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Geological Survey

Ground-water resources and problems of the Cactus Flat-Artesia area, San Simon Basin, Arizona

By

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With a section on quality of water

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INTRODUCTION

Purpose and cooperation

The ground-water resources and geology of the Cactus Flat-Artesia area of the San Simon Basin have been studied by the Division of Ground Water in the Water Resources Branch of the United States Geological Survey. The area was studied by the Geological Survey in 1939 and 1940, in connection with an inventory of the water resources of the Safford Basin. More detailed studies of the Cactus Flat-Artesia area were made during 1946, in connection with the State-wide investigation of ground-water basins requested by the Arizona State Legislature in order that it might have the basic data upon which to base a ground-water code. These data are being obtained under a cooperative program between the Arizona State Land Commissioner and the Federal Geological Survey. The present studies, as well as the earlier work, have been under the direct supervision of S. F. Turner, District Engineer (Ground Water) of the Geological Survey. Field work was done by M. B. Booher, R. L. Cushman, L. C. Halpenny, H. R. McDonald, and W. T. Stuart, engineers, and by R. B. Morrison, geologist.

Location

The Cactus Flat-Artesia area lies in the lower or northern end of the San Simon Basin, in Graham County, Arizona. The area is on the west side of San Simon Creek, and it is bounded on the west by the Pinaleno Mountains and the divide between Graveyard and Freeman Washes; on the south by an arbitrary east-west line 1 mile south of the line between Townships 8 and 9 South, Gila River Base Line; on the east by an arbitrary line 1 mile west of the line between Ranges 26 and 27 East, Gila and Salt River Meridian; and on the north by the San Jose Extension canal, in the Safford Basin of the Gila River. The area studied comprises about 65 square miles, but most of the wells are in an area of about 15 square miles.

The drainage in the Cactus Flat-Artesia area is directly to the Gila River through Stockton Wash, and on this basis the area might be considered to belong to the Safford Basin and not to the San Simon Basin. Schwennesen[1/], however, considered the area as part of the San Simon Basin because the artesian conditions in the area are similar to those in the flowing-well area near the town of San Simon. In this report the area is considered to be in the San Simon Basin but the artesian aquifers are probably separate from those of the Safford Basin and from those of the San Simon Basin near the town of San Simon.

Climatological data

No temperature and precipitation records were available for the Cactus Flat-Artesia area. Records from the U. S. Weather Bureau station at Thatcher (elevation 2,900 feet), 7 miles north and 2 miles west of Cactus Flat, yield the following information: The rainfall averaged 9.50 inches a year during a 34-year period of record and the average temperature was 62.5 degrees Fahrenheit during a 42-year period of record. The maximum temperature at Thatcher was 116° F. and the

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1/ Schwennesen, A. T., Ground water in San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, pp. 3, 26, 1917.

minimum 7° F. during the 42-year period of record. The frost-free season at Thatcher averaged 203 days a year, beginning about April 11 and ending about October 31 during a 26-year period of record. Cactus Flat is about 500 feet higher in elevation than Thatcher, and therefore the average rainfall is probably slightly more than 9.50 inches a year.

History of development

The first known settlement of the area was by prehistoric Indians, who located their dwellings near supplies of water. Evidence of an Indian village has been found in sec. 8, T. 8 S., R. 26 E., near Cactus Flat. Stock grazing began in the San Simon Basin about 1867 and the first settlement in the Cactus Flat-Artesia area was established at Artesia about 1890. A supply of surface water for irrigation was obtained by constructing a dam in Marijilda Canyon about 1900. This surface-water supply often failed in times of drought and it was not adequate to furnish water to all the irrigable land of the area.

Water for domestic and stock use was obtained from dug wells or small-diameter drilled wells in the Cactus Flat-Artesia area as early as 1890. These wells penetrated non-artesian aquifers at depths of less than 100 feet. Further prospecting for water in the non-artesian aquifers was curtailed in the early 1900's, after the discovery of artesian aquifers at greater depths. The first flowing wells were completed near Stockton Wash in 1902. Schwennesen2/, in 1915, reported between 30 and 40 flowing wells, and about 800 acres under irrigation. The development continued and Knechtel3/, in 1934, reported about 100 flowing wells. In 1946 there were about 125 flowing wells, 13 of which were being pumped. There are about 85 fields, comprising 2,300 acres, in the area. A total area of approximately 1,000 acres was irrigated in 1946. The principal crops are cotton and hay.

GEOLOGY AND ITS RELATION TO GROUND-WATER SUPPLIES

The Cactus Flat-Artesia area occupies a portion of the huge structural trough which extends northwest from Rodeo, New Mexico, along San Simon Creek and the Gila River (see fig. 1). The trough is limited on the west in the Cactus Flat-Artesia area by the older rocks which comprise the Pinaleno (Graham) Mountains. These older rocks are mostly gneiss, which is hard and resistant and for the most part impermeable, although the rocks carry some water that issues as springs from cracks, fissures, and weathered zones. The geology of the area is shown on the generalized geologic map, plate 2. The trough in which the Cactus Flat-Artesia area lies is partly filled with more or less unconsolidated deposits of gravel, sand, silt, and clay. The ground water occurs principally within these deposits.

2/ Schwennesen, A. T., Ground water in the San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, pp. 26-27, 1917.

3/ Knechtel, M. M., Geology and ground-water resources of the valley of Gila River and San Simon Creek, Graham County, Ariz.: U. S. Geol. Survey Water-Supply Paper 796-F, 1938.

Older alluvial fill

The larger part of the more or less unconsolidated deposits in the area is termed "older alluvial fill" in this report. These deposits were derived mainly from the hard rocks of the Pinaleno Mountains and were washed into the area by streams and sheet runoff. The older alluvial fill was deposited in a large closed basin, and a shallow lake of the playa or semi-playa type was formed along the axis of the basin. The thickness of the older alluvial fill is at least 1,700 feet[4/].

