overlying till; if this interpretation is correct, the vegetation that formed the peat grew during the period between the retreat of one glacier and the advance of the next.

1. Section in bluff north of Knik Arm about one-quarter mile east of Goose Bay

	Feet (estimated)
Windblown sand	3
Till, gray-brown, silty; includes a few layers of poorly sorted gravel	15
Pebble and cobble gravel, sandy; interbedded horizontal sand lenses as much as 1 foot thick and 40 feet long show crossbedding	20
Peat, brown-black, slabby, containing compressed twigs and stems of wood	2½
Silty, gray	1
Sand, silty, somewhat iron-stained	3
Pebble and cobble gravel, sandy, conspicuously iron-stained; locally consolidated	1
Covered	5
-----------Beach deposits----------	
Total	50½

2. Section in bluff west of Matanuska River about 3 miles northwest of Matanuska River Bridge

	Feet (estimated)
Windblown sand	20
Pebble and cobble gravel, sandy; horizontally bedded	40
Till, gray, silty	40
Pebble and cobble gravel, sandy and silty; slightly consolidated; locally deformed beneath overlying till	60
Covered	70
River	
Total	230

Table 2.--Selected drillers' logs showing the presence of older glacial deposits in the Matanuska Valley agricultural area
[Logs through courtesy of Alaska Rural Rehabilitation Corp.]

	Feet	Interpretation	
ARRC tract 132, well 9 (abandoned; near USGS 305)			
Topsoil	0 - 15		
Gravel	15 - 63		
Blue mud and gravel	63 - 101	Till	63 - 101
Gravel, loose running	101 - 116		
Gravel	116 - 155		
Gravel, cemented	155 - 178	Slightly consolidated gravel	155 - 178
Pea gravel	178 - 181		
Gravel, cemented	181 - 187	do	181 - 187
Gravel	187 - 198		
Blue mud	198 - 215	Till(?)	198 - 226?
Blue mud and shale rock, pipe stopped at 226 feet on 2-foot ledge of hard shale	215 - 226		
Shale, open hole from 226 feet on	226 - 510		
Well abandoned - dry hole.			
ARRC tract 14 (USGS 578)			
Topsoil	0 - 5		
Sand and gravel	5 - 75		
Sand, coarse	75 - 90		
Gravel, mud, and sand; water blue and mucky; will bail out	90 - 110	Till	90 - 174
Glacier mud and gravel, blue and thick; water seeping	110 - 128		
Glacier mud and sand	128 - 139		
Blue mud	139 - 174		
Water, gravel; water stands to 75 feet; red gravel	174 - 177	Oxidized gravel	174 - 177
Water, gravel	177 - 180		
ARRC tract 95 (USGS 364)			
Topsoil	0 - 5		
Gravel	5 - 28	Till	28 - 86
Blue mud	28 - 40		
Granite wash	40 - 45		
Blue lime shell	45 - 55		
Water, gravel, sand	55 - 59	Sorted layers	55 - 59
Gravel and mud	59 - 64		
Sand and gravel; some water	64 - 65	do	64 - 65
Blue mud and gravel	65 - 73		
Gravel and sand	73 - 77	do	73 - 77
Blue mud	77 - 86		
Water gravel; 60 feet of water in pipe	86 - 88	Older gravel	86 - 88

The thickness of the near-surface till, in wells that pass through it, commonly ranges from 10 to about 60 feet. The thickest section of till known to the writer is in well 258; till extends from 10 feet beneath the surface to the bottom of the well, which was at a depth of about 150 feet in November 1951.

A bench on the slope of Lazy Mountain is interpreted as a lateral moraine deposited along the contact between glacier and valley walls. Gullies cutting the bench exposed till resting upon bedrock. This bench lies between 1,700 and 2,100 feet above sea level. Two miles north of Palmer the upper surface of the till deposited beneath the same glacier is at an altitude of about 300 to 400 feet. The thickness of the ice over this part of the valley may therefore have been about 1,600 feet. A discontinuous bench which appears essentially similar to that on Lazy Mountain extends along the slope of the Talkeetna Mountains westward from Moose Creek and beyond the Little Susitna River. Over a distance of 6 miles this bench slopes westward from about 2,500 feet above sea level to about 2,000 feet, or about 80 feet per mile.

The age of till deposits in the Matanuska Valley agricultural area can be discussed most conveniently after the other glacial deposits have been described.

Outwash Sand and Gravel

Outwash deposits, formed by streams that derive part or all of their water and sediment from glacial ice, cover a large part of the Matanuska Valley agricultural area. They include not only deposits formed in association with the ice that once lay over this area but also deposits such as those of the existing Matanuska and Knik Rivers, formed at some distance from the ice.

The mechanical composition of samples of outwash sand and silt and the finer fraction of gravel are shown by the data given in table 4. The absence of large proportions of silt and clay is well shown by these data. These samples are probably representative of most of the outwash deposits of the agricultural area. Some stream-laid deposits are so poorly sorted, however, that they resemble till. The other extreme of sorting is represented by openwork gravel composed of pebbles or cobbles of approximately equal size and without interstitial finer materials. Such a gravel consisting entirely of pebbles is known locally as "pea gravel."

The stones in the gravel represent all the rock types found in the Matanuska Valley and in the surrounding mountains, although relatively soft and weak sedimentary and metamorphic rocks naturally are less common than massive igneous rocks. The sand consists predominantly of grains of quartz and dark minerals and fragments of schist and greenstone.

Bedding is well or moderately well developed in many exposures of sand and gravel; but, where exposures are extensive, the beds are generally seen to pinch out laterally. Crossbedding is commonly observed, in places associated with channel-and-fill structure. Faults are present in some exposures, particularly in thin beds of sand, and are attributed to slumping of the deposits.

Thin layers of silt are included in the sand and gravel. Other deposits, such as till, peat, fine-grained sediments deposited in ponds, are present locally.

The outwash materials in the agricultural area are relatively permeable. Where the land surface is underlain by sand and gravel, it is generally well drained except where till lies beneath the sand and gravel at shallow depth. Martin and Katz (1912, p. 70-71) describe gravel-covered benches to an altitude of about 2,200 feet, where the valley of Moose Creek emerges from the high mountains. They suggest that these deposits were formed in ponded water within the tributary valley at a time when the main Matanuska Glacier stood across the mouth of the tributary valley.

The geologic map (pl. 1) shows that the ground moraine west and northwest of Wasilla is crossed by many gravel-floored valleys. These are drainage channels followed by glacial meltwater. North of Knik Arm, and near the experiment station and near Palmer, farther east, are similar deposits beneath terraces. Throughout the agricultural area are other smaller tracts underlain by gravel deposits of meltwater streams. All these deposits are mapped as <u>alluvial-plain deposits</u>. Many of them are considered to have been formed in close association with glacial ice and were somewhat modified by its melting; they are ice-contact deposits. Others, like the flood-plain deposits of the modern Matanuska and Knik Rivers and deposits in terraces near these streams, are similar although formed farther from the ice or not modified by its melting; these are proglacial deposits. The deposits of the modern flood plain of the Little Susitna River are considered proglacial deposits although the stream is only partly of glacial origin. Little information is available regarding the thickness and composition of these deposits in the western part of the agricultural area, but the form of the topography, the presence of small hills of till which protrude through the gravel, and a few exposures suggest that in general the gravel is relatively thin (perhaps 20 to 30 feet thick or less). West of Wasilla and the experiment station most of the alluvial-plain deposits are in valleys cut in the ground moraine, and till probably lies beneath all these gravel deposits.

Southwest of the experiment station alluvial-plain deposits are about 30 to 70 feet thick; they are terraced. At Palmer and beneath the lower terraces north of the city (pl. 1) these deposits are commonly 30 feet thick or less and rest on till or bedrock. Meager evidence suggests that the deposits of the terraces on the lower slope of Lazy Mountain, near Wolverine Creek, are also relatively thin. Deposits beneath the extensive terrace south of Palmer are thicker; many wells 75 to 100 feet or more deep do not reach till or bedrock, and 2 wells (table 5, wells 160 and 161) 175 and 200 feet deep may be in gravel throughout their entire depth.

Nothing is known of the maximum thickness of gravel in the area between the Matanuska and Knik Rivers; several wells about 50 feet deep and 2 about 110 feet deep, all near Bodenburg Butte, do not pass out of the gravel. The thin gravel deposits, such as those of the terraces immediately north of Palmer, seem to represent deposition during terrace cutting, not extensive deposition after such cutting.

The maximum thickness of alluvial deposits beneath the existing Matanuska and Knik River flood plains is not known. Stream measurements by the Water Resources Division of the Geological Survey show that the depth of channel scour at the Matanuska River bridge during high water is at least 23 feet. Three telephone poles were driven 19 to 21 feet into flood-plain gravel beside the approach to the Knik River bridge without encountering bedrock.

The alluvial-plain deposits are composed of silt, sand, and pebble and cobble gravel. Where it is exposed, the material is horizontally bedded and fairly well sorted. Isolated boulders are present in many localities, however, particularly in reworked deposits or in those laid down near the ice.

Gravel in a tract north and west of the Matanuska River and extending southwestward from eskerine deposits west of Moose Creek was deposited by aggrading streams from ice which stood near Moose Creek. The extension of this deposit southwestward was partly laid down by the same streams, but there the form of the deposit was modified by the melting of buried blocks of ice. The whole deposit may have been a valley train.

An elongate southwest-trending tract between Palmer, Four Corners, and the experiment station is characterized by sinuous ridges. Near the experiment station the ridges have a relief as much as 150 feet and are conspicuously parallel; several of them, approximately level with each other, grade into a flat surface at the experiment station. Clean sand and clean cobble gravel are exposed in a gravel pit in one of the ridges. Rockie (1942, p. 365) has interpreted these ridges as crevasse fillings, deposits formed in crevasses between narrow ridges of ice which later melted, leaving the interridge valleys. The writer believes this interpretation to be correct.

Sinuous and irregular ridges that cover much of the tract immediately east and west of Moose Creek and extending about 3 miles west of that stream are probably eskers. Similar ridges near Pittman, where they are associated with hills of till and with gravel deposits modified by the melting of buried ice, also are considered eskers. Elsewhere in the agricultural area, and particularly about 1½ miles northwest of Wasilla, there are isolated sinuous ridges which contain gravel and which also probably are eskers.

Some deposits of outwash sand and gravel were not differentiated during mapping. Most of these deposits undoubtedly were stream laid. Some of them cap small isolated hills of older deposits. Some, as the deposits between Wasilla and Kings Lake, may be superglacial sorted debris let down upon ground moraine by the melting of the last ice. Outwash deposits in the tract west and north of Pittman probably are chiefly alluvial-plain deposits and fillings around the edges of ice-block holes. Reconnaissance field work was done in that part of the agricultural area, however, and because of lack of exposures and poor topographic expression no attempt to differentiate the deposits is made at present.

The tract characterized by crevasse fillings, extending northeastward from the experiment station, grades northward and southward into areas of irregular ridges and depressions. Cuts along the Palmer-Four Corners road expose horizontally bedded gravel on hilltops between depressions. The depressions are interpreted as ice-block holes. These ~~cuts~~ depressions are prominent in gravel deposits north and west of Palmer and extending south and west as far as Matanuska and Wasilla.

Pitted topography is conspicuous also between Eska and Moose Creeks; there relief as much as 150 feet is common. The large depression that forms the lake basins south of Wishbone Hill consists of ice-block holes.

The ice-block origin of the lake basins near Wasilla and northwest of Pittman has already been discussed (p. 9-10).

Because of the number, size, and distribution of ice-block holes over most of the Matanuska Valley agricultural area west of the Matanuska River, the writer concludes that stagnation of ice and the resultant pitting of the ground moraine and outwash deposits were the dominant factors in the formation of the topography.

Throughout much of the agricultural area glacial deposits have been modified by stream erosion. Small terraces are present in many localities; in some there are several terraces standing one above another. Terraces are most conspicuously developed along the Matanuska River, between the Matanuska and Knik Rivers, and above the bluff overlooking Knik Arm. Several of these terraces north of Knik Arm and also those along the Matanuska River near and north of Palmer are pitted; the terraces were formed while blocks of stagnant ice still lay buried in the gravel. Pitting of terraces is most conspicuous in the narrow tract west and north of Palmer (pl. 1); these terraces give way to pits toward the southwest. All the higher terraces along the Matanuska River near Palmer, down to and including that on which Palmer is situated, are attributed to the action of meltwater from ice which lay up the Matanuska Valley. Some of them may be equivalent to terraces near Eska Creek, and possibly to those east of Kings River or about 19 miles upstream from Palmer. Terraces north of Knik Arm may be remnants of alluvial plains of both the Matanuska and Knik Rivers.

Several terraces lower than the one on which Palmer is situated are preserved on both sides of the Matanuska River near the highway bridge and between the bridge and the Knik River. Some of these were formed by the Knik River. They are not pitted.

At many places along the Matanuska River low tree-covered terraces stand a few feet above the highest deposits of the present alluvial plain. Alluvial fans of many streams flowing into the Matanuska River, such as those of Moose and Eska Creeks, have been eroded by the river and trenched by their own streams. These low terraces and fans, which appear to be at least as old as the cottonwoods growing upon them (about 100 years?), suggest that the Matanuska River has recently been eroding its alluvial plain.

Most of the preceding discussion has been concerned with deposits of sand and gravel at or just beneath the land surface, and the general thickness of these deposits has been described. In the discussion of the till of the Matanuska Valley agricultural area older gravel deposits which underlie the younger till were mentioned. The older gravel seems to differ from the younger gravel chiefly in having slightly cemented layers or streaks. In exposures in the Matanuska bluff (section 2) the older gravel seems to be slightly consolidated because of binding by silt; deposits of silty sand and gravel at the base of the bluff, formed by rainwash, are as firmly consolidated as gravel in the bluff. Similar slight consolidation was observed in gravel in the bluff at Goose Bay. In addition, however, gravel at Goose Bay locally has been cemented by iron oxide (section 1); some of the gravel is sufficiently cemented that masses of it which have fallen from the bluff remain as boulders on the beach below. Slightly consolidated gravel, in layers that alternate with loose gravel, is also suggested by some well logs which record older glacial deposits (table 2). The thickness of the older gravel is known at only one locality, ARRC tract 132 (table 2); there the gravel is 97 feet thick and rests on what may be older till.

Peat in gravel beneath till at Goose Bay has been described briefly (section 1). A sample of wood from this peat, together with samples from other peat deposits in Alaska, was analyzed for the Geological Survey by the Lamont Geological Observatory of Columbia University. The age of the wood, as determined by radio-carbon dating, is 19,100 ± 900 years (Kulp and others, 1952, p. 412-413). A peat sample collected by Ernest Dobrovolny, of the Geological Survey, beneath till on the south bank of the Eagle River, across Knik Arm from Goose Bay, was dated at 14,300 ± 600 years (Kulp, 1952, p. 263). Correlation of surficial till deposits at Goose Bay and the Eagle River is justified by their proximity in the same valley. If the average values for the radio-carbon dates are accepted, therefore, it is necessary to postulate that the ice-free period preceding the advance of the ice that laid down the till overlying the dated peat deposits must have lasted at least 4,800 years in this part of the region.

From previously determined radio-carbon dates Flint and Deevey (1951, p. 263) conclude that the time maximum of the Mankato ice advance in the State of Wisconsin was about 11,000 years ago. Samples of wood from tills of the Cary(?) substage are older than 17,000 years, and samples from tills of the Cary (?) or Tazewell(?) substage, older than 15,000 years (Flint and Dewey, 1951, p. 286).

The writer concludes tentatively that the glacial episode during which the surficial and near-surface till in the Matanuska Valley agricultural area was deposited corresponds approximately in time to the Mankato, although it may have begun sooner and lasted longer than the Mankato in the Midwest; and that the peat at Goose Bay and the Eagle River dates from the preceding warmer interval. The postulated older till cannot be dated on the basis of available evidence, but it was probably deposited during the glacial episode preceding the last.

Fluvioestuarine Deposits

Along and in Knik Arm, glacial silt brought into brackish water by the Knik and Matanuska Rivers is being deposited in the form of beaches and bars. North of Knik Arm and west of Matanuska is a flat surface which stands 20 to 30 feet above mean sea level. This flat is underlain by tough, relatively impermeable gray silt. Streams crossing it are tidal; to the west they are nearly bankfull at the average high tide (the tide range at Anchorage, farther west on Knik Arm, is about 30 feet), and probably the flat is partly covered at very high tides. Farther east, near Reedy Lake, there are fresh-water bogs underlain by gray silt which resembles the estuarine silt seen farther west. Stream-laid sand forms the surface of the flat at Matanuska and near the point at which Wasilla Creek enters the flat. The boundary between stream and fluvioestuarine deposits is thus established only within broad limits (pl. 1).

On a similar flat at the Eklutna CAA station, south of Knik Arm, the silt ranges from 4 to more than 11 feet thick; a well about 20 feet deep passes through the silt and obtains water from underlying gravel. The deposits beneath the flat north of Knik Arm may be of similar thickness, but no information is available. It is possible that the center of the estuary formerly was much deeper than at present, and that thick deposits were laid down there during the postglacial rise of sea level.

Bars in the modern estuary reach a level somewhat lower than high tide. It seems likely that this relation existed during formation of the flat north of Knik Arm, and that the flat was formed during a stand of the sea several feet higher, relative to the land surface, than that of the present. Later deposition during flooding by very high tides probably has built up the flat somewhat and smoothed irregularities in its surface.

Nonglacial Deposits

Windblown Deposits

Windblown deposits mantle the surface of the Matanuska Valley agricultural area, with the exception of alluvial plains along existing streams, some recent terraces, flats subject to tidal flooding, and a few steep slopes in bedrock. Over most of the agricultural area this mantle consists of silt or sandy silt (loess). Sand is present in several local areas, generally as dunes. These windblown deposits have been discussed by Tuck (1938), Rockie (1946), and Black (1951).

Samples of loess and dune sand (table 4) show the excellent sorting characteristic of windblown deposits.

Cobbles and pebbles present in the lowest foot or so of the silt in many exposures of loess are attributed to overturn of near-surface gravel, when the loess was thinner than at present, as a result of the fall of trees and the tearing up of the roots (Lutz and Griswold, 1939).

Samples of sand and silt examined under the microscope consist chiefly of quartz grains which, except for the larger grains, are fresh and angular. Chips of dark rock are included among the sand grains.

Interbedded with windblown sand and silt are layers of light-colored volcanic ash. Where the deposits are thick, near the Matanuska River, five ¼- to ½-inch layers are present; two are together near the base of the section, two are higher, and one is by itself in the upper part of the section. In a thinner section of loess west of Palmer it is not possible to distinguish all five layers or any closely spaced pairs. West of Wasilla, ash was recognized only in thick silt deposits which evidently had been reworked; elsewhere the ash, if present, is masked by weathering.

Many sections of windblown material also contain roots, fragments of wood and bark, and ¼- to 1½-inch layers of woody debris. In some exposures the loess contains small shells, and most exposures are characterized by darker and lighter brown-color bands due to weathering.

The dunes are composed of inclined beds. Some of the sand and all the loess deposits are bedded parallel to the land surface.

Old dunes covered by weathered sand and silt are present southwest of Fish Creek and above the west bluff of Moose Creek. Modern dunes extend from the Knik River near Jim Creek about a mile northwestward toward Bodenburg Butte. A ridge of horizontally bedded windblown sand capped by cliff-head dunes that probably are still being formed extends northward about 2 miles along the west Matanuska bluff, beginning about 1½ miles northwest of the highway bridge near Palmer.

