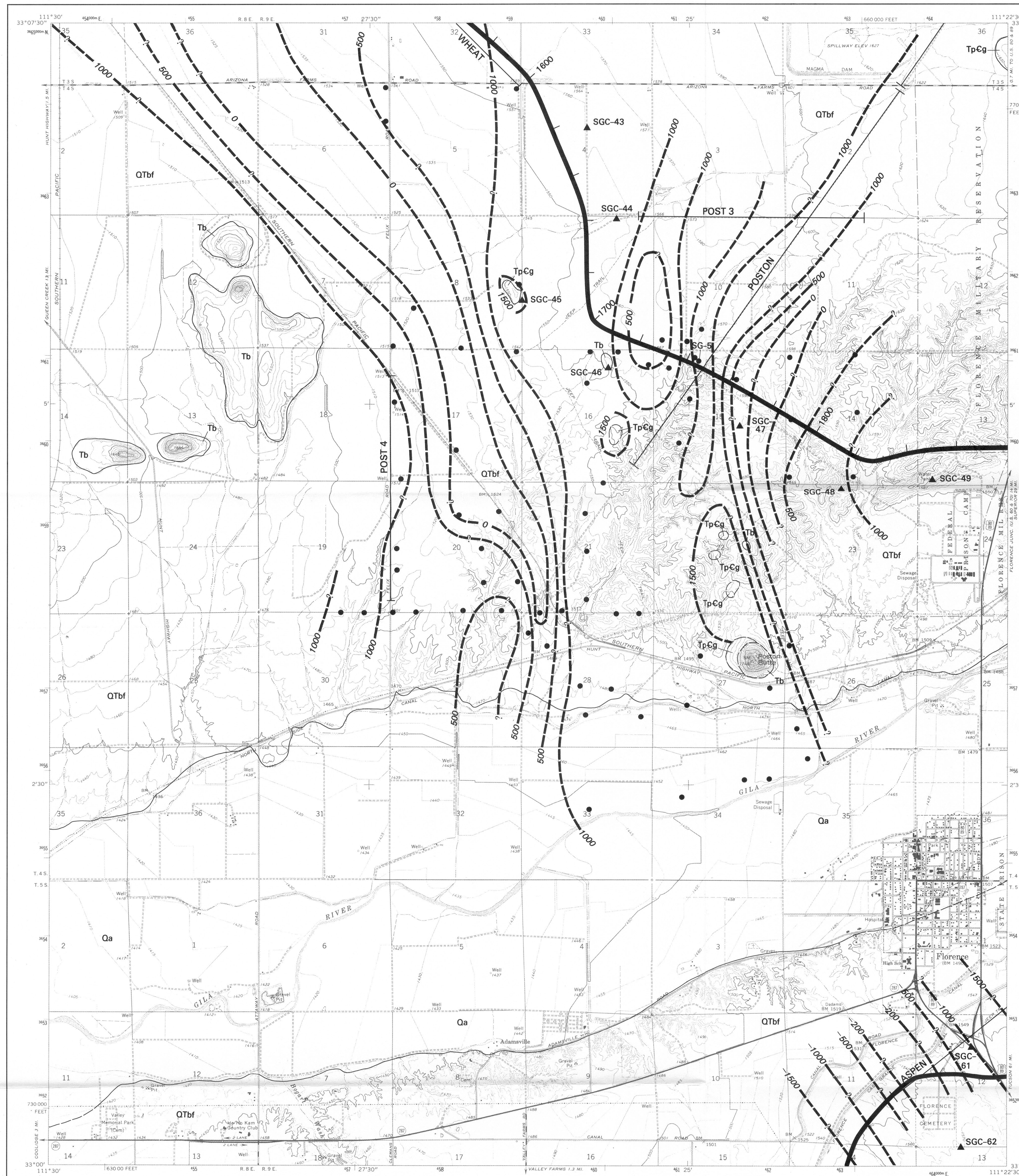
PREPARED IN COOPERATION WITH THE
UNITED STATES BUREAU OF RECLAMATION



Mapped, edited, and published by the Geological Survey in cooperation with the Bureau of Reclamation.
Control by USGS and USC&GS.
Topography by photogrammetric methods from aerial photographs taken 1963 and planetable surveys 1985.
Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, central zone

