

VENTURA COUNTY DEPARTMENT OF PUBLIC WORKS
FLOOD CONTROL DISTRICT

VENTURA COUNTY WATER RESOURCES MANAGEMENT STUDY
AQUIFER DELINEATION IN THE OXNARD-
CALLEGUAS AREA, VENTURA COUNTY

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This Technical Information Record was prepared to document pertinent information as it was developed during the Ventura County Water Resources Management Investigation.

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INTRODUCTION

The purpose of this Technical Information Record (T.I.R.) is to document findings of geohydrologic studies conducted to define the vertical and areal extent of water-bearing units within ground water basins of the Oxnard-Calleguas area of Ventura County. Important ground water basins within the study area include the: Oxnard Plain Pressure, Oxnard Plain Forebay, Pleasant Valley, North and South Las Posas and Santa Rosa Valley Basins and the Mugu unconfined area. A major portion of this report describes the Oxnard Plain, an area of complex, but related multiple aquifer zones. During the initial stages of the investigation, all previous studies of the area pertaining to ground water resources were reviewed. A list containing reports utilized during the study appears at the end of this report as "References Cited".

Data to determine the extent and configuration of important aquifer zones was obtained, primarily from existing subsurface records of wells drilled for water, oil and gas. The principal and most reliable sources of subsurface data were electrical logs of water and petroleum wells. These records are invaluable since they constitute a physical record of formations penetrated adjacent to the borehole. The availability of these records allows qualitative determination of subsurface lithology

and water quality. Fortunately, these records are numerous in the Oxnard-Calleguas area due to the progressive design techniques employed by some water well drilling contractors and extensive subsurface exploration by petroleum companies. More than 200 such records were obtained within the area of investigation, the majority of which penetrate or approach the base of the ground water reservoir.

The greatest number of subsurface records are lithologic logs of materials penetrated at the time of drilling. Within the study area greater than 1,000 of these records were inspected, many of which were selected to supplement electrical log data.

During this study, a series of maps and Geologic Sections depicting various parameters were prepared. Maps depict the vertical and areal boundaries of aquifer zones and thickness of water-bearing materials within these zones. The Geologic Sections provide a visual description of subsurface relationships which occur from ground surface to the base of the ground water reservoir. Location of these sections and basin boundaries are shown in Plate 6. The discussion which follows contains material considered pertinent to modeling studies and selection of an operational plan for water resources management. A more detailed discussion of geologic aspects is contained in the Geology report.

OXNARD PLAIN FOREBAY BASIN (MONTALVO BASIN)

The Oxnard Plain Forebay Basin encompasses an area of approximately 9.5 square miles and constitutes the principal area

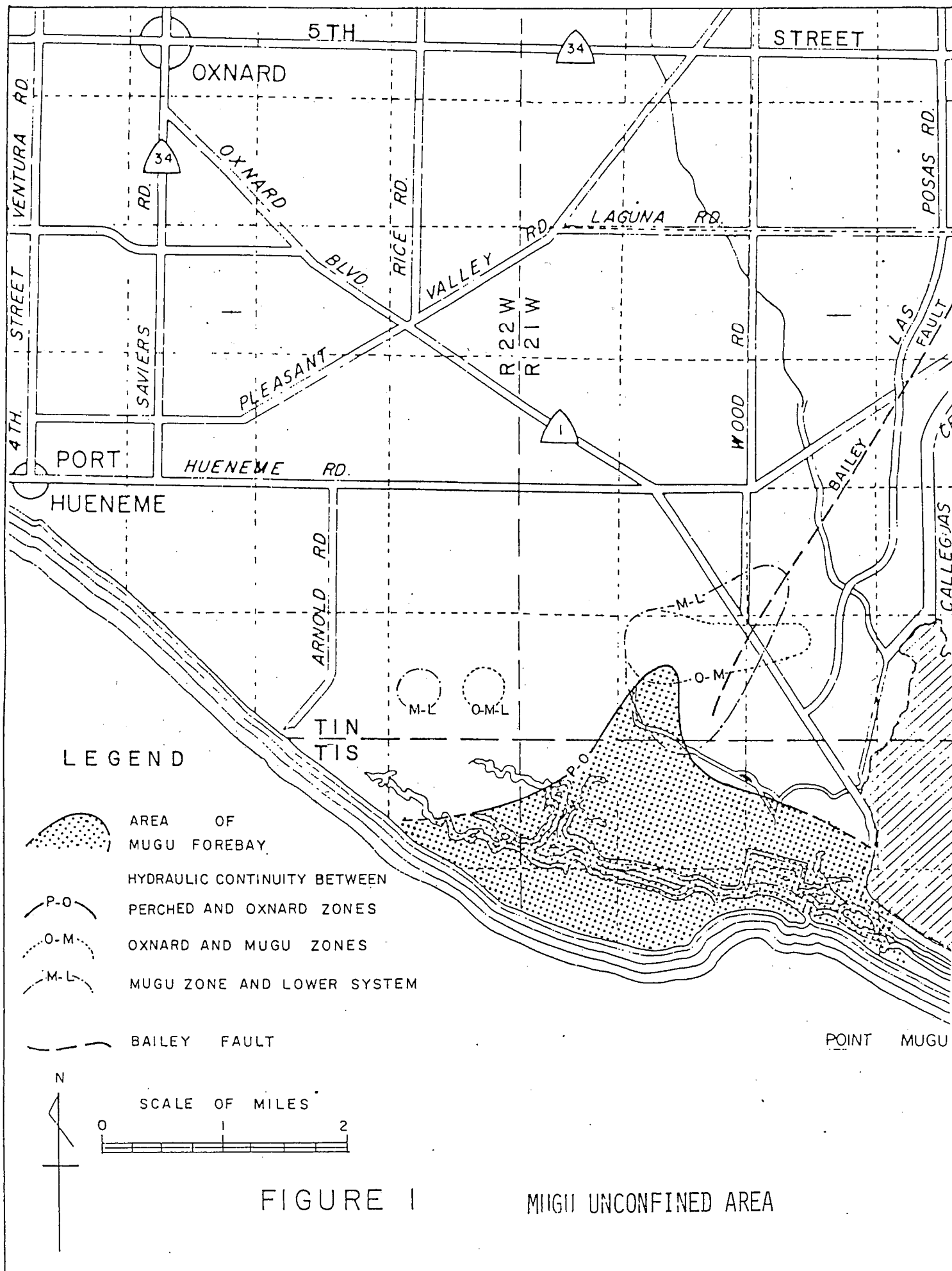
of ground water recharge within the Oxnard Plain. The areal extent of the Oxnard Plain Forebay Basin is shown in Plate 1. The principal criteria used for delineation of the extent of this basin was lack of a low permeability confining member from ground surface to the top of the initial major aquifer zone. The northwest boundary of the basin is generally contiguous with the north bank of the present Santa Clara River channel. Northwest of this boundary numerous subsurface records indicate a predominance of low permeability materials and an absence of the Oxnard aquifer zone. The northerly limit of the Oxnard Plain Forebay Basin coincides with the location of the McGrath fault, a branch of the Oak Ridge fault zone. Remaining boundaries are coincident with a thickening of the "clay cap" which effectively confines the Oxnard aquifer zone over most of the Oxnard Plain. Within the boundaries of the Oxnard Plain Forebay Basin, artificial and natural ground water recharge is a source of replenishment to the Upper and Lower Aquifer Systems.

