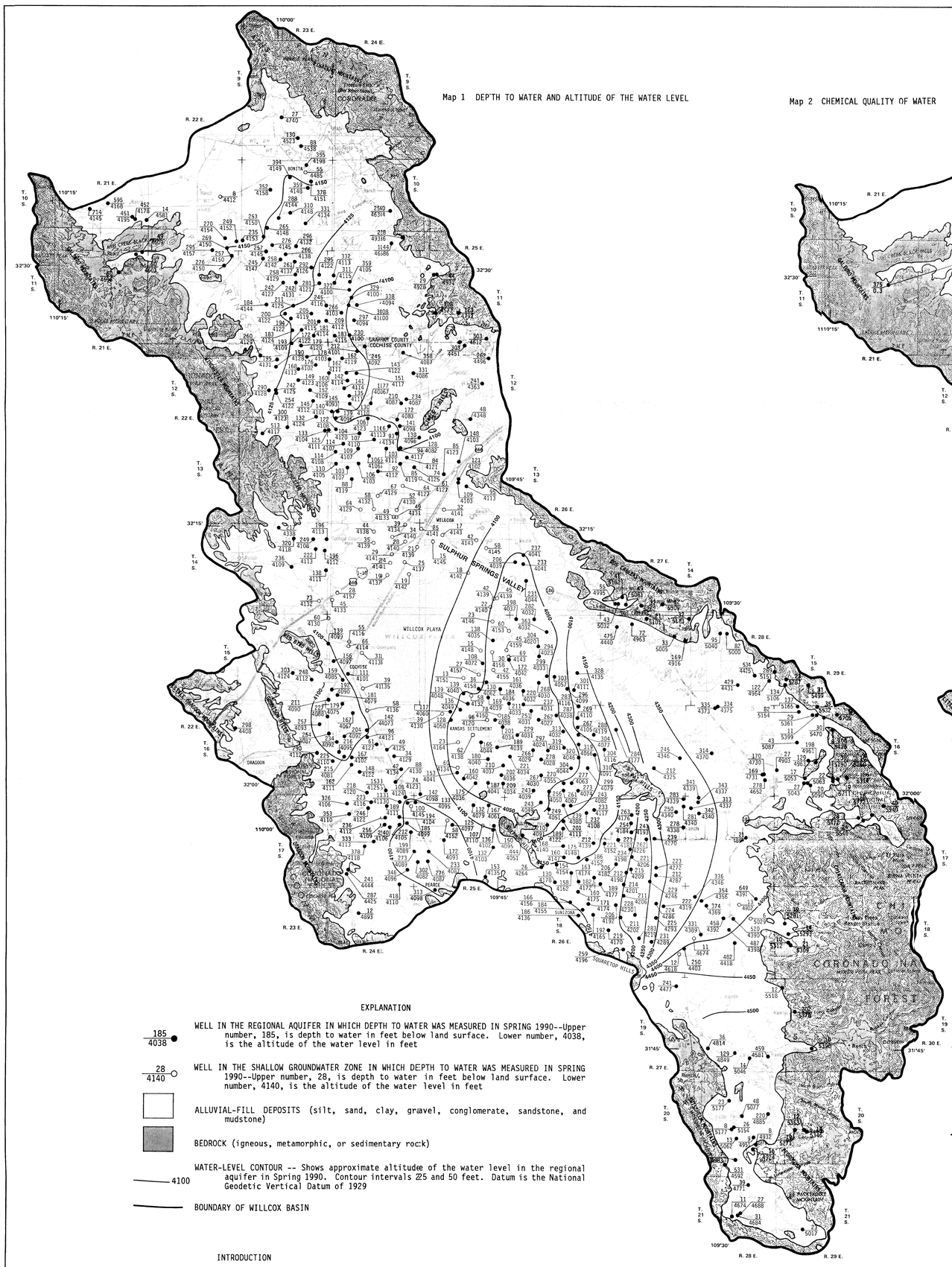
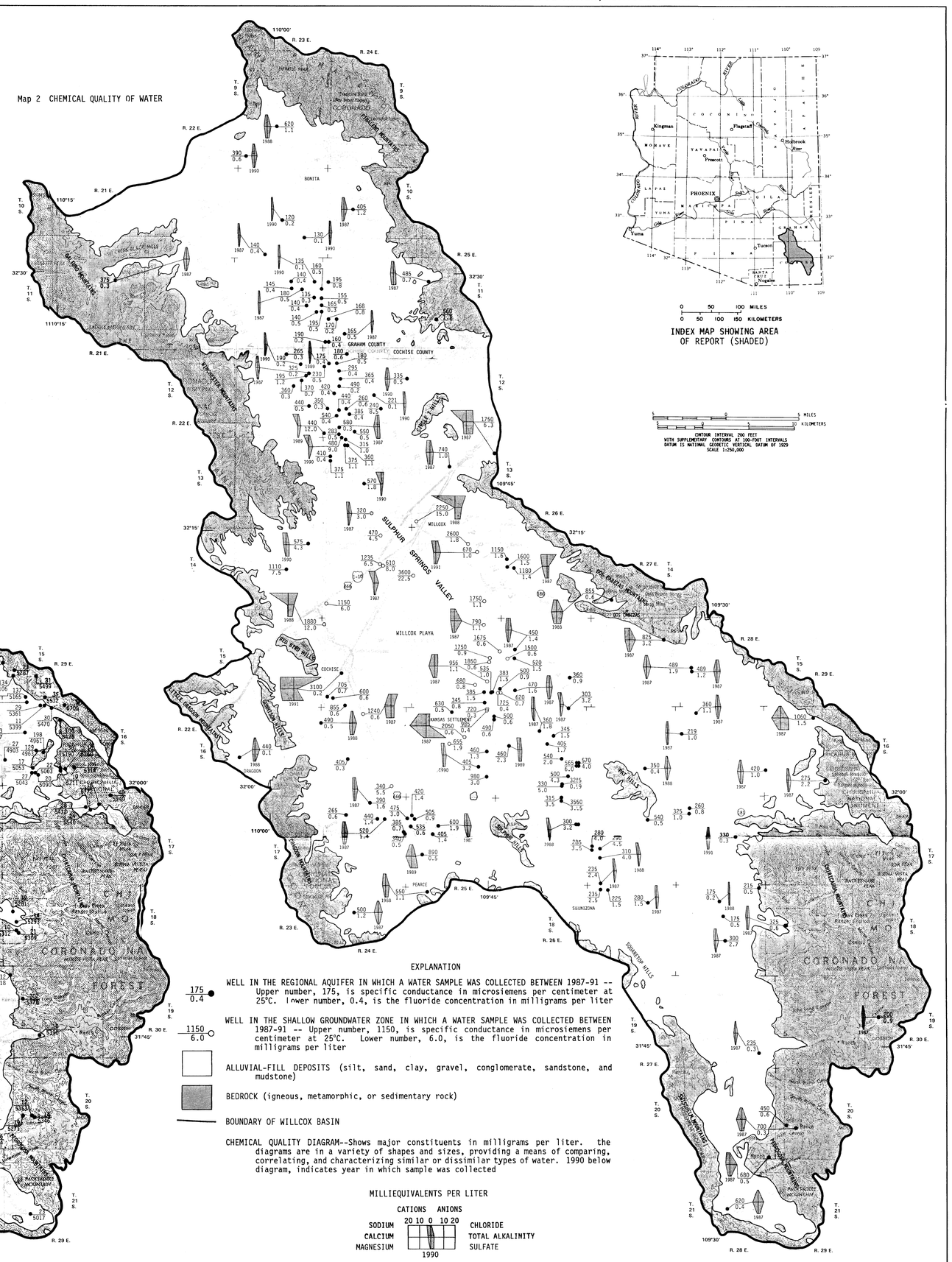




