Wa. Co. Utility D.

EVALUATION OF THE WATER SUPPLY FROM WELLS ALTERNATIVE: PURITY UTILITIES, INC.

DOCKET 84-1003

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Project No. 85-360

Prepared for:

State of Nevada
Public Service Commission

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

FINDINGS

1. Purity Utilities Well No. 3 can be rated to yield 1,000 gallons per minute on a sustained basis virtually indefinitely.

2. The source of water derived from Purity Well No. 3 is ground water. There is no evidence that the discharge of the well is derived from induced infiltration of surface water from the Truckee River to the production zones tapped by the well. Furthermore, the ultimate source of the ground water derived from the well is induced upward vertical leakage from water-bearing strata below a depth of 191 feet.

3. Extraction of ground water from Purity Well No. 3 will not have any affect on the quantity of the flow in the Truckee River. The affect on water levels in nearby wells due to pumping Purity Well No. 3 will be insignificant. Conversely, surface water flows in the Truckee River will have no impact on neither the yield of Purity Well No. 3 nor the chemical quality of the ground water derived from the well. Nor will pumping of existing wells in the vicinity have any significant affect on water levels in Purity Well No. 3.

4. Chemical quality of the ground water derived from Purity Well No. 3 during testing meets state and federal drinking-water standards. However, evaluation of testing results strongly suggests that, given a sustained pumping rate of 1,000 gallons per minute, the concentration of arsenic in the discharge from the well could exceed the drinking-water standards within two years.

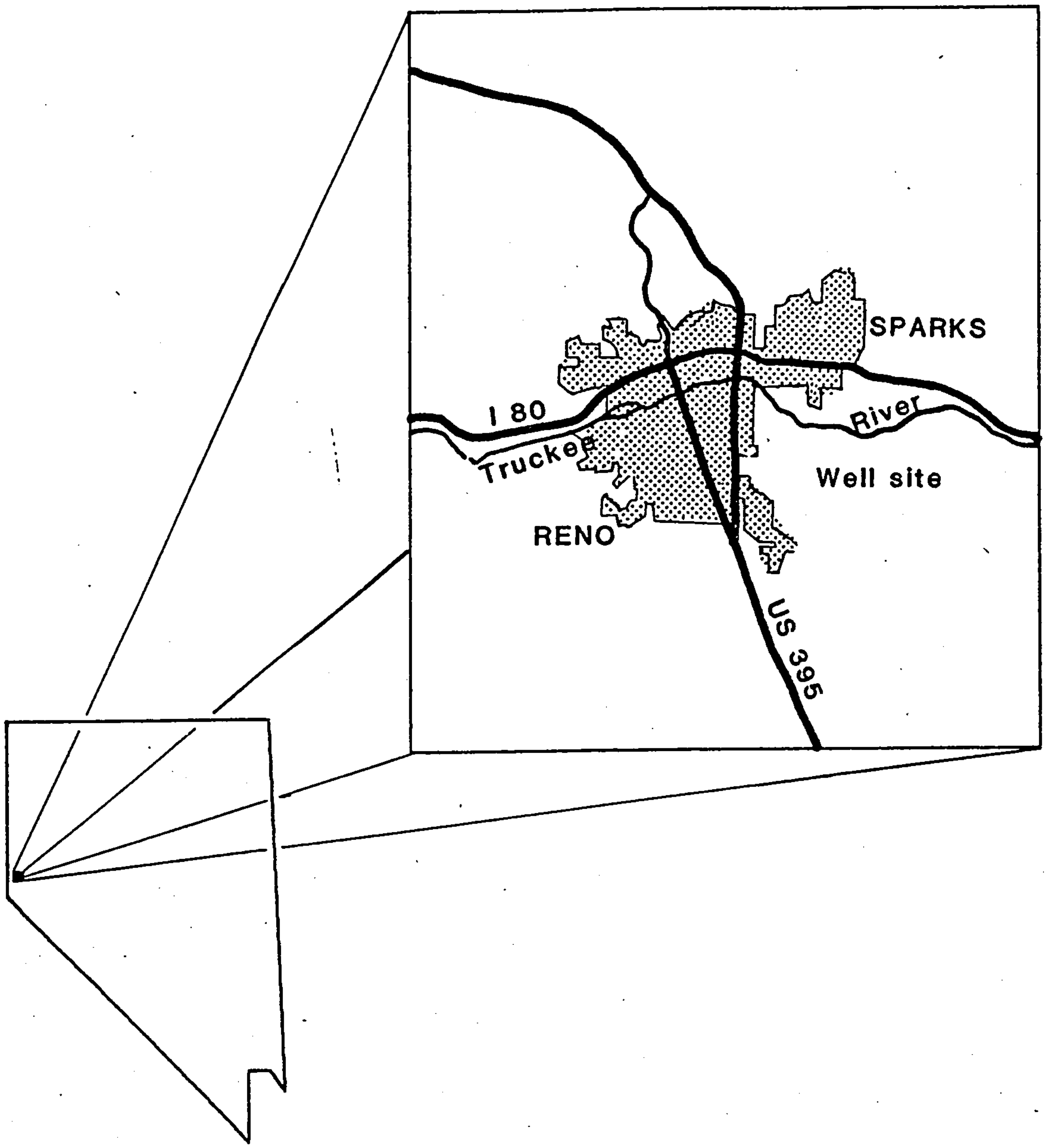
2.0 INTRODUCTION

In an effort to develop ground-water supplies which meet state and federal drinking-water standards, Purity Utilities, Inc. drilled and test pumped a 380 feet deep test well (Test Hole No. 1) in June and July 1984. This test well, located in the NW 1/4 of Section 11, Township 19 N., Range 20 E., was drilled south of the Truckee River (Figure 1), approximately 1.6 miles north of Purity Well No. 2 (nee Hidden Valley Water Company Well No. 2). Because Well No. 2 had shown a general increase in arsenic concentration since being put into service in 1977, an attempt was made to identify potential sources of arsenic-laden ground water in the test well. This was accomplished by collecting water samples from as many as five individual water-bearing horizons penetrated by the well bore. Results of chemical analyses show a general increase in arsenic concentration with depth (Appendix A). For this reason a new production well (Purity Well No. 3) was completed to a depth of only 191 feet in an attempt to isolate shallower water-producing zones from the poorer quality ground water encountered at depth, as in the nearby test well.

Upon completion, Purity Well No. 3 was test pumped for a period of approximately seven days between September 5 and 12, 1984. The well was pumped at a rate of 1,000 gallons per minute (gpm) for the first five days after which the pumping rate was reduced to 750 gpm for the remainder of the test. Testing results strongly suggested that the well could be expected to yield 1,000 gpm indefinitely. Results of a single water sample collected at the conclusion of testing showed that the overall chemical quality of the ground water derived from the well met drinking water standards. However, the concentration of arsenic, from multiple samples collected throughout the test for arsenic analyses, increased from 0.019 mg/l to 0.023 mg/l during the first two days of the test after which it appeared to remain relatively constant at 0.023-0.022 mg/l (Appendix B). It should be noted that the arsenic concentration in well discharge water remained essentially constant during the last five days of pumping even though the discharge rate had been reduced by 25 percent the last two days.

On November 19, 1984, WILLIAM E. NORK, INC. was retained by the PUBLIC SERVICE COMMISSION OF NEVADA to examine, in detail, the results of the investigative effort conducted to date by Purity Utilities, Inc. Questions which this review and a subsequent investigative effort by WILLIAM E. NORK, INC. were to address (PSC letter dated 11/29/84, Appendix C) are paraphrased below.

1. What is the long-term yield of Purity Well No. 3?



PROJECT: NEVADA PSC FILE: 85-360 LOCATION: RENO NV	REFERENCE MAP
WILLIAM E. NORK, INC.	FIGURE: 1

2. What is the source of water derived from Purity Well No. 3? Is it surface water induced to infiltrate from the nearby Truckee River or ground water?

3. What impact will withdrawals of water from Purity Well No. 3 have on nearby wells and the flow in the Truckee River or vice versa?

4. What is the chemical quality of ground water derived from Purity Well No. 3? Can it be expected to remain constant or will it deteriorate with time?

5. If the chemical quality of the ground water will deteriorate with time, how long will it take for drinking water standards to be violated?

Given the history of arsenic concentrations in ground water derived from water wells completed in the alluvial aquifer elsewhere in the eastern Truckee Meadows, the questions posed are most appropriate. The answers to the above questions are attainable via a rigorous analysis of two sets of data. The first was provided by previous investigations conducted by Purity Utilities, Inc. The second was acquired by WILLIAM E. NORK, INC. as a part of their investigation. All of the data were evaluated using accepted, widely used analytical techniques.

TD=191'

The initial test of Purity Well No. 3 (September 5-12, 1984) was principally a well performance test, not an aquifer stress test, and left several questions unanswered regarding the physical character of the alluvial aquifer in the vicinity of the well (W.E. Nork, Inc. letter dated 11/21/84, Appendix D). Test data suggested the presence of a recharge boundary, presumably the Truckee River which is located approximately 300 feet northwest of the well site. However, a lack of observation well data precluded distinguishing the observed response from that which might occur as a result of vertical leakage, (1) (2) partial penetration effects, or an increase in transmissivity (3) in some indeterminate direction. Because possible direct hydraulic communication between the production zones of the well and the river could influence the long-term chemical quality of the ground water derived from the well, a detailed aquifer stress test was proposed.

In addition to the pumped well (Purity Well No. 3) three observation wells were monitored during the second test conducted December 13, and 14, 1984. These were Observation Well No. 1, a 101 feet deep well located 670 feet southwest of Purity No. 3; Observation Well No. 2, (Purity Utilities Test Hole No. 1), located 10.25 feet northeast of Purity No. 3; and Observation Well No. 3, a 31 feet deep piezometer located 490 feet northeast of Purity Well No. 3. Observation Well No. 3 was drilled specifically for the purpose of investigating

what's depth? =340'

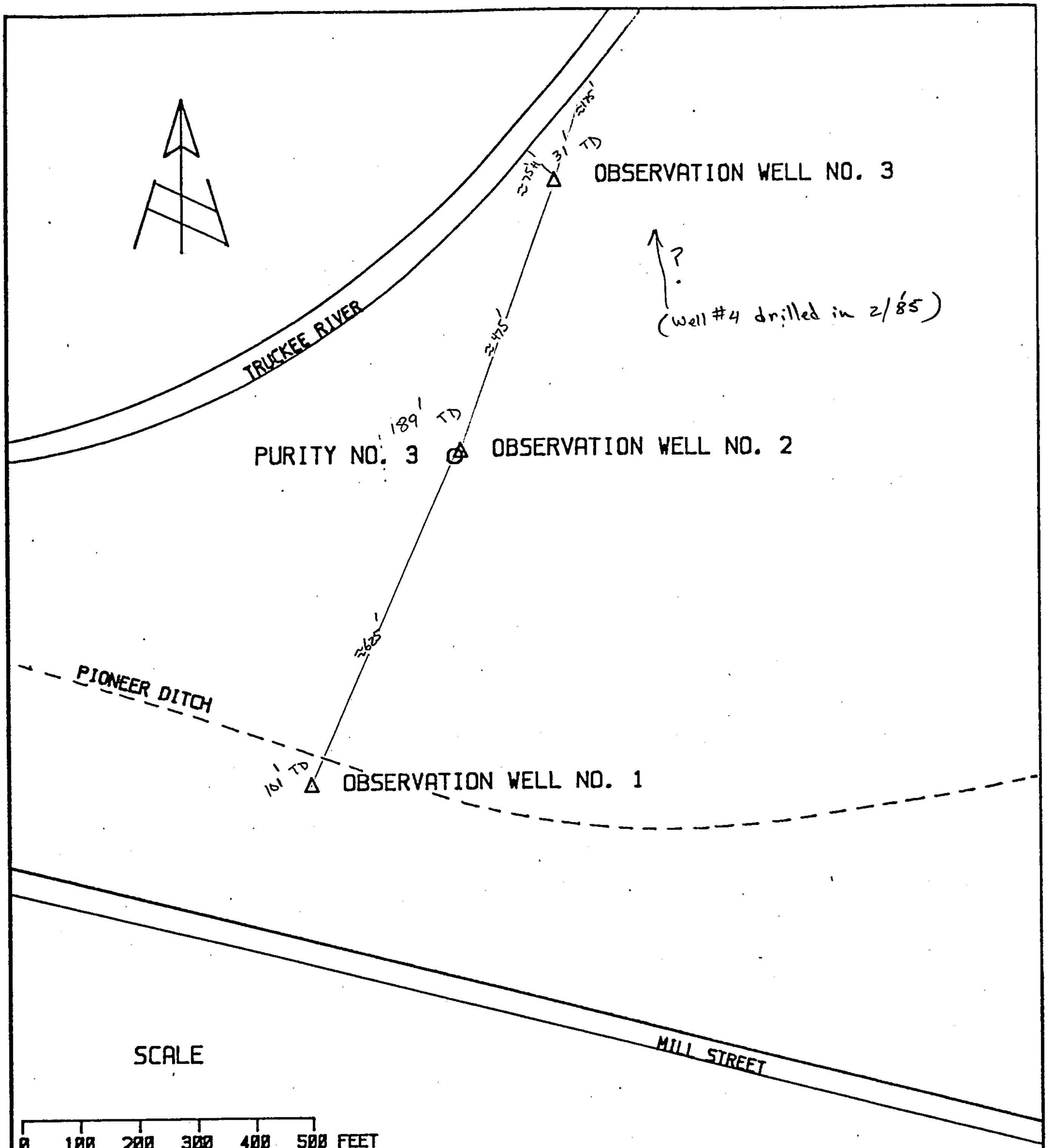
1) Purity test hole #1 = observation well #2 = right next to Purity #3

2) observation well #3 = located next to Purity #4

3) observation well #1 = ?

the response of the water-table aquifer to pumping of the deeper zones. The water-table aquifer is known to be in direct communication with the Truckee River (Cooley, et al., 1971 and Cunningham, 1977). Locations of the wells are shown in Figure 2.

A pumping rate of 1,000 gpm was selected for the December 13-14, 1984 stress test. This was the same rate chosen for the first five days of the September 1984 test and provided direct comparison of the results from the two tests.



PROJECT: NEVADA PSC FILE: 85-360 LOCATION: NW-11-19-20	WELL LOCATIONS
WILLIAM E. NORK, INC.	FIGURE: 2

3.0 AQUIFER TESTING

3.1 TESTING RESULTS

The aquifer stress test was conducted from 1230 hours, December 13, 1984 to 1930 hours, December 14. This time period consisted of a pumping portion lasting 24 hours followed by seven hours of (monitored) recovery. The reason the stress test was limited to a 24-hour duration is that the apparent boundary affects observed during the earlier seven-day test were manifest during the first few hours of pumping. Pumping for a period in excess of 24 hours would not have added appreciably to the information sought in the stress test. A summary of testing results is presented below.

Pumping well, Purity Well No. 3

screen= 107-127 153-187

Static water level prior to testing was 13.63 feet below the measuring point (M.P. = top of casing). Pumping commenced 1230 hours 12/13/84. Pumping rate was held constant at 1,000 gpm for 24 hours. Drawdown at conclusion of pumping was 55.47 feet, a pumping water level of 69.10 feet.

Within seven hours after termination of pumping, water levels in the pumped well recovered 99 percent.

Observation Well No. 2.

screen= 100-340 @ intervals

Static water level prior to testing was 12.68 feet below the measuring point (M.P. = top of casing). Drawdown at the conclusion of the pumping test was 21.65 feet. = 34.33' below casing

Water levels in this observation well recovered 96 percent within seven hours.

Observation Well No. 1

screen= 49-101

Static water level prior to testing was 11.97 feet below the measuring point (M.P. = top of casing). Drawdown at the conclusion of the pumping test was 0.56 feet. = 12.53' below casing

Water levels recovered 68 percent within seven hours.

Observation Well No. 3

Static water level prior to testing was 12.97 feet below the measuring point (M.P. = top of casing). Water level at conclusion of testing was 13.13 feet, a drawdown of 0.16 foot.

Screen = 21-31

Water levels in this well did not recover following the conclusion of the pumping test.

Testing data are plotted in Figures 3 through 14 and tabulated in Appendix E.

3.2 ANALYSIS OF PUMPING TEST DATA

Drawdown and recovery data for the pumped well and nearby Observation Well No. 2 were analyzed by a variety of methods to determine aquifer characteristics. These methods include the Cooper-Jacob straight line approximation of the Theis equation (Cooper and Jacob, 1946), the Theis recovery method (Jacob, 1962), the non-steady state leaky artesian aquifer analysis (Hantush & Jacob, 1955), and the steady-state leaky artesian aquifer analysis (Jacob, 1946). Analyses results are summarized in Table 1.

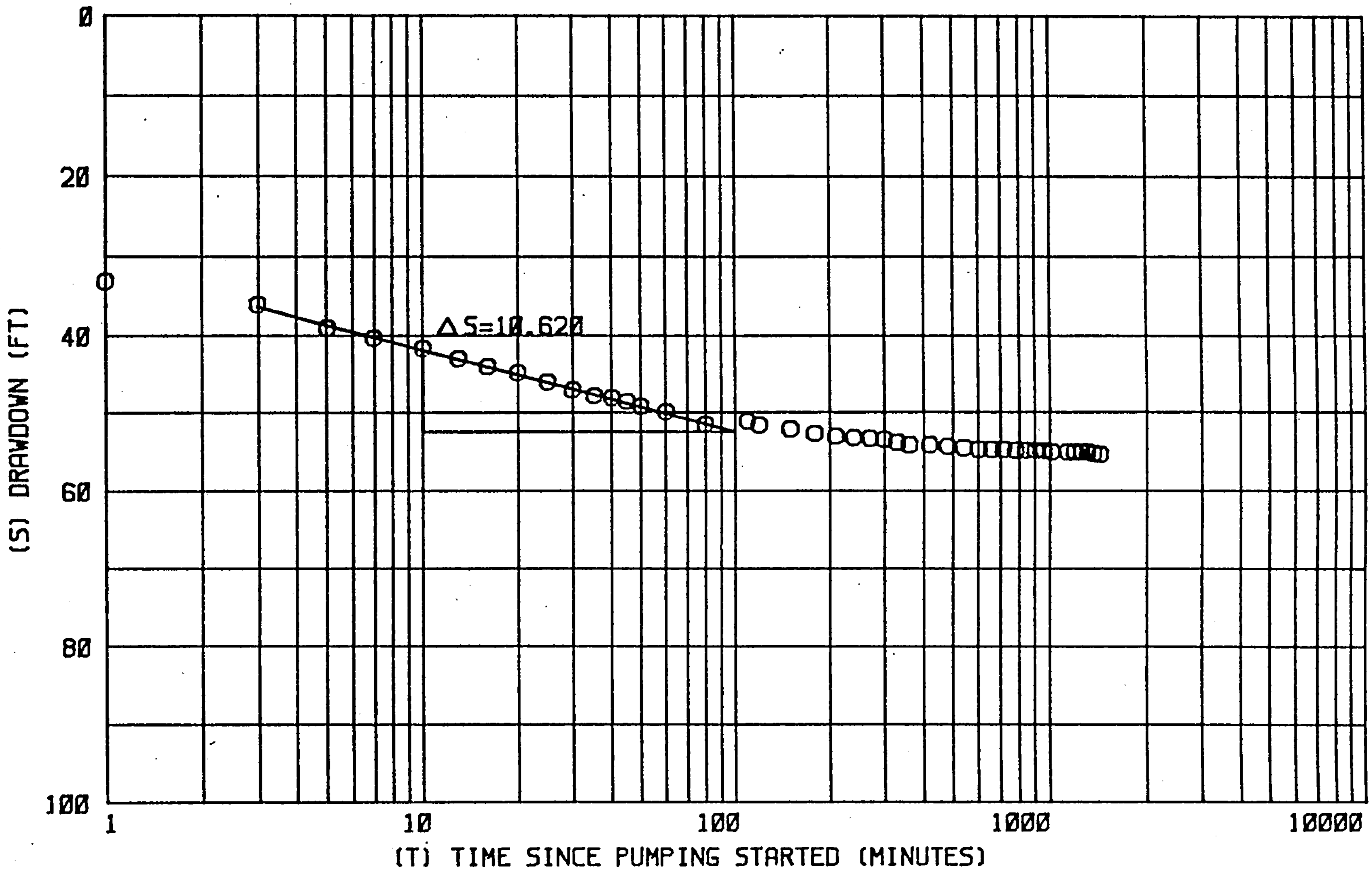
It is readily apparent from the above analyses results that the transmissivity values for the pumped well are approximately 60 percent less than values calculated from the observation well data. This may be accounted for by the relative depths of the two wells. The nearest observation well (No. 2) is completed to a depth of 340 feet versus 191 feet for the pumped well (Purity No 3). The fact that the pumped well penetrates a lesser saturated thickness of the aquifer than the observation well may account for the lower value for transmissivity.

90' addit. screen

Alternatively, the difference may be explained by leaky aquifer theory developed by Neuman and Witherspoon (1972). They state that "...ideally the values of T [transmissivity] and S [coefficient of storage] should be calculated using drawdown or buildup data from the pumped well itself because here the effect of leakage is always the smallest." They also state "...as r [radial distance from the pumped well] increases, the value of T should become more exaggerated." This is precisely what was observed in the testing results. Trans-

But, the wells are very close together. r = 10.25'.