The horizontally bedded sand along the Matanuska bluff is locally at least 40 feet thick. It grades westward into loess. Near Palmer the loess is 3 to 5 feet thick. Thick deposits of loess are present also near Bodenburg Butte. At Wasilla the loess is commonly 18 inches thick or less. Over the part of the agricultural area west of Wasilla it is generally less than 12 inches thick.

Near Palmer the loess and sand may be correlated by means of the layers of volcanic ash they contain; the topographically continuous deposits farther west are probably of about the same age. All these deposits are postglacial. The windblown material was probably derived chiefly from bare alluvial plains of the Matanuska and Knik Rivers. Near the Matanuska River modern deposition of windblown dust continues at a measurable rate (Tuck, 1938, p. 649). It is unlikely, however, that deposition is now significant in the western part of the agricultural area.

Windblown sand and silt in the agricultural area are relatively permeable; except where they are underlain by impermeable material, they are well drained.

Other Deposits

The rounded upper slopes of Lazy Mountain are covered by a mantle composed of a heterogeneous mixture of angular rock fragments and fine-grained material. In appearance it differs from sandy till in the weathered character of its fragments and in its lack of compaction. The deposit is attributed to breaking and transportation of rock material by frost action. Similar deposits formed from underlying unconsolidated materials have been recognized at a few localities on the valley floor. The coarse frost-disturbed material is relatively permeable, the silty material less so.

At an altitude of about 2,800 feet on the southwest slope of Lazy Mountain the frost-disturbed mantle contains rounded granitic boulders unlike the bedrock exposed on Lazy Mountain. These boulders may represent an older glaciation during which ice covered Lazy Mountain.

Talus deposits are present beneath rock cliffs along the sides of the valley; they are best developed beneath Pioneer Peak. They are composed of angular rock fragments of a wide range of sizes. The deposits have been formed by rockfall, rockslide, and avalanche (snowslide). They are relatively permeable.

Deposits of silty poorly sorted and poorly permeable material transported by slumping, rainwash, or mudflow are present locally along bluffs cut in unconsolidated material. Most of these deposits consist of silt encrusting the faces of bluffs and of silty gravel in layered or massive accumulations below bluffs. Some of them closely resemble till.

Several small alluvial fans are present west and south of Lazy Mountain. They are composed of poorly sorted sand and gravel in which many of the stones are angular or subangular. Irregular bedding and channel cut-and-fill structure were observed at one locality on the slope of Lazy Mountain. These deposits are relatively permeable.

Lake ramparts--ridges of sand and gravel built along lakeshores by ice push--are present at many of the lakes in the agricultural area. Commonly they are a few feet high. At some lakes several ramparts are present.

Beaver dams may be seen along many streams, or at the downstream ends of ponds, in the agricultural area. Most of the dams the writer has seen are abandoned, breached, and tree covered.

Deposits of reworked gravel, sand, and silt occur along the channels of existing nonglacial streams. Many of the lakes of this area are being filled by the deposition of peat in the water near shore. Peat is also being deposited in poorly drained tracts throughout the area. The thickest peat known to the writer is a section 2.7 meters thick measured by W. S. Benninghoff, of the Geological Survey; this section lies to one side of the axis of the bog, so that a greater thickness is probably present. The bog is about 2½ miles southeast of Wasilla. According to D. L. Irwin (personal communication, 1949), deposits of calcareous marl, formed by the plant Chara, are present in many lakes. Scattered clam shells may be seen on the bottoms of some of the lakes, but the writer has not seen accumulations of these shells.

Perennially Frozen Ground (Permafrost)

Perennially frozen ground (permafrost) was found in three bogs. On plate 1 these bogs are located as follows: 2½ miles southeast of Wasilla, 2-3/4 miles east-southeast of Wasilla, and 2¼ miles west of the experiment station. A fourth locality, in a bog three-quarters of a mile south of Palmer, is described by Dachnowski-Stokes (1941). No doubt there are many additional localities in the agricultural area in which small poorly drained areas are underlain by thin bodies of perennially frozen ground.

A pit dug in the bog about 2½ miles southeast of Wasilla exposed frozen peat underlain by frozen wind-deposited silt (loess) 21 inches thick, in turn underlain by nonfrozen saturated gravel. The frozen loess contains crystals, veinlets, and small irregular masses of ice, together with many well-preserved twigs and other bits of wood. The same loess, where it overlies the gravel on the hilltop adjacent to the bog on the south, is 18 to 20 inches thick; in some sections on the hilltop the loess contains poorly preserved woody material. The writer believes it likely that the presence of many wood fragments was characteristic of the loess in general during its deposition, and that they are not peculiar to the loess now found beneath the frozen peat. It seems likely that wood in the loess beneath the bog was preserved by being frozen at some time subsequent to deposition, and that wood in unfrozen loess nearby was largely destroyed by weathering.

The perennially frozen ground in this bog rests on glacial deposits and involves loess; it is therefore postglacial. It probably was not formed until the loess mantle had reached approximately its total thickness in this part of the agricultural area; if it had been present during deposition of a large fraction of the loess, silty peat probably would have been deposited in the bog. It has remained frozen for all or almost all of the time since its formation; if it had been been thawed for long intervals, weathering of the loess and its organic contents should have become well advanced. The evidence obtained does not permit more detailed dating of the formation of the frozen ground.

The writer saw no evidence suggesting that postglacial perennially frozen ground has been widespread in the agricultural area, or that in bogs such as those cited it has extended very far beyond the present borders of the bogs.

Postglacial Weathering and Erosion

Postglacial weathering and erosion in the agricultural area began in each part of the area as soon as it became exposed by the melting of the glacial ice.

Greenstone and closely jointed shale, where they are exposed, have generally undergone deeper weathering than massive graywacke and clean sandstone. The only glacial polish the writer has seen preserved on bedrock is on Bodenburg Butte, in spots where the polish has been protected until recently by the loess cover. Disintegration of bedrock is chiefly by frost wedging, but weakening and expansion due to chemical changes probably are important contributory factors. Erosion of bedrock is unimportant within the agricultural area. Cutting of rock walls by the Matanuska River upstream from Palmer, and by Moose and Wolverine Creeks, may have occurred during deglaciation; possibly the gorges are partly inherited from a time preceding the last glaciation. Modern erosion of bedrock is most evident along the walls of the valley, where talus is still being formed by rockfall, rockslide, and snowslide.

Over much of the agricultural area till and gravel are protected to some extent from weathering by the loess mantle. Postglacial erosion of till and gravel has not been important except along the Matanuska and Knik Rivers and along Knik Arm. The conspicuous terraces described in earlier pages of this report were formed chiefly during deglaciation, although cutting of the lower terraces appears to have continued to the present. The most conspicuous modern erosion is by undercutting and slumping of the Matanuska bluffs south and northeast of Palmer. There is much erosion of channel deposits by the Knik River during its annual flood.

No evidence of important erosion was found in most loess sections, but a greater thickness of deposits in many valleys and a lesser thickness on adjacent hills suggest that erosion of the loess has occurred. The topography does not seem sufficient to cause differential original deposition by the wind. The writer believes that throughout the period of deposition newly fallen dust was washed or blown from hillsides into adjacent valleys. Folding of older layers of volcanic ash and of weathering zones may be seen in many exposures of loess. This deformation, which occurs on flat tracts as well as on slopes, is attributed to frost action during the earlier part of the period of loess deposition. Chemical weathering of loess is shown by alternating bands of lighter and darker brown silt in many exposures. These bands are commonly parallel to the present land surface; they probably were formed during periods of temporarily slower dust deposition before being buried by further deposition. Over most of the agricultural area west of Wasilla the loess is so iron stained that ash layers and color bands, if they were present, are completely masked except in thicker deposits in valley bottoms.

The soils of the area have been described by Rockie (1946) and by Kellogg and Nygard (1951). In the eastern part of the area, particularly near Palmer, soil is developing on windblown sand and silt which is relatively thick; soil formation at no time has progressed far because of continual addition of fresh parent material to the land surface. In the western part of the area, where the loess is commonly less than a foot thick, soil-forming processes have affected not only the loess itself but, in many sections, the uppermost part of the underlying glacial material. Kellogg and Nygard (1951, p. 72) believe that podzolization (formation of podzols or forest soils) is the dominant soil-forming process but that podzols have been formed only where deposition of windblown material is slow enough that podzolization can keep pace with addition of new material.

Water erosion of the loess mantle is unimportant. The high permeability of the material and the presence of the vegetative cover (and perhaps the low rainfall intensity) make surface runoff negligible. Wind erosion, except on bare alluvial flats, was insignificant prior to the introduction of agriculture in this area. At present wind erosion is a serious problem in some cleared agricultural land, particularly in the path of winter storms moving down the Matanuska Valley.

Quaternary History

There is little evidence of the form of the preglacial topography in this region, but the mountains must have presented a different appearance before the glacial oversteepening of slopes. Oversteepening is most pronounced along the front of the Chugach Range, where several prominent spurs were truncated. Bodenburg Butte and the other bedrock hills between the Matanuska and Knik Rivers probably are remnants of the preglacial divide separating those streams.

The writer has found evidence for two, at the most, glacial episodes in this area. The older, less well established, of these episodes, which the writer believes resulted in deposition of the now-buried older till and gravel, has no surface expression in the topography of the valley floor.

The deposits of the younger ice form the surface over most of the agricultural area. Nonglacial processes, during and after melting of the last ice that lay over the valley floor, have modified the deposits left by the ice and formed nonglacial deposits.

The geologic map (pl. 1) and the section given in figure 2 summarize the surficial and near-surface deposits of the Matanuska Valley agricultural area. A brief summary of the development of the topography of the valley floor, as already interpreted in this report, follows.

The last ice tongue to lie over the agricultural areas, a large glacier formed by the merging of the Matanuska and Knik Glaciers of that time (and possibly including ice from farther up the Matanuska Valley), extended a few miles west of what is now Big Lake, where its end moraine is preserved as an arcuate band of hills. Deglaciation over most of the valley floor was by stagnation. The behavior of the Knik Glacier at that time is not known. It has been suggested that during melting of the ice the topography formed depended largely on the distribution of rock debris in the ice. Water from the melting ice cut shallow valleys across the ground moraine and deposited gravel in them. The last fragments of ice that remained, blocks lying in depressions on the moraine, were partly surrounded by gravel deposits before they melted entirely. Farther east, masses of stagnant ice were surrounded or buried by thicker gravel deposits. Melting of the buried ice blocks and collapse of the gravel covering them led to formation of the irregular topography characteristic of this part of the valley floor.

The glaciation upon the valley floor was accompanied by glaciation in the surrounding mountains. The larger mountain valleys held tributary glaciers which joined the main ice stream. In many of the smaller mountain valleys were glaciers which did not join larger glaciers; their moraines may be seen in valleys above Eklutna Lake, up the Little Susitna Canyon, and up the valleys of Moose and Wolverine Creeks. Many valleys and mountain slopes which were not glaciated were affected by frost action due to the same cold climate that produced the glaciers, and these were covered by a mantle of frost-disturbed debris. Rock glaciers now preserved in some of the mountain valleys may have been formed at this time.

Meltwater from ice farther up in the Matanuska Valley flowed southward upon leaving the mountain valley northeast of the site of Palmer. This change of course may have been because of ice which lay in the way to the west. The meltwater streams repeatedly made channels and trenched them, producing the conspicuous terraces which border the present Matanuska River.

During or after deglaciation streams flowing down the mountainsides bordering the valley began to build alluvial fans. Beneath steep slopes talus began to accumulate. These deposits are still being formed today. Probably during deglaciation, and certainly afterward, wind carried dust from the bare alluvial plains and deposited it over the surface of the valley floor. Deposition of windblown dust has continued to the present; the silt forms the parent material of most of the cultivated soil in the agricultural area. During the early part of the period of dust deposition there was at least one period characterized by frost disturbance of the loess. Local bodies of perennially frozen ground were formed in bogs; they have not been dated but are probably later than this frost action.

The gradients of the terraces that stand at about the level of the present Matanuska River and Knik Arm suggest that the water body into which the meltwater streams flowed stood considerably below present sea level. During deglaciation sea level rose; salt water partly filled the lower reaches of the Matanuska-Knik Valley and an estuary, Knik Arm, was formed. Glacial silt carried into Knik Arm was deposited as bars. Some of these bars, which now stand above the level of average high tide, suggest that at least once during postglacial time sea level was somewhat higher, relative to the land surface, than it is now. Activity of the streams continues, and low terraces along the Matanuska River suggest that the river has recently been eroding its alluvial plain.

GROUND WATER

Occurrence

Below a certain level in the near-surface part of the earth, the pores or interstices between fragments of unconsolidated sediments and the fissures and other openings in bedrock are saturated with water. The upper surface of this zone of saturation is known as the water table. Water occurring below the water table is ground water. Between the water table and the land surface there is commonly a zone of aeration in which the pore spaces and other openings are not saturated.

Ground water is derived from rain, from the melting of snow, and from surface bodies of water. The water moves downward through the zone of aeration until it reaches the water table; it then migrates from higher to lower parts of the saturated zone until it is discharged naturally through seeps and springs into streams or lakes, or by evaporation, and by transpiration of plants. Artificial discharge may take place from wells and improved springs, which are excavations extending below the water table.

Locally, fine-grained or dense material which does not permit easy passage of water (that is, which is relatively impermeable) may be surrounded by relatively permeable material. If the upper surface of such an impermeable mass is below the land surface and is sufficiently extensive, it may hold in the permeable material above it a body of perched ground water that stands higher than the general water table in the surrounding area. Streams, marshes, and lakes are present at places where the land surface intersects the water table; these features are therefore commonly considered to mark the local position of the water table. Bodies of surface water may be perched upon impermeable material, however, and caution must be used in interpreting a lake or stream as an indicator of the local water table.

Water-Bearing Materials

Bedrock

Although several wells have penetrated bedrock in the Matanuska Valley agricultural area particularly in the vicinity of Palmer, only a few have obtained water from it. Well 70 (well records, table 5), on the farm of Victor Falk, Jr., near Bodenburg Butte, is in rock from 36 feet below the surface to its total depth of 110 feet. The rock is probably greenstone. The driller's log reports water at several places, chiefly below 65 feet; it is probably derived from fractures in the rock.

The Lester (123), Gregerson (120), Knapp (136), Mehan (376), and Cope (142) wells, in or near Palmer, penetrate bedrock, although the Knapp well, at least, may derive its water from overlying gravel. The old slaughterhouse well (144), in rock, and the old hospital well (135), which may have penetrated rock, obtained salt water (see section on "Quality of water"). Two other wells, probably also in Palmer, obtained salt water which may have come from bedrock.

Bedrock is at best a poor water-bearing material in the Matanuska Valley agricultural area. In most drilled wells which penetrate bedrock, the bedrock part of the hole serves merely to collect and hold water derived from the overlying unconsolidated material. Wells such as those on the Bugge and Thuma farms (128 and 145), which are seated on bedrock below the water table, have proved satisfactory. If bedrock is found near the surface during well construction, it will probably be wiser to move to one side, space permitting, and begin a new well rather than to undertake blasting in a dug well or more difficult drilling in a drilled well.

Till ("hardpan")

About 25 wells have obtained water from till in the Matanuska Valley agricultural area. Many other wells have passed into or through till and derive their water from gravel lying over or beneath it.

The till is relatively impermeable. Field tests made with a variable-head permeameter suggest that its permeability is of the order of 1/10,000 that of outwash sand in this area. The permeability of thin sand layers in the till, on the other hand, is comparable with that of surficial outwash sand. Where till lies near the land surface, bodies of surface water or bodies of ground water in gravel may be perched above it; where till lies at and immediately below the water table, water in reasonable quantity cannot be obtained from the upper part of the saturated zone.

In almost all wells that obtain water from till, the water occurs in sand or gravel layers within the till. These permeable layers are commonly 1 foot or less in thickness, as in the Nash (6), Venne (22), Moore (230), and Bailey (343), wells, but there are some thicker water-bearing zones. The Withey well (474) obtains water from a 2½-foot zone of sandy material. A Geological Survey test hole (4) in till penetrated 1 foot of coarse sand, 2 feet of gravelly material, and 1 foot of fine and medium sand before passing into till again at a depth of 26 feet. Water seeps into well 2, at the Lazy Mountain Childrens Home, at several levels; the water-bearing material may be superglacial till rather than layered sand or gravel, however.

Water obtained from near-surface till, as at the Lazy Mountain Childrens Home, is probably derived from precipitation falling upon the land surface. The writer believes that water obtained from included sand or gravel layers is derived from the till itself by downward percolation, and that the quantity of water obtainable depends not only upon the permeability of the till and the size of the well which collects the water but also upon the roof area of the sand or gravel layer.

The importance of fractures cutting till, and sandy or stony layers in it, in the movement of ground water through the till cannot be estimated because of the inadequacy of exposures.

Springs issuing from till are unimportant. Seepage from thin sand or gravel layers in till may be observed in some exposures, as in the east bluff of the Matanuska River about half a mile north of the highway bridge. The flow of water from seeps the writer has observed is not sufficient for more than a very small supply, but the water may present a drainage problem if the till is to be excavated.

The yields of wells in till are small at best, but a well penetrating one or more water-bearing layers may provide a modest supply for a household or for a limited number of livestock. The Cook well (338) yielded about 50 gallons of water per day in 1949 but was dry during the dry summer of 1950. The Nash well (6) yields about 100 gpd regularly, and the Kibbe well (586), 150 gallons. Geological Survey test well 3 (well 4 in table of well records) was pumped steadily at the rate of 30 gallons per hour over a 3-hour period, with a drawdown of 19 feet. The recovery of water levels in wells in till may be slow; an extreme example is the Bradley well (607), a large-diameter dug well, in which the water level required 7 days to recover after 250 gallons had been pumped in 45 minutes.

The development of ground-water supplies from till, even in limited amounts, must be considered because of the current need for water supplies in areas of till that are already settled and because of possible future need in large unsettled areas of potential agricultural land that are underlain by till.

Outwash Sand and Gravel

In the Matanuska Valley agricultural area sandy gravel and subordinate sand and clean gravel are of such permeability as to be good water-bearing material wherever they occur below the water table. Most wells obtain their water from these materials.

Over a large part of the agricultural area ground water is present under water-table conditions. Perched water bodies cause apparent local irregularities in the level of the water table. On ground moraine in the western part of the area lakes, marshes, and bodies of ground water in gravel are commonly perched on till. In some horizontally bedded gravel deposits ground-water bodies are perched on silty layers. The Brown (42), Rippy (43), and Bastian (44) wells, at the east end of Bodenburg Butte, obtain water at a depth of 28 to 35 feet. The Gallagher well (47), a few hundred feet west of the Bastian well, passed through a thin body of water at about 34 feet. The static (non-pumping) water level in the Gallagher well was 53 feet below the land surface in September 1951. It is likely that all these wells reached or passed through the same body of water; the impervious layer beneath it may be buried channel floored with silt. Perched water, in bodies as much as a few feet thick, was found at several other levels in the Gallagher well (Frey, J. D., personal communication, 1951).

Apparent irregularities in the water table may also be due to the presence of relatively impermeable material at and below the level of the water table. A till layer in gravel beneath part of Wasilla lies at the water table over an area of at least 1 to 2 acres. It was found in the F. Swanson (513), Wasilla Hotel (519), G. Swanson (520), and Teeland Store (521) wells (Fabian, Jack, personal communication, 1949). In several of these wells water is reported to have risen as much as several feet when the base of the till was penetrated. Till in the Bergman well (531) is beneath the water table. Till was not found in wells surrounding those listed above.