0 50 100 MILES
0 50 100 150 KILOMETERS

INDEX MAP SHOWING AREA OF REPORT (SHADED)

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929
SCALE 1:250,000

EXPLANATION

185/4038 ● WELL IN THE REGIONAL AQUIFER IN WHICH DEPTH TO WATER WAS MEASURED IN SPRING 1990--Upper number, 185, is depth to water in feet below land surface. Lower number, 4038, is the altitude of the water level in feet

28/4140 ○ WELL IN THE SHALLOW GROUNDWATER ZONE IN WHICH DEPTH TO WATER WAS MEASURED IN SPRING 1990--Upper number, 28, is depth to water in feet below land surface. Lower number, 4140, is the altitude of the water level in feet

ALLUVIAL-FILL DEPOSITS (silt, sand, clay, gravel, conglomerate, sandstone, and mudstone)

BEDROCK (igneous, metamorphic, or sedimentary rock)

4100 WATER-LEVEL CONTOUR -- Shows approximate altitude of the water level in the regional aquifer in Spring 1990. Contour intervals 25 and 50 feet. Datum is the National Geodetic Vertical Datum of 1929

BOUNDARY OF WILLCOX BASIN

EXPLANATION

175/0.4 ● WELL IN THE REGIONAL AQUIFER IN WHICH A WATER SAMPLE WAS COLLECTED BETWEEN 1987-91 -- Upper number, 175, is specific conductance in microsiemens per centimeter at 25°C. Lower number, 0.4, is the fluoride concentration in milligrams per liter

1150/6.0 ○ WELL IN THE SHALLOW GROUNDWATER ZONE IN WHICH A WATER SAMPLE WAS COLLECTED BETWEEN 1987-91 -- Upper number, 1150, is specific conductance in microsiemens per centimeter at 25°C. Lower number, 6.0, is the fluoride concentration in milligrams per liter

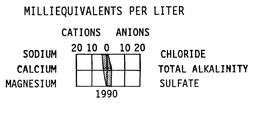
ALLUVIAL-FILL DEPOSITS (silt, sand, clay, gravel, conglomerate, sandstone, and mudstone)

BEDROCK (igneous, metamorphic, or sedimentary rock)

BOUNDARY OF WILLCOX 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



INTRODUCTION

The Willcox basin, located in southeastern Arizona, occupies the northern part of a large northwest-trending intermontane structural trough known as the Sulphur Springs Valley. The basin is about 90 miles long and varies from 10 to 30 miles wide and includes approximately 1,911 square miles. The Willcox basin is bounded on the north by the surface-drainage divide with the Aravaipa Creek basin, and the Pinaleno Mountains; on the east by the Dos Cabezas and Chiricahua Mountains; on the south by the Pedregosa and Swisshelm Mountains, the Squaretop Hills, and a series of smaller hills and ridges between the communities of Pearce and Sunizona; and on the west by the Dragoon, Little Dragoon, Winchester, and Galiuro Mountains.

