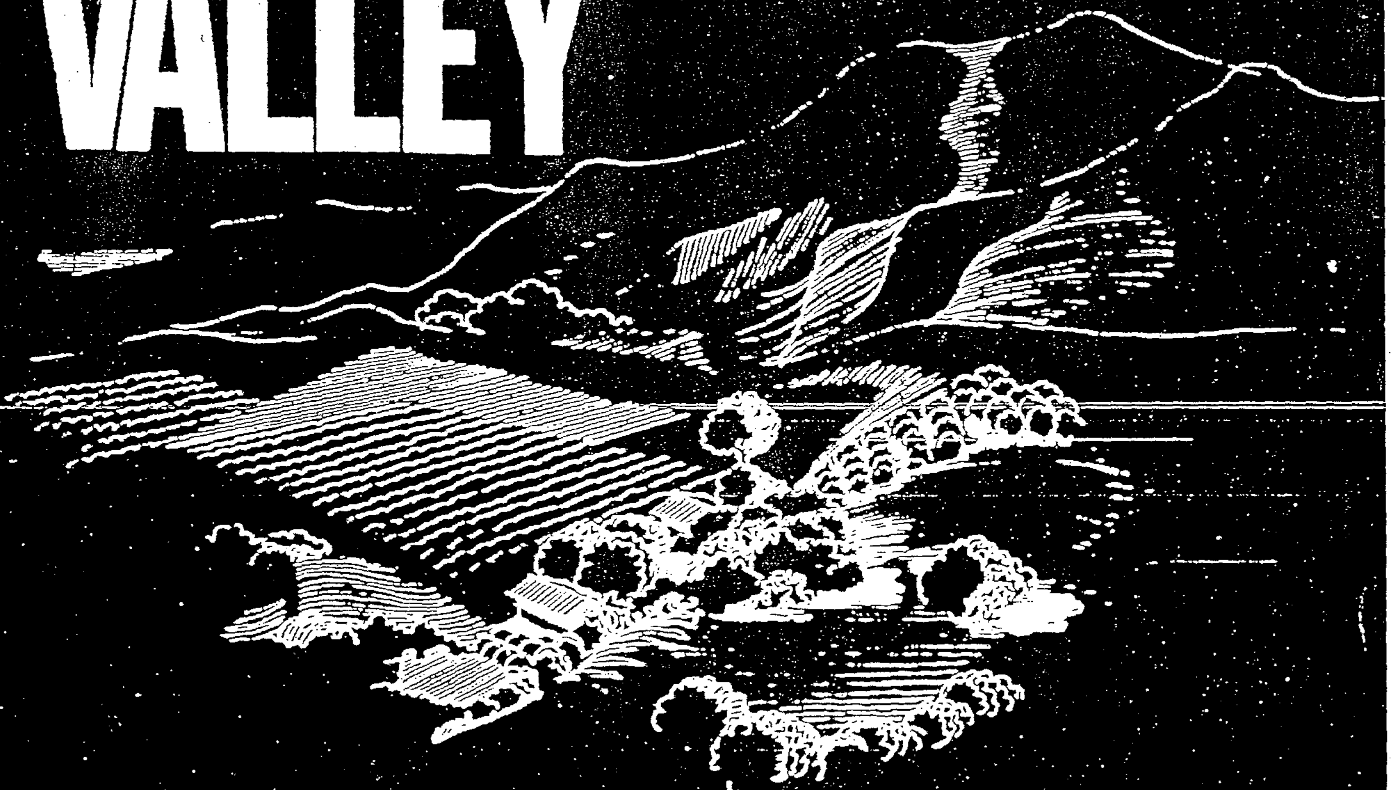
SANTA MARIA VALLEY



WATER RESOURCES STUDY

toups corporation

Engineers, Planners, Landscape Architects

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A Planning Research Corporation Company

July 15, 1976

City of Santa Maria
110 East Cook Street
Santa Maria, California 93454

Attention: Mr. Reese Riddiough
Director of Public Works

Gentlemen:

Toups Corporation is please to submit the final report of the Santa Maria Valley Water Resources Study. The report presents an up-to-date evaluation of available water resources and future requirements within the Santa Maria Valley, with regard to both quantity and quality. For your convenience, we have included as the foreword to the report, a summary of the scope and objectives of the study and our conclusions and recommendations.

We are grateful for the cooperation and assistance received from all the City, County, and special districts personnel who took part in the preparation of this report.

Very truly yours,

TOUPS CORPORATION

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October 12, 1976

Work Order
No.: 249-004-0

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Mr. Reese N. Riddiough
Director of Public Works
City of Santa Maria
110 East Cook Street
Santa Maria, CA 93454

Dear Reese:

This is in response to your letter dated September 22, 1976, requesting explanations to three items in the report, "Santa Maria Valley Water Resources Study." The following item numbers correspond to those in your letter.

Item 1(a)

Consumptive use by irrigated agriculture currently amounts to 98,000 acre-feet, made up of two components; (1) applied water from irrigation; (2) precipitation. The form of the hydrologic equation used in our analysis did not separate these two components of consumptive use. Footnote [b] emphasizes this point. If the consumptive use by irrigated agriculture included only the component of applied irrigation water, the percentage of total consumptive use by irrigated agriculture would decrease a small amount, and the percentage of total consumptive use by urban, industrial, and livestock uses would each increase slightly.

Item 1(b)

Your pointing out the typographical error in the tabulation on page ix is appreciated. A check of the basic data for the tabulation indicates the urban consumptive use figure should be 8,000 acre-feet per year instead of the 5,000 shown in the tabulation. The check of basic data also disclosed another typographical error in the tabulation. Urban water delivery should be 15,000 acre-feet annually, instead of the 13,000 shown.

Item 2

Your suggestion recommending a table of contents for the appendices on page iii is a good one and is being followed. Seventy-four new page iii's, modified accordingly, are enclosed.

Item 3

Present annual salt load to the groundwater reservoir of 7,000 tons from urban sources, shown in Table 7-3 on page 110, includes the total urban salt additions in the entire study area. The salt quantity of 2,331 tons from pages VII-3 and VII-4 of the John Carollo Engineers' report referred to in your letter and on page 160, is only the quantity of salt used for water softener recharging within the City of Santa Maria, and so was not sufficient

	RIDDIOUGH
①	LITZENBERG

toups corporation

Mr. Reese N. Riddiough
Director of Public Works

to use directly to obtain the total study area urban salt load for Table 7-3. The method used to develop the 7,000-ton figure involved calculation of the amount of salt contained in wastewater over that contained in fresh water. This procedure insured that the total urban salt addition passing through wastewater treatment plants was accounted for. The most recent year when complete records were available was 1974, which was the year used for the calculation. The following tabulation gives details of the procedure.

Wastewater Treatment Plant	Fresh Water TDS Concentration (mg/l)	Waste-Water TDS Concentration (mg/l)	Difference (mg/l)	Difference (ton/ac-ft)	Wastewater Discharge (ac-ft)	Salt Addition (tons)
City of Santa Mara	770	1,380	610	0.83	5,600	4,600
City of Guadalupe	1,195	1,450	255	0.35	500	200
Santa Maria Airport	770	1,120	350	0.48	400	200
Laguna County Sanitation District	600	1,300	700	0.95	1,500	1,400
Rural		Data Not Available				
Total						6,400

Census data indicates a sizeable rural population in the study area residing outside of sewered areas. To approximately account for the salt addition by residents of unsewered areas, the above total of 6,400 tons was rounded upward to 7,000 tons, which is considered to be within the overall limits of accuracy of the total calculation.

I hope the above responses to your questions are satisfactory. If additional information is needed, please let me know.

Very truly yours,

TOUPS CORPORATION

Bill

William R. Mills, Jr.
Vice President

WRM/yeh

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FOREWORD

Growth and development in the Santa Maria Valley have placed new demands for high quality water on the area's available supplies. This study investigates water supplies within all areas of the Santa Maria Valley. Using currently available data, the study evaluates water resources in the area and provides a definition of needs for additional water to the year 2025.

SUMMARY

The study provides answers to eight major concerns for water supply and water quality in the Valley:

1. What is the current (1975) use of water in Santa Maria Valley?

2. How much water is available for replenishment of the groundwater basin?

3. What effect has Twitchell Reservoir had on recharge of the groundwater basin?

4. What effect will future growth and development have on water supplies in the Valley?

5. What needs to be done to maximize development of the offshore groundwater basin to meet increasing water demands?

6. How much water can be mined from the basin before seawater intrusion becomes a significant problem?

7. What effect has increased agricultural land use had on deterioration of groundwater quality?

8. What alternatives are available to increase water supplies in Santa Maria Valley?

Prior studies have not provided conclusive information on the area's water resources and their capability to meet future needs. These studies were forced to rely on insufficient data and as a result, discrepancies exist in their findings. Collection and availability of new data has enabled this study to provide conclusions regarding each of the above concerns.

1. WHAT IS THE CURRENT (1975) USE OF WATER IN SANTA MARIA VALLEY?

Water delivery and consumption in the Santa Maria Valley are broken down as follows:

	Acre-feet Per Year		
	Delivery	Consumptive Use[a]	Percentage of Consumptive Use
Irrigated Agriculture	116,000	98,000[b]	87
Urban	15,000	8,000	7
Industrial	9,000	6,000	5
Livestock	[c]	1,000	1
TOTAL		113,000	100

[a] Consumptive use is the amount of water lost to the atmosphere by evaporation and plant tranpiration.
[b] Includes precipitation.
[c] Not determined.

2. HOW MUCH WATER IS AVAILABLE FOR REPLENISHMENT OF THE GROUNDWATER BASIN?

The largest source of replenishment is recharge from the Santa Maria River. This amount averages 55,000 acre-feet annually. Other sources are underflow into the basin and precipitation which together amounts to 52,000 acre-feet annually. These two sources total 107,000 acre-feet. 6,000 acre-feet are mined from the groundwater basin annually to meet the 113,000 acre-feet total water consumption.

3. WHAT EFFECT HAS TWITCHELL RESERVOIR HAD ON RECHARGE OF THE GROUNDWATER BASIN?

Twitchell Reservoir has increased the basin's recharge rate by an average of 20,000 acre-feet annually. The average recharge rate of the Santa Maria River historically was 35,000 acre-feet making the total with Twitchell Reservoir equal to 55,000 acre-feet annually. It may be concluded that Twitchell Reservoir has had a beneficial effect on the basin water supply. It has resulted in an observable rise in water levels in some parts of the basin during a period when levels would be expected to fall.

4. WHAT EFFECT WILL FUTURE GROWTH AND DEVELOPMENT HAVE ON WATER SUPPLIES IN THE VALLEY?

The desirable environment of the Valley, urban pressures on farmers in neighboring counties to relocate, and increasing demands for agricultural products will result in increased development. The anticipated growth will increase the current overdraft of 6,000 acre-feet annually to 25,000 acre-feet annually by the year 2025, unless additional water sources are developed. This could accumulate to about 750,000 acre-feet during the next 50 years.

5. WHAT NEEDS TO BE DONE TO MAXIMIZE DEVELOPMENT OF THE OFFSHORE GROUNDWATER BASIN TO MEET INCREASING WATER DEMANDS?

Use of increasing amounts of groundwater will reverse hydraulic gradients and cause movement of water shoreward from the offshore extension of the Santa Maria groundwater basin. This gradient reversal has already occurred in the northwestern coastal portion of the basin during periods of heavy pumping.

Investigations are needed to maximize the development of this potential water source. There is presently no firm information for estimating the extent of the offshore extension of the groundwater basin or the quality of water contained in it. A special water quality sampling program should be established for selected wells near the coast to monitor trends in water quality.

The most conclusive means of obtaining information on the offshore groundwater system would be offshore drilling. Such a program could be expensive but if data could be collected in conjunction with future oil well drilling operations, costs would be less.

An additional tool for developing information would be mathematical modeling of the Santa Maria groundwater basin. This would be effective in developing a basin management program, particularly with respect to optimal utilization of the offshore reserves.

6. HOW MUCH WATER CAN BE MINED FROM THE BASIN BEFORE SEAWATER INTRUSION BECOMES A SIGNIFICANT PROBLEM?

The size of the offshore fresh water supply, and the impermeability of the protecting soil layer to passage of seawater will largely determine the amount of fresh water that can be mined before seawater intrusion occurs. Both of these factors are presently unknown. However, at the time seawater intrusion does occur, implementation of a basin management program will allow the extraction of a large quantity of water with minimum adverse effects. The quantity of water that could be mined might be as much as 1,000,000 acre-feet, which should meet fresh water needs for the next 50 years.

7. WHAT EFFECT HAS INCREASED AGRICULTURAL LAND USE HAD ON DETERIORATION OF GROUNDWATER QUALITY?

Irrigated agriculture and urban activities represent 93 percent and 6 percent, respectively, of the total man-made salinity impact. Livestock production comprises one percent.

Groundwater quality in the central portion of the basin at present pumping depths generally does not meet recommended Environmental Protection Agency standards for domestic use. It does however meet State and County standards. Its use for irrigation has not caused serious problems. Better quality water appears to be available at greater depths and around the periphery of the basin. The annual salt imbalance in the basin, on the order of 9,000 tons, is not severe.

Groundwater quality is expected to gradually deteriorate in the future. The degradation is not predicted to become unmanageable during the 50-year study period.

8. WHAT ALTERNATIVE PROGRAMS ARE AVAILABLE TO INCREASE WATER SUPPLIES IN SANTA MARIA VALLEY?

Supplemental water can be made available to the Santa Maria Valley from a number of sources. The following itemization represents potential sources of supply.

° Importation

° Additional local water resources development

In-channel spreading
Off-channel spreading
Round Corral Reservoir
Weather modification
Watershed management

° Desalination of brackish groundwater or seawater

The costs of each of these potential sources are presented in Chapter 10. However, of the physical measures and management strategies available to the study area for increasing water supply, construction of spreading grounds within or adjacent to the Santa Maria River represents the most economical and practical alternative. Up to 7,000 acre-feet per year could be secured from this source on a long-term basis. This would reduce the accumulated overdraft in the year 2025 by 350,000 acre-feet. Implementation of weather modification and watershed programs would further reduce the overdraft condition.

OBJECTIVES AND SCOPE OF INVESTIGATION

The objectives of this study are to evaluate in detail the water resources within all areas of Santa Maria Valley and to further define the Valley's needs for additional water. The area of study includes the alluvial plains of the Sisquoc and Santa Maria Rivers, the Nipomo Mesa area in San Luis Obispo County, all other areas overlying the water-bearing deposits and all land within the hydrologic drainage of the Santa Maria Valley. Future needs are projected to the year 2025, a 50-year study period.

The following tasks have been outlined to accomplish the objectives of the study:

EVALUATE HISTORICAL GROUNDWATER QUANTITY AND QUALITY:

- Review groundwater elevation data and determine trends.
- Define and interpret the geologic structure of the basin.
- Prepare estimates of base period components of water supply and disposal to and from the basin environment.
- Estimate total volume of groundwater in storage.
- Determine the change in storage that occurred during the base period.
- Evaluate the occurrence and extent of overdraft, if any.
- Review groundwater quality trends.
- Define annual salt loading to the basin.

PROJECT EXISTING AND FUTURE WATER REQUIREMENTS:

- Review land use and population projections.
- Develop estimates of future land uses and population through 2025.
- Prepare unit water use factors.
- Determine projected water requirements through 2025.

PREDICT FUTURE GROUNDWATER CONDITIONS:

- Analyze the mechanism of seawater intrusion, and relate findings to the off-shore and on-shore portions of the Santa Maria groundwater basin.

- Predict future groundwater quality.

DETERMINE SUPPLEMENTAL WATER REQUIREMENTS:

- Prepare estimates of supplemental water required through 2025.

EVALUATE SOURCES OF SUPPLEMENTAL WATER:

- Analyze and determine the economic feasibility of generating or conserving additional local surface supplies, importing State Project Water, and demineralizing poor quality water sources.

CONCLUSIONS

AQUIFER CHARACTERISTICS

1. The Santa Maria groundwater basin is divided naturally into four distinct components: (1) the unconfined forebay area which extends southeastward from about midway between Santa Maria and Guadalupe; (2) the semiconfined pressure area extending westward from the forebay area (wells in this region were historically artesian in nature; today free-flowing wells are found only near the coast.); (3) the unconfined Orcutt Upland area to the south of the pressure area; (4) the unconfined Nipomo Mesa area to the north of the pressure area.

Infiltrating flows may be locally perched beneath portions of the Nipomo and Orcutt uplands, but eventually reach the main Santa Maria groundwater basin. Despite the presence of clay layers and lenses interspersed throughout the groundwater basin, the aquifer system generally functions as a confluent hydraulic unit. Only in the semi-confined coastal pressure area are perched waters isolated to a large degree from underlying groundwater.

2. The hydrologic equations developed in this study point to the conclusion that the lower member of recent alluvium extending over the pressure area is not an impervious strata, but rather allows deep percolation of a portion of the recharge occuring in this area. It is estimated about 20 percent of the available water penetrates the confining layer to recharge the basin supply. The remaining 80 percent is wasted.

3. A northeastern trending fault exists in the southeastern part of the Santa Maria Valley. The base of fresh water upstream from the fault appears to be vertically offset to depths up to 1,500 feet greater than the base immediately downstream. Downgradient movement of groundwater is inhibited at the fault interface. The retarding effect produced by the fault zone, in conjunction with recharge through this region, tends to stabilize groundwater elevations in local wells upgradient from the fault.

WATER SUPPLY

4. A number of wet-dry climatic cycles are evident in the recorded precipitation history of the Santa Maria Valley. The most recent of these, the 38-year period from 1935 to 1972, is used in this water resources investigation to provide a common base period during which components of water supply and disposal are equated.

5. The quantity of water contained in the groundwater basin was 250,000 acre-feet less in 1972 than in 1935 (an average decrease of 7,000 acre-feet per year). Most of this deficiency accumulated prior to 1965.

6. Groundwater levels in the pressure area can be expected to decline below present levels in response to increased demands for fresh water. In the Oso Flaco region, the total quantity of fresh water now being pumped cannot be replenished by underflow from the inland forebay area at a rate sufficient to satisfy pumping demands so groundwater levels during periods of heavy pumping are drawn down well below sea level. This induces landward flow from the offshore aquifer. There exists no evidence that seawater intrusion is beginning to occur in the on-shore groundwater basin and represents a mining of freshwater from the off-shore aquifer.

8. The seaward hydraulic gradient in the coastal portion of the Santa Maria groundwater basin has experienced a relatively continuous decline since the early 1900's, and under anticipated levels of development within the Valley, is expected to be depressed even lower than at present.

9. Because the period since construction of Twitchell Dam has exhibited greater than average runoff and recharge (103 percent and 118 percent respectively, of base period averages) total supply for these years has exceeded extractions from the groundwater basin. This is evidenced by rising water levels in the forebay area. However, if present water use is compared to long-term basin hydrology, a minor overdraft condition is found to exist. Magnitude of this overdraft may approach 6,000 acre-feet per year.

10. Anticipated increases of urban and agricultural development in the Valley will aggrevate the overdraft condition. It is feasible to develop additional local water resources to help alleviate this situation.

11. A substantial quantity of fresh water in the offshore system may be available for withdrawal under proper management of the on-shore groundwater basin. However, increasing pumping demands in the pressure area with accompanying lower aquifer pressure, may induce the infiltration of seawater through the clay strata overlying the off-shore aquifer.

GROUNDWATER QUALITY

12. Groundwater quality in the main portion of the basin now generally does not meet recommended Environmental Protection Agency standards for domestic use at present pumping depths. Better quality water appears to be available at greater depths and around the periphery of the basin. Quality will continue to deteriorate in the zone of pumping and special management practices may be required to allow continued use of the groundwater resource.

13. The annual salt imbalance in the basin, on the order of 9,000 tons, is not severe. Discharge of irrigation return flows from the area overlying the clay cap represents a major source of salt export.

14. Natural sources are responsible for about 77 percent of the total salt load to the Valley. Man-made sources of salt contribute the remaining 23 percent.

BASIN MANAGEMENT

15. Of the physical measures and management strategies available to the study area for increasing local water supply, construction of spreading grounds within or adjacent to the Santa Maria River represents the most economical and practical alternative. Up to 7000 acre-feet per year could be secured from this source on a long-term basis. Implementation of weather modification and watershed management programs would further reduce the overdraft condition.

16. In order to realize the maximum potential of the off-shore freshwater resource, the on-shore groundwater basin should be mined. This strategy will enable off-shore groundwater to flow landward where it can be extracted.

17. At some future time when seawater is detected in producing wells, these wells should be incorporated into a hydraulic extraction barrier for seawater intrusion control. A properly implemented groundwater management program of barrier maintenance, combined with controlled pumping in the semiconfined area would make a larger volume of groundwater available for mining from the reservoir in the basin forebay. This resource should be adequate to satisfy water requirements for the next 50 years.

18. Mathematical modeling of the Santa Maria groundwater basin would be an effective tool in developing a basin management program, particularly with respect to optimal utilization of the offshore reserves.

CHAPTER 1

SANTA MARIA VALLEY DESCRIPTION

The Santa Maria Valley of California is a large coastal basin occupying the northwest portion of Santa Barbara County and the southwest extreme of San Luis Obispo County. The Valley, depicted on Figure 1-1, extends inland from the coast approximately 20 miles and has a maximum width of 18 miles. About 260 square miles are encompassed by the Santa Maria Valley. A small alluvial area of approximately 15 square miles, known as the Sisquoc Plain, adjoins the Santa Maria Valley at Fugler Point and extends up the Sisquoc River more than nine miles. The upper exteme of the Sisquoc Plain is located in the general vicinity of USGS gaging station 11138500.

The climate, soil, and topography of the Santa Maria study area contribute to the agricultural nature of the region. Most of the Santa Maria and Sisquoc plains are intensively cultivated. Crop production is also a dominant enterprise on the Nipomo Mesa. In addition to agriculture, the petroleum industry is the principal component of the valley economy.

PHYSICAL FEATURES

The Santa Maria study area intercepts drainage from the watersheds of three major rivers: the Santa Maria, the Sisquoc, and the Cuyama. Figure 1-2 identifies the location and extent of these drainages. The Santa Maria River is formed by the confluence of the Cuyama and Sisquoc Rivers at Fugler Point, a location about 20 miles inland from the coast. Upstream from Fugler Point, the drainage system reflects the nature of what is essentially a mountainous headwater region. With the exception of the alluvial expanse of the Sisquoc plain and the dissected Orcutt Upland to the south, the 1,600 square mile headwater region is underlain at shallow depth by older consolidated rocks [USGS WSP 1000 1951].

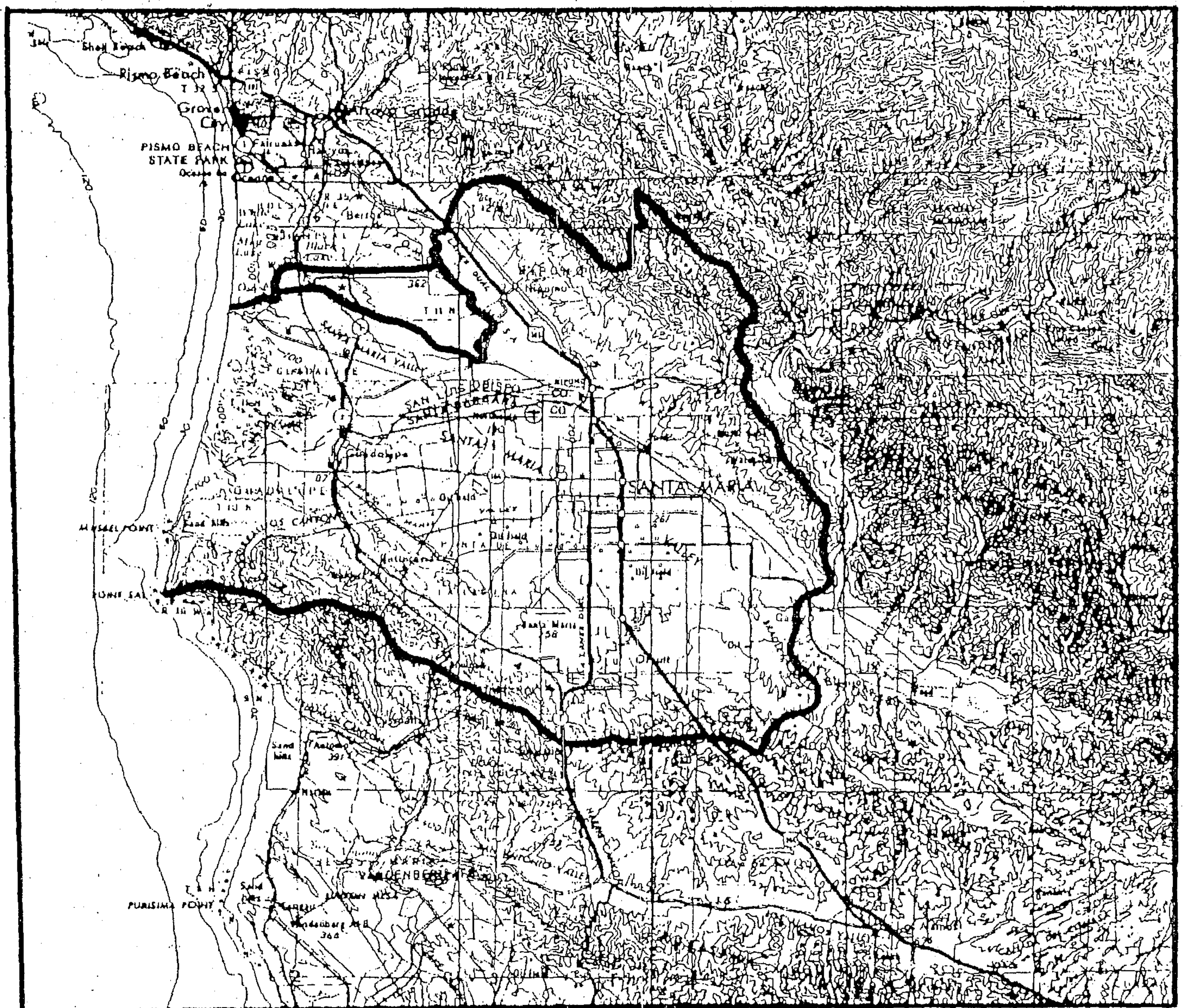


FIG. I-1 SANTA MARIA VALLEY

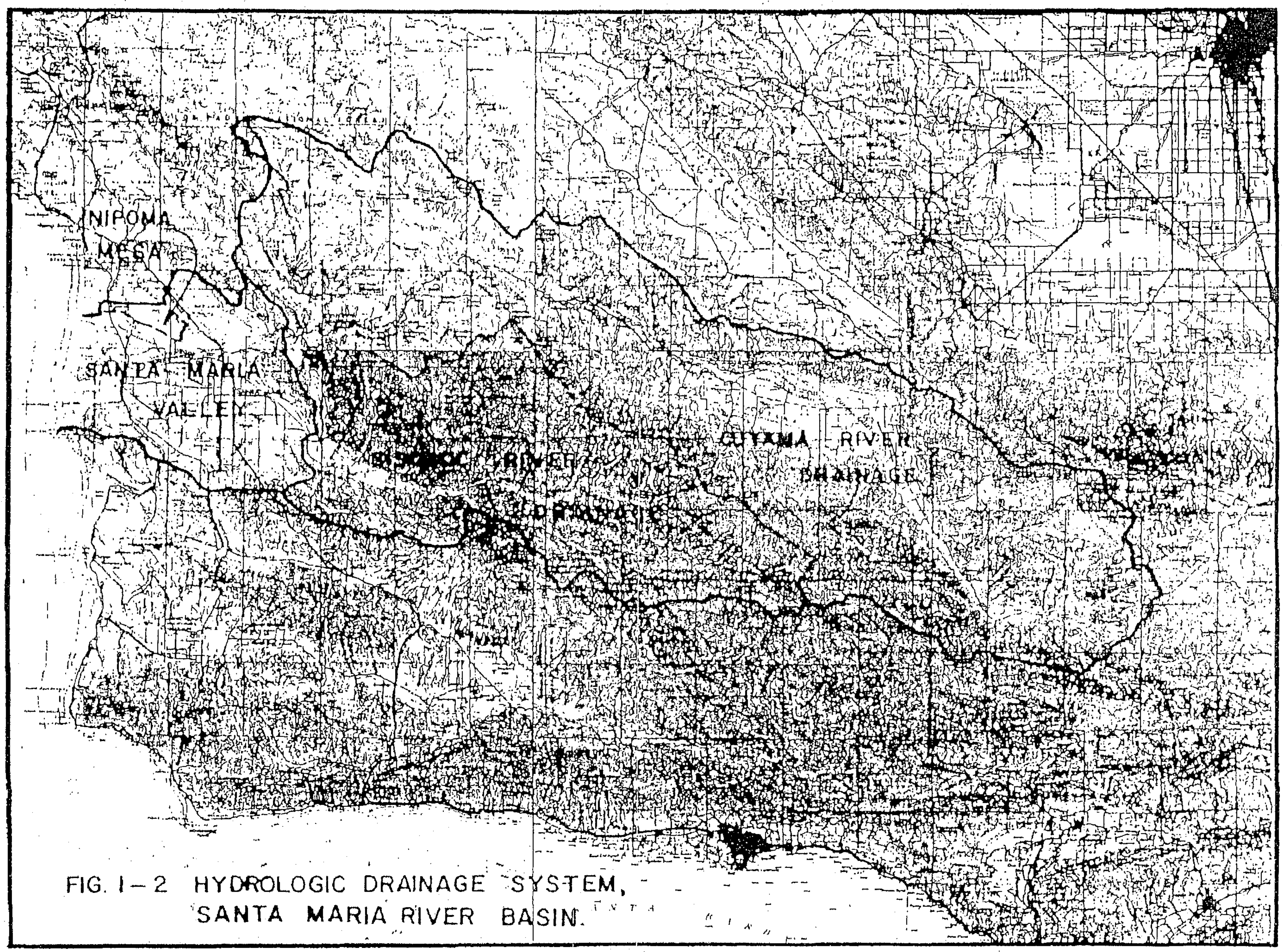


FIG. I—2 HYDROLOGIC DRAINAGE SYSTEM,
SANTA MARIA RIVER BASIN.

The Cuyama River drains a 1,130 square mile watershed area that includes southeastern San Luis Obispo County, northeastern Santa Barbara County, and relatively small portions of Ventura and Kern Counties [USGS 1973]. On the north, the Cuyama River basin is flanked by the dry, semi-barren Caliente Mountains. This range attains a maximum elevation of 5,095 feet [USBR 1951]. The rugged, chaparral-covered Sierra Madre Mountains form the southern boundary of the Cuyama River basin and reach an elevation of 5,880 feet. Major tributaries to the Cuyama River are Huasna River and Alamo Creek. Since February, 1959, flow in the Cuyama River has been regulated by Twitchell Reservoir. This impoundment possesses a capacity of 239,000 acre-feet and retards a portion of intercepted storm flow for later release [USGS WSP 1819A 1966].

The Sisquoc River, the second major drainage of the headwater region, receives runoff from a watershed area of approximately 470 square miles [USGS 1973]. The watershed of the Sisquoc River is defined by the northwestward-trending Sierra Madre Mountains on the north and the westward-trending San Rafael Mountains on the south. The San Rafael mountains rise to 6,828 feet [USBR 1951]. Most of the Sisquoc River drainage lies within the boundaries of the Los Padres National Forest.

The Santa Maria Valley covers the 260 square-mile watershed area downstream from the Cuyama-Sisquoc River confluence. Much of the Valley consists of a broad alluvial area known as the Santa Maria Plain. This plain is underlain by a broad downward-trending geologic trough, or syncline. Anticlines or regional uplifts are expressed as adjacent highlands and mountains [USGS WSP 1000 1951]. The San Rafael Mountains and the Solomon and Casmalia Hills are representative of the latter topography, and respectively form the northeast and the southeast boundaries of the Valley basin. Relatively elevated terrace surfaces and dune sands border the Santa Maria Plain on the north and south. These deposits comprise the Nipomo Mesa, which rises gently northward to the western extension of the San Rafael Mountains, and the Orcutt Upland, which rises southward to the Solomon and Casmalia Hills.

The Santa Maria River historically has possessed two outlets to the ocean through sand dune deposits in the westerly extreme of the basin. The active river channel presently discharges to the coast south and west of Guadalupe. Flow at Guadalupe is zero during much of the year, however flows may occur in winter during periods of heavy storm runoff. An additional point of discharge, now blocked, occurred through Oso Flaco Lake along the northern boundary of the Valley. The abandoned channel veers from the active river course about three miles upstream from Guadalupe. It follows the course of Oso Flaco Creek, which presently conveys drainage to Oso Flaco Lake. Oso Flaco Creek does not possess flow adequate to maintain an opening to the ocean through the dunes.

A historically inactive channel of the Santa Maria River is situated in the southern portion of the Santa Maria Plain. This drainage, known as Green Canyon, encompasses the area south of Guadalupe from U.S. Highway 101 to the mouth of the Santa Maria River [USGS WSP 1000 1951]. This inactive channel generally exhibits characteristics typical of the alluvial valley plain. The westernmost portion of Green Canyon serves to collect runoff from a local drainage of about 17 square miles as well as storm inflow from the watershed of Corralitos Canyon and Orcutt Creek. The latter two tributaries intersect Green Canyon at locations approximately one and one-third miles south of Guadalupe. These water-courses convey drainage from watershed areas of about 4-1/2 and 38 square miles, respectively. Flows conveyed to Green Canyon are discharged to the Santa Maria River at a location slightly more than one mile southwest of the river mouth.

CLIMATE

The climate of the Santa Maria River Basin is characterized by a short, rainy winter season and a dry summer season. In the area of the coastal plain, summers are typically moderate and mediterranean in nature; in interior mountain valleys, summers are hot.

Essentially all precipitation within the Santa Maria Valley occurs within the seven month period from October through April. Lower-lying coastal plain areas typically receive less rainfall than inland hilly and mountainous regions. Native water resources generated by runoff from the local watersheds of the Santa Maria River Valley are relatively minor compared to supplies introduced to the Valley from mountainous headwater drainages of the Cuyama and Siquoc Rivers. Storms moving in from the Pacific Ocean introduce heaviest rainfall to the region.

Annual precipitation for the City of Santa Maria Station during the 89 year period from water year 1886 to 1974 is summarized in Table 1-1 and shown graphically on Figure 1-3. Wet-dry climatic cycles are evident in this figure. These cycles were identified by first graphing accumulated departure from the mean of record (1886-1975) to derive the general trend in precipitation. Figure 1-3 was then prepared by plotting accumulated departure from the mean annual precipitation of the most recent climatic cycle 13.30 inches. The most recent cycle, 1935 through 1972, was utilized to define a "base period" for the City of Santa Maria, a relatively short and recent period which represents the long-term average water supply. This 38 year base period is utilized in this study to provide a common time-frame in which various components of water accretion and depletion are related. The base period mean is two percent less than the long-time mean, 13.56 inches. The long-time mean represents average annual precipitation throughout two identified climatic cycles, 1901-1934 and 1935-1972.

The following hydrologic inventory of the Santa Maria Valley quantifies natural and man-induced influences on water supply and use. The response of the groundwater basin (in terms of change of water in storage) to historic levels of development is used to verify and refine the magnitude of items comprising the hydrologic equation.

TABLE 1-1. PRECIPITATION AT CITY OF SANTA MARIA [a]
(Based on 38 year base period average = 13.30 inches)

Water Year	Precip.	Index (%)	+ Mean (%)	Accumulated + Mean (%)
1886	19.12	143.8	43.8	43.8
1887	9.66	72.6	-27.4	16.4
1888	11.47	86.2	-13.8	2.6
1889	16.04	120.6	20.6	23.2
1890	28.42	213.7	113.7	136.9
1891	11.52	86.6	-13.4	123.5
1892	9.80	73.7	-26.3	97.2
1893	17.69	133.0	33.0	130.2
1894	9.63	72.4	-27.6	102.6
1895	12.56	94.4	-5.6	97.0
1896	11.66	87.7	-12.3	84.7
1897	15.11	113.6	13.6	98.3
1898	6.52	49.0	-51.0	47.3
1899	11.56	86.9	-13.1	34.2
1900	9.23	69.4	-30.6	3.6
1901	16.40	123.3	23.3	26.9
1902	12.20	91.7	-8.3	18.6
1903	12.79	96.2	-3.8	14.8
1904	14.59	109.7	9.7	24.5
1905	17.33	130.3	30.3	54.8
1906	17.79	133.8	33.8	88.6
1907	18.06	135.8	35.8	124.4
1908	14.93	112.3	12.3	136.7
1909	21.78	163.8	63.8	200.5
1910	17.23	129.5	29.5	230.0
1911	20.04	150.7	50.7	280.7
1912	9.63	72.4	-27.6	253.1
1913	5.46	41.1	-58.9	194.2
1914	18.85	141.7	41.7	235.9
1915	18.93	142.3	42.3	278.2
1916	19.17	144.1	44.1	322.3
1917	11.97	90.0	-10.0	312.3
1918	16.19	121.7	21.7	334.0
1919	11.40	85.7	-14.3	319.7
1920	9.19	69.1	-30.9	288.8
1921	11.48	86.3	-13.7	275.1
1922	16.44	123.6	23.6	298.7
1923	12.66	95.2	-4.8	293.9
1924	6.11	45.9	-54.1	239.8

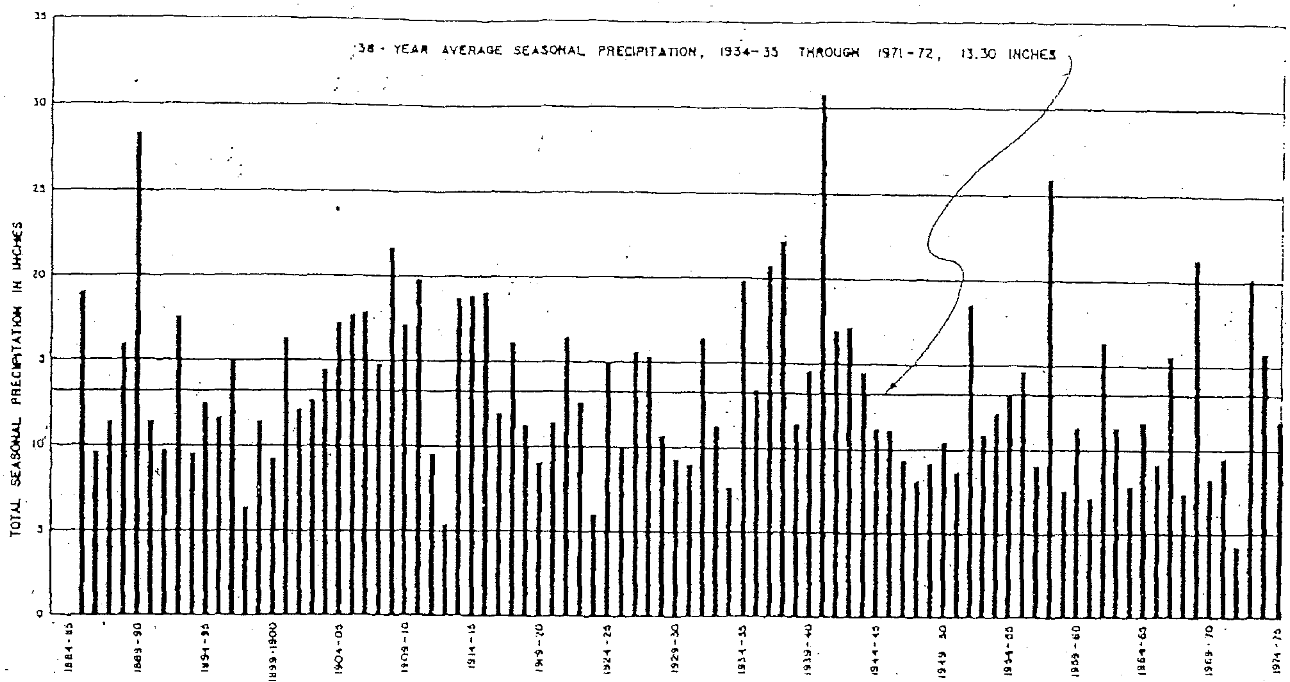
TABLE 1-1. Continued

Water Year	Precip.	Index (%)	+ Mean (%)	Accumulated + Mean (%)
1925	15.04	113.1	13.1	252.9
1926	10.08	75.8	-24.2	228.7
1927	15.59	117.2	17.2	245.9
1928	15.34	115.3	15.3	261.2
1929	10.70	80.4	-19.6	241.6
1930	9.33	70.1	-29.9	211.7
1931	8.97	67.4	-32.6	179.1
1932	16.48	123.9	23.9	203.0
1933	11.35	85.3	-14.7	188.3
1934	7.68	57.7	-42.3	146.0
1935	19.55	147.0	47.0	193.0
1936	13.48	101.4	1.4	194.4
1937	156.6	56.6	251.0	
1938	22.18	166.8	66.8	317.8
1939	11.51	86.6	-13.4	304.4
1940	14.61	109.9	9.9	314.3
1941	30.75	231.2	131.2	445.5
1942	16.95	127.5	27.5	473.0
1943	17.22	129.5	29.5	502.5
1944	14.56	109.5	9.5	512.0
1945	11.31	85.1	-14.9	497.1
1946	11.08	83.3	-16.7	480.4
1947	9.42	70.8	-29.2	451.2
1948	8.20	61.7	-38.3	412.9
1949	9.17	69.0	-31.0	381.9
1950	10.47	78.7	-21.3	360.6
1951	8.66	65.1	-34.9	325.7
1952	18.57	139.6	39.6	365.3
1953	10.87	81.7	-18.3	347.0
1954	12.12	91.1	-8.9	338.1
1955	13.17	99.0	-1.0	337.1
1956	14.56	109.5	9.5	346.6
1957	9.01	67.8	-32.2	314.4
1958	25.86	194.5	94.5	408.9
1959	7.62	57.3	-42.7	366.2

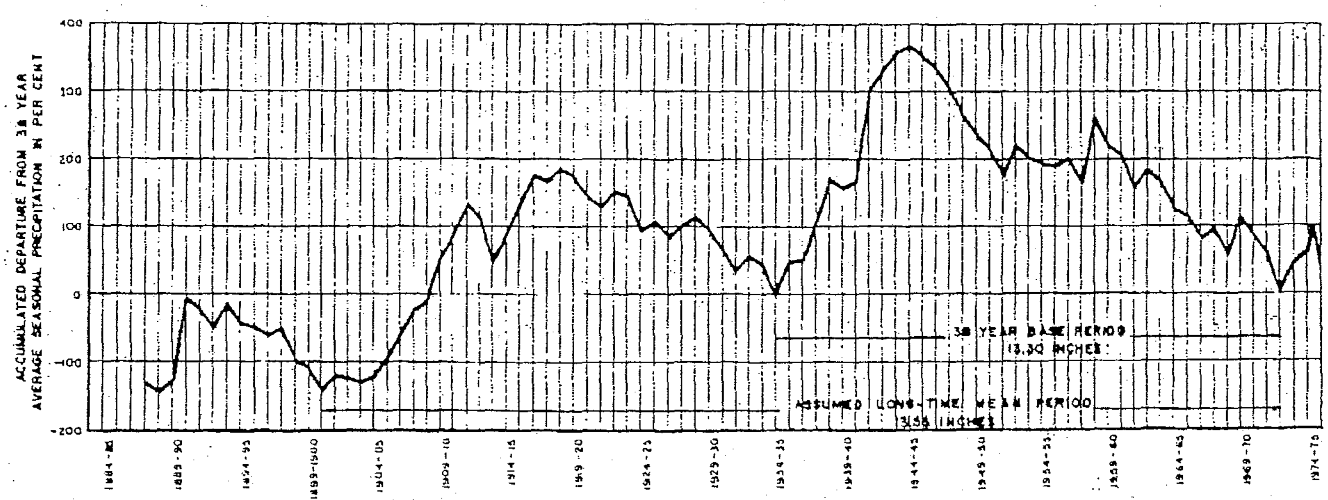
TABLE 1-1. Continued

Water Year	Precip.	Index (%)	+ Mean (%)	Accumulated + Mean (%)
1960	11.33	85.2	-14.8	351.4
1961	7.11	53.5	-46.5	304.9
1962	16.39	123.2	23.2	328.1
1963	11.30	85.0	-15.0	313.1
1964	7.81	58.7	-41.3	271.8
1965	11.62	87.4	-12.6	259.2
1966	9.13	68.7	-31.3	227.9
1967	14.96	112.5	12.5	240.4
1968	8.25	62.0	-38.0	202.4
1969	20.84	156.7	56.7	259.1
1970	9.59	72.1	-27.9	231.2
1971	9.82	73.8	-26.2	205.0
1972	5.45	41.0	-59.0	146.0
1973	19.63	147.6	47.6	193.6
1974	15.21	114.4	14.4	208.0
1975	11.59	87.1	-12.9	195.1

[a] 38-year base period mean (1935-1972).



SEASONAL PRECIPITATION



ACCUMULATED DEPARTURE FROM AVERAGE SEASONAL PRECIPITATION

FIG. - I-3 PRECIPITATION CHARACTERISTICS AT SANTA MARIA

Data for various precipitation stations in San Luis Obispo and Santa Barbara Counties are summarized in Table 1-2. Locations are depicted on Figure 1-4. Mean annual values for precipitation represent base period averages. Lines of equal precipitation, representative of these base period data, were constructed and are also shown on Figure 1-4. These isohyets are used in Chapter 3 to develop an estimate of ungaged recharge and the volume of precipitation tributary to the Santa Maria River Valley. Isohyetal map development is discussed in Chapter 3.

GEOLOGY

Definition of subsurface geology within all or part of the Santa Maria Valley has occurred as the direct or indirect result of several studies conducted by USGS, USDA, USBR, and by the California Department of Water Resources. Several local agencies active in the study area provide services which now or in the past have caused them to exhibit interest in the subsurface geology of the region. Among these are the Santa Barbara County Flood Control and Water Conservation District, the Santa Barbara County Water Agency, Office of the Santa Barbara County Oil Administrator, Santa Maria Valley Water Conservation District, the City of Santa Maria, and the San Luis Obispo County Flood Control and Water Conservation District. Individuals and private firms, such as Union Sugar, have sponsored hydrogeologic investigations [Bradberry and others 1955]. In addition, dozens of oil companies have drilled and continue to operate wells in the Santa Maria Valley. Drilling records and EC logs generated by activities of the petroleum industry have provided an extremely valuable source of primary geologic data. Geophysical characteristics of water-bearing strata underlying the Santa Maria Valley have also been detailed by logs of domestic and agricultural wells.

TABLE 1-2. PRECIPITATION DATA - SANTA MARIA VALLEY AND VICINITY [a]

Name	Station Designation	County	Latitude	Longitude	(feet)	Water Years of Record	Base Period Mean Annual Precip. (inches)
Almar Ranch	T12012920	SB	34.850	120.366	900	1964-pres.	14.92
Arroyo Grande No. 1	T10032000	SLO	35.123	120.573	105	1960-pres.	16.25
Betteravia	T12071900	SB	34.916	120.516	155	1898-pres.	13.37
Guadalupe [d]		SB			100	1921-1945	11.11
Huasna	T12414400	SLO	35.133	120.400	715	1941-pres.	18.40
Lompoc Hwy. Maint Sta.	T14506440	SB	34.650	120.450	100	1938-pres.	14.08
Los Alamos	T13510700	SB	34.750	120.283	565	1910-pres.	14.90
Nipomo 2NW	T12620700	SLO	35.066	120.500	360	1921-pres.	16.21
Pismo Beach	T10694300	SLO	35.133	120.633	80	1950-pres.	16.72
Santa Maria	T12794000	SB	34.950	120.433	224	1886-pres.	13.30
Santa Maria, 12 E. Smith [e]	T12794665	SB	34.900	120.250	800	1946-pres.	20.13
Sisquoc Ranch	T12826701	SB	34.833	120.166	600	1905-1915 1938-1950 1954-pres.	14.97
Suey Ranch	T12862700	SLO	34.994	120.376	390	1910-pres.	14.67
Twitchell Dam	T12911100	SB	34.983	120.316	582	1964-pres.	16.62

[a] Water year October - September. Data from Santa Barbara County Flood Control and Water Conservation District, San Luis Obispo County Flood Control and Water Conservation District, and USGS, WSP 1000, 1951; USGS, WSP 1928, 1970; US Department Commerce, Summaries.

[b] SB: Santa Barbara County
SLO: San Luis Obispo County

[c] Datum mean sea level.

[d] Data from USGS, WSP 1000, 1951.

[e] Also referred to as Tepusquel Canyon Rd (Smith).

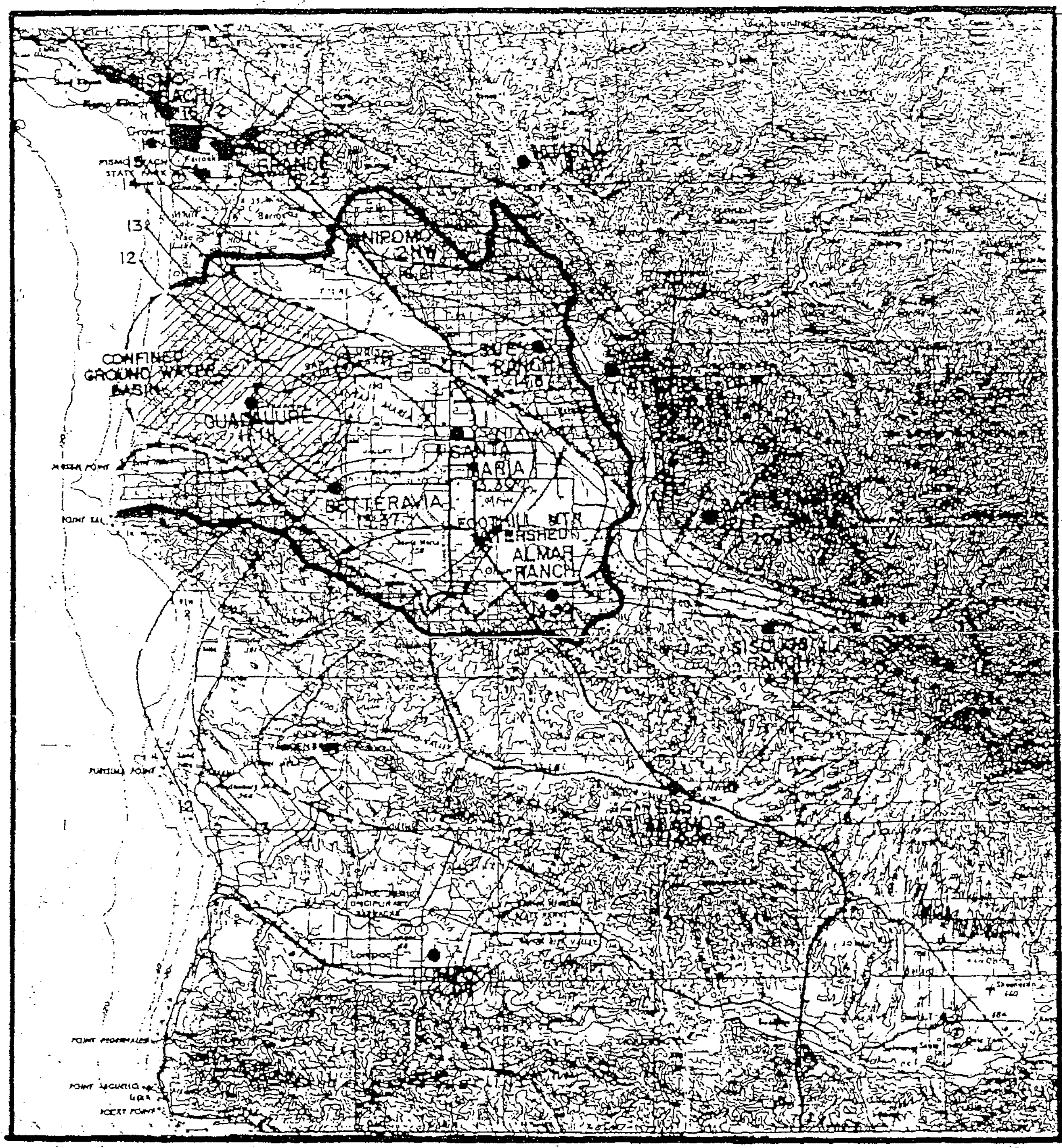


FIG. 1 - 4 PRECIPITATION CHARACTERISTICS AND STATION LOCATIONS [a]

[a] ANNUAL AVERAGE PRECIPITATION DURING BASE PERIOD INDICATED BELOW STATION NAME

GEOLOGIC HISTORY

Present surficial and subsurface characteristics of the Santa Maria Valley are the culmination of a complex sequence of geologic events. A clear perspective of existing land forms and aquifers is provided by a brief review of recent geologic history.

In the early Miocene epoch (beginning 25 million years ago) nonmarine sediments were deposited in the regional area that encompasses the present-day Santa Maria Valley [DWR February 1970]. This was followed by a period in which the sea encroached upon and covered the area. Marine sediments of middle and late Miocene age, including sandstones, shales, siltstones, claystones, and mudstones, were deposited. At the same time, deformation of marine strata and introduction of Miocene volcanic rocks took place. Monterey Shale is a consolidated rock of marine origin that was formed during this period. It comprises the core of the Casmalia and Solomon Hills, underlies the Santa Maria Valley and Sisquoc Plain at considerable depth, and warps upward to form the main part of the San Rafael Mountains. Although considerably thinner elsewhere, this formation attains a maximum thickness of about 7,000 feet in the structural trough beneath the town of Orcutt [USGS WSP 1000 1951]. Monterey Shale is the principal source rock of petroleum.

The Sisquoc Formation, of late Miocene and early Pliocene age, unconformably overlies the Monterey Shale. This consolidated marine formation is exposed high along the north flank of the Solomon and Casmalia Hills. It extends beneath the valleys of the Santa Maria and lower Sisquoc Rivers.

The sea continued to cover the region until the end of the Pliocene epoch (beginning seven million years ago). Throughout the Pliocene, deformation was minor but continued. The Foxen Mudstone was deposited during the latter Pliocene age. It is consolidated in nature and includes the mudstone, siltstone, and fine-grained silty sandstone which conformably overlie the Sisquoc Formation in the western part of the Valley and which unconformably overlie it in the east. The north flank of the Casmalia Hills is marked by the only surficial outcrop of Foxen Mudstone in the area. The Foxen extends beneath the Santa Maria Valley, where it exhibits a maximum thickness of approximately 3,000 feet near the town of Betteravia [USGS WSP 1000 1951].

Careaga Sand was deposited during late Pliocene time. This unconsolidated water-bearing marine formation outcrops out along the north side of the Casmalia and Solomon Hills; conformably overlies the Foxen Mudstone beneath the Santa Maria Valley and Sisquoc Plain; and tapers out upon the consolidated rocks that underlie the northern edge of the Valley floor.

The Paso Robles Formation was deposited in the early Pleistocene epoch (beginning two to three million years ago). This formation is generally considered to be continental in origin. Near the present-day coast, however, it is locally of lagoonal or brackish water origin. This relates to the fact that it was laid down in synclinal troughs that were still submerged at or near the coastline [DWR February 1970]. The Paso Robles outcrops along the north flank of the Casmalia and Solomon Hills and is warped downward in the synclinal trough of the Santa Maria and lower Sisquoc Valleys. The deposition of both the Careaga Sand and the Paso Robles Formation was accompanied by minor deformation.

The present limits of the groundwater basin were established in middle Pleistocene time. Intense folding and major deformation occurred during this period. The Paso Robles Formation was partially removed from the region of Nipomo Mesa. Emergence of the Casmalia Hills in the southern portion of the study area severely warped the Careaga Sand and the Paso Robles Formation in an upward direction. Conversely, this caused these strata to be depressed into the adjacent syncline situated immediately north of the highland area. Faulting of the Careaga Sand and the Paso Robles Formation occurred during this period.

The extreme deformation that characterized middle Pleistocene time was followed by a period of relative stability that continued into the late Pleistocene. Ancestral streams deposited the Orcutt Formation during these quiescent times. The last period of faulting and folding to influence the formation of the groundwater basin underlying the Santa Maria Valley occurred subsequent to the deposition of the Orcutt Formation [DWR February 1970]. This was followed by an age in which ancestral rivers and streams formed fluvial and marine terraces. These streams were assumed to occupy much the same positions that they do today.

Sea level was substantially lowered during the Wisconsin glacial age that occurred at the end of the Pleistocene. As a result, channels of rivers and streams were further entrenched.

The retreat of the Wisconsin glaciation signalled the conclusion of the last glacial period. The level of the sea rose, causing Recent alluvial and channel deposits to backfill the coastal valleys [DWR February 1970]. These materials comprise the aquifer of Recent alluvium. This formation is made up of gravel, sand, silt, and clay, graded initially to a position of sea level, about 230 feet below present level [USGS WSP 1000 1951]. Grain size becomes progressively finer from east to west across the valley [USGS WSP 1819A 1966]. The alluvium is actually composed of two members: an upper fine grained member and a lower coarse grained member. These members are generally indistinguishable in the eastern portion of the valley, but assume distinct characteristics in the west. The upper member underlies and forms the surface of the Sisquoc Plain and the plain of the Santa Maria Valley. It extends beneath the channel deposits of principal rivers and streams [USGS WSP 1000 1951]. A confined groundwater zone is produced by the presence of silts and clays in the upper alluvial member. Average thickness of the confining layer is about 100 feet [USGS WSP 1819A 1966]. It extends westward from its periphery, located approximately midway between Santa Maria and Guadalupe. The lower member generally assumes a distribution comparable to that of the upper member, except it is absent in portions of the Oso Flaco district. The two members are each about 115 feet thick near the coast. The upper and lower members thin eastward to thicknesses of 75 feet and 40 feet respectively, at Fugler Point [USGS WSP 1000 1951].

Erosion is an on-going force that shapes and modifies the features of the coastal environment. Projecting headlands are worn down by the action of wind and sea, and sand is transported inland to protected areas by waves and longshore currents.

AQUIFER SYSTEM

The Santa Maria groundwater basin is a continuous aquifer system that extends in a westerly direction from the upper end of the Sisquoc Plain to a location beneath the ocean, estimated to extend up to 20 miles from the coast. The offshore portion of the aquifer system extends from Point Sal in the south to the vicinity of Pismo Beach in the north. The groundwater basin is composed of unconsolidated water-bearing formations which include dune sand, river channel deposits, alluvium of Recent age, and undifferentiated deposits which form the Paso Robles Formation and Careaga Sand. The onshore aquifer system averages approximately 1,000 feet in saturated thickness. It possesses a maximum thickness of more than 2,300 feet. The permeable sand and gravel deposits which form the water-bearing strata of the basin are separated locally by relatively impermeable beds of silt and clay. However, despite the presence of these strata and lenses, the various aquifers reflect characteristics of an essentially contiguous hydraulic system.

In the western portion of the Valley, aquifers situated in deposits of Pliocene and Pleistocene age (Careaga Sand and Paso Robles Formation) are mostly confined. This portion of the basin is unique in that many wells in this region were historically artesian in nature. Today, free flowing wells that still exist are found only immediately adjacent to the coast. The confining layer is believed to extend eastward to about midway between Guadalupe and Santa Maria, the historic limit of artesian flow. Areal extent of the confined groundwater zone is shown on Figure 1-4, presented previously. Approximately 50 square miles of surface area overlie the confined portion of the groundwater basin.

The Careaga Sand and the Paso Robles Formation contain most of the groundwater in the aquifer system. However, the lower alluvium of Recent age represents the most productive and most extensively utilized water-bearing zone.

Minor Groundwater Bodies

Minor bodies of perched groundwater exist in several areas of the Valley. These include the area overlying confining strata in the western portion of the basin, beneath Nipomo Mesa, and locally beneath the Orcutt Upland.

The thin and possibly discontinuous minor water body underlying the central part of the Orcutt Upland is contained in dune sand, perched above the main groundwater body on fine-grained deposits or old soils of the Orcutt Formation [USGS WSP 1000 1951]. Recharge of this area is wholly by infiltration of rain. Water not retained in storage or with-drawn by wells eventually reaches the main water body below.

A relatively thin minor water body exists beneath the Nipomo Upland, contained in terrace deposits and upheld by consolidated rocks [USGS WSP 1000 1951]. Yields from wells tapping this formation are generally not substantial. Rain serves as the main source of recharge, augmented partly by infiltration from local streams. Groundwater south of the drainage divide that is not extracted moves southwesterly through the deposits and eventually reaches the main Santa Maria groundwater basin.

Overlying the confined area of the main groundwater basin, a shallow minor groundwater body exists in the uppermost part of the alluvium and in the channel deposits [USGS WSP 1000 1951]. It extends westward into dune sand at the coastal extreme of the Santa Maria Plain. The perched groundwater body is recharged by infiltration of rain and irrigation water, and by stream seepage. The minor water body discharges westward toward the ocean. It sustains the perennial dry-season flow in the lower reaches of the Santa Maria River and Oso Flaco Creek. The hydrologic equations developed in Chapter 6 of this study support the conclusion that only a portion of the recharge tributary to the shallow perched groundwater body actually deep percolates through the confining clay strata to the main groundwater body. Magnitude of this deep percolation is apparently on the order of twenty percent of the total recharge to the perched groundwater.

Base of Fresh Water

A number of agencies have investigated and defined the base of fresh water underlying all or part of the Santa Maria groundwater basin. Among these are included the U.S. Geological Survey, [USGS WSP 1000 1951] the California Department of Water Resources, [DWR 1971] and the Santa Barbara County Petroleum Department [SBCPD 1974].

In 1966, USGS prepared generalized contours at the base of the fresh groundwater [USGS WSP 1819A 1966]. The areal extent of that map very closely corresponds to the study area defined herein. Consolidated rocks form the bottom of the aquifer system. Their density and high degree of compaction render them incapable of transmitting water [USGS WSP 1000 1951]. Most of the consolidated rock formations possess fractures, joints, and fissures induced by a geologic history of faulting and folding. It is believed that adjacent unconsolidated, water-bearing deposits within the main groundwater basin are recharged to a limited extent by water transmitted through fractures in the consolidated rocks [USGS WSP 1000 1951]. Where fractured and close enough to the surface to have been recharged, the Sisquoc and Monterey Formations, although better known for their oil-bearing properties, could conceivably contain fresh water [SBCPD 1974].

The base of the Santa Maria groundwater basin is depicted on Figure 1-5. This figure was constructed from results of investigations prepared by the Santa Barbara County Petroleum Department [SBCPD 1974] and the California Department of Water Resources [DWR 1971]. Two methods, differing slightly, were utilized in these two studies to define the limit of quality for usable fresh water.

The base of groundwater underlying the Oso Flaco and Nipomo Mesa areas of San Luis Obispo County was defined according to Department of Water Resources interpretation. This definition assumed that chloride ion concentrations must be less than 500 mg/l and that at least 25 percent of the vertical section as reported on drillers' logs must consist of sands and gravels.

The base of fresh water determination prepared by the Santa Barbara County Petroleum Department is oriented exclusively toward the portion of the Santa Maria study area within that county. Figure 1-5 is based on the Petroleum Department investigation rather than the earlier USGS report because the county analysis is relatively recent (1974) and was able to rely on the many new drillers logs generated since 1966. The county and USGS fresh water definitions appear to be quite compatible with one another, however.

Electric surveys of oil wells served as primary data in the county study. By analyzing resistivity and spontaneous potential curves, and

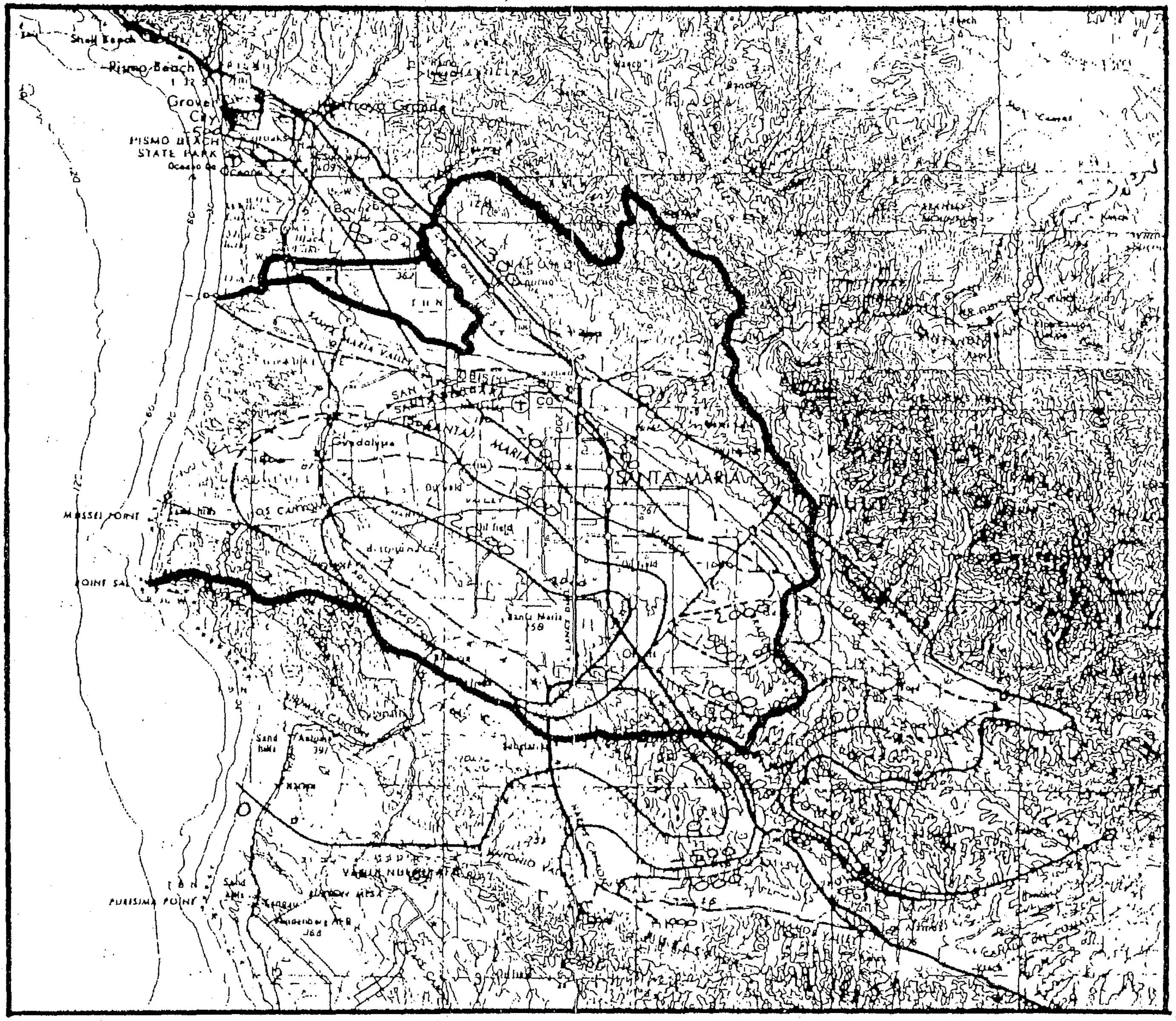


FIG. I.-5 BASE OF FRESH GROUNDWATER

employing a knowledge of local subsurface geology, the Petroleum Department was able to define the effective base of fresh water. Resistivity of 2,500 mg/l TDS water was used in the definition. Since one of the Department's primary responsibilities is protecting all usable fresh water within the county against possible degradation by petroleum operations, the fresh water definition encompasses supplies which future developments in technology could economically refine to practical levels of water quality. The "resistivity of electric current flow" method utilized to determine usable fresh water was checked by the County against test data available from the California Department of Water Resources [SBCPD 1974]. In areas of the basin where no electric logs were run, these tests, in conjunction with geology of the areas, served to define probable groundwater depths.

CHAPTER 2

POPULATION AND LAND USE

The nature and extent of municipal, industrial, and agricultural activities within the Santa Maria Valley and Sisquoc Plain determine not only magnitude of consumptive water use, but also the response of the groundwater basin to present and projected levels of development. The latter item is chiefly concerned with the potential of seawater intrusion induced by lowered groundwater levels in coastal areas and the change of groundwater in storage. Demographic features of the Santa Maria Valley and their respective demands for available water resources are evaluated to the year 2025. This derivation is developed in terms of the Santa Maria Valley and the alluvial plain of the lower Sisquoc River.

HISTORIC LAND USE

Intensively irrigated agriculture dominates much of the Santa Maria Valley. Vegetables, which are the most important crops, were historically rotated with sugar beets, beans, alfalfa, and dry-land crops [USDA Apr. 2, 1950]. Flower seeds are also raised. Most of the land is multiple cropped, requiring widespread use of fertilizer. Summer crops in the Santa Maria Valley consist of lettuce, celery, and strawberries. Cole crops (broccoli, cauliflower, cabbage), are the most important winter crops. Celery, lettuce and broccoli can usually be triple cropped. New crops are started as growing plants rather than as seeds, since seed development would extend too far into the growing season. Bean cultivation represents a major agricultural land use. Lima beans typically require irrigation. Garbanzo beans, which are also grown in the Valley, are non-irrigated [DWR Mem. 1969].

Cropping patterns in various portions of the Santa Maria study area have been identified by a number of land use investigations. Data that characterize early base period years were developed by the Santa Barbara County Agricultural Commissioner and presented in annual agricultural crop reports. These reported crop acreages were representative of the combined areas of the Santa Maria Valley, including the Oso Flaco Lake region of San Luis Obispo County, and the Sisquoc Plain. Information for Nipomo Mesa was not available. Truck crop acreages reflect double cropping. Agricultural acreage within the drainage of San Antonio Creek (Los Alamos groundwater basin), is also summarized by these early surveys with the Santa Maria total. However, such acreages are relatively small. Since little background information on these surveys is available, the validity and degree of accuracy of the findings are subject to conjecture.

In 1938, the Santa Barbara County Water Agency sponsored an aerial land use reconnaissance of the County. Because results of this survey were presented in terms of Districts within the County, rather than by hydrologic drainage basins, data specifically oriented toward the Santa Maria study area were not generated. Nevertheless, irrigated and urban acreages reported for the Fifth District appear to correspond to those within the study area.

A land-classification survey was conducted by the U.S. Department of Agriculture in 1947 as part of that Agency's flood control and erosion prevention survey report [USDA Ap. 1 & 2 1950]. Extent and distribution of vegetative cover types were analyzed in detail as basic data for investigations undertaken by the survey. Natural cover in the watershed was segregated into seven major types. Agricultural areas were designated as either irrigated or non-irrigated. No breakdown of individual crops was provided.

A land use survey was conducted by the State Water Resources Board and published in 1955. Unfortunately the "Santa Maria" Hydrologic Unit utilized in the report includes the Cuyama River Valley, an area not considered in this present study. Hence data are not compatible with the study area definition.

Estimates of land use within the Santa Maria Valley were prepared by the California Department of Water Resources in 1959 and again in 1968 as part of land use studies encompassing the Counties of Santa Barbara and San Luis Obispo [DWR No. 103 1964; Mem. 1969]. Areal breakdown of hydrologic units into smaller subunits was accomplished in great detail in the 1959 land use survey. Selected subunits can be reassembled to approximate the area encompassed by the Santa Maria Valley and Sisquoc Plain. Fallow land identified by the California Department of Water Resources in its 1959 Land Use Survey was resurveyed three times at intervals of four months by this Agency to determine the type and extent of crops subsequently planted. In the Santa Maria Valley it was found that portions of the fallow acreages were planted to truck crops 70 percent of the time, field crops 20 percent, and left fallow all year ten percent [DWR No. 103 1964]. Fallow acreage should be distributed to the appropriate crop categories when determining agricultural water use. However, this adjustment does not appear in the survey acreage values for 1959 and 1968.

Land use data and maps representative of Santa Barbara County were updated by the University of California, Santa Barbara, Geography Department, Remote Sensing Unit (GRSU) and the County Farm Advisor and his staff at the request of the Santa Barbara County Water Agency UCSB 1974; 1975]. The 1975 survey also included the area in southern San Luis Obispo County between the Santa Maria River and Nipomo Mesa. Acreages of agricultural crops are representative of 1973 and 1975 conditions. Primary data was deduced from aerial photographs, field checked by UC Cooperative Extension agriculturalists with assistance from GRSU personnel. Information was mapped at a scale of 1:24,000 using 7-1/2 minute USGS topographical quadrangles as base maps. By discounting selected acreages, data from these studies can be aggregated to reflect agricultural land uses in most of the study area defined herein. Data developed by all of the aforementioned land use surveys are summarized in Tables 2-1 and 2-2.

FUTURE LAND USE

Cropping patterns in the Santa Maria Valley are projected to the year 2025 in Table 2-3. Future land use is anticipated to reflect a general trend of reduced field crop acreage in favor of truck crops. Increased costs associated with pumping and applying irrigation water and economic incentive produced by accelerated local urban demand for truck crops are believed to be major factors responsible for this trend. Projections of Table 2-3 assume measures will be implemented in the Santa Maria Valley to maintain and intensify agricultural production despite decreasing quality of irrigation water in some areas. Elaborate drainage ditch systems, tile drains, and deepened irrigation wells which tap better quality water in lower aquifers are remedial actions in this regard. Estimates of future land use were guided by data in the proposed Santa Barbara County Comprehensive Plan regarding suitability of lands for agricultural expansion (Livingston and Blaney, et. al. August 1974).

TABLE 2-3. PROJECTED IRRIGATED CROP ACREAGES - SANTA MARIA VALLEY

Irrigated Agriculture	1980	1990	2000	2010	2020	2025
Alfalfa & Pasture	5,000	5,000	5,000	5,000	5,000	5,000
Truck Crops	27,500	28,000	28,500	29,000	29,500	29,800
Field Crops	7,500	7,000	6,500	6,000	5,500	5,200
Vineyards	2,000	3,000	4,000	4,500	5,000	5,000
Fallow	500	500	500	500	500	500
TOTAL	42,500	43,500	44,500	45,000	45,500	45,500

TABLE 2-1. HISTORIC LAND USE, SANTA MARIA STUDY AREA [a]

Land Use	1935[b,c]	1936[c,d]	1937[38,c]	1938[c,e]	1939[c,f]	1947[g]	1952[46,h]
CULTIVATED LAND							
Ornamentals							60
Alfalfa	5,500	5,350	5,100	4,714	5,867	1,592[h]	2,062
Pasture							2,309
Citrus & Subtropicals							
Truck Crops							
Anise	150	223	287	174			45
Artichokes							456
Bean, Lima	1,807	?	3,755	3,252			576
Broccoli	357	1,601	2,132	1,711			8,265
Cabbage	106	121	107	72			312
Carrots	3,664	2,898	1,122	813			1,208
Cauliflower	4,312	5,647	5,694	5,394			4,073
Celery	725	832	1,164	1,549			1,666
Chicory	184	516	966	319			293
Lettuce	5,951	7,400	7,880	7,490			11,060
Mixed Vegetables	2,000	582	733	388			58
Onions		10	10	14			
Parsley	50						
Peas	1,997	1,830	2,745	1,191			199
Peppers	151	189	238	341			659
Potatoes	1,659	1,096	995	1,593	1,240	4,014[h]	2,923
Romaine							81
Strawberries							766
Tomatoes	1,792	3,919	4,967	1,603			250
Subtotal Vegetables	24,905	?	32,795	25,904		28,760[i,h]	32,890
Flower and/or vegetable seeds	820	842	730	1,045		1,921[h]	711
TRUCK CROPS TOTAL	25,725		33,525	26,949		30,681[h]	33,601

TABLE [illegible]. (continued)

Land Use	1935[b,c]	1936[c,d]	1937[38,c]	1938[c,e]	1939[c,f]	1947[g]	1952[46,h]
Field Crops							
Field Corn					1,805		
Mustard	560	1,950	221	117	967	267[h]	
Sugar Beets	3,629	3,552	2,059	3,598	?	5,693[h]	4,607
Grain sorghums					273		
Dry Beans	22,922	?	15,375	20,255	?	?	5,446
FIELD CROPS TOTAL	27,111	?	17,655	23,970	?	?	10,053
Deciduous Fruits and Nuts			32	32			
Small Grains							
Barley	11,400	14,750	10,700	10,621	9,831		
Wheat	1,825	4,946	11,740	16,280	9,283		
Oats	4,980	4,550	2,245	4,811	5,996		
Total	18,205	24,246	24,685	31,712	25,110		1,946
Grain Hay	16,000	9,000	8,400	8,500	10,361		1,250
Vineyards							
TOTAL CROPLAND	92,541	93,003	89,397	95,877			
TOTAL IRRIGATED AGRICULTURE[j]		32,000[41]		29,000[1]		38,710[k]	36,800
TOTAL NON-IRRIGATED AGRICULTURE(est.)		44,000[m]		50,750[m]		48,500[n]	
USABLE RANGELAND [o]						50,982[44]	
COMMERCIAL WOODLOTS						1,300[44]	
NON-AGRICULTURAL LAND							
Urban, including industrial				1,395[42]		1,610[44,q]	
Other watershed[p]						7,763[44]	
Semi-barren						325[44]	
River washes, swamps, and dunes						6,840[r]	

[a] Reflects land acreages that produced crops during a particular year, but does not consider multiple cropping.

Data for years 1935 through and including 1939 represent the Santa Maria Valley (including Oso Flaco District of San Luis Obispo County) and Sisquoc Plain, but do not include Nipomo Mesa. Agricultural acreage in the San Antonio Creek drainage (an area outside the Study Area) is also included. However, such acreage is relatively small.

Data for years 1947 and 1952 represent acreage within the Santa Maria Valley Water Conservation District. The District includes 51,525 acres that encompass the valley floor of the Santa Maria Valley, a small portion of the westernmost Sisquoc Plain, and the Oso Flaco District. Data for acreage of truck crops for 1947 and 1952 are representative of that land use in the Santa Maria Study Area. Data for field crops and typically non-irrigated crops are not representative of the Study Area.

Crop grouping was rearranged from historic interpretation in some cases to correspond to California Department of Water Resources land use definitions.

[b] Reference Kellogg, 1936; except as noted.
[c] The area represented by these acreages corresponds to the drainage basins of the Santa Maria and Sisquoc Rivers, and San Antonio Creek. The San Antonio area is outside the Santa Maria Study Area defined by this report.
[d] Reference Kellogg, 1937; except as noted.
[e] Reference Kellogg, 1939; except as noted.
[f] Reference Page and O'Brien, 1940; except as noted.
[g] Reference Santa Maria Valley, 1950; except as noted.
[h] Area within Santa Maria Valley Conservation District only.
[i] Includes 24,746 acres of non-potato vegetables.
[j] Irrigated acreage for 1930: 26,625 acres [Lippincott, 1931] 1940: 33,000 acres (est.) [USGS, 1951]; 1941: 33,000 acres (est.) [USGS, 1951]; 1942: 34,000 acres (est.) [USGS, 1951]; 1943: 34,000 acres (est.) [USGS, 1951]; 1944: 35,000 acres (est.) [USGS, 1951]; 1950: 35,700 acres [USBR, 1951].
[k] 36,600 acres in Santa Maria Subunit; 2,050 acres in Sisquoc Subunit [USDA, 1950a].
[l] 29,388 acres [Santa Barbara Co., 1940] minus 400 irrigated acres in Cuyama Valley [USGS, Open File, 1970].
[m] Non-irrigated agriculture estimate was computed as follows:
non-irrigated agriculture = total cropland - (irrigated acreage x 1.27 multiple cropping factor [USBR, 1951]) - average non-irrigated acreage in Sisquoc Subunit not on Sisquoc Plain (11,040 [USDA, 1950a] - 2,750).
[n] 45,780 acres in Santa Maria subunit; plus a portion of the 11,040 acres identified in Sisquoc Subunit [USGS, Open File, 1970] estimated to average approximately 2,750 acres.
[o] Includes open grassland, sagebrush, pinyon-juniper, semi-barren and some land also used for production of petroleum.
[p] Includes mixed conifer, oak woodland, chamise, and chaparral.
[q] Includes 25 acres in Sisquoc Subunit.
[r] Includes 6,185 acres in Santa Maria Valley [USDA, 1950b] and 655 acres in entire hydrologic drainage of the Sisquoc River. [USDA, 1950b]] Not all of these 655 acres overlies the Sisquoc Plain, however.

TABLE 2-2. HISTORIC [illegible] USE, SANTA MARIA STUDY AREA [a]

Land Use Category[b]	1959[g] (acres) Santa Maria Subunit	Sisquoc Subunit[c]	Nipomo Mesa Subunit [d]	Total	1966 Santa Maria Valley[m]	Oso Flaco[n]	Total
Water Service Area							
Urban and Suburban							
Residential	1,680	20	70	1,770	4,810[g]		4,810[g]
Commercial	240	[f]	[f]	240	[g]		[g]
Industrial	190	[f]	20	210	[h]		[h]
Unsegregated urban and suburban	1,110	150	90	1,260	1,965	147	2,112
Subtotal	3,220	170	180	3,570	6,775	147	6,922
Included non-water service area	2,450	290	170	2,910			
TOTAL URBAN AND SUBURBAN	5,670	460	350	6,480			
Irrigated Agriculture							
Ornamentals	--	--	--	--			
Alfalfa	2,230	590	[f]	2,820			
Pasture	2,430	400	0	2,830	6,340[i]	2,087[i]	8,427
Citrus & Sub-tropicals	0	0	0	0	30		30
Truck Crops	15,260	230	150	15,640	18,090	6,570	24,660
Field Crops	7,370	1,330	10	8,710	5,800	412	6,212
Deciduous Fruits & Nuts	20	0	50	70	5		5
Small Grains	30	10	0	40	30		30
Vineyards	0	0	0	0	100		100
Subtotals	27,340	2,560	210	30,110	30,395	9,069	39,464
Fallow	5,320	100	10	5,430	240		240
Included non-water service area	1,990	270	10	2,270	1,915		1,915
Other	--	--	--	--		--	--
Total Irrigated Agriculture	34,650	2,930	230	37,810	32,550	9,069	41,619
Total Water service area	40,320	3,390	580	44,290			
Nonwater Service Area							
Nonirrigated Agriculture	5,230	2,870	340	8,440	9,450		9,450
Native vegetation	64,460	18,660	14,210	97,330			
Unclassified	40,240	278,840	1,060	320,140			
Total non-water service area	109,930	300,370	15,610	425,910			
GRAND TOTAL	150,250	303,760	16,190	470,200			

[a] Land use for the Study Area, in its entirety, is not available for 1966, 1968, 1973, and 1975 because data representative of the Nipomo Mesa was not compiled. In addition, the 1973 data do not include the portion of the Study Area in San Luis Obispo County between Santa Maria River and Nipomo Mesa. See Appendix B for graphic presentation of major agricultural land uses.

[b] Land use categories are standard California Department of Water Resources definition.

[c] This subunit encompasses the entire drainage of the Sisquoc River. Hence, much of the total acreage is outside the study area. However, almost all of the urban and agricultural land use occurs in the alluvial plain of the lower Sisquoc River, an area within the boundaries of this study.

[d] Area of Nipomo Mesa not tributary to the Arroyo Grande Hydrologic Subunit. Includes that portion of the Mesa that drains to Black Lake, an area outside the study boundaries.

[e] Data represent land use on the alluvial plain of the lower Sisquoc River only, Do not include crops in Tepusquet Canyon, and in the Zaca Lake region, upstream from USGS gaging station 11138500.

1968[o]			1973[p]			1975[q]		
Sa[illegible] M[illegible] Subunit	Sisquoc Subunit[c]	Total	Santa Maria Subunit	Sisquoc Subunit[e]	Total[k]	Santa Maria Subunit	Sisquoc Subunit[e]	Total[l]
3,030	20	3,050						
540	[f]	540						
240	[f]	240						
1,380	150	1,530	773	44	817	--	--	429
5,190	170	5,360						
5,870	3,000	8,870						
11,060	3,170	14,230						
--	--	--	336	0	336	--	--	626
4,950	680	5,660						
2,930	400	3,330	3,619[i]	1,721[i]	5,340[i]			5,461[i]
70	40	110	0	2	2			
15,520	250	15,770	15,772	191	15,963			26,876
9,510	1,880	11,390	9,985	1,507	11,492			9,818
20	0	20	0	2	2			
70	10	80						
0	90	90	2,593	3,019	5,612			4,588
33,100	3,350	36,450	32,305	6,442	38,747			47,369
5[illegible]	100	5,220						
2,190	310	2,500						
--	--	--						
40,410	3,760	44,170						
51,470	6,930	58,400						
3,950	2,290	6,240	2,419[j]	1,101[j]	3,520			1,615
55,350	15,980	71,330						
39,480	278,560	318,040						
98,780	296,830	395,610						
50,250	303,760	454,010						

[g] Includes both residential and commercial acreages.
[h] Industrial acreage excluding extractive (oil) activities not compiled.
[i] Includes alfalfa acreage.
[j] Includes grain, hay, and other non-irrigated crops.
[k] Does not include any portion of Study Area in San Luis Obispo County.
[l] Includes portion of Study Area in San Luis Obispo County north of Santa Maria River, extending up to, but not including, Nipomo Mesa. Reflects replanting of between-crop (fallow) acreage during the year.
[m] USGS, Open File, 1970.
[n] Lawrance, 1967.
[o] DWR, 1969.
[p] UCSB, 1974.
[q] UCSB, 1975.

POPULATION

Historic population data have been derived from a number of sources, and in some cases are aggregated to represent the number of residents within the Santa Maria study area.

Population projections for their respective portions of the study area have been prepared by the local planning agencies of Santa Barbara and San Luis Obispo Counties. These data, summarized in Table 2-4 and on Figure 2-1, are used to forecast urban water requirements.

Three population forecasts have been developed by the State Department of Finance which reflect a range of population growth in the Santa Maria study area. These projections are presented in Table 2-4 following the local agency projections. The Department of Finance low projection assumes a fertility rate of 2,110 births per thousand women and a net immigration of zero into the State. The middle or base projection assumes a fertility rate of 2,450, with net immigration for the state regarded to stabilize at 150,000 during the years 1980 to 2000. The high projection assumes a fertility rate of 2,780 and net state immigration of 300,000 [SWRCB Prt. II Apr. 1975] All Department of Finance figures are higher than the local agency projections.

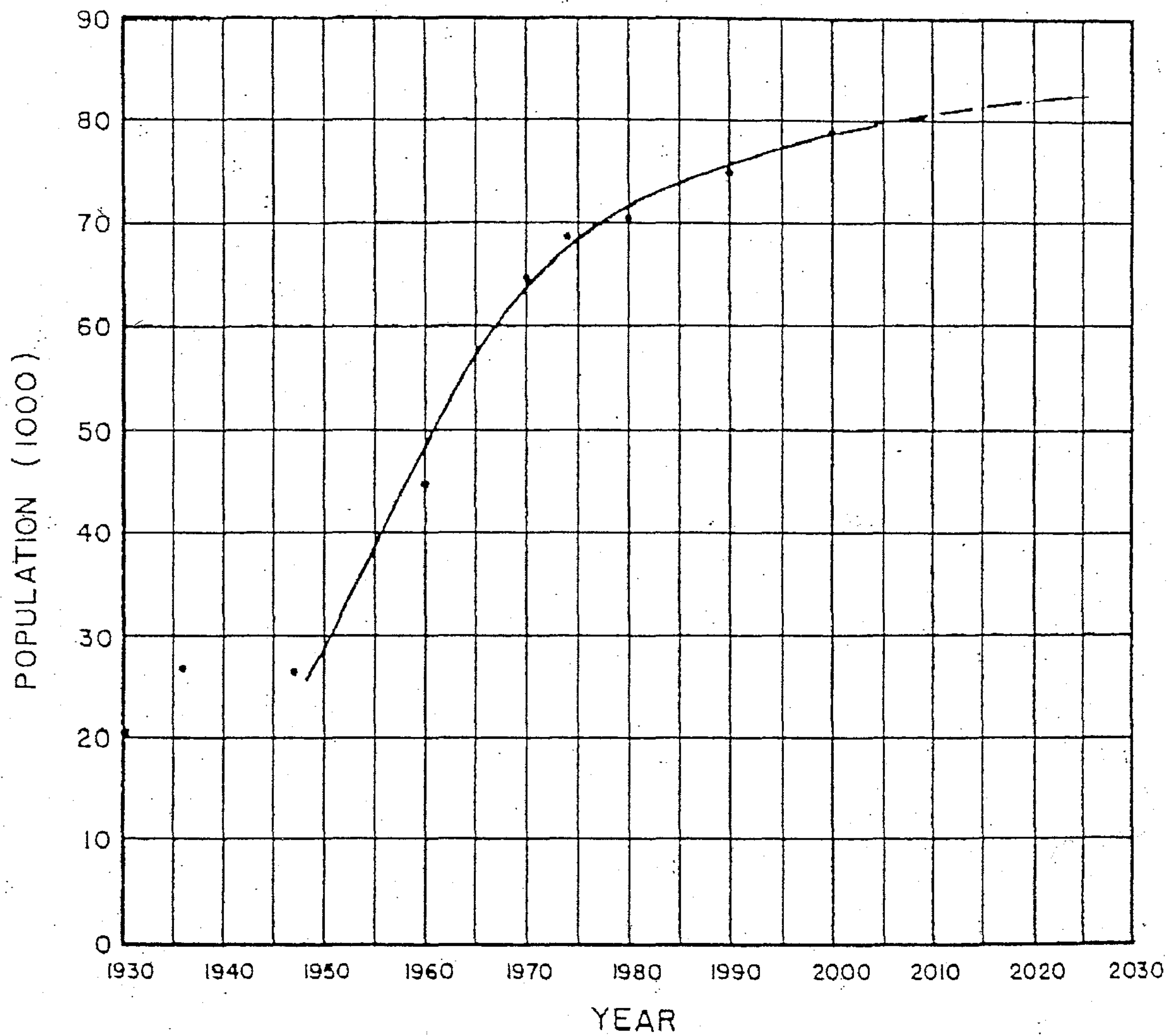
TABLE 2-4. HISTORIC AND PROJECTED POPULATION, SANTA MARIA STUDY AREA [a]

City/Area	1930[b]	1931[51]	1936[50]	1947[50]	1953[46]	1960[c]	1965[53]	1970[c]	1972[53]	1974[c]
Santa Maria	7,057		8,000	12,300	12,500	20,027	30,063	32,749	33,625	33,906
Guadalupe	2,418		2,650	2,900		2,614	2,813	3,145	3,219	3,281
Orcutt	996		1,150	1,400						
Betteravia	750		750	800						
Sisquoc	300		300	300						
Garey	150		175	175						
Casmalia[g]	150		150	150						
Rural Area within SMVWCD[h]					3,500					
Area outside SMVWCD					6,000					
Urban Territory SMVWCD			7,150	8,500						
Study Area, Santa Barbara Co. [i]						39,667	52,813	56,630	58,062	58,625
Study Area, San Luis Obispo County						4,668[j]				
Nipomo[k]								3,642[59]		4,683[59]
Rural[l]								4,194[59]		5,018[59]
TOTAL, Study Area	20,000 [n,o]	20,325 [m]	26,525 [m]	26,000 [m]		44,335		64,466		68,326

Table 2-4. Continued.

City/Area	1975[d]	1980[e]	1990[e]	2000[e]	2010[f]	2020[f]	2025[f]
Santa Maria		35,562	37,594	39,156			
Guadalupe		3,469	3,750	4,000			
Orcutt							
Betteravia							
Sisquoc							
Garey							
Casmalia[g]							
Rural Area within SMVWCD[h]							
Area outside SMVWCD							
Urban Territory SMVWCD							
Study Area, Santa Barbara Co. [i]		61,124	64,688	67,500			
Study Area, San Luis Obispo County							
Nipomo[k]	5,254[59]	4,930[m]	6,060[m]	7,180[m]			
Rural[l]	5,553[59]	4,210[m]	4,090[m]	3,980[m]			
TOTAL, Study Area [p,q]		70,264	74,838	78,660	80,500	82,000	82,700
Total Study Area [SWRCB, Part II, April 1975]							
High:		73,000	117,660	185,400			
Base:		69,910	108,650	152,440			
Low:		65,460	78,730	91,200			

[a] Primary data has been generated by several agencies. This tabulation reassembles data in terms of the general study area boundary.
[b] SMVWCD, except as noted.
[c] SBCPD, July 1, 1973, Revised, except as noted. Census population.
[d] SBCPD, July 1, 1973, Revised, except as noted.
[e] SBCPD, July 1, 1973, except as noted. Includes impact of Vandenberg AFB Space Shuttle Program.
[f] Projected by Toups based on population curve, Figure 2-1.
[g] Casmalia is situated outside the Santa Maria Study Area. However, source water for the community water system is imported from the Santa Maria Groundwater Basin by Union Oil Company.
[h] SMVWCD: Santa Maria Valley Water Conservation District.
[i] Corresponds to summation of "Santa Maria", "Orcutt", and "Guadalupe" Areas, defined by Santa Barbara County Planning Department.
[j] Corresponds to summation of 1960 census population of Enumeration Districts 40.59, 40.50, and 40.49.
[k] Unincorporated town of Nipomo.
[l] Rural population of Arroyo Grande Division. Includes some rural population outside Santa Maria Study Area.
[m] Breska, Nov. 1975. Population projections based on 1970 data are the most current available. When compared to 1975 data, are slightly low.
[n] Includes Oso Flaco District in San Luis Obispo County; does not include Nipomo Mesa.
[o] Lippincott, March 1931.
[p] Summation of local agency projections.
[q] Average population of Santa Maria Valley during base period years was 37,000.



[a] BASED ON LOCAL AGENCY DATA IN TABLE 2-5
(DASHED PORTION OF CURVE
PROJECTED BY TOUPS)

FIG. 2-1 HISTORIC AND PROJECTED POPULATION, SANTA MARIA STUDY AREA [a]

CHAPTER 3

SURFACE WATER SUPPLY

Water resources tributary to the Santa Maria Valley consist of native precipitation and runoff from local watersheds, surface water inflow from upstream drainage basins, and subsurface inflow of stream seepage and groundwater. The various components of water supply that are expressed as surface water flow are quantified in this chapter. Subsurface recharge is examined in Chapter 6.

PRECIPITATION

Three precipitation stations within the Santa Maria Valley and one nearby station (Los Alamos) possess records which extend throughout the base period. Data for these key stations are identified in Table 3-1. Annual records were summed and averaged to provide a base comparison, which was then used to generate years of missing data at neighboring stations by double-mass analysis. The relationship between accumulated annual mean precipitation for incomplete stations and key stations is depicted graphically in Appendix A. Actual and prorated yearly precipitation at various stations is presented in Table 3-2. These data were used to develop the base period averages, summarized previously in Table 1-2, as well as the isohyetal distribution of Figure 1-4.

Native precipitation falling directly on Valley floor and mesa lands represents a component of water supply that is not considered in the recoverable water determination, to be developed later in this chapter, for ungaged mountain and foothill watershed areas within the Valley. Hence, an independent analysis of this parameter is in order.

TABLE 3-1. BASE PERIOD MEAN ANNUAL PRECIPITATION, KEY STATIONS
(inches)

Water Year	T12071900 Betteravia	T13510700 Los Alamos	T12620700 Nipomo 2NW	T12794000 City of Santa Maria	4-Station Mean
1935	16.94	18.23	23.44	19.55	19.54
1936	13.04	13.54	15.42	13.48	13.87
1937	18.65	21.25	21.02	20.82	20.44
1938	20.75	20.60	22.78	22.18	21.58
1939	13.13	13.78	10.79	11.51	12.30
1940	12.04	13.57	17.49	14.61	14.43
1941	29.16	35.29	31.09	30.75	31.57
1942	16.04	17.72	18.86	16.95	17.39
1943	14.45	16.30	18.28	17.22	16.56
1944	13.09	17.36	13.57	14.56	14.65
1945	11.39	12.25	15.16	11.31	12.53
1946	10.90	13.41	10.77	11.08	11.54
1947	7.77	8.92	11.23	9.42	9.34
1948	8.12	8.08	11.55	8.20	8.99
1949	10.55	11.68	12.09	9.17	10.87
1950	11.50	12.43	14.71	10.47	12.28
1951	9.21	10.20	11.04	8.66	9.78
1952	18.51	21.69	23.48	18.57	20.56
1953	12.02	12.51	13.65	10.87	12.26
1954	11.55	13.46	15.00	12.12	13.03
1955	12.37	13.24	14.00	13.17	13.20
1956	13.67	16.79	18.37	14.56	15.85
1957	13.63	10.27	11.27	9.01	11.05
1958	21.50	29.17	28.37	25.86	26.23
1959	8.65	8.59	9.28	7.62	8.53
1960	12.03	12.91	15.46	11.33	12.93
1961	8.39	7.20	9.93	7.11	8.16
1962	18.85	23.27	22.57	16.39	20.27
1963	13.18	14.18	15.45	11.30	13.53
1964	8.08	9.27	11.58	7.81	9.19
1965	13.12	13.79	16.94	11.62	13.87
1966	10.02	12.64	14.98	9.13	11.69
1967	17.33	17.51	22.78	14.96	18.15
1968	9.17	9.38	10.78	8.25	9.40
1969	24.87	27.22	29.45	20.84	25.59
1970	9.10	10.05	11.63	9.59	10.09
1971	10.14	11.21	14.56	9.82	11.43
1972	5.03	7.38	7.02	5.45	6.22
1973	21.15	21.58	25.59	19.63	21.99
1974	16.89	15.98	22.74	15.21	
1975				11.59	
Base Period Mean Annual Precip. 1935-72	13.37	14.90	16.21	13.30	14.44

TABLE 3-2. BASE PERIOD MEAN ANNUAL PRECIPITATION, SELECTED REGIONAL STATIONS [a]
(inches)

Water Year	T12012920 Almar Ranch	T10032000 Arroyo Grande No. 1	Guadalupe	T14506440 Lompoc Hiway Maint. Station	T10694300 Pismo Beach
1935	(20.13)	(22.08)	16.89	(18.56)	(22.67)
1936	(14.29)	(15.67)	13.16	(13.18)	(16.09)
1937	(21.05)	(23.10)	16.21	(19.42)	(23.71)
1938	(22.23)	(24.39)	18.19	25.09	(25.03)
1939	(12.67)	(13.90)	10.45	14.68	(14.27)
1940	(14.86)	(16.31)	9.97	13.60	(16.74)
1941	(32.52)	(35.67)	24.06	40.34	(36.62)
1942	(17.91)	(19.65)	13.49	17.15	(20.17)
1943	(17.06)	(18.71)	10.53	11.38	(19.21)
1944	(15.09)	(16.55)	10.58	14.39	(16.99)
1945	(12.91)	(14.16)	9.68	11.42	(14.53)
1946	(11.89)	(13.04)	(8.77)	12.40	(13.39)
1947	(9.62)	(10.55)	(7.10)	8.69	(10.83)
1948	(9.26)	(10.16)	(6.83)	7.82	(10.43)
1949	(11.20)	(12.28)	(8.26)	13.54	(12.61)
1950	(12.65)	(13.88)	(9.33)	10.20	(14.24)
1951	(10.07)	(11.05)	(7.43)	7.92	(11.34)
1952	(21.18)	(23.23)	(15.63)	21.11	23.41
1953	(12.63)	(13.85)	(9.32)	11.97	13.16
1954	(13.42)	(14.72)	(9.90)	12.17	16.08
1955	(13.60)	(14.92)	(10.03)	12.23	15.06
1956	(16.33)	(17.91)	(12.05)	15.82	17.80
1957	(11.38)	(12.49)	(8.40)	10.86	11.07
1958	(27.02)	(29.64)	(19.93)	25.00	32.74
1959	(8.79)	(9.64)	(6.48)	7.74	9.15
1960	(13.32)	13.87	(9.83)	9.25	14.38
1961	(8.40)	9.99	(6.20)	8.01	9.87
1962	(20.88)	18.95	(15.41)	20.61	16.93
1963	(13.94)	14.97	(10.28)	15.05	16.72
1964	11.80	10.14	(6.98)	9.51	10.45
1965	12.37	14.97	(10.54)	15.37	14.23
1966	10.84	12.43	(8.88)	12.66	12.89
1967	19.90	21.55	(13.79)	13.85	20.89
1968	11.25	10.75	(7.14)	6.79	13.08
1969	28.46	29.54	(19.45)	21.94	35.51
1970	10.11	10.55	(7.67)	9.58	12.03
1971	10.29	13.97	(8.69)	9.12	14.14
1972	5.49	8.12	(4.73)	6.68	6.87
1973	21.63	25.25		20.24	25.89
1974	17.16	21.05		16.66	20.72
Base Period Mean Annual Precip. 1935-72	14.92	16.25	11.11	14.08	16.72

TABLE 3-2. BASE PERIOD MEAN ANNUAL PRECIPITATION, SELECTED REGIONAL STATIONS [a] (cont.)
(inches)

Water Year	T12794665 Santa Maria 12 E. Smith	T12826701 Sisquoc Ranch	T12862700 Suey Ranch	T12911100 Twitchell Dam	T12414400 Huasna
1935	(26.97)	(20.32)	20.55	(22.47)	(25.01)
1936	(19.14)	(14.42)	13.14	(15.95)	(17.75)
1937	(28.21)	(21.26)	20.55	(23.51)	(26.16)
1938	(29.78)	24.18	23.60	(24.82)	(27.62)
1939	(16.97)	6.93	11.25	(14.15)	(15.74)
1940	(19.91)	16.94	15.98	(16.59)	(18.47)
1941	(43.57)	36.89	30.27	(36.31)	34.80
1942	(24.00)	17.57	17.52	(20.00)	20.54
1943	(22.85)	17.96	19.07	(19.04)	25.29
1944	(20.22)	15.77	14.60	(16.85)	16.72
1945	(17.29)	13.75	12.07	(14.41)	16.34
1946	14.25	11.85	(11.66)	(13.27)	15.34
1947	12.18	8.02	(9.43)	(10.74)	12.81
1948	15.10	9.71	(9.08)	(10.34)	12.92
1949	16.95	11.11	(10.98)	(12.50)	12.41
1950	17.23	12.09	(12.40)	(14.12)	16.94
1951	20.82	(10.17)	(9.88)	(11.25)	14.37
1952	30.98	(21.38)	(20.77)	(23.64)	25.52
1953	17.67	(12.75)	(12.38)	(14.10)	16.00
1954	15.32	13.12	(13.16)	(14.98)	16.54
1955	17.18	13.56	(13.33)	(15.18)	15.95
1956	22.19	15.27	(16.01)	(18.23)	17.98
1957	15.65	9.81	(11.16)	(12.71)	12.62
1958	38.34	27.25	(26.49)	(30.16)	34.72
1959	10.14	8.89	(8.62)	(9.81)	9.35
1960	17.73	8.29	13.41	(14.87)	16.09
1961	10.71	8.33	9.36	(9.38)	11.17
1962	27.38	22.58	19.45	(23.31)	24.18
1963	18.34	13.66	13.93	(15.56)	15.73
1964	13.97	8.20	10.17	10.76	11.55
1965	22.17	15.33	12.84	14.82	16.97
1966	15.69	13.05	10.82	12.13	13.71
1967	27.98	21.85	19.29	23.85	30.33
1968	12.44	11.16	10.87	11.74	12.00
1969	30.35	26.85	25.13	28.95	34.96
1970	13.78	10.68	9.64	9.99	11.67
1971	14.08	11.03	12.08	13.49	15.79
1972	7.49	7.00	6.50	7.41	7.23
1973	26.57	21.78	22.37	25.67	26.84
1974	20.68	16.64	19.94	21.69	20.39
Base Period Mean Annual Precip. 1935-72	20.13	14.97	14.67	16.62	18.40

[a] Stations identified by name and California DWR index number; data in parentheses prorated by double-mass comparison with mean annual key station precipitation.

The isohyetal method of averaging precipitation over an area is considered to be the most reliable statistical procedure [Linsley 1958]. According to this method, average precipitation for an area is computed by weighting the average precipitation between successive contours of equal precipitation (isohets) by the area between isohyets, summing the resultant products, and dividing by the total area.

Results of the foregoing procedure conducted for the Santa Maria Valley are presented in Table 3-3. They indicate that 31,800 and 88,100 acre-feet of rainfall, respectively, are generated on an average annual basis over the semi-confined and remaining unconfined portions of the groundwater basin. Because of the varying impact on Valley water resources of precipitation falling directly on areas of semi-confined or unconfined groundwater, native precipitation is derived with respect to these two areas. Average precipitation over the Sisquoc Plain is quantified in Table 3-4.

TABLE 3-4. NATIVE PRECIPITATION ON THE SISQUOC PLAIN [a]

Isohyet	Net Area (sq mi)	Average Precip. (inches)	Volume
20	0.6	20.0	12.0
19	0.9	19.5	17.6
18	1.4	18.5	25.9
17	4.7	17.5	82.2
16	4.6	16.6	76.4
15	2.8	15.5	43.4
	15.0		257.5

mean annual precipitation on Sisquoc Plain = 257.5/15 = 17.17 inches = 13,740 acre feet.

[a] Precipitation quantified by isohyetal method; refer to Figure 1-4. Area considered in this analysis is the 15 square mile area of the Sisquoc Plain.

TABLE 3-3. NATIVE PRECIPITATION ON VALLEY FLOOR AND MESA LANDS [a]

isohyet	net area (sq mi)	precip. (inches)	precip. volume
Confined Area[b]			
13	7	13.5	95
12	12	12.4	149
less than 12	31	11.4	353
	50		597

mean annual precipitation on confined area
= 597/50 = 11.94 inches = 31,840 acre feet [c]

isohyet	net area (sq mi)	precip. (inches)	precip. volume
Remaining Unconfined Area[d]			
16	1	16.2	16
15	7	15.5	109
14	42	14.4	605
13	50	13.5	675
12	15	12.6	189
less than 12	5	11.6	58
	120		1,652

mean annual precipitation on remaining area
= 1,652/120 = 13.77 inches = 88,128 acre feet [c]

[a] Precipitation quantified by isohyetal method; refer to Fig. 1-4. Area considered in this analysis excludes the 90 sq. mi. mountain/foothill "watershed" area identified on Fig. 1-4 utilized in the recoverable water determination summarized in Table 3-5.
[b] Represents 50 sq. miles identified on Fig. 1-4. Boundary of confined area based on USGS, 1951, extended to border of Nipomo Mesa.
[c] Does not consider any evaporative or other losses (to be quantified in a subsequent chapter).
[d] Represents 120 sq mi, identified on Fig. 1-4.

This tabulation, the result of an isohyetal analysis, indicates that 13,700 acre-feet of rainfall are contributed annually to the Plain. It should be emphasized that the foregoing quantifications of precipitation do not take into consideration evaporation or other losses. These will be treated in Chapter 4.

UNGAGED SURFACE WATERS

Quantification of native water resources generated within the immediate watershed of the Santa Maria Valley comprise an integral part of the hydrologic inventory. Only three watercourses within the Santa Maria Valley are gaged. An assessment of the annual water contribution provided by gaged and ungaged streams, as well as by the percolating component of local precipitation, is in order.

A review of the literature pertinent to estimating water contributions from precipitation in ungaged mountain and foothill areas identified as a methodology formulated by USGS as most appropriate [USGS 1965]. The USGS procedure is based on observed relationship between recoverable water from precipitation and physiographic factors related to elevation, geographical environment and surficial basin rock formations. Results of the USGS empirical method of analysis are considered to reflect long-term hydrologic conditions, in excess of twenty-five years, and hence are appropriate to this study. Estimates of recoverable water computed by the analysis are most reliable for basins lying entirely within the Transverse and Peninsular Mountain Ranges of southern California. This area is defined by the western tip of Santa Barbara County to the Salton Sea region in the Colorado Desert. Because of its very close similarity to the southern California regime, in terms of geographic location and common climatic influences, the Santa Maria basin is considered to be well suited for recoverable water definition by the USGS methodology.

The aforementioned analysis identified the following hydrologic influences in the Santa Maria River basin:

- Precipitation, weighted basin mean: 14.60 inches
- Potential Evapotranspiration, weighted basin mean: 53.64 inches
- Recoverable Water, weighted basin mean (adjusted): 0.30 inches
- Natural Water Loss, weighted basin mean: 14.30 inches

The data utilized in computing the foregoing basin characteristics are presented in Table 3-5. Contours of equal precipitation for the Santa Maria Valley, presented previously on Figure 1-4, were prepared after compiling base period precipitation records for local and regional stations as well as reviewing the isohyetal maps respectively developed by the Santa Barbara County and San Luis Obispo County Flood Control and Water Conservation Districts [Holland 1975; Britton 1975; USDCa; USDCb; Copeland 1975]. Precipitation residual after natural water losses are satisfied (native recoverable water) assumes the form of either surface runoff or groundwater recharge. Total volume of recoverable water generated from the ungaged 90 square mile mountain and foothill watershed area of the Valley averages slightly in excess of 1,440 acre-feet per year on a long-term basis.

GAGED SURFACE WATERS

The surface water regime of the Santa Maria Valley is depicted schematically on Figure 3-1. This diagram indicates the presence of USGS stream gaging stations and shows the interrelationship among watercourses tributary to the Valley. The exact locations of stations where surface flows are monitored by USGS are shown on Figure 3-2 [USGS 1974a].

Twelve gaging stations are currently maintained by USGS in or near the area of the Santa Maria Valley. However, no annual record of flow is maintained at any station that extends intact throughout the 38 year

TABLE 3-5. COMPUTATION OF RECOVERABLE WATER - SANTA MARIA RIVER BASIN [a]

Altitude (feet)[b]	Percent of Watershed between given Altitude [c]	Precipitation (inches) [d]	Potential Evapo-transpiration (inches) [e]	P/E [f]	R/E [g]	R [h]	R Adjusted [i]	L [j]
+200-400	19	13.60	51.0	0.27	0.01	0.51	0.28	13.32
+400-600	26	14.47	53.0	0.27	0.01	0.53	0.29	14.18
+600-800	21	14.66	54.0	0.27	0.01	0.54	0.30	14.36
+800-1,000	16	15.00	55.0	0.27	0.01	0.55	0.30	14.70
+1,000-1,200	9	15.34	55.5	0.28	0.01	0.56	0.31	15.03
+1,200-1,400	6	15.62	55.8	0.28	0.01	0.56	0.31	15.31
+1,400-1,600	3	15.18	56.0	0.27	0.01	0.56	0.31	14.87
TOTAL	100							
Weighted Watershed Mean		14.60	53.64			0.54	0.30[k]	14.30

[a] Based on methodology and empirical data [USGS, 1965]. Recoverable water is the precipitation residual after satisfying natural water loss. It appears as direct recharge from precipitation or as surface water runoff. The areas considered in this recoverable water analysis are the foothill/mountain watershed regions in the northeast and southern portions (90 sq mi area) of the Santa Maria Valley. Precipitation falling directly on valley floor lands is quantified independently in Table 3-3 and Table 3-4.

[b] Datum, mean sea level.

