ANALYSIS AND COMPARISON OF THE WELLS IN THE PLEASANT VALLEY AREA OF VENTURA COUNTY, CALIFORNIA

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DENNIS E. WILLIAMS, a native of California, received his advanced degrees in hydrology and ground-water hydrology at the New Mexico Institute of Mining and Technology, where he studied under M.S. Hantush and C.E. Jacob. Following graduation he planned and directed geologic and hydrologic studies in the Owens and Mono basins with regard to the amount of surface and ground-water resources available to the city of Los Angeles. From 1971 to 1975 Dr. Williams was involved in the planning and execution of a number of ground-water projects in Iran. Form 1976 to 1978 he was a consultant to the government of Iran as special advisor to the Ministry of Energy. He is also a consultant to the United Nations (UNPD). Dr. Williams currently serves as president of Geoscience Support Services, a company specializing in advanced technology consulting as applied to engineering and earth sciences.

Table of Contents

Chapter 1

1.0 INTRODUCTION

1.1 Purpose and Scope

This report compares the production capabilities of a group of high capacity water wells of varying design drilled in the Pleasant Valley Basin near the city of Camarillo, California (**see Figure 1**). Thirty four wells were chosen for the study and represent different screen types in addition to development and completion methods. The type of screens in the wells range from low open area milled and punched slotted casing to higher open area continuous wire wrap and horizontal louver shutter screen. The total depth and length of screen varies considerably between wells as does the type of aquifer penetrated.

Because of the variety of screen types and development methods, the Pleasant Valley area affords an excellent opportunity to study the relationship between well yields and screen design.

The scope of the investigation included plotting of a typical geologic cross section through the Pleasant Valley aquifers and a computer analysis and comparison of specific capacities per foot of screen for each of the wells.

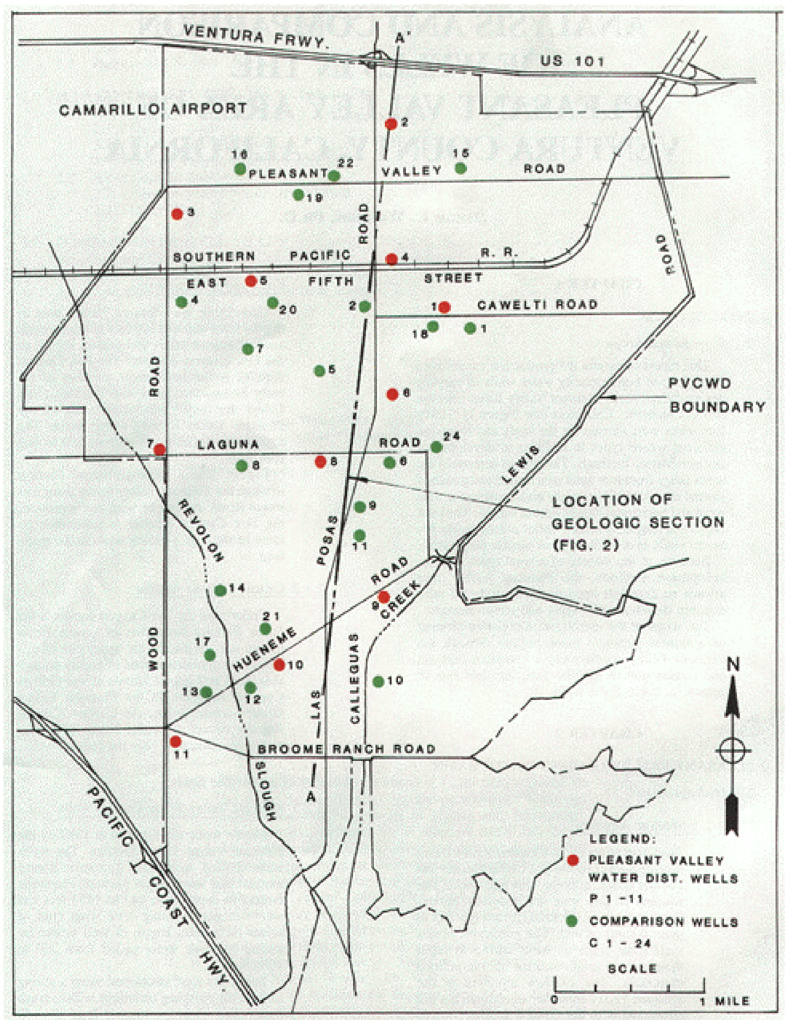

FIG. 1 LOCATION OF STUDY WELLS IN THE PLEASANT VALLEY AREA

Figure 1

Chapter 2

2.0 PLEASANT VALLEY GROUND-WATER BASIN

2.1 Hydrogeology

2.1.1 Shallow Aquifers

The upper strata of the Pleasant Valley Basin is composed of recent and Upper Pleistocene alluvial sands, gravels, silts and clays. The aquifers in this zone are generally unconfined and very in thickness from a few feet to several hundred feet. The permeable lenses yield little water to wells owing to rapid thinning and predominance of fine-grained materials. The shallow aquifers in the Pleasant Valley Basin are equivalent but not connected with the Oxnard aquifer lying to the West.

