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April 15, 1983

Board of Supervisors
San Luis Obispo County
County Courthouse
San Luis Obispo, California 93408

Gentlemen:

In accordance with our agreement dated January 15, 1980, as amended, we have completed the necessary engineering studies and are pleased to submit our final report of the Phase I Water Quality Management Study for County Service Area No. 9. The report is presented in two volumes:

Volume I, report text and figures;
Volume II, appendices

Our study concludes that shallow groundwater in the Los Osos-Baywood Park area is contaminated by nitrate concentrations in excess of 45 milligrams per liter as NO_3, the maximum contaminant level for this constituent. The cause of the contamination is discharge of wastewater to the ground in the urban development area. Groundwater quality degradation is expected to increase in the future with continued development in this area.

We recommend that the County continue its program of water quality management by performing Phase II, Evaluation of Alternatives, of the Facilities Planning Study to determine the most cost-effective, viable alternative plan for improving water quality in this area. We further recommend that a more detailed assessment be made of the long-term safe yield of the Los Osos groundwater basin, and of the future water supply and water distribution needs in the planning area.

In bringing this Phase I study to a close, we express our appreciation to Mr. Clinton Milne and Mr. James L. Jonte of the County Engineering Department for their assistance. We will be pleased to discuss our findings, conclusions, and recommendations with you at your convenience.

Respectfully submitted,

BROWN AND CALDWELL

J. Lynn Hartford
Vice President

N. Thomas Sheahan
Project Manager

JLH:NTS:aa
Enclosure

San Luis Obispo County
Service Area No. 9

Los Osos
Baywood Park

PHASE I WATER QUALITY MANAGEMENT STUDY

Volume I - Project Report

April 1983

Brown and Caldwell

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CHAPTER 1

INTRODUCTION

San Luis Obispo County Service Area No. 9 (CSA 9) is experiencing a continued population growth in its residential areas. The growth is centered in the communities of Los Osos, Baywood Park, and Cuesta-By-Sea, which are shown in Figure 1-1. These communities, located immediately south of and adjacent to Morro Bay, receive their entire water supply from local groundwater sources. Wastewater disposal is through individual, on-site disposal systems and several community septic tank-leach field systems.

In recent years, there has been a concern by the County over the level of nitrate found in water samples from certain wells. These nitrate levels and the concentration of individual waste disposal systems in densely populated portions of the area indicate the potential for current and future degradation of water quality in the groundwater basin. In response to this concern, CSA 9 has undertaken a program of water quality management planning to identify and define the water quality degradation, to identify and evaluate feasible alternative plans for alleviating any water quality problems, and to provide proper planning for future wastewater management in this area.

HISTORY

Conflicting reports concerning the potential threat of groundwater quality degradation, if any, and the possible causes of nitrate levels found in groundwater quality samples, prompted the Regional Water Quality Control Board (RWQCB), Central Coast Region, to issue their Resolution Number 78-07 asking the State Water Resources Control Board (SWRCB) to perform a study of the area and to answer specific questions. That study was initiated in October 1978 and was expected to be completed in early 1979 in order to provide the basis for facilities planning studies to be subsequently performed by the County.

San Luis Obispo County expected that the SWRCB report would provide a complete Phase I, Problem Definition Study, as required for an adequate Step One, 201 Facilities Plan. Consequently, the County prepared a plan of study for Phase II, Facilities Planning Study, in order to complete the Step One Facilities Plan. Brown and Caldwell was selected in July 1979 to perform the Phase II investigation.

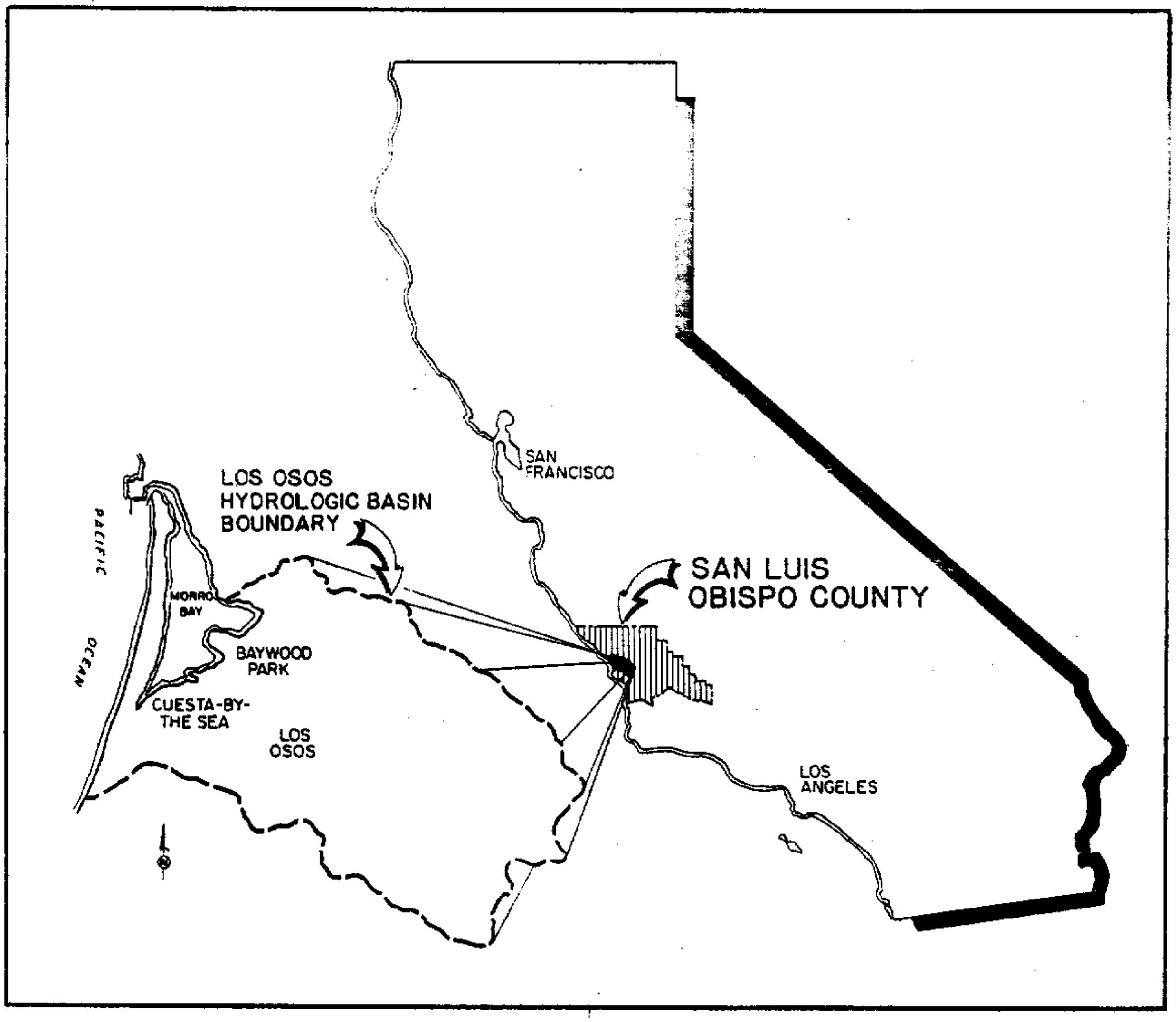

Figure 1-1 Location Map

Following completion of the SWRCB study in October 1979, a review was made of the study results by the County, the RWQCB, and other entities. It was generally agreed among the reviewers that the report did not represent an adequate Phase I study, and the question was raised concerning whether or not there had been sufficient data available to adequately perform such a study. In September 1980, Brown and Caldwell was asked to perform an evaluation of the data utilized in preparation of the SWRCB report, to provide an opinion as to accuracy, to propose a data acquisition program, if necessary, and to prepare a detailed scope of work for completing the Phase I study. The report presenting results of this study was submitted to San Luis Obispo County in December 1980. Brown and Caldwell was then asked to prepare a proposal for amending the current agreement for completing the Phase I study, and after negotiations the County requested grant funding through the SWRCB under the Clean Water Grant Program for funding of this effort. Following approval by the SWRCB, Brown and Caldwell was given formal notice to proceed with the Phase I study on July 16, 1981.

PURPOSE OF STUDY

This investigation is funded in part by the U.S. Environmental Protection Agency (USEPA) and by the State of California under the Federal Wastewater Treatment Works Construction Grants Program, and the State Clean Water Grants Program. The study, presented in two volumes, Volume I Project Report and Volume II Appendices, is termed a Phase I Water Quality Management Study and is aimed principally at determining the present and potential water quality problems, if any, in the study area. A decision whether or not to proceed with Phase II scope of work, the alternatives evaluation and problem-solving phase, will be made after review of this Phase I report.

PLANNING OBJECTIVES

The primary objective of this Phase I Water Quality Management Study is to provide data collection, analyses, and correlation together with problem identification and documentation within the study area. Following are the major elements of the objectives of this study:

1. Establish the geohydrologic framework of the Los Osos-Baywood Park Groundwater Basin and the water quality characteristics of the surface water and groundwater;
2. Determine the sources and characteristics of pollution being discharged, percolated, or leached into the surface water and groundwater causing water quality degradation.
3. Evaluate the effects of the sources of pollution upon water quality, and evaluate the natural mechanisms that may be contributing to the degradation of water quality in the study area;
4. Determine the impacts of continued wastewater discharge to the surface water and groundwater under existing conditions and future land-use plans, and with projected population increases;

5. Evaluate the existing land-use policies under different levels of development and their potential effects on surface water and groundwater quality;

6. Ascertain the significance of the existing and potential water quality problems.

ORGANIZATION OF STUDY

This investigation was carried out jointly by Brown and Caldwell, Pasadena, California, and the County of San Luis Obispo. The County staff provided much of the data used in the study and prepared portions of the draft report. Specifically, the County provided all of the information summarized in Chapter 3, performed the wastewater discharge inventory, and performed all field sampling and chemical analyses of water and wastewater samples. Project staff met periodically with the South Bay Water Quality Advisory Committee, composed of interested residents from the study area, and received valuable input and guidance from this committee. The detailed scope of work for this study is included in Volume II.

SOURCES OF INFORMATION

An investigation of this type must necessarily rely heavily on previously developed data and information. Agencies which have published or otherwise provided a significant amount of geohydrologic and water quality information include the U.S. Geological Survey, the California Department of Water Resources, the San Luis Obispo County staff, and other agencies and individuals. A complete bibliography of published sources of information, together with annotations showing location and availability of documents, is presented in Volume II. References used in the report are cited either in the text or in the list of references for each chapter presented at the end of this volume.

ACKNOWLEDGEMENTS

San Luis Obispo County appointed Mr. James L. Jonte as project coordinator for this study to coordinate the efforts of Brown and Caldwell with those of the County staff. Mr. Paul Broberg, and Mr. Glenn Britton of the County staff provided much of the data acquisition and report preparation work for the County, and Mr. Clinton Milne, Deputy County Engineer, provided direction, review, and

guidance of this effort. The participation of these members of the County staff, and other County personnel, was invaluable to this investigation and is greatly appreciated.

In addition to the various agencies mentioned previously that have furnished information, the assistance of the RWQCB, Central Coast Region, in providing needed data on wastewater dischargers and in overviewing and guiding the project, is appreciated. Mr. Roger Briggs of the RWQCB acted as project coordinator for this study and was very helpful throughout the planning and investigation stages. We also wish to thank the members of the South Bay Water Quality Advisory Committee for their time spent in reviewing the progress of the study and for their contributions to this investigation.

CHAPTER 2

SUMMARY

For the convenience of those readers who wish to obtain an overview of this study in a short time period, we have provided a summary of the important points of this report. Information pertaining to the nature and scope of this study is presented in a condensed form to allow the acquisition of a useable knowledge of this information as quickly as possible. Each of the major report chapters is described in a brief section below.

STUDY AREA CHARACTERISTICS

San Luis Obispo County Service Area No. 9, the Baywood Park-Los Osos Area, is located south and east of Morro Bay and comprises the Los Osos hydrologic sub-area of the San Luis Obispo hydrologic subunit of the Central Coastal Hydrologic Study Area. The study area boundaries, which coincide with the hydrologic boundary of the Los Osos hydrologic basin, encompass approximately 18,000 acres in the coastal region of San Luis Obispo County.

Topographically, the study area consists of Los Osos Valley, the southerly flank of Park Ridge, and the northern flank of the Irish Hills. Within the Irish Hills lies Clark Valley, a small alluvial valley. The Los Osos Valley is a gently rolling coastal plain. The western portion of the valley is covered with an upland area consisting of stabilized older sand dunes.

Typical of Southern California coastal areas, the study area experiences a Mediterrean-type climate. Annual precipitation averages approximately 17 inches per year, and falls primarily during the winter months.

The geology of the study area is characterized by an east-west trending synclinal depression in rocks of the Franciscan Formation. Lower Pleistocene sediments of the Paso Robles Formation cover the majority of the depression within the study area. Overlying the Paso Robles Formation are Upper Pleistocene sand dune deposits. These sand dune deposits occupy the western portion of the study area and cover the majority of the planning area within the study area

Current population within the study area is 10,933, as recorded in the 1980 census. The area has experienced rapid growth of population over the past decade, up from approximately 3500 people in 1970. The cultural environment within the study area is predominently suburban in the western portion of the basin, and primarily agricultural in the eastern portion. Commerce within the study area is almost entirely devoted to serving the needs of local residents and a small tourist trade.

GEOHYDROLOGIC CONDITIONS

Water demand within the study area is entirely supplied from groundwater within the Los Osos groundwater basin. The basin sediments in the study area comprise a fairly thick sequence of fresh water bearing rocks. These fresh water bearing sediments within the groundwater basin can be divided into two aquifer zones or groups of aquifers. The upper zone, or group of aquifers, consists chiefly of dune sand deposits occupying the upper 100-200 feet within the western portion of the study area. These upper aquifers contain a shallow, unconfined water table aquifer and a lower zone which contains groundwater in a semi-confined state. Below these aquifers is a transition zone, primarily made up of rocks of the upper Paso Robles Formation, which in certain instances yields water to shallow wells.

The transition zone, which lies below the dune sand deposits, provides an effective aquitard, restricting flow between the upper aquifers and the Paso Robles Formation aquifers. The thick sequence of Paso Robles Formation sediments comprise the largest fresh water source within the study area.

WATER QUALITY CHARACTERISTICS

Waters within the Los Osos hydrologic basin can be grouped into two different types of water based on their chemical characteristics. Surface runoff in Los Osos Creek and groundwater within the Paso Robles Formation aquifers are very similar in nature, having a magnesium and sodium bicarbonate character. Groundwater within the upper dune sand aquifers and surface runoff in Eto Creek and Eto Lake are chemically similar in their sodium chloride-sodium bicarbonate character. Chemical character of water within the basin is determined by the source of origin of this water. Water in the Paso Robles Formation aquifers is derived from surface water recharge to the aquifers from Los Osos Creek. Groundwater within the upper sand dune aquifers is derived chiefly from precipitation. Surface runoff in Eto Creek is derived from the discharge of groundwater from the sand dune aquifers. As such, the chemical characteristics of the sand dune aquifer groundwater and surface discharge of Eto Creek are similar.

A comparison of analyses of water quality samples taken from the Los Osos groundwater basin with the California Drinking Water Standards shows the water quality in the study area to be below the maximum contaminant levels or recommended limits, with the exceptions of nitrate and total dissolved soldis. An apparently good correlation exists between areas of high total dissolved solids and nitrates in groundwater and areas of urban development.

WASTE DISCHARGE CHARACTERISTICS

Wastewater in the study area includes septic tank effluent from domestic and commercial sources, agricultural return flow, and leachate from landscape irrigation. There is no industrial wastewater in the study area, and no toxic or hazardous wastes were encountered. Since the area is unsewered, domestic wastewater within the Los Osos basin is discharged to the subsurface through septic tanks and leach fields. Due to the recent rapid growth in population within the area and the fact that the entire water supply for the area is the underlying groundwater basin, there is much concern over the quality of the domestic and other wastewaters discharged to the basin. Although the wastewaters discharged within the Los Osos groundwater basin do not appear to contain large concentrations of contaminants, the accumulation of these contaminants is beginning to show an effect upon basin groundwater. This effect is manifested in an increase in total dissolved solids and nitrate concentrations within the shallow groundwater.

EXISTING WATER QUALITY PROBLEMS

Wastewater discharge in the planning area, and percolation of discharged wastewater to the groundwater table, is causing increased concentrations of nitrate and total dissolved solids in the shallow groundwater. Shallow groundwater quality immediately underlying the urban development area shows nitrate levels ranging from 25 milligrams per liter as NO_3 to greater than 45 milligrams per liter as NO_3, the maximum contaminant level for this constituent. In general, the municipal water supply systems produce water from wells which draw from the deeper Paso Robles Formation aquifers, so that direct recirculation of degraded groundwater does not generally occur. Where water supply is derived from the shallow water table aquifers, such as individual domestic wells, there is a potential health hazard from high nitrate concentrations.

FUTURE CONDITIONS AND POTENTIAL PROBLEMS

Population in the study area is anticipated to increase from its current number of approximately 11,000 persons to an absorption population approaching 29,000. Based on current water utilization factors, future water demand for the study area can potentially be greater than 6000 acre-feet per year with this absorption population. Under these conditions, the total consumptive use of groundwater from the groundwater basin would be approximately 2,700 acre-feet per year. This would reduce the subsurface outflow from the basin to approximately 470 acre-feet per year, which would be insufficient to retard sea water intrusion. Therefore, at absorption population the community within the study area would need to augment the existing supply. Under the anticipated future conditions, groundwater quality problems which exist today will most likely increase significantly in magnitude. It is anticipated that the character of wastewaters discharged within the study area will remain relatively the same in the future, however, the total waste loads entering the groundwater basin would increase dramatically. This would result in higher concentrations of nitrate, in the shallow groundwater, increased areal distribution of high nitrate and a general increase of total dissolved solids in the shallow groundwater. Should the increased water demand of the basin not be met by imported water supplies, the additional demand on the groundwater basin could allow sea water intrusion. Should this happen, it would be expected that wells located near the coastline would become unusable and have to be abandoned.

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

A detailed listing of specific findings, conclusions and recommendations is presented in Chapter 9. In summary, the Phase I Water Quality Management Study found nitrate contamination of the shallow groundwater in the planning area, with concentrations of nitrate in excess of the maximum contaminant level for this constituent. Nitrate contamination was correlated with urban development in the planning area and with total dissolved solids concentrations. The causative element for nitrate contamination of shallow groundwater is wastewater discharge from the urban development area. In this sense, wastewater includes sewage effluent from septic tanks in commercial and residential areas, landscape irrigation return water percolating past the root zone carrying contaminants to the water table, and irrigation return water from any agricultural activities occurring in the urban development areas. No geologic, hydrologic, or ecologic processes were found to have any significant effect on nitrate contamination in the shallow groundwater. Although no specific type of wastewater discharge could be pinpointed by water quality characteristics as the principal or most significant cause, the total wastewater discharge was found, conclusively, to be the cause of contamination, and septic tank effluent is a major contributor of nitrogen to the ground. As a result of definition of the water quality problems in the study area, it is recommended that San Luis Obispo County authorize completion of Phase II, Evaluation of Alternatives, of the Facilities Planning Study program. In addition, further definition of the geohydrology and safe yield of the groundwater basin is recommended. Finally, it is recommended that the County implement the detailed recommendations presented and establish a firm program of water quality and water quantity management for the Los Osos groundwater basin.

CHAPTER 3

STUDY AREA CHARACTERISTICS

This chapter presents a summary of the study area characteristics of the Los Osos hydrologic basin. A complete description of study area characteristics is included as Appendix III, in Volume II and was prepared by San Luis Obispo County Engineering Department for this study.

EXTENT OF STUDY AREA

The study area boundaries coincide with the boundaries of the Los Osos hydrologic basin as shown in Figure 3-1. The basin includes the westerly-draining half of Los Osos Valley and Clark Valley. It is bounded on the north by a line of hills known as Park Ridge, and on the south by the Irish Hills. The basin extends from the Morro Bay estuary eastward and inland approximately 6.5 miles. Total areal extent of the Los Osos hydrologic basin is approximately 18,000 acres.

PHYSICAL ENVIRONMENT

This section describes the characteristics of the study area in terms of its geography, topography, climate, hydrology, geology, and soils.

Topography and Geography

The Los Osos Valley is a relatively small Southern California coastal basin, consisting of a relatively flat alluvial plain lying between two parallel ranges of low-lying hills. The Irish Hills, which bound the study area on the southern side, range in elevation from 1,500 feet at the southeast corner of the study area, sloping gradually to a peak of approximately 1,300 feet at the length of the southerly study area boundary, and declining rapidly to sea level at the southwestern extremity of the study area. Park Ridge is composed of a linear series of volcanic necks which range from 800 to 900 feet in elevation for the full length of the northern boundary of the study area. Los Osos Valley is a relatively flat to slightly rolling alluvial plain near its eastern extremities, but is abruptly bisected by Los Osos Creek flood plain which trends north through the center of the study area. To the west of the flood plain is an elevated upland which consists of stabilized sand dunes. The undulating surface of the sand dune deposits ranges in elevation from sea level to more than 400 feet.

Drainage in the area is provided by Los Osos Creek, Eto Creek, several unnamed, less prominent depressions in the dune sands which provide drainage for part of the study area, and an unnamed tributary which flows westerly toward the ocean from the eastern extremity of the study area in Los Osos Valley, through Warden Lake, a marshy depression at the approximate midpoint of the study area, to a junction with Los Osos Creek just prior to its entry into Morro Bay. Los Osos Creek originates within the Irish Hills along the southern flank of the study area. The creek flows through Clark Valley, a small alluvial valley, enters the Los Osos Valley, and flows northward through that flood plain into Morro Bay. Eto Creek is a short but well defined water course occupying a depression in the dune sands. Eto Creek drains into Eto Lake and then into Los Osos Creek.

Climate

The climate within the study area is classified as Mediterranean. It is characterized by long, dry, warm summers with frequent ocean fogs. This is followed by a short, wet winter accompanied by cooler temperatures, with more than 80 percent of total annual precipitation occurring during the months of December through March. The cool onshore breezes, typical of California coastal areas, occur at all times of the year. Precipitation in the study area averages approximately 17 inches annually. The highland areas to the north and to the south of the Los Osos Valley receive considerably more precipitation, as shown by the contours on Figure 3-1. The average daily high temperature fluctuates between 60 and 70 degrees F. Average daily low temperature fluctuates between 40 and 55 degrees F.

Hydrologic Features

Surface water features include Eto Creek, Los Osos Creek and its tributaries, and a few small lakes and impoundments. The Los Osos groundwater basin underlies most of the study area. Analysis of rainfall data by the State Department of Water Resources (DWR) indicates that during an average year, approximately 5,800 acre-feet of surface runoff is generated. Of this amount, approximately 2,700 acre-feet flow into Morro Bay and approximately 3,100 acre-feet percolate deeply into the ground. Groundwater occurs in Holocene and Pleistocene sediments of the basin. These sediments include Holocene alluvium, Pleistocene old dune sands, and Lower Pleistocene Paso Robles Formation. Groundwater occurs at relatively shallow depths throughout the basin, and is generally of good quality with total dissolved solids concentrations ranging from about 100 to 500 milligrams per liter.

Geology

Geologic units of the study area are depicted on Figure 3-2. The Franciscan Formation forms the basement complex of bedrock

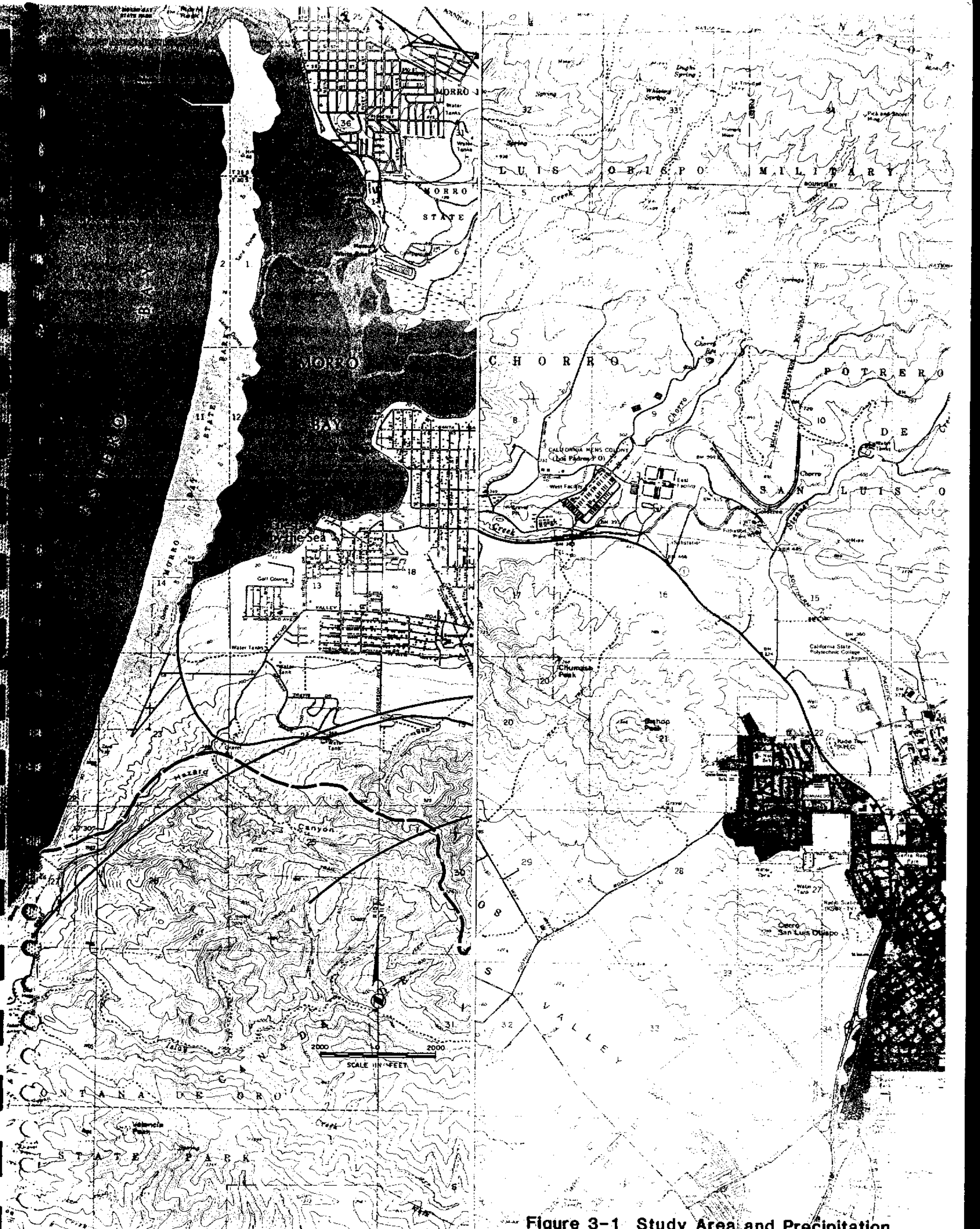

Figure 3-1 Study Area and Precipitation

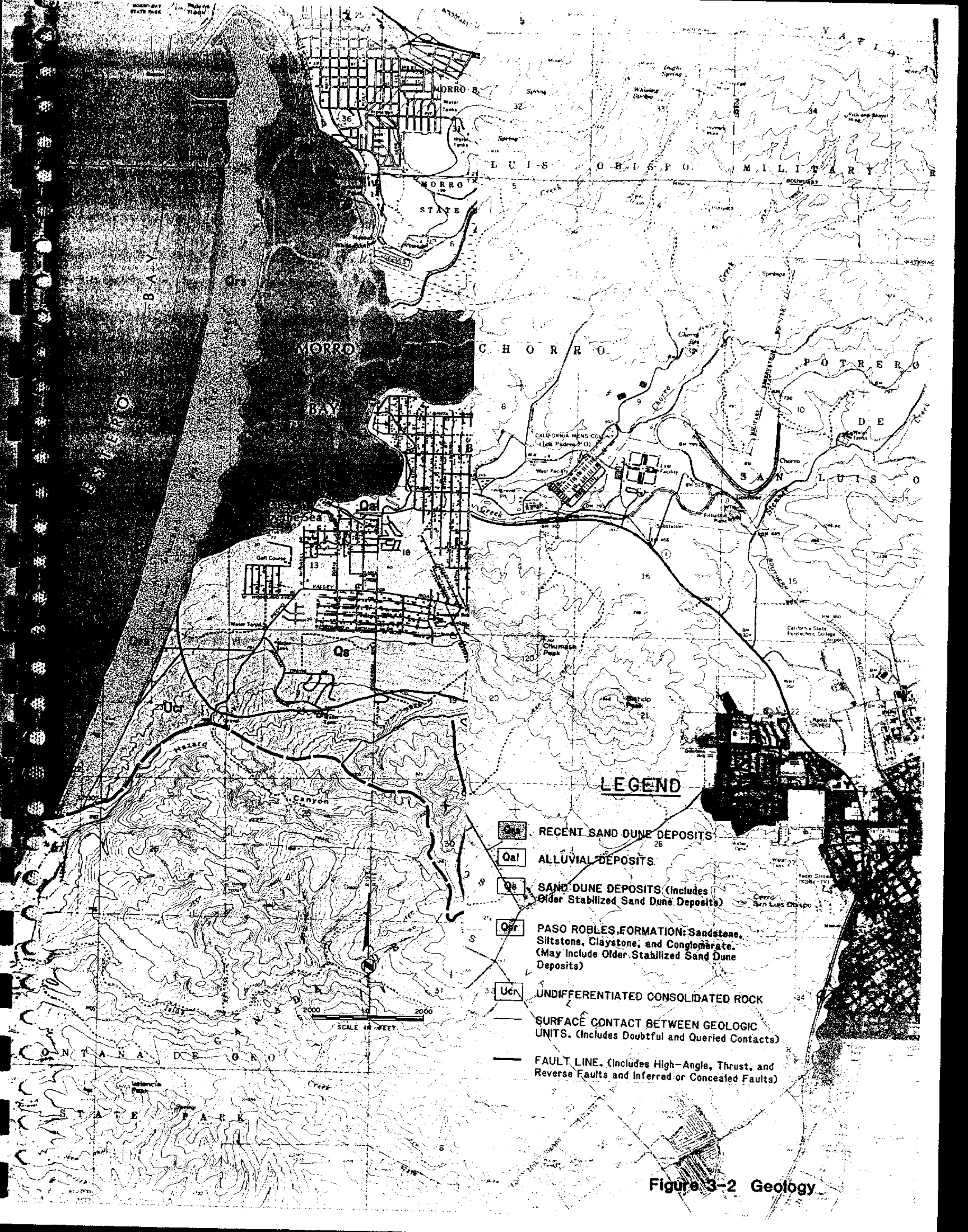

Figure 3-2 Geology

which underlies the entire study area. According to a 1973 report by the DWR, undiferentiated marine sedimentary deposits of the Miocene Age Monterey Formation unconformably overlie the Franciscan Formation along the southern flank of the Los Osos Valley in the Irish Hills. A series of volcanic plugs have intruded the Franciscan Formation along the northern boundary of Los Osos Valley. The best known of these volcanic plugs is Morro Rock.

