LIST OF FIGURES

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

By

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INTRODUCTION

The privately-owned Alpine Woods water system was constructed during 1983 and 1984 to provide water from wells to a planned subdivision of 54 single-family homes in the Hillside area of South Anchorage. The occurrence of long-term water-level declines and residential well failures at lower Hillside locations (Dearborn and Munter, 1985; Munter, 1985) has caused concern regarding the effects of new developments in the area. An application by the owner of the Alpine Woods water system to the Alaska Division of Land and Water Management for a permit to extract 27,000 gallons per day (gpd) of water prompted a hydrogeologic study of section 23, T12N, R3W, SM, where the Alpine Woods water system is located (fig. 1). The objectives of the study were to determine the effects, if any, 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 of 27,000 gpd from the Alpine Woods wells.

HYDROGEOLOGY

Section 23 is located in a foothills area between the Chugach Mountains and the metropolitan lowland area of Anchorage (Barnwell and others, 1972). Surficial deposits are mapped as Quaternary-age glacial, marine, and alluvial deposits (Schmoll and Dobrovolny, 1972), with much of the section exhibiting knob and kettle topography indicative of a glacial moraine. Examination of local exposures and logs of water wells submitted by drillers suggests that most of the nonlithified deposits are silty and of generally low hydraulic conductivity. The thickness of nonlithified sediments increases substantially

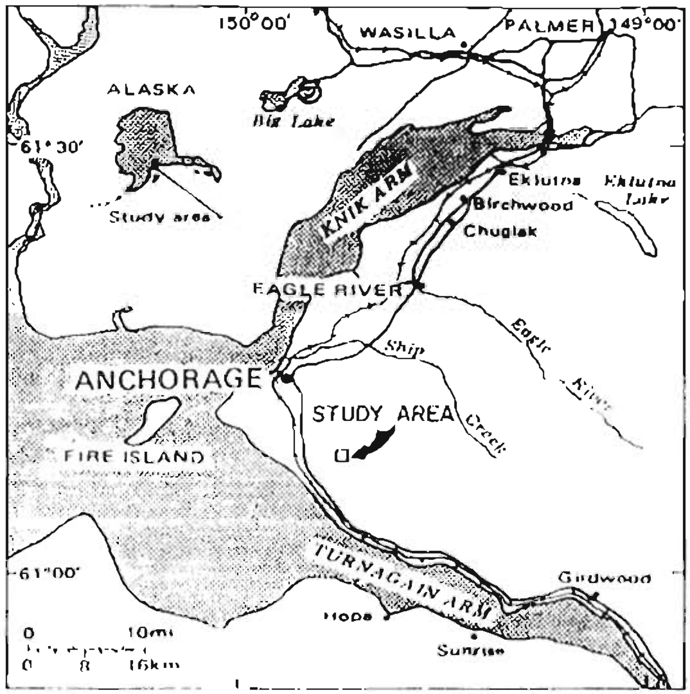

Figure 1. Location of study area.

from southeast to northwest, attaining a probable thickness of over 300 ft (fig. 2).

Metamorphic rocks (hereafter termed "bedrock") underlie the nonlithified deposits. Although bedrock to the east of section 23 is mapped as the Mesozoic-age McHugh Complex, consisting of metaclastic and metavolcanic rocks (Clark, 1972), the Border Ranges fault zone (MacKevett and Plafker, 1974), described locally as the Knik fault by Clark (1972), traverses the section. Other metamorphic rock types may occur beneath the Quaternary sediments in section 23 west of the Border Ranges fault zone.