Geologic Section C-C' indicates the generalized subsurface relationships from ground surface to the effective base of the ground water reservoir within the Oxnard Plain Forebay Basin. Within this basin the Oxnard aquifer zone consists almost entirely of permeable sand and gravel. Although the underlying Mugu aquifer contains a significantly greater percentage of low permeability material than the Oxnard zone, the lenticular nature of these materials allows relatively unimpeded replenishment to the entire Mugu aquifer.

A smaller area within the basin was delineated through which ground water recharge occurs to the Hueneme and Fox Canyon aquifer zones of the Lower Aquifer System (Plate 1). These zones were upwarped and partially eroded prior to deposition of the Mugu aquifer, resulting in hydraulic communication to water-bearing sands and gravels of the Lower Aquifer System. The relationship between Lower Aquifer System materials and overlying deposits are shown in Geologic Sections B-B' and C-C'.

MUGU UNCONFINED AREA

This unconfined area is located at the extreme southerly portion of the Oxnard Plain and encompasses an area of approximately 4 square miles. It is bounded by nonwater-bearing rocks of the Santa Monica Mountains to the east, a thickening of the confining clay cap to the north and west and the Pacific Ocean on the south. It is characterized by absence or minimum thickness of the confining clay cap normally present above the Oxnard aquifer zone. Approximate boundaries are shown in Figure 1. Boundaries of this basin are tentative because of inadequate subsurface information and, therefore, they should be modified as additional data becomes available. This unconfined area is similar to the Oxnard Plain Forebay, since both are characterized by lack of a significant clay cap confining the Oxnard aquifer zone. Sea-water intrusion now occurs in the Oxnard aquifer zone throughout the entire Mugu Forebay. Aquifer Section A-A' indicates the general stratigraphic relationships of a portion of the Mugu Forebay Basin.



Available data indicates that the Mugu aquifer is effectively separated from the overlying Oxnard aquifer zone by a low permeability layer over all but the extreme northerly portion of the Mugu Forebay. Figure 1 indicates this relationship and also areas of hydraulic continuity of other zones within and in the vicinity of the Mugu Forebay. Hydraulic continuity between the Oxnard aquifer zone and the Mugu aquifer within and adjacent to the Mugu Forebay assumes an east-west elongated configuration which covers an area of about 0.5 square miles. About one mile west of here, the log and water quality data from well 1N/22W-36K4, which is sealed from ground surface to a depth of 380 feet, indicate hydraulic continuity and sea-water intrusion into the Mugu and possibly Lower Aquifer System.

Extensive hydraulic continuity between the Mugu aquifer and the Fox Canyon aquifer zone is believed to occur in a one-square-mile area extending northerly from the Mugu Forebay. Within this area wells 1N/21W-28N2 and 32A1, both completed only in the Lower Aquifer System, indicate relatively high chloride concentration of 306 and 193 milligrams per liter, respectively. It is possible that sea water is migrating downward in the gravel pack from the Mugu aquifer in well 1N/21W-28N2 because the seal to 250 feet is above the base of the Mugu aquifer. Downward leakance through the gravel pack of well 1N/21W-32A1 is not possible because the well is sealed to a depth of 460 feet, which is considerably below the base of the Mugu zone. Smaller areas of hydraulic continuity between the Mugu aquifer and Lower Aquifer System are believed to exist about one mile west of the Mugu Forebay.

Active sea-water intrusion combined with hydraulic continuity and downward hydraulic gradient, which exist within and adjacent to the Mugu Forebay, poses a serious threat to all major aquifer zones of the Oxnard Plain Basin.

OXNARD PLAIN PRESSURE BASIN

The bases for delineating the extent of the Oxnard Plain Basin are the areal limits of the Oxnard aquifer zone and the Mugu aquifer. This basin differs from the Oxnard Forebay Basin and Mugu Forebay in that it contains a "clay cap" over the Oxnard aquifer zone.

The Oxnard Plain Basin encompasses an area of approximately 75.2 square miles and is bounded by the Mound and Oxnard Forebay Basins to the north, the North Las Posas and Pleasant Valley Basins to the east, and the Mugu Forebay and nonwater-bearing rocks of the Santa Monica Mountains to the south. Although the Oxnard aquifer zone extends offshore, the westerly basin boundary is arbitrarily assigned at the coastline because this study was confined to the onshore area. The offshore extent and configuration of various aquifer zones is contained in a report being prepared by the United States Geological Survey in Menlo Park, California. The Oxnard Plain Basin is a relatively flat alluviated area which ranges in elevation from sea level to approximately 100 feet. It is underlain by numerous important aquifer zones, which, in the center of the basin beneath El Rio, extend to depths of greater than 2,100 feet below sea level (Plate 5).

During early stages of the investigation, it was determined that major water-bearing zones beneath the Oxnard Plain could be grouped into three major units on the basis of differing piezometric levels, water quality and geologic structure. These are: 1) the semiperched aquifer and clay cap; 2) the Upper Aquifer System; and 3) the Lower Aquifer System.

SEMIPERCHED AQUIFER AND CLAY CAP

The semiperched aquifer and clay cap consist of all materials above the Oxnard aquifer zone within the Oxnard Plain Basin. The semiperched aquifer extends from the base of developed soil horizons to an average depth of approximately 75 feet over most of the Oxnard Plain Basin. This aquifer consists primarily of geologically Recent stream-deposited sands and gravels, with minor silt and clay interbeds. Permeable sand and gravel deposits are continuous in a direction generally parallel to the present course of the Santa Clara River and lenticular in a perpendicular direction as indicated on Geologic Sections A-A' and C-C'. Historically, there have been very few water wells completed within this zone because of limited well yield and poor water quality caused by agricultural return water and evapotranspiration. Recent studies in an area north of Channel Islands Harbor indicate local occurrence of ground water of acceptable quality for most beneficial uses (mineral concentration 850 to 950 milligrams per liter) within lower permeable portions of this zone. The occurrence of acceptable quality water within this portion of the zone is believed to reflect the

local effectiveness of aquicludes and aquitards within and above permeable portions of the semiperched zone. These materials prevent substantial downward migration of degraded applied and surface water under present extraction conditions. The depth to water within this zone is normally only several feet below ground surface.

Highest water levels are found in heavily irrigated areas where, without tile drains, water level rises high enough to adversely affect the growth of plantings. The maximum depth to water in this zone is approximately 10 feet. This occurs in the fall of dry years in nonirrigated areas where the depth to water is controlled by limits of evaporation from the water table.

The "clay cap" underlies the semiperched aquifer zone and extends to the top of the Oxnard aquifer zone. Plate 1 indicates that the clay cap extends to greater than 180 feet below sea level at two locations near the ocean. The clay cap consists of Recent silty clay, silt and clay with lenses of sand and silt. In results of earlier water resources studies, it was theorized that the clay cap contains areas where downward leakage occurs to the Oxnard aquifer zone. A recent cooperative investigation between the Department of Water Resources and the University of California indicated that the clay cap is an aquitard through which significant quantities of water can migrate vertically under conditions of differential head.

Because of generally poor water quality and limited quantity of recoverable storage within the semiperched aquifer zone

it is recommended that materials overlying the Oxnard aquifer zone not be modeled as an aquifer system during the current investigation. Because leakage within this zone affects underlying zones, it is recommended that results of the aquitard study, published in Department of Water Resources Bulletin 63-4, be utilized during development and verification of the mathematical ground water basin model.

