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Albuquerque, N. Mex.

Water-Supply Development at the  
National Aeronautics and Space Agency -  
Apollo Propulsion System Development facility,  
Dona Ana County, N. Mex.

By

G. C. Doty

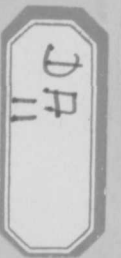
OPEN-FILE REPORT ~~63-29~~

Dec. 10, 1963

Prepared in cooperation with the U. S. Army, Corps of Engineers

Administrative report

October 1963



United States  
Department of the Interior  
Geological Survey  
Albuquerque, New Mexico

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Water-Supply Development at the National Aeronautics and  
Space Agency - Apollo Propulsion System Development Facility,  
Dona Ana County, N. Mex.

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Summary of events

A water requirement of 300 gpm (gallons per minute) per 16 hour day was scheduled for the NASA-Apollo PSD (National Aeronautics and Space Agency-Apollo Propulsion System Development) facility to be built about 8 miles north of Organ, N. Mex., in the Jornada del Muerto on the west flank of the San Andres Mountains. In an effort to establish this water requirement NAA (North American Aviation Company) under contract from NASA, caused four exploratory wells (C, D, G, and H) to be drilled on the fan slope of the San Andres Mountains near the proposed location of the facility. The general location of the area and the sites of wells are shown in figure 1. The sites for wells C, D, G, and H were selected

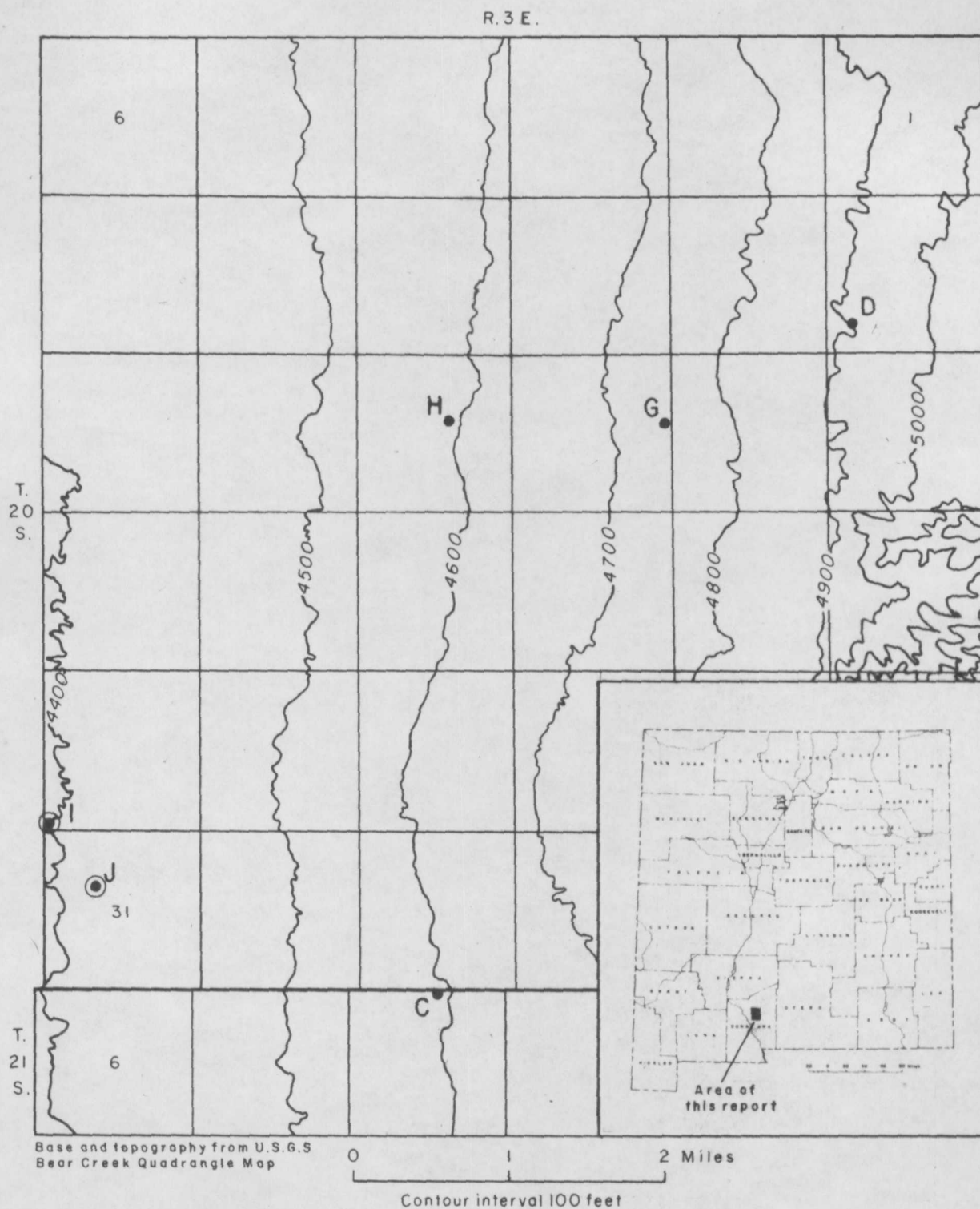
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Figure 1.--General location of NASA-Apollo PSD facility and sites of wells, Dona Ana County, N. Mex.

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by NAA from recommendations made by the Ralph M. Parsons Company.

The U.S. Corps of Engineers assumed responsibility for the water supply at the Apollo PSD facility on April 1, 1963 and requested the services of the USGS (U.S. Geological Survey) in evaluating the water problem. After a review of file data, examination of the records and drill cuttings from the wells drilled for NAA, and a visit to the Jornada del Muerto area, the USGS selected a site for a fifth well (I) (fig. 1) and also monitored the reaming, developing, and testing of well C. The yield from well C was inadequate and the USGS selected a site for a sixth well (J) (fig. 1). Drilling and testing of wells I and J were supervised by USGS personnel.



#### EXPLANATION

•  
Well

⊙  
Well to be used for  
water supply

Figure 1.--General location of NASA-Apollo PSD facility and sites of wells, Dona Ana County, N. Mex.

## Methods and procedures

All wells at the Apollo PSD facility were drilled by the hydraulic rotary method by the Layne-Texas Company. Drilling operations began in December 1962 at well C and ended in May 1963 at well J (table 1). Sample descriptions of the cuttings from wells C, D, G, and H were prepared by USGS personnel after the wells were drilled; descriptions of cuttings were made during the drilling of wells I and J (table 2). An electric log was made of each well except G (table 3). Wells C, I, and J were reamed to 16-inch diameter, cased with 12-3/4-inch OD steel casing and developed by bailing and surging. The water level in well C was lowered so much by bailing that further testing was unnecessary and the well was abandoned. Water samples were collected by air jetting through the drill stem and from the discharge pipe of wells in which test pumps were installed.

## Geology and ground water occurrence

The Jornada del Muerto is a topographic basin whose southern extremity, in which the Apollo PSD facility lies, is between the Dona Ana and San Andres Mountains. The rocks exposed in these mountains on either side of the basin have been eroded, filling the basin to an unknown depth. The sediments in this basin include the Santa Fe Group of middle(?) Miocene to Pleistocene(?) age and Recent alluvium; they are hereinafter referred to as bolson deposits.

The bolson deposits consist of irregular beds and lenses of unconsolidated to semi-consolidated clay, silt, sand, and gravel, and mixtures of these particle sizes. Wells in the Jornada obtain water, which is unconfined or semiconfined, from permeable beds of sand and gravel in the bolson deposits. The bolson deposits and the saturated zone within the deposits thin toward the mountains: thus the probability of obtaining an adequate supply of water decreases with nearness to the mountains. Wells C, D, G, and H apparently did not penetrate a sufficient thickness of saturated bolson deposits to yield the required quantity of water. Wells I and J penetrated 682 and 602 feet of saturated bolson deposits, respectively, and when cased as water wells, each had 400 feet of slotted casing open to the saturated sections.