Near the Pinaleno Mountains the older alluvial fill consists of boulders, gravel, and conglomerate with small amounts of sand and silt, and is termed the "gravel zone" in this report. The width of the gravel zone is from 1 to 2 miles (see fig. 2). The gravel zone of the older alluvial fill is partly consolidated and moderately permeable. Layers of relatively impermeable caliche existed near the surface in most of the outcrop area of the gravel zone. Streams have cut channels through these layers, enabling water from rain and from stream flow to enter the fill along the stream channels.

The older alluvial fill gradually becomes finer-grained outward from the mountains, grading first to interbedded sand and silt with some gravel, then to silt with some sand, and finally, along San Simon Creek in the playa or "lake-bed zone", to silt and clay with local stringers of sand. The silts and clays of the lake-bed zone are relatively impermeable and contain some salt and gypsum.

Younger alluvial fill

Washes that drain the Pinaleno Mountains have cut valleys into the older alluvial fill and have deposited sedimentary materials in the bottoms of these valleys (see pl. 2). The materials that underlie these washes are gravel, sand, and silt and are termed "younger alluvial fill" in this report. The thickness of these materials ranges from 2 feet near the hard rocks of the mountains to about 50 feet at the point where Stockton Wash enters the inner valley of the Gila River.

GROUND-WATER RESOURCES

Older alluvial fill

Occurrence of ground water

Ground water is found in the numerous beds of gravel and sand of the older alluvial fill, many of which are very permeable. These beds are from 2 to 10 feet thick and occur at depths ranging from 100 to at least 1,700 feet. The water in these beds is confined under artesian pressure, and flowing wells exist in a north-south belt about 3 miles east of the contact between the older alluvial fill and the hard rocks of the Pinaleno Mountains. The water-bearing gravel and sand beds are confined between silt and clay beds of the lake-bed zone (see fig. 2).

4/ Knechtel, M. M., Geology and ground-water resources of the valley of Gila River and San Simon Creek, Ariz.: U. S. Geol. Survey Water-Supply Paper 796-F, well 284, well record table facing p. 222, 1938.

Source of ground water

The principal source of recharge to the water-bearing gravel and sand beds of the older fill is seepage from streams on the outcrops of the gravel zone. It has been found in tests on Queen Creek[5] and on the Santa Cruz River and Rillito Creek[6] that clear water from melting snow or slow winter rains percolates into the material underlying the stream channel as much as 15 times faster than does silty water from flash floods. During the spring of 1940 and the spring of 1941 many measurements of stream flow were made in streams that originate in the Pinaleno Mountains. It was found that these streams lose a total of as much as 20 cubic feet a second of flow on the outcrops of the gravel zone in the Cactus Flat-Artesia area. No gaging stations were established, and therefore no exact measurements of the total number of acre-feet of water that passed underground could be made. It was estimated, however, that an average of 4,800 acre-feet of recharge occurred each spring, on the basis of a rate of 20 cubic feet a second for a period of 4 months. It was also estimated that 500 to 1,000 acre-feet of recharge occurred from flood flows during the remainder of the year. Two factors tend to prevent much recharge from rainfall upon the gravel zone of the older fill: (1) The older fill contains layers of caliche near the surface except where streams have cut channels below these layers; (2) the steep surface slopes in the area cause a large part of the rainfall to run off the surface and enter streams.

Discharge from older alluvial fill

Natural discharge

Ground water is discharged from the older alluvial fill by the following natural means: (1) Artesian leakage, (2) use by phreatophytes, and (3) evaporation.

Water is discharged from the artesian aquifers along fault zones and by diffused upward seepage through the more permeable parts of the silt and clay lake beds that confine the artesian aquifers. Two cienagas in the Cactus Flat-Artesia area are believed to be formed by artesian leakage that reaches the land surface along fault zones. One of these cienagas is in sec. 9, T. 8 S., R. 26 E., and extends along the channel of Jacobson Wash for a distance of about half a mile. The flow from this cienaga was reported to have irrigated eight farms during the late 1890's and early 1900's. The flow has gradually diminished since the development of flowing wells, and in October 1946 it was estimated to be 15 gallons a minute. The other cienaga is in secs. 10 and 15, T. 8 S., R. 26 E., and extends along the channel of Stockton Wash for a distance of about a mile. The amount of water reaching the land surface at this cienaga has also gradually diminished since the development of flowing wells. In October 1946 there was no water at the land surface in this cienaga, but luxuriant plant growth in the cienaga indicated that ground water was at a shallow depth. The diminishing

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5/ Babcock, H. M., and Cushing, E. M., Recharge to ground-water from floods in a typical desert wash, Pinal County, Ariz.: Am. Geophys. Union Trans., Reports and papers, Hydrology, pp. 49-56, 1942.

6/ Turner, S. F., and others, Ground-water resources of the Santa Cruz Basin, Ariz.: U. S. Geol. Survey (mimeographed), pp. 45-53, 1943.

supply of water at these cienagas following the development of flowing wells indicates that the cienagas receive water from the artesian aquifers. There is a possibility that artesian water may move laterally out of the Cactus Flat-Artesia area into the San Simon Basin or the Safford Basin. The available data do not indicate the direction or magnitude of such lateral movement.

The phreatophytes in the Cactus Flat-Artesia area consist mostly of mesquite (see pl. 3). The mesquite that uses ground water from the older alluvial fill is located within the two cienagas mentioned above. On the basis of studies of the water used by mesquite in the nearby Safford Basin[7], it was estimated that the mesquite in the cienagas uses about 1.5 acre-feet of water from the ground-water reservoir per year per acre of growth of average density. A field reconnaissance and a study of aerial photographs show that there are about 300 acres of mesquite growing in the two cienagas. It is estimated, therefore, that the total amount of water from the older alluvial fill used by these plants is about 450 acre-feet per year.

The amount of ground water discharged by evaporation from the older alluvial fill is negligible. The total area of continuously wetted soil in the cienagas is less than 10 acres, and the rate of evaporation from this area is about 5 acre-feet per acre per year.

Artificial discharge

Ground water is artificially discharged from the older alluvial fill through flowing and pumped wells. Approximately 5,600 acre-feet was discharged from 125 flowing wells and 13 pumped wells during 1946.

Wells in older alluvial fill

The artesian wells range in depth from 200 to 1,700 feet and range in diameter from 3 to 12 inches. The average well is about 5 inches in diameter and between 800 and 900 feet deep.

