GROUND-WATER CONDITIONS AND SHALLOW TEST-WELL INFORMATION IN THE EASTERN HALF OF MERCED COUNTY, CALIFORNIA, 1977-82

By Ann L. Elliott

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CONVERSION FACTORS

For readers who may prefer to use International System of Units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
acres	0.4047	hectares
acre-ft (acre-feet)	0.001234	cubic hectometers
ft (feet)	0.3048	meters
in (inches)	25.4	millimeters
mi (miles, statute)	1.609	kilometers
mi^2 (square miles)	2.590	square kilometers

GROUND-WATER CONDITIONS AND SHALLOW TEST-WELL INFORMATION IN THE EASTERN HALF OF MERCED COUNTY, CALIFORNIA, 1977-82

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ABSTRACT

The city of Merced, other municipalities, and many irrigators in the vicinity of Merced in the San Joaquin Valley of California depend on ground water for water supply. Water-level data for 1977-81 show that there has been no significant change in water levels, indicating that during this period, recharge in the project area balances natural discharge and withdrawal by pumping. Information from shallow test wells drilled around Merced indicate shallow, fine-grained material in the aquifer that could interfere with surface artificial recharge to the aquifer system. Short-term and seasonal fluctuations of water levels in wells perforated at different depths and in different aquifers show dissimilar patterns in some areas. The expansion and refinement of the observation-well network will provide a data base for water-management decisions and for assessments of ground-water conditions in the future.

INTRODUCTION

The city of Merced in the San Joaquin Valley of California (fig. 1) has recognized the need for long-term management of ground water, which is its sole water supply. To gain a better understanding of the ground-water system in the Merced vicinity, the city of Merced and the U.S. Geological Survey started a cooperative study in 1975. Preliminary findings of the study, in a 112 mi^2 area surrounding Merced (fig. 1), were presented in "Appraisal of Ground-Water Conditions in Merced, California, and Vicinity," by R. W. Page (1977). That report and another by Page and Balding (1973), described the geomorphology, geology, hydrology, and ground-water quality in the Merced vicinity.

Purpose and Scope

The purposes of this report are (1) to determine if water levels in aquifers in the Merced vicinity are declining, (2) to describe water-level fluctuations in different aquifers in response to pumping patterns, recharge, and aquifer characteristics, (3) to determine if a ground-water supply problem exists, and (4) to describe further the shallow aquifer around Merced and the feasibility of artificial recharge.

The data presented in this report include lithologic logs of shallow test wells drilled in 1977 as a part of the study, ground-water pumpage, surface-water distribution, and hydrographs of ground-water levels. This information was collected for an area of 1,129 mi^2 in the Merced vicinity (fig. 1) by local agencies, the city of Merced, and the Geological Survey.

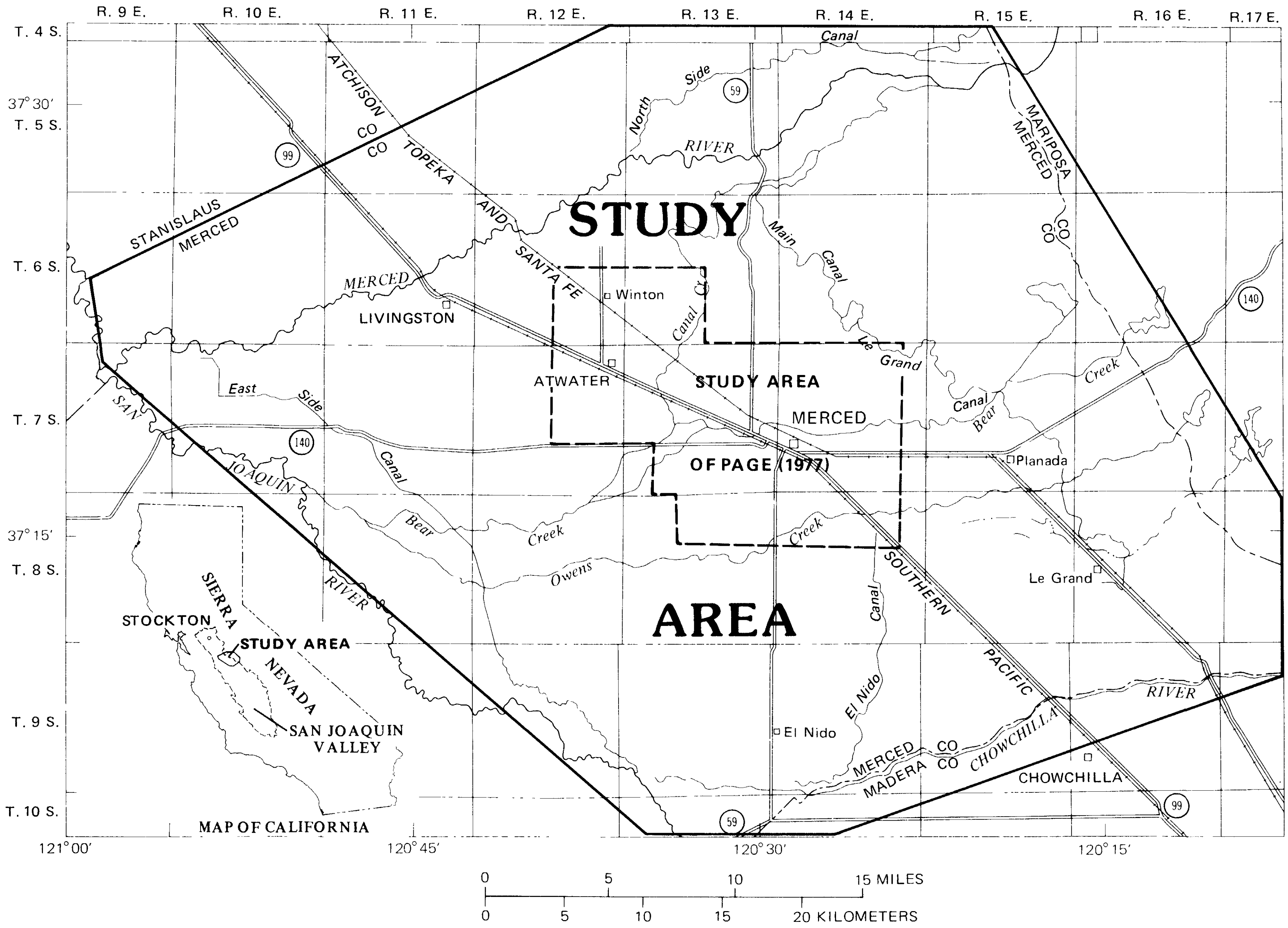


FIGURE 1. – Location of study area.

Well-Numbering System

Wells are identified according to their location in the rectangular system for subdivision of public land (fig. 2). For example, in the number 9S/13E-22A1 M, assigned to a well about 2 miles west of El Nido, the part of the number preceding the slash indicates the township (T. 9 S.) and the number between the slash and hyphen indicates the range (R. 13 E.); the digits following the hyphen indicate the section (sec. 22); the letter following the section number indicates the 40-acre subdivision of the section as shown by figure 2. Within each 40-acre tract, the wells are numbered sequentially as they are inventoried and recorded with the State of California, as indicated by the final digit. Wells not yet assigned official State numbers will not have this final digit. The final letter, separated from the rest of the number by a space, indicates the base line and meridian. Because all wells in the study area are referenced to the Mount Diablo base line and meridian (M), the final letter will be omitted.

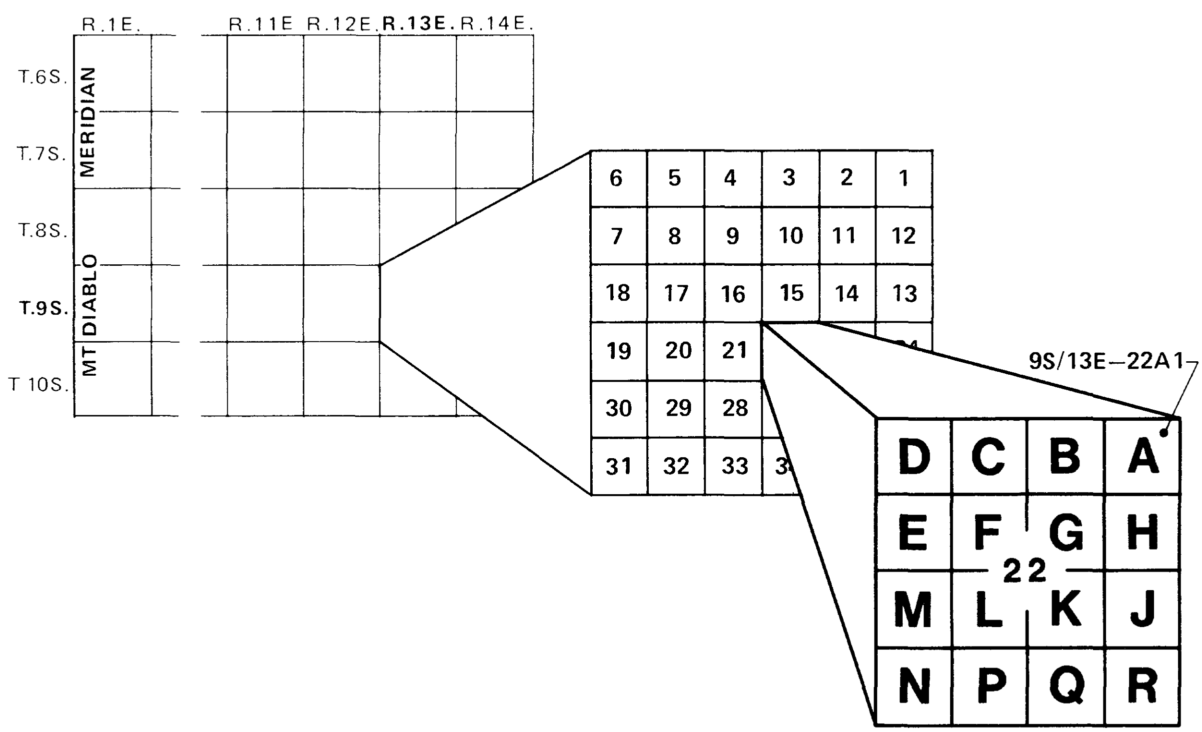


FIGURE 2. – Well-numbering system.

GEOHYDROLOGIC SETTING

The physical setting, geologic units and their water-bearing properties, and aquifer system in the Merced vicinity were described by Page and Balding (1973) and Page (1977). Included in this report is a condensed description of the geologic units and the aquifers in the study area. Lithologic logs of test wells provide information about the shallow aquifer. Maps of water-level contours show directions of ground-water flow.

Geologic Units

The study area lies mostly within the San Joaquin Valley. The eastern edge is in the foothills of the Sierra Nevada. Consolidated rocks which crop out in the foothills include the basement complex of pre-Tertiary age; the Ione Formation of Eocene age; the Valley Springs Formation of Oligocene and Miocene age; and the Mehrten Formation of Miocene and Pliocene age. The basement complex consists of igneous and metamorphic rocks; the Ione Formation principally of sandstone and conglomerate; the Valley Springs Formation of rhyolitic sandstone, siltstone, claystone, and conglomerate; and the Mehrten Formation of conglomerate, sandstone, siltstone, and claystone derived from andesite sources (Marchand and Allwardt, 1981). The consolidated sedimentary rocks dip westerly and underlie the study area. The Mehrten Formation underlies most of the study area at depth. Figure 3 is a generalized diagram of the location of the geologic units and the aquifers in an east-west cross section of the study area.

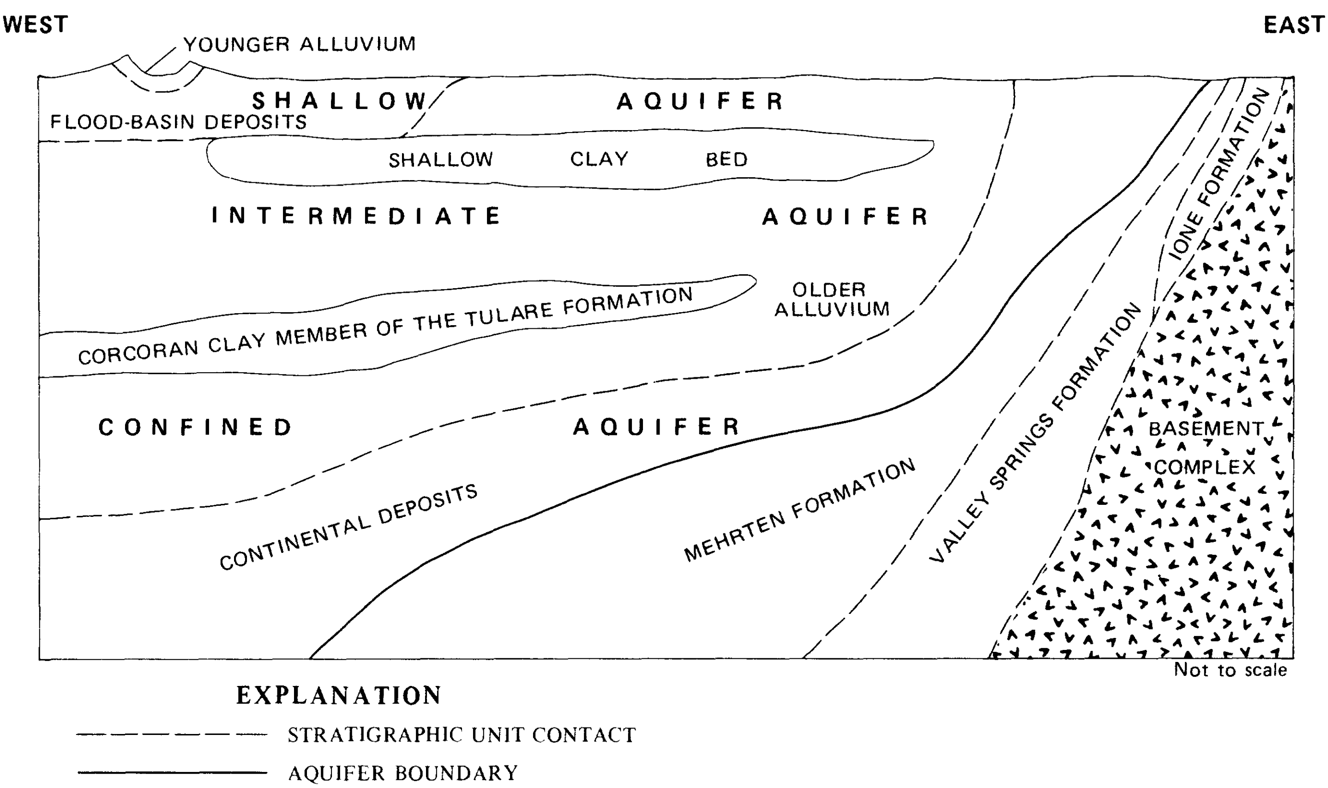


FIGURE 3. – Diagrammatic section across the central part of the study area showing geologic units and aquifers.

Unconsolidated rocks in the valley include continental deposits of Pliocene and Pleistocene (?) age, older alluvium of Pleistocene and Holocene (?) age, flood-basin deposits of Holocene age, and younger alluvium of Holocene age. The continental deposits consist of poorly sorted gravel, sand, silt, and clay. They are generally finer grained than the older alluvium which consists of intercalated beds of gravel, sand, silt, clay, and some hardpan. The continental deposits and the older alluvium each range in thickness from 0 feet near the east edge of the study area, to more than 700 feet in the southwestern part of the study area (Page and Balding, 1973, p. 23). The flood-basin deposits consist of intercalated lenses of bluish-gray, brown, and reddish-brown fine sand, silt, and clay. They occur on the surface in the southwestern quarter of the study area and range in thickness from 0 to 100 feet (Page and Balding, 1973, p. 37). The younger alluvium consists mostly of sand and gravel with little or no hardpan. It is located along stream channels in the study area and ranges in thickness from 0 to 100 feet.

At least two confining beds of lacustrine and marsh deposits occur in the subsurface. They are the Corcoran Clay Member of the Tulare Formation of Pleistocene age, and a shallow clay bed of Holocene (?) age. In the eastern part of the San Joaquin Valley, the Corcoran Clay Member is also considered to be a member of the Turlock Lake Formation of Pleistocene age (Marchand and Allwardt, 1981). The northeastern edge of the Corcoran Clay Member extends diagonally through the center of the study area (figs. 4-6). Along this edge the depth to the top of the Corcoran Clay Member ranges from less than 50 feet southeast of Merced to more than 100 feet west of Atwater; near the San Joaquin River, the depth to the top is approximately 200 feet (Page, 1977, pl. 2). The thickness of the Corcoran Clay Member ranges from 0 feet along its northeastern edge to 60 feet or more near the San Joaquin River. In places, the shallow clay bed is not well defined. In the 112 mi^2 surrounding the city of Merced, Page (1977) found that the depth to the top of the clay ranges from 10 to 35 feet and the thickness from 5 to 40 feet.

EXPLANATION TO FIGURES 4, 5, AND 6

— — — PROJECTION OF NORTHEAST EDGE OF CORCORAN CLAY MEMBER OF TULARE FORMATION AND TURLOCK LAKE FORMATION (R.W. Page, U.S. Geological Survey, written commun., 1982)

—120—?— POTENTIOMETRIC CONTOUR – Shows altitude at which water level would have stood in tightly cased wells in confined aquifer. Contour interval 10 feet. National Geodetic Vertical Datum of 1929. Contour queried where data are inconclusive

o **36J1** **108** OBSERVATION WELL IN AREA WHERE THERE ARE NOT ENOUGH DATA TO CONTOUR – Upper number is well number; Lower number is altitude of potentiometric surface, in feet. National Geodetic Vertical Datum of 1929

——— STUDY AREA

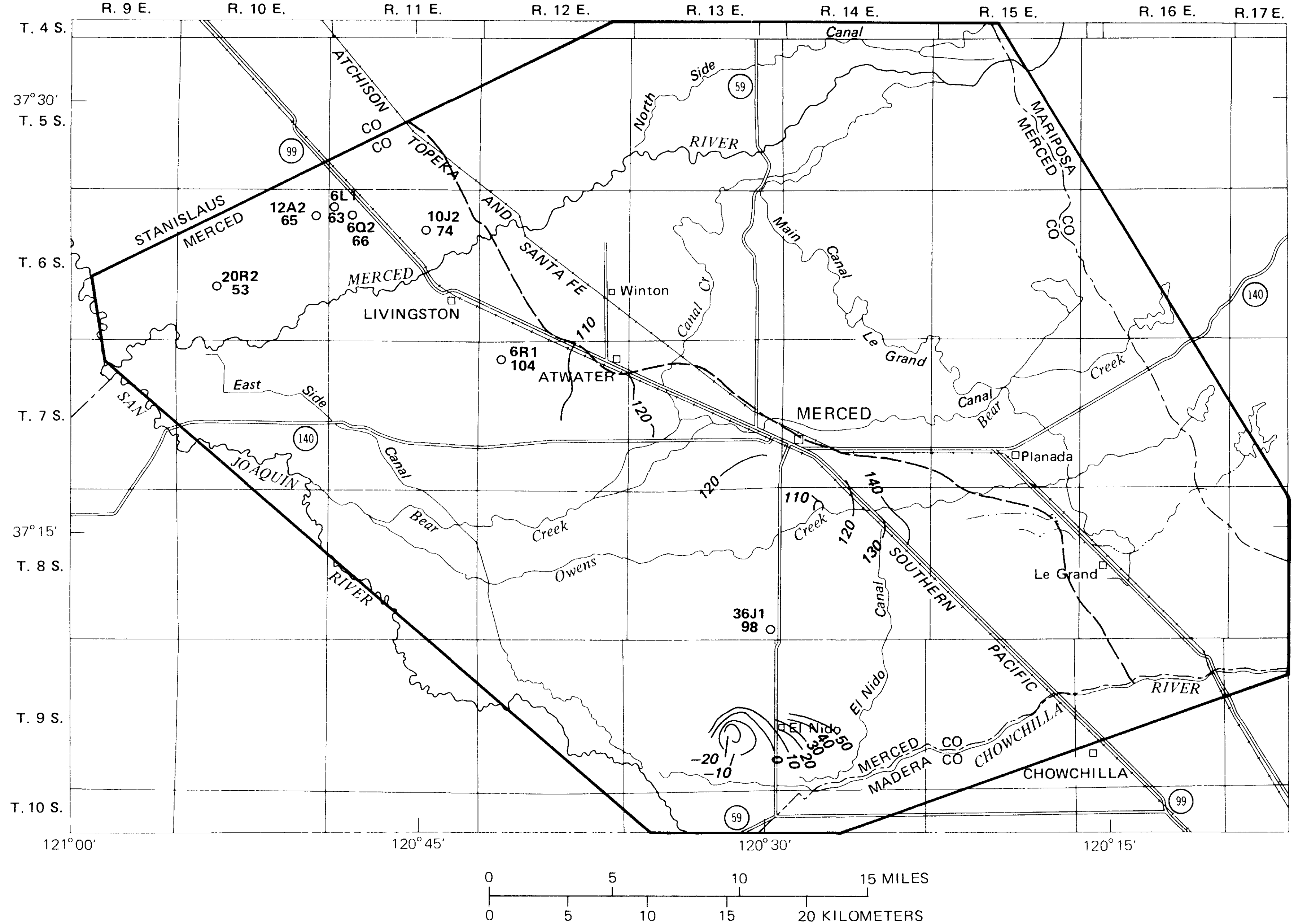


FIGURE 4. – Altitude of potentiometric surface in the confined aquifer, August 1980.