### Aquifer test

Wells I and J were test pumped at approximately 1,000 gpm (gallons per minute) for 24 hours with a turbine pump driven by a gas powered motor. Water levels were measured with an electric tape during drawdown and recovery (figs. 2 and 3). The discharge fluctuated throughout the

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Figure 2.--Drawdown and recovery of water level, and pumping rate during 24-hour pumping test at well I, May 1-2, 1963.

Figure 3.--Drawdown and recovery of water level, and pumping rate during pumping test at well J, May 30-31, 1963.

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tests due to variances in speed of the motor, and the drawdown part of each test is of little value for computing aquifer characteristics. A semi-log plot of water-level recovery versus time indicates the coefficient of transmissibility is about 48,000 gpd (gallons per day) per ft for well I and about 80,000 gpd per ft for well J (figs. 4 and 5).

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Figure 4.--Water-level recovery data for test at well I on May 1-2, 1963.

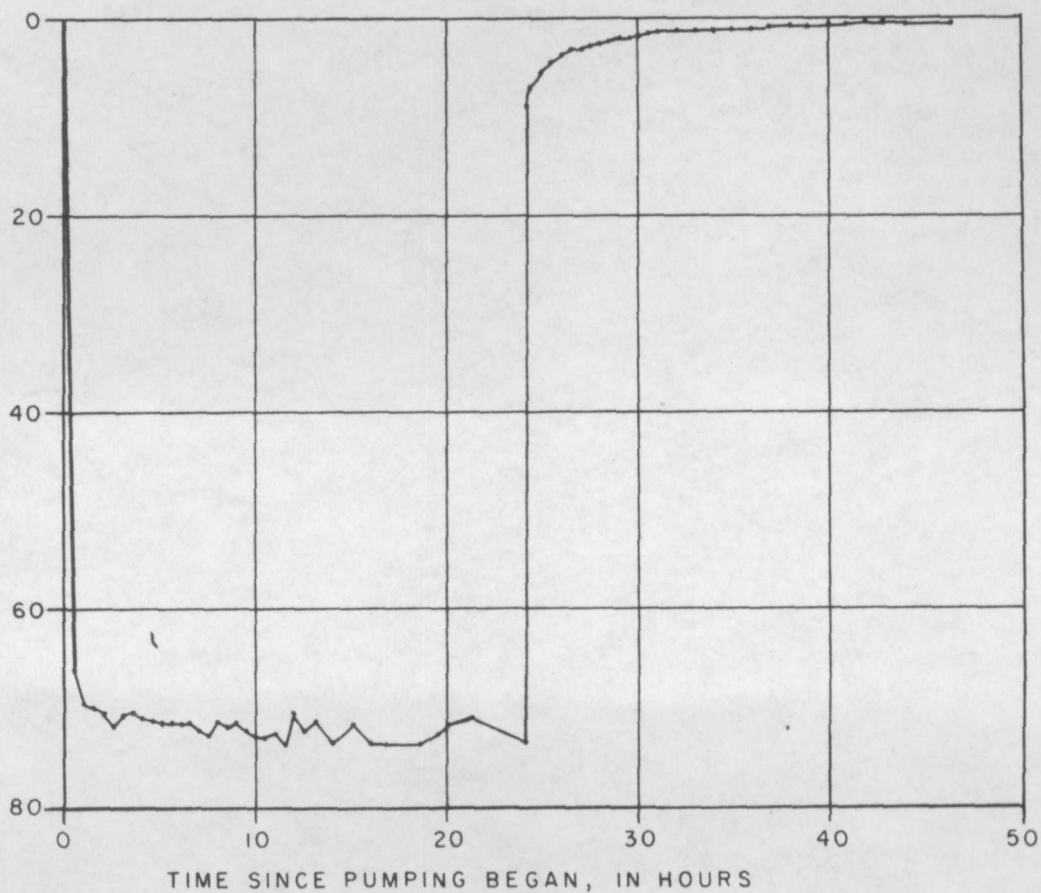
Figure 5.--Water-level recovery data for test at well J on May 30-31, 1963.

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The coefficients of transmissibility are on the order of those expected from bolson deposits, and the relatively small drawdown of water levels indicates that the wells are in good hydraulic connection with the aquifer.



WATER LEVEL CHANGE, IN FEET, FROM NONPUMPING  
LEVEL OF 315.45 FEET BELOW LAND SURFACE



DISCHARGE RATE, IN GPM

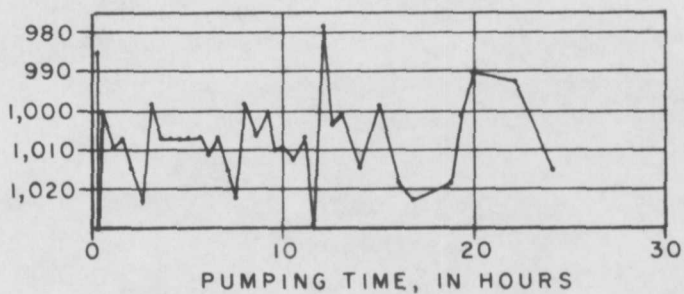


Fig. 42--Drawdown and recovery of water level and pumping rate  
during pumping test at well I, May 1-2, 1963.

