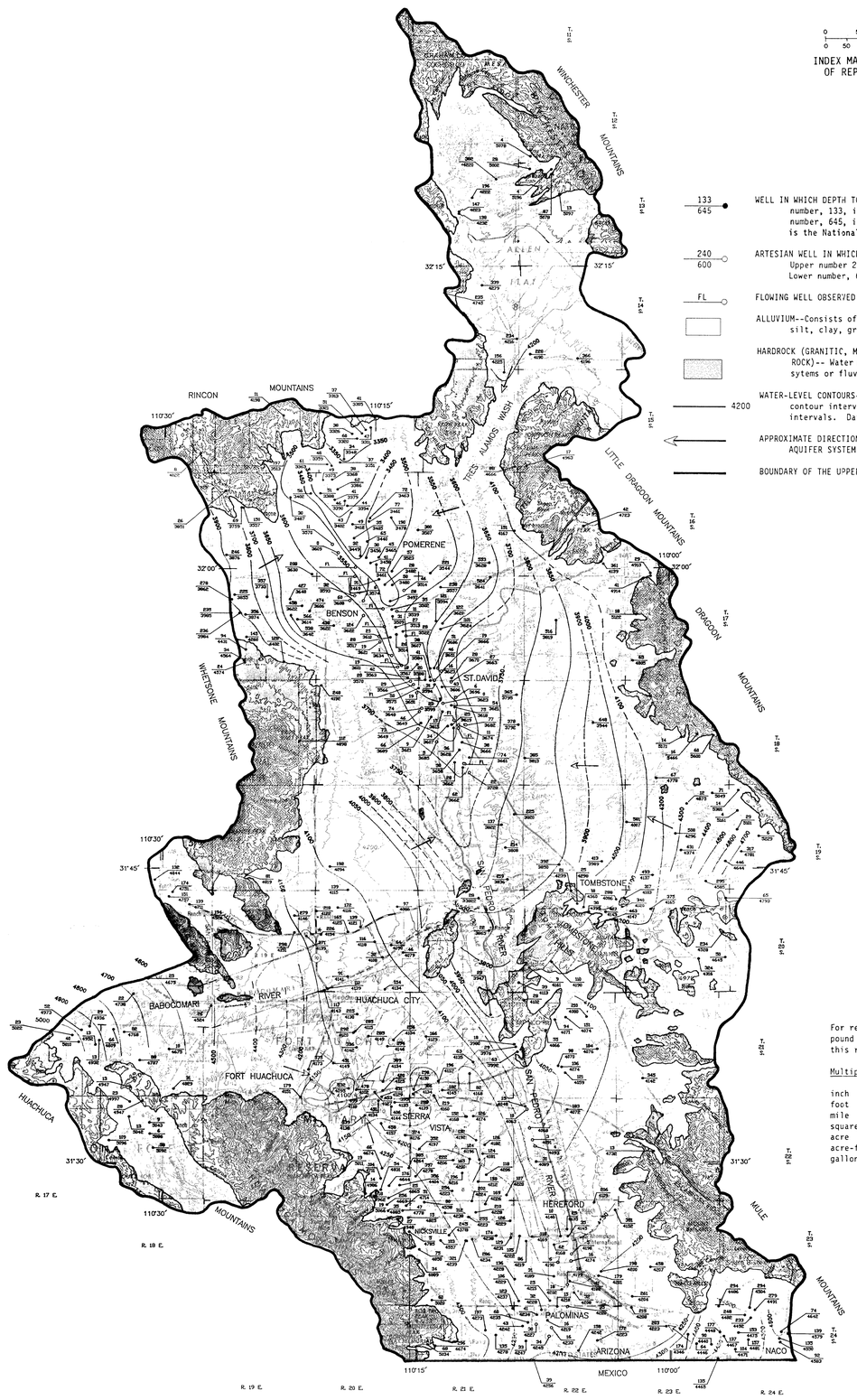
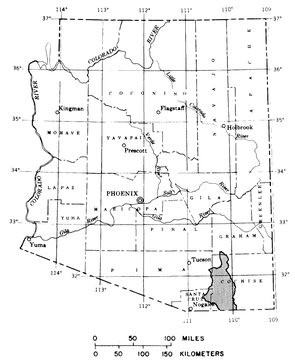
MAP 1 DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL





INDEX MAP SHOWING AREA OF REPORT (SHADED)

EXPLANATION

133/645 — WELL IN WHICH DEPTH TO WATER WAS MEASURED IN NOV.-DEC. 1990--Upper number, 133, is depth to water in feet below land surface. Lower number, 645, is the altitude of the water level, in feet. Datum is the National Vertical Geodetic Datum of 1929.

