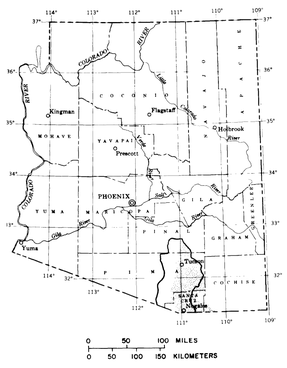
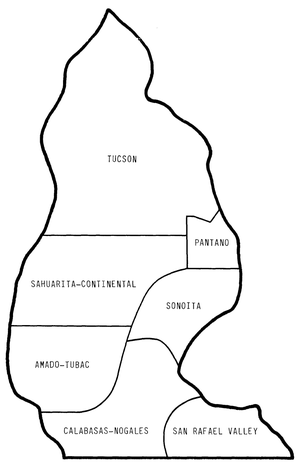


INDEX MAP SHOWING AREA OF REPORT (SHADED)
TUCSON ACTIVE MANAGEMENT AREA (OUTLINED)



INSET
SUBAREAS OF THE
UPPER SANTA CRUZ BASIN AREA

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 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL
SCALE 1:125,000

INTRODUCTION

The Upper Santa Cruz basin area, most of which is in the Tucson Active Management Area (AMA), includes about 3,160 square miles in southeastern Arizona (see index map). The basin area includes: the Santa Cruz Valley from the international boundary between the Republic of Mexico and the United States to Cortaro, the major tributary drainages of the Santa Cruz River, the San Rafael Valley, and the Cienega Creek drainage. The San Rafael Valley and the Cienega Creek drainage are outside the Tucson AMA. The basin area is within the Basin and Range physiographic province, which is characterized by broad alluvial-filled basins bounded by steep, rugged, fault-block mountains. The Upper Santa Cruz basin area is bounded on the north by the Tortolita and Santa Catalina Mountains and on the east by the Tanque Verde, Rincon, Empire, Santa Rita, Whetstone, San Cayetano, Patagonia, and Huachuca Mountains and the Canelo Hills. On the west the basin area is bounded by Black Mountain and the Tucson, Sierrita, Cerro Colorado, Tumacacori, Atascosa, and Pajarito Mountains.

Climate varies widely in the Upper Santa Cruz basin area and is largely dependent on altitude. In general, precipitation decreases and air temperature increases with decreasing altitude. Near Cortaro, the lowest part of the basin area, the average annual precipitation is about 11 inches. At Lochiel, near the headwaters of the Santa Cruz River, the average annual precipitation is about 17 inches. In the higher altitudes in the mountains surrounding the basin area, precipitation may be as much as 29 inches per year. Most of the precipitation throughout the basin area occurs during July, August, and September when moist tropical air from the Gulf of Mexico flows into the state creating afternoon thundershowers.

The average daily maximum air temperature for Cortaro is 67°F in January and 103°F in July and 60°F and 89°F, respectively, for Lochiel. The average daily minimum air temperature for Cortaro is 34°F in January and 73°F in July and 24°F and 59°F, respectively, for Lochiel. Extremes of 120°F in July and -7°F in January have been recorded (Sellers and Hill, 1974, p. 130, 172, 201, 258, 337, 338, 345, 346, 350, 357, 416, 418, 442, 450, 525, 526, 529, 530, 533, 534).

The basin area is drained by the Santa Cruz River and its tributaries. The Santa Cruz River rises in the San Rafael Valley and continues south about 9 miles, where it enters the Republic of Mexico. After a 35-mile course through Mexico, the river reenters Arizona about 5 miles east of Nogales and continues generally north for about 85 miles and exits the basin area near Cortaro. Major tributaries of the Santa Cruz River include Nogales Wash, Potrero Creek, Sonoita Creek, Sopori Wash, Cienega Creek, Pantano Wash, Tanque Verde Creek, Sabino Creek, Rillito Creek and Cañada del Oro. Through most reaches, the Santa Cruz River and its tributary streams are ephemeral and flow only in direct response to rainfall or snowmelt.

Because of the ephemeral nature of the river and other streams in the Upper Santa Cruz basin area, groundwater is the only dependable source of water. In the Upper Santa Cruz basin area groundwater is used for agricultural irrigation, mining, livestock watering, recreation, and municipal and domestic supply.