The amounts of casing in the wells range from a short length of collar casing to a casing that extends from the land surface down to a point within a few feet of the well bottom. Most wells that have only a short length of casing at the land surface develop water from every aquifer penetrated. Generally, wells constructed since 1935 are lined with non-perforated casing from the land surface down to a particular water-bearing bed, and an uncased hole penetrates the bed. Using this method of well construction, wells can be closely spaced and each well can be made to develop water from a different aquifer. Examples are wells 903, 904, and 905 (pl. 1), which are spaced along a line only 15 feet long (see pl. 3). Well 903 is 1,216 feet deep and is cased to a depth of 1,173 feet; well 904 is 1,022 feet deep and is cased to a depth of 990 feet; and well 905 is 700 feet deep and is cased to a depth of 650 feet. Well 903 yields 90 gallons a minute at a temperature of 102° F., well 904 yields 70 gallons a minute at a temperature of 96° F., and well 905 yields 20 gallons a minute at a temperature of 88° F. The waters from these wells differ in chemical character (see table 2).

7/ Turner, S. F., and others, Water resources of Safford and Duncan-Virden Valleys, Ariz. and N. Mex.: U. S. Geol. Survey (mimeographed), p. 11, 1941.

Insufficient amounts of casing in many of the older artesian wells have resulted in obstructions below the casing, formed by caving of formations and by growth of plant roots. These obstructions increase the friction head and consequently reduce the flow of water from the wells.

The casings in the older wells have deteriorated. Breaks probably have developed in the casings of many wells below the land surface and water leaks from the wells into permeable formations above the artesian aquifers. The casings in several old wells formerly protruded above the land surface but have disintegrated by rusting so that the top of the casing is now below the surface. The locations of these wells are marked by vegetation which uses the water that seeps upward from the buried wells.

Head of the artesian water

The pressure head of the artesian water has decreased since the first artesian wells were constructed, although the original pressure head is not known. Wells at higher elevations in the area have ceased flowing, and the water now (1946) stands in these wells as much as 6 feet below the land surface. The pressure head in well 722 (pl. 1), was sufficient to raise the water to an orifice 3 feet above land surface in September 1940, but the water stood 4 feet below land surface in November 1946. The pressure head in well 726 (pl. 1), raised the water 9 feet above land surface in September 1940 but only 6 feet above land surface in April 1942. Leaky casings in these wells might have contributed to this decline in water level. The principal reason for the decline, however, was the decrease in head of the artesian water.

Fluctuations in artesian head

Fluctuations in artesian head in the Cactus Flat-Artesia area are principally the result of interference among wells. Water discharges from an artesian well because the pressure head of water in the aquifer is sufficient to raise the water above the orifice of the well. Movement of water into the well causes a reduction in pressure head within the aquifer. This pressure reduction extends from the well in all directions in the aquifer and decreases as the distance from the well increases. Water moves from the areas of least pressure reduction to the well, where the pressure reduction is greatest. This pressure reduction in the aquifer at the well gradually approaches a maximum, and the well then flows at a nearly constant rate. The areas of pressure reduction caused by several discharging wells that obtain water from the same aquifer eventually overlap and result in additional pressure reduction at each well. This causes the rate of discharge of water from each well to decrease. Well owners have reported decreases in discharge or cessation of flow from wells in the Cactus Flat-Artesia area when new wells were constructed nearby. Well 776 (pl. 1), flowed until three wells were constructed 400 feet distant, developing water from the same aquifer as well 776. The orifices of the three new wells were at a lower elevation than that of well 776, and the new wells reduced the pressure head in the aquifer sufficiently to cause the water level in well 776 to decline almost to the elevation of the orifices of the new wells. A few of the artesian wells in the Cactus Flat-Artesia area are pumped heavily at times, and the resulting pressure reduction in the aquifer has caused nearby wells temporarily to cease flowing.

Younger alluvial fill

Occurrence of ground water

Ground water is found in the beds of gravel and sand of the younger fill. The water table ranges from 20 to 45 feet below the land surface and the water is not under artesian pressure. A few domestic and stock wells and one irrigation well produce water from the younger fill. In a few areas of the younger fill the sediments of the fill are only a few feet in thickness and yield no water to wells.

Source of ground water

Water enters the younger fill from (1) seepage of water from surface flows into the gravel and sand lining the wash channels; (2) seepage of irrigation water from ditches, canals, and fields; and (3) leakage of artesian water through faulty casings in the artesian wells, along faults, and by diffused upward seepage through the older fill.

The recharge of water to the younger fill from surface flows is about 500 acre-feet per year, on the basis of data collected in 1941 during a study of the water resources of Safford Valley.

A part of the irrigation water in ditches, canals, and fields seeps into the younger fill. Turner and others[8] state that in the Safford Valley about one-third of all water carried in canals and about one-fourth of all irrigation water applied to the land passes downward to the water table. As the infiltration capacity of the soils in the Cactus Flat-Artesia area is about the same as in the Safford Valley, it is assumed that the proportion of seepage losses would be about the same in both areas. About 2,000 acre-feet of the 5,600 acre-feet of water annually produced from wells is diverted through canals and one-third of this water, or about 700 acre-feet, is estimated to be lost by seepage from the canals and to return to the ground-water reservoir. About 4,900 acre-feet of the water is applied to the land and one-fourth of this water, or about 1,200 acre-feet, is estimated to seep downward to the water table. Therefore, approximately 1,900 acre-feet of water recharges the ground-water reservoir in the younger alluvial fill from irrigation water taken from wells.

Artesian water seeps into the younger fill through breaks in the artesian-well casings, or by moving upward around the outside of the well casings. It also moves into the younger fill along faults and perhaps in some places by diffused upward seepage. The amount of this recharge to the younger fill has not been determined.

Discharge from younger alluvial fill

Natural discharge

Ground water discharges from the younger alluvial fill of the Cactus Flat-Artesia area as underflow beneath Stockton Wash and Graveyard Wash. The underflow of these washes in 1941 was estimated to be about 3 cubic feet per second or roughly 2,000 acre-feet a year, on the basis of data collected during the study of the water resources of Safford Valley.