2.1.2 Fox Canyon Aquifer

Underlying the Pleasant Valley area at depths from 400 to 1500 feet is a prominent zone of marine sands and gravels known as the Fox Canyon Aquifer. The Fox Canyon Aquifer is the lower-most member of the early Pleistocene San Pedro formation and forms the major producing zone of the Pleasant valley ground-water Basin. The aquifer is confined and is from 100 to 300 feet thick. **Figure 2** is a geologic cross section through the Pleasant Valley Basin along Las Posas Road. As can be seen in the section, the Fox Canyon aquifer is penetrated by most of the high yielding wells in the study area.

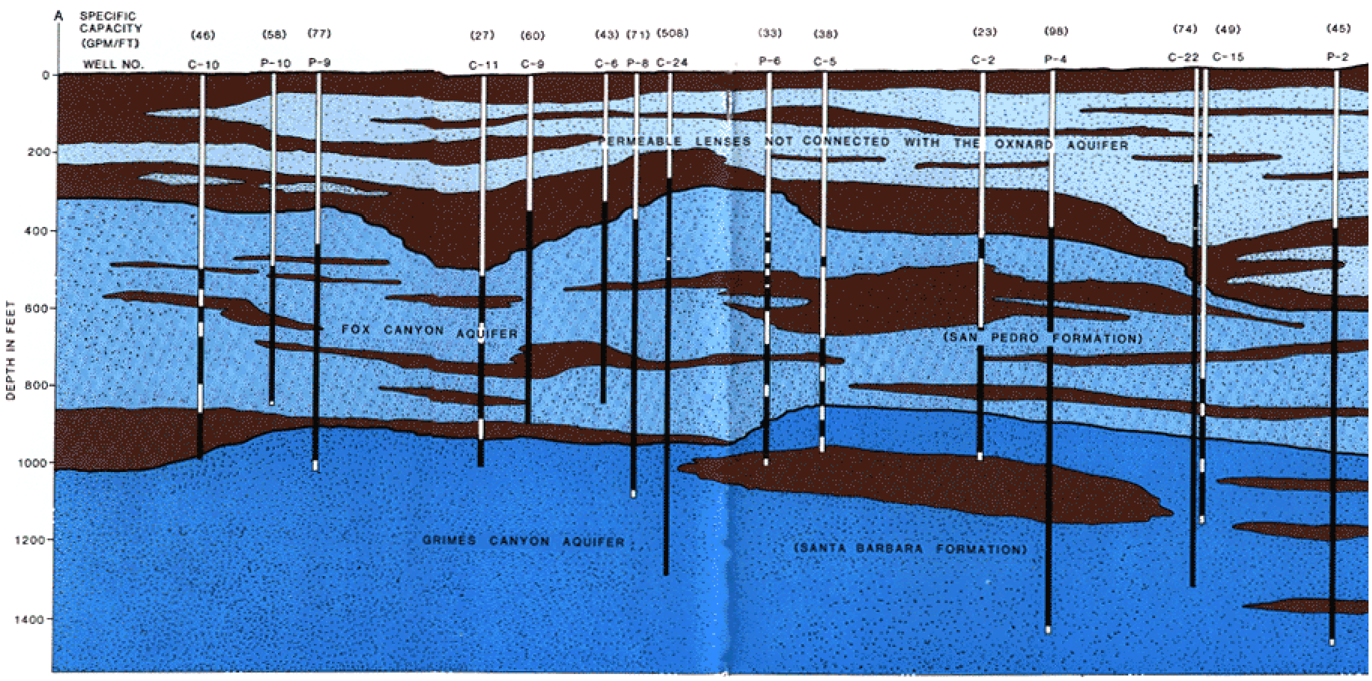

FIG. 2 GEOLOGIC SECTION ALONG LOS POSAS ROAD IN THE PLEASANT VALLEY

Figure 2

2.1.3 Grimes Canyon Aquifer

Underlying the Fox Canyon aquifer is the Santa Barbara formation of Lower Pleistocene age. In places, the upper part of this formation contains a zone of highly permeable sand and gravel known as the Grimes Canyon Aquifer. In the Pleasant Valley ground-water Basin, the Grimes Canyon Aquifer occurs at depths below 1000 feet and is penetrated by only the deepest wells.

