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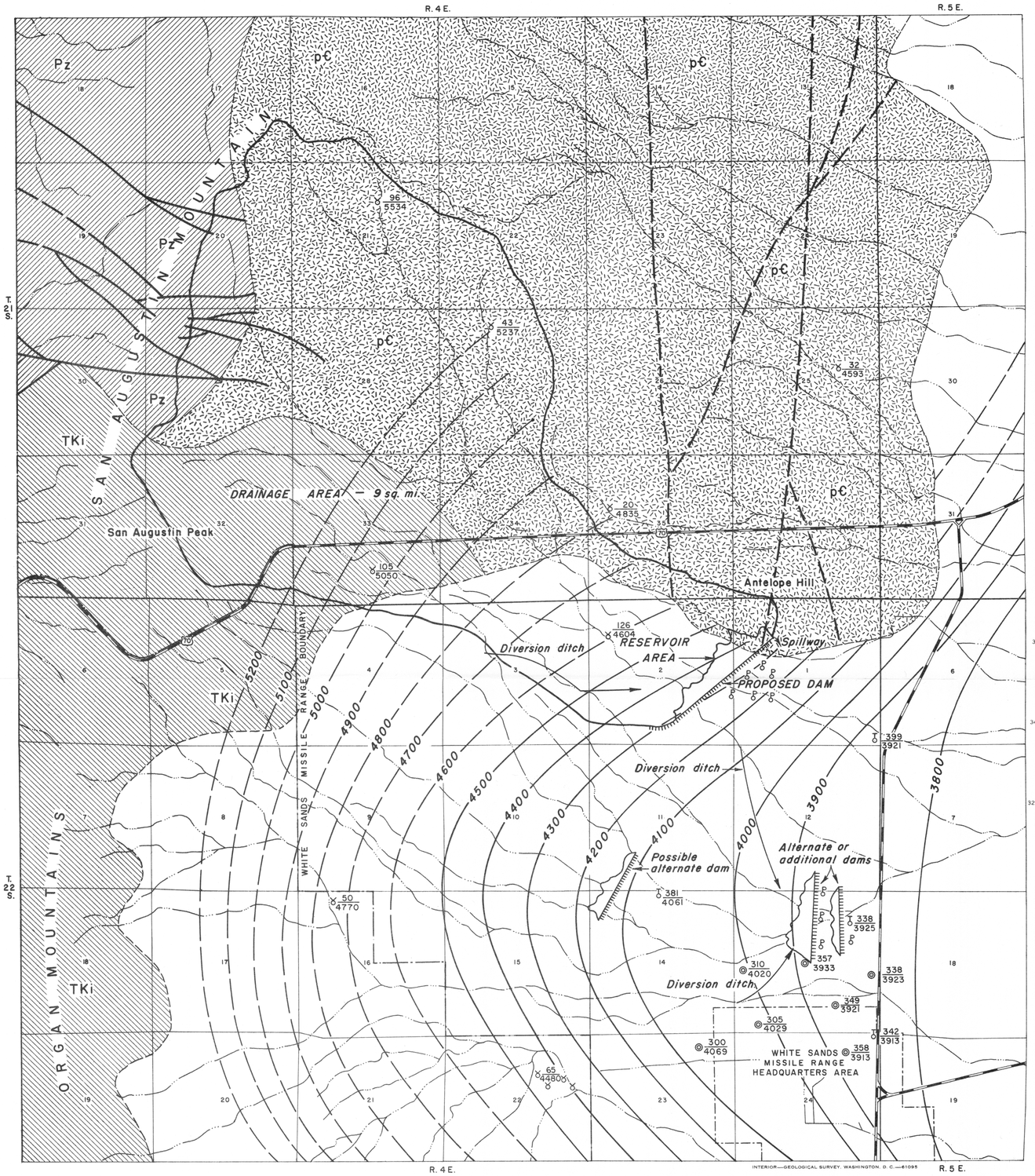


