APPENDICES

APPENDIX A

METEROLOGIC DATA

Jacumba Monthly Precipitation Records (County of San Diego, 1980, personal communication)

Water Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1962-1963									1.18	0.60	0	0	
1963-1964	0	0	1.02	2.46	0.33	0.20	1.06	0.70	1.68	0.15	0.35	0	7.95
1964-1965	0	0	0	0.36	0.88	0.55	0.21	1.21	0.05	2.38	0	0	5.64
1965-1966	0.35	0.31	0.08	0	3.82	4.03	2.00	1.38	0.74	0	0	0	12.71
1966-1967	0.46	0.25	0	1.45	0.42	3.68	0.87	0	0.43	2.13	0.04	0	9.73
1967-1968	0.25	0.33	1.50	0	2.38	3.83	0.07	0.28	0.81	0.75	T	0	10.20
1968-1969	1.71	0.12	0	0.11	0.29	0.91	2.43	2.18	0.77	0.11	0.40	0	9.03
1969-1970	1.77	0.02	0.29	0	1.38	0.19	0.27	1.81	2.93	0.48	0	0.03	9.17
1970-1971	0.08	1.43	0.04	0.32	0.82	2.14	0.71	0.75	0.26	0.69	0.07	0	7.31
1971-1972	0.10	1.32	0.14	0.56	0.02	1.68	0	0.03	0	0.09	0.05	0.47	4.46
1972-1973	0.01	0	0.01	1.78	1.40	1.38	1.03	2.35	2.56	0.10	0	0	10.62
1973-1974	0	0.74	0	0	0.81	0.04	3.00	0.06	0.41	0.13	0.06	0	5.25
1974-1975	1.46	0	0.67	0.92	0.17	0.73	0.29	0.61	2.22	0.98	0	0	8.05
1975-1976	0.41	0.02	0.17	0.06	1.88	0.30	0.05	3.15	1.32	0.93	0.18	0	8.47
1976-1977	1.26	0	4.56	0.12	0.66	0.43	1.31	0.32	1.38	0.04	0.63	0	10.71
1977-1978	0.09	2.13	0	1.06	0.08	2.79	3.91	2.19	2.70	0.87	0.19	0	16.01
1978-1979	0	0.11	0.35	0.83	2.56	2.76	3.13	1.47	2.36	0	0.38	0	13.95
1979-1980	0.05	0.40	0.19	0.26	0.06	0.23	6.56	5.26	2.63	1.12	0.91	0	17.67
MEAN	0.47	0.42	0.53	0.61	1.06	1.52	1.58	1.40	1.36	0.64	0.18	0.03	9.82

Boulevard Monthly Precipitation Records (United States Environmental Sciences Services Administration, 1965-1980; United States Weather Bureau, 1931-1964; NOAA, 1980, personal communication)

Water Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1924-1925						1.90	0.30	0.49	1.92	2.29	0.05	0.04	IR
1925-1926	1.90	0.90	0	3.85	1.43	0.70	0.83	2.53	0.40	4.63	0.14	0	17.31
1926-1927	0	0.15	0	0	0.38	10.70	0.76	11.58	3.22	1.15	0.53	0	28.47
1927-1928	0.63	0	0	2.33	0.88	3.81	0.54	2.77	0.60	0	0.18	0	11.74
1928-1929	0	0	0	0.35	0.51	1.50	2.19	2.10	1.28	0.97	0	0	8.90
1929-1930	0.96	1.51	3.38	NR	NR	NR	7.98	0.86	2.69	0.40	2.60	0	IR
1930-1931	0	2.16	0	0	1.79	0	1.95	4.12	0	0.90	0.40	0	11.32
1931-1932	0	0.53	0	0.49	1.81	2.75	NR	NR	NR	NR	NR	NR	IR
1932-1933	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
1933-1934	NR	NR	NR	NR	0.61	1.63	0.31	1.58	0.12	0	0	0.04	IR
1934-1935	0.40	2.45	0.04	0.43	0.36	1.91	3.36	4.21	3.07	2.47	0	0	18.70
1935-1936	0.11	0.69	0	0.04	0.20	0.95	0.48	5.27	2.13	0.76	0	0	10.63
1936-1937	1.65	4.96	0	1.60	0.79	6.86	3.83	5.51	3.91	0.56	0.12	0.11	29.90
1937-1938	0.15	0.95	0	0	0	1.21	1.32	4.96	5.85	0.85	0.16	0	15.45
1938-1939	2.57	0.25	0	0	0	4.81	3.10	2.26	1.65	0.38	0	0	15.02
1939-1940	0	1.00	5.94	0.41	1.06	0.67	1.98	3.91	0.82	2.25	0	0	18.04
1940-1941	0	0.46	0.21	1.41	0.72	7.90	2.09	3.32	4.90	4.79	0	0	25.80
1941-1942	0.10	1.83	0.15	2.61	0.48	5.44	0	3.05	2.02	1.26	0	0	16.94
1942-1943	0	0	0	0.33	0	1.07	5.60	1.74	2.47	2.04	0	0	13.25
1943-1944	NR	NR	NR	NR	NR	NR	1.54	7.10	1.16	0.92	NR	NR	IR

Boulevard Monthly Precipitation Records (Continued)

Water Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1944-1945	NR	NR	NR	NR	4.55	0.74	1.03	1.03	4.35	0.06	NR	0	IR
1945-1946	0	3.28	1.54	0.16	0	3.88	1.11	0.79	2.37	1.08	0.01	NR	IR
1946-1947	1.52	0.90	1.62	0.80	3.80	1.75	0.62	0.44	0.44	1.19	0.03	0	13.11
1947-1948	0	0.53	0.12	0.24	0.26	2.85	0.18	1.93	2.61	0.45	0.09	0.50	9.76
1948-1949	0	0	0.23	0.99	0	2.77	6.69	2.25	1.48	0.09	0.71	0	15.21
1949-1950	0	0.13	0	0.83	0.92	2.96	2.34	1.21	1.33	0.43	0.34	0	10.49
1950-1951	0.71	0	0	0	0.72	0.38	3.22	0.91	0.91	2.37	0.30	0	9.52
1951-1952	0.35	1.89	0	0.56	1.01	5.12	4.82	0.45	7.21	1.59	0	0	23.00
1952-1953	0	0.44	0.23	0	3.84	2.92	1.14	0.57	1.54	0.97	0.40	0.03	12.08
1953-1954	0.07	0.79	0.10	0	0.61	0.16	4.50	1.72	6.05	0.16	0	0.10	14.26
1954-1955	1.03	0.01	0.30	0	0.57	0.68	3.78	1.01	0.64	0.47	1.70	0.03	10.22
1955-1956	0.58	3.72	0	0	1.13	1.44	1.77	1.50	0.02	2.35	0.56	0	13.07
1956-1957	0.61	0	0	0.14	0	0.35	6.68	0.56	1.43	0.99	2.64	0.35	13.75
1957-1958	0	0.16	0	2.81	0.68	0.74	0.50	3.11	5.20	4.17	0.28	0.08	17.57
1958-1959	0.05	1.41	0.74	0.03	1.23	0.05	1.15	4.37	0	0.05	0.11	0	9.19
1959-1960	0.01	2.29	0.47	1.00	0	1.98	2.84	2.42	0.30	0.92	0.29	0	12.52
1960-1961	0.36	0	1.66	0	1.21	0.25	0.95	0	1.41	0	0	0	5.84
1961-1962	0	2.08	0	0.12	0.03	2.14	3.34	2.93	1.36	0	0.63	0.03	12.66
1962-1963	0	0	0.26	0.07	0	0.61	0.51	2.02	1.56	1.38	0	0	6.41
1963-1964	0	0.23	2.15	0.64	1.70	0.32	1.81	0.96	2.70	0.81	0.64	0	11.96

Boulevard Monthly Precipitation Records (Continued)

Water Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1964-1965	0.74	0.12	0	0.40	1.60	1.34	0.31	1.73	0.34	4.34	0	0	10.92
1965-1966	0.17	0.15	0.18	0	5.74	4.37	1.92	1.51	0.74	0	0.06	0	14.84
1966-1967	0.10	0.10	0	1.35	0.75	4.76	1.15	0	0.67	2.51	0.36	0.13	11.88
1967-1968	0.86	0.31	1.96	0	2.31	3.90	NR	NR	NR	NR	NR	NR	IR
1968-1969	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
1969-1970	NR	NR	NR	0	2.05	0.39	0.71	1.07	4.36	1.52	0	0.03	IR
1970-1971	0.30	1.71	0.03	0.32	2.00	3.96	1.43	1.51	0.63	1.76	0.92	0	14.57
1971-1972	0	0.67	0.22	1.36	0.12	4.45	0	0.25	0	0.33	0.30	0.25	7.95
1972-1973	0	0.02	0.11	1.66	2.57	1.92	2.34	3.60	5.74	0.22	0.10	0	18.28
1973-1974	0	0.75	0	0.07	1.88	0.07	5.13	0.17	1.11	0.38	0.16	0	9.72
1974-1975	1.02	0	0.31	2.53	0.57	1.47	0.22	1.76	4.63	1.99	0.16	0.15	14.81
1975-1976	0.53	0.19	0.69	0.12	3.01	0.79	0.02	5.39	2.32	2.09	0.13	0	15.28
1976-1977	2.48	0	3.73	1.22	1.04	0.89	2.59	0.61	2.14	0.27	1.41	0	16.38
1977-1978	0.75	2.60	0	0.13	0.21	3.72	7.04	5.95	5.69	1.95	0.26	0	28.30
1978-1979	0.06	0.05	0.58	0.99	3.81	4.92	5.69	2.39	5.70	0.10	0.42	0	24.71
1979-1980	0	0.50	0.03	1.09	0.17	0.85	10.92	8.93	4.42	2.22	1.42	0	30.55
MEAN	0.42	0.87	0.55	0.67	1.20	2.38	2.43	2.55	2.35	1.27	0.37	0.04	15.10

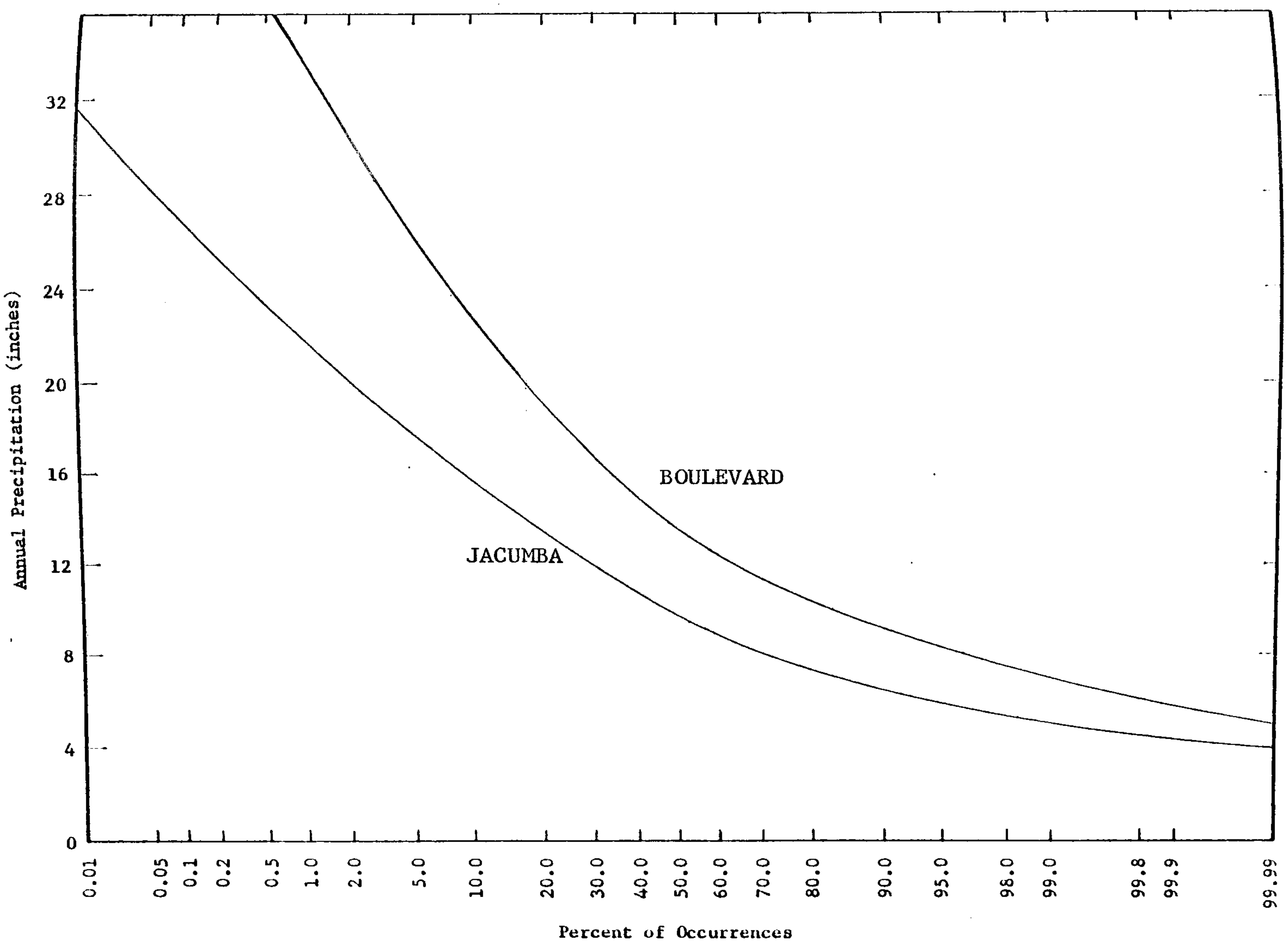

Figure 34. Probability of Occurrence of Yearly Precipitation for Jacumba and Boulevard

Extrapolated Boulevard Yearly Precipitation Records

Water Year	Yearly Precipitation	Correlation Station
1887-1888	9.3	Lake Cuyamaca
1888-1889	21.8	Lake Cuyamaca
1889-1890	25.3	Lake Cuyamaca
1890-1891	26.2	Lake Cuyamaca
1891-1892	16.5	Lake Cuyamaca
1892-1893	16.5	Lake Cuyamaca
1893-1894	6.7	Lake Cuyamaca
1894-1895	22.6	Lake Cuyamaca
1895-1896	10.0	Lake Cuyamaca
1896-1897	16.9	Lake Morena
1897-1898	12.8	Lake Morena
1898-1899	11.0	Lake Morena
1899-1900	15.7	Lake Morena
1900-1901	17.8	Lake Cuyamaca
1901-1902	15.1	Lake Cuyamaca
1902-1903	17.7	Lake Cuyamaca
1903-1904	10.0	Lake Cuyamaca
1904-1905	23.8	Lake Cuyamaca
1905-1906	23.2	Lake Cuyamaca
1906-1907	20.3	Lake Morena
1907-1908	14.1	Lake Morena
1908-1909	19.7	Lake Morena
1909-1910	16.0	Lake Morena
1910-1911	14.9	Lake Morena
1911-1912	16.4	Lake Morena
1912-1913	12.3	Lake Morena
1913-1914	15.7	Lake Morena
1914-1915	22.2	Lake Morena

Water Year	Yearly Precipitation	Correlation Station
1915-1916	28.2	Lake Morena
1916-1917	18.2	Lake Morena
1917-1918	14.3	Lake Morena
1918-1919	14.7	Lake Morena
1919-1920	20.7	Lake Morena
1920-1921	12.5	Lake Morena
1921-1922	27.6	Lake Morena
1922-1923	16.1	Lake Morena
1923-1924	13.2	Lake Morena
1924-1925	14.4	Lake Morena
1929-1930	17.3	Lake Morena
1931-1932	21.3	Lake Morena
1932-1933	14.2	Lake Morena
1933-1934	8.9	Lake Morena
1943-1944	19.4	Lake Morena
1944-1945	15.8	Lake Morena
1967-1968	19.6	Lake Morena
1968-1969	15.7	Lake Morena
1969-1970	9.1	Lake Morena

Extrapolated Boulevard Precipitation Data

The extrapolated Boulevard precipitation data was calculated by comparing the available yearly data with yearly data from Lake Morena and Lake Cuyamaca. The line which best fits the data plotted in Figures 35 and 36 was determined by linear regression using the method of least squares.

The 95% confidence interval for the mean response $\mu y/x_o$ was determined using the following equation (Walpole and Myers, 1972):

$$\hat{y}_o - t_{\frac{\alpha}{2}} s \sqrt{\frac{1}{n} + \frac{(x_o - \bar{x})^2}{S_{xx}}} < \mu y/x_o < \hat{y}_o - t_{\frac{\alpha}{2}} s \sqrt{\frac{1}{n} + \frac{(x_o - \bar{x})^2}{S_{xx}}}$$

$t_{\frac{\alpha}{2}}$ is a value of the $t_{\frac{\alpha}{2}}$ distribution with n-2 degrees of freedom

$$s = \sqrt{\frac{S_{yy} - \rho S_{xy}}{n-2}}$$

n = number of points

$\bar{x}$ = mean of x values

$\bar{y}$ = mean of y values

$$S_{xx} = \sum_{i=1}^{n} (x_i - \bar{x})^2 \qquad S_{xy} = \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})$$

$$S_{yy} = \sum_{i=1}^{n} (y_i - \bar{y})^2$$

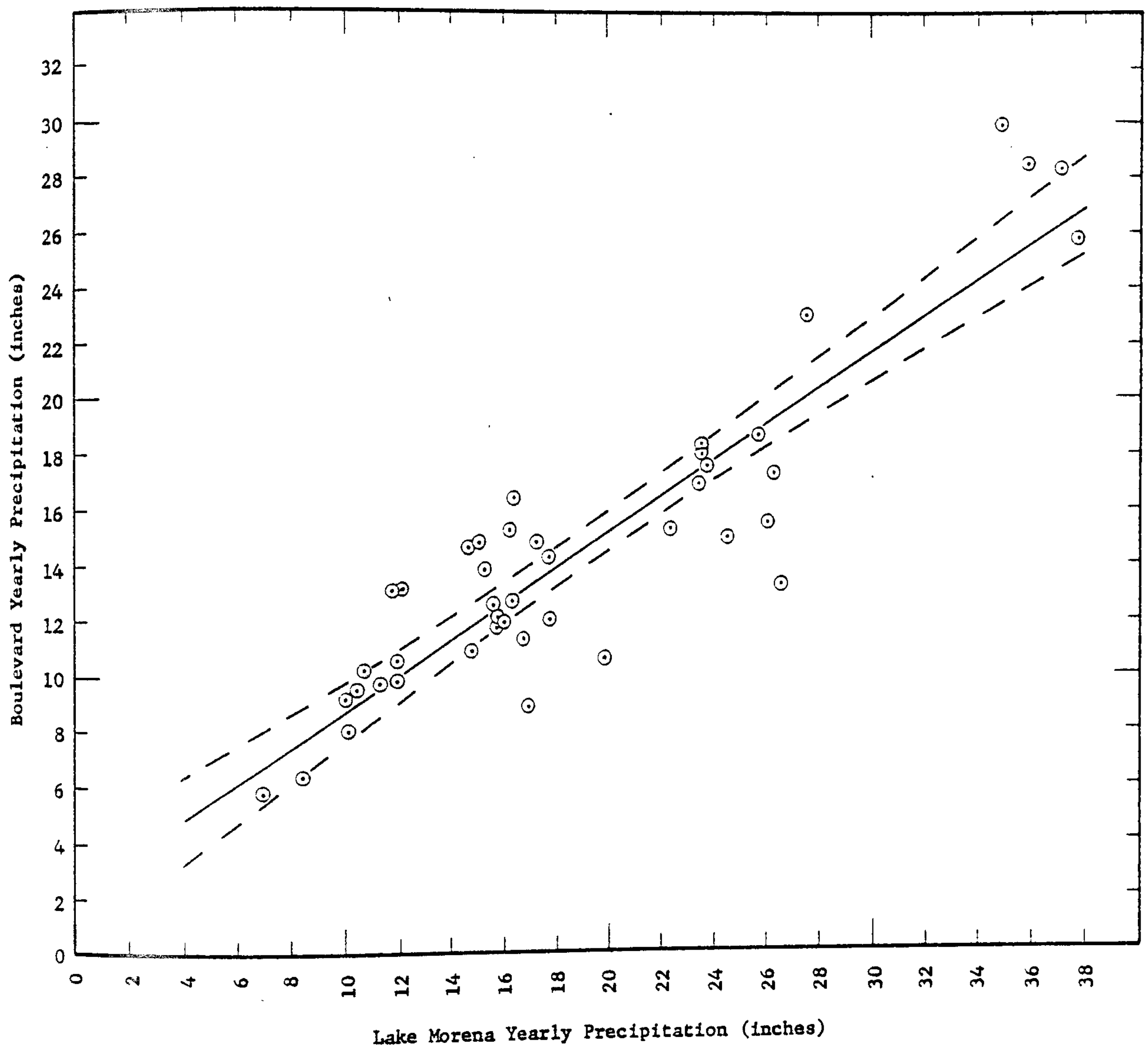

Figure 35. Data Plot of Boulevard and Lake Morena Yearly Precipitation and 95% Confidence Interval for the Mean Response $\mu y/x_o$

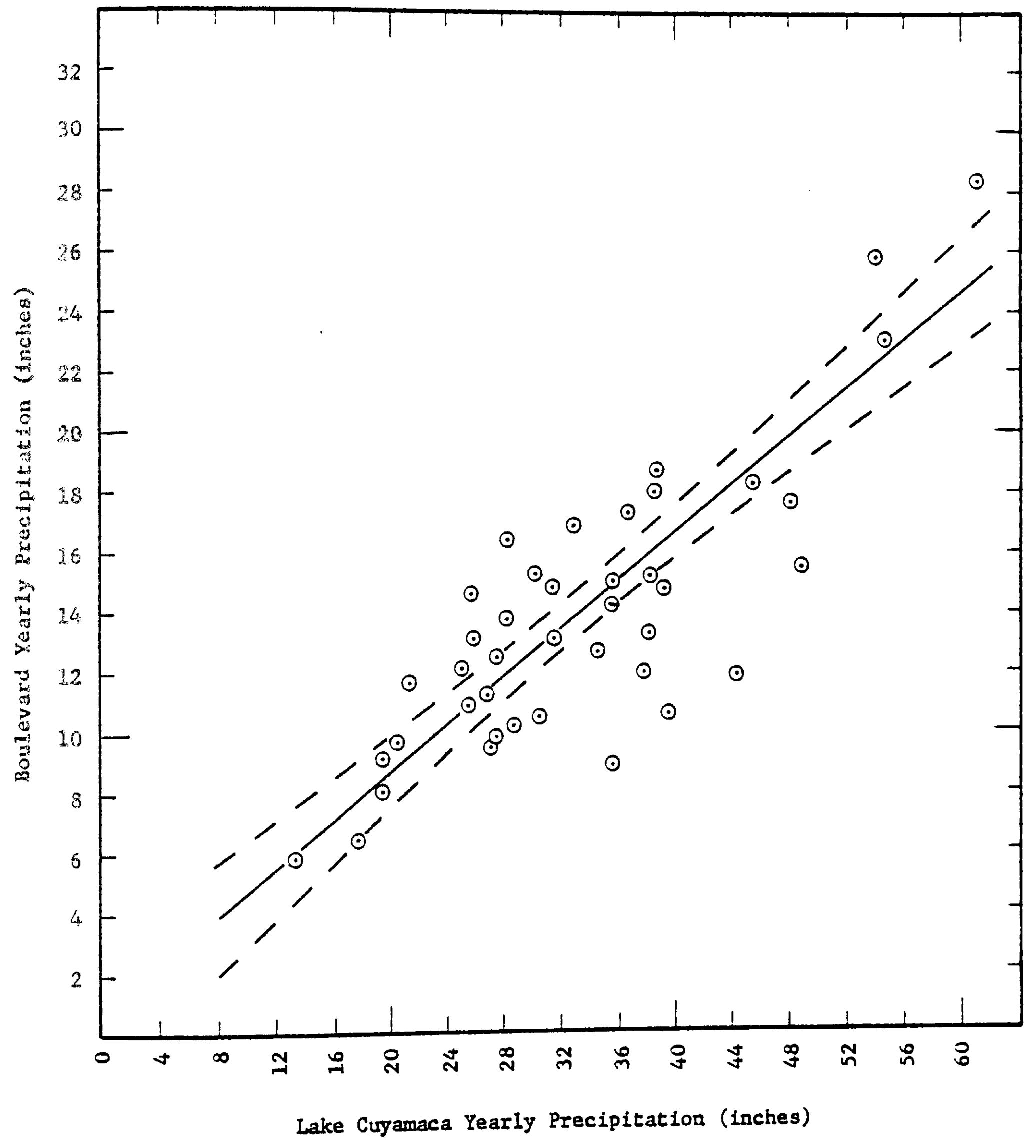

Figure 36. Data Plot of Boulevard and Lake Cuyamaca Yearly Precipitation and 95% Confidence Interval for the Mean Response $\mu y/x_o$

MEAN PAN EVAPORATION DATA FOR LAKE MORENA, CALIFORNIA

Mean monthly and yearly evaporation from a class L pan located at Morena Dam (1946-1974) (Calif. Dept. of Water Resources, 1974)

July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Yearly (inches)
8.15	7.65	5.97	4.22	2.24	1.70	1.63	1.81	2.83	4.09	5.59	7.12	53.01

APPENDIX B

SOILS

SOILS

The soil classification used in this report was based on eleven soil samples that were collected from the Jacumba Valley watershed and tested in the laboratory. The collection location of each sample is shown on the geologic map. Each soil sample was collected in a pipe 1.5 inches in diameter that was driven into the ground by a hand sledge. After removal from the ground, the ends of the pipes were plugged to prevent loss of soil. In the laboratory, each sample was submerged in water for about one week. The saturated sample was then weighed on a scale. The samples were then drained and weighed followed by drying in an oven and the weighing of the dried sample.