The Willcox basin is a debris-filled valley that has been without external surface drainage throughout most of its geologic history (Coates, 1952, p. 178). Whitewater Draw in the extreme southern end of the basin drains into the adjacent Douglas basin, and all the remaining surface drainage is internal and flows to a large, roughly triangular-shaped alkali flat known as the Willcox Playa. The playa, a nearly level plain almost devoid of vegetation, occupies approximately 50 square miles in the central part of the basin and is a remnant of the Pleistocene-age Lake Cochise. Land-surface altitudes in the Willcox basin range from 4,134 feet on the Willcox Playa, to 10,720 feet atop Mount Graham in the Pinaleno Mountains on the northern basin boundary.

The climate in the Willcox basin is semiarid and is characterized by hot summers and cool, moderate winters. Precipitation principally occurs during two peak periods. Thunderstorms produce intense rains of short duration from July to September, and frontal-type storms produce gentle rains of longer duration, and some snow during the winter months (Brown and Schumann, 1969, p. 6). July and August are the wettest months of the year throughout the Willcox basin; May is the driest month. Average annual rainfall ranges from about 11 inches near the community of Cochise to over 18 inches at the Chiricahua National Monument. Average annual snowfall ranges from 1 to 4 inches per year on the valley floor to over 13 inches in the mountains surrounding the basin. The annual average daily maximum air temperature at the City of Willcox is about 77°F. The annual average daily minimum air temperature at Willcox is about 41°F. A maximum temperature of 114°F was recorded at the community of Dragoon in June 1902, and near Cochise in May 1912. A minimum temperature of -10°F was recorded at the Chiricahua National Monument in January 1913 (Sellers and others, 1985, p. 88-93, 100-105, 112-115, 132-135).

Agriculture and ranching are the major industries in the Willcox basin. Prior to the 1870's the Sulphur Springs Valley was occupied almost exclusively by the Chiricahua Apaches (Meinzer and Kelton, 1913, p. 11). The first settlers to occupy the basin were cattle ranchers who entered the basin in the late 1860's. Their ranch locations were determined by the availability of springs or shallow groundwater. One of the first settlers was H.C. Hooker who established the Sierra Bonita cattle ranch in the northern part of the basin, where water could be found by digging only a few feet below land surface (Meinzer and Kelton, 1913, p. 18, 214). The discovery of copper and silver in adjacent basins in 1877, particularly near the Towns of Bisbee and Tombstone, brought prospectors to the general area in search of instant wealth. As the mining population grew, there developed a need for locally produced agricultural and dairy products (Meinzer and Kelton, 1913, p. 14-16). Both industries required water. The first attempts at agriculture by settlers were by means of dry farming or a combination of dry farming and flood-water farming. These methods relied totally on seasonal rainfall and, therefore, crop yields were smaller in years of reduced rainfall (Meinzer and Kelton, 1913, p. 215-220). In 1880 the Southern Pacific Railroad built a main line across the Willcox basin roughly from east to west. Willcox, located on the line, grew as a supply station to service the area (Meinzer and Kelton, 1913, p. 13,14).

To augment the unreliable water sources, 57 irrigation wells had been dug or drilled in the Willcox basin by 1910, primarily in the north-central part of the basin where groundwater was shallow (Meinzer and Kelton, 1913, plate II). A typical irrigation well of the early 1900's consisted of an open pit dug to within a foot of the water table and a hand-augered hole extending down into the water-bearing strata. A horizontal centrifugal pump was then set into the pit and driven by a belt from a gasoline engine at the surface (Meinzer and Kelton, 1913, p. 188). The development of the deep-well turbine pump in the 1930's and the availability of affordable electric power helped make agriculture the leading industry in the Willcox basin by the early 1950's.

GROUNDWATER OCCURRENCE AND MOVEMENT

The Willcox basin includes a long, broad valley formed by large-scale faulting and the subsequent uplifting and eroding of the surrounding mountain blocks. The structural trough was likely completed by Middle to Late Tertiary time. As the igneous, metamorphic, and sedimentary rocks of the adjacent mountains eroded, large quantities of detritus were deposited into the basin (Cooley and Davidson, 1963, p. 7-35). These deposits, in ascending order, are consolidated alluvium and unconsolidated alluvium. The consolidated alluvium (Tertiary) has been divided into moderately consolidated alluvium consisting of conglomerate, sandstone, and mudstone, and poorly consolidated alluvium (Tertiary-Quaternary) consisting of poorly cemented lenticular beds of sand, gravel, silt, and clay. The unconsolidated alluvium (Quaternary) has been divided into stream deposits consisting of lenticular interbedded gravel, sand, silt, and clay, and lake-bed deposits consisting of clay and silt, locally overlain by thin beach gravel and sand dunes (Brown and Schumann, 1969, p. 11). The maximum thickness of both units in the central part of the valley is about 6,400 feet (Oppenheimer and Sumner, 1980).