8/ Turner, S. F., and others, Water resources of Safford and Duncan-Virden Valleys, Ariz. and N. Mex.: U. S. Geol. Survey (mimeographed), pp. 15, 18, 28, and 36, 1941.

There are about 500 acres of mesquite and other natural vegetation in the Cactus Flat-Artesia area that derive their water from the younger fill. These plants are estimated to use about 750 acre-feet of water a year. The method used in estimating this amount is the same as that described in the section on natural discharge under the heading "older alluvial fill".

Estimated safe yield

The estimated annual safe yield of the artesian aquifers in the Cactus Flat-Artesia area is approximately equal to the average annual recharge to the artesian aquifers minus the amount of water wasted from leaking or abandoned wells or discharged by natural means. The safe yield is estimated to be approximately 5,000 acre-feet of water a year. The amount of water available for human use could be increased by (1) plugging the abandoned wells from top to bottom, (2) casing the used wells from the land surface to the producing aquifer, and (3) installing shut-off valves on these properly-cased wells and restricting the flow to the amount necessary for beneficial uses.

QUALITY OF WATER

By

J. D. Hem

Chemical character of the ground water

Fifteen samples of ground water from the Cactus Flat-Artesia area were analyzed during the 1946 investigation. The analyses for 10 of these samples are given in table 2. In addition, 6 analyses are available for the area that were made in 1940-42 during studies in the adjoining Safford Valley[9] and the report by Knechtel[10] contains analyses of samples from 21 wells in the area. Knechtel's samples were collected in 1933-34, but resampling of a few of the wells in 1941 indicated that little change in the chemical character of the artesian waters had occurred. The analyses in Knechtel's report are therefore still of value in indicating the quality of ground waters in the Cactus Flat-Artesia area.

The analyses of ground water from the area show a rather wide range in concentration. The most dilute sample was collected by Knechtel from a non-flowing well between Cactus Flat and Artesia and had a total of 163 parts per million of dissolved solids. The most concentrated sample was collected in 1946 from a deep flowing well in Cactus Flat and had a total of 2,600 parts per million of dissolved solids. All the ground waters in the area are similar in chemical character. They are soft and contain mostly sodium, chloride, and sulfate. Nearly all of them contain excessive quantities of fluoride.

9/ Morrison, R. B., McDonald, H. R., and Stuart, W. T., Records of wells and springs, well logs, water analyses, and map showing locations of wells and springs in Safford Valley, Graham County, Ariz.: U. S. Geol. Survey (mimeographed), pp. 99-101, 1942.

10/ Knechtel, M. M., Geology and ground-water resources of the valley of Gila River and San Simon Creek, Ariz.: U. S. Geol. Survey Water-Supply Paper 796-F, p. 222, 1938.

Study of the analyses indicates that the most dilute waters are likely to be found at comparatively shallow depths (less than 500 feet) in the older fill, near the mouths of canyons draining the slopes of the Pinaleno Mountains. At greater distances from the mountains these shallower aquifers yield waters of higher concentration. At any place in the area the waters encountered at depths greater than 500 feet are more highly mineralized than those encountered nearer the land surface. These deeper aquifers also seem to contain more concentrated water at increasing distances from the mountains.

Chemical character of surface waters

Data available for the dissolved solids in surface waters entering the area are limited. A few samples were taken from Stockton and Marijilda Washes in the spring of 1941 when they were carrying runoff from melting snow. Water from these streams is of low mineral content, usually containing less than 100 parts per million of dissolved solids, mostly sodium, calcium, and bicarbonate.

Relation of quality of water to use

The ground water in the Cactus Flat-Artesia area has a very high percentage of sodium, and because of this characteristic nearly all of the water is in the "injurious to unsatisfactory" classification of Wilcox and Magistad[11]. Waters with a high percentage of sodium tend to harden the soil on which they are used, and some of the land in the area has been damaged by continued use of these waters. In addition to the high percentage of sodium, some of the deep artesian waters in the area are too high in dissolved solids and chloride to be satisfactory for irrigation.

Most of the waters in the area are soft and in this respect are satisfactory for domestic use, but many of them are too highly mineralized to be drinkable. The fluoride content in nearly all of the waters analyzed was above 1.5 parts per million, and such water may cause permanent mottling of the teeth when used continuously by young children. The highest concentrations of fluoride are generally found in waters from the deepest aquifers.

Source of dissolved matter in ground water

The water from surface runoff in the area that seeps into the ground-water reservoir contains very small amounts of dissolved matter. The older alluvial fill in the area contains sodium salts, which are dissolved as ground waters pass through the beds. As a result, the greater the distance that ground water travels through the fill from the recharge area to the point of discharge, the more dissolved matter the water is likely to contain. The shallowest waters of the older fill are generally the most dilute because they travel a shorter distance through the fill than do the waters which percolate to the deep aquifers. Also, most of the movement of ground water in the older fill is in the shallowest beds, which have been leached more effectively than the deeper beds, where movement of water is at a slow rate.

[11] Wilcox, L. V., and Magistad, O. C., Interpretation of analyses of irrigation waters and the relative tolerance of crop plants: U. S. Dept. Agr., Bur. Plant Industry, Soil and Agr. Research Administration; Riverside, Calif., (mimeographed), 8 pp., May 1943.

Discharge of dissolved solids from the basin

Soluble matter is removed from the Cactus Flat-Artesia area either in surface drainage or in movement of underground water. No analyses a available for ephemeral streams leaving the area. However, it is unlike that appreciable amounts of soluble matter leave the area in surface drainage. Ground waters may leave the area by movement both in the aquifers of the older fill and in those of the younger fill. It is possible that ground water in the older fill moves northward into the deep aquifers of the Safford Valley or eastward into the San Simon Basi An area of highly mineralized ground water occurs in the Safford Valley near San Simon Creek, and it is possible that the high mineralization is the result of leakage of artesian water of the San Simon Basin into the recent alluvial fill of the Safford Valley.

Excess irrigation water cannot return to the artesian aquifers but can only increase the amount of ground water in the younger fill of the area. The analyses show that water in the younger fill enters the Safford Valley along Stockton and Graveyard Washes. The quality of ground water in the Safford Valley, however, is not strongly affected by this inflow.