Sample 1 (Type Z)

The soil is clay rich alluvium from the northern end of Jacumba Valley.
The sampling pipe was driven 27 inches into the ground.
The soil sample was 10 inches long. There was 17 inches of compaction.

Saturated weight (2/28/80)	22 ounces
Drained weight (3/1/80)	22 ounces
Drained weight (3/5/80)	22 ounces
Dried weight (3/18/80)	16 ounces

Volume of water = 10.3 cubic inches
Volume of sample = 17.7 cubic inches

Porosity = 59% (the porosity was probably greater before compaction during sampling)

Specific retention = 0.59 $inches^3$ of $water/inch^3$ of soil (this value may have been affected by the compaction during sampling)

Sample 2 (Type W)

This sample is sandy alluvium from an alluvial fan on the eastern edge of the valley.
The sampling pipe was driven 25.5 inches into the ground.
The sampling was 20 inches long. There was 5.5 inches of compaction.

Saturated weight (2/28/80)	48 ounces
Drained weight (3/1/80	46 ounces
Drained weight (3/5/80)	46 ounces
Dried weight (3/18/80)	42 ounces

Volume of water (saturated) = 10.3 cubic inches
Volume of water (drained) = 6.9 cubic inches
Volume of sample = 35.3 cubic inches

Porosity = 37% (corrected for compaction, porosity before correction was 29%)
Specific retention = 0.16 inches^3 of water/inch^3 of soil (corrected for compaction, specific retention before correction was 0.20 inches^3 of water/inch^3 of soil)

Sample 3 (Type X)

This soil was developed on metamorphic terrain.
The sampling pipe was driven 10.5 inches into the ground.
The soil sample was 8.75 inches long. There was 1.75 inches of compaction.

Saturated weight (2/28/80)	21 ounces
Drained weight (3/1/80)	21 ounces
Drained weight (3/5/80)	21 ounces
Dried weight (3/18/80)	18 ounces

Volume of water (saturated) = 5.7 cubic inches
Volume of water (drained) = 5.7 cubic inches
Volume of sample = 15.46 cubic inches

Porosity = 40% (corrected for compaction, porosity before correction was 33%)
Specific retention = 0.28 inches^3 of water/inch^3 of soil (corrected for compaction, specific retention before correction was 0.33 inches^3 of water/inch^3 of soil)

Sample 4 (Type Y)

This sample is of clay rich soil that developed on the Jacumba Volcanics.
The sampling pipe was driven 11.5 inches into the ground.
The soil sample was 5.5 inches long. There was 6 inches of compaction.

Saturated weight (2/28/80)	13 ounces
Drained weight (3/1/80)	13 ounces
Drained weight (3/5/80)	13 ounces
Dried weight (3/18/80)	11 ounces

Volume of water (saturated) = 3.5 cubic inches
Volume of water (drained) = 3.5 cubic inches
Volume of sample = 9.7 cubic inches

Porosity = 74% (corrected for compaction, porosity before correction was 35%)
Specific retention = 0.35 $inches^3$ of $water/inch^3$ of soil (because clay was a major constituent in this sample the value for specific retention was not corrected for compaction)

Sample 5 (Type Y)

This soil sample consisted of fine sandy alluvium collected from the center of Jacumba Valley.
The sampling pipe was driven 10.5 inches into the ground.
The soil sample was 9.5 inches long. There was 1 inch of compaction.

Saturated weight (2/28/80)	22 ounces
Drained weight (3/1/80)	22 ounces
Drained weight (3/5/80)	22 ounces
Dried weight (3/18/80)	18 ounces

Volume of water (saturated) = 6.9 cubic inches
Volume of water (drained) = 6.9 cubic inches
Volume of sample = 16.8 cubic inches

Porosity = 45% (corrected for compaction, porosity before correction was 41%)
Specific retention = 0.37 $inches^3$ of $water/inch^3$ of soil (corrected for compaction, specific retention before correction was 0.41 $inches^3$ of water/ $inch^3$ of soil)

Sample 6 (Type X)

This soil was developed on metamorphic terrain.
The sampling pipe was driven 10.5 inches into the ground.
The soil sample was 9.5 inches long. There was 1 inch of compaction.

Saturated weight (2/28/80)	24 ounces
Drained weight (3/1/80)	23 ounces
Drained weight (3/5/80)	23 ounces
Dried weight (3/18/80)	20 ounces

Volume of water (saturated) = 6.9 cubic inches
Volume of water (drained) = 5.2 cubic inches
Volume of sample = 16.8 cubic inches

Porosity = 45% (corrected for compaction, porosity before correction was 41%)
Specific retention = 0.28 $inches^3$ of $water/inch^3$ of soil (corrected for compaction, specific retention before correction was 0.31 $inches^3$ of water/$inch^3$ of soil)

Sample 7 (Type W)

This soil sample is of sandy alluvium from an alluvial fan on the eastern edge of Jacumba Valley.
The sampling pipe was driven 20.5 inches into the ground.
The soil sample was 15.0 inches long. There was 5.5 inches of compaction.

Saturated weight (3/26/80)	1023 grams
Drained weight (3/28/80)	974 grams
Drained weight (3/31/80)	969 grams
Dried weight	845 grams

Volume of water (saturated) = 10.9 cubic inches
Volume of water (drained) = 7.6 cubic inches
Volume of sample = 26.5 cubic inches

Porosity = 56% (corrected for compaction, porosity before correction was 41%)
Specific retention = 0.21 $inches^3$ of $water/inch^3$ of soil (corrected for compaction, specific retention before correction was 0.29 $inches^3$ of water/$inch^3$ of soil)

Sample 8 (Type X)

This soil was developed on plutonic terrain.
The sampling pipe was driven 10.75 inches into the ground.
The soil sample was 8.5 inches long. There was 2.25 inches of compaction.

Saturated weight (3/26/80)	569 grams
Drained weight (3/28/80)	558 grams
Drained weight (3/31/80)	558 grams
Dried weight	479 grams

Volume of water (saturated) = 5.5 cubic inches
Volume of water (drained) = 4.8 cubic inches
Volume of sample = 15.0 cubic inches

Porosity = 46% (corrected for compaction, porosity before correction was 37%)
Specific retention = 0.25 inches^3 of water/inch^3 of soil (corrected for compaction, specific retention before correction was 0.32 inches^3 of water/inch^3 of soil)

Sample 9 (Type Y)

This sample is of clay rich soil that developed on the Jacumba Volcanics.
The sampling pipe was driven 10.75 inches into the ground.
The soil sample was 5.25 inches long. There was 5.5 inches of compaction.

Saturated weight (3/26/80)	272 grams
Drained weight (3/28/80)	267 grams
Drained weight (3/31/80)	267 grams
Dried weight	205 grams

Volume of water (saturated) = 4.1 cubic inches
Volume of water (drained) = 3.8 cubic inches
Volume of sample = 9.3 cubic inches

Porosity = 90% (corrected for compaction, porosity before correction was 44%)
Specific retention = 0.41 inches^3 of water/inch^3 of soil (because clay was a major constituent in this sample, the value for specific retention was not corrected for compaction)

Sample 10 (Type X)

This soil was developed on metamorphic terrain.
The sampling pipe was driven 10.75 inches into the ground.
The soil sample was 9.25 inches long. There was 1.5 inches of compaction.

Saturated weight (3/26/80)	593 grams
Drained weight (3/28/80)	577 grams
Drained weight (3/31/80)	577 grams
Dried weight	486 grams

Volume of water (saturated) = 6.5 cubic inches
Volume of water (drained) = 5.5 cubic inches
Volume of sample = 16.3 cubic inches

Porosity = 46% (corrected for compaction, porosity before correction was 40%)
Specific retention = 0.29 inches^3 of water/inch^3 of soil (corrected for compaction, specific retention before correction was 0.34 inches^3 of water/inch^3 of soil)

Sample 11 (Type X)

This soil was developed on metamorphic terrain.
The sampling pipe was driven 10.5 inches into the ground.
The soil sample was 9.5 inches long. There was 1.0 inches of compaction.

Saturated weight (3/26/80)	612 grams
Drained weight (3/28/80)	586 grams
Drained weight (3/31/80)	586 grams
Dried weight	516 grams

Volume of water (saturated) = 5.9 cubic inches
Volume of water (drained) = 4.3 cubic inches
Volume of sample = 16.8 cubic inches

Porosity = 39% (corrected for compaction, porosity before correction was 35%)
Specific retention = 0.23 inches^3 of water/inch^3 of soil (corrected for compaction, specific retention before correction was 0.25 inches^3 of water/inch^3 of soil)

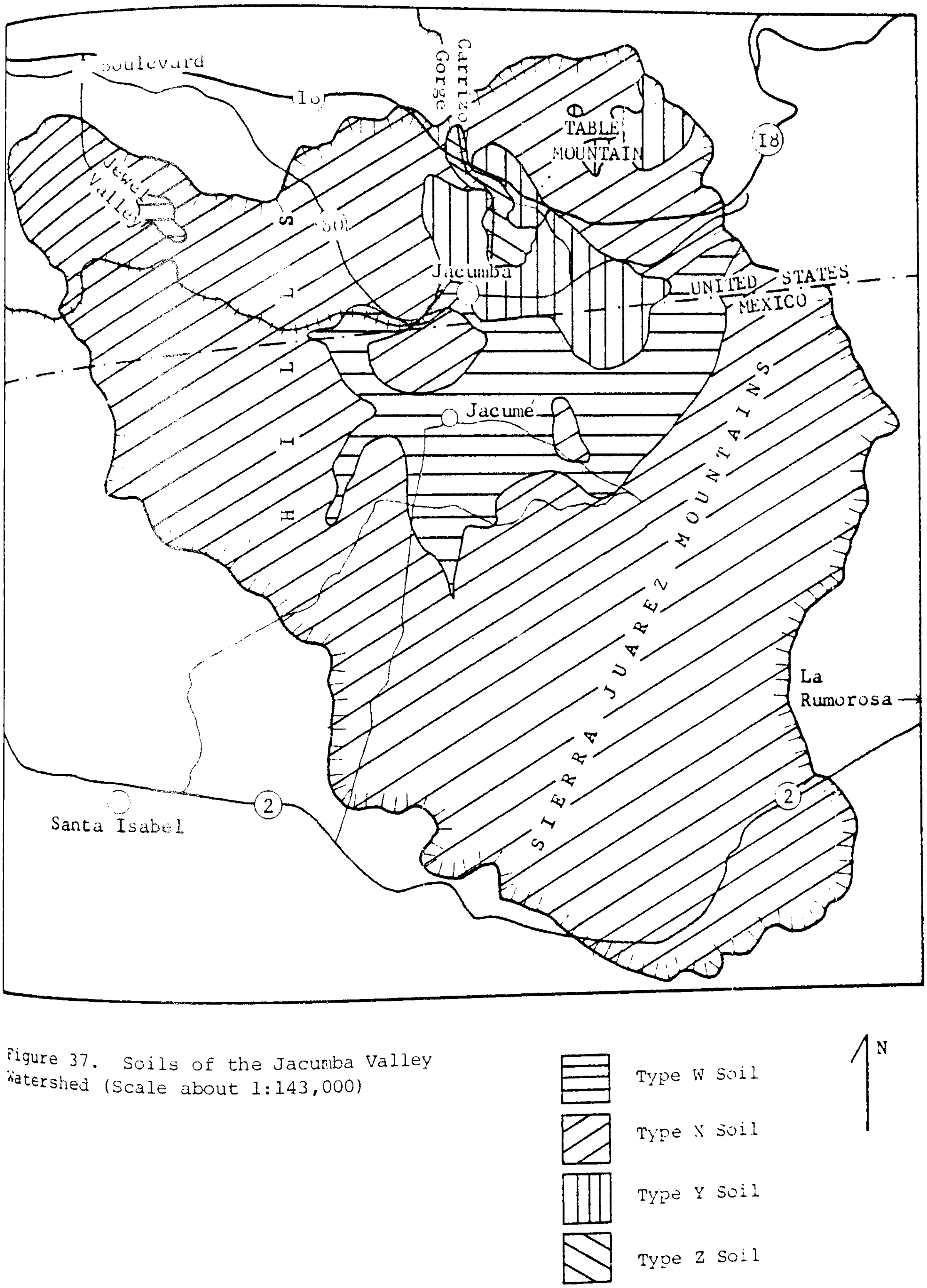

Figure 37. Soils of the Jacumba Valley Watershed (Scale about 1:143,000)

Soil Type	Sample #	Porosity	Specific Retention	Description
W	2	37%	0.16 $in.^3/in.^3$ soil	Sandy alluvium
	7	56%	0.21 $in.^3/in.^3$ soil	Sandy alluvium
	Mean	46%	0.19 $in.^3/in.^3$ soil	

This soil type is composed of medium to coarse-grained sand and gravelly sand found on alluvial fans, in stream channels, and as alluvian fill in small mountain valleys. Eolian deposits are also included. The assumed active depth for this soil type is 36 inches. In the portion of the Jacumba Valley watershed that receives Boulevard precipitation this soil type covers about 9.9×10^6 square feet. It covers about 3.898×10^8 square feet in that portion of the watershed receiving Jacumba precipitation.

Soil Type	Sample #	Porosity	Specific Retention	Description
X	3	40%	0.28 $in.^3/in.^3$ soil	Metamorphic residuum
	6	45%	0.28 $in.^3/in.^3$ soil	Metamorphic residuum
	8	46%	0.25 $in.^3/in.^3$ soil	Plutonic residuum
	10	46%	0.29 $in.^3/in.^3$ soil	Metamorphic residuum
	11	39%	0.23 $in.^3/in.^3$ soil	Metamorphic residuum
	Mean	43%	0.27 $in.^3/in.^3$ soil	

This soil type is composed of residuum formed on the metamorphic and plutonic bedrock which crops out in the hills and mountains surrounding Jacumba Valley. The active depth of this soil type is 24 inches because it only forms a thin cover on the bedrock. In the portion of the Jacumba Valley watershed that receives Boulevard precipitation, this soil type covers about 6.441×10^8 square feet. It covers about 2.0415×10^9 square feet in that portion of the watershed receiving Jacumba precipitation.

Soil Type	Sample #	Porosity	Specific Retention	Description
Y	4	74%	0.35 in.^{3}/in.^{3} soil	Volcanic residuum
	5	45%	0.37 in.^{3}/in.^{3} soil	Fine sand alluvium
	9	90%	0.41 in.^{3}/in.^{3} soil	Volcanic residuum
	Mean	70%	0.38 in.^{3}/in.^{3} soil	

This soil type is composed of clay rich residuum developed on the Jacumba Volcanics and the fine sandy alluvium in Jacumba Valley, The assumed active depth for this soil type is 36 inches. In the portion of the Jacumba Valley watershed that receives Jacumba precipitation, this soil type covers about 1.916×10^8 square feet. There is no soil of this type in that portion of the watershed receiving Boulevard precipitation.

Soil Type	Sample #	Porosity	Specific Retention	Description
Z	1	>59%	0.59 $in.^3/in.^3$ soil	Clay rich alluvium

This soil type is composed of clay rich alluvium found in the northern end of Jacumba Valley. The assumed active layer for this soil type is 36 inches. In the portion of the Jacumba Valley watershed that receives Jacumba precipitation, this soil type covers about 2.31×10^7 square feet. There is no soil of this type in that portion of the watershed receiving Boulevard precipitation.

The United States Soil Conservation Service and Forest Service (1973) mapped and classified the soils on the United States side of the Jacumba Valley watershed. Listed below are the soil types classified by the Soil Conservation Service.

Soils of the Jacumba Valley Watershed as Classified by the United States Soil Conservation Service and Forest Service (December, 1973)

Soil Type	Permeability	AWHC*	Runoff	Hydrologic Group	Soil Depth
Acid igneous rock land	none	0 (inches)	rapid	D	shallow (inches)
Calpine coarse sandy loam (slope 5-9%)	mod. rapid	4.5 - 6.5	slow	B	up to 60
Calpine coarse sandy loam (slope 9-15%)	mod. rapid	4.5 - 6.5	slow - med.	B	up to 60
Carrizo very gravelly sand	very rapid	1.5 - 3.0	very slow	A	up to 60
Indio silt loam (slope 0-2%)	moderate	7.5 - 9.5	slow	C	up to 60
Indio silt loam (slope 2-5%)	moderate	7.5 - 9.5	slow	C	up to 60
Indio silt loam, saline (slope 0-2%)	moderate	7.5 - 9.5	very slow	C	up to 60
La Posta loamy coarse sand	rapid	2.0 - 3.0	medium	A	16 - 30
La Posta rocky loamy coarse sand	rapid	1.0 - 2.0	medium	A	
La Posta - Sheephead complex	mod. rapid	1.0 - 2.5	med.-rapid	A,C	10 - 32
Loamy alluvial land	moderate	6.0 - 9.0		B	greater than 60
Mecca coarse sandy loam	moderate	5.0 - 6.0	slow	B	greater than 60
Metamorphic rock land	none	none	very rapid	D	shallow
Mottsville loamy coarse sand (slope 2-9%)	very rapid	4.0 - 5.0	slow-med.	A	up to 60
Mottsville loamy coarse sand (slope 9-15%)	very rapid	4.0 - 5.0	medium	A	up to 60
Ramona sandy loam (slope 5-9%)	mod. slow	8.5 - 10.5	slow-med.	C	up to 74
Ramona sandy loam (slope 9-15%)	mod. slow	8.5 - 10.5	medium	C	up to 74

* Available water holding capacity

Soils of the Jacumba Valley Watershed as Classified by the United States Soil Conservation Service and Forest Service (December, 1973) (Continued)

Soil Type	Permeability	AWHC*	Runoff	Hydrologic Group	Soil Depth
Reiff fine sandy loam	mod. rapid	7.5 - 9.5	very slow	B	up to 60
Rositas loamy coarse sand	rapid	3.0 - 4.0	slow-med.	A	up to 60
Rough broken land	none	none	very rapid	D	little
Sloping gullied land	none	none	very rapid	B	debris
Stony land	none	none	very rapid	A	talus
Tollhouse rocky coarse sandy loam (slope 5-30%)	rapid	1.0 - 2.0	med.-rapid	C	5 - 20
Tollhouse rocky coarse sandy loam (slope 30-65%)	rapid	1.0 - 2.0	very rapid	C	5 - 20

*Available water holding capacity

UNITED STATES SOIL CONSERVATION SERVICE HYDROLOGIC SOIL GROUPS

Hydrologic Group	Description
A	Soils have high infiltration rate when thoroughly wetted, permeability is rapid to very rapid. Chiefly deep soils, well drained to excessively drained sand and/or gravel. The rate of water transmission is high, very slow to medium runoff potential. 0-30% slopes. Available water holding capacity is 1.0-5.0 inches.
B	Soils have moderate infiltration rate when thoroughly wetted, permeability is moderate to moderately rapid. Chiefly moderately deep to deep soils, moderately well drained to well drained moderately coarse grained texture. The rate of water transmission is moderate, very slow to medium runoff potential. 0-9% slopes. Available water holding capacity is 4.5-9.5 inches.
C	Soils have slow infiltration rate when thoroughly wetted, permeability is moderately slow to moderately rapid. Chiefly soils that have a layer impeding downward movement of water, moderately fine to fine texture. The rate of water transmission is slow, slow to rapid runoff potential. 0-65% slopes. Available water holding capacity is 1.0-10.5 inches.
D	Soils have very slow infiltration rate when thoroughly wetted, little permeability. Chiefly clays with high shrink-swell potential, soils that have high permenent water table, soils that have claypan or clay layer at or near the surface, or soils that are shallow over nearly impervious material, generally rock areas with little soil. The rate of water transmission is very slow, runoff potential is rapid to very rapid. No available water holding capacity.

APPENDIX C

VEGETATION

The vegetation in the Jacumba Valley watershed has been grouped into three different plant communities. Oberbauer (personal communication, 1980) provided the following list of plants that are typical of two of these communities:

Creosote Bush Scrub -	Creosote bush (Larrea tridentata) Burroweed (Ambrosia dumosa) Ocotillo (Fouqueria splendens) Brittlebush (Encelia farinosa) Jumping cholla (Opuntia bigelovii) Barrel cactus (Ferocactus acanthodes) Desert lavender (Hyptis emoryi) Cheesebush (Hymenoclea salsola)
Desert Transition -	Turpentine broom (Thamnosma montana) Desert apricot (Prunus fremontii) Condaliopsis (Condaliopsis parryi) Nolina (Nolina bigelovii) California junipers (Juniperus californicus) Scrub oak (Quercus turbinella)

Patric Webber (1979) studied two sites within the Jacumba Valley watershed (see geologic map in pocket). Vegetation data from these sites are presented below.

Site 70 - Species	Percent Cover
Adenostoma fasciculatum	45%
Adenostoma sparsifolium	1%
Ceanothus greggii	15%
Eriogonum fasciculatum	2%
Opuntia prolifera	1%
Rhus ovata	5%
Salvia mellifera	1%
Sambucus mexicana	1%
Yucca schidigeri	2%
Tree cover	0%
Shrub cover	73%
Herb cover	25%
Cryptogam cover	3%
Litter	25%
Rock cover	5%
Bare soil cover	40%

Site 71 - Species	Percent Cover
Adenostoma fasciculatum	30%
Asctostaphylas glanca	8%
Eriogonum fasciculatum	1%
Gutierrezia california	1%
Haplopappus linearifolius	3%
Juniperus california	5%
Lotus scoparius	1%
Opuntia littoralis	2%
Quercus dumosa	6%
Rhus ovata	5%
Yucca schidigeri	3%
Tree cover	0%
Shrub cover	66%
Herb cover	2%
Cryptogam cover	1%
Litter	15%
Rock cover	45%
Bare soil cover	30%

APPENDIX D

RUNOFF

RUNOFF

No significant surface flow occurred in Jacumba Valley between June, 1979 and February, 1980. Between February, 1980 and June, 1980, the surface flow in the valley was measured. Stream flow measurements were made at five localities in the valley (see Runoff Data, page ; Figures 38 and 39). The surface flow in Boundary Creek was gaged beneath the Old State Highway 80 bridge west of Jacumba and along the artificial channel on the northern edge of Jacumba. Surface flow from the Mexican side of Jacumba Valley was measured in a ditch on the eastern side of Jacumba near a trailer park. Surface flow in the drainage west of Jacumé was gaged twice to the west of that town. The surface flow leaving Jacumba Valley and entering Carrizo Gorge was measured at the old dam at the north end of the valley.

Measurements made at the old dam were made in the same manner as for flow over a broad-crested weir. All other measurements were made by determining the average cross sectional area of the channel and then timing a floating object as it traversed a 50-foot section. Because of the wide and shallow nature of most of the channels, these measurements are only estimates.

