INTRODUCTION

The Big Chino sub-basin, located in northwest Arizona in Yavapai and Coconino Counties, is the northernmost of the three sub-basins that comprise the Verde River basin. The Big Chino sub-basin encompasses approximately 1,848 square miles including Big Chino Valley, Williamson Valley, and over 600 square miles north of Interstate 40, roughly in the area between and north of the Towns of Seligman and Ashfork. The Aubrey Cliffs and the Juniper and Santa Maria Mountains form the western boundary of the Big Chino sub-basin. On the north, the sub-basin is bounded by the Coconino Plateau, a segment of the larger Colorado Plateau. On the southeast, it is bounded by Granite Mountain, Sullivan Buttes, and Big Black Mesa. The northeast boundary is defined by the surface-water divide between the Big Chino sub-basin and the Verde Valley sub-basin. Its southeast boundary is approximately 25 miles northwest of the City of Prescott.

The sub-basin boundaries outline a north- to northwest-trending area, approximately 60 miles long and varying from less than 6 miles wide at the southern end near Granite Mountain, to over 40 miles wide in the northern portion where Interstate 40 crosses the sub-basin. Land-surface altitudes range from 4,400 feet at the community of Paulden in the southeastern part of the sub-basin, to 7,160 feet on the peak of Trinity Mountain in the northern part of the sub-basin.

The principal streams that drain the sub-basin are Big Chino Wash and Williamson Valley Wash. Both streams are ephemeral. Big Chino Wash originates 13 miles north of Seligman and flows approximately 49 miles southeast across the sub-basin. Williamson Valley Wash flows southeast from the base of the Santa Maria Mountains for approximately 5 miles, then turns to the northeast. It continues flowing northeast for about 10 miles, curves around Sullivan Buttes, and then joins Big Chino Wash at Sullivan Lake. The confluence of these two washes form the headwaters of the Verde River. Streams tributary to the Big Chino Wash include Partridge Creek, Pine Creek, Walnut Creek, and Antelope Creek. Tributary streams in the southern part of the sub-basin drain into Williamson Valley Wash and include Hitt Wash, Dillon Wash, and Mud Tank Wash.

The semiarid climate in the Big Chino sub-basin is characterized by warm summers and cold winters. Average maximum temperatures in July, the hottest month, range from 91.0°F at Seligman to 92.5°F at the Town of Chino Valley, just outside the southeastern boundary of the sub-basin. Average minimum temperatures in January, the coldest month, range from 20.6°F at Ashfork to 21.1°F at Chino Valley. Annual average precipitation varies from 11.3 inches at Seligman, altitude approximately 5,240 feet, to 20.8 inches at Camp Wood, altitude approximately 5,660 feet. Other annual average precipitation readings include 12.7 inches at Ashfork, 16.3 inches at Walnut Creek, and 12.0 inches at Chino Valley. Roughly one-third of the annual precipitation occurs during the months of July and August when tropical moisture moves northward over Arizona and produces intense but short-term thunderstorms. Average annual snowfall ranges from 9.5 inches at Chino Valley to 27.9 inches at Camp Wood (Sellers and others, 1985, p. 88-93, 112-115, 132-135; National Oceanic and Atmospheric Administration, 1986-91, vol. 90-95, p. 4, 5, 11).

Cattle ranchers began settling the area in the early 1860's, and cattle ranching continues to be the primary industry in the sub-basin. At the present time, less than 2,000 acres of the Big Chino Valley is used to cultivate crops. The two main crops are corn and alfalfa.