UPPER AQUIFER SYSTEM

The Upper Aquifer System delineated within the Oxnard Plain Basin consists of the Oxnard aquifer zone and the Mugu aquifer. These two water-bearing units were combined primarily on the basis of similar subsurface structure although under natural conditions water levels and water quality were probably more similar than they are today. The structure of the Upper Aquifer System is more planar than the Lower System because these materials are younger and have not been subjected to as much folding as the deeper lower Pleistocene water-bearing materials (Geologic Sections A-A', B-B' and C-C'). Because of their relatively young age, they have also not been subjected to displacement by fault movement to as great an extent.

The base of the Mugu aquifer constitutes the base of the Upper Aquifer System. The nature of the unconformity between the base of the Mugu aquifer and the top of the Lower Aquifer System is very significant with regard to sea-water intrusion, and, at this time, is not thoroughly understood in all areas.

Prior to deposition of the Mugu aquifer, sea level dropped considerably causing extensive erosion of previously deposited materials on the Oxnard Plain.

The major source of erosive force during this period was the Santa Clara River which meandered over the entire Plain. Of secondary importance was the erosive energy provided by Calleguas Creek and numerous small tributary drainages. The result of this extensive period of erosion was surface exposure of numerous previously folded underlying water-bearing zones. Following this period, sea level rose inundating most or all of the Oxnard Plain. During this time, deposition of the Mugu aquifer occurred upon the previously developed unconformity in a shallow marine inland sea. The result of the sequence of erosion is extensive hydraulic continuity between the Mugu aquifer zone and important aquifer zones of the Lower Aquifer System. Recent overdraft of the Oxnard and Mugu aquifer zones has resulted in serious inland sea-water intrusion at Port Hueneme and Point Mugu. At Port Hueneme sea-water intrusion is known to occur only in the Oxnard aquifer zone where the most recent information indicates an onshore affected area of approximately 8 square miles. A far more serious condition is found at Point Mugu where the Oxnard and Mugu aquifer zones are both intruded. Here onshore intrusion of the Oxnard zone now covers an area greater than 9 square miles. The areal extent of sea-water intrusion in the Mugu aquifer is at this time undetermined. Active intrusion into exposed suballuvial materials of the Lower Aquifer System is also indicated in Sections 28 and 32 adjacent to the Mugu unconfined area.

The thickness of permeable materials in the Upper Aquifer System was contoured and is shown in Plate 3. Maximum thickness is reached in the area of the Las Posas syncline while minimum thickness generally occurs at the easterly boundary of the basin.

OXNARD AQUIFER ZONE

The Oxnard aquifer zone is the initial important water-bearing unit penetrated by water wells on the Oxnard Plain. Historically, this zone was considered to be the most important because shallow wells completed in this zone were capable of producing large quantities of acceptable quality water. Pollution of this zone by sea-water intrusion and leakage of poor quality perched waters has degraded the quality of this zone and caused many deeper wells to be drilled. In previous studies the areal extent of this zone was utilized to delineate the boundary of the Oxnard Plain Basin. During the present investigation, the maximum extent of both the Oxnard zone and the Mugu aquifer was utilized since both constitute the Upper Aquifer System which will be modeled as one unit. Combining these zones resulted in a minor easterly extension of the Oxnard Plain Basin boundary in the Pleasant Valley (Camarillo) area as shown in Plate 1.

The Oxnard aquifer zone is a laterally continuous layer of nonmarine gravel and cobbles ranging from 1/4 to 6 inches in diameter and coarse to fine sand. Interbedded within this zone are clay, silty clay and silt lenses that form localized aquicludes which restrict vertical movement of water within the zone and affect lateral movement as evidenced by differential sea-water

intrusion near the ocean. In some areas water-bearing materials are segregated into two or three zones as indicated in Plates 7 and 9. Because of this feature, the term Oxnard aquifer used in previous investigations has been revised to Oxnard aquifer zone.

The top of the Oxnard zone is an irregular surface ranging from greater than 20 feet above sea level east of Saticoy-El Rio to greater than 180 feet below sea level northwest of Port Hueneme (Plate 1). The irregularity of the top of this zone results primarily from differential erosion and sedimentation of the Santa Clara River rather than structural warping. An exception is found in the northwest Oxnard Plain near the ocean where the top of this zone appears to have been upwarped and/or faulted. South of this location near 5th Street, downwarping, probably related to the Las Posas syncline, is apparent. The base of the Oxnard aquifer zone occurs as a more regular surface, ranging from an elevation of sea level just east of the Saticoy Spreading Grounds to greater than 300 feet below sea level near Point Mugu. It is less irregular because it was deposited upon a relatively smooth erosional unconformity. The base of this zone was previously contoured and published in Department of Water Resources Bulletin 74-9, "Water Well Standards, Ventura County", and is recommended for use during the current investigation. In the northwest Oxnard Plain, the base of this zone exhibits the same structural features as the top. In addition, land surface subsidence in the vicinity of Point Mugu Naval Air Station is indicated. In the northern half of the Oxnard Plain the base of this zone has the appearance of a large alluvial fan.

MUGU AQUIFER

Between the base of the Oxnard zone and the top of the Lower Aquifer System is the Mugu aquifer of upper Pleistocene age.

Historically, few wells produced from this zone because adequate water supplies were available from the overlying Oxnard aquifer zone. Within the past 25 years, numerous multiple zone wells have been completed within this unit and more than 10 have been completed only within the Mugu aquifer.

The Mugu aquifer consists of sand and gravel with interbedded silt and clay with a maximum aggregate thickness of about 270 feet. Of this, a maximum thickness slightly greater than 200 feet consists of permeable sands and gravels.

The Mugu aquifer is an almost continuous layer of water-bearing materials deposited directly upon the erosional unconformity developed on the San Pedro formation and older underlying rocks. The basal portion of this unit generally consists of coarse materials deposited under very shallow marine or nonmarine conditions and is in hydraulic continuity with underlying zones over much of the Oxnard Plain. Later as sea level continued to rise, deposition of finer sands and gravels occurred, especially near the present shoreline. Generally, materials become finer grained toward the ocean and more coarse grained in the easterly Oxnard Plain. In the easterly Oxnard Plain much of the Mugu aquifer is believed to be of continental origin.

The top of the Mugu aquifer is in most areas overlain by a low permeability clay cap which varies from 10 to 100 feet in thickness. Exceptions are found near the Santa Clara River,

at Port Hueneme and in the Oxnard Plain and Mugu Forebays where well data indicates that water-bearing portions of the Mugu aquifer merge with the Oxnard zone.

Over most of the Oxnard Plain the top of the Mugu aquifer is relatively flat and slopes toward the ocean. The greatest irregularities of this surface are thought to be depositional rather than structural. Mild downwarping of this surface is indicated in the vicinity of the Las Posas syncline, while greater upwarping is indicated near the Santa Clara River. A contour map depicting the top of this zone was not prepared during this study because the Oxnard aquifer zone and Mugu aquifer are to be modeled as one unit.

The base of the Mugu aquifer is a more irregular surface, which ranges in elevation from less than 50 feet below sea level near the tip of South Mountain to almost 500 feet below sea level 3 miles north of Port Hueneme (Plate 2). This greater irregularity is caused by more intensive folding and sporadic nonmarine deposition. The area of greatest downwarping is coincident with the northeast-southwest trending Las Posas syncline which enters the Oxnard Plain from the Las Posas Valley and extends across the basin into the ocean. Upwarped areas include the nose and westerly extension of the Camarillo Hills and the northerly portion of the basin paralleling the present course of the Santa Clara River.

