FINAL REPORT

GROUND WATER BASIN EVALUATION

CITY OF SAN LUIS OBISPO

Project Manager	William T. Hetland, P.E. Utilities Director
Project Engineer	Gary Henderson, P.E. Utilities Engineer

BOYLE ENGINEERING CORPORATION

Project Manager	Christine M. Ferrara, P.E.
Project Geologist	Robert S. Ford, R.E.
Project Hydrologist	KENNETH D. SCHMIDT & ASSOC. Kenneth D. Schmidt, R.G.

VT-S35-200-01

January 1991

CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

REGISTERED PROFESSIONAL ENGINEER
CHRISTINE M. FERRARA
No. C 042090
Exp. 3-31-92
CIVIL
STATE OF CALIFORNIA

PROJECT MANAGER
CHRISTINE M. FERRARA, RCE 42090

REGISTERED GEOLOGIST
ROBERT S. FORD
No. EG67
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

PROJECT GEOLOGIST
ROBERT S. FORD, EG 67

BOYLE ENGINEERING CORPORATION

JOB NO. VT-S35-200-01

CITY OF SAN LUIS OBISPO
GROUND WATER BASIN EVALUATION

TABLE OF CONTENTS

Table of Contents (cont'd)

List of Tables

List of Plates

EXECUTIVE SUMMARY

General

On June 6, 1990, Boyle Engineering Corporation entered into a contract with the City of San Luis Obispo to prepare the San Luis Obispo Ground Water Basin Evaluation. The objectives of this evaluation are to define the basin boundary and its associated hydrogeology, assess the movement of ground water within the basin, and assess the City's current ground water development program. This evaluation is also intended to identify further opportunities for ground water development and to estimate the sustained yield of the basin. Environmental impacts associated with short-term overdraft of the basin have also been addressed.

The study area consists of approximately 28 square miles of land which underlies the City and extends into Edna Valley as illustrated in **Plate 1**. Basin 3-9, illustrated in **Plate 4**, is that basin from which the City is currently extracting water. Edna Valley makes up a "contiguous ground water terrane" which contributes ground water flow to the City area. Thus, both Basin 3-9 and the Edna Valley area were studied in this investigation.

The bedrock surface underlying the basin was found to be highly irregular, but there are overlying well-defined areas of water-bearing deposits. A large portion of the basin which underlies the downtown area consists of a relatively thin layer of unconsolidated materials and is therefore characterized by wells of low to moderate yield (100 gallons per minute (gpm) or less).

Higher yielding ground water zones exist in the southern portion of the incorporated area (up to 1,000 gpm wells), however, this area is heavily irrigated for agricultural purposes and competition for ground water is high.

Current Basin Status

Examination of existing data leads to the conclusion that, during the period from 1978 to 1990, Basin 3-9 has <u>not</u> been in a state of sustained overdraft. Long-term water level records in particular indicate that, while the basin water levels do decline significantly during drought periods, they recover relatively quickly each winter and after a drought period. The current City extractions of approximately 2,000 acre-feet per year (AFY) are resulting in significant water level declines which may be considered a "short term overdraft" but not a long term one. With the current drought year sequence, however, the basin may suffer a long-standing overdraft situation from which it would take longer than ordinarily expected to recover.

The City's current ground water program entails the use of six municipal wells and two or more irrigation wells. Approximately 40% of current domestic demands are being met from ground water supplies with annual extractions amounting to approximately 2,000 AFY.

The opportunity for additional well development within the City limits *during the current drought* is limited. Four of the existing wells are showing sharp declines in pumping water elevation and are being operated on a rotation basis.

There are opportunities to activate additional wells as a long-term supplemental water supply to the City. Several moderate yielding wells in the downtown area (80 to 100 gpm) could be activated and used during non-drought periods. Use of this supplemental source would permit Whale Rock and Salinas Reservoirs to more fully recover during years of normal to above-normal rainfall.

Further, two areas have been identified that may support high ground water extractions (in the order of 500+ gpm), however, both these areas lie outside the corporate boundary. The City would have to weigh carefully the jurisdictional and environmental impacts, and the transmission facility needs in evaluating sources outside the City limits.

Basin Storage Capacity and Sustained Yield

The estimated storage capacity of Basin 3-9 is 24,000 acre-feet, which represents that volume of saturated deposits above rocks of the nonwater-bearing series. This is essentially in agreement with the California Department of Water Resource's 1958 published estimate of 22,000 acre-feet.

The maximum quantity of water that is available from a ground water basin on an annual basis is defined as the basin's sustained yield. This yield is limited by detrimental effects that would be caused by over pumping and by operating the basin in a manner such that extractions exceed replenishments.

In the analysis of the sustained yield of Basin 3-9, the sustained yield of the basin was determined based on the inflows and outflows (**Plate 9**). The, average annual recharge to the basin from the surface sources (ie., rainfall, agricultural return flow, etc.) is estimated to be 3,700 AFY. Agricultural and municipal and industrial extractions total approximately 5,800 AFY. The average annual subsurface outflow from the basin is estimated about 100 AFY through the underflow in the San Luis Obispo Creek channel deposits at Santa Fe Narrows. Water level contours indicate that the direction of water movement is in the direction of Basin 3-9 from Edna Valley. While sufficient data do not exist to state specifically what this quantity of inflow is, long-term records of water levels throughout the basin indicate that the basin has not been overdrafted. Therefore, the estimated inflow from Edna Valley coupled with seepage from stream flow and from treated effluent recharge is equal to annual extractions. Hence, the sustained yield of the basin presently is estimated at 5,900 AFY.

The City is currently extracting ground water at a rate of approximately 2,000 AFY. In doing so, a short-term overdraft of the basin is occurring. However, the City's pumping is serving to make greater use of the treated wastewater and has probably increased the amount of recharge associated with that source. Moreover, future use of the City wells as described in Section 5 is expected to increase the recharge to the basin (thus, increase ground water available for City consumption) by several thousand acre feet.

We conclude that the City can extract several thousand acre feet (approximately 2,000 to 3,000 AFY) of ground water annually if steps are taken to increase available recharge from the wastewater treatment plant and if the basin is properly managed to better utilize recharge from stream flow.

To better define this range, we recommend that existing or new monitoring wells be constructed and monitored as a significant aid in defining basin boundary flows. Also, stream gauges upstream and downstream of the City's wastewater treatment plant outfall should be installed and monitored to better define the benefits derived from that source of basin recharge.

Recommended Location of Additional Wells

Considering the extensive exploration (over 52 sites) and well construction program undertaken in the past two years and in light of remaining potential well sites on parcels owned by the City, we conclude that additional well construction within the City limits on City parcels is not recommended. We do recommend that the existing Mitchell Park well be re-designed for municipal use. This must be coordinated with the Parks & Recreation Department and with the Architectural Review Committee.

Other than areas within the corporate boundary, the hydrogeology of two areas near the City suggest a potential for relatively high yielding wells. One area lies to the south of the Airport and is near the boundary between Basin 3-9 and Edna Valley. The second area is along Lower Higuera Street near the southernmost Highway 101 interchange which is within Basin 3-9.

Both locations are likely to consist of a relatively thick layer of unconsolidated materials and may yield quantities in the order of 500 gpm. Exploration of these sites should include some initial exploratory methods (geophysics, etc.) followed by test well drilling, if appropriate. Other overriding issues will affect the development of a well field outside the City limits, such as negotiating with private land owners and the cost of transporting such water to the City. Although beyond the scope of this investigation, potential jurisdictional concerns must be addressed in the evaluation of any new source of supply.

We recommend that the City consider well field development in these two areas and proceed with a hydrogeologic exploratory program. If found to be promising, then the City should more carefully examine these water supply options as long-term supplies to the City.

Conjunctive Use

For current operations, we recommend that the City continue to maximize the yield from the existing wells and use surface water as needed to meet monthly demand. Both Basin 3-9 and Edna Valley have a history of relatively rapid water level recovery following years of below average rainfall and is expected to recover in the coming rainy seasons.

While stream flow is occurring in San Luis Obispo Creek and while Whale Rock and Salinas Reservoirs are recovering, continue to maximize use of the ground water basin. In doing so, higher priority will be given toward reservoir recovery as opposed to basin recharge. This is recommended since the basin yield is limited and unused water will flow out of the basin, principally as surface water, and not be put to beneficial use.

During years of "normal operation" when both the reservoirs and the basin are full to near-full, we recommend that the City use ground water supply in the winter months when stream flow is occurring in order to make use of the water that otherwise would run off into the ocean. Moderate use of wells in the summer would make better use of the two sources conjunctively. More detailed operational studies would be needed to more specifically outline an operational plan for the City. Also, the recently completed conjunctive use study would need to be amended to include ground water supply as a third variable in the operations of the City's two reservoirs.

There are many aspects to consider in comparing alternative water supply options which are outside the scope of this evaluation. However, the City should recognize that the yield from both surface reservoirs and ground water supply are "rainfall dependent" and are susceptible to drought impacts. For this reason, supplies not wholly dependent upon local rainfall patterns are desirable. State Water Project supply and desalination present such options.

Recommended Management Strategy

Presently, some stream flow and ground water leave the basin, and do not contribute to ground water recharge in the basin. That is, when water levels are high (ie., close to the ground surface), there is little storage space for recharge. Ground water basins such as Basin 3-9 must be adequately pumped in order to maximize recharge. Substantial ground water pumpage is possible during sufficient stream flow periods from alluvial deposits in areas near streams.

In addition, treated wastewater is a valuable source of water, one that could augment basin recharge or offset current agricultural extractions. Effluent could be treated and used directly for crop irrigation, lakes, and golf courses as permitted under current Department of Health Services regulations. On the other hand it could be recharged, either in percolation basins or in normally dry stream channels after some channel modifications, and subsequently pumped for reuse. The City's plans to move the outfall location approximately 3,500 feet upstream of its current location will increase the length over which stream infiltration may occur and is expected to benefit the basin.

Managing the ground water basin entails coordinating pumpage with surface water supplies so as to minimize stream flow losses to the ocean, as well as minimizing the ground water overdraft.

Problems with well interference can be minimized by siting new wells at an adequate distance from existing wells (approximately one-half mile or closer nearer to the creeks), and by conducting aquifer tests, so that drawdowns at various pumping rates can be predicted for new wells.

Recommendations for Actions by the City

The following recommendations are made relative to basin management and future well construction:

1. Adopt a policy to maximize ground water extractions during times when there is surface flow in the creeks.

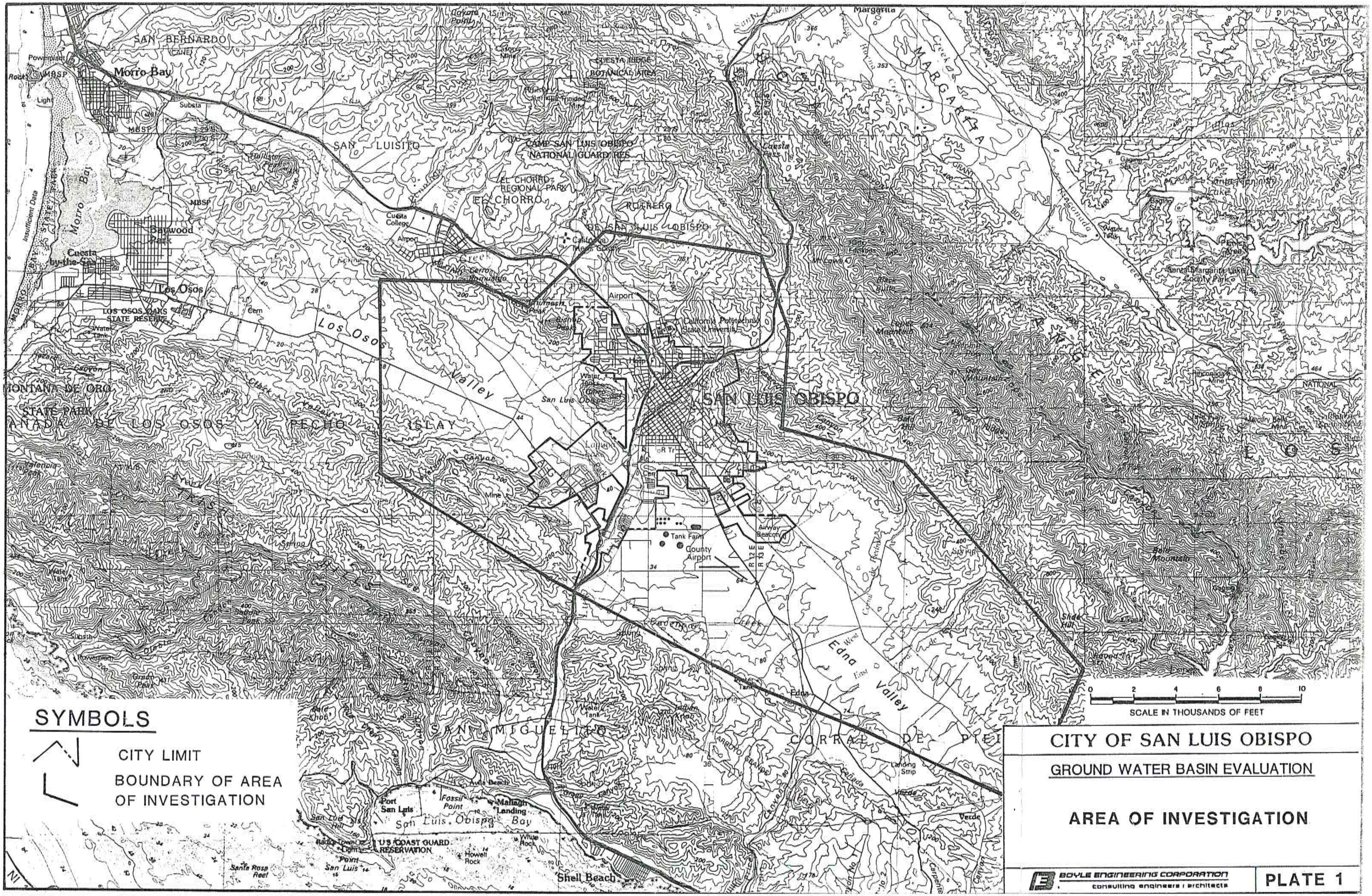
2. Formulate a plan to maximize the recharge available from the City's wastewater treatment plant, or implement a plan for beneficial use of the City's effluent. As a starting point, the amounts of seepage of sewage effluent from San Luis Obispo Creek should be measured. This could be done by installing and monitoring stream gauges upstream and downstream of the City's outfall.

3. When future wells are drilled, well efficiencies should be determined from constant-rate pump tests. Improved well construction procedures should be evaluated, including the use of reverse circulation rotary drilling (without using bentonite), use of appropriate gravel gradation and slot size based on a sieve analysis of drill cuttings, and improved well development procedures.

4. Static water levels should be measured at least on a quarterly basis in all City wells (active and unused) in order to provide more information regarding the basin yield and will yields.

5. The feasibility of utilizing surface geophysical surveys (electrical, gravity, or seismic) should be investigated to determine the thickness and nature of the alluvial materials at potential well sites.

6. Establish a program whereby existing or new wells would be monitored near the boundary with Subbasin 3-8 and at the Santa Fe Narrows. This monitoring data would aid in refining the estimates of boundary flows into and out of Basin 3-9.


SYMBOLS
CITY LIMIT
BOUNDARY OF AREA OF INVESTIGATION
0 2 4 6 8 10
SCALE IN THOUSANDS OF FEET
CITY OF SAN LUIS OBISPO
GROUND WATER BASIN EVALUATION
AREA OF INVESTIGATION
BOYLE ENGINEERING CORPORATION
consulting engineers / architects
PLATE 1
SAN LUIS OBISPO
Morro Bay
Los Osos
Baywood Park
Cuesta by-the-Sea
MONTANA DE ORO STATE PARK
LOS OSOS OAKS STATE RESERVE
SAN BERNARDO
SAN LUISITO
EL CHORRO
EL CHORRO REGIONAL PARK
CAMP SAN LUIS OBISPO NATIONAL GUARD RES
POTRERO DE SAN LUIS OBISPO
Los Osos Valley
ISLAY
California Polytechnic State University
Cuesta College
Airport
Tank Farm
County Airport
Edna Valley
Edna
SAN MIGUELITO
CORRAL DE PIE
Port San Luis
San Luis Obispo Bay
Avila Beach
U S COAST GUARD RESERVATION
Shell Beach
Margarita
Morro Bay
Cuesta Pass

Section 1

INTRODUCTION

1.1 Background and Objectives

Beginning in 1988, the City of San Luis Obispo began implementation of a ground water development program; the first use of well supply for domestic purposes since the 1940's. Today approximately 40% of the City's water demand is being met from wells. The largest producing wells (200 to 700 gallons per minute) are located in the southern end of the City known as the Lower Higuera Area.

In the past, the focus of the City's ground water development program had been to bring wells on-line as quickly as practical in order to ensure continuing supply during the current drought. The number of wells in operation today testifies to the success of this approach. Today the City recognizes the need to shift into a different phase of the program by performing the studies necessary to evaluate the ground water basin and to determine the sustained annual yield. DWR is currently investigating Basin 3-9 and is developing an estimate of sustained yield, however, the timing of this study is such that results are not likely to be released until sometime in late 1991 or after. Due to this unacceptable time frame, the City contracted with Boyle Engineering Corporation to prepare this evaluation of the ground water basin.

The objectives of this evaluation are to define the basin boundary, define the geology of the basin, interpret available data regarding the movement of water within the basin, and discuss the City's current ground water development program. This evaluation is also intended to identify further opportunities for ground water development and to estimate the sustained yield of the basin. Environmental impacts associated with short-term overdraft of the basin are also discussed.

The area of investigation comprises all of the area within the corporate boundary of the City of San Luis Obispo (City) and the outlying areas that comprise the basin. Thus, the area analyzed extends southeast into Edna Valley as well. **Plate 1** shows the area of investigation and the City's corporate limits.

The San Luis Obispo Ground Water Basin has been identified and defined by the California Department of Water Resources (DWR) as Basin 3-9. The southwest boundary of Basin 3-9 is the northwest boundary of the adjacent Edna Basin. DWR Bulletin 118, published in 1975, provides baseline information for Basin 3-9. Much of the information provided was derived from data presented in DWR Bulletin 18, published in 1958. Data developed during the current investigation modify and update much of the data presented in Bulletin 18. This investigation, for example, concludes that the annual basin recharge (not accounting for inflow from Edna Valley) is on the order of 3,700 AFY, whereas, DWR estimated recharge to be 2,250 AFY. This accounts for a large part of the difference between the current estimate of sustained yield and that of DWR in 1958.

1.2 Current Ground Water Supply to the City

The City currently operates six municipal wells. These are identified as the Auto Park, Dalidio, Pacific Beach #1 and #2, Calle Joaquin, and the Fire Station No. 4 wells. Of these, five wells are owned by the City. The sixth, the Dalidio well, is leased from a private property owner for use during the current drought.

In addition to these wells, the City operates two irrigation wells, one at the Laguna Lake Municipal Golf Course and one at Mitchell Park. **Table 1** shows the amount of water extracted from the municipal wells since the time each was brought on-line. The City is currently utilizing ground water at a rate of approximately 2,000 AFY.

1.3 Data Collection Program

Existing records such as well logs, previous studies, DWR records, etc. were referenced in defining the basin and in preparing estimates of water balance within the basin.

Requests for well information were distributed to DWR, the County of San Luis Obispo, and to area drillers. A total of 371 well driller's logs for sites within the San Luis Obispo Basin and Edna Valley area were gathered in the course of this investigation. Due to the confidential nature of these logs, individual well logs have not been identified here and are not available for inspection by the general public.[1] Several wells were field-located with the assistance of County Engineering Department personnel and DWR staff. Existing records were utilized and additional exploratory drilling was not performed specifically for the purposes of this investigation.

In addition to existing well driller's logs, area water purveyors were contacted to estimate their annual basin extractions. Further, the County Agriculture Commission prepared a detailed map of irrigated parcels throughout the basin. This information was used to estimate irrigation demand and evapotranspiration rates throughout the study area.

Stream gauge records for stations along the San Luis Obispo and Stenner Creeks, as maintained by the County of San Luis Obispo Hydraulics Division, were referenced as an aid in determining annual basin recharge. Long-term rainfall records at the closest gauge station were also obtained.

The bulk of this data was used to define the basin geology and hydrogeology and to conduct the water balance for the basin.

---

1 California Water Code Section 13752.

Table 1

CITY WELL SUPPLY 1989-1990

DATE	T'MENT PLANT SUPPLY** AC-FT	DOMESTIC WELL FLOW DATA, (AC-FT)* (DATE OPERATIONAL) FS #4 (4-18-89)	PB #1 (4-28-89)	FIRING RN (9-5-89)	DALIDIO (9-10-89)	AUTO PARK (10-17-89	DENNY'S (4-20-90)	PB #2 (5-16-90)	MONTHLY GW TOTALS	% GW SUPPLY
1/89	535.62	-	-	-	-	-	-	-	0	%.00
2/89	481.32	-	-	-	-	-	-	-	0	%.00
3/89	513.09	-	-	-	-	-	-	-	0	%.00
4/89	576.03	5.36	3.36	-	-	-	-	-	8.72	%1.49
5/89	521.5	11.35	33.18	-	-	-	-	-	44.53	%7.87
6/89	501.53	12.06	31.61	-	-	-	-	-	43.67	%8.01
7/89	511.7	12.55	26.09	-	-	-	-	-	38.64	%7.02
8/89	468.05	11.94	27.17	-	-	-	-	-	39.11	%7.71
9/89	391.37	10.07	22.31	4.88	29.44	-	-	-	66.7	%14.56
10/89	333.34	10.48	27.38	.19	62.69	10.14	-	-	110.88	%24.96
11/89	329.31	.46	.36	0	65.5	4.2	-	-	70.52	%17.64
12/89	290.31	0	0	0	56.04	0	-	-	56.04	%16.18
1/90	299.49	3.49	6.42	.75	55.41	0	-	-	66.07	%18.07
2/90	186.71	6	11.25	4.58	54.98	81.07	-	-	157.88	%45.82
3/90	196.29	7.83	15.93	5.42	69.56	93.54	-	-	192.28	%49.48
4/90	221.29	12.03	38.96	4.86	64.06	88.59	8.95	-	217.45	%49.56
5/90	247.05	10.3	30.86	0	29.78	85.82	26.78	11.21	194.75	%44.08
6/90	239.13	7.56	20.64	0	9.91	83.9	26.31	22.72	171.04	%41.70
7/90	242.56	6.55	21.5	0	30.39	83.37	27.61	22.94	192.36	%44.23
8/90	260.9	5.71	20.48	0	29.62	82.13	26.93	19.11	183.98	%41.35
9/90	250.36	4.62	20.4	0	19.56	83.98	24.99	2.98	156.53	%38.47
10/90	271.9	4.98	24.9	0	15.05	84.87	25.45	0	155.25	%36.35
11/90	233.02	4.32	21.23	0	8.96	81.92	25.37	0	141.8	%37.83
12/90	191.81	4.4	3.55	0	9.71	82.77	25.57	0	126	%39.65
1/91	217.39	5.74	0	0	10.16	74.47	25.88	0	116.25	%34.84

** Source: Mr. Ken Earing's Monthly Statistical Reports of Treatment Plant Operations.*
*** Supply to the City of San Luis Obispo only.*

In addition to this, records of pump tests and well efficiency tests were researched to better define the movement of water throughout the basin. The local office of Pacific Gas & Electric Co. assisted in researching well efficiency tests dating back to 1985. Of 80 tests conducted in the vicinity only 19 were found to be valid for the purposes of this investigation (ie. the well site could be correlated with a known State Well Number, a full set of test data was provided, well lies within the basin, etc.). Sufficient data from other sources was uncovered to reasonably conduct this aspect of the evaluation.

1.4 Previous Relevant Publications

Foremost of the relevant studies and publications referenced in the course of this investigation is the current DWR basin investigation on the subsurface geology and hydrology of Basin 3-9. Close contact has been maintained with DWR staff to coordinate various phases of this investigation with that of DWR.

With regard to completed work, the earliest definitive work on the water resources of the San Luis Obispo area was Bulletin No 18, published by DWR in 1958. This bulletin discussed the ground water and surface water supply, water utilization, and water requirements for all of San Luis Obispo County and presented alternative plans for water supply development. In 1975, DWR published Bulletin No. 118, which identified the extent of the San Luis Obispo Ground Water Basin, designated it as Basin 3-9, and also identified an area of contiguous ground water terrane in Edna Valley. In 1980, DWR Bulletin 118-80 also showed the same ground water basin and contiguous ground water terrane. Basin 3-9 and the Edna Valley terrane are considered to act as a single ground water basin and therefore have been analyzed as such in this investigation. A key element of the estimate of sustained yield prepared as part of this study is the estimate of underflow entering Basin 3-9 from Edna Valley.

In 1986, the DWR Southern District issued two reports dealing with the ground water resources of the San Luis Obispo area. The first dealt with water demand, water supply, and supplemental water needed, while the second was an update of the County's master water plan.

In 1973, the California Division of Mines and Geology published a detailed geologic map of the Arroyo Grande 15-minute quadrangle. The map includes part of the San Luis Obispo Ground Water Basin as well as all of Edna Valley. In 1979, the U.S. Geological Survey (USGS) published a companion map which extended from the north side of the California Division of Mines and Geology map north and west beyond Morro Bay.

Also referenced in the course of this investigation were the 1988 John L. Wallace and Associates reports which were prepared in association with Timothy S. Cleath, Geologist. These reports for the City described ground water properties underlying the City and documented the construction of five test wells and five borings.

In addition to studies in the San Luis Obispo Ground Water Basin, a number of studies by DWR and USGS also have been performed in the adjacent Los Osos Valley Ground

Water Basin. Information contained in the DWR and USGS reports provide insight to hydrogeologic conditions in the area of the common boundary between the two ground water basins.

A bibliographic listing of all of these maps, bulletins, and reports is provided as **Appendix A** to this report.

Section 2

HYDROGEOLOGIC SETTING

2.1 Physiographic Setting and Drainage

The City of San Luis Obispo is located along San Luis Obispo Creek and most of the City lies within the boundary of the San Luis Obispo Basin. A bench mark in the downtown area shows an average elevation of 200 feet and the corporate limit of the City ranges from an elevation of about 120 feet up to about 800 feet. The northwestern portion of the San Luis Obispo Basin is drained by Prefumo Creek, a major tributary to San Luis Obispo Creek, and by Stenner Creek. Laguna Lake is located along Prefumo Creek at an average elevation of 118 feet. (Refer to **Plate 1**.)

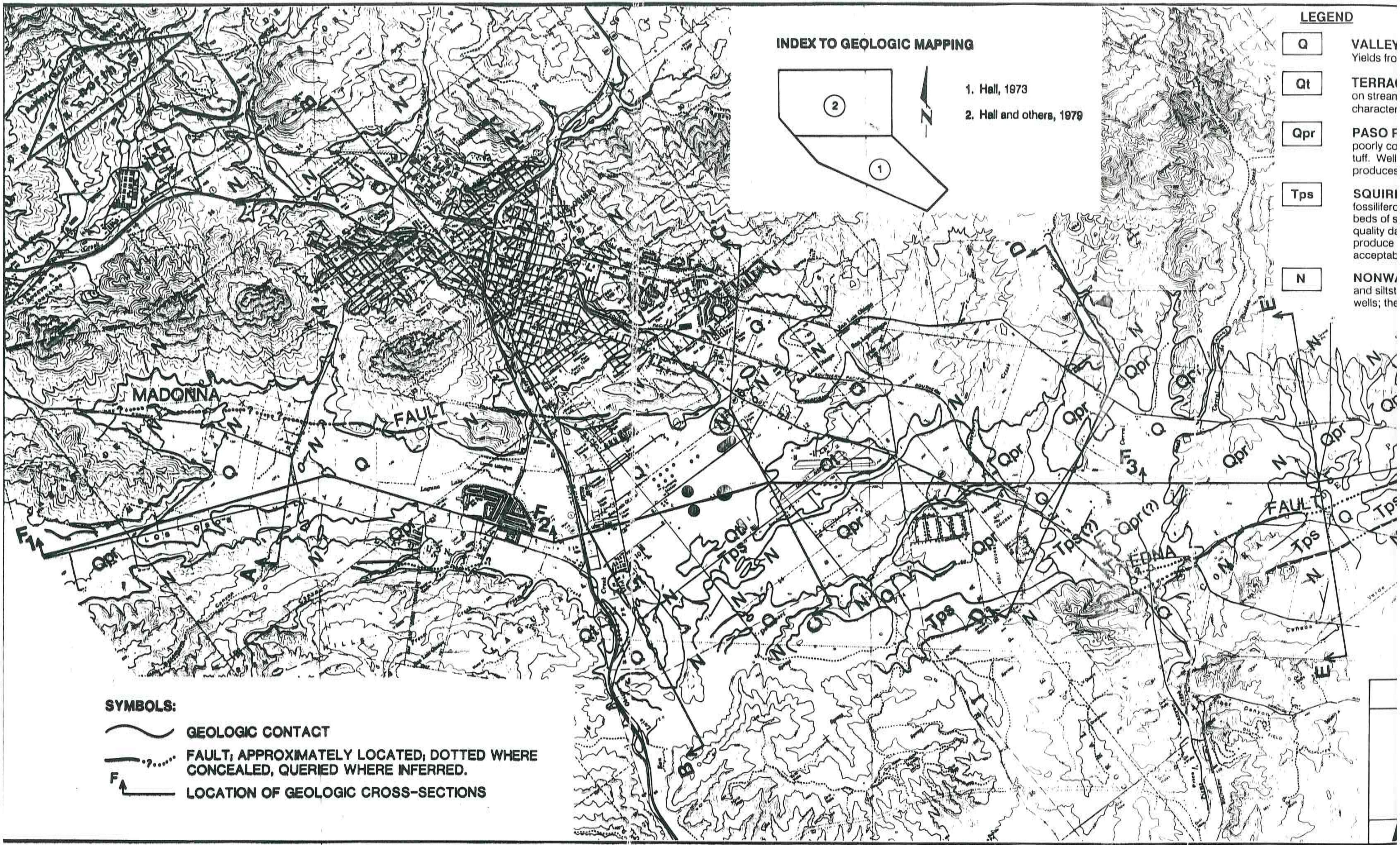
To the south of the San Luis Obispo County Airport where the floor of the basin rises, the area is locally known as Edna Valley. This undulating terrain rises in a southward direction from an elevation of from 120 to 200 feet at the southern boundary of the San Luis Obispo Basin to an elevation of over 700 feet along the eastern boundary of the valley. The southern half of Edna Valley is tributary to Pismo Creek. Most of the remainder is tributary to Davenport Creek, which enters San Luis Obispo Creek about one-half mile south of the boundary of the San Luis Obispo Basin.