12°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1987

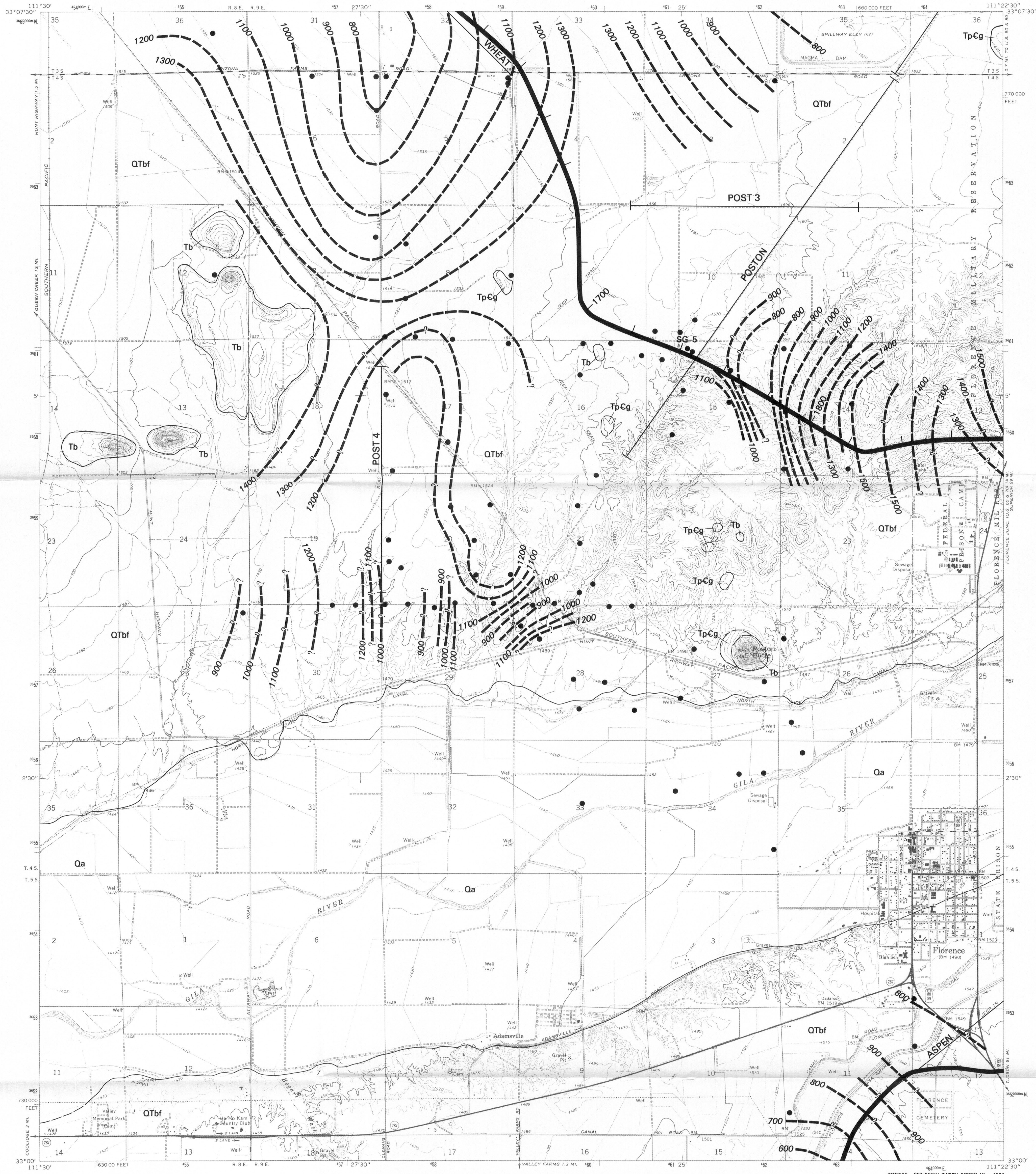
SCALE 1:36 000

1 — 1/2 — 0 — 1 MILE

1 — .5 — 0 — 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

ALTITUDE OF THE TOP OF THE CRYSTALLINE ROCKS, SURFICIAL GEOLOGY, AND CHANGE IN ALTITUDE OF THE LAND SURFACE AT SELECTED BENCH MARKS



QUADRANGLE LOCATION

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1987

Geology by R.L. Laney and L.W. Pankratz, 1980. Based in part on data from Conoco, Inc., and Asarco, Inc.; Cooley (Written commun., 1973); and U.S. Bureau of Reclamation (Written commun., 1979)

ALTITUDE OF THE TOP OF THE SEDIMENTARY AND BASALTIC ROCKS AND SURFICIAL GEOLOGY

EXPLANATION

Qa — ALLUVIUM (Qa)—Consists of silty sand, gravel, cobbles, and boulders that underlie the flood plain of the Gila River. Alluvium is as much as 100 feet thick. Similar deposits, which are as much as a few tens of feet thick, underlie washes tributary to the Gila River and are not mapped in this report — QUATERNARY

QTbf — BASIN FILL (QTbf)—Consists mainly of poorly sorted sand, gravel, silt, and clay; lesser amounts of mudstone, siltstone, sandstone, and moderately to well-cemented gravel. Well-cemented gravel is mainly in the lower part. Basin fill in the quadrangle may be as much as 700 feet thick — QUATERNARY AND TERTIARY

Ts, Tb — SEDIMENTARY (Ts) AND BASALTIC (Tb) ROCKS—The sedimentary rocks, which are present mainly in the subsurface, consist largely of conglomerate interbedded with some mudstone. Conglomerate is well cemented and includes a younger part, which is associated with basalt flows, and an older part, which predates the basalt flows. Mudstone is a well-indurated calcareous to gypsiferous deposit of low hydraulic conductivity and may contain