The Los Osos Valley consists of a northwest-southeast trending synclinal depression within the Franciscan Formation. The oldest units which lie within this depression comprise the Paso Robles Formation. This formation tapers from zero thickness at the edges of the valley, and across the valley in the vicinity of Warden Lake, to a thickness of perhaps 300 to 350 feet at the eastern edge of Morro Bay. The Paso Robles Formation is fluvial in nature, consisting of alternating layers of sand, silt, gravel, and clay. In some areas, the upper 60 feet of the Paso Robles Formation consist of silt and clay which serve to separate the lower sand and gravel deposits from the overlying old dune sand deposits. These Upper Pleistocene old dune sands unconformably overlie the Paso Robles Formation throughout the majority of the western portion of the study area. The thickness of these sediments varies considerably due to the undulating topography of the area. Generally, the thickness of the old dune sands is believed to be up to 150 feet. Deposits of Holocene alluvium, found in the flood plain of Los Osos Creek, consist of approximately 30 feet of clay, silt, sand, and gravel derived chiefly from Franciscan rocks.

Soils

The soils of the study area consist primarily of fine sands in the western portion of the study area and find sandy loams throughout the eastern portion of the Los Osos Valley. Baywood Fine Sand occurs throughout the western portion of the Los Osos Valley west of the Los Osos Creek flood plain. These soils show relatively little development and consist almost entirely of older dune sands. In the eastern portion of the valley, a number of differing fine sandy loams and clay soils exist.

AIR QUALITY

The Office of County Air Pollution Control District does not monitor air quality in the study area. Based upon records for Morro Bay and San Luis Obispo, where non-residential pollution sources such as petroleum handling, power generation, and light industry can be identified, and where air pollution standards are rarely exceeded, it is the opinion of that office that present air quality is good within the study area.

CULTURAL ENVIRONMENT

The economic and institutional activity within the study area is related to serving the local community. Land use dynamics show a trend of continued development within the study area.

Economic Activity

Commercial activity within the study area is almost entirely devoted to serving needs of the local residents and the tourist trade. Restaurants, shopping areas, health and grooming establishments, and construction are the dominant commercial activities.

A significant amount of the land area within the study area is taken up with agricultural practices. Approximately 312 acres are presently irrigated, and approximately 1,500 acres, located generally east of Los Osos Creek, are dry farmed.

Institutional Activity

The San Luis Coastal Unified School System operates three schools in the area. The state of California owns the Los Osos Oaks Preserve south of Los Osos Valley Road along the west bank of Los Osos Creek. The Bay-Osos Branch of the United States Postal Service is located on Los Osos Valley Road in the community of Los Osos.

Public transportation is provided through bus service. Buses operate between the shopping areas of Baywood, Los Osos, Morro Bay and San Luis Obispo.

Various zones of County Service Area No. 9 provide utilities services for water, fire protection, drainage, street lights, and sewage treatment. Police protection is provided by the County Sheriffs Department. Traffic enforcement and motorists aid are provided by the California Highway Patrol. The County Engineering Department provides maintenance of roads within the County Roads System. Other utilities providing services in the area are the Pacific Gas and Electric Company, Pacific Telephone and Telegraph Company, Southern California Gas Company, Southern California Water Company, S&T Mutual Water Company, and Falcon Cable Television.

Areal Development

Prior to the mid-1950s, the early subdivisions of Baywood Park, Los Osos, and Cuesta-By-the-Sea remained virtually uninhabited and were not used for farming or grazing. Lands to the east of Los Osos Creek were used for grazing and farming activities as far back as the 1800s. By 1958, a residential subdivision had been created east of Los Osos Creek on Los Osos Valley Road. By 1960 land west of Los Osos Creek had been largely subdivided but was as yet mostly undeveloped.

Population in the South Bay grew to approximately 3,500 people in 1970. By 1980 this population had reached 10,933, an increase of 214 percent, which made this area the fastest growing area within San Luis Obispo County. Population projections to the year 2010 are shown on Figure 3-3 for high growth, low growth, and most probable growth.

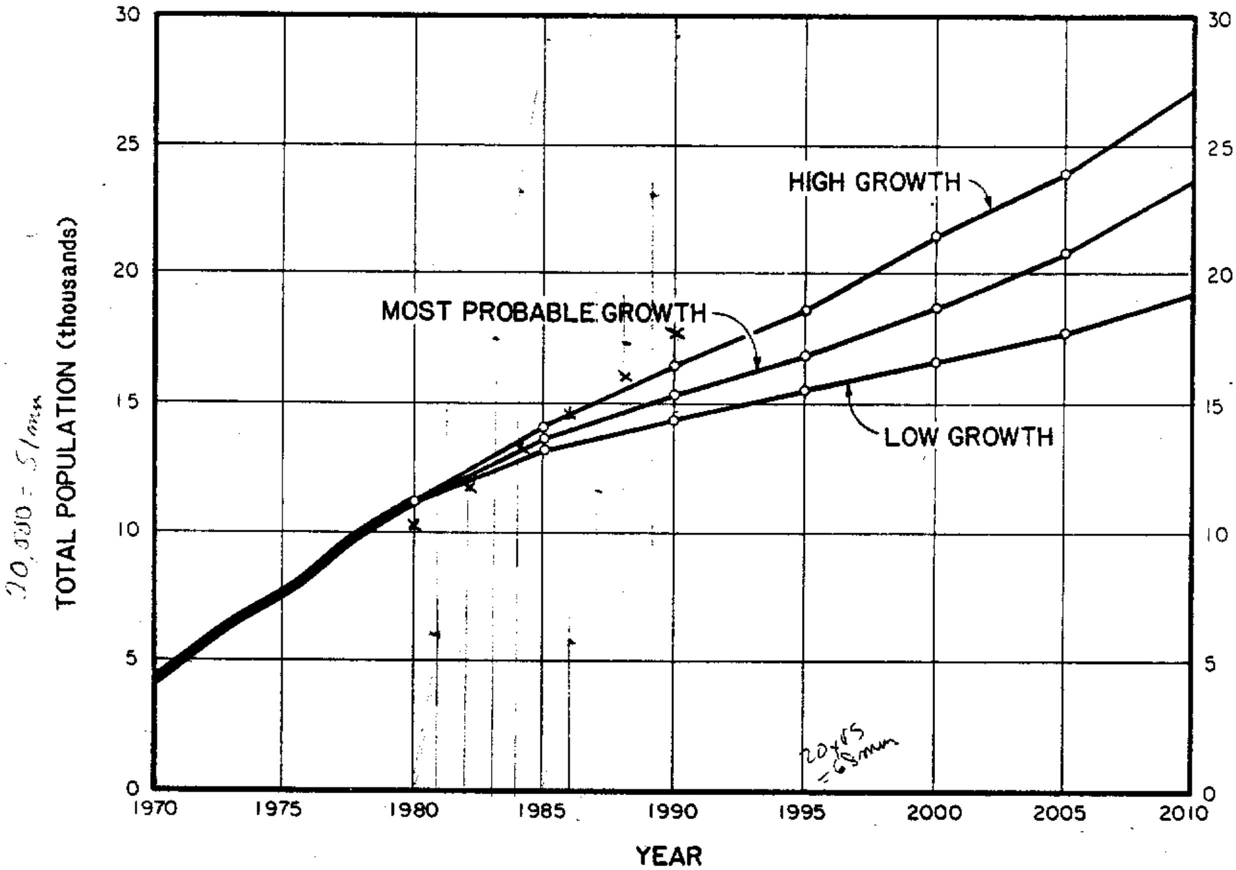

Figure 3-3 Population Projections

Current land use in the area west of Los Osos Creek and in the subdivision just east of the creek continues to be primarily residential. Small commercial centers have developed in Baywood Park and Los Osos, serving local residential and construction needs. Planned future land use for the Los Osos Baywood Park area is shown on Figure 3-4.

WATER DEMAND

The water demand within the study area is primarily for domestic and agricultural uses.

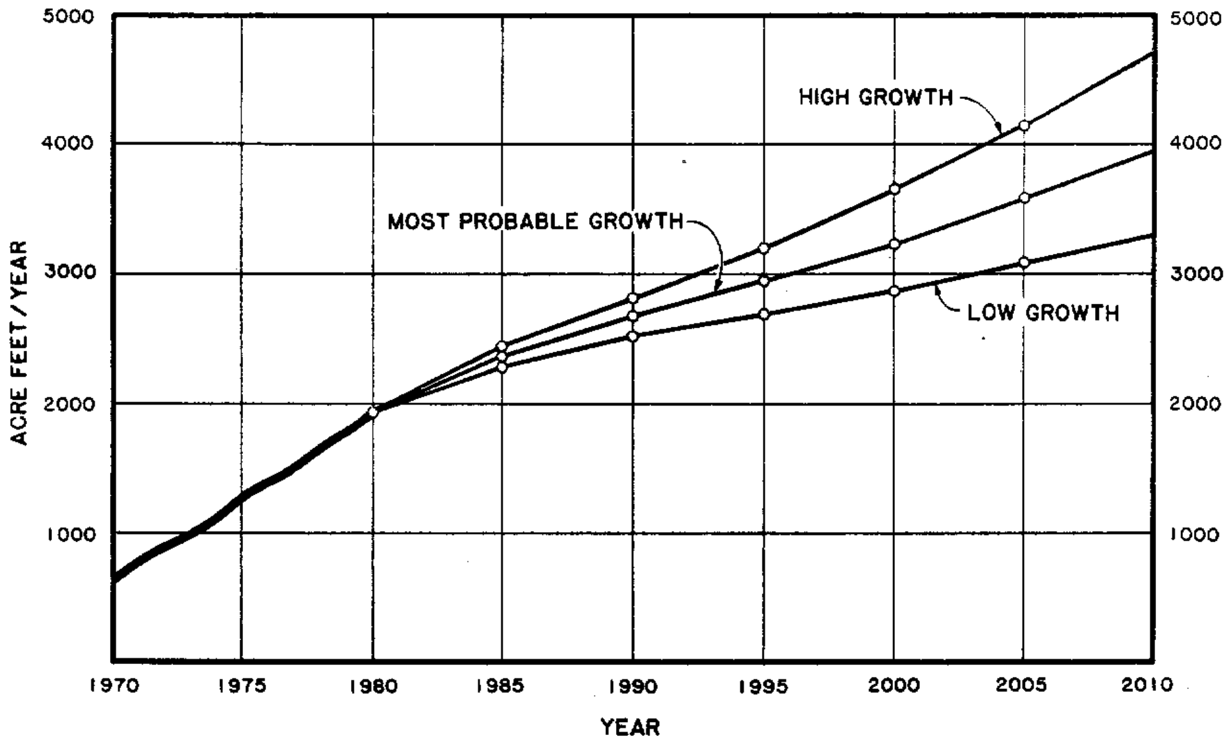

Figure 3-5 Projected Residential Water Demand

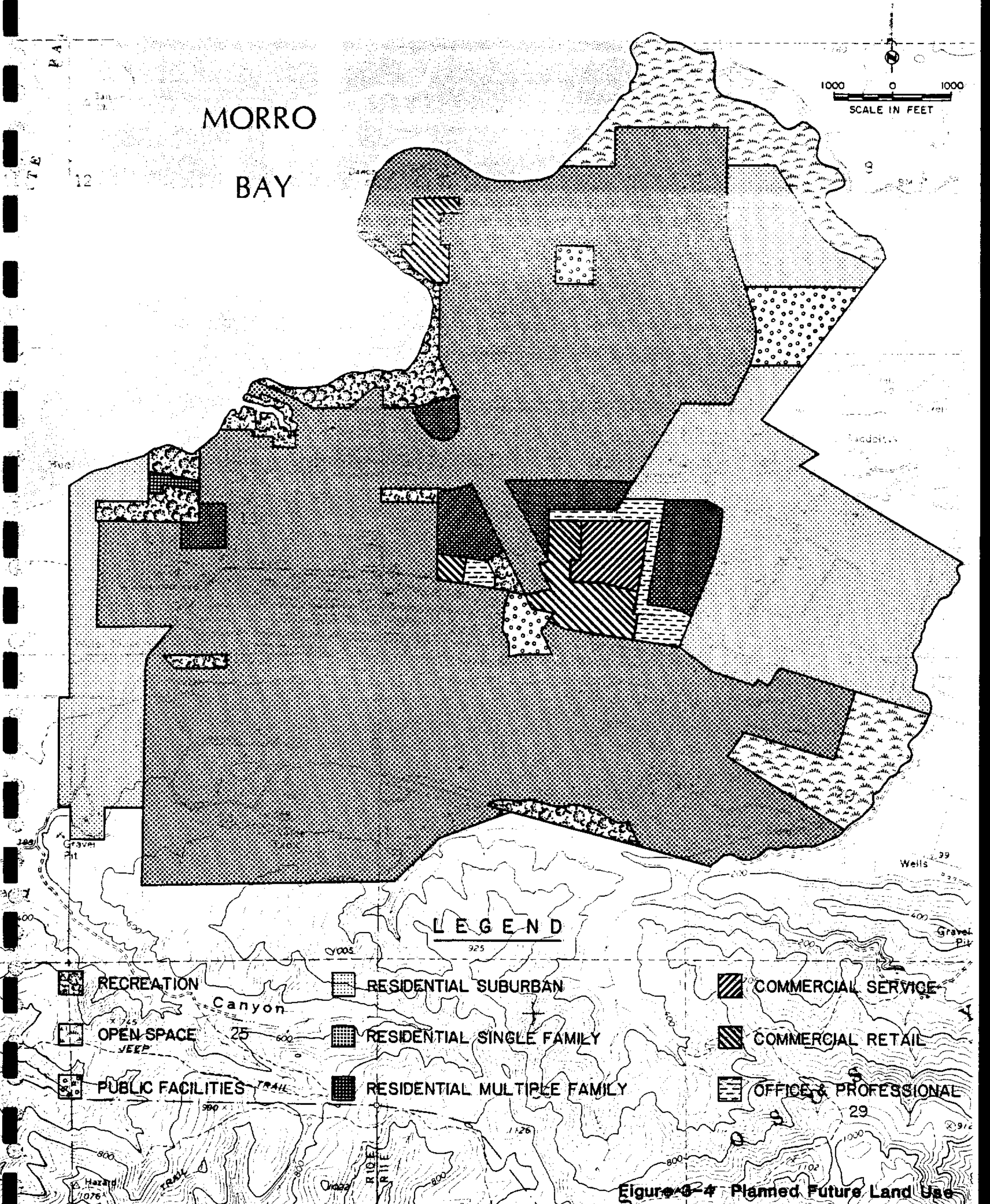

Figure 3-4 Planned Future Land Use

Source of Supply

Groundwater from wells provides all of the local water supply within the study area. Local surface water supplies are not utilized nor is any water presently imported. Wastewater re-entering the groundwater basin via leach fields and agricultural return flows is an important source of groundwater basin recharge within the study area. Possible future sources of water supply to the study area are the Nacimiento Project and the State Water Project.

Water Use

Current water use factors for both urban and agricultural water utilization have been calculated for the study area. An urban applied water use factor of 0.177 acre-foot per capita per year was derived by dividing the annual water utilization by the 1980 census data. Actual consumptive use is about 42 percent of that value, and the Water Action Plan concludes that approximately 15 to 17 percent conservation will be obtained in the future.

Total annual water demand for agricultural practices is calculated at approximately 1,070 acre-feet per year. Figure 3-5 presents the projected residential water demand for the study area. Current 1980 total water demand is approximately 3,000 acre-feet per year. Utilizing projections of most probable growth and the applied water use factor, projected total water demand for the year 2010 will be slightly more than 5,000 acre-feet per year. Utilizing projected absorption population for the area, the ultimate total water demand can potentially be as high as 6,200 acre-feet per year.

CHAPTER 4

GEOHYDROLOGIC CONDITIONS

The natural geohydrologic conditions existing within a hydrologic basin affect the quantity, movement, and natural quality of the waters within that basin. Geohydrologic conditions may also control the degree to which man's activities may affect the waters of the basin. This section presents a detailed discussion of the geohydrologic characteristics of the Los Osos hydrologic basin which provide the controlling influences upon the basin's ground-water quality.

HYDROLOGIC BASIN

The Los Osos hydrologic basin encompasses an area of approximately 18,000 acres in the coastal region of San Luis Obispo County. The extent of the Los Osos hydrologic basin is presented in Figure 4-1. The basin consists of the westerly draining half of Los Osos Valley, the south flank of Park Ridge, and the north flank of the Irish Hills. Included in the Irish Hills is Clark Valley, a small alluvial valley which drains into the Los Osos Valley. The basin comprises the Los Osos hydrologic sub-area of the San Luis Obispo hydrologic sub-unit.

Hydrologic Budget

The Los Osos hydrologic basin is a dynamic water system in terms of storage, inflow, and outflow of water. A typical dynamic water system of a hydrologic basin can be expressed by the following simple equation:

$$Pr + Si + Ui + Wi - (Cu + So + Uo + Wo) = Sc \qquad \text{(Eq. 4-1)}$$

where: Pr = precipitation;

Si = surface water inflow;

Ui = subsurface inflow;

Wi = imported water, including irrigation return water and disposed sewage effluent;

Cu = consumptive use, including evapotranspiration;

So = surface outflow;

Uo = subsurface outflow;

Wo = exported water; and

Sc = change in storage.

Inflow To and Outflow From Hydrologic Basin

Certain elements of Equation 4-1 do not exist in the Los Osos hydrologic basin. The majority of inflow to the basin is from precipitation. There is no surface inflow to the basin, since surface runoff of precipitation is derived totally from within the boundaries of the basin. Return water from irrigation and from the disposal of sewage effluent (septic tanks and leach fields) makes up the remainder of the inflow to the basin.

Subsurface inflow is believed to not contribute any appreciable amount. The east end of the basin, which is a drainage divide for surface water, was evaluated during this study, and, based on the evaluation, is believed to be a groundwater divide, also. That is, groundwater does not enter into the Los Osos basin from the adjacent basin. Outflow from the hydrologic basin consists of surface runoff to Morro Bay from Los Osos Creek and the unnamed creek which drains Warden Lake, and subsurface outflow to Morro Bay and/or to the ocean through the water-bearing sediments of the Paso Robles Formation and the old dune sands.

If there is no change in storage in the basin, and no surface water inflow, Equation 4-1 can be set up as an equality with inflow elements being equal to the outflow components. The equation can then be written as:

$$PR + Ui + Wi = Cu + So + Uo + Wo \qquad \text{(Eq. 4-2)}$$

GROUNDWATER BASIN

The Los Osos groundwater basin is a subset of the Los Osos hydrologic basin. The perimeter of the groundwater basin, as shown on Figure 4-1, follows the outline of the valley floor. The groundwater basin, particularly the western portion, is the primary object of this study.

An adequate assessment of groundwater quality cannot be made without the ability to also quantify the amount and movement of water in the groundwater basin. The following equality presents the factors which have the greatest effect upon quantities and movement of groundwater within the basin:

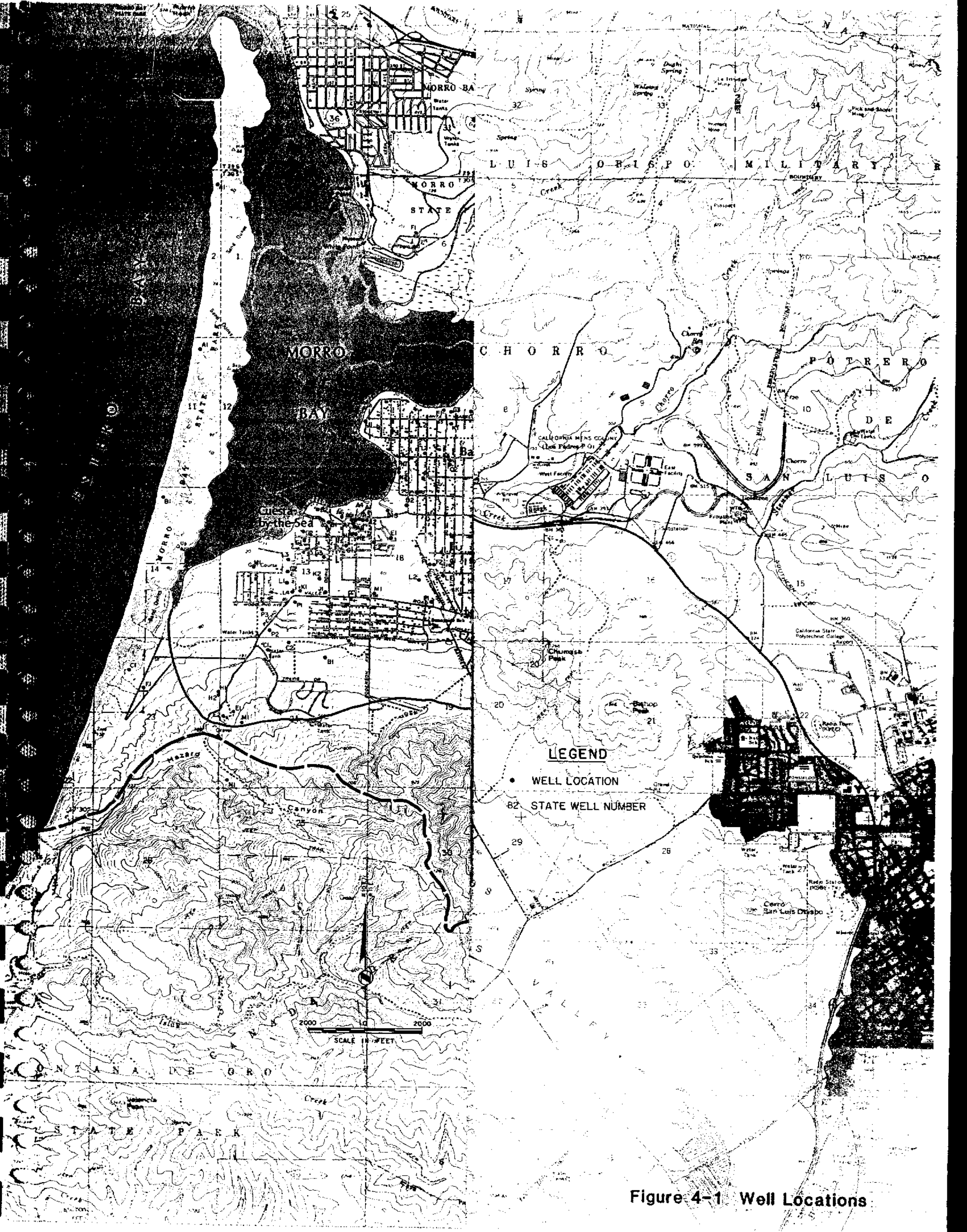

Figure 4-1 Well Locations

$$Rn + Ru + Ra + Rs = Uo + Du + Da \qquad \text{(Eq. 4-3)}$$

where: Rn = natural recharge due to direct infiltration of precipitation and infiltration of runoff;

Ru = recharge due to return of urban irrigation water;

Ra = recharge due to return of agricultural irrigation water;

Rs = recharge due to percolation of septic tank effluent;

Uo = subsurface outflow from the basin;

Du = discharge from the basin due to groundwater pumpage for urban demand; and

Da = discharge from the basin due to groundwater pumping for agricultural demand.

Equation 4-3 is set up as an equality of inflow and outflow. For the purposes of this study, no change in groundwater storage is assumed. This assumption is verified and substantiated through analysis of existing and new data on groundwater levels.

Groundwater elevation data were available for this study from many wells within the study area. During analysis of the data, it was observed that, although individual wells show trends over the past 20 years of either rising or declining water levels, on a basin-wide basis groundwater elevations appear to remain fairly stable. Additional confirmation of relatively insignificant changes in groundwater levels throughout the basin is presented in other reports.[1,2,3,4]

Inflow to Groundwater Basin

The inflow to the Los Osos groundwater basin, as presented in Equation 4-3 above, is primarily derived from the infiltration of direct rainfall, percolation of rainfall runoff, return water from agricultural and urban landscape irrigation, and return water from the disposal of sewage effluent.

Surface Inflow. Surface inflow to the groundwater basin is derived exclusively from rainfall within the confines of the hydrologic basin boundary. The inflow of this water is either direct or indirect. Direct infiltration of rainfall occurs over a wide portion of the planning area. The planning area, as shown on Figure 4-2, consists of the western portion of the groundwater basin which lies to the west of the eastern bank of the Los Osos Creek flood plain. The soils within the planning area are almost exclusively derived from older dune sand deposits and are highly permeable. Almost 100 percent of rainfall on this area infiltrates directly to the groundwater table. In the remainder of the basin, only a portion of the annual rainfall infiltrates directly to the groundwater table.

The precipitation which does not directly infiltrate and percolate to the groundwater table runs off the slopes of the Irish Hills and forms Los Osos Creek. Runoff from Park Ridge along the north side of the hydrologic basin and runoff from the eastern end of Los Osos Valley combine to form an unnamed tributary which flows through Warden Lake and eventually joins Los Osos Creek. Infiltration of surface runoff from the unnamed tributary occurs along its length throughout the eastern portion of the Los Osos Valley, and, particularly in Warden Lake, a marshy depression. Infiltration into the groundwater basin from Los Osos Creek occurs along the Creek from its most southerly point in the Los Osos Creek flood plain to the point where Eto Lake drains into the Creek. Infiltration also occurs along Los Osos Creek in Clark Valley. Clark Valley lies outside the boundaries of the Los Osos groundwater basin, and this percolated water does not contibute to the surface inflow of the Los Osos groundwater basin.

Table 4-1 presents a value of 3,100 acre-feet per year as the surface inflow from infiltration of rainfall and runoff. This value was reported by the Department of Water Resources in 1973.[1] This calculated value for infiltration of precipitation and surface runoff is as valid today as in 1973. The degree of detail of available data has not increased sufficiently to warrant recalculation of this number, as recalculation would not increase its accuracy.

Additional surface inflow to the groundwater basin occurs from sources of return water. These sources consist of percolating irrigation water from both agricultural and urban landscaping, wastewater disposal from individual and community domestic septic tanks, and wastewater disposal from commercial establishments. San Luis Obispo County data on agricultural practices within the Los Osos groundwater basin indicate that approximately 590 acre-feet per year of agricultural return irrigation water percolate to the groundwater table from irrigated crops.

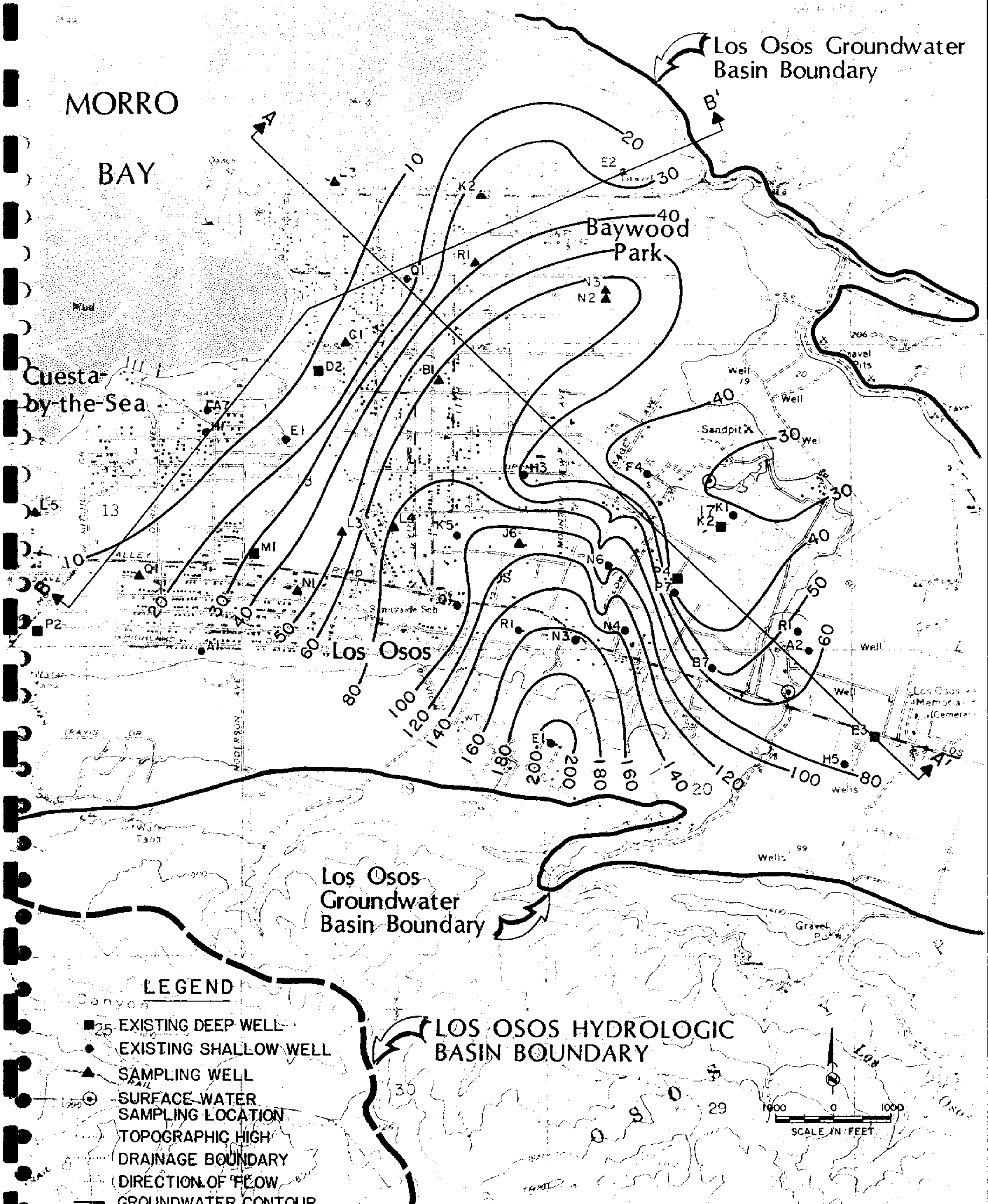

Figure 4-2 Shallow Groundwater Contours

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Table 4-1 Hydrologic Equation for the Los Osos Groundwater Basin, 1972 and 1980 Conditions

Item	1972[a]	1980
INFLOW:		
Infiltration of Precipitation and Infiltration of Runoff	3100	3100[b]
Agricultural Irrigation Return Water	470	590[c]
Urban Irrigation Return Water	230	500[d]
Return Sewage	300	650[d]
TOTAL INFLOW[g]	4100	4840
OUTFLOW		
Pumpage for Agricultural Irrigation Use	1100	1070[e]
Pumpage for Urban Use	920	1990[f]
Subsurface Outflow	2080	1780
TOTAL OUTFLOW[g]	4100	4840

[a] Brown and Caldwell 1974 Report, "Preliminary Groundwater Basin Management Study", Page 17.