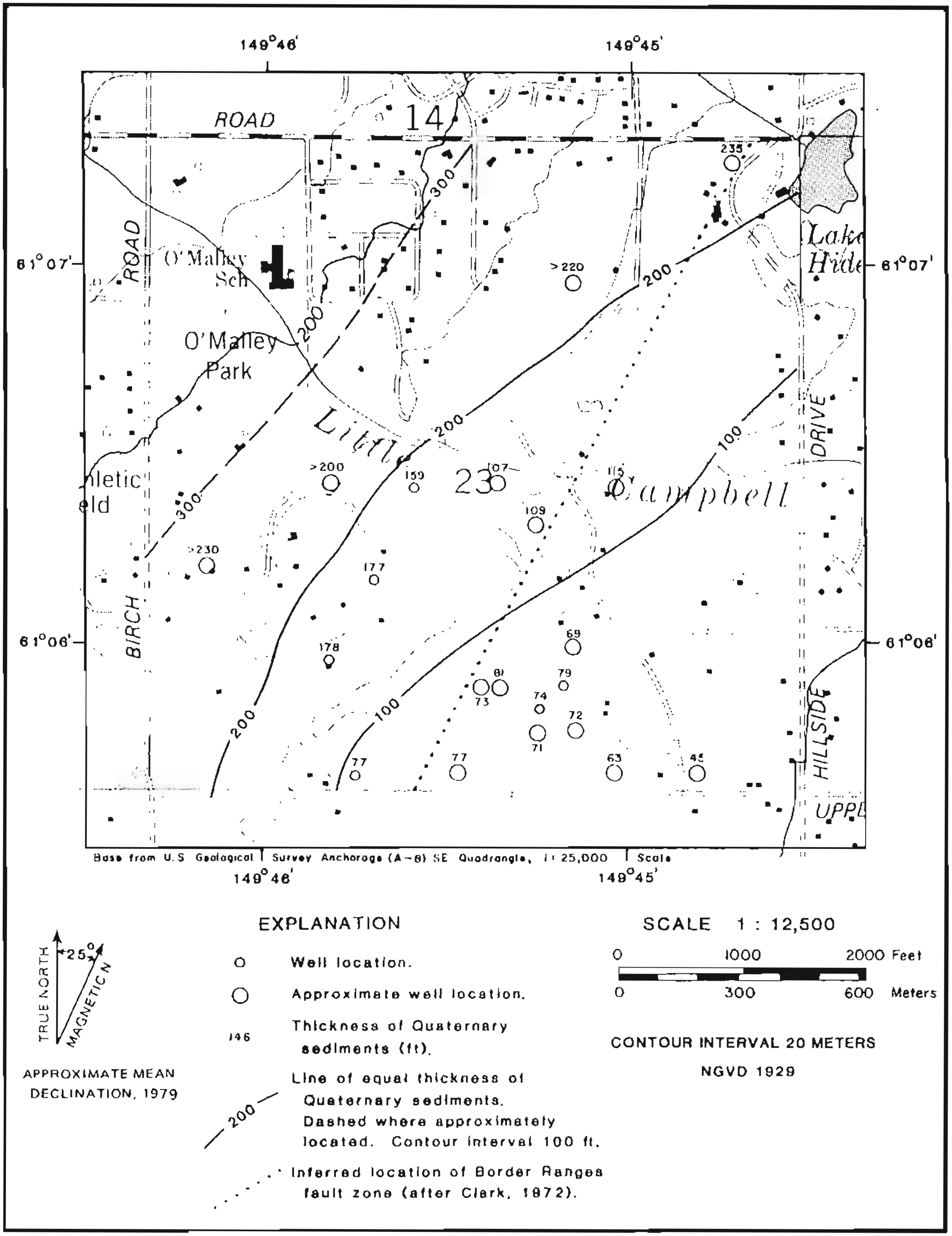

Figure 2. Thickness of Quaternary sediments in the study area.

Most wells in section 23 obtain water from confined sand and gravel aquifers a few feet thick and of limited lateral extent within the sequence of silty sediments. By considering the total assemblage of sand and gravel aquifers as a single confined aquifer system, maps showing the altitudes of (1) the top of the aquifer system and (2) the potentiometric surface (fig. 3, fig. 4) can be constructed. The maps utilize data from drillers' logs of water wells drilled from 1952-1985.

