STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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Report of Investigations 87-13
EVALUATION OF AQUIFERS NEAR
ALPINE WOODS SUBDIVISION,
SOUTH ANCHORAGE, ALASKA

By
J.A. Munter

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

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EVALUATION OF AQUIFERS NEAR ALPINE WOODS SUBDIVISION, SOUTH ANCHORAGE, ALASKA

by
J.A. Munter[1]

INTRODUCTION

The privately owned Alpine Woods water system was constructed during 1983-84 to bring water from wells to a planned subdivision of 54 single-family homes in the Hillside area of South Anchorage. Development of new water systems in the area has caused concern because of long-term water-level declines and residential well failures at lower Hillside locations (Dearborn and Munter, 1987; Munter, 1987). An application submitted by the owner of the Alpine Woods water system to the Alaska Division of Land and Water Management to extract 27,000 gallons per day (gpd) of water prompted a hydrogeologic study of sec. 23, T. 12 N., R. 3 W., Seward Meridian, where the Alpine Woods water system is located (fig. 1). The objectives of the study were to determine the effects of historic ground-water extraction in the area, to field test the aquifer system tapped by the Alpine Woods wells, and to estimate the likely drawdown in the immediate area of the proposed extraction.

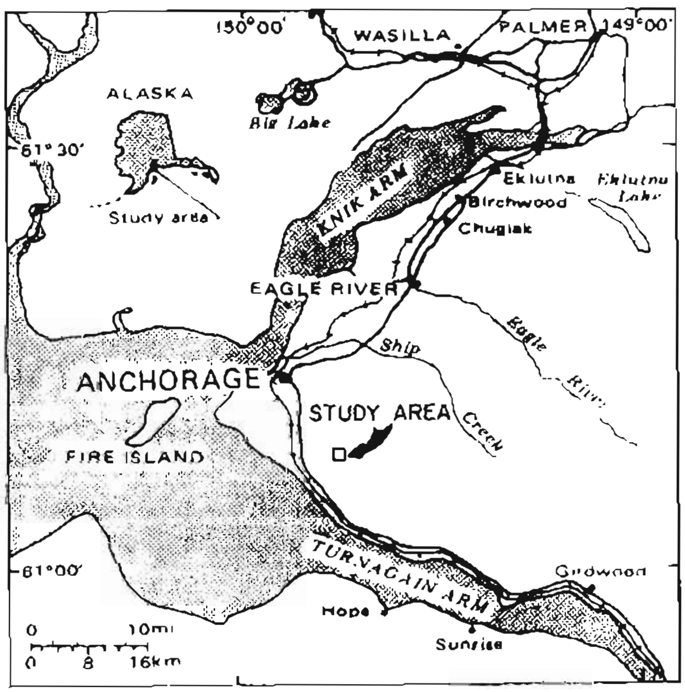

Figure 1. Location of study area.

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HYDROGEOLOGY

Sec. 23 is located in the foothills between the Chugach Mountains and the lowland area of Anchorage (Barnwell and others, 1972). Surficial deposits in the area consist of glacial, marine, and alluvial sediments of Quaternary age (Schmoll and Dobrovolny, 1972). Much of the section exhibits knob and kettle topography. Examination of local exposures and of logs of water wells submitted by drillers suggest that most of the nonlithified deposits are silty and generally of low hydraulic conductivity. The thickness of the nonlithified sediments increases substantially from southeast to northwest, attaining a probable thickness of over 300 ft (fig. 2).

Metamorphic rocks (hereafter termed bedrock) underlie the nonlithified deposits. To the east of sec. 23, bedrock consists of metaclastic and metavolcanic rocks mapped as the McHugh Complex of Mesozoic age (Clark, 1972). Other types of metamorphic rock, however, may underlie the Quaternary sediments west of the Border Ranges fault zone (fig. 2; MacKevett and Plafker, 1974). This fault traverses the section from northeast to southwest and is described locally as the Knik fault by Clark (1972).