2.2 Wells Used in the Study

2.2.1 Pleasant Valley Water District Wells

Eleven wells were drilled in 1980 by the Pleasant Valley Water District. The wells were drilled using the hydraulic rotary method and were gravel packed. The wells ranged in depth from 943 to 1453 feet and were completed using wire wrap type of screen. The total length of well screen installed in these wells varied from 360 to 1060 feet.

The wells were developed using a jetting and air lift pumping technique with average times of development ranging from 40 to 60 hours per well.

2.2.2 Other Wells Used for Comparison

To compare the effect of different well screen types and lengths on the producing capabilities in the Pleasant Valley Basin, 23 other wells were chosen for analysis. These "Comparison" wells, also drilled by the hydraulic rotary method, were selected at random and represent a variety of screen types ranging from milled and punched slotted casing to shutter screen. Total depth of these wells vary from 268 feet to 1338 feet with lengths of screens from 120 to 1076 feet.

These wells were primarily developed by bailing, with development times averaging only four hours per well. The production results from these wells in general exceeded results from the Water District wells completed using wire wrap screens and developed using jetting and air lift pumping.

Figure 1 shows the location of the wells used in the study and **Figure 6** (Appendix) summarizes the production properties. The Pleasant Valley Water District wells are numbered P-1 through P-11 and the comparison wells are numbered C-1 through C-24.

Chapter 3

3.0 COMPARISON OF WELL YIELDS

3.1 Specific Capacity per foot of screen

It is an established fact that the specific capacity of a well (Discharge in gpm/Drawdown in ft) is directly dependent upon the total thickness of aquifer penetrated by the well. For exapmle, a well constructed with 1000 feet of screen will yield approximately twice the discharge of one with only 500 feet of screen if all other properties are held constant (e.g. drawdown and aquifer parameters).

Because of this fact, and in order to make a fair comparison between wells in the Pleasant Valley area, specific capacity per foot of well screen were calculated for each of the wells. (The method of calculation is shown in Appendix). **Figure 7** (Appendix) is a list of Specific Capacities per Foot of Well Screen in order from highest to lowest. **Figure 3** is a simplified bar chart of the same data showing the relationship for the 34 wells.