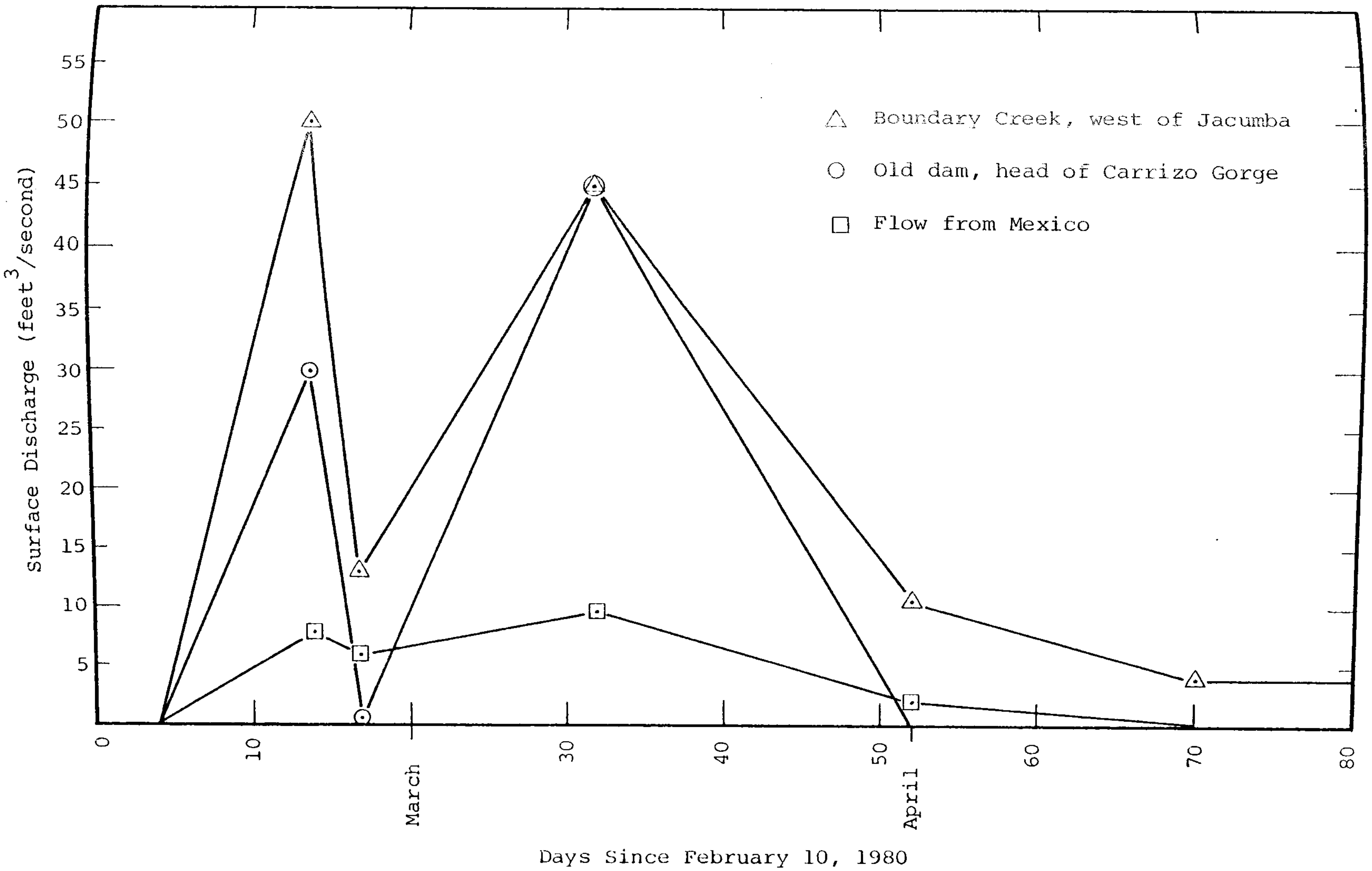

Figure 38. Selected Stream Flow Measurements Made During February, March, and April, 1980

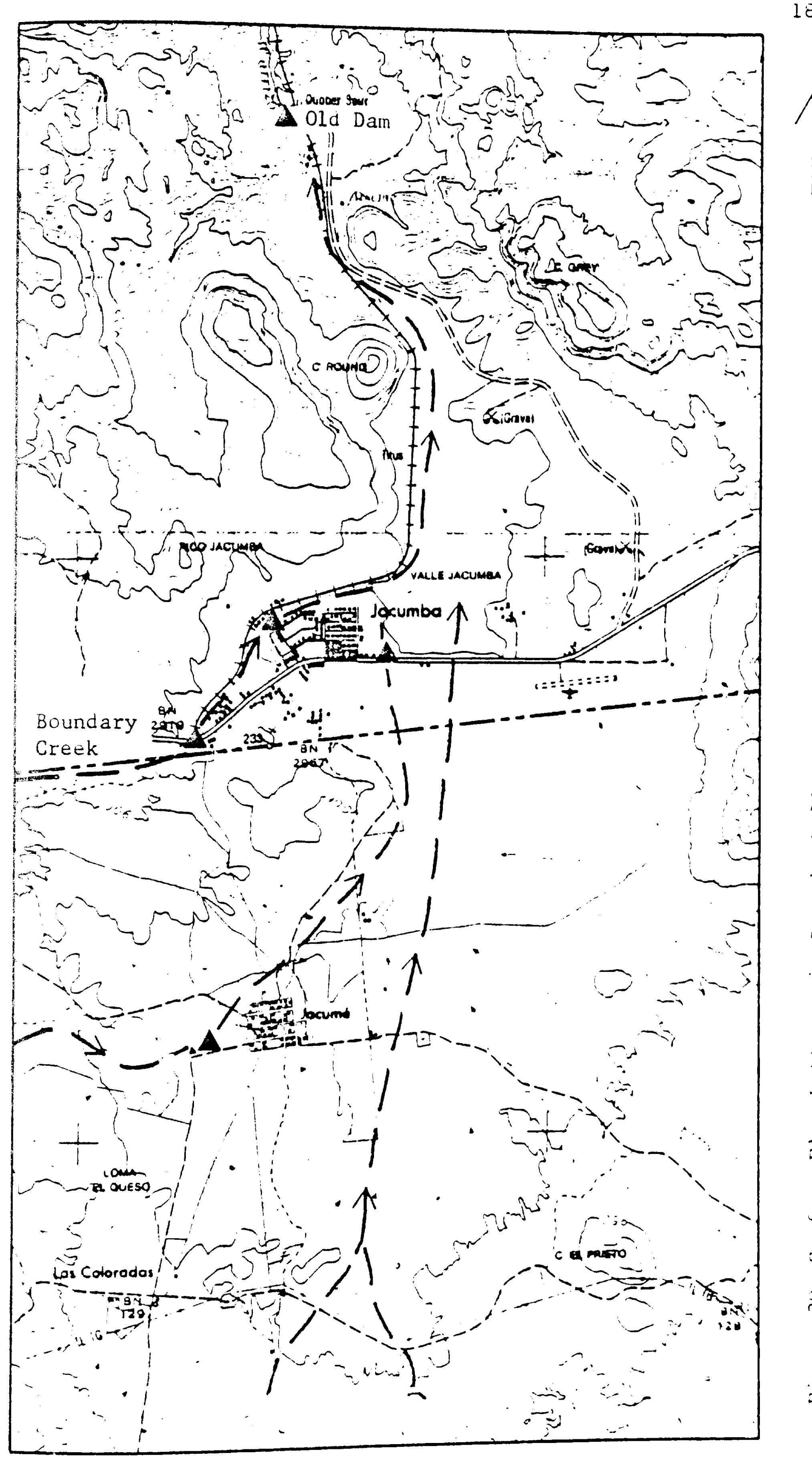

Figure 39. Surface Flow Patterns in Jacumba Valley During the Months of February, March, and April, 1980 (Scale 1:50,000)

RUNOFF DATA, FEBRUARY THROUGH MAY, 1980

Date	Location	Discharge
2/12/80	No surface flow entering Jacumba Valley	
2/24/80	Boundary Creek, west of Jacumba	50 $feet^3$/second
	Boundary Creek, north of Jacumba	37 $feet^3$/second
	Flow from Mexico, east of Jacumba	8 $feet^3$/second
	Old dam, head of Carrizo Gorge	30 $feet^3$/second
2/27/80	Boundary Creek, west of Jacumba	13 $feet^3$/second
	Boundary Creek, north of Jacumba	9 $feet^3$/second
	Flow from Mexico, east of Jacumba	6 $feet^3$/second
	Old dam, head of Carrizo Gorge	0.8 $feet^3$/second
3/12/80	Boundary Creek, west of Jacumba	40 $feet^3$/second
	Boundary Creek, north of Jacumba	49 $feet^3$/second
	Flow from Mexico, east of Jacumba	9.6 $feet^3$/second
	Old dam, head of Carrizo Gorge	45 $feet^3$/second
4/1/80	Boundary Creek, west of Jacumba	10.5 $feet^3$/second
	Flow from Mexico, east of Jacumba	2 $feet^3$/second
	Drainage west of Jacumé	5 $feet^3$/second
	Old dam, head of Carrizo Gorge	0.06 $feet^3$/second
4/13/80	Drainage west of Jacumé	4.5 $feet^3$/second
4/20/80	Boundary Creek, west of Jacumba	3.8 $feet^3$/second
	Flow from Mexico, east of Jacumba	No Flow
	Old dam, head of Carrizo Gorge	No Flow
5/9/80	Boundary Creek, west of Jacumba	3.7 $feet^3$/second
	No other gauging station had surface flow.	
5/29/80	Boundary Creek, west of Jacumba	4 $feet^3$/second
	No other gauging station had surface flow.	

RUNOFF ANALYSIS

The total estimated discharge of Boundary Creek, as measured west of Jacumba, between February 14th and April 1st, was 1.15×10^8 cubic feet. The surface flow entering the United States side of Jacumba Valley from Mexico was roughly 2.5×10^7 cubic feet and the total estimated discharge over the old dam at the head of Carrizo Gorge was 8.4×10^7 cubic feet.

The Boundary Creek watershed covers about 5.06×10^8 square feet. The majority of this watershed receives the precipitation recorded at Boulevard. The February and March discharge of Boundary Creek, as measured west of Jacumba, accounted for about 20%, 2.7 inches, of the February and March precipitation on the Boundary Creek watershed. The 2.7 inches of precipitation that ranoff is equivalent to about 12% of the January through March precipitation. The February through May runoff accounts for about 3.3 inches or 14% of the January through March precipitation. Precipitation during the months of April and May was not included because the potential evapotranspiration exceeded the precipitation. These values are only estimates of the actual runoff. The stream flow measurements were not made often enough to accurately gauge the runoff. Upstream from the gauging station on the west side of Jacumba, Boundary Creek flows through a small alluviated valley. This alluvium probably absorbed a portion of the runoff and reduced the volume of flow measured. Because of the lack of information, it was assumed that Boundary Creek runoff was representative of the other areas of runoff in the Jacumba Valley watershed.

The discharge into Carrizo Gorge accounted for about 74% of the February and March runoff measured in Boundary Creek. Except during periods of peak runoff, the runoff reaching the old dam was predominantly from Boundary Creek. In order to conservatively estimate the amount of infiltration, it was assumed that only the Boundary Creek runoff was reaching Carrizo Gorge. Using this assumption, roughly 26% of the Boundary Creek runoff was lost through infiltration and evaporation as it traversed a portion of Jacumba Valley. This is equivalent to about 0.7 inches of precipitation on the Boundary Creek watershed. The loss, due to infiltration and evaporation, from the runoff originating south of the international border was much greater due to the greater distance the flow had to traverse in the valley. The few runoff measurements made near Jacumé support this.

Based on the above information, it was conservatively assumed that 70% of all runoff that entered Jacumba Valley, during the months of February through May, 1980, evaporated as it flowed across the valley or was discharged from the watershed into Carrizo Gorge. The remaining 30% of the runoff was assumed to have infiltrated into the stream channels and valley alluvium and recharged the valley's ground water system.

The stream flow measurements and the determination of the total runoff are subject to significant error. The assumptions made over estimated the loss to the Jacumba Valley watershed. This would result in an underestimation of the ground water recharge.

DAILY PRECIPITATION RECORDS FOR BOULEVARD, CALIFORNIA, JANUARY-APRIL, 1980*

January:

7	-	0.30 (inches)
8	-	0.20
9	-	1.35
10	-	1.18
11	-	1.48
12	-	0.33
13	-	0.05
14	-	0.08
15	-	0.03
18	-	0.72
27	-	0.03
28	-	0.32
29	-	2.11
30	-	2.70
31	-	0.04

February:

13	-	0.55
14	-	1.01
15	-	0.81
16	-	0.17
17	-	0.90
18	-	2.10
19	-	1.37
20	-	1.22
21	-	0.80
22	-	T

March:

2	-	T
3	-	1.03
4	-	0.10
6	-	0.93
7	-	0.13
10	-	0.50
11	-	0.81
18	-	0.19
19	-	0.16
22	-	0.35
26	-	0.22

April:

1	-	0.34
2	-	0.20
21	-	0.01
22	-	0.30
23	-	0.74
24	-	0.04
28	-	0.03
29	-	0.51
30	-	0.05

*Taken from United States Environmental Service Administration monthly issues.

APPENDIX E

GROUND WATER RECHARGE CALCULATIONS

Ground Water Recharge Calculations: Jacumba Precipitation Data, Type W Soil

Soil Type W

Water Year	Precipitation	Runoff	Evapotranspiration	Calculated Recharge
1963-1964	7.95 (inches)	0 (inches)	7.95 (inches)	0 (inches)
1964-1965	5.64	0	5.64	0
1965-1966	12.71	0	12.71	0
1966-1967	9.73	0	9.73	0
1967-1968	10.20	0	10.20	0
1968-1969	9.03	0	9.03	0
1969-1970	9.17	0	9.17	0
1970-1971	7.31	0	7.31	0
1971-1972	4.46	0	4.46	0
1972-1973	10.62	0	10.62	0
1973-1974	5.25	0	5.25	0
1974-1975	8.05	0	8.05	0
1975-1976	8.47	0	8.47	0
1976-1977	10.71	0	10.71	0
1977-1978	16.01	0	16.01	0
1978-1979	13.95	0	13.95	0
1979-1980	17.67	0	14.45	3.22
17 year mean				0.19

Ground Water Recharge Calculations: Jacumba Precipitation Data, Type X Soil

Soil Type X

Water Year	Precipitation	Runoff	Evapotranspiration	Calculated Recharge
1963-1964	7.95 (inches)	0 (inches)	7.95 (inches)	0 (inches)
1964-1965	5.64	0	5.64	0
1965-1966	12.71	0	12.71	0
1966-1967	9.73	0	9.73	0
1967-1968	10.20	0	10.20	0
1968-1969	9.03	0	9.03	0
1969-1970	9.17	0	9.17	0
1970-1971	7.31	0	7.31	0
1971-1972	4.46	0	4.46	0
1972-1973	10.62	0	10.62	0
1973-1974	5.25	0	5.25	0
1974-1975	8.05	0	8.05	0
1975-1976	8.47	0	8.47	0
1976-1977	10.71	0	10.71	0
1977-1978	16.01	0	16.01	0
1978-1979	13.95	0	13.95	0
1979-1980	17.67	0	14.09	3.58
17 year mean				0.21

Ground Water Recharge Calculations: Boulevard Precipitation Data, Type W Soil

Soil Type W

Water Year	Precipitation	Runoff	Evapotranspiration	Calculated Recharge
1925-1926	17.31 (inches)	0 (inches)	17.31 (inches)	0 (inches)
1926-1927	28.47	3.94	14.62	9.91
1927-1928	11.74	0	11.74	0
1928-1929	8.90	0	8.90	0
1929-1930	incomplete record			
1930-1931	11.32	0	11.32	0
1931-1932	incomplete record			
1932-1933	no record			
1933-1934	incomplete record			
1934-1935	18.70	0	18.57	0.13
1935-1936	10.63	0	10.63	0
1936-1937	29.90	3.02	22.21	4.67
1937-1938	15.45	0	13.58	0.92
1938-1939	15.02	0	15.02	0
1939-1940	18.04	0	18.04	0
1940-1941	25.80	0	18.08	7.72
1941-1942	16.94	0	16.94	0
1942-1943	13.25 (no record for May and June)			0
1943-1944	incomplete record			
1944-1945	11.49 (no record for July - September)			
1945-1946	14.22	0	14.22	0
1946-1947	13.11	0	13.11	0
1947-1948	9.76	0	9.76	0
1948-1949	15.21	0	13.94	1.27
1949-1950	10.49	0	10.49	0

Ground Water Recharge Calculations: Boulevard Precipitation Data, 193
Type W Soil (Continued)

Soil Type W

Water Year	Precipitation	Runoff	Evapotranspiration	Calculated Recharge
1950-1951	9.52 (inches)	0 (inches)	9.52 (inches)	0 (inches)
1951-1952	23.00	0	17.82	5.18
1952-1953	12.08	0	12.08	0
1953-1954	14.26	0	13.22	1.04
1954-1955	10.22	0	10.22	0
1955-1956	13.07	0	13.07	0
1956-1957	13.75	0	13.75	0
1957-1958	17.57	0	17.57	0
1958-1959	9.19	0	9.19	0
1959-1960	12.52	0	12.52	0
1960-1961	5.84	0	5.84	0
1961-1962	12.66	0	12.66	0
1962-1963	6.41	0	6.41	0
1963-1964	11.96	0	11.96	0
1964-1965	10.92	0	10.92	0
1965-1966	14.84	0	13.31	1.53
1966-1967	11.88	0	11.88	0
1967-1968	incomplete record			
1968-1969	no record			
1969-1970	10.13 (no record for July - September)			0
1970-1971	14.57	0	14.57	0
1971-1972	7.95	0	7.95	0
1972-1973	18.28	0	16.10	2.18
1973-1974	9.72	0	9.72	0
1974-1975	14.81	0	14.81	0
1975-1976	15.28 (inches)	0 (inches)	15.28 (inches)	0 (inches)
1976-1977	16.38	0	16.38	0
1977-1978	28.30	2.80	18.32	7.18
1978-1979	24.71	0	16.19	8.52
1979-1980	30.55	3.64	17.51	9.40
48 year mean				1.24
Recharge due to infiltration from runoff				4.02

Ground Water Recharge Calculations: Boulevard Precipitation Data, Type X Soil

Soil Type X

Water Year	Precipitation	Runoff	Evapotranspiration	Calculated Recharge
1925-1926	17.31 (inches)	0 (inches)	17.31 (inches)	0 (inches)
1926-1927	28.47	3.94	14.26	10.27
1927-1928	11.74	0	11.74	0
1928-1929	8.90	0	8.90	0
1929-1930	incomplete record			
1930-1931	11.32	0	11.32	0
1931-1932	incomplete record			
1932-1933	no record			
1933-1934	incomplete record			
1934-1935	18.70	0	18.21	0.49
1935-1936	10.63	0	10.63	0
1936-1937	29.90	3.02	21.85	5.03
1937-1938	15.45	0	13.22	1.28
1938-1939	15.02	0	14.93	0.09
1939-1940	18.04	0	18.04	0
1940-1941	25.80	0	17.72	8.08
1941-1942	16.94	0	16.94	0
1942-1943	13.25 (no record fro May and June)			0
1943-1944	incomplete record			
1944-1945	11.49 (no record for July - September)			0
1945-1946	14.22	0	14.22	0
1946-1947	13.11	0	13.11	0
1947-1948	9.76	0	9.76	0
1948-1949	15.21	0	13.58	1.63
1949-1950	10.49	0	10.49	0

Ground Water Recharge Calculations: Boulevard Precipitation Data, Type X Soil (Continued)

Soil Type X

Water Year	Precipitation	Runoff	Evapotranspiration	Calculated Recharge
1950-1951	9.52 (inches)	0 (inches)	9.52 (inches)	0 (inches)
1951-1952	23.00	0	17.46	5.54
1952-1953	12.08	0	12.08	0
1953-1954	14.26	0	12.86	1.40
1954-1955	10.22	0	10.22	0
1955-1956	13.07	0	13.07	0
1956-1957	13.75	0	13.75	0
1957-1958	17.57	0	17.57	0
1958-1959	9.19	0	9.19	0
1959-1960	12.52	0	12.52	0
1960-1961	5.84	0	5.84	0
1961-1962	12.66	0	12.66	0
1962-1963	6.41	0	6.41	0
1963-1964	11.96	0	11.96	0
1964-1965	10.92	0	10.92	0
1965-1966	14.84	0	12.95	1.89
1966-1967	11.88	0	11.88	0
1967-1968	incomplete record			
1968-1969	no record			
1969-1970	10.13 (no record for July - September)			0
1970-1971	14.57	0	14.57	0
1971-1972	7.95	0	7.95	0
1972-1973	18.28	0	15.74	2.54
1973-1974	9.72	0	9.72	0
1974-1975	14.81	0	14.81	0
1975-1976	15.28 (inches)	0 (inches)	15.28 (inches)	0 (inches)
1976-1977	16.38	0	16.38	0
1977-1978	28.30	2.80	17.96	7.54
1978-1979	24.71	0	15.83	8.88
1979-1980	30.55	3.64	17.15	9.76
48 year mean				1.34
Recharge due to infiltration from runoff				4.02

GROUND WATER RECHARGE CALCULATIONS

The mean annual ground water recharge for the Jacumba Valley watershed was calculated in the following manner:

Boulevard Precipitation Data:

Soil type W covers 9.91 x 10^6 square feet. This soil type averaged 1.24 inches of recharge per year.
The mean annual recharge for the type W soil is 1.02 x 10^6 cubic feet.

Soil type X covers 6.4415 x 10^8 square feet. This soil type averaged 1.34 inches of recharge per year.
The mean annual recharge for the type X soil is 7.193 x 10^7 cubic feet.

Jacumba Precipitation Data:

Soil type W covers 3.8979 x 10^8 square feet. This soil type averaged 0.19 inches of recharge per year.
The mean annual recharge for the type W soil is 6.17 x 10^6 cubic feet.

Soil type X covers 2.04145 x 10^9 square feet. This soil type averaged 0.21 inches of recharge per year.
The mean annual recharge for the type X soil is 3.573 x 10^7 cubic feet.

The total mean annual ground water recharge due to infiltration from precipitation is 1.1485 x 10^8 cubic feet.

Ground water recharge due to infiltration from runoff in Jacumba Valley equalled 4.02 inches for the 48 years of precipitation records in Boulevard. This runoff was generated on both type W and type X soils in the Boulevard portion of the watershed. The total ground water recharge for the entire 48 years was 2.1911 x 10^8 cubic feet. The mean annual recharge is 4.56 x 10^6 cubic feet.

The total mean annual ground water recharge for the Jacumba Valley watershed is 1.1942×10^8 cubic feet (3.3815×10^6 cubic meters (2740 acre-feet).

ERROR ANALYSIS FOR GROUND WATER RECHARGE CALCULATIONS

Error

A 10% error in determining the specific retention of a soil type would result in a 10-15% error in the calculated recharge for that soil type.

Type X Soil

specific retention = 0.27 $inch^3$ of water/$inch^3$ of soil
10% error = 0.03
If the true specific retention were = 0.30 $inch^3$ of water/$inch^3$ of soil, the the following change in the calculated recharge would result:

Boulevard Precipitation Data:

Year Recharge Occurred	Recharge (inches)	Recharge with Error (inches)
1926-1927	10.27	9.54
1934-1935	0.49	0
1936-1937	5.03	4.31
1937-1938	1.28	0.63
1938-1939	0.09	0
1940-1941	8.08	7.43
1948-1949	1.63	0.98
1951-1952	5.54	4.89
1953-1954	1.40	0.75
1965-1966	1.89	1.24
1972-1973	2.54	1.89
1977-1978	7.54	6.82
1978-1979	8.88	8.23
1979-1980	9.76	9.04
Total	64.42	55.75
Mean (48 years)	1.33	1.16
Error		13%

Jacumba Precipitation Data:

1979-1980	3.58	2.98
Mean (17 years)	0.21	0.17

The error calculated above for type X soil would result in a 13% decrease in the mean annual calculated recharge for the entire watershed. A 10% error in the specific retention for type W soil would result in only a 1% error in the total calculated recharge. This is because type X soil covers a much greater area than type W soil.

RECHARGE CALCULATIONS BASED ON THE UNITED STATES SOIL CONSERVATION SERVICE HYDROLOGIC SOIL GROUPS

Soil Groups	Available Water Holding Capacity (inches)	Active Soil Depth (inches)
A	0.05-0.07	36
B	0.09-0.13	36
C	0.10-0.14	36
D	0	0

Using the above values, yearly recharge calculations were made in the same manner as the original recharge calculations. These calculations are summarized in Error Analysis for Ground Water Recharge Calculations, page . The mean annual ground water recharge for the Jacumba Valley watershed, based on the above hydrologic soil groups, was calculated in the following manner:

Boulevard Precipitation Data:

Group A soil covers 2.0259 x 10^8 square feet. This soil group averaged 3.18-3.85 inches of recharge per year.
The mean annual recharge for the group A soil is 5.369-6.500 x 10^7 cubic feet.

Group B soil covers 9.03 x 10^6 square feet. This soil group averaged 1.97-2.60 inches of recharge per year.
The mean annual recharge for the group B soil is 1.48-1.96 x 10^6 cubic feet.

Group C soil covers 3.7971 x 10^8 square feet. This soil group averaged 1.76-2.38 inches of recharge per year.
The mean annual recharge for the group C soil is 5.57-7.53 x 10^7 cubic feet.

Jacumba Precipitation Data:

Group A soil covers 3.0716 x 10^8 square feet. This soil group averaged 1.07-1.42 inches of recharge per year.

The mean annual recharge for the group A soil is 2.739-3.635 x 10^7 cubic feet.

Group B soil covers 1.4044 x 10^8 square feet. This soil group averaged 0.53-0.85 inches of recharge per year.

The mean annual recharge for the group B soil is 6.20-9.95 x 10^6 cubic feet.

Group C soil covers 8.2731 x 10^8 square feet. This soil averaged 0.40-0.76 inches of recharge per year.

The mean annual recharge for the group C soil is 2.758-5.240 x 10^7 cubic feet.

The total mean annual ground water recharge due to infiltration from precipitation is 1.7204-2.4096 x 10^8 cubic feet.

