POTENTIOMETRIC SURFACE OF THE EDWARDS-TRINITY AQUIFER SYSTEM AND CONTIGUOUS HYDRAULICALLY CONNECTED UNITS, WEST-CENTRAL TEXAS, WINTER 1974-75

By
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INTRODUCTION

The potentiometric surface of the Edwards-Trinity aquifer system and contiguous hydraulically connected units (from December 1974 through February 1975) was mapped as part of the Edwards-Trinity Regional Aquifer-System Analysis (RASA) project. A major goal of the Edwards-Trinity RASA project is to understand and describe the regional flow system (Bush, 1986). The development of a digital ground-water flow model of the aquifer system is a key part of the project. This potentiometric map will be used in the calibration of the ground-water flow model and in understanding ground-water movement in the aquifer system.

The map depicts the potentiometric surface of the major aquifers of the Edwards-Trinity aquifer system and contiguous units that form a continuous hydraulically connected regional aquifer within the study area in west-central Texas (fig. 1). The potentiometric surface of an aquifer is an imaginary surface defined by contouring locations of equal static head (the altitude to which water will rise in a well). The potentiometric surface map shows the direction of ground-water flow from higher to lower altitude.

The study area extends beyond the aquifers of the Edwards-Trinity system to hydrologic divides, including the Colorado River and the Rio Grande (fig. 2).

The data used to compile this map were obtained from the Texas Natural Resources Information System on magnetic tape and from Rees and Buckner (1980). The winter of 1974-75 (December 1974 through February 1975) was selected for mapping for two reasons: (1) More water-level data were available throughout the study area for this winter season than for other winter seasons, and (2) during winter there is almost no loss of ground water as a result of evaporation, irrigation withdrawals, and transpiration.

PHYSIOGRAPHY

The area underlain by the Edwards-Trinity aquifer system in west-central Texas is divided into four regions: Edwards Plateau, Hill Country, Trans Pecos, and Balcones fault zone (fig. 1). The Hill Country region is characterized by rough rolling terrain ranging in altitude from 400 to 2,400 ft (Ashworth, 1983, p. 2). The Edwards Plateau region in the center of the study area is characterized by "***rolling plains to flat tableland and rugged, steep-walled canyons and draws***" ranging in altitude from 1,000 to 3,300 ft (Walker, 1979, p. 7)

The Edwards-Trinity aquifer system is bounded by a series of mountain ranges west of the Trans Pecos region, which is characterized by the flat alluvial valley of the Pecos River on the north and east, and by highly dissected flat plateaus and mesas on the south. Altitudes in the Trans Pecos region range from 1,200 ft in the south to 4,500 ft at the eastern edge of the Davis Mountains (Rees and Buckner, 1980, p. 2)

The Balcones fault zone region in the southern part of the study area is characterized by an escarpment created by a series of en echelon faults, which trend east to west along the length of the region (fig. 1). In the eastern part of the Balcones fault zone, the altitude of land surface ranges from about 500 to 1,000 ft. In the western part of the Balcones fault zone altitudes range from about 500 to 1,500 ft.

The major rivers that drain west-central Texas are the Colorado, Guadalupe, Nueces, and Pecos Rivers, and the Rio Grande (fig. 2). Many of these rivers are incised into the Edwards-Trinity aquifer system. Base flow, consisting of ground-water discharge to streams, ranged from 25 to 90 percent of the total streamflow for December 1974 through March 1977 (Kuniansky, 1989).

The climate varies from subhumid, subtropical in the east to arid, temperate in the west. There are two rainy seasons in the eastern part of the study area, one in spring and one in fall. Storms in the eastern part of the area usually are widespread. In the western part of the study area precipitation usually occurs in the summer. These summer storms may be intense, but are local in extent. Precipitation has the greatest spatial variability and the least frequency in the west. Mean annual precipitation (1951-80) throughout the study area ranges from 32 in. in the east to 10 in. in the west (Riggio and others, 1987, fig. 11).