Most wells in sec. 23 tap confined sand and gravel aquifers that occur within the sequence of silty Quaternary sediments. These aquifers are a few feet thick and of limited lateral extent. If the total assemblage of sand and gravel aquifers are considered as a single confined aquifer system, maps can be constructed that show the elevations of the top (fig. 3) and the potentiometric surface (fig. 4) of the aquifer system. In this report, the maps were constructed with data from water wells drilled during 1952-85.

The contour map of the top of the aquifer system (fig. 3) shows a fairly uniform decrease in elevation from southeast to northwest across sec. 23, similar to the slope of the land surface. This contrasts with the slope of the potentiometric surface (fig. 4), which is fairly flat in the southeast and northwest parts of the section but dips steeply to the northwest through the central part. This suggests that the average transmissivity of the aquifer system in the central part of the section is low relative to areas to the northwest and southeast. The close proximity of the area of the inferred low to the Border Ranges fault zone suggests that the fault may have an influence on the hydraulics of the Quaternary aquifer system.

Correlation of data from well logs has resulted in the identification of several aquifers in sec. 23 (fig. 3). Two of these aquifers, herein informally called the Raven Woods and Alpine Woods aquifers, are important to the characterization of the Alpine Woods water system. Where the mapped aquifers occur in close proximity, water-level data (fig. 4) were used to differentiate the aquifers. Horizontal hydraulic gradients within the aquifers are generally <0.1; horizontal gradients between aquifers are generally >0.1.

EFFECTS OF HISTORICAL GROUND-WATER EXTRACTION

To estimate the effects of historic ground-water extraction in the SW¼ of sec. 23, water-level measurements were made in private domestic wells and