The structure contour map of the top of the aquifer system (fig. 3) shows a fairly uniform decrease in altitude from southeast to northwest across section 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 and dips steeply through the central part of the section. This suggests that the average transmissivity of the aquifer system surface in the vicinity of the steeply inclined portion of the potentiometric surface is low, relative to areas to the northwest and southeast. The close proximity of the area of inferred low transmissivity to the Border Ranges fault zone suggests that the fault zone 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 section 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.

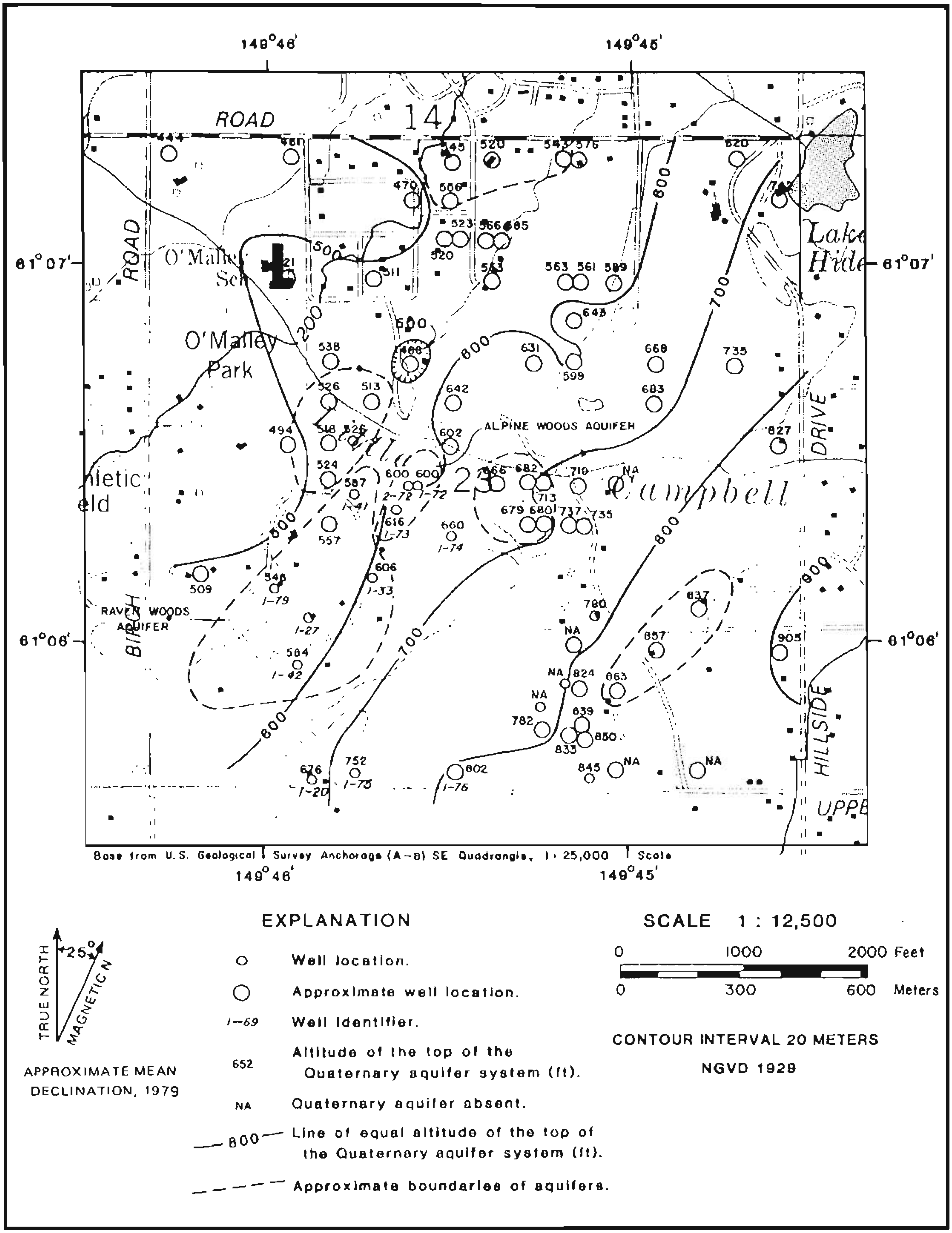

Figure 3. Structure contour map of the top of the Quaternary aquifer system.

