DETERMINATION OF THE LONG TERM AVAILABILITY OF WATER FROM SELECTED WELLS AT EL DORADO AT SANTA FE

Submitted to

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Submitted by

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SUMMARY AND CONCLUSIONS

All pertinent records of water wells which El Dorado at Santa Fe are legally entitled to draw upon and which are situated in proximity to the present development area were reviewed. All pumping test data which was deemed useable was incorporated into the present analysis. Where aquifer performance test (pumping test) data were not available, short term pumping tests were carried out by AGC. All aquifer performance test data were analysed by standard hydrological and oilfield methods to determine undamaged aquifer transmissivities and flow efficiencies where possible. In addition, thermal injection tests were carried out on all wells to determine the "live" rock units penetrated by the wells. The "live" part of the well is that part of the rock sequence penetrated which yields water to the well. In the cases of wells W-3 and W-4, for example, it was found that only a small part of the rock sequence penetrated by the well was actually producing water.

Long-term continuous pumping rates were calculated for each of the wells taking into consideration the results of both the aquifer performance tests and the thermal injection tests. The available long-term continuous water supply which is believed to be available is summarized in the table on the following page.

Based upon an average consumption of 0.21 acre feet per dwelling unit which is the measured consumption at Sunlit Hills directly to the north of El Dorado at Santa Fe and bearing in mind the similar character of the two areas, the number of dwelling units which may be supported by all wells exclusive of W-2 is 246. Including W-2 in the water system will bring the number of dwellings which may be supported to 1,350.

El Dorado Well No.	SEO Well No. (RG)	Maximum Continuous Discharge Rate (gpm)	Acre Feet Per Year
W-2	18529	144	232
W-3	18543	2.7	4.4
W-4	18550	25	40.4
X-4	18515	5+	8.1
W-8000	18570	1.4	2.2
W-8001	18591	1	1.6
W-8002	18567	6	9.7
W-8004	18568	4.5	7.3
		189.6	305.7

W.U = .3AF/DU/yr = 947.63 lots

= 710.72 lots

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INTRODUCTION

Under the terms of the Stipulation and Agreement entered into by Eldorado at Santa Fe, Inc. and the office of the New Mexico State Engineer, as later affirmed by judgment of the District Court of the First Judicial District (Docket Number 45612), Eldorado at Santa Fe is entitled to divert underground waters of the Rio Grande Underground Water Basin from wells RG-18528 (W-1), RG-18529 (W-2), RG-18543 (W-3), and RG-18550 (W-4). Eldorado at Santa Fe also has the right to place to beneficial use water from wells RG-18570 (8000), RG-18591 (8001), and RG-18568 (8004), which are situated in the vicinity of the area of present development at Eldorado. At the present time Eldorado at Santa Fe is undergoing growth which is accompanied by increased demand for water. In July, 1977, American Ground Water Consultants was retained to determine the limit of water availability from the above mentioned wells.

Under the subdivision regulations of Santa Fe County, it is generally necessary that subdividers demonstrate, in a technically competent manner, the amount of water which will be available to the subdivision over a 40-year period of time. For subdivisions which are remote from existing areas of population, it is generally sufficient to carry out closely controlled aquifer performance tests (pumping tests) from which the maximum continuous pumping rate necessary to lower the pumping water level to the pump intakes at the end of 40 years may be determined.

APPROACH

All records pertaining to the Eldorado ground-water development program were reviewed, and pertinent information on well construction details were obtained. This information has been compiled into Table 1. Although reference was made in the records to pumping tests, no pumping test data was located.

In 1974, Leupold & Stevens water level recorders were installed on wells W-3 and W-4. These records were carefully examined, and periods of pumping were selected such that the water level records could be analysed by standard hydrological and oilfield methods. At the time wells 8000, 8001 and 8004 were completed, the drilling company carried out pumping tests which are probably useable for analytical purposes. At the time the present study was undertaken, only wells W-2 and X-4 had no pumping test data available for analysis. As a result, short term tests of these wells were carried out under the present study.

At the present time, the wells are presumably producing at their present physical capacity. The maximum present capacity of the wells may be restricted by encrustation of solids in the casing or in the aquifer either through direct chemical precipitation or through biological activity. Flow reduction may be caused by friction losses as the water in the formation passes through the slots in the casing. Finally, the flow may be reduced by the creation of a low permeability zone adjacent to the boreface caused by the invasion of permeable

Table 1. Pertinent details on existing wells at Eldorado at Santa Fe.

Eldorado Well No.	SEO File No. (RG)	Legal Status[1]	Depth (ft)	Casing Size (in)	Original Reported Yield (gpm)	Hydrological No. (E)
W-1	18528	1	719	8-5/8	94	1
W-2	18529	1	350	8-5/8	190	2
W-3	18543	1	324	10-3/4	51	3
W-4	18550	1	374	10-3/4	51	4
X-1	18512	2	244	6	3	5
X-2	18513	2	74	6	8	6
X-3	18514	2	140	6	3	7
X-4	18515	2	192	6	18	8
X-5	18516	2	197	6	4.5	9
X-8	18517	2	90	6	15	10
X-9	18518	2	170	5	3	11
X-10	18519	2	110	6	3	12
X-11	18520	2	226	7	8	13
X-12	18521	2	50	6	3	14
X-13	18522	2	60	6	3	15
X-14	18523	2		6	3	16
X-15	18524	2		6	3	17
X-16	18525	2	760	6	3	18
X-17	18526	2		8	3	19
X-18	18527	2		6	3	20
WX-1W	18531 ✓	3,4	305	4-1/2	400	21
WX-3BN	18571	3,4	260	4-1/2	120	22
WX-3DE	18594	3,4	328	4-1/2	25	23

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W-4	18550	1	374	10 3/4	51	4
X-1	18512	2	244	6	3	5
X-2	18513	2	74	6	8	6
X-3	18514	2	140	6	3	7
X-4	18515	2	192	6	18	8
X-5	18516	2	197	6	4.5	9
X-8	18517	2	90	6	15	10
X-9	18518	2	170	5	3	11
X-10	18519	2	110	6	3	12
X-11	18520	2	226	7	8	13
X-12	18521	2	50	6	3	14
X-13	18522	2	60	6	3	15
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Table 1 (Cont)

Eldorado Well No.	SEO File No. (RG)	Legal Status[1]	Depth (ft)	Casing Size (in)	Original Reported Yield (gpm)	Hydrological No. (E)
WX-2E	18572	3,4	300	4 1/2	99	22
WX-3N	18595	3,4	250	4 1/2	400	23
WX-9S	18561	3,4	240/320	4 1/2	25	24
WX-11W	18563	3,4	260	4 1/2	15	25
WR-61E	18566	3,4	300	4 1/2	500	26
W-8000	18570	3,4	250	4 1/2	6	27
W-8001	18591	3,4	239	4 1/2	15	28
W-8002	18567	3,4	244	4 1/2	17	29
W-8004	18568	3,4	280	4 1/2	14	30

[1]

1. Eldorado at Santa Fe, Inc., its administrators, successors and assigns, may in accordance with law, divert the underground waters of the Rio Grande Underground Water Basin and apply them to beneficial use for domestic, municipal, construction and recreation purposes, by means of wells numbered RG-18528, RG-18529, RG-18543 and RG-18550, to the capacity of those wells as completed before December 31, 1970.

2. Eldorado at Santa Fe, Inc., has the right to complete the repair, rehabilitation and conversion of, but not to deepen or enlarge, those wells numbered consecutively from RG-18512 to and including RG-18527 and to divert the waters of the Rio Grande Underground Water Basin therefrom, and to apply said water to beneficial use for domestic, municipal, industrial, recreational and construction purposes within a reasonable time, to the capacity those wells had on or before December 31, 1970.

3. Upon prior notice in writing to the State Engineer Office, Eldorado at Santa Fe, Inc., may enlarge but may not deepen wells numbered RG-18531, RG-18556, RG-18561, RG-18563, RG-18567, RG-18568, RG-18570, RG-18571, RG-18572, RG-18591, RG-18594 and RG-18595; Eldorado at Santa Fe, Inc., may divert and place to beneficial use for domestic, municipal, industrial, recreation and construction purposes within a reasonable time, by means of said wells, the water of the Rio Grande Underground Water Basin, to the extent of the capacity of those wells as enlarged and equipped.

4. Eldorado at Santa Fe, Inc., may not change, partially or totally, the point of diversion or place or purpose of use of wells numbered RG-18531, RG-18556, RG-18561, RG-18563, RG-18567, RG-18568, RG-18570, RG-18571, RG-18572, RG-18591, RG-18594, and RG-18595 by means of replacement or supplemental wells except when and to the extent that the rights to said water may have then vested by actual beneficial use.

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zones by drilling mud during the drilling of the well. It is clear that the present capacities of wells W-3 and W-4 are not as great now as they were reported by the drillers and engineers who were responsible for such matters when the wells were constructed. To determine if in fact the reduced production was caused by abnormal impedance of the water as it flows towards and into the well, pressure build-up tests were carried out utilizing data collected from the Leupold & Stevens water-level recorders. Discussion of pertinent matters for each well follows.

WELL CONSTRUCTION, DEVELOPMENT AND TESTING

All records for each well of interest in the present study were assembled and reviewed. A narrative summary of well drilling, development, and testing activities has been prepared for each well. The results of aquifer performance tests using the wells are discussed following the narrative summary for each well.

Well-2

Well-2 was drilled by Shamrock Drilling Company of Española, New Mexico. The drilling method is not specified in the records; however, Shamrock has always utilized cable tool drilling methods. The well was drilled to a total depth of 350 feet and cased with 246.5 feet of blank casing. On May 10, 1970, Schlumberger shot-perforated the casing from 120-133 feet and from 161-207[1] feet. Minton reports that 60 shots were used. The Shamrock drilling report indicates that 180 shots were used. In all likelihood, 60 rounds of three shots each were fired. Following the perforation of the casing, a test pump was lowered into the well, and the well was developed by pumping and surging. Presumably, surging was accomplished by turning off the pump and allowing the water level to rise somewhat. Development continued from 1700 hours on May 10th to 1800 hours on May 11th for a total of 25 hours of more or less continuous pumping. During this initial period of development, the pumping rate was gradually increased from 150 gpm to 200 gpm. The pumping water level at the end of the initial development was about 254 feet for a drawdown of about 100 feet.

[1]Report by Minton indicates perforations from 161 to 233 feet.

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Well-2 was drilled by Shamrock Drilling Company of Expanola, New Mexico. Drilling commenced on December 26, 1969 and was completed on February 10, 1970. The drilling method is not specified in the records however, Shamrock has always utilized cable tool drilling methods. The well was drilled to a total depth of 350 feet and cased with 246.5 feet of blank casing. On May 10, 1970, Schlumberger reportedly shot-perforated the casing from 120-133 feet and from 161-207[1] feet. Minton reports that 60 shots were used. The Shamrock drilling report indicates that 180 shots were used. In all likelihood, 60 rounds of three shots each were fired. Following the perforation of the casing, a test pump was lowered into the well, and the well was developed by pumping and surging. Presumably, surging was accomplished by turning off the pump and allowing the water level to rise somewhat. Development continued from 1700 hours on May 10th to 1800 hours on May 11th for a total of 25 hours of more or less continuous pumping. During this initial period of development, the pumping rate was gradually increased from 150 gpm to 200 gpm. The pumping water level at the end of the initial development was reportedly 254 feet for a drawdown of about 100 feet.

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On May 12th, the well was acidized with 1,000 gallons of presumably 15 percent by volume of muriatic acid. The acid was introduced at 1400 hours on May 12th, and the well was shut in until 1200 hours on May 13th when the second stage of development began. At 1200 hours on May 14th, the well had discharged for 24 hours more or less continuously at about 191 gpm with a maximum pumping water level of 220 feet. Following termination of the development and testing period, the water level (reportedly) rose 73 feet to stand at 147 feet in 15 minutes.

Determination of Aquifer Characteristics Utilizing Well-2

On August 26, 1977, American Ground Water Consultants carried out an aquifer performance test with Well-2. Prior to the test, the well had not been operated for some time, and the static water levels were not changing in response to some prior activity. Well-2 is powered by a gasoline engine operated on propane which drives a line-shaft turbine pump. Because of the difficulty in maintaining a constant discharge during the drawdown period, the drawdown data was not used in the analysis. Because the total discharge was measured with a Rockwell 3-inch turbometer and the exact duration of discharge was known, the recovery data was used to determine the aquifer characteristics. Figure 1 shows the plot of residual drawdown versus the ratio of the logarithm of the time since pumping began to the time since pumping ceased. The data has been plotted according to standard

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D

W-2

$S_{\Delta t=0}$	112.23
S_{1hr}	0.40
ΔS	0.528
S	.1
T	101,000
r_w^2	0.1289
t	180
Δt	60

$s = 238.24$

$\Delta p_{skin} = 109.44$

$FE = 2.4\%$

$$\frac{112.23 - 0.082 - 109.44}{112.23 - 0.082}$$

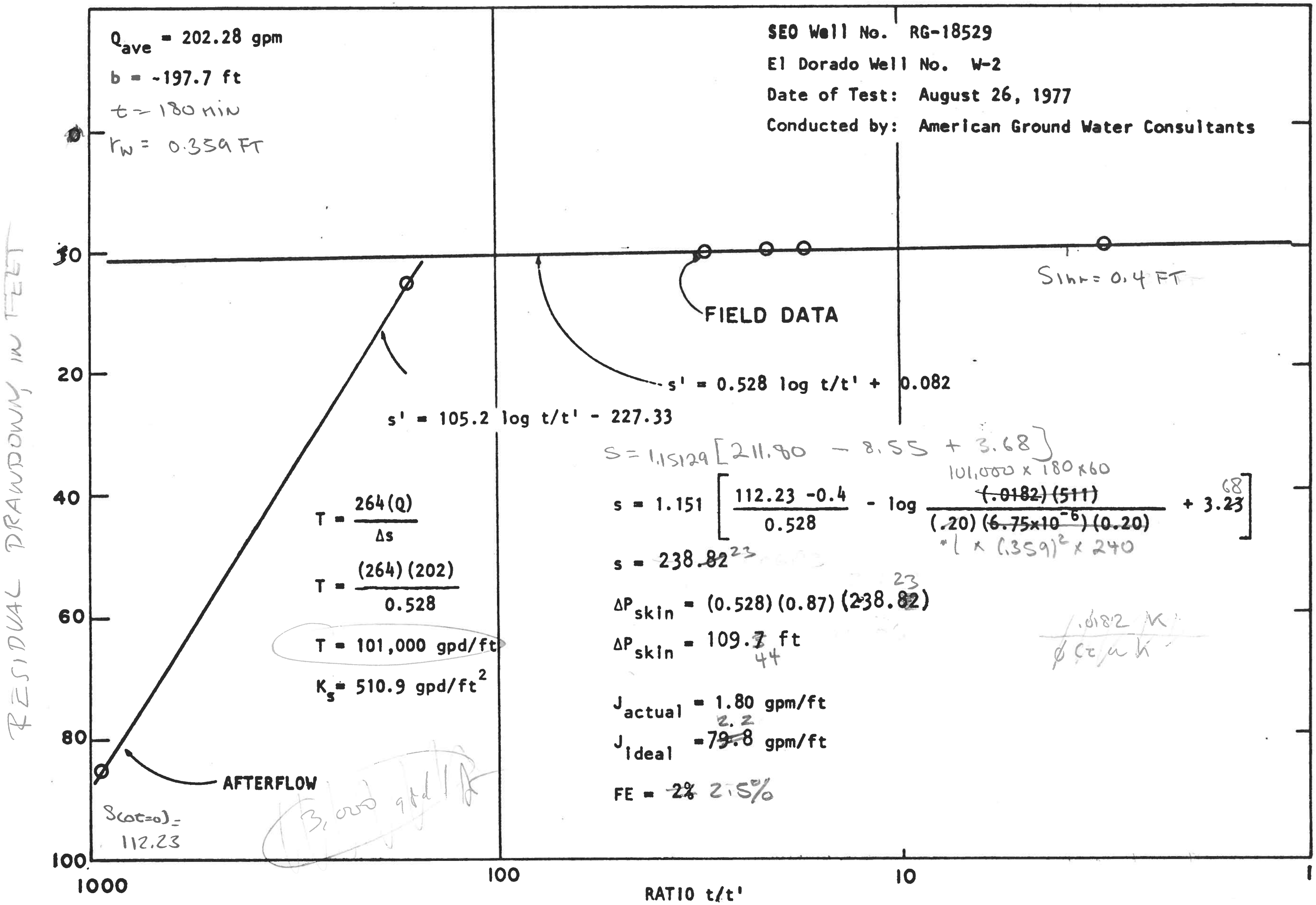
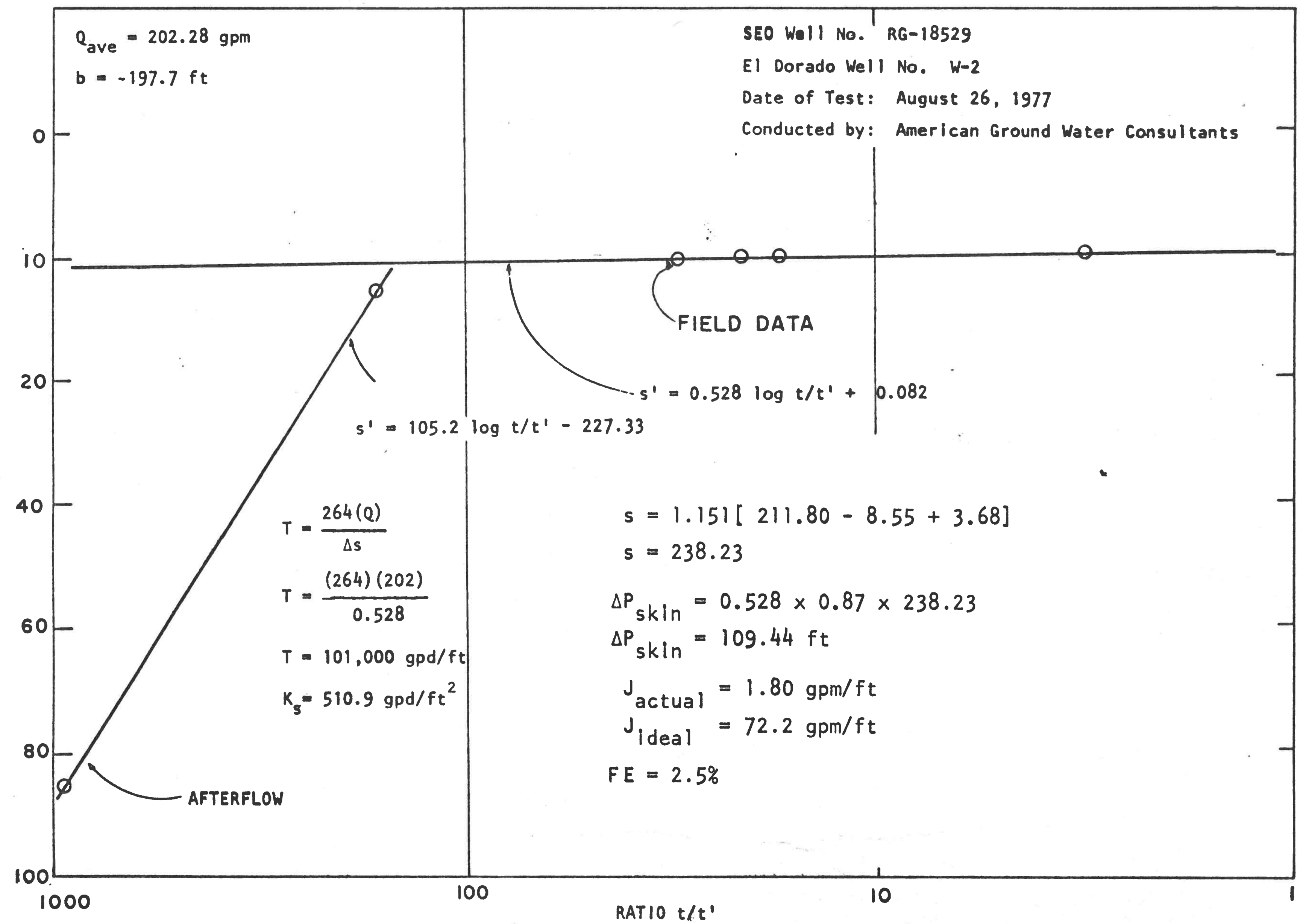


