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HYDROLOGIC CHARACTERISTICS OF THE LOS ALAMOS WELL FIELD, WITH REFERENCE TO THE OCCURRENCE OF ARSENIC IN WELL LA-6

by

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ABSTRACT

The Los Alamos well field is composed of six wells, ranging in depth from 870 to 1965 ft, that are completed in the Tesuque Formation, the main aquifer of the Los Alamos area. The water from the field is used for industrial and municipal supply by the Los Alamos Scientific Laboratory and the community of Los Alamos. The quality of water from individual wells varies slightly, with only three wells of the same general type.

The occurrence and increase of arsenic in well LA-6 during the latter part of 1974 and early 1975 now precludes use of water from this well. Studies were made using a combination of wells and restricting pumpage from well LA-6 and on dilution by other wells in the system to determine if acceptable arsenic levels could be obtained. An attempt was also made to determine which zone of the aquifer was yielding the high arsenic concentration to the well. Water samples collected at selected depths within the well were analyzed and compared to geophysical logs. These data were then applied to select zones to be blocked at below depths of 1550, 1440, 1210, and 875 ft within the well. These tests failed to isolate the arsenic bearing waters.

The high concentration of arsenic occurs throughout the aquifer adjacent to the well. The average arsenic concentration at well LA-6 for nine tests ranged from 159 to 201 $\mu g/\ell$. Arsenic concentrations measured after blocking selected zones ranged from 141 to 203 $\mu g/\ell$. It was calculated that the arsenic level from the well would have to be reduced to 100 $\mu g/\ell$ at a pumping rate of 300 gpm for dilution in the system to reach the acceptable limits of 50 $\mu g/\ell$ for municipal use. Therefore, the well was placed on "standby" to be used only in extreme emergency.

This report summarizes the hydrologic characteristics of the wells in the Los Alamos well field for necessary background material. It also presents a summary and interpretation of data related to arsenic concentrations in wells in the field, with special reference to tests made of well LA-6 during the period August 1975 — June 1976.

TABLE I

SUMMARY OF WELL CHARACTERISTICS

	Well					
	LA-1B	**LA-2**	**L.**	**LA-4**	**LA-5**	**LA-6**
Depth (ft)	1750	870	870	1965	1750	1790
Length of Screen (ft)	591	765	765	400	400	420
Water Level (1975)						
Nonpumping (ft)	42	103	80	272	149	113
Pumping (ft)	168	320	253	335	309	151
Drawdown (ft)	126	217	173	83	160	38
Production Rate (1975)						
Pumping Rate (gpm)	537	290	313	591	460	551
% of Field	19	11	11	22	17	20
Specific Capacity (gpm/ft)	4.3	1.3	1.8	7.1	2.9	14.6
Transmissivity (gpd/ft)	5700	2500 [a]	2500 [a]	9600	4800	15 500
Coefficient of Permeability (gpd/ft^2)	9.6	8 [a]	8 [a]	24	12	37
Production						
$\times 10^6$ gal (1975)	74	40	43	82	64	52
% of Field (1975)	21	11	12	23	18	15
Total $\times 10^9$	1.4	1.0	1.3	2.9	2.5	2.9

[a]Data from Theis and Conover, Ref. 5.

wide vertical strip of the aquifer. The transmissivities of wells LA-2 and -3 were determined by Theis and Conover in 1950.[5] These wells are about 870 ft in depth and only penetrate a part of the aquifer. The test indicated transmissivity of about 2500 gpd/ft at wells LA-2 and -3, which are the lowest in the field (Table I). The transmissivities for wells LA-1B, -4, -5, and -6 were determined in December and January 1975-76 from a method devised by Theis[6] and later described by Wenzel.[7] The transmissivity was determined from the rate of drawdown of water level during a pumping period by the formula

$$T = 264\ Q/\Delta h,$$

where

T = transmissivity in gpd/ft,

Q = pumping rate in gpm, and

Δh = the ratio of $\log_{10}$ t/s that is determined graphically by plotting $\log_{10}$ t (t = time) against corresponding values of s (water level drawdown) and using the ratio (Δh) of the slope of the straight line drawn through the plotted points (Fig. 3).

Wells LA-1B, -4, -5, and -6 range in depth from 1750 to 1965 ft and also only penetrate a part of the aquifer.

The transmissivities of these wells ranged from 4800 to 15 500 gpd/ft (Fig. 3). Well LA-1B, completed at a depth of 1750 ft, had a transmissivity of 5700 gpd/ft with a specific capacity of 4.3 gpm/ft of drawdown. The transmissivity of well LA-4, completed at a depth of 1965 ft, was 9600 gpd/ft with a specific capacity of 7.1 gpm/ft. The transmissivity of

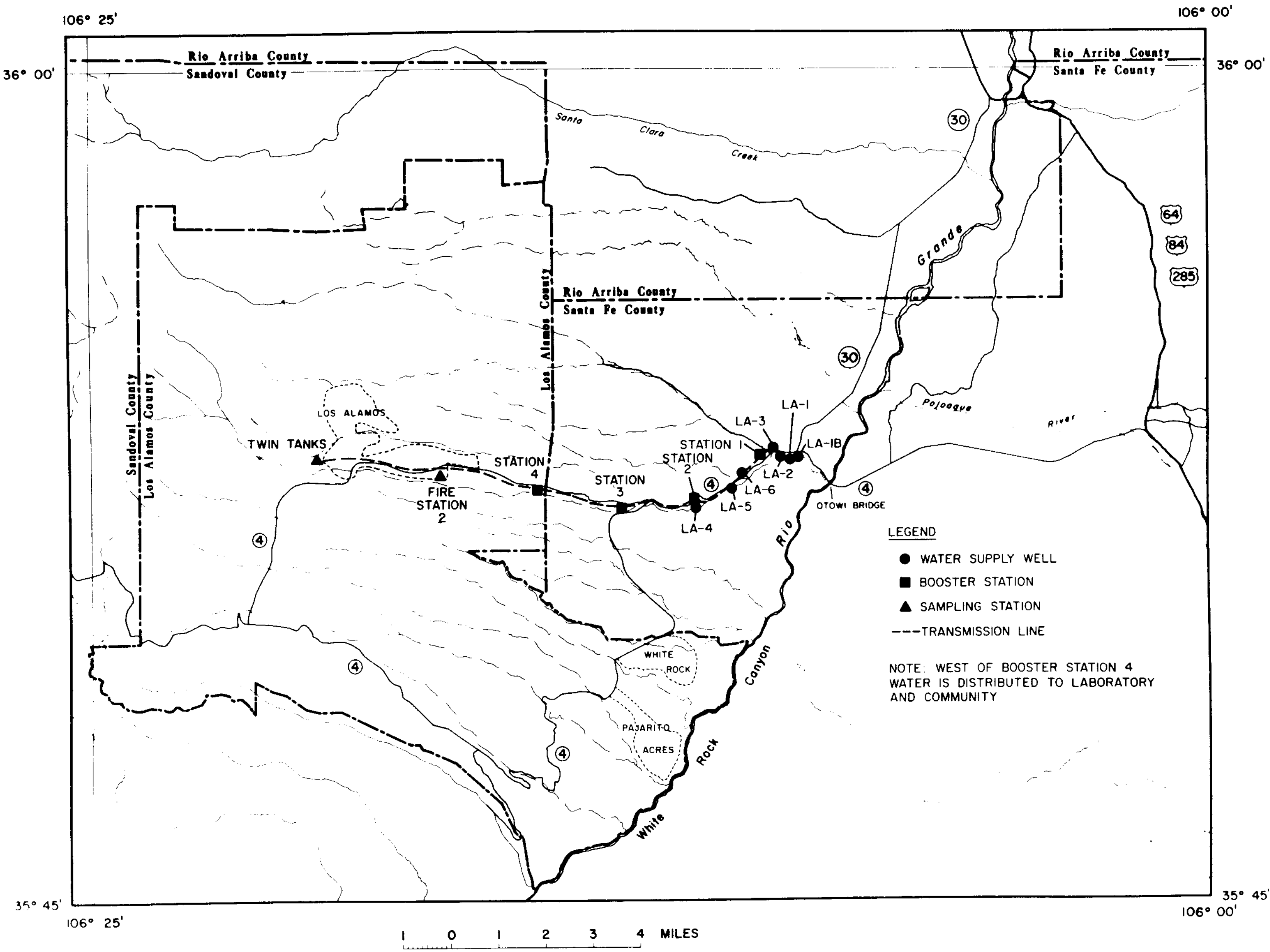

Fig. 1.

Location of wells, booster stations, transmission lines, and sampling stations.

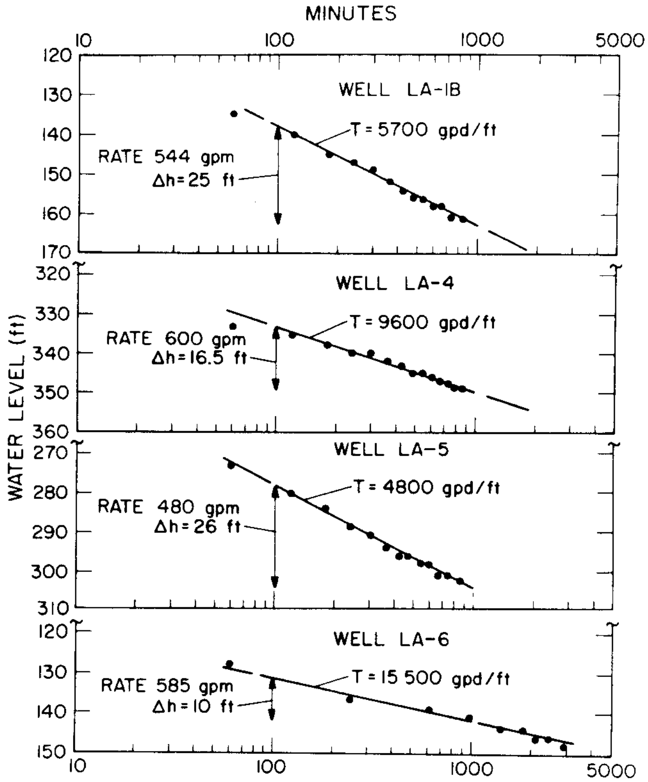

Fig. 3.
Transmissivity of wells LA-1B, -4, -5, and -6.

The net water level declines in the individual wells for the period of record have ranged from 43 to 88 ft. Anticipated water level declines range from 10 to 25 ft by the year 1983 with production of about 500 × 10^6 gal annually.[9]

Well characteristics for individual wells for the period of record are found in Appendix B. Driller's logs, casing schedules (wells LA-2 through -6), and geophysical logs (wells LA-1B, -4, -5, -6) are found in Appendix C.

B. Distribution System

The distribution system for the well field consists of four booster stations and 12 mi of 14-in. steel water line. The production and transmission system transports the water to terminal storage at the Twin Tanks. Water is supplied to the community and four technical areas prior to reaching terminal storage.[10]

The booster stations contain pumps and small storage reservoirs. Water from wells LA-1B, -2, and -3 move through Booster 1. Booster 2 handles water from Booster 1 and wells LA-4, -5, and -6 (Fig. 1). Boosters 3 and 4 are located to the west and move water through the transmission lines into the community and technical areas.

The water usage by the Laboratory and community determines the volume of daily pumpage needed from the wells. Thus the wells are pumped in combinations to meet the demand in the most efficient way considering economic and hydrologic conditions. For example, operation of the wells and boosters is restricted to off-peak electrical loads, generally from 4 p.m. to 8 a.m. The wells are pumped at rates which allow maximum yield from the well without causing excessive drawdown of the aquifer to ensure the longevity of the well field.

The combinations of wells pumped are, generally, wells LA-1B, -2, -3, -4, -5, and -6 during peak demand, or wells LA-1B, -2, and -3, or wells -4, -5, and -6, during off-peak demand periods. Other combinations of operation are possible; however, the pumpage must be sufficient to meet the capacity of the pumps at each booster station. For example, at Booster 4, one pump transfers 1000 gpm, two pumps 1800 gpm, and three pumps 2300 gpm.

For this study, Booster 4 was used as a sampling station to determine arsenic levels. This station was chosen as a control point because it is the last station on the line prior to distribution to the community and Laboratory, and the mixing of water from the various wells is at a maximum since the water has moved through three storage tanks and three booster stations. A study with residual water, left in the tanks and lines from previous pumpage, determined that it takes about 3 hr for the water to move from Booster 2 to Booster 4.

Fire Station 2, located on DP Road about 2.5 mi west of Booster 4, has also been used as a sampling station in the distribution system. Lag time in the distribution system from Booster 4 to this station ranges from 8 to 72 hr and is a function of the demand at TA-21.

C. Quality of Water

The quality of water from a well depends on the depth of the well, the lithology of the aquifer, and the yield from individual beds within the aquifer. The quality of water from the individual wells will vary due to these local aquifer conditions in the individual wells in the Los Alamos field (Table II).

The quality of water has been determined for constituents Ca, Mg, Na, CO_3, HCO_3, Cl, F, NO_3, TDS

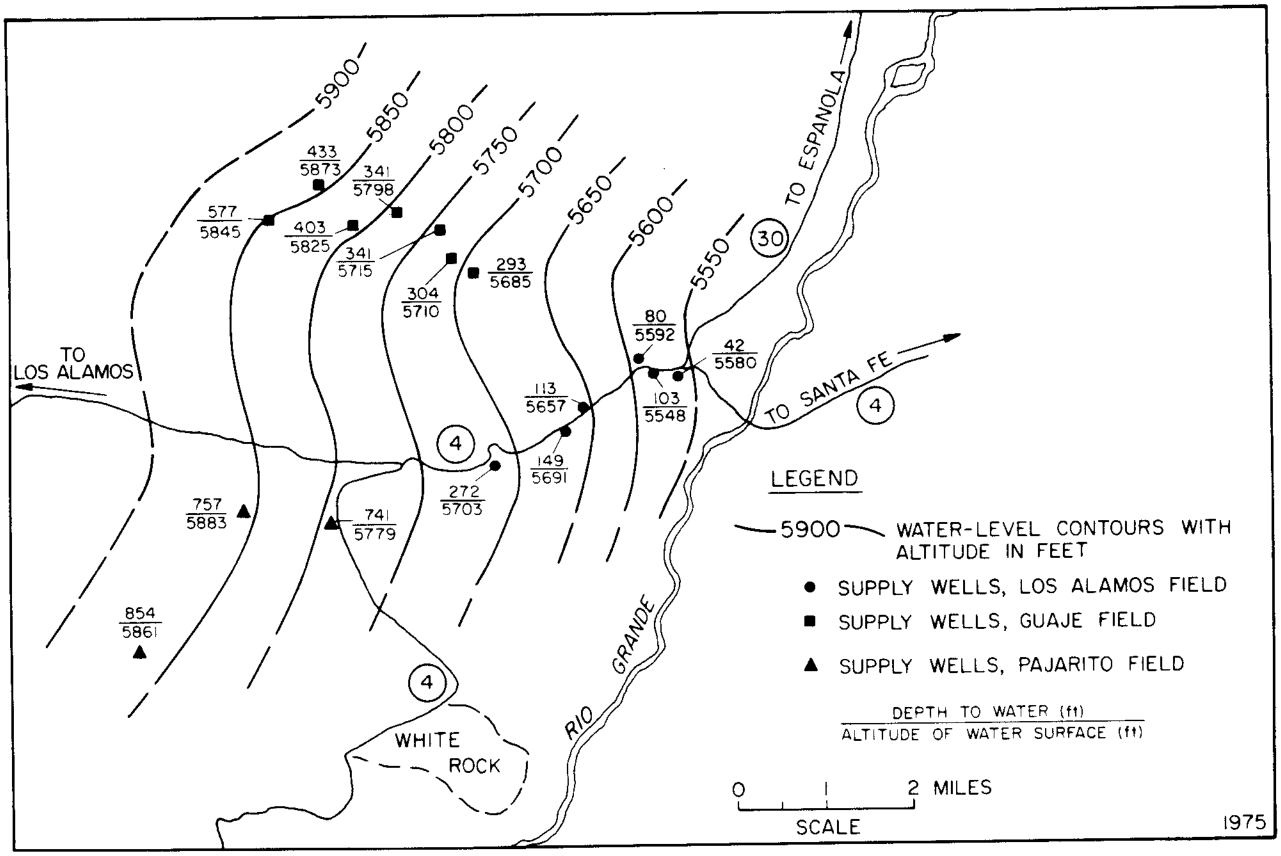

Fig. 2.
Generalized contours on top of the main aquifer.

the well LA-5, completed at a depth of 1750 ft, was 4800 gpd/ft with a specific capacity of 2.9 gpm/ft. Well LA-6 had the highest transmissivity. It was completed at a depth of 1790 ft and had a transmissivity of 15 500 gpd/ft with a specific capacity of 14.6 gpm/ft.

The specific capacity is a product of the transmissivity. Increased transmissivity is indicated by increased specific capacity. The coefficient of permeability is the ratio of transmissivity to the thickness of the aquifer yielding water to the well. The length of screen sections in wells LA-1B, -4, -5, and -6 was based on interpretation of electric logs to determine the permeable sections of the aquifer. The length of screen sections was used to indicate the thickness of the aquifer yielding water to the well. The coefficient of permeability ranged from 8 to 37 gpd/ft^2 (Table I).

The hydrologic characteristics indicate that the relative importance of the wells, from poorest to best producers, respectively, is LA-2, -3, -5, -1B, -4, and -6. Based on specific capacity, transmissivity, and coefficient of permeability, well LA-6 was a better well than the next best well, LA-4, by about a factor of 2. Well LA-6 had a slightly lower production rate than LA-4 due to the size of the pump. As indicated, well LA-6 is a valuable part of the production system in the Los Alamos field.

