National Water-Quality Assessment Program---Central Arizona Basins

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In 1991, the U.S. Geological Survey (USGS) began to implement a full-scale National Water-Quality Assessment (NAWQA) program. The long-term goals of the NAWQA program are to describe the status and trends in the quality of a large, representative part of the Nation's surface-water and ground-water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources. In meeting these goals, the program will produce a wealth of water-quality information that will be useful to policymakers and managers at the National, State, and local levels.

Studies of 60 hydrologic systems that include parts of most major river basins and aquifer systems (study-unit investigations) are the building blocks of the national assessment. The 60 study units range in size from 1,000 to about 60,000 mi2 and represent 60 to 70 percent of the Nation's water use and population served by public water supplies. Twenty study-unit investigations were started in 1991, 20 additional studies started in 1994, and 20 more are planned to start in 1997. The Central Arizona Basins study unit began assessment activities in 1994.

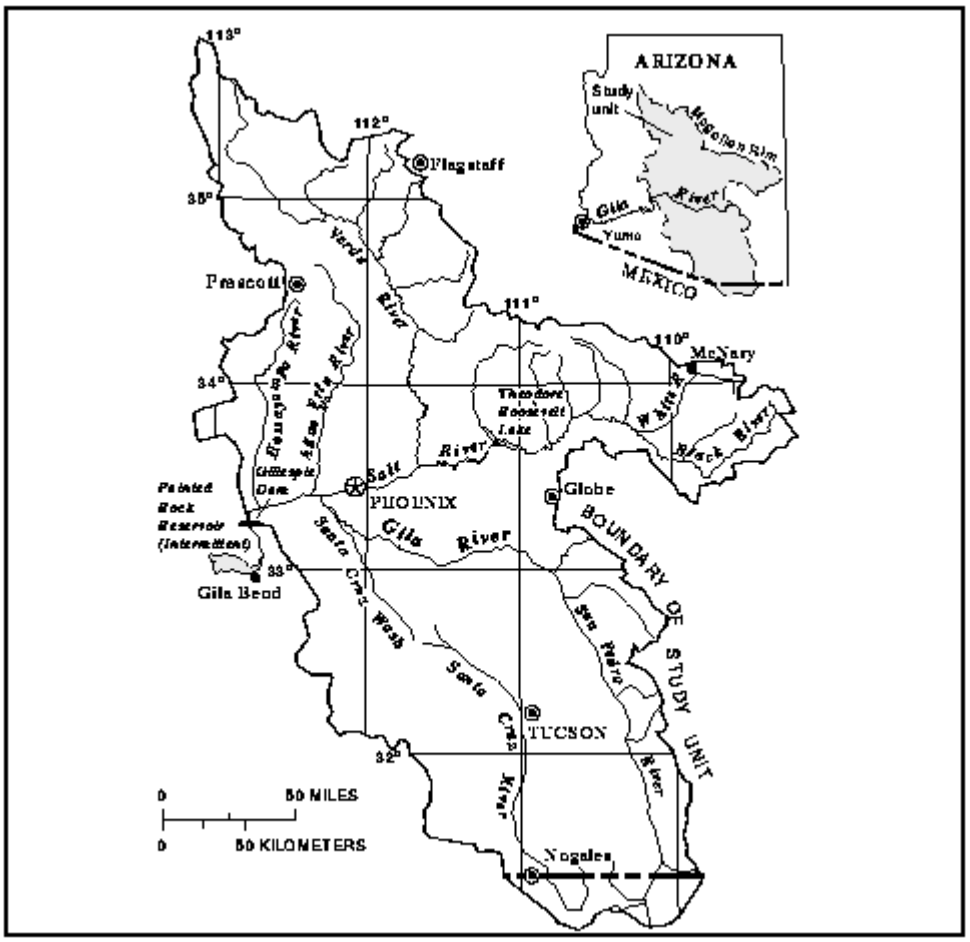
Description of the Central Arizona Basins Study Unit

The Central Arizona Basins study unit encompasses about 34,700 mi2 in central and southern Arizona and northern Mexico. The boundary of the study unit is the Mogollon Rim in the north and other surface-water drainage divides along the west, east, and south. Five major river systems---the Gila, Salt, Verde, Santa Cruz, and San Pedro drain the area. The Salt, Verde, Santa Cruz, and San Pedro Rivers are tributary to the Gila River, which is tributary to the Colorado River near Yuma. The population of the study unit exceeds 3.1 million people. Phoenix and Tucson---the two major population centers---are in the central part of the area and provide water to more than 2.5 million people.

Most of the Central Arizona Basins study unit is in the Basin and Range physiographic province, which is characterized by generally north- to northwest-trending mountain ranges separated by wide, flat alluvial basins. Altitudes in the study unit range from about 800 ft above sea level near Gillespie Dam at the western edge of the study unit to about 11,400 ft at Mt. Baldy, southeast of McNary.