PUMPING TEST ANALYSIS   STRAIGHT LINE APPROXIMATION METHOD



PROJECT:	NEVADA PSC	WELL NO.:	PURITY NO.3	ΔS=	10.620 FT
FILE:	360	Q=	1000 USGPM	T=	24859 USGPD/FT
LOCATION:	NW-11-19-20	S.W.L.=	13.63	S=	

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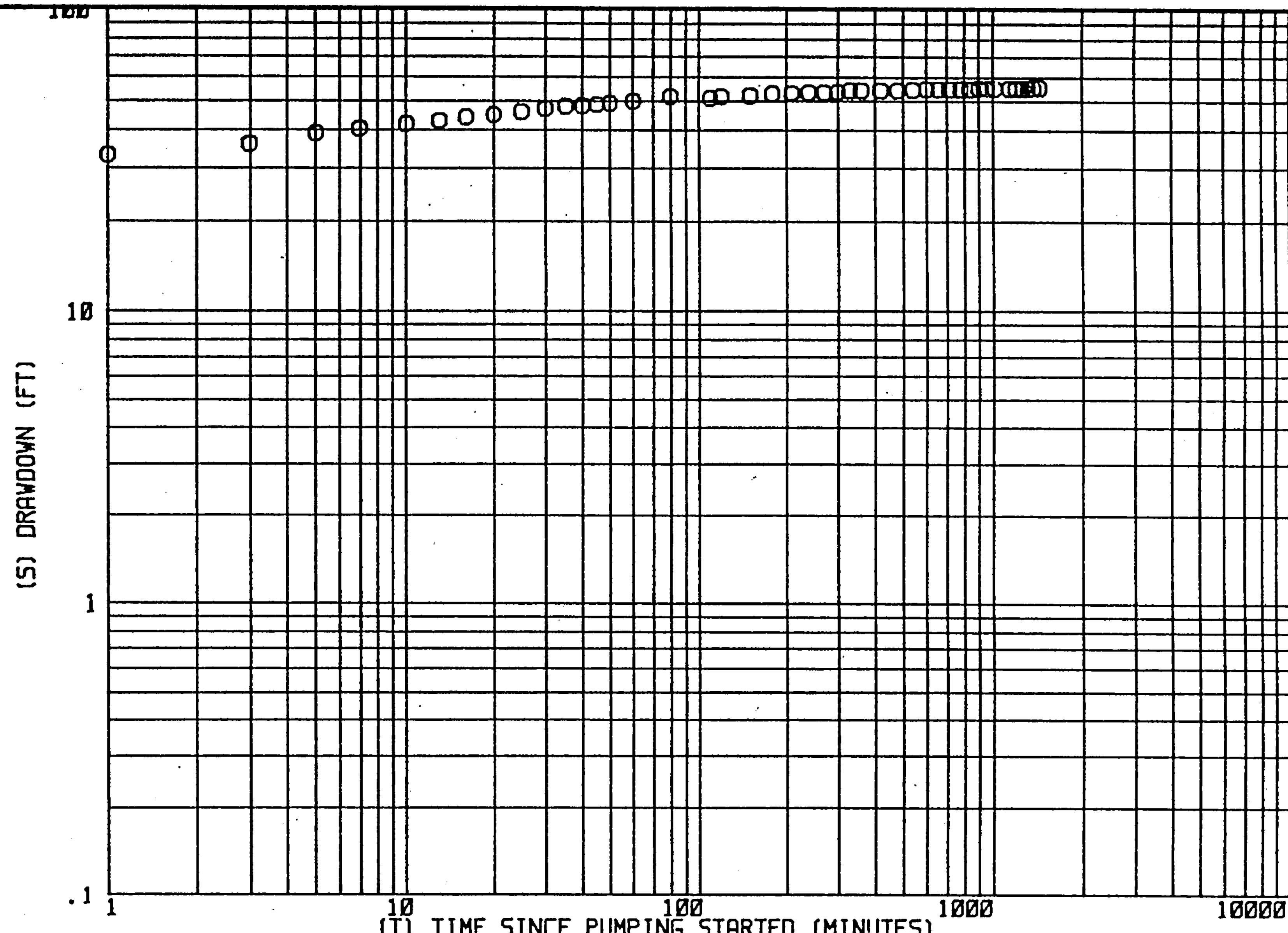
FIGURE 3



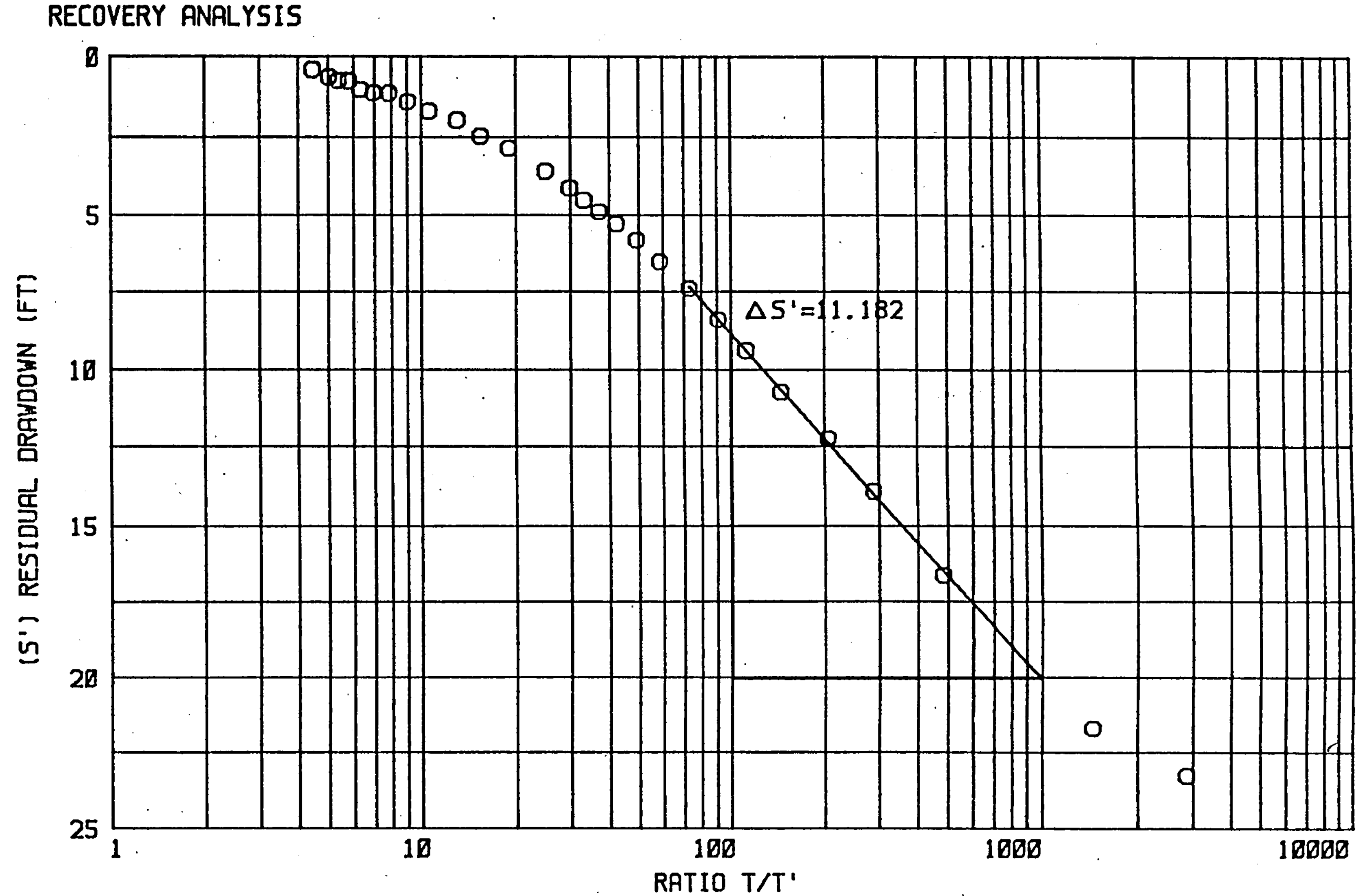
PROJECT NEVADA PSC
LOCATION NW-11-19-20

FILE 360
WELL No. PURITY N

PUMPING TEST ANALYSIS
TYPE CURVE SOLUTION

WILLIAM E. NORK, INC.

FIGURE 4



PROJECT: NEVADA PSC
FILE: 360
LOCATION: NW-11-19-20

WELL NO.: PURITY NO.3
Q= 1000 USGPM
S.W.L.= 13.63

ΔS'=11.182 FT
T= 23610 USGPD/FT
S=

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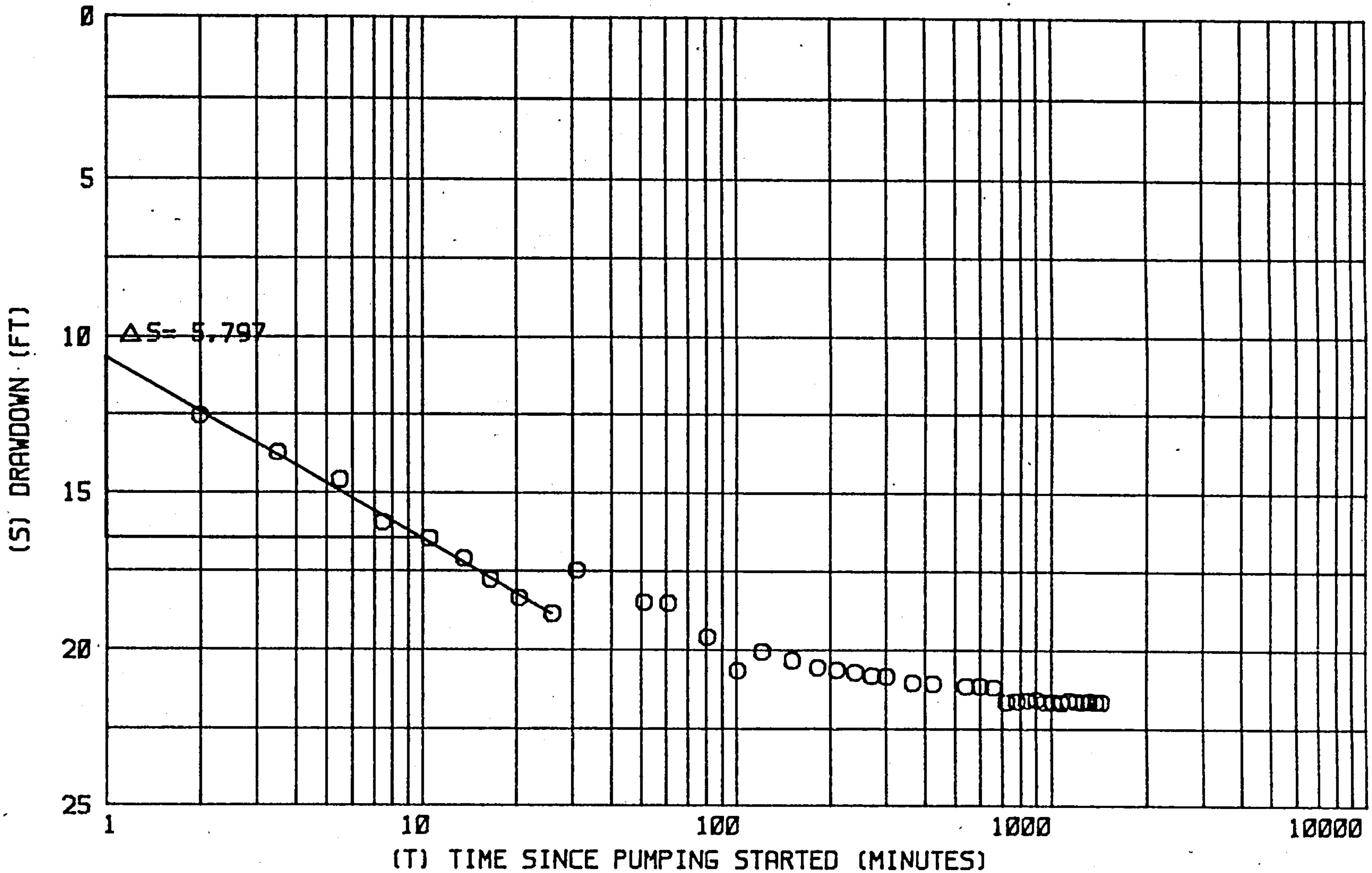
FIGURE 5

PUMPING TEST ANALYSIS — STRAIGHT LINE APPROXIMATION METHOD



PROJECT: NEVADA PSC FILE: 360 LOCATION: NW-11-19-20	WELL NO.: OBS NO.2 Q= 1000 USGPM S.W.L.= 12.68	ΔS= 5.797 FT T= 45540 USGPD/FT S= .00131

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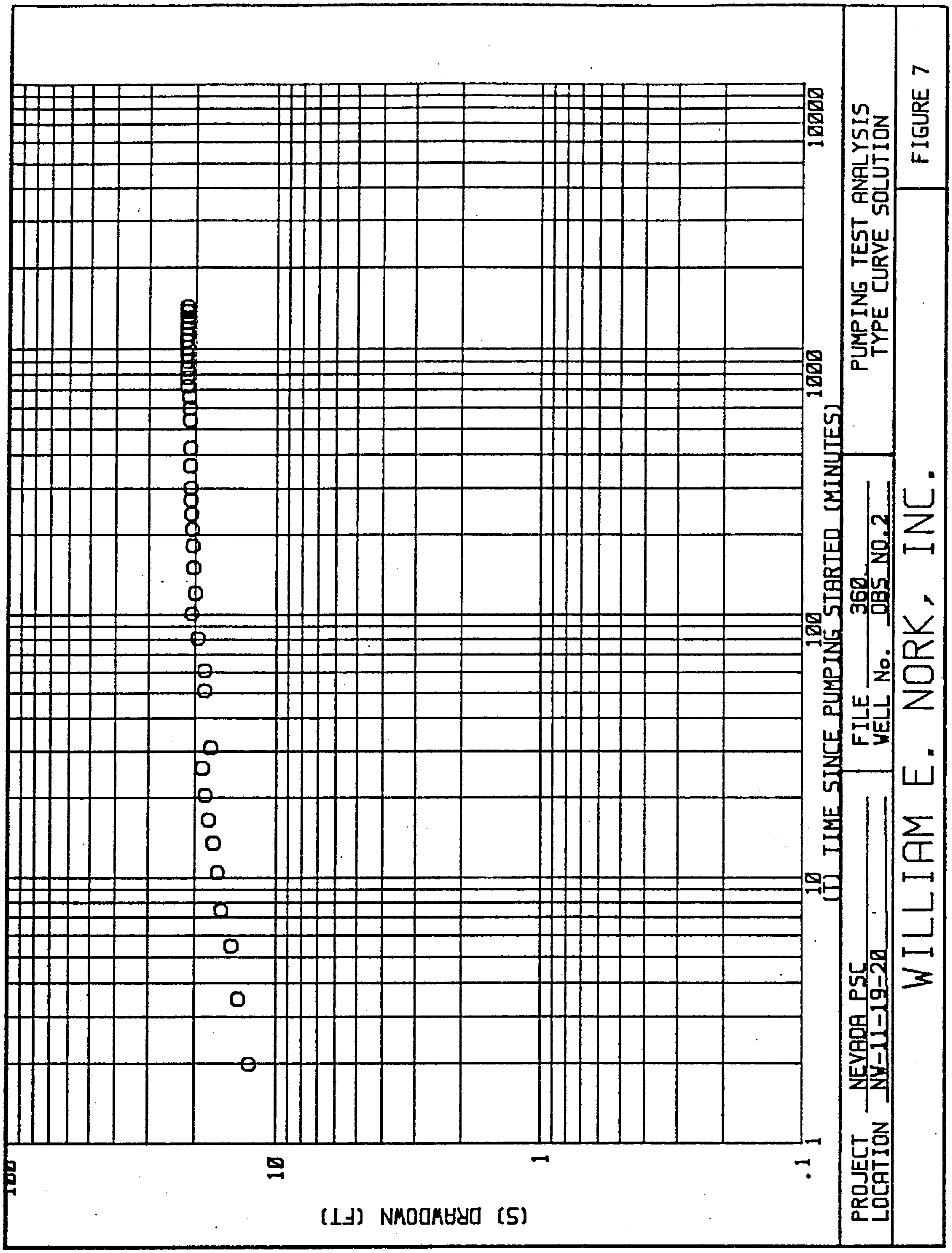
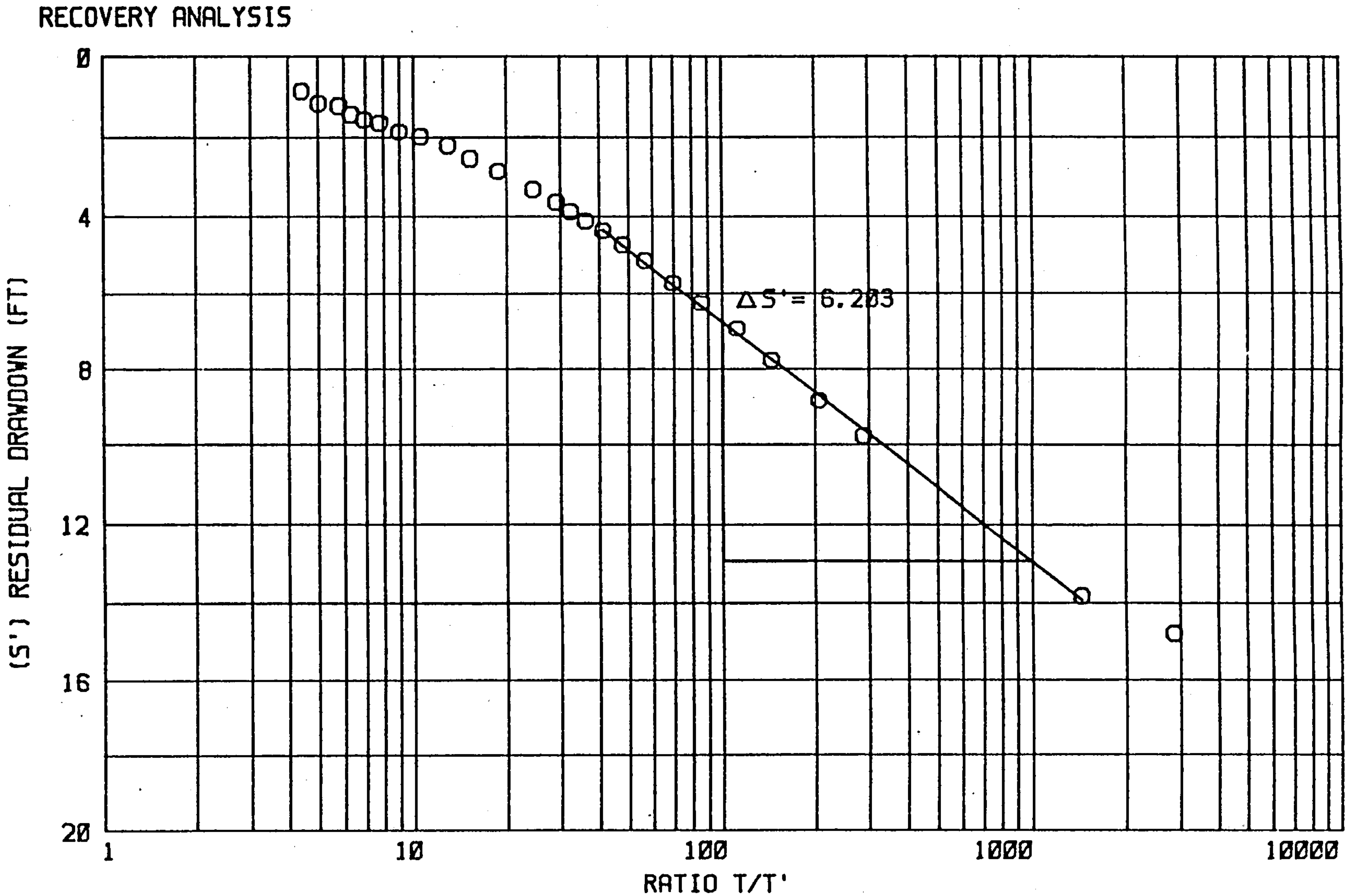
FIGURE 6


(S) DRAWDOWN (FT)
100
10
1
.1
1
10
100
1000
10000
(T) TIME SINCE PUMPING STARTED (MINUTES)
PROJECT NEVADA PSC
LOCATION NV-11-19-20
FILE 360
WELL No. OBS NO.2
PUMPING TEST ANALYSIS
TYPE CURVE SOLUTION
FIGURE 7
WILLIAM E. NORK, INC.



PROJECT: NEVADA PSC
FILE: 360
LOCATION: NW-11-19-20

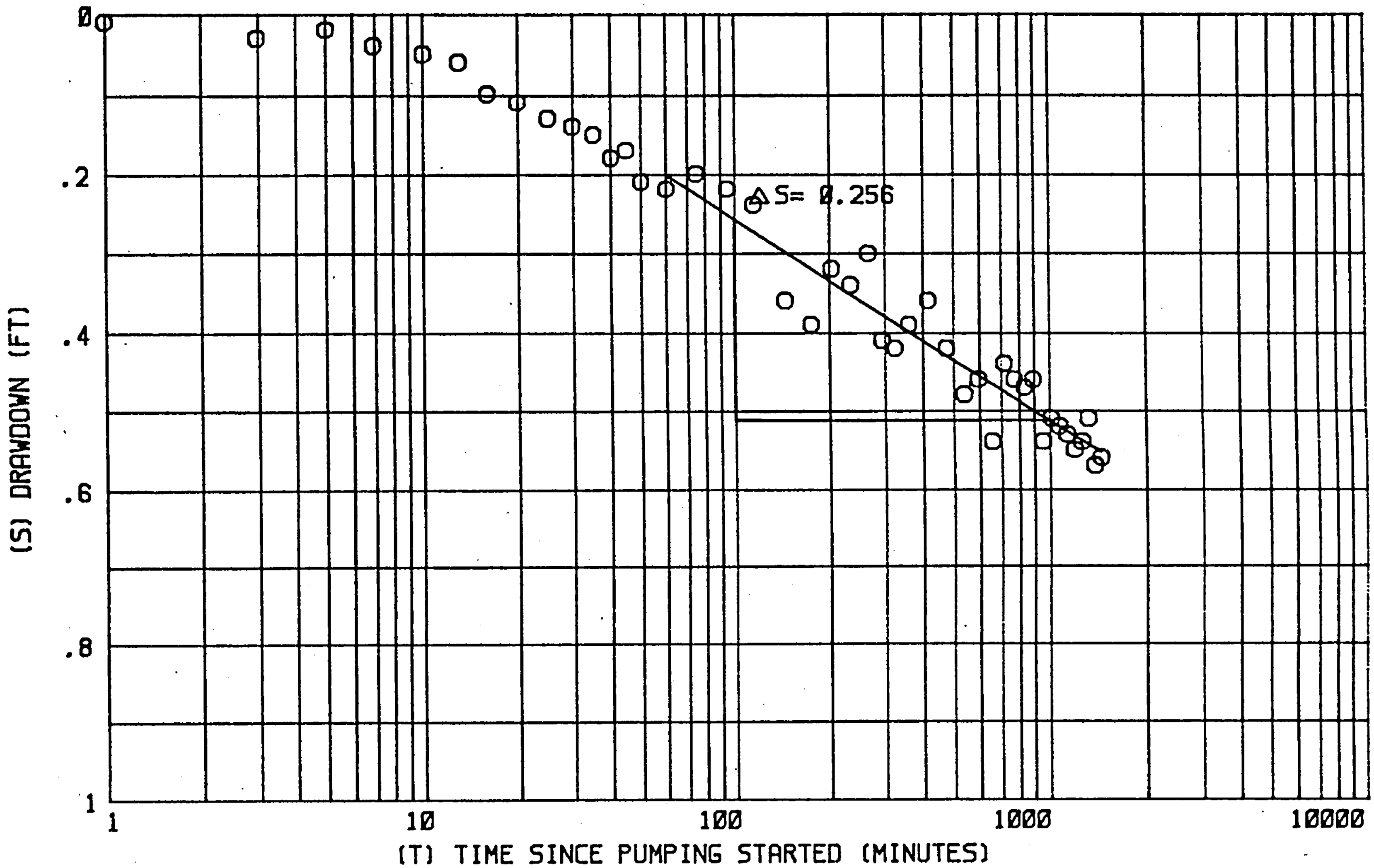
WELL NO.: OBS NO.2
Q= 1000 USGPM
S.W.L.= 12.68

ΔS' = 6.203 FT
T= 42562 USGPD/FT
S=

WILLIAM E. NORK, INC.

