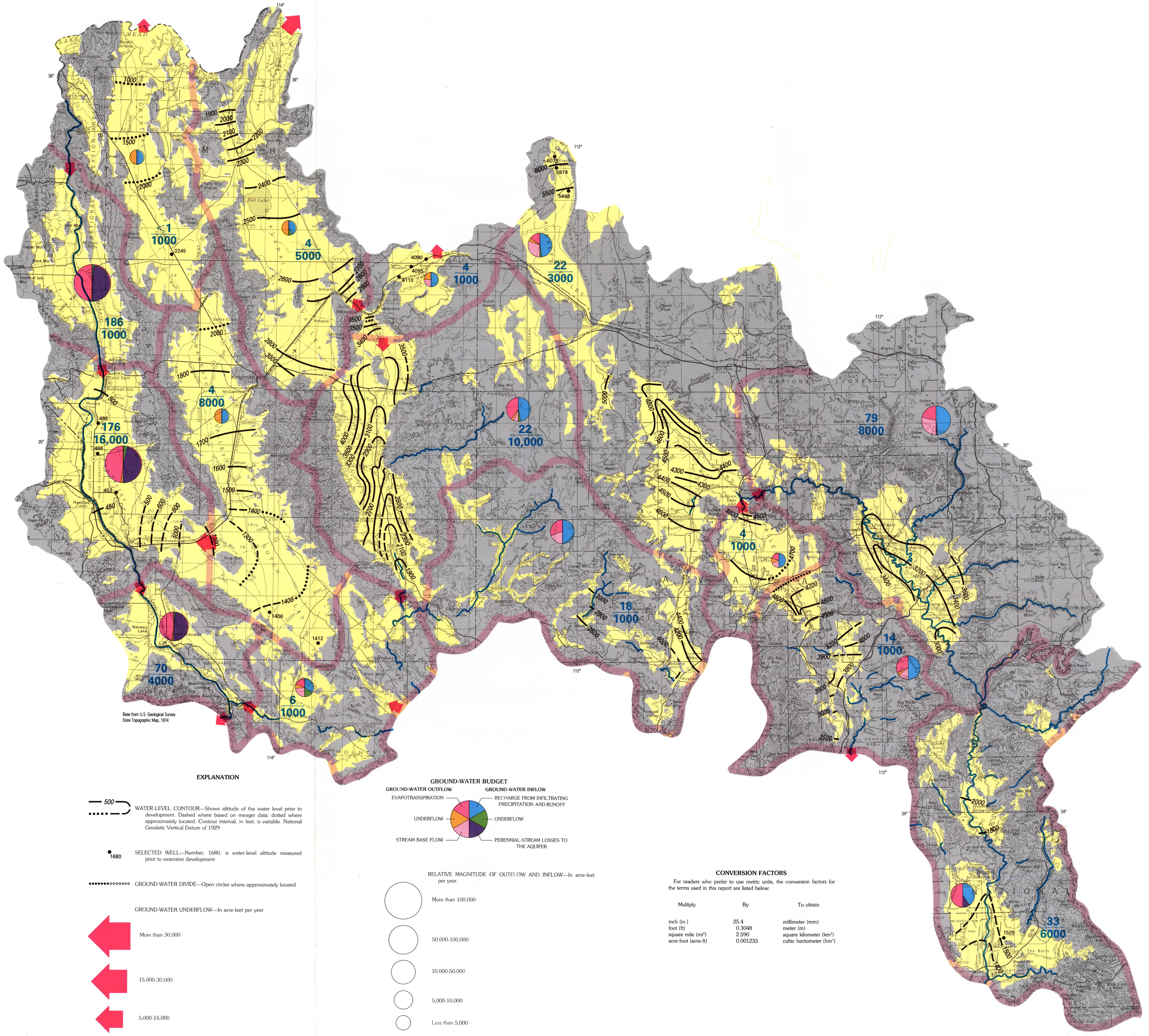

Base from U.S. Geological Survey
State Topographic Map, 1974

Geology modified from Wilson and others (1969)