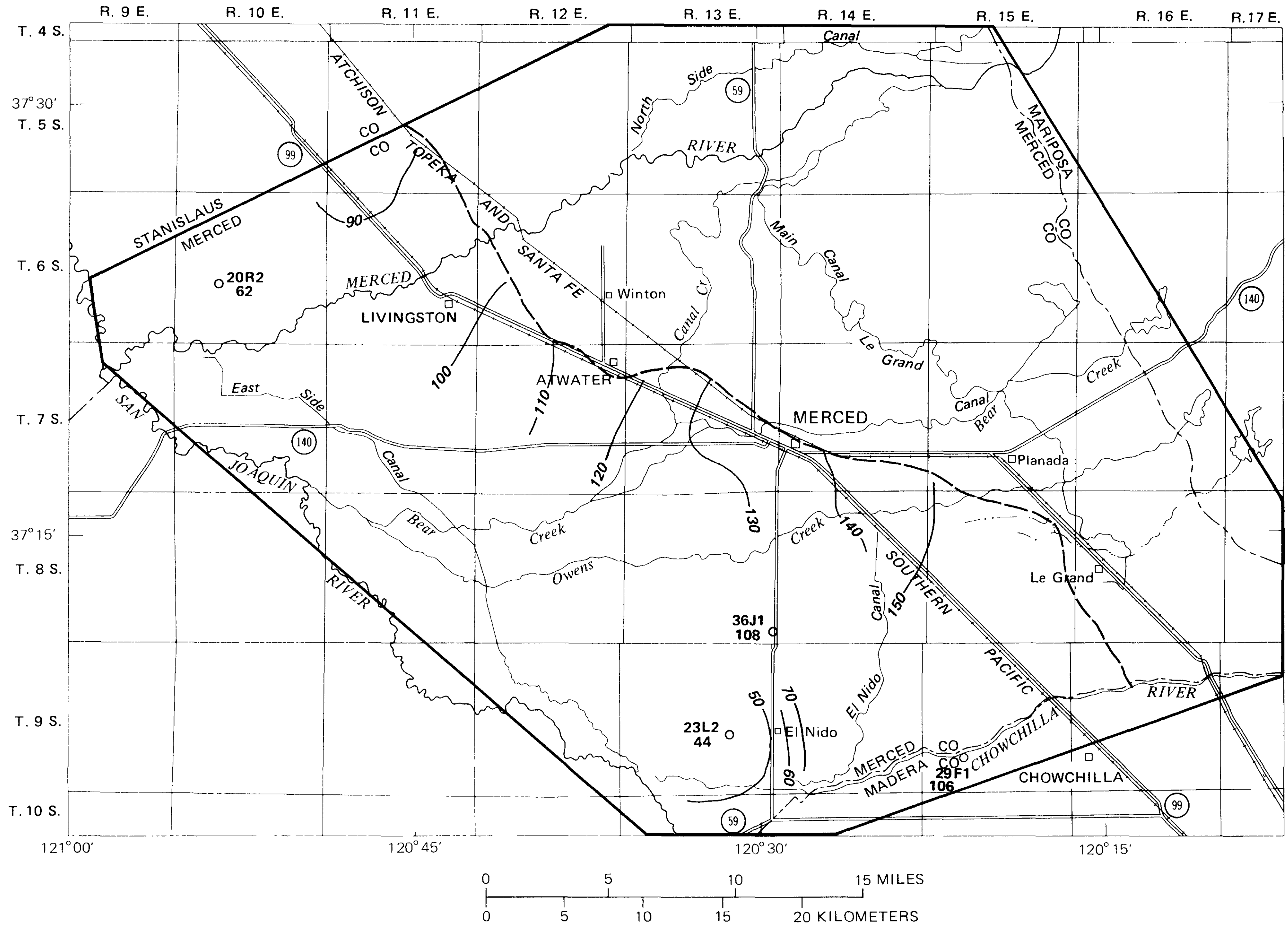


FIGURE 5. — Altitude of potentiometric surface in the confined aquifer, December 1980.

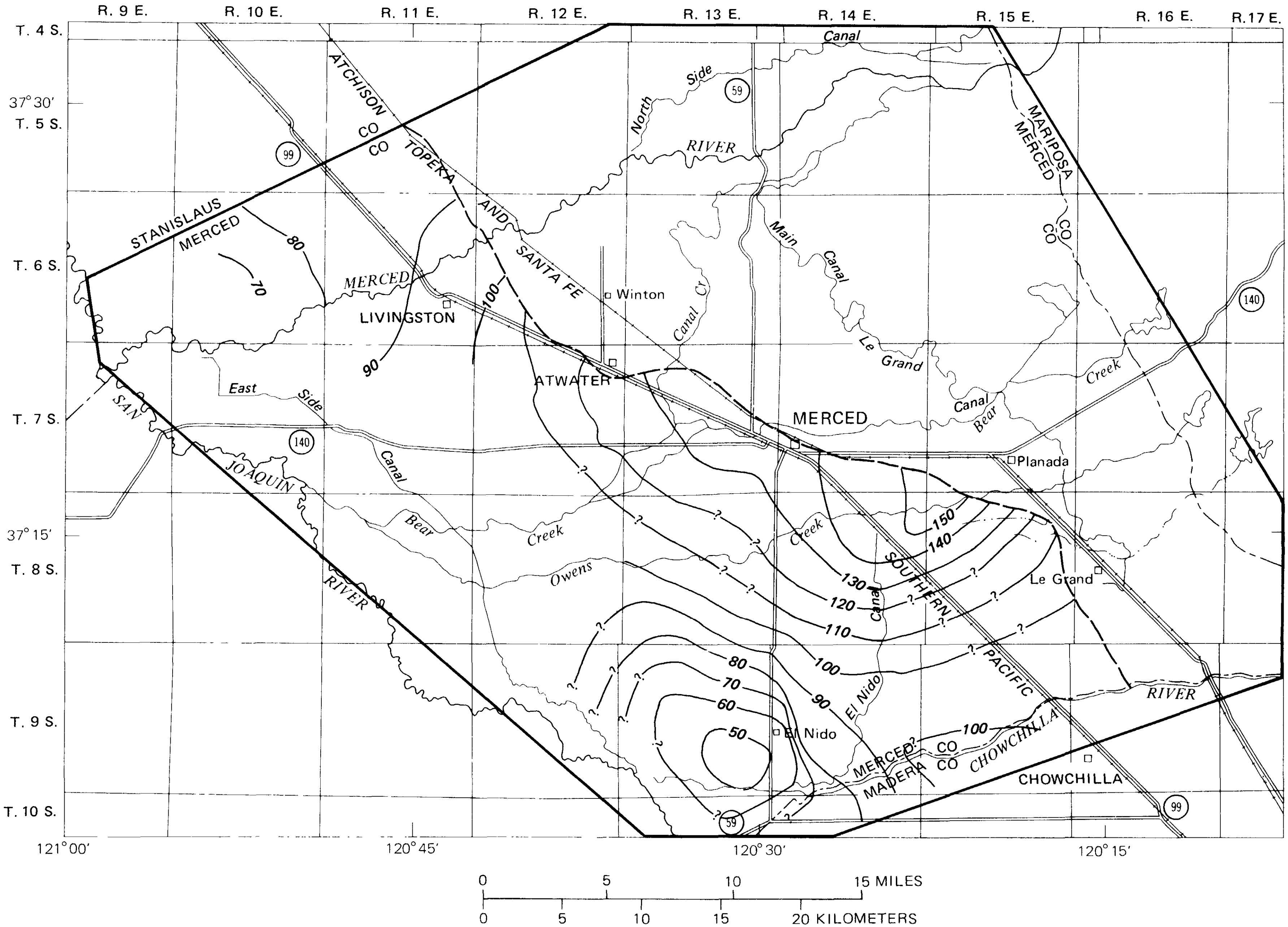


FIGURE 6. – Altitude of potentiometric surface in the confined aquifer, January and February 1982.

Aquifers

The study area has a thick section of saturated unconsolidated and consolidated sedimentary rocks consisting of the shallow, intermediate, and confined aquifers, and parts of the Mehrten Formation and other consolidated rocks (Page, 1977) (fig. 3). Observation wells in the foothills (eastern part of the study area) penetrate the consolidated rocks of the basement complex, the Ione Formation, the Valley Springs Formation, and the Mehrten Formation. Observation wells in the valley penetrate the Mehrten Formation and the unconsolidated deposits of the confined, the intermediate, and the shallow aquifers, as defined by Page (1977). The continental deposits and the older alluvium below the Corcoran Clay Member make up the confined aquifer. The intermediate aquifer consists of similar deposits above and outside the extent of the Corcoran Clay Member. The intermediate aquifer is locally confined by the shallow clay bed, but is unconfined when water levels in the aquifer fall below the shallow clay bed and where the shallow clay bed is not present. The shallow aquifer, which is unconfined, consists of older alluvium and younger alluvium above the shallow clay bed.

Shallow Test Wells

Fifteen test wells were drilled in the central part of the study area from July 25 to 28, 1977, (fig. 7) to define further the shallow aquifer and to evaluate the potential for artificial recharge. The wells were drilled with a continuous flight auger to depths of 35 to 65 feet. Drill cuttings were analyzed to make a lithologic log of each well (table 1).

Information from the test wells indicate extensive fine-grained material at a depth between 10 and 20 feet in the shallow aquifer. Some deposits of sand and other coarse-grained material occur, and in these areas water from the shallow aquifer may move down to the intermediate aquifer. Water levels in the shallow aquifer fluctuate seasonally, with the highest levels occurring during the irrigation season from June to September when water levels are commonly less than 5 feet below the land surface (Page, 1977). This pattern of fluctuation is different from patterns of fluctuation in the deeper aquifers, which generally have highest water levels in the nonpumping season. This difference indicates a separation between the shallow aquifer and the deeper ones, so that surface artificial recharge to the shallow aquifer might not greatly benefit the deeper aquifers although the vertical gradient, as indicated by comparison of water levels in Page (1977, pl. 3 and 4), is down.

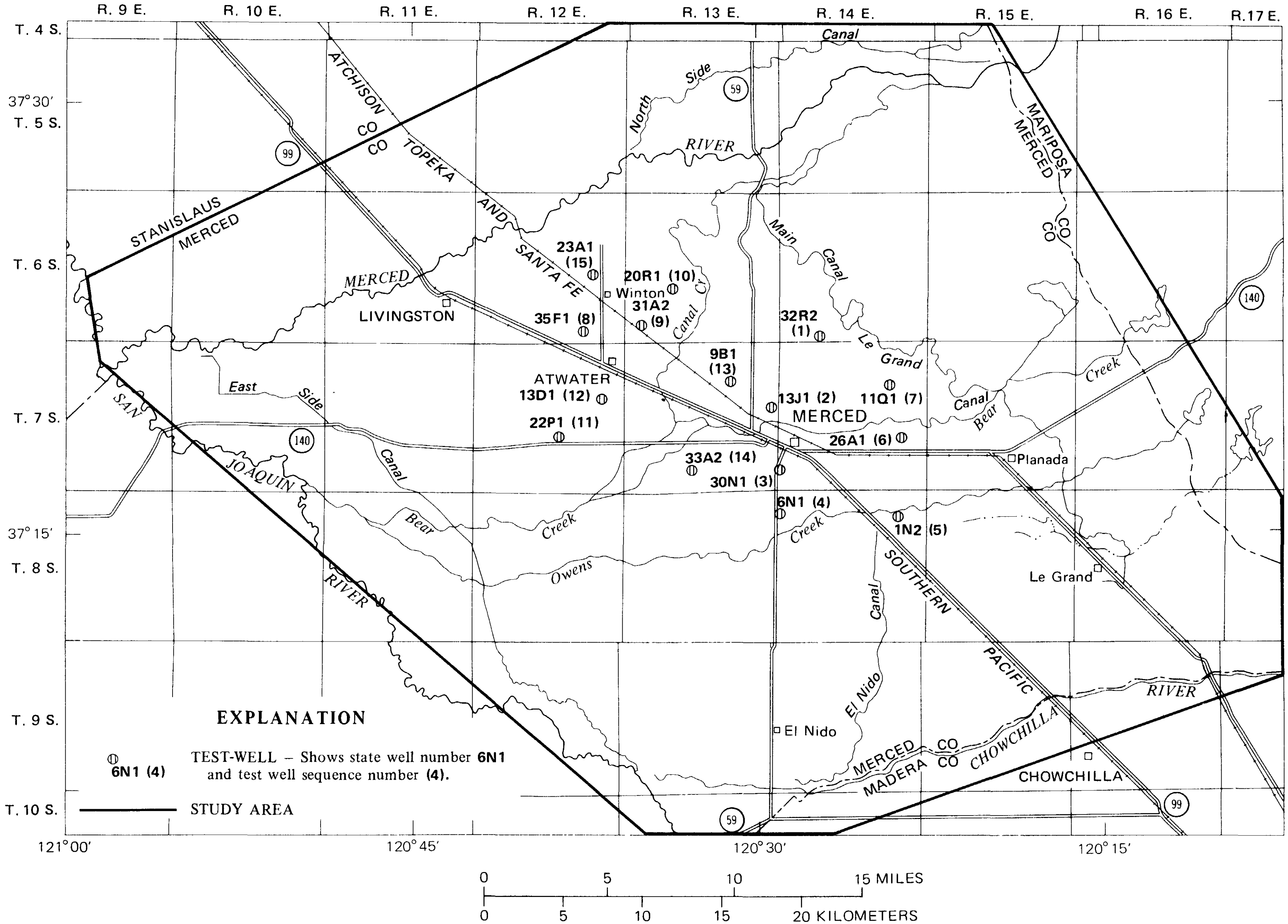


FIGURE 7. – Test-well locations.

TABLE 1. - Logs of test wells

Material	Depth to top of unit (feet)	Thickness (feet)
Test well 1, 6S/14E-32R2. Altitude of land surface 205 feet. 58 feet of 3-inch casing installed; top of casing 1.5 feet above land surface. Water first found at 58 feet below land surface datum. Water level after casing 44 feet below land surface.		
Not logged--	0	10
Silt, some clay, light-brown, damp-----------------	10	30
Silt, clayey, yellow-brown, moist and somewhat plastic, micaceous, some dark mottling.	40	2
Silt, clayey, some sand, yellow-brown, damp, micaceous-muscovite, some dark mottling.	42	16
Same, saturated------------------------------------	58	Bottom.
Test well 2, 7S/13E-13J1. Altitude of land surface 165 feet. 45 feet of 3-inch casing installed; top of casing 0.7 foot above land surface. Water first found at 55 feet below land surface datum. Water level after casing 31.9 feet below land surface. Water flowing in entrenched Black Rascal Creek 25 feet from well about 10 feet below land surface.		
Not logged---	0	15
Clay, silty, greenish-brown, micaceous, some dark mottling, slightly damp.	15	7
Sand, fine, silty, some clay, greenish-brown---------	22	6
Sand, coarse, silty-clayey, some pebbles, subrounded, subangular, quartz and fledspar.	28	2
Clay, greenish-brown---------------------------------	30	10
Sand, fine to medium, clayey, and silt, sandy, greenish-brown, wet but not saturated.	40	5
Clay, silty, reddish-brown--------------------------	45	15
Clay, some silt, greenish-gray, hard and dense, micaceous, saturated.	60	Bottom.
Test well 3, 7S/14E-30N1. Altitude of land surface 162 feet. No casing installed, backfilled.		
Not logged---	0	6
Silt, sandy, brown, moist--------------------------	6	4
Silt, fine, sandy, brown, plastic; first water at 18 feet.	10	20
Silt, fine, sandy, brown, plastic; some coarse sand--	30	5
Silt, fine, sandy, gray; some clay binder------------	35	25
Alternating layers of dense and less dense sandy silt. Density probably depends on amount of silt and clay binder. No samples because water washed material off auger.	60	Bottom

TABLE 1. - Logs of test wells--Continued

Material	Depth to top of unit (feet)	Thickness (feet)
Test well 4, 8S/14E-6N1. Altitude of land surface 154 feet. 25 feet of 3-inch casing installed; top of casing 2.8 feet above land surface. Depth of hole after casing 10.8 feet; material came up inside of casing. Well was dry after casing.		
Not logged	0	8
Sand, silty, brown, water	8	10
Dense layer, probably clayey silt (samples of water-washed material from auger).	18	7
Sand, fine to coarse, silty, brown; some pebbles up to 3 inches, subrounded; probably water bearing (samples of water-washed material from auger).	25	33
Silt, clayey, sandy medium, brown, probably tight	58	7
Same	65	Bottom.
Test well 5, 8S/14E-1N2. Altitude of land surface 190 feet. 61 feet of 3-inch casing installed; top of casing 1.5 feet above land surface. Depth of hole after casing 18 feet; material came up inside casing. Well was dry.		
Not logged	0	15
Silt, brown-gray, dry. Little or no clay	15	1
Same as above, wet silt	16	21
Silt, clayey, coarse sand, gray, tight	37	28
Same as above, coarser sand and some gravel up to 3/8 inch.	65	Bottom.
Test well 6, 7S/14E-26A1. Altitude of land surface 196 feet. 55 feet of casing installed; top of casing 2.0 feet above land surface. Depth of hole after casing 15.6 feet; material came up inside casing.		
Not logged	0	15
Sand, fine, silty, reddish-brown	15	10
Sand, fine, gravelly; quartz pebbles up to ½ inch long, subrounded.	25	3
Sand, fine, silty, brown, damp; cobbles up to 3 inches.	28	2
Same as above, some clay; saturated	30	15
Clay (hard drilling)	45	10
Silt? (looser material, easier drilling)	55	10
Clay, silty, brown, damp	65	Bottom.

TABLE 1. - Logs of test wells--Continued

Material	Depth to top of unit (feet)	Thickness feet)
Test well 7, 7S/14E-11Q. Altitude of land surface 196 feet. 67 feet of 3-inch casing installed; top of casing 2.0 feet above land surface. Obstruction at 47.7 feet.		
Not logged--	0	13
Silt, clayey, gravelly, brown, plastic; pebbles up to 1/2 inch, subrounded (cobbles, subrounded, at 18 feet).	13	7
Silt, clayey, gravelly, brown plastic, moist; pebbles to 2 inches.	20	11
Silt, clayey, gravelly, brown, plastic-------------	31	7
Gravel--	38	2
Silt, clayey, sandy, coarse, dense, plastic---------	40	25
Same--	65	Bottom.
Test well 8, 6S/12E-35F1. Altitude of land surface 148 feet. 40 feet of 3-inch casing installed; top of casing 1.6 feet above land surface. Depth of hole after casing 35 feet; material came up inside casing. Caving at 25 feet.		
Not logged---	0	10
Sand, medium, clean, light brown, damp--------------	10	20
Same as above, slightly finer grained---------------	30	5
Same as above, medium to coarse sand----------------	35	25
Same---	60	Bottom.
Test well 9, 6S/13E-31A2. Altitude of land surface 175 feet. 51.5 feet of 3-inch casing installed; top of casing 1.3 feet above land surface. Depth of hole 47 feet after casing; material came up inside casing. Well was dry.		
Not logged---	0	5
Sand, medium silt, red-brown, hardpan---------------	5	20
Same, less red, more brown, no hardpan--------------	25	5
Same as above, some clay; clay content increasing to 55-foot depth.	30	25
Sand, medium, brown, no clay------------------------	55	5
Same---	60	Bottom.

Material	Depth to top of unit (feet)	Thickness feet)
Test well 10, 6S/13E-20R1. Altitude of land surface 195 feet. 62 feet of 3-inch casing installed; top of casing 1.5 feet above land surface. Depth of hole 60.5 feet after casing; material came up inside casing. Well was dry.		
Not logged--	0	2
Sand, silty, red------------------------------------	2	1
Sand, medium, silty, some clay----------------------	3	8
Sand, medium, silty, no clay, dark brown, damp-------	11	12
Silt, sandy, clayey, tight, plastic, medium-brown, moist.	23	2
Sand, silty, no clay, medium-brown, moist-----------	25	13
Same as above with clay-----------------------------	38	2
Sand, fine, and silt, no clay, medium-brown, dry----	40	13
Sand, medium, and silt, clay, medium-brown----------	53	7
Same, saturated-------------------------------------	60	Bottom.
Test well 11, 7S/12E-22P1. Altitude of land surface 116 feet. 25 feet of 3-inch casing installed; top of casing 3.4 feet above land surface. Depth of hole after casing 20.5 feet; material came up inside casing.		
Not logged--	0	8
Silt, gray--	8	2
Sand, medium; and silt; clean, brown, saturated------	10	10
Sand, fine; and silt, brown-------------------------	20	25
Sand, medium to coarse, some silt, clean, brown,-----	45	11
Silt, sandy, clayey, plastic, tight, red and brown, resistive to drilling.	56	4
Same--	60	Bottom.
Test well 12, 7S/12E-13D1. Altitude of land surface 140 feet. 24 feet of 3-inch casing installed; top of casing 1.4 feet above land surface. Depth of hole after casing 13.1 feet; material came up inside casing. Water first foundat 18 feet below land surface datum. After casing water level 6.6 feet below land surface.		
Not logged--	0	5
Sand, fine, brown, and silt, some mica, dry----------	5	27
Silt, clayey, tight, brown--------------------------	32	3
Sand, silty, brown----------------------------------	35	Bottom.

TABLE 1. - Logs of test wells--Continued

Material	Depth to top of unit (feet)	Thickness (feet)
Test well 13, 7S/13E-9B1. Altitude of land surface 165 feet. 62 feet of 3-inch casing installed; top of casing 2.0 feet above land surface. Depth of hole 60 feet. Water level after casing 43.7 feet below land surface.		
Not logged---	0	10
Sand, fine, and silt, medium, brown, moist-----------	10	15
Sand, fine, silty, medium-brown, moist---------------	25	25
Silt, sandy, some clay-------------------------------	50	10
Same---	60	Bottom.
Test well 14, 7S/13E-33A2. Altitude of land surface 143 feet. 20 feet of 3-inch casing installed; top of casing 1.6 feet above land surface. Depth of hole after casing 9 feet; material came up inside casing. Water first found at 26 feet below land surface datum.		
Not logged---	0	14
Silt, sandy, brown, damp-----------------------------	14	6
Silt, clayey, sandy, micaceous, tight, brown, damp---	20	8
Silt, sandy, clayey, red pieces of hardpan (?)-------	28	7
Sand, silty, partially cemented, hardpan (?), red----	35	5
Sand, medium to coarse; silt, brown, water-bearing---	40	20
Same---	60	Bottom.
Test well 15, 6S/12E-23A1. Altitude of land surface 180 feet. No casing installed; backfilled.		
Not logged---	0	5
Sand, medium, and silt, some clay, dark green, damp. Gravel and cobbles to 3 inches, subrounded at 8 feet.	5	13
Sand, fine; silt, no clay, light brown---------------	18	7
Sand, medium; silt, some clay, dark brown, damp. Cobbles, 4 inches, rounded at 23 feet.	25	13
Sand, medium, silty, no clay, medium brown, damp-----	38	10
Clay, silty, brownish-gray---------------------------	48	13
Sand, medium, silty, no clay, brown (water in this sand).	61	4
Same---	65	Bottom.

Movement of Ground Water

Water-level contour maps of the confined and intermediate aquifers (figs. 4-6 and 8-10) were drawn using observation well data gathered in August 1980, December 1980, and January and February 1982. Before the observation well network was expanded in 1982, observation wells were concentrated in the central part of the study area and were scarce elsewhere. Therefore, the contours from the 1980 data are limited. Water levels at individual wells are shown where data are too scarce to contour. The observation well network does not include wells in the shallow aquifer, but in September 1975, the general direction of ground-water movement in the shallow aquifer was westward and southwestward (Page, 1977).