Figure 1. Diagram showing recovery data for Well W-2.



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oilfield pressure buildup methods. The initial part of the recovery graph shows very rapid filling of the casing or afterflow. Later data gives the undamaged aquifer transmissivity as 101,000 gpd/ft. Analysis of the data shows a significant skin effect and a significant head loss across the skin resulting in a flow efficiency for the well of only two and one half percent. Examination of the well construction methods indicates that the well produces large amounts of water through shot perforated casing. Indeed the magnitude of the skin is largely attributable to the small amount of open area in the casing through which the water is constrained to flow in passing through the casing into the well.

Utilizing the Theis non-leaky, non-equilibrium relationships, the long-term ideal yield of the well necessary to draw the water level to the pump intakes after continuously discharging for 40 years is 7,182 gallons per minute. Because the flow efficiency is only about two percent, the actual possible long-term yield from the well is about 144 gallons per minute. The amount determined on theoretical grounds agrees well with the known capability of the well.

Well-3

Well-3 was constructed from test hole R-35. Test hole R-35, a 4 3/4-inch hole, was constructed by mud rotary methods by the Steinberger Drilling Company. R-35 was begun on March 24, 1970, and reached a total depth of 333 feet on March 31st. Self potential, resistivity and gamma ray logs were run in the hole. Subsequently, Mr. Minton, the engineer-in-charge of water development, authorized oilfield pressure buildup methods. The initial part of the recovery graph shows very rapid filling of the casing or afterflow. Later data gives the undamaged aquifer transmissivity as 101,000 gpd/ft. Analysis of the data shows a significant skin effect and a significant head loss across the skin resulting in a flow efficiency for the well of only two and one half percent. Examination of the well construction methods indicates that the well produces large amounts of water through shot perforated casing. Indeed the magnitude of the skin is largely attributable to the small amount of open area in the casing through which the water is constrained to flow in passing through the casing into the well.

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On April 30, 1970, Perry Brothers Drilling Company began the enlargement of test hole R-35 using mud rotary methods. On May 20th, the hole reached 324 feet. A string of 211 feet of slotted 10 3/4-inch casing followed by 113 feet of blank casing was run into the hole. A packer was set at 113 feet, and the blank casing was cemented to the surface. The perforations consisted of 16 sets of 3/8-inch-wide slots, 3 inches wide per lineal foot of pipe. The total open area in the casing is estimated at 36 square inches.

Development was carried out by first washing the hole with 4,000 gallons of clear water. On May 22nd, the hole was bailed and surged, and 200 pounds of polyphosphate were added to break up the mud cake. On May 26th, a test pump was set and after pumping and surging the well for 4 1/2 hours, the well produced 50 to 75 gallons per minute from a pumping water level of 273 feet for a total drawdown of about 158 feet.

Minton subsequently ordered the well shut down and sealed by welding a plate between the discharge pipe and the casing. On May 27th, 2,000 gallons of 15 percent muriatic acid was injected into the well. This was followed by 1,000 gallons of water. On May 29th, the test pump was restarted and the well was pumped and surged for five hours at the end of which time Minton reported that the well would sustain 160 gallons per minute with a pumping water level of 255 feet.

On May 30th, Minton added an additional 4,000 gallons of 15 percent acid chased by 1,000 gallons of fresh water. For the remainder of June, Minton carried out "tests" on Well-3. His report on the tests has not been located. On July 1st, Perry Brothers pulled the test pump.

On November 2, 1970, Hydrotechnics, the predecessor company to American Ground Water Consultants, carried out an aquifer performance test of Well-3. The results of this test and the results of analysis of more recent data are discussed in the following section.

Determination of Aquifer Characteristics Utilizing Well-3

In determining the aquifer characteristics utilizing Well-3, a set of heretofore unanalysed data collected by Hydrotechnics on November 2, 1970, was analysed. The test was carried out using the pump which was in the well at the time. Water from the well was discharged into an earthen pond which had been lined with an impermeable membrane liner. Prior to the test, the well had not pumped for at least a week. The discharge rate was controlled by a gate valve and was measured with a five-gallon bucket and stopwatch. The discharge rate fluctuated somewhat during the test and in the later part of the test may have increased. The test data indicates that an average constant discharge rate of about 44 gallons per minute was hours at the end of which time Minton reported that the well would sustain 160 gallons per minute with a pumping water level of 255 feet.

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As part of the present study, records from a Leupold & Stevens water-level recorder were studied, and a period of record from November 13 to 25, 1974, was selected as suitable for aquifer performance analysis. From November 13th to 18th, the pump was off, and water levels were recovering from the last previous period of pumping. Control was initiated at 2216 hours on November 18th and terminated at 1010 hours on November 19th. Water levels continued to rise until the well turned on again on November 25th. The recovery data following termination of control was corrected for the trend of the rising water levels which existed before control was initiated.

All pertinent drawdown and corrected recovery data is presented in Attachment 1. The drawdown data is plotted versus the logarithm of time, and the recovery data is plotted as the residual drawdown versus the logarithm of the ratio of the time since discharge began to the time since discharge ceased. These plots are Figures 3 and 4.

From the data used in this analysis, it may be concluded that there is almost no skin effect and that the well is efficient for the low rates of ground water extraction obtained. The efficiency of the well has not decreased in the period since the well was completed. The aquifer transmissivity is about 100 gallons per day per foot. The more recent data suggests a smaller transmissivity than the earlier set of data. However, the aquifer permeability is almost the same. This suggests that the saturated thickness of the aquifer under test

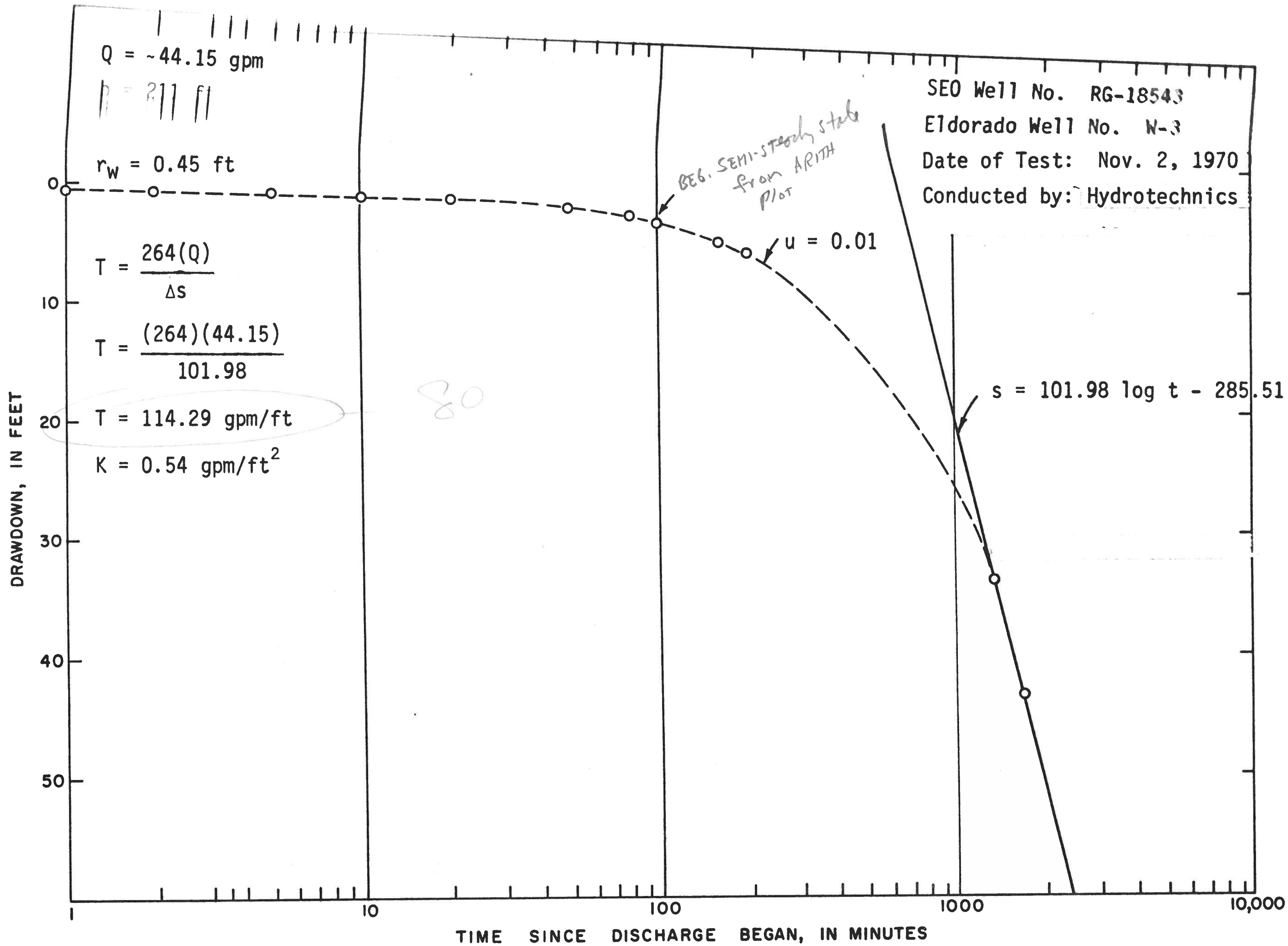

Figure 2. Diagram showing drawdown data for Well W-3 collected on November 2, 1970.

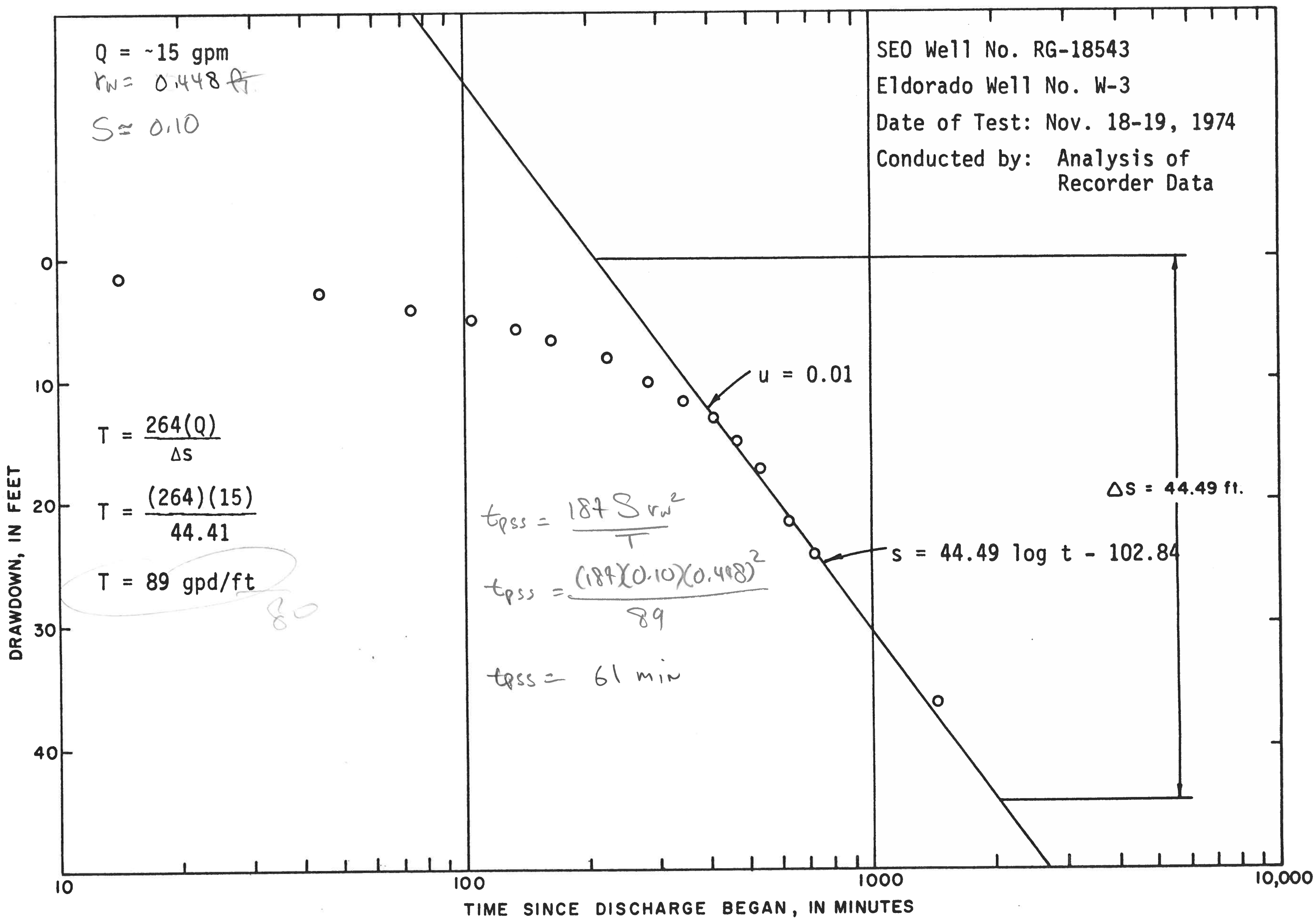

Figure 3. Diagram showing drawdown data for Well W-3 collected on November 18-19, 1974.