GROUNDWATER OCCURRENCE

Groundwater in the Upper Santa Cruz basin area occurs in the sedimentary rocks and alluvium that underlie the Santa Cruz and San Rafael Valleys and the Cienega Creek drainage. In general, groundwater in the Upper Santa Cruz basin area is under water-table (unconfined) conditions; however, it may occur under artesian (confined) or perched conditions. These units may yield from a few to more than a thousand gallons per minute of water to properly constructed wells. Minor amounts of groundwater occur in the thin alluvium in stream channels that drain the mountains surrounding the basin area, and in fractured and weathered volcanic, granitic, metamorphic, and sedimentary rocks that comprise the mountains. For the purpose of discussing groundwater conditions, the hydrogeology, depth to groundwater, and changes in water level in the sedimentary rocks and alluvium that underlie the basin area, the basin area has been divided into seven subareas (see inset). They are: the Tucson, Pantano, Sahuarita-Continental, Amado-Tubac, Calabasas-Nogales, San Rafael Valley, and Sonoita subareas.

The Tucson subarea includes that part of the Santa Cruz Valley from Pima Mine road to the north end of the basin area. The Pantano subarea includes the Cienega Creek drainage from the north boundary of Township 18 South to Pantano. Like the Tucson subarea, the subareas of Sahuarita-Continental, Amado-Tubac, and Calabasas-Nogales all lie within the Santa Cruz Valley. The Sahuarita-Continental subarea includes the area from Arivaca Junction to Pima Mine Road. The Amado-Tubac subarea includes the area north of Township 23 South to Arivaca Junction. The Calabasas-Nogales subarea includes the area from the international boundary to Township 23 South plus the Sonoita Creek drainage that lies south of the groundwater divide in Township 20 South, Range 16 East. The San Rafael Valley subarea includes the area bounded by the international boundary to the Canelo Hills from the Patagonia Mountains to the Huachuca Mountains. The Sonoita subarea includes the Cienega Creek drainage from the Canelo Hills to Township 18 South.

The sedimentary rocks of the Tucson, Pantano, and Sahuarita-Continental subareas include three major units that form a single aquifer (Davidson, 1973, p. E16-E30). The units are the Pantano Formation, the Tinaja beds, and the Fort Lowell Formation. The Fort Lowell Formation provides most of the groundwater that is withdrawn in these areas.

The Pantano Formation generally is a reddish-brown silty sandstone to gravel. The formation crops out in the foothills of the Santa Catalina Mountains and overlies bedrock. Near Davidson Canyon, the Pantano Formation is at least 6,400 feet thick. In the central part of the Tucson subarea and northern part of the Sahuarita-Continental subarea, more than 1,000 feet of the Pantano has been penetrated.

The Tinaja beds consist of the upper beds, which are gray to grayish-brown sandy gravel, and the lower beds, which change from a gray to grayish-brown to a reddish- to medium-brown gypsiferous clayey silt and mudstone from west to east across the basin area. These beds crop out in the same mountain foothills as the Pantano Formation and they overlie either the Pantano Formation or bedrock. The Tinaja beds vary in thickness from several hundred feet near the edges of the basin area to more than 2,000 feet in the center of the basin area.

The Fort Lowell Formation consists of unconsolidated to moderately-consolidated sediments that range in color from dark- to light-reddish brown. The formation grades from a silty gravel near the edges of the Upper Santa Cruz basin area to a sandy silt and clayey silt in the central part of the basin area. Surface exposures occur in the foothills of the Sierrita Mountains and along streams, roadcuts, mine pits, and hills. The formation overlies the Tinaja beds or older units and is generally 300 to 400 feet thick.

In the Tucson subarea depth to water in the sedimentary rocks ranges from 15 feet below land surface near the confluence of Tanque Verde Creek and Pantano Wash to 557 feet below land surface west of the Rincon Mountains. In the Pantano subarea depth to water in the sedimentary rocks ranges from 1 foot below land surface near Cienega Creek to 336 feet below land surface north of the Whetstone Mountains. In the Sahuarita-Continental subarea depth to water in the sedimentary rocks ranges from 30 feet near the Cerro Colorado Mountains to 670 feet below land surface near the Santa Rita Mountains.

In the Amado-Tubac and Calabasas-Nogales subareas the water-bearing units are the Nogales Formation, the older alluvium, and the younger alluvium. The younger alluvium provides most of the groundwater that is withdrawn in these subareas. Streamflow provides the principal source of groundwater recharge to the younger alluvium.

The Nogales Formation is a well-cemented conglomerate that crops out in and near the City of Nogales. Other surface exposures have been identified as far north as the foothills of the Rincon Mountains in the Pantano subarea (Drewes, 1977). However, only in the Calabasas-Nogales subarea has the Nogales Formation been identified in the subsurface, where it overlies bedrock. The Nogales Formation has been estimated to be more than 7,000 feet thick (Simons, 1974, p. 8).