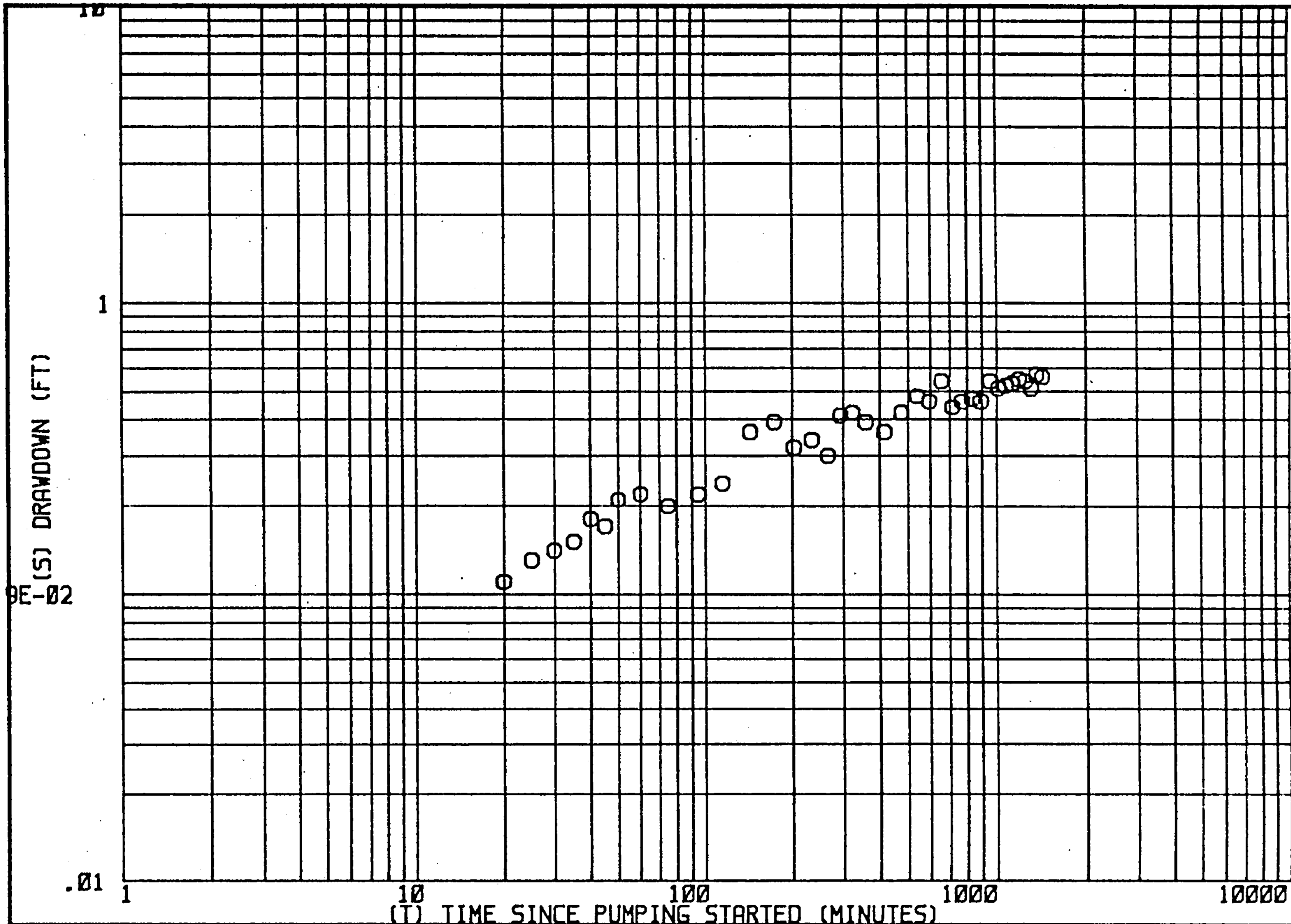
FIGURE 8

PUMPING TEST ANALYSIS   STRAIGHT LINE APPROXIMATION METHOD



PROJECT: NEVADA PSC FILE: 360 LOCATION: NW-11-19-20	WELL NO.: OBS NO.1 Q= 1000 USGPM S.W.L.= 11.97	ΔS= Ø.256 FT T= Z1Ø31892 USGPD/F S= .ØØ476

WILLIAM E. NORK, INC. FIGURE 9

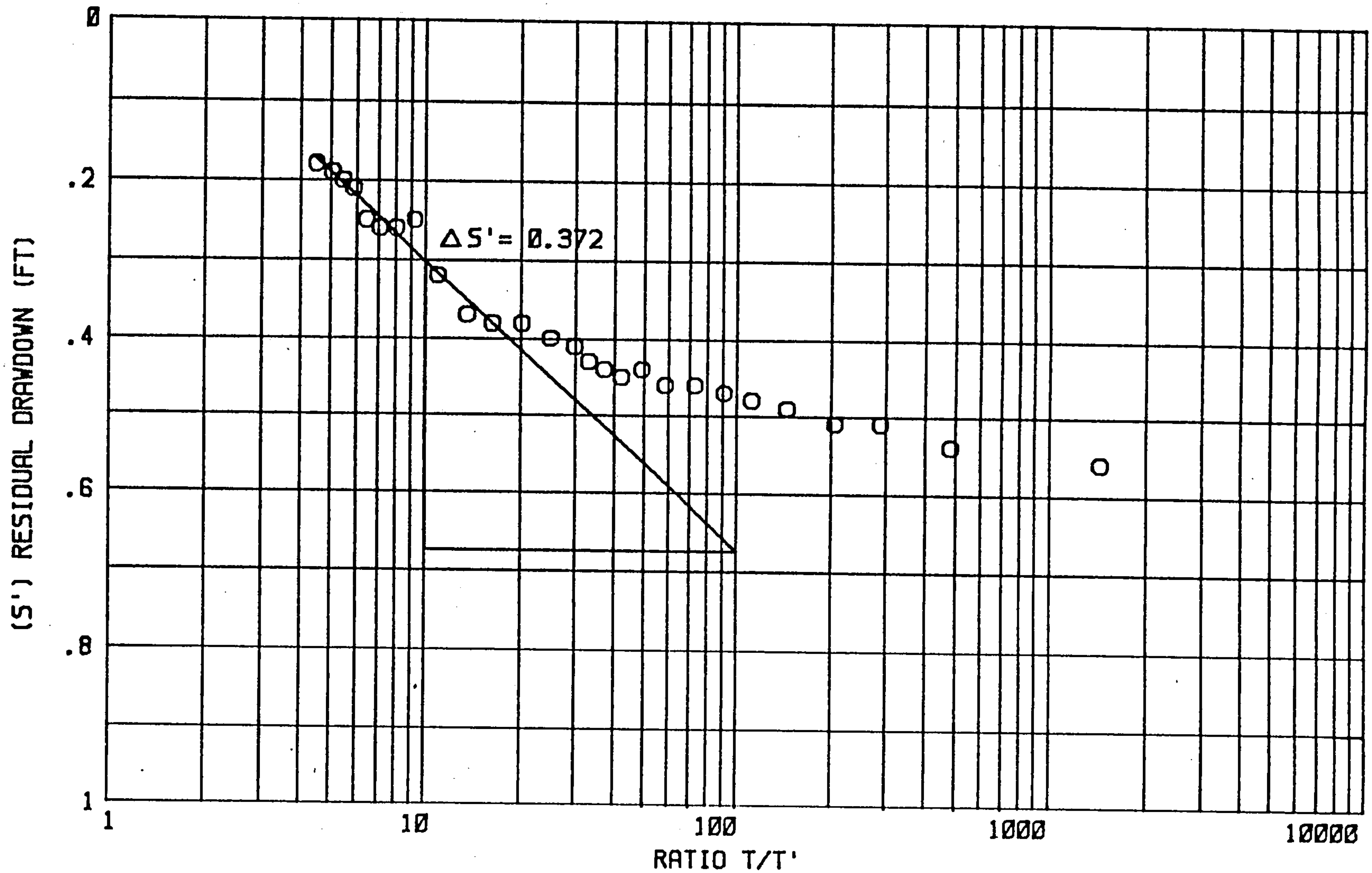


PROJECT NEVADA PSC LOCATION NW-11-19-20	FILE 360 WELL No. OBS NO.1	PUMPING TEST ANALYSIS TYPE CURVE SOLUTION

WILLIAM E. NORK, INC.

FIGURE 10

RECOVERY ANALYSIS

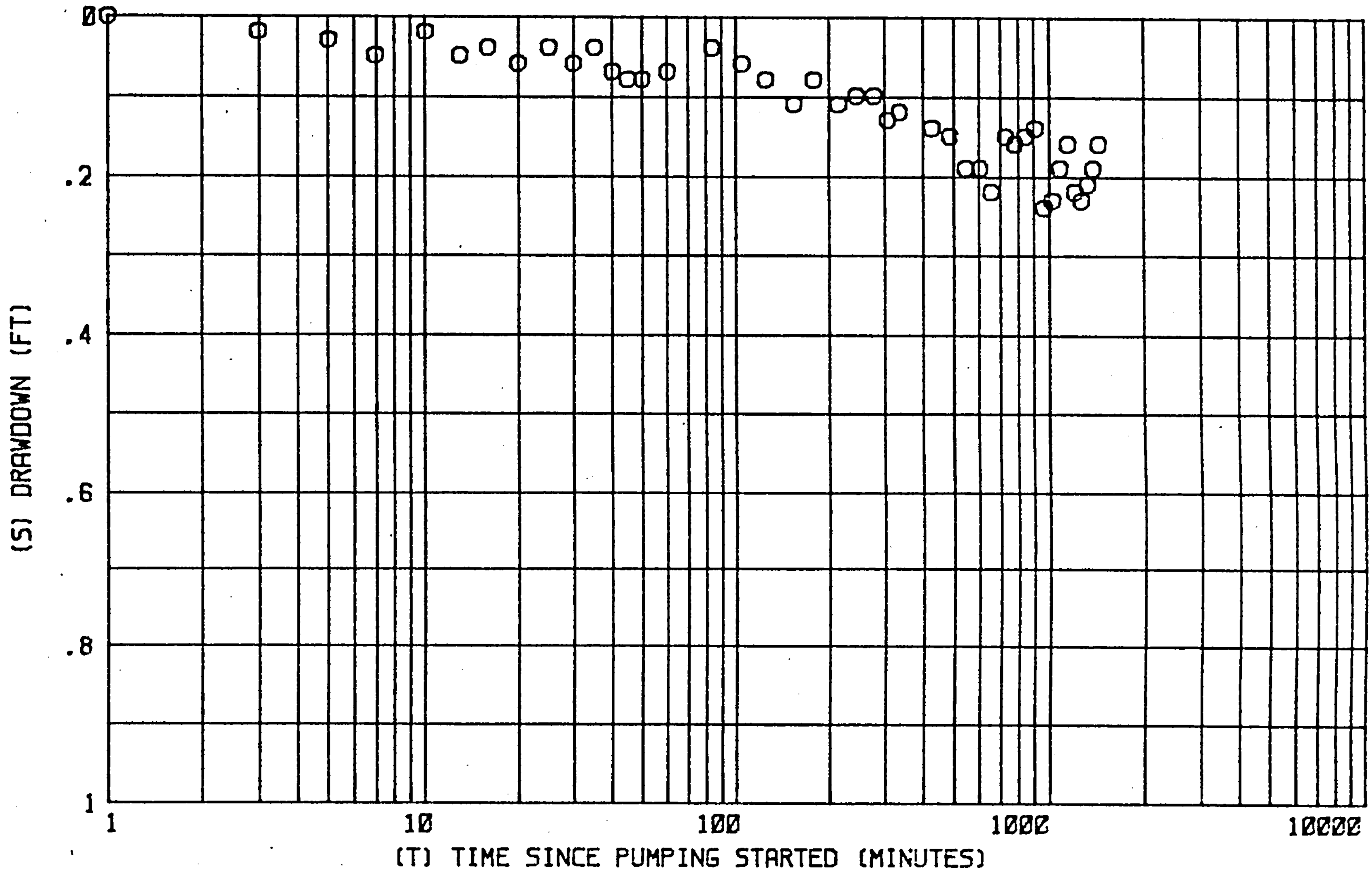


PROJECT: NEVADA PSC FILE: 360 LOCATION: NW-11-19-20	WELL NO.: OBS NO.1 Q= 1000 USGPM S.W.L.= 11.97	ΔS'= 0.372 FT T= 709926 USGPD/FT S=

WILLIAM E. NORK, INC.

FIGURE 11

PUMPING TEST ANALYSIS   STRAIGHT LINE APPROXIMATION METHOD



PROJECT: NEVADA PSC FILE: 360 LOCATION: NV-11-19-20	WELL NO.:	OBS NO. 3		ΔS=
	Q=	1000 USGPM		T=
	S.W.L.=	12.97		S=

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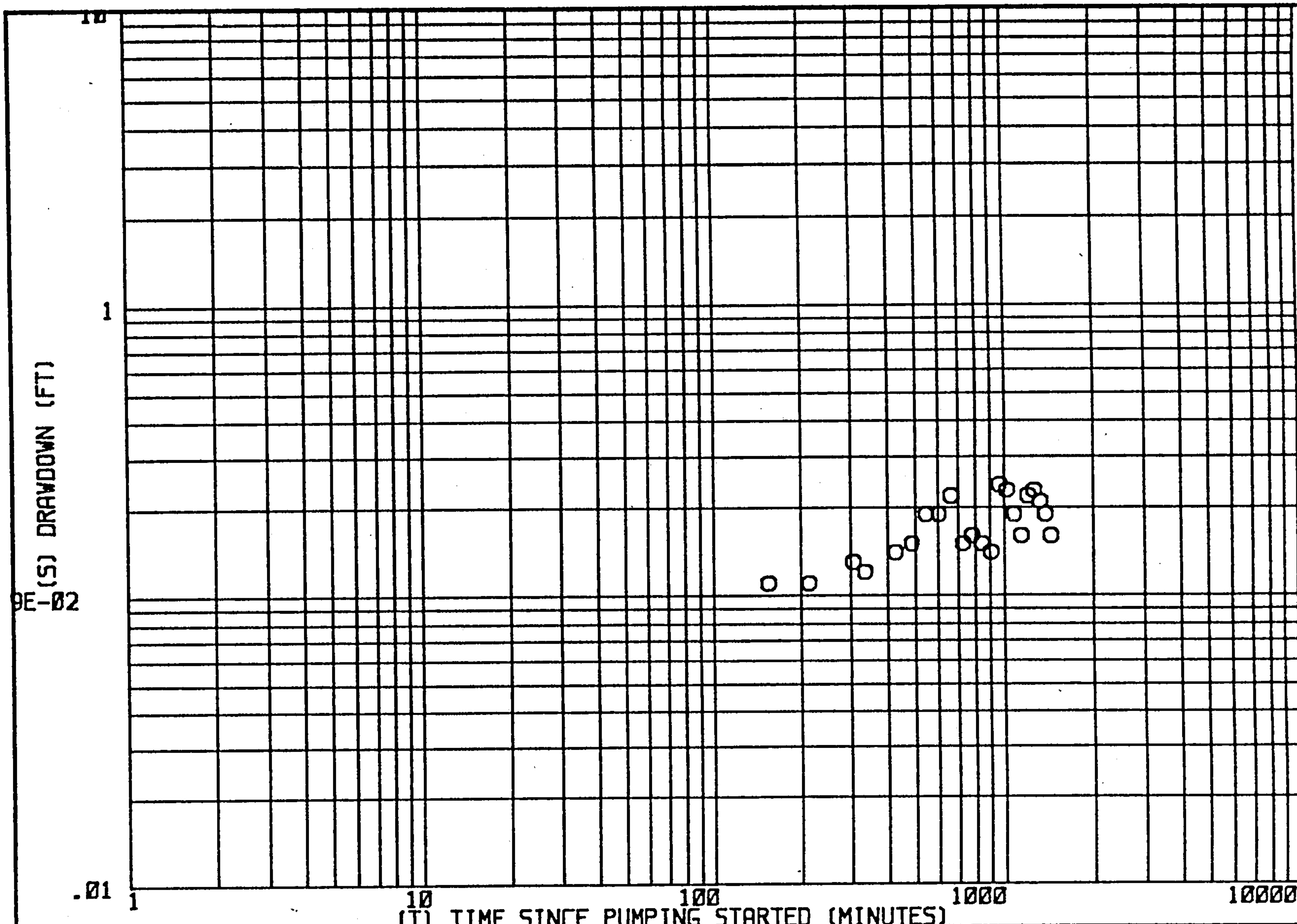
FIGURE 12

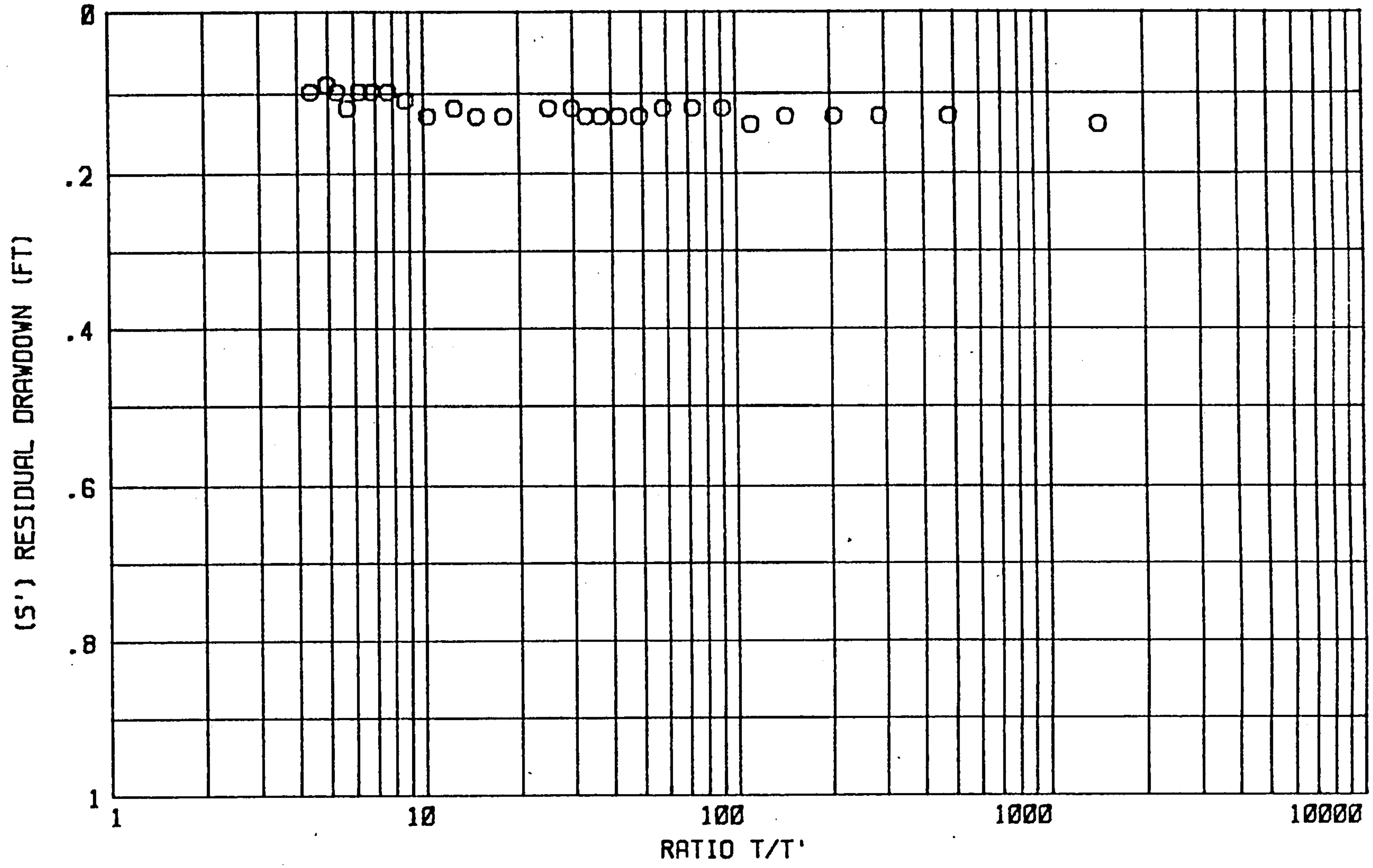


PROJECT NEVADA PSC LOCATION NW-11-19-20	FILE 360 WELL No. OBS NO.3	PUMPING TEST ANALYSIS TYPE CURVE SOLUTION

WILLIAM E. NORK, INC.

FIGURE 13

RECOVERY ANALYSIS



PROJECT:	NEVADA PSC	WELL NO.:	OBS NO. 3	ΔS'=	
FILE:	360	Q=	1000 USGPM	T=	
LOCATION:	NW-11-19-20	S.W.L.=	12.97	S=	

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FIGURE 14

* confined has S=.005 – .00005

Table 1. Summary of analysis results

Well	Data	Method	Transmissivity (GPD/ft)	Coefficient of Storage	Vertical Permeability of Aquitard (GPD/ft^2)
Purity No. 3 (pumped well)	drawdown	Cooper-Jacob	24,859	-	-
Purity No. 3	drawdown	Hantush & Jacob	28,650	-	-
Purity No. 3	residual drawdown	Theis recovery	23,610	- (.0011)	-
Observation Well No. 2	drawdown	Cooper-Jacob	45,540	1.3×10^{-3}	- (screen from 100'-340')
Observation Well No. 2	drawdown	Hantush & Jacob	42,444	1.5×10^{-4} (.00015)	5.1-10.2
Observation Well No. 2	residual drawdown	Theis recovery	42,562	-	-
Observation Wells No.1 & 2	distance-drawdown	Jacob	36,935	-	5.5-11.0
Observation Wells No. 1 & 2	distance-drawdown	Cooper-Jacob	42,000	-	-

S values

missivity values ranged from an average of 25,700 GPD/ft for the pumped well to an average of 41,870 GPD/ft for Observation Well No. 2 (r=10.25 feet) to over 100,000 GPD/ft for Observaton Wells No. 1 and 3 (r=670 and 490 feet, respectively). For this reason results of time-drawdown analyses for the distant observation wells (Observation Wells No. 1 and 3, Figures 9 through 14) are not believed to yield representative values of aquifer properties.

Examination of the semilogarithmic drawdown and recovery data plots for the pumped well and Observation Well No. 2 (Figures 3, 5, 6 and 8) shows a distinct decrease in slope beginning about 100 minutes after pumping began. This flattening of the slope is typical of drawdown data from wells near a recharge boundary. However, analysis of these data shows that only Observation Well No. 2 data actually stabilized (note specifically late-time drawdown data in Figures 3 and 6). For this reason it appears that this response is attributable to vertical leakage as opposed to some horizontally located boundary, e.g. the Truckee River. This follows because "...the rate of leakage per unit area relative to...drawdown is negligibly small in the immediate vicinity of the pumped well but becomes increasingly important for larger values of r [radial distance from the pumped well]" (Neuman and Witherspoon, 1972). Had the drawdown cone of depression intercepted the Truckee River, the pumping water level in the well would be expected to stabilize also.

cause Recharge bdry would what if stability is not fully effective?

Hantush (1964) derived an equation which describes the rate of yield from storage in a leaky aquifer with storage in a semipervious layer (aquitard). This equation is

$$q_s = (Q/\delta_1) \exp(-\nu t/\delta_1 B^2)$$

where:

q_s	is the rate of yield from storage in the main aquifer (L^2T^{-1})
δ_1	is 1 + S'/3S
ν	is the hydraulic diffusivity (L^2T^{-1})
t	is the time since pumping started (T)
B	is the leakage factor (L) (from leaky aquifer analysis)

Substituting values obtained from analysis of the testing data,

Q = 1,000 GPM = 192,513 FT^3/day (discharge rate from 12/84 pumping test)

δ_1 = 1 (assuming S'>>S)

$$\nu = T/S = 5{,}400\ FT^2/day\ /\ 0.0001 \text{ (from Table 1)}$$
$$= 5.4 \times 10^7\ FT^2/day$$

t = 1 day

B = 330 FT (from leaky aquifer analysis, Appendix F)

yields

$$q_s = 192{,}513\ \frac{FT^3}{day} \exp\left\{-\left[\frac{(5.4\times10^7\ FT^2/day)}{(330\ FT)^2}\right]\right\}$$

$$= 192{,}513\ \frac{FT^3}{day} \exp(-496)$$

$$= 0$$

The result indicates that the main aquifer, that is, the aquifer penetrated by Purity Well No. 3, contributes virtually nothing to the well yield after one day of pumping and that the induced vertical leakage provides almost 100 percent of the discharge of the well.

As stated earlier, Purity Well No. 3 was completed to a depth of 191 feet in an attempt to isolate production zones from deeper, arsenic-laden ground water. This construction, however, did not take into account the potential for vertical upward leakage through a semipervious layer (aquitard) separating shallower and deeper water yielding zones. On the basis of the electric log of Test Hole No. 1, this aquitard appears to be intercalated beds or lenses of clay and sand and not a thick, relatively continuous aquiclude. The consequences of upward leakage from deeper zones on the long-term chemical quality of the ground water derived from the well are discussed in Section 4.3.