conglomerate beds. Mudstone is present mainly in the eastern part of the area north of the Gila River. The basaltic rocks consist mostly of andesitic basalt but also contain some interbedded pyroclastic rocks and conglomerate. Andesitic basalt is mostly finely crystalline and dense and is vesicular in places. A potassium-argon date of 8.12 ± 0.64 million years was made on samples from a basalt flow interbedded with conglomerate at Poston Butte (Shafiqullah and others, 1980, p. 258). Pyroclastic rocks are mostly fine-grained tuff and tuffaceous volcanic breccia — TERTIARY

Tp€g — CRYSTALLINE ROCKS (Tp€g)—Consist of intrusive igneous rocks and metamorphic rocks of variable composition. Scattered exposures of the unit are present north of the Gila River. — TERTIARY AND PRECAMBRIAN

?— —800 APPROXIMATE ALTITUDE OF THE TOP OF THE SEDIMENTARY AND BASALTIC ROCKS—Queried where uncertain. The contours showing altitudes of the top of the sedimentary and basaltic rocks are based on seismic-refraction profiling, test-hole and water-well data, and surficial geologic mapping. Contour interval 100 feet. National Geodetic Datum of 1929

?— —500 APPROXIMATE ALTITUDE OF THE TOP OF THE CRYSTALLINE ROCKS—Queried where uncertain. The contours showing the altitudes of the top of the crystalline rocks are based on seismic-refraction profiling, test-hole and water-well data, and surficial geologic mapping. Contour interval 300 and 500 feet. National Geodetic Vertical Datum of 1929

CONTACT—Dashed where approximately located

SG-5 — WELL OR TEST HOLE—Letters and number, SG-5, denote test hole drilled as part of this study

SGC-47 — BENCH MARK—Bench mark where altitude of the land surface was measured, 1971–83. Number, SGC-47, is bench-mark number used by the U.S. Bureau of Reclamation