Many of the small streams flowing across gravel deposits appear to be perched. Water in the Carson well (576) stands 33 feet below the surface; a creek a few hundred feet away is only about 6 feet lower than the ground surface at the well, or 27 feet above the water table at the well. Well 412, on the Kirchner and Menk property, is 20 feet from Wasilla Creek and 6 feet above it; the water level in the well is about 7 feet lower than the bed of the stream, and according to reports, movement of ground water at the time the well was dug was in the direction opposite that of stream flow. The water level in USGS test well 2 (well 57) is about 30 feet below the bed of Bodenburg Creek, 50 feet away. It seems likely that the beds of these streams have been rendered relatively impermeable by a "seal" of silt in the gravel over which they flow, although they probably feed the ground-water body to a slight degree.

In many wells that pass through a buried stratum of till and into gravel beneath, water rises into the well to a level higher than the base of the till. In several such wells (for example, the Bryant (287), Gaylord (294), Palmer (363), Benson (364), and Hemmer (398) wells, west and northwest of Palmer) the static water level is higher than the upper surface of the till. In the Palmer test well (363), on a hill which rises 30 to 40 feet above the surrounding surface, the water rose within 20 feet of the surface. Figure 5 summarizes the available information on the depth and thickness of the till stratum and the water level in wells along a section west and northwest of Palmer. It is evident that imperfect artesian conditions are developed locally where the buried till stratum is present.

With the exception of seeps from sand layers in till, all the springs seen by the writer derive their water from gravel. The springs occur in three general situations: (1) in saturated gravel below the water table, exposed by recent stream erosion, as at springs along the Matanuska bluff south of Palmer and near Matanuska; (2) in topographic depressions where the water table intersects the land surface, as is probably the case at Brazil Springs northwest of Palmer; and (3) at the contact of saturated gravel and underlying till, as on the hillside above (east of) the mouth of Fish Creek.

Only one well in the Matanuska Valley agricultural area has been pumped at a rate greater than 100 gpm. This is well 363, drilled as a test well for the city of Palmer. It yielded 118 gpm with 35 feet of drawdown, after 16 hours of pumping (Bourne, 1952). Therefore its specific capacity was about 3.4 gpm per ft of drawdown. This well was finished with a screen. It obtains water from sand and sandy gravel beneath a buried stratum of till. USGS test well 1 (well 37) yielded 44 gpm with a drawdown of 5.6 feet after 4½ hours of pumping. It is a 3-inch open-end well. In view of its small size, lack of a screen, and higher specific capacity, it must penetrate material more productive than did well 363. These are the only wells in the agricultural area that have been pumped at a rate greater than about 20 gpm. Farm wells are usually pumped at rates of a few gpm for only short periods. According to Rivers (1950, p. 17), the Hemmer well (398) has yielded 5.65 gpm with a drawdown of 7 feet, in a 24-hour test.

Most wells in the agricultural area, and all those producing more than about 200 gpd, obtain their water from outwash sand and gravel. There is no reason to doubt that yields of wells in sandy gravel in the agricultural area can be substantially increased by use of well screens and proper development practices.

Windblown Sand and Silt

The windblown sand and silt which mantle glacial deposits in the Matanuska Valley agricultural area lie above the water table and generally are not saturated. They are important in the hydrologic cycle, however, because they are permeable and permit rapid infiltration of water that reaches the land surface. Information obtained during irrigation experiments (Wilson, C. W., personal communication, 1951) shows that on 2 farms, 1 at Palmer and the other near Matanuska, infiltration of water into agricultural soil may take place at the rate of at least one-third inch per hour for several hours, without perceptible runoff.

Small perched bodies of water occur in eolian sand and silt on the Holtet property, along the Matanuska bluff about 4 miles north of Palmer. The water is present only beneath depressions, which are interpreted as pits formed by the melting of buried blocks of glacial ice. The impermeable layer which retains the water is probably the residue of unsorted glacial debris which was left upon melting of the ice or the deposit formed in a pond which may have occupied the pit during melting of the ice. By prospecting with a posthole auger Mr. Holtet has found water in many of the pits on his farm; no test holes on hilltops or ridges between pits struck water, however. The sand and silt range from 9 to 14 feet in thickness; the perched water bodies are from 3 to 7 feet thick. Most individual pits cover a few acres or less. Figure 4 is a section through a typical pit. It is evident that the water is derived only from precipitation received within the pit itself, and that the quantity of water present in a single pit is small. Perched water in eolian deposits has not been reported elsewhere in the agricultural area; it is probably present only in restricted areas near the Matanuska River where the eolian material is thick and is underlain locally by impermeable material.

Hydrology of Physiographic Units

As an aid in the discussion that follows, the writer has divided the Matanuska Valley agricultural area into physiographic units. The differences in the land surface in these units are a reflection of major differences in their geology. These differences cause significant changes in hydrologic conditions from one unit to another. The location and boundaries of the physiographic units are indicated in figure 2. Geographic names are applied to the units only for convenience of reference in this report.

Lazy Mountain (Unit 1)

The western slope of Lazy Mountain and the tract that extends westward from it to the Matanuska River (hereafter termed the lower slope) constitute physiographic unit 1. The higher slopes were not glaciated and are composed of rock covered by slope deposits. An intermediate section of the slope consists of lateral-moraine and alluvial-fan deposits. The lower slope, which is more than half of the unit, is composed of ground moraine or gravel-covered terraces cut into it.

The talus and frost-disturbed deposits on the upper slopes of Lazy Mountain are relatively permeable. Streams which derive their water from these materials, and possibly in part from fractured bedrock beneath them, continue flowing down the west slope of the mountain during prolonged dry weather. The alluvial fans at the foot of the steep slope are composed of relatively permeable sand and gravel. The lateral moraine and the lower slope are relatively impermeable till. Seeps occur along the lower edges of the alluvial fans where the underlying till reappears at the surface.

The lower slope is poorly drained and, in places, marshy. Wells in the till have ranged from unsuccessful to moderately successful. USGS test well 3 (well 4) and the Beechik (5) and Nash (6) wells penetrated thin water-bearing layers in the till. A well at the Lazy Mountain Childrens Home (2) obtains water from slightly permeable near-surface till. According to reports a well begun on the Copenburg property, about a quarter of a mile north of well 4, is dry at a depth of about 50 feet. The success of a well in the till is dependent upon its penetrating a sorted layer that is water-bearing. The location, thickness, and extent of these layers cannot be predicted on the basis of available evidence. The probability of finding water-bearing material in till near the surface seems to be highest if the well is located in one of the shallow valleys that trend down the lower Lazy Mountain slope. It is unlikely that the average well in the till will yield more than a modest household or farm supply.

Small seeps occur along the bluff about half a mile north of the Matanuska Bridge. Similar seeps from till along the hillside overlooking the lower ground south of the lower slope of Lazy Mountain yield enough water to hinder excavation or to make drainage of completed excavations difficult.

In the triangular tract between the Matanuska River and Wolverine Creek several terraces indent the original till surface. Each of these terraces is covered by gravel. The Stewart well (1), on the uppermost terrace, passes into till 10 feet beneath the surface. No other wells have been constructed on these terraces, and the thickness of the gravel deposits is not known. By analogy with terraces on the other side of the Matanuska, however, it seems likely that till is near the surface on the higher terraces here. Exposures along the river and along Wolverine Creek suggest that bedrock is near the surface on the lower terraces. Nonetheless, this terraced tract is the most promising area for development of ground-water supplies on the slope of Lazy Mountain. Where a choice of location is possible, the most favorable is toward the center of a terrace, away from its inner and outer edges.

Small gravel-covered terrace remnants are present on the slope above (north of) the Matanuska River bridge. A spring on the Clark property discharges 3 to 5 gpm and is reported (Clark, Frank, personal communication, 1949) to have a fairly regular flow.

The writer believes it unlikely that a deeper gravel stratum is present beneath till on the slope of Lazy Mountain.

All the ground water present in deposits on this slope is derived from precipitation upon it.

Bodenburg Terrace Area (Unit 2)

The land surface in most of physiographic unit 2, which is the tract between the Matanuska and Knik Rivers and the mountains to the east, consists of stream-laid sand and sandy gravel. Bodenburg Butte and smaller hills of bedrock, and a few hills of till, protrude through the gravel deposits.

The part of this area mapped for this report is well drained; to the southeast the surface is lower and marshy. Bodenburg Creek, east of the Anchorage-Palmer highway near the Knik River, appears to be a "perched" stream (p. 19). During the annual late-summer flood of the Knik River the water table near the river fluctuates in response to changes in river level.

Whatever ground water is in the rock comprising Bodenburg Butte and similar hills occurs in fractures in the rock. Only one well (70) obtains water from the rock, and there is no information regarding the amount of water available in general from rock in this area. The lake on the east end of Bodenburg Butte is spring-fed; the water may be derived partly from fractures in the rock, but it probably comes also from the glacial deposits mantling the rock.

Till is present in two hills left by erosion in the northern part of this area and under the higher sloping ground below (south of) the lower slope of Lazy Mountain. In these areas the till will make acquisition of ground-water supplies relatively difficult.

The lower slope of the mountain wall east of this area is mantled by relatively permeable alluvial-fan and talus deposits.

The remainder of the Bodenburg terrace area is underlain by permeable gravel. Small perched bodies of ground water are present locally (p. 19) southeast of Bodenburg Butte near its east end. Ground water probably moves southward and southwestward through most of this area. North of the bedrock hills near Bodenburg Butte, and also on the terrace southwest of Bodenburg Butte, the water table stands close enough to the land surface to be accessible to suction pumps. Geological Survey test well 1 (37) yielded 44 gallons of water per minute from an open-end 3-inch casing having no screen. Similar quantities of water probably can be obtained from wells in gravel elsewhere in this area, and larger quantities might be expected if screens were used and the wells developed.

Ground water in this area is derived from precipitation upon the land surface and from runoff from the mountains to the east.

For quantity of water available and the cost of its acquisition, this physiographic unit is probably the most favorable part of the Matanuska Valley agricultural area for the development of ground-water supplies.

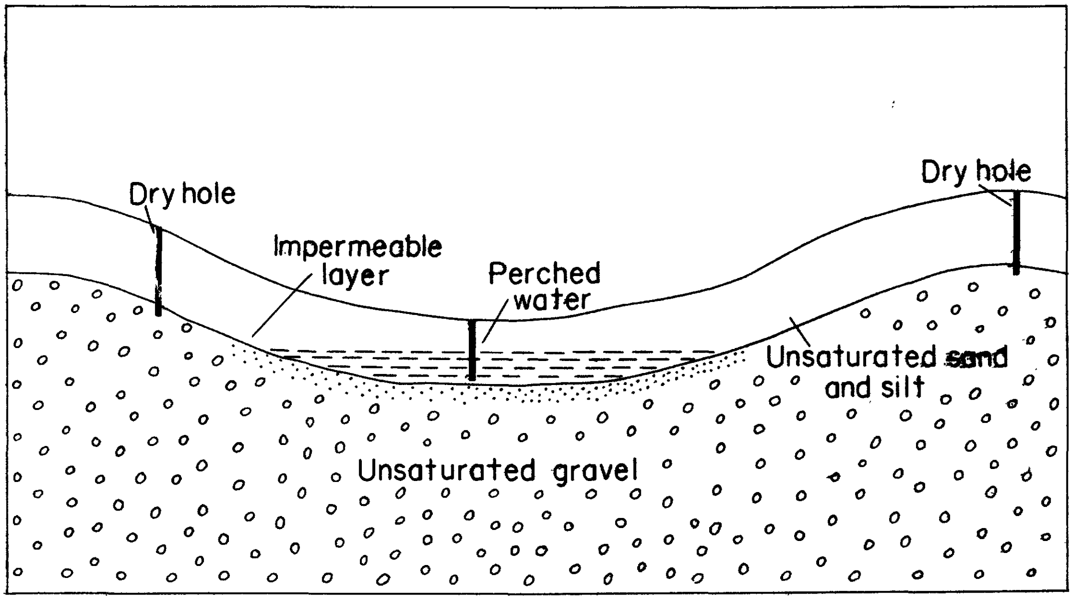

Figure 4. Generalized section showing perched ground water in windblown sand and silt.

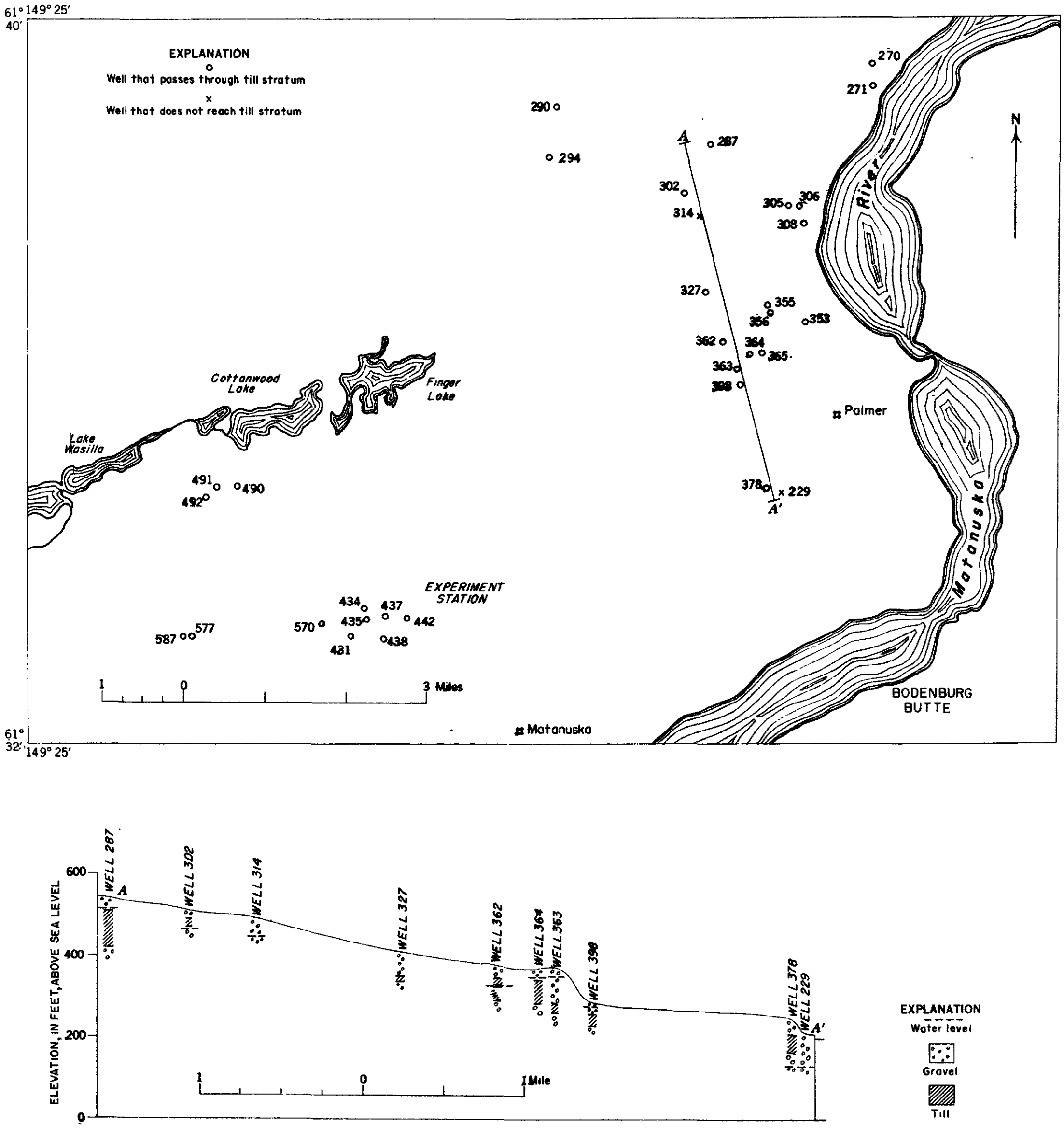

Figure 5. Map and section showing distribution of older glacial deposits known from well logs.

Matanuska-Knik Flats and Alluvial Plains (Unit 3)

The flats bordering Knik Arm, together with existing alluvial plains of the Matanuska and Knik Rivers, constitute an area in which the water level stands no more than a few feet beneath the land surface. Water in gravel beneath estuarine silt at the Eklutna CAA station becomes brackish during very high tide (Westernbarger, Kenneth, personal communication, 1951). Water beneath the similar flat north of Knik Arm is certainly brackish or salty at least part of the time. Large quantities of water are undoubtedly available from the alluvial deposits along the Matanuska and Knik Rivers, but recurrent flooding renders settlement of such low areas unwise. The community of Matanuska is said to have been abandoned because of flooding by the Matanuska River. Flooding and channel shifting along these braided streams would prevent installation and use of infiltration galleries in the alluvial deposits.

Palmer Terrace (Unit 4)

The Palmer terrace is the single extensive terrace upon which Palmer is situated. Permeable gravel underlies the surface of most of the terrace, and except for a few depressions containing ponds the surface is well drained.

In general, farm wells in the area south of Palmer have been successful. Over most of the terrace the water stands below the limit of suction lift. Locally it is necessary to drill somewhat below the level of the water table before water is brought into the well; this seems to be due to the presence of local layers of relatively impermeable silty material. The water table slopes south and southeast toward the Matanuska River, and seeps occur along the base of the bluff. Seasonal fluctuations in the elevation of the water table are less than in most of the rest of the agricultural area, and the maximum expectable fluctuation is probably not more than a few feet. It is possible that in a few places rock or deep-lying till will be penetrated before the water table is reached, but this is not so likely as it is at or north of Palmer. There are no data from which to estimate the possible yields of wells.

Subsurface conditions are more irregular near and north of Palmer. Till and bedrock are at or near the surface in many places. Surface exposures and well logs suggest that a partly buried bedrock ridge or series of knolls extends westward from the Matanuska River bridge. Other bedrock hills, some of them buried in gravel, are in Palmer or just south of the city. The Bugge (128) and Felton (130) wells have been in use for many years (the Bugge well since 1914) and have yielded supplies sufficient for many families; they penetrate water-bearing gravel. Three other wells (now abandoned and filled) dug by individuals in Palmer are reported to have been successful, and during establishment of the agricultural colony four successful colony wells, 37 to 46 feet deep, were constructed in gravel. Five other colony wells in Palmer, in gravel, till(?), or bedrock, were "dry holes." A sixth, which reached bedrock at 72 feet, is reported (ARRC log) to have obtained "sulphur water" at 121 feet. Two colony wells (135 and 144) at Palmer obtained salt water; two other colony wells, probably in Palmer, also obtained salt water. In three of these wells salt water was reached at 140 to 160 feet above sea level. In the old slaughterhouse well (144) salt water was reached at a depth of 569 feet, or about 340 feet below sea level; this well is reported to have penetrated shale and limestone from 18 to 590 feet below the surface. The difference in chemical composition of water from two of the wells, 134 and 135(see section on "Quality of water"), and the absence of salt water in other wells in the vicinity of Palmer suggest that the highly mineralized water is of local occurrence. It probably has been trapped in the rock since a time when this area was covered by marine or estuarine water; it is not modern salt water from Knik Arm.

