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REGIONAL SPECIFIC YIELD OF THE EDWARDS AND ASSOCIATED LIMESTONES IN THE SAN ANTONIO, TEXAS, AREA

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ABSTRACT

The regional specific yield in the recharge area of the Edwards and associated limestones, the principal aquifer in the San Antonio, Texas, area, is estimated to be about 0.025. This estimate is based on annual differences between recharge and discharge and on the averages of annual water-level changes in 10 observation wells in and near the outcrop area.

HYDROGEOLOGY OF THE AREA

The Edwards and associated limestones of Early Cretaceous age consist of the Comanche Peak, Edwards, and Georgetown Limestones (fig. 1). These light-gray limestones form a single hydrologic unit and generally are hard, dense, and fine grained. They are characterized by numerous solution-enlarged openings at various depths. The total thickness of the limestones is 400 to 500 feet in the artesian area and about 400 feet in the water-table or recharge area. The artesian part of the aquifer is confined by the Del Rio Clay above and the Glen Rose Limestone below.

In the San Antonio area, the limestone aquifer dips south and southeast towards the Gulf of Mexico at a rate of 10 to 20 feet per mile. The Balcones Fault Zone, an area of moderate to intense block faulting within the study area, is characterized by high-angle normal faults, downthrown to the south or southeast, with displacements of as much as 500 feet (fig. 2). The faults provide passageways for circulating ground water, which in turn enlarges the openings by dissolving the limestone.

The effective porosity (precentage of total pore volume occupied by interconnected interstices available for fluid flow) of the aquifer in the Balcones Fault Zone is mostly secondary in origin and consists of caverns, vugs, solution-enlarged fractures, and leached burrows. Primary or intergranular porosity occurs locally in leached granular dolomitic beds.

At several road cuts in the outcrop area, the limestone is not uniformly porous, but contains vertical zones, 1 to 10 feet thick, of relatively high porosity separated by zones of dense limestone containing few open fractures. Honeycombed rock commonly occurs at different vertical positions within the aquifer. The burrowed beds near the base of the unit may form one of the more laterally extensive porous and permeable zones. In general, the porosity in the outcrop area seems to be greater in the middle and lower parts of the unit.

The most significant effective porosity probably occurs along fractures; the larger openings probably extend along major fractures that are oriented in the general direction of regional ground-water flow. The continuity and extent of the honeycombed limestone in the artesian zone is uncertain. Many of the drillers' logs indicate honeycombed and cavernous limestone at different depths in the artesian zone, but no laterally extensive zones of honeycombed rock in the subsurface have been identified.

REGIONAL SPECIFIC YIELD

The regional specific yield of the limestone aquifer is the capacity of the rock in the recharge area to yield water by gravity drainage with a lowering of the water table. It is a measure of interconnected porosity of the rock within the zone of annual water-level fluctuations in the recharge area:

The regional specific yield was determined by the following equation:

$$Sy = \frac{(R-D)/A}{\Delta h}$$

where:

Sy = the regional specific yield (dimensionless);

R = the annual recharge in acre-feet;

D = the annual discharge in acre-feet;

A = the computed acreage in the recharge area (10.0×10^5); and

Δh = the average annual change in water levels in 10 key observation wells, in feet.

The following assumptions were made: (1) The average of the annual changes in water levels in 10 selected wells are indicative of the change in storage by gravity drainage in and near the recharge area, and (2) the system approaches a steady-state condition at the end of each year.

The first assumption is reasonably fulfilled inasmuch as six of the 10 wells used were in or near the recharge area. The other four wells are in the artesian area, but the pattern of water-level fluctuations in these wells, as a group, is similar to that in the water-table wells. The second assumption is generally valid near the end of the year when recharge and pumping are at a minimum and reasonably constant.

Records of water levels in 10 observation wells having a common period of record (1958-66) were used to estimate the average change in head at the end of the year. Hydrographs of these wells show similar patterns of seasonal water-level fluctuations (fig. 3).

The regional specific yield calculated for the limestone aquifer in the recharge area averaged about 0.025 (table 1). The individual estimates ranged from less than 0.01 to 0.03. The best estimates of specific yield can be made for those years when the difference between recharge and discharge is large. Because the effects of recharge and discharge during the winter are generally at a minimum and relatively uniform, the water levels are fairly constant during that time.

The conditions for comparing storage changes with head changes are particularly favorable during long periods of continuous rises or declines in regional head. Transitional periods between regional rises and declines or periods of local inconsistencies generally are not suitable. Consideration of periods with above-average recharge, but with small net changes in storage also may give unreasonable results.