THE EDWARDS-TRINITY AQUIFER SYSTEM AND CONTIGUOUS HYDRAULICALLY CONNECTED UNITS

The major aquifers of the Edwards-Trinity aquifer system are in rocks of Cretaceous age. The principal aquifers are named the Edwards in the Balcones fault zone, the Trinity in the Hill Country, and the Edwards-Trinity in the Edwards Plateau and Trans Pecos regions. Lithologically, these aquifers are predominantly carbonate with some basal sand formations in the Edwards-Trinity and Trinity aquifers.

Throughout the Trans Pecos, Edwards Plateau, and Hill Country regions, the Edwards-Trinity and Trinity aquifers are unconfined to semiconfined. The sediments forming these aquifers were laid down in a marine environment in several depositional cycles and are horizontally bedded with many vertical joints.

In the Hill Country, rocks of the Edwards Group (Rose, 1972) and much of the upper layers of the Glen Rose Formation have been eroded by streams. Rocks of the Edwards Group cap some hill tops, and rocks of the upper Glen Rose are exposed along the hillsides. In the northeastern part of the Hill Country streams have eroded much of the Glen Rose formation exposing the Hensel Sand and Cow Creek Limestone Members along the Pedernales River (Ashworth, 1983, fig. 5).

The Edwards aquifer is unconfined in a narrow strip of outcropped rocks of the Edwards Group (Rose, 1972) along the southern edge of the Edwards Plateau and Hill Country regions. Most of this aquifer is confined downdip from the outcrop. Rocks of this formation tend to be honeycombed, horizontally bedded, and in general are more permeable than rocks of the adjacent Trinity aquifer. Dissolution of the rocks parallel to the faults has resulted in higher permeability along the faults than across the faults.

Throughout the study area, erosional unconformities result in contiguous hydraulically connected water-bearing units ranging in depositional age from Precambrian to Recent. Figure 1 shows the relation of hydrogeologic units and major aquifers and their stratigraphic equivalents [1/], and indicates those hydrogeologic units from which data were used for drawing the potentiometric maps. Contours of the altitude of the bottom of the open interval of wells are shown in figure 2; water-level data from these wells were used for the potentiometric map. Symbols on figure 2 indicate which aquifer or hydrogeologic unit a water level represents. Wells in contiguous non-Cretaceous units are screened at about the same depth as wells in the Edwards-Trinity aquifer.

In the Trans Pecos and Edwards Plateau regions, the Edwards-Trinity aquifer is overlain by and hydraulically connected to the alluvial aquifer in sediments of Cenozoic age near the Pecos River (Oglibee and Wesselman, 1962, pl. 5-7; Rees and Bucker, 1980, fig. 3). Cretaceous rocks adjacent to the Pecos River were completely eroded and the alluvial aquifer also is connected hydraulically to the Santa Rosa Sandstone of Triassic age (White, 1968, p. 20).

The High Plains aquifer northwest of the Edwards-Trinity is formed by sediments of Cenozoic age adjacent to and hydraulically connected to the sands of the Edwards-Trinity in the Edwards Plateau (Walker, 1979, p. 39).

North of the Edwards Plateau, several stratigraphic units composed of sediments both older and younger than the Edwards-Trinity aquifer form a shallow ground-water aquifer that drains towards the Colorado River and its tributaries (Lee, 1986, p. 9).

East of the Edwards Plateau, the Marble Falls aquifer in the Pennsylvanian Marble Falls Limestone, the Ellenberger-San Saba (limestone) aquifer in the Ordovician Ellenberger Group and underlying Cambrian San Saba Member of the Wilberns Formation, and the Hickory aquifer in the Cambrian Hickory Sandstone Member of the Riley Formation are older rocks of Paleozoic age. Precambrian metamorphic and igneous rocks of highly eroded, faulted, and fractured granite, gneiss, and shist also crop out in the region (Walker, 1979, table 2). These Precambrian rocks yield small quantities of water to domestic and stock wells (Mason, 1961, p. 16).

1/ The stratigraphic nomenclature used in this report was determined from several sources and may not necessarily follow usage of the U.S. Geological Survey.