[c] Santa Maria River Basin altitudes planimetered from USGS topographic maps: Santa Maria, California and San Luis Obispo, California. Scale: 1:250,000.

[d] Precipitation was computed from the weighted relationship between the isohyets of Figure 1-4 and the area-altitude distribution.

[e] Potential evapotranspiration was computed by relating it to the area-altitude distribution within the watershed by means of empirical curve [USGS, 1965]. This reference considers that evaporation from a free water surface (lake evaporation) most nearly approaches potential evaporation.

[f] Relationship between precipitation and potential evapo-transpiration for each zone of altitude (precipitation/potential evapotranspiration).

[g] Relationship between recoverable water and potential evapotranspiration for each zone of altitude. Derived from empirical relationship [USGS, 1965].

[h] Recoverable water was computed for each zone of altitude from the value of potential evapotranspiration and relationship between recoverable water and potential evapotranspiration (potential evapotranspiration x R/E).

[i] Recoverable water was adjusted by a retention factor, K, which reflects the influence of surficial rock type within the watershed area. For the ungaged Santa Maria Valley watershed, distribution of surficial rock types was determined to be as follows:

Quaternary (except old alluvium):	9%
Old alluvium:	20%
Tertiary (except potato sandstone):	71%

Areas planimetered from USBR, 1951. Based on retentivity values developed [USGS, 1965], the Geologic Index (I) = 2,090. This corresponds to a retention factor (K) = 0.55.

[j] Natural water loss, L, is the difference between precipitation and recoverable water.

[k] Recoverable water available to Santa Maria Valley: 0.30 inches x 57,600 acres = 1,440 ac-ft.

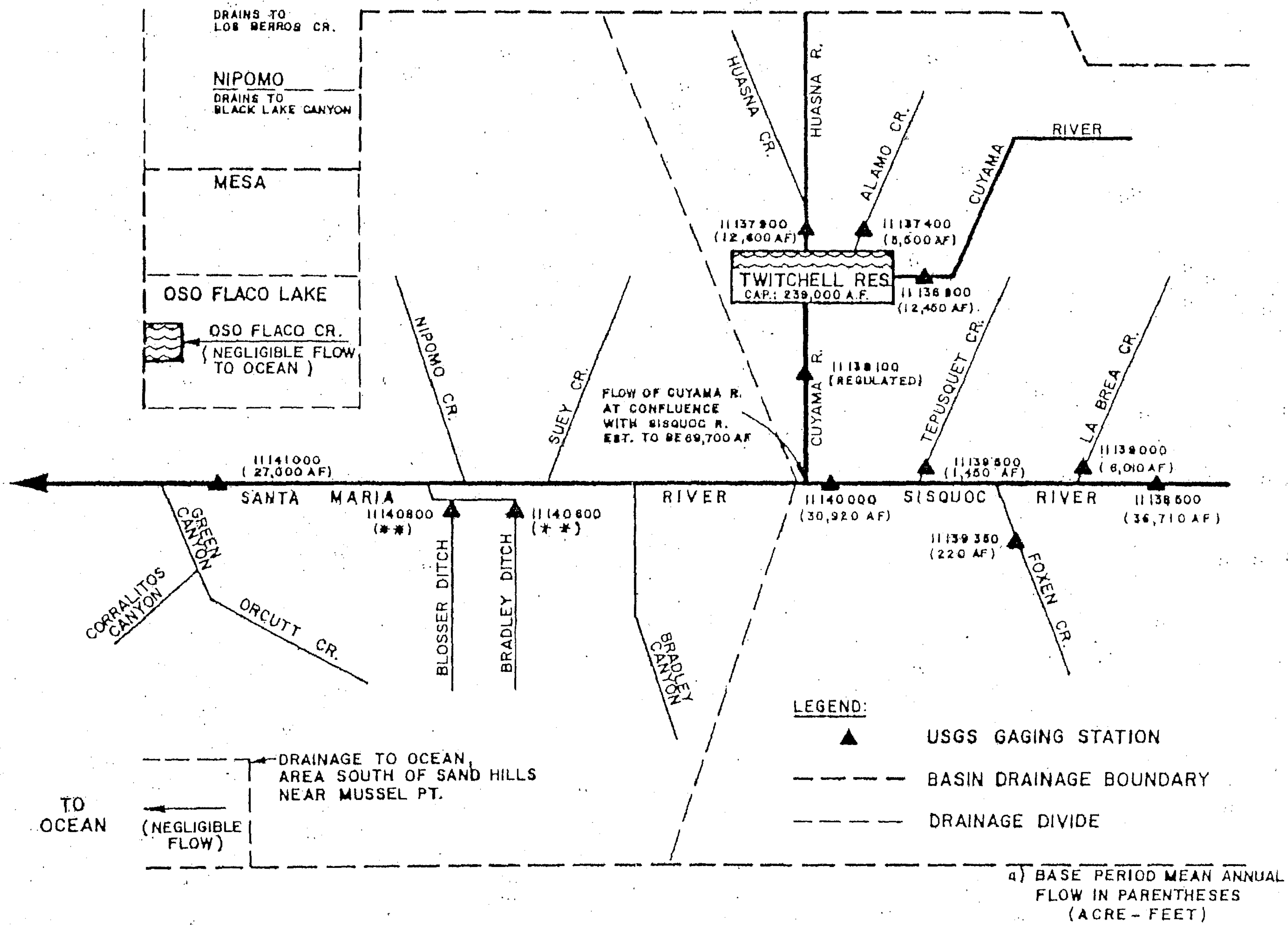


FIGURE 3-1

SCHEMATIC DIAGRAM OF SURFACE WATER FLOW[a]

SANTA MARIA VALLEY

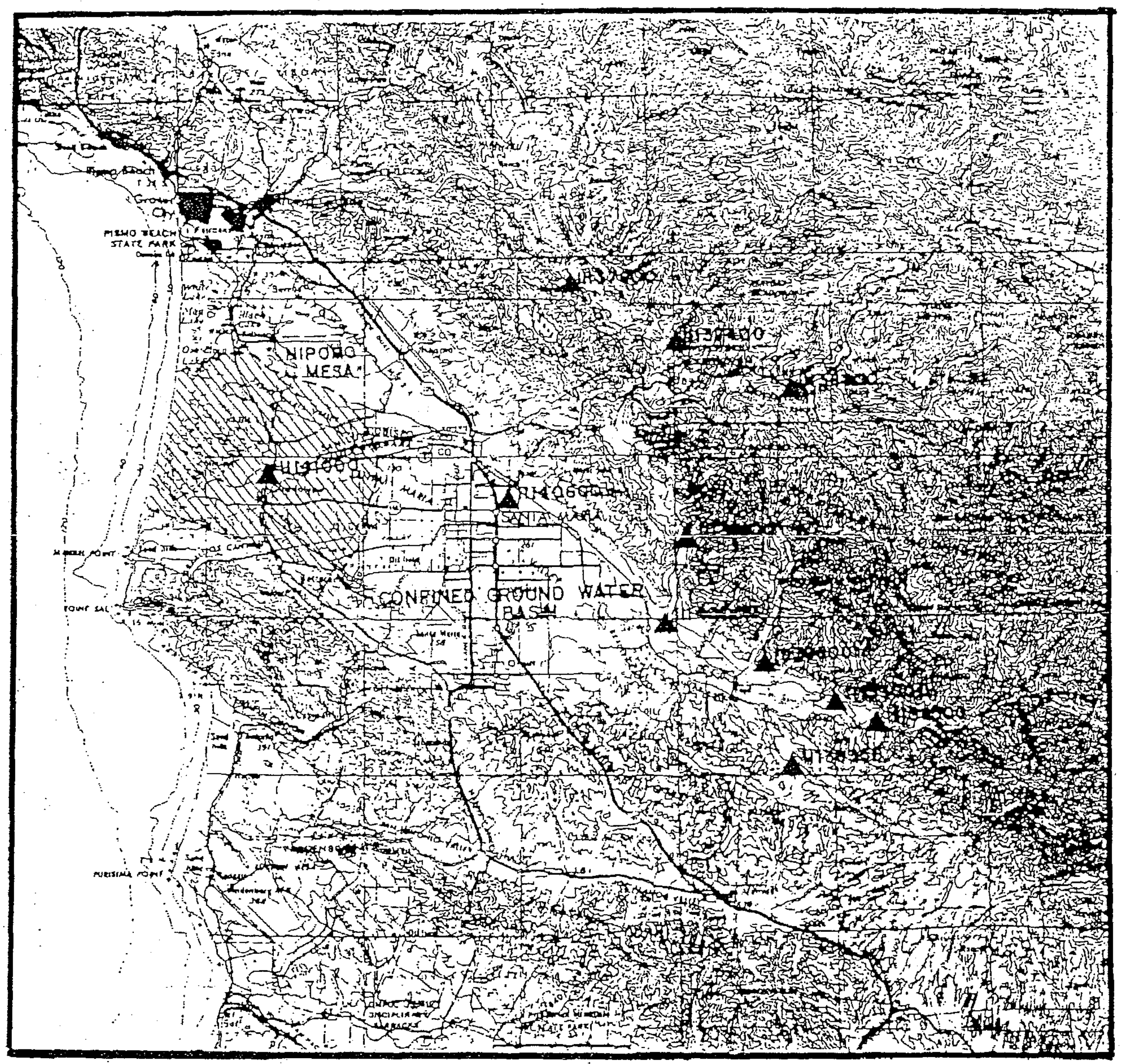


FIG. 3-2 SURFACE WATER GAGING STATIONS

base period defined for the study area. Only two stations, Cuyama River near Santa Maria (11137000) and Huasna River near Santa Maria (11138000), possess records which encompass the first six years of the base period. Monitoring activity was discontinued at these stations in the early 1960's.

Double mass analysis is a statistical procedure that is well suited to interpolating or extrapolating streamflow data for years of missing data. This method involves a graphic comparison between accumulated mean annual flow of a station with incomplete record and accumulated mean annual flow at one or more "key" stations that possess a complete record of annual flows. Accumulated data is plotted for the period that the incomplete station and the key stations have in common, and the relationship between their respective flows is determined. This relationship is then used to prorate the average of mean annual flows at the key stations to years of missing data at the comparison station.

The curves prepared by double mass analysis for stations with incomplete records are included in Appendix A of this report. Average annual surface water discharges developed for years of missing record at the various gaged watercourses in the regional area of the Santa Maria Valley are presented in Table 3-6. This table summarizes existing records of flow and provides a determination of mean annual discharge for the base period.

Accumulated annual flow averaged for stations Cuyama River near Santa Maria (11137000) and Huasna River near Santa Maria (11138000) was used to generate data for early base period years at stations Sisquoc River near Sisquoc (11138500), La Brea Creek near Sisquoc (11139000), Tepusquet Creek near Sisquoc (11139500), and Sisquoc River near Garey (11140000). These stations were then utilized in prorating data for the remainder of the stations with sufficient record for double-mass comparison. Station 11141000, Santa Maria River at Guadalupe, was an exception to this

TABLE 3-6. AVERAGE ANNUAL SURFACE WATER DISCHARGE [a,b]
(cubic feet per second)

Water Year	11137000 Cuyama River near Santa Maria	11138000 Huasna River near Santa Maria	11138500 Sisquoc River near Sisquoc	11139000 La Brea Creek near Sisquoc	11139500 Tepusquet Creek near Sisquoc	11140000 Sisquoc River near Garey	11137500 Alamo Creek near Santa Maria
1935	12.7	9.76	(24.7)	(4.0)	(1.1)	(19.8)	(5.8)
1936	12.6	25.4	(41.8)	(6.8)	(1.9)	(33.4)	(9.9)
1937	60.4	53.4	(125.2)	(20.5)	(5.7)	(100.1)	(29.6)
1938	77.4	68.2	(160.2)	(26.2)	(7.3)	(128.1)	(37.9)
1939	12.8	1.74	(16.0)	(2.6)	(0.7)	(12.8)	(3.8)
1940	8.42	8.17	(18.3)	(3.0)	(0.8)	(14.6)	(4.3)
1941	88.0	94.3	(200.6)	(32.8)	(9.1)	203.0	(47.4)
1942	12.9	16.0	(31.8)	(5.2)	(1.4)	21.6	(7.5)
1943	38.3	63.6	(112.1)	(18.3)	(5.1)	91.6	(26.5)
1944	26.1	10.7	55.8	9.46	2.10	52.1	6.05
1945	13.6	9.50	33.3	4.11	1.20	23.4	3.95
1946	9.50	3.95	24.0	0.20	0.49	11.8	1.82
1947	8.05	1.29	10.6	0	0.30	3.08	1.13
1948	2.52	0.71	1.07	0	0.205	0	0.71
1949	2.95	0.53	5.08	0	0.31	0.123	0.305
1950	2.80	3.47	9.51	0.15	0.34	1.65	1.30
1951	1.11	4.09	1.64	0	0.37	0	0.92
1952	62.4	55.8	106.0	28.5	3.69	102.0	28.9
1953	6.74	7.00	16.1	1.61	1.08	7.14	3.45
1954	7.18	6.24	19.0	2.91	1.27	13.7	2.86
1955	1.70	1.96	7.27	0.79	0.74	0.84	1.71
1956	5.14	14.4	19.4	2.85	1.59	11.5	4.59
1957	0.89	0.95	4.73	0	0.27	0.13	1.27
1958	71.2	67.6	153.0	26.5	6.29	137.0	39.5
1959	5.37	1.58	13.6	0.02	0.22	3.33	2.19
1960	0.55	1.53	4.01	0	0.21	0.07	1.37
1961	0.48	0.67	1.14	0	0.062	0	Discon.
1962	46.4	Discon.	67.3	11.2	3.39	64.3	
1963	Discon.		7.70	0	0.34	0.38	
1964			3.46	0	0.18	0	
1965			17.6	0.90	0.36	4.41	
1966			33.5	1.50	0.405	13.6	
1967			150.0	36.7	4.51	132.0	
1968			15.9	0.65	0.34	4.52	
1969			361.0	67.2	11.1	397.0	
1970			23.5	1.24	1.16	7.10	
1971			21.6	0.80	0.43	5.43	
1972			10.0	0	0.15	1.41	
1973			64.1	7.12	4.19	50.4	
1974						7.79	
1975						11.30	
Base period average annual discharge (cfs)			50.7	8.3	2.0	42.7	
Acre feet [c]			36,710	6,010	1,450	30,920	

T 6. AVERAGE ANNUAL SURFACE WATER DISCH b] (continued)
(cubic feet per second)

Water Year	11141000 Santa Maria River at Guadalupe	11136800 Cuyama River below Buckhorn Canyon	11137400 Alamo Creek near Nipomo	11137900 Huasna River near Arroyo Grande	11138100 Cuyama River below Twitchell Dam	11139350 Foxen Creek near Sisquoc	11140600 Bradley Ditch near Donovan Road	11140800 Blosser Ditch near Donovan Road
1935	(6.5)	(8.1)	(3.6)	(8.2)		(0.2)		
1936	(15.0)	(13.6)	(6.1)	(13.8)		(0.3)		
1937	(132.0)	(40.9)	(18.2)	(41.5)		(0.8)		
1938	(188.0)	(52.3)	(23.3)	(53.1)		(1.0)		
1939	(3.0)	(5.2)	(2.3)	(5.3)		(0.1)		
1940	(4.0)	(6.0)	(2.7)	(6.1)		(0.1)		
1941	253.0	(72.4)	(32.3)	(73.5)		(1.3)		
1942	1.50	(9.8)	(4.4)	(9.9)		(0.2)		
1943	99.3	(36.9)	(16.5)	(37.5)		(0.7)		
1944	18.7	(19.4)	(8.7)	(19.7)		(0.3)		
1945	6.89	(10.1)	(4.5)	(10.2)		(0.2)		
1946	6.74	(5.9)	(2.6)	(6.0)		(0)		
1947	3.49	(2.3)	(1.0)	(2.3)		(0)		
1948	0	(0.2)	(0.1)	(0.2)		(0)		
1949	0	(0.9)	(0.4)	(0.9)		(0)		
1950	3.4	(1.9)	(0.8)	(1.9)		(0)		
1951	0	(0.3)	(0.2)	(0.3)		(0)		
1952	155.0	(39.0)	(17.4)	(39.6)		(1.0)		
1953	0.50	(4.2)	(1.9)	(4.3)		(0.1)		
1954	1.75	(6.0)	(2.7)	(6.1)		(0.1)		
1955	0	(1.6)	(0.7)	(1.6)		(0)		
1956	5.78	(5.7)	(2.6)	(5.8)		(0.1)		
1957	0	(0.8)	(0.4)	(0.8)		(0)		
1958	184.0	(52.5)	(23.4)	(53.3)		(1.0)		
1959	0	(2.8)	(1.2)	(2.8)	5.94	(0)		
1960	0	0.53	0	0.59	1.46	(0)		
1961	0	0.38	0	0.10	0.031	(0)		
1962	33.5	43.6	15.6	31.1	80.9	(0.4)		
1963	0	0.41	0	2.40	3.36	(0)		
1964	0	0.002	0	0.28	2.30	(0)		
1965	0	0.75	0.033	4.53	4.16	(0)		
1966	1.25	6.11	0	3.86	7.39	0.062		
1967	44.3	52.2	31.9	69.3	104.0	0.182		
1968	0.14	1.69	0.0003	1.14	60.9	0.095		
1969	248.0	141.0	64.2	135.0	206.0	2.22		
1970	0.18	5.15	0.024	4.22	154.0	0.48		
1971	0	2.82	0.061	2.99	7.92	0.16	0.47	
1972	0	0.77	0	0.11	0.0003	0.11	0.38	
1973	13.8	18.2	10.6	21.5	58.3	0.47	2.16	2.04
1974	0.29				46.0			
1975	0.42				8.04			
Base period average annual discharge (cfs)	37.3	17.2	7.6	17.4		0.3		
Ac/ft[c]	27,000	12,450	5,500	12,600		220		

[a] USGS gaging stations located in Santa Maria, Cuyama, and Sisquoc River Basins; stations identified by name and number. Flow data in terms of cubic feet per second throughout water year. Data in parentheses prorated by double-mass comparison with mean annual base station discharge, except for Station 11141000, which was generated by means of inflow-discharge curve on Figure A-1.

[b] USGS, 1974a; USGS, 1960; USGS, 1964; USGS 1970a; USGS, 1967; USGS, 1968b; USGS, 1969; USGS, 1970b; USGS, 1971; USGS 1972; USGS, 1973.

[c] Rounded.

procedure. The relationship between flows at Guadalupe and tributary flows at upstream stations was plotted on an annual basis. This is depicted on Figure A-1, in Appendix A. Development of streamflow data at Guadalupe by this method for base period years of missing record (1935-1940) is considered appropriate due to the permeable nature of the upstream channel alluvium. Percolation claims much of the flow that would otherwise appear at Guadalupe. Hence, it is the generally larger upstream discharges that contribute to flow passing Guadalupe.

Drainage from upstream watersheds is conveyed to the Santa Maria River basin through the channels of the Cuyama and Sisquoc Rivers. With the exception of an ungaged section of Cuyama River extending 3.5 miles upstream from the confluence with Sisquoc River, surface flows in these watercourses are currently recorded. For the base period years 1959 through 1972, the magnitude of water introduced yearly to the Santa Maria Valley near Fugler Point was derived from mean annual Cuyama River flow gaged at USGS station Cuyama River below Twitchell Dam (11138100), Sisquoc River flow gaged at USGS Station Sisquoc River near Garey (11140000), and estimated drainage contributed to the ungaged 3.5 mile section of Cuyama River below station Cuyama River below Twitchell Dam (11138100). These data are summarized in Table 3-7 and presented graphically on Figure 3-3. The ungaged component of flow was determined by relating drainage area tributary to the ungaged reach of river and average Cuyama River watershed yield. Surface flow passing Fugler Point for the base period years 1935 through 1958 is also detailed in Table 3-7. These data were computed by summarizing mean annual streamflow at Stations Cuyama River near Santa Maria (11137000), Huasna River near Santa Maria (11138000), Alamo Creek near Santa Maria (11137500), and Sisquoc River near Garey (11140000). An additional yearly component of flow was added for contributions from the Cuyama watershed downstream from the three gaged locations, but upstream from Fugler Point. Total surface water inflow near Fugler Point for the base period is regarded to average 96.2 cfs, or 69,700 acre-feet per year.

TABLE 3-7. SURFACE INFLOW TO SANTA MARIA VALLEY AT FUGLER POINT
(cubic feet per second)

Water Year	11137000 Cuyama River near Santa Maria	11138000 Huasna River near Santa Maria	11137500 Alamo Creek near Santa Maria	ungaged (36 sq mi)	11140000 Sisquoc River near Garey	11138100 Cuyama River Below Twitchell Dam	ungaged (11 sq mi)	Inflow at Fugler Point cfs	Inflow at Fugler Point (ac-ft) (1000's)
1935	12.7	9.76	(5.8)	0.9	(19.8)			49.0	35.5
1936	12.6	25.4	(9.9)	1.5	(33.4)			82.8	59.9
1937	60.4	53.4	(29.6)	4.6	(100.1)			248.1	179.6
1938	77.4	68.2	(37.9)	5.9	128.1)			317.5	229.9
1939	12.8	1.74	(3.8)	0.6	(12.8)			31.7	22.9
1940	8.42	8.17	(4.3)	0.7	(14.6)			36.2	26.2
1941	88.0	94.3	(47.4)	7.4	203.0			440.1	318.6
1942	12.9	16.0	(7.5)	1.2	21.6			59.2	42.9
1943	38.3	63.6	(26.5)	4.1	91.6			224.1	162.2
1944	26.1	10.7	6.05	1.4	52.1			96.4	69.8
1945	13.6	9.50	3.95	0.9	23.4			51.4	37.2
1946	9.50	3.95	1.82	0.5	11.8			27.6	20.0
1947	8.05	1.29	1.13	0.3	3.08			13.9	10.1
1948	2.52	0.71	0.71	0.1	0			4.0	3.9
1949	2.95	0.53	0.305	0.1	0.123			4.0	3.9
1950	2.80	3.47	1.30	0.2	1.65			9.4	6.8
1951	1.11	4.09	0.92	0.2	0			6.3	4.6
1952	62.4	55.8	28.9	4.7	102.0			253.8	183.7
1953	6.74	7.00	3.45	0.6	7.14			24.9	18.0
1954	7.18	6.24	2.86	0.5	13.7			30.5	22.1
1955	1.70	1.96	1.71	0.2	0.84			6.4	4.6
1956	5.14	14.4	4.59	0.8	11.5			36.4	26.3
1957	0.89	0.95	1.27	0.1	0.13			3.3	2.4
1958	71.2	67.6	39.5	5.7	137.0			321.0	232.4
1959					3.33	5.94	--[a]	9.3	6.7

TABLE 3-7 (continued)

(cubic feet per second)

Water Year	11137000 Cuyama River near Santa Maria	11138000 Huasna River near Santa Maria	11137500 Alamo Creek near Santa Maria	ungaged (36 sq mi)	11140000 Siquoc River near Garey	11138100 Cuyama River Below Twitchell Dam	ungaged (11 sq mi)	Inflow at Fugler Point cfs	Inflow at Fugler Point (ac-ft) (1000's)
1960					0.07	1.46	--	1.5	1.1
1961					0	0.031	--	---	negl.
1962					64.3	80.9	0.8	146.0	105.7
1963					0.38	3.36	--	3.7	2.7
1964					0	2.30	--	2.3	1.7
1965					4.41	4.16	--	8.6	6.2
1966					13.6	7.39	--	21.0	15.2
1967					132.0	104.0	1.0	237.0	171.6
1968					4.52	60.9	0.6	66.0	47.8
1969					397.0	206.0	2.0	605.0	438.0
1970					7.10	154.0	1.5	162.6	117.7
1971					5.43	7.92	--	13.4	9.7
1972					1.41	0.0003	--	1.4	1.0
1973					50.4	58.3	0.6	109.3	79.1
1974					7.75	46.0	0.4	54.2	39.2
1975					11.30	8.04	--	19.3	14.0
Base period mean annual surface inflow								96.2	69.7

[a] -- = less than 0.1 cfs.

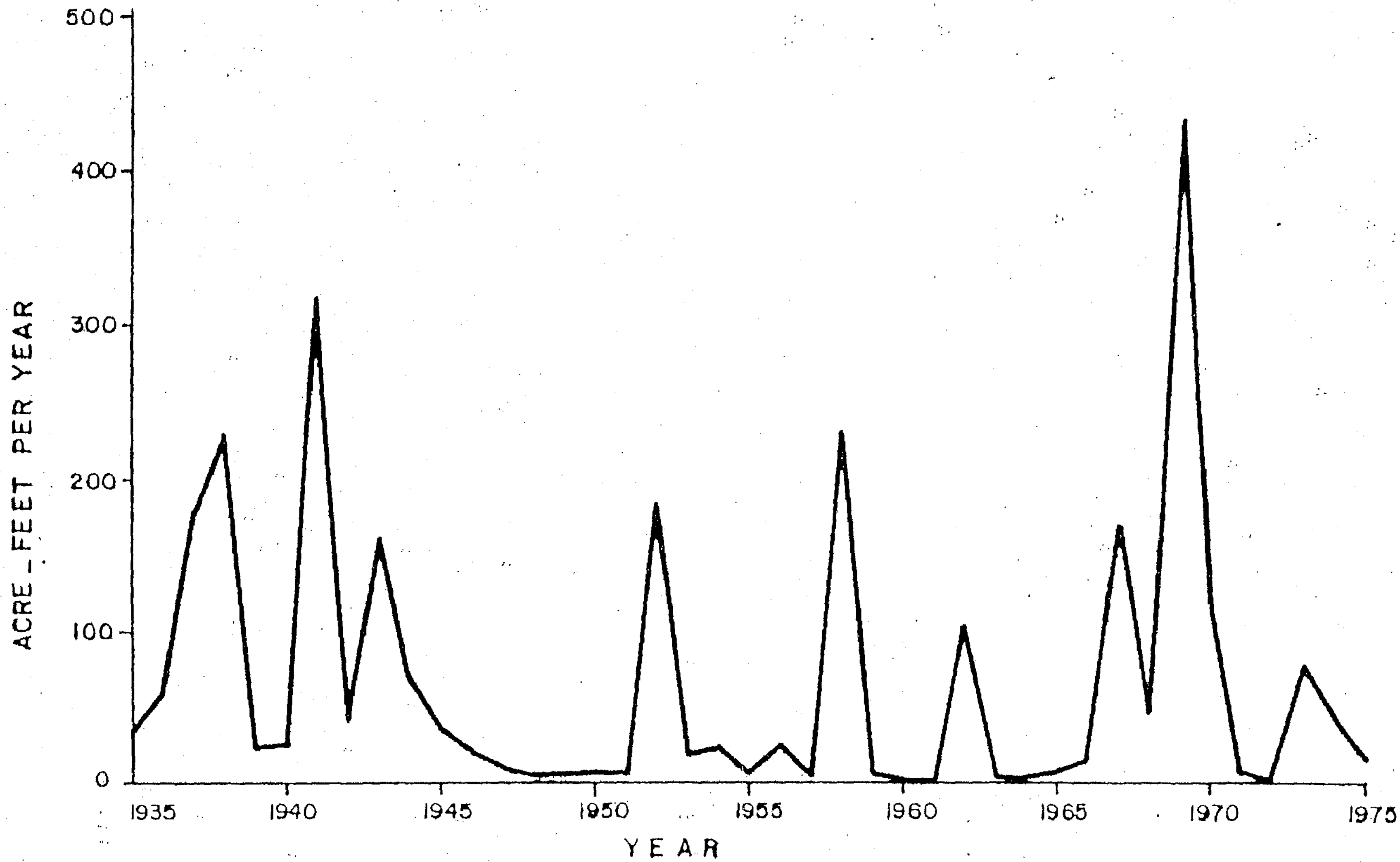


FIG. 3-3 SURFACE INFLOW AT FUGLER POINT

Surface water runoff generated within the Santa Maria Valley contributes flow to a number of established drainage courses. Suey, Nipomo, Orcutt, and Oso Flaco Creeks intercept much of the drainage. Blosser and Bradley Ditches transport flows that essentially represent runoff from urban areas. The Santa Maria River, formed by the confluence of the Cuyama and Sisquoc Rivers, receives the flow of all major streams within the basin except Oso Flaco Creek. The latter watercourse drains a watershed located in the northwest portion of the valley and empties into Oso Flaco Lake. Flows in the lower reach of Oso Flaco Creek are also maintained by groundwater discharge of waters from infiltrating rainfall, stream seepage, and irrigation, perched over the confining clay layer in the western portion of the valley. Discharge to the ocean from the Oso Flaco drainage is in the form of seepage through sand deposits that form a surficial drainage divide between the lake and the ocean [USGS 1951].

Three gaging stations are maintained by the USGS at locations within the immediate Santa Maria Valley. These stations monitor flows in Blosser Ditch (Station 11140800), Bradley Ditch (Station 11140600), the Santa Maria River at Guadalupe (Station 11141000).

Regulation of flow in the Cuyama River by Twitchell Reservoir has increased native water resources available to the Santa Maria Valley. Yield of this project is analyzed in Chapter 5. Conservation of water is accomplished because flood flows otherwise tributary to the Santa Maria River during periods of high flow are not lost to the ocean but are rather allowed to percolate in the alluvium of the Santa Maria River channel when released at a later date. A total maximum flow of 300 cfs is considered to the optimum rate for percolation in the Santa Maria River channel [USGS 1966]. Mean annual flow in the Santa Maria River passing Guadalupe averaged 37.3 cfs for the base period. This corresponds to a yearly discharge of 27,000 acre-feet.

CHAPTER 4

MUNICIPAL AND INDUSTRIAL WATER DEMAND

Water resources of the Santa Maria Valley are subject to depletion by a variety of natural and human influences. Free surface evaporation, evapotranspiration by native and cultivated vegetation or crops, consumptive municipal and industrial uses, surface and subsurface outflow, and trans-basin export represent the principal means by which water is lost to the valley environment. It is the purpose of this chapter to determine the magnitude of municipal and industrial water losses. Other components of water loss will be developed in Chapter 6 and subsequently related to the available long-term basin water supply.

MUNICIPAL WATER REQUIREMENTS

Municipal use of water typically relates to activities that are residential or commercial in nature. Residential water requirements are associated with lawn and plant watering, swimming pool use, car washing, and driveway and walk cleaning. These uses of water are defined as "outdoor" residential demands. "Indoor" residential uses of water involve household activities such as clothes and dish washing, food preparation, cleaning, and certain forms of air conditioning. Personal water requirements such as toilet flushing, bathing, drinking, and other hygienic uses are also identified as "indoor" residential uses.

Commercial establishments require water for many of the same uses associated with residential activity. In addition, water is used as liquid or steam for many commercial purposes. Municipal uses of water include fire fighting, street washing, park and golf course irrigation, construction, and dust control. Water distribution system losses and other miscellaneous uses or losses are also considered to be elements of municipal water use. It should be noted that a portion of total water used is returned to the Valley environment in the form of wastewater.

Climatic and socio-economic factors influence the magnitude of municipal water demand. Temperature is of overriding importance, augmented by influences of precipitation, humidity, and wind. Socio-economic factors which relate to the pattern of municipal water use include income level, price of wholesale and retail water, family size and age, metering, sewering, and miscellaneous other factors.

Major water purveying agencies serving urban consumers within the Santa Maria Valley are identified in Table 4-1. The systems operated by the City of Santa Maria and by the City of Guadalupe, deliver water to industrial as well as residential and commercial service connections.

INDUSTRIAL WATER REQUIREMENTS

Petroleum refining and food processing represent the major industrial water using activities within the Santa Maria Valley. Two generalized types of water demand are exerted by industry: those that require high quality water and those that do not. Food processing is a high quality water using industry. Cooling water supply, hydraulic conveyance, gravel washing, secondary oil recovery, and fire protection are industrial applications that do not depend primarily on water quality.

Quantities of industrial water delivered by major urban water systems in the Santa Maria Valley typically supply food processing requirements. This use is non-consumptive in nature. Essentially, all of the intake water supply appears as wastewater. Since wastewater is discharged to sewerage systems that utilize land disposal of treated effluent, losses to the groundwater basin are relatively minor.

Production and refining of oil is the most significant industrial water consuming activity in the Santa Maria Valley. This relates to the fact that fresh water sources, when used, are normally lost to the basin environment through deep well injection for oil field stimulation or wastewater disposal.

TABLE 4-1. MAJOR URBAN WATER SYSTEMS - SANTA MARIA VALLEY, 1975[a]

AGENCY	Service Connections	Service Population	Total Water Distributed (af/yr)	Total Water Distributed (mgd)[b]	Total Water Distributed (gpcd)	Well System[c]	Treatment Provided	Storage Capacity (mg)
California Cities Water Co. [d]								
Orcutt-Orcutt Wye	4,405	15,000	3,686	3.29	219	8(300-1000 gpm)	Chlorination	3.14
Sisquoc System	60	200	21	0.02	94	1(140 gpm)	Chlorination	0.012
Tanglewood System	337	1,150	163	0.15	127	2(500 & 700 gpm)	Filtration, Chlorination	None
Vista (Nipomo) System [e]	521	1,770	304	0.27	153	2(300 & 400 gpm)	Filtration, Aeration, Chlorination	0.067
Subtotal	5,323	18,120	4,174	3.73				3.22
Guadalupe, City of [f]	1,068[g]	3,300	766[h]			2(ea. 400 gpm) 1(400+ gpm)[i] 1(350 gpm)[i]	Chlorination	0.1
Lake Marie Water Co. [j]	133	465	233	0.21	448[k]	2(300 & 600 gpm)[l]	Chlorination	0.55
Nipomo Community Services Dist.[m]	600	2,000	300	0.27	134	3(ea. 200 gpm)	Chlorination	0.5
Santa Maria City of[n]	9,551	34,250	7,185			9(800-2800 gpm)[o]	Chlorination	8.5
TOTAL	16,675	58,135	12,658					12.87

TABLE 4-1. Footnotes

[a] All systems rely exclusively on groundwater as the source of supply.
[b] Rounded.
[c] Number of wells indicated; approximate capacity of wells, or range of capacity of well system, indicated in parentheses.
[d] Hartsell, 1975.
[e] Sulfide problems encountered in source water, hence additional treatment provided.
[f] Chamberlain, except as noted.
[g] 1043 connections on flat rate (municipal consumers); 25 industrial or school connections.
[h] Representative of water sypply system before new 350 gpm well came on line during Summer 1975. Value is low because only two of three producing wells were metered; af/yr distributed does not account for contributions from unmetered 400+ gpm well, formerly used for peaking purposes in summer and for fire flow.
[i] The 400+ gpm unmetered well produces relatively hard water, presently maintained and operated as a backup for peaking and fire flow demand; was replaced in the system in summer 1975 by a new 350 gpm well.
[j] Gilliland, 1975.
[k] Service area is one-mile square, encompasses Lake Marie Estates. High municipal per capita consumption related to socio-economic nature of service area.
[l] 600 gpm well generally utilized for peaking purposes only.
[m] Jones, 1975.
[n] Riddiough, 1975; except as noted.
[o] Two wells produce hard water; remaining seven wells produce about 95 percent of water distributed by system. Total capacity of well system is 9000 gpm.

OIL INDUSTRY

Production of petroleum constitutes a major economic activity within the Santa Maria Valley. Existing wells are generally situated within five principal oil fields. These include Casmalia, Cat Canyon, Guadalupe, Orcutt, and the Santa Maria Valley fields.

Secondary and tertiary recovery of oil from existing reserves provides a means by which recovery of petroleum resources native to the United States can be optimized. This aspect of oil production becomes more important as the discovery of additional oil reserves becomes increasingly difficult. Legal pressures from environmental, air quality, and other groups and organizations concerned with sulfur content of fuels have caused the use of many locally produced oils to be discontinued in favor of expensive low-sulphur foreign oils. Crude oil shortages, national energy demands, technological pollution control advances for sulphur emissions, and escalating prices paid for foreign oil will eventually make reactivation and stimulation of many well fields a profitable course of action.

In the past, water injection projects to stimulate and enhance oil production have served as a valuable means of disposing of brines and wastewater produced in conjunction with oil field activities. Water flooding, which includes water injection, steam soak and steam flood, represents the most important method of secondary recovery. It should be noted that steam soak or steam flood operations typically utilize fresh water in the generation of steam. This type of flood, by introducing heat into shallow, low-gravity oil fields, increases the ability of oil to flow by reducing its viscosity. Water injection operations, on the other hand, generally rely on brines and wastewater as a source of water supply. In this type of secondary recovery, a portion of the residual subsurface oil is collected from soil pores by the creation of a bank of oil ahead of the injected water flood. Historic quantities of water and steam injected for stimulation are presented in Table 4-2 according to each oil field within the Santa Maria Valley. The trend in secondary recovery, while presently at a relative standstill due to environmental constraints on sulphur content of crude oil produced in the Valley, is anticipated to become one of even greater emphasis in the future.

TABLE 4-2. SUMMARY OF FRESH WATER USE BY OIL FIELD ACTIVITIES [a]
(acre-feet)

Year	Casmalia Field	Cat Canyon Field	Guadalupe Field	Orcutt Field	Santa Maria Field	Total
1963	--	12.9	--	--	--	12.9
1964	--	51.6	--	--	--	51.6
1965	--	141.7	--	--	--	141.7
1966	45.0	191.2	87.3	--	23.6	347.1
1967	63.0	273.4	81.2	--	0	417.6
1968	28.9	230.3	137.3	--	2.0	395.5
1969	4.4	247.4	159.1	--	9.9	420.8
1970	2.9	226.8	173.7	--	12.7	416.1
1971	8.7	325.3	146.3	--	0.1	480.4

[a] Zulberti, 1972.

Industrial wastewater from oil refining activities in the Santa Maria Valley consists of operating and process water, boiler blowdown water, cooling tower blowdown water, oil field brines, and stormwater drainage [SWRCD 1975]. Average water use at the Union Oil Company's Santa Maria Refinery near Oso Flaco Lake is about 600 gpm (970 acre-feet per year) [West 1975]. Of this amount, 275 gpm (445 acre-feet) is evaporated from the atmospheric cooling tower and 325 gpm (525 acre-feet) appears as treated effluent. No water is returned to groundwater [West 1975]. Future operations at the Santa Maria Refinery are expected to use essentially the same amount of water as at present.

Current fresh water use by other Union Oil Company activities in the Santa Maria Valley is approximately 740 acre-feet per year [Bailey 1975].

OTHER INDUSTRIES

The Union Sugar Refinery at Betteravia produces water from its own well system at a rate of approximately 1,500 gallons per minute during the seasonal operating period, which normally lasts from 180 to 265 days per year (1200-1750 acre-feet per year) [Bingham 1975]. This represents process makeup water. Wastewater is discharged to ponds located near the refinery. The bottoms of these ponds are relatively impervious, a fact that discourages groundwater recharge by percolating flows [SWRCD 1975]. Hence, the bulk of wastewater that is not recycled within the refinery for cooling purposes or beet transportation is lost through evaporation.

The Sinton and Brown Company produces livestock feed by dehydrating sugar beet pulp generated at the Union Sugar Refinery. Wastewater associated with this activity, approximately 650 gpm or 1050 acre-feet per year, is mixed with well water and used to irrigate pasture [SWRCD 1975].

CHAPTER 5

HISTORICAL GROUNDWATER CONDITIONS

Groundwater in storage beneath the Santa Maria Valley represents the most important component in the water supply system of the region. It is the purpose of this chapter to depict historical groundwater elevation contours, to determine change in storage that occurred in the Santa Maria groundwater basin during the base period, and to evaluate total groundwater in storage. The change in storage analysis will provide data vital to verification of the hydrologic equation, presented in Chapter 6. This equation relates elements of net basin water recharge with those of basin discharge, including consumptive use requirements exerted by municipal, industrial, and agricultural activities. Any imbalance in the equation will appear as a net increase or decrease in the amount of water stored within the groundwater reservoir.

GROUNDWATER LEVELS

Groundwater elevation contours representative of initial and final years of the base period are vital to the change in groundwater determination. Because of the multitude of wells monitored in recent years in the Santa Maria Valley, contours representative of 1972 conditions are subject to a great deal of control. Water level contours for 1935 do not possess comparable control.

Figure 5-1 depicts groundwater conditions that prevailed in the Santa Maria Valley in 1935. This presentation is based on a groundwater elevation map prepared by the USGS for 1936 adjusted by selected water level data representative of 1935 [USGS 1951]. These latter data are summarized in Table 5-1. It was necessary to rely on and adjust the 1936 contour map because data from 1935 water level surveys do not exist in a quantity that allows original preparation of basin-wide contours

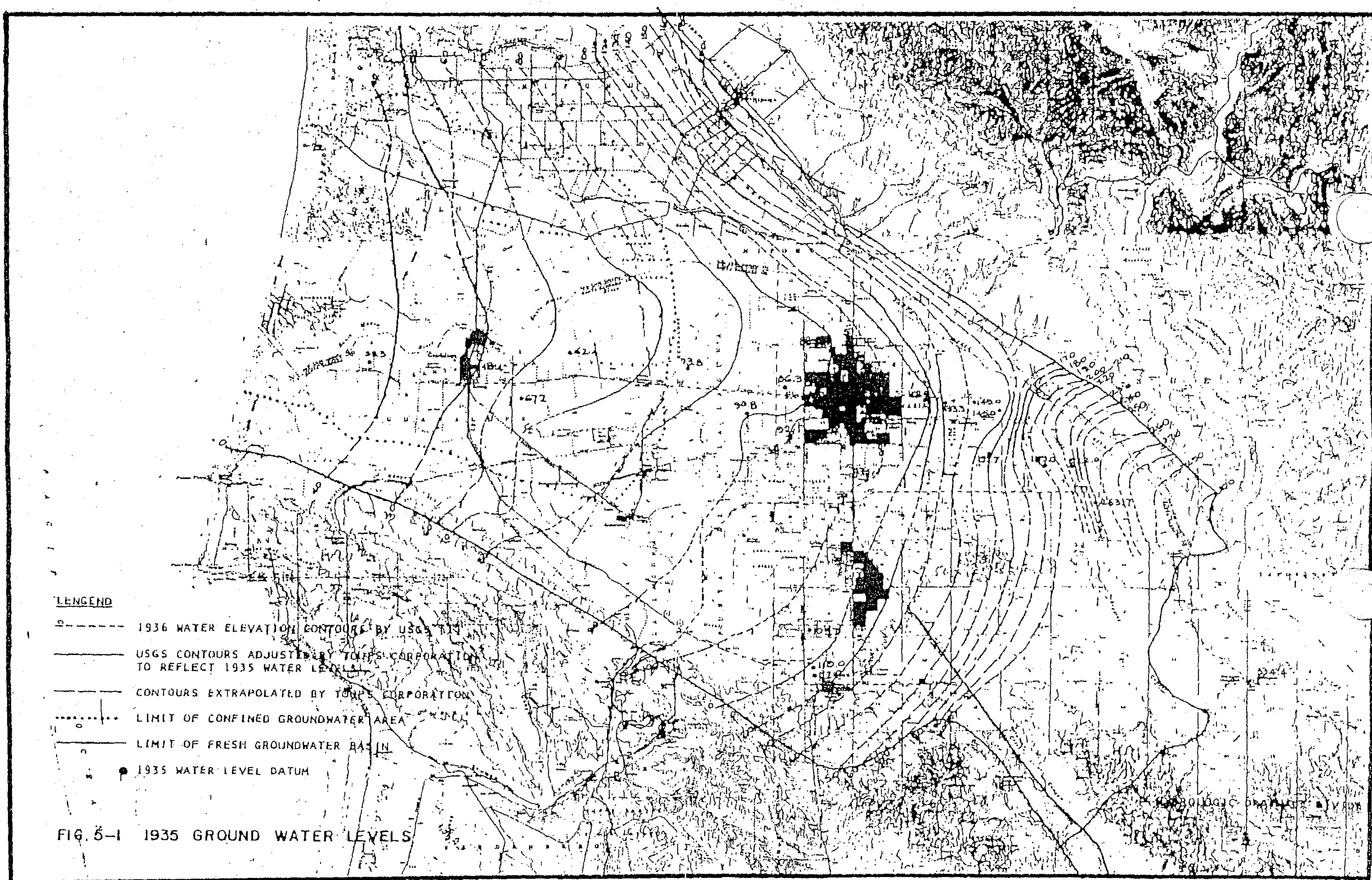


FIG. 5-1 1935 GROUND WATER LEVELS

TABLE 5-1. GROUNDWATER LEVELS, 1935 [a]

Well Number	Land Surface Datum [c]	Depth to water Below Land Surface	Water Level MSL [d]	Month Monitored
9/32-7N2	432	97.6	334.4	Jan. [e]
9/34-3N3	254	150.3	103.7	Aug. [f]
9/34-10M1	303	193.0	110.0	Apr. [e]
9/34-10M2	303	191.0	112.0	Dec. [e]
10/33-18C1	269	120.00	149.0	Aug. [g]
10/33-18H2	272	116.5	155.5	Aug. [k]
10/33-18M1	265	120.00	145.0	Aug. [g]
10/33-19B1	275	115.33	159.7	Aug. [h]
10/33-20H1	300	101.00	199.0	Aug. [g]
10/33-21F2	312	90.00	222.0	Aug. [g, i]
10/33-28A1	325	71.33	253.7	Aug. [g]
10/34-3P1	203	114.08	88.9	Aug. [g]
10/34-7G1	164	90.17	73.8	Aug. [g]
10/34-9Q1	192	105.75	86.3	Aug. [g]
10/34-13A1	257	123.75	133.3	Aug. [g]
10/34-13C1	249	141.50	107.5	Aug. [g]
10/34-14E3	225	128.1[j]	96.9	Aug. [f]
10/34-16R1	205	112.94	92.1	Aug. [g]
10/34-17H1	181	90.17	90.8	Aug. [g]
10/35-7F1	50	14.75	35.3	Aug. [g]
10/35-9F1	89	40.6	48.4	June [h]
10/35-11C2	124	61.59	62.4	Aug. [g]
10/35-15C1	106	38.84	67.2	Aug. [g]

[a] USGS, 1944.
[b] San Bernardino Baseline and Meridian.
[c] Feet above sea level, datum of 1929.
[d] Mean sea level.
[e] Monitored by Union Oil Company of California.
[f] Monitored by City of Santa Maria.
[g] Monitored by San Joaquin Power Division of Pacific Gas and Electric Company.
[h] Monitored by Santa Maria Valley Water Conservation District.
[i] Well subsequently abandoned and covered.
[j] Average of four levels monitored during August 1935.

for that year. Discretion was used in generating contours in the area of Nipomo Mesa. Water levels available for later years, prior to intense agricultural development of the Mesa, were utilized in this regard. Groundwater levels for 1972 and 1975 are depicted in Figures 5-2 and 5-3, respectively.

CHANGE IN STORAGE

Data and calculations pertinent to the base period change in groundwater analysis are presented in Appendix B. Unit values of specific yield indicated in Appendix B reflect groundwater basin characteristics in the portion of the saturated zone above sea level. These values were utilized in computing the change in groundwater storage that occurred during the base period. This derivation identifies a net depletion of water from the Santa Maria groundwater basin that averaged slightly less than 7,000 acre-feet per year during the years 1935 through 1972, or 253,000 acre-feet for the entire 38 year period.

It is estimated in Appendix B that the total groundwater volume stored within the onshore portion of the Santa Maria Groundwater Basin (excluding saturated deposits underlying the Sisquoc Plain) is approximately 20 million acre-feet. The volume of groundwater was determined for the zone between 1972 groundwater levels and the base of fresh water. Average specific yields of Pliocene and Pleistocene age deposits (Careaga Sand and Paso Robles Formation, respectively) were obtained from the USGS [1966].

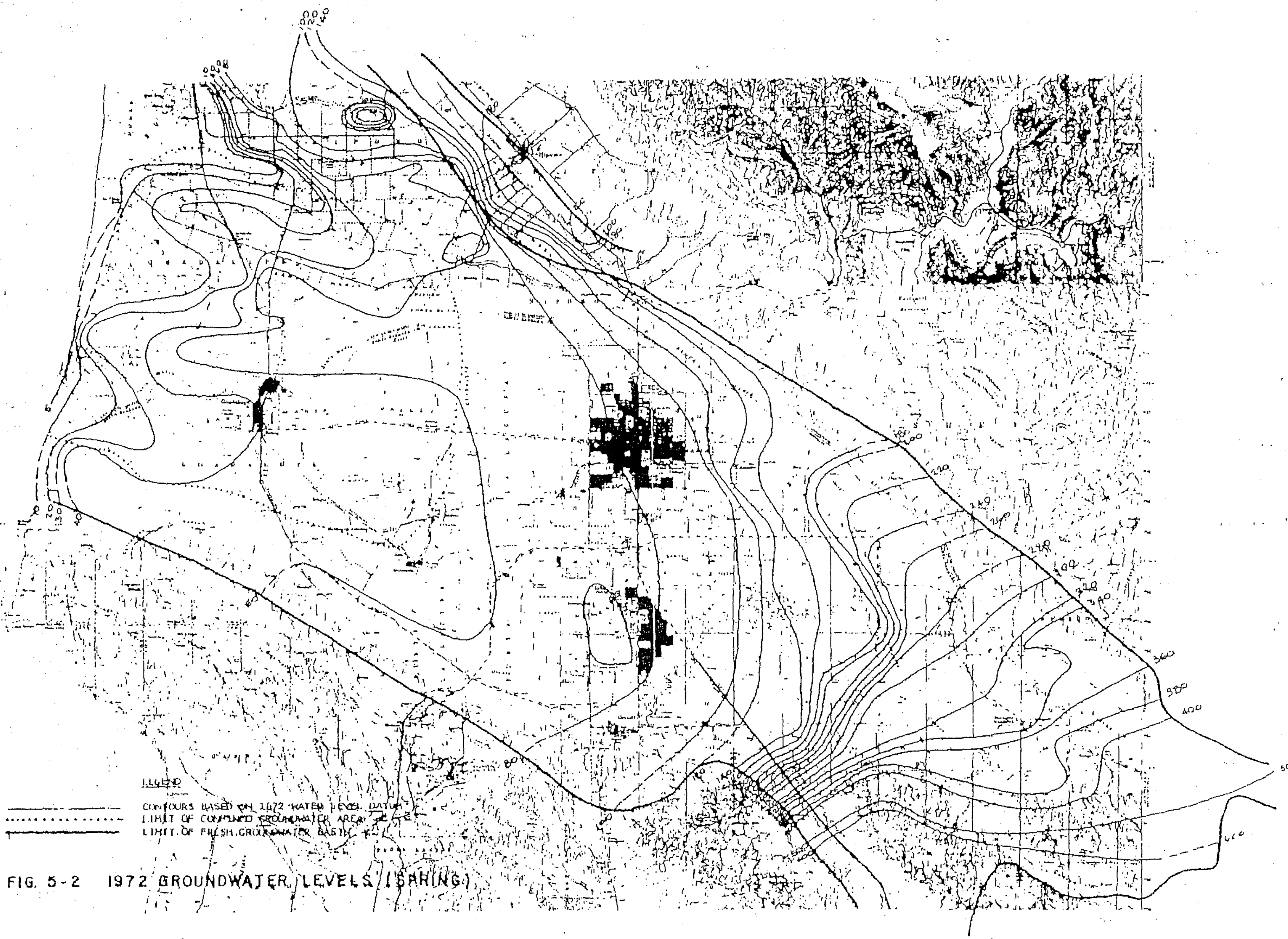


FIG. 5-2 1972 GROUNDWATER LEVELS (SPRING)

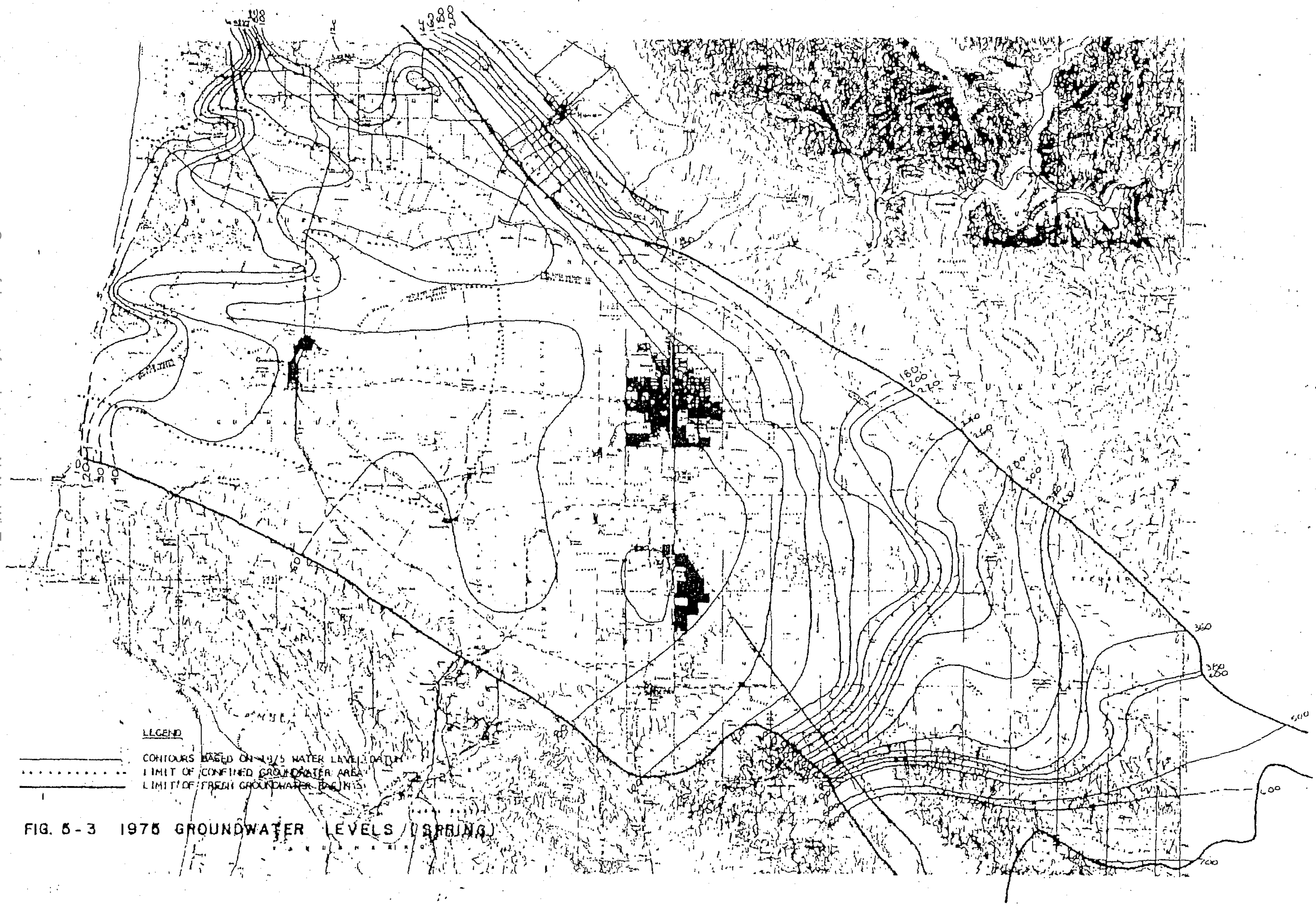


FIG. 5-3 1975 GROUNDWATER LEVELS (SPRING)

CHAPTER 6

HYDROLOGIC BALANCE
HISTORIC AND EXISTING CONDITIONS

In this chapter various components of water supply are related to items of water disposal. The resulting hydrologic equation describes, on an average annual basis, the net depletion or accretion of regional water resources that occurred during the base period.

Hydrologic inventories developed herein are summarized separately for the Sisquoc Plain and the Santa Maria Valley. Such independent treatment of these two systems allows computation of subsurface outflow from the Sisquoc Plain to the Santa Maria Valley, an item not subject to physical measurement.

A number of hydrologic supply and disposal elements, notably streamflow and precipitation, were quantified in previous chapters in terms of average yearly impact throughout the base period. Primary data depicting land uses and population were also presented. These latter data were related in this chapter to unit consumptive use factors. In this manner, magnitude of water depletion from these sources was determined.

Figure 6-1 is a free-body diagram summarizing components of water supply (+) and disposal (-) that are quantified in this chapter. These hydrologic items are developed or reviewed in detail herein.

HYDROLOGIC BALANCE OF THE SISQUOC PLAIN

Water resources tributary to the Sisquoc Plain are amenable to definition in terms of the 1935-72 base period. Net water losses are also subject to quantification.

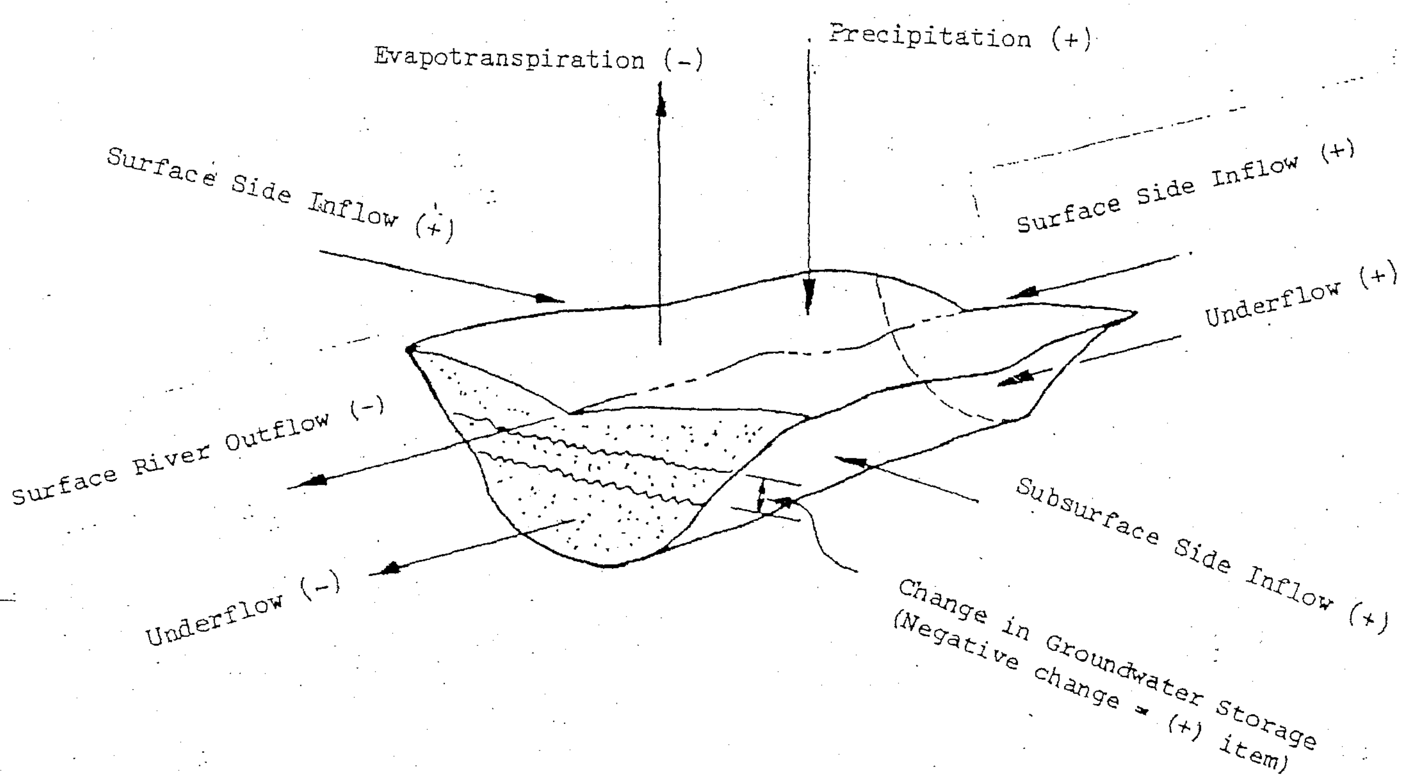


FIG. 6-1 COMPONENTS OF WATER SUPPLY AND DISPOSAL

PRECIPITATION (SUPPLY)

Rain falling directly on the Sisquoc Plain was quantified by isohyetal analysis in Table 3-4. Double-mass comparison of long-term station records were utilized to extend incomplete records at shorter-term stations throughout the base period. The volume of tributary precipitation is gross in nature; evaporative and consumptive losses are not reflected in this supply item.

SURFACE WATER INFLOW (SUPPLY)

Watercourses tributary to the Sisquoc Plain were identified schematically on Figure 3-1. The plain encompasses the alluvium of the Sisquoc River from the confluence with the Cuyama River near USGS gaging station 11140000 (Sisquoc River near Garey) upstream to approximately the location of USGS gaging station 11138500 (Sisquoc River near Sisquoc). Mean annual surface water flow of the Sisquoc River into the plain of the Sisquoc River during base period years 1935 to 1972 (36,710 acre-feet) was determined from records maintained at station 11138500, summarized previously in Table 3-6. Three additional streams convey runoff to the Sisquoc Plain at locations within the alluvial valley reach proper. These include La Brea, Foxen, and Tepusquet Creeks, which are monitored by USGS gaging stations 11139000, 11139350, and 11139500, respectively. Annual flows in these tributaries were presented in Table 3-6. On an average annual basis throughout the base period, flows are as follows: La Brea - 6,010 acre feet; Tepusquet - 1,450 acre feet; and Foxen - 220 acre feet.

SUBSURFACE WATER INFLOW (SUPPLY)

Subsurface inflow of water to the upstream end of the Sisquoc Plain through alluvial sediments in the region of USGS gaging station 11138500 (Sisquoc River near Sisquoc) is estimated not to exceed a few hundred acre-feet per year. The relatively small magnitude of this component of inflow relates to the presence of a low concrete dam about 1,000 feet upstream from the USGS gage. This dam reportedly extends to bedrock and thus intercepts upstream channel seepage [USGS 1951].

Essentially all flow in Tepusquet Creek is monitored as surface flow by USGS gaging station 11139500, which is located in a narrow rock-walled canyon 1.1 miles upstream from the stream mouth. In La Brea Creek, some in-channel seepage loss undoubtedly occurs prior to gaging, but quantities involved are extremely small. The USGS station is situated on valley fill 0.4 mile above the La Brea Creek mouth and about 0.3 mile downstream from the consolidated rock channel. Flow in Foxen Canyon is measured 3.0 miles upstream from the Foxen Creek mouth. Almost all drainage from tributary watersheds has been introduced to Foxen Creek upstream of the gaging station. Subsurface flow is considered to be negligible.

VEGETATIVE CONSUMPTIVE USE (DISPOSAL)

A major component of net water depletion in the Sisquoc Plain is that of vegetative consumptive use. Agricultural activities are responsible for much of the consumptive use of water that occurs within the Sisquoc Plain. Riparian and non-riparian vegetation are also responsible for water loss. The magnitude of consumptive use was determined by relating average base period acreages of crops and vegetation to consumptive use requirements of each particular vegetative type [DWR 1975a; Toups 1973; SWRB 1962]. This is indicated in Table 6-1. Average patterns of cultivated crops and native vegetation, representative of base period conditions, are shown graphically in Appendix C. These acreages were estimated from land use studies summarized previously in Tables 2-1 and 2-2.

TABLE 6-1. SISQUOC PLAIN VEGETATIVE CONSUMPTIVE WATER USE BASE PERIOD AVERAGE ANNUAL CONDITION

Land Use	Estimated Average Annual Acreage[a]	Estimated Growing Season Evapotranspiration ac-ft/ac	Annual Consumptive Water Use ac-ft (1000's)
<u>Irrigated Agriculture</u>			
Alfalfa and Pasture	950	4.54[b]	4.3
Truck Crops[c]	300	2.7[b]	0.8
Field Crops	1,350	3.16[b,d]	4.3
Vineyard	150	1.30[e]	0.2
Subtotal	2,750		9.6
Non-Irrigated Agriculture[f]	2,750	1.2[g]	3.3
Native Vegetation[h]	3,590		
Riparian	20	2.1[b]	--
Non-riparian	3,570	1.2[g]	4.3
Other[i]	489	0.5[b]	0.2
TOTAL	9,600		17.4

[a] Refer to Table 2-1 and graphs in Appendix C.
[b] Based on evapotranspiration values summarized by Toups [Toups, 1973] Appendix F.
[c] Considers multiple cropping of truck crops on the Sisquoc Plain to be negligible.
[d] Evapotranspiration representative of miscellaneous field crops and sugar beets.
[e] Based on transpiration values developed by DWR [DWR, 1975a], Table 17.
[f] Includes grain, hay, and other non-irrigated crops.
[g] Based on evapotranspiration value developed in Reference SWRB, 1962.
[h] Native vegetation acreage = Total area of Sisquoc Plain (9,600 acres) - non-irrigated agriculture (2,750 acres) - irrigated agriculture (2,750) - urban area (30 acres) [USDA, 1950b] - river wash (480 acres) = 3590 acres.
[i] River wash and urban land.

HYDROLOGIC INVENTORY

Construction of a water budget for the Sisquoc Plain provides a means by which the quantity of channel seepage from the Sisquoc River available for percolation to the Santa Maria Valley can be determined. This analysis, presented in Table 6-2, is possible because all major components of inflow and outflow to the Sisquoc Plain are known, except underflow to the Santa Maria Valley.

It is apparent from the derivation in Table 6-2 that a flow of 9,900 acre-feet is available for groundwater recharge within the Sisquoc River Valley on a mean annual basis. Because groundwater in storage beneath the plain of the Sisquoc River is hydraulically contiguous with subsurface supplies underlying the Santa Maria Valley, and because groundwater gradients slope in a downstream direction, surplus recharge to the Sisquoc Plain can be considered tributary to the Santa Maria Valley on a long-term basis.

It should be noted that the magnitude of tributary Sisquoc River underflow, computed by means of a water balance for the Sisquoc Plain, provides an estimate that compares favorably with underflow estimates computed by using Darcy's law.

HYDROLOGIC BALANCE OF THE SANTA MARIA VALLEY

The major elements of water supply and disposal within the Santa Maria Valley are amenable to comprehensive analysis and subsequent quantification. However, a number of hydrologic influences are impossible to measure and extremely difficult to estimate. Such items include inflow from older geologic formations of the mountain basement complex which surrounds the Valley, recharge over the area of confined groundwater, and the dynamic interaction between the on-shore and off-shore fresh groundwater basins.

TABLE 6-2. HYDROLOGIC INVENTORY, SISQUOC PLAIN
BASE PERIOD AVERAGE ANNUAL CONDITION

Hydrologic Item	Ac-ft/yr[a] (1000's)
SOURCES OF WATER SUPPLY	
Surface inflow	
Sisquoc River [b]	36.7
La Brea Creek [c]	6.0
Foxen Creek [d]	0.2
Tepusquet Creek [e]	1.5
Subtotal	44.4
Underflow, Sisquoc River (inflow) [f]	negl.
Underflow, side tributaries [g]	negl.
Precipitation on plain[h]	13.8
TOTAL SUPPLY	58.2
SOURCES OF WATER DISPOSAL	
Surface outflow - Sisquoc River [i]	30.9
Evapotranspiration by irrigated agriculture [j]	9.6
Evapotranspiration by non-irrigated agriculture [j]	3.3
Evapotranspiration by native vegetation [j]	
Riparian	--
Non-riparian	0.2
Other	--
Subsurface Outflow - Sisquoc River [k]	9.9
TOTAL DISPOSAL	58.2
Subsurface base period recharge of Santa Maria Valley from Sisquoc Plain [l]	9.9

[a] Average throughout base period.
[b] USGS gaging station 11138500 (see Table 3-6).
[c] USGS gaging station 11139000 (see Table 3-6).
[d] USGS gaging station 11139350 (see Table 3-6).
[e] USGS gaging station 11139500 (see Table 3-6).
[f] Low concrete dam about 1,000 feet upstream from USGS gage 11138500, reportedly extends to bedrock [USGS, 1951]
[g] La Brea, Foxen and Tepusquet Creeks.
[h] See Table 3-4.
[i] USGS gaging station 11140000
[j] See Table 6-1.
[k] This value is the computed difference between components of water supply and components of water disposal.
[l] Equivalent to subsurface outflow from the Sisquoc Plain.

SURFACE INFLOW - FUGLER POINT (SUPPLY)

Combined flow of the Sisquoc and Cuyama Rivers serves as a major source of replenishment of water resources of the Santa Maria Valley. Surface inflow at Fugler Point was developed previously in Table 3-7. Throughout the base period, this source discharged 69,700 acre-feet per year to the Valley environment.

SUBSURFACE INFLOW - FUGLER POINT (SUPPLY)

Water percolating through stream channel deposits is introduced to the Santa Maria Valley near Fugler Point. Stream underflow from the Siquoc River represents the only important source of groundwater inflow from upstream tributary watersheds. Magnitude of this subsurface flow was determined in Table 6-2 to have averaged 9,900 acre-feet per year throughout the base period. Underflow contributions from the Cuyama River are considered to be very small, on the order of a few hundred acre-feet per year at most [USGS 1951]. This relates to the fact that between Gypsum Canyon and Fugler Point, the Cuyama River flows through a narrow rock canyon characterized by a channel bottom underlain by bedrock or by thinly distributed alluvial deposits.

PRECIPITATION (SUPPLY)

Precipitation available to the Santa Maria Valley was determined by two independent methodologies. The first procedure, summarized in Table 3-5, involved derivation of recoverable water provided by rainfall falling on the 90 square-mile mountain and foothill watershed area within the Valley. This empirical analysis revealed that on an average annual basis, 1,400 acre-feet would be available as runoff or groundwater recharge after evapotranspiration losses from native soils and vegetation in the highland area had been considered.

Precipitation in the remaining unconfined and confined areas of the Santa Maria Valley was analyzed by the isohyetal method. Total volume of rainfall over these areas was computed in Table 3-3. These derivations do not reflect any evapotranspiration or other losses.

SUBSURFACE INFLOW-SOUTHEAST GROUNDWATER DIVIDE (SUPPLY)

The Santa Maria groundwater basin is in hydraulic continuity with groundwater located outside the surficial drainage divide in the southeast portion of the Valley [SBCPD 1974]. This is apparent on Figure 1-5. Recharge to the Valley is accomplished by means of recoverable water percolating to the Santa Maria trending side of the groundwater divide. Supply from this source is estimated to be on the order of 1,000 acre-feet per year.

SUBSURFACE INFLOW-FISSURES IN CONSOLIDATED ROCKS (SUPPLY)

Recharge of groundwater in the Santa Maria Valley is accomplished to a limited extent by seepage from joints and fractures in the consolidated rocks which form the eastern periphery of the basin. Direct evidence of inflow from the mountain basement complex is found in the existence of small springs which issue from fissures in the south flank of the San Rafael Mountains [USGS 1951]. It is reported that a few wells have been drilled into consolidated rocks in search of water for domestic and stock use, particularly near the town of Nipomo [USGS 1951]. These wells occasionally produced small yields.

It is doubtful that valley inflow from the consolidated fracture system is sizable. This relates to the reasonable balance exhibited by base period estimates of supply, disposal, and change in storage.

An analysis of recoverable water tributary to the 1,600 square-mile drainage area of the Cuyama and Sisquoc Rivers was prepared to check the magnitude of possible subsurface inflow from consolidated formations. Precipitation residual after natural loss by evaporation and evapotranspiration was computed to be on the order of 90,000 acre-feet per year. Of this amount, approximately 75,000 acre-feet appear annually as surface and subsurface flow in the channels of the Cuyama and Sisquoc Rivers. Allowing for consumptive use of replenishment water in the Cuyama Valley, it is estimated that roughly 5,000 acre-feet per year are available to recharge the fractured consolidated rock system. Direction of such seepage is a matter subject to conjecture. Flow need not exclusively follow established surficial drainage patterns, but could rather drain northward, southward, or eastward, depending upon the orientation of individual fissures.

The quantity of subsurface inflow from consolidated rocks is impossible to measure directly. However, the order of magnitude of such seepage in other areas of Santa Barbara County has been approximated by a number of water resources investigations. The methodology used to estimate this source of supply was similar to that utilized herein, whereby various components of supply, outflow, and change in groundwater storage, are equated. If a hydrologic imbalance is observed to exist, it points to the presence of an unknown element, such as subsurface inflow. In the Santa Barbara and Montecito areas of Santa Barbara County seepage from consolidated rocks is estimated to contribute about 300 acre-feet per year, or from 10 to 15 percent of the total average inflow [USGS 1968a]. In the Goleta and Carpinteria groundwater basins subsurface recharge is thought to represent a substantial portion of inflow. The most liberal underflow estimates are in the range of 30 to 46 percent of total inflow, respectively, for these basins [USGS 1962]. Quantity of this inflow is on the order of 1,000 to 2,000 acre-feet per year.

The existence of considerable quantities of groundwater within the fracture system of mountains in Santa Barbara County is substantiated by seepage into unlined sections of tunnels which penetrate these consolidated rocks. Characteristics of the four existing tunnels are summarized in Table 6-3.

TABLE 6-3. EXISTING INFILTRATION TUNNELS - SANTA BARBARA COUNTY [a]

Tunnel	Size	Length (feet) Total	Length (feet) Unlined	Firm Yield Total (ac-ft/yr)	Firm Yield Unit (ac-ft/yr/ 100 ft)[b]
Tecolote Tunnel	7' dia.	33,800	19,100	2,800	14.7
Mission Tunnel	3' dia.	20,000	9,800	700[c]	7.0
Doulton Tunnel		11,500	7,000	200	2.9
Cold Springs Tunnel	4' x 4'	5,000	3,300	100	3.0

[a] Toups, 1974.
[b] Based on unlined length.
[c] Since 1950, infiltration is estimated to have been 1,100 acre-feet per year. During prolonged drought periods, tunnel infiltration is reduced to about 700 acre-feet per year. [Brown and Caldwell, 1969]

Magnitude of groundwater inflow to the tunnels reflects the long-term variation of rainfall. The average firm yield from the tunnels amounts to about 3,800 acre-feet annually [Toups 1974].

Comprehensive geologic and hydrologic investigations of additional groundwater basins in southern California have approximated the magnitude of subsurface inflow from cracks and fractures in the adjacent mountain basement complex. The mathematical model developed in the course of the San Gabriel Valley groundwater basin analysis estimated the rate of seepage to be 5,000 acre-feet per year, or about 200 acre-feet per frontal mile of the San Gabriel Mountains.

SURFACE OUTFLOW - SANTA MARIA RIVER (DISPOSAL)

Average annual discharge of the Santa Maria River to the ocean is considered to be equivalent to flows passing USGS gaging station 11141000, Santa Maria River at Guadalupe. Records at this station were summarized previously in Table 3-6. Yearly surface outflow was determined to average 27,000 acre feet during the base period.

SUBSURFACE OUTFLOW - SANTA MARIA GROUNDWATER BASIN (DISPOSAL)

Under natural conditions, the seaward hydraulic gradient at the west end of the valley causes groundwater in the lower member of alluvium, Paso Robles and Orcutt Formations, and Careaga sand to discharge to the ocean. Maximum annual underflow to the ocean, 16,000 acre-feet, occurred in 1918 and 1919 when the groundwater basin was nearly full and the hydraulic gradient was ten feet per mile [USGS 1966]. By 1935, the beginning of the base period utilized in this study, underflow to the ocean below the clay cap had dropped to about 10,000 acre-feet per year. Under conditions which prevailed in the groundwater basin in 1972, underflow was computed to be slightly in excess of 2,000 acre-feet. Groundwater outflow from the confined zone during the base period is depicted graphically in Figure 6-2. Average discharge during this period was about 8,000 acre-feet per year.

VEGETATIVE CONSUMPTIVE USE (DISPOSAL)

Cultivated crops and native vegetation in the Santa Maria Valley represent the principal means by which local water resources are depleted. Table 6-4 itemizes average acreages of various land uses characteristic of the base period. These are related in Appendix D to unit evapotranspiration use factors. Since much of the historic land use data for early base period years was in terms of the entire Santa Maria study area, Table 6-4 deducts acreages representative of the Sisquoc Plain to define land use in the Santa Maria Valley. Derivation of base period average acreages relied on historic land use data in Tables 2-1 and 2-2, presented graphically in Appendix C. Table 6-5 summarizes truck crop acreages and patterns of multiple cropping.

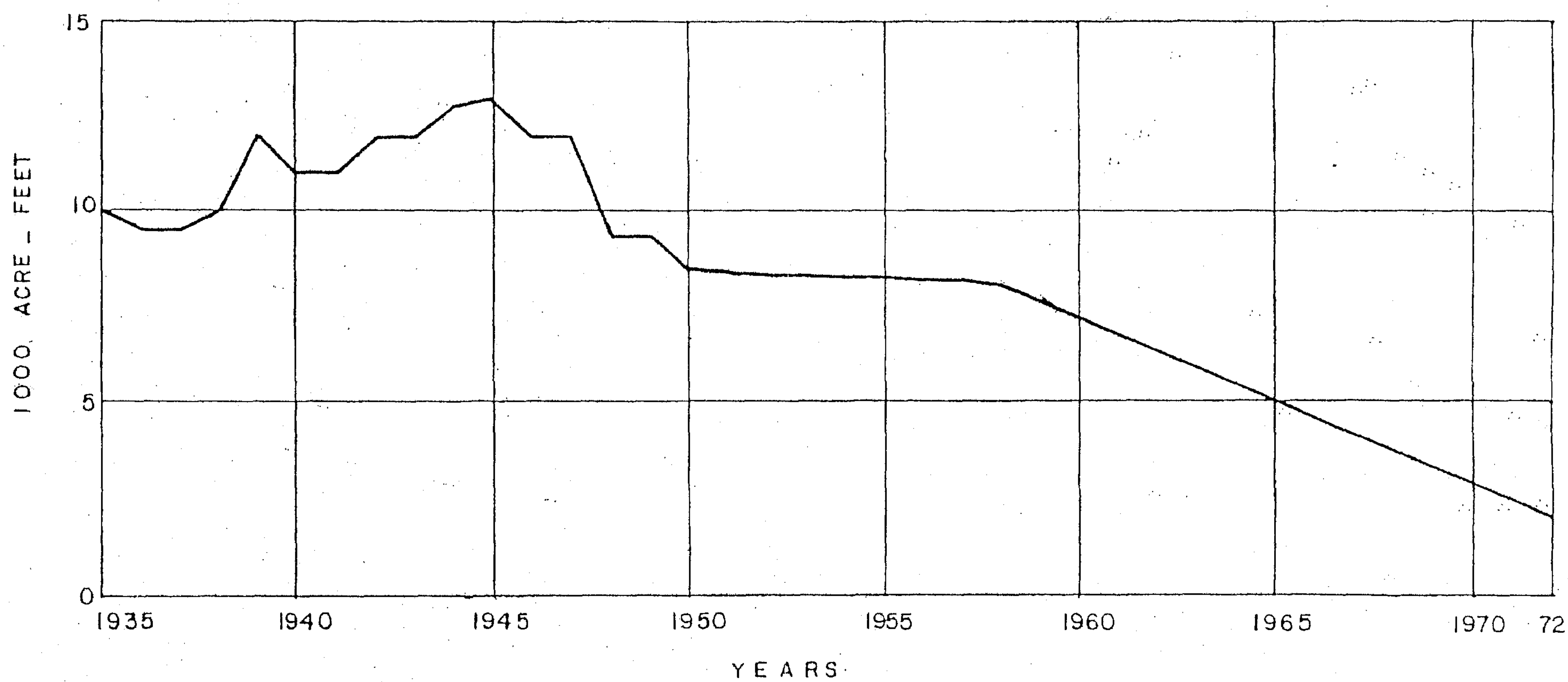


FIG. 6-2 GROUNDWATER FLOW TO THE OCEAN 1935-72 [a]

[a] DATA FROM REFS.[1] & [4]

TABLE 6-4. SANTA MARIA VALLEY ACREAGES - BASE PERIOD AVERAGE ANNUAL CONDITION

Land Use	Santa Maria Study Area	Sisquoc Plain	Santa Maria Valley
	Estimated Average Annual Acreage[a]		
Alfalfa & Pasture	5,250	950	4,300
Truck crops	21,150	300	20,850
Field crops	10,140	1,350	8,790
Vineyard	260	150	110
Fallow		--	500
Subtotal	37,300	2,750	34,550
Non-Irrigated Agriculture	28,150	2,750	25,400
Native Vegetation			
Riparian[b]	2,000	20	1,980
Non-Riparian[c]	99,600	3,570	96,030
Subtotal	101,600	3,590	98,010
TOTAL	167,050	9,090	157,960
River wash, dunes [b]	6,700	480	6,220
Urban	2,250	30	2,220[d]
GRAND TOTAL	176,000	9,600	166,400

[a] Refer to Tables 2-1 and 2-2; and graphs in Appendix C. Acreages reflect base period average conditions.
[b] Based on land use maps and acreages developed by California Department of Water Resources, 1959, backup for DWR, 1964. Data reviewed by Toups, 1975.
[c] Distribution of non-riparian vegetation determined to be 20 percent light, 70 percent medium, 10 percent heavy.
[d] Base period weighted average. See Appendix C.

TABLE 6-5. HISTORIC ACREAGE OF TRUCK CROPS [a]

Year	Reported Acres [b]	Percent Multiple Cropping	Actual Acres[c]
1935	25,725[d]	26.7[e]	20,300
1937	33,525[f]	26.7[e]	26,460
1938	26,949[g]	26.7[e]	21,270
1945		40.0[h]	
1947	30,681[i]	50.0[i]	20,454
1952	33,601[j]	60.0(est)	21,000
1959			19,440[k,l]
1966			24,660[m.n]
1968			19,424[o,l]
1973			19,463[l,p,q]
Base Period Average			20,850

[a] Acreage of truck crops is representative of Santa Maria Study Area. Multiple cropping is representative of Santa Maria Valley only, since double cropping of truck crops is negligible on Sisquoc Plain.

[b] See Tables 2-1 and 2-2 for detailed crop breakdown. Data for years 1935 through 1952 include multiple-crop acreages.

[c] Average acreage in truck crops, discounting multiple crops produced on same acreage.

[d] Kellogg, 1936.

[e] Multiple cropping reportedly averaged 26.7 percent for years 1935 through 1940. [USBR, 1951]

[f] Kellogg, 1937.

[g] Kellogg, 1939.

[h] USBR, 1951.

[i] Santa Maria Valley, 1950.

[j] Santa Maria Valley, 1953.

[k] DWR, 1964

[l] Truck crop survey acres for 1959, 1968 and 1973 were increased by amount of fallow acreage for those years that was replanted in truck crops (70%). [DWR 1964] Fallow acreage in 1973 estimated to have been 5,000 acres.

[m] Santa Barbara Co., 1967.

[n] Lawrence, 1967.

[o] DWR, 1969.

[p] UCSB, 1974.

[q] Does not include truck crop acreage in San Luis Obispo County portion of study area.

URBAN CONSUMPTIVE USE (DISPOSAL)

The category of urban water use encompasses residential and commercial activity, and any industrial enterprises that are served by municipal, community, or district water systems. Table 6-6 presents historic urban water use for the City of Santa Maria. Average daily per capita use during the base period was determined to be approximately 178 gallons. This unit use, when equated to the average Valley population, 36,200, provides a determination of total average urban water use.

Several comprehensive water use investigations have found that 45 percent of delivered water is used within the home, and subsequently discharged to sewers [SWRB 1962; DWR 1965] The remaining 55 percent is utilitized for outdoor purposes, particularly lawn watering. The percolating flows and water evapotranspired were determined to be 14 percent and 86 percent, respectively [DWR 1965] Water lost to the Valley from urban outdoor uses averaged about 3,400 acre-feet per year during the base period.

INDUSTRIAL WATER CONSUMPTION (DISPOSAL)

Water use by industries not served by municipal, community, or district water systems represents a minor, but established, source of water loss. Principal water consuming industrial activities include sugar beet processing (Union Sugar), animal feed preparation (Sinton and Brown Company), oil refining (Union Oil Company), Western Refrigeration Company, Santa Maria Refinery-Nipomo, Santa Maria Valley ABS Plant, Battles Road, Douglas Oil Company - Santa Maria Refinery), and oil field stimulation for secondary recovery.

LIVESTOCK WATER CONSUMPTION (DISPOSAL)

The Santa Maria Valley possesses an historic reputation as a cattle and dairy center. Consumptive use of water by beef and dairy cattle is

TABLE 6-6. REPRESENTATIVE MUNICIPAL AND INDUSTRIAL PER CAPITA WATER USE FOR THE CITY OF SANTA MARIA [a]

Year of Data	Total Water into System (ac-ft)	Estimated average Population served[b]	gpcd[c]
1940	1,340	8,522	140
1941	1,392	8,714	142
1942	1,563	8,906	156
1943	1,765	9,098	172
1944	1,815	9,290	174
1945	2,037	9,482	190
1946	2,197	9,674	202
1947	2,251	9,866	203
1948	2,148	10,058	190
1949	1,932	10,250	167
1950	1,866	10,440	158
1951	1,847	11,109	148
1952	2,298	11,778	174
1953	2,732	12,447	195
1954	2,610	13,117	176
1955	2,688	13,391	178
1956	2,866	13,665	186
1957	2,845	13,939	182
1958	2,930	14,216	183
1959	3,676	17,121	190
1960	3,749	20,066	166
1961	4,618	20,447	202
1962	5,083	23,403	194
1963	5,245	27,532	170
1964	6,267	29,736	188
1965	6,282	30,530	184
1966	6,476	31,647	183
1967	5,993	31,804	168
1968	6,580	32,053	183
1969	6,538	32,464	180
1970	7,047	32,793	192

[a] Data not available for base period years 1935 through 1939. Data from 1940 through 1959 from DWR, 1968. Data from 1960 through 1970 from DWR, 1975.

[b] Active service population slightly exceeds city census population.

[c] gpcd = gallons per capita per day.

estimated to have averaged approximately 1,000 acre-feet per year throughout the base period.

HYDROLOGIC INVENTORY

Two distinct hydrologic equations appear in Appendix D of this report. These equations represent the conclusions of two independent methodologies, which differ from one another in their consideration of recharge in the clay cap - semiconfined groundwater area of the valley. Components of supply and disposal quantified by each method are identical, with the following exceptions:

Method 1: Assumes the occurrence of recharge through the clay cap.

Sources of supply:

- Total precipitation available over semiconfined and unconfined portions of groundwater basin.

Sources of disposal:

- Applied water evapotranspired by irrigated crops.
- Precipitation evapotranspired by native vegetation and non-irrigated crops.
- Water transpired by phreatophytes (riparian vegetation).
- The portion of urban outdoor water that is evapotranspired.

Method 2: Assumes negligible recharge through the clay cap.

Sources of supply:

- No deep percolation is considered to occur from precipitation or irrigation return flows over semiconfined groundwater area.

° No deep percolation is considered to occur from urban indoor or outdoor water used over semiconfined groundwater area.

Sources of disposal:

° Total water applied on irrigated crops over semiconfined groundwater area.

Conclusions of the two methodologies are summarized in Table 6-7. They provide an upper and lower range of water depletion from the Santa Maria Valley under today's culture. The actual physical situation in the Valley is nearer that indicated in the Method 2 analysis. This is apparent from the results of the base period change of groundwater in storage analysis, developed in Appendix B. It is important to recognize that the average annual water deficit, which may range up to 6,000 acre-feet, represents an overdraft with respect to average, long-term hydrology.

TWITCHELL RESERVOIR

Completed in 1959 and intercepting Cuyama River flows since 1962, Twitchell Reservoir has served to control floods and conserve water resources tributary to the Santa Maria Valley. The base period hydrologic inventory summarized in Table 6-7 and itemized in Appendix D reflects the impact of the Twitchell Project only for the fourteen-year period during which the reservoir was actually operable. Any assessment of existing or future water resources available to the study area must recognize and quantify the additional supply provided by Twitchell Reservoir throughout future years. For this reason, the yield of the Twitchell Project was evaluated.

The computer analysis used to derive the yield of the Twitchell Project superimposed the reservoir on hydrologic conditions that existed during the 38-year base period. Daily records of flow in gaged watercourses

TABLE 6-7. HYDROLOGIC INVENTORY, SUMMARY
(1000 acre-feet)

	Change in Storage[a] 1935-1972	Method 1[b] 100% Recharge	Method 2[c] Negligible Recharge	Basin Condition[d]
Base period average annual condition [e]	-6.7	+2.3	-8.6	-6.7
Present condition [f]		+5.4	-8.8	-6.0

[a] Calculated change of groundwater in storage, 1935-1972. See Appendix B.
[b] Assumes 100 percent recharge through clay cap. See Appendix D.
[c] Assumes negligible recharge through clay cap. See Appendix D.
[d] Actual condition of Santa Maria Valley Groundwater Basin regarding water supply vs. water disposal is between upper and lower extremes indicated by Method 1 and Method 2 analyses. Based on a comparison with the base period change in groundwater storage, it appears as though recharge on the order of twenty percent occurs through the clay cap. The "basin condition" column acknowledges this recharge.
[e] 38-year period, 1935-1972.
[f] 1975 acreages [UCSB, 1975] and valley culture equated to average base period hydrology which considers long-term influence of Twitchell Reservoir.

served as primary data. Daily flows at gaging stations with incomplete records were generated by means of double mass comparison with long-term stations. The program is sophisticated and comprehensive. It also incorporates a routine by which additional water resources development projects (off-channel spreading grounds) can be evaluated. Results of these supplemental water analyses appear in Chapter 10.

The reservoir possesses a conservation pool of 151,000 acre feet and flood control storage equivalent to an additional 89,000 acre feet. Average silt storage is approximately 2,300 acre-feet [USBR 1975]. Operation of Twitchell Reservoir was analyzed during both conservation and flood conditions. During conservation operation, flow in the Sisquoc River was compared with a channel discharge at Fugler Point of 300 cfs, a flow considered to be an optimum condition for in-channel percolation in the Santa Maria River. If flow in the Sisquoc River equalled or surpassed the 300 cfs criterion, no reservoir release was indicated by the computer program. If flow in the Sisquoc River was less than 300 cfs, releases were directed from the reservoir to make up the difference. If storage in Twitchell Reservoir was insufficient to maintain the 300 cfs discharge past Fugler Point, the reservoir was emptied. For all flows at Fugler Point, the computer analysis determined the corresponding percolation that would occur within the Santa Maria River channel. The percolation characteristics of the river alluvium were obtained from the U.S. Bureau of Reclamation [USBR 1955]. Outflow to the ocean is computed as the difference between the flow at Fugler Point and in-channel percolation.

During flood conditions on the Cuyama River, releases for Twitchell Reservoir were computed based on volume of water in reservoir storage according to the operational schedule developed by the Bureau [USBR 1959]. Flow passing Fugler Point and corresponding downstream percolation in the channel of the Santa Maria River was subsequently computed. In terms of base period hydrology, yield of the Twitchell Project was determined by computer analysis to average 19,750 acre feet per year. A summary of reservoir operational data is presented in Appendix H.

STATIC WATER LEVELS

The present hydrologic status of the Santa Maria groundwater basin was depicted previously in Table 6-7. This analysis indicates that present water consumption in the valley exceeds average long-term supply. Net water deficit may range up to 6,000 acre-feet per year.

Groundwater levels in much of the basin began to respond to recharge from Twitchell Reservoir in about 1965. This is evident in Figure 6-3 which shows the relationship between recharge from the Santa Maria River and groundwater levels in six representative wells located throughout the valley. The correlation between the curve of the accumulated departure from average recharge, and the six-well hydrographs is good.

It has been observed by water purveying agencies in the forebay area of the basin that water levels in production wells have either increased or remained relatively static from the 1960's to date. At the request of Lake Marie Water Company, trends in water elevations in key wells throughout the study area were analyzed. In order to reflect the full impact of Twitchell Reservoir, the period subsequent to 1958 was selected for purposes of review.

Depth to groundwater data were statistically analyzed by computer using multilinear regression techniques. These procedures determined an equation which most reasonably interprets the observed data for each well. In this manner, a trend not readily discernable is defined. Results of the computer analyses are presented in Appendix E. Location of key wells and their respective trend in water level increase or decrease are shown on Figure 6-4. Table 6-8 describes various characteristics of key wells, including height of land surface datum and area of perforations.

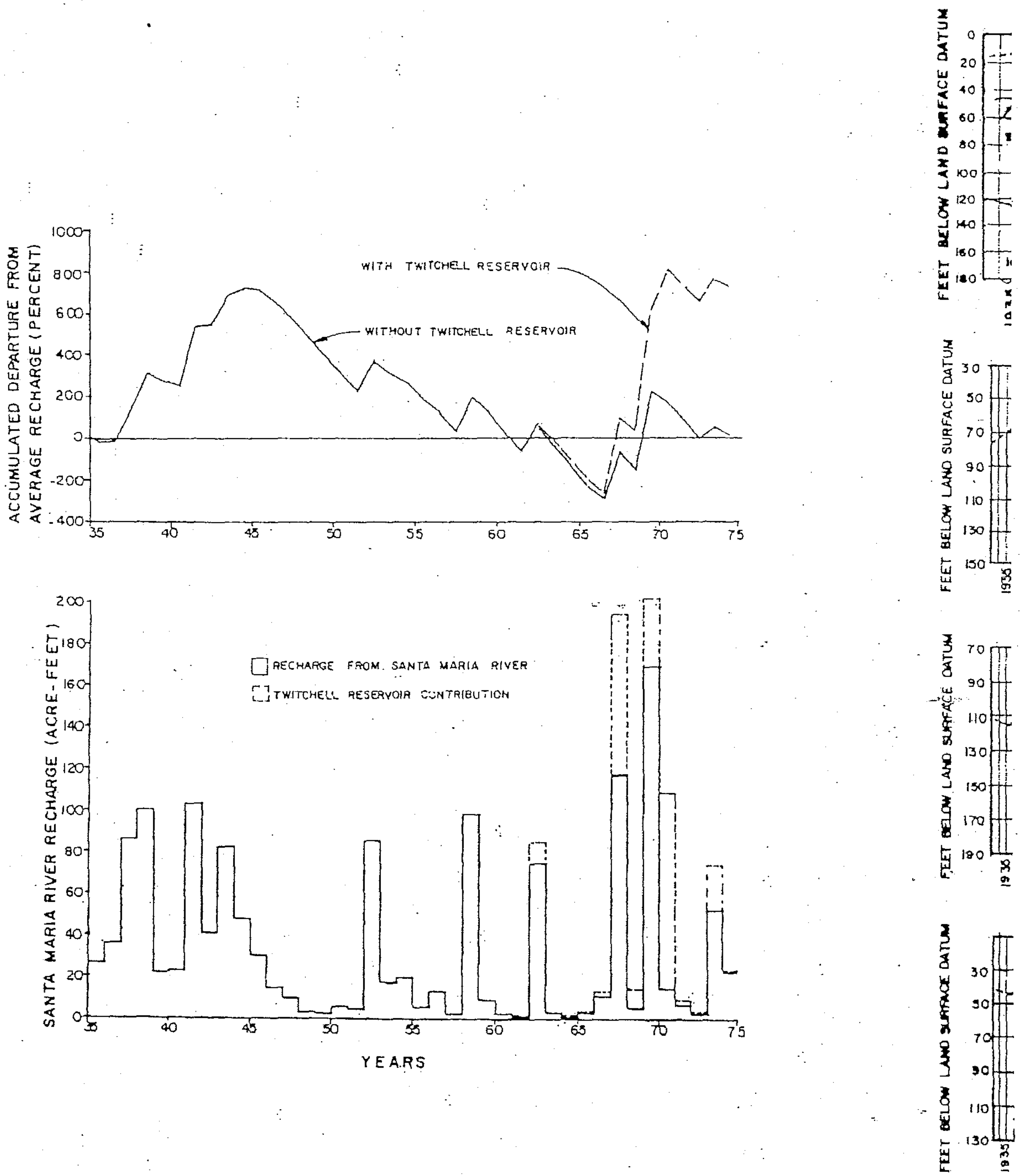
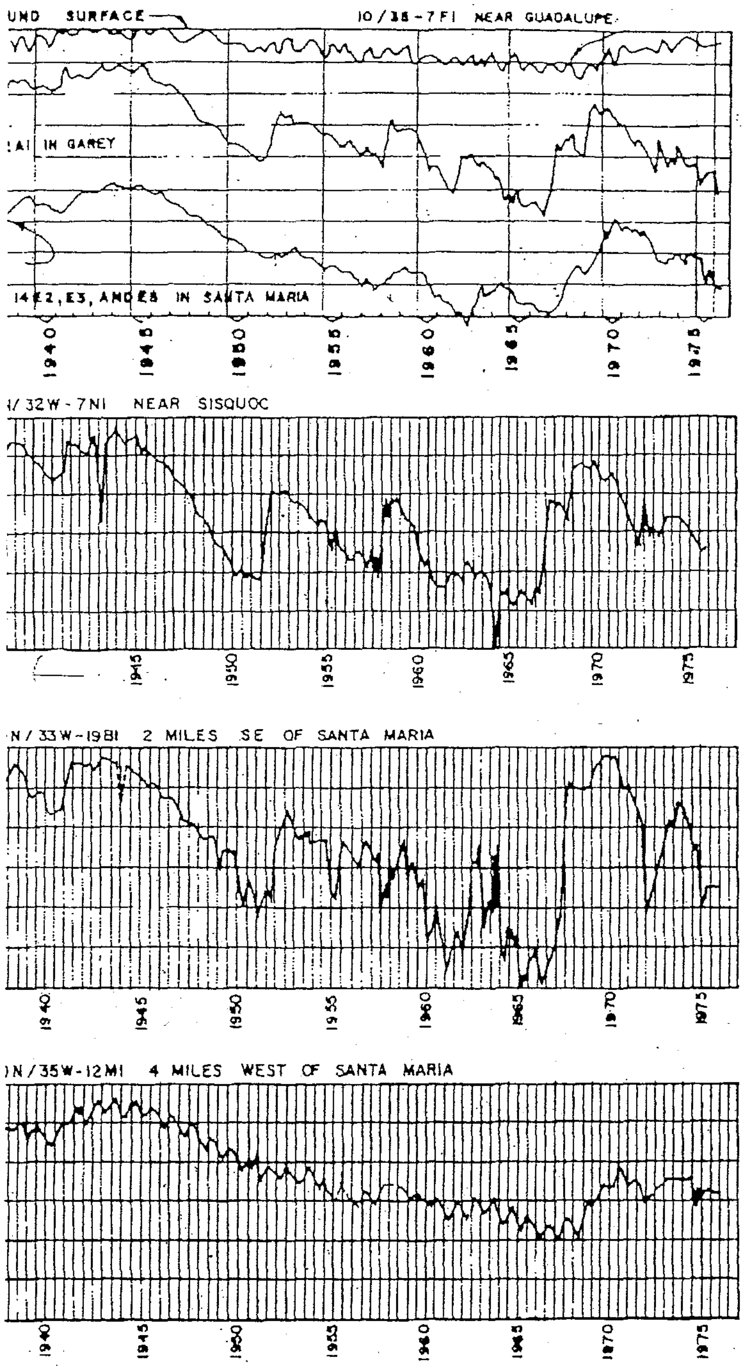


FIG. 6-3 TRENDS OF GROUNDWATER RECHARGE AND WATER L

WATER LEVELS IN SELECTED WELLS



EI-

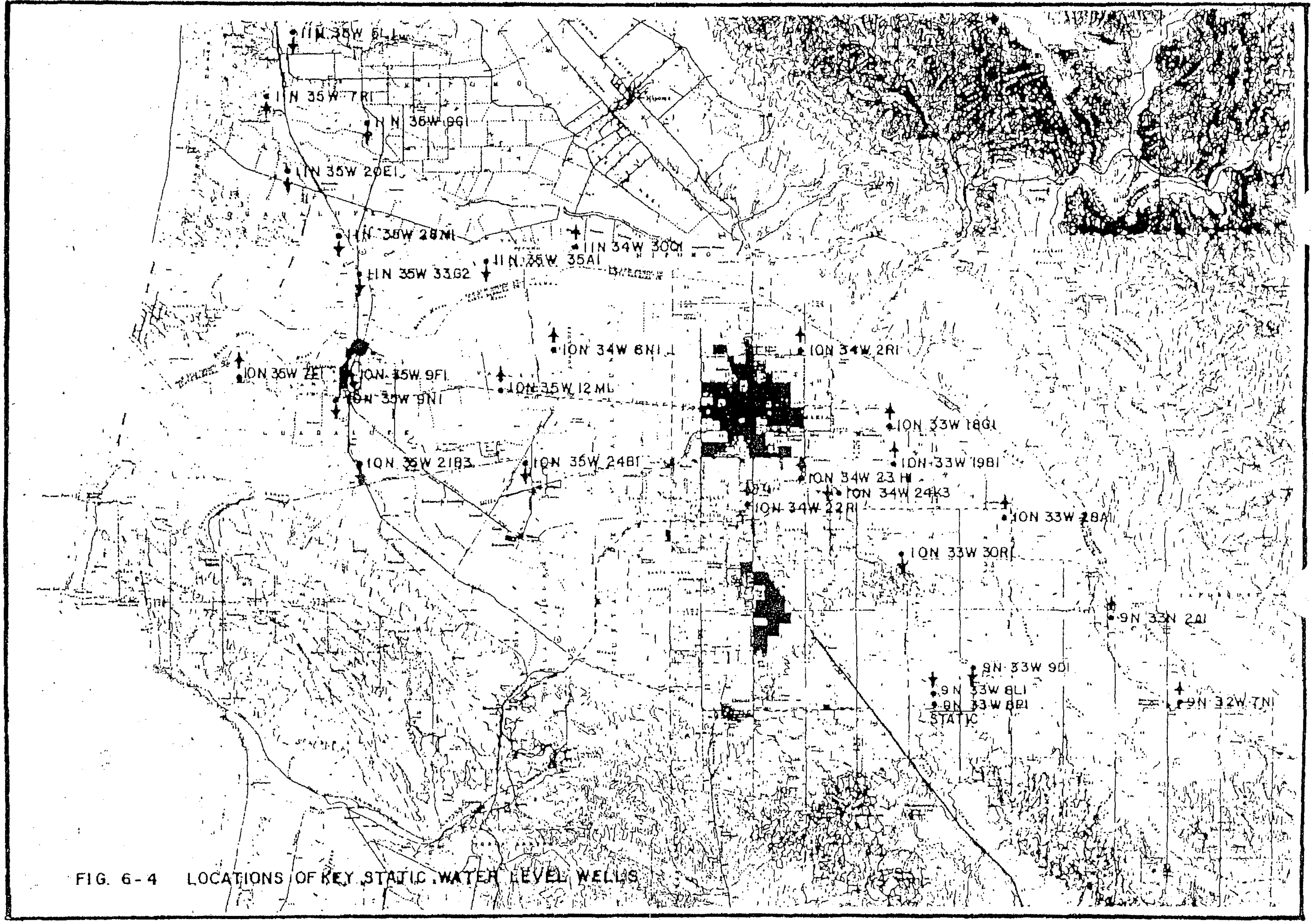


FIG. 6-4 LOCATIONS OF KEY STATIC WATER LEVEL WELLS

TABLE 6-8. INDEX OF WELLS - STATIC WATER LEVEL ANALYSIS [a,b]

Well Number	Ground Surface Elevation Feet,MSL[c]	Depth, MSL[c] Top of Perforated Interval	Depth, MSL[c] Bottom of Perforated Interval
9N32W7N1	422	+340	+237
9N33W2A1	379	?	+211[h]
9N33W8L1[d,e]	706	+56	-266
9N33W8P1[d,f]	780	-40	-220
9N33W9D1[d,g]	715	+30	-675
10N33W18G1	273	+141	-149
10N33W19B1	275	+183	+27
10N33W28A1	325	+225	-10
10N33W30R1	335	+253	-121
10N34W2R1	230	+124	+4
10N34W6N1	152	?	-38[h]
10N34W22R1	217	+99	-25
10N34W23H1	242	+62	-168
10N34W24K3	245	+17	-406
10N35W7F1	48	-92	-177
10N35W9F1	88	?	-110[h]
10N35W9N1	87	-41	-145
10N35W12M1	138	?	?
10N35W21B3	94	?	?
10N35W24B1	144	+22	-144
11N34W30Q1	148	?	-32[h]
11N35W5L1[i]	109	?	-91[h]
11N35W7R1[i]	100	?	-707[h]
11N35W9G1[i]	200	?	-395[h]
11N35W20E1	49	-101	-395
11N35W28M1	77	?	?
11N35W33G2	91	?	?
11N35W35A1	123	-2	-66

[a] Refer to Appendix E.
[b] Wells monitored by Santa Maria Valley Water Conservation District, except as noted.
[c] Datum: mean see level.
[d] Well monitored by Lake Marie Water Company, Inc.
[e] Lake Marie Water Company Well Number 4A.
[f] Lake Marie Water Company Well Number 3.
[g] Lake Marie Water Company Well Number 6.
[h] Drill depth.
[i] Well monitored by San Luis Obispo County.

It is evident in the analyses of water level trends that elevations are rising in the alluvial forebay of the Valley. At the same time, levels appear to be dropping in the area of confined groundwater, in portions of the southern upland area, in the Oso Flaco District, and in much of Nipomo Mesa. The most severe problem currently impacting water resources in the Valley appears to be one of inadequacy in water distribution rather than in deficiency of total water supply. Geologic characteristics of each particular area determine in large degree the response groundwater levels will exhibit to recharge from the Santa Maria River. Alluvium in the unconfined portion of the basin readily accepts percolating flows from the River. Wells situated in this region, regardless of drill depth, demonstrate positive increases in groundwater levels. Surface recharge in the area of semiconfined groundwater is restricted by the impermeability of the confining layer. Subsurface recharge of the confined zone from the forebay area is inhibited by the relative tightness of the lower aquifer system. Hence, although groundwater levels in the forebay are increasing, the resultant gradient is not steep enough to maintain historic pressure elevations in the area of confined groundwater.

The occurrence of the overall rising trend in forebay groundwater levels for the period 1958 through 1975 is attributable to the greater than average recharge that occurred during these years. This is evident in Table 6-9. Although precipitation at the City of Santa Maria recording station for 1958 through 1975 was only 93 percent of the base period average, inflow to the Valley and subsequent recharge were 103 percent and 118 percent, respectively, of average. The regulatory function provided by Twitchell Reservoir enabled inflow at Fugler Point to percolate in quantities that exceeded total extraction from the groundwater basin.

TABLE 6-9. BASIN HYDROLOGY, 1958-1975

Precipitation (inches)

Base Period 1935-1972	13.3
1958-1975	12.4
1958-1975 as percent of Base Period 1935-1972	93%

Surface Water Flow (ac-ft/year)

	Inflow Fugler Point	Outflow Guadalupe	Percolation
Base Period 1935-1972	69,700	27,000	42,700
1958-1975	71,700	21,200	50,500
1958-1975 as percent of Base Period 1935-1972	103%	79%	118%

CHAPTER 7

WATER QUALITY

The compound effects of increased water consumption, and additions of salts from nature and man's activities, are degrading and threatening water quality in some areas of Santa Maria Valley. Subsurface outflow from the groundwater basin and surface outflow of drainage water are presently the means for salt removal from the onshore groundwater reserve. A determination of the amount of salts currently added to the groundwater reservoir together with historical groundwater quality trends provides a means of studying the quality of groundwater supplies.

HISTORIC AND PRESENT WATER QUALITY

Evaluation of water quality for the entire base period is not possible because groundwater quality data is nonexistent for the early years. In order to obtain trends for the years when records are available, sixteen wells located throughout the basin were chosen for analysis. The criteria for selection included length of water quality records, frequency of analysis, and location. Well locations are shown on Figure 7-1. Analysis for chloride ion in two wells commenced in 1941, but analysis for other constituents generally did not begin until the mid 1950's for a few wells. Most complete analyses have been performed during the 1960's and 1970's.

Present water quality for each of four parameters; total dissolved solids (TDS), sulfate (SO_4), chloride (Cl), and nitrate (NO_3) is shown in Table 7-1. All of the sixteen wells exceeded the recommended U.S. Public Health Service (USPHS) drinking water standards of 500 mg/l for TDS, and all of the wells in the Guadalupe and main central part of the basin exceeded the 1000 mg/l upper limit of the California Department of

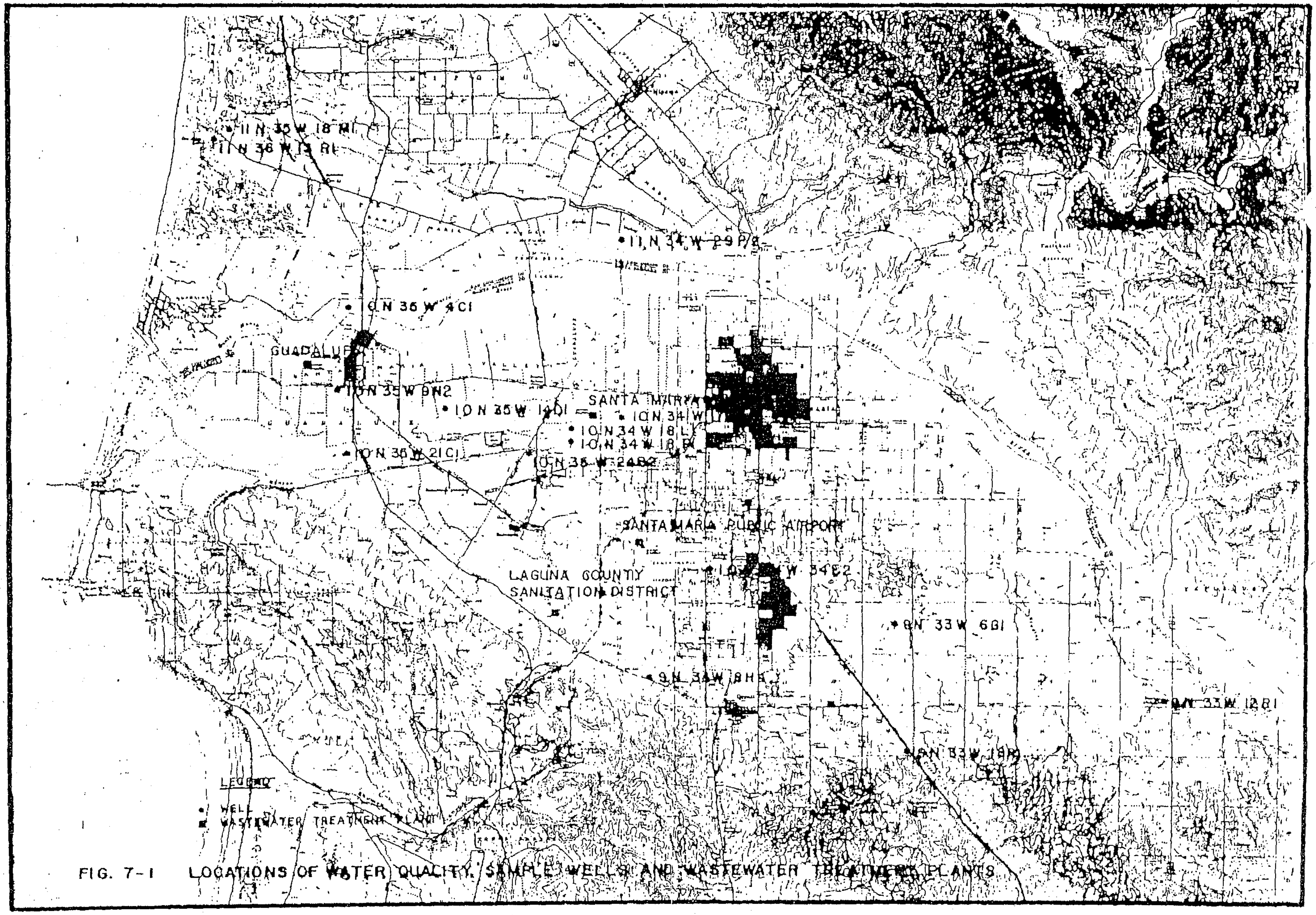


FIG. 7-1 LOCATIONS OF WATER QUALITY SAMPLE WELLS AND WASTEWATER TREATMENT PLANTS

TABLE 7-1. EXISTING GROUNDWATER QUALITY

Area and Well No.	Depth msl[a] Top of Sample Interval	Bottom of Sample Interval	Present Water Quality (mg/l) TDS	SO_4	Cl	NO_3	Historic Annual Trend in Water Quality (mg/l/year) TDS	SO_4	Cl	NO_3
Oso Flaco										
11N35W18M1	?	-155	900	331	50	3	-8.6	-28.1	+5.6	+0.3
11N36W13R1[b]	?	?	895	450	39	2	-6.5	-1.5	-0.4	+0.03
Guadalupe										
10N35W4C1[b]	-60	?	1,380	641	72	22	+13.3	-0.4	+0.9	+0.7
10N35W9N2	?	-377	1,000	464	61	12	+13.6	+2.3	+0.6	+0.3
10N35W14D1	+22	-184	1,320	600	110	46	+7.8	+3.9	+0.9	+2.2
10N35W21C1[b]	?	?	1,410	590	170	57	+22.2	+6.0	+2.8	+0.7
North Central										
11N34W29P2	+36	-30	789	320	48	56	-3.4	-3.0	-1.0	+1.4
Main Central										
10N34W17F1	+85	?	1,560	780	85	68	+12.1	+14.9	+1.1	+4.2
10N3418L1	+46	-102	1,530	430	286	48	-15.3	-4.8	+9.3	-2.0
10N34W18P1	+59	-80	1,640	640	230	62	+44.7	-2.8	+31.6	+3.9
10N35W24B2	+30	?	1,430	586	132	60	+6.3	+2.9	+0.6	+0.5
South Central										
10N34W34E2	+40	-1,165	588	250	33	6	-12.8	-23.8	+0.2	+0.3
9N34W8H4	-212	-342	641	240	40	4	-8.8	+1.6	-0.9	+0.1
South Canyon										
9N33W6G1	+21	-555	698	290	28	5	+6.5	+0.5	-0.7	+0.3
9N33W18R1	-20	-44	501	68	110	20	-4.7	+1.9	-2.4	+0.4
Sisquoc										
9N33W12R1	+229	+144	909	390	33	28	+11.0	+5.4	+0.2	+0.8

[a] Datum: Mean sea level.
[b] No well log on file with California Department of Water Resources.