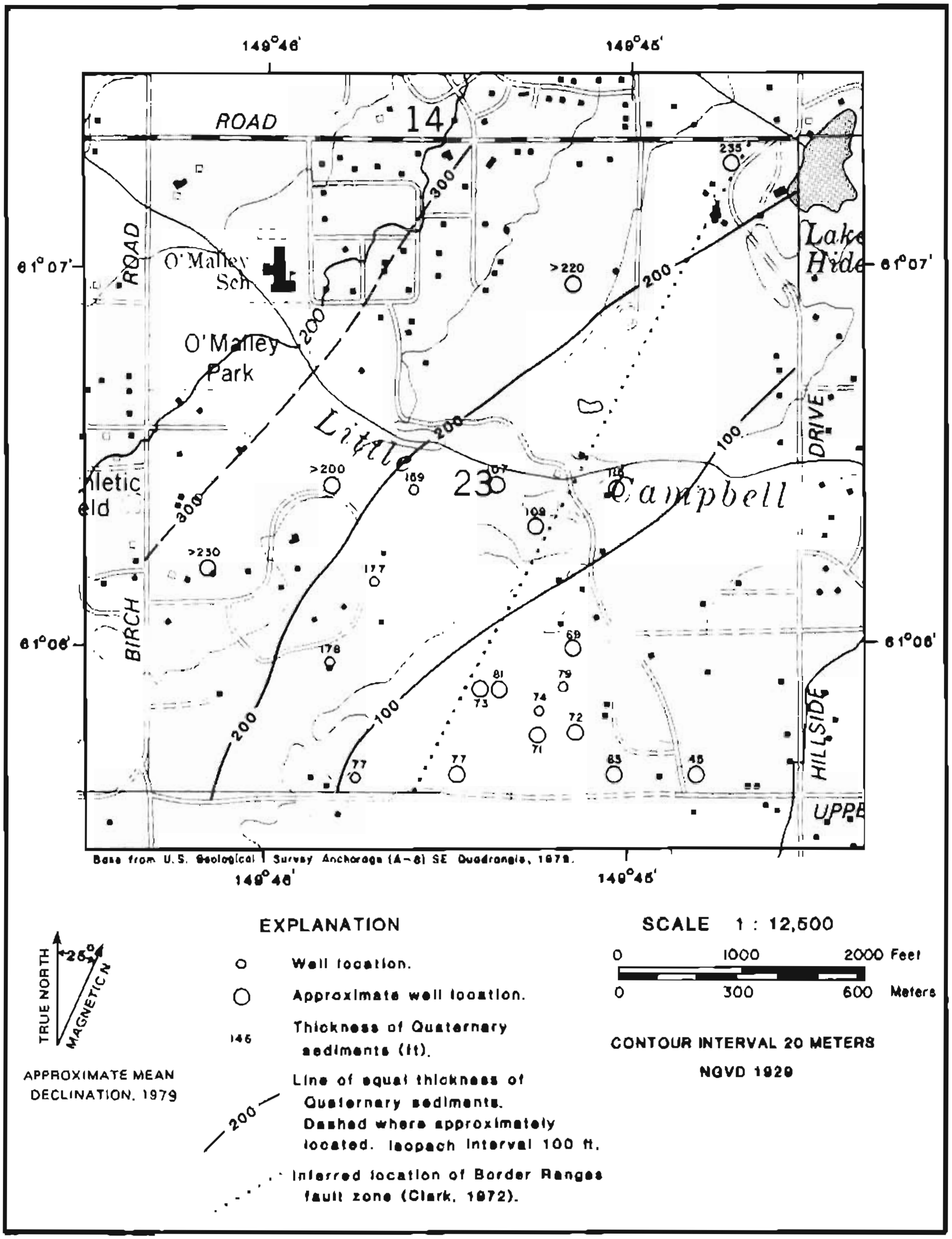

Figure 2. Isopach map of Quaternary sediments in study area.