Large-scale normal faulting during the Basin and Range disturbance, 14 to 6 million years ago, created a series of upthrown and downthrown blocks. Sediments eroded from the surrounding mountain blocks, evaporites, and volcanics filled the subsiding basins. The basin-fill deposits range in thickness from a few thousand feet to more than 10,000 ft. The mountains consist mainly of extensively folded and faulted intrusive and metamorphic rocks that form impermeable boundaries between alluvial basins.

The climate of the study unit is arid to semiarid. Average annual precipitation ranges from 25 to 40 in. at the higher altitudes in the northern part of the area to 6 to 10 in. at the lower altitudes south of Phoenix. Precipitation is extremely variable within any given year and from year to year. About 90 to 99 percent of precipitation is lost to evapotranspiration.



Precipitation, runoff, ground-water discharge, irrigation return flow, and treated sewage effluent are the main sources of surface-water flow in the study unit. The Verde and Salt Rivers are perennial in their upper reaches in the north and northeast, but most of the flow in these streams is diverted or dammed for irrigation or public supply. Streams in the southern part of the study

unit are intermittent or ephemeral except for short perennial reaches such as the upper San Pedro and Santa Cruz Rivers. Some reaches of the upper Santa Cruz, lower Salt, and middle Gila Rivers have perennial flow that is sustained by treated sewage effluent.

The regional ground-water flow system closely parallels the direction of surface-water drainage. North and south of the Gila River, ground water flows toward and along the river. Within individual basins, water in the basin-fill deposits moves from the mountain front toward the basin axis where it discharges at land surface or mixes with existing underflow. Where the upper part of the basin-fill deposits is saturated, it is a productive, unconfined aquifer. At depth, water occurs in permeable sand and gravel lenses and may be unconfined or locally confined. In general, the alluvial deposits in the basins are hydraulically connected to form a single aquifer system. Ground water is near land surface along perennial streams but may be more than 300 to 800 ft deep near the mountain fronts.

Most of the land in the study unit is desert shrubland, open woodland, and grassland that is used for grazing. The main irrigated areas, which cover a small area of the unit, are adjacent to Phoenix and along the corridor between Phoenix and Tucson. Cotton, hay, and grains are the main crops. Urban land use continues to grow as the population increases. From 1980 to 1990, the population of Arizona increased by 35 percent, resulting in some changes from irrigated to urban land use. Copper and precious metals are extracted from several commercial mines in the study unit.

Water use in the study unit is dominated by agriculture, which requires large volumes of water to grow crops. As much as 40 percent of water used for agriculture is lost by seepage from unlined canals and reservoirs, infiltration below the root zone, or evaporation from the soil and open-water surfaces. With rapid population growth in the Phoenix (Maricopa County) and Tucson (Pima County) areas, water use is changing from agricultural to domestic, commercial, and industrial uses. Surface water and ground water each supply about 50 percent of the water used in the study unit. Ground water is the main water-use component in the southern part of the area, and surface water is the main component in the northern part of the area.

In 1990, the surface-water diversions and ground-water withdrawals in the Central Arizona Basins NAWQA study unit, by use category, in acre-feet, were:

Wateruse	Surface-water[1]	Ground-water
Agricultural	1,680,550	1,676,022
Municipal	325,280	319,451
Industrial	92,270	206,045
Total	2,098,100	2,201,518

[1]The values for surface-water include 593,860 acre-ft (agriculture) and 150,646 acre-ft (municipal and industrial) of Central Arizona Project water diverted from the Colorado River.

The major water issue in Arizona is the imbalance between the quantity of water consumed and the quantity that is recharged back to the aquifers. For many years, ground-water withdrawals have exceeded recharge, causing depletion of the ground water in storage. Water-level declines of as much as 500 ft and associated land subsidence and earth fissures have resulted. The Central Arizona Project (CAP), a large canal that carries water from the Colorado River to the major water-use areas in central Arizona, was built to help alleviate overdraft pumping.

Major Water-Quality Issues

The major water-quality issues in the Central Arizona Basins study unit include:

- Effects of the discharge of treated sewage effluent on surface-water and ground-water quality, aquatic life, and instream flows near Phoenix, Tucson, and Nogales, Arizona;
- Effects of artificial recharge of Central Arizona Project water on ground-water quality;
- Effects of contamination from acid mine drainage on surface water, ground water, and human health;
- Movement and fate of organic contaminants in ground water from industrial discharges, spills, landfills, and other point sources in urban areas;
- Nitrate in ground water from natural and anthropogenic sources at concentrations that exceed National Drinking-Water Standards;
- Large concentrations of naturally occurring trace elements (fluoride, barium, arsenic, boron, and chromium) and activities of radon in ground water;
- Movement and fate of fertilizers, pesticides, and other contaminants from nonpoint sources such as irrigation return flow and storm-water runoff; and
- Effects of ground-water and surface-water quality on riparian areas and associated wildlife.

Communication and Coordination

Communication and coordination between USGS personnel and other interested scientists and water-management organizations are critical components of the NAWQA program. The liaison committee for the Central Arizona Basins study unit has proved very effective in this process and consists of representatives from Federal, State, and local agencies; universities; and the private sector who have water-resources responsibilities and interests.

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Information on technical reports and hydrologic data related to NAWQA can be obtained from:

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