[b] Department of Water Resources 1973 Report, "Los Osos-Baywood Ground Water Protection Study", Page 23.

[c] Calculated as difference between applied water and evapotranspiration figures from County prepared tables.

[d] See text.

[e] See Volume II, Appendix III, Table III-6.

[f] Based upon Unit Urban Water Use factor and 1980 population. See Volume II, Appendix III.

[g] Assuming no change in storage, total inflow equals total outflow.

Irrigation return flow from urban irrigation practices is calculated to be approximately 500 acre-feet per year. This number was calculated utilizing the following assumptions: a portion of the water delivered to urban water users will be consumed during use; the consumptive water requirement for residential, commercial and industrial uses without wastewater export is assumed to be 42 percent of the water delivered to urban areas; a value which has been used by the Department of Water Resources to represent southern California conditions and which agrees well with values found to exist for the City of San Luis Obispo (40 percent) and the City of Arroyo Grande (44 percent).[2] The portion of the delivered water which is not consumptively used becomes wastewater and is considered to be available for reuse if released in areas where it can percolate into usable groundwater basins. If wastewater is exported, net water demands will be approximately 75 percent of the applied water production for urban use.[2]

San Luis Obispo County provided Brown and Caldwell with a figure of 1,030 acre-feet per year attributable to return flow from domestic sewage disposal, only. This number was derived from population data and design capacities for engineering septic tanks and leach fields. As such, this figure may be significantly higher than the actual return flow from domestic sewage. Assuming that 42 percent of all urban water demand is consumptively used, 58 percent of that water would constitute return either through disposal of domestic sewage or from irrigation return. Utilizing these factors results in a value of about 1,150 acre-feet per year for return flow from combined effluent and urban irrigation return water. This compares favorably with the figure of 1,030 acre-feet per year, which excludes urban irrigation return water but includes the safety factor for design of septic tanks and leach fields. Of the total 1980 urban water demand of approximately 1,990 acre-feet per year, 75 percent makes up consumption and sewage return, leaving 25 percent utilization for landscape and other urban irrigation return flow. Utilizing these figures results in 500 acre-feet per year of return urban irrigation and about 650 acre-feet per year of return sewage.

Subsurface Inflow. Subsurface inflow to the Los Osos groundwater basin consists of seepage of groundwater from fractures and the soil mantle covering the Irish Hills and Park Ridge, and some amount of groundwater underflow from Clark Valley along Los Osos Creek. While these flows may be significant in terms of an individual domestic water supply, this amount of flow is not believed to exert any controlling influence on the hydrologic budget for the Los Osos groundwater basin.

Outflow From Groundwater Basin

Outflow from the Los Osos groundwater basin consists of surface outflow such as groundwater pumping for urban demand, and groundwater pumping for agricultural demand, and subsurface outflow from the groundwater basin aquifers.

Surface Outflow. Surface outflow from the Los Osos groundwater basin due to pumpage from basin wells was calculated for both domestic use and agricultural use. The domestic or urban water use was calculated by multiplying the 1980 census population figures by a unit water use factor of 0.177 acre-feet per year per capita. This figure was derived by San Luis Obispo County Engineering Department, and is described more fully in Volume II, Appendix III. Agricultural water demand was determined by San Luis Obispo County Engineering Department utilizing a different method. Irrigated crops were inventoried as to crop type, area farmed by crop type, and water use factor for individual crops. Other surface outflow, due to evaporation and evapotranspiration, is accounted for in the hydrologic budget by including it with the water consumed. Water consumed is included in the items of inflow and outflow of the basin.

Exfiltration of groundwater to streams is the final component of surface outflow. Our study of groundwater levels in the planning area indicates that a significant amount of groundwater surfaces and flows into Eto Creek, and thence into Eto Lake. Outflow from Eto Lake flows into Los Osos Creek, and then either re-enters the groundwater basin through infiltration in the stream bed or flows out to Morro Bay. This amount of outflow is not included separately in the hydrologic budget for the groundwater basin as it is not sufficient to provide a controlling factor for groundwater quantities. Instead, this outflow is included in subsurface outflow.

Subsurface Outflow. Subsurface outflow of groundwater from the Los Osos groundwater basin results primarily from seaward flow of groundwater through the basin aquifers. Groundwater is not believed to flow eastward out of the basin into adjoining basins as the neck of the valley at its eastern extremity is believed to be a groundwater divide. Also, the rocks in the north and south flanking hills surrounding the basin are sufficiently low in permeability to prevent any significant seepage of groundwater through the hills into adjacent basins. The subsurface outflow from the basin is calculated at approximately 1,780 acre-feet per year.

As previously stated, this hydrologic budget assumes no change in storage for the groundwater basin, which is justified by the lack of large amounts of fluctuation in the basin's groundwater levels. This leaves subsurface outflow as the only figure calculated totally through the hydrologic budget. With no change in storage, and a constant natural inflow from precipitation and infiltration of runoff, increases in groundwater pumpage and utilization will result in a decrease in subsurface outflow from the basin. Had 1980 subsurface outflow remained the same as in 1972, an increase in groundwater pumpage would have resulted in a significant decline in groundwater levels within the basin.

It is noted that inflow of seawater is not included in the hydrologic budget. If seawater intrusion were occurring, it would show up as a negative value within the subsurface outflow parameter. Although it is possiblle for both seawater intrusion and subsurface outflow to be occurring concurrently in a groundwater basin, the magnitude of calculated subsurface outflow, and the absence of any water quality indication of seawater intrusion leads to the conclusion that seawater is not currently intruding into the groundwater basin.

Groundwater Storage

The Los Osos groundwater basin contains a thick sequence of sedimentary deposits which provide storage for groundwater. The sediments in the basin form a wedge approximately 400 feet thick at its thickest point at the eastern edge of Morro Bay, tapering inland to a thickness of zero feet at the groundwater basin boundaries. These sediments form a system of aquifers which are divided into two principal zones; an upper zone composed mostly of the old dune sand deposits, and a lower zone consisting of the Paso Robles Formation sediments. Figures 4-3 and 4-4 present cross-section views depicting the relative geometry of these two water bearing zones. Locations of the cross-sections are shown on Figure 4-2.

The upper zone of aquifers is primarily composed of deposits from stabilized older dune sands. These materials are fine- to medium-grained sand, approximately 100 feet in thickness, and overlie alternating layers of sand, silt, and clay. The lower sediments in this upper zone are laterally discontinuous, but grouped together, form a somewhat separate lower water-bearing unit in the upper zone distinct from the overlying unconfined aquifer in the older dune sands.

Underlying the upper aquifer zone is a semi-confining layer composed of fairly continuous fine-grained sediments ranging from clayey sand and sandy clay to almost pure clay. This semi-confining zone occurs in the upper Paso Robles Formation, and segregates the upper and lower aquifer zones. The Paso Robles Formation includes a sequence of alternating layers of sand, gravel and clay, which together form an aquifer system. The deeper aquifer system underlies the majority of the groundwater basin and all of the planning area.

<u>Aquifer Geometry.</u> In the upper aquifer system, the old sands dune form a cap overlying the planning area. These sediments average approximately 100 feet in thickness. The discontinuous, alternating-layered sediments immediately underlying the older dune sands comprise a transition zone between the old dune sands and the

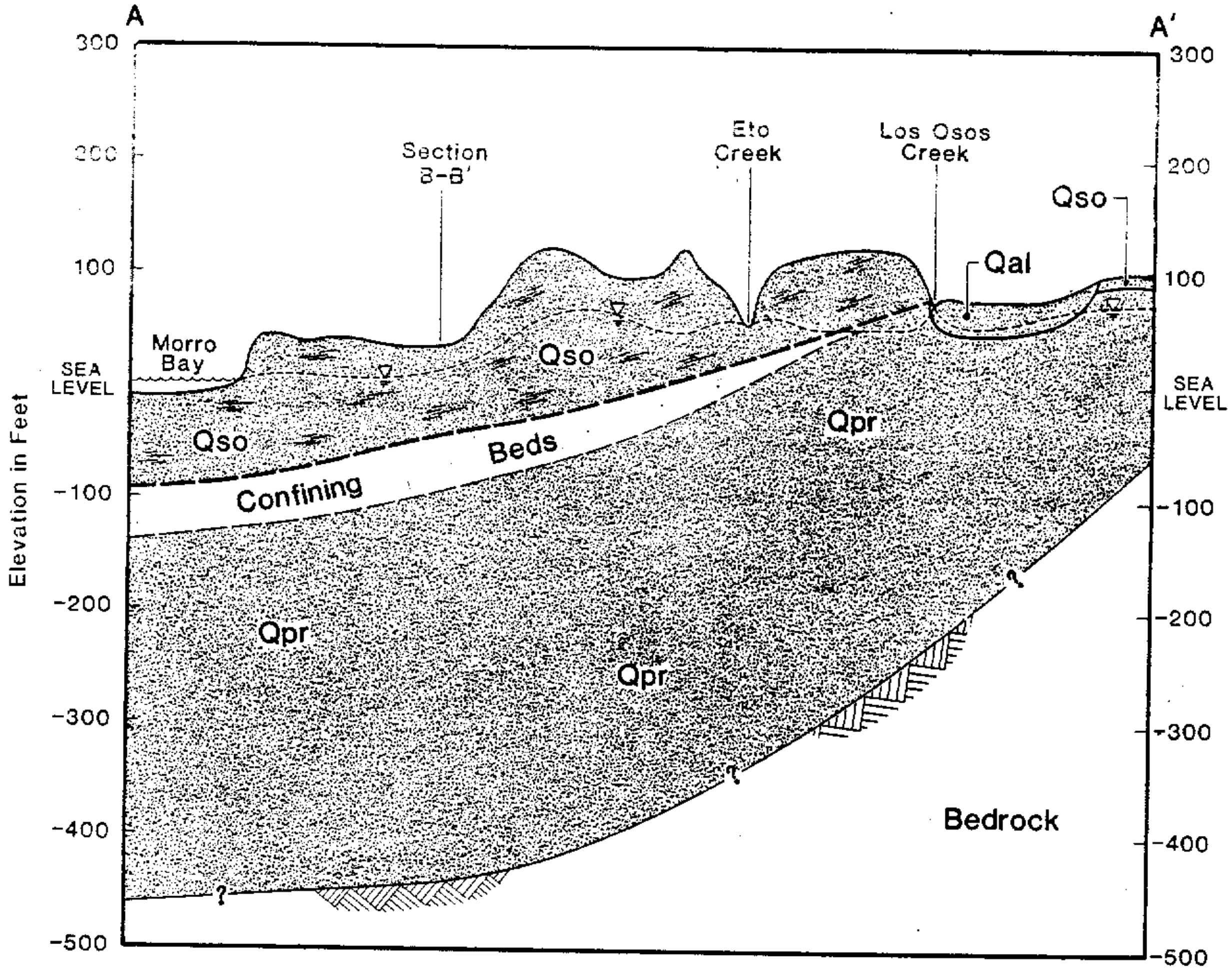

Figure 4-3 Geologic Section A-A'

underlying Paso Robles Formation. This transition zone can be distinguished from the overlying older dune sands, and comprises a lower zone in the upper aquifer system. The transition zone extends to a depth of approximately 50 feet below sea level at the western edge of the planning area, and rises in elevation to the east where it apparently pinches out in the vicinity of Los Osos Creek.

Recharge for the upper zone of aquifers is from direct percolation of rainfall. The groundwater levels in these sediments generally follow the surficial topography. Discharge for these aquifers is to Morro Bay, and to Eto Creek which flows into Eto Lake, then into Los Osos Creek, and finally to the ocean.

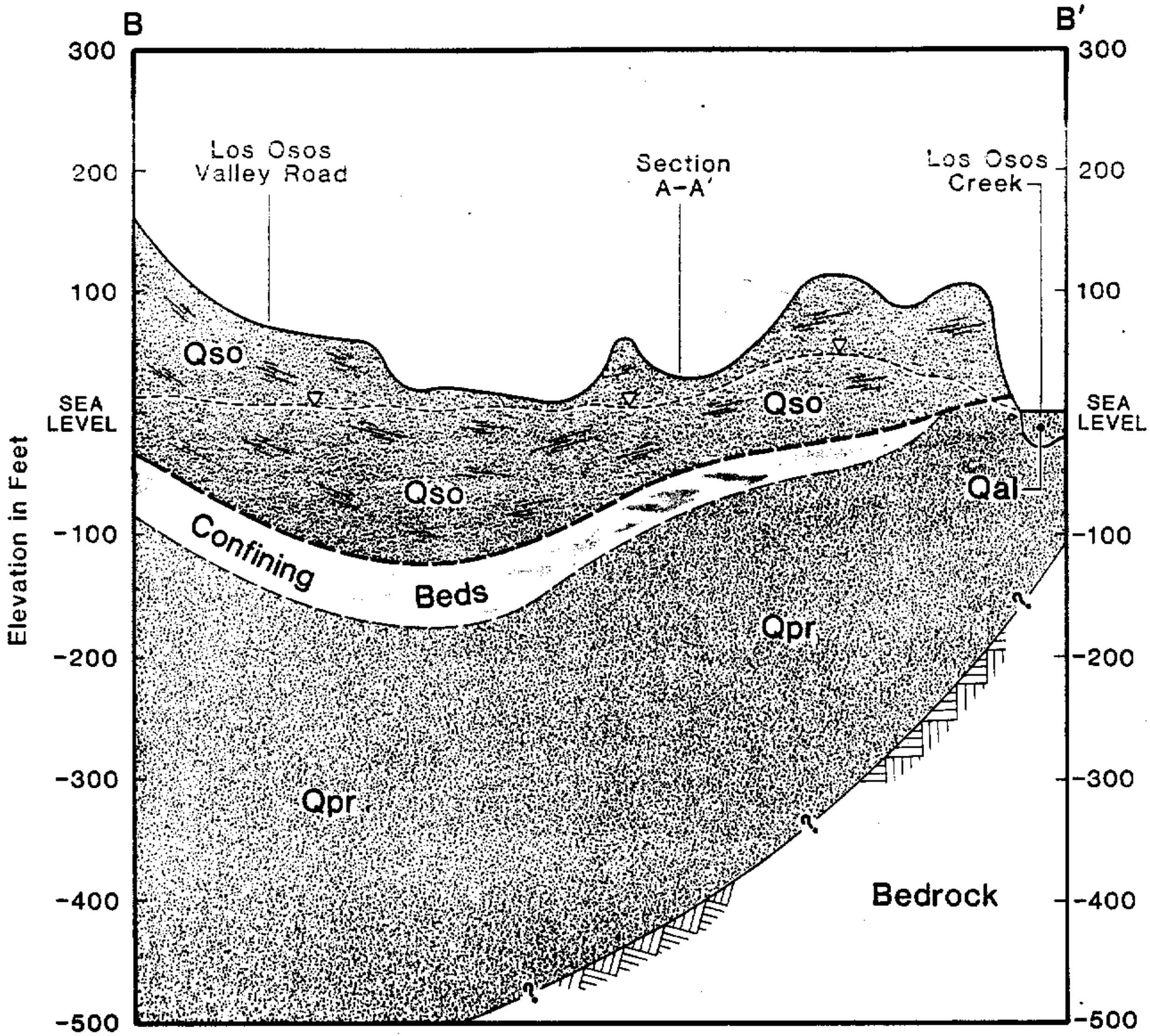

Figure 4-4 Geologic Section B-B'

The Paso Robles Formation forms a wedge-shaped series of confined to semi-confined aquifers extending from west of Morro Bay landward to just east of the Los Osos Creek flood plain where it outcrops, as shown on Figure 3-2. The thickness of Paso Robles Formation sediments at the eastern edge of Morro Bay is approximately 300 to 350 feet. These sediments are believed to be on the order of 100 feet or less in thickness at the eastern edge of the planning area. The aquifer system in the Paso Robles Formation is confined by a series of fairly continuous clay layers which appear in the upper horizons of the formation. This series of clayey sediments is eroded through in the vicinity of Los Osos Creek flood plain. The alluvium in the flood plain is in hydraulic communication with the Paso Robles Formation sediments.

Recharge to the Paso Robles Formation aquifers is primarily along and east of Los Osos Creek. Additional recharge occurs through Warden Lake and the unnamed tributary which extends from Warden Lake to Los Osos Creek. Discharge from the Paso Robles Formation aquifers occurs along a front extending more or less north-south across Morro Bay. Fresh water extends in these sediments seaward under Morro Bay to a point somewhere to the east of the very prominent sand spit which protects Morro Bay. Evidence of seawater in the Paso Robles Formation sediments directly beneath the sand spit was found during an investigation conducted by the Department of Water Resources.[4]

Water Level Fluctuations. A representative selection of groundwater level history from selected wells is presented in Figure 4-5. The wells depicted in this Figure were selected to represent the areal extent and depth of the Los Osos groundwater basin. As evidenced by the figure, groundwater levels have remained approximately at the same elevation in the basin. Examination of hydrographs from wells presented in other reports[1,2,3,4] show that long term trends exist for particular wells, however, as some trends show rising water levels and others show declining and or fluctuating water levels, basin-wide water levels remain relatively constant.

Contours on elevations of the shallow groundwater table are presented on Figure 4-2. These are contours on the elevation of the groundwater surface of the shallow or upper groundwater aquifers, and therefore are not comparable to those presented in other reports. Examination of the reports presented in the references for this chapter shows that these authors have drawn groundwater elevation contours from wells extending into both the shallow zone and the Paso Robles Formation aquifers. The groundwater elevation contours which appear in Figure 4-2 are based solely on older dune sand aquifer water levels, while those presented in other reports represent a mixture of basin-wide groundwater levels for several aquifers.

Aquifer Storage. Accurate estimates of aquifer storage within the Los Osos groundwater basin are not possible at this time due to the lack of an accurate definition of the base of the Paso Robles Formation. Without knowing the total volume of fresh-water-bearing rocks, an estimate of the storage capacity of those rocks is not possible. Certain information is available, however, which allows the determination of certain aquifer storage characteristics.

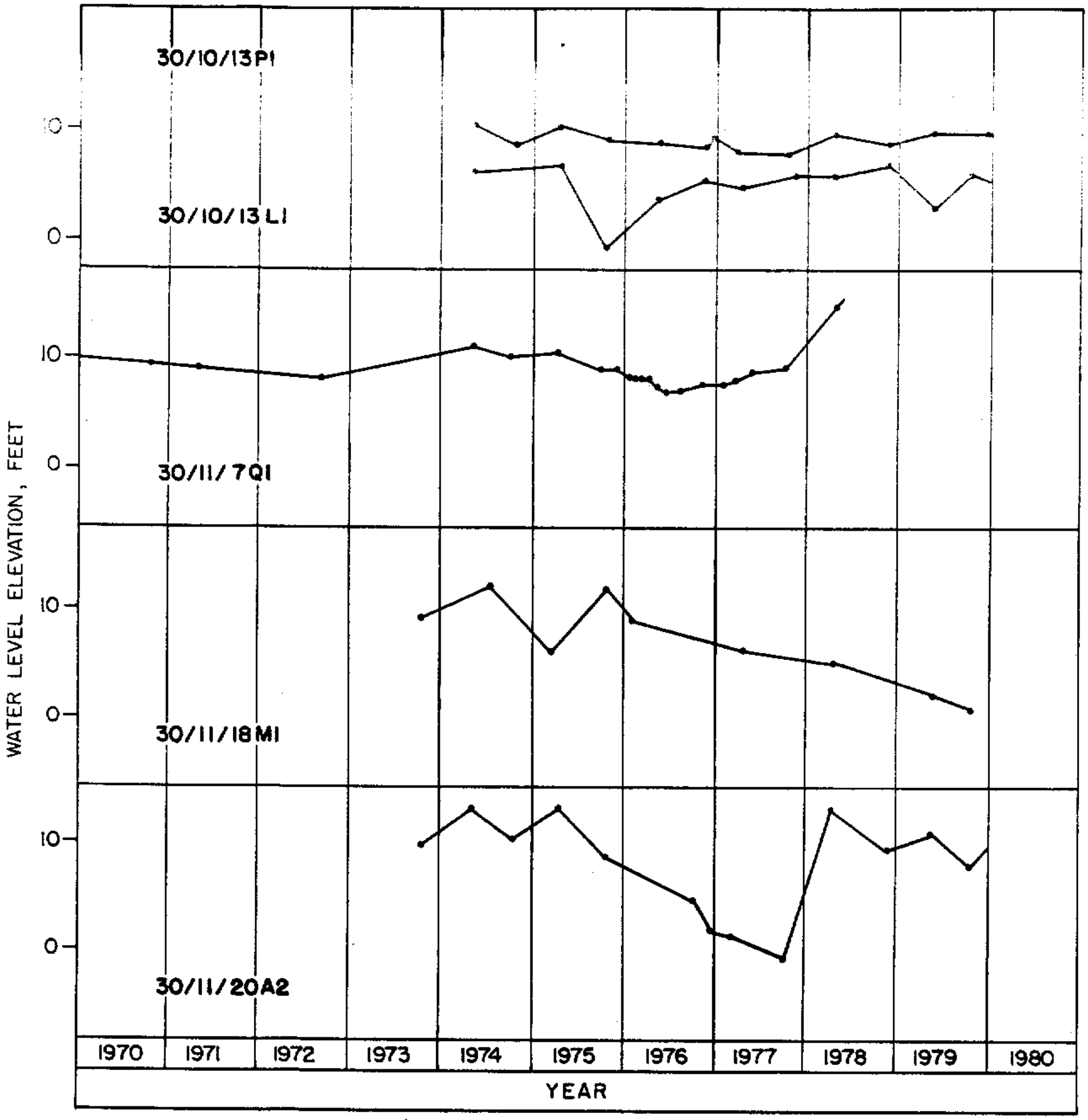

Figure 4-5 Hydrographs of Selected Wells

A widely accepted method for determining the change in storage of an aquifer or groundwater basin is to relate that change in storage to either a rise or decline in groundwater level elevations. As the groundwater level elevations within the Los Osos groundwater basin have remained relatively constant over the past 10 years, sufficient evidence exists for the conclusion that the change in storage of groundwater in the basin aquifers has been very small. Due to this fact, the calculated hydrologic budget for the Los Osos groundwater basin was based on no change in storage of groundwater.

Two factors indicate that the storage capacity of the Los Osos groundwater basin is greater than the amount presently stored within the basin. The hydrologic budget calculations for the groundwater basin show that present subsurface outflow from the basin is approximately 1,780 acre-feet per year. 1972 conditions indicated that 2,080 acre-feet per year flowed out of the basin as subsurface outflow. This, combined with the evidence compiled by the Department of Water Resources[4] which reports seawater in the aquifers directly beneath the Morro Bay sand spit, indicates a greater storage capacity, at least for the Paso Robles Formation aquifers. Previous studies of safe yield of the Los Osos groundwater basin indicate a basin-wide safe yield of between 1,300 and 1,800 acre-feet per year.[2] Hydrologic budget calculations indicate present consumption of groundwater at approximately 1,300 acre-feet per year. This indicates that, at present, the safe yield of the groundwater basin is being approached. However, safe yield has not yet been defined for the individual aquifers within the basin. These calculations indicate that, at present, there may not be a surplus of groundwater within the Los Osos groundwater basin.

Groundwater Flow Patterns

The groundwater flow patterns within the Los Osos groundwater basin are controlled primarily by three factors; hydraulic gradient, areas of recharge and discharge, and physical barriers to flow. Figure 4-2 presents the groundwater elevation contours of the shallow aquifers, surface drainage subareas, and groundwater flow patterns within those zones.

Hydraulic Gradient. The hydraulic gradient in the shallow or upper zones of aquifer is controlled almost entirely by topography. The small sub-basins shown on Figure 4-2, which are defined by surface topography, exert the major controlling influence on flow direction within the shallow groundwater zone. High groundwater elevation is also shown near the mouth of Clark Valley. At this point, groundwater in Clark Valley flows underground into the alluvium of Los Osos Creek and into the old dune sand aquifer. This groundwater mound intersects ground surface and discharges to

Eto Creek, which then flows to Eto Lake. The hydraulic gradient within the Paso Robles Formation aquifers is presumed to be seaward in direction, originating from the recharge areas near the flood plain of Los Osos Creek. The gradient varies locally due to pumping of wells penetrating these aquifers.

Restrictions to Flow. In general, the restrictions to flow of groundwater within the basin consist primarily of permeability differences. In the upper aquifers, the horizontal permeability is approximately 10 to 100 times greater than the vertical permeability, due to sedimentation and the inclusion of silt and clay layers. This difference restricts vertical downward movement of water, while allowing horizontal flow to occur at a much more rapid rate. The confining clay beds, which separate the upper zone of aquifers from the Paso Robles Formation aquifers, almost completely inhibit inter-aquifer flow. Horizontal-to-vertical permeability differences within the Paso Robles Formation aquifers are anticipated to be on the order of 100:1. The confining clay beds overlying the Paso Robles Formation aquifers are believed to be thin, discontinuous, and/or absent in areas underlying the Los Osos Creek flood plain. The alluvium within this flood plain is part of the recharge area for the Paso Robles Formation aquifers, and is in hydraulic communication with those aquifers.

Basin Outflow. The hydrologic budget for the Los Osos groundwater basin indicates subsurface outflow of approximately 1,780 acre-feet per year. Rough calculations of subsurface outflow, based strictly upon hydraulic gradients and average aquifer transmissivities, yield figures of subsurface outflow on the order of 2,000 acre-feet per year, two thirds of which comes from the upper or dune sand aquifers. Calculations of subsurface outflow from the basin are estimates, only. It is particularly difficult to arrive at accurate figures without detailed knowledge of the base of the aquifers.

CHAPTER 5

WATER QUALITY CHARACTERISTICS

The primary source of water supply for the Los Osos-Baywood Park area and the study area is the groundwater that exists in the aquifers beneath the valley. As discussed in Chapter 4, this groundwater is replenished by direct infiltration of precipitation, streambed infiltration, and recharge of septic tank effluent in various portions of the study area. The aquifers also receive recharge from leached irrigation water, and from commercial and other wastes that are discharged to the ground surface.

This chapter presents information on the quality characteristics of the groundwater basin, which supplies water for domestic, agricultural, and commercial purposes. To evaluate the known quality parameters, a preliminary discussion on water quality criteria for various uses is presented first.

WATER QUALITY STANDARDS

Water supplies are normally appraised for domestic, industrial, or agricultural use from the standpoint of five quality factors: taste and odor; appearance; temperature; chemical balance; and safety. Safety with respect to bacteriological, organic, and inorganic chemical constituents is the most important factor evaluated in this investigation. The nitrate form of nitrogen, in particular, is a constituent which is present in groundwater in the Los Osos-Baywood Park area and can result in specific potential public health problems.

Many of the homes in the study area are served by individual wells and are not directly affected by the legal standards. These water quality standards, however, form an excellent basis for evaluating the quality of the total supply.

Federal and State Standards

The applicable drinking water standards are contained in the California Domestic Water Quality and Monitoring Regulations, Title 22 of the California Administrative Code.[1] These regulations incorporate the requirements of the National Interim Primary Drinking Water Regulations which have been promulgated by the United States Environmental Protection Agency (USEPA) in conformance with the Safe Drinking Water Act (PL 93-523).[2]

The state regulations contain requirements for both primary and secondary drinking water standards. The primary standards pertain to those contaminants which, if exceeding the maximum contaminant levels, would present a risk to the health of humans when continually used for drinking or culinary purposes. The secondary standards pertain to contaminants which, if exceeding the maximum contaminant levels, may be objectionable to an appreciable number of people, but are generally not hazardous to health. The California drinking water standards are summarized in Table 5-1.

Table 5-1 California Drinking Water Standards

Primary standards: Parameter	Maximum contaminant level[a]	Secondary standards: Parameter	Maximum contaminant level[a]
Inorganic chemicals		Consumer acceptance limits	
Arsenic	0.05	Color, units	15
Barium	1	Copper	1.0
Cadmium	0.010	Corrosivity	relatively low
Chromium	0.05	Iron	0.3
Fluoride,[b]		Manganese	0.05
if added	0.8 - 1.7	Odor-threshold, units	3
if naturally occurring	1.4 - 2.4	Foaming agents (MBAS)	0.5
Lead	0.05	Turbidity, units[e]	5
Mercury	0.002	Zinc	5.0
Nitrate, as NO_3	45	Mineralization	
Selenium	0.01	Total dissolved solids	
Silver	0.05	Recommended	500
Organic chemicals		Upper	1,000
Endrin	0.002	Short-term	1,500
Lindane	0.004	Specific conductance, micromhos/cm	
Methoxychlor	0.1	Recommended	900
Toxaphene	0.005	Upper	1,600
2, 4-D	0.1	Short-term	2,200
2, 4, 5-TP Silvex	0.01	Chloride	
Radioactivity		Recommended	250
Radium-226 + radium-228, pCi/l	5	Upper	500
Gross Alpha particle activity, pCi/l	15	Short-term	600
Tritium, pCi/l	20,000	Sulfate	
Strontium-90, pCi/l	8	Recommended	250
Gross Beta particle activity, pCi/l	50	Upper	500
Bacteriological	c	Short-term	600
Turbidity, units[d]	1		

[a] In milligrams per liter (mg/l) unless otherwise indicated.