POTENTIOMETRIC SURFACE, WINTER 1974-75

The potentiometric surface of an aquifer is an imaginary surface defined by contouring locations of equal static head (the altitude to which water will rise in a well). The potentiometric map was constructed using water-level data from 804 wells and 24 spring pools (sheet 2). Water levels were measured from December 1974 through February 1975, with the exception of data for the southern part of the Trans Pecos region and Upton and Reagan Counties in the Edwards Plateau west of San Angelo. Data for the southern part of the Trans Pecos region were collected in 1973. Data for six wells in the two counties west of San Angelo were collected during December in 1970 and 1972.

The potentiometric surface map shows the direction of ground-water flow from higher to lower altitudes. In an isotropic aquifer (an aquifer in which hydraulic properties are independent of direction) ground-water movement is perpendicular to the potentiometric contours. The potentiometric map shown on sheet 2 represents the potential for ground-water flow in the Edwards-Trinity aquifer system and hydraulically connected units during winter 1974-75. Water levels from wells screened in water-bearing units of non-Cretaceous age were used to draw contours that represent the water table.

The potentiometric surface shown on sheet 2 shows ground-water movement toward the perennial streams over the unconfined part of the aquifer system in the Trans Pecos, Edwards Plateau, and Hill Country regions. In this area the potentiometric surface tends to follow the topography, with the hydraulic gradient steepest at the western edge of the Trans Pecos region near the mountains and flattest at the center of the Edwards Plateau. The potentiometric surface varies from near land surface adjacent to some streams to more than 800 ft below land surface near the mountains. In the Balcones fault zone, anisotropy caused by dissolution of the rocks presents less resistance to flow along the faults. The gradient from west to east is very small, but the flow in this direction is great. Gradients shown on a more detailed potentiometric map of the Edwards aquifer (Maclay and Small, 1986, fig. 23) indicate flow from southwest to northeast along the strike of the fault zone.

The potentiometric surface also indicates areas of recharge, discharge, and changes in aquifer characteristics. In general, highs in the surface indicate areas of recharge and lows in the surface indicate areas of discharge. Recharge is indicated along the edge of the aquifer system adjacent to the mountains in the Trans Pecos region. In addition, water appears to enter the Edwards-Trinity aquifer laterally from the High Plains aquifer. Areas where hydraulic gradients anomalously steepen may indicate a reduction in aquifer transmissivity. Such areas are not apparent on this surface.

The perennial streams are not only surface-water drains, but also are drains of the regional ground-water flow system in the Trans Pecos, Edwards Plateau, and Hill Country regions. The Colorado and Pecos Rivers, and the Rio Grande drain the Edwards-Trinity aquifer system and the hydraulically connected units, as evidenced by the hydraulic gradient toward these rivers.

In the Hill Country there are more streams than in the Trans Pecos and Edwards Plateau regions. However, the potentiometric surface does not show hydraulic gradients toward streams covering large areas, indicating that ground-water discharge to these streams is more localized. This localized flow is indicated by the many small springs (less than 10 ft^3/s) and seeps along the hillsides forming the headwaters of the rivers. At the headwaters of the Nueces River, there were more of these smaller springs and seeps than on the other rivers in the Hill Country.

Numerous springs are natural discharge locations for the system. The largest springs are along the Balcones fault zone. Some of the larger springs in this area are Goodenough, San Felipe, Las Moras, Leona, San Antonio, Hueco, Comal, San Marcos, and Barton. Goodenough, Comal and San Marcos springs discharge more than 100 ft^3/s (Brune, 1975). Contours on the potentiometric surface show little of this natural discharge from the Edwards aquifer because of the regional anisotropy and high transmissivity of the Edwards aquifer.

The largest municipal and industrial ground-water use is in the San Antonio area where about 270,000 acre-ft of water were pumped in 1974. No cone of depression appears on the regional map because of the high transmissivity of the Edwards aquifer and the regional anisotropy. Near the Pecos River, there are two cones of depression. Irrigation withdrawals in this area in 1974 were about 460,000 acre-ft (Texas Water Development Board, 1986).