The estimated recharge for wet periods contains larger errors than those for relatively dry periods, and unless the storage changes are large, these errors may be significant in the computations of specific yield. This may be the case for part of the results for 1961, 1965, and 1966. Conversely, the recharge estimate for 1964 was below average during a period when the change in storage was not large; therefore, the specific yield appears reasonable. It is also noted that 1964 was a transitional period from a generally declining head to a slightly rising head.

Table 1.--Estimates of regional specific yield

Year	Recharge R AF(x)1,000	Discharge D AF(x)1,000	(R-D) AF(x)1,000	$\frac{(R-D)}{\text{unconfined area}}$ (feet)	Mean water-level alt. January 1 (feet)	Mean water-level alt. December 31 (feet)	Δh alt. (feet)	Regional specific yield $\frac{(R-D)/A}{\Delta h}$ (feet)
a/ 1958	1,711	617.5	1,093.5	1.10	722.2	762.7	+40.5	0.03
a/ 1959	690.4	619.0	71.4	.07	762.7	766.9	+ 4.2	.02
a/ 1960	824.8	655.4	169.4	.17	766.9	772.9	+ 6.0	.03
a/ 1961	717.1	683.5	33.6	.03	772.9	770.4	- 2.5	-
a/ 1962	249.4	589.0	-339.6	.34	770.4	752.1	-18.3	.02
a/ 1963	170.3	516.0	-345.7	.35	752.1	734.4	-17.7	.02
a/ 1964	411.2	474.0	- 62.8	.06	734.4	732.0	- 2.4	.03
b/ 1965	623.5	578.9	44.6	.04	732.0	746.1	+14.1	c/ >.01
b/ 1966	615.2	571.2	44.0	.04	746.1	744.3	- 1.8	c/ >.01

Average regional specific yield = 0.025

a/ Garza (1966).

b/ Data from Edwards Underground Water District.

c/ Not used in estimate.

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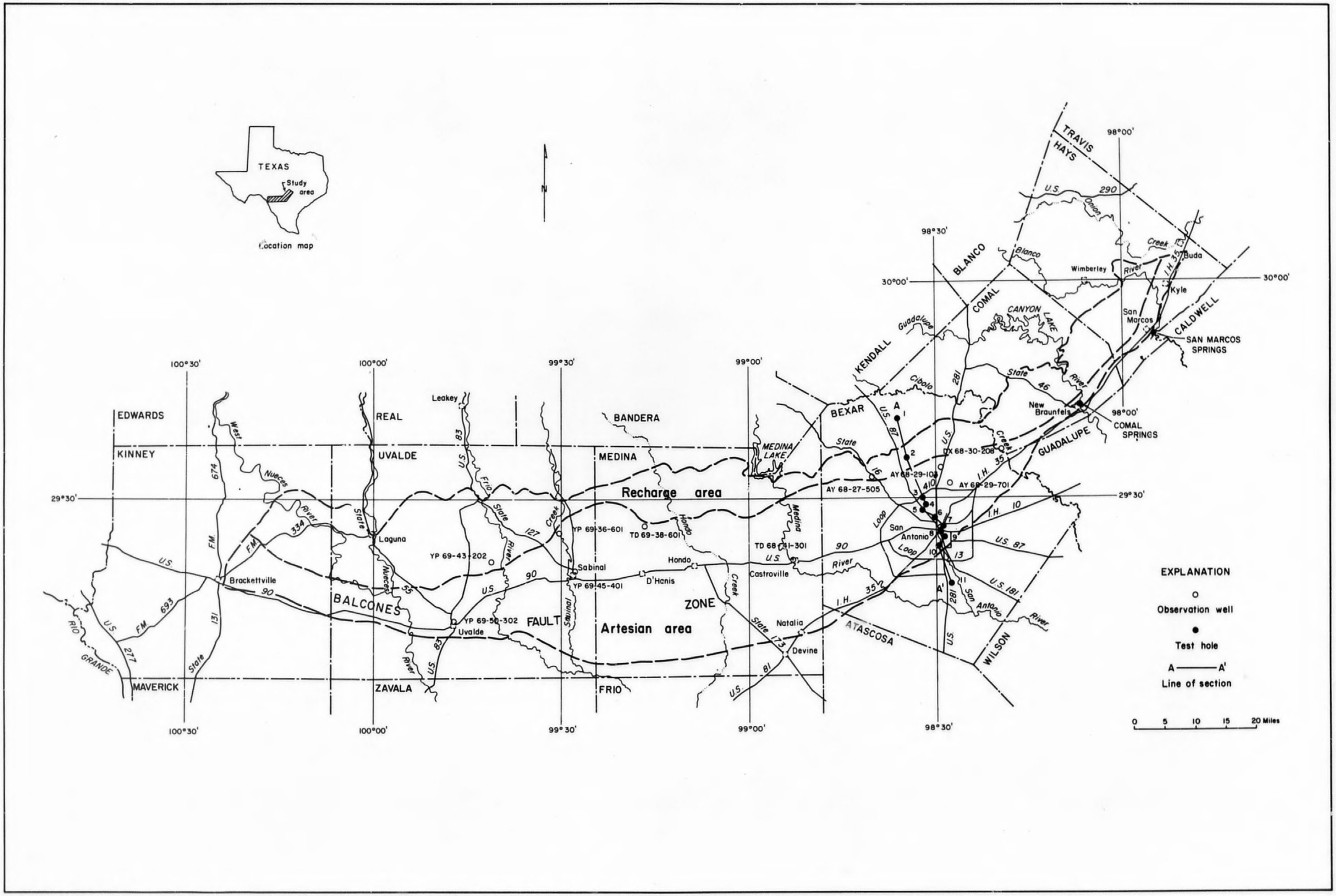