The older alluvium, which consists of unconsolidated to moderately consolidated gravel, sand, silt, and clay is exposed in the area between the present stream courses and the mountains and overlies either the Nogales Formation or bedrock. The maximum thickness of the older alluvium is unknown but more than 300 feet of it has been penetrated in Section 16, Township 24 South, Range 15 East (Terry Turner, Hydrologist, Arizona Department of Water Resources, Phoenix, Arizona, oral commun., 1983).

The younger alluvium is composed predominantly of unconsolidated gravel and sand and comprises the present stream courses and flood plains of the Santa Cruz River and its major tributaries. It rests predominantly on the older alluvium but locally overlies older units. Along the Santa Cruz River the thickness of the younger alluvium ranges from about 45 feet at the international boundary to about 100 feet near Calabasas.

In the Amado-Tubac subarea depth to water in the sedimentary rocks and alluvium ranges from 6 feet below land surface near the Santa Cruz River to 344 feet below land surface near the Tumacacori Mountains. In the Calabasas-Nogales subarea depth to water in the sedimentary rocks and alluvium ranges from 6 feet below land surface near the Santa Cruz River to 313 feet below land surface near the Patagonia Mountains.

In the San Rafael Valley subarea groundwater occurs in undifferentiated alluvium that consists of gravel, sand, silt, and clay. The alluvium occurs at the surface and overlies bedrock. Maximum thickness is unknown but almost 1,000 feet of the alluvium has been penetrated in Section 14, Township 23 South, Range 17 East. Depth to water in the alluvium ranges from 10 feet below land surface near the Canelo Hills to 207 feet below land surface near the Patagonia Mountains.

In the Sonoita subarea groundwater occurs in an undifferentiated sandstone and shale unit and in undifferentiated alluvium that consists of gravel, sand, silt, and clay. The alluvium provides most of the groundwater that is withdrawn in this area. The sandstone and shale unit is a consolidated sedimentary rock that underlies the alluvium. In the north half of Township 19 South, Range 17 East an abundance of clay in the lower part of the alluvium forms a confining layer that creates artesian conditions in the sandstone and shale. The extent of this artesian condition and the extent and maximum thickness of the sandstone and shale unit are unknown but a thickness of more than 450 feet has been penetrated in Section 17, Township 19 South, Range 17 East.

The alluvium occurs at the surface and overlies the sandstone and shale unit or bedrock. The alluvium is approximately 400 to 500 feet thick where it overlies the sandstone and shale in the north half of Township 19 South, Range 17 East. To the south of this area the alluvium thickens to more than 1,000 feet in Section 32, Township 19 South, Range 17 East. The sandstone and shale unit was not identified in that area. Water levels in the Sonoita subarea range from 30 feet above land surface in the artesian area to a depth of 617 feet below land surface near the Santa Rita Mountains in Section 4, Township 19 South, Range 16 East.

EXPLANATION

- 142 / 3208 — WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1981-82--Upper number, 142, is depth to water in feet below land surface. Plus sign before number indicates height of water above land surface. Lower number, 3208, is the altitude of the water level in feet above mean sea level
- 4575 — SPRING FIELD CHECKED IN 1981-82--Number, 4575, is the altitude of the spring in feet above mean sea level
- BEDROCK (VOLCANIC, GRANITIC, METAMORPHIC, OR SEDIMENTARY ROCK)--Water may occur in weathered or fractured zones, joint systems, or thin alluvium overlying consolidated rocks
- WATER-BEARING UNITS (GRAVEL, SAND, SILT, CLAY, CONGLOMERATE, SANDSTONE, MUDSTONE, SHALE)
- 2800 — WATER-LEVEL CONTOUR--Shows approximate altitude of the water level. Contour interval 50 and 100 feet. Datum is mean sea level
- GROUNDWATER DIVIDE--Approximately located
- ARBITRARY BOUNDARY OF GROUNDWATER AREA

BASE FROM U.S. GEOLOGICAL SURVEY
NOGALES, AZ., 1956, REV. 1969, 1:250,000
TUCSON, AZ., 1956, REV. 1977, 1:250,000

DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL, SPRING 1982
MAPS SHOWING GROUNDWATER CONDITIONS IN THE UPPER SANTA CRUZ BASIN AREA, PIMA, SANTA CRUZ, PINAL AND COCHISE COUNTIES, ARIZONA--1982

BY
B. A. MURPHY AND J. D. HEDLEY

These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Unit, 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: Federal Building, 301 West Congress Street, Tucson, and Valley Center, 241 North Central Avenue, Suite 1880, Phoenix, Arizona.