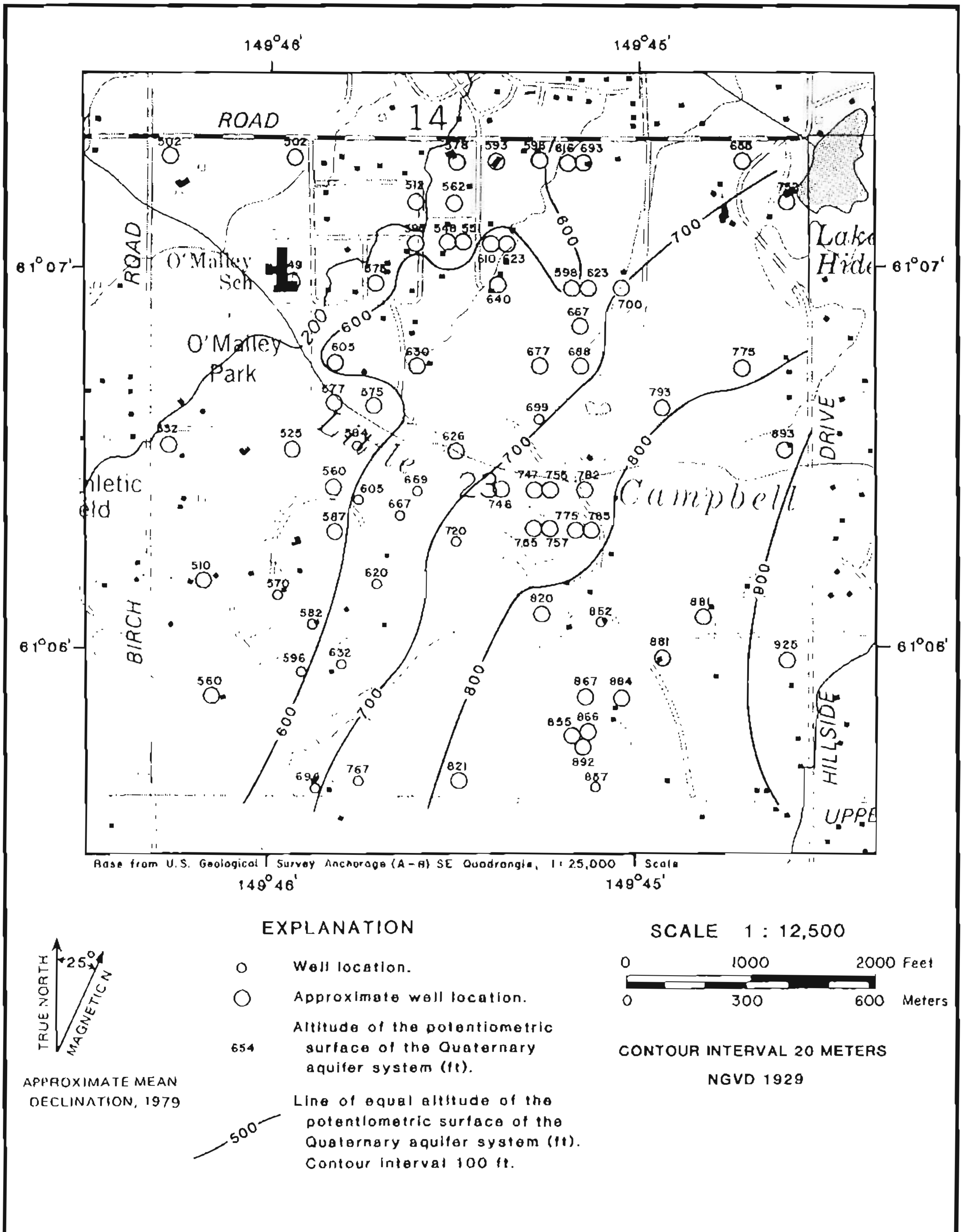

Figure 4. Potentiometric surface of the Quaternary aquifer system.