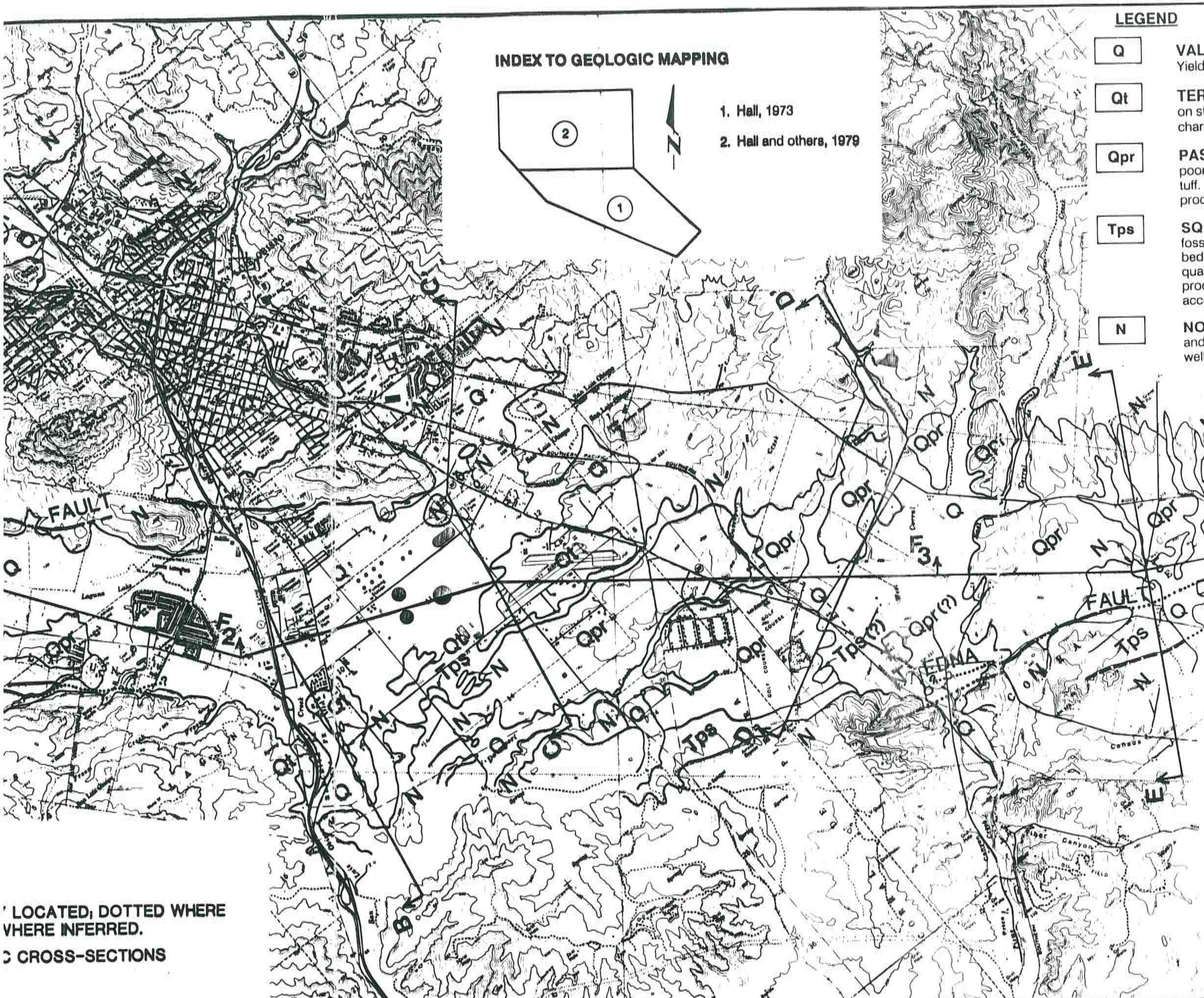
2.2 Geologic Formations and Their Water-Bearing Properties

The various geologic formations of the San Luis Obispo area may be divided into two basic groups for the purpose of ground water studies. Consolidated rocks, which range in composition from marine sediments to volcanic rocks and serpentine, are considered generally to be nonwater-bearing. These rocks produce relatively small quantities of water to wells and springs.

By far the most important hydrogeologic materials in the valley portion of the San Luis Obispo Basin are the sedimentary or "basin fill" deposits. These consist of a sequence of unconsolidated alluvium and older alluvial deposits ranging in composition from sand and gravel to silt and clay. Also included as a part of the basin fill deposits are certain older beds of fossiliferous sandstone. Nearly all of the water wells in the San Luis Obispo - Edna Valley area derive their supply from these deposits.

The consolidated rocks of the nonwater-bearing series and the sedimentary deposits of the water-bearing series are briefly described below. The outcrops of the consolidated rocks as well as the surficial extent of the various units of the sedimentary deposits are depicted on **Plate 2**. Note that **Plate 2** includes the locations of the geologic cross sections which are illustrated in **Plate 3**.


INDEX TO GEOLOGIC MAPPING
1. Hall, 1973
2. Hall and others, 1979
LEGEND
Q
VALLEY
Yields fro
Qt
TERRA
on strean
character
Qpr
PASO F
poorly co
tuff. Well
produces
Tps
SQUIRI
fossilifero
beds of s
quality da
produce
acceptab
N
NONWA
and siltst
wells; the
MADONNA
FAULT
EDNA
SYMBOLS:
GEOLOGIC CONTACT
FAULT; APPROXIMATELY LOCATED; DOTTED WHERE CONCEALED, QUERIED WHERE INFERRED.
LOCATION OF GEOLOGIC CROSS-SECTIONS



LEGEND

Q	**VALLEY ALLUVIUM** Unconsolidated clay, silt, sand, and gravel. Yields from 20 to 300 gpm of generally excellent quality water to wells.
Qt	**TERRACE DEPOSITS** Unconsolidated sand, silt, and gravels; located on stream terraces. Low yields (at most 20 gpm) and poor quality water characterize wells tapping these deposits.
Qpr	**PASO ROBLES FORMATION** Poorly sorted, unconsolidated to poorly consolidated conglomerate, sandstone, siltstone, claystone and tuff. Well yields are variable, ranging up to at least 200 gpm. Generally produces an excellent quality water.
Tps	**SQUIRE MEMBER OF THE PISMO FORMATION** White fossiliferous sandstone, claystone, siltstone, and conglomerate. Contains beds of shells and zones of tar sands. Well production data and water quality data are lacking, but properly - designed wells should be able to produce at least 300 gpm; the quality of produced water should be acceptable for most beneficial purposes.
N	**NONWATER - BEARING SERIES** Marine sandstone, claystone, and siltstone; volcanic rocks; serpentine. Will produce at most 10 gpm to wells; the quality of water ranges from good to poor.

CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

AREAL GEOLOGY AND LOCATION OF GEOLOGIC SECTIONS

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PLATE 2

2.2.1 Nonwater-Bearing Series

Consolidated rocks of the nonwater-bearing series are exposed in the Santa Lucia Range, in the San Luis Range, and at peaks adjacent to the valley such as Bishop Peak. These rocks underlie the sedimentary deposits at depths from less than 50 feet to as much as 500 feet near the San Luis Obispo Country Club. These rocks mark the lower limit of dependable ground water production in the San Luis Obispo Basin.

Small promontories of various types of consolidated rocks protrude through the floor of Basin 3-9 and also through the floor of Edna Valley. Further, in the vicinity of the County Airport there is only a thin cover of sedimentary deposits overlying consolidated rocks. For example, rock was encountered at a depth of 19 feet near the west end of the east-west runway during the construction of a water well.

The nonwater-bearing series is composed of a variety of marine sandstone, claystone, and siltstone, and also of volcanic rocks and serpentine. Ground water contained in these rocks exists largely in fractures, joints, shear zones and faults. These rocks usually provide only small quantities of ground water to wells.

2.2.2 Water-Bearing Series

The sediments comprising the water-bearing series are present as beds of unconsolidated to semi-consolidated clay, silt, sand, and gravel and also poorly consolidated fossiliferous sandstone. The materials comprising this series can be grouped into four geologic units: 1) Squire Member of the Pismo Formation, 2) Paso Robles Formation, 3) Terrace Deposits, and 4) Valley Alluvium. The areal extent of these materials is shown on **Plate 2**. A brief description of each of these units is presented below.

Squire Member of the Pismo Formation

The oldest geologic unit of importance to ground water in the San Luis Obispo area is the Pismo Formation. It is generally of marine origin, consisting of claystone, siltstone, sandstone, and conglomerate, and is estimated to be at least 2,500 feet thick. The uppermost member yields potable water to wells and is described as a massive white medium to coarse grained fossiliferous sandstone and pebble conglomerate. It has been named the Squire Member and has a maximum stratigraphic thickness of 550 feet, although its thickness in the study area probably ranges from 30 to 100 feet. It has been included in the water bearing series based on the number of water wells in Edna Valley and elsewhere which tap white sands, sandstone with shells, and bituminous sands. The Squire Member is exposed along the western side of Edna Valley. Northwest of the town of Edna, its outcrop ranges from 500 to 1,500 feet in width. The Member rests on older marine sediments of the Pismo

Formation that presumably contain unusable saline water. The Member dips gently northeasterly beneath a cover of younger Paso Robles sediments.

The subsurface extent of the Squire Member is not definitely known. It crops out in a small area along an unnamed creek to the west of the County Airport. Twenty-three wells apparently have penetrated this Member and draw their water from it. One well, 31S/12E-10D01, is located on Calle Joaquin near the intersection of Los Osos Valley Road and Highway 101. It was drilled for the City in August 1989 and bottomed at a depth of 180 feet in red shale, presumably belonging to the non-water bearing series. Between the depths of 155 and 172 feet, the log indicates "seashells, gravel, and sand"; this log notation is interpreted to refer to sediments belonging to the Squire Member. The well was perforated in shallow alluvial deposits (50-90 feet) as well as in the Squire Member (150-170 feet). This well was pump tested at 200 gpm. The reported depth to standing water at the time of well completion was 8 feet.

A second well believed to have penetrated the Squire Member is San Luis Obispo Golf Course Well No. 7. Confidential well data indicates that this well bottomed in hard blue shale after passing through 150 feet of white to blue sandstone. No well construction, depth to water, well yield, or water quality data are available for this well.

A third well, which also is near the golf course well, also bottomed in hard shale after passing through 75 feet of coarse to fine sand. The well was perforated in the sand interval, but no depth to water, well yield, or water quality data are available. Most of the remaining wells which presumably tap the Squire Member are located in Edna Valley, to the southeast of San Luis Obispo Country Club.

Paso Robles Formation

The Paso Robles Formation is the next youngest water-bearing unit. It generally is composed of poorly sorted, unconsolidated to poorly consolidated conglomerate, sandstone, siltstone, claystone, and beds of tuff. It is of unknown thickness and rests upon a variety of older geologic materials including those of the Squire Member. The formation was deposited on a gently sloping, northwesterly trending floodplain. Subsequent to deposition, the formation was uplifted, faulted, and eroded.

The Paso Robles Formation is exposed throughout Edna Valley, except along stream tributaries and the topographic depression in the vicinity of the community of Edna, where it is overlain by valley alluvium. The Paso Robles Formation also is exposed along the lower elevations of the Irish

Hills, to the west of Laguna Lake. The Formation forms the topographic divide between the Laguna Lake portion of Los Osos Valley and its westward extension to Morro Bay. It also is exposed at the base of the unnamed hills on the north side of the Laguna Lake portion of Los Osos Valley.

Because of an inability to positively identify Paso Robles sediments on water well logs, the subsurface extent of the formation is not positively known. However, it is presumed to underlie much of the valley extending from northwest of Laguna Lake southeasterly to the alluvium/Paso Robles Formation contact.

Fifty-one wells are known, or suspected to tap the Paso Robles Formation and obtain their supplies from it; most of these wells are located to the south of County Airport. However, two of these wells were constructed for the City near the Pacific Beach School in 1988. Both wells were air-lifted at 200 gpm.

Terrace Deposits

Four areas of terrace deposits are shown on Plate 1. The largest terrace is in the area of the County Airport; the other three extend westward therefrom to San Luis Obispo Creek. These deposits consist of unconsolidated sand, silt, and gravel, and they were deposited by San Luis Obispo Creek and other streams. The log of a well at the airport indicates that the terrace deposits at this location are less than 20 feet thick; they are underlain by consolidated rocks. Other terraces are underlain by sedimentary deposits or consolidated rocks. The thickness of these other terrace deposits is not known but is probably at most 50 feet.

Data are available for five wells that apparently draw their supplies from the terrace deposits. The wells are not good producers of water, yielding at most 20 gpm. The low yields may be due to a high proportion of clays in the terrace deposits coupled with poor well design.

Valley Alluvium

The youngest unit of the water-bearing series is the valley alluvium. It consists of unconsolidated, stream deposited clay, silt, sand, and gravel, and occurs in the lowest areas of the San Luis Obispo Basin, such as in the vicinity of Laguna Lake, along San Luis Obispo Creek, and along other drainageways. Valley alluvium also occurs along Davenport Creek, East and West Corral de Piedra Creek, and other streams in Edna Valley. The valley alluvium ranges in thickness from only a few feet to probably about 50 feet. It overlies consolidated rocks and sedimentary deposits.

In the subsurface at certain locations, the valley alluvium contains sinuous buried stream channel deposits. Where tapped, these deposits of coarse sand and gravel can provide moderate quantities of ground water to wells.

Data from 25 wells indicate that the valley alluvium yields from 20 to 300 gpm. A lack of suitable pump test data precludes any further appraisal of the water-yielding capability of the valley alluvium.

2.2 Geologic Structure

The principal geologic structural feature of importance to ground water in the San Luis Obispo Basin is the Edna Fault. This feature was identified as extending from southeast of Edna Valley to a point near the community of Edna. The fault has not been traced in a northwesterly direction, but it may be related to an unidentified fault near Davenport Creek.

To the southeast, the movement along the Edna Fault has brought the Paso Robles Formation into contact with rocks of the non-water-bearing series. In this area, the fault forms the western limit of the contiguous ground water terrain, as shown on **Plate 2**. The fault also locally cuts sediments of the Squire Member as well as valley alluvium. To the northwest of Edna, an unidentified fault also cuts the valley alluvium of Davenport Creek.

Available water level and other data indicate no effect of faults on the movement or quality of ground water.

2.3 Subsurface Geology

Although the valley floor of Basin 3-9 is fairly level and the Edna Valley area is characterized by rolling topography, the subsurface features of the entire area are made up of several now buried, rugged erosional surfaces.

The base of the San Luis Obispo Ground Water Basin is composed of consolidated rocks of the nonwater-bearing series. The upper surface of these rocks, which is concealed by later deposition, is highly irregular, having been shaped by erosion during the long geologic period of time that these rocks were exposed to the sea and the atmosphere. Such irregular topography was made further complicated by movement along numerous faults. Such irregular topography was further complicated by movement along numerous faults. A clue to the nature of this rugged surface can be seen by the isolated hills near the City, as for example Bishop Peak, and the sporadic outcropping of rocks of the non-water bearing series found within the valley floor area. Such outcroppings are identified on **Plate 2**; the nature of this rugged subsurface expression can be seen on the geologic sections, **Plate 3**, sheets 1 through 8.

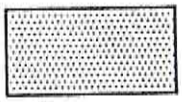
Many of the canyon and valley areas that were formed in the consolidated rocks subsequently became the scene of deposition of sands belonging to the Squire Member. That much of this deposition took place under near-shore marine conditions is shown by the numerous reports of "shells" and "sea life" on logs from water wells topping this member. After deposition of the Squire Member, a period of erosion and faulting ensued leaving a number of discrete areas mantled by sediments of the Squire Member. These areas are illustrated in profile on the various geologic sections.

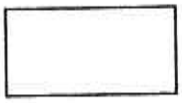
After another period of erosion, deposition of clays and gravels belonging to the Paso Robles Formation began. This Formation apparently was deposited on a northwesterly trending, sloping trough that was bordered by the sea. A thickness of several hundred feet of Paso Robles sediments accumulated in the trough by the close of the period of deposition. Again, the entire area was subjected to the forces of erosion and there probably also was continued tectonic activity. The various zones of Paso Robles sediments are illustrated in profile on the various geologic sections.

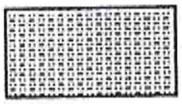
The present drainage systems were established after the close of Paso Robles deposition. San Luis Obispo Creek and its tributaries, formed the surficial features of the ground water basin. This drainage system also formed the various terraces, as well as deposited the veneer of alluvial materials seen along Stenner Creek, other streams and in the vicinity of Laguna Lake. This veneer, which consists of sandy clay with discontinuous lenses of sandy gravel, is illustrated on the geologic sections.

LEGEND FOR GEOLOGIC SECTIONS

WATER-BEARING SERIES


SAND, GRAVEL, SAND & GRAVEL, CLAY & GRAVEL

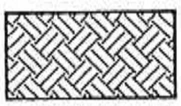

CLAY, SILT


SHELL BED


WHITE SAND, SANDY CLAY


TAR SAND

NONWATER-BEARING SERIES

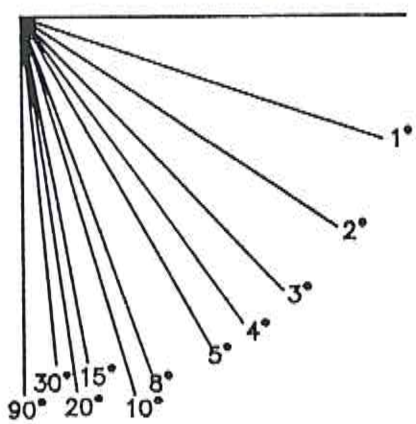


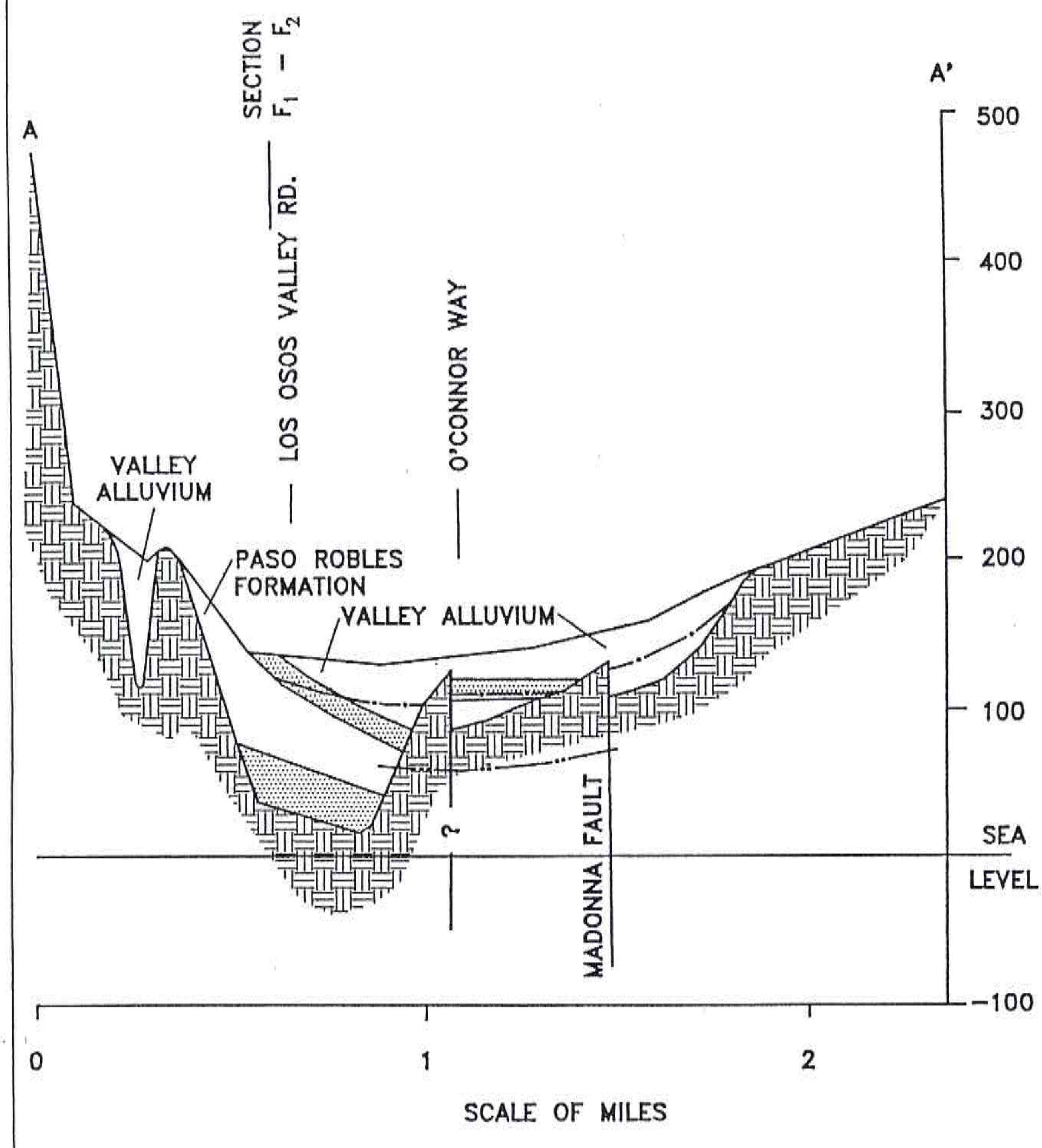
SYMBOLS

—— · ———— · —— PRINCIPAL WATER LEVEL

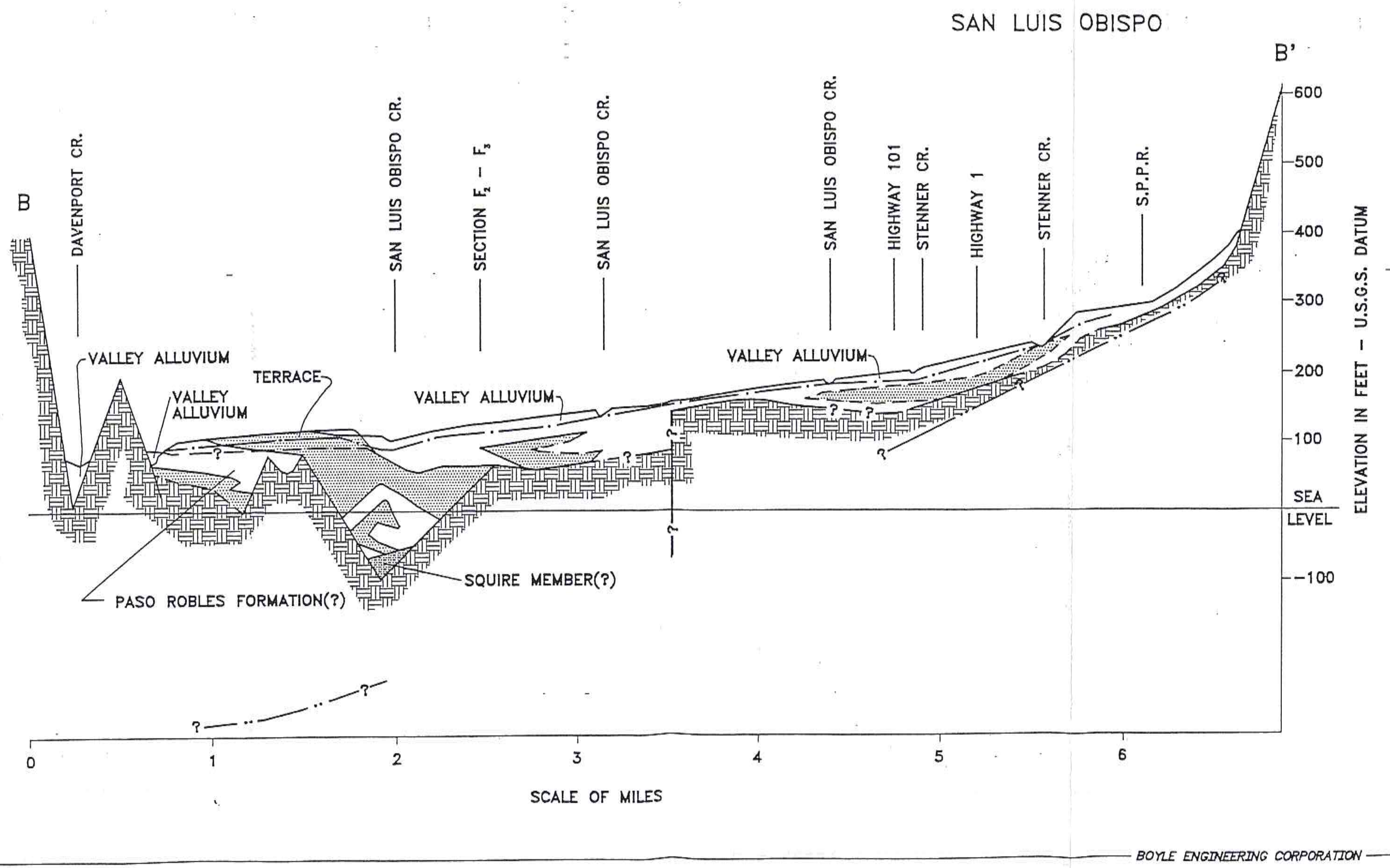
—— · · ———— · · —— DEEP WATER LEVEL(S)

NOTE – Geologic sections are presented at a 20:1 vertical to horizontal exaggeration. The following diagram shows degrees of dip at this exaggeration.