Ground water recharge due to infiltration from runoff in Jacumba Valley equalled 4.02 inches for the 48 years of precipitation records in Boulevard. The total ground water recharge for the entire 48 years was 1.9810 x 10^8 cubic feet. The mean annual recharge is 4.13 x 10^6 cubic feet.

The total mean annual ground water recharge for the Jacumba Valley watershed is 1.7617-2.4509 x 10^8 cubic feet (4.9886-6.9402 x 10^6 cubic meters)(4043-5624 acre-feet).

Groundwater Recharge Calculations Based on the United States Soil Conservation Service and Forest Service (December, 1973) Soil Groups

Boulevard Precipitation Data

Water Year	Soil Group A	Soil Group B	Soil Group C
1926-1927	14.22 - 15.06 (inches)	12.18 - 13.50 (inches)	11.61 - 13.14 (inches)
1927-1928	1.00 - 1.84	0 - 0.28	0
1928-1929	0 - 0.51	0	0
1930-1931	1.36 - 2.20	0 - 0.42	0 - 0.06
1934-1935	4.45 - 5.29	2.41 - 3.73	1.84 - 3.37
1935-1936	1.63 - 2.47	0 - 0.91	0 - 0.55
1936-1937	8.99 - 9.83	6.95 - 8.27	6.38 - 7.91
1937-1938	5.24 - 6.08	3.20 - 4.52	2.63 - 4.16
1938-1939	4.05 - 4.89	2.01 - 2.95	1.44 - 2.97
1939-1940	0.96 - 1.88	0 - 0.24	0
1940-1941	12.79 - 12.88	10.00 - 11.32	9.43 - 10.96
1941-1942	2.41 - 3.25	0.37 - 1.69	0 - 1.33
1942-1943	2.90 - 3.74	0.86 - 2.18	0.29 - 1.82
1944-1945	2.03 - 2.87	0.08 - 1.40	0 - 0.95
1945-1946	0.17 - 1.01	0	0
1946-1947	0.27 - 1.11	0	0
1947-1948	0 - 0.31	0	0
1948-1949	5.59 - 6.43	3.45 - 4.87	2.98 - 4.50
1949-1950	0.45 - 1.29	0	0
1950-1951	0 - 0.40	0	0
1951-1952	9.50 - 10.34	7.46 - 8.78	6.89 - 8.42
1952-1953	1.48 - 2.32	0 - 0.76	0 - 0.40
1953-1954	5.36 - 6.20	3.32 - 4.64	2.75 - 4.28
1954-1955	0.12 - 0.96	0	0
1956-1957	3.02 - 3.86	0.98 - 2.30	0.41 - 1.94
1957-1958	3.85 - 4.79	1.81 - 3.13	1.24 - 2.77

Groundwater Recharge Calculations Based on the United States Soil Conservation Service and Forest Service (December, 1973) Soil Groups (Continued)

Water Year	Soil Group A	Soil Group B	Soil Group C
1958-1959	0.59 - 1.43 (inches)	0 (inches)	0 (inches)
1959-1960	1.12 - 1.96	0 - 0.40	0 - 0.04
1961-1962	2.29 - 3.13	0	0
1965-1966	5.85 - 6.69	3.81 - 5.13	3.24 - 4.77
1966-1967	1.06 - 1.90	0 - 0.34	0
1969-1970	0 - 0.70	0	0
1970-1971	1.21 - 2.05	0 - 0.49	0 - 0.13
1971-1972	0.74 - 1.58	0 - 0.02	0
1972-1973	6.50 - 7.34	4.46 - 5.78	3.89 - 4.42
1973-1974	1.47 - 2.31	0 - 0.75	0 - 0.39
1974-1975	0.62 - 1.46	0	0
1975-1976	1.94 - 2.78	0 - 1.22	0 - 0.86
1977-1978	10.94 - 11.78	8.90 - 10.22	8.33 - 9.86
1978-1979	12.84 - 13.68	10.80 - 12.12	10.23 - 11.76
1979-1980	13.72 - 14.56	11.68 - 13.00	11.11 - 12.64
48 year mean	3.18 - 3.85	1.97 - 2.60	1.76 - 2.38

Jacumba Precipitation Data

Water Year	Soil Group A	Soil Group B	Soil Group C
1965-1966	3.54 - 4.38 (inches)	1.50 - 2.82 (inches)	0.93 - 2.46 (inches)
1966-1967	0 - 0.81	0	0
1967-1968	0.93 - 1.77	0 - 0.21	0
1969-1969	0 - 0.52	0	0
1972-1973	0 - 0.06	0	0
1973-1974	0 - 0.18	0	0
1975-1976	0 - 0.20	0	0
1977-1978	3.49 - 4.33	1.45 - 2.77	0.88 - 2.41
1979-1980	7.54 - 8.38	5.50 - 6.82	4.93 - 6.46
17 year mean	1.07 - 1.42	0.53 - 0.85	0.40 - 0.76

APPENDIX F

AQUIFER PROPERTIES

AQUIFER PROPERTIES

Calculations of the Saturated Volume of the Table Mountain Aquifer

Calculations of saturated volume were based on the cross-sections A-A' and B-B' and the water level measured in well R1. The aquifer was divided into two sections along the northwesterly trending fault that passes between Round Mountain and the long flat hill to the west.

East Section

This section is 5200 feet wide. It was divided into three portions.

Northern portion: 4600 feet long. Saturated thickness ranges from 0 in the north to 600 in the south.
Volume = (5200 ft)(4600 ft)(600 ft)1/2 =
7.176×10^9 cubic feet

Middle portion: 9400 feet long. The saturated thickness ranges from 600 feet in the north to 550 feet in the south.
Volume = (5200 ft)(9400 ft)(575 ft) =
2.8106×10^{10} cubic feet

South portion: 4200 feet long. Saturated thickness ranges from 550 feet in the north to 200 feet in the south.
Volume = (5200 ft)(4200 ft)(50 ft) +
(5200 ft)(4200 ft)(550 ft)1/2 =
7.098×10^9 cubic feet

West Section

This section is 4100 feet wide. It was divided into three portions.

Northern portion: 6000 feet long. The saturated thickness ranges from 0 in the north to 600 feet in the south.
Volume = (4100 ft)(6000 ft)(600 ft)1/2 =
7.380×10^9 cubic feet

Middle portion: 4000 feet long. The saturated thickness is 600 feet.
Volume = (4100 ft)(4000 ft)(600 ft) = 9.840×10^9 cubic feet

Southern portion: 8300 feet long. The saturated thickness ranges from 600 feet in the north to 200 feet in the south.
Volume = (4100 ft)(8300 ft)(200 ft) +
(4100 ft)(8300 ft)(400 ft)1/2 =
1.3612×10^{10} cubic feet

Total Saturated Volume = 7.3212×10^{10} cubic feet (2.0731×10^{9} cubic meters)

Recoverable Water, based on a 5% specific yield, 3.661×10^{9} cubic feet (1.037×10^{8} cubic meters) (84,000 acre-feet)

based on a 10% specific yield, 7.321×10^{9} cubic feet (2.073×10^{8} cubic meters) (168,000 acre-feet)

Calculations of the Saturated Volume of the Quarternary Alluvium Aquifer

The calculations were based on two different water levels in the alluvial aquifer: (1) the water table as measured in November, 1979, and (2) the maximum water level on record, about 30 feet below the surface in well J1 in 1955. The alluviated portion of Jacumba Valley where ground water occurs in significant quantities was divided into five sections for the calculations (Figure 40).

Section A

Width = 1250 feet
Length = 7000 feet
Saturated thickness (1) north to south 0-30 feet,
east to west 0-30-0
average thickness is 15 feet
(2) north to south 0-50 feet,
east to west 0-50-0
average thickness is 25 feet

Volume: (1) (1250 ft)(7000 ft)(15 ft) = 1.31×10^8 cubic feet
(2) (1250 ft)(7000 ft)(25 ft) = 2.19×10^8 cubic feet

Section B

Width = 2000 feet
Length = 2000 feet
Saturated thickness (1) 30 feet
(2) 50 feet

Volume: (1) (2000 ft)(2000 ft)(30 ft) = 1×10^5 cubic feet
(2) (2000 ft)(2000 ft)(50 ft) = 2×10^5 cubic feet

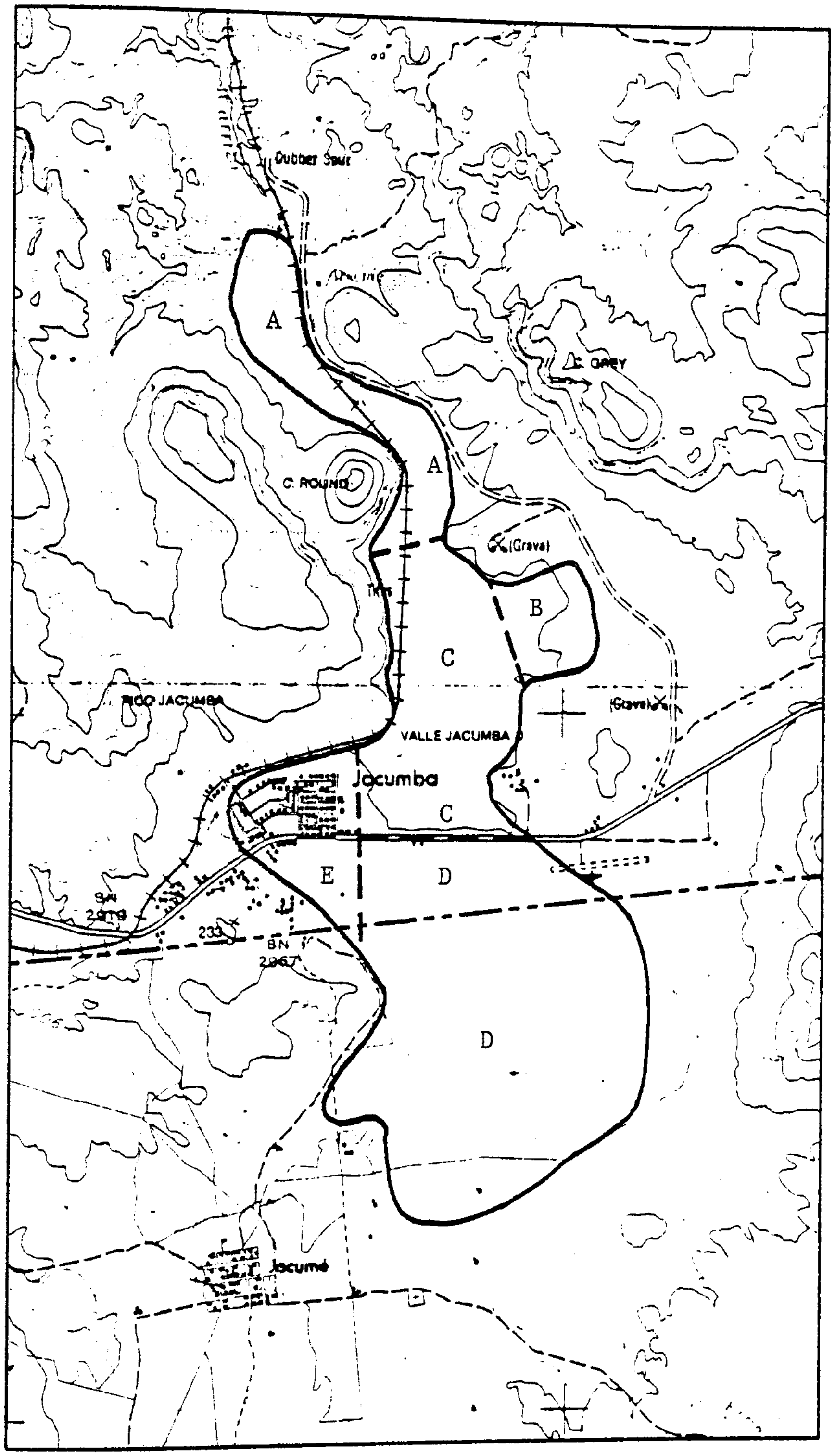

Figure 40. Sections of the Quaternary Alluvial Aquifer Used for the Calculation of the Saturated Volume (Scale 1:50,000)

Section C

Width = 2330 feet
Length = 6000 feet
Saturated thickness (1) north to south 30-60 feet,
east to west 30-0 in northern half
and 0-60 in southern half
average is 45 feet
(2) north to south 50-90 feet,
east to west 50-0 in northern half
and 0-90 in southern half
average is 70 feet

Volume: (1) (2330 ft)(6000 ft)(45 ft) = 6.29×10^8 cubic feet
(2) (2330 ft)(6000 ft)(70 ft) = 9.79×10^8 cubic feet

Section D

Width = 7100 feet
Length = 8300 feet
Saturated thickness (1) north to south 60-0 feet,
east to west 0-60-0
average is 30 feet
(2) north to south 90-0 feet,
east to west 0-90-0
average is 45 feet

Volume: (1) (7100 ft)(8300 ft)(30 ft)1/2 = 1.768×10^9 cubic feet
(2) (7100 ft)(8300 ft)(45 ft)1/2 = 2.652×10^9 cubic feet

Section E

Width = 3300 feet
Length = 5200 feet
Saturated thickness (1) north to south 0-60-0 feet,
east to west 0-60 feet
average is 30 feet
(2) north to south 0-90-0 feet,
east to west 90-0
average is 45 feet

Volume: (1) (3300 ft)(5200 ft)(30 ft)1/2 = 2.57×10^8 cubic feet
(2) (3300 ft)(5200 ft)(45 ft)1/2 = 3.86×10^8 cubic feet

Total Saturated Volume: (1) 2.785×10^9 cubic feet
(7.89×10^7 cubic meters)

(2) 4.236×10^9 cubic feet
(1.200×10^8 cubic meters)

Recoverable Water: Based on a 5% specific yield:

(1) 1.39×10^8 cubic feet
(3.94×10^6 cubic meters)
(3195 acre-feet)

(2) 2.12×10^8 cubic feet
(6.00×10^6 cubic meters)
(4860 acre-feet)

Based on a 10% specific yield:

(1) 2.79×10^8 cubic feet
(7.89×10^6 cubic meters)
(6390 acre-feet)

(2) 4.24×10^8 cubic feet
(1.20×10^7 cubic meters)
(9720 acre-feet)

Attempted Calculation of Specific Yield

The specific yield of the Table Mountain aquifer and the alluvial aquifer was calculated by using data on fluctuations in the aquifers water tables caused by localized, intense ground water recharge events. The propagation of the recharge pulse through the aquifers was assumed to be similar to the propagation of heat through a semi-infinite solid. Carslaw and Jaeger (1951) present equations relating the velocity of propagation of the heat pulse and the change in amplitude of the pulse to the diffusivity of the medium. The basic equation for a heat pulse propagating through a semi-infinite solid is: $V = Ae^{-kx}\text{Cos}(\omega t - kx - \varepsilon)$. V is the velocity of propagation of the pulse, A is the amplitude of the pulse, k is the diffusivity of the medium, x is the distance the pulse has moved through the medium, $\omega = \frac{2\Pi}{\text{Period}}$. From this basic equation, Carslaw and Jaeger (1951) derived the equation $V = (2k\omega)^{1/2}$, which relates the velocity of propagation of the heat pulse to the diffusivity of the medium. The equation

$$A_d = A_s e^{-x\sqrt{\frac{\omega}{2k}}}$$

was derived relating the change in amplitude in the pulse to the diffusivity of the medium. A_s is the amplitude of the pulse at the surface and A_d is the amplitude of the pulse at some depth within the medium.

Table Mountain Aquifer

Surface flow on the Mexican side of Jacumba Valley recharged the Table Mountain aquifer, probably in the area between Jacumé and the international border. The recharge began on February 14th and was first recorded in well R1 eighty-five days later on May 9th. The period of the recharge pulse, as determined at well Km, was fifty days. The distance between the place of recharge and well R1 is 2100-3000 meters. From this the velocity was determined to be 25-36 meter/day and the diffusivity of the aquifer was 2485-5147 $meter^2$/day.

The transmissivity of the Table Mountain aquifer, as determined by the pump test on well R2, is 0.62 $meter^2$/day. The calculated specific yield for this aquifer is 1.2×10^{-4} to 2.5×10^{-4}. Because of the unreasonably low values, it is apparent that these values represent the storage coefficient and not the specific yield. The fact that the storage coefficient was calculated and not the specific yield may be due to the partial confinement of the Table Mountain aquifer.

Quaternary Alluvium Aquifer

Recharge to the alluvial aquifer occurred in the vicinity of well Km. The recharge began on February 14th.

The period of the recharge pulse was fifty days, as determined by the surface runoff data and the water level measurements in well Km. The attempt to calculate the diffusivity and specific yield of the aquifer used data from well Km, K1, and K3. The calculations were based on the velocity of propagation of the recharge pulse and the change in amplitude of the pulse. The transmissivity of the alluvial aquifer is 2850 $meter^2$/day, as determined by the pump test on well J1.

Boundary Creek to well K1

Distance = 270 meters
The recharge pulse was first measured in the well 27 days after the beginning of recharge near well Km
Velocity = 10 meters/day
Diffusivity = 403 meter^2/day

Amplitude at the surface = 6.71 meters
Amplitude at depth = 2.74 meters
Diffusivity = 5,710 meter^2/day
Specific Yield = 50%

Boundary Creek to well K3

Distance = 670 meters
The recharge pulse was first measured in the well 85 days after the beginning of recharge near well Km
Velocity = 7.9 meters/day
Diffusivity = 250 meter^2/day

Amplitude at the surface = 6.71 meters
Amplitude at depth = 0.96 meters
Diffusivity = 7460 meter^2/day
Specific Yield = 38%

Well K1 to well K3

Distance = 480 meters
The recharge pulse was first measured at the two wells 58 days apart
Velocity = 8.3 meters/day
Diffusivity = 270 meter^2/day

Amplitude at well K1 = 2.74 meters
Amplitude at well K3 = 0.96 meters
Diffusivity = 13,390 meter^2/day
Specific Yield = 21%

Mean Values

Mean diffusivity based on the velocity of propagation calculations = 308 $meter^2$/day

Mean specific yield = 926%

Mean diffusivity based on the change in amplitude calculations = 8,853 $meter^2$/day

Mean specific yield = 32%

The value of specific yield determined by the velocity of propagation calculations is unreasonably high. The value of specific yield determined by the change in amplitude calculations also appears rather high and shows considerable variation in the calculations. As a result, none of the calculated values are considered valid estimates of the aquifer's specific yield. The inability to calculate the specific yield may be due to the long periods between the water level measurements in the wells. This made the determination of the velocity of propagation and the change in amplitude inaccurate. It is also possible that while the recharge pulse was propagating through the entire aquifer, the value of transmissivity was determined for only the coarsest portion of the aquifer.

APPENDIX G

GROUND WATER BUDGET

GROUND WATER BUDGET

Subsurface Discharge Calculations

The subsurface discharge of ground water from the Table Mountain and Quaternary Alluvium aquifers, into the bedrock at the north end of Jacumba Valley, was estimated by calculating the volume of water that could flow through the aquifers in the area north of Interstate 8. Darcy's law and data obtained from pump tests and water level measurements were used to make the calculations. The results of the calculations are estimates and are assumed to represent the maximum possible subsurface discharge. The actual subsurface discharge from the aquifers into the bedrock is undoubtedly less due to the lower hydraulic conductivity of the bedrock.

Table Mountain Aquifer

$Q = KA\Delta h/L$
$T = 0.62$ meter^2/day
$b = 150$ meters
$K = T/b = 4.13 \times 10^{-3}$ meters/day
A (north of Interstate 8) = (1440 meters)(150 meters) = 216,000 square meters
L (to well R1) = 3800 meters
Δh (from the water level in well R1 to the lower contact of the formation just north of Interstate 8) = 170 meters

$Q = 40$ meter^3/day = 14,600 meter^3/year (12 acre-feet/year)

Quaternary Alluvium Aquifer

$Q = Ka\Delta h/L$
$T = 2850 \text{ meter}^2/\text{day}$
$b = 16.8$ meters
$K = T/b = 170$ meters/day
A (north of Interstate 8) = (450 meters)(5 meters) = 2250 square meters
L (to well K3) = 3650 meters
Δh (Nov. 1979) = 18.3 meters (in well K3)
Δh (1955) = 27.4 meters (in well K3)

Q (Nov. 1979) = 1918 meter^3/day = 699,975 meter^3/year (567 acre-feet/year)

Q (1955) = 2871 meter^3/day = 1,048,050 meter^3/year (849 acre-feet/year)

Ground Water Budget 1955-1979

The ground water budget for Jacumba Valley, during the period 1955-1979, was calculated using the available data on ground water recharge and changes in water levels in the alluvial aquifer.

Calculated Ground Water Recharge 1955-1978

Ground water recharge only occurred in the Boulevard portion of the Jacumba Valley watershed. It was assumed that all of the recharge during the 1977-1978 water year had reached the valley's ground water system and that none of the 1978-1979 recharge had reached the valley. The actual case is that a portion of each year's recharge had already reached Jacumba Valley, while the remainder was still moving through the bedrock aquifer to the west of the valley. Estimates of recharge were made for the water years 1967-1968 and 1968-1969, 3.5 inches and 1.0 inches respectively.

Type W Soil

16.32 inches of total recharge between 1955-1978.
The area covered by type W soil in the Boulevard portion of the watershed is = 9.91×10^6 square feet.
Total recharge = 1.35×10^7 cubic feet (3.82×10^5 cubic meters)

Type X Soil

17.40 inches of total recharge between 1955-1978.
The area covered by type X soil in the Boulevard portion of the watershed is = 6.44147×10^8 square feet.
Total recharge = 9.340×10^8 cubic feet (2.645×10^7 cubic meters)

Total ground water recharge 1955-1978 = 2.683×10^7 cubic meters (21,740 acre-feet)

Loss from Storage in the Alluvial Aquifer 1955-1979

During the period 1955-1979 the water level in well K3 declined from 2760 feet to 2728 feet. The loss of available storage due to this decline is:

3.90×10^6 cubic meters (3160 acre-feet) based on a 5% specific yield

6.00×10^6 cubic meters (4860 acre-feet) based on a 10% specific yield

Total Ground Water Budget 1955-1979

The total ground water budget for Jacumba Valley shows a net loss of between 3.07×10^7 cubic meters (24,900 acre-feet) and 3.28×10^7 cubic meters (26,600 acre-feet) depending on the specific yield of the aquifer.

The average yearly loss is: 1.3×10^6 cubic meters (1040 acre-feet)

to

1.4×10^6 cubic meters (1110 acre-feet)

The ground water budget is an estimate. In its calculation, it was assumed that there was no loss of stored water in the Table Mountain aquifer. There was very likely some loss of storage in that aquifer; however, there is no water level data to indicate a loss.

APPENDIX H

WATER LEVEL RECORDS

WATER LEVEL RECORDS

Date	Well	Depth to Water	Well Elevation	Recorded by
7/55	K3	38.5 (feet)	2798.5 (feet)	driller (Ketchum, 1980)
	08 J	43.3	2790.0	Calif. D.W.R. (1980)*
9/55	08 K	46.3	2790.0	" " " "
	08 Q	55.4	2790.0	" " " "
10/55	J1	43	2800	driller (C.S.D.P.H., 1980)#
5/56	08 Q	56.3	2790.0	Calif. D.W.R., (1980)*
	09 H	100.1	2860.0	" " " "
9/56	08 J	54.2	2790.0	" " " "
	08 Q	62.2	2790.0	" " " "
	09 H	100.1	2860.0	" " " "
5/57	08 J	52.1	2790.0	" " " "
	08 K	55.0	2790.0	" " " "
	08 Q	63.0	2790.0	" " " "
	09 H	98.4	2860.0	" " " "
4/58	K1	37	2781	driller (Ketchum, 1980)
	K2	41	2781	" " " "
5/58	09 H	98.0	2860.0	Calif. D.W.R., (1980)*
7/63	J2	80	2800	driller (C.S.D.P.H., 1980)#
7/66	J3A	22	2843	" " " " "
9/72	J4	20	2840	" " " " "
11/20/79	J3	6.6	2850	author
	J2	72.6	2800	" "
	K3	69.9	2798	" "
11/27/79	J2	72.7 (J1 pumping)	2800	" "
	K1	60.7	2781	" "
	K3	69.8	2798	" "
	Km	49.6	2793	" "

* California Department of Water Resources
\# County of San Diego, Department of Public Health

WATER LEVEL RECORDS (Continued)

Date	Well	Depth to Water	Well Elevation	Recorded by
12/11/79	K1	57.5 (feet)	2781 (feet)	author
	K3	69.45	2798	" "
	H1	193.5		" "
2/12/80	J3	5.15	2850	" "
	J2	72.05	2800	" "
	K3	68.6	2798	" "
	K1	56.4	2781	" "
	Km	46.15	2793	" "
	H1	193.2		" "
2/27/80	J3	4.6	2850	" "
	J2	70.7	2800	" "
	K3	68.0	2798	" "
	K1	55.7	2781	" "
	Km	pumping		" "
	H1	193.0		" "
3/12/80	J3	4.5	2850	" "
	J2	70.3	2800	" "
	K3	67.55	2798	" "
	K1	53.55	2781	" "
	Km	33.45	2793	" "
	H1	192.6		" "
4/01/80	J2	69.55	2800	" "
	K3	66.7	2798	" "
	K1	48.5	2781	" "
	Km	24.2	2793	" "
	H1	192.1		" "
	R1	106.3	2847	" "

WATER LEVEL RECORDS (Continued)

Date	Well	Depth to Water	Well Elevation	Recorded by
4/20/80	J3	4.5	2850	author
	J2	68.7	2800	" "
	K3	65.7	2798	" "
	K1	46.7	2781	" "
	Km	pumping		" "
	H1	191.75		" "
	R1	106.2	2847	" "
5/09/80	J2	67.6	2800	" "
	K3	64.5	2798	" "
	K1	45.9	2781	" "
	Km	24.2	2793	" "
	H1	191.3		" "
	R1	102.3	2847	" "
5/29/80	J3	4.5	2850	" "
	J2	66.3	2800	" "
	K3	63.25	2798	" "
	K1	45.3	2781	" "
	Km	pumping		" "
	H1	190.75		" "
	R1	105.6	2847	" "
9/06/80	J3	pumping		" "
	J2	58.8	2800	" "
	K3	55.9	2798	" "
	K1	42.3	2781	" "
	Km	pumping		" "
	H1	188.5		" "
	R1	105.7	2847	" "

APPENDIX I

PUMP TESTS

PUMP TESTS

Quaternary Alluvial Aquifer

A pump test on well J1 was performed in November, 1979. Well J2, located 150 feet from well J1, and well K3, 340 feet from well J1, were used as observation wells. Well J1 is 124 feet deep, well J2 is 140 feet deep, and well K3 is 117 feet deep. The pump test lasted for only four hours due to the limited size of the reservoir the water was being pumped into. The change in water level in each well was monitored. The pumping well, J1, showed a rapid decline in water level, followed by a much slower rate of decline which fluctuated due to some fluctuation of the discharge. The data from this well were not useable and were not included in this report. The data from well J2 were useable and are presented below and in Figure 42. Well K3 showed no change in water level.