In January and February 1982, water in the confined aquifer moved southwestward from Merced (fig. 6); however, west of Merced, it moved more toward the west and, near Livingston, it moved west-northwestward. Southeast of Merced, water in the confined aquifer moved south and southeast and toward a depression caused by pumping southwest of El Nido.

In January and February 1982, water in the intermediate aquifer moved west from Merced (fig. 10). Northwest of Merced, movement was generally westward with local variations, such as a recharge area north of Winton and a discharge further west along the Merced River. South of Merced, ground water moved toward the southwest and toward a pumping depression southwest of El Nido.

EXPLANATION TO FIGURES 8 AND 9

——*120*—— POTENTIOMETRIC CONTOUR – Shows altitude at which water level would have stood in tightly cased wells in intermediate aquifer. Contour interval 10 feet. National Geodetic Vertical Datum of 1929

o 1A2 / 102 OBSERVATION WELL IN AREA WHERE THERE ARE NOT ENOUGH DATA TO CONTOUR – Upper number is well number; Lower number is altitude of potentiometric surface, in feet. National Geodetic Vertical Datum of 1929

———— STUDY AREA

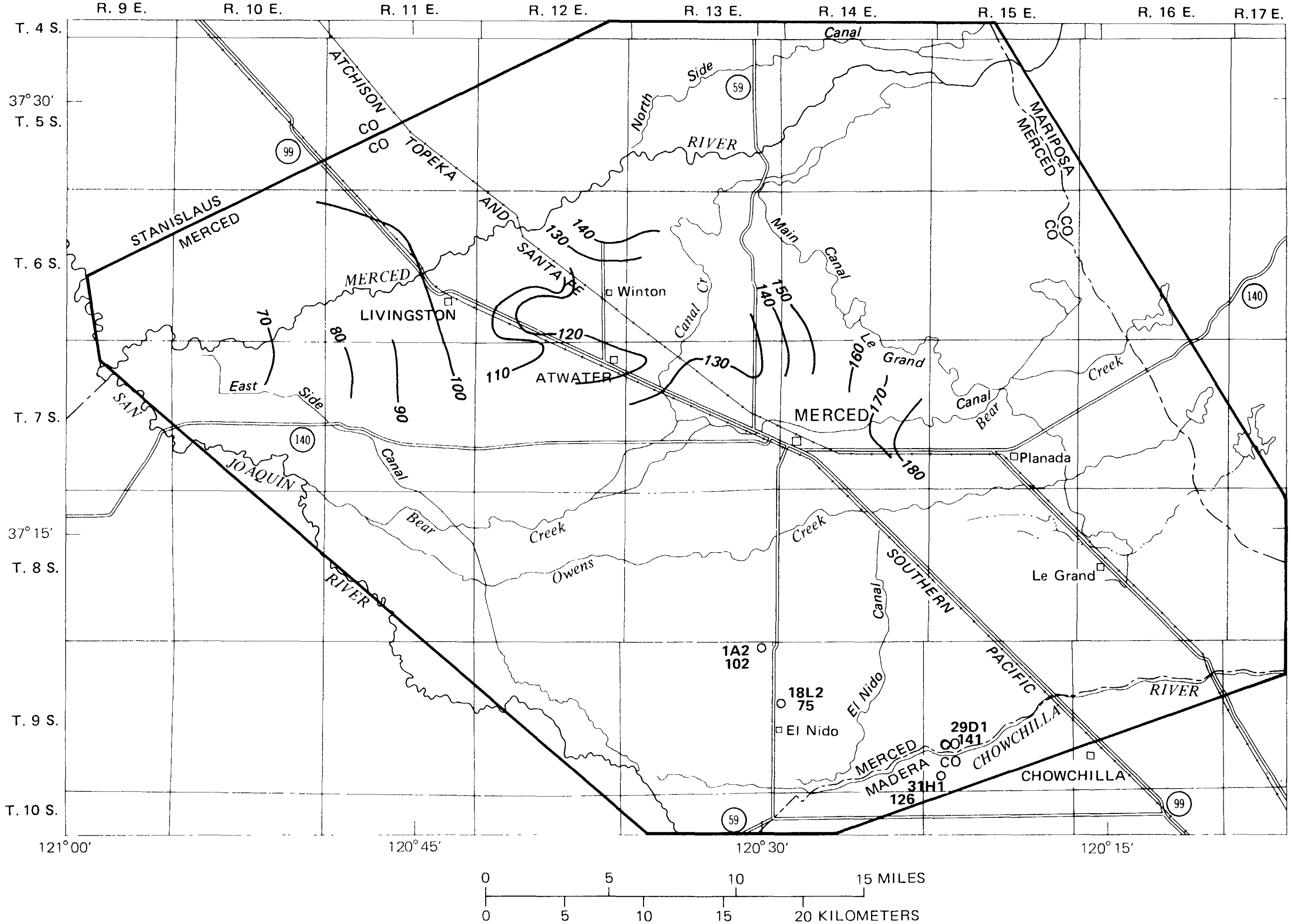


FIGURE 8. – Altitude of potentiometric surface in the intermediate aquifer, August 1980.

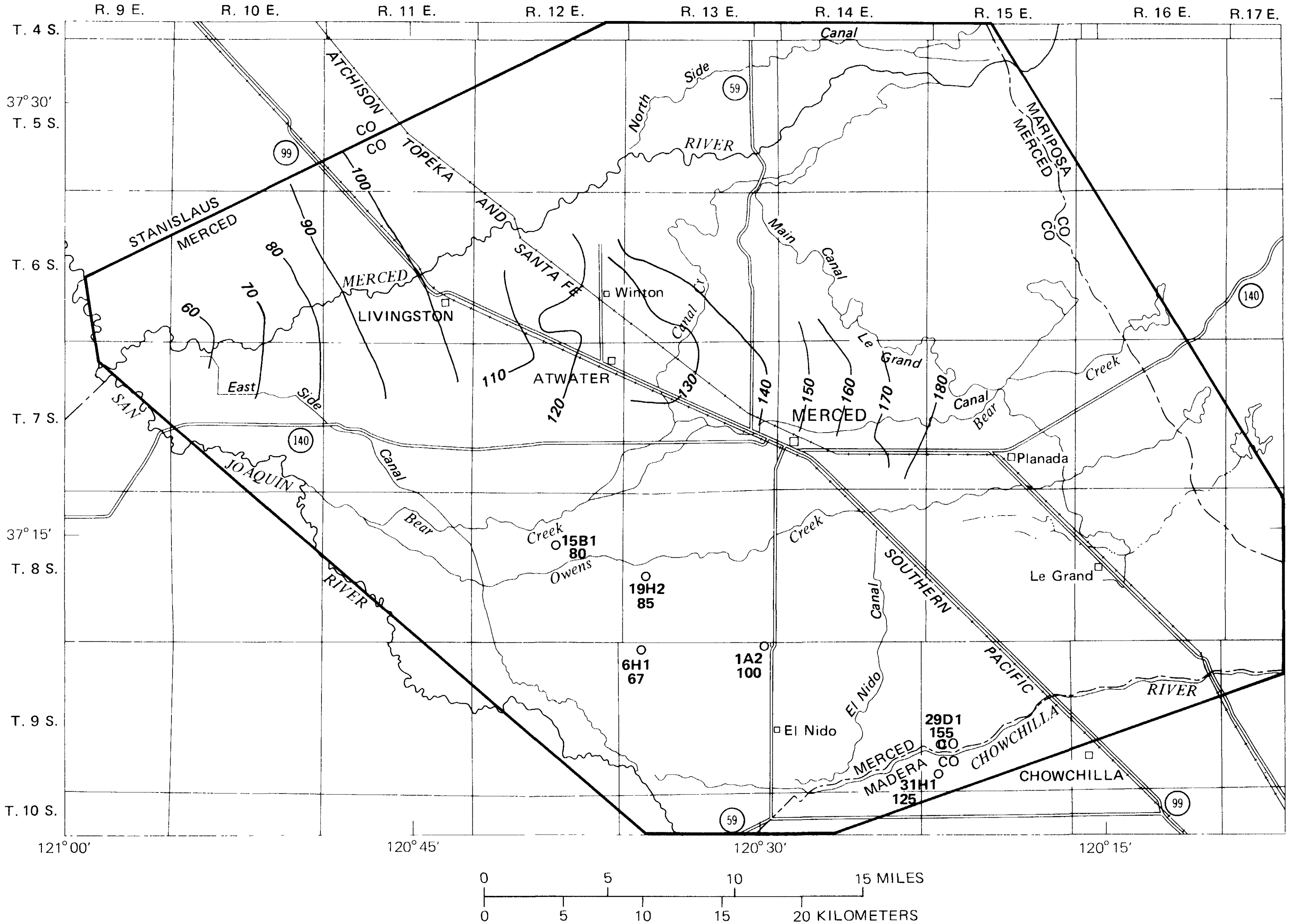


FIGURE 9. – Altitude of potentiometric surface in the intermediate aquifer, December 1980.

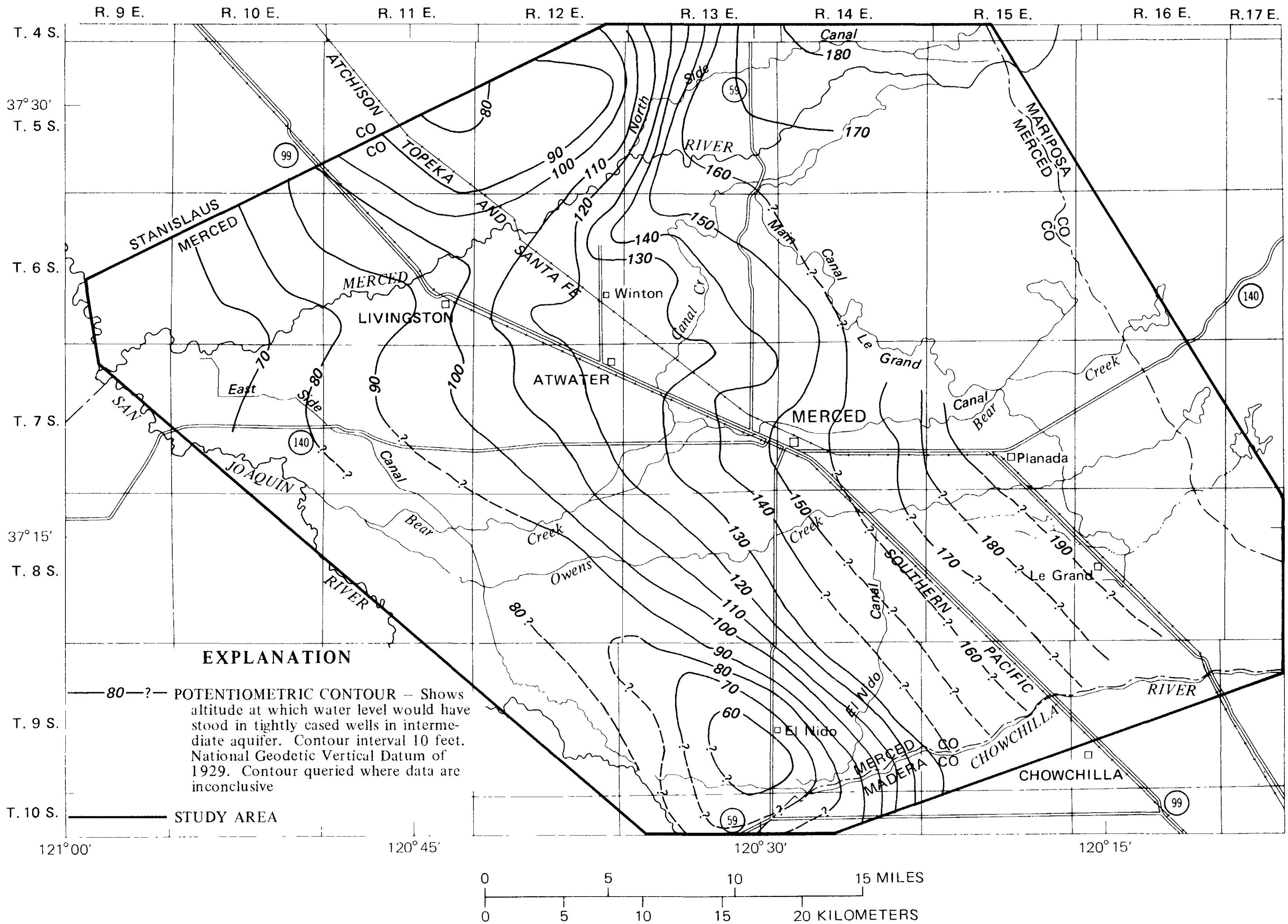


FIGURE 10. – Altitude of potentiometric surface in the intermediate aquifer, January and February 1982.

WATER USE AND CHANGES IN GROUND-WATER LEVELS

Ground-Water Withdrawals

Ground water is pumped for irrigation, domestic supplies, and industry in the study area, but irrigation is the main use (fig. 11). Four irrigation districts in the area (fig. 12), along with private landowners, pump ground water for irrigation. The Merced Irrigation District, by far the largest user of water in the study area, compiles summaries of the water it pumps by month and year and maintains annual pumpage records for each of the divisions in its service area. Pumpage values are not available for the parts of the study area within Turlock, El Nido, Chowchilla, and other small irrigation districts and outside areas. However, pumpage from these areas constitutes only a small percent of that pumped by the Merced Irrigation District. Municipalities record monthly and annual pumpage from their wells although only the more recent records are available for some.

Within the Merced Irrigation District, which supplies water to a large part of the central study area, pumpage varies each year. The amount pumped depends primarily on the availability of surface water (fig. 13).

Ground water is the only source of water for domestic and industrial use in the study area. The population of Merced County increased from 104,629 in 1970 to 134,560 in 1980 (U.S. Department of Commerce, 1981), which increased the domestic demand for ground water. Pumpage from the city of Merced wells (fig. 14) in general shows an increasing trend from 1951, until the drought in 1976 and 1977 when voluntary water conservation lowered the demand. From 1977 to 1980 pumpage increased, but was lower than if pumpage had continued the 1951 to 1976 trend. Recent records of pumpage from other communities in the study area also show an increasing demand for ground water.

Seasonal trends for both irrigation and domestic pumpage are illustrated by graphs of monthly pumpage for the Merced Irrigation District and the city of Merced (fig. 15). From a winter base level, pumpage usually increases in spring to a peak in July and then decreases through autumn.

Surface-Water Distribution

Surface-water distribution data are important when evaluating the ground-water supply. Surface water applied to irrigated fields is the largest source of recharge to the shallow aquifer (Page, 1977). Ground water from the shallow aquifer might also move to the deeper aquifers.

The Merced Irrigation District diverts water from the Merced River for distribution throughout its service area. Between 1964 and 1980 it diverted an annual mean of 535,000 acre-ft of water between March and October (fig. 13). This surface water is usually more than 80 percent of the total irrigation supply.

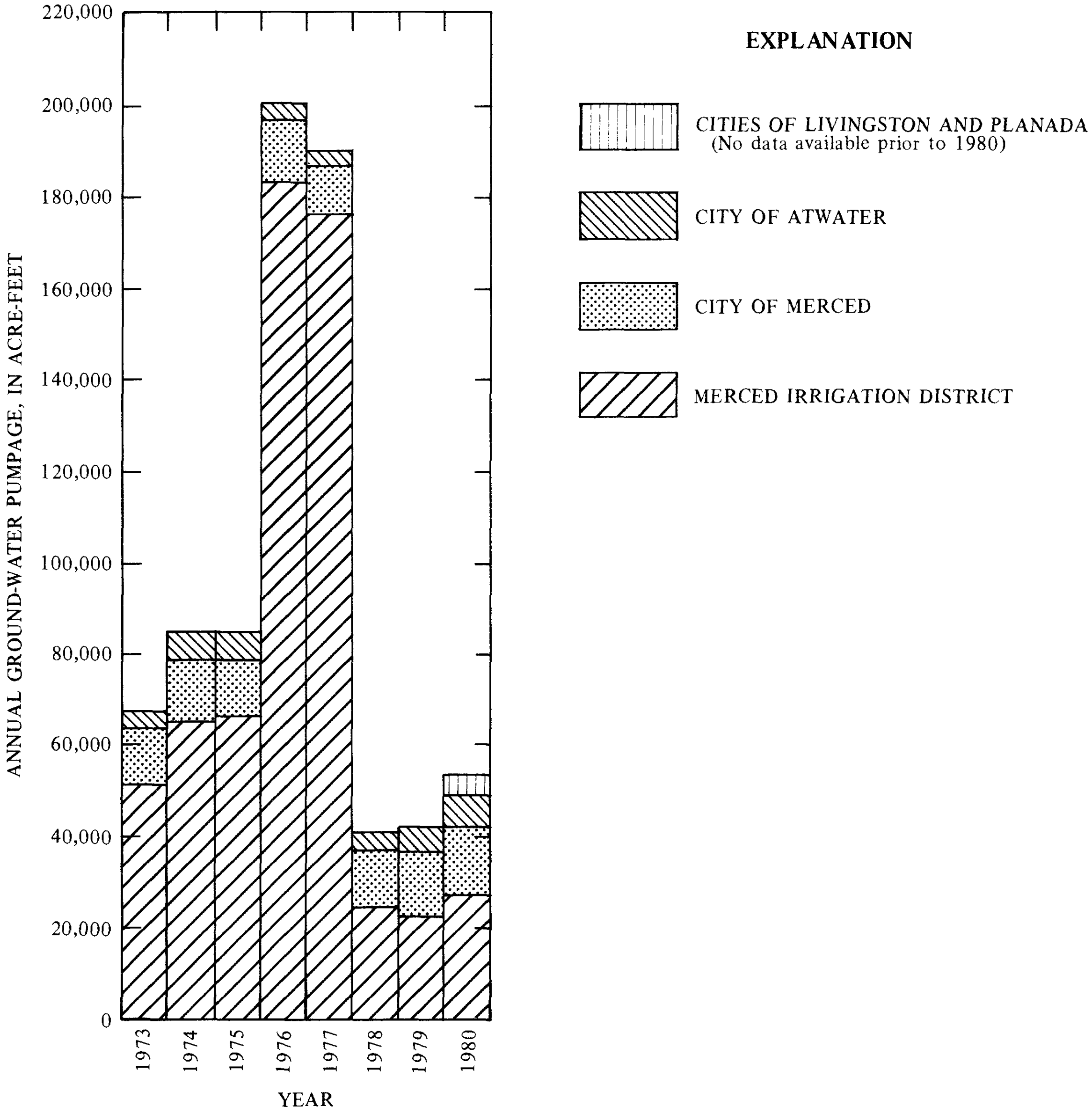


FIGURE 11. – Annual ground-water pumpage by Merced Irrigation District, city of Merced, city of Atwater, and cities of Livingston and Planada, 1973-80.

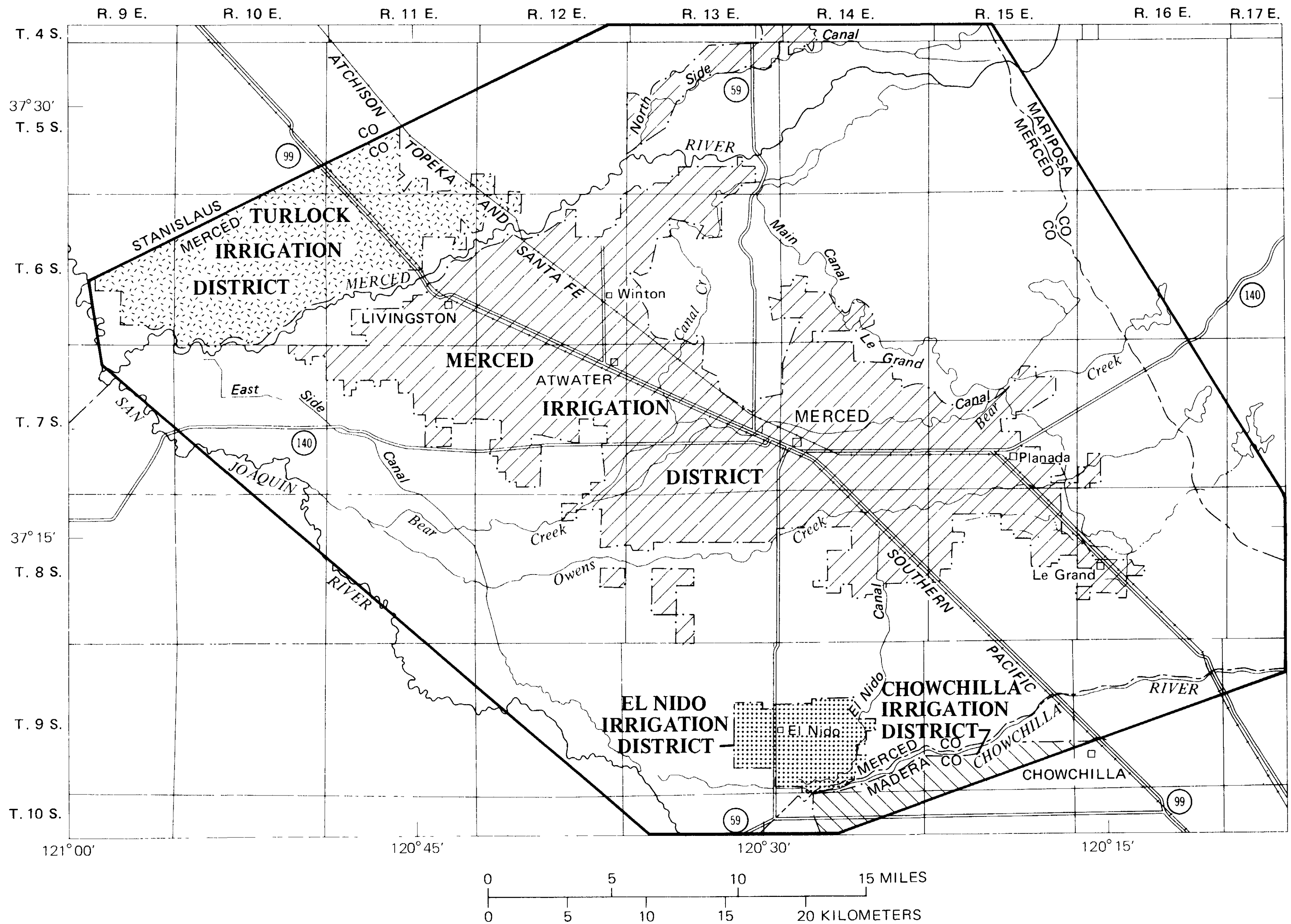


FIGURE 12. – Major irrigation districts in the eastern half of Merced County.