[b] Varies with ambient temperature.

[c] Maximum contaminant level depends upon analytical technique.

[d] Surface water source not exposed to significant sewage hazards or significant recreational use.

[e] Applies to water in the distribution system.

Previous studies and investigations as well as current data indicate that the mineral content of groundwater of 100 to 500 milligrams per liter (mg/l) of total dissolved solids (TDS) in the Los Osos-Baywood area is generally suitable for all beneficial uses in the area with the exception of local areas identified as having nitrate ion concentrations in excess of recommended standards.

Nitrate. An excellent review of the relationships between nitrate in drinking water and the occurrence of infantile methemoglobinemia was prepared by Winton et al. in 1971.[3] The following discussion is based on that paper.

The presence of nitrate in drinking water was first associated with the disease in 1945. In the following 25 years, approximately 2,000 cases were reported in the United States and Europe with a mortality rate of approximately 7 to 8 percent. It has been estimated that the actual number of cases occurring may be 10 times the number reported.

It is important, however, to put these figures into perspective. Eight percent of 2,000 cases over 25 years amounts to about six deaths per year. If the actual number of cases is 10 times that amount, the average number of deaths might be as high as 60 per year. The population of the United States, however, is about 226 million persons. This mortality rate, spread over the total population, is about three one hundred thousandth of a percent. Any unnecessary death or health hazard, of course, is tragic, especially if it afflicts principally the very young. Nitrate contamination of drinking water supplies, therefore, is an important consideration.

Development of the disease, largely confined to infants under 3 months of age, is caused by conversion of the relatively innocuous nitrate into nitrite. Nitrite then converts hemoglobin, the blood pigment that carries oxygen from the lungs to the tissues, to methemoglobin. Because the altered pigment can no longer transport oxygen, the physiologic effect is suffocation, hence the term "blue babies."

There are several reasons why young infants are particularly susceptible to the disease. First, the infant's total fluid intake per unit of body weight is approximately three times that of an adult. In addition, the infant's ability to secrete gastric acid is not completely developed; this allows the gastric pH to become high enough to permit nitrate-reducing bacteria to reside in the high gastrointestinal tract. From this location, the bacteria are able to reduce the nitrate before it is absorbed into the circulation. Another fact that predisposes the infant is that the predominant form of hemoglobin present at birth, hemoglobin F, is more susceptible to methemoglobin formation than the adult form, hemoglobin A. Finally, there is decreased activity in infants of the enzyme that is normally responsible for methemoglobin reduction.

Development of a case of methemoglobinemia from nitrate in drinking water is a complicated process which involves a number of steps and depends on several variables. At each step in the process, infant formula preparation, bacterial reduction of nitrate, or reaction of nitrite with hemoglobin, there are variables that determine whether methemoglobinemia will or will not occur. The level of nitrate in drinking water is only the initial variable in this disease process; the lower the nitrate level, the more things have to go wrong at various steps before the disease develops.

An investigation to determine the adequacy of the recommended maximum nitrate concentration of 45 mg/l was prompted by the lack of reported cases of infant methemoglobinemia in some locations with water supplies exceeding the 45 mg/l limit, sometimes by a factor of two.[3] It was hoped that the limit could be raised, however, sufficient evidence exists to suggest that cases of methemoglobinemia may result from nitrate concentrations slightly above, and even slightly below, the 45 mg/l level. It was concluded, therefore, that the limit was appropriate.

Organic Compounds. The U.S. Environmental Protection Agency (USEPA) is proposing regulations to control the presence of organic compounds in treated water. The final form of these organics regulations to be promulgated by USEPA is in considerable doubt. Since California has primacy under the 1974 Safe Drinking Water Act (SDWA), it is likely that the state regulations will closely resemble the federal regulations as they have in the past. The organics regulations that have been proposed consist of two parts:

1. A maximum contaminant level (MCL) of 0.10 mg/l for total trihalomethanes (TTHM) with established population levels affected, monitoring frequencies, and constraints on modifications to disinfection procedures.

2. A granular activated carbon (GAC) treatment requirement for systems with "vulnerable" supplies that will be operated using a set of three criteria and installed on a strict schedule.

Between the time the regulations were proposed and the close of the comment period in September 1978, USEPA received a large number of comments that were generally critical of the means and goals of the regulations. USEPA is currently evaluating these comments, and it is expected that the revised regulations will be promulgated within several months.

Bacteriological Characteristics. As a result of the safeguards provided in construction, operation, and testing of urban water supplies, cases of water-borne disease have become a rarity in the United States. Pathogenic or disease-producing organisms of primary significance are those which produce typhoid and paratyphoid fever, cholera, bacillary and amoebic dysentery, gastroenteritis and some types of virus infections, notably hepatitis.

The isolation and identification of specific pathogens involves tedious and time-consuming techniques which are impracticable for routine purposes. For this reason, control test procedures involve a relatively simple examination for nonpathogenic organisms of the coliform or intestinal groups. These organisms are present in large numbers in the intestinal tract of warm blooded animals, including man, and hence are indicators of the possible presence of water-born pathogens.

Standards of bacterial quality have been established by the State Department of Health Services. These apply only to water at points of delivery to customer connections; consequently, they have no direct significance in relation to untreated water from surface streams or other sources. At the present time, limits of bacterial quality of water prior to treatment for public uses are defined by the Department of Health Services "Guide for Treatment of Surface Waters of Various Water Qualities for Domestic Use." In considering the subject of treatment requirements, the guide places water supplies in three groups, all based on the degree of treatment required. Simple chlorination is required for surface water meeting other USPHS Standards but containing an average most probable number (MPN) of not more than 50 MPN coliform bacteria per 100 milliliters (ml) in any one month. Filtration without coagulation, or coagulation and sedimentation, only, followed by disinfection, is required for water having coliform bacteria counts averaging not more than 500 MPN in any one month and having a turbidity of less than 50 standard units averaged over any 24-hour period. Complete treatment involving coagulation, filtration, and disinfection is required for water having a coliform count up to 20,000 MPN per 100 ml measured by a monthly geometric mean.

Water Quality Control Plan. A Water Quality Control Plan (Basin Plan) has been prepared for the Central Coastal Basin.[4] The Basin Plan sets forth water quality objectives designed to protect the various waters for beneficial uses. The approach used is consistent with the State's "Non-degradation Policy" which states:

"...whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with the maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies."

The objectives state that water used for municipal and domestic supply shall meet objectives established by the California State Department of Public Health, shown in Table 5-1, as applied to water actually served. Specific groundwater objectives for the Los Osos groundwater basin are: 200 mg/l total dissolved solids, median; 50 mg/l chloride; 0.1 mg/l boron; and 5 mg/l nitrogen as N (equivalent to about 23 mg/l as NO_3). These objectives are intended to provide a baseline of water quality for evaluating water quality management in the basin.

Local Standards

In order to maintain and/or achieve the physical, chemical, and bacteriological water quality standards promulgated by federal and state agencies as well as help prevent degradation of the groundwater in the county, San Luis Obispo County has adopted well construction and destruction standards.[5] The standards are in general conformance with California State Department of Water Resources Bulletin No. 74 and require the installation of sanitary seals to specified depths below ground surface for various uses of wells.[6] These requirements apply only to the construction of new wells, and no attempt has been made by local agencies to upgrade deficiencies that are undoubtedly present in many existing, active wells in the study area.

As discussed in Chapter 3, there are two private water companies serving customers in the study area. If the water from these companies were to fail to meet state standards, as specified in Table 5-1, it is the responsibility of the state Department of Health Services to force compliance.

Agricultural Standards

Numerous classifications of water for agricultural purposes have been developed in the United States. Because of the number of variables involved in the development of classification schemes, only the Wilcox-Magistad classification of irrigation water as modified by L.D. Doneen, University of California Cooperative Extension, is presented.

Criteria for the determination of suitability of water for irrigation use are usually based on four factors. These include electrical conductivity, chloride concentration, boron concentration, and percentage sodium.

The classification of irrigation water and definitions of class terms and suitability are presented in Table 5-2. The

Table 5-2 Classification of Irrigation Waters

Constituent	Class 1	Class 2	Class 3
Electrical conductivity in micromhos at 25 degrees C	Less than 1,000	1,000-3,000	More than 3,000
Chloride in parts per million	Less than 175	175-355	More than 355
Sodium in percent of total cations in equivalents per million	Less than 60	60-75	More than 75

values presented are to be used as a guide only, because permissible limits vary widely with different crops, soils, and climate. For this method, the following definitions of the class descriptions are:

Class 1--Excellent to Good. Regarded as safe and suitable for most plants under any condition of soil and climate.

Class 2--Good to Injurious. Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3--Injurious to Unsatisfactory. Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

FIELD SAMPLING PROGRAM

To update and augment existing surface water and groundwater quality information in the study area, a field sampling program was conducted in which qualified surface water and groundwater sources were sampled. Qualified wells and surface water discharge points in the study area were identified on the basis of existing data. These data were integrated with historic data to characterize and classify groundwater in the study area according to major chemical constituents.

Selection of Qualified Wells

Criteria used in selecting qualified wells in the study area were based on a review of existing data and included the following items:

1. Accurate well number and location.
2. Wells with reasonably good data on static water level, well depth and perforated intervals.
3. Wells located in areas where existing or potential water quality problems exist.
4. Wells from which water level information and water samples can be obtained.

Due to the wide variety in depth of well, and depth of

Table 5-3 Qualified Wells

Well name	Perforated interval: Depth to static water level, feet	Top depth, feet	Bottom depth, feet	Shallow (S) or deep (D) well[b]	Common well name
30S10E13A7	40	30	40	S	
30S10E13H1	23	36	44	S	
30S10E13H2	40	30	40	S	
30S10E13J1	104	290	406	D	SCWC Rosina
30S10E13L1	30	80	140	D	S&T No.1
30S10E13L2	30	100	140	D	S&T No.2
30S10E13L4	68	240	380	D	SCWC Pecho No. 1
30S10E13L5[a]	23	32	35	S	
30S10E13M1	30	128	168	D	
30S10E13P1	69	115	135	D	
30S10E13P2	103	280	320	D	
30S10E13P3	75	120	160	D	
30S10E13Q1[a]	90	97	100	S	
30S10E24A1	172	172	248	S	SCWC No.1
30S10E24B1	230	288	308	D	
30S10E24C1	170	250	500	D	SCWC Rodman No.1
30S11E7J1	31	80	80	S	
30S11E7K2[a]	53	62	65	S	
30S11E7L1	40	30	40	S	
30S11E7L2	20	125	135	D	
30S11E7L3[a]	34	42	45	S	
30S11E7N1	4	61	83	D	CSA9 3rd St.
30S11E7Q1	20	29	75	S	CSA9 8th St.
30S11E7R1[a]	19	27	30	S	
30S11E8E1	100	95	145	S	
30S11E8E2	100	100	152	S	
30S11E8M3	60	80	120	S	
30S11E8N1	80	112	172	D	
30S11E8N2[a]	34	42	45	S	
30S11E8N3[a]	34	87	90	D	
30S11E16N2	17	78	101	D	
30S11E17E1	90	170	230	D	
30S11E17E4	94	100	200	D	
30S11E17E6	85	122	132	S	
30S11E17E7	140	80	160	S	
30S11E17E9	68	82	110	S	
30S11E17E10	60	80	140	D	

[a] New groundwater sampling well.

[b] "Shallow" (S) means more than 50 percent of perforations located within upper 50 feet of saturated soil. "Deep" (D) refers to all wells perforated deeper than "shallow" wells.

Table 5-3 Qualified Wells (continued)

Well name	Perforated interval				Common well name
	Depth to static water level, feet	Top depth, feet	Bottom depth, feet	Shallow (S) or deep (D) well [b]	
30S11E17E11	140	100	170	S	
30S11E17E12	99	220	260	D	
30S11E17E14	30	60	140	D	
30S11E17E15	40	80	140	D	
30S11E17F2	70	140	180	D	
30S11E17F3	69	120	160	D	
30S11E17F4	36	48	72	S	
30S11E17F5	89	120	160	D	
30S11E17F6	60	98	118	S	
30S11E17F7	60	60	120	S	
30S11E17K1	76	90	150	S	
30S11E17K2	75	100	160	D	
30S11E17K3	76	110	150	D	
30S11E17K4	76	120	160	D	
30S11E17L1	37	90	110	D	
30S11E17L2	86	100	140	S	
30S11E17L3	90	90	160	S	
30S11E17L4	75	80	85	S	
30S11E17L5	40	65	130	D	
30S11E17L10	80	58	118	S	
30S11E17L11	80	60	140	S	
30S11E17L12	90	90	165	S	
30S11E17L13	70	85	125	S	
30S11E17L14	90	90	160	S	
30S11E17L15	72	70	130	S	
30S11E17L16	71	120	160	D	
30S11E17L18	82	140	190	D	
30S11E17L19	80	80	150	S	
30S11E17L21	120	120	180	S	
30S11E17L23	75	120	160	D	
30S11E17N4	10	40	60	S	
30S11E17N5	12	20	40	S	
30S11E17N6	200	180	260	S	
30S11E17N7	106	120	200	D	
30S11E17P2	80	85	155	S	

[a] New groundwater sampling well.

[b] "Shallow" (S) means more than 50 percent of perforations located within upper 50 feet of saturated soil. "Deep" (D) refers to all wells perforated deeper than "shallow" wells.

Table 5-3 Qualified Wells (continued)

Well name	Perforated interval: Depth to static water level, feet	Top depth, feet	Bottom depth, feet	Shallow (S) or deep (D) well[b]	Common well name
30S11E17P3	70	70	160	S	
30S11E17P4	60	90	150	D	
30S11E17P5	102	80	140	S	
30S11E17P7	70	78	158	S	
30S11E17Q3	65	70	125	S	
30S11E17R1	20	45	65	S	
30S11E18B1[a]	19	29	32	S	
30S11E18C1[a]	19	29	32	S	
30S11E18D2	25	73	88	D	
30S11E18E1	40	40	60	S	
30S11E18F1	95	183	345	D	Old Farrel Ave.
30S11E18F2	420	425	620	D	New Farrel Ave. (both CSA9)
30S11E18G3	24	20	30	S	
30S11E18H1	105	113	231	D	CSA9 12th St.
30S11E18H8	66	80	100	S	
30S11E18H9	63	65	85	S	
30S11E18J1	100	130	210	D	
30S11E18J5	15	40	100	D	
30S11E18J6[a]	15	22	25	S	
30S11E18K1	137	170	254	D	CSA9 10th St.
30S11E18K3	85	148	232	D	SCWC No. 3, Los Olivos
30S11E18K5	55	76	92	S	
30S11E18L1	95	183	346	D	
30S11E18L3[a]	39	52	55	S	
30S11E18L4[a]	14	22	25	S	
30S11E18M1	98	330	575	D	
30S11E18N1[a]	72	87	90	S	
30S11E18P1	110	170	230	D	
30S11E18Q1	66	76	86	S	
30S11E18R1	26	40	50	S	
30S11E20A2	21	45	65	S	
30S11E20A3	19	60	80	D	
30S11E20A4	18	30	50	S	
30S11E20A5	52	60	80	S	
30S11E20A7	30	60	80	S	
30S11E20A9	40	60	150	D	

a New groundwater sampling well.

b "Shallow" (S) means more than 50 percent of perforations located within upper 50 feet of saturated soil. "Deep" (D) refers to all wells perforated deeper than "shallow" wells.

Table 5-3 Qualified Wells (continued)

Well name	Perforated interval: Depth to static water level, feet	Top depth, feet	Bottom depth, feet	Shallow (S) or deep (D) well[b]	Common well name
30S11E20A10	19	60	80	D	
30S11E20A11	18	60	100	D	
30S11E20B1	58	100	183	D	
30S11E20B3	50	60	120	S	
30S11E20B4	80	80	160	S	
30S11E20B7	180	140	220	S	
30S11E20B9	82	80	150	S	
30S11E20D1	34	47	57	S	
30S11E20E1	57	60	80	S	
30S11E20H1	15	45	142	D	
30S11E20H2	17	78	101	D	
30S11F20H3	25	207	284	D	
30S11E20H4	37	88	148	D	
30S11E20M1	122	200	220	D	
30S11E21D2	23	85	175	D	
30S11E21D3	20	125	140	D	
30S11F21D4	23	40	160	D	
30S11E21D6	20	125	135	D	
30S11E21D7	35	55	100	S	
30S11E21D8	27	30	80	S	
30S11E21D11	22	35	80	S	
30S11E21D13	21	35	100	S	
30S11E21D14	37	20	100	S	
30S11E21D16	40	80	140	D	
30S11E21E1	30	140	143	D	
30S11E21E2	30	80	100	D	
30S11E21E3	20	60	100	D	
30S11E21E4	16	115	155	D	
30S11E21E7	40	46	136	D	
30S11E21E8	60	60	100	S	
30S11E21M1	80	60	140	S	
30S11E21M2	70	60	120	S	
30S11E21M3	58	60	140	S	
30S11E21M4	40	60	140	D	
30S11E21M5	100	100	180	S	

[a] **New groundwater sampling well.**

[b] **"Shallow" (S) means more than 50 percent of perforations located within upper 50 feet of saturated soil. "Deep" (D) refers to all wells perforated deeper than "shallow" wells.**

well, usually at the well head itself. If the well was inactive at the time of sampling, a sample was deemed representative only after the well had been operated for a sufficient length of time to ensure a fresh sample from the aquifer.

Prior to initiating the sampling program, methods for sampling, sample handling, and analysis were defined and reviewed with San Luis Obispo County Laboratory personnel. The program outlined is shown in Volume II, Appendix V. All groundwater samples were analyzed in the San Luis Obispo County Laboratory, and the results of analyses are shown in Volume II, Appendix VIII.

WATER QUALITY CONDITIONS

Existing data on the historical and current water quality conditions in the Los Osos-Baywood Park area are generally recognized as being adequate for characterizing and classifying surface water and groundwater, but are considered poor, both in terms of accuracy and adequacy for identification of specific causes of existing water quality problems. Existing water quality conditions are described in this section as they pertain to the geohydrology of the study area as discussed in Chapter 4. Within the accuracy of available data, water quality variations in the study area are discussed both from the standpoint of lateral variations as well as vertical variations evident within specific aquifer zones. Special emphasis is placed on the occurrence and distribution of nitrate in the study area.

Water Quality Characterization

All water, except distilled water, contains mineralization in the form of dissolved solids. The total dissolved solids are made up principally of the elements calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate, and carbonate. Water tends to dissolve these constituents in a proportion depending upon the environment through which the water travels. Water flowing over or through formations in the earth dissolves minerals in those formations. Although the groundwater may increase in total dissolved solids due to continued dissolution of minerals in the formation, the balance among the various constituents dissolved remains approximately the same. This balance among constituents is often heavily influenced by the chemical quality of the water which initially recharges the groundwater-bearing formation.

Mixtures of water of one quality with water of another quality produce a composite which has a balance of constituents roughly equivalent to the proportion of the two waters used in making the mixture. Water subjected to evaporation, however, will show an increase in total dissolved solids but the balance of constituents will remain approximately the same. For example, if groundwater is pumped to the surface and applied to irrigate a crop, the evapotranspiration of the plants will tend to concentrate the dissolved solids in the remaining water resulting in an increased total dissolved solids in the irrigation return flow. As the irrigation return water percolates back to the groundwater table, it carries with it the increased total dissolved solids, which results in an increase in total dissolved solids in the groundwater body. The balance among the constituents, however, remains nearly the same in the irrigation return water, and therefore the balance of constituents in the groundwater body does not change appreciably.

Similarly, natural vegetation consumes water through transpiration, but leaves some of the dissolved solids in solution at higher concentrations, or deposited on soil particles. Solids deposited in the soil may be redissolved by infiltrating rainfall, to percolate down to the groundwater table, carrying the higher concentrations of dissolved solids with it. Some of the dissolved solids, nitrate for example, are taken up and consumed by the vegetation in the growth process.

Because of these characteristics of dissolved constituents in water, it is possible to characterize and classify water according to the balance of its principle constituents. The methodology used is to calculate the milliequivalents per liter (meq/l) for each of the major constituents listed above. The sum of milliequivalents per liter is then determined for both the cations and anions, and a percentage is calculated for each constituent as percentage of total cations and total anions.

In this manner, the apparent difference between the chemical quality of two water samples due to differences in total dissolved solids is eliminated, since the total percentage of milliequivalents equals 100 percent for both samples. The balance of constituents for each of the samples can then be compared using the percentages. The comparison is commonly performed by plotting the constituents on an appropriate graph, and comparing the graphical presentations, one with another. A convenient form of graphical presentation is the trilinear plot, and this type of presentation is used herein.

<u>Trilinear Plotting Systems.</u> Groundwater, and most natural waters, can be represented as solutions of three cationic constituents, calcium, magnesium, and the alkali metals; and of three anionic constituents, sulfate, chloride, and those contributing to alkalinity. The composition of a water, therefore, can be represented conveniently by trilinear plotting.[7]

The simplest trilinear plots utlize two triangles, one for cations and one for anions. Each vertex represents 100 percent of a particular ion or group of ions. The composition with respect to the cations is indicated by a point plotted in the cation triangle on the basis of the percentages of the three which are present. The composition with respect to anions is indicated by the position of a similar point in the anion triangle.

Commonly, most trilinear diagrams include a third plotting field that represents a projection of the triangles into a common area where the analysis can be represented by one point. The position of the single point is dependent upon the relative concentration of one cation with respect to the sum of the other two, and of one anion with respect to the sum of the other two. Which cation and anion are singled out depends upon the arrangement of the plotting fields.[7] Water samples of the same chemical character may have widely different total dissolved solids concentrations. Using a trilinear plot, however, waters with very different total concentrations can have identical representations on this diagram. A single trilinear diagram has greater potential to accommodate a larger number of analyses without becoming confusing, and is convenient for showing the effects of mixing two waters from different sources. The mixture of two different waters will plot on the straight line joinng the two points.[8] Similarly, in the case of a mixture from three sources, the solution will be represented in each of the three fields by a point located inside a triangle defined by the three end members. Again, all ionic constituents will have been mixed in the same proportions.[9]

Groundwater. An evaluation was made of the recorded water quality data available in the study area. In order to bring out the more meaningful and representative data, only those data from qualified wells were utilized. The data were selected to provide a uniform areal distribution, as well as a uniform distribution by depth of perforated zone. In addition, only those analyses which include all of the constituents described above were usable for this evaluation. For those qualified wells with more than one complete chemical analysis, a recent analysis was selected which appeared to be representative of the group of analyses available. As a result of this process, a total of 28 water quality analyses from separate qualified wells, distributed as uniformly as possible both areally and vertically, were selected for further evaluation.

Notwithstanding the rigorous selection process employed in identifying the 28 samples, it was obvious that some discretion and suspicion must be employed in utilizing these previous analyses. The chemical analyses are recorded data, and there is no information on sampling procedures, chain-of-custody between field sampling and delivery to the laboratory, and no information on the laboratory procedures utilized in performing the analyses. In many instances, the analyses were performed by different laboratories, using different techniques and different personnel. For example, it is normally expected that the difference of total milliequivalents per liter for cations be within 3 percent of the total milliequivalents per liter for anions in a given analyses. Many of the recorded analyses showed excessive imbalance between cations and anions, indicating that some error in analysis of one or more of the constituents may be present. With proper caution, however, these data are usable in evaluation of water quality characteristics of groundwater in the study area.

To provide a base of water quality data requiring a minimum of caution in utilization, a field sampling program was performed as part of this study. A total of 40 wells and two surface water sources were selected, including 13 new sampling wells, and all samples were obtained and analyzed by San Luis Obispo County personnel under a strict, rigorous procedure for sampling, sample handling, analyses, and reporting. These sampling locations are shown in Table 5-4, and on Figures 5-3 and 5-4, presented later in this chapter. In addition to the 40 groundwater samples, and two surface water samples six wastewater samples were obtained and analyzed.

The field and laboratory data obtained during the field sampling program, and a detailed description of the program itself, are presented in Volume II in the following appendices:

Appendix V	Field Sampling Program
Appendix VI	Well Logs for Sampling Wells
Appendix VII	Soils Test Data
Appendix VIII	Water Quality Analyses
Appendix IX	Wastewater Analyses

Due to the obvious difference in geology between the Los Osos Creek Valley, located immediately east of Los Osos Creek, and the rest of the study area west of Los Osos Creek, the analyses for the wells in Los Osos Creek Valley were compared. These analyses are shown plotted on Figure 5-1. The surface water sample analysis from Los Osos Creek is also shown on Figure 5-1, together with the analysis for seawater.

An examination of the other analyses showed that samples from certain other wells showed similar characteristics. In particular, five of the municipal supply wells located in the central and western portions of the study area showed water quality characteristics very similar to those of Los Osos Creek Valley groundwater and Los Osos Creek surface water. These analyses are also shown plotted on Figure 5-1. These samples are from the following wells: Southern California Water Company (SCWC), No. 5 (18M1); County Service Area No. 9 (CSA9), Old Ferrel Avenue Well (18F1); CSA9, New Ferrel Avenue Well (18F2); SCWC, Pecho No. 1 (13L4); and CSA9 Third

Table 5-4 Summary of Water Sampling Locations

Purpose	Sampling location: Existing well	Sampling location: New sampling well	Comments
Group 1			
Shallow qualified wells sample for up-date and control.	30/10-13H1 30/10-24A1 30/11-7Q1 30/11-17F4		These wells have some history of chemical analysis. Correlation of new analyses with old, limited analyses.
Group 2			Note: "Group" refers to sampling category, see Volume II, Appendix V. "Area" refers to wastewater discharge area, see Volume II, Appendix IV.
Shallow qualified wells down gradient from areas of high density (≥ 1000 gad) and special waste-water discharge.			
Area (1)	30/11-20B7		
Area (2)	30/11-17N6		
Area (3)		30/11-18L3	No qualified well(s) exist near this optimum location.
Area (4)	30/10-13A7		
Area (5)			No down gradient sample is appropriate. Discharge is from a single point source.
Area (6)		30/11-7L3	No potential alternate well(s). Also to be utilized in evaluation of water quality up-gradient from Area(7).
Area (7)			Location of area makes down-gradient sampling inappropriate.
Area (8)	30/11-17R1		
Group 3			
Shallow qualified wells located within areas of high (≥ 1000 gad) and special wastewater discharge.			
Area (1)	30/11-17N4		No potential alternate well(s) exist.
Area (2)		30/11-18J6	No qualified well(s) exist near this optimum location.
Area (3)		30/11-18L4	No qualified well(s) exist near this optimum location.

Table 5-4 Summary of Water Sampling Locations (continued)

Purpose	Sampling location: Existing well	Sampling location: New sampling well	Comments
Area (4)	30/11-18E1		No potential alternate well(s) exist.
Area (5)			No sample is appropriate. Discharge from a single point.
Area (6)			No need for sample. Previously identified well 30/11-7Q1 is properly located for this purpose.
Area (7)			No need for sample due to area location.
Area (8)	30/11-20A2		
<u>Group 4</u>			
Shallow, qualified wells up-gradient from high density (≥ 1000 gad) and special wastewater discharge.			
Area (1)	30/11-20E1		Alternate well needs static water level measurements for qualification.
Area (2)	30/11-18R1		No potential alternate well(s) exist.
Area (3)	30/11-18Q1		No potential alternate well(s) exist.
Area (4)			No sample needed. Previously identified sampling well 30/11-18L3 is optimally located. No alternate exists.
Area (5)		30/11-8N2	No qualified well(s) exist in this location. No alternative well(s) exist.
Area (6)		30/11-7R1	Same as above.
Area (7)			No sample needed. Previously identified well 30/11-7L3 will be utilized.
Area (8)	30/11-20H5		No potential alternate well(s) exist.

Table 5-4 Summary of Water Sampling Locations (continued)

Purpose	Sampling location		Comments
	Existing well	New sampling well	
Group 5			
Shallow qualified wells within area of medium density (500 to 999 gad) waste discharge.	30/11-18K5 30/11-18H3		No alternate well(s) exist.
	30/11-17N3[a]	30/11-7K2	No qualified well(s) exist.
		30/11-18N1 30/10-13Q1 30/11-18C1 30/11-18B1	No qualified well(s) exist near these optimum locations.
Group 6			
Shallow qualified wells within areas of low density (1 to 499 gad) wastewater discharge and wells necessary for water quality assessment in areas lacking data.	30/11-17K1 30/11-8E2 30/11-17P7		No alternate exists. Well near nursery.
		30/10-13L5	No qualified shallow well exists near this optimal location.
Group 7			
Deep qualified wells, not municipal wells and lacking water quality data, to be sampled.	30/10-13P2[a] 30/11-17K2[a] 30/11-17P4 30/11-18D2 30/11-18M1 30/11-21E3	30/11-8N3	No alternative qualified wells exist for this group. They were chosen for their location to complement existing data on deep wells (primarily municipal).
Group 8			
Surface water sampling locations.	30/11-20Ac[b] 30/11-17Fd[b]		Los Osos Creek. Eto Creek.

[a]Additional qualified wells used in analysis due to sampling error.

[b]Surface water sampling points are located by 10-acre quadrant within 40-acre tract, labelled a,b,c,d counterclockwise beginning in the northeast quadrant.