Health Standards for TDS. Drinking water standards are summarized in Table 7-2. All but two wells, both located in the southeastern part of the basin, exceeded the recommended USPHS standard of 250 mg/l for SO_4. Most of the wells in the Guadalupe and main central part of the basin exceeded the California Department of Health Standards upper limit of 500 mg/l for SO_4. All but one well located in the main central part of the basin were below the USPHS recommended limit of 250 mg/l for Cl. Most of the wells in the Guadalupe and main central part of the basin exceed the USPHS recommended limit of 45 mg/l for NO_3.

The isoconcentration maps of Figures 7-2 through 7-6 depict water quality in the basin. Shown are fall 1973 through spring 1974 lines of equal concentration for the water quality parameters TDS, Na, SO_4, Cl, and NO_3. Data collected or reported by DWR, USGS, San Luis Obispo County, City of Santa Maria, and Santa Maria Valley Water Conservation District were used in the preparation of these figures. Water with lower salt concentration is contained in the groundwater basin below the present pumping zone. Better quality water is also available around the periphery of the basin.

For each of the sixteen wells, four parameters, TDS, SO_4, Cl, and NO_3 were analyzed by a multiple-regression technique to obtain the best fit of a trend line through all available data. The resulting graphs are shown in Appendix F. Water quality trends from these graphs were used to compute the average annual changes in water quality in the sixteen wells shown in Table 7-1.

The two wells located in the Oso Flaco area declined in TDS at an average annual rate of about 7.5 mg/l during the period of record. This decline may be attributable to the suspected shoreward flow of groundwater resulting from the onshore hydraulic gradient induced during periods of heavy pumping. One of these wells has a chloride ion concentration of 50 mg/l and has an increasing trend, which is an indication that water

TABLE 7-2. DRINKING WATER STANDARDS [a]

Constituent	USPHS Drinking Water Standards [b] Recommended limits mg/l	Mandatory limits mg/l	California Department of Health Standards[84] Upper limit mg/l	Short-term limit mg/l	EPA Interim Primary Water Standards mg/l[83]
Physical Characteristics:					
Turbidity, units	5	--	0.5	--	
Color, units	15	--	15	--	
Odor, threshold odor number	3	--	3	--	
Nonfilterable residue	--	--	--	--	
Taste	--	--	--	--	
Chemical Characteristics:					
Alkyl benzene sulfonate (ABS)	0.5	--	--	--	
Aluminimum (Al)	--	--	--	--	
Arsenic (As)	0.01	0.05	0.1	--	0.05
Barium (Ba)	--	1.0	1.0	--	1.0
Cadmium (Cd)	--	0.01	0.01	--	0.01
Carbon-chloroform extract (CCE)	0.2	--	0.7	--	
Chloride (Cl)	250	--	500[d]	600	
Chromium (Cr, hexavalent)	--	0.05	0.05	--	0.05
Copper (Cu)	1.0	--	1.0	--	
Cyanide (CN)	0.01	0.2	0.2	--	0.2
Fluoride (F) [c]	0.8-1.0	1.3	0.8-1.0	1.3	[e]
Hardness (as $CaCO_3$)	--	--	--	--	
Iron (Fe)	0.3	--	0.3	--	
Lead (Pb)	--	0.05	0.05	--	0.05
Magnesium (Mg)	--	--	--	--	
Manganese (Mn)	0.05	--	0.05	--	
Mercury (Hg)	--	--	0.005	--	0.002
Nitrate (NO_3)	45	--	--	--	
Nitrate-N+ Nitrite-N	10	--	10	--	10
Phenols	0.001	--	--	--	
Selenium (Se)	--	0.01	0.01	--	0.01
Silver (Ag)	--	0.05	--	--	0.05
Sulfate (SO_4)	250	--	500[d]	600	
Total dissolved solids (TDS)	500	--	1,000[f,g]	1,500[h]	
Zinc (Zn)	5	--	5	--	

[a] Units are milligrams per liter, unless otherwise stated.
[b] United States Public Health Service Drinking Water Standards of 1962.
[c] Fluoride concentrations in public water supplies in California are regulated by the State Board of Public Health. For mean annual temperature of 60°F, fluoride concentration cannot exceed 1.0 mg/l.
[d] Recommended: 250 mg/l.
[e] For mean annual temperature of 60°F, fluoride concentration cannot exceed 2.0 mg/l.
[f] Recommended: 500 mg/l (specific conductance: 800 micromhos).
[g] Upper limit: 1,000 mg/l (specific conductance: 1,600 micromhos).
[h] Short-term limit: 1,500 mg/l (specific conductance: 2,400 micromhos).

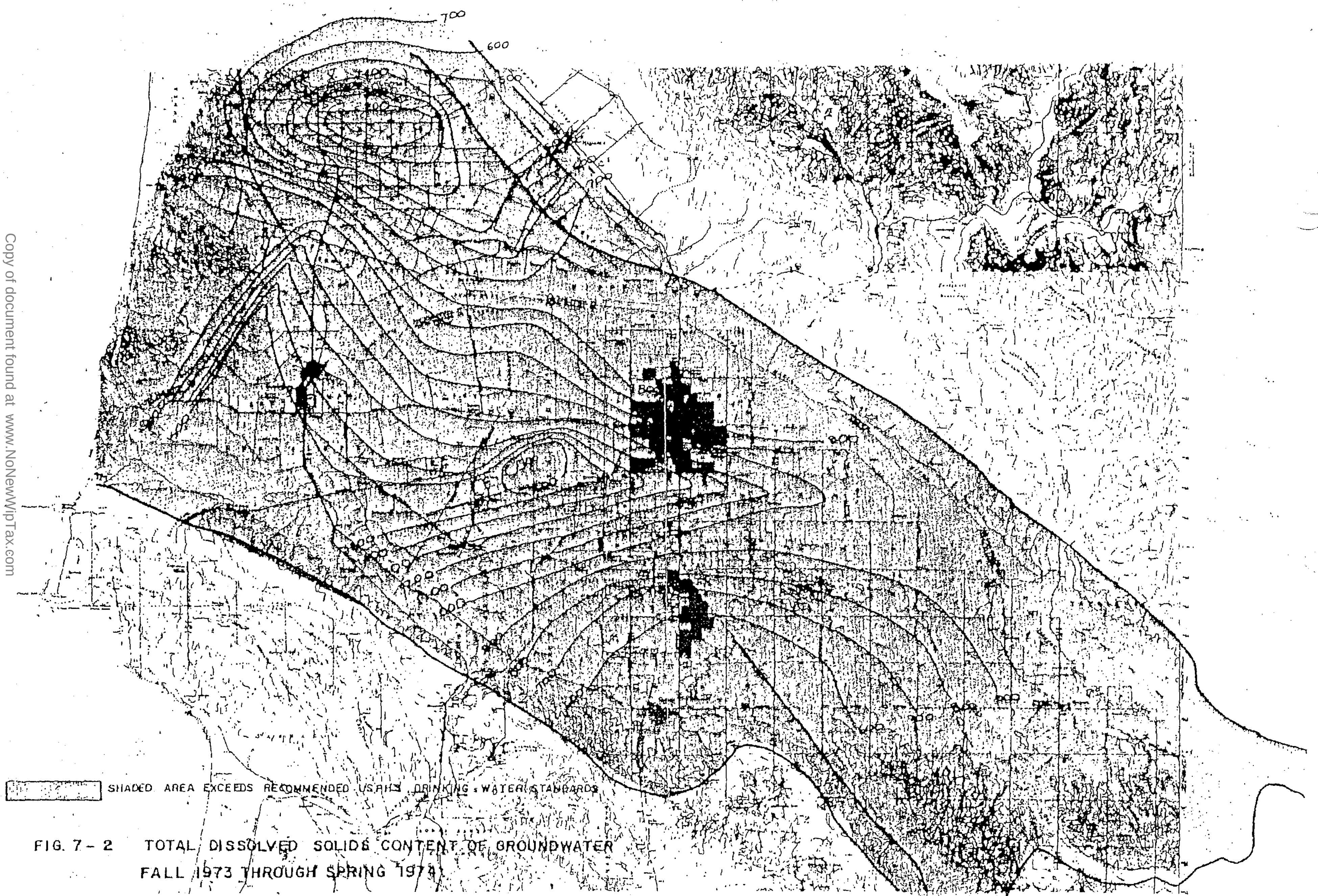


FIG. 7 - 2 TOTAL DISSOLVED SOLIDS CONTENT OF GROUNDWATER
FALL 1973 THROUGH SPRING 1974

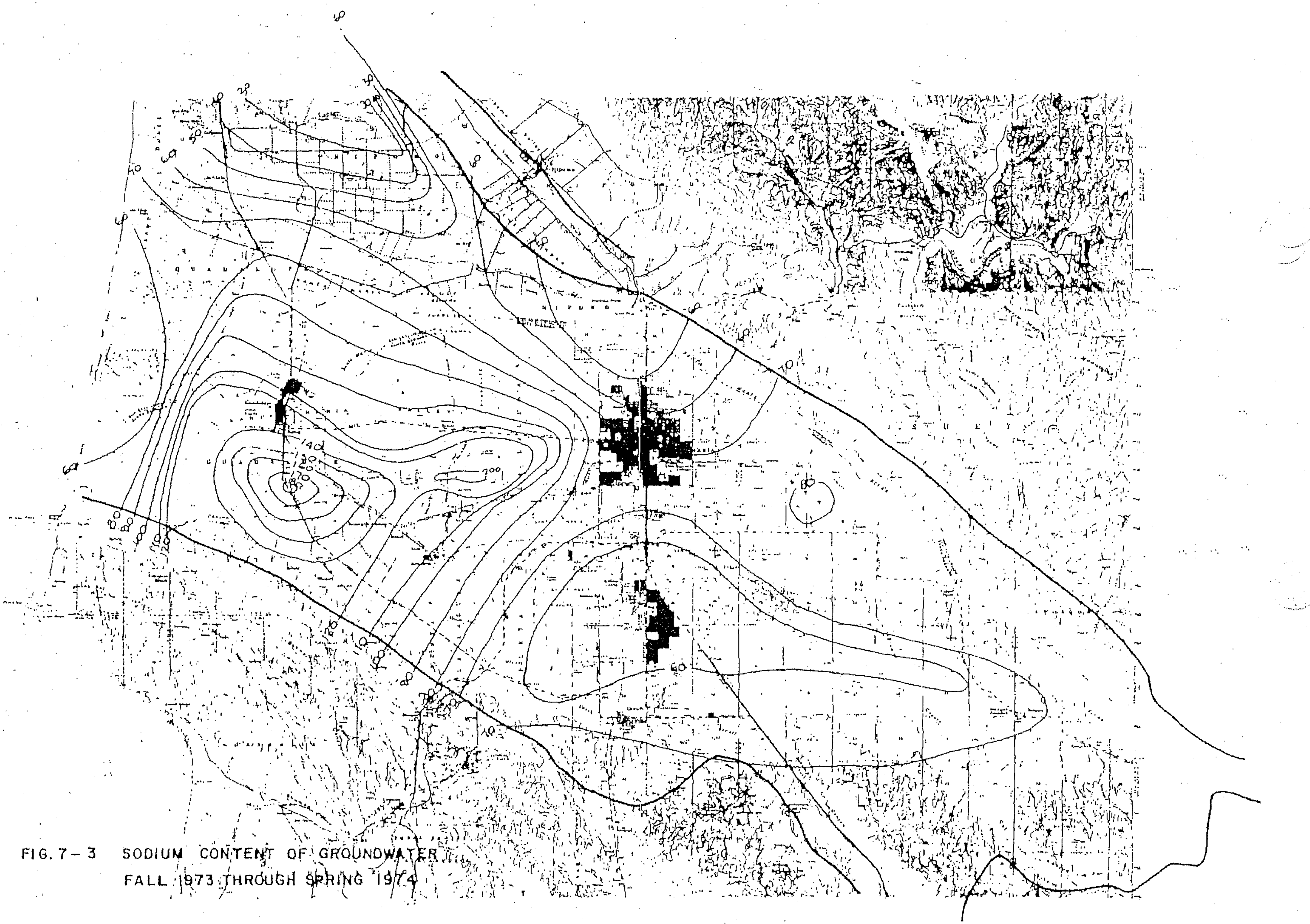
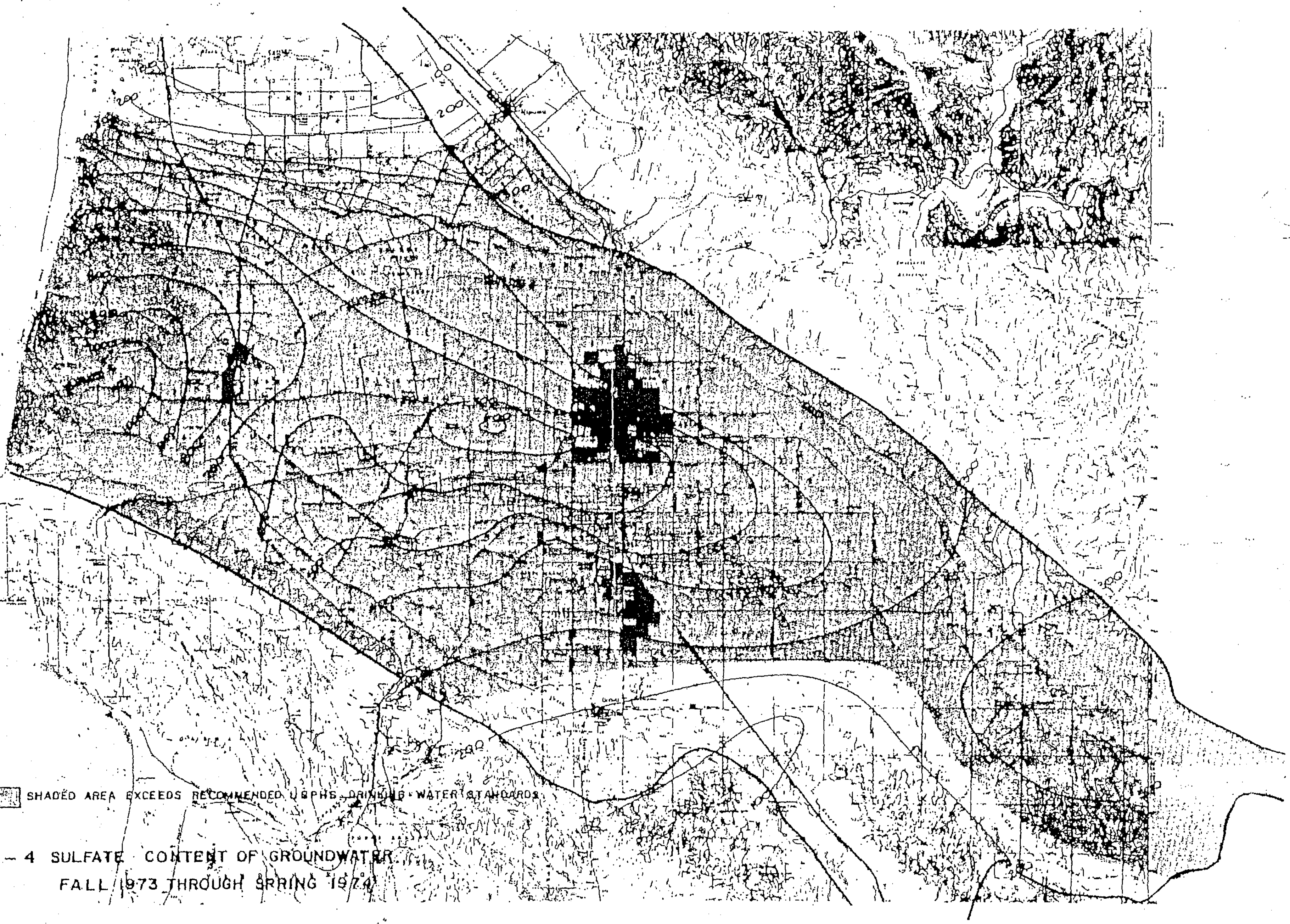


FIG. 7-3 SODIUM CONTENT OF GROUNDWATER
FALL 1973 THROUGH SPRING 1974



SHADED AREA EXCEEDS RECOMMENDED USPHS DRINKING WATER STANDARDS

FIG. 7 — 4 SULFATE CONTENT OF GROUNDWATER
FALL 1973 THROUGH SPRING 1974

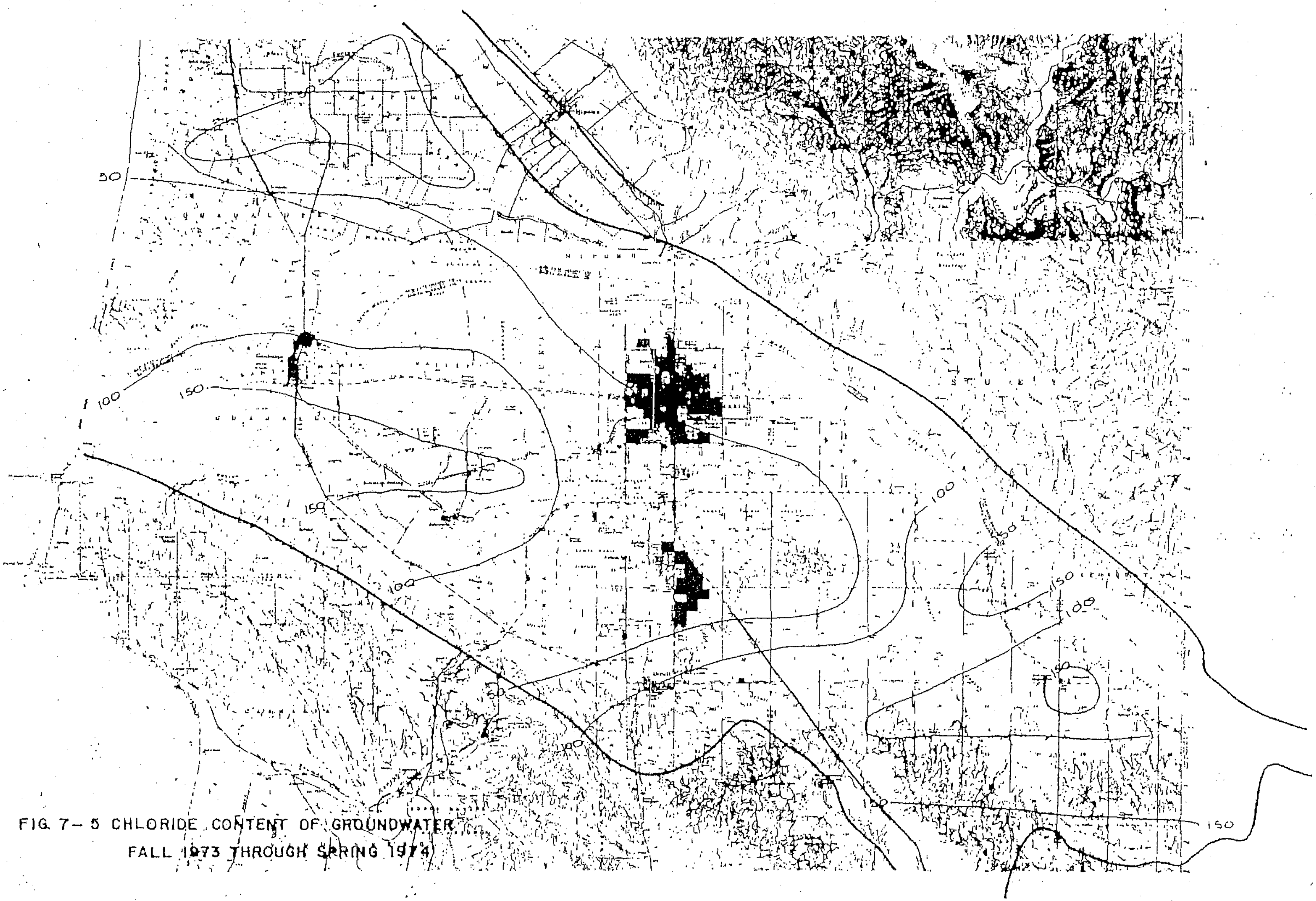


FIG. 7— 5 CHLORIDE CONTENT OF GROUNDWATER
FALL 1973 THROUGH SPRING 1974

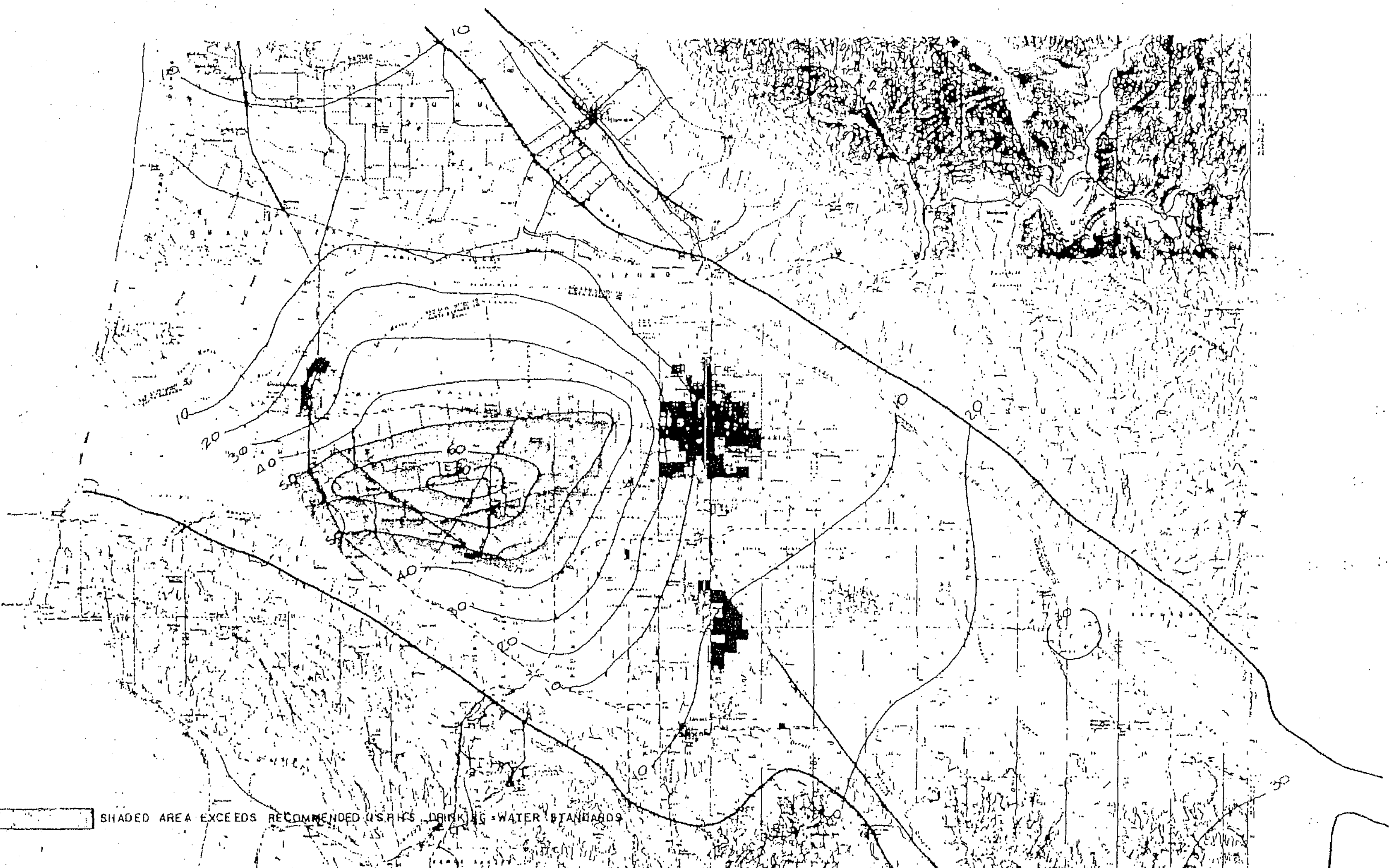
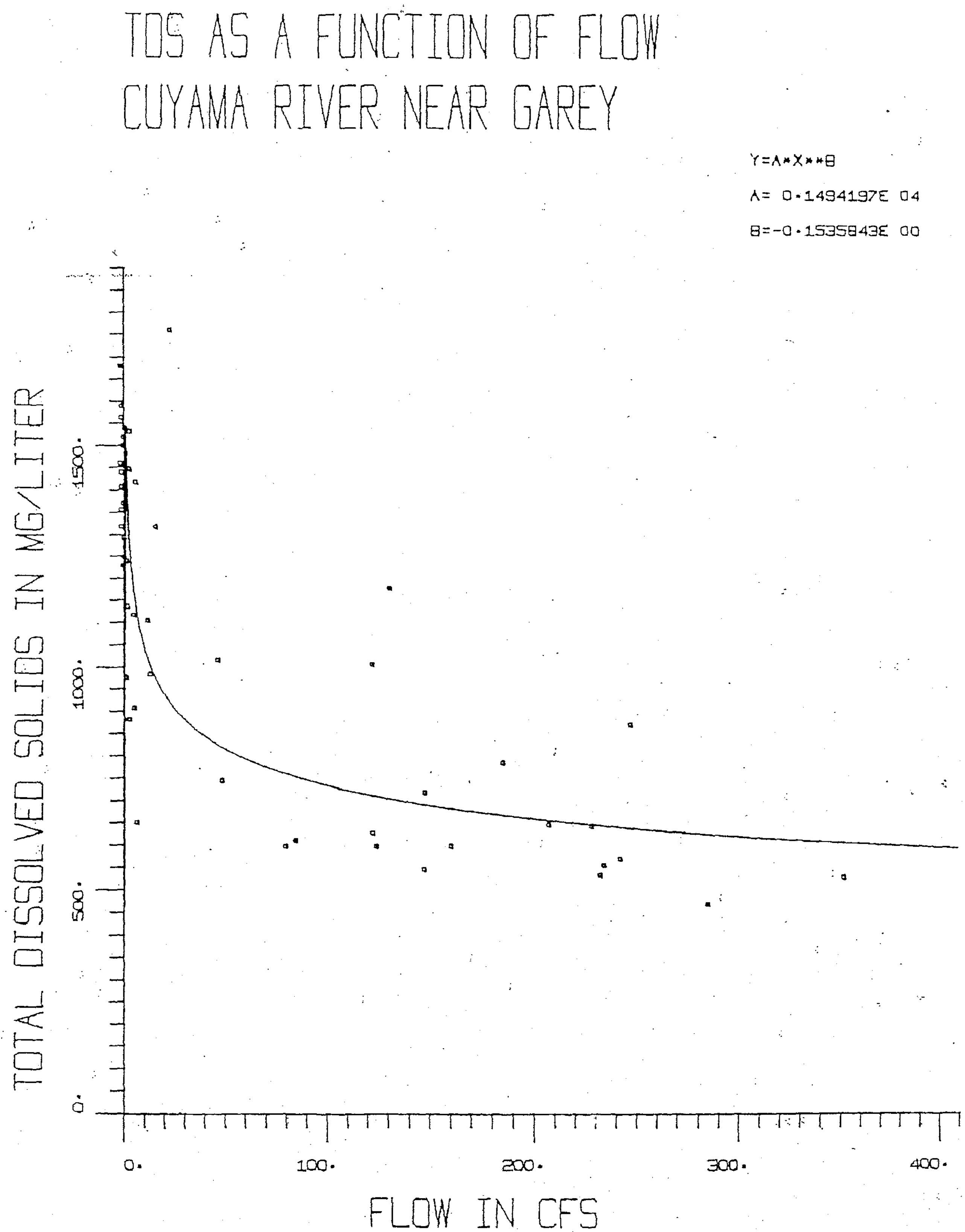


FIG. 7– 6 NITRATE CONTENT OF GROUNDWATER
FALL 1973 THROUGH SPRING 1974

FIG. 7-7


TDS AS A FUNCTION OF FLOW
CUYAMA RIVER NEAR GAREY
Y=A*X**B
A= 0.1494197E 04
B=-0.15358843E 00
TOTAL DISSOLVED SOLIDS IN MG/LITER
0.
500.
1000.
1500.
0.
100.
200.
300.
400.
FLOW IN CFS

quality in this area should be monitored closely. A chloride ion concentration of 100 mg/l is sometimes used as an arbitrary designator that signals the presence of poor quality water.

The four wells in the Guadalupe area increased in TDS at an annual rate of about 14 mg/l during the period of record. The three individual constituents generally increased at lesser rates.

In the main central portion of the basin, four wells indicated an average increase in TDS of about 12 mg/l annually during the period of record, even though one of the wells showed an annual decrease in TDS of 15.3 mg/l. The reason for this decrease is not apparent, however the trend is based on only five fairly scattered analyses, and is not well correlated.

The two wells in the south central part of the basin decreased in TDS at an average annual rate of about 11 mg/l during the period of record. One of these wells was pumping from a depth over 1,100 feet below mean sea level and the other from a depth over 300 feet below mean sea level which indicates that better quality water exists below average pumping depths.

In the southeastern part of the basin one well decreased in TDS at a rate of about 5 mg/l annually during the period of record, and the other increased at an annual rate of about 6 mg/l. The increasing trend was not well correlated however, as shown by the very scattered points on Figure F-1A in Appendix F. Increasing TDS does not appear to be a problem in this area of the basin.

The summary data in Table 7-1 shows increases in Cl and NO_3 concentrations in most of the wells. The largest increases were in the main central portion of the basin.

The largest contribution of salts to the basin is from natural sources, a situation that makes practical control exceedingly difficult. This is depicted in Table 7-3. The percolating component of Cuyama River inflow serves to recharge the groundwater basin with 35,000 acre-feet annually on an average basis, and is the largest single natural salt source. This contribution represents 31,000 tons annually. The Sisquoc River is the next largest salt source with an average annual contribution to the groundwater basin of 20,000 acre-feet and a salt load of 15,000 tons.

The average annual concentration of recharge quantities is about 650 mg/l for the Cuyama River and about 550 mg/l for the Sisquoc River. These tonnages and concentrations were obtained by correlating all of the known water quality analyses from the rivers with corresponding flows, using a multiple-regression analysis. This data is shown in Tables F-1 and F-2 of Appendix F. The curves in Figures 7-7 and 7-8 were developed from this analysis. Figure 7-7 shows that 49 analyses were available over a wide range of flows for the Cuyama River, making a reasonably good correlation possible. All of the analyses are for the period after Twitchell Reservoir came into operation. Figure 7-8 shows that only nine analyses were available for the Sisquoc River, and all but two of these are for periods of relatively low flow, indicating a need for more analyses of higher flows.

The quantity of salt added to the groundwater reservoir from man-made sources is not large, as shown in Table 7-3. Community wastewater treatment and disposal systems are the main sources of these salts. The important systems are listed in Table 7-4 and their locations are shown on Figure 7-1. While control of these sources would not be particularly significant in reducing salinity from the standpoint of the entire basin, control of individual point sources would significantly reduce salinity in the vicinity of individual waste discharges.

FIG. 7-8

TDS AS A FUNCTION OF FLOW
SISQUOC RIVER, SISQUOC PLAIN

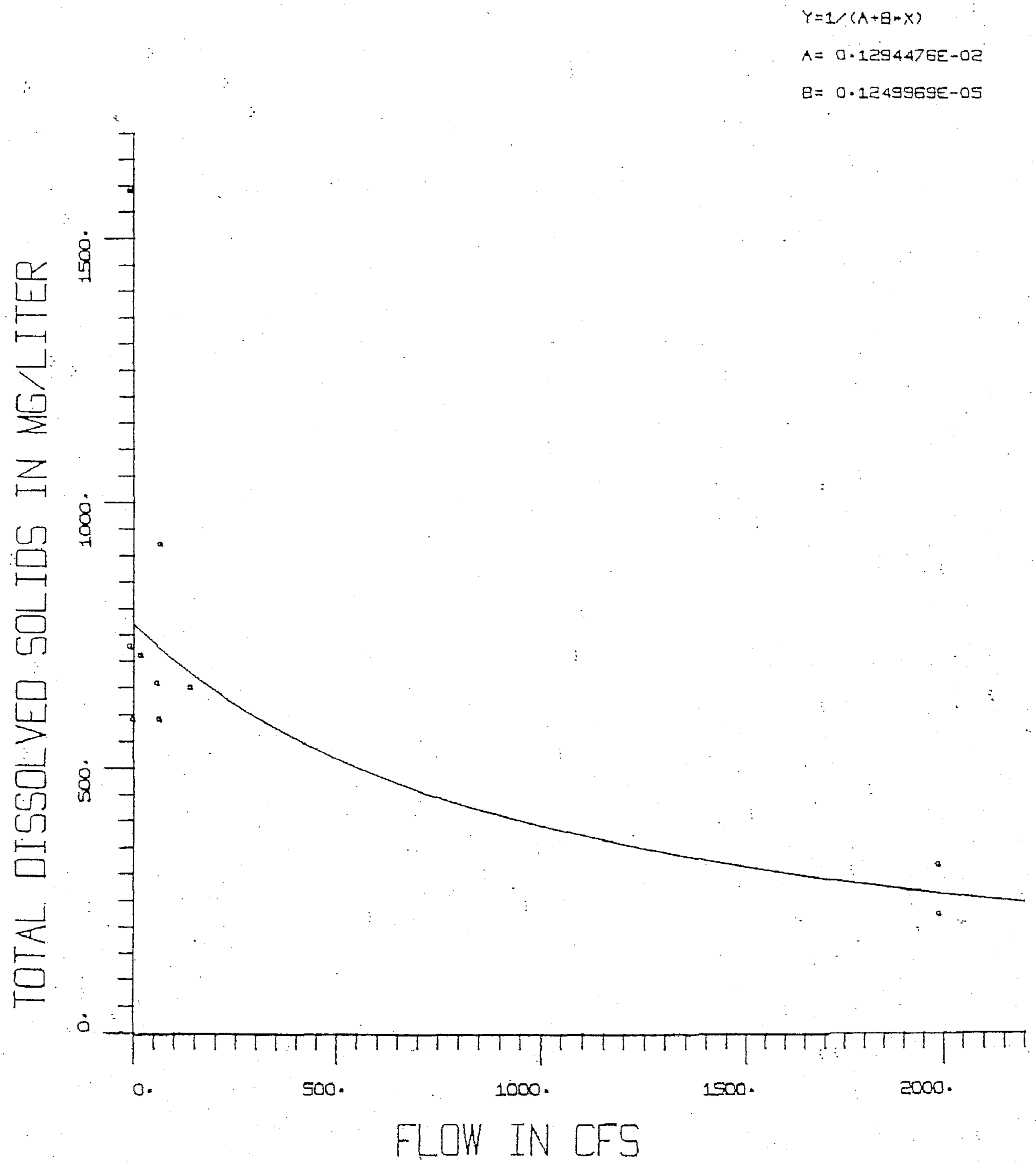


TABLE 7-3. PRESENT ANNUAL SALT LOAD TO GROUNDWATER RESERVOIR

Salt Additions	tons/year
Natural Sources [a]	
Cuyama River	31,000
Sisquoc River	15,000
Other natural sources	2,000
Man-made Sources	
Urban	7,000
Fertilization from agriculture	5,000
Livestock	2,000
Salt Removal [b,c]	
Surface Outflow	-50,000
Subsurface Outflow	-3,000
Net Addition	9,000

[a] Considers only the percolating components of river inflow.
[b] Salt removal by Santa Maria River outflow from the valley passing Guadalupe does not appear in this tablulation because only percolating components of river inflow were quantified as a source of salt addition.
[c] Salt removal by percolation of agricultural return flow through dune sand to the ocean and by discharge to the lower reaches of the Santa Maria River and Oso Flaco Creek.

TABLE 7-4. COMMUNITY WASTEWATER TREATMENT AND DISPOSAL SYSTEMS, 1970 [a,b]

Agency	Contributing Popultion	Type of Treatment	Plant Capacity (mgd)	Average Annual Flow (mgd)	Effluent Disposal Practice	Tributary Area
Guadalupe, City of	3,300	secondary	0.5	0.5	irrigation	City of Guadalupe
Laguna County Sanitation District	16,600	secondary	1.3	1.16	land outfall	Water service area of California Cities Water Co. (Orcutt-Orcutt Wye system, Tanglewood system)
Santa Maria, City of	33,000	secondary	6.5	4.3[c]	Percolation ponds; irrigation	City of Santa Maria
Santa Maria Public Airport District	2,400	secondary	0.75	0.30	irrigation	Santa Maria Airport; industrial development within airport boundaries; small residential area east of airport

[a] Location of treatment plants is indicated on Figure 7-1.
[b] SWRCB, 1975.
[c] Western Refrigeration Company (food processing) operates its own water supply system. Wastewater is contributed to the City of Santa Maria municipal wastewater treatment system, and may comprise up to 40 percent of the treatment plant influent.

Consumptive use of water by irrigation and the resultant concentration of the remaining salt in the reduced volume of water percolating back to the groundwater reserves is the single most important factor contributing to groundwater degradation in the Valley. The salt, remaining after the essentially salt-free consumption by evapotranspiration, is in part eventually percolated back to the groundwater and added to the supply of water remaining, thereby increasing the concentration. The annual quantity of salt from irrigated agriculture involved in this process is estimated to be 80,000 tons. The percentage of salt from each source contributing to the imbalance is shown below:

Natural sources	39%
Urban	6%
Fertilization from agriculture	4%
Livestock	1%
Irrigated agriculture	50%

The above percentages do not reflect the total impact of each salt source on the increase in concentration of water in the groundwater reservoir, since the concentration, in addition to being directly related to the quantity of salt, is also inversely proportional to the volume of water remaining for dilution and mixing in the groundwater reservoir. This volume has been assumed to extend areally over the entire onshore basin and vertically from the water table or confining layer, downward to the bottom of the pumping depth. The reservoir is roughly estimated to contain 3.5 million acre-feet. Using the above data, the relative percentage impacts of the major contributors to salinity were calculated and are as follows:

Urban	6%
Fertilization from agriculture	3%
Livestock	1%
Irrigated agriculture	90%

These percentages were calculated on the assumption that complete mixing of salts occurs throughout the entire onshore pumping zone. The assumption was also made that all salts added at the surface of the unconfined area, and 20 percent of those added at the surface of the semiconfined area, reach the groundwater.

FUTURE WATER QUALITY

Future groundwater quality was estimated by use of the graphs of TDS trends in Appendix F. A linear trend line was fitted to the TDS graphs, and extended to the year 2025. The resulting projections are shown in Table 7-5.

No projections were made for the two Oso Flaco sample wells, however it is anticipated that the TDS will stabilize near the present levels, until some time in the future when seawater degrades their quality.

The four sample wells in the Guadalupe area are predicted to increase in TDS from the present average of 1280 mg/l to about 1770 mg/l by 2025. This increase is based on continuation of present wastewater disposal practices and would be reduced somewhat with implementation of one of several alternative plans of the Regional Water Quality Board.

The sample well in the north central area is expected to remain near its present TDS concentration. This is because the area is located near the recharge supply.

In the main central portion of the basin four sample wells are expected to increase from a present average of 1540 mg/l TDS to 2640 mg/l by 2025. The projection is based on continuation of present waste disposal practices and would be alleviated somewhat with implementation of one of several alternative plans of the Regional Water Quality Control Board.

TABLE 7-5. PROJECTED GROUNDWATER QUALITY

Area & Well No.	1980	1990	2000	2010	2020	2025
	Projected Groundwater Quality TDS (mg/l)					
Oso Flaco						
11N35W18M1	--	--	--	--	--	--
11N36W13R1[b]	--	--	--	--	--	--
Guadalupe						
10N35W4C1[b]	1,486	1,619	1,752	1,885	2,018	2,085
10N35W9N2	1,125	1,264	1,403	1,542	1,681	1,750
10N35W14D1	1,375	1,453	1,530	1,609	1,687	1,725
10N35W21C1[b]	1,425	1,447	1,469	1,491	1,513	1,524
North Central						
11N34W29P2	765	765	765	765	765	765
Main Central						
10N34W17F1	1,645	1,766	1,887	2,008	2,129	2,189
10N3418L1	1,392	1,239	1,086	1,000	1,000	1,000
10N34W18P1	1,953	2,400	2,847	3,294	3,741	3,964
10N35W24B2	1,487	1,550	1,613	1,676	1,739	1,770
South Central						
10N34W34E2	500	500	500	500	500	500
9N34W8H4	562	500	500	500	500	500
South Canyon						
9N33W6G1	744	808	874	938	1,004	1,036
9N33W18R1	500	500	500	500	500	500
Sisquoc						
9N33W12R1	986	1,096	1,206	1,316	1,426	1,481

Quality of water in wells of the southeastern part of the basin and the Sisquoc area is not expected to reach unmanageable levels during the study period. The proximity of these areas to the recharge supply is the primary reason for this condition.

Measures implemented to supplement water resources available to the Santa Maria Valley will result in an increase in the salt load addition to groundwater. Table F-3 summarizes salt additions from surface inflow under natural conditions as well as in conjunction with various capacity off-channel spreading grounds proposed to augment water supply.

Importation of supplemental water to the Santa Maria Valley will introduce salts to the study area environment. Quality of State water in the Coastal Branch near Devil's Den exhibits a range in TDS from 128 to 271 mg/l, with an average of 202 mg/l [DWR 1975b]. An imported volume of 10,000 acre-feet per year would add approximately 3,000 tons of salt to valley groundwater [Gill 1973]. However, distribution of State Project water within the City of Santa Maria municipal system would minimize or negate the need for commercial, industrial, and home softening, a practice which is estimated to contribute about 2,300 tons of salt annually to groundwater [Carollo 1975]. Hence, the net increase to the present basin salt load attributable to importation of State Project water would be relatively minor.

CHAPTER 8

FUTURE WATER REQUIREMENTS

The future condition of the Santa Maria study area is anticipated to reflect both expansion of the urban environment and intensification of agricultural land use and cropping practices. Demographic projections were identified previously in Chapter 2.

Conclusions of analyses of water supply and disposal for future years is presented in Table 8-1. The conclusions were developed by the preparation of two distinct hydrologic equations, in a manner similar with that used in Chapter 6 and Appendix D. These two equations differ from one another in their consideration of recharge in the area of semiconfined groundwater.

It should be emphasized that future population and land use estimates for the Santa Maria study area all point to a situation of accelerated growth. A number of major influences are responsible for this occurrence. These include the attractive and desirable environment of the Santa Maria Valley, urban pressure on farmers in neighboring counties to relocate, and escalating requirements of local and state metropolitan populations for agricultural produce.

It is evident, as shown in Table 8-1, that projected levels of development will magnify the overdraft condition of the Santa Maria groundwater basin. The effects of this hydrologic imbalance will be examined in Chapter 9.

TABLE 8-1. HYDROLOGIC INVENTORY, SUMMARY
(1000 acre-feet)

Year	Method 1 100 percent Recharge[a]	Method 2 Negligible Recharge[b]	Basin Condition[c]
1980	-1.6	-17.0	-13.9
1990	-7.8	-24.2	-20.9
2000	-9.3	-25.9	-22.6
2025	-11.0	-28.3	-24.8

[a] Assumes 100 percent recharge through clay cap.
[b] Assumes negligible recharge through clay cap.
[c] Actual condition of Santa Maria groundwater basin regarding water supply vs. water disposal is between upper and lower extremes indicated by Method 1 and Method 2 analyses. The "basin condition" column acknowledges twenty percent recharge through the clay cap.

CHAPTER 9

FUTURE GROUNDWATER CONDITIONS

The hydrologic inventory developed in Chapter 6 for current levels of water use in the Santa Maria Valley points to a situation of minor groundwater overdraft, recognizing average long-term water supply. The most important feature of basin hydrology today concerns the physical limitations on distribution of water supply within the groundwater reservoir, rather than the total volume of tributary recharge available to the basin. Analyses of water elevation trends, depicted previously in Chapter 6, identified a situation of rising groundwater in the basin forebay and lowered groundwater in much of the coastal and upland region. The net effect of this resource imbalance is a depression of the hydraulic gradient in the area of confined groundwater. A brief review of the mechanism of seawater intrusion is in order to emphasize the dynamic relationship that exists between the on-shore and off-shore fresh groundwater systems, and to demonstrate the effects which a lowered gradient in the on-shore basin will have on water movement in the off-shore aquifer.

OFF-SHORE AQUIFER

Interest in the off-shore groundwater aquifer system has increased in recent years as the use of groundwater in Santa Maria Valley has overtaken supply. Unfortunately, geological information on which to base estimates of the extent of the system is virtually non-existent, and such important parameters as transmissibility, hydraulic gradient and storage capacity are unknown. Available evidence indicates a likelihood that the onshore aquifer system extends offshore a considerable distance.

A seismic survey conducted off a portion of the California coast in November 1973 by the USGS to identify offshore geological features, such as faults, landslides and slumping, which could be potential hazards to large coastal installations, uncovered no geological anomolies that would preclude existence of the offshore aquifer system [USGS 1974b]. In addition, water quality analyses from deep wells near the coast show no indication of seawater intrusion, despite the likelihood that localized onshore hydraulic gradients have been induced by heavy pumping. There is no evidence to indicate the quality of the offshore water. Figure 9-1 shows the ocean floor surface elevation extended several miles offshore. Its slope averages less than 13 feet per mile for the first 15 miles, then increases to about 30 feet per mile for the next 10 miles. Figure 9-2 shows a bathymetric map of the area.

Because of the complexities and unknowns involved, any kind of analysis of the offshore aquifer system is virtually impossible without application of theoretical concepts which are difficult and uncertain. Even so, because of the importance of this matter, it seems prudent to use this type of analysis to gain as much insight as possible into the offshore system.

The coastal segment of Santa Maria groundwater basin consists of several permeable aquifers of sand and gravel confined and separated by relatively impermeable zones of silt and clay. Because the water in the main water body under the confining layer is considered to be essentially confluent throughout, the hydraulic gradients then are applicable to the full cross section area of the aquifer.

The seaward hydraulic gradient along the coastline has decreased in recent years and some seawater encroachment has almost certainly occurred at the offshore end of the aquifer system. Hydraulic gradients along one section through the Valley for various years are shown on Figure 9-1.

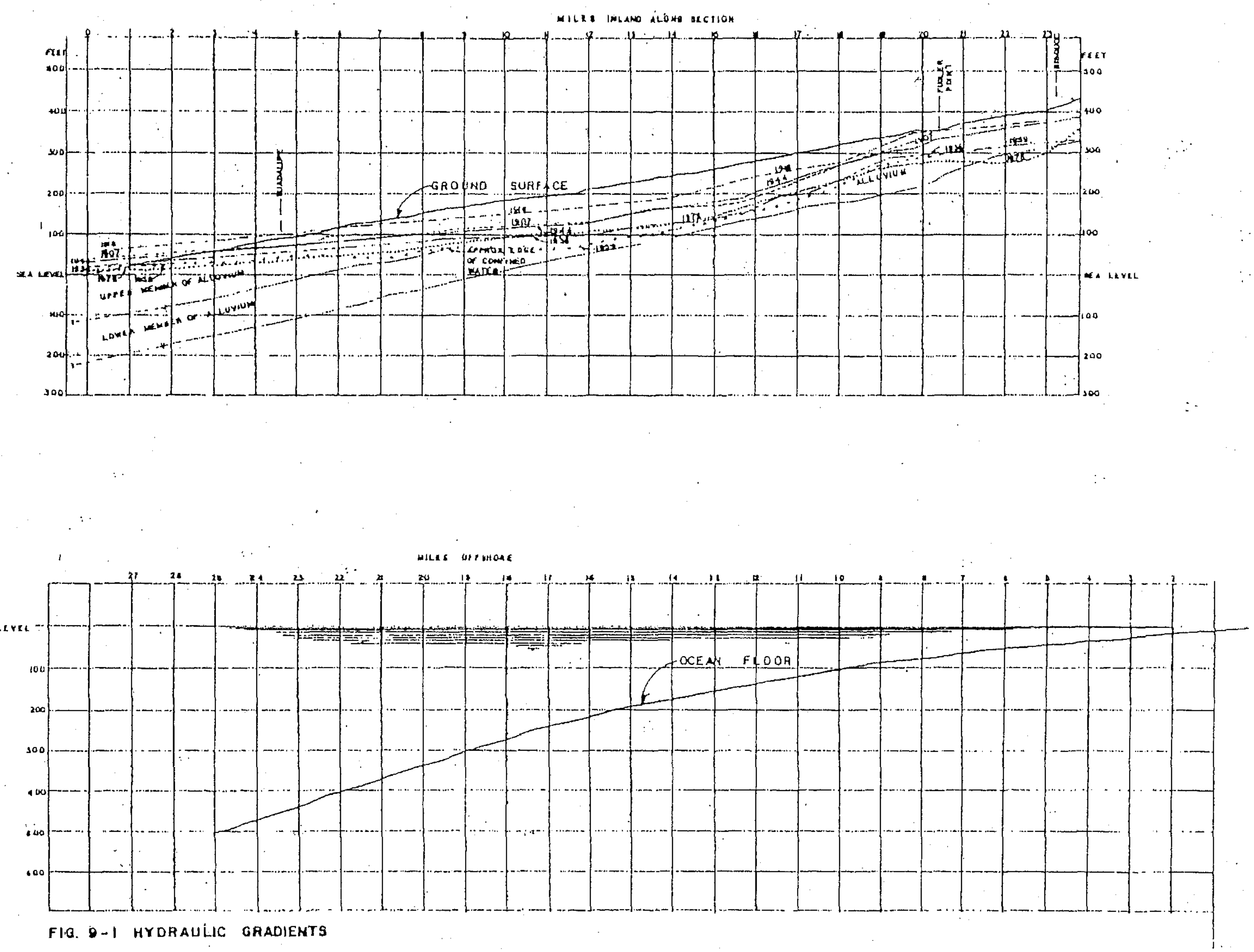


FIG. 9-1 HYDRAULIC GRADIENTS

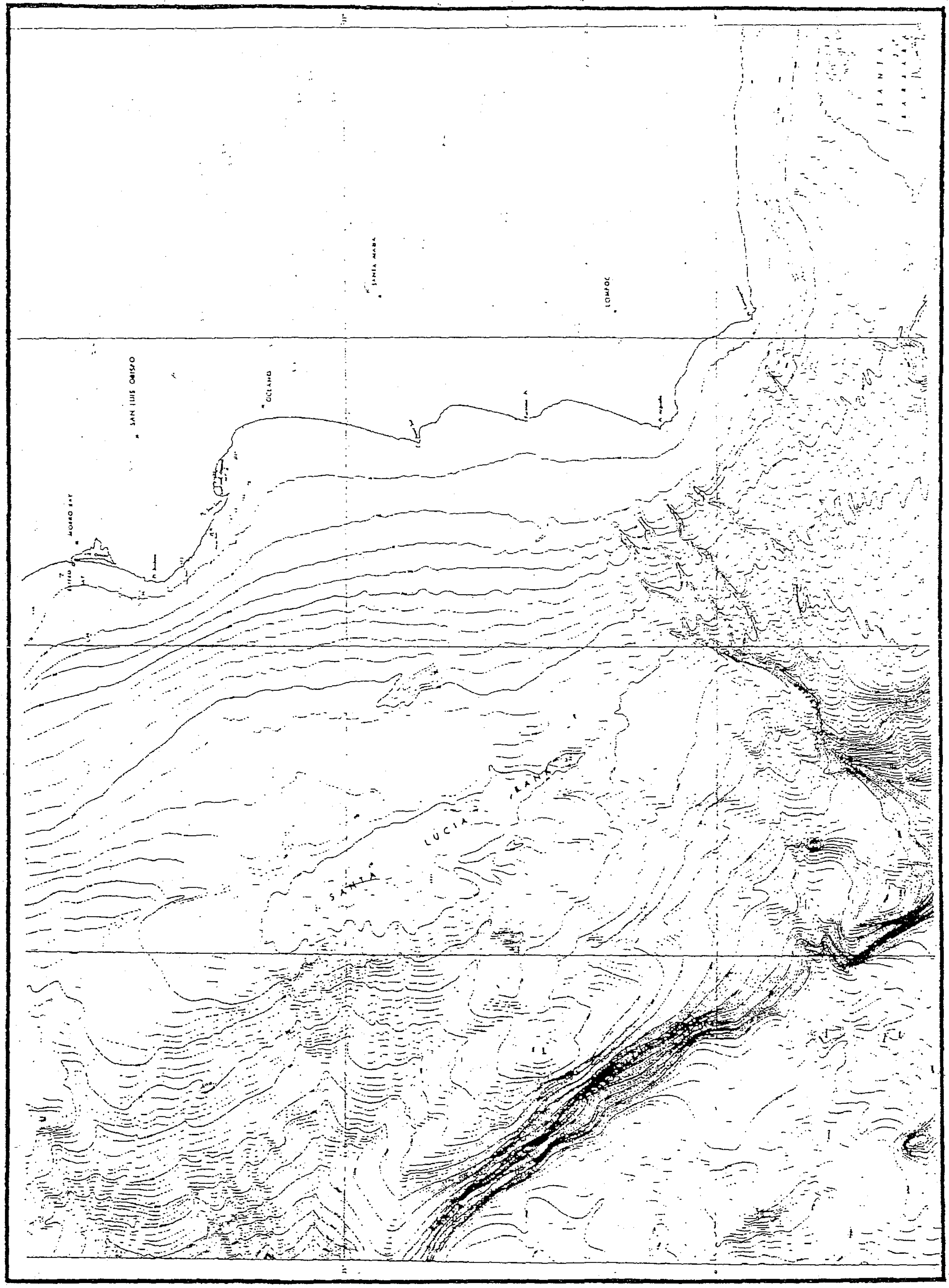


FIG. 9-2 BASIN BATHYMETRY

The depth of the interface between groundwater and salt water in an aquifer undergoing seawater intrusion is determined theoretically by applying the principal of differential density between fresh and salt water. In proportion to the slightly greater density of seawater the contact between the two will be depressed about 40 feet below sea level for each foot of fresh water head above sea level, assuming the specific gravity of sea water to be 1.025.

The alluvial deposits along the coast are estimated to attain a maximum thickness of about 1,500 feet along the axis of the Santa Maria syncline [USGS 1951; Santa Barbara County 1974; DWR 1971] Therefore, a fresh water head at the coast of about 38 feet would be necessary to completely block seawater intrusion. Figure 9-3 shows the relationship between fresh water head at the coast in 1907, 1918, 1936, 1944, 1959, 1966, and 1975, and the depth of the potential fresh water/salt water interface.

A maximum head of about 55 feet above sea level occurred in 1918, and this is believed to represent a maximum condition. The 1918 hydraulic gradient of about ten feet per mile is also believed to be a maximum. The fresh water head along the coastline now is about ten feet above sea level. This head would theoretically cause a potential fresh water/salt water interface to be about 400 feet below sea level at the coast, which would not prevent the intrusion of sea water into the deep aquifer system. Recent water quality analyses show that seawater intrusion has not occurred in the onshore groundwater basin. However, the analyses were from depths too shallow to detect the presence of a wedge intruding the deep aquifer system, if such a wedge were present. The trend in recent years has been toward both reduced head at the coast and reduced potential depth of the fresh water/salt water interface.

The length of an intruded seawater wedge into an aquifer is theoretically dependent upon the length of the wedge is directly proportional to the

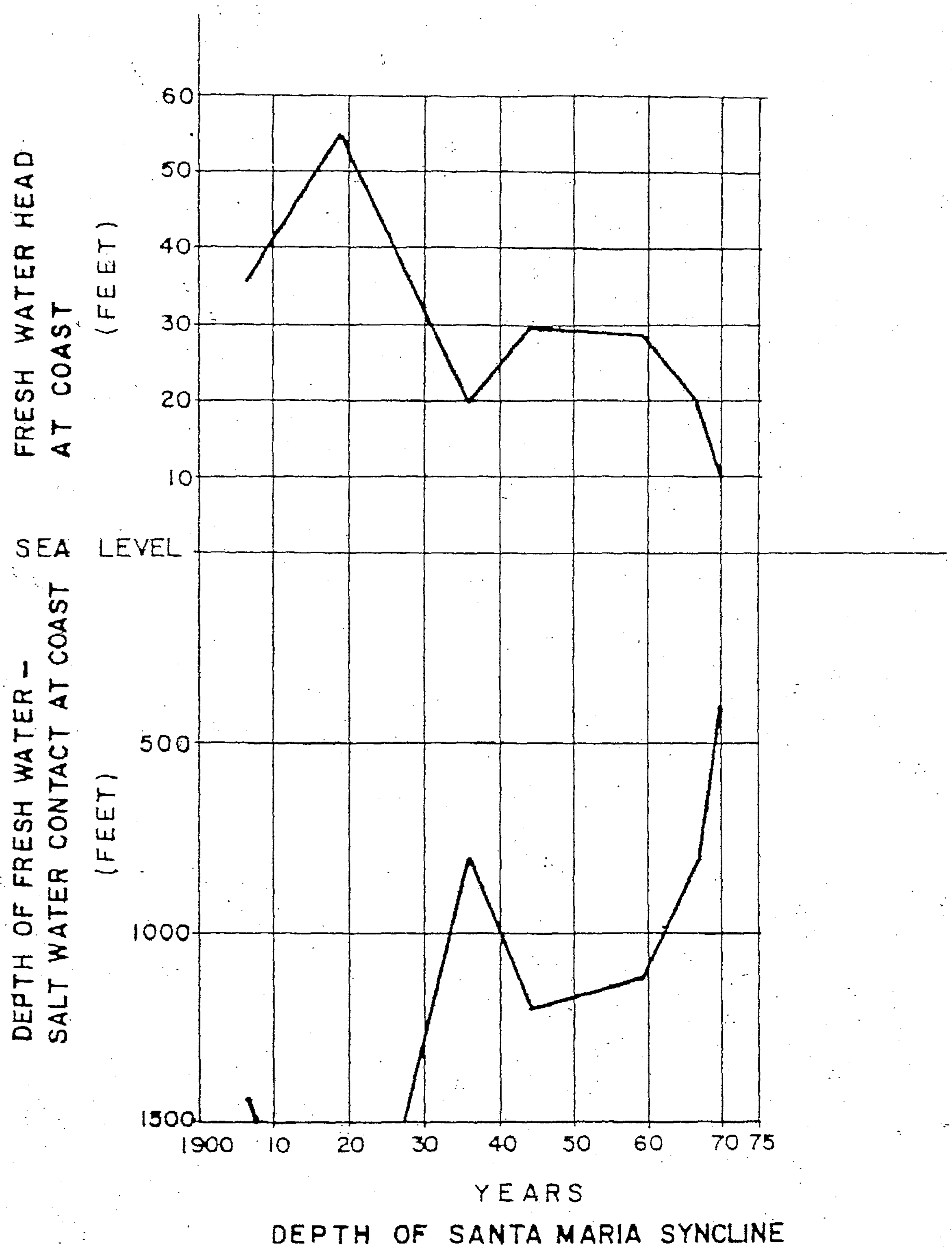


FIG. 9-3 RELATIONSHIP BETWEEN FRESH WATER HEAD AND DEPTH OF FRESH WATER - SALT WATER CONTACT

thickness of the aquifer. It is inversely proportional to the hydraulic gradient of the groundwater discharge. These relationships are expressed by the following mathematical equation:

$$L = \frac{(S-1)m}{2I} \tag{1}$$

where

L = length of intruded seawater wedge (ft)

m = thickness of pressure aquifer (ft)

$S = \frac{w_s}{w} = \frac{1.025}{1}$ = ratio of unit weight of sea water to fresh water

(w_s is density of sea water; w is density of fresh water

I = hydraulic gradient (in ft per ft).

Using the above equation, it is possible to estimate the length of the intruded seawater wedge if thickness of the aquifer is assumed. At the coastline the maximum thickness of water bearing deposits below the confining layer is about 1,200 feet. Assuming this maximum thickness throughout the entire offshore aquifer system with the year 1918 gradient of ten feet per mile, the salt water wedge developed under these conditions would extend shoreward about 1.5 miles from the location offshore where the fresh water aquifer discharges from the ocean floor. The estimated groundwater outflow to maintain the wedge in this location was 16,000 acre-feet annually.

In 1935, the beginning of the base period, the hydraulic gradient was about six feet per mile. The length of the intruded salt water wedge under this gradient would be about 2.5 miles from the ocean floor fresh water discharge area. The estimated groundwater outflow to maintain the wedge in this location was 9,500 acre-feet annually.

The average hydraulic gradient in 1972, the end of the base period, was no more than two feet per mile. The length of the salt water wedge under this gradient would be about 7.5 miles. The estimated groundwater outflow to maintain the wedge in this location was 2,000 acre-feet annually.

The above analysis indicates a rate of advance of the salt water wedge between 1918 and 1935 of 0.85 feet per day, and between 1935 and 1972 of 1.90 feet per day. The 1935 to 1972 rate appears excessive when compared to measured rates of sea water intrusion into coastal aquifers in Los Angeles and Orange Counties, which amount to about 1.0 feet per day and 1.15 feet per day, respectively. Because a salt water wedge in the Santa Maria off-shore aquifer would be moving under an adverse gradient, a rate of one-half foot per day is assumed for the years 1935 through 1972. This would place the intruded salt water wedge about two and one-half miles from the ocean floor fresh water discharge area.

The difference in volume between the 1935 wedge and the 1972 wedge represents the amount of fresh water lost by the aquifer to seawater intrusion during the base period. If it is assumed that the offshore aquifer system maintains its coastal configuration throughout the offshore portion, the amount of fresh water lost to seawater intrusion amounts to well over 5,000 acre-feet annually during the base period. The above analysis shows clearly that while fresh groundwater outflow is occurring, underlying salt water is flowing landward. This seawater intrusion will continue unless the hydraulic gradient of the aquifer is stabilized. The fresh water head at the coast, if sufficiently high, would hold out seawater intrusion, but it too is related to the hydraulic gradient; as the gradient diminishes, the fresh water head lowers. This relationship is shown on Figure 9-4.

It is not possible to predict the amount of fresh water remaining in storage in the offshore aquifer system, since the extent and porosity of the system are unknown. The quality of this water is also unknown.

Based on the above theoretical analysis it can be concluded that the offshore aquifer system is being intruded by seawater, which will accelerate in the future, as the hydraulic gradient in the semi-confined area is further reduced.

ON-SHORE AQUIFER

The hydrologic equations summarized in Chapter 8 for future levels of groundwater development in the Santa Maria Valley point to a condition of overdraft. This situation will serve to further depress the seaward gradient in the coastal portion of the on-shore aquifer system. Hence, the process of seawater flow into the off-shore fresh groundwater system will continue. Since it is apparent that the confining clay layer in the on-shore regime is not totally impervious to percolation, it is overly-optimistic to assume that the same strata immediately offshore would exhibit extremely different properties. Therefore, seawater is anticipated to appear as infiltration through the offshore clay layer as well as in the form of additional movement of the classic seawater wedge or wedges.

The off-shore system has historically protected the valley from intrusion by seawater. The most practical and economical course of action available to water users in the Santa Maria Valley is to maintain the current practice of overdraft. This will result in exploitation of the offshore freshwater resource to the greatest possible extent.

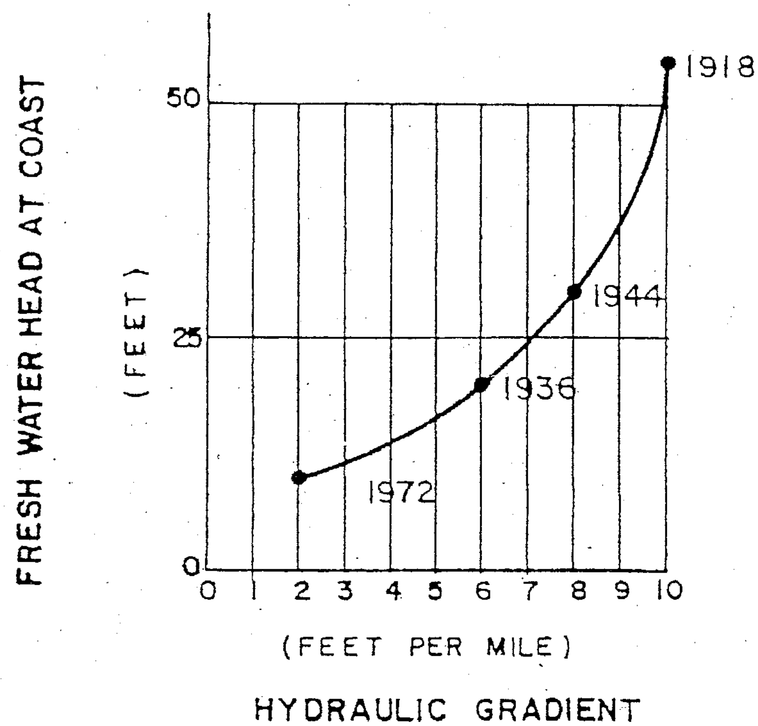


FIG. 9-4 RELATIONSHIP OF HYDRAULIC GRADIENT TO FRESH WATER HEAD AT THE COAST

At the time seawater is detected in producing on-shore wells, management strategies can be implemented which will maintain the productivity of the groundwater basin. A number of general stratagies can be implemented which will prevent or control seawater intrustion at such time when it is detected [DWR 1975c]. These strategies include:

° Raising the off-shore trending gradient above sea level by reductions in extractions, by rearrangement of the areal pattern of pumping, or by a combination thereof.

° Direct recharge of depressed aquifers to maintain groundwater levels above sea level.

° Development of a fresh water injection barrier along the coast.

° Maintenance of a pumping trough between saline water and the principal areas of groundwater extraction.

° Implementation of a combination injection-extraction barrier.

° Construction of a static subsurface physical barrier.

All of the foregoing control measures require that basin groundwater be managed in a coordinated manner. A primary emphasis of any strategy for seawater intrusion control is the assurance of an adquate water supply to lands whose economy depends on groundwater. Control measures differ from one another principally with regard to the degree they permit storage capacity of the groundwater basin to be utilized. The option of reduced extraction is especially limiting in this regard. Implicit in strategies incorporating recharge is acquistion of source water through additional local water resources development, water importation, or redistribution of groundwater from forebay areas.

A practical course of action that could be pursued in the Santa Maria Valley to maintain the integrity of the groundwater basin in light of seawater intrusion involves implementation of a two-phase program of salt water extraction and reduced or curtailed pumping in the area of semiconfined groundwater. Production wells along the coast would be converted to extraction wells once seawater has intruded their radius of influence. It would be desirable to incorporate new wells into the extraction barrier. Experience obtained in similar seawater control operations indicates that it is nessary to space barrier wells about 500 feet apart. In relatively permeable formations, closer spacing may be required.

To effectively control the intrusion problem the extraction operation would be complimented by a coordinated program of restricted pumpage in the semiconfined area and delivery of groundwater extracted from the forebay to users over the clay cap. Because of the dynamic interrelationship among these various hydrologic components, a mathematical model of the basin would become an indispensable aid in program management. If properly implemented, the strategy of barrier maintenance and managed pumping would make a large volume of groundwater available for mining from the reservoir in the basin forebay. This resource should be adequate to satisfy water requirements projected to 2025.

CHAPTER 10

SUPPLEMENTAL WATER

Water resources native to the Santa Maria Valley are incapable of indefinitely supporting present or anticipated levels of agricultural and urban development. This deficiency was quantified previously in Chapters 6 and 8. The historic imbalance between sources of water supply and components of water disposal has resulted in mining of stored groundwater to meet water demands.

Supplemental water can be made available to the Santa Maria Valley from a number of sources. In addition, existing supplies can be augmented or more fully utilized by implementing various management strategies. The following itemization represents potential sources of supply.

- Importation
- Additional local water resources development
  - In-channel spreading
  - Off-channel spreading
  - Round Corral Reservoir
  - Weather modification
  - Watershed management
- Desalination of brackish groundwater or seawater

IMPORTATION OF STATE PROJECT WATER

Figure 10-1 depicts existing facilities of the State Water Project in the Central Coastal region area. Located south of Kettleman City, the coastal stub of the California Aqueduct diverts flows and conveys water a distance of fifteen miles to the Devil's Den Pumping Plant in the northwestern extreme of Kern County.

The Coastal Branch, also shown on Figure 10-1, is a proposed aqueduct extending through San Luis Obispo County to the Santa Maria terminus. As presently planned, untreated State water would be lifted over the Temblor Range by means of Devil's Den, Sawtooth, and Polonio pumping plants. After proceding southwesterly to the vicinity of the City of San Luis Obispo, the aqueduct would veer southeasterly. It would then continue to a terminal structure immediately north of the Santa Maria River just east of the City of Santa Maria [Bookman-Edmonston 1975]. Total length of the Coastal Branch is anticipated to be about 100 miles, including the existing fifteen-mile canal which comprises the Coastal Stub. Construction proposed for the remaining 85-mile stretch would exclusively involve pipeline.

Design capacity of the Coastal Branch is 82,700 acre-feet per year [Bookman-Edmonston 1975]. This capacity is sufficient to uniformly deliver the maximum annual entitlements for San Luis Obispo and Santa Barbara Counties, 25,000 acre-feet and 57,700 acre-feet respectively [Bookman-Edmonston 1975]. Sizing considerations also include allowance for seepage and evaporative losses, operational outages, and service interruptions for maintenance. Construction of the Coastal Branch would be a State responsibility. In-county conveyance, treatment, and management of State Water would be the responsibility of the county, or that of local water purveying agencies.

The Santa Maria Valley is strategically located with regard to State Water importation. State Project Water would most probably be exclusively used to satisfy municipal and industrial requirements within the City of Santa Maria. It is doubtful that conjunctive use of the Santa Maria Groundwater Basin and imported State Project Water would be implemented. It is to the City's advantage to distribute the best quality water possible through its municipal water system to meet stringent waste discharge requirements developed by the Regional Water Quality Control Board, and to reduce consumer penalty costs associated with the use of

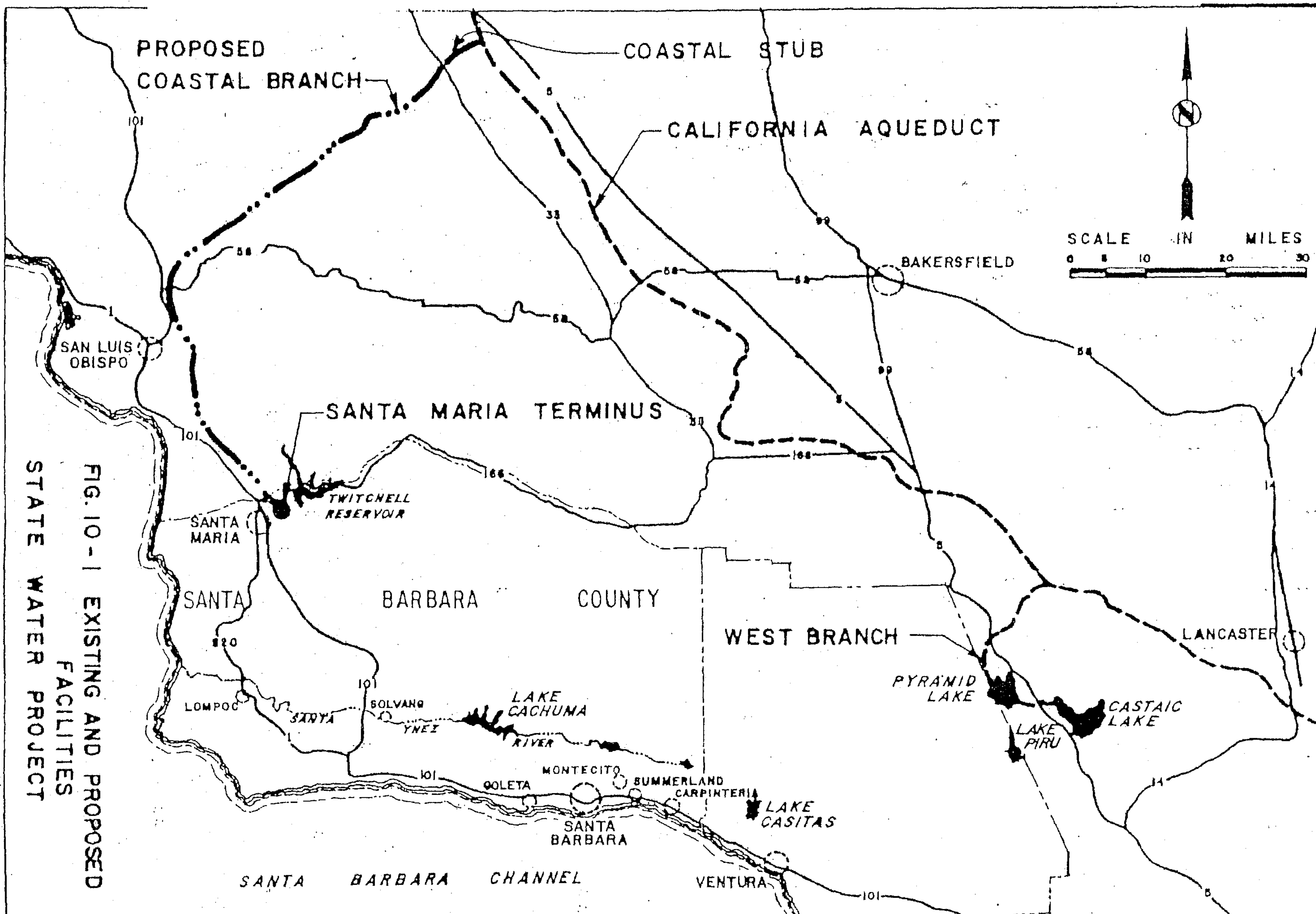


FIG. 10-1 EXISTING AND PROPOSED FACILITIES
STATE WATER PROJECT

mineralized water. Also, agricultural participation in a conjunctive use program involving State Project Water is extremely unlikely because of the associated economic burden. Costs borne by the City of Santa Maria would relate to payment of the Coastal Branch and participation in in-county treatment and conveyance facilities from a turnout structure near the Santa Maria Terminus to the City.

Costs associated with Santa Barbara County participation in the Coastal Branch were developed recently by Bookman-Edmonston Engineering, Inc., at the request of the Santa Barbara County Water Agency [Edmonston 1974] Dollar per acre-foot cost of State Water delivered to the Santa Maria Valley is based on a percentage allocation according to maximum entitlements. Costs associated with low and high allocation estimates, updated to reflect the present construction cost index (ENR 2600), ranged from $252 to $296 per acre-foot. It should be emphasized that these State Water costs represent only expenditures associated with county participation in funding of the Coastal Branch to the Santa Maria Terminus, and do not reflect conveyance and treatment costs incurred by the City of Santa Maria.

ADDITIONAL LOCAL WATER RESOURCES DEVELOPMENT

Natural percolation of stream flow within the alluvial channel of the Santa Maria River and deep percolation of precipitation and return flows represent the principal components of groundwater recharge within the study area. This water recharge can be augmented and enhanced by implementation of physical in-channel or off-channel improvements or watershed management strategies. Various practical alternatives that would facilitate generating or capturing locally available water resources are reviewed below.

IN-CHANNEL IMPROVEMENTS

Streambed infiltration characteristics can be enhanced by forming small levees within the Santa Maria River channel. The levees are formed in "hooks" so that flow velocities are reduced and water is spread over most of the channel invert. Utilization of hook levees has proven to be a very successful and economical technique of conserving water.

Hook levees should be constructed so that they wash out during major storms. To do so, the hook levee elevations should be well below the river levee elevations. Furthermore, the portion of the levee which is normal to the channel flowline should be at a lower elevation than that portion which is parallel to the flowline. In this manner, flows will be concentrated in one area and quickly erode the levee when high flows are encountered.

Prior to the construction of any facilities within the channel, the potential problems and risks should be determined and resolved. According to the Santa Barbara County Flood Control District, the Santa Maria Valley Water Conservation District previously maintained cross levees extending from the Corps of Engineers' levee at right angles to the north in the reach of river easterly of Bradley Canyon. These cross levees trapped considerable amounts of water, but also trapped sediment which caused the bed of the river to have a cross slope to the north. During the 1969 floods, the main current in the river was pushed against the bluffs of the north edge of the river until they reached a point below the water conservation facilities where the main current crossed back to the south levee and impinged on it at a sharp angle undercutting the rip-rap and resulting in a partial failure of the levee [Stubchaer 1976].

OFF-CHANNEL IMPROVEMENTS

Off-channel spreading facilities provide a means by which flood flows normally lost to the ocean can be diverted from the Santa Maria River and allowed to percolate underground. A base period operational analysis of Twitchell Reservoir is presented in Appendix G. This hydrologic simulation evaluates in detail the additional yield obtained by various sized off-channel spreading grounds. Data from Appendix G is summarized in Table 10-1 and on Figure 10-2. A graphical picture of the recharge contribution of a 1,000-cubic feet per second spreading operation during the base period is shown on Figure 10-3.

TABLE 10-1. YIELD OF OFF-CHANNEL SPREADING BASIN OPERATIONS [a]

Daily Percolation Capacity of Spreading Basin (cfs)	1000 af/yr		
	Total Average Annual Percolation [b]	Yield of Spreading Basin [c]	Yield of Twitchell Project
0[d]	35.206	--	
0[e]	54.960	--	19.75
100[e]	56.295	1.335	
200[e]	57.363	2.403	
300[e]	58.254	3.294	
400[e]	59.025	4.065	
500[e]	59.702	4.742	
600[e]	60.302	5.342	
700[e]	60.849	5.889	
800[e]	61.352	6.392	
900[e]	61.811	6.851	
1,000[e]	62.251	7.291	

[a] Based on base period hydrology.
[b] Summation of percolating flows in various sized spreading basins and percolating flows in channel of Santa Maria River. See Appendix G for detailed operational data.
[c] Increased percolation attributable to off-channel spreading basins. See Figure 10-2.
[d] Assumes no reservoir in operation.
[e] Assumes reservoir in operation throughout base period.

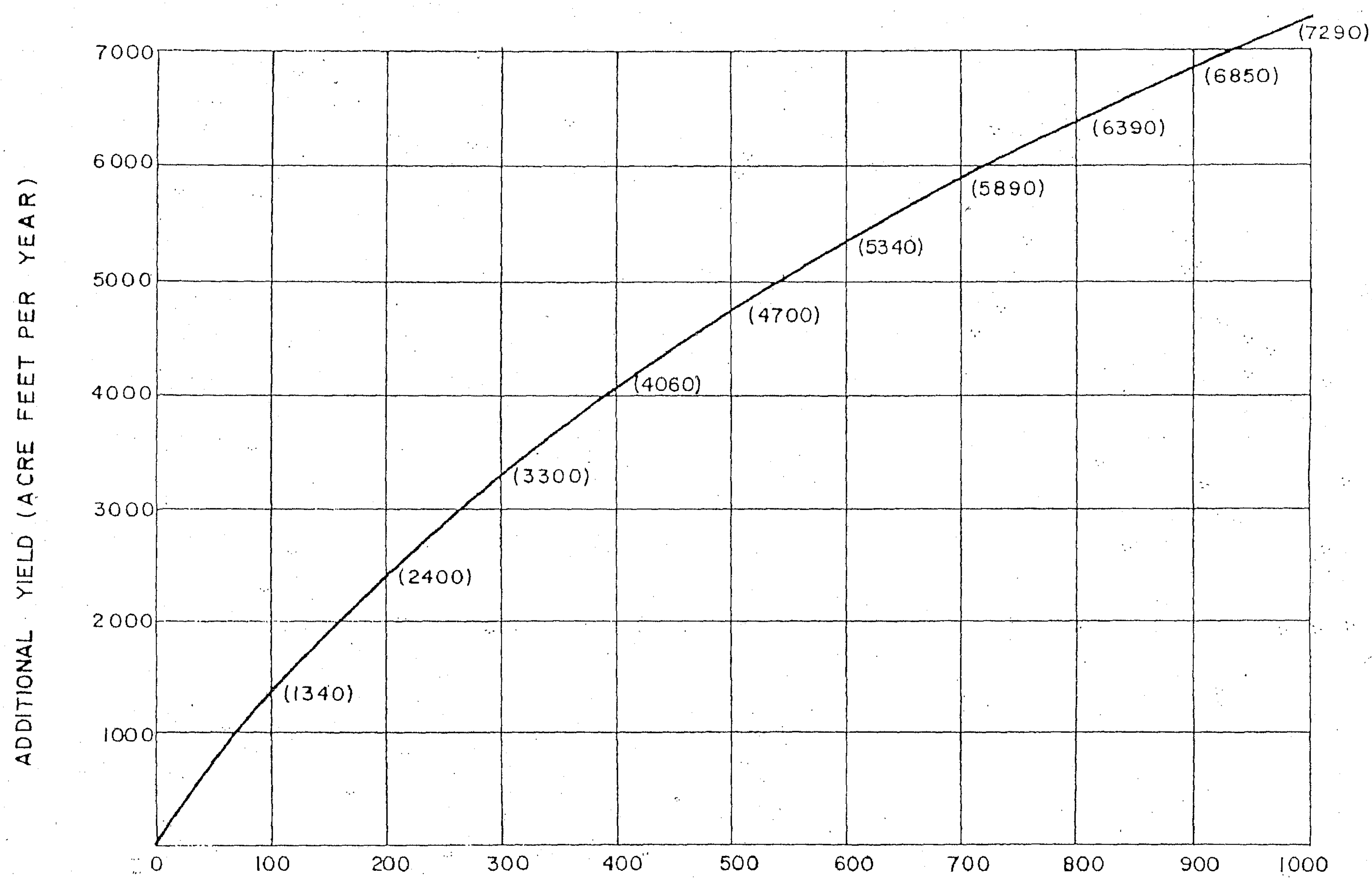


FIG. 10-2 OFF-CHANNEL SPREADING DEMAND (CFS)

ADDITIONAL TWITCHELL RESERVOIR PROJECT YIELD VS. OFF-CHANNEL SPREADING DEMAND

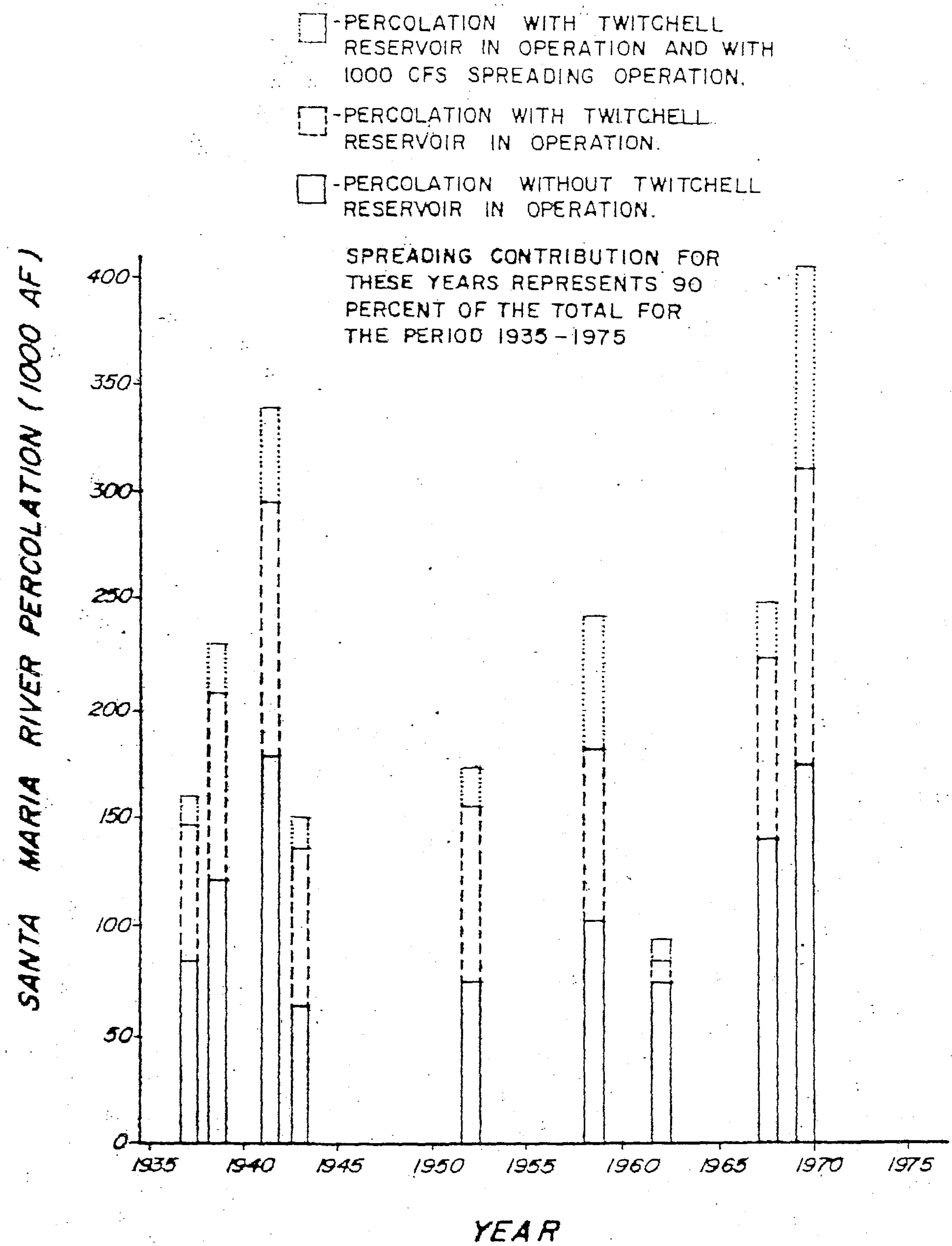


FIG. 10-3 RECHARGE CONTRIBUTION OF 1000 CFS SPREADING OPERATION DURING MAJOR STORMS

The development of off-channel spreading grounds provide additional surface areas to impound water and to allow it to percolate into the groundwater basin. The design of spreading grounds is dependent on several factors, including topography, geology, hydrology and water quality. In the last several years, other factors such as aesthetics and recreational uses have strongly influenced designs; however, they are not considered in this analysis.

Geology

Spreading grounds must be located such that the impounded water is in direct hydraulic continuity with the water-bearing formations. The soil should be highly permeable and care must be taken to avoid potential hydraulic boundaries such as faults and impermeable soil lenses. In general, geological conditions are such that spreading grounds can be located almost anywhere in the Santa Maria Valley, with the exception of the westerly end of the valley where there is a confining clay layer over the water-bearing formations. Based on USGS Water-Supply Paper 1000, [USGS 1951] the upper reaches of the valley appear to be more permeable and therefore this area is probably a more desirable location.

Groundwater Levels

The location of off-channel spreading grounds is usually selected so that areas of existing groundwater mounds are avoided. When the piezometric level of groundwater approaches the ground surface, the development of additional spreading is generally not desirable because the initial percolation capacity is much greater than the transmissivity of the aquifer.

In the Santa Maria area, the groundwater contours for spring 1972 and spring 1975 indicate that a mound is forming along the Santa Maria and Sisquoc Rivers. Unfortunately, precise interpretation of groundwater contour maps is not highly reliable because the location of the contours is subject to individual judgment during the preparation of the map. The drawings do indicate the possibility of potential mounding problems if the contours are the result of geologic conditions; but there may be no mounding problems if the contours are the result of pumping patterns.

Potential mounding or interference problems can be reduced by locating spreading grounds as far away from Santa Maria River as possible. However, this alternative will probably require expensive conveyance facilities.

The fact that depth to groundwater is about one hundred feet in many areas indicates additional off-channel spreading grounds could probably be located adjacent to Santa Maria River. Prior to development of extensive off-channel facilities, a large-scale field test should be conducted within the Santa Maria River during non-storm periods to confirm the spreading capabilities near the River.

Topography

In many cases, the topography dictates the economic feasibility of using certain land parcels for development of spreading grounds. The proposed site should be relatively level to minimize the number of interbasin levees and to avoid large water surface elevations between basins. The elevation of the proposed site should be low enough so that flows can be conveyed to the site without pumping, although pumping can be economically feasible.

In the Santa Maria Valley, topography limits the potential spreading sites to areas adjacent to Santa Maria River and to Sections 17, 18, 19, 20, 28, 29 and 34 of T10N, R33W. Land parcels which are westerly of these sections are also feasible based on topography; however, spreading sites are probably not feasible due to the urbanization of the area.

Potential Spreading Ground Locations

There are many potential sites for off-channel spreading grounds. Some sites are adjacent to the Santa Maria and Sisquoc Rivers and others are quite distant from the channels.

The sites adjacent to the Santa Maria River should be limited to areas upstream of Highway 101, based on permeability tests by USGS. However, parcels with active or abandoned sand and gravel operations should be investigated despite their locations. The areas adjacent to active or inactive landfill operations should be investigated very carefully in order to preclude any possibility of water quality problems.

There are potential sites within Sections 17, 18, 19, 20, 28, 29 and 34 of T10N, R33W. These sites will also require alignment studies for the required conveyance facilities.

Development of Spreading Grounds

The development of off-channel spreading grounds will require the construction of: 1) channel diversion structure; 2) conveyance and inlet facilities; 3) spreading basins and appurtenant structures; 4) an outlet structure. Based on past experience, the maximum design capacity of any single spreading grounds should be limited to about 500 cfs during the preliminary design phase.

Channel Diversion Structure

A channel diversion structure will be required to divert flows from the Santa Maria River to the spreading grounds. In other areas, agencies have constructed many types of structures including radial gates, rubber dams and earthen levees. Based on somewhat similar conditions and structures in Los Angeles and Orange Counties, an earthen levee approximately six feet in height can be extended over a portion of Santa Maria

River. The levee will direct flows to gated pipe conduits which are placed in the river levees. The estimated costs will depend on the design flowrate. Based on a cursory study, the estimated costs would be about the following magnitudes.

Design Q	Estimated Cost for Channel Diversion
100 cfs	$ 25,000
250 cfs	40,000
500 cfs	70,000

Conveyance and Inlet Facilities

Conveyance and inlet facilities are those facilities required to convey flows from the channel diversion structure into the first basin. Conveyance facilities will be required if the spreading areas are not located adjacent to the River.

If spreading areas away from Santa Maria River are found to be desirable, there is a possibility of conveying flows in unlined, open channels. Assuming there are no security problems and right-of-ways can be purchased for an open channel, the costs would be relatively small in comparison to other alternatives (for example, a mile of 66-inch pipeline to convey 150 cfs was recently constructed in Orange County at a cost of about one million dollars). The costs for a one-mile channel, assuming three locations for vehicle crossings and optimistic conditions, are estimated to be as follows:

Design Q	Estimated Costs for One-Mile Conveyance Facility (Open Channel)
100 cfs	$100,000
250 cfs	$156,000
500 cfs	$263,000

The development of deep basins does not appear to be warranted at this time, because of the ability to regulate flows at Twitchell Dam and the base period hydrology. Although conditions may change in the future to make deep basins more desirable, there appears to be no need to construct expensive intake facilities.

Spreading Basins and Appurtenant Structures

There are two general types of spreading basins: deep basins and shallow basins. In general, deep basins are constructed when the flows are stochastic and conservation of significant quantities are possible only if storage capacity is available. The percolation rate can often be increased by increasing the depth of water in the basin, however precise determination of this increase is not highly reliable. Other factors, such as desilting or recreational benefits, may also cause a need for deep basins.

In the past, the sale of the material from spreading basins often provided royalties to offset a portion of the right-of-way and development costs. However, construction activities which would consume substantial quantities of sand and gravel appear to be limited at the present. Highway and road construction, which historically required substantial quantities of base material, may be limited for several years. Therefore construction of deep basins is not warranted on this basis.

The development of spreading grounds will require the construction of access roads, fencing, interbasin levees, control structures, dewatering structures, and weirs. The costs of a typical spreading ground were developed on the basis that land could only be purchased in about quarter-section increments and that the system would have little operational requirements.

The flows diverted from Santa Maria River would be conveyed to the forebay. The forebay would permit most of the settleable solids to be removed. A control structure would be placed at the downstream end of the forebay. Flows would then be diverted to the first basin. The size of the first basin (and subsequent basins) is dependent on the topography, i.e., steeper lands require more interbasin levees. The structure to convey flows from the first to the second basin is a triangular weir. This type of structure permits coverage of the basin and spills when the basin reaches operating water surface elevations. A distribution channel is provided to convey flows to individual basins or to empty the basins. Based on these assumptions, cost of spreading grounds were developed for the following rates:

Design Q	Estimated costs for right-of-ways	Estimated costs for Improvements	Total
100 cfs	$ 370,000	$ 80,000	$ 450,000
250 cfs	$ 925,000	$200,000	$1,125,000
500 cfs	$1,850,000	$400,000	$2,250,000

Land costs were based on discussions with real estate firms in Santa Maria and adjusted for contingencies and non-usable areas [Beaver 1976; Williams 1976].

Outlet Structures

In general, the practice has been to place an outlet structure to divert flows back to the river in case of a catastrophic event. For those spreading sites near the river, pipes are usually placed through the river levee with flap gates on the river channel side. The estimated costs for outlet structures are as follows:

Design Q	Estimated costs for Outlet Structure
100 cfs	$ 14,000
250 cfs	$ 26,000
500 cfs	$ 49,000

Summary of Costs for Development of Spreading Grounds

The costs for the development of spreading grounds have been developed for sites adjacent to the Santa Maria River and for a site about one mile away from the river. The estimated costs for spreading grounds adjacent to the Santa Maria River are as follows:

SPREADING GROUNDS ADJACENT TO THE SANTA MARIA RIVER

Design Q cfs	Channel Diversion	Right-of-ways	Spreading Grounds Improvements	Outlet	Total
100	$25,000	$ 370,000	$ 80,000	$14,000	$ 489,000
250	$40,000	$ 925,000	$200,000	$26,000	$1,191,000
500	$70,000	$1,850,000	$400,000	$49,000	$2,369,000

The estimated costs for spreading grounds about a mile away from Santa Maria River are shown below. Note that this site has no outlet structure in case the inflow exceeds the capacity of the spreading grounds, therefore there is an additional risk.

SPREADING GROUNDS AWAY FROM THE SANTA MARIA RIVER

Design Q cfs	Channel Diversion	Conveyance[a] Facilities	Right-of-ways	Spreading Grounds Improvements	Total
100	$ 25,000	$ 100,000	$ 370,000	$ 80,000	$ 575,000
250	$ 40,000	$ 156,000	$ 925,000	$ 200,000	$1,321,000
500	$ 70,000	$ 263,000	$1,850,000	$ 400,000	$2,583,000

[a] Includes right-of-way costs for channel.

The estimated annual capital costs of spreading ground construction adjacent to and away from the Santa Maria River are shown in Tables 10-2 and 10-3 respectively. These two tables were determined assuming an economic life of 50 years for all improvements and an infinite life for right-of-way costs. The annual costs were determined for interest rates of 6-1/8 percent and seven percent. The lower interest rate is the same as that used by the U.S. Bureau of Reclamation.

The annual costs to develop spreading grounds per acre-foot of additional yield were also determined and shown in the previous tables. These unit costs represent the costs required to place additional water into storage. To be comparable with other sources of water supply, costs to operate and maintain the spreading grounds and costs to extract the water must also be added. The costs for operation and maintenance will depend on the design of the spreading grounds, but will probably amount to about $15 per acre-foot; and the costs for extracting the water will probably be about $35 per acre-foot.

ROUND CORRAL RESERVOIR

The proposed Round Corral Reservoir site on the Sisquoc River is the most favorable location for water resources development in that watershed. Discharge of the Sisquoc River at the proposed dam site would very nearly equal average annual flow at USGS gaging station 11385000, Sisquoc River near Sisquoc, since the reservoir would be situated two miles upstream from the station.

The Bureau of Reclamation has conducted a reservoir operation study utilizing Twitchell and Round Corral Reservoirs in combination to maximize water conservation in the Santa Maria Valley. [USBR 1965] Average increase in yield over that of Twitchell Reservoir alone was computed to be approximately 8,300 acre-feet per year.

TABLE 10-2. ANNUAL CAPITAL COST OF SPREADING GROUNDS ADJACENT TO SANTA MARIA RIVER

Design Q cfs	Channel Diversion	Right-of-ways	Spreading Grounds Improvements	Outlet	Total	Cost/AF
Interest Rate = 6-1/8%						
100	1,615	22,660	5,165	905	$ 30,345	$22.65
250	2,580	56,655	12,910	1,680	$ 73,825	$25.45
500	4,520	113,315	25,820	3,165	$ 146,820	$31.25
Interest Rate = 7%						
100	1,810	25,900	5,795	1,015	$ 34,520	$25.75
250	2,900	64,750	14,490	1,885	$ 84,025	$28.95
500	5,070	129,500	28,985	3,550	$ 167,105	$35.55

TABLE 10-3. ANNUAL CAPITAL COST OF SPREADING GROUNDS AWAY FROM SANTA MARIA RIVER

Design Q cfs	Channel Diversion	Conveyance Facilities	Right-of-way	Spreading Grounds Improvements	Total	Cost/AF
Interest Rate = 6-1/8%						
100	1,615	6,365	22,660	5,165	$ 35,805	$26.70
250	2,580	9,950	56,655	12,910	$ 82,095	$28.30
500	4,520	16,815	113,315	25,820	$ 160,470	$34.15
Interest Rate = 7%						
100	1,810	7,180	25,900	5,795	$ 40,685	$30.35
250	2,900	11,215	64,750	14,490	$ 93,355	$32.20
500	5,070	18,935	129,500	28,985	$182,490	$38.85

Construction details and associated costs for Round Corral Reservoir are summarized in Appendix H. In terms of October 1975 dollars, capital cost of reservoir construction is in excess of 53 million. When converted to its equivalent uniform annual cost, construction costs represent a uniform yearly disbursement of 3.29 million. This derivation is based on the current user project formulation interest rate of 6-1/8 percent and a project life of 100 years [Toeynes 1976]. Assuming a flood control benefit comparable to that of Twitchell Reservoir (17%), cost of supplemental water generated by Round Corral Reservoir is $330/acre-foot.

WEATHER MODIFICATION

Although the physics of clouds is not completely understood, it is known that several conditions are necessary for precipitation to occur. As cloud droplets rise to high altitudes, they become supercooled. Unless various impurities in the atmosphere are present which can serve as ice nuclei, supercooled water droplets may remain liquid at temperatures down to -40°C [Henningson 1975]. Silver iodide is an artificial nucleating agent that will induce the freezing process at a warmer temperature than would occur with naturally-occurring nuclei. The conversion of cloud droplets to precipitation is facilitated because silver iodide particles provide for ice crystal growth. The heat release resulting from ice crystal formation (change in state from liquid water to solid ice) creates new buoyancy and enhances up-drafts. This stimulates additional condensation and subsequent precipitation. Silver iodide may be either dispersed from aircraft or generated as a smoke from the ground.

Extensive field studies were conducted in the early 1960's to determine the structure of storms influencing the Santa Barbara County area [Elliott 1964, Elliott 1960]. These investigations clearly identified the existence of irregularly spaced, intense precipitation cells, grouped into bands. Most precipitation associated with storms is contributed by these convective bands. Bands embedded within a storm system usually take one to one and one-half hours to pass a given location and are spaced three to four hours apart. From 1967 to 1970 under naturally occurring, unseeded conditions, 83 percent of the precipitation at the Santa Maria Airport was produced from convective bands. The portion of storm systems located between convective bands contributed the remaining seventeen percent [Elliott 1971]. In addition to generating the bulk of total storm precipitation, convective bands contain strong updrafts and associated supercooled water that are ideal for effective cloud seeding. Such conditions optimize entrainment and distribution of artificial nuclei.

Cloud seeding operations have been conducted in Santa Barbara County for fourteen of the past twenty five years [Brown 1975]. Sponsoring agencies and municipalities have included the U.S. Navy, the Santa Barbara County Water Agency, the City of Santa Barbara, and Montecito County Water District. Programs have included both operational and research programs [Brown 1975]. The U.S. Navy has authorized the most current weather modificiation activity, a randomized research project spanning the period 1967 through 1974 [Elliott 1971; Aerometric Rsch. 1973]. The history of weather modification activity in Santa Barbara County is summarized in Table 10-4 [Special Committee 1976].

Cloud seeding activities in Santa Barbara County have employed a technique that utilizes individual rain bands associated with storm systems for randomly selected seeding [Brown 1974]. Radar at the Vandenburg Air Force Base provides a means by which such bands can be detected and tracked toward the coast.

Recent aerial seeding procedure utilizes a seeding track that consists of a series of parallel legs approximately 20 to 40 miles long, parallel to and within the long axis of the convective band. The operation is initiated about 25 miles off the coast, and continues until the traveling edge of the band has reached the coast [Aerometric Rsch. 1973].

TABLE 10-4. WEATHER MODIFICATION ACTIVITY

Rainy Season	Coverage	Sponsor	Nature and Purpose
Most of 1950-51	Upper Santa Ynez Drainage Basin	City of Santa Barbara & Montecito CWD	To increase precipitation and runoff
1951-52 & 1952-53	Santa Barbara Co. Santa Barbara Co.	S.B. Co. Water Agency S.B. Co. Water Agency	Increase yields of watershed
Early 1955	Santa Barbara Co.	S.B. Co. Water Agency	Increase yields of watershed
1956-57 through 1959-60	Santa Barbara Co.	U.S. Naval Weapons Center	Special Research
1967-68 through 1973-74	Santa Barbara Co. (North of Santa Ynez Mountain Range)	U.S. Naval Weapons Center	Special reseasrch (randomized cloud-seeding)

The practice of weather modification in Santa Barbara County has undoubtedly affected precipitation and runoff tributary to the Santa Maria Valley Study Area. While quantative data have not been developed by performing organizations regarding annual effective precipitation increase on an average annual basis, evidence supports the conclusion that storms with seeded bands contributed significantly more precipitation than storms that were not artificially seeded [Aerometric Rsch. 1973; Special Committee 1976]. Intensive cloud seeding programs in other coastal areas of California have reportedly yielded long-term annual rainfall increases from 10-15 percent over that which normally could be expected without seeding [Henningson 1975]. Permanent implementation of a high-level operational program of weather modification in Santa Barbara County could conceivably yield similar results. Because seeding activity conducted in the County since 1951 has been intermittent in nature, and oriented toward research as well as operations, the resultant increase in precipitation is doubtlessly less than yields sustained by intense seeding programs. Since any increase in precipitation will tend to add to flood flows generated from upstream tributary watersheds, water resources development facilities for storing or percolating these flows will help maximize the total benefits that can be realized from weather modification activities.

WATERSHED MANAGEMENT

Watershed management involves increasing overall watershed productivity by controlled burning, land treatment, or related measures. The opportunity exists for augmenting locally available runoff by reducing evapotranspirative water losses associated with native vegetation.

The 1,600 square-mile drainage area of the Cuyama and Sisquoc Rivers possesses a long history of wildfire. Most of the area has burned at least once during the past 100 years. Native vegetation on the watershed in excess of 75 years in age is considered to be old. Figure 10-4 depicts age of brush in a selected portion of the Cuyama-Sisquoc drainages in the region of Twitchell Reservoir. This presentation is indicative of the general burn history of that area.

The boundaries of the Los Padres National Forest encompass the bulk of the 1,130-square mile Cuyama River watershed. Fire prevention and suppression has traditionally been practiced in this region. In recent years the U.S. Forest Service has adopted a new perspective to wildfire management which incorporates a program of fuel and land management. Prescribed burns, vegetative type conversion, firebreaks, and fuel breaks are major features in the wildfire control strategy. Fuelbreaks are wide, 200-400 foot strips or blocks, on which native vegetation has been permanently modified to facilitate the extinguishing of tributary fires [USDA Env. Anal.]. Prescribed burning involves combustion of vegetative fuels in a definite area under appropriate conditions of weather, fuel, fine fuel moisture, and soil moisture.

Much of the 470 square-mile Sisquoc River watershed is within the confines of the San Rafael Wilderness area of the Los Padres National Forest. Because of its wilderness status, this 143,000-acre area is not amenable to the fuel and vegetative management programs that characterize wildfire control policy in the remainder of the Los Padres National Forest. The Wellman Burn of 1966 represents the most recent wildfire in the San Rafael Wilderness area. Approximately 90,000 acres were consumed in this blaze [Greimam 1976].

The Los Padres National Forest has been subdivided by the Forest Service into separate "fuel management blocks" to implement appropriate fuel management-fuel reduction measures. One of these, the proposed Twitchell Fuel Management Block, occupies 158,000 acres of Cuyama River watershed in southeastern San Luis Obispo County and northwestern Santa Barbara County. The project area is located entirely within forest boundaries. The northern periphery of the project extends eastward from Hi Mountain

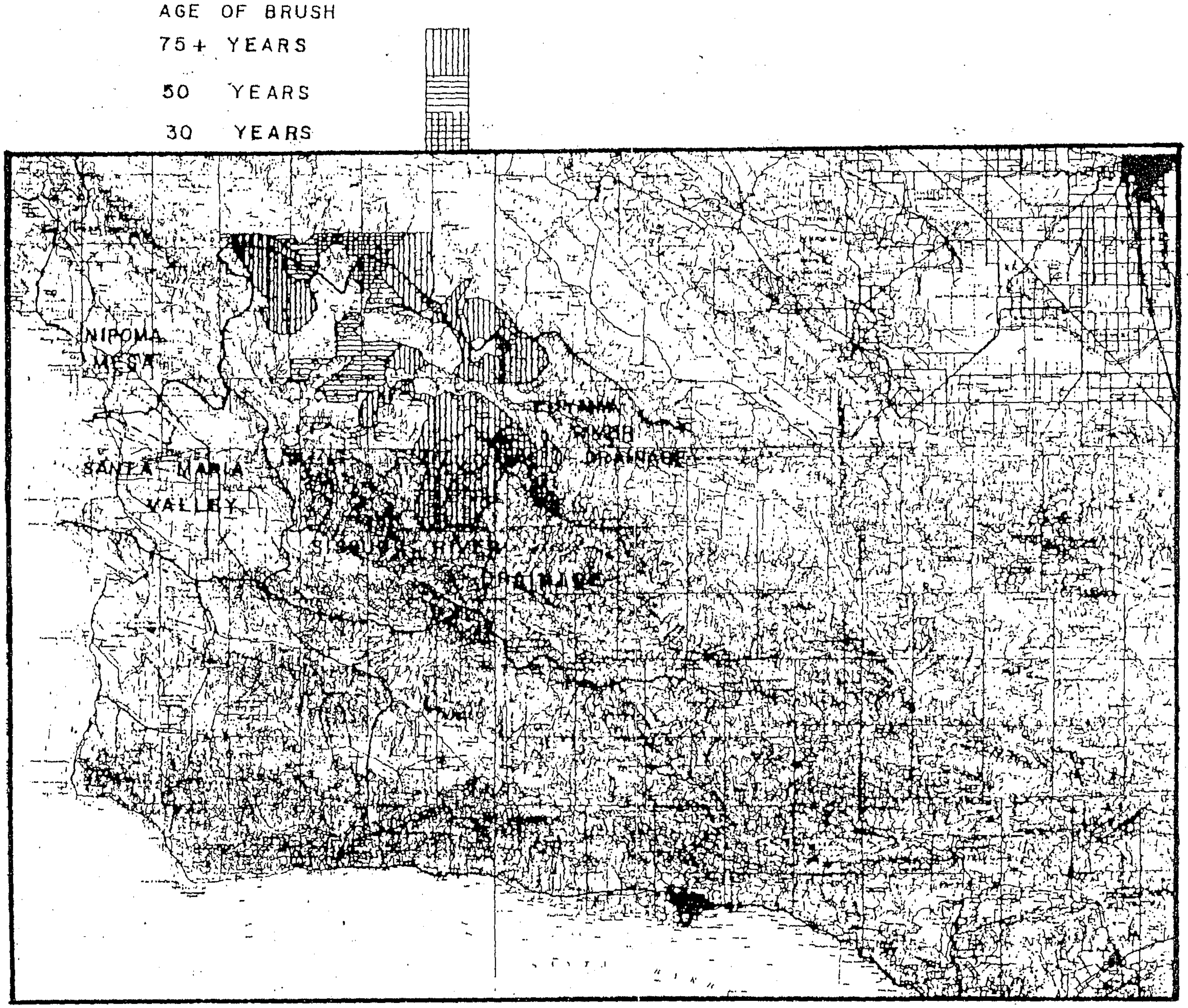


FIG. 10-4 AGE OF BRUSH
TWITCHELL WATERSHED

Lookout to the Garcia Range, Los Pelados, Pilitas Mountain, and Branch Mountain. It veers southeast to Sycamore Ridge, and then proceeds northwestward to the Forest border near Tepusquet Road. From Buckhorn Ridge, the project boundary intercepts La Brea Canyon Road at Smith Saddle. It parallels the road northeastward to Miranda Pine Mountain. The southeastern boundary lies between Miranda Pine Mountain and McPherson Peak [USDA Env. Anal.].