Base from U. S. Geological Survey topographic maps, Scale 1:24 000

Geology modified from K. C. Dunham, 1935
Hydrology by E. H. Herrick, 1955

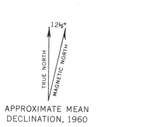
GEOLOGIC MAP OF WHITE SANDS MISSILE RANGE HEADQUARTERS AREA, DONA ANA COUNTY, NEW MEXICO, SHOWING LOCATION OF WELLS, CONTOURS ON THE WATER TABLE, AND LOCATION OF PROPOSED DAMS, RESERVOIRS, AND RECHARGE-DISCHARGE WELLS

By
E. H. Herrick

SCALE 1:31 680

1 0 1 2 Miles

1961



APPROXIMATE MEAN DECLINATION, 1960

EXPLANATION

Qal — Valley fill (QUATERNARY)

TKi — Intrusive igneous rocks (CRETACEOUS(?) AND TERTIARY)

Pz — Sedimentary rocks, undifferentiated (PALEOZOIC)

pC — Mostly granite; some metamorphic rocks (PRECAMBRIAN)

Fault
Dashed where approximately located

Well, unequipped

Well, equipped with windmill

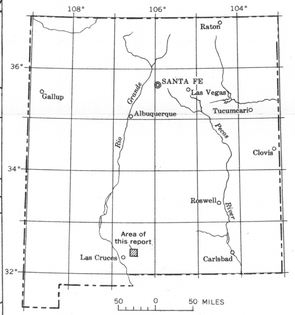
Well, equipped with turbine pump

338/3925 — Test hole
Upper figure at well or test hole indicates depth to water below land surface, in feet; lower figure indicates altitude of water level, in feet

Proposed site for recharge or dual-purpose well

4500 — Contour on water table
Dashed where approximate. Datum is mean sea level

Boundary of drainage basin above proposed reservoir site



INDEX MAP OF NEW MEXICO

INTRODUCTION

Consideration has been given to the possibility of impounding and utilizing floodwater at White Sands Missile Range to augment the ground-water supply. The proposed dam site and reservoir are in secs. 1 and 2, T. 22 S., R. 4 E., approximately 2½ miles north of the headquarters area. The preliminary proposal was to construct one or more shallow wells below the dam from which to pump water that seeped from the reservoir, allowing the intervening materials to act as a filter for the stored water. In the same proposal, small check dams west of the supply-well field were suggested as a means of recharging the aquifer near the wells presently used.

Many projects that utilize floodwater for artificial recharge of ground water have been constructed in the southwestern United States. These projects differ considerably in nature and purpose. Some consist merely of check dams to spread floodwater over areas of recharge; others utilize infiltration ditches or pits. Many have the dual purpose of providing flood control and augmenting ground-water recharge. Some check dams are built in conjunction with recharge wells, which are used to transfer surface water to the ground-water reservoir. Some surface reservoirs have been constructed in conjunction with dual-purpose wells which are used both for recharge and as supply wells.

THE PROPOSAL AND AVAILABLE RUNOFF DATA

The proposed dam as shown on the map would form a reservoir having a capacity of about 1,080 acre-feet (about 350 million gallons) and would catch runoff from a drainage area of about 9 square miles.