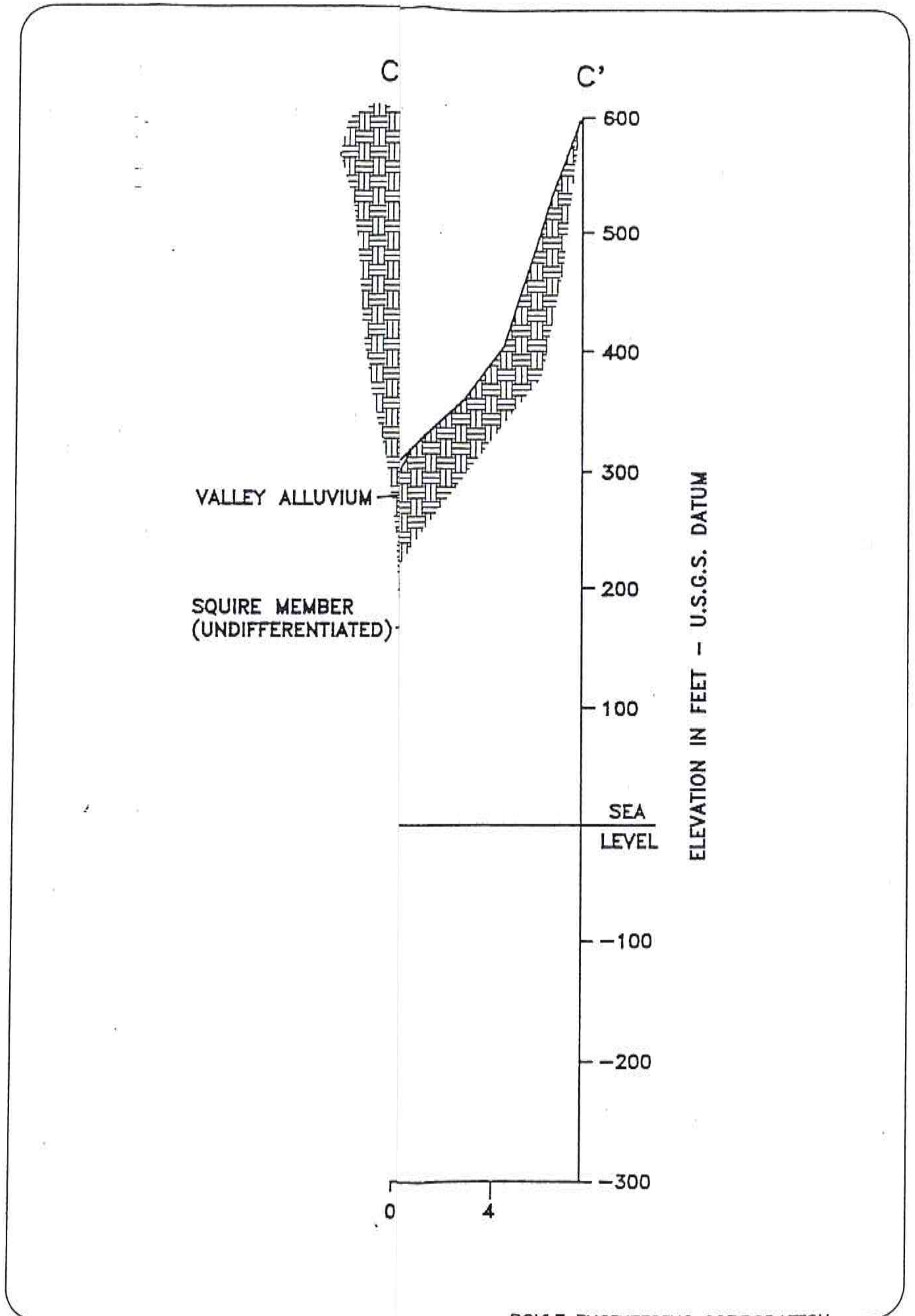


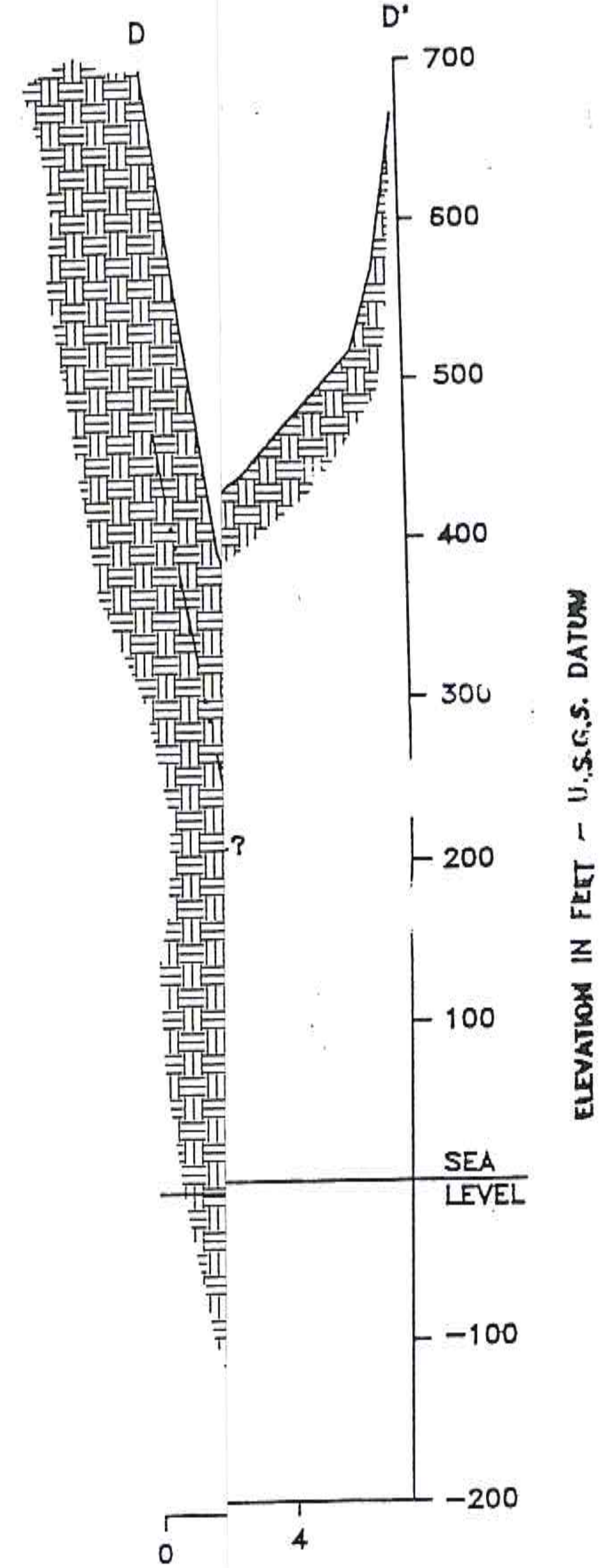


A
A'
SECTION F1 – F2
LOS OSOS VALLEY RD.
O'CONNOR WAY
VALLEY ALLUVIUM
PASO ROBLES FORMATION
VALLEY ALLUVIUM
?
MADONNA FAULT
SEA LEVEL
500
400
300
200
100
−100
ELEVATION IN FEET – U.S.G.S. DATUM
0
1
2
SCALE OF MILES

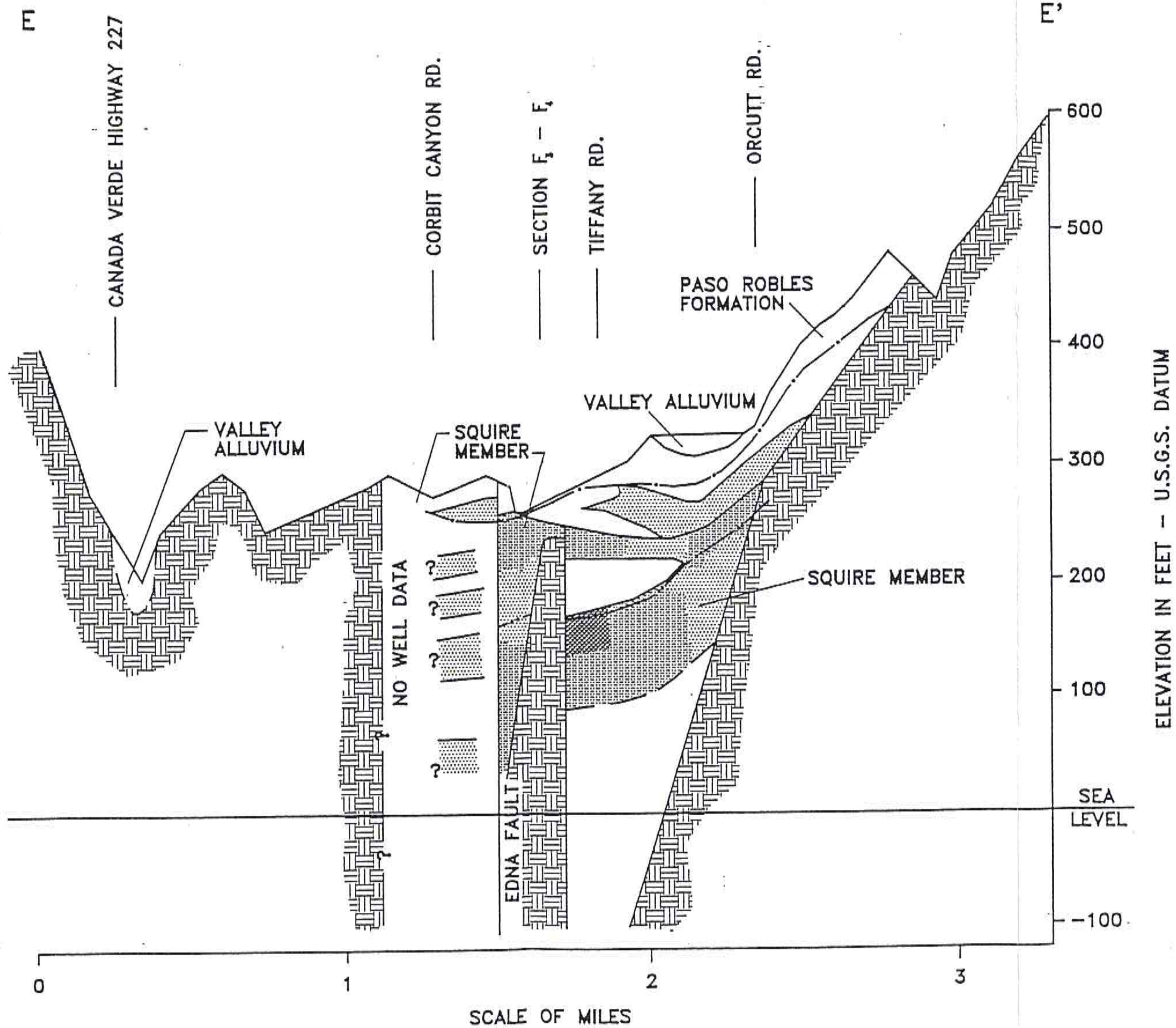


SAN LUIS OBISPO
B
B'
DAVENPORT CR.
SAN LUIS OBISPO CR.
SECTION F2 - F3
SAN LUIS OBISPO CR.
SAN LUIS OBISPO CR.
HIGHWAY 101
STENNER CR.
HIGHWAY 1
STENNER CR.
S.P.P.R.
VALLEY ALLUVIUM
TERRACE
VALLEY ALLUVIUM
VALLEY ALLUVIUM
VALLEY ALLUVIUM
SQUIRE MEMBER(?)
PASO ROBLES FORMATION(?)
600
500
400
300
200
100
SEA LEVEL
-100
ELEVATION IN FEET - U.S.G.S. DATUM
0
1
2
3
4
5
6
SCALE OF MILES
BOYLE ENGINEERING CORPORATION

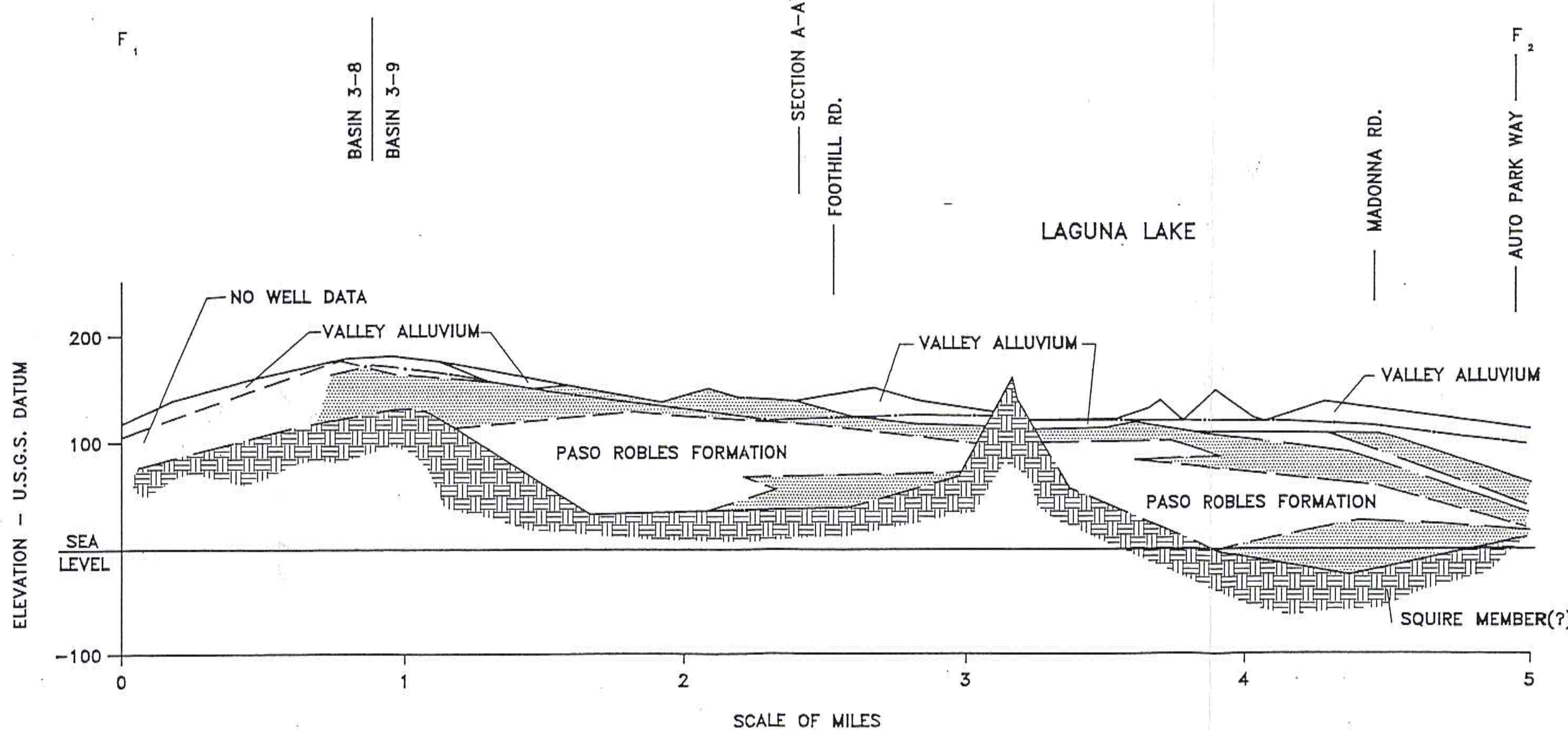

C
C'
600
500
400
300
200
100
SEA
LEVEL
-100
-200
-300
0
4
VALLEY ALLUVIUM
SQUIRE MEMBER
(UNDIFFERENTIATED)
ELEVATION IN FEET - U.S.G.S. DATUM
BOYLE ENGINEERING CORPORATION