Features due primarily to deposition of fine materials are found just east of Port Hueneme.

LOWER AQUIFER SYSTEM

The Lower Aquifer System consists of the Hueneme, Fox Canyon and Grimes Canyon aquifer zones all of lower Pleistocene age. Collectively, they constitute the most valuable water-bearing zones in the Oxnard Plain Basin.

HUENEME AQUIFER ZONE

The Hueneme aquifer zone constitutes the upper portion of the San Pedro formation on the Oxnard Plain and is the uppermost unit of the Lower Aquifer System. It consists of up to 1,150 feet of sediments in the deepest portion of the basin. Previous investigators have not realized the thickness or areal extent of this unit because of insufficient deep subsurface data. The recent trend of completing deeper wells and additional data provided by petroleum companies has resulted in a more thorough understanding of the configuration and extent of this unit. Many wells penetrating deeper zones have been completed within this zone.

The Hueneme aquifer zone is composed of interbedded sand, silt and clay and minor gravel and is more lenticular than underlying zones. The somewhat lenticular nature of this unit is indicative of deposition under nonmarine conditions; however, the lack of extensive quantities of gravel would seem to indicate at least partial marine deposition, however, this has not been verified by paleontological data.

The Hueneme aquifer zone has been subjected to considerable folding, faulting and erosion since deposition, as indicated on Geologic Sections A-A' and C-C'. This activity has largely affected the areal distribution and occurrence of this unit on the Oxnard Plain. North of the Oxnard Plain this unit cannot be readily correlated. East of the Oxnard Plain, in the Las Posas Valley, water-bearing portions are extremely lenticular or absent and as a result wells do not produce much water from this zone. In Pleasant Valley some water is produced; however, most is extracted from deeper zones.

Much of the Hueneme zone has been removed by erosion of upwarped areas since deposition. On the south Oxnard Plain all of this unit has apparently been removed generally south of Hueneme and Etting Roads. In the north Oxnard Plain, just south of the Santa Clara River, much of it has also been removed by erosion since deposition due to upwarping and possibly faulting followed by erosion.

The map depicting contours on top of the Lower Aquifer System (Plate 4) has a very similar configuration to that on the base of the Upper Aquifer System over much of the Oxnard Plain. Exceptions are found within the southerly portion of the Oxnard Plain Basin where numerous irregularities occur between the two surfaces. The two most prominent features occur between Port Hueneme and Mugu Lagoon where two deep depressions ranging from 400 to 550 feet are apparent. These occur in areas where coarse water-bearing materials of the Hueneme aquifer zone are very thin or absent. This condition is also prevalent here in deeper zones

indicating a lagoonal or embayment environment of deposition for a considerable period of geologic time.

The most significant feature produced by the unconformity developed upon the Hueneme aquifer zone followed by deposition of coarse materials is extensive hydraulic continuity between this zone and the Mugu aquifer. Fortunately, onshore sea-water intrusion in the Mugu zone has occurred only near Point Mugu where the Hueneme zone is absent. Apparent lack of hydraulic continuity in much of the intruded area makes this unit increasingly important as a source of future water supply to the Oxnard Plain.

FOX CANYON AQUIFER ZONE

The Fox Canyon aquifer zone is the basal unit of the San Pedro formation. Paleontological evidence indicates that it is of lower Pleistocene age and was deposited in a shallow water marine environment over the entire Oxnard Plain Basin. Where paleontological data are available, the top and base of this zone is readily recognized by its characteristic fossil assemblage. Marine deposition resulted in a more or less uniform series of layers which can be correlated by use of electric logs over almost the entire Oxnard Plain. In recent years the Fox Canyon zone has been exploited more as a source of water supply, especially in coastal areas where shallow zones have been intruded by sea water.

On the Oxnard Plain permeable portions of the Fox Canyon aquifer zone consist primarily of fine to medium sand with stringers of gravel. Lower permeability clay, silt and sandy clay interbeds constitute about 20 percent of this zone. Water-bearing materials

become finer toward the present coastline because they were deposited farther from the ancient shoreline. The Fox Canyon aquifer zone is present throughout almost the entire Oxnard Plain. An exception is found at the tip of South Mountain where subsurface records indicate that nonwater-bearing portions of the Santa Barbara formation are penetrated beneath the Mugu aquifer. The lack of the Fox Canyon zone in this area may be attributed to upwarping and subsequent removal by erosion of the Santa Clara River as shown in Geologic Section C-C'. Another area where this zone is thought to be lacking is in the south coastal area. Here limited subsurface information indicates that an approximate one-mile band along the ocean extends from about 0.5 mile north of Arnold Road southerly to and beyond the Bailey fault where it changes trend to a northeasterly direction for about four miles and terminates against the Bailey fault zone about 0.5 mile west of Round Mountain. The apparent lack of occurrence in this area is attributed primarily to uplift and erosion in middle Pleistocene time prior to deposition of overlying zones.

The Fox Canyon aquifer zone constitutes the effective base of fresh water in north and westerly portions of the basin where the Grimes Canyon aquifer zone is absent. The most prominent structural features here are the Las Posas syncline and the Montalvo anticline which have warped this zone into its present east-west trending configuration.

Basal members of this zone may be correlated over almost the entire Oxnard Plain by use of electric logs. A key horizon is the basal sand or gravel of quite uniform thickness. Another key horizon lies above this marker zone and is separated from it

by a low permeability layer of variable thickness. This marker horizon is up to several hundred feet thick and exhibits almost identical resistivity responses on electric logs over much of the Oxnard Plain. Because of its greater thickness, wide distribution and ease of correlation on electric logs, it is considered to be the "main aquifer" of the Fox Canyon zone. In the southerly portion of the basin, correlation of the Fox Canyon zone becomes more difficult because of removal by erosion and presence of the Grimes Canyon zone.

The top of the Fox Canyon aquifer zone is more difficult to determine by correlating electric logs. Unlike the two basal aquifers, layers lying above cannot be correlated as readily over large areas. Along the coast these two members are overlain by one additional member, 100 to 150 feet thick, which constitutes the top of the zone. Inland, the clay layer separating this member from the main underlying zone disappears and they become one unit.

Generally, in cross section, the top of the Fox Canyon zone assumes a configuration similar to, but somewhat less warped than the base. A map depicting the top of this zone was not prepared because the overlying Hueneme zone is to be modeled as a part of the same system.

GRIMES CANYON AQUIFER ZONE

Throughout most of the Oxnard Plain Basin the Santa Barbara formation consists of bluish clays and shales deposited in an offshore marine environment. Low permeability and lack of flushing since deposition cause these materials to be placed in the nonwater-bearing category.

The Grimes Canyon aquifer zone is the uppermost member of the Santa Barbara formation. On the Oxnard Plain, it is composed primarily of sand with only minor amounts of gravel deposited in a near-shore marine environment. It is present only in the southerly and easterly portions of the Oxnard Plain where it underlies about 35 percent of the total basin area. Approximate northerly and westerly limits are shown in Plate 5. From this location the Grimes Canyon aquifer zone extends southeasterly to and beyond the Bailey fault zone and easterly into the Pleasant Valley Basin. Here it is the basal water-bearing unit and generally overlies nonwater-bearing portions of the Santa Barbara formation.