Time Since Start of Pumping (minutes)	Depth to Water (feet)	Drawdown (feet)
0	72.13	0
1	72.18	0.05
2	72.18	0
8	72.18	0
33	72.18	0
64	72.20	0.02
116	72.24	0.06
165	72.26	0.08
217	72.26	0.08
248	72.30	0.12
250 stop pump test		

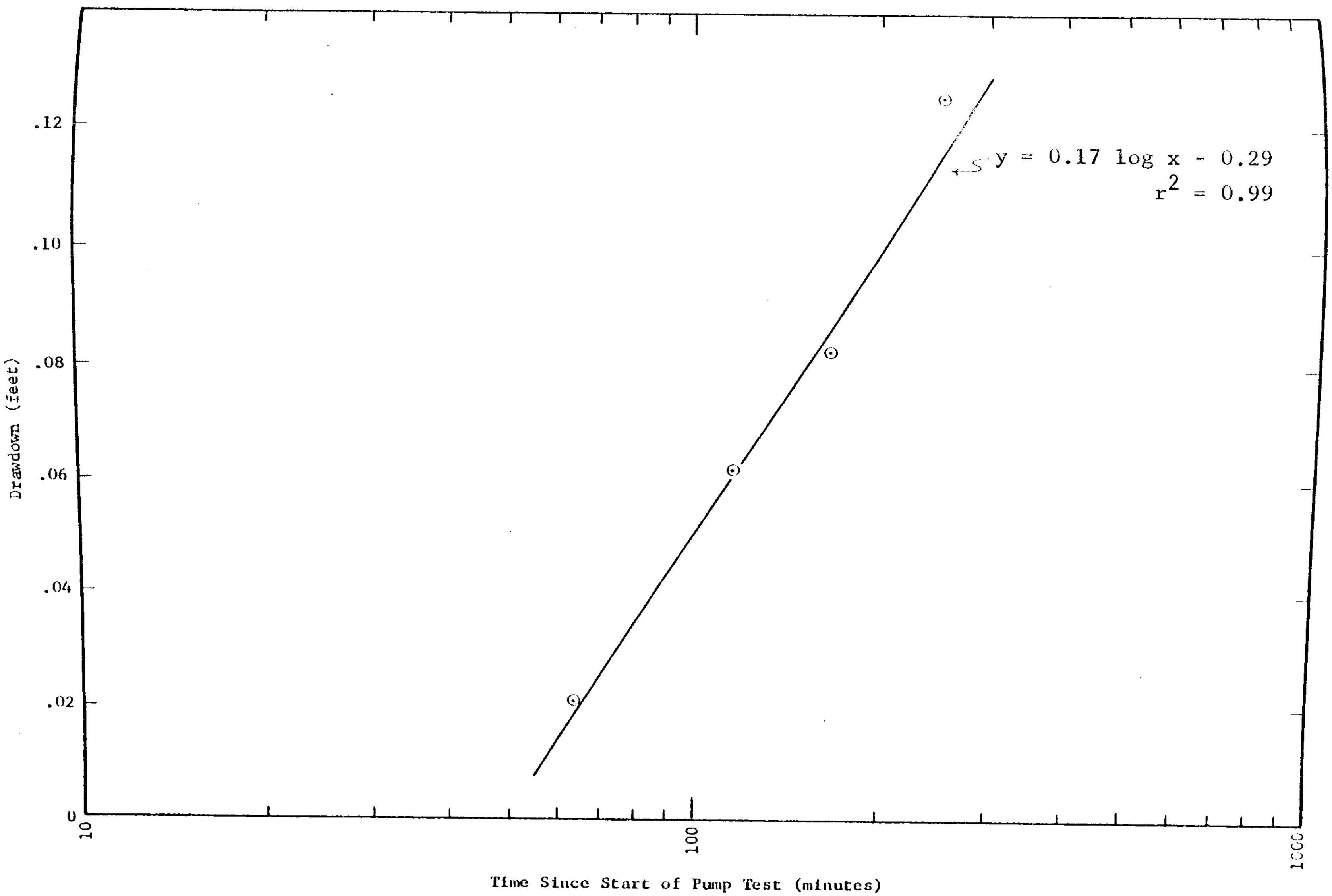

Figure 42. Alluvial Aquifer Pump Test. Observation Well J2.

It was not possible to directly measure the discharge during the pump test on well J1. Instead, the average discharge was calculated in the following manner:

37 kilowatt-hours of electricity was used during the pump test or an average of 0.15 kilowatt-hours/minute (398280 foot-pounds/minute).

A pressure gauge on the head of the pump showed an average of 68 pounds/inch^2 of head during the pump test.

The water level in the pumping well averaged about 76 feet below the ground surface.

The total head = 68 lb/in^2 + 76 ft
= 157 ft of H2O + 76 ft
= 233 feet

$$\frac{\text{Work}}{\text{Time}} = \frac{(\text{unit weight water})(\text{discharge})(\text{head})}{(\text{efficiency})}$$

$$\text{Discharge} = \frac{(\text{efficiency})(\text{work/time})}{(\text{unit weight water})(\text{head})}$$

$$= \frac{(\text{efficiency})(398280 \text{ ft-lb/min})}{(62.2 \text{ lb/ft}^3)(233 \text{ ft})}$$

$$= (\text{efficiency})(27.48 \text{ ft}^3/\text{min})$$

An estimate of the efficiency of the pump was used in the above equation to calculate the discharge. This calculated discharge was compared to the performance graph of efficiency versus discharge supplied by the pump manufacturer, and a new estimate of efficiency was determined. This new estimate of efficiency was used in the above equation. This process was repeated until the value of discharge remained constant. Using this method, the discharge of the pump in well J1 averaged:

148 gallons/minute

or

19.8 feet^3/minute

Error Analysis:

Discharge = 19.8 $feet^3$/minute $\pm$ 10%
slope = 0.17 $\pm$ .02 feet = $\pm$ 12%

T = 21.3 $\pm$ 22% $feet^2$/minute

PUMP TESTS

Table Mountain Aquifer

Two brief pump tests and a recovery test were performed on well R2 in May, 1980. Well R2 is 400 feet deep. The water levels in well R2 and well R1 350 feet away were monitored during the tests. Only well R2 showed a change in the water level. The pump tests were abbreviated because the pump was only about 40 feet below the surface of the water; as a result, the pump began sucking air shortly after the start of the test. The discharge from the pump was measured with a 2.5 gallon bucket and a stop watch. The discharge averaged 8 gallons/minute.

Pump Test #1

$Q = 1.1 \text{ feet}^3/\text{minute} \pm 10\%$
slope $= 30.0$ feet $\pm 2\%$

$$T = \frac{(2.3)(1.1 \text{ ft}^3/\text{min})}{4\pi\ (30.0 \text{ ft})}$$

$$T = 6.7 \times 10^{-3} \text{ feet}^2/\text{minute} \pm 12\%$$

Recovery Test

$Q = 1.1 \text{ feet}^3/\text{minute} \pm 10\%$
slope $= 82.4$ feet $\pm 1\%$

$$T = \frac{(2.3)(1.1 \text{ ft}^3/\text{min})}{4\pi\ (82.4 \text{ ft})}$$

$$T = 2.4 \times 10^{-3} \text{ feet}^2/\text{minute} \pm 11\%$$

Pump Test #2

$Q = 1.1$ feet^3/minute $\pm$ 10%
slope = 41.7 feet $\pm$ 1%

$$T = \frac{(2.3)(1.1\ ft^3/min)}{4\Pi\ (41.7\ ft)}$$

$T = 4.8 \times 10^{-3}$ feet^2/minute $\pm$ 11%

Mean of three tests:

$T = 4.6 \times 10^{-3}$ feet^2/minute $\pm$ 12%, or

$T = 4.3 \times 10^{4}$ meter^2/minute

PUMP TEST DATA FOR WELL R2. STATIC WATER LEVEL = 110.8 FEET

Time Since Start of Pump Test (Minutes)	Drawdown (feet)
1	2.4
2	5.3
3	7.6
4.5	11.6
6	13.6
9	19.2
11	21.4
14 pump automatic shut off tripped	
18	20.9
21	26.9
24	32.2
28	38.5
31 pump sucking air, shut off	
Start of Recovery Test	
34	38.5
36	37.6
37	36.6
38	35.9
39	35.2
40	34.4
41	33.9
42	33.0
43	32.3
44	31.7

Time (minutes)	Drawdown (feet)
45	31.1
46	30.5
47	29.8
48	29.3
49	28.8
50	28.3
51	27.9
52	27.4
53	26.9
54	26.4
55	25.9
56	25.4
57	24.9
58	24.5
59	24.1
60	23.7
61	23.3
62	22.9
63	22.6
64	22.2
65	21.9
66	21.5
67	21.2
68	20.8
70	20.2

Time Since Start of Pump Test (Minutes)	Drawdown (feet)
71	20.0
72	19.8
73	19.5
74	19.3
75	19.1
76	18.8
78	18.4
80	17.9
82	17.3
84	16.8
86	16.4
88	15.9
90	15.5
92	15.1
94	14.7
96	14.3
98	13.8
100	13.4
102	13.0
104	12.8
106	12.4
108	12.2
111	11.8
116	11.3
121	10.7
126	10.2

Time (minutes)	Drawdown (feet)
131	9.8
136	9.4
146	8.6
161	7.7
166	7.5
196	6.4
226	5.6
256	5.2
276	4.9

Start Pump Test #2

Time Since Start of Pump Test #2 (minutes)	Total Drawdown (feet)
0	4.9
0.5	6.8
1.0	8.1
1.5	9.4
2.0	11.0
2.5	12.1
3.0	13.3
3.5	15.1
4.0	16.3
5.0	18.7
6.0	20.4
7.0	22.5
8.0	24.9
9.0	27.0
10.0	28.9
11.0	30.7

(Continued)

Time Since Start of Pump Test #2 (minutes)		Total Drawdown (feet)
13.0		34.6
16.0		38.8
17.0	Pump sucking air, end test	

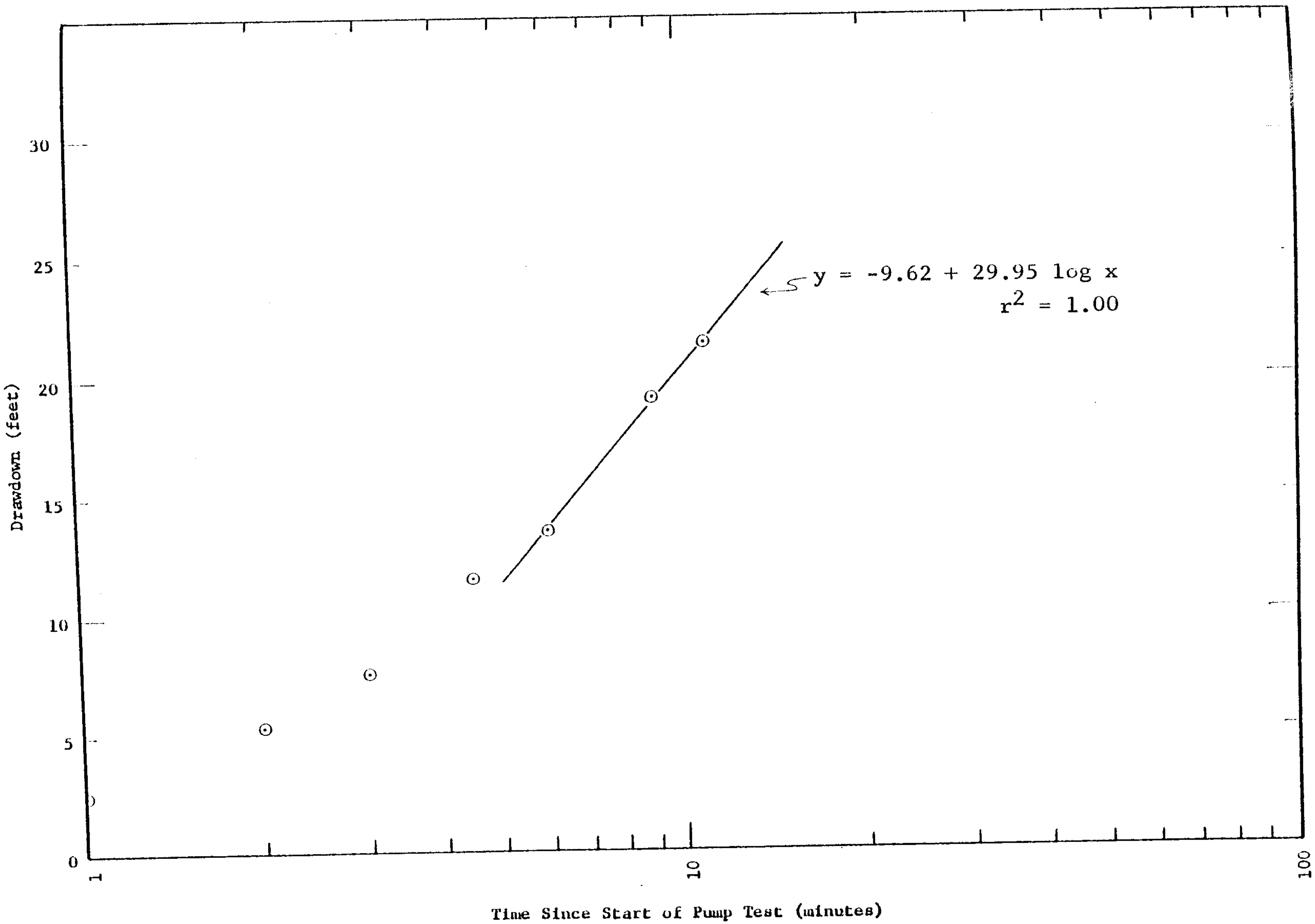

Table 43. Table Mountain Aquifer, Pump Test #1, Well R2

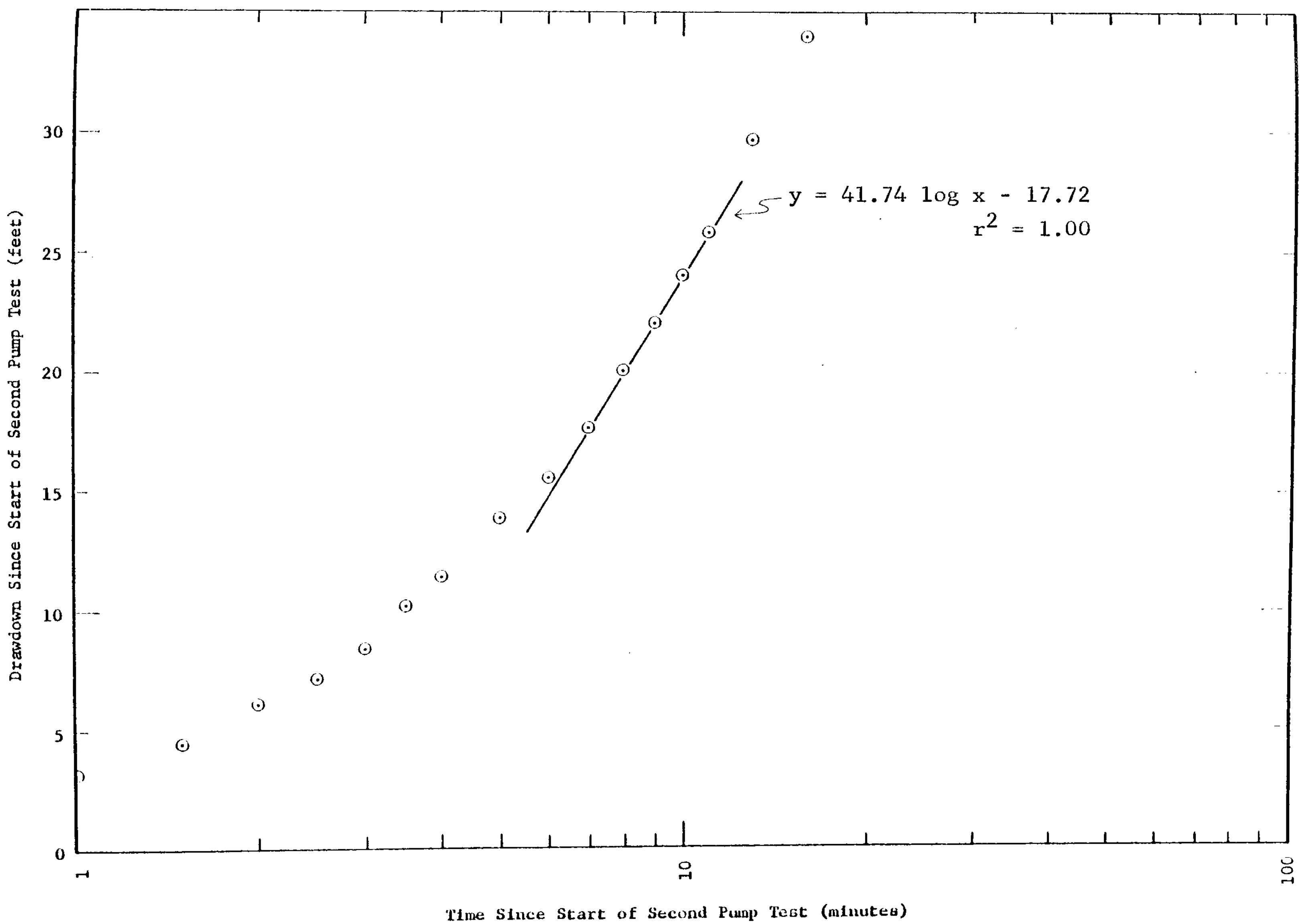

Figure 44. Table Mountain Aquifer, Pump Test #2, Well R2

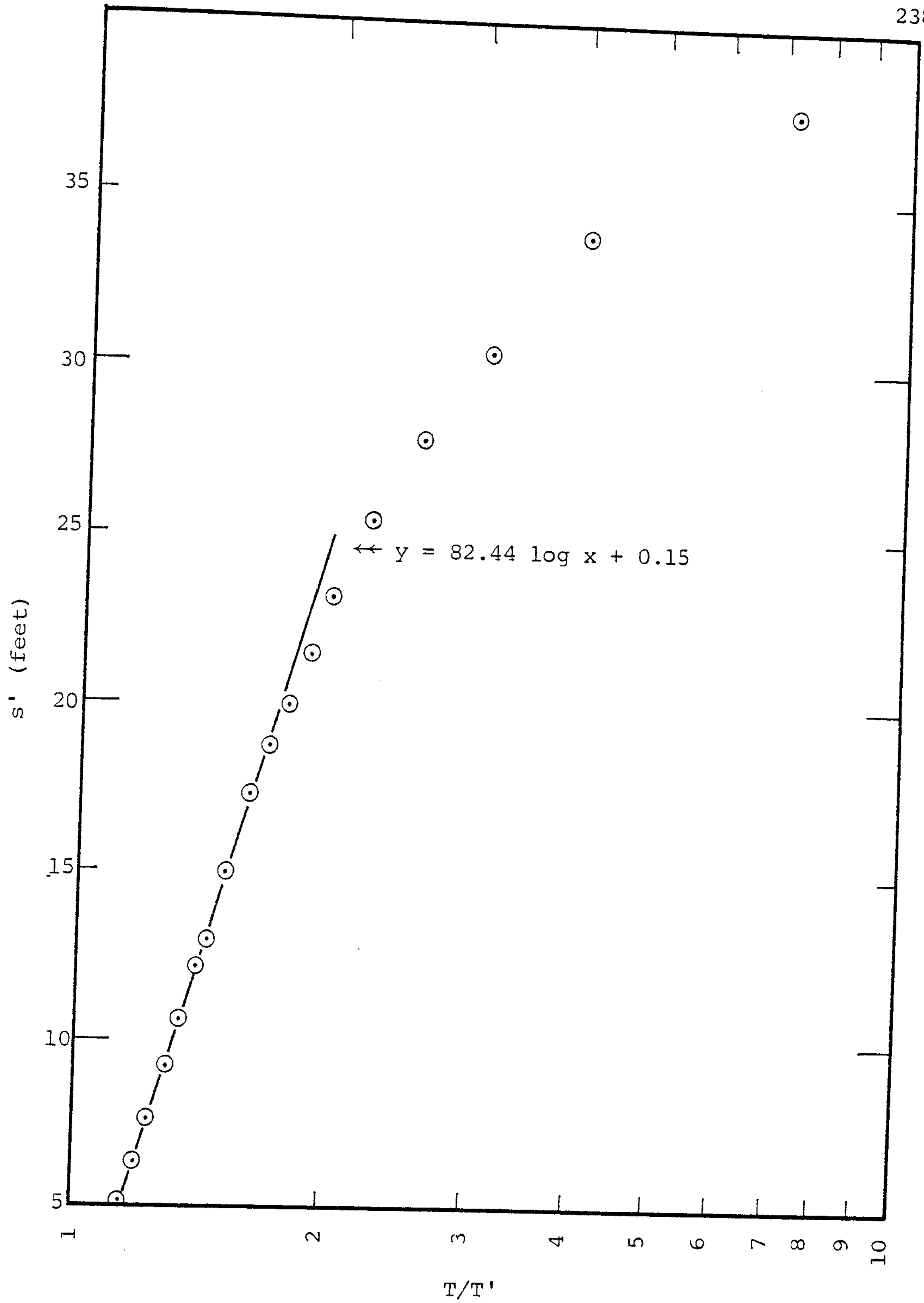

Figure 45. Table Mountain Aquifer, Recovery Test, Well R2

APPENDIX J

ELECTRICAL RESISTIVITY DATA AND ANALYSIS

Electrical Resistivity Soundings

Four successful electrical resistivity soundings were made in Jacumba Valley. A Bison Earth Resistivity Transmitter Model 2390-T50 and a Bison Earth Resistivity Receiver Model 2390 R were used in Schlumberger arrays. Calculation of the apparent resistivity used the following equation:

$$\rho = \pi \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \frac{\Delta V}{I}$$

AB = Outer electrode spacing

MN = Inner electrode spacing

ΔV = Potential difference

I = Induced current

Computer interpretation of the data was done with a program (Auto-interpret Ves with Mdz and convolution) by Adel A. R. Zody (1973).