W3

$S_{\Delta t=0}$ = 24.40

S_{1hr} = 51.46

ΔS = 42.90

T = 92

t = 714

Δt = 60

S = .1

r_w^2 = .20

$t+\Delta t$ = 774

S = [redacted] −2.71

Δp_{skin} = −101.03

$$\text{Flow Eff} = \frac{24.40 - 3.82 + 101.03}{24.40 - 3.82} = 591\%$$

t_c =

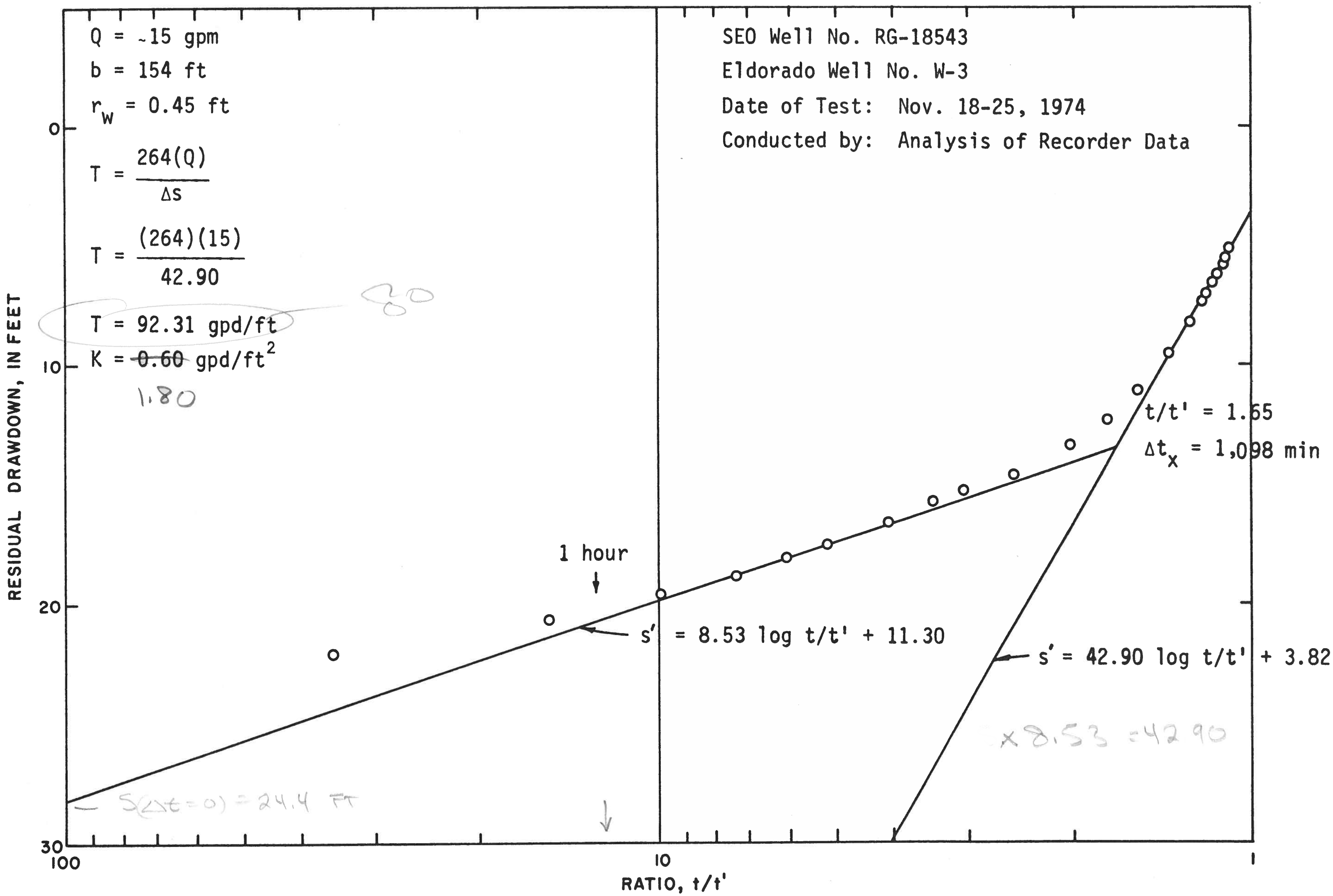

Figure 4. Diagram showing recovery data for Well W-3 collected on November 18-25, 1974.

in 1970 was slightly greater than it was in 1974. This borne out by the fact that the test using 1974 data was carried out before the well had recovered completely.

Based upon an undamaged aquifer transmissivity of 90 gpd/ft and given 211 feet of available drawdown and an assumed storage coefficient of 0.10[1], the maximum continuous discharge rate which may be sustained over a period of 40 years by Well-3 is estimated by the Theis (1935) non-leaky nonequilibrium relationships as about 10 gallons per minute.

Well-4

Well-4 was constructed as the result of apparently favorable results from test hole R-52. Drilling of R-52 began on May 18, 1970, by the Steinberger Drilling Company using rotary drilling methods. The 4 3/4-inch hole was begun on air but at a depth of 40 feet, a seep of water was reportedly encountered and drilling proceeded with mud. At 78 feet drilling with air was resumed because of lost circulation problems. At 242 feet drilling with mud resumed again, and the hole reached a total depth of 375 feet on May 21, 1970.

In drilling R-52, the driller noted fractured sandstone units, and in particular, a white and gray limestone at 332 to 336 feet which caused lost circulation problems. The test hole seems to have bottomed in Precambrian crystalline rock.

---

[1]Digital computer model studies of the Sunlit Hills area directly to the north of the Eldorado property indicate that the storage coefficient of the Galisteo Formation is about 0.10. The absence of barometric fluctuations in the water level during the recovery periods indicates unconfined aquifer conditions.

On June 6, 1970, Perry Brothers Drilling Company began drilling Well-4 using mud rotary methods. The hole size was 12 1/4-inches. It is not clear whether Perry Brothers began drilling in the test hole or whether they chose a location close to R-52. In all likelihood, they chose a location close to R-52. On the first day they reached a depth of 40 feet and lost some tools in the hole. Minton had them skid the rig about three feet and begin the hole again, which they did on June 9th. At 308 feet Minton reported that Perry was having mud problems, and he recommended that the mud be thinned to increase drilling rate. On June 23rd, the hole had reached its total depth of 374 feet.

On June 24th, Perry Brothers began to run 10 3/4-inch casing into the hole. There is no indication that the hole was first flushed with clear water. On June 25th, the casing became stuck in the hole. The driller reports that it was stuck at 265 feet, and Minton reports that it was stuck at 347 feet. In any event, Perry Brothers moved in a spudding rig and drove the casing to 363.3 feet on June 25th. The casing string consisted of 75.6 feet of blank 10 3/4-inch casing followed by 289.6 feet of perforated casing. The perforated casing reportedly contains 16 sets of 3/8-inch wide slots, 3 inches long per lineal foot. The total open area in the casing is estimated at 36 square ~~inches~~ FEET.

Subsequent to setting the casing, Perry Brothers bailed and surged the well for 4.5 hours on June 27th. On June 29th, they spent an additional 5.5 hours bailing and surging, after which they cemented the annulus to a depth of 73.6 feet below land surface.

By the morning of July 2nd, Perry Brothers had installed the test pump, and pumping was begun at 0835. By 1315, the water level in the hole had dropped to about 228 feet to a pumping water level

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By the morning of July 2nd, Perry Brothers had installed the test pump, and pumping was begun at 0835. By 1315, the water level in the hole had dropped to about 228 feet to a pumping water level of 306 feet with a reported pumping rate of 28 gallons per minute. Perry Brothers continued to surge and pump the well until the evening of July 3rd, at which time it was producing about 24 gallons per minute. At 2000 hours on July 3rd, Minton introduced 4,000 gallons of 15 percent muriatic acid into the hole and sealed the hole. The pressure created by the reaction of the acid with limestone in the hole caused a blowout which emanated from the initial 40-foot hole. It is not known whether the acid-carbon dioxide-water mixture moved up the annulus of Well-4 and then short-circuited into the 40-foot hole or whether the mixture moved through fissures in the limestone to intersect the old test hole R-52 through which it moved to the surface. In any event, gas, acid and water blew for about 10 minutes. Calculations by American Ground Water consultants indicate that a pressure of up to 1,400 pounds per square inch could have developed in the well as a result of the acidization.

The acid, or what remained of it, was left in the well until the morning of July 6th, when the test pump was again turned on. The initial pumping rate was measured at 51 gallons per minute. When Minton returned to the site on the morning of July 7, the discharge rate had dropped off to 41 gallons per minute from a pumping water level of 215 feet. On July 8th, Minton had Perry Brothers pump the well to clean out whatever acid remained in the aquifer. On July 10, 1970, Perry Brothers moved away from Well-4. From his notes, it is evident that Minton prepared a report on Well-4, but this report has not been located.

Determination of Aquifer Characteristics Using Well-4

To evaluate the transmissivity of the aquifer as well as the efficiency of the well itself, water-level records collected by a Leupold & Stevens model A-71 recorder were examined to locate a period of time in which the pumping period was both preceded and followed by long periods of inactivity. The period of record selected began on August 6, 1974, and ended on August 12, 1974. Control was initiated at 0900 hours on August 8 and was terminated at 1634 on the same day. Drawdown and corrected recovery data corrected for the long term trend of rising water levels ascertained from the pre-discharge period are given in Attachment 1. Figures 5 and 6 are graphs of drawdown versus the logarithm of time since discharge began and of residual drawdown versus the ratio of time since discharge began to the time since discharge terminated. Meter readings from this well indicate that it operates at about 30 gallons per minute.

The data, when plotted, yield highly interesting results. The early drawdown data indicate the presence of a significant skin effect which has caused the immediate drawdown of about 35 feet. That is, at least 35 feet of hydraulic head difference exist between the undamaged aquifer and the pumping water level before any significant amount of water will flow into the well. Because the discharge rate was not closely controlled and because the test was not of long duration, the gradual flattening of the time-drawdown curve may be due to the gradually diminishing discharge rate as the water level drops. Indeed,

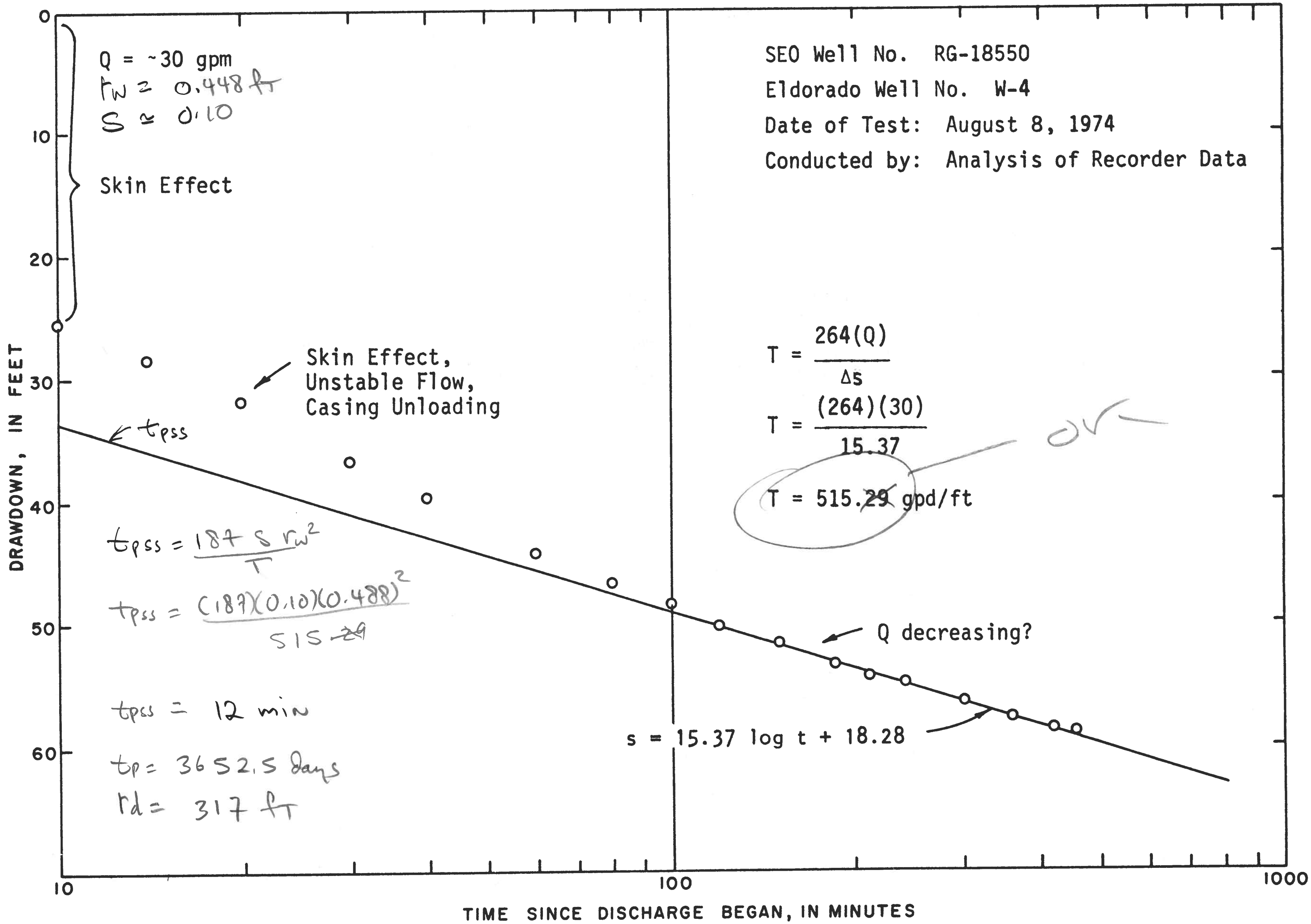

Figure 5. Diagram showing drawdown data for Well W-4.

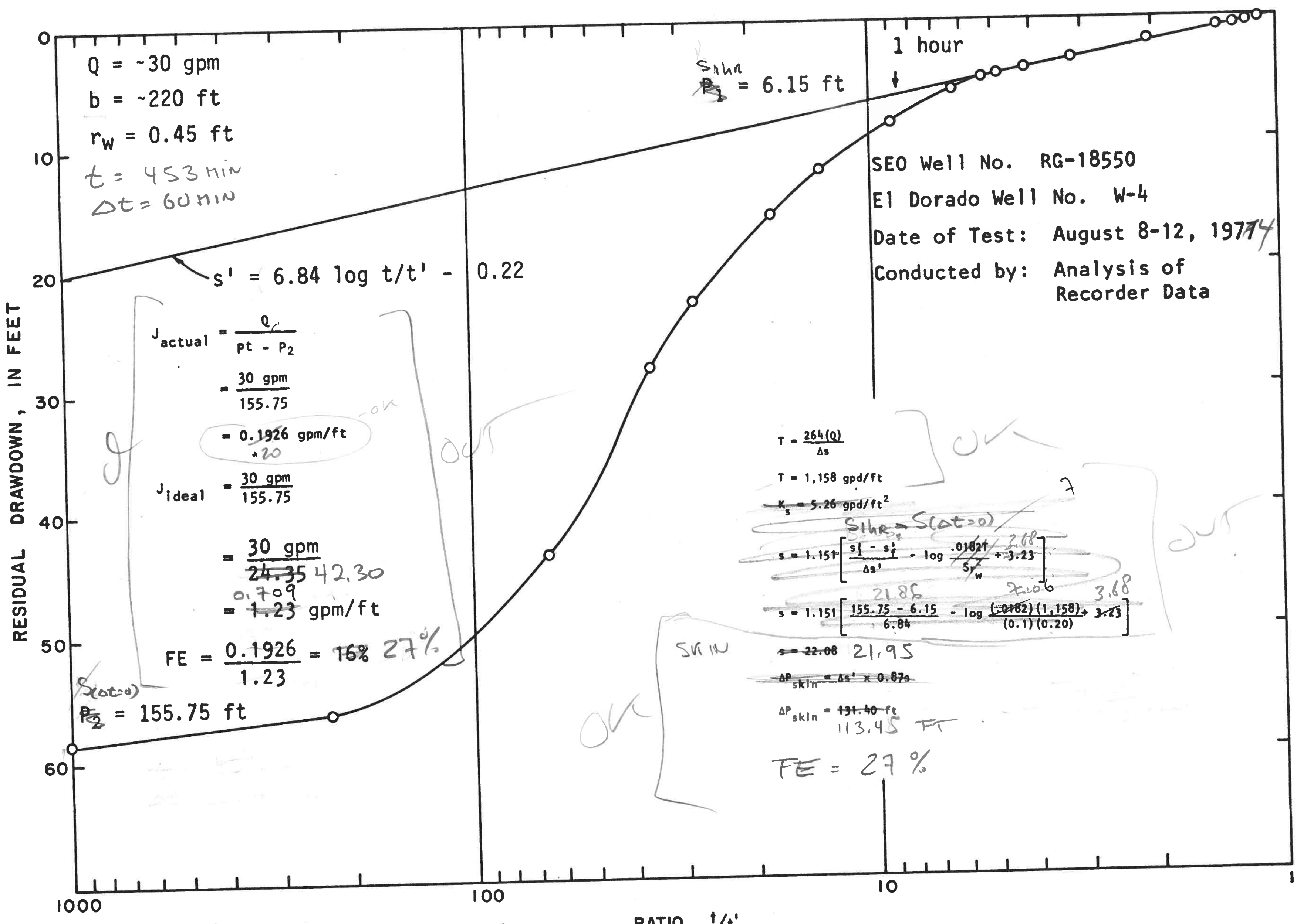

Figure 6. Diagram showing recovery data for Well W-4.