240/600 — ARTESIAN WELL IN WHICH DEPTH TO WATER WAS MEASURED IN NOV.-DEC. 1990--Upper number 240, is depth to water, in feet, below land surface. Lower number, 600 is the altitude of the water level in feet

FL — FLOWING WELL OBSERVED IN DEC. 1990

ALLUVIUM--Consists of semi-consolidated to poorly consolidated samd, silt, clay, gravel and conglomerate

HARDROCK (GRANITIC, METAMORPHIC, VOLCANIC OR CONSOLIDATED SEDIMENTARY ROCK)-- Water may occur in weathered or fractured zones, joint, sytems or fluvial deposits overlying bedrock

4200 — WATER-LEVEL CONTOURS--Shows the approximate altitude of the water level. contour interval 100 feet. With supplementary contours at 50 feet intervals. Datum is the National Vertical Geodetic Datum of 1929

APPROXIMATE DIRECTION OF GROUNDWATER FLOW IN THE PRIMARY PART OF THE MAIN AQUIFER SYSTEM

BOUNDARY OF THE UPPER SAN PEDRO 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

5 0 5 MILES
5 0 10 KILOMETERS

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929
SCALE 1:250,000

INTRODUCTION

The upper San Pedro basin is an intermontaine valley which includes approximately 1,875 square miles in southeast Arizona. The basin is bounded on the west by the Huachuca, Whetstone, and Rincon Mountains, and on the east by the Mule, Dragoon, Little Dragoon and Winchester Mountains. The basin extends approximately 58 miles along the San Pedro River, from the international boundary with the Republic of Mexico on the south, to the Narrows, approximately 11 miles north of Benson. The north sloping, north-to-northwest-trending valley ranges from 6 to 39 miles wide, and is divided into two sub-basins; Allen Flat and Sierra Vista.

The basin is drained by the San Pedro River and its main tributaries, the Babocomari River and Tres Alamos Wash. The San Pedro River flows northward from its headwaters, 25 miles south of the international boundary. The river enters the basin just south of the community of Palominas at an altitude of 4,275 feet, and exits at the Narrows, at an altitude of 3,309 feet, yielding a topographic gradient of nearly 17 feet per mile. Within the upper San Pedro basin the San Pedro River is an intermittent watercourse, except for a perennial reach from north of the community of Hereford to south of the community of Fairbank, a distance of approximately 25 miles, where the river channel intercepts the water table (Konieczki, 1980, sheet 1).

The climate in the upper San Pedro basin is semiarid, characterized by hot summers and mild winters (Roeske and Werrell, 1973, p. 9). Rainfall primarily occurs during two peak periods. During the months of December, January and February gentle rains, occasionally of long duration, are common. Intense, short-duration rainfall resulting from monsoonal thunderstorms make July and August the wettest months of the year. May is the driest month of the year, typically with little or no recorded precipitation. Average annual rainfall ranges from 11 inches at Benson to 15 inches in the area around Fort Huachuca-Sierra Vista, to more than 22 inches at the Coronado National Memorial. Snowfall contributes a minor amount of precipitation in the upper San Pedro basin, with a yearly total of 1.5 to 3 inches throughout most of the valley floor, and from 5 to 15 inches in the foothills of the mountains. Much more snow and rainfall occurs in the mountains surrounding the basin. June is the hottest month of the year, and average daytime temperatures range from the mid-to-high 90's °F near Benson to approximately 90 °F in the southern part of the basin. The coolest month is January, when average daytime highs range from the low 60's °F near Benson to the high 50's °F in the southern part of the basin. Extremes of 116 °F at Benson in June 1904, and -7 °F at St. David in December 1978 have been recorded (Sellers and others, 1985, p. 86-93, 112-114, 132-133).

Settlement of the upper San Pedro basin was hastened by mining which brought early settlers to the area around Bisbee and Tombstone. The first homesteads were established in the late 1800's. Mormons settled at St. David in 1877, and Camp Huachuca (now Fort Huachuca) was established by the U.S. Army the same year (Barnes and Granger, 1960, p. 40, 49). To supply the needs of the booming mining districts, agriculture became important, resulting in the need for reliable sources of water. Early reports mention that groundwater under artesian pressure was first noted in 1887. Water reportedly flowed for several hours from a fissure caused by a strong earthquake (Lee, 1905, p. 169). There is evidence to support such a claim as an estimated magnitude 7.2 earthquake, centered 30 miles southeast of Douglas, caused damage throughout southeastern Arizona in 1887 (Fellows, 1995, p. 1). The first flowing well in the upper San Pedro basin, and possibly the first in the state, was drilled in 1892 (Roeske and Werrell, 1973, p. 6). In his 1903 investigation of the valley, W.T. Lee (1905, p. 166) observed that over 200 wells had been drilled between Benson and Fairbank, a distance of only 20 miles.