EXPLANATION

WATER-LEVEL CONTOUR—Shows altitude of the water level prior to development. Dashed where based on meager data; dotted where approximately located. Contour interval, in feet, is variable. National Geodetic Vertical Datum of 1929

1680 SELECTED WELL—Number, 1680, is water-level altitude measured prior to extensive development

GROUND-WATER DIVIDE—Open circles where approximately located

GROUND-WATER UNDERFLOW—In acre-feet per year

- More than 30,000
- 15,000-30,000
- 5,000-15,000
- 1,000-5,000
- Less than 1,000

🟨 BASIN-FILL DEPOSITS

▨ BEDROCK OF THE MOUNTAINS

GROUND-WATER BUDGET

RELATIVE MAGNITUDE OF OUTFLOW AND INFLOW—In acre-feet per year

- More than 100,000
- 50,000-100,000
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4
11,000 RATIO OF ANNUAL INFLOW TO TOTAL VOLUME STORED IN THE GROUND-WATER SYSTEM—Upper number, 4, is the estimated average inflow and outflow to the aquifer of the basin, in thousands of acre-feet. Lower number, 11,000, is the estimated recoverable ground water in the basin-fill material to a depth of 1,200 feet below land surface, in thousands of acre-feet, rounded to the nearest million acre-feet

PERENNIAL STREAM

BOUNDARY OF GROUND-WATER BASIN

CONVERSION FACTORS

For readers who prefer to use metric units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
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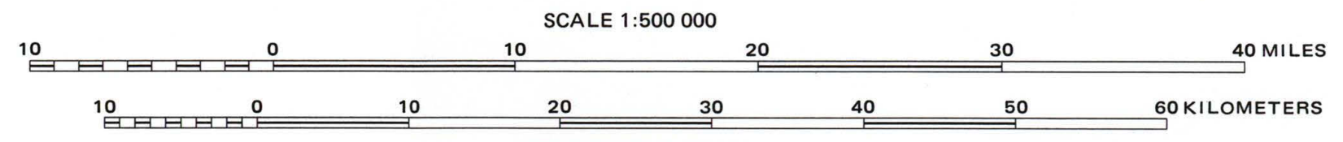
SCALE 1:500 000



CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

INTRODUCTION

The objectives of the Southwest Alluvial Basins, Regional Aquifer-System Analysis (Swab/RASA) Project included an overall assessment of the hydrologic conditions that existed prior to man's activities that might have altered the natural hydrologic systems. Prior to development, the ground-water systems were assumed to be in equilibrium—long-term inflow was equal to long-term outflow and no change in storage occurred. The purpose of this atlas is to summarize the predevelopment hydrologic conditions using available data and hydrogeologic knowledge.

The data presented in this atlas represent a conceptual model of the predevelopment hydrologic system of the entire area and each individual basin. The quantities of inflow and outflow and the volume of water in storage were estimated from field data, numerical modeling, and transfer of selected parameter values from basins for which data were available to basins for which data were not available. The transfer of information was based on known similarities in physiography and hydrology and assumed similarities in lithology of the basin-fill sediments between adjacent or nearby basins.

GEOHYDROLOGIC FRAMEWORK

The study area includes about 82,000 mi^2 and is divided into 72 subareas or basins that represent, for the most part, separate ground-water systems (fig. 1). The area is characterized by sharply rising mountains separated by broad alluvial basins. The basins are filled with a sequence of permeable sediments that represent different depositional environments. The basin-fill deposits, which constitute the aquifer system of the area, generally are several thousand feet thick and store large quantities of water. The bedrock of the mountains is relatively impermeable.

The specific flow components of the hydrologic system within each basin differ in quantity because of different topographic, climatic, hydrologic, and geologic characteristics. Components of inflow to the aquifers include ground-water underflow from adjacent basins, mountain-front recharge, and infiltration of streamflow along the major drainages. Components of outflow include ground-water underflow to adjacent basins, discharge to streams, and evapotranspiration losses (fig. 2). Owing to the aridity of the area, values for the flow components commonly are small, especially in comparison to the vast quantities of water that are stored in the basin-fill deposits.