FIGURE 1.-Recharge and artesian areas of the Edwards and associated limestones

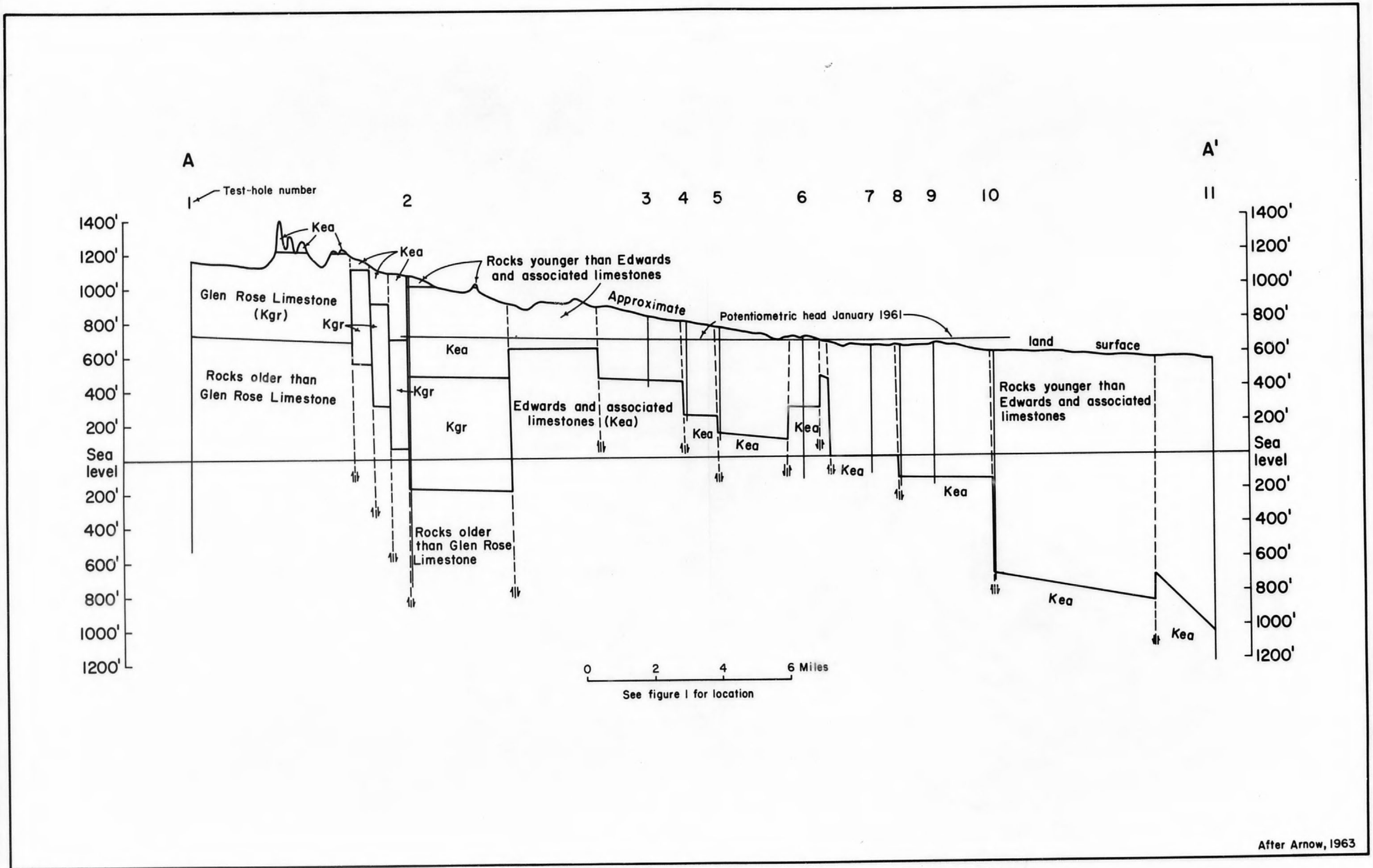

FIGURE 2. - Geologic section showing the altitude of the potentiometric surface in January 1961