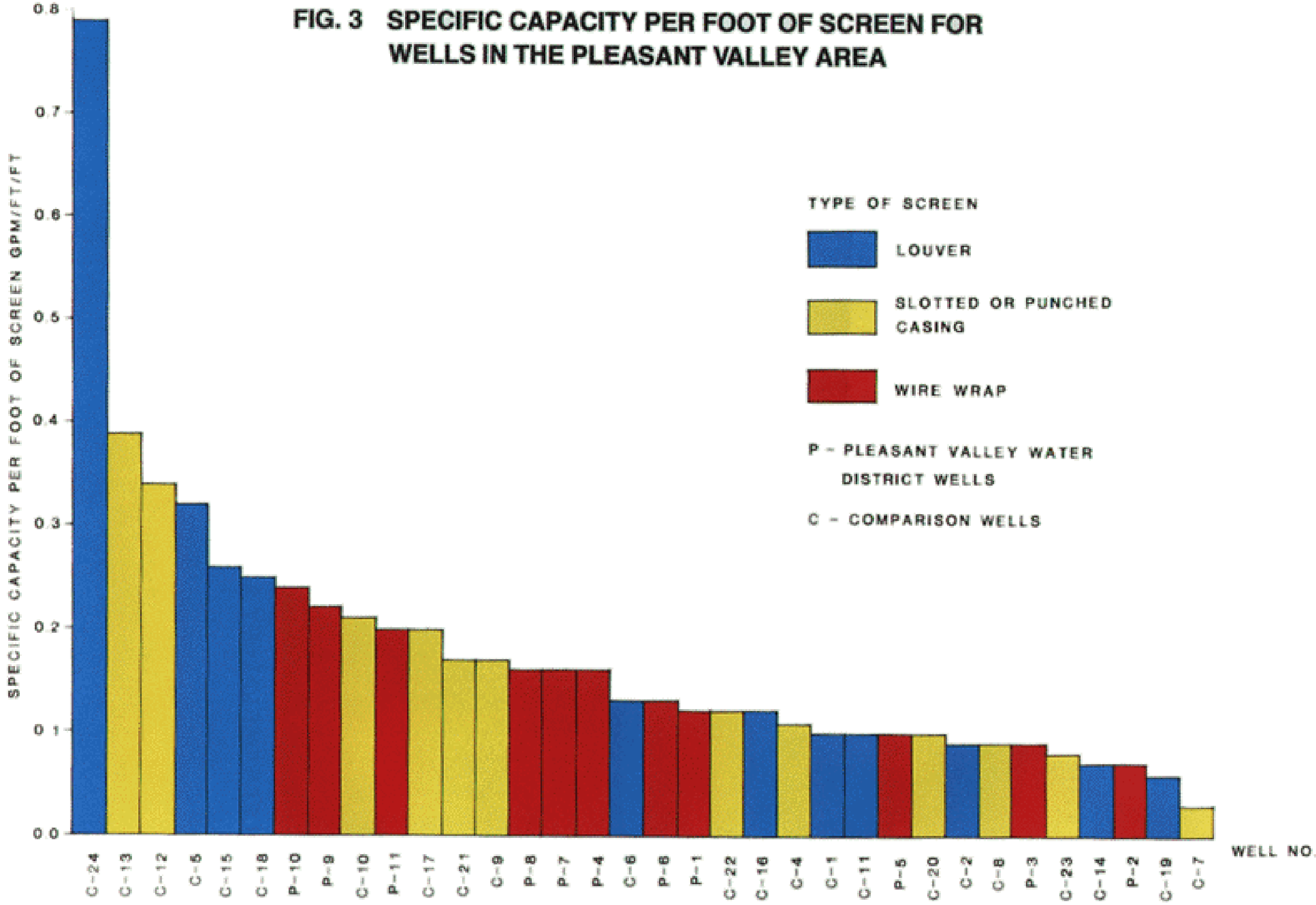

Figure 3

As can be seen, there is no relationship between well screen open area and specific capacity. In fact, the lowest percentage open area screens show the lowest percentage open area screens show the highest specific capacity per foot. This last observation confirms field and laboratory studies which show that above 3-5% open area, no significant gain in well efficiency is obtained.

3.2 Relationship of Specific Capacity to Aquifer Properties

To confirm the relationship between high yielding aquifers (e.g. sands and gravels) and high yielding wells, a plot of specific capacity versus aquifer Hydraulic Conductivity was made. **Figure 4** clearly shows the direct dependence of specific capacity on aquifer properties. In other words, wells penetrating high yielding aquifers result in high discharges as compared to wells producing from lower yielding aquifers (for the same length of screen).