Lack of the permeable Grimes Canyon aquifer zone in the north Oxnard Plain is attributed primarily to a facies change caused by relatively deep water deposition of fine-grained materials seaward of the defined limits of this zone.

The offshore limits of this zone in the south Oxnard Plain are unknown. Here, preliminary results of the United States Geological Survey-State Department of Water Resources cooperative offshore sparker survey do not indicate subsea stratigraphic units correlative with the onshore occurrence of the Grimes Canyon aquifer zone. This may indicate an offshore facies change to fine-grained materials like that which occurs on the north Oxnard Plain. If this is the case, offshore intrusion of sea water into this zone is not a threat. However, if permeable portions of this zone are exposed in the Mugu or Hueneme submarine canyons or the steeply sloping sea floor between them, then sea-water intrusion is actively moving landward because of long-time water level conditions below sea level.

Limited water quality data indicate that some basal portions of the Grimes Canyon aquifer zone contain brackish water. The primary areas where this is thought to occur are downwarped portions of the basin having inadequate circulation. Subsurface data indicates that the Grimes Canyon aquifer zone is in hydraulic continuity with the overlying Fox Canyon aquifer zone over most of the area where they occur together on the Oxnard Plain. Most of the water wells which produce from this zone are also perforated in the Fox Canyon aquifer zone.

PLEASANT VALLEY BASIN

The Pleasant Valley Basin is differentiated from the Oxnard Plain Basin by a lack of the Oxnard and Mugu aquifer zones. It is separated from the Las Posas Basins and the Santa Rosa Basin by faulting and folding.

The Pleasant Valley Basin covers an area of approximately 41.6 square miles and has a drainage area of almost 57 square miles. The basin ranges in elevation from about 20 feet near its southerly boundary to greater than 800 feet in the Camarillo Hills.

The geology of the Pleasant Valley Basin is very complex and not thoroughly understood. The area is characterized by intense folding and faulting and rapid facies changes in upper water-bearing zones.

Water-bearing units within the Pleasant Valley Basin include Recent and upper Pleistocene alluvium and the lower Pleistocene San Pedro and Santa Barbara formations. Water-bearing zones within

the San Pedro formation consist of an upper series probably equivalent to the Hueneme aquifer zone of the Oxnard Plain and the underlying Fox Canyon aquifer zone. The Santa Barbara formation contains the Grimes Canyon aquifer zone which is the basal water-bearing unit within the Pleasant Valley Basin.

These formations are underlain by the Pico and Santa Margarita formations, Modelo shale and volcanics of Miocene age which are considered to be nonwater-bearing. The volcanic rocks are exposed along the southeast edge of the basin in the Santa Monica Mountains.

The following is a more complete description of water-bearing units in the Pleasant Valley Basin with emphasis upon their application to modeling studies.

RECENT AND UPPER PLEISTOCENE ALLUVIUM

Recent and upper Pleistocene alluvium of variable thickness occurs in all low-lying areas of the Pleasant Valley Basin. These materials consist of yellow and blue clay and gray sand and gravel which generally reach a thickness of 300 to 400 feet. Throughout most of the westerly Pleasant Valley Basin these materials are very lenticular and do not constitute a large, reliable source of water. The lenticular nature of these deposits is such that extensive hydraulic continuity with equivalent zones (Oxnard aquifer zone and Mugu aquifer) is very unlikely. The large quantity of low permeability materials indicates that these

deposits are confined or semi-confined throughout most of the basin. One area where unconfined conditions are strongly expected is the area 1/2 to 1 mile southwest of Somis in the vicinity of Calleguas Creek where subsurface data indicates the presence of highly permeable materials to considerable depths.

There are two areas in the Pleasant Valley Basin where water supplies derived from Recent and upper Pleistocene materials have been utilized. One area lies north of the Camarillo fault and southeast of the Camarillo Hills, while the other area lies generally southeast of the Camarillo fault in the Calleguas Creek portion of the basin. Wells in these areas have exhibited yields ranging from less than 100 to 1,000 gallons per minute with the average yield being about 400 gallons per minute.

Geologic Section B-B' indicates subsurface relationships across a portion of the Pleasant Valley Basin. Between the Springville and Camarillo fault zones, Recent and upper Pleistocene deposits (water-bearing alluvium) are extremely lenticular in the westerly portion of the basin, while on the southeast side of the Camarillo fault water-bearing materials are less lenticular up to the Bailey fault zone. The higher quantity of permeable material here is probably caused by downfaulting of this block during sedimentation by Calleguas and Conejo Creeks. Southeast of the Bailey fault the lenticular nature of water-bearing materials is again apparent. The large percentage of low permeability materials here probably reflects a lack of coarse-grained deposition by major water courses because of relative uplift during the depositional cycle. Much of the Recent and upper Pleistocene materials

present here are thought to be fines produced by weathering and erosion of volcanic rocks in the Santa Monica Mountains. The quality of water derived from these materials is generally inferior to that extracted from deeper zones. The poor quality combined with sporadic and doubtful sustained yield make these deposits quantitatively unimportant for modeling purposes.

SAN PEDRO FORMATION (FOX CANYON AQUIFER ZONE)

The San Pedro formation underlies all of the Pleasant Valley Basin except that area southeast of the Bailey fault zone. It is exposed in the Camarillo and Las Posas Hills where it has been uplifted by anticlinal forces and fault movement. The upper portion of the San Pedro formation consists of sand, clay and gravel equivalent to the Hueneme aquifer zone found on the Oxnard Plain. It differs from the Hueneme zone in that it is more lenticular in nature and contains a large percentage of low permeability layers. The occurrence of permeable zones seems to closely coincide with occurrences of permeable zones in Recent and upper Pleistocene deposits. The upper San Pedro formation is not found on the southeast side of the Bailey fault.

The Fox Canyon aquifer zone is the major water-bearing unit within the Pleasant Valley Basin. It is in hydraulic continuity with the Oxnard Plain Basin and present in all water-bearing areas of the basin, except southeast of the Bailey fault. It consists of, more or less, continuous layers of marine gravels, sands and clays which are confined in most areas and range from

about 100 feet in thickness near the Santa Rosa Valley to about 400 feet thick in the deepest portions of the basin. Average thickness is about 300 feet. This zone has been affected by extensive faulting and folding since lower Pleistocene deposition. This structural activity has resulted in displacement of the zone in numerous areas, which has had a great influence upon the occurrence and movement of ground water in the Pleasant Valley Basin. In the Camarillo and Las Posas Hills the Fox Canyon aquifer zone has been upwarped and eroded to an extent which has exposed portions of it at ground surface. Upwarping combined with fault movement have resulted in dewatering portions lying near anticlinal axes. Geologic Section B-B' indicates a vertical displacement of the Fox Canyon zone across the Springville fault in excess of 250 feet. This has caused a "barrier effect" which significantly reduces ground water underflow from the Las Posas Basin on the north and east into the Pleasant Valley Basin. It is suspected that the Springville fault extends easterly creating a barrier effect between the Camarillo and Las Posas Hills. However, well log data are insufficient to accurately delineate this extension.