Well LA-6 was completed at a depth of 1790 ft in 1948. The well contains 420 ft of screen, ranging in lengths of 10 to 40 ft, set at selected intervals of greater permeability in the well. Prior to April 1976, the pump had only been removed from the well once. In January 1963, the pump was removed and sediments were cleaned from a depth of 1775 ft to the original depth of 1790 ft.[8] The specific capacity of the well is greater than any other well in the field. The specific capacity ranged from 13 to 14 gpm/ft prior to October 1971 and since that time has been about 15 gpm/ft or above. The reason for the increase has not been apparent.[9]

TABLE III

TRACE ELEMENTS IN WATER FROM WELLS IN THE LOS ALAMOS FIELD (mg/ℓ)

Constituents	National Interim Standards (Ref. 1)	Analyses[a] by	Date	Los Alamos Well Field					
				LA-1B	LA-2	LA-3	LA-4	LA-5	LA-6
Surfactants (LAS)	---	EIA	1972	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic (As)	0.05	H-8	1974	0.065	0.011	0.003	<0.002	0.012	0.127
Barium (Ba)	1.0	EIA	1974	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium (Cd)	0.01	EIA	1972	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chloride (Cl)	---	H-8	1974	20	16	6	8	8	10
Chromium (Cr)	0.05	EIA	1972	0.02	<0.01	<0.02	<0.01	<0.01	<0.01
Copper (Cu)	---	EIA	1972	<0.01	<0.01	<0.01	<0.01	<0.01	0.08
Cyanide (Cn)	0.02	CEP	1972	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (Fe)	---	EIA	1972	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead (Pb)	0.05	EIA	1972	0.004	0.008	0.001	0.001	0.002	0.010
Manganese (Mn)	---	EIA	1974	<0.05	<0.05	<0.01[b]	<0.05	<0.05	<0.05
Mercury (Hg)	0.002	EIA	1974	<0.0005	<0.0005[c]	---	<0.005	<0.005	<0.005[c]
Nitrate (NO_3)	45	H-8	1974	2.2	2.6	2.2	1.3	1.8	1.3
Selenium (Se)	0.01	H-8	1974	0.001	<0.0005	0.0003	<0.0005	<0.0005	<0.0005
Silver (Ag)	0.05	EIA	1974	<0.05	<0.05	<0.01[b]	<0.05	<0.05	<0.05
Sulfate (SO_4)	---	EIA	1972	44	8.6	4.4	1.8	1.8	4.4
Total Dissolved Solids (TDS)	---	H-8	1974	534	262	212	166	202	374
Zinc (Zn)	---	EIA	1972	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

[a]EIA, State Environmental Improvement Agency.
CEP, Controls for Environmental Pollution, Inc., Santa Fe, NM.
H-8, Los Alamos Scientific Laboratory, Group H-8.

[b]Analyses by CEP.

[c]Analyses by H-8.

TABLE II

CHEMICAL QUALITY OF WATER
(March 1974)

Constituents	Units	Well LA-1B	LA-2	LA-3	LA-4	LA-5	LA-6
Arsenic (As)	μg/ℓ	34	12	6	4	9	211
Silica (SiO_2)	mg/ℓ	43	32	35	32	41	36
Calcium (Ca)	mg/ℓ	7	8	12	12	10	3
Magnesium (Mg)	mg/ℓ	<1	<1	<1	<1	1	<1
Sodium (Na)	mg/ℓ	132	50	28	25	21	53
Carbonate (CO_3)	mg/ℓ	0	0	0	0	0	6
Bicarbonate (HCO_3)	mg/ℓ	292	128	100	68	76	152
Chloride (Cl)	mg/ℓ	18	14	6	5	5	5
Fluoride (F)	mg/ℓ	2.4	1.6	0.6	0.4	0.6	2.1
Nitrate (NO_3)	mg/ℓ	1.7	3.0	2.2	1.7	2.6	1.7
Total Dissolved Solids (TDS)	mg/ℓ	510	286	160	112	176	290
Hardness (Hard)	mg/ℓ	18	20	30	32	28	8
pH		7.9	7.6	8.1	8.2	8.1	8.6
Conductance	(μmho/cm)	640	310	210	160	170	310

(total dissolved solids), and Hard (total hardness) for the period of production from the individual wells. Regression analyses indicated no significant change in these select constituents during the period of production from the individual wells.

In general, in the Los Alamos field there are four slightly different types of water based on Cl, F, and TDS (Fig. 4). Three wells, LA-3, -4, and -5, have similar waters, with Cl of 5 to 6 mg/ℓ, F of 0.4 to 0.6 mg/ℓ, and TDS of 112 to 176 mg/ℓ. Slightly different waters occur at LA-1B with Cl of 18 mg/ℓ, F of 2.4 mg/ℓ, and TDS of 510 mg/ℓ; LA-2 with Cl of 14 mg/ℓ, F at 1.6 mg/ℓ, and TDS of 286 mg/ℓ; and LA-6 with Cl of 5 mg/ℓ, F of 2.1 mg/ℓ, and TDS of 290 mg/ℓ.

There is a slight, but not significant, change in the seasonal quality of water from periods of light (winter) and heavy (summer) production. The average increase for TDS for individual wells from February to July 1974 was about 80 mg/ℓ. The largest increases were from wells LA-1B (408 to 534 mg/ℓ) and LA-6 (238 to 374 mg/ℓ). The TDS increase was slight in the remainder of the wells.

Trace element analyses were made of water from the six wells in 1972-74 (Table III). Only arsenic in water from wells LA-1B and LA-6 exceeded the established levels for municipal use.

Tests were conducted on individual wells in June and July 1973 to determine arsenic concentrations, TDS, and temperature over a 10-hr pumping period. The test period was preceded by an off period for the well of at least 24 hr. The pumping rates ranged from 292 gpm at well LA-2 to 571 gpm at well LA-4 (Table IV). The arsenic concentrations in water from well LA-1B generally decreased during the first 2 hr of the test and then apparently stabilized (Table IV). The TDS and temperature decreased with the increased pumpage.

The arsenic concentration in water from wells LA-2, -3, and -4 varied slightly, but showed no particular trends. Total dissolved solids decreased slightly at LA-2, and temperatures increased about 3°F; both remained stable during the test at LA-3. Total dissolved solids remained stable, and the temperature of the water increased about 8°F during testing at well LA-4.

The arsenic concentration at well LA-5 increased between the 2 and 4 hr of pumpage and then stabilized at about 28 μg/ℓ. Total dissolved solids increased about 60 mg/ℓ and temperature increased about 6°F (Table IV). The arsenic concentration and temperature of water increased slightly during the test at well LA-6. Total dissolved solids varied slightly during the period of pumping.

TABLE IV

ARSENIC, TOTAL DISSOLVED SOLIDS, AND TEMPERATURES DURING A 10-HR PUMPING PERIOD

	Hours Pumped Prior to Sample							
	0.5	1.0	2.0	3.0	4.0	6.0	8.0	10.0
LA-1B (537 gpm)								
As (μg/ℓ)	47	43	40	40	41	38	40	40
TDS (mg/ℓ)	490	470	450	430	420	400	380	380
T (°F)	85	85	85	84	83	83	83	83
LA-2 (292 gpm)								
As (μg/ℓ)	21	20	18	20	19	19	20	23
TDS (mg/ℓ)	230	220	230	230	220	220	220	215
T (°F)	72	73	74	74	75	75	75	75
LA-3 (375 gpm)								
As (μg/ℓ)	9	9	10	10	8	9	<7	<7
TDS (mg/ℓ)	130	130	130	130	130	130	130	130
T (°F)	67	67	67	67	67	67	67	67
LA-4 (571 gpm)								
As (μg/ℓ)	11	12	13	11	12	12	10	12
TDS (mg/ℓ)	100	100	100	100	100	100	100	100
T (°F)	75	76	76	77	78	80	82	83
LA-5 (472 gpm)								
As (μg/ℓ)	12	12	15	23	29	29	27	28
TDS (mg/ℓ)	110	110	110	110	120	150	160	170
T (°F)	71	72	73	74	75	76	76	77
LA-6 (568 gpm)								
As (μg/ℓ)	127	127	125	132	133	129	132	135
TDS (mg/ℓ)	320	330	340	340	330	330	330	300
T (°F)	82	83	83	83	83	83	84	84

dilution with pumpage from well LA-6. The test results are summarized in Table VII, with complete analyses presented in Appendix F.

Six tests were run at well LA-4 to determine arsenic trends with time (Table VII). The average pumping rate for each test ranged from 563 to 593 gpm. There was no significant change in arsenic concentrations during a pumping period. The concentrations ranged from 3 to 7 μg/ℓ.

Six tests were similarly run at well LA-5 to determine arsenic trends with time. The average pumping rate ranged from 440 to 465 gpm. The arsenic concentrations during the first 4 hr of pumping increased sharply from 7 to 20 μg/ℓ, then varied from 20 to 28 μg/ℓ during the remainder of the tests.

Nine tests were run at well LA-6 to determine arsenic trends with pumpage. The average pumping rates ranged from 308 to 773 gpm. The arsenic concentration generally increased during a pumping period. Pumping at different rates resulted in slightly different levels of arsenic, but with no apparent trends. The minimum values ranged from 152 to 191 μg/ℓ; maximum values ranged from 162 to 211 μg/ℓ.

Eight tests were run at Booster 4 on combinations of pumpage from wells LA-4, -5, and -6 (Table VII).

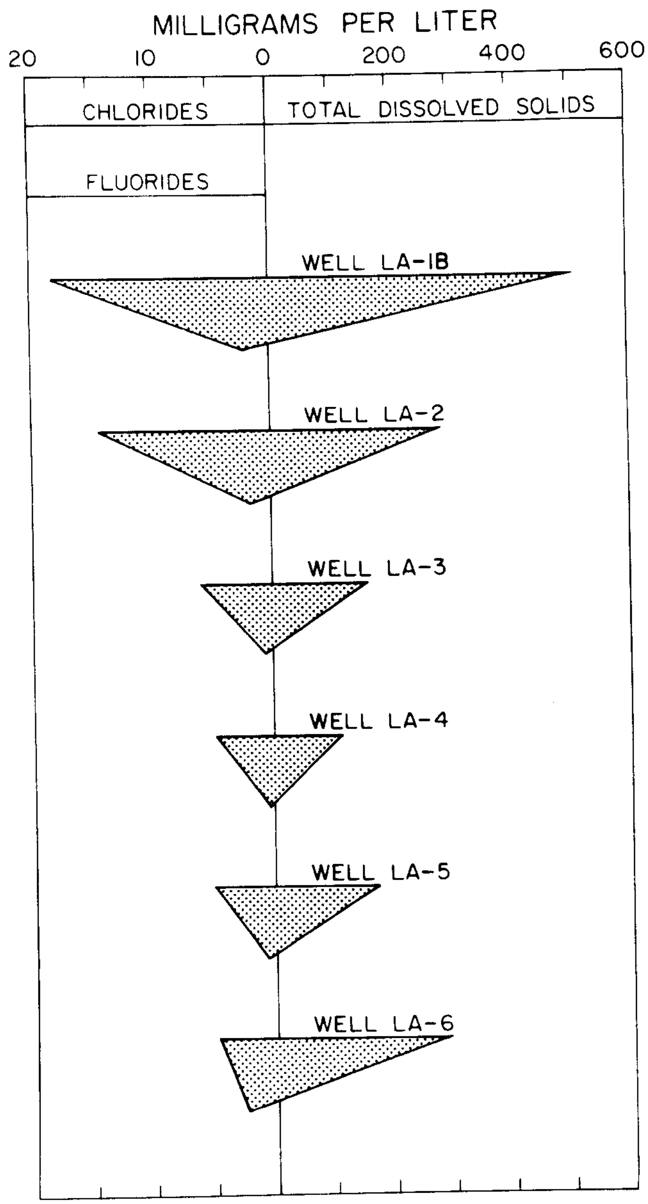

Fig. 4.
Graphic comparisons of chlorides, fluorides, and TDS in water from wells LA-1B, -2, -3, -4, -5, and -6.

From 1972 through 1975, arsenic concentrations from wells LA-1B through LA-5 varied slightly but were within acceptable limits (Table V). The arsenic concentrations at well LA-6 have shown a marked increase since late 1974. Due to the high concentrations, ranging from 160 to 225 μg/ℓ, the well was taken off the line on August 13, 1975. It was determined that dilution within the system could not be attained to meet the acceptable level of 50 μg/ℓ.[1] Since this date, the well has been pumped only for additional tests.

II. ARSENIC STUDIES, AUGUST 1975 — FEBRUARY 1976

Studies were made, through a series of individual tests, to determine arsenic concentrations resulting from pumping certain combinations of wells. Pumpage from well LA-6 was restricted, increased, or diluted with pumpage from wells LA-4 and -5. The arsenic levels were determined by atomic absorption spectrophotometry. Appendix D presents the method of sample collection and quality control data.

A. Combinations of Wells

Arsenic concentrations related to pumpage from certain combinations of wells were measured at Booster 4 and Fire Station 2 during a 62-day period from August to October 1975. Five combinations of well pumpage were used, giving combined pumping rates which ranged from 1055 to 2780 gpm.

All combinations of wells which included pumpage from well LA-6 contained arsenic levels at Booster Station 4 which exceeded the limits of 50 μg/ℓ (Table VI). Individual arsenic concentrations, by various combinations of pumpage from wells at Booster 4, are presented in Appendix E. Pumpage from wells excluding well LA-6 generally contained arsenic concentrations less than 50 μg/ℓ. Pumpage from wells LA-1B, -2, and -3 contained arsenic concentrations of 52 μg/ℓ and 78 μg/ℓ on Aug 15 and Sept 25, respectively, which may have been residual in the system from pumpage of LA-6. These tests indicated that with normal pumping (560 gpm) from LA-6, water in the distribution system will have arsenic concentrations above the acceptable levels.

B. Wells LA-4, -5, -6 and Booster 4

The wells most commonly pumped in combination with well LA-6 are wells LA-4 and -5, which have a high production rate. By restricting the pumping rate of LA-6, it was believed that a mixture of water would result with an arsenic level acceptable for the distribution system. A series of tests were made at wells LA-4 and -5 to establish the base level of arsenic concentration on which to relate mixing or

TABLE VI

SUMMARY OF ARSENIC CONCENTRATIONS AT BOOSTER 4 RESULTING FROM PUMPING BY COMBINATION OF WELLS

Wells Pumped	Combined Pumping Rate (gpm)	No. of Analyses	Arsenic at Booster 4 (μg/ℓ) Range Min	Max	Av
LA-1B, 2, 3, 4, 5, 6	2780	2	72	73	72
LA-4, 5, 6	1625	7	55	74	64
LA-1B, 2, 3, 4, 5	2210	13	3	26	13
LA-1B, 2, 3	1155	9	14	78	33
LA-4, 5	1055	8	6	22	12

-6 in operation. The capacity of three pumps operating at the station is 2300 gpm with about 850 gpm coming from storage.

With one pump (1000 gpm) operated with water going to storage, arsenic concentrations ranged from 54 to 63 μg/ℓ, with an average of 57 μg/ℓ. The arsenic levels increased when two pumps (1800 gpm) were in operation and water was being withdrawn from storage. During the first hour the arsenic averaged 90 μg/ℓ, then dropped to about 53 μg/ℓ during the remainder of the time the two pumps were in operation. When three pumps (2300 gpm) were in operation with water coming both from storage and the wells, the arsenic ranged from 51 to 58 μg/ℓ. The details of the test are presented in Appendix G.

It is apparent from the 6-hr test that mixing of water from the three wells is not complete even though it passes through three stations, tanks, and pumps. Therefore, there will be intervals of pumpage at the station which will contain high arsenic levels that will enter the main distribution line to the Laboratory and community.

Due to incomplete mixing of pumpage from well LA-6 with pumpage from wells LA-4 and -5, it was estimated that the arsenic level in water from well LA-6 would have to be reduced to 100 μg/ℓ at a yield of 300 gpm to reach a safe level in the distribution system. The estimate is based as follows:

Well	Pumping Rate	% of Yield	Av. Con.	Dilute Con.
LA-4	580	43	3	1
LA-5	460	34	25	9
LA-6	300	22	100	22
Estimated concentration at Booster 4				32

Thus an estimated concentration of 32 μg/ℓ at Booster 4 would allow for the surges of high arsenic due to incomplete mixing and maintain levels below limits of 50 μg/ℓ in the distribution system.

Samples were collected in January and February at Fire Station 2 on DP Road and at the storage Twin Tanks in the western area of the community (Table VIII). The fire station receives water from the Los Alamos well field. High levels of arsenic (above 50 μg/ℓ) occurred at the fire station on Jan. 23, Feb. 3, and Feb. 5. The arsenic levels at the Twin Tanks were high on Feb. 5.

All results indicate that high arsenic concentrations will occur in the distribution system when well LA-6 is pumped. There is not enough dilution from the field to reduce the arsenic to levels acceptable for municipal use when LA-6 is being pumped.

III. OCCURRENCE OF ARSENIC AT WELL LA-6

A comparison of the chemical quality of water in well fields reveals that fluorides are generally higher in wells that contain some arsenic. The fluorides in well LA-6 are significantly higher than other wells in the field except wells LA-1B and -2 (Table II). Arsenic concentrations in these wells (LA-1B and -2) average about 40 and 15 μg/ℓ, respectively. The occurrence of fluoride and arsenic is generally associated with igneous rocks; thus, the occurrence of arsenic in high concentrations is probably due to water circulation on or through igneous rocks. Though nearby wells LA-4 and -5 are of about the same depth as well LA-6, the difference in chemical quality of water from well LA-6 when compared to

TABLE V

ARSENIC CONCENTRATIONS IN WELLS IN THE LOS ALAMOS FIELD

($\mu g/\ell$)

Date	Well LA-1B	LA-2	LA-3	LA-4	LA-5	LA-6
1972						
11-4	10	<10	<10	<10	<10	50
12-21	30	<20	<20	<20	<20	160
12-29	---	---	---	---	---	150
1973						
4-12[a]	33	---	---	---	---	138
4-20	33	13	8	7	14	140
6-25[b]	41	20	9	---	---	---
7-10[b]	---	---	---	12	22	130
7-20	72	20	9	12	29	122
9-4[c]	37	---	---	---	---	148
9-14[c]	42	21	---	---	---	161
9-15[d]	---	---	---	---	23	148
10-18	31	8	<1	<1	16	131
1974						
2-28	60	4	3	2	<1	162
5-1	65	15	5	5	15	127
8-1	41	11	3	2	12	127
10-10	35	15	3	3	17	160
1975						
3-27	34	12	6	4	9	211
6-17	36	12	7	5	14	171
10-13	34	12	7	3	16	225

[a]LA-1b Av of 10 analyses.
LA-6 Av of 13 analyses.
[b]Av of 8 analyses.
[c]Av of 3 analyses.
[d]Av of 2 analyses

Note: 11-4-72 analyses by State EIA.
12-21 and 12-29-72 analyses by CEP.

The pumping rate of well LA-6 was varied to control the amount of dilution that occurred in the system. The minimum values during the tests ranged from 7 to 47 $\mu g/\ell$ and maximum values ranged from 51 to 97 $\mu g/\ell$. Due to incomplete mixing in the system, the concentrations varied during the tests, but the general trend was for the concentrations to increase.

As a result of these variations in arsenic concentrations at Booster 4 during testing, the arsenic trend over a 6-hr period was determined by using one, two, and three pumps to transfer water in the system at the booster. The sample collection interval was 0.25 hr. One pump operating at the booster has a capacity to transfer 1000 gpm; thus with LA-4, -5, and -6 in operation about 450 gpm will be diverted into tank storage at the booster. With two pumps operating at the booster about 350 gpm would be withdrawn from storage with LA-4, -5, and

TABLE VIII

ARSENIC CONCENTRATIONS AT FIRE STATION NO. 2 AND TWIN TANKS

January – February 1976

Date	Fire Station No. 2	Twin Tanks
	J	
1-23 (a.m.)	57 ± 3	---
1-23 (p.m.)	60 ± 3	---
1-26	21 ± 2	---
1-27	20 ± 2	---
1-28	12 ± 1	23 ± 2
1-29	20 ± 2	19 ± 2
1-30	20 ± 2	18 ± 1
2-2	21 ± 2	22 ± 2
2-3	55 ± 2	23 ± 1
2-4	21 ± 1	75 ± 3
2-5	52 ± 2	25 ± 1
2-6	56 ± 1	25 ± 1

wells LA-4 and -5 indicates that well LA-6 is located on or near a fault. The fault acts as a highly permeable zone from an igneous source to the well and would account for the high yield of the well and the high arsenic concentration.