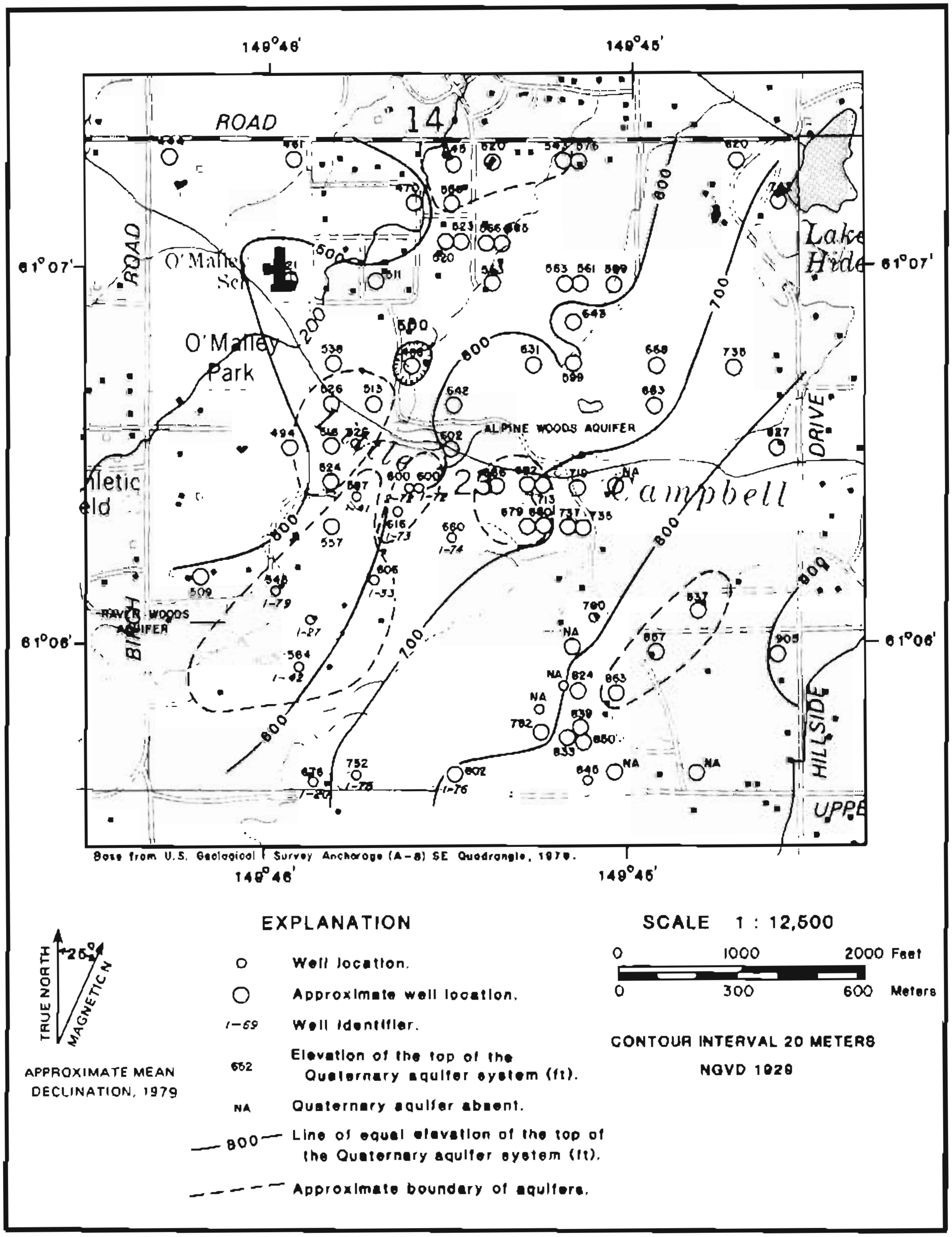

Figure 3. Contour map of top of Quaternary aquifer system in study area.