The major cities, towns and communities in the basin include Sierra Vista, Tombstone, Huachuca City, Fort Huachuca, Benson, St. David, Naco, Pomerene, Hereford, Palominas and Nicksville. Farming, ranching and mining are the notable industries in the basin, with major groundwater users being farming, mining, military and municipalities. In 1988-89 there were approximately 12,700 irrigated acres in the upper San Pedro basin (Arizona Department of Water Resources, 1990, p. 131).

GEOLOGY

The upper San Pedro basin is an elongated trough formed by the uplift of the surrounding mountain blocks relative to the blocks underlying the valley floor. The resultant mountains are made up mainly of granite, schist, gneiss, volcanics and consolidated sedimentary rocks ranging in age from Precambrian to Tertiary. The structural and, to some degree, the hydrologic system are affected by the Tombstone Hills which jut out into the basin between Tombstone and the San Pedro River. These outcrops are composed of Tertiary granite and volcanics. As the surrounding mountains eroded, the basin subsequently filled with alluvium. The estimated maximum depth to bedrock along the axis of the basin may exceed 6,000 feet in the southern part, and is less than 5,000 feet in the northern part (Oppenheimer and Sumner, 1980, map). Pediments are known to exist in some places beneath the alluvial fill along the mountain fronts (Heindl, 1952, p. 70).

Unconformably overlying the bedrock is the Pantano Formation. The Pantano Formation is a sedimentary deposit which has been firmly established as Tertiary in age. This unit is a poorly to moderately indurated conglomerate, with clasts ranging in size from pebbles to boulders. They are composed of granite, limestone and volcanics, embedded in a coarse sandstone matrix (Brown and others, 1966, p. 9-13). The Pantano Formation may exceed 1,000 feet in thickness in the area around Sierra Vista and Fort Huachuca (Putman and others, 1988, p. 11).

Unconformably overlying the Pantano Formation are the Quatenary and Tertiary (Pliocene) basin-fill deposits. The basin-fill deposits, unlike the Pantano Formation, are post Basin and Range development (Brown and others, 1966, p. 15). The lower unit of the basin fill consists of whitish-gray to light-brown lenticular beds of strongly to weakly cemented gravel, sandstone, siltstone and clay. The lower unit is up to 1,000 feet thick in the center of the basin. The unit grades into coarse-grained beds a few feet thick near the mountain fronts (Roeske and Werrell, 1973, p. 10-11).

The upper unit of the basin fill is characterized by weakly cemented, sometimes compacted beds of reddish-brown to brown sediments of gravel, sandstone, siltstone and clays. The unit tends to be well-bedded silt, sandy-silt and clays in the center of the valley and grading into clayey-silty gravel near the mountain fronts. This unit may be as much as 800 feet thick (Roeske and Werrell, 1973, p. 11). This unit can form steep slopes where capped by well-cemented terrace deposits, but erodes into badlands topography if not protected by the terrace deposits (Brown and others, 1966, p. 16). In 1902, when referring to these deposits, W.P. Blake noted that in the area of Benson on both sides of the San Pedro Valley, there are unconsolidated red clays and sediments in horizontal beds of great thickness, often terraced by river erosion, and extending high up on both sides of the bordering mountains (Meinzer and Kelton, 1913, p. 60).

In places, the basin-fill deposits are overlain by the beds of the flood-plain alluvium. They are unconsolidated, lenticular, river-and stream-laid deposits of gravel, sand and silt. These beds are found along the channels and flood plain of the San Pedro and major tributaries, and range from less than a mile to several miles wide and from 40 to 150 feet in thickness.

With the exception of the Pantano Formation, all of the previously mentioned basin-fill units are also present in Allen Flat. However, the units are not as thick (Putman and others, 1988, p. 65). Depth to bedrock in the Allen Flat sub-basin has been estimated to be from 1,600 to 3,200 feet (Oppenheimer and Sumner, 1980, map).

GROUNDWATER OCCURRENCE

The predominant aquifers in the upper San Pedro basin are the basin fill deposits and the flood-plain alluvium (Roeske and Werrell, 1973, p. 24). Groundwater occurs under unconfined conditions in the flood-plain alluvium and under both confined and unconfined conditions in the basin-fill deposits.

Basin-Fill Deposits

The basin-fill deposits, consisting of the upper and lower units and the basal conglomerate (Pantano Formation), form the principal aquifer in the upper San Pedro basin. The basin-fill deposits are stratigraphically complex. Locally, some areas exhibit confined conditions, but regionally the basin-fill aquifer is unconfined (Freethey, 1982, p. 49).

Unconfined

Both the upper and lower units are good sources of groundwater, and together they produce most of the water pumped from the regional aquifer. Yields of 100 to 2,800 gallons per minute have been reported from wells completed in the upper and lower units (Roeske and Werrell, 1973, p. 13). The Pantano Formation is generally well cemented and not a reliable aquifer, but well yields up to several hundred gallons per minute have been reported (Roeske and Werrell, 1973, p. 10). In 1990, measured depths to water in the unconfined areas of the regional aquifer ranged from less than 100 feet to nearly 600 feet below land surface.