The Camarillo fault has also displaced Fox Canyon and younger sediments resulting in a "barrier effect" to subsurface flow in this zone. The vertical component of movement approaches 150 feet in Geologic Section B-B' with the northerly block elevated relative to the southerly block. Between the Camarillo and Bailey faults the Fox Canyon aquifer zone and other water-bearing units have been downfaulted and folded into a synclinal graben. This

structural activity has resulted in the lowering of equivalent rock units relative to those on either side. Vertical relative movement has been greatest along the Bailey fault zone where the Fox Canyon and other lower Pleistocene aquifer zones are in fault contact with Miocene volcanic rocks of the Santa Monica Mountains.

Some wells penetrating the Fox Canyon aquifer zone yield greater than 2,000 gallons per minute; however, the average yield is in the vicinity of 1,000 gallons per minute. The quality of water derived from this zone is generally acceptable for most beneficial uses. The large storage capacity, yield and generally acceptable quality of water derived from the Fox Canyon aquifer zone indicate its importance in modeling studies. The generally confined nature of the San Pedro formation combined with its equivalence and hydraulic continuity with deposits on the Oxnard Plain indicate that it should be modeled as a portion of the Lower Aquifer System.

GRIMES CANYON AQUIFER ZONE

This zone is present throughout much of the Pleasant Valley Basin and, where present, constitutes the basal water-bearing unit. The Grimes Canyon aquifer zone constitutes the uppermost member of the Santa Barbara formation and in this area consists primarily of rusty brown sand with some gravel and clay. Over most of its area of occurrence, well logs indicate hydraulic continuity with the overlying Fox Canyon zone. Like the Fox Canyon

zone, the Grimes Canyon aquifer zone has been intensely faulted and folded since deposition resulting in changes in transmissive capability probably similar to those of the Fox Canyon zone.

Where present, the thickness of the Grimes Canyon aquifer zone is believed to vary from less than 50 feet to more than 500 feet.

Surface and subsurface geologic data indicates that the Grimes Canyon aquifer zone is generally absent beneath the south flank of the Camarillo Hills and beneath the Las Posas Hills.

The yield of the Grimes Canyon zone is not adequately defined since water wells completed within this zone are also completed in the overlying Fox Canyon or shallower San Pedro zones. Inspection of well logs, however, indicates a large quantity of permeable materials which should produce substantial quantities of water.

Water produced from basal portions of this zone in synclinal areas are generally somewhat brackish indicating inadequate circulation or flushing of stored water.

Because of extensive hydraulic continuity with the overlying Fox Canyon zone, suspected substantial yield and generally acceptable quality of water, the Grimes Canyon aquifer zone should be modeled as a part of the Lower Aquifer System.

NORTH LAS POSAS BASIN

Previously the areas north and east of the Pleasant Valley Basin were delineated as the East and West Las Posas Basins on the basis of a north-south surface water drainage divide located

about 1.5 miles west of Somis. The presence of this drainage divide is thought to be quite arbitrary with regard to the occurrence, movement or quality of ground water and, therefore, a new subdivision of this area is proposed. For data storage and retrieval purposes use of the previous designations may be necessary.

The North Las Posas Basin is differentiated from the Oxnard Plain Basin because of a lack of the Upper Aquifer System at or near the basin boundary and from the Pleasant Valley Basin by distinct structural barriers. The delineation of the subdivision between the North and South Las Posas Basins is based primarily upon structural features and distinct water quality differences.

The North Las Posas Basin covers an area of about 58 square miles and has a drainage area of some 73 square miles. It is bounded on the north by nonwater-bearing rocks of the South Mountain Oak Ridge area which extends from the Oxnard Plain Forebay Basin to and beyond Happy Camp Canyon. It is bounded on the west by the Oxnard Plain Basin and on the south by the Pleasant Valley and South Las Posas Basins. The drainage divide of the Camarillo Hills approximates an anticlinal axis and provides the boundary separating this basin from the Pleasant Valley Basin. The boundary between the North and South Las Posas Basins is formed by the anticlinal structure of the Moorpark hills and distinct water quality differences between these hills and the Camarillo Hills. The easterly boundary is formed by the nonwater-bearing rocks east of Happy Camp Canyon Wash.

The elevation of the drainage area ranges from less than 200 feet at the boundary of the Oxnard Plain to more than 2,800 feet on Oak Ridge.

The North Las Posas Basin is an east-west trending structure which has been highly folded as shown in Geologic Section D-D'. It is very unusual to see folding this intense in lower Pleistocene sediments and is indicative of relatively recent intense structural activity. In addition to intense folding, the North Las Posas Basin has been tilted so that water-bearing materials now plunge toward the Oxnard Plain.

Water-bearing materials include Recent and upper Pleistocene alluvium and terrace deposits, the Epworth Gravels and Fox Canyon aquifer zone of the San Pedro formation and the Grimes Canyon zone of the Santa Barbara formation. Nonwater-bearing formations which underlie these units include the Sespe, Vaqueros, Modelo and Pico formations.

RECENT AND UPPER PLEISTOCENE ALLUVIUM AND TERRACE DEPOSITS

Within the North Las Posas Basin these deposits consist primarily of relatively thin stream channel, valley filling and terrace materials. Stream channel and terrace deposits generally consist of sand and silt with some gravel and clay while valley-filling materials are usually of lower permeability with clay and silt predominating. Their aggregate thickness ranges from 0 to about 200 feet. Historically, several low-yield water wells have been completed within these materials.

One part of the basin where more extensive water supplies have been obtained is the Fairview area. The Fairview area is an east-west trending subbasin located in the northeast portion of the basin. Here Recent and upper Pleistocene deposits consist of sands and gravels with minor clays. These materials are unconfined

and are believed to reach depths of 200 to 400 feet. The thickness of these materials is difficult to determine because of the difficulty in distinguishing these deposits from the underlying Epworth Gravels of the San Pedro formation. Historically, numerous wells have been completed within this zone and have extracted excellent quality water for various beneficial uses. Mining of ground water from these materials has resulted in a severe lowering of water levels throughout the subbasin, necessitating abandonment of most wells. Prior to lowering of water levels, average well yield was about 500 gallons per minute.

Because of low-sustained yield, poor water quality or severe dewatered conditions, Recent and upper Pleistocene materials are considered unimportant in modeling studies.

SAN PEDRO FORMATION (EPWORTH GRAVELS AND FOX CANYON AQUIFER ZONE)

The San Pedro formation is the major water-bearing unit within the North Las Posas Basin. It reaches a maximum thickness of about 2,000 feet north of the Camarillo Hills and underlies almost the entire water-bearing portion of the basin. It is absent only in the northeast portion of the basin where the Grimes Canyon aquifer zone is the principal water-bearing unit.

EPWORTH GRAVELS

The Epworth Gravels are the major water-bearing unit within the upper portion of the San Pedro formation.

Throughout most of basin portions of the San Pedro formation which lie above the Fox Canyon aquifer zone consist of blue,

yellow and red clays, silty clays and silts of low permeability. These materials compose an aggregate thickness which exceeds 1,000 feet in some areas and effectively confines water-bearing zones which lie beneath.

The Epworth Gravels are exposed north of the Fairview subbasin and at its easterly terminus. From their westerly extension adjacent to Long Canyon, they extend eastward for a distance of about five miles and then trend southerly to a point approximately two miles north of Moorpark. The Epworth Gravels occur near the top of the San Pedro formation and are composed of about 200 feet of gravel, gravelly clay and silt which grades southward and westward into silt and clay materials. The limited extent of these deposits may indicate that they are remnants of an alluvial fan which has been folded and eroded resulting in its present outcrop configuration. Well logs indicate that they underlie an area totaling about 6 square miles and are probably in hydraulic continuity with Recent and upper Pleistocene deposits in the Fairview subbasin. The average yield of wells completed within this zone has been about 300 gallons per minute of excellent quality water. However, continuously declining water levels, limited area of extent and lack of hydraulic continuity with deeper zones make this unit unimportant in modeling studies.

