EXECUTIVE SUMMARY

The Fox Canyon Groundwater Management Agency (FCGMA, or the Agency) has developed this Groundwater Sustainability Plan (GSP) for the Oxnard Subbasin (Subbasin; DWR Basin 4-004.02) of the Santa Clara River Valley Groundwater Basin (DWR Basin 4-004), in compliance with the 2014 Sustainable Groundwater Management Act (SGMA; California Water Code, Section 10720 et seq.). The purpose of this GSP is to define the conditions under which the groundwater resources of the entire Oxnard Subbasin, which support agricultural, municipal and industrial, and environmental uses, will be managed sustainably in the future.

Historical groundwater production has resulted in seawater intrusion in the five primary aquifers of the Subbasin. These aquifers have been divided into an Upper Aquifer System, which comprises the Oxnard and Mugu Aquifers, and a Lower Aquifer System, which comprises the Hueneme, Fox Canyon, and Grimes Canyon Aquifers. The average rate of groundwater production from the Upper Aquifer System between 2015 and 2017 was approximately 40,000 acre-feet per year (AFY). The average production from the Lower Aquifer System between 2015 and 2017 was approximately 29,000 AFY. Numerical groundwater simulations indicate that if these production rates were carried into the future, seawater intrusion would continue in the Subbasin and the area currently impacted by concentrations of chloride greater than 500 milligrams per liter would grow. The landward extent of this area is referred to as the *saline water impact front*.[1]

Combinations of projects and management actions were explored to estimate the rate of groundwater production that would prevent future expansion of the area of the Subbasin currently impacted by concentrations of chloride greater than 500 milligrams per liter. This rate of groundwater production is referred to as the sustainable yield. With the currently available projects and management actions, the sustainable yield of the Upper Aquifer System, was calculated to be approximately 32,000 AFY, with an uncertainty of ± 4,100 to 6,000 AFY. The sustainable yield of the Lower Aquifer System was calculated to be approximately 7,000 AFY, with an uncertainty of ± 2,300 to 3,600 AFY.

Adoption of this GSP represents the first step in achieving groundwater sustainability within the Oxnard Subbasin by 2040, as required by SGMA. Evaluation of this GSP is required at a minimum of every 5 years following submittal to the California Department of Water Resources (DWR). As part of the 5-year evaluation process, the sustainable yield for each aquifer system will be refined and adjusted. These refinements will be based on new data, additional studies undertaken to fill data gaps, and groundwater modeling. Refinements and adjustments will also be made to the minimum threshold water levels developed to avoid undesirable results, the measurable objective water levels

[1] Sources of water high in chloride in the Oxnard Subbasin include modern-day seawater as well as non-marine brines and connate water in fine-grained sediments. Therefore, the area of the Subbasin impacted by concentrations of chloride greater than 500 milligrams per liter is referred to as the *saline water impact area*, rather than the *seawater intrusion impact area*, to reflect all the potential sources of chloride to the aquifers in this area.

that account for the need to continue groundwater production during drought cycles and the associated interim milestones to help gauge progress toward sustainability over the next 20 years.

In order to minimize the pumping reductions required to achieve sustainable management of the Subbasin, investment in large-scale projects to increase water supply, provide the infrastructure to redistribute pumping, and/or directly control seawater intrusion should be investigated. Basin optimization studies, groundwater modeling, and project feasibility studies will be conducted over the next 5 years to explore practicable processes and approaches to increasing the sustainable yield of the Oxnard Subbasin.

ES.1 INTRODUCTION

The Oxnard Subbasin is a coastal alluvial groundwater subbasin, located in Ventura County, California, that is in hydrologic communication, to varying degrees, with adjoining groundwater basins to the north and east, and with the Pacific Ocean to the west and southwest. The climate is typical of coastal Southern California, with average daily temperatures ranging generally from 50°F to 78°F in summer and from 40°F to 75°F in winter. Land use on the Oxnard Plain is roughly equally divided between agricultural and urban uses. DWR has designated the 90-square-mile Subbasin as high priority and subject to critical conditions of overdraft.

Historical groundwater production in the Subbasin was first found to have induced seawater intrusion into the aquifers of the Oxnard Subbasin in the 1930s. In 1982, the California Legislature formed the FCGMA, an independent special district, to manage and protect the aquifers within its jurisdiction for the common benefit of the public and all groundwater users. Extractors within FCGMA jurisdiction are subject to the Agency's GSPs, ordinances, and policies created for the sustainable management of groundwater management actions.

Three groundwater sustainability agencies (GSAs) have jurisdiction over portions of the Subbasin. FCGMA is the GSA for the area of the Subbasin that falls within its jurisdiction. The Camrosa ~~OPV~~ Water District—Oxnard Subbasin GSA has jurisdictional control over the portion of the Camrosa Water District ~~S~~service area in the Subbasin that is south and east of the Bailey Fault, and the Oxnard Outlying Areas GSA has jurisdictional control over portions of the Subbasin not within FCGMA or Camrosa ~~OPV~~ Water District—Oxnard Subbasin GSA jurisdiction. This FCGMA GSP is the sole GSP prepared for the Subbasin, and covers the entire Subbasin, including all areas of the Subbasin outside of FCGMA's jurisdiction.

Public participation and stakeholder feedback have played a critical role in the development of this GSP. The FCGMA maintains a list of stakeholders interested in the GSP process, known as the *List of Interested Parties*. A monthly newsletter, meeting notices, and notices of GSP documents available for review ~~are~~ were sent electronically to the List of Interested Parties. Public workshops were held to inform stakeholders and the general public on the contents of the GSPs and to solicit feedback on that content. To further facilitate stakeholder understanding, the FCGMA Board of Directors (Board) approved release of a preliminary draft GSP for public comment in November 2017. Additionally, the FCGMA Board formed a Technical Advisory Group, which held monthly public meetings throughout the GSP development process beginning in July 2015. Updates on the development of the GSP were given at meetings of the FCGMA Board beginning in April 2015. All FCGMA Board meetings, Technical Advisory Group meetings, Board-appointed committee meetings, and Board special workshops ~~are~~ were noticed in accordance with the Brown Act, and opportunities for public comment ~~are~~ were provided at all FCGMA Board meetings, Technical Advisory Group meetings, Board-appointed committee meetings, and workshops.

ES.2 SUMMARY OF BASIN SETTING AND CONDITIONS

There are five commonly recognized aquifers in the Subbasin: the Oxnard, Mugu, Hueneme, Fox Canyon, and Grimes Canyon Aquifers. These aquifers are grouped into the Upper Aquifer System and the Lower Aquifer System, with the Oxnard and Mugu Aquifers composing the Upper Aquifer System and the Hueneme, Fox Canyon, and Grimes Canyon Aquifers composing the Lower Aquifer System. The majority of recharge that replenishes the Subbasin comes from surface water diversions of the Santa Clara River, which are directed to spreading basins in the Oxnard Forebay operated by the United Water Conservation District (UWCD). In the Forebay, the Upper Aquifer System rests directly on the folded and eroded upper surface of the Hueneme Aquifer and the Fox Canyon Aquifer. Elsewhere in the Subbasin, the aquifers of the Lower Aquifer System are separated from those of the Upper Aquifer System by low-permeability clay beds. A low-permeability clay cap also overlies the aquifers of the Upper Aquifer System throughout the Subbasin, except in the Forebay. Water that recharges in the Forebay is able to migrate throughout the Subbasin.

Groundwater elevations and flow directions have varied historically in the Subbasin. During periods of above average precipitation, when UWCD has been able to operate its recharge basins from the diversion of Santa Clara River water, groundwater elevations have been higher than sea level, generating a seaward-directed gradient that prevents seawater intrusion. At other times in the past, and since the onset of the drought period beginning in 2011, groundwater elevations have been below sea level, creating a landward gradient that allows for inland migration of seawater. Absolute changes in groundwater levels over cycles of drought and recovery vary both geographically and vertically within the aquifers of the Subbasin, although the general patterns of decline and recovery are similar throughout the Subbasin.

Seawater intrusion tends to occur preferentially in the vicinity of Port Hueneme and Point Mugu, where submarine canyons are close to the coast, and the onshore freshwater aquifer units are exposed in the canyon walls. The current extent of seawater intrusion varies by aquifer, but in general the impacted area of the Subbasin lies to the south of Hueneme Road and west of

Highway 1. Groundwater quality not related to seawater intrusion is also a concern in the Forebay of the Subbasin, where nitrate concentrations exceeding the water quality objectives for the Subbasin are present in the groundwater. These concentrations are likely a legacy of historical septic discharges and historical agricultural fertilizer application practices, and may also be influenced by current agricultural return flows.

The water budget for the Subbasin provides an accounting and assessment of the average annual volume of groundwater and surface water entering (i.e., inflow) and leaving (i.e., outflow) the Subbasin and enables an accounting of the cumulative change in groundwater in storage over time. UWCD developed the Ventura Regional Groundwater Flow Model, a MODFLOW numerical groundwater flow model, for the Oxnard Subbasin, the Mound Basin, the western part of the Las Posas Valley Basin, and the Pleasant Valley Basin. A peer review study of the UWCD model was conducted for this GSP. The historical groundwater budget for the Subbasin is based on the UWCD model, which had a historical base period from 1985 to 2015. During average conditions (1988, 1991, 1992, 1994, 1996, 1997, 2000, 2001, 2003, 2006, 2008, 2010, and 2011), which are defined as water years in which the precipitation in the Oxnard Subbasin was between 75% and 150% of the average annual precipitation, the net change in groundwater storage for the Upper Aquifer System without seawater intrusion was an increase in 1,856 AFY and the net change in storage without seawater intrusion in the Lower Aquifer System was a decrease of 4,196 AFY. The net seawater intrusion during these years was 4,189 AFY in the Upper Aquifer System, and 5,225 AFY in the Lower Aquifer System. Groundwater pumping during these average condition years averaged 47,080 AFY in the Upper Aquifer System and 28,893 AFY in the Lower Aquifer System.