W-4

$\Delta_{\Delta t=0}$ = 58.95

$\Delta_{1\,hour}$ = 6.~~15~~ 5

ΔS = 6.84

T = 1158

t = 453

Δt = 60

S = .1

r_w^2 = .20

$t+\Delta t$ = 513

O = 5.66

~~Δ~~ s_{skin} = 33.69

$$FE = \frac{58.95 - 0.22 - 33.69}{58.95 - 0.22} = 43\%$$

5.64

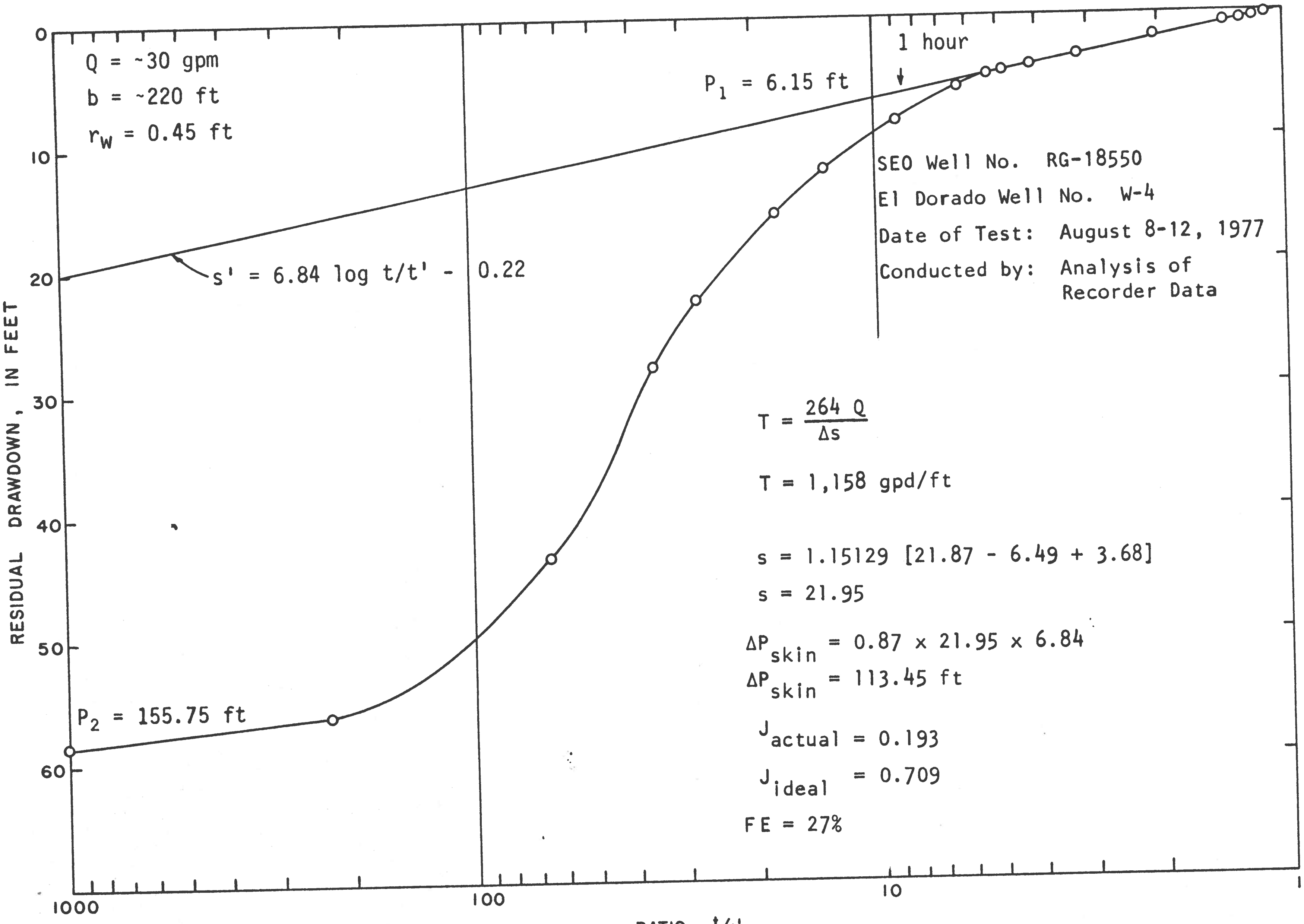

Figure 6. Diagram showing recovery data for Well W-4.

as will be seen, the transmissivity value calculated from the time-drawdown graph is too low, indicating that the discharge rate was still falling off at the end of the pumping period.

Figure 6 is more informative than Figure 5. Figure 6 is a classical recovery curve for a well with significant borehole damage. A pressure buildup analysis of this data indicates an undamaged aquifer transmissivity of about 1,158 gpd/ft. A skin effect of ~~22.08~~ 21.95 is determined which leads to a pressure drop across the skin of about ~~131.39~~ 113.45 feet. That is to say that until a pressure drop of that magnitude exists across the skin of the discharging well, the aquifer transmissivity determined from the time-drawdown graph may not be relied upon. From the head loss across the skin, the flow efficiency of the well is determined to be about ~~16~~ 27 percent.

Based upon an undamaged aquifer transmissivity of about 1,158 gpd/ft and given 266 feet of available drawdown and an assumed storage coefficient of 0.10, the maximum continuous discharge rate which may be sustained over a period of 40 years by Well-4 is estimated by the Theis non-leaky non-equilibrium relationships as about 152 gallons per minute. However, with a flow efficiency of only ~~16~~ 27 percent, the actual long-term yield may be only about ~~24~~ 41 gallons per minute. This is ~~slightly less~~ more than is pumped from the well presently, ~~indicating close agreement between the theoretical analysis and reality~~. It may be mentioned here that at a pumping rate of 30 gallons per minute, the pumping water level does not presently reach the pump intakes. A long term sustained yield of 25 ~~gpm~~ gallons per minute is, therefore, not unreasonable.

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Well X-4

Well X-4 was drilled prior to 1969 and provided the domestic needs of the ranch headquarters. Well X-4 continues to supply water to the Eldorado system. Unfortunately, there is no information available on the construction of Well X-4. It may be presumed that the lithologies encountered by Well X-4 are similar to those encountered by the 8000 series wells which are close by. The 8000 series wells penetrated a thin zone of granite wash before entering and bottoming in what appears to be Precambrian granite. As will be discussed, the transmissivity of the water-bearing rock encountered by the 8000 series wells is very low and is not untypical of relatively unfractured granite. Well X-4 reportedly produces 12 gallons per minute continuously.

Determination of Aquifer Characteristics Utilizing Well X-4

To determine the long-term yield of Well X-4, a short duration aquifer performance test was carried out on August 18-19, 1977.

Prior to the initiation of control, the well had been shut down for about one week. Control was initiated at 1620 hours on August 18th at a discharge rate of about 4.6 gallons per minute. Discharge was measured by means of a Rockwell meter and stopwatch. Water levels were measured electrically by means of a Powers M-Scope and steel surveyors tape. Control was maintained until at least 1730 hours on August 19th. No recovery data were obtained. Drawdown data for this test are given in Attachment 1. Figure 7 is the time-drawdown plot of the aquifer performance test data.

Figure 7 indicates rapid drawdown to a depth of about 7 feet within one minute of initiating control. This may be due to bore-hole damage but is due also to the higher rate of discharge in the first four minutes of the test. The aquifer transmissivity determined from the test using Well X-4 is estimated to be 1,325 gpm/ft.

Based upon the transmissivity determined in this test and an assumed storage coefficient of 0.10 and given 60 feet of available drawdown, the maximum continuous discharge rate which may be sustained over a period of 40 years by Well X-4 is about 38.8 gallons per minute. This is a theoretical maximum value which has not been adjusted to reflect the efficiency of the well. Because it seems that the well is not completely efficient, the final analysis will have to await the results of a recovery test using the well. It is appropriate to say, however, that the well can sustain five gallons per minute for at least 40 years.

Wells 8000, 8001, 8002, and 8004

Well construction details of the four 8000 series wells are quite similar and are discussed together. Wells 8000, 8002 and 8004 were drilled by Lloyd Scott Drilling Company in October and November of 1970 using mud rotary methods. All wells penetrated granite wash sediments before entering Precambrian granitic basement rock at about 215 feet. Table 1 presents some pertinent information on the four 8000 wells of interest.

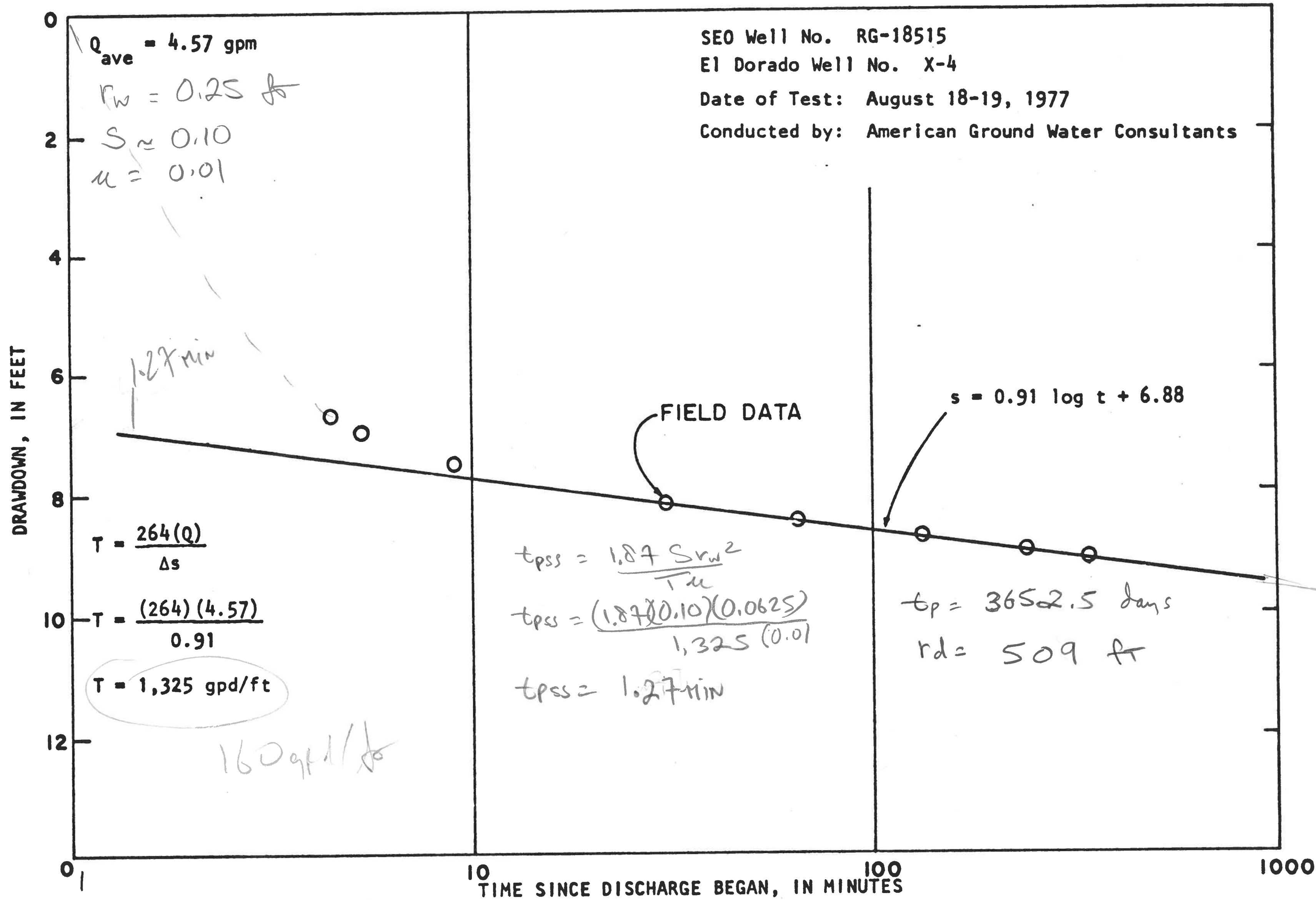

Figure 7. Diagram showing drawdown data for Well X-4.

Well 8001 was drilled by Rodgers & Company in February, 1971. All wells were cased with slotted pipe. The method of perforation is not known but was probably either with a mills knife or acetylene torch.

Aquifer Performance Tests Using the 8000 Series Wells

Rodgers & Company set pumps in all of the 8000 wells and tested each one in a manner which should allow the use of the data to arrive at approximate long term yields of the well. The data for each of the aquifer performance tests obtained by Rodgers & Company which is used in the present study is presented in Attachment 1. Figures 8 through 10 are time-drawdown graphs prepared from drawdown data given in Attachment 1.

Analysis of the data from Well 8000 indicates an aquifer transmissivity of about 15.8 gpd/ft. Assuming a storage coefficient of 0.10 and given 122 feet of available drawdown, Well 8000 should yield about 1.8 gallons per minute continuously for 40 years.

Analysis of aquifer performance test data from Well 8001 indicates an aquifer transmissivity of about 13 gpd/ft. If the storage coefficient is 0.10 and the available drawdown is 104 feet, Well 8001 should be able to sustain a continuous yield of about 1.0 gallon per minute for 40 years.

Based upon data collected from Well 8004, the aquifer transmissivity is about 47 gpd/ft. Again, if the storage coefficient is about 0.10 and with 145 feet of available drawdown, the maximum continuous yield of Well 8004 for a 40-year period is about 4.1 gallons per minute.

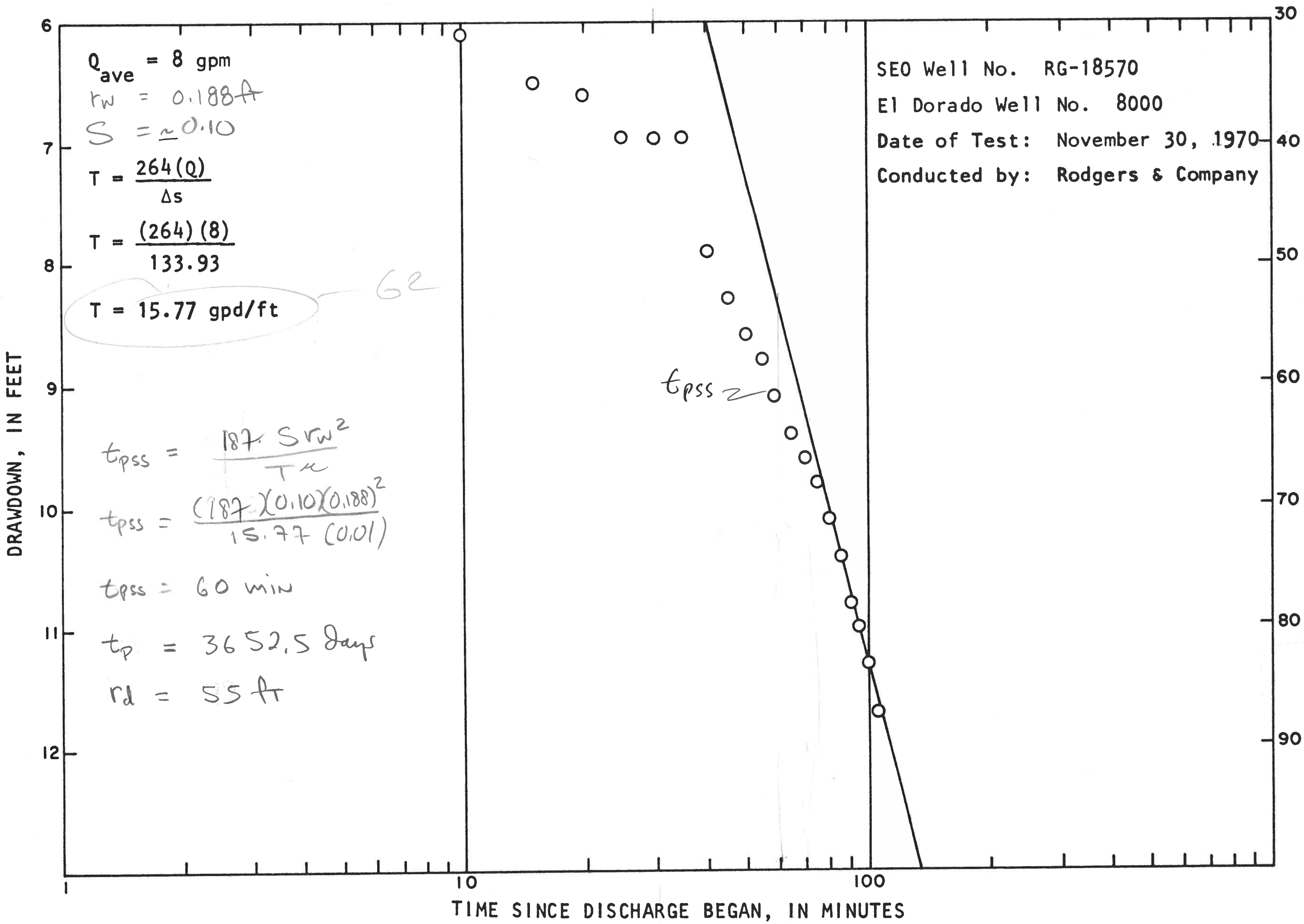

Figure 8. Diagram showing drawdown data for Well 8000.