GEOLOGY

The Big Chino sub-basin lies along the northern margin of the physiographic province known as the Central Mountain Province, or Transition Zone. The Central Mountain Province, and hence the Big Chino sub-basin, is a blend of geologic structures characteristic of both the Colorado Plateau Province to the northeast, and the Basin and Range Province to the southwest (Nations and Stump, 1983, p. 79-80). The northern part of the sub-basin and Big Black Mesa, consist of Precambrian granitic basement rock overlain by thick, relatively horizontal beds of Paleozoic sedimentary sequences. Paleozoic strata include the Cambrian Tonto Group (sandstone and shale), the Devonian Martin Formation (limestone), the Mississippian Redwall Limestone, the Pennsylvanian Supai Formation (siltstone, shale, and sandstone), and the Permian Coconino Sandstone. Tertiary basalt flows cap the Paleozoic sediments over much of the northern part of the sub-basin. The Big Chino Fault separates the Paleozoic sediments on Big Black Mesa from Big Chino Valley to the southwest. This is a major normal fault whose trace extends approximately 26 miles northwesterly across the sub-basin from a point about 2 miles north of Paulden (Krieger, 1965, p. 98). Big Chino Valley, the down-dropped block, is a narrow elongate trough that ranges from less than 2 miles wide at the upper end to approximately 6 miles wide at the southeastern end. Numerous smaller faults underlie Big Chino Valley, some parallel to Big Chino Fault, some transverse, creating a multitude of stair-step blocks (Water Resources Associates, 1989, p. 9). The southern and western parts of the sub-basin, including Williamson Valley, consist of Precambrian granitic basement rock overlain by Cenozoic terrace and pediment deposits including gravel, sand, silt and clay, and local occurrences of basalt and andesite.

Approximately two-thirds of all the wells drilled in the Big Chino sub-basin lie within the narrow belts of Big Chino Valley and Williamson Valley. Data from geophysical and drillers' logs indicate that Big Chino Valley contains a thick accumulation of basin-fill sediments including terrace and pediment gravels, streambed and lacustrine sediments, and one or more layers of volcanics. The basin-fill sediments are estimated from drillers' logs at over 2,400 feet thick in the central and upper Big Chino Valley and vary from 300 feet to over 800 feet thick in the extreme southeastern end of the Big Chino Valley and Williamson Valley. The alluvial portion of the basin fill consists of older (Tertiary) and younger (Quaternary) unconsolidated and semi-consolidated, poorly sorted gravel, sand, conglomerate, silt, and varying amounts of clay. The clay component increases toward the center of Big Chino Valley. Interposed between these sediments are volcanic rocks, consisting of basalt flows and ashflows.

Toward the center of Big Chino Valley, the coarser streambed sediments are replaced laterally and vertically by a thick clay layer. Described in drillers' logs as tough, sticky, and of various colors, this clay layer probably developed as a result of intra-basin lakes. The areal extent of the clay layer is approximately 4 to 5 miles wide, 10 miles long, and roughly includes the southwest quarter of T. 19 N., R. 3 W., the southeast quarter of T. 19 N., R. 4 W., and the northern half of T. 18 N., R. 3 W. An exploratory well in sec. 28, T. 19 N., R. 3 W., revealed 60 feet of sand and gravel underlain by 2,280 feet of clay. Interbedded within the clay layer are thin lenses of sandy clay and clay mixed with gravel.

In the southeastern end of Big Chino Valley, south and east of Paulden, basalt flows are exposed at land surface; north and west of Paulden basalt flows are encountered at depths varying from 5 feet to 147 feet below land surface. In the upper and central portions of Big Chino Valley, volcanics are found at depths ranging from 370 feet to more than 600 feet below the land surface. Described as "ranging from massive to extremely fractured and cavernous" (Water Resources Associates, 1989, p. 11), the volcanics range from 74 feet to over 400 feet thick. Several drillers' logs from around Paulden report intervals of up to 140 feet of "lost circulation", indicating large cavities or openings within the basalt. Basalt flows may or may not be present in Williamson Valley. Most of the wells in Williamson Valley are less than 200 feet deep and the few well logs available do not indicate any volcanics present to that depth.

OCCURRENCE OF GROUNDWATER

Groundwater throughout the Big Chino sub-basin occurs under both water-table (unconfined) and artesian (confined) conditions. The principal aquifer in the sub-basin occurs in the basin-fill sediments and basalt flows of Big Chino and Williamson Valleys. There exists good hydraulic connection between the interlayered basin-fill sediments and basalt flows. Thus, the sediments and flows function as a single aquifer system. Well-yield data obtained from drillers' reports for wells completed around Paulden range from 7 gallons per minute (gal/min) to 2800 gal/min.

In the central part of Big Chino Valley, where the thick subsurface clay layer exists, wells are sparse and only produce from the coarser lenses within the clay or from coarser overlying sediments. The clay layer has much lower hydraulic conductivities and specific yields than the adjoining coarser sediments.