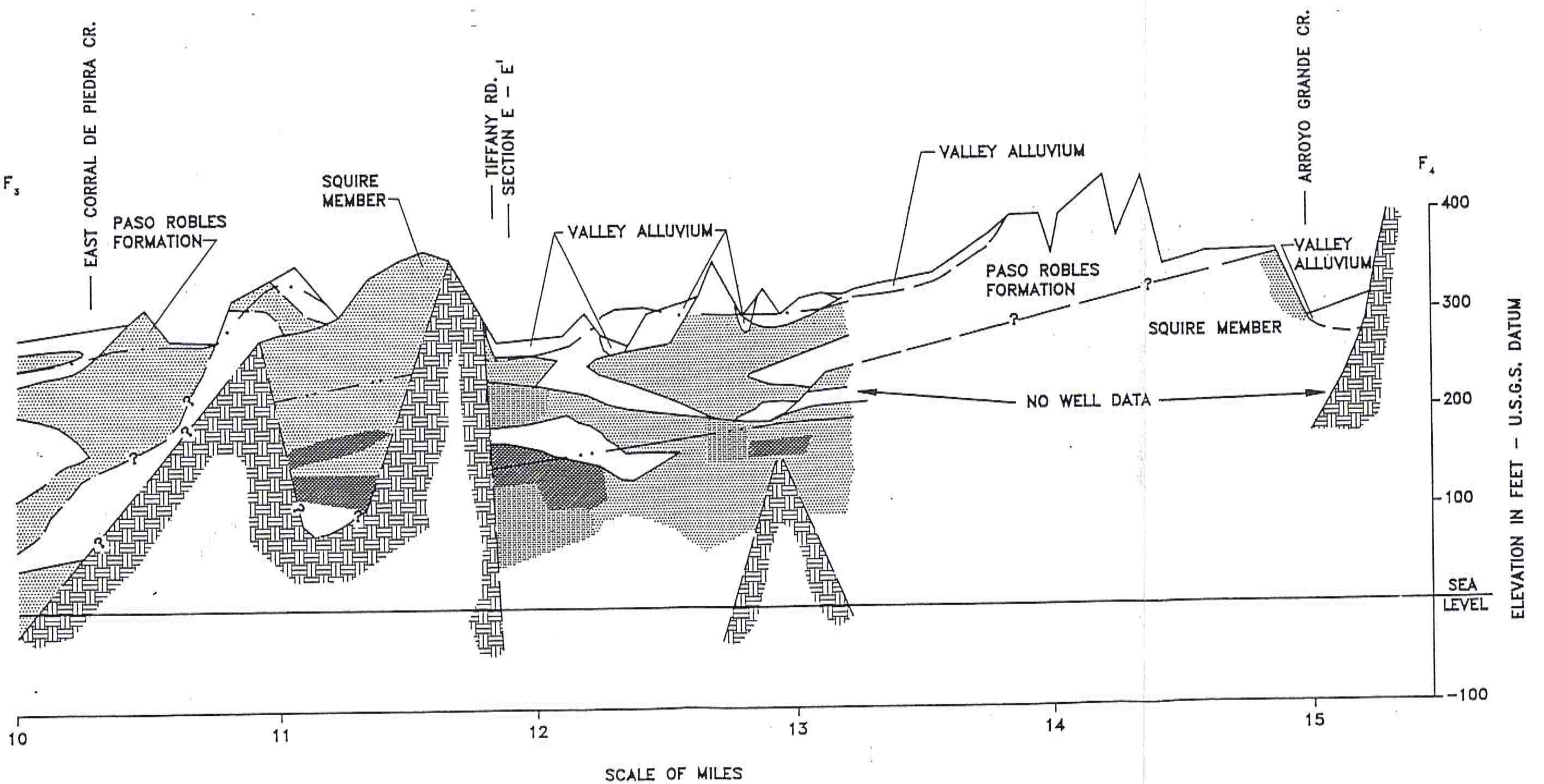
BOYLE ENGINEERING CORPORATION



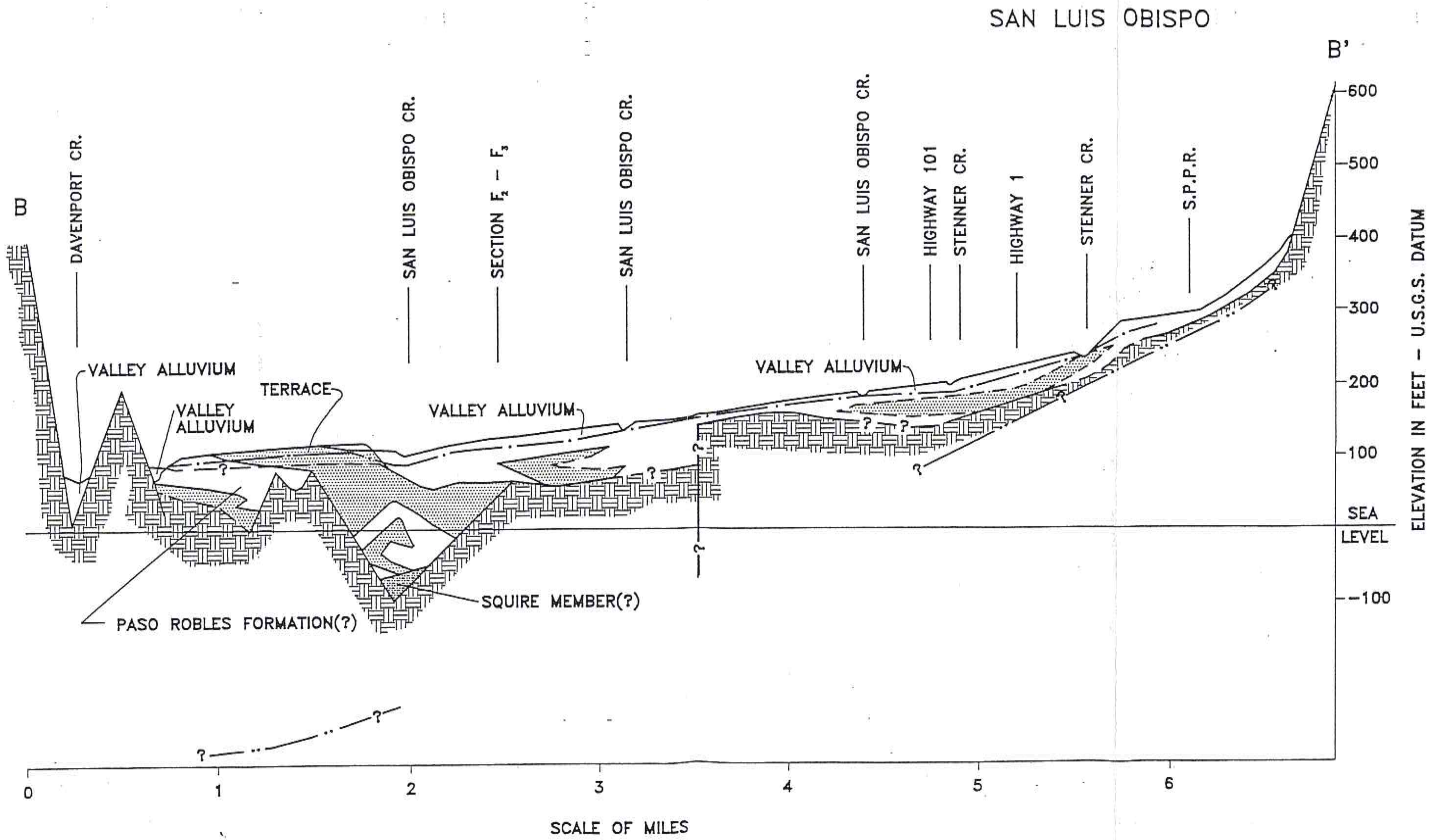
BOYLE ENGINEERING CORPORATION



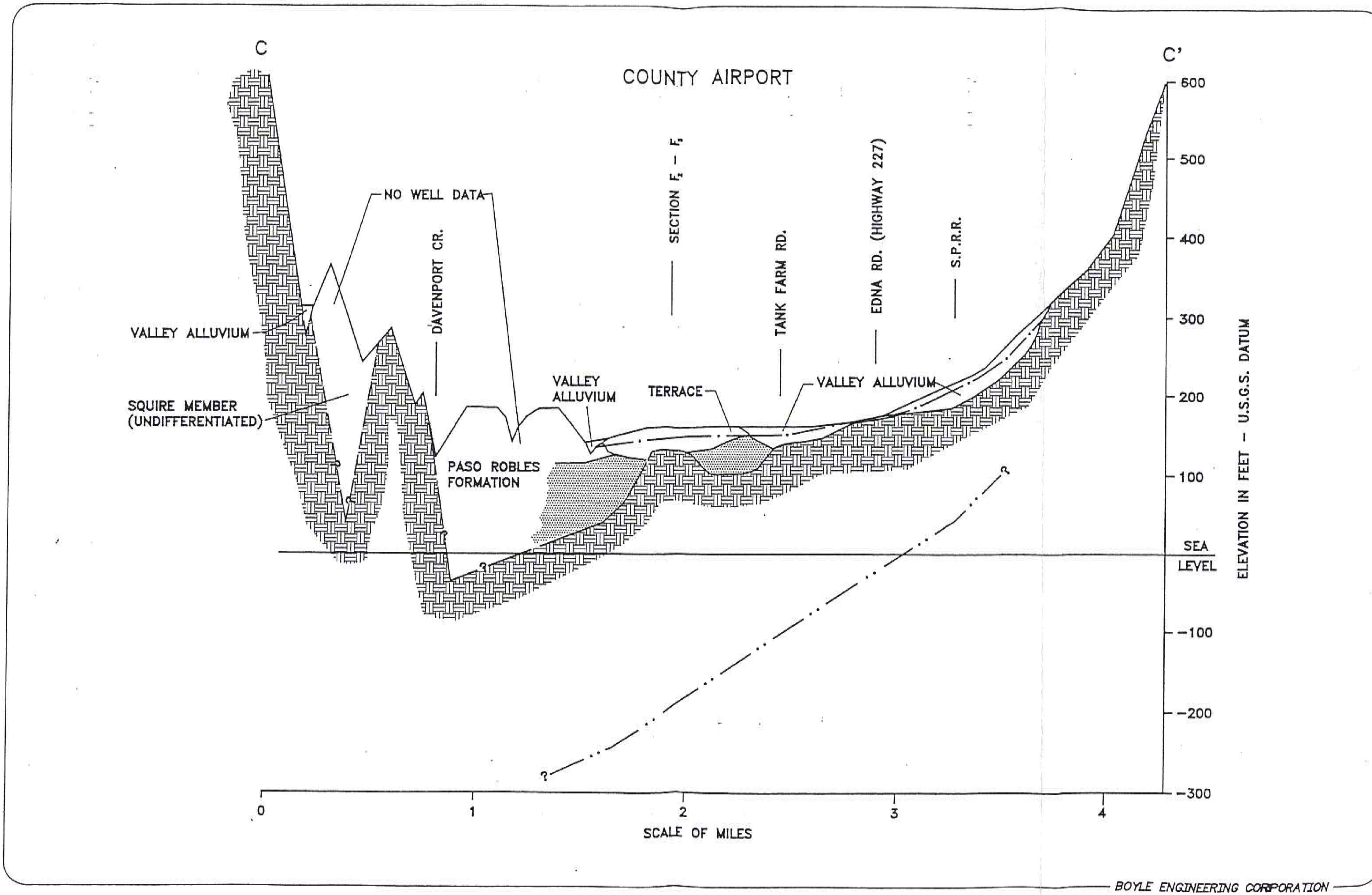
BOYLE ENGINEERING CORPORATION

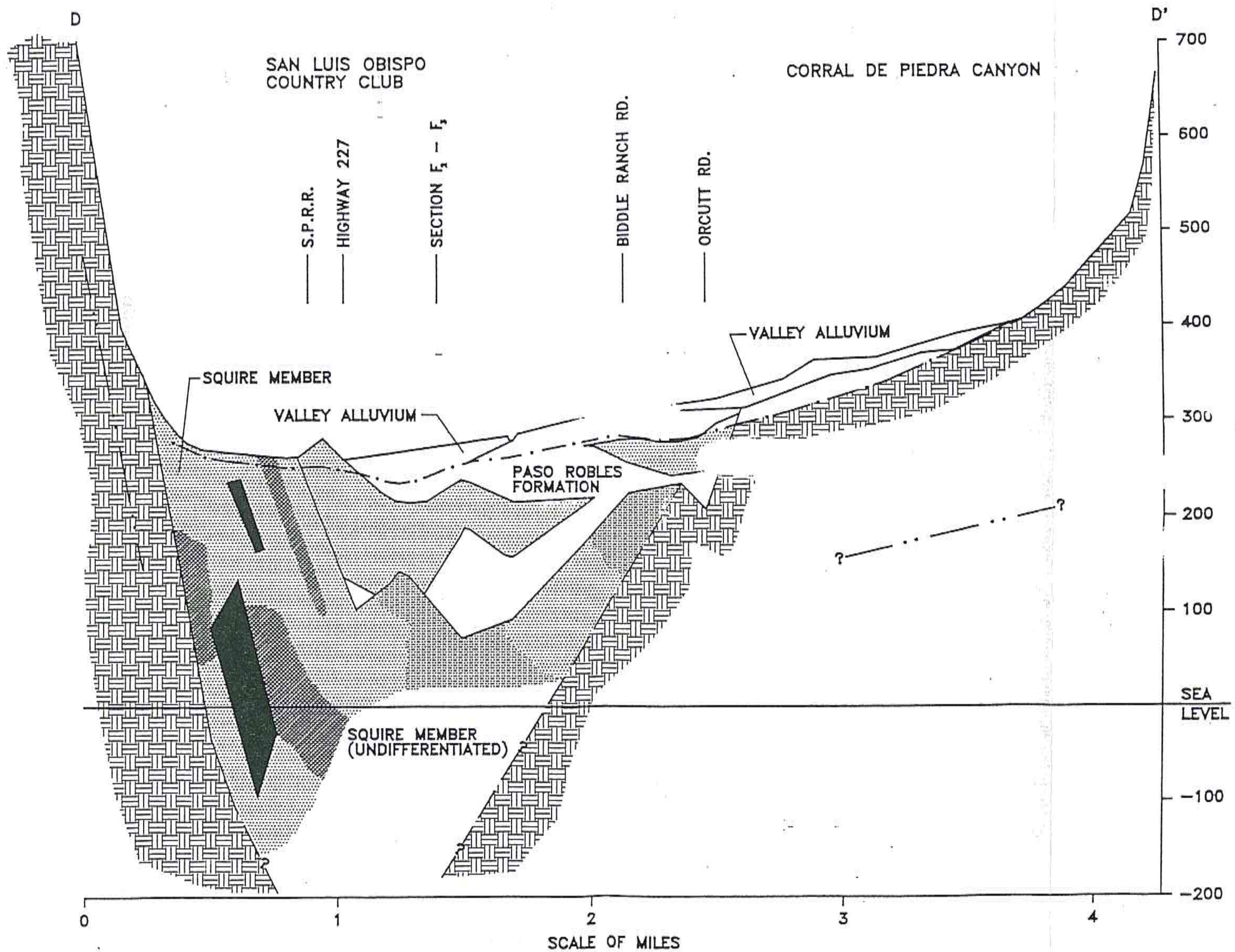


BOYLE ENGINEERING CORPORATION

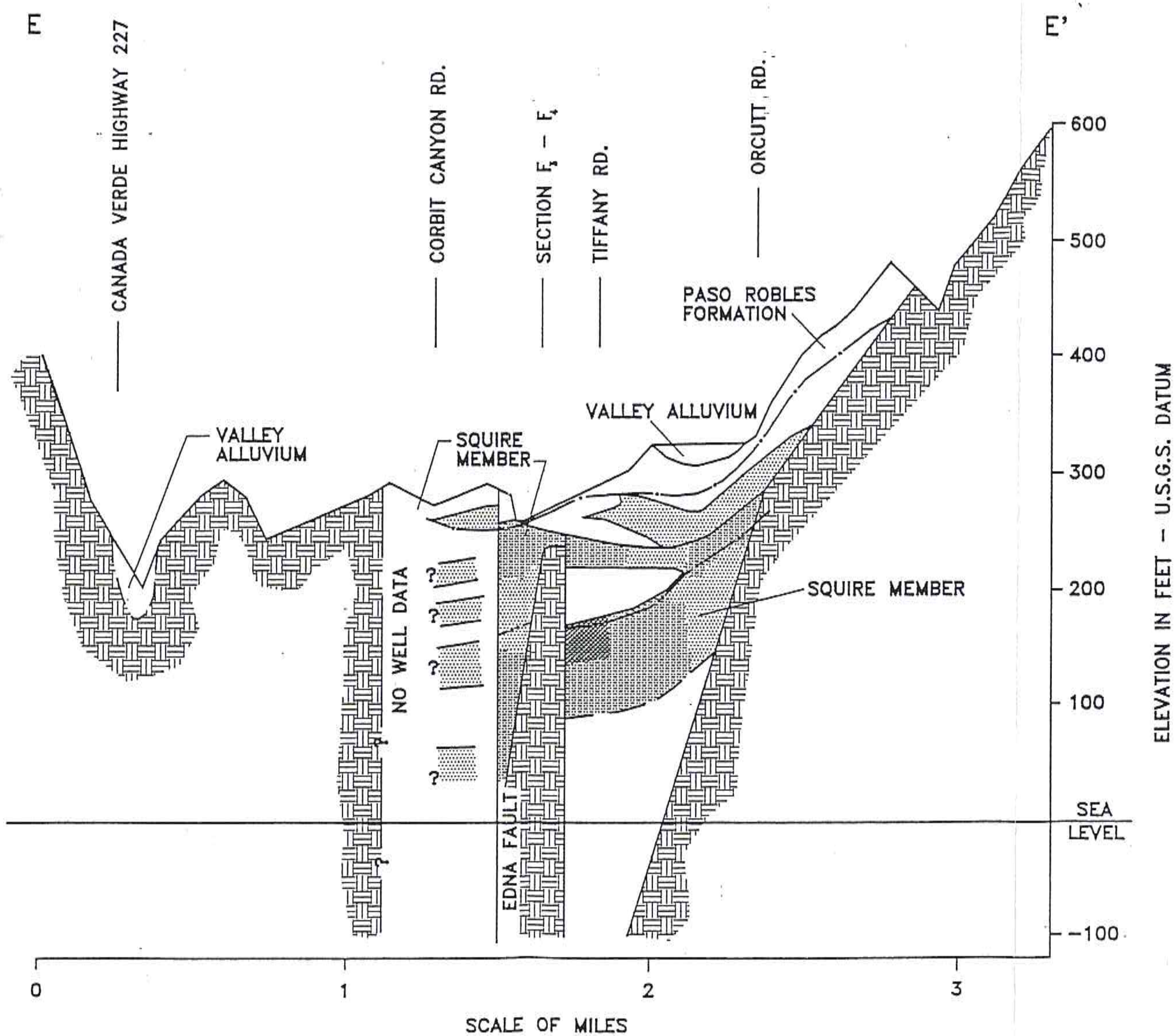


BOYLE ENGINEERING CORPORATION

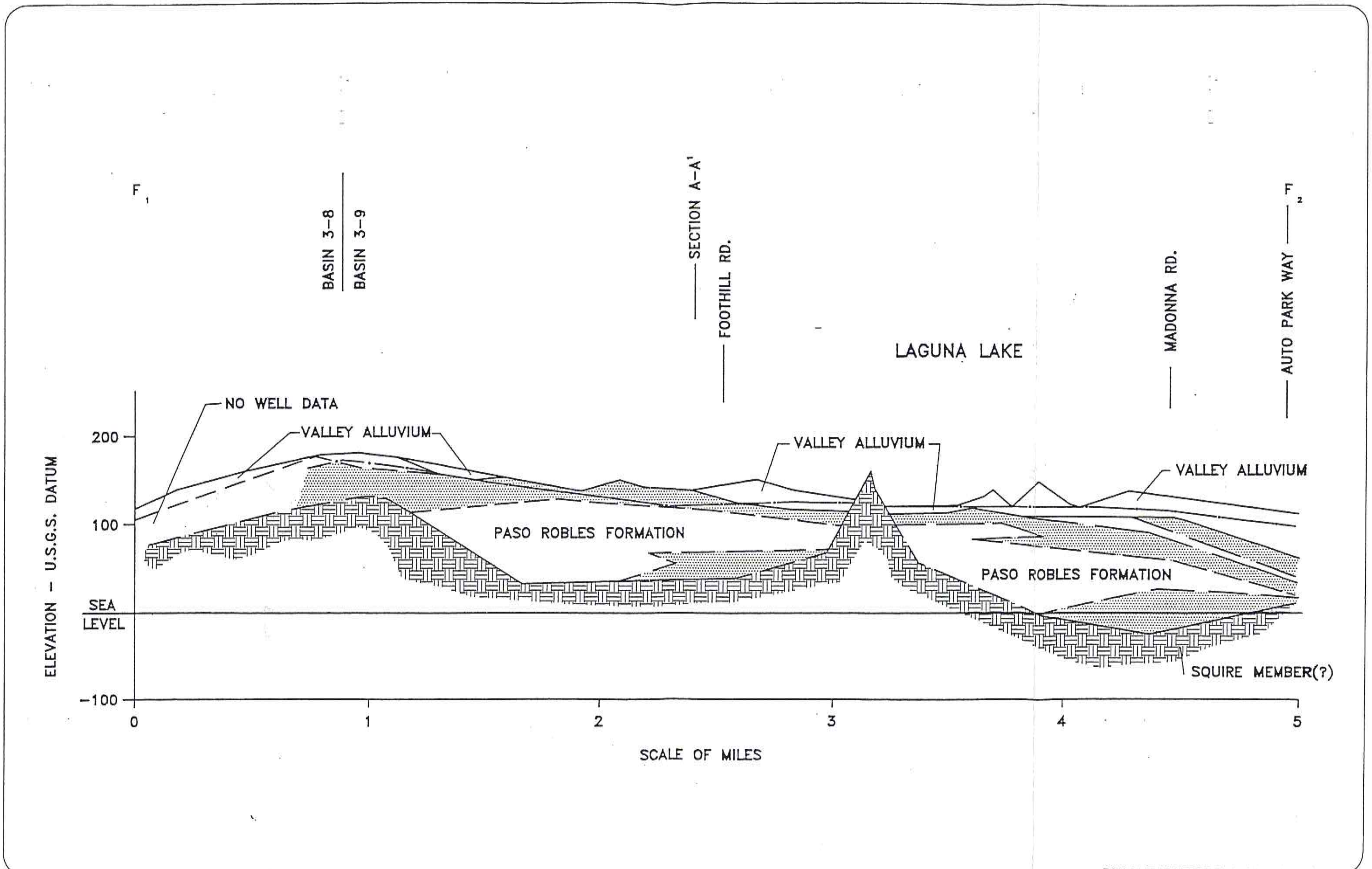

C
C'
COUNTY AIRPORT
NO WELL DATA
VALLEY ALLUVIUM
SQUIRE MEMBER (UNDIFFERENTIATED)
DAVENPORT CR.
PASO ROBLES FORMATION
VALLEY ALLUVIUM
SECTION F_2 – F_3
TERRACE
TANK FARM RD.
VALLEY ALLUVIUM
EDNA RD. (HIGHWAY 227)
S.P.R.R.
600
500
400
300
200
100
SEA LEVEL
-100
-200
-300
ELEVATION IN FEET – U.S.G.S. DATUM
0
1
2
3
4
SCALE OF MILES
BOYLE ENGINEERING CORPORATION



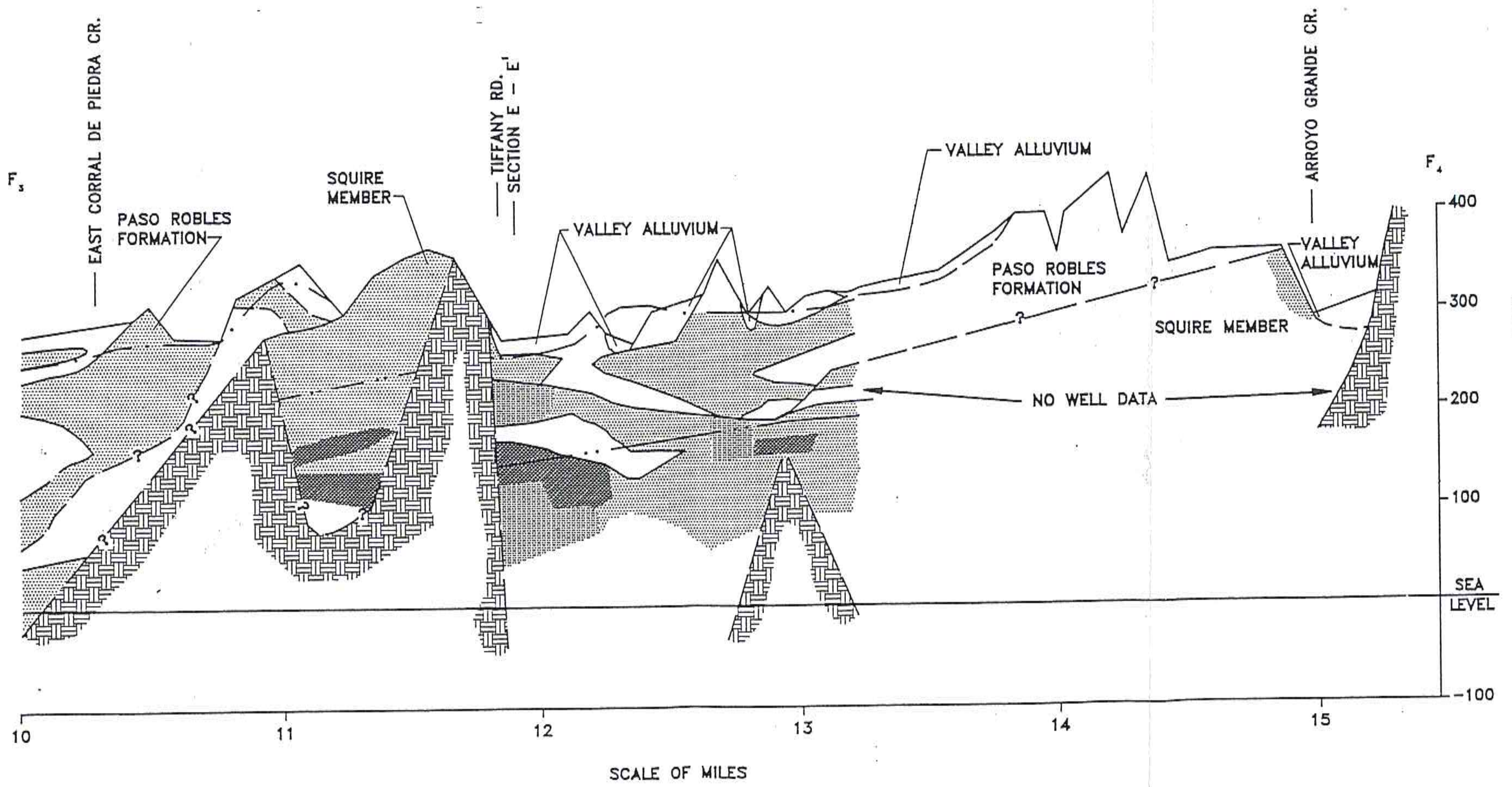
BOYLE ENGINEERING CORPORATION



BOYLE ENGINEERING CORPORATION



BOYLE ENGINEERING CORPORATION



BOYLE ENGINEERING CORPORATION

Section 3

GROUND WATER

3.1 Basin Boundary

Basin 3-9, shown on **Plate 4**, encompasses 18 square miles and includes the drainage of San Luis Obispo Creek above the narrows immediately below Ranchita de Santa Fe (Santa Fe Narrows). This drainage also includes that of Prefumo Creek and Laguna Lake. For the purposes of this investigation Basin 3-9 has been divided into four subbasins. Adjacent subbasins are separated one from the other by a constriction in the alluvial materials through which surface water and ground water moves. The constriction is caused by rocks being at or very near the ground surface. Each of the four subbasins is briefly described below.

<u>City Subbasin</u> Extends along San Luis Obispo Creek, from Cuesta Park to Madonna Road. Encompasses 1.5 square miles (988 acres).

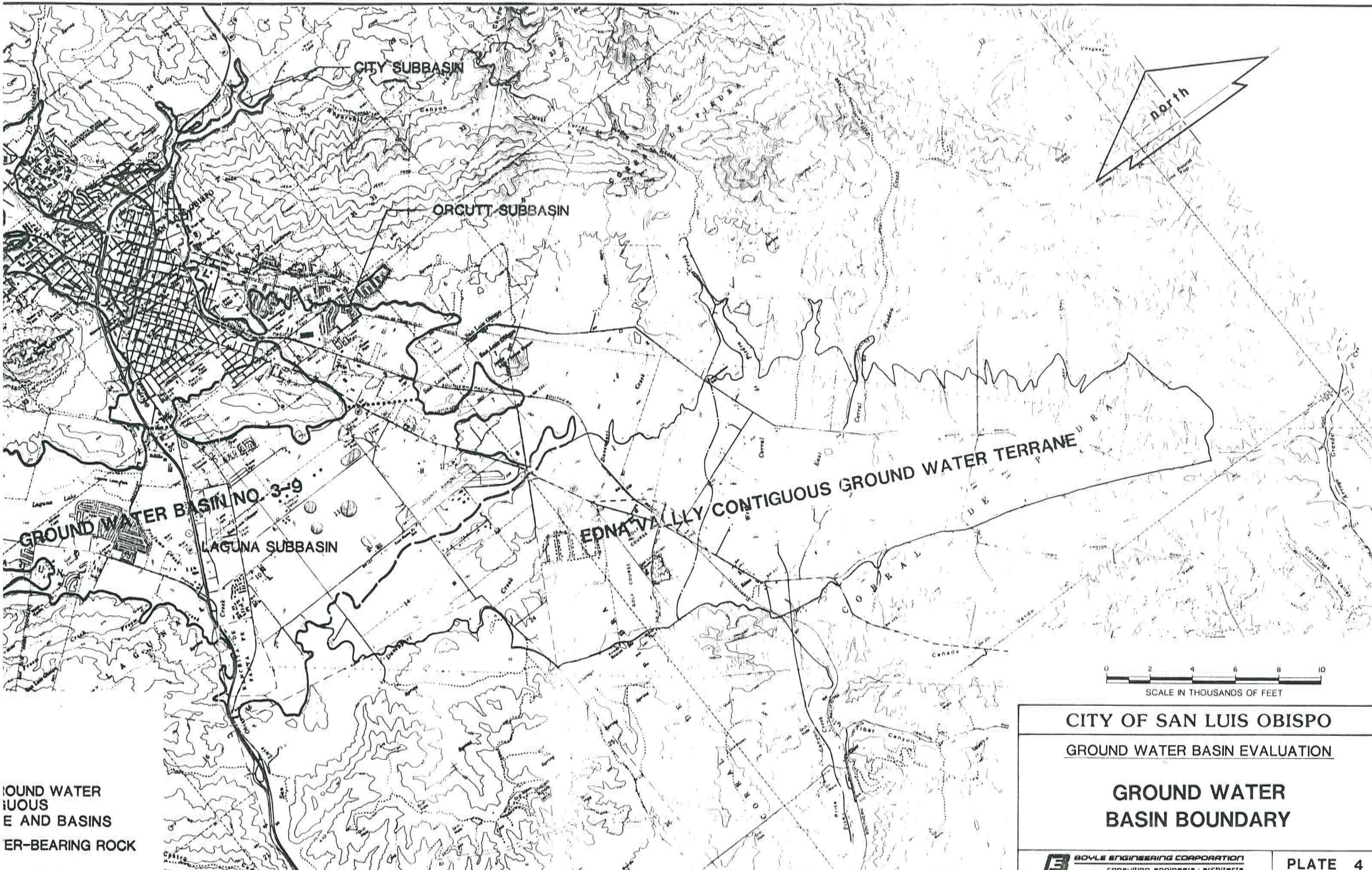
<u>Stenner Subbasin</u> Extends along Stenner Creek, from the Filtration Plant to its confluence with San Luis Obispo Creek; includes the drainage of Brizziolari Creek. Encompasses 1.0 square mile (636 acres).

<u>Orcutt Subbasin</u> Includes the small valley area to the southeast of Terrace Hill. Encompasses 1.0 square mile (644 acres).

<u>Laguna Subbasin</u> Includes the remainder of Basin 3-9. Extends along San Luis Obispo Creek from Madonna Road westerly to Santa Fe Narrows and includes area to west tributary to Laguna Lake and Prefumo Creek as well as area to southeast to and including the County Airport. Encompasses 14.5 square miles (5,851 acres).

The boundary of all but the southern side of Basin 3-9 is at the surficial contact between rocks of the nonwater-bearing series and geologic materials of the water-bearing series (Squire Member, Paso Robles Formation, terraces, and alluvium). In the subsurface, the base of the basin is formed by the stratigraphic contact of the overlying valley fill deposits and the underlying rocks of the nonwater-bearing series. The nature of this subsurface contact apparently is highly irregular based on well log data and on the numerous outcrops of rock which appear as isolated hills in valley floor areas.

Plate 5 shows thickness contours of the sedimentary deposits. This map was prepared after reviewing a draft map prepared by DWR.



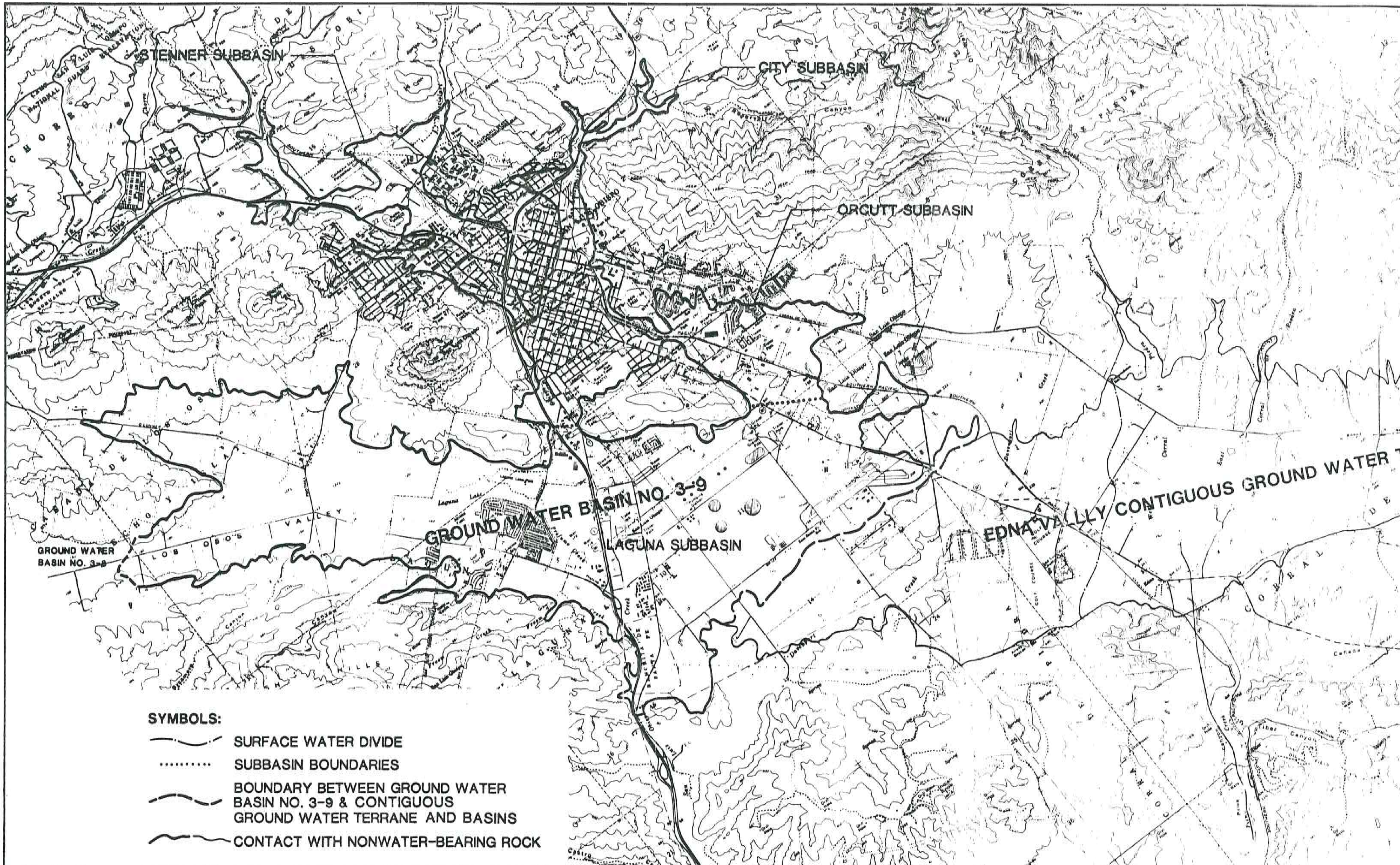
CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

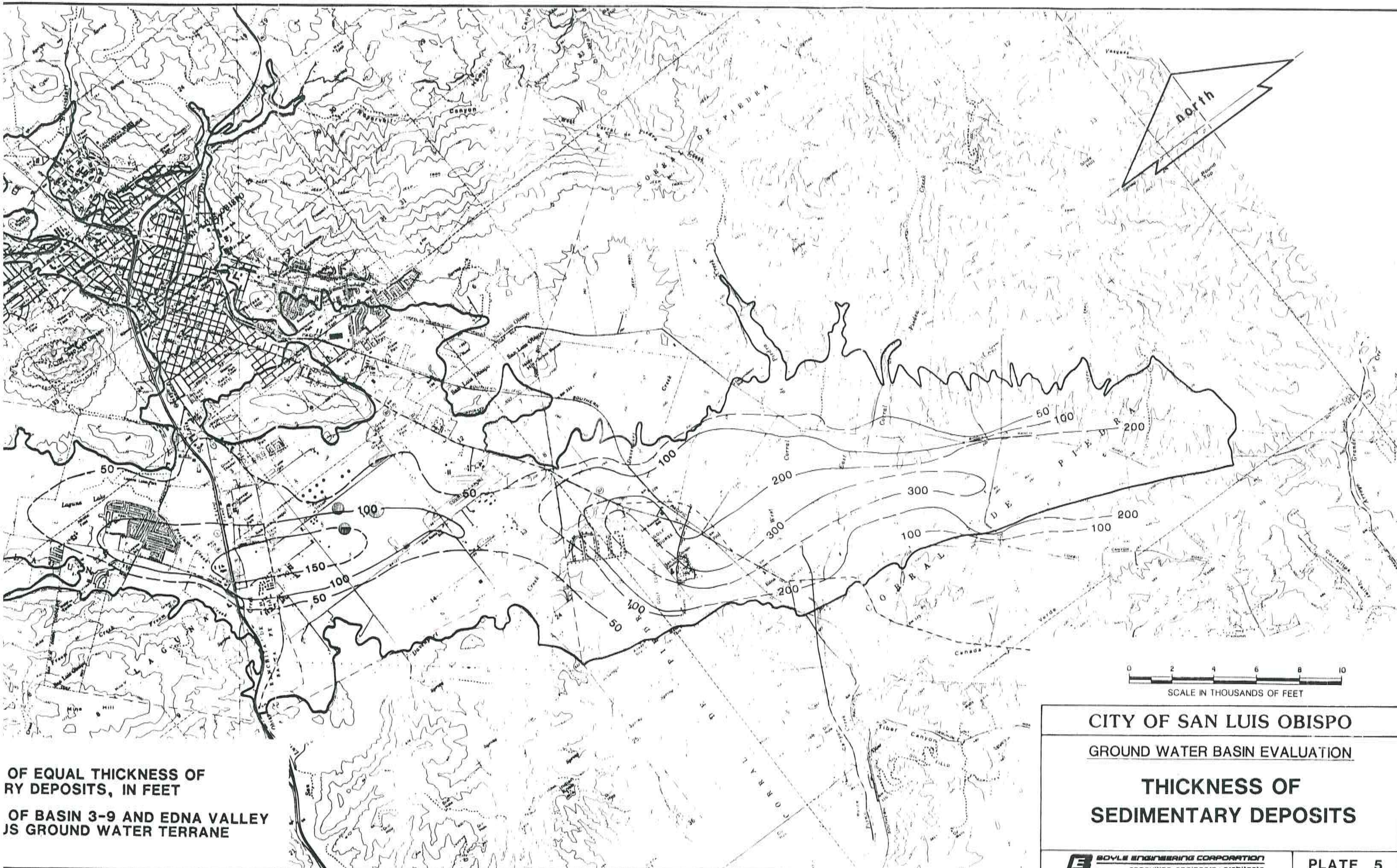
GROUND WATER BASIN BOUNDARY

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PLATE 4



STENNER SUBBASIN
CITY SUBBASIN
ORCUTT SUBBASIN
GROUND WATER BASIN NO. 3-9
LAGUNA SUBBASIN
EDNA VALLY CONTIGUOUS GROUND WATER TE
GROUND WATER BASIN NO. 3-8
LOS OSOS VALLEY
SYMBOLS:
SURFACE WATER DIVIDE
SUBBASIN BOUNDARIES
BOUNDARY BETWEEN GROUND WATER BASIN NO. 3-9 & CONTIGUOUS GROUND WATER TERRANE AND BASINS
CONTACT WITH NONWATER-BEARING ROCK



OF EQUAL THICKNESS OF
RY DEPOSITS, IN FEET

OF BASIN 3-9 AND EDNA VALLEY
JS GROUND WATER TERRANE

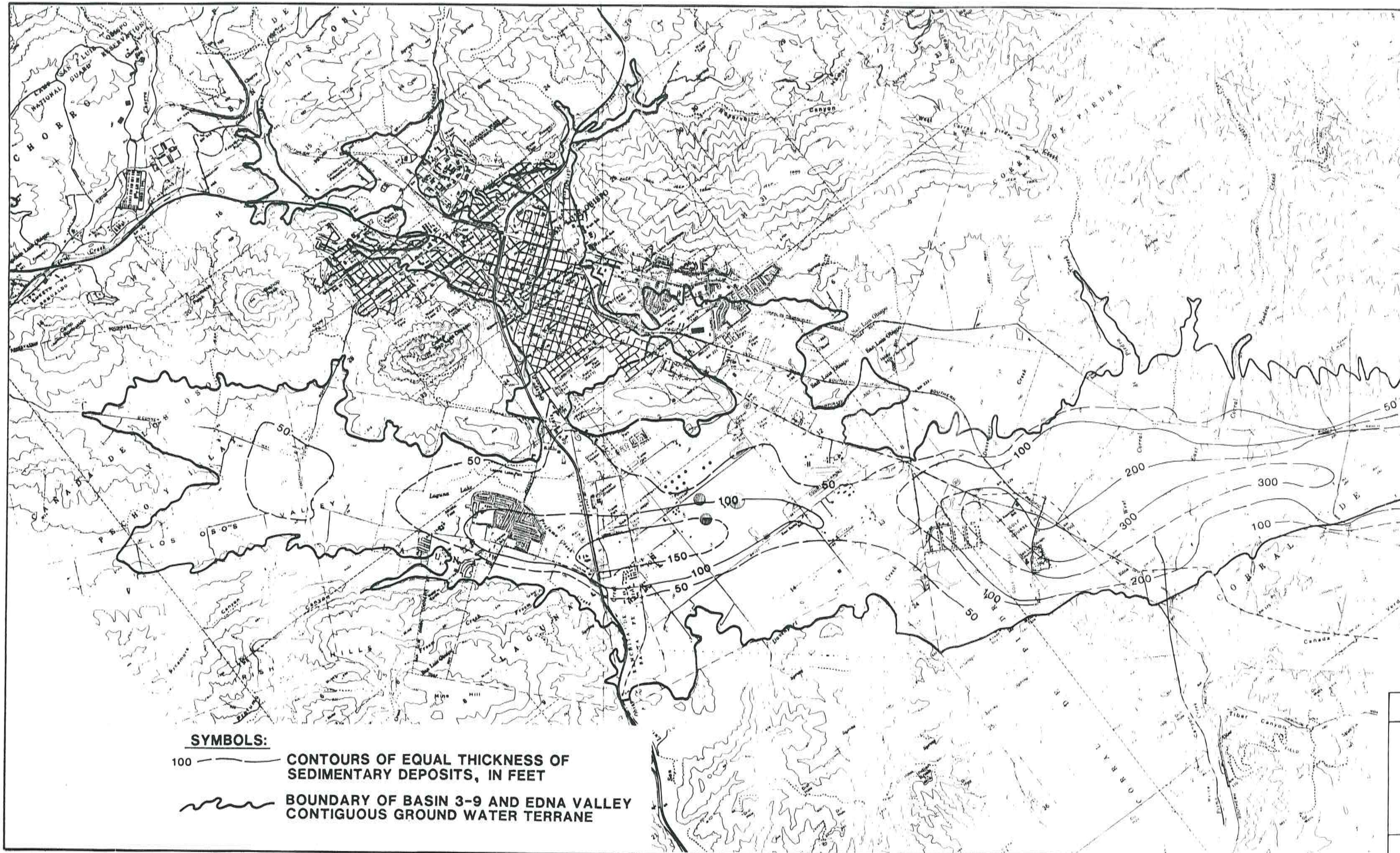
CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

THICKNESS OF SEDIMENTARY DEPOSITS

BOYLE ENGINEERING CORPORATION
consulting engineers | architects

PLATE 5


SYMBOLS:
100 CONTOURS OF EQUAL THICKNESS OF SEDIMENTARY DEPOSITS, IN FEET
BOUNDARY OF BASIN 3-9 AND EDNA VALLEY CONTIGUOUS GROUND WATER TERRANE
LOS OSOS VALLEY
Laguna Lake
50
100
150
200
300

In addition, well logs were obtained, including those for the recent City test holes. There are three noteworthy areas in Edna Valley, southeast of the airport where sedimentary deposits are more than 200 feet thick over a relatively large northwest-southeast trending area, and from 300 to 400 feet thick in the central portion of this area. The sedimentary deposits thicken toward the central part of Edna Valley, away from the outcrops of the consolidated rocks.