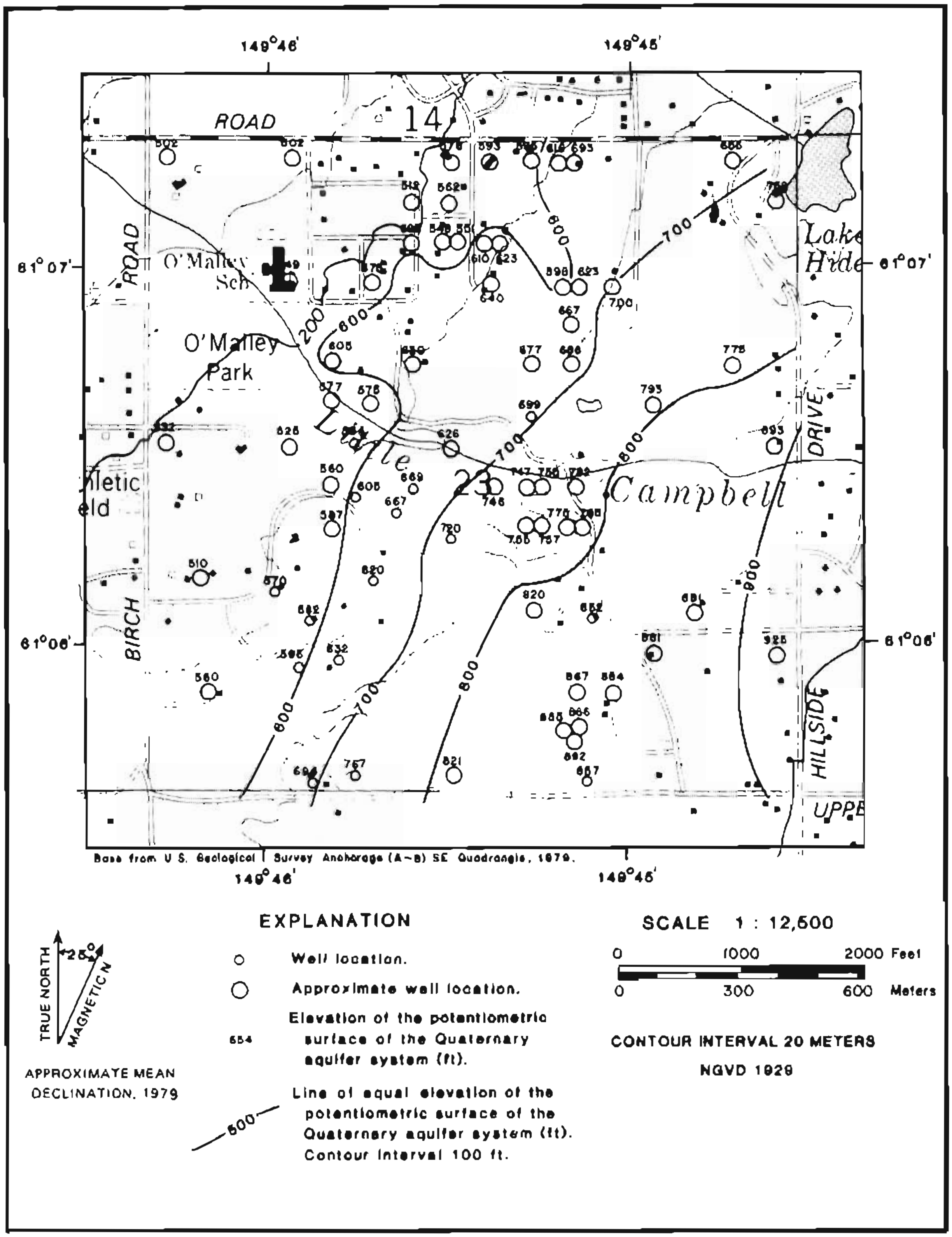

Figure 4. Potentiometric map of Quaternary aquifer system in study area.

compared, where possible, to water levels reported by drillers at the time of well construction. Table 1 summarizes the results, which exhibit no significant trend of increasing or decreasing water levels in the area. Thus, historic ground-water pumpage is concluded to have had insignificant effect on water levels in wells in the vicinity of Alpine Woods subdivision.

Table 1. Comparison of water-level data obtained during 1985 with reported data from previous years.

Well identifier[a]	Depth to water (ft below land surface)	Date measured	Water-level rise (+) or drop (-) (ft)
1-72	65	05/16/83	
	65.4	09/12/85	-0.4
1-73	90	10/25/76	
	87.7	06/24/85	+2.3
1-41	142	12/28/76	
	139.1	06/24/85	+2.9
1-33	149	09/21/78	
	150.4	09/25/85	-1.4
1-79	161	04/09/69	
	160.2	07/09/85	+0.8
1-27	164	08/25/75	
	167.4	06/25/85	-3.4
1-42	169	05/15/76	
	162.4	06/25/85	+6.6
1-20	116	07/08/65	
	111	12/03/79	+5.0
	112.1	06/20/85	-1.1

[a]See figure 3 for location of wells.

ALPINE WOODS WATER SYSTEM

The Alpine Woods water system uses well 1-72 as a primary source and well 1-74 as a backup source. Wells 1-75 and 1-76 are not connected to the distribution system. Well 2-72, which was abandoned as a production well because a screen could not be properly set, is an observation well located 0.2 ft from well 1-72; well 1-72 and 2-72 are of similar depths. Wells 1-72, 2-72, and 1-73 tap the Alpine Woods aquifer. The Raven Woods aquifer is tapped by numerous other domestic wells in the area. (See fig. 3.)

ALPINE WOODS AQUIFER TEST 1

On June 26, 1985, an aquifer test was conducted using well 1-72 as the production well. Water was discharged through the Alpine Woods water system to an outlet located about 0.5 mi from the production well. The test was terminated after about 8 hr of pumping at an average rate of about 50 gallons per minute (gpm) because of large irregularities in the pumping rate, including several pumping shutdowns. The maximum drawdown noted in observation well 1-73 was 37 ft. A standard projection of drawdown by the Theis method (1935), using aquifer coefficients estimated from the test data, suggested that wells 1-73 and 1-72 would both fail if well 1-72 was pumped at a rate of 27,000 gpd. This result prompted more extensive and better controlled testing of the Alpine Woods aquifers to evaluate the effects of boundary conditions on long-term aquifer performance.