Near Paulden, a number of wells penetrate limestone, probably the Redwall Limestone, beneath the basin-fill sediments and basalt flows. In some of these wells the limestone lies in direct contact with the overlying basalt flows; in other wells there is sand and gravel between the basalt flows and the limestone. The Redwall Limestone is known to contain channels, sinkholes, fissures, and caves formed from the dissolution of limestone by rainwater and groundwater, and thus locally may be capable of large water production capacity.

Water levels were measured throughout Big Chino Valley and Williamson Valley in March 1975 (Wallace and Laney, 1976, sheet 1), and again in February 1992. Depth to water in Big Chino Valley and Williamson Valley in 1992 ranged from flowing at land surface to 273 feet below land surface. In most wells the depth to water was less than 80 feet below land surface. Water-level changes in the basin-fill sediments between 1975 and 1992 ranged from a decline of 5 feet to a rise of 40 feet, but most of the wells measured showed little to virtually no change. Wells that showed large rises in water level were clustered along a narrow strip of farmland in central Big Chino Valley. These water-level rises may be due to the reduction in total acres irrigated since 1975, winter crops being irrigated at the time of the first water-level measurement, or a combination of these factors. Only four wells in the sub-basin had more than 10 years of historical water-level measurements (hydrographs A through D) and none of the wells exhibit any significant changes. The most recent annual groundwater pumpage estimate by the U.S. Geological Survey for the Big Chino sub-basin is 5,000 acre-feet for 1985 (Wilson, 1991, sheet 1).

Groundwater in the upper end of Big Chino Valley flows from the northwest to the southeast, and parallels the surface drainage. Groundwater in Williamson Valley flows north-northeast and converges with the groundwater from Big Chino Valley north and west of Sullivan Buttes. The groundwater then flows toward Paulden and exits the sub-basin north and east of Paulden. A U.S. Geological Survey stream-gaging station on the Verde River, about 7 miles east of Paulden, recorded 25,658 acre-feet of surface-water flow in the 1991 calendar year (Frank Brewsaugh, U.S. Geological Survey, oral commun., 1993), but it is unknown how much of this surface water is attributable to groundwater discharge from the Big Chino sub-basin.

Groundwater also occurs in the Paleozoic sediments in the northern part of the sub-basin. One example is the public-supply well for the Town of Ashfork, located in sec. 14, T. 21 N., R. 2 W. The well was drilled to a depth of 1,700 feet and encountered a thin layer of alluvial sediments, basalt flows, and 1,400 feet of Paleozoic rocks. Estimating from the well log and the most recent (1984) static-water level of 999 feet below land surface, the water is probably derived from the Martin Formation. The well has a reported yield of 130 gal/min (Ashfork Water Service, oral commun., 1993).

The major source of groundwater recharge in the Big Chino sub-basin is infiltration of runoff from the mountain fronts and streamflow along the main drainages. Only a small percentage of the annual precipitation in the sub-basin reaches the groundwater table. Most precipitation is lost as surface runoff, evaporation, and transpiration by plants.

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Map 1 DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL

EXPLANATION

178 / 4590 — WELL IN WHICH DEPTH TO WATER WAS MEASURED IN JANUARY 1992 - AUGUST 1992-- Upper number, 178, is depth to water, in feet below land surface. Lower number, 4590, is the altitude of the water level in feet. Datum is National Vertical Geodetic Datum of 1929

UNDIFFERENTIATED ROCK--Comprised of Paleozoic sedimentary rock, basalt flows and alluvial deposits, which consist of unconsolidated and semi-consolidated conglomerate, sand, silt, and clay, and one or more layers of volcanics

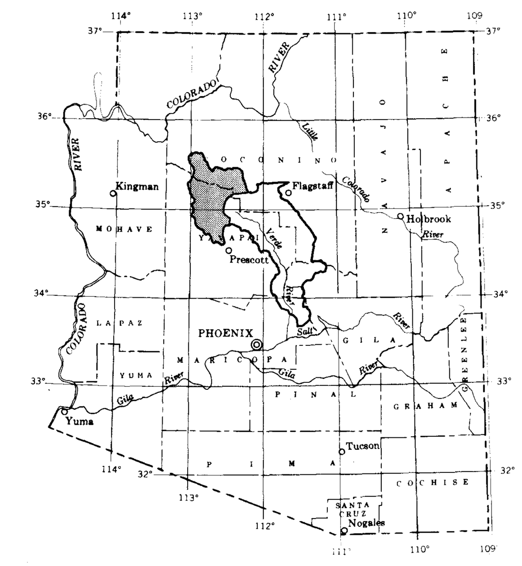
BEDROCK--Consists of Precambrian granitic basement rock