BASE FROM U.S. GEOLOGICAL SURVEY
NOGALES, AZ., 1956, REV. 1969, 1:250,000
TUCSON, AZ., 1956, REV. 1977, 1:250,000

CHANGE IN WATER LEVEL, 1953-1982, AND HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS

MAPS SHOWING GROUNDWATER CONDITIONS IN THE UPPER SANTA CRUZ BASIN AREA, PIMA, SANTA CRUZ, PINAL AND COCHISE COUNTIES, ARIZONA--1982

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EXPLANATION

APPROXIMATE LINE OF EQUAL CHANGE IN WATER LEVEL--Based principally on data from 1953 and 1982. Intervals 20 feet

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

BEDROCK (VOLCANIC, GRANITIC, METAMORPHIC, OR SEDIMENTARY ROCK)--Water may occur in weathered or fractured zones, joint systems, or thin alluvium overlying consolidated rocks

WATER-BEARING UNITS (GRAVEL, SAND, SILT, CLAY, CONGLOMERATE, SANDSTONE, MUDSTONE, SHALE)

ARBITRARY BOUNDARY OF GROUNDWATER AREA

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL
SCALE 1:125,000

5 0 5 10 KILOMETERS
5 0 5 MILES

CHANGE IN WATER LEVEL

In the Tucson subarea, an area of significant groundwater withdrawal, water-level changes range from rises of more than 30 feet to declines that exceed 100 feet. In the northeast part of Township 14 South, Range 14 East, water levels have declined as much as 111 feet. Records indicate steady declines in water levels have occurred since the early 1950's (see Hydrograph C). In Township 15 South, Range 13 East, water levels have declined as much as 113 feet. Water levels here have been declining at least since the late 1940's (see Hydrograph E). An inspection of water-level measurements, observations of cascading water, and historic water-level records indicate that a perched-water zone now exists in this area. The perched-water zone probably formed here because the aquifer was dewatered below a clay layer that now retards the downward movement of water, and water above the clay layer is perched above the regional aquifer (compare Hydrographs D and E). In the upper reaches of Canada del Oro, water levels have risen as much as 31 feet (see Hydrograph B). The water-level rises are attributed to increased mountain front recharge and infiltration of stream-channel runoff that has occurred during years of high precipitation.

In the Sahuarita-Continental subarea, another area of significant groundwater withdrawal, maximum water-level declines exceed 150 feet. Along the Santa Cruz River between Sahuarita and Continental, water levels have declined as much as 132 feet and records indicate a steady decline in water levels since the 1940's (see Hydrographs H and I). Water levels have also declined as much as 156 feet in Sections 34 and 35, Township 16 South, Range 13 East. Most of the wells in this area were drilled in the early 1960's and water-level records indicate steady declines since that time (see Hydrograph F).

Throughout the Amado-Tubac and Calabasas-Nogales subareas, water levels generally have risen except for two localized areas where small declines have occurred. The changes in water level in these subareas range from 31 feet of rise to 28 feet of decline. The rise in water levels probably is a result of recharge to the groundwater from infiltration of stream-channel runoff during years of high precipitation (see Hydrograph L).

The Fantano, Sonoita, and San Rafael Valley subareas have traditionally small amounts of groundwater withdrawal. Although few long-term water-level records are available, indications are that no significant changes in water levels have occurred (see Hydrograph M).

ESTIMATED GROUNDWATER PUMPAGE IN THE UPPER SANTA CRUZ BASIN AREA

YEAR	PUMPAGE IN THOUSANDS OF ACRE-FEET	YEAR	PUMPAGE IN THOUSANDS OF ACRE-FEET
PRIOR TO 1915	80	1948	135
1915	7	1949	132
1916	7	1950	160
1917	8	1951	180
1918	8	1952	195
1919	10	1953	200
1920	35	1954	200
1921	20	1955	200
1922	30	1956	200
1923	37	1957	200
1924	45	1958	175
1925	42	1959	165
1926	40	1960	165
1927	40	1961	175
1928	45	1962	200
1929	40	1963	180
1930	38	1964	175
1931	25	1965	200
1932	20	1966	190
1933	16	1967	200
1934	30	1968	210
1935	28	1969	236
1936	32	1970	240
1937	35	1971	258
1938	40	1972	253
1939	50	1973	280
1940	62	1974	264
1941	70	1975	280
1942	94	1976	281
1943	95	1977	257
1944	100	1978	220
1945	106	1979	215
1946	109	1980	228
1947	136	1981	225
		TOTAL:	8,,654

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS SHOWN ON THE MAP

(Dashed line indicates inferred water level)