The fuel-management strategy applied to the Twitchell Block proposes construction of six high-priority fuelbreaks, which will be used to implement a designated program of prescribed burning. Desired amounts of vegetation will be removed from the fuelbreak areas by discing, ball and chain crushing, beam crushing, and prescribed burning. Discing will affect about 550 acres, crushing nearly 1,700 acres, and prescribed burning an estimated 27,800 acres [USDA Env. Anal.]. Once prepared, the areas will be maintained in a shrub-grassland mixture of young age-class chaparral communities by controlling natural reinvasion of the cleared area by chaparral species.

The fuel-management, fuel-reduction program proposed for the Twitchell Block would minimize destructive effects of wildfire by limiting brush accumulations and by modifying watershed lands to inhibit large uncontrolled burns. The proposed project will also help prevent and reduce sedimentation of Twitchell Reservoir.

The Forest Service has been implementing a program of prescribed burning on Buckhorn Ridge near Horseshoe Springs on the watershed divide between the Cuyama and Sisquoc Rivers [Lawrance 1975]. The program is now about 77 percent complete, with 600 acres burned out of the designated 780.

Prescribed burning provides a means by which locally available runoff from watershed areas can be optimized by reducing evapotranspirative losses from native vegetation. The order of magnitude by which watershed productivity can be increased is demonstrated by data generated in the Forest Service Paradise Study, 1973-74 [USDA 1974]. This study measured runoff water and movement of debris on a prescribed burned chaparral watershed in the Los Padres National Forest. Data obtained for unburned and burned areas on steep and gentle slopes are as follows:

	Runoff Yield [USDA 1974]	
Slope	Burned	Unburned
Steep (50%)	0.26 af/ac	0.008 af/ac
Gentle (20%)	0.19 af/ac	0.001 af/ac

Annual rainfall during the course of the study was 15.39 inches [USDA Env. Anal.].

When the runoff values observed in the Paradise Study are equated to the burnable 27,800 acres within the proposed 158,000-acre Twitchell Fuel Management Block, the order of magnitude of increased watershed yield from prescribed burning in this area can be estimated. Approximately 6,300 acre-feet of runoff would be generated from the prescribed burned area, assuming rainfall characteristics are similar to those of the Paradise Study area. The same area left unburned would yield only about 260 acre-feet of runoff [USDA Env. Anal.]. The increase in runoff approximation is probably conservative. Mean annual precipitation within the Twithchell Fuel Management Block is actually in excess of twenty inches, according to the isohyetal contours depicted on Figure 1-4.

Within the Los Padres National Forest, it appears doubtful that a major program of prescribed burning oriented toward increasing water supply will ever be implemented [Lawrance 1975]. In any such large-scale operation, there is too much risk of burning the brush upon which soil stability in numerous watershed locations depends. A less intensive program of controlled burning (burning in a mosaic pattern on the watershed) is still a potential, though by no means certain, management strategy which might reduce erosion hazards while increasing runoff [Lawrance 1975].

It appears very likely that the extensive burn-history of the Cuyama and Sisquoc River watersheds has influenced runoff tributary to the Santa Maria Valley during the base period defined in this investigation. Quantification of the positive impact on water resources is an extremely difficult, if not impossible, task. It is further complicated by the fact that accelerated runoff from burned areas may add to flood flows lost to the ocean and thus may not totally contribute to recharge of the Santa Maria groundwater basin. This especially relates to flows in the Sisquoc River. Because of the combustible nature of the study area chaparral watersheds, it is assumed herein that a dynamic cycle of conflagration will be perpetuated in unmanaged areas in future years. It is anticipated that increased watershed yield from a controlled program of burning and vegetative management will be greater and more consistent than that which historically occurred from wildfire.

DEMINERALIZATION

Local brackish perched groundwater and seawater represent two sources of water which could supplement Valley freshwater resources if their qualities were enhanced to appropriate levels. Demineralization is the process by which dissolved minerals (TDS) are removed from water. Adsorption, crystallization, filtration, and distillation are the fundamental means by which this can be accomplished.

Minerals extracted from feedwater are in the form of a concentrated brine, which usually comprises about ten to fifteen percent of the feedwater volume. Such brine requires disposal. Considering existing technology and anticipated future developments, distillation and membrane processes are regarded to represent the more practical demineralization alternatives for the study area.

Distillation techniques are well suited to demineralizing feedwaters with TDS concentrations similar to that of seawater (33,000 mg/l). These processes involve a change in state of feedwater. The basic amount of energy required is equal to the latent heat of evaporation. In many applications, economies are realized through multi-stages and reduced pressures, which tend to reduce energy requirements. Cost per acre-foot of seawater conversion is indicated for various sized facilities in Figure 10-5.

Reverse osmosis and electrodialysis are appropriate methods for demineralizing brackish groundwaters and poor quality agricultural return flows. Electrodialysis is practically suited to feedwater TDS concentrations ranging upward to about 2,000 mg/l. Reverse osmosis provides effective and economical TDS removal for concentrations from 1,000 to 10,000 mg/l. Costs for groundwater demineralization are depicted in Figure 10-5. They reflect prevailing commercial power rates in the Santa Maria Valley, 2.5¢/kWh, and are based on ENR 2600 [Plesche 1976].

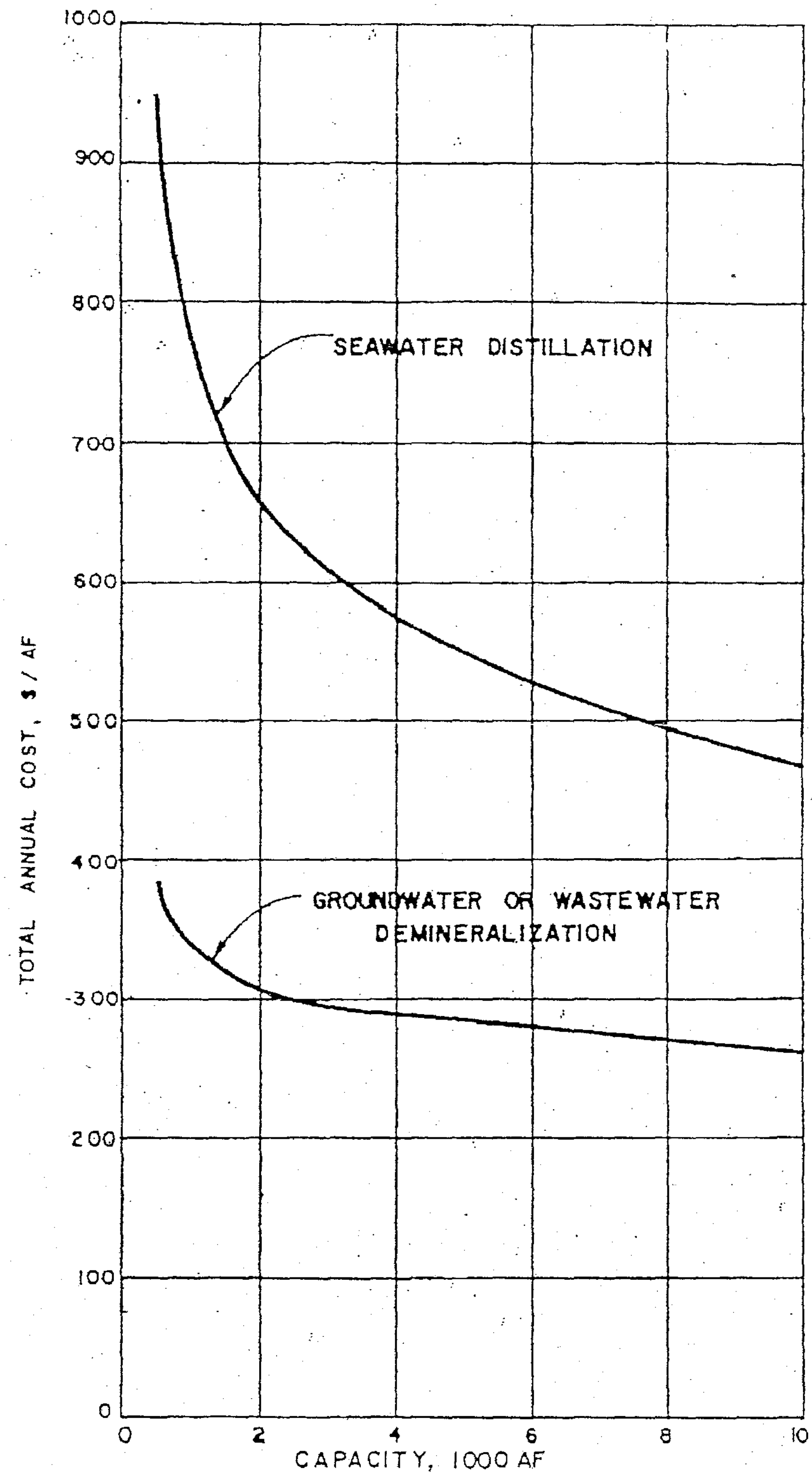


FIG. 10-5 DEMINERALIZATION COSTS (ENR 2600)

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APPENDIX A

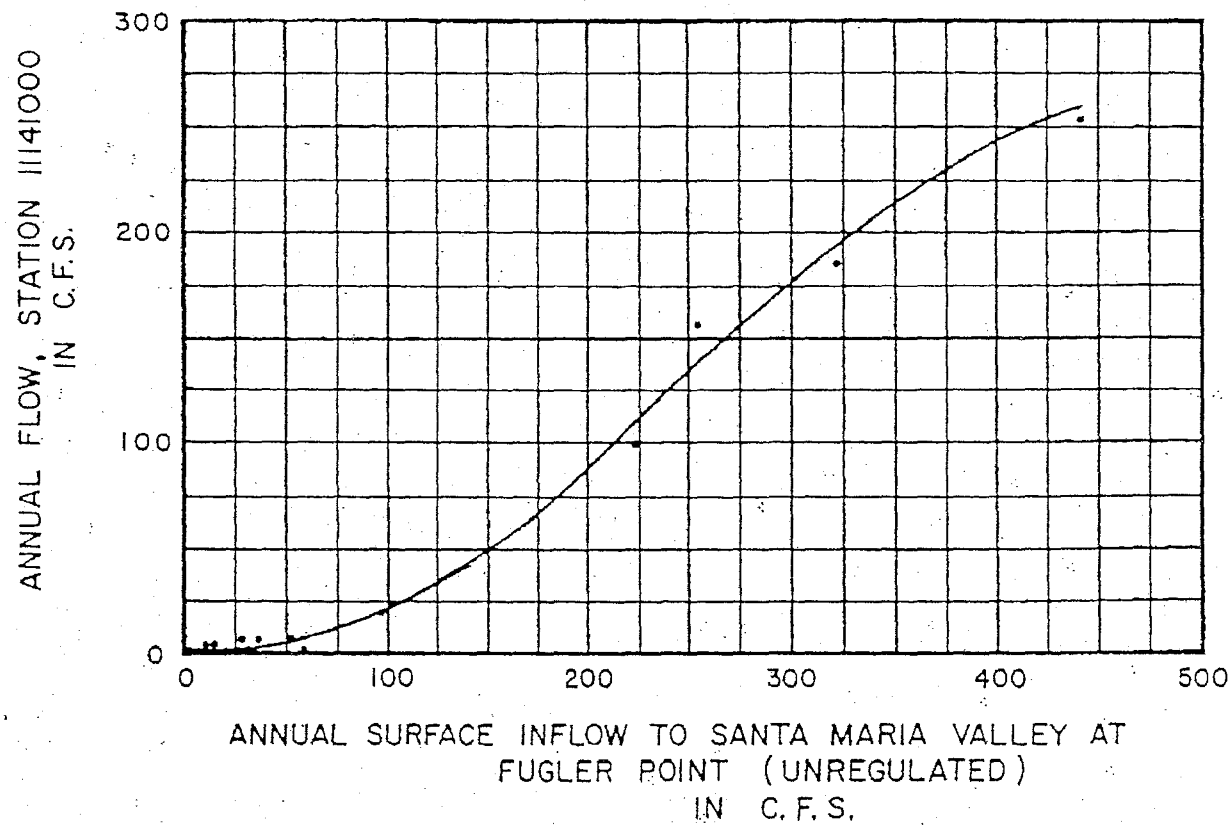
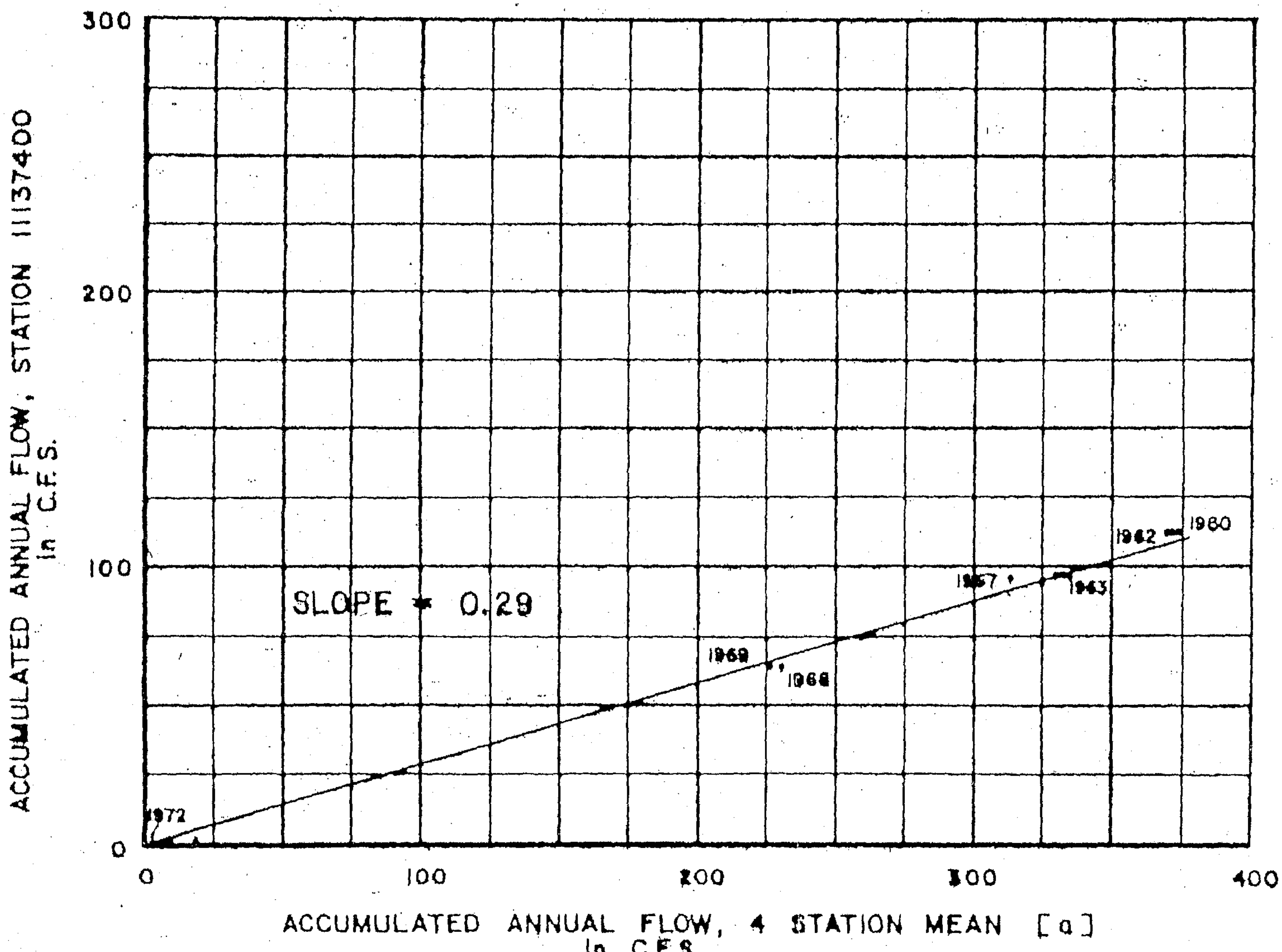
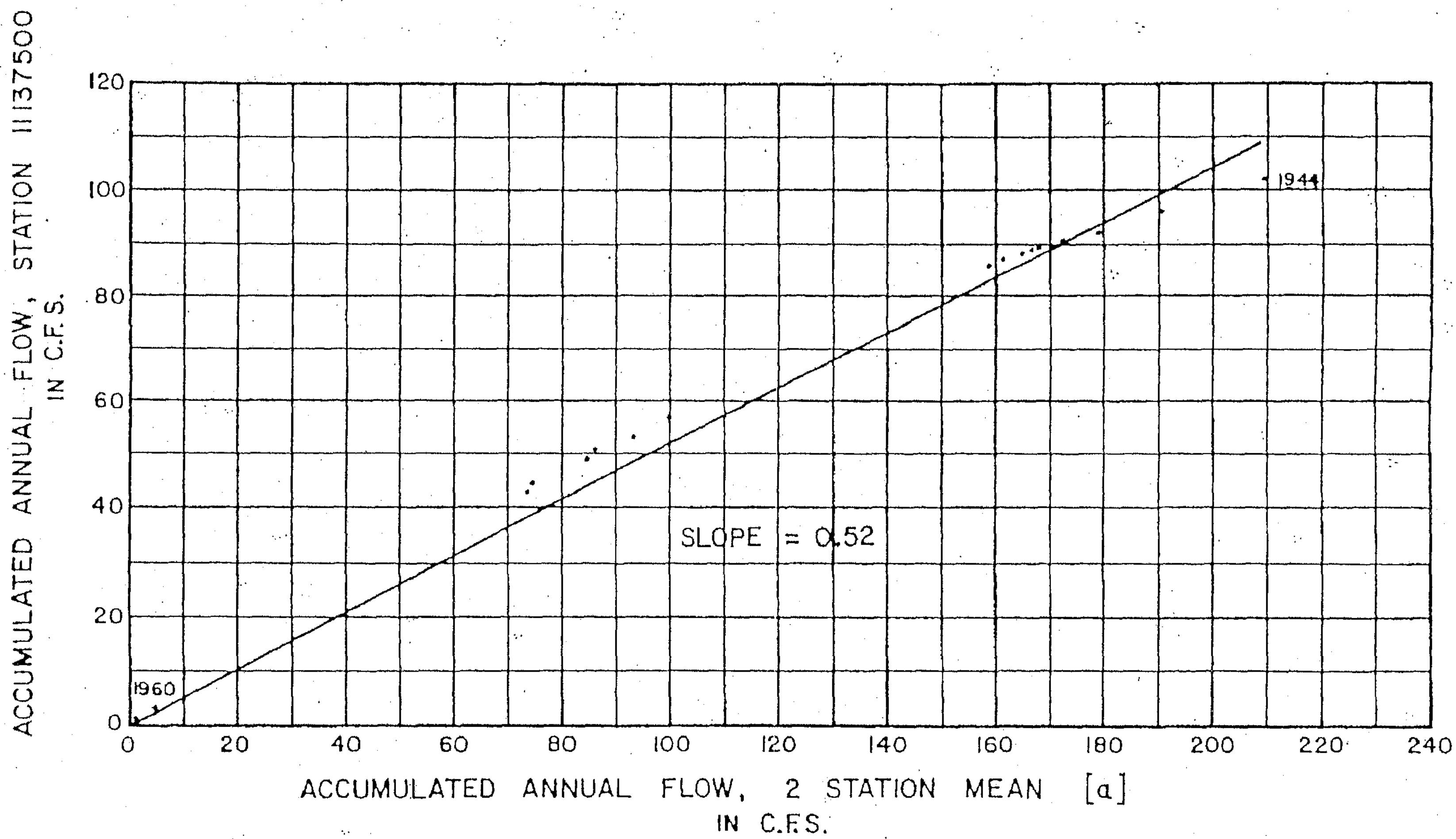


FIG. A-1 RELATIONSHIP BETWEEN MEAN ANNUAL SURFACE INFLOW AT FUGLER POINT (UNREGULATED) AND FLOWS AT STATION 11141000, SANTA MARIA RIVER AT GUADALUPE



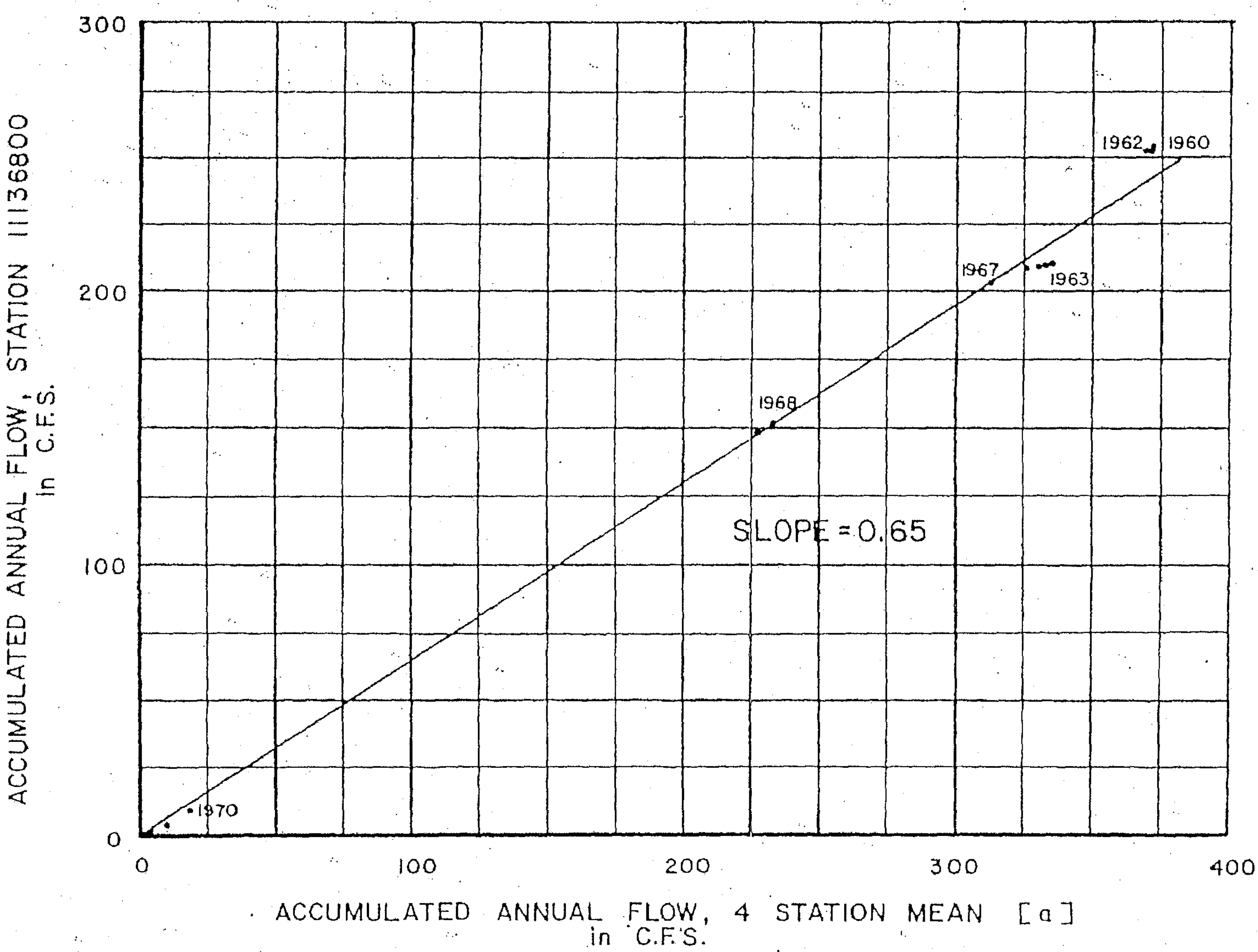
[a] STATIONS 11138500, 11139000, 11139500 & 11140000

FIG. A-2 DOUBLE MASS ANALYSIS, STATION 11137400
ALAMO CREEK NEAR NIPOMO



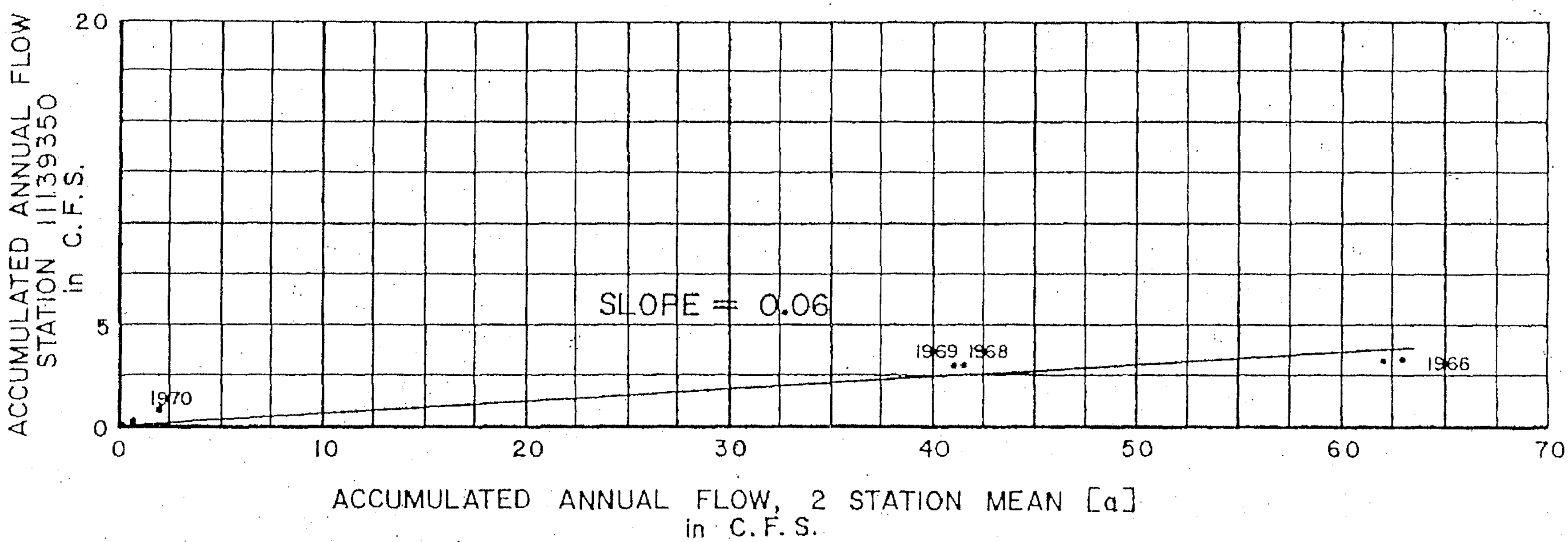
[a] STATIONS 11137000 & 11138000

FIG. A-3 DOUBLE MASS ANALYSIS, STATION 11137500
ALAMO CREEK NEAR SANTA MARIA



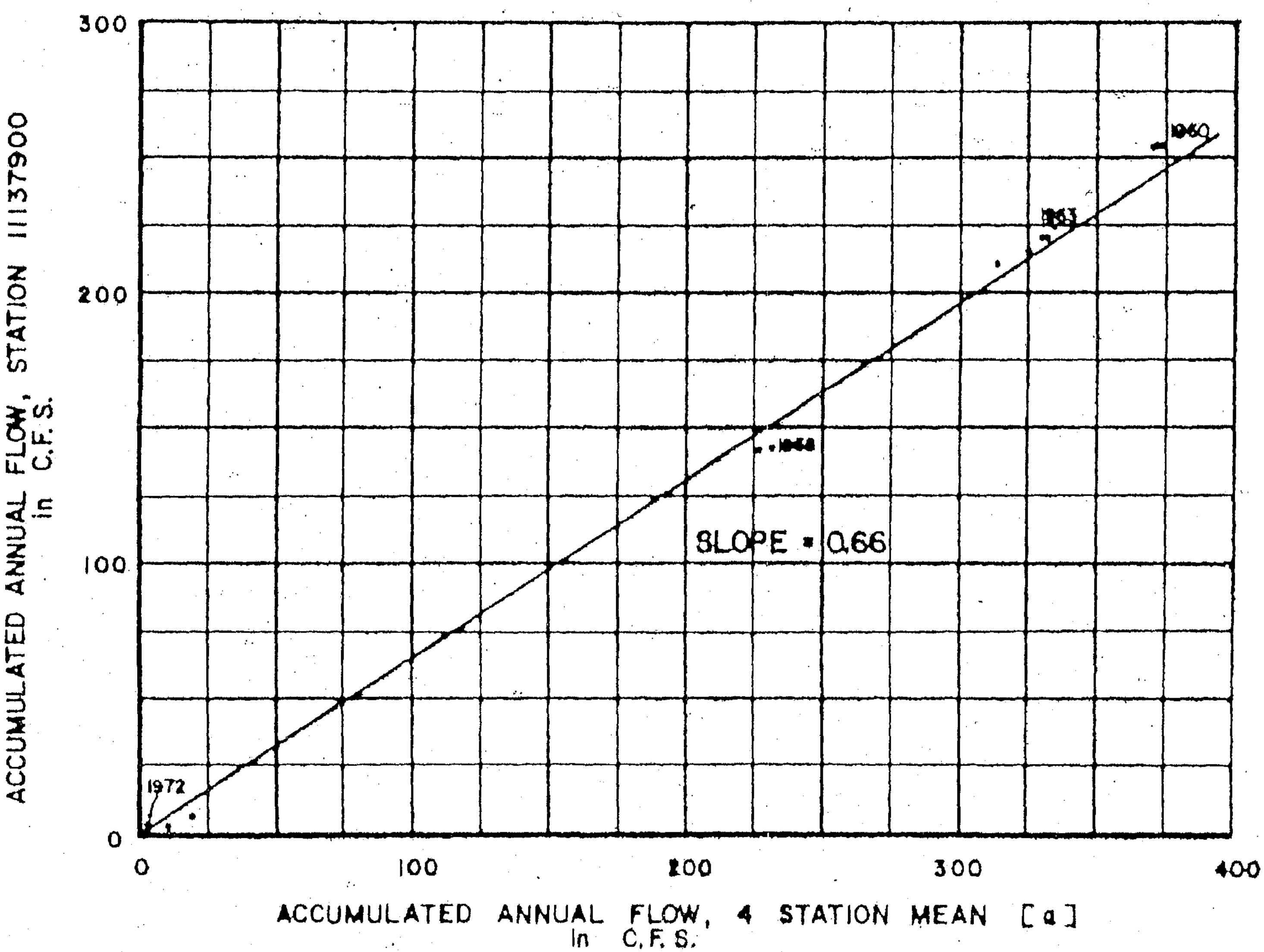
[a] STATIONS 11138500, 11139000, 11139500 & 11140000

FIG. A-4 DOUBLE MASS ANALYSIS, STATION 11136800
CUYAMA RIVER BELOW BUCKHORN CANYON



[a] STATIONS 11139000 & 11139500

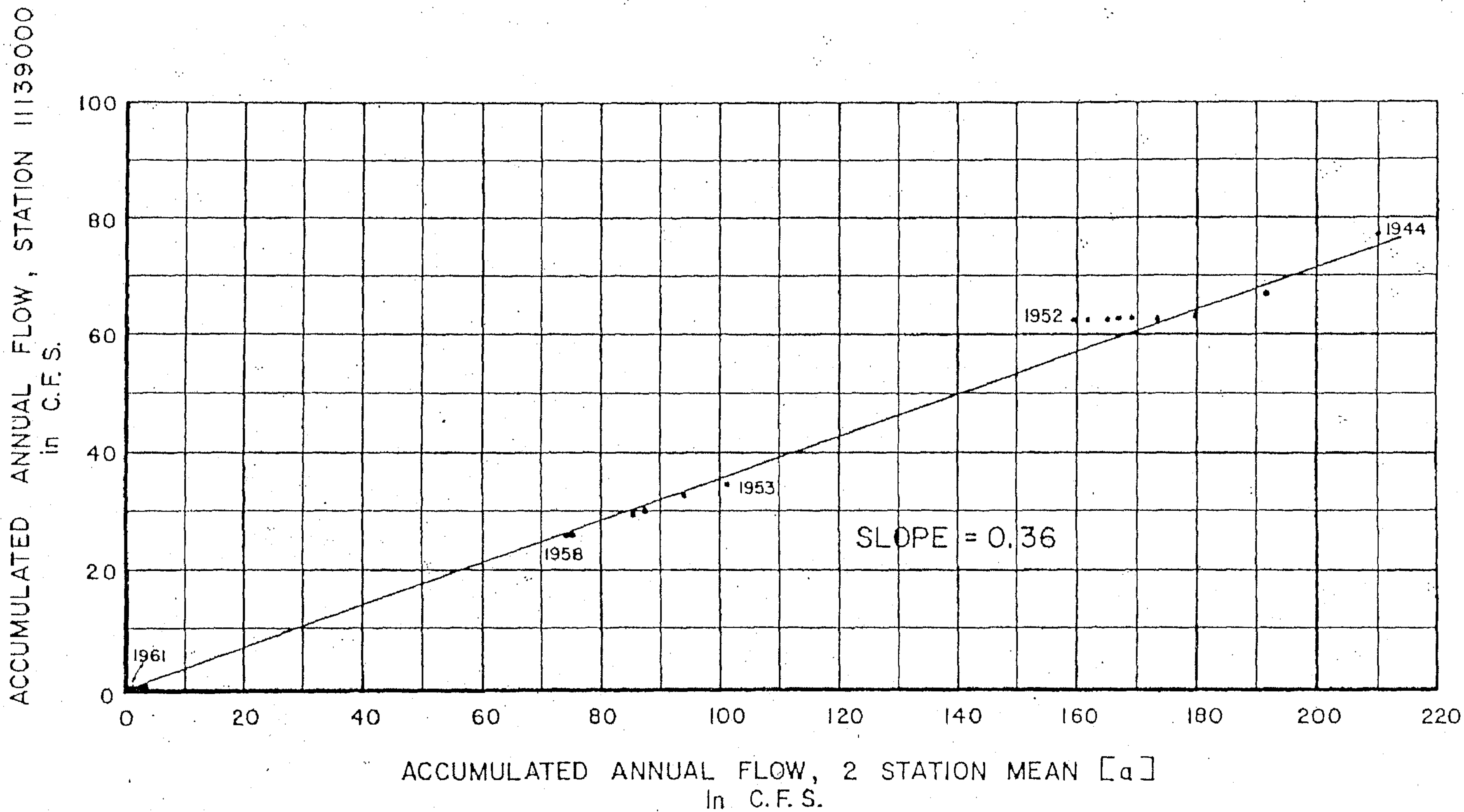
FIG. A-5 DOUBLE MASS ANALYSIS, STATION 11139350
FOXEN CREEK NEAR SISQUOC



ACCUMULATED ANNUAL FLOW, 4 STATION MEAN [a]
In C.F.S.

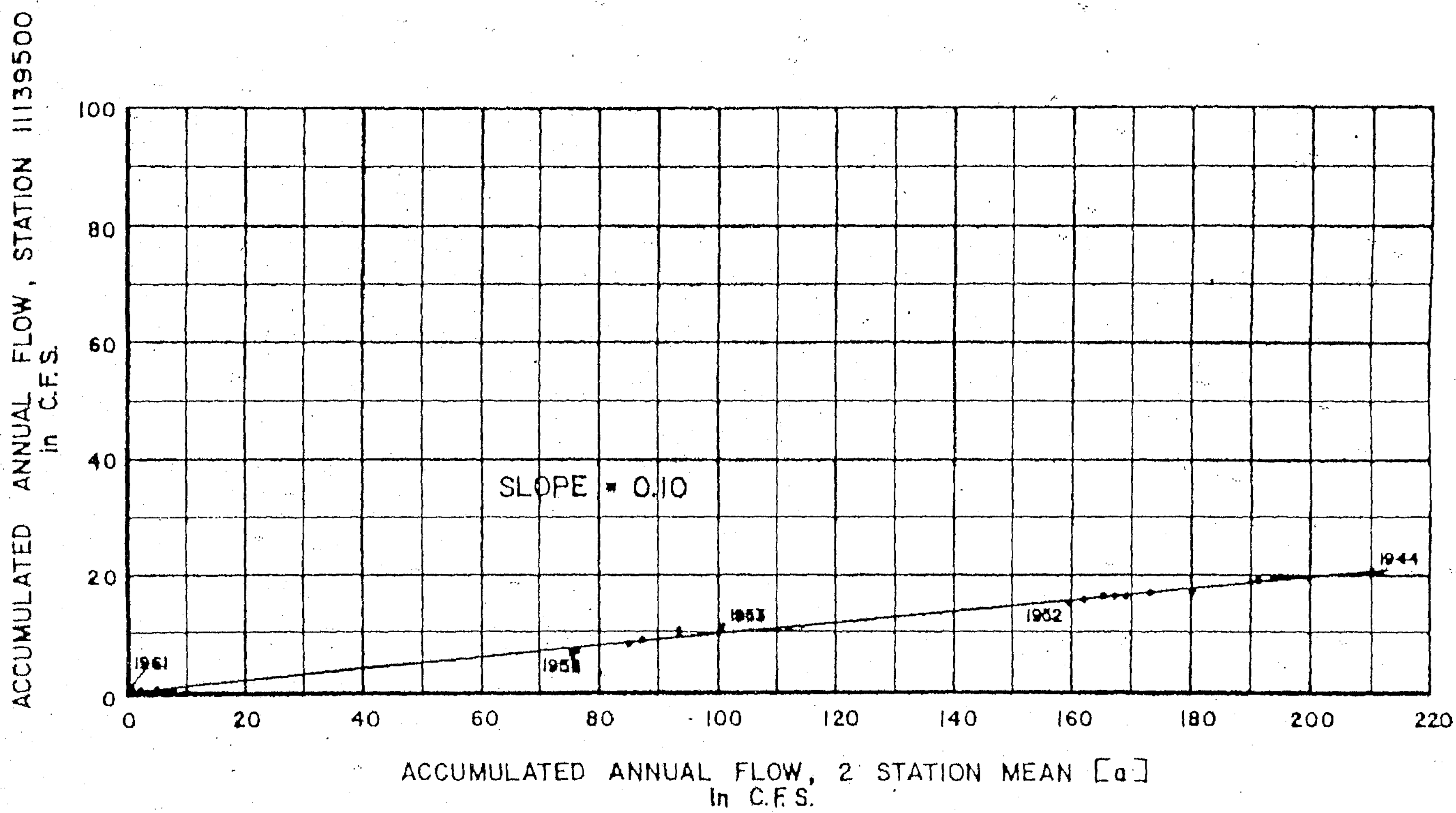
[a] STATIONS 11138500, 11139000, 11139800 & 11140000

FIG. A-6 DOUBLE MASS ANALYSIS, STATION 11137900
HUASNA RIVER NEAR ARROYO GRANDE



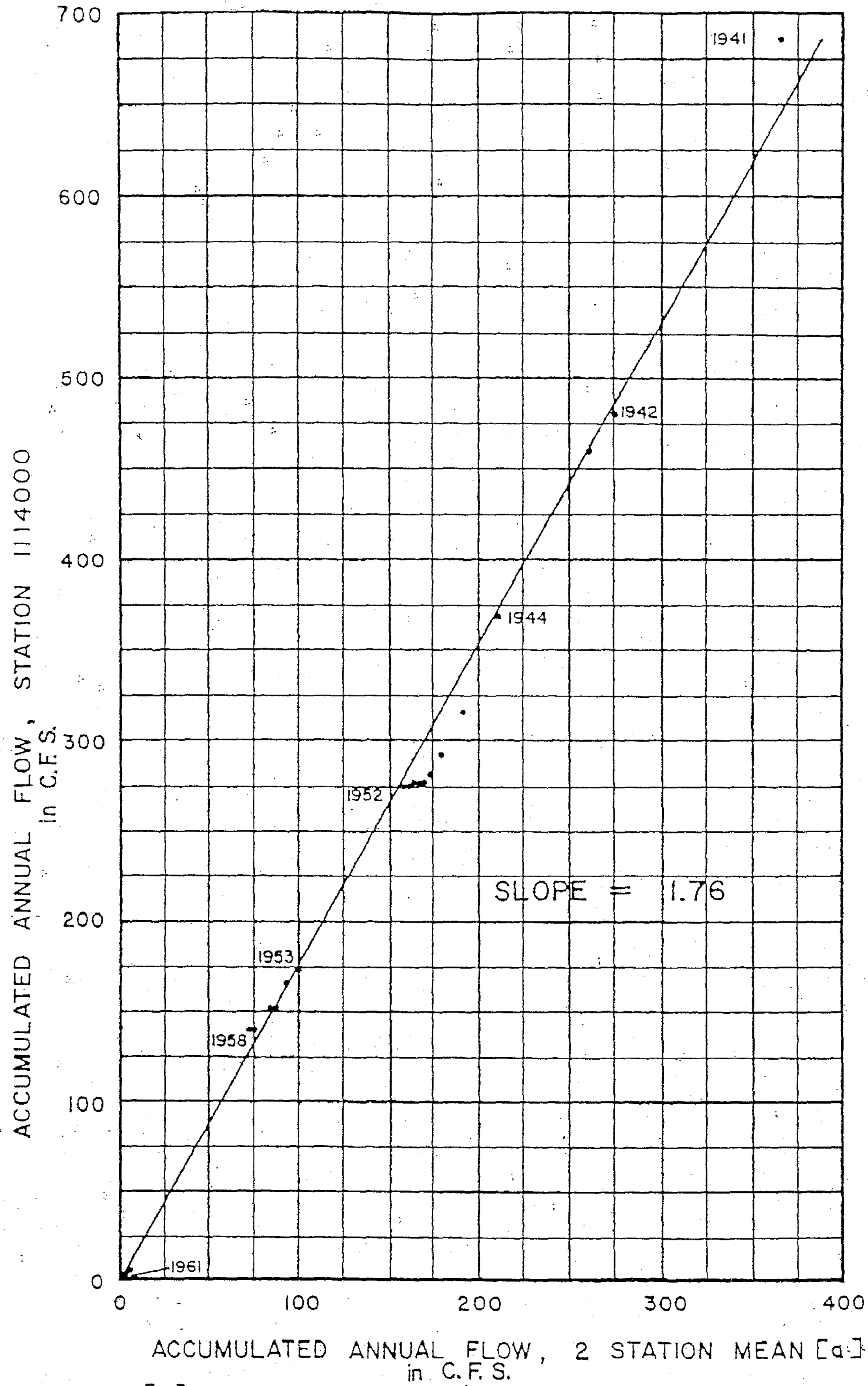
[a] STATIONS 11137000 & 11138000

FIG. A-7 DOUBLE MASS ANALYSIS, STATION 11139000
LA BREA CREEK NEAR SISQUOC



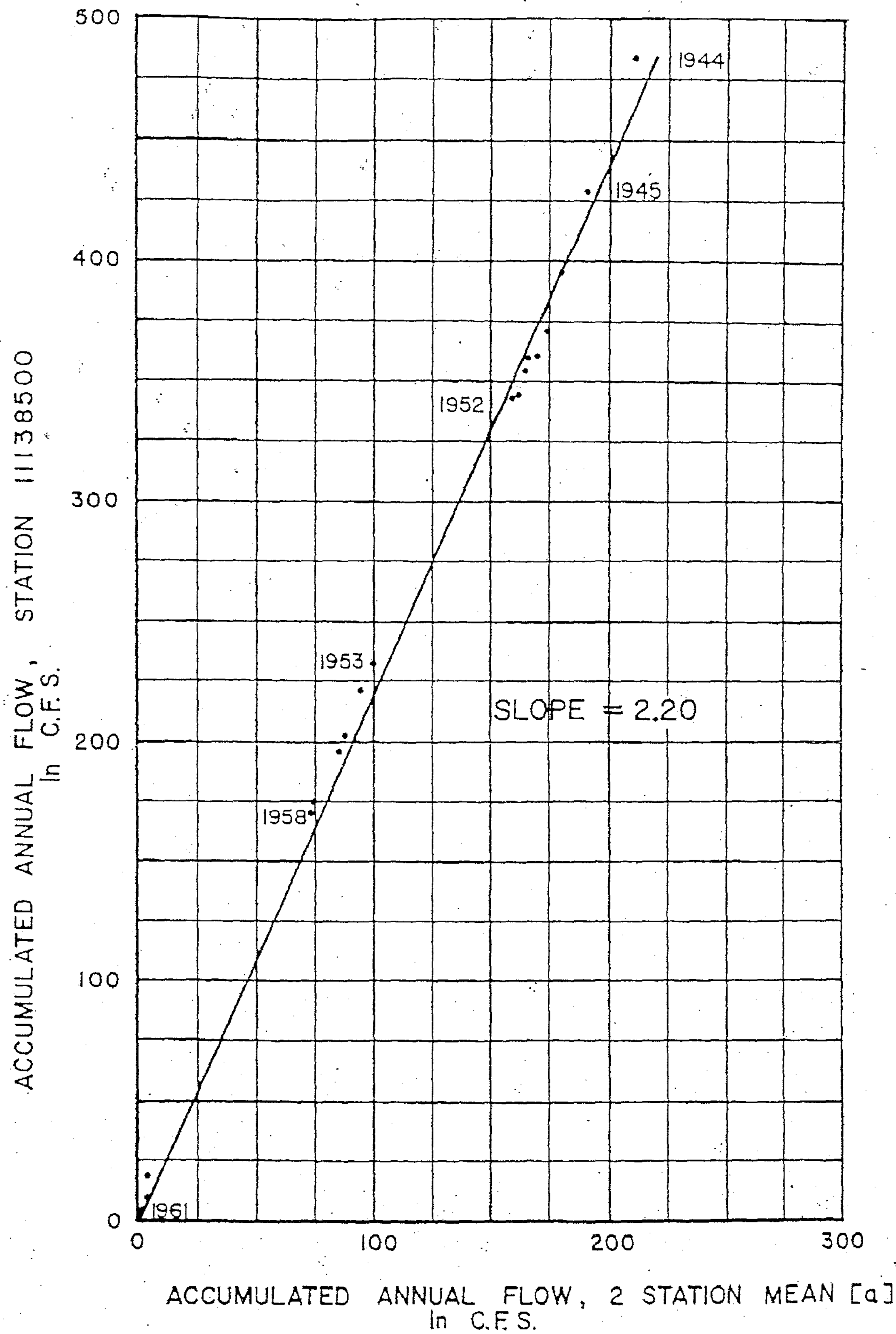
[a] STATIONS 11137000 & 11138000

FIG. A-8 DOUBLE MASS ANALYSIS, STATION 11139500
TEPUSQUET CREEK NEAR SISQUOC



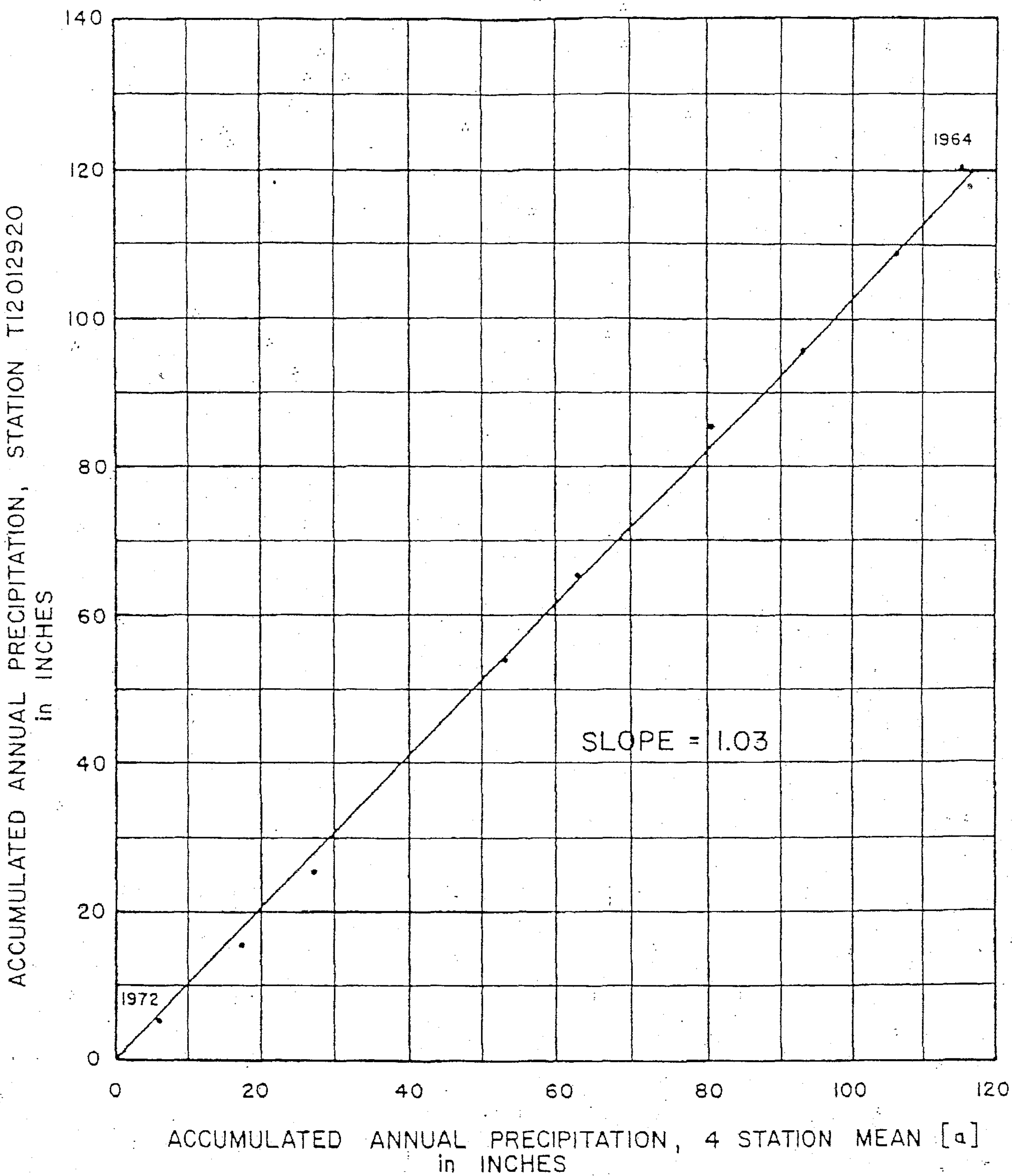
[a] STATIONS 11137000 & 11138000

FIG. A-9 DOUBLE MASS ANALYSIS
STATION 11140000
SISQUOC RIVER NEAR GAREY



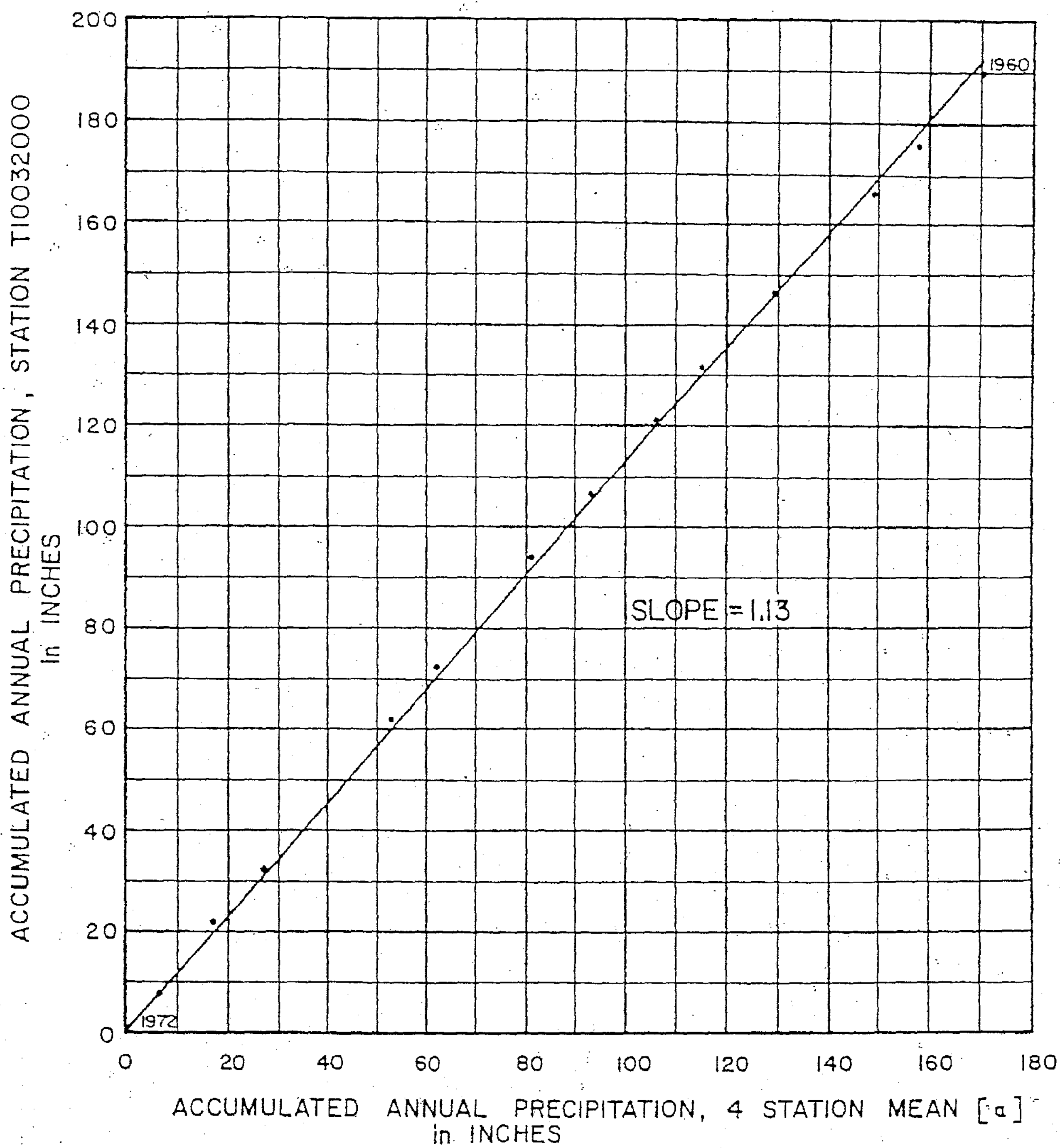
[a] STATIONS 11137000 & 11138000

FIG. A-10 DOUBLE MASS ANALYSIS
STATION 11138500
SISQUOC RIVER NEAR SISQUOC



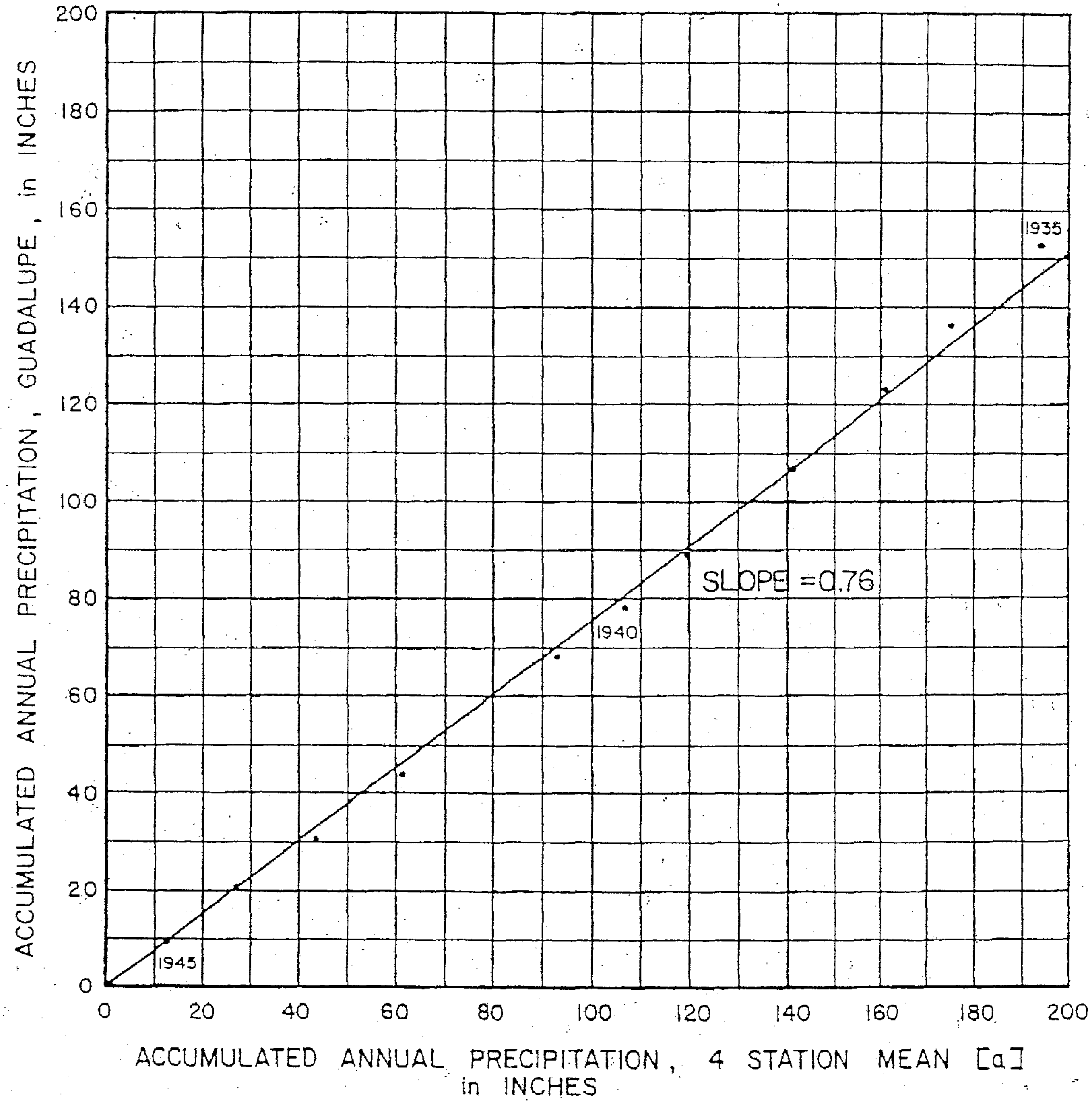
[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-11 DOUBLE MASS ANALYSIS, STATION T12012920
ALMAR RANCH



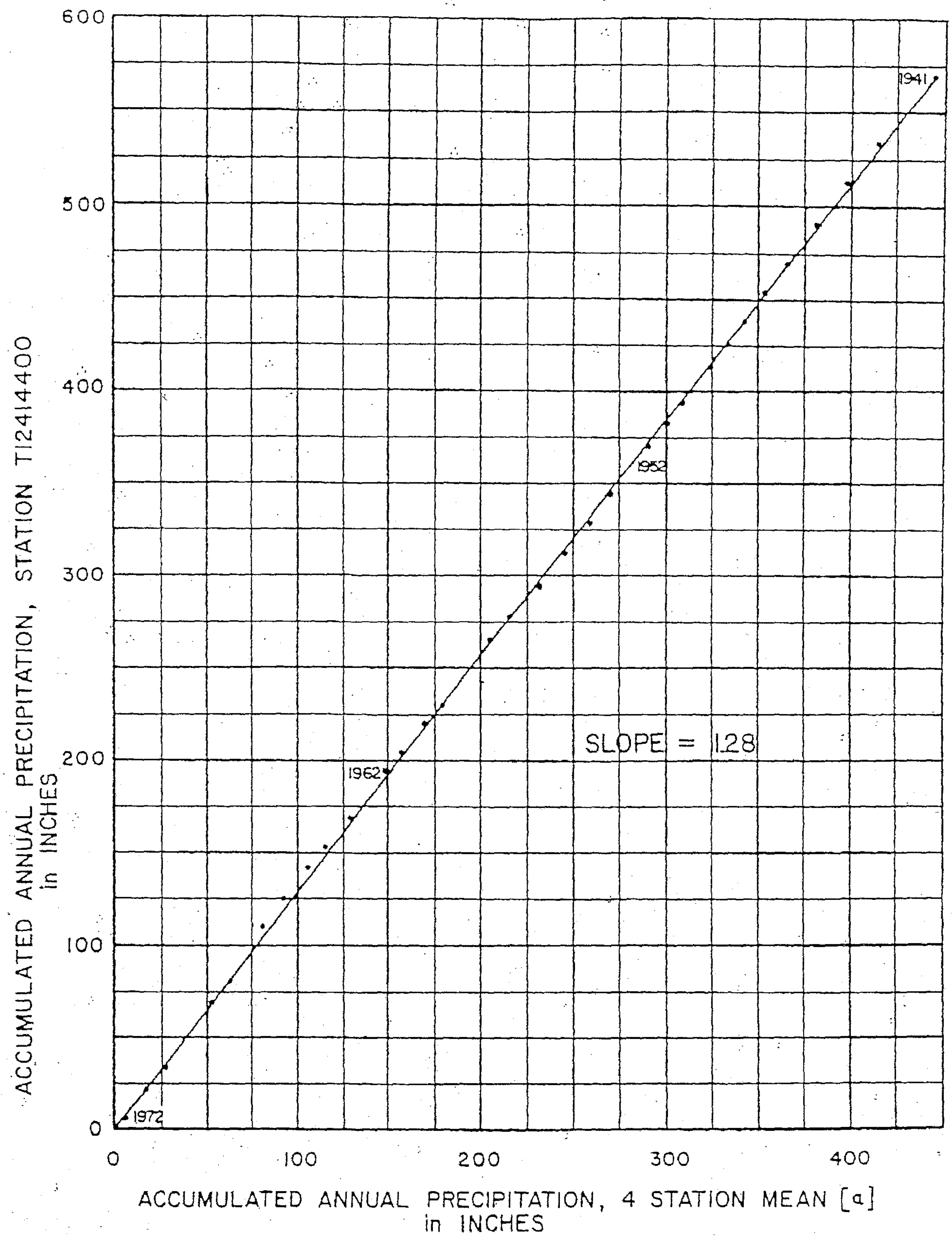
[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-12 DOUBLE MASS ANALYSIS, STATION T10032000 ARROYO GRANDE



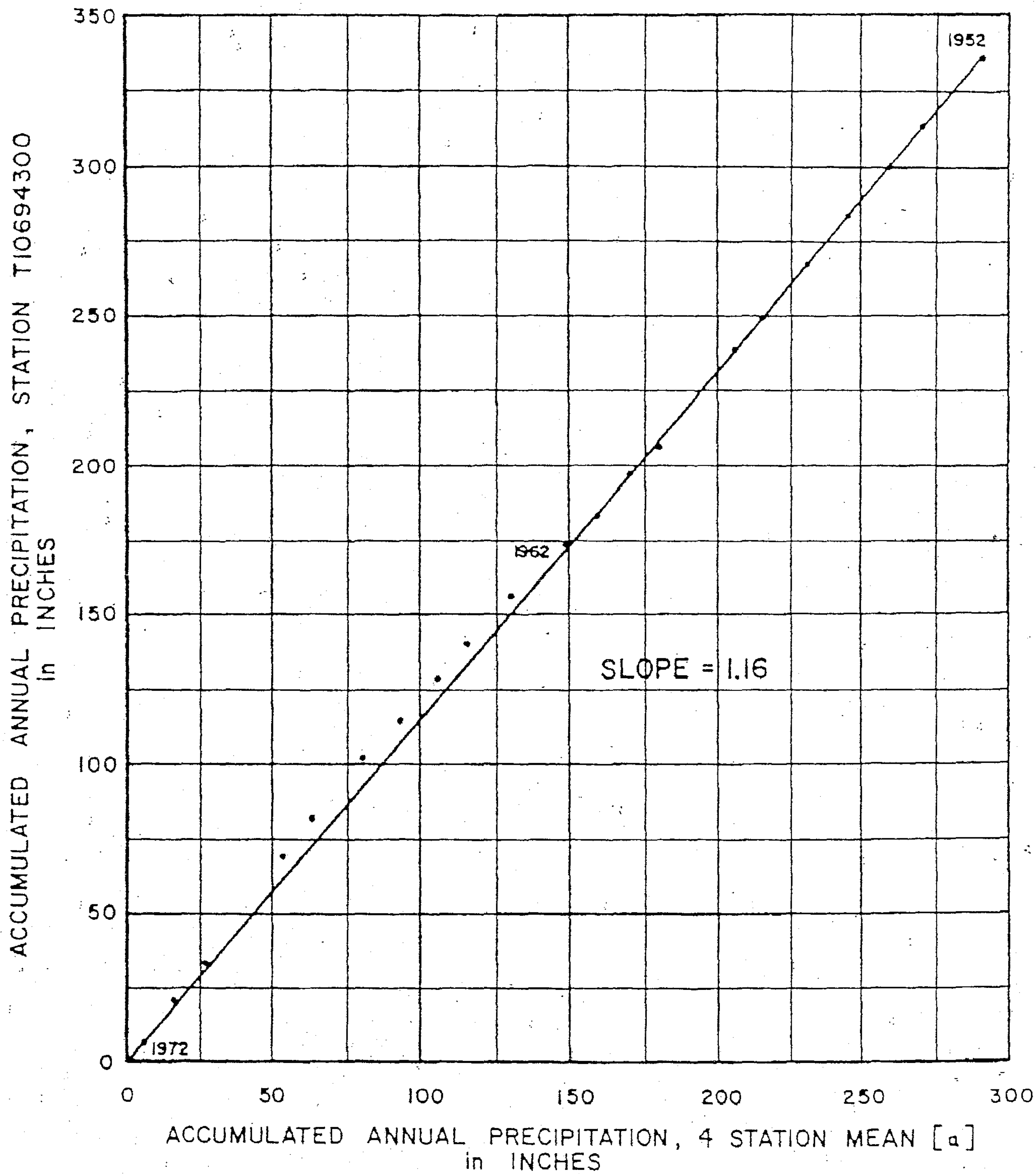
[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-13 DOUBLE MASS ANALYSIS, GUADALUPE



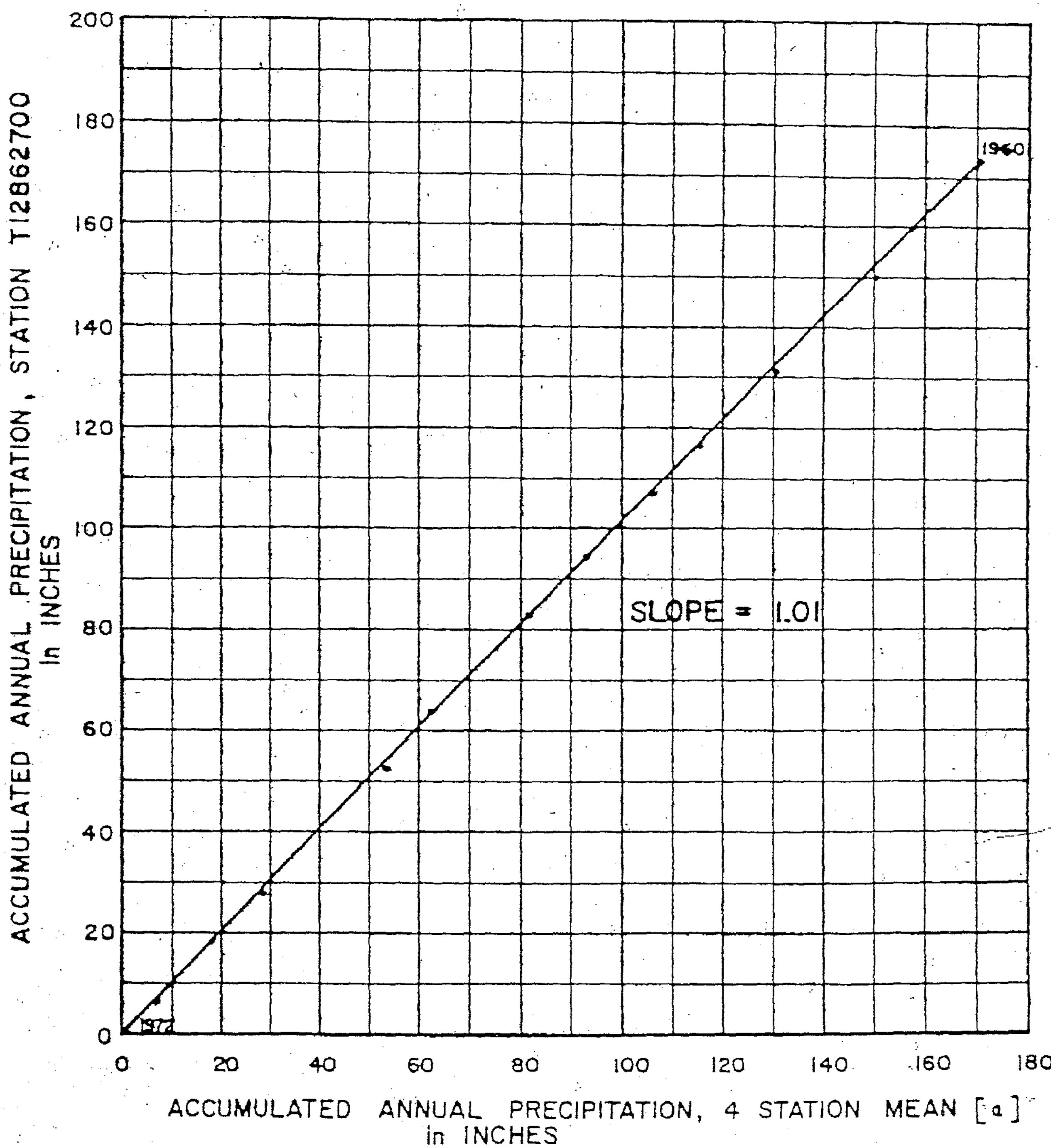
[a] STATIONS T12071900, T13510700, T12620700 & 12794000

FIG. A-14 DOUBLE MASS ANALYSIS, STATION T12414400
HAUSNA



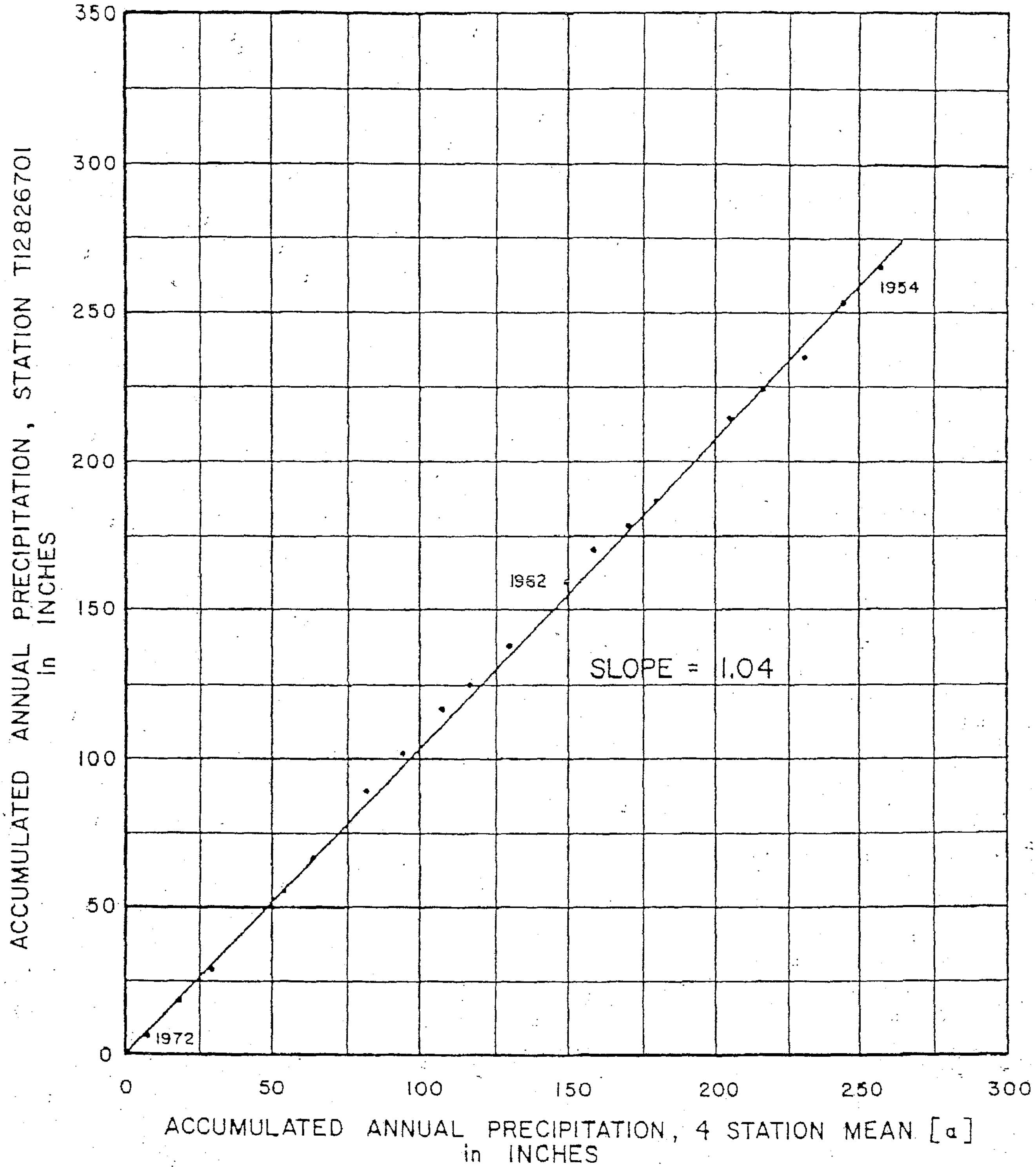
[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-15 DOUBLE MASS ANALYSIS, STATION T10694300 PISMO BEACH



[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-18 DOUBLE MASS ANALYSIS, STATION T12862700
SUEY RANCH

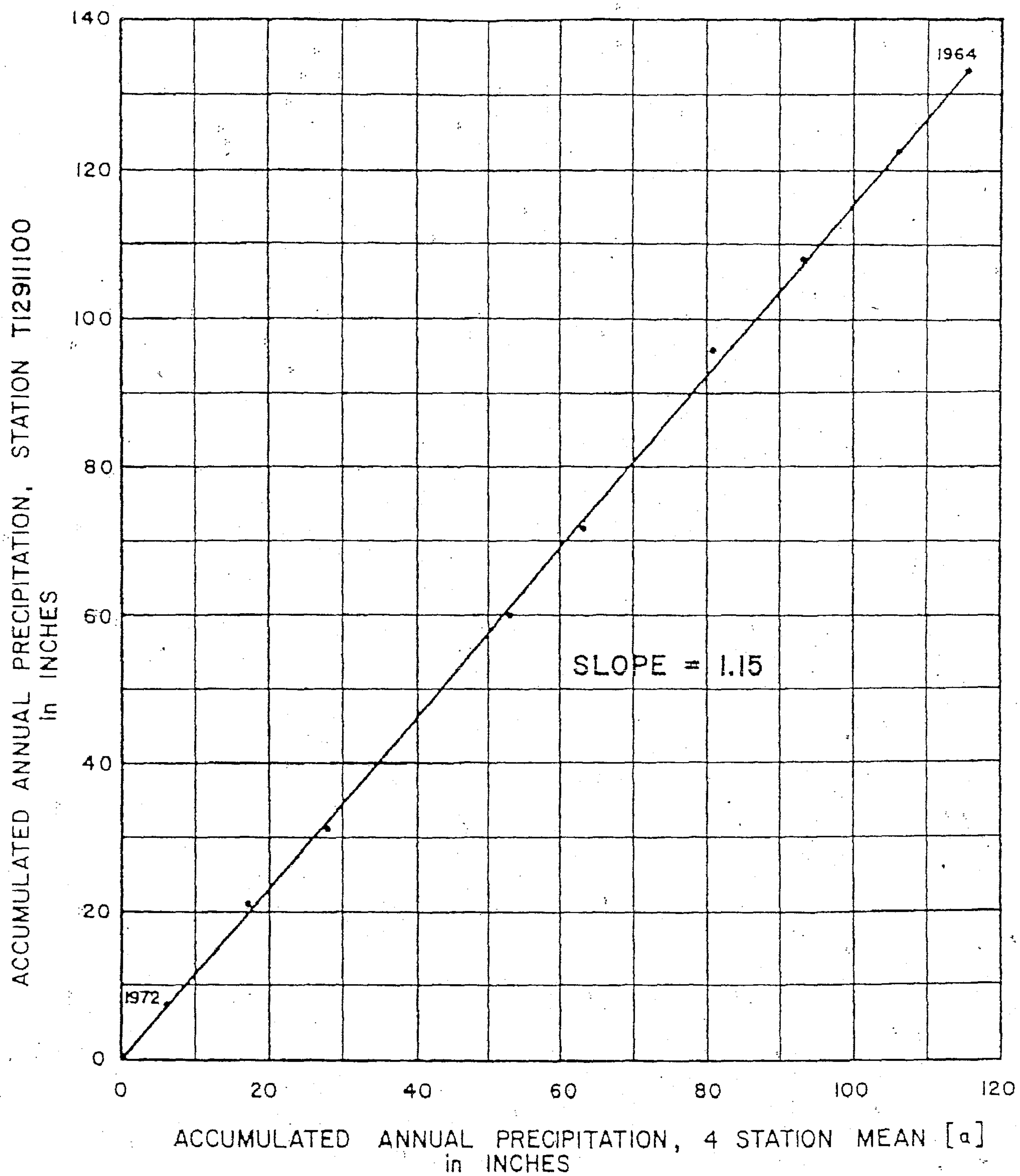


[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-17 DOUBLE MASS ANALYSIS, STATION T12826701
SISQUOC RANCH

TABLE B-2. GROUNDWATER CONDITIONS - T9N/R34W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1	-2000	135	95	-40	14.0[h]	-3.58	187.7
2	-2000	120	85	-35	14.4	-3.23	192.2
3	-2100	110	65	-45	15.9	-4.58	220.3
4	-2200	100	70	-30	15.3	-2.94	222.3
5	-2300	95	70	-25	13.0[h]	-2.08	197.2
6	-2300	95	65	-30	11.0	-2.11	166.5
7	-2000	100	70	-30	13.0[h]	-2.50	172.2
8	-2200	105	75	-30	13.7	-2.63	199.5
9	-2150	105	80	-25	16.7	-2.67	238.3
10	-2100	115	80	-35	16.3	-3.65	227.4
11	-2050	130	90	-40	16.9	-4.33	231.5
12	-1900	150	100	-50	12.0[h]	-3.84	153.6
13[f]	-1500	170	120	-50	12.4	-2.78	90.0
14	-2000	145	100	-45	16.9	-4.87	227.1
15	-2050	130	90	-40	12.6	-3.23	172.6
16	-2050	120	85	-35	15.0[h]	-3.36	205.0
17[f]	-2000	110	80	-30	16.0[h]	-1.54	106.5
18[f]	-2000	105	75	-30	16.0[h]	-0.61	42.5
19			--				
20			--				
21[f]	-1800	135	90	-45	12.0[h]	-1.38	58.1
22[f]	-1800	145	100	-45	12.0[h]	-2.76	116.7
23[f]	-1600	160	110	-45	12.0[h]	-1.92	65.7
24[f]	-1500	170	120	-50	12.0[h]	-0.38	12.4
TOTAL						-60.97	3,505



[a] STATIONS T12071900, T13510700, T12620700 & T12794000

FIG. A-19 DOUBLE MASS ANALYSIS, STATION T12911100
TWITCHELL DAM

APPENDIX B

TABLE B-1. GROUNDWATER CONDITIONS - T9N/R33W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1			--		16.9		
2[f]	-1900		300[g]		16.7		47.0
3	-1900		280[g]		13.4		187.0
4	-1500		220[g]		14.0[h]		154.1
5	-1250	190	160	-30	16.5	-3.17	148.9
6	-1600	160	120	-40	13.5	-3.46	152.1
7	-1500	180	130	-50	10.8	-3.46	112.7
8	-1500	200	170	-30	14.4	-2.76	156.7
9	-1400		260[g]		14.0[h]		146.9
10	-1650		310[g]		14.1		176.9
11[f]	-1500		320[g]		13.0		30.3
12			--		13.0		--
13[f]	-1000		370[g]		10.3		9.0
14[f]	-1250		360[g]		11.0[h]		79.3
15	-1300		360[g]		11.4		121.1
16	-1250		310[g]		11.0[h]		109.8
17	-1200		220[g]		11.0[h]		100.0
18	-1000	180	160	-20	10.7	-1.37	79.4
19	-700		270[g]		10.0[h]		62.1
20	-700		360[g]		11.0[h]		74.6
21	-1000		480[g]		13.0[h]		123.1
22[f]	-1000		480[g]		13.1		86.9
23[f]	-1000		380[g]		14.9		32.9
24			--				
25			--				
26			--				
27[f]	-800		635[g]		14.0[h]		25.7
28[f]	-600		635[g]		14.0[h]		88.5
29[f]	-300		530[g]		14.0[h]		44.6
30			--				
31			--				
32			--				
33[f]	-200		670[g]		14.0[h]		11.7
34			--				
35			--				
36			--				
TOTAL						-14.22	2,361

TABLE B-4. GROUNDWATER CONDITIONS - T10N/R33W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1			--				
2			--				
3			--				
4			--				
5			--				
6[f]	-100	155	155	0	17.0[h]	0	15.7[i]
7	-250	150	150	0	16.9	0	41.0[i]
8[f]	-200	175	170	-5	17.0[h]	-0.38	26.5[i]
9[f]	-100	210	175	-35	17.0[h]	-1.90	14.1[i]
10			--				
11			--				
12			--				
13			--				
14			--				
15[f]	-100	255	210	-45	17.0[h]	-2.94	20.2
16	-200	235	200	-35	17.0[h]	-3.81	41.0[i]
17	-300	190	180	-10	17.0	-1.09	49.2[i]
18	-450	145	155	+10	14.9	+0.95	57.7
19	-750	155	135	-20	15.9	-2.04	85.0[i]
20	-500	190	180	-10	15.8	-1.01	65.3[i]
21	-400	230	225	-5	15.7	-0.50	60.0[i]
22	-400	270	235	-35	16.0[h]	-3.58	61.0[i]
23[f]	-500	290	240	-50	16.0[h]	-3.07	42.6[i]
24[f]	-200	300	260	-40	16.0[h]	-0.40	4.4[i]
25[f]	-500	300	275	-25	16.0[h]	-0.64	18.6[i]
26	-1000	295	270	-25	16.0[h]	-2.56	121.9[i]
27	-1700	270	255	-15	16.3	-1.56	187.7[i]
28	-700	225	200	-25	14.6	-2.34	84.1
29	-700	180	160	-20	16.6	-2.12	91.4
30	-1000	155	125	-30	13.6	-2.61	97.9
31	-1500	155	125	-30	13.5[h]	-2.59	140.4
32	-1200	185	150	-35	16.0[h]	-3.58	138.2
33	-2000	220	170	-50	13.2	-4.22	183.3
34	-2000	260	260	0	13.6	0	196.7
35[f]	-1700	295	280	-15	12.7	-0.61	80.5
36[f]	-1200	305	330	+25	16.0[h]	+0.26	15.4
TOTAL						-42.34	1,940

TABLE B-3. GROUNDWATER CONDITIONS - T9N/R35W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1	-2300	90	65	-25	6.0	-0.96	90.8
2[f]	-2100	90	65	-25	6.0[h]	-0.67	58.2
3[f]	-2000	85	65	-20	6.0[h]	-0.15	15.9
4							
5							
6							
7							
8							
9							
10							
11							
12[f]	-2100	95	70	-25	6.0[h]	-0.38	33.3
TOTAL						-2.16	198

TABLE B-6. GROUNDWATER CONDITIONS - T10N/R35W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
(1)	-1300		(15)		18.0		126.2[i]
(2)	-1500		(-5)		18.0[h]		143.5[i]
(3)	-1600		(-30)		18.7		150.7[i]
(4)	-1600		(-40)		10.1		100.8
(5)	-1500		(-65)		9.7		90.6
(6)	-1500		(-85)		5.6		51.4
(7)	-1600		(-85)		11.5		97.0[i]
(8)	-1700		(-65)		11.8		104.6[i]
(9)	-1800		(-40)		12.2		112.6[i]
(10)	-1800		(-30)		10.3		116.7
(11)	-1700		(-5)		13.7		141.0[i]
(12)	-1600		(+15)		16.7		155.0[i]
(13)	-1800		(+15)		15.8		174.2[i]
(14)	-1900		(-5)		12.5		151.6
(15)	-1950		(-30)		10.7		131.5
(16)	-1900		(-45)		10.3		118.7[i]
(17)	-1800		(-65)		11.1		111.01[i]
(18)	-1650		(-85)		14.2		100.2[i]
19	-1650	45	45	0	11.0[h]	0	108.5[i]
20[j]	-1800	50	50(-65)	0	11.0[h]	0	116.2[i]
21[j]	-2000	60	55(-40)	-5	11.5	-0.18	128.5[i]
22[j]	-2100	70	55(-30)	-15	11.4	-0.11	133.0[i]
(23)	-2100		(-5)		12.5		167.6
24[j]	-2000	80	55[+15)	-25	17.7	-0.85	168.7[i]
25[j]	-2200	85	55(+15)	-30	11.0[h]	-1.48	157.9
26[j]	-2200	80	60(-5)	-20	11.0[h]	-0.99	157.7
27	-2150	75	60	-15	11.0[h]	-1.06	155.6
28	-2000	70	60	-10	6.0[h]	-0.38	79.1
29[f]	-1000	55	55	0	6.0[h]	0	28.4
30[f]	-1000	50	50	0	6.0[h]	0	12.1
31			--				
32			--				
33[f]	-2000	80	60	-20	6.0[h]	-0.38	39.6
34	-2100	80	60	-20	6.0[h]	-0.77	82.9
35	-2200	85	60	-25	6.0[h]	-0.96	86.8
36	-2300	85	60	-25	11.0[h]	-1.76	166.1
TOTAL						-8.92	3,966

TABLE B-5 . GROUNDWATER CONDITIONS - T10N/R34W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1	-200	140	135	-5	17.1	-0.55	34.3[i]
2	-500	115	110	-5	16.7	-0.53	58.6[i]
3	-700	95	90	-5	21.4	-0.68	86.0]i]
4	-900	85	75	-10	21.3	-1.36	99.8[i]
5	-1000	80	70	-10	20.6	-1.32	109.6[i]
6[j]	-1200	75	65(25)	-10	18.1	-0.70	119.9[i]
7[j]	-1500	75	60(25)	-15	16.7	-1.12	148.8[i]
8	-1300	80	70	-10	18.3	-1.17	131.5[i]
9	-1200	85	70	-15	20.0	-1.92	121.9[i]
10	-900	90	80	-10	21.0	-1.34	100.4[i]
11	-700	100	95	-5	20.7	-0.66	81.4[i]
12	-500	125	120	-5	18.2	-0.58	67.5[i]
13	-700	120	120	0	18.0	0	84.0[i]
14	-900	100	90	-10	20.3	-1.30	101.4[i]
15	-1200	95	80	-15	22.2	-2.13	131.1[i]
16	-1300	90	70	-20	19.8	-2.53	131.5[i]
17	-1500	85	65	-20	19.1	-2.44	150.2[i]
18	-1700	80	60	-20	15.8	-2.02	169.0[i]
19	-1800	85	60	-15	20.3	-1.95	154.8[i]
20	-1750	90	65	-15	19.8	-1.90	168.0[i]
21	-1700	90	70	-20	20.8	-2.66	169.9[i]
22	-1400	95	75	-20	22.5	-2.88	141.6[i]
23	-1200	100	85	-15	18.5	-1.78	123.4[i]
24	-1000	125	80	-15	16.2	-4.67	103.7[i]
25	-1300	130	90	-40	16.3	-4.17	145.0
26	-1400	110	80	-30	16.3	-3.13	154.4
27	-1700	100	70	-30	17.9	-3.44	202.8
28	-1800	95	70	-25	15.1	-2.42	180.7
29	-2000	90	65	-25	11.4	-1.82	150.7
30	-2100	90	60	-30	11.5[h]	-2.21	159.0
31	-2200	90	55	-35	11.0[h]	-2.46	158.8
32	-2200	95	60	-35	12.0[h]	-2.69	173.6
33	-2100	100	60	-40	13.7	-3.51	189.4
34	-1900	105	60	-45	16.7	-4.81	209.5
35	-1800	115	80	-35	14.8	-3.32	178.1
36	-1900	130	90	-40	14.0[h]	-3.58	178.3
TOTAL						-75.75	4,869

TABLE B-6. GROUNDWATER CONDITIONS - T10N/R35W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
(1)	-1300		(15)		18.0		126.2[i]
(2)	-1500		(-5)		18.0[h]		143.5[i]
(3)	-1600		(-30)		18.7		150.7[i]
(4)	-1600		(-40)		10.1		100.8
(5)	-1500		(-65)		9.7		90.6
(6)	-1500		(-85)		5.6		51.4
(7)	-1600		(-85)		11.5		97.0[i]
(8)	-1700		(-65)		11.8		104.6[i]
(9)	-1800		(-40)		12.2		112.6[i]
(10)	-1800		(-30)		10.3		116.7
(11)	-1700		(-5)		13.7		141.0[i]
(12)	-1600		(+15)		16.7		155.0[i]
(13)	-1800		(+15)		15.8		174.2[i]
(14)	-1900		(-5)		12.5		151.6
(15)	-1950		(-30)		10.7		131.5
(16)	-1900		(-45)		10.3		118.7[i]
(17)	-1800		(-65)		11.1		111.01[i]
(18)	-1650		(-85)		14.2		100.2[i]
19	-1650	45	45	0	11.0[h]	0	108.5[i]
20[j]	-1800	50	50(-65)	0	11.0[h]	0	116.2[i]
21[j]	-2000	60	55(-40)	-5	11.5	-0.18	128.5[i]
22[j]	-2100	70	55(-30)	-15	11.4	-0.11	133.0[i]
(23)	-2100		(-5)		12.5		167.6
24[j]	-2000	80	55[+15)	-25	17.7	-0.85	168.7[i]
25[j]	-2200	85	55(+15)	-30	11.0[h]	-1.48	157.9
26[j]	-2200	80	60(-5)	-20	11.0[h]	-0.99	157.7
27	-2150	75	60	-15	11.0[h]	-1.06	155.6
28	-2000	70	60	-10	6.0[h]	-0.38	79.1
29[f]	-1000	55	55	0	6.0[h]	0	28.4
30[f]	-1000	50	50	0	6.0[h]	0	12.1
31			--				
32			--				
33[f]	-2000	80	60	-20	6.0[h]	-0.38	39.6
34	-2100	80	60	-20	6.0[h]	-0.77	82.9
35	-2200	85	60	-25	6.0[h]	-0.96	86.8
36	-2300	85	60	-25	11.0[h]	-1.76	166.1
TOTAL						-8.92	3,966

TABLE B-7. GROUNDWATER CONDITIONS - T10N/R36W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
(1)	-1450		(-110)		6.0[h]		51.5
(2)[i]	-1400		(-115)		6.0[h]		39.5
(11)	-1300		(-115)		11.5[h]		75.8[i]
(12)	-1500		(-110)		11.5[h]		89.0[i]
13[j]	-1300	35	55(-110)	-20	11.5[h]	+0.59	80.4[i]
14[j]	-1000	35	35(-115)	0	11.5[h]	0	63.4[i]
15[f]	-1000	35	10	-25	11.5[h]	-0.55	19.4[i]
22[f]	-100	35	10	-25	14.0[h]	-0.34	1.1[i]
23[f]	-500	35	30	-5	14.0[h]	-0.13	10.2[i]
24[f]	-1000	40	55	+15	14.0[h]	+0.94	47.3[i]
TOTAL						+0.51	478

TABLE B-8. GROUNDWATER CONDITIONS - T11N/R34W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1			--				
2			--				
3			--				
4			--				
5			--				
6[f]	+120	170	170	0	10.0[h]	0	1.6
7	+100	170	150	-20	10.0[h]	-1.28	3.2
8[f]	+150	200	180	-20	12.0[h]	-0.61	0.9
9			--				
10			--				
11			--				
12			--				
13			--				
14			--				
15			--				
16[f]	+150	200	190	-10	12.0[h]	-0.23	0.9
17	+100	180	180	0	12.1	0	6.2
18	-100	145	105	-40	9.4	-2.41	12.3
19	-200	110	40	-70	13.4	-6.00	20.6
20	-100	150	130	-20	13.0	-1.66	19.1
21[f]	+150	160	170	+10	13.0[h]	+0.58	1.2
22[f]	+70	170	190	+20	13.0[h]	+0.42	2.5
23			--				
24			--				
25			--				
26[f]	-100	165	165	0	19.0[h]	0	9.7
27	-200	155	150	5	19.0[h]	-0.61	42.6
28	-300	135	120	-15	17.0[h]	-1.63	45.7
29	-400	125	80	-45	16.6	-4.78	49.2[i]
30	-500	90	65	-25	17.9	-2.86	57.9[i]
31[j]	-1000	80	65(25)	-15	18.0	-1.21	101.1[i]
32	-800	90	70	-20	18.0[h]	-2.30	89.1[i]
33	-700	105	90	-15	19.0[h]	-1.82	80.9[i]
34	-500	125	110	-15	19.8	-1.90	66.4[i]
35	-400	140	140	0	17.0[h]	0	55.3[i]
36	-200	155	155	0	17.0[h]	0	36.3[i]
TOTAL						-28.30	703

TABLE B-9. GROUNDWATER CONDITIONS - T11N/R35W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl[k]	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
1[f]	-1--	155	160	+5	15.0[h]	+0.01	6.2
2			--				
3			--				
4			--				
5			--				
6			--				
7[f]	-600	45	3	-42	10.0	-1.08	15.4
8[f]	-600	50	10	-40	15.0[h]	-2.69	41.0
9[f]	-550	65	55	-10	15.0[h]	-0.58	34.8
10[f]	-500	80	95	+15	18.0[h]	+1.58	41.1
11[f]	-300	90	90	0	21.1	0	36.9
12[f]	-100	125	120	-5	15.0[h]	-0.34	14.8
13	-250	105	60	-45	10.0[h]	-2.88	19.8
14	-400	85	55	-30	15.0[h]	-2.88	43.7
15	-600	70	40	-30	18.0[h]	-3.46	73.7
16[j]	-700	60	10(-40)	-50	18.0[h]	-3.46	79.5
17[j]	-800	50	5(-65)	-45	19.5	-1.12	71.9[i]
(18)	-850		(-85)		20.0		63.6[i]
(19)	-1000		(-85)		16.7		70.3[i]
(20)	-900		(-65)		18.2		64.1[i]
(21)	-800		(-40)		14.5		63.2[i]
(22)	-700		(-30)		15.9		64.3[i]
23[j]	-500	80	45(-5)	-35	15.0[h]	-1.34	49.4
24[j]	-400	90	45(+15)	-70	11.1[i]	-2.24	30.9
25[j]	-500	85	65(+15)	-25	15.9	-0.51	50.4[i]
(26)	-900		(-5)		17.8		85.9[i]
(27)	-1000		(-30)		14.0		86.9
(28)	-1200		(-40)		13.0		96.5
(29)	-1200		(-65)		12.2		79.9[i]
(30)	-1100		(-85)		12.0[h]		65.0[i]
(31)	-1300		(-85)		10.0[h]		77.8
(32)	-1400		(-65)		10.7		85.4[i]
(33)	-1400		(-40)		9.4		81.8
(34)	-1250		(-30)		15.6		117.1[i]
(35)	-1250		(-5)		14.9		118.7
(36)	-1200		(+15)		18.0[h]		140.0
TOTAL						-20.99	1,970

TABLE B-10. GROUNDWATER CONDITIONS - T11N/R36W

Section [a]	Base of Fresh Water[b]	Groundwater Elevations(ft)[d] 1935 msl[c]	1972 msl	Change	Specific Yield[e]	Groundwater Volume 1,000 AF Change 1935-72	Total 1972
(13)[j]	-900		(-110)		20.0[h]		35.4[i]
(23)[i]	-1100		(-115)		17.0[h]		12.6[i]
(24)	-1000		(-110)		17.0[h]		57.0[i]
(25)	-1100		(-115)		12.0[h]		63.0[i]
(26)[j]	-1200		(-115)		12.0[h]		20.8[i]
(35)[j[	-1300		(-115)		10.0[h]		45.5
(36)	-1300		(-110)		10.0[h]		76.2
TOTAL						--	311
GRAND TOTAL						-253.1	20,301
Average Annual 1935-72						-6.7	

TABLES B-1 through B-10. FOOTNOTES

[a] Sections designated by parentheses are located totally within area of confined groundwater.

[b] See Figure 1-5.

[c] Datum mean sea level.

[d] See Figures 5-1 and 5-2. A dash in the groundwater elevation column indicates that the section so identified is entirely outside the Santa Maria Valley groundwater basin.

[e] Values of specific yields determined by USGS unless otherwise noted. Unit values are characteristic of saturated deposits in the portion of groundwater basin above sea level. Such data represent unpublished backup for Reference 4.

[f] Portion of section is located outside the Santa Maria groundwater basin.

[g] Water elevations for these sections are not available for 1935. Groundwater in the area was not pumped until relatively recent years. Hence, 1935-72 change in storage for these sections assumed to be negligible.

[h] Value of specific yield estimated by Toups from known specific yields of adjacent sections.

[i] Unit value of specific yield used to compute total groundwater in storage was adjusted from value appearing in this table to reflect characteristics of pre-alluvium aquifers extending to base of fresh water.

[j] Portion of section is located within the area of confined groundwater. Change to groundwater elevation and change in groundwater in storage during base period reflect only unconfined portion of section.

[k] Datum in parentheses representative of elevation of the lower surface of clay strata overlying area of confined groundwater. Where two elevations are indicated, they reflect water surface elevation in unconfined portion of section and water below clay cap, respectively.

[l] Value of specific yield determined by California Department of Water Resources. [Iwanaga, 1975] Preliminary in nature.

