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Rehabilitation of Murray well,
White Sands Missile Range, New Mexico

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The yield from Murray well in the north-central part of the White Sands Missile Range declined until the supply for peak use periods was inadequate. Reference is made to the report "Test Wells Drilled at Mockingbird Gap, Socorro County, N. Mex., June to October 1965," by the U.S. Geological Survey, for information pertinent to the occurrence of ground water in this area. Test wells drilled near the Murray well in 1965 did not disclose a reliable source of water suitable in quality for domestic use, and the decision was made to rehabilitate the Murray well to provide the required amount of water.

The rehabilitation work was to include increasing the well diameter from 6 to 10 inches and cleaning out the well to a depth of 290 feet. The well was then to be logged with electrical and other equipment, cased, developed, test pumped, and returned to service. The U.S. Geological Survey was requested by White Sands Missile Range to monitor drilling and test-pumping phases of the rehabilitation work, and to provide logging equipment.

Construction data for the old Murray well were lacking, but when the casing was removed at the start of the rehabilitation work, it was found to consist of 236 feet of 6-inch casing; the lower 30 feet of pipe was slotted with randomly spaced torch-cut slots approximately $3/8 \times 8$ inches, 4 slots per round. Many of the slots were partially closed by encrustation of minerals, or fragments of rock or sand.

The contractor experienced little difficulty in removing the old casing and began reaming the hole with an 11-inch bit on April 5, 1966. The new construction is summarized in the attached tabulation entitled "Record of Murray well rehabilitation." When the reaming reached a depth of 202 feet the rest of the hole was found to be filled with cuttings from the upper part of the hole. At a depth of about 236 feet the driller estimated that he had reached the bottom of the old hole, because no more of the reamed material was picked up by the bailer, and the drill penetrated a reddish-tan clay. At a depth of about 262 feet a 10 to 12 foot thick bed of coarse sand and gravel was penetrated, and below this thin beds of sand, fine gravel, and clay ranging from 0.5 to 1.5 feet in thickness were penetrated to a depth of 290 feet. The cuttings were mixtures of rounded particles of limestone and granitic materials and were believed to be bolson or fan deposits. A lithologic column, based on the logs and samples of well cuttings, is included with the electric log. It summarizes the character of the rock materials from the new well depth. (See fig. 1.)

Figure 1 (caption on next page) belongs near here.

Figure 1.--Logs of Murray well, White Sands Missile Range, New
Mexico.

On May 7, 1966, the Geological Survey logging unit made a conventional electric log, gamma log, neutron log, caliper log, and fluid-conductivity log of the Murray well. The logs are included for reference. (fig. 1). They substantiate the record obtained from the cutting samples. Several of the thin beds not recorded by the single trace-resistivity electric log are shown by the relative activity gamma and neutron logs. The higher resistivity and shift toward the left by the SP curve on the electric log above 240 feet to fluid level, and a corresponding shift on the gamma and neutron logs, probably are the result of a change in hole diameter, as shown by the caliper log, as well as to a decrease in particle size. The fluid-conductivity curve indicates an increase in total dissolved solids toward the bottom of the hole; however, the well was not being pumped when the conductivity log was made and the increased conductivity may be the result of mud in the bore hole.

The possibility of water of higher total dissolved-solids content entering from the lower part of the well was also suggested by a water sample collected from the bottom of the hole by bailer at the close of drilling April 6, 1966. The results of chemical analysis of samples collected before, during, and after the rehabilitation work are tabulated for ease of comparison (table 1). During development pumping, a sample was collected of the composite water from the well (see footnotes 3 and 4, table 1), and an attempt was made to sample the lower section of the well by inflating a packer on the pump column. The packer did not hold, or water circulated down the outside of the casing, and the quality of water entering the well from the lower section, if any, is not known. However, the quality of water before and after rehabilitation of the well is not appreciably different.

Table 1.--Chemical analyses of water from Murray well.

Analyses by Geological Survey, United States Department of the Interior
 9-268 q (parts per million)

| Murray Well | <u>1/</u> | <u>2/</u> | <u>3/</u> | <u>4/</u> | <u>5/</u> | <u>6/</u> |
|--------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Date of collection | 2/20/66 | 4/6/66 | 4/27/66 | 4/27/66 | 4/28/66 | 4/28/66 |
| Silica (SiO ₂)..... | 27 | | | | | 29 |
| Iron (Fe)..... | | | | | | .01 |
| Manganese (Mn)..... | | | | | | |
| Calcium (Ca)..... | 116 | | | | | 100 |
| Magnesium (Mg)..... | 31 | | | | | 36 |
| Sodium (Na)..... | } 39 | | | | | } 46 |
| Potassium (K)..... | | | | | | |
| Bicarbonate (HCO ₃)..... | 161 | | | | | 175 |
| Carbonate (CO ₃)..... | 0 | | | | | 0 |
| Sulfate (SO ₄)..... | 286 | 405 | 274 | | | 277 |
| Chloride (Cl)..... | 46 | 51 | 40 | 40 | | 40 |
| Fluoride (F)..... | 1.0 | | | | | 1.4 |
| Nitrate (NO ₃)..... | 5.8 | | | | | 6.0 |
| Dissolved solids | | | | | | |
| Calculated..... | 631 | | | | | 621 |
| Residue on evaporation at 180°C .. | 655 | | | | | 651 |
| Hardness as CaCO ₃ | 416 | | | | | 396 |
| Noncarbonate hardness as CaCO ₃ .. | 284 | | | | | 252 |
| Alkalinity as CaCO ₃ | 132 | | | | | |
| Specific conductance (micromhos at 25°C)..... | 927 | 1,130 | 924 | 934 | 929 | 919 |
| pH..... | 7.6 | | | | | 7.5 |
| Color..... | 0 | | | | | |