The Bugge (128) and Thuma (145) wells are seated on bedrock. In the Thuma well, which is 24 feet deep, 2 feet of saturated gravel overlies the bedrock. In the Cope well (142), about half a mile east and at the same altitude, the water stands about 75 feet below the surface. In the Moffitt well (229), about half a mile south and 10 feet lower, the static level is about 85 feet below the surface. Water in the vicinity of the Thuma well thus appears to be perched on bedrock. In other wells in or near Palmer the water stands about 30 to 40 feet beneath the land surface. In wells within a radius of a mile to the southeast and south (Green (138), Cope (142), Stock (152), Moffitt (229), and others) the static level is 75 feet or more beneath the surface. The writer believes that water-bearing gravel in the immediate vicinity of Palmer is not only very local and thin but rests on bedrock or till so that the water is perched above the level of the water table in the thicker gravel to the south. New household wells in Palmer may or may not be successful, depending upon chance location, but it is unlikely that large quantities of water can be obtained there.

Ground water in the Palmer terrace is derived not only from precipitation upon its surface but from water moving beneath the surface from the higher ground to the north and northwest.

Eska Creek-Matanuska Agricultural Experiment Station Area (Unit 5)

Unit 5 may be considered to comprise three smaller tracts (fig. 2), in each of which gravel deposits as much as 50 to 100 feet thick rest on older glacial deposits or on bedrock. This unit is conspicuously different from those already described, in which the surface is largely of ground moraine or of extensive terraces, and from the physiographic unit lying to the west, in which the surface consists of ground moraine or thin gravel deposits.

Conspicuous ridges and hills in the area between Eska and Moose Creeks and extending about 3 miles west of Moose Creek (unit 5a) are underlain by gravel. The surface is well drained. Bedrock is exposed along the Matanuska River and Moose Creek and in Wishbone Hill just north of this area. Till has been found in some wells (such as, 253, 256, 257, and 258) and probably lies near the surface over much of the tract. Little is known of the hydrologic conditions in unit 5a. Few wells have been begun and most of them have not been completed. The water stands 75 feet below the land surface in the Boulter well (253); the water is derived from what may be either a sorted layer in till or gravel beneath the till. The water level may be nearer the surface on the lower terraces along the Matanuska River, or in depressions farther from the river. Recharge of ground water in this area is from local precipitation and from runoff and underground flow down the slopes to the north, except in an area east of Moose Creek which is separated from Wishbone Hill by a deep valley and which probably receives water only from local precipitation.

Between the area just described and the Palmer-Wasilla Road the topography is irregular but more gently rolling than near Moose Creek. This part of the physiographic unit (unit 5b) is bounded on the west by an arbitrarily-chosen line which lies to the east of Finger Lake and the lakes north of it. East of this line the till is generally covered by thick gravel; to the west the till is exposed or is covered by thin gravel. The surface is commonly well drained, although some of the deeper depressions contain lakes. Many of the wells in this part of the unit pass through surficial gravel into a buried stratum of till (fig. 5 and table 2). The surficial gravel is about 20 to 100 feet thick. The underlying till is 15 to 90 feet thick; it is probably absent locally. Most wells that pass through the till obtain water from gravel beneath it; in some of these wells the water is under artesian pressure (fig. 5). Several wells on the Owen Moffitt farm (ARRC tract 132) were "dry holes" even though they penetrated the lower gravel to greater depths than successful wells nearby. This may be due to local relative impermeability of the gravel because of cementation; slight consolidation of the lower gravel has been reported in well logs (table 2). One well (305) on tract 132 obtained water after being deepened by drilling in 1951.

Well 363, drilled for the city of Palmer and completed in January 1952, yielded 118 gallons of water per minute with 35 feet of drawdown; the nonpumping level is 20 feet below the surface. This well obtains its water from sand and sandy gravel beneath the buried till. The well was finished with a 20-foot section of well screen. Similar quantities of water should be available at many other localities in this area if wells are constructed with screens; larger quantities might be available if larger pumps are used.

Some other wells in this part of the physiographic unit obtain water from the younger gravel. In most places this gravel lies upon the buried till, but in some places it is likely that gravel-filled channels indent the upper surface of the till or even that the till is discontinuous. The writer believes that the ground water in unit 5b is most reasonably considered as a single body. Most wells that pass through the till stratum obtain water under artesian pressure; many wells do not reach till, however, and these encounter water-table conditions. It seems likely that the till is absent locally, and that at such places the body of unconfined water is connected with the confined water beneath the till stratum nearby.

The local occurrence of water in windblown sand near the Matanuska bluff has already been described (p. 20).

Brazil Springs, at the bend of the Palmer-Fishook road about 3 miles northwest of Palmer, provided the Palmer water supply for many years. The water issues from gravel at the base of a small hill. It probably reaches the springs by movement down (southwest) the small valley that crosses the Henry LaRose property (near wells 314 and 315) and in which there are two small lakes (pl. 1). On the basis of the local topography and of records of wells nearby (302, 315, 317, and 318) the writer believes that the small valley may be floored by till at shallow depth but that the hills are composed of gravel. If this interpretation is correct, the springs probably mark the intersection of the water table by a slight topographic depression. Spring flow is probably about 150 to 200 gpm when the water table is at its average position; during the dry season of 1950 and in 1951 the spring flow declined so markedly that the existing pipeline was extended north to Carnegie Creek to obtain surface water.

The part of this physiographic unit described in the preceding paragraphs grades southward and southwestward into a more rolling surface having more conspicuous ridges and hills. This more rugged tract (unit 5c) extends from an arbitrarily chosen line between Palmer and Four Corners to the bluff overlooking the flats west of Matanuska. The surface is well drained. The only stream is Wasilla Creek. Lakes occupy several depressions near Matanuska. Springs along the base of the bluff near Matanuska are fed by groundwater flow from the north. One of these springs supplied the community of Matanuska (now mostly abandoned). In 1949 the Alaska Railroad obtained 8,000 to 9,000 gpd from this spring.

Hydrologic conditions in the area between Palmer and the experiment station are poorly known. The water table slopes southward. In the Blunck well (378) the water stands 119 feet below the surface. No other wells have been drilled west or southwest of this one, in this physiographic unit, except several near Wasilla Creek and near the experiment station. The Blunck well and several wells near the experiment station obtain water from gravel beneath a buried till stratum which may be the same as that found northwest of Palmer. Water in the Blunck well is not under artesian pressure; the till stratum is probably interrupted to the northwest. Artesian conditions are present in some wells west of the experiment station.

Little Susitna-Goose Bay Morainic Area (Unit 6)

The Little Susitna-Goose Bay physiographic unit is characterized by extensive areas of ground moraine separated by gravel-floored valleys. The topography shows a conspicuous southwestward trend, and drainage is toward the southwest.

Three large areas in which the surface is ground moraine are shown on plate 1. One extends from the vicinity of the experiment station and Wasilla to Goose Bay; another is north and west of Wasilla; the third lies north and west of Pittman. In each of these areas till forms the surface over extensive tracts or is mantled by thin deposits of gravel. Many small valleys and closed depressions contain somewhat thicker gravel deposits which are the most promising sources of near-surface ground water in areas of ground moraine. It is emphasized that wells in till are likely to obtain water, and in small quantities, ~~however~~ only ~~small quantities are obtainable~~ from layers of sand or gravel in the till. If gravel deposits are present nearby, shallow wells in till should not be constructed.

Five extensive areas of gravel deposits are present in this physiographic unit. Gravel-covered terraces indent the ground moraine above the bluff north of Knik Arm. The topography of the eroded surface of till beneath the gravel is irregular, and locally hills of till protrude through the gravel (pl. 1). At the bluff overlooking Knik Arm near Lucy Lake till is exposed at the land surface; in well 631, about 1 mile southwest, the gravel, as reported by R. Lathrop (personal communication, 1950), is at least 60 feet thick. Elsewhere, however, shallow wells reach till (for example, well 623, in which till is 15 feet beneath the surface), and it is likely that till is near the surface over much of the area of these terraces. Poor surface drainage on some of the terraces is probably due to the presence of till near the surface.

An extensive area of pitted gravel deposits lies northeast of Wasilla. Locally the gravel is thick (46 feet in well 470), but elsewhere the gravel is thin. The old King well (463) south of Kings Lake reached till 10 feet beneath the land surface.

Stream-laid gravel deposits border the series of lakes extending northeast of Wasilla. To the southwest these deposits merge to form a conspicuous narrow alluvial plain. Locally, as at Wasilla, the gravel is pitted. Small islands of till protrude through the gravel west of Wasilla; narrow valleys joining the alluvial plain are gravel floored. The gravel, particularly in the smaller valleys, probably is generally thin.

Another alluvial plain extends southwestward from the vicinity of Kings Lake; it merges southwest of Pittman with the alluvial plain west of Wasilla. The thickness of the gravel in these deposits is not known.

Gravel deposits associated with ground moraine north and west of Pittman have not been differentiated (pl. 1). They consist of outwash gravel in alluvial-plain deposits, pitted deposits, and thin deposits which locally mantle hills of till. Alluvial-plain gravel at the gravel pit $1\frac{1}{2}$ miles west of Pittman is 20 feet thick or more; it rests on relatively impermeable till. Elsewhere in this vicinity crevasse fillings of till which protrude through gravel show that the gravel is relatively thin (probably not thicker than about 10 to 20 feet). Gravel in some of the alluvial plains is locally openwork cobble gravel.

The gravel in all these deposits is excellent water-bearing material wherever it is saturated. Springs along the walls of the conspicuous valley 2 miles southeast of Wasilla, and on the hillside east of the mouth of Fish Creek, and probably those on the Fleckenstein property $1\frac{1}{2}$ miles southwest of Wasilla, are contact springs; they derive their water from gravel lying on till and discharge at the outcrop of the contact between the gravel and the till.

Little is known of ground water in the gravel-covered terraces north of Knik Arm. The writer believes that the gravel is thin in most localities (as in wells 622 and 623), and that the quantities of water available are small. Quantities of water sufficient for household use should be readily available in valleys on these terraces, however.

Few wells have been drilled in the pitted deposits northeast of Wasilla, but it appears that water is readily available between the lakes. Deposits beside (to the north and south of) the lakes are more likely to be underlain by till. Till was found in wells 502 and 506, beside Wasilla Lake.

Wasilla, situated on gravel deposits between Wasilla Lake and Lake Lucile, undoubtedly has large available supplies of ground water. Till is known to be present as a thin layer beneath part of the community (p. 18). Till found in the Bergman well (531) may be a part of this layer or of a thicker body. Because the till beneath Wasilla may be part of a thin layer, it may reasonably be excavated for a depth of several feet in the hope that the underlying gravel will be reached. However, this is not true on the hills north and south of Wasilla (and north and south of the lakes to the east and west); under these hills the till is probably much thicker.

Ground water should be readily available almost anywhere in the alluvial-plain deposits west and north of Wasilla. The quantity of water available is limited, however, where till is near the surface (that is, where the saturated gravel is thin). Where till does not crop out, poor drainage of gravel deposits may be a sign of its presence not far beneath the surface.

North and west of Pittman even the most extensive gravel deposits appear to be thin. Water should be readily available to these deposits, however, even in closed depressions, for the surrounding higher ground is underlain by relatively impermeable till. Household or farm water supplies are probably available from gravel in many of the shallow basins in this part of the area, but larger quantities of water will be more difficult to obtain.

The occurrence of ground water in gravel beneath a stratum of buried till, near Palmer and near the experiment station, has been described in preceding pages. The writer believes that the buried till in these localities and the till at or near the surface west of Wasilla are the same. About 3 miles east of Wasilla and 2 to 3 miles west and northwest of the experiment station, four wells (490, 491, 577, and 578) obtain water from gravel beneath till. In well 490 the water stands 45 feet above the base of the till, and 100 feet in well 578.

The presence of water-bearing gravel beneath till in three areas suggests that the older gravel underlies the till in much of the agricultural area west of the Matanuska River and east of Wasilla. Undoubtedly the till is interrupted locally. Geologic evidence suggests that this same till is at or near the surface over the greater part of the agricultural area west of Wasilla. At Goose Bay this till lies upon older gravel. The writer believes it likely that the older gravel underlies the till elsewhere in the area west of Wasilla. If the gravel is so extensive, it may offer the possibility of the development of larger ground-water supplies than are probably available from surface gravel west of Wasilla.

QUALITY OF WATER

Water containing less than 500 parts per million (ppm) of dissolved solids is generally satisfactory for domestic use unless it is exceptionally hard or contains objectionable amounts of iron. Hardness in excess of 150 ppm is noticeable in ordinary use and may cause the formation of scales in boilers and heating units.

Chemical analyses of water samples (table 3) suggest that ground water in the agricultural area generally contains less than 300 ppm of dissolved solids. The hardness is generally 100 to 200 ppm and is due largely to calcium and magnesium bicarbonate. Water from well 145, which is seated on bedrock, is very hard (490 ppm) and has a relatively high content of dissolved solids (652 ppm). Water from wells that penetrate bedrock (wells 70 and 123) also has a higher mineral content than water from most wells in unconsolidated sediments. Well 494, which is in gravel, obtains hard water having a relatively high content of dissolved solids (638 ppm). The reason for the high mineral content of this water is not evident. Chemical softening of this water has been necessary for satisfactory household use (Richards, Harold, personal communication, 1950). The iron in water from well 462 makes this water objectionable for household consumption or use by livestock. The iron content of water from several other wells (123, 60, and 347) is sufficient to cause staining of clothing laundered in it.

Most of the water samples listed are chemically suitable for human consumption. The nitrate content, a possible indicator of organic pollution, is high in water from some wells (2, 494, 123, 145, 347, and 502). All but one (494) of the samples of high-nitrate water are from shallow dug wells, which are particularly susceptible to pollution.

Water of the chemical character of any of these samples would be satisfactory chemically for use in irrigation.

Water from gravel beneath the buried till northwest of Palmer does not seem to differ significantly from water from wells that obtain their water above the till (compare analyses of water from wells 363 and ~~382~~). 315 The till layer is probably discontinuous locally, so that water above and beneath it is in a single ground-water body.

Water in small perched bodies in windblown sand (well 275) is less concentrated in most constituents than other ground-water samples analyzed. This may be due to the recharge of these ground-water bodies from local precipitation; the water has not traveled long distances through the sediments, as ground water represented by many other samples probably has. Furthermore, the windblown sand probably is thoroughly leached and contains little soluble material. It is likely also that the water in the small perched bodies is continually renewed by rainfall, and discharged by plants and by leakage through the floors of the small basins, so that the water does not remain long in the sediments.

During the early days of the agricultural colony several wells were drilled that obtained highly mineralized water. There is listed in the files of the Alaska Rural Rehabilitation Corp. an abandoned well in Palmer that obtained "sulphur water" in bedrock at a depth of 121 feet. Salt water was found in the old slaughterhouse (144) and hospital (135) wells and in two other wells. According to reports, analysis of water from the hospital well showed a carbonate hardness of 4,300 ppm, a chloride content of 3,520 ppm, and a pH of 6.0. The writer believes that this salt water is old and unrelated to that in Knik Arm (p. 23).

Water-Level Fluctuations

Reports of well owners indicate that the fluctuation of ground-water levels between wet and dry seasons is as much as several feet. Seasonal fluctuations, the water levels being lower in winter and early spring, have also been reported in several wells. Since 1949 the Geological Survey has carried on periodic observation of selected wells.

Climatologic data for 1949 are incomplete but available information indicates that 1949 was an average year in precipitation. The year 1950 was abnormally dry; 1951 probably approached the average. Because the ground is usually frozen during the melting of most or all of the snow in this area, and because wind usually removes much of the snow cover, recharge of ground water seems to be chiefly from rainfall.

Table 3.--Analyses of ground water from the Matanuska Valley agricultural area, Alaska
[Results expressed in parts per million]

	Well no. and Alaska laboratory no.									
	70	123	145	38	60	101	187	315	347	363
	306	157	215	158	309	20252/	213	155	20242/	1071
Silica(SiO_2)	19	16	16	8.2	9.1	10	7.0	13	14	13
Total iron(Fe)	.03	.06	.02	.02	.06	.08	.02	.02	.05	.04
Calcium(Ca)		75	147	51		76	41	46	55	37
Magnesium(Mg)		20	30	5.6		9.4	4.6	5.9	20	9.4
Sodium(Na) and Potassium(K)		34	33	5.5		9.2	5.5	2.5	11	5.7
Bicarbonate(HCO_3)	194	266	371	143	168	236	102	160	172	159
Sulfate(SO_4)	120	35	73	36	27	38	40	8.7	58	9.6
Chloride(Cl)	4	42	74	4.5	8	4.8	5.0	1.8	3	1.8
Fluoride(F)	.2	.1	.0	.1	.0	.1	.0	.1		.0
Nitrate(NO_3)	.3	35	96	.8	2.7	9.4	1.6	2.3	46	.2
Dissolved solids	...	388	652	182	...	273	155	159	292	155
Hardness as $CaCO_3$	244	269	490	150	162	228	122	140	219	131
pH	8.0	6.8	6.8	7.7	7.9	...	7.0	7.3	...	7.6
Date of collection	7-13-50	8-26-49	8-30-49	8-27-49	6-15-50	10-4-48	8-29-49	8-22-49	Oct.1948	1-31-52

	462	494	2	502	522	660	75	Brazil Spring	Spring Dinkle1/
	159	153	217	151	216	324	1060	2023 2,3/	2143/
Silica(SiO_2)	23	26	20	21	15	28	15	16	18
Total iron(Fe)	7.2	.02	.02	.03	.02	1.5	.02	.05	.02
Calcium(Ca)	...	178	29	45	27		14	46	18
Magnesium(Mg)	...	21	7.6	10	5.1	2.5	3.5	5.5	
Sodium(Na) and Potassium(K)	3.4	15	3.9	18	5.5		3.2	7.8	1.6
Bicarbonate(HCO_3)	128	471	91	135	94	145	55	162	76
Sulfate(SO_4)	2.6	20	6.1	12	7.6	1	5.9	8.2	3.8
Chloride(Cl)	7.0	65	8.0	21	5.2	2	.8	3	2.0
Fluoride(F)	.1	.0	.0	.0	.0	.0	...	...	.2
Nitrate(NO_3)	.6	81	24	51	9.9	1.1	.8	1.6	1.3
Dissolved solids	...	638	143	245	122	...	69	166	88
Hardness(as $CaCO_3$)	111	530	104	154	88	188	45	130	68
pH	7.7	7.0	6.9	6.8	7.8	8.0	6.9	...	6.5
Date of collection	8-14-49	8-22-49	8-29-49	7-27-49	8-31-49	6-28-50	11-16-51	Oct.1948	8-22-49

1/ 2-1/2 miles southeast of Wasilla.
2/ Salt Lake City laboratory number.
3/ Spring.

Table 4.--Data from mechanical analysis of sediments from the Matanuska Valley agricultural area

[Expressed in percent by weight]

Type sediment	Sample	4-2 mm	2-1 mm	1-½ mm	½-¼ mm	¼-1/8 mm	Finer than 1/8 mm	1/8-1/16 mm	Finer than 1/16 mm	1/16-1/256 mm	Finer than 1/256 mm	Locality
Till	2A		3	3	6	10		9		66	3	Matanuska bluff about 1 mile north of Palmer.
Do	2I		4	6	12	20		18		38	2	Road cut, Hornung farm, about one-half mile southwest of experiment station.
Sand (layer in till)	S40			2	59	30		6	3			East bluff of Matanuska River about one-half mile north of Matanuska River highway bridge.
Do	S39			3	9	71		11	6			Do.
Fine fraction of gravel.	S27		29	34	24	7		3	3			Road cut three-fifths mile east of Wasilla.
Outwash sand	S1		1	2	37	45		5	10			Modern flood plain at Matanuska River highway bridge.
Do	S5		2	31	57	9	1					Gravel pit at north edge of Wasilla
Do	S18		2	7	6	12		31	42			Road cut about 3-1/3 miles west of Four Corners.
Outwash silt	2F				1	6		10		80	3	Modern flood plain at Matanuska River highway bridge.
Dune sand.	S2	2	5	15	31	33		7	7			Dune on Matanuska bluff about 2 miles north of Palmer.
Loess.	O					6		40		52	2	Road cut on Eckert Farm, at northwest edge of Palmer.