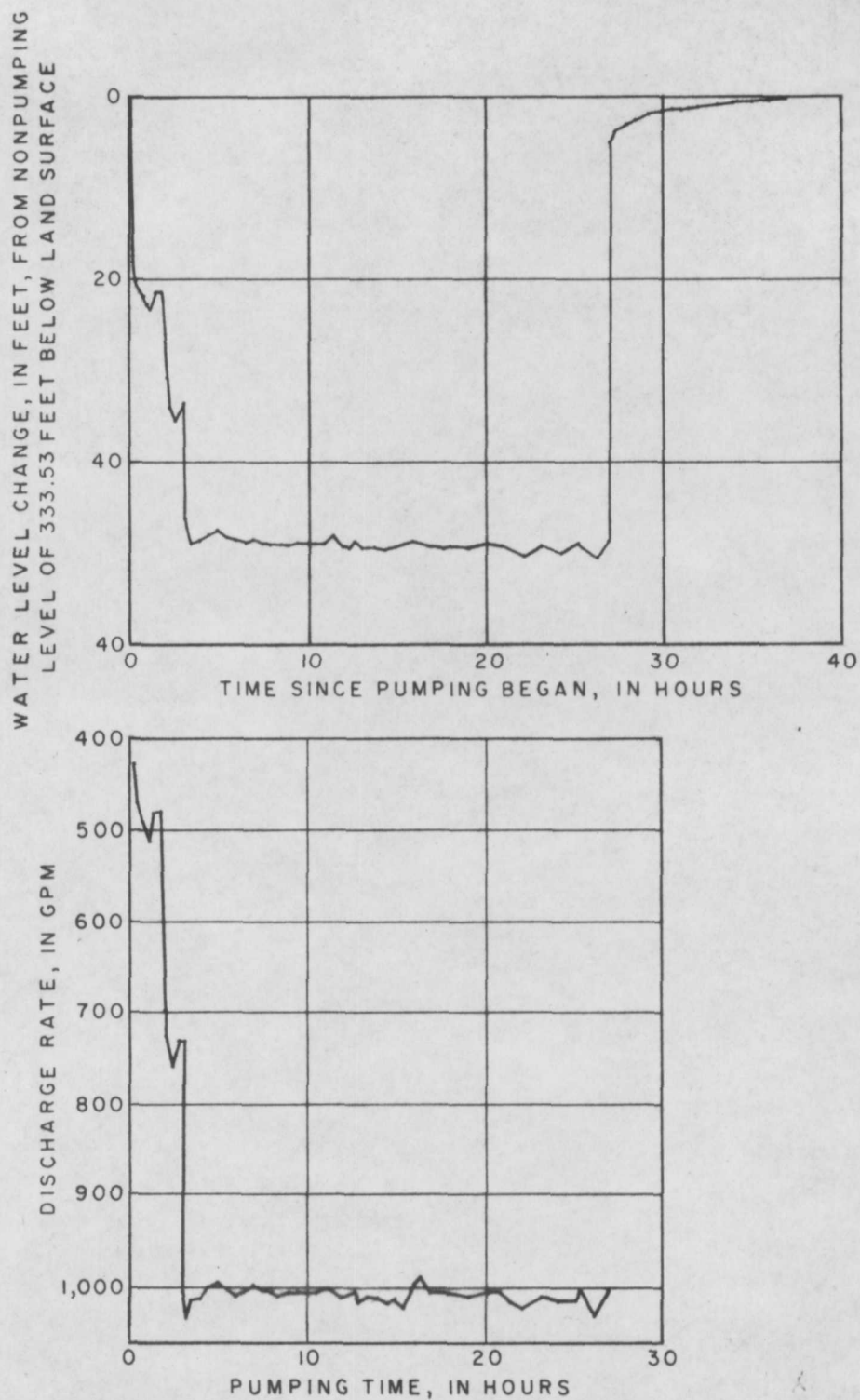
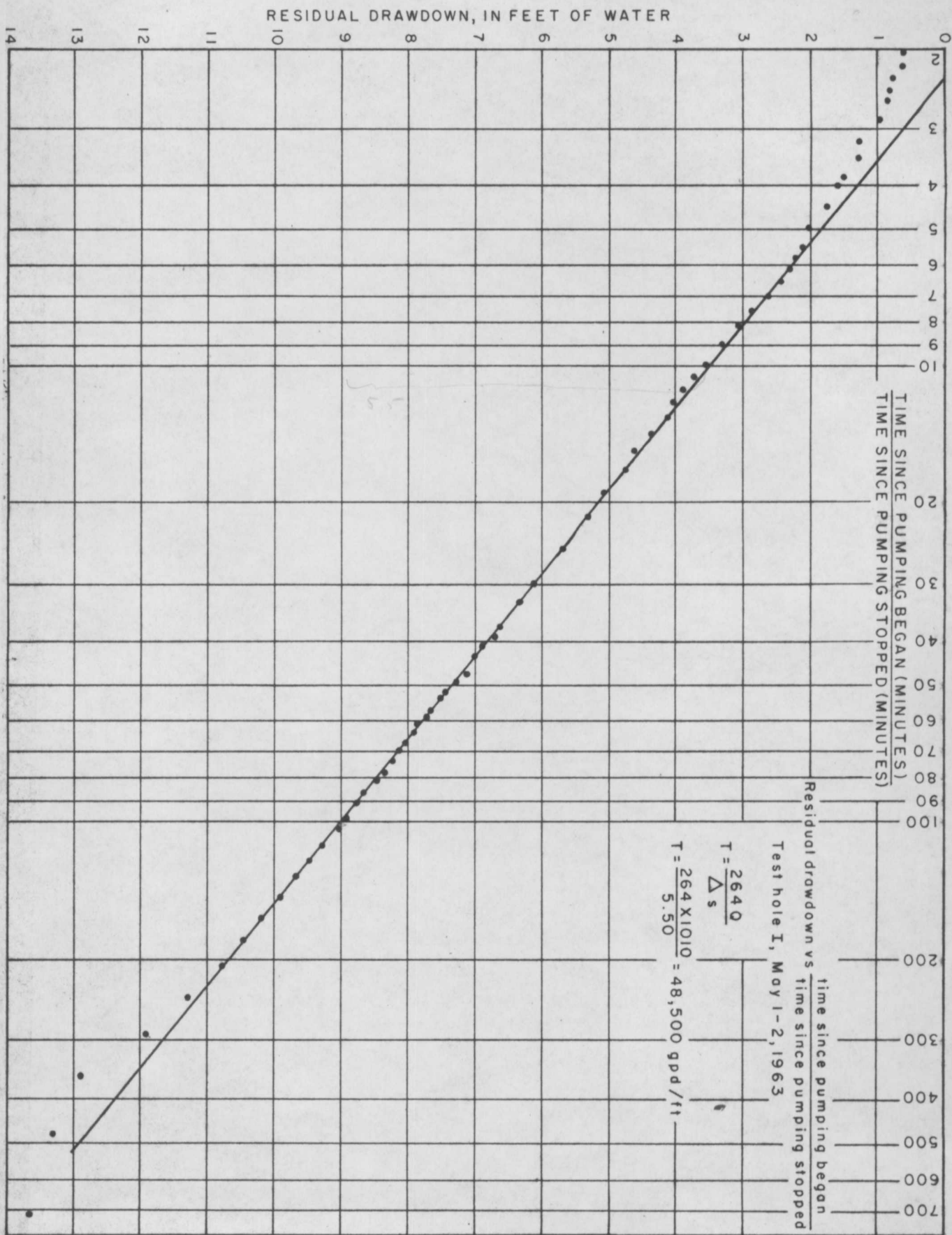


Fig. 3.--Drawdown and recovery of water level and pumping rates during pumping test at well J, May 30-31, 1963.

Fig. 4.--Water-level recovery data for test well I on May 1-2, 1963.