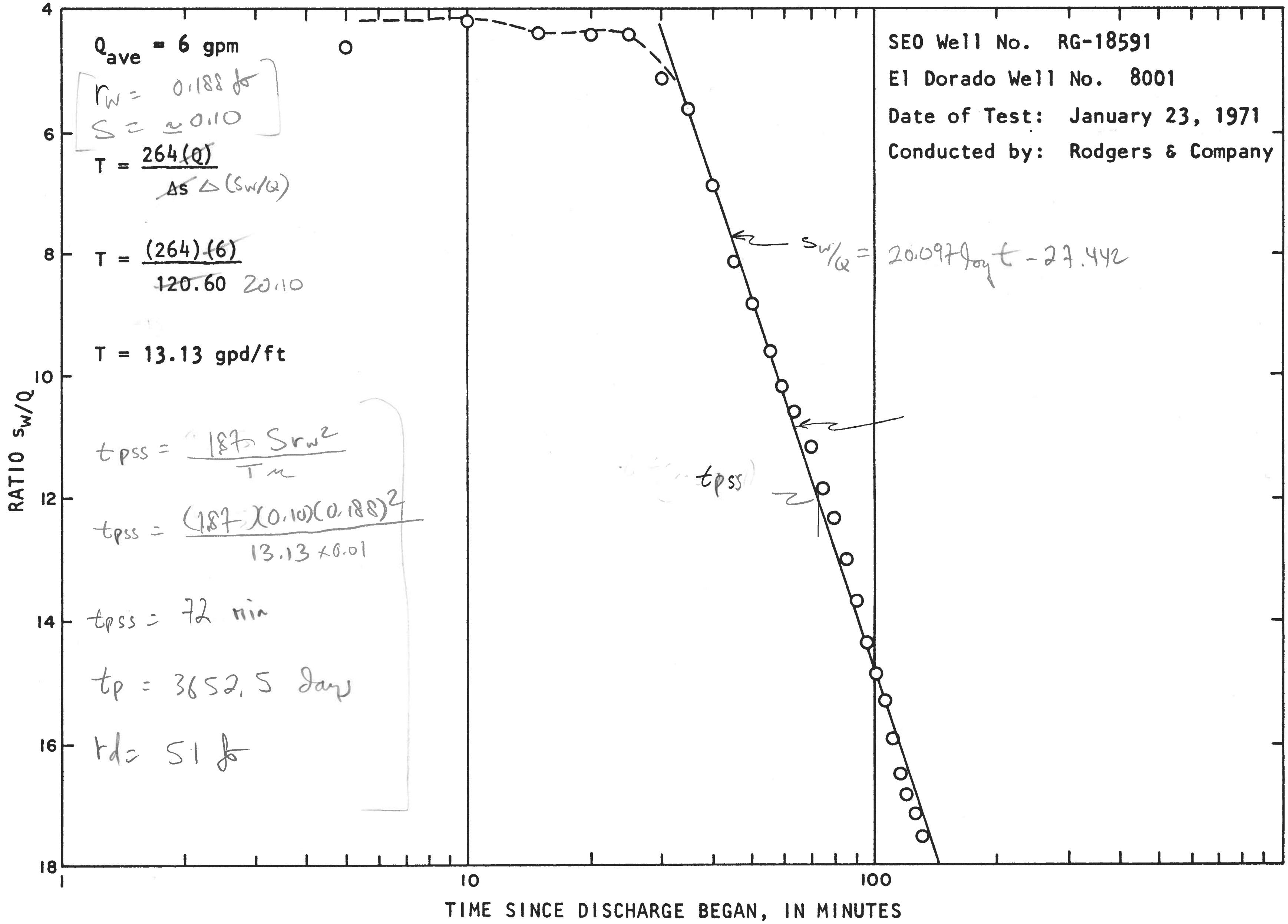

Figure 9. Diagram showing drawdown data for Well 8001.

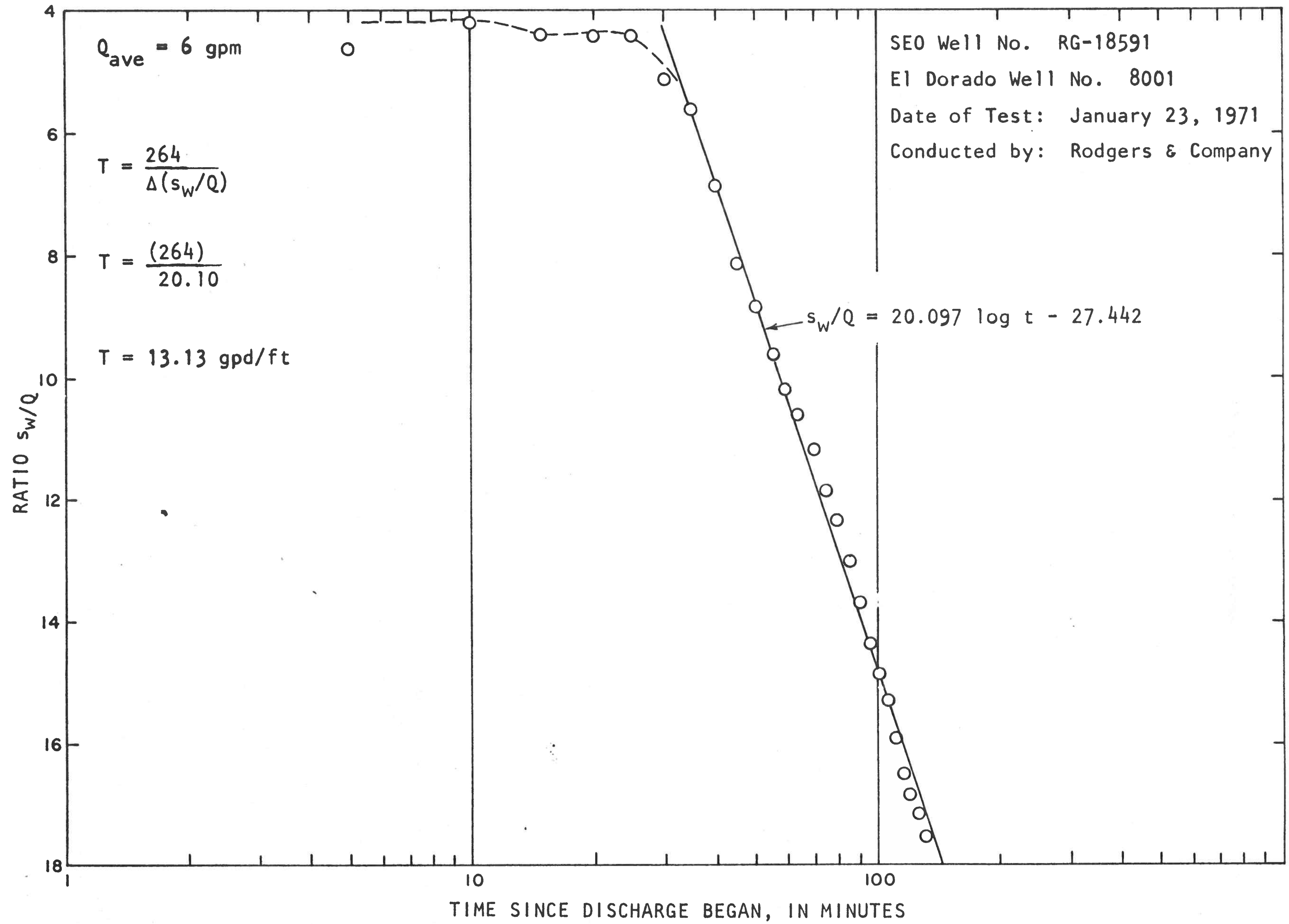

Figure 9. Diagram showing drawdown data for Well 8001.

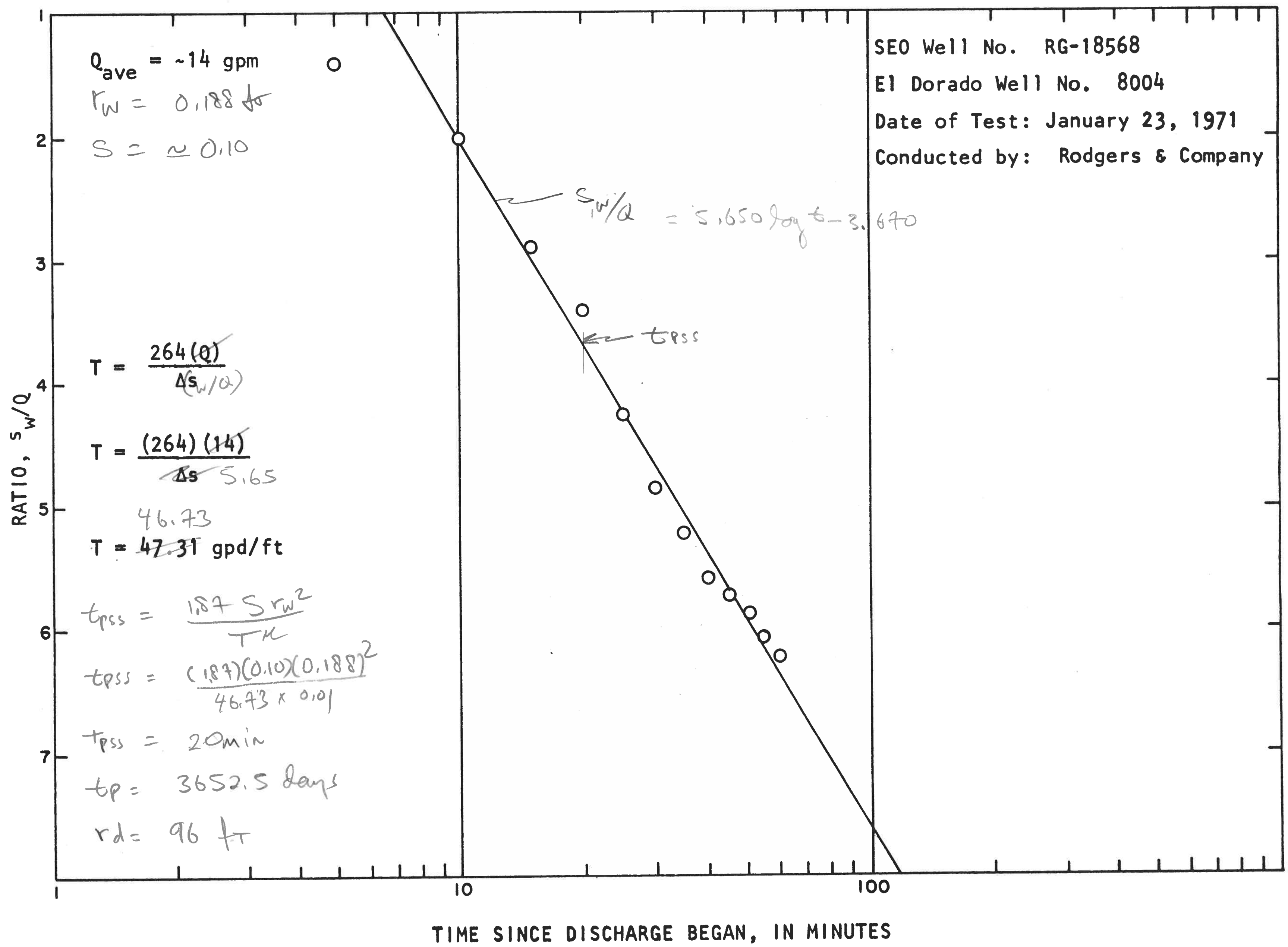

Figure 10. Diagram showing drawdown data for Well 8004.

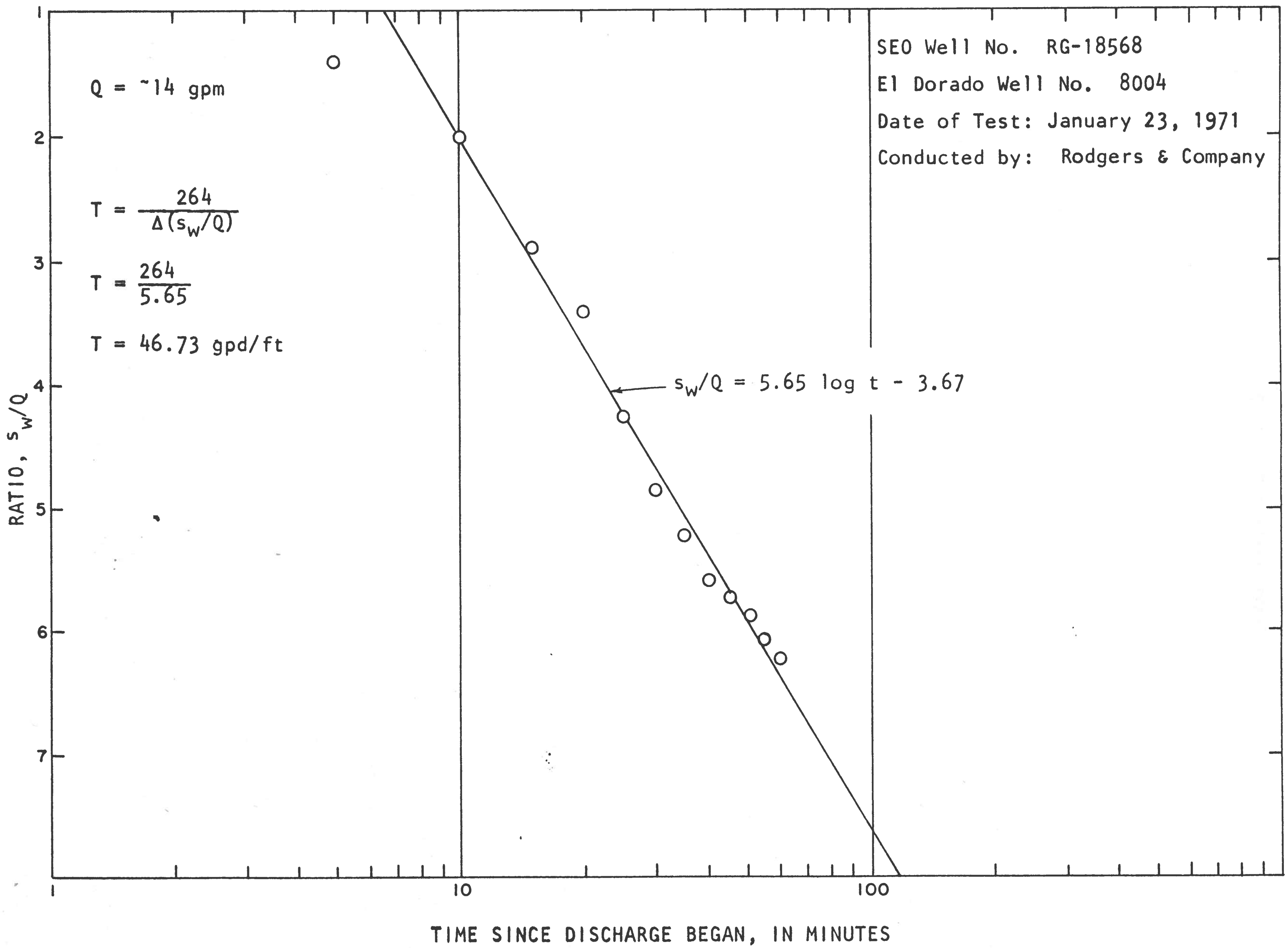

Figure 10. Diagram showing drawdown data for Well 8004.

Pump test data for Well 8002 could not be located. Discussions with Rodgers and Company indicate that Well 8002 pumped about 820 gallons per hour with a drawdown of 15 feet. This yields a specific capacity of about 0.91 gpm/ft. Applying a rule of thumb of 2,000 times the specific capacity, the transmissivity of the aquifer penetrated by the well is estimated at 1,822 gpm/ft, which is significantly higher than the other 8000 wells. The long-term yield of this well is therefore in excess of the long-term yield calculated for Well 8004.

LIMITATIONS

Given the geological setting of the Eldorado property, it is possible that the wells which exist on the property penetrate water-bearing rock units which themselves have differing water transmission characteristics. That is, a well in the North Boundary Channel may pass through a thickness of relatively young, unconsolidated alluvial material of the Ancha Formation and then pass into the better indurated and interbedded sandstone and red clay sequence of the Galisteo Formation. The Ancha Formation has a higher transmissivity and probably also a larger storage coefficient than the sandstone units of the Galisteo Formation. Likewise, wells which penetrate the Precambrian granite basement rock of the area may encounter a fracture within the granite which provides most of the water to the well when it is pumped.

Because of these conditions, it may be argued (and it has been argued in the past) that once the pumping water level in a well falls below either the base of the Ancha Formation or the level of a fracture which provides most of the water to a well, that the yield of the well will fall off rapidly. This is a valid argument provided the conditions in the well are as outlined above.

Another potential limitation to the amount of water which may be ultimately available from the wells of interest and particularly those wells close to the development area will be the degree to which each of the wells interferes with the others. Wells which mutually interfere tend to lower the pumping water level in each other. This has the effect of reducing the amount of total water available because the pumping water level in any given hole will reach the pump intakes sooner than if only the well in question were pumping alone.