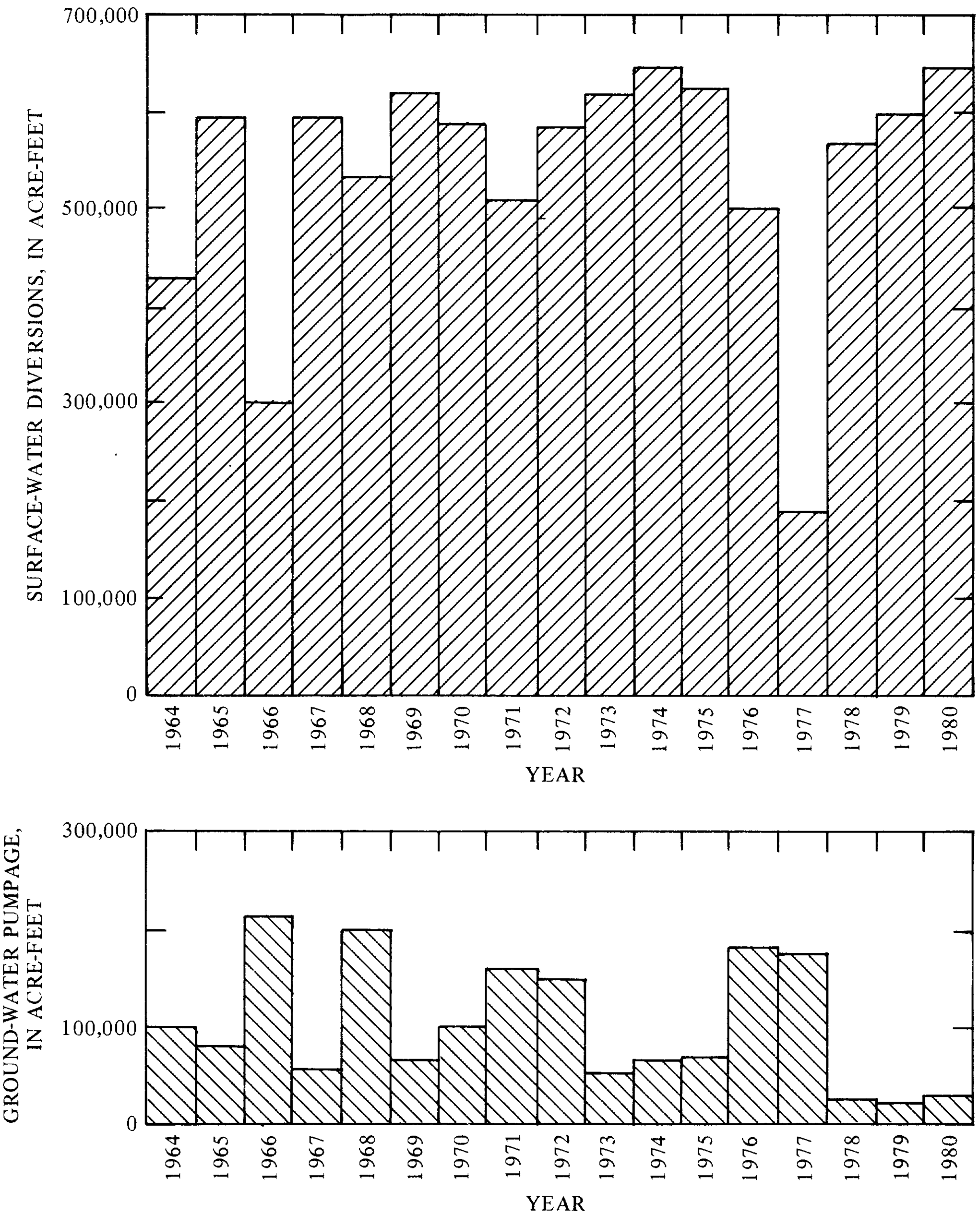


FIGURE 13. – Annual surface-water diversions and ground-water pumpage by Merced Irrigation District, 1964-80.

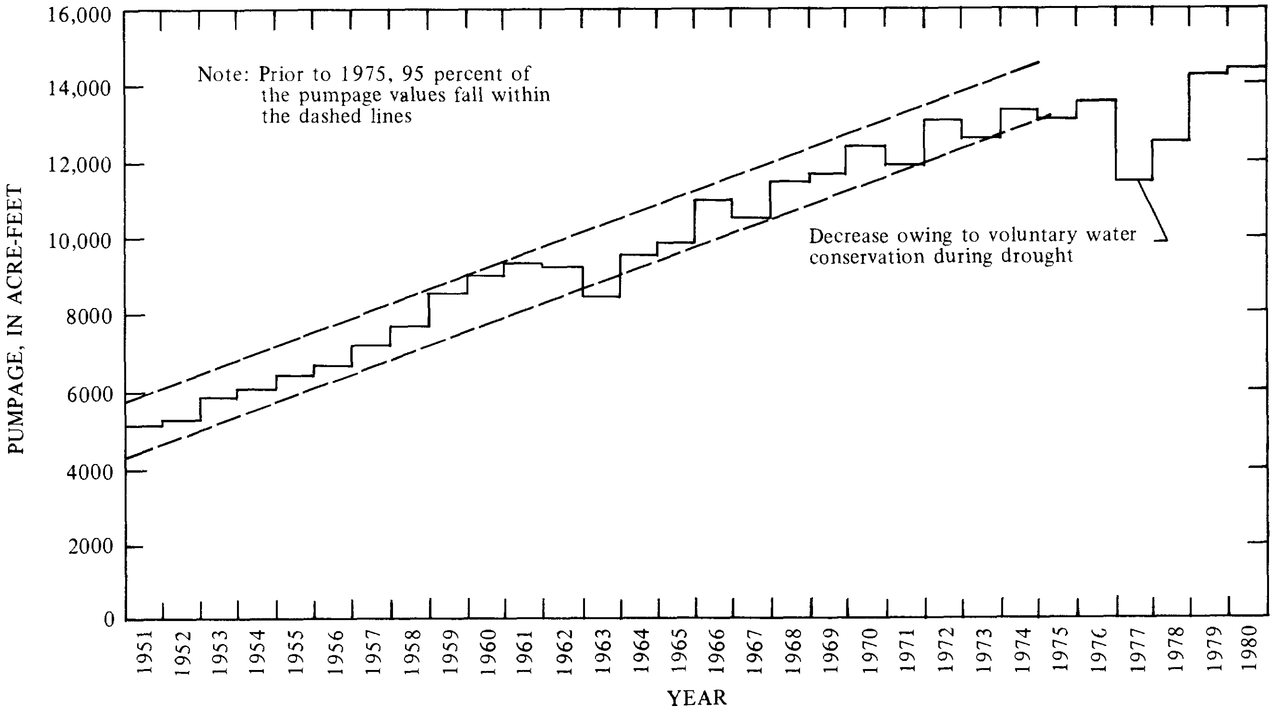


FIGURE 14. – Annual pumpage, city of Merced, 1951-80. Modified from Page, 1977.

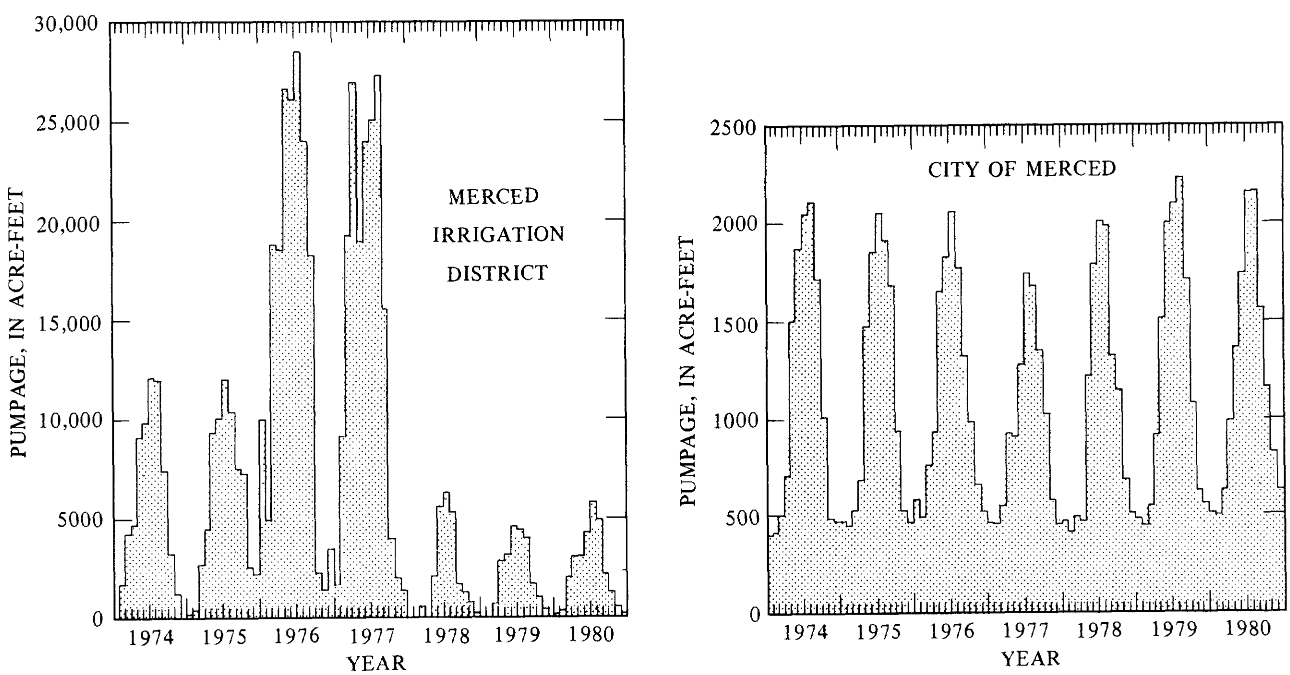


FIGURE 15. – Monthly ground-water pumpage for Merced Irrigation District and the city of Merced, 1974-80.

Water-Level Fluctuations

Water-level fluctuations indicate trends in ground-water storage. A change in the rate of decline or rise in the water level indicates a change in discharge and/or recharge. Water levels in wells generally fluctuate seasonally in areas where there is considerable pumping. The fluctuations reflect the irrigation and domestic pumping patterns. Water levels usually decline during increased pumping from spring to autumn and rise during the decreased pumping from autumn to spring.

Water levels were measured monthly in the city of Merced's 13 municipal wells by city personnel, and in observation wells at 4- to 6-week intervals throughout the rest of the area by Geological Survey personnel. The observation wells were chosen where possible in groups of two or more wells open to different aquifers or different depths. This arrangement facilitated comparison of the response of water levels to pumping from the various aquifers and depths.

To further facilitate the comparison, the study area was divided into nine subareas, A through I (fig. 16). The division was made by natural or manmade boundaries such as rivers, canals, or townships; and by the quantity of irrigation water applied.

Differences between the short-term, or seasonal, water-level fluctuations in wells open to different aquifers were apparent in subareas A, D, E, G, and H. Less pronounced differences occurred in subareas B, C, and I. Substantial differences occurred in subareas D, F, and G in wells close to each other but perforated at different depths in the same aquifer.

EXPLANATION TO FIGURE 16

● OBSERVATION WELL PERFORATED IN INTERMEDIATE AQUIFER

○ OBSERVATION WELL PERFORATED IN CONFINED AQUIFER

⊙ OBSERVATION WELL PERFORATED IN A COMBINATION OF AQUIFERS OR IN CONSOLIDATED ROCKS, OR WITH UNKNOWN PERFORATIONS

——— STUDY AREA

——— BOUNDARY OF SUBAREAS

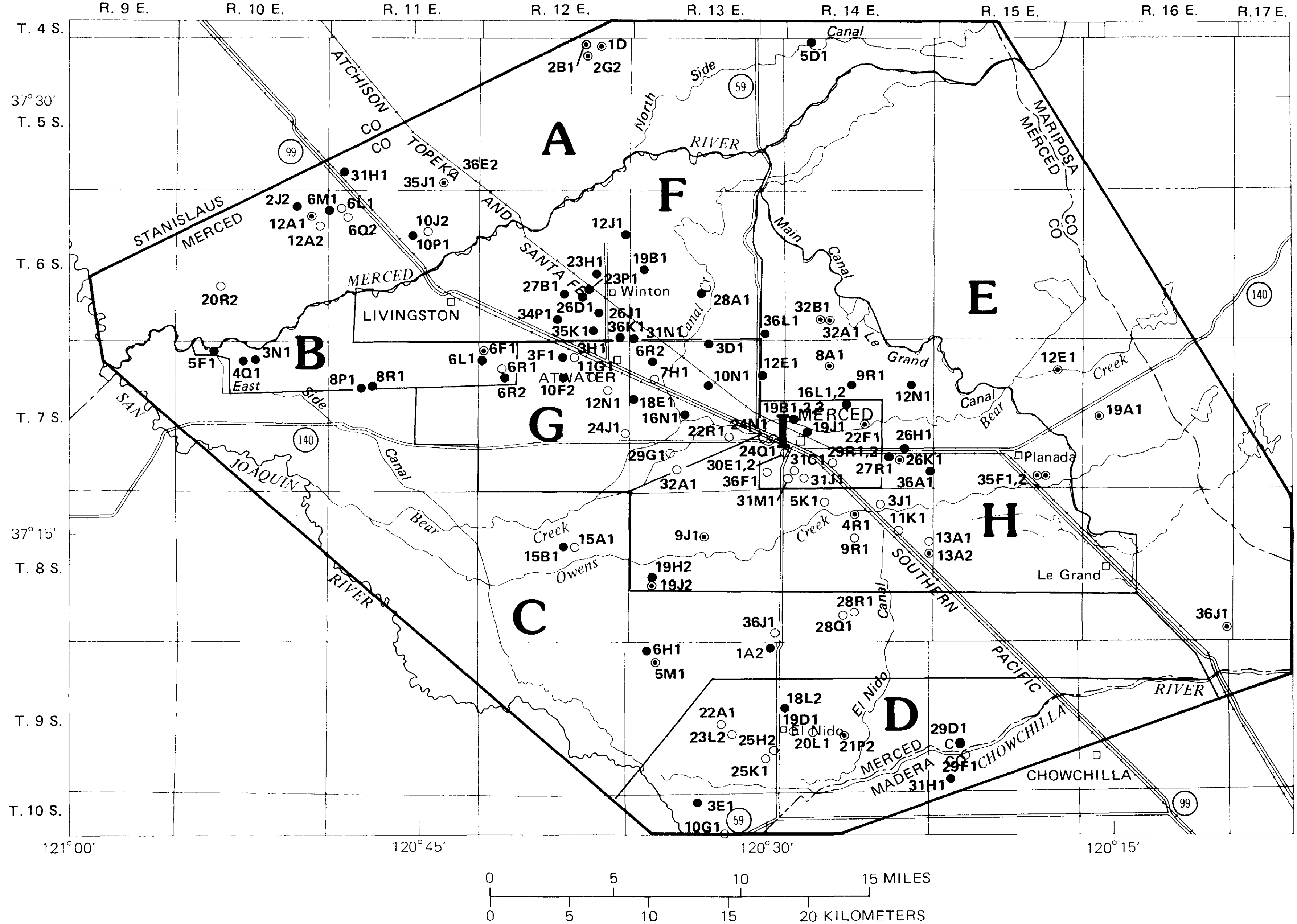


FIGURE 16. – Subareas and observation well locations.

In the longer term, the water-level data indicate a general rise since the end of the 2-year drought ending in 1977, followed by a leveling out. A comparison of the current data with those of Page (1977) indicates there has been no significant long-term change in water levels in the Merced area since 1960, although there have been declines of perhaps as much as 10 feet in a few shallow wells. The data indicate that over the long term, recharge to the ground-water system has equaled pumpage plus natural discharge in the Merced area.

A description of each subarea including information about surface-water deliveries, irrigation rates, land use, and aquifers follows.

Subarea A

Subarea A includes the study area north of the Merced River (fig. 16). Information on how much irrigation water is delivered to the western part of the subarea, in Turlock Irrigation District, is not available. However, division 19 of Merced Irrigation District, further east along the river (fig. 12), received an annual average of 3 acre-ft of water per acre of irrigated land from 1977 to 1980. Other irrigated land along the river with water rights may be receiving comparable amounts of water. Most of the subarea is under cultivation except for the farthest northeast part in the foothills, which is rangeland. Observation wells penetrate the intermediate and confined aquifers in the west part of the subarea, and the intermediate aquifer and the consolidated rocks in the east.

The water-level fluctuations in wells in subarea A are shown in figure 17. Water levels measured during the 2-year period show no substantial net rise or decline. The fluctuations in wells perforated only in the intermediate aquifer are similar, but they differ from the fluctuations in wells perforated only in the confined aquifer. This difference indicates that a layer of low permeability separates the intermediate and confined aquifers in subarea A.

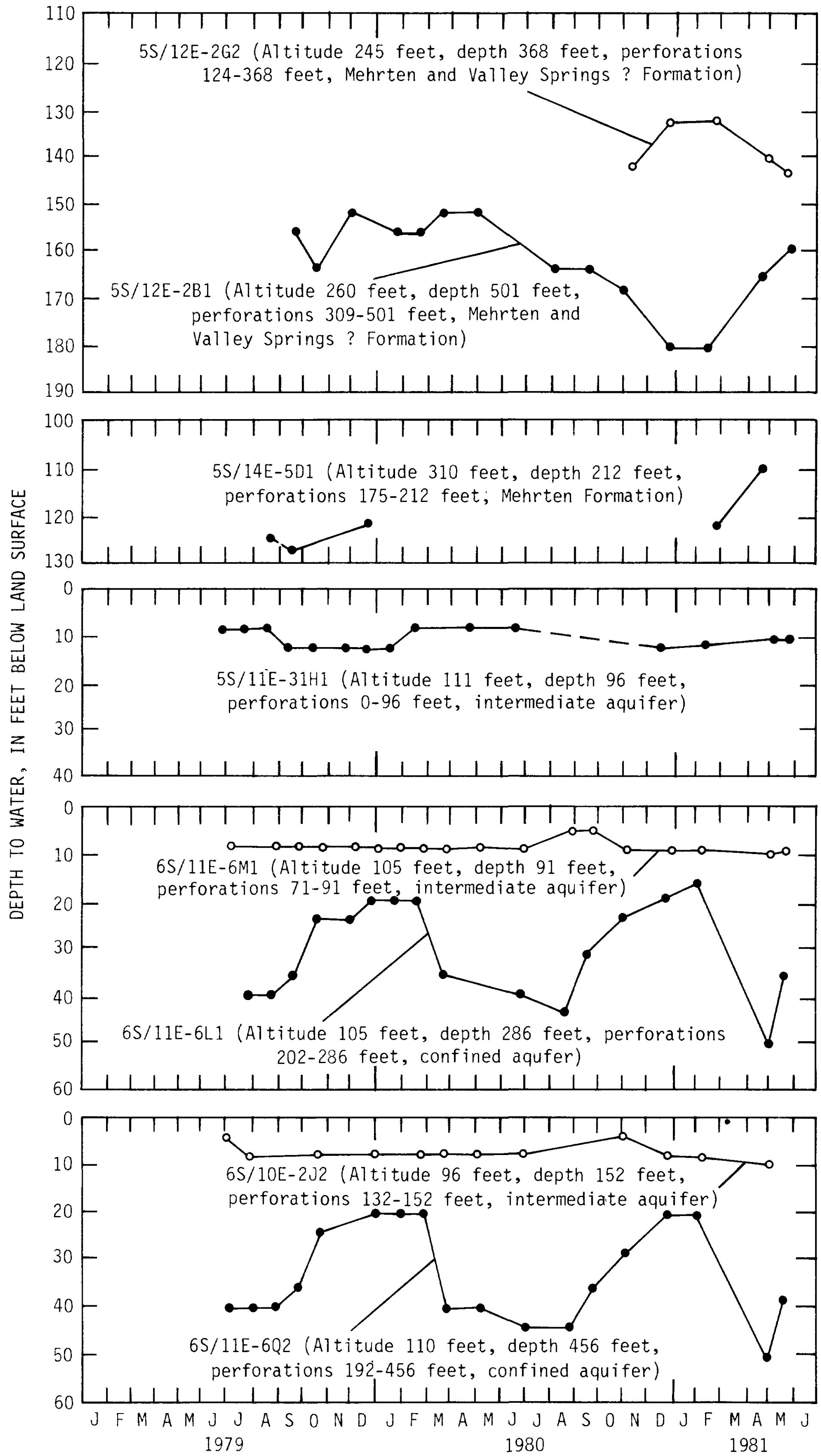


FIGURE 17. – Water-level fluctuations for wells in subarea A.