WATER-LEVEL CONFIGURATION AND IMPLICATIONS

The water-level contours represent the altitude at which water stood in wells finished in the unconfined aquifers in the basins prior to development. An exception is the configuration shown for the San Simon-Bowie area near the Arizona-New Mexico State boundary. Because the data for the unconfined aquifer in the northern part of the basin were inadequate, the contours represent the potentiometric surface of the confined aquifer system in this area. The water table generally follows the trend of the topographic surface overlying it but is less steep. The depth to water therefore is shallowest in the topographic low area of the basin and gradually increases away from the basin axis and toward the topographic high areas (fig. 2).

The contours were based on water-level data obtained from reports and data files of the U.S. Geological Survey and other agencies. Recent water-level data were used for basins where development is minor and long-term changes in water level can be assumed to be small and negligible. Data from the early 1900's to about 1940, which precedes the period of greatest development, were used for highly developed basins. In places, water-level contours were based on the location and altitude of perennial streams (Brown and others, 1981) and descriptions of the streams given in historical accounts of the Gila River drainage system. In a few basins for which data are practically nonexistent, the water-level contours were estimated on the basis of available water-level or perennial-stream altitude and known or assumed similarities between basins.

The predevelopment water-level contours can be interpreted to indicate the general ground-water movement. Ground water flows from areas of high head to areas of low head. The individual basins are linked together to varying degrees in a dendritic pattern to form a regional flow system. The shapes of the water-level contours generally indicate areas of inflow and outflow. Basins in which contours are U-shaped and nearly parallel to the mountain fronts probably receive a significant amount of mountain-front recharge. Basins in which contours are relatively straight and nearly perpendicular to the mountain fronts receive little or no mountain-front recharge. Significant variations in water-level gradients indicate changing physical or hydraulic properties of the aquifer.

The contours shown are assumed to represent the head throughout the entire aquifer thickness. On a regional basis, this assumption is probably valid. Minor head differences, both greater and lesser with depth, occur in places in the study area but are not known to be extensive or mappable. Areas in which this assumption may not be valid are in zones of inflow and outflow where vertical-flow components may be significant.

VOLUME OF GROUND WATER IN STORAGE

The volume of recoverable ground water in storage in the saturated zone that extends to 1,200 ft below the land surface is estimated to be 900 million acre-ft in the study area prior to development. This value, which was estimated using a specific yield ranging from 0.03 to 0.25 and estimated aquifer volumes, is less than previously estimated (Brown, 1976). Water-quality constraints were not imposed on the estimates, although all the water is not necessarily potable or usable. As a result of the Swab/RASA study, new information was developed on the lateral extent of the aquifer and the specific yield of the aquifer materials. A depth-to-bedrock map (Oppenheimer and Sumner, 1980), which was developed using gravity-modeling techniques, provided an estimate of the geometry of each basin. Regional and vertical patterns of specific yield were developed using empirical values of specific yield for particular sediment types and a computerized integration technique. The estimated areal patterns were used and evaluated in numerical models of several basins. The most significant lithologic feature that influences the estimates of recoverable ground water in storage is the presence of thick, extensive fine-grained facies in the basin fill in the central parts of most basins. The fine-grained facies typically contain more than 50 percent of sediments that are less than 0.0625 mm in diameter. Calibration of transient ground-water flow models of basins with areally extensive fine-grained facies required specific-yield values ranging from 0.05 to 0.13. This range of values is lower than those used in previous estimates of ground water in storage.

The ratio of the annual inflow to each basin to the estimated volume of water in storage within each basin is shown on the maps. The ratio ranges from about 1:5 to 1:14,000. The low value represents a basin with a small extent of basin-fill deposits and thus a small volume of water stored within it. The high value represents a basin in which the annual inflow is small and the volume of water in storage is large. The typical range for the major developed basins is from about 1:200 to 1:2,000.

GROUND-WATER BUDGET

The development of a ground-water budget for each of the 72 basins of the study area resulted from an iterative process of balancing inflow and outflow components for adjacent basins. Components that were reliably known were considered fixed; unknown components were estimate by balancing the water budget for the basin. All unknown components were maintained within the general limits indicated by knowledge of that component in similar basins. The reliability of each estimated was considered when adjusting components to balance the regional budget.