If the water is from a deep source and entering the well near the bottom, it may be possible to seal that portion of the aquifer off and produce water from higher zones in the well which would be of a lower arsenic concentration. Therefore, tests were made in April 1976 to try to determine the zones yielding the arsenic to well LA-6.

A. Arsenic at Select Depths

Well LA-6 was pumped for 10 hr at a rate of 570 gpm during April 12 and 13. The pump was pulled from the hole on April 13 through 16. Birdwell Geophysical Surveys collected 20 samples from the well, with a special sampler which allowed samples to be collected adjacent to screens at selected depths. The samples were analyzed for chemical constituents which included arsenic (Table IX). The results of the analyses indicated that below 860 ft the quality of the water deteriorates, with increased concentrations of arsenic, fluorides, and TDS (Fig. 5).

The samples collected at depths of 250 and 350 ft were in blank sections of the casing above screen sections. They indicated no particular trend and contained low concentrations of arsenic and high concentrations of fluoride.

The results of analyses from 480 to 860 ft indicated lower concentrations of arsenic, fluoride, and TD than the samples collected below 860 ft. This indicated movement of water into the well bore which was diluting the higher concentrations of these constituents pumped from the lower sections.

B. Geophysical Logs

Birdwell Geophysical Surveys ran a salinometer log, a gamma ray-neutron log, and four temperature logs in well LA-6 from April 16 through 18. The temperature logs were run prior to and after 30×10^3 gal of water were injected into the well. The logs were made to identify zones of higher yield in the well for use in interpreting results of sample analyses collected at select intervals. The well was logged with a bore hole TV camera to determine depth, length of screens, and condition of the casing.

The salinometer log is a measure of the resistivity of the water to electric current, and thus is a roughly accepted measurement of the TDS. For interpretation purposes, the log is shown as conductance (Fig. 6). The calibration is not refined and should not be construed as conductance reported in Table IX, but is roughly a relative measurement in change of TDS in the bore hole. The conductivities log shows the same general trend as the fluorides and TDS; a general decrease in conductivity through the section below the blank casing at 420 ft to 860 ft, with an increase below that depth. The interpretation is that there is a general inflow of relatively fresh water, of better quality, into the bore hole between the depths of 420 and 850 ft (Fig. 6).

The gamma ray-neutron log was run to determine the lithology of the various units that make up the aquifer adjacent to the bore hole of the well. The log was used, in conjunction with the electric log of well LA-6 (Appendix C), to delineate the more impermeable units — clays and shale — that potentially separate the various water-bearing beds in the aquifer. The impermeable beds would in part separate waters of slightly different quality. The location of the impermeable beds is essential for location of "plugs" for trying to seal off zones containing water with high arsenic concentrations. The

TABLE VII

ARSENIC CONCENTRATIONS DURING TESTS
September 1975 — February 1976

	1975					1976			
	9-22[a]	9-23[a]	9-29	10-1	10-16	1-12	1-23	2-2	2-5[b]
Length of Test (hr)	9.5	8.0	10.5	20.5	23.5	47.6	49.0	47.3	
Well LA-4									
% of Pumpage	40	40	40	43	41	43	39	36	---
Arsenic ($\mu g/\ell$)									
No. of Analyses	---	---	7	11	4	7	5	5	---
Min	---	---	5	6	---	3	3	2	---
Max	---	---	6	7	5	5	5	4	---
Av	---	---	6	6	5	4	4	3	---
Well LA-5									
% of Pumpage	31	31	31	34	31	34	31	28	---
Arsenic ($\mu g/\ell$)									
No. of Analyses	---	---	7	11	2	7	5	5	---
Min	---	---	7	7	---	14	4	2	---
Max	---	---	24	28	28	23	24	22	---
Av	---	---	18	21	28	20	19	16	---
Well LA-6									
% of Pumpage	29	29	29	23	28	23	30	36	100
Arsenic ($\mu g/\ell$)									
No. of Analyses	6	5	7	11	9	14	8	9	6
Min	152	186	176	191	153	160	165	171	156
Max	203	211	194	211	162	185	190	184	168
Av	177	193	185	201	159	169	177	176	160
Booster 4									
Arsenic ($\mu g/\ell$)									
No. of Analyses	6	5	7	11	9	14	8	9	---
Min	18	47	27	19	37	7	21	14	---
Max	77	87	88	97	51	66	61	70	---
Av	48	76	51	64	45	44	52	56	---

[a]No samples collected from wells LA-4 and -5.
[b]Well LA-6 pumped to waste.

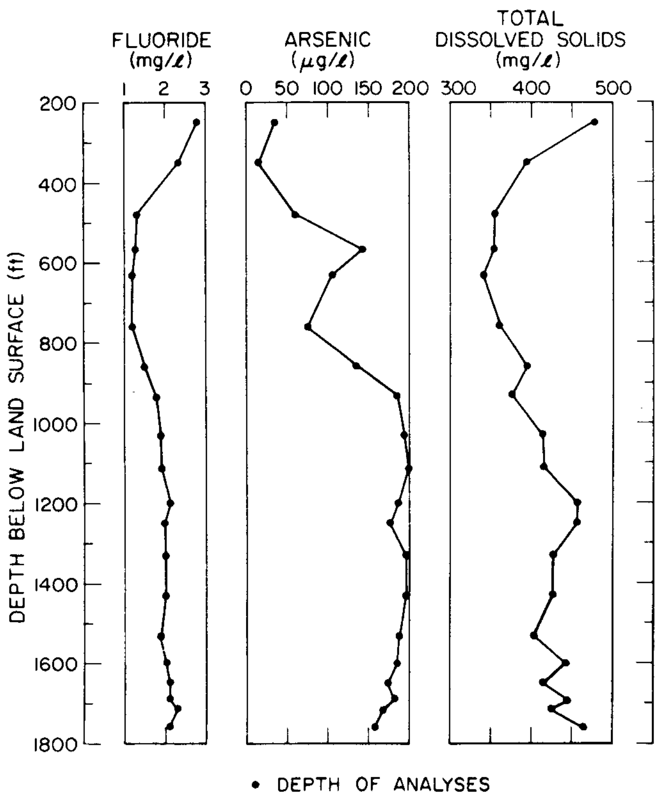

Fig. 5.
Fluoride, arsenic, and TDS at selected depths, well LA-6.

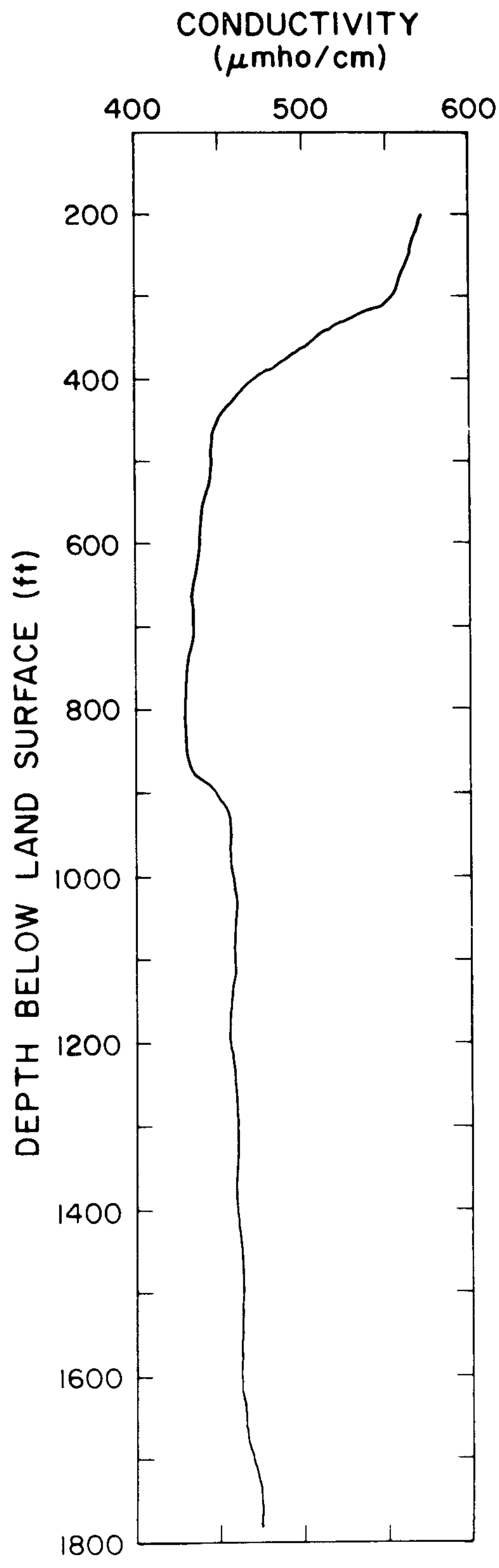

Fig. 6.
Conductance log, well LA-6.

Maximum recovery was about 1.5°F. Recovery temperature logs are shown in Appendix H.

A small temperature recovery after 29 hr below a depth of 820 ft indicates that a larger volume of water was lost in the interval between 820 to 1708 ft, thus depressing the temperature of water in the aquifer. The most permeable section of the well lies below the 800-ft depth. Adjacent wells LA-2 and -3 are completed at depths of 870 ft and the yield from these wells is low when compared to deeper wells in the field.

The well was logged with a TV viewer to determine depth and length of screens and condition of the casing. The casing schedule is shown in Appendix H. There were no breaks in the screens or casing. The screens below a depth of 1300 ft were encrusted with scale to a greater degree than those screens above that depth. The casing and screens were in good condition considering that the well has been in service for about 28 yr.

TABLE IX

CHEMICAL QUALITY OF WATER FROM SELECT DEPTHS
Well LA-6, April 1976

Depth (ft)	Milligrams per Liter											μmho/cm	
	As	Ca	Mg	Na	CO_2	HCO_3	Cl	F	NO_3	TDS	Hard	Cond	pH
250	0.034	10	<1	62	0	140	13	2.8	2.2	479	14	370	7.6
350	0.014	10	<1	57	0	136	8	2.3	2.6	394	12	305	8.4
480	0.060	6	1	48	0	116	4	1.3	2.2	351	12	280	8.4
565	0.142	8	<1	53	0	112	3	1.3	0.9	351	10	280	7.9
630	0.109	6	<1	47	0	114	1	1.2	1.8	342	10	280	8.2
760	0.077	6	1	48	0	116	<1	1.2	3.5	360	12	280	8.3
860	0.137	6	<1	51	0	132	8	1.5	1.8	394	8	305	8.3
935	0.182	8	<1	55	0	136	6	1.8	0.9	377	8	295	8.3
1025	0.193	6	<1	55	0	146	4	1.9	1.8	411	8	325	8.4
1115	0.203	6	<1	55	0	144	7	1.9	1.8	411	8	325	8.3
1200	0.185	8	<1	57	0	146	6	2.1	2.2	455	10	340	8.1
1250	0.179	10	<1	57	10	148	6	2.0	2.2	455	12	340	8.5
1330	0.197	6	1	57	10	148	5	2.0	1.8	428	10	335	8.5
1430	0.195	8	<1	57	0	160	2	2.0	1.8	428	10	335	7.9
1530	0.189	6	<1	57	0	152	2	1.9	1.8	402	8	315	8.2
1600	0.185	8	<1	57	12	154	2	2.0	1.8	445	10	350	8.7
1650	0.171	4	1	57	8	158	2	2.1	2.2	418	10	335	8.5
1685	0.181	6	1	57	8	156	3	2.1	2.2	445	10	350	8.6
1715	0.169	4	<1	51	6	162	4	2.3	1.8	428	6	335	8.6
1760	0.156	6	1	60	4	160	3	2.1	2.2	462	12	360	8.6

gamma ray neutron-log, location of screened sections, and temperature logs of the well made by Birdwell Geophysical Surveys are shown in Appendix H.

Interpretation of the gamma ray-neutron log and electrical logs indicates a number of lenses or units of sediments of relatively low permeability (Table X). These units would provide partial or perhaps total separation within the aquifer adjacent to the well bore and would be a satisfactory depth to set a plug to provide a seal from flow in the lower part of the well.

The first temperature log was run after the well had been shut down for 88 hr. The normal temperature gradient in the area is an increase of 1°F for each 100 ft of depth. The temperature gradient was normal to a depth of about 750 ft, then exceeded the normal gradient to a depth of about 1300 ft (Fig. 7). There were four sharp increases in temperature at depths of 750, 850, 940, and 1040 ft due to the warmer water in the aquifer adjacent to the bore hole.

Below a depth of 1300 ft, the normal temperature gradient became isothermal, averaging about 82°F to about 1700 ft. At this depth, it increased rapidly to reach a normal gradient at 1780 ft of 87.5°F. There was a negative flexure ($\simeq$0.5°F) in the temperature curve at a depth of 1700 ft, indicating a zone containing water of a slightly lower temperature (Fig. 7).

About 30 × 10^3 gal of water were injected in the hole, and temperature logs were run 1.5 and 29 hr after injection. The temperature of the water that was injected was about 76°F. The injected water caused a maximum increase in temperature of 4.5°F in the upper part of the well, to a depth of about 820 ft, in the logs run 1.5 hr after injection. The temperature returned to near normal in this zone 29 hr after injection.

Below a depth of 820 ft, the injected water decreased the temperature for a maximum of 3.5°F in logs run 1.5 hr after injection. The temperature did not return to normal 29 hr after the injection.

was pumped for 70 hr at an average rate of 569 gpm for the first 40.5 hr and at an average rate of 466 gpm for the remaining 29.5 hr. The maximum temperature of the water was 82°F; field conductance ran about 320 μmho/cm for both periods. During the first 40 hr the arsenic concentration ranged from 121 to 156 μg/ℓ, with an average of 142 μg/ℓ (Table XI). In general, the arsenic concentration increased during the first 40 hr of the test (Fig. 8). At the reduced rate of 466 gpm during the remaining 29.5 hr of the test, the arsenic concentration ranged from 140 to 154 μg/ℓ, with an average of 148 μg/ℓ.

The well was shut down for 68 hr, and testing resumed for the period May 10-12. When the pump was removed from the well the sand level had dropped to 1550 ft. It is evident from the increase in the specific capacity that the sand level dropped when the well was shut down prior to the test of May 10-12. The specific capacity increased from 8.8 gpm/ft to 10.6 gpm/ft when another 20-ft section of screen was opened to the well.

During the May 10-12 tests, the well was pumped for 45.5 hr, at a rate of 340 gpm for 31 hr and at a rate of 260 gpm for the remaining 14.5 hr (Table XI). The maximum temperature of the water reached 82°F, with a maximum field conductance of 335 μmho/cm. The arsenic concentrations ranged from 127 to 149 μg/ℓ during the first 31 hr and from 134 to 153 μg/ℓ, with an average of 146 μg/ℓ, during the remainder of the test. The arsenic did not show any specific trends throughout the test period (Fig. 8).

The sand level was raised to 1210 ft below land surface. The gamma ray-neutron log indicated a clay or siltstone from a depth of 1228 to 1246 ft (Table X). The well was pumped for 65 hr at an average rate of 382 gpm for the first 20.5 hr, 437 gpm for the next 24.5 hr, and at 484 gpm for the remaining 20 hr (Table XI). The maximum temperature reached during the first 45 hr of pumping was 81°F; however, during the remaining 20 hr the temperature increased to 82°F. The maximum field conductance during the three periods of pumping at different rates was 340 μmho/cm.

Arsenic concentrations during the first 20.5 hr ranged from 170 to 201 μg/ℓ, with an average of 192 μg/ℓ, at a pumping rate of 382 gpm. During the next 24.5 hr, at a pumping rate of 437 gpm, the arsenic concentrations ranged from 197 to 208 μg/ℓ, with an average of 203 μg/ℓ. For the remaining 20 hr of the test, at a rate of 484 gpm, the concentrations ranged

TABLE XI

ARSENIC CONCENTRATION AND HYDROLOGIC CHARACTERISTICS AT DIFFERENT SAND LEVELS
Well LA-6

Date of Test	Sand Level (ft)	Average Pumping Rate (gpm)	Length of Test (hr)	Maximum Temp (°F)	Maximum Field Cond (μmho/cm)	Arsenic (μg/ℓ) No. of Analyses	Arsenic Range Min	Arsenic Range Max	Arsenic Range Av
May 4-7	1440	569	40.5	82	320	12	121	156	142
	1440	466	29.5	82	325	8	140	154	148
May 10-12	1550	340	31.0	82	335	8	127	149	141
	1550	260	14.5	82	335	3	134	153	146
May 24-27	1210	382	20.5	81	340	6	170	201	192
	1210	437	24.5	81	340	5	197	208	203
	1210	484	20.0	82	340	5	200	208	202
June 7-10	875	385	44.0	79	330	13	112	173	153
	875	300	23.0	79	330	4	168	175	172
	875	560	4.5	79	320	---	---	---	---

TABLE X

INTERPRETATION OF IMPERMEABLE ZONE FROM GEOPHYSICAL LOGS
Well LA-6

Lithology	Depth (ft) From	Depth (ft) To	Thickness (ft)
Silty Sandstone	520	548	28
Clay or Siltstone	770	806	36
Clay or Siltstone	874	912	38
Clay or Siltstone	1066	1077	11
Sandy Clay	1134	1192	58
Clay or Siltstone	1228	1246	18
Clay or Siltstone	1256	1262	6
Siltstone	1342	1410	68
Sandy Clay	1442	1496	54
Clay	1724	1730	6

C. Tests at Selected Depths

As previously stated, below a depth of 860 ft the quality of water deteriorates with increases in arsenic, fluorides, and TDS. Further, the temperature changes after injecting water into the hole indicate the most permeable section of the aquifer occurs below a depth of 800 ft. Based on these data, it was decided to seal this lower section of the well, from the bottom up, at selected intervals and then test to determine if arsenic concentrations decline with the decreased yield.

The intervals were sealed with sand plugs run in the hole with a dump bailer. The sand was mixed with chlorine to prevent bacteria contamination of the well. Sand was used as it could be removed with a sand pump, thus not destroying the well. During tests, water from the well was pumped to waste and into the adjacent canyon, and not into the distribution system. The sand levels in the well were set at depths of 1440 ft, 1210 ft, and 875 ft. The well was pumped for intervals ranging from 45 to 70 hr, with samples collected at intervals over a pumping period. Details of the tests are presented in Appendix I.