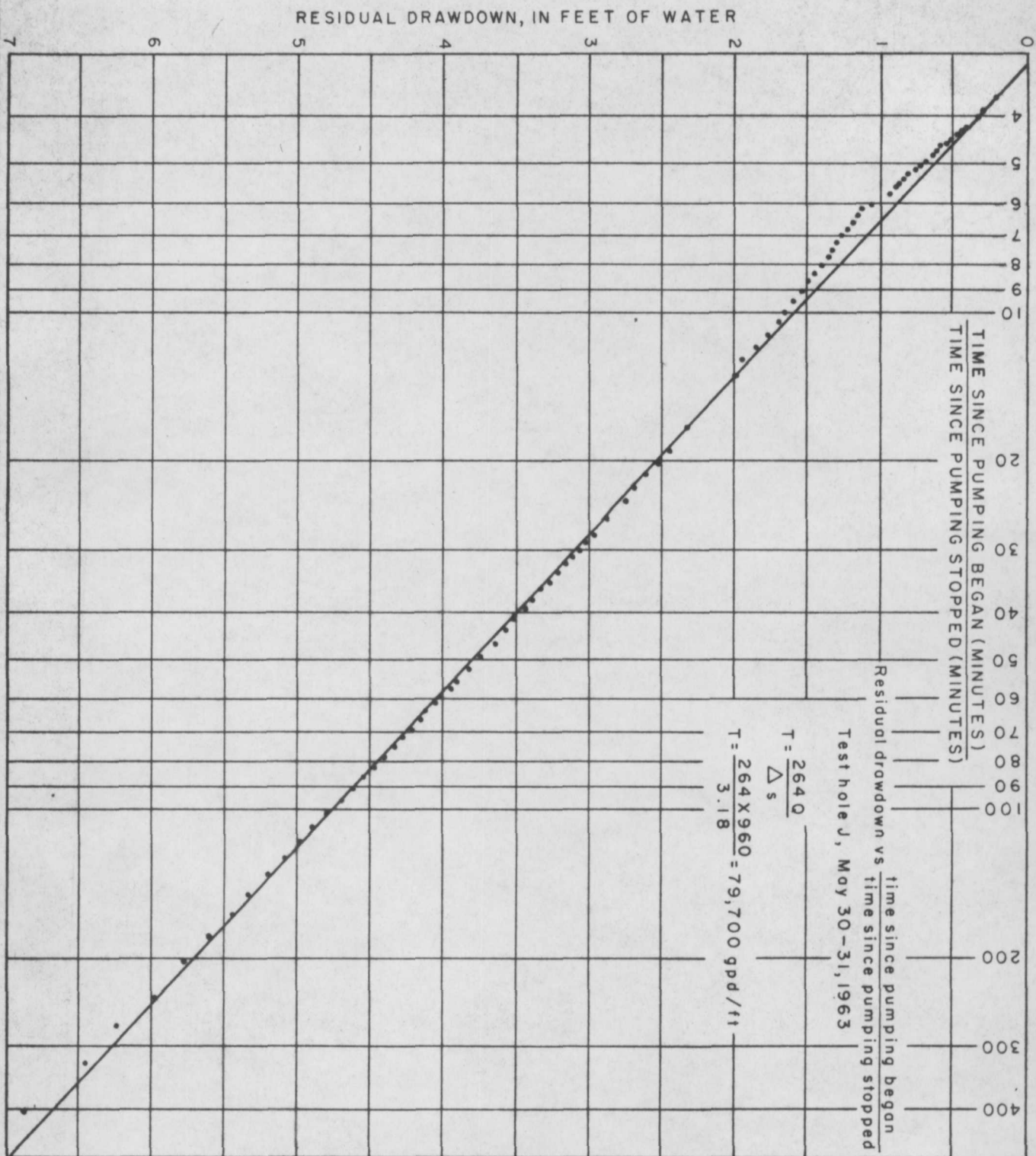


Fig. 5.--Water-level recovery data for test well J on May 30-31, 1963.



## Chemical quality of water

The chemical quality of ground water in the Jornada ranges widely. Sulfate is the principal contaminant in water of poor quality. The sulfate is derived from gypsum that weathers out of rocks exposed in the San Andres Mountains. The quality of water from the Apollo PSD facility wells is shown in tables 4 and 5. The analyses of water from wells C, D, G, and H were made by an independent laboratory for NAA (table 4); the analyses of water from wells I and J were made by the U.S. Geological Survey laboratory (table 5).

The sulfate content of water from all the wells except C was above the U.S. Public Health Service recommended limits of 250 ppm (parts per million). The water from wells I and J contains about 300 ppm sulfate and is therefore inferior water by Public Health Service standards. The water is extremely hard; the hardness as  $\text{CaCO}_3$  of water from wells I and J is 378 and 418 ppm, respectively. Water of appreciably better quality probably cannot be obtained within a reasonable distance of the facility; water of comparable quality with that from I or J is widely used for domestic and municipal supplies in New Mexico.

Table 1.--Records of wells drilled at Apollo PSD  
facility, Dona Ana County, N. Mex.

Well C

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 4, T. 21 S., R. 3 E., Dona Ana County, N. Mex.

Altitude: Land-surface altitude 4,590 feet above sea level datum,  
interpolated from USGS topographic maps.

Depth: 1,011 feet below land surface datum.

Date completed: April 22, 1963 (Plugged and abandoned)

Drilling contractor: Layne-Texas Co., El Paso, Tex.

Drilling method: Hydraulic rotary

Casing and well record: 8-inch test well drilled to 1,011 feet December 6-18, 1962. Well reamed to 16-inch and cased full depth with 12 3/4-inch casing March 27 to April 15, 1963. Casing perforated with 3/16 x 2-inch mill-cut slots, 12 slots around, staggered rows, from 350-460, 590-650, 690-720, and 800-1,000 feet. 24-inch surface casing cemented to 30 feet.

Well completion record: 12 3/4-inch casing pulled and well plugged with heavy mud and abandoned April 22, 1963. Steel cap welded on surface casing.



Table 1.--Records of wells - Continued

Well C - Continued

Geologic source:

Probably bolson deposits, from 360 to 450 feet. Water level was lowered from 362 to 752 feet by bailing at a rate of about 38 gpm with 90-gallon bailer indicating that the well was incapable of producing the desired yield.

Formation logs: (1) Sample description (2) Electrical log. See table 3.

Water sample: See table 4.

Summary of material penetrated: See table 2.

Material	Depth interval (feet)
Bolson deposits -----	0-453
Igneous rock (weathered) -----	453-503
Igneous rock (unweathered) -----	503-1,011

Table 1.--Records of wells - Continued

Well D

Location: NE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 12, T. 20 S., R. 3 E., Dona Ana County, N. Mex.

Altitude: Land-surface altitude 4,900 feet above sea level datum,  
interpolated from USGS topographic maps.

Depth: 1,321 feet below land surface datum

Date completed: January 24, 1963

Drilling contractor: Layne-Texas Co., El Paso, Tex.

Drilling method: Hydraulic rotary

Casing and well record: 8-inch well to 1,321 feet, not cased.

Well completion record: Plugged and abandoned

Geologic source: Unknown. Yield insufficient to justify further  
development.

Formation logs: (1) Sample description (2) Electrical log. See table 3.

Water sample: See table 4.

Summary of material penetrated: See table 2.

Material	Depth interval (feet)
Bolson deposits -----	0-265
Older sedimentary rocks. -----	265-1,319

Table 1.--Records of wells - Continued

Well G

Location: NE<sup>1</sup><sub>4</sub>NE<sup>1</sup><sub>4</sub>SE<sup>1</sup><sub>4</sub> sec. 15, T. 20 S., R. 3 E., Dona Ana County, N. Mex.

Altitude: Land-surface altitude 4,740 feet above sea level datum.

interpolated from USGS topographic maps.

Depth: 578 feet below land surface datum

Date completed: February 8, 1963

Drilling contractor: Layne-Texas Co., El Paso, Tex.

Drilling method: Hydraulic rotary

Casing and well record: 8-inch well to 578 feet, not cased.

Well completion record: Plugged and abandoned.

Geologic source: Unknown. Yield insufficient to justify  
further development.

Formation logs: (1) Sample description

Water sample: See table 4.

Summary of material penetrated: See table 2.

Material	Depth interval (feet)
Bolson deposits-----	0-180
Volcanic rocks -----	180-250
Limestone and shale,-----	250-578

Table 1.--Records of wells - Continued

Well H

Location: SW<sup>1</sup>/<sub>4</sub>SW<sup>1</sup>/<sub>4</sub>NE<sup>1</sup>/<sub>4</sub> sec. 16, T. 20 S., R. 3 E., Dona Ana County, N. Mex.

Altitude: Land-surface altitude 4,590 feet above sea level datum,  
interpolated from USGS topographic map.

Depth: 1,445 feet below land-surface datum

Date completed: March 2, 1963

Drilling contractor: Layne-Texas Co., El Paso, Tex.

Drilling method: Hydraulic rotary

Casing and well record: 10-inch well to 1,445 feet. 6-inch casing wedged  
in well at 350 feet, and could not be pulled or  
driven.

Well completion record: Plugged and abandoned.

Geologic source: Probably bolson deposits. Water level lowered  
from 272 to 739 feet by pumping at 35 gpm  
with submergible pump.

Formation logs: (1) Sample description (2) Electrical log. See table 3.

Water sample: See table 4.

Summary of material penetrated: See table 2.

Material	Depth interval (feet)
Bolson deposits -----	0-285
Igneous rock (weathered) -----	285-335
Igneous rock (unweathered) -----	335-1,445

Table 1.--Records of wells - Continued

Well I

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 30, T. 20 S., R. 3 E., Dona Ana County, N. Mex.

Altitude: Land surface altitude, 4,385 above sea level datum, interpolated from USGS topographic map.

Depth: 862 feet below land surface

Date completed: May 2, 1963

Drilling contractor: Layne-Texas Co., El Paso, Tex.

Drilling method: Hydraulic rotary

Casing and well record: 8-inch test well drilled to 1,000 feet. 30 feet of 18-inch surface casing cemented in and well reamed to 16-inch to 862 feet. Well cased full depth with 862 feet of 12 3/4-inch casing perforated from 430-660 and 680-850 feet with 3/16 x 2-inch mill cut slots, 12 slots around, alternate rows staggered.

Well completion record: Fitted with temporary steel cap.