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METRIC CONVERSIONS

Factors for converting inch-pound units to metric (International System) units are given in the following table:

Multiply inch-pound unit	By	To obtain metric units
foot (ft)	0.3048	meter (m)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

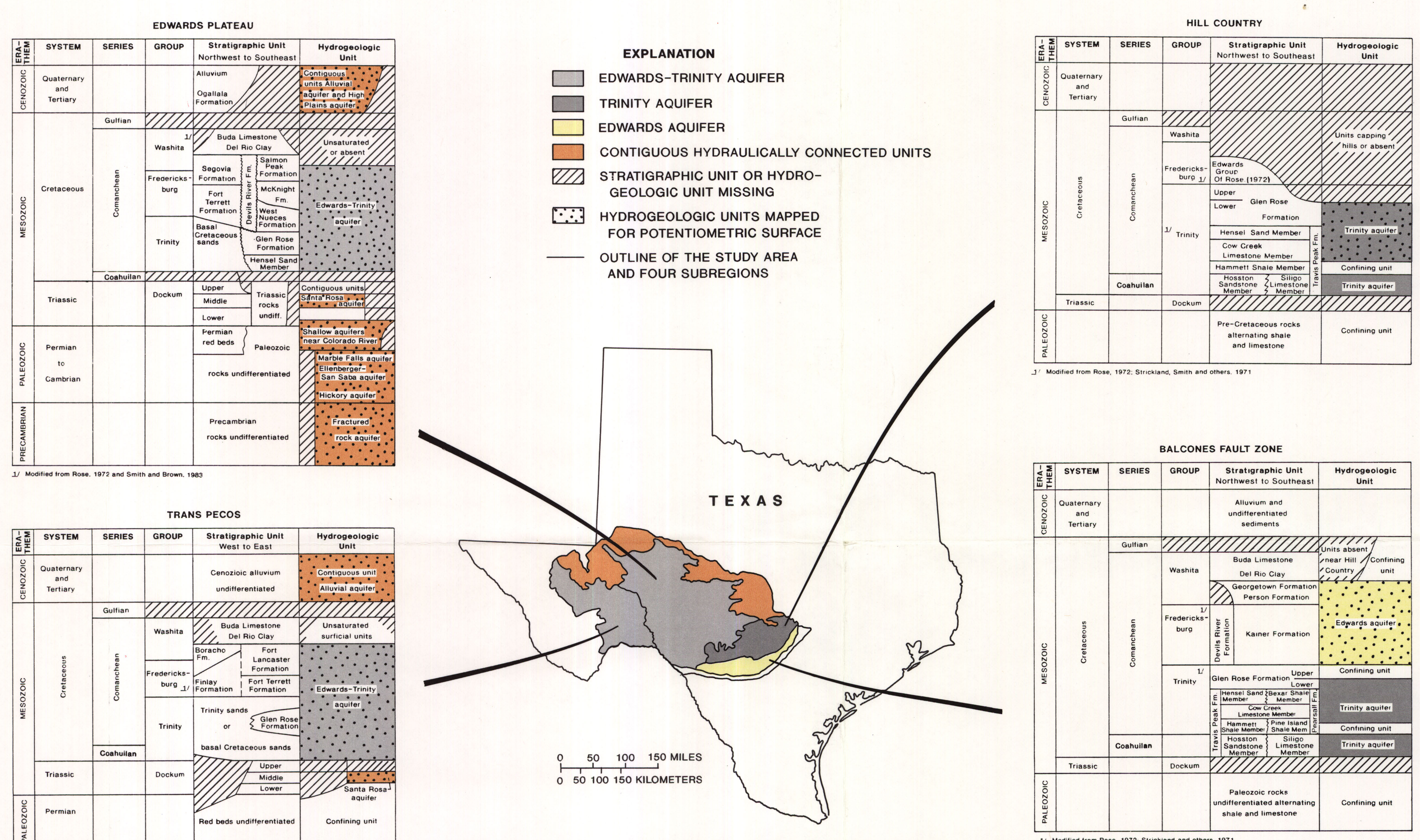

Figure 1.--Location of the study area and generalized correlation of the stratigraphic units with hydrogeologic units of the Edwards-Trinity aquifer system and contiguous hydraulically connected units.