Groundwater in the Willcox basin occurs predominately in a regional aquifer system in which the unconsolidated alluvium is the main water-bearing unit. Although the bulk of this unit consists of impermeable silt and clay, the relatively thin and interconnected sand and gravel layers are highly permeable and, in some areas, are capable of yielding large quantities of water to irrigation and domestic wells (Brown and Schumann, 1969, p. 11-18). Groundwater also occurs in the older consolidated alluvium that underlies the unconsolidated alluvium. The poorly to moderately cemented deposits of the consolidated alluvium exhibit very low to moderate permeability, but large quantities of water may be obtained if sufficient thickness of saturated material is penetrated by a well (Brown and Schumann, 1969 p. 11-13).

The lake-bed deposits in the unconsolidated alluvium form confining layers that result in local confined (artesian) conditions near the Willcox Playa. Sand and gravel beds in that area are interfingered within the clay and silt of the lake-bed deposits and may contain water under artesian pressure (Jones and Cushman, 1947, p. 12). A shallow groundwater zone occurs in the area around the Willcox Playa and probably extends to several miles north of Interstate 10 into Township 13 South. Lake-bed deposits crop out on the playa and are interbedded with stream deposits at depths of 200 to 300 feet in other parts of the basin (Mann and others, 1978, sheet 1). In and around the playa the lake-bed deposits form a relatively impermeable layer that impedes the downward percolation of water. The areal extent of the shallow groundwater zone is most clearly defined on the east and south sides of the playa. Relatively shallow depths to water found in these areas clearly contrast with the greater depths to water in the regional aquifer. To the north and west of the playa the areal extent of the shallow groundwater zone is difficult to define. The shallow zone apparently grades into the regional aquifer along these margins. Wells denoted as open circles have been arbitrarily assigned to the shallow groundwater zone to illustrate the distinction between the shallow zone and the regional aquifer. Elsewhere, wells shown as open circles clearly have anomalously shallow depths to water. Shallow groundwater was also found in one well north of Willcox in Township 10 South, Range 23 East, and in several wells east of Sunizona in Township 18 South, Ranges 27 and 28 East. These areas of shallow groundwater may be hydraulically connected to the shallow groundwater zone. However, due to the paucity of well data around these areas, such connections are not distinct.

In the spring of 1990 the depth to groundwater in the regional aquifer ranged from 34 feet below land surface in well (D-16-24)23ACD to 649 feet below land surface in well (D-18-28)02DDB. The depth to groundwater in the shallow zone ranged from 13 feet below land surface in well (D-15-25)28AAD to 107 feet below land surface in well (D-17-25)11DCC3.

The direction of groundwater flow in the regional aquifer has been significantly altered since the development of agriculture in the basin. Predevelopmental groundwater flow is thought to have mirrored surface drainage and moved from the outer margins of the basin toward the playa. The direction of groundwater flow in the regional aquifer in 1990 was toward several main agricultural pumping centers, where four groundwater depressions have developed. Three of the depressions were first described by Brown and others (1963, fig. 13). One large depression is located in the Kansas Settlement area where large-scale groundwater withdrawals for irrigation began in 1953 (Brown and Schumann, 1969, p. 25). Another large depression encompasses an area northwest of Willcox, in Townships 11, 12, and 13 South, Range 24 East. The withdrawal of groundwater for irrigation in this area began as early as 1910, but it was not until the mid 1940's that any significant amounts of groundwater were withdrawn (Brown and Schumann, 1969, p. 22, 23). The third depression is located north of Pearce, and a fourth and smaller depression is located southwest of Cochise. The development of groundwater for irrigation near Pearce and Cochise began in 1952. Discharge measurements of irrigation wells in the regional aquifer performed by the U.S. Geological Survey between 1977 and 1982 ranged from 108 gallons per minute (gal/min) in well (D-13-24)05BBB1 to 2,199 gal/min in well (D-12-24)22DAA.

Groundwater may also occur in the weathered and fractured zones in the bedrock that form the surrounding mountains, and within thin alluvial deposits overlying the bedrock. Where wells and springs exist in these areas, yields are usually not more than a few gallons per minute.

The principal source of recharge in the Willcox basin is from infiltration of runoff along the mountain fronts. Little or no recharge is believed to result from direct precipitation, due to high evapotranspiration rates (Brown and Schumann, 1969, p. 19). Seepage from applied irrigation water may contribute a significant amount of water as recharge to the regional aquifer in the heavily pumped agricultural areas. Prior to groundwater development in the Willcox basin the aquifer was in equilibrium with inflow (recharge from infiltration of runoff and direct precipitation) equaling outflow (evapotranspiration) at about 45,000 acre-feet per year (Freethey and Anderson, 1986, sheet 3).

Groundwater is discharged from the Willcox basin by both artificial and natural means. The withdrawal of groundwater by pumping is the primary source of discharge in the Willcox basin. A small amount of groundwater also discharges from the basin as underflow to adjacent basins through the alluvial fill. One avenue of outflow is southward to the Douglas basin from the area southwest of Sunizona, and another is northward to the Aravaipa basin.