Confined

The upper San Pedro basin has long been known as an area having hundreds of artesian wells. Nearly all these wells are located in two geographically small areas along the San Pedro River. The larger of the artesian areas is located roughly from Land (3½ miles south of St. David), north to Pomerene, a distance of about 12 miles long, and 2 to 3 miles wide. This area includes Benson and St. David. A second area, about 10 miles long and 1 mile wide, is located between Hereford and Palominas. In these two areas deep wells drilled in or adjacent to the flood plain of the San Pedro River encounter confined waters (Heindl, 1952, p. 70). Gravel beds of the lower basin fill are overlain by up to several hundred feet of silt and clay. Depth to the confined waters vary depending upon location. The shallowest is in the Hereford-Palominas area, where well depths of about 200 feet are required (Roeske and Werrell, 1973, p. 12). At St. David, and south to Land, well depths of 300 feet and deeper are required to reach the confined aquifer. The deepest confined waters are found between Benson and Pomerene, at depths of 500 to 1,000 feet. Confined groundwater has also been encountered in the upper unit of the basin fill, where sand and gravel beds are overlain by clay and silt lenses. Where flowing, discharges from these wells are much less than the wells completed in the lower basin fill. In December of 1990, approximately 150 artesian wells were visited while collecting data for this study. Of that group, 47 flowing wells were observed. Many other flowing wells were not accessible, and some wells flow only seasonally. Of the artesian wells that were not flowing, depth to water ranged from a few inches to as much as 50 feet below land surface.

In 1903, a maximum discharge of 80 gallons per minute was observed in the artesian wells of the upper San Pedro basin. The average discharge was about 10 gallons per minute (Lee, 1905, p. 169). In December of 1990, estimated discharges ranged from over 50 gallons per minute to a trickle. Although no flowing wells were observed in the Hereford-Palominas area, some wells were reported to flow seasonally.

Flood-Plain Alluvium

The flood-plain alluvium is more porous and permeable than the basin fill. However, due to its limited areal extent, it is only an important aquifer locally, along the axis of the valley. Water levels are generally less than 50 feet below the land surface, and fluctuate seasonally in response to pumpage, evapotranspiration and recharge from river flow. Because of its high permeability and close proximity to the river, the flood-plain alluvium is easily recharged, and rapid recovery rates in wells are common. Many of the irrigation wells in the basin obtain water from the flood-plain alluvium (Roeske and Werrell, 1973, p. 11). Discharges from wells commonly range from 200 to 1,800 gallons per minute, and some have produced up to 2,000 gallons per minute (Roeske and Werrell, 1973, p. 13).

Secondary Sources

A pediment aquifer is located along the northeastern slope of the Huachuca Mountains, south of Sierra Vista. The pediment aquifer is a shallow alluvial aquifer, which is not connected to the regional aquifer. Very shallow water levels, some less than 30 feet below land surface, have been measured in this area. Other secondary sources of groundwater include the crystalline rocks and consolidated sedimentary rocks which make up the mountains surrounding the basin. Where sufficiently fractured and saturated, these rocks may yield a few gallons per minute to wells. Numerous springs are located in the surrounding mountains. Discharges from these springs are generally small and may have periods of no flow. The most significant springs in the basin are located in Garden Canyon in the Huachuca Mountains, where combined maximum discharge has reached 1,800 gallons per minute (Brown and others, 1966, p. 36).

RECHARGE

Groundwater in the upper San Pedro basin is recharged by mountain-front runoff, river and streambed infiltration, underflow from Mexico, and seepage from applied irrigation. Due to high evapotranspiration rates, direct recharge from precipitation seepage is negligible. The regional aquifer is recharged mainly by mountain-front runoff, and to a lesser degree by underflow from Mexico and by streambed infiltration. Streambed and riverbed infiltration as well as infiltration from adjacent and underlying sediments are major sources of recharge to the flood-plain alluvium aquifer. Seepage from applied irrigation contributes to a lesser degree.

Groundwater recharge estimates are 29,000 acre-feet per year from streambed infiltration and mountain-front runoff and 900 acre-feet per year as underflow from Mexico (Arizona Department of Water Resources, 1990, p. 131). Seepage from applied irrigation water contributes an indeterminate amount of recharge to the basin.