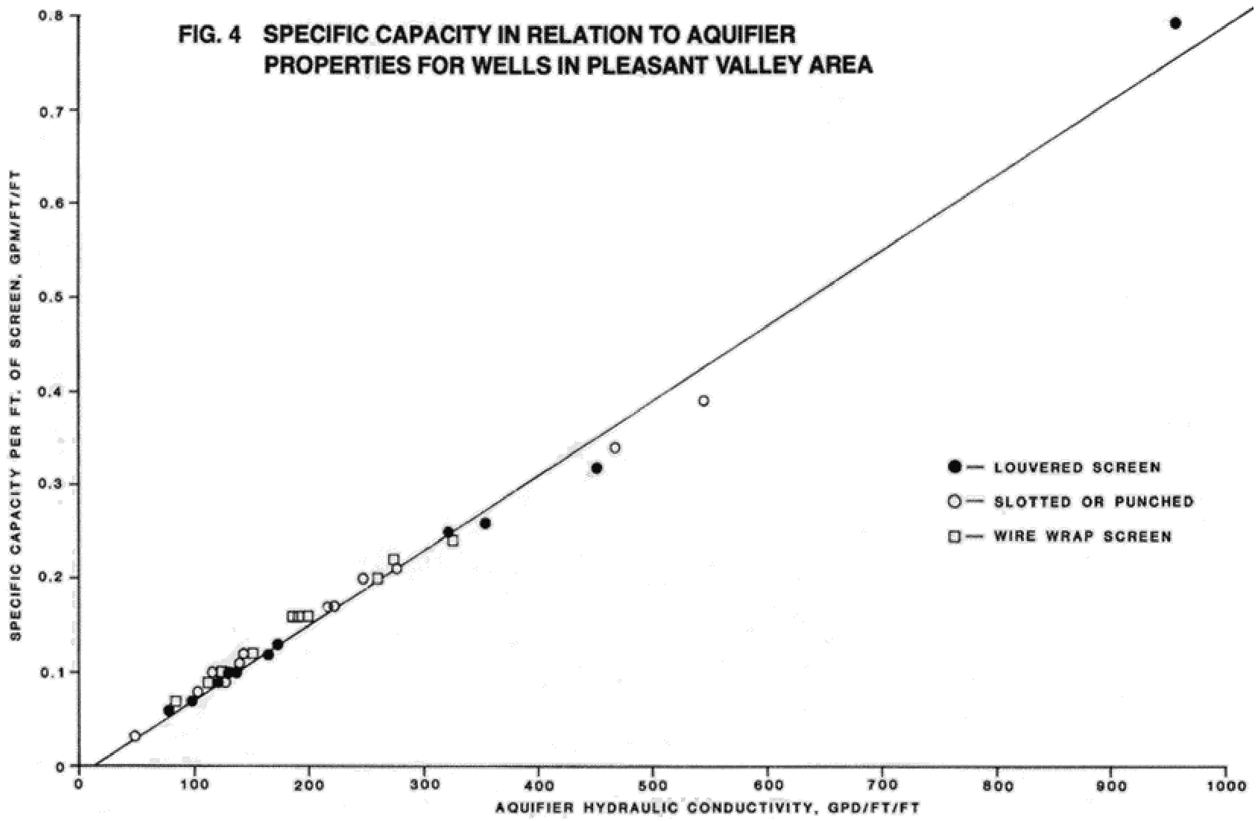

Figure 4

3.3 Specific Capacity and Length of Well Screen

A comparison between specific capacity and length of installed well screens was made for the 34 wells in the Pleasant Valley area. The wells were grouped into three principle screen types:

1 - Shutter Screen
2 - Milled or punched slotted casing
3 - Continuous wire wrap type screen

Data on specific capacity were analyzed with the results shown graphically in **Figure 5**. As can be seen, the more well screen installed in a well, the higher the specific capacity and consequently the well yield. The following simple example illustrates the importance of this point:

Using the average of the wells completed with Shutter Screen, the specific capacity for a well with 300 feet of screen would be 40 gpm/ft (see uppermost curve on **Figure 5**). If it were desired to pump this well at 2000 gpm, the total drawdown would be 50 feet (2000/40).

Given the same well with 900 feet of screen, the specific capacity as obtained from the graph on **Figure 5** would be 120 gpm/ft. For the same discharge of 2000 gpm, the drawdown in this case would be only 17 feet. This amounts to a savings of 33 feet of pumping lift. Over the lifetime of this well, the savings in pumping costs would more than pay for the additional length of screen and borehole.

Simple analyses such as these illustrate the importance of proper well screen length regardless of open area in well design.