ALPINE WOODS AQUIFER TESTS 2 AND 3

A second test of the Alpine Woods aquifer was conducted from September 25 to 27, 1985, at an average rate of 16.1 gpm. The test was prematurely terminated by a power failure after 39.2 hr of pumping. The drawdown test was restarted on October 2, 1985, and was terminated on October 15, 1985, 12.8 days later. The third test was interrupted for 4 hr on October 8 by a power failure. Data collected from well 2-72 during tests 2 and 3 are shown in figure 5. Drawdowns observed during test 3 were slightly less than drawdowns observed during test 2, which corresponds with the slightly lower rate of pumping of well 1-72 during test 3. Drawdowns observed during the latter parts of tests 2 and 3 were not as large as were expected, probably because the Alpine Woods aquifer received water from leaky confining beds during the test.

Detailed drawdown data were collected for well 1-73 during the early part of test 2 but were not collected during the early part of test 3. With an adjustment of the data from test 2 for the slightly higher pumping rate, the data from tests 2 and 3 were superimposed (fig. 6) and then analyzed as if a single aquifer test had been conducted. Using the leaky confined-aquifer type-curve method of Cooper (1963), as described by Lohman (1972), values of transmissivity (T) of 69 ft^2/day and storativity (S) of 2.6×10^{-5} were calculated. Cooper's (1963) method is based on vertical flow to a confined aquifer (such as the Alpine Woods aquifer) through a confining bed of thickness b' with a vertical hydraulic conductivity K'. Given a distance r from the pumping well, the dimensionless parameter $v = r/2\ (K'/b'T)^{\frac{1}{2}}$ can be determined from the curve-matching technique. The value of v determined from the data in figure 6 is 0.06. The parameters T, S, and v can be used to estimate the effects of extracting water from the Alpine Woods aquifer at rates and durations of pumping that are different from rates and durations used during the aquifer tests.

To assess the effects on the Raven Woods aquifer of extracting water from the Alpine Woods aquifer, water-level data were collected from wells 1-41 and 1-42 during the October 2 to 15, 1985, test. The data are shown in figure 7 along with data collected at wells 1-75 and 2-72, which illustrate background water-level trends in the area. Only well 1-41 exhibited a declining water-

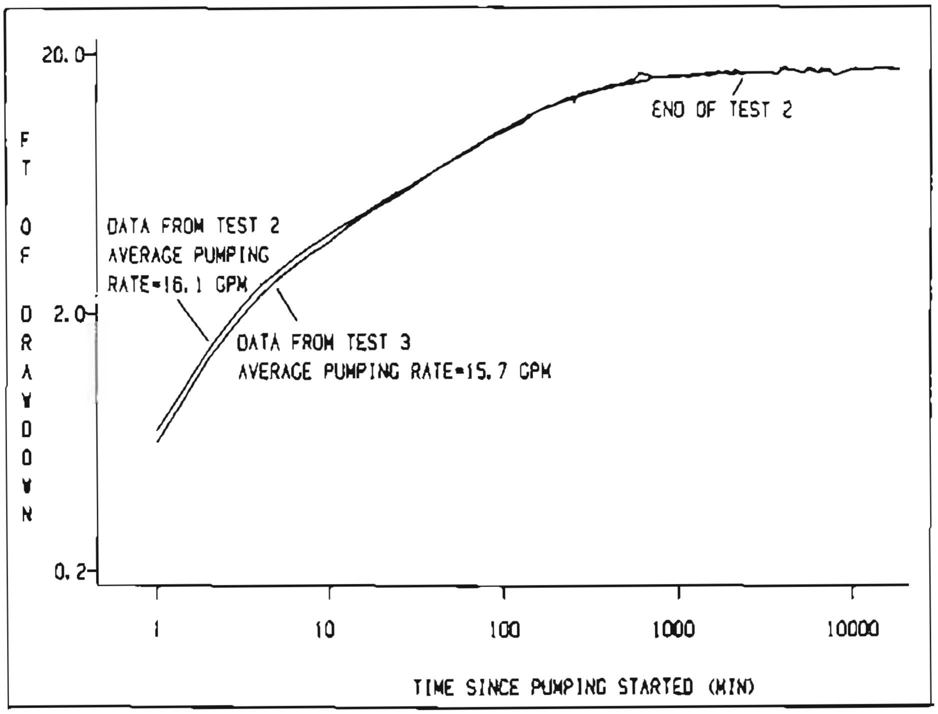

Figure 5. Drawdown data collected from well 2-72 during tests 2 and 3. See figure 3 for location of well.