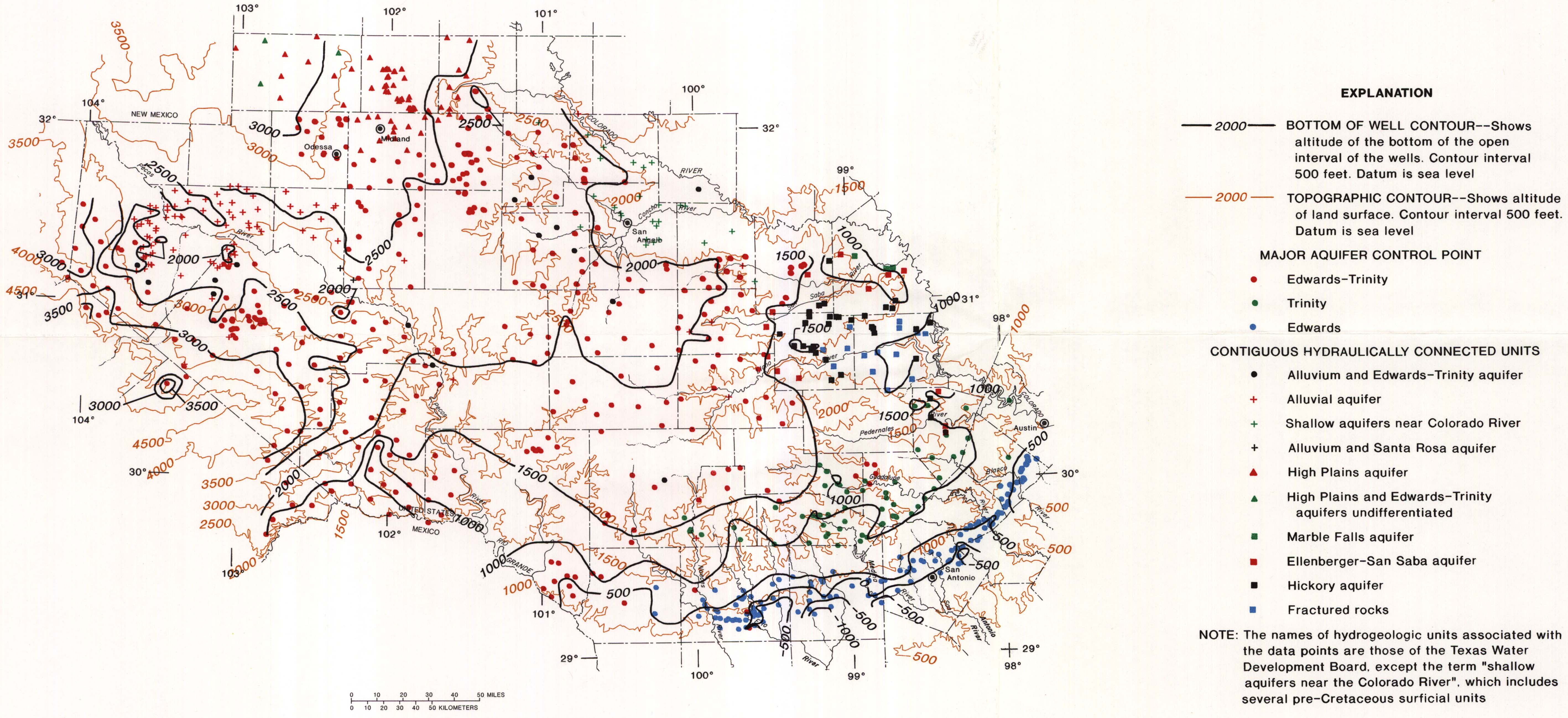

Figure 2.--Altitude of the bottom of the open interval of wells used for mapping the potentiometric surface.

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