The second area where the sedimentary deposits are more than 100 feet and up to 150 feet thick extends from Laguna Lake on the northwest to near the airport on the southeast direction, and is about three miles long and from about one-half to one mile wide. The third area is in Los Osos Valley and is only several hundred acres in size, limited to several wells within a half mile of each other.

The southern boundary of Basin 3-9, just south of Buckley Road, is at the surficial contact of alluvial materials and the Paso Robles Formation. This boundary is not a boundary in the strictest sense, as ground water apparently moves unimpeded from Paso Robles sediments exposed south of Buckley Road (in Edna Valley) to Paso Robles and younger sediments northerly therefrom.

Most of Edna Valley is within the watershed of Pismo Creek, although the northern portion drains into Davenport Creek, a tributary of San Luis Obispo Creek. This northern portion accounts for about one-third of the 10 square miles length of Edna Valley. Most of the boundary of the Edna Valley terrane is at the surficial contact between sedimentary deposits and consolidated rocks. The southeastern portion of the boundary is formed by the Edna Fault.

3.2 Ground Water Occurrence and Movement

3.2.1 Water Level Hydrographs

Ground water is present nearly everywhere within the San Luis Obispo Ground Water Basin. However, the presence of ground water at a particular location within the basin does not imply that it is present in quantities necessary for municipal purposes.

The period of record for water level measurements for various wells throughout the basin are listed in **Table 2**.

Table 2

Summary of Wells with

Long-Term Water Level Records

Well No.	Period of Record
30S/12E-32J01	1963-90
31S/12E-03P02	1965-90
10F03	1965-90
10G02	1965-90
12E03	1965-90
12Q03	1965-90
14C01	1963-90
15R01	1965-90
31S/13E-16N01	1963-90
17Q04	1974-90
18J02	1974-90
18R01	1974-90
19A03	1974-90
19H01	1963-90
20K01	1974-90
27D03	1965-90
27M01	1976-90
29C01	1965-90

Source: County of San Luis Obispo Engineering Records

Water level hydrographs were prepared for 18 wells with long-term records in the San Luis Obispo/Edna Valley area. Essentially all of the hydrographs indicate a long-term stability in water levels (ie. no ground water overdraft) during the past several decades. Of crucial importance, however, are the water level declines during drought periods which also may show the effects of well interference. Water level records are available from which these declines can be determined for two drought periods: 1975-1977 and 1986-1990. Spring water level measurements were used to evaluate declines during these periods because they generally represent conditions of minimal pumping, particularly in irrigated areas. These measurements also allow the influence of winter recharge to be assessed. Both the total and the average annual rate of water level decline were determined during each of these two drought periods, and the results are summarized in **Table 3** .

Table 3

SUMMARY OF WATER LEVEL DECLINES DURING DROUGHT

San Luis Obispo Basin (3-9):

Well No.	1975 - 1977 Total Decline (ft)	1975 - 1977 Rate (ft/yr)	1986 - 1990 Total Decline (ft)	1986 - 1990 Rate (ft/yr)
30S/12E-32J01	7.6	3.8	6.8	1.7
31S/12E- 3P02	2.3	1.2	14.9	7.5
10F03	1.2	0.6	10.9	2.7
10G02	0	0	11.7	2.9
12E03	5.5	2.8	7.0*	2.3
12Q03	1.0	0.5	8.0*	4.0
14C01	6.5	2.2	6.5	1.6
15R01	1.0	0.5	6.5	1.6

Edna Valley:

Well No.	1975 - 1977 Total Decline (ft)	1975 - 1977 Rate (ft/yr)	1986 - 1990 Total Decline (ft)	1986 - 1990 Rate (ft/yr)
31S/13E-16N01	39	19.5	21.5	7.2
17Q04	N.A.	N.A	10	5.0
18J02	0	0	21	5.3
18R01	21	10.5	15	5.0
19A03	37	18.5	32	8.0
19H01	26	13	38	9.5
20K01	21	10.5	30.5	6.1
27D03	16.4	8.2	25.6	6.4
27M01	35.2	17.6	34.0	8.5
29C01	13.0	6.5	32.9*	11.0

Source: Spring measurements from County of San Luis Obispo.

** These values are only for the 1986-1989 period.*

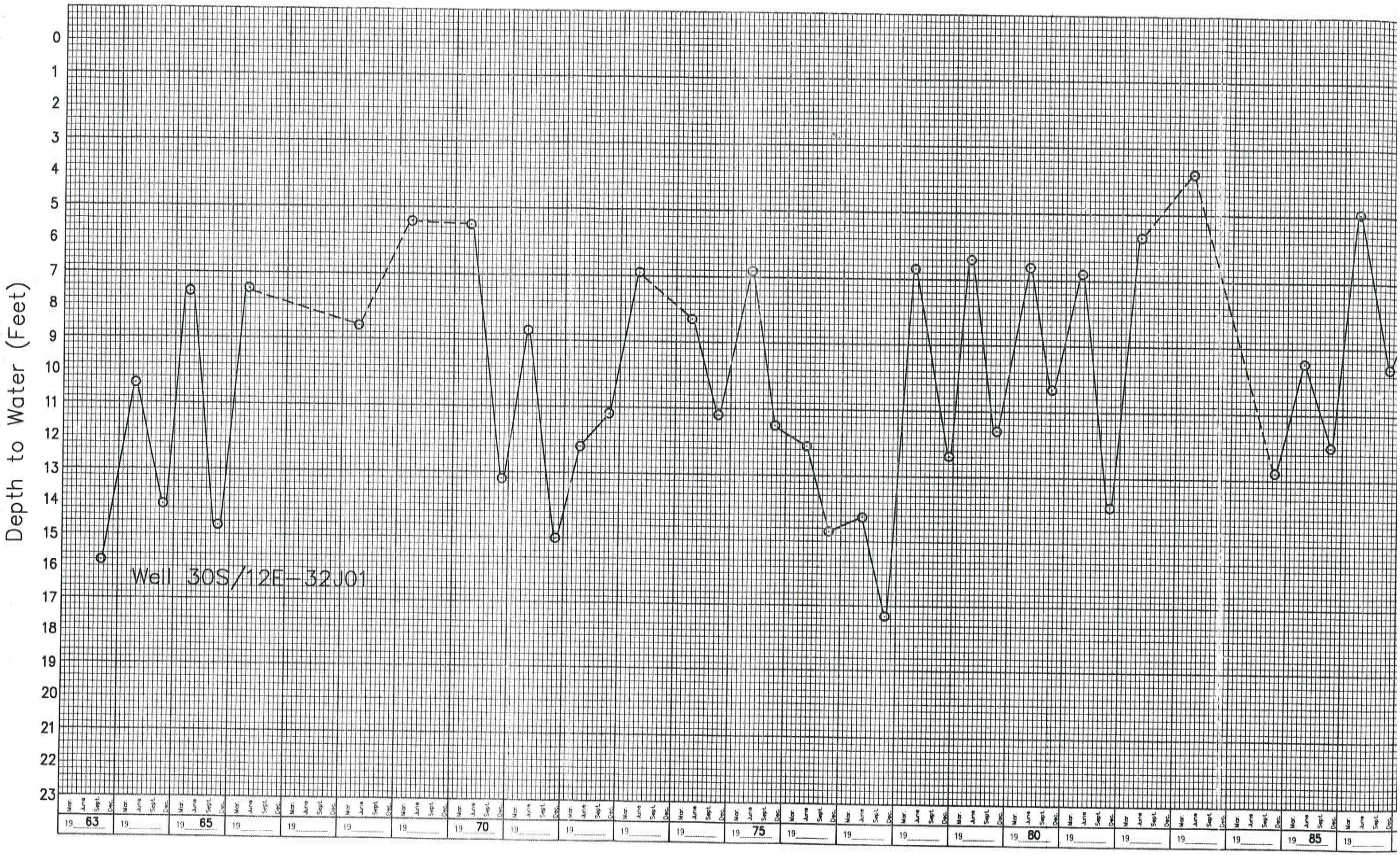
Water level fluctuations in wells in the San Luis Obispo/Edna Valley area can be grouped into two geographic areas. The first is the San Luis Obispo Ground Water Basin, or Basin 3-9, where relatively small seasonal fluctuations in water levels have occurred. A typical water level hydrograph for this basin is presented for Well 30S/12E-32J01, **Plate 6**.

In the San Luis Obispo Basin, water levels during the 1975-1977 drought declined as much as 8 feet. The rate of decline from Spring 1975 to Spring 1977 ranged from zero to about 4 feet per year. Water levels quickly recovered following the end of this drought. Water levels in this basin during the 1986-1990 drought declined from about 6.5 to 12 feet, except for one well. In this well (31S/12E-03P02), the water level declined almost 15 feet. A water level hydrograph for this well is shown in **Plate 6**. The rate of water level decline from Spring 1986 to Spring 1990 ranged from about 1.5 to 4 feet per year in this basin, except for Well 03P02. The rate of decline in this well was 7.5 feet per year from Spring 1986 through Spring 1990. This well is located along Highway 101, between the Dalidio Well and the Calle Joaquin Well. The greater water level decline in Well 03P02 is believed to be due to a combination of City pumping and increased agricultural pumping in that area during 1989-1990, which was not done as intensely during the earlier drought period.

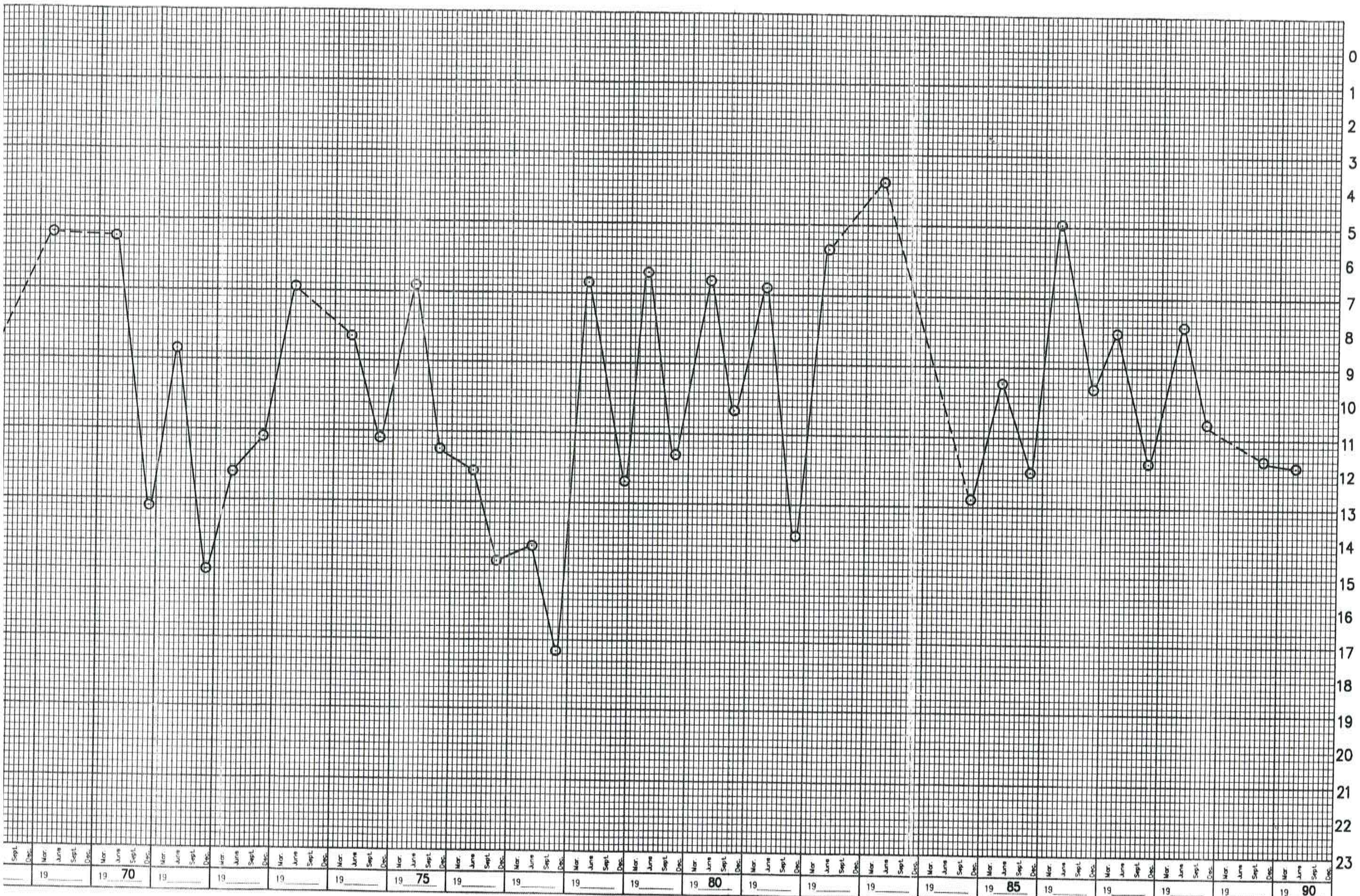
The relatively small seasonal variations in depth to water in the San Luis Obispo Basin are attributed primarily to 1) the presence of unconfined ground water conditions, and 2) a source of recharge from stream flow in San Luis Obispo Creek and its tributaries.

Plate 6 also shows water level hydrographs for two other wells in the San Luis Obispo Basin (31S/12E-10F03 and 10G02). Water levels in these wells declined from 11 to 12 feet between Spring 1986 and Spring 1990. Between April 1989 and April 1990, water levels in these wells declined 6.7 feet and 8.7 feet, respectively. The greater rate of decline after April 1989 and April 1990, is probably due to City pumping in the area plus increased agricultural pumping. These two wells are located southeast and within about one-half mile of the Calle Joaquin Well. Based on water level measurements in Wells 03P01, 10F03 and 10G02 and in other wells farther from the new City wells, the influence of City pumping during 1989-1990 appears to be limited to within about one-half mile of the pumped wells. Efforts should be made to separate municipal wells by approximately one-half mile, except closer to streams where higher permeabilities and less interference is anticipated. At stream locations, a separation of one-quarter mile may be acceptable.

The second geographic area is Edna Valley, where much greater water level fluctuations have occurred, particularly during drought periods. Typical hydrographs for two wells in the valley (31S/13E-16N01 and 17Q04) are also shown in **Plate 6**. During the 1975-1977 drought, water levels in the Edna Valley declined from 13 to 39 feet. Rates of decline between Spring 1975 and Spring 1977 ranged from 6.5 to 19.5 feet per year. However, water levels quickly recovered at the end of this drought.

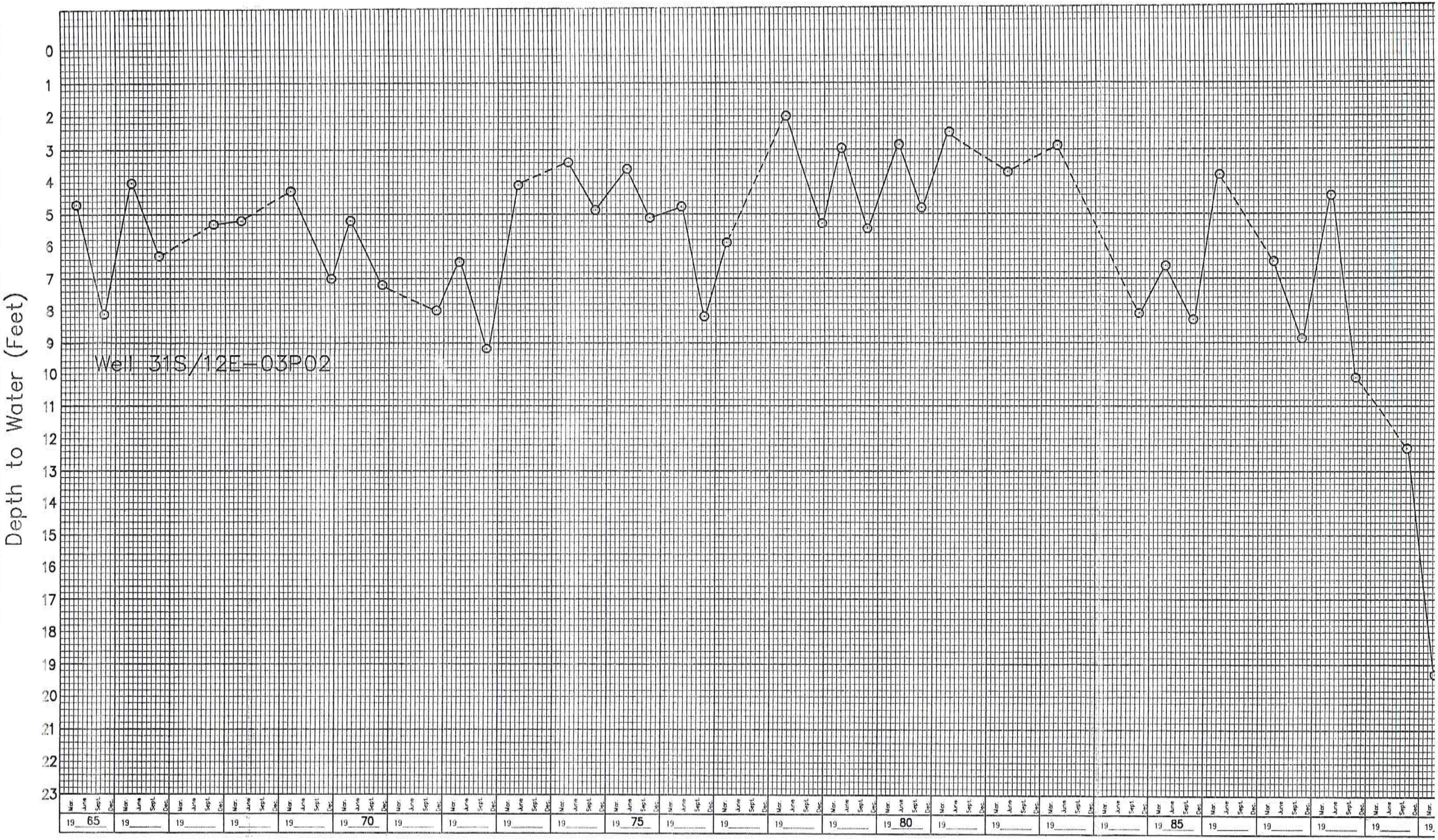


Water Level Hydrograph For Well 30S/12E-32J01



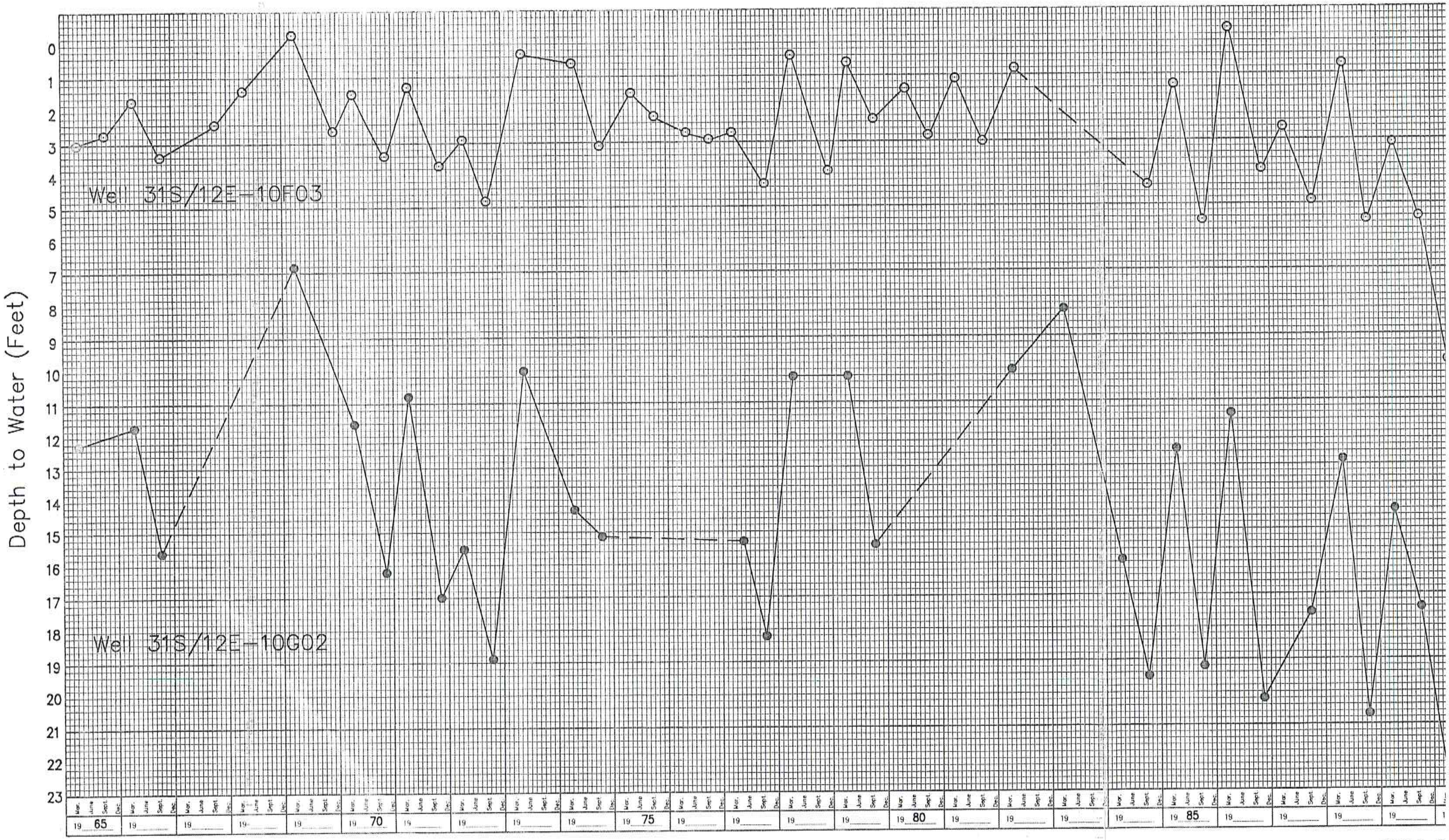
Water Level Hydrograph For Well 30S/12E-32J01

Plate 6
Sheet 1 of 4



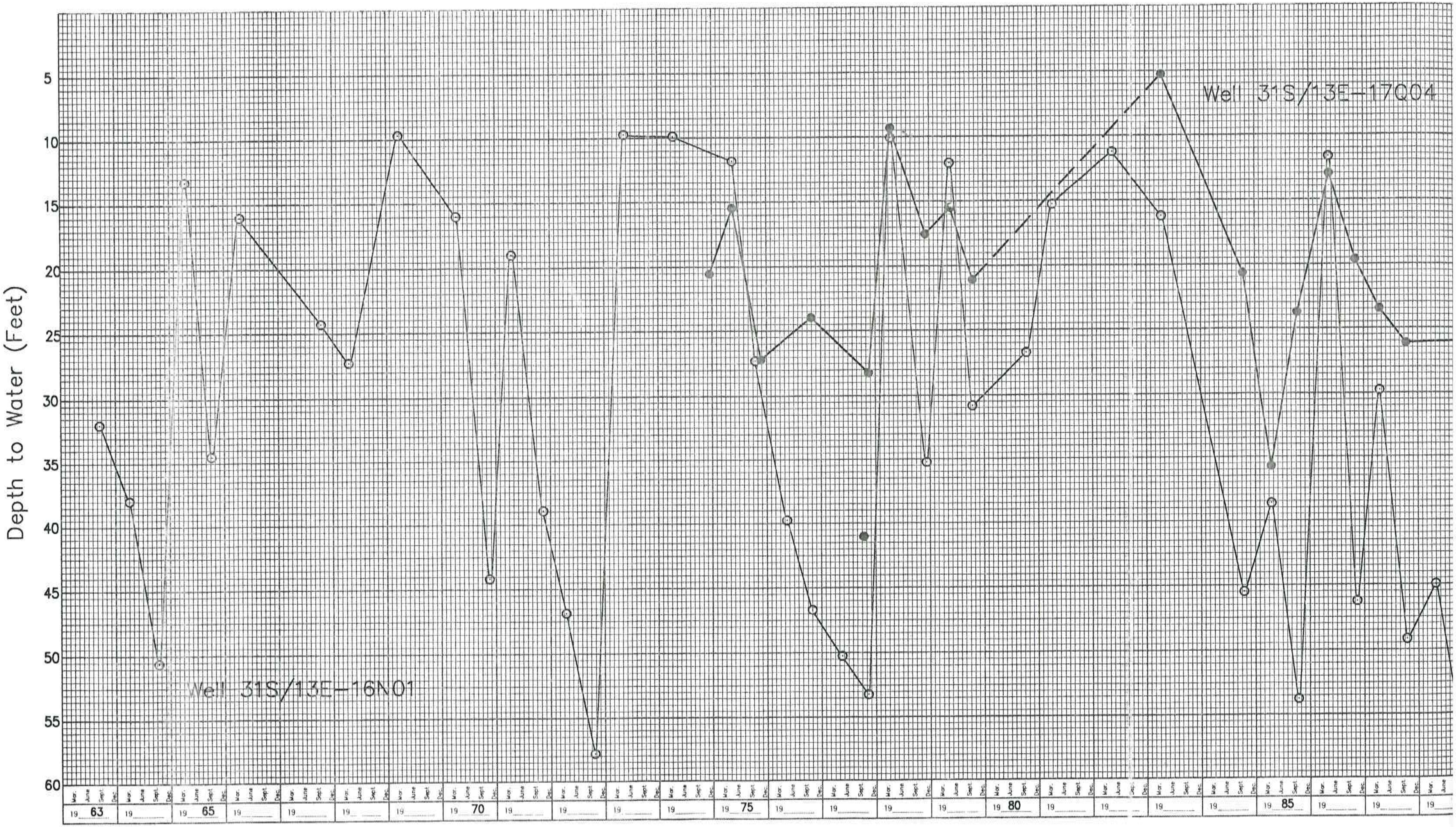
Water Level Hydrograph For Well 31S/12E-03P02

Plate 6
Sheet 2 of

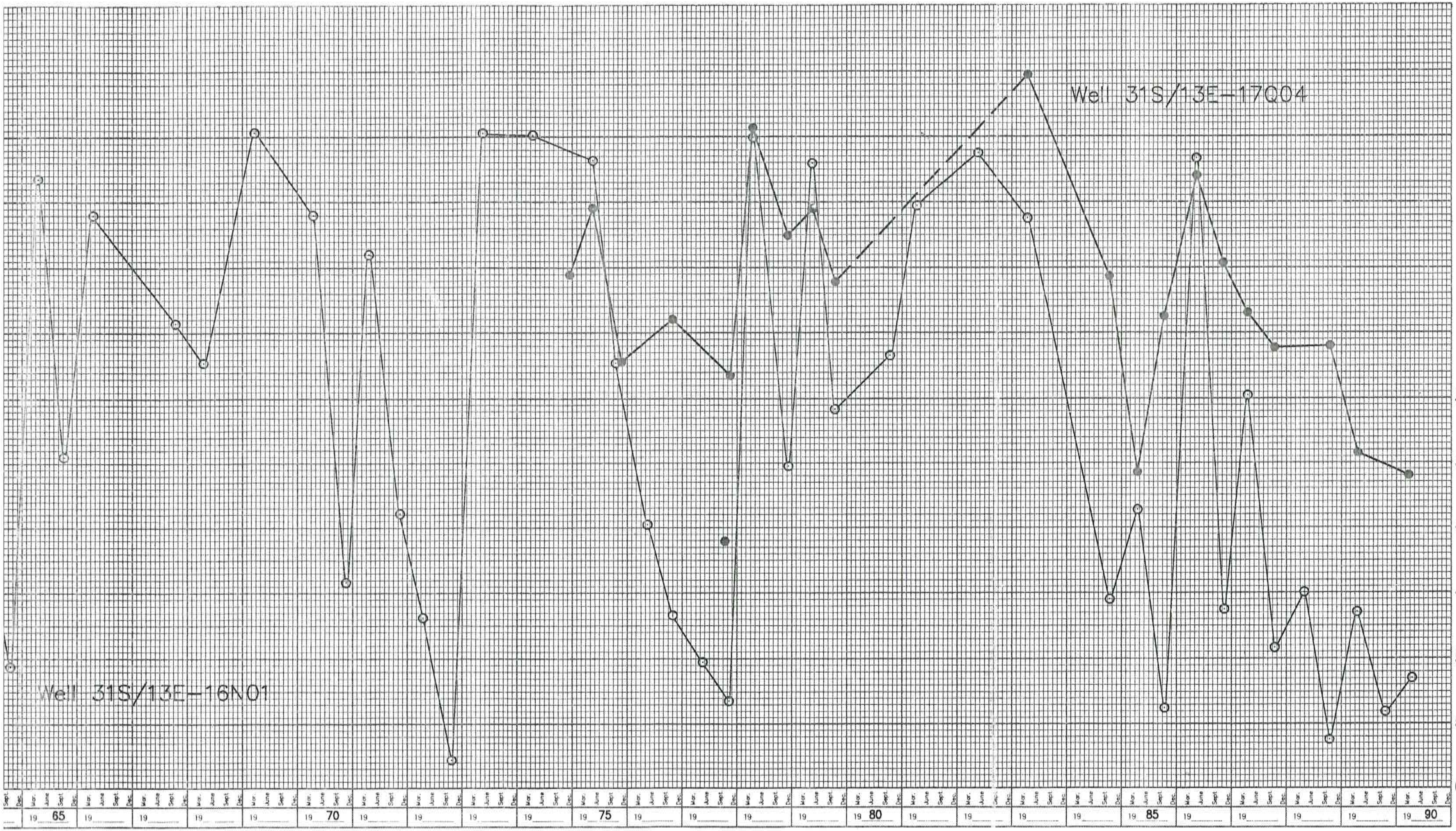


Water Level Hydrographs For Well 31S/12E-10F03 & Well 31S/12E-10G02

Plate 6
Sheet 3 of



Water Level Hydrographs For Well 31S/12E-16N01 & Well 31S/13E--17Q04



Water Level Hydrographs For Well 31S/12E-16N01 & Well 31S/13E-17Q04

Plate 6
Sheet 4 of 4

During the 1986-1990 drought, water levels in wells in Edna Valley fell from 10 to 38 feet. Rates of decline from Spring 1986 to Spring 1990 ranged from 5 to 11 feet per year. The relatively large seasonal water level fluctuations and water level changes during drought periods are highly indicative of a confined ground water system in Edna Valley.