The sand level was set at a depth of 1440 ft for the test run May 4-7, just below a 30-ft section of screen. The gamma ray-neutron log indicated a sandy clay from 1442 to 1496 ft (Table X), which should form a partial horizontal boundary in the aquifer. The well

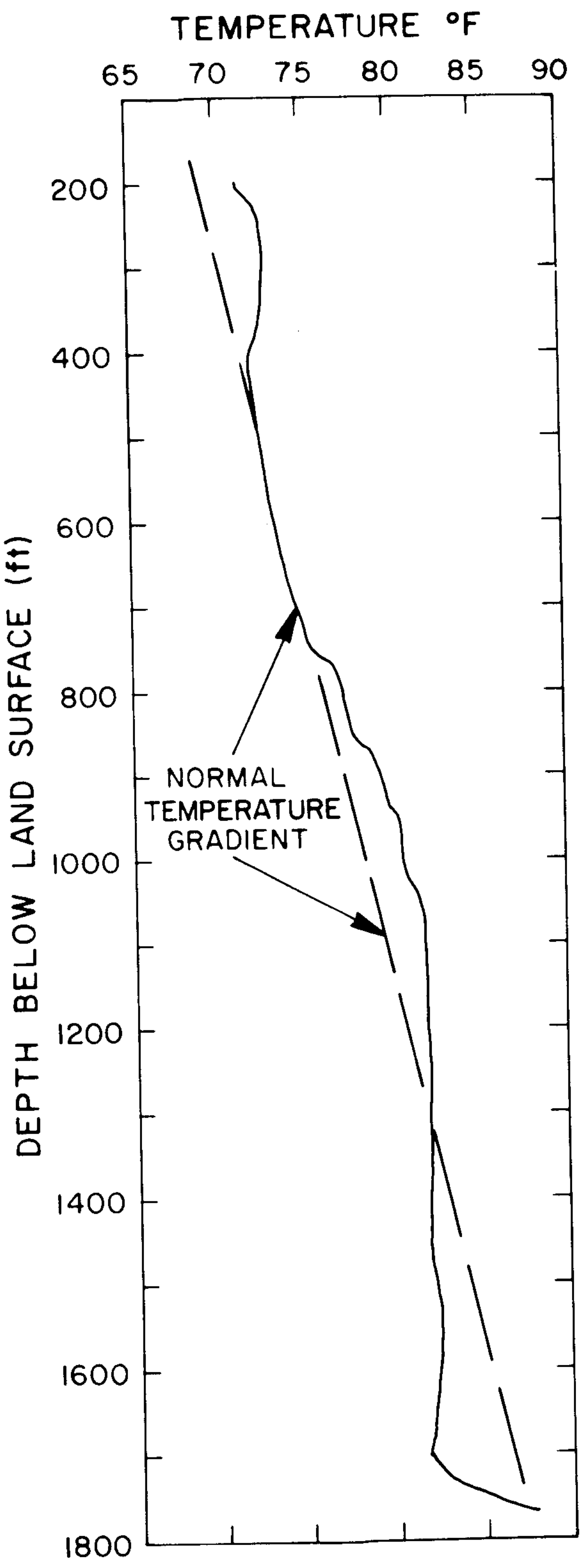

Fig. 7.
Temperature log and normal temperature gradient, well LA-6.

the well with sand would not reduce the arsenic concentrations to levels that would be acceptable in the system.

D. Aquifer Characteristics During Tests

Aquifer characteristics of well LA-6 were identified at selected depths in conjunction with arsenic studies. The transmissivity was calculated to delineate the zones of the aquifer yielding water to the well. The transmissivity was determined during tests where the sand level was at depths of 1440, 1550, 1210, and 875 ft (Fig. 9) by methods previously described.

The well, completed at a depth of 1790 ft, has a permeable section of 420 ft based on length of screen in the well between the depth of 420 to 1790 ft. The specific capacities decreased from 16.7 gpd/ft of drawdown with a permeable section of 420 ft open to the well to 5.8 gpd/ft of drawdown when the permeable section was reduced to 150 ft (Table XII). The transmissivity decreased from 15 500 to 4100 gpd/ft, along with the decrease in the permeable section.

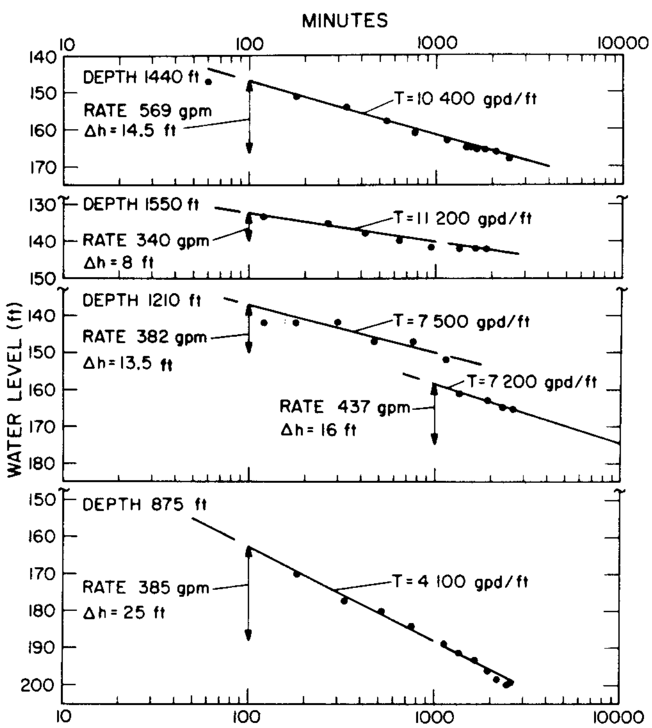

Fig. 9.
Transmissivity at depths of 1440, 1550, 1210, and 875 ft, well LA-6.

The percent of yield at selected depths of the sand level was estimated from the transmissivity. The largest percentage of yield (28%) came from the 1550- to 1790-ft zone, with the next largest (20%) from 420 to 875 ft (Fig. 10). About 54% of the yield came from screen sections below the depth of 1210 ft. Using a velocity survey, Cushman calculated that 50% of the yield from well LA-1B was from screens below 1100 ft.[8]

The transmissivities of the individual sections ranged from 800 to 4300 gpd/ft, with coefficient of permeabilities ranging from 27 to 72 gpd/ft^2 (Table XIII). Based on the coefficient of permeability, the most permeable section of the well is within the 1550- to 1790-ft zone, which is from a 60-ft section of screen (Fig. 11). This is a factor of 3 greater than the section from 420 to 875 ft, which is from 150 ft of screen. In general, the coefficient of permeability increases with depth within the aquifer and corresponds with the interpretation of temperature changes and recoveries that occurred with injecting water into the well during the geophysical logging.

Sand was removed from 875 to 1200 ft during the latter part of July 1976. A 6-hr aquifer test was run on October 5, 1976, to determine if any damage to the well had resulted from the sand placed in the well. The well was pumped to waste at an average rate of 715 gpm. The transmissivity computed during water level drawdown was 7300 gpd/ft, while the transmissivity determined from water level recovery was about 7550 gpd/ft (Fig. 12). The test made in May 1976 at a depth of 1210 ft indicated transmissivity of 7200 to 7500 gpd/ft. There was a slight, but not significant, change in the transmissivity when the two tests were compared.

The nonpumping water level at the start of the test was at 103 ft. The pumping level after 10 hr (projected from Fig. 12 for comparison with a prior test) was at 195 ft. Using the pumping rate of 715 gpm and a drawdown of 92 ft, the specific capacity of the well after 10 hr of projected pumping would be about 7.8 gpm/ft of drawdown. The specific capacity had declined about 1.1 gpm/ft of drawdown when compared to the previous test (Table XII). The change in specific capacity is not considered significant, considering differences in pumping rates of the two tests (May, 382 gpm; October, 715 gpm). The arsenic concentrations during this test ranged from 142 to 172 μg/ℓ.

from 200 to 208 μg/ℓ, with an average of 202 μg/ℓ. In general, after the first 5 hr of pumping when the arsenic concentration increased, there were no significant changes in the arsenic levels (Fig. 8).

The sand level was raised to a depth of 875 ft for the tests of June 7-10. The gamma ray-neutron log indicated a clay or siltstone from a depth of 874 to 912 ft (Table X). The well was pumped for 71.5 hr at

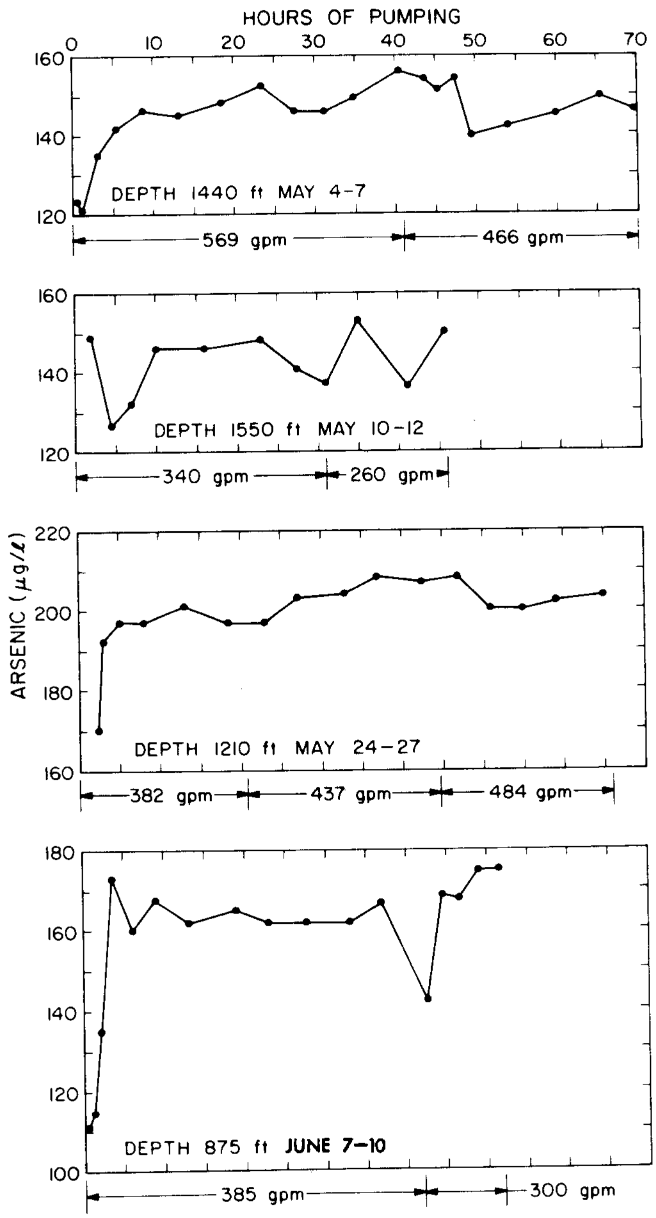

Fig. 8.
Arsenic concentrations during tests with sand levels at depths of 1440, 1550, 1210, and 875 ft, well LA-6.

an average rate of 385 gpm for the first 44 hr, 300 gpm for the next 23 hr, and 560 gpm for the remaining 4.5 hr. The maximum temperature reached during the entire test was 79°F. Water bearing zones deeper in the well had been sealed (Fig. 7).

The arsenic concentrations for the first 44 hr of pumping, at a rate of 385 gpm, ranged from 112 to 173 μg/ℓ with an average of 153 μg/ℓ. During the next 23 hr of pumping, at a rate of 300 gpm, the arsenic ranged from 168 to 175 μg/ℓ, with an average of 172. No samples were collected during the latter part of the test because the rate was increased to 560 gpm to test the hydrologic characteristics of the well at a high rate of production.

The arsenic concentration during the test of June 7-10 increased rapidly during the first 5 hr of the test and then varied slightly (Fig. 8). There was a sharp decline in concentration to about 142 μg/ℓ, when the pumping rate was reduced after 44 hr of pumping; however, the next four analyses increased, in the range of 168 to 175 μg/ℓ, to the end of the test (Fig. 8).

The sealing off of selected depth intervals in the well did not reduce the arsenic level in well LA-6 enough to allow dilution in the system to meet acceptable standards. The well was cleaned out to a depth of 1200 ft, where a 10-ft tail pipe from the pump was lost in the well during the test of May 24-27. Attempts to retrieve the tail pipe from the well failed. A recovery tool attached to the tail pipe was left in the well. The sand had compacted around the tail pipe so that it could not be recovered. The pump was replaced in the well, and it was placed on standby to be used only for emergencies. The discharge line from the well was modified so that the well can be pumped to waste. This allows the well to be run periodically for maintenance without pumping directly into the system.

It is evident from the tests that the bore of the well crosses, or is located adjacent to, a fault that is a permeability zone carrying arsenic laden water up from depth. Permeable beds in the aquifer, which intersect the fault and well, have distributed the water throughout the entire section of the well. Testing terminated at 875 ft because the yield of the well had been reduced and further blocking of screen sections would have reduced the yield so that it would not be economical for use. Also, it was apparent, due to the distribution of arsenic throughout the aquifer, that further reduction of the depth of

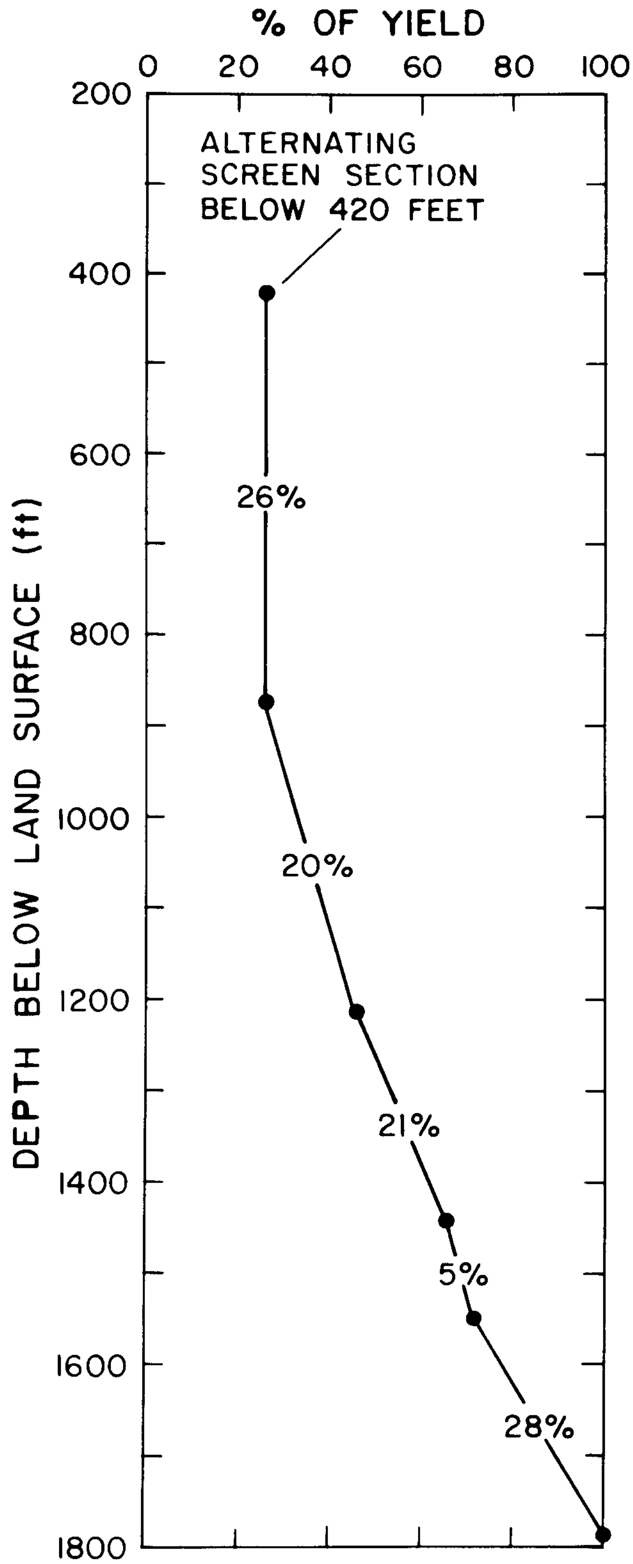

Fig. 10.
Percentage of yield from total depth (1790 ft) based on transmissivity, well LA-6.

TABLE XII

SPECIFIC CAPACITIES AND TRANSMISSIVITY OF WELL LA-6 May — June 1976

Depth (ft) From	Depth (ft) To	Permeable[a] Section (ft)	Specific[b] Capacity (gpd/ft)	Transmissivity (gpd/ft)
420	1790	420	16.7	15 500
420	1550	360	12.1	11 200
420	1440	340	10.3	10 400
420	1210	250	8.9	7 200
420	875	150	5.8	4 100

[a]Based on screen section.
[b]After 10 hr of pumping.

TABLE XIII

TRANSMISSIVITY AND COEFFICIENT OF PERMEABILITY OF DIFFERENT ZONES WELL LA-6 May — June 1976

Depth (ft) From	Depth (ft) To	Permeable[a] Section (ft)	Transmissivity (gpd/ft)	Coefficient of Permeability (gpd/ft^2)
420	875	150	4100	27
875	1210	100	3300	33
1210	1440	90	3000	33
1440	1550	20	800	40
1550	1790	60	4300	72

[a]Based on screen section.

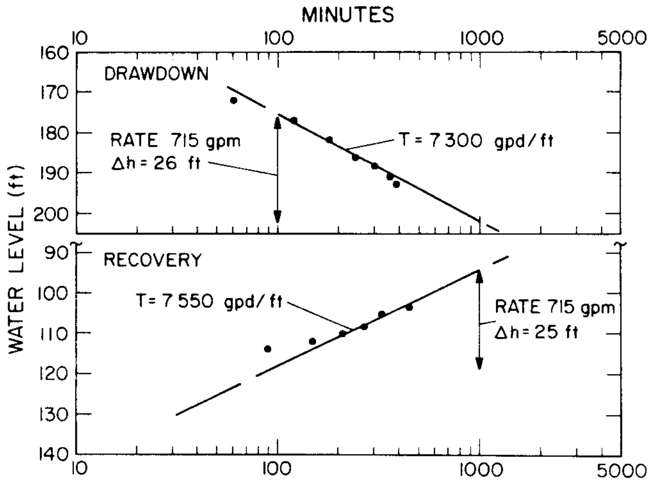

Fig. 12.

Transmissivity (drawdown and recovery) after sand removal from 875 to 1210 ft, well LA-6.

IV. CONCLUSIONS

The wells of the Los Alamos field are completed in the Tesuque Formation; however, due to localized conditions of the aquifer adjacent to the wells, hydrologic characteristics and the chemical quality of water from the individual wells are different.

The high arsenic concentration in water from well LA-6 (range 141 to 203 μg/ℓ) precludes use of this water for municipal water supply. It was calculated that the arsenic level from well LA-6 would have to be reduced to 100 μg/ℓ, at a pumping rate of 300 gpm, for dilution by pumpage from the other wells in the field to bring it to an acceptable level in the distribution system.