The average annual precipitation at the White Sands Missile Range Air Weather Station (altitude 4,250 feet) during the period 1948–53 was 8.31 inches. The average annual precipitation at the J. M. Cox ranch in the NE¼ sec. 22, T. 22 S., R. 4 E., altitude 4,550 feet, during the same period was 10.06 inches, and during the period 1923–53 was 12.91 inches (J. M. Cox, written communication, 1954). It is estimated that the normal annual precipitation in the drainage area of the proposed dam (altitude 4,600 feet) probably is more than 12 inches, a large part of which occurs in heavy showers during July, August, September, and October. The land surface in the upper part of the drainage area has a steep gradient, and the direct runoff from this area has been estimated by the Field Engineering Branch of White Sands Missile Range as about 95 percent of the precipitation. However, this estimate seems high. Evaporation, transpiration, and percolation should reduce the runoff by considerably more than 5 percent. However, if runoff were as much as 55 percent, a storm producing an average precipitation of 4 inches on the drainage area theoretically would yield enough water to fill the proposed reservoir. Extrapolated records of precipitation at the Cox Ranch indicate that a single storm of sufficient intensity to fill the reservoir probably will occur about once in every 50 years. However, precipitation sufficient to fill the reservoir in 1 month probably will occur every 3 years, and probably the reservoir will be filled twice a year about one year in every 20 to 30 years. The reservoir would be partly filled at least once during an average year, and at least 200 acre-feet of floodwater would be stored temporarily and salvaged during such an average year. As much as 2,000 acre-feet of floodwater could be salvaged during very wet years.

Consideration might be given to the construction of a dam to impound only 500 acre-feet. Such a reservoir would intercept most of the runoff from the 9-square-mile drainage area, although occasional storms might cause some spill over the dam. Nevertheless, a 500-acre-foot reservoir appears to be more practical than a 1,000-acre-foot reservoir in view of the anticipated quantity of runoff.

GEOLOGY AND RELATED HYDROLOGY

Granite and some metamorphic rocks of Precambrian age crop out in the mountains north of the headquarters area. These rocks form the core of the San Andres Mountains to the north and of the Organ Mountains to the south (Dunham, 1935, p. 28–39). In general these rocks are dense and impervious to infiltration of water except where they are fractured or highly weathered. Only small yields are obtained from the few stock wells penetrating the granite.

Sandstone, dolomite, limestone, and shale, ranging in age from Cambrian and Ordovician through Carboniferous (Pennsylvanian), overlie the Precambrian rocks in successively younger beds on the backslope of the San Augustin Mountains in the northwestern part of the area shown on the map. Like the granite, these rocks are dense and impervious to infiltration of water except where they are fractured.

Igneous rocks, mainly monzonite, thought to be Tertiary in age intrude the Precambrian and Paleozoic rocks of the area. These monzonites form the organ "pipes," or spires, of the Organ Mountains to the west and southwest. The rock is similar texturally to the granite, and its hydrologic characteristics are much the same as those of the granite.

The valley fill of Quaternary age is composed mainly of unconsolidated sand, gravel, and silt derived principally from the granite and monzonite that crop out on the nearby mountains. The fill ranges in thickness from 0 to more than 1,000 feet in the area shown on the map. The fill is saturated below depths of 300 to 400 feet in the headquarters area. Several wells that yield moderate quantities of water are completed in the fill material. Computations based on pumping-test data from wells in the area indicate an annual recharge of about 25 percent of the precipitation.

The map indicates that most of the dam and reservoir would lie on unconsolidated valley fill. The thickness of the valley fill in that area is not known; however, it is probable that the surface of the granite bedrock that makes up most of Antelope Hill continues to slope sharply beneath the fill south of Antelope Hill. Test hole T-1, in the extreme southeast corner of sec. 1, T. 22 S., R. 4 E., about 0.75 mile south of Antelope Hill, was drilled to a depth of 1,000 feet without encountering bedrock.

Based on the altitude of the land surface (4,600 feet) and on the water-table contours, the depth to water below the land surface along the eastern side of the proposed reservoir site ranges from 200 feet or less at the northeast corner to about 300 feet at the southwest corner. Two or three test holes drilled along the eastern side of the proposed reservoir site would provide a profile of the contact of the valley fill with the bedrock, as well as more accurate data on the depth to water. Tests to determine the permeability of the valley fill near the reservoir site could be made on these test holes.

IMPLEMENTATION AND PROBLEMS OF ARTIFICIAL RECHARGE

Several methods of utilizing the water impounded by the proposed dam might be considered. To determine the method best suited to the physical conditions of the site and to the needs of the Missile Range will require additional study and a consideration of facts presently unknown.