WATER-LEVEL CHANGES

Groundwater has been used in the Willcox basin since the early 1900's, but it was not until the late 1940's and early 1950's that large-scale withdrawals for agriculture began. As the amount of cultivated land and the number of wells in the basin increased, annual groundwater withdrawals increased, reaching a peak of about 339,000 acre-feet in 1974 (Wilson, 1991, sheet 1). The U.S. Geological Survey estimates that the total amount of groundwater pumped in the Willcox basin since groundwater development began is in excess of 7.2 million acre-feet (table 1, sheet 2). Water levels in at least nine wells declined more than 200 feet between 1954 and 1970 (Mann and others, 1975, sheet 1). Due to economic conditions many marginally successful farms went out of production in the late 1970's. Since that time annual groundwater pumpage has steadily decreased. As a result of the decrease in pumpage, water levels in the formerly heavily pumped areas have risen. Wells in the Kansas Settlement area have shown the greatest rises in water levels since 1975 (hydrographs K, M, O, P, Q, sheet 2). Wells in the north-central part of the basin in Townships 11, 12, and 13 South, Ranges 23, and 24 East, have shown smaller rises in water levels (hydrographs A, C, E, F, sheet 2). Wells completed in the shallow groundwater zone, near the playa, have remained relatively unchanged since 1975 (hydrographs H, I, N, sheet 2). Water levels in some wells outside of the major pumping areas declined during the period 1975-90 (map, sheet 2). Water-level changes during the period 1975-90 ranged from a decline of 67 feet in well (D-12-24)28AAA to a rise of 61 feet observed in two wells, (D-16-26)14DAA and (D-16-26)17DDD near Kansas Settlement.

Extensive groundwater withdrawal can cause the finer grained parts of the alluvium to compact. The compaction can result in land subsidence and earth fissures (Schumann and Genualdi, 1986). Water levels north of Willcox in wells (D-11-24)18AAA and (D-13-24)16BBB have declined as much as 100 feet since the early 1950's. Holzer (1980, sheet 2) states that 1.63 meters (5.3 feet) of subsidence was documented at one land-survey bench mark in the northeast corner of section 6 in Township 13 South, Range 24 East. Subsidence and earth fissures have also been reported near Kansas Settlement southeast of Willcox, where water levels in a few wells have declined more than 200 feet since the mid 1950's (Schumann and Genualdi, 1986).

WATER QUALITY

During the period 1987-91 a total of 177 water samples were collected and analyzed. Detailed chemical analyses were performed on 71 of the samples while 106 samples were analyzed for specific conductance, fluoride, pH, and temperature. Test results indicate the groundwater in the Willcox basin is generally good and suitable for most agricultural and industrial uses. However, domestic users should be aware of locally high fluoride concentrations.

Specific-conductance values of water collected from wells in the Willcox basin ranged from 120 to 3,600 microsiemens per centimeter (µS/cm). Dissolved-solids concentration may be approximated by multiplying specific-conductance values by 0.6, which is the approximate ratio of dissolved solids in milligrams per liter (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 833 µS/cm. SMCLs are guidelines only, and are not enforceable standards (U.S. Environmental Protection Agency, 1988, p. 9). SMCLs are based on the aesthetic quality of water such as taste, odor, and color. Water with contaminant levels above the SMCLs are not necessarily a health risk. Twenty-six of the 177 water samples analyzed exceeded the SMCL for dissolved solids; 24 of the samples were from wells completed near the Willcox Playa.

The maximum contaminant level (MCL) for fluoride in Arizona has been established as 4.0 mg/L (Arizona Department of Environmental Quality, 1991, p. 26). The above standard applies to public drinking-water systems only. The MCL is an enforceable standard set by the U.S. Environmental Protection Agency for drinking water. Fluoride concentrations in water samples within the Willcox basin ranged from 0.1 to 22.5 mg/L. Eighteen of the 177 water samples analyzed exceeded the MCL for fluoride for public drinking-water systems. Groundwater in the north part of the basin generally contains less than 2.0 mg/L fluoride, and the majority of wells in that area contain less than 1.0 mg/L fluoride; only three wells sampled in the north part of the basin had fluoride concentrations in excess of the MCL. Ten wells sampled immediately north of and to within a few miles north of the playa exceeded the MCL for fluoride. Fluoride levels in wells sampled near Kansas Settlement were generally less than 3.0 mg/L, and the majority of wells had values less than 2.0 mg/L. Four wells sampled in the area southeast of Kansas Settlement and north of Sunizona between the Sulphur Hills and the Pat Hills contained fluoride concentrations in excess of the MCL. In the area around Cochise and Pearce fluoride concentrations in wells sampled were generally below 2.0 mg/L; only one well exceeded the MCL for fluoride.

The MCL for arsenic in public drinking-water systems in Arizona is 50 micrograms per liter (µg/L) as established by the Arizona Department of Environmental Quality (1991, p. 26). Two of 71 wells sampled in the Willcox basin exceeded the MCL for arsenic. Arsenic concentrations of 57 µg/L in well (D-13-25)31CAB2 and 110 µg/L in well (D-15-24)06BCD were obtained during the sample period in the Willcox basin.