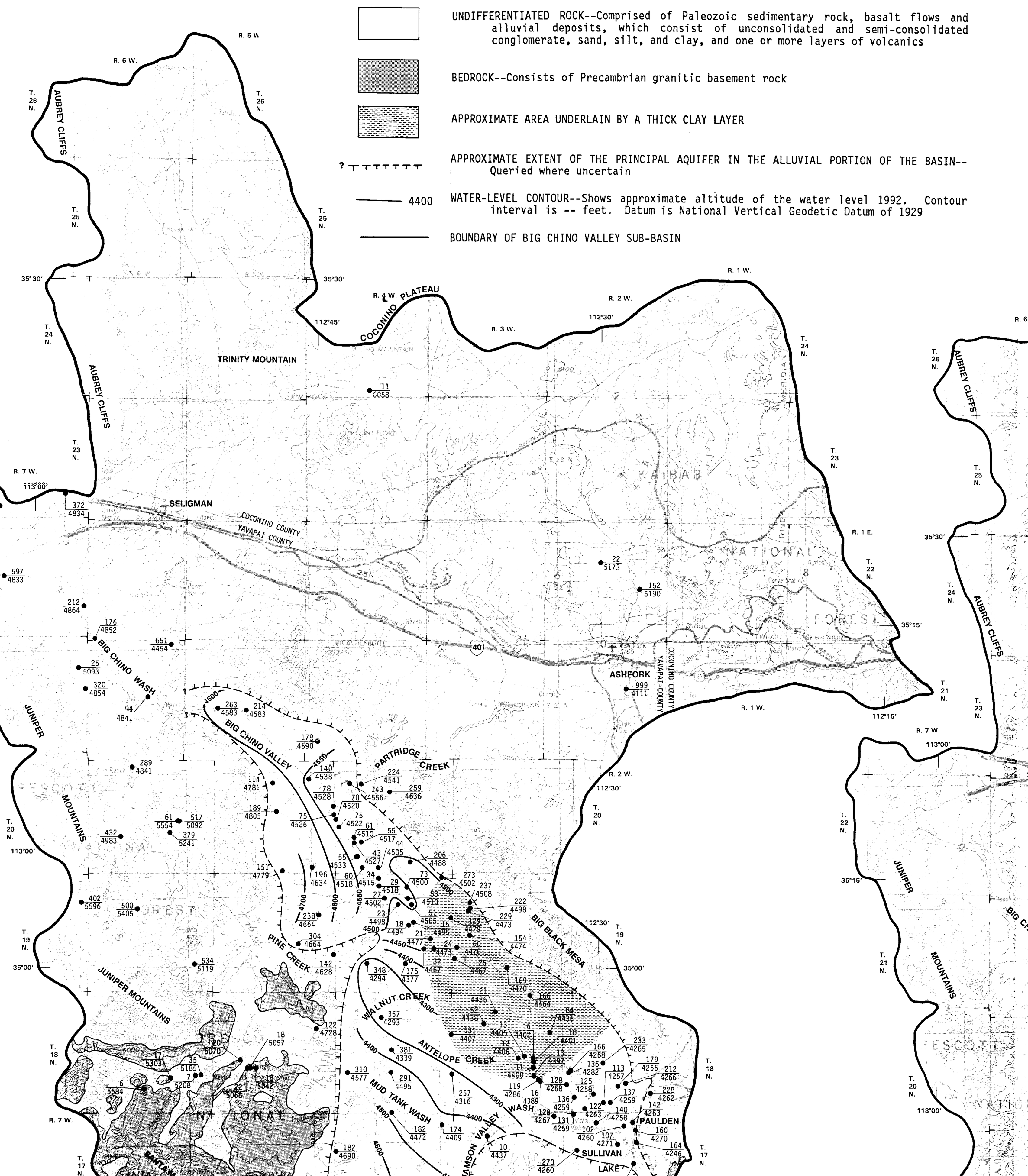
APPROXIMATE AREA UNDERLAIN BY A THICK CLAY LAYER

APPROXIMATE EXTENT OF THE PRINCIPAL AQUIFER IN THE ALLUVIAL PORTION OF THE BASIN-- Queried where uncertain