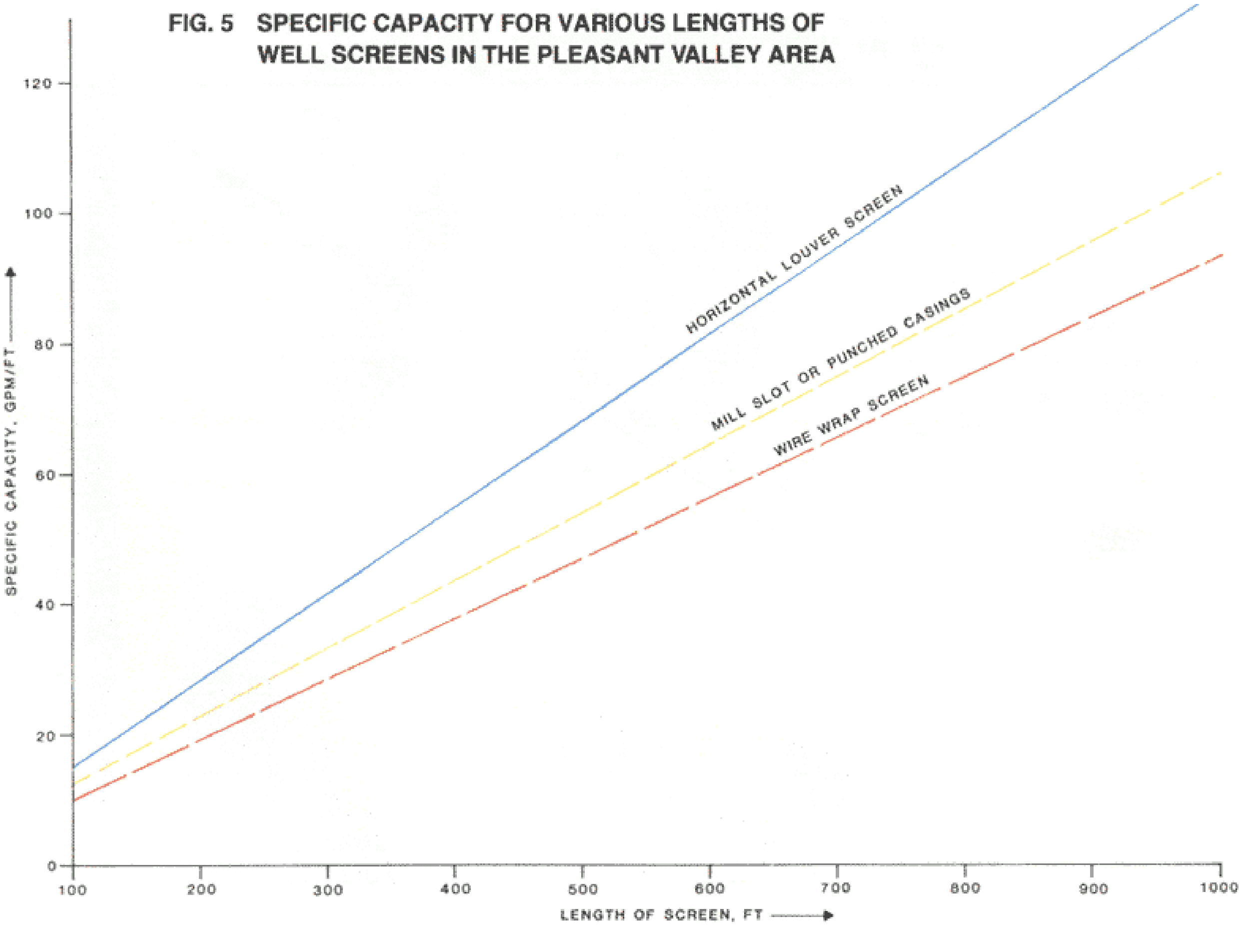

Figure 5

Chapter 4

4.0 SUMMARY AND CONCLUSIONS

4.1 Summary

Well data from 34 wells in the Pleasant Valley area were analyzed and production capabilities compared. The study area represents typical aquifer types of the southwestern United States (i.e., interlayered sands, gravels, silts and clays). Some local variation in aquifer properties between the wells was found and is normally expected in such hydrogeologic environments.

Eleven of the wells were completed using wire wrap screen and developed from 40 to 60 hours each using jetting and air lift pumping.

The remainder of the wells were completed using three other well screen types, milled and punched slotted casing, and Shutter Screen. These wells were developed using a simple bailing technique with an average development time of only four hours per well.

As the specific capacity of each well is directly dependent on the total length of well screen installed, it was necessary to "normalize" the specific capacities in order that comparisons be made on an equal basis (i.e., some wells had over 1000 ft of screen while others had only 200 feet).

Computer analysis of the data was made and results of the well and aquifer properties compared.

4.2 Conclusions

Study results show that production capabilities of wells in the Pleasant Valley area are a function of the length of well screen installed and the water yielding properties of the aquifer. Specifically, the following conclusions were reached:

1. Length of well screen and type of aquifer penetrated are the major factors in well production and specific capacity, not the percentage open area of the screen.

2. Well drilled in areas where high yielding aquifers occur produce more water for the same length of screen than do wells tapping aquifers with lower water yielding properties. (**Figure 4**).

3. The specific capacity of wells in the Pleasant Valley Ground-Water Basin is a direct function of the total length of screen installed. (**Figure 5**).

4. There is no relationship between high percentage open area screens and high specific capacities. (**Figure 3**).

Chapter 5 - Appendix

5.0 APPENDIX

5.1 Method of Analysis

5.1.1 Basic equation of ground-water flow

It has been shown by Jacob in 1947 that the drawdown in the vicinity of an artesian well varies according to the following equation:

$s = [264\ Q/T] \log [0.3\ T\ t/r2S]$ (1)

Q = discharge of the well [gpm]
T = aquifer Transmissivity [gpd/ ft] = K b
t = length of time pumping [days]
r = distance away from the pumping well [ft]
S = aquifer Storage coefficient

Aquifer Transmissivity (T) is defined as the product of the Hydraulic Conductivity (K) times the saturated thickness (b). An estimate of the aquifer Transmissivity in the Pleasant Valley area can be made by applying the following relation (Theis et. al.1963):

$T = 2000\ Q/s$ (2)

where:
T = aquifer Transmissivity [gpd/ ft]
Q/s = specific capacity of the well after 1 day [gpm/ ft]

5.1.2 Estimation of Aquifer Hydraulic Conductivity

Due to interlayering of aquifers and aquitards in the Pleasant Valley area, it is safe to assume that the length of the well screen installed in the Pleasant Valley wells is equivalent to the total saturated aquifer thickness penetrated by the well (ie. Saturated thickness (b) = sum of installed screen lengths).