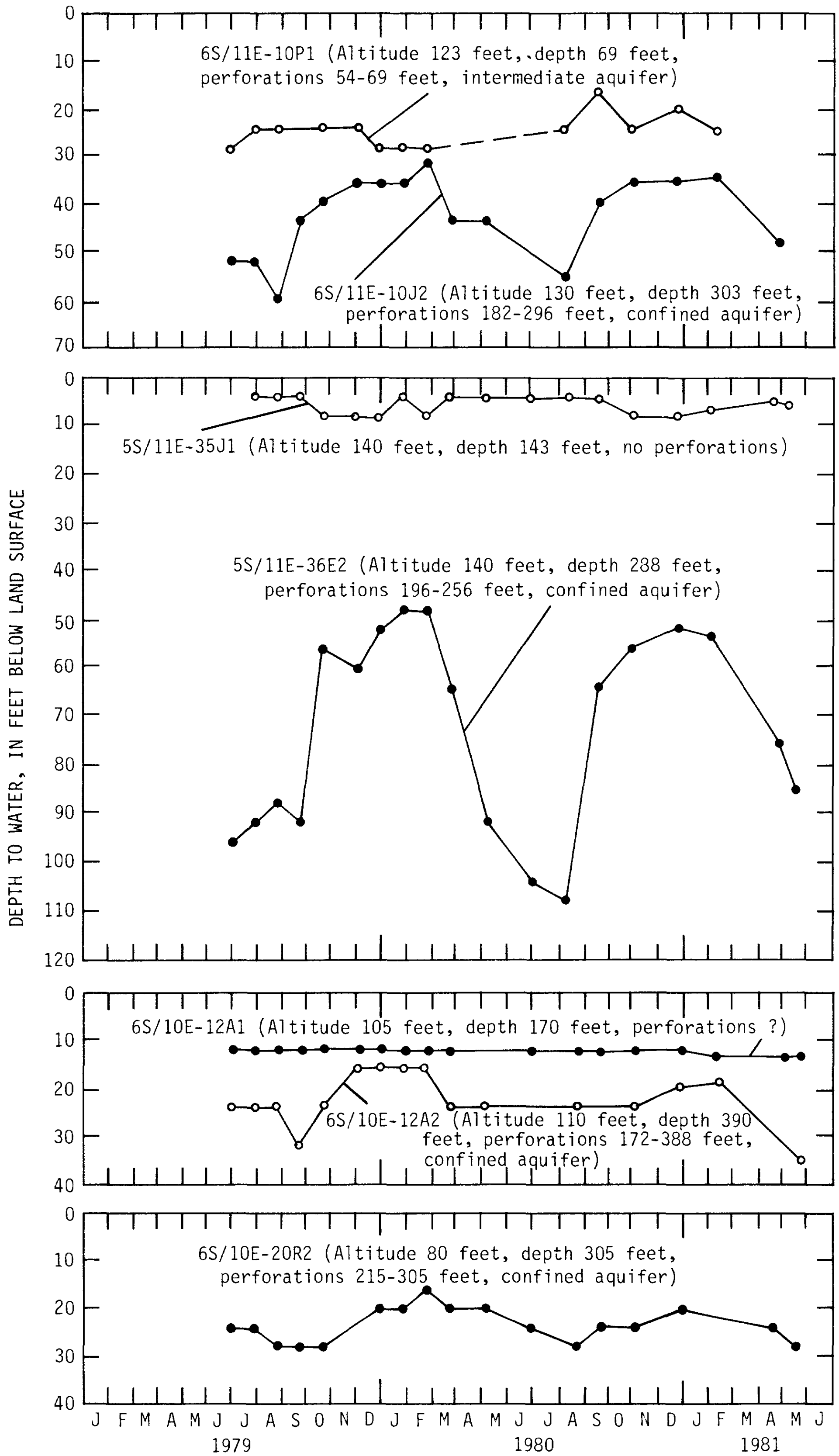


FIGURE 17. – Continued.

Subarea B

Subarea B (fig. 16) contains the westernmost divisions of the Merced Irrigation District. From 1977 to 1980 an annual average of 3.2 feet of water was applied to each acre of irrigated land in these divisions. During the 1977 drought year, 70 to 85 percent of the irrigation water was ground water. From 1978 to 1980 about 80 percent of the irrigation water was surface water. The aquifers in subarea B include the confined aquifer and the intermediate aquifer.

Water-level fluctuations in wells in subarea B are shown in figure 18. No continuing trend of declines or rises in water levels are evident in the 2-year period of measurement. Water levels in wells perforated in the intermediate aquifer generally had seasonal fluctuations. Too few measurements were made in the one well open in the confined aquifer to establish the nature of the hydraulic connection between the confined and intermediate aquifers in this area.

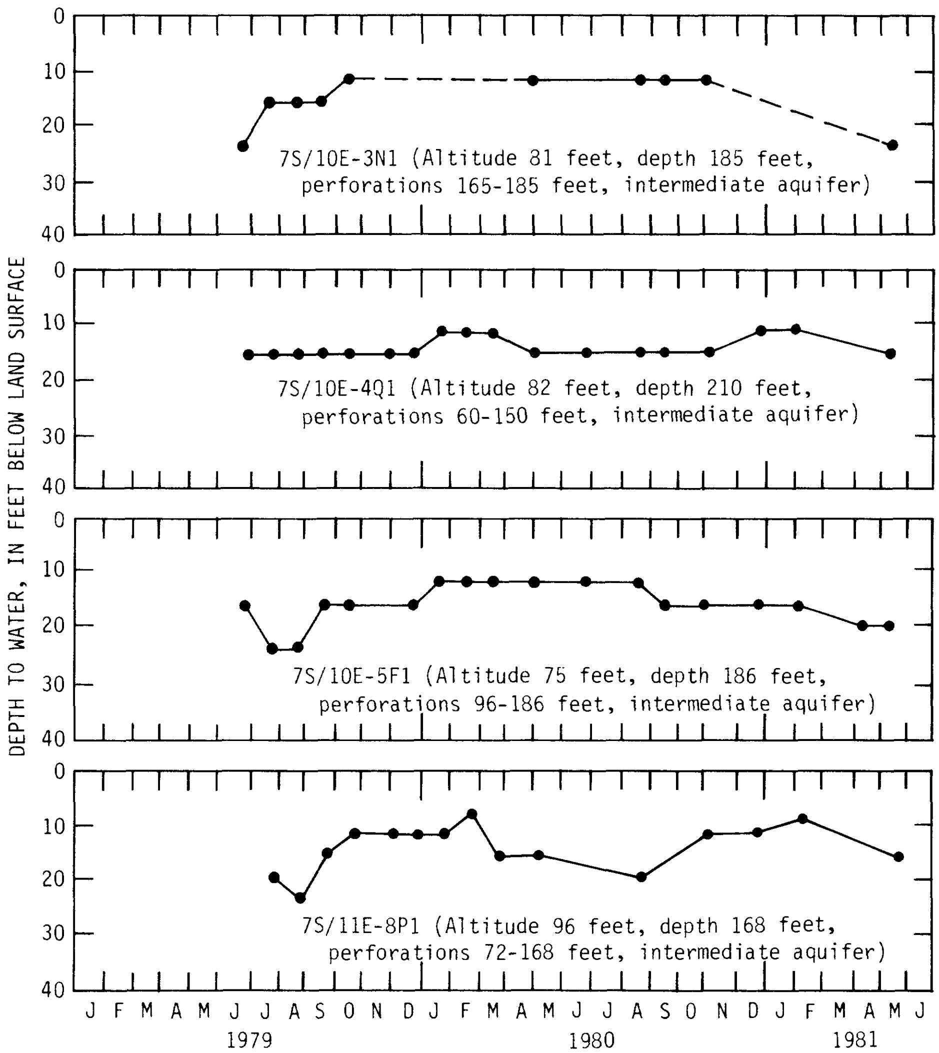


FIGURE 18. – Water-level fluctuations for wells in subarea B.

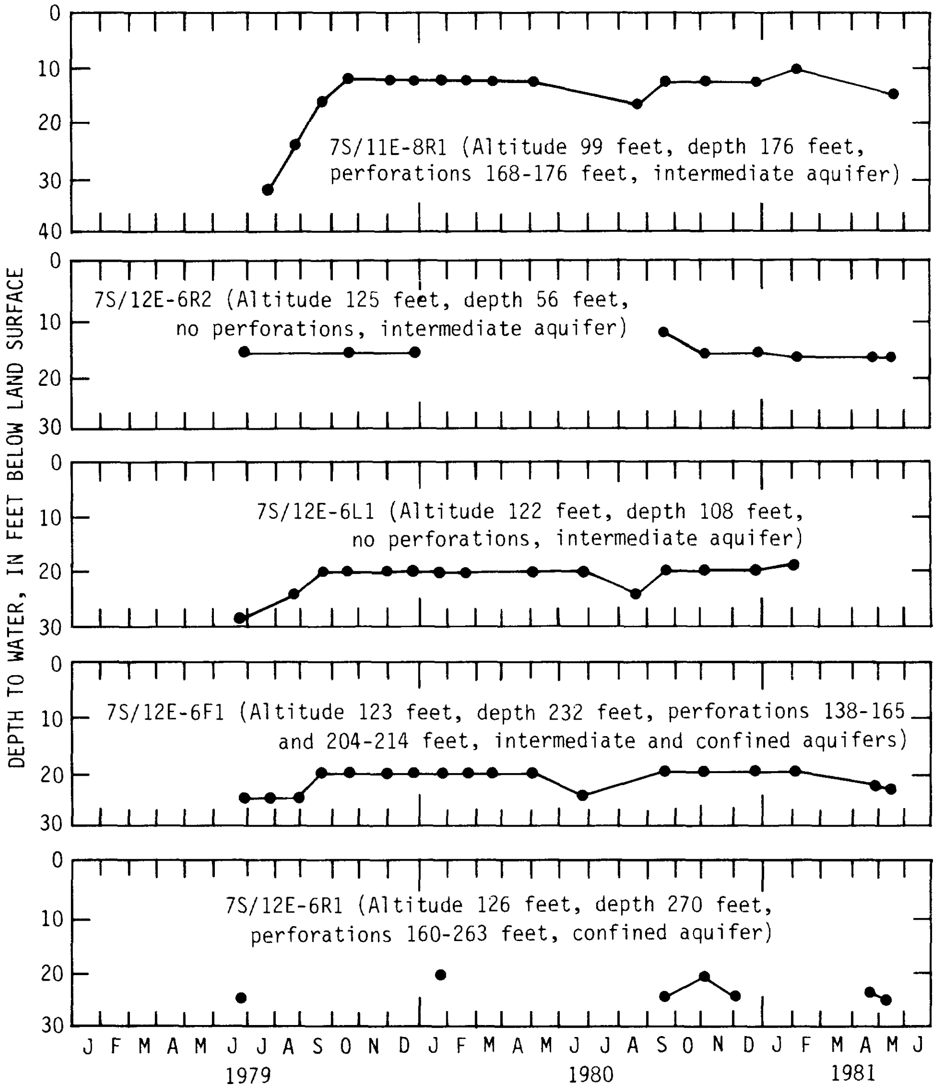


FIGURE 18. – Continued.

Subarea C

Most of subarea C (fig. 16) is not serviced by irrigation districts. Information on irrigation rates within the subarea is not available. Most irrigation water is pumped from the ground, with some water pumped directly from creeks and the San Joaquin River. Subarea C is about evenly divided between cultivated land and rangeland. Several areas of marsh and wetland are in the western part of the subarea. All the observation wells in subarea C are in the area where the Corcoran Clay Member underlies surface deposits.

Hydrographs of water-level fluctuations in wells in subarea C are shown in figure 19. Trends over the 2 years of measurement indicate no declines or rises in water levels.

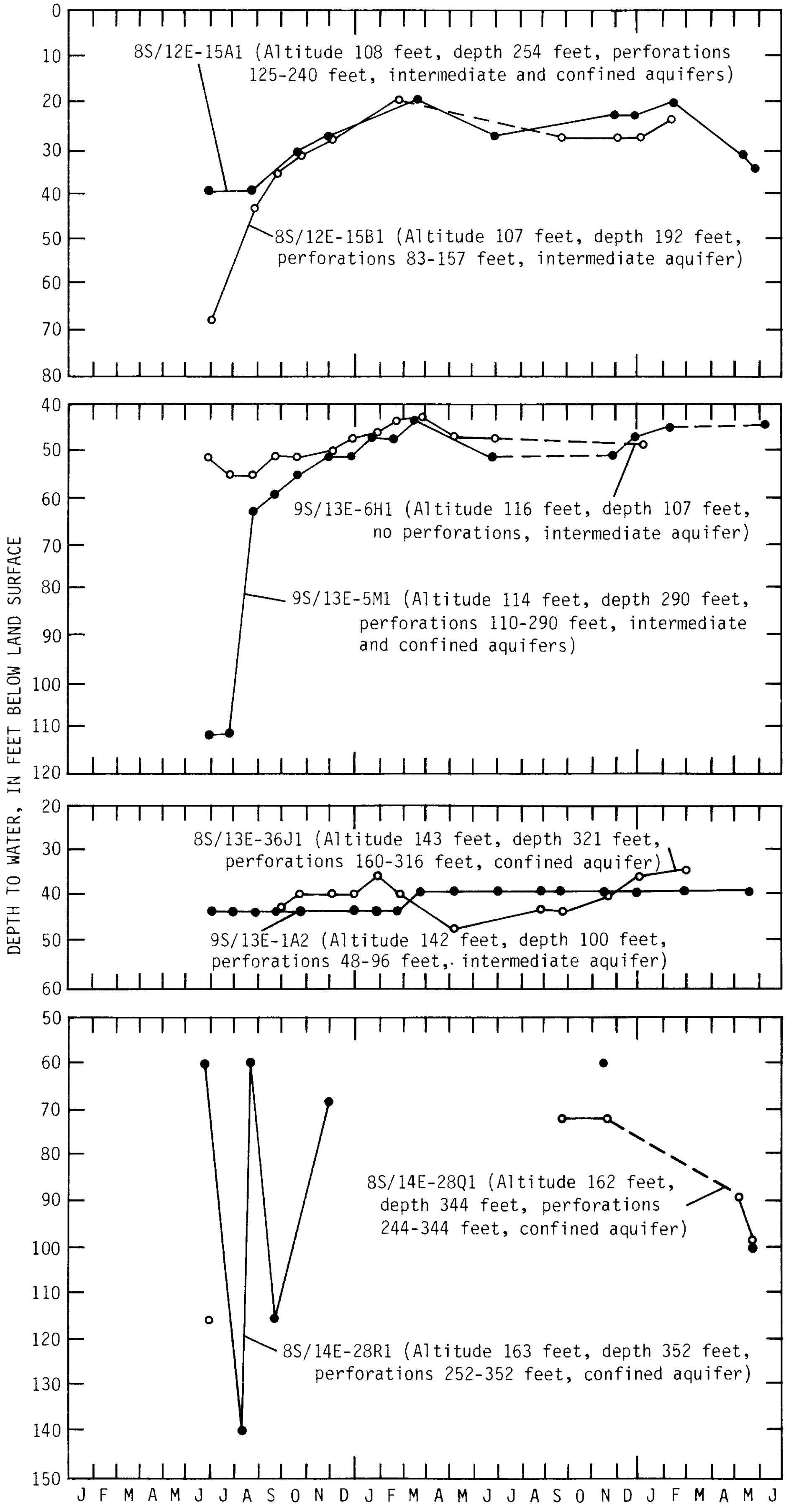


FIGURE 19. – Water-level fluctuations for wells in subarea C.

Wells 8S/12E-15B1 and 9S/13E-6H1, which are perforated adjacent to the intermediate aquifer, and wells 8S/12E-15A1 and 9S/13E-5M1, which are perforated adjacent to the intermediate and confined aquifers, had similar seasonal water-level fluctuations (fig. 19). The similarity does not necessarily result from leaky confining conditions, but is a reflection of the common response of the intermediate aquifer.

Farther east, well 8S/13E-36J1, which is perforated in the confined aquifer, and nearby well 9S/13E-1A2, which is perforated in the intermediate aquifer, had different water-level fluctuations (fig. 19). This difference indicates that the confining layer in subarea C is fairly continuous and is not very permeable.

Subarea D

Subarea D includes El Nido Irrigation District and land along the Chowchilla River (fig. 16). In the 1977 drought year the district received no water from Merced Irrigation District. From 1978 to 1980, it purchased between 15,000 and 20,000 acre-ft of water each year. The El Nido Irrigation District estimated that an average of 3 acre-ft of water per each of the 10,000 acres of irrigated land in the district was applied each year from 1978 to 1980. An estimate of ground-water pumpage would be the difference between that total used and the amount of water imported. Most of the subarea south of the Chowchilla River is in the Chowchilla Irrigation District. Information on water distribution in that area is not available. All but the eastern edge of subarea D is in the area underlain by the Corcoran Clay Member.

Hydrographs of wells in subarea D are shown in figure 20. Water-level fluctuations over the 2 years of measurements show no lasting rises or declines that are evident throughout the subarea. In general, water-level fluctuations in wells open in the intermediate aquifer had no definite seasonal fluctuations, whereas wells open in the confined aquifer fluctuated seasonally with deeper levels in summer and shallower levels in winter. This difference indicates a fairly tight confining layer between the two aquifers in subarea D.

Within the confined aquifer, there may be another confining bed in the area of subarea D. Wells open in the older alluvium of the confined aquifer had different water-level fluctuations from those of wells open in both the older alluvium and the continental deposits of the confined aquifer.

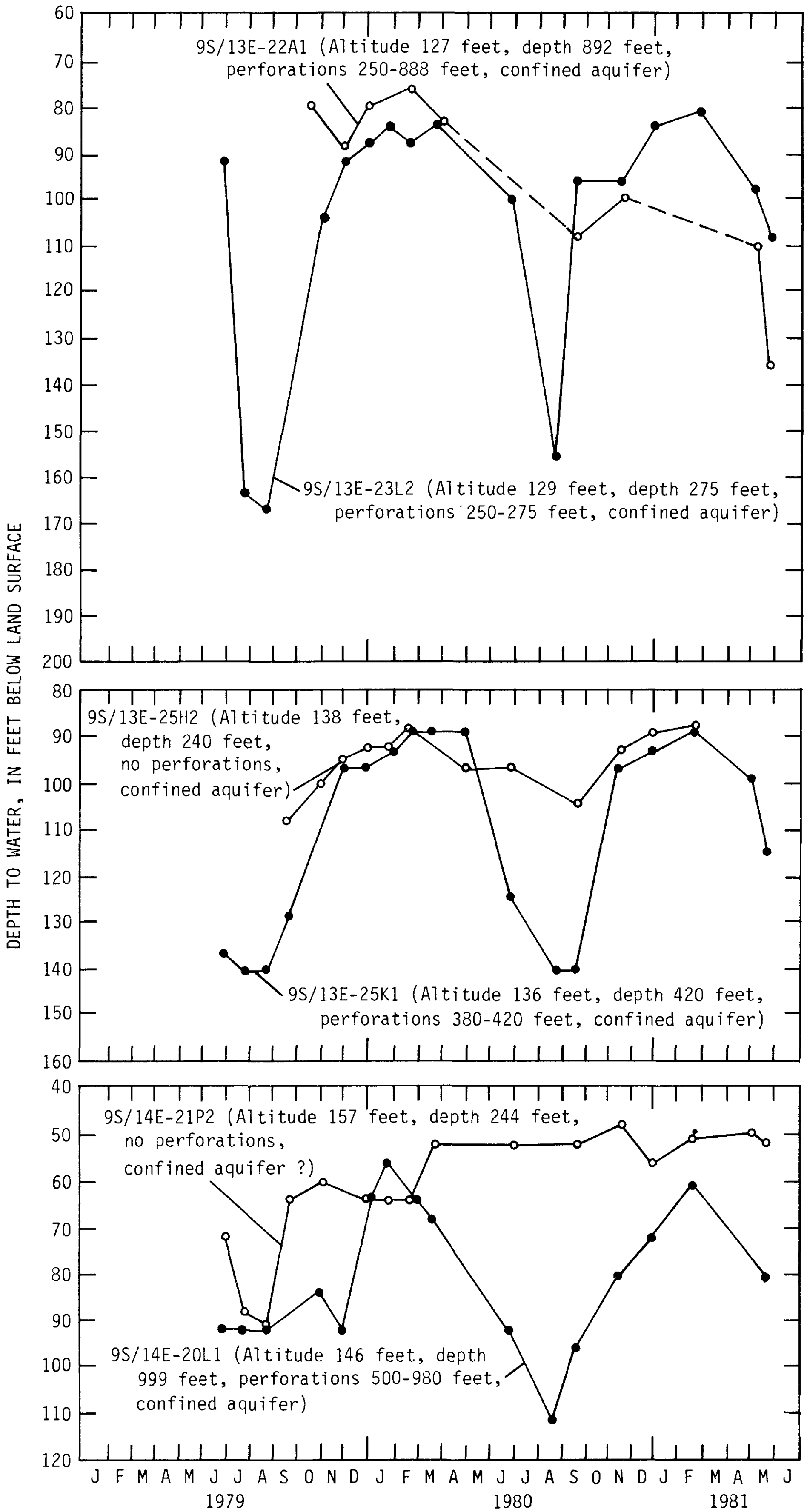


FIGURE 20. – Water-level fluctuations for wells in subarea D.

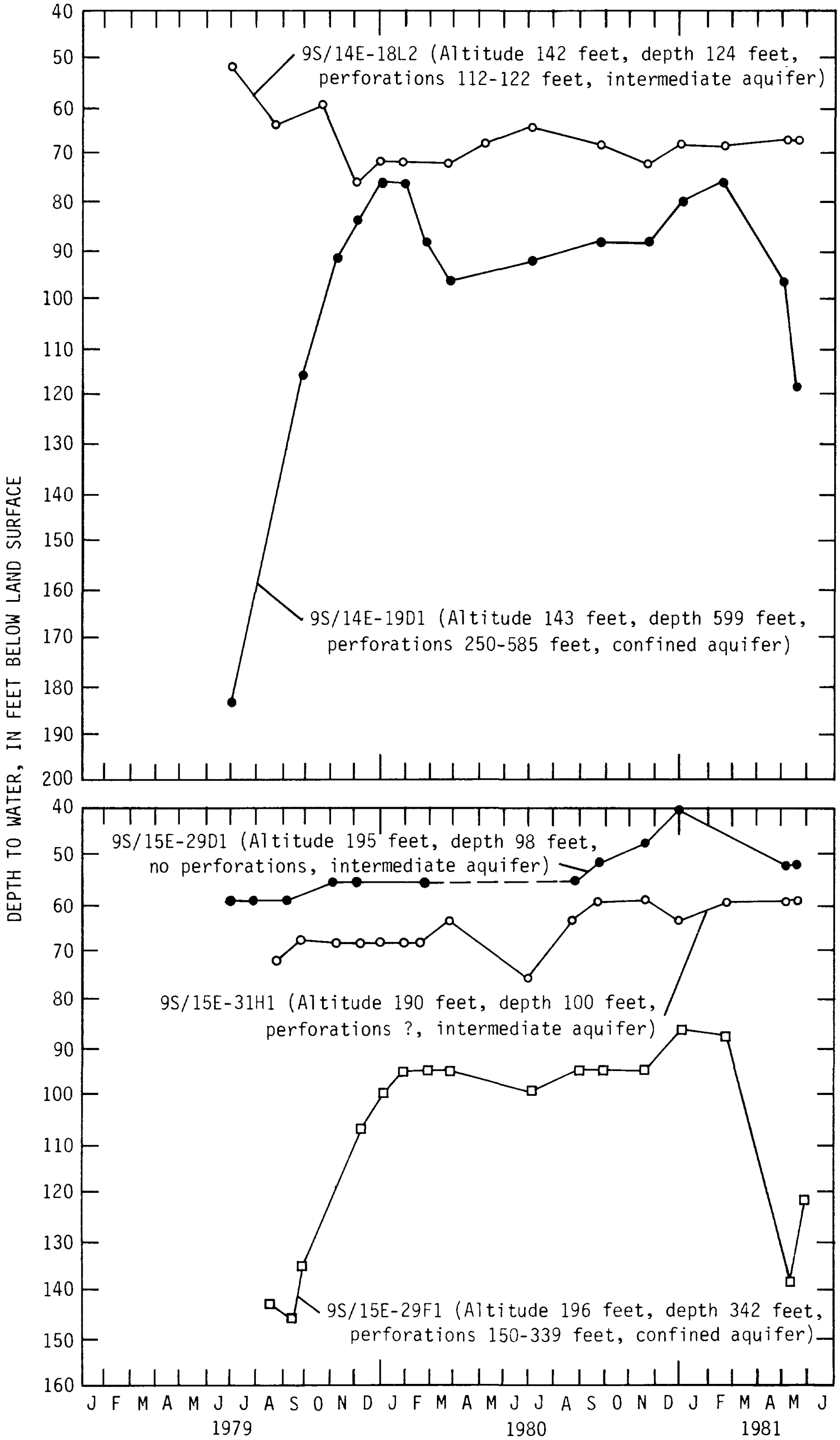


FIGURE 20. – Continued.