EFFECTS OF HISTORICAL GROUND-WATER EXTRACTION

To estimate the effects of historical ground-water extraction in the SW¼ of section 23, measurements were made in private domestic wells and compared, where possible, to water levels reported by drillers at the time of well construction. Table 1 summarizes the results.

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

Well identifier*	Depth to water (ft below land surface)	Date measured	Feet of water-level rise (+) or drop (-)
1-71	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

* See figure 3

The data shown in Table 1 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.

ALPINE WOODS WATER SYSTEM

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

ALPINE WOODS AQUIFER TEST 1

On June 26, 1985, an aquifer test was conducted using well 1-72 as the production well, with discharge of water through the Alpine woods water system to an outlet located about 0.5 mi from the production well. The test was terminated after approximately 8 hrs of pumping at an average rate of about 50 gpm because of large irregularities in the pumping rate, including several pumping shutdowns. The maximum drawdown observed in well 1-73 was 37 ft. Aquifer coefficients estimated from the test data suggested that a standard projection of drawdown by the Theis Method (1935), which does not consider the effects of aquifer boundary conditions, would result in the failure of both well 1-73 and 1-72 with a pumping rate of 27,000 gpd from well 1-72. The effects of boundary conditions could not be identified because of the short duration of the test.

ALPINE WOODS AQUIFER TESTS 2 AND 3

A second test of the Alpine Woods aquifer was conducted September 25-27, 1985, at an average rate of pumping of 16.1 gpm. The test was unexpectedly and prematurely terminated by a power failure after 39.2 hrs of pumping. The test was restarted on October 2, 1985, and was terminated on October 15, 12.86 days later. This third test was interrupted by a power failure for 4 hrs on October 8. Data collected from well 2-72 from tests 2 and 3 are shown in figure 5. Drawdowns observed during test 3 were slightly less than drawdowns observed during test 2, corresponding 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. The most feasible explanation for this appears to be that the Alpine Woods aquifer received water from leaky confining beds during the test.