Knowing the saturated aquifer thickness in each well, Hydraulic Conductivity (K) can be calculated from the estimate of Transmissivity (T) as follows:

$K = T/b$ (3)

5.1.3 Calculation of Specific Capacity per foot of well screen

Equation (1) can be rearranged and simplified to:

$Q/s = (K\ b)/\ 264[\log(K\ b) + \text{beta}]$ (4)

The constant "beta" can now be determined for each well knowing the specific capacity (Q/s), the hydraulic conductivity (K) and the total installed well screen lengths (b). The specific capacity used in the calculation for "beta" was obtained from pumping test data results when the wells were new.

Once beta is determined, the specific capacity as a function of well screen length (b) can be calculated for each well using equation (4).

5.2 Calculation of Specific Capacity per foot of well screen

The analysis consisted of first estimating the Hydraulic conductivity in the vicinity of each well knowing the specific capacity (Q/s), and Transmissivity (K b).

Once the constant "beta" was determined, specific capacities for different lengths of well screens were calculated. Specific capacities for the following three screen lengths were chosen for comparison:

1. 1 ft
2. 500 ft
3. 1000 ft

The specific capacities for each of the 3 screen lengths can be seen in the far right-hand columns of Figure 7.

The calculated specific capacities for the various screen lengths have been sorted from highest to lowest. As can be seen in the figure, the sorted specific capacities do not show any apparent relationship between well screen type and specific capacity (ie. Screens with the highest percentage open area do not have the highest specific capacities).

FIG. 6 PRODUCTION DATA FROM WELLS USED IN THE PLEASANT VALLEY STUDY

WELL NUMBER	SCREEN TYPE	TOTAL DEPTH (FT)	TOTAL SCREEN	Q (GPM)	SWL (FT)	DRAW (FT)	Q/S
P-1	WIREWRAP	1033	540	4000	107	97	41
P-2	WIREWRAP	1483	1060	4000	146	89	45
P-3	WIREWRAP	1341	750	2800	103	66	42
P-4	WIREWRAP	1453	1030	4000	102	41	98
P-5	WIREWRAP	1240	820	3000	95	58	52
P-6	WIREWRAP	1020	400	3000	91	91	33
P-7	WIREWRAP	1383	760	4000	62	54	74
P-8	WIREWRAP	1103	700	4000	67	56	71
P-9	WIREWRAP	1023	560	4000	57	52	77
P-10	WIREWRAP	883	360	3500	62	60	58
P-11	WIREWRAP	943	460	3000	55	50	60
C-1	LOUVERS	1000	716	2600	125	56	46
C-2	LOUVERS	1004	370	2600	72	113	23
C-4	MILL SLT	1110	380	2750	80	103	27
C-5	LOUVERS	964	170	1800	115	47	38
C-6	LOUVERS	852	516	2500	90	58	43
C-7	MILL SLT	268	120	360	68	122	3
C-8	MILL SLT	900	260	2200	97	133	17
C-9	MILL SLT	904	550	2500	92	42	60
C-10	MILL SLT	996	335	2720	89	59	46
C-11	LOUVERS	1015	395	2500	63	93	27
C-12	MILL SLT	624	209	2100	73	43	49
C-13	MILL SLT	610	200	1800	70	33	55
C-14	LOUVERS	1050	300	2500	197	167	15
C-15	LOUVERS	1170	276	2000	164	41	49
C-16	LOUVERS	912	200	1215	141	74	16
C-17	PUNCHSLT	809	624	2000	28	26	77
C-18	LOUVERS	748	460	2000	148	27	74
C-19	LOUVERS	709	448	1325	55	75	18
C-20	PUNCHSLT	1150	946	1950	20	35	56
C-21	PUNCHSLT	775	558	2580	58	42	61
C-22	PUNCHSLT	1338	1032	3250	96	44	74
C-23	PUNCHSLT	855	600	2400	25	78	31
C-24	LOUVERS	1300	1076	2034	73	4	508