The observed response in Observation Well No. 3 during the test was a decline in the water level of 0.16 foot. This appears to result from a slight but possibly significant decrease in flow in the Truckee River, a general decline in water level in the shallow, unconfined aquifer, or a combination of the two. USGS streamflow records show a decrease in the discharge in the Truckee River of approximately 42 cfs (10 per cent of the total flow) between the start of the test and end of recovery measurement (December, 1984 Truckee River discharge records). In addition, water levels measured in this observation well showed a decline of 0.11 foot for the nine-day period preceeding the test. A combination of these two influences may account for a substantial portion, if not all, of the 0.16 foot change in water level observed during the test.

Look at water Quality too

3.3 POTENTIAL FOR A HYDRAULIC CONNECTION WITH THE TRUCKEE RIVER

A cursory examination of the data from the September, 1984 performance test of Purity Well No. 3 could lead to an erroneous conclusion that the drawdown cone of depression of the well intercepted a recharge boundary, e.g. the Truckee River. This may appear intuitively obvious based on previous investigations (Cooley, et al., 1971 and Cunningham, 1977) which clearly establish a direct hydraulic connection between ground water in the Truckee Meadows and the Truckee River. That this direct connection may be limited solely to the shallow water-table aquifer becomes evident when the crudely stratified nature of the alluvium is considered. Evidence that the production zones tapped by Purity Well No. 3 are not connected to the river are summarized below.

1. The electric log of Test Hole No. 1 indicates a potential confining layer at a depth of approximately 8Ø feet below land surface. The spontaneous potential (SP) log suggests that the waters above and below this layer are of slightly different character.

   If this is the case, surface contaminants will not migrate to well.

2. The coefficient of storage calculated from test data indicate that the aquifer is confined. This is supportive of No. 1 above.

3. Testing results indicate the well is completed in a leaky artesian aquifer and do not suggest the presence of a recharge boundary.

4. Water chemistry data (Section 4.Ø) clearly indicate that waters derived from production zones more closely resemble that derived from deeper water-bearing horizons and this indicates that leakage is vertically upward rather than downward.

   (ie. As increases over time?)

3.4 POTENTIAL IMPACT ON EXISTING WELLS

Interference affects resulting from pumping Purity Well No. 3 may be calculated using the leaky aquifer theory of Hantush and Jacob. Drawdown at distances of 5ØØ, 1,ØØØ, and 1,5ØØ feet from the pumped well were calculated for one year of pumping at a sustained rate of 1,ØØØ gpm. Calculations in support of the results tabulated below are presented in Appendix F.

Radial distance from the pumped well, r	Drawdown, s, after one year
500 FT	1.2 FT
1,000 FT	0.7 FT
1,500 FT	0.06 FT

These results indicate that the potential impact on existing wells in the vicinity will be negligible. The nearest large production well is Sierra Pacific Power Company's Pezzi Well locate approximately one-quarter of a mile to the southwest. Anticipated drawdown in this well due to interference affects will be less than 0.1 foot. after 1 year Conversely, interference affects due to ground-water extractions from other wells in the vicinity on water levels in Purity Well No. 3 will be negligible also.

4.Ø WATER QUALITY

4.1 TRENDS IN ARSENIC CONCENTRATION

Previous investigations by WILLIAM E. NORK, INC. (1977) for the Washoe County District Health Department determined that the concentration of arsenic in ground water derived from wells completed in the alluvium in the eastern Truckee Meadows was related to withdrawal rates and duration of pumping. Data for Hidden Valley Well No. 1 clearly illustrated this general rise in the concentration of arsenic and its correlation to water usage.

A similar trend is exhibited by Purity Well No. 2 data. Initial concentration of arsenic immediately after completion of the well was reported as Ø.Ø35 mg/l. Monthly data for the period December, 1981 to December, 1984 (Appendix G) show a general increase in arsenic concentration to approximately Ø.Ø6 mg/l with peak levels of Ø.Ø8 mg/l. Comparison with monthly water use data suggests that the correlation between water usage and arsenic found elsewhere are valid for this well too. The data show some scatter which may be attributable to variations in pumpage preceeding sample collection. A three-point moving average of the data reduces the amount of the scatter and more clearly illustrates the arsenic/usage trend.

Similar relationships between pumpage and arsenic concentration are suggested by data from Sierra Pacific Power Company's Pezzi Well which is located approximately one-quarter of a mile southwest of Purity Well No. 3. This well was completed with the screened interval placed between 214 and 266 feet, roughly equivalent to zone 4 of Purity Test Hole No. 1. Chemical analyses for samples collected 6/17/83 and 11/4/83 yielded arsenic concentrations of Ø.Ø73 mg/l and Ø.Ø62 mg/l, respectively (Guyton and Assts., 1984). Differences in the concentration appear to be related to pumpage prior to collection of the samples. For a period of two months prior to sampling the well on 6/17/83 the reported pumpage was 19 million gallons compared to a mere Ø.5 million gallons prior to sampling the well on 11/4/83. Although data are insufficient to be statistically significant, they strongly suggest correlation between total pumpage and arsenic concentration for this well also.

Water samples for chemical analysis were collected from five water-producing zones penetrated by Purity Test Hole No. 1, referred to in this report as Observation Well No. 2. Analyses results showed significant changes in water chemistry with increased depth. Most significant were the arsenic data which showed concentrations ranging from Ø.ØØ2 mg/l for the shallowest zone sampled (1ØØ-13Ø feet depth) to Ø.Ø9Ø mg/l for deeper zones (25Ø-28Ø feet depth) (Appendix A).

4.2 PURITY WELL NO. 3 WATER QUALITY DATA

Water samples for chemical analysis were collected after one, six, 12, 18, and 23.5 hours of pumping during the December 13-14, 1984 pumping test. They are identified in this report as sample numbers 360-1 through 360-5. The analysis results are summarized in Table 2. Examination of these data show a general increase in total dissolved solids (T.D.S), sodium, sulfate, and arsenic with pumping duration. Stiff diagrams (Figure 15) illustrate the differences in gross water chemistry that occurred as pumping duration increased. Comparison with Figure 16 shows that water derived from Purity Well No. 3 late in the test very closely resembled ground water derived from deeper zones (below 170 feet depth) penetrated by Test Hole No. 1 and was significantly different from ground water derived solely from shallower zones.

The contribution of ground water from the two zones tapped by Purity No. 3 during the pumping test can be calculated using the continuity equation

$$C_{tot} Q_{tot} = C_1 Q_1 + C_2 Q_2$$

where:

C_{tot} is concentration of arsenic in the well discharge;

Q_{tot} is the discharge of the well;

C is the arsenic concentration in individual contributing zones;

Q is the contribution from individual water-producing zones; and

the subscripts 1 and 2 refer to the shallower and deeper production zones, respectively;

The equation may be rewritten and solved directly for the contribution of either zone since the total discharge, concentration of arsenic in each production zone and the well discharge are known.

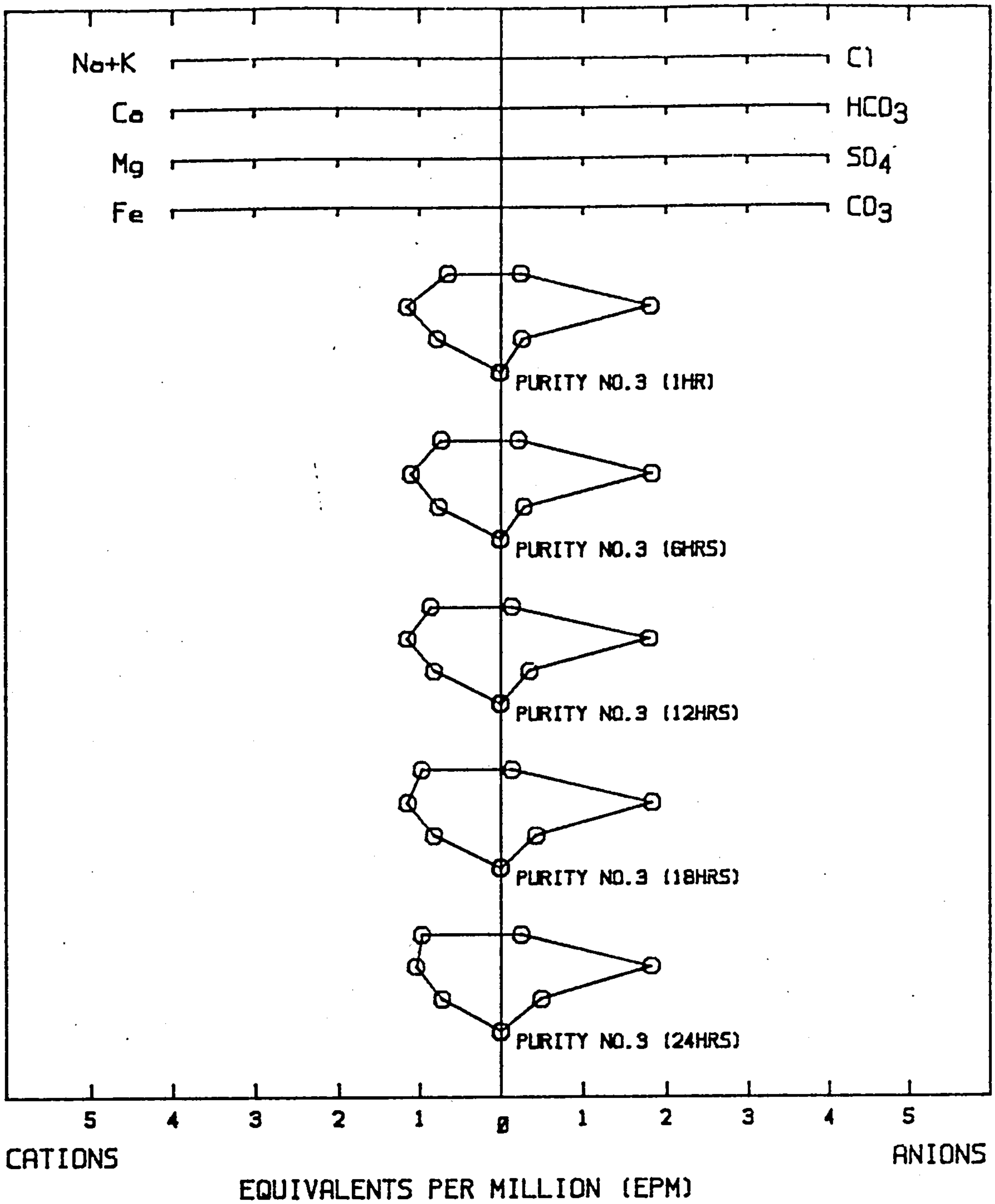
Substituting

$$Q_1 = Q_{tot} - Q_2$$

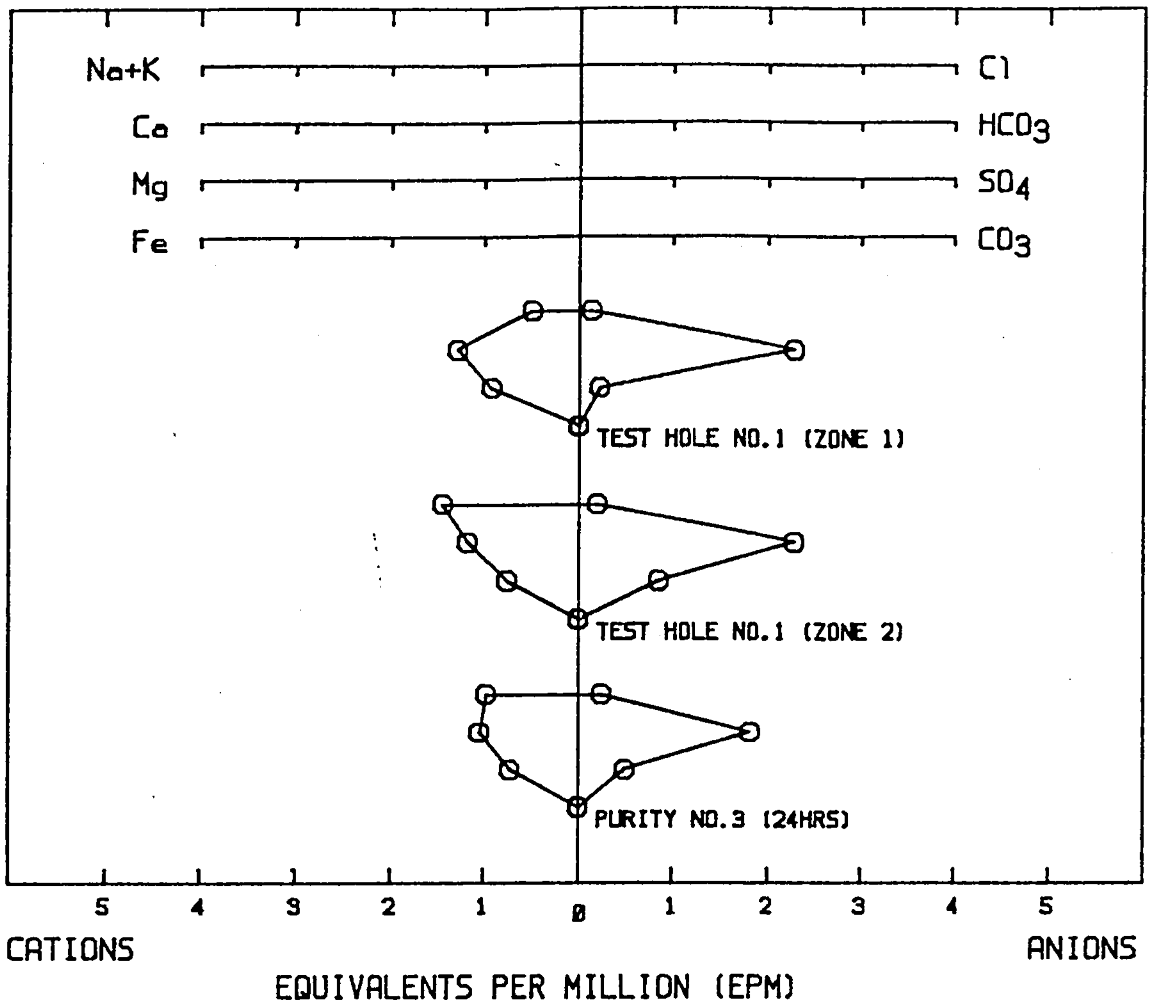
TABLE 2. Purity Well No. 3 water chemistry data

Sample No.	360-1	360-2	360-3	360-4	360-5	Drinking Water Standards
Date	12/13/84	12/13/84	12/14/84	12/14/84	12/14/84	
Time	1330	1830	0045	0630	1200	
Pumping Duration (hrs)	1	6	12.25	18	23.5	
Analysis Labs	S.E.M.	S.E.M.	ST LAB	ST LAB	S.E.M.	
Temperature(C)		13.2	12.9	12.0	13.4	
Field E.C. (mho/cm)		219	308	324	317	
T.D.S.	150	174	171	170	198	1,000[2]
pH	7.4	7.4	7.74	7.75	7.3	
Ca	23	22	23	23	21	
Mg	9.5	9.3	10	10	8.8	150[2]
Na	13	15	18	20	20	
K	3.0	3.0	3	4	4.0	
Alkalinity($CaCO_3$)	111	112	110	112	111	
SO_4	13	14	17	21	24	500[2]
Cl	9	8	5	5	9	400[2]
N (as NO_3)	2.9	4.4	5	5	4.3	45[1]
F	0.1	0.1	0.10	0.12	0.2	1.4-2.2[1]
Fe	0.05	<0.02	0	0	<0.02	0.6[2]
Mn	<0.02	<0.02	0.01	0.01	<0.02	0.1[2]
As	0.007	0.014	0.022	0.024	0.024	0.05[1]
B	0.1	0.1	0	0	0.1	

1-USEPA Primary Drinking Water Standard
2-State of Nevada Secondary Drinking Water Standard



PROJECT: NEVADA PSC FILE: 85-360 LOCATION: NW-11-19-20	STIFF GRAPH
WILLIAM E. NORK, INC.	FIGURE: 15



PROJECT: NEVADA PSC
FILE: 85-360
LOCATION: NW-11-19-20

STIFF GRAPH

WILLIAM E. NORK, INC.

FIGURE: 16

and rearranging the equation terms to solve for Q_2 yields

$$Q_2 = \frac{C_1 - C_{tot}}{C_1 - C_2} \times Q_{tot}$$

Substituting values for arsenic concentration obtained from the packer tests (Appendix A) and the December 13-14, 1984 test, and equating Q_{tot} to 100 per cent of the discharge, the equation becomes

$$Q_2 = \frac{0.002 \text{ mg/l} - 0.024 \text{ mg/l}}{0.002 \text{ mg/l} - 0.030 \text{ mg/l}} \times 1.00$$

$$= 0.79$$

and indicates that the deeper of the two production zones tapped by Purity Well No. 3 contributed approximately 80 percent of the total well discharge by the end of the test. conflicts with page 23, but? ?

This result cannot be directly compared to the result in Section 3.2 which states that induced vertical leakage can account for 100 percent of the well discharge within 24 hours of pumping. This follows because 24 hours is an insufficient period of time for the water derived from the next lower zone between 210 and 230 feet to actually flow across the aquitard from this zone of leakage to the production zones (Section 4.3 and Appendix F).

In general, the water chemistry data tends to support the leaky-aquifer response described in Section 3.2, the consequences of which are discussed in Section 4.3.

4.3 ANTICIPATED ARSENIC CONCENTRATION

The concentration of arsenic in the ground water derived from Purity Well No. 3 will increase with pumping duration above the level of 0.024 mg/l observed at the end of the December 13-14, 1984 pumping test. The leaky aquifer response and water chemistry data discussed in Sections 3.2 and 4.2, respectively, support this conclusion.

The best-case scenario provides that the source of the induced leakage will be confined to the zone immediately below the lower production zone. In this case the arsenic concentration can be expected to approach 0.035 mg/l as a limit once sufficient time has elapsed for induced leakage to provide 100 percent of the well discharge. This can be expected to occur after one to two months of sustained pumping if the trend observed during the December stress test continues.

The time, t, it takes a slug of water from the next deeper zone to reach the production zones of Purity Well No. 3 can be calculated from existing data. Substituting values advanced from testing results, drillers' reports, and the geopyhysical log:

vertical permeability, K'	= 0.68 FT/day
Average vertical hydraulic gradient across the aquitard due to pumping, i'	= 0.33 FT/FT
thickness of aquitard, m'	= 15 FT
porosity of aquitard, n	= 0.30

into the equation for interstitial velocity, v, derived from Darcy's Law yields

$$v = \frac{K'\ i'}{n} = \frac{0.68\ \text{FT/day} \times 0.33}{0.30} = 0.75\ \text{FT/day}$$

and

$$t = \frac{m'}{v} = \frac{15\ \text{FT}}{0.75\ \text{FT/day}} = 20\ \text{days}$$

Assuming that some retardation, dispersion, and mixing with the better quality ground water in the shallower zones takes place, it may take somewhat longer for the arsenic concentration of the discharge to reach 0.035 mg/l.

The worst-case scenario assumes that leakage will be induced from a still deeper zone (250 to 280 feet) where the concentration of arsenic approaches 0.090 mg/l.

Substituting

$i' = 0.17$ FT/FT
$K' = 1.36$ FT/day
$m' = 30$ FT

into the equations above indicates that arsenic-laden ground water from the deeper zone (250 to 280 feet) can be expected to begin mixing with ground water in the producton zones after 43 days.

The time it will take for the concentration of arsenic in the water derived from Purity Well No. 3 to exceed the standard of Ø.Ø5 mg/l, assuming a sustained pumping rate of 1,ØØØ gpm, may be advanced from the results of the arsenic analyses. Extrapolation of a plot of arsenic concentration versus logarithm of time shows that the concentration of arsenic will reach Ø.Ø5Ø mg/l in 1.9 years (Figure 17).

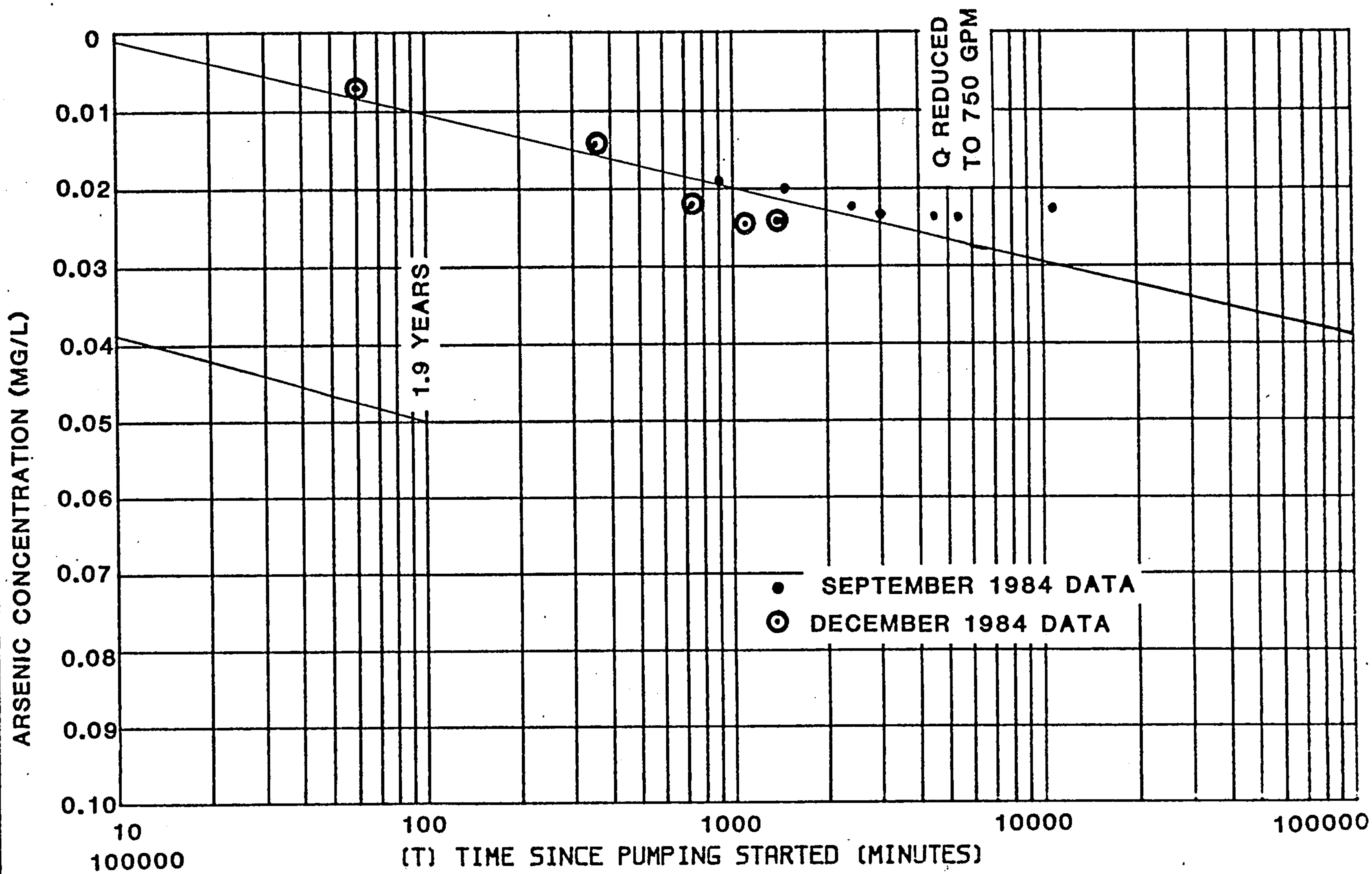
The operation scheme proposed for the system uses Purity Well No. 3 and the yet-to-be constructed Well No.4 (induced infiltration well) as the primary sources of water supply with Purity No. 2 serving as backup or peaking water supply (Summit Engineering, 1984; Appendix H). Some cautions regarding this scheme are worth considering. These are :

1. The induced infiltration well is a modified surface-water source and may be legally available only during the irrigation season - April 1 to November 1 each year. Purity Well No. 3 and No. 2 could be conceivably be called on to meet peak daily demand in the off (non-irrigation) season.