The arsenic bearing waters at well LA-6 are from a deep source and are circulated upward through a permeable fault zone that crosses or lies adjacent to the well. Permeable beds intersecting the well bore have distributed arsenic throughout the vertical section of the aquifer penetrated by the well; hence,it is impossible to seal arsenic bearing waters out of the well. Hydrologic characteristics determined during testing of well LA-6 indicate that over 50% of the total yield was from a depth of below 1210 ft and that the most permeable zone in the well occurred below the depth of 1550 ft.

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7. L. K. Wenzel, "Methods for Determining Permeability of Water-Bearing Materials," U. S. Geol. Survey Water-Supply Paper 887 (1942).
8. R. L. Cushman, "An Evaluation of Aquifer and Well Characteristics of Municipal Well Fields in Los Alamos and Guaje Canyons, Near Los Alamos, New Mexico," U. S. Geol. Survey Water-Supply Paper 1809-D (1965).
9. R. L. Cushman and W. D. Purtymun, "Evaluation of Yield and Water-Level Relations," Los Alamos Scientific Laboratory report LA-6086-MS (1975).
10. "Comprehensive Plan for Water System Improvements, Los Alamos, New Mexico," Gordon Herkinhoff and Associates, Inc., Engineers and Planners, 302 8th St., Albuquerque, New Mexico, 87102, Contract Number AT(29-1)-2201 (1947).

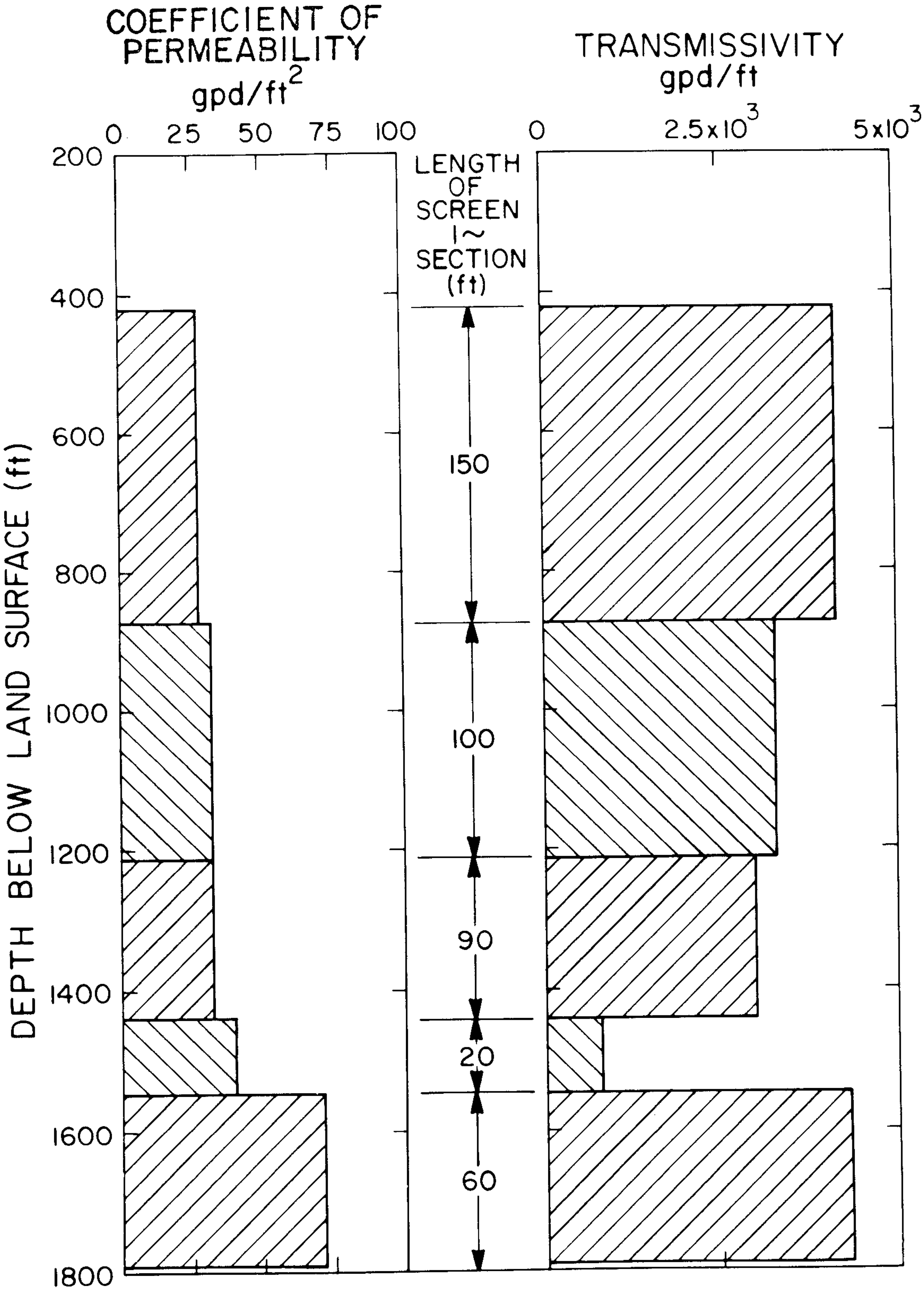


Fig. 11.

Coefficient of permeability, length of screen (permeable section), and transmissivity of intervals tested, well LA-6.

public hearing on granting the variance subject to the prescribed compliance schedule; (4) if a variance is granted, the water supplier must undertake to meet the compliance schedule as expeditiously as practicable as the state determines may reasonably be achieved; and (5) a variance must be conditioned on compliance by the public water system with the prescribed timetable in the schedule.

The Act provides for procedures for EPA approval, review, and revocation of a state issued variance. EPA has the responsibility for granting variances if a state does not have a primary responsibility for enforcement of the Act. There are no absolute deadlines for revocation of a variance. Except as subject to the requirements of a schedule of compliance, a variance may be continued indefinitely. Variances are to be reviewed every three years, but will not be revoked or rescinded unless there is a definite change in technology available.

Abstracted from "Safe Drinking Water Act," Twenty-First Annual New Mexico Water Conference, New Mexico Water Resources Research Institute, Las Cruces, New Mexico (1976).

APPENDIX A

EXEMPTIONS AND VARIANCES FROM THE SAFE DRINKING WATER ACT (SWDA-PL93-523)

The Act provides for a system of either state or EPA issued exemptions and variances that allow at least temporary, conditional use of a water supply that fails to meet a Primary Regulation. Because of the incorporation of compliance schedules in all exemptions and variances, it is anticipated that eventually virtually all public water will comply with the Primary Regulations. Some exceptions under the variance provisions may be possible so that a system may never have to come into compliance if certain conditions exist (e.g., adequate technology is not available).

Exemptions

By state approval, one or more exemptions may be obtained for any supply, either with respect to meeting maximum contaminant level regulations or a treatment requirement that is specified as a Primary Regulation.

The reasons for granting an exemption for systems that were in operation at the time that a Primary Regulation became effective are: (1) compelling factors such as economics prevent a public water supply system from meeting either a maximum contaminant level or a treatment technique requirement; and (2) granting an exemption will not result in an unreasonable risk to health.

Exemptions are relatively short-termed, depending on financing, construction, and other factors, and have finite deadlines for discontinuance. The conditions for granting an exemption to a public water supply are: (1) within one year after granting an exemption, a state must issue a schedule of compliance that contains deadlines for increments of progress for each element in the Primary Regulations not met; (2) any control measures specified by the state as a condition must be implemented; (3) the state provides notice and opportunity for public hearing because schedule of compliance is ordered; and (4) the public water supply meets the compliance schedule to lift the exemption, as expeditiously as practicable, but certainly by the specific deadlines.

Specific deadlines for exemptions are: (1) for those based on the Interim Primary Regulations, all single public water systems must be in compliance by January 1, 1981; and (2) for those based on Revised Primary Regulations, seven years after the effective date of a revised regulation and an additional two years may be granted to suppliers joining a regional system.

EPA and a state must act on an application for exemption within a reasonable period of time after it is submitted. EPA has the responsbility for granting exemptions if a state does not have primary responsibility for enforcement under provisions of the Act. Enforcement of an exemption compliance schedule is to be under state law, or by EPA if a state does not qualify for enforcement responsibility.

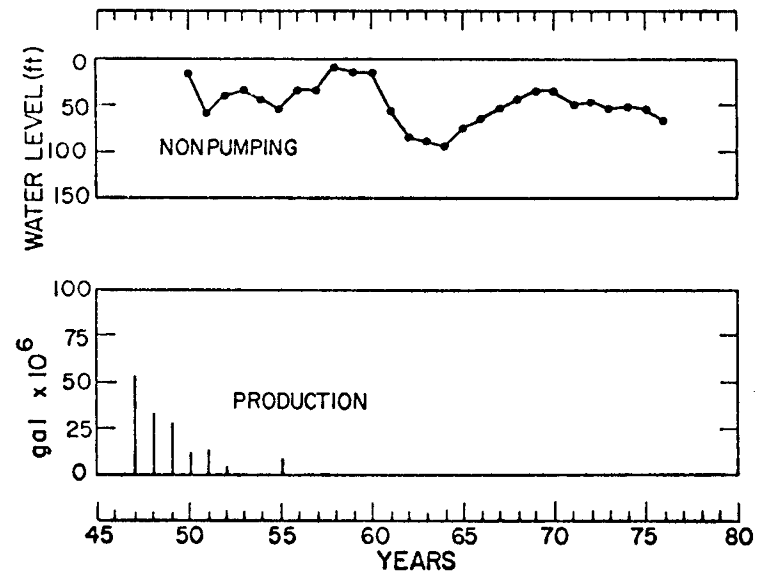
Variances

The reasons for granting a variance are: (1) the available sources of raw water have characteristics that cannot meet requirements respecting maximum allowable contaminant levels, despite the application of best available technology, treatment techniques, or other means, taking costs into the consideration, and that unreasonable risk to public health will not result; or (2) a public water system demonstrates to the state's satisfaction that a treatment process specified by the Regulations is not necessary to protect the health of the persons because of the nature of the raw water source of such a system. (Such a variance is conditioned on monitoring or other requirements as EPA may prescribe.)

The conditions for granting variances are: (1) before a proposed variance may take effect, a state must provide notice and opportunity for public hearing; (2) if a state grants a variance, it must, within one year, provide a schedule for compliance including increments of progress, and the system must implement any control measure that the state may require; (3) before a state-prescribed schedule may take effect, it must provide notice and hold a

Well LA-1

Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)
1947	3468	54.0	259.6	---
1948	2988	34.7	193.4	---
1949	1361	26.7	327.3	---
1950	563	10.5	310.9	18.9
1951	1215	14.6	200.3	59.1
1952	286	3.4	201.0	40.0
1953	0	0.0	0.0	35.7
1954	0	0.0	0.0	44.0
1955	690	9.7	234.8	51.3
1956	39	0.0	0.0	33.5
1957	0	0.0	0.0	33.2
1958	0	0.0	0.0	10.0
1959	0	0.0	0.0	13.3
1960	0	0.0	0.0	13.2
1961	0	0.0	0.0	58.7
1962	0	0.0	0.0	83.9
1963	0	0.0	0.0	90.4
1964	0	0.0	0.0	95.4
1965	0	0.0	0.0	76.3
1966	0	0.0	0.0	69.7
1967	0	0.0	0.0	52.3
1968	0	0.0	0.0	42.0
1969	0	0.0	0.0	37.7
1970	0	0.0	0.0	37.1
1971	0	0.0	0.0	50.7
1972	0	0.0	0.0	49.4
1973	0	0.0	0.0	55.0
1974	0	0.0	0.0	52.7
1975	0	0.0	0.0	57.5
1976	0	0.0	0.0	69.2



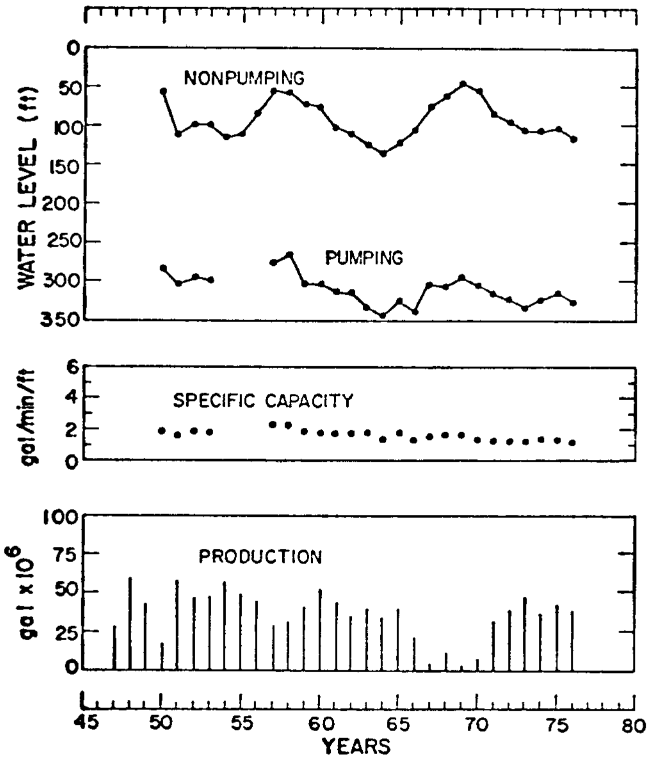
Annual average nonpumping water level and annual production, Los Alamos Well LA-1.

APPENDIX B

CHARACTERISTICS OF WELLS IN THE LOS ALAMOS FIELD

Well LA-2

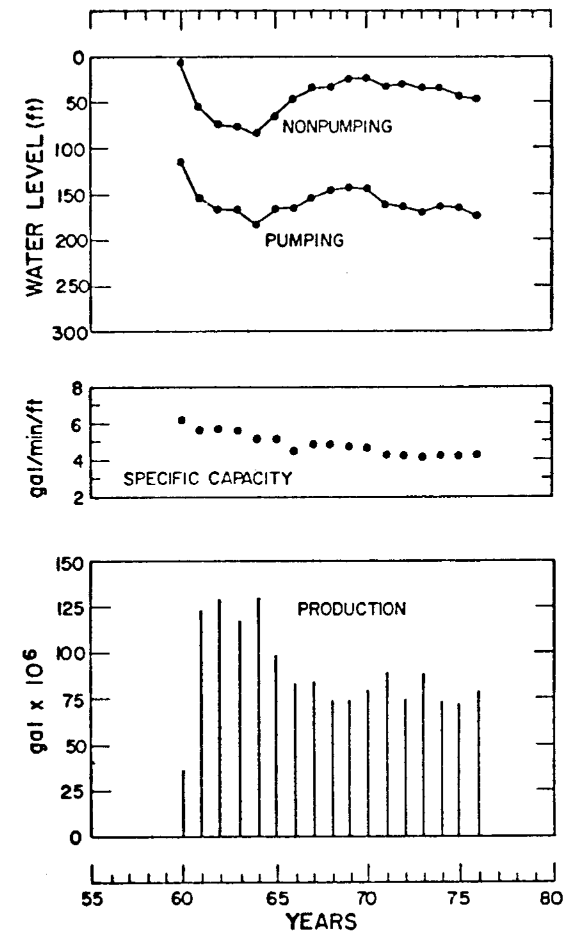
Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)	Pump (ft)	Drawdown (ft)	Spec Cap (gpm/ft)
1947	963	27.6	297.4	---	---	---	---
1948	3659	59.3	270.1	---	---	---	---
1949	1654	41.8	420.9	---	---	---	---
1950	614	15.6	423.6	58.7	285.4	226.8	1.9
1951	2415	57.7	296.8	111.2	304.7	193.5	1.5
1952	1980	46.3	379.8	100.8	299.6	198.8	1.9
1953	2201	47.2	357.8	100.4	300.7	200.3	1.8
1954	2601	56.8	364.1	116.0	---	---	---
1955	2223	49.4	370.2	110.3	---	---	---
1956	1805	44.2	407.8	83.8	---	---	---
1957	1066	29.6	463.0	53.5	277.0	223.5	2.1
1958	1166	31.1	445.1	59.6	269.7	210.1	2.1
1959	1599	40.7	424.6	71.3	303.0	231.7	1.8
1960	2169	51.6	396.6	76.4	304.7	228.2	1.7
1961	2149	44.4	344.3	101.2	312.9	211.7	1.6
1962	1823	35.7	326.3	110.7	313.8	203.1	1.6
1963	1999	40.7	339.7	126.9	332.2	205.3	1.7
1964	1924	34.2	296.3	137.3	346.7	209.5	1.4
1965	1911	39.8	346.7	121.2	329.8	208.7	1.7
1966	1070	21.4	332.7	108.4	340.5	232.1	1.4
1967	238	4.9	346.4	77.6	303.7	226.1	1.5
1968	502	11.3	374.8	63.8	305.0	241.2	1.6
1969	155	3.8	407.2	49.8	297.4	247.6	1.6
1970	341	7.2	353.8	59.3	309.8	250.5	1.4
1971	1787	31.8	296.2	87.5	317.6	230.1	1.3
1972	2189	39.3	299.0	96.4	322.4	226.0	1.3
1973	2625	46.7	296.5	106.4	333.7	227.3	1.3
1974	2033	36.8	301.4	109.2	324.6	215.3	1.4
1975	2310	40.2	289.9	102.7	319.7	217.0	1.3
1976	2488	39.9	367.3	113.2	322.1	208.9	1.3



Annual average nonpumping and pumping water levels, annual average specific capacity, and annual production, Los Alamos Well LA-2.