FIG.7 SORTED LIST IN ORDER OF HIGHEST SPECIFIC CAPACITY PER FOOT OF SCREEN

WELL #	SCREEN TYPE	TOTAL DEPTH	TOTAL SCREEN	Q (GPM)	SWL (FT)	DRAW (FT)	Q/S	EST K (GPM/FT2)	BETA	1	100	500	1000
C-24	LOUVERS	1300	1076	2034	73	4	508	945.17	0.1568E+01	0.79	55	247	475
C-13	MILL SLT	610	200	1800	70	33	55	545.45	0.2538 E+01	0.39	28	130	250
C-12	MILL SLT	624	209	2100	73	43	49	467.34	0.2586 E+01	0.34	24	111	214
C-5	LOUVERS	964	170	1800	115	47	38	450.56	0.2692 E+01	0.32	23	106	205
C-15	LOUVERS	1170	276	2000	164	41	49	353.48	0.2586 E+01	0.26	19	85	165
C-18	LOUVERS	748	460	2000	148	27	74	322.06	0.2405 E+01	0.25	18	80	154
P-10	WIREWRAP	883	360	3500	62	60	58	324.07	0.2509 E+01	0.24	17	80	153
P-9	WIREWRAP	1023	560	4000	57	52	77	274.73	0.2389 E+01	0.22	15	69	133
C-10	MILL SLT	996	335	2720	89	59	46	275.23	0.2611 E+01	0.21	15	67	129
P-11	WIREWRAP	943	460	3000	55	50	60	260.87	0.2497 E+01	0.20	14	65	125
C-17	PUNCHSLT	809	624	2000	28	26	77	246.55	0.2389 E+01	0.20	14	62	120
C-21	PUNCHSLT	775	558	2580	58	42	61	220.17	0.2486 E+01	0.17	12	55	107
C-9	MILL SLT	904	550	2500	92	42	60	216.45	0.2500 E+01	0.17	12	54	105
P-8	WIREWRAP	1103	700	4000	67	56	71	204.08	0.2421 E+01	0.16	11	52	100
P-7	WIREWRAP	1383	760	4000	62	54	74	194.93	0.2405 E+01	0.16	11	50	96
P-4	WIREWRAP	1453	1030	4000	102	41	98	189.44	0.2285 E+01	0.16	11	49	95
C-6	LOUVERS	852	516	2500	90	58	43	167.07	0.2640 E+01	0.13	9	42	80
P-6	WIREWRAP	1020	400	3000	91	91	33	164.84	0.2757 E+01	0.13	9	41	78
P-1	WIREWRAP	1033	540	4000	107	97	41	152.73	0.2659 E+01	0.12	8	38	74
C-22	PUNCHSLT	1338	1032	3250	96	44	74	143.15	0.2406 E+01	0.12	8	37	72
C-16	LOUVERS	912	200	1215	141	74	16	164.19	0.3059 E+01	0.12	9	39	75
C-4	MILL SLT	1110	380	2750	80	103	27	140.52	0.2848 E+01	0.11	8	35	67
C-1	LOUVERS	1000	716	2600	125	56	46	129.69	0.2608 E+01	0.10	7	33	64
C-11	LOUVERS	1015	395	2500	63	93	27	136.11	0.2845 E+01	0.10	7	34	65
P-5	WIREWRAP	1240	820	3000	95	58	52	126.16	0.2561 E+01	0.10	7	32	62
C-20	PUNCHSLT	1150	946	1950	20	35	56	117.79	0.2529 E+01	0.10	7	31	59
C-2	LOUVERS	1004	370	2600	72	113	23	124.37	0.2913 E+01	0.09	7	31	59
C-8	MILL SLT	900	260	2200	97	133	17	127.24	0.3056 E+01	0.09	7	31	59
P-3	WIREWRAP	1341	750	2800	103	66	42	113.13	0.2647 E+01	0.09	6	29	56
C-23	PUNCHSLT	855	600	2400	25	78	31	102.56	0.2787 E+01	0.08	6	26	50
C-14	LOUVERS	1050	300	2500	197	167	15	99.80	0.3100 E+01	0.07	5	24	47
P-2	WIREWRAP	1483	1060	4000	146	89	45	84.80	0.2622 E+01	0.07	5	22	43
C-19	LOUVERS	719	448	1325	55	75	18	78.87	0.3028 E+01	0.06	4	20	38
C-7	MILL SLT	268	120	360	68	122	3	49.18	0.3805 E+01	0.03	2	11	22