APPENDIX C

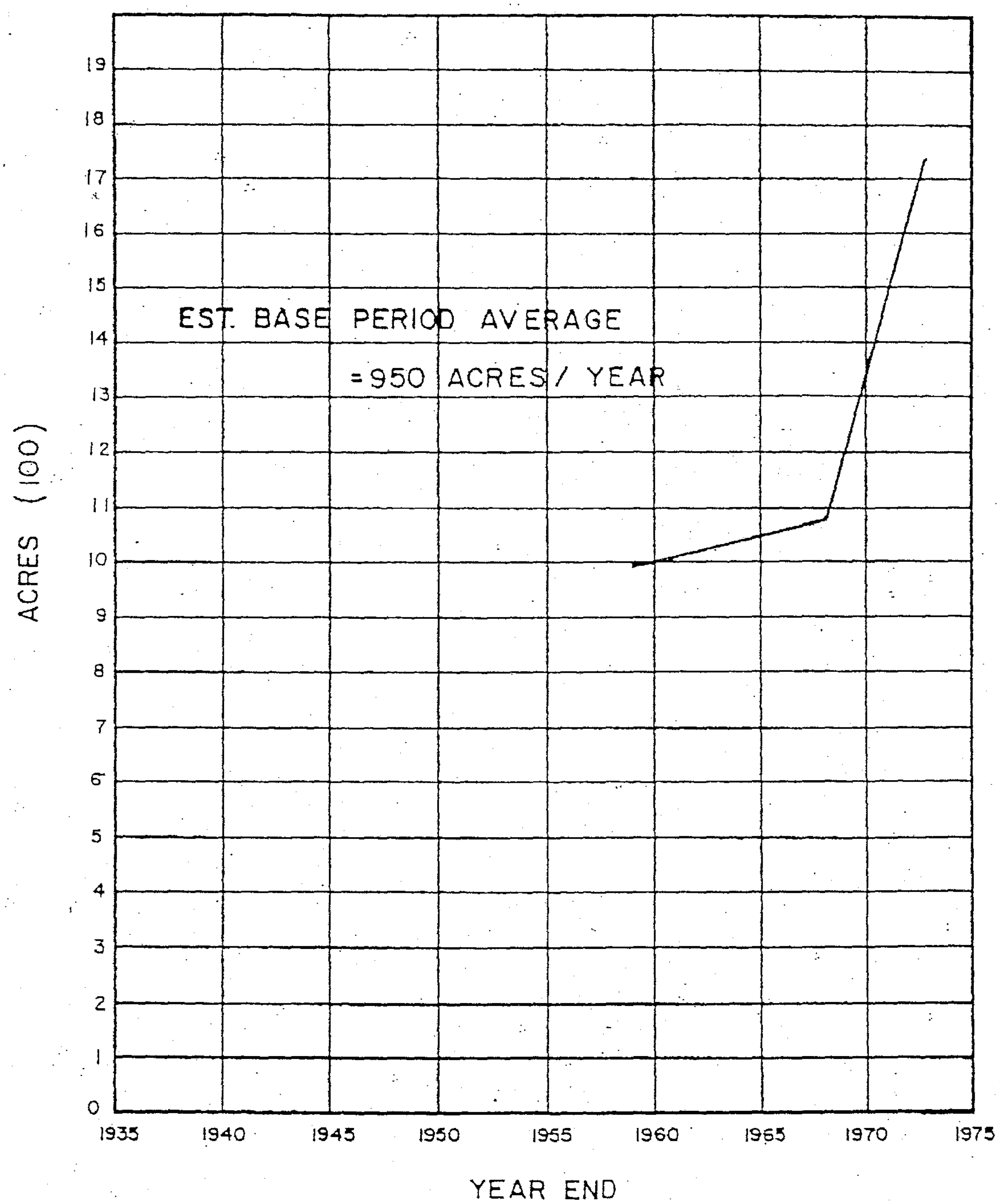


FIG.C-1 SISQUOC PLAIN, AGRICULTURAL ACREAGE
ALFALFA AND PASTURE

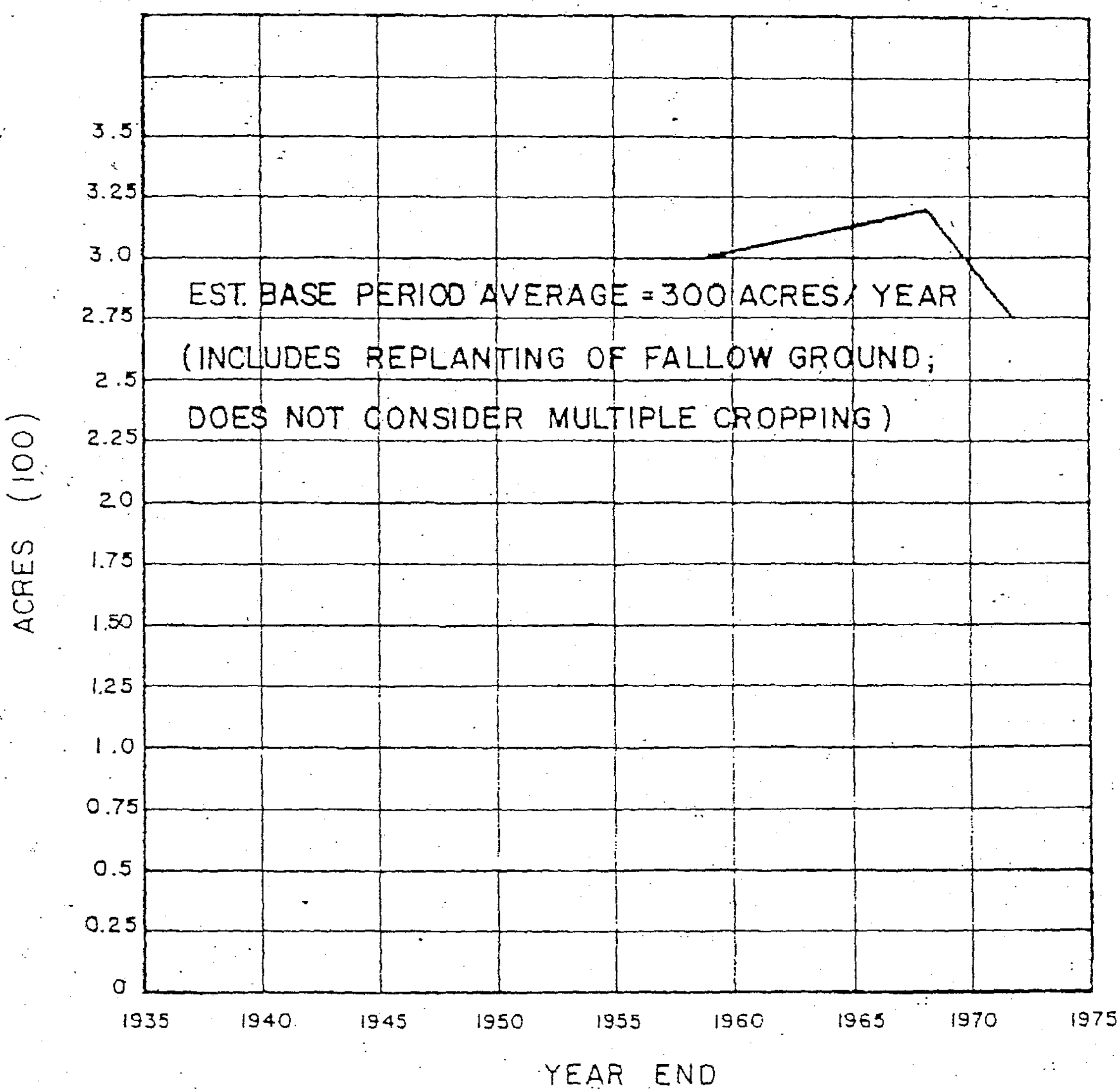


FIG. C-2 SISQUOC PLAIN, AGRICULTURAL ACREAGE
TRUCK CROPS

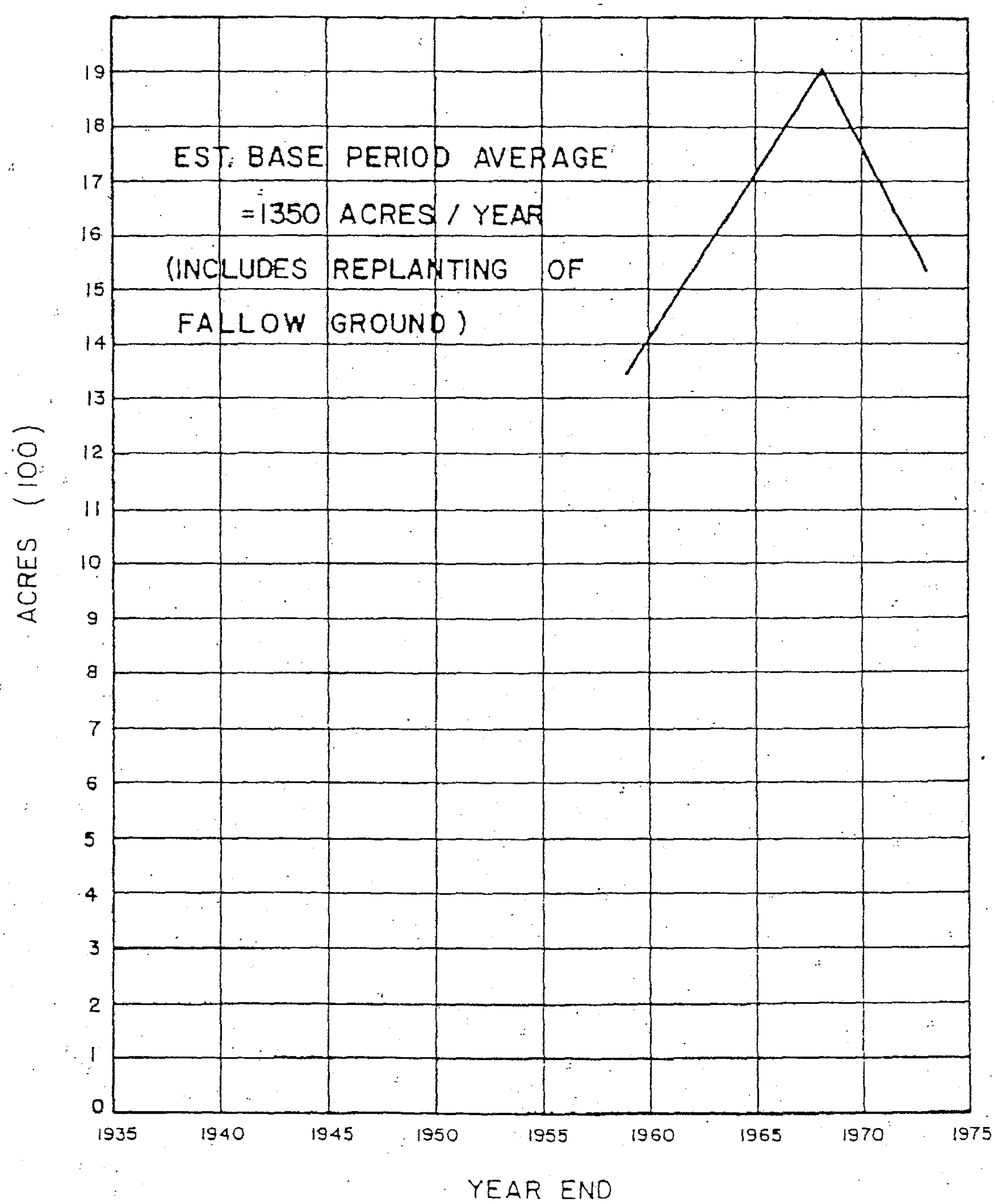


FIG. C-3 SISQUOC PLAIN, AGRICULTURAL ACREAGE
FIELD CROPS

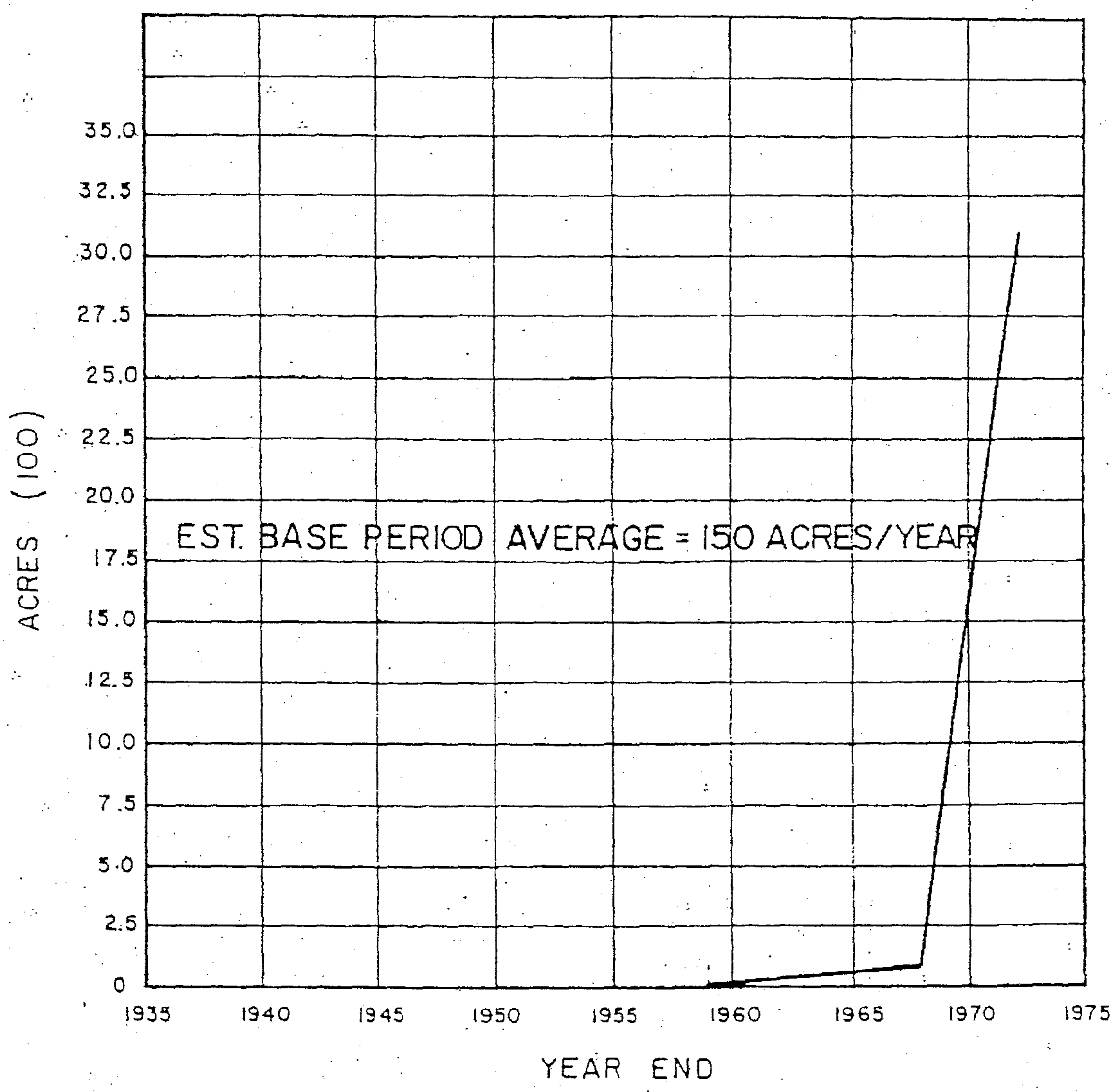


FIG. C-4 SISQUOC PLAIN, AGRICULTURAL ACREAGE
VINEYARD

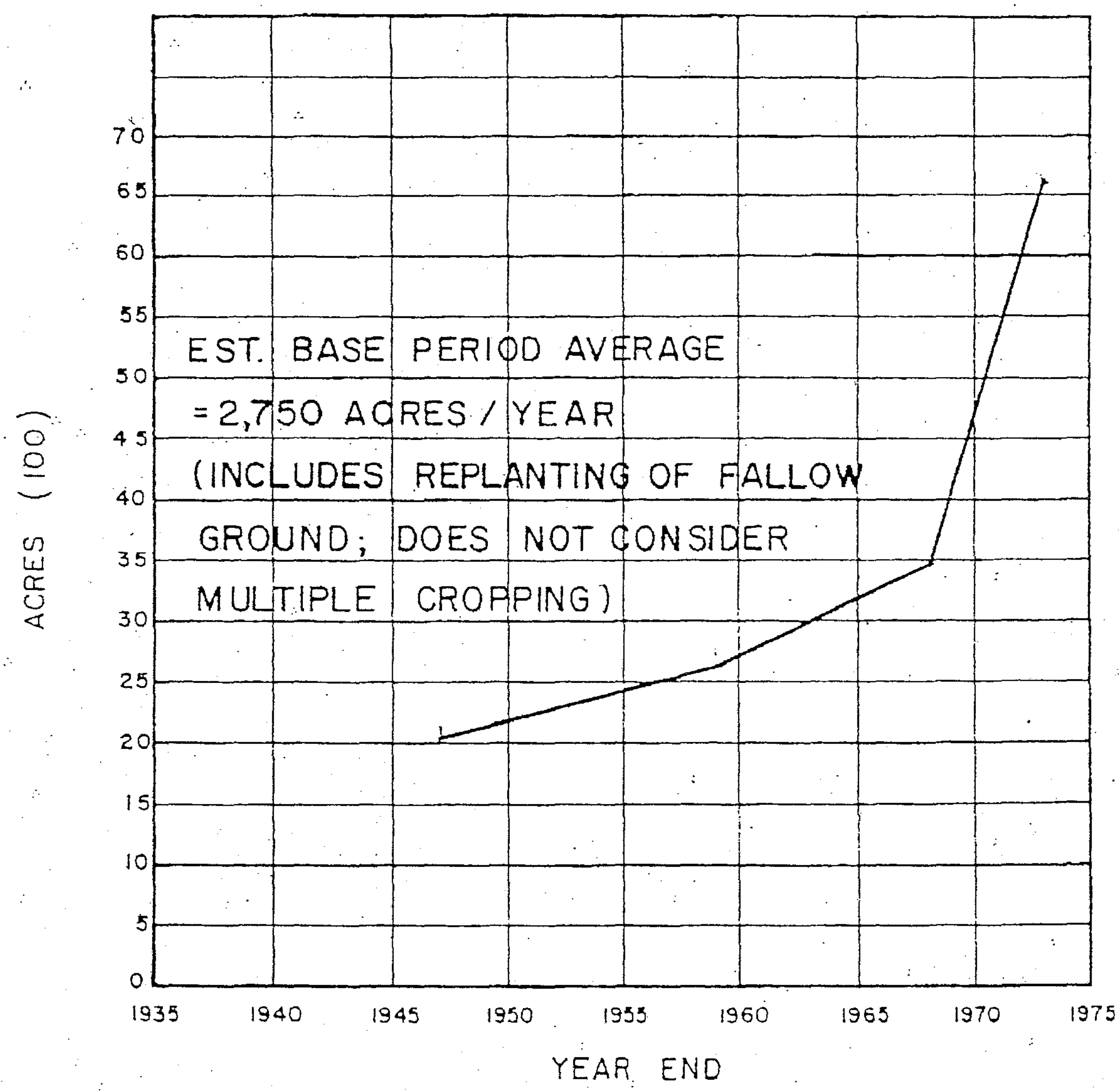


FIG. C-5 SISQUOC PLAIN, AGRICULTURAL ACREAGE

TOTAL IRRIGATED AGRICULTURE

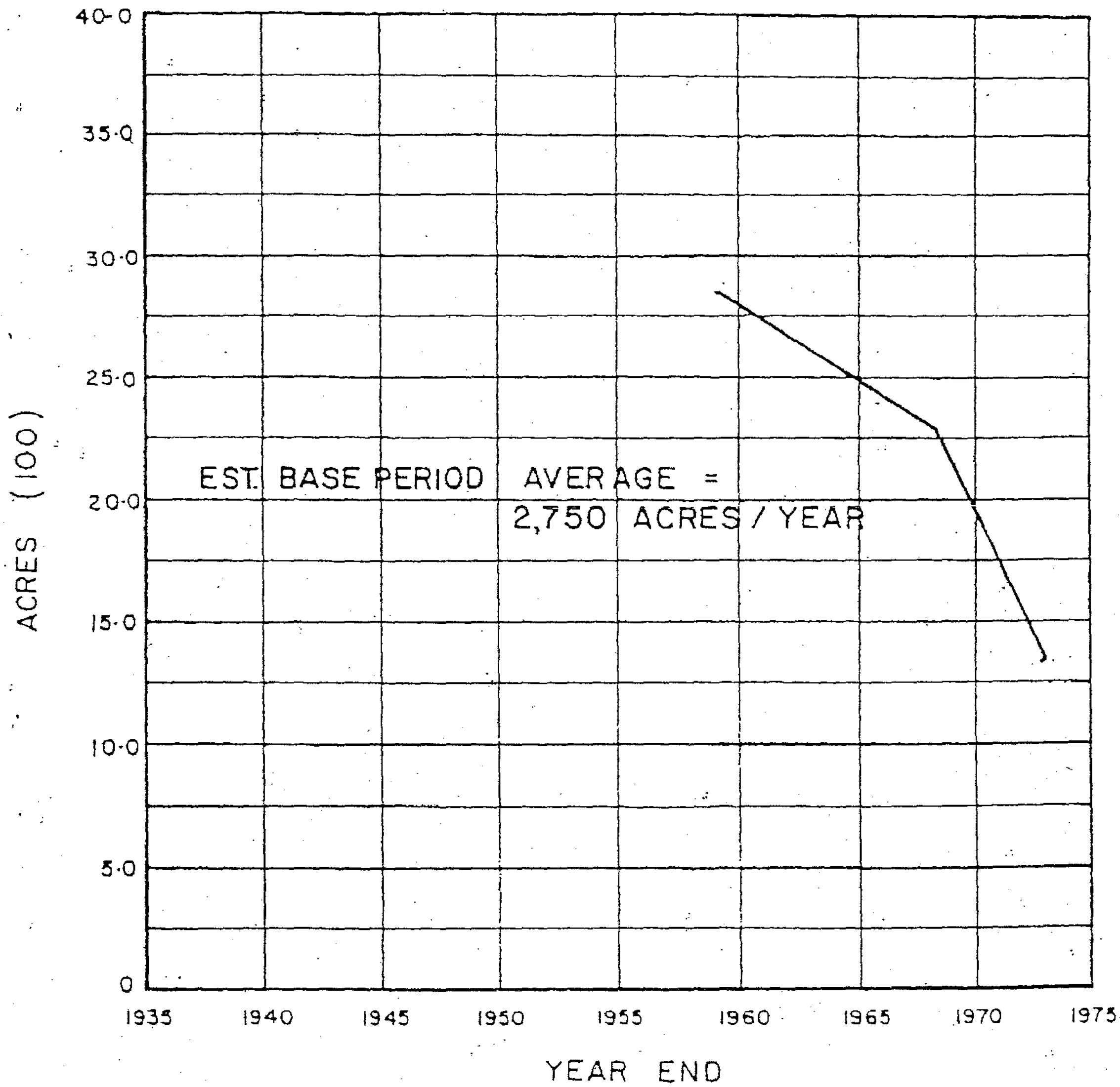


FIG. C-6 SISQUOC PLAIN, AGRICULTURAL ACREAGE
TOTAL NONIRRIGATED AGRICULTURE [a]

[a] INCLUDES GRAIN, HAY, OATS, DRYLAND BEANS, AND OTHER NON-IRRIGATED CROPS

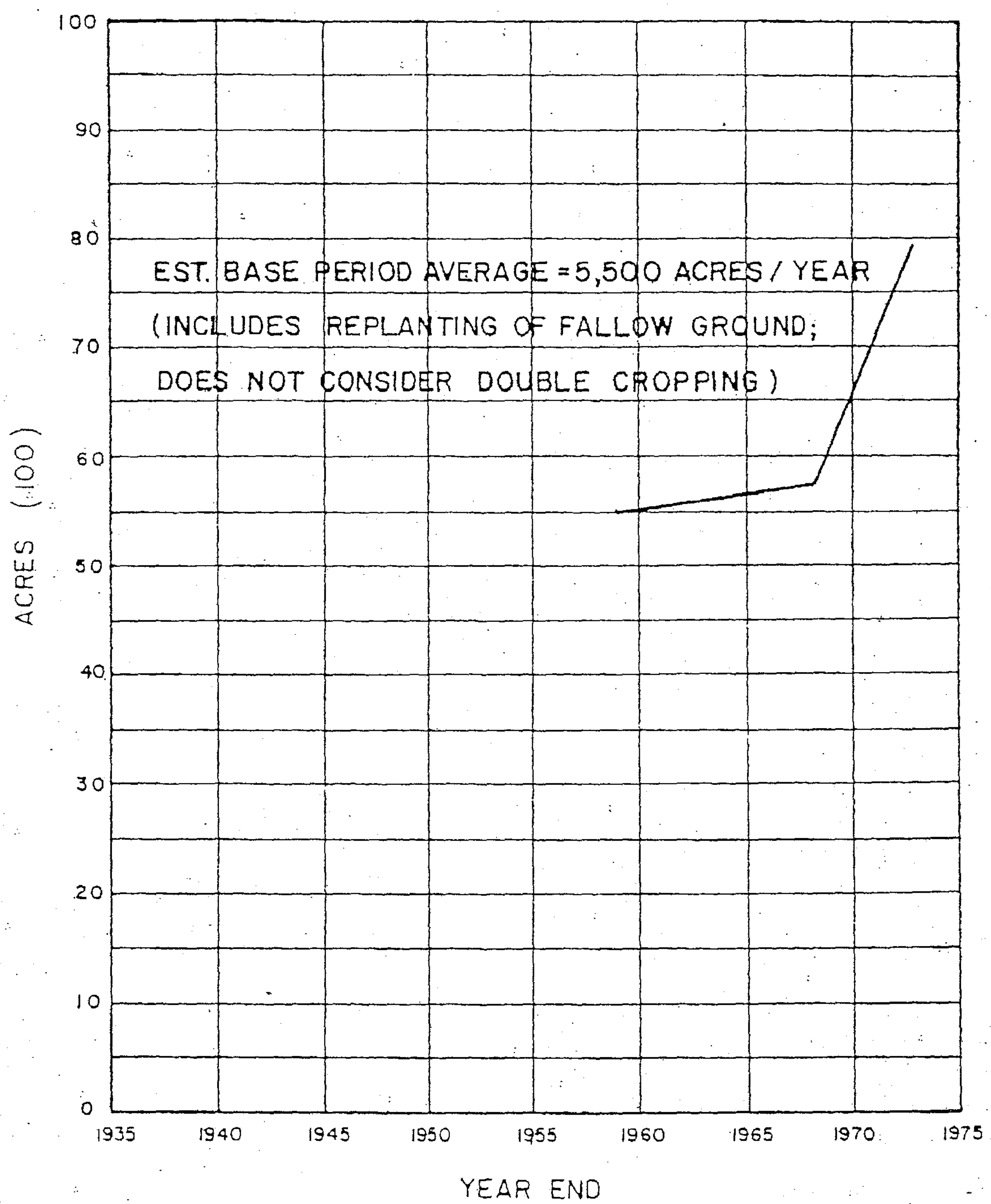


FIG. C-7 SISQUOC PLAIN, AGRICULTURAL ACREAGE
TOTAL IRRIGATED AND NONIRRIGATED AGRICULTURE

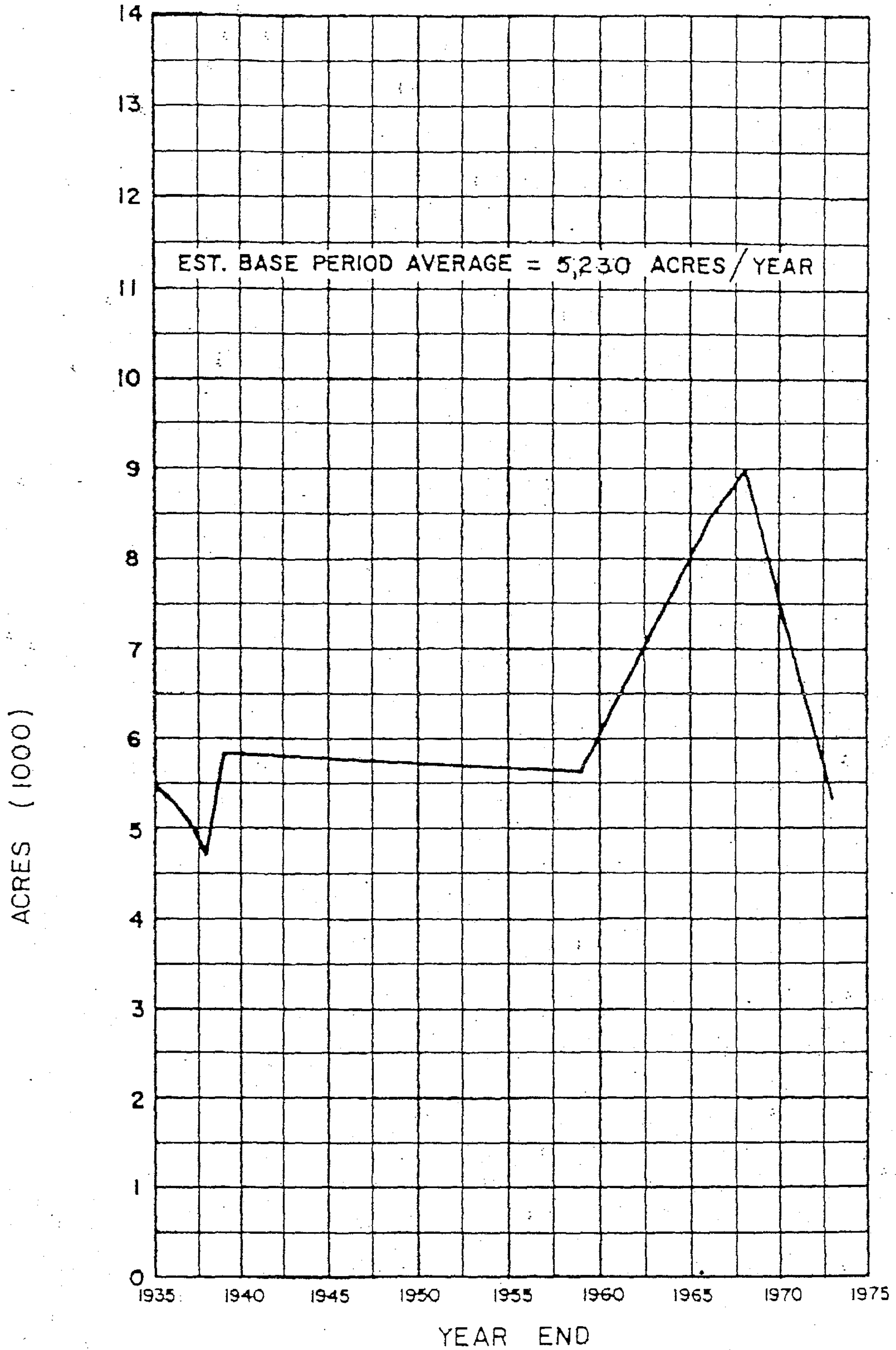


FIG. C-8 SANTA MARIA STUDY AREA AGRICULTURAL ACREAGE
ALFALFA AND PASTURE

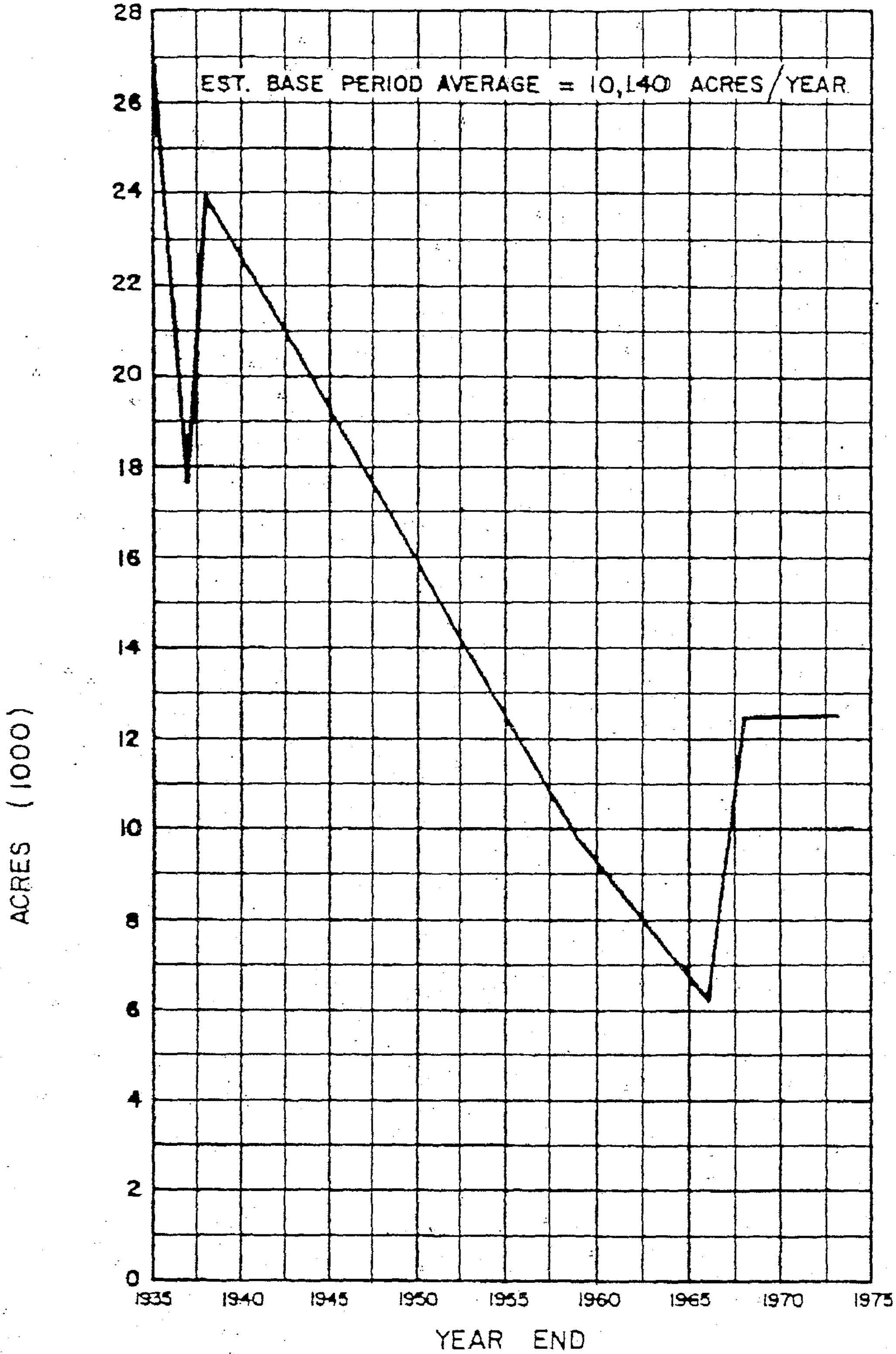


FIG. C-9 SANTA MARIA STUDY AREA AGRICULTURAL ACREAGE
FIELD CROPS

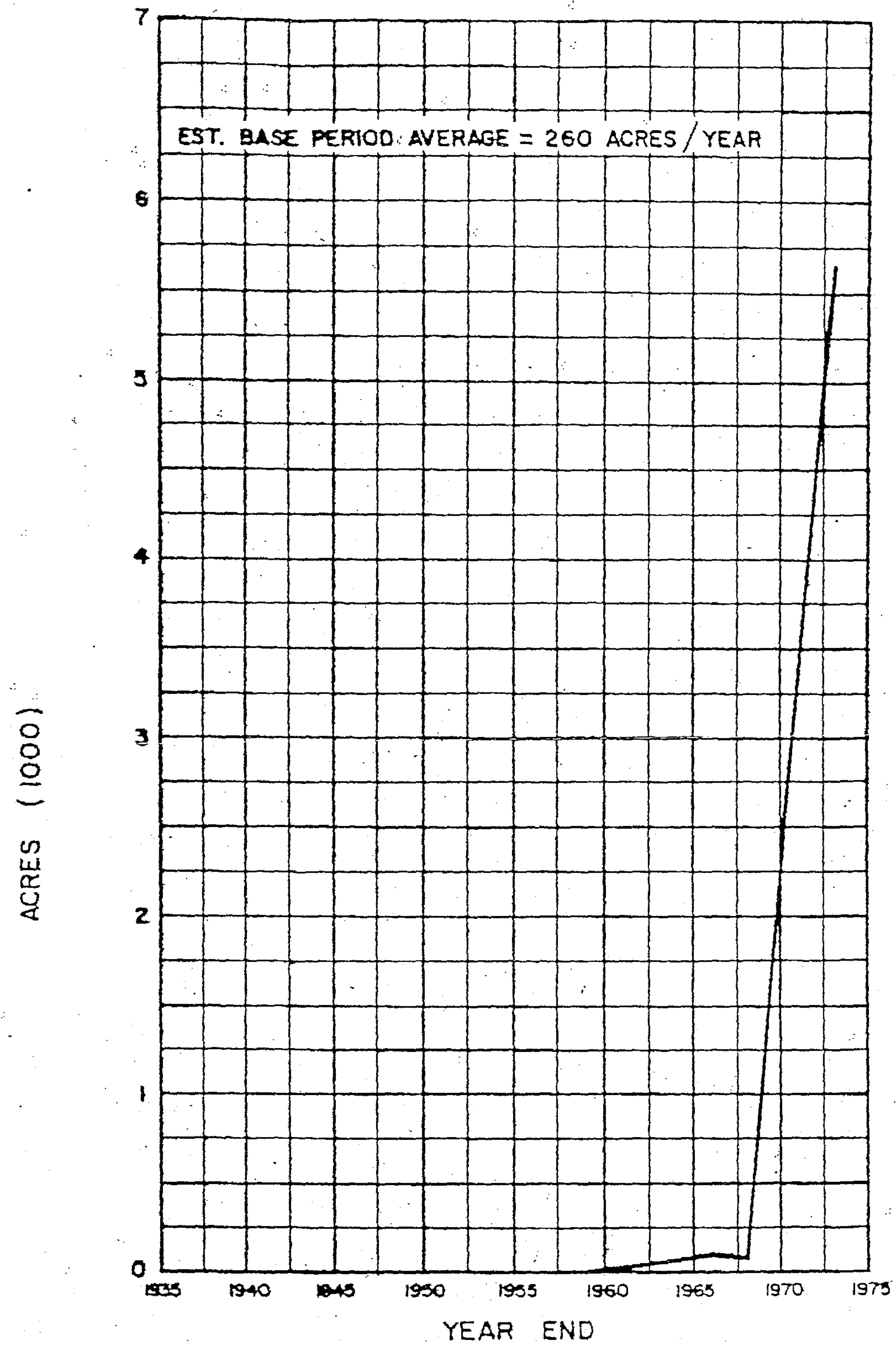


FIG. C-10 SANTA MARIA STUDY AREA AGRICULTURAL ACREAGE
VINEYARDS

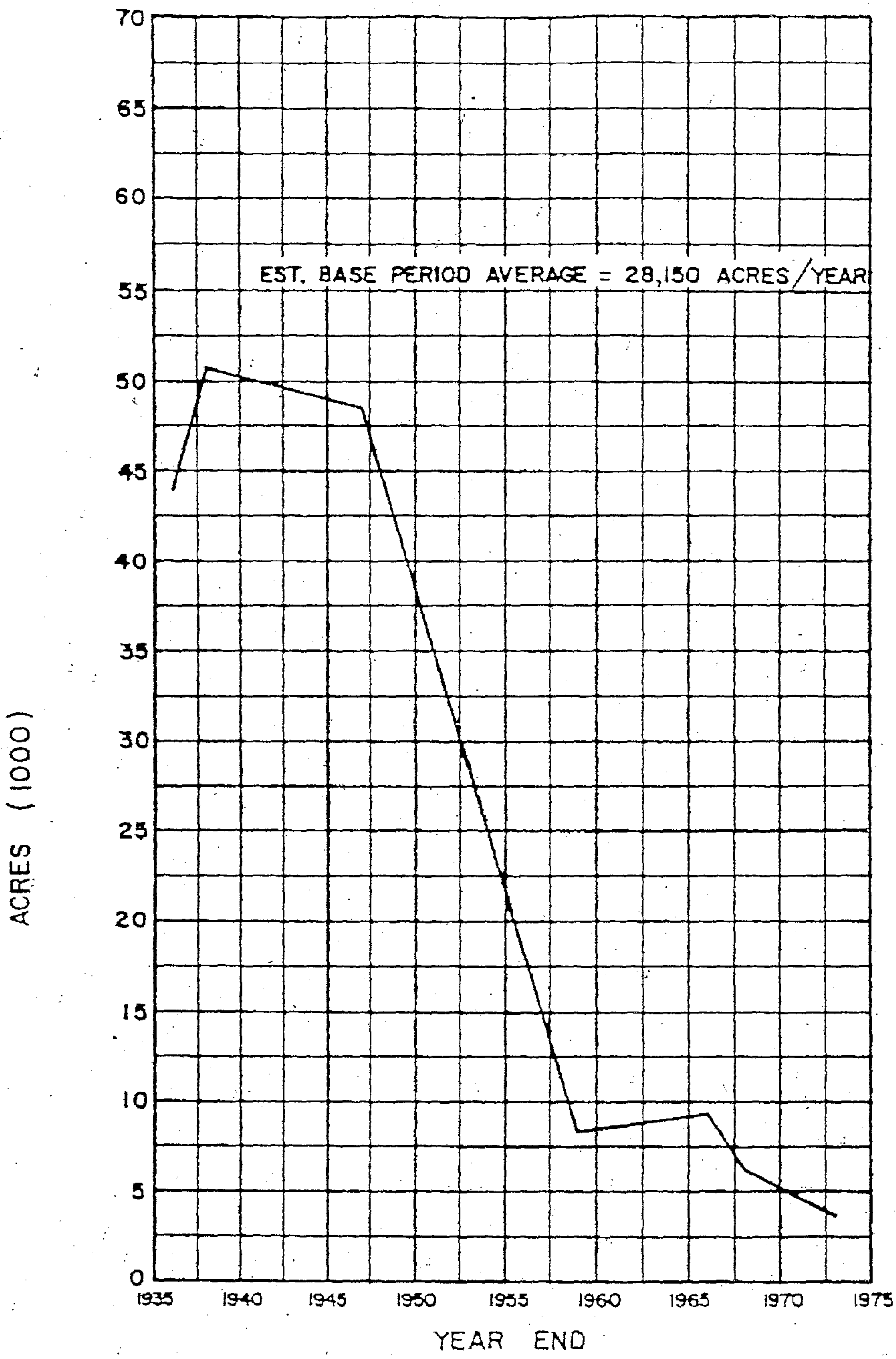


FIG. C-11 SANTA MARIA STUDY AREA AGRICULTURAL ACREAGE
NONIRRIGATED AGRICULTURE

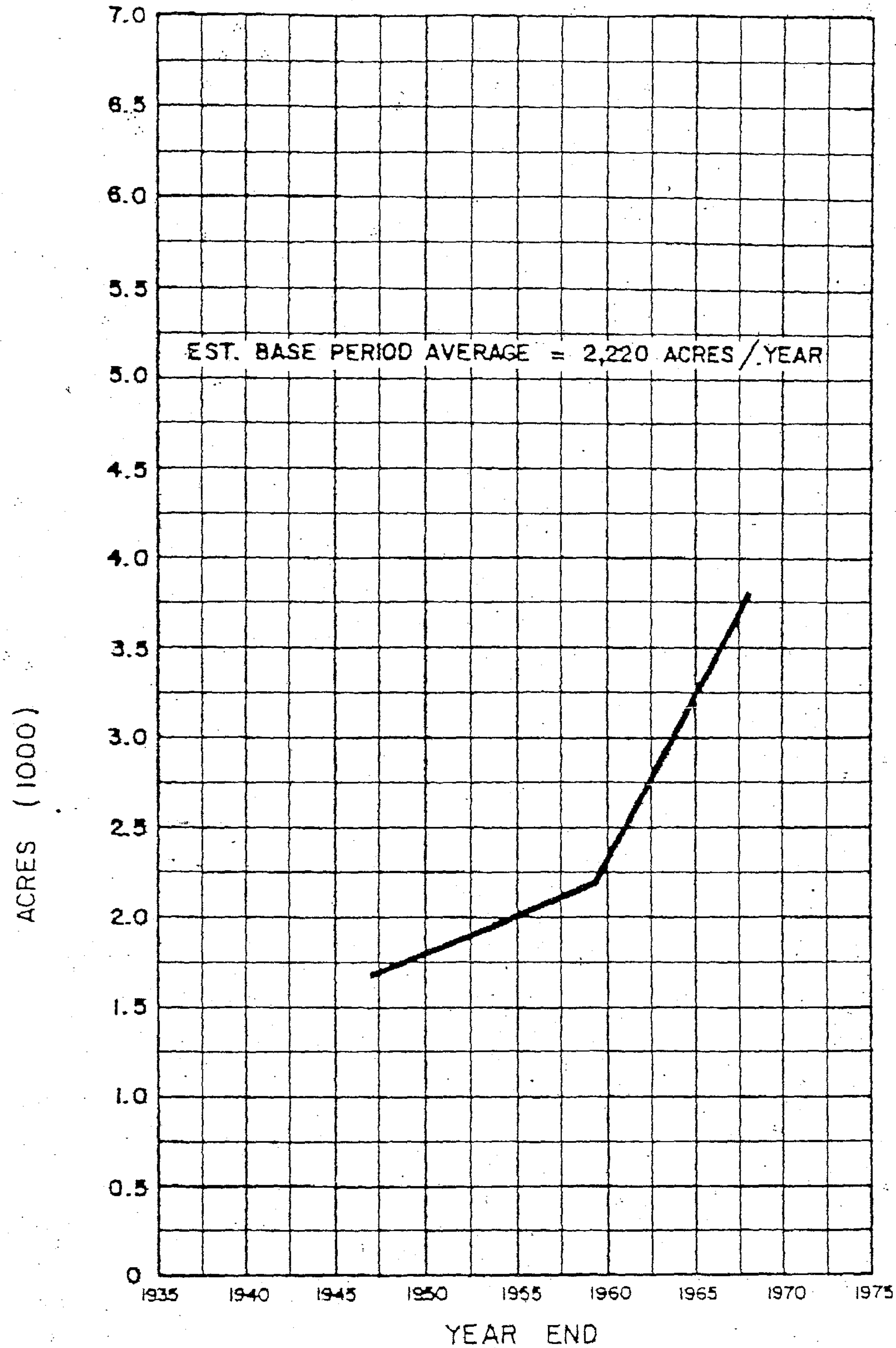


FIG. C-12 SANTA MARIA VALLEY URBAN ACREAGE

APPENDIX D

HYDROLOGIC EQUATION

METHOD 1

RECHARGE THROUGH CLAY CAP

TABLE D-1. SANTA MARIA VALLEY VEGETATIVE CONSUMPTIVE WATER USE BASE PERIOD AVERAGE ANNUAL CONDITION[a]

Land Use	Santa Maria Study Area	Sisquoc Plain	Santa Maria Valley	Estimated Growing Season Evapotranspiration ac-ft/ac	Annual consumptive water use ac-ft (1000's)
	Estimated Average Annual Acreage[b]				
Irrigated Agriculture					
Alfalfa & Pasture	5,250	950	4,300	4.08[c]	17.5
Truck crops	21,150	300	20,850	2.21[d]	46.1
Field crops	10,140	1,350	8,790	2.32[c]	20.4
Vineyard	260	150	110	1.1 [e]	0.1
Fallow	500	—	500	0.2 [c]	0.1
Subtotal	37,300	2,750	34,550		84.2
Non-Irrigated Agriculture	28,150	2,750	25,400	1.0 [f]	25.4
Native Vegetation					
Riparian[g]	2,000	20	1,980	2.1 [c]	4.2
Non-Riparian[h]	99,600	3,570	96,030[i]	1.0 [f]	38.4
Subtotal	101,600	3,590	98,010		42.6
TOTAL	167,050	9,090	157,960		152.2
River wash, dunes [g]	6,700	480	6,220	0.5 [c]	3.1
Urban	2,250	30	2,220[j]		3.4[k]
GRAND TOTAL	176,000	9,600	166,400		158.7

[a] Methodology assumes 100 percent recharge through clay cap.
[b] Refere to Tables 2-1 and 2-2; and graphs in Appendix C.
[c] Toups, 1973, Appendix F.
[d] Toups, 1973, Appendix F, modified to reflect average estimated multiple cropping practices during base period.
[e] DWR, 1975a, Table 17 modified by use of Figure 2 of the same reference to reflect nearness to the ocean.
[f] SWRB, 1962, modified by use of Figure 2 in DWR, 1975a to reflect nearness to the ocean.

[g] Based on land use maps and acreages developed by California Department of Water Resources, 1959, DWR 1964. Data reviewed by Toups, 1975.

[h] Distribution of non-riparian vegetation determined to be 20 percent light, 70 percent medium, 10 percent heavy.

[i] "Recoverable water" available to the Santa Maria Valley from a 90-square mile(57,600 acres) foothill/mountain watershed area was computed independently in Chapter 3. Therefore, non-riparian acreage considered in the computation of consumptive use is reduced by the 57,600-acre area.

[j] Base period weighted average. See Appendix C.

[k] This value was determined as follows: based on an average base period population of 37,000, and an average water consumption of 178 gpcd, the annual urban water use was calculated to be 7,300 acre-feet. Using data from SWRB, 1962 and DWR, 1965, 45 percent of the total use was estimated to be inside use and disposed of as sewage (3,300 ac-ft). The remaining 55 percent (4,000 ac-ft) was considered to be used outside with disposition as follows: 85 percent evapotranspiration (3,400 ac-ft); 15 percent deep percolation (600 ac-ft).

TABLE D-2. HYDROLOGIC INVENTORY, SANTA MARIA VALLEY BASE PERIOD AVERAGE ANNUAL CONDITION[a]

Sources of Water Supply	acft/yr[b] (1000's)
Surface inflow Fugler Point [c]	69.7
Underflow, Sisquoc River (inflow) [d]	9.9
Recoverable water, mountain/foothill area [e]	1.4
Precipitation on valley floor [f]	120.0
Subsurface Inflow, Southeast Groundwater Divide	1.0
Total Supply	202.0
Sources of Water Disposal	
Surface outflow - Santa Maria River [g]	27.0
Subsurface outflow - Santa Maria groundwater basin	8.0
Irrigated agriculture [h]	84.2
Non-irrigated agriculture and native vegetation [h]	63.8
Riparian native vegetation [h]	4.2
Urban water consumption [h]	
Indoor	negl.
Outdoor	3.4
Industrial water consumption	5.0
Livestock water consumption	1.0
Transbasin export [i]	negl.
Other [j]	3.1
Total Disposal	199.7

[a] Methodology assumes 100 percent recharge through clap cap.
[b] Average throughout base period.
[c] Combined Sisquoc and Cuyama River flows (see Table 3-7).
[d] See Table 6-2.
[e] Ninety square-mile mountain/foothill area (see Table 3-5).
[f] See Table 3-3. Considers precipitation over confined groundwater area.
[g] USGS gaging station 11141000, Santa Maria River at Guadalupe (see Table 3-6).
[h] See Table D-1.
[i] Union Oil Company exports water from the Santa Maria groundwater basin to the community of Casmalia (15.13 af/yr). [Lunt, 1975] Union Oil also furnishes water to the Airox Mine. This mine is located within the Santa Maria Valley, however.
[j] River wash.

TABLE D-3. SANTA MARIA VALLEY VEGETATIVE CONSUMPTIVE WATER USE PRESENT CONDITION [a]

Land Use	Acreage Santa Maria Valley [a]	Estimated Growing Season Evapotranspiration (ac-ft/ac)	Annual consumptive water use ac-ft (100's)
Alfalfa & Pasture	4,800	4.08[g]	19.6
Truck crops [c]	26,600	2.38[h]	63.3
Field crops [d]	8,000	2.32[g]	18.6
Vineyard	1,500	1.1[i]	1.6
Fallow	500	0.2[g]	0.1
Subtotal	41,400		103.2
Non-Irrigated Agriculture	200	1.0[j]	0.2
Native Vegetation			
Riparian[e]	1,980	2.1[g]	4.2
Non-Riparian[f]	112,790	1.0[j]	55.2
Subtotal	114,770		59.4
TOTAL	156,370		162.8
River wash, dunes[e]	6,220	0.5[g]	3.1
Urban	3,810[l]		6.9[k]
GRAND TOTAL	166,400		172.8

[a] Methodology assumes 100 percent recharge through clay cap.
[b] Based on 1975 acreages except as noted. Data from UCSB, 1974, adjuseted by estimating and discounting acreages in Sisquoc Plain.
[c] Truck crop and field crop survey acres for 1975 reflect amount of fallow acreage for that year that was replanted in each crop.
[d] Field crop acreage includes acreage in ornamentals.
[e] Based on land use maps and acreages developed by California Department of Water Resources, 1959, [DWR, 1964]. Data reviewed by Toups, 1975.
[f] "Recoverable water" available to the Santa Maria Valley from a 90-square mile (57,600 acres) foothill/mountain watershed area was computed independently in Chapter 3. Therefore, non-riparian acreage considered in the computation of consumptive use is reduced by the 57,600-acre area.

[g] Toups, 1973. Appendix F.

[h] Toups, 1973, Appendix F, modified to reflect multiple cropping practices.

[i] DWR, 1975a. Table 17, and modified by use of Figure 2 of the same reference to reflect nearness to the ocean.

[j] SWRB, 1962, and modified by use of Figure 2 in DWR, 1975a to reflect nearness to the ocean.

[k] This value was determined as follows: based on the 1974 population of 68,326 (Table 2-5), and an average water consumption of 192 gpcd (Table 6-5), the annual urban water use was calculated to be 14,700 acre-feet. [Toups, 1973; SWRB, 1962]. 45 percent of the total use was estimated to be inside use and disposed of as sewage (6,600 ac-ft). The remaining 55 percent (8,100 ac-ft) was considered to be used outside with disposition as follows: 85 percent evapotranspiration (6,900 ac-ft); 15 percent deep percolation (1,200 ac-ft).

[l] DWR, 1969.

HYDROLOGIC EQUATION

METHOD 2

NEGLIGIBLE RECHARGE THROUGH CLAY CAP

TABLE D-4. HYDROLOGIC INVENTORY, SANTA MARIA VALLEY PRESENT CONDITION [a]

Sources of Water Supply	acft/yr [b] (1000's)
Surface inflow Fugler Point [c]	68.0
Underflow, Sisquoc River (inflow) [d]	9.9
Recoverable water, mountain/foothill area [e]	1.4
Precipitation on valley floor [f]	120.0
Subsurface Inflow, Southeast Groundwater Divide	1.0
Total Supply	200.3
Sources of Water Disposal	
Surface outflow - Santa Maria River [g]	13.1
Subsurface outflow - Santa Maria groundwater basin	2.0
Irrigated agriculture [h]	103.2
Non-irrigated agriculture and non-riparian native vegetation [h]	55.4
Riparian native vegetation [h]	4.2
Urban water consumption [h]	
Indoor	negl.
Outdoor	6.9
Industrial water consumption	6.0
Livestock water consumption	1.0
Transbasin export [i]	negl.
Other [j]	3.1
Total Disposal	194.9

[a] Methodology assemes 100 percent recharge through clay cap.
[b] Based on 1975 acreages. [UCSB, 1975]
[c] Combined Sisquoc and Cuyama River flows (see Appendix E).
[d] See Table 6-2.
[e] Ninety square-mile mountain/foothill area (see Table 3-5).
[f] See Table 3-3.
[g] USGS gaging station 11141000, Santa Maria River at Guadalupe (see Appendix E).
[h] See Table D-3.
[i] Union Oil Company exports water from the Santa Maria groundwater basin to the community of Casmalia (15.13 af/yr). [Lunt, 1975] Union Oil also furnishes water to the Airox Mine. This mine is located within the Santa Maria Valley, however.
[j] River wash.

TABLE D-5. SANTA MARIA VALLEY APPLIED WATER USE - CONFINED GROUNDWATER AREA BASE PERIOD AVERAGE ANNUAL CONDITION [a]

Land Use	Estimated Average Annual Acreage [b]	Estimated Total Applied Water ac-ft/ac	Annual water use ac-ft (1000's)
Irrigated Agriculture			
Alfalfa & Pasture	1,120	4.20[c]	4.7
Truck crops	12,640	1.77[c]	22.4
Field crops	2,240	1.92[c]	4.3
Vineyard	--	--	--
Fallow	240	--	--
Subtotal	16,240		31.4
Non-Irrigated Agriculture and Non-Riparian Native Vegetation	12,360		--
Riparian Native Vegetation	550[d]		
Subtotal	12,910		--
TOTAL	29,150		31.4
River wash, dunes	2,500[d]		--
Urban	350		1.0[e]
GRAND TOTAL	32,000		32.4

[a] Methodology assumes negligible recharge through clay cap.

[b] Irrigated agricultural acreage over the confined groundwater area represented 47 percent and 48 percent, respectively, of the total for the Valley indentified during the 1959 and 1968 DWR land use surveys. Individual categories of crops over the confined area were proportioned as follows: Truck: 79% of total crops; [DWR, 1967] field and pasture: 21% of total crops [DWR, 1967] individually prorated according to distribution for total Valley, (14% and 7%, respectively of crops over confined area). Fallow acreage: 47% of total Valley fallow.

[c] Irrigation efficiency was estimated to be 70 percent (Reference 205), and 85 percent of the total rainfall was estimated to be consumptively used. [SWRB, 1962] The applied water value was therefore calculated as follows: [Estimated annual evapotranspiration (from Table D-6) - (1.0-inch rainfall x 0.85)] x 1.30 = Applied water.

[d] Based on land-use maps and acreages developed by California Department of Water Resources, 1959. [DWR, 1964] Data reviewed by Toups, 1975.

[e] Average City annual water use of City of Guadalupe (rounded).

TABLE D-6. SANTA MARIA VALLEY CONSUMPTIVE WATER USE - UNCONFINED GROUNDWATER AREA BASE PERIOD AVERAGE ANNUAL CONDITION [a]

Land Use	Estimated Average Annual Acreage [b]	Estimated Annual Evapotrans-piration ac-ft/ac	Annual consumptive water use ac-ft (1000's)
Alfalfa & Pasture	3,180	4.08[c]	13.0
Truck crops	8,210	2.21[d]	18.2
Field crops	6,550	2.32[c]	15.2
Vineyard	110	1.1 [e]	0.1
Fallow	260	0.5 [f]	0.1
Subtotal	21,950		46.6
Non-Irrigated Agriculture and Non-Riparian Native Vegetation	109,070[g]	1.0 [h]	51.5
Riparian Native Vegetation	1,430	2.1 [c]	3.0
Subtotal	110,500		54.5
TOTAL	128,810		101.1
River wash, dunes [h]	3,720	0.5 [f]	1.9
Urban	1,870		3.2 [i]
GRAND TOTAL	134,400		106.2

[a] Methodology assumes negligible recharge through clay cap.
[b] Toups, 1973, Appendix F.
[c] Toups, 1973, Appendix F, modified to reflect average estimated multiple cropping practices during base period.
[e] DWR, 1975d, Table 17 and modified by use of Figure 2 of the same reference to reflect nearness to the ocean.

[f] SWRB, 1962.

[g] "Recoverable water" available to the Santa Maria Valley from a 90-square mile (57,600 acres) foothill/mountain watershed area was computed independently in Chapter 3. Therefore, non-riparian acreage considered in the computation of consumptive use is reduced by the 57,600-acre area.

[h] SWRB, 1962. modified by Figure 2 in Reference 62 to reflect nearness to the ocean.

[i] This value was determined as follows: based on an average base period population over the unconfined area of 34,000, and an average water consumption of 178 gpcd, the annual urban water use was calculated to be 6,800 acre-feet. Using data from Reference 201 and 202, 45 percent of the total use was estimated to be inside use and disposed of as sewage (3,100 ac-ft). The remaining 55 percent (3,700 ac-ft) was considered to be used outside, with disposition as follows: 85 percent evapotranspiration (3,200 ac-ft); 15 percent deep percolation (500 ac-ft).

TABLE D-7. HYDROLOGIC INVENTORY, SANTA MARIA VALLEY
BASE PERIOD AVERAGE CONDITION [a]

Sources of Water Supply	acft/yr[b] (1000's)
Surface inflow Fugler Point [c]	69.7
Underflow, Sisquoc River (inflow) [d]	9.9
Recoverable water, mountain/foothill area [e]	1.4
Precipitation on valley floor [f]	88.0
Subsurface Inflow, Southeast Groundwater Divide	1.0
Total Supply	170.0
Sources of Water Disposal	
Surface outflow - Santa Maria River [g]	27.0
Subsurface outflow - Santa Maria groundwater basin	8.0
Irrigated agriculture [h]	78.0
Non-irrigated agriculture and native vegetation [h]	51.5
Riparian native vegetation [h]	3.0
Urban water consumption [h]	
Indoor	negl.
Outdoor	3.2
Industrial water consumption	5.0
Livestock water consumption	1.0
Transbasin export [i]	negl.
Other [j]	1.9
Total Disposal	178.6

[a] Methodology assumes negligible recharge through clay cap.
[b] Average throughout base period.
[c] Combined Sisquoc and Cuyama River flows (see Table 3-7).
[d] See Table 6-2.
[e] Ninety square-mile mountain/foothill area (see Table 3-5).
[f] See Table 3-3. Does not consider precipitation over confined groundwater area.
[g] USGS gaging station 11141000, Santa Maria River at Guadalupe (see Table 3-6).
[h] See Table D-6.
[i] Union Oil Company exports water from the Santa Maria groundwater basin to the community of Casmalia (15.13 af/yr). [Lunt, 1975] Union Oil also furnishes water to the Airox Mine. This mine is located within the Santa Maria Valley, however.
[j] River wash.

TABLE D-8. SANTA MARIA VALLEY APPLIED WATER USE - CONFINED GROUNDWATER AREA PRESENT CONDITION [a]

Land Use	Estimated Average Annual Acreage [b]	Estimated Total Applied Water ac-ft/ac	Annual water use ac-ft (1000's)
Irrigated Agriculture			
Alfalfa & Pasture	1,345	4.20[c]	5.6
Truck crops	15,175	1.99[c]	30.2
Field crops	2,690	1.92[c]	5.2
Vineyard	--	--	--
Fallow	240	--	--
Subtotal	19,450		41.0
Non-Irrigated Agriculture and Non-Riparian Native Vegetation	9,150		--
Riparian Native Vegetation	550		--
Subtotal	9,700		--
TOTAL	29,150		41.0
River wash, dunes	2,500		--
Urban	350		1.0
GRAND TOTAL	32,000		42.0

[a] Methodology assumes negligible recharge through clay cap.

[b] Irrigated agricultural acreage over the confined groundwater area represented 47 percent and 48 percent, respectively, of the total for the Valley indentified during the 1959 and 1968 DWR land use surveys. Individual categories of crops over the confined area were proportioned as follows: Truck: 79% of total crops; [DWR, 1967] field and pasture: 21% of total crops; [DWR, 1967] individually prorated according to distribution for total Valley, (14% and 7%, respectively of crops over confined area). Fallow acreage: 47% of total Valley fallow. Assumed to reflect the existing culture.

[c] Irrigation efficiency was estimated to be 70 percent. [USDA, 1963] 85 percent of the total rainfall was estimated to be consumptively used. [SWRB, 1962] The applied water value was therefore calculated as follows: [Estimated annual evapotranspiration (from Table D-9) minus (1.0-inch rainfall x 0.85)] x 1.30 = Applied water.

[d] Based on land-use maps and acreages developed by California Department of Water Resources, 1959. [DWR, 1964] Data reviewed by Toups, 1975. Assumed to reflect the present culture.

[e] Average City annual water use of City of Guadalupe (rounded).

TABLE D-9. SANTA MARIA VALLEY CONSUMPTIVE WATER USE - UNCONFINED GROUNDWATER AREA PRESENT CONDITION [a]

Land Use	Estimated Average Annual Acreage [b]	Estimated Annual Evapotranspiration ac-ft/ac	Annual consumptive water use ac-ft (1000's)
Alfalfa & Pasture	3,455	4.08[c]	14.1
Truck crops	11,425	2.38[d]	27.2
Field crops	5,310	2.32[c]	12.3
Vineyard	1,500	1.1[e]	1.6
Fallow	260	0.5[f]	0.1
Subtotal	21,950		55.3
Non-Irrigated Agriculture and Non-Riparian Native Vegetation	103,840[g]	1.0[h]	46.2
Riparian Native Vegetation	1,430	2.1[c]	3.0
Subtotal	105,270		49.2
TOTAL	127,220		104.5
River wash, dunes [h]	3,720	0.5[f]	1.9
Urban	3,460		6.6[i]
GRAND TOTAL	134,400		113.0

[a] Methodology assumes negligible recharge through clay cap.
[b] Irrigated acreage over the unconfined groundwater area assumed to represent 53 percent of the total for the valley.
[c] Toups, 1973, Appendix F.
[d] Toups, 1973, Appendix F. Modified to reflect present multiple cropping practices.
[e] DWR, 1875, Table 17, and modified by use of Figure 2 of the same reference to reflect nearness to the ocean.

[f] USDA, 1963.

[g] "Recoverable water" available to the Santa Maria Valley from a 90-square mile (57,600 acres) foothill/mountain watershed area was computed independently in Chapter 3. Therefore, non-riparian acreage considered in the computation of consumptive use is reduced by the 57,600-acre area.

[h] SWRB, 1962. Modified by Figure 2 DWR, 1975a to reflect nearness to the ocean.

[i] This value was determined as follows: based on the 1974 population over the unconfined area of 65,000 and an average water consumption of 192 gpcd, the annual urban water use was calculated to be 14,000 acre-feet. Forty-five percent of the total use was estimated to be inside use and disposed of as sewage (6,300 ac-ft). The remaining 55 percent (7,700 ac-ft) was considered to be used outside with disposition as follows: 85 percent evapotranspiration (6,550 ac-ft); 15 percent deep percolation (1,150 ac-ft). [SWRB, 1962; DWR, 1965]

TABLE D-10. HYDROLOGIC INVENTORY, SANTA MARIA VALLEY EXISTING CONDITION [a]

Sources of Water Supply	ac-ft/yr [b] (1000's)
Surface inflow - Fugler Point [c]	68.0
Underflow, Sisquoc River (inflow) [d]	9.9
Recoverable water, mountain/foothill area [e]	1.4
Precipitation on valley floor [f]	88.0
Subsurface Inflow, Southeast Groundwater Divide	1.0
Total Supply	168.3
Sources of Water Disposal	
Surface outflow - Santa Maria River [g]	13.1
Subsurface outflow - Santa Maria groundwater basin	2.0
Irrigated agriculture [h]	96.3
Non-irrigated agriculture and non-riparian native vegetation [h]	46.2
Riparian native vegetation [h]	3.0
Urban water consumption [h]	
Indoor	negl.
Outdoor	7.6
Industrial water consumption	6.0
Livestock water consumption	1.0
Transbasin export [i]	negl.
Other [j]	1.9
Total Disposal	177.1

[a] Methodology assumes negligible recharge through clay cap.
[b] Based on 1975 acreages. [ucsb, 1975]
[c] Combined Sisquoc and Cuyama River flows (see Appendix E).
[d] See Table 6-2.
[e] Ninety square-mile mountain/foothill area (see Table 3-5).
[f] See Table 3-3.
[g] USGS gaging station 11141000, Santa Maria River at Guadalupe (see Appendix E).
[h] See Table D-9.
[i] Union Oil Company exports water from the Santa Maria groundwater basin to the community of Casmalia (15.13 af/yr). [Lunt, 1975] Union Oil also furnishes water to the Airox Mine. This mine is located within the Santa Maria Valley, however.
[j] River wash.

APPENDIX E

FIG. E-1

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 9N32W7N1

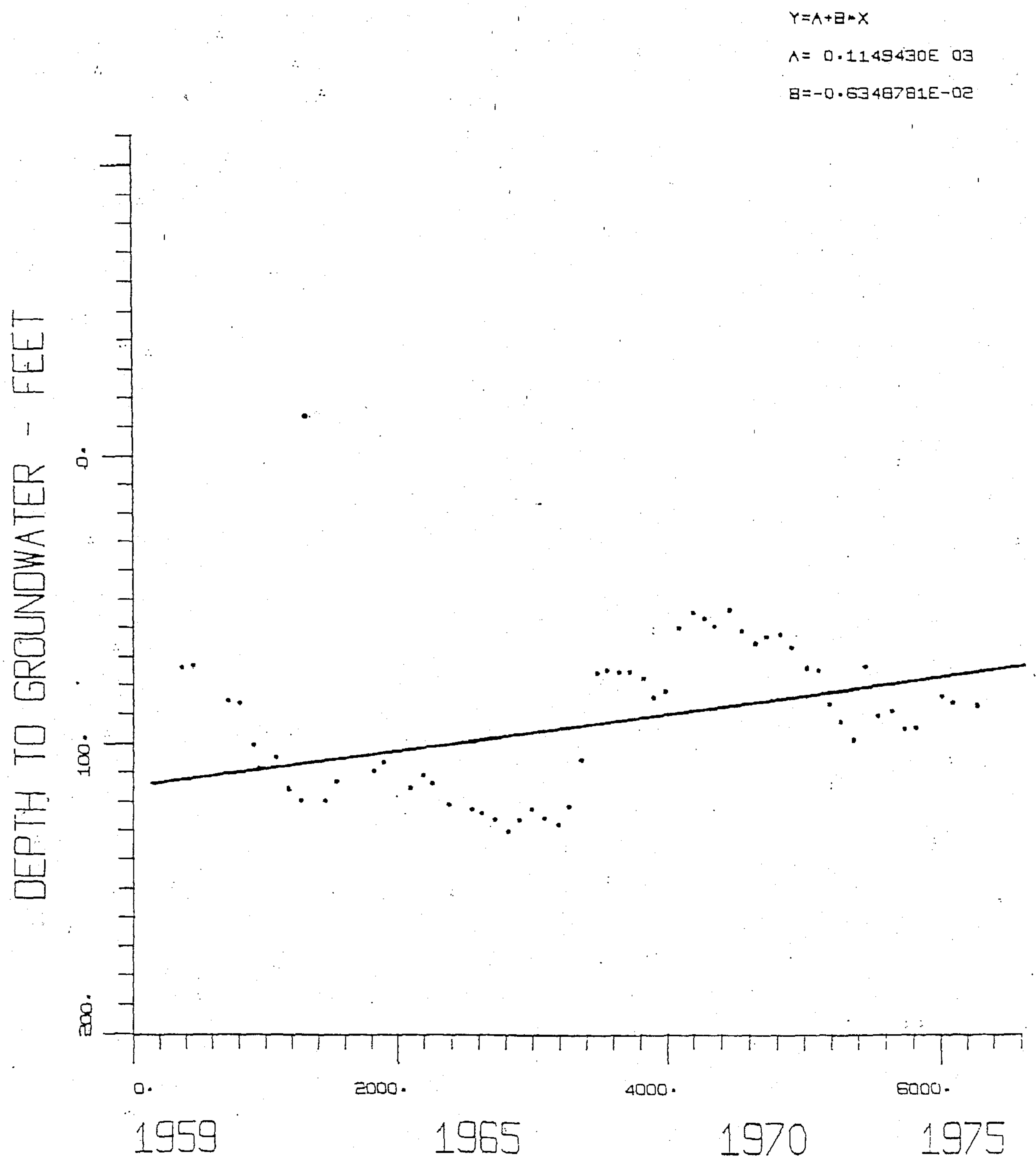


FIG. E-2

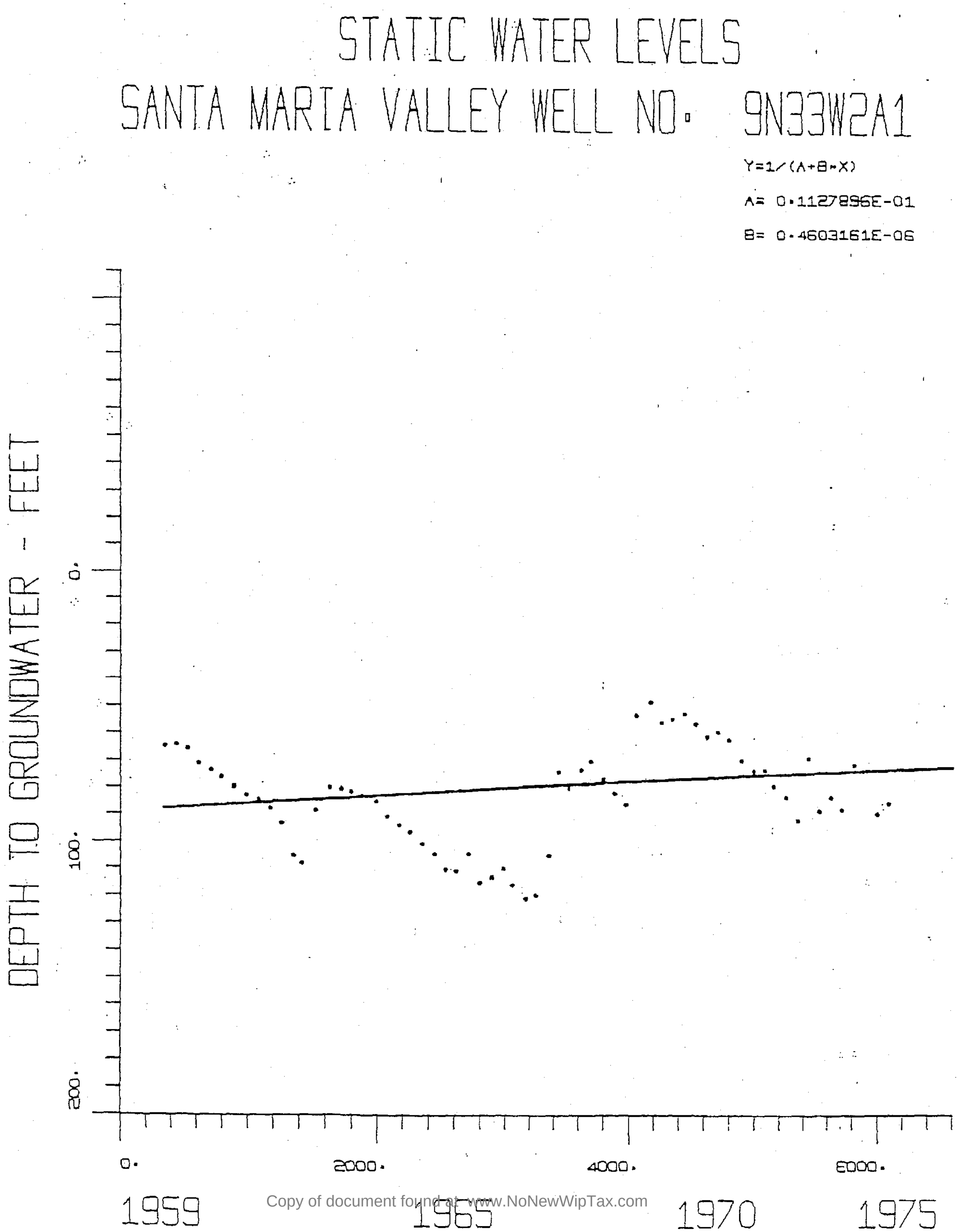

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 9N33W2A1
Y=1/(A+B*X)
A= 0.1127896E-01
B= 0.4603161E-06
DEPTH TO GROUNDWATER - FEET
0.
100.
200.
0.
2000.
4000.
6000.
1959
1965
1970
1975

FIG. E-3

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 9N33W8L1

Y=X/(A+B*X)

A= 0.9484085E-01

B= 0.1724526E-02

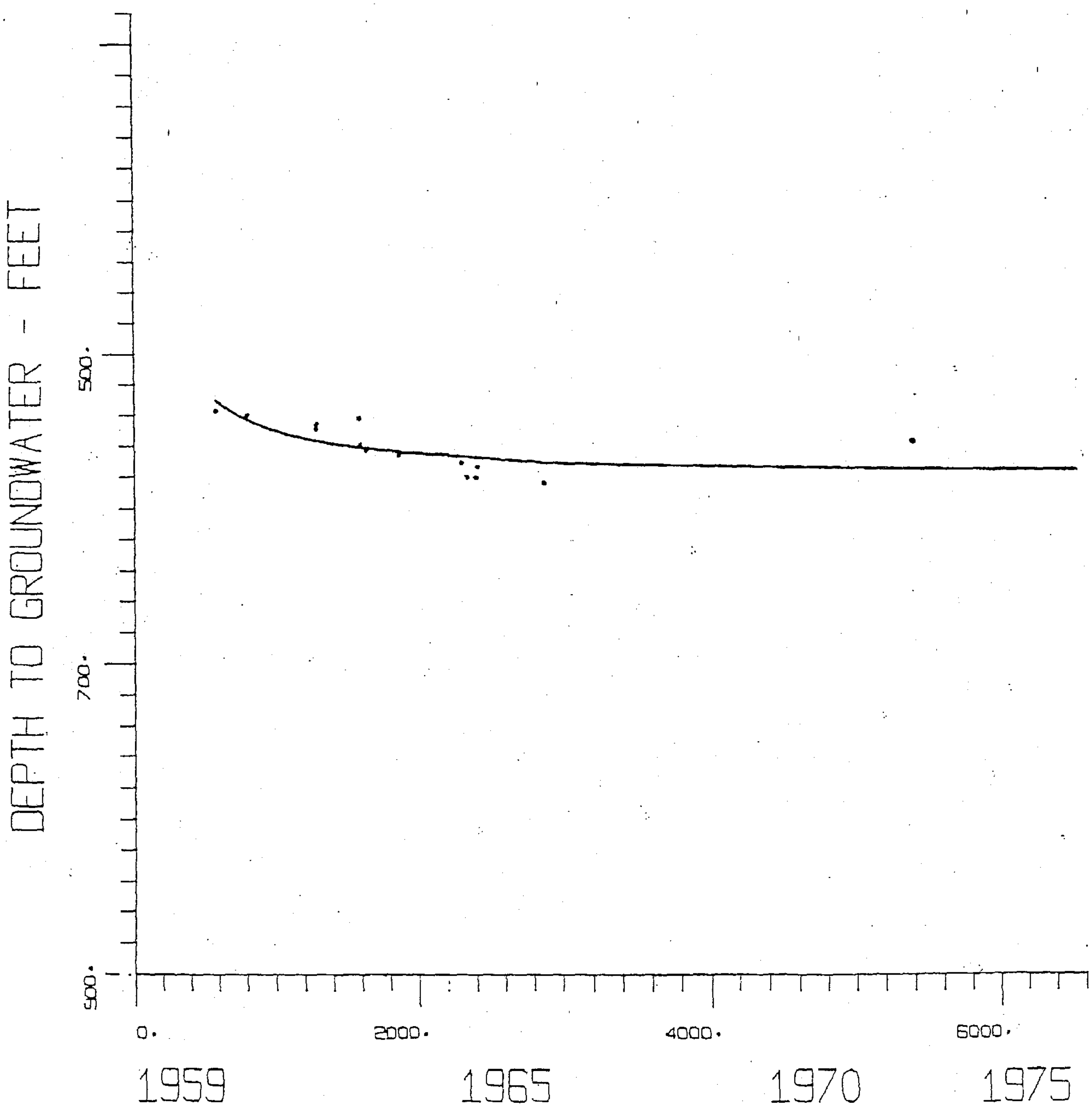


FIG. E-4

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 9N33W8P1

Y=A+B*X

A= 0.6440285E 03

B=-0.2197647E-03

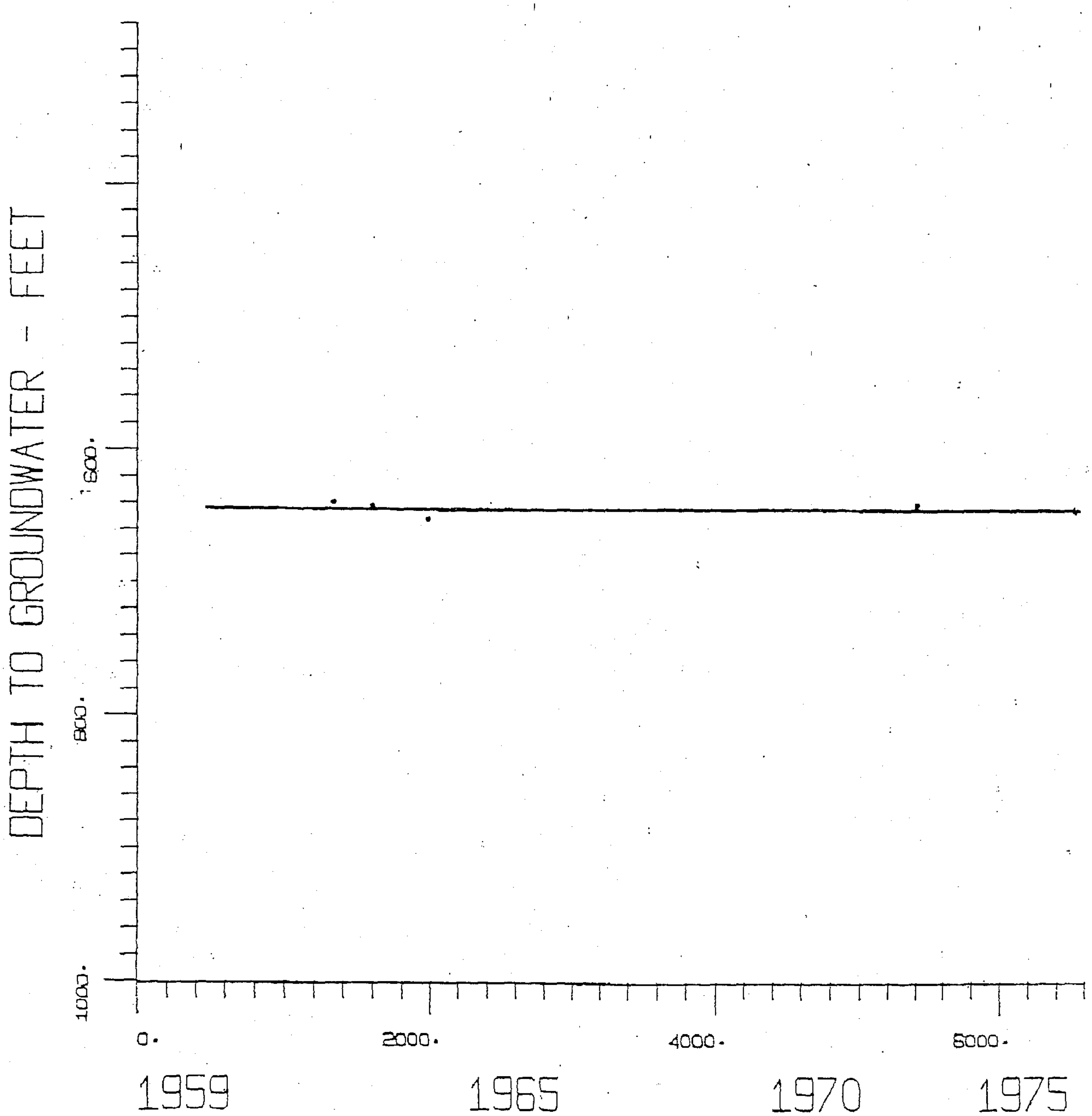


FIG. E-5

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 9N33W9D1

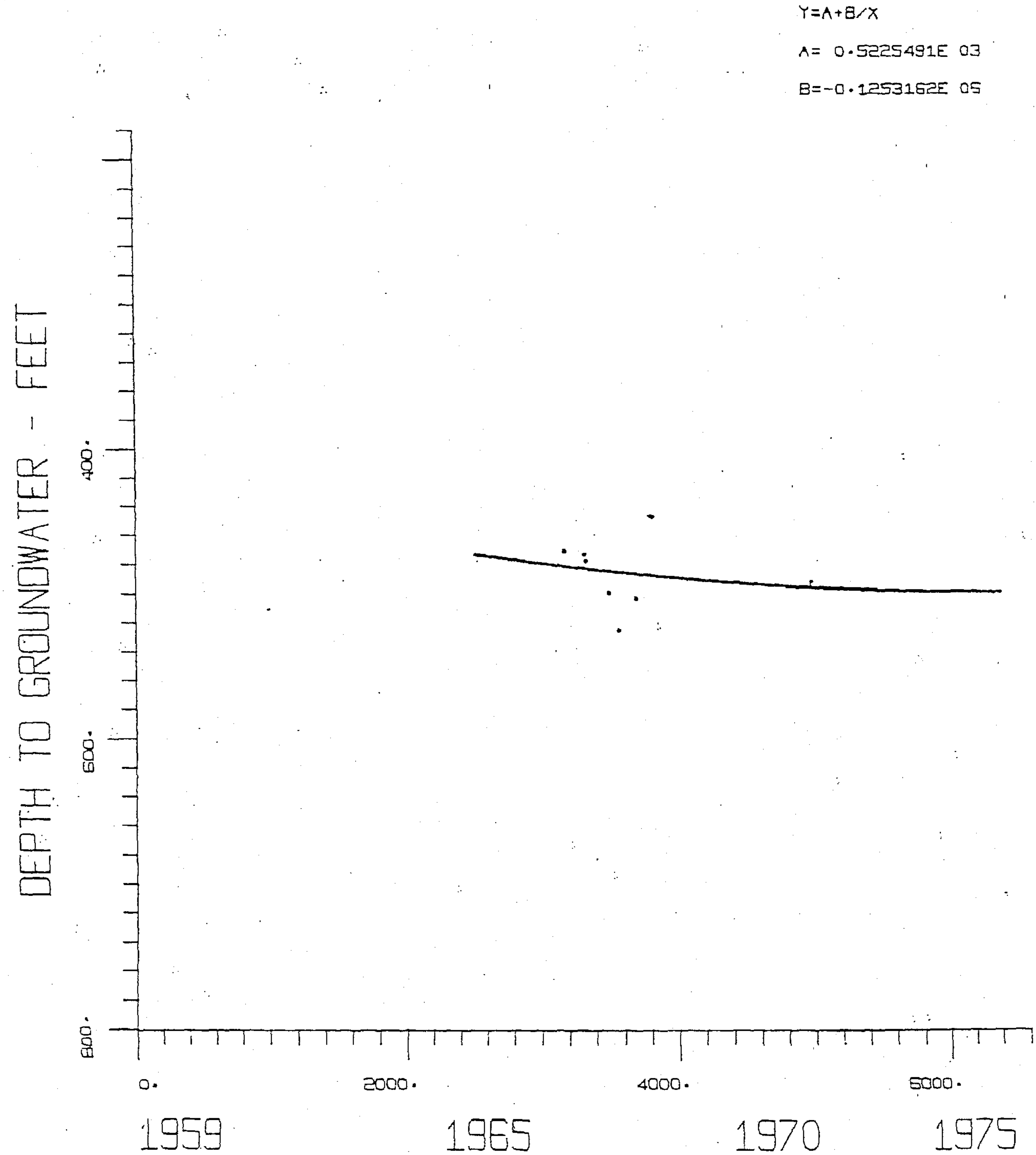


FIG. E-6

STATIC WATER LEVELS

SANTA MARIA VALLEY WELL NO. 10N33W18G1

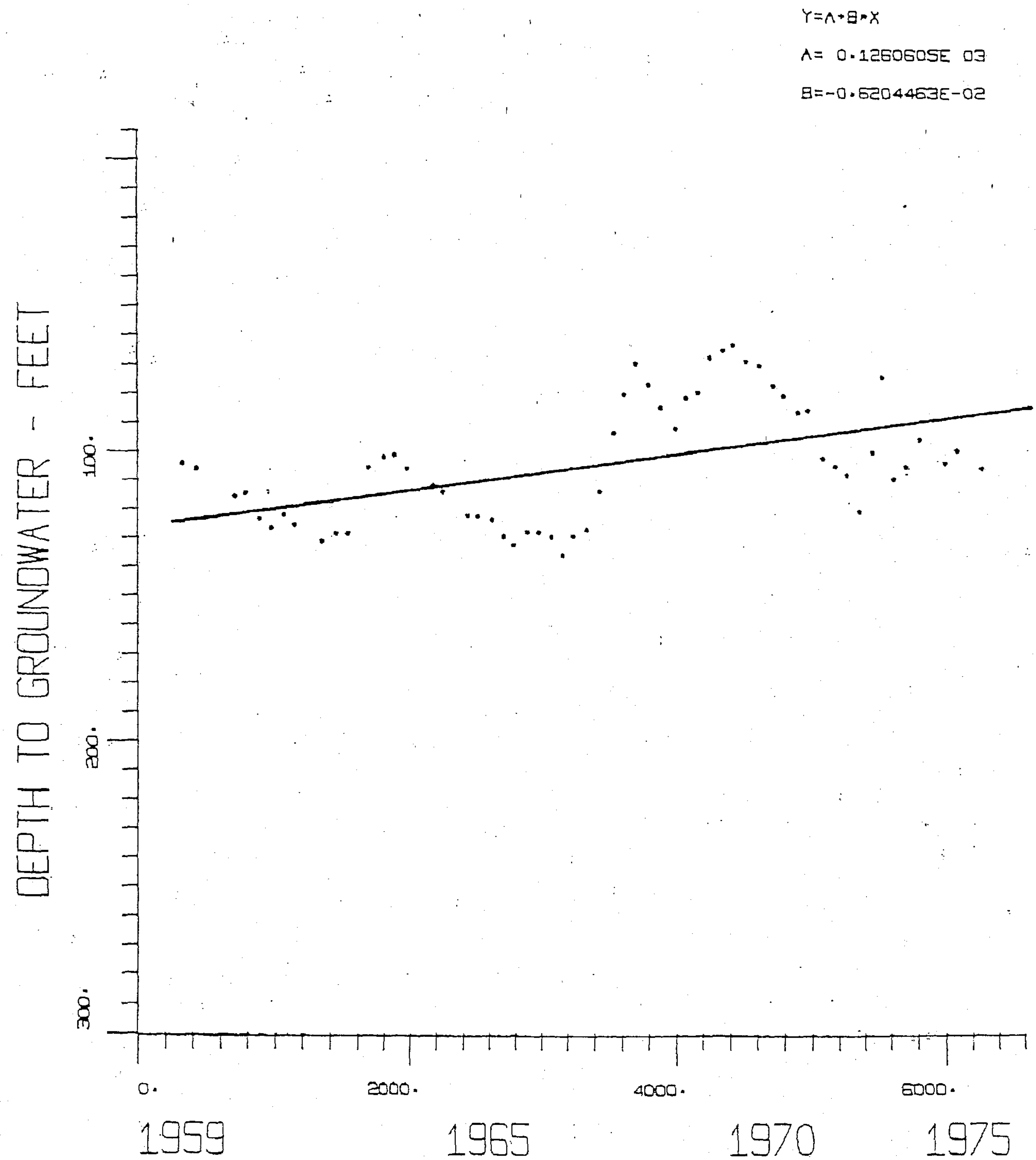


FIG. E-7

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N33W19B1

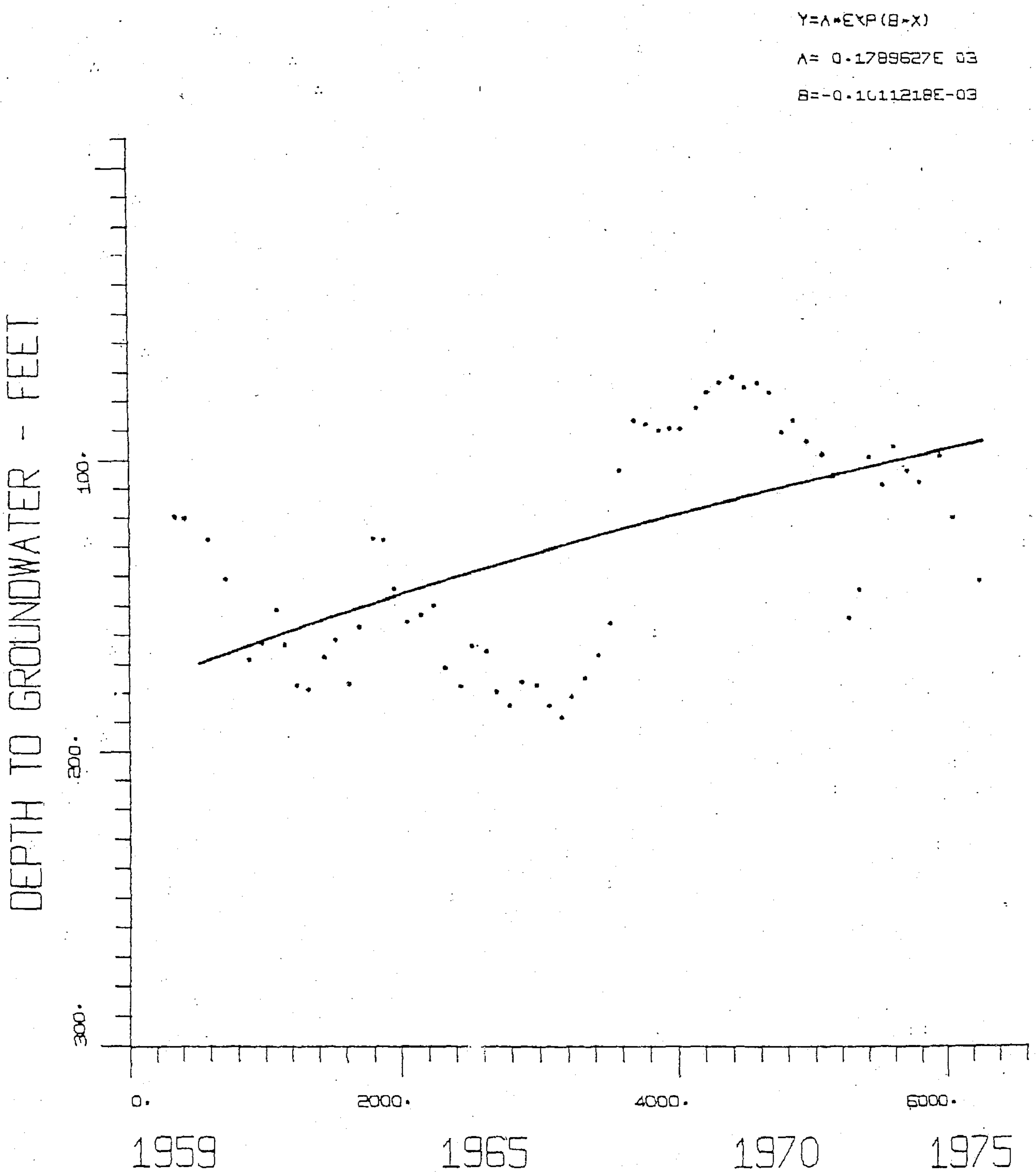


FIG. E-8

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N33W28A1

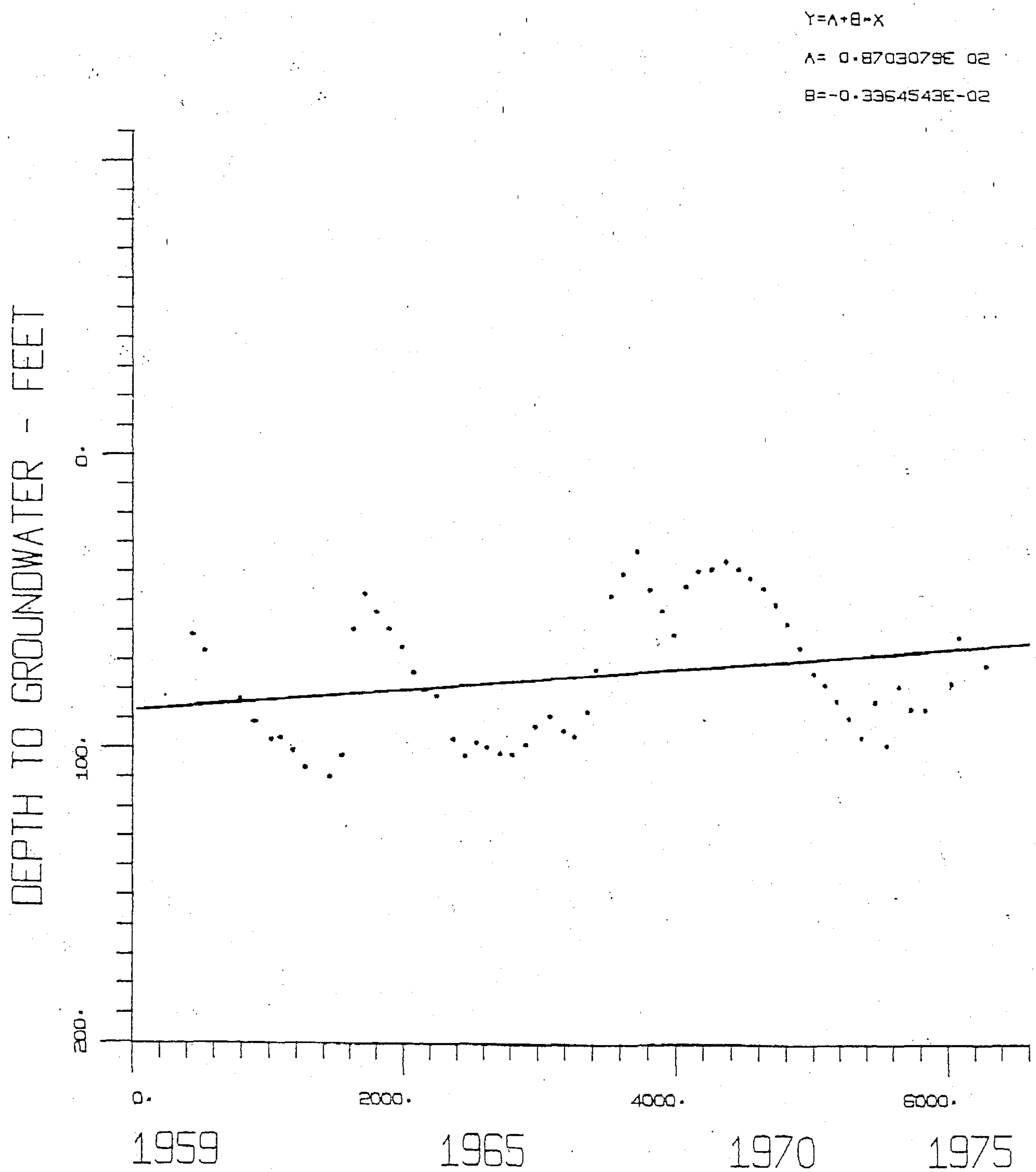


FIG. E-9

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N33W30R1

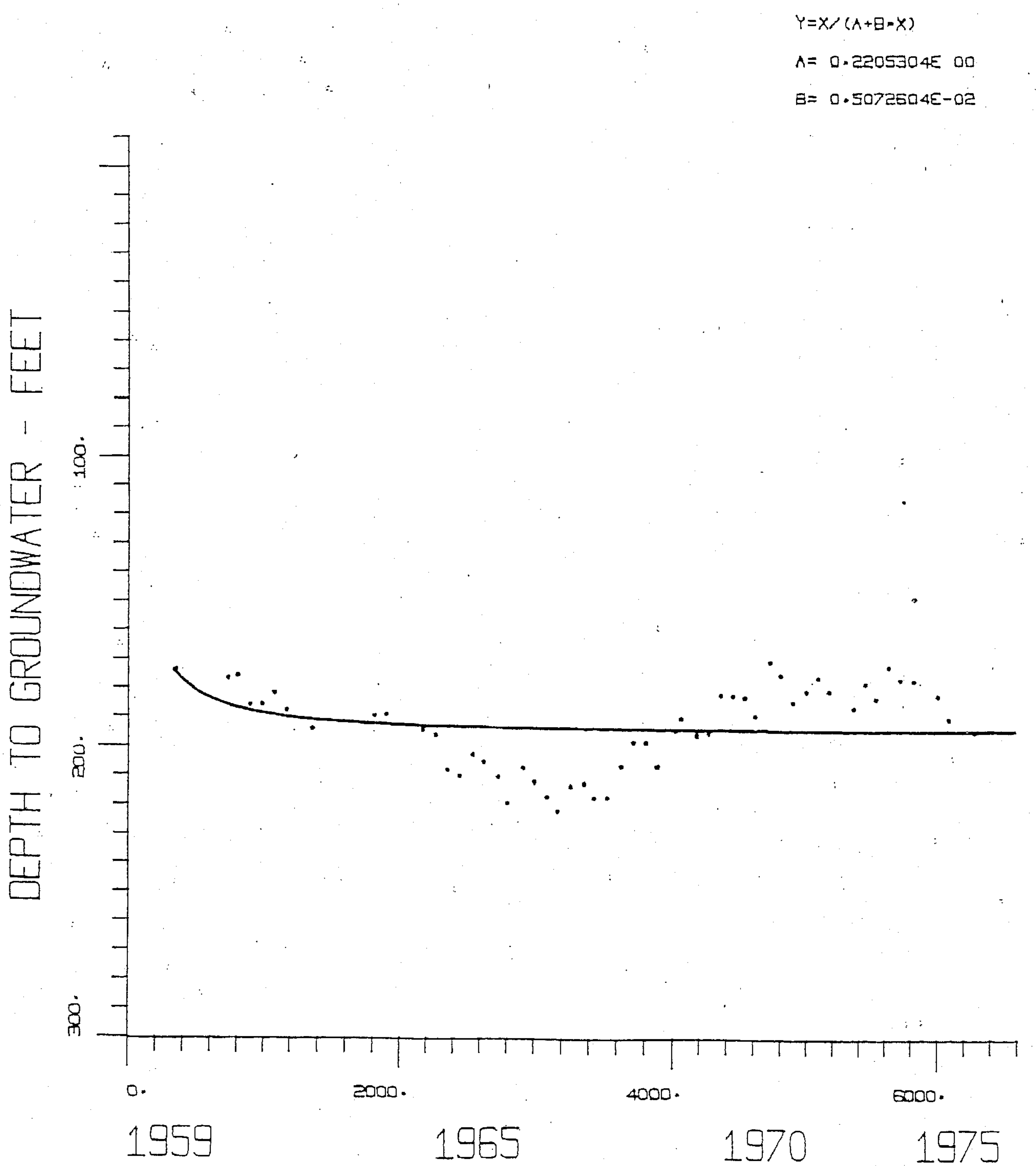


FIG. E-10

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N34W 2R1

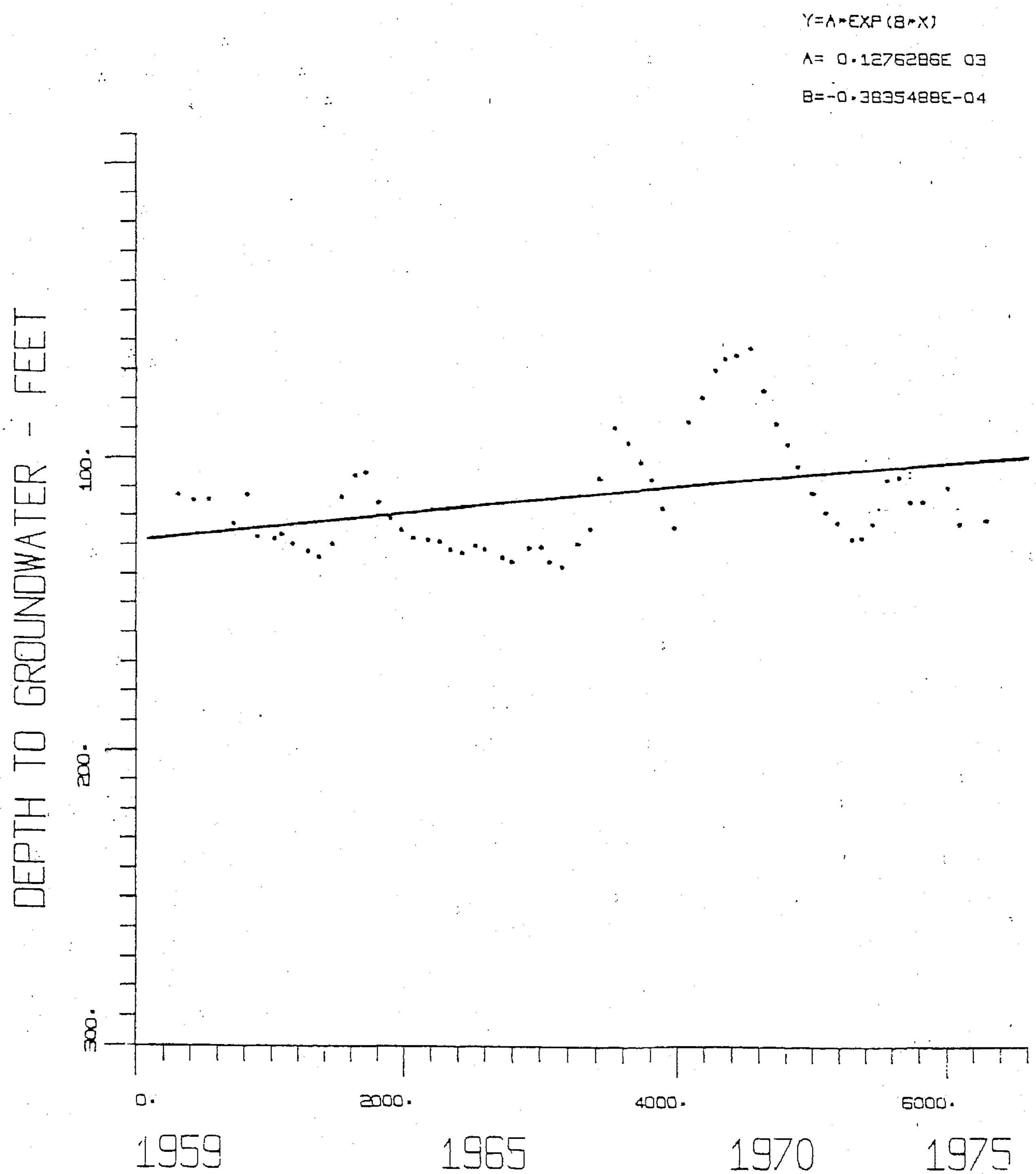


FIG. E-11

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N34W6N1

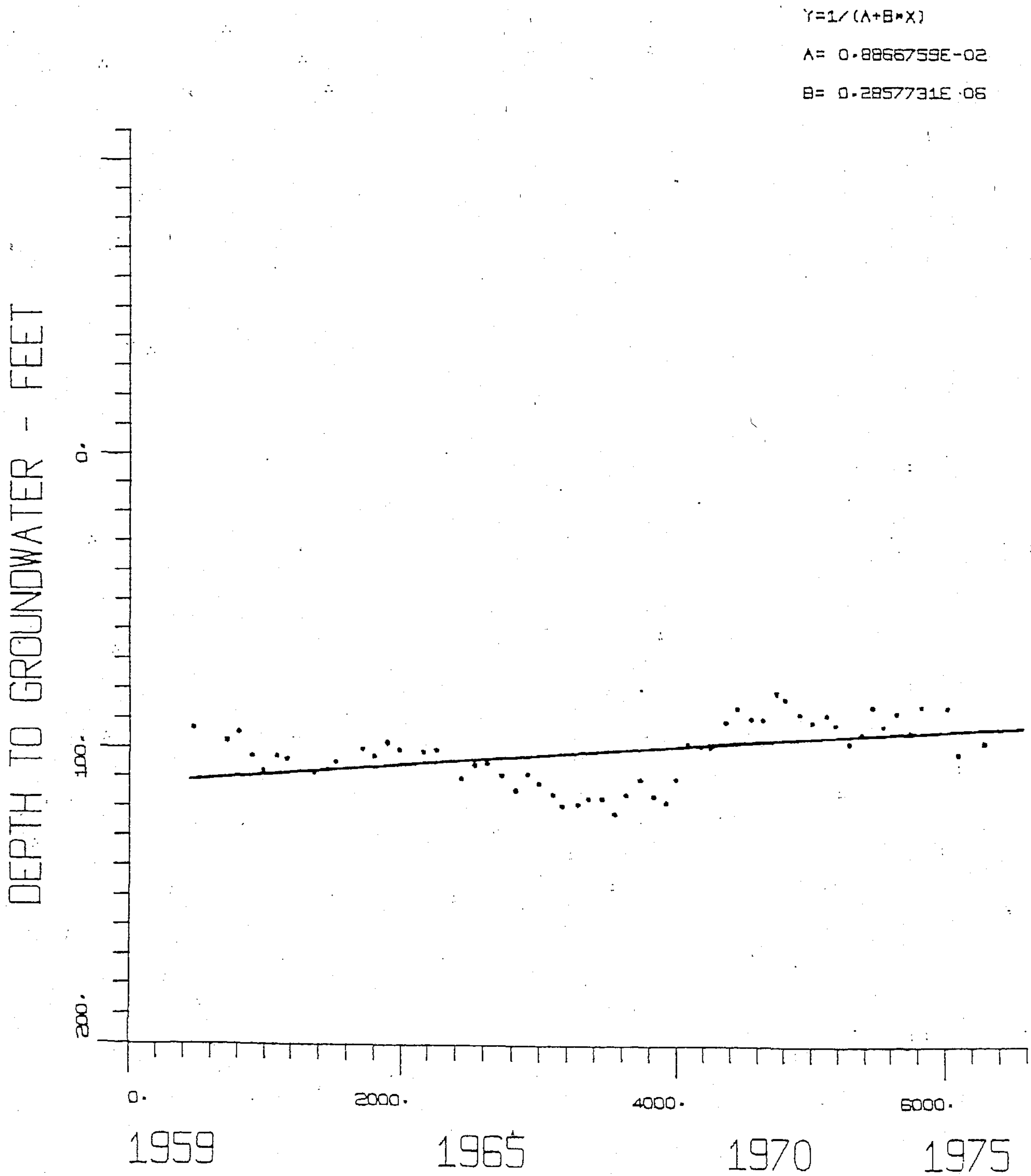


FIG. E-12

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N34W22R1

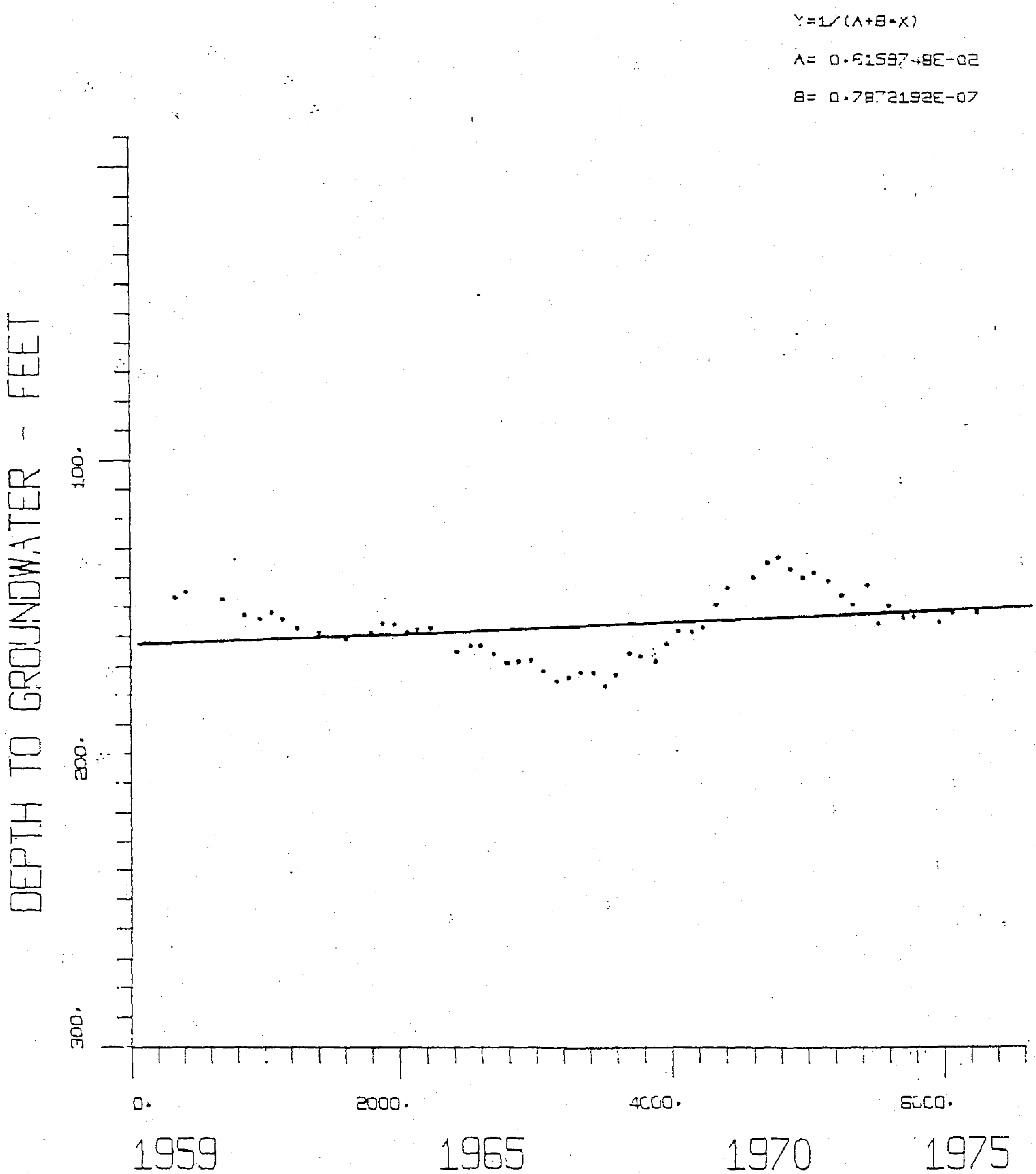


FIG. E-13

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N34W23H1

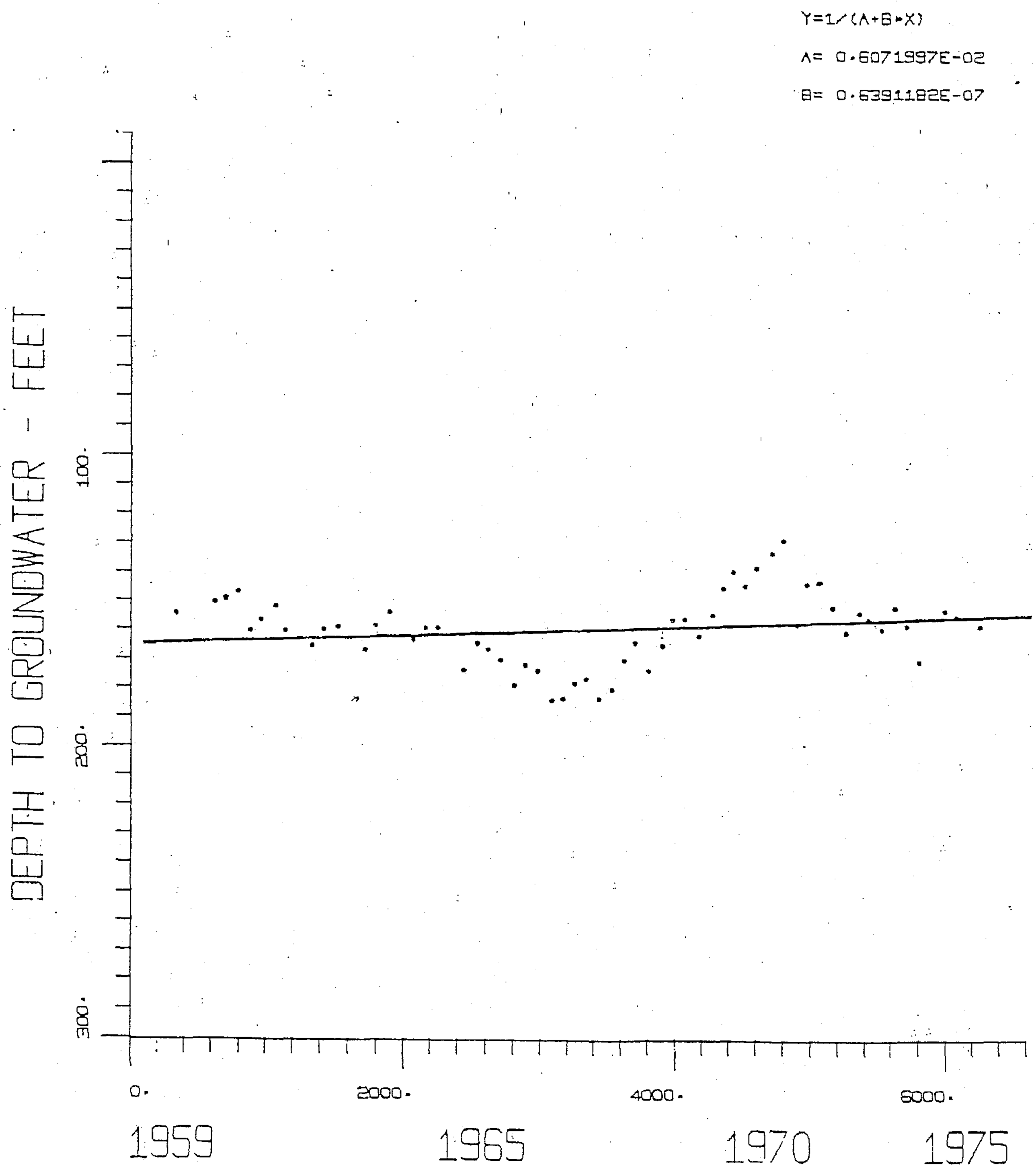


FIG. E-14

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N34W24K3

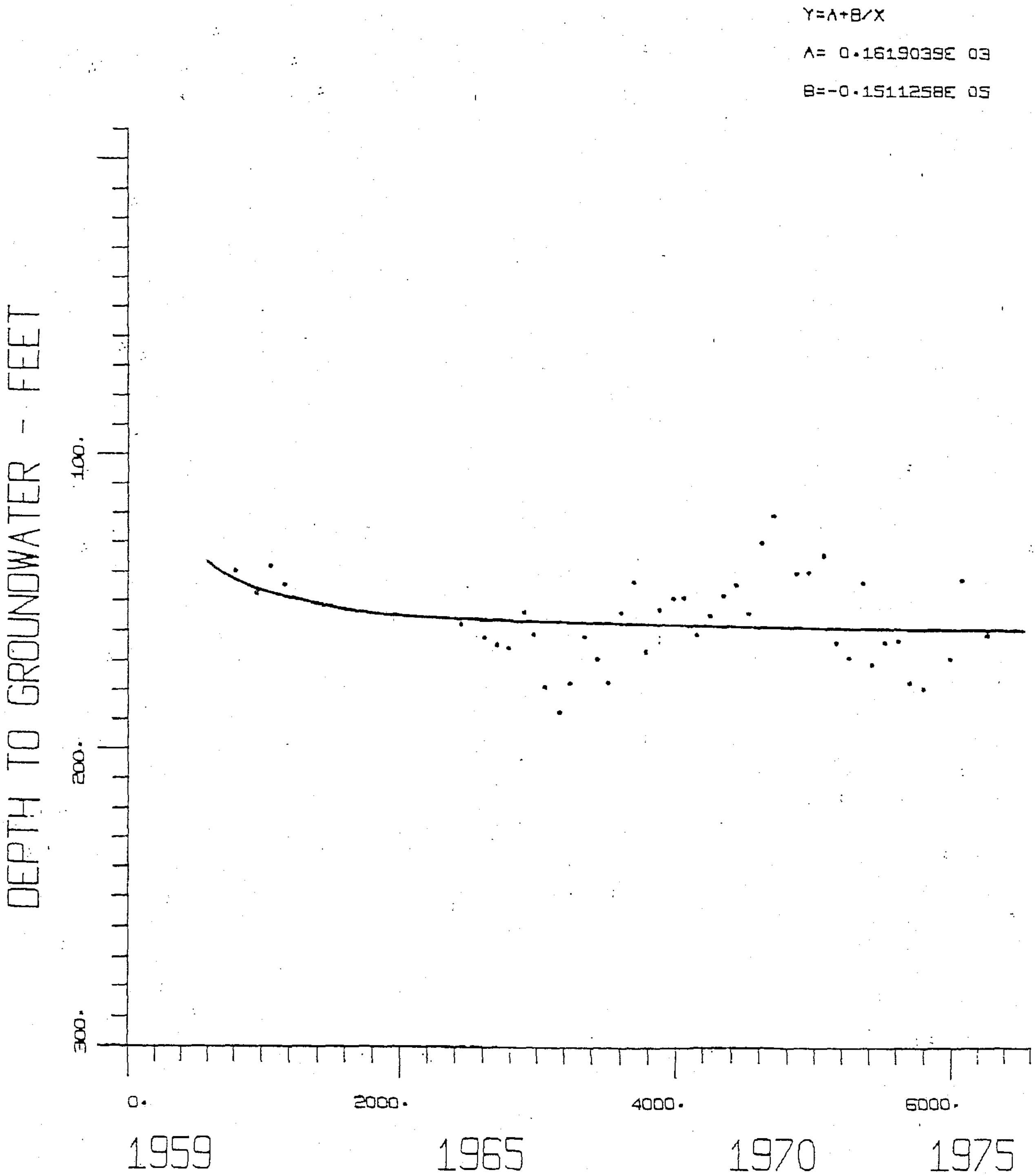


FIG. E-15

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N35W7F1

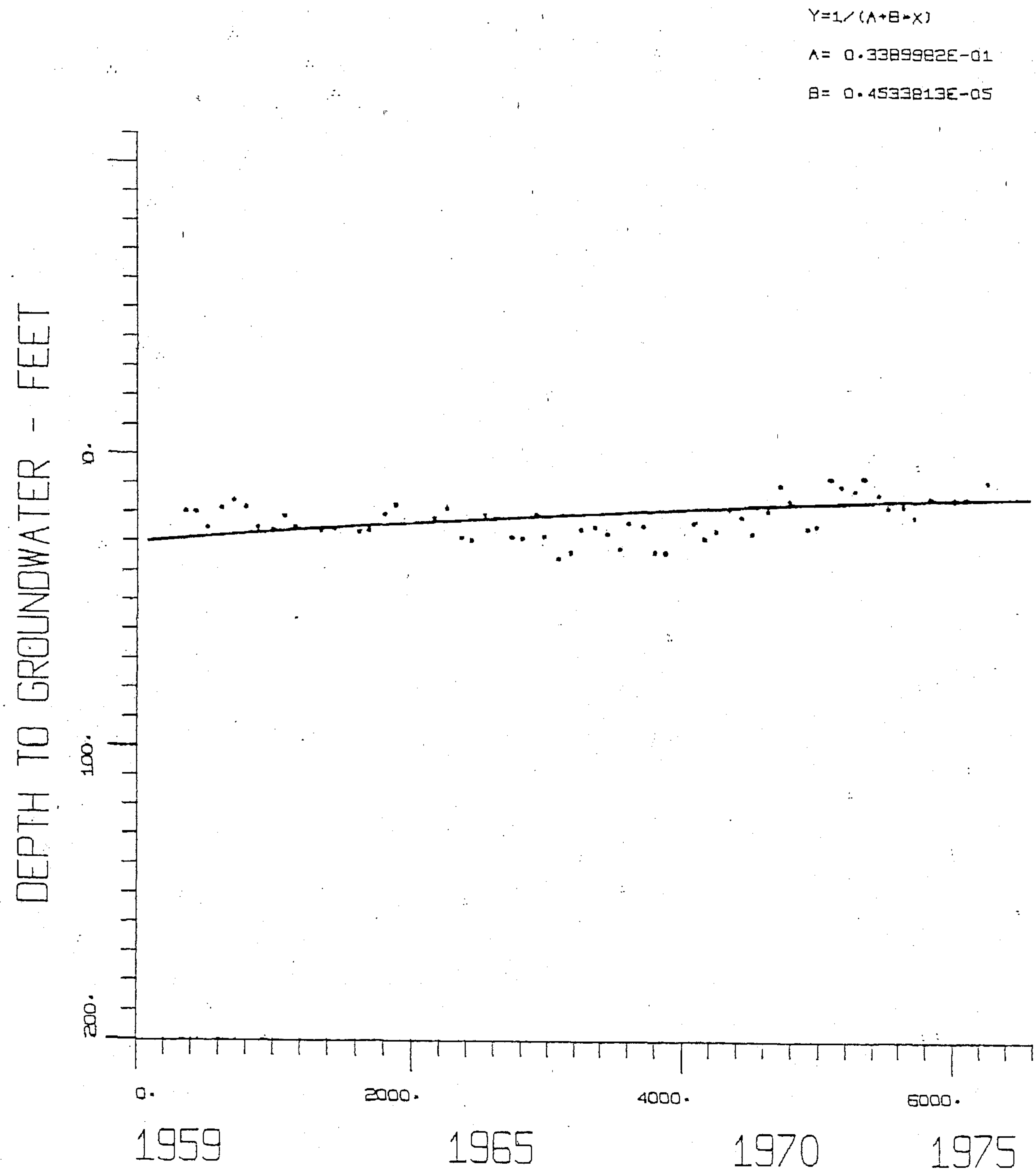


FIG. E-16

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N35W9F1

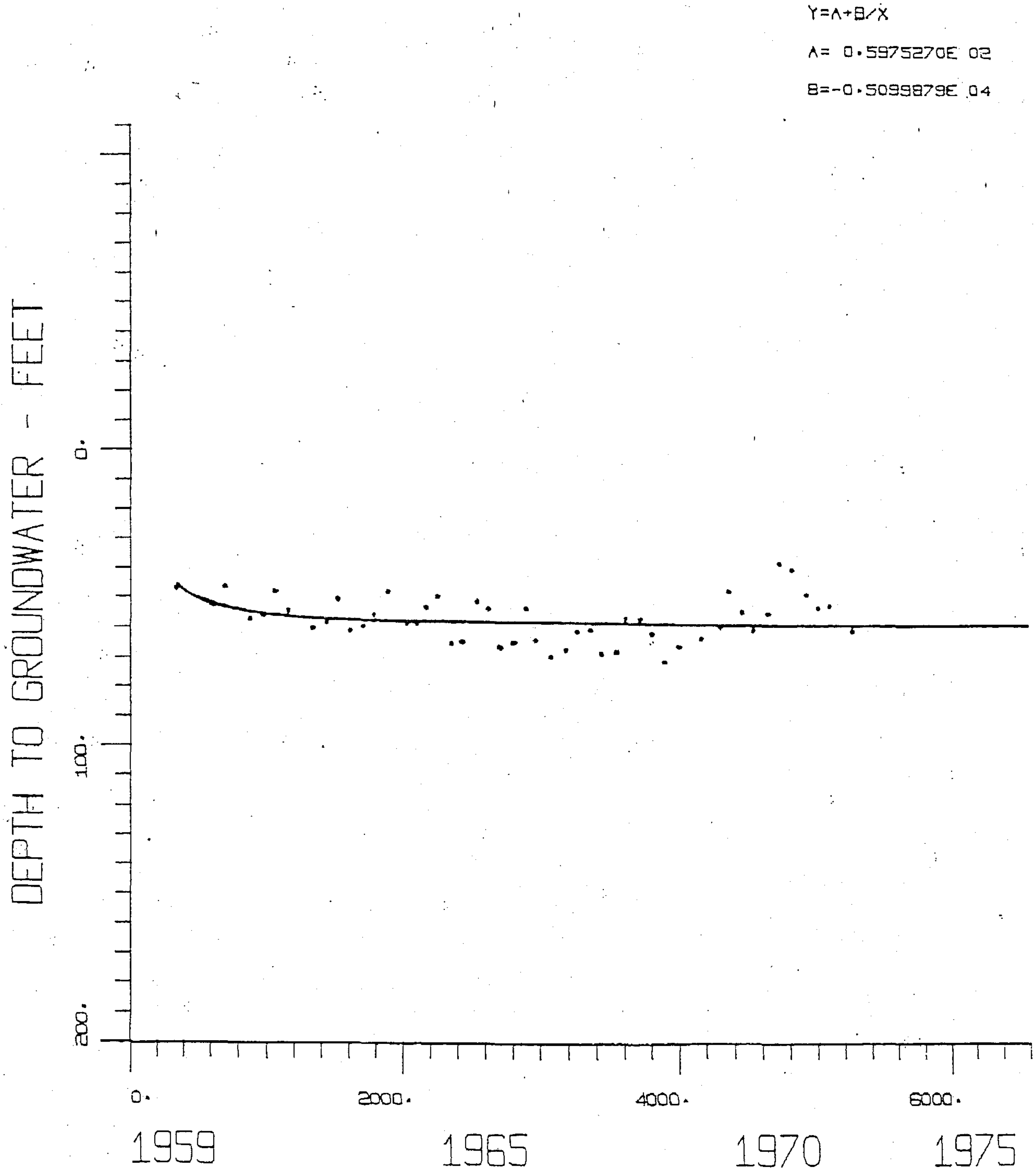


FIG. E-17

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N35W9N1

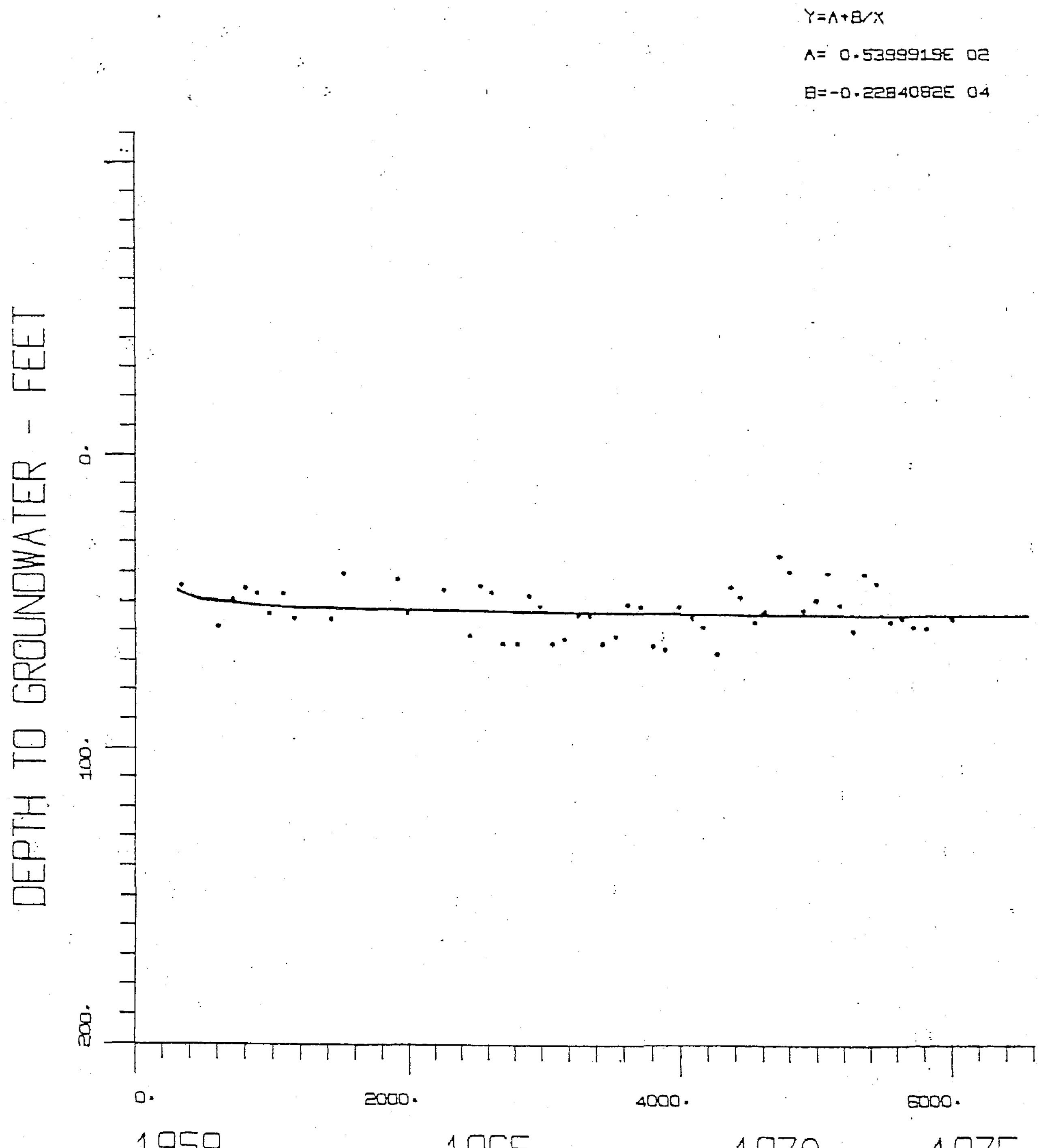


FIG. E-18

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N35W12M1

Y=1/(A+B*X)