The above two potential limitations to the availability of water from the wells of present interest have been examined, and they are discussed in more detail below.

THERMAL INJECTION TESTS

To determine the uniformity or lack of uniformity of water transmission characteristics of the water-bearing rock encountered by the wells of present interest, thermal injection tests were carried out on each well. The test is conducted by introducing water into the well which is at a significantly higher temperature than the water in the well.

The warm water will displace the water in the well and will force itself into the water-bearing rock unit. The more permeable the rock penetrated by the well, the greater the mass of warm water that will be accepted by this zone. Upon completion of the injection, temperature logs are run on each hole at intervals to be determined in the field. Those zones which require the longest period of time to re-establish thermal equilibrium will be the zones of the highest permeability. Ideally, to substantiate the calculations of long-term well yield in the area, the rock encountered by the well should have uniform permeability or permeability increasing with depth.

In 1970, Hydrotechnics measured temperatures in all wells on the Eldorado property. The temperatures measured within the wells of interest may be expected to return to these temperatures in time.

RESULTS OF THERMAL INJECTION TESTS

For the purpose of the present study, temperature profiles were measured in all wells. Very warm water was obtained from the Eldorado swimming pool which is a heated swimming pool. The temperature of the water was about 82°F (27°C). The water was loaded into a 4,000 gallon tank truck from whence it was injected into the wells under study. The injection rates varied from about 30 gallons per minute to more than 280 gallons per minute for different wells.

Several temperature profiles were made subsequently in each of the wells under study. These measurements have been plotted in Figures 11 through 17.

Well W-2

It is evident from Figure 11 that most of the formation seems to have taken water. Well W-2 accepted about 4,200 gallons of water at take rates of up to 280 gpm. The entire sequence penetrated by the well seems to be cooling rather uniformly. This seems to be in conflict with the engineers who reported that the casing was shot perforated to only 233 feet. It is likely that the lower part of the well from about 285 feet down does contain either blank casing or non-permeable rock. Subsequent inspection of the well by television camera verified this Because of the apparent occurrence of high permeability units throughout the sequence of rock penetrated by the well, the original estimated long-term yield based upon 197.7 feet of available drawdown will not be changed.

See later TV unrevealed

interpretation by revealing the well to be cased from top to bottom with slotted casing.

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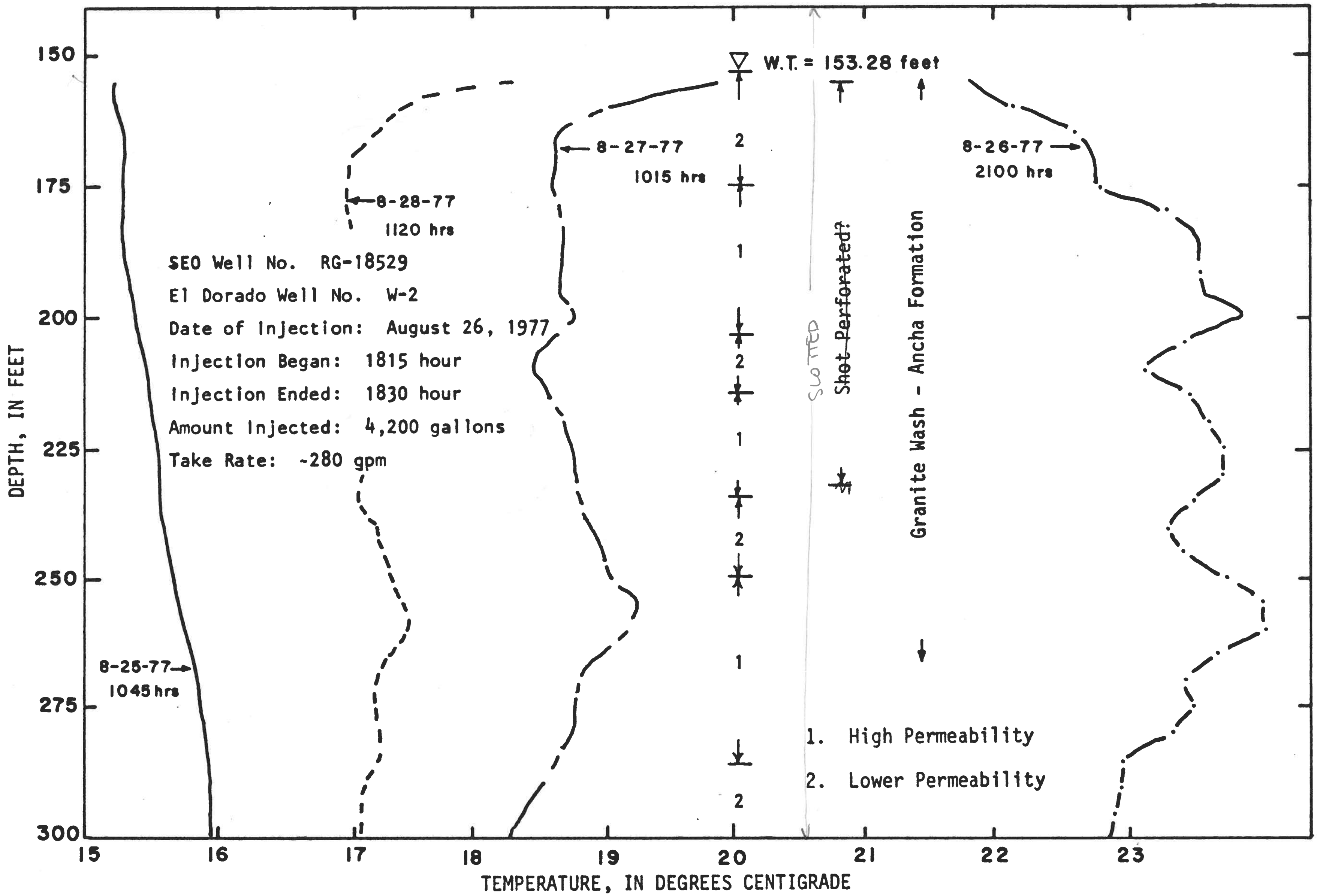

Figure 11. Temperature profiles of Well W-2 measured before and after injection of hot water.

Well W-3

Well W-3 received about 2,200 gallons of water at a take rate of up to 150 gallons per minute. The thermal profiles taken in Well W-3 are given in Figure 12. Figure 12 shows that no warm water was accepted by the rock sequence penetrated by the well below about 195 feet. Therefore, the interpretation is that this well does not produce water beneath 195 feet. Reflecting back on the aquifer performance tests reported earlier, the drawdown obtained during these tests never exceeded about 50 feet and as a result, never fell below the bottom of the productive zone. In the earlier test conducted by Hydrotechnics at the higher pumping rate, it is noted that the drawdown curve continues to steepen beyond the point at which the argument of the well function "u" is less than 0.01. This is undoubtedly caused by the continual decrease in the saturated thickness as the pumping water level falls.

As a result of the thermal injection test, the long-term yield of Well W-3 must be re-evaluated in terms of the available "live" drawdown. That is, drawdown within that part of the aquifer which can yield water to the well. Therefore, if the available drawdown is only 46 feet and all other items are the same, the long-term continuous discharge which may be obtained from Well W-3 is 2.66 gallons per minute.

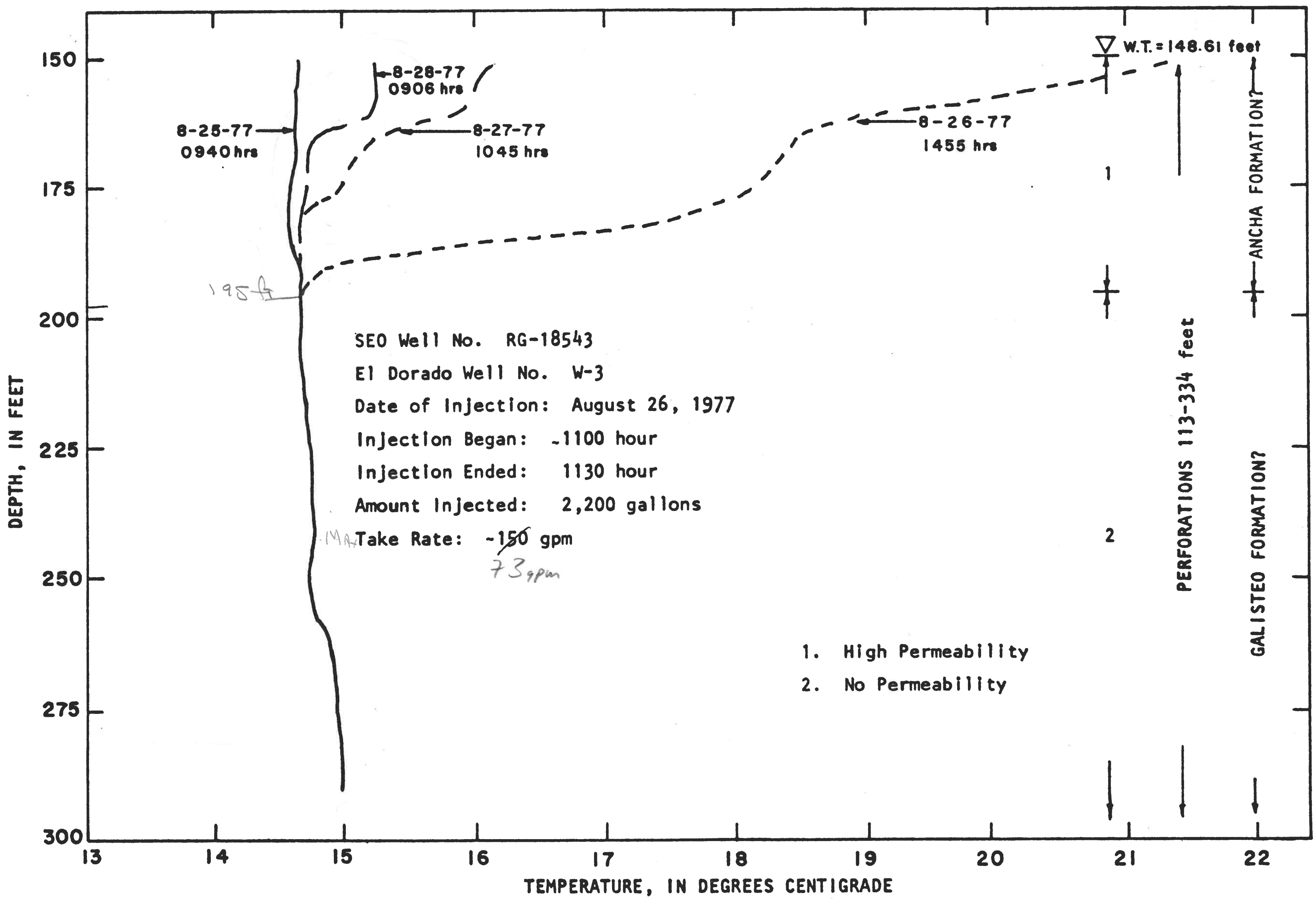

Figure 12. Temperature profiles of Well W-3 measured before and after injection of hot water.

Well W-4

The thermal injection test of Well W-4, like Well W-3, shows that only the rock units penetrated by the well from the water table to a depth of 220 feet produce any water. Of that zone, only the rocks from the water table to a depth of about 170 feet have any significant permeability.

As a result of the thermal injection test, the long-term yield of the well must be re-evaluated in terms of the zone of "live" drawdown and in terms of the well efficiency determined above. Given a total "live" drawdown of 72 feet and all other items the same, the long-term yield of Well W-4 is 33.6 gpm, at 100 percent efficiency. Because the efficiency increases as the actual discharge rate decreases, the well may become 71 percent efficient if the actual discharge rate remains at 24 or 25 gallons per minute.

Well X-4

Figure 14 shows the thermal profiles determined prior to and after injection of warm water into Well X-4. These profiles indicate that the well penetrates permeable rock from the water table to the bottom of the zone in which measurements could be taken. It may possibly be presumed that the zone of moderate permeability continues to the bottom of the well.

As a result of the thermal injection test carried out on Well X-4, no modifications to the analysis of aquifer performance test data made earlier are necessary even though it may be reasoned that the yield will drop off some when the pumping water level reaches about 160 feet. At the discharge rate of the test, the pumping water level would

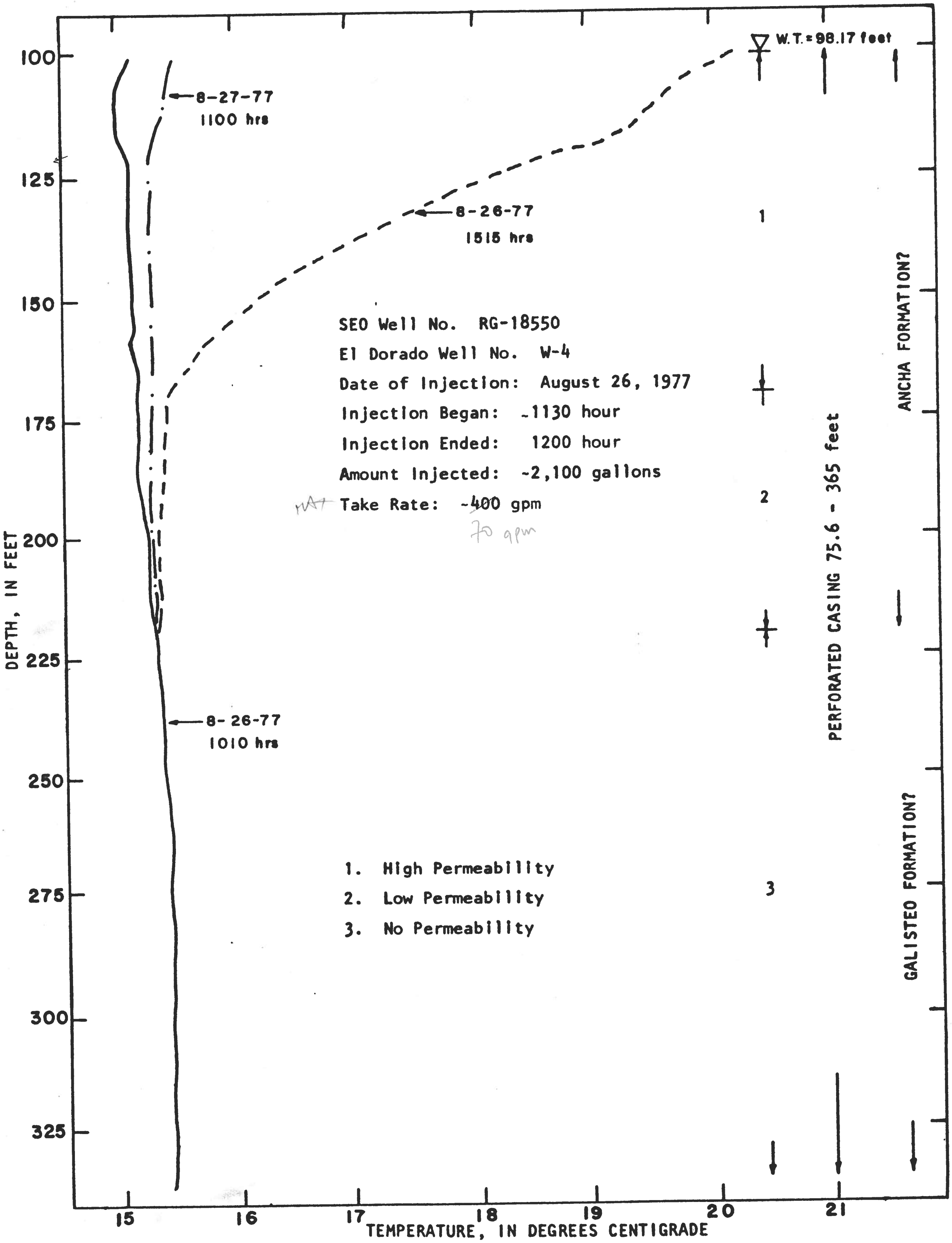

Figure 13. Temperature profiles of Well W-4 measured before and after injection of hot water.