The principal quality-of-water problem in the Cactus Flat-Artesia area is that caused by the use of waters with high sodium percentages fo irrigation. These waters bring about a chemical reaction that hardens the soils upon which they are used. This reaction is almost independent of drainage conditions. The problem of salt removal is of secondary importance, although the available data indicate that soluble salts are accumulating in the irrigated portion of the area.

SUMMARY AND CONCLUSIONS

The Cactus Flat-Artesia area lies at the lower, or northern, end of the San Simon Basin, adjacent to the Safford Basin of the Gila River. The area comprises about 65 square miles.

The artesian water occurs in beds of gravel and sand between beds of silt and clay. These beds of gravel and sand are found at depths ranging from 100 feet to at least 1,700 feet.

The first flowing wells in the area were completed in 1902. There were about 125 flowing wells in 1946, and 13 of these wells were pumped for irrigation. About 5,600 acre-feet of water was produced from these wells in 1946, and an area of about 1,000 acres was irrigated. Most of the wells are badly in need of repair, as they are partially obstructed and leak below the land surface.

Approximately 1,200 acre-feet of water is used annually in the area by natural vegetation. The annual safe yield of the artesian aquifers is estimated to be about 5,000 acre-feet per year, not including water now lost through leaky wells and discharged by natural means, but this amount can be increased by conservation measures.

Ground waters in the area have high percentages of sodium and contain mostly sodium and chloride. Most of the waters are "injurious to unsatisfactory" for irrigation and contain too much fluoride to be satisfactory for children to drink.

Unanswered problems of area

One of the problems of the Cactus Flat-Artesia area is the loss of water from the artesian aquifers to the younger fill through wells with faulty casing or with only a short length of casing near the surface.

Another problem is the lack of knowledge regarding the relations that may exist between the artesian aquifers of the Cactus Flat-Artesia area and those in the San Simon Basin to the southeast and the Safford Basin to the northwest.

Any proposed regulation of ground water in the area should provide for proper spacing of wells that develop water from the same artesian aquifer, so that the interference among wells may be kept to a minimum.

Table 1. Records of typical wells in Cactus Flat-Artesia area, Graham County, Arizona.
(All wells are drilled. Table 2 lists analyses of water from all wells.)

No.	Location	Owner	Driller	Date completed	Depth of well (feet)	Diameter of well (in.)
	T. 8 S., R. 25 E.					
725	NE¼NE¼ sec. 12	Amos Cook	Brig Elmer	1939	1,100	8
	T. 8 S., R. 26 E.					
788	NE¼SW¼ sec. 32	John C. Frazier	-	-	-	-
790	do.	do.	-	-	65	12
903	SE¼NE¼ sec. 7	Bert Morris	R. M. Uptain	1946	1,216	4
904	do.	do.	do.	1946	1,022	4
905	SW¼NE¼ sec. 7	do.	do.	1946	700	4
913	SW¼NW¼ sec. 7	A. C. Rabb	do.	-	370	14
967	SW¼SW¼ sec. 28	Noel B. Whitmire	M. H. Smithson	-	435	3
973	SE¼SW¼ sec. 32	R. G. Layton	R. M. Uptain	-	457	10
978	SW¼SE¼ sec. 33	R. M. Uptain	do.	-	432	9

a/ F, flowing well; measuring point of well 725 was top of discharge pipe.
b/ T, turbine; G, gasoline.

Well records obtained by R. L. Cushman and M. B. Booher

No.	Water level: Depth below measuring point (feet) a/	Water level: Date of measurement	Pump and power b/	Use of water c/	Temp. °F.	Remarks
725	30.0	June 7, 1940	None	N	98	Measured flow 40 gallons a minute, April 12, 1942: 55 gallons a minute, July 10, 1946.
788	F	-	-	I	92	Measured flow 35 gallons a minute, July 11, 1946.
790	-	-	T,G	I	78	Pumped well; reported discharge 260 gallons a minute.
903	F	-	-	I	102	Measured flow 90 gallons a minute, Sept. 9, 1946. Cased to 1,173 feet.
904	F	-	-	I	96	Measured flow 70 gallons a minute, Sept. 9, 1946. Cased to 990 feet. Seven feet south of well 903.
905	F	-	-	I	88	Measured flow 20 gallons a minute, Sept. 9, 1946. Eight feet south of well 904.
913	-	-	T,G	I	80	Pumped well; measured discharge 432 gallons a minute, July 3, 1946. Cased to 265 feet.
967	F	-	-	D,I	82	Measured flow 30 gallons a minute, Aug. 6, 1946. Cased to 350 feet. Well 376 in Water-Supply Paper 796-F.
973	-	-	T,G	I	83	Pumped well; measured discharge 550 gallons a minute, July 2, 1946. Reported formerly flowed 90 gallons a minute; flow ceased when well dynamited. Cased to 185 feet.
978	-	-	T,G	I	88	Pumped well; estimated discharge 400 gallons a minute. Well 410 in Water-Supply Paper 796-F.

c/ I, irrigation; D, domestic; N, none.

Table 2. Analyses of water from typical wells in Cactus Flat-Artesia area, Graham County, Arizona. Numbers correspond to numbers in table 1 and plate 1. Analyses by Geological Survey (parts per million).