Figure 6 shows graphically the water-level fluctuations observed in four wells. Each well shows a marked decline in water level during 1950, interpreted as reflecting lack of recharge from rainfall. Water-level recovery is most complete in the Woods well; this well is on the extensive terrace south of Palmer, where the water table is controlled by the Matanuska River. Data for the Linn well, and possibly for the Tryck well, suggest slight recovery during the late spring of 1950 before further decline. Each well shows partial recovery during the summer of 1951. The LaRose well, which is on a hillside, shows the greatest decline and the most sluggish recovery. The Tryck well is on a hillside northeast of Lake Lucile. The Linn well is on a hill but the ground-water level is probably controlled by the water table beneath the alluvial flat west of Matanuska; hence the water-level fluctuation in the Linn well, like that in the Woods well, is relatively slight.

If recovery of ground-water levels continues during 1952, the declines shown by figure 6 probably may be taken as representative of those to be expected after an unusually dry year.

The rapid decline and slow recovery of ground-water levels, as shown by these data, suggest that annual additions to the ground-water body represent only a small proportion of the annual precipitation received in the agricultural area.

Construction of Wells

Dug wells

Most of the wells constructed by individuals in the Matanuska Valley agricultural area are hand-dug wells. They are generally less than 50 feet deep but a few are much deeper. The Collier well (272) is 105 feet deep, and the Owen Moffitt well (305) was 95 feet deep before it was deepened by drilling. Commonly dug wells in this area are square or rectangular, and 3 to 4 feet on a side.

The walls of wells in till stand after excavation, but in most places gravel must be supported during the digging. Pea gravel is particularly difficult to excavate because walls in it commonly slump before they can be supported. Wood cribbing is most commonly used to line dug wells. Poles or rough boards have been used, extending vertically and fastened to cross supports, but they are difficult to put in place and to support satisfactorily. More generally short notched logs or 2- by 6-inch boards are used; the notched sections are added to the bottom of the cribbing, parallel to the bottom of the hole, as digging proceeds. Several types of wood have been found satisfactory for well cribbing; spruce is considered excellent, but cottonwood is said (Wilson, T., personal communication, 1949) to give the water a taste of organic decomposition. Other materials that have been used for lining dug wells include concrete blocks, poured concrete, concrete pipe, and metal oil barrels. Attempts to add pipe or barrels at the top and follow the digging with the lining have generally been unsuccessful in this area, so that linings of pipe or barrels, as well as those of blocks or poured concrete, must be constructed from the bottom up. In gravel wood cribbing must be used and later removed from the bottom as the permanent lining is constructed. These other types of lining are more permanent than wood and, if properly constructed, more sanitary. They do not, however, permit much inflow of water from water-bearing layers higher than the bottom of the well, as may be desirable in wells dug in till.

Although dug wells are less satisfactory than drilled wells for many reasons, their lesser cost and the fact that they can be constructed by individuals account for the large number of dug wells. Dug wells generally can be constructed only a few feet deeper than the water table, and some wells dug during seasons of high water table have gone dry during drier seasons. Some of these wells have been deepened by additional digging or by drilling.

For sanitary reasons, few of the dug wells in this area are satisfactory. Many are close to barns or privies; the wood cribbing does not prevent entrance of near-surface water into the wells; and few are adequately sealed at the surface.

Driven Wells

Conditions suitable for the construction of driven wells seldom persist to sufficient depth in this area to permit wells of this type to reach water. The Clay Johnson (35) and Rocca (650) wells obtain water from clean sand at depths less than 20 feet. The presence of gravel or till at or near the land surface in most of the agricultural area makes the success of driven wells unlikely.

Drilled Wells

Since establishment of the agricultural colony most of the wells constructed, including all but a few of those deeper than 50 feet, have been drilled. For many years the Alaska Rural Rehabilitation Corp. operated a cable-tool drilling machine; more recently this machine has been purchased and operated by private drillers. Several other private drillers have been active in this area in recent years.

Most of the wells drilled in this area are lined with 4-inch steel casing; a few are 6-inch wells, relined with 4-inch casing which extends to greater depth. In all but a few of the drilled wells water passes into the casing through the open lower end and through ¼- to ½-inch slots cut longitudinally in the lower few feet of the casing. In only one well in this area has a screen been employed. Open-end and slotted casing has proved satisfactory in most wells supplying water for home or farm use, but it is unlikely that any of these wells has been pumped at a rate exceeding 10 gpm, or that many have been pumped continuously at any rate for periods longer than a few hours. Exceptions are wells 37, 57, and 363 (see well records).

Thick sand was penetrated in a few wells. Quicksand was penetrated between depths of 47 and 185 feet in the Hosler well (213), and difficulty was experienced in drilling. It was necessary to drill the well to a depth of 187 feet to reach gravel which could be developed with the open-end casing, but the water level in the completed well stood at 47 feet.

Of the several types of drilling machines the cable-tool is the one best suited to conditions in this area. Cobbles and occasional boulders are found in both gravel and till. The tough silty matrix of till and the coarse cobbles and boulders of all deposits yield best to cutting and crushing by a heavy drill bit. Because of its greater weight, a 6-inch string of tools is more satisfactory than a smaller one.

The availability of electric power on farms in this district has resulted in the widespread use of electric pumps. Lift is by jet pump in nearly half the wells; small centrifugal pumps are used in a few wells. Lift-type hand pumps are still widely employed, although many are equipped with motor and pump jack. In only a small proportion of the wells is the lift by bucket and windlass. The electric pumps in use are equipped with motors in the $\frac{1}{4}$- to $1\frac{1}{2}$-horsepower range; at the levels for which these pumps are used the pumping rates are generally less than 10 gpm. Most of the electrically driven pumps are connected with pressure systems and are in-

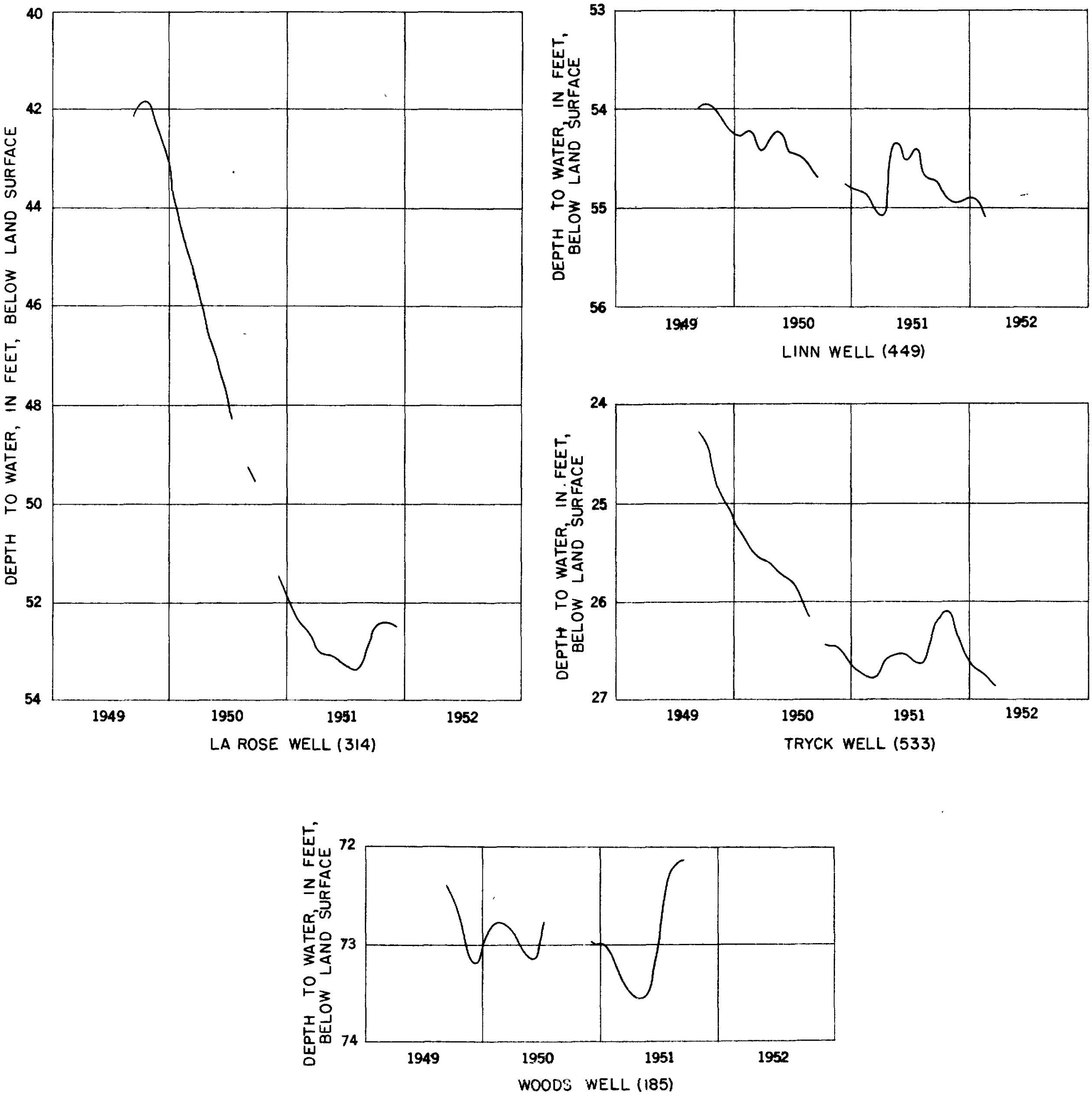

Figure 6. Graphs showing water-level fluctuations in wells.

stalled in cellars, in pump houses, or in covered pits above the wells. Water pipes leading from wells to buildings or passing between buildings in this region must be buried 7 to 8 feet beneath the surface, below the depth of winter freezing.

Utilization of Ground Water

Public Supply

Palmer is the only community in the Matanuska Valley agricultural area in which residents do not generally use individual wells. Initial drilling in the town site during establishment of the agricultural colony was most unsuccessful. For many years the Matanuska Valley Farmers Cooperating Association supplied water to its creamery and other establishments by means of a 22,000-foot conduit of wooden-stave pipe from Brazil Springs, about 3 miles northwest of Palmer. Excess water was sold to the residents of Palmer at monthly rates. After the dry season of 1950, the spring flow was insufficient to meet needs. In 1951 the existing pipeline was extended, and water is now obtained from Carnegie Creek about a mile northwest of the springs.

A test well (363) was completed for the city of Palmer in January 1952.

A community well (515) was dug in Wasilla several years ago, but it is not in use. At present individual wells supply water for all inhabitants.

Domestic and Farm Supplies

During most seasons individual wells are capable of providing sufficient water for domestic and farm use throughout most of the agricultural area. Many farmhouses have plumbing and pressure water systems, and the water use includes supplying livestock and cooling milk. Well water is used for watering gardens on a very small scale.

CONSTRUCTION MATERIALS

Sand and Gravel

The wide distribution of deposits of sand and gravel in the agricultural area facilitates construction of roads. Pit-run gravel is used for fill in the initial construction of all types of roads, and in finishing and repair of secondary roads. For construction of paved highways during 1950, screened gravel was used in part, and crushed gravel was used in the hard-surfacing.

Sand and gravel are used locally in making concrete. A local plant makes most of the concrete blocks used in the agricultural area.

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RECORDS OF WELLS

Table 5.—Records of wells in the Matanuska Valley agricultural area, Alaska

[Location of wells is shown on plate 1]

Type of well: B, bored with soil auger; D, dug; Dn, driven; Dr, drilled; J, jetted.
Depth of well: Depths of wells and of water levels recorded to the nearest foot are reported values; depths to nearest tenth or hundredth of a foot are measured.

Method of lift: Power: E, electric motor; G, gasoline motor, H, hand.
Pump: C, centrifugal; J, jet; L, lift; P, pitcher; W, windlass.
Use of water: D, domestic; N, not in use; O, observation well; S, stock (may include cooling milk).

Well no.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
	T. 18 N., R. 2 E.														
1	NW¼ sec. 23	Robert Stewart	Owner	1949	Terrace	590	D	22	36	. . .	. . .	. . . .	EJ	D	Gravel 10 ft thick, resting on till; water probably from gravel; well dry 1950–51.
2	SE¼ sec. 23	Lazy Mountain Childrens Home	Kenneth Hughes	. .	Gentle hill slope	721	D	11		Till ("hardpan")	. . .	. . . .	EJ	. .	Water seeps from loose till near land surface; 150 gpd used, 1949.
3	Do.	do.	do.	1950	do.	721	D	30		do.	. . .	. . . .	EJ	. .	Low yield; supply augmented by surface water.
4	SW¼ sec. 23	USGS test well 3	USGS	1950	Hillside above stream	584	J	26.5	4	do.	3.8	Aug. 8, 1950		N	Water from sand and gravel, 22 to 26 ft in till; pumped ½ gpm, 3 hrs, drawdown 19 ft.
5	SE¼ sec. 22	Paul Beechik	A. Moffitt	1951	Gentle hill slope		Dr	55	4	do.	. . .	. . . .	. .	. .	Thin water-bearing sandy layers at 16, 43, and 54 ft below surface; insufficient supply; not completed.
6	NW¼ sec. 26	John Nash	Owner	. .	do.	748	D	24	42	do.	7 20	Spring 1949 Sept. 1950	EJ	D,S	1-foot sand layer in till yields 100 gpd.
15	NE¼ sec. 34	Ray Ferrin	do.	1951	Base of hill	. .	D	11	36	do.	10.5	Aug. 6, 1951	EJ	D	Water from sand layer in till. Measuring point (MP) top of wood cribbing, 5 ft below land surface.
20	NW¼ sec. 35	Horace DuFour	do.	. .	Valley	260	D	6	. .	Gravel	0	July 9, 1949	N	D,S	
21	SE¼ sec. 35	M. Kopperud	George Venne	. .	Base of hill	. .	D	9	. .	do.	. . .	. . . .	HL	D	
22	SE¼ sec. 35	George Venne	do.	. .	Hillside	. .	D	. .	. .	Till	. . .	. . . .	HL	D	Soil, 0 to 1½ ft; till, 1½ to 22 ft; gravel, 22 to 23 ft; bedrock at 23 ft. Water in gravel at base of till.
	T. 17 N., R. 2 E.														
24	NE¼ sec. 2	M. B. Martin	. . . . .	. .	Terrace	176	D	28.0	42	Gravel	21.5	July 13, 1949	HW	D	
25	NE¼ sec. 2	A. Brager	Former owner	1950	do.	183	D	27.0	30	do.	24.46	Aug. 28, 1950	HW	D	MP top of wood cribbing, 3.10 ft above land surface.
26	Do.	L. W. Bixby	Ferber Bailey	1951	do.	163	D	22	48	do.	19	Nov. 1951	. .	D	
27	SE¼ sec. 2	F. R. Sims	T. Moffitt	1949	do.	160	Dr	17	4	do.	8.7	July 13, 1949	EJ	D	
28	Do.	H. Mackie	do.	1949	do.	163	Dr	17	4	do.	10	Apr. 1949	HP	D	
29	Do.	Mrs. M. Hosler	. . . . .	1950	do.	156	D	17	36	do.	14	May 1950	EJ	D	Greenhouse.
30	NE¼ sec. 11	James Childers	Owner	. .	Base of terrace	151	D	7	. .	do.	4	1949	. .	N	
31	Do.	do.	. . . . .	1948	Terrace	163	Dr	28	4	do.	. . .	. . . .	EC	D	Deepened from 24 ft after going dry in April 1949.
35	SE¼ sec. 11	Clay Johnson	Owner	1949	do.	143	Dn	18	1½	Sand	10	. . . .	HP	D,S	Screened drive point.
37	NE¼ sec. 14	USGS test well 1	USGS	1950	do.	124	J	31	3	Gravel	2.03	Aug. 8, 1950	. .	N	Yielded 44 gpm with 5.6 ft of drawdown after 4½ hrs.
38	SE¼ sec. 14	Clyde King, Jr.	Owner	. .	do.	113	D	12	36	do.	10	1949	EJ	D	
39	Do.	Clyde King	do.	1950	do.	115	D	18.2	48	do.	17.1	June 13, 1950	EJ	D	
42	NE¼ sec. 23	Wallace Brown	do.	1950	do.	107	D, Dn	38	. .	do.	30	May 1950	HL	D	Dug to 28 ft; dry in 1951; probably perched ground water.
43	Do.	John Rippy	do.	1950	do.	105	D	31	24	do.	27.42	Aug. 18, 1951	HW	D	Probably perched ground water.
44	SE¼ sec. 23	C. L. Bastian	Ferber Bailey	1951	do.	102	D	38	48	do.	35	Spring 1951	. .	. .	Do.
45	NW¼ SE¼ sec. 23	H. H. Kirk	A. and J. D. Frey	1951	do.	100	Dr	68	4	do.	58	1951	. .	D	