2. The concentration of arsenic in a blend of water from the three potential sources was calculated by Summit Engineering (Appendix H; III., D., 2.). A concentraton of Ø.Ø23 mg/l was assumed for water derived from Purity Well No. 3 based on results of the September 1984 performance test (Appendix H; III., B., 2.) A more realistic value falls somewhere between Ø.Ø35 and Ø.Ø9Ø mg/l. The former value yields a concentration for the composite water blended from Well Nos. 2, 3 and 4 of Ø.Ø33 mg/l, which is still acceptable. However, if the concentration of arsenic approaches the higher value, then the resultant concentration will exceed the maximum acceptable level.

3. It has yet to be proven that a shallow well near the river will yield 1,ØØØ gpm. The electric log for Test Hole No. 1 suggests that only the upper 5Ø to 75 feet of the alluvium may be directly coupled to the river. Wells constructed deeper than this run the risk of inducing upward leakage, much like Purity No. 3. If so, then the arsenic level in water derived from this well could become significant.

There are at least three alternatives for verifying the results of this analysis. The first is to test pump the well for a minimum of at least 3Ø days at a rate of 1,ØØØ gpm and collect numerous samples for chemical analysis so that data trends observed in the first two tests can be verified. The second is to tie the well into the system and monitor water chemistry closely so that as data become available the accurracy of the predictions may be evaluated. This would allow up to two years for remedial action such as advanced water treatment to be instituted. The third is to develop and calibrate a predictive model of the aquifer.



PROJECT:	NEVADA PSC	WELL NO.:	PURITY NO.3	PROJECTED ARSENIC CONCENTRATION
FILE:	360	Q=	1000 GPM	
LOCATION:	NW-11-19-20	S.W.L.=	13.63	

WILLIAM E. NORK, INC.

FIGURE 17

The first alternative is impractical in terms of both cost and relatively small amount of data generated. The second alternative carries the risk that within two years, Purity Utilities, Inc. will be confronted with the same problem that they now faced. Of the three, the third alternative is the most attractive. It, too, is relatively costly in terms of the data necessary for calibrating the model. However it would allow prediction of water chemistry for a wide range of water use schemes.

SOURCES OF INFORMATION

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Other Sources

Nork, W.E., Inc., 1984. Letter to Nevada PSC dated November 21, 1984.

Summit Engineering, 1984. Design and operation scheme.

Washoe County Dist. Health Dept. Arsenic concentration and water useage records for Purity Utilities Well No. 2.

USGS Truckee River discharge records for December 1984.

APPENDIX A

PURITY UTILITIES TEST HOLE NO. 1
WATER QUALITY DATA

HYDRO CONDUIT CORPORATION

(2)

TESTING RESULTS + AS DETERMINATIONS IN 5 ZONES OF PURITY EXPL HOLE

DATE ____________

PAGE ______ OF ______ PAGES

PROJECT: TEST WELL INTERVAL TESTING

- SEALED OFF 5 AQUIFERS FOR TESTING

ZONE NO.	PERF.	PUMP SET	TEST RESULTS: ARSENIC	TEST RESULTS: PUMPING RATE (GPM)	TEST RESULTS: PUMPING DURATION (HRS)
1	100-130	113	.002	13	*
			.002	12	24
			.002	12	48
			.002	12	72
2	170-190	176	.006	12.50	*
			.030	12	24
			.030	12	48
			.030	12	72
3	210-230	218	.035	12	*
4	250-280	260	.035	12	*
			.090	11.50	72
5	300-340	307	.008	11.50	*

* INITIAL SAMPLES TAKEN AFTER WATER CLEARED UP.

COMBINED TESTING - ZONES 1 & 2

		159	.003	65	*
			.002	65	16
			.004	65	64
		176	.014	65	72

APPENDIX B

PURITY UTILITIES WELL NO. 3
WATER QUALITY DATA

HYDRO CONDUIT CORPORATION

(1)

DATE ____________

PAGE ______ OF ______ PAGES

PROJECT Purity Utilities

		As	Mg	Fe	
9/7	8:00 PM	.023	.06	.04	
9/8	8:00 PM	↑	↑	.02	
9/10	8:00 AM	↓		↑	1000 GPM
9/10	10:25 AM	.023	↓		
9/10	5:30 PM	.022	.06		
9/11	9:00 AM	↑	.05		
9/11	5:00 PM	↓	↕	↓	750 GPM
9/12	9:00 AM	.022	.05	.02	

9/6	8:00 AM	.019	.05	.02	
9/6	8:00 PM	.020	.06	.02	1000 GPM
9/7	8:00 AM	.022	.06	.10	
		.05	.10	.6	

STARTED PUMPING 5:00PM 9/5/84

APPENDIX C

PUBLIC SERVICE COMMISSION LETTER
DATED 11/29/84

STATE OF NEVADA
PUBLIC SERVICE COMMISSION OF NEVADA
505 East King Street
Carson City, Nevada 89710
(702) 885-4180

RICHARD H. BRYAN
Governor

November 29, 1984

Mr. Bill Nork
c/o William E. Nork, Inc.
1026 W. First Street
Reno, Nevada 89503

Re: Purity Utilities, Inc. Docket 84-1003

Dear Bill:

This is intended to define your role in the above docket pursuant to the approval on November 19, 1984 by the Board of Examiners of a consulting contract whereby you were retained by the Staff of the Public Service Commission to assist them in the preparation of their analysis of this docket. It should also serve to inform other interested parties of the anticipated time tables and work programs.

Docket 84-1003 is an application by Purity Utilities, Inc. to extend its service area solely to incorporate a transmission line from wells proposed by the utility to solve its water quality problems. Notice of Intent to Intervene has been filed by the Consumer Advocate's Office and the homeowner's association in the Purity service area. The basic question asked whether, the pipeline and thus the corridor applied for is a prudent venture by the utility? This entails determining if the existing wells the utility drilled are adequate or if in the general area of the proposed pipeline adequate wells could be drilled, and if the well drilling program is adequate compared to other alternatives available to the utility to solve the water quality problems.

The scope of your assignment will be first: determined from existing data and additional tests as necessary the properties of the new wells drilled by the utility; then, determine the adequacy to serve a hook-up load of 1,200 customers indefinitely addressing potential impacts on existing wells and sources of water in the vicinity, as well as impacts of these sources and wells on the Purity wells.

Specific questions to be answered are:

> What is the source of water in the existing well?
>
> Given a progressive build out to 1,200 hook-ups, for what period will the existing well be adequate to supply both the required quantity and quality of water?

Supply an appropriate analysis which can be used in the economic comparisons of the well drilling alternative to the other alternating available to the utility to improve quality.

Also, as a result of your data gathering and analysis please offer an opinion of the probability of adequacy of the well drilling program proposed by the utility, or at least a time and cost estimate of what it would take to determine the feasibility of the program. As additional data is made available and results are obtained undoubtly additional specific questions will need to be addressed and we will deal with those as they arise. Upon completion of your work we would expect a full report which will be incorporated as part of STaff's case. You will be expected to present your position to the Commission at a formal hearing.

The timetable we are striving for is as follows:

November 26-30: If arrangements for access to observations wells and test areas can be made by the utility, a test well will be drilled.

December 3-7: Wells will be tested and samples taken.

December 7-28: Samples analyzed.

December 31-January 31: Analysis of results and preparation of testimony for hearing: Testimony to be coordinated between staff and the consultant.

A tentative hearing date has been set for January 29, 1984.

We will attempt to supply you with the following information from the following utilities by approximately December 15th, 1984.

From Purity Utilities, Inc.

Operational plan for the new wells.

From Sierra Pacific Power Company

Water quality test results for the period from 1975 to the present with; test stations defined; frequency; blending controls; occurrence of well operation.

Gyton reports.

Well drilling history and well modifications of Sierra Pacific Power Company wells.

As a note, we anticipate because of the tight time frames and the informal method you will be required to use to assemble data that their will be numerous requests for you to analysis aspects of this issue which we have not requested. We would instruct you to direct these requests to us and we will determine their appropriate for of our case.

Thank you for your assistance.

Sincerely,

TIMOTHY F. HOLT, P.E.
Water Engineer

TFH:lh

cc: State Engineer
Purity Utilities Inc.
OCA
Montgomery
Mendive
Hidden Valley Property Owner's Association

APPENDIX D

WILLIAM E. NORK, INC. LETER
DATED 11/21/84

WILLIAM E. NORK, Inc.

CONSULTING SERVICES IN HYDROLOGY AND GEOLOGY

1026 W. First Street • Reno, Nevada 89503

Phone (702) 322-2604

November 21, 1984
84-360

Tim Holt, P.E.
NEVADA PUBLIC SERVICE COMMISSION
505 E. King Street
Carson City, NV 89701

Re: Preliminary analysis of Purity Well No. 3 testing and water chemistry data

Dear Mr. Holt:

To date we have examined pumping and water chemistry data from Purity Utilities's test well and Well No. 3. Specific data are the results of packer tests conducted 6/26-29, 6/29-7/2, 7/10-13, and 7/13-16/84; chemical analyses of water samples collected during these tests; and pumping and water chemistry data from the seven-day test conducted in Well No. 3 9/5-12/84.

As best as we can determine from the record and an interview with the pumping contractor, Bruce McKay, the packer tests were not of the straddle-packer type - that is, packers were not placed above and below the zone of interest. Straddle-packer tests isolate a single production zone from other water-bearing zones. Although the zones were not isolated, the low pumping rates of 10-12 gallons per minute (gpm) for the first two tests may have reduced flow up the casing so that samples are more or less representative of the zones directly opposite the pump intake. Differences in gross water chemistry do exist for various water-bearing zones as shown in Figures 1 and 2.

During the test conducted 6/26-29 a pump was installed at a depth of 176 feet (opposite zone 2) with a packer set at 154 feet. This arrangement excluded zone 1 (100-130 feet). Upon conclusion of three days pumping, the packer was raised to 91 feet and the pump raised to 113 feet (directly opposite zone 1). Comparison of the chemical analysis of the water sample collected at the end of the second three days pumping with the previous analysis results (Figures 1 and 2) shows a difference in gross chemistry of waters derived from the two zones.

Upon completion of this testing sequence, the well was backfilled with sand and a packer placed at 182 feet - midway up the perforations of zone 2. The pump was placed at a depth of 159 feet and a sample collected after three days pumping. Comparison with the previous two analyses (Figures 1 and 2) shows that the water derived from the test well in this configuration closely resembled water derived from zone 1. A likely explanation is that the ground water changes character below a depth of about 180 feet. Examination of the electric borehole log suggests a change in water chemistry below 180 feet and that this lower zone (below 180 feet) was effectively isolated from the top half of zone 2 and all of zone 1 during the the 7/10-13 test. The last packer test (7/13-16) involved lowering the pump to 174 feet with little affect on water chemistry and supports the aforementioned conclusion.

In general, drawdown data collected from the packer tests (Figures 3 through 8) yielded little information regarding hydraulic characteristics of the individual water-bearing zones. Pumping rates were insufficient to stress the aquifer enough to provide meaningful drawdown data. The noteable exception is the data collected from the 7/10-13 test, at which time the well was pumped at 68 gpm. These data yielded a value for transmissivity equal to 19,947 GPD/ft (gallons per day per foot) (Figure 7) which compares favorably with a value of 26,667 GPD/ft calculated from early-time drawdown data from the Well No. 3 pumping test.

Except for the chemical quality data derived from the samples taken during the series of packer tests, the most important other data available may be the hydraulic head (water level) information. These data show that composite piezometric head increases with depth, indicating a potential for upward leakage of ground water. To carry this one step farther, as wells completed in the shallower zones are pumped, the head difference between deeper and shallower zones will increase, thereby enhancing the potential for upward leakage. If these deeper waters contain arsenic, as the packer test results show, then the concentration of arsenic can be expected to increase with time as the arsenic-laden water is induced to flow vertically upward. Although the electric log and driller's log indicate several clay strata, these may not be sufficiently thick or areally extensive to prevent vertical flow of ground water under the influence of pumping.

The Purity Utilities Well No. 3 pumping test conducted 9/5-12/84 appears to be adequate for selecting a production pump for the well. However, it leaves a lot to be desired from the stand point of determining the physical nature of the aquifer in this area. The major short coming, i.e. the lack of observation-well data, raises more questions than were answered by the test. These are:

1. Was a recharge boundary, i.e. the Truckee River, encountered during testing?

2. Did upward vertical leakage occur during testing, and, if it did, how does this affect long-term concentration of arsenic?

3. If a recharge boundary was not felt and leakage did not occur, how do you explain the testing results?

A cursory examination of the test data (Figure 10 and 11) suggests that a recharge boundary may have been intercepted by the cone of depression during the test. Because the Truckee River is very close to the well site and the river is known to be hydraulically connected to the shallow water-table aquifer in this area, a recharge boundary may be expected. However, the same data may be interpreted as a highly transmissive aquifer of unknown extent or character. This second interpretation is suported by testing of the Sea and Ski well located approximately one-quarter mile southwest where no boundaries were observed and transmissivity was calculated between 100,000 and 200,000 GPD/ft. Late-time Well No. 3 drawdown data yielded a value for transmissivity equal to 155,000 GPD/gft, and suggest the aquifer transmissivity increases to the south, away from the Truckee River. Additional evidence that that transmissivity increases to the southwest is offered by data presented in Figure 9. These data show the chemical quality of ground water derived from the Sea and Ski well compared to water derived ferom Purity Well No. 3.

Also, it is reported that Hidden Valley No. 2 was once rated to yield 1,200 gpm with minimal drawdown, hinting that this well penetrated similar, highly transmissive aquifer materials.

The three different scenarios suggested by the test data have an impact on the concentration of arsenic which can be expected given continuous use of Well No. 3. If the river was in fact encountered, then Purity can expect the chemical quality of the water to remain essentially constant since good quality Truckee River water will in fact be a major source of water to the well even during low-flow periods. This, however raises the question whether surface or ground water permits are applicable. If leakage in fact occurs, then water quality can be expected to deteriorate with time as arsenic-laden ground water moves vertically upward and mixes with good quailty shallow ground water tapped by the well. The presence or absence of a recharge boundary, relative location of areas of high transmissivity, and presence or absence of vertical leakage can be determined with suitable observation-well data. Observation wells were available but for some unknown reason were not used during the test of Well No. 3.

To address the questions either unanswered or posed by the first pumping test, we recommmend that Purity Well No. 3 be retested. At the very least, the test hole should be used as an observation well and an additional shallow observation well be drilled near the Truckee River. Nearby wells not currently in use would also serve as useful observation wells. Considering the response of the well during the previous test, the second test need not be any longer than 24 to 36 hours. If the well is to be retested, water samples for analysis of major cations and anions should be collected periodically from the well discharge to determine whether or not gross chemistry remains constant throughout the test. Suggested sampling times are at 0.5, 1, 2, 6, 12, 24 and 36 hours.

Please do not hesitate to contact our office if this letter raises any questions.

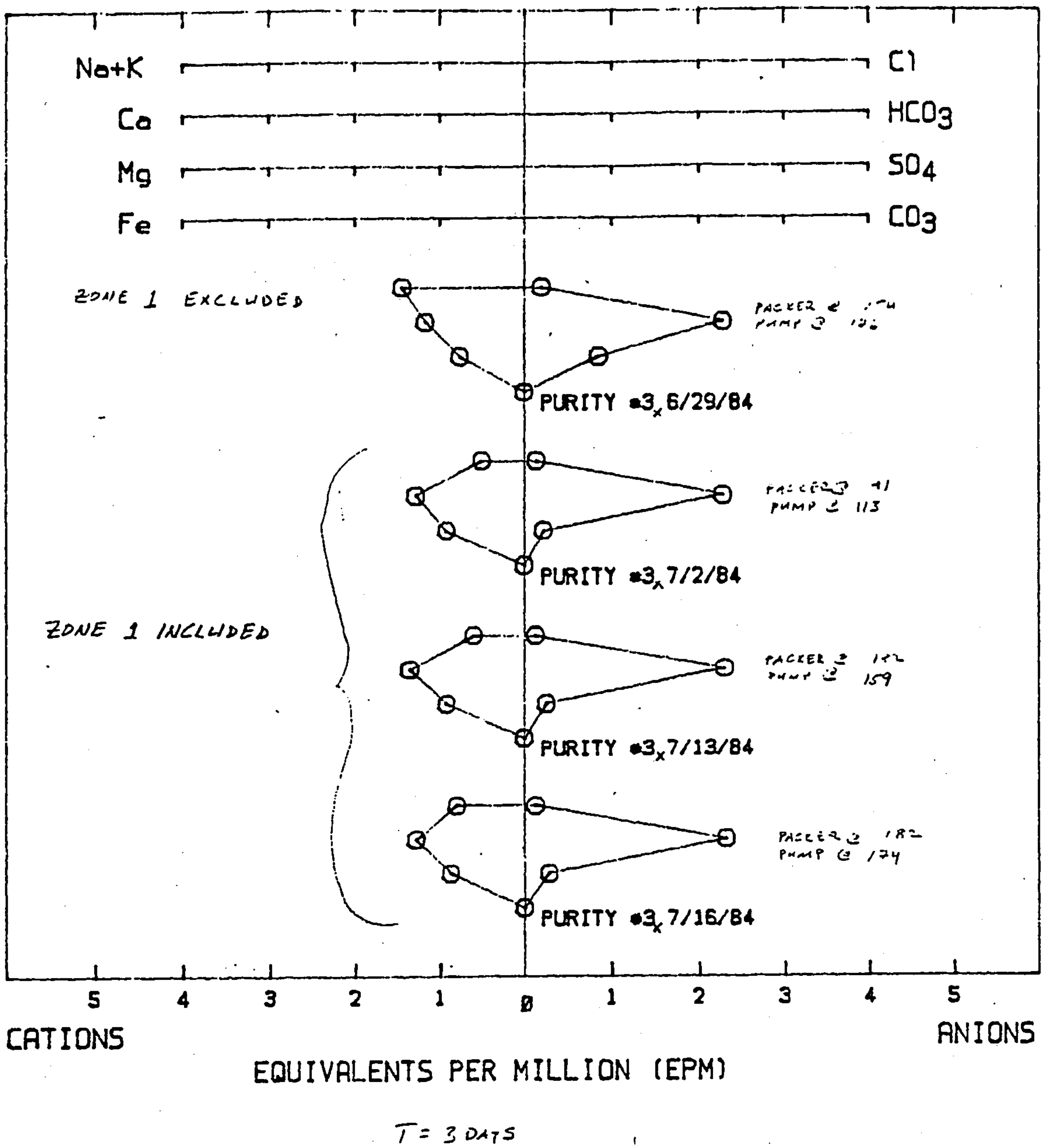
Sincerely,

WILLIAM E. NORK, INC.

Dale C. Bugenig

Dale C. Bugenig
Hydrogeologist

Attachments

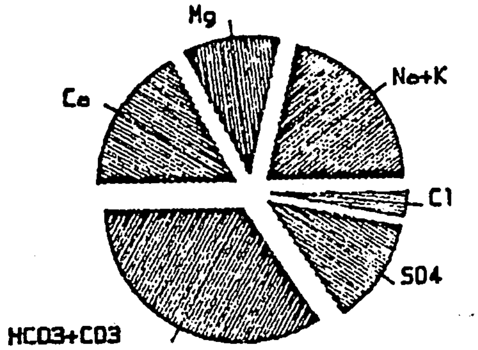


PROJECT: NV PSC
FILE: 84-360
LOCATION: RENO

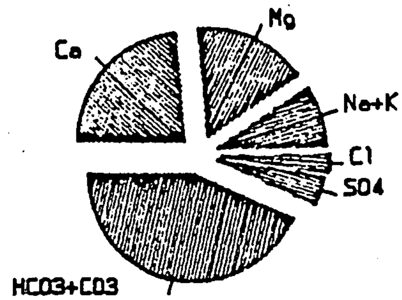
STIFF GRAPH

WILLIAM E. NORK, INC.

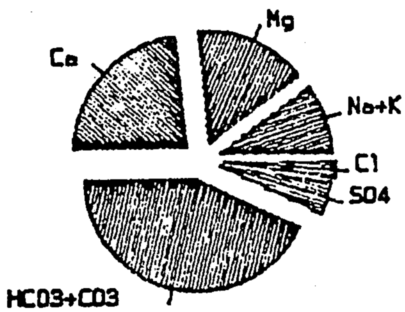
FIGURE: ~~10~~ 1



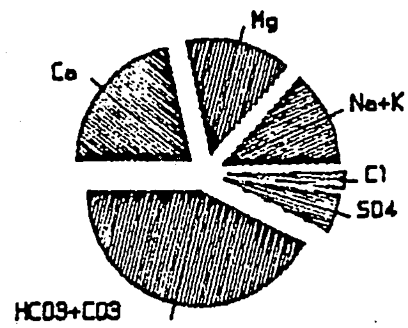
PURITY #3 6/29/84



PURITY #3 7/2/84



PURITY #3 7/13/84



PURITY #3 7/16/84

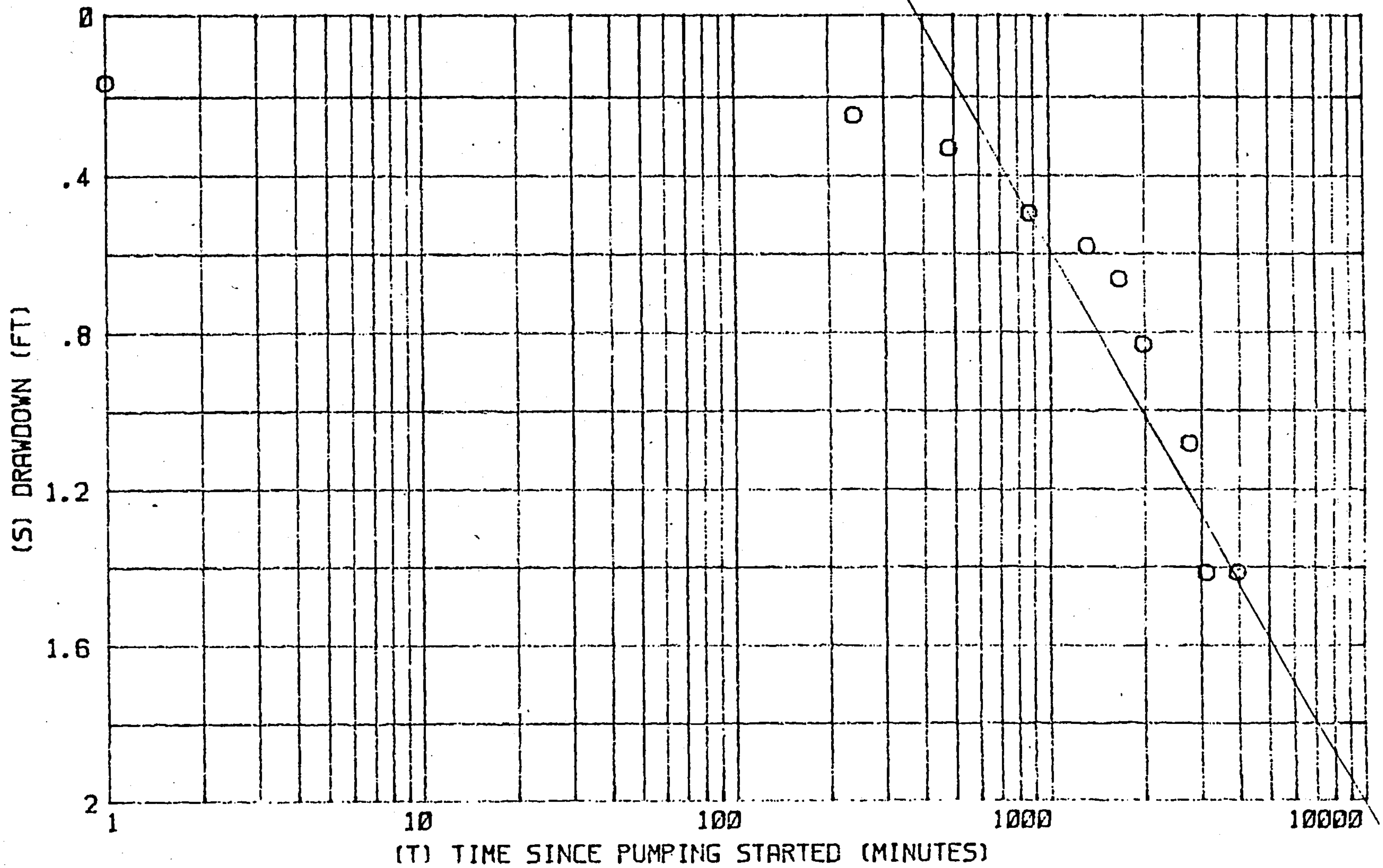
0 5 10

SCALE OF RADII
(TOTAL OF EQUIVALENTS
PER MILLION)