Previously reported estimates of various components, which included stream base flow and ground-water underflow, were compiled. Estimates of evapotranspiration were obtained from reports, and the areal extent of riparian vegetation was compiled from 1936 aerial photomosaics. Estimates of recharge were based on previous studies and on precipitation-recharge relations developed as part of this study. Results of previous and ongoing ground-water modeling studies were used extensively. Reports from which particular flow-component estimates and water-level information were obtained are listed in "Selected References."

The individual components shown in the ground-water-budget diagrams should not be considered exact values for a specific basin. The values represent an approximation of each component derived by balancing the entire regional water budget. The diagrams represent a means of comparing the magnitude of the total budget and the individual components between basins and parts of the study area.

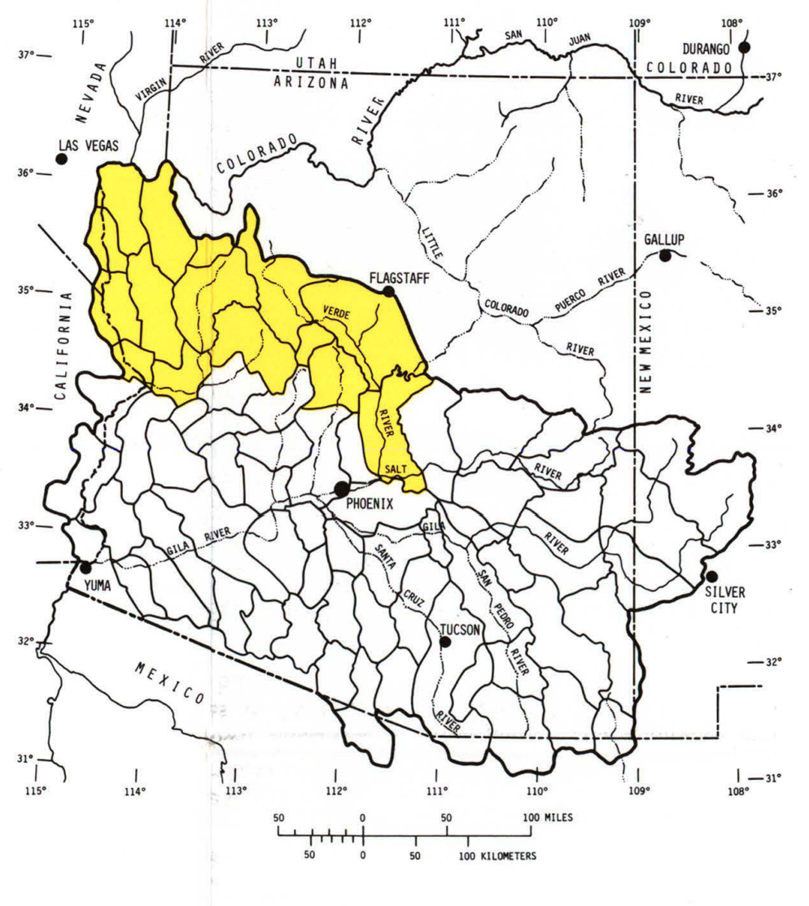


FIGURE 1.—*Study area and basins.*

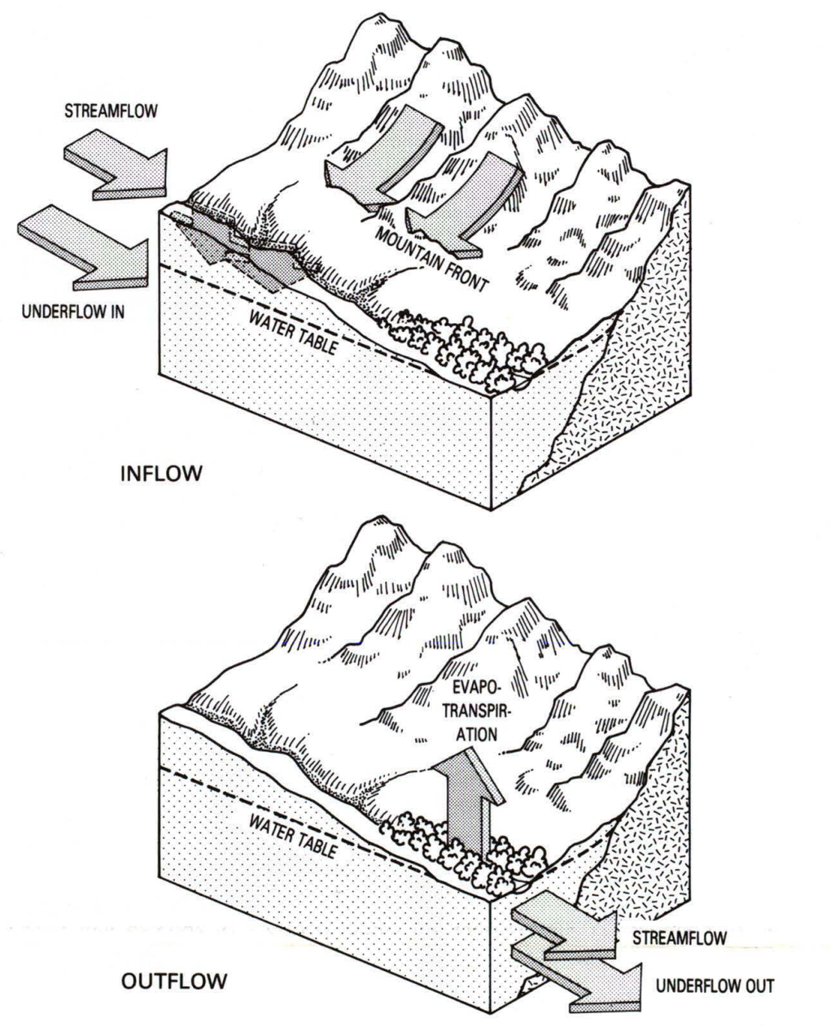


FIGURE 2.—*Mechanisms of natural inflow and outflow in typical basins in the study area.*

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1986—W84364

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By

Geoffrey W. Freethey and T. W. Anderson

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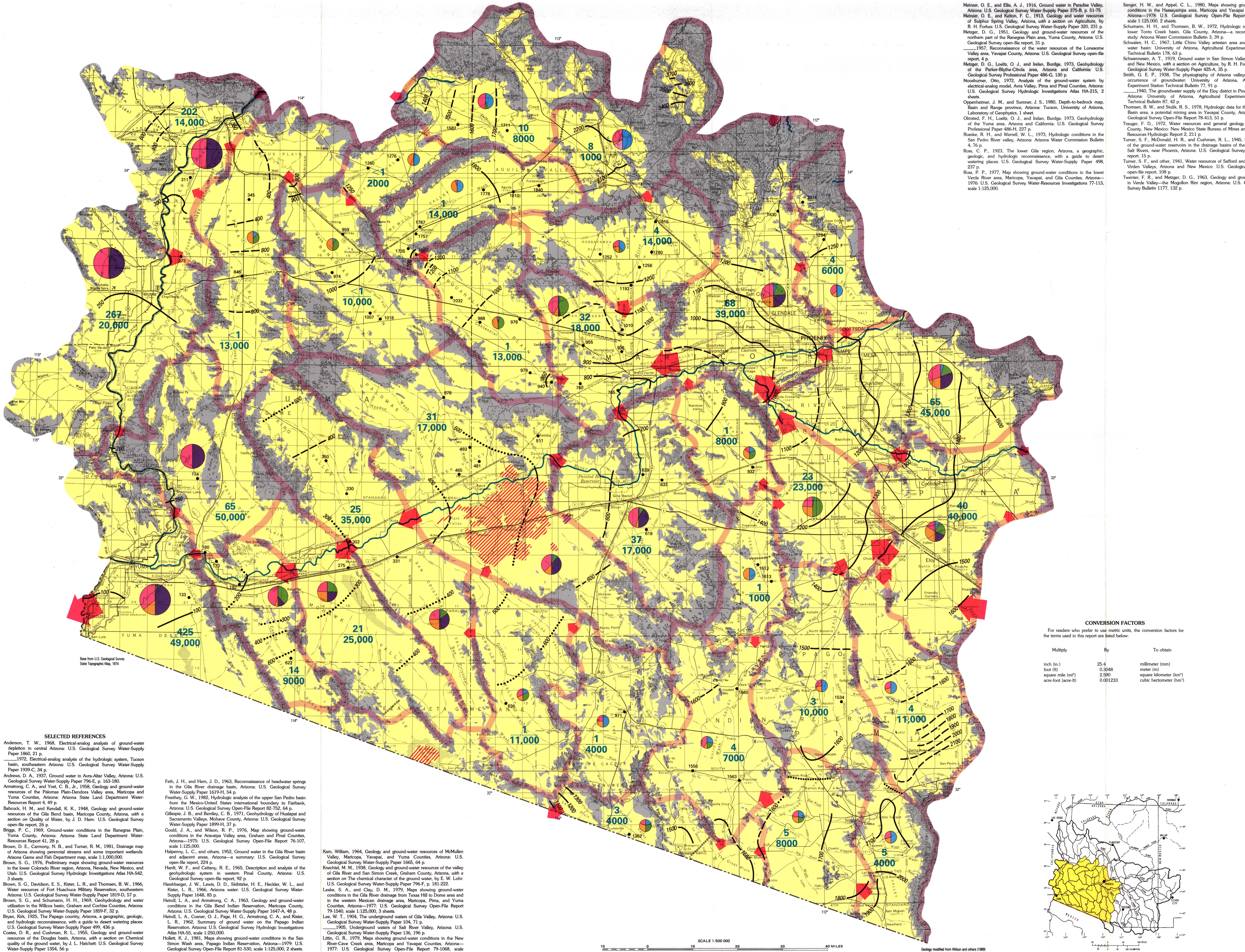