Several model scenarios were developed to assess the future sustainable yield of the Subbasin. Each future scenario covered a 50-year timeframe, from 2020 to 2069. In two scenarios, the 2015–2017 average groundwater extraction rate was continued throughout the 50-year modeled period. The results of each of these scenarios indicated that continuing the 2015–2017 extraction rate would contribute to net seawater intrusion in both the Upper Aquifer System and Lower Aquifer System. In three additional scenarios, the groundwater production rate was decreased gradually over the first 20 years. These model scenarios indicated that reduced groundwater production from the Subbasin can eliminate net seawater intrusion in the Subbasin over periods of drought and recovery. Based on the suite of model scenarios, the sustainable yield of the Upper Aquifer System was calculated to be approximately 32,000 AFY, with an uncertainty of ± 4,100 to 6,000 AFY. The sustainable yield of the Lower Aquifer System was calculated to be approximately 7,000 AFY, with an uncertainty of ± 2,300 to 3,600 AFY.

It is anticipated that the analysis for the 5-year update to the GSP will focus on developing new water supply projects, as well as examining the potential impacts of differential extractions on the coast and inland, particularly in the Lower Aquifer System. Additional modeling is recommended for the 5-year update process to understand how changes in pumping patterns and the addition of new water supply projects can increase the overall sustainable yield of the Subbasin. As this understanding improves, projects to support increases in the overall sustainable yield can be developed.

To reflect the current understanding of the hydrogeologic characteristics of the Subbasin, and in anticipation of future management strategies the Subbasin has been divided into five management areas. These areas are the Forebay Management Area, the West Oxnard Plain Management Area, the Oxnard Pumping Depression Management Area, the Saline Intrusion Management Area, and the East Oxnard Plain Management Area. These areas are separated by hydrogeologic and water quality characteristics.

ES.3 OVERVIEW OF SUSTAINABILITY CRITERIA

The sustainability goal in the Subbasin is to increase groundwater elevations inland of the Pacific coast in the aquifers that compose the Upper Aquifer System and the Lower Aquifer System to elevations that will prevent the long-term, or climatic cycle net (net), landward migration of the area currently impacted by seawater intrusion; prevent net seawater intrusion in the Upper Aquifer System; and prevent net seawater intrusion in the Lower Aquifer System.

Under SGMA, undesirable results occur when the effects caused by groundwater conditions occurring throughout the Subbasin cause significant and unreasonable impacts to any of the six sustainability indicators:

- Chronic lowering of groundwater levels
- Reduction of groundwater storage
- Seawater intrusion
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water

All six sustainability indicators are applicable to the Subbasin. Minimum thresholds and measurable objectives, which are quantitative metrics of groundwater conditions in the Subbasin, were established for the sustainability indicators determined to be a current and/or potential future undesirable result. Groundwater elevations that achieve the sustainability goal for seawater intrusion were used as a proxy for other sustainability indicators in establishing the minimum thresholds and measurable objectives.- This is because if the minimum thresholds and measurable objectives for seawater intrusion are achieved, then undesirable results for the other sustainability indicators are avoided.

The measurable objective water levels for the Subbasin are the groundwater levels throughout the Subbasin, at which there is neither seawater flow into nor freshwater flow out of the Upper Aquifer System or Lower Aquifer System. If groundwater levels in the Subbasin remained at the measurable objective in perpetuity, no groundwater would flow from the aquifer systems into the Pacific Ocean, and no ocean water would flow into the aquifer systems. To allow for operational flexibility during drought periods, water levels in the Subbasin are allowed to fall below the measurable objective. In order to prevent net seawater intrusion over periods of drought and recovery, the periods during which groundwater elevations are below the measurable objective must be offset by periods when the groundwater elevations are higher than the measurable objective.

The minimum thresholds for all six sustainability indicators are groundwater levels that were selected to limit seawater intrusion and allow declines in groundwater elevations during periods of future drought to be offset by recoveries during future periods of above-average rainfall. These thresholds were tested with future groundwater model simulations. The model simulations suggest that if groundwater levels fall below the minimum threshold elevations, the Subbasin is likely to experience net landward migration of the 2015 saline water impact front after 2040. These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by limiting seawater intrusion. This allows for long-term use of groundwater supplies in the Subbasin.

Although exceedance of a minimum threshold at any given well in the Subbasin may indicate an undesirable result is occurring in the Subbasin, a single exceedance is not necessarily sufficient to indicate that Subbasin-wide conditions are causing undesirable results. Additionally, conditions in the Upper Aquifer System may differ from those in the Lower Aquifer System. Therefore, to define the conditions under which undesirable results will occur in the Subbasin, criteria were developed for each aquifer system. The Upper Aquifer System would be determined to be experiencing an undesirable result if:

- In any single monitoring event, groundwater levels in 6 of 15 identified key wells are below their respective minimum thresholds.
- The groundwater elevation at any individual key well is below the historical low water level for that well.
- The groundwater level in any individual key well is below the minimum threshold for either three consecutive monitoring events or three of five consecutive monitoring events, which occur in the spring and fall of each year.

The Lower Aquifer System would be determined to be experiencing an undesirable result if:

- In any single monitoring event, groundwater levels in 8 of 19 identified key wells are below their respective minimum thresholds.

- The groundwater elevation at any individual key well is below the historical low water level for that well.
- The groundwater level in any individual key well is below the minimum threshold for either three consecutive monitoring events or three of five consecutive monitoring events, which occur in the spring and fall of each year.

ES.4 OVERVIEW OF THE SUBBASIN MONITORING NETWORK

The overall objective of the monitoring network in the Subbasin is to track and monitor parameters that demonstrate progress toward meeting the sustainability goals. In order to accomplish this objective, the monitoring network in the Subbasin must be capable of the following:

- Monitoring changes in groundwater conditions (in six sustainability indicator categories)
- Monitoring progress toward minimum thresholds and measurable objectives
- Quantifying annual changes in water budget components

The existing network of groundwater wells includes both monitoring wells and production wells. This network is capable of delineating the groundwater conditions in the Subbasin and has been used for this purpose in the past. The current groundwater well network will be used to monitor groundwater conditions moving forward, in order to continue to assess long-term trends in groundwater elevation and groundwater quality in the Subbasin.

Although the current monitoring network is adequate to monitor groundwater conditions in the Subbasin, it can be improved as funding becomes available An additional well, or wells, in the Oxnard Pumping Depression Management Area would provide aquifer-specific groundwater elevations in an area that does not have local wells screened solely in the Mugu Aquifer or the Hueneme Aquifer, and does not have a dedicated monitoring well screened in any of the primary aquifers.

Additionally, the monitoring network in the West Oxnard Plain Management Area could be improved by adding a monitoring well to the area north of Highway 101 and south of the Oxnard Forebay, and adding a monitoring well to the area north of 6th Street and west of Ventura Road. A monitoring well north of Highway 101 and south of the Oxnard Forebay would provide for aquifer-specific water levels adjacent to the West Las Posas Management Area boundary. These groundwater levels could be used to constrain the gradient between the West Las Posas Management Area and the Subbasin. A monitoring well north of 6th Street and west of Ventura Road would help constrain groundwater gradients in the northwestern Subbasin.

There are currently no monitoring wells in the East Oxnard Plain Management Area, which has minimal known groundwater production. Addition of a monitoring well in the vicinity of Calleguas

Creek in this management area would help constrain the relationship between groundwater elevations in the East Oxnard Plain Management Area and groundwater conditions in the adjacent Oxnard Pumping Depression and Saline Intrusion Management Areas.

In addition to supplementing the existing monitoring network with new wells, monitoring can also be improved in the future by coordination of monitoring schedules to ensure that groundwater monitoring activities occur over a 2-week window during the key reporting periods and mid-March and mid-October. As funding becomes available, pressure transducers should be added to wells in the groundwater monitoring network. Pressure transducer records provide the high-temporal-resolution data that allows for a better understanding of water level dynamics in the wells related to groundwater production, groundwater management activities, and climatic influence.

In the future, to the extent possible, additional dedicated monitoring wells will be incorporated into the existing monitoring network. These wells will provide information on groundwater conditions in geographic locations where data gaps have been identified, or where a dedicated monitoring well would better represent conditions in the aquifers than a production well currently used for monitoring.

ES.5 PROJECTS AND MANAGEMENT ACTIONS

Projects and management actions have been identified to address potential impacts to beneficial uses and users of groundwater in the Subbasin resulting from groundwater production in excess of the current sustainable yield. The five projects included in this GSP were suggested by stakeholders and were reviewed by the Operations Committee of the FCGMA Board. The inclusion of these projects does not constitute a commitment by the FCGMA Board to construct or fund the projects, but rather signals that these projects were sufficiently detailed to be included in groundwater modeling efforts that examined the quantitative impacts of the projects on groundwater elevations and the sustainable yield of the Subbasin. Projects included in the GSP or any amendment thereof ~~which~~that increase the available supply of groundwater are necessary to meet the sustainability goal for the Subbasin in a manner ~~which~~that avoids adverse impacts to beneficial uses and users of groundwater within the Subbasin.

Project No. 1 – GREAT Program Advanced Water Purification Facility

Under this project, the City of Oxnard's Groundwater Recovery Enhancement and Treatment (GREAT) Program's Advanced Water Purification Facility (AWPF) ~~will~~ could provide the Subbasin with a source of reclaimed water that can be used for landscape irrigation, agricultural, industrial process water, and groundwater recharge. The AWPF product water that will be put to use in the Subbasin is secondary wastewater effluent that is currently discharged to the Pacific Ocean. Therefore, this project provides a new source of water for use in the Subbasin.

Project No. 2 – GREAT Program Advanced Water Purification Facility Expansion Project

The purpose of the GREAT Program AWPF Expansion Project is to increase the production of high-quality recycled water within the City of Oxnard, the Subbasin, and the Pleasant Valley Basin. This project will provide additional reclaimed water for Subbasin recharge, in-lieu groundwater production, or indirect potable reuse. The AWPF Expansion Project product water that will be put to use in the Subbasin is secondary wastewater effluent that is currently discharged to the Pacific Ocean. Therefore, this project provides a new source of water for use in the Subbasin.