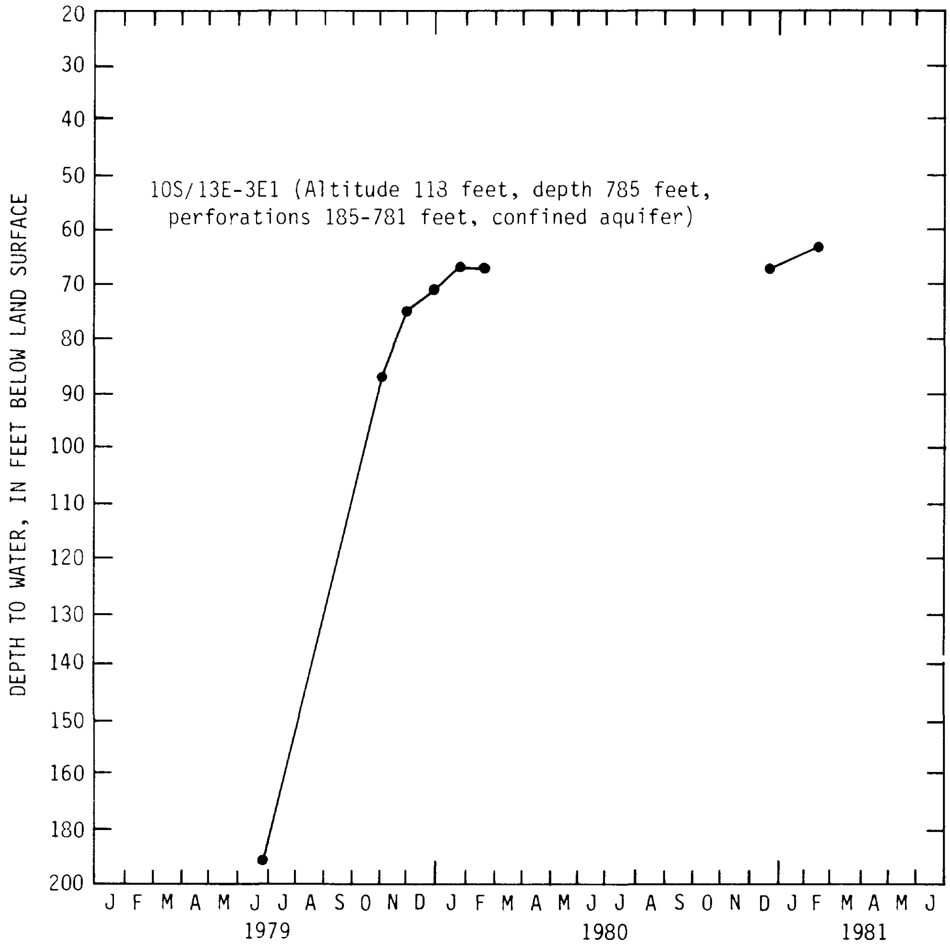


FIGURE 20. – Continued.

Subarea E

Most of subarea E (fig. 16) is rangeland. Some of the land along the creeks and canals east of Planada and Le Grand is under cultivation and some is in the service area of Merced Irrigation District. Data are not available on irrigation rates in the area. All three observation wells in subarea E are in the cultivated land. The geologic units exposed in the western part of the subarea are the older alluvium and continental deposits of the intermediate aquifer. The consolidated rocks crop out in the eastern part. No lasting rises or declines are evident from the 2 years of water-level data in the three observation wells in subarea E (fig. 21), but seasonal fluctuations are evident in wells 7S/16E-19A1 and 8S/16E-36J1.

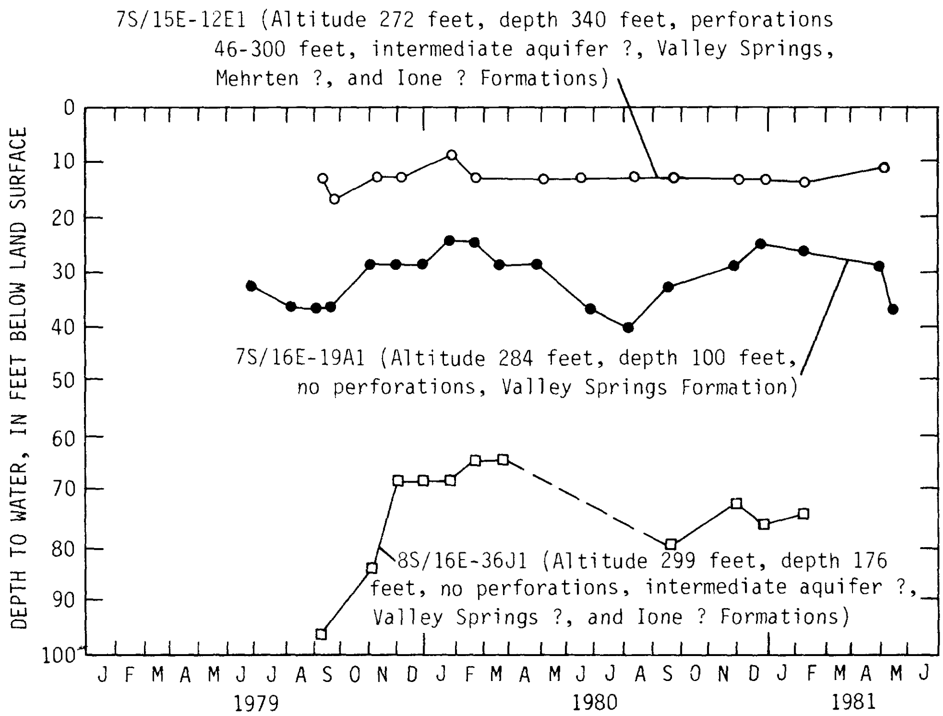


FIGURE 21. – Water-level fluctuations for wells in subarea E.

Subarea F

Most of subarea F (fig. 16) is cultivated land served by the Merced Irrigation District. In the District service area, an average of 2.4 acre-ft of water per acre of irrigated land was delivered each year from 1977 to 1980. Surface water constituted 90 percent of the irrigation water used in this area from 1978 to 1980. Ground water supplied close to 50 percent during 1977. The Corcoran Clay Member occurs in the western section of subarea F but all the observation wells lie east of the Corcoran Clay Member area and are perforated or open in the intermediate aquifer.

Hydrographs of water levels in wells in subarea F showed no continuing rises or declines during the 4½ years of measurement (fig. 22). In general, water levels were lower in 1977-78 than in 1979-80. The lower water levels probably are residual effects of the 1976-77 drought. The variations in water-level fluctuations in these wells probably result from local variations in pumping patterns.

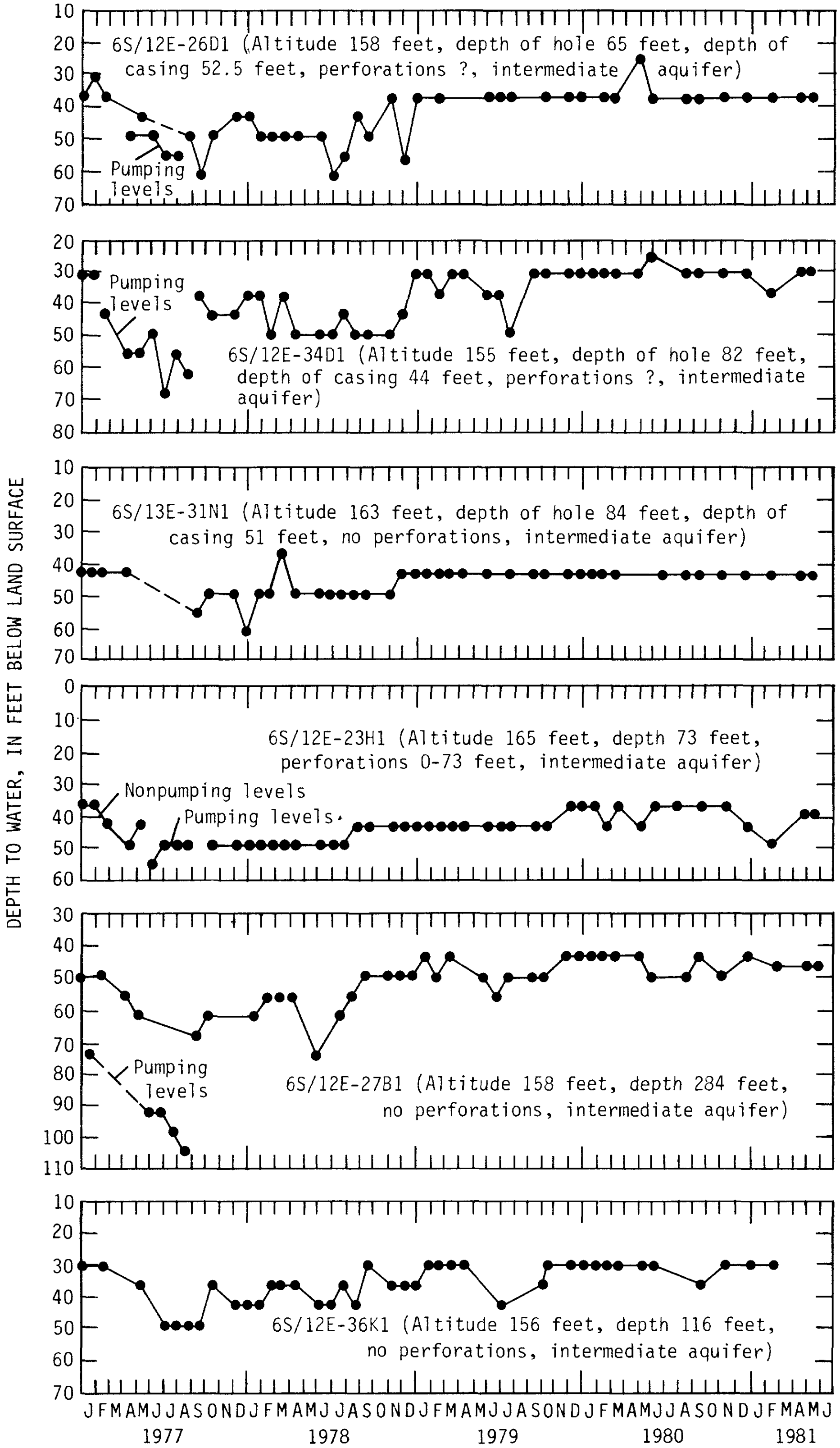


FIGURE 22. – Water-level fluctuations for wells in subarea F.

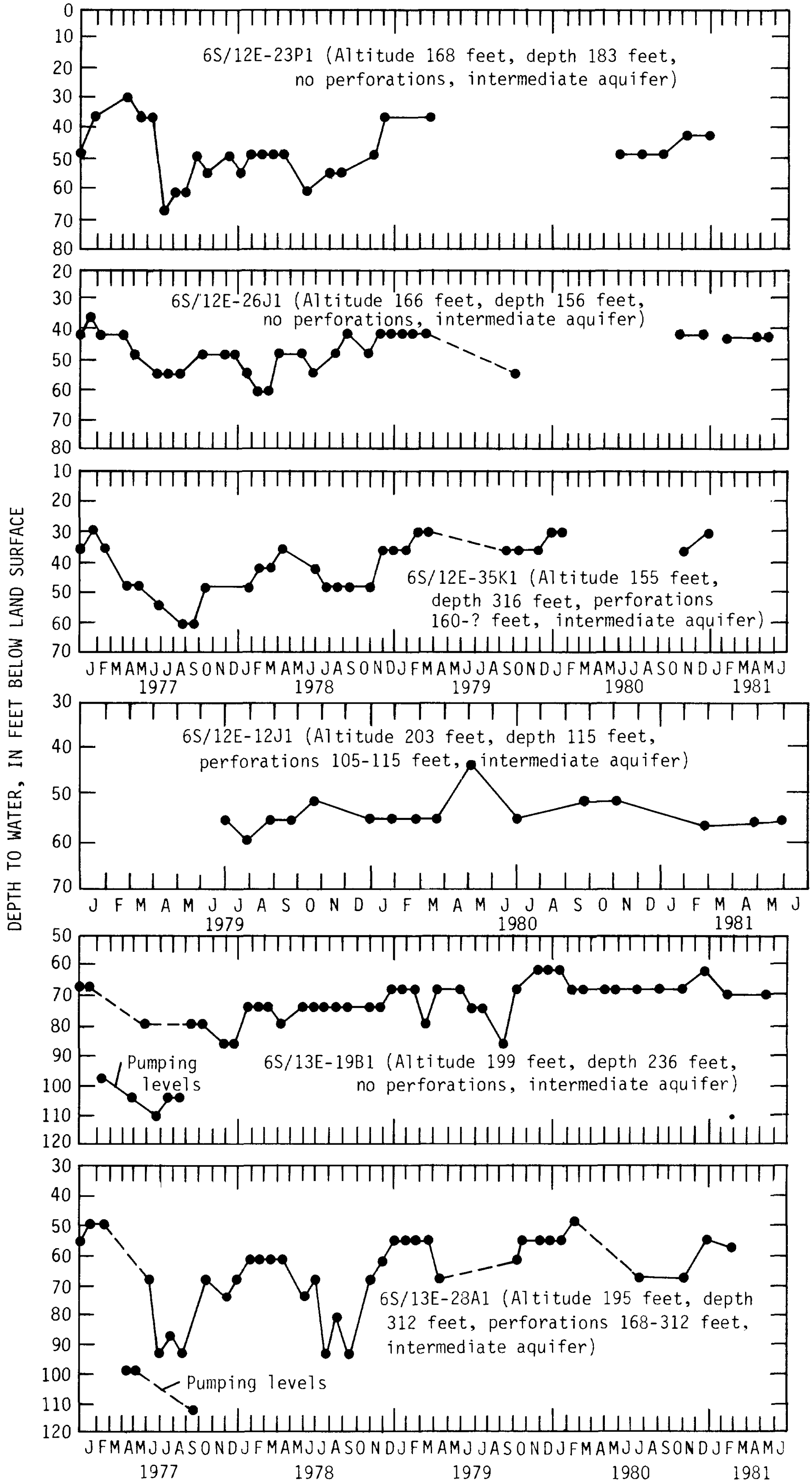


FIGURE 22. – Continued.

Subarea G

Subarea G includes mostly cultivated land within the Merced Irrigation District and suburban areas around the city of Atwater (fig. 16). From 1977 to 1980, irrigated land in the area received an average of 3 acre-ft per acre of Merced Irrigation District water each year. During 1977, ground water supplied between 50 and 95 percent of the irrigation water for each of the Irrigation District divisions in this subarea. From 1978 to 1980, ground water usually constituted less than 15 percent of the irrigation water.

Water levels in all 15 of the observation wells in subarea G had similar general patterns from 1977 to May 1981 (fig. 23). From January to August 1977, water levels declined 15 to 40 feet as a result of the 1976-77 drought. Levels then rose from August 1977 through 1979. From January 1980 to May 1981, water levels in wells without seasonal fluctuations were near their January 1977 levels, and winter levels of wells that had seasonal water-level fluctuations were also near their January 1977 levels.

In general, the water-level fluctuations in wells open to the confined aquifer had a greater range and more distinct seasonal patterns than those in wells open to the intermediate aquifer. This indicates a fairly tight confining layer between the aquifers in the vicinity of subarea G.

Subarea H

Subarea H includes the part of the study area that borders Merced, on the north, east, and south (fig. 16). Much of it is included in Merced Irrigation District. The District service area southwest of Merced received an average of 4 acre-ft of water per acre of irrigated land from 1977 to 1980. The rest of subarea H in Merced Irrigation District received an average of 2.8 acre-ft per acre. Ground water supplied less than 10 percent of the irrigation water from 1978 to 1980. During 1977, it supplied up to 50 percent of the water in some of the Merced Irrigation District divisions in subarea H. Most of the subarea is cultivated cropland. The northern section of subarea H lies northeast of the Corcoran Clay Member. Here the intermediate aquifer and the Mehrten Formation are present. South of Township 7, subarea H is in an area where the intermediate and confined aquifers are separated by the Corcoran Clay Member.

The pattern of water-level fluctuations in wells in subarea H (fig. 24) is similar to those in subarea G; water levels declined in 1977 during the drought and then rose through 1978. Water levels remained fairly stable after 1978.

Water-level fluctuations in wells open in the intermediate aquifer and/or the Mehrten Formation have varying patterns throughout subarea H. This reflects local pumping and recharge patterns. Seasonal high and low water levels are consistent in all the wells perforated in the confined aquifer.

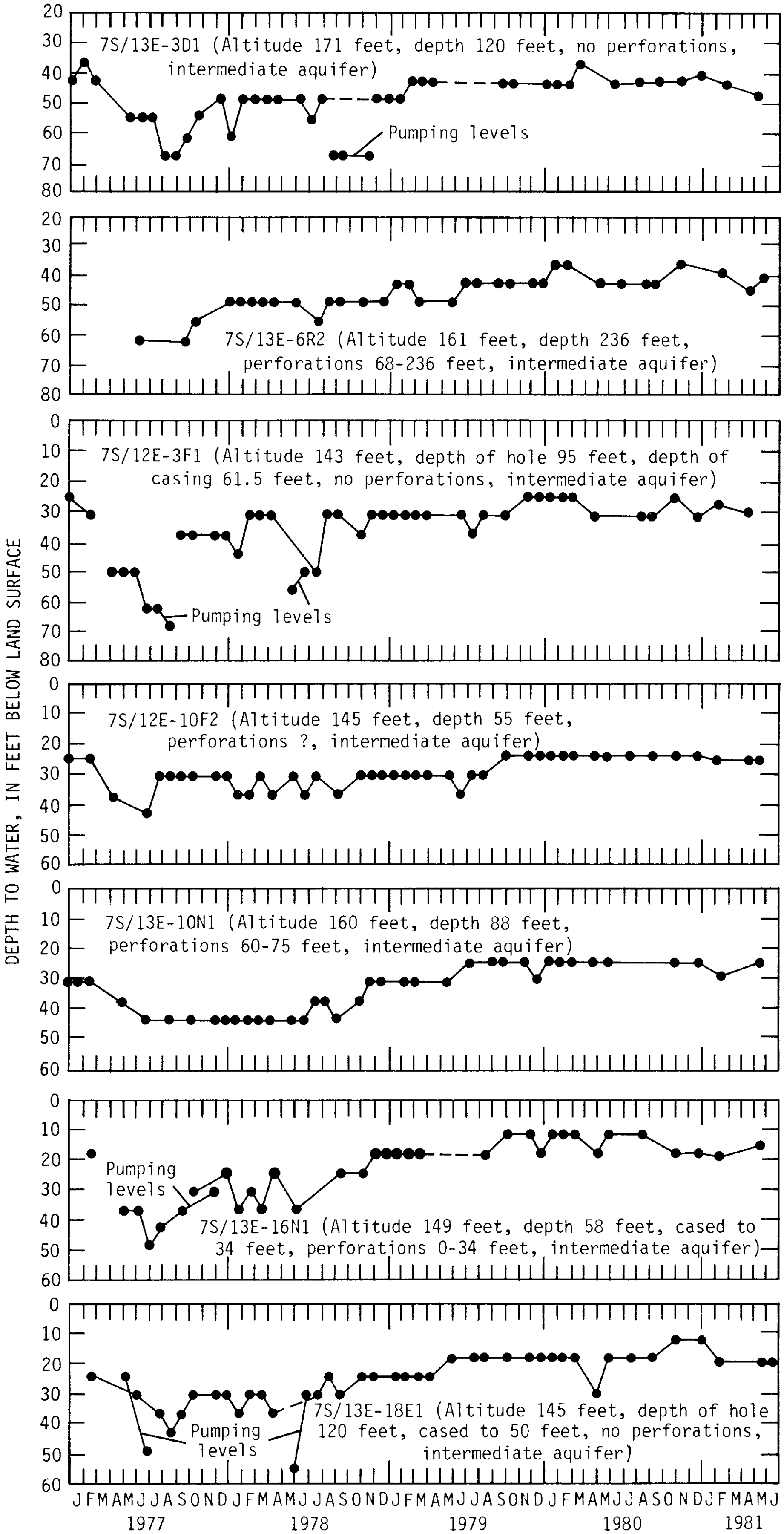


FIGURE 23. – Water-level fluctuations for wells in subarea G.