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GROUND-WATER BUDGET

GROUND-WATER OUTFLOW	GROUND-WATER INFLOW
EVAPOTRANSPIRATION	RECHARGE FROM INFILTRATING PRECIPITATION AND RUNOFF
UNDERFLOW	UNDERFLOW
STREAM BASE FLOW	PERENNIAL-STREAM LOSSES TO THE AQUIFER

RELATIVE MAGNITUDE OF OUTFLOW AND INFLOW—In acre-feet per year

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INDEX MAP SHOWING STUDY AREA AND BASINS

SCALE 1:500 000

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 60 KILOMETERS

CONTOUR INTERVAL 500 FEET
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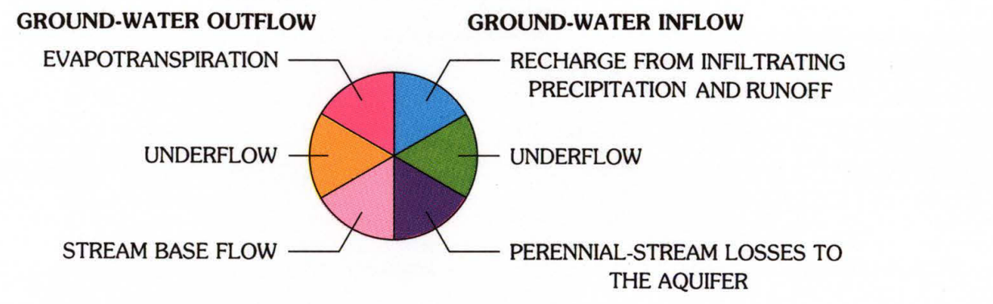