Project No. 3 – RiverPark–Saticoy GRRP Recycled Water Project

The RiverPark–Saticoy Groundwater Replenishment and Reuse Project (GRRP) Recycled Water Project will convey water produced by the GREAT Program AWPF Expansion Project to the Saticoy Groundwater Recharge Facility and El Rio Groundwater Recharge Facility operated by UWCD. The RiverPark–Saticoy Pipeline and the GRRP will help ensure that excess flows from the AWPF will be used for groundwater recharge and implementation of this project is expected to improve groundwater quality in the Forebay.

Project No. 4 – Freeman Expansion Project

The Freeman Expansion Project will expand the recharge facilities operated by UWCD adjacent to the Santa Clara River, to be able to accommodate diversions from the river at higher flow rates. The benefits of this project are multifold. It will provide additional recharge, improve water quality in the Forebay, and reduce pump lift, and therefore energy consumption, for municipal and agricultural pumpers.

Project No. 5 – Temporary Agricultural Land Fallowing

The Temporary Agricultural Land Fallowing Project will decrease groundwater production in the portions of the Subbasin that are susceptible to seawater intrusion. This project will benefit the Subbasin by mitigating seawater intrusion in the Subbasin and would complement a water market that is currently being developed for the Subbasin by providing an alternative method for landowners to monetize pumping allocations.

Management Action No. 1 – Reduction in Groundwater Production

The primary management action proposed under this GSP is a reduction in groundwater production from the Subbasin. FCGMA has had the authority to monitor and regulate groundwater production in the Subbasin since 1983. The primary benefit related to reduction in groundwater production is recovery of groundwater elevations that have historically allowed for seawater intrusion in the Subbasin. Reduction in groundwater production can be used to close any differential between groundwater elevations that can be obtained through implementation of projects and the groundwater elevations necessary to prevent future net seawater intrusion in the Upper Aquifer System and the Lower Aquifer System.

FCGMA approved an ordinance to establish an allocation system for the Oxnard Subbasin and the Pleasant Valley Basin PVB on October 23, 2019. The purpose of this ordinance is to facilitate adoption and implementation of the GSP and to ensure that the Oxnard Subbasin and PVB the Pleasant Valley Basin are operated within their sustainable yields. It is not the purpose of the ordinance to determine or alter water right entitlements, including those whichthat may be asserted pursuant to California Water Code sSections 1005.1, 1005.2, or 1005.4.A comprehensive water allocation system for groundwater users in the Subbasin is under development by FCGMA, with ongoing contributions from stakeholder groups. This allocation system will allow for long-term sustainable management of the groundwater resources of the Subbasin.

Management Action No. 2 – Water Market Pilot Program

A water market pilot program is currently being conducted by FCGMA as a means of increasing operational management of groundwater in the Subbasin. Analysis of the water market pilot program will be conducted and its suitability for incorporation as a management action for the Subbasin will be determined after the pilot program is completed in July 2019.

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CHAPTER 1
ADMINISTRATIVE INFORMATION

1.1 PURPOSE OF THE GROUNDWATER SUSTAINABILITY PLAN

The Fox Canyon Groundwater Management Agency (FCGMA), acting as the Groundwater Sustainability Agency (GSA) for the Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin (4-004; Oxnard Subbasin [Subbasin]), has developed this Groundwater Sustainability Plan (GSP) in compliance with the 2014 Sustainable Groundwater Management Act (SGMA) (California Water Code, Section 10720 et seq.). This GSP has been developed to apply to the entirety of the Oxnard Subbasin, including those portions of the Subbasin that lie outside FCGMA's jurisdictional boundary, primarily consisting of fringe areas of the Subbasin. The County of Ventura (County) and the Camrosa Water District (CWD) have each elected to act as the GSA for portions of the Subbasin not within FCGMA's jurisdiction. The County and CWD will rely on this GSP and coordinate with FCGMA as necessary to ensure that the Subbasin is sustainably managed in its entirety, in accordance with SGMA.

SGMA defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained over a 50-year planning and implementation horizon without causing undesirable results. Undesirable results are defined in SGMA and are summarized here as any of the following effects caused by groundwater conditions occurring throughout the Subbasin:[1]

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

As described in Chapter 2, Basin Setting, of this GSP, undesirable results within the Oxnard Subbasin are occurring with respect to significant and unreasonable reduction of groundwater storage and seawater intrusion. Portions of the Subbasin are experiencing, or under threat of experiencing, degraded water quality. Chronic lowering of groundwater levels has not occurred because declines in groundwater elevation are offset by seawater intrusion. Land subsidence has

1 As defined in SGMA, "basin" means a groundwater basin or subbasin identified and defined in Bulletin 118 or as modified pursuant to California Water Code, Section 10720 et seq. (Basin Boundaries).

occurred historically in the Subbasin and has the potential to occur in the future if groundwater conditions are not managed sustainably. Depletions of interconnected surface water have not occurred historically in the Subbasin, because the Groundwater-Dependent Ecosystems (GDEs) in the Subbasin are supported by shallow groundwater flows that are generally separated and disconnected from the primary groundwater aquifers (see Section 1.3.2, Geography;, Section 2.2.1, Geology;, and Section 2.3.7, Groundwater--Dependent Ecosystems).

The purpose of this GSP is to define the conditions under which the groundwater resources of the entire Oxnard Subbasin, which support agricultural, municipal and industrial (M&I), and environmental uses, will be managed sustainably in the future. The publication adoption of this GSP represents the first step in achieving groundwater sustainability within the Oxnard Subbasin by 2040, as required by SGMA. Over the next 20 years, data will continue to be gathered and used to refine the estimated sustainable yield and potential paths for achieving sustainability set forth in the following chapters. As the understanding of the Subbasin improves, this GSP will be updated to reflect the new understanding of the Subbasin. This GSP outlines a plan for annual reporting and periodic (5-year) evaluations (Chapter 1); characterizes groundwater conditions, trends, and the cumulative impacts of groundwater pumping for each of the SGMA-defined sustainability indicators (Chapter 2); establishes minimum thresholds, measurable objectives and interim milestones by which sustainability can be measured and tracked (Chapter 3, Sustainable Management Criteria); outlines the monitoring network used to support and document progress toward sustainability (Chapter 4, Monitoring Networks); and identifies projects and management actions to be implemented by the GSA and/or stakeholders to minimize[2] undesirable results (Chapter 5, Projects and Management Actions).[3] This GSP documents a viable path, determined by the GSA in collaboration with stakeholders and informed by the best available information, to achieving the sustainability goal within the Oxnard Subbasin.

1.2 AGENCY INFORMATION

1.2.1 Agency Name

Fox Canyon Groundwater Management Agency (FCGMA or Agency)

1.2.2 Agency Address

Mailing Address:

[2] ~~All references in this GSP to minimizing, limiting, or mitigating undesirable results in this section means doing so in such a manner tothat culminates in the absence of (i.e., avoidance of) undesirable results by 2040 and thereafter during the planning and implementation horizon.~~

[3] All references in this GSP to *minimizing*, *limiting*, or *mitigating* undesirable results means doing so in a manner that culminates in the absence of (i.e., avoidance of) undesirable results by 2040 and thereafter during the planning and implementation horizon.

Fox Canyon Groundwater Management Agency
800 South Victoria Avenue
Ventura, California 93009-1610

Office Location:

Ventura County Government Center
Hall of Administration
800 South Victoria Avenue
Ventura, California 93009

1.2.3 Organization and Management Structure

FCGMA is governed by five Board of Directors (Board) members who represent (1) the County, (2) the United Water Conservation District (UWCD), (3) the seven mutual water companies and small water districts within the Agency (Alta Mutual Water Company, Pleasant Valley County Water District (PVCWD), Berylwood Mutual Water Company, Calleguas Municipal Water District (CMWD), CWD, Zone Mutual Water Company, and Del Norte Mutual Water Company), (4) the five incorporated cities within FCGMA (Ventura, Oxnard, Camarillo, Port Hueneme, and Moorpark), and (5) the farmers (FCGMA 2019a). Four of these Board members, representing the County, UWCD, the mutual water companies and small water districts, and the incorporated cities, are appointed by their respective organizations or groups. The representative for the farmers is appointed by the other four seated Board members from a list of candidates jointly supplied by the Ventura County Farm Bureau and the Ventura County Agricultural Association. An alternate Board member is selected by each appointing agency or group in the same manner as the regular member and acts in place of the regular member in case of absence or inability to act.

All members and alternates serve for a 2-year term of office, or until the member or alternate is no longer an eligible official of the member agency. All Board members and alternates serve on a volunteer basis and no compensation is provided for attendance at FCGMA meetings or events. Information regarding current FCGMA Board representatives can be found on the Agency's website (FCGMA 2019b).

Extractors within Oxnard Subbasin will be subject to FCGMA's GSP and any management actions created for this GSP. These actions are administered by the Agency Executive Officer, who is appointed by the FCGMA Board. The Agency Executive Officer and other FCGMA staff are provided by the County of Ventura Public Works Agency pursuant to a contract with the County of Ventura. FCGMA does not construct, operate, or maintain capital facilities but does have the authority to adopt ordinances requiring registration of groundwater wells, requiring reporting of groundwater use, regulating groundwater extractions, and requiring fees. FCGMA contracts with the County to provide staff to support FCGMA (FCGMA 2019a).

1.2.4 Plan Manager

Executive Officer of FCGMA, Jeff Pratt, PE

Mailing Address:

Fox Canyon Groundwater Management Agency
800 South Victoria Avenue
Ventura, California 93009-1610

Phone: 805.654.2073

Email: Jeff.Pratt@ventura.org

1.2.5 Legal Authority

FCGMA is an independent special district formed by the California Legislature in 1982 to manage and protect the aquifers within its jurisdiction for the common benefit of the public and all agricultural, domestic, and M&I users (FCGMA et al. 2007). FCGMA's jurisdiction was established as the area overlying the FCA and includes portions of the Oxnard Subbasin and the Las Posas Valley Basin (LPVB), the Pleasant Valley Basin (PVB), and the Arroyo Santa Rosa Valley Basin. FCGMA may adopt ordinances for the purpose of regulating, conserving, managing, and controlling the use and extraction of groundwater within its territory (FCGMA Act, Section 403).