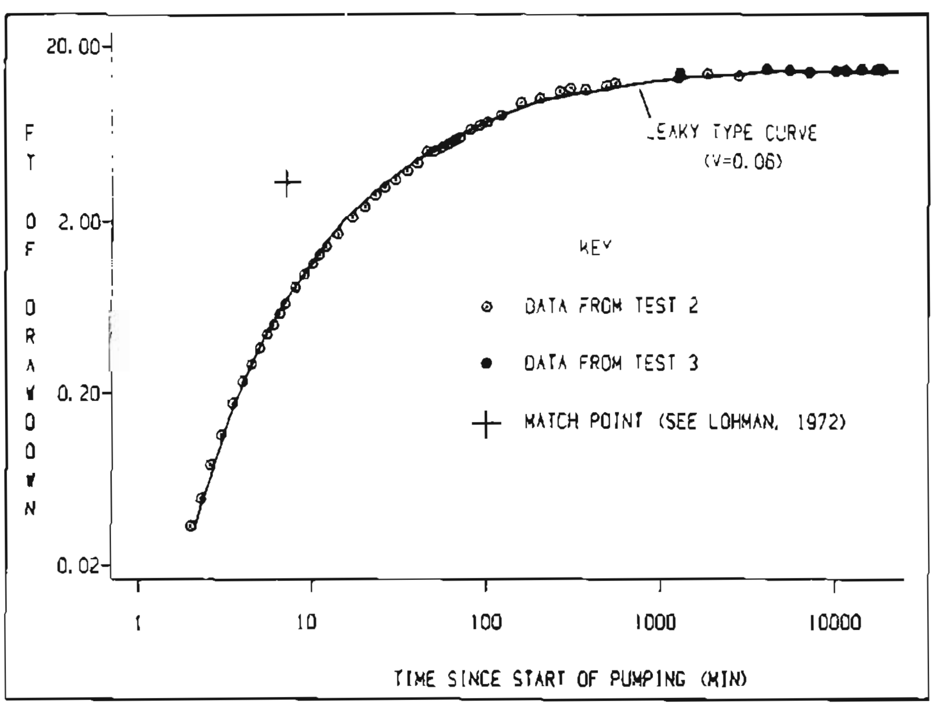

Figure 6. Drawdown data collected from well 1-73 during tests 2 and 3. See figure 3 for location of well.