A= 0.9486466E-02

B= 0.4425779E-06

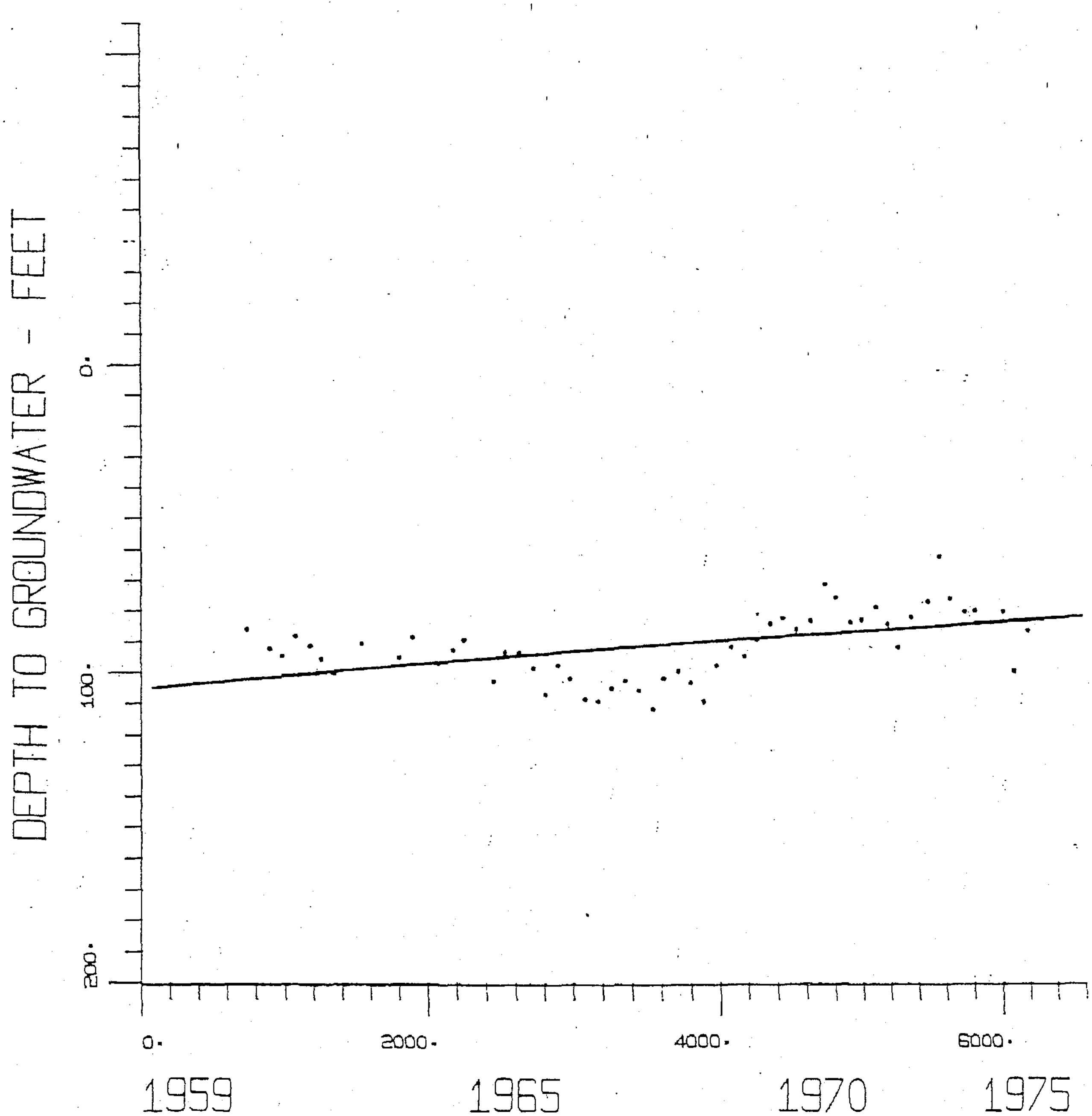


FIG. E-19

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N35W21B3

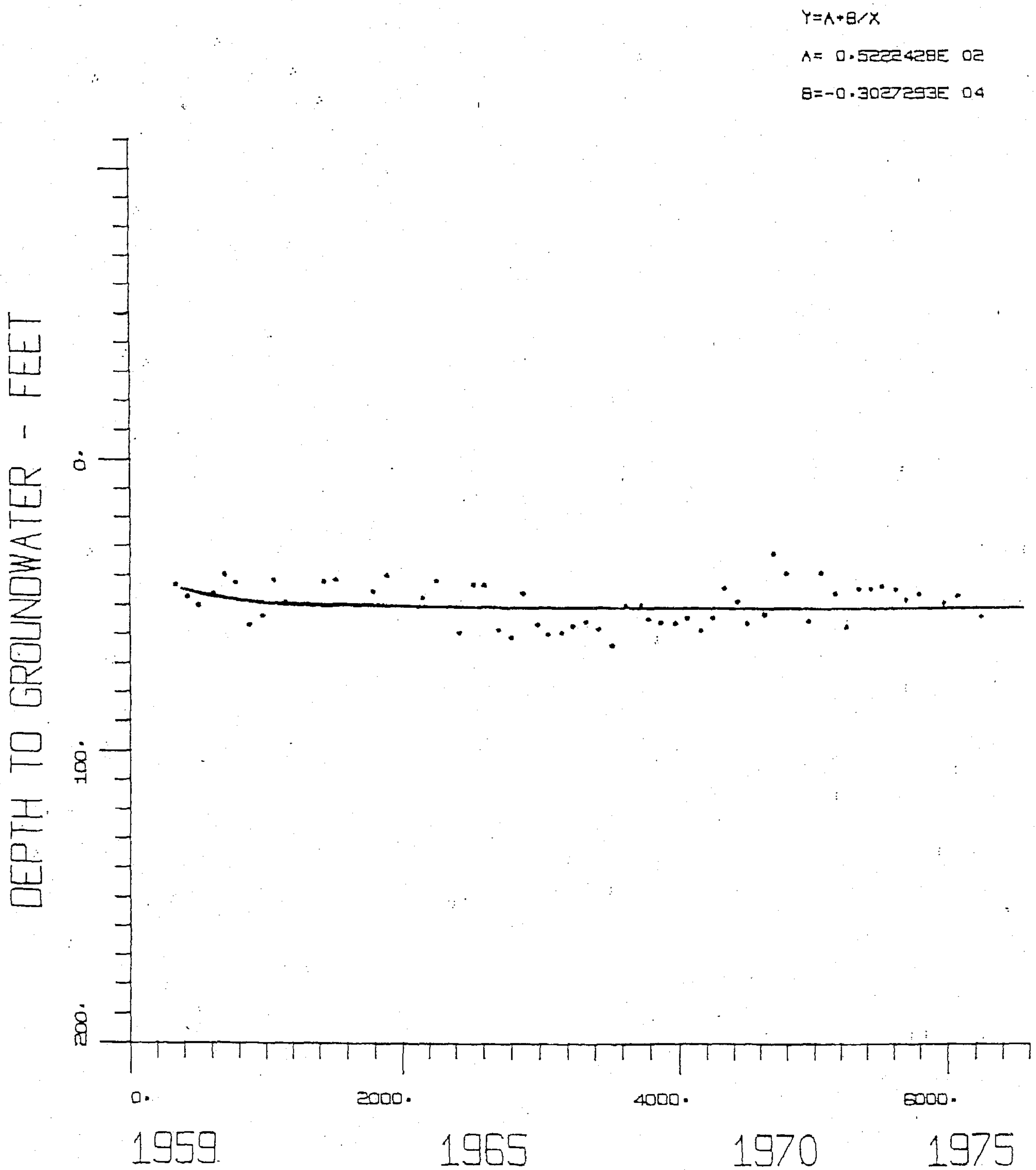


FIG. E-20

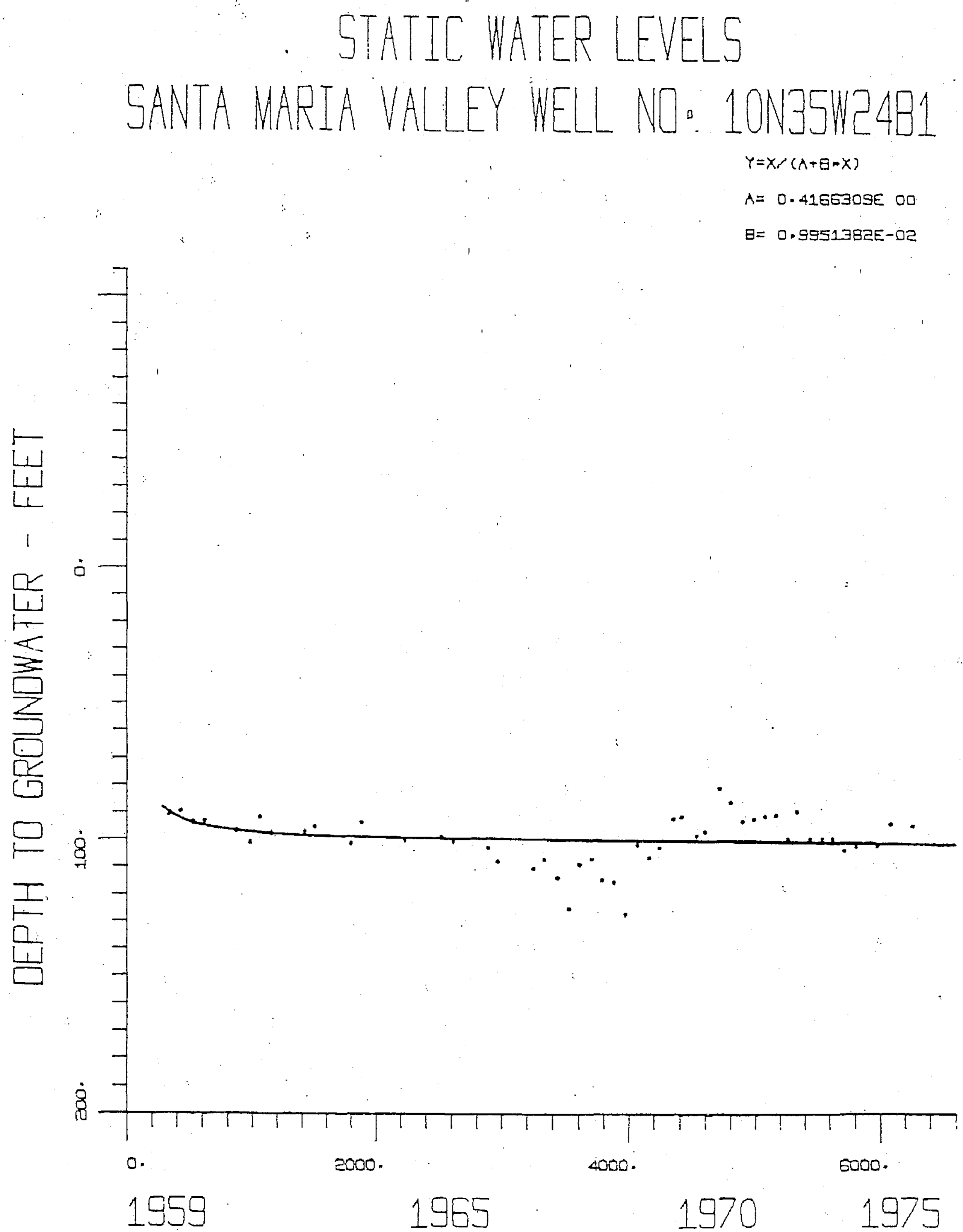

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 10N35W24B1
Y=X/(A+B*X)
A= 0.4166309E 00
B= 0.9951382E-02
DEPTH TO GROUNDWATER - FEET
0.
100.
200.
0.
2000.
4000.
6000.
1959
1965
1970
1975

FIG. E-21

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N34W30Q1

Y=1/(A+B*X)

A= 0.86060850E-02

B= 0.54473700E-06

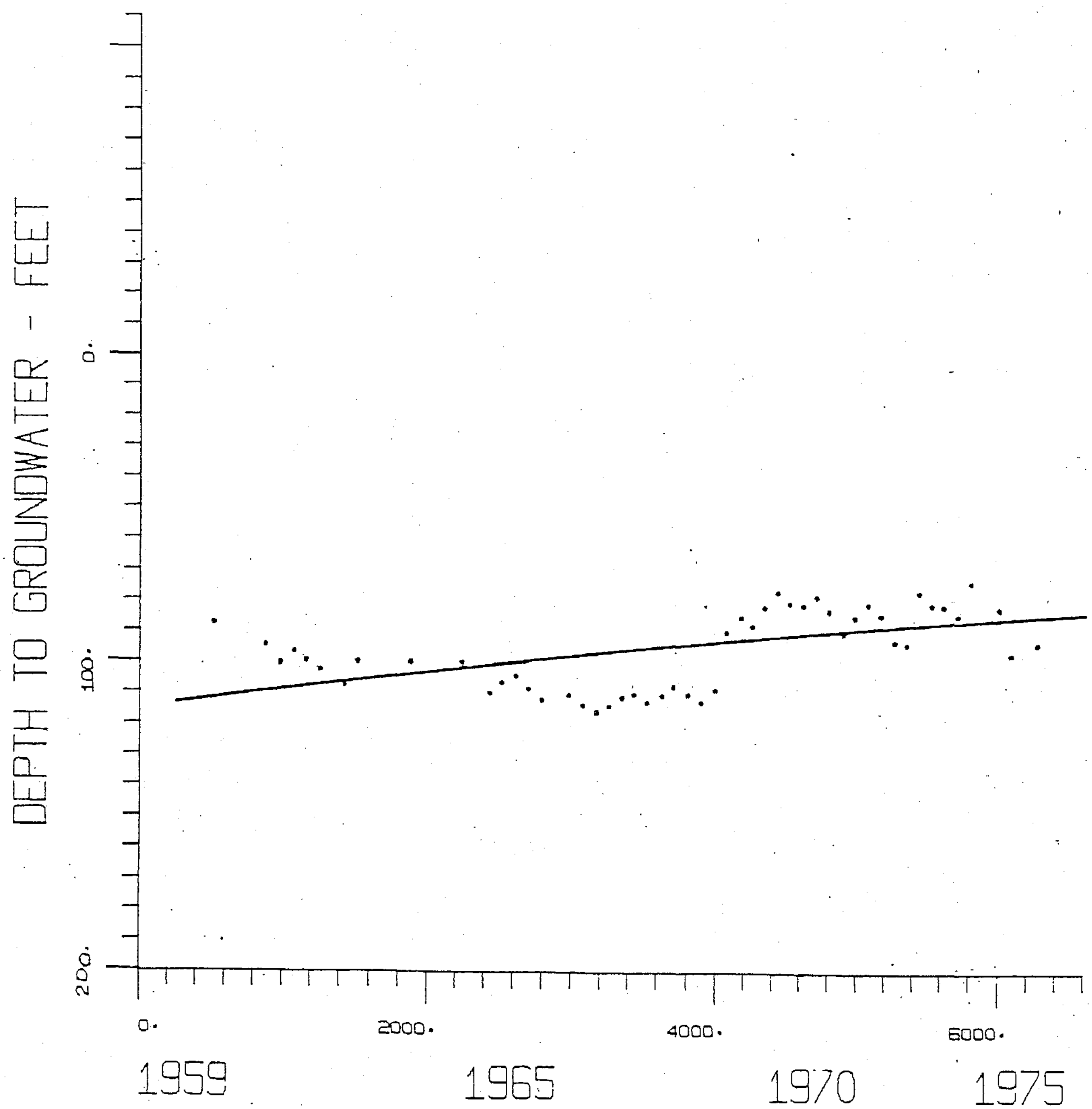


FIG. E-22

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W5L1

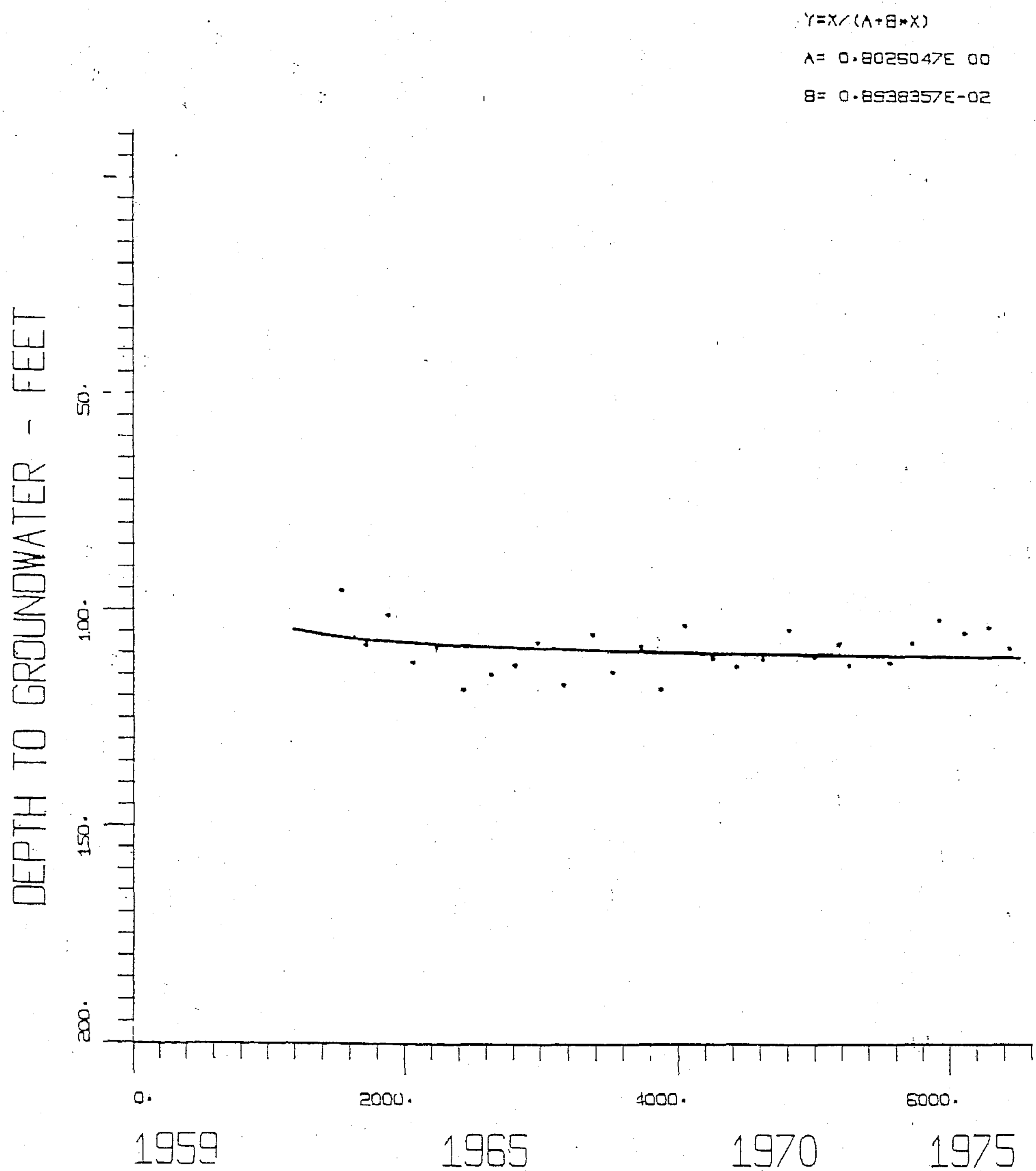


FIG. E-23

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W7R1

Y=X/(A+B*X)

A= 0.1268499E 01

B= 0.1302932E-01

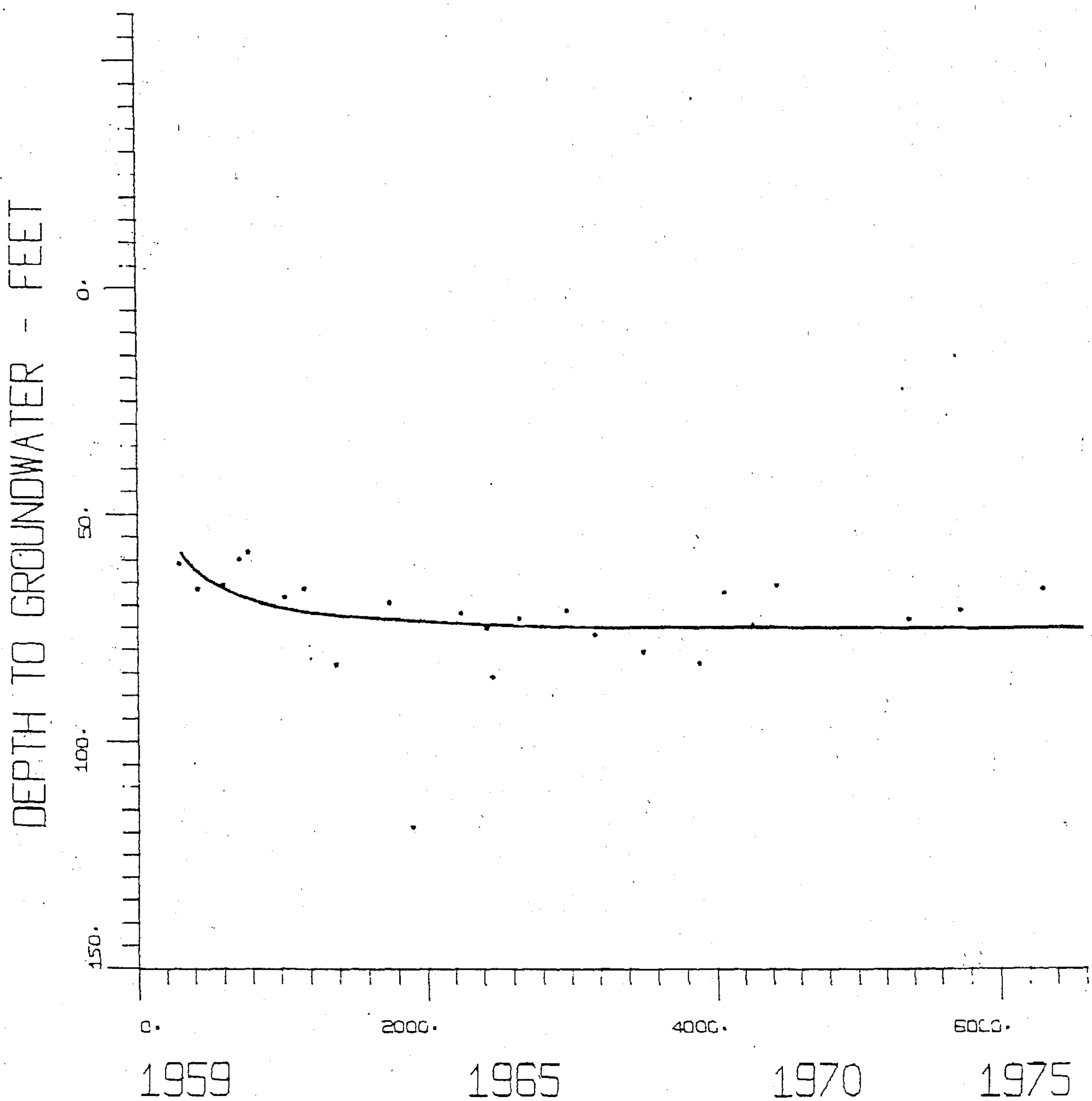


FIG. E-24

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W9G1

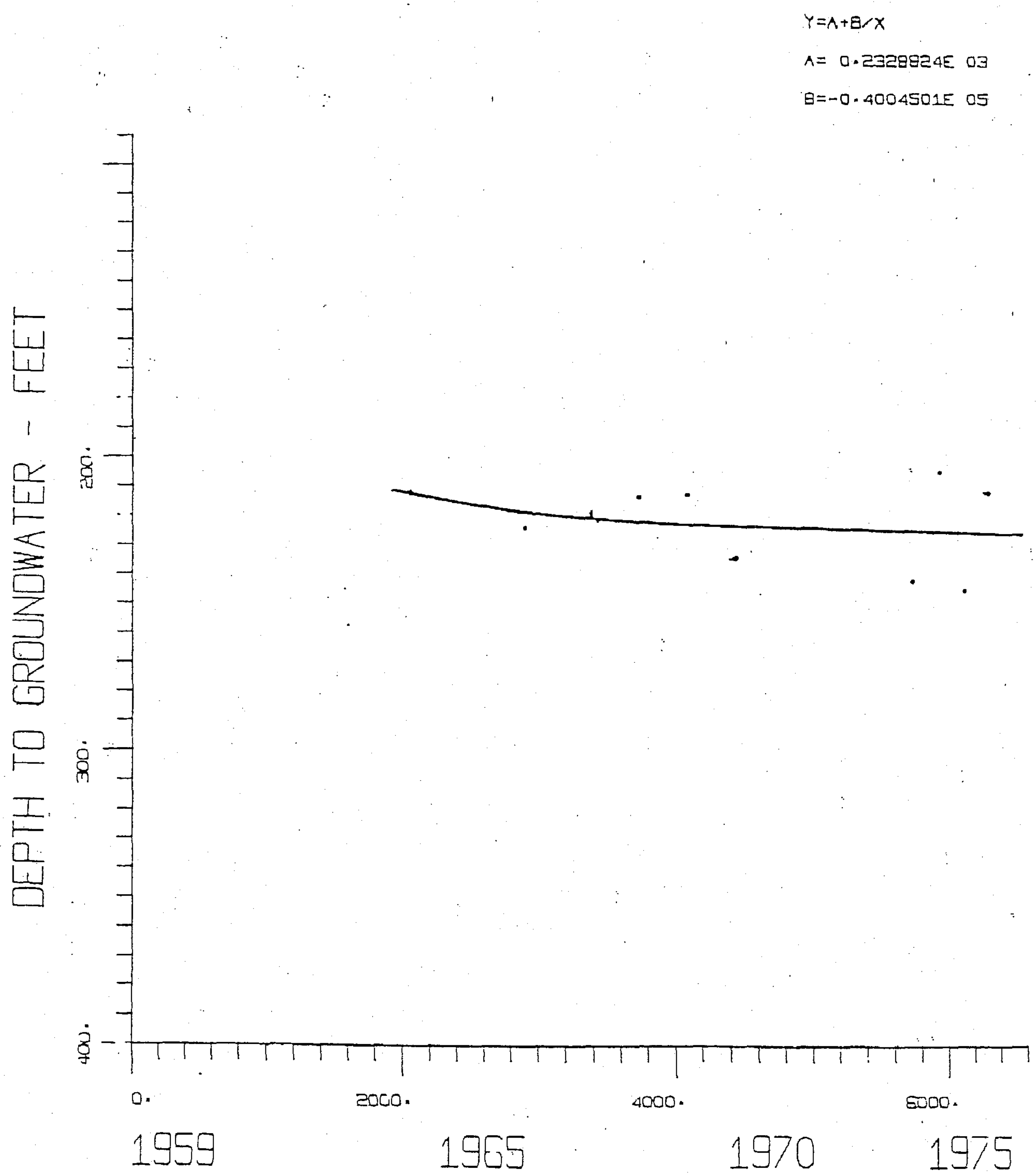


FIG. E-25

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W20E1

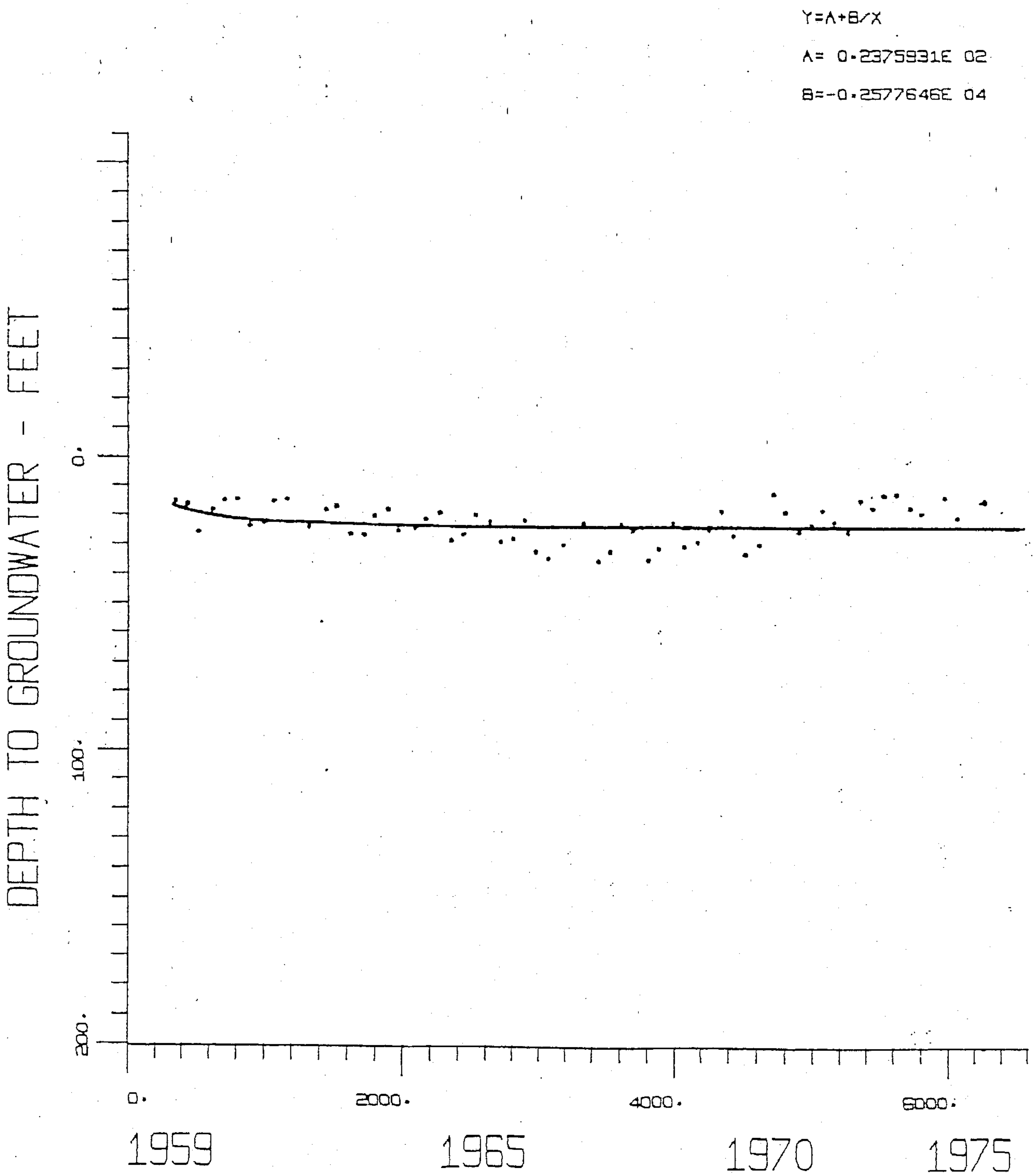


FIG. E-26

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W28M1

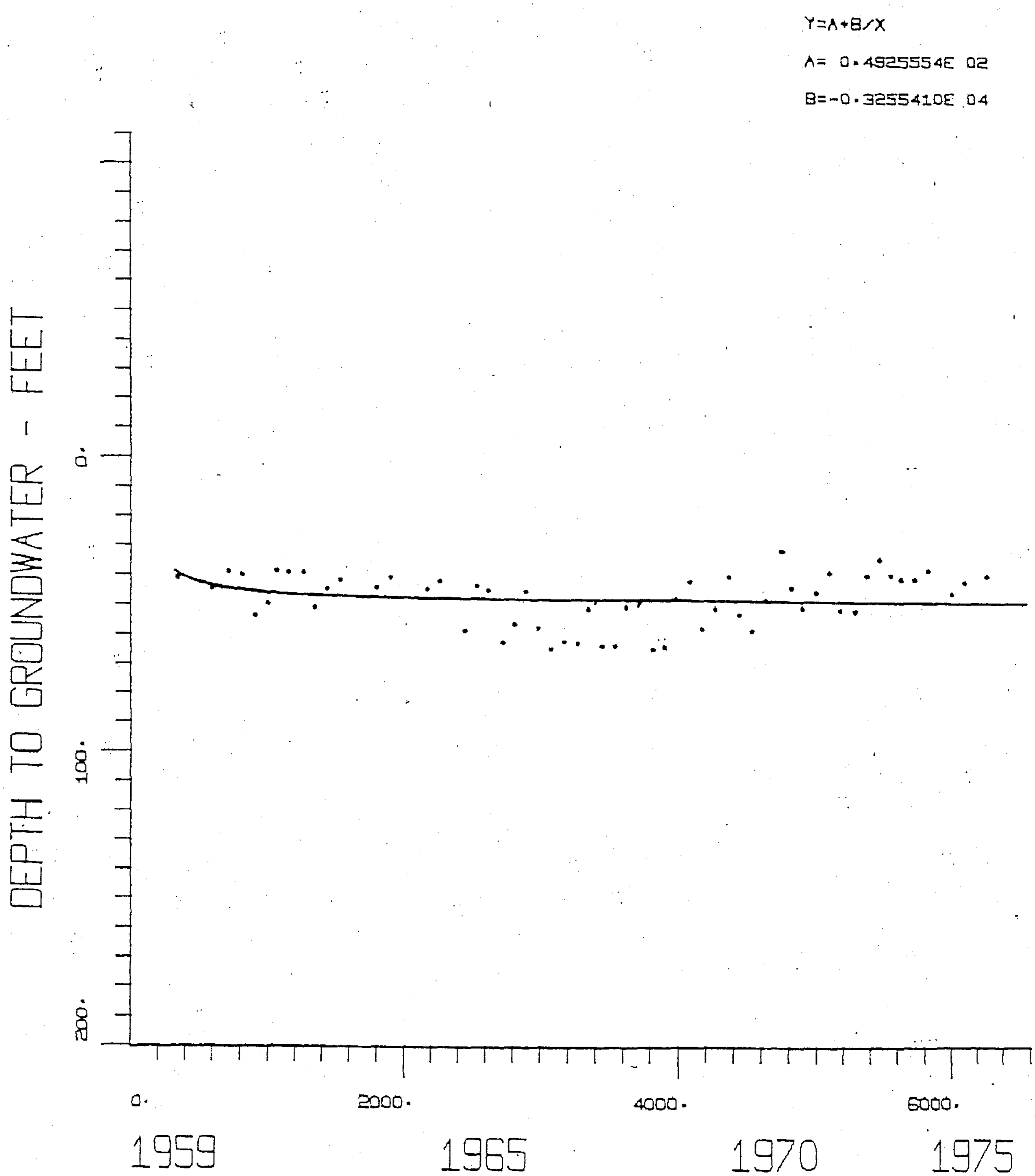


FIG. E-27

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W33G2

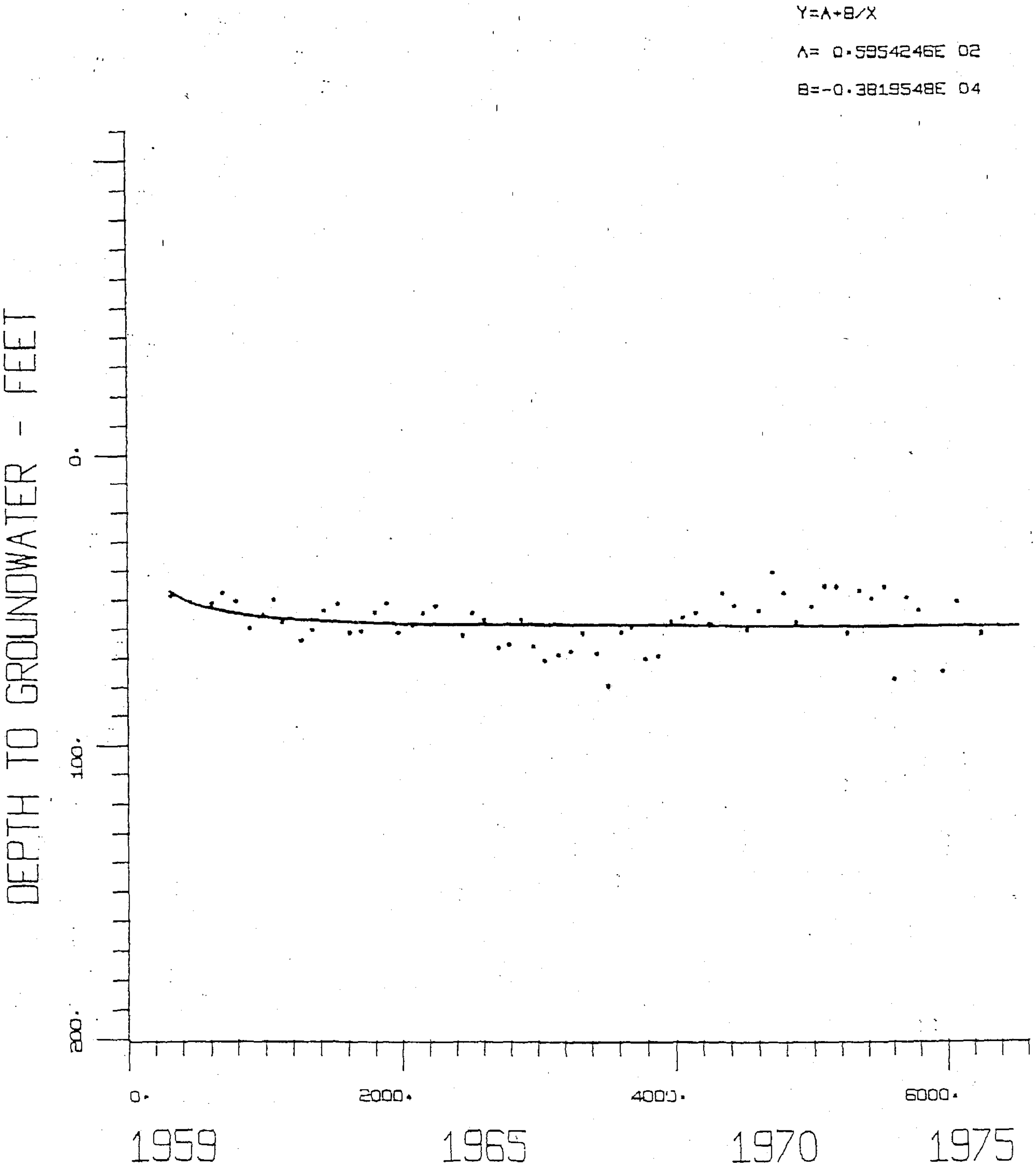
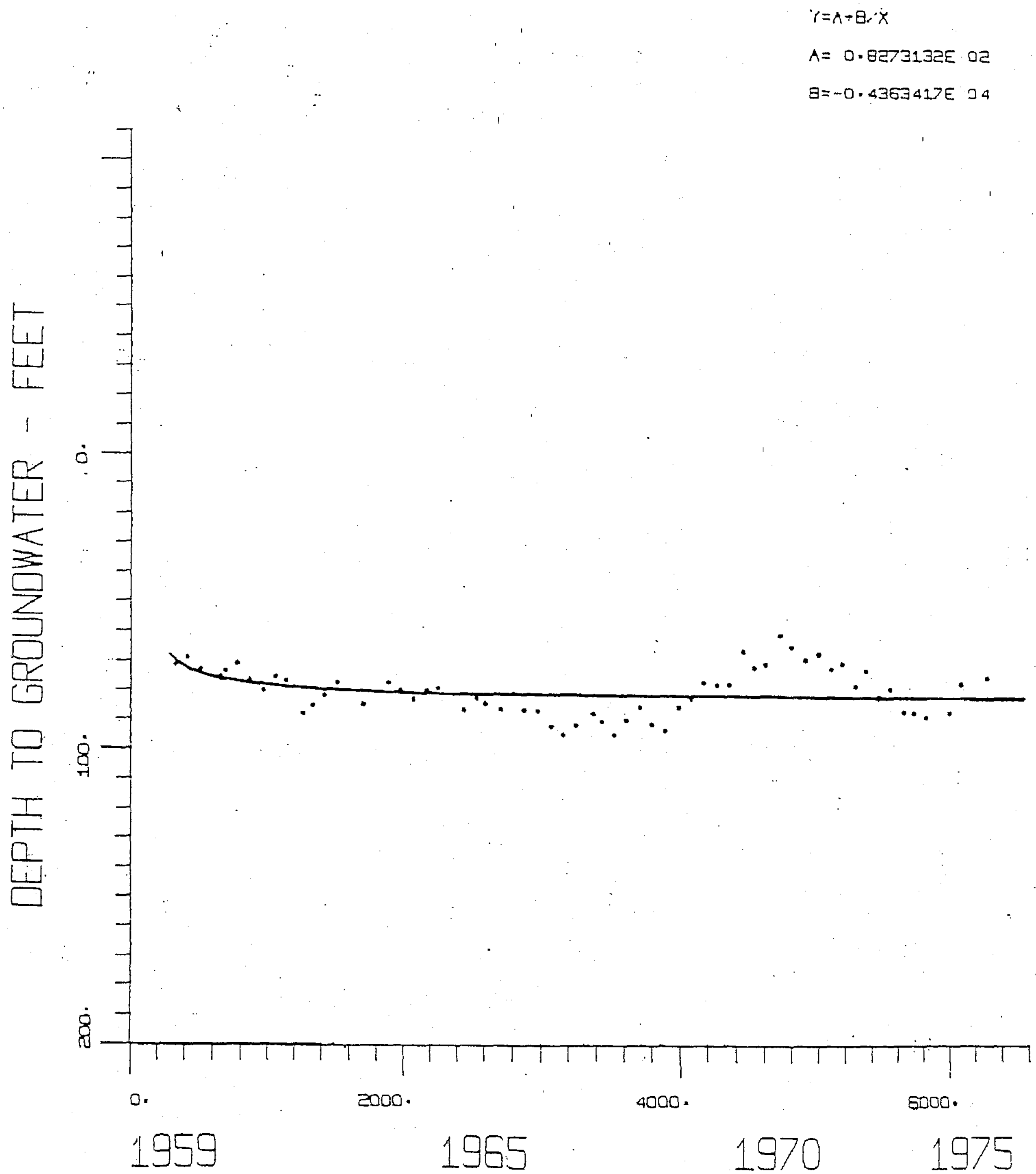


FIG. E-28

STATIC WATER LEVELS
SANTA MARIA VALLEY WELL NO. 11N35W35A1



APPENDIX F

FIG. F-1A

GROUNDWATER CHEMICAL CONSTITUENT
SANTA MARIA VALLEY WELL NO. 9N33W6G1

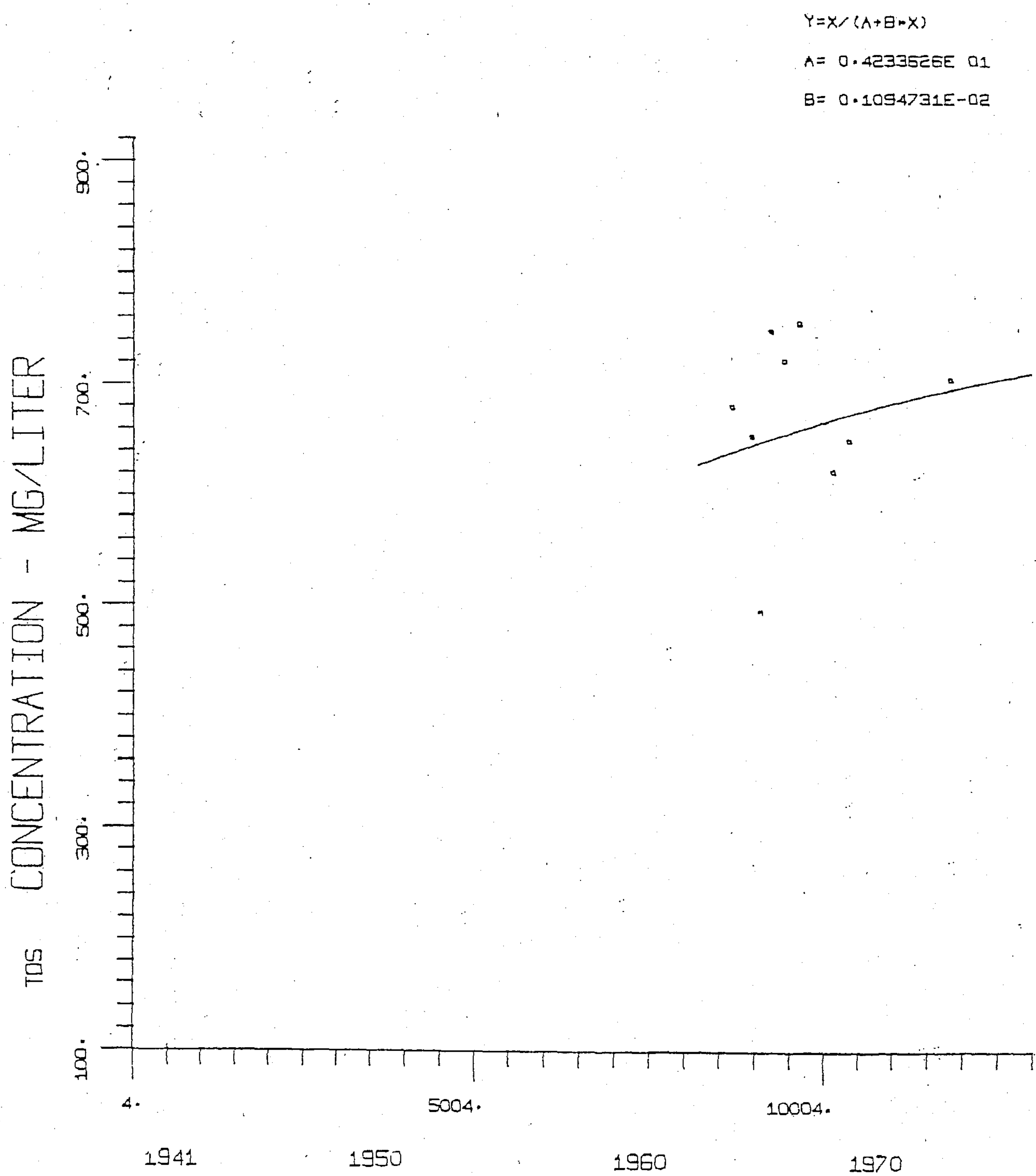


FIG. F-1B

GROUNDWATER CHEMICAL CONSTITUENT
SANTA MARIA VALLEY WELL NO. 9N33W6G1

Y=X/(A+B*X)

A= 0.1580550E 01

B= 0.3307709E-02

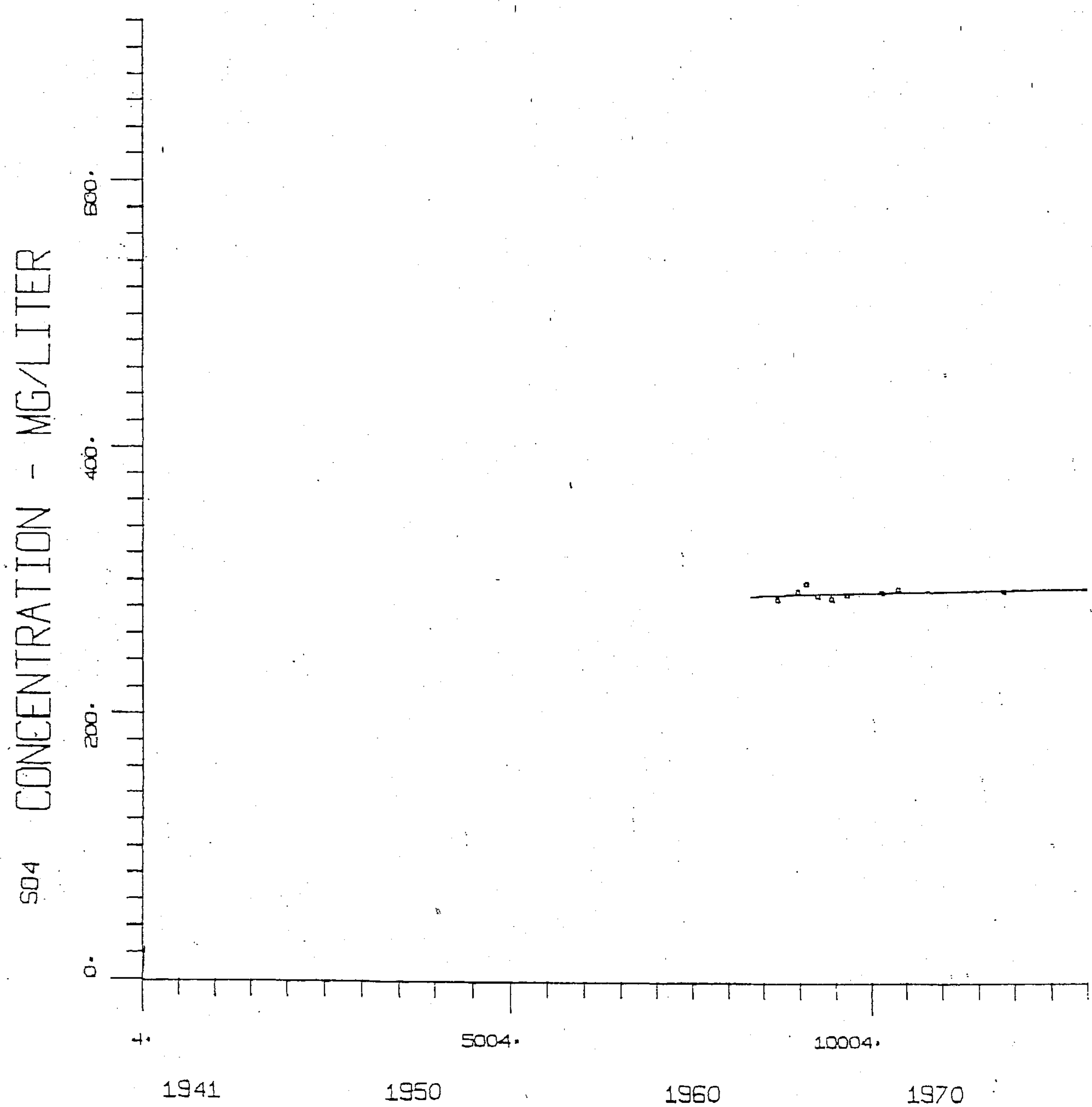


FIG. F-1C

GROUNDWATER CHEMICAL CONSTITUENT
SANTA MARIA VALLEY WELL NO. 9N33W6G1

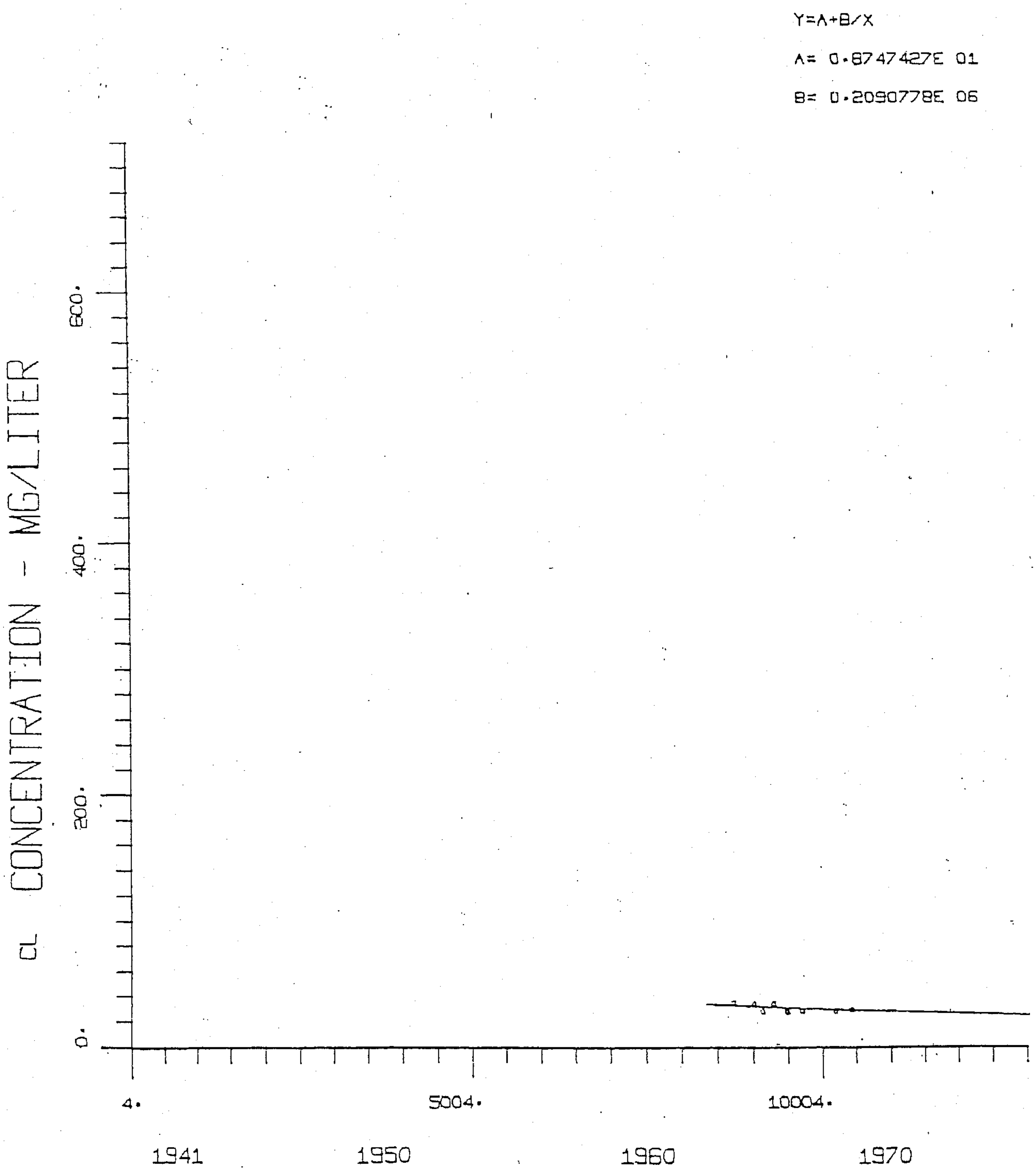


FIG. F-1D

GROUNDWATER CHEMICAL CONSTITUENT
SANTA MARIA VALLEY WELL NO. 9N33W6G1

Y=A+B/X
A= 0.1365833E 02
B=-0.9511493E 05

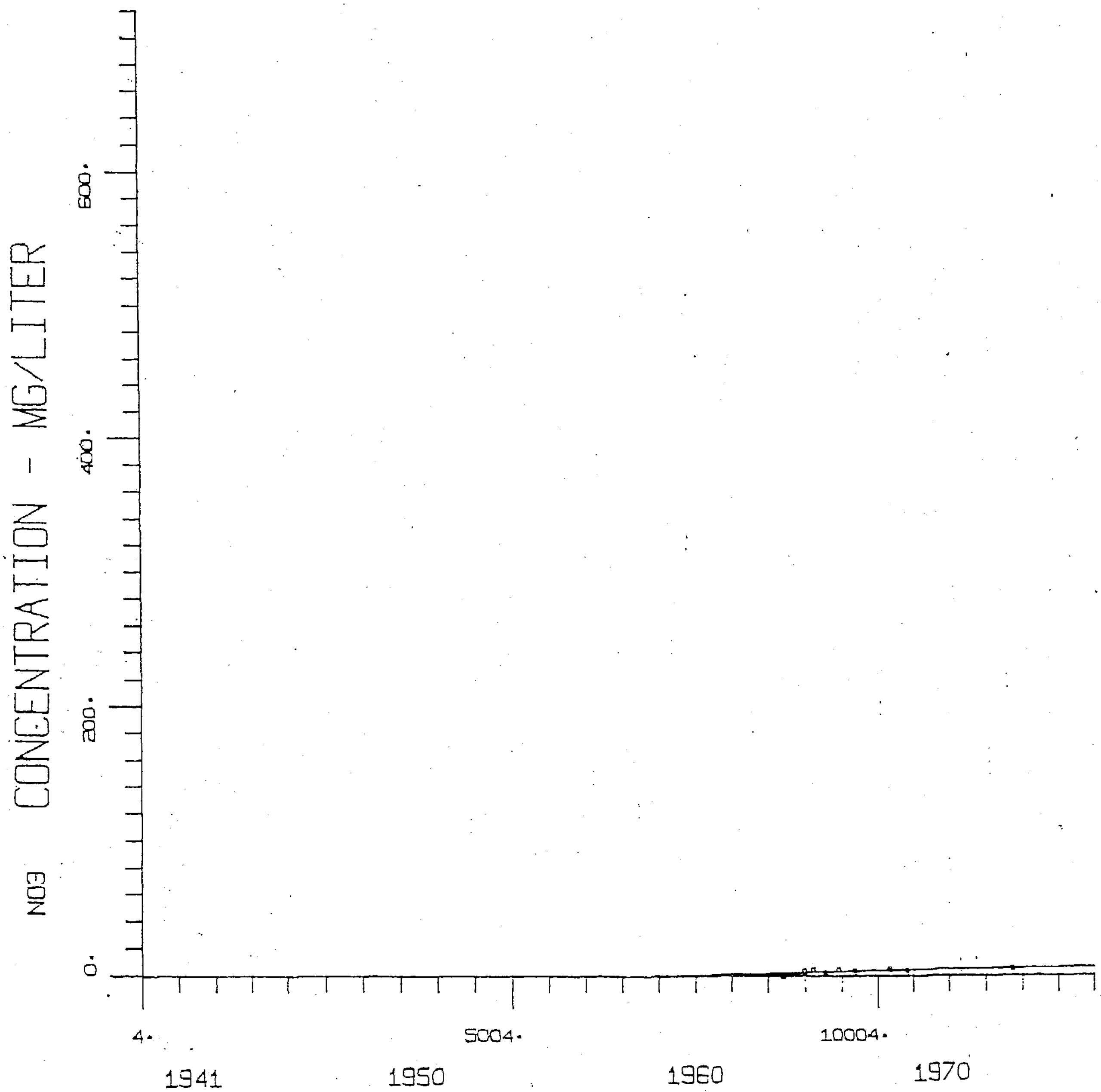


FIG. F-2A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W12R1

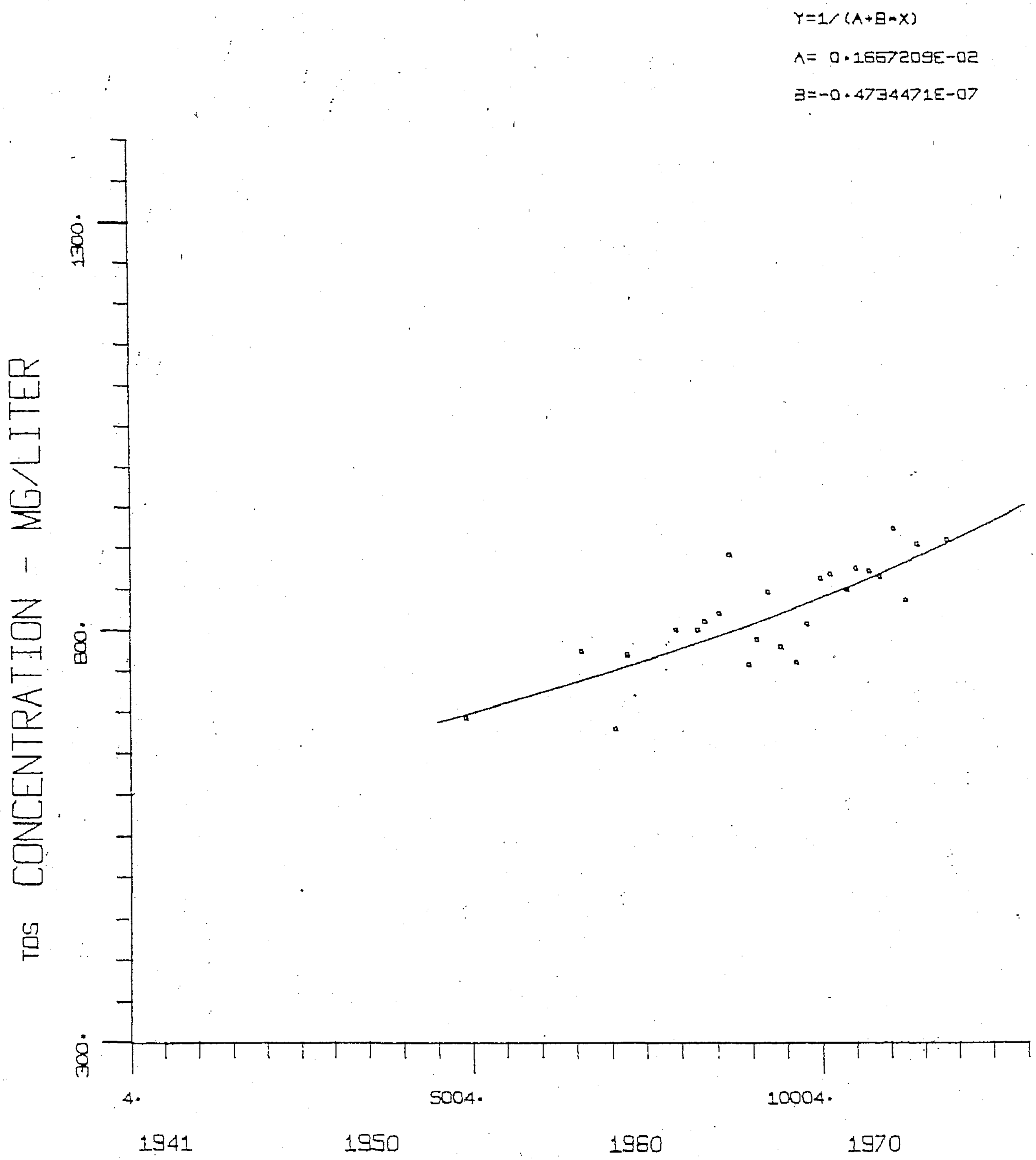


FIG. F-2B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W12R1

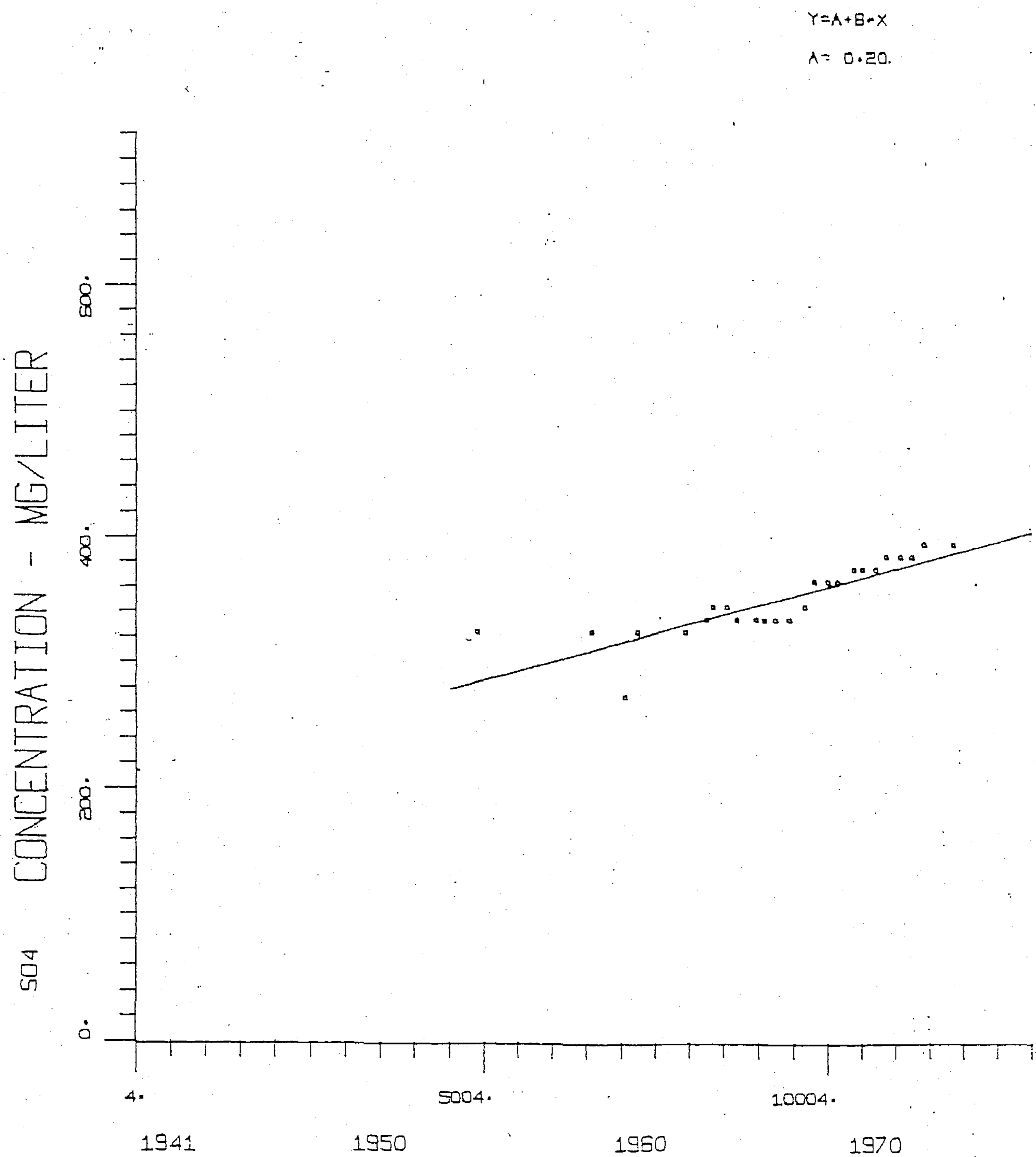


FIG. F-2C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W12R1

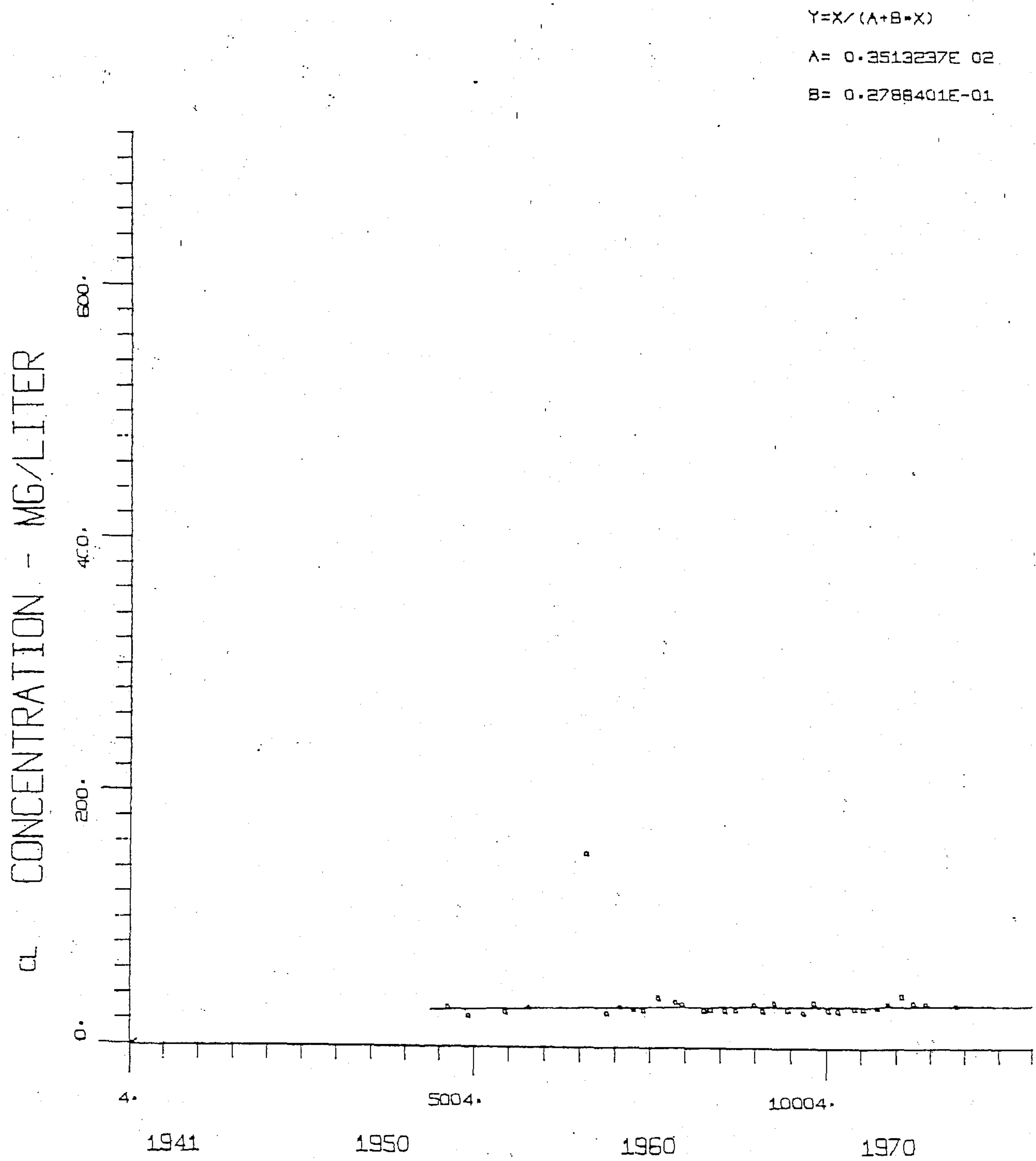


FIG. F-2D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W12R1

Y=A+B*X

A=-0.2675239E 01

B= 0.2215883E-02

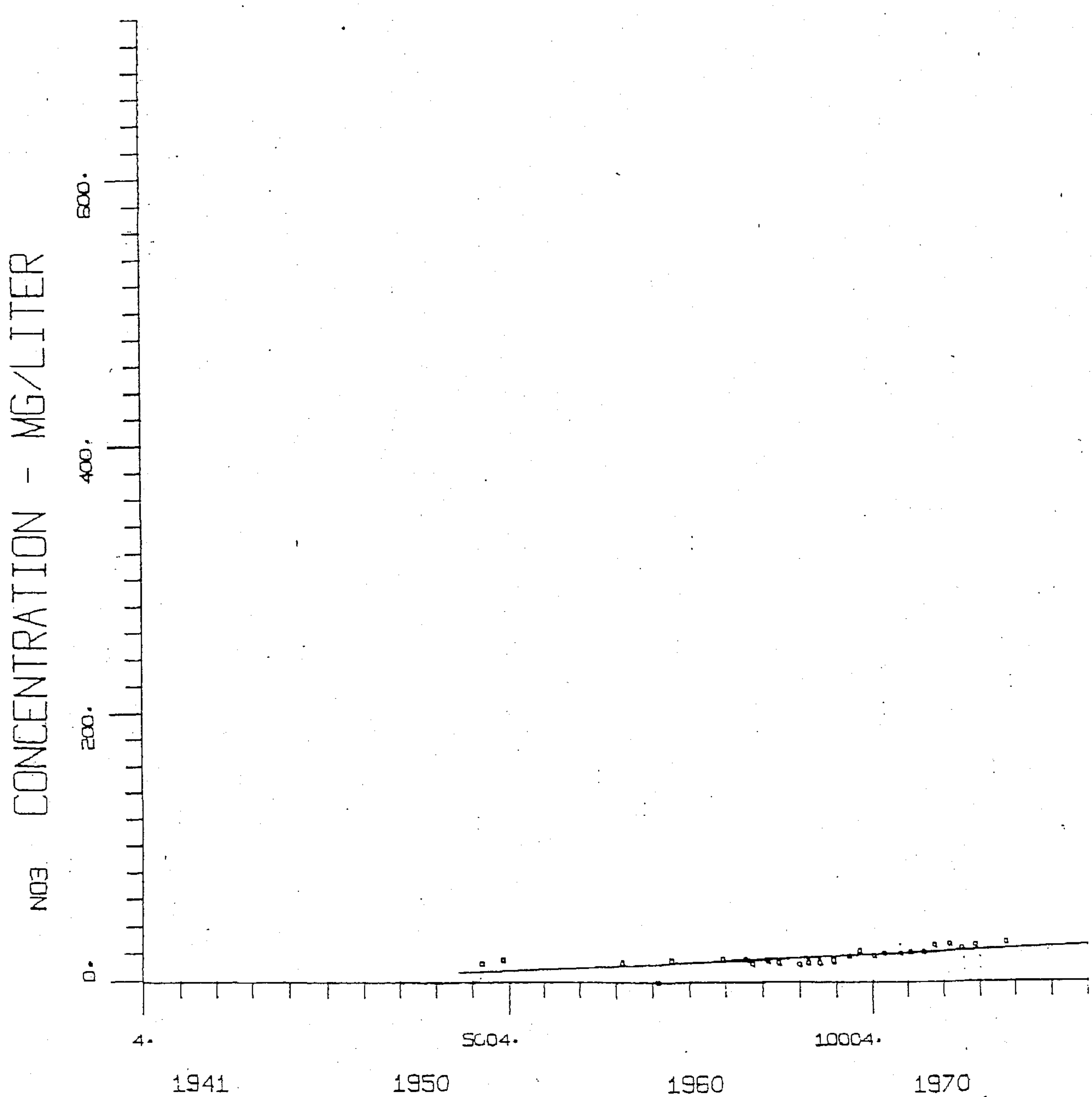


FIG. F-3A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W18R1

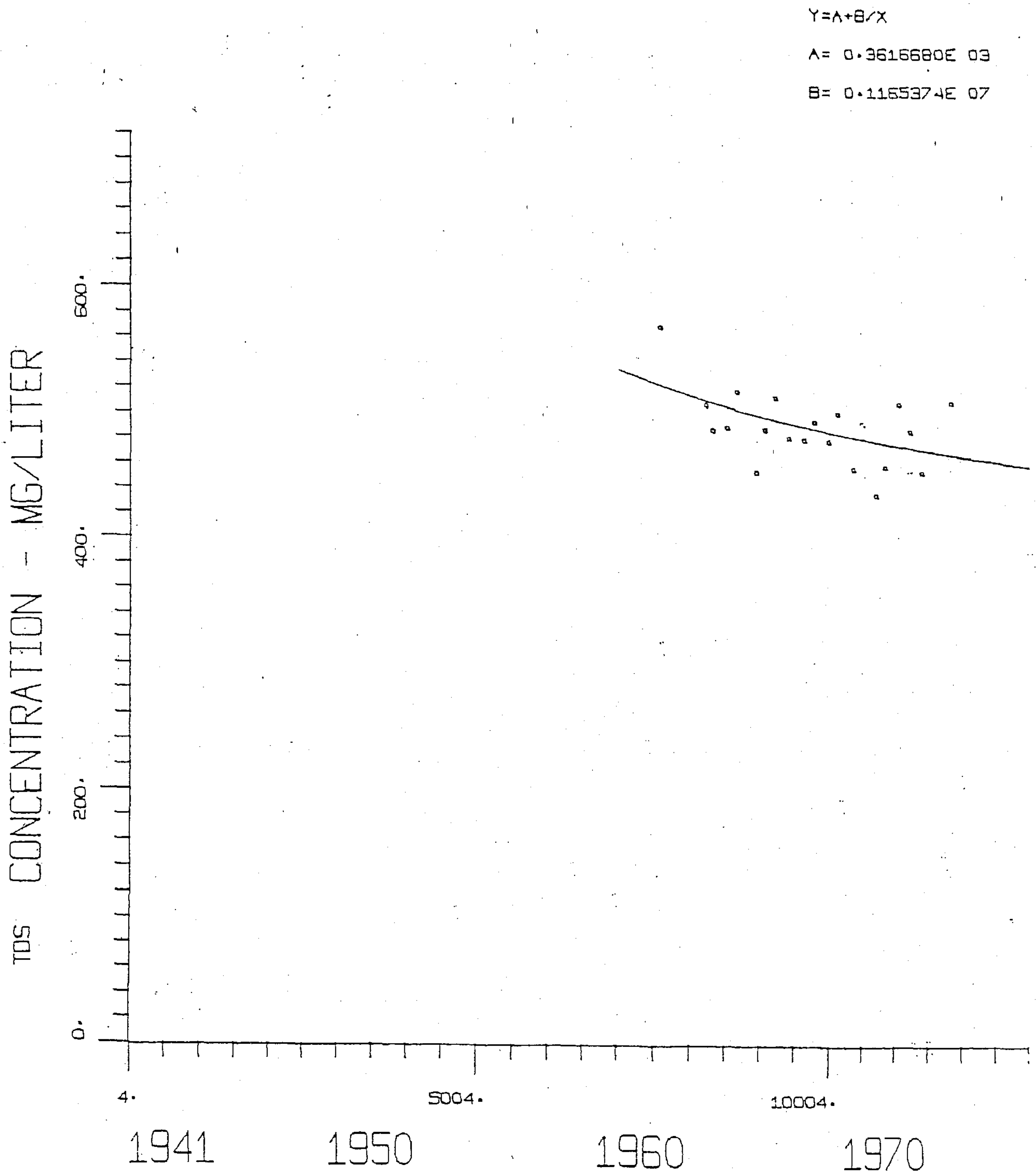


FIG. F-3B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W18R1

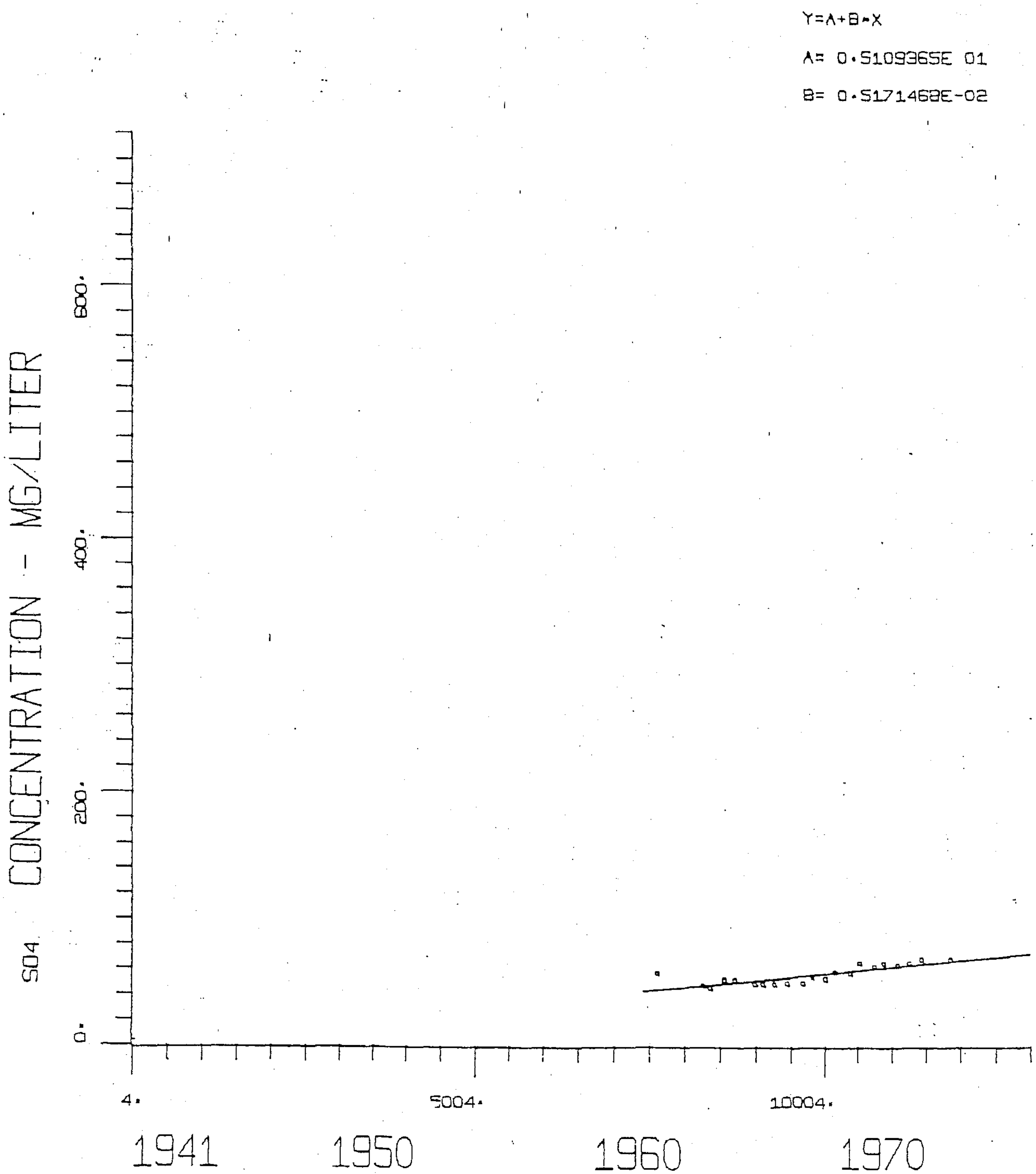


FIG. F-3C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W18R1

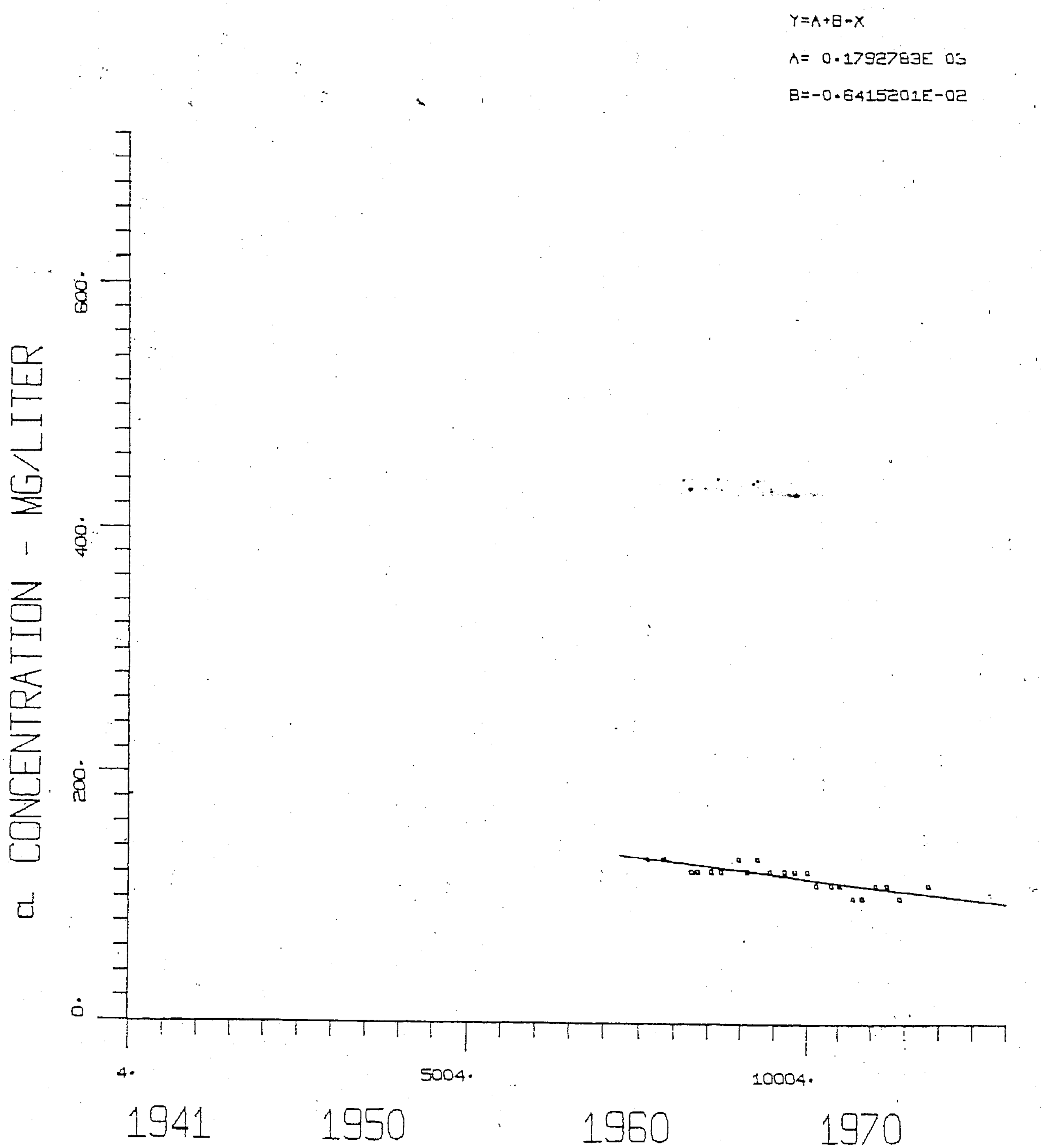


FIG. F-3D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N33W18R1

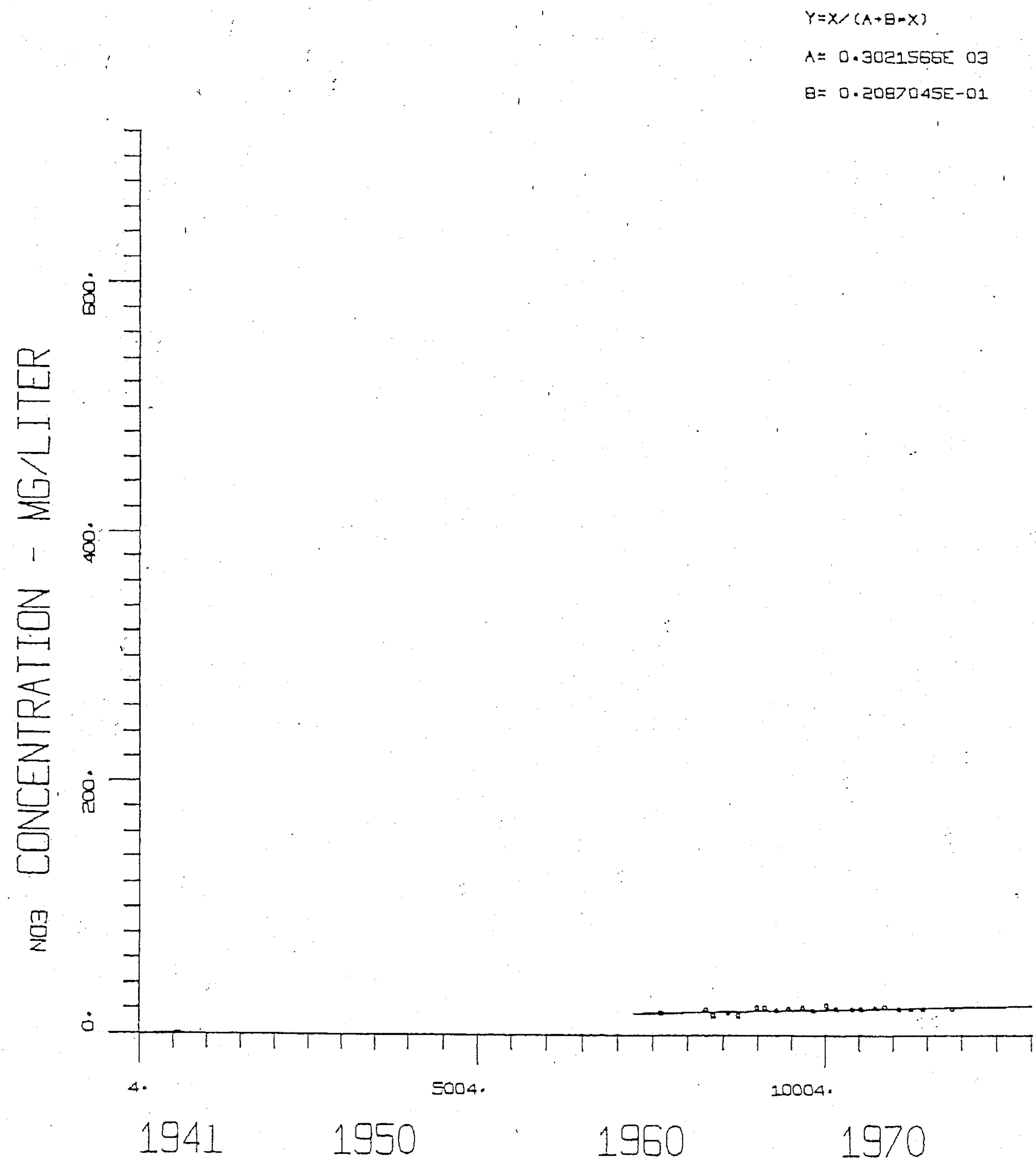


FIG. F-4A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N34W8H4

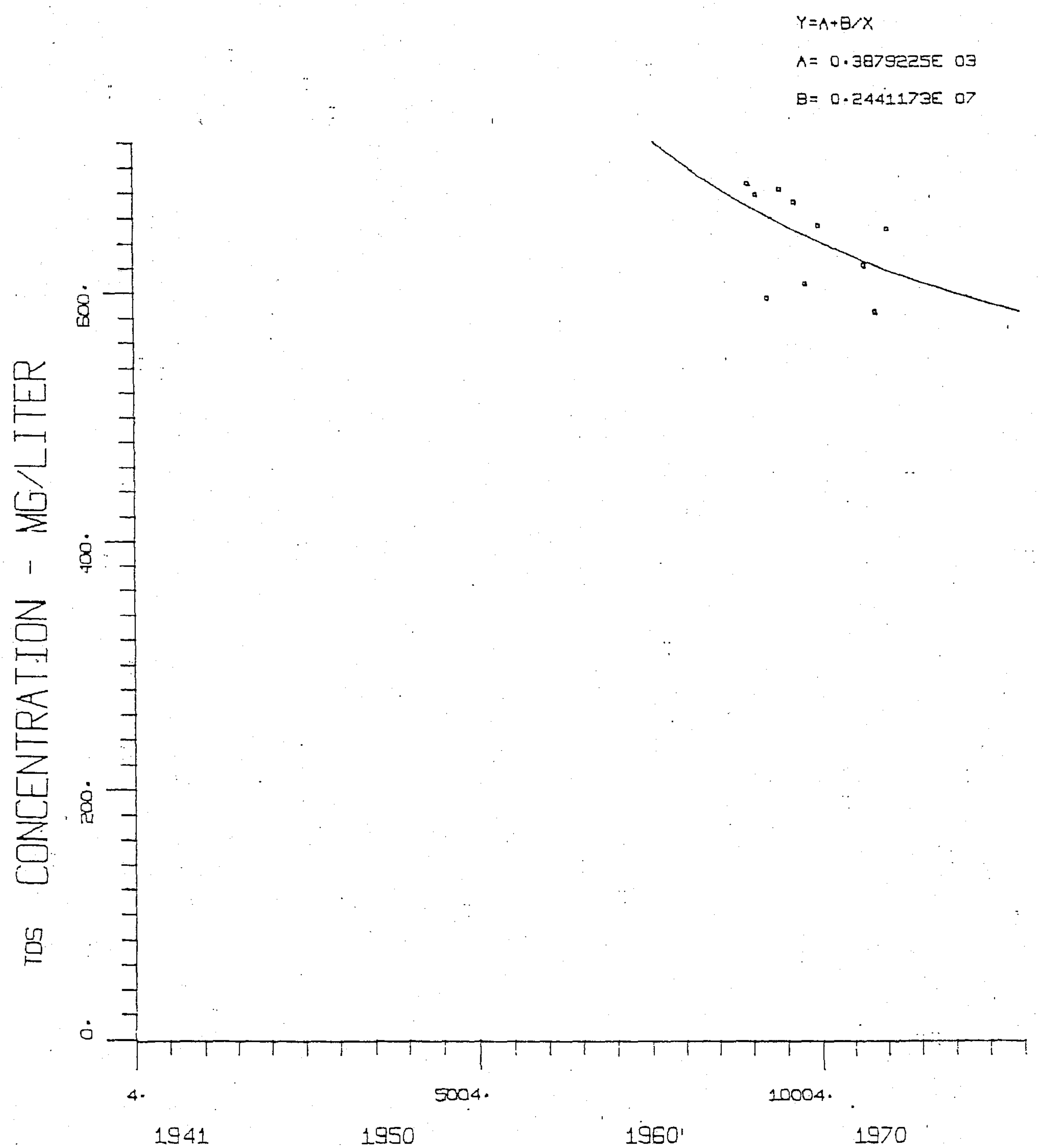


FIG. F-4B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N34W8H4

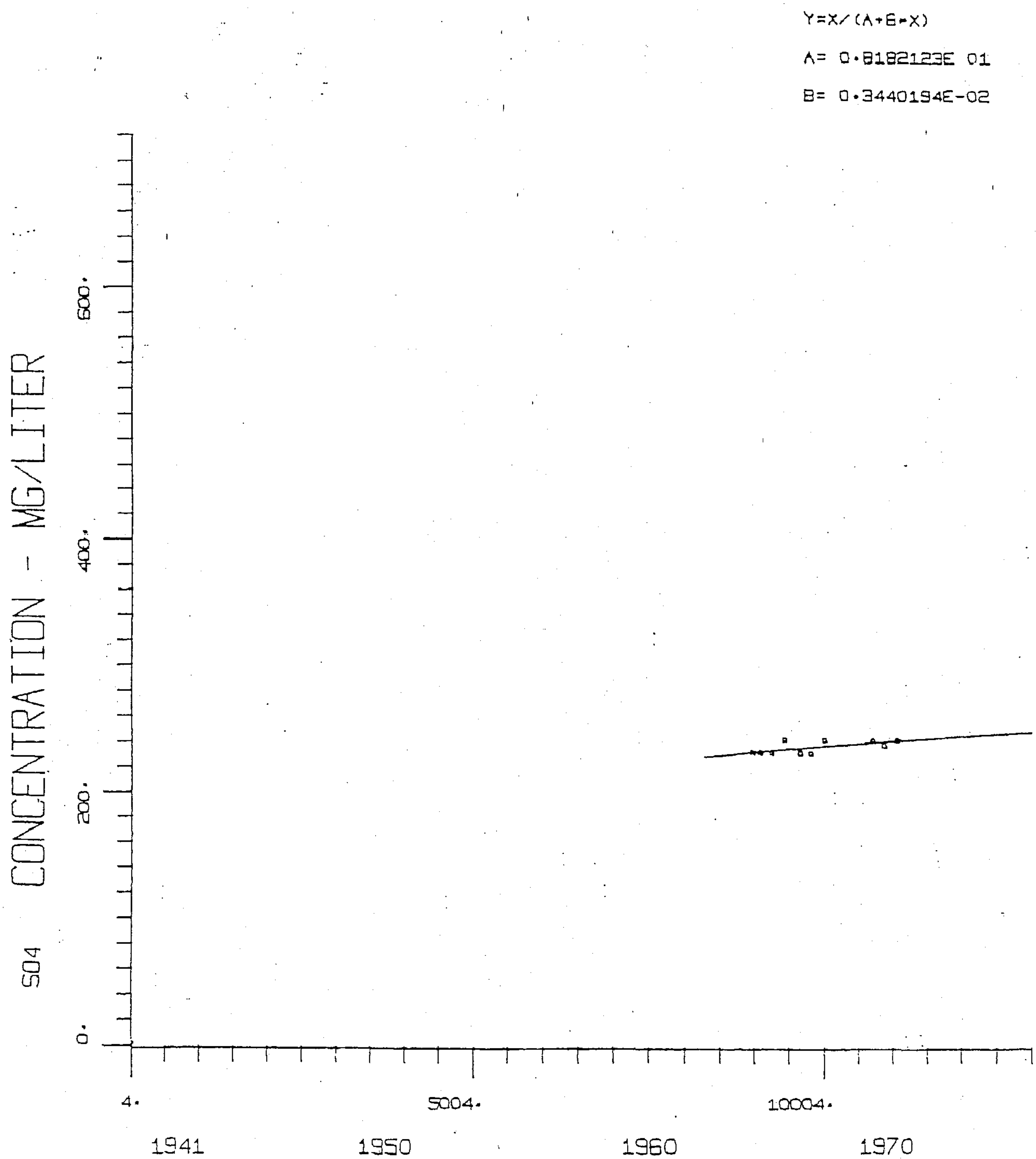


FIG. F-4C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N34W8H4

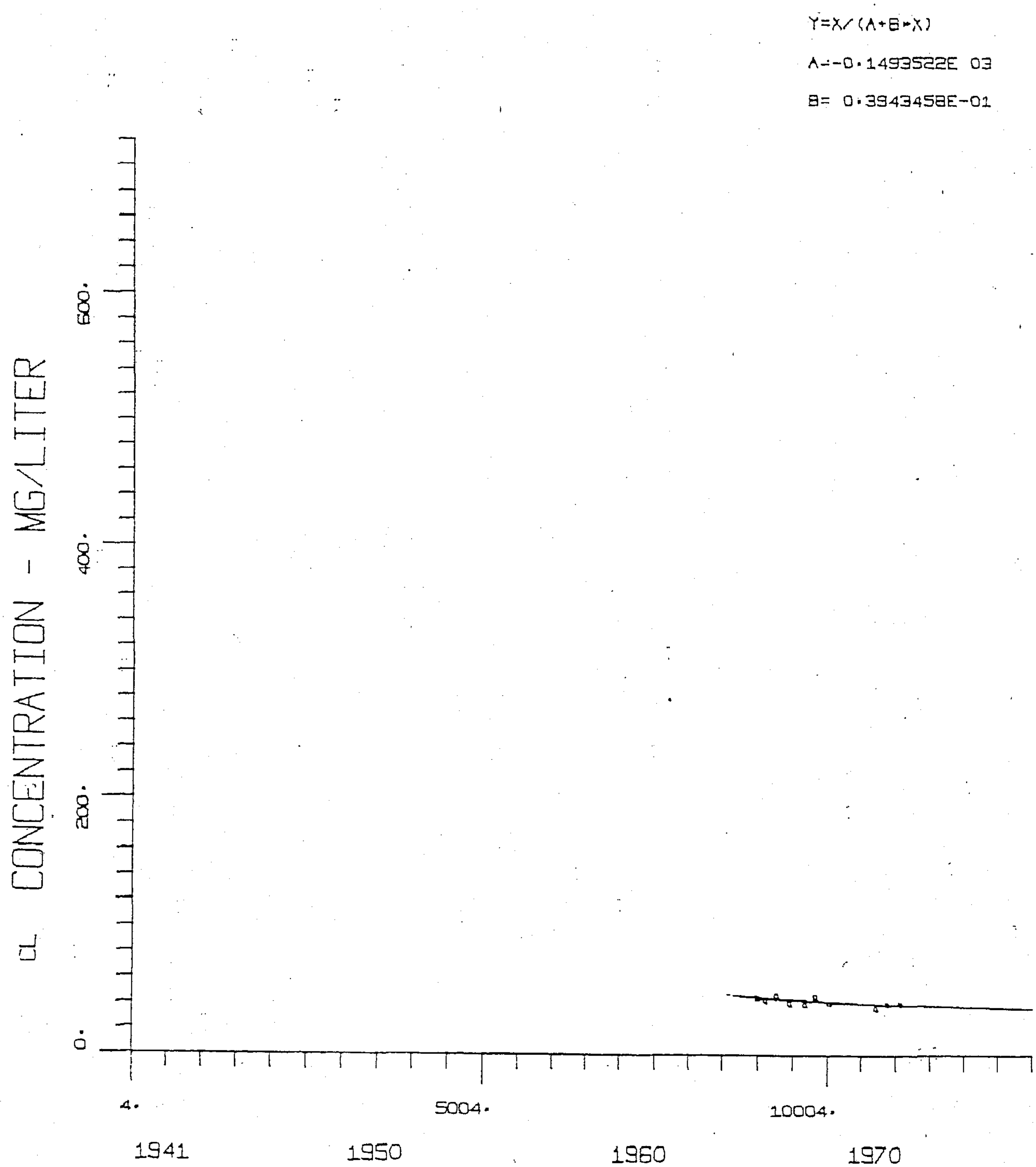


FIG. F-4D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 9N34W8H4

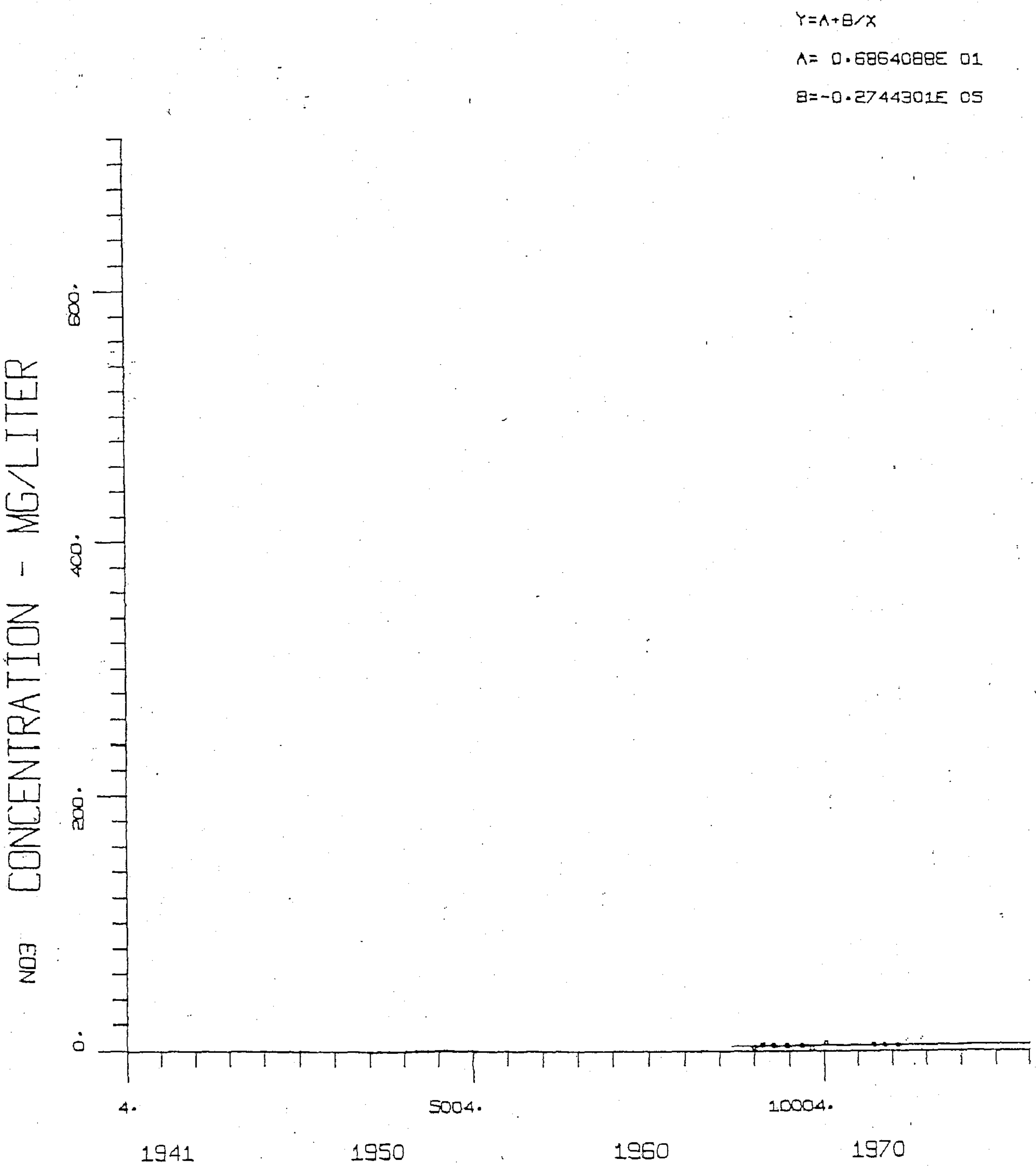


FIG. F-5A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W17F1

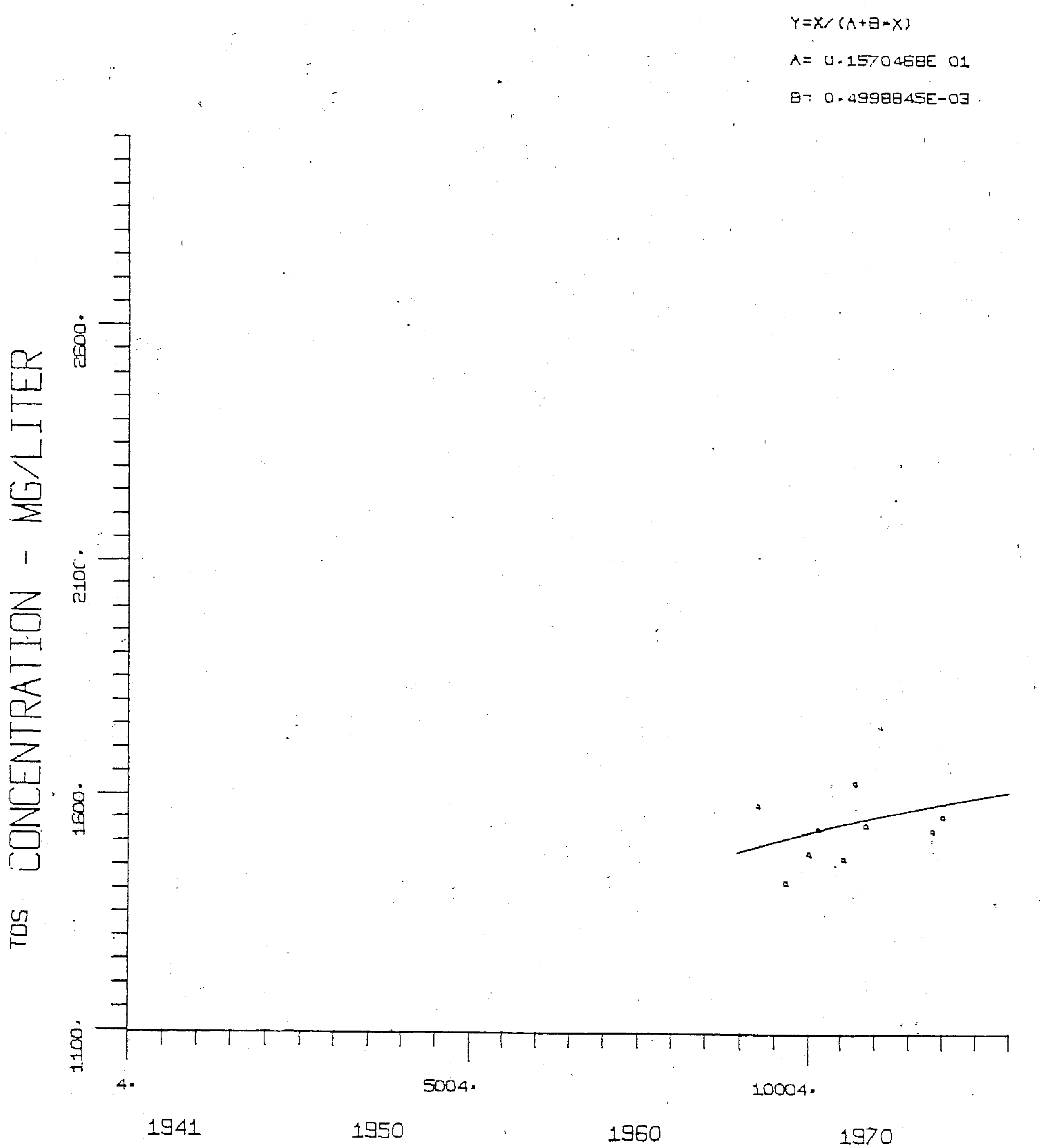


FIG. F-5B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W17F1

Y=X/(A+B*X)