DISCHARGE

Groundwater is discharged in the upper San Pedro basin by both natural and artificial means. Freethey and Anderson (1986, sheet 3) estimate that less than 1,000 acre-feet per year of groundwater was discharged to the lower San Pedro basin as outflow under pre-developmental conditions. This figure is likely little changed today. Contributing to total discharge is evapotranspiration and the evaporation of surface water from the perennial reach of the San Pedro River (Hereford to Fairbank) where groundwater enters the riverbed as baseflow and near Charleston, where groundwater is forced to the surface by bedrock. Numerous springs also contribute to total discharge. Production from wells is the major source of groundwater discharge, (see pumpage table, sheet 2). In the course of this investigation, no less than 150 artesian wells were identified, of which 47 were flowing. In spite of the large number of flowing wells, total discharge from this source is quite small, owing to low rates of flow. Irrigation is the largest user, followed by public supply, domestic and industrial users. In 1990, an estimated 37,000 acre-feet of groundwater was pumped. The peak year for pumpage was 1981, when 75,000 acre-feet was pumped. Between 1966 and 1990, 1,126,000 acre-feet of groundwater was pumped from the upper San Pedro basin (Anning and Duet, 1994, sheet 1). Pre-1966 pumpage records are not available for this basin.

MOVEMENT AND STORAGE

Direction of groundwater flow generally mirrors surface-water drainage in the basin. Groundwater moves from the mountain fronts and higher elevations toward the center of the basin, then moves in a north-northwest direction along the axis of the valley. Natural flow direction has been disrupted near Sierra Vista due to the development of a significant groundwater depression. Water under the influence of the depression now flows toward its center. In places, groundwater can also freely move between alluvial units within the aquifers. Some exchange of water between the confined parts of the regional aquifer and the flood-plain aquifer can also take place due to well casings perforated in both aquifers and also due to rotted well casings. Freethey and Anderson (1986, sheet 3) estimated that prior to development, there were 36 million acre-feet of recoverable groundwater in the basin-fill material to a depth of 1,200 feet below land surface. This figure is likely little changed as hydrographs suggest only modest declines in water levels, except in the vicinity of Sierra Vista-Huachuca City.

WATER-LEVEL CHANGE

In the upper San Pedro basin, the annual water-level decline rates are generally small. (See hydrographs A thru M, Q and S thru W.) Water levels fluctuate seasonally in response to pumping, evapotranspiration and recharge, especially in the flood-plain alluvium along the San Pedro River. However, net changes are slight, except in the area around Sierra Vista-Fort Huachuca where groundwater withdrawal is greater than recharge. Declines in this area are significant. (See hydrographs N, O, P and R.) Based on 1968 data, a small eliptical cone of depression was described by Roeske and Werrell (1973, p. 16). The depression was enclosed within the 4,150 foot contour. It encompassed about 5 square miles and was centered in section 33, Township 21 South, Range 20 East. The major axis of the eliptical cone was northeast-southwest in orientation. Data collected by the Geological Survey in the winter of 1977-78 supports Konieczki's (1980, sheet 1) reference to a small depression centered within the 4,150 foot contour near Sierra Vista-Fort Huachuca. Several wells which were measured for this study (December 1990), lie within the cone of depression, 17 of which were also measured in the winter of 1977-78. During the 13-year period between measurements there was a maximum decline of 16.7 feet at well (D-22-20)01BCC, and a minimum decline of 3.3 feet at (D-21-20)16AAC1, (hydrograph M). Well (D-21-20)22BBB1 exhibited a rise of 4.1 feet. The average decline at the 17 wells was 7.9 feet over the 13-year period, or 0.6 feet per year.

Putman and others (1988, p. 98), using data collected in the winter of 1985-86, stated that the cone of depression within the 4,150 foot contour still extended in a northeast-southwest direction, and had increased arealy to the east and southeast of Sierra Vista, to about 7.5 square miles or by a factor of 1.5 since 1978. Eight wells measured in 1990 within the cone of depression also had water-levels that were collected in the winter of 1985-86. Declines were recorded at all 8 wells. A maximum decline of 9.16 feet was observed at well (D-21-21)31CAC, while the minimum observed decline was 2.2 feet at well (D-21-20)35CBC. The average decline of the 8 wells was about 4.5 feet over the 5 year period, or about 0.9 feet per year, indicating a slight increase in the rate of decline.

The cone is still centered or deepest in section 33, Township 21 South, Range 20 East. However, the deepest part of the cone can now be encircled by the 4,100 foot water-level altitude contour. At 532.1 feet below land surface in December 1990, well (D-21-20)33ACC at the center of the cone has dropped 40.2 feet since 1958, or an average of 1.26 feet per year. Water levels in wells within the influence of the depression generally are declining approximately 0.5 to 1.0 feet per year. The depression is generally expanding in an east-southeasterly direction from the deepest part of the cone.

WATER QUALITY

Water samples from 155 wells and springs were collected for this study. Of that number, 59 were detailed analyses and the remainder were analyzed for fluoride, specific-conductance and pH only.