DATA FOR ELECTIFCAL RESISTIVITY SOUNDING #1

Electrical Resistivity Sounding #1

AB/2 (feet)	MN/2 (feet)	V (millivolts)	I (milliamps)	$\overline{\rho}$ (ohm-feet)
10	2	81.7	20.2	305
15	2	30.7	20.2	264
20	2	17.8	20.2	274
25	2	13.3	20.2	321
30	2	10.2	20.2	355
40	2	6.7	20.2	416
50	2	5.7	20.2	553
60	2	4.70	20.2	657
50	10	24.0	20.2	448
60	10	18.1	20.2	493
80	10	12.80	20.2	627
100	10	8.73	20.2	672
125	10	6.59	20.2	796
125	20	11.87	20.2	703
150	20	8.49	20.2	730
175	20	6.82	20.2	801
200	20	5.32	20.2	819
200	40	9.62	20.2	718
250	40	5.19	20.2	614
300	40	2.54	20.2	437
300	60	3.58	20.2	401
350	60	2.11	20.2	325
400	60	1.00	20.2	203
450	60	0.662	20.2	171
450	80	1.355	20.2	258
400	80	0.755	20.2	113

DATA FOR ELECTRICAL RESISTIVITY SOUNDING #1 (Continued)

$\frac{AB}{2}$ (feet)	$\frac{MN}{2}$ (feet)	V (millivolts)	I (milliamps)	$\bar{\rho}$ (ohm-feet)
500	80	1.635	20.2	387
600	80	2.27	20.2	780
600	70	1.646	20.2	649
500	70	2.20	20.2	599
400	70	2.86	20.2	493
700	70	5.53	20.2	2980
800	70	7.37	20.2	5200
800	160	16.56	20.2	4945
900	160	23.4	20.2	8920
1000	160	20.7	20.2	9803
1500	160	2.24	20.2	2422

Electrical Resistivity Sounding #1
Computer Interpretation

AB/2 (feet)	Calculated VES (ohm-feet)
10.0	274
14.7	281
21.5	310
31.6	377
46.4	491
68.1	640
100.0	803
146.8	944
215.4	1007
316.2	965
464.2	896
681.3	943

Reduced Thickness (feet)	Reduced Depth (feet)	Reduced Resistivity (ohm-feet)
2	2	319
18	20	259
88	108	2020
169	277	300
Infinite	Infinite	4464

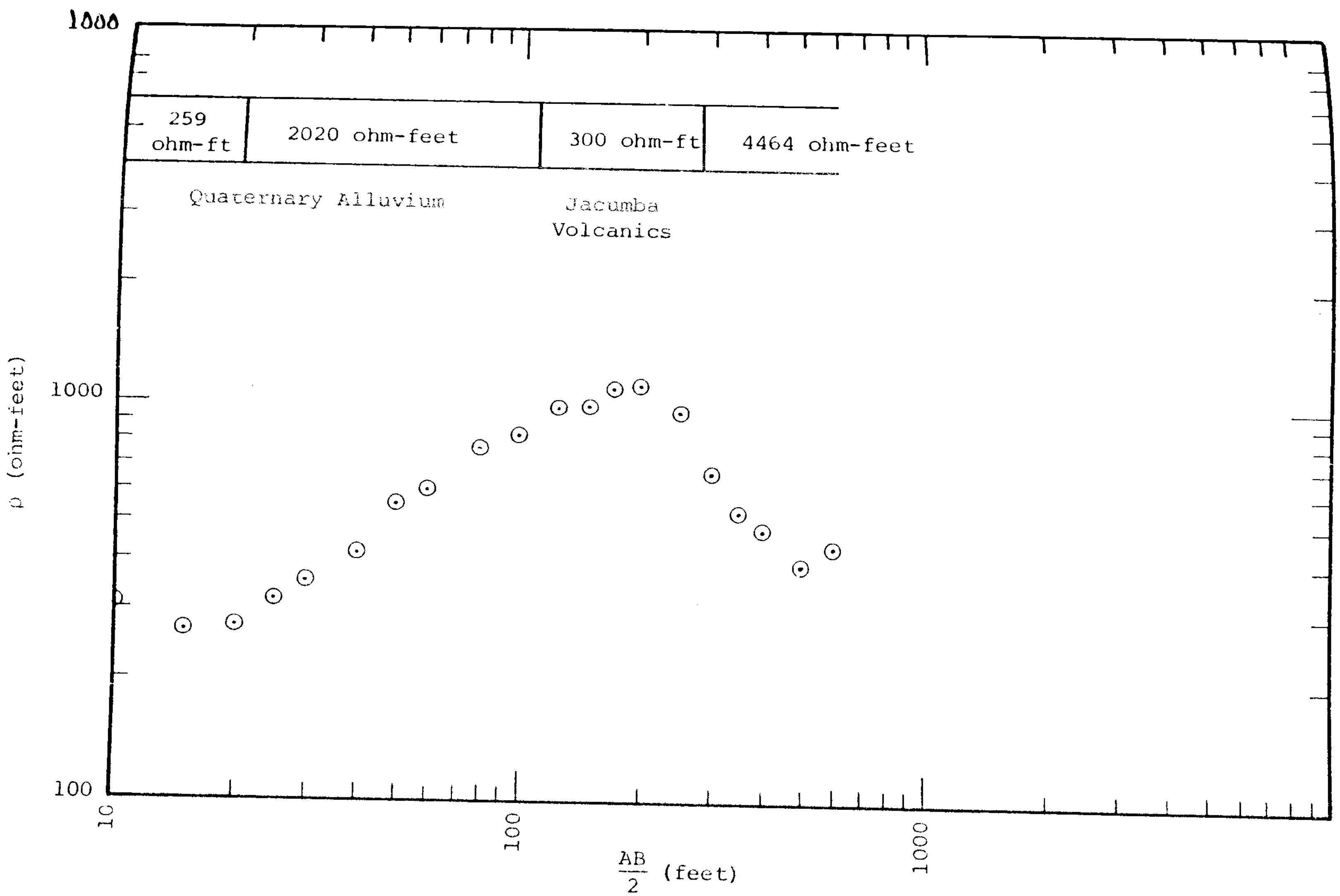

Figure 46. Electrical Resistivity Sounding #1. Corrected data plot and computer interpretation.

DATA FOR ELECTRICAL RESISTIVITY SOUNDING #2

Electrical Resistivity Sounding #2

AB/2 (feet)	MN/2 (feet)	V (millivolts)	I (milliamps)	$\bar{\rho}$ (ohm-feet)
10	2	22.0	20.2	82
15	2	11.0	20.2	95
20	2	7.0	20.2	108
25	2	4.77	20.2	115
30	2	3.49	20.2	122
40	2	2.19	20.2	136
50	2	1.45	20.2	141
50	10	7.13	20.2	133
60	10	4.83	20.2	131
70	10	3.47	20.2	130
80	10	2.57	20.2	126
100	10	1.50	20.2	115
100	20	2.89	20.2	108
125	20	1.581	20.2	94
150	20	1.009	20.2	87
175	20	0.727	20.2	85
200	20	0.556	20.2	86
200	40	1.155	20.2	86
250	40	0.743	20.2	88
300	40	0.511	20.2	88
400	40	0.299	20.2	92
400	80	0.607	20.2	91
500	80	0.423	20.2	100
600	80	0.324	20.2	111
700	80	0.248	20.2	117
700	140	0.416	20.2	109

DATA FOR ELECTRICAL RESISTIVITY SOUNDING #2 (Continued)

$\frac{AB}{2}$ (feet)	$\frac{MN}{2}$ (feet)	V (millivolts)	I (milliamps)	$\bar{\rho}$ (Ohm-feet)
800	140	0.388	20.2	134
900	140	0.266	20.2	117
1000	140	0.231	20.2	126
1000	200	0.341	20.2	127
1200	200	0.286	20.2	156
1500	200	0.193	20.2	166

Electrical Resistivity Sounding #2
Computer Interpretation

AB/2 (feet)	Calculated VES (ohm-feet)
10.0	101
14.7	110
21.5	116
31.6	120
46.4	121
68.1	119
100.0	113
146.8	105
215.4	102
316.2	107
464.2	118
681.3	133
1000.0	157
1467.8	198

Reduced Thickness (feet)	Reduced Depth (feet)	Reduced Resistivity (ohm-feet)
3	3	73
56	59	126
81	140	75
674	814	133
Infinite	Infinite	1009

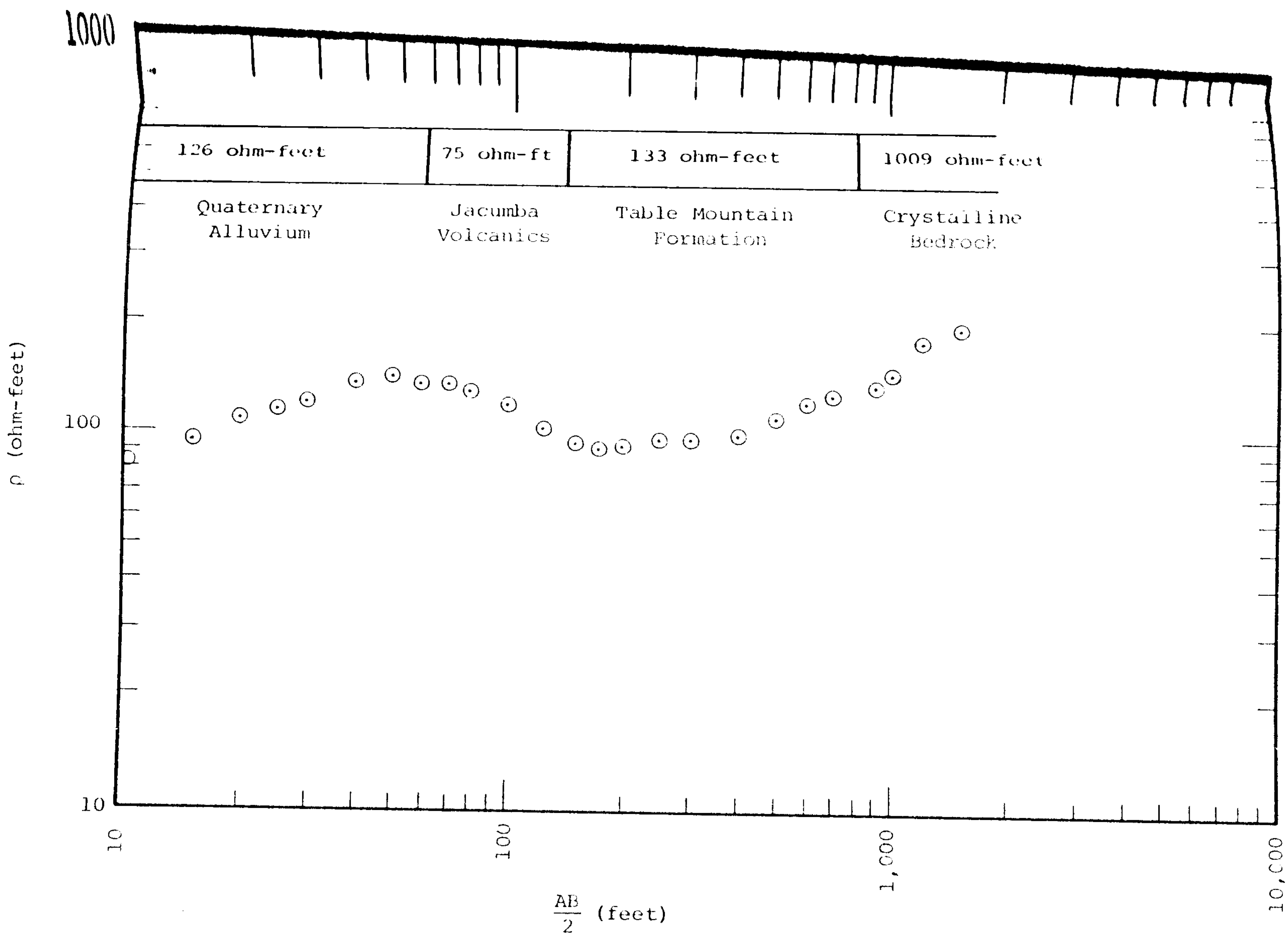

Figure 47. Electrical Resistivity Sounding #2. Corrected data plot and computer interpretation.

DATA FOR ELECTRICAL RESISTIVITY SOUNDING #3

Electrical Resistivity Sounding #3

AB/2 (feet)	MN/2 (feet)	V (millivolts)	I (milliamps)	$\bar{\rho}$ (ohm-feet)
10	2	133.7	20.2	499
15	2	45.8	20.2	394
20	2	23.5	20.2	362
30	2	10.24	20.2	357
40	2	6.13	20.2	380
50	2	4.19	20.2	407
60	2	2.93	20.2	410
70	2	2.16	20.2	411
80	2	1.605	20.2	399
100	2	0.957	20.2	372
100	20	9.30	20.2	347
125	20	5.28	20.2	313
150	20	3.37	20.2	290
200	20	1.624	20.2	250
200	40	3.50	20.2	261
300	40	0.915	20.2	157
400	40	0.426	20.2	131
400	80	0.875	20.2	131
500	80	0.509	20.2	121
600	80	0.338	20.2	116
600	120	0.462	20.2	103
800	120	0.240	20.2	97
1000	120	0.167	20.2	107
1000	200	0.260	20.2	97
1200	200	0.185	20.2	101
1500	200	0.139	20.2	119

Electrical Resistivity Sounding #3
Computer Interpretation

AB/2 (feet)	Calculated VES (ohm-feet)
10.0	452
14.7	418
21.5	401
31.6	403
46.4	412
68.1	411
100.0	380
146.8	318
215.4	241
316.2	170
464.2	126
681.3	111
1000.0	119
1467.8	140

Reduced Thickness (feet)	Reduced Depth (feet)	Reduced Resistivity (ohm-feet)
4	4	577
21	24	375
25	49	583
89	138	260
520	659	87
Infinite	Infinite	257

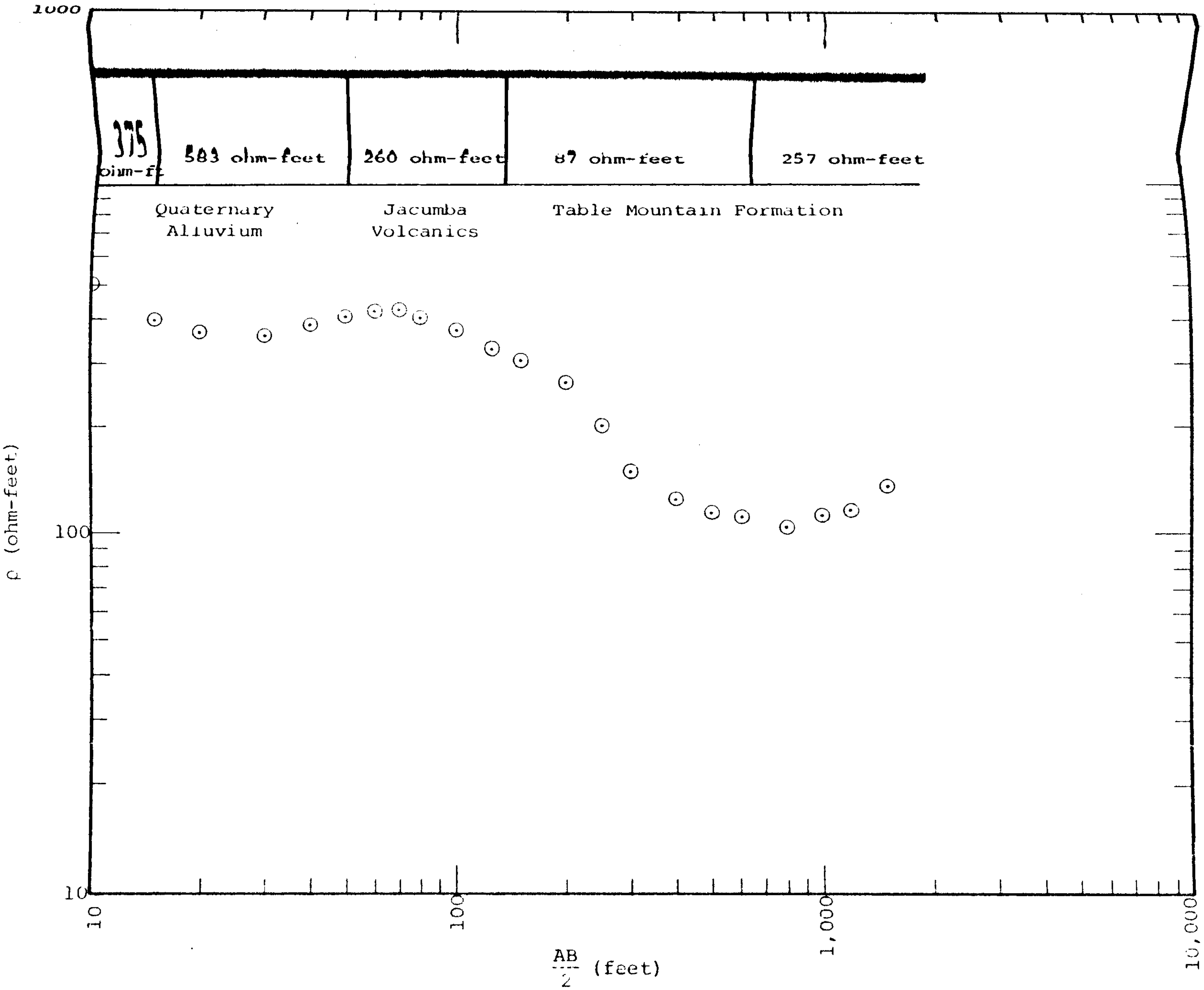

Figure 48. Electrical Resistivity Sounding #3. Corrected data plot and computer interpretation.

DATA FOR ELECTRICAL RESISTIVITY SOUNDING #4

Electrical Resistivity Sounding #4

AB/2 (feet)	MN/2 (feet)	V (millivolts)	I (milliamps)	$\bar{\rho}$ (ohm-feet)
10	2	56.0	20.2	209
15	2	18.4	20.2	158
20	2	7.88	20.2	121
25	2	3.81	20.2	92
30	2	2.14	20.2	75
40	2	0.841	20.2	52
50	2	0.418	20.2	41
50	10	1.967	20.2	37
60	10	1.139	20.2	31
70	10	0.736	20.2	27
80	10	0.504	20.2	25
100	10	0.287	20.2	22
100	20	0.550	20.2	21
150	20	0.236	20.2	20
200	20	0.136	20.2	21
200	40	0.236	20.2	18
250	40	0.154	20.2	18
300	40	0.112	20.2	19
300	60	0.158	20.2	18
400	60	0.108	20.2	22
500	60	0.084	20.2	27
500	100	0.117	20.2	22
600	100	0.108	20.2	29
800	100	0.077	20.2	38
900	100	0.071	20.2	44

Electrical Resistivity Sounding #4

Computer Interpretation

AB/2 (feet)	Calculated VES (ohm-feet)
10.0	206
14.7	156
21.5	106
31.6	70
46.4	48
68.1	33
100.0	25
146.8	22
215.4	24
316.2	29
464.2	39
681.3	56

Reduced Thickness (feet)	Reduced Depth (feet)	Reduced Resistivity (ohm-feet)
7	7	266
20	27	67
226	253	18
Infinite	Infinite	2971

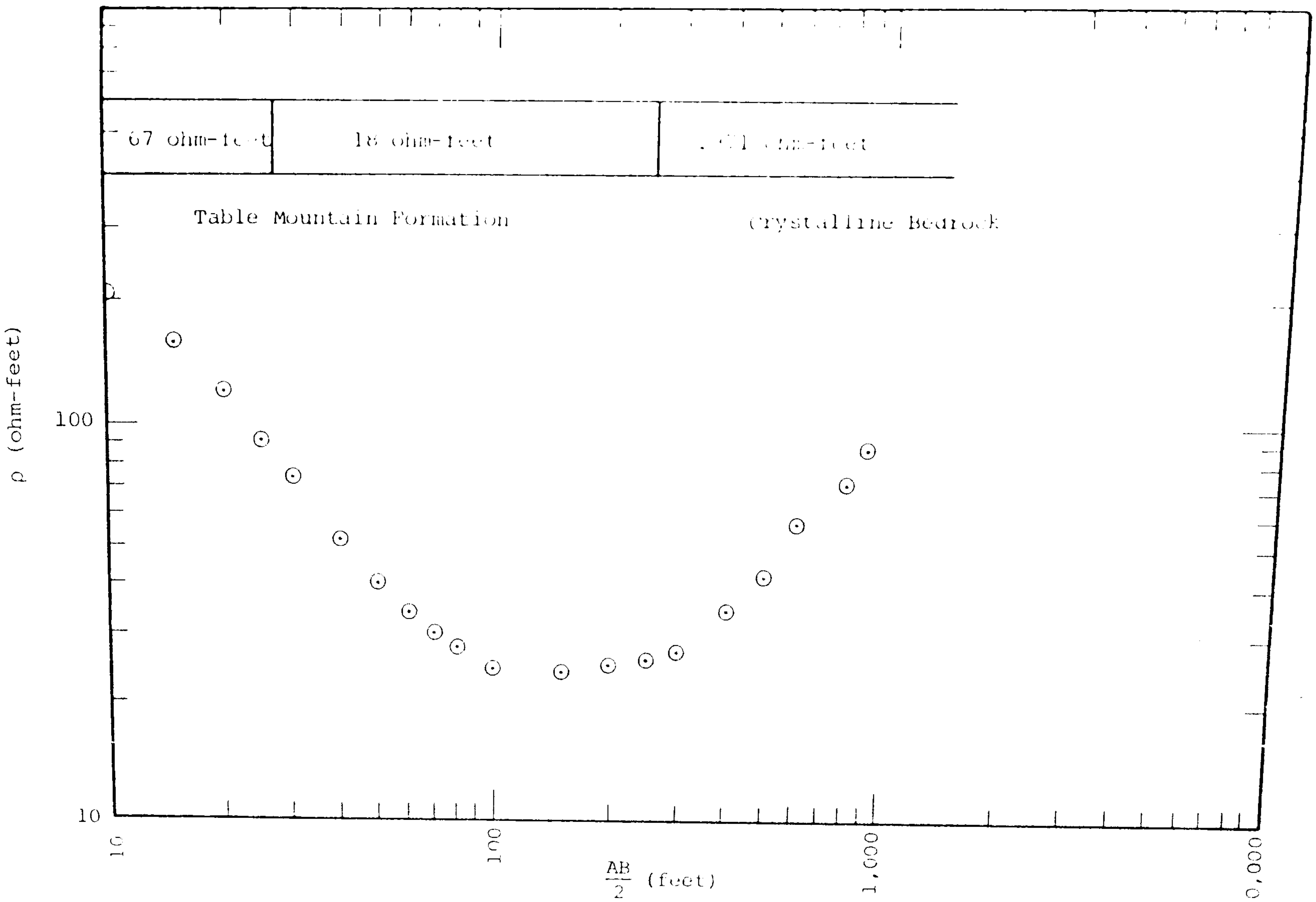

Figure 49. Electrical Resistivity Sounding #4. Corrected data plot and computer interpretation.

GROUND WATER CHEMISTRY

Collection and Analysis of Ground Water Samples

Sample J3A: collected from well head after pumping for 5 minutes.

Sample Km: collected from holding tank.

Sample J1: collected from well head after pumping for 10 minutes.

Sample R2: collected from holding tank.

Sample JHS: collected from well head, pump continuously operating.

Sample Ma: collected from standing pond.

Sample Mb: collected from standing pond.

Field Methods of Analysis (Hach, 1973)

Temperature: 100°C mercury thermometer

pH: pH paper (Hydrion)

Alkalinity: Phenolphthalein-brom cresol green-methyl red titrimetric method (Hach Kit)

H_2S:. Has generation method (Hach Kit)

CO_2: Titrimetric method for free carbon dioxide (Hach Kit)

Laboratory Methods of Analysis (American Public Health Assn., 1976)

Ca: EDTA titrimetric method

Mg: same as Ca

Total Hardness: Same as Ca

Na: Flame emission (Instrumentation Laboratory aa/ae Model 151)

K: Flame emission (Instrumentation Laboratory aa/ae Model 151)

Laboratory Methods (continued)

Fe:	Atomic absorption (Instrumentation Laboratory aa/ae Model 151)
Mn:	Atomic absorption (Instrumentation Laboratory aa/ae Model 151)
Li:	Flame emission (Instrumentation Laboratory aa/ae Model 151)
SiO2:	Molybdosilicate method (Hitachi Spectrophotometer Model Number 60)
Cl:	Mercuric nitrate titrimetric method
SO4:	Gravimetric method with drying of residue
Br:	Selective ion probe (Bechman Monitor II)
F:	Selective ion probe (Bechman Monitor II)

All constituents were analyzed within the time constraints recommended by the American Public Health Association (1976).