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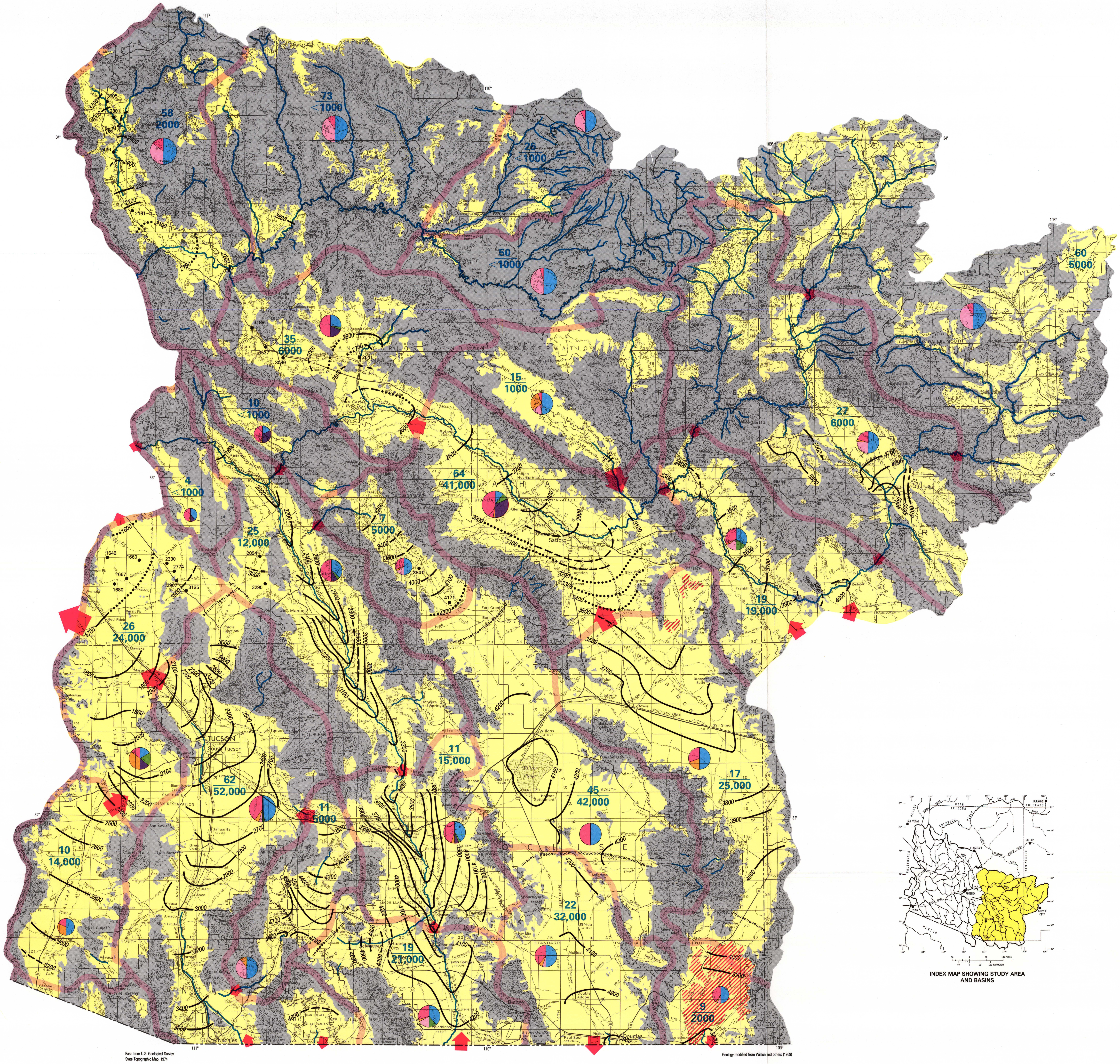
— PERENNIAL STREAM

▬ BOUNDARY OF GROUND-WATER BASIN



INDEX MAP SHOWING STUDY AREA AND BASINS

Base from U.S. Geological Survey
State Topographic Map, 1974

Geology modified from Wilson and others (1969)

CONVERSION FACTORS

For readers who prefer to use metric units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
square mile (mi²)	2.590	square kilometer (km²)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm³)

SCALE 1:500 000

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 60 KILOMETERS

CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1986—W84364

PREDEVELOPMENT HYDROLOGIC CONDITIONS IN THE ALLUVIAL BASINS OF ARIZONA AND ADJACENT PARTS OF CALIFORNIA AND NEW MEXICO

By

Geoffrey W. Freethey and T. W. Anderson

1986

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