The valley fill in the area of the proposed reservoir is fairly permeable, and initial percolation from a reservoir might be fairly rapid. However, the permeability of the floor of the reservoir would be reduced rather quickly as it became clogged with fine-grained sediment. Also, the reservoir would fill with sediment as a function of the average sediment load in the runoff. As the rate of percolation declined and as the reservoir filled with sediment, evaporation would claim an increasing percentage of the water. The annual evaporation at White Sands Missile Range is estimated to exceed 90 inches, as the average annual evaporation at the Jornada Experimental Range, about 20 miles northwest of the headquarters area at an altitude of 4,265 feet, is 96 inches. For these reasons the water should be stored underground as rapidly as possible in order to reduce the amount lost by evaporation. Underground storage probably could be accomplished most efficiently by means of recharge wells or infiltration ditches below the dam. Periodic scarification of the reservoir floor might improve the percolation from the reservoir. Periodic removal of sediment from the reservoir also would be necessary.

Recharge wells should be constructed carefully and developed thoroughly. They could be constructed as dual-purpose wells, to be used as recharge wells when water has collected in the reservoir and as supply wells at other times. However, problems of bacterial contamination and suspended matter might arise in using these wells for supply. The water introduced to the recharge wells should be free from sediment and chlorinated to discourage the growth of algae in the wells. Retention of the floodwater for a few days in the reservoir should cause all but the finest clay and colloids to settle out. If stilling in the reservoir does not settle the sediment sufficiently, consideration might be given to the addition of flocculating chemicals.

An example of a dual-purpose well is one constructed near the edge of a wet-weather lake in southwestern Floyd County, Tex. The well acts as a recharge well when the lake contains water and at other times is used as a discharge well to furnish water for irrigation. A brief discussion of this installation appears in The Cross Section (High Plains Underground Water Conservation District No. 1, 1957). According to that article, numerous farmers throughout the High Plains have installed dual-purpose wells near wet-weather lakes and have achieved a high degree of success. The bacterial contamination and sediment problems would not be as critical in an irrigation well as in wells used for drinking water.

The dual-purpose well in Floyd County, Tex., was pumped at a rate of 1,100 gpm (gallons per minute) and took water at an average rate of about 920 gpm if pumped for about and hour during each 24-hour period to remove sediment.

Hydraulic considerations.—In order to determine the rate at which water can be injected into wells in the headquarters area it will be necessary to make injection tests on a well constructed specifically for that purpose. An estimate of the probable injection rate can be made, however, by using data from other wells in the headquarters area. Supply wells 14, 15, and 16 were tested by pumping, and the computed transmissibilities of the aquifer at these wells were 8,000, 30,000, and 35,000 gpd (gallons per day) per foot, respectively. These wells were cased through 450, 480, and 540 feet of saturated materials. If it is assumed that the values obtained for the transmissibility of the valley fill are for the saturated section above the bottom of the well, the average permeability of the saturated material at wells 14, 15, and 16 is about 50 gpd per square foot.

The thickness of saturated materials at the proposed reservoir site probably ranges from a few feet to more than 500 feet and may average about 200 feet. Using 50 gpd per square foot for the permeability of these sediments, the transmissibility of the saturated material should be about 10,000 gpd per foot. A production well drilled in this locality might be expected to yield 400 gpm with 40 to 60 feet of drawdown.

The presently unsaturated material at the proposed reservoir site is about 400 feet thick. The material should have about the same permeability as the saturated material below. Thus water could be injected into 500 to 600 feet of material having an estimated transmissibility of more than 20,000 gpd per foot. Under these conditions an injection rate of 500 gpm or more might be maintained in a well for a considerable time.

It seems reasonable to presume, therefore, that wells near the reservoir site should yield about 400 gpm, and that the injection rate into a well constructed to take water into both saturated and presently unsaturated material should be at least 500 gpm and probably would be greater than that.