A= 0.8170839E 01

B= 0.5602294E-03

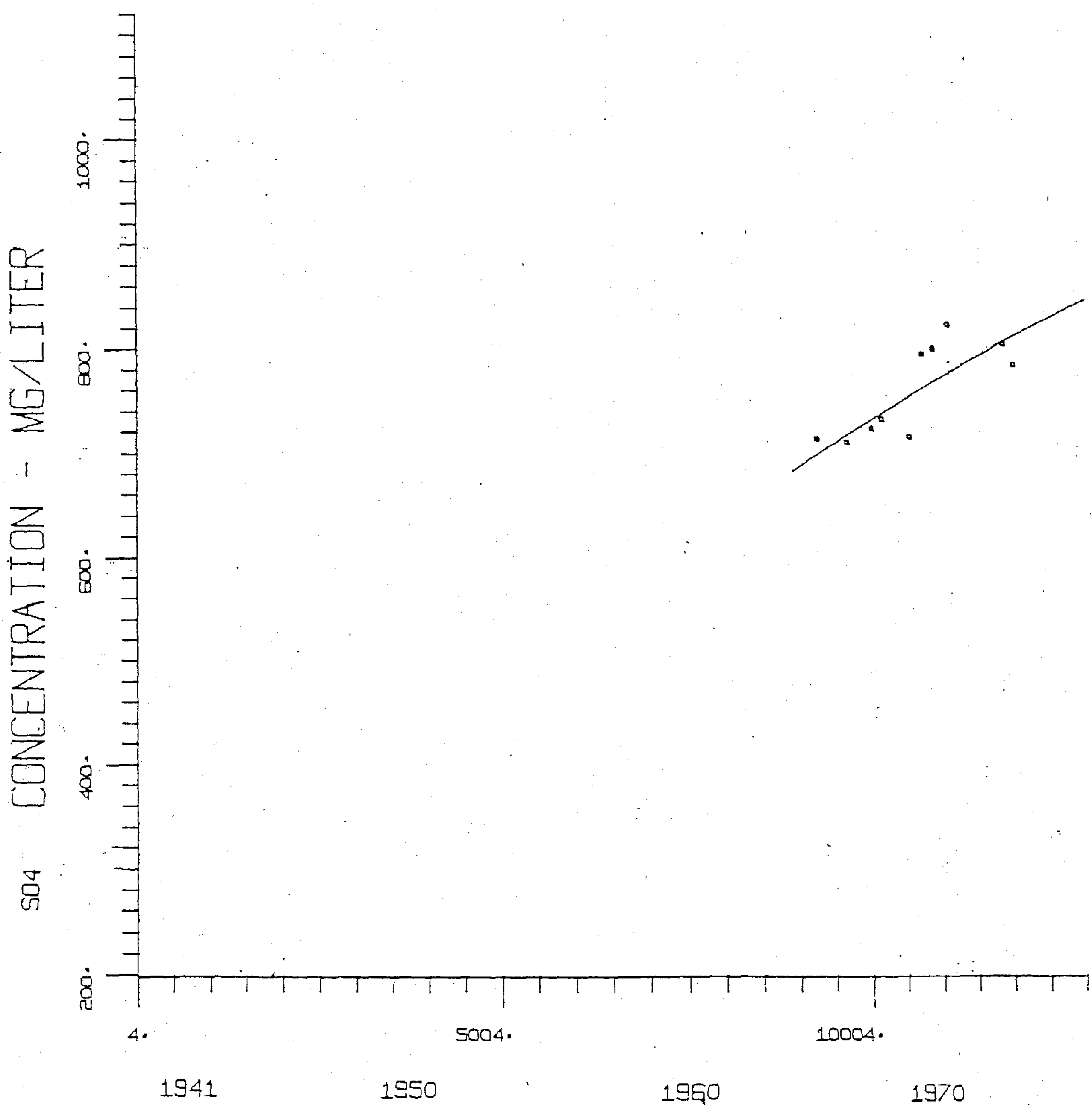


FIG. F-5C

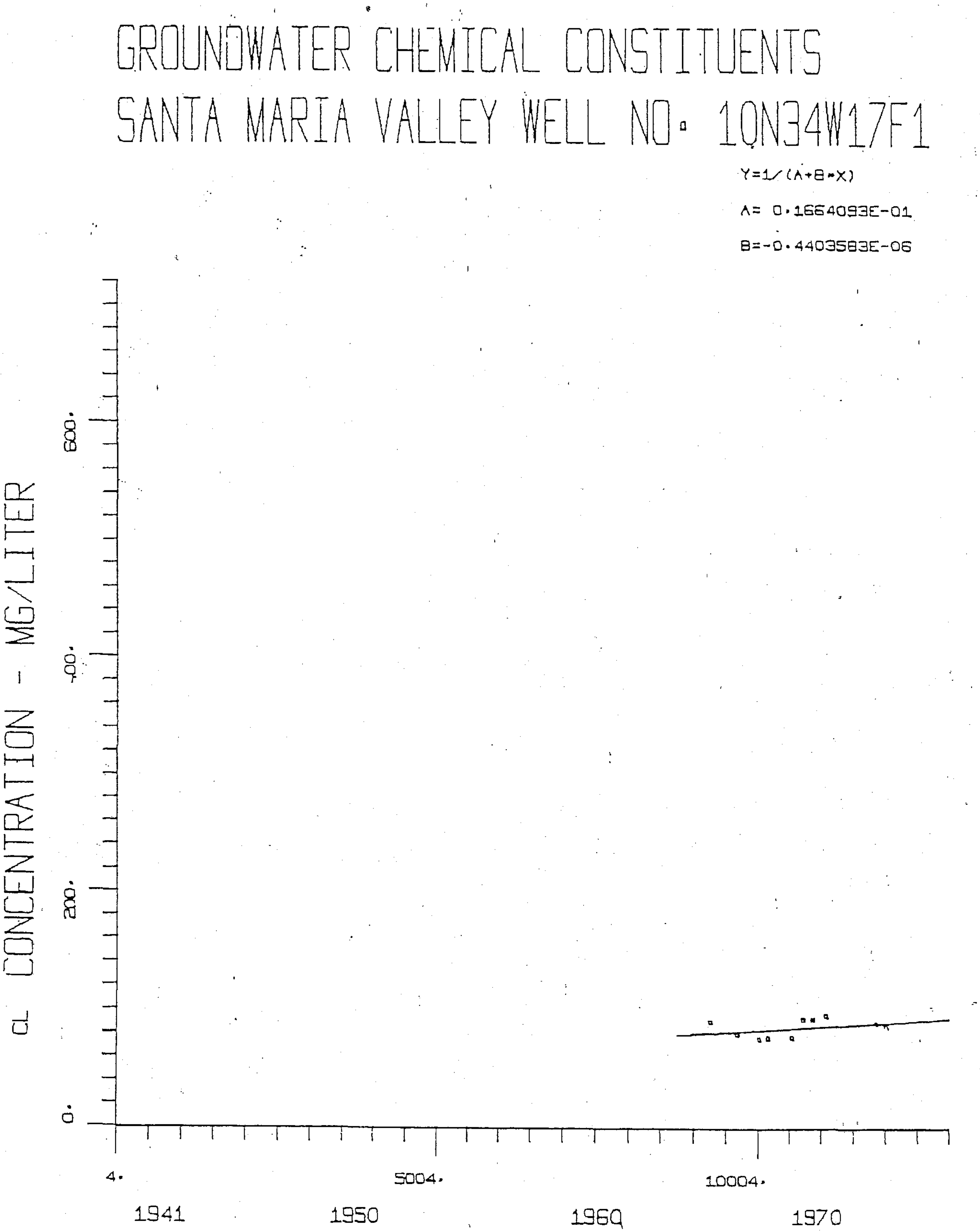

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W17F1
Y=1/(A+B*X)
A= 0.1664093E-01
B=-0.4403583E-06
CL CONCENTRATION - MG/LITER
600.
400.
200.
0.
4.
5004.
10004.
1941
1950
1960
1970

FIG. F-5D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W17F1

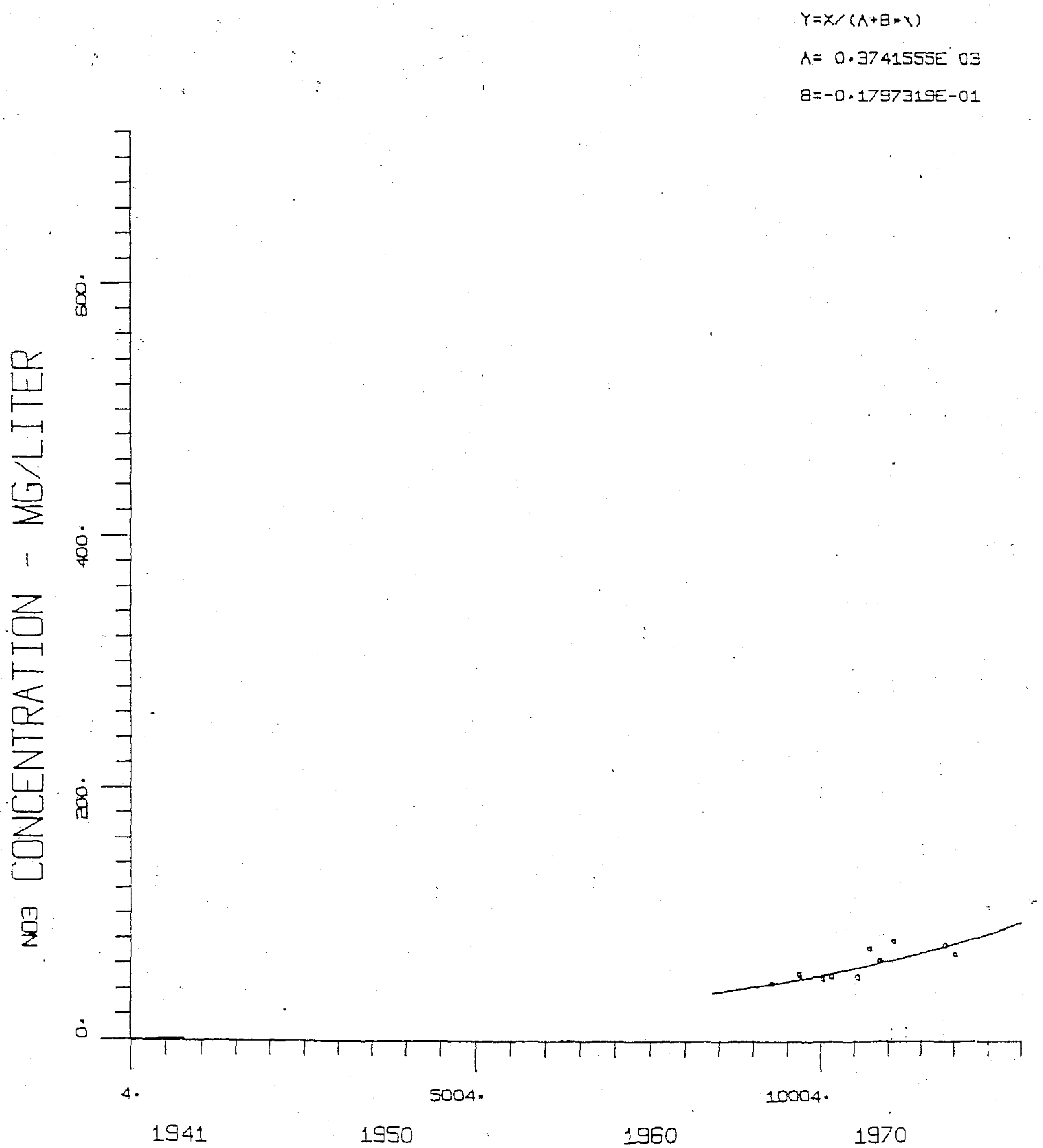


FIG. F-6A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18L1

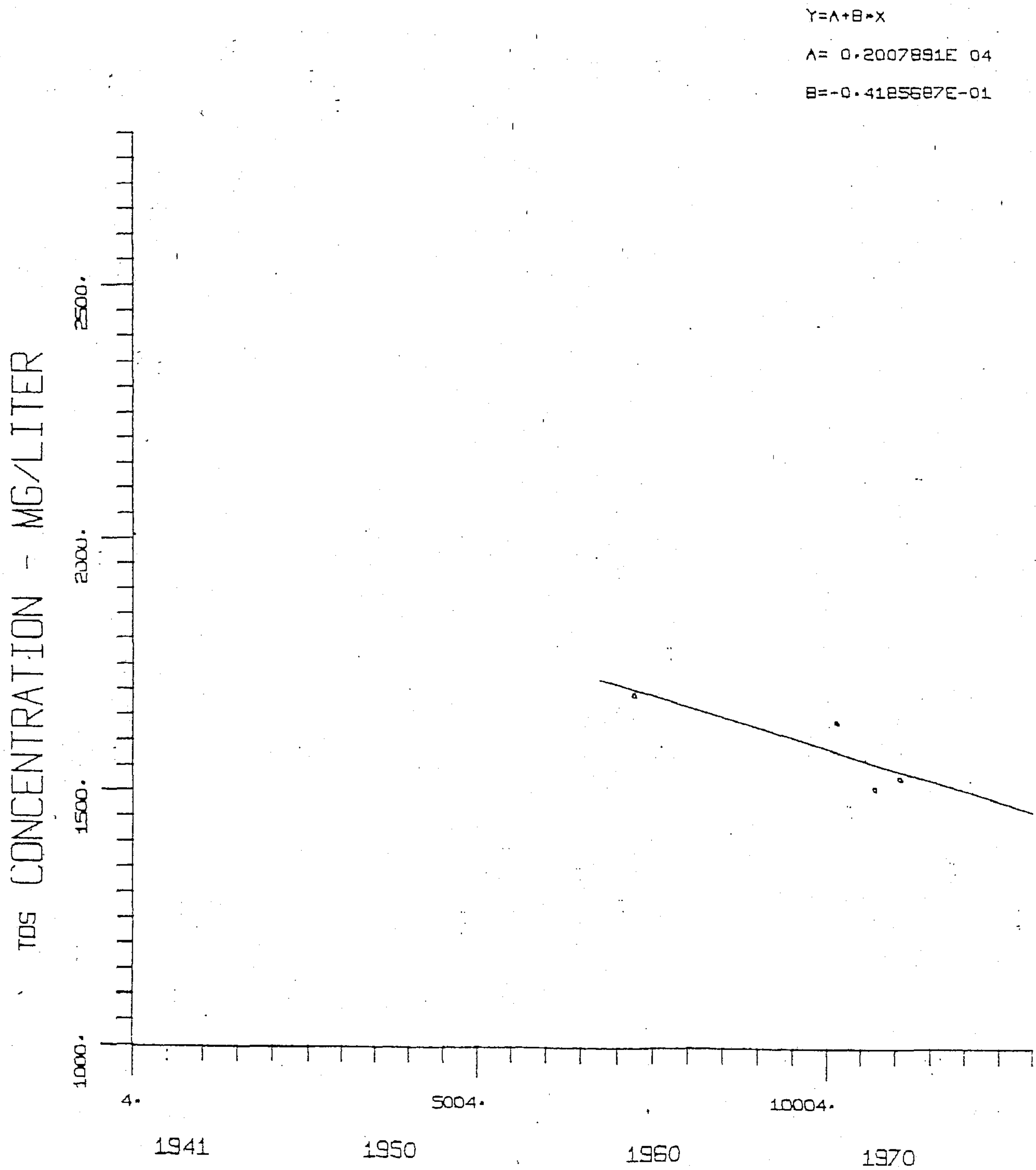


FIG. F-6B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18L1

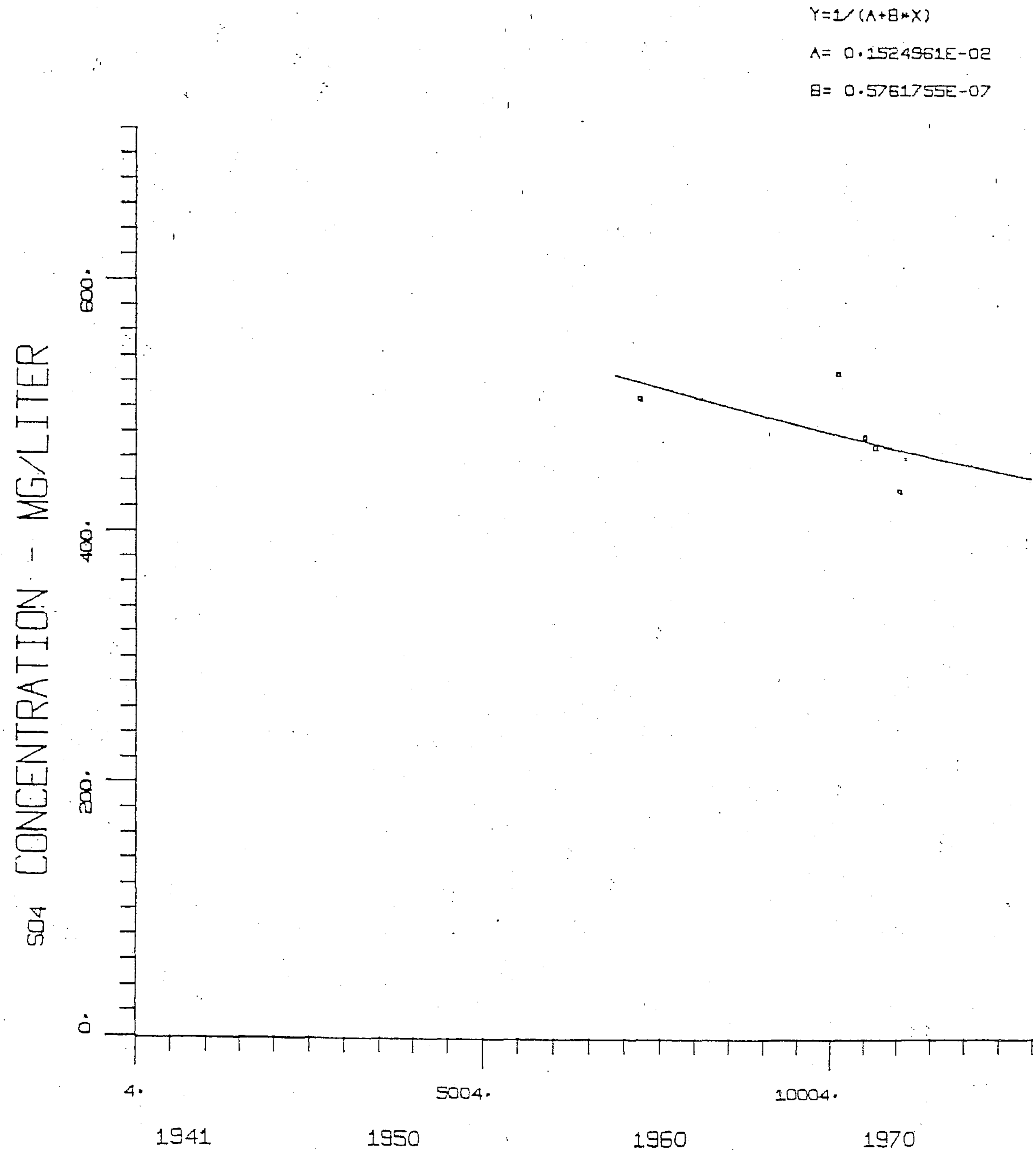


FIG. F-6C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18L1

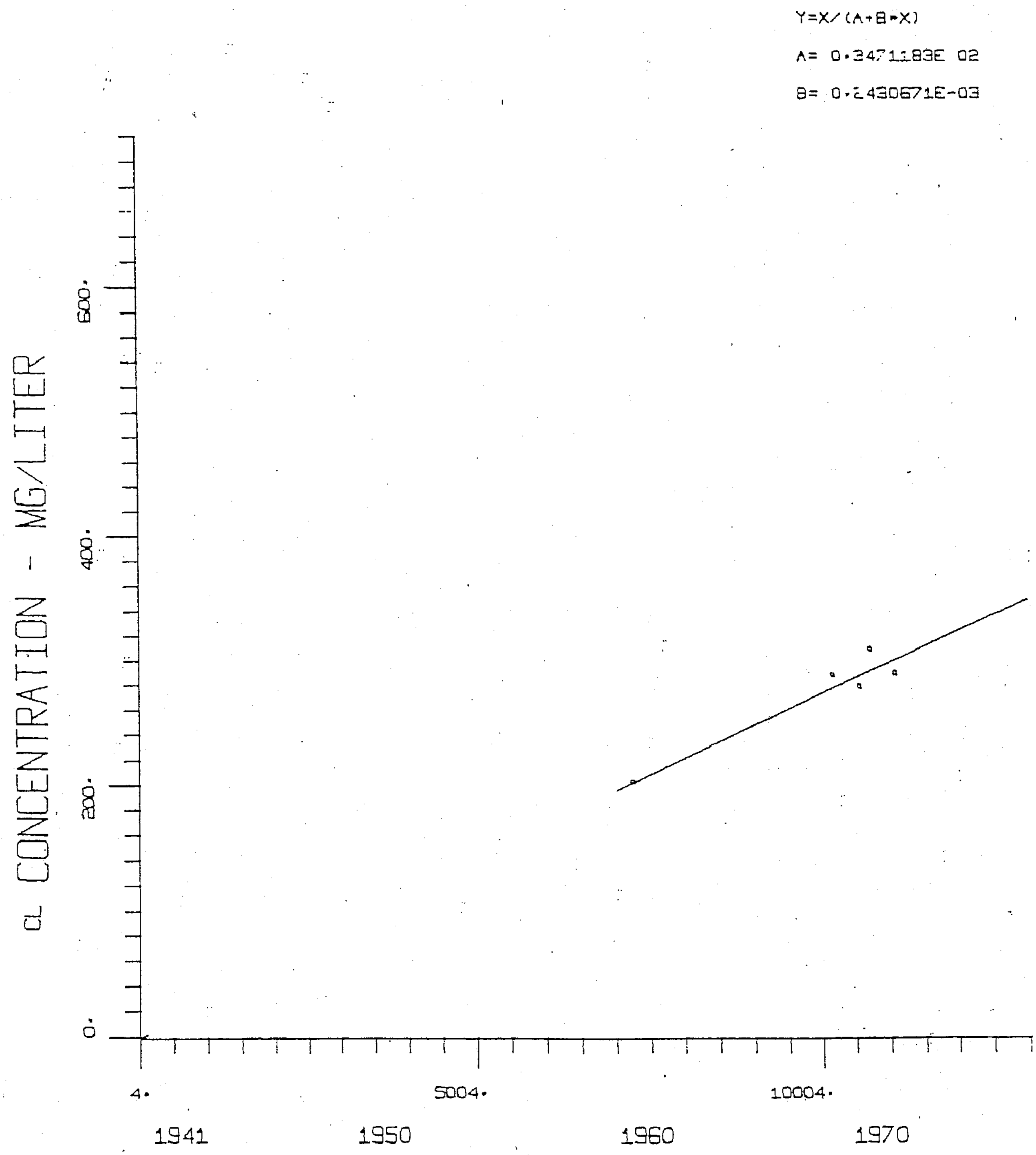


FIG. F-6D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18L1

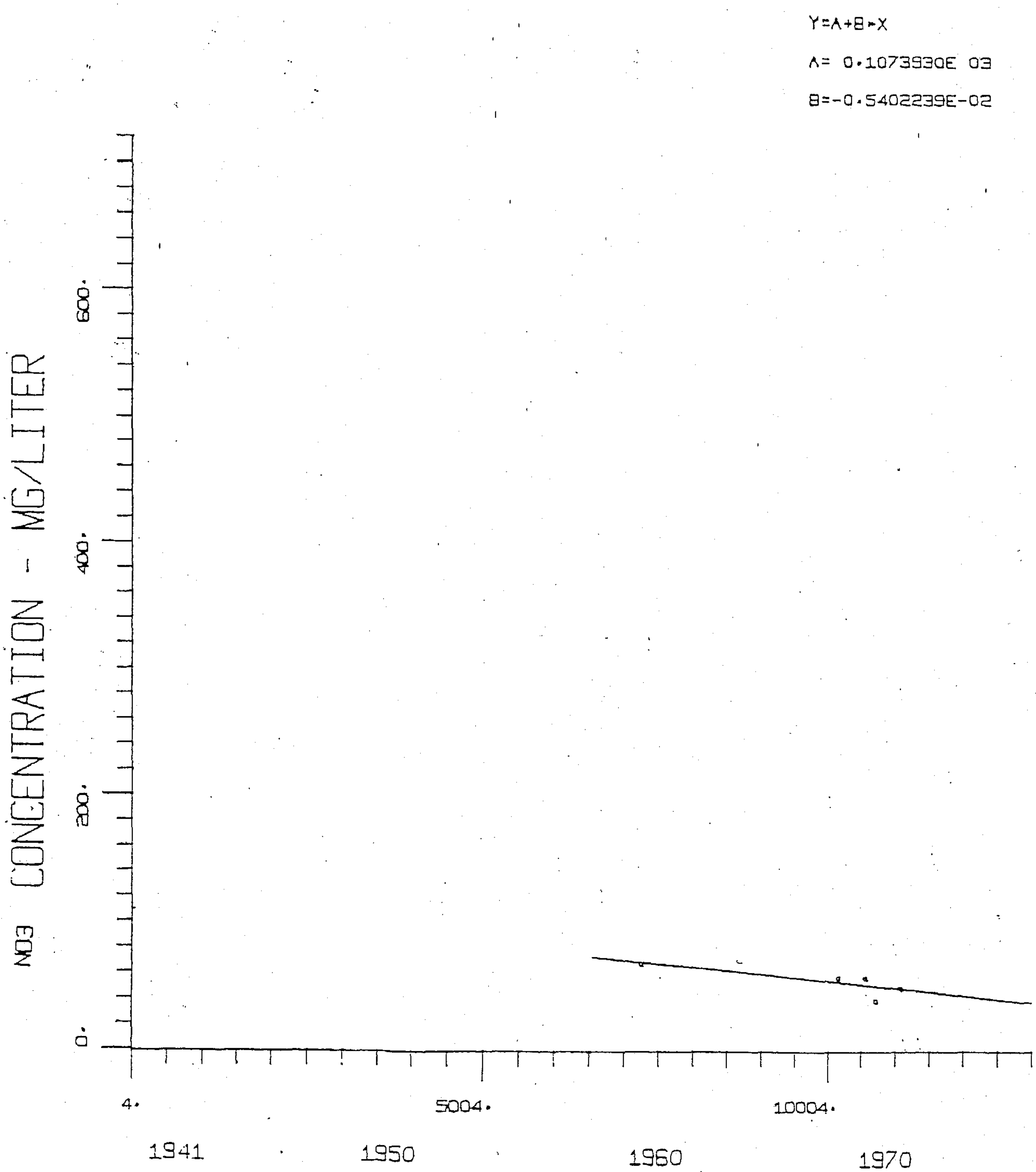


FIG. F-7A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18P1

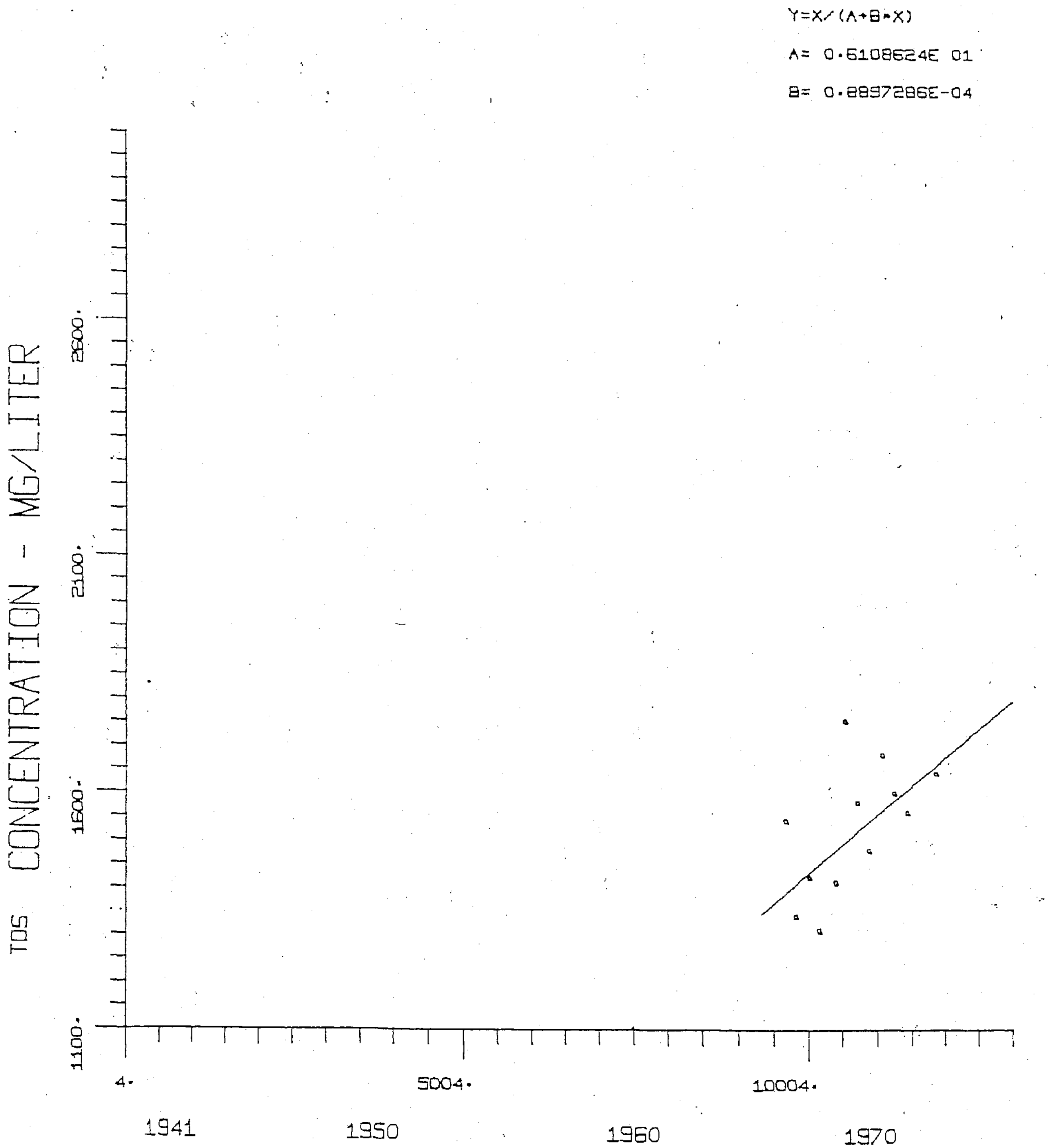


FIG. F-7B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18P1

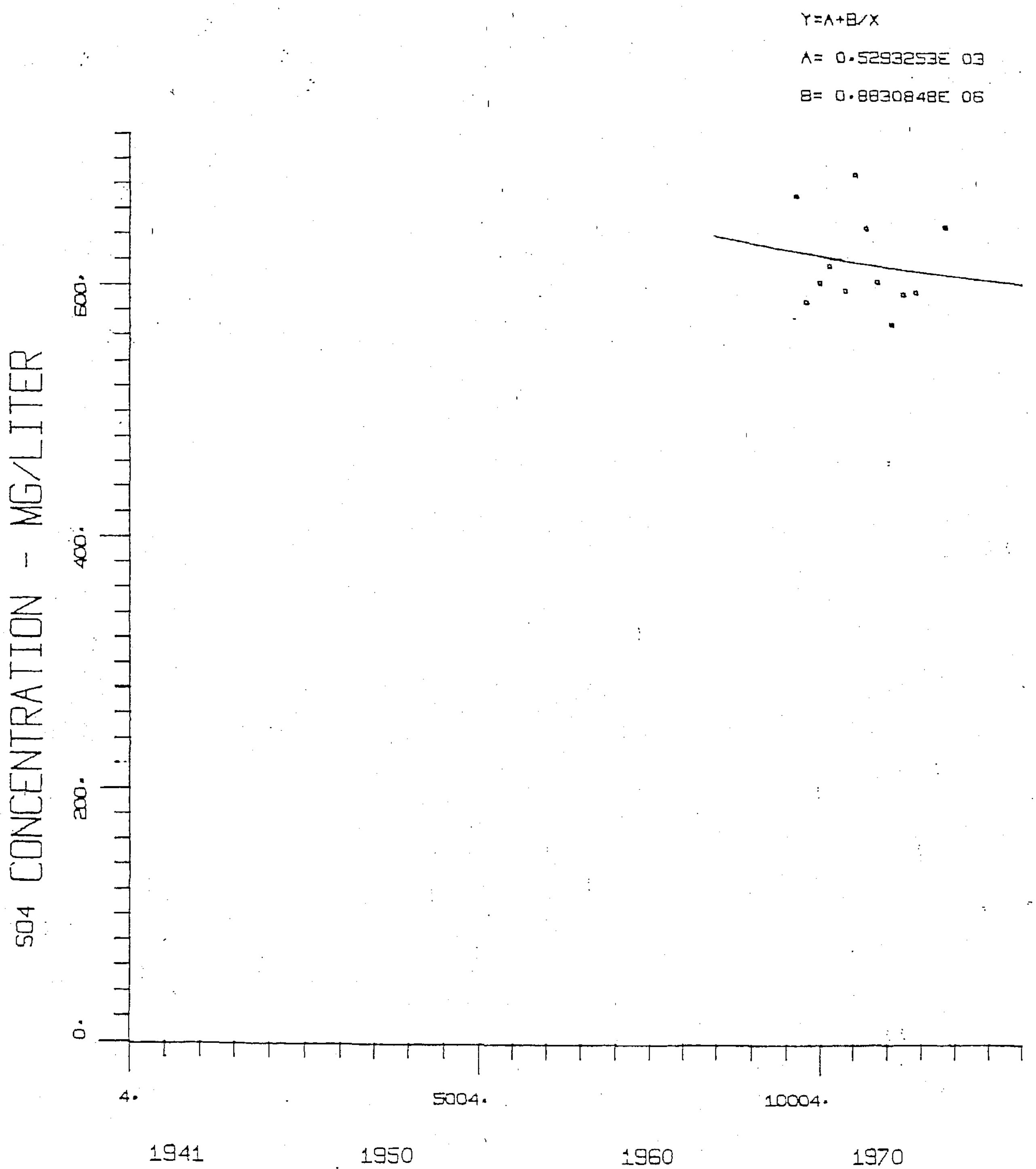


FIG. F-7C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18P1

Y=X/(A+B*X)

A= 0.3206201E 03

B=-0.2346158E-01

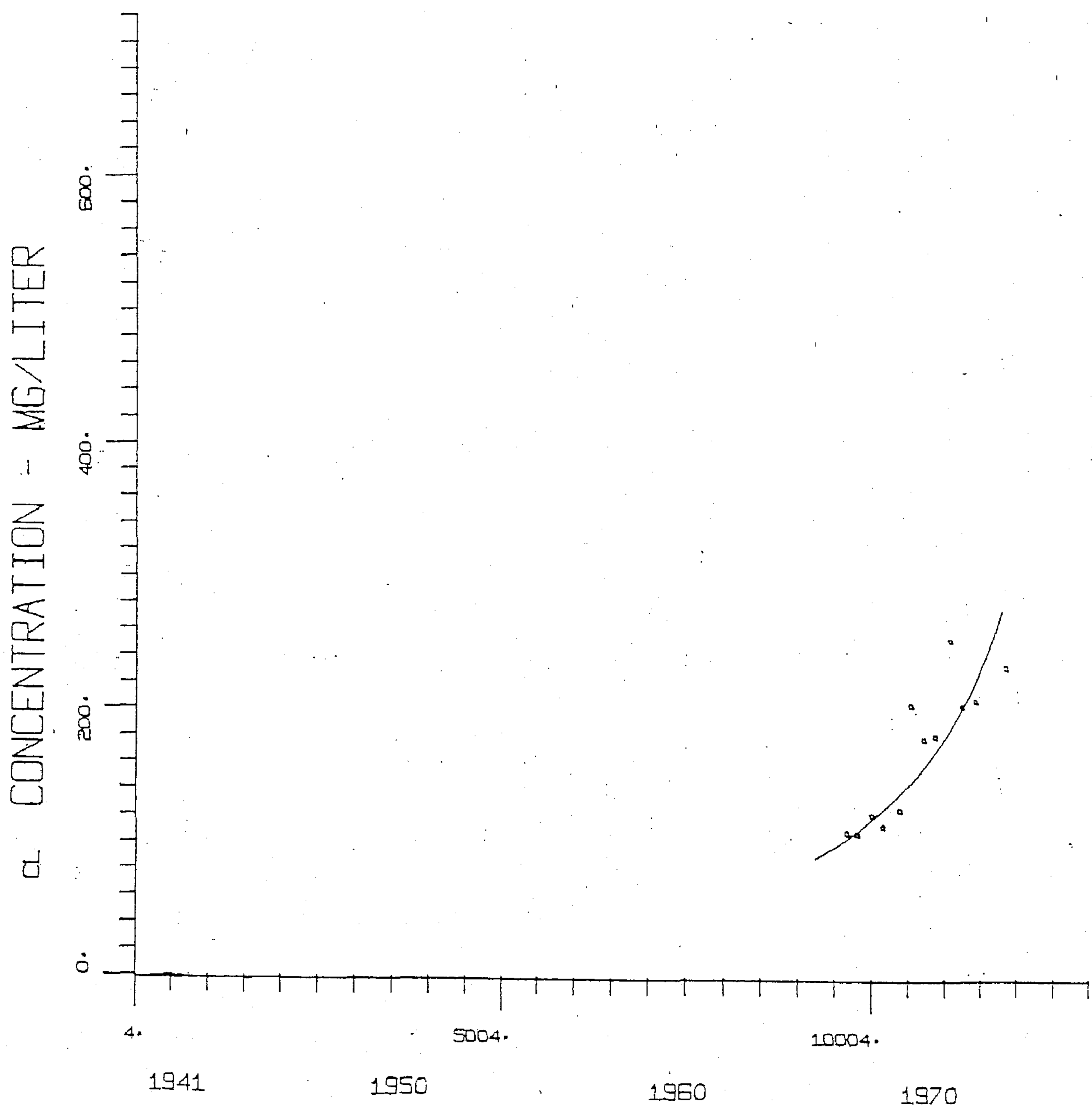


FIG. F-7D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W18P1

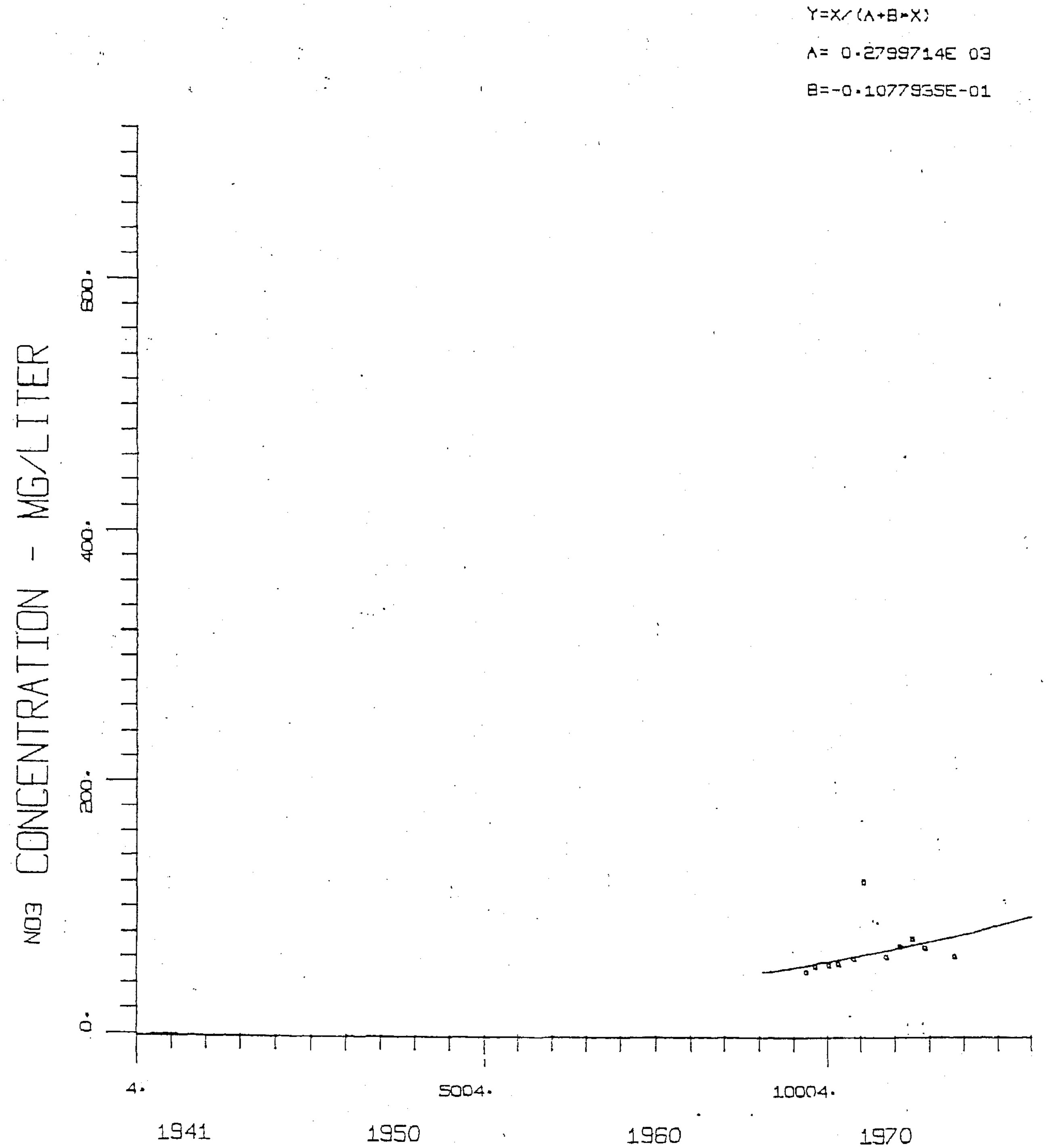
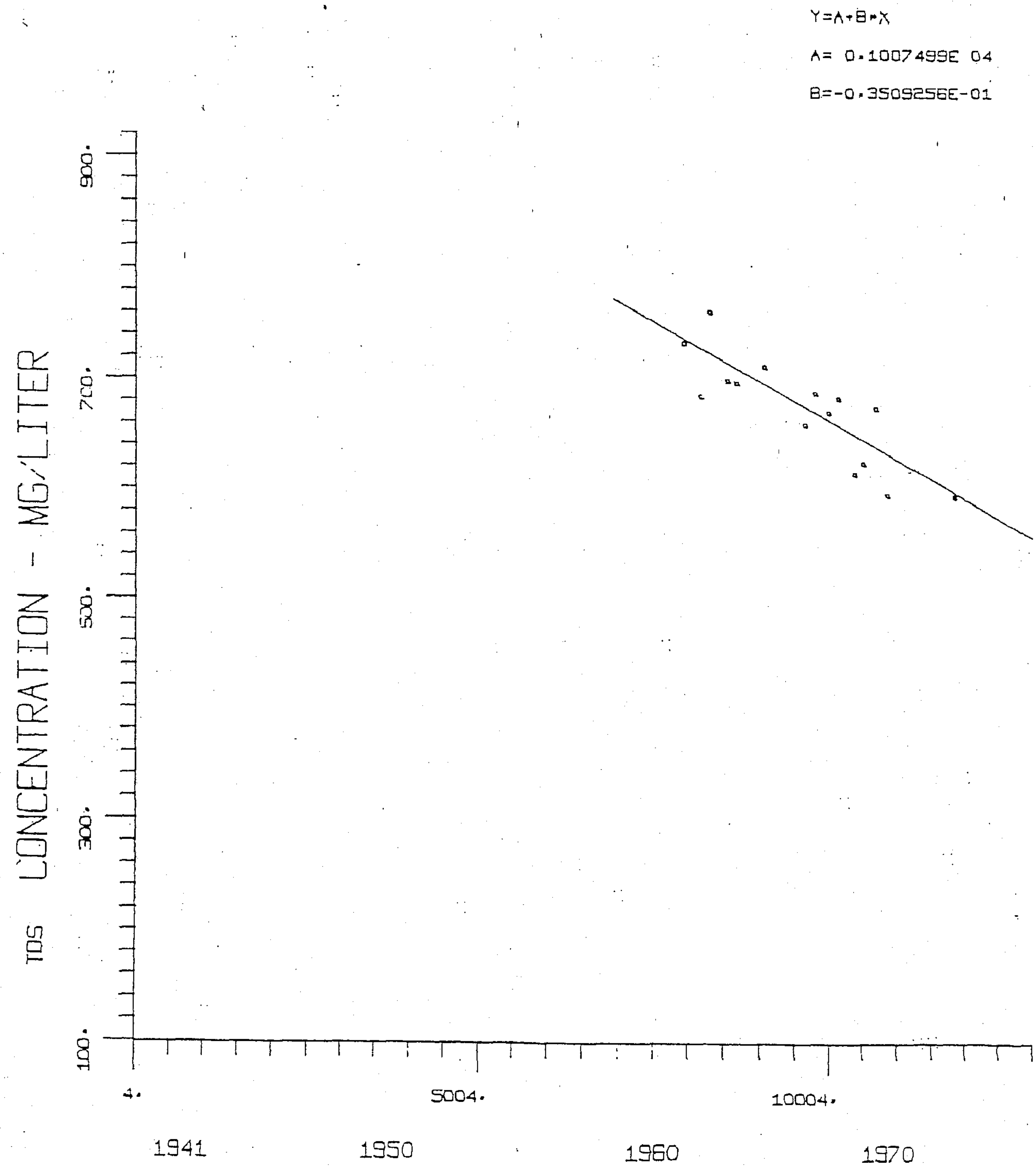


FIG. F-8A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W34E2



GROUNDWATER CHEMICAL

SANTA MARIA VALLEY \

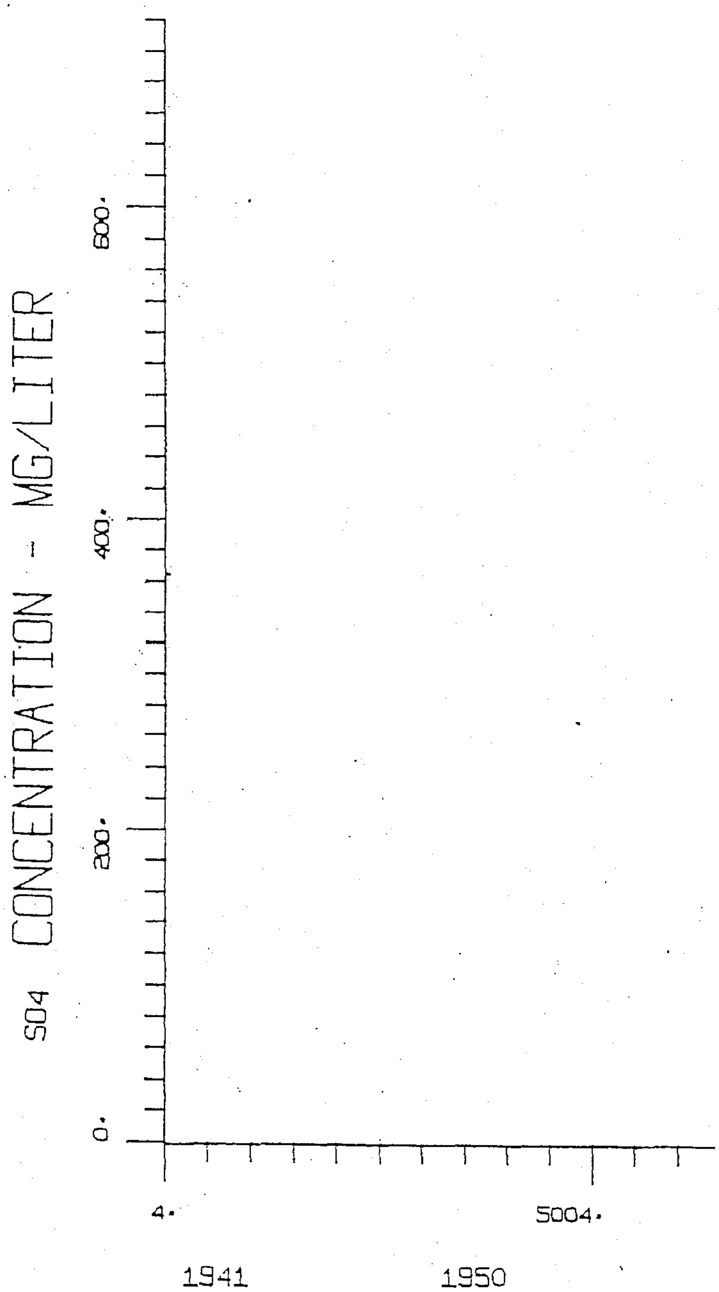


FIG. F-8B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W34E2

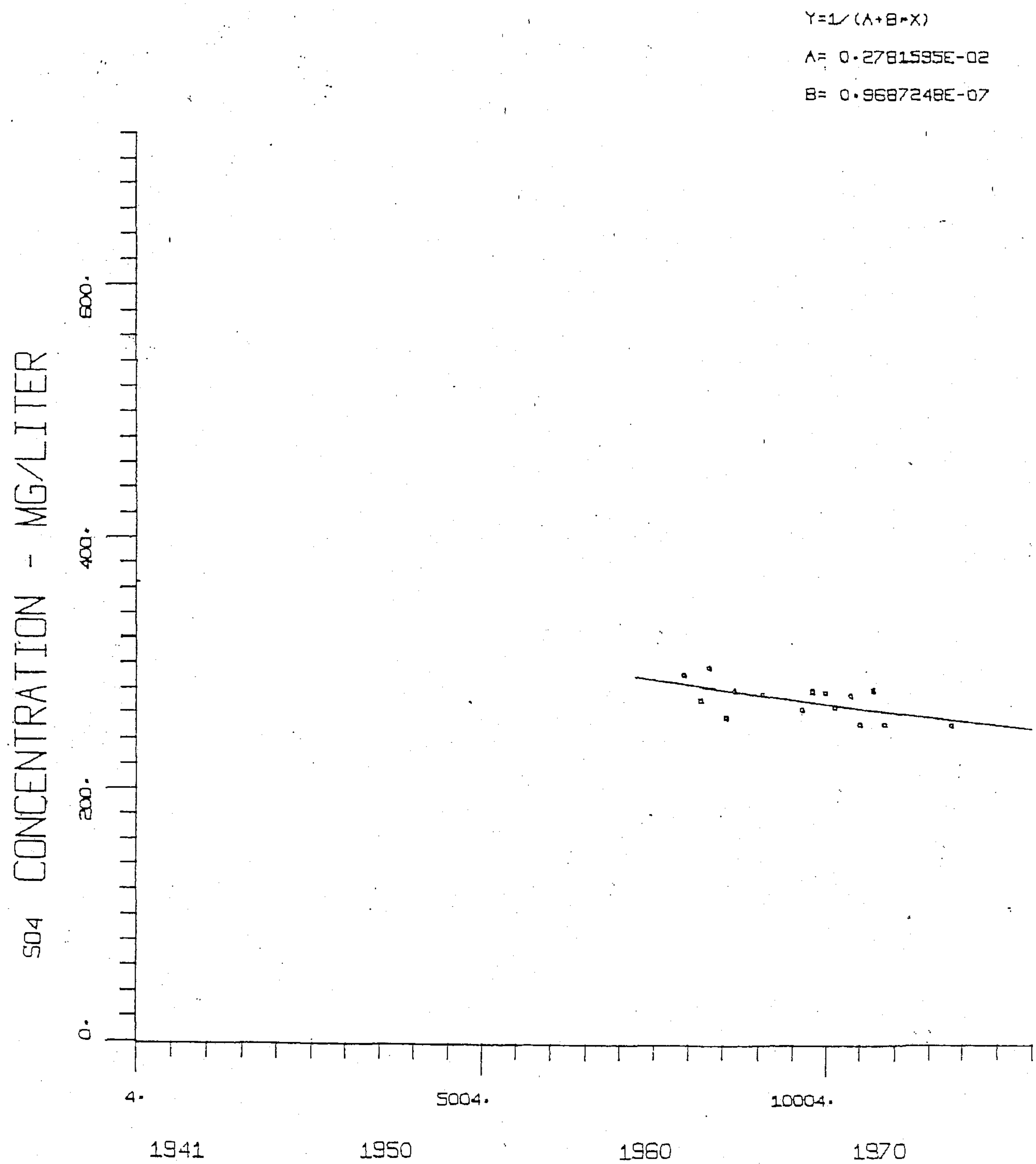


FIG. F-8C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W34E2

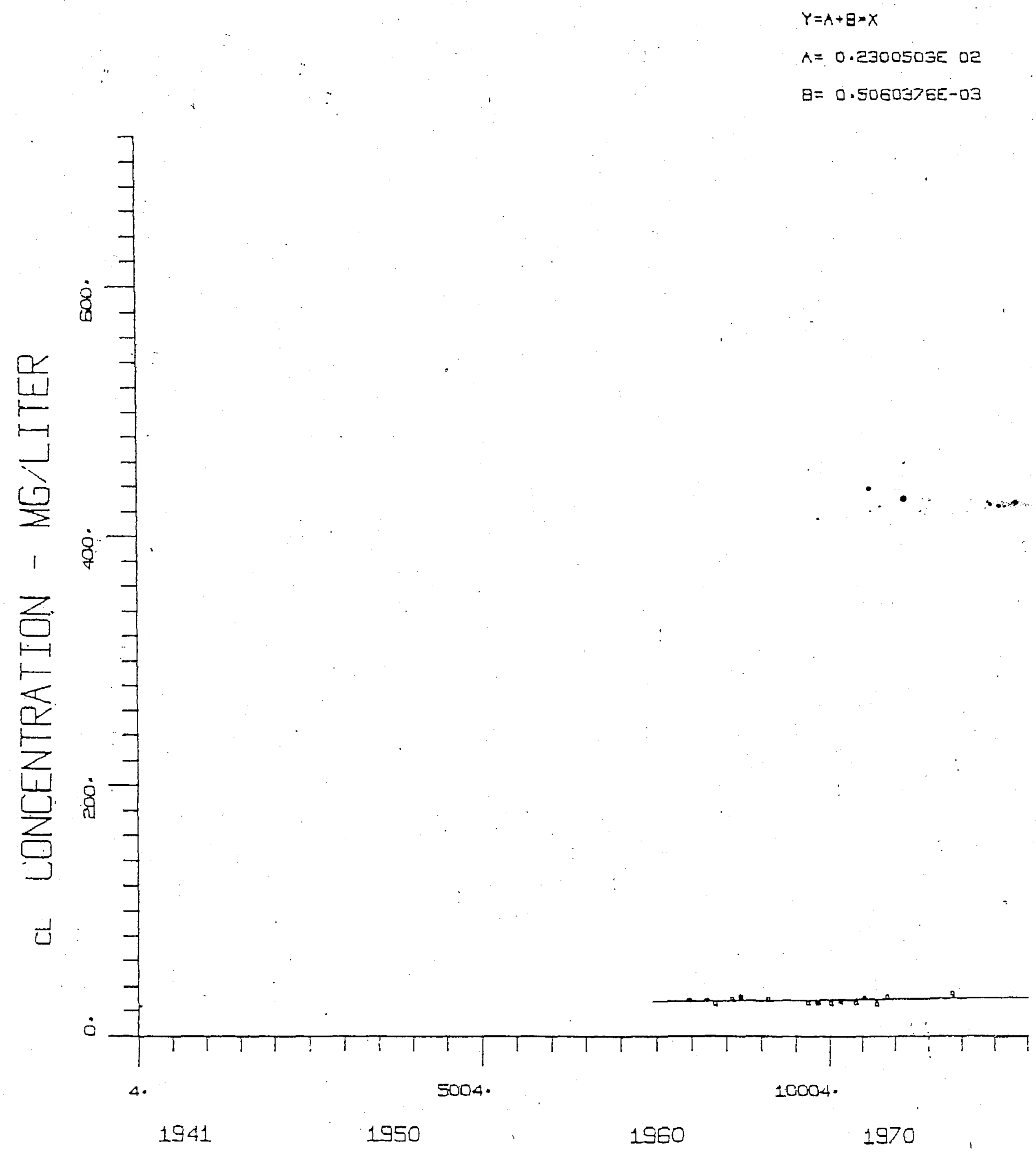


FIG. F-8D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N34W34E2

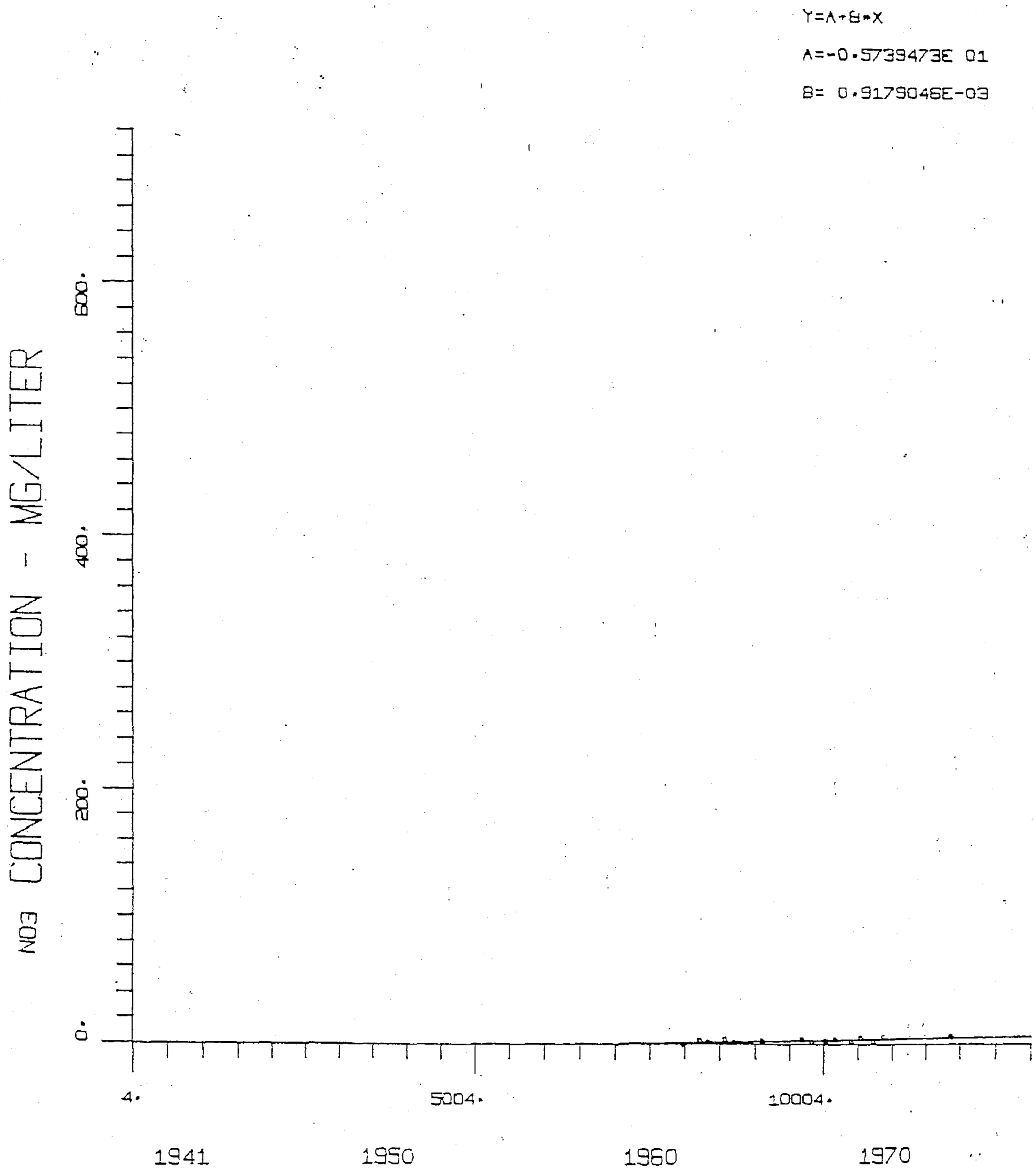


FIG. F-9A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W4C1

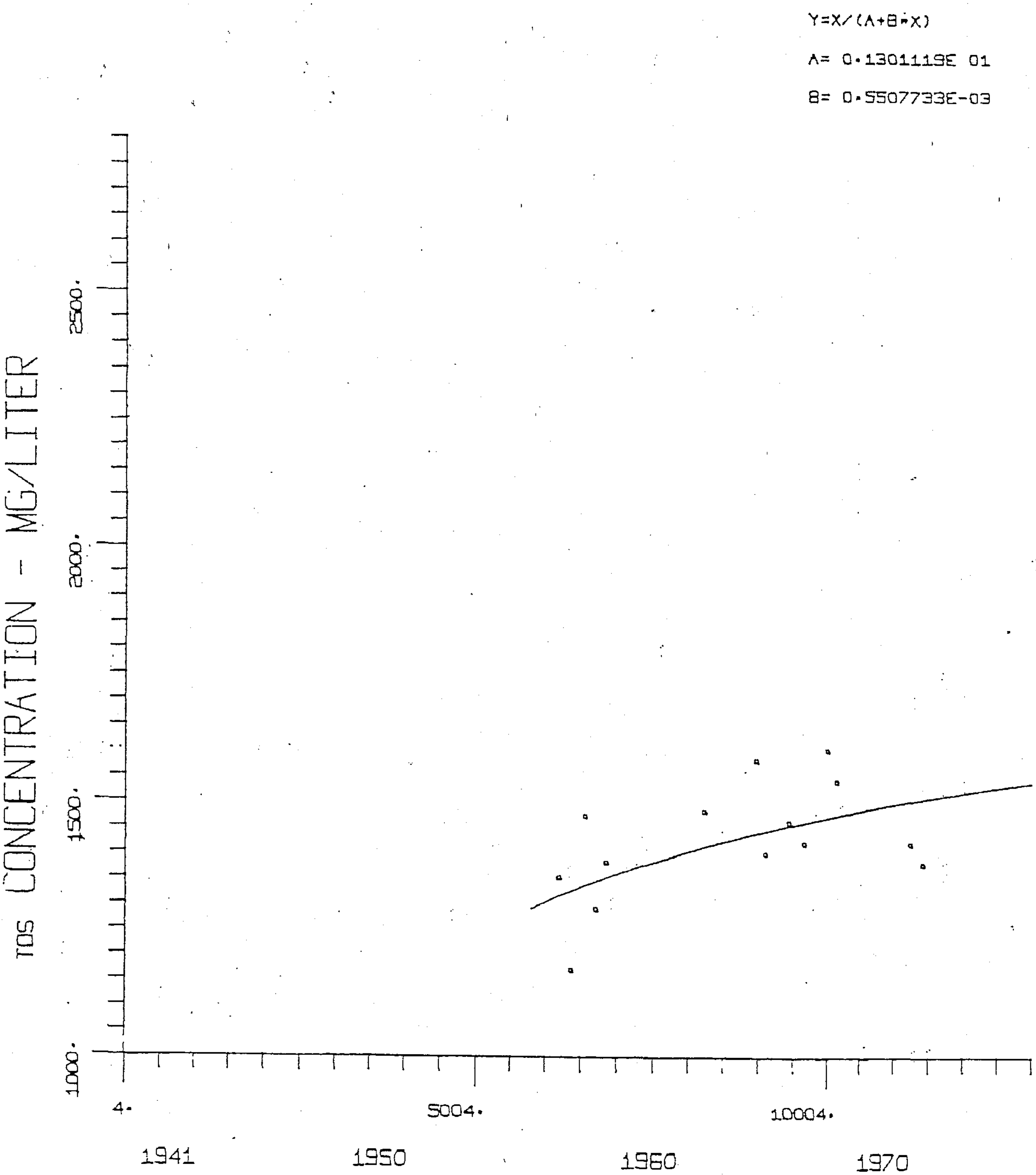


FIG. F-9B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W4C1

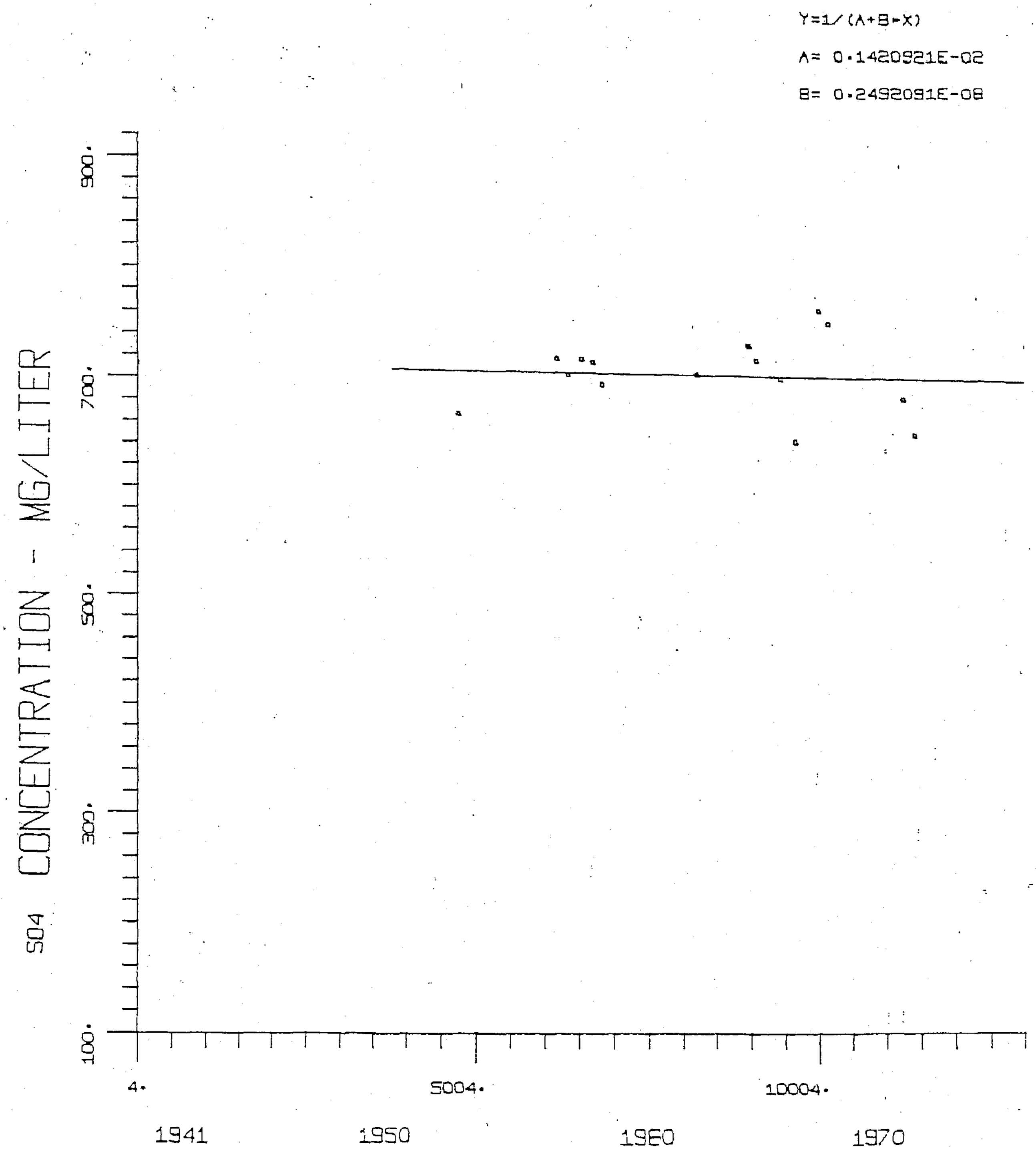


FIG. F-9C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W4C1

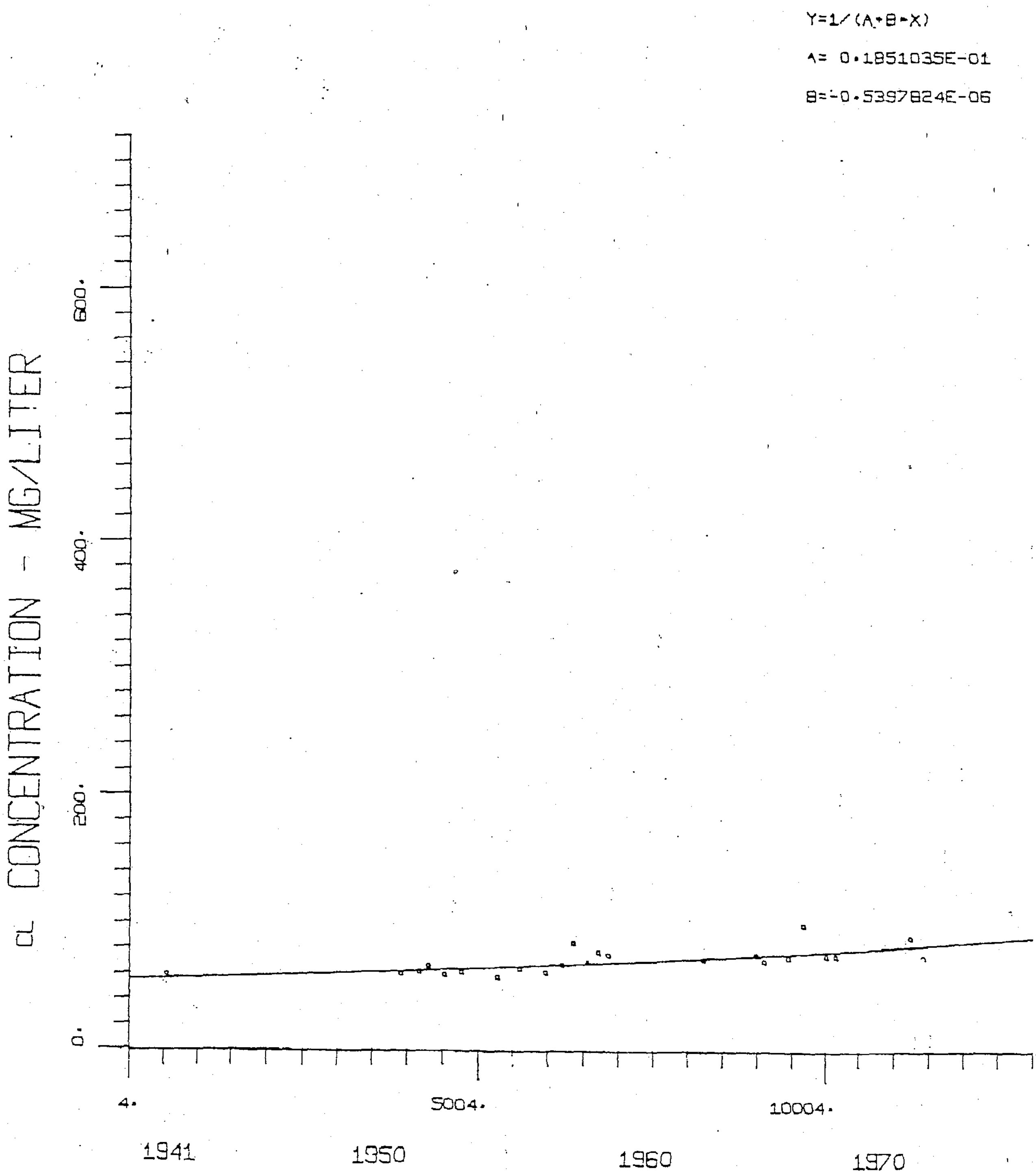


FIG. F-9D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W4C1

Y=A+B*X

A=-0.31376553E 01

B= 0.2005857E-02

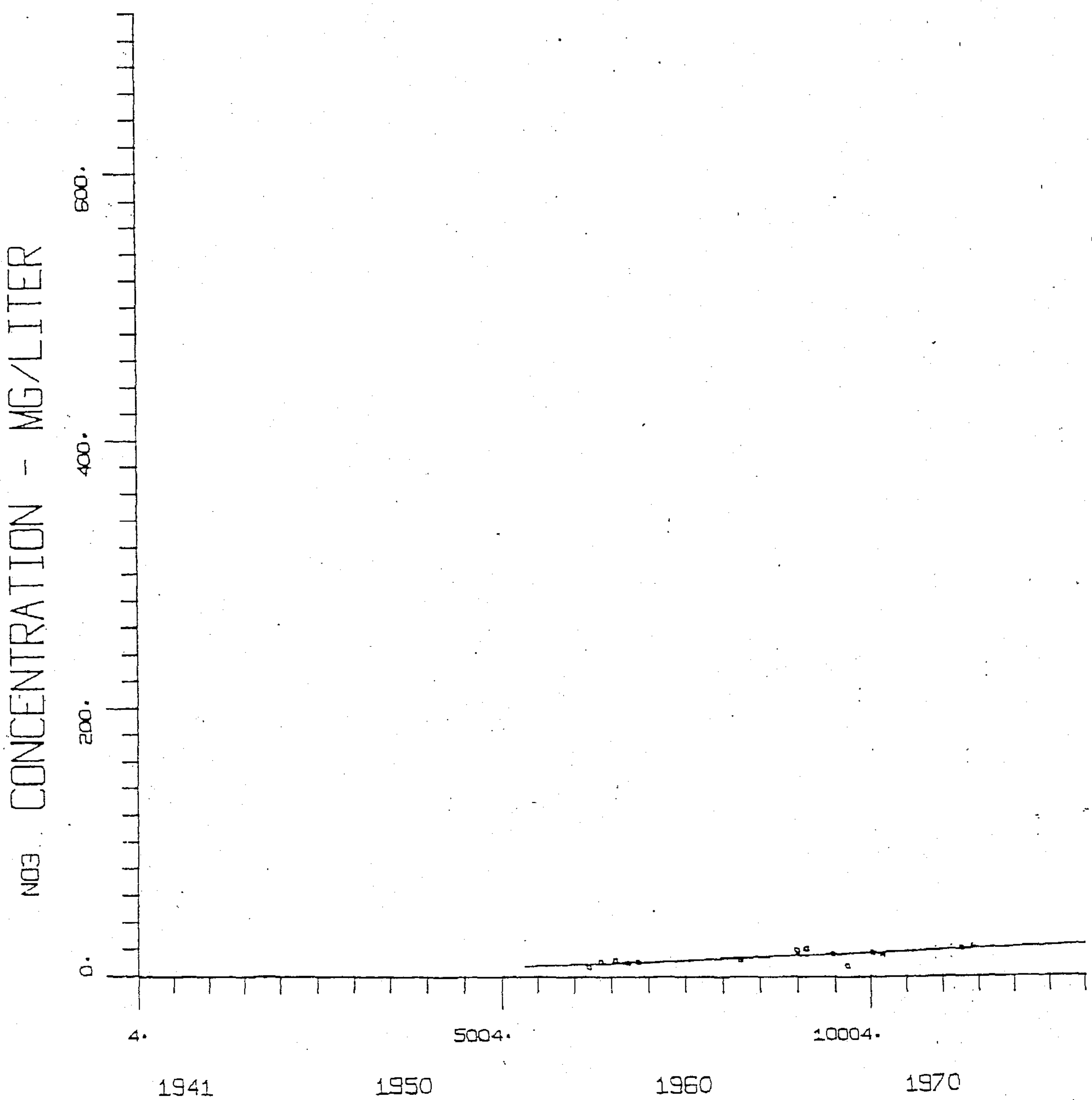


FIG. F-10A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W9N2

Y=A+B*X

A= 0.6096102E 03

B= 0.3708406E-01

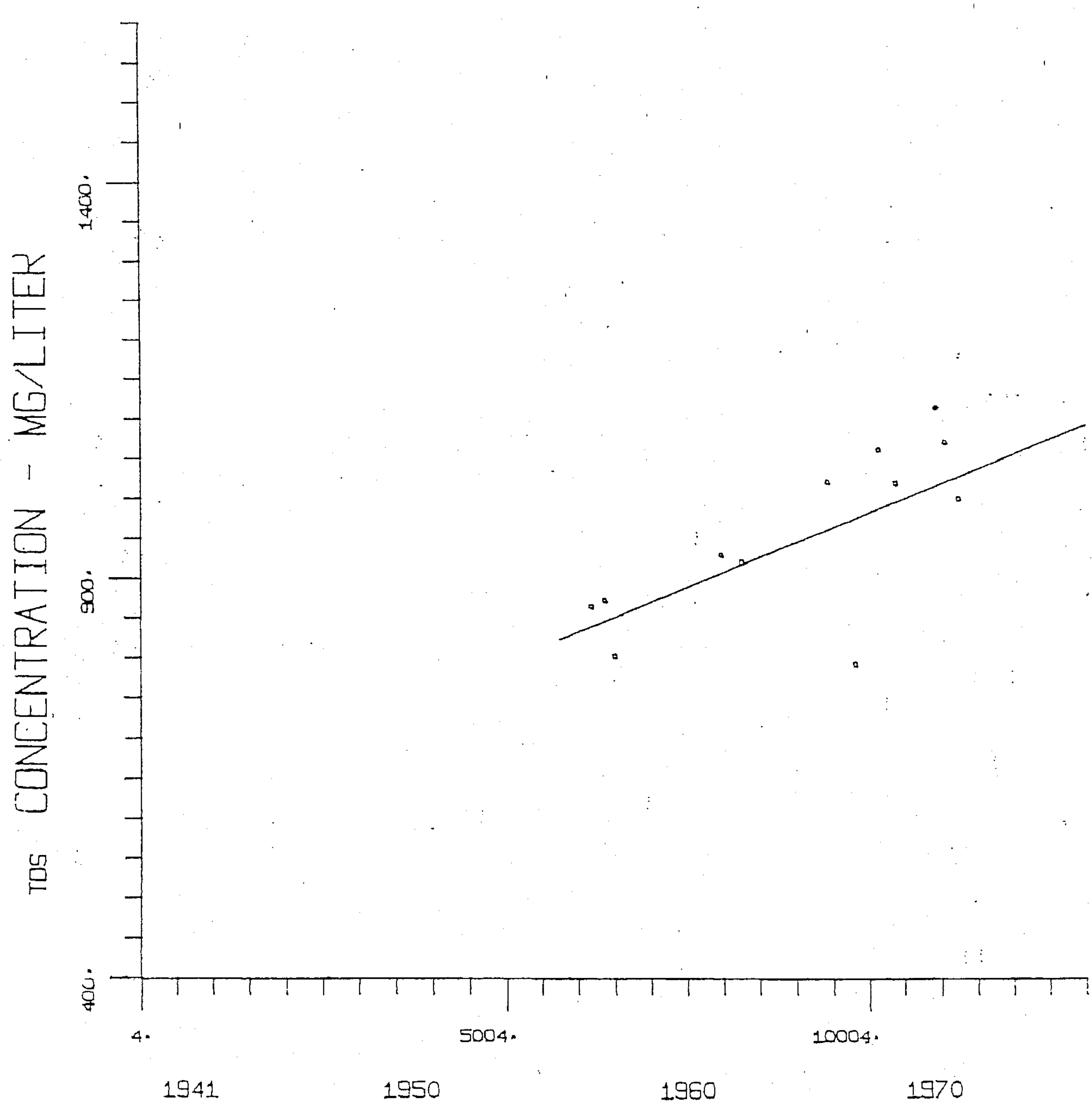


FIG. F-10B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W9N2

Y=A+B*X

A= 0.3647721E 03

B= 0.6400693E-02

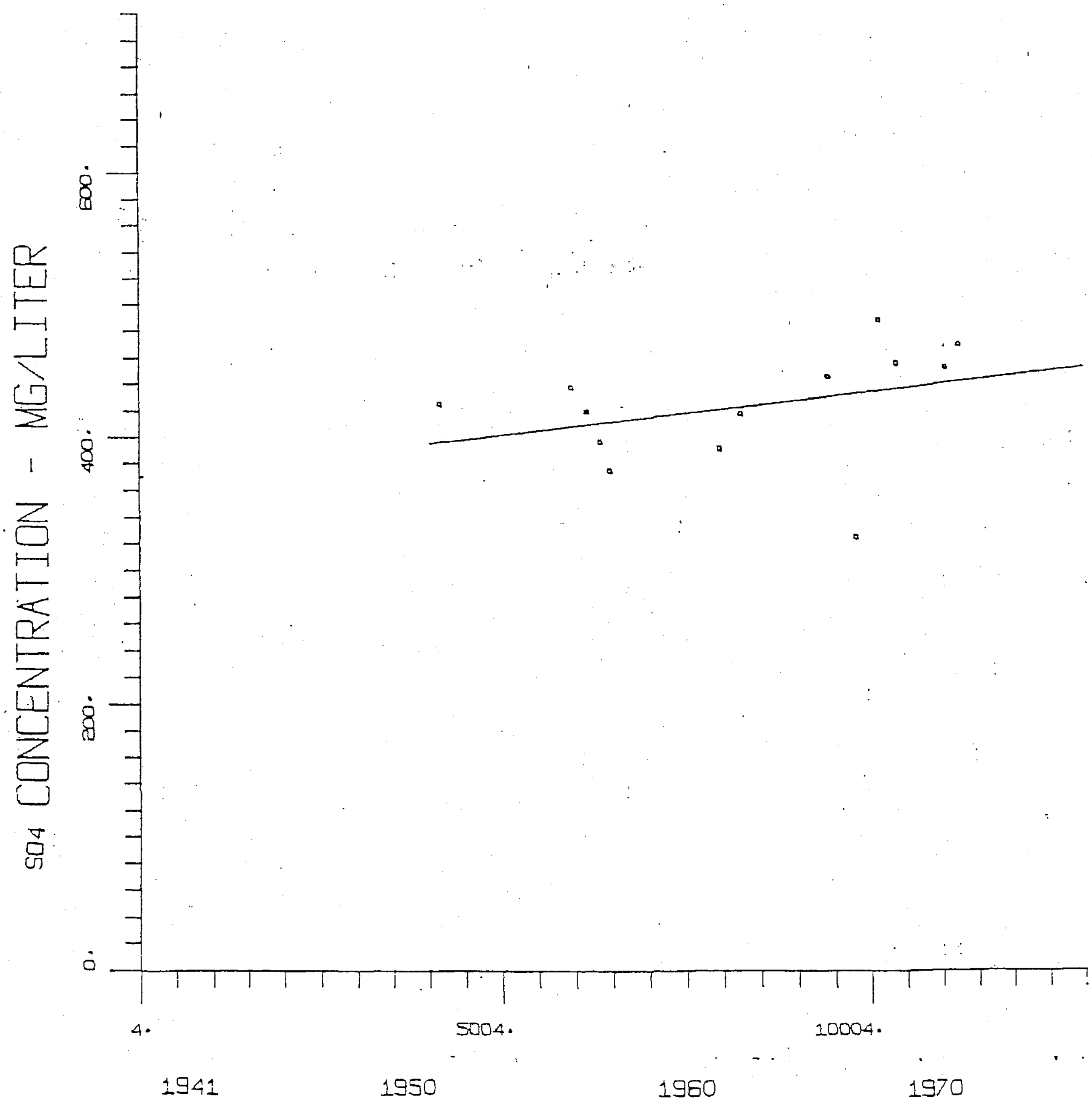


FIG. F-10C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W9N2

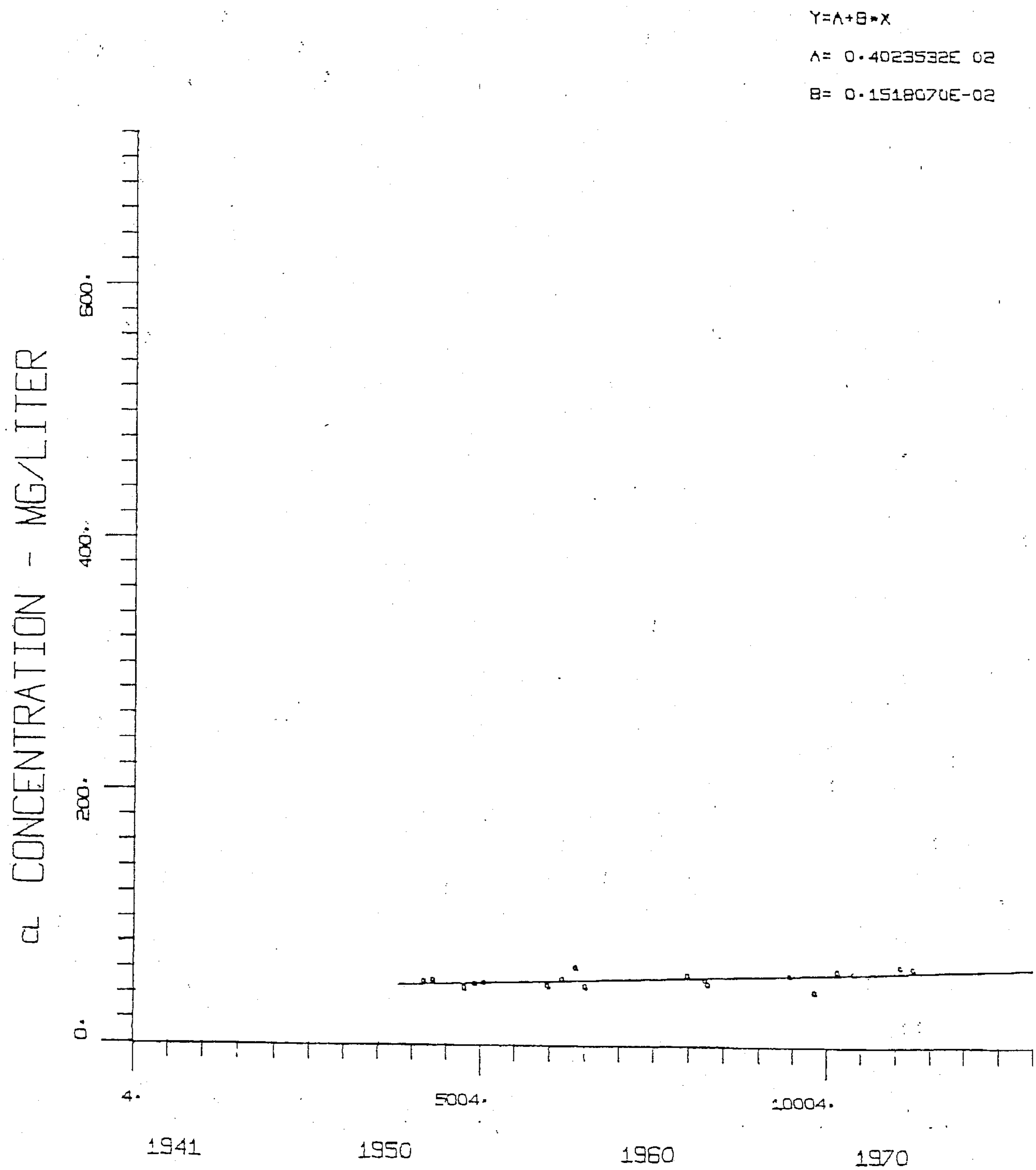


FIG. F-10D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W9N2

Y=A+B*X

A= 0.1747344E 01

B= 0.8415789E-03

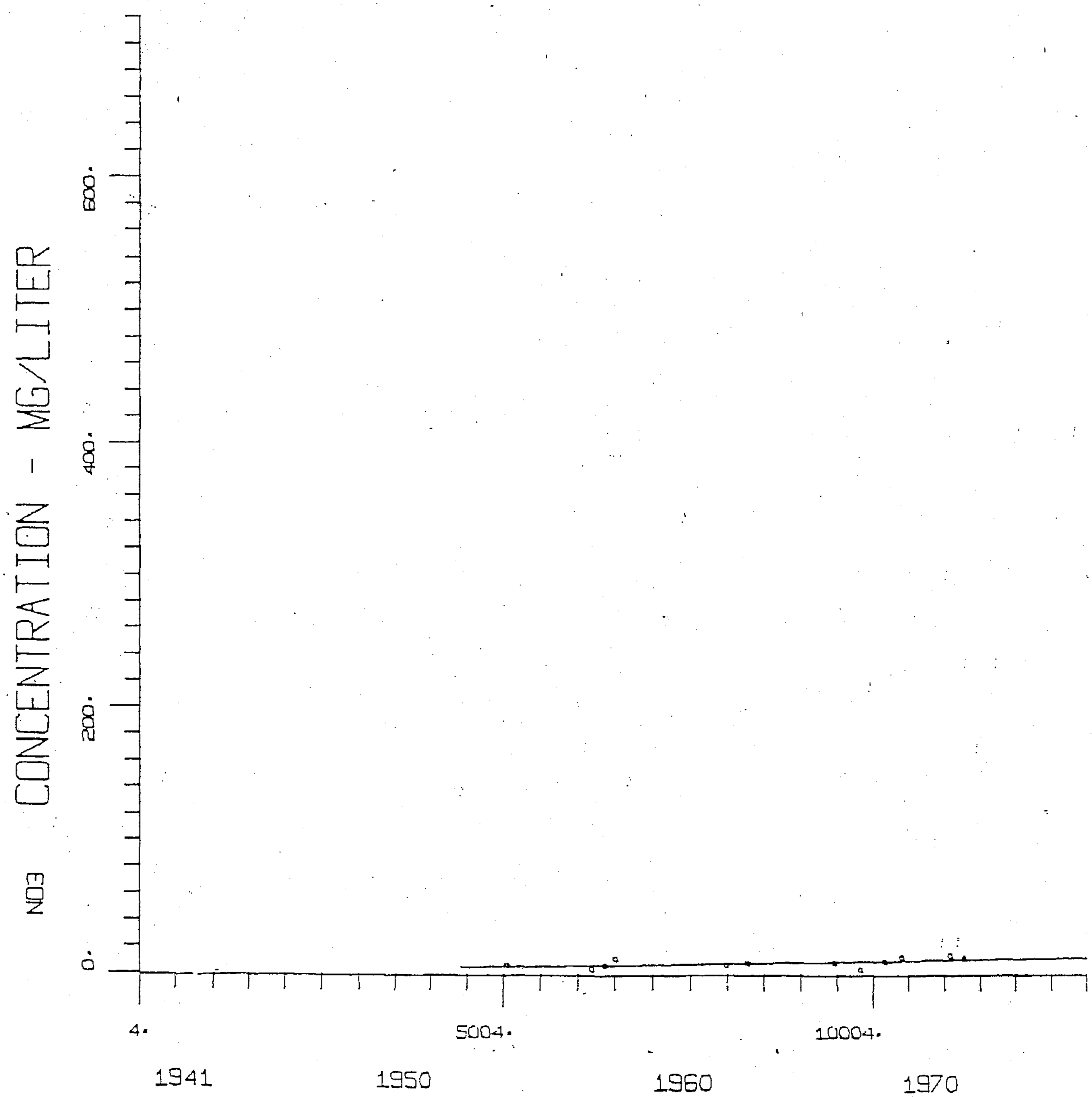


FIG. F-11A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W14D1

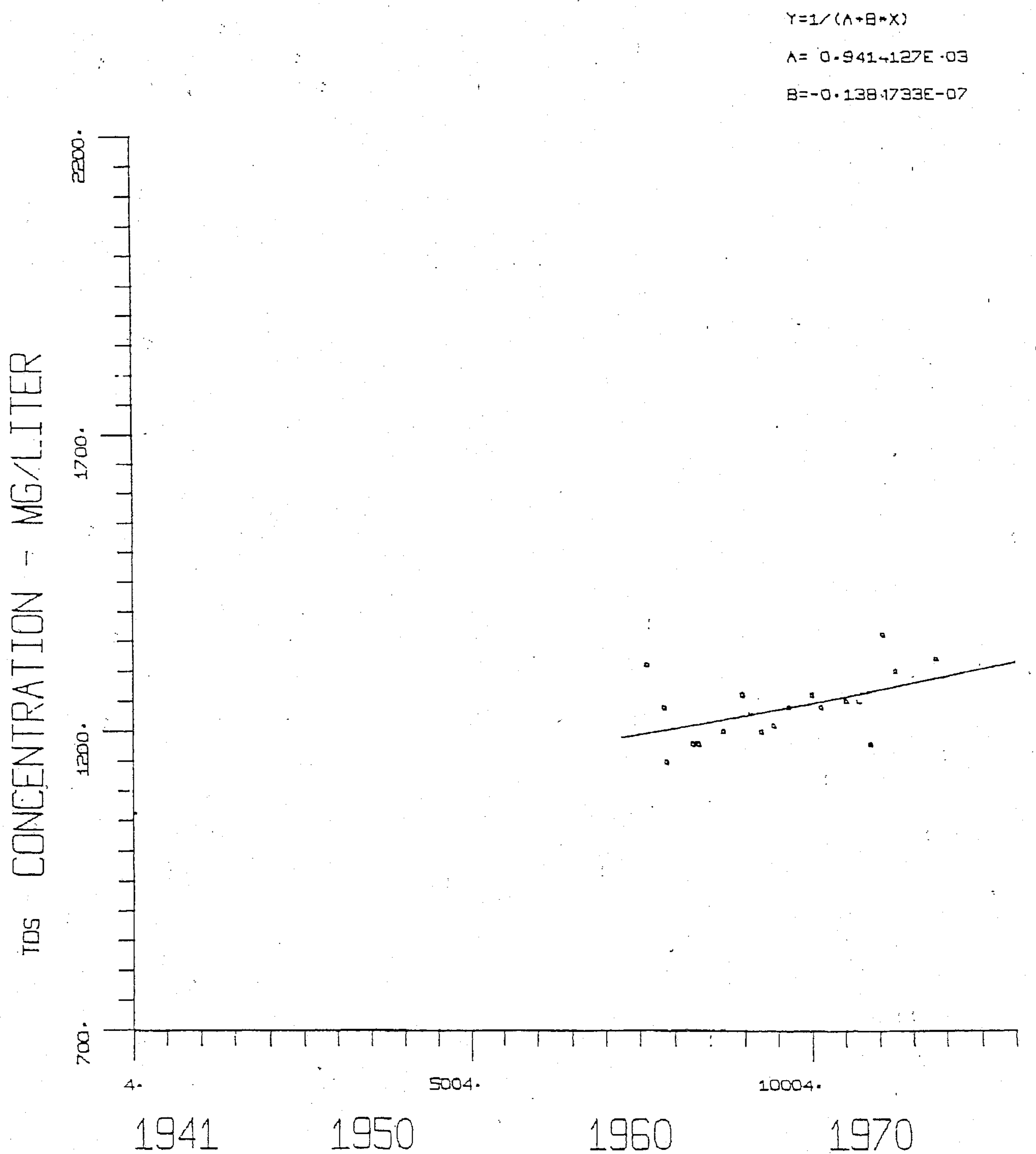


FIG. F-11B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W14D1

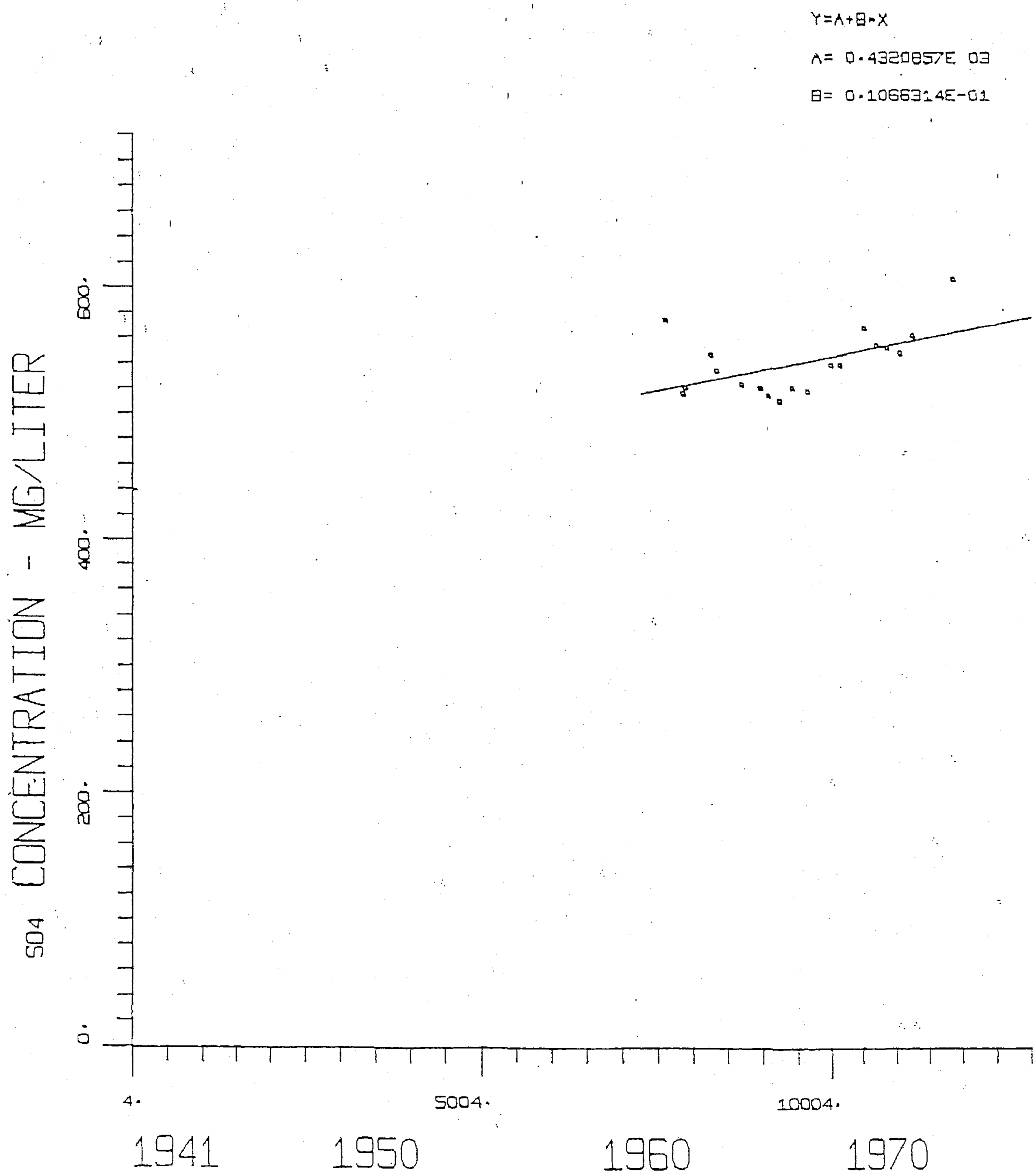


FIG. F-11C

GROUNDWATER CHEMICAL CONSTITUENTS SANTA MARIA VALLEY WELL NO. 10N35W1401

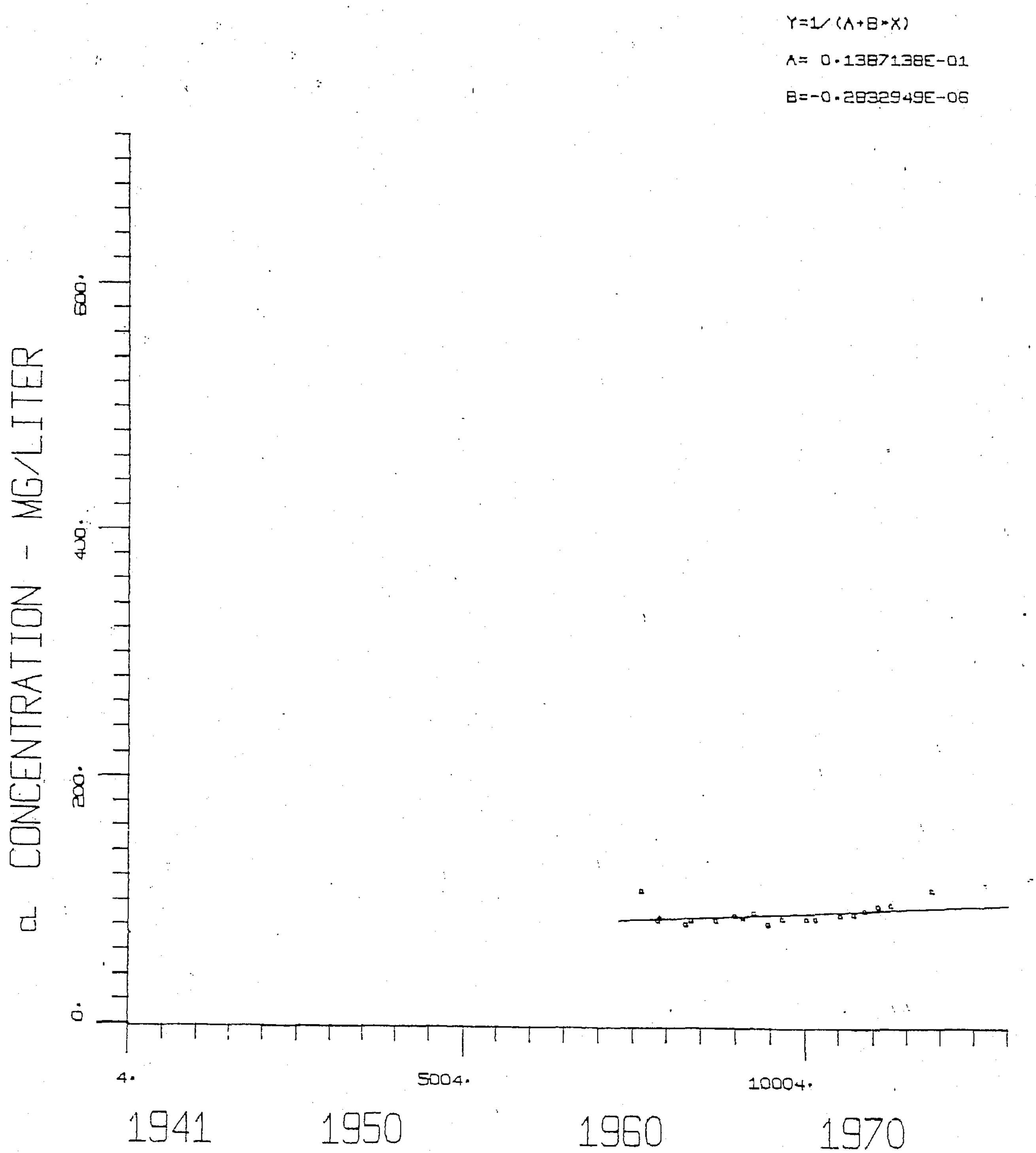


FIG. F-11D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W1401

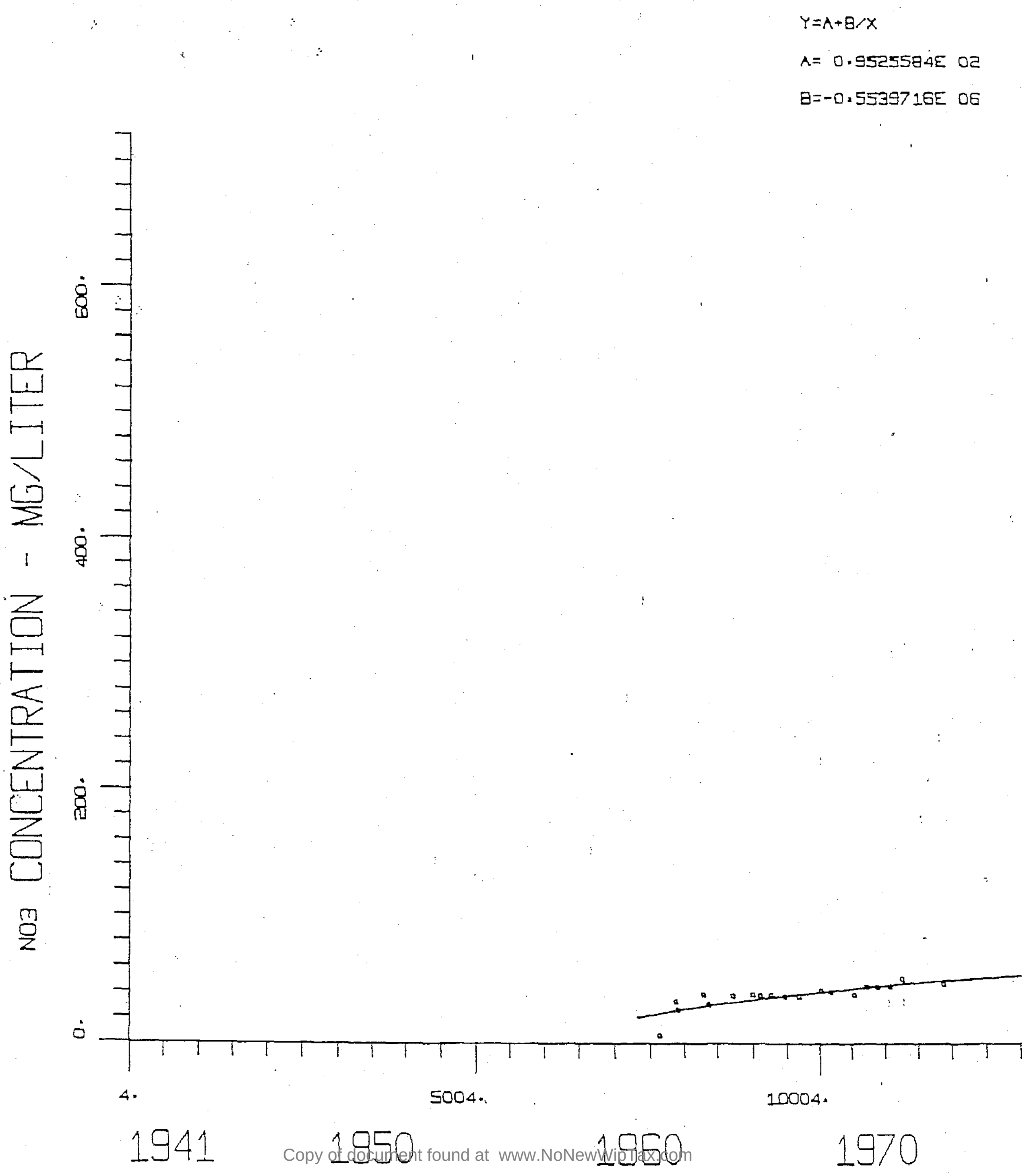


FIG. F-12A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W21C1

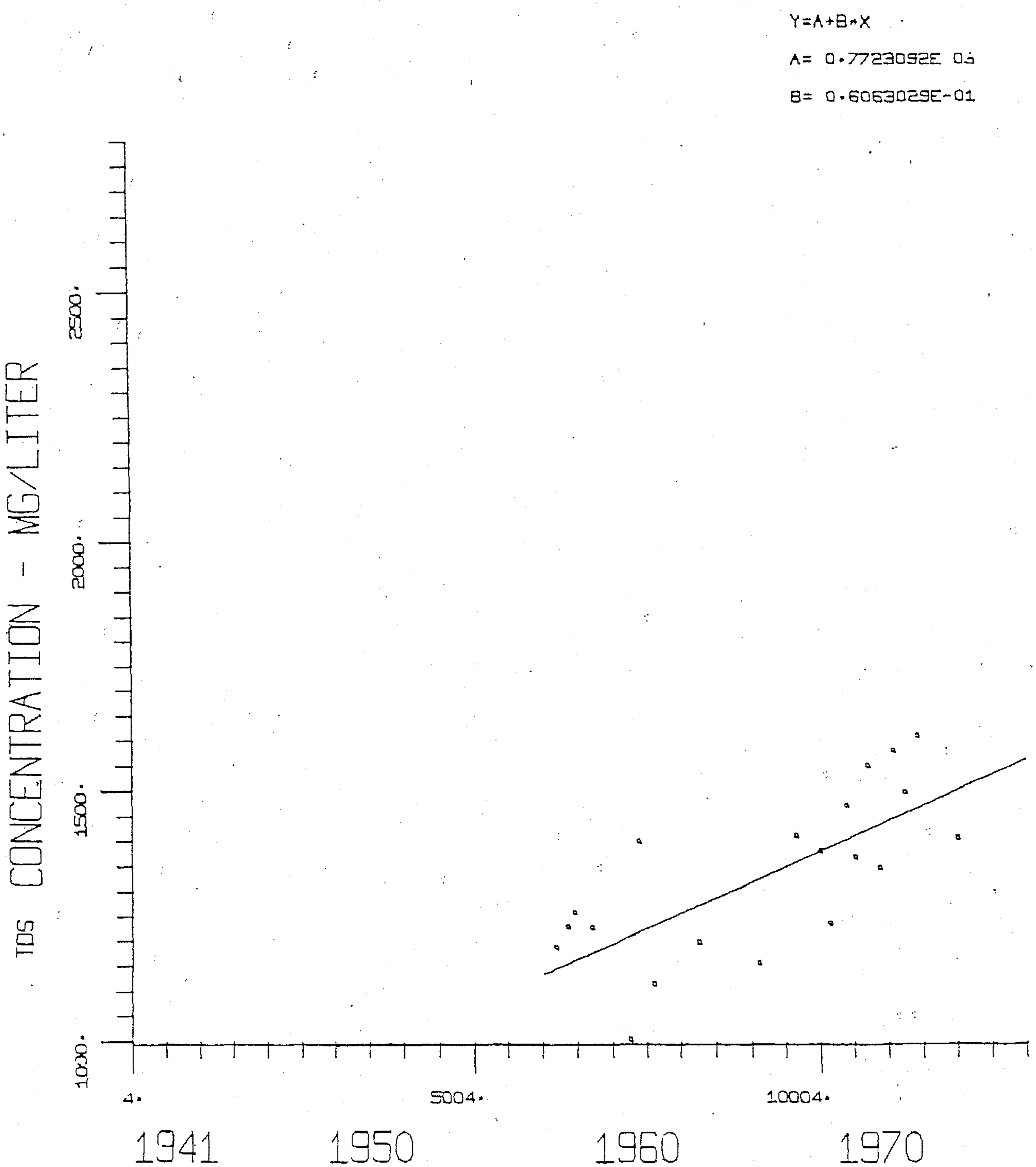


FIG. F-12B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W21C1

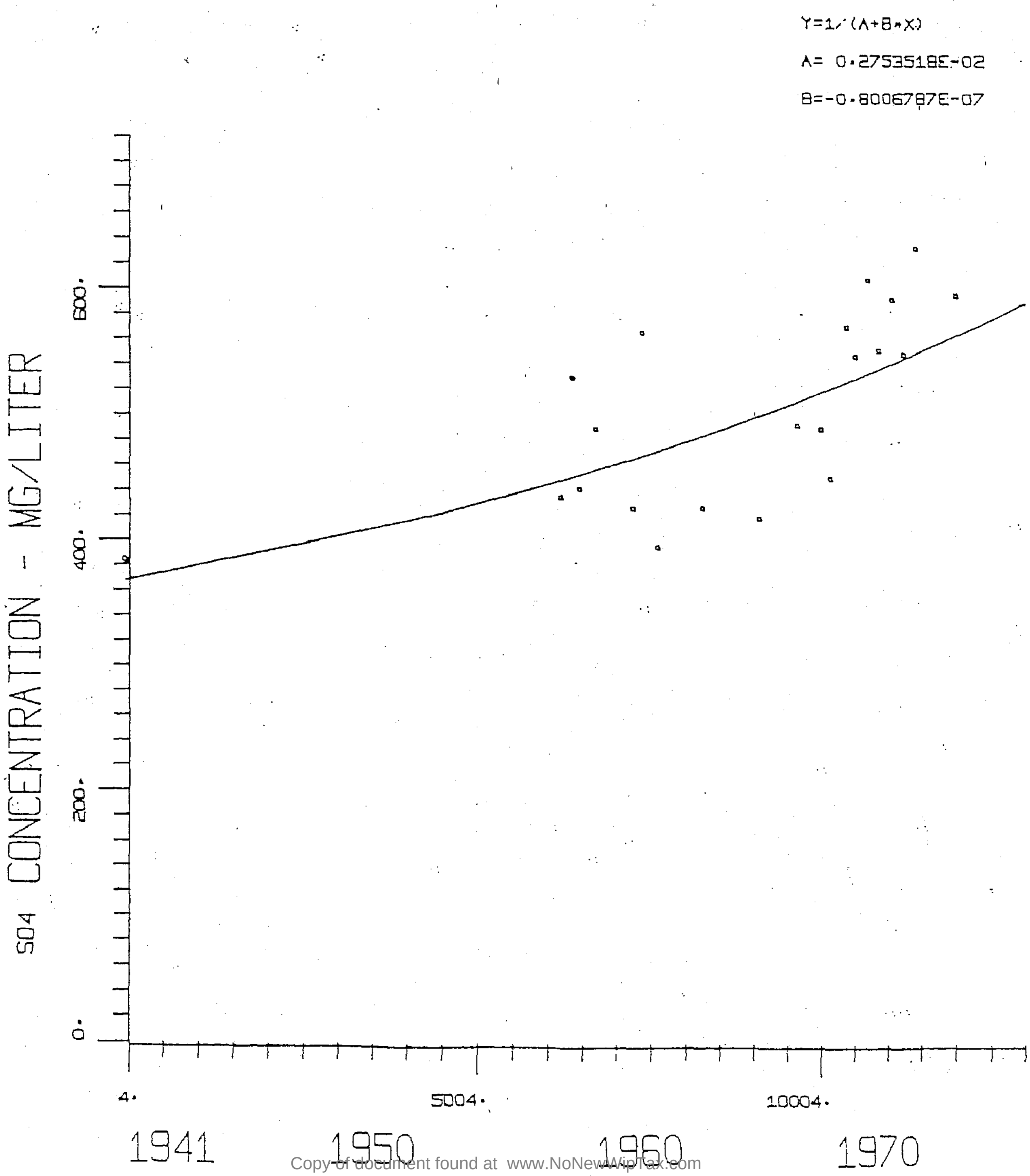


FIG. F-12C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W21C1

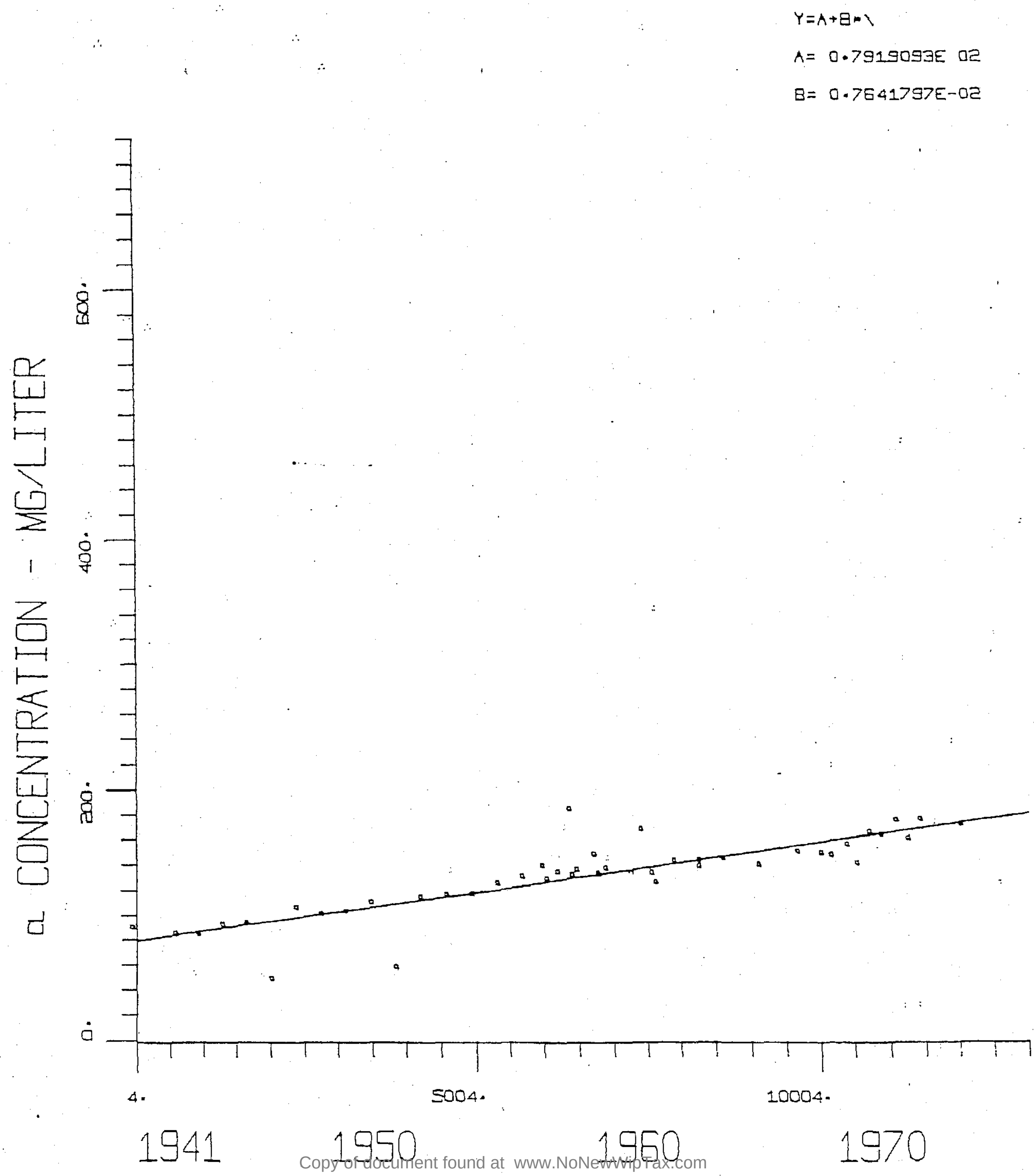


FIG. F-12D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W21C1

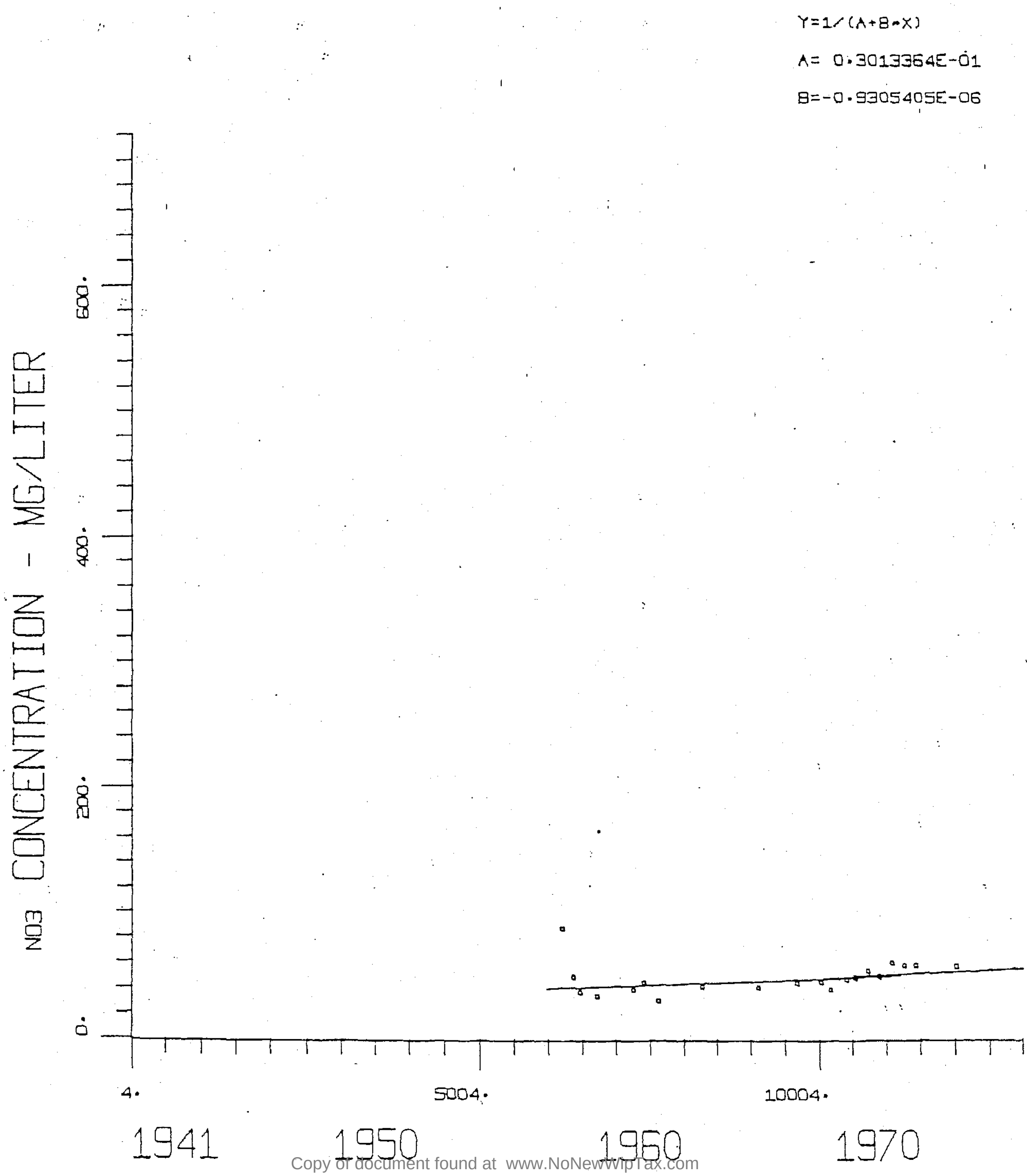


FIG. F-13A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W24B2

Y=A*EXP(B*X)