Geologic source: Bolson deposits. Water level lowered from 318<sup>391</sup> to 391 feet by pumping for 24 hours at rate of 1,000 gpm. (93)

Formation logs: (1) Sample description (2) Microlog and induction-electrical logs. See table 3.

Water sample: See table 5.

Summary of material penetrated: See table 2.

1,000 feet of bolson deposits.



Table 1.--Records of wells - Concluded

Well J

Location: NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 31, T. 20 S., R. 3 E., Dona Ana County, N. Mex.

Altitude: Land surface altitude 4,410 feet above sea level datum,  
interpolated from USGS topographic map.

Depth: 850 feet below land surface

Date completed: May 31, 1963

Drilling contractor: Layne-Texas Co., El Paso, Tex.

Drilling method: Hydraulic rotary

Casing and well record: 10-inch test well drilled to 939 feet. 30 feet of 18-inch surface casing cemented in and well reamed 16-inch to 850 feet. 12 3/4-inch casing installed to full depth. Casing perforations: mill-cut 3/16 x 2-inch slots. 12 slots around, staggered rows. Perforated intervals: 400-700, 740-840 feet.

Well completion record: Fitted with temporary steel cap.

Geologic source: Bolson deposits. Water level lowered from <sup>388</sup>337  
to 388 feet by pumping at rate of 1,000 gpm  
for 24 hours.

Formation logs: (1) Sample description (2) Microlog and induction electrical  
log: See table 3.

Water sample: See table 5.

Summary of material penetrated: See table 2.

939 feet of bolson deposits.



Table 2.--Descriptions of cuttings from wells at Apollo PSD  
facility, Dona Ana County, N. Mex.

Well C

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{2}$  sec. 4, T. 21 S., R. 3 E.

Material	Depth interval (feet)
No sample taken -----	0-20
Pebbles, dark-gray to black, and limestone-----	20-25
No sample taken-----	25-30
Silt, light-brown with limestone, gravel and pebbles to $\frac{1}{2}$ inch-----	30-40
Gravel, with limestone pebbles to $\frac{1}{2}$ inch, in light-brown clay matrix-----	40-45
Silt, light-brown, with limestone pebbles to $\frac{1}{2}$ inch -----	45-50
Silt, light-brown with small angular gravels ----	50-70
Sand to small pebbles, light-gray and cream, angular to sub angular -----	70-75
Sand and limestone pebbles to $\frac{1}{4}$ inch, angular-----	75-80
Sand and limestone pebbles to 1 inch, angular----	80-85
Silt, light-brown with small limestone gravel----	85-90
Sand to small pebble size particles, light-gray and cream, angular to sub angular -----	90-95

Table 2.--Descriptions of cuttings from wells - Continued

Well C - Continued

Material	Depth interval (feet)
Silt, light-brown with small limestone gravel -----	95-100
Pebbles, limestone, to $\frac{1}{2}$ inch, silt matrix -----	100-110
Pebbles, to $\frac{1}{2}$ inch, sub angular, more silt than above -----	110-115
Gravel, limestone, angular to broken to $\frac{1}{8}$ inch, trace silt -----	115-125
Silt, light-brown with pebbles to $\frac{1}{2}$ inch -----	125-140
Silt, light-brown, sand and some small limestone gravel, cream, pebbles to $\frac{1}{8}$ inch -----	140-150
Silt, light-brown, some small gravel -----	150-155
Silt, with broken limestone pebbles -----	155-160
Pebbles, limestone, to $\frac{1}{2}$ inch, angular -----	160-165
Silt, light-brown to cream with small gravel -----	165-175
Silt, light-gray with small limestone gravel -----	175-180
Silt, light-brown with pebbles to $\frac{1}{4}$ inch -----	180-185
Silt, light-brown with pebbles to $\frac{1}{8}$ inch -----	185-190
Gravel, limestone, to 1 inch, angular to sub angular, with some pebbles sub angular -----	190-195
Gravel, broken angular limestone fragments to $\frac{1}{4}$ inch -----	195-210

Table 2.--Descriptions of cuttings from wells - Continued

Well C - Continued

Material	Depth interval (feet)
Silt, light-brown, with angular limestone fragments to 1/8 inch -----	210-215
Gravel, broken limestone fragments to 1/4 inch-----	215-240
Pebbles, limestone, with quartz sand, and light-gray clay-----	240-300
Pebbles, broken limestone fragments to 1/4 inch---	300-305
Pebbles, limestone, with light-gray clay-----	306-350
Clay, dark-gray, hard, with some quartz sand ----	350-363
Clay, tan, sandy, with sandy to granule size particles of andesite and limestone-----	363-393
Pebbles, limestone, sub angular to broken to 1 1/4 inch -----	393-403
Sand, brown-purple, fine, with clay-----	403-408
Pebbles, limestone, sub angular and broken to 1 inch-----	408-413
Sand, brown-purple, fine, with clay-----	413-428
Sand, brown-purple, fine, with limestone fragments -----	428-448
Clay, magenta, and fine sand (Base of Bolson)----	448-453

Table 2.--Descriptions of cuttings from wells - Continued

Well C - Concluded

Material	Depth interval (feet)
Rhyolite, medium-gray, altered and weathered with some quartz and feldspar -----	453-473
Rhyolite, medium-gray, some fragments dark gray, altered and weathered with some quartz and feldspar -----	473-503
Rhyolite, as above, mostly dark-gray with unweathered appearance -----	503-653
Clay or shale, reddish-gray -----	653-658
Clay or shale, brick-red -----	658-663
Clay or shale, gray -----	663-668
Clay or shale, brick-red -----	668-678
Rhyolite, same as 503-653 -----	678-683
Clay or shale, brick-red -----	683-688
Clay or shale, dull-red -----	688-698
Rhyolite, mostly dark-gray -----	698-703
Rhyolite, reddish cast probably due to mud -----	703-803
Sand, gray to reddish-gray, fine, quartz, fragments of volcanic rock and some red silt and clay; may be erosional interval between two flows --	803-858
Rhyolite, medium to dark-gray, unaltered -----	858-938
No sample taken -----	938-943
Rhyolite, light-gray, altered, with fine sand --	943-1,011

TD

Table 2.--Descriptions of cuttings from wells - Continued

Well D

Location: NE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 12, T. 20 S., R. 3 E.

Material	Depth interval (feet)
Gravel, granule size, possibly silty and clayey, rounded to angular, contains gray limestone, and little red siltstone; little caliche-----	0-50
Silt and clay, light-brownish-red-----	50-60
Sandstone, light brownish-red and white, silty, very calcareous, fine to very fine, medium- cemented-----	60-65
Sandstone, light brownish gray, very calcareous, dolomitic, coarse to fine, cemented, grades locally to limestone-----	65-80
Gravel, pebbles, rounded to subrounded, mostly limestone pebbles; thin limestone bed at 83 ft. -----	80-90
Clay and silt, pale-red to reddish-tan-----	90-105
Sandstone, light brownish red to white, silty, calcareous, fine to medium-----	105-110



Table 2.--Descriptions of cuttings from wells - Continued

Well D - Continued

Material	Depth interval (feet)
Gravel, pebble size, silty, subrounded to rounded, pebbles mostly limestone and red sandstone-----	110-120
Sandstone, brownish red, silty, argillaceous(?), calcareous, fine to very fine-----	120-125
Gravel, consists of sandy limestone and coarse to fine sandstone; little red sandstone-----	125-150
Shale, medium-bluish-gray, partly pyritic-----	150-160
Siltstone, light purplish red, sandy, shaly, very slightly calcareous-----	160-173
Gravel, granule size with fine pebbles of gray limestone, very sandy in lower part; white sandstone and red siltstone-----	173-190
Sand, very light-gray, very clayey, slightly gravelly, very coarse-----	190-200
Clay and silt interbedded, medium-gray to light-brownish gray, contains brown limestone nodules and fragments of limestone, sandstone, and bluish-gray shale-----	200-225
Gravel, pebble size, very sandy, subrounded-----	225-235