Well LA-1B

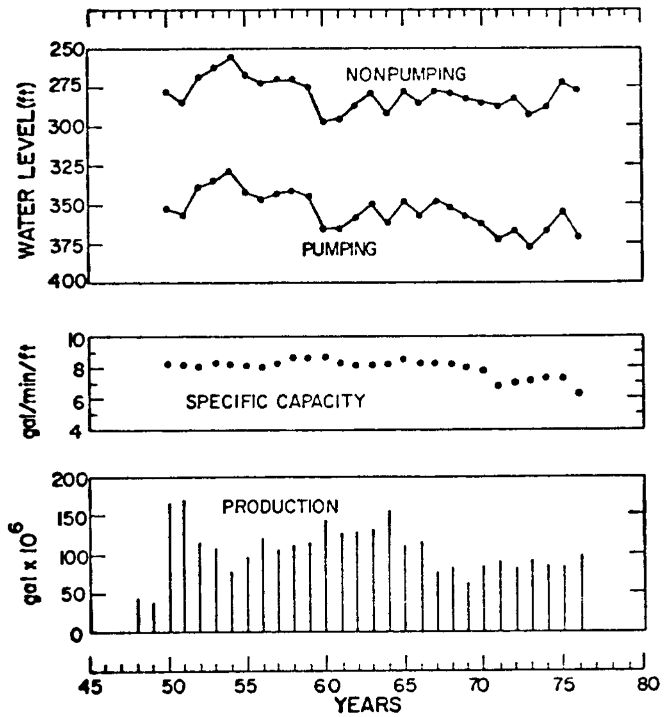
Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)	Pump (ft)	Drawdown (ft)	Spec Cap (gpm/ft)
1960	415	36.3	644.3	6.5	111.5	105.0	6.1
1961	3727	124.7	557.8	53.8	154.2	100.3	5.6
1962	3936	129.1	546.8	71.9	168.7	96.7	5.7
1963	3649	117.4	536.0	74.3	169.6	95.2	5.6
1964	4174	130.2	520.3	81.3	182.8	101.5	5.1
1965	3007	97.9	542.5	63.3	169.5	106.3	5.1
1966	2589	83.9	540.4	49.9	169.2	119.3	4.5
1967	2519	84.9	562.0	39.2	153.2	114.0	4.9
1968	2183	74.0	564.9	31.8	146.5	114.7	4.9
1969	2244	75.7	562.2	21.9	142.3	120.4	4.7
1970	2369	79.7	560.6	22.4	143.2	120.8	4.6
1971	2633	89.1	564.3	31.2	161.7	130.5	4.3
1972	2215	75.3	566.2	30.7	162.8	132.2	4.3
1973	2628	87.2	553.0	37.1	170.4	133.3	4.1
1974	2282	73.9	539.7	35.2	161.3	126.2	4.3
1975	2308	74.4	537.4	42.4	168.0	125.6	4.3
1976	2521	79.6	526.3	49.8	175.8	126.0	4.2



Annual average nonpumping and pumping water levels, annual average specific capacity, and annual production, Los Alamos Well LA-1B.

Well LA-4

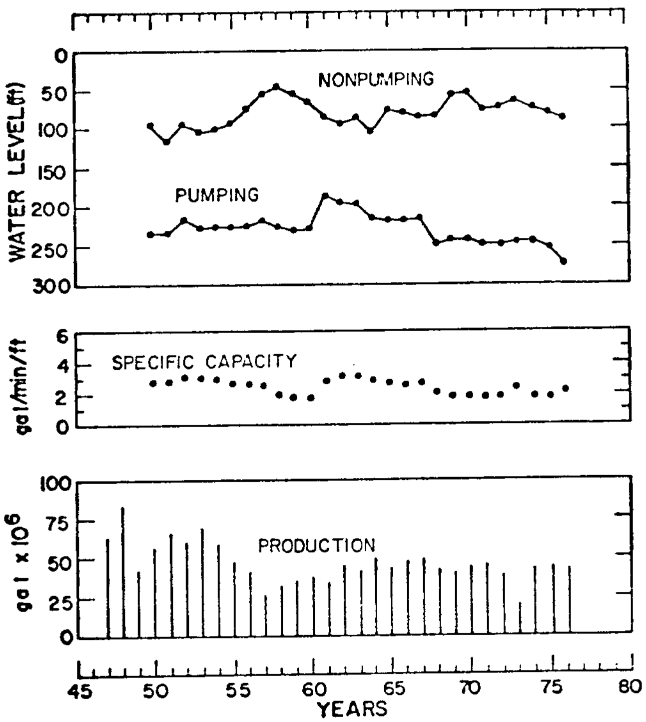
Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)	Pump (ft)	Drawdown (ft)	Spec Cap (gpm/ft)
1948	1570	42.7	453.6	---	---	---	---
1949	940	37.5	664.7	---	---	---	---
1950	4350	164.9	632.0	277.5	352.7	75.2	8.4
1951	4909	173.6	589.6	285.0	356.7	71.7	8.2
1952	3429	119.6	581.2	267.3	339.2	71.9	8.1
1953	3034	109.1	599.4	263.7	335.4	71.7	8.4
1954	2133	78.2	611.0	255.0	328.8	73.8	8.3
1955	2647	94.5	594.9	268.3	341.5	73.2	8.1
1956	3402	120.2	589.0	272.8	346.3	73.5	8.0
1957	2844	105.4	617.5	270.0	344.7	74.7	8.3
1958	2973	110.3	618.6	270.4	342.4	72.0	8.6
1959	3084	113.5	613.4	275.0	345.9	70.9	8.6
1960	4084	145.6	594.2	296.3	365.4	69.1	8.6
1961	3687	129.7	586.2	295.5	365.2	69.7	8.4
1962	3688	129.3	584.5	286.4	358.7	72.3	8.1
1963	3718	130.5	584.9	279.8	350.8	71.0	8.2
1964	4500	155.0	574.2	291.0	361.1	70.1	8.2
1965	3110	111.4	597.1	279.1	349.4	70.3	8.5
1966	3279	115.6	587.8	285.3	356.0	70.7	8.3
1967	2127	77.1	604.5	277.5	349.9	72.5	8.3
1968	2276	81.7	598.0	279.6	351.5	71.9	8.3
1969	1694	61.8	608.1	282.0	358.0	76.0	8.0
1970	2333	83.5	596.5	285.7	363.4	77.7	7.7
1971	2519	89.0	588.6	287.0	372.6	85.6	6.9
1972	2322	82.6	592.8	282.3	366.6	84.2	7.0
1973	2616	92.4	588.5	294.2	376.6	82.3	7.1
1974	2306	82.2	593.9	286.1	366.5	80.4	7.4
1975	2319	82.3	591.4	272.0	355.0	83.0	7.1
1976	2802	98.2	584.1	277.2	373.5	96.3	6.1



Annual average nonpumping and pumping water levels, annual average specific capacity, and annual production, Los Alamos Well LA-4.

Well LA-3

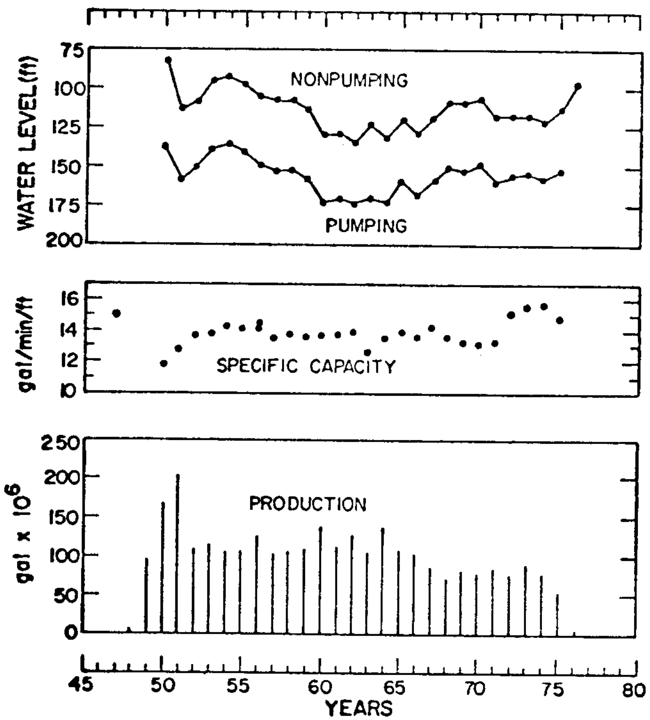
Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)	Pump (ft)	Drawdown (ft)	Spec Cap (gpm/ft)
1947	1476	64.9	373.2	---	---	---	---
1948	3647	82.5	377.0	---	---	---	---
1949	1505	41.7	461.7	---	---	---	---
1950	2793	57.8	344.6	97.0	231.1	134.1	2.6
1951	3554	66.9	313.5	116.2	232.6	116.4	2.7
1952	2514	58.6	388.2	94.1	218.1	124.0	3.1
1953	3104	69.7	374.1	102.7	229.1	126.4	3.0
1954	2595	57.3	368.1	100.7	224.7	123.9	3.0
1955	2195	48.7	369.4	91.2	225.7	134.6	2.7
1956	1849	42.1	379.7	73.8	221.6	147.8	2.6
1957	1080	26.1	402.4	55.7	218.6	162.9	2.5
1958	1612	33.6	347.7	49.4	224.8	175.4	2.0
1959	1821	35.0	319.9	54.1	230.9	176.8	1.8
1960	2174	38.4	294.4	67.6	229.5	161.9	1.8
1961	1939	34.7	298.4	85.0	189.2	104.2	2.9
1962	2361	45.4	320.5	92.6	192.3	99.7	3.2
1963	2128	42.5	332.5	89.8	197.0	107.2	3.1
1964	2574	50.4	326.4	104.5	217.4	112.9	2.9
1965	1961	43.4	368.8	79.2	219.8	140.6	2.6
1966	2236	46.1	343.9	80.9	219.3	138.4	2.5
1967	2274	47.4	347.4	86.0	217.7	131.7	2.6
1968	2127	42.7	334.9	81.6	250.6	169.0	2.0
1969	2072	40.1	322.2	58.3	246.2	187.8	1.7
1970	2303	44.0	318.7	55.0	241.1	186.1	1.7
1971	2556	45.4	296.3	76.8	250.4	173.6	1.7
1972	2205	39.7	299.8	72.7	250.6	177.8	1.7
1973	977	20.3	346.4	64.6	248.0	183.4	1.9
1974	2291	43.5	316.4	72.8	244.5	171.7	1.8
1975	2306	43.3	313.0	79.9	252.7	172.7	1.8
1976	2474	42.3	284.9	88.0	221.5	133.5	2.1



Annual average nonpumping and pumping water levels, annual average specific capacity, and annual production, Los Alamos Well LA-3.

Well LA-6

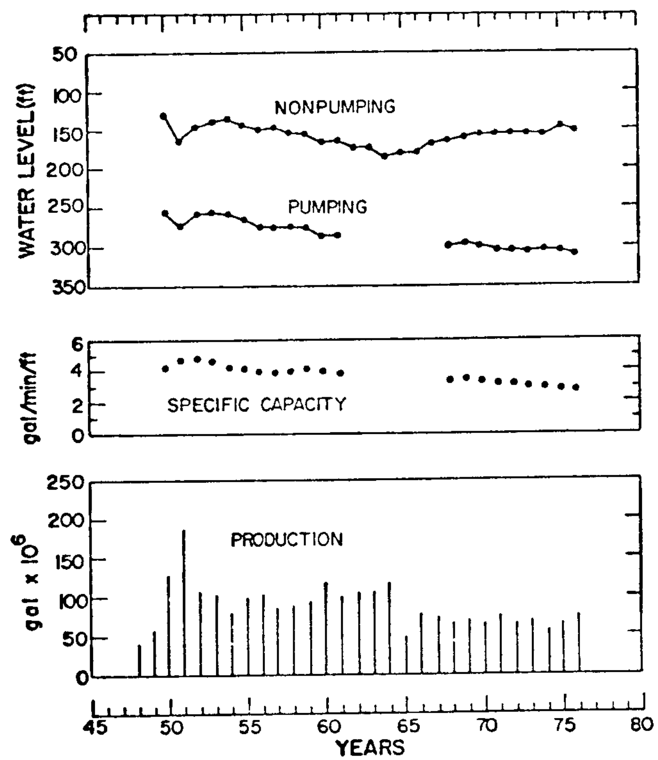
Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)	Pump (ft)	Drawdown (ft)	Spec Cap (gpm/ft)
1948	116	4.9	698.1	---	---	---	---
1949	2451	95.8	651.5	---	---	---	---
1950	4490	167.9	623.3	83.4	136.4	53.0	11.8
1951	5882	201.5	570.9	114.9	159.7	44.7	12.8
1952	3168	110.3	580.5	108.2	150.7	42.5	13.7
1953	3177	113.8	597.2	95.2	138.5	43.2	13.8
1954	2894	107.1	616.8	92.3	135.1	42.7	14.4
1955	2911	108.0	618.1	96.7	140.1	43.4	14.2
1956	3438	125.8	609.8	105.9	149.2	43.2	14.1
1957	2833	102.4	602.5	107.3	152.0	44.7	13.5
1958	2957	106.9	602.7	107.7	151.5	43.8	13.8
1959	3096	108.3	583.1	114.6	157.6	43.0	13.6
1960	4084	138.6	565.7	130.0	171.6	41.6	13.6
1961	3284	112.5	571.0	129.4	170.9	41.5	13.8
1962	3886	129.4	555.1	135.2	174.9	39.7	14.0
1963	2953	102.9	580.5	124.8	170.8	46.0	12.6
1964	4244	138.3	543.3	131.9	172.2	40.3	13.5
1965	3145	103.8	549.9	120.4	159.9	39.5	13.9
1966	3173	104.0	546.1	129.1	169.2	40.2	13.6
1967	2511	85.4	566.5	118.2	157.5	39.4	14.4
1968	2111	71.6	565.0	108.7	150.2	41.4	13.6
1969	2402	81.6	565.9	109.0	151.3	42.3	13.4
1970	2337	79.1	564.0	106.2	149.1	42.9	13.1
1971	2472	82.5	556.0	118.6	160.0	41.4	13.4
1972	2317	79.2	569.4	117.3	155.0	37.7	15.1
1973	2638	90.6	572.6	117.8	154.7	36.9	15.5
1974	2337	79.8	568.8	120.1	156.4	36.3	15.7
1975	1571	51.9	551.0	113.3	151.0	37.7	14.6
1976	175	5.1	485.7	95.7	---	---	---



Annual average nonpumping and pumping water levels, annual average specific capacity, and annual production, Los Alamos Well LA-6.

Well LA-5

Year	Pump Time (hr)	Pumpage (million gal)	Pump Rate (gpm)	Non-Pump (ft)	Pump (ft)	Drawdown (ft)	Spec Cap (gpm/ft)
1948	1171	40.4	574.6	---	---	---	---
1949	1763	58.5	552.6	---	---	---	---
1950	4052	130.1	535.0	130.7	254.0	123.3	4.3
1951	6004	187.4	520.2	162.1	271.8	109.7	4.7
1952	3425	109.6	533.3	147.0	259.0	112.0	4.8
1953	3278	103.9	528.4	140.8	256.7	115.9	4.6
1954	2546	80.1	524.4	137.2	258.7	121.5	4.3
1955	3158	97.3	513.3	144.8	266.7	121.9	4.2
1956	3476	104.5	501.1	150.1	275.7	125.6	4.0
1957	2868	86.0	500.0	149.7	277.1	127.4	3.9
1958	3009	89.9	498.0	151.1	276.6	125.5	4.0
1959	3088	93.5	504.6	155.3	379.5	124.2	4.1
1960	4088	119.1	485.4	167.7	287.7	120.0	4.0
1961	3534	100.3	473.1	165.0	287.6	122.6	3.9
1962	3735	107.7	480.6	171.7	---	---	---
1963	3726	105.0	469.6	171.1	---	---	---
1964	4236	118.8	467.3	184.5	---	---	---
1965	1740	50.5	484.0	180.2	---	---	---
1966	2817	79.3	469.1	180.3	---	---	---
1967	2533	73.7	484.9	167.5	---	---	---
1968	2233	63.3	472.2	161.1	300.1	139.0	3.4
1969	2402	68.5	475.3	160.6	297.7	137.2	3.5
1970	2353	66.1	468.1	156.9	300.0	143.1	3.3
1971	2659	74.4	466.4	154.8	302.5	147.7	3.2
1972	2301	64.4	466.6	153.5	304.3	150.8	3.1
1973	2476	68.3	460.0	155.9	308.4	152.5	3.0
1974	1903	52.5	460.0	154.4	306.2	151.8	3.0
1975	2318	63.9	459.7	149.2	308.7	159.5	2.9
1976	2799	77.6	462.1	150.0	310.2	160.2	2.9



Annual average nonpumping and pumping water levels, annual average specific capacity, and annual production, Los Alamos Well LA-5.

LA-1

DRILLER'S LOG

Depth (ft)		
From	To	Description
0	9	Packed Sand
9	28	Boulders-Gravel
28	69	Gravel-Quicksand
69	72	Clay
72	76	Gravel
76	92	Sticky Clay
92	113	Clay
113	134	Sandy Clay
134	139	Sand-Clay strata
139	139.5	Rock
139.5	142	Clay
142	151	Sand and Boulders-not loose
151	159	Clay
159	174	Sand, few clay streaks
174	185	Clay
185	191	Sand-not loose
191	195	Clay
195	220	Sandy clay
220	237	Sandy Clay Gravel
237	244	Coarse Sand-Gravel-Water
244	253	Clay
253	270	Sandy Clay with gravel
270	274	Hard clay
274	314	Sandy Clay with gravel
314	320	Sand Clay mixed
320	336	Sandy clay
336	340	Sand and clay streaks
340	343	Rock
343	347	Clay
347	364	Soft white clay
364	375	Brown clay-sand and clay
375	403	Dirty sand and gravel
403	423	Sandy clay with gravel
423	424	Hard streak
424	425	Sandy Clay
425	430	Hard Clay
430	432	Loose fine sand
432	443	Hard dirty sand and gravel
443	456	Sand and clay streaks
456	461	Sand and clay
461	466	Sand and clay streaks
466	475	Fine sand-loose
475	502	Sand and clay streaks
502	503	Hard streak
503	519	Sand gravel and clay
519	523	Hard streak
523	586	Clay and gravel
586	591	Sand
591	602	Clay and gravel
602	607	Sandy Clay-mixed
822	828	Sandy Clay mixed Hard Streak 10"
828	840	Sandy Clay mixed
840	844	Hard Streak gravel
844	848	Rock not too hard
848	850	Rock too hard for drag bit - pulled rods
850	852	Rock not too hard
852	866	Sand Rock takes little water (or cemented sand and gravel)
866	868	Cemented sand and gravel
868	870	Hard streak gravel
870	888	Cemented Sand clay
888	938	Sandy clay
938	940	Hard streaks gravel
940	956	Cemented sand clay
956	970	Sandy clay with hard streaks
970	992	Cemented sand gravel clay
992	1001	Cemented sand gravel clay - good pure clay sample on bit

NOTE: Driller's logs have been reproduced verbatim.