Computions based on a coefficient of transmissibility of 10,000 gpd per foot, an estimated coefficient of storage of 0.2, and an injection rate of 500 gpm for 100 days indicate that water levels might be expected to rise about 30 feet at a distance of 100 feet from an injection well, about 4 feet at a distance of 1,000 feet, and less than 0.2 foot 2,500 feet from an injection well at the end of a period of 100 days.

If six dual-purpose wells capable of receiving 500 gpm each were constructed downslope from the proposed dam, they should be capable of injecting a total of about 3.5 million gallons of water per day to the ground-water reservoir. If the surface reservoir held about 1,000 acre-feet, or 325 million gallons of water, when full, it should be possible by means of the six wells to inject the water into the ground-water reservoir in about 75 days by means of gravity lines in which the flow from the reservoir could be controlled by valves. During average years when the reservoir impounds 200 acre-feet at least once or twice annually, water from the surface reservoir could be injected into the ground-water reservoir through 6 wells in about 20 days.

Possible alternate sites for reservoirs and use of infiltration ditches.—Possible alternate or supplemental locations for a reservoir similar to that proposed above are indicated on the map in secs. 12 and 13 and secs. 11 and 14, T. 22 S., R. 4 E. Dams could be constructed at the alternate sites on an experimental basis at a nominal cost, and test holes T-2 (NE¼ sec. 13) and (or) T-3 (NE¼NW¼ sec. 14), T. 22 S., R. 4 E., after they are cleaned and redeveloped, could be used as recharge wells. These test holes are cased with 4-inch diameter casing, much smaller than a final recharge or dual-purpose well should contain, but they could be used in the experimental phases of the project. If promising results are indicated, recharge wells of more satisfactory size and construction could be developed, and test holes T-2 and T-3 could be used as observation wells. By constructing diversion ditches in the northern and southern parts of the reentrant, nearly all the drainage in the reentrant could be diverted to the suggested dam site in sec. 13. Artificial recharge at the alternate sites in secs. 13 and 14 would introduce water more directly to the area of greatest drawdown from pumping. However, the individual reservoir(s) would be about one-half to two-thirds the size of the one originally proposed. Experiments may indicate that all the sites could be utilized with worthwhile results.

Ditches, if of adequate length and constructed properly by excavating and backfilling with clean, well-sorted, coarse gravel, might be as efficient as recharge wells. It would be necessary to clarify the floodwater just as must be done for recharge wells. Even so, it is likely that the ditches may clog with sediment after some use. They could be replaced cheaply, however, or periodically cleaned.

CONCLUSIONS

The proposed dam and reservoir for impounding and utilizing floodwater may be a practical method of augmenting ground-water supplies, not only at White Sands Missile Range but also in other parts of the Tularosa Basin and similar desert basins. Additional data are needed to appraise fully the feasibility of the proposal. Two or three test holes drilled a short distance below the proposed dam site at White Sands Missile Range would provide needed data on the permeability and thickness of the valley fill. These test holes, if carefully located, could later be developed as dual-purpose wells or as supply wells.

Records of floodflows in the drainage area of the proposed reservoir are needed. Such records, to be accurate, would require either some careful spot measurements or installation of recording gages.

Perhaps the most practical proposals for salvaging floodwaters in the Missile Range headquarters area are as follows:

1. Construct smaller dams or a dam near test hole T-2, and possibily test hole T-3, as experimental recharge facilities.

2. According to the success of the experimental recharge facilities, construct a dam at the originally proposed site with about 500 acre-feet of reservoir capacity. As indicated by precipitation records, a reservoir this size would be adequate to retain most normal runoff. Construct about six recharge wells below the dam with probable recharge capacities of about 500 gpm. Thus when the reservoir was full the water could be put into ground-water storage in about 40 days. Infiltration ditches could be built below the dam as an alternate consideration to construction of wells or to augment the wells.

REFERENCES CITED

Dunham, K. C., 1935, The geology of the Organ Mountains, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Bull. 11, 52 p.

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For sale by the U. S. Geological Survey, price 50 cents