The water level fluctuations observed in the San Luis Obispo/Edna Valley area are typical of those in many other similar ground water areas in California. Fluctuations indicate that recharge is rapid, and although water levels decline during drought periods, they tend to recover quickly after the drought has been concluded. Hence, the area is <u>not</u> in a state of overdraft.

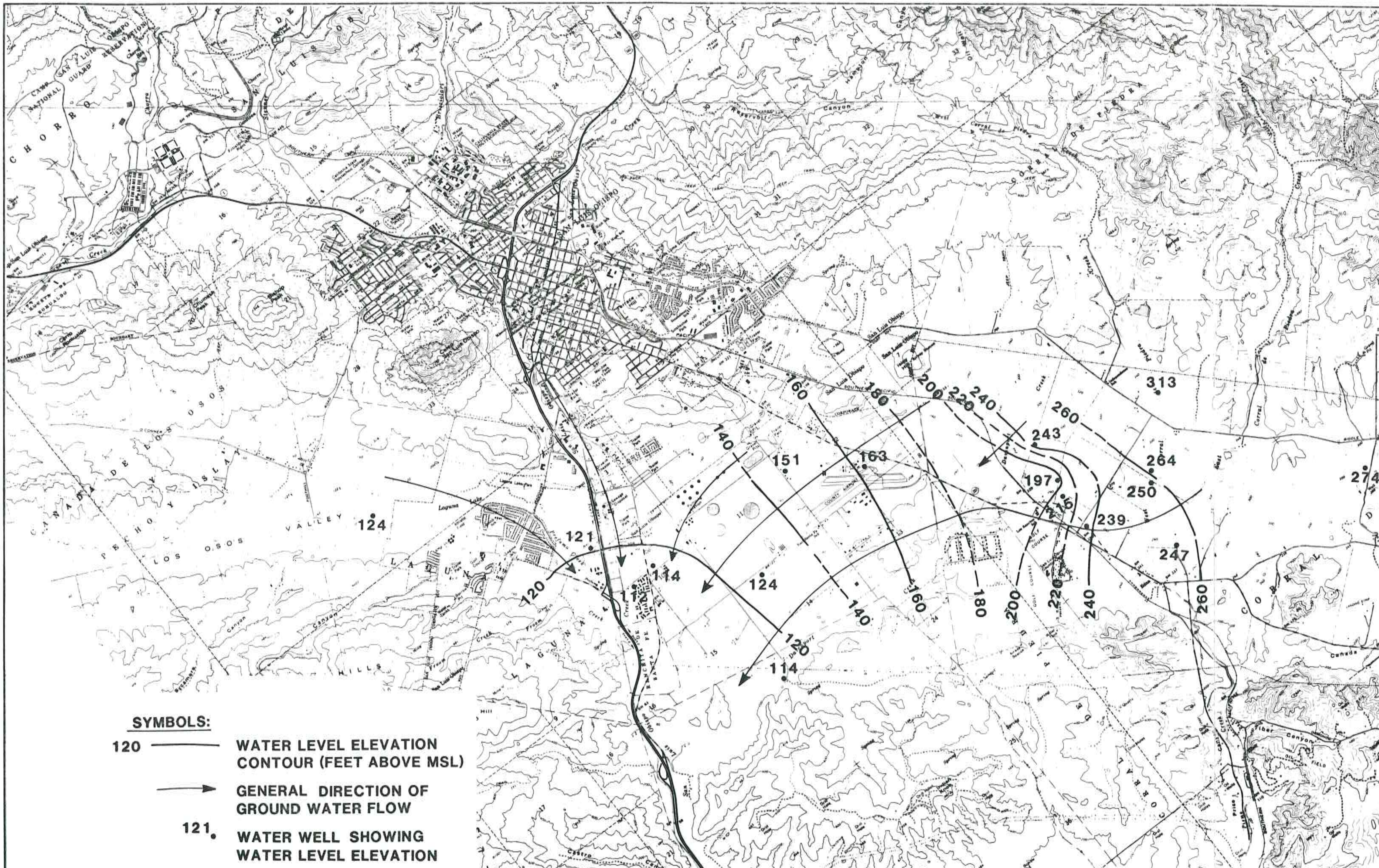
The term "overdraft" refers to a decline in the water table resulting from ground water extractions in excess of recharge. It is a regional phenomenon that is documented by long-term water level records. The City has experienced rapid declines in pumping water levels in recent months. This is more indicative of local well interference and is not in itself indicative of long-term overdraft. Sustained yield and basin management techniques are discussed in greater detail in Sections 4 and 5.

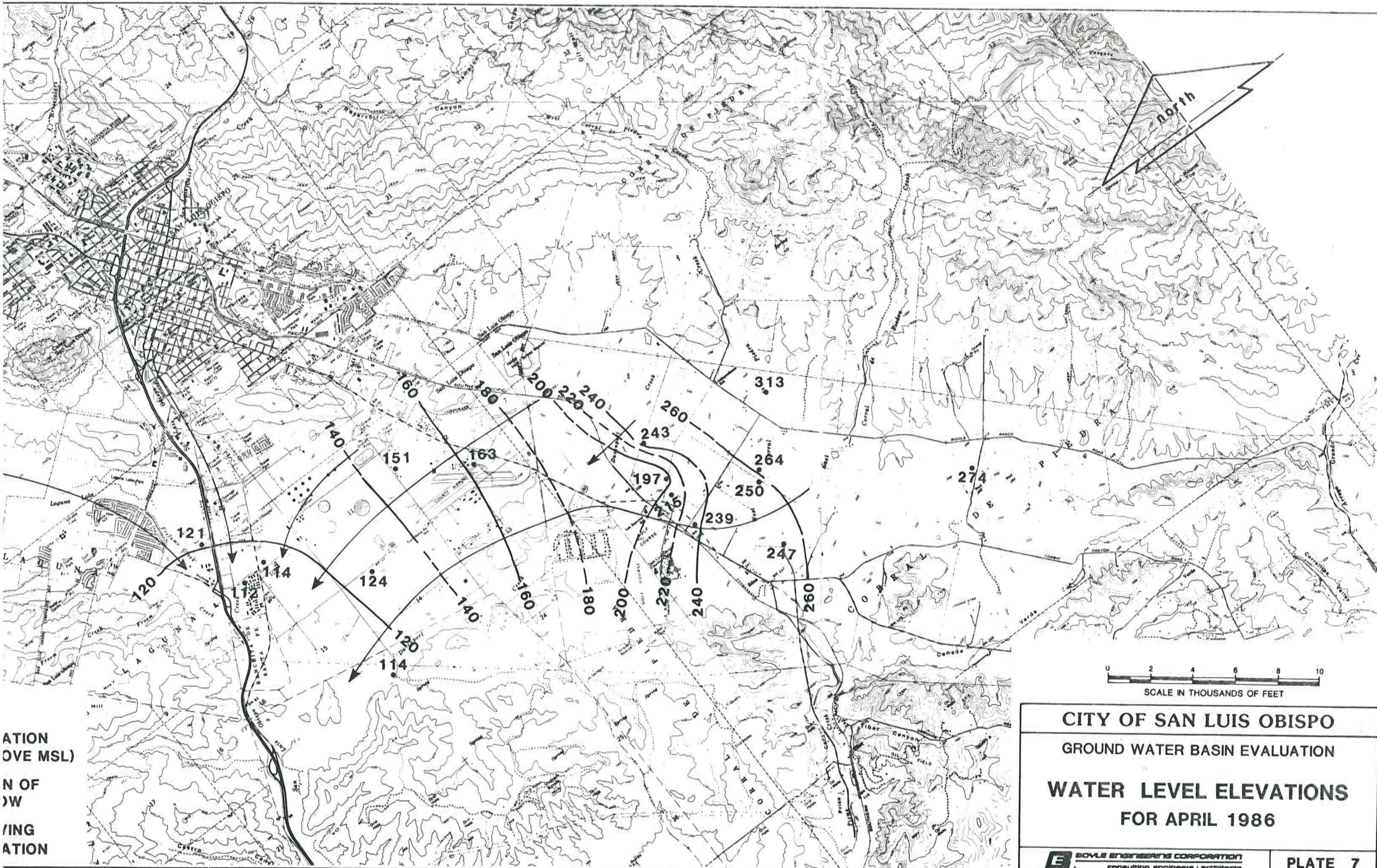
3.2.2 Water Levels

A water level elevation contour map for Fall 1954 was presented in DWR Bulletin 18 (Plate 9B). Water level elevations in the San Luis Obispo/Edna Valley area ranged from less than 110 feet above sea level near the confluence of Prefumo and San Luis Obispo Creeks, to more than 150 feet in Los Osos Valley. Water level elevations generally increased to the east in Edna Valley, to more than 280 feet beneath the southeast portion. The direction of ground water flow at that time was essentially toward San Luis Obispo Creek and the mouth of the basin.

As part of this investigation, two water level elevation contour maps were prepared. The first was for Spring 1986, following a relatively wet winter. The second was for Spring 1990, following several years of drought. **Plate 7** shows water level elevation contours for April 1986, based on County of San Luis Obispo measurements. Water level elevations near the confluence of Prefumo and San Luis Obispo Creeks were about 110 to 115 feet above sea level in April 1986. The direction of flow in Edna Valley was generally to the west in April 1986.

Few measurements were available for that time period in Los Osos Valley or central San Luis Obispo. Beneath the Airport, water level elevations ranged from about 150 to 170 feet. Water level elevations in southeastern Edna Valley exceeded 260 feet in Spring 1986.


SYMBOLS:
120 WATER LEVEL ELEVATION CONTOUR (FEET ABOVE MSL)
GENERAL DIRECTION OF GROUND WATER FLOW
121 WATER WELL SHOWING WATER LEVEL ELEVATION
120
140
160
180
200
220
240
260
313
243
264
274
197
250
239
247
151
163
124
121
114
172
114
124
LOS OSOS VALLEY
CHORRO
LAGUNA
CORRAL DE PIEDRA



CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

WATER LEVEL ELEVATIONS FOR APRIL 1986

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PLATE 7

Plate 8 illustrates a water level elevation contour map for April 1990. Some measurements were available for City wells, in addition to the County measurements. Water level elevations throughout most of the area were lower in Spring 1990 than in Spring 1986. Near the confluence of Prefumo Creek and San Luis Obispo Creek, water level elevations were about 100 feet above sea level. Beneath the airport, water level elevations ranged from about 140 to 160 feet. Overall, water level elevations were about ten feet lower in April 1990 than in April 1986.

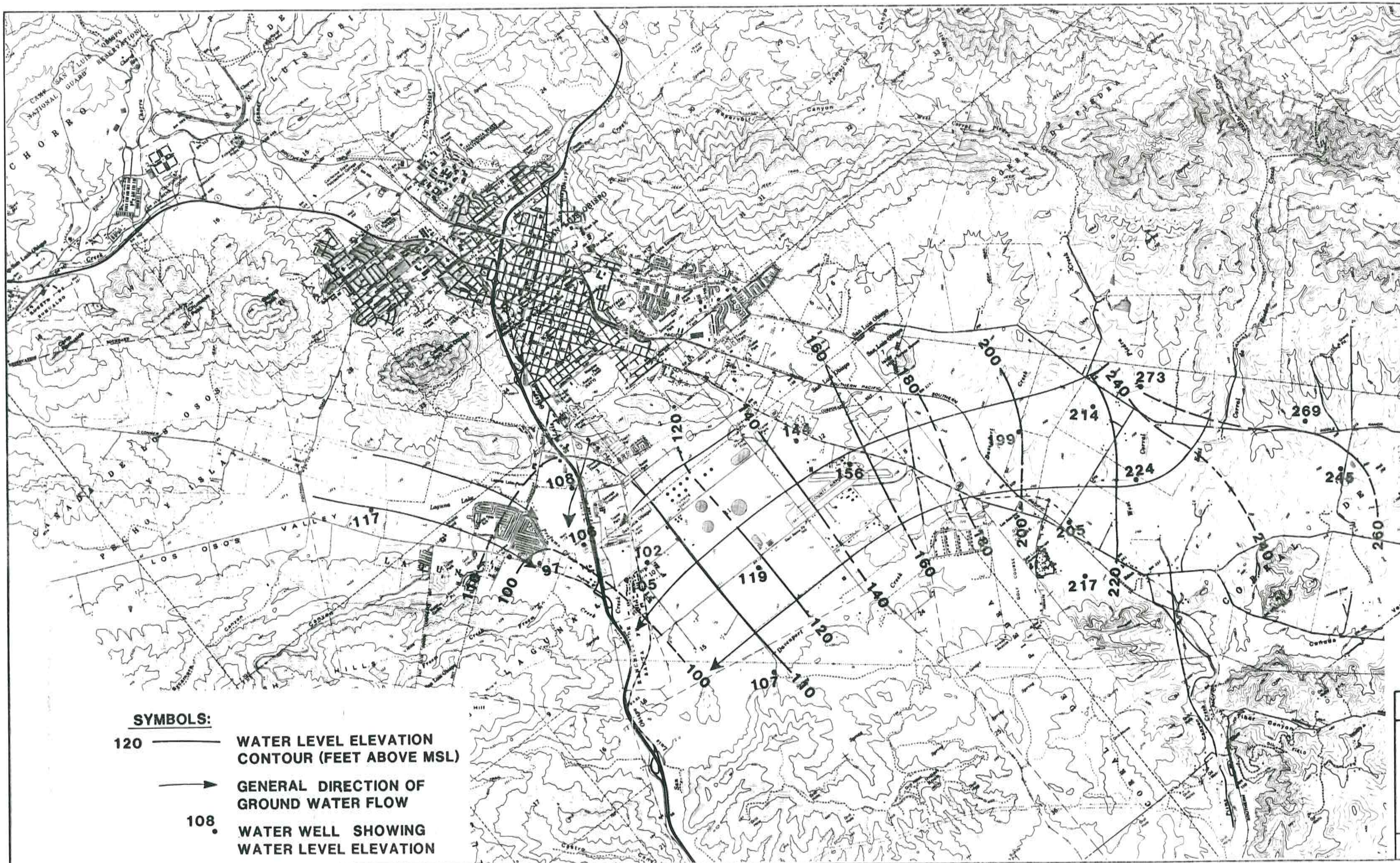
3.2.3 Evaluation of City Pumping

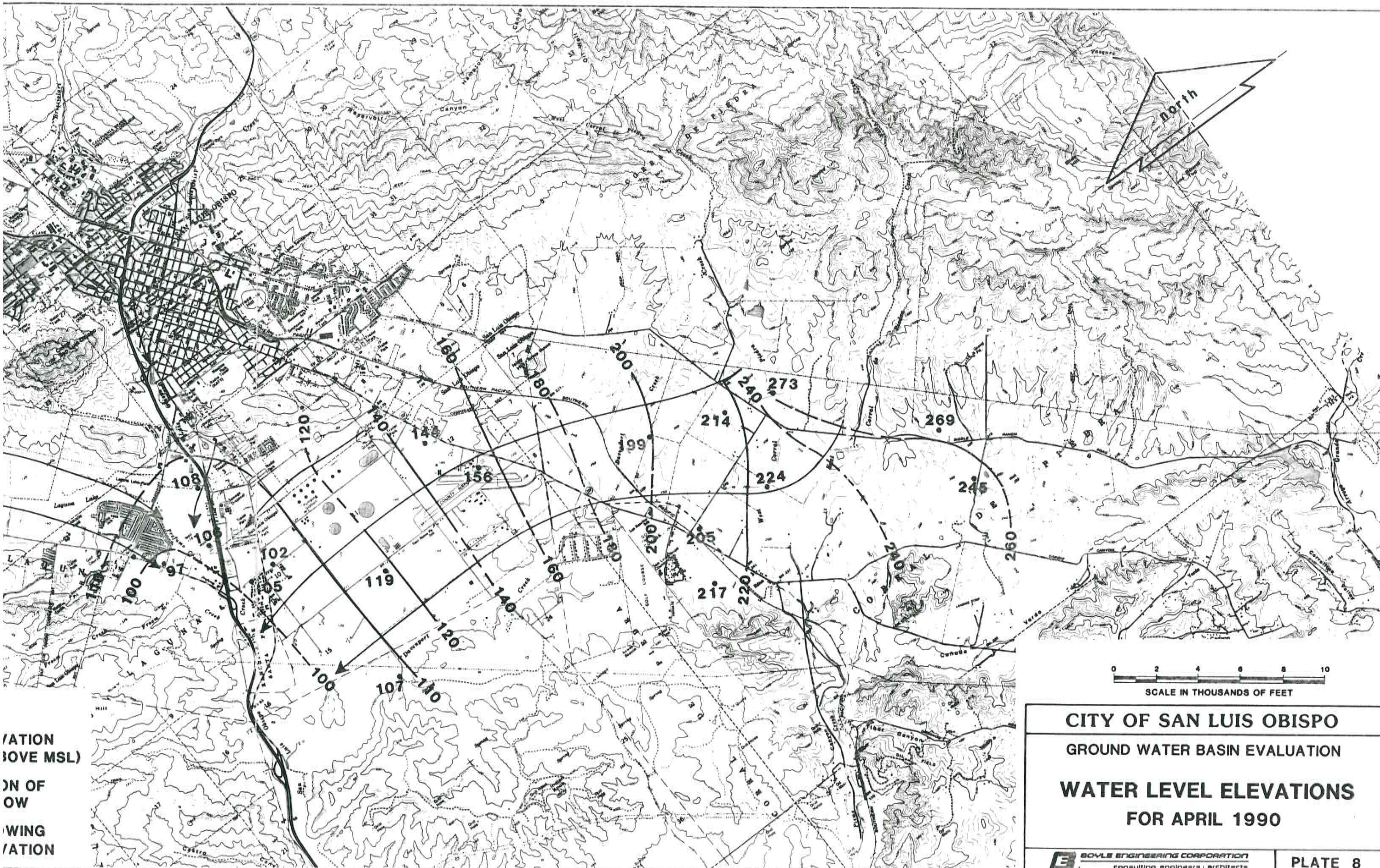
An evaluation was performed of the water level declines associated with pumping of the new City wells during 1989-1990. **Table 4** contains a summary of the amounts of water pumped and the associated declines in static water levels. In general, larger water level declines have occurred at greater distances from San Luis Obispo Creek. At both the Auto Park and Dalidio Wells, static levels have declined relatively slightly compared to the amount of water pumped. This is likely due primarily to recharge of treated effluent from the channel of San Luis Obispo Creek. Based on the amounts of pumpage and the associated water level declines, the ratio between the acre-feet pumped and the feet of water level decline were developed. These values are as follows:

Well	Acre-Feet Pumped per Foot of Decline
Dalidio	62
Auto Park	35
Pacific Beach No. 1	17
Pacific Beach No. 2	4
Fire Station	3

By comparing the static water level measurements with well construction data, an estimate can be made of how much additional water can be pumped from each well. Static levels can probably not be drawn down more than about one-half of the saturated thickness of sedimentary deposits in the vicinity of the pumping well without encountering significant declines in pumping rate.

The idea of maintaining static levels at half of the saturated thickness or greater is based on experience in managing similar basins and serves somewhat as an operational guideline for the City. Activation of an ongoing static water level recording system and a more tightly controlled method of conducting pump tests would further assist the City in successful basin management.


SYMBOLS:
120 WATER LEVEL ELEVATION CONTOUR (FEET ABOVE MSL)
GENERAL DIRECTION OF GROUND WATER FLOW
108 WATER WELL SHOWING WATER LEVEL ELEVATION
100
120
140
160
180
200
220
240
260
273
269
214
199
224
245
156
144
108
117
106
97
102
105
119
107
110
205
217
LOS OSOS VALLEY
Laguna Lake



/ATION
3OVE MSL)

)N OF
OW

)WING
/ATION

CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

WATER LEVEL ELEVATIONS FOR APRIL 1990

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PLATE 8

Table 4

PUMPAGE AND DECLINES IN WATER LEVELS FOR CITY WELLS

Well Name	Pumping Period	Total Extraction (acre feet)	Static Water Level Date	Level (feet)
Fire Station	4/89-11/89	74.3	4/89	16.8
	3/90- 8/89	50.0	7/90	55.5
Pacific Beach #1	4/89-11/89	171.5	7/89	15.0
	1/90- 8/90	166.0	12/89	21.0
Pacific Beach #2	5/90- 8/90	76.0	4/90	29.8
Auto Park	2/90- 8/90	598.4	10/89	15.5
			8/90	32.5
Dalidio	9/89- 8/90	557.4	8/89	26.0
			4/90	29.0
			7/90	35.0
Calle Joaquin	4/90- 8/90	116.6	3/90	15.0

3.3 Aquifer Characteristics

Aquifer tests were previously conducted on five City wells during 1988 (John L. Wallace & Associates and Timothy S. Cleath, 1988). These tests can be used to determine the transmissivity and permeability of the sedimentary deposits. **Table 5** summarizes the results of these tests. A constant discharge test was conducted following the development and step drawdown test for each new well. For the constant discharge tests, pumping durations ranged from nine to twenty-four hours, and pumping rates ranged from 70 to 300 gpm. Specific capacities ranged from 1.4 to 24 gpm per foot of drawdown (gpm/ft), and were less than 5 gpm/ft for four of the five wells. Transmissivities ranged from 11,200 to 71,000 gallons per day per foot (gpd/ft), and exceeded 34,000 gpd/ft for four of the tests.

Permeabilities can be estimated by dividing the transmissivity by the saturated thickness of the permeable deposits. Assuming that most of the water production came from coarse grained deposits, permeabilities of these deposits ranged from about 750 to 4,400 gpd/ft^2. Permeabilities of the coarse grained deposits ranged from 750 to 1,750 gpd/ft^2 at three of the wells, and these values are considered typical for sand and/or gravel. At the Corporation Yard and Mitchell Park wells, permeabilities of the coarse grained deposits ranged from 4,100 to 4,400 gpd/ft^2, which is considered high. These values probably represent clean sand and/or gravel. A comparison of specific capacities with transmissivity values indicates relatively low well efficiencies, particularly for the Old Reservoir, Pacific Beach, and Fire Station wells. That is, the specific capacities values are very low compared to the transmissivity values.

Table 5

Summary of Aquifer Tests for

City of San Luis Obispo Wells

Well	Date	Test Duration (minutes)	Average Pumping Rate (gpm)	Specific Capacity (gpm per foot)	Transmissivity (gpd per foot)
Corporation Yard	6/30/88	1,440	134	24.0	71,000
Old Reservoir	7/19/88	480	80	04.2	35,000
Pacific Beach	7/27/88	1,300	300	04.8	40,000
Fire Station	8/20/88	654	85	01.4	11,200
Mitchell Park	8/04/88	540	70	19.0	49,000

Source: Pump test measurements and graphical plots referenced from John L. Wallace & Associates and Timothy S. Cleath (1988).

3.4 Water Quality

Water quality data are available from 20 wells tapping the valley alluvium. The water in these wells closely reflects the character of the surface water which recharges the alluvial materials. With the exception of one well located near the town of Edna and producing an excellent-quality calcium bicarbonate water, all wells tapping the valley alluvium yield an excellent to poor quality magnesium bicarbonate water. Ten of the wells are located in Basin 3-9. Where the valley alluvium becomes thinner and the water quality becomes affected by poor quality water contained in underlying materials, the quality of water in the valley alluvium deteriorates.

Six shallow wells tapping the valley alluvium yield a poor-quality magnesium bicarbonate water. All of the water exceeds the recommended maximum contaminant levels (MCLs) specified in Section 64473, Title 22, California Code of Regulations (CCR). The wells are located in Basin 3-9 as well as in Edna Valley. Analyses of the water from these wells all indicate excessive amounts of nitrate ion and elevated amounts of chloride ion.

Water quality data are available from six wells in the area which are believed to tap the rocks of the non-water bearing series. The wells yield a sodium chloride to magnesium chloride water having an electrical conductivity in the range of 1,000 to 2,600 micromhos per centimeter. Two of the wells are used for domestic water supplies; use of the other wells includes those for industrial, irrigation, and stock watering purposes. Five of the six wells produce a saline water that exceeds upper MCL specified in Title 22, CCR. The sixth well, a stock well located near the southeast end of Edna Valley, produces a saline water that exceeds the recommended limit but is below the upper limit of contaminant levels specified in Title 22, CCR.

Samples from eight wells were analyzed for both regulated and unregulated organic chemicals. In all but three wells, all 70 organic compounds were reported as "Not Detected". Tetrachloroethylene (PCE) was detected in three wells as shown below; the detection limit for PCE is 0.5 micrograms per liter (μg/l) and the MCL is 5.0 μg/l.

Well Number	Well Designation	PCE (μg/l)
31/12-03G02	Dalidio "C"	21.0
31/12-03N01	Auto Park	12.0
31/12-10D80	Frangie	6.4

The source of the PCE cannot be identified at this time nor can the extent of its contamination.

None of the above chemicals were detected in any of the samples. Samples from the three wells also were analyzed for ethylene dibromide (EDB), Dibromochloropropane (DBCP), and other pesticides. None were present in amounts above detection limits.

Samples from well 31/12-03G02 (Dalidio "C") also were analyzed for glyphosate, aldicarb, paraquat, and dithiocarbamates. None were present in amounts above detection limits. Samples from 33 wells in the basin and 20 in Edna Valley have been analyzed for nitrate ion. Only two wells in the basin and two wells in Edna Valley produce water containing nitrate ion in excess of the allowable limit of 45 mg/l specified in Title 22, CCR. Data for these wells are presented below.

Well Number	Area	Well Use	Years Sampled	NO_3 (mg/l)
31/12-01N03[1]	Basin	Stock	1954	67
31/12-12E03	Basin	Irrigation and Stock	1965-68	124
31/13-19H02[2]	Edna Valley	Irrigation	1954-68	62
31/13-27R01	Edna Valley	Domestic	1965-68	149

[1] *This well also was sampled in 1967.* $NO_3 < 45$ *mg/l.*

[2] *Well depth = 110 feet*

The reason for the excessive nitrate concentration in water from these four wells has not been determined.

The Pacific Beach #1 and #2 wells produce a magnesium-calcium bicarbonate or sodium bicarbonate water that generally is hard (total hardness exceeds 200 mg/l). Three other wells produce water that exceeds the total dissolved solids and specific conductance limits specified in Section 64473, Title 22, CCR.

Water quality data are available from two of the wells that penetrate terrace deposits. Both yield a poor quality magnesium bicarbonate water with a total dissolved solids content that exceeds the recommended MCL contained in Section 64473, Title 22, CCR.