The FCGMA Act prohibits the Agency from engaging in water supply activities normally and historically undertaken by its member agencies.– Nonetheless, FCGMA may exercise the water supply powers and authorities authorized under SGMA provided the Board makes a finding that FCGMA is otherwise unable to sustainably manage the basin.~~FCGMA was created under State Assembly Bill 2995, which was passed by the California Legislature and approved by the Governor in September 1982. This original legislation, which became effective on January 1, 1983, set up the means of administration and the governmental powers of the Agency, including adoption of ordinances.~~

The full text of the FCGMA Act, Assembly Bill 2995, as well as amendments and additional legislation, can be accessed on the Agency's website (FCGMA 2019c). FCGMA is identified in SGMA as an agency created by statute to manage groundwater that is the exclusive GSA within its territory with powers to comply with SGMA (SGMA, Section 10723[c][1][D]). FCGMA notified the California Department of Water Resources (DWR) of its intent to undertake sustainable groundwater management under SGMA on January 26, 2015, and was granted exclusive GSA status under SGMA, Section 10723(c) (Appendix A, GSA Formation Documentation, to this GSP).

1.2.6 Groundwater Sustainability Plan Implementation and Cost Estimate

This GSP will be implemented by FCGMA, with cooperation from the Camrosa ~~Oxnard Subbasin Pleasant Valley Basin (OPV)~~Water District—Oxnard Subbasin GSA and County for the small portion of the Subbasin outside FCGMA jurisdiction (see Section 1-3, Description of Plan Area). The following sections provide a discussion of the standards for and costs associated with GSP implementation, including annual reporting, periodic updates, monitoring protocols, and projects and management actions. Potential funding sources and mechanisms are presented along with a tentative schedule for implementing the GSP's primary components. In addition, annual reporting and 5-year evaluation procedures for the Oxnard Subbasin are described.

1.2.6.1 Standards for Plan Implementation

Annual Reporting

The GSA shall submit an annual report to DWR by April 1 of each year following the adoption of the GSP. The annual report shall include the following components for the preceding water year (23 CCR, Section 356.2):

- General information, including an executive summary and a location map depicting the basin covered by the report
- A detailed description and graphical representation of
  - Groundwater elevation data from wells identified in the monitoring network
  - Groundwater extraction for the preceding water year
  - Change in groundwater in storage
  - Surface water supply used or available for use
  - Total water use
- A description of progress toward implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report

The description and graphical representation of groundwater elevations will include groundwater elevation contour maps for each principal aquifer in the Subbasin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions. Additionally, hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year, will be included in the annual report. As described in Section 1.2.6.2, Data Collection, Validation, and Analysis, relevant data collected by entities within the PVB are regularly provided to FCGMA and will be used to prepare the annual reports submitted to DWR.

The description and graphical representation of change in groundwater storage will include a graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.

Five-Year Evaluation

FCGMA will evaluate the GSP at least every 5 years. This 5-year evaluation will be provided as a written assessment to DWR. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin. The evaluation will include the following:

- A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones, and minimum thresholds
- A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions
- Revisions, if any, to the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives
- An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes
- A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of the GSP Regulations (23 CCR, Sections 352.4 and 354.34[c])
- A description of significant new information that has been made available since GSP adoption, amendment, or the last 5-year assessment
- A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the GSP
- Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin
- A description of completed or proposed GSP amendments
- A summary of coordination that occurred between FCGMA and other agencies, if appropriate, in the Subbasin, as well as between FCGMA and other agencies in hydrologically connected basins

1.2.6.2 GSP Implementation Budget

The primary costs associated with implementing the GSP are anticipated to be connected with the following:

- Data collection, validation, and analysis
- Ongoing data gap analysis and assessments of priorities for filling data gaps
  - Filling of data gaps
  - Operations and maintenance
- Annual report preparation and preparation of the 5-year GSP evaluation
- Regional studies for basin optimization, groundwater modeling
- Management, administration, and other costs

Data Collection, Validation, and Analysis

FCGMA has historically obtained data from the Ventura County Watershed Protection District (VCWPD) to monitor streamflow, precipitation, groundwater elevation, and groundwater quality throughout the Oxnard Subbasin. Besides VCWPD, entities that monitor groundwater level and groundwater quality in the Oxnard Subbasin include the United Water Conservation District (UWCD), the Cities of Oxnard and Camarillo, PVCWD, and small mutual water companies. Relevant data collected by these entities is regularly provided to VCWPD, and the data are shared with FCGMA for use in the FCGMA annual groundwater reports. This process will continue, but analysis will now include comparison of collected data against sustainable management criteria established by this GSP.

The majority of water level and water quality data in the Oxnard Subbasin are generated by VCWPD and UWCD. To date, this data sharing has not required expenditures from FCGMA because FCGMA did not control the location or timing of data and sample collection. The existing monitoring schedules and locations are discussed in Chapter 4, Monitoring Networks. It is anticipated that as long as the existing schedules are maintained, VCWPD will continue to host the data for the Oxnard Subbasin and FCGMA will be able to use the data for annual monitoring reports and the 5-year GSP evaluations. However, to the degree that monitoring schedules and locations will change, a cost-sharing agreement will be developed between VCWPD and FCGMA.

Data Gap Analysis and Priorities

During the initial 5-year period after the GSP is adopted, FCGMA will explore options for filling data gaps identified in this GSP. The primary data gaps identified in the historical data are spatial and temporal gaps in groundwater elevation and groundwater quality measurements.

In order to assess the priorities for filling these gaps, FCGMA plans to review options and potential costs associated with those options to direct funding toward the solutions that are needed most. One option that will be investigated would include adding pressure transducers to existing agricultural wells in the monitoring network. These transducers would record water levels at regular intervals (e.g., hourly) to determine static, or recovered, water levels. The cost for purchasing and installing transducers in agricultural wells must be assessed and incorporated into the cost of GSP implementation. As instrumentation is added to the monitoring network, the annual cost of operations and maintenance will also be factored in to the budget for GSP implementation.

In addition to assessing the need for new instrumentation, the analysis of data gaps and priorities will review the potential cost and need to substitute existing agricultural wells in the monitoring network with dedicated monitoring wells, or install monitoring wells in key areas where there are no appropriate wells to monitor. While monitoring wells are often preferred to agricultural wells, for the time being, the agricultural well data provide a link to historical data. This link is critical in assessing progress toward sustainability. Therefore, the data gap analysis and priorities assessment will review which agricultural wells may need to be substituted and which wells should be retained for ongoing historical comparison.

Annual Report Preparation and Preparation of the 5-Year Evaluation

Details of the information that will be included in the annual reports are presented in Section 1.2.6.1, Standards for Plan Implementation. It is currently anticipated that the annual reports will be produced by FCGMA staff and the costs associated with these reports will be incorporated in the annual operating budget of FCGMA.

Every fifth year of GSP implementation and whenever the GSP is amended, the GSA is required to prepare and submit an Agency Evaluation and Assessment Report to the DWR together with the annual report for that year. The tasks associated with preparing this report include updating the water budget, updating the groundwater model, and reassessing the sustainable yield, minimum thresholds, and measurable objectives (see Section 1.2.6.1). Additionally, the evaluation will provide an assessment of the pumping and groundwater conditions. It is currently anticipated that the 5-year evaluation reports will be produced by FCGMA staff with the assistance of consultants and that the costs associated with these reports will be incorporated in the annual operating budget of FCGMA.

Basin Optimization Studies, Groundwater Modeling, and Project Feasibility

During the initial 5-year period after the GSP is adopted, FCGMA will explore opportunities to optimize basin management. The work required to assess these opportunities includes implementing and supporting regional studies and groundwater modeling efforts that assess how to maximize the sustainable yield of the Oxnard Subbasin and adjoining basins. These studies are anticipated to include more detailed feasibility studies of projects that were proposed and modeled for this GSP, as well as an investigation of how the projects will be implemented, the costs associated with project implementation, and potential cost-sharing agreements for these projects.

It should be noted that Chapter 5 of this GSP includes projects that were far enough along in development and/or implementation that meaningful information could be included about their potential to improve sustainable management of the Subbasin. Additional projects may be implemented within the next 20 years to, for example, minimize the need for pumping reductions. This GSP does not preclude future projects or existing projects that are too early in the stage of development to be included in Chapter 5 from being investigated or undergoing feasibility analysis in the coming years. Relevant information about new projects and/or updates to existing projects described in Chapter 5 will be provided in annual reports and 5-year evaluations.

Current anticipated costs for implementing projects in the Oxnard Subbasin that were analyzed as part of this GSP are presented in Table 1-1.

In addition, it is anticipated that basin optimization studies will be undertaken in the initial 5-year period after the GSP is implemented adopted to assess projects that were not included in this GSP. This assessment is expected to include an investigation of how adjustments to the location of groundwater production will minimize seawater intrusion in the Oxnard Subbasin, while maximizing the sustainable yield of the combined aquifer systems of the Oxnard Subbasin, the PVB, and the West Las Posas Management Area. Basin optimization investigations are inherently tied to groundwater modeling, which would be conducted to provide the estimated sustainable yield for all scenarios analyzed.

Lastly, as part of the project feasibility analyses, FCGMA anticipates evaluating potential revenue streams for implementing the projects required to optimize basin management. This analysis will include a review of the potential for implementing basin replenishment fees and the costs associated with proposing and passing such fees.