	T. 17 N., R. 2 E.														
46	NW¼ SE¼ sec. 23	H. H. Kirk	A. and J. D. Frey	1951	Terrace	. .	Dr	63	4	Gravel	56		1951	HL	D	
47	SE¼ sec. 23	Peter Gallager	do.	1951	do.	. .	Dr	59	4	do.	53	Sept. 1951	. .	D	Driller reports several perched water bodies as much as 3 ft thick; one is 34 ft beneath surface.
50	SE¼ SE¼ sec. 23	W. B. Barnhardt	do.	1951	do.	. .	Dr	58	4	do.	52	1951	. .	D	
53	NE¼ sec. 26	"The Butte"	Ferber Bailey	1951	do.	. .	D	57	48	do.	54	1951	. .	D	Roadhouse.
56	SE¼ NE¼ sec. 26	J. D. Frey	A. and J. D. Frey	1951	do.	85	Dr	53	4	do.	43	1951	. .	D	
57	NE¼ SE¼ sec. 26	USGS test well 2	USGS	1950	do.	83	J	52.0	4	do.	37.0	Aug. 1950	. .	O	
	T. 16 N., R. 2 E.														
59	NE¼ sec. 2	Thomas Lepak	....	. .	do.	61	D	22.0	30	do.	17.20	June 15, 1950	H	D	MP top of wood cribbing, 2.20 ft above land surface.
60	Do.	Russell Dow	Owner	. .	do.	55	D	17.0	42	do.	11.64	July 26, 1950	H	D	MP top of wood cribbing, 1.5 ft above land surface.
	T. 17 N., R. 2 E.														
70	SW¼ sec. 14	Victor Falk, Jr.	Alaska Rural Rehabilitation Corp. (ARRC)	1936	Hillside	152	Dr	110	6	Bedrock	62(?)	June 1936	HL	D,S	
72	NW¼ sec. 23	Charles Weidner	A. and J. D. Frey	1951	Terrace	. .	Dr	47	4	Gravel	38	1951	. .	D	
75	SW¼ SE¼ sec. 15	Victor Falk	ARRC	1936	do.	156	Dr	80	4	do.	30 35	May 1936 June 1948	EJ	D,S	Has watered as many as 50 cows.
76	SW¼ NE¼ sec. 22	Darrell Frank	do.	. .	do.	136	Dr	44	4	do.	34	....	EJ	D,S	
78	SW¼ sec. 22	Arthur Holbrook	do.	. .	do.	129	D	32	42	do.	29	1947	EJ	D,S	Estimated use, about 400 gpd.
80	SW¼ SW¼ sec. 22	Lee McKinley	do.	. .	do.	108	Dr	52	4	do.	38.2	Aug. 18, 1949		D	
81	NW¼ NW¼ sec. 27	E. Winsok	do.	. .	do.	102	Dr	55	4	do.	. . .	....	EJ	D	Well formerly used for construction camp.
82	SE¼ NW¼ sec. 27	Mrs. G. Dreghorn	do.	. .	do.	97	Dr	56	4	do.	. . .	....	. .	N	
83	Do.	do.	....	. .	On terrace scarp	79	D	40	. .	do.	35	....	EJ	D	
84	SW¼ NW¼ sec. 27	do.	ARRC	. .	Terrace	58	Dr	24	4	do.	22	....	HL	S	
85	NE¼ SW¼ sec. 27	do.	do.	. .	do.	54	Dr	18.5	4	do.	11.58	Aug. 27, 1949	. .	N	MP well-house floor, 1 ft above land surface.
86	Do.	Joseph Lentz	do.	. .	do.	54	Dr	26	4	do.	12	....	EJ	D,S	
88	NW¼ NW¼ sec. 34	Harry Kendrick	do.	. .	do.	54	Dr	22	4	do.	21	....	HL	D,S	
90	SW¼ NW¼ sec. 34	V. K. Moonier	T. Moffitt	1949	do.	51	Dr	22	4	do.	20	1949	EJ	D	
91	NW¼ SW¼ sec. 34	W. B. Barnhardt	ARRC	. .	do.	51	Dr	22	4	do.	16	....	HL	D	
94	NW¼ NE¼ sec. 34	Olaf Nelson	do.	. .	do.	64	Dr	22	4	do.	20	....	EJ	D,S	
95	NE¼ NE¼ sec. 34	William Casler	do.	. .	do.	64	Dr	30	4	do.	21	....	EL	D,S	
96	SE¼ SE¼ sec. 27	Donald Parks	do.	. .	do.	67	Dr	33	4	do.	24	....	EJ	D,S	Formerly watered 1,000 sheep.
97	SW¼ SE¼ sec. 27	Alfred Church	do.	. .	do.	75	Dr	35	4	do.	. . .	....	EJ	D,S	
99	SW¼ NE¼ sec. 27	Laurin Smith	do.	. .	do.	74	Dr	34	4	do.	. . .	....	EL	D,S	
101	SW¼ NW¼ sec. 26	James Hurley	do.	. .	do.	83	Dr	48	4	do.	. . .	....	EJ	D	
103	NE¼ NE¼ sec. 27	Paul Nelson	do.	. .	do.	85	Dr	111	4	do.	50	....	EJ	D,S	Well on adjoining 40-acre tract to west not in use, reached water at 36 to 41 ft.
104	NW¼ NW¼ sec. 26	I. M. Sandvik	do.	. .	do.	85	Dr	112	4	do.	45	....	EJ	D,S	Originally 47 ft deep; deepened to increase yield.
	T. 18 N., R. 2 E.														
120	SE¼ NW¼ sec. 33	A. Gregerson	Owner	. .	do.	260	D	23	6	Bedrock(?)	. . .	....	HL	N	Bedrock below 17 ft; casing gravel-packed; formerly yielded 75 gpd.
121	Do.	E. Useok	do.	. .	do.	256	D	31	42	Sand	30	....	. .	N	
122	SW¼ NW¼ sec. 33	J. L. Allman	do.	. .	do.	259	D	27	42	Gravel	24	Aug. 1948	HL	D	Till below 25 ft.
123	Do.	Parker Lester	A. Moffitt	1949	do.	258	D	37	48	Bedrock(?)	. . .	....	EJ	N	Soil, sand, and gravel, 0 to 19 ft; till, 19 to 28 ft; bedrock, 28 to 37 ft; very slow recovery after pumping.
126	NW¼ SW¼ sec. 33	Earl Johnson	.....	. .	do.	257	D	21	36	....	20	....	EJ	D	
127	NE¼ SE¼ sec. 32	D. Sullivan	John Bugge	. .	do.	254	D	35	36	Gravel	33	July 1949	HL	D	
128	SE¼ SE¼ sec. 32	John Bugge	Owner	1915	do.	240	D	30	36	do.	29	....	HL	D	Bedrock encountered at 30 ft; well formerly supplied 40 people.
130	NW¼ SW¼ sec. 33	James Felton	do.	. .	do.	250	D	28	. .	do.	26	....	HL	N	
134	SE¼ SW¼ sec. 33	Civic Center Power House	ARRC	. .	do.	238	Dr	95	4	Sand	. .	....	. .	N	Soil; gravel 0 to 53(?) ft; till(?) 53 to 82 ft; sand, 82 to 95 ft; reported hardness, 55 ppm; chloride, 26 ppm.
135	Do.	Civic Center Hospital	do.	. .	do.	235	Dr	155	4	. . .	. .	....	. .	. .	Log suggests till(?) or bedrock(?) below 34 ft; reported hardness, 4,300 ppm; chloride, 3,520 ppm. pH, 6.0.

Table 5.—Records of wells in the Matanuska Valley agricultural area, Alaska—Continued

Well no.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
	T. 17 N., R. 2 E.														
136	SE¼ NE¼ sec. 5	Roy Knapp	ARRC	. .	Terrace	230	Dr	47	4	Bedrock(?)	. . .	. . . .	. .	D	Gravel resting on bedrock at about 10 ft.
138	NE¼ sec. 4	L. Green	Owner	1949	do.	. .	D	76	42	Sand	74	1949	HL	D	
139	Do.	Lloyd Hill	T. Moffitt	. .	do.	. .	D, Dr	72	4	do.	70 64	1949 1950	EJ	D	Originally dug by owner to 52 ft.
142	NE¼ SW¼ sec. 4	John Cope	ARRC	1936	do.	223	Dr	300	4	Bedrock(?)	75	. . . .	. .	N	Till, 90 to 112(?) ft; bedrock below 112 ft.
143	NW¼ SW¼ sec. 4	E. J. LeDuc	do.	. .	do.	223	Dr	97	4	Gravel	. . .	. . . .	. .	N	Casing pulled.
144	NW¼ sec. 4	Slaughter House	do.	1936	do.	225	Dr	590	4	Bedrock	. . .	. . . .	. .	N	Soil; gravel, 0 to 18 ft; shale 18 to 80 ft; limestone, 80 to 590 ft; salt water at 569 ft; well plugged.
145	SE¼ sec. 5	Harold Thuma	Owner	1934	do.	222	D	24	42	Gravel	22	1949	EJ	D, S	Bedrock, at 24 ft; southeastward movement of water observed in well.
148	SE¼ SW¼ sec. 4	William Fogg	ARRC	1936	do.	208	Dr	113	4	do.	107	1936	EL	D	
149	SW¼ SW¼ sec. 4	John Cope	do.	1936	do.	208	Dr	114	4	do.	102	1936	. .	N	Capped.
150	NW¼ NW¼ sec. 9	Merle Anderson	. . . . . .	. .	do.	200	Dr	106	4	. . .	100	. . . .	EJ	D, S	
152	NE¼ NW¼ sec. 9	L. C. Stook	J. Currie	1950	do.	208	Dr	109	6	Gravel	99	Aug. 1950	EJ	D	
153	SE¼ sec. 4	Harold Thuma	. . . . . .	. .	do.	212	D	105	. .	. . .	103	. . . .	HL	N	
154	NE¼ NE¼ sec. 9	R. P. Mohan	ARRC	1936	do.	214	Dr	123	6	Gravel	. . .	. . . .	EL	D, S	
155	NW¼ NE¼ sec. 10	J. J. Tully	Owner	. .	do.	. .	D	86	48	do.	. . .	. . . .	HW	N	Dry in 1949.
156	NE¼ NW¼ sec. 10	E. LeWalters	ARRC	1936	do.	199	Dr	85	4	do.	. . .	. . . .	EJ	D	
157	SW¼ NW¼ sec. 10	L. M. DePriest	do.	1935	do.	202	Dr	106	4	do.	87	1935	EJ	D, S	
160	NW¼ SW¼ sec. 10	H. S. Bauer	do.	1935	do.	196	Dr	175	4	do.	79	Aug. 22, 1949	EL	D, S	MP top of casing, 2 ft above land surface; clay reported at 68 to 78 ft, may be till.
161	Do.	do.	do.	. .	do.	196	Dr	200	4	. . .	. . .	. . . .	. .	N	
162	SE¼ SW¼ sec. 10	K. T. Foster	do.	. .	do.	189	Dr	76	4	do.	72	. . . .	EL	D	Well nearby on same property was in sand from 70 ft to total depth of 147 ft.
165	NE¼NW¼ sec. 15	Paul Martin	do.	. .	do.	. .	Dr	77	6, 4	do.	. . .	. . . .	. .	. .	6-inch casing to 33 ft.
170	SE¼ NE¼ sec. 16	Clifford Grover	do.	1936	do.	150	Dr	63	4	do.	56	Jan. 2, 1936	EJ	D, S	
171	NW¼ NE¼ sec. 16	E. H. Harrington	do.	1936	do.	. .	Dr	81	4	do.	75	June 30, 1936	EJ	D, S	
172	NE¼ NW¼ sec. 16	A. Brooks	do.	. .	do.	. .	Dr	72	6	do.	62	. . . .	EL	D, S	Also reported to be 95 ft deep.
175	NW¼ SE¼ sec. 9	Carl Rasmussen	do.	. .	do.	200	Dr	84	4	. . .	78	Aug. 1949	. .	D, S	
176	NE¼ SW¼ sec. 9	Clem Watkinson	do.	. .	do.	197	Dr	113	4	Gravel	70	. . . .	. .	D, S	
180	NW¼ SW¼ sec. 9	A. C. Erickson	do.	. .	do.	184	Dr	95	4	do.	81	May 1949	EJ	D	
182	NW¼ SE¼ sec. 8	Ray Rebarchek	do.	. .	do.	190	Dr	89	6, 4	Sand, gravel	84	. . . .	EJ	D, S	Well a few hundred feet away, not completed, reported to have struck water at 37 ft.
185	SW¼ SW¼ sec. 9	G. M. Woods	do.	. .	do.	179	Dr	83	4	do.	72.44	Aug. 30, 1949	. .	O	MP top of casing, 0.50 ft above land surface; temperature, Nov. 23, 1951, 39°F.
186	NE¼ NE¼ sec. 17	do.	do.	1936	do.	177	Dr	75	4	do.	. . .	. . . .	EL	D, S	
187	NW¼ NW¼ sec. 16	C. O. Huntley	do.	. .	do.	177	Dr	72	6, 4	Gravel	. . .	. . . .	EL	D, S	6-inch casing to 40 ft.
188	SW¼ SE¼ sec. 8	William Bowens	do.	. .	do.	180	Dr	78	4	do.	72	. . . .	EL	D, S	
189	NW¼ NE¼ sec. 17	A. A. Rempel	do.	. .	do.	185	Dr	85	6, 4	Sand	. . .	. . . .	. .	D, S	6-inch casing to 42 ft.
190	NE¼ NW¼ sec. 17	Roy Brook	do.	1936	do.	. .	Dr	74	4	Gravel	71	Jan. 23, 1936	. .	D, S	
191	SW¼ SW¼ sec. 8	William Hoskins	. . . . . .	. .	do.	. .	Dr	70	4	do.	60	. . . .	HL	D	
198	SW¼ NW¼ sec. 16	Chester Liebing	ARRC	1935	do.	158	Dr	63	4	do.	57	Dec. 15, 1935	. .	D, S	
199	SE¼ NE¼ sec. 17	C. F. Liebing	do.	. .	do.	154	Dr	82	4	Sand	56	. . . .	HL	D, S	
201	NE¼ SE¼ sec. 17	Joseph Loyer	do.	1935	do.	151	Dr	62	4	Gravel	52	. . . .	EJ	D	
202	NW¼ SE¼ sec. 17	Irvin Plitt	do.	. .	do.	146	Dr	61	4	Silty gravel	. . .	. . . .	. .	D	
203	NW¼ SE¼ sec. 17	William Rempel	T. Moffitt	1950	do.	141	Dr	60	4	Sand	. . .	. . . .	EJ	D	
208	NW¼ NW¼ sec. 20	William Smith	ARRC	1936	do.	124	D, Dr	55	4	Gravel	52	1949	EL	D, S	
209	NE¼ NE¼ sec. 19	Woodward Bros.	do.	. .	do.	124	Dr	45	4	Sand	39	Oct. 15, 1946	EJ	D, S	

	T. 17 N., R. 2 E.														
210	SW¼ SW¼ sec. 17	R. R. Webb	ARRC	1936	Terrace	128	D, Dr	134	4	Sand	44 55	Apr. 15, 1936 June 1947	EJ	. .	Sand, 45 to 134 ft; originally dug to 45 ft.
213	NW¼ SW¼ sec. 17	Mrs. M. Hosler	do.	1945	do.	137	Dr	187	4	Gravel	47	1945	EJ	D	Sand, 47 to 187 ft; water from gravel beneath sand; used for greenhouse.
215	SE¼ NE¼ sec. 18	George McNeese	do.	. .	do.	134	Dr	43	4	do.	. . .	. . . .	EJ	D	Greenhouse.
217	SW¼ SE¼ sec. 18	L. D. Wright	do.	. .	do.	. .	D, Dr	37	4	do.	35	. . . .	EL	D, S	
218	NW¼ SE¼ sec. 18	J. C. Church, Jr.	A. and J. D. Frey	1950	do.	128	Dr	32	4	do.	22	1950	. .	D	
219	SW¼ NE¼ sec. 18	Cecil Kurtz	ARRC	. .	do.	130	Dr	53	4	do.	47	. . . .	EJ	D, S	
220	NE¼ NE¼ sec. 18	A. McGiboney	do.	. .	do.	139	Dr	41	4	do.	. . .	. . . .	EJ	D, S	
221	NW¼ NE¼ sec. 18	Gus Scheibl	do.	1935	do.	140	D, Dr	42	4	do.	39	. . . .	EJ	D, S	Bedrock reported at 42 ft.
224	SW¼ NW¼ sec. 8	Clarence Patten	do.	1936	do.	179	Dr	93	4	do.	68	. . . .	EJ	D, S	
229	NW¼ NE¼ sec. 8	A. Moffitt	T. Moffitt	1948	do.	212	Dr	93	4	do.	85	Spring 1949	. .	D	Small flow of water reported at 26 ft.
230	SE¼ SW¼ sec. 5	Harold Moore	A. Moffitt	1949	do.	212	Dr	96	4	Till	. . .	Aug. 1949	HL	D	Slotted casing set at 86 ft; water from 1-foot sand layer in till at 77 ft; till below 65 ft.
	T. 19 N., R. 3 E.														
250	NW¼ sec. 27	Alpine Inn	P. O'Neill	. .	Terrace	458	D	34	36	Gravel	. . .	. . . .	EJ	D	Inn.
253	NE¼ sec. 28	Don Boulter	A. Moffitt	1951	do.	523	Dr	81	4	Gravel, sand	75	Aug. 1951	EJ	D	Till, 51(?) to 71 ft; water in gravel and sand beneath till.
255	NW¼ sec. 28	Drift Inn	Ralph Dye	1949	do.	650	D	18	42	Gravel	. . .	. . . .	. .	. .	Till at 18 ft; dry in 1950.
256	SE¼ NW¼ sec. 32	Walter Mayer	Owner	. .	Hill-side	. .	D, Dr	34	42, 4	. . .	. . .	. . . .	. .	. .	Gravel to 33 ft; till below 33 ft; not completed (1951).
257	SE¼ NW¼ sec. 31	Kenneth Wallace	do.	. .	Hilltop	. .	Dr	37	4	. . .	. . .	. . . .	. .	. .	Till with gravel layers, beneath soil layer; not completed (1951).
258	SE¼ SW¼ sec. 30	Richard Diedrick	A. Moffitt	. .	Level ground	839	Dr	148	4	. . .	. . .	. . . .	. .	. .	Till below 10 ft; not completed (1951).
	T. 18 N., R. 2 E.														
265	SW¼ sec. 1	R. W. Wade	Owner	. .	Hill-side	. .	D	63	42	Gravel	. . .	. . . .	. .	. .	Not completed (1950).
270	NW¼ SE¼ sec. 9	Leroy Hammond	ARRC	. .	Level ground	608	Dr	93	6, 4	do.	. . .	. . . .	EJ	D, S	Log suggests till, 39 to 52 ft, 71(?) to 83(?) ft; 6-inch casing to 41 ft.
271	SE¼ SE¼ sec. 9	Warren Rice	do.	. .	Hill-side	608	Dr	124	6, 4	do.	80	1951	EJ	D, S	Till, 96 to 108 ft; 6-inch casing to 70 ft.
272	SE¼ SW¼ sec. 9	A. J. Collier	H. Stephan	. .	Level ground	600	D	105	48	do.	. . .	. . . .	. .	D	Reported by some individuals to be 220 ft deep.
273	Do.	do.	ARRC	. .	do.	600	Dr	88	6, 4	do.	86	June 1950	. .	N	Till, 68 to 86 ft; dry in September 1950; 6-inch casing to 48 ft.
275	NW¼ NE¼ sec. 16	Olav Holtet	Owner	. .	Depres-sion	. .	B	14	10	Sand	9.0	Nov. 26, 1951	. .	D	Water in windblown sand above impermeable layer in ice-block hole (pit); well representative of several others not in use; temperature, November 26, 1951, 37° F.
280	NW¼ SW¼ sec. 16	Harold Stephan	ARRC	1936	Level ground	558	Dr	90	4	do.	82	Apr. 1936	EJ	D, S	
282	NE¼ sec. 17	Miss L. Kellogg	T. Moffitt	. .	Hilltop	556	Dr	24	4	Gravel	20	. . . .	EJ	D, S	
283	NW¼ sec. 17	James Kucherry	. . . . .	. .	do.	596	Dr	46.5	4	. . .	37.5	Aug. 16, 1949	HL	D, S	
285	SW¼ SW¼ sec. 17	James Berry	ARRC	1936	Hill-side	525	Dr	94	6, 4	Sand	45	. . . .	EJ	D, S	Till, 52 to 82 ft; 6-inch casing to 50 ft.
286	SE¼ SE¼ sec. 18	C. Quanstrom	do.	1936	do.	530	Dr	54	6	Gravel	46 19	Apr. 25, 1936 1948	EJ	D, S	
287	NW¼ SE¼ sec. 18	David Bryant	do.	1936	do.	. .	Dr	132	4	Sand	25	Feb. 17, 1936	EJ	D	Till, 30 to 116(?) ft.
	T. 18 N., R. 1 E.														
290	NE¼ NE¼ sec. 14	Ralph Ware	ARRC	1936	Level ground	578	Dr	76	4	Gravel	46	Oct. 7, 1936	HL	D, S	Till, 45 to 65 ft.
292	NE¼ SE¼ sec. 14	R. N. Cather	do.	1936	Hilltop	540	Dr	55	4	do.	31 19	Jan. 18, 1936 1945	EJ	D, S	Childrens Home.
293	Do.	do.	A. and J. D. Frey	1951	do.	540	Dr	69	4	do.	23	1951	EJ	D, S	Do.
294	SW¼ SE¼ sec. 14	F. R. Gaylord	ARRC	1935	do.	560	Dr	194	4	Sand	61	Dec. 11, 1935	EL	D, S	Till, 71 to 163 ft.
295	SE¼ SE¼ sec. 14	Leonard Kyger	. . . . .	. .	Depres-sion	. .	D	20	36	Gravel	12	July 1951	EC	D	
297	SE¼ SW¼ sec. 13	do.	. . . . .	. .	Flood-plain	. .	D	14	24	do.	12	Aug. 27, 1951	EJ	D, S	MP top of concrete well curb, 7 ft below ground surface.