- 1/ Annual sample collected prior to rehabilitation work
- 2/ Sample from bailer off bottom of hole, well depth 290 feet
- 3/ Composite sample collected during development pumping
- 4/ Sample collected below packer at 268 feet
- 5/ Sample collected at start of test pumping
- 6/ Sample collected at end of test pumping (8 hours)

An aquifer test at the Murray well was made April 28, 1966. The well was pumped for 30 minutes at rates of 100 gpm (gallons per minute) and 125 gpm, and for 7 hours at a rate of 150 gpm. Water levels were measured with an airline gage during pumping and for 20 minutes after pumping stopped; they were measured also with a steel tape for several hours after pumping had stopped, as the change was too small to detect with the airline gage. Water-level fluctuations are summarized on the included hydrograph (fig. 2).

Figure 2 (caption on next page) belongs near here.

The depth to water prior to pumping was 201.63 feet below the concrete floor of the pumphouse; 7 hours after pumping stopped the depth to water was 201.94 feet. Maximum drawdown during pumping was about 18.5 feet. Water-level change at the beginning and at the end of pumping was very rapid; the water level declined rapidly in response to an increase in pumping rate and rose rapidly when the pump was stopped.

The depth to water could be read only to the nearest foot with the airline gage; therefore, the aquifer-test data are only approximate. A straight line (semilog) plot of residual drawdown measured with a steel tape versus the ratio of time since pumping began to the time since pumping stopped suggests that the coefficient of transmissibility (T) is about 100,000 gallons per day per foot. The specific capacity for the period of pumping is about 7.5 gpm per foot of drawdown. (See fig. 3.)

Figure 3 (caption on next page) belongs near here.

Figure 2.--Hydrograph of aquifer test, Murray well, 4/28-29/66.

Figure 3.--Graph of Residual Drawdown Versus $\frac{\text{Time Since Pumping Began}}{\text{Time Since Pumping Stopped}}$

For Murray Well Aquifer Test, 4/28-29/66.

Rehabilitation of Murray well increased the amount of water that can be pumped with a given amount of drawdown (table 2). The increase in yield probably results from the improved mechanical condition of the well. Whether the material penetrated by the drill below the original casing depth is producing water at all, or producing water of the same quality as that from the upper beds, is not known. The reaction of the well to sustained pumping cannot be predicted from the available data. Water levels and pumping rate should be monitored carefully to determine the reaction of the well to production pumping. Samples of water for chemical analysis, or at least for conductance determination, should be collected at monthly intervals during the first pumping season to monitor the chemical quality.

Table 2.--Record of Murray well rehabilitation

Location: N 35 35E $\frac{1}{2}$ sec. 32, T. 8 S., R. 5 E.

Altitude: Land surface altitude 5,115 feet above mean sea level

interpolated from UGS topographic map.

Depth: Reamed old 6-inch hole to 236 feet and drilled new hole from 235 to 290 feet April 5-6, 1966.

Date started: April 5, 1966

Date completed: April 28, 1966 (test pumped)

Drilling contractor: McClendon Drilling Co., Alamogordo, N. Mex.

Drilling method: Cable-tool rig.

Casing and well record: 236 feet of 6-in casing, the bottom 30 feet torch slotted (approximately 5/8 x 8-inch slots, 4 slots per round, randomly spaced) removed from well April 4, 1966. Hole enlarged and drilled with 11-inch bit to 290 feet April 5-6, 1966; 10-inch casing installed to a depth of 290 feet April 21, 1966, with 1/8 x 2-inch mill-cut slots, 6 slots per round, 4 in rounds per foot/adjacent depth intervals of 205 to 245 feet, and 272 to 287 feet. Torch-cut slots for cementing off lower section in depth interval 255 to 260 feet.

Water levels and aquifer test: Depth to water prior to rehabilitation work on April 4, 1966, was 201.67 feet below concrete pump house floor; depth to water immediately prior to test pumping on April 28, 1966, was 101.83 feet below

Table 2.--Record of Murray well rehabilitation - Concluded

Water levels and aquifer test - **Concluded**

concrete pump house floor. Well was pumped at an average rate of 140 gallons per minute for 3 hours, with a drawdown of 18.5 feet.

Well completion record: Well equipped with submersible pump capable of pumping 140 gpm against line head and returned to service.