DEPTH TO WATER, IN FEET, BELOW LAND SURFACE

PREPARED IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY
ARIZONA DEPARTMENT OF WATER RESOURCES

D.W.R. HYDROLOGIC MAP SERIES REPORT NO. 11
SHEET 2 OF 3
CHANGE IN WATER LEVEL AND HYDROGRAPHS

GROUNDWATER QUALITY

The groundwater generally is of suitable chemical quality for most uses in all seven subareas of the Upper Santa Cruz basin area. Specific conductance values for groundwater samples collected from wells and springs range from 40 to 2,600 micromhos per centimeter at 25°C and dissolved-solids concentrations estimated from specific conductance values range from 24 to 1,560 milligrams per liter (mg/L). [1/] The dissolved-solids concentration exceeds the maximum contaminant level [1/] in fifty-nine of the 491 samples analyzed. Groundwater that contains dissolved solids in excess of this limit occurs in all seven subareas but a concentration of it is present in the Tucson subarea along the Santa Cruz River between Cortaro and Jaynes.

Fluoride concentrations in the groundwater samples collected range from 0 to 7.0 mg/L. Fluoride concentrations exceed the acceptable maximum concentration [2/] in thirty-three of the 491 samples analyzed. Groundwater that contains fluoride in excess of this limit occurs in all but the San Rafael Valley and Sonoita subareas; however, it is most predominant in the Sahuarita-Continental subarea along the Santa Cruz River near Sahuarita.

Several other chemical constituents in the groundwater of the Upper Santa Cruz basin area exceed the recommended or mandatory limits. Excessive nitrate and sulfate levels occur in groundwater along the Santa Cruz River in the Tucson subarea between Cortaro and Jaynes and in the Sahuarita-Continental subarea between Sahuarita and Continental (Wilson and others, 1983, p. 4-20 - 4-43; Upper Santa Cruz Basin Mines Task Force, 1979, p. 30-32). Also, excessive levels of trichloroethylene (TCE) have been detected in groundwater near the Tucson International Airport in the Tucson subarea (Hargis and Montgomery, 1983, volume I, Appendix F).

NOTES

1/ The dissolved-solids concentration may be approximated by multiplying the specific conductance value by 0.6. The maximum contaminant level allowable in public water supplies under National Secondary Drinking Water regulations is 500 mg/L (U.S. Environmental Protection Agency, 1977b, p. 17146).

2/ The maximum acceptable concentration of fluoride in public water supply depends on the annual average maximum daily air temperature (U.S. Environmental Protection Agency, 1977a, p. 67). The annual average maximum daily air temperature for the lower elevations (below 3,500 feet) is about 82°F and the maximum acceptable fluoride concentration is 1.4 mg/L. For the higher elevations (above 3,500 feet) the annual average maximum daily air temperature is about 71°F and the maximum acceptable fluoride concentration is 1.6 mg/L.

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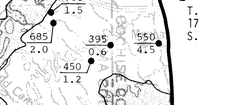
EXPLANATION

- 325 / 0.2 — WELL FOR WHICH A WATER SAMPLE WAS COLLECTED IN 1981-82--Upper number, 325, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Lower number, 0.2, is the fluoride concentration in milligrams per liter
- 690 / 0.4 — SPRING FOR WHICH A WATER SAMPLE WAS COLLECTED IN 1981-82--Upper number, 690, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Lower number, 0.4, is the fluoride concentration in milligrams per liter
- BEDROCK (VOLCANIC, GRANITIC, METAMORPHIC, OR SEDIMENTARY ROCK)--Water may occur in weathered or fractured zones, joint systems, or thin alluvium overlying consolidated rocks
- WATER-BEARING UNITS (GRAVEL, SAND, SILT, CLAY, CONGLOMERATE, SANDSTONE, MUDSTONE, SHALE)
- ARBITRARY BOUNDARY OF GROUNDWATER AREA

CHEMICAL QUALITY DIAGRAM--Shows major constituents in milliequivalents per liter. The diagram are in a variety of shapes and sizes, providing a means of comparing, correlating, and characterizing similar or dissimilar types of water. Year, 1979, below diagram indicates sample collected in year other than 1981-82

MILLIEQUIVALENTS PER LITER



5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL
SCALE 1:125,000

BASE FROM U.S. GEOLOGICAL SURVEY
NOGALES, AZ., 1956, REV. 1969, 1:250,000
TUCSON, AZ., 1956, REV. 1977, 1:250,000

CHEMICAL QUALITY OF WATER, 1981-82

MAPS SHOWING GROUNDWATER CONDITIONS IN THE UPPER SANTA CRUZ BASIN AREA, PIMA, SANTA CRUZ, PINAL AND COCHISE COUNTIES, ARIZONA--1982

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