Table 2.--Descriptions of cuttings from wells - Continued

Well D - Continued

Material	Depth interval (feet)
Sand, light gray, quartzose, contains fragments of white quartzite, bluish-gray shale, and limestone -----	235-240
Shale, reddish-brown, red at top, silty, non-calcareous; trace of bluish-gray shale, interbedded(?) -----	240-265
Sandstone, very light-gray to very light-greenish-gray, silty, slightly glauconitic, quartzose, fine to very fine, hard, siliceous cement -----	265-285
Sand, quartzose, coarse to very fine, very coarse, subrounded to rounded, few mica books (phlogopite ?); little bluish gray shale and red siltstone -----	285-312
Shale, bluish-gray, non-calcareous -----	312-316
Sand, quartzose, fine to very fine, subangular, incoherent -----	316-328
Shale, medium-gray, non-calcareous -----	328-337
Sandstone, very light greenish gray, argillaceous, mostly silty, glauconitic, feldspathic, medium to fine, friable, siliceous cement; little purple shale interbedded-----	337-435

Table 2.--Descriptions of cuttings from wells - Continued

Well D - Continued

Material	Depth interval (feet)
Shale, medium to dark-gray, very silty, very sandy, very slightly micaceous; few sandstones interbedded, very light gray, silty, especially at 455 and near base; little buff limestone-----	435-510
Sandstone, light-gray to very light-gray, silty, glauconitic, medium to very fine, noncalcareous, siliceous cement; very few partings(?) lavender shale-----	510-595
Siltstone, dark-gray, very sandy, argillaceous, part slightly pyritic, grades to silty shale at base-----	595-620
Shale, dark-gray, very silty, sandy, hard, grades from overlying unit-----	620-630
Shale, dark-gray, clay, slightly sandy-----	630-663
Sandstone, light gray, silty; little lavender, reddish-brown clay; trace coal, pyritic-----	663-670
Shale, dark-gray, clay-----	670-685
Sandstone, light-gray, silty, argillaceous, very fine to medium, calcareous, soft, contains dark grains-----	685-690
Shale, medium to dark-gray, silty-----	690-695

Table 2.--Descriptions of cuttings from wells - Continued

Well D - Continued

Material	Depth interval (feet)
Sandstone, medium-gray, silty, argillaceous, very fine to medium, soft -----	695-705
Shale, dark-gray, silty -----	705-709
Sandstone, medium-gray, as above -----	709-713
Shale, dark-gray, silty, non-calcareous -----	713-730
Sandstone, light-gray, silty, argillaceous, slightly calcareous, medium to very fine-----	730-742
Shale, dark-gray, silty -----	742-750
Sandstone, light-gray, as above -----	750-760
Shale, dark-gray, silty -----	760-764
Sandstone, light-gray, argillaceous, silty, medium-grained, tight -----	764-782
Shale, medium- to dark-gray, partly silty and sandy, calcareous -----	782-794
Sandstone, silty, slightly calcareous, pyritic, medium to fine grained -----	794-798
Shale, medium-gray, silty, calcareous; little lavender shale -----	798-806
Sandstone, light-gray, silty, slightly calcareous, medium to fine, pyritic-----	806-810

Table 2.--Descriptions of cuttings from wells - Continued

Well D - Continued

Material	Depth interval (feet)
Shale, medium-gray, silty, calcareous; sandstone, as above -----	810-820
Sandstone, dark-gray, very argillaceous, silty, fine-----	820-828
Shale, medium- to dark-gray, silty-----	828-832
Sandstone, light greenish gray in upper part, light gray in lower part, very silty, calcareous, fine to very fine, little medium, contains feldspar(?) and dark grains including glauconite, partly micaceous and pyritic, hard, tight; gray shale interbedded 867 to 872 -----	832-907
Shale, gray, silty -----	907-927
Sandstone, medium-gray, very silty, argillaceous, feldspathic, very fine to fine, angular -----	927-950
Siltstone and shale, dark-gray, slightly micaceous-----	950-975
Shale, gray, very silty, micaceous -----	975-1,006
Sandstone, medium-gray, silty, feldspathic, very fine to fine -----	1,006-1,012
Shale, dark-gray, slightly calcareous-----	1,012-1,038
Shale, gray, silty, calcareous-----	1,038-1,080

Table 2.--Descriptions of cuttings from wells - Continued

Well D - Continued

Material	Depth interval (feet)
Shale, dark-gray, slightly calcareous-----	1,080-1,095
Shale, gray, silty, calcareous; little sandstone interbedded-----	1,095-1,130
Siltstone, dark-gray, shaley, calcareous-----	1,130-1,148
Shale, dark-gray, silty-----	1,148-1,200
Shale, gray, very silty, very calcareous; little limestone, dark brownish-gray, very argillaceous, silty-----	1,200-1,220
Shale, dark-gray, slightly calcareous-----	1,220-1,240
Shale, black-----	1,240-1,246
Shale, black, silty, slightly sandy, slightly calcareous; trace of lavender to purple clay-----	1,246-1,260
Anhydrite, pale grayish-tan, pyritic, micro- crystalline; dolomite, tan, pyritic, speckled, fine grained-----	1,260-1,272
Shale and siltstone, dark brownish-gray, dolomitic-----	1,272-1,284
Dolomite, dark brownish-gray; very calcareous, fine; shale, pale greenish-gray, disseminated pyrite; little lavender clay-----	1,284-1,295



Table 2.--Descriptions of cuttings from wells - Continued

Well D - Concluded

Material	Depth interval (feet)
Shale, dark-gray, silty, dolomitic -----	1,295-1,308
Sandstone, very pale-greenish-gray, silty, slightly glauconitic, slightly pyritic, feldspathic, very fine to medium; little siltstone, very pale greenish gray -----	1,308-1,319 TD

Table 2.--Descriptions of cuttings from wells - Continued

Well G

Location: NE $\frac{1}{2}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 15, T. 20 S., R. 3 E.

Material	Depth interval (feet)
No sample -----	0-29
Gravel, pebble size, sandy and silty near base----	29-45
Gravel, pebble size, little or no sand -----	45-60
Gravel, granule to pebble size, slightly sandy, little caliche -----	60-90
Gravel, granule to pebble size, sandy, sub- angular, to angular; caliche; fine sand, especially in lower half of unit; little clay near top -----	90-145
Gravel, granule to pebble size, sandy, sand coarse in upper part and fine near base; caliche -----	145-165
Gravel, granule to pebble size, very little sand, limestone fragments predominate, also contains quartzite, chert, other; caliche -----	165-180
Andesite or quartz latite, dark-gray, slightly weathered to reddish near top, some euhedral quartz, some "caliche" coating near top -----	180-200
Andesite, gray to reddish, contains feldspar pheno- crysts, caliche coating and clear calcite present-	200-250

Table 2.--Descriptions of cuttings from wells - Continued

Well G - Continued	
Material	Depth interval (feet)
Limestone, dark-gray, reddish-gray at top, finely crystalline, contains calcite veinlets, very clayey in lower 10 feet; few thin(?) red sandstones interbedded between 280 and 315 ----	250-370
Shale, reddish-brown, calcareous; limestone, gray; little red sandstone -----	370-380
Limestone, dark-gray, dolomitic(?), finely crystalline; shale, calcareous, dark red; gray shale interbedded in lower 10 feet -----	380-400
Shale, gray, non-calcareous, non-fissile; very little red shale interbedded below 440 -----	400-465
Limestone, argillaceous, gray to brownish-gray, probably dolomitic -----	465-475
Shale, reddish-brown; little limestone and gray shale interbedded -----	475-485
Shale, gray; limestone, dark-gray, mottled -----	485-490
Limestone, dark-gray, finely crystalline, little vein calcite; little gray, silty shale -----	490-500
Shale, medium to dark-gray, non-calcareous, non-fissile; limestone, dark-gray, interbedded ----	500-510
Shale, reddish-brown, slightly calcareous -----	510-520

Table 2.--Descriptions of cuttings from wells - Continued

Well G - Concluded

Material	Depth interval (feet)
Shale, medium-gray, non-calcareous; limestone, argillaceous, medium-to dark-gray -----	520-525
Limestone, dark-gray, finely crystalline, little vein calcite; very little red shale and red sandstone -----	525-560
Limestone, light-gray; shale, gray -----	560-570
Limestone, dark-gray; shale, gray, near bottom --	570-578

TD

Table 2.--Descriptions of cuttings from wells - Continued

## Well H

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 16, T. 20 S., R. 3 E.