4400 — WATER-LEVEL CONTOUR--Shows approximate altitude of the water level 1992. Contour interval is -- feet. Datum is National Vertical Geodetic Datum of 1929

BOUNDARY OF BIG CHINO VALLEY SUB-BASIN





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

Multiply inch-pound unit	By	To obtain metric unit
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second

ESTIMATED GROUNDWATER PUMPAGE IN THE BIG CHINO SUB-BASIN OF THE VERDE RIVER BASIN

[Numbers rounded to nearest thousand acre-feet]

Year	Pumpage, in thousands of acre-feet	Year	Pumpage, in thousands of acre-feet
1950	22	1971	11
1951	22	1972	10
1952	22	1973	10
1953	22	1974	13
1954	22	1975	14
1955	22	1976	12
1956	22	1977	11
1957	22	1978	8
1958	22	1979	7
1959	22	1980	7
1960	22	1981	8
1961	22	1982	2
1962	22	1983	2
1963	22	1984	3
1964	22	1985	5
1965	22		
1966	22	TOTAL	541
1967	11		
1968	11		
1969	11		
1970	11		

Map 2 CHANGES IN WATER LEVEL AND HYDROGRAPHS OF SELECTED WELLS

EXPLANATION

-9 — WELL IN WHICH A WATER LEVEL WAS MEASURED IN 1975 AND 1992--Number, -9, is the difference, in feet, between the 1975 and 1992 water levels (unsigned values denote rises in water levels and values with negative signs denote declines in water levels)

(A) — WELL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN WATER LEVEL IS SHOWN

UNDIFFERENTIATED ROCK--Comprised of Paleozoic sedimentary rock, basalt flows and alluvial deposits, which consist of unconsolidated and semi-consolidated conglomerate, sand, silt, and clay, and one or more layers of volcanic rocks

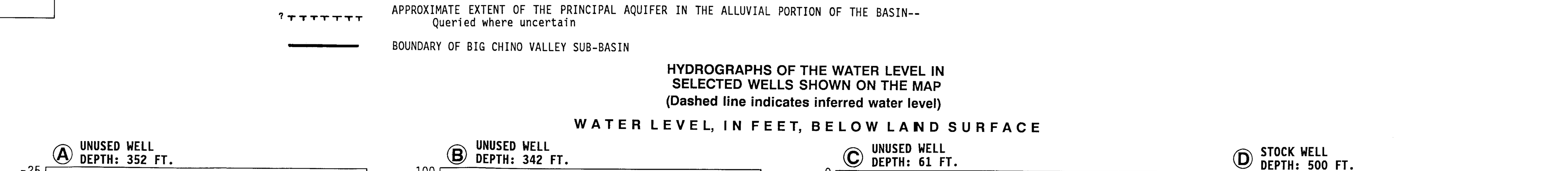
BEDROCK--Consists of Precambrian granitic basement rock

APPROXIMATE AREA UNDERLAIN BY A THICK CLAY LAYER

APPROXIMATE EXTENT OF THE PRINCIPAL AQUIFER IN THE ALLUVIAL PORTION OF THE BASIN-- Queried where uncertain

BOUNDARY OF BIG CHINO VALLEY SUB-BASIN

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS SHOWN ON THE MAP
(Dashed line indicates inferred water level)



BASE FROM U.S. GEOLOGICAL SURVEY
PRESCOTT, ARIZONA, 1954, REV. 1970, 1:250,000
WILLIAMS, ARIZONA, 1954, REV. 1970, 1:250,000

MAPS SHOWING GROUNDWATER CONDITIONS, SPRING 1992, BIG CHINO SUB-BASIN OF THE VERDE RIVER BASIN, COCONINO AND YAVAPAI COUNTIES, ARIZONA-1992