Both the surface water and ground water in the basin is hard to very hard. Ground water in Edna Valley is equally hard. Data for range of hardness and average hardness as calcium carbonate is given below.

Source	Area	Samples	Hardness Min.	Hardness Max.	Hardness Average
Ground water	Basin 3-9	44	270	956	546
Ground water	Edna Valley	28	125	977	471
Surface water	Basin	6	336	562	382

None of the samples obtained by DWR were analyzed for either iron or manganese. Of those obtained by the City as part of the current study, ten wells produced water with both iron and manganese levels below the MCL as specified in Title 22, CCR. Well 31S/12E-03K02, the Corporation Yard well, produces water meeting standards for iron but manganese is present at 0.11 mg/l which exceeds the MCL of 0.05 mg/l. The water is very similar to one sample obtained from Laguna Lake, which also had a manganese content of 0.11 mg/l.

Samples were obtained from four City wells for analysis of total alpha activity. All samples contained less than 5 picocuries per liter of total alpha activity, which is the MCL specified for public water systems in Section 64441, Title 22, CCR.

Section 4

WATER BUDGET AND BASIN HYDROLOGY

4.1 Introduction

In order to determine the sustained yield of the San Luis Obispo Ground Water Basin, it was necessary to analyze the long-term hydrologic balance in the basin. In particular, the long-term effects of recharge and pumping are critical in determining sustained yield.

The base period used for the hydrologic balance was water years 1978 through 1989. This period was selected because it had the most data available, the period includes both wet and dry cycles in the hydrology of the basin, and represents the most recent water supply and demand for the area. The 1977 drought was not included in the base period since the inclusion of this water year would have unreasonably "thrown" the average values of this eleven year period. Water level records and other data collected during and following the 1977 event were examined, however, in evaluating other aspects of the basin.

The water budget of the ground water basin is based on the hydrologic balance equation:

Change in Storage = Supply - Withdrawals

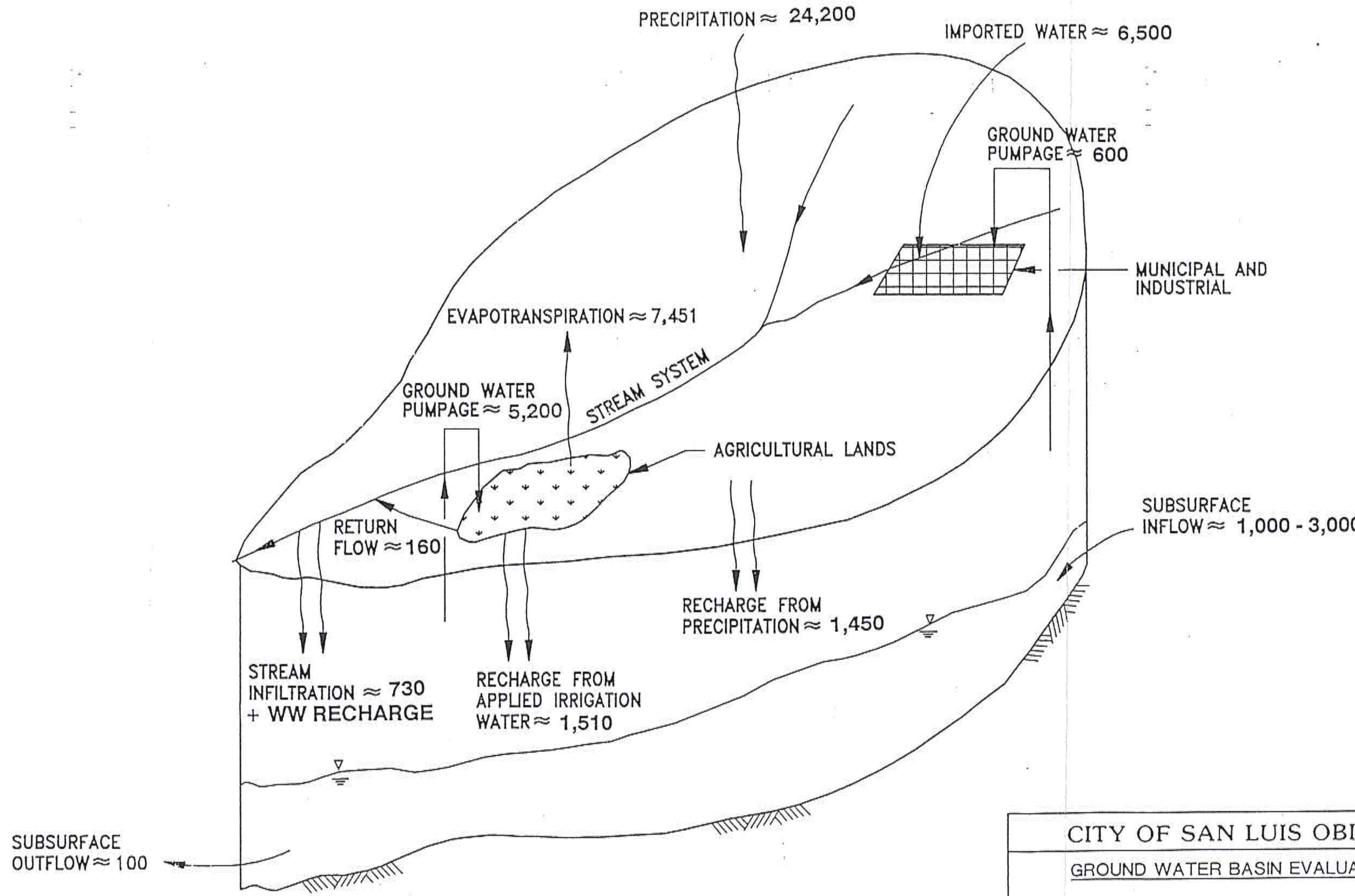
The components of the hydrologic balance, sources of data, and the present and future conditions are discussed below. These components are shown in **Plate 9.**

4.2 Sources of Supply

The sources of water for users within the basin consist of precipitation, local stream flow, water imported from nearby reservoirs, reclaimed effluent, and ground water.

Precipitation

The estimate of precipitation for the study area was obtained from the DWR gaging station No. 7851-00 located on the California Polytechnic State University Campus. These data are assumed to be representative of the entire study area. The average annual rainfall in the area is 25 inches with a minimum of 11.9 inches in 1990 and a maximum of 49 inches in 1978. This correlates to an average annual precipitation of 24,000 acre-feet over the entire study area.



Average annual values are expressed in acre-feet

CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

COMPONENTS OF HYDROLOGIC BALANCE IN THE GROUND WATER BASIN

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PLATE 9

In order to estimate the recharge and runoff from rainfall within the basin boundary, the Soil Conservation Service (SCS) method of rainfall-runoff computation was used. According to the SCS definition, when runoff from individual storms is the major concern, the soil properties can be represented by a hydrologic parameter, "the minimum rate of infiltration for bare soil after prolonged wetting." The influences of both the surface and the horizons of soil are thereby included. This parameter is used by SCS as a qualitative classification of soils into four hydrologic groups[2]:

A. Low Runoff potential- Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderate fine to fine texture. These soils have a slow rate of water transmission.

D. High runoff potential- Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

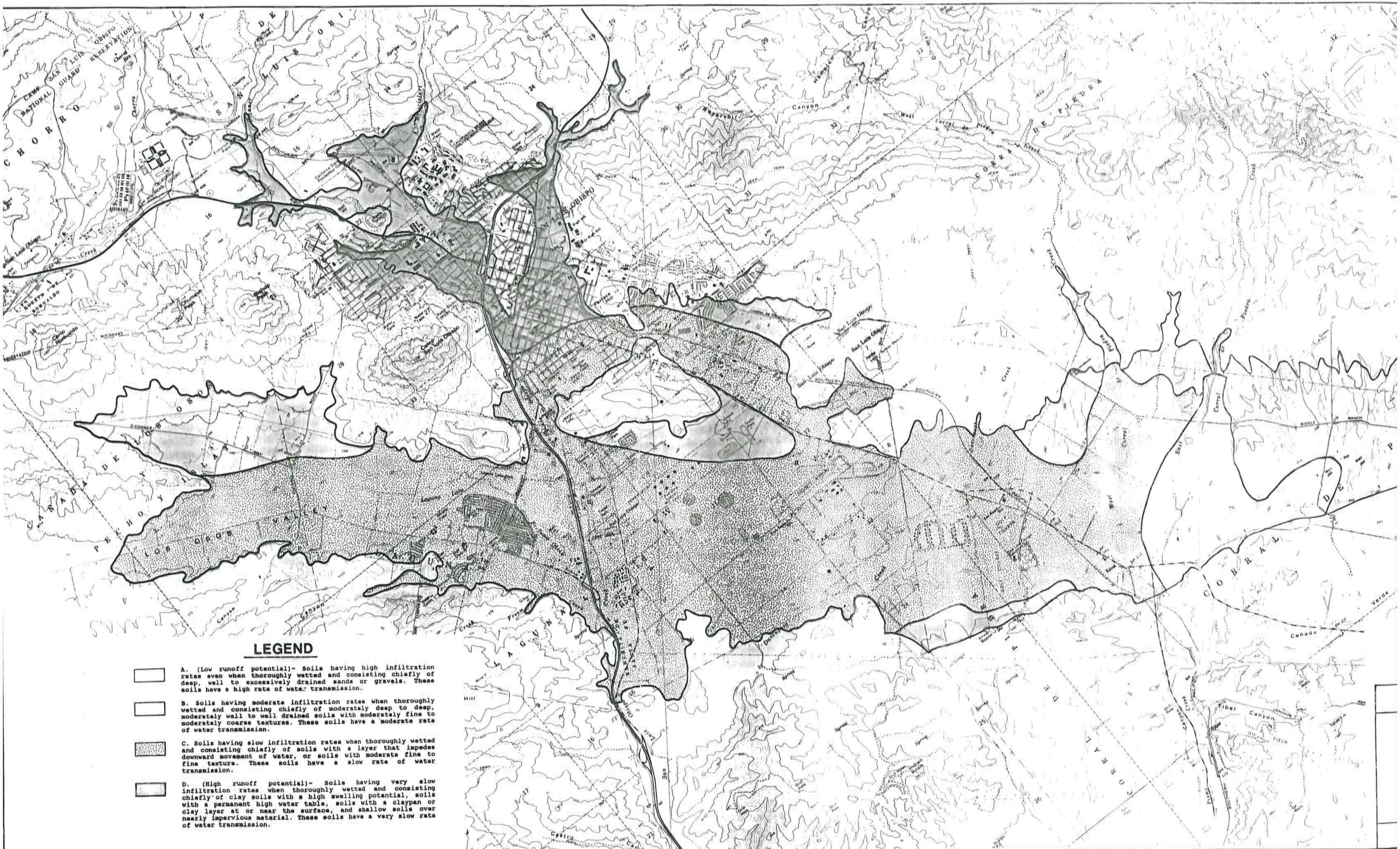
Based on the SCS soil survey maps available for the County, a composite hydrologic soil map was developed (**Plate 10**). In order to compute the average annual infiltration rate in the basin, the following equation is recommended by SCS:

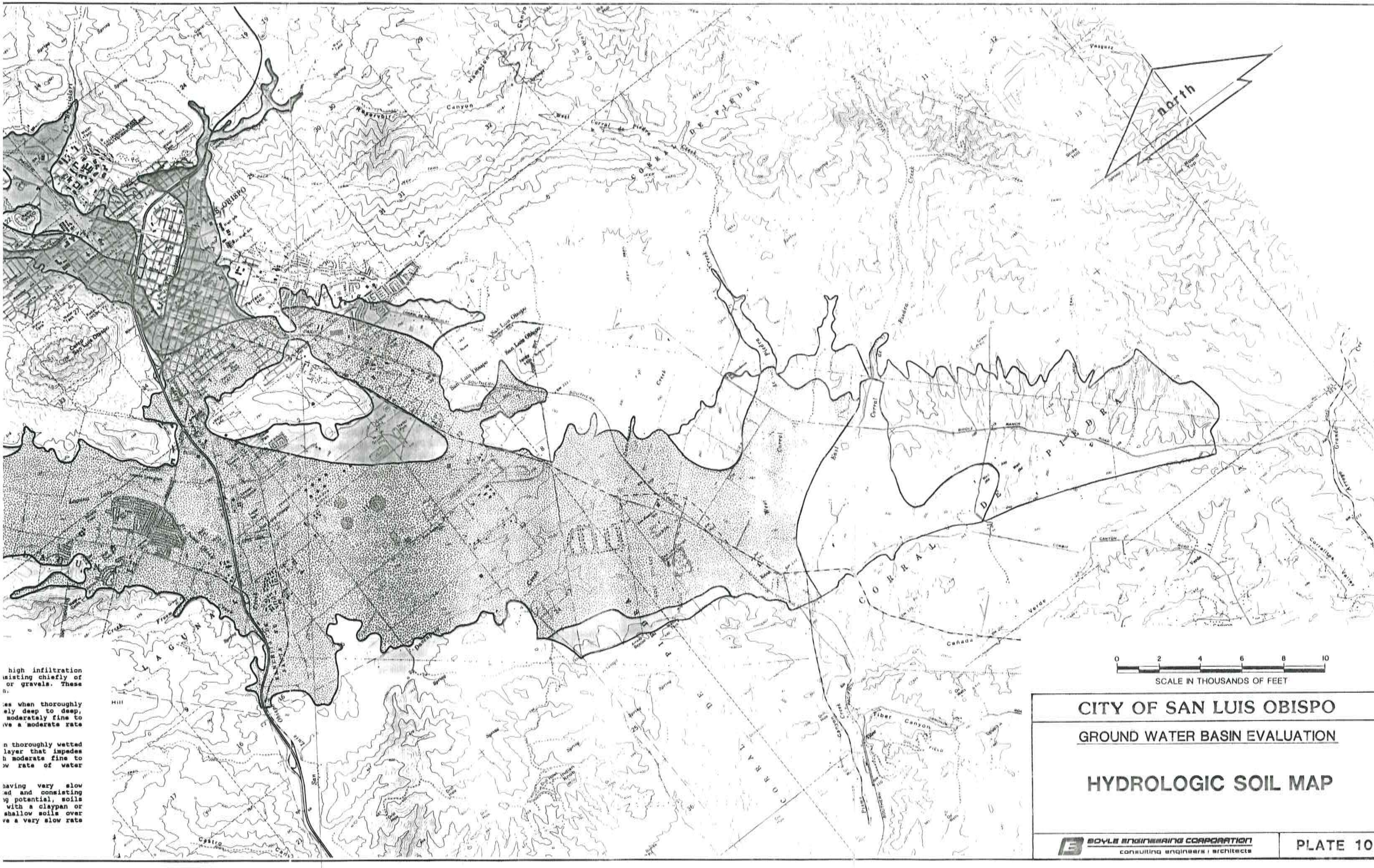
$$S = \frac{1000}{CN} - 10$$

In which CN is a curve number derived from information on hydrologic soil types, crop patterns and irrigated acreages. In general CN has a range of 20 to 100, with 100 representing most impervious surfaces such as asphalt or concrete. In the case of this study area, a CN of 75 was arrived at based on the crop types and irrigated acreage provided by the County Agricultural Commission. From the above equation, the average infiltration from rainfall would then be about 3.3 inches or 1,450 acre-feet per year in Basin 3-9 and a total of 3,200 acre-feet/year over the entire study area.

---

2 U.S. Department of Agriculture, 1985.


SAN LUIS OBISPO
CHORRO
CAMP SAN LUIS OBISPO NATIONAL GUARD RESERVATION
CORRAL DE PIEDRA
LOS OSOS
CANADA DE LOS OSOS
PECHO Y ISLAY
LOS OSOS VALLEY
LAGUNA
CORRAL DE PIEDRA
Canyon
Tiber Canyon
LEGEND
A. (Low runoff potential)- Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderate fine to fine texture. These soils have a slow rate of water transmission.
D. (High runoff potential)- Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.



high infiltration
isisting chiefly of
or gravels. These
n.

tes when thoroughly
ely deep to deep,
moderately fine to
ive a moderate rate

n thoroughly wetted
layer that impedes
h moderate fine to
ow rate of water

having very slow
ed and consisting
ig potential, soils
with a claypan or
shallow soils over
ve a very slow rate

CITY OF SAN LUIS OBISPO

GROUND WATER BASIN EVALUATION

HYDROLOGIC SOIL MAP

BOYLE ENGINEERING CORPORATION
consulting engineers / architects

PLATE 10

Local Stream flow

The two major streams in the study area are San Luis Obispo Creek and Stenner Creek. These creeks are seasonal and carry the winter runoff from the surrounding watershed. **Table 6** shows the annual flow for each creek as it enters the basin. Lacking sufficient information on amount and location of any diversion or tributary inflow made on these creeks, the average annual seepage from the streams to the ground water body was estimated based on the stream bed materials, soil types, and engineering judgement to be about 10 percent of the total flow, i.e., about 430 acre-feet/year, in Basin 3-9. This suggests that 90 percent of the surface water flow is lost to evaporation or leaves the basin rather than serving to recharge the basin. Possibilities for increasing the amount of seepage from streams through the construction of recharge facilities appears minimal, as discussed in Section 4-4. There are good opportunities to employ basin management techniques which would increase recharge from stream flow as is discussed in Section 5.

Table 6

Stream Flow Records in Acre-Feet

Water Year*	San Luis Obispo Creek	Stenner Creek
1978	4,640	5,630
79	410	520
80	2,760	3,860
81	870	960
82	1,230	1,710
83	8,490	6,520
84	660	1,240
85	380	380
86	4,410	-----
87	320	-----
88	380	-----
89	330	-----

* *Water year extends from October 1 to September 30.*

Imported Water

Imported water for municipal and industrial (M&I) use is supplied by two reservoirs in the County located outside the study area, the Whale Rock and Salinas (Santa Margarita Lake) reservoirs. Whale Rock reservoir is located about one-half mile northeast of the community of Cayucos and has a storage capacity of 40,600 acre-feet. Currently, the reservoir is estimated to yield 4,400 acre-feet per year, of which 660 acre-feet have been assigned to downstream users. The reservoir provides about 2,060 acre-feet to the City, 410 acre-feet to the California Men's Colony at Camp San Luis Obispo, and about 1,270 acre-feet to California Polytechnic State University. Surplus water is also being provided to the City of Morro Bay on a temporary basis.

Salinas reservoir is located about 7 miles southeast of the community of Santa Margarita. The storage capacity initially was 26,000 acre-feet with a firm yield of 5,000 acre-feet per year. However, due to sedimentation, both the storage capacity and the yield have been reduced. The present yield is estimated to be 4,800 acre-feet per year, which is entirely allocated to the City.

Reclaimed Waste Water

In general, reclaimed waste water is used mostly for landscape irrigation and golf course irrigation. Although the City of San Luis Obispo is not actively reclaiming wastewater for such purposes, a portion of the treated effluent does contribute to the recharge of the basin.

The rate of average annual effluent from the City of San Luis Obispo plant for the base period has been 2,500 acre-feet. It is estimated that after evaporation and other losses are taken into account, about 75 percent of this effluent, or 1,875 acre-feet, returns to the San Luis Obispo Creek. While this return flow does benefit the localized area, the location of the treatment plant within the basin (ie. near the outflow from the basin) does not allow significant basin recharge. Therefore, in the overall water budget, recharge from the City's wastewater treatment plant is estimated to be approximately several hundred acre-feet per year. Note that the planned relocation of the City's wastewater treatment plant outfall is expected to favorably affect the amount of treated effluent that recharges the basin.

The potential for reclaiming a larger portion of the City's treated waste water represents one of the most likely means of supplementing ground water supplies at this time. This could be accomplished by either direct recharge (injection wells or other), or by treating effluent to a degree suitable for irrigation/agricultural purposes. Since the potential volume of treated wastewater available for recharge is large when compared to the storage volume of the basin, it is imperative to maintain a high quality effluent to mitigate degradation of overall basin quality and of native vegetation. This is discussed more in Section 5

Ground Water

Ground water is the major source of supply for both M&I and agricultural use. It forms about 85 percent of the study area's dependable water supply. Many individuals and different local water districts in the rural areas have their own wells which have operated for years. The agricultural sector relies on ground water for almost all irrigation requirements. There is currently no system for monitoring overall ground water pumpage in the San Luis Obispo Basin. The only areas where well production is monitored are the City of San Luis Obispo, the Country Club, and the Edna Road water supply systems of the Southern California Water Company. An estimate of the ground water pumpage was made by using well production records, where available, coupled with crop data and land use and population data provided by the County.

4.3 Water Use

Water use within Basin 3-9 is divided between agricultural use and M&I uses. The estimated annual agriculture use of 5,200 acre-feet is for irrigation of cultivated lands within Basin 3-9. The average annual M&I use of 7,300 acre-feet consists of water supplied to domestic, commercial, industrial, governmental, and recreational sectors in Basin 3-9. Of the 7,300 acre-feet per year demand, approximately 6,500 acre-feet per year is met from surface water supplies. The irrigated agriculture sector, therefore, uses about 42 percent of the total water supply within Basin 3-9.

Agricultural Water Use

Agricultural water use within Basin 3-9 was estimated based on the irrigated acreage and type of crop, the consumptive use of the crop (evapotranspiration), and irrigation efficiency, as shown in **Table 7**. The irrigated acreage data was supplied by the County Agricultural Commission. Estimates of crop unit water usage are made based on the crop type, soil conditions, and climatological conditions (DWR, 1986). An average irrigation efficiency is estimated for each crop based on the irrigation methods employed and on crop type (DER, 1986).

Because there are no records of surface water diversions for irrigation, the water required for irrigation was assumed to be fully supplied by ground water. Based on interviews with local agencies and Agricultural Commission staff, there is practically no irrigation tailwater, or surface runoff, during the irrigation season because of the sprinkler and drip irrigation systems used in the area and because there are no major drainage systems for the irrigated agriculture in the basin. The only tailwater may be due to the winter storm runoff. Therefore, 1 percent of irrigation applied water is assumed to be returned to streams in the form of irrigation tailwater. The estimated annual ground water pumping for agricultural lands is shown in **Table 8**, and is estimated to be 5,200 AFY.

Irrigation Water Recharge

The recharge from irrigation applied water is computed as follows:

Total applied water - Tailwater - Consumptive use by crops = Recharge

Total applied water is assumed to come from ground water pumping. An average basin irrigation efficiency of 68 percent is assumed, based on estimates from DWR (1986). In this manner the average annual recharge from irrigated agriculture in Basin 3-9 is estimated at 1,500 AFY **(Table 8).**

Municipal and Industrial Use

The M&I usage is limited to use within the City and rural residential areas, as shown in **Table 9.** The average water use rate for the rural communities is 120 gallons per day per capita based on 1986 DWR estimates. The rural community is estimated to use 100 percent ground water. Average M&I ground water use since 1978 is estimated to be 600 AFY, not including the recent City extractions.

Table 7

Estimated Irrigation Water Requirement

Basin 3-9

(1) Crop Type	(2) Irrigated Area (Acres)	(3) Unit Water Use (Ac-Ft/Ac)	(4) Irrigation Efficiency (%)	(5) (2)x(3)x(4) Irrigation Water Req. (Ac-Ft)
Vineyard	0	1.50	60%	0
Orchard	33	2.00	75%	90
Field Crops	75	1.90	70%	200
Vegetable	1152	1.70	60%	3260
Pasture	354	3.00	67%	1590
Nursery	20	2.00	75%	50
Other *	3637	N/A	N/A	---
Total:	5271			5190
Average:		2.02	68%	

Notes:

(2) Source: SLO County Agricultural Commission, October 1990.
(3) SLO County Master Water Plan Update, DWR (March 1986).
(4) SLO County Master Water Plan Update, DWR (March 1986).

* Non-irrigated range lands and native vegetation.

N/A = Not Applicable

Table 8

Estimated Recharge from Agricultural Lands

Basin 3-9

(1) Water Year	(2) Irrigation Water Req. (Ac-Ft)	(3) Surface Water Supply (Ac-Ft)	(4) Groundwater Pumping (Ac-Ft)	(5) Avg. Annual Precipitation (inches)	(6) Recharge from Rainfall (Ac-Ft)	(7) Irrigation Tailwater (Ac-Ft)	(8) Recharge from Irrigation (Ac-Ft)	(9) (6)+(8) Total Recharge from Ag Lands (Ac-Ft)
1978	5190	0	5190	49.00	1450	267	1402	2850
1979	5190	0	5190	19.78	1450	139	1531	2980
1980	5190	0	5190	33.35	1450	198	1471	2920
1981	5190	0	5190	18.48	1450	133	1536	2990
1982	5190	0	5190	28.61	1450	178	1492	2940
1983	5190	0	5190	47.15	1450	259	1410	2860
1984	5190	0	5190	18.80	1450	134	1535	2980
1985	5190	0	5190	14.76	1450	117	1553	3000
1986	5190	0	5190	30.48	1450	186	1484	2930
1987	5190	0	5190	14.04	1450	114	1556	3000
1988	5190	0	5190	19.87	1450	139	1530	2980
1989	5190	0	5190	17.14	1450	127	1542	2990
1990	5190	0	5190	11.90	1450	104	1565	3010
Average:	5190	.0	5190	24.9	1450	161	1508	2960

Notes:

Total Irrigated Acreage (based on 1989 land use data): 5271 acres.

(6) Computed as (3.3/12)*Irrigated acreage, where 3.3 is the average annual rainfall infiltration in inches. Recharge from rainfall is a function of soil type, not directly correlated to rainfall amount.

(7) Percent of total applied water and precipitation that is considered to be irrigation return flow, and is assumed to be: 1%

(8) Includes range lands and native vegetation, computed as [(2)-(7)-IE*(2)], where IE is the average basin irrigation efficiency.

Table 9

Estimated Municipal and Industrial Water Demand

Basin 3-9

(1) Water Year	(2) Urban Population	(3) Surface Water Supply to City (Ac-Ft)	(4) GW Supply to the City (Ac-Ft)	(5) Total Supply to the City (Ac-Ft)	(6) Rural Population	(7) Rural M&I Water Use Rate (GPD/Capita)	(8) (6)x(7) Pumping in Unincorp. areas (Ac-Ft)	(9) (4)+(8) Total M&I Pumping (Ac-Ft)
1978	33550	5830	None	5830	3650	120	490	490
1979	34510	4390	None	4390	3680	120	490	490
1980	35470	5400	None	5400	3700	120	500	500
1981	36440	6960	None	6960	3730	120	500	500
1982	37400	6500	None	6500	3750	120	500	500
1983	38370	6640	None	6640	3780	120	510	510
1984	39330	7580	None	7580	3800	120	510	510
1985	40290	7720	None	7720	3830	120	510	510
1986	40480	8030	None	8030	4330	120	580	580
1987	40660	8490	None	8490	4840	120	650	650
1988	40840	8180	None	8180	5350	120	720	720
1989	41030	6260	240	6500	5860	120	790	1030
1990	42200	3030	1770	4800	6210	120	840	2610
Average:	38500	6540	1005	6700	4350	120	580	740

Notes:
(2) Population estimates from SLO County Land Use Element.
(3) Records of water delivery to City from the treatment plant - 2% system losses.
(4) City of SLO well production records.
(6) Population estimates from SLO County Land Use Element.
(7) SLO County Master Water Plan Update, DWR (March 1986).

4.4 Ground Water Recharge

Recharge to the ground water basin is derived from infiltration of rainfall, applied irrigation water (deep percolation), and seepage losses from stream flow. The estimated infiltration from these sources was based on the hydrologic soil types for the study area shown on Soil Conservation Service (SCS) soil maps. Runoff curve numbers were computed using the SCS method. The average annual ground water inflow from infiltration of rainfall through the soil was estimated to be about 3.3 inches. Although rainfall varies from year-to-year, the infiltration rate from rainfall holds fairly constant due to the composition of the soils. Thus, the estimated 3.3 inches per year of rainfall infiltration is shown to be constant throughout the base period **(Table 8)**. This rainfall is assumed to infiltrate through irrigated agricultural land as well as non-irrigated lands such as native vegetation and range lands.

DWR (1958) has estimated that recharge to the Basin 3-9 amounts to 2,250 acre-feet per year, or about 0.2 AFY per acre. Results of the present study indicate that the average recharge to the basin for the years 1978 through 1990 is 3,650 AFY, or about 0.45 AFY per acre (see **Table 10**). The new estimate is based on updated agricultural land use information, recent SCS soil surveys and considering new geologic and hydrogeologic information. Since the long term constant water level hydrographs **(Plate 6)** support the new estimates of basin recharge, the 0.45 AFY per acre is believed to be a more realistic estimate for the current basin conditions.

The soils of Basin 3-9 have been mapped and categorized by the Department of Agriculture. This categorization included an estimate of each series' permeability. From this data, the recharge capability of each subbasin has been derived.

The soils and their permeability and natural/artificial recharge capability for each subbasin within Basin 3-9 are briefly discussed below.

Stenner Subbasin. Natural recharge to the Stenner Subbasin averages about 290 AFY. Most of the soils of this subbasin are fine to very fine grained and range from loam to silty clay loam. They have permeabilities that range from less than 1 gallon per day per square foot (gpd/ft^2) to as much as 10 gpd/ft^2. Because much of this subbasin is urbanized, exposed soils in their natural state provide only minimal natural recharge to the ground water body and would not be suitable for siting of any artificial recharge project.