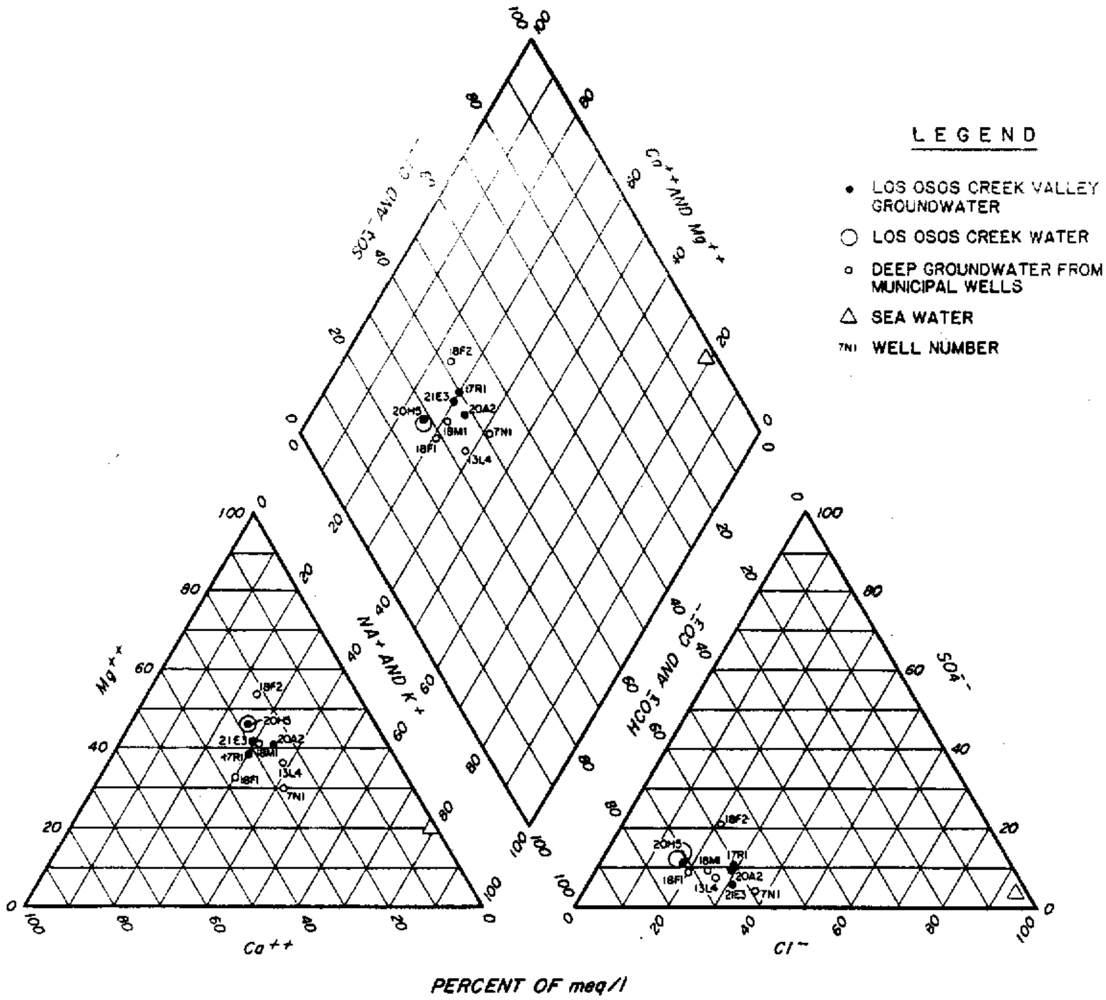

Figure 5-1 Trilinear Plot of Deep Groundwater, Los Osos Creek, and Seawater

Street Well (7N1). In particular, the analyses of samples previously analyzed from the following wells showed distinct differences: SCWC, Rodman No. 1 (24C1); CSA9, 12th Street (18H1); CSA9, 10th Street (18K1); and SCWC, No. 3, Los Olivos (18K3). A further evaluation was necessary to explain these differences.

Since the wells along Los Osos Creek Valley draw water from the alluvium and/or the Paso Robles Formation, which occurs near ground surface in that area, it appeared that there may be a uniform water quality of all groundwater in the Paso Robles

Formation. An examination of the well logs for the five municipal wells plotted on Figure 5-1 showed all of these wells to be perforated within the Paso Robles Formation. Certain of the other municipal wells (18H1, 18K1, and 18K3) also appeared at first to be perforated in the Paso Robles Formation. An evaluation of the detailed electric logs from wells 18M1 and 12J1 disclosed a persistent layer of clay beds at the top of the Paso Robles Formation occurring between elevations minus 100 to minus 170, approximately. The logs for wells 18H1, 18K1, and 18K3 indicate that all three wells terminate above elevation minus 150, and are interpreted to be not perforated below upper top clay beds of the Paso Robles Formation. Therefore, these wells draw their water from the shallower older dune sand deposits.

Well 24C1, however, extends to approximately elevation minus 300, a considerable distance below the apparent base of the clay-bed layer. However, the top of the perforated zone is at approximately elevation minus 50, and therefore a considerable portion of the perforated zone is within the older dune sand deposits. It is possible, consequently, that this well is producing a large proportion of its total flow from the shallower deposits, and only a smaller proportion from the Paso Robles Formation. This would account for the difference in quality for well 24C1.

The remainder of the 40 groundwater samples obtained as part of this study, and the surface water sample obtained from Eto Creek, were studied to determine if any significant differences could be observed. These water quality analyses are shown plotted on Figure 5-2. As the figure shows, samples from shallow wells and samples from deep wells are distributed within the same general area of the trilinear plot, an area distinctively different from that shown by the samples plotted on Figure 5-1. It appears that the deep wells whose analyses are shown on Figure 5-2 are wells which do not produce significant quantities of water from the Paso Robles Formation. The distribution of analyses is greater than that for the deep municipal wells shown on Figure 5-1, but the limits of distribution of analyses define a characteristic area significantly different than that shown on Figure 5-1 for deep municipal wells and Los Osos Creek Valley groundwater.

Wells, 18J6 and 7R1 stand out as exceptions. These analyses fit neither the characteristic area for Paso Robles Formation groundwater nor the area for the shallower, older dune sand deposits. These wells are sampling wells installed as part of this project, and are only 25 to 30 feet deep. There is no explanation apparent for these variations. It can only be surmised that some unique, local conditions or some errors in sampling or analysis may have occurred.

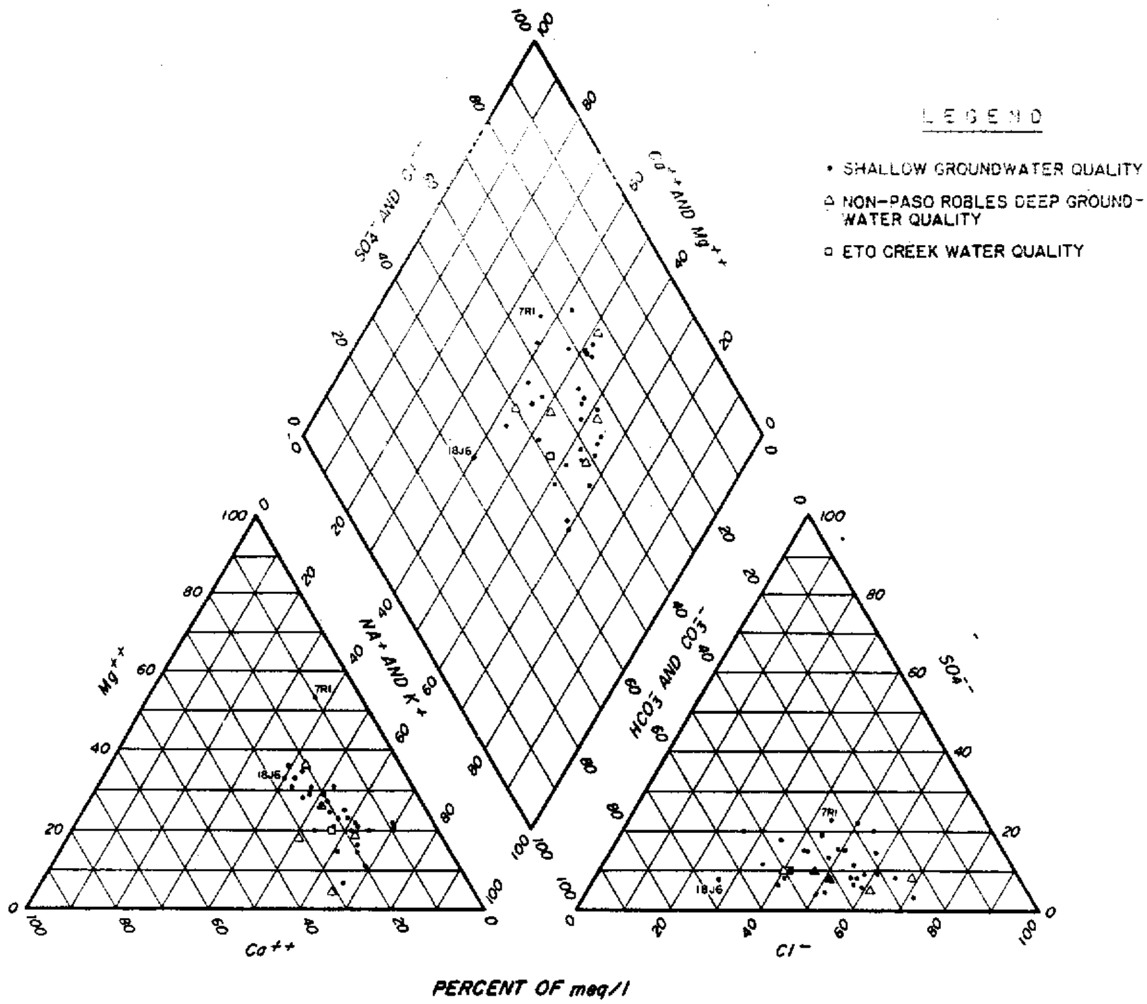

Figure 5-2 Trilinear Plot of Shallow Groundwater, Non-Paso Robles Groundwater, and Eto Creek

Surface Water. The position of the analysis for Eto Creek water within the shallow groundwater grouping on Figure 5-2 is not surprising. An examination of the shallow groundwater contours on Figure 4-1 shows that Eto Creek is an effluent creek, producing much of its flow by discharge of shallow groundwater. Therefore, it is to be expected that Eto Creek surface water would be similar in composition to shallow groundwater in the area.

Los Osos Creek surface water originates as runoff from Clark Valley. The section of Los Osos Creek near the sampling point, at its intersection with Los Osos Valley Road, exhibits only intermittent flow characteristics, and is dry throughout much of the year. It appears, therefore, that Los Osos Creek is an influent stream, allowing percolation of surface water into the alluvial deposits which overlie, and are hydraulically connected to, the Paso Robles Formation below. The recharge to the Paso Robles Formation by Los Osos Creek water is further supported by the similarity in quality between this surface source, the Los Osos Creek Valley groundwater, and the Paso Robles Formation groundwater considerably west of the creek.

Classification of Water Quality

Utlizing the distinctive distribution limits of water quality as shown on Figures 5-1 and 5-2, groundwater and surface water can be classified according to the balance of constituents shown. For convenience, the distribution shown on Figure 5-1 is classified as Type A water, and the distribution shown on Figure 5-2 is classified as Type B water. From these analyses, a range of values for each constituent was selected, and a typical value for each constituent was established for each type of water. The range of values and typical value for each constituent are shown in Table 5-5. In addition, typical values for seawater are also shown in Table 5-5. Furthermore, the table presents a description of the specific water analyses which comprise each type.

The typical analysis for each group represents approximately a mid-point for the group of analyses for both cations and anions. Using the typical analyses for Type A and Type B waters, a verbal description is possible. As shown on Table 5-5, Type A water is classified as magnesium-sodium bicarbonate water, while Type B water is classified as sodium chloride water. Seawater is, of course, classified as sodium chloride water, also.

Existing Water Quality Conditions

Using the results of water quality analyses, it is possible to characterize water quality conditions in the study area with regard to degradation of water quality. The following paragraphs discuss the existing water quality conditions for both groundwater and surface water.

Groundwater. A comparison of the water quality analyses with the California Drinking Water Standards, shown in Table 5-1, shows the water quality in the study area to be within the maximum contaminant levels (MCLs) or recommended limits with the exception of nitrate and total dissolved solids. Since both nitrate and total dissolved solids can be expected to increase as a result of

Table 5-5 Classification of Waters

Item	Groundwater				Seawater
	Type A		Type B		
	Range[a]	Typical[a]	Range[a]	Typical[a]	Typical[a]
Calcium	22 - 38	29	8 - 33	23	3.5
Magnesium	27 - 54	38	5 - 37	20	18.0
Sodium and Potassium	24 - 45	33	36 - 71	57	78.5
Chloride	16 - 38	25	26 - 72	51	90.6
Sulfate	3 - 21	11	2 - 23	12	9.1
Bicarbonate	57 - 74	64	22 - 54	37	0.3
Classification	Magnesium-sodium Bicarbonate $(Mg-Na)HCO_3$		Sodium Chloride NaCl		Sodium Chloride NaCl
Description	Los Osos Creek surface water, Los Osos Creek Valley groundwater, and deep groundwater from the Paso Robles Formation pumped principally from municipal wells.		Eto Creek surface water, shallow groundwater, and deep groundwater pumped principally from older dune sand deposits.		Representative of ocean water, Morro Bay water, and sea spray. Reference: The Water Encyclopedia, 1970, Table 3-39.

[a]Values are percent milliequivalents per liter for total cations and total anions.

man's activities, it is important to further evaluate the possible degradation to water quality resulting from these activities as demonstrated by these constituents.

An analysis was made of recorded groundwater quality data in an attempt to define trends in water quality variation. Although the data generally show increases in nitrate and total dissolved solids concentrations with time, none of the data sources were sufficiently illustrative to present graphically.

Due to the wide variation and inconsistency among previously recorded values for nitrate in the water quality analyses, only those analyses obtained as part of the field sampling and analysis program, performed during this study, were utilized in assessing nitrate contamination. Using these data, nitrate values for each of the 40 groundwater samples were plotted on a map of the study area, and appropriate contours on nitrate content in the shallow groundwater were drawn. These are shown on Figure 5-3. Using these contours, the study area was subdivided into the following subareas: (1) less than 25 milligrams per liter (mg/l) nitrate, as NO_3; areas with nitrate concentrations ranging between 25 and 45 mg/l nitrate, as NO_3; and areas with nitrate concentrations in excess of 45 mg/l nitrate, as NO_3. The areas depicted on Figure 5-3 with nitrate levels above 25 mg/l, an approximate upper limit for background nitrate content, show a very good correlation with areas of urban development in the study area. As would normally be expected, it appears that nitrate levels in the shallow groundwater increase with increased urban development, and are the highest near the central portions of development.

Similarly, it may be expected that the total dissolved solids content of the shallow groundwater would follow a similar pattern of correlation with urban development. Contours on total dissolved solids, also based on the 40 samples obtained as part of this study, are shown on Figure 5-4. As in the case of nitrate, there is a good correlation between higher values of total dissolved solids in the shallow groundwater and urban development in the study area. In fact, there appears to be a good correlation between areal distribution of total dissolved solids and areal distribution of nitrate in the study area.

To further evaluate the apparent correlation between total dissolved solids and nitrate, a plot was made of the 40 groundwater samples showing total dissolved solids plotted against nitrate concentration. This plot is shown in Figure 5-5. At first inspection, the plotted points appear to be randomly scattered over the graph. As a first assumption, it is reasonable to anticipate that, if a correlation exists, the relationship would be linear. Therefore, a simple linear regression was performed utilizing all 40 samples. As might be expected from the appearance of the plot, the correlation coefficient for this analysis was very small, 0.004.

Inspection of the plot shows a wide range of total dissolved solids values associated with several very low values of nitrate. Using the approximation of 25 mg/l nitrate, as NO_3, as the upper limit of the background values for nitrate, and eliminating all those samples with nitrates less than 25, a linear regression was again performed. This analysis showed a correlation coefficient of 0.4, an improvement of two orders of magnitude, but still not sufficiently high to indicate a definite useable relationship.

Further examination of the data showed three wells, 13L5, 18L4, and 13Q1, to have inordinately high values for total dissolved solids and high values, but less than 50 mg/l, for nitrate, in comparison with the remainder of the data. All three wells are

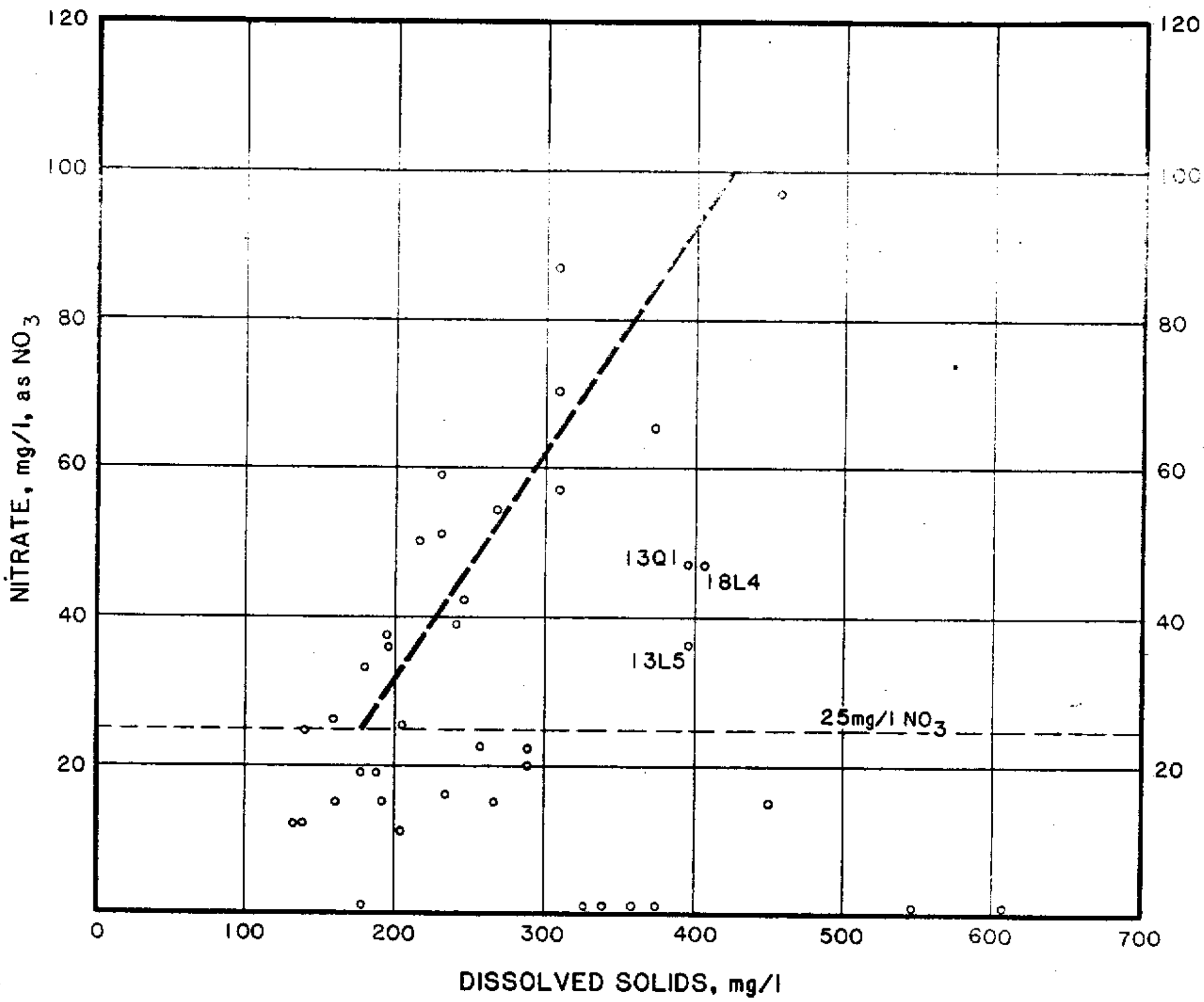

Figure 5-5 Correlation Between Nitrate and Total Dissolved Solids

shallow sampling wells constructed as part of this investigation. Wells 13L5 and 13Q1, however, are the two most westerly and most near the ocean of any of the sampling wells constructed. Under the assumption that these two wells, sampling the upper few feet of a shallow groundwater table very near the sea coast, may be showing an inordinately high value of TDS as a result of greater amounts of sea spray mixing with the shallow groundwater, it was decided to drop these two wells out of the data utilized for correlation analysis. Well 18L4, being further inland, was considered to show no similar rationale for being eliminated from comparison with the other remaining wells. The linear regression performed on data points with nitrate levels greater than or equal to 25 mg/l, but eliminating wells 13L5 and 13Q1, showed a correlation coefficient of 0.62. A correlation coefficient greater than 0.5 is commonly considered to indicate a definite relationship between variables. Although inconclusive, it appears from the analysis that there is a correlation between total dissolved solids and nitrate concentrations in shallow groundwater within the study area.

Similar attempts were made to correlate changes in nitrate concentration with changes in other constitutents or groups of constituents. No other meaningful relationships, however, were discovered.

Surface Water. Los Osos Creek water, being surface runoff from Clark Valley, would not normally be expected to demonstrate effects of man's activities in the study area. This is, in fact, borne out by examination of the water quality analysis from this source. Total dissolved solids content is in the low end of the range of values for Los Osos Creek Valley groundwater, and the nitrate concentration is less than 2 mg/l as NO_3.

The water quality characteristics for the Eto Creek surface water sample are similar to those of shallow groundwater in the vicinity, as expected. Total dissolved solids content is 253 mg/l and nitrate concentration is 3 mg/l as NO_3. Although this creek may be draining groundwater from an area which shows higher values of nitrate and TDS and which may therefore contain wastewater effluent, the shallow depth to groundwater would minimize the aerobic conditions necessary to provide nitrification of nitrogen in wastewater effluent percolating to the groundwater table. Consequently, any such nitrogen would come out as nitrogen gas, leaving the nitrate concentration of the water low. This aspect, and other environmental conditions in this area affecting nitrate content are further discussed in Chapter 6.

In general, therefore, based on the two surface water samples analyzed, the existing surface water quality conditions do not indicate any degradation. Although surface water is not used for potable supplies in the study area, the importance of surface water quality conditions to this study lies in the fact that surface water provides a significant source of recharge to the Paso Robles Formation aquifers along Los Osos Creek.

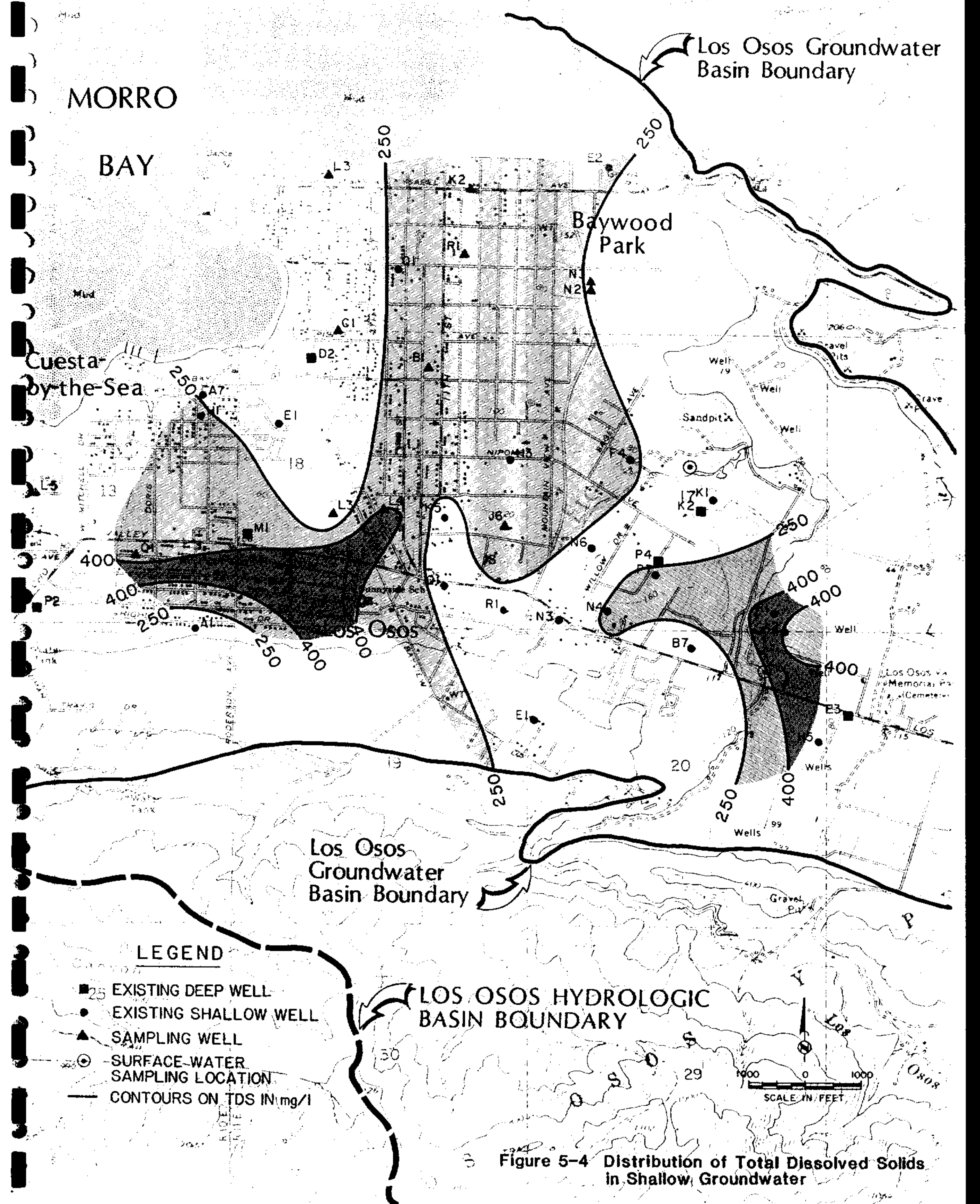

Figure 5-4 Distribution of Total Dissolved Solids in Shallow Groundwater

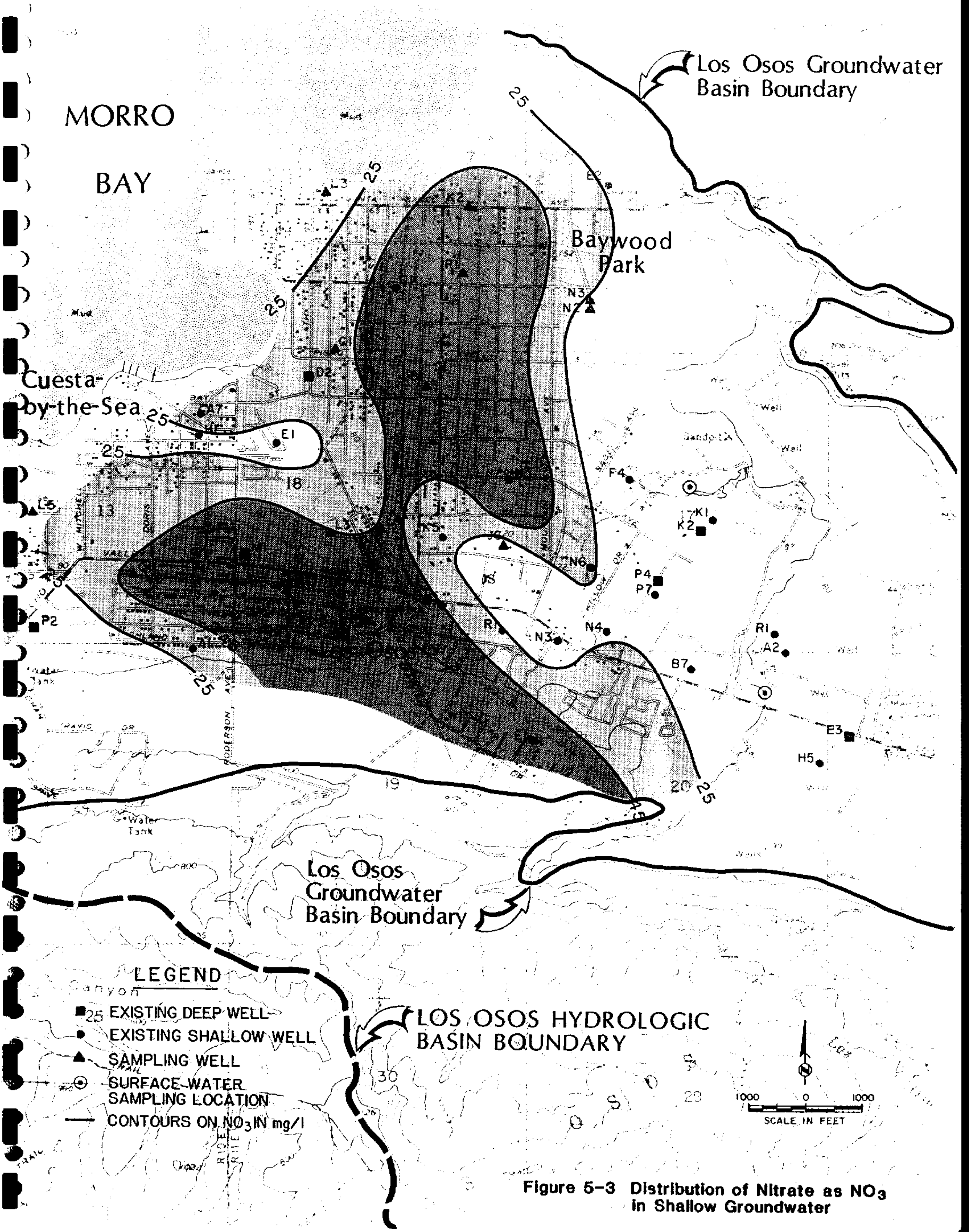

Figure 5-3 Distribution of Nitrate as NO_3 in Shallow Groundwater

CHAPTER 6

WASTE DISCHARGE CHARACTERISTICS

Review of the number, types and characteristics of waste discharges in the study area is essential to full evaluation of past, present, and future water quality problems. Wastewater contains many constituents that can cause adverse health effects or produce other water quality problems. The material in this chapter, however, will focus mainly on nitrate. This contaminant has been detected in many wells in the area and has caused concern on the part of area residents. Although nitrate is the principal contaminant under investigation, other water quality parameters are discussed as they pertain to present or potential water quality problems in the study area.