NOTE ERROR (IF ANY) IN CATION/ANION
BALANCE HAS BEEN REMOVED

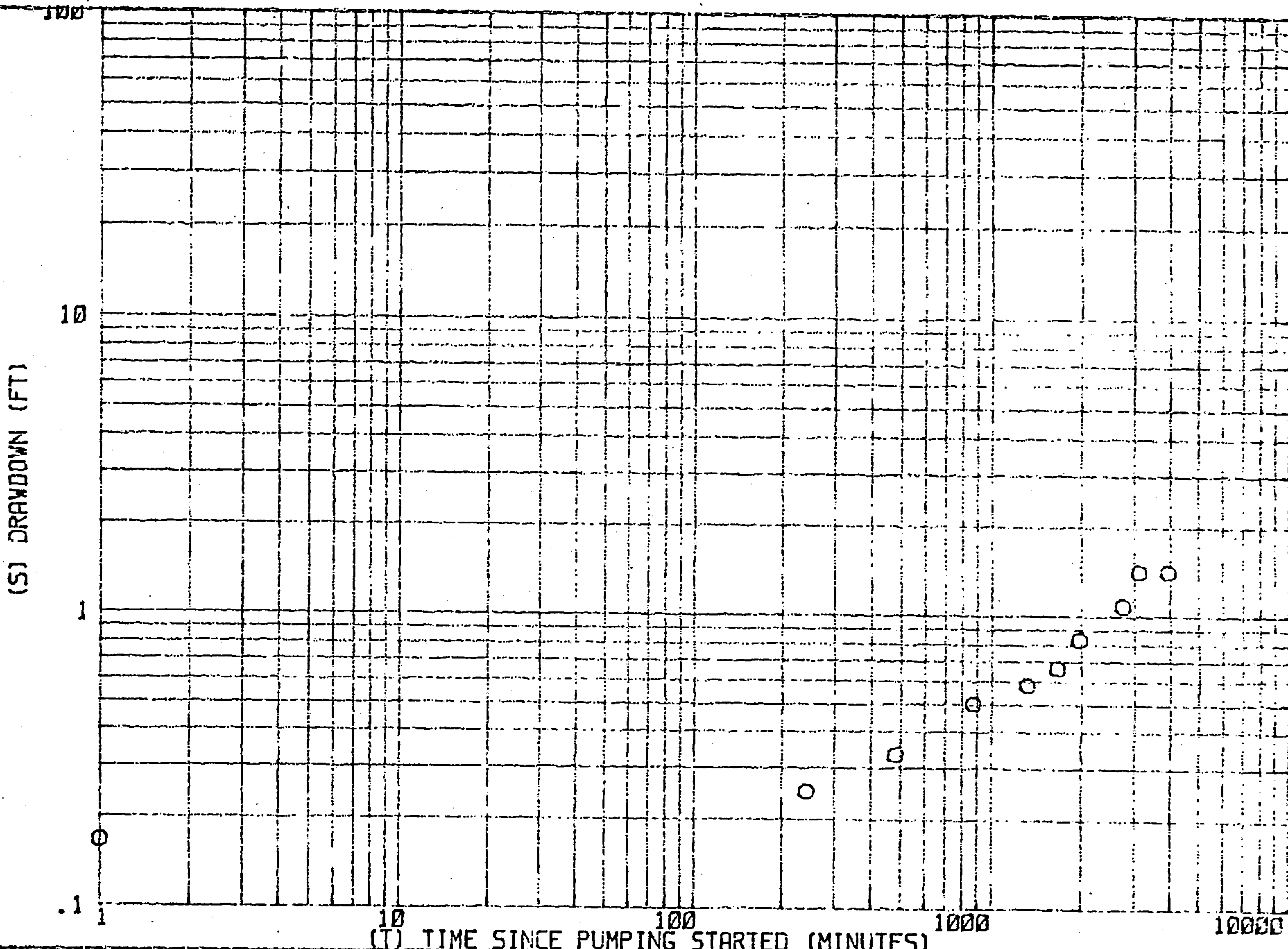
PROJECT: NV PSC FILE: 84-360 LOCATION: RENO	PIE DIAGRAMS SHOWING WATER QUALITY
WILLIAM E. NORK, INC.	FIGURE: ~~12~~ 2

PUMPING TEST ANALYSIS   STRAIGHT LINE APPROXIMATION METHOD



PROJECT: NV PSC FILE: 84-360 LOCATION: RENO	WELL NO.: PURITY #3 Q= 11.5 USGPM S.W.L.= 12.92	ΔS= T= S=

WILLIAM E. NORK, INC.   FIGURE 3

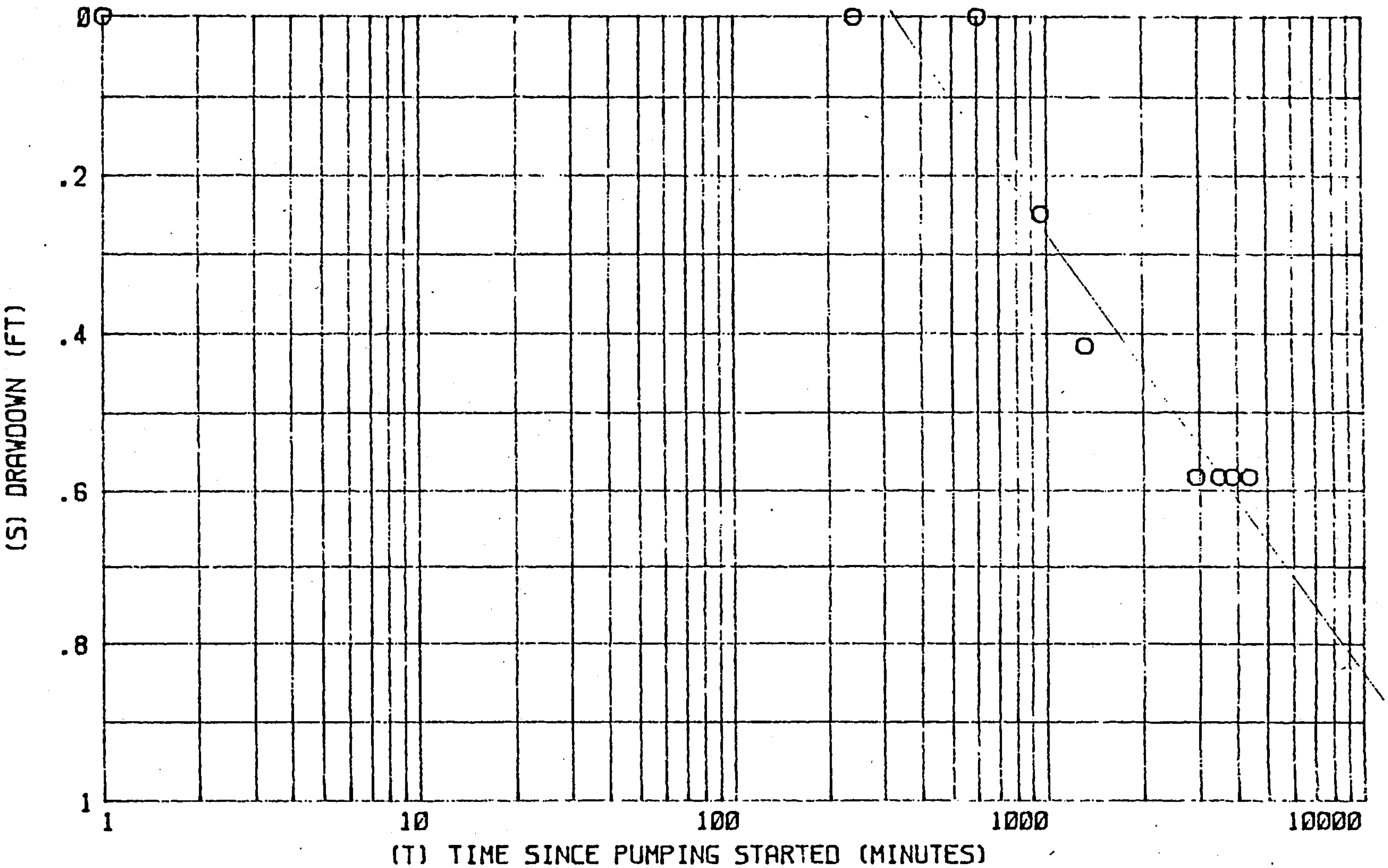


PROJECT NV PSC LOCATION RENO	FILE 84-360 WELL No. PURITY #	PUMPING TEST ANALYSIS TYPE CURVE SOLUTION

WILLIAM E. NORK, INC.

FIGURE 4

PUMPING TEST ANALYSIS STRAIGHT LINE APPROXIMATION METHOD

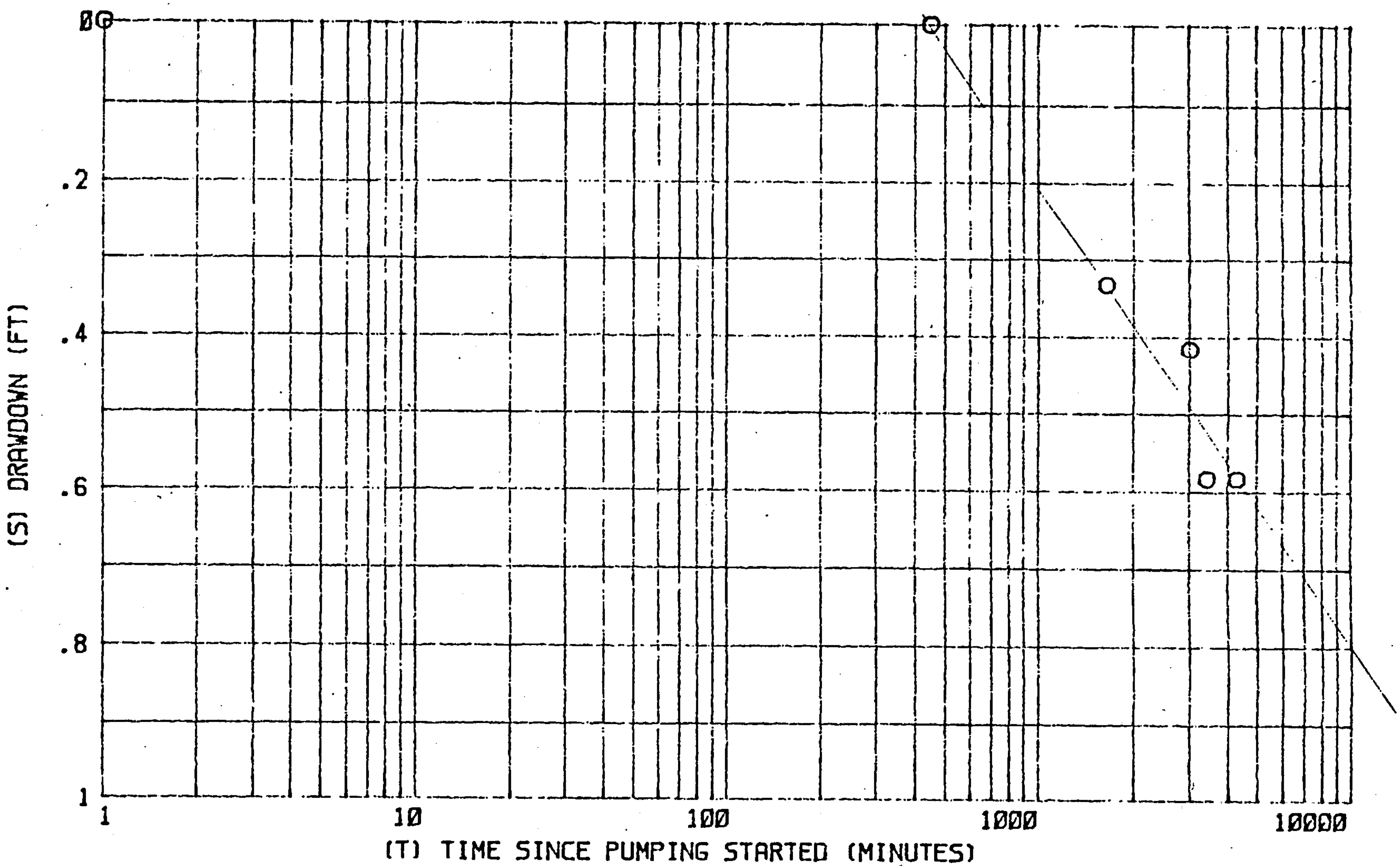


PROJECT:	NV PSC	WELL NO.:	PURITY #3	ΔS=
FILE:	84-360	Q=	12.0 USGPM	T=
LOCATION:	RENO	S.W.L.=	13.42	S=

WILLIAM E. NORK, INC.

FIGURE 5

PUMPING TEST ANALYSIS   STRAIGHT LINE APPROXIMATION METHOD



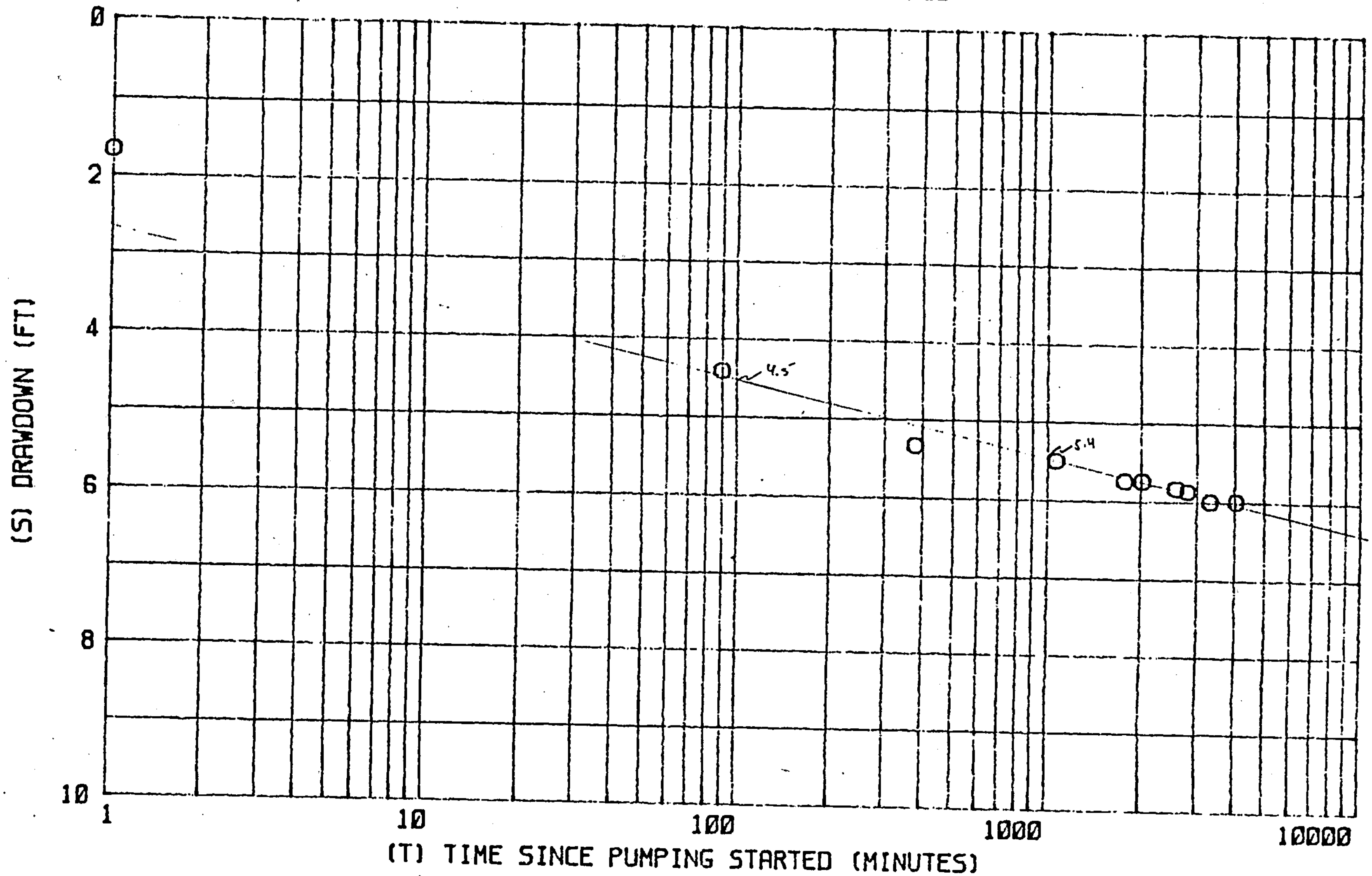
PROJECT: NV PSC FILE: 84-360 LOCATION: RENO	WELL NO.: PURITY #3 Q= 12.0 USGPM S.W.L.= 15.42	ΔS= T= S=

WILLIAM E. NORK, INC.

FIGURE 6

$T = \frac{264 \times 68}{0.9} = 19,947$ GPD/FT

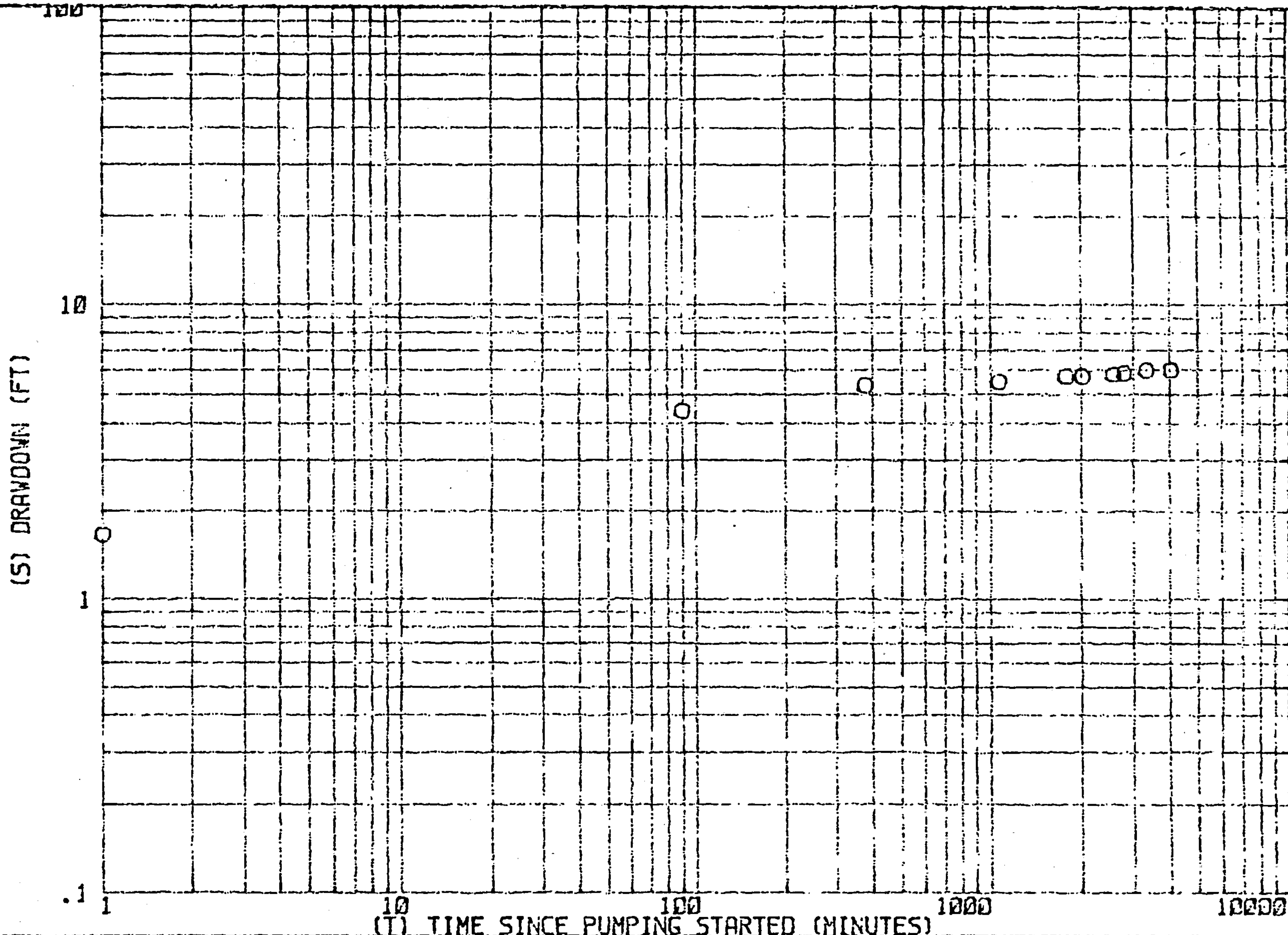
PUMPING TEST ANALYSIS STRAIGHT LINE APPROXIMATION METHOD



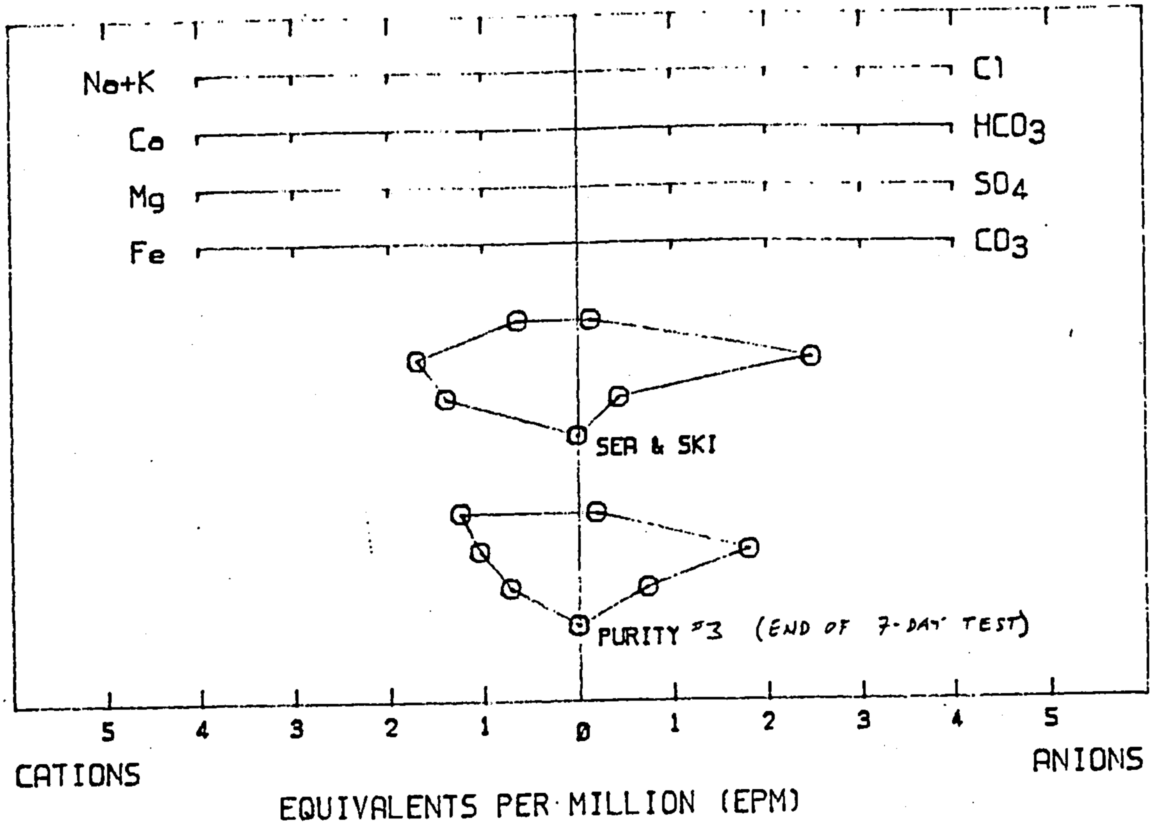
PROJECT: NV PSC FILE: 84-360 LOCATION: RENO	WELL NO.: PURITY Q= 68 USGPM S.W.L.=	ΔS= T= S=

WILLIAM E. NORK, INC.