The maximum contaminant level (MCL) for fluoride in Arizona public drinking water is 4.0 milligrams per liter (mg/L), as established by the United States 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.

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 microsiemens per centimeter at 25°C (µS/cm). The U.S. Environmental Protection Agency has established the secondary maximum contaminant level (SMCL) for dissolved solids at 500 mg/L, which is approximately equivalent to a specific-conductance value of 833 µS/cm. The SMCL's are guidelines only, and are not enforceable standards (U.S. Environmental Protection Agency, 1988, p. 9). The 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.

The groundwater of the upper San Pedro basin is generally of good chemical quality. Of the 155 total samples, the MCL's for fluoride or dissolved solids were exceeded in only 25 wells. Of the 25 wells in which one or both of the MCL's were exceeded, 20 of the wells are located either in the confined part of the regional aquifer or in the flood-plain alluvium. Water from these two areas is generally used for irrigation. When the basin is viewed in its entirety, these two areas represent a very small percentage of the total area.

Flood-Plain Alluvium

Some of the poorest quality water in the basin is found in the flood-plain alluvium. Between St. David and the Narrows, the specific-conductance values are the highest in the basin, ranging from 850 to 2,800 µS/cm, or approximately 510 to 1,680 mg/L dissolved solids. South of St. David, specific-conductance values range from 307 to 620 µS/cm, or approximately 184 to 372 mg/L dissolved solids, decreasing in value with distance south of St. David. Fluoride values range from a low of 0.2 mg/L northwest of Hereford to a high of 3.0 mg/L near St. David. North of St. David values range from 0.5 to 1.9 mg/L and south of St. David from 0.2 to 1.0 mg/L. Average water temperature in the flood-plain alluvium is about 19.6°C (67.3°F).

Basin Fill Deposits

In the artesian area from St. David north to Benson, specific-conductance values range from 180 to 550 µS/cm, or approximately 108 to 330 mg/L dissolved solids, which is well within the SMCL limits. Fluoride values range from 0.1 to 8.8 mg/L; the higher values generally occur from just south of Benson to Land. The temperature of the artesian waters averages 24.2°C (75.6°F). There is a small area from just southwest to northwest of Pomerene in which five flowing wells were sampled. These wells have anomalously high temperatures which range from 28°C to 30°C and average 28.9°C (84°F). Each of these wells is at least 1,000 feet deep. Other artesian wells in the same general area produce water in the 20°C to 25°C range.

Only five of the wells sampled in the unconfined regional aquifer produce water which exceeds one of the MC 's for fluoride or dissolved solids. This certainly is supportive of historical claims that the regional aquifer is of good quality.

Fluoride values in the unconfined regional aquifer range from 0.1 mg/L to a high of 4.0 mg/L. Specific-conductance values range from 160 µS/cm to 3,100 µS/cm, and average 448 µS/cm. Temperatures range from 17°C to 29°C, and average 22.2°C (72°F).

Water from 13 springs was analyzed for this study. Fluoride values range from 0.5 to 1.9 mg/L. Specific-conductance values range from 210 to 833 µS/cm, approximately 126 to 500 mg/L dissolved solids. Temperatures range from 7.5°C at spring (D-17-23)04BCC to 24.5°C at spring (D-17-23)18AAD, both located in the Dragoon Mountains.

High sulfate and/or nitrate levels were detected in a few wells in the upper San Pedro basin. These wells are mainly located in the flood-plain alluvium, roughly from St. David to the Narrows. The sulfate MCL of 250 mg/L was exceeded at three wells and the nitrate MCL of 10 mg/L was exceeded at two wells.

One well, (D-19-20)30DAA (360 mg/L), southeast of the Whetstone Mountains, completed in the regional aquifer produces water with high sulfate concentrations.

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BASE FROM U.S. GEOLOGICAL SURVEY
TUCSON, ARIZONA, 1956, REV. 1974 1:250,000
DOUGLAS, ARIZONA, 1957, REV. 1970, 1:250,000
NOGALES, ARIZONA, 1955, REV. 1969, 1:250,000

MAPS SHOWING GROUNDWATER CONDITIONS IN THE UPPER SAN PEDRO BASIN, COCHISE, GRAHAM, AND SANTA CRUZ COUNTIES ARIZONA--1990

BY
R.L. BARNES

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.

MAP 2 CHEMICAL QUALITY OF GROUNDWATER

3490 / 1.6 — WELL IN WHICH WATER WAS SAMPLED IN 1987-1990--Upper number, 3490, is specific conductance in mecrosiemens per centimeter at 25 C. Lower number, 1.6, is the fluoride concentration in milligrams per liter.