POST 4 — SEISMIC-REFRACTION LINE AND NAME

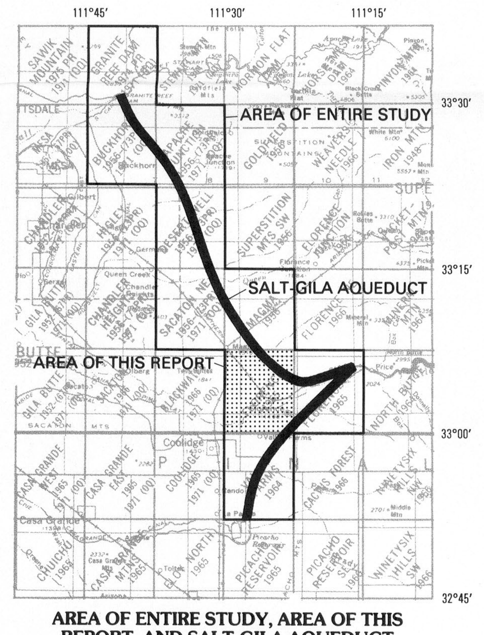
1600 — SALT-GILA AQUEDUCT—Number, 1600, is stationing scheme in hundreds of feet from an arbitrary origin

CONVERSION FACTORS

For readers who perfer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

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 "Mean Sea Level."



AREA OF ENTIRE STUDY, AREA OF THIS REPORT, AND SALT-GILA AQUEDUCT

INTRODUCTION

An investigation of land subsidence and earth fissures along the Salt-Gila aqueduct of the Central Arizona Project was begun in 1977. The purpose of the investigation was to determine the amount and rate of land subsidence that could result from present and future water-level declines and to identify the areas along the aqueduct route that are subject to the formation of earth fissures. This report is the first in a series of maps showing the altitudes of the tops of the consolidated rocks, surficial geology, and land subsidence along the Salt-Gila aqueduct.

Methods of investigation included seismic-refraction and seismic-reflection profiling, gravity surveys, magnetometer surveys, test drilling, one-dimensional laboratory consolidation tests, aquifer tests, leveling surveys, horizontal-strain measurements near earth fissures, water-level measurements, and compaction measurements. Most of the field data were collected from 1977 to 1980. Results of the gravity surveys were published by Hassemer and Dansereau (1980). Geophysical investigations of earth fissures along the northern part of the Salt-Gila aqueduct were done by Pankratz and others (1978).

WATER-LEVEL DECLINE, LAND SUBSIDENCE, AND EARTH FISSURES

In areas of south-central Arizona where water levels have declined, differential compaction of the unconsolidated basin fill may be a major cause of earth fissures. The Salt-Gila aqueduct route crosses an area where water levels have declined as much as 350 ft owing to the withdrawal of ground water (Laney and others, 1978). In places the land surface is subsiding as much as 0.2 ft/yr. More than 2 ft of land subsidence has been measured since 1971 along the aqueduct route south of Apache Junction, Arizona (Schumann and others, 1983). Earth fissures have formed in places near the northern part of the aqueduct.

Since the 1940's, water levels may have declined as much as 200 ft in the northern part of the Florence quadrangle and as much as 150 ft in the southern part (Laney and others, 1978). Long-term water-level data are not available for much of the aqueduct route in the quadrangle. Leveling surveys of selected bench marks indicate that virtually no land subsidence has been detected along the aqueduct route in the quadrangle from 1971 to 1983. Precision of the leveling measurements is second order as defined by the U.S. Department of Commerce (1974). No earth fissures have been reported in the Florence quadrangle.