Well No.	Date of collection 1946	Depth (ft.)	Specific conductance ($K \times 10^5$ at 25°C.)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium
725	July 10	1,100	335	-	-	-	131	-	720	-	-	-	-	-
788	July 11	-	95.6	6.0	0.8	204	148	97	145	13	2.2	541	18	96
790	July 11	98	52.6	11	2.0	104	138	70	42	5.9	.1	303	36	86
903	July 11	1,216	328	40	3.7	675	39	504	705	12	1.1	1,960	115	93
904	July 11	1,022	327	11	1.4	702	103	478	675	9.7	1.5	1,930	34	98
905	Sept. 12	700	297	7.5	1.9	648	214	358	610	9.8	2.0	1,740	26	98
913	July 3	370	145	12	4.3	296	103	207	258	9.9	1.3	839	48	93
967	Aug. 6	435	101	22	4.9	189	147	161	132	3.9	.7	586	75	85
973	July 2	457	69.2	12	1.5	138	146	89	76	5.9	2.7	397	36	89
978	July 12	432	103	47	4.6	165	132	169	145	2.3	1.6	600	136	72

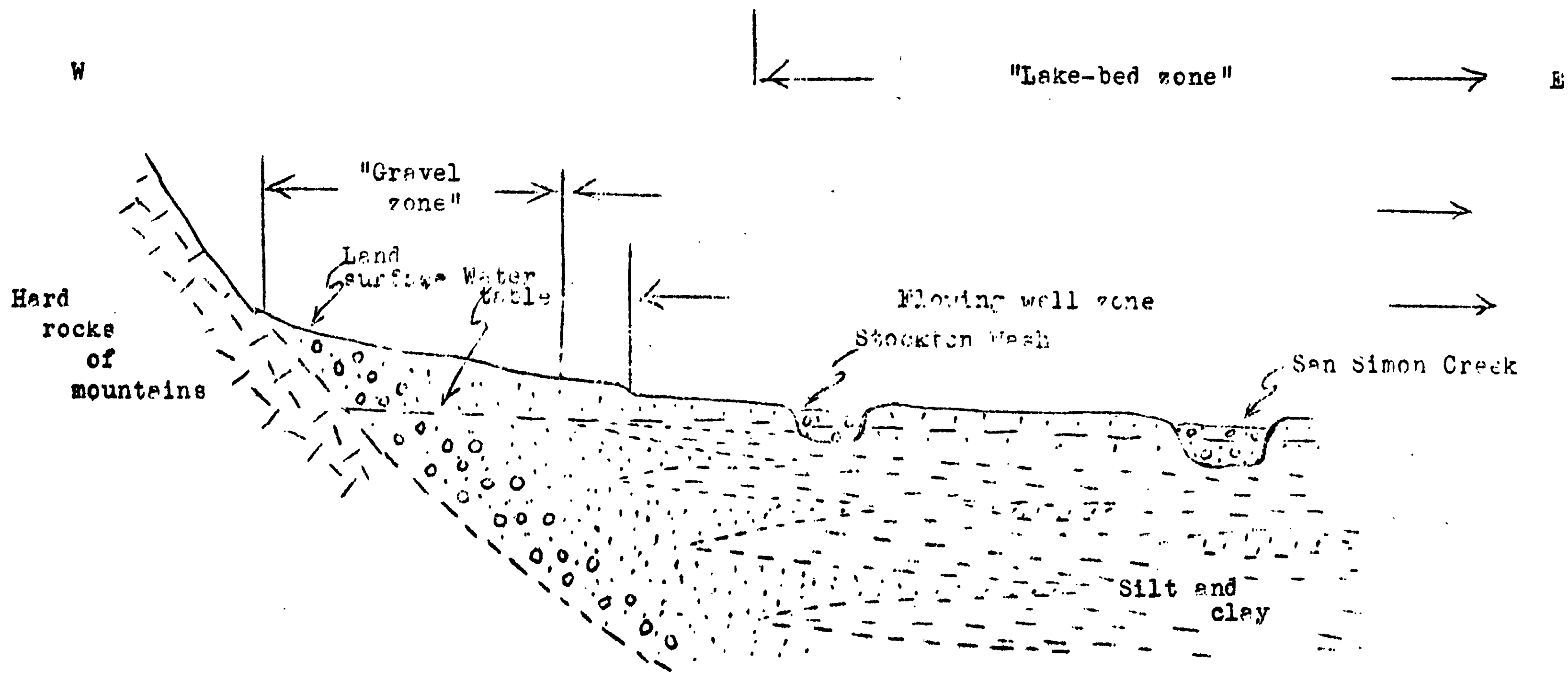
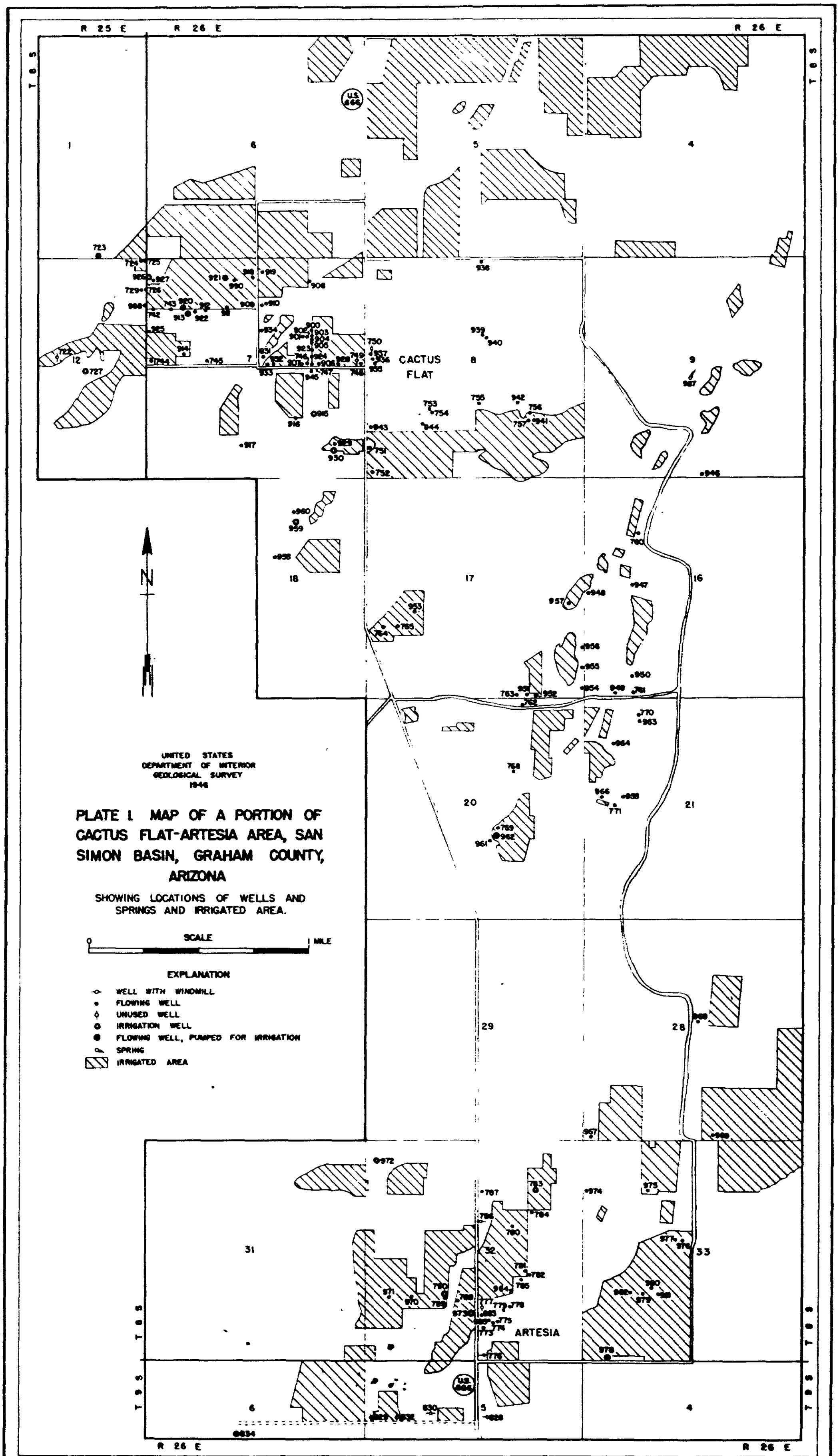