FIGURE 7



PROJECT NV PSC LOCATION RENO	FILE 84-360 WELL No. PURITY	PUMPING TEST ANALYSIS TYPE CURVE SOLUTION
WILLIAM E. NORK, INC.		FIGURE 8



PROJECT: NV PSC
FILE: 84-360
LOCATION: RENO

STIFF GRAPH

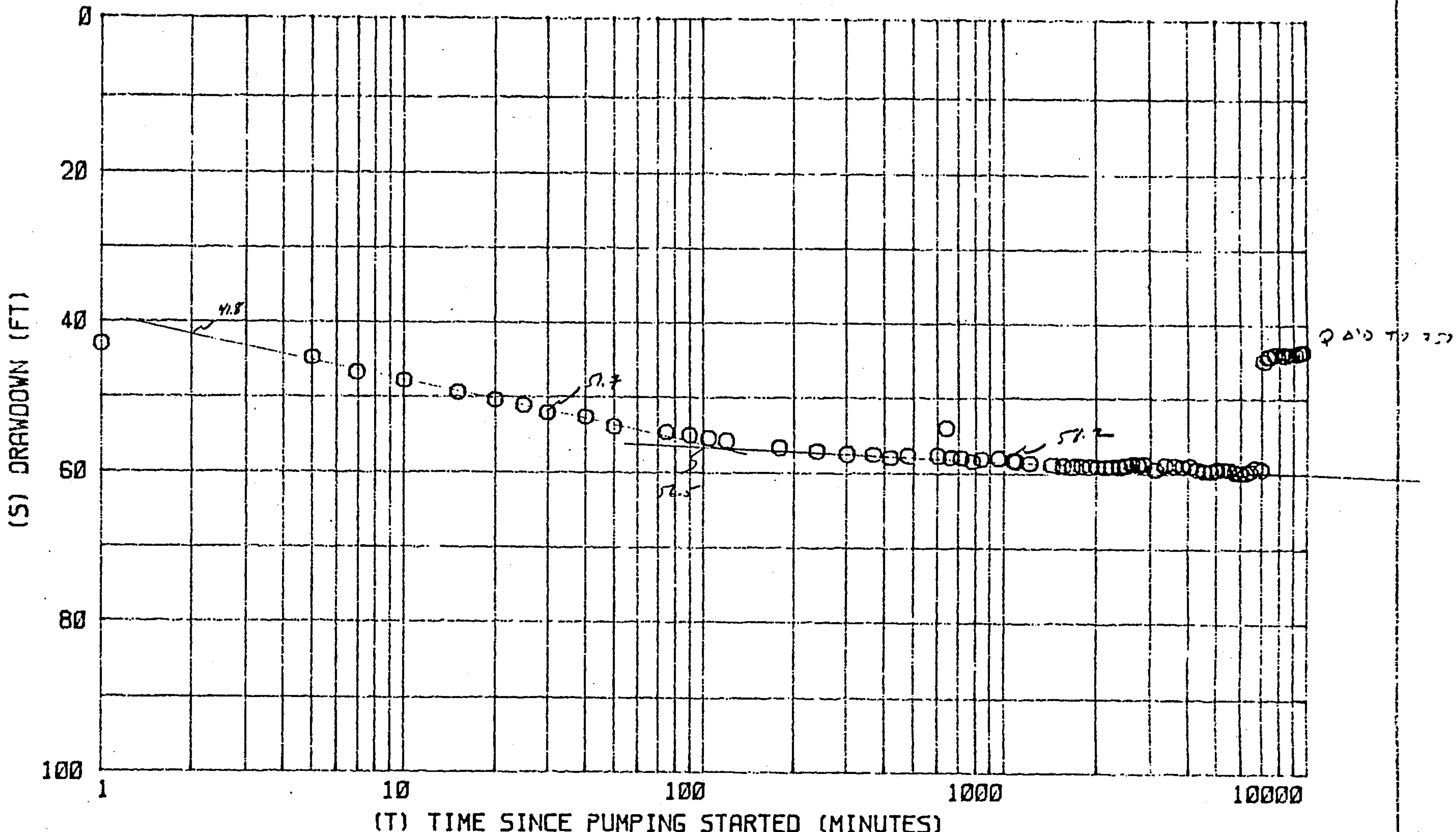
WILLIAM E. NORK, INC.

FIGURE: 9

LATE TIME DATA

EARLY-TIME DATA

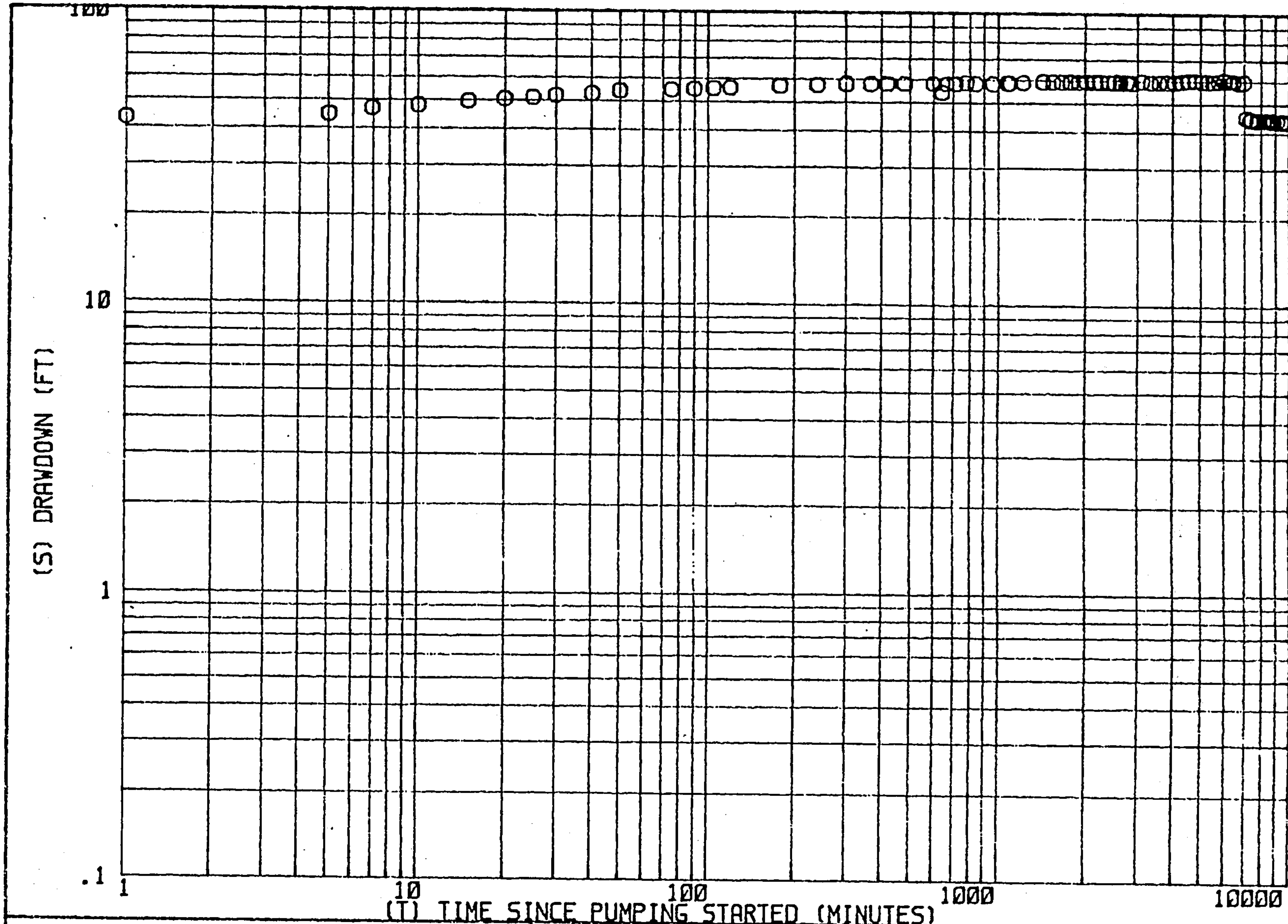
PUMPING TEST ANALYSIS STRAIGHT LINE APPROXIMATION METHOD



PROJECT: NV PSC FILE: 84-360 LOCATION: RENO	WELL NO.: PURITY #3 Q= 1000 USGPM S.W.L.= 12.5	ΔS= T= S=

WILLIAM E. NORK, INC.

FIGURE 10



PROJECT NV PSC LOCATION RENO	FILE 84-360 WELL No. PURITY #	PUMPING TEST ANALYSIS TYPE CURVE SOLUTION

WILLIAM E. NORK, INC.

FIGURE 2 "

APPENDIX E

PUMPING TEST DATA

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS: 90 ?
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: PURITY NO.3
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 13.63
R = ----- FROM
SCREEN INTERVAL: 105 TO 191

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	12	30	0.00	13.630	0.000	%1000.00
13	12	31	1.00	46.870	33.240	%1000.00
13	12	33	3.00	49.730	36.100	%1000.00
13	12	35	5.00	52.700	39.070	%1000.00
13	12	37	7.00	54.050	40.420	%1000.00
13	12	40	10.00	55.360	41.730	%1000.00
13	12	43	13.00	56.680	43.050	%1000.00
13	12	46	16.00	57.720	44.090	%1000.00
13	12	50	20.00	58.570	44.940	%1000.00
13	12	55	25.00	59.720	46.090	%1000.00
13	13	0	30.00	60.750	47.120	%1000.00
13	13	5	35.00	61.500	47.870	%1000.00
13	13	10	40.00	61.720	48.090	%1000.00
13	13	15	45.00	62.200	48.570	%1000.00
13	13	20	50.00	62.830	49.200	%1000.00
13	13	30	60.00	63.550	49.920	%1000.00
13	13	50	80.00	65.160	51.530	%1000.00
13	14	20	110.00	64.770	51.140	%1000.00
13	14	30	120.00	65.320	51.690	%1000.00
13	15	0	150.00	65.790	52.160	%1000.00
13	15	30	180.00	66.400	52.770	%1000.00
13	16	0	210.00	66.750	53.120	%1000.00
13	16	30	240.00	66.900	53.270	%1000.00
13	17	1	271.00	67.020	53.390	%1000.00
13	17	30	300.00	67.220	53.590	%1000.00
13	18	0	330.00	67.610	53.980	%1000.00
13	18	30	360.00	67.940	54.310	%1000.00
13	19	30	420.00	67.920	54.290	%1000.00
13	20	30	480.00	68.050	54.420	%1000.00
13	21	30	540.00	68.260	54.630	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS: 90
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: PURITY NO.3
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 13.63
R = ----- FROM
SCREEN INTERVAL: 105 TO 191

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	22	30	600.00	68.460	54.830	%1000.00
13	23	30	660.00	68.430	54.800	%1000.00
14	0	30	720.00	68.480	54.850	%1000.00
14	1	30	780.00	68.510	54.880	%1000.00
14	2	30	840.00	68.540	54.910	%1000.00
14	3	30	900.00	68.600	54.970	%1000.00
14	4	30	960.00	68.720	55.090	%1000.00
14	5	30	1020.00	68.760	55.130	%1000.00
14	7	30	1140.00	68.750	55.120	%1000.00
14	8	30	1200.00	68.800	55.170	%1000.00
14	9	30	1260.00	68.760	55.130	%1000.00
14	10	30	1320.00	68.820	55.190	%1000.00
14	11	30	1380.00	68.950	55.320	%1000.00
14	12	30	1440.00	69.100	55.470	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS:
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: OBS NO.2
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 12.68
R = 10.25 FT FROM
SCREEN INTERVAL: 100 TO 340

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	12	30	0.00	12.680	0.000	%1000.00
13	12	32	2.00	25.250	12.570	%1000.00
13	12	34	3.50	26.460	13.780	%1000.00
13	12	36	5.50	27.310	14.630	%1000.00
13	12	38	7.50	28.650	15.970	%1000.00
13	12	41	10.50	29.150	16.470	%1000.00
13	12	44	13.50	29.800	17.120	%1000.00
13	12	47	16.50	30.470	17.790	%1000.00
13	12	51	20.50	31.070	18.390	%1000.00
13	12	56	26.00	31.550	18.870	%1000.00
13	13	1	31.00	30.170	17.490	%1000.00
13	13	21	51.00	31.180	18.500	%1000.00
13	13	31	61.00	31.210	18.530	%1000.00
13	13	51	81.00	32.300	19.620	%1000.00
13	14	11	101.00	33.350	20.670	%1000.00
13	14	31	121.00	32.740	20.060	%1000.00
13	15	1	151.00	33.030	20.350	%1000.00
13	15	32	182.00	33.250	20.570	%1000.00
13	16	1	211.00	33.330	20.650	%1000.00
13	16	31	241.00	33.390	20.710	%1000.00
13	17	3	273.00	33.500	20.820	%1000.00
13	17	33	303.00	33.530	20.850	%1000.00
13	18	35	365.00	33.720	21.040	%1000.00
13	19	35	425.00	33.740	21.060	%1000.00
13	21	33	543.00	33.830	21.150	%1000.00
13	22	32	602.00	33.830	21.150	%1000.00
13	23	32	662.00	33.870	21.190	%1000.00
14	0	35	725.00	34.320	21.640	%1000.00
14	1	32	782.00	34.310	21.630	%1000.00
14	2	32	842.00	34.290	21.610	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS:
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: OBS NO.2
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 12.68
R = 10.25 FT FROM
SCREEN INTERVAL: 100 TO 340

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
14	3	32	902.00	34.280	21.600	%1000.00
14	4	33	963.00	34.350	21.670	%1000.00
14	5	32	1022.00	34.340	21.660	%1000.00
14	6	32	1082.00	34.360	21.680	%1000.00
14	7	31	1141.00	34.290	21.610	%1000.00
14	8	32	1202.00	34.310	21.630	%1000.00
14	9	31	1261.00	34.330	21.650	%1000.00
14	10	31	1321.00	34.310	21.630	%1000.00
14	11	31	1381.00	34.340	21.660	%1000.00
14	12	30	1440.00	34.330	21.650	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVAD PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS:
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: OBS NO.1
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 11.97
R = 670 FT FROM
SCREEN INTERVAL: 49 TO 101

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	12	30	0.00	11.970	0.000	%1000.00
13	12	31	1.00	11.980	0.010	%1000.00
13	12	33	3.00	12.000	0.030	%1000.00
13	12	35	5.00	11.990	0.020	%1000.00
13	12	37	7.00	12.010	0.040	%1000.00
13	12	40	10.00	12.020	0.050	%1000.00
13	12	43	13.00	12.030	0.060	%1000.00
13	12	46	16.00	12.070	0.100	%1000.00
13	12	50	20.00	12.080	0.110	%1000.00
13	12	55	25.00	12.100	0.130	%1000.00
13	13	0	30.00	12.110	0.140	%1000.00
13	13	5	35.00	12.120	0.150	%1000.00
13	13	10	40.00	12.150	0.180	%1000.00
13	13	15	45.00	12.140	0.170	%1000.00
13	13	20	50.00	12.180	0.210	%1000.00
13	13	30	60.00	12.190	0.220	%1000.00
13	13	45	75.00	12.170	0.200	%1000.00
13	14	5	95.00	12.190	0.220	%1000.00
13	14	25	115.00	12.210	0.240	%1000.00
13	14	55	145.00	12.330	0.360	%1000.00
13	15	25	175.00	12.360	0.390	%1000.00
13	15	55	205.00	12.290	0.320	%1000.00
13	16	25	235.00	12.310	0.340	%1000.00
13	16	57	267.00	12.270	0.300	%1000.00
13	17	25	295.00	12.380	0.410	%1000.00
13	17	55	325.00	12.390	0.420	%1000.00
13	18	30	360.00	12.360	0.390	%1000.00
13	19	25	415.00	12.330	0.360	%1000.00
13	20	25	475.00	12.390	0.420	%1000.00
13	21	28	538.00	12.450	0.480	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVAD PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS:
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: OBS NO.1
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 11.97
R = 670 FT FROM
SCREEN INTERVAL: 49 TO 101

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	22	25	595.00	12.430	0.460	%1000.00
13	23	25	655.00	12.510	0.540	%1000.00
14	0	28	718.00	12.410	0.440	%1000.00
14	1	26	776.00	12.430	0.460	%1000.00
14	2	25	835.00	12.440	0.470	%1000.00
14	3	25	895.00	12.430	0.460	%1000.00
14	4	26	956.00	12.510	0.540	%1000.00
14	5	24	1014.00	12.480	0.510	%1000.00
14	7	25	1135.00	12.500	0.530	%1000.00
14	8	25	1195.00	12.520	0.550	%1000.00
14	9	25	1255.00	15.510	3.540	%1000.00
14	10	25	1315.00	12.480	0.510	%1000.00
14	11	25	1375.00	12.540	0.570	%1000.00
14	12	30	1440.00	12.530	0.560	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS: 50
CONDITIONS: UNCONFINED

FILE NO.: 360
WELL NO.: OBS NO. 3
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 12.97
R = 490 FT FROM
SCREEN INTERVAL: 21 TO 31

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	12	30	0.00	12.970	0.000	%1000.00
13	12	31	1.00	12.970	0.000	%1000.00
13	12	33	3.00	12.990	0.020	%1000.00
13	12	35	5.00	13.000	0.030	%1000.00
13	12	37	7.00	13.020	0.050	%1000.00
13	12	40	10.00	12.990	0.020	%1000.00
13	12	43	13.00	13.020	0.050	%1000.00
13	12	46	16.00	13.010	0.040	%1000.00
13	12	50	20.00	13.030	0.060	%1000.00
13	12	55	25.00	13.010	0.040	%1000.00
13	13	0	30.00	13.030	0.060	%1000.00
13	13	5	35.00	13.010	0.040	%1000.00
13	13	10	40.00	13.040	0.070	%1000.00
13	13	15	45.00	13.050	0.080	%1000.00
13	13	20	50.00	13.050	0.080	%1000.00
13	13	30	60.00	13.040	0.070	%1000.00
13	13	54	84.00	13.010	0.040	%1000.00
13	14	15	105.00	13.030	0.060	%1000.00
13	14	35	125.00	13.050	0.080	%1000.00
13	15	5	155.00	13.080	0.110	%1000.00
13	15	30	180.00	13.050	0.080	%1000.00
13	16	5	215.00	13.080	0.110	%1000.00
13	16	35	245.00	13.070	0.100	%1000.00
13	17	8	278.00	13.070	0.100	%1000.00
13	17	37	307.00	13.100	0.130	%1000.00
13	18	7	337.00	13.090	0.120	%1000.00
13	19	37	427.00	13.110	0.140	%1000.00
13	20	37	487.00	13.120	0.150	%1000.00
13	21	37	547.00	13.160	0.190	%1000.00
13	22	35	605.00	13.160	0.190	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - DRAWDOWN DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS: 50
CONDITIONS: UNCONFINED

FILE NO.: 360
WELL NO.: OBS NO. 3
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 12.97
R = 490 FT FROM
SCREEN INTERVAL: 21 TO 31

TIME			ELAPSED TIME	WATER LEVEL	DRAWDOWN	(Q)
DY	HR	MN	t (MIN)	(ft)	s (ft)	(USGPM)
13	23	25	655.00	13.190	0.220	%1000.00
14	0	40	730.00	13.120	0.150	%1000.00
14	1	36	786.00	13.130	0.160	%1000.00
14	2	35	845.00	13.120	0.150	%1000.00
14	3	36	906.00	13.110	0.140	%1000.00
14	4	37	967.00	13.210	0.240	%1000.00
14	5	35	1025.00	13.200	0.230	%1000.00
14	6	36	1086.00	13.160	0.190	%1000.00
14	7	35	1145.00	13.130	0.160	%1000.00
14	8	35	1205.00	13.190	0.220	%1000.00
14	9	35	1265.00	13.200	0.230	%1000.00
14	10	35	1325.00	13.180	0.210	%1000.00
14	11	36	1386.00	13.160	0.190	%1000.00
14	12	30	1440.00	13.130	0.160	%1000.00

WILLIAM E. NORK, INC.

PUMP TEST - RECOVERY DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS: 90
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: PURITY NO.3
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 13.63
R = ----- FROM
SCREEN INTERVAL: 105 TO 191

TIME			PUMPING STARTED	PUMPING ENDED	RATIO	WATER LEVEL	RESIDUAL DRAWDOWN
DY	HR	MN	t (MIN)	t' (MIN)	t/t'	(ft)	(ft)
14	12	31	1440.50	0.50	2881.00	36.910	23.280
14	12	31	1441.00	1.00	1441.00	35.350	21.720
14	12	33	1443.00	3.00	481.00	30.270	16.640
14	12	35	1445.00	5.00	289.00	27.560	13.930
14	12	37	1447.00	7.00	206.71	25.870	12.240
14	12	40	1450.00	10.00	145.00	24.390	10.760
14	12	43	1453.00	13.00	111.77	23.030	9.400
14	12	46	1456.00	16.00	91.00	22.060	8.430
14	12	50	1460.00	20.00	73.00	21.030	7.400
14	12	55	1465.00	25.00	58.60	20.170	6.540
14	13	0	1470.00	30.00	49.00	19.450	5.820
14	13	5	1475.00	35.00	42.14	18.940	5.310
14	13	10	1480.00	40.00	37.00	18.550	4.920
14	13	15	1485.00	45.00	33.00	18.170	4.540
14	13	20	1490.00	50.00	29.80	17.780	4.150
14	13	30	1500.00	60.00	25.00	17.250	3.620
14	13	50	1520.00	80.00	19.00	16.520	2.890
14	14	10	1540.00	100.00	15.40	16.150	2.520
14	14	30	1560.00	120.00	13.00	15.650	2.020
14	15	0	1590.00	150.00	10.60	15.370	1.740
14	15	30	1620.00	180.00	9.00	15.050	1.420
14	16	0	1650.00	210.00	7.86	14.800	1.170
14	16	30	1680.00	240.00	7.00	14.780	1.150
14	17	0	1710.00	270.00	6.33	14.680	1.050
14	17	30	1740.00	300.00	5.80	14.420	0.790
14	18	0	1770.00	330.00	5.36	14.390	0.760
14	18	30	1800.00	360.00	5.00	14.280	0.650
14	19	30	1860.00	420.00	4.43	14.060	0.430

WILLIAM E. NORK, INC.