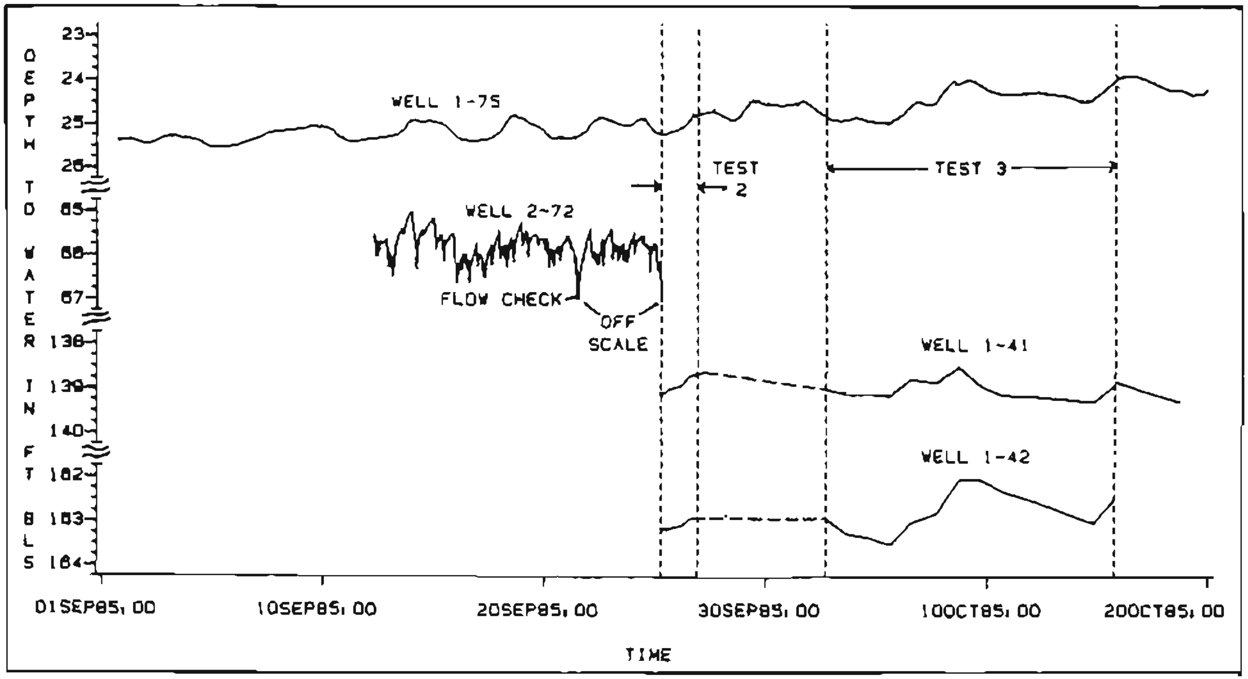

Figure 7. Water-level data collected from selected wells. See figure 3 for location of wells.

level trend during the test period, although the average rate of decline, about 0.02 ft/day, was small. The trend is not of sufficient magnitude to be attributable to pumping at well 1-72.

ESTIMATES OF POTENTIAL DRAWDOWN

The medium-term drawdown in the Alpine Woods aquifer can be estimated by using the aquifer coefficients described previously and the leaky aquifer methodology of Cooper (1963). By extracting an average 27,000 gpd of water (18.75 gpm) from well 1-72, drawdown in well 1-73 would be expected to stabilize at about 16 ft of drawdown. Cooper's (1963) theory must be applied cautiously to the Alpine Woods setting, however, because the local geology differs in several ways from geologic conditions of the theory.

Whereas Cooper's (1963) theory is modeled on an infinite aquifer confined by one impermeable unit and one semi-permeable unit, the Alpine Woods aquifer is bounded laterally, above, and below by semi-permeable units. The theory also assumes that an unlimited source of water occurs on the other side of the semi-permeable confining unit. Most likely, however, water in the Alpine Woods aquifer is drawn in part from another aquifer that is subject to drawdown in response to withdrawal of water from the Alpine Woods aquifer. In view of these differences, long-term water-level declines, in addition to those described previously, may occur in the Alpine Woods aquifer or adjacent aquifers as a result of extracting 27,000 gpd of water from well 1-72.

Two observations are relevant to the estimation of long-term drawdowns that may result from extracting 27,000 gpd from well 1-72. First, as noted previously, the existing population in the vicinity of Alpine Woods subdivision has not caused an observable water-level decline in the area. Second, the proposed population of Alpine Woods subdivision is not significantly different than the existing population of the surrounding area. These two factors suggest that long-term drawdowns may not occur in or near Alpine Woods subdivision in response to the proposed extraction. If development of the Alpine Woods aquifer proceeds, the acquisition of additional water-level and water-use information will be critical to identifying and assessing any long-term drawdown effects.

ACKNOWLEDGMENTS

Martin Kjelstad (Alaska Development Consultants, Inc.) assisted with the logistics of the aquifer tests, and residents of the area greatly cooperated during collection of the water-level data. Steve Mack (DGGS) provided an able review of the manuscript.

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