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

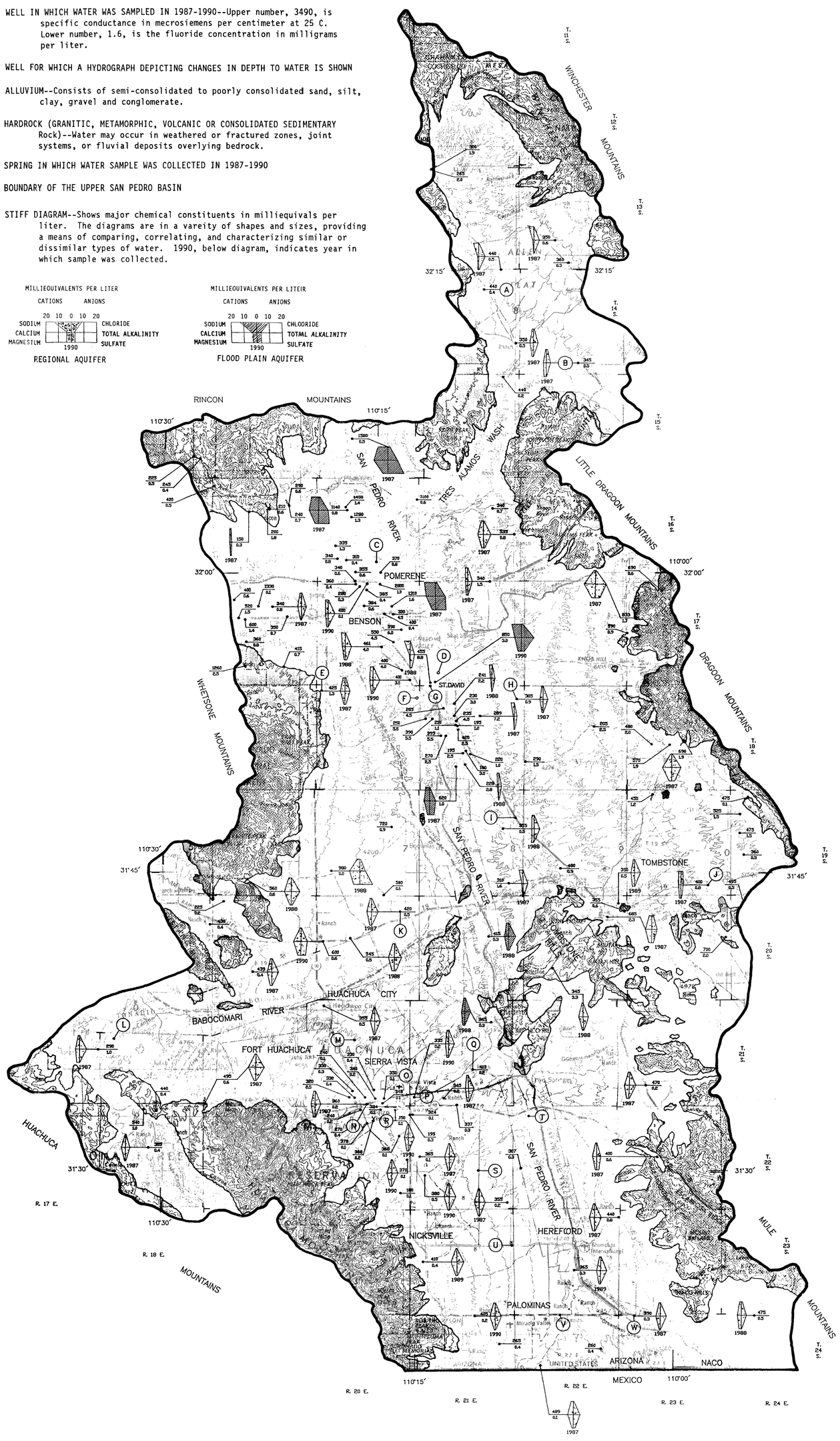
ALLUVIUM--Consists of semi-consolidated to poorly consolidated sand, silt, clay, gravel and conglomerate.

HARDROCK (GRANITIC, METAMORPHIC, VOLCANIC OR CONSOLIDATED SEDIMENTARY Rock)--Water may occur in weathered or fractured zones, joint systems, or fluvial deposits overlying bedrock.