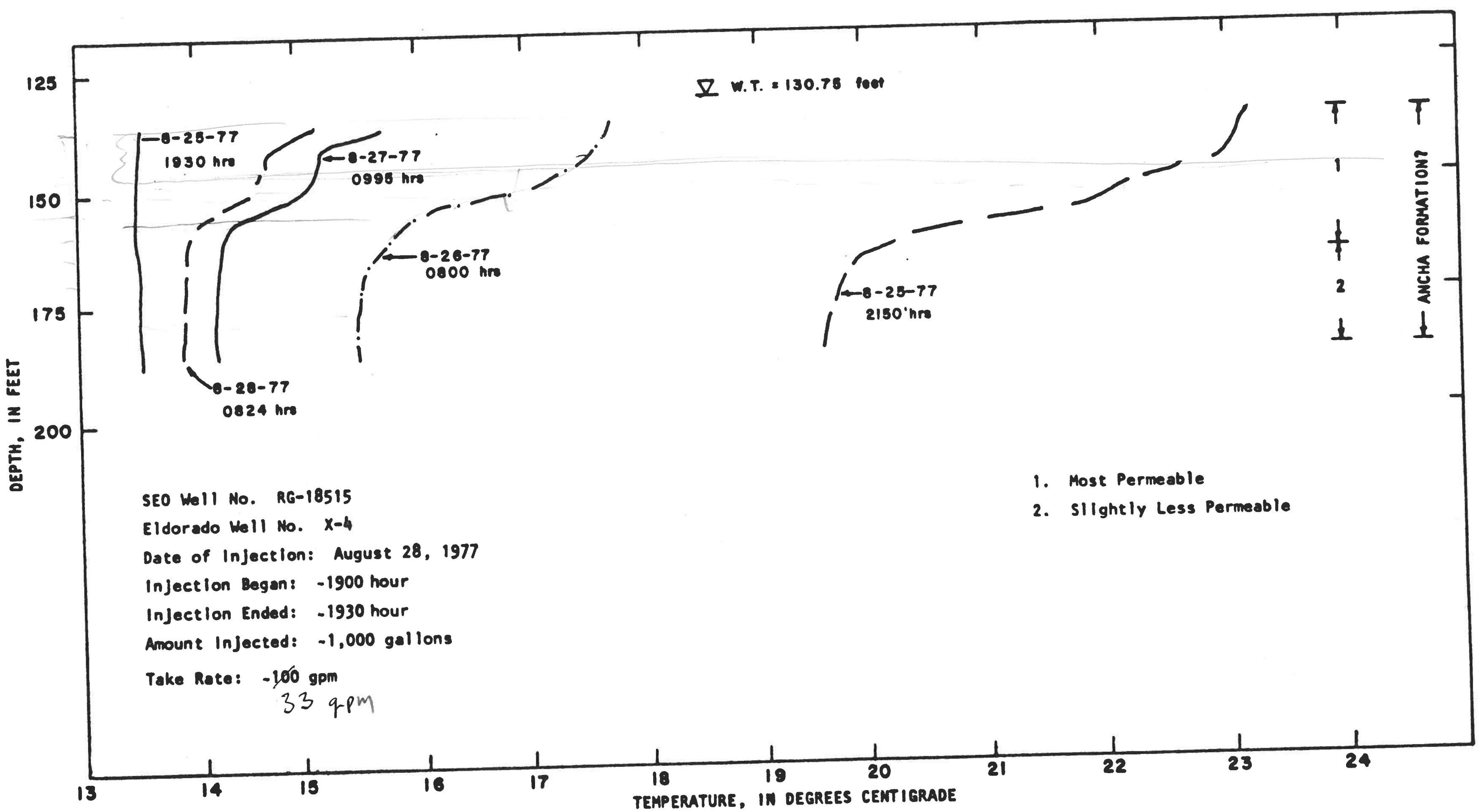

Figure 14. Temperature profiles of Well X-4 measured before and after injection of hot water.

never effectively reach the zone where the permeability of the rock changes. Of greatest importance in determining the actual long-term pumping rate of this well is its efficiency. Information on this has not been obtained.

Well 8001

Figure 15 shows the temperature profiles measured in Well 8001 before and after injecting warm water into the well. The profiles show that for all intents and purposes, the well penetrates permeable rock for almost its entire depth. As a result, no major adjustment of the actual long-term yield calculated earlier in this report is necessary.

Well 8002

Figure 16 shows the temperature profiles from Well 8002. These profiles are quite remarkable in that they correlate well with the reported intervals of perforated casing, and they show that the well penetrated highly permeable materials from the water table to about 235 feet. Indeed this well had a take rate significantly in excess of the other 8000 wells. No pumping test data were found for Well 8002. The take rate for 8002 is much greater than the take rate for Well 8004 which was the best of the wells tested. Consequently, we may assume that its long-term yield will be at least as good as the long-term yield for Well 8004.

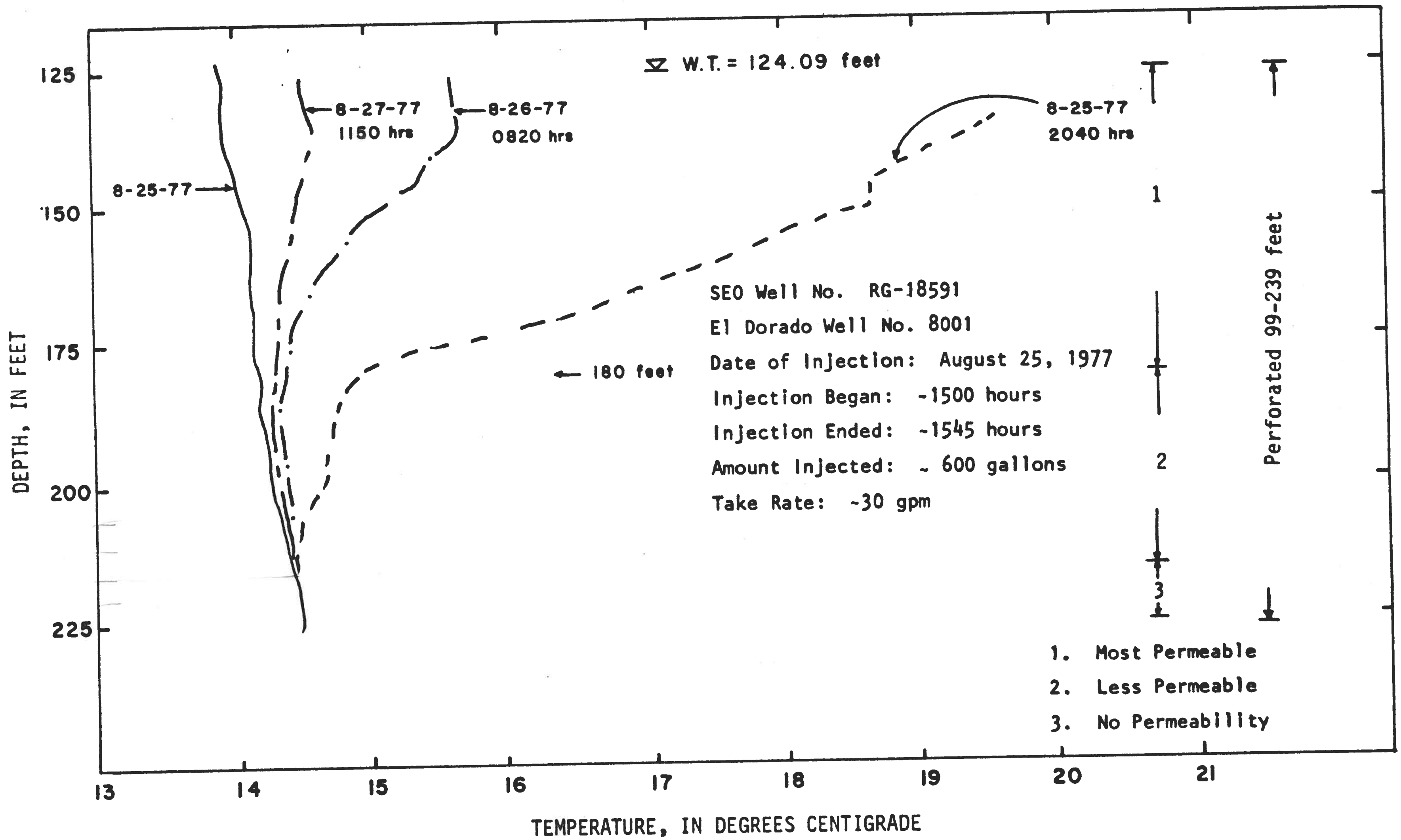

Figure 15. Temperature profiles of Well 8001 measured before and after injection of hot water.

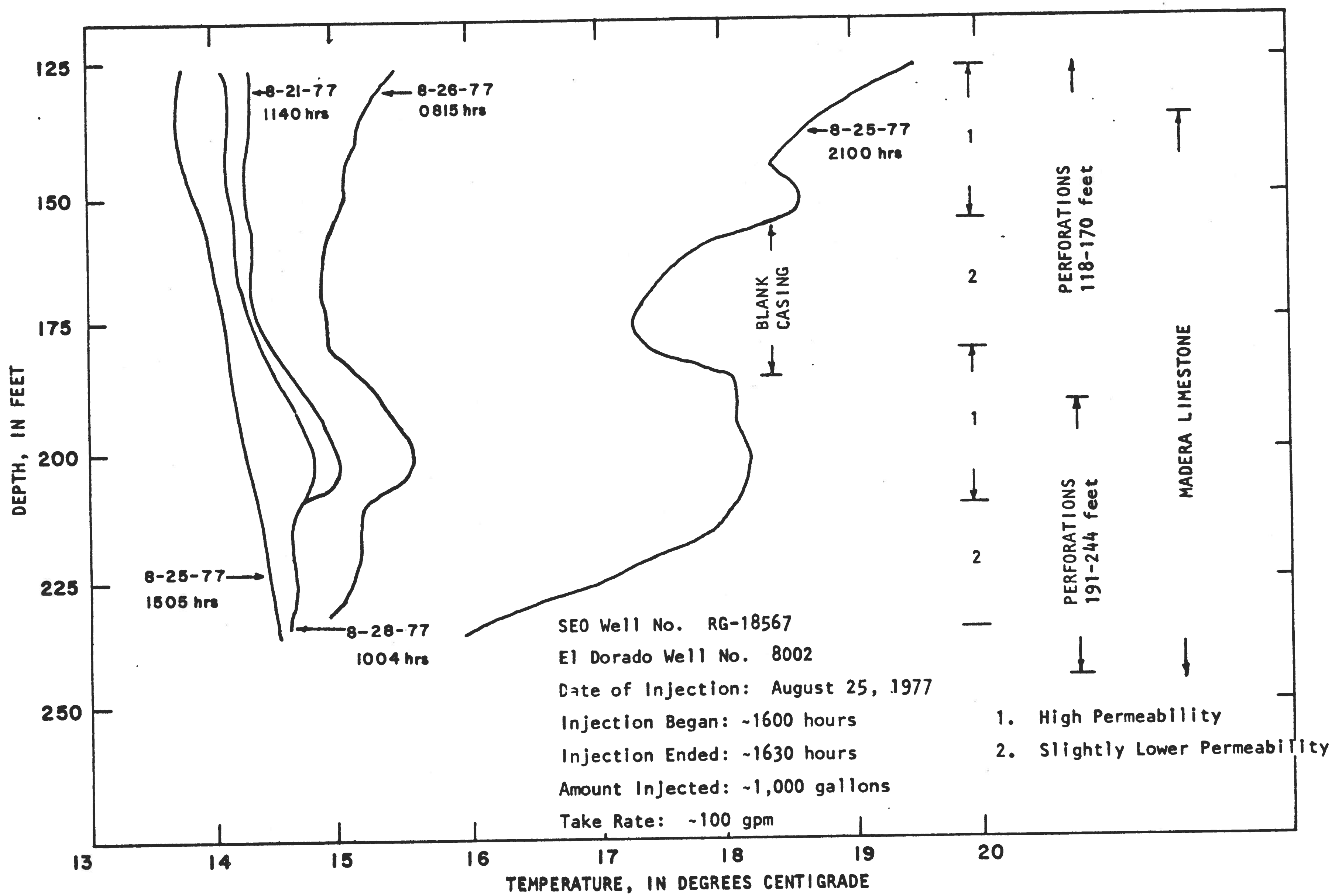

Figure 16. Temperature profiles of Well 8002 measured before and after injection of hot water.

Well 8004

Figure 17 shows the results of the thermal injection test using Well 8004. From this figure, it is evident that a highly permeable zone exists from 180 feet to about 215 feet. From the water table to a depth of 180 feet, nothing can be deduced about the permeability of the aquifer because the rocks have been shut off from the well by blank casing. It does seem, however, that some water may have escaped through faulty welds at about 140 and 160 feet.

No change in the estimated 40-year yield of this well is thought necessary.

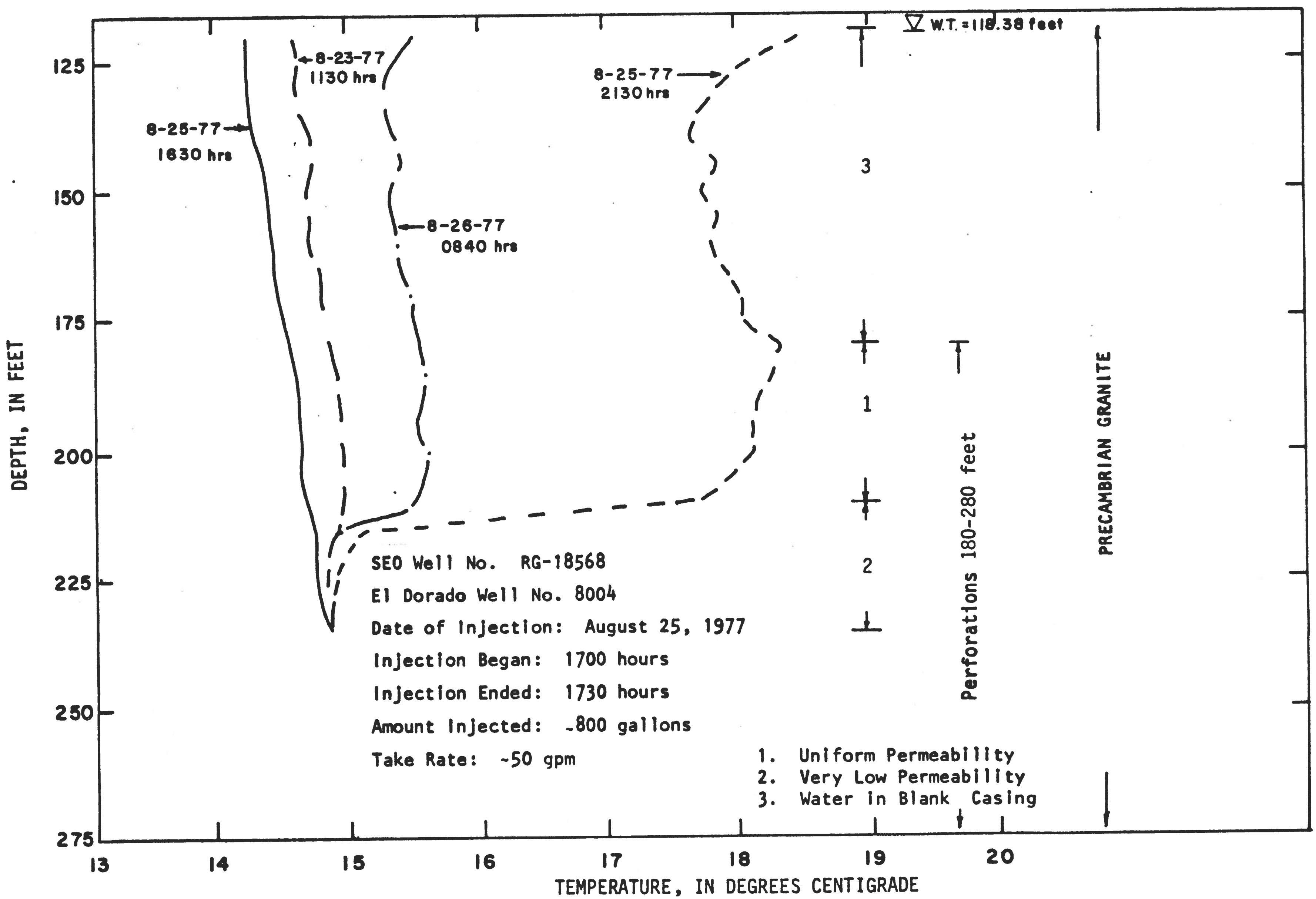

Figure 17. Temperature profiles of Well 8004 measured before and after injection of hot water.

RELIABILITY OF RESULTS

In any technical study of the type reported here, it is general procedure to analyse existing data and carry out simple tests where no existing data are available. It is the rule to utilize the least costly methods, initially, in the hope of acquiring sufficient information to obtain reliable results, In some instances, early tests may point up the need for more specialized tests to answer all questions. The following sections discuss the reliability of the data analysis for each well.

W-2

The short-term aquifer performance test using W-2 was difficult to control. Only three drawdown measurements were made using etched steel tape. All other measurements were obtained using an electrical device. Generally, electrical water level measurement devices do not yield highly accurate data when the water levels are charging rapidly. Such was the case during the recovery period. Consequently, more accurate data may indicate an aquifer transmissivity somewhat lower than obtained, but nevertheless quite high.

If a storage coefficient for an unconfined aquifer is used, then a greater flow efficiency is obtained. The flow efficiency must, however, be very low because of the reported well completion procedures. This conflict may be resolved by decreasing the transmissivity or the storage coefficient.

A more closely controlled aquifer performance test could resolve these questions. However, because of the rapidity of the response of the water levels to discharge in this well, automatic data acquisition equipment will be necessary.

W-3

The results for all tests carried out on W-3 lead us to satisfactory estimates of 40-year discharge.

W-4

The results from all tests carried out on Well W-4 seem to lead to satisfactory estimates of 40-year discharge. Because this well is inefficient, estimates could be refined by carrying out a step drawdown test using this well.

X-4

This well can apparently sustain a discharge rate in excess of 5 gallons per minute. However, it is an inefficient well and without results of a step drawdown test, it is not possible to estimate long-term yields.