FOX CANYON AQUIFER ZONE

The Fox Canyon aquifer zone is the most important source of ground water supply in the North Las Posas Basin. It consists of 100 to about 600 feet of continuous white or gray sand and

gravel with minor silt and clay lenses and interbeds. Although the Fox Canyon aquifer zone extends over almost the entire North Las Posas Basin, well data indicates that it is thickest in the central portion of the basin where coarse sands are present.

Along the South Mountain-Oak Ridge exposure it is of variable thickness and consists of gravel and sand which grades into fine sand near Happy Camp Canyon where it pinches out. It was first named the Fox Canyon aquifer because of its excellent surface exposure in Fox Canyon which is located approximately one mile west of Bradley Road. This zone is exposed almost continuously along the south flank of the South Mountain-Oak Ridge area from the Oxnard Plain to Happy Camp Canyon Wash, a distance of some 15 miles.

Along its outcrop trend it is not exposed in canyons because it is buried by shallow Recent alluvium. Paleontological evidence indicates that this zone was deposited under shallow water marine conditions. Where exposed, this zone is easily differentiated from the Grimes Canyon aquifer zone because of a distinct color difference. In the subsurface, delineation of the contact between these zones is very difficult.

From its area of exposure on South Mountain, the Fox Canyon zone dips to the south where it is down and upfolded by synclinal and anticlinal structures. Geologic Section D-D' indicates the degree of folding between South Mountain and the South Las Posas Basin. Here this unit has been folded by the Long Canyon syncline and anticline and the Las Posas syncline. In the eastern

part of the basin, it has been folded by the Epworth syncline beneath the Fairview Basin and the Moorpark anticline in the hills above Moorpark.

In synclinal areas of the basin, the Fox Canyon aquifer zone lies at great depths. In the area of the Las Posas syncline, north of the Camarillo Hills, the top of this zone is reached at depths exceeding 1,000 feet below ground surface and as a result the deepest water wells in the county are completed here. Some wells in this basin are greater than 1,800 feet deep; however, the average depth is about 1,300 feet.

In the northwest portion of the basin near Aggen Road, subsurface records and pumping tests indicate thinning of the zone resulting in reduced pumping capacity. In the Happy Camp Canyon surface geologic mapping indicates that the zone is entirely absent.

The quality of water derived from the Fox Canyon aquifer zone is excellent in the eastern half of the basin with a total dissolved solids concentration averaging about 275 milligrams per liter. In the western portion of the basin, it is of acceptable quality with an average mineral concentration of about 750 milligrams per liter.

Wells completed within the Fox Canyon aquifer zone have variable yield; however, the average yield is about 900 to 1,000 gallons per minute. Excessive extraction of ground water from this zone causes water levels to decline about 4.5 feet per year;

however, extensive permeable outcrops of this zone provide excellent areas for artificial replenishment if and when water becomes available for spreading.

The extensive nature of this unit combined with good to excellent water quality makes it an important computer modeling unit. Because it is almost entirely confined and equivalent to deeper zones on the Oxnard Plain, it should be modeled as a portion of the Lower Aquifer System. Near outcrop areas and under parts of the Camarillo Hills this zone is dewatered beneath the confining layer and should be treated as an unconfined system in the model.

GRIMES CANYON AQUIFER ZONE

The Grimes Canyon aquifer zone is present throughout much of the North Las Posas Basin where it constitutes the base of water-bearing materials. It is the upper member of the Santa Barbara formation which consists of up to 2,000 feet of clay, silt, sand and gravel. Along South Mountain, west of Bradley Road, surface exposures of this formation consist of low permeability clay or silt. Subsurface data also indicates nonwater-bearing materials below the Fox Canyon zone under the Camarillo Hills. Based upon this data and the lack of occurrence in the north Oxnard Plain, the Grimes Canyon zone is thought to be absent or of only limited extent west of Bradley Road.

East of Bradley Road outcrops of permeable sand and gravel materials become more and more prominent until in Happy Camp Canyon they make up almost the entire Santa Barbara formation. Here

extensive exposures are estimated to have a vertical thickness of about 1,000 feet. The Grimes Canyon aquifer zone is overlain by the Fox Canyon zone. At some outcrops and in some basin areas, a clay member separates this member from the Fox Canyon zone; however, other exposures and well logs indicate that they are in direct contact. Geologic Section D-D' indicates that a clay member separating the two is present throughout much of the central portion of the basin. East of the Long Canyon area the two zones are believed to be primarily in hydraulic continuity. The quality of water extracted from this zone is believed to be quite similar to that obtained from the Fox Canyon zone. Exceptions are found in some synclinal areas where the total dissolved solids concentration sometimes exceeds 1,200 milligrams per liter. Projection of water levels into the area near Happy Camp Canyon indicates that permeable materials may be almost thoroughly dewatered here. The large available storage, exposure of permeable materials and hydraulic continuity with the Fox Canyon aquifer zone indicate that this area would be ideal for use as an artificial replenishment facility.

The Grimes Canyon aquifer zone should be modeled as a portion of the Lower Aquifer System because of its stratigraphic position, expected vertical hydraulic continuity with the Fox Canyon zone and generally good water quality. In and near aquifer outcrop areas this zone is dewatered and should be treated as an unconfined system.

SOUTH LAS POSAS BASIN

The South Las Posas Basin has an area of about 19.4 square miles and a total drainage area of about 39.1 square miles. It is located in the southeasterly portion of the study area and is delineated from other basins because of water quality differences and structural barriers. Its northerly boundary coincides with the axis of the Moorpark anticline and distinct water quality differences between this basin and the North Las Posas Basin. It is bounded on the south by the Las Posas Hills and on the east by the Simi Basin and nonwater-bearing rocks of the Simi Hills. The Pleasant Valley Basin forms the westerly boundary in an area near the possible extension of the Springville fault.

The North Las Posas Basin is an east-west trending basin formed by downfolding of the Moorpark syncline in the vicinity of Arroyo Simi and uplift by the Moorpark anticline to the north and Las Posas anticline and Santa Rosa fault to the south.

Water-bearing units include Recent and upper Pleistocene alluvium and the San Pedro formation. The Grimes Canyon aquifer zone is not believed to be present in the South Las Posas Basin.

Nonwater-bearing rocks include low permeability portions of the Santa Barbara formation, the Pico and Sespe formations and some Miocene volcanic rocks.

RECENT AND UPPER PLEISTOCENE ALLUVIUM

Recent and upper Pleistocene alluvium fills channels tributary to Arroyo Las Posas. In these channels it is usually less than 100 feet thick and consists of sand and silt with some clay and gravel. The most extensive alluviated area lies beneath

and adjacent to Arroyo Las Posas where these deposits reach a depth of greater than 200 feet in a band which extends the entire length of the basin. Here these materials consist of sand, gravel and clay with some silt. In their area of occurrence, these deposits are unconfined and receive replenishment from stream percolation and precipitation. Wells have been completed within this zone primarily in the Arroyo Las Posas area and yield an average of 400 gallons per minute. Other tributary areas are generally only partially saturated or entirely dewatered.