Cost Estimate

The estimated total GSP implementation costs are presented in Table 1-2. The starting cost for monitoring systems, coordination of data collection, obtaining data form other GSAs in the basin is estimated to be $1 million for 2020. Costs were increased annually, using a 2.8% inflation rate, from 2020 to 2040 (Table 1-2). The annual reviews to DWR are anticipated to be included as part of the operations and monitoring costs for FCGMA. The management, administration, and other costs for 2020 are based on the 2019–2020 fiscal year budget, in which these costs are estimated to be $1,455,000.

The 5-year evaluation costs are anticipated to cover the professional specialty services to evaluate and assess the GSP and perform the additional work necessary to fill data gaps and analyze projects and management actions for the Oxnard Subbasin, as well as for the PVB and LPVB. FCGMA has prepared the GSPs for the entire area of the Oxnard Subbasin, Las Posas Valley Basin, and Pleasant Valley Basin. FCGMA will be responsible for evaluating these GSPs, for each basin, every 5 years. Cost sharing for these evaluations may be investigated with the other GSAs in each basin in the future. Initial costs for the 5-year evaluation were estimated to be $100,000 per basin, with 2.8% inflation between 2020 and 2024. Costs for 2025 through 2029 were estimated to be $100,000 if the work were performed in 2020, but the costs in the budget account for 2.8% annual inflation between 2020 and 2025. Costs between 2030 and 2033 were calculated from the 2.8% annual inflation on $50,000. Subsequent years were calculated either based on 2.8% inflation on $100,000, or 2.8% inflation on $50,000, depending on whether the year included preparation of a physical report for DWR.

Finally, the estimated implementation costs include a 10% contingency on the total operating and monitoring costs, management administration and other costs, and the 5-year evaluation.

1.2.6.3 Funding Sources

In general, FCGMA plans to fund its basic operations costs using groundwater extraction charges. Surcharges for extractions in excess of an allocation may also be used in carrying out FCGMA's groundwater management functions. FCGMA collects a groundwater extraction base rate fee of $6 per acre-foot and imposes a surcharge of up to $1,961 for excess extractions. Together, these pump fees have generated more than $1 million in operating revenues each fiscal year (ending in June) between 2013 and 2016. FCGMA anticipates using this existing revenue structure, along with eventual implementation of a replenishment fee, to fund the GSP implementation and direct costs.

Under SGMA, ~~its enabling legislation,~~ FCGMA gained additional authority to impose regulatory fees and currently collects a sustainability of fee of $11 per acre-foot in addition to its groundwater extraction fee.– The sustainability fee is projected to generate additional annual revenue of $1,375,000.– The sustainability fee will increase to $14 per acre-foot in 2020 and generate an additional $375,000 in annual revenue.- Upon adoption of this GSP, FCGMA will have authority to impose replenishment fees and ~~was limited to management actions that influence groundwater demand. As a GSA, FCGMA obtained additional authority~~ to ~~also implement~~ fund projects and management actions that can influence groundwater supply. Projects to achieve sustainability are anticipated to require funding beyond that generated by the existing extraction and sustainability fees. FCGMA anticipates working with other agencies and stakeholders to understand how individual projects will impact stakeholders and identify the most appropriate funding sources for these projects.

1.3 DESCRIPTION OF PLAN AREA

1.3.1 Description

The Oxnard Subbasin (the Subbasin; DWR Groundwater Basin 4-004.02) is a coastal alluvial subbasin of the Santa Clara River Valley Groundwater Basin (4-004). It is bounded to the east by the LPVB (4-008), the Camarillo Hills, and the PVB (4-006); to the southeast by the Santa Monica Mountains; to the west and southwest by the Pacific Ocean; and to the north by the Mound (4-004.03) and Santa Paula (4-004.04) Subbasins of the Santa Clara River Valley Groundwater Basin (Figure 1-1, Vicinity Map for the Oxnard Subbasin).

The Oxnard Subbasin is in hydrologic communication, to varying degrees, with the LPVB and PVB to the east, the Mound and Santa Paula Subbasins to the north, and the Pacific Ocean to the west and southwest.

The Oak Ridge and McGrath Faults form the boundary between the Oxnard Subbasin and the Mound and Santa Paula Subbasins to the north (DWR 2016a). The boundary between the Oxnard Subbasin and the LPVB is a jurisdictional boundary that corresponds to property lines and associated water sources. It is parallel and proximal to the surface expression of the Wright Road Fault. The boundary between the Oxnard Subbasin and the PVB is defined by a facies change between the predominantly coarse-grained sand and gravel deposits that compose the Upper Aquifer System (UAS) in the Oxnard Subbasin and finer-grained clay- and silt-rich deposits in the PVB. The southeastern boundary of the Oxnard Subbasin is the contact between permeable alluvium and semi-permeable rocks of the Santa Monica Mountains (SWRCB 1956; DWR 2016a).

The Oxnard Subbasin has historically been divided into two subareas by local practitioners (UWCD 2014). Across most of the Oxnard Plain, the main water-producing aquifers are confined beneath a low-permeability, clay-rich layer that separates the UAS from the topmost unconfined semi-perched aquifer groundwater unit. This clay layer and the semi-perched aquifer are absent in the northeastern area known as the Oxnard Forebay, and as a result, unconfined aquifer conditions exist in the UAS in this area (Figure 1-1).

In this report, to distinguish between features on the land surface and in the subsurface, the term "Oxnard Plain" will be used to refer to the geographic area overlying the Oxnard Subbasin.

Administrative Boundaries

Multiple boundaries have been used to define or manage the Subbasin (Figure 1-2, Administrative Boundaries for the Oxnard Subbasin), including the following:

1. The boundary of the Subbasin defined by DWR in its 2016 Basin Boundary Modification
2. The jurisdictional boundary of FCGMA
3. The boundaries of the Oxnard Forebay historically used by FCGMA
4. The boundary of the Oxnard Subbasin historically used by FCGMA

The boundary of the Oxnard Subbasin defined by DWR in its 2016 Basin Boundary Modification extends beyond FCGMA jurisdiction to the southeast, northwest, and northeast (Figure 1-2). The jurisdictional boundary of FCGMA was established based on a vertical projection of the interpreted extent of the FCA, as provided by the Fox Canyon Groundwater Management Agency Act (FCGMA Act) in 1982. The FCA is absent in the areas of the DWR Bulletin 118 boundaries for the Oxnard Subbasin that lie outside of FCGMA jurisdiction (Figure 1-2). The majority of the area that is outside FCGMA jurisdiction but inside the 2016 Subbasin boundary lies within the jurisdiction of the County of Ventura. The County has filed to be the GSA for the Oxnard Basin Outlying Areas (see Appendix A; Figure 1-2). The remaining area outside of FCGMA jurisdiction but within the boundary of the Subbasin currently used by DWR will be managed by CWD, which has filed to be the GSA for the Camrosa ~~Oxnard Subbasin Pleasant Valley Basin (OPV)~~Water District ~~Management Area – –~~Oxnard Subbasin, which covers the portion of CWD's service area that lies within the Oxnard Subbasin (Appendix A; Figure 1-2). Table 1-3 presents a breakdown of all GSAs that intersect the boundary of the Oxnard Subbasin defined by DWR in its 2016 Basin Boundary Modification. The 2016 Basin Boundary Modification was used instead of the 2018 Basin Boundary Modification to be consistent with the groundwater model used in this GSP. The County (by Resolution 17-088) and CWD (by Resolution 17-11) have each elected to act as the GSA for portions of the Subbasin not within FCGMA's jurisdiction (Appendix A). The County and CWD will rely on this GSP and coordinate with the FCGMA, as necessary, to ensure that the Subbasin is sustainably managed in its entirety, in accordance with SGMA.

The external boundary of the Oxnard (4-004.02), Mound (4-004.03), and Santa Paula (4-004.04) Subbasins were adjusted in DWR's 2018 Basin Boundary Modification process (DWR 2019). The adjustment was made by request of the Mound Basin GSA, who notified FCGMA of the proposed change, which was ultimately approved by DWR in 2019. The purpose of the boundary change was to better align the boundaries of the Mound Subbasin, FCGMA, and the Santa Paula basin adjudication. Compared with the 2016 boundary for the Oxnard Subbasin, the 2018 Basin Boundary Modification aligned the north-northwestern border of the Subbasin with FCGMA's jurisdictional boundary, resulting in subtraction of 75.2 acres from the Subbasin near the Pacific

Coastline south of the Santa Clara River, and the addition of 614.7 acres to the Subbasin in a narrow zone north of the Santa Clara River (DWR 2016a, 2019).

From a technical and sustainable management perspective, the effect of the change in area for the Oxnard Subbasin between 2016 and 2018 is negligible, because the area does not newly include or exclude representative monitoring sites or production wells and does not affect the model domain, boundary conditions, and/or other parameters used in the Ventura Regional Groundwater Flow Model. Therefore, the effect on water budget for the Subbasin would be limited to the inclusion and/or exclusion of model grid cells for inflow and outflow calculations along the northern boundary of the Subbasin. The dimension of the model grid cells (2,000 feet) is greater than the maximum change in distance between the 2016 and 2018 boundaries for the Oxnard Subbasin (1,300 feet or less), which suggests that any difference could be within the margin of error associated with the model grid resolution. Because this change represents just 0.9% of the Subbasin's total area and is an administrative rather than a scientific/technical boundary modification, and because this GSP was largely completed prior to adoption of the change in 2019, Subbasin condition information presented in this GSP reflects DWR's 2016 Basin Boundary Modification.

Land Ownership and Jurisdiction

Land within the Oxnard Subbasin is under a variety of municipal, County, state, and federal jurisdictions. The City of Oxnard and Port Hueneme are entirely encompassed by the Oxnard Subbasin. The Cities of Ventura and Camarillo lie primarily outside the Subbasin; however, the cities' outer edges are crossed by the Subbasin boundary. Land under County jurisdiction outside the incorporated cities composes the majority (55.5%) of the Subbasin's land area. State agencies that own and/or manage land within the Oxnard Subbasin include the California Department of Parks and Recreation, California State University, and California Department of Corrections and Rehabilitation. Federal land within the Subbasin consists of the Naval Base Ventura County (Naval Construction Battalion Center Port Hueneme and Point Mugu Naval Air Station), which occupies about 10% of the Subbasin's land area. Finally, The Nature Conservancy owns and manages land along the lower reach of the Santa Clara River and Ormond Beach for conservation purposes. A summary of land ownership and jurisdiction is provided in Table 1-4.