Table 5.—Records of wells in the Matanuska Valley agricultural area, Alaska—Continued

Well no.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of ~~water~~ well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
	T. 18 N., R. 2 E.														
300	NW¼ NE¼ sec. 19	R. L. Buzby	ARRC	1936	Hill-side	513	D, Dr	50	4	Gravel	40	Jan. 1949	EJ	D, S	Originally dug to 44 ft.
301	NE¼ NW¼ sec. 19	G. LaRose	do.	1936	do.	508	D	38	. .	do.	34	Mar. 12, 1936	. .	D, S	
302	SE¼ NW¼ sec. 19	Lew Hanks	do.	1936	do.	512	D, Dr	. .	4	Sand	42	Aug. 1951	EJ	D	Drilled to 43 ft, 1936, and to 53 ft, 1951; till, 19 to 37(?) ft.
305	SW¼ NE¼ sec. 20	Owen Moffitt	ARRC; owner	1936; 1951	Hilltop	540	D, Dr	150	4	Gravel	. . .	. . . .	E	D, S	Dug to 95 ft; till, 71 to 95+ ft; small supply of water in gravel above till; upon deepening water obtained from several levels in slightly consolidated gravel; several other deep wells on this property had been dry holes.
306	SE¼ NE¼ sec. 20	Wallace Moffitt	ARRC	1935	Hill-side	528	Dr	120	4	Gravel	79	Nov. 13, 1935	EL	D, S	Till, 79 to 90 ft.
307	NW¼ SE¼ sec. 20	William Lentz	Owner	. .	do.	528	D	65	24	do.	. . .	. . . .	EJ	D, S	Lined with metal culvert pipe.
308	NE¼ SE¼ sec. 20	Oscar Kerttula	ARRC	. .	Hilltop	. .	Dr	110	4	do.	. . .	. . . .	EJ	D, S	Till, 76 to 91 ft.
310	SW¼ NW¼ sec. 20	Mrs. F. Warner	. . . . .	. .	do.	. .	D	54	42	do.	. . .	. . . .	EJ	D, S	Dug before 1914.
311	NE¼ SE¼ sec. 19	C. R. Monoghan	ARRC	1936	Hill-side	. .	D	58	42	do.	49	June 30, 1936	HL	D	
312	SE¼ SE¼ sec. 19	H. F. Loomis	. . . . .	. .	Hilltop	. .	Dr	80	4	. . . .	. . .	. . . .	EJ	D	
314	NW¼ SE¼ sec. 19	Henry LaRose	ARRC	. .	Hill-side	488	Dr	58.0	4	. . . .	42.38	Aug. 30, 1949	. .	O	MP top of casing, which is 1.0 ft above land surface.
315	NE¼ SW¼ sec. 19	do.	Owner	. .	do.	465	Dr	36	4	Gravel	. . .	. . . .	EJ	D, S	
317	SW¼ SW¼ sec. 19	M. Johanson	ARRC	1935	Hill-side	440	D	21	36	do.	19	. . . .	EJ	D, S	
318	NE¼ NW¼ sec. 30	Alfred Kirsch	do.	1936	Level ground	440	Dr	50	4	do.	37	Sept. 21, 1936	EJ	D	
319	Do.	J. R. Elmore	J. Curry	1951	Hill-side	455	Dr	53	6	do.	24	Aug. 1951	EJ	D	Small inflow of water reported at 23 ft and at 32 ft during drilling.
320	SW¼ NW¼ sec. 30	Earl Hecker	. . . . .	. .	Hilltop	455	D	54	. .	. . .	. . .	. . . .	. .	D, S	In drilled well nearby, 47 ft deep, water level was 42 ft, August 28, 1936.
321	SE¼ NW¼ sec. 30	do.	ARRC	1936	. . . .	. .	Dr	50	4	Gravel	13	Sept. 15, 1936	. .	N	Till, 40 to 46 ft.
325	NE¼ SW¼ sec. 30	T. Bentti	Owner	1948	Depres-sion	. .	D	9	36	do.	0	July 6, 1949	HL	D	
326	NW¼ NW¼ sec. 30	Harry Campbell	ARRC	1936	Level ground	444	Dr	28	4	do.	24	. . . .	HL	D	
327	NW¼ SE¼ sec. 30	T. Moffitt	do.	1936	Hill-side	. .	Dr	77	4	do.	. . .	. . . .	. .	N	Till(?), 60 to 73 ft.
330	NW¼ NW¼ sec. 29	C. R. Monoghan	. . . . .	. .	do.	. .	D	20	36	do.	. . .	. . . .	E	D	
331	NE¼ NW¼ sec. 29	Vernon Williams	ARRC	1936	do.	487	Dr	63	4	do.	55	Feb. 4, 1936	EJ	D, S	
332	SE¼ SW¼ sec. 20	John Reed	. . . . .	. .	Depres-sion	475	D, Dr	60	4	do.	. . .	. . . .	EJ	D	Originally dug to 45 ft; till below 45 ft; water from gravel in till, 53 to 58 ft.
333	NW¼ NE¼ sec. 29	M. D. Snodgrass	ARRC	1935	Hilltop	485	D, Dr	107	4	do.	95	Dec. 5, 1935	EJ	D, S	Originally dug to 65 ft.
334	NW¼ NW¼ sec. 29	Alva Saxton	do.	. .	Terrace	480	Dr	101	4	do.	88	. . . .	. .	D	
338	SW¼ NW¼ sec. 28	Earl Cook	T. Moffitt	1947	do.	475	Dr	45	4	Till	. . .	. . . .	. .	N	Dry since 1949; never yielded more than 50 gpd.
339	NW¼ NW¼ sec. 28	T. Dickinson	Owner	1949	do.	490	D	70	42	do.	66	1949	HW	D	MP top of well cribbing, about 5 ft below original land surface; well on dune ridge, sand 40 ft thick.
340	SW¼ sec. 28	Ferber Bailey	do.	1949	do.	472	D	58	42	do.	46.0	July 12, 1949	HW	D	Till below 36 ft; water derived from till at depth of 48 to 58 ft.
341	Do.	William Reid	F. Bailey	1950	do.	440	D	27	42	Gravel	25.42	June 15, 1950	EJ	D	MP top of well cribbing, 0.50 ft above land surface.
342	Do.	John Sisley	do.	1950	do.	440	D	25	42	do.	24.00	June 15, 1950	EJ	D	MP top of well cribbing, at ground level.
343	Do.	Ferber Bailey	do.	1950	do.	440	D	31	42	Till	. . .	. . . .	. .	N	Till below 27 ft; water in 6-inch gravel layer at 28 ft.

	T. 18 N., R. 2 E.														
344	SW¼ sec. 28	Carl Stoekle	F. Bailey	1950	Terrace	442	D	27	42	Gravel	25	1950	. .	N	
345	Do.	Mrs. G. Edmunds	do.	1950	do.	. .	D	14	42	do.	12	1950	. .	N	
346	Do.	Richard Demming	S. Kozloski	1952	do.	435	Dr	122	6	. . .	. . .	. . . .	. .	D	
347	Do.	C. E. Albrecht	. . . . . .	. .	do.	. .	D	35	48	Gravel	. . .	. . . .	. .	D	
348	Do.	A. Trowbridge	A. and J. D. Frey	1951	do.	. .	Dr	97	4	. . .	. . .	. . . .	. .	N	Water from gravel beneath till(?).
350	NE¼ SE¼ sec. 29	D. L. Irwin	. . . . . .	1949	do.	. .	D	30.0	36	Gravel	21.10	July 8, 1949	EJ	D	
352	SE¼ SE¼ sec. 29	Howard Estelle	ARRC	1935	do.	422	Dr	62	4	do.	48	Dec. 28, 1935	EL	D,S	
353	Do.	do.	do.	1935	do.	. .	Dr	119	4	do.	91	Nov. 26, 1935	. .	N	Till, 43 to 115 ft.
355	NE¼ SW¼ sec. 29	Clarence Hoffman	do.	1936	Hilltop	438	Dr	63	4	Sand	43	. . . .	EJ	D,S	Till, 43 to 61 ft.
356	SE¼ SW¼ sec. 29	Leonard Moffitt	do.	1936	Hillside	415	Dr	80	4	Gravel	53	July 27, 1936	EJ	D,S	Till, 50 to 70 ft.
359	SE¼ SW¼ sec. 30	L. Z. Scott	do.	. .	Hilltop	431	Dr	120	4	Till	63	Sept. 1947	EJ	D	Till below 55 ft; originally dug to 55 ft.
360	NW¼ NE¼ sec. 31	L. Wiederkehr	Owner	1948	Hillside	374	D	18	48	Gravel	11.9	July 7, 1949	EC	D	
362	NE¼ NE¼ sec. 31	A. Thompson	ARRC	1947	Level surface	374	Dr	110	4	Sand	50	. . . .	EJ	D,S	Till, 28 to 84 ft; inadequate supply of water in gravel, on till, at 28 ft.
363	SE¼ NE¼ sec. 31	Palmer Test Well	J. Currie, E. Young, S. Kozloski	1951	Hilltop	375	Dr	165	6	Gravel	20	Dec. 1951	. .	. .	Till, 90 to 114 ft; well finished with 20-foot screen; drawdown, 35 ft after 16 hrs pumping at 118 gpm.
364	SW¼ NW¼ sec. 32	Mrs. Irene Benson	ARRC	1936	do.	. .	Dr	88	4	do.	26	May 23, 1936	HL	S	Till, 65 to 86 ft.
365	SE¼ NW¼ sec. 32	Oscar Beylund	do.	1936	do.	365	Dr	79	4	do.	. . .	. . . .	HL	N	Till, 58 to 76 ft.
366	NE¼ NW¼ sec. 32	Frank McAllister	do.	. .	do.	. .	Dr	67	4	do.	30	1942	EJ	D,S	Estimated use 800 gpd.
369	NW¼ NE¼ sec. 32	Robert Klem	do.	1936	Terrace	321	Dr	72	4	Sand	50	Nov. 26, 1936	. .	N	No till reported; water reported struck at 70 ft.
370	Do.	do.	do.	. .	do.	321	D	15	42	Gravel	14	. . . .	. .	D,S	Till at 15 ft; estimated use 300 gpd.
371	NE¼ NE¼ sec. 32	Neil Miller	do.	. .	do.	309	D	24	. .	. . .	22	. . . .	EC	D	In dug well, nearly 16 ft deep, till was tapped at 15 ft; 2 ft of water in overlying gravel.
372	SE¼ NE¼ sec. 32	Virgil Eckert	do.	. .	do.	309	D	18	. .	Gravel	16	. . . .	EJ	D,S	Water in gravel overlying till.
375	NE¼ SE¼ sec. 32	Eino Wirtanen	. . . . . .	. .	do.	. .	D	25	. .	. . .	15	. . . .	. .	D	Till reported, 8 to 25 ft; water in gravel layer in till, 16 to 21 ft.
	T. 17 N., R. 2 E.														
376	NE¼ sec. 5	John Mehan	ARRC	. .	Hillside	239	Dr	34	4	Bedrock	15	Spring 1949	EJ	D	Casing set in rock 10 ft below ground surface; well yields 30 to 40 gal between periods of recovery.
377	Do.	Leo Lucas	. . . . . .	. .	do.	265	D	28	. .	Gravel	24	. . . .	HL	D,S	
378	NE¼ NW¼ sec. 8	H. H. Blunck	ARRC	. .	Terrace	247	Dr	126	4	do.	119	Summer 1948	EL	D,S	Till, 41 to 76 ft; well yields 20 to 30 gal between periods of recovery.
380	NE¼ NW¼ sec. 5	D. L. Irwin	do.	. .	Hilltop	266	Dr	74	4	do.	66	. . . .	EJ	D	
381	NW¼ NW¼ sec. 5	M. Perkins	do.	. .	do.	277	Dr	83	4	Sand	55	Aug. 1951	EJ	D	
382	NE¼ NW¼ sec. 5	G. E. Murphy	J. Cebula	1949	Hillside	259	D	44	48	Gravel (?)	42	Spring 1949	EC	D	Till below 42 ft.
383	NW¼ NW¼ sec. 5	Mrs. P. Harder	A. Moffitt	1948	Hilltop	266	Dr	90	4	Gravel	60	1948	. .	. .	
385	NW¼ NE¼ sec. 6	Vernon France	ARRC	. .	do.	. .	Dr	144	4	do.	. . .	. . . .	. .	. .	Till, 60 to 130 ft.
386	NE¼ NW¼ sec. 6	Mrs. G. France	. . . . . .	1947	Depression	284	D	30	48	do.	27	. . . .	EJ	D	
388	NW¼ NW¼ sec. 6	Carl Mielke	. . . . . .	. .	Hillside	314	Dr	63	4	do.	55	. . . .	EJ	D	
	T. 18 N., R. 2 E.														
395	SW¼ SE¼ sec. 32	A. W. Pearson	ARRC	1947	Hilltop	272	D,Dr	100	4	Till	55	. . . .	EJ	D	Well ends in till; top of till probably near 80 ft; originally dug to 52 ft.
396	SE¼ SW¼ sec. 32	Henry Harrison	. . . . . .	1914	Hillside	. .	D	14	36	Gravel	13	. . . .	HL	D	
397	SW¼ SW¼ sec. 32	Victor Johnson	ARRC	1936	Hilltop	279	D,Dr	82	4	do.	. . .	. . . .	EJ	D,S	Till, 55 to 64 ft; originally dug to 44 ft.
398	NW¼ SW¼ sec. 32	P. J. Hemmer	do.	1936	Level surface	286	Dr	61	4	Sand	6	1949	EJ	D,S	Till, 28 to 59 ft; yielded 5.65 gpm, drawdown 7 ft, in 28-hour test.
399	SW¼ sec. 31	Glenn Harrison	Owner	1949	Hillside	. .	D	28	48	Gravel (?)	27.10	July 5, 1949	HW	D	Ground surface built about 3 ft higher than original surface; till below about 27 ft.
	T. 18 N., R. 1 E.														
401	SE¼ SE¼ sec. 36	William Roark	ARRC	. .	Hillside	. .	Dr	102	4	. . .	82	. . . .	EJ	D,S	
405	SE¼ SE¼ sec. 35	George Black	. . . . . .	. .	Hilltop	383	D,Dr	86	4	Gravel	61	Feb. 1947	EL	D	Originally dug to 60 ft.
407	SE¼ SW¼ sec. 35	O. A. Berg	. . . .	. .	Hillside	. .	D	22	4	Sand	. . .	. . . .	HL	D	Cased after barrel was placed in bottom of well.
410	NE¼ sec. 35	Eugene Reid	Owner	. .	Hilltop	399	D	58.0	42	Gravel	56.0	July 15, 1949	EJ	D	
411	SW¼ SE¼ sec. 27	Mrs. A. Havemister	ARRC	1936	do.	366	D	23	36	do.	19.0	July 15, 1949	EJ	D,S	

Table 5.—Records of wells in the Matanuska Valley agricultural area, Alaska—Continued

Well no.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of ~~water~~ well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
	T. 18 N., R. 1 E.														
412	SE¼ SE¼ sec. 27	Emil Kircher and Walter Menk	Owners	1942	Flood plain	374	D	16	. .	Gravel	14	1942	EJ	D, S	Drilled well nearby 60 ft deep was in gravel.
	T. 17 N., R. 1 E.														
420	NW¼ NE¼ sec. 2	Robert Wendt	A. W. Pearson	1948	Hillside	343	D	22	6	Till	21	1948	EJ	D	Cased after concrete slabs were placed in bottom to make a reservoir. Till below 16 ft.
421	NE¼ NW¼ sec. 2	Charles Schaeffer	Owner	. .	Hilltop	338	D	40	. .	Gravel	32	. . . .	EJ	D	Till at 40 ft.
422	NW¼ NW¼ sec. 2	Peter Johnson	do.	. .	Hillside	300	D	21	42	do.	17.5 19.27	June 28, 1949 Aug. 28, 1950	HW	D, S	
424	NW¼ SE¼ sec. 3	A. H. Curtis	do.	. .	Flood plain	. .	D	14	. .	do.	9	. . . .	HW	D, S	
425	NW¼ NW¼ sec. 10	John Martin	. . . . . .	. .	Hillside	. .	D	21	42	do.	14.0	June 28, 1949	HW	D, S	
430	SW¼ SW¼ sec. 16	David Philo	ARRC	. .	Gentle slope	168	D, Dr	50	4	do.	25	. . . .	EJ	D	
431	SE¼ SW¼ sec. 16	J. E. Church	do.	. .	Level surface	178	Dr	70	4	do.	30	1945	EJ	D, S	Till, 54 to 69 ft.
432	NW¼ SW¼ sec. 16	Henry Jensen	ARRC	1936	Gentle slope	168	Dr	24	4	do.	20.68	Aug. 31, 1949	. .	N	MP top of casing, which is 0.50 ft above land surface.
434	SE¼ NW¼ sec. 16	Fred Larson	do.	. .	Terrace	180	Dr	136	4	Sand	. . .	. . . .	. .	N	Till, 31 to 112 ft.
435	NE¼ SW¼ sec. 16	do.	do.	. .	do.	180	Dr	300(?)	4	. . .	50(?)	. . . .	EJ	D, S	Till, 40 to 60 ft.
436	NW¼ SE¼ sec. 16	F. Blom	do.	. .	do.	163	Dr	318(?)	4	. . .	48	. . . .	. .	. .	
437	Do.	do.	do.	. .	do.	163	Dr	91	6,4	Sand	. . .	. . . .	EL	D, S	Till, 29 to 86 ft; 6-inch casing to 80 ft.
438	SW¼ SE¼ sec. 16	Henry Jensen	do.	. .	do.	141	Dr	214	6	Gravel	30	. . . .	EJ	D, S	Till, 67 to 208 ft; well yields about 50 gal between periods of recovery.
439	SE¼ SE¼ sec. 16	Lloyd Short	do.	. .	do.	141	Dr	192	4	do.	25	July 1949	HL	D, S	Well supplies several thousand chickens but yields only about 40 gal between periods of recovery; till, 69 to 180(?) ft.
440	SE¼ NE¼ sec. 16	D. E. Eldridge	Charles Marino	. .	do.	169	D	39	42	do.	34	. . . .	HL	D	Supplied 20 families and 17 horses in 1935.
441	NW¼ NW¼ sec. 15	M. D. Snodgrass	. . . . . .	. .	do.	. .	D	11.0	. .	do.	8.94	Sept. 14, 1950	HL	N	
442	NE¼ SE¼ sec. 16	F. Blom	ARRC	. .	do.	176	Dr	68	4	Till	. . .	. . . .	HL	N	Till, 42 to 126 ft; casing pulled back to 68 ft; water from sand and gravel layer in till.
443	SW¼ NE¼ sec. 15	U. S. Dept. Agr.	. . . . . .	. .	do.	. .	D	36	42	Gravel	31 33	July 1947 Sept. 1948	EJ	D, S	Agricultural Experiment Station.
445	NW¼ NW¼ sec. 22	L. Loberg	ARRC	1936	do.	. .	Dr	298	4	do.	74	. . . .	EJ	D, S	
448	NE¼ SE¼ sec. 15	Frank Linn	do.	. .	Hilltop	138	Dr	108	4	do.	. . .	. . . .	EJ	D, S	
449	Do.	do.	do.	. .	do.	138	Dr	96	6,4	do.	54.00	Aug. 31, 1949	. .	O	MP top of casing, which is 1.00 ft above land surface; temperature, November 23, 1951, 38° F.
450	NW¼ NE¼ sec. 23	J. T. Kepler	Owner	. .	Hillside beside lake	40	D	12(?)	. .	do.	. . .	. . . .	EJ	D	Land surface at well 12 ft above lake level (July 1949).
	T. 18 N., R. 1 E.														
460	NE¼ sec. 33	E. W. Barry	Owner	. .	Hillside	. .	D	10	. .	do.	8	. . . .	E	D, S	
462	SW¼ NW¼ sec. 29	Harry Duff	ARRC	. .	Gentle slope	. .	Dr	32	4	do.	. . .	. . . .	EJ	D	High iron content (see analysis).
463	SW¼ sec. 30	Kings Lake Camp	Clyde King, Sr.	. .	Hillside near lake	. .	D	10	. .	do.	. . .	. . . .	. .	. .	Till at 10 ft; two dry wells in till, 50 and 65 ft deep, are on this property.
466	SW¼ sec. 17	. . . . .	. . . .	. .	Terrace, below hill	577	D	. .	36	. . .	34.7	Sept. 4, 1950	. .	N	