The alluvial materials in the Arroyo Las Posas area contain water of unacceptable quality for domestic uses and marginal quality for many agricultural uses. Average mineral concentration is about 1,850 milligrams per liter. The poor quality of water here is attributed to poor quality runoff and rising water derived from the Simi basin and perhaps contribution of saline water from adjacent and underlying nonwater-bearing rocks.

Although water quality is quite poor, the quantity of water is significant and saturated materials in the vicinity of Arroyo Las Posas should be modeled as an unconfined system.

SAN PEDRO FORMATION (FOX CANYON AQUIFER ZONE)

The San Pedro formation is present throughout the entire South Las Posas Basin. It has been upfolded in the Moorpark and Las Posas Hills where it is partially exposed.

UPPER SAN PEDRO FORMATION

Within the South Las Posas Basin the upper San Pedro formation has variable lithology. Throughout most of the basin it consists primarily of low permeability clay and silt materials with included sand and gravel lenses which effectively confine the Fox Canyon aquifer zone. However, in the vicinity of Moorpark and westerly from there, a distance of some four miles adjacent to Arroyo Las Posas, subsurface records indicate hydraulic continuity between ground surface and the Fox Canyon aquifer zone indicating the presence of extensive permeable materials in the upper San Pedro formation.

Here the upper San Pedro formation should be modeled as an unconfined water-bearing unit. In other portions of the basin, it should be considered a confining member overlying the Fox Canyon aquifer zone.

FOX CANYON AQUIFER ZONE

This zone is present throughout most of the South Las Posas Basin where it constitutes the effective base of the ground water reservoir. It is exposed only along the north flank of the Las Posas Hills where it provides some replenishment from rainfall and limited runoff.

The Fox Canyon aquifer zone consists primarily of sand and gravel layers with clay and silt lenses. It is not believed to be present in extreme eastern portions of the basin. From its first easterly occurrence, it gradually thickens to a maximum of

about 400 feet in the western portion of the basin. Average thickness throughout its area of occurrence is about 200 feet.

Throughout the basin the Fox Canyon aquifer zone contains variable quality water. The quality of water extracted is largely determined by the location of wells with relation to geologic structure. In anticlinal areas ground water generally has a mineral concentration of less than 1,000 milligrams per liter while that which occurs in the area of the Las Posas syncline is poor in the vicinity of Moorpark with an average mineral concentration of 1,800 to 2,000 milligrams per liter. The poor quality of water which is present here is believed to be the result of hydraulic continuity with overlying and adjacent materials. Throughout most of the South Las Posas Basin, the Fox Canyon aquifer zone is confined and should be modeled in that manner. Exceptions are noted beneath the outcrop area of the Las Posas Hills, dewatered portions of the Moorpark Hills and in the unconfined area beneath Arroyo Las Posas near Moorpark where free-water table conditions are believed to predominate.

SANTA ROSA BASIN

With a water-bearing area of 6.3 square miles and a drainage area of only 12.8 square miles the Santa Rosa Basin is the smallest in the study area. Although it is of small size and limited storage capacity, it is one of the most complex basins because of intense structural activity. The Santa Rosa Basin is

bordered on the south and east by volcanic rocks of the Santa Monica Mountains, on the north by the Las Posas Hills and on the west by the Pleasant Valley Basin. The westerly boundary is somewhat arbitrary and may have to be altered in the future.

The Santa Rosa Basin ranges in elevation from about 200 feet at its westerly terminus to about 600 feet at the northerly limits of the San Pedro formation. The maximum elevation of the drainage area reaches about 1,200 feet above sea level in the Santa Monica Mountains.

Major water-bearing units within the Santa Rosa Basin include Recent alluvium and Quaternary terrace deposits and the San Pedro and Santa Margarita formations. Nonwater-bearing formations include the Santa Barbara, Topanga and Sespe formations and Tertiary volcanic rocks.

The Santa Rosa Basin is an east-west trending downfolded and faulted area as indicated in Geologic Section D-D'. Major folds include the Santa Rosa syncline and the Las Posas anticline. Major faults include the Santa Rosa and Bailey fault zones which have undergone considerable displacement since deposition of water-bearing materials. The Santa Rosa fault zone is part of an extensive system which extends through the Simi Valley and into Los Angeles County. Where present in water-bearing materials, it probably forms an effective barrier to north-south subsurface flow. The Bailey fault zone provides a substantial barrier to east-west underflow

of ground water. Water level data indicates that water levels are about 100 feet higher on the east side of the fault than on the west. These structural features combined with large amounts of uplift in the Santa Monica Mountains have resulted in complex geohydrologic conditions which are not thoroughly understood at this time.

The quality of water extracted on the northwest side of the Bailey fault zone is generally good with total dissolved solids ranging from about 500 to almost 800 milligrams per liter. On the southeast side of the Bailey fault zone, water quality is more variable. Here, beneath low-lying portions of the valley, the total dissolved solids concentration ranges from about 800 to 1,100 milligrams per liter and nitrate concentration ranges from 10 to 200 milligrams per liter. Along the northerly slopes of the valley much lower salinity and nitrate concentrations are generally found.

RECENT ALLUVIUM AND QUATERNARY TERRACE DEPOSITS

Recent alluvium consists of stream deposited gravel, sand, silt and clay which occurs along and adjacent to Conejo Creek and Arroyo Santa Rosa. These deposits are unconfined and reach a maximum thickness of 150 feet or less in the main portion of the Santa Rosa Valley. East of the Bailey fault zone these deposits are more porous sands and gravels while west of it they are more clayey.

Quaternary terrace deposits consist of boulders, gravels, sands, and clays which are exposed along the south slopes of the Las Posas Hills and extend to the valley floor. They are also present as eroded remnants beneath Recent alluvial deposits. These deposits have a wide range of thickness; however, their maximum thickness is believed to be no greater than 250 feet. The greatest thickness of these materials occurs on the northwest side of the easterly Bailey fault branch. Alluvium and terrace materials should be modeled as an unconfined aquifer system.

SAN PEDRO FORMATION (FOX CANYON AQUIFER ZONE)

The San Pedro formation is exposed along the south flank of the Las Posas Hills for almost the entire length of the Santa Rosa Basin. East of the Bailey fault zone the San Pedro formation is not believed to contain the basal Fox Canyon member. Here it is composed of lenticular beds of sand, gravel, silt and clay which are probably semi-confined. West of the Bailey fault well logs indicate presence of the Fox Canyon aquifer zone which is composed of sand and gravel layers about 100 feet thick. Above this zone the presence of low permeability materials indicates confined conditions except on the Las Posas Hills where the Fox Canyon aquifer zone may be near ground surface. This zone is the basal water-bearing unit on the west side of the easterly Bailey fault branch.

SANTA MARGARITA FORMATION

The Santa Margarita formation of upper Miocene age was derived from erosion and deposition of the Conejo volcanics. It

is exposed in the eastern portion of the Santa Rosa Valley where it consists of volcanic conglomerate, sandstone and tuff. It varies in thickness from 300 to 1,000 feet; however, the base of water-bearing portions of this unit is about 550 feet below ground surface. It is the basal water-bearing unit east of the Bailey fault zone and water level information indicates similar water levels as those in overlying alluvial and terrace deposits. This unit should, therefore, be modeled as an unconfined system.

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