The MCL for nitrate in public drinking-water systems in Arizona expressed as nitrogen as established by the Arizona Department of Environmental Quality is 10 mg/L. Two of the 71 wells sampled for nitrate exceeded the MCL. Nitrate concentrations of 13 mg/L in well (D-13-25)12ABB and 20.0 mg/L in well (D-15-25)25BBC were obtained during the sample period.

SELECTED REFERENCES

Arizona Department of Environmental Quality, 1991, Public and semi-public water supply systems rules: Arizona Department of Environmental Quality duplicated report, 57 p.

Brown, S.G., Schumann, H.H., Kister, L.R., Johnson, P.W., 1963, Basic ground-water data of the Willcox basin, Graham and Cochise Counties, Arizona: Arizona State Land Department Water-Resources Report 14, 93 p., 15 figs.

Brown, S.G., Schumann, H.H., 1969, Geohydrology and water utilization in the Willcox basin, Graham and Cochise Counties, Arizona: U.S. Geological Survey Water-Supply Paper 1859-F, 32 p., 3 pls., 7 figs., 2 tables.

Coates, D.R., 1952, Willcox basin, Cochise and Graham Counties, in Ground water in the Gila River basin and adjacent areas, Arizona--a summary by L.C. Halpenny and others: U.S. Geological Survey open-file report (unnumbered), p. 177-185.

Cooley, M.E., Davidson, E.S., 1963, The Mogollon Highlands--their influence on Mesozoic and Cenozoic erosion and sedimentation: Arizona Geological Society Digest, v. 6, p. 7-35.

Freethey, G.W., Anderson, T.W., 1986, Predevelopment hydrologic conditions in the alluvial basins of Arizona and adjacent parts of California and New Mexico: U.S. Geological Survey Hydrologic Investigations Atlas HA-664, 3 sheets.

Holzer, T.L., 1980, Reconnaissance maps of earth fissures and land subsidence, Bowie and Willcox areas, Arizona: U.S. Geological Survey Miscellaneous Field Studies MF-1156, map.

Jones, R.S., Cushman, R.L., Hem, J.D., 1947, Geology and ground-water resources of the Willcox basin, Cochise and Graham Counties, Arizona, with a section on Quality of water: U.S. Geological Survey open-file report (unnumbered), 35 p., 1 pl., 1 fig., 4 tables.

Mann, L.J., White, N.D., Wilson, R.P., 1978, Maps showing ground-water conditions in the Willcox area, Cochise and Graham Counties, Arizona--1975: U.S. Geological Survey Water-Resources Investigations 78-60, 3 sheets.

Meinzer, O.E., Kelton, F.C., Forbes, R.H., 1913, Geology and water resources of Sulphur Spring Valley, Arizona, with a section on Agriculture: U.S. Geological Survey Water-Supply Paper 320, 231p.

Oppenheimer, J.M., 1980, Gravity modeling of the alluvial basins, southern Arizona: University of Arizona, unpublished master's thesis, map.

Schumann, H.H., Genualdi, R.B., 1986, Land subsidence, earth fissures, and water-level change in southern Arizona: Arizona Bureau of Geology and Mineral Technology, Map 23.

Sellers, W.D., Hill, R.E., Sanderson-Rae, M., 1985, Arizona climate, the first hundred years, 1885-1985: Institute of Atmospheric Physics, University of Arizona, 143 p.

U.S. Environmental Protection Agency, 1986a, Quality criteria for water--1986: EPA-44015/5-86-001, 501 p.

_____1986b, National primary and secondary drinking water regulations; fluoride; final rule: Washington, Federal Register, v. 51, no. 63, p. 11396-11397.

Wilson, R.P., 1991, Summary of ground-water conditions in Arizona: U.S. Geological Survey Water-Resources Investigations Report 90-4179, 4 sheets.