BY

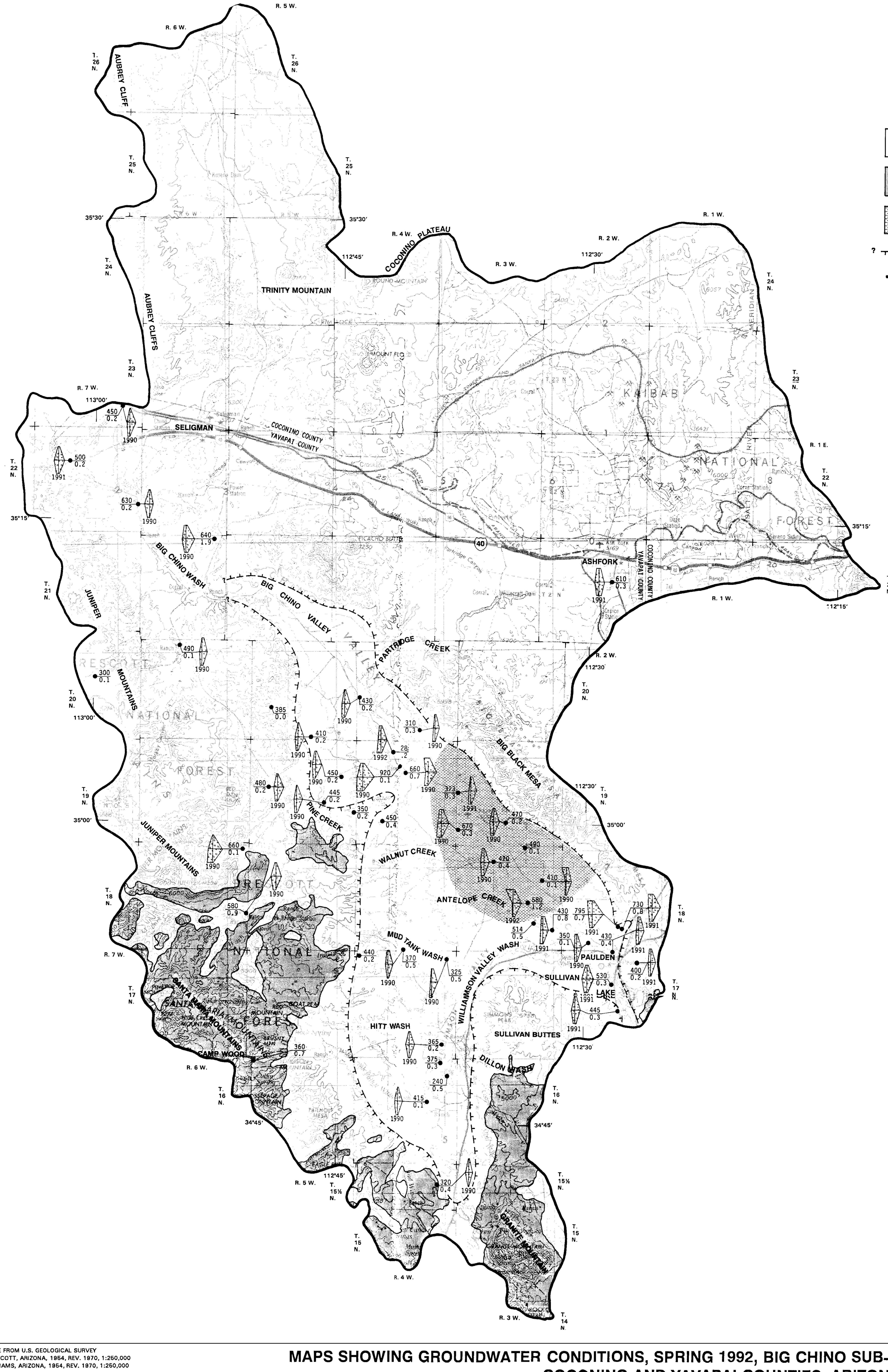
K. J. SCHWAB

These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Section, 2810 South 24th Street, Suite 122, Phoenix, Arizona, 85034. The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Department of Water Resources and at the U.S. Geological Survey offices located at: 375 S. Euclid, Tucson, Arizona, 85719, and 1545 West University, Tempe, Arizona, 85281.