PUMP TEST - RECOVERY DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS:
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: OBS NO.2
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 12.68
R = 10.25 FT FROM
SCREEN INTERVAL: 100 TO 340

TIME			PUMPING STARTED	PUMPING ENDED	RATIO	WATER LEVEL	RESIDUAL DRAWDOWN
DY	HR	MN	t (MIN)	t' (MIN)	t/t'	(ft)	(ft)
14	12	31	1440.50	0.50	2881.00	27.480	14.800
14	12	31	1441.00	1.00	1441.00	26.510	13.830
14	12	35	1445.00	5.00	289.00	22.470	9.790
14	12	37	1447.00	7.00	206.71	21.530	8.850
14	12	40	1450.00	10.00	145.00	20.470	7.790
14	12	43	1453.00	13.00	111.77	19.620	6.940
14	12	47	1457.00	17.00	85.71	18.940	6.260
14	12	51	1461.00	21.00	69.57	18.420	5.740
14	12	56	1466.00	26.00	56.38	17.840	5.160
14	13	1	1471.00	31.00	47.45	17.430	4.750
14	13	6	1476.00	36.00	41.00	17.080	4.400
14	13	11	1481.00	41.00	36.12	16.810	4.130
14	13	16	1486.00	46.00	32.30	16.570	3.890
14	13	21	1491.00	51.00	29.24	16.340	3.660
14	13	31	1501.00	61.00	24.61	16.020	3.340
14	13	51	1521.00	81.00	18.78	15.550	2.870
14	14	11	1541.00	101.00	15.26	15.230	2.550
14	14	31	1561.00	121.00	12.90	14.920	2.240
14	15	1	1591.00	151.00	10.54	14.690	2.010
14	15	31	1621.00	181.00	8.96	14.570	1.890
14	16	1	1651.00	211.00	7.82	14.360	1.680
14	16	31	1681.00	241.00	6.98	14.270	1.590
14	17	1	1711.00	271.00	6.31	14.140	1.460
14	17	31	1741.00	301.00	5.78	13.940	1.260
14	18	31	1801.00	361.00	4.99	13.880	1.200
14	19	31	1861.00	421.00	4.42	13.560	0.880

WILLIAM E. NORK, INC.

PUMP TEST - RECOVERY DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS:
CONDITIONS: CONFINED

FILE NO.: 360
WELL NO.: OBS NO.1
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 11.97
R = 670 FT FROM
SCREEN INTERVAL: 49 TO 101

TIME			PUMPING STARTED	PUMPING ENDED	RATIO	WATER LEVEL	RESIDUAL DRAWDOWN
DY	HR	MN	t (MIN)	t' (MIN)	t/t'	(ft)	(ft)
14	12	31	1441.00	1.00	1441.00	12.530	0.560
14	12	33	1443.00	3.00	481.00	12.510	0.540
14	12	35	1445.00	5.00	289.00	12.480	0.510
14	12	37	1447.00	7.00	206.71	12.480	0.510
14	12	40	1450.00	10.00	145.00	12.460	0.490
14	12	43	1453.00	13.00	111.77	12.450	0.480
14	12	46	1456.00	16.00	91.00	12.440	0.470
14	12	50	1460.00	20.00	73.00	12.430	0.460
14	12	55	1465.00	25.00	58.60	12.430	0.460
14	13	0	1470.00	30.00	49.00	12.410	0.440
14	13	5	1475.00	35.00	42.14	12.420	0.450
14	13	10	1480.00	40.00	37.00	12.410	0.440
14	13	15	1485.00	45.00	33.00	12.400	0.430
14	13	20	1490.00	50.00	29.80	12.380	0.410
14	13	30	1500.00	60.00	25.00	12.370	0.400
14	13	45	1515.00	75.00	20.20	12.350	0.380
14	14	5	1535.00	95.00	16.16	12.350	0.380
14	14	25	1555.00	115.00	13.52	12.340	0.370
14	14	55	1585.00	145.00	10.93	12.290	0.320
14	15	25	1615.00	175.00	9.23	12.220	0.250
14	15	55	1645.00	205.00	8.02	12.230	0.260
14	16	25	1675.00	235.00	7.13	12.230	0.260
14	16	55	1705.00	265.00	6.43	12.220	0.250
14	17	25	1735.00	295.00	5.88	12.180	0.210
14	17	55	1765.00	325.00	5.43	12.170	0.200
14	18	25	1795.00	355.00	5.06	12.160	0.190
14	19	25	1855.00	415.00	4.47	12.150	0.180

WILLIAM E. NORK, INC.

PUMP TEST - RECOVERY DATA

PROJECT: NEVADA PSC
LOCATION: NW-11-19-20
DATUM POINT: TOC
PUMPING RATE: 1000 USGPM
AQUIFER THICKNESS: 50
CONDITIONS: UNCONFINED

FILE NO.: 360
WELL NO.: OBS NO. 3
ELEV. OF DATUM POINT: 4400
STATIC WATER LEVEL: 12.97
R = 490 FT FROM
SCREEN INTERVAL: 21 TO 31

TIME			PUMPING STARTED	PUMPING ENDED	RATIO	WATER LEVEL	RESIDUAL DRAWDOWN
DY	HR	MN	t (MIN)	t' (MIN)	t/t'	(ft)	(ft)
14	12	31	1441.00	1.00	1441.00	13.110	0.140
14	12	33	1443.00	3.00	481.00	13.100	0.130
14	12	35	1445.00	5.00	289.00	13.100	0.130
14	12	37	1447.00	7.00	206.71	13.100	0.130
14	12	40	1450.00	10.00	145.00	13.100	0.130
14	12	43	1453.00	13.00	111.77	13.110	0.140
14	12	46	1456.00	16.00	91.00	13.090	0.120
14	12	50	1460.00	20.00	73.00	13.090	0.120
14	12	55	1465.00	25.00	58.60	13.090	0.120
14	13	0	1470.00	30.00	49.00	13.100	0.130
14	13	5	1475.00	35.00	42.14	13.100	0.130
14	13	10	1480.00	40.00	37.00	13.100	0.130
14	13	15	1485.00	45.00	33.00	13.100	0.130
14	13	20	1490.00	50.00	29.80	13.090	0.120
14	13	30	1500.00	60.00	25.00	13.090	0.120
14	13	55	1525.00	85.00	17.94	13.100	0.130
14	14	15	1545.00	105.00	14.71	13.100	0.130
14	14	35	1565.00	125.00	12.52	13.090	0.120
14	15	5	1595.00	155.00	10.29	13.100	0.130
14	15	35	1625.00	185.00	8.78	13.080	0.110
14	16	5	1655.00	215.00	7.70	13.070	0.100
14	16	35	1685.00	245.00	6.88	13.070	0.100
14	17	5	1715.00	275.00	6.24	13.070	0.100
14	17	35	1745.00	305.00	5.72	13.090	0.120
14	18	5	1775.00	335.00	5.30	13.070	0.100
14	18	35	1805.00	365.00	4.95	13.060	0.090
14	19	35	1865.00	425.00	4.39	13.070	0.100

WILLIAM E. NORK, INC.

APPENDIX F

CALCULATIONS IN SUPPORT OF TEXT

N-STEADY STATE LEAKY ARTESIAN AQUIFER ANALYSIS (HANTUSH & JACOB, 1955)

in, ILL. WATER SURVEY BULL 49
WALTON, 1962

MATCH POINT

$W(u, r/B) = 1$

$1/u = 10^{3}$

$r/B = 0.03$

$t = 10$ MIN

$s = 2.7$ FT

$$T = \frac{114.6\ Q\ W(u, r/B)}{s} = \frac{114.6\ (1{,}000\ \text{GPM})\ 1}{2.7\ \text{FT}} = 42{,}444\ \text{GPD/FT}$$

$$S = \frac{u\ T t}{2693\ r^2} = \frac{10^{-3}\ (42{,}444\ \text{GPD/FT})}{2693\ (10.25\ \text{FT})^2} = 1.5 \times 10^{-4}$$

$$P' = \frac{T m' \left(\frac{r}{B}\right)^2}{r^2} = \frac{42{,}444\ \text{GPD/FT}\ (15\ \text{FT})\ (0.03)^2}{(10.25\ \text{FT})^2}$$

$$= 5.5\ \text{GPD/FT}^2 = 0.73\ \text{FT/DAY}$$

STEADY STATE LEAKY ARTESIAN AQUIFER ANALYSIS (JACOB, 1946)
IN: ILL WATER SURVEY BULL 49
WALTON, 1962

MATCH POINT

$$K_0\left(\frac{r}{B}\right) = 1$$

$$r/B = 1$$

$$r = 330 \text{ FT}$$

$$s = 6.2 \text{ FT}$$

$$T = \frac{229\ Q\ K_0\left(\frac{r}{B}\right)}{s} = \frac{229\ (1000 \text{ GPM})\ 1}{6.2 \text{ FT}} = 36{,}935 \text{ GPD/FT}$$

$$P' = \frac{T\ m'\ \left(\frac{r}{B}\right)^2}{r^2} = \frac{36{,}935 \text{ GPD/FT}\ (15 \text{ FT})\ 1^2}{(330 \text{ FT})^2} =$$

$$= 5.1 \text{ GPD/FT}^2 = 0.68 \text{ FT/DAY}$$

NOTE - THIS ANALYSIS MAY NOT BE COMPLETELY APPLICABLE BECAUSE STEADY STATE CONDITIONS MAY NOT HAVE BEEN SATISFIED @ OBSERVATION WELL NO. 1 (UNR #1) BY THE END OF THE TEST

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CALCULATED DRAWDOWN (HANTUSH & JACOB, 1955)

ASSUME: $S = 1.5 \times 10^{-4}$, FROM TABLE 1
$B = 330$ FT, FROM APPENDIX –
$T = 42000$ GPD/FT, FROM SECTION 3.2
$Q = 1{,}000$ GPM
$t = 1$ yr $= 525{,}600$ MIN

FOR r = 500 FT

$r/B = 500\text{ FT} / 330\text{ FT} = 1.52$

$$u = \frac{2693\, r^2 S}{T t} = \frac{2693\,(500\text{ FT})^2\, 0.00015}{42{,}000\text{ GPD/FT}\,(525{,}600\text{ MIN})} = 4.6 \times 10^{-6} \approx 0$$

FROM WALTON, 1962; APPENDIX A, VALUES OF $W(u, r/B)$

$W(u, r/B) \approx 0.43$

$$\therefore\ s = \frac{114.6\, Q\, W(u, r/B)}{T} = \frac{114.6\,(1{,}000\text{ GPM})\, 0.43}{42{,}000\text{ GPD/FT}} = 1.17\text{ FT}$$

FOR r = 1,000 FT

$r/B = 1{,}000\text{ FT} / 330\text{ FT} = 3.03$

$$u = \frac{2693\, r^2 S}{T t} = \frac{2693\,(1{,}000\text{ FT})^2\, 0.00015}{42{,}000\text{ GPD/FT}\,(525{,}600\text{ MIN})} = 1.8 \times 10^{-5} \approx 0$$

$W(u, r/B) \approx 0.25$

$$\therefore\ s = \frac{114.6\, Q\, W(u, r/B)}{T} = \frac{114.6\,(1{,}000\text{ GPM})\, 0.25}{42{,}000\text{ GPD/FT}} = 0.68\text{ FT}$$

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CALCULATED BY DCB DATE
CHECKED BY DATE
SCALE

FOR r = 1,500 FT

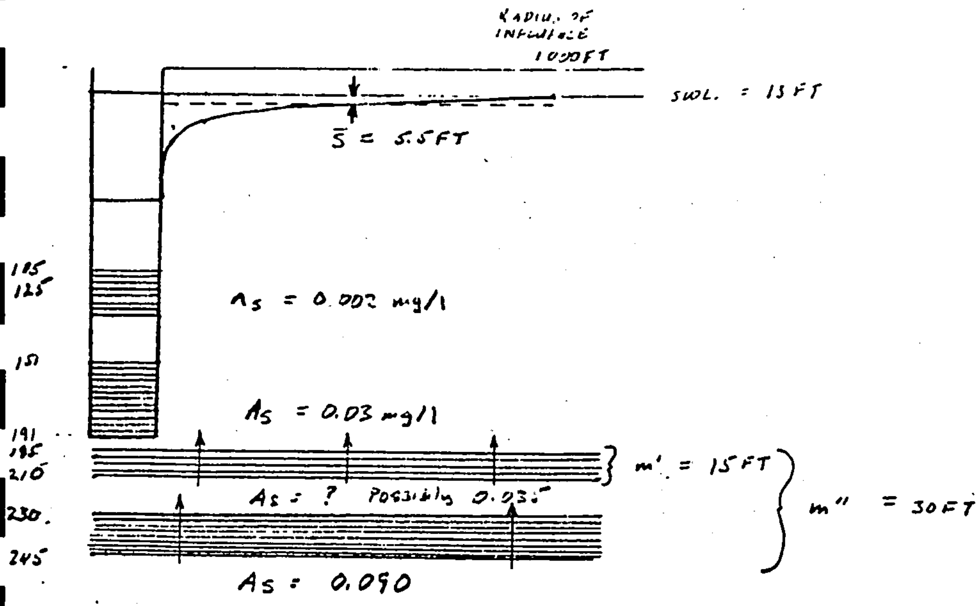
$r/B = 1,500 \text{ FT} / 330 \text{ FT} = 4.55$

$$u = \frac{2693 \; r^2 \; S}{T \; t} = \frac{2693 \; (1,500 \text{ FT})^2 \; 0.00015}{(42,000 \text{ GPD/FT}) \; 526,000 \text{ MIN}} = 4.1 \times 10^{-5} \approx 0$$

$$W(u, r/B) \approx 0.02$$

$$\therefore \; s = \frac{114.6 \; Q \; W(u, r/B)}{T} = \frac{114.6 \; (1,000 \text{ GPM}) \; 0.02}{42,000 \text{ GPD/FT}} = 0.06 \text{ FT}$$

ESTIMATED TIME FOR A [illegible] OF GW TO FLOW THRU AQUITARD [illegible] DEEPER [illegible] TO PRODUCTION ZONE (NO RETARDATION OF DISPERSION)



RADIUS OF INFLUENCE ≈ 1,000 FT

AREA WEIGHTED DRAWDOWN ≈ 5.5 FT

$P' = 5.1$ GPD/FT^2 TO 10.2 GPD/FT^2 DEPENDING ON VALUE FOR THICKNESS OF THE AQUITARD

$i' = 5\text{ FT} \div 15\text{ FT} = 0.33$ FT/FT

$V = K'i = 0.68\text{ FT/DAY} \times 0.33\text{ FT/FT} = 0.22\text{ FT/DAY}$

$t = \frac{m'}{V_n} = 15\text{ FT} \div \frac{0.22\text{ FT/DAY}}{0.3} =$ [illegible] DAYS

$i'' = 5\text{ FT} \div 30\text{ FT} = 0.17$ FT/FT

$V = K''i = 1.36\text{ FT/DAY} \times 0.17\text{ FT/FT} = 0.23\text{ FT/DAY}$

$t = \frac{m''}{V_n} = 30\text{ FT} \div \frac{0.23\text{ FT/DAY}}{0.20} =$ [illegible] DAYS

AREA WEIGHTED DRAWDOWN

1-10 $s = \frac{(35+23)}{2} = 29$ FT

10-100 $s = \frac{23+11}{2} = 17$ FT

100-1000 $s = \frac{11}{2} = 5.5$ FT

$A_{1-10} = 76\ FT^2$

(7854)

$A_{10\text{-}100} = 7779\ FT^2$

(785392)

$A_{100-1000} = 777619\ FT^2$

$76\ FT^2 \times 29\ FT = 2204\ FT^3$

$7779\ FT^2 \times 17\ FT = 132,243\ FT^3$

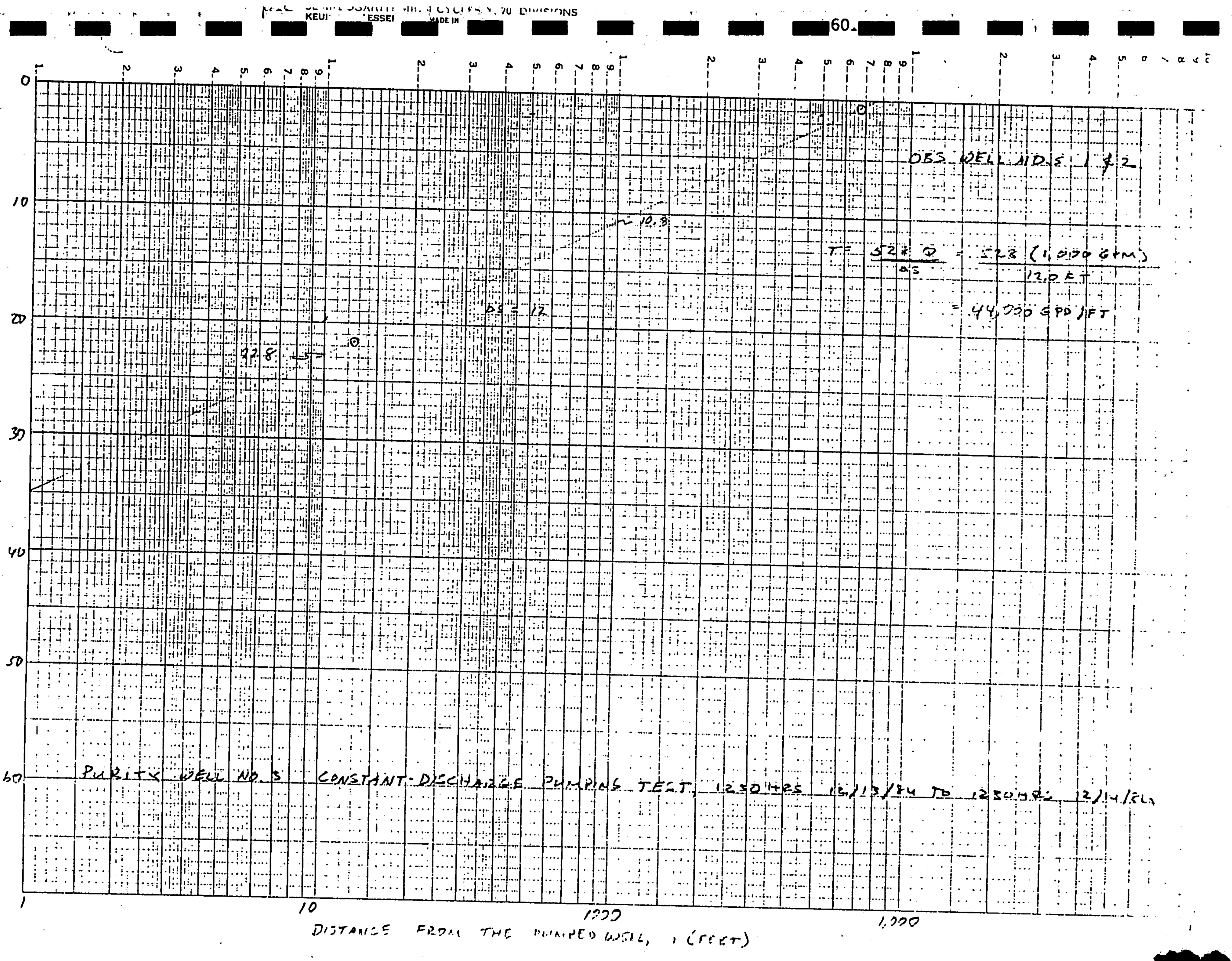
$777619\ FT^2 \times 5.5\ FT = 4,276,905$

$S_{AV} = 5.$ FT

IF SWL OF ALL ZONES ARE EQUAL

$i' = 5.5\ FT \div 15\ FT = 0.33\ FT/FT$

$i'' = 5.5\ FT \div 30\ FT = 0.17\ FT/FT$



OBS WELL NOS 1 & 2
T = 528 Q / ΔS = 528 (1,000 GPM) / 12.0 FT
= 44,000 GPD/FT
ΔS = 12
10.8
22.8
PURITY WELL NO. 3 CONSTANT-DISCHARGE PUMPING TEST, 1230 HRS 12/13/84 TO 1230 HRS 12/14/84
DISTANCE FROM THE PUMPED WELL, r (FEET)
0
10
20
30
40
50
60
1
10
100
1,000
KEUFFEL & ESSER
60

APPENDIX G

PURITY UTILITIES WELL NO. 2
ARSENIC CONCENTRATION DATA AND
MONTHLY WATER USAGE

APPENDIX H

SUMMIT ENGINEERING DESIGN AND OPERATION PLAN

WILLIAM E. NORK, Inc.

Reno, Nevada 89503

Design And Operation

I. Purpose Of New System

A. Meet Governing standards for quality

1. Arsenic, primary standard
Maximum concentration = 0.05 mg/l

2. Manganese, secondary standard
Maximum concentration = 0.10 mg/l

B. Meet quantity requirements to serve issued will serve commitments

1. 1,137 issued will serve commitments

II. Water Quantity

A. District Health Department is governing agency over systems water quality and number of units that may be served. Based on the State design standards for usage per unit, the Health Department staff determined that the system would have been able to produce 750 gpm with the largest producing well out of service to serve 1,137 units.

B. Well #3 is drilled and test pumped

1. Can safely produce 1,000 gpm

C. Preliminary determination of quantity of water to be produced by wells #2 and #4

1. Considered factors

a. Meet quantity and quality requirements
b. Ability to use existing equipment from wells #1 and #2
c. Keep reasonable velocity in 14" main in Pembroke Drive
d. Assumption of how much water well #4 will be able to produce

2. Procedure

a. 14" main in Pembroke Drive
use V_{max} = 6 fps

then Q_{max} = 2,800 cfs gpm

Q_{max} from wells #2 & #4 = 2,800 - 1,000 = 1,800 cfs

b. Existing equipment in well #1 (existing backup, to be abandoned)

1. 100 horsepower motor and control panel
2. Pump assembly outdated
3. Assume to use motor from well #1 in well #2 for new system

assume 80% efficiency from pump @ 2,800 gpm:

H_L from #2 to tank = 121

Elevation head = 335'

$$HP = \frac{(Head)(Q)}{(3960)(eff)}$$

$$Q_{max} = \frac{(100)(3960)(.80)}{456}$$

Q_{max} = 695 cfs

@ 2,700: H_L = 115

Q_{max} = 704 cfs

use 700 cfs

3. Assumed quantity from well #4

a. No real data to base an assumption on
b. Assumed 1,000 gpm based on closeness to river and amount of water rights applied to be transferred to site. Also fits with previous calculations for Pembroke main and existing equipment. And, increasing the production of this well above 1,000 gpm does not increase the capacity of the system, and thus is not cost effective.

4. With largest well out of service, system able to produce 1,700 gpm which exceeds requirements.

III. Water Quality

A. Existing quality in well #2 (worst case)

1. Arsenic - .08 mg/l

2. Manganese - .28 mg/l

B. Quality from test pumping of well #3

1. Arsenic - .023 mg/l

2. Manganese - .06 mg/l

C. Expected quality from well #4 (based on river water quality)

1. Arsenic - trace

2. Manganese - .01 mg/l

D. Expected quality from mixing water from 3 wells

1. Q_2 = 700 gpm

Q_3 = 1,000 gpm

Q_4 = 1,000 gpm

2. Arsenic: $C = \frac{(700)(.08)+(1000)(.023)+(1000)(0)}{2700} = 0.029$ mg/l

$0.029 < 0.05$ OK

3. Manganese: $C = \frac{(700)(.28)+(1000)(.06)+(000)(.01)}{2700} = 0.0985$ mg/l

$0.0985 < 0.10$ OK

E. Proposed system meets quality requirements

IV. Proposed System Operation

The operation scheme proposed for the new system uses the new wells, #3 and #4, as the primary producers and well #2 as a back up well and a supplementary producer during peak useage periods. Using this operating scheme allows a greater percentage of the users' water to be the higher quality water from the new wells, while leaving the total supply available for peak periods.

WILLIAM E. NORK, Inc.

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