Results of the Chemical Analyses Performed by the Author

	J3A	Km	J1	R2	JHS	Ma	Mb
Cl (mg/l)	80	125	155	68	86	126	99
SO4 (mg/l)	57	83	222	87	17	62	23
HCO3 (mg/l)	159	293	183	183	35	88	150
CO3 (mg/l)	0	0	0	0	35	0	0
Ca (mg/l)	32	53	57	36	2.2	4.2	16
Mg (mg/l)	26.	38	40	32	0.1	1.7	3.0
Na. (mg/l)	70	95	118	56	100	128	95
K (mg/l)	2.1	2.2	3.1	5.6	0.5	4.0	10.5
SiO2 (mg/l)	39	29	38	39	48	51	34
Fe (mg/l)	0.001	0	0.001	0.001	0	0.016	0.031
F (mg/l)	1.15	2.0	2.2	1.1	7.8	7.5	5.2
Br (mg/l)	1.55	2.08	2.80	1.50	30.0	7.0	4.0
Li (mg/l)	0.001	0.001	0.001	0	0.001	0	0
Mn (mg/l)	0	0	0	0	0	0	0.008
CO2 (mg/l)	52	76	34	44	0	-	-
pH	6	6	6	5	8	6	6
calculated TDS (mg/l)	468	722	821	510	362	480	440
total hardness as CaCO3 (mg/l)	185	290	310	220	5	17.	50-55
calcium hardness as CaCO3 (mg/l)	80	133	140	90	5-6	10-11	40
magnesium hardness as CaCO3 (mg/l)	105	157	164	130	0.5	7	10-15
temperature °C	19	-	22	-	38.5	-	-

Ground Water Chemistry from Thesken (1977)

	T1	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Cl (ppm)	94	102	104	1050	129	60	80	350	145	92	350
SO4 (ppm)	29	53	12	420	66	37.5	58	399	296	45	99
HCO3 (ppm)	210	104	24	140	203	170	160	220	70	185	152
CO3 (ppm)	0	0	66	0	0	0	0	0	0	0	0
Ca (ppm)	69	27	1.2	440	77	56	64	232	110	78	142
Mg (ppm)	19	8.1	0.83	182	21	20	36	63	151	22	28
Na (ppm)	27	110	106	350	84	27	27	84	42	32	74
K (ppm)	2	1.8	1.2	7.5	2.5	0.5	0.5	8.7	14	4	2.2
SiO2 (ppm)	42	47	52	46	37	46	47	24	53	40	44
B (ppm)	-	0.50	0.64	-	0.16	-	-	-	-	-	-
Li (ppm)	-	0.046	0.036	-	0.041	-	-	-	-	-	-
Fe (ppm)	0.07	0.17	0.01	0.22	0	0.15	0.05	7.9	3.2	0.21	0.15
TDS (ppm)	492	453	367	2636	620	417	473	1388	884	498	891
pH	6.0	5.7	6.8	6.0	5.9	5.8	5.8	5.5	5.5	6.0	5.8
temperature °C	27	26	38	25	25	20	20	22	22	22	21

Ground Water Chemistry Data from Previous Studies

	Jacumba Cold Sp. (Brown, 1923)	Jacumba Cold Sp., 1951 (C.S.D.P.H.)	Jacumba Cold Sp. (Babcock, 1958)	Well J3, 1964 (C.S.D.P.H.)	Well J3A, 1966 (C.S.D.P.H.)	Well J4, 1972 (C.S.D.P.H.)	Well J1, 1957 (C.S.D.P.H.)	Well J1 (Babcock, 1958)	Well J2, 1963 (C.S.D.P.H.)	Well 18S/8E 9H (Babcock, 1958)	Jacumba Hot Sp. (Waring, 1915)	Well JHS, 1960 (C.S.D.P.H.)
Cl (ppm)	61	92	82	123	123	103	210	151	180	187	77	201
SO4 (ppm)	30	46	35	52	54	78	310	116	320	270	32	260
HCO3 (ppm)	222	202	32	218	212	184	-	320	201	188	42	228
CO3 (ppm)	0	-	29	-	-	0	-	0	-	0	23	-
Ca (ppm)	43	58	0	65	69	64	139	87	113	147	2.4	-
Mg (ppm)	13	18	1	17	18	14	35	24	34	54	0.1	47
Na (ppm)	64	73	105	84	82	83	156	103	152	54	101	140
K (ppm)			0.6	2.4	2.0	3.1	3	2.6	2.4	6.2	1.2	3.2
SiO2 (ppm)	39	-	-	36	35	42	-	-	40	-	56	35
B (ppm)	-	-	0.7	-	-	0.17	-	0.4	-	-	0.6	-
Fe (ppm)	0.2	-	-	0.1	0.1	0.008	0.08	-	0	-	6.0	0
F (ppm)	-	0.4	4.0	0.8	0.3	0.3	1.2	1.3	1.3	0.5	1.8	1.2
CO2 (ppm)	-	-	-	30	14	10	-	-	11	-	-	25
TDS (ppm)	-	-	310	505	490	513	1105	815	940	1135	316	915
pH	-	6.7	8.8	7.1	7.4	7.4	-	7.6	7.5	7.7	9.3	7.2
temperature °C	-	-	-	-	-	-	-	-	-	-	35	-

(C.S.D.P.H.) - County of San Diego, Department of Public Health (1980)

Ground Water Chemistry Data from Previous Studies

	Jacumba Cold Sp. (Brown, 1923)	Jacumba Cold Sp., 1951 (C.S.D.P.H.)	Jacumba Cold Sp. (Babcock, 1958)	Well J3, 1964 (C.S.D.P.H.)	Well J3A, 1966 (C.S.D.P.H.)	Well J4, 1972 (C.S.D.P.H.)	Well J1, 1957 (C.S.D.P.H.)	Well J1 (Babcock, 1958)	Well J2, 1963 (C.S.D.P.H.)	Well 18S/8E 9H (Babcock, 1958)	Jacumba Hot Sp. (Waring, 1915)	Well JHS, 1960 (C.S.D.P.H.)
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CO3 (ppm)	0	-	29	-	-	0	-	0	-	0	23	-
Ca (ppm)	43	58	0	65	69	64	139	87	113	147	2.4	-
Mg (ppm)	13	18	1	17	18	14	35	24	34	54	0.1	47
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K (ppm)			0.6	2.4	2.0	3.1	3	2.6	2.4	6.2	1.2	3.2
SiO2 (ppm)	39	-	-	36	35	42	-	-	40	-	56	35
B (ppm)	-	-	0.7	-	-	0.17	-	0.4	-	-	0.6	-
Fe (ppm)	0.2	-	-	0.1	0.1	0.008	0.08	-	0	-	6.0	0
F (ppm)	-	0.4	4.0	0.8	0.3	0.3	1.2	1.3	1.3	0.5	1.8	1.2
CO2 (ppm)	-	-	-	30	14	10	-	-	11	-	-	25
TDS (ppm)	-	-	310	505	490	513	1105	815	940	1135	316	915
pH	-	6.7	8.8	7.1	7.4	7.4	-	7.6	7.5	7.7	9.3	7.2
temperature °C	-	-	-	-	-	-	-	-	-	-	35	-

(C.S.D.P.H.) - County of San Diego, Department of Public Health (1980)

ABSTRACT

ABSTRACT

Jacumba Valley and its watershed cover 307 square kilometers in the southeastern corner of San Diego County and northern Baja California.

Jacumba Valley is a graben. The bedrock in the watershed is composed of metamorphics which have been intruded by plutons of the Peninsular Ranges Batholith. Unconformably overlying the bedrock is the Table Mountain Formation. This formation is up to 200 meters thick. It is a medium to coarse-grained, arkosic sandstone and conglomeratic sandstone. The Table Mountain Formation is overlain by the Jacumba Volcanics, a 90-meter-thick sequence of pyroclastics sandwiched between two 40-meter-thick sequences of basaltic lava flows. In Jacumba Valley, Quaternary alluvium overlies the volcanics and Table Mountain Formation to a maximum thickness of 45 meters. The lithology of the alluvium is mixed ranging from gravelly sand to fine sand and silt.

Shallow stress-relief fractures in the bedrock terrain supply ground water to some dwellings in the Jacumba Valley watershed.

Of the two aquifers in the subsurface of Jacumba Valley, the Table Mountain aquifer is the largest but least developed. Based on an assumed specific yield of 5%-10%, this aquifer contains an estimated 1.0×10^8-2.1×10^8 cubic meters of

recoverable water. The transmissivity is 4.3×10^{-4} meters^2/minute.

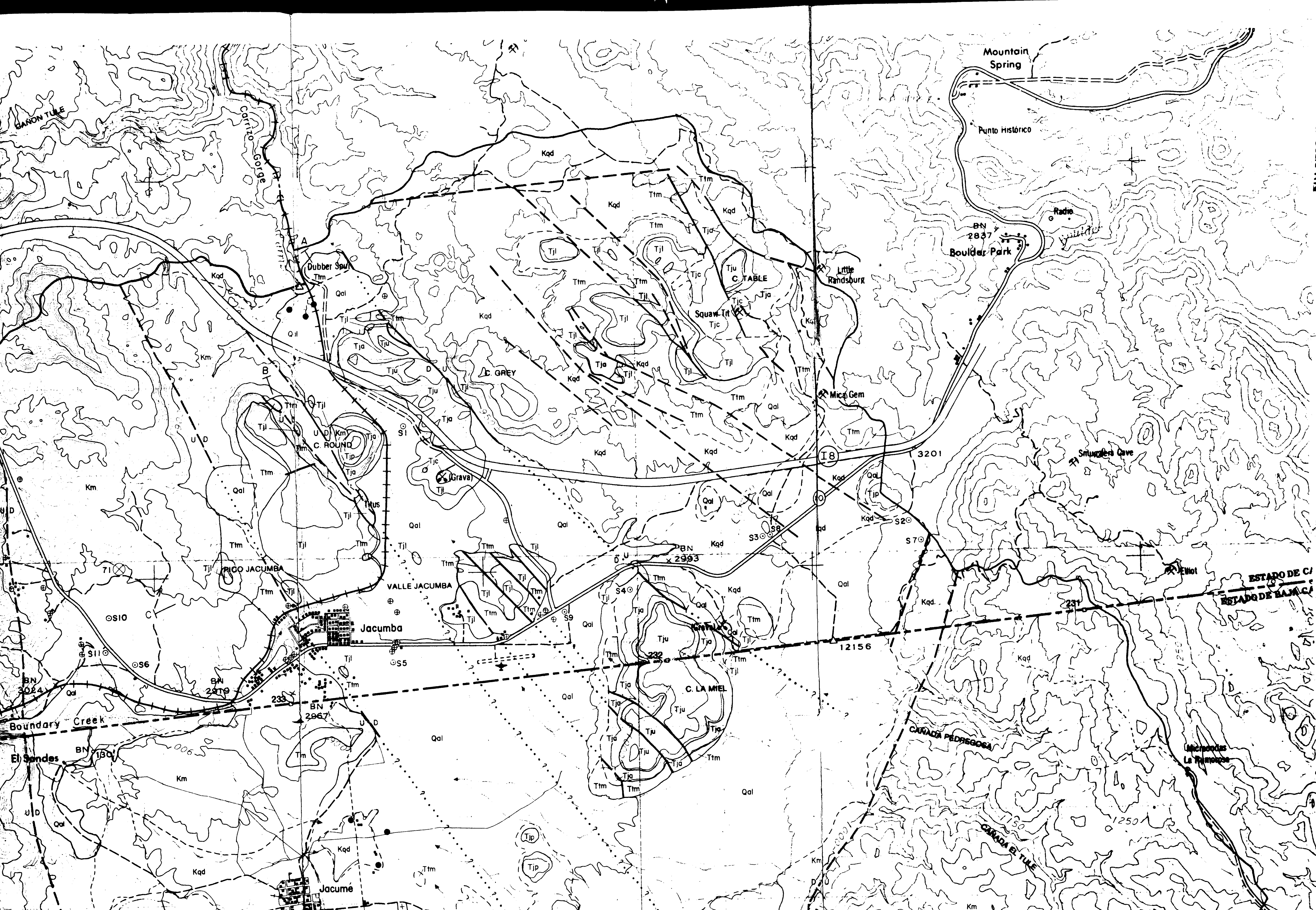
The Quaternary alluvium is currently supplying ground water to the town of Jacumba. The transmissivity of the alluvium is about 2.0 meters^2/minute. In the past, Jacumba's water supply has been threatened because of the small storage capacity of this aquifer. Based on an assumed 5%-10% specific yield, the estimated amount of recoverable water in the alluvium is 3.9×10^6-7.9×10^6 cubic meters.

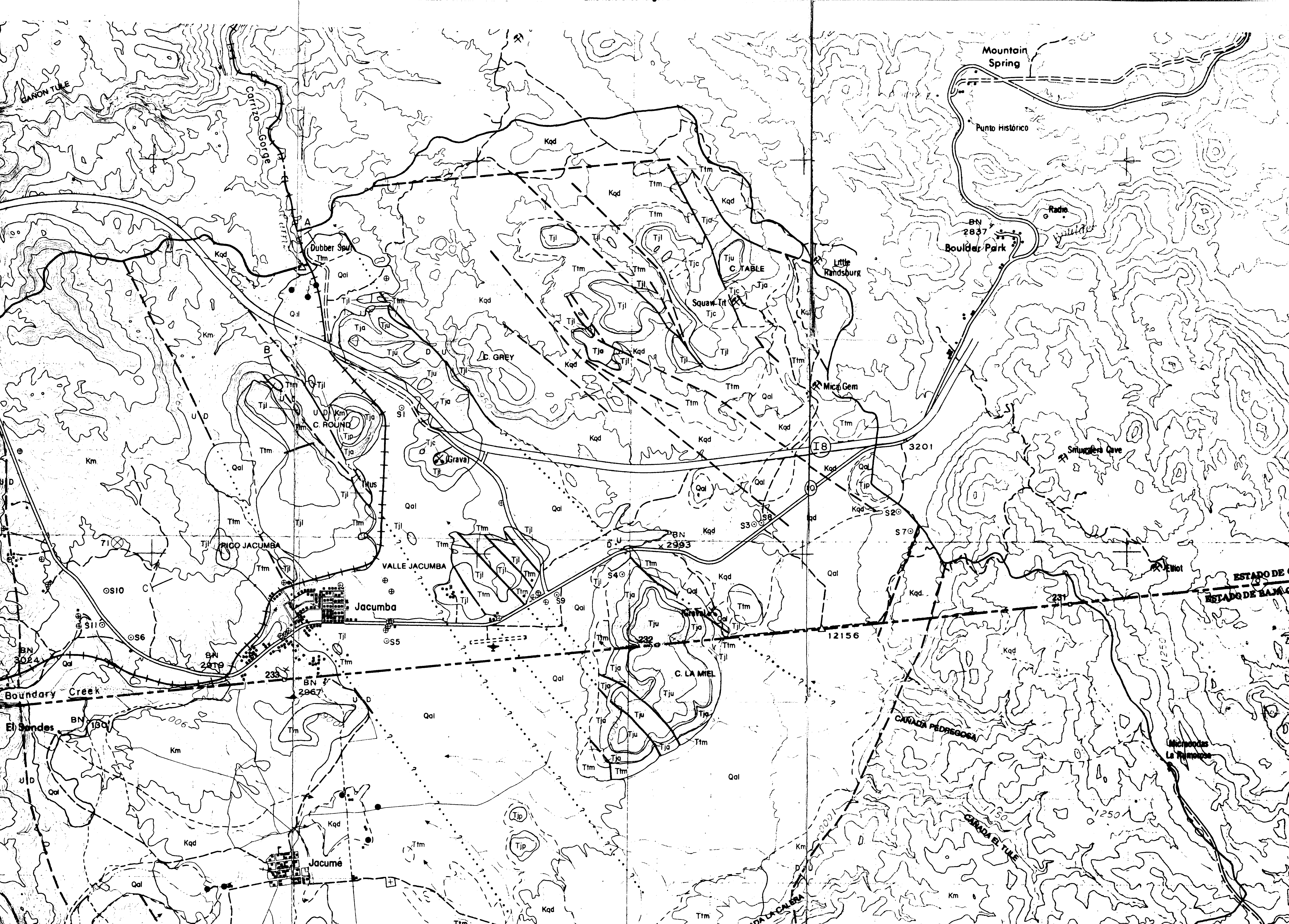
The variables considered in the ground water recharge calculations for Jacumba Valley were: precipitation, potential evapotranspiration, soil moisture deficiency, and surface runoff. The calculated mean annual ground water recharge is 3.39×10^6 cubic meters. Virtually all of the recharge is due to infiltration from precipitation.

About 90% of the calculated ground water recharge for Jacumba Valley occurs in the hills and mountains to the west and south of the valley. This recharge reaches the valley through flow in the bedrock ground water system. The ground water in Jacumba Valley's aquifers flows northward to the head of Carrizo Gorge where it is discharged through evapotranspiration, subsurface flow, and surface flow from springs.

The estimated discharge, due to evapotranspiration and subsurface flow, from the valley's ground water system is 1.19×10^6-1.84×10^6 cubic meters/year. Over long periods of time, the valley's ground water budget is balanced because springs at the north end of the valley are activated when the water table in the valley is high. During shorter periods of time, the budget can fluctuate considerably. If the water table in the valley were artifically maintained below the level that activates the springs, then a long-term ground water budget would show a net increase of between 1.55×10^6 and 2.19×10^6 cubic meters/year.

Line Reference Target LRT-BE4-V2




Mountain Spring
Punto Histórico
Radio
Boulder Park
Carrizo Gorge
Dubber Spur
Little Randsburg
C. TABLE
Squaw Tit
C. GREY
Mica Gem
C. ROUND
Titus
(Grava)
Smugglers Cave
PICO JACUMBA
VALLE JACUMBA
Jacumba
Elliot
ESTADO DE BAJA C
Boundary Creek
El Sondes
C. LA MIEL
CAÑADA PEDREGOSA
CAÑADA EL TULE
Jacumé
Kqd
Tfm
Tjl
Tju
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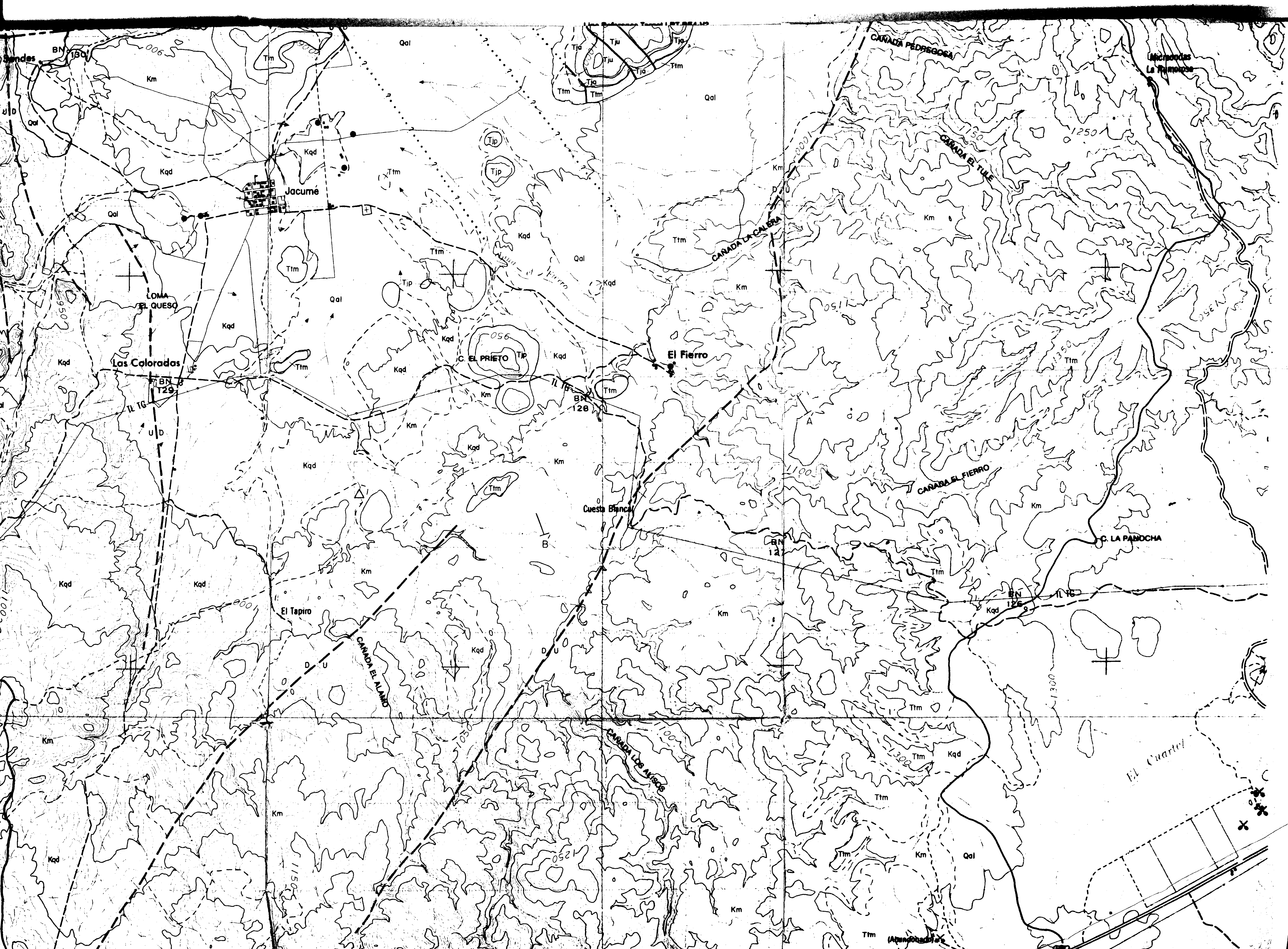
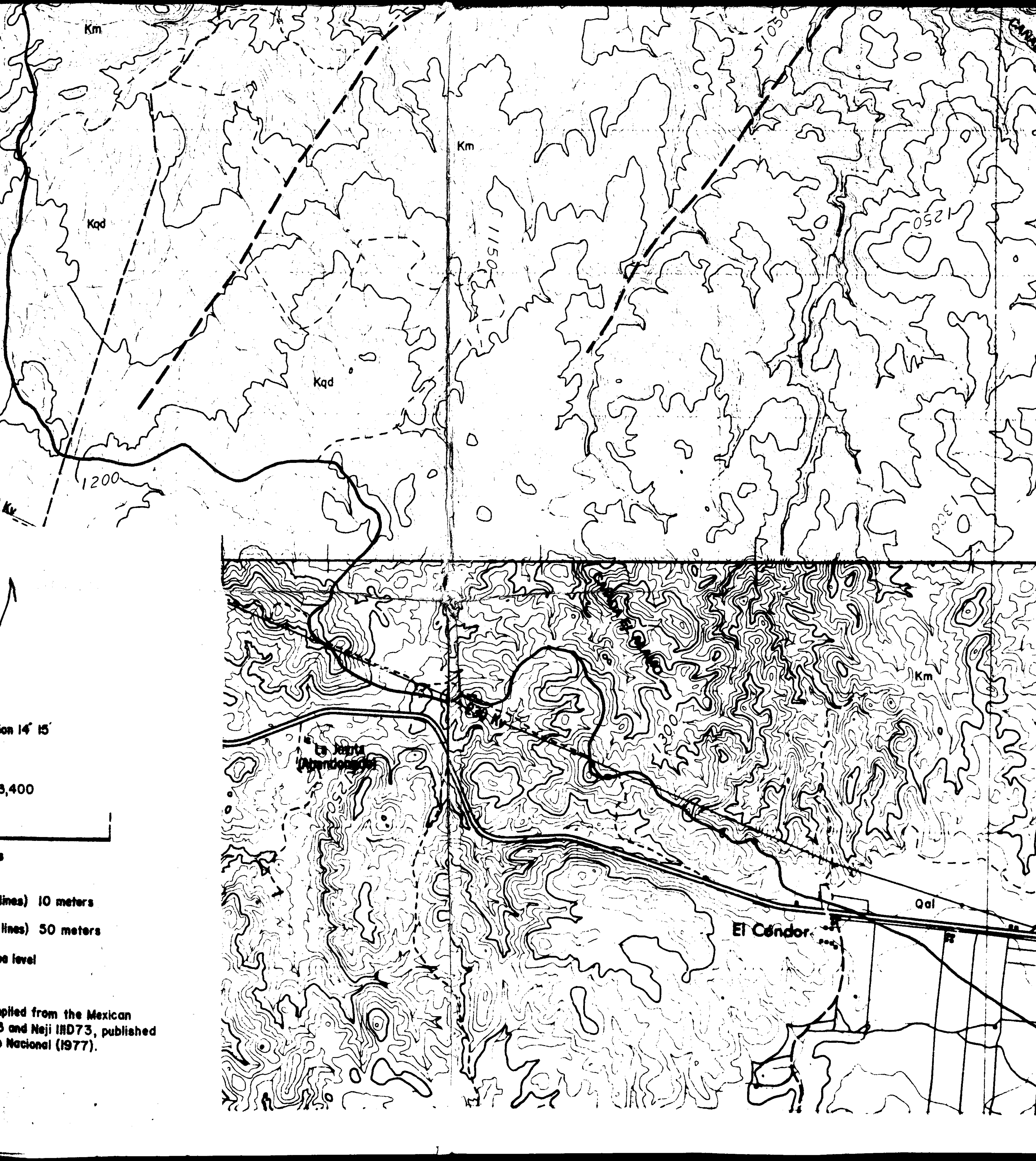


Qal
Km
Kqd
Ttm
Tjp
Jacumé
LOMA EL QUESO
Los Coloradas
BN 129
BN 128
BN 126
IL TG
C. EL PRIETO
El Fierro
Cuesta Blanca
El Tapiro
CAÑADA EL ALAMO
CAÑADA LOS ALISOS
CAÑADA LA CALERA
CAÑADA PEDREGOSA
CAÑADA EL TULE
CAÑADA EL FIERRO
C. LA PANOCHA
El Cuartel