There also is an area of riverwash along Stenner Creek. This deposit extends about 4,000 feet along Stenner Creek near the Filtration Plant and covers about 18 acres. Riverwash is excessively drained and has a permeability in excess of 350 gpd/ft^2. This reach of Stenner Creek probably provides most of the natural recharge to the Stenner Subbasin. Surface soils suggest that this is a potential location for an artificial recharge project; however, the lack of significant thicknesses of water-yielding materials downstream would minimize any benefits gained from such a project.

No deposits of riverwash were identified by the Department of Agriculture as being present along Brizziolari Creek.

<u>City Subbasin.</u> Natural recharge to the City Subbasin averages about 440 AFY. The soils of this subbasin belong to the same series as those in the Stenner Subbasin. Because much of the City Subbasin is urbanized, exposed soils in their natural state provide only minimal natural recharge to the ground water body and wold not be suitable for siting of any artificial recharge project.

An area of riverwash extends along San Luis Obispo Creek, from its crossing with Highway 101 upstream a distance of about 6,000 feet; it covers an area of about 35 acres. This reach of San Luis Obispo Creek probably provides most of the natural recharge to the City Subbasin. Like conditions in the Stenner Subbasin, the lack of significant thicknesses of water-yielding materials in the City Subbasin would minimize any benefits gained from an artificial recharge project along this reach of San Luis Obispo Creek.

<u>Orcutt Subbasin.</u> Natural recharge to the Orcutt Subbasin averages about 290 AFY. All of the soils of this subbasin are fine to very fine grained, and range from loam to clay loam. Most have permeabilities that range from less than 1 gpd/ft^2 to 3.5 gpd/ft^2. A small area of clay loam is present near the intersection of Orcutt Road and Laurel Lane that has a permeability in the range of 10 to 35 gpd/ft^2. Because a significant part of the Orcutt Subbasin is urbanized, exposed soils in their natural state provide only minimal natural recharge to the ground water body and would not be suitable for siting of any artificial recharge project due to the general fineness of grain, the lack of significant thicknesses of water-yielding materials, and the limited extent of any area of benefit.

<u>Laguna Subbasin.</u> Natural recharge to the Laguna Subbasin averages about 2,630 AFY. Nearly all of the soils of this subbasin are fine to very fine grained, and range from clay to clay loam, silty clay loam, and sandy loam. According to the Department of Agriculture, even the channel of San Luis Obispo Creek is underlain by silty clay loam and sandy clay loam. All of these soils have permeabilities that range from less than 1 gpd/ft^2 to 10 gpd/ft^2. Like most soils in the other subbasins, these soils in their natural state provide only minimal recharge to the ground water body due to urbanization and other factors. Hence, they would not be suitable for siting of artificial recharge project.

One small area along the channel of Froom Creek has been identified by the Department of Agriculture as being composed of riverwash. This area is about 1,500 feet in length, is about six acres in areal extent, and is located at the foot of Mine Hill, about 1,000 feet west of Los Osos Valley Road. Infiltration of runoff from Froom Creek may provide some local recharge to the ground water body in the vicinity of Well 31/12-03N01 (Auto Park Way) and Well 31/12-10D01 (Calle Joaquin). If such is the case, enhancement of the riverwash along this reach of Froom Creek through construction of percolation ponds may tend to stabilize water levels at these two city wells during periods of high demand. The identification of such a potential artificial recharge site is based on the assumption that there would be an adequate supply of surface water in Froom Creek.

Table 10

Estimated Ground Water Recharge

Basin 3-9

(1) Water Year	(2) Agricultural Pumping (Ac-Ft)	(3) M & I Pumping (Ac-Ft)	(4) Total Groundwater Pumping (Ac-Ft)	(5) Recharge From Irrig. (Ac-Ft)	(6) Recharge from Rainfall (Ac-Ft)	(7) Stream Seepage Losses (Ac-Ft)	(8) Reclaimed WW Recharge (Ac-Ft)	(9) Total Groundwater Recharge (Ac-Ft)
1978	5190	490	5680	1402	1450	1027	300	4180
1979	5190	490	5680	1531	1450	94	300	3370
1980	5190	500	5690	1471	1450	662	300	3880
1981	5190	500	5690	1536	1450	184	300	3470
1982	5190	500	5690	1492	1450	294	300	3540
1983	5190	510	5700	1410	1450	1500	300	4660
1984	5190	510	5700	1535	1450	190	300	3470
1985	5190	510	5700	1553	1450	76	300	3380
1986	5190	580	5770	1484	1450	995	300	4230
1987	5190	650	5840	1556	1450	32	300	3340
1988	5190	720	5910	1530	1450	38	300	3320
1989	5190	1030	6220	1542	1450	34	300	3330
1990	5190	2610	7800	1565	1450	N/A	300	3310
Average:	5190	740	5930	1510	1450	430	300	3650

Notes:
(5) See explanation in text (Section 4-2).
(7) 10% of sum of Upper San Luis Obispo Creek and Stenner Creek.
(8) See explanation in text (Section 4-4).

4.5 Opportunities for Basin Recharge

The above discussion of recharge to the ground water body addresses only surface recharge (natural and artificial). Artificial recharge to the ground water body by way of recharge wells is an alternative method of placing water underground. However, there are several considerations to using this method that must be addressed, foremost of which is identification of a source for recharge. Imported water or retained winter stream flows may provide a source of water for recharge by injection but neither source appears likely for the City. Other considerations pertaining to the water to be recharged via injection wells include:

- Must be chemically compatible with the receiving waters (i.e., no precipitates can be allowed to form),
- Must be free of all particulate matter (i.e., mechanical clogging of the recharge well must be minimized),
- Must be free of iron, manganese, and iron bacteria,
- Must be treated to a level that equals drinking water standards (Title 22, CCR),
- Must be free of entrained air, and
- Recharge wells must be properly designed for maximum injection well efficiency.

Specific locations cannot be provided without benefit of detailed studies which would identify:

- Quantities, quality, and delivery points for water to be recharged,
- Detailed subsurface hydrogeologic conditions in the several candidate areas, and
- Determination of aquifer characteristics (transmissivity and storage coefficient) of the several candidate areas.

Absent any of the above data, it can be concluded that injection wells should not be sited in the Stenner, City, or Orcutt Subbasins, and that one or more artificial recharge wells may be able to be sited in the Laguna Subbasin in the vicinity of Los Osos Valley Road, from Pacific Beach School southeasterly to Highway 101.

We do not recommend that the City pursue injection wells at this time as other more attainable means of increasing the yield from the ground water basin are available to the City at this time.

4.6 Ground Water Storage Capacity

The ground water storage capacity of each of the subbasins comprising Basin 3-9 was estimated by analysis of water well driller's logs for 73 wells within the basin. For the purposes of this study "ground water storage capacity" is equivalent to "usable storage capacity," which is defined in DWR Bulletin 118:

> "The quantity of ground water of acceptable quality that can be economically withdrawn from storage."

In the case of Basin 3-9, this capacity is represented by that volume above rocks of the nonwater-bearing series and within the average saturated interval.

The average specific yield of sediments intercepted by each well was derived using driller's logs and specific yield values modified from those developed by Davis and others (1959). Although depth to water data on a number of well logs indicate that there is some degree of confinement throughout the basin (depth to water after completion often is less than depth to "first water"), for the purposes of determining storage capacity, it has been assumed that all ground water is unconfined.

Table 11 presents the estimated ground water storage capacity for each subbasin within Basin 3-9. Also shown is the estimated ground water storage capacity for that area of each subbasin within the corporate limit of the City. For purposes of comparison, the estimated ground water storage capacity of Edna Valley also is shown.

The estimated total ground water storage capacity for Basin 3-9 of 24,000 acre-feet essentially is in agreement with the previously published value of 22,000 acre-feet for the basin (State Water Resources Board, 1958; DWR, 1975).

Table 11

Ground Water Storage Capacity

Subbasin	Surface area (acres)	Average saturated interval (feet)	Average specific yield (per cent)	Estimated subbasin storage capacity (acre-feet)	Estimated storage capacity within City (acre-feet)
Stenner	630	18.8	9.3	1,100	500
City	988	20.4	15.8	1,400	1,100
Orcutt	644	5.3	12.3	400	200
Laguna	5,851	56.8	9.6	21,000	9,000
Basin 3-9	**Total**			**23,900**	**10,800**
Edna Valley	6,818	102.9	9.1	46,000	0

Note: *Estimated subbasin storage capacity derived from product of subbasin surface area, average saturated interval, average specific yield, and estimated subsurface configuration factor (ranges from 0.5 to 1.0).*

4.7 Subsurface Inflow and Outflow

Except for three areas to be discussed below, Basin 3-9 is surrounded by rocks of the nonwater-bearing series. Hence, for all practical purposes, most of the basin boundary can be considered to be a "no flow" boundary, that is there is no appreciable subsurface flow across this boundary. Any flow of ground water into the basin across this portion of the boundary is of very small quantity, is of poor quality (i.e. saline), and is not usable for most beneficial purposes. This is no outflow of ground water across this portion of the boundary. The location of the "no flow" portion of the basin boundary is depicted on **Plate 4.**

The three portions of the basin boundary that are not comprised of rocks of the nonwater-bearing series are:

1. Boundary with Edna Valley Contiguous Ground Water Terrane
2. Boundary with Basin 3-8, Los Osos Valley
3. Boundary at Santa Fe Narrows

Each of these are individually discussed below; their locations are shown on **Plate 4.**

Boundary with Edna Valley Contiguous Ground Water Terrane This portion of the basin boundary extends for a distance of about 2¾ miles and constitutes a portion of the southern boundary of the basin (see **Plate 4**). The boundary is formed by the surficial contact between sediments of the Paso Robles Formation in Edna Valley with those of the alluvial deposits in the basin. Several isolated outcrops of rocks of the nonwater-bearing series occur along this portion of the basin boundary. Data suggest that Paso Robles sediments extend in the subsurface to the north of this portion of the boundary.

Water level data (see **Plates 7 and 8**) suggest that ground water moves from Edna Valley across this boundary and into the basin. The quantity of subsurface inflow to the basin in this area cannot presently be determined due to a lack of reliable data. However, the quantity is estimated to be as much as several thousand acre-feet per year.

Boundary with Basin 3-8 This portion of the basin boundary is at the surface water divide between the Baywood-Los Osos portion of Los Osos Valley (Basin 3-8) and the Laguna Lake portion of Los Osos Valley (Basin 3-9). It has a length of about 2,000 feet and is underlain by sediments of the Paso Robles Formation. According to Yates and Wiese (1988) little or no ground water moves from Basin 3-9 into Basin 3-8. Because well data are lacking in the vicinity of this portion of the basin boundary, it is assumed that there is no movement of ground water in either direction across the surface water divide and hence, this portion of the boundary of Basin 3-9 is assumed to be a "no flow" boundary.

Boundary at Santa Fe Narrows San Luis Obispo Creek exits Basin 3-9 at this location. This portion of the basin boundary is about 500 feet long and is composed of stream channel deposits occupying a notch cut in rocks of the nonwater-bearing series. There are no subsurface data available to determine the depth and permeability of the stream channel deposits at this location. It is estimated that the deposits are at most 75 feet deep.

As surface water exits the basin, so does ground water, moving as underflow in the stream channel deposits. Because of a lack of water-level and other subsurface data, it is assumed that the ground water gradient approximates that of the surface water gradient at this location and it is assumed that the stream channel deposits have an average permeability of about 1,200 gallons per day per square foot. Consequently, it is estimated that subsurface outflow from the ground water basin is about 100 acre-feet per year. This value assumes that ground water (i.e. San Luis Obispo Creek underflow) continually is at the ground surface. During extended dry periods when surface water flow is nonexistent and the elevation of the ground water surface declines, outflow will be less. Further, as potentiometric levels in the basin decline (as during extended drought periods), the elevation of the potentiometric surface could decline below that of the "bedrock lip" at this location, and subsurface outflow would cease.

4.8 Evaluation of Sustained Yield

The maximum quantity of water that is available from a ground water basin on an annual basis is defined as the basin's sustained yield. This yield is limited by detrimental effects that would be caused by over pumping and by operating the basin in a manner such that extractions exceed replenishments.

If ground water is withdrawn at a rate greatly in excess of replenishment (ie., in excess of recharge), mining of the resource results and the basin soon can be placed in a state of overdraft. If on the other hand, extractions are maximized but do not exceed long-term replenishment, then the sustained yield of the basin is attained.

Because of the rigid court definition of the term "safe yield"[3], the California Department of Water Resources and other water planning agencies now use the more general term "sustained yield" to describe long-term optimum extractions of ground water from a basin. If a basin is operated to exceed its sustained yield, undesirable results may occur, such as falling ground water levels, uneconomic pumping lifts, deteriorating water quality, land subsidence, and in the case of coastal aquifers, sea-water intrusion.

In order to determine the sustained yield of a basin, it is necessary to analyze the undesired results that may accrue which would result in an overdrafted basin. Factors

---

3 " 'The maximum quantity of water which can be withdrawn annually from a ground water supply under a given set of conditions without causing an undesirable result'. The phrase "undesirable result" is understood to refer to a gradual lowering of the ground water levels resulting eventually in depletion of the supply." (Los Angeles v. San Fernando)

that govern the sustained yield determination may be (a) a progressive reduction of the water resource which would result in an overdraft condition, (b) economic considerations which are due to increased pumping costs when pumping lifts are increased beyond a given level, and (c) water quality considerations which can include pumping water of poor quality or drawing of polluted water from nearby areas.

In the analysis of the sustained yield of Basin 3-9, it was concluded that the economic and water quality data are very limited and could not be used as major factors in the analysis. Thus, sustained yield of the basin is determined based on the inflows and outflows relating to the basin.

The average annual recharge to the basin from the surface sources is estimated to be 3,650 AFY. Agricultural and M&I extractions total approximately 5,800 AFY. The average annual subsurface outflow from the basin is estimated about 100 AFY through the underflow in the San Luis Obispo Creek channel deposits at Santa Fe Narrows. Water level contours indicate that the gradient of water movement is in the direction of Basin 3-9 from Edna Valley. While sufficient data do not exist to state specifically what this rate of inflow is, long-term records of water levels throughout the basin indicate that the basin has not been overdrafted. Therefore, the estimated inflow from Edna Valley coupled with seepage from stream surface flow and from treated effluent recharge is equal to annual extractions. Hence, the sustained yield of the basin presently is estimated at 5,900 AFY. ←**

The City is currently extracting ground water at a rate of approximately 2,000 AFY, which when combined with agricultural pumping totals approximately 5,900 AFY. In doing so, a short-term overdraft of the basin is occurring. However, the City's pumping is serving to make greater use of the treated wastewater and has probably increased the amount of recharge associated with that source. Moreover, future use of the City wells as described in Section 5 is expected to increase the recharge to the basin (thus, increase ground water available for City consumption) by several thousand acre feet. We conclude that the City can extract several thousand acre feet (approximately 2,000 to 3,000 AFY) of ground water annually *if steps are taken* to increase available recharge from the wastewater treatment plant and if the basin is properly managed to better utilize recharge from stream flow. This is discussed in Section 5.

In a previous study, DWR (State Water Resources Board, 1958) estimated the maximum sustained yield of the basin to be 2,000 AFY. The estimate was based on land use, soil, and geologic data available at the time. The surface recharge now is estimated to be 3,650 AFY, which is more than that estimated by DWR in 1958. In addition, it now is estimated that subsurface inflow from Edna Valley is more than the DWR estimate.

In the determination of sustained yield, although the governing factor was recharge from surface sources, the subsurface inflow and outflow are of significance. Therefore, aquifer tests in the vicinity of Edna Valley, near the boundary with Subbasin 3-8, and at Santa Fe Narrows would help significantly in the estimates of boundary flows.

Section 5

GROUND WATER MANAGEMENT STRATEGY

5.1 Evaluation of Existing City Well System

The City's six active municipal wells supply approximately 40 percent of the current water demand. Monthly ground water production totals from all City wells ranged from 158 to 217 acre-feet/month from February through September 1990.

Pacific Beach #1 and #2 are off-line and Fire Station #4 is expected to soon follow due to declines in pumping water level. Similarly, the Dalidio well has been throttled back to less than 100 gpm from its original pumping rate of 550 gpm last winter. The Auto Park and Calle Joaquin wells have not experienced significant declines in pumping water level.

Such declines are expected due to normal seasonal fluctuations and due to the lack of recharge from rainfall in recent years. Auto Park and Calle Joaquin may be capable of sustaining their yield more reliably than other City wells due to the fact that these wells tap relatively large volumes of water bearing materials and that these wells probably benefit from nearby recharge of treated effluent. This form of passive water reclamation is encouraged.

Boyle recommended to the City in a letter dated September 25, 1990, that a rotated well operations schedule be adopted. The intent of the rotated schedule is to allow several wells to recover for a week before putting them into use. Doing so may reduce the need to throttle back on the discharge rate, thereby lessening wear on the pumps.

No additional changes in current well operations are proposed at this time. The City is encouraged to continue to maximize ground water yield during the current drought and to minimize demand through the continuation of the water conservation program. Potential environmental impacts are discussed in Section 6.

5.2 Recommended Location of Additional Wells

Since 1988, the City has examined more than 52 potential well sites. Subsurface augering or drilling has been conducted on approximately half of these sites with the most recent round of exploratory drilling concluding in September 1990.

Of the seven sites drilled in September 1990, one was found to yield sufficient quantity for production purposes. This well is located in the Murray Street median and was pump tested at 100 gpm. Water quality results indicated a high level of manganese and specialized treatment is required to meet health standards.

Considering the extensive exploration and well construction program undertaken in the past two to three years and in light of remaining potential well sites on parcels owned by the City, we conclude that additional well construction within the City limits on City parcels is not recommended. We do recommend that the existing Mitchell Park well be re-designed for municipal use (plans for which are now underway). This must be coordinated with the Parks and Recreation Department and with the Architectural Review Committee.

Several private well owners have approached the City with a willingness to negotiate an agreement in exchange for use of well water. Most private well owners are seeking compensation that may outweigh the benefits of use of the well. For example, one large user proposed use of a well in exchange for free water supply equal to the yield of the well. The cost of supplying the well water to this particular user would not be recovered, plus the user may perceive an exemption from mandatory water conservation. In this case, it may be better to negotiate more reasonable terms so that use of the well would benefit the overall community.

Other private well owners have sought development rights in exchange for well water. Such terms are difficult to justify given the City's commitment to serve current customers.

The City may have the opportunity to negotiate for the use of relatively high producing wells that otherwise would be operated for agricultural purposes. Each offer of a private well should be carefully examined and benefits compared to potential drawbacks.

Other than areas within the corporate boundary, the hydrogeology of two areas near the City suggest a potential for relatively high yielding wells. These are south of the Airport area and along Lower Higuera Street near the southernmost Highway 101 interchange. Both locations are likely to consist of a relatively thick layer of unconsolidated materials and may yield in the order of 500 gpm. Exploration of these sites should include some initial exploratory methods (geophysics, etc.) followed by test well drilling, if appropriate. (Geophysical testing for an approximately 200 acre site to the south of the City is scheduled for the week of February 4, 1991.) Other overriding issues will affect the development of a well field outside the City limits, such as negotiating with private land owners and the cost of transporting such water to the City. The City would have to weigh carefully the jurisdictional and environmental impacts, and the transmission facility needs in evaluating sources outside the City limits.

We recommend that the City consider well field development in these two areas and proceed with a hydrogeologic exploratory program. If found to be promising, then the City should more carefully examine these water supply options as long-term supplies to the City.

5.3 Conjunctive Use

The City's options for future water supply include:

- Surface supply from Whale Rock and Salinas reservoirs
- Ground water
  - existing wells
  - use of downtown wells with manganese removal plant
  - use of private wells
  - exploration outside of City limits
- Activation of Hansen/Gularte surface supply
- Desalination
- State Water Project
- Other sources

It is within the scope of this evaluation to make recommendations regarding the conjunctive use of the ground water basin and the existing surface water supplies.

Conjunctive use of surface and ground water may be defined as the management of the two resources in coordinated operation such that the total yield of the combined system over a period of years exceeds the sum of the yields of the separate components of the system resulting from an uncoordinated program. There are several types of conjunctive use systems, the most relevant of which to the City is discussed here.

The City should study the possibility of coordination in the use of the surface water supplies from Salinas and Whale Rock Reservoirs with the ground water pumped from the existing wells in order to maximize the yield of the combined system. The San Luis Obispo Basin has a history of relatively rapid recovery following years of below average rainfall. In addition, the only point of subsurface outflow from the basin is through the Santa Fe Narrows and as base flow through the alluvial channel of the San Luis Obispo Creek. It is desirable to maintain the water level in the basin at a low enough level to prevent an outflow from the basin, thus storing the usable water in the ground water basin.

On the other hand, the surface reservoirs have large evaporative losses from the surface as well as an occasional spill during the rainy season. It is then desirable to keep the reservoirs full during the rainy periods and low during the drier periods of the year when evaporation rates are highest.

From a conjunctive use stand point, the long term planning of the basin should consider the use of surface supplies prior to the use of ground water resources, as long as no ground water is lost from the basin in the form of outflow. A monthly operational analysis of the reservoir system along with the ground water basin operations would be necessary to determine the preferred mix of water as well as the timing of use from each source.

For the current operations during the drought period, it is recommended that the City continue to judicially use the ground water from the existing wells and allow the surface reservoirs to fill during the forthcoming rains, as long as there are no spills from the surface reservoirs.

During years of "normal operation" when both reservoirs and the basin are full to near-full, we recommend that the City pump ground water during the winter months to the extent that water levels are low enough to prevent outflow from the basin. In the meantime, any spills from the reservoirs should be minimized. The surface supplies should then be drawn during the dry months before any ground water is pumped. A more detailed operational study is required to make specific recommendations on the timing and amount of use of each source.

Regarding the other ground water supply options, we do not recommend additional well activation during the current drought. The exception is the possible use of some private wells if reasonable terms can be negotiated for existing private wells that are not expected to interfere with existing wells. Also, the Mitchell Park well should be equipped for municipal use and is not expected to interfere with other City wells or known private wells.

The City has considered the construction of a manganese removal facility that would treat water from two existing City wells (Mission Street Tot Lot and Murray Street) plus one nearby private well for a total estimated annual yield of 400+ acre-feet. The basin in this vicinity consists of a relatively thin unconsolidated layer and is likely to decline rapidly during drought years. For this reason, the activation of these wells as a means of supplemental water during the drought is not recommended. In other words, it is likely that wells in this area will not sustain significant yield during a drought condition. However, this is a viable source in the long-term as it will allow year-to-year extractions in this portion of the basin. The City is recommended to consider construction of the manganese removal facility as a long-term supplemental water supply.

There are many aspects to consider in comparing alternative water supply options which are outside the scope of this evaluation. However, the City should recognize that the yield from both surface reservoirs and ground water supply are "rainfall dependent" and somewhat susceptible to drought impacts. For this reason, supplies not wholly dependent upon local rainfall patterns are desirable. State Water Project supply and desalination present such options.

5.4 Recommended Management Strategy

Several ground water management alternatives for the basin have been discussed by Merriam (1986) and John L. Wallace and Associates (1988a). Presently, some stream flow and ground water leave the basin, and do not contribute to ground water recharge in the basin. Ground water basins such as the San Luis Obispo Valley basin must be adequately pumped in order to maximize recharge. That is, when water levels are close to the ground elevation, there is little storage space for recharge. Substantial ground water pumpage is possible during sufficient stream flow periods from alluvial deposits in areas near streams.

In addition, reclaimed wastewater is a valuable source of water. Effluent could be treated and used directly for crop irrigation, lakes, and golf courses as permitted under current Department of Health Services regulations. On the other hand it could be recharged, either in percolation ponds or in normally dry/modified stream channels, and subsequently pumped for reuse.

Managing the ground water basin entails coordinating pumpage with surface water supplies so as to minimize runoff of stream flow out of the basin. In addition, at some point in the future, attempts should be made to better match the quality of the water pumped with its use. That is, as much ground water of potable quality should be used for that purpose as possible, and water with contaminants such as nitrate, should be used for irrigation.

Problems with well interference can be minimized by siting new wells at an adequate distance from existing wells (approximately one-half mile or less nearer to the creeks), and by conducting aquifer tests, so that drawdowns at various pumping rates can be predicted for new wells.

5.5 Recommendations for Actions by the City

The following recommendations are made relative to basin management and future well construction:

1. Static water levels should be measured at least quarterly in all City wells (active and unused). Spring and Fall measurements would be done at the same time that other wells are measured by the County. If the well is pumping prior to these measurements, the time since pumping stopped should be recorded. The pump should be off for at least two hours prior to these measurements.

2. When future wells are drilled, well efficiencies should be determined from constant-rate pump tests. The apparent low efficiencies of many of the new City wells should be investigated and improved well design, development and testing techniques implemented. Proper well construction procedures include the use of reverse-circulation rotary drilling (without using bentonite drilling fluid), use of appropriate filter material and slot size, and packer isolation of selected intervals during well development.

3. Amounts of recharge from treated effluent to San Luis Obispo Creek should be measured by metering flow in the creek at two locations, one upstream and one downstream of the City's outfall.

4. The feasibility of utilizing geophysical surveys (electrical, gravity, or seismic) should be investigated to determine the thickness and nature of the alluvial materials at potential well sites. Further, down-hole geophysical methods (electric logs) should be utilized in each new well constructed by the City. Such down-hole methods will assist with well design by identifying the depth and thickness of water-yielding zones.

Section 6

ENVIRONMENTAL IMPACTS

6.1 Withdrawals in Excess of Sustained Yield

Withdrawals in excess of sustained yield is a common occurrence within the basin, particularly in dry years. During the current prolonged drought the withdrawals in excess of sustained yield have occurred for an extended period of time. Normally, during the winter months the basin is replenished, agricultural extractions drop off significantly, and water levels return to their previous levels. Continuation of this method of operation of the basin is not expected to result in any adverse environmental impacts. The only adverse impact that might be experienced would be consolidation of clays in the Laguna Lake area from long term overdrafts which in turn could result in some minor shallow subsidence. This is not expected to be a problem since the system has not operated in this fashion for a sustained period of time. Reports of suspected subsidence should be cross-referenced to the City's established bench mark system to determine whether significant shallow subsidence has occurred. If so, further specific studies should be conducted to verify the extent and possible causes of such subsidence.

6.2 Water Quality Considerations

Past experience with operating the basin by withdrawals in excess of sustained yield in the summer months followed by winter recharge has not resulted in water quality degradation over the years. However, sustained pumping to low levels in shallow water-yielding zones could result in impaired water quality from those wells during periods of excessive overdraft.

6.3 Mitigation Measures

The previous section of the report, Section 5, dealing with ground water management strategy, outlines a program for integrating the use of ground water into the overall water supply system. These strategies should be sufficient to preclude the types of adverse impacts described above.

APPENDIX A
REFERENCES

California Department of Water Resources, "California's Ground Water", Bulletin No. 118, September 1975.

________. "Ground Water Basins in California: A Report to the Legislature in Response to Water Code Section 12924", Bulletin 118-80, January 1980.

________. "San Luis Obispo County Master Water Plan Update", Southern District Report, March 1986.

________. "Geohydrology and Management of Los Osos Valley Ground Water Basin, San Luis Obispo County", Southern District Report, July 1989.

Davis, G.H. and others, "Ground-Water Conditions and Storage Capacity in the San Joaquin Valley, California", U.S. Geological Survey Water-Supply Paper 1469, 1959.

Ernstrom, Daniel J., "Soil Survey of San Luis Obispo County, Coastal Part", U.S. Department of Agriculture, Soil Conservation Service, September 1984.

Hall, Clarence A., "Geology of the Arroyo Grande Quadrangle, California", California Division of Mines and Geology, Map Sheet 24, 1973.

Hall, C.A., Jr. and others, "Geologic Map of the San Luis Obispo - San Simeon Region, California", U.S. Geological Survey, Map I-1097, 1979.

John L. Wallace & Associates, "Ground Water Study: Survey of Resources and Constraints Analysis", Report to City of San Luis Obispo, 1988a.

________. "Ground Water Study: Phase 3 Exploration Results", Report to City of San Luis Obispo, 1988b.

Loo, C. Ben. "Water Demand, Water supply, and Supplemental Water Needed, San Luis Obispo County", Department of Water Resources, Southern District, Technical Information Record No. 1335-8301-5, February 1986.

Merriam, John L., "Reconnaissance Study of Central Portion of San Luis Obispo Sub Basin and Dalidio Property", April 1986.

Schneider, Anne J., "Ground Water Rights in California: Background and Issues", Governor's Commission to Review California Water Rights Law, Staff Paper No. 2, July 1977.

State Water Resources Board, "San Luis Obispo Investigation", Bulletin No. 18, May 1958.

U.S. Department of Agriculture, Soil Conservation Service, "National Engineering Handbook: Section 4-Hydrology", March 1985.

Yates, Eugene B. and John H. Wiese, "Hydrogeology and Water Resources of the Los Osos Valley Ground Water Basin, San Luis Obispo County, California", U.S. Geological Survey Water-Resources Investigations Report 88-4081, 1988.