APPENDIX C

DRILLER'S LOGS AND CASING AND SCREEN SCHEDULES OF WELLS LA-1, -2, -3, -4, -5, AND -6 AND GEOPHYSICAL LOGS OF LA-1B, -4, -5, AND -6

LA-5

DRILLER'S LOG

Depth (ft) From	Depth (ft) To	Description
0	207	No record
207	255	Clay
255	320	Hard Packed Sand & Gravel, Hard Streaks
320	394	Sand & Gravel with Hard Streaks
394	404	Clay, Gravel Streaks
404	427	Clay
427	450	Fine Sand
450	498	Fine Sand or Fine Sand Rock
498	521	Clay & Streaks of Gravel
521	567	Sandy Clay or Sand Rock with Hard Streaks
567	570	Clay
570	615	Sandy Clay with Hard Streaks
615	799	Fine Sand or Fine Sand Rock
799	822	Clay with Fine Sand
822	1236	Fine Sand or Fine Sand Rock
1236	1328	Medium Coarse Sand or Sand Rock
1328	1384	Sandy Clay with White Chalk Shavings
1384	1476	Fine Sand or Sand Rock
1476.	1489	Sandy Clay
1489	1619	Fine Sand or Fine Sand Rock, cuts like Sand Rock
1619	1627	Hard Red Clay - Change Bits
1627	1634	Hard Red Clay
1634	1665	Sand Rock or Fine Sand
1665	1673	Hard Sandy Clay, 1 ft extra hard, almost like rock
1673	1696	Hard Red Clay or Shale
1696	1719	Sandy Clay, easy drilling
1719	1729	Hard Red Clay
1729	1742	Medium Coarse Sand Rock or Sand
1742	1859	Sandy Clay, with Hard Streak, Extra Hard for Rock Bit
1859	1905	Fine Sand or Sand Rock, Extra Fine
1905	1928	Sandy Yellow Clay
1928	1974	Sandy Clay
1974	2014	Sand Rock with Clay Streak
2014	2024	Pummy Rock

LA-6

DRILLER'S LOG

Depth (ft) From	Depth (ft) To	Description
0	244	No Record
244	254	Soft pumice rock
254	264	Stick gray clay
264	348	Clay
348	379	Sandy clay with streaks of gravel 0.5 to 1 ft
379	402	Sand and gravel streaks
402	530	Sand or sand rock
530	553	Hard sand rock
553	599	Sand Rock
599	622	Sand rock - cuts easy
622	645	Sand rock - little coarser
645	668	Sand rock with hard streaks
668	691	Sand rock but finer grade
691	714	Sand rock with clay streaks
714	740	Sand rock with hard streaks
740	806	Sandy clay
806	829	Sand and clay mixed
829	852	Sand rock
852	875	Sand rock and streaks of clay 0.1 to 0.2 ft
875	921	Sand rock - cuts easy
921	944	Sand rock little clay streaks
944	954	Clay
954	967	Sandy clay
967	1036	Sand rock - clay streaks
1036	1046	Clay
1046	1082	Sand rock
1082	1128.	Sand rock very fine
1128	1174	Sand clay with streaks of clay 0.4 to 0.5 ft
1174	1184	Clay
1184	1197	Sandy clay - makes own mud 0.1 to 0.2 ft
1197	1220	Sandy clay and clay streaks 0.1 to 0.2 ft, cuts slow
1220	1402	Sandy clay - makes own mud
1402	1504	Sandy clay
1504	1540	Fine sand and streaks of clay
1540	1701	Sand rock with hard streaks 2 to 3 ft thick
1701	1711	Clay
1711	1724	Sand rock - cuts easy
1724	1747	Sand with clay streaks
1747	1908	Sandy clay
1908	1964	Sandy clay with hard streaks
1954	1977	Sand rock with clay streaks 2 to 3 ft
1977	2030	Sand rock with clay streaks
2030	TD	

LA-2

DRILLER'S LOG

Depth (ft) From	To	Description
0	83	No record
83	88	Clay
88	100	Clay
100	115	Sand-Little Clay Started Flowing
115	125	Sand-Little Clay Started Flowing
125	183	Sand with Streaks of Clay
183	198	Loose Sand
198	215	Sandy Clay
215	250	Sandy Clay with hard streaks
250	270	Sandy with streaks of Clay
270	300	Sandy with little clay
300	335	Sandy with little clay
335	340	Clay with gravel streaks
340	345	Cemented Sand & Gravel
345	350	Clay
350	385	Loose Sand with clay streaks 0.5 to 1.5 ft
385	390	Clay
390	415	Sand with clay streaks
415	420	Clay
420	435	Sandy Clay
435	440	Clay-White Chalky
440	455	Cemented Sand & Gravel
455	460	Loose Sand
460	470	Cemented Sand & Gravel
470	495	Loose Sand with clay streaks (20 ft in 30 min)
495	510	Sandy Clay
510	520	Cemented sand and gravel
520	550	Sandy Clay
550	580	Cemented sand & gravel
580	630	Sandy clay with hard streaks of gravel
630	652	Loose sand with little clay mixed
652	699	Sandy Clay
699	700	Rock
700	720	Sandy Clay
720	735	Loose sand with hard streaks
735	740	Cemented sand and gravel
740	750	Sand Rock
750	765	Cemented sand and gravel streaks
765	775	Sandy clay
775	803	Cemented sand and gravel streaks
803	815	Loose sand
815	836	Sandy Clay
836	860	Cemented sand with gravel streaks-hard
860	865	Sand
865	882	Cemented Sand and gravel and clay streaks

LA-3

DRILLER'S LOG

Depth (ft)		
From	To	Description
92	154	Clay and sand streaks
154	157	Sand
157	175	Sand and clay streaks
175	185	Clay
185	191	Loose Sand
191	199	Clay
199	201	Sand
201	208	Clay
208	213	Sand
213	215	Clay
215	223	Tight Sand
223	224	Clay
224	263	Packed Sand-Clay Streaks
263	287	Sand-clay streaks
287	294	Packed Sand
294	308	Soft sandstone
308	325	Clay
325	355	Cemented sand hard streaks of gravel
355	384	Sand cuts easy-hard streaks 0.5 to 1.0 ft
384	415	Cemented sand and gravel-cuts hard
415	460	Sand with hard streaks
460	470	Cemented sand and gravel-Some Clay Mixed
470	485	Clay little sandy
485	516	Sand not too loose
516	525	Sandy clay
525	545	Cemented Sand and gravel hard streaks
545	570	Sand little clay with hard streak
570	599	Sandy clay
599	637	Cemented Sand and gravel
637	646	Sand with hard streak
646	715	Sand rock very soft (very fine sand)
715	730	Sandy Clay
730	769	Soft Sand Rock
769	775	Sandy Clay
775	785	Cemented sand and gravel-Cuts hard
785	795	Sand-not too loose
795	815	Cemented sand and gravel
815	825	Sand with hard streaks
825	830	Sandy clay
830	845	Sandy clay with hard streaks
845	860	Cemented sand and gravel hard streaks 0:1 to 0:3 ft
860	866	Loose Sand
866	870	Cemented sand and clay
870	888	Cemented sand and clay hard streaks 0.5 to 1.0 ft
888	893	White chalk-very soft
893	910	Sandy Clay

LA-1
Casing and Screen Schedule

Depth (ft) From	To	Type of Casing
0	60	12 in. Blank
60	125	12 in. Slotted
125	155	12 in. Screen
155	235	12 in. Slotted
235	245	12 in. Screen
245	380	12 in. Slotted
380	400	12 in. Screen
400	430	12 in. Slotted
430	440	12 in. Screen
440	465	12 in. Slotted
465	475	12 in. Screen
475	585	10 in. Slotted
585	590	12 in. Screen
590	660	10 in. Slotted
660	670	12 in. Screen
670	735	10 in. Slotted
735	745	12 in. Screen
745	855	10 in. Slotted
855	865	12 in. Screen
865	870	10 in. Blank

LA-2
Casing and Screen Schedule

Depth (ft) From	To	Type of Casing
0	105	12 in. Blank
105	125	12 in. Screen
125	185	12 in. Slotted
185	195	12 in. Screen
195	275	12 in. Slotted
275	335	12 in. Screen
335	365	12 in. Slotted
355	385	12 in. Screen
385	455	12 in. Slotted
455	460	12 in. Screen
460	475	12 in. Slotted
475	495	12 in. Screen
495	630	10 in. Slotted
630	650	12 in. Screen
650	720	10 in. Slotted
720	735	12 in. Screen
735	805	10 in. Slotted
805	815	12 in. Screen
815	860	10 in. Slotted
860	865	12 in. Screen
865	870	10 in. Blank

LA-3
Casing and Screen Schedule

Depth (ft) From	To	Type of Casing
0	105	12 in. Blank
105	186	12 in. Slotted
186	191	12 in. Screen
191	360	12 in. Slotted
360	380	12 in. Screen
380	430	12 in. Slotted
430	445	12 in. Screen
445	550	10 in. Slotted
550	565	12 in. Screen
565	665	10 in. Slotted
665	705	12 in. Screen
705	735	10 in. Slotted
735	765	12 in. Screen
765	785	10 in. Slotted
785	795	12 in. Screen
795	860	10 in. Slotted
806	865	12 in. Screen
865	870	10 in. Blank

LA-4
Casing and Screen Schedule

Depth (ft) From	To	Type of Casing
0	754	12 in. Blank
754	804	10 in. Screen
804	832	10 in. Blank
832	872	10 in. Screen
872	920	10 in. Blank
920	930	10 in. Screen
930	953	10 in. Blank
953	963	10 in. Screen
963	1027	10 in. Blank
1027	1037	10 in. Screen
1037	1075	10 in. Blank
1075	1085	10 in. Screen
1085	1103	10 in. Blank
1103	1113	10 in. Screen
1113	1132	10 in. Blank
1132	1142	10 in. Screen
1142	1161	10 in. Blank
1161	1171	10 in. Screen
1171	1190	10 in. Blank
1190	1200	10 in. Screen
1200	1218	10 in. Blank
1218	1228	10 in. Screen
1228	1247	10 in. Blank
1247	1257	10 in. Screen
1257	1332	10 in. Blank
1332	1402	10 in. Screen
1402	1440	10 in. Blank
1440	1450	10 in. Screen
1450	1487	10 in. Blank
1487	1507	10 in. Screen
1507	1524	10 in. Blank
1524	1534	10 in. Screen
1534	1571	10 in. Blank
1571	1601	10 in. Screen
1601	1744	10 in. Blank
1744	1754	10 in. Screen
1754	1792	10 in. Blank
1792	1802	10 in. Screen
1802	1829	10 in. Blank
1829	1839	10 in. Screen
1839	1898	10 in. Blank
1898	1908	10 in. Screen
1908	1934	10 in. Blank
1934	1964	10 in. Screen

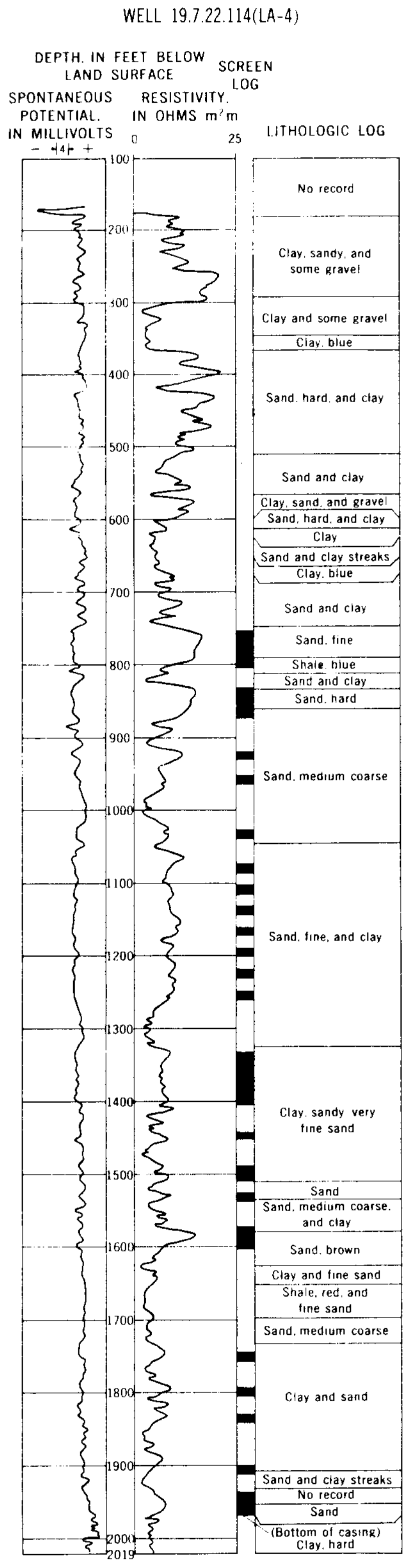
LA-5
Casing and Screen Schedule

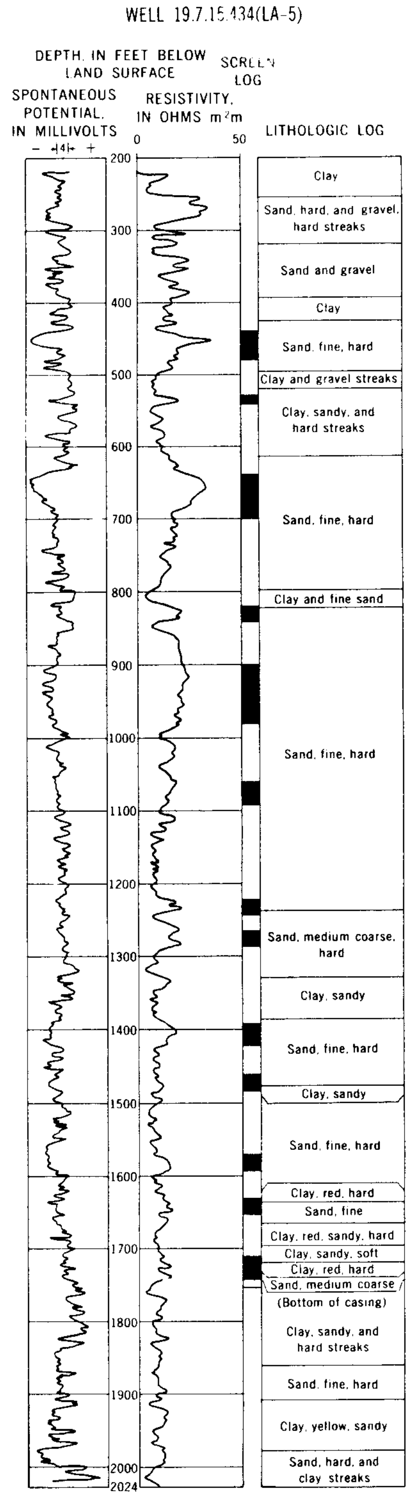
Depth (ft) From	To	Type of Casing
0	440	12 in. Blank
440	480	12 in. Screen
480	530	12 in. Blank
530	540	12 in. Screen
540	630	12 in. Blank
630	640	10 in. Blank
640	700	10 in. Screen
700	820	10 in. Blank
820	840	10 in. Screen
840	900	10 in. Blank
900	980	10 in. Screen
980	1061	10 in. Blank
1061	1091	10 in. Screen
1091	1220	10 in. Blank
1220	1240	10 in. Screen
1240	1264	10 in. Blank
1264	1284	10 in. Screen
1284	1390	10 in. Blank
1390	1420	10 in. Screen
1420	1460	10 in. Blank
1460	1480	10 in. Screen
1480	1570	10 in. Blank
1570	1590	10 in. Screen
1590	1630	10 in. Blank
1630	1650	10 in. Screen
1650	1710	10 in. Blank
1710	1740	10 in. Screen
1740	1750	10 in. Blank

LA-6
Casing and Screen Schedule

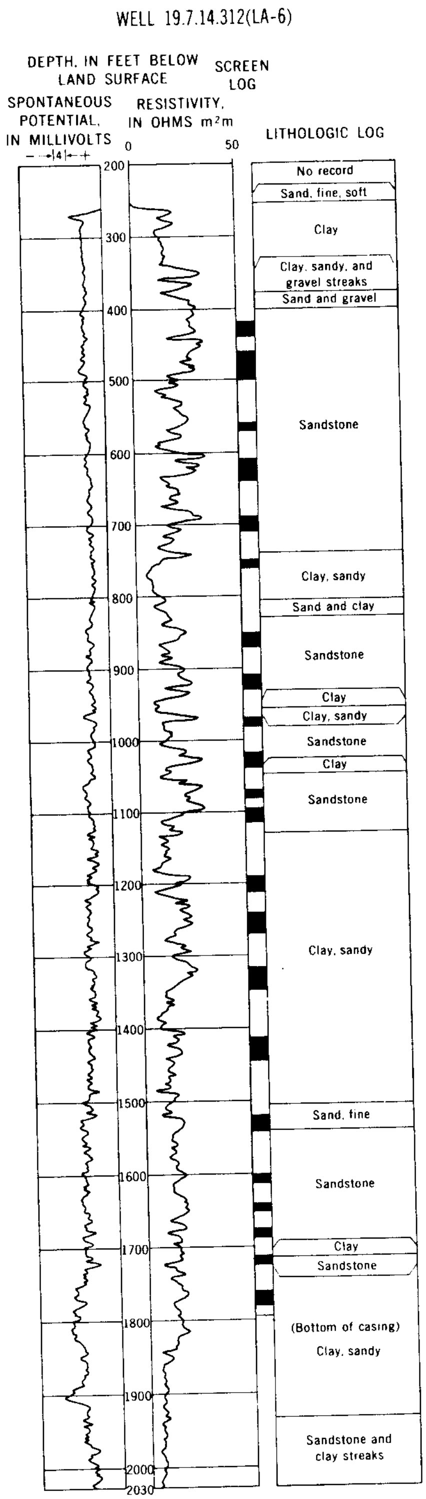
Depth (ft) From	Depth (ft) To	Type of Casing
0	420	12 in. Blank
420	440	12 in. Screen
440	460	12 in. Blank
460	500	12 in. Screen
500	560	12 in. Blank
560	570	12 in. Screen
570	597	12 in. Blank
597	599	12 in. to 10 in. reducer
599	610	10 in. Blank
610	640	10 in. Screen
640	690	10 in. Blank
690	710	10 in. Screen
710	750	10 in. Blank
750	760	10 in. Screen
760	850	10 in. Blank
850	870	10 in. Screen
870	909	10 in. Blank
909	929	10 in. Screen
929	970	10 in. Blank
970	980	10 in. Screen
980	1019	10 in. Blank
1019	1039	10 in. Screen
1039	1070	10 in. Blank
1070	1080	10 in. Screen
1080	1095	10 in. Blank
1095	1115	10 in. Screen
1115	1190	10 in. Blank
1190	1210	10 in. Screen
1210	1240	10 in. Blank
1240	1270	10 in. Screen
1270	1315	10 in. Blank
1315	1345	10 in. Screen
1345	1412	10 in. Blank
1412	1442	10 in. Screen
1442	1520	10 in. Blank
1520	1540	10 in. Screen
1540	1600	10 in. Blank
1600	1610	10 in. Screen
1610	1640	10 in. Blank
1640	1650	10 in. Screen
1650	1676	10 in. Blank
1676	1686	10 in. Screen
1686	1710	10 in. Blank
1710	1720	10 in. Screen
1720	1758	10 in. Blank
1758	1778	10 in. Screen
1778	1790	10 in. Blank

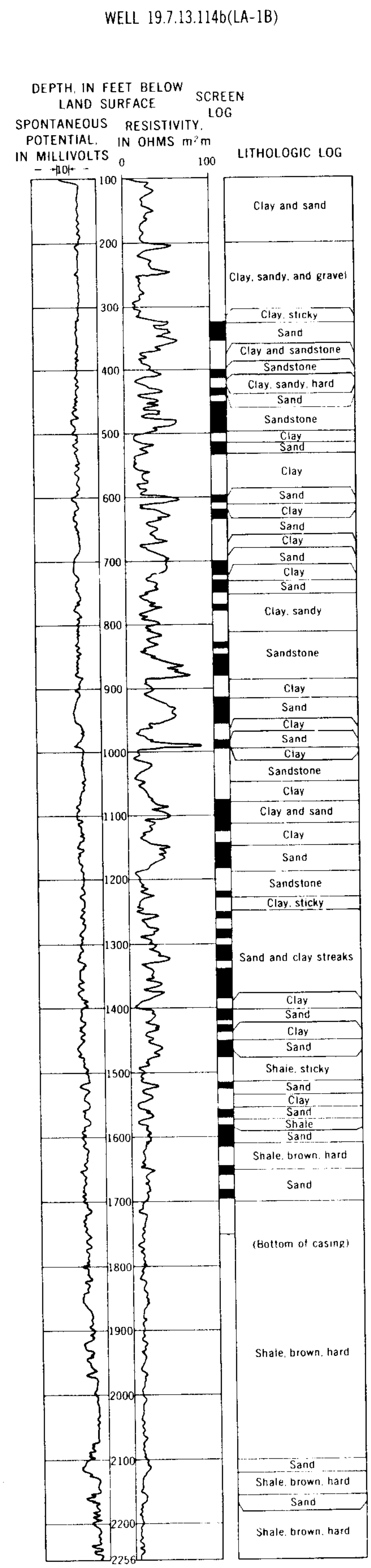
GEOPHYSICAL LOGS





GEOPHYSICAL LOGS





APPENDIX D

QUALITY CONTROL DATA FOR ARSENIC ANALYSES

Nitric acid was added (5 mℓ to every 500 mℓ of sample) when the samples were collected to keep the arsenic (As) in solution. The As determinations were made using AA (atomic absorption spectrophotometry). The quality control program consisted of analyses of (1) duplicates, (2) dilution and standard additions, (3) standard additions, and (4) comparison with NAA (neutron activation analyses). The results are compared using the $\overline{x}$ (the mean), S (standard deviation), and CV (coefficient of variation; $\overline{x}:S \cdot 100$).