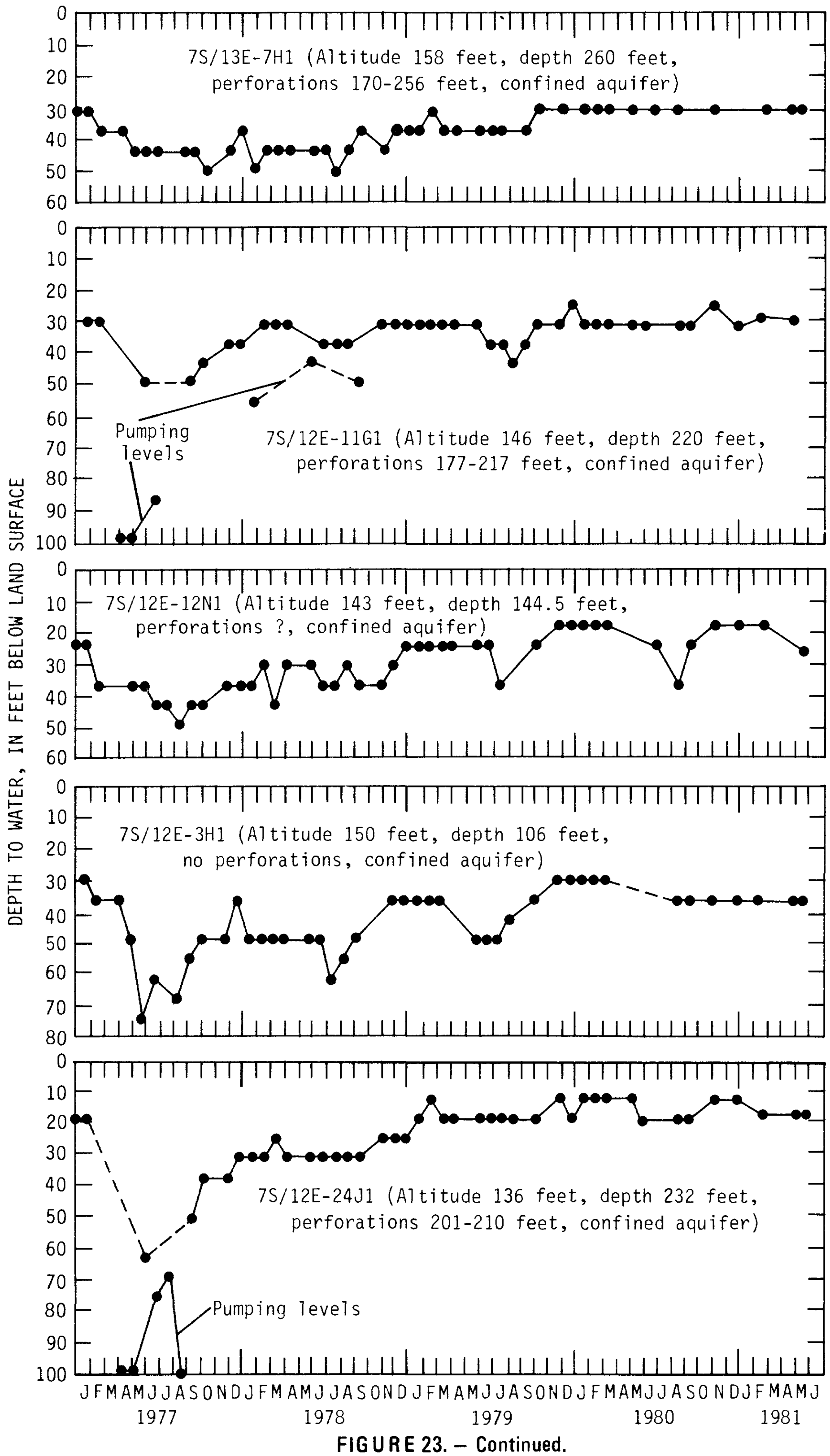


FIGURE 23. – Continued.

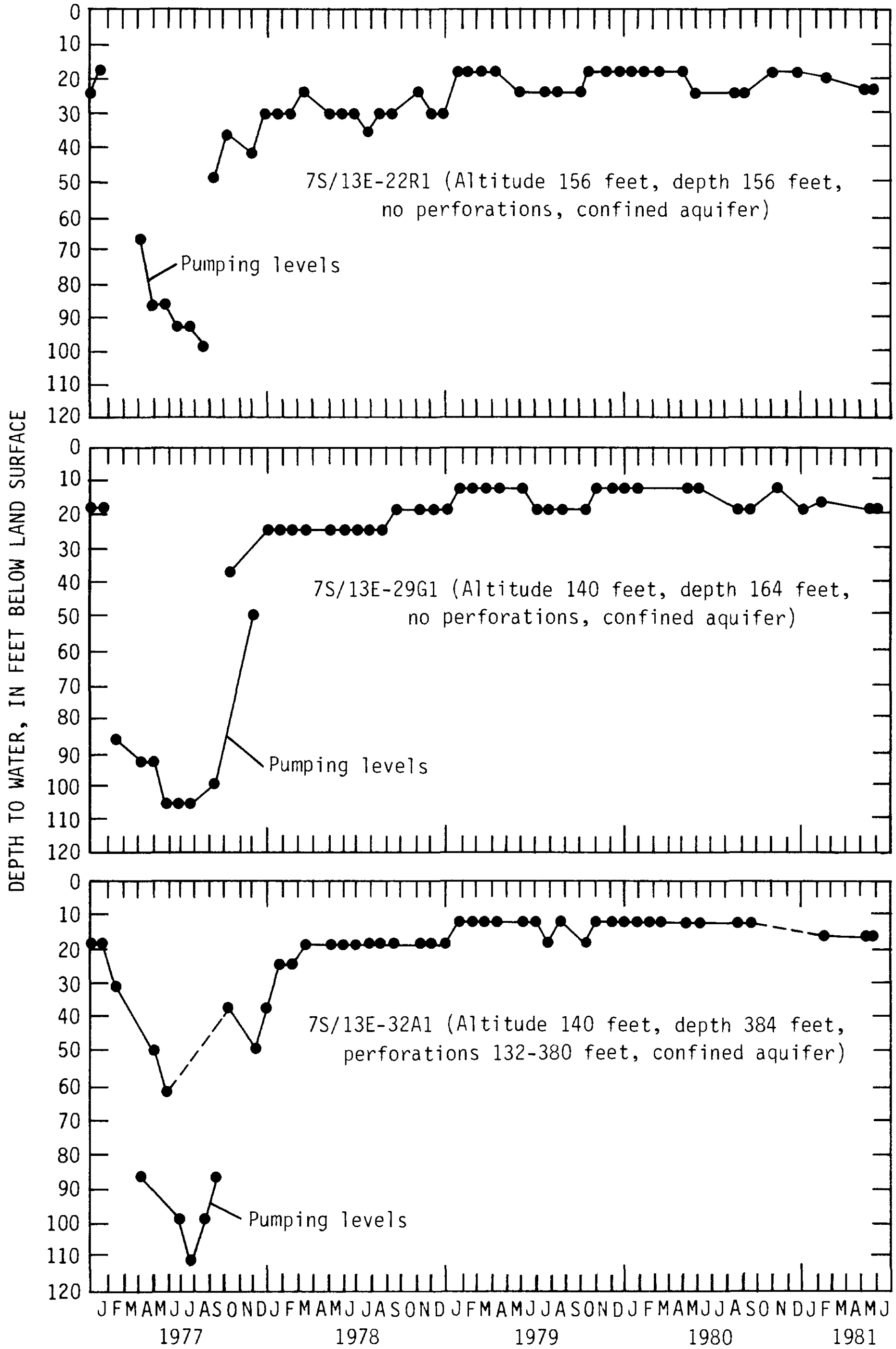


FIGURE 23. – Continued.

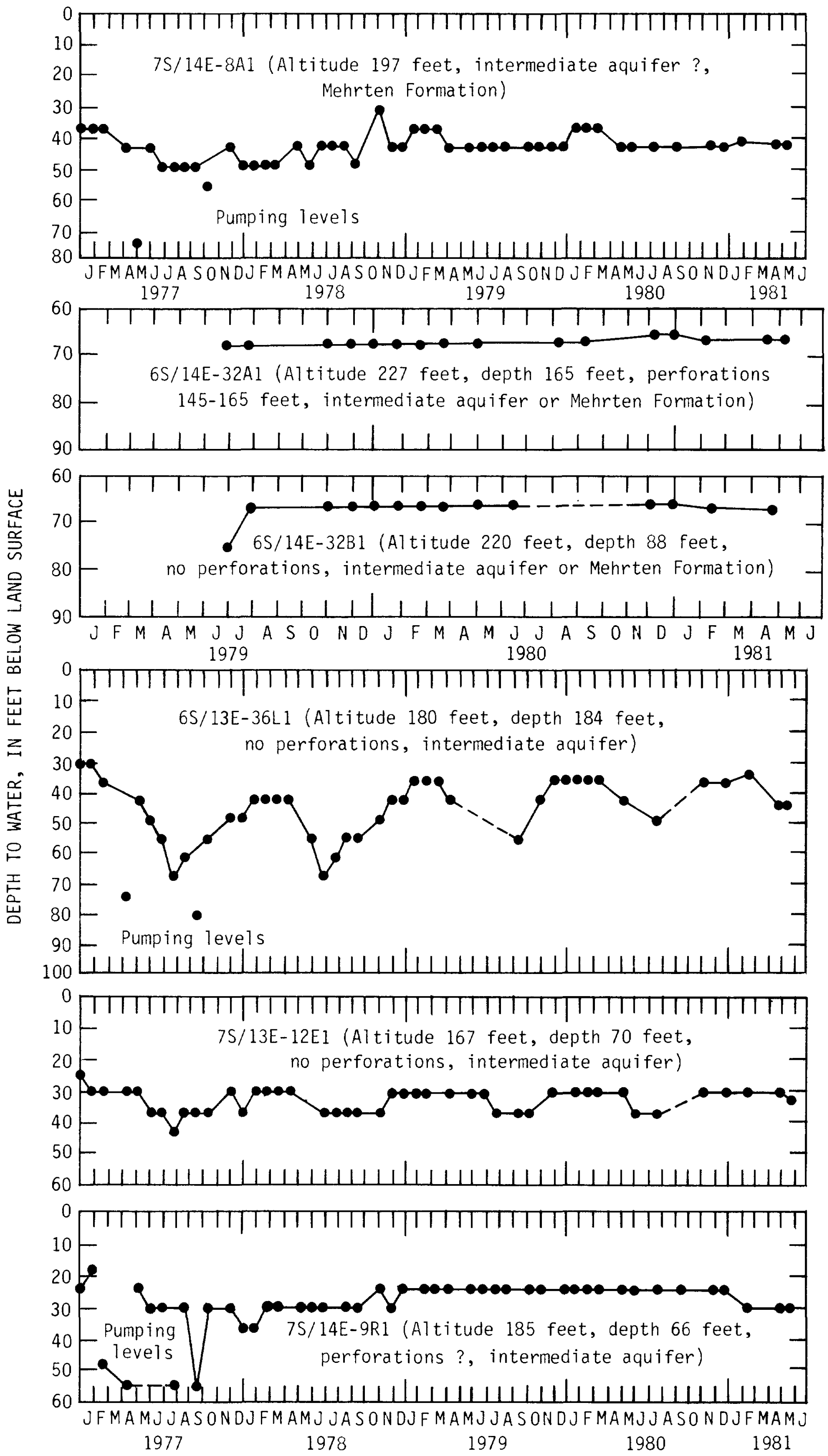


FIGURE 24. – Water-level fluctuations for wells in subarea H.

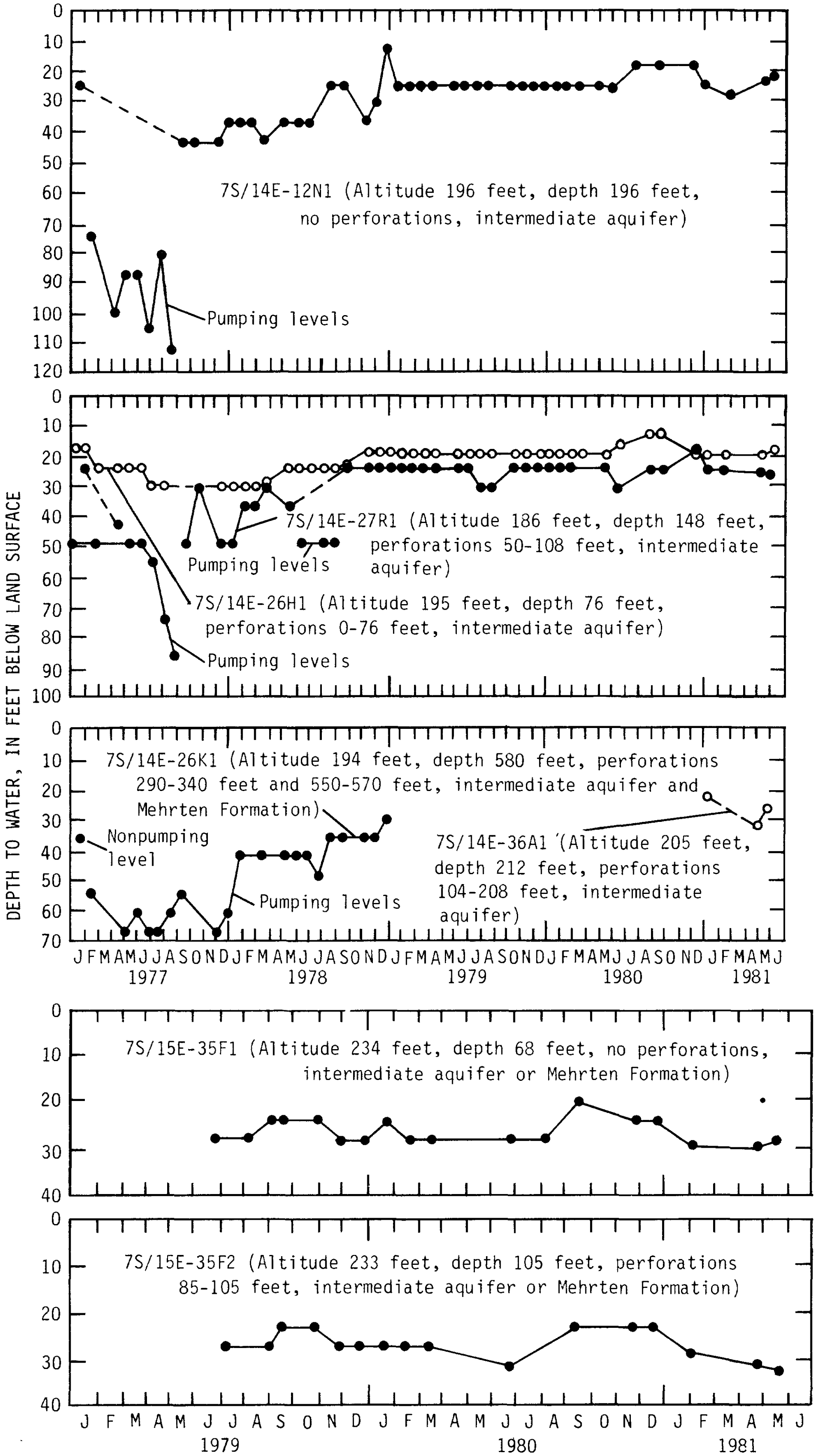


FIGURE 24. – Continued.

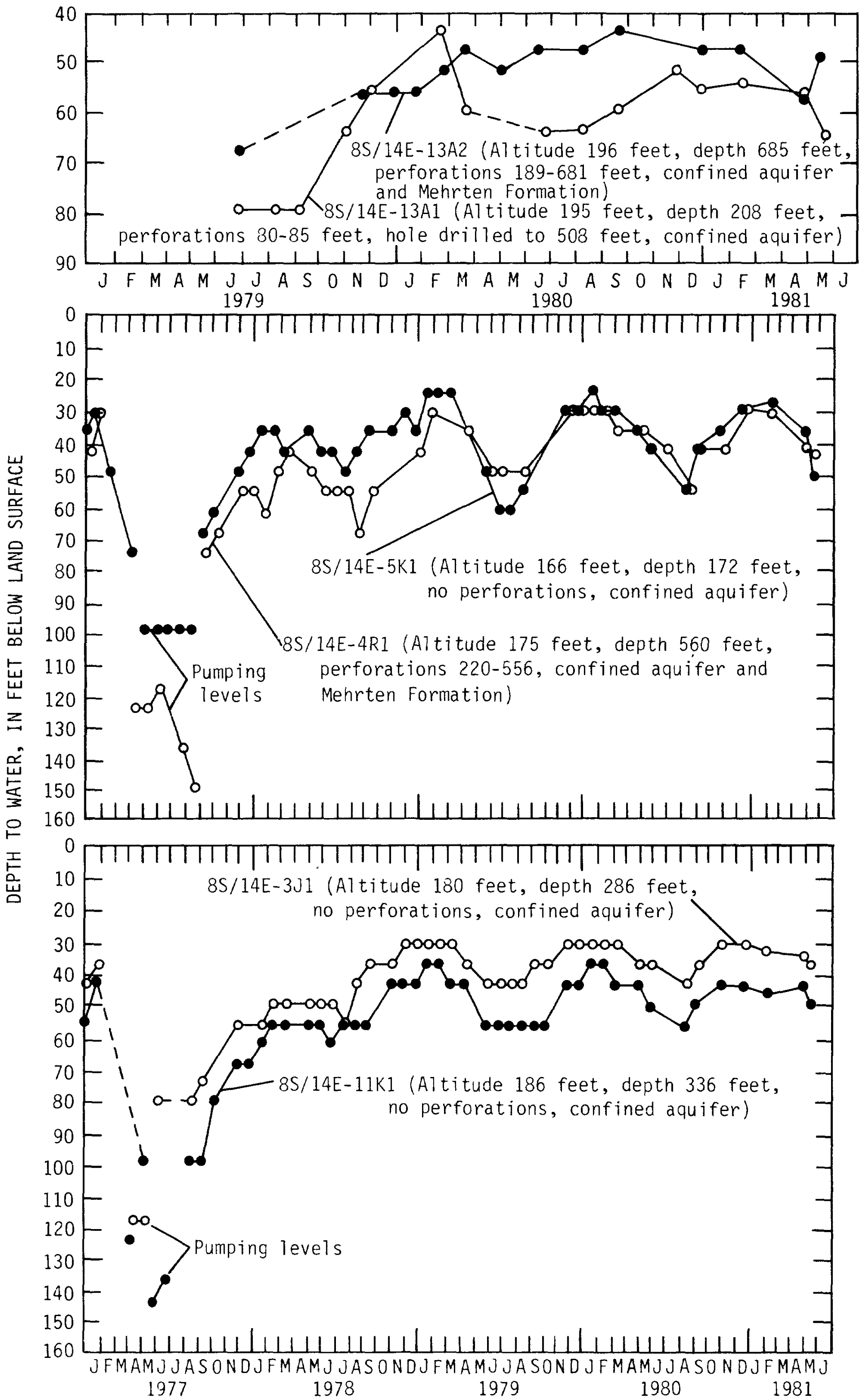


FIGURE 24. – Continued.

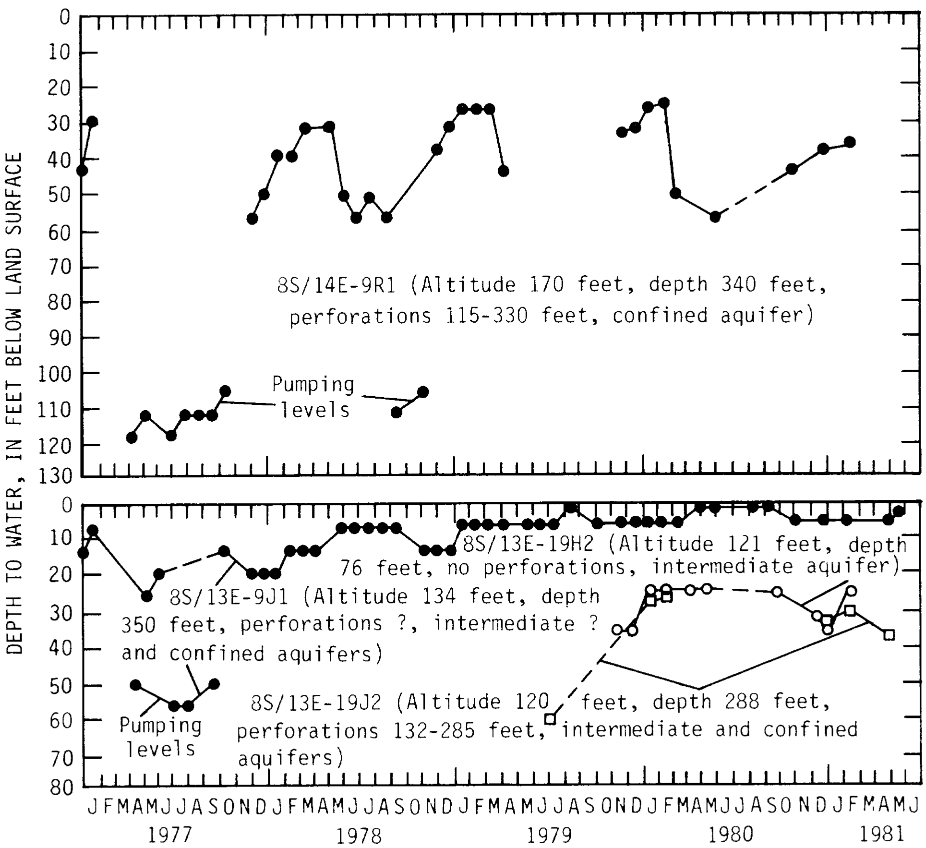


FIGURE 24. – Continued.

Subarea I

Subarea I includes the city of Merced and immediate vicinity (fig. 16). Some cultivated land within the Merced Irrigation District is on the eastern and southern edge of this subarea, but most of the land is urban. The northeastern edge of the Corcoran Clay Member extends through the middle of Merced at a depth between 50 and 100 feet below land surface (figs. 4-6). Observation wells in the area are open to the intermediate aquifer, confined aquifer, and Mehrten Formation. Thirteen of the seventeen observation wells in Subarea I supply domestic water to Merced. They are single wells or groups of two or three wells located at eight stations. The other observation wells belong to the Merced Irrigation District.

Three Merced Irrigation District wells, 7S/13E-36F1, 7S/14E-31J1, and 7S/14E-31M1, are on the southern edge of Subarea I. They are open in the confined aquifer. Water levels in these wells fluctuated seasonally (fig. 25) but indicate no long-term trend.

Water levels in all of the city of Merced wells fluctuate seasonally, but show no long-term trends (fig. 25-27). The effects of the 1976-77 drought are reflected only in the longer period of depressed water levels in 1977.