1.3.2 Geography

1.3.2.1 Surface Water and Drainage Features

The dominant surface water bodies in the Oxnard Plain are the Santa Clara River, Revolon Slough, and Calleguas Creek, all three of which drain watersheds that extend beyond the boundaries of the Subbasin. In addition, the relatively flat areas within the Cities of Oxnard and Port Hueneme are drained by several lined drains that discharge directly into the Pacific Ocean (Figure 1-3, Weather Station and Stream Gauge Locations).

The Santa Clara River is close to and generally parallels the northern boundary of the Oxnard Subbasin and discharges to the Pacific Ocean through the Santa Clara River Estuary north of the Oxnard Subbasin. Flow in the channel infiltrates into sediments overlying the Oxnard Forebay and is a source of recharge to the aquifers in the Subbasin. In addition, UWCD, under permit, diverts surface water from the Santa Clara River at the Freeman Diversion. The diversion, which was constructed in 1991, replaced an earthen diversion that had been in place since 1928. The diversion is located upstream of the Subbasin boundary and discharges Santa Clara River water to infiltration basins overlying the Oxnard Forebay (Figure 1-3). West of the Oxnard Forebay, the Santa Clara River channel overlies a confining clay layer and does not communicate directly with the confined aquifers of the UAS and the Lower Aquifer System (LAS). In this portion of the channel (including the estuary) the semi-perched aquifer, which is located above the uppermost confining clay layer, supplies water to the Lower Santa Clara River (Section 2.1, Introduction to Basin Setting).

Revolon Slough drains the eastern portion of the Oxnard Plain and the western portions of the LPVB and PVB (which are east of the Oxnard Plain) (Figure 1-3). The drainage area of Revolon Slough includes western Camarillo. Flow in the slough is generally southward, parallel to the eastern Oxnard Subbasin boundary, until it joins with Calleguas Creek. Calleguas Creek drains the approximately 250-square-mile Calleguas Creek Watershed to the northeast of the Oxnard Subbasin and crosses the Oxnard Subbasin boundary with the PVB at the base of the Santa Monica Mountains (Figure 1-3). Within the Oxnard Subbasin, Calleguas Creek flows generally southward along the southeastern boundary of the Subbasin and discharges into the Pacific Ocean through Mugu Lagoon near Point Mugu (Figure 1-3). Recharge from surface waters into the Oxnard Subbasin is discussed in Section 2.3.6, Groundwater–Surface Water Connections.

Characterization of Flow

Streamflow records for four active and five inactive streamflow gauging stations (Figure 1-3; Table 1-5) were used to characterize flow in the Santa Clara River (Stations 708, 708A, 723, and 724), in the Revolon Slough Watershed (Stations 776, 776A, 780, and 782), and in Calleguas Creek (Station 805).

Some reaches of the Santa Clara River are typically dry in dry weather (for example, at Stations 708 and 708A; Figure 1-3). Sources of dry-weather flow to Revolon Slough include discharge from private tile drains in the Oxnard Plain. Although dry-weather flow is observed in some portions of Calleguas Creek (i.e., at Station 805), in other reaches, Calleguas Creek is dry in dry weather (VCWPD 2009). The primary sources of dry-weather flow to Calleguas Creek are two wastewater treatment plants: the Hill Canyon Wastewater Treatment Plant, operated by the City of Thousand Oaks, which discharges to Arroyo Conejo, a tributary to Arroyo Santa Rosa; and the Camarillo Sanitary District Wastewater Treatment Plant, operated by the City of Camarillo, which discharges to Conejo Creek. Both Arroyo Santa Rosa and Conejo Creek are tributaries of Calleguas

Creek. Irrigation water from agriculture and/or landscaping may also serve as a source of flow in all three channels during some parts of the year.

In the Santa Clara River, the available stream flow record within the Subbasin extends from 1927 to 2014, with a gap from 1932 to 1950 (Figure 1-4, Average Daily Flows [ADF] and Monthly Minimum ADF in Oxnard Surface Waters [A]). Peak flow typically occurs between November and April of any given water year and baseflow generally falls to 0 cubic feet per second (cfs) between July and September, except in reaches above and below the Oxnard Forebay. There are some exceptions, particularly in 1980, 1983, 1993, 1998, and 2005, when flow continued through the summer months. The highest gauged flow was 92,300 cfs in March 1969 (Figure 1-4[A]).

In the Revolon Slough, the available streamflow record within the Subbasin extends from 1979 to 2014. Peak flow typically occurs between December and March of any given water year, and baseflow tends to drop to between 2 and 25 cfs between July and September. The highest gauged flow was 2,870 cfs in January 2005 (Figure 1-4[B]).

In Calleguas Creek, the available streamflow record within the Subbasin extends from 1968 to 2014. Peak flow typically occurs between December and March of any given water year, and baseflow tends to drop to between 5 and 13 cfs between July and September. The highest gauged flow was 9,686 cfs in March 1983 (Figure 1-4[C]).

To quantitatively assess changes in baseflow, all streamflow gauges were assigned a minimum average daily flow for each month of the record, and this monthly minimum was plotted in Figures 1-4(D) through 1-4(F). In Calleguas Creek, flows from 2005 to 2015 were lower than those in the 1980s and 1990s. The low flows correspond with a period of below-average rainfall associated with the recent drought. Because surface water in Calleguas Creek and its tributaries is diverted by property owners and by CWD and delivered as a water supply in lieu of groundwater pumping, decreased flow in Calleguas Creek will affect groundwater management in the Subbasin. On the Santa Clara River, decreased flows in the past 5 years have impacted artificial recharge operations and other management decisions made by UWCD.

1.3.2.2 Current, Historical, and Projected Climate

Current Climate

The climate of the Oxnard Plain is typical of coastal Southern California, with average daily temperatures ranging generally from 50°F to 78°F in summer and from 40°F to 75°F in winter, as measured at the California Irrigation Management Information System (CIMIS) weather station in Oxnard, which was active from October 2001 through April 2017 (CIMIS 2018). Typically, approximately 85% of precipitation in the Ventura County region falls between November and April (Hanson et al. 2003).

Records of rainfall were collected from VCWPD weather stations located within the boundary of the Oxnard Plain (12 active and 11 inactive; Figure 1-3, Figure 1-5 (Oxnard Plain Annual Precipitation), and Table 1-6). Annual precipitation varies from gauge to gauge (Figure 1-5 and Table 1-6).

Evaporation as pan evaporation rate is measured at one VCWPD weather station within the Oxnard Plain (Station 239, El Rio–UWCD Spreading Grounds). The Station 239 evaporation record begins in 1972 and ends in 2016. Monthly average evaporation ranges from 3.7 inches in January to 7.2 inches in July, with an average total annual evaporation of 63.0 inches.

Evapotranspiration is measured at CIMIS Station 156, located on the River Ridge Golf Course, approximately 800 feet south of the Santa Clara River and 725 feet west of North Ventura Road. The monthly average evapotranspiration calculated for data collected between 2001 and 2017 using the Penman–Monteith equation at Station 156 ranges from 2.01 inches in December to 5.12 inches in July. The average total annual evapotranspiration is 44.93 inches.

Historical Climate Trends

In order to characterize rainfall variability in the Oxnard Plain over the past century, two stations whose combined records cover the entire period were selected: Stations 032 and 168 (Figure 1-3). Station 032 (Oxnard–Water Department) is located approximately 1.5 miles east of Station 168 (Oxnard Airport). Precipitation records can vary based on several factors, including geographic location, the type of gauge used to measure precipitation, and the physical characteristics of the area surrounding a measurement site. Therefore, in order to examine how rainfall recorded at these two stations compared to the other stations, correlation coefficients (R) were calculated for the period of time in which the station records overlap. The correlation coefficients between all pairs of station records, excepting pairs that included Stations 223, 273, 412, and 503, exceeded 0.9. Stations 273, 412, and 503 have less than 8 years of overlapping data, which may explain the poorer correlation between these sites and Stations 032 and 168. The low correlation between Station 223, which is located near the southwest corner of the Oxnard Plain near Point Mugu, and Stations 032 and 168 is due in part to anomalously low values recorded at Station 223 in some years in the 1950s, 1960s, and 1970s. Because the record from Station 223 does not correlate with the records from any other station in the area, this station cannot be used to typify trends in the Oxnard Plain.

The variability in the records of precipitation measured at Stations 032 and 168 is similar to that measured at the other precipitation stations, and can be used to characterize the precipitation trends in Oxnard Plain over the 113-year period from 1903 to 2015 (Figure 1-5).

The long-term trend record was based on the record from Station 032 for the period from 1902 to 2003. After 2003, no data are available for Station 032. Therefore, from 2003 to 2016, the annual precipitation value recorded at Station 168 was used to predict a value for the location of Station

032, based on a linear regression of the annual precipitation values in the 46 years of overlap (1957–2002) in the records for Stations 032 and 168 (see formula below).

*Station 032 (inches) = 1.0127 * Station 168 (inches) + 0.0011* ($R^2 = 0.9766$)

The root-mean-squared error (RMSE) between the observed annual precipitation at Station 032 and the predicted precipitation using Station 168 was 1.3 inches per year. The bias was −0.00058 inches. Thus, some uncertainty is introduced by extending the Station 032 record using Station 168. However, this slight uncertainty does not outweigh the benefit of being able to use the resulting 113-year record to characterize long-term climate trends.