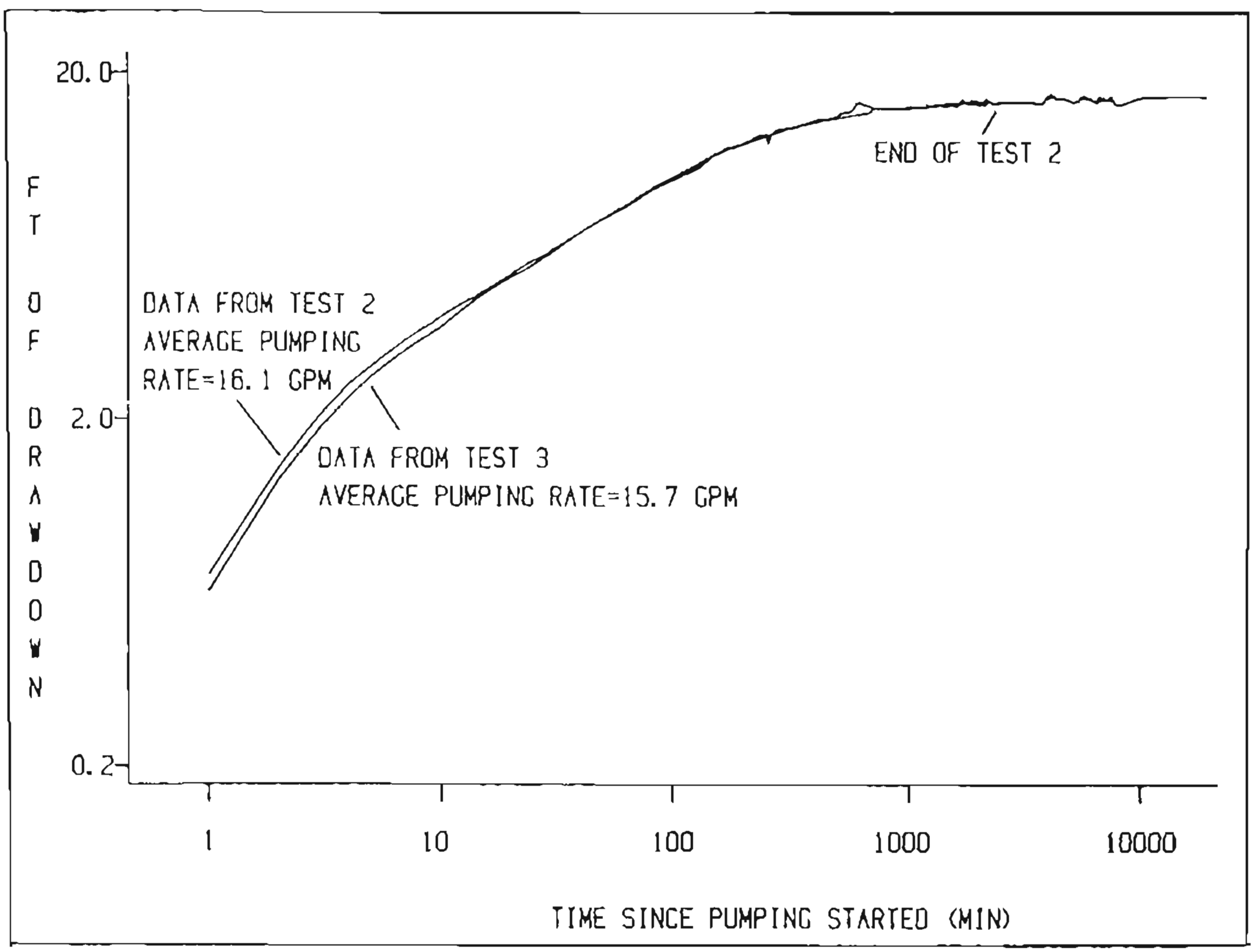

Figure 5. Drawdown data collected from well 2-72 during tests 2 and 3.

Detailed drawdown data were collected in well 1-73 during the early portion of test 2, but were not collected during the early portion 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 are superimposed on figure 6 and are 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 X 10^{-5} are 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'. At 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 than the rates and durations utilized during the aquifer tests.

In order to assess the effects of extracting water from the Alpine Woods aquifer on the Raven Woods aquifer, water-level data were collected from wells 1-41 and 1-42 during the October 2-15, 1985 test. The data are shown in figure 7, along with data collected at well 1-75 and well 2-72, which illustrate background water-level trends in the area. Only well 1-41 exhibited a declining water level trend during the test period, and the average rate of decline, about 0.02 ft/day, is small. The trend is not of sufficent magnitude to be attributed conclusively to pumping at well 1-72.