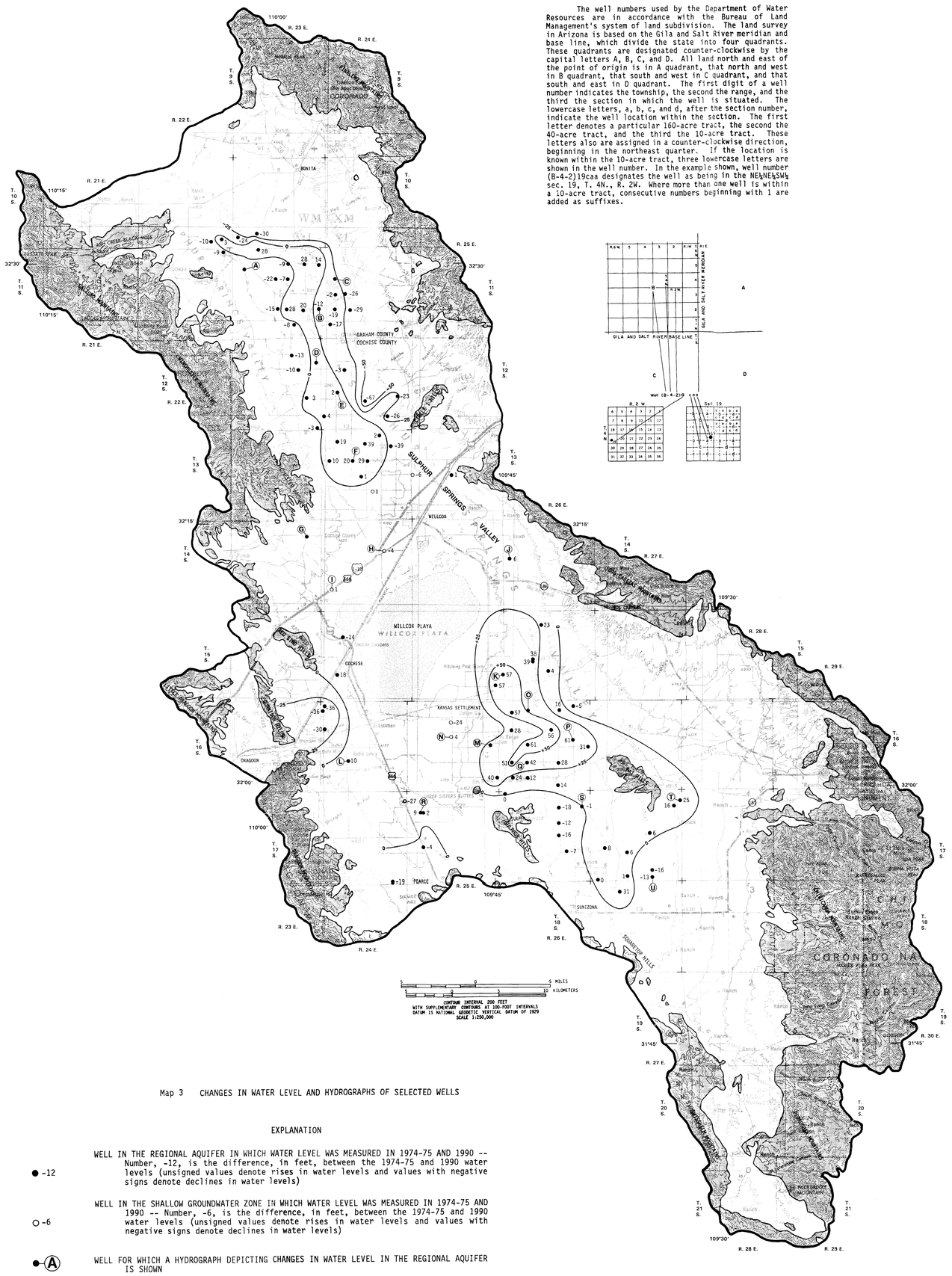
BASE FROM U.S. GEOLOGICAL SURVEY
TUCSON 1:250,000, 1956
DOUGLAS 1:250,000, 1959
SILVER CITY 1:250,000, 1954

MAPS SHOWING GROUNDWATER CONDITIONS IN THE WILLCOX BASIN GRAHAM AND COCHISE COUNTIES, ARIZONA - 1990

BY
PAUL O RAM III

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.

The well numbers used by the Department of Water Resources are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the state into four quadrants. These quadrants are designated counter-clockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters, a, b, c, and d, after the section number, indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counter-clockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (B-4-2)19caa designates the well as being in the NE¼NE¼SW¼ sec. 19, T. 4N., R. 2W. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.



Map 3 CHANGES IN WATER LEVEL AND HYDROGRAPHS OF SELECTED WELLS

EXPLANATION

- ● -12 — WELL IN THE REGIONAL AQUIFER IN WHICH WATER LEVEL WAS MEASURED IN 1974-75 AND 1990 -- Number, -12, is the difference, in feet, between the 1974-75 and 1990 water levels (unsigned values denote rises in water levels and values with negative signs denote declines in water levels)
- ○ -6 — WELL IN THE SHALLOW GROUNDWATER ZONE IN WHICH WATER LEVEL WAS MEASURED IN 1974-75 AND 1990 -- Number, -6, is the difference, in feet, between the 1974-75 and 1990 water levels (unsigned values denote rises in water levels and values with negative signs denote declines in water levels)
- ●Ⓐ — WELL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN WATER LEVEL IN THE REGIONAL AQUIFER IS SHOWN
- ○Ⓗ — WELL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN WATER LEVEL IN THE SHALLOW GROUNDWATER ZONE IS SHOWN
- ALLUVIAL-FILL DEPOSITS (silt, sand, clay, gravel, conglomerate, sandstone, and mudstone)
- BEDROCK (igneous, metamorphic, or sedimentary rock)
- +25 — APPROXIMATE LINE OF EQUAL CHANGE IN WATER LEVEL IN THE REGIONAL AQUIFER, 1974-75 TO 1990 --Interval 25 feet
- BOUNDARY OF WILLCOX 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

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

(Dashed line indicates inferred water level)