A= 0.1091573E 04

B= 0.1444741E-04

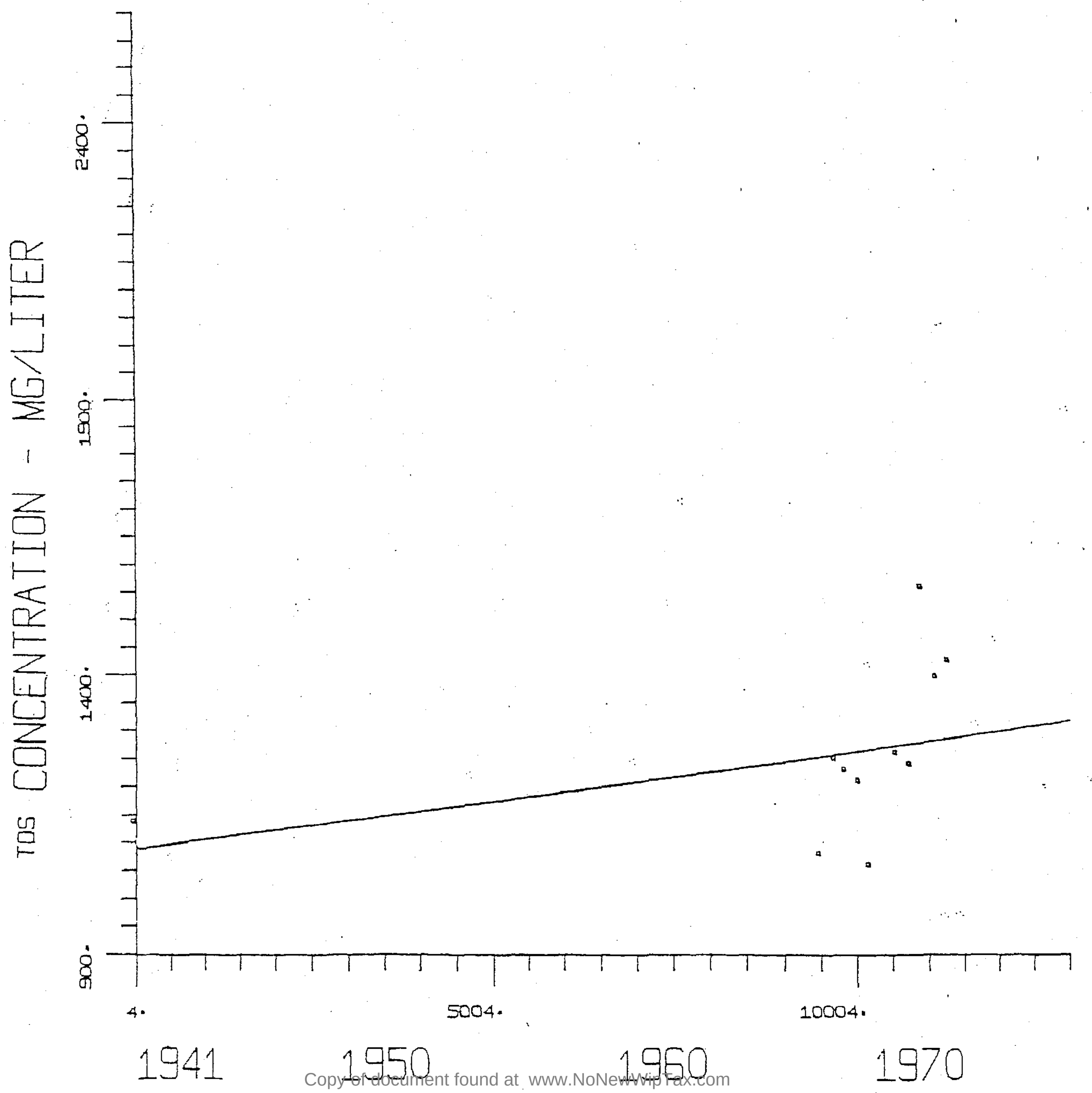


FIG. F-13B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W24B2

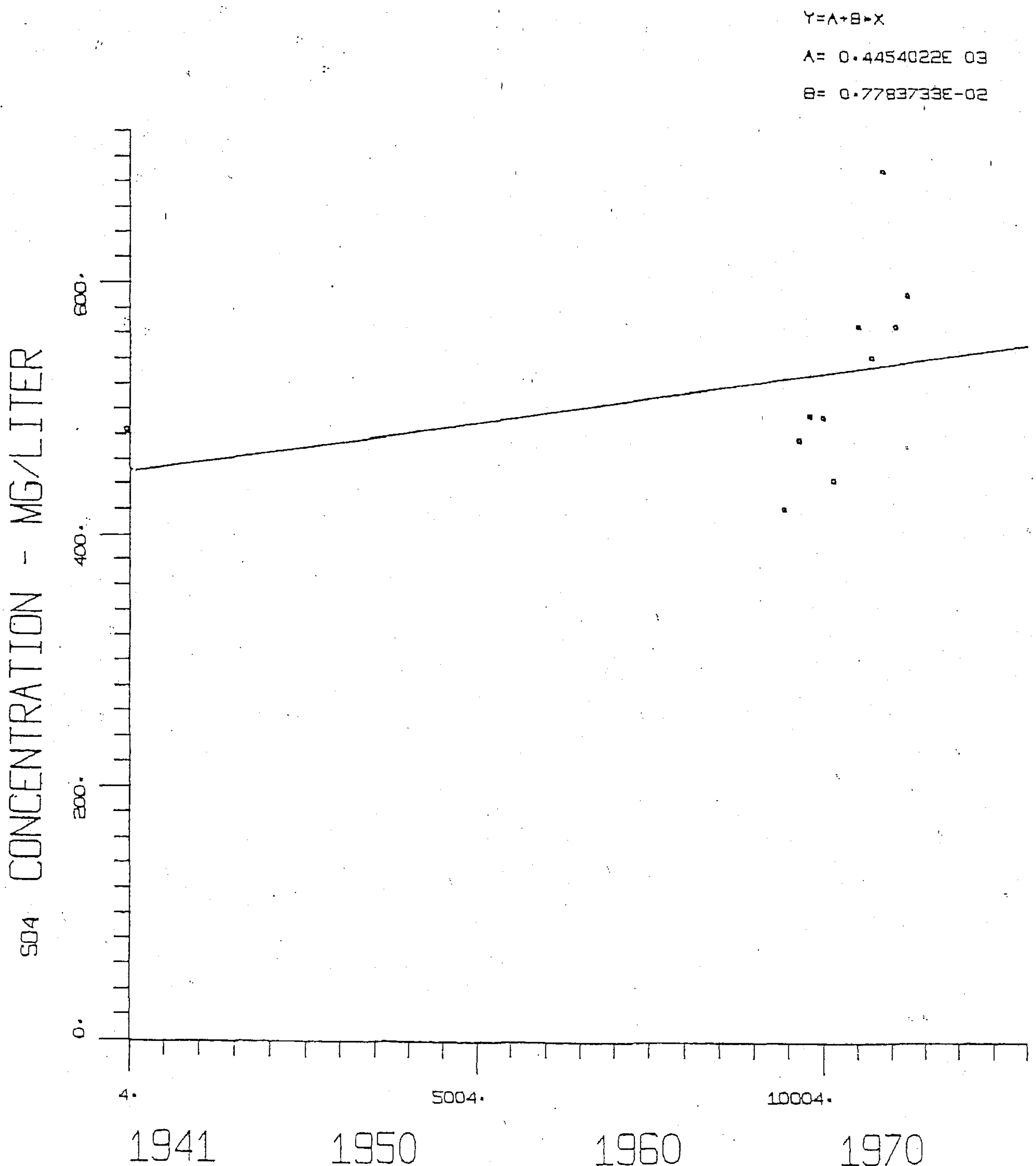


FIG. F-13C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W24B2

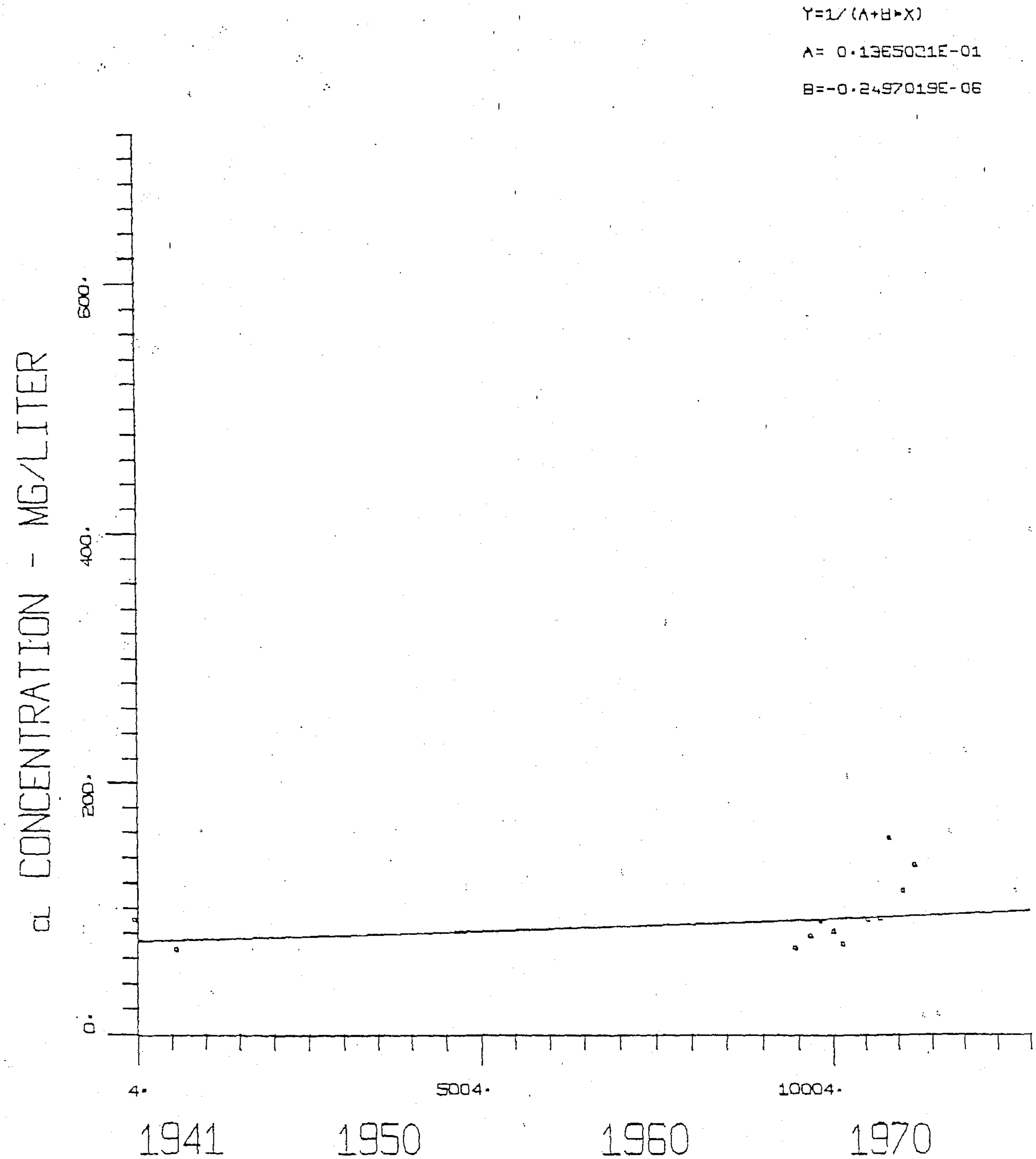


FIG. F-13D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 10N35W24B2

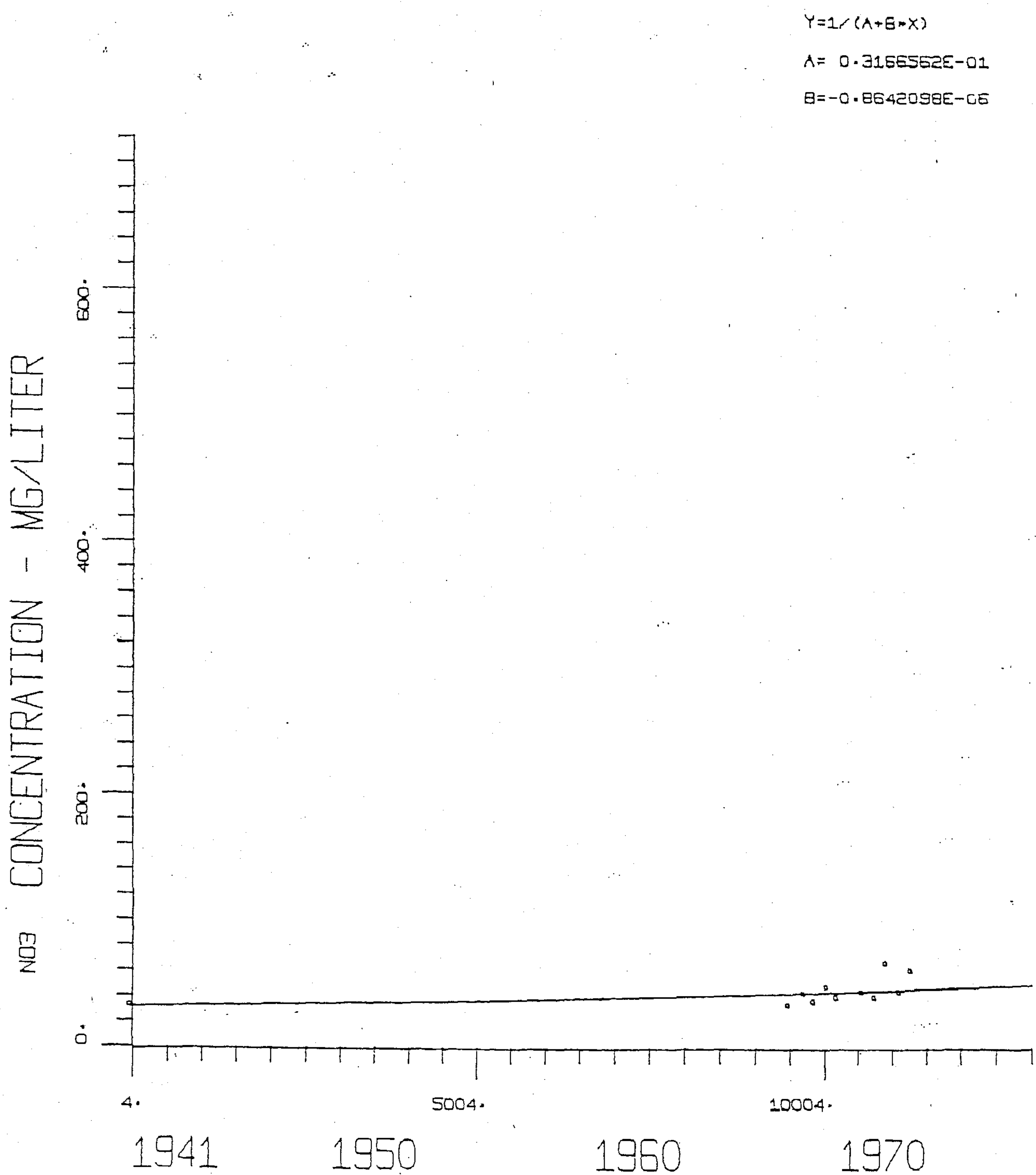


FIG. F-14A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N34W29P2

Y=A+B/X

A= 0.7502081E 03

B= 0.6314136E 05

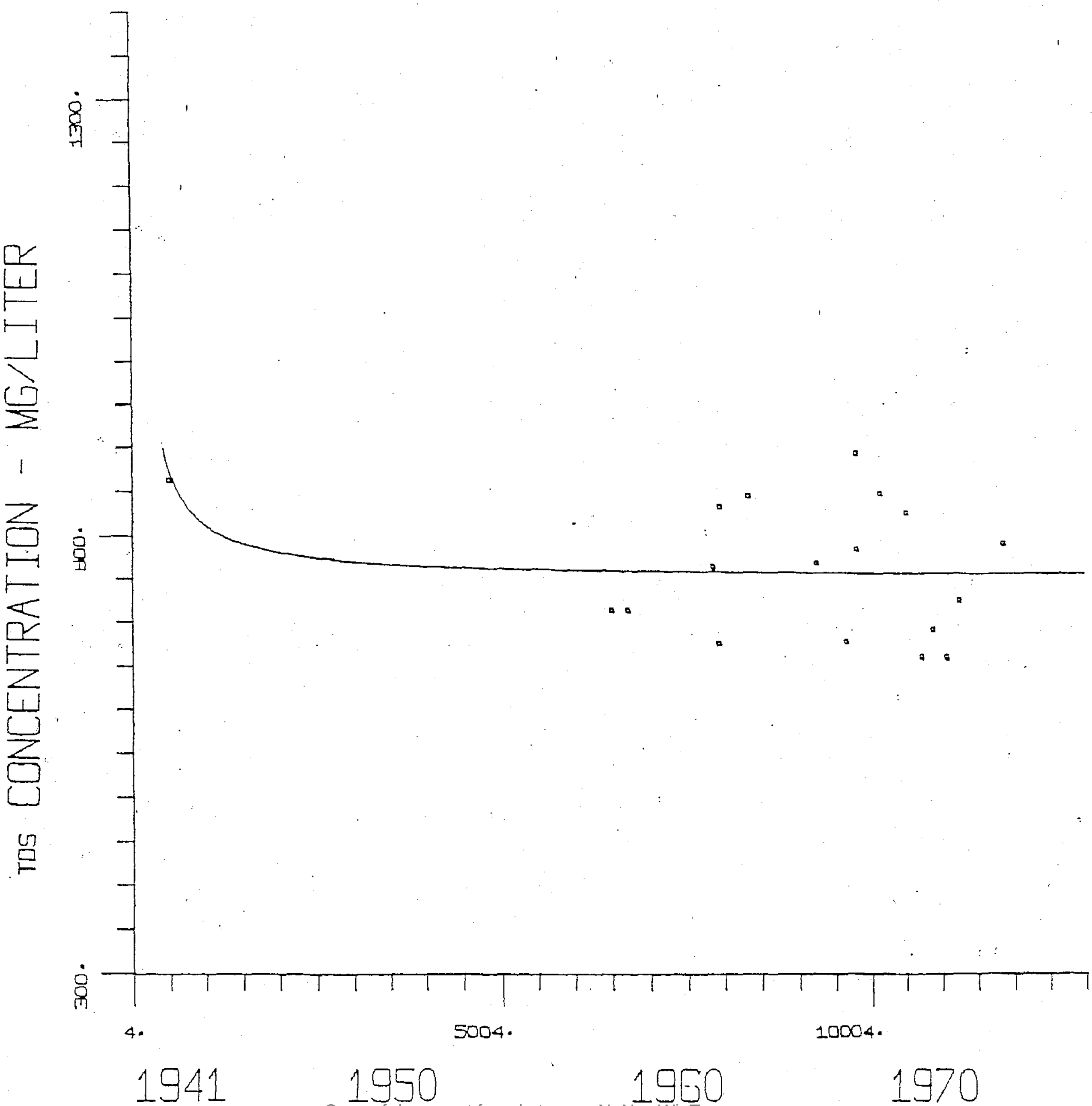


FIG. F-14B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N34W29P2

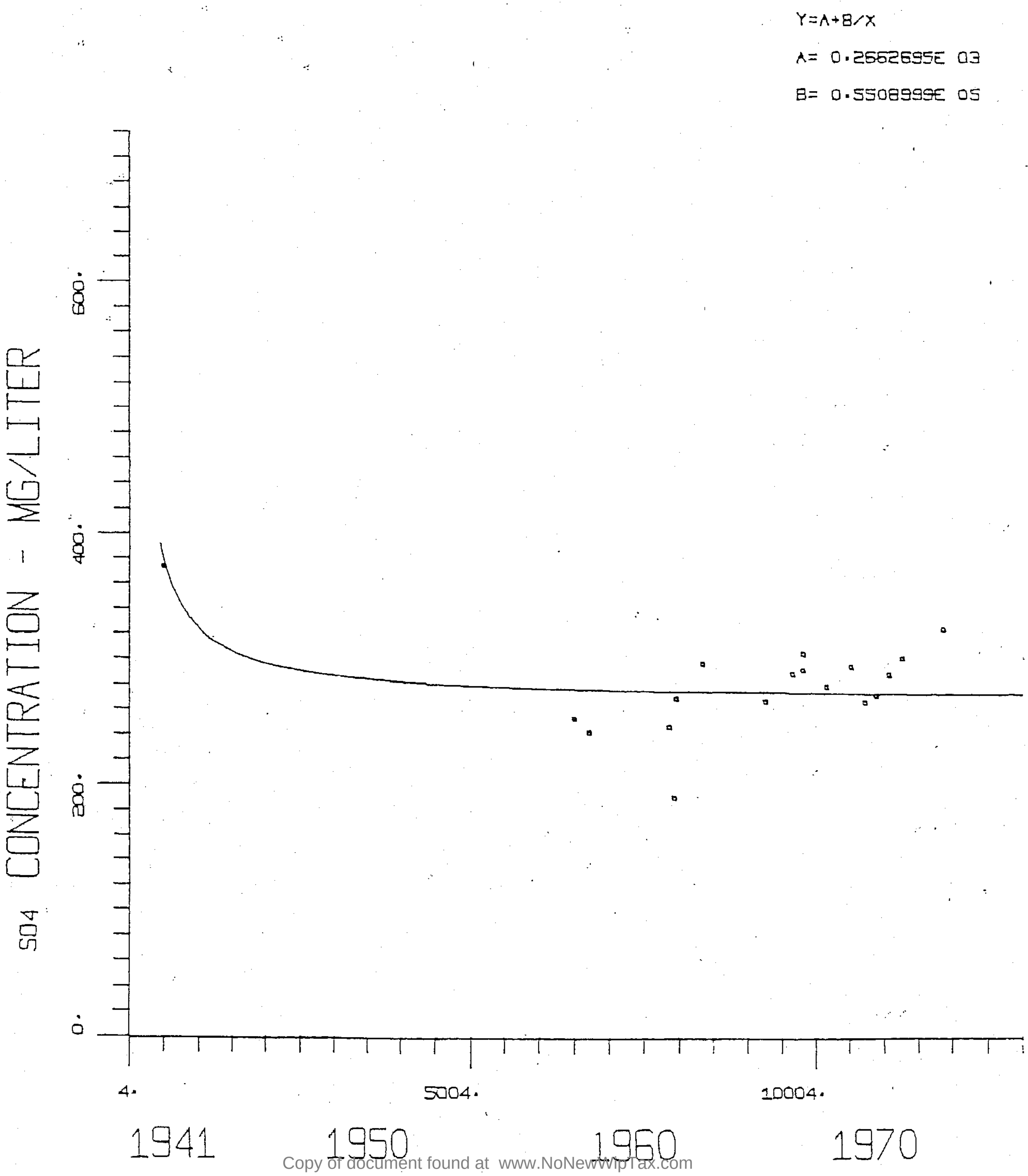


FIG. F-14C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N34W29P2

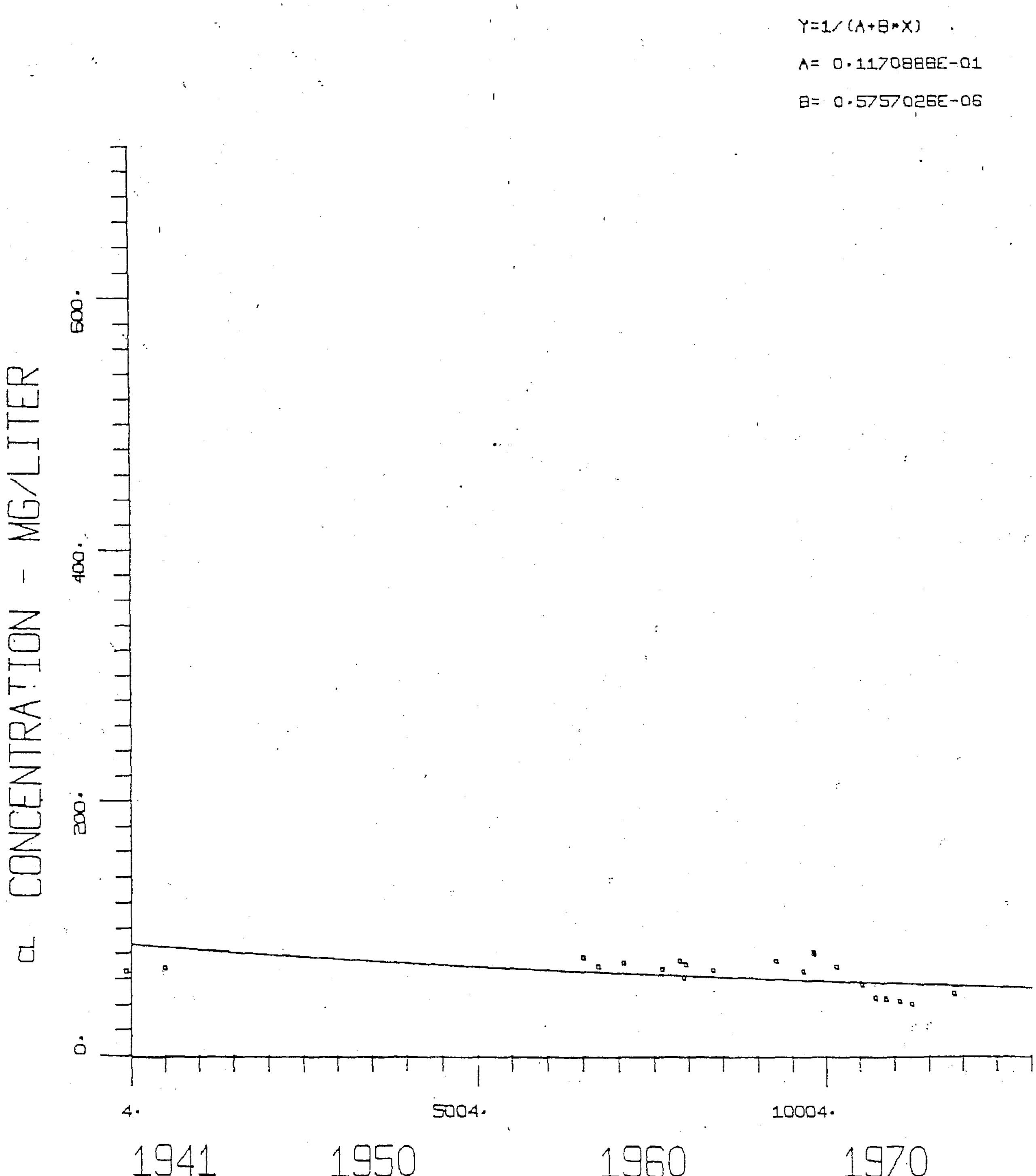


FIG. F-14D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N34W29P2

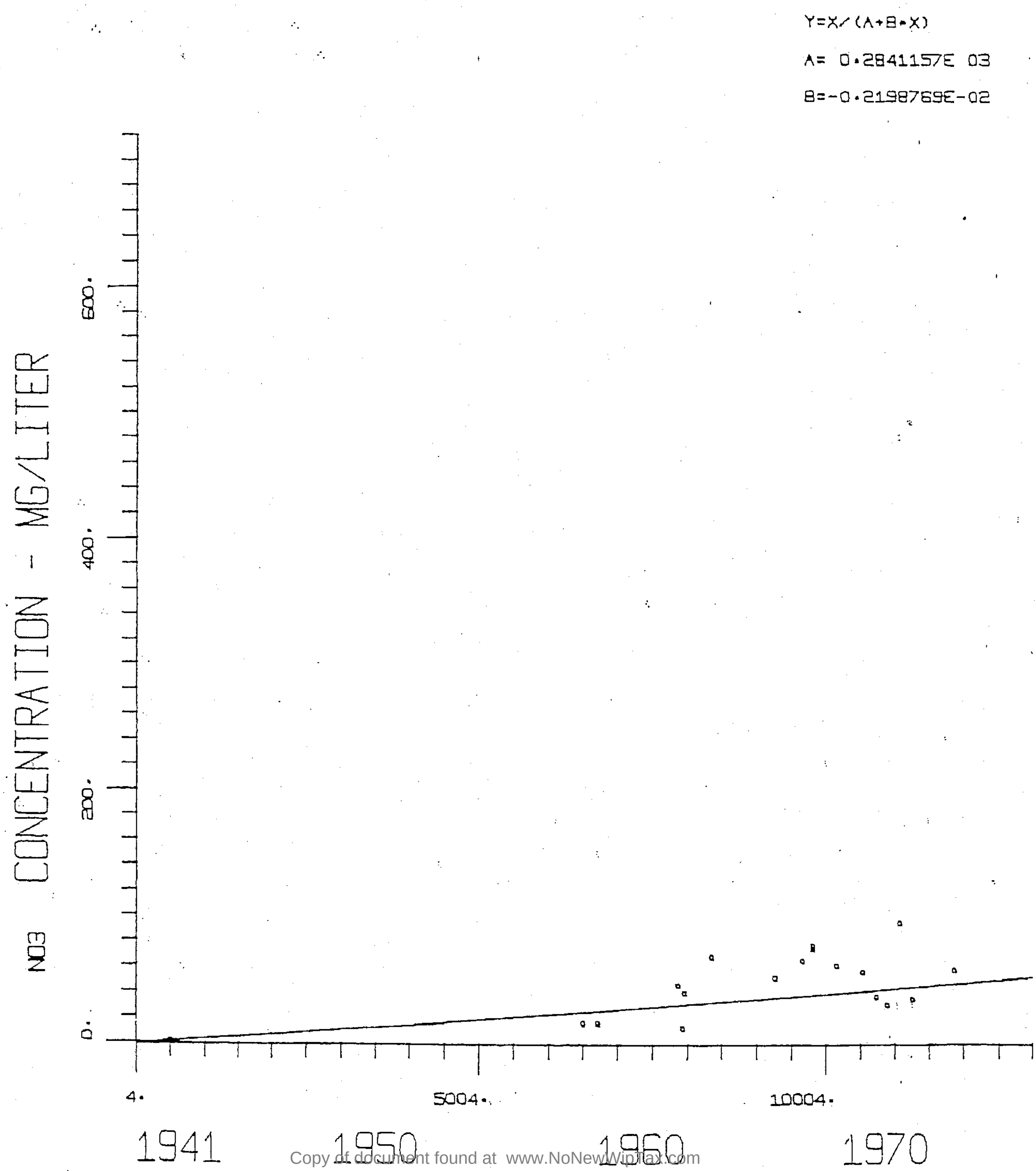


FIG. F-15A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N35W18M1

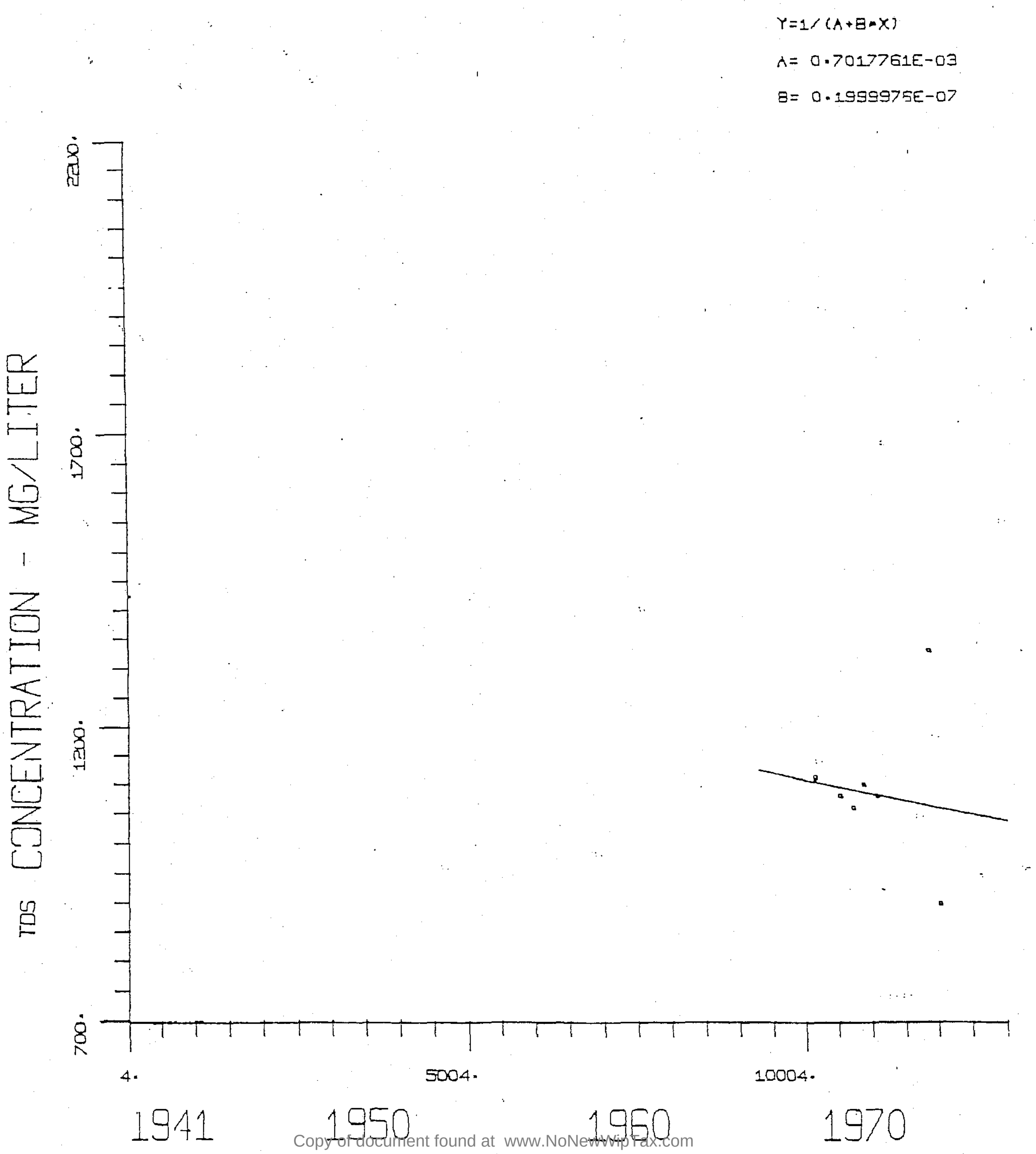


FIG. F-15B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N35W18M1

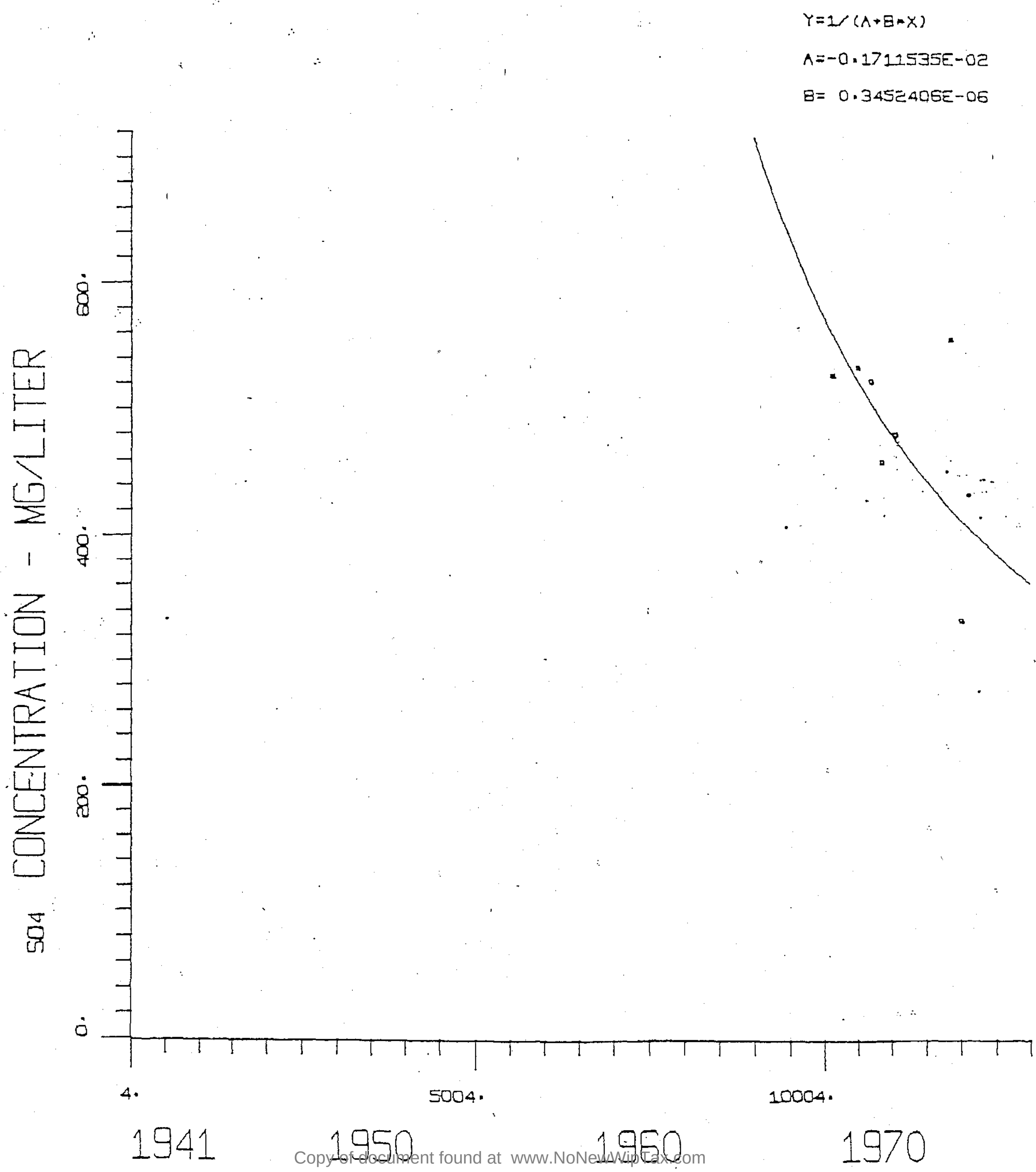


FIG. F-15C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N35W18M1

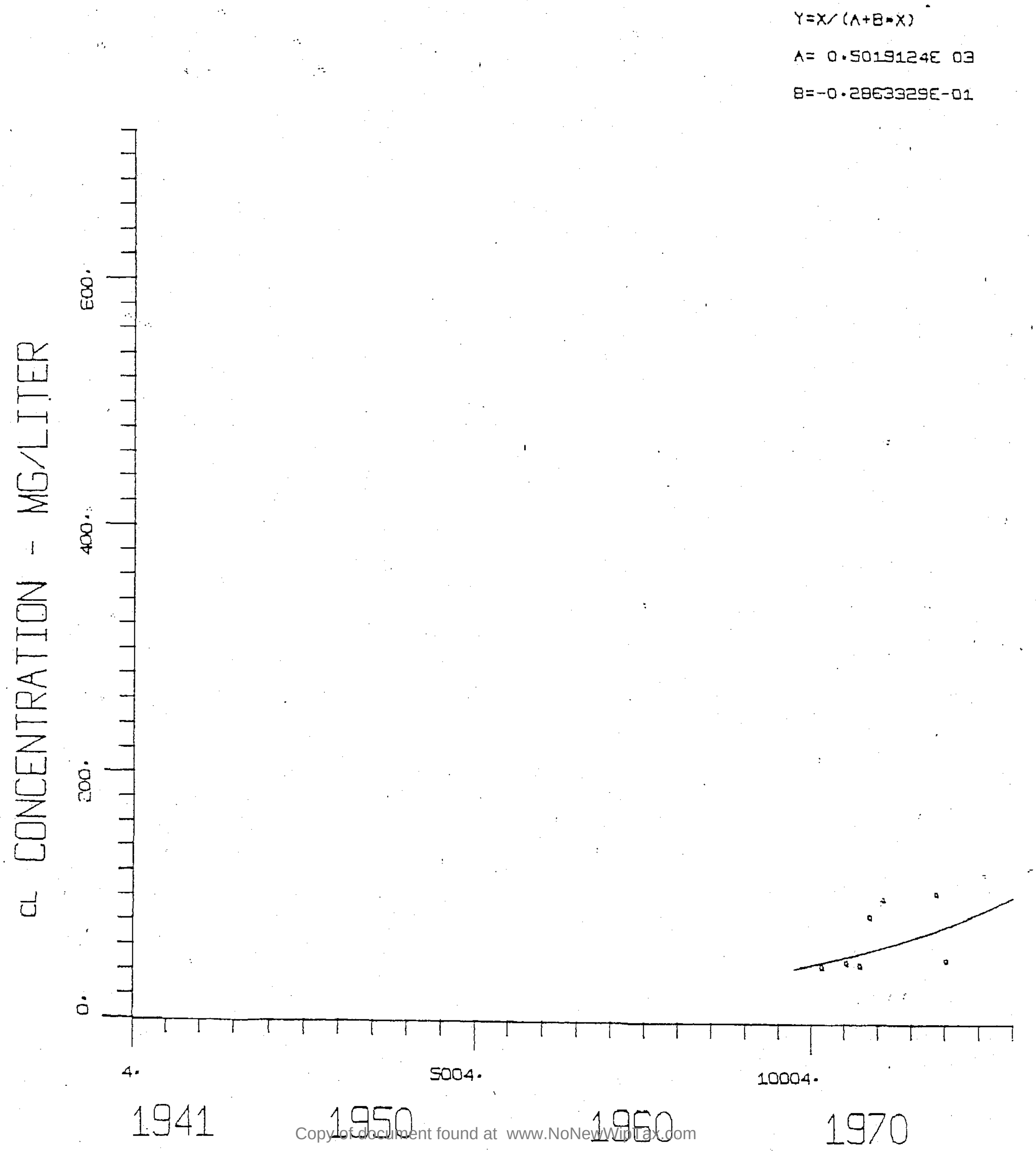


FIG. F-15D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N35W18M1

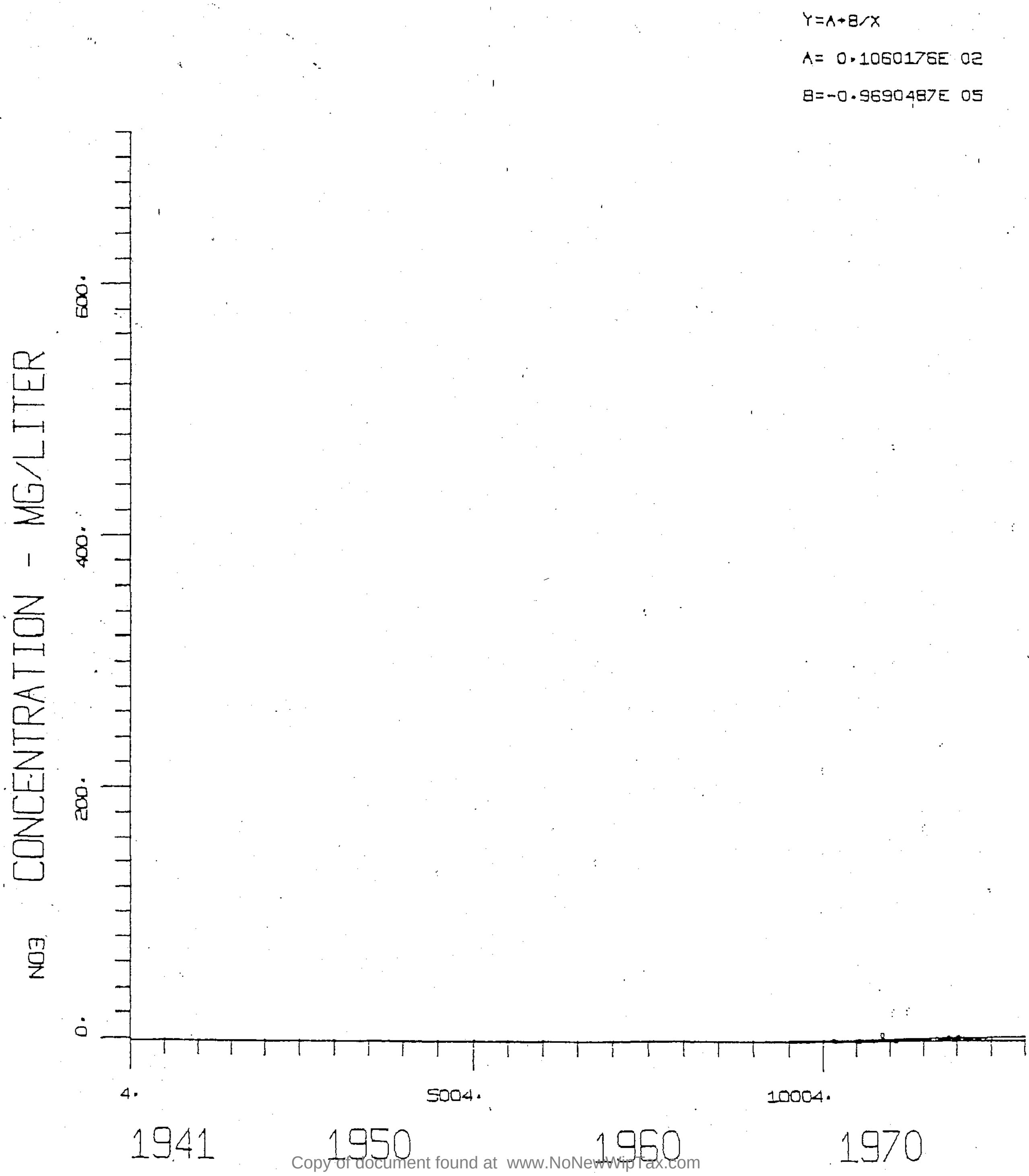


FIG. F-16A

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N36W13R1

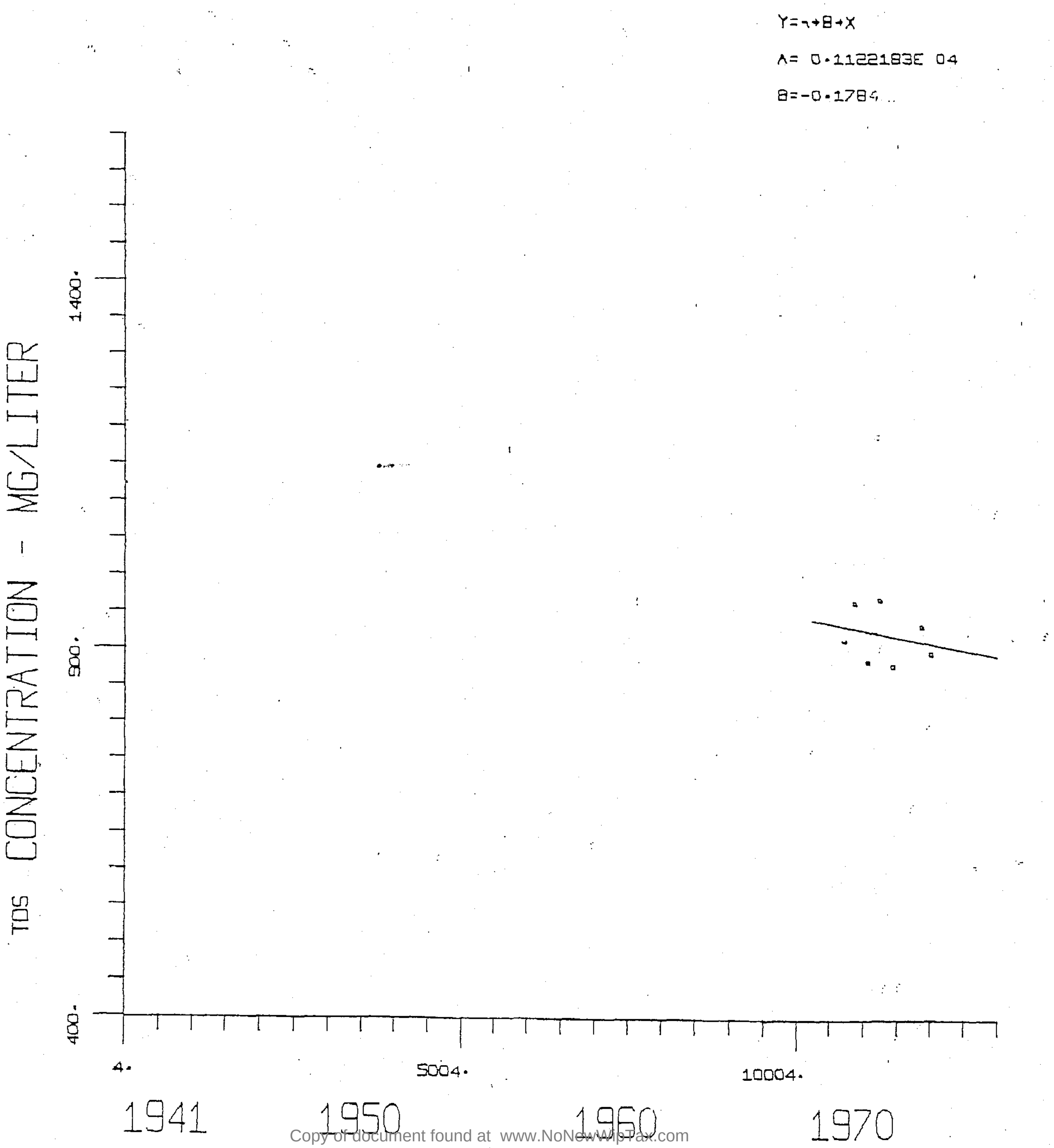


FIG. F-16B

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N36W13R1

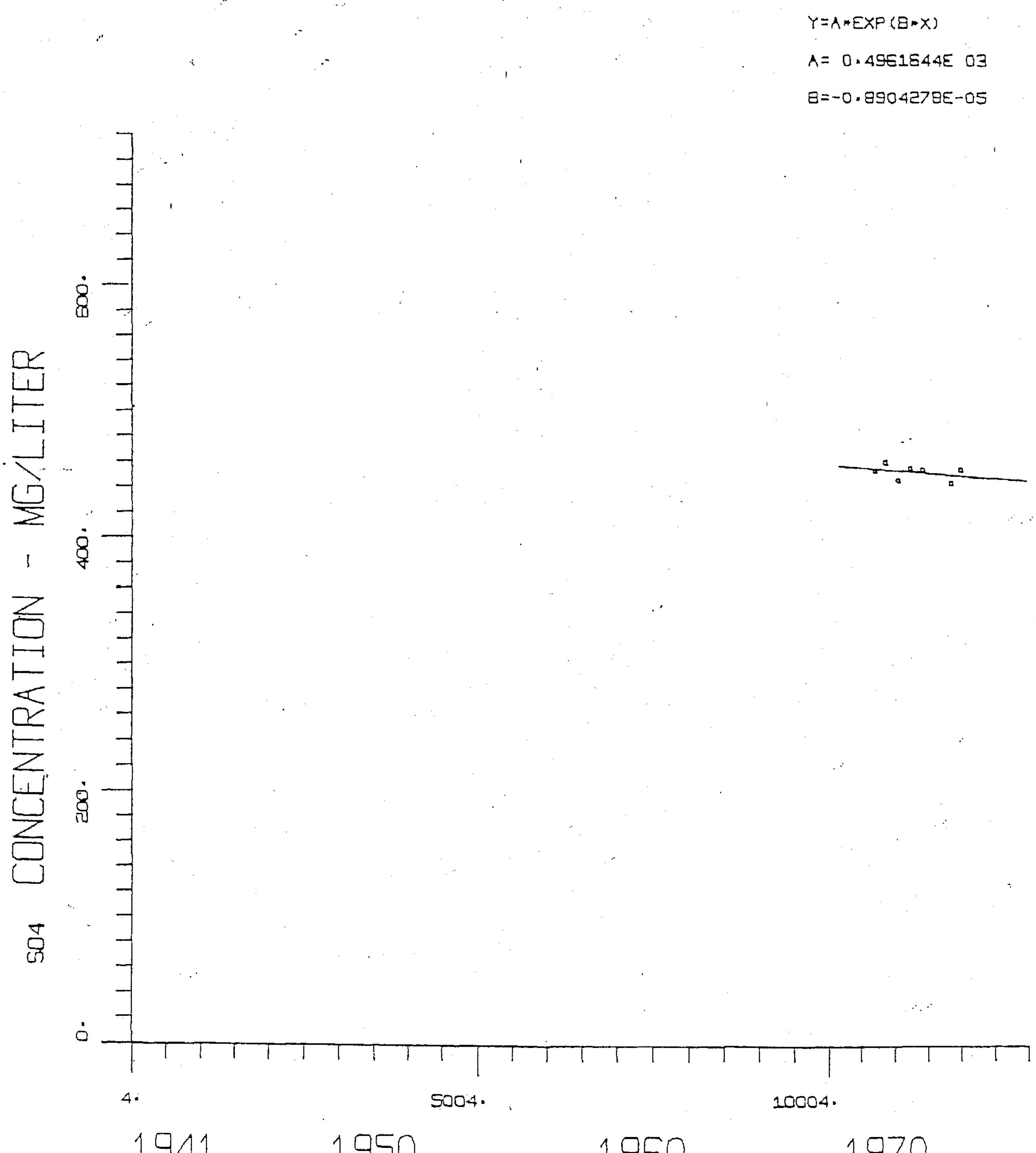


FIG. F-16C

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N36W13R1

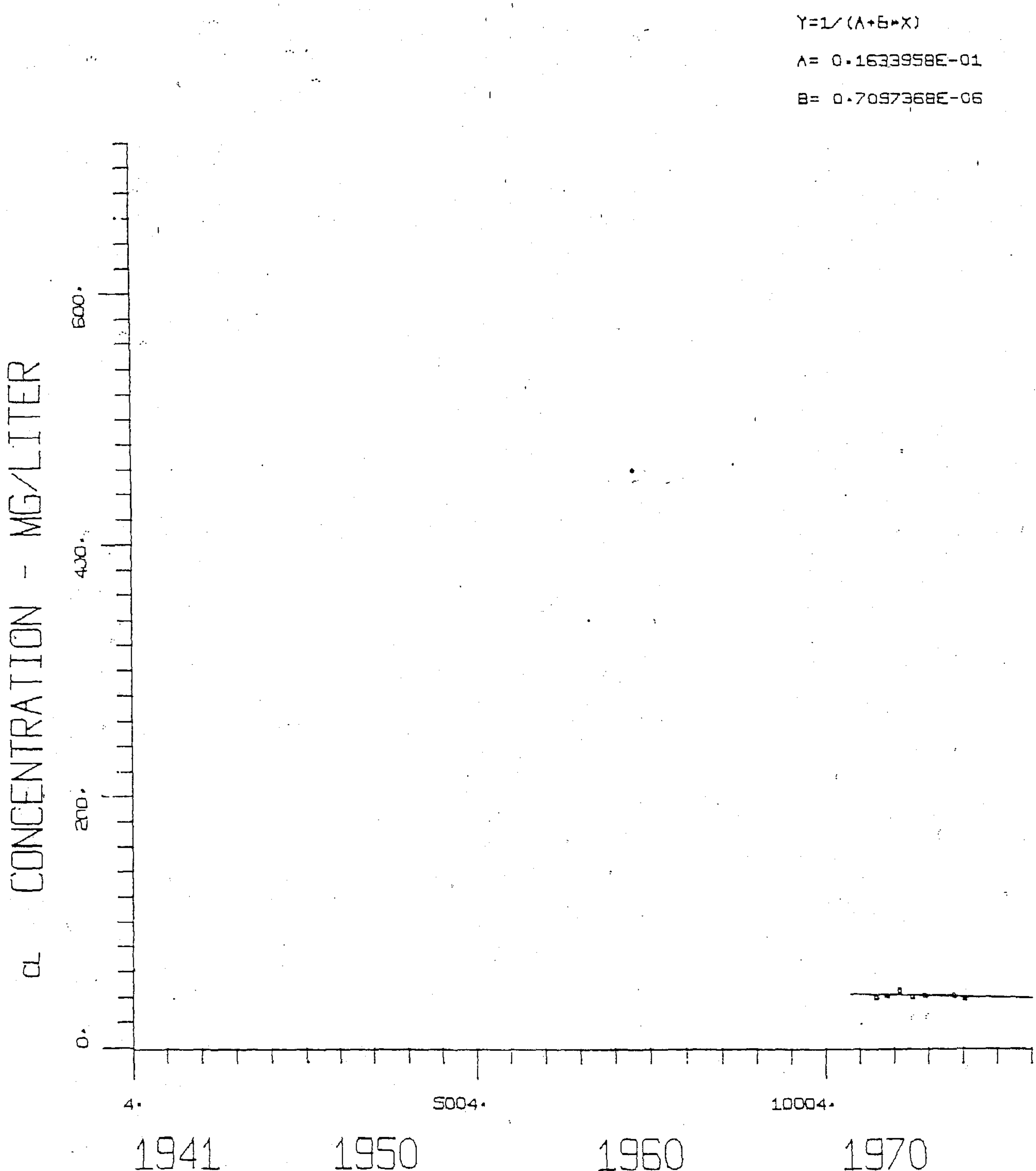


FIG. F-16D

GROUNDWATER CHEMICAL CONSTITUENTS
SANTA MARIA VALLEY WELL NO. 11N36W13R1

Y=A+B*X

A= 0.6912579E 00

B= 0.8970781E-04

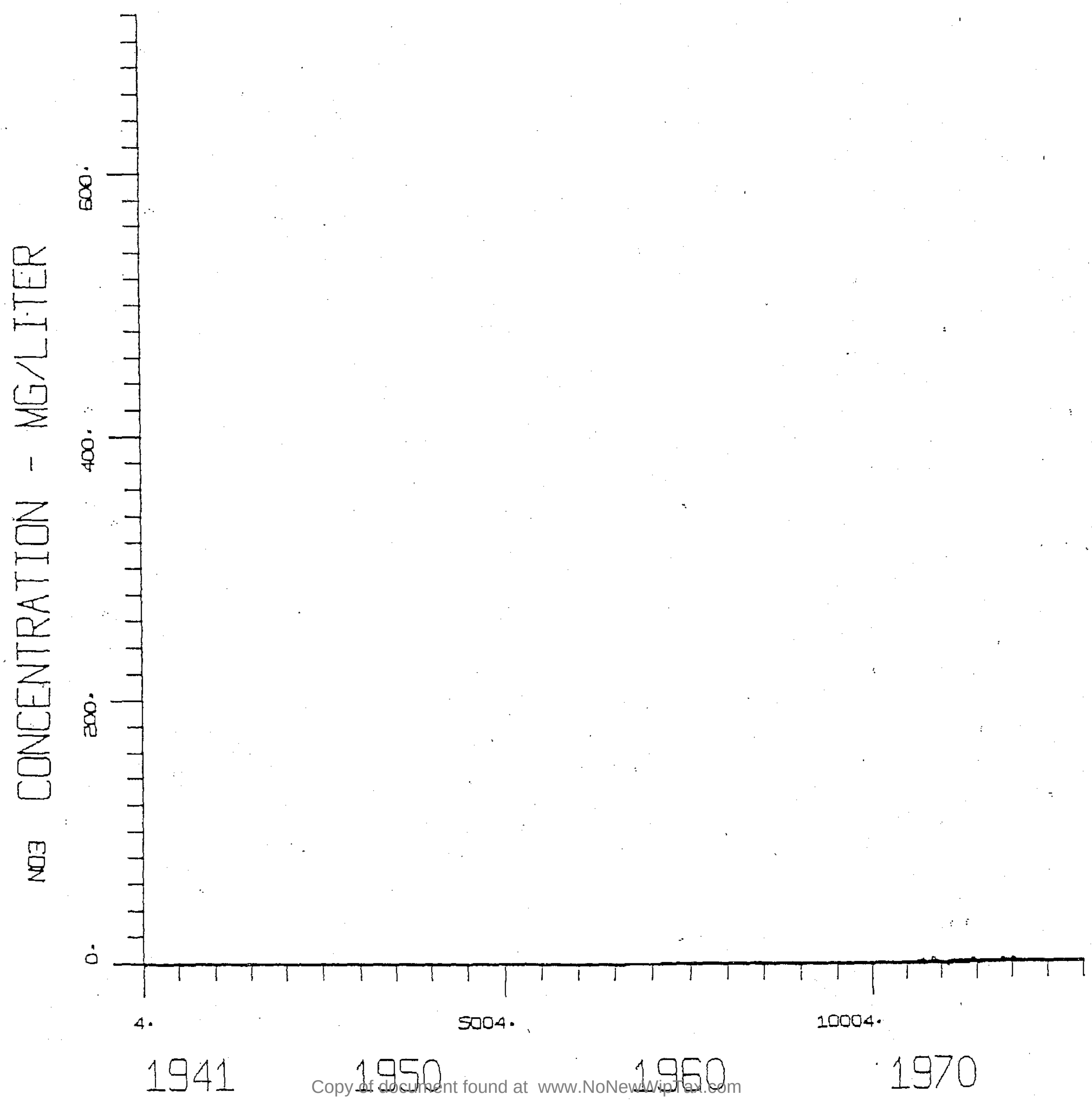


TABLE F-1. CUYAMA RIVER NEAR GAREY - TOTAL DISSOLVED SOLIDS [a]

Water Year		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug.	Sept	Total Yearly Flow (af)
58-59	MO-AF[b]	31	50	61	235	1,780	1,860	215	66	6.5	0	0	0	4,300
	cfs[c]	2	2	2	2	2	25	7	2	—	—	—	—	
	TDS[d]	167	—	—	—	—	1,760	—	1,523	—	—	—	—	
59-60	MO-AF	0	0	0	0	601	273	111	78	0.2	0	0	0	1,063
	cfs	—	—	—	—	5	2	1	1	—	—	—	—	
	TDS	—	—	—	—	886	1,370	—	1,440	—	—	—	—	
60-61	MO-AF	0	0	0	6.5	13	2.6	0	0	0	0	0	0	22
	cfs	—	—	—	—	—	—	—	—	—	—	—	—	
	TDS	—	—	—	—	—	—	—	—	—	—	—	—	
61-62	MO-AF	0	0	0	0	975	664	7,880	19,530	16,360	11,530	1,610	14	58,560
	cfs	—	—	—	—	—	5	1	250	250	275	49	1	
	TDS	—	—	—	—	—	1,448	—	875	—	—	1,020	1,355	
62-63	MO-AF	0	0	0	0	54	39	922	1,400	25	0	0	0	2,440
	cfs	—	—	—	—	1	—	—	15	1	1	—	—	
	TDS	—	—	—	—	1,589	—	—	989	1,319	1,408	—	—	
63-64	MO-AF	0	0	0	0	0	0	0	1,670	2.8	0	0	0	1,670
	cfs	—	—	—	—	—	—	—	—	—	—	—	—	
	TDS	—	—	—	—	—	—	—	—	—	—	—	—	
64-65	MO-AF	0	0	0	417	29	14	2,470	75	5	0	0	0	3,010
	cfs	—	—	—	—	—	0.5	1	4	0.5	—	—	—	
	TDS	—	—	—	—	—	1,680	1,564	1,140	1,460	—	—	—	
65-66	MO-AF	0	375	491	80	49	4,170	172	20	0.8	0	0	0	5,350
	cfs	—	—	133	1.6	2.5	—	8	—	—	—	—	—	
	TDS	—	—	1,180	1,500	1,540	—	1,420	—	—	—	—	—	
66-67	MO-AF	0	0	0.6	105	107	158	256	4,290	12,770	16,940	20,910	19,560	75,100
	cfs	—	—	—	—	—	—	—	150	—	237	355	235	
	TDS	—	—	—	—	—	—	—	550	—	558	530	536	

67-68	MO-AF	8,620	8,620	7,780	7,800	6,410	4,060	539	213	150	6.0	0	0	44,190
	cfs	82	163	127	125	--	125	14	1.9	--	--	--	--	
	TDS	600	600	600	629	--	1,007	1,104	1,230	--	--	--	--	
68-69	MO-AF	0	0	0	279	8,900	65,940	420	12,460	13,970	15,640	15,590	15,960	149,200
	cfs	--	--	--	--	--	--	4.9	--	--	245	--	--	
	TDS	--	--	--	--	--	--	1,533	--	--	572	--	--	
69-70	MO-AF	17,830	15,360	15,430	9,030	8,920	6,370	11,950	13,480	11,490	1,370	49	17	111,300
	cfs	288	--	--	7.5	--	--	210	--	--	3.5	--	--	
	TDS	470	--	--	909	--	--	648	--	--	977	--	--	
70-71	MO-AF	25	173	1,150	2,620	774	523	282	139	48	5.9	0.02	0	5,730
	cfs	--	--	--	51	--	--	6.8	--	--	--	--	--	
	TDS	--	--	--	747	--	--	1,117	--	--	--	--	--	
71-72	MO-AF	0	0	0.2	0	0	0	0	0	0	0	0	0	0.
	cfs	--	--	--	--	--	--	--	--	--	--	--	--	
	TDS	--	--	--	--	--	--	--	--	--	--	--	--	
72-73	MO-AF	0	4.9	0	112	499	267	167	28	4,390	13,690	11,430	11,600	42,190
	cfs	--	--	--	--	--	--	--	--	18	231	--		
	TDS	--	--	--	--	--	--	--	--	1,319	646	546		
73-74	MO-AF	--	--	--	--	--	--	--	--	--	--	--	--	
	cfs	--	87	8.6[e]	2.2	2.1[f]	--	--	150	00	188	--	--	
	TDS	--	614	654	1,293	1,250[f]	--	--	722	--	787	--	--	
74-75	MO-AF													
	cfs					3.4[f]								
	TDS					1,240[f]								

a] Surface water sampling station D-6-3050.00 (California Department of Water Resources designation). Data from DWR Bulletin 130 series, except as noted.
b] Total flow, acre feet per month. Data from USGS, Water Resources Data for California, Volume 1, Annual Summary. USGS gaging station 11138100, Cuyama River below Twitchell Dam.
c] Flow in cfs at time of water quality sampling.
d] Total dissolved solids, mg/l.
e] Sample actually collected 11/30/73.
f] USGS, Water Quality Analysis, Jerry Hughes, Water Resources Division, Laguna Niguel, California.

TABLE F-2. SURFACE WATER QUALITY SANTA MARIA VALLEY AND VICINITY [a]

Surface Water	Date of Sample	Location of Sample	Flow (cfs)	TDS (mg/l)
RIVERS AND STREAMS				
Sisquoc River [b]	3-19-52	Co. Road Bridge at Garey	150	650[c]
	4-15-58	Co. Road Bridge at Garey	2,000	319
	4-2-59	Co. Road Bridge at Garey	10	593
	2-4-60	Co. Road Bridge at Garey	0.5	729
	2-9-62	Co. Road Bridge at Garey	2,000	225
	3-22-62	Co. Road Bridge at Garey	77	922
	9-11-62	Co. Road near Siquoc	1.8	1,590
	1-4-66	Santa Maria Mesa Road Bridge	70	665
	2-19-74[d]	USGS gaging station 11138500 Sisquoc River near Sisquoc	28	717
	2-5-75[d]	Near Garey	75	598
Santa Maria River	4-3-58	Bridge at Suey Co. Park (Whitney Road)	4,000	316
	2-5-58	Highway 1 Bridge at Guadalupe	80	250
	2-5-75[d]	Santa Maria River at Guadalupe	2.0	402
Foxen Creek	2-19-74[d]	USGS gaging station 11139350 Foxen Creek near Sisquoc	0.06	1,540
La Brea Creek	2-19-74[d]	USGS gaging station 11139000 La Brea Creek near Sisquoc	1.5	989
Tepusquet Creek	2-19-74[d]	USGS gaging station 11139500 Tepusquet Creek near Sisquoc	1.7	897
Nipomo Creek	2-12-75[d]	Bridge at Highway 101	0.5	774
LAKES				
Twitchell Reservoir	3-6-62	At Dam		872
Oso Flaco Lake	11-7-53	At access road on eastside, flow from north-easterly lake		1,476
	9-22-60	" " "		1,190
	9-20-62	" " "		1,254

Guadalupe Lake	1 - 57	North shore of Lake at intake pump	1,262
	1 - 58	" " " "	1,206
	12 - 58	" " " "	1,118
	2-22-61	" " " "	678

Data from files of California Department of Water Resources, except as noted.

[a] Cuyama River water quality data is tabulated separately in Table F-17.
[b] Relationship between TDS and flow is presented on Figure 7-8.
[c] Computed using ratio between TDS and Electrical Conductivity as 0.74.
[d] U.S. Geological Survey, Water Quality Analysis, Jerry Hughes, Water Resources Division, Laguna Niguel, California.

ıBLE F-3. TIVE SURFACE WATER - SALT INVENTORY

Off-channel Spreading Demand (cfs)		Salt Additions (tons) Sisquoc[b] River	Cuyama[c] River	Fugler[d] Point	Santa[e] Maria Channel	Salt Depletions at Guadalupe[f] (tons)	Total Days of flow at Fugler Point	Flow Weighted Average[g] TDS (tons/af)	TDS (mg/l)
0[h]	38-year total	632.11	1141.62	1773.74	1144.33	629.40	11,645	0.677	498
	Annual average	16.63	30.04	46.68	30.11	16.56			
0	38-year total	632.11	1284.51	1916.63	1755.62	161.01	12,148	0.741	545
	Annual average	16.63	33.80	50.44	46.20	4.24			
100	38-year total	632.11	1260.42	1892.53	1755.70	136.83	12,142	0.730	537
	Annual average	16.63	33.17	49.80	46.20	3.60			
200	38-year total	632.11	1242.25	1874.37	1756.13	118.24	12,148	0.722	531
	Annual average	16.63	32.69	49.33	46.21	3.11			
300	38-year total	632.11	1228.60	1860.71	1757.23	103.48	12,148	0.716	527
	Annual average	16.63	32.33	48.97	46.24	2.72			
400	38-year total	632.11	1217.81	1849.93	1758.79	91.13	12,148	0.711	523
	Annual average	16.63	32.05	48.68	46.28	2.40			
500	38-year total	632.11	1209.00	1841.12	1760.63	80.49	12,148	0.708	520
	Annual average	16.63	31.82	48.45	46.33	2.12			
600	38-year total	632.11	1201.69	1833.81	1762.41	71.39	12,148	0.705	518
	Annual average	16.63	31.62	48.26	46.38	1.88			
700	38-year total	632.11	1195.77	1827.89	1764.61	63.28	12,147	0.702	516
	Annual average	16.63	31.47	48.10	46.44	1.67			
800	38-year total	632.11	1191.02	1823.13	1767.04	56.09	12,147	0.700	515
	Annual average	16.63	31.34	47.98	46.50	1.48			
900	38-year total	632.11	1186.64	1818.76	1769.05	49.71	12,147	0.698	514
	Annual average	16.63	31.23	47.86	46.55	1.31			
1,000	38-year total	632.11	1182.80	1814.92	1771.25	43.66	12,146	0.697	512
	Annual average	16.63	31.13	47.76	46.61	1.15			

[a] Percolation capacity of various sized off-channel spreading basins.
[b] Total Dissolved Solids (TDS) contributed by surface flow of Sisquoc River as determined from TDS vs flow characteristics (Figure 7-8).
[c] Total dissolved solids contributed by surface flow of Cuyama River as determined from TDS vs flow characteristics (Figure 7-7).
[d] Sum of TDS contributed by Cuyama and Sisquoc Rivers.
[e] TDS additions to groundwater basin due to percolation of surface flows in Santa Maria Channel and off-channel spreading grounds.
[f] TDS depletions to ocean due to surface outflow at Guadalupe.
[g] Flow-weighted average of TDS from Cuyama and Sisquoc Rivers for total days of flow at Fugler Point.
[h] This analysis was made with no Twitchell Reservoir in operation for the entire period.

APPENDIX G

TABLE G-1. TWITCHELL RESERVOIR YIELD RUNS - 38-YEAR SUMMARY

(1000 af)

Off-Channel Demand (cfs) [a]	Sisquoc River [b]	Reservoir Inflow [c]	Net Evaporation [d]	Precipi-tation [e]	Channel Releases [f]	Off-Channel Releases [g]	Spill [h]	Flood Releases [i]
0	1,164.930 30.656	1,456.293 38.324	0	0	0	0	0	0
0	" "	" "	35.633 0.938	21.083 0.555	1,353.180 35.610	0	0	67.479 1.776
100	" "	" "	29.324 0.772	19,160 0.504	1,025.841 26.996	334.585 8.805	0	66.542 1.751
200	" "	" "	25.354 0.667	18.195 0.479	834.612 21.963	531.240 13.980	0	65.087 1.713
300	" "	" "	22.668 0.597	17,592 0.463	711.227 18.717	660.392 17.379	0	62.005 1.632
400	" "	" "	20.837 0.548	17.156 0.451	629.239 16.559	746.634 19.648	0	59.583 1.568
500	" "	" "	19.535 0.514	16.794 0.442	574.470 15.118	805.746 21.204	0	56.543 1.488
600	" "	" "	18.555 0.488	16.489 0.434	533.105 14.029	851.586 22.410	0	53.048 1.396
700	" "	" "	17.814 0.469	16.226 0.427	502.671 13.228	886.673 23.334	0	49.135 1.293
800	" "	" "	17.245 0.454	15.998 0.421	481.910 12.682	912:128 24.003	0	45.010 1.184
900	" "	" "	16.786 0.442	15.791 0.416	463.987 12.210	934.874 2.602	0	40.647 1.070
1,000	" "	" "	16.424 0.432	15.602 0.411	451.848 11.891	952.114 25.056	0	35.907 0.945

TABLE G-1. Continued

Final Reservoir Storage [j]	Initial Reservoir Storage [j]	Channel Flow [k]	Off-Channel Flow [l]	Channel Flow [m]	Off-Channel Percolation [n]	Total Percolation [o]	Outflow to Ocean [p]	Totals
[r]	[r]	2,621.221		1,337.813	0		1,283.408	38-year
		68.980		35.206		35.206	33.774	Average Annual
2,290	2,290	2,585.588	0	2,088.491	0		497.097	38-year
		68.042		54.960		54.960	13.082	Average Annual
2,290	2,290	2,182.204	409.693	1,729.525	409.623		452.679	38-year
		57.426	10.781	45.514	10.781	56.295	11.913	Average Annual
2,290	2,290	1,930.947	664.920	1,514.869	664.920		416.078	38-year
		50.814	17.498	39.865	17.498	57.363	10.949	Average Annual
2,290	2,290	1,757.663	840.891	1,372.756	840.891		384.907	38-year
		46.254	22.129	36.125	22.129	58.254	10.129	Average Annual
2,290	2,290	1,633.058	967.327	1,275.634	967.327		357.424	38-year
		42.975	25.456	33.569	25.456	59.025	9.406	Average Annual
2,290	2,290	1,541.030	1,060.658	1,208.008	1,060.658		333.022	38-year
		40.553	27.912	31.790	27.912	59.702	8.764	Average Annual
2,290	2,290	1,466.656	1,126.012	1,155.452	1,136.012		311.204	38-year
		38.596	29.895	30.407	29.895	60.302	8.190	Average Annual
2,290	2,290	1,406.852	1,196.558	1,115.707	1,196.558		291.145	38-year
		37.022	31.488	29.361	31.488	60.849	7.662	Average Annual
2,290	2,290	1,360.292	1,243.686	1,087.674	1,243.686		272.618	38-year
		35.797	32.729	28.623	32.729	61.352	7.174	Average Annual
2,290	2,290	1,319.340	1,285.097	1,063.706	1,285.097		255.634	38-year
		34.719	33.818	27.992	33.818	61.811	6.727	Average Annual
2,290	2,290	1,285.953	1,318.846	1,046.692	1,318.846		239.261	38-year
		33.841	34.706	27.545	34.706	62.251	6.296	Average Annual

TABLE G-1. Footnotes

[a] Daily percolation capacity of various sized off-channel spreading basins.
[b] Flow of Sisquoc River at USGS gaging station 11140000, Sisquoc River near Gary.
[c] Inflow to Twitchell Reservoir, computed as the sum of Cuyama and Huasna Rivers and Alamo Creek. Incomplete station records extended by double-mass comparison with long-term stations.
[d] Daily net evaporation = daily total evaporation - daily precipitation on reservoir.
[e] Daily precipitation on reservoir.
[f] Releases from Twitchell Reservoir to sustain 300 cfs flow in Santa Maria River channel when possible.
[g] Releases from Twitchell Reservoir to satisfy percolation capcity of the various sizes off-channel spreading basins.
[h] Twitchell Reservoir spills when volume of water in storage exceeds 240,113 acre-feet. However, no spills have occurred historically or in this base period hydrologic computer simulation.
[i] Releases from Twitchell Reservoir during flood operation (when volume of water in storage exceeds 151,000 acre-feet) according to USBR operation schedule. [70]
[j] Silt storage estimated to be 2,290 based on USBR Twitchell Reservoir Daily Operations Summary. Reservoir is dry at beginning and end of the 38-year hydrologic base period (1935-1972).
[k] Flow in the Santa Maria River channel at Fugler Point. Algebraic sum of off-channel flow requirement plus in-channel flow.
[l] Flow diverted to off-channel spreading basins. Equivalent to off-channel percolation.
[m] Computed percolation in Santa Mara River based on percolation characteristics of channel alluvium idenitified by USBR. [69]
[n] Computed percolation in off-channel spreading basins. Equivalent to off-channel flow.
[o] Sum of channel percolation and off-channel percolation.
[p] Flow in Santa Maria River passing USGS gaging station 11141000, Santa Maria River at Guadalupe.
[q] Base period average annual flow in Sisquoc River near Gary (USGS gaging station 11140000) computed in this analysis (30,656 af) differs slightly from 38 year average developed in Table 3-1 (30,920 af). The computer analysis generates missing data for flows in the Sisquoc River during water years 1935 to 1940 by a double mass comparison with daily flows in long-term adjacent watercourses. The missing data in Table 3-1 were developed by double-mass comparison with annual flows in these same long-term stations. Hence totals have been rounded.
[r] This run made with no reservoir in operation.

APPENDIX H

TABLE H-1. ROUND CORRAL DAM AND RESERVOIR RECONNAISANCE COST ESTIMATE [a]

Item	Cost
Dam [b]	
Diversion of River [c]	$ 615,000
Earthwork	9,295,000
Rock and Grouting	$ 1,100,000
30% Contingencies	3,303,000
TOTAL	$ 14,313,000
Spillway [d]	$ 18,387,000
Outlet Works [e]	8,172,000
Reservoir [f]	
Clearing	443,000
Access Road	1,107,000
Subtotal	$ 1,550,000
25% Contingencies	388,000
TOTAL	$ 1,938,000
Construction Total	$ 42,810,000
25% Construction facilities, engineering and administration	10,703,000
GRAND TOTAL [g]	$ 53,513,000

TABLE H-1. FOOTNOTES

[a] Based on preliminary reconnaissance cost estimate developed by U.S. Bureau of Reclamation, Region 2, for Santa Maria Definite Plan Report, Hydrology Appendix, 1965. October 1965 costs were updated to October 1975 conditions by use of ENR Irrigation and Hydro Cost Indexes for the West.

[b] Round Corral is a proposed zoned earthfill-type dam. Crest elevation is 954 feet, crest length is 2,000 feet. Dam volume is 6,217,000 cubic yards.

[c] Diversion consists of 23-foot diameter tunnel. Capacity is 18,000 cfs.

[d] Spillway is gated chute type. Maximum capacity is 133,000 cfs at water surface elevation 946 feet. Gates are radial, three in number, 40' x 40'.

[e] Outlet works consist of 48-inch diameter pipe. Capacity is 300 cfs at water surface elevation 750 feet.

[f] Reservoir capacity is 100,000 acre-feet at water surface elevation 941 feet.

[g] Does not consider cost of right-of-way.

APPENDIX I

SPONSORING ORGANIZATIONS AND AGENCIES

The water resources evaluation of the Santa Maria Valley was conducted under the auspices of the City of Santa Maria. Sponsoring organizations and agencies include:

- Gilliland Oil and Land Company
- City of Santa Maria
- County of Santa Barbara
- California Cities Water Company
- Santa Maria Valley Water Conservation District
- Lake Marie Water Company

Four progress report meeting were held during the course of the study to review preliminary draft submittals and to solicit comments from the investigation sponsors. The City of Santa Maria provided conference facilities. A fifth meeting was held to review the final draft report. Minutes of the four progress report meetings are presented herein.

Meeting No. 1

WATER RESOURCES STUDY

August 21, 1975

A meeting on the above subject was held on Thursday, August 21, 1975 at 1:30 p.m. in the Library Conference Room.

Agencies Represented

S. B. County Water Agency	(Charles Lawrence & Leon Lunt)
Lake Marie Water Company	(Joseph H. Gilliland)
S. M. V. Water Conservation District	(Maurice Twitchell)
City of Santa Maria	(Reese Riddiough & Robert Grogan)
TOUPS Corporation	(Bill Mills & Rich Drew)

Also Attending

Santa Barbara County	(Norman H. Caldwell)
San Luis Obispo County	(Clinton Milne)

Agencies NOT Represented

California Cities Water Company

Purpose of Meeting

The purpose of the meeting was to get the study going formally. It was noted that Bill Mills, TOUPS Engineering, has started some of the ground work; however, some additional information is needed as will be discussed later.

It is desired that we get together for a progress meeting as necessary. Another meeting was tentatively scheduled for Thursday, September 25, 1975 at 1:30 p.m. Mr. Riddiough will send a letter to the various agencies confirming the meeting.

Completion date for this supplemental water study will be in the future--probably late October. Mills stated there is 120 days allowed in the contract; the contract was signed in June.

Study Boundaries

The boundaries are basically the same as the former report prepared for the City in 1970, (location map is attached). The study does go into San Luis Obispo County to some extent; it extends all the way up to the Pismo Beach/Arroyo Grande area (ground water divide). The topographic divide coincides with the ground water divide.

The south boundary is south of Sisquoc at the Paso Robles lease.

General

It was noted that the water movement is towards the ocean.

It was pointed out that the State Water Resources has undertaken a $1/4 million study that includes drilling test wells and analysis. This study should be completed by fall, however, it could be a couple of years before it is published. It was the general feeling of all present that the impact from the Water Resources Study should be considered in our study for supplemental water.

Norm Caldwell informed the group that additional information may be obtained from U.S.G.S., who is doing a study, financed by the State Water Quality Control Board, on the quality of water. It was felt that this information should be incorporated in our study report; however, it is imperative that we avoid duplication. Bill Mills stated he understood this to be a salt impact study, however, indicated he would look into it further for any information that may be helpful in our study.

Mr. Gilliland stated that often times there would be conflicting findings in each study that is made; therefore, he felt TOUPS should go ahead, do the work on their own and make their own determinations. He also indicated that the gas and oil companies would make information available to the Division of Oil and Gas regarding casing points, locations, electric log info, etc. that may be helpful in this study.

Information Required

Following are some areas that Mr. Mills has touched on which require additional information:

1. Precipitation - No problem; information readily available.

2. Steam Flow Data - Output from Twitchell. (Jim Stubchaer, Flood Control Engineer, Santa Barbara County, may have some information in this area.)

3. Began to construct two groundwater maps for Spring 1973 and 1975; no information received from Santa Maria Valley Water Conservation District as yet. (Mr. Twitchell indicated it should be in with USGS data.) *(Minutes corrected by Toups Corp.)*

   The Orcutt plan area is of much concern. Mr. Mills indicated they have two sources of information: U.S.G.S. and Joe Green, who has developed fresh water analysis. Mr. Gilliland then mentioned they have drilled a number of wells since that analysis was made.

   The perforated zones for the nine City wells were questioned. It was noted that the deepest well on the airport is 1,400 feet; most are 1,000 feet deep. It is believed City wells are in Paso Robles formation. Things have not changed over the number of years the wells have been in service; the water level stays the same. It was noted that 4-5 wells produce somewhere in the 2000 - 3000 G.P.M. range.

4. Water Quality - Mills has got all information available from U.S.G.S. The State Department of Water Resources must be contacted to get update information on wells. It was noted that U.S.G.S. is approximately five years behind in their wells.

5. Requested latest set of water quality calculations--chemical concentrations. It was noted that tests have been made in 1975, but probably are not analyzed yet.

Mr. Gilliland reiterated that the engineers should not rely on information received from U.S.G.S., but obtain their own.

6. Information is available from the land use general plan. The County does have a more comprehensive plan, however, it is not yet adopted; therefore, Levingston-Blayney plan would be the best one to use.

7. Future water use in Valley--what kind of population and crops? Any specifics available? It was noted that the Levingston-Blayney figures are better to use for people; for agriculture, County projections may be better.

It was noted that LAFCO now has a proposal from the Nipomo area (Water District) for agriculture development requiring 1 1/2 acre feet of supplemental water in addition to the 1 1/2 acre feet they now have.

8. Waste Disposal - It was pointed out that the City's plans for waste disposal, in all likeness, will remain as is; it appears to be the most cost effective.

9. Chemical Concentrations - (City of Santa Maria and Cal Cities Water Company) It was noted that samples are taken at each well site in addition to the system annually. Public Works Department has ample information on these analyses. It was noted that for each well, information regarding physical characteristics of the well that is not available through the Public Works Department, Floyd Wells, who did the installations, would be most willing to supply the information.

10. Source Control Program - The City's consultant is now in process of development a source control program which hopefully would be implemented within the next six months to a year. Information regarding this program would be available from John Carollo Engineers in their Walnut Creek office.

This study also gets into the Laguna Sanitation District area. The County does have a source control program in that area. Mr. Vernon Bugh, Santa Barbara County, is the man to contact in this regard.

Additional Information

It was pointed out that cleaning brush from land would be most helpful in creating more water. The State will allow you more water if you keep your land clean. It was noted that the Forest Service has background data on this and other control burning.

The Forest Service also has a "cold burn" control program which is not only helpful for water conservation, but also for silt conservation. It was felt that this should also aid the water situation.

Meeting No. 2

WATER RESOURCES STUDY

October 16, 1975

A second meeting on the above subject was held on Thursday, October 16, 1975 at 1:30 p.m. in the City Hall Conference Room.

Agencies Represented

S. B. County Water Agency	(Leon Lunt)
S. M. V. Water Conservation District	(Maurice Twitchell)
California Cities Water Company	(Bill Hartsell)
City of Santa Maria	(Reese Riddiough & Bill Litzenberg)
TOUPS Corporation	(Bill Mills & Rich Drew)

Also Attending

San Luis Obispo County	(Clinton Milne)

Agencies NOT Represented

Lake Marie Water Company	(Joseph H. Gilliland)

Purpose of Meeting

The purpose of this meeting was basically to learn the progress made on the study, to obtain any additional information necessary, and to learn of the comments from the various agencies involved.

Copies of the preliminary draft of Chapter 1 - 4 of the report were mailed to each agency for review. It was pointed out that there will probably be ten chapters in the complete report.

General

The draft of the first four chapters was scanned through briefly with various items highlighted.

It was requested that some special attention be given to the Sisquoc area as some of the new vineyards are draining the water in the area; it is felt there is a decrease in the water table.

Mr. Mills pointed out that his firm has done no work on the off shore basin; they will be relying on the findings of the Department of Water Resources in their study.

Mr. Twitchell reported briefly on the forest service burn program which is in the "mill" now and felt to be implemented soon.

Meeting No. 3

WATER RESOURCES STUDY

December 18, 1975

A third meeting on the above subject was held on Thursday, December 18, 1975 at 1:30 p.m. in the City Hall Conference Room.

Agencies Represented

California Cities Water Company	(Richard Gruszka)
S. B. County Water Agency	(Charles Lawrence)
City of Santa Maria	(Reese Riddiough, Bill Litzenberg)
TOUPS Corporation	(Rich Drew, Elwood Johnson)

Also Attending

S.L.O. County Engineering Dept.	(Wally Burt)

Agencies NOT Represented

Lake Marie Water Company	(Joseph H. Gilliland)
S.M.V.W. Conservation District	(Maurice Twitchell)

Purpose of Meeting

The purpose of this meeting was to learn the progress made on the study, to obtain any additional information necessary and to learn of the comments from the various agencies involved.

Copies of the preliminary draft of Chapters 5 and 6 of the report plus various amendments in the first four chapters were mailed to each agency prior to the meeting for review.

General

One item discussed was an up-to-date accounting of the urban acreage in the valley. It was proposed to have UCSB do the work with a price involved. The Committee discussed sharing of the cost and all agencies involved tentatively agreed they could share the cost. Santa Barbara County Water Agency representative stated the Board of Supervisors would probably support the idea. Following discussion, it was agreed that the change in urban land use patterns since 1972, the most recent date of the DWR survey, has been insignificant, and thus there would be no need at this time to devote additional effort to this aspect.

There was a short review of what has been discussed in the two previous meetings.

Rich Drew gave the Committee a brief background on Elwood Johnson's background as he has just joined the TOUPS staff.

Additional Information

The question was raised if there are any areas where additional work is believed necessary.

It was mentioned once again that the main objective of the study is to see if there is a need for supplemental water; if so, when and how much? It was felt there should be some statement made in the report indicating what we can expect if we continue as is with no supplemental water prior to getting water from the State Water System, what water levels and water tables will look like in the future.

Completion Date

It was pointed out that there are some items that may delay the study.

A preliminary report could be ready in approximately three months from now (end of the year); however, the final report should not be finalized until the other studies are completed such as the U.S.G.S. Study and the S.L.O. County Water Agency study. It is felt there definitely would be some advantage to waiting for these other studies.

Future Meeting

Another meeting will be scheduled in approximately six weeks from now. December 4 is the tentative date; same time and same place.

Mr. Riddiough will follow up and confirm the next meeting date.

Meeting No. 4

WATER RESOURCES STUDY

January 29, 1976

A fourth meeting of the above subject was held on Thursday, January 29, 1976 at 1:30 p.m. in the City Hall Conference Room.

Agencies Represented

California Cities Water Company	(Bill Hartzell, Marty Jones, Richard Gruszk)
City of Santa Maria	(Reese Riddiough, Bill Litzenberg)
TOUPS	(Bill Mills, Rich Drew)
Lake Marie Water Company	(Joseph Gilliland)

Also Attending

San Luis Obispo County	(Clinton Milne)
Santa Barbara County	(Larry Lavagnino)

Agencies Not Represented

Santa Barbara County Water Agency	(Charles Lawrence)
S.M.V.W. Conservation District	(Maurice Twitchell)

Purpose of Meeting

It was noted that all Agencies concerned received a draft copy of Chapter 7, 8 and 10 in the mail for review before the meeting. Also distributed by TOUPS at the meeting were inserts for these chapters.

General

TOUPS identified in Chapter 7, Water Quality, the tons of salt coming from various sources into the basin which include minimal manmade sources and agricultural sources. Included in this discussion was the hardness of water, the problems that could arise, the salt in the natural flow and its dangers. Committee briefly went over each table in Chapter 7 and discussed salt concentration and other constituents in the water. TOUPS stated generally water quality is worsening; however, there are individual areas where it is improving. Also, the large amount of salt coming into basin does not have an adequate outflow area and the future is going to be a problem.

Bill Mills stated TOUPS does not have adequate recent information on ground water levels. Mr. Riddiough assured Mr. Mills that Public Works could provide recent years information indicating ground water depths for the City's downtown field wells around the Airport well field. Also discussed was deep wells vs. shallow wells. TOUPS will follow up with obtaining some kind of definition of this.

The Committee did not discuss Chapters 8 or 9.

General - Continued

The Committee discussed chapters 5 and 6 including such items as fresh water base resources available, protection for beneficial purposes, base ground water levels and defining the base of ground water. Rich Drew assured the members that all available data and standards will be used and obtained including the State Health Department's standards. Other items pointed out included the following:

Techniques by which land use data is assembled was discussed and it was pointed out that at this time there is no way of determining the bases of how data was collected. Toups went ahead and used these figures. The Committee briefly discussed complications of transient population in the County with regards to students, tourism, government employees and including the V.A.F.B. space shuttle project. An upper and lower range median will be included.

Complications of ground water basin data due to fire was briefly discussed. Santa Barbara County Water Agency agreed to send Toups some information regarding burns.

The present ground water levels between 1935 and 1972 in the Santa Maria area, the impact of the Twitchell Dam Project, present problems now facing the north coastal area and the cost to further investigate this problem area were discussed. Toups will finalize their analysis of these problems. A brief summary of Chapter 6 was given by Rich Drew. He explained that Chapter 6 verified the information in Chapter 5 and included a summary of hydrologics.

Additional Information

Reese Riddiough inquired about what the other chapters would contain. Rich Drew informed the members that Chapter 7 will deal in water quality, Chapter 8 - future water requirements, Chapter 9 - future ground water conditions, and Chapter 10 - supplemental water.

Future Meeting

Another meeting has been scheduled for January 29, 1975; same time and same place.

Mr. Riddiough to follow up.

General - Continued

Chapter 10 dealt with Supplemental Water Sources and its potential costs and improvements. The Committee briefly discussed the Round Corral Reservoir and its costs. The insert to Chapter 10 was devoted to the cost associated with the development of spreading grounds for infiltration in and adjacent to the Santa Maria River.

There was a very lengthy discussion on salt water intrusion, salt water control, salt water barrier, and salt water intrusion inland to the first producing wells. Water is increasing; however, the area that needs the most water around the coast has decreased. The Committee discussed the salt water wedge that appears to be moving in and the basic problem of the continuing lowering of ground water levels near the coast line. TOUPS will follow up on how fast the wedge is moving in and research ground water levels.

Mr. Gilliland expressed his feelings concerning the amount of water in the area and why have a water resources study. He further stated that his deep well water levels are rising. Mr. Litzenberg noted the City's deep well water levels have been relatively constant in recent years with fluctuations up and down slightly, which probably reflect wet and dry years. Mr. Gilliland feels the water is coming from some place such as Twitchell Reservoir. TOUPS stated they could further look into the increasing amount of water in the area.

An insert to Chapter 6, Estimates of Truck Crops for Reported Acreage, was briefly discussed.

Future Meeting

TOUPS stated there will be a final draft distrubuted to all concerned Agencies for review before the next meeting. Tentative date has been scheduled for March 4, 1976, same time and same place.

Santa Maria
All-America City

CITY OF SANTA MARIA · 110 EAST COOK STREET, ROOM 3 · SANTA MARIA, CALIFORNIA 93454-5190 · 805-925-0951, EXT.306

STATE OF CALIFORNIA)
COUNTY OF SANTA BARBARA) ss.
CITY OF SANTA MARIA)

I, PATRICIA A. PEREZ, Chief Deputy City Clerk and ex-officio Clerk of the City Council of the City of Santa Maria, County of Santa Barbara, State of California, do hereby certify that the attached are true and correct copies of official City documents:

1. Report on Water Conservation and Flood Control of the Santa Maria River in Santa Barbara and San Luis Obispo Counties, March 1931.

2. Santa Maria Valley Water Resources Study by Toups Corporation, July 1975.

3. Final Environmental Impact Report, State Water Project, Coastal Branch, Phase II and Mission Hills Extension, Department of Water Resources, Volume One, May 1991.

4. Final Environmental Impact Report, State Water Project, Coastal Branch, Phase II and Mission Hills Extension, Department of Water Resources, Volume Two, May 1991.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the Seal of said City to be affixed this 14th day of October, 2003.

Chief Deputy City Clerk