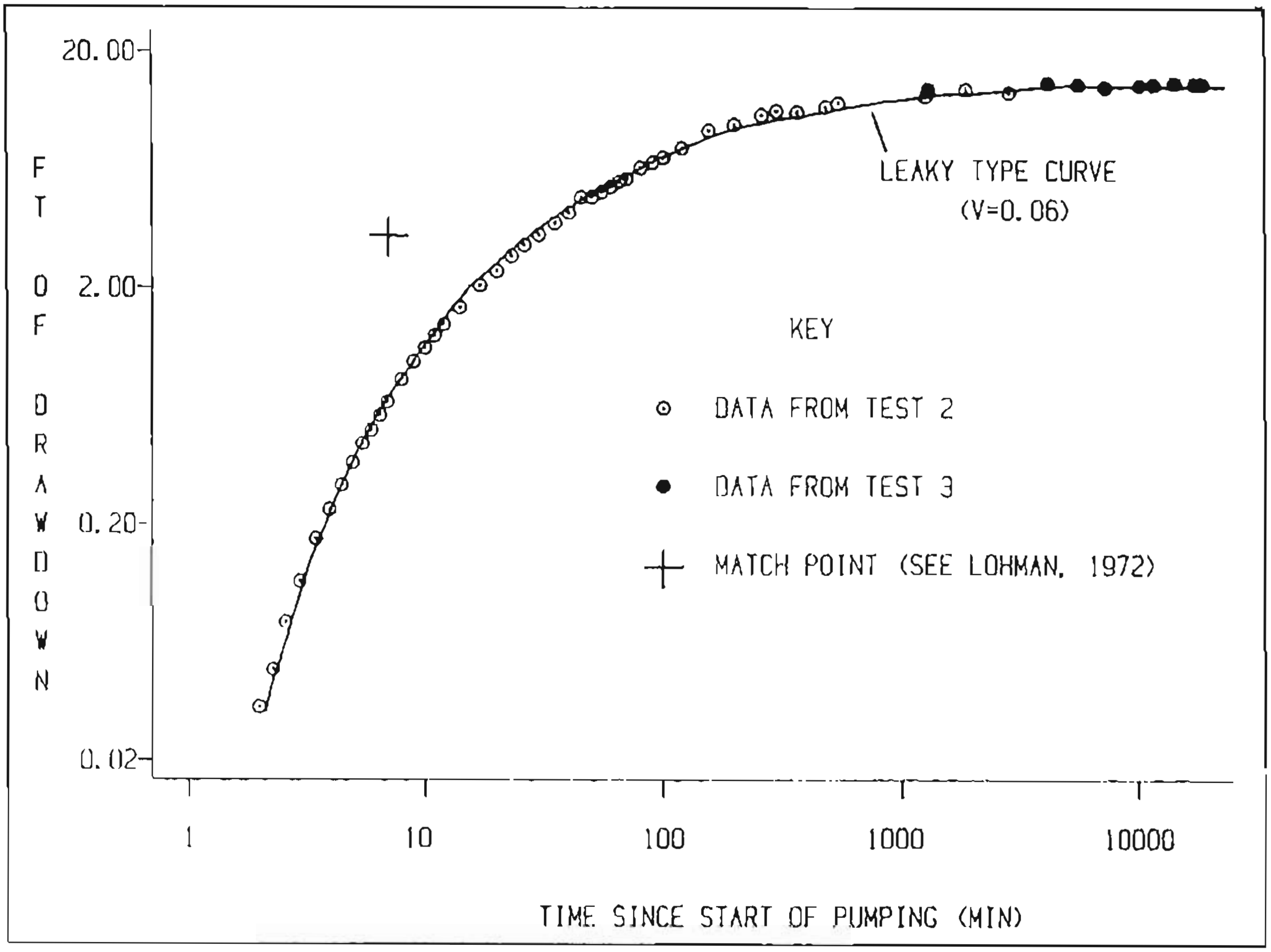

Figure 6. Drawdown data collected from well 1-73 during tests 2 and 3.