Waste discharges can be conveniently grouped into two types: point sources and non-point sources. Point sources are those where the waste stream can be conveniently collected for treatment, storage, and disposal. In the study area, discharges from individual septic tank systems and community systems are the principal point sources. Non-point sources (sometimes termed diffuse sources) are those where collection and treatment would be difficult or impossible to implement. Runoff from urban and nonurban areas and leached irrigation waters are the main non-point discharges in the Los Osos-Baywood Park area. Both point sources and non-point sources will be evaluated in this chapter.

APPLICABLE WASTEWATER REGULATIONS

Wastewater must be disposed of or reused in a manner that will protect public health, maintain surface water and groundwater quality consistent with its beneficial uses, prevent nuisance in the vicinity of the disposal area, and comply with specific local, state, and federal requirements. These conditions determine the degree and often the type of treatment which must be provided prior to disposal or reuse. Applicable federal, state, and county regulations and policies are summarized below.

Federal Requirements

Federal law is aimed principally at treatment facilities serving sewered communities rather than at individual septic tank systems. A national program of water quality control was established by the Federal Water Quality Control Act of 1965. This act requires establishment of quality standards for interstate waters, review of such standards by the (then) Water Pollution Control Administration and the Department of Health, Education and Welfare, and adoption of the standards by state water pollution control agencies. The act, which was amended as recently as 1977, is now administered by the U.S. Environmental Protection Agency (USEPA). The general objective, as stated in the 1972 amendments (PL 92-500), is the restoration and maintenance of "the chemical, physical and biological integrity of the nation's waters."

With the passage of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), in the absence of more stringent state-imposed receiving-water quality requirements, regulation of wastewater discharges was established on the basis of effluent limitation. For any wastewater disposal or project involving publicly owned treatment works, state and federal guidelines require evaluation of alternative wastewater management technologies as outlined in 40 CFR, 35.917-1(d)(5), best practicable waste treatment. In February 1976, USEPA published revised criteria for best practicable waste treatment. Publicly-owned treatment works must comply with these criteria by July 1, 1983. The criteria state that three alternative techniques for waste treatment management must be considered by applicants for construction grant funds: (1) treatment and discharge into navigable waters, (2) land application and utilization practices, and (3) reuse of treated wastewater. An alternative is "best practicable" if it is determined to be cost effective and if it will meet the criteria set forth by USEPA.

For publicly-owned treatment works which discharge to surface water, secondary treatment is required as a minimum. Requirements for additional treatment, or alternative management techniques, will depend on several factors, including availability of cost-effective technology, economic burden, and the specific characteristics of the receiving water body.

For land application or irrigation reuse techniques, treatment requirements are based on the impact of effluent on groundwater resources. In situations where the groundwater is used for drinking water supply, the groundwater resulting from the land application of wastewater must meet the following criteria:

1. The maximum contaminent levels for inorganic chemicals and organic chemicals in the National Interim Primary Drinking Water Regulations (or any later revisions to these regulations) should not be exceeded except where levels in the native groundwater are already higher. In

those cases, there should not be an increase in the concentration of that parameter due to land application of wastewater.

2. The maximum microbiological contaminant levels specified in the National Interim Primary Drinking Water Regulations should not be exceeded in cases where the groundwater is used without disinfection.

The USEPA National Interim Primary Drinking Water Standards, presented in Table 6-1, establish limits on the bacteriological, physical, and chemical quality of water supplies, and establish limits on radioactivity and pesticide content.

State Requirements

The Porter-Cologne Water Quality Control Act, as amended, forms the basis of state requirements for water quality control. Under the Porter-Cologne Act, regulation of sources of water pollution starts with the adoption of a water quality control plan, or basin plan, by the regional board. The basin plan, which prescribes water quality for the study area of this project was adopted by the California Regional Water Quality Control Board, Central Coastal Region, one of the nine such regional boards established within the State of California, under the general guidance and authority of the State Water Resources Control Board. In water quality control plans, regional boards are required to establish water quality objectives necessary to protect the beneficial uses of receiving water, including groundwater, and to describe implementation programs by public and private agencies necessary to achieve objectives.

Specific requirements with respect to the quality of treated wastewater and its effect on the quality of receiving water, both surface water and groundwater, are established by the regional board for each discharge or water reuse. State waste discharge requirements are established under cooperative agreement with USEPA according to the National Pollutant Discharge Elimination System (NPDES). To ensure compliance with discharge requirements, the regional boards establish monitoring and reporting programs for both effluent and receiving water. The regional boards also establish long-range objectives and policies, act upon applications for federal and state Clean Water Grants, and enforce requirements through orders and court action, when necessary.

Coastal Commission and County Requirements

Although the state has the authority under the Porter-Cologne Act to directly impose regulations on design, construction, and maintenance of individual waste treatment and disposal systems

Table 6-1 Groundwater Quality Objectives for Use as a Public Drinking Supply

Contaminant	Maximum contaminant level, mg/l unless otherwise noted	
	EPA Manual for evaluating public drinking water supplies	EPA National interim primary drinking water standards
Chemical contaminants		
Arsenic (As)	0.1	0.05
Barium (Ba)	1.0	1.0
Cadmium (Cd)	0.010	0.010
Chloride (Cl)	250	-
Chromium (Cr)	0.05	0.05
Copper (Cu)	1.0	-
Cyanide (CN)	0.2	-
Fluoride (F)		
50.0-53.7F[a]	1.8	2.4
53.8-58.3	1.7	2.2
58.4-63.8	1.5	2.0
63.9-70.6	1.4	1.8
70.7-79.2	1.2	1.6
79.3-90.5	1.1	1.4
Foaming agents as Methylene Blue Active Substances	0.5	-
Iron (Fe)	0.3	-
Lead (Pb)	0.05	0.05
Manganese (Mn)	0.05	-
Mercury (Hg)	0.005	0.002
Nitrate-nitrogen	10.0	10.0
Organics - Carbon Absorbable		
CCE-m	0.3	-
CAE-m	1.5	-
Selenium (Se)	0.01	0.01
Silver (Ag)	0.05	0.05
Sodium (Na)	270	-
Sulfate (SO_4)	250	-
Zinc (Zn)	5	-
Radioactivity		
Gross alpha activity, pCi/l	1[b]	-
Gross beta activity, pCi/l	10[c]	-
Pesticides		
Aldrin	0.01	-
Aldrin and dieldrin	0.01	-
Chlordane	0.01	-
DDT	0.01	-
Endrin	0.003	0.0002
Heptachlor	0.02	-
Heptachlor epoxide	0.02	-
Heptachlor and heptachlor epoxide	0.02	-
Lindane	0.1	0.004
Methoxychlor	0.5	0.1
Organophosphate and carbamate insecticides[d]	0.1	-
Toxaphene	0.1	0.005
Chlorophenols		
2,4-D	1.0	0.1
2,4,5-T	0.005	-
2,4,5-TP	0.2	0.01

[a]Annual average of maximum daily air temperature.

[b]Or Radium 226 - 1 pCi/l when the gross activity is greater than 1 pCi/l but less than 10 pCi/l.

[c]Or Strontium 90 - 10 pCi/l when gross beta activity, after the Potassium 40 activity has been subtracted, is greater than 10 pCi/l but less than 100 pCi/l.

[d]Expressed in terms of parathion equivalent cholinesterase inhibition.

(septic tanks and leach fields), it has generally permitted county authorities to undertake this task. Only in situations where severe public health hazards have occurred due to septic tank failures and where county authorities have failed to take appropriate corrective measures, has the state stepped in and imposed direct controls.

Since the study area is located within the coastal zone, installations of septic systems in the study area fall under the jurisdiction of the Coastal Commission and are regulated by the Coastal Commission Guidelines and the appropriate County Code. In all cases, the more restrictive of these requirements apply. The applicable portions of these documents are excerpted below.

Central California Coastal Commission Guidelines. This section presents excerpts from the current Coastal Commission guidelines, and a proposed revision to the guidelines which may be in effect soon after publication of this report:

SEPTIC TANKS (PRC Sections 30230, 30231, 30240)

Septic tanks are an issue in the entire area, especially in areas of high groundwater, and are related to water quality.

Guideline:

1. The attached (see attachment 1) adopted Septic Tank Conditions shall be used for single family residences in the areas where (1) depth to groundwater is less than ten feet, or (2) the proposed building site lies adjacent to or within close proximity to the bayfront and the likelihood for surface or subsurface water quality degradation is determined by staff to require a specially designed septic system.

ATTACHMENT 1, (adopted April 1, 1977)

SEPTIC TANK CONDITIONS

1) SEPTIC TANK: A minimum 1000 gallon capacity septic tank shall be used. This tank shall be divided into at least two compartments, with the primary chamber providing from 1/2 to 2/3 of the total tank volume.

2) DISPOSAL FIELD EXCAVATIONS: The disposal field excavations shall consist of two separate trenches, or sets of trenches, each with the following dimensions: width - maximum two (2) feet; sidewall depth - minimum two (2) feet; trench bottom area - minimum seventy (70) square feet per bedroom. These trenches should be placed as far apart as practical, but in no instance closer than four (4) feet from one another.

3) DISPOSAL PIPES: The disposal pipes shall be split into two separate disposal fields and provided with a change-over valve to allow the use of the separate disposal fields in alternate years. These disposal pipes shall be placed over a minimum of eighteen (18) inches of crushed rock/ an additional six (6) inches of crushed rock shall be placed over the disposal pipes. This crushed rock shall be no coarser than 1/2" x 1/2".

4) DISPOSAL FIELD FILTER: To prevent the infiltration of fine Baywood sands into the disposal fields, a permanent filter shall be placed over the rock fill utilized in the disposal field excavations, but shall not extend down the side-walls of the excavations. This filter may consist of gravel and sand placed in graded layers, a permeable synthetic fabric, or other suitable material of similar durability as approved by the County Building Department.

5) GROUNDWATER SEPARATION: A minimum of five (5) feet separation between the bottom of the disposal field excavations and the groundwater shall be maintained at all times. This minimum separation shall not be achieved through the use of any fill material or otherwise artifically created.

To determine the five (5) feet separation, measurements shall be taken until the groundwater elevation stabilizes in the test boring. Test borings shall be of a small diameter (not to exceed 12 inches) and located in the proposed disposal field site. (Refer to staff for specific methodology.)

6) INSPECTION RISERS: The septic tank shall be provided with a riser over the primary chamber and shall extend to or above the finished grade to allow adequate inspection and periodic maintenance of the

septic tank. The riser shall exceed the diameter of the septic tank chamber lid by at least eight (8) inches, but in no instance to less than twenty (20) inches in diameter. The manhole cover over the riser shall be bolted down, locked or otherwise secured to prevent its easy removal.

7) DIAGRAM AND PLOT PLAN: Prior to the installation of the septic system the applicant shall submit to the Executive Director a diagram and plot plan of the septic system indicating the location and dimensions of all elements of the system, including the septic tank, risers, disposal field excavations, change-over valve, and the disposal pipes; a copy of these plans shall be transmitted with the ownership of the residence.

8) CERTIFICATION OF INSTALLATION: Prior to occupancy of the residence, the applicant shall certify in writing to the Executive Director that the septic system has been installed in accordance with the design standards set forth in the above conditions and that the groundwater level is at least five (5) feet below the bottom of the leach field excavations. This certification shall be in the form of a Certificate of Occupancy issued by the County Building Department or a letter from the applicant's registered civil engineer.

9) SEWER CONTRACT: Prior to occupancy of the residence, the applicant shall submit to the Executive Director evidence of a contract with a certified septic service contractor providing for the regular inspection of the septic tank, switching of the disposal field change-over valve on an annual basis, and the periodic servicing or pumping out of the septic tank as necessary. This contract shall extend for a minimum of five (5) years.

PROPOSED REVISION

The following revision to Guideline 1., above, has been proposed and may be in effect soon after publication of this report:

1. New development shall meet the septic tank requirements of the Regional Water Quality Control Board

(RWQCB). Current RWQCB standards specify that depth to bedrock or other impervious material should be greater than eight feet and depth to groundwater should be greater than 10 feet at all times. Separation between the bottom of the disposal field and the groundwater level shall be a minimum of five feet. In those areas of the community with known high ~~water~~ groundwater levels, a piezometer ~~reading~~ (plus the possible requirement of the drilling of additional piezometers within the proposed leach trenches or field area) shall be drilled and read by a qualified engineer or soils specialist. The piezometer(s) shall establish that an adequate separation between the bottom of the disposal field excavation and the groundwater ~~will~~ shall be maintained at all times. Additionally, within areas of high groundwater levels, the piezometer(s) shall be read at weekly intervals at the last half of the wet season (February through April).

If a high groundwater level is established, the use of alternative methods of onsite wastewater disposal (alternative wastewater disposal systems) shall be investigated and allowed, if the proposed alternative wastewater disposal system can adequately demonstrate that the proposed system will not degrade or otherwise have an adverse effect on the groundwater or other biological systems (such as the estuarine system of Morro Bay). In addition, the chosen alternative wastewater disposal system shall not create a public hazard, health or safety problem.

Until the County approves and Coastal Commission certifies the Local Coastal Program, development shall meet the requirements of the Coastal Commission adopted septic system conditions/technical design criteria. Specific criteria/standards shall be consistent with the Coastal Commission septic system conditions and the criteria/design standards shall be developed in a Phase III task. The Phase III standards shall require equal or greater standards of performance and technical design criteria as the Commission's present standards and may also identify mechanisms and areas where adequate groundwater separatation can be achieved through grade modification of lots so long as such modifications do not conflict with the building height and setback standards of the LUP.

San Luis Obispo County Code. The following are excerpts from the current County Code, applicable to this study:

19.24.010 Adopted. That certain plumbing code known and designated as the "Uniform Plumbing Code, 1973 Edition," which code is promulgated and published by the International Association of Plumbing and Mechanical Officials, 5032 Alhambra Avenue, Los Angeles, California, 90032, and the "Manual of Septic-Tank Practice," published by the U.S. Department of Health, Education and Welfare, are adopted by reference with the same force and effect as if fully set forth, except as otherwise provided herein.

In such cases where the Uniform Plumbing Code and Manual of Septic-Tank Practice provide conflicting standards or regulations, the more restrictive shall apply. (Ord. 1509 S2(part), 1975).

19.24.011 Section 1001 Amended. Section 1001 of the Uniform Plumbing Code is amended by adding the following sentence:

"Water transported to a building site shall be deemed adequate only if approved as to source, transportation method and on-site storage by the County Health Department." (Ord. 1509 S2 (part), 1975).

19.24.012 Additional Standards and Replaced Systems - Definitions:

(a) "Leaching system or area" means that area in which treated wastewater is disposed of mainly by soil infiltration, or more specifically the lowest point of the leaching trench or seepage pit.

(b) "Septic system" means any combination of septic tanks and leaching systems or area.

(c) "Septic tanks" means multichambered tanks which separate solids from wastewater by sedimentation and flotation to prepare wastewater for soil infiltration to leaching systems or area.

19.24.013 Additional Standards - New or Enlarged Systems: The following standards regarding any new or enlarged septic system shall be met in addition to those prescribed by the Uniform Plumbing Code and the Manual of Septic Tank Practices.

(a) Except where exempted by the building official for sandy soil areas, percolation tests shall be provided for all lots less than one acre in size.

(b) Where a percolation test is required, a minimum of three percolation test holes shall be dug for any leach area.

(c) a percolation rate of between 0 to 30 minutes per inch of fall is sufficient to permit individual sewage disposal systems using leach lines. Percolation rates of more than 30 minutes per inch of fall may be approved provided the system is designed and certified to work by a registered engineer.

(d) A minimum leaching area of 125 square feet per bedroom shall be provided.

(e) Existing lots of record as of the effective date of this ordinance which are served by an individual on-site well may be approved for a septic system only if the parcel has an area of one acre or more.

(f) Except as provided by Section 19.04.190 any person installing a septic system shall hold a current state license to perform such work.

(g) Septic or leaching systems installed on slopes of 20 percent or more shall be designed, and installation certified to, by a registered engineer. Design shall minimize grading disruption associated with access for installation and maintenance.

(h) Unless it is an approved system designed by a registered engineer, a minimum distance of 8 feet shall be maintained from the bottom of leaching systems to bedrock or impermeable strata. This distance shall be verified by test borings where required by the Building Official pursuant to the Uniform Plumbing Code.

(i) Depth from the bottom of the leach area to the water table shall be greater than 5 feet at all times during the year. The Building Official shall utilize available information or require an Engineer's design and certification in cases where seasonal fluctuation of groundwater may reduce the minimum separation to less than 8 feet.

(j) Sixty days after the effective date of this ordinance, all new septic systems installed shall include a monitoring and access port of at least six (6) inches in diameter extended from the top of the septic tank to the finished grade or above. Such port shall include a non-vented but detachable cap to allow inspection and pumping access.

(k) Within any domestic reservoir watershed, as indicated on Exhibit "C" attached, all systems shall be located on parcels with a minimum of 2-1/2 acres. No land within a horizontal distance of 200 feet from the reservoir impoundment, as determined by the spillway elevation, shall qualify for computing parcel size or for septic system siting.

19.24.014 Replaced Systems: Where an existing septic system has failed and where a replaced system cannot be installed to meet the criteria set out in Section 19.24.013, the Building Official may approve a replacement septic system which meets all of the following minimum standards:

(a) The system is designed by a registered engineer.

(b) The proposed system carries the approval of the County Health Department.

(c) The installation of the approved system is inspected and certified by the design engineer.

19.24.015 Relief From Provisions of Sections 19.24.013 and 19.24.014: If any applicant for a permit to install or replace a septic system, or any portion thereof, feels himself aggrieved by any of the provisions of Sections 19.24.013 or 19.24.014 or by the administration of said sections by the officials responsible therefore, he may appeal said matter to the Board of Supervisors by orally advising the responsible official that he is thereby aggrieved which official shall then prepare a written statement of the grievance which the applicant shall sign. In the event of immediate health hazard, determined by the health officer, said official shall then present the matter to the Board of Supervisors for its determination at its regular meeting next following said advice; otherwise the normal appeal process shall apply.

The Board of Supervisors shall have authority to relieve or excuse any applicant from any or all of the requirements of Sections 19.24.013 and 19.24.014. Any decision of the Board of Supervisors on such an appeal shall be final.

WASTEWATER TREATMENT AND DISPOSAL FACILITIES

There are no municipal sewerage systems in the Los Osos-Baywood Park area, although there are community collection systems for the Vista de Oro and Baybridge Estates subdivisions. A small amount of the wastewater discharged to subsurface leach fields may be used by vegetation, however, nearly all of the wastewater discharged in the study area eventually reaches the groundwater table.

Inventory of Waste Dischargers

To a large extent, the contaminants contained in the raw wastewater are removed before the water reaches the main groundwater body. Passage through soil is an excellent wastewater treatment process. Particulate matter is removed by filtration, organic material is degraded by soil bacteria, and adsorbable constituents adhere to negatively-charged soil particles. One contaminant, however, which may travel a long distance through soil without significant removal is nitrate. High nitrate levels have often been found in groundwater where a high density of septic tank systems, fertilized irrigated agriculture, or land disposal of wastewater exist above the groundwater table.

As part of this study, an inventory of wastewater treatment and disposal facilities, and waste dischargers in the study area was prepared by the County Engineering Department. This inventory is presented in Volume II, Appendix IV.

Septic System Failures

As a result of the above-normal precipitation during the winter of 1982/1983, several locations within the Baywood Park community in the study area experienced local flooding and high groundwater levels. Rainfall during this winter priod, through February 1983 was reported to be 183 percent of normal annual precipitation. The resulting high groundwater levels caused a number of septic system leach fields to be drowned out, creating inconveniences to the affected residents, as well as a potential health hazard. In response to this situation, the County Engineering Department presented a report to the Board of Supervisors on March 14, 1983, entitled "Drainage Problems in Los Osos Area." The full text of the report is included in Volume II, Appendix IV. This section presents a summary of the septic system failures reported.

Properties on both sides of Paso Robles Avenue, between 15th Street and 18th Street, have experienced problems. Both surface drainage problems and drowning out of septic tank leach fields have occurred, and at least 15 homes have been flooded.

At the intersection of 8th Street and El Moro Avenue, properties have experienced surface drainage problems and drowning out of septic tank leach fields. At least two homes have been flooded.

Properties along Los Olivos Avenue, between 11th Street and 12th Street, particularly in the vicinity of the property at 1173 Los Olivos Avenue and the next three properties west of this address, have experienced problems. Although the problems are related to high groundwater levels, the number of properties flooded and the number of septic tank leach fields that have been drowned out, if any, are not reported.

In the vicinity of Don Avenue and Mitchell Drive, at least one home has been flooded. The report does not indicate if drowning out of septic tank leach fields has occurred.

At the intersection of Pecho Road and Grove Street, two septic tank leach fields have been drowned out, although no homes have been flooded.

Three possible solutions to the high groundwater conditions causing leach field failure are presented: (1) subdrainage system; (2) conventional sewering of the areas; and (3) conversion from leach fields to pressure-mound systems. The report does not recommend that the County take any action at this time, but suggests that the County await completion of Phase II, the evaluation of alternatives, of the on-going facilities planning study.

FIELD SAMPLING PROGRAM

Some information on wastewater quantity and quality from various local sources was available from the Central Coastal Regional Water Quality Control Board. To augment this information, a field sampling program was conducted to obtain wastewater quality analyses to help characterize wastewater in the study area.

The rationale and method of selection of sampling points, location of sources, and compositing of samples is presented in the Field Sampling and Analysis Program, included in Volume II as Appendix V. The method of sampling, method of analysis and results of wastewater analyses, as provided by the County, are presented in Volume II, Appendix IX.

WASTEWATER CHARACTERISTICS AND WASTE LOADINGS

Based on results of the sampling program, data from the regional board, and information from the technical literature, calculations and estimates of wastewater characteristics and loadings have been made for the Los Osos-Baywood Park area. Wastewater characteristics of interest include flow, BOD_5 , suspended solids, and nitrogen concentrations. Nitrogen loadings for water percolating to the groundwater are presented.

Wastewater Characterization

Presented in Table 6-2 are typical concentrations for septic tank effluent and assumed concentrations of three constituents for septic tank leachate in the Los Osos-Baywood Park area.[1,2,3,4,5,6]

Table 6-2 Composition of Septic Tank Effluent

Constituent	Concentration, mg/l[a]						
	Hansel	Brown	Dudley	Biggar	Popkin	Feth	Assumed for study area
BOD_5	140-175	-	-	-	-	-	150
Total organic carbon	-	95	-	-	-	-	100
Suspended solids	45-65	-	-	-	-	-	50
Ammonia-nitrogen	30-60	25	35	25	25	-	-
Organic-nitrogen	-	7	10	10	6	-	-
Nitrite-nitrogen	-	0.05	0.5	0.003	0.01	-	-
Nitrate-nitrogen	1	0.24	0.5	0.15	0.2	-	-
Total nitrogen	50-60	32	45	35	31	20-40	-
Total phosphorus	-	-	25	-	-	7-14	-
Phosphate-phosphorus	-	8	-	20	-	-	-
Fecal coliforms, MPN per 100 ml	-	1.1×10^6	-	-	-	-	-

[a]Except where noted

Table 6-3 presents wastewater analyses from the six sources sampled during this study, and the average or assumed values deemed to be representative of septic tank effluent in the study area.

Table 6-3 Wastewater Characteristics of Septic Tank Effluent

Constituent[a]	Composite of Residential Septic Tank Area 85-T	Daisy Hill and Sunny Oaks Mobil Home Parks	Sunnyside School[d]	Valley Liquor	Williams Brothers Market	Village Mall	Average or Assumed Value for Study Area
Total Filtrable Residue at 180 degrees C	687	368	475	601	337	608	513
Calcium	21.6	18.2	25.3	21.1	23.8	17.2	21.2
Magnesium	36.5	16.7	20.3	14.7	16.3	26.2	21.8
Sulfate	58	30	17.2	24.2	9.8	72	35.2
Copper	0.025	0.160	0.335	0.015	0.173	0.600	0.218
Zinc	0.365	0.270	1.587	0.050	0.445	0.772	0.582
Total Hardness as $CaCO_3$	204	114	147	113	126	151	143
Manganese	0.117	0.150	0.427	0.012	0.037	0.128	0.145
Sodium	139.0	79.5	61	123	54.5	83.5	90.1
Potassium	26.5	14.5	22	19.5	22.0	50	25.8
Iron	0.540	1.92	26.6	0.183	1.965	3.197	5.73
Specific Conductance at 25 degrees C	1091	643	1050	871	637	1158	909
Carbonates as $CaCO_3$	0	0	0	0	0	0	0
Bicarbonates as $CaCO_3$	377	217	438	228	244	292	299
Total Alkalinity as $CaCO_3$	377	217	438	228	244	292	299
Chloride	81.1	51.1	91	71.6	79.9	96.4	78.5
Foaming Agent (MBAS)	2.0	1.4	0.4	0.4	1.6	24	5.0
Hydroxide Alkalinity as $CaCO_3$	0	0	0	0	0	0	0
Nitrate as N	1.08	0.50	1.77	2.11	0.76	2.22	1.41
Nitrate as NO_3	4.78	2.22	7.84	9.35	3.37	9.83	6.23
Nitrite as N	< .001	< .001	< .001	2.14	.0075	< .005	0.36
Nitrite as NO_2	< .003	< .003	< .003	7.03	0.025	< .016	1.20
Ammonia as N	35.2	27.6	71.4	1.46	25.5	52.5	27.0[b]
Ammonia as NH_3	42.6	33.7	87.1	1.78	31.1	64.1	55.0[b]
Total Nitrogen as N	62.7	28.7	357.5	2.95	36.31	79.53	42[b]
Total Chemical Oxygen Demand	1937	219	5709	92	531	2903	1899
Total Phosphorus as P	6.89	250	4.50	10.19	3.126	5.045	6.0[b]
Biochemical Oxygen Demand BOD_5	-	-	-	-	-	-	150[c]
Total Organic Carbon	-	-	-	-	-	-	100[c]
Suspended Solids	-	-	-	-	-	-	50[c]
Fecal Coliform, MPN/100 ml.	≥ 240	≥240	≥240	≥240	≥240	≥240	≥ 240

[a]Values in milligrams per liter unless otherwise noted.

[b]Average of five samples, excluding Sunnyside School.

[c]Assumed value based on Table 6-2.

[d]Sample taken from septic tank influent, not effluent, resulting in high values for total nitrogen and other constituents.

Nitrogen in septic tank effluent is in the organic and ammonia form. Organic nitrogen is transformed to ammonia in the soil, and this, together with the ammonia initially present in the wastewater, is transformed to nitrate.

Wastewater Quality

For comparison with groundwater and surface water quality in the planning area, a trilinear plot of wastewater quality was prepared and is shown in Figure 6-1. As the figure shows, all

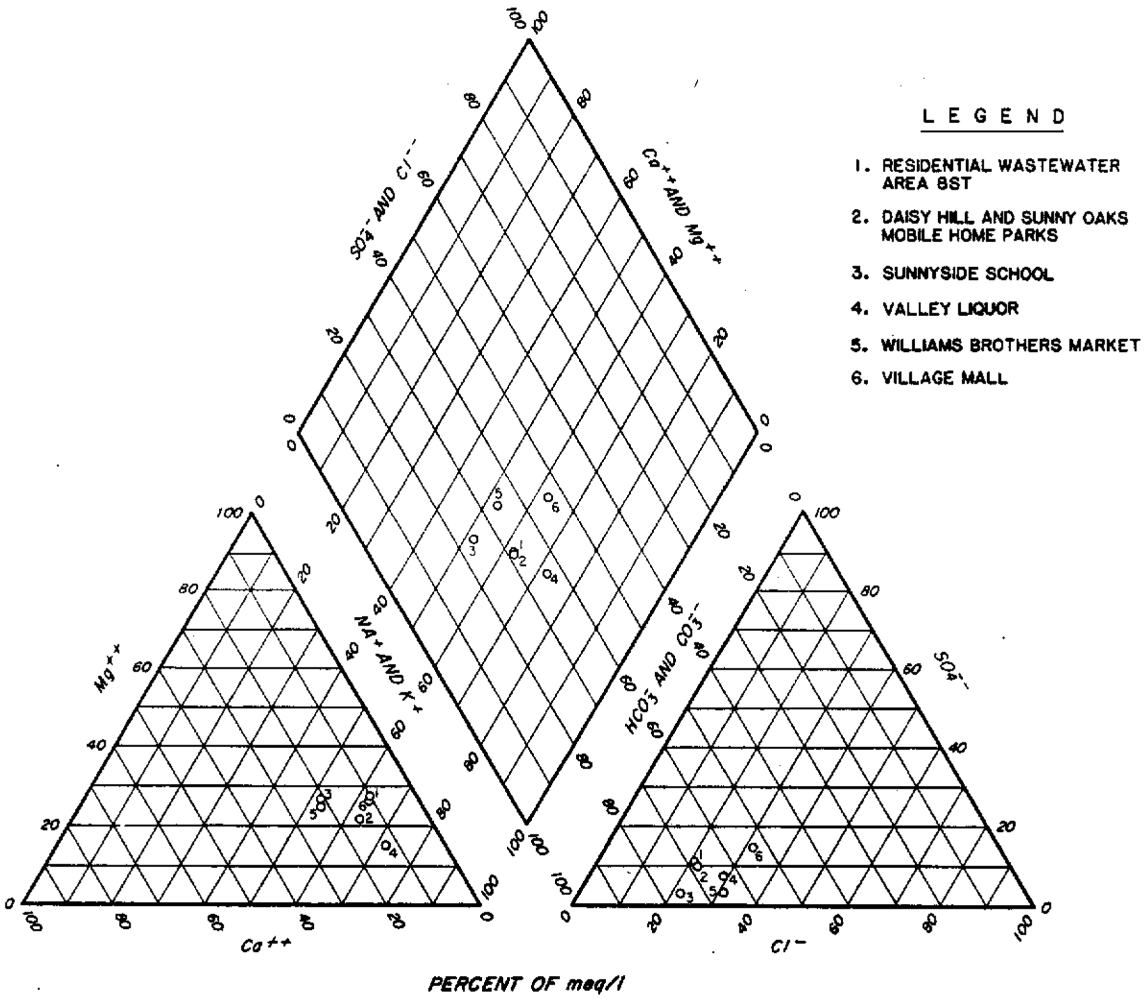

Figure 6-1 Trilinear Plot of Wastewater Quality

wastewater samples plot within a well-defined area. This allows characterization of wastewater quality in a manner similar to that used for water quality. Table 6-4 presents the wastewater classification from this analysis. Wastewater for all sources can be considered a sodium bicarbonate water with total dissolved solids of approximately 500 mg/l and total nitrogen concentration of 42 mg/l as N.