Based on this long-term record, the calculated mean annual precipitation in the central Oxnard Plain is 14.4 inches (Figure 1-6, Long-Term Precipitation Trends in the Oxnard Plain). For each water year in the record, the total annual precipitation was compared to the long-term mean annual precipitation in order to calculate the cumulative departure from mean precipitation (Figure 1-6). Historical drought periods were defined as a falling limb on the cumulative departure from the mean curve (Figure 1-6). Based on the historical record, a drought in the Oxnard Plain can be defined as a period of years in which the area experiences no more than one consecutive year of above-average precipitation and at least 24 inches of cumulative precipitation deficit (see Table 1-7 and Figure 1-6).

The century-long precipitation record demonstrates that drought cycles have frequently impacted the Oxnard Plain. The average drought duration in the past century was 8.2 years, and the average cumulative rainfall deficit during the droughts was −30.25 inches. The duration of periods of average or above-average rainfall was rarely more than 10 years. In this historical context, the approximately 20-year period in the 1990s and 2000s constitutes an unusually long wet period (Figure 1-6). Consequently, planning for drought cycles in the coming decades will be an integral component of water resources management.

The FCGMA contracted and received evapotranspiration data collected at private weather stations located in the Oxnard Subbasin during the period 1992 to 2013. The number of weather stations in the Subbasin fluctuated over the years. The data collected from the private weather stations were used for determining the annual irrigation efficiency allocation during the period 1992 to 2013. These data are available from FCGMA Board Meeting Agenda packets and were reported to FCGMA on a monthly basis.

Projected Climate

The literature review conducted in support of the U.S. Bureau of Reclamation's Los Angeles Basin Stormwater Conservation Study Task 3.1 Report found that the following changes are anticipated in Southern California due to global climate change (Bureau of Reclamation 2013):

- Increased temperature (1°C to 3°C)
- Increased evaporation rate
- Decrease in annual precipitation (2% to 5%)
- Increase in extreme precipitation events

Future climate conditions were modeled for the Oxnard Subbasin using climate change factors provided by DWR. The impacts to the future water budget are discussed in more detail in Chapter 2, Basin Setting.

1.3.2.3 Historical, Current, and Projected Land Use

Historical land uses on the Oxnard Plain were determined based on review of data from the Southern California Association of Governments (SCAG), which has mapped more than 105 land use categories to a minimum 2-acre resolution for the years 1990, 1993, 2001, and 2005 (SCAG 2005). Current land uses within the Oxnard Plain were determined based on review of the General Plan land use map for Ventura County (VCPD 2015), and are shown on Figure 1-7, Land and Water Use. Existing land use patterns and trends are expected to continue, and are described based on information contained in General Plan documents.

The majority of the Oxnard Plain consists of unincorporated areas of Ventura County, though it also encompasses nearly all of the Cities of Oxnard and Port Hueneme. Land use on the Oxnard Plain consists of 47% agriculture, 47% urban uses, and 6% vacant/open space (Table 1-8). About 83% of the agricultural uses consist of orchards, cropland, and improved pasture land with the remaining 17% consisting of nurseries, horse ranches, and other uses (Table 1-8). The primary crops grown in the Oxnard Plain are strawberries, raspberries, celery, peppers, kale, cut flowers, and nursery stock (VCFB 2016). Urban and residential land uses are concentrated in Oxnard and Port Hueneme. Federal lands consist of two Naval Base Ventura County operations within the Oxnard Subbasin, Point Mugu and Port Hueneme, and the Channel Islands Air National Guard Station. The Naval Base Ventura County was formed in 2000 through the merger of Naval Air Station Point Mugu (located in the southern portion of the Oxnard Subbasin in unincorporated Ventura County) and Naval Construction Battalion Center Port Hueneme (located in the west-central part of the Oxnard Subbasin within the City of Port Hueneme along the coast). Currently, there are about 19,000 military, civilian, and contract personnel working or stationed at Naval Base Ventura County (City of Oxnard 2011).

Recreational land uses on the Oxnard Plain consist of state and local beaches, golf courses, and community parks in Oxnard and Port Hueneme. Open space (i.e., not consisting of agricultural, military, or urban uses) is limited to the Santa Clara River corridor, beaches, and lagoons. Table

1-8 shows the County General Plan land uses within the Oxnard Plain, tabulated by area in acres and by percentage of total area.

With the exception of several high-rise buildings in north Oxnard, the City of Oxnard is characterized by one- or two-story residential and commercial buildings and several industrial areas (City of Oxnard 2011). Most of Oxnard's higher-intensity development lies adjacent to primary thoroughfares, such as Highway 101, Gonzales Road, Rose Avenue, Rice Avenue, Oxnard Boulevard, Hueneme Road, Ventura Road, Victoria Avenue, and Saviers Road, and in the central business district (City of Oxnard 2011). Growth is directed into one of Oxnard's 14 Specific Plans, which are in various stages of planning or buildout. City of Oxnard projects currently in the planning, permitting, or construction stages consist of 19 residential projects (greater than 50 units), 18 commercial projects, and 6 industrial projects (City of Oxnard 2016a). The largest planned development consists of the Teal Club Specific Plan (located west of Ventura Road between Doris Avenue and Teal Club Road), where up to 990 residential units are envisioned (City of Oxnard 2016a).

In the future, agricultural preservation and open space land use policies are expected to limit the rate and reach of "greenfield" development and direct growth through infill development and zoning policies that allow higher-density and mixed-use development (VCPD 2015). Furthermore, large-scale development is highly restricted in the California Coastal Zone, so development is likely to be concentrated on the urban fringes of Oxnard and Port Hueneme that are outside the coastal zone. For unincorporated areas within the Oxnard Plain, the Ventura County General Plan Environmental Impact Report identifies the widening of roads as a potential growth-inducing effect of the General Plan land uses and policies, as well as policies that allow for the creation of substandard-sized parcels for farmworker housing complexes and an increase in allowable building coverage for farmworker housing complexes in Agricultural and Open Space designations (VCPD 2005). Demographics and population growth within the Oxnard Plain are addressed in Section 1.3.2.4.

1.3.2.4 Historical, Current, and Projected Demographics

There are several sources of population data for the Oxnard Plain, most of which are derived from decennial census counts, which last occurred in 2010. Sources of population information are as follows:

- **U.S. Census Bureau**: The U.S. Census Bureau conducts a census count every 10 years. Census data are gathered by tracts, blocks, and census-designated places. Census tracts were intersected with the Oxnard Plain boundary to determine the population overlying the Oxnard Subbasin for 2010. Census tracts that intersected the boundaries of the Oxnard Plain were area-weighted to determine the population that falls within the Oxnard Plain.

- **City and County General Plans**: The Cities of Oxnard and Port Hueneme and the County of Ventura gather data on development, growth, and land use patterns, and make population estimates in conjunction with census data. The cities' and county's general plans and websites were reviewed for historical and current population data.
- **Southern California Association of Governments**: SCAG is the nation's largest metropolitan planning organization, representing 6 counties, 191 cities, and more than 18 million residents. SCAG produces demographics data and growth forecasts for the entire Southern California region.

At a countywide level, population growth is skewed toward incorporated cities. The population distribution within Ventura County is the result of a 1969 County–City agreement, called the Guidelines for Orderly Development, which directs urban-level development to incorporated cities in Ventura County (VCPD 2015). That agreement limits urban-level development and services within unincorporated areas. The total increase in population within unincorporated areas in Ventura County was only 1.9% from 2000 to 2010, whereas population in the cities increased by 10.4% over the same period.

Table 1-9 shows the past, current, and projected population for Ventura County, the Cities of Oxnard and Port Hueneme, and the Oxnard Plain. The population of the Oxnard Plain is estimated to have been 237,871 in 2010, based on census data. The population of the City of Oxnard is over 200,000 residents, as of 2015, with an average household size of 3.99 (City of Oxnard 2011; SCAG 2016). The City of Port Hueneme has about 22,000 residents and an average household size of 2.99 (City of Port Hueneme 2016a). The population of unincorporated areas within the Oxnard Plain is less than 10% of the total population of the Oxnard Plain.

The aforementioned population information is limited to the population that resides within the Oxnard Subbasin boundary. It should be noted that the City of Ventura overlies a portion of the Oxnard Subbasin, but this portion consists of commercial, recreational, and industrial land uses, with a negligible permanent population. The City of Ventura relies on groundwater from the Oxnard Plain for part of its groundwater supply. The population for the City of Ventura's water service area, as reported in its 2015 UWMP, is 112,412 (City of Ventura 2016).

1.4 EXISTING MONITORING AND MANAGEMENT PLANS

Over the past few decades, multiple agencies have implemented programs to monitor and manage water within the Oxnard Subbasin. Local and state agencies have worked together and with stakeholders to develop management strategies and monitoring programs. Table 1-10 and Table 1-11 summarize the monitoring and management programs, projects, and strategies that are currently in effect.

1.4.1 Monitoring Programs

Table 1-10 provides a summary of existing monitoring programs. It is subdivided into monitoring programs that are primarily for surface water and those primarily for groundwater. These monitoring programs are anticipated to continue, independent of the development of this GSP; however, the data from these programs will continue to be used to help assess groundwater conditions in the Oxnard Subbasin. Specifically, groundwater elevation data collected by VCWPD at key wells throughout the Subbasin will be compared to the minimum thresholds and measurable objective established in Chapter 3, Sustainable Management Criteria, of this GSP. VCWPD will continue to host the data for the Oxnard Subbasin and FCGMA will use the data for annual monitoring reports and the 5-year GSP evaluations (Section 1.2.6, Groundwater Sustainability Plan Implementation and Cost Estimate).

1.4.2 Management Programs

Table 1-11 provides a summary of management programs, projects, and strategies. Similar to Table 1-10, it is subdivided into projects that address primarily surface water and those that address primarily groundwater. It also contains a third category, "other," for projects that address both surface water and groundwater or an additional parameter.