	T. 18 N., R. 1 W.														
468	NE¼ SE¼ sec. 25	Kings Lake Camp	. . . .	. .	Valley leading to lake	. .	D	17	42	Gravel	. . .	. . . .	EJ	D	Scout camp; inadequate supply during 1950-51.
469	Do.	do.	U. S. Bureau of Reclamation	1951	Hillside above lake	462	Dr	35.0	4	do.	21.6	Nov. 7, 1951	EJ	D	Scout camp.
470	Do.	do.	do	1951	Hilltop	469	Dr	45.8	4	do.	25.5	Nov. 7, 1951	. .	N	Do.
471	SE¼ sec. 24	Clyde Poisal	Owner	1951	Level surface	. .	D	31	36	Till	30.0	Sept. 4, 1951	. .	N	Inadequate supply.
472	NE¼ sec. 25	Frank Sorenson	do.	1949	Hillside above lake	. .	D	20	20	Gravel	15	Sept. 1951	E	D	MP basement floor, 5 ft below land surface; lined with concrete pipe.
473	Do.	J. H. Shrook	do.	1946	Level surface	. .	D	20	. .	. . .	. . .	. . . .	HL	D	Well has been dry, September to March of every winter.
474	SE¼ sec. 26	A. E. Withey	do.	1950	do.	. .	D	22	48	Till	20	1950	. .	D	Till below 10 ft; water from sandy streaks, 19.5 to 22 ft.
477	SE¼ sec. 22	D. E. Sullivan	. . . .	. .	do.	. .	D	24	. .	. . .	. . .	. . . .	HW	D	
480	NE¼ sec. 35	H. Nickles	Owner	1950	Hillside	. .	D	50	. .	. . .	. . .	. . . .	EJ	D	Water reported at 48 ft; probably derived from sandy till or from gravel.
481	NW¼ sec. 35	do.	do.	1950	. . . .	. .	D	55	. .	Gravel	53	1950	. .	N	
	T. 17 N., R. 1 E.														
490	SE¼ SE¼ sec. 6	Anthony Viokaryous	ARRC	. .	Hilltop	. .	Dr	106	4	Gravel	36	1945	HL	D, S	Till, 30 to 81 ft.
491	SW¼ SE¼ sec. 6	do.	do.	. .	Gentle slope	. .	Dr	109	4	do.	. . .	. . . .	HL	N	Till, 42 to 107 ft.
492	NE¼ NW¼ sec. 7	E. B. Hjellen	. . . .	. .	Terrace	. .	Dr	42	6	. . .	38	June 1, 1951	EJ	D	A 78-ft well on this property penetrated till(?), 42 to 55 ft with sand and gravel beneath.
494	SW¼ SW¼ sec. 6	Harold Richards	. . . .	. .	do.	. .	Dr	40	4	. . .	. . .	. . . .	E	D	Children's Home, about 50 people; hard water (see analysis).
495	NE¼ SW¼ sec. 6	do.	. . . .	. .	Valley bottom	. .	D	16.0	4	. . .	15.5	Aug. 27, 1951	. .	N	
	T. 17 N., R. 1 W.														
500	SW¼ SW¼ sec. 1	Fred Hurd	Owner	. .	Level surface near lake	329	D	14	. .	Gravel	12	. . . .	EC	D, S	
501	NE¼ NE¼ sec. 11	D. W. Roth	. . . .	. .	do.	. .	D	14	. .	do.	. . .	. . . .	EC	D	Greenacres Roadhouse.
502	SE¼ NW¼ sec. 11	Martin Olson	Owner	. .	Shore of lake	. .	D	22	. .	. . .	13.0	July 20, 1949	E	D	Till below 12 ft; well may obtain water from gravel above till.
505	SW¼ sec. 2	E. L. Peck	do.	. .	Hillside above lake	. .	D	18	42	Gravel	15	. . . .	. .	D	
506	Do.	do.	do.	. .	do.	. .	D	32	42	do.	. . .	. . . .	. .	D	Till below 28 ft.
510	NE¼ NW¼ sec. 10	Mrs. W. Wilson	. . . .	. .	Hillside	340	D	16.8	. .	do.	11.77	Aug. 31, 1949	HL	D	MP, well curb, 2.0 ft above land surface.
511	NW¼ NW¼ sec. 10	T. L. Carter	. . . .	. .	Hilltop	350	D	30	. .	do.	28	. . . .	E	D	
512	NE¼ NW¼ sec. 10	A. L. Hilburn	. . . .	. .	Hillside	348	D	26	. .	do.	22.0	July 25, 1949	EC	D	Lined with concrete pipe.
513	SE¼ NW¼ sec. 10	Frank Swanson	. . . .	. .	do.	348	D	23	. .	do.	19	. . . .	. .	D	Till, 20 to 21 ft.
514	NW¼ NW¼ sec. 10	Wasilla Cafe	T. Moffitt	. .	do.	348	Dr	28	4	do.	. . .	. . . .	. .	D	Cafe.
515	NW¼ NW¼ sec. 10	Wasilla Community Well	Jack Fabian	. .	Hilltop	350	D	32	42	do.	. . .	. . . .	. .	N	
516	NE¼ NW¼ sec. 10	E. Gustafson	Owner	. .	Hillside	345	D	17	36	do.	15	1945	. .	D	
517	SE¼ NW¼ sec. 10	do.	do.	. .	do.	345	D	21	36	do.	18	1946	EC	D	
518	Do.	U. S. Post Office	. . . .	. .	do.	345	Dr	. .	. .	. . .	. . .	. . . .	. .	N	
519	Do.	Wasilla Hotel	Jack Fabian	. .	do.	338	D	22	. .	Gravel	18	1949	EJ	D	Hotel and restaurant; till, 3-foot layer with top at 15(?) ft.
520	Do.	Gus Swanson	. . . .	. .	do.	342	D	16.6	. .	do.	13.7	July 25, 1949	HW	D	Till layer reported.
521	SW¼ NW¼ sec. 10	Teeland's Shopping Center	Jack Fabian	. .	do.	338	D	16	36	do.	13	April 1949	E	D	Till below 15 ft.
522	SE¼ NW¼ sec. 10	U. S. Dept. Interior, Alaska Railroad	. . . .	. .	Level surface	333	D	21	. .	do.	18	. . . .	EJ	D	Well lined with concrete pipe; on low divide between Wasilla Lake and Lake Lucile.

Table 5.—Records of wells in the Matanuska Valley agricultural area—Continued

Well no.	Location	Owner or name	Driller	Year completed	Topographic situation	Altitude above sea level (feet)	Type of well	Depth of ~~water~~ well below land surface (feet)	Diameter of well (inches)	Water-bearing material	Water-level (feet below land surface)	Date of measurement	Method of lift	Use of water	Remarks
	T. 17 N., R. 1 W.														
523	SW¼ NW¼ sec. 10	William Betts	Owner	1951	Hilltop	340	D	26	42	Gravel	24	Nov. 1951	HW	D	
524	SW¼ sec. 10	Wenter Harvey	do.	. .	do.	. .	D	40	48	do.	. . .	. . . .	HL	N	Dry in 1950-51.
530	NW¼ NW¼ sec. 10	C. L. Cadwallader	. . . . . .	. .	Hillside	340	Dr	16	4	do.	13	Feb. 1949	EJ	D	
531	Do.	Ray Bergman	Owner	. .	do.	348	D	26	. .	do.	23	Aug. 1948	HL	D	Till at 26 ft.
532	Do.	Neil Brown	do.	. .	do.	346	D	20	12	do.	. . .	. . . .	EJ	D	Lined with metal drums and backfilled.
533	Do.	Oscar Tryck	do.	. .	Hilltop	350	D	28	36	do.	. . .	. . . .	HW	D,O	MP top of cribbing, which is 3.0 ft above ground surface.
540	SW¼ NW¼ sec. 10	Peter Nelson	do.	. .	Hillside	340	D	25	30	do.	. . .	. . . .	E	D	Lined with poured concrete.
541	Do.	James Kennedy	do.	. .	Gentle slope	326	D	9.6	36	do.	6.7	July 20, 1949	. .	D	
542	SE¼ NE¼ sec. 9	Garrett Snider	do.	. .	Lake shore	315	D	9	. .	do.	7	1949	EJ	D	
543	SW¼ sec. 4	J. C. Baldwin	do.	. .	Hillside	359	D	5	. .	do.	4	July 1949	. .	D,S	Do.
	T. 17 N., R. 1 E.														
560	NW¼ NW¼ sec. 4	Henry Ohnstad	Owner	1949	Hilltop	382	D	32	48	. . .	. . .	. . . .	. .	N	Not completed; gravel to 30 ft, till below 30 ft.
561	NW¼ NW¼ sec. 9	J. W. Reeder	do.	1949	Hillside	342	D	30	48	. . .	. . .	. . . .	. .	. .	Insufficient supply; gravel to 10 ft; till below 10 ft.
562	NE¼ NE¼ sec. 8	J. K. Dunlap	ARRC	. .	do.	308	Dr	62	4	Gravel	42(?)	. . . .	EJ	D,S	
565	NW¼ SW¼ sec. 9	H. Roach	. . . . . .	. .	do.	203	D	12	. .	do.	7	. . . .	. .	. .	Several springs issue from hillside in valley near well.
566	SW¼ SW¼ sec. 9	John McDonald	ARRC	1935	Flood plain	198	D	12	. .	do.	11	. . . .	E	D,S	
570	NE¼ SE¼ sec. 17	M. M. Newby	do.	. .	Hillside	176	Dr	361	4	do.	46.0	July 2, 1949	. .	N	Till, 40 to 120 ft.
572	NW¼ SE¼ sec. 18	R. A. Newell	do.	. .	do.	191	D	10	36	do.	9	. . . .	EJ	D,S	
573	SW¼ NW¼ sec. 18	H. Gerschmel	do.	. .	Hilltop	. .	Dr	95	4	Sand	. . .	. . . .	EL	D,S	
574	SW¼ sec. 7	James Hurley	. . . . . .	. .	do.	. .	D	65	48	. . .	49.7	July 18, 1949	HW	N	Till below 12 ft in excavation nearby.
576	NE¼ SW¼ sec. 18	A. R. Carson	ARRC	. .	Hillside	202	D,Dr	44	4	Gravel	33	. . . .	EJ	D,S	Originally dug to 33 ft.
577	SE¼ SW¼ sec. 18	Johan Johnson	do.	1936	Hilltop	238	Dr	136	4	Sand	50	July 1949	EJ	D,S	Till, 60 to 75 ft.
578	SW¼ SW¼ sec. 18	Joseph Gislason	do.	1936	do.	238	D,Dr	180	4	Gravel	75 80	July 24, 1936 1948	. .	. .	Till, 90(?) to 174 ft; originally dug to 73 ft.
	T. 17 N., R. 1 W.														
585	NE¼ sec. 17	. . . . . .	. . . . . .	. .	Level surface	. .	D	. .	42	. . .	14.45	Aug. 28, 1950	. .	N	MP top of cribbing, which is 2.50 ft above land surface.
586	NW¼ SE¼ sec. 13	R. C. Kibbe	. . . . . .	1949	do.	259	D	42	. .	Till	18	. . . .	. .	D	About 150 gpd used.
587	NE¼ NE¼ sec. 24	R. L. Teague	. . . . . .	. .	Hillside	. .	D	18	. .	. . .	. . .	. . . .	HL	D	Till exposed in road cut nearby.
588	NW¼ NE¼ sec. 24	Fred Edlund	Owner	. .	Level surface	. .	D	25	. .	Till	. . .	. . . .	. .	N	Till below 15 ft.
589	SW¼ NE¼ sec. 24	Anton Edlund	. . . . . .	. .	Terrace	. .	Dr	35	4	. . .	27	Aug. 1948	HL	D,S	
590	SE¼ sec. 24	R. F. Davis	Owner	. .	do.	. .	D	10	. .	Sand	. . .	. . . .	HL	D,S	
591	SE¼ sec. 23	John Hornung	T. Moffitt	. .	do.	76	Dr	. .	. .	Gravel	64.56	Aug. 28, 1950	HL	N	Till, 5 to 55 ft.
595	SE¼ sec. 14	R. A. Lincoln	Earl McHenry	. .	Gentle slope	. .	D	20	36	Sand	6.2	July 19, 1949	HW	D,S	
596	NW¼ NE¼ sec. 23	Ralph Bradley	. . . . . .	. .	Level surface	. .	D	35	48	Till	11.84	Aug. 31, 1949	. .	N	MP top of platform, 1.0 ft above ground surface. Recovery in 7 days after 250 gal pumped in 45 min.
597	NW¼ sec. 23	Thomas Wilson	Owner	. .	do.	. .	D	31	. .	Till(?)	. . .	. . . .	EJ	D,S	
598	SW¼ sec. 14	Herbert Holstein	do.	. .	do.	. .	D	54	. .	Till(?)	45	. . . .	EJ	D,S	Limited supply of water.
599	NW¼ sec. 23	James Wilson	. . . . . .	. .	Gentle slope	. .	D	22	. .	Gravel	. . .	. . . .	HL	D	

604	T. 17 N., R. 1 W. SE¼ NE¼ sec. 22	Oscar Downing	Owner	. .	Gentle slope	171	D	14	. .	Gravel	12	. . . .	HW	D	
605	SW¼ SW¼ sec. 23	T. Knutson	. . . . . .	. .	Terrace	168	Dr	42	4	do.	28.0	July 18, 1949	HL	D	
610	NE¼ sec. 21	L. W. Hunter	Owner	1949	do.	207	D	9.7	36	Gravel	9.5	Aug. 28, 1950	. .	N	
615	NW¼ sec. 15	F. D. Smith	do.	. .	Hillside	313	D	18	. .	. . .	12	1949	HL	D	Till, 13 to 18 ft; water derived from gravel beneath till (may be gravel layer in till).
616	NE¼ sec. 16	S. D. Fleckenstein	do.	. .	Hilltop	311	D	16	36	Gravel	15	1949	EJ	D	
618	SE¼ sec. 17	Hubert Sager	. . . . . .	. .	Hillside	283	D	7	. .	do.	6	. . . .	HL	D	
620	NW¼ sec. 20	William Senske	Owner	. .	Terrace	267	D	18	48	do.	14	Aug. 1950	HW	D,S	
621	NW¼ sec. 19	J. L. Levan	do.	1950	Hilltop	. .	D	27	48	Till	15 26	1949 Aug. 1950	HW	D	Well deepened, summer, 1950.
622	SW¼ sec. 19	O. L. Byers	do.	. .	Terrace	. .	D	27	42	do.	18.25	Aug. 11, 1951	HL	D	Gravel to 16 ft; till 16 to 26 ft; gravel (possibly layer in till), 26 to 27 ft; MP top of cribbing, which is 4 ft below land surface.
623	NW¼ NW¼ sec. 30	Vincent Smith	do.	. .	do.	. .	D	20	. .	Gravel (?)	. . .	. . . .	. .	D	Till below 15 ft.
624	SW¼ NW¼ sec. 30	J. Mazy	do.	. .	Hillside	. .	D	11	. .	Gravel	. . .	. . . .	HL	D	Water level low, January to March each winter.
625	SE¼ sec. 30	Earl Combs	do.	. .	Terrace	. .	D	11	. .	do.	7	. . . .	HL	D	
630	T. 16 N., R. 2 W. NW¼ NW¼ sec. 1	W. S. Osborne	Owner	. .	Level surface	. .	D	30	42	. . .	25	. . . .	HW	D,S	Water may be derived from till; till is exposed in nearby bluff.
631	NW¼ SE¼ sec. 2	Robert Lothrop	do.	. .	Hillside	. .	D	60	48	Gravel	. . .	. . . .	. .	. .	Dry in August, 1950.
635	T. 17 N., R. 2 W. NW¼ sec. 25	A. H. Tober	Owner	. .	Hillside	. .	D	13	42	Till	10.64	Aug. 18, 1950	HW	D	Water apparently derived from sand layer in till; MP is well cover, 1.8 ft above ground surface.
640	T. 16 N., R. 2 W. SW¼ sec. 8	Stanley Collins	Owner	. .	Hilltop	. .	D	30	42	Till	28	1950	. .	. .	Small inflow of water reported at 20 and 26 ft; water at 30 ft may be from gravel layer.
641	SW¼ sec. 18	Raymond Redington	do.	1950	Terrace	. .	D	28	36	Gravel	25.95	Aug. 18, 1950	HL	D	Till at 15 ft in hill nearby.
642	T. 16 N., R. 3 W. SW¼ sec. 24	Chester Burden	Owner	. .	Terrace	88	D	30	. .	Gravel	28	1950	HL	D	
643	NE¼ sec. 26	Roy Tuttle	. . . . . .	. .	do.	. .	D	. .	. .	Sand	28.0	Aug. 26, 1950	HL	D	MP top of well cribbing, which is 2.4 ft above ground surface.
650	NE¼ sec. 21	Clayton Rocca	Owner	. .	Lake shore	. .	Dn	14	1¼	do.	. . .	. . . .	HL	D	
651	NW¼ sec. 28	Herman Grunwald	do.	. .	do.	. .	D	17	36	Gravel	15	. . . .	HL	D	
652	NW¼ sec. 28	Oscar Anderson	do.	. .	do.	. .	D	16	. .	do.	14	. . . .	HL	D	
660	T. 17 N., R. 2 W. NE¼ NE¼ sec. 9	U. S. Dept. Interior, Alaska Railroad (Pittman)	. . . . . .	1945	Gentle slope	286	Dr	40	4	Till(?)	. . .	. . . .	HL	D	About 500 gpd used; well is easily pumped dry.

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