The standard deviation may appear large for high concentrations, but as shown by the coefficient of variation, it is only a small percentage of the total concentration. There is more variation shown by the standard deviation and coefficient of variation at low concentrations.

Quality control using duplicate samples for AA analyses consisted of 24 sets (Table D-I). Of the 24 sets, Nos. 5164-65 and 5176-77 were not comparable.

Quality control using AA and dilution of or addition of As to the sample is shown in Table D-II. The results have been adjusted to the As of the sample prior to dilution or addition. Again, low or high As in original water appears large and out of line, but is not significant. One set of analyses (No. 5046) is not comparable.

Quality control using AA and additions of known concentrations of As are shown in Table D-III. The additions ranged from 20 to 200 μg/ℓ of As. The results are adjusted to the known concentrations. One analysis (No. 5000) is not comparable.

The AA method of analysis was compared to the NAA method (Table D-IV). In general, for the nine analyses compared, the NAA results were slightly higher than the AA results for six analyses. The AA and NAA results were comparable.

The quality control data obtained during the test are good, indicating the results of analyses made during the tests are acceptable values upon which to base conclusions and recommendations relating to the As problem in the well field.

TABLE D-I

QUALITY CONTROL DUPLICATES

Test	Sample No.	As (μg/ℓ) Results		$\bar{x}$	S	CV
1-12-76	4879 - 80	165 ± 7	155 ± 7	160	7	4.4
	83 - 84	163 ± 7	168 ± 7	166	3.5	2.1
	4911 - 12	14 ± 1	14 ± 1	14	0	0
	13 - 14	18 ± 1	18 ± 1	18	0	0
	20 - 21	3 ± 1	3 ± 1	0	0	
	22 - 23	4 ± 1	3 ±1	3.5	0.7	20
	4895 - 96	7 ± 1	7 ± 1	7	0	0
	99 - 00	63 ± 3	63 ± 3	63	0	0
1-23-76	5036 - 37	180 ± 12	190 ± 12	185	7	3.8
	38 - 39	170 ± 12	165 ± 12	168	3.5	2.1
	47 - 48	21 ± 2	22 ± 2	22	0.7	3.2
	49 - 50	54 ± 3	55 ± 3	55	0.7	1.3
	81 - 82	4 ± 2	4 ± 2	4	0	0
	84 - 85	22 ± 2	22 ± 2	22	0	0
	88 - 89	3 ± 3	4 ± 2	3.5	0.7	20
	91 - 92	5 ± 3	5 ± 2	5	0	0
2-3-76	5151 - 52	172 ± 9	178 ± 9	175	4.2	2.4
	53 - 54	171 ± 9	167 ± 9	169	2.8	1.7
	62 - 63	14 ± 2	14 ± 2	14	0	0
	64 - 65	34 ± 5	55 ± 8	44	15	34
	73 - 74	2 ± 1	2 ± 1	2	0	0
	76 - 77	22 ± 3	13 ± 2	18	6.3	35
	80 - 81	4 ± 1	4 ± 1	4	0	0
	83 - 84	2 ± 1	5 ± 1	3.5	2.1	60

TABLE D-II

QUALITY CONTROL DILUTION AND ADDITIONS

Test	Sample No.	Dilution		Addition		As (μg/ℓ) Results			$\bar{x}$	S	CV
1-12-76	4902	---	---	20	40	36 ± 1	33 ± 1	29 ± 1	33	3.5	11
	4903	1:3	---	---	---	37 ± 2	37 ± 2	---	37	0	0
	4910	1:3	1:3	---	---	66 ± 3	55 ± 3	63 ± 3	61	5.6	9.2
	4910	---	---	20	---	66 ± 3	56 ± 3	---	61	7.1	12
	4886	1:4	1:3	---	---	162 ± 7	163 ± 7	162 ± 7	162	0.6	0.4
	4894	1:5	1:3	---	---	184 ± 7	171 ± 7	177 ± 7	177	6.5	3.7
	4919	---	---	20	40	23 ± 1	22 ± 1	17 ± 1	21	3.2	15
	4928	---	---	20	40	4 ± 1	4 ± 1	2 ± 1	3.3	1.2	36
1-23-76	5046	1:5	1:3	---	---	180 ± 12	180 ± 12	174 ± 9	178	3.5	2.0
	5046	1:5	1:5	20	40	180 ± 12	155 ± 12	115 ± 12	150	33	22
	5080	---	---	20	40	51 ± 3	51 ± 3	43 ± 3	48	4.6	9.6
	5064	---	---	20	40	59 ± 3	57 ± 3	58 ± 3	58	1.0	1.7
	5076	---	---	20	40	58 ± 3	58 ± 3	48 ± 3	55	5.8	11
	5094	---	---	20	40	5 ± 2	2 ± 2	8 ± 2	5	3	60
	5021-22-26	---	---	100	150	4 ± 2	5 ± 2	−15 ±	−2	11	−18
	5024-27-28	1:5	1:5	150	200	5 ± 2	−5 ±	10 ±	3.3	8	242
	5087	---	---	20	40	24 ± 2	24 ± 2	20 ± 2	23	2.3	10

TABLE D-III

QUALITY CONTROL STANDARD ADDITIONS

Sample No.	As (μg/ℓ) Additions	Results	$\bar{x}$	S	CV
4998	20	17 ± 1	18	2.1	11.7
99	40	36 ± 1	38	2.8	7.3
5000	20	30 ± 1	25	7	28
01 [a]	40	36 ± 2	38	2.8	7.3
02 [a]	150	154 ± 7	152	2.8	1.8
03 [a]	200	196 ± 8	198	2.8	1.4
04 [a]	150	146 ± 7	148	2.8	1.9
05 [a]	200	200 ± 8	200	0	0

[a]Dilution 1:5.

TABLE D-IV

QUALITY CONTROL COMPARISON OF ATOMIC ABSORPTION AND NEUTRON ACTIVATION ANALYSES

Sample No.	AA	NAA	$\bar{x}$	S	CV
4879	165 ± 7	159 ± 16	162	4	2.5
80	155 ± 7	169 ± 17	162	9	5.6
83	163 ± 7	181 ± 18	167	11	6.6
84	168 ± 7	177 ± 18	172	6	3.5
87	170 ± 7	187 ± 19	178	12	6.7
89	172 ± 7	183 ± 18	177	8	4.5
91	175 ± 7	184 ± 18	180	6	3.3
93	185 ± 7	183 ± 18	184	1	0.5
5004	146 ± 7	140 ± 14	143	4	2.8

APPENDIX E

ARSENIC CONCENTRATIONS AT BOOSTER 4 AND FIRE STATION 2 BY COMBINATION OF WELLS, 1975

Wells LA-1B, -2, -3, -4, -5, and -6

Date	Arsenic (μg/ℓ) Booster 4	Arsenic (μg/ℓ) Fire Station 2
8-11	72 ± 9	65 ± 8
8-13	73 ± 9	56 ± 7

Wells LA-4, -5, and -6

Date	Arsenic (μg/ℓ) Booster 4	Arsenic (μg/ℓ) Fire Station 2
8-7	61 ± 7	---
8-12	74 ± 9	52 ± 6
9-23	60 ± 8	20 ± 3
9-24	70 ± 8	77 ± 7
9-30	68 ± 2	25 ± 1
10-1	58 ± 2	45 ± 2
10-2	55 ± 2	60 ± 2

Wells LA-1B, -2, -3, -4, and -5

Date	Arsenic (μg/ℓ) Booster 4	Arsenic (μg/ℓ) Fire Station 2
8-19	26 ± 1	14 ± 1
8-20	8 ± 1	19 ± 1
8-21	12 ± 1	15 ± 1
8-22	13 ± 1	18 ± 1
8-25	3 ± 1	12 ± 1
8-26	9 ± 1	9 ± 1
8-27	12 ± 1	9 ± 1
8-28	13 ± 1	10 ± 1
9-2	12 ± 1	10 ± 1
9-5	13 ± 1	12 ± 1
9-11	10 ± 1	12 ± 1
9-15	11 ± 1	9 ± 1
9-19	23 ± 4	22 ± 4

Wells LA-1B, -2, and -3

Date	Arsenic (μg/ℓ) Booster 4	Arsenic (μg/ℓ) Fire Station 2
8-14	40 ± 9	53 ± 7
8-15	78 ± 2	24 ± 1
8-29	14 ± 1	15 ± 1
9-4	15 ± 1	10 ± 1
9-9	14 ± 1	8 ± 1
9-17	28 ± 1	25 ± 4
9-25	52 ± 2	61 ± 2
9-26	28 ± 2	21 ± 2
9-29	28 ± 2	18 ± 2

Wells LA-4 and -5

Date	Arsenic (μg/ℓ) Booster 4	Arsenic (μg/ℓ) Fire Station 2
9-3	8 ± 1	9 ± 1
9-8	6 ± 1	13 ± 1
9-10	7 ± 1	11 ± 1
9-12	10 ± 1	11 ± 1
9-16	8 ± 1	13 ± 1
9-18	22 ± 1	27 ± 1
9-22	20 ± 3	29 ± 3

APPENDIX F

ARSENIC CONCENTRATION AT WELLS AND BOOSTER STATION
September 1975 - February 1976

September 22, 1975

	Arsenic ($\mu g/\ell$)	
Hour[a]	**LA-6**	**Booster 4**
1	190 ± 7	19 ± 3
2	203 ± 18	18 ± 3
3	152 ± 15	19 ± 3
5.5	159 ± 15	77 ± 3
7.5	167 ± 15	77 ± 3
9.5	193 ± 15	75 ± 3
Well	**gpm**	**% of Yield**
LA-4	587	40
LA-5	463	31
LA-6	428	29

Note: No analyses LA-4 and -5.

September 23, 1975

	Arsenic ($\mu g/\ell$)	
Hour[a]	**LA-6**	Booster 4
1	188 ± 17	47 ± 7
2	186 ± 17	---
4	186 ± 17	86 ± 7
6	196 ± 17	86 ± 8
8	211 ± 18	87 ± 8
Well	**gpm**	**% of Yield**
LA-4	587	40
LA-5	463	31
LA-6	434	29

Note: No analyses LA-4 and -5.

September 29, 1975

Hour[a]	Arsenic (μg/ℓ) LA-4	LA-5	LA-6	Booster 4
1	5 ± 1	7 ± 1	189 ± 15	27 ± 2
2	6 ± 1	12 ± 1	182 ± 15	29 ± 2
3	6 ± 1	17 ± 1	189 ± 15	29 ± 2
4	6 ± 1	20 ± 1	176 ± 14	88 ± 2
6.5	6 ± 1	23 ± 1	188 ± 15	73 ± 3
8.5	6 ± 1	24 ± 1	194 ± 16	68 ± 3
10.5	6 ± 1	23 ± 1	---	45 ± 2

Well	gpm	% of Yield
LA-4	593	40
LA-5	466	31
LA-6	432	29

October 1, 1975

Hour[a]	Arsenic (μg/ℓ) LA-4	LA-5	LA-6	Booster 4
1	6 ± 1	7 ± 1	210 ± 17	72 ± 3
2	6 ± 1	12 ± 1	211 ± 17	19 ± 2
3	7 ± 1	22 ± 1	199 ± 16	57 ± 1
4	6 ± 1	19 ± 1	197 ± 16	71 ± 2
5.5	6 ± 1	21 ± 1	193 ± 16	44 ± 2
6.5	6 ± 1	23 ± 1	201 ± 16	88 ± 2
8	6 ± 1	24 ± 1	196 ± 16	58 ± 2
10	6 ± 1	27 ± 1	200 ± 16	60 ± 2
11.5	6 ± 1	28 ± 1	211 ± 16	97 ± 2
19.5	---	---	191 ± 16	78 ± 2
20.5	7 ± 1	28 ± 2	199 ± 16	55 ± 2

Well	gpm	% of Yield
LA-4	588	43
LA-5	461	34
LA-6	308	23

October 16, 1975

Hour[a]	Arsenic (μg/ℓ) LA-4	LA-5	LA-6	Booster 4
1	---	---	157 ± 8	37 ± 2
2	---	---	159 ± 9	38 ± 2
4	---	---	162 ± 8	38 ± 2
7	---	---	157 ± 8	49 ± 2
10	---	---	159 ± 8	50 ± 2
13.5	5 ± 1	---	159 ± 8	---
16.5	5 ± 1	---	162 ± 8	---
20.5	5 ± 1	28 ± 1	153 ± 8	51 ± 2
23.5	5 ± 1	28 ± 1	160 ± 8	51 ± 2

Well	gpm	% of Yield
LA-4	576	41
LA-5	440	31
LA-6	404	28

January 12, 1975

Hour[a]	Arsenic (μg/ℓ) LA-4	LA-5	LA-6	Booster 4
0.5	---	---	160 ± 7	7 ± 1
2	3 ± 1	14 ± 1	162 ± 7	59 ± 2
3.7	---	---	164 ± 7	29 ± 1
7.5	3 ± 1	18 ± 1	165 ± 7	63 ± 3
11.5	---	---	161 ± 7	36 ± 1
15.5	4 ± 1	21 ± 1	162 ± 7	36 ± 1
19.5	---	---	170 ± 7	37 ± 2
23.5	4 ± 1	2 ± 1	170 ± 7	63 ± 3
27.5	---	---	172 ± 7	31 ± 1
31.5	4 ± 1	23 ± 1	167 ± 7	37 ± 2
35.5	---	---	175 ± 7	37 ± 2
39.5	4 ± 1	23 ± 1	175 ± 7	60 ± 2
43.5	---	---	185 ± 7	50 ± 2
47.5	4 ± 1	23 ± 1	184 ± 7	66 ± 3

Well	gpm	% of Yield
LA-4	581	43
LA-5	451	34
LA-6	308	23

January 23, 1976

Hour[a]	Arsenic (μg/ℓ) LA-4	LA-5	LA-6	Booster 4
1	3 ± 3	4 ± 2	185 ± 12	21 ± 2
7	---	---	165 ± 12	55 ± 3
13	4 ± 2	22 ± 2	165 ± 12	57 ± 3
19	---	---	175 ± 12	61 ± 3
25	5 ± 2	22 ± 2	165 ± 12	54 ± 3
31	---	---	---	55 ± 3
37	5 ± 2	24 ± 2	190 ± 12	54 ± 3
43.3	---	---	190 ± 12	55 ± 3
49.5	5 ± 2	24 ± 2	180 ± 12	51 ± 3

Well	gpm	% of Yield
LA-4	563	39
LA-5	450	31
LA-6	440	30

February 2, 1976

Hour[a]	Arsenic (μg/ℓ) LA-4	LA-5	LA-6	Booster 4
1.1	4 ± 1	2 ± 1	175 ± 9	14 ± 2
7.0	---	---	171 ± 9	45 ± 6
13.1	4 ± 1	21 ± 3	179 ± 9	60 ± 3
19.0	3 ± 1	18 ± 2	181 ± 9	69 ± 4
26.0	---	---	184 ± 10	66 ± 4
31.6	---	---	178 ± 9	56 ± 4
37.1	2 ± 1	22 ± 3	172 ± 9	69 ± 4
43.0	---	---	176 ± 9	70 ± 4
47.0	2 ± 1	14 ± 2	179 ± 9	70 ± 4

Well	gpm	% of Yield
LA-4	585	36
LA-5	461	28
LA-6	585	36

February 2, 1976[b]

Hour[a]	Arsenic (μg/ℓ) LA-6
0.8	186 ± 8
5.5	186 ± 8
11.0	160 ± 8
17.0	156 ± 8
22.5	156 ± 8
27.0	156 ± 8

Well	gpm	% of Yield
LA-6	773	100

[a]Hours pumped prior to sample.
[b]Pumped to waste.

APPENDIX G

ARSENIC CONCENTRATIONS AT BOOSTER 4 DURING TEST OF JANUARY 23, 1976, FOR A 6-HR PERIOD

Hour	Rate (gpm)	Arsenic (μg/ℓ)
25.0	1000	54 ± 3
25.25	1000	56 ± 2
25.50	1000	54 ± 2
25.75	1000	61 ± 2
26.0	1000	57 ± 2
26.25	1000	57 ± 2
26.50	1000	56 ± 2
26.75	1000	57 ± 2
27.0	1000	57 ± 2
27.25	1000	58 ± 2
27.50	1000	62 ± 3
27.75	1000	59 ± 3
28.0	1800	91 ± 3
28.25	1800	91 ± 3
28.50	1800	89 ± 3
28.75	1800	89 ± 3
29.0	1800	93 ± 3
29.25	1800	51 ± 2
29.50	1800	55 ± 2
29.75	1800	54 ± 2
30.0	2300	51 ± 2
30.25	2300	56 ± 2
30.50	2300	56 ± 2
30.75	2300	58 ± 3
31.0	2300	55 ± 3

	Arsenic (μg/ℓ)		
	Min	Max	Av
1000 gpm (1 pump)	54	63	57
1800 gpm (2 pumps)	51	93	77
2300 gpm (3 pumps)	51	58	55

APPENDIX H

GAMMA RAY-NEUTRON CASING SCHEDULES AND TEMPERATURE LOGS OF WELL LA-6