Material	Depth interval (feet)
Gravel, dark-gray to black, 1 inch, sub- angular -----	0-40
Gravel, pebbles, sub-angular to angular -----	40-50
Gravel, pebbles, sub-angular to angular, with light-brown clay -----	50-75
Gravel, pebbles, sub-angular to angular, with many broken angular fragments -----	75-85
Gravel, pebbles, sub-angular to angular with clay -----	85-120
No sample -----	120-140
Silt, light-brown with broken gravel fragments of dark-gray igneous rock -----	140-145
Silt, light-brown, with a few broken gravel fragments -----	145-150
Silt, light-brown; no rock fragments -----	150-155
Silt, light-brown with a very few broken gravel fragments-----	155-165



Table 2.--Descriptions of cuttings from wells - Continued

Well H - Continued

Material	Depth interval (feet)
Gravel, and some sand, multicolored; multicolored particles range from $\frac{1}{2}$ inch pebbles to very fine sand; few rounded particles most are bit-cut fragments of dark-gray limestone, chert, and volcanic rocks; some clay -----	165-220
Silt, light-brown, some rock fragments -----	220-230
Silt, light-brown, many rock fragments -----	230-235
Gravel, particles are sub-angular to angular to $\frac{1}{2}$ inch; some clay -----	235-250
Gravel, dark-gray, sub-angular to angular, particle size ranges from silt to $\frac{1}{4}$ inch -----	250-255
Gravel, finer than above with silt -----	255-260
Gravel, dark-gray, angular to sub-angular, no silt, to $\frac{1}{4}$ inch -----	260-275
Gravel, angular, to $\frac{1}{8}$ inch, with clay -----	273-285
Gravel, light-gray, fine, igneous (andesite), with biotite, feldspar, and rock fragments from above (weathered) -----	285-290
Andesite, gray-green, weathered, with biotite, feldspar -----	290-335

Table 2.--Descriptions of cuttings from wells - Continued

Well H - Concluded

Material	Depth interval (feet)
Andesite, with biotite, feldspar, darker-gray than above, unweathered appearance -----	335-365
Andesite, reddish-purple -----	365-375
Andesite, light-gray -----	375-500
Samples in this interval were scanned during cutting operations. No significant difference in color or rock type was noted -----	
	500-1,445

Table 2.--Descriptions of cuttings from wells - Continued

Well I

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 30, T. 20 S., R. 3 E.

Material	Depth interval (feet)
Soil, silt, and fine sand -----	0-10
Clay, light red, silt, and fine sand -----	10-20
Clay, sand, and sub-rounded pebbles -----	20-35
Sand, clay, caliche and angular pebbles -----	35-40
Sand, gravel and clay -----	40-45
Sand, clay, and gravel -----	45-60
Gravel, clay and sand -----	60-80
Clay, fine sand and gravel -----	80-85
Clay and some gravel -----	85-100
Clay -----	100-110
Clay and fine sand -----	110-115
Clay -----	115-145
Clay and very fine sand -----	145-150
Clay -----	150-155
Clay and very fine sand -----	155-235
Clay and some gravel -----	235-240
Clay, hard -----	240-245
Clay and very fine sand -----	245-265
Sand and clay -----	265-270

Table 2.--Descriptions of cuttings from wells - Continued

Well I - Continued

Material	Depth interval (feet)
Clay and some very fine sand -----	270-310
Clay -----	310-350
Clay, fine sand, and some pebbles -----	350-375
Clay, some fine sand -----	375-380
Sand, gravel and some clay -----	380-385
Sand, coarse, and gravel -----	385-395
Gravel, sand and clay -----	395-400
Clay, sand and gravel -----	400-405
Gravel and some clay -----	405-410
Clay, fine sand, and some gravel -----	410-415
Gravel, sand, and clay -----	415-420
Gravel, coarse sand, and clay; some pebbles of limestone, quartzite, and volcanic rocks -----	420-470
Sand, coarse, and clay -----	470-475
Sand, coarse -----	475-485
Sand, coarse, and boulders -----	485-510
Sand, fine, and gravel -----	510-515
Sand, gravel, and boulders -----	515-525
Sand, fine, and gravel -----	525-550
Sand, fine, and boulders -----	550-560
Sand, fine, gravel and some clay -----	560-565
Gravel, fine sand and clay -----	565-600

Table 2.--Descriptions of cuttings from wells - Continued

Well I - Continued

Material	Depth interval (feet)
Gravel, coarse sand and clay -----	600-615
Gravel, sand and white to red clay -----	615-630
Gravel and clay -----	630-650
Clay, gravel, and sand -----	650-655
Gravel, sand and clay -----	655-660
Gravel and sand -----	660-675
Sand, fine, and rounded pebbles -----	675-680
Sand, coarse, pebbles and some clay -----	680-715
Pebbles, multicolored, mostly dark limestone and some rounded quartz -----	715-735
Same as 715-735 with more clay -----	735-750
Same as 715-735 -----	750-765
Sand, fine (may be bit-ground), and pebbles of limestone and volcanic rocks. -----	765-770
Sand, fine, quartz, well-rounded; particles of rhyolite, andesite, chert and limestone, some clay -----	770-805
Sand, coarse, rounded, quartz and volcanic rocks -	805-825
Sand, coarse, gravel and clay. A few rounded pebbles -----	825-840



Table 2.--Descriptions of cuttings from wells - Continued

Well I - Concluded

Material	Depth interval (feet)
Gravel and coarse sand; rounded pebbles -----	840-870
Sand, coarse and clay; some rounded pebbles ----	870-900
Gravel, fine sand and clay -----	900-930
Sand, fine gravel and clay -----	930-935
Clay, sand and rounded pebbles -----	935-940
Sand, fine to coarse -----	940-955
Clay, and some sand, fine to coarse -----	955-960
Clay, dark red, and sand, fine to medium -----	960-965
Clay, sand and gravel -----	965-970
Sand, coarse and clay -----	970-975
Clay, sand and fine gravel -----	975-980
Gravel, sand and clay -----	980-985
Clay, sand and gravel -----	985-1,000
	TD

Table 2.--Descriptions of cuttings from wells - Continued

Well J

Location: NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 31, T. 20 S., R. 3 E.