8000 Series Wells

All 8000 series wells with the exception of 8002 seem to have sufficiently good data that long-term yields can be determined. No aquifer performance test has been carried out for the 8002 well. Consequently, estimates of long-term discharge for 8002 are based upon the relative take rate during injection. A long-term aquifer performance test should probably be made on Well 8002.

MUTUAL INTERFERENCE AND BARRIER BOUNDARIES

Because of the low well efficiencies and/or the low aquifer transmissivities encountered by the wells of present interest, it is anticipated that the radii of influence of the wells will be quite small such that mutual interference effects and barrier boundaries will not pose a limitation on the amount of water available from the wells. The radius of influence is defined as the distance from the well at which a water table lowering of 10 feet takes place. To examine this matter further, the radii of influence of each of the wells has been calculated and is given in Table 2 below.

Table 2. Pertinent data in the determination of the effective radii for the wells under study at the end of 10 years.

El Dorado Well No.	Transmissivity (gpd/ft)	Long Term Discharge (gpm)	$W_{(u)}$	u	Radius of Influence (ft)
W-2	101,000	144	61.2	$<1\times10^{-15}$	<1
W-3	90	2.7	2.91	$\sim3.1\times10^{-2}$	233
W-4	1,158	25	4.04	1.2×10^{-2}	150
X-4	1,325	5	23.12	5.1×10^{-11}	<1
8000	15.8	1.4	0.98	2.7×10^{-1}	289
8001	13.1	1	1.14	2.2×10^{-1}	237
8002	1,822	6	26.5	1.7×10^{-12}	<1
8004	47	4.5	0.91	3.0×10^{-1}	524

The results of this exercise indicate that for the higher capacity wells, their radii of influence are not very large. Indeed Wells W-2, W-3, and W-4 are situated close to the east-west set of faults that occurs beneath the North Boundary Channel, and these wells are also likely to fall under the influence of a high permeability zone associated with the faults. These faults on the Sunlit Hills property directly to the north are zones of high transmissivity.

Wells X-4 and 8002 also have very small radii of influence and are not likely to be affected by any nearby barriers for a very long time. Wells 8000, 8001 and 8004 encounter water-bearing rock of lower transmissivity and their radii of influence are greater because water is withdrawn from storage in close proximity to the wells. In all likelihood, however, the effects of pumping these wells will probably cause encounter with the water-bearing rock of higher transmissivity penetrated by Wells X-4 and 8002. This rock of higher transmissivity will behave as a recharge barrier, and the rate of decline of the pumping water levels in Wells 8000, 8001, and 8004 will be retarded.

As a result of the present analysis, there appears to be no reason on grounds of mutual interference or barrier boundaries for reducing the estimated long-term yields of the wells under study.

SUMMARY OF WELL YIELDS

Table 3 below summarizes the ~~40~~ 10-year continuous yield based upon the determined aquifer transmissivities, a storage coefficient of 0.10, and the original assumed total available drawdown. Also in Table 3 ~~are~~ below, summarize the continuous maximum yields for a 10-year period based upon the aquifer transmissivity, a storage coefficient of 0.10 and the available "live" drawdown determined from the thermal injection tests. A 10-year period has been selected because it is realized that within 10 years Well W-2 will have to be placed in service. Well W-2 is one of the best wells in the area, and it is currently distant from the development area.

Table 3. Summary of maximum continuous discharge rate for a period of 10 years.

Well No.	Available Drawdown (ft)	Transmissivity (gpd/ft)	Discharge Rate 10 Years (gpm)
W-2	198	101,000	144
W-3	46	90	2.6
W-4	72	1,158	25
X-4	60	1,325	5+
8000	122	15.8	1.4
8001	104	13.1	1
8002	109	1,822	6
8004	145	47	4.5

SUMMARY OF WELL YIELDS

Table 3 below, summarizes the continuous maximum yields for a 10-year period based upon the aquifer transmissivity, a storage coefficient of 0.10 and the available "live" drawdown determined from the thermal injection tests. A 10-year period has been selected because it is realized that within 10-years Well W-2 will have to be placed in service. Well W-2 is one of the best wells in the area, and it is currently distant from the development area.

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W-3	46	90	2.7
W-4	72	1,158	25
X-4	60	1,325	5+
8000	122	15.8	1.4
8001	104	13.1	1
8002	109	1,822	6
8004	145	47	4.5

ATTACHMENT 1

AQUIFER PERFORMANCE TEST DATA FOR WELLS
W-2, W-3, W-4, X-4, 8000, 8001, AND 8004

REV-1

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18529
Eldorado Well No. W-2
Static Water Level: 153.38 feet
Date of Test: August 26, 1977
Average Discharge: 202.28 gpm

Base of Aquifer 300+ ft
Do = m 146.62+
.25 Do = 36.66
.5 Do = 73.31

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)	CORR DD	Yield (gpm)		Sw/Q	CORR Sw/Q
2.98	2.30	2.28	~ 32.43	.071	14.10	0.07
6.20	6.90	6.74	~100	.069	14.49	.067
8.03	4.92	4.84		0.49	20.33	.048
15	5.72	5.61	~100	0.57	17.48	.056
19	6.88	6.72		0.69	14.53	.067
24	5.85	5.73	~130	0.45	22.22	.044
26	47.55	39.84	~250	0.190	2.43	.306
28	50.85	42.03	~250	0.203	4.92	.168
29	54.60	44.43		0.218	4.58	.178
32	69.85	53.21	~240	0.291	3.44	.222
33	84.85	60.29	~200	0.424	2.59	.301
35	85.74	60.67	~220	0.390		.276
169	112.23	69.27		0.509	1.85	.315
180	Pump off	X				X

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18529

Eldorado Well No. W-2

Static Water Level: 153.38 feet

Date of Test: August 26, 1977

Average Discharge: 202.28 gpm

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)	Yield (gpm)	Sw/Q
2.98	2.30	~ 32.43	0.071
6.20	6.90	~100	.069
8.03	4.92		.49
15	5.72	~100	.57
19	6.88		.69
24	5.85	~130	.45
26	47.55	~250	.190
28	50.85	~250	.203
29	54.60		.218
32	69.85	~240	.291
33	84.85	~200	.424
35	785.74	~220	.390
169	112.23		.509
180	Pump off		

SEO Well No. RG-18529

Eldorado Well No. W-2

RECOVERY DATA

Elapsed Time (t) (min)	Time Since Pumping Stopped (t') (min)	t/t'	Residual Drawdown (ft H_2O)	
180	0			
180.19	0.19	948.37	85.85	60.72
181.10	1.10	164.64	5.85	5.73
186.09	6.09	30.56	0.90	.90
188.61	8.61	21.91	0.75	.75
191.02	11.02	17.33	0.65	.65
195.98	15.98	12.26	0.71	.71
205	25	8.20	0.60	.60
205.98	25.98	7.93	0.60	.60
245	65	3.77	0.46	.46
265	85	3.12	0.40[1]	.40

[1] All recovery data measured with Powers M-Scope except value at 265 minutes which was measured with steel tape.

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18543

Eldorado Well No. W-3

STATIC WATER LEVEL: 143.78

Date of Test: November 18 - 19, 1974

Average Discharge: ~15 gpm

BASE of AQUIFER 195 ft

Do = m = 51.22 ft

0.25 Do = 12.81 ft

0.5 Do = 25.61 ft

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)	Corrected DD ft	
0			
14	1.53	1.50	
44	2.97	2.88	
74	4.06	3.90	
104	5.04	4.79	
134	5.86	5.52	
164	6.67	6.24	
224	8.49	7.79	
284	10.27	9.24	25%
344	12.13	10.69	
404	13.67	11.85	
464	15.33	13.04	
524	17.72	14.65	
584	20.23	16.23	
644	22.12	17.34	
714	24.40	18.59	

48.576 log2 − 114.255

log DD vs log
2 cycle paper

SEO Well No. RG-18543

Eldorado Well No. W-3

DD vs log t/t'

RECOVERY DATA

Elapsed Time (t) (min)	Time Since Pumping Stopped (t') (min)	t/t'	Residual Drawdown (ft H_2O)[1]	
734	20	36.70	22.04	17.30
764	50	15.28	20.62	16.47
794	80	9.93	19.64	15.87
824	110	7.49	18.83	15.37
854	140	6.10	18.11	14.91
884	170	5.20	17.52	14.52
944	230	4.10	16.53	13.86
1,004	290	3.46	15.75	13.33
1,064	350	3.04	15.28	13.00
1,184	470	2.52	14.60	12.52
1,424	710	2.01	13.43	11.67
1,664	950	1.75	12.43	10.92
2,024	1,310	1.55	11.46	10.18
2,624	1,910	1.37	9.59	8.69
3,344	2,630	1.27	8.31	7.64
4,064	3,350	1.21	7.47	6.93
4,424	3,710	1.19	7.15	6.65
5,144	4,430	1.16	6.62	6.19
5,864	5,150	1.14	6.23	5.85
6,584	5,870	1.12	5.91	5.57
7,304	6,590	1.11	5.74	5.42
8,024	7,310	1.10	5.52	5.22
8,744	8,030	1.09	5.40	5.12
9,464	8,750	1.08	5.28	5.01

S = 36.774 log [illegible] + 3.778

[1] Corrected for antecedent trend

semi log

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18543

Eldorado Well No. W-3

Static Water Level: 113.23 feet

Date of Test: November 2, 1970

Average Discharge: ~44.2 gpm

Base of Aquifer = 195 ft

$m = 81.77$
$\simeq 82$

$s' = s - \frac{s^2}{2m}$

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)	
0		
1	0.77	.77
2	.83	.83
3	.87	.87
4	.91	.90
5	1.09	1.08
6	1.03	1.02
7	1.09	1.08
8	1.17	1.16
9	1.19	1.18
10	1.24	1.23
15	1.49	1.48
20	1.44	1.43
25	1.36	1.35
30	1.71	1.69
35	1.91	1.89
40	2.11	2.08
45	2.27	2.24
50	2.45	2.41
55	2.60	2.56
60	2.76	2.71
65	2.88	2.83
72	3.10	3.04
75	3.12	3.06
80	3.02	2.96

SEO Well No. RG-18543

Eldorado Well No. W-3

DRAWDOWN DATA (Cont)

Elapsed Time (min)	Drawdown (ft)	
90	3.50	3.43
95	3.69	3.61
100	3.87	3.78
120	4.38	4.26
140	4.87	4.72
160	5.32	5.15
173	5.65	5.45
180	5.79	5.59
200	6.20	5.96

$s = 8.219 \log t - 12.747$

20.44 [illegible] = 25%

AQUIFER PERFORMANCE TEST DATA

Base of aquifer 220 ft

D_o = m =

SEO Well No. RG-18550

Eldorado Well No. W-4

Static Water Level: 96.8 feet

Date of Test: August 8, 1974

Average Discharge: ~30 gpm

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)	
0	0	
5	11.70	10.14
10	25.35	22.74
14	28.20	24.97
20	31.85	27.73
30	36.75	31.27 ~25%
40	39.80	33.37
60	44.05	36.17
80	46.70	37.85
100	48.50	38.95
120	50.05	39.88
150	51.70	40.85
185	53.20	41.71
210	54.20	42.28
240	54.95	42.70
300	56.32	43.45
360	57.60	44.14
420	58.60	44.66
453	58.95	44.85

$0.5 D_o$ = 61.60 ft

SEO Well No. RG-18550

Eldorado Well No. W-4

RECOVERY DATA

Elapsed Time (t) (min)	Time Since Pumping Stopped (t') (min)	t/t'	Residual Drawdown (ft H_2O)[1]	
455	2	227.5	56.50	42.54
460	7	65.71	43.25	35.66
466	13	35.85	28.25	25.01
470	17	27.65	22.50	20.45
480	27	17.78	15.75	14.74
490	37	13.24	12.25	11.64
510	57	8.95	8.41	8.12
540	87	6.21	5.71	5.58
560	107	5.23	4.81	4.72
570	117	4.87	4.51	4.43
600	147	4.08	4.02	3.95
660	207	3.19	3.07	3.03
900	447	2.01	1.65	1.64
1,620	1,667	1.39	0.71	.71
2,340	1,887	1.24	0.58	.58
3,060	2,607	1.17	0.26	.26
3,780	3,327	1.14	0.21	.21
4,500	4,047	1.11	0.14	.14
5,220	4,767	1.10	0.03	.03

[1] Corrected for antecedent trend

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18515

Eldorado Well No. X-4

Static Water Level: 131.98 feet

Date of Test: August 18-19, 1977

Average Discharge: ~4.7 gpm

Base Aquifer >192.0 FT

Do > 60.02 ~~FT~~

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)	CORR DD	Discharge (gpm)
0	0		
4.01	6.77	6.39	
5.43	7.04	6.63	
9.08	7.59	7.11	4.51
31.31	8.28	7.71	4.94[1]
66.70	8.59	7.98	
134	8.75	8.11	4.58
245	8.99	8.32	4.56
340	9.14	8.44	4.57
1,510	9.84	9.03	4.55[2]

25% = 15.01 ft

[1] Average discharge for first 29 minutes.

[2] Average discharge for pumping period 4.57 gpm.

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18570
Eldorado Well No. 8000
Static Water Level: 118 feet
Date of Test: November 30, 1970
Average Discharge: ~7 gpm

BASE OF AQUIFER ≅ 220 ft
Do ≅ 102 ft
0.25Do = 25.50 ft
0.5Do = 51 ft

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)		Yield (gpm)	s_w/Q	
0			5		
5	30	25.59	5	6.00	5.12
10	32	26.98	5	6.40	5.40
15	35	29.00	5	7.00	5.80
20	37	30.29	5	7.40	6.06
25	39	31.54	5	7.80	6.31
30	39	31.54	5	7.80	6.31
35	39	31.54	5	7.80	6.31
40	49	37.23	8	6.13	4.65
45	53	39.23	8	6.63	4.90
50	56	40.63	8	7.00	5.08
55	58	41.51	8	7.25	5.19
60	61	42.76	8	7.63	5.34
65	64	43.92	8	8.00	5.49
70	66	44.65	8	8.25	5.58
75	68	45.33	8	8.50	5.67
80	71	46.29	8	8.88	5.79
85	74	47.16	8	9.25	5.89
90	78	48.18	8	9.75	6.02
95	80	48.63	8	10.00	6.08
100	83	49.23	8	10.38	6.15
105	87	49.90	8	10.88	6.24

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18591
Eldorado Well No. 8001
Static Water Level: 125 feet
Date of Test: January 23, 1971
Average Discharge: ~6 gpm

BASE OF AQUIFER ~ 220 ft
Do = m ≈
.25 Do = 23.75 ft
.5 Do = 47.5 ft

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)		Yield (gpm)	s_w/Q	Corrected
0			3		
5	14	12.97	3	4.67	4.32
10	21	18.68	5	4.20	3.74
15	22	19.45	5	4.40	3.89
20	22	19.45	5	4.40	3.89
25	22	19.45	5	4.40	3.89
30	31	25.94	6	5.17	4.32
35	34	27.92	6	5.67	4.65
40	41	32.15	6	6.83	5.36
45	49	36.36	6	8.17	6.06
50	53	38.22	6	8.83	6.37
55	58	40.29	6	9.67	6.72
60	61	41.42	6	10.17	6.90
65	63	42.11	6	10.50	7.02
70	67	43.37	6	11.17	7.23
75	71	44.47	6	11.83	7.41
80	74	45.18	6	12.33	7.53
85	78	45.98	6	13.00	7.66
90	82	46.61	6	13.67	7.77
95	86	47.07	6	14.33	7.85
100	89	47.31	6	14.83	7.89
105	92	47.45	6	15.33	7.91
110	96	47.49	6	16.00	7.92
115	99	47.42	6	16.50	7.90
120	101	47.31	6	16.83	7.89
125	103	47.16	6	17.17	7.86
130	105	46.97	6	17.50	7.83

25% = 23.75

$s_w/Q = 20.097 \log t - 22.35$

$s_w/Q = 21.161 \log t - 27.442$

AQUIFER PERFORMANCE TEST DATA

SEO Well No. RG-18568

Eldorado Well No. 8004

Static Water Level: 125 feet

Date of Test: January 23, 1971

Average Discharge: ~14 gpm

Base of Aquifer 215 ft
Do = m = 90 ft
0.25 Do = 22.5 ft
0.5 Do = 45.0 ft

DRAWDOWN DATA

Elapsed Time (min)	Drawdown (ft)		Yield (gpm)	s_w/Q	
0	0		5		
5	7	6.73	5	1.40	1.35
10	16	14.58	8	2.00	1.82
15	22	19.31	11	2.91	1.76
20	48	35.20	14	3.43	2.51
25	60	40.00	14	4.29	2.86
30	68	42.31	14	4.86	3.02
35	73	43.39	14	5.21	3.10
40	78	44.20	14	5.57	3.16
45	80	44.44	14	5.71	3.17
50	82	44.64	14	5.86	3.19
55	85	44.86	14	6.07	3.20
60	87	44.95	14	6.21	3.21
65	87	44.95	14	6.21	3.21
70	87	44.95	14	6.21	3.21

-3.718 -3.670 5.680 5.650 sw/Q