PREPARED IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

ARIZONA DEPARTMENT OF WATER RESOURCES

DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL, QUALITY OF WATER



Map 3 CHEMICAL QUALITY OF WATER

EXPLANATION

430 / 0.2 — WELL IN WHICH A WATER SAMPLE WAS COLLECTED IN--Upper number, 430, is specific conductance in microsiemens per centimeter at 25°C. Lower number, 0.2, is the fluoride concentration in milligrams per liter

UNDIFFERENTIATED ROCK--Comprised of Paleozoic sedimentary rock, basalt flows and alluvial deposits, which consist of unconsolidated and semi-consolidated conglomerate, sand, silt, and clay, and one or more layers of volcanics

BEDROCK--Consists of Precambrian granitic basement rock

APPROXIMATE AREA UNDERLAIN BY A THICK CLAY LAYER

APPROXIMATE EXTENT OF THE PRINCIPAL AQUIFER IN THE ALLUVIAL PORTION OF THE BASIN--Queried where uncertain

BOUNDARY OF BIG CHINO VALLEY SUB-BASIN

CHEMICAL QUALITY DIAGRAM--Shows major constituents in milligrams per liter. The diagrams are in a variety of shapes and sizes, providing a means of comparing, correlating, and characterizing similar or dissimilar types of water. 1990 below diagram, indicates year in which sample was collected

MILLIEQUIVALENTS PER LITER

CATIONS ANIONS

SODIUM 20 10 0 10 20 CHLORIDE
CALCIUM TOTAL ALKALINITY
MAGNESIUM SULFATE
1990

QUALITY OF GROUNDWATER

Groundwater in the Big Chino sub-basin is generally suitable for all uses. Between 1990 and 1992, 47 samples were collected for this study. Of that number, 36 had detailed major-ion and trace-metal analyses performed and the remainder were analyzed for fluoride and specific conductance only.

Fluoride concentrations in the collected water samples ranged from 0.1 to 1.9 mg/L. The maximum contaminant level (MCL) for fluoride in Arizona public drinking water is 4.0 milligrams per liter (mg/L), as established by the U.S. Environmental Protection Agency (1986, p. 11396-11397) and the Arizona Department of Environmental Quality (1989, p.7). The MCL is an enforceable standard set by the U.S. Environmental Protection Agency for drinking water. States must comply with this standard, but are free to set levels which are more stringent.

Specific-conductance values ranged from 310 to 920 microsiemens per centimeter at 25°C (μS/cm). Dissolved-solids concentrations may be approximated by multiplying specific-conductance values by 0.6, which is the approximate ratio of dissolved solids in mg/L to specific conductance in μS/cm. The U.S. Environmental Protection Agency has established the secondary maximum contaminant level (SMCL) for total dissolved solids at 500 mg/L, which is approximately equivalent to a specific-conductance value of 833 μS/cm. SMCL's are guidelines only, and are not enforceable standards (U.S. Environmental Protection Agency, 1988, p.9). SMCL's are based on aesthetic qualities such as taste, odor, and color. Water with contaminant levels above the SMCL are not necessarily a health risk. Only one sample, from a well in sec. 9, T. 19 N., R. 4 W., apparently exceeded the SMCL for dissolved solids with a value of 920 μS/cm.

Moderate to high amounts of dissolved arsenic were found in 13 of the water samples from the Big Chino sub-basin. The U.S. Environmental Protection Agency MCL for arsenic is 50 micrograms per liter (μg/L). One sample, collected from a well in sec. 1, T. 17 N., R. 4 W., had an arsenic concentration of 51 μg/L. Twelve samples had concentrations between 10 μg/L and 38 μg/L. Most of these samples came from wells located in the southeastern end of Big Chino Valley.

BASE FROM U.S. GEOLOGICAL SURVEY
PRESCOTT, ARIZONA, 1954, REV. 1970, 1:250,000
WILLIAMS, ARIZONA, 1954, REV. 1970, 1:250,000

MAPS SHOWING GROUNDWATER CONDITIONS, SPRING 1992, BIG CHINO SUB-BASIN OF THE VERDE RIVER BASIN, COCONINO AND YAVAPAI COUNTIES, ARIZONA-1992

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