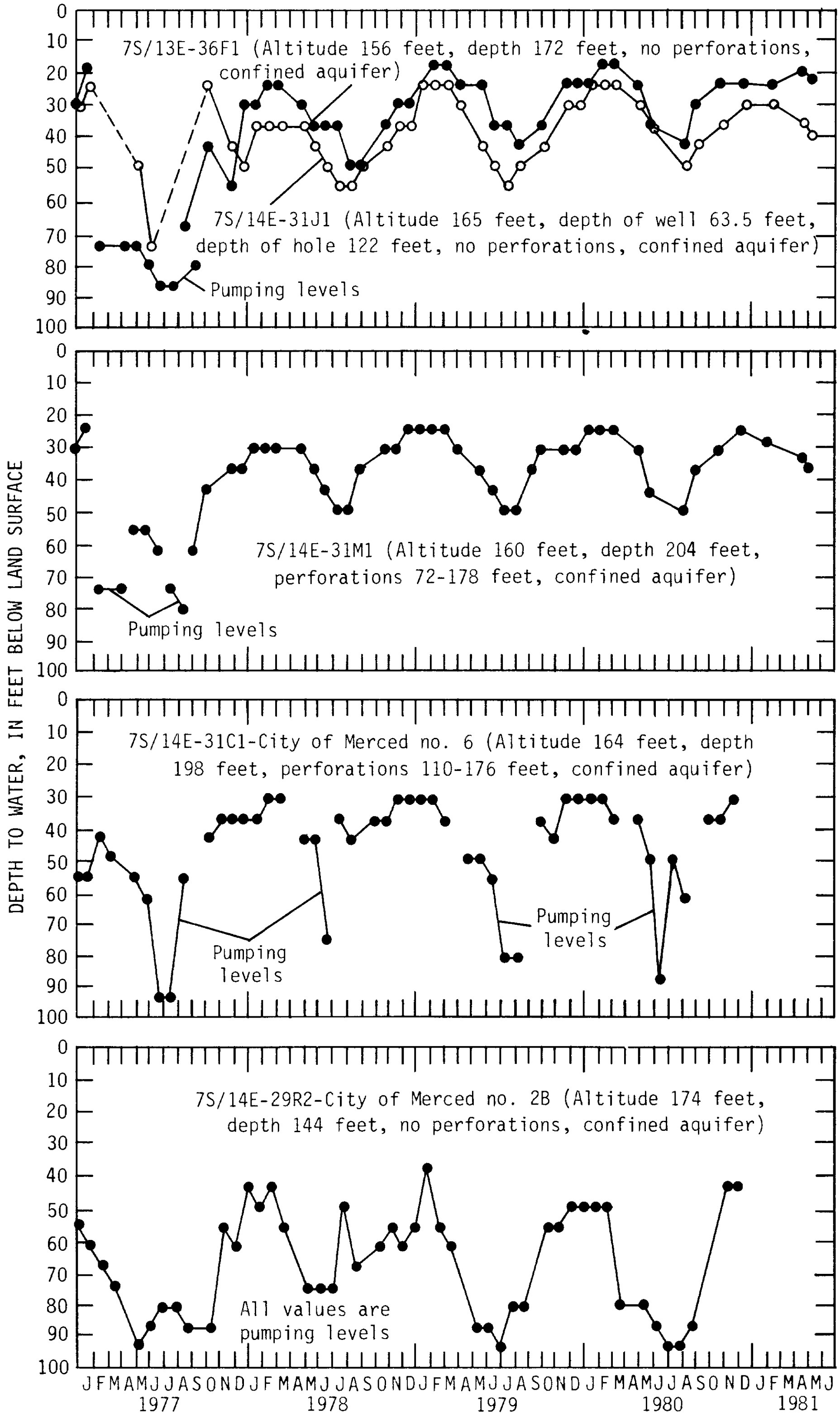


FIGURE 25. — Water-level fluctuations for wells in subarea I.

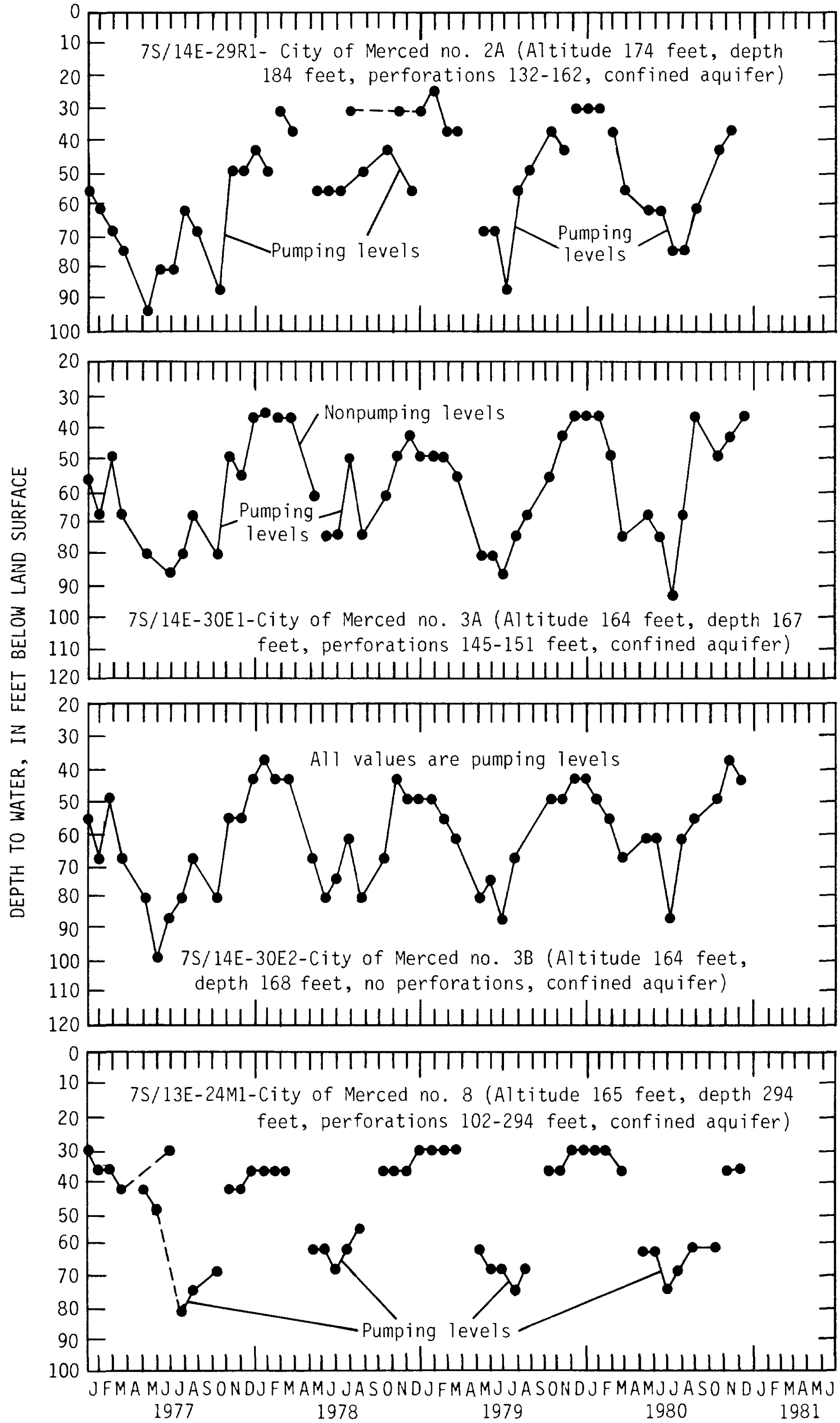
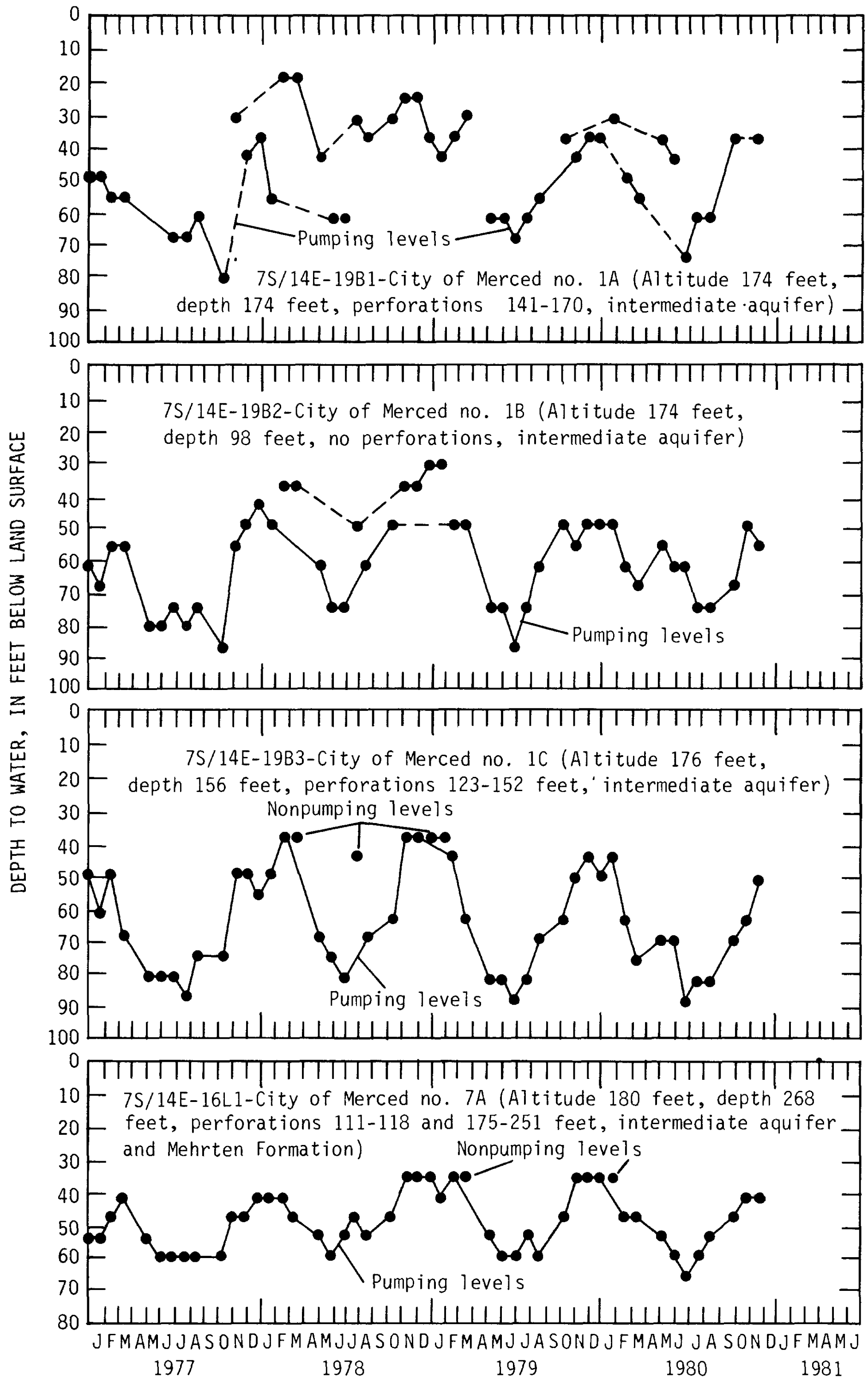


FIGURE 25. – Continued.



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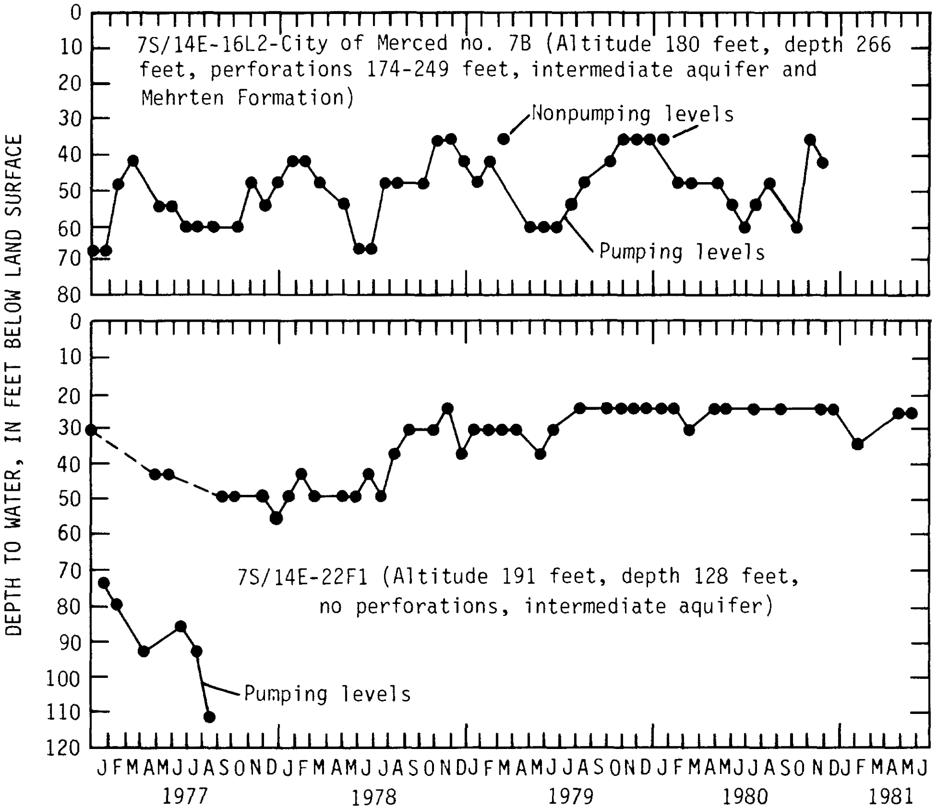

FIGURE 25. – Continued.

Monthly pumpage and water-level fluctuations of well 7S/13E-24Q1, which is open in the confined aquifer, are shown in figure 26, modified from Page (1977). Pumpage from the well was less from 1976 to 1980 than from 1971 to 1975. Nonpumping water levels were also slightly lower from 1976 to 1980. Pumping levels were nearly the same throughout 1971-80.

Well 7S/14E-19J1 is just north of the area underlain by the Corcoran Clay Member and is open in the intermediate aquifer. Water-level fluctuations and monthly pumpage from this well at city of Merced station 4 are shown in figure 27, modified from Page (1977). Much less water was pumped from this well from 1977 to 1980 as compared to 1971 to 1976. Except during the drought years of 1976-77, winter nonpumping water levels remained fairly stable.

Well 7S/14E-22F1, a Merced Irrigation District well, is open in the continental deposits of the intermediate aquifer. Its water level did not fluctuate seasonally (fig. 25).

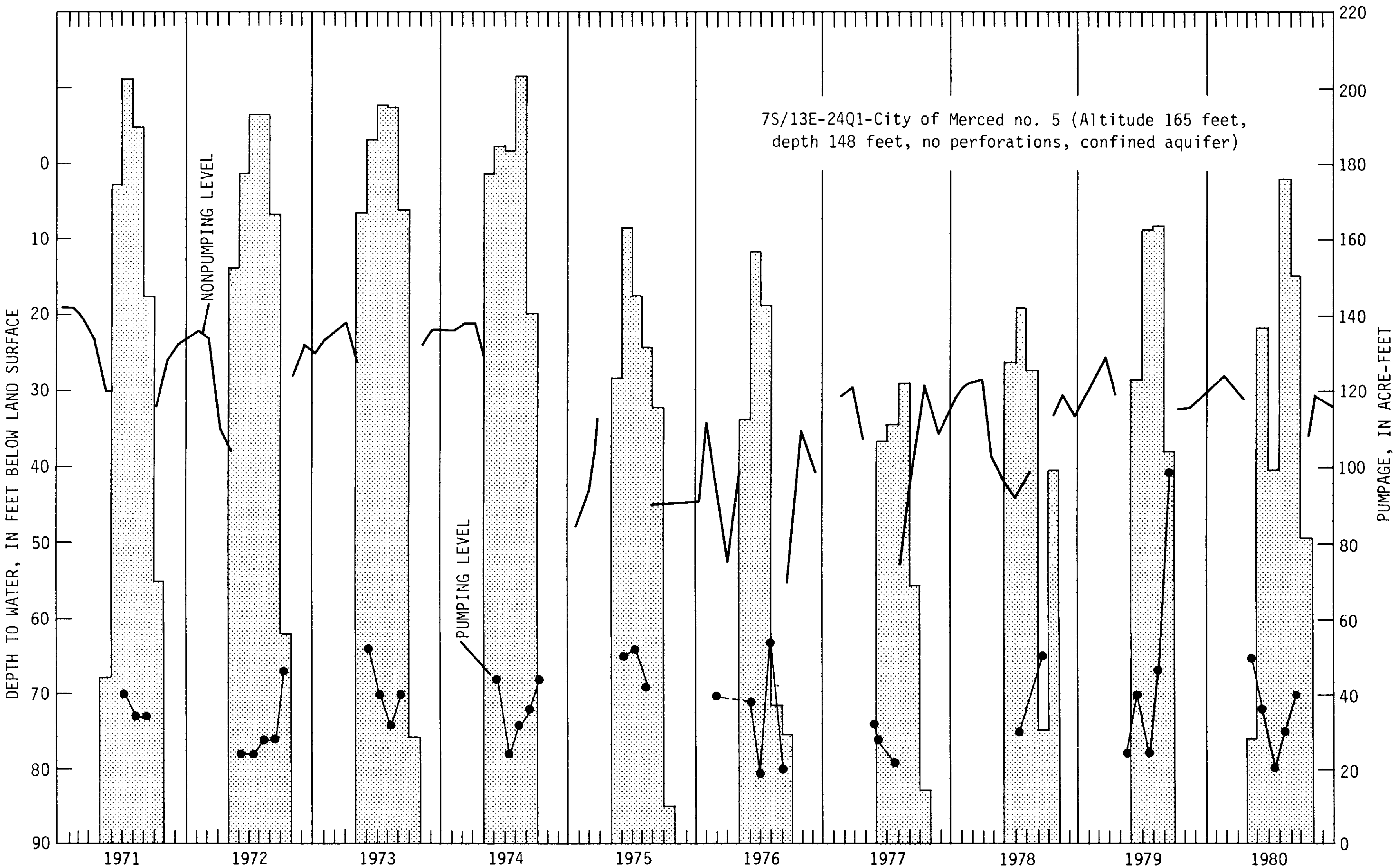

FIGURE 26. — Pumpage and water-level fluctuations in well 7S/13E-24Q1.

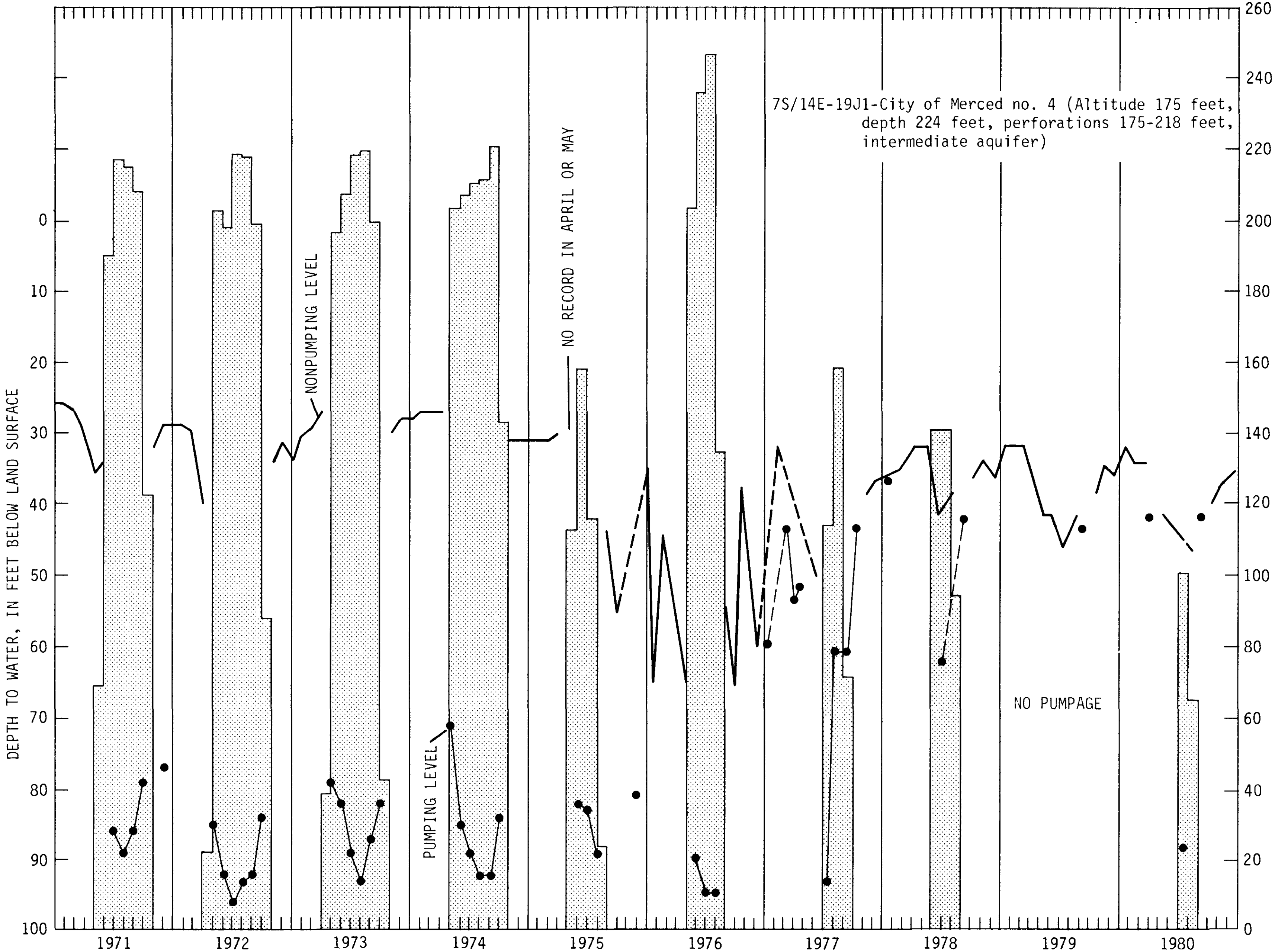

FIGURE 27. – Pumpage and water-level fluctuations in well 7S/14E-19J1.

MONITORING NEEDS

A ground-water monitoring network is needed to provide water-level data of each aquifer over the entire study area. Contour maps of the potentiometric surfaces of the aquifers are important tools for interpreting changes in the storage and movement of ground water.

Prior to 1982, the network of observation wells did not provide the data needed to define the potentiometric surface. The deficiency in that network is apparent in figures 5, 6, 8, and 9. Outside the central part of the study area, observation wells were too scattered to allow reliable contouring. For this reason, the observation-well network was expanded to cover as much of the confined and intermediate aquifer as possible. Winter 1982 baseline water-level contour maps are shown in figures 7 and 10. Once summer baseline water-level contour maps are prepared, ground-water conditions can be monitored by quarterly measurements of selected key wells. At 5-year intervals, or when large annual changes in ground-water levels are detected in the key wells, the entire network of wells can be measured to obtain data for new contour maps.

SUMMARY

Data show no significant net decline or rise in water levels. This indicates that in the study area, recharge balances natural discharge and withdrawals by pumping. Information from shallow test wells indicate extensive fine-grained material at depths between 10 and 20 feet in the shallow aquifer that could interfere with surface artificial recharge to the aquifer system.

Throughout much of the study area, water-level fluctuations in wells open to different aquifers generally had dissimilar seasonal fluctuations. In some areas wells open to different depths within the same aquifer also had dissimilar short-term fluctuations. These dissimilarities probably are due to differing recharge and pumping patterns and differing aquifer characteristics, such as degree of confinement.

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