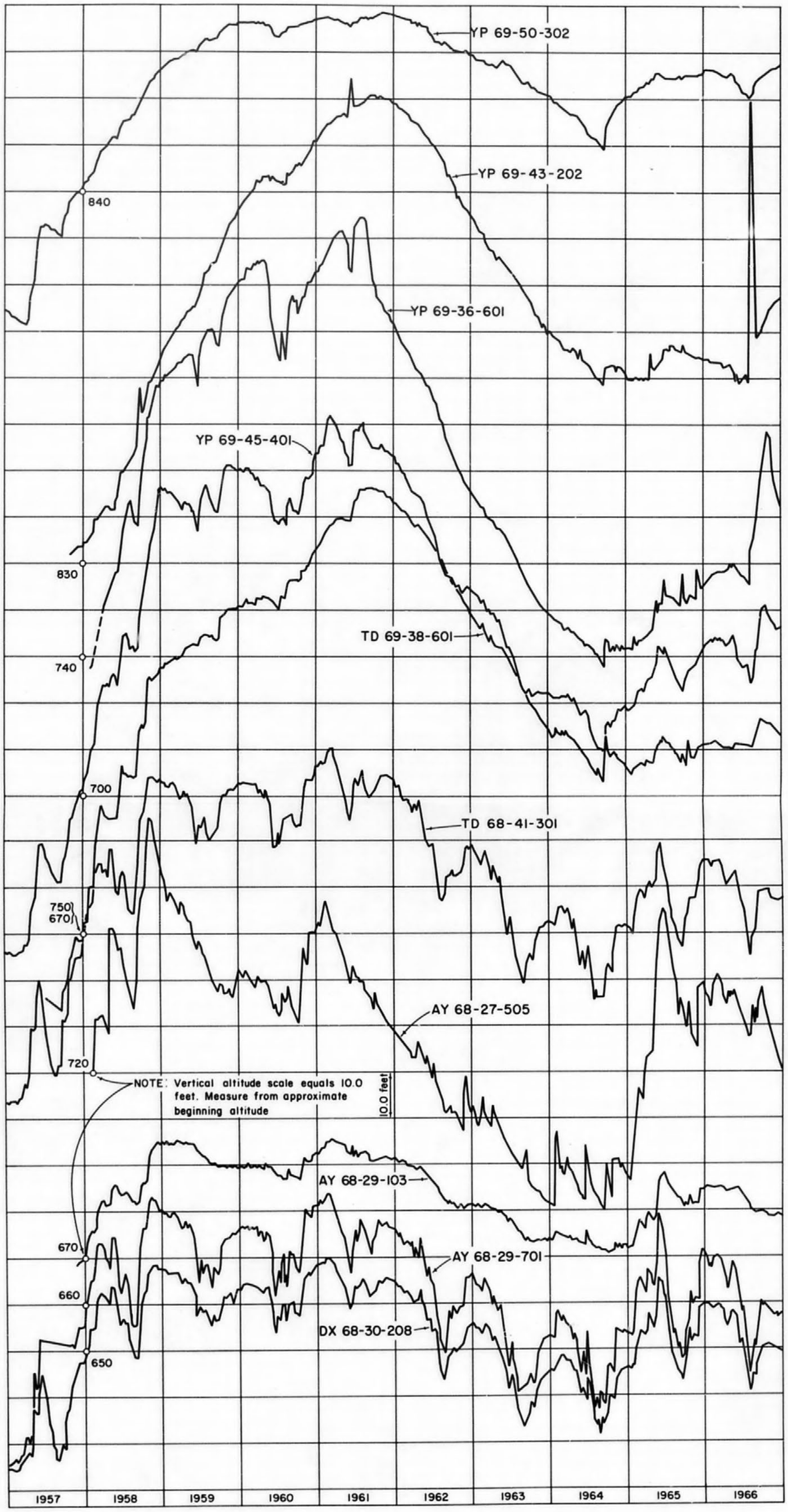

FIGURE 3. - Hydrographs for observation wells