ROCK UNITS AND FACTORS AFFECTING THEIR SUSCEPTIBILITY TO COMPACTION

Analysis of seismic-refraction data early in the study indicated that earth fissures were most common in the unconsolidated basin-fill deposits that overlie irregularities in the consolidated rocks (Pankratz and others, 1978). Differential compaction of the consolidated rocks over the irregularities in the underlying consolidated rocks therefore may be a major cause of earth fissures. An evaluation of the extent, thickness, and type of unconsolidated rocks and the altitude and configuration of the surface of the consolidated rocks was begun to determine the susceptibility of the aquifer to compaction and the potential for developing earth fissures.

The unconsolidated rocks include the alluvium and basin fill. The alluvium, which consists of silty sand, gravel, and cobbles and boulders, is as much as 100 ft thick and is present along the Gila River. The unit yields large quantities of water to wells where saturated. Because the alluvium is mostly coarse grained and has a small saturated thickness, withdrawals of ground water resulting in water-level decline probably would not cause appreciable aquifer compaction and resultant land subsidence.

The basin fill consists largely of poorly sorted sand, gravel, silt, and clay and is coarser grained near the Gila River than elsewhere along the aqueduct route. The unit is as much as 700 ft thick but generally is less than 500 ft thick along much of the aqueduct route in the quadrangle. Saturated thickness may be less than 300 ft; however, north of the Gila River along the aqueduct route, wells with measurable water levels were too widespread to construct a map of the water table. The basin fill is the principal aquifer in south-central Arizona and yields moderate to large quantities of water to wells. Where large amounts of fine-grained material are present, the unit is subject to compaction, land subsidence, and the formation of earth fissures when water levels decline. The coarse-grained nature of the basin fill and small saturated thickness in this area probably account for the lack of measurable land subsidence along the aqueduct.

The consolidated rocks consist of the sedimentary and basaltic rocks and the crystalline rocks. These units contain small quantities of water, mostly in fractures. The basaltic rocks locally may contain moderate amounts of water in vesicular zones. In contrast to the removal of water from pore spaces of the unconsolidated rocks, the consolidated rocks are not subject to significant amounts of compaction as water is withdrawn from fractures. In terms of the pressure changes involved with probable amounts of water-level decline, the consolidated rocks are considered uncompressible.

REFERENCES CITED

Hassemer, J.H., and Dansereau, Danny, 1980, Gravity survey in parts of Maricopa and Pinal Counties, Arizona: U.S. Geological Survey Open-File Report 80-1255, 65 p.

Laney, R.L., Raymond, R.H., and Winikka, C.C., 1978, Maps showing water-level declines, land subsidence, and earth fissures in south-central Arizona: U.S. Geological Survey Water-Resources Investigations 78–83, 2 sheets.

Pankratz, L.W., Hassemer, J.H., and Ackermann, H.D., 1978, Geophysical studies relating to earth fissures in central Arizona [abs.]: Geophysics, v. 44, no. 3, p. 367.

Schumann, H.H., Littin, G.R., and Wallace, B.L., 1983, Monitoring water-level change, aquifer compaction, and land subsidence along the Salt-Gila aqueduct in south-central Arizona [abs.], in Land subsidence—design and solutions: The Arizona Consulting Engineers Association, Second Arizona Symposium on Subsidence, Phoenix, Arizona, October 21, 1983, p. 14.

Shafiqullah, M., Damon, P.E., Lynch, D.J., Reynolds, S.J., Rehrig, W.A., and Raymond, R.H., 1980, K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas: Arizona Geological Society Digest 12, p. 201–260.

U.S. Department of Commerce, 1974, Classification, standards of accuracy, and general specifications of geodetic control surveys: Federal Geodetic Control Committee, National Oceanic and Atmospheric Administration, 12 p.

INVESTIGATIONS OF LAND SUBSIDENCE AND EARTH FISSURES NEAR THE SALT-GILA AQUEDUCT, MARICOPA AND PINAL COUNTIES, ARIZONA

Altitudes of the tops of the consolidated rocks, surficial geology, and land subsidence in the Florence quadrangle

By

R.L. Laney and L.W. Pankratz

1987

For sale by U.S. Geological Survey, Map Distribution, Box 25286, Federal Center, Denver, CO 80225