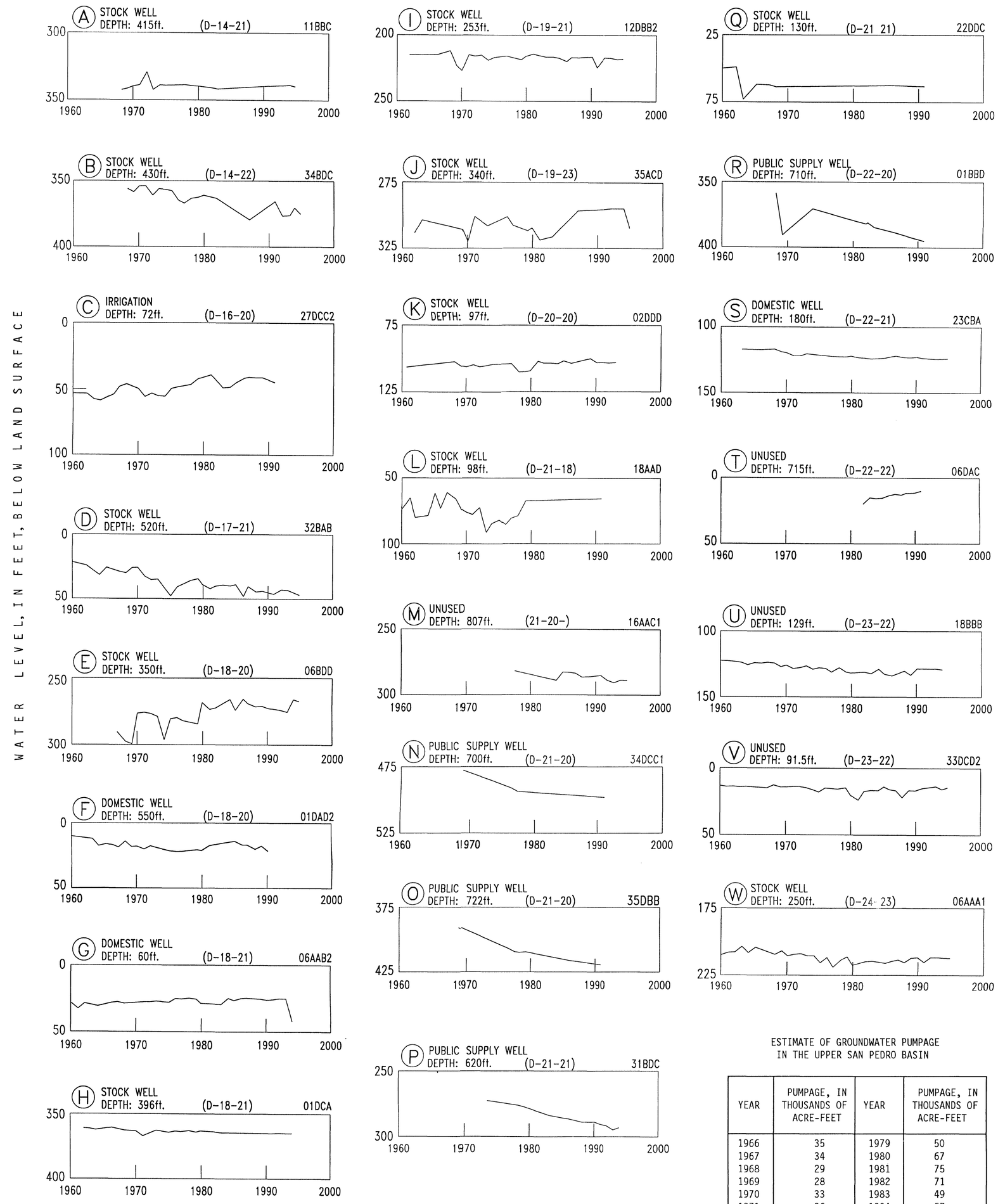
SPRING IN WHICH WATER SAMPLE WAS COLLECTED IN 1987-1990

BOUNDARY OF THE UPPER SAN PEDRO BASIN

STIFF DIAGRAM--Shows major chemical constituents in milliequivals per liter. The diagrams are in a vareity 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.



HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS



ESTIMATE OF GROUNDWATER PUMPAGE IN THE UPPER SAN PEDRO BASIN

YEAR	PUMPAGE, IN THOUSANDS OF ACRE-FEET	YEAR	PUMPAGE, IN THOUSANDS OF ACRE-FEET
1966	35	1979	50
1967	34	1980	67
1968	29	1981	75
1969	28	1982	71
1970	33	1983	49
1971	36	1984	57
1972	38	1985	31
1973	41	1986	35
1974	45	1987	38
1975	52	1988	43
1976	59	1989	43
1977	54	1990	37
1978	46	TOTAL	1126

(Numbers rounded to nearest thousands acre-feet)
(* Pumpage for USP was not estimated prior to 1966)

BASE FROM U.S. GEOLOGICAL SURVEY
TUCSON, ARIZONA, 1956, REV. 1974 1:250,000
DOUGLAS, ARIZONA, 1957, REV. 1970, 1:250,000
NOGALES, ARIZONA, 1955, REV. 1969, 1:250,000

MAPS SHOWING GROUNDWATER CONDITIONS IN THE UPPER SAN PEDRO BASIN, COCHISE, GRAHAM, AND SANTA CRUZ COUNTIES ARIZONA--1990

BY
R.L. BARNES

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.