Table 6-4 Classification of Wastewater

Item	Wastewater	
	Range[a]	Typical[a]
Calcium	9 - 23	16
Magnesium	13 - 32	22
Sodium and Potassium	51 - 73	62
Chloride	20 - 32	27
Sulfate	3 - 16	8
Bicarbonate	57 - 71	65
Classification	Sodium Bicarbonate $NaHCO_3$	
Description	Composite residential wastewater; composite sample from Daisy Hill and Sunny Oaks Mobil Home Parks; and samples from Sunnyside School, Valley Liquor, Williams Brothers Market, and Village Mall.	

[a]Values are percent milliequivalents per liter for total cations and total anions.

Domestic Wastewater

Essentially all the nitrate from septic tank effluent will eventually percolate downward with the wastewater. A small amount might be utilized as fertilizer by vegetation, but on an overall basis, this is likely to be only a small percentage of the total. Denitrification, or conversion of nitrate to nitrogen gas, is another possible reaction that would limit nitrate leaching. Denitrification does not occur under the aerobic conditions essential to a properly functioning leach field.

For the purposes of this report, it is assumed that all of the nitrogen leaving the septic tank will eventually reach the groundwater table. Based on the wastewater inventory presented in Volume II, Appendix IV, the current wastewater flow from residential areas and schools in the study area is 851,700 gallons per day. Applying the average concentration of nitrogen of 42 mg/l from Table 6-3, results in an annual loading of 109,100 pounds of nitrogen percolating to the groundwater table from residential and school areas. The total area of residential and school development is 1,770 acres. The unit loading of nitrogen in residential and school areas, therefore, is 62 pounds per acre per year. This is a significant amount of nitrogen loading for the planning area. If all of this nitrogen is converted to nitrate, this source would be sufficient, by itself, to account for the high nitrate content of the shallow groundwater.

Landscape Irrigation Return Water

No information is available to quantify the nitrogen load resulting from percolation of return water from landscape irrigation. It can be assumed, however, that landscape irrigation return water from both residential and commercial areas is an important contributor of nitrogen to the ground. The surface soil predominant in the planning area, the Baywood Fine Sand, is highly permeable and generally low in organic content and water holding capacity. To maintain a lawn in a healthy state requires frequent and ample applications of both water and fertilizer. Due to the high soil permeability, much of the applied fertilizer, which is normally high in nitrogen content, no doubt enters the ground, combining with the leachate from irrigation, to percolate to the groundwater table. Consequently, this non-point source of wastewater may be a significant contributor to nitrate contamination of the groundwater.

Commercial Wastewater

The approximately 26 commercial establishments in Los Osos-Baywood Park produce a total wastewater flow of 72,000 gallons per day, with constituent concentrations assumed equal to those produced by domestic systems. This results in an annual loading of 9,200 pounds of nitrogen entering the groundwater from these sources. Commercial establishments occupy approximately 70 acres in the study area, based on the waste inventory in Volume II, Appendix IV. The unit loading of nitrogen in commercial areas, therefore, is 131 pounds per acre per year. Although the unit loading of nitrogen is more than double that of domestic wastewater, the total acreage of commercial areas is only four percent of the total residential acreage. Therefore, even if all the nitrogen from these point sources were converted to nitrate and percolated to the groundwater table, the total impact of these sources would be much less significant in causing groundwater quality degradation than domestic wastewater. As point sources, however, these discharges may have serious local impacts.

Agricultural Sources

Agricultural wastewater includes both wastes and leached irrigation water. Nitrogen leached from fertilized cropland represents a major nitrogen loading and is difficult to estimate. The amount of nitrogen from this non-point source that enters the groundwater is a function of three parameters: (1) the land area to which agricultural fertilizer is applied; (2) the amount of fertilizer applied per acre; and (3) the fraction of applied nitrogen that is leached downward. County and state land-use maps and aerial photographs were reviewed to permit estimates to be made of agricultural acreages in the study area. These estimates are presented in Volume II, Appendix III, and include irrigated pasture.

The total area devoted to agriculture in the study area is 2,070 acres. Only 327 acres are irrigated, and this includes approximately 15 acres devoted to the cemetary located east of Los Osos Creek. Total applied water for irrigation is 1,070 acre-feet per year, or approximately 0.5 acre-feet per year per acre. Assuming a 60 percent irrigation efficiency, the unit irrigation return flow percolating to the groundwater table is, therefore, 0.2 acre-feet per acre per year.

The only agricultural areas within the planning area are those within the Los Osos Creek valley. Total agricultural area within this valley is approximately 475 acres. Thus, the total agricultural return flow reaching the groundwater, assuming all of this area is irrigated, is 95 acre-feet per year.

Typically, the nitrogen uptake from crops is approximately 180 pounds per acre per year.[7] It is common practice for fertilizer to be applied at rates up to 200 percent of the actual crop uptake requirements. For purposes of this study, it is assumed that fertilizer application is approximately 150 percent of crop uptake, and therefore approximately 90 pounds per acre per year of unused nitrogen exists in the shallow soil water. It is estimated that approximately 50 percent of this total nitrogen is lost by denitrification, resulting in approximately 45 pounds per acre per year of nitrogen percolating to the groundwater table. Applying the irrigation water return flow of 95 acre-feet per year results in an average concentration of 83 milligrams per liter nitrogen in the agricultural return flow.

Over the 475 acres of agricultural land in the planning area, the total nitrogen reaching the groundwater table is 21,400 pounds per year.

Due to the difficulty in estimating nitrogen loading from agricultural areas, it is more appropriate to consider a range of nitrogen loading rather than a single estimate. For purposes of this study, therefore, the range of agricultural nitrogen loading reaching the groundwater table is 20,000 to 40,000 pounds per year, and the unit loading of nitrogen in agricultural areas, therefore, ranges from 40 to 90 pounds per acre per year.

Summary of Nitrogen Loading

Using the estimated totals for commercial wastewater and domestic wastewater, the total estimated quantity of nitrogen percolating to the groundwater table from these sources in the planning area is 118,300 pounds of nitrogen per year. To test the reasonableness of this estimate, another approach was used to determine the total load of nitrogen from these sources.

The current and projected water use factor for the planning area is 158 gallons per day per person. The estimated consumptive use of this water is 42 percent, and therefore 58 percent is returned to the groundwater table through landscape irrigation return and septic tank effluent. Applying these factors to the current population, approximately 11,000 people, with an average concentration of 42 mg/l of nitrogen, the resulting waste load for domestic and commercial sources is 129,100 pounds per year. This value compares favorably with the 118,300 pounds per year previously determined. Therefore, a reasonable range of nitrogen load from these sources is 120,000 to 130,000 pounds per year.

Utilizing this range for domestic and commercial wastewater, and the estimated range of 20,000 to 40,000 pounds per year for agricultural wastewater, a reasonable range of nitrogen loading for the planning area is 140,000 to 170,000 pounds of nitrogen per year reaching the groundwater table. The midpoint of this range is approximately 155,000 pounds per year, and this estimate can be used for further evaluation of effects of nitrogen loading.

EFFECT OF WASTEWATER DISCHARGE ON GROUNDWATER

Percolation of high nitrate and high total dissolved solids wastewater to the groundwater table over the approximately 1,840 acres of urban development in the planning area causes an increase in the nitrate concentration and total dissolved solids in the shallow groundwater. Background concentrations of nitrate in the planning area are less than approximately 25 milligrams per liter as NO_3, and background concentrations of total dissolved solids in the shallow groundwater are approximately 200 milligrams per liter. Average wastewater concentrations are approximately 186 milligrams per liter as NO_3, and approximately 500 milligrams per liter total dissolved solids. Such an influx of high concentrations of contaminants to a static groundwater system would quickly produce large increases in nitrates and total dissolved solids. The Los Osos groundwater basin, however, is not static, and is in fact a complex system of aquifers rather than a single groundwater basin.

Due to the high permeability of the surface soils in the planning area, nearly all of the precipitation falling on this area percolates to the groundwater table. There is little chance for evaporation of precipitation in this area, and the sparse natural vegetation consumes only a small fraction of the rainfall infiltrating into the ground. Based on an average annual rainfall of 17 inches in the planning area, and assuming 70 percent infiltration, the total quantity of rainfall percolating to the groundwater table in the urban development area is approximately 1,800 acre-feet per year. From Table 4-1, the total amount of wastewater percolating to the water table is 1,150 acre-feet per year. The total inflow into the groundwater basin underlying the urban development area, therefore, is 2,950 acre-feet per year. The 1,150 acre-feet per year of infiltrating wastewater is only about 40 percent of the total inflow to the groundwater basin in this area. This includes all point and non-point sources within the urban development area.

For purposes of this study, rainfall can be considered to be essentially free of nitrate and dissolved solids, and therefore acts as a diluting mechanism for the wastewater. It can be assumed that the resultant concentration of nitrate in the total quantity of water percolating through the groundwater table is roughly 40 percent of the wastewater concentration, or about 70 milligrams per liter as NO_3.

Due to the occurrence of confining layers, or semi-confining layers, separating the shallow aquifers from the deep Paso Robles Formation, and the fact that the horizontal permeability of the shallow water bearing deposits is approximately 10 to 100 times greater than the vertical permeability, the groundwater with increased nitrate and total dissolved solids concentrations is principally confined to the upper portion of the shallow aquifer.

Subsurface outflow from the groundwater basin, as shown in Table 4-1, is approximately 1,780 acre-feet per year. From the steeper water table gradient occuring in the shallow aquifer and the higher horizontal permeability, in comparison to the vertical permeability, it is estimated that approximately two-thirds of the subsurface outflow is derived from the shallow deposits above the Paso Robles Formation. This movement of water out of the aquifer serves to reduce the total concentration of nitrate and total dissolved solids in the shallow groundwater, below that which would otherwise occur if there were no subsurface outflow. As a result, the average concentration of nitrate and total dissolved solids over the urban development area is much lower than might be indicated by the wastewater concentrations of 186 milligrams per liter nitrate as NO_3 and total dissolved solids of 500 milligrams per liter.

It is not possible to determine the actual, resultant concentrations in the shallow groundwater from this analysis, but the ranges of approximately 45 to 70 milligrams per liter nitrate as NO_3, and total dissolved solids of 250 to 400 milligrams per liter appear to represent conditions which will not change markedly in the future without changes in urban development or in methods of wastewater treatment and/or disposal.

An important consideration of wastewater discharge in the planning area is its effect on groundwater quantity. From Table 4-1, urban wastewater is approximately 24 percent of total inflow to the basin. In the planning area, wastewater discharge is approximately 40 percent of the total inflow. Return sewage from septic tanks and leach fields in the planning area, amounts to approximately 22 percent of the total inflow in the urban development area. Because of this, exportation of return sewage, instead of percolation to the groundwater table, would have a significant impact on the total inflow into the groundwater basin.

CHAPTER 7

EXISTING WATER QUALITY PROBLEMS

The existing water quality problems in the Los Osos groundwater basin are due to natural processes, such as the mineralization of water, and the effects of man's development upon the area. Basin-wide problems with groundwater quality are described in the following paragraphs in terms of both the effects of natural processes on water quality and the effects due to urban and rural development.

IMPACT OF NATURAL ELEMENTS ON WATER QUALITY

All surface and groundwater begins as atmospheric water, essentially distilled and pure, which then condenses and precipitates to the ground. Water, one of the best solvents on earth, has the ability to dissolve and accumulate matter as it travels through the environment.

Geologic Processes

As atmospheric water condenses and precipitates to the ground, it dissolves and assimilates carbon dioxide gas, lowering its pH. When precipitation falls to the earth, it either percolates directly into the ground or accumulates and runs off forming streams, rivers, and lakes. With the assimilated carbon dioxide, surface runoff and percolating water are slightly acidic. Surface water picks up sediment which it transports and begins to dissolve. Similarly, percolating water dissolves soluble minerals as it moves through the lithosphere. Surface water and groundwater gain a chemical character which depends upon the rocks and geologic formations through which they pass. As different geologic formations contain different soluble minerals, surface water and groundwater passing from one geologic formation to another pick up and dissolve additional minerals which, depending upon the solubility of those minerals, may change the chemical character of the water.

Surface Water. The surface water in the Los Osos hydrologic basin derives its chemical character primarily from the rocks of the Franciscan formation over which it passes. These rocks impart a magnesium and calcium bicarbonate nature to these surface waters.

Groundwater. Two basic types of groundwater exist within the Los Osos basin. The chemical character of the water depends entirely upon the geologic materials with which it comes in contact Precipitation falling on the planning area provides little runoff and is primarily percolated directly to the upper aquifer groundwater table. As the water percolates through the old dune sands, it picks up sodium chloride, which is derived from sea spray, and sodium bicarbonate, which is derived from the soluble minerals within the dune sands themselves. Groundwater within the Paso Robles Formation aquifers is derived primarily from recharge through Los Osos Creek and the area just east of the creek. The chemical quality of this groundwater closely resembles the chemical character of the surface water of Los Osos Creek.

The Paso Robles Formation is composed of materials eroded from the Franciscan Formation, which outcrops in the hills south of the groundwater basin. Precipitation falling on slopes of Franciscan Formation materials picks up chemical character by dissolution of Franciscan Formation materials. As it runs off, the precipitation collects in Clark Valley, forming Los Osos Creek, and in Los Osos Valley, forming the unnamed tributary that flows into Warden Lake. Part of the water in these surface streams percolates into the ground, recharging the Paso Robles Formation aquifers. Since the Paso Robles Formation consists of materials derived from the Franciscan Formation, it is understandable that the chemical character of the groundwater is nearly the same as that of Los Osos Creek. While the groundwater may dissolve minerals within the Paso Robles Formation, thereby increasing in total dissolved solids content, the minerals continue to be dissolved in the same proportions. Thus, the chemical character of the groundwater continues to closely resemble the chemical character of the surface water of Los Osos Creek.

Ecologic Processes

The ecologic processes which affect the chemical character of surface water and groundwater consist of the assimilation and dissolution of plant and animal matter, and the decomposition of that matter by bacteria. In addition, vegetation takes up certain minerals, such as nitrate, using them in the growth process, and reduces the concentrations of these minerals in the groundwater. The effects of natural ecologic processes on surface water and groundwater is subtle. In the Los Osos groundwater basin, ecologic processes are overshadowed by the effects of rural development.

Inflow to Hydrologic Basin

As demonstrated in the preceeding discussion, natural geologic materials can impart a chemical characteristic or group of characteristics, to waters passing over or through them.

Variations in Surface Water Quality. Within the planning area, there are two sources of surface water. By far the greatest source is the runoff from Los Osos Creek. As the runoff to Los Osos Creek passes over rocks of the Franciscan Formation in the Irish Hills, it picks up and dissolves soluble minerals of the formation and derives a magnesium and sodium bicarbonate character. Surface water from Eto Creek has a sodium chloride to sodium bicarbonate chemical character due to the fact that the water originated as groundwater from the shallow dune sand aquifer.

Variations in Groundwater Quality. Variations in groundwater quality due to natural processes are in fact nearly identical to the effects on surface water. Geologic processes impart the predominent chemical characteristics to the two basic types of groundwater found within the Los Osos basin. Groundwater from the Paso Robles Formation aquifers has a chemical quality similar to that of Los Osos Creek water. The magnesium and sodium bicarbonate character of this water is derived from surface water flow across Franciscan Formation rocks which is then recharged along Los Osos Creek and down into the Paso Robles Formation aquifers. The Paso Robles Formation sediments impart similar chemical characteristics to the groundwater. Groundwater within the shallow dune sand aquifers derives its chemical character from the minerals dissolved during the percolation of rainfall to the groundwater table. The sodium chloride character of the water results from the proximity to the coast where percolating water picks up sea spray. The sodium bicarbonate water is more characteristicly from the lower portion of the upper zone of aquifers. The finer grained materials contained within these zones are more easily dissolved by percolating groundwater, and mineralization of this groundwater occurs to a limited degree.

HISTORICAL GROUNDWATER QUALITY DEGRADATION

In order to properly define existing water quality problems in the planning area, it is necessary to assess the evidence of degradation, the causes of water quality degradation and those factors which affect water quality changes in the planning area.

Evidence of Degradation

An examination of current and historical water quality data over the planning area, and water quality data representative of various vertical zones within the groundwater basin, generally shows higher concentrations of nitrate and total dissolved solids in the shallow groundwater in the vicinity of the urban development area, in comparison with groundwater in deeper zones and groundwater in areas outside the area of urban development. Although the historical data are sparse, there is a general trend towards increase of nitrate and total dissolved solids with time in the shallow groundwater. Currently, the shallow groundwater exhibits nitrate concentrations in excess of 25 milligrams per liter as NO_3 over nearly all of the urban development area, and concentrations in excess of 45 milligrams per liter as NO_3, the maximum contaminant level (MCL) for this constituent, over much of the developed area. Total dissolved solids concentrations range between 250 to 400 milligrams per liter over most of the developed area, and portions of the urban development area show total dissolved solids in excess of 400 milligrams per liter. Although there is no MCL established for total dissolved solids, the recommended maximum level is 500 milligrams per liter, as shown in Table 5-1.

Background concentrations for nitrate in the shallow groundwater are generally below 25 milligrams per liter as NO_3, and background total dissolved solids concentrations are generally under 200 milligrams per liter. The current high levels of nitrate and total dissolved solids, and the historical trend of increase in these constituents shown by water quality records, are irrefutable evidence that the shallow groundwater quality is degraded.

Causes of Quality Degradation

The historical and current activities within the planning area, which have produced and are continuing to produce increased levels of nitrate and total dissolved solids, are: (1) percolation of septic tank effluent; (2) percolation of urban landscape irrigation return flow; and (3) percolation of agricultural irrigation return flow. The current estimated quantities of each of these return flows are discussed in Chapter 4. Wastewater quality, and concentrations of nitrate and total dissolved solids entering the basin, are presented in Chapter 6.

Agricultural Irrigation. Currently, the only agricultural activity within the planning area is on the 475 acres in Los Osos Valley. This area is part of the recharge area for the Paso Robles Formation, the deepest aquifer within the planning area. The potential exists, therefore, for agricultural return flow to cause degradation of groundwater quality in the Paso Robles Formation. However, the surface of the Los Osos Valley is covered by a mantle of alluvial deposits, and irrigation return flows in this area percolate into the groundwater within the alluvial deposits. Due to the stratified nature of the alluvial deposits, and the coarse-grained character of these materials, the horizontal permeability is one to three orders of magnitude larger than the vertical permeability. Therefore, agricultural return water percolating to the groundwater table is intercepted by the horizontal flow within the alluvial deposits and is discharged at the north end of the valley. As a result, there is little or no occurrence of water quality degradation to the Paso Robles Formation. This is confirmed by the low nitrate concentrations generally found in this formation.

In the remainder of the planning area, there is no significant current agricultural activity. It is reasonable to assume, however, that agricultural activity has occurred in the past, although the sandy soil conditions generally prevalent throughout this area are not conducive to major agricultural development. Smaller, more specific agricultural activities more likely occurred.

It has been reported that, prior to urban development, a strawberry patch existed in the vicinity of 13th Street and Nipomo Street. Such agricultural activity, given the granular character of the soils and the need for fertilization, may very well have caused percolation of high nitrate irrigation return flow to the water table in this vicinity. Other, localized agricultural practices throughout the planning area in the past may have had similar results. Consequently, the background levels of nitrate and total dissolved solids in the vicinity of past agricultural activities may be elevated. In fact, the high nitrates and total dissolved solids concentrations in shallow groundwater existing at present may be due, in part, to past agricultural activities. Existing data are insufficient for determining this specific effect.

Landscape Irrigation. Fertilization and irrigation of landscape areas within the urban development portion of the planning area, result in percolation of a significant quantity of water to the groundwater table. Excessive application of fertilizer with a high nitrate content results in higher concentrations of nitrate in the urban irrigation return water. It is not possible to identify the actual increase in nitrate from this cause with any degree of accuracy using existing data, however, the magnitude of urban irrigation return flow indicates that this non-point source is a significant cause of degradation to the shallow groundwater quality.

Domestic and Commercial Wastewater. Septic tank effluent percolating to the groundwater table generally throughout the urban development area of the planning area is a significant cause of water quality degradation in the shallow groundwater. The high concentration of nitrate, 186 milligrams per liter as NO_3, and total dissolved solids, 500 milligrams per liter, of these point sources are the major cause of current groundwater quality degradation. As discussed in Chapter 4, the current quantity of return sewage is 640 acre-feet per year. The amount of nitrogen entering the shallow groundwater from domestic and commercial sources, alone, is approximately 120,000 to 130,000 pounds per year. It is clear, therefore, that the degradation in groundwater quality due to percolation of septic-tank effluent within the urban development area is the most significant cause of groundwater quality degradation.

FACTORS AFFECTING WATER QUALITY CHANGES

Having established the fact of groundwater quality degradation in the planning area, and the principal causes of quality degradation, it is important to understand those factors which affect water quality changes. Such factors include land-use patterns, soil types, background water quality, and wastewater quality.

Land Use Patterns

A comparison of the current urban development area with the areas of high nitrate and high total dissolved solids concentration in the groundwater, as shown in Figures 5-3 and 5-4, respectively, shows clearly that land use patterns directly affect groundwater quality changes. It is this urban development area that has the relatively high density of septic tanks and leach fields, which are the sources of sewage return flow to the groundwater table. Those areas outside the urban development area show little or no groundwater quality degradation.

Within the urban development area, however, local variations in waste discharge occur. Septic tanks serving mobile home parks, apartment complexes, and certain commercial establishments are point-sources of high nitrate and high total dissolved solids with greater discharge rates than residential septic systems. Groundwater immediately below and down-gradient of these sources can be expected to show more degradation than groundwater in the vicinity of the more dispersed residential septic tanks.

Soil Types

Surface soils throughout the planning area are silty sands and sandy silts of recent or reworked older dune sand deposits. These soils exhibit high permeability and, being composed principally of silica, have little or no chemical interaction with percolating water. Generally, the organic content of surface soils is very low. This fact, coupled with the generally good depth to the groundwater table, results in sparse vegetation throughout most of the planning area.

In the southeastern portion of the planning area, however, the groundwater table intersects the surface topography, resulting in surface outflow of groundwater. This occurs along, and is the principle source of water in, Eto Creek. The generally high water table in this area affects groundwater quality in three ways. First, since Eto Creek is a groundwater discharge area, there is little chance for accumulation of degrading constituents such as nitrate and total dissolved solids in the shallow groundwater. Upflow of groundwater in the vicinity of the creek continues to flush these chemical constituents from the shallower portions of the groundwater table. Second, due to the shallow depth to groundwater, septic tank effluent percolating to the groundwater table has a much reduced time for aerobic conditions, and therefore nitrification is retarded. As a result, nitrogen in the wastewater is more readily lost to the atmosphere as nitrogen gas. The overall effect is a reduced nitrate content of the shallow groundwater, and of the surface water in Eto Creek. Third, the high water table in this vicinity is more conducive to supporting vegetation than other portions of the planning area. These root systems, for the increased density of brush and for the groves of oak and eucalyptus trees in the southeastern portion of the planning area, penetrate to the upper portion of the groundwater table. Any nitrate present in the upper portion of the groundwater table is then available for uptake by this vegetation. The result is a reduction in nitrate content in the shallow groundwater.

The occurrence of higher density vegetation in this area, and its effect on water quality, was further evaluated to determine if this would account for the differences in correlation between total dissolved solids and nitrate in certain portions of the study area. An examination of Figures 5-3 and 5-4 shows the southeast area to be generally lower in nitrate, although not necessarily lower in total dissolved solids. Using aerial photos of the planning area, the areas of more dense vegetation were delineated and correlated with the distribution of nitrate in shallow groundwater. Figure 7-1 shows the vegetation areas and nitrate contours. As shown on that figure, there is generally good correlation between the areas of higher density vegetation and areas of lower nitrate content. Use of vegetation in the planning area as a means for mitigating increases in nitrate in the groundwater may be an important aspect of future water quality management.

Wastewater Quality

Degradation of groundwater quality resulting from wastewater application will vary in degree depending largely upon the quality of wastewater percolating to the groundwater table. Although wastewater quality has been characterized as relatively uniform within the urban development area, wastewater in fact varies considerably in quality. Table 6-3 shows the individual analyses for wastewater from six different sources or composite groups. Total dissolved solids concentrations range from as low as 337 milligrams per liter at the Williams Brothers Market to as high as 687 in the composite of residential septic tank effluent. Similarly, total nitrogen in septic tank effluent ranges from as low as about 3 milligrams per liter as N for Valley Liquor to as high as about 80 for Village Mall. The indiviual locations of these particular wastewater discharges have impacts on groundwater quality degradation in the vicinity of the sources.

Groundwater Quality

The areal distribution of variations in total dissolved solids shown on Figure 5-4 does not distinguish between those areas where total dissolved solids are higher as a result of groundwater quality degradation and those areas where the groundwater is naturally higher in total dissolved solids. In those portions of the planning area where the native, non-degraded shallow groundwater is low in total dissolved solids, degradation due to percolation of wastewater will produce higher total dissolved solids and higher nitrate concentrations. However, in areas where native groundwater is naturally high in total dissolved solids, the impact on quality of wastewater discharge may be much reduced or absent, with regard to total dissolved solids, although nitrate degradation may still be quite apparent.

For example, the total dissolved solids content of the groundwater sample taken from well 17R1, one of the wells in the Los Osos Valley, is 450 milligrams per liter. The shallow aquifers in this vicinity are the alluvial deposits and the Paso Robles Formation. Recharge to these aquifers occurs principally from infiltration of surface water from Los Osos Creek. The total dissolved solids content of the sample taken from Los Osos Creek showed total dissolved solids of 395 milligrams per liter. Therefore, it can be assumed that the native, groundwater quality in this vicinity is very nearly the same as that found in well 17R1. Consequently, high values of total dissolved solids in this vicinity are not indicative of groundwater quality degradation.

Similarly, the occurrence of high total dissolved solids concentrations in samples taken from deeper aquifers, such as the sample from well 18M1 which produces water from the Paso Robles Formation, is not necessarily indicative of groundwater quality degradation. This well shows no evidence of contamination, yet has a total dissolved solids content of 357 milligrams per liter. By comparison, with the 395 milligrams per liter total dissolved solids content of Los Osos Creek water, however, it is apparent that this relatively high total dissolved solids content in well 18M1 represents native, non-degraded water quality.

The two distinct types of groundwater quality, and the characteristic quality of wastewater, are shown in Figure 7-2. This figure is a composite of the trilinear plots shown in Figures 5-1, 5-2, and 6-1, and is presented for comparison of the three groups.

PRESENT WATER QUALITY PROBLEMS

Studies of the planning characteristics, geology, geohydrology, water quality, and wastewater quality, have disclosed that groundwater quality is being degraded. This section discusses the problems associated with such degradation.