Fig. 2.- Schematic cross-section of Cactus Flat-Artesia Area, Graham County, Arizona, showing relations between materials comprising older alluvial fill.



R 25 E
R 26 E
R 26 E
T 8 S
T 9 S
CACTUS
FLAT
ARTESIA
U.S. 666
UNITED STATES
DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY
1946
PLATE I. MAP OF A PORTION OF CACTUS FLAT-ARTESIA AREA, SAN SIMON BASIN, GRAHAM COUNTY, ARIZONA
SHOWING LOCATIONS OF WELLS AND SPRINGS AND IRRIGATED AREA.
SCALE
0
1 MILE
EXPLANATION
WELL WITH WINDMILL
FLOWING WELL
UNUSED WELL
IRRIGATION WELL
FLOWING WELL, PUMPED FOR IRRIGATION
SPRING
IRRIGATED AREA

Plate 3.-Flowing wells and mesquite thicket in Cactus Flat-Artesia area, Graham County, Arizona. From left to right, wells 905, 904 and 903.

47-35

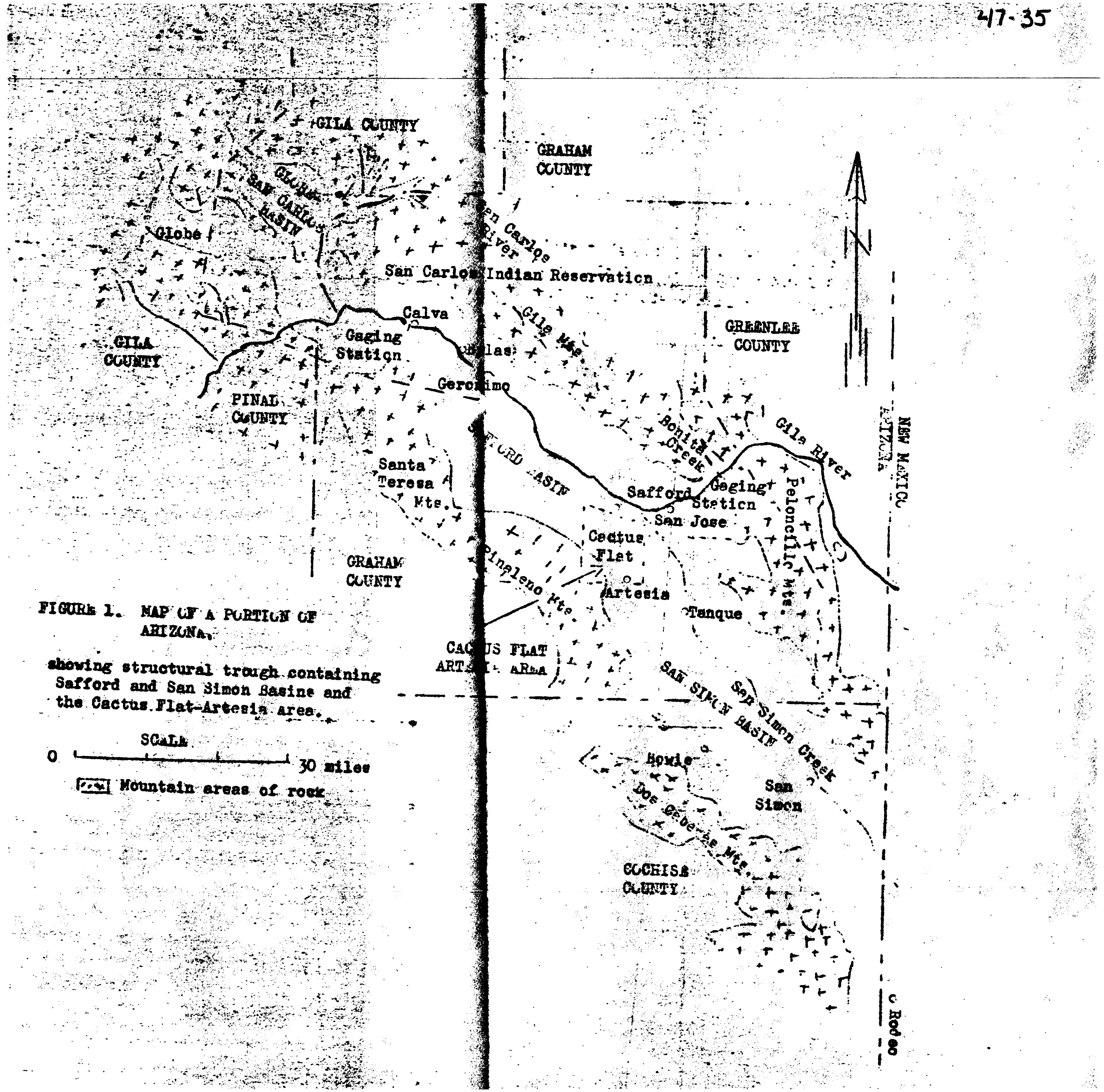


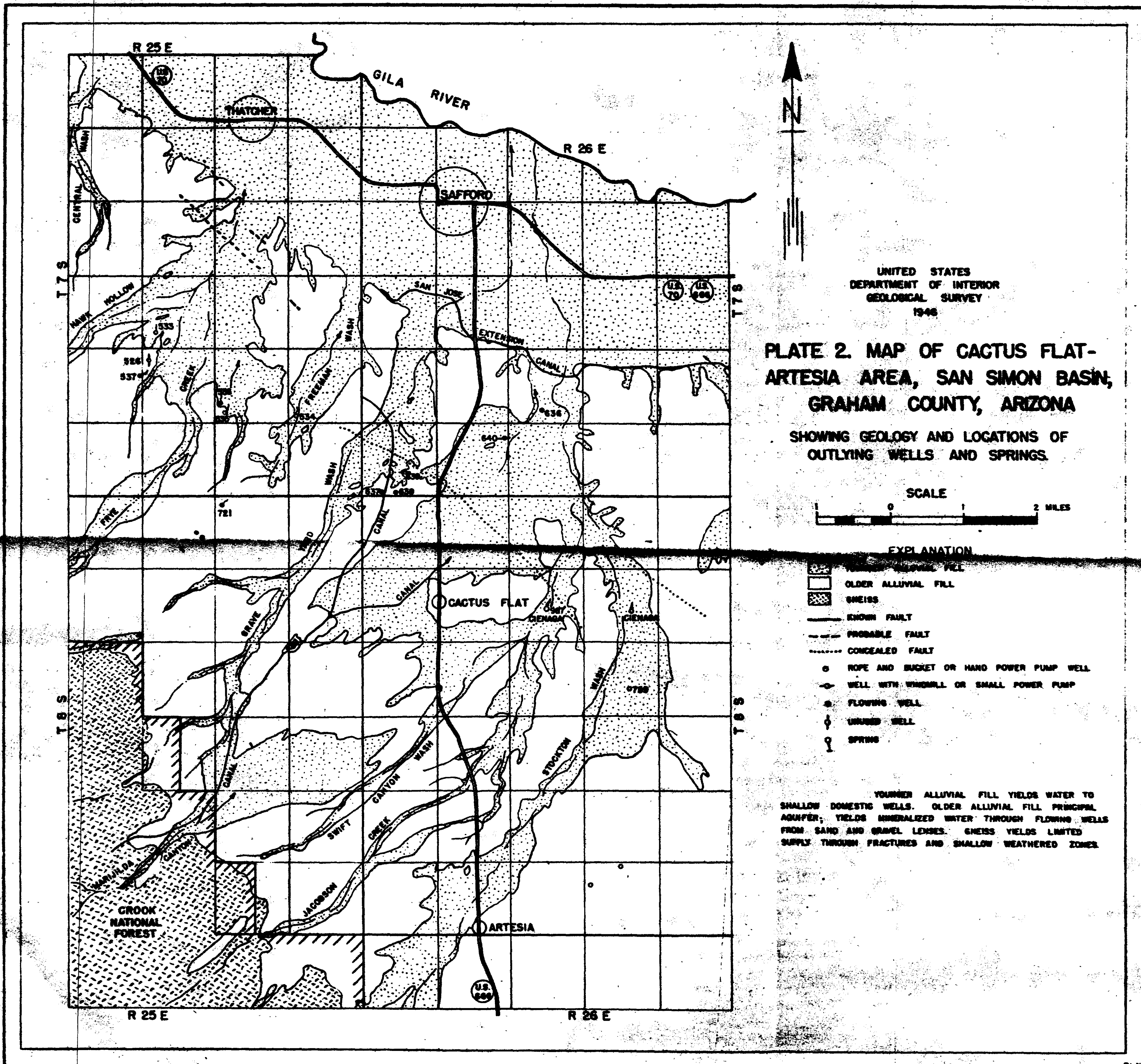
FIGURE 1. MAP OF A PORTION OF ARIZONA,

showing structural trough containing Safford and San Simon Basins and the Cactus Flat-Artesia area.