Material	Depth interval (feet)
Soil and very fine sand -----	0-10
Sand, coarse -----	10-15
Gravel, some sand and caliche -----	15-30
Gravel and sand -----	30-35
Gravel -----	35-45
Clay, tan, silty and very fine sand; some gravel -----	45-55
Gravel and sand; some clay -----	55-85
Sand, reddish-tan, clay and gravel -----	85-110
Clay, tan, with some sand and a few pebbles ----	110-230
Clay, tan -----	230-235
Clay, tan, pebbles and sand; gravel probably thin bedded; some caliche -----	235-325
Gravel and tan clay -----	325-330
Sand, very coarse, pebbles, and tan clay -----	330-350
Clay, tan, and gravel -----	350-360
Gravel and clay -----	360-365
Gravel, very coarse sand and clay -----	365-370

Table 2.--Descriptions of cuttings from wells - Continued

Well J - Continued

Material	Depth interval (feet)
Clay, pebbles and very coarse sand -----	370-385
Gravel and clay -----	385-395
Sand, well rounded, and clay -----	395-415
Sand, gravel and clay -----	415-470
Gravel, sand, and clay -----	470-525
Sand, fine to coarse, gravel and clay -----	525-540
Clay and very coarse, well rounded sand -----	540-550
Sand, fine to coarse, gravel and clay -----	550-555
Gravel, clay and sand -----	555-565
Gravel and little clay, some sand; beds probably well cemented -----	565-665
Sand, coarse, gravel and little clay -----	665-670
Gravel and sand -----	670-680
Sand, fine to coarse, gravel and clay -----	680-735
(Bit and drill collars lost in hole; log continues on hole drilled 15 feet away)	
Gravel, sand, and some clay-----	735-745
Sand, some gravel -----	745-750
Gravel and clay -----	750-760
Sand, very coarse and gravel -----	760-775
Clay and fine to coarse sand -----	775-825
Sand, medium to fine, some gravel and clay -----	825-830

Table 2.--Descriptions of cuttings from wells - Concluded

Well J - Concluded

Material	Depth interval (feet)
Clay, sand and gravel -----	830-860
Gravel and coarse sand -----	860-885
Sand and gravel, cemented, very hard -----	885-937
	TD

Table 3.--Electric logs of wells C, D, H, I, and J

in the Apollo PSD facility, Dona Ana County,

N. Mex. (Logs are in pocket.)

Electrical log of well C

" " " " D

" " " " H

Induction-Electrical log of well I

Microlog of well I

Induction-Electrical log of well J

Microlog of well J



Table 4.---Analyses of water samples from wells C, D, G, and H,  
Apollo PSD, by commercial laboratory for NAA.

(Chemical constituents are in parts per million except as noted.)

	Well C	Well D	Well G	Well H
Silica	25	10	10	
Iron	.05	.15	.05	.05
Calcium Oxide	136	122	140	
Magnesium Oxide	86	18	116	
Bicarbonate	223	190	216	99
Carbonate	nil	nil	nil	
Sulfate	227	658	562	713
Chloride	44	168	122	110
Fluoride	1.5	1.1	1.4	2.1
Dissolved Solids	743	1750	1487	
Suspended Solids	304	56	113	
Hydroxide	nil	nil	nil	
Arsenic	nil	nil	nil	
Lead	nil	nil	nil	
Alumina	15	4	9	
Hardness as $\text{CaCO}_3$	413	267	630	340
Sodium Oxide		500	300	
Color	Colorless (with sediment)	Colorless	Colorless	
Odor	None	Odorless	Odorless	
pH	7.95	7.5	8.5	

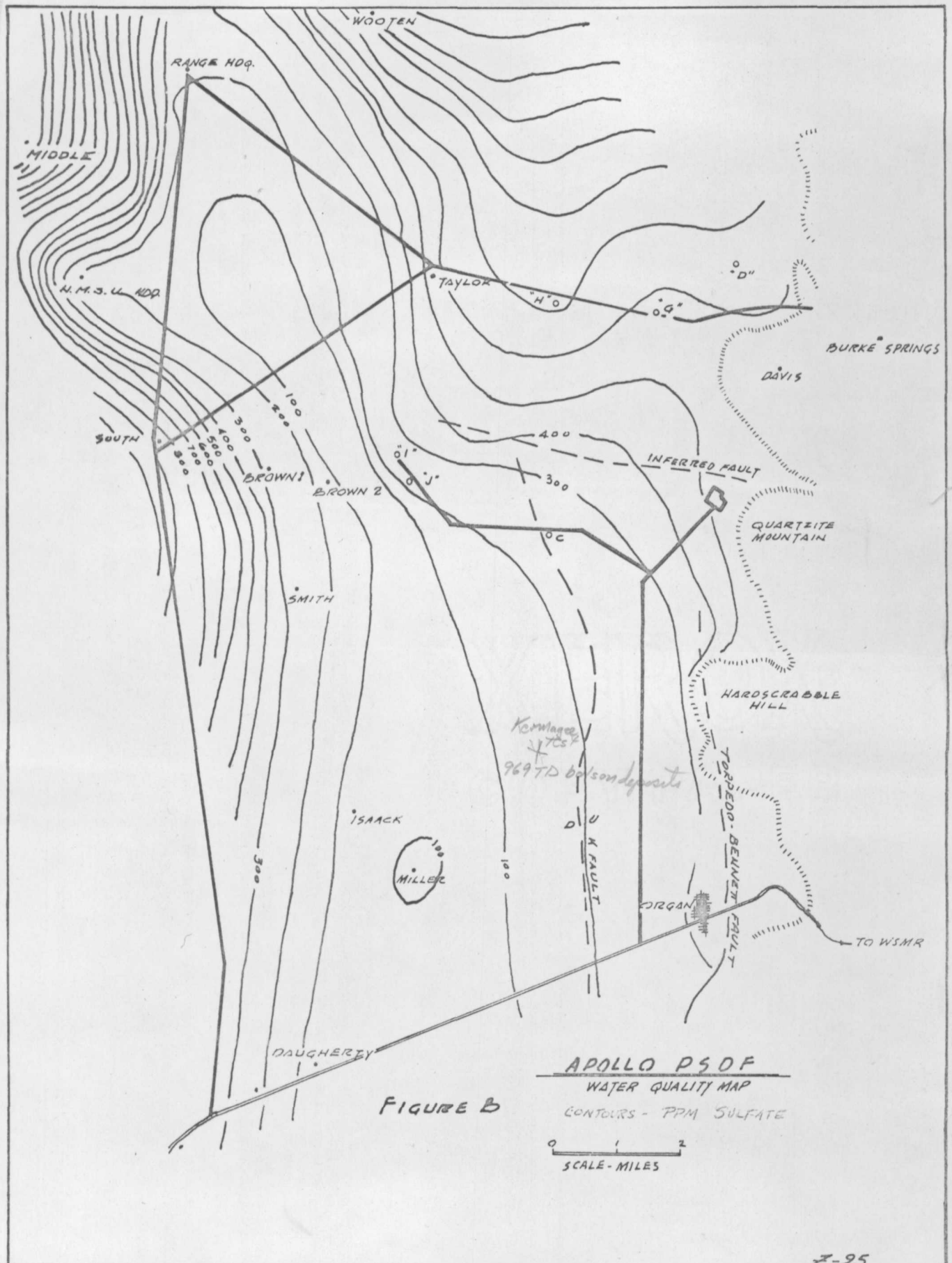
Table 5.---Analyses of water samples from wells I and J, Apollo PSD,

by U.S. Geological Survey.

(Chemical constituents are in parts per million except as noted.)

	Well I			Well J		
Date of collection	4-10-63	4-14-63	4-27-63	5-2-63	5-19-63	5-31-63
Silica (SiO <sub>2</sub> )				29	34	42
Iron (Fe), in solution at time of analysis.				0.04	0.01	0.03
Calcium (Ca)				69	68	80
Magnesium (Mg)				50	41	53
Sodium (Na)				83	151	65
Potassium (K)				209	138	232
Bicarbonate (HCO <sub>3</sub> )				0	0	0
Carbonate (CO <sub>3</sub> )				305	410	296
Sulfate (SO <sub>4</sub> )	336	374	498	46	76	40
Chloride (Cl)	44	49	52			
Fluoride (F)				.6	.6	.7
Nitrate (NO <sub>3</sub> )				3.9	21	3.5
Dissolved solids						
Sum				690	870	694
Residue on evaporation at 180°C				720	886	746
Hardness as CaCO <sub>3</sub>				378	338	418
Non-carbonate				206	225	228
Specific conductance (micromhos at 25°C)	1,070	1,100	1,250	1,020	1,240	981
pH				7.6	8.0	7.3
Color				1	3	3

Map from Say Out ZIA Company 9 May 65



Water-Supply Development at NASA

Apollo Propulsion System Development facility

By

G. C. Doty

Table 3