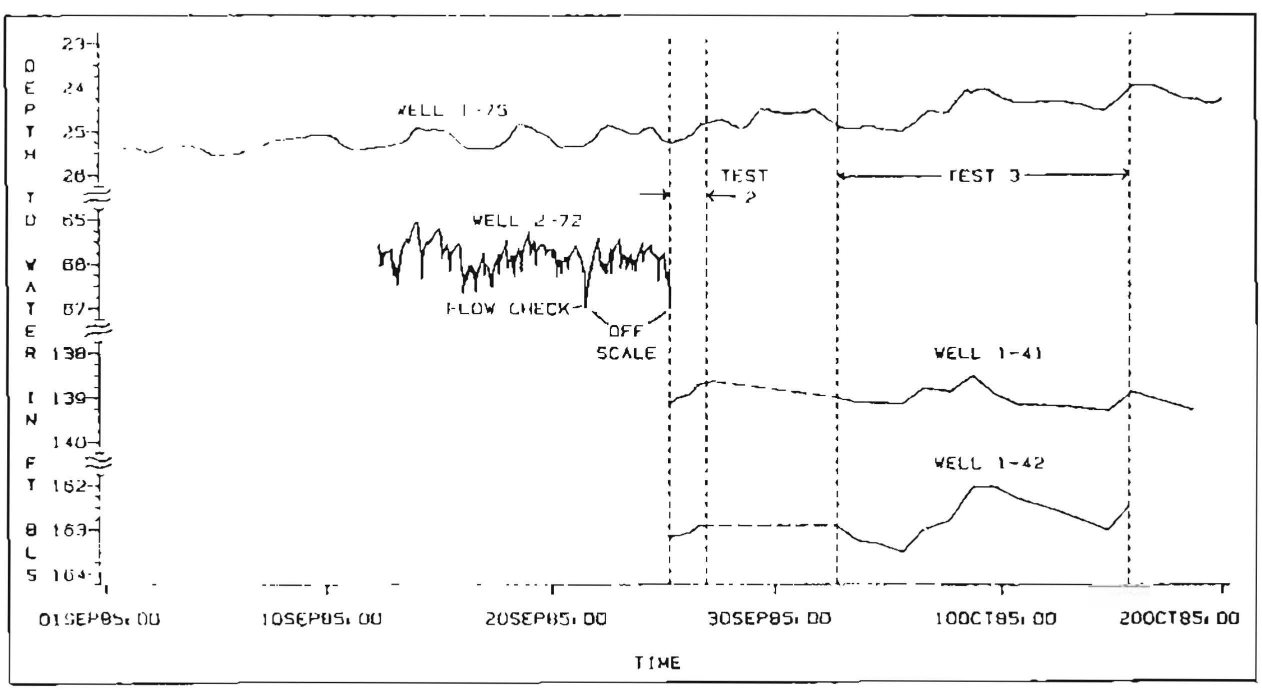

Figure 7. Water-level data collected from selected wells. Locations from fig. 3.

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 approximately 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 conditions of the theory.

While Cooper's (1963) theory is modeled on an infinite aquifer confined by one impermeable confining unit and one semi-permeable confining unit, the Alpine Woods aquifer is bounded laterally, above, and below by semi-permeable confining units. The theory also assumes that an unlimited source of water occurs on the other side of the semi-permeable confining bed. Most likely, however, water is obtained from another aquifer that is subject to drawdown in response to the withdrawal of water. The effect of these differences is that 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 density in the vicinity of Alpine Woods subdivision has not resulted in an observable water-level decline in the area. Second, the proposed population density of Alpine Woods subdivision is not significantly different than the existing population density 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 that may occur.

REFERENCES CITED

Barnwell, W.W., George, R.S., Dearborn, L.L., Weeks, J.B., and Zenone, Chester, 1972, Water for Anchorage, an atlas of the water resources of the Anchorage area, Alaska: City of Anchorage and the Greater Anchorage Area Borough, 77 p.

Clark, S.H.B., 1972, Reconnaissance bedrock geologic map of the Chugach Mountains near Anchorage, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-350, scale 1:250,000, 1 sheet.

Cooper, H.H., Jr., 1963, Type curves for nonsteady radial flow in an infinite leaky artesian aquifer, in Bentall, Ray, compiler, Shortcuts and special problems in aquifer tests: U.S. Geological Survey Water-Supply Paper 1545-C, p. C48-C55.

Dearborn, L.L., and Munter, J.A., 1985, Water-level declines in wells tapping lower Hillside aquifers, Anchorage, Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 85-13, 12 p.

Lohman, S.W., 1972, Ground-water Hydraulics: U.S. Geological Survey Professional Report 708, 70 p.

MacKevett, E.M., and Plafker, G., 1974, The Border Ranges fault in south-central Alaska: Journal Research, U.S. Geological Survey p. 323-329.

Munter, J.A., 1985, Water-level declines in wells in South Anchorage, a presentation to the Alaska Water Board: Alaska Division of Geological and Geophysical Surveys Public Data File 85-35, 5 p.

Schmoll, H.R., and Dobrovolny, Ernest, 1972, Generalized geologic map of Anchorage and vicinity, Alaska: U.S. Geological Survey Map I-787-A, scale 1:24,000, 1 sheet.