Km
Kqd
Kqd
1200
1150
1050
1250
1300
Km
Km
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El Cóndor
ion 14' 15'
3,400
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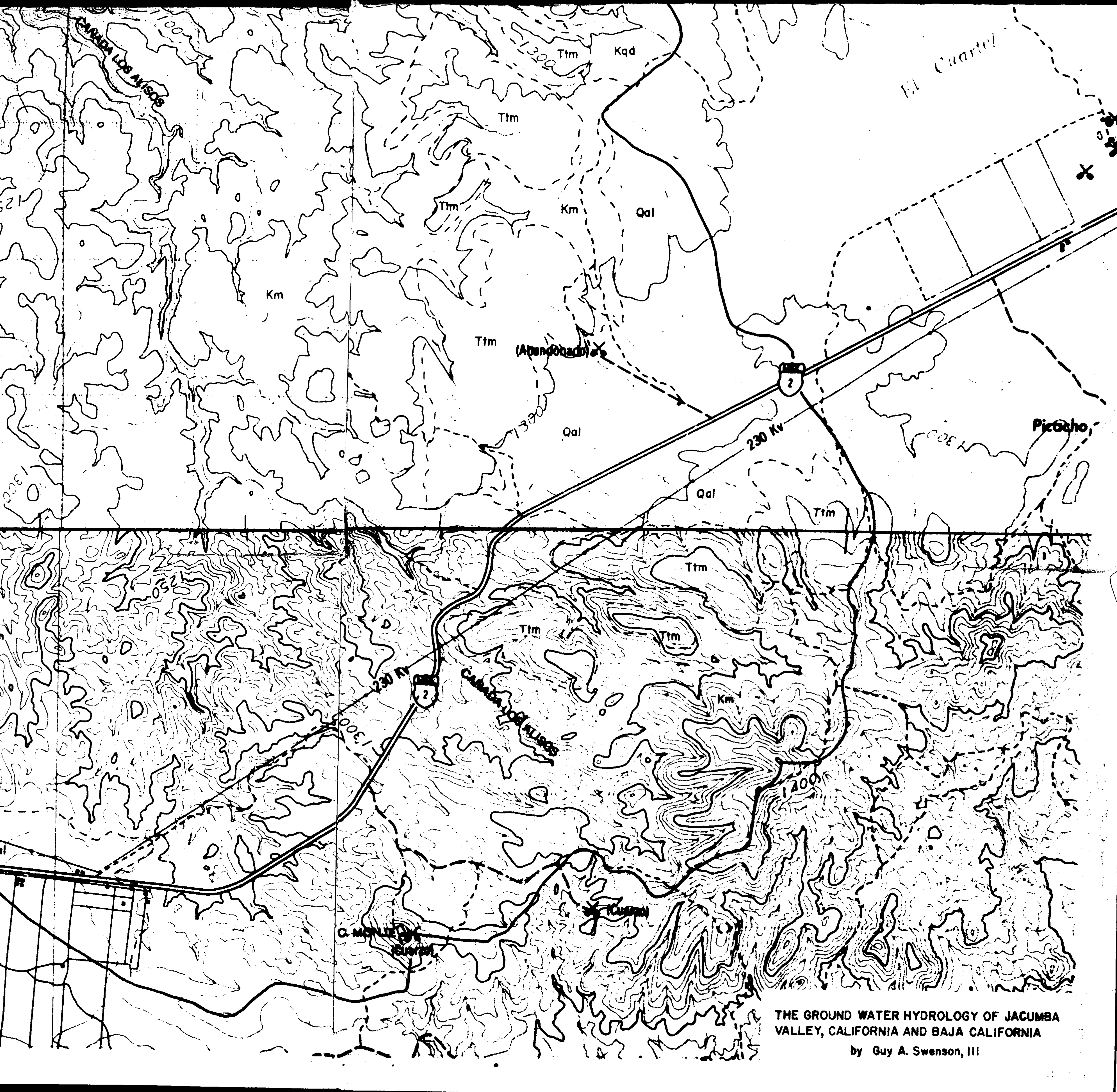
Nacional (1977).

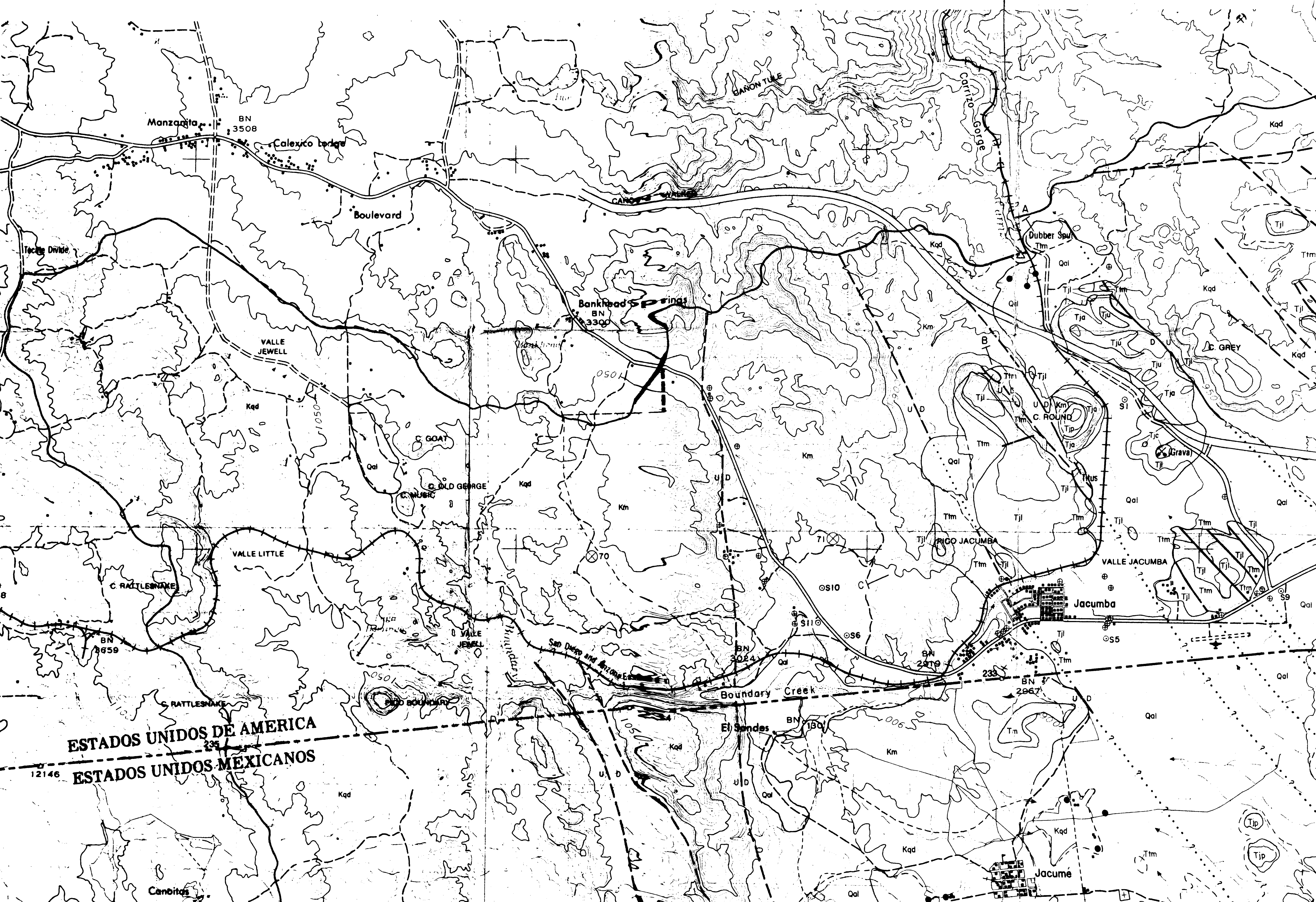


THE GROUND WATER HYDROLOGY OF JACUMBA VALLEY, CALIFORNIA AND BAJA CALIFORNIA

by Guy A. Swenson, III

Target LRT-BE4-V2

Line Reference



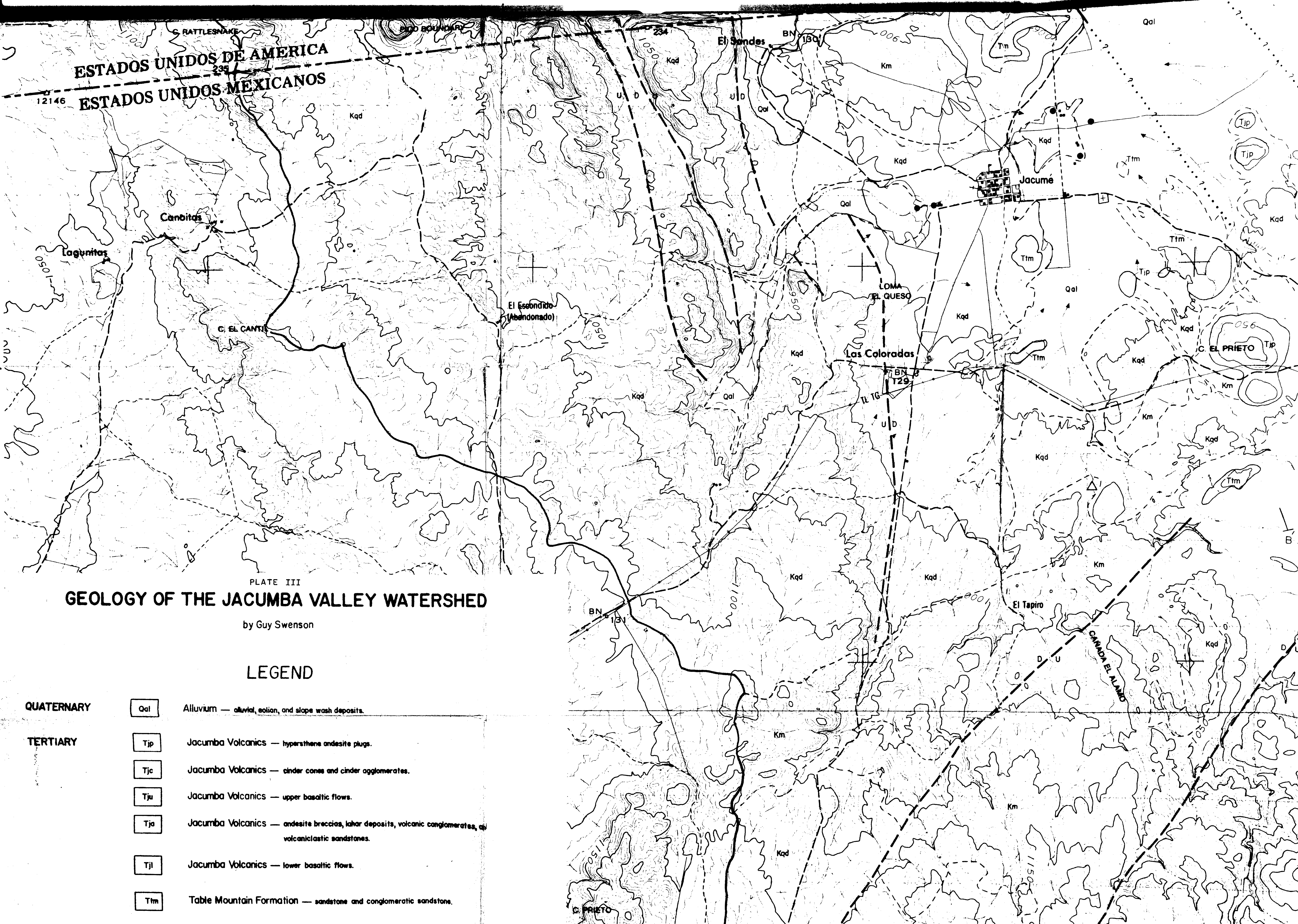


PLATE III

GEOLOGY OF THE JACUMBA VALLEY WATERSHED

by Guy Swenson

LEGEND

QUATERNARY	Qal	Alluvium — alluvial, eolian, and slope wash deposits.
TERTIARY	Tjp	Jacumba Volcanics — hypersthene andesite plugs.
	Tjc	Jacumba Volcanics — cinder cones and cinder agglomerates.
	Tju	Jacumba Volcanics — upper basaltic flows.
	Tja	Jacumba Volcanics — andesite breccias, lahar deposits, volcanic conglomerates, and volcaniclastic sandstones.
	Tjl	Jacumba Volcanics — lower basaltic flows.
	Ttm	Table Mountain Formation — sandstone and conglomeratic sandstone.

TERTIARY

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Tjl	Jacumba Volcanics — lower basaltic flows.	
Ttm	Table Mountain Formation — sandstone and conglomeratic sandstone.	

CRETACEOUS

Kqd	Peninsular Ranges Batholith — quartz diorite and granodiorite.
Km	Julian Schist and leucocratic plutonic rocks — schist, gneiss, quartzite, marble, granodiorite, diorite, and pegmatites.

MAP SYMBOLS

FAULTS

Definite location.

Approximate location.

Covered.

Covered, existence uncertain.

CONTACTS

Definite location.

Approximate location.

⊕ Active or open wells.

Prominent springs and seeps.

Ephemeral streams.

⊙S3 Soil sample sites.

⊗70 Vegetation sites, (Webber, 1979).

△ Dams.

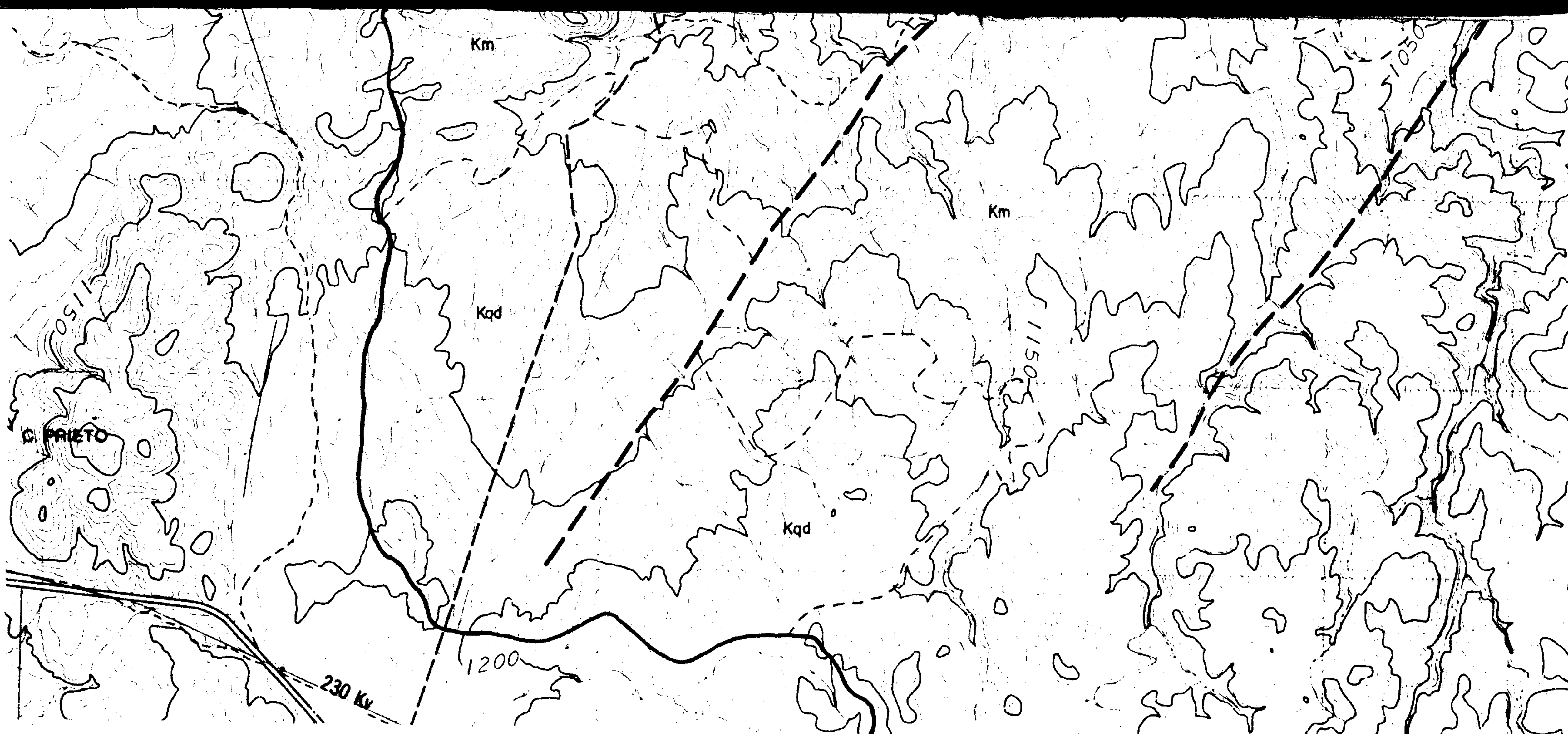
Interstate highway.

Paved roads.

Unpaved roads.

Railroad.

The geology of the Table Mt. area is after Minch and Abbott (1973). The geology of the metamorphic and plutonic terrain south of the international border is after the Mexican geologic maps La Rumorosa I11D63 and Neji I11D73, published by the Comision de Estudios del Territorio Nacional (1977).



N

Magnetic Declination 14° 15′

Scale 1 : 23,400

.5 0

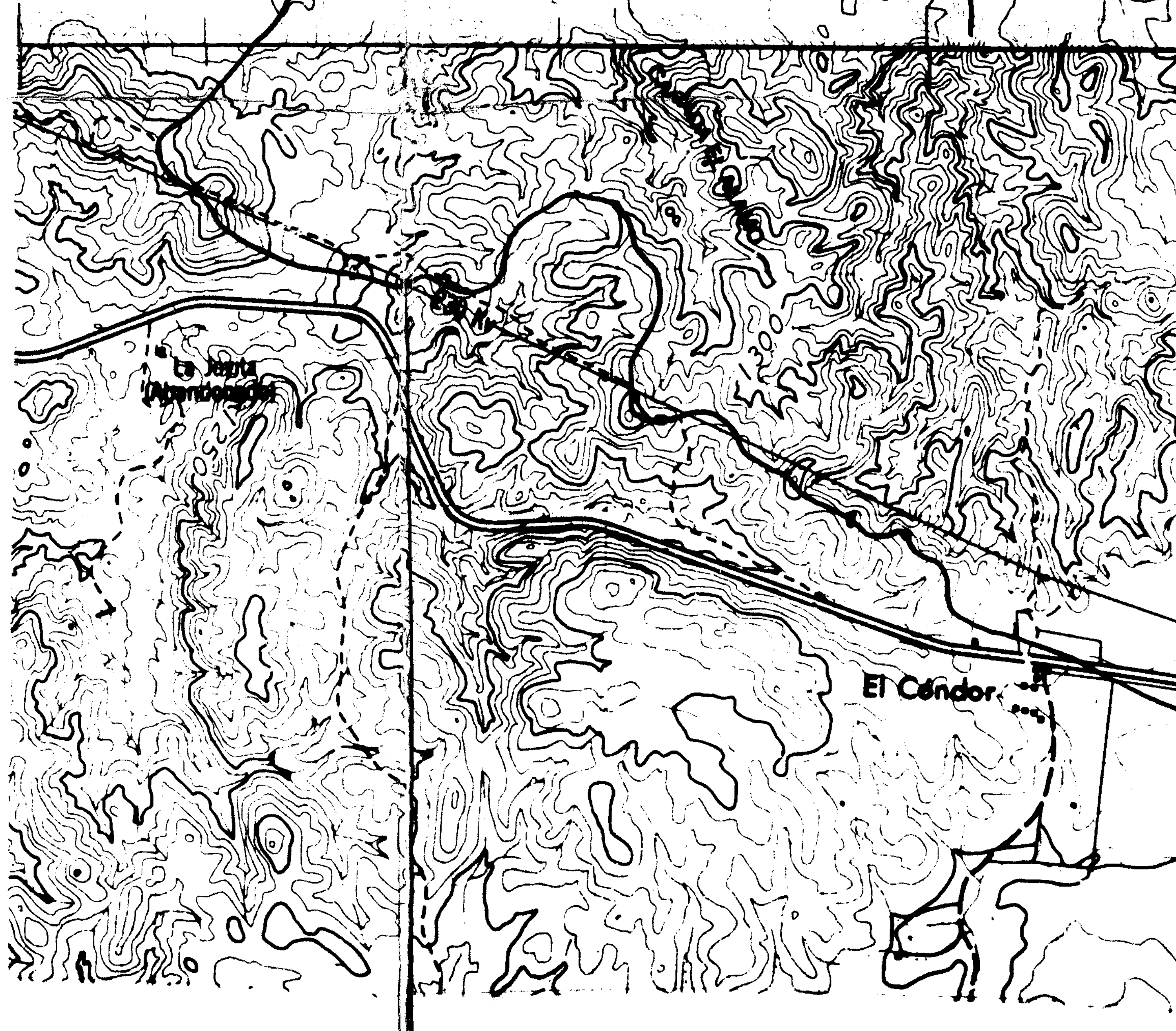
Kilometers

Contour Interval (light lines) 10 meters

(dark lines) 50 meters

Datum is mean sea level

The topographic base map was compiled from the Mexican 1:50,000 scale maps La Rumorosa I11D63 and Neji I11D73, published by the Comision de Estudios del Territorio Nacional (1977).



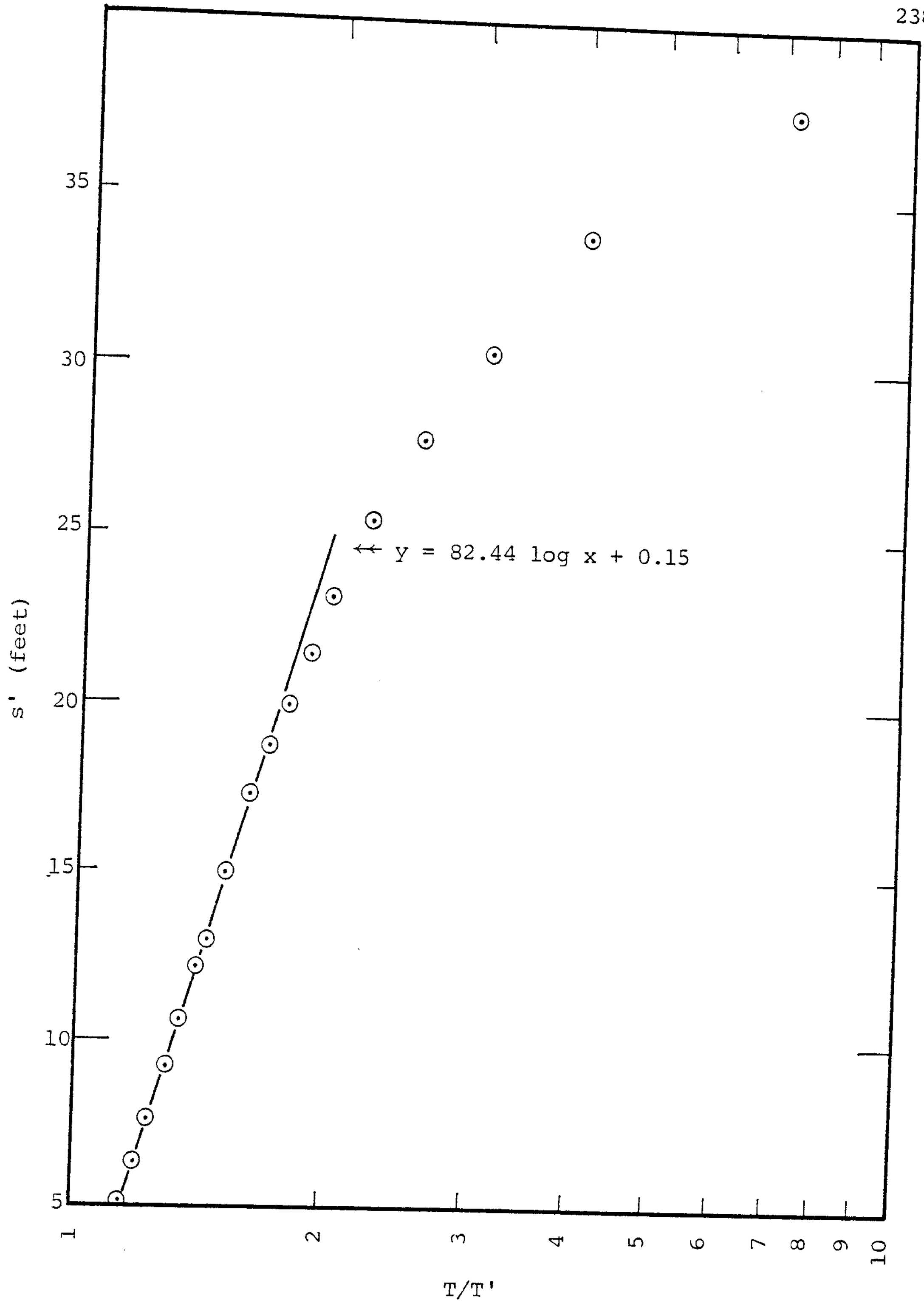


Figure 45. Table Mountain Aquifer, Recovery Test, Well R2