Problem Identification

Wastewater discharge in the planning area, and percolation of discharged wastewater to the groundwater table, is causing increased

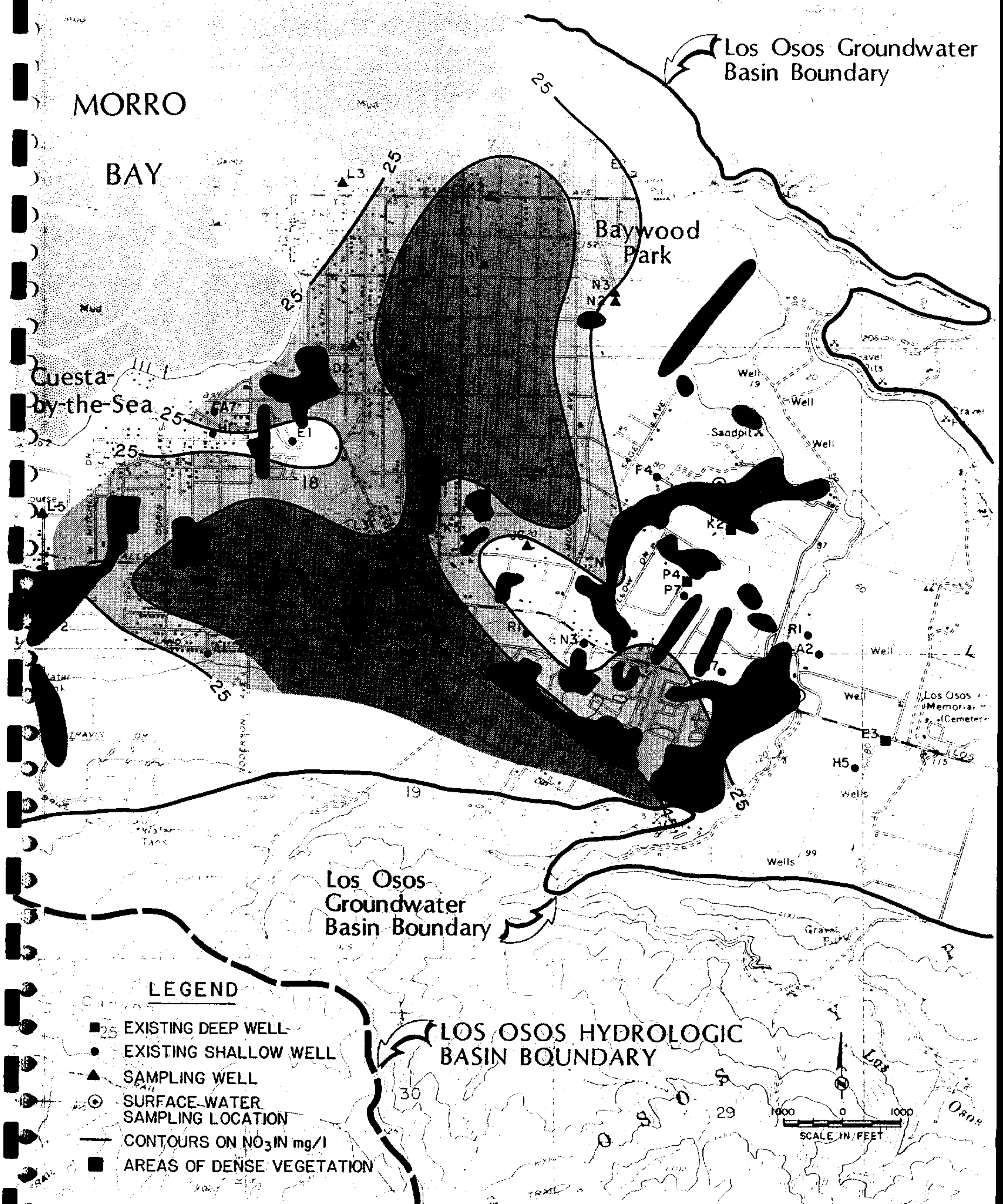

Figure 7-1 Effect of Vegetation on Nitrate

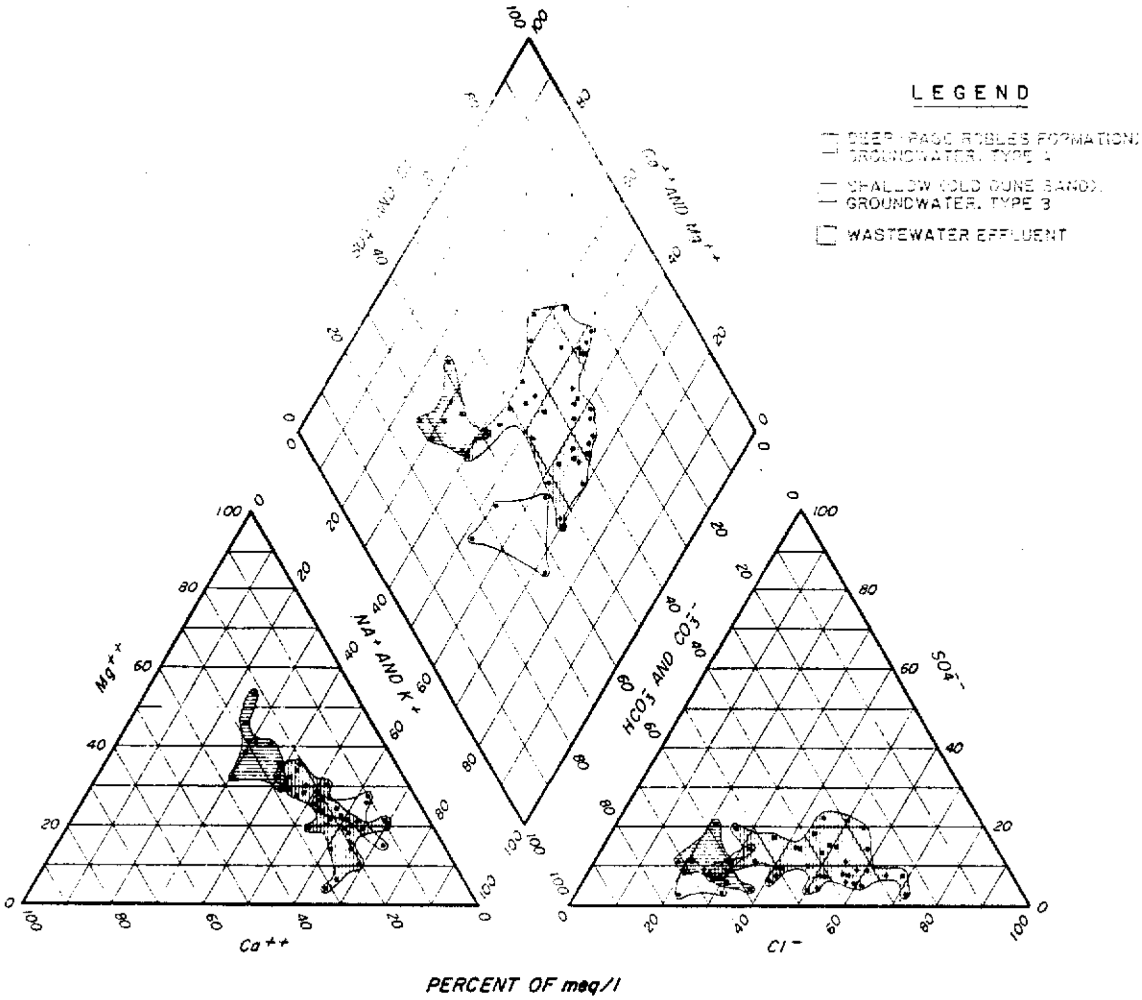

Figure 7-2 Trilinear Plot of Water Quality Groups

concentrations of nitrate and total dissolved solids in the shallow groundwater. Shallow groundwater quality immediately underlying the urban development area shows nitrate levels ranging from 25 milligrams per liter as NO_3 to greater than 45 milligrams per liter as NO_3, the maximum contaminant level (MCL) for this constituent. The MCL of 45 milligrams per liter NO_3 was established due to a greater incidence of reported cases of infantile methemoglobinemia in persons consuming water of that concentration or greater. Therefore, the principle water quality problem in the planning area is that persons consuming groundwater from wells which pump from the shallow groundwater formation may be exposed to this disease.

The problem is somewhat limited, however, by the fact that most of the population of the planning area receives its water supply through one or another of the municipal water supply systems in the area which generally produce water from deeper aquifers. The deeper aquifers, especially the Paso Robles Formation aquifers, are protected to a great extent by the zone of confining clay beds separating these aquifers from the shallow groundwater in the upper zone of aquifers. As a result, direct recirculation of shallow groundwater to the deeper aquifers is restricted over much of the area. Of course, vertical leakage from shallow to deep can occur through abandoned wells, or along the zone outside the casing in poorly constructed wells, but these instances, if they occur at all, are believed to be rare. The high nitrate problem, therefore, is confined principally to those areas where water supplies are obtained from shallow, individual wells. This is a relatively small portion of the planning area, generally located in the southeastern portion of the area along Los Osos Valley Road.

Wastewater discharge may also be increasing the total dissolved solids content of the shallow groundwater. This increase is noticeable due to the low background concentration of total dissolved solids in this groundwater. Water from the Paso Robles Formation, at greater depth, contains total dissolved solids concentrations approximately equal to the total dissolved solids of the degraded shallow groundwater. In addition, groundwater produced from Los Osos Valley exhibits a high total dissolved solids content, similar to the surface water flowing in Los Osos Creek.

Although no maximum contaminant level has been established for total dissolved solids, the recommended upper limit is 500 milligrams per liter, which is very near the existing concentration in the deeper aquifer and in the shallow, degraded groundwater. The Los Osos-Baywood Park community is totally dependent upon groundwater from this basin for its water supply. Consequently, continued increases in total dissolved solids in the groundwater basin, as a whole, may be construed to be a problem with regard to groundwater quality.

Causitive Elements

Discharge of wastewater and percolation of wastewater to the groundwater table, in general, is the cause of the current degradation in groundwater quality in the shallow groundwater. Domestic and commercial wastewater has an average concentration of 186 milligrams per liter nitrate as NO_3 and total dissolved solids of 500 milligrams per liter. There are three principle categories of wastewater discharge: (1) agricultural irrigation return water; (2) urban landscape irrigation return water; and (3) septic tank effluent. Each of these is discussed in the following paragraphs.

Agricultural Irrigation Return Water. Although past agricultural practices within the central portion of the planning area may have occurred, and may have resulted in groundwater quality degradation which is still present, the only current agricultural activities occur in Los Osos Valley, located on the eastern edge of the planning area. Agricultural irrigation return water has the potential for causing large increases in nitrate concentrations in groundwater. In this area, however, the shallow alluvial deposits appear to be containing the high nitrate groundwater and transporting it northward out of the valley. Consequently, little or no high nitrate groundwater is infiltrating into the Paso Robles Formation, the principle aquifer in this area, and none of this nitrate is entering the shallow groundwater in the old dune sands.

Urban Landscape Irrigation Return Water. Landscape irrigation return water is discharged to the groundwater table generally throughout the urban development portion of the planning area. Applications of high nitrate fertilizer in landscaping, dissolution of excess amounts of nitrate, and percolation of this water to the groundwater table has the potential for causing groundwater quality degradation in the shallow groundwater. Although this discharge may be a significant portion of the total nitrogen loading in the planning area, an accurate estimate of this loading is not available at this time. The contributuion to degradation from this discharge, in comparison with the nitrogen loading estimated for septic tank effluent, is considered less significant.

Septic Tank Effluent. Wastewater discharged from septic tanks in the planning area occurs principally in the urban development portion of that area. Total annual nitrogen loading resulting from this cause is approximately 120,000 to 130,000 pounds. Septic tanks in the lower-density residential areas, although point sources, act as a diffuse source of wastewater, while septic tanks serving multiple dwelling units and mobile home parks, as well as certain commercial establishments, act as higher-discharge point sources of wastewater. Septic tank effluent is the most significant cause of degradation in the planning area.

In considering the groundwater quality degradation due to increased total dissolved solids, it is important to understand that, except for a small portion of the planning area, water supplies throughout most of the urban development portion come from municipal wells screened in the lower aquifers which exhibit higher levels of total dissolved solids.

Interrelationships

The native background concentration of total dissolved solids in the shallow groundwater is approximately 200 milligrams per liter, while the native total dissolved solids content of the deeper groundwater is approximately 400 milligrams per liter.

Thus, wastewater discharge, averaging 500 milligrams per liter total dissolved solids, represents an increase in total dissolved solids in the wastewater of only about 100 milligrams per liter. Therefore, much of the increase in total dissolved solids shown in the shallow groundwater is a result of intermixing with wastewater derived from deeper aquifers with high natural total dissolved solids content.

Infiltration rates for both precipitation and wastewater discharge in the planning area are very high. It is estimated that approximately 70 percent of all precipitation percolates to the shallow groundwater table. As a result, precipitation acts to dilute the concentrations of nitrate and total dissolved solids in the total volume of water percolating to the groundwater table. This acts to mitigate the increases in these constituents which might otherwise occur. Subsurface outflow of groundwater from the planning area occurs mainly from the shallower aquifers. The subsurface outflow acts to remove degraded groundwater from the shallow zone, creating available groundwater storage for acceptance of percolated precipitation and other waters. Subsurface outflow, therefore, also mitigates groundwater quality degradation due to elimination of portions of the waste load applied to the basin.

Interrelationships between the shallow groundwater formations and deeper groundwater formations can occur as a result of leakage of shallow groundwater through the semi-confining layers, drainage of shallow groundwater and surface water through abandoned well casings to the deeper zone, and leakage of shallow groundwater along the casings of improperly constructed wells to the deeper aquifers. Although leakage along well casings may be the cause of certain occassional high nitrate readings in one or more of the deep wells in the past, the quantity of contaminants entering the deeper formation by this means is considered negligible. Similarly, the vertical leakage through the semi-confining layers is insignificant in comparison with the horizontal flow of shallow groundwater resulting in subsurface outflow.

SUMMARY OF WATER QUALITY PROBLEMS

The existing groundwater quality problems can be defined as increased nitrate concentrations in the shallow groundwater occurring in the urban development portion of the planning area, caused by wastewater discharge principally from septic tanks located throughout the urban development area. Nitrate concentrations in excess of the maximum contaminant level occur throughout much of the urban development area, and are a potential cause of methemoglobinemia to those persons who obtain their drinking water supply from shallow, individual water wells. Increases in total dissolved solids in the shallow groundwater may be construed as a water quality problem in that an increase in total dissolved solids is against the state policy of non-degradation, and does not meet the water quality objectives established in the Basin Plan for the Los Osos groundwater basin.

CHAPTER 8

FUTURE CONDITIONS AND POTENTIAL PROBLEMS

In order to assess the overall effects of current water quality practices in the planning area, it is important to predict future conditions and to assess the possible water quality problems, and other problems, that may arise. This chapter presents an estimate of future conditions based on current planning, and a discussion of future impact on water quality in the planning area.

Future Conditions

The basis for assessing future conditions in the planning area is established in Chapter 3. Factors affecting future conditions are population projections, water use, and land use.

Population Projections. According to information provided by San Luis Obispo County, as presented in Volume II, Appendix III, population in the study area is anticipated to increase from its current value of approximately 11,000 persons to an absorption population of approximately 29,000. This value includes 28,220 urban population and 780 rural population.

Water Demand. Based on the population projections, and utilizing the unit water use factor of 0.177 acre-feet per person per year discussed in Chapter 3, future water demand for the study area has been established, as shown on Figure 3-2. On this basis, upon development of the study area to absorption population, the total applied water demand will be 6,200 acre-feet per year. Of this total, 1,067 acre-feet per year is for agricultural applied water, 4,995 acre-feet per year is for the urban poplation, and 138 acre-feet per year is for the rural population.

Considering net water use, or consumptive water use, and amounts of water which would be returned to the groundwater basin under these conditions, the total consumptive use of groundwater from the groundwater basin would be 2,630 acre-feet per year. This would reduce subsurface outflow to 470 acre-feet per year, which would probably be insufficient to retard seawater intrusion. Therefore, under absorption population, the community must necessarily augment its existing water supplies. The importation of water is discussed more fully in the 1974 report by Brown and Caldwell.[1] For purposes of this report, it is assumed that the total water demand will be obtained from the groundwater basin. This will allow consideration of future impacts to groundwater basin water quality.

Land-Use Projections. Planned future land use in the planning area is depicted on Figure 3-4. Future land-use patterns do not differ appreciably from current land-use patterns. As population increases in the future, it is expected that the density of the urban developmment area will continue to increase rather than for land-use patterns to change. This is consistent with the current County Land-Use Plan.

Future Impact of Natural Elements on Water Quality

As population increases in the study area, the impact on water quality due to natural elements may change. Such natural elements include changes in geologic processes, hydrologic processes, and ecologic processes.

Changes in Geologic Processes. Continued urbanization of the planned urban development area will cause a greater amount of the land surface in the planning area to be covered with asphalt, concrete, and structures. As a result of this increased urbanization, the potential for infiltration of precipitation may be reduced, and the potential for urban runoff may increase. As a result, it may be that the total infiltration of precipitation into the groundwater basin will diminish. It is the policy of San Luis Obispo County, however, that new development be done in such a manner as to provide for collection of surface flow for infiltration into the groundwater basin. Therefore, the loss of infiltrating precipitation will be minimized. Based on existing available data, it is not possible to accurately predict the magnitude of this change. It is reasonable to assume, however, that infiltration may be reduced by some amount. Increased urban runoff, especially in the eastern portion of the planning area, may increase flow to Los Osos Creek and Eto Creek, reducing the mineralization of water in those two intermittent streams. Reduced infiltration of precipitation, however, may cause the shallow groundwater levels to decrease.

Hydrologic Processes. As population increases, water supply demands on the municipal water purveyors in the planning area will increase. It will be necessary to drill additional wells, install additional transmission mains, and possibly look for sources of imported water. Increased pumping from the Paso Robles Formation will reduce the piezometric head in these aquifers, which will increase the potential for seawater intrusion into this lower zone. In addition, it is anticipated that additional wells screened in the shallower deposits may be necessary. Reduced piezometric levels in the Paso Robles Formation may induce additional recharge from shallower aquifers and from surface waters of Los Osos Creek, and the Warden Lake area, tending to reduce runoff of surface water from these streams. The overall impact on the streams, however, is expected to be negligible.

Ecologic Processes. Due to the increased water demand, and the possible lowering of the shallow water table, it is anticipated that there may be a reduction in areas of natural vegetation. Those heavily vegetated areas in the eastern portion of the planning area, as shown on Figure 7-1, which now exist due to the nearness of the shallow groundwater table to ground surface, are expected to be impacted most heavily. The grove of oak trees located in the southeast corner of the planning area, and the groves of eucalyptus trees located elsewhere, may not be able to extend their root systems deep enough or fast enough to meet their water demands. Consequently, trees would die and, especially in the case of eucalyptus trees, branches would break and fall and whole trees may topple. There would be a resultant impact on wildlife of the area if vegetation decreases.

No impact on groundwater due to ecologic processes is anticipated, however, the surface water of Eto Lake may be impacted. Eto Lake is now fed by Eto Creek, which is an effluent stream being supplied by groundwater. Reduction of groundwater levels would reduce the flow of water to Eto Creek, and thus Eto Lake, possibly causing stagnation and eutrophication of this water.

Future Water Quality Problems

Under anticipated future conditions, existing problems will continue and will be augmented in certain instances. In addition, other problems will arise. The following paragraphs describe anticipated future water quality problems due to the future conditions discussed above.

Problem Identification. Increases in population will result in increases in wastewater discharge. Although it is anticipated that the character of wastewater will remain relatively the same, it is possible that concentrations of nitrate and total dissolved solids may increase. For example, if water demand becomes critical, severe water conservation measures may be undertaken. In this instance. the quantity of waste disposal from domestic and commercial sources would not increase at a uniform rate with population, but the waste loadings due to domestic and commercial use of water would increase in relative proportion to the population. Consequently, it can be anticipated that the concentration of nitrate and total dissolved solids in the wastewater, under conservation conditions, would increase. Either way, the total waste loads entering the groundwater basin would increase to over 300,000 pounds per year of nitrogen at ultimate development, which would result in higher concentrations of nitrate in the shallow groundwater, increased areal distribution of high nitrate and a general increase in total dissolved solids in shallow groundwater.

If seawater intrusion is allowed to occur, the usability of the groundwater basin would be impaired. It can be expected that wells located near the coastline may become intruded and need to be abandoned. Because of the increased water demand, these wells will need to be relocated farther east in the groundwater basin. Increased total dissolved solids and other constituents in water supplied for domestic and commercial uses may result in additional costs for treatment and may make certain types of uses impossible. For example, nurseries producing orchids have a low tolerance for changes in water quality. If delivered-water quality decreases, it may be uneconomical to continue operation of this type of business. The result would be economic loss to the community.

Causative Elements. In the future, under anticipated conditions, water quality problems will occur principally as a result of additional wastewater discharge to the groundwater basin. Additional factors arise, however, which augment the water quality problems and produce additional water quality problems in the planning area.

Increased pumping from the deeper wells to meet future water demand will not only result in a greater potential for seawater intrusion, but may also cause induced infiltration of the shallow, degraded groundwater into the deeper Paso Robles Formation through the semi-confining beds. As a result, there would be a more wide-spread vertical distribution of contaminants throughout the groundwater basin and degradation of all aquifers may occur. This situation would produce a recycling of groundwater: from the aquifer to the user; wastewater discharge to the groundwater table; infiltration of degraded groundwater into the aquifer and into the well; and recycling of degraded groundwater back to the user. Each time water is recycled, additional waste loads of nitrogen and total dissolved solids are added, and the degradation would increase.

The potential for disease due to high nitrate increases with increasing nitrate concentrations. Infiltration of degraded water into the deeper aquifers increases the potential for high nitrate content in delivered water. In addition, because of limitations on the deeper aquifer caused by potential seawater intrusion, development of wells in the shallower aquifers may be necessary. Water produced from these aquifers is expected to be higher in nitrate due to direct addition of wastewater.

Reductions in piezometric levels in the Paso Robles Formation will cause increased potential for infiltration of water from the alluvial deposits in Los Osos Valley. High nitrate concentrations in the shallow alluvium, due to agricultural activities in that valley, may enter the Paso Robles Formation raising the potential for contamination of groundwater from that source.

If increased urbanization is allowed to cause a reduction in infiltration of precipitation, this will reduce the total availability of groundwater for use, and will reduce the dilution of wastewater by infiltrating precipitation which presently occurs. These elements, therefore, interrelate to augment the degradation problem. As degradation increases, water quality decreases, and as water demand increases, additional recycling of water results, which increases water quality degradation. In general, then, it can be stated that future water quality problems will increase with increased population, but the problems will increase at a more rapid rate than population increases.

CHAPTER 9

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a brief summary of significant findings of the Phase I Water Quality Management Study of the Los Osos-Baywood Park area, the principle conclusions of the study, and recommendations for further action by San Luis Obispo County in managing water quality in the study area.

Findings

1. Evaluation of water quality records from qualified wells, and chemical analyses of water and wastewater performed under rigorous quality control as part of this study, shows three distinctly different types of water. Type A water is magnesium-sodium bicarbonate water occurring in deep wells screened in the Paso Robles Formation, wells in Los Osos Valley (also Paso Robles Formation), and surface water in San Luis Obispo Creek. Type B water is predominantly sodium chloride in nature, but distinctively different than seawater or sea-spray quality. Type B water includes groundwater from the shallow formations in the older dune sand deposits overlying the Paso Robles Formation, and the surface water in Eto Creek. The third type of water is wastewater effluent, which is classified as sodium bicarbonate water.

2. Wastewater effluent samples from domestic residential and commercial septic tank systems showed similar characteristics in terms of classification. Other forms of wastewater in the study area, which are non-point sources, are urban landscape irrigation return water and agricultural irrigation return water. Prior to urban development, agricultural practices reportedly occurred within the presently developed urban area.

3. None of the water samples from qualified wells showed characteristics indicative of seawater intrusion in the groundwater basin. Even though Type B water is classified as sodium chloride, its chemical characteristics are distinctly different than those of seawater.

4. Background nitrate concentrations in groundwater, in areas of little or no development, are less than 25 milligrams per liter (mg/l) as NO_3. Groundwater samples with nitrate

concentrations in excess of 45 mg/l as NO_3, the maximum contaminant level (MCL) for this constituent, definitely indicate contamination. A significant number of samples from wells throughout the central portion of the urban development area show nitrate concentrations in excess of 45 mg/l as NO_3.

5. There is a correlation between areas of urban development and occurrence of nitrate concentrations greater than 25 mg/l as NO_3 in the shallow groundwater. High nitrate concentrations were not found in any of the samples from the deep wells screened in the Paso Robles Formation.

6. High concentrations of total dissolved solids were found in samples of shallow groundwater and deep groundwater. There is a general correlation between high total dissolved solids content in shallow groundwater and the area of urban development.

7. The high total dissolved solids content in the Paso Robles Formation is a natural condition and is consistent with the high total dissolved solids content of surface water in Los Osos Creek, which acts as a source of recharge for this formation.

8. There is a meaningful correlation between total dissolved solids content and nitrate concentration in groundwater for those samples with nitrate concentrations greater than the background level, approximately 25 mg/l as NO_3.

9. No geologic, hydrologic, or ecologic processes are at work in the study area which could naturally cause the high nitrate concentrations found. The occurrence of dense vegetation and groves of eucalyptus and oak trees, in areas where the shallow groundwater table is near ground surface, causes a reduction in nitrate levels in shallow groundwater due to uptake of nitrate by this vegetation.

10. A detailed evaluation of shallow groundwater quality from wells located upgradient, downgradient, and within areas reported by the County to be high density wastewater discharge areas showed generally high nitrate concentrations in the shallow groundwater. However, no distinct correlation with, or effects specifically from, the individual wastewater discharge point sources were determined. The absence of natural causes of high nitrate and the correlation between high nitrate concentrations in shallow groundwater and the areas of urban development within the planning area establish a definite cause-and-effect relationship between wastewater discharge and nitrate contamination of the shallow groundwater.

11. Evaluation of water quality data did not demonstrate a distinct water quality correlation with any one of the specific types of wastewater discharge more than any of the others. All of the following types of wastewater discharged to the groundwater table in the planning area may be contributing to nitrate contamination of shallow groundwater: residential septic tank effluent; commercial septic tank effluent; urban landscape irrigation return water; and agricultural irrigation return water.

12. Nitrogen loading to the shallow groundwater table in the planning area from domestic, commercial and agricultural sources of wastewater currently discharged ranges from 140,000 to 170,000 pounds of nitrogen per year. Nitrogen loading from residential and commercial sources, only, in the planning area ranges from 120,000 to 130,000 pounds of nitrogen per year.

13. A significantly large amount of nitrogen is discharged through percolation of wastewater from septic tank effluent in the planning area. This source, by itself, is sufficient to account for the high nitrate concentrations in the shallow groundwater, assuming that most all of the nitrogen in septic tank effluent is converted to nitrate and percolates to the groundwater table.

14. If population growth continues to the absorption population, the nitrogen loading from residential and commercial sources alone will exceed 300,000 pounds of nitrogen per year discharged to the groundwater table.

Conclusions

1. Shallow groundwater in the planning area is contaminated by nitrate concentrations in excess of the 45 mg/l MCL, as NO_3, established for this constituent.

2. There are no naturally occurring geologic, hydrologic, or ecologic processes which could cause the nitrate contamination found in the shallow groundwater.

3. The distinct correlation of high nitrate levels in shallow groundwater with the area of urban development establishes conclusively that wastewater discharge is the cause of high nitrate contamination. Using water quality data, alone, it is not possible to establish a distinct cause-and-effect relationship between high nitrate concentrations in shallow groundwater and any one of the following specific types of wastewaters discharged: residential septic tank effluent;

commercial wastewater; urban landscape irrigation return water; and agricultural irrigation return water. It is concluded, therefore, that wastewater discharge, in general, is the cause of nitrate contamination in the shallow groundwater.

4. There is a potential health hazard to the community as a result of the nitrate contamination of shallow groundwater. Studies have shown a high incidence of occurrence of infantile methemoglobinemia in communities utilizing drinking water supplies with nitrate concentrations in excess of 45 mg/l as No_3.

5. Although occasional past records of chemical quality of water from deeper aquifers show elevated nitrate concentrations, no contamination of deep groundwater was determined in this study.

6. The geohydrology and aquifer geometry of the planning area show the groundwater basin to consist of a multiple aquifer system, not a single groundwater system as has been previously reported. The multiple aquifers distinguished include the following: a shallow, unconfined water table aquifer occurring in the upper portion of the old dune sand deposits; a deeper, semi-confined aquifer system in the lower portion of the old dune sand deposits composed of semi-confined aquifers occurring in a transitional zone between the old dune sand deposits and the underlying Paso Robles Formation; and a deep system of semi-confined to confined aquifers occurring in the Paso Robles Formation, beneath an upper layer of confining clay beds.

7. The deeper semi-confined to confined aquifer system is protected to a large extent from contamination from the shallow groundwater system by the clay layers which act as semi-confining or confining layers separating the upper and lower aquifer systems.

8. The potential public health problem due to high nitrate contamination of the shallow groundwater occurs only in those portions of the planning area where water supplies are obtained through wells producing water from the shallow groundwater system.

9. Notwithstanding the multiple aquifer system in this portion of the groundwater basin, the Los Osos groundwater basin is currently the only source of water to the study area. Contamination is confirmed only in the shallow groundwater.

10. As the population of the planning area increases, discharge of wastewater to the groundwater table will also increase causing increased nitrate contamination of the groundwater. Population growth will also cause increased water demands on the groundwater system. The combination of increased water demands and increased wastewater discharge will cause groundwater quality to degrade at a rate in excess of the rate of increase in population.

11. Increases in water demand on the groundwater basin will require increases in groundwater pumping which will reduce piezometric levels and perhaps lower the groundwater table in the study area. Lowering of piezometric levels below a critical point will cause seawater intrustion into the aquifers, principally the aquifers in the Paso Robles Formation. Seawater intrusion into the deeper aquifer system may necessitate greater utilization of the shallow, contaminated groundwater system which may increase the potential for health hazards in the area.

Recommendations

Based on the findings and conclusions determined during this study, we recommend that San Luis Obispo County take the following actions:

1. Authorize completion of Phase II, Evaluation of Alternatives, of the Facilities Planning Study Program. The scope of work for the Phase II study identifies the following alternatives for further evaluation in determining the most cost-effective, feasible approach toward solving water quality problems in the Los Osos-Baywood Park area:

    a. No project (no action taken).

    b. Sewering part or all of the planning area, using conventional or pressure sewer systems with;

        (1) regional treatment at the City of Morro Bay,

        (2) community treatment and disposal by ocean discharge, wastewater reuse or percolation disposal, or

        (3) "neighborhood" subsystems.

    c. Modifying water supply practices by either:

        (1) relocation of groundwater extraction,

        (2) supplemental water supplies, or

        (3) changes in delivery or use practices.

    d. Combinations and subalternatives.

In addition to the alternatives already identified in the scope of work for Phase II, that study should also evaluate: utilization of "gray water" for urban landscape irrigation; revision of septic tank design requirements for future developments to include denitrification of wastewater; and relocation of municipal water supply wells to eliminate those currently producing water from the shallow groundwater system. The study should also address future contamination due to urban landscape irrigation return water if septic tank effluent is controlled, and provision of groundwater recharge facilities to augment groundwater supplies.

2. Prepare a detailed hydrologic budget of the entire Los Osos hydrologic basin, a more complete hydrologic budget of the groundwater basin, a specific hydrologic budget of the portion of the groundwater basin in the vicinity of the planning area, and a more detailed assessment of the long-term safe yield of the groundwater basin aquifers.

3. Further evaluate the geohydrology and aquifer geometry in the groundwater basin, redefine the aquifer systems in the groundwater basin to more specifically follow the aquifer geometry in the basin, and establish a groundwater basin management plan.

4. Evaluate the possibility of recharging the Paso Robles Formation using a series of in-stream dams in Los Osos Creek to augment infiltration of Los Osos Creek water, and using additional water from Warden Lake for groundwater recharge through Los Osos Creek facilities.

5. Perform a water supply study for the area assessing available water supplies, defining current and future water distribution system needs, and assessing the need for and sources of possible imported water to meet future water demands.

6. Install necessary wells in the Paso Robles Formation and necessary distribution systems to provide municipal water supplies to those residents currently using shallow domestic wells.

7. Establish a program for identifying abandoned wells which may be carrying contaminants from the shallow groundwater system to the deeper, uncontaminated aquifers, and a program for sealing and destroying abandoned wells which potentially threaten groundwater quality.

8. Implement the above recommendations and establish a firm program for managing water quality and water quantity in the Los Osos groundwater basin.

APPENDIX

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Note: A complete bibliography is presented in Volume II, Appendix II, to this report.

APPENDIX

References