WATER LEVEL, IN FEET, BELOW LAND SURFACE

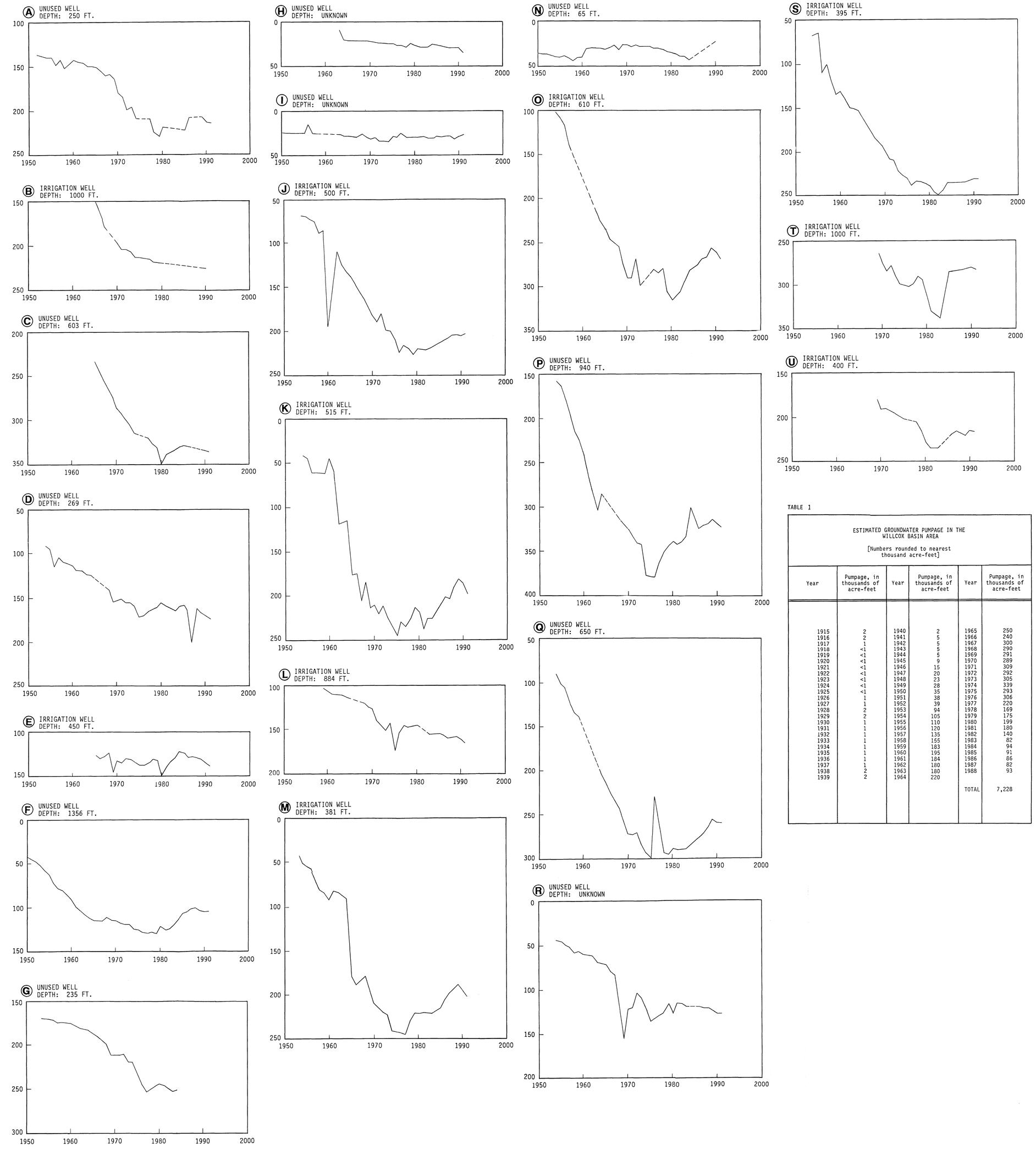


TABLE 1

ESTIMATED GROUNDWATER PUMPAGE IN THE WILLCOX BASIN AREA

[Numbers rounded to nearest thousand acre-feet]

Year	Pumpage, in thousands of acre-feet	Year	Pumpage, in thousands of acre-feet	Year	Pumpage, in thousands of acre-feet
1915	2	1940	2	1965	250
1916	2	1941	5	1966	240
1917	1	1942	5	1967	300
1918	<1	1943	5	1968	290
1919	<1	1944	5	1969	291
1920	<1	1945	9	1970	289
1921	<1	1946	15	1971	309
1922	<1	1947	20	1972	292
1923	<1	1948	23	1973	305
1924	<1	1949	28	1974	339
1925	<1	1950	35	1975	293
1926	1	1951	38	1976	306
1927	1	1952	39	1977	220
1928	2	1953	94	1978	169
1929	2	1954	105	1979	175
1930	1	1955	110	1980	199
1931	1	1956	120	1981	180
1932	1	1957	135	1982	140
1933	1	1958	155	1983	82
1934	1	1959	183	1984	94
1935	1	1960	195	1985	91
1936	1	1961	184	1986	86
1937	1	1962	180	1987	82
1938	2	1963	180	1988	93
1939	2	1964	220		
				TOTAL	7,228

BASE FROM U.S. GEOLOGICAL SURVEY
TUCSON 1:250,000, 1958
DOUGLAS 1:250,000, 1959
SILVER CITY 1:250,000, 1964

MAPS SHOWING GROUNDWATER CONDITIONS IN THE WILLCOX BASIN GRAHAM AND COCHISE COUNTIES, ARIZONA - 1990

BY

PAUL ORAM III

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