SCALE

0 — 30 miles

Mountain areas of rock


UNITED STATES
DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY
1946
PLATE 2. MAP OF CACTUS FLAT-ARTESIA AREA, SAN SIMON BASIN, GRAHAM COUNTY, ARIZONA
SHOWING GEOLOGY AND LOCATIONS OF OUTLYING WELLS AND SPRINGS.
SCALE
1 0 1 2 MILES
EXPLANATION
OLDER ALLUVIAL FILL
GNEISS
KNOWN FAULT
PROBABLE FAULT
CONCEALED FAULT
ROPE AND BUCKET OR HAND POWER PUMP WELL
WELL WITH WINDMILL OR SMALL POWER PUMP
FLOWING WELL
UNUSED WELL
SPRING
YOUNGER ALLUVIAL FILL YIELDS WATER TO SHALLOW DOMESTIC WELLS. OLDER ALLUVIAL FILL PRINCIPAL AQUIFER; YIELDS MINERALIZED WATER THROUGH FLOWING WELLS FROM SAND AND GRAVEL LENSES. GNEISS YIELDS LIMITED SUPPLY THROUGH FRACTURES AND SHALLOW WEATHERED ZONES.
N
R 25 E
R 26 E
T 7 S
T 8 S
GILA RIVER
THATCHER
SAFFORD
CACTUS FLAT
ARTESIA
CROOK NATIONAL FOREST
SAN JOSE
EXTENSION
CANAL
FREEMAN
WASH
CREEK
CENTRAL
HAWK HOLLOW
FRYE
GRAVE
STOCKTON
CIENAGA
SWIFT
CANYON
JACOBSON
MARIJILDA
721
RLN
12349