Table 1-11 indicates whether each project or program is associated with conjunctive use. As used herein, "conjunctive use" applies to programs, projects, and strategies that meet the 2003 Bulletin 118 definition of the term: "Conjunctive management in its broadest definition is the coordinated and combined use of surface water and groundwater to increase the overall water supply of a region and improve the reliability of that supply" (DWR 2016a). For example, CWD provides reclaimed wastewater from the Hill Canyon WWTP diverted from Conejo Creek to its non-potable customers in the Arroyo Santa Rosa Valley Basin and the PVB and to PVCWD for delivery to agricultural users in the Oxnard Subbasin and PVB, thereby reducing the amount of groundwater pumped from these basins (FCGMA 2014a). For a description of some of the most important projects and programs, see Section 1.5, Existing Conjunctive-Use Programs.

Due to the overlapping jurisdictions of the agencies that manage groundwater resources, there are many programs that occur within the Subbasin or benefit multiple basins. Therefore, Tables 1-10 and 1-11 include a column ("Multi-Basin Program") that lists the basins in which the programs are conducted or those that benefit from each program.

1.4.3 Operational Flexibility Limitations

Operational flexibility is a key consideration in integrated water resource management because it helps water purveyors adapt to known legal, operational, and environmental constraints, and plan for an uncertain future, especially as it relates to drought resiliency and the effects of climate change. Operational flexibility can be measured over a given time horizon and/or geographic scale (e.g., water district service area) as the difference between available water supply and service area demand. Operational flexibility is maximized when a water purveyor has a large variety of sources in a water supply portfolio, when it has local control over such sources, and when such sources are connected to each other (i.e., conjunctively managed). On a general statewide scale, water purveyors are increasingly looking to minimize reliance on imported water supplies by promoting stormwater recharge, maximizing wastewater recycling, and sustainably developing local sources of water.

For the Oxnard Subbasin, water purveyors collectively draw from a combination of sources—including local surface water, groundwater, imports from the State Water Project (SWP), and increasingly, recycled water—which differ in terms of the volume available, area served, timing of peak availability, and reliability. Climate and regulatory constraints (e.g., water quality standards, water rights, and minimum environmental flows) have historically had a greater impact on the availability of surface water supplies.~~, whereas g~~Groundwater sources with adequate water quality were historically limited only by the capacity of production wells accessing the aquifer~~, leading to pumping in excess of many basins' sustainable yie~~until ~~ld~~1991, when FCGMA initiated a groundwater allocation reduction system. With the passage of SGMA and the sustainable management criteria established in this GSP (Chapter 3), once adopted, groundwater extraction will be further limited by minimum thresholds established for each sustainability indicator. FCGMA has exercised its authority to limit groundwater production since 1983, and thus has managed the basin in an effort to avoid critical overdraft. ~~Sustainable~~ Because in 2015 the State Department of Water Resources listed the Oxnard Subbasin as being in a state of Critical Overdraft, the sustainable management criteria adopted in this GSP may limit operational flexibility by further reducing allowable groundwater production.

The GSP complements and enhances existing projects and programs currently in place to maximize beneficial use of water resources and increase operational flexibility within the Oxnard Plain and within FCGMA jurisdiction as a whole. Existing water monitoring and management activities are described in Tables 1-10 and 1-11. Because the basins are all interconnected either physically or through water sources, the opportunity for operational flexibility exists and has been used by FCGMA and local water agencies. Examples of projects that have increased operational flexibility within the Oxnard Plain include the City of Oxnard's Groundwater Recovery Enhancement and Treatment (GREAT) ~~project~~Program~~ject,~~ and the Oxnard–Hueneme (OH) Pipeline and the Freeman Diversion Project, both operated by UWCD (Table 1-11).

Despite the coordination of projects and programs within the Oxnard Subbasin, limits to operational flexibility remain. These limits include constraints imposed by interaction with other regulatory programs, including the federal Endangered Species Act and the Recycled Water Policy (2009, amended 2013) that was adopted by the State Water Resources Control Board. The

Recycled Water Policy intends to encourage the safe use of recycled water by recognizing its benefits, establishing statewide recycled water goals and targets, clarifying regulatory agency roles and permitting approaches for various types of recycled water projects, and establishing an approach to avoid or minimize potential adverse consequences (e.g., excessive salts, nutrients, and/or constituents of emerging concern). For example, the policy requires that local water and wastewater entities prepare Salt and Nutrient Management Plans (SNMPs) for the groundwater basin in which they operate. The SNMP for the Lower Santa Clara River, which includes the Oxnard Forebay, has been accepted by the Los Angeles Regional Water Quality Control Board (LARWQCB), and the SNMP for the Oxnard Plain and Pleasant Valley Basins has been submitted to the LARWQCB (VCWPD 2015; City of Oxnard 2016b).

UWCD has prepared a Multiple Species Habitat Conservation Plan as part of its application for incidental take permits under Section 10(a)(1)(B) of the federal Endangered Species Act (UWCD 2018). The Multiple Species Habitat Conservation Plan specifies conditions under which flow diversions from the Santa Clara River would be allowed. The diverted flow at the Freeman Diversion, one of the oldest and most important sources of supply to the Oxnard Subbasin, is used to recharge groundwater and provided for in-lieu use in both the Oxnard Subbasin and the PVB. The operational flexibility provided by this project is constrained by habitat requirements for the federally endangered Southern California steelhead (*Oncorhynchus mykiss*) in the Santa Clara River. Climate fluctuations and future climate may also impact the quantity of water diverted from the Santa Clara River. Currently, the project permit limits access to flows. Water diversion is primarily during ~~large~~ the recession of a large storm event~~s~~, and during conditions allowed per National Marine Fisheries Service diversion constraints.

In addition to local projects, parts of the Oxnard Plain depend on imported water from the SWP. Such supplies have been, and may continue to be, limited by climate, infrastructure, and increased commitment for environmental and supply purposes (see Section 1.6.2, Urban Water Management Plans, under Calleguas Municipal Water District UWMP).

1.5 EXISTING CONJUNCTIVE-USE PROGRAMS

In the California Water Plan, DWR (2013) describes conjunctive use as follows: "Conjunctive management or conjunctive use refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. Surface water and groundwater resources typically differ significantly in their availability, quality, management needs, and development and use costs. Managing both resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit. Conjunctive management thus involves the efficient use of both resources through the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure."

Due to the history of interagency collaboration on groundwater management within FCGMA jurisdiction on the Oxnard Plain, multiple conjunctive-use programs are currently operational. These are identified and described in Table 1-11, as introduced in Section 1.4, Existing Monitoring and Management Plans. Some of the most important of these projects and programs are described in this section. The GSP will occur in conjunction with and build upon existing and planned conjunctive use programs in the Subbasin.

UWCD Freeman Diversion Project. The UWCD Freeman Diversion Project is a critical component of water supply within the Oxnard Subbasin. Its predecessor was constructed in 1927 as a series of earthen levies that diverted water from the Santa Clara River, which were washed out and replaced after large flows. The current project, constructed in 1991, diverts on average more than 62,000 acre-feet per year (AFY). About 75% of the water diverted has been sent to spreading basins within the Oxnard Forebay for groundwater recharge. Water from the project is also delivered to the Oxnard Subbasin and PVB through the Pumping Trough Pipeline and Pleasant Valley Pipeline, which supply water for non-potable applications (see Table 2-10, Summary of Water Deliveries). The water provided by the Freeman Diversion Project offsets groundwater production in coastal areas of the Subbasin, thereby helping to alleviate seawater intrusion. One of the projects and management actions identified in this GSP (Chapter 5) would build upon the existing facilities by increasing the Freeman Diversion Project's capability to divert surface flows (by capturing higher flow rates with higher sediment loads) and by developing additional recharge capabilities (using two former gravel mines).

City of Oxnard Advanced Water Purification Facility. The City of Oxnard's Advanced Water Purification Facility (AWPF) is part of the City of Oxnard's GREAT ~~p~~Program, which focuses on using existing water resources more efficiently. As the key project of the GREAT ~~p~~Program, the AWPF provides the City with Title 22 recycled water source that can be used for landscape irrigation, agriculture, industrial process water, and groundwater recharge. The AWPF is designed to initially treat approximately 8 to 9 million gallons per day (mgd) of secondary effluent and produce 6.25 mgd (7,000 AFY) of product water for reclaimed water uses with infrastructure in place to ultimately produce 25 mgd (28,000 AFY) of product water for reuse. The main treatment processes consist of microfiltration ~~(MF)~~, reverse osmosis ~~(RO)~~, and ultraviolet disinfection using advanced oxidation ~~(UV/AOP)~~. Several of the projects and management actions identified in this GSP (Chapter 5) ~~would~~ could build upon the GREAT ~~p~~Program by ~~expending~~ expanding the AWPF's capacity, increasing utilization of the recycled water in lieu of groundwater for irrigation~~, and connecting the recycled water delivery system to groundwater recharge facilities operated by UWCD~~.

CMWD SWP Deliveries. SWP deliveries are an important source of water within the Oxnard Subbasin. Supplied by CMWD, the vast majority of SWP water is delivered to and used by the City of Oxnard, with minor amounts used by the Port Hueneme Water Agency (PHWA). CMWD treats SWP water to potable standards and delivers it to M&I customers within its service area (see Section 2.4, Water Budget, for a discussion of this in the context of the water budget, including Table 2-10). In addition, up to 5,000 AFY of the Ventura County SWP allocation may be delivered to Lake Piru and later released for percolation or diversion at the Freeman Project. Note that CMWD is a member agency of the Metropolitan Water District of Southern California (MWD), which supplies water from a number of sources, including the Colorado River. One of the management actions to be implemented by FCGMA will be to reduce groundwater extraction allocations over time to a rate that will prevent net seawater intrusion after 2040. Reduced groundwater allocations may put increased pressure on water purveyors to use the maximum SWP allocations available, which are already highly limited by climate and competing demands. However, other projects and management actions in the GSP—including temporary agricultural land fallowing, expansion of recycled water sources and reach, and better utilization of existing and new stormwater recharge facilities—are expected to minimize this potential effect.

Fox Canyon Groundwater Management Agency Programs. FCGMA has been charged with groundwater management for decades and implements several programs that encourage efficient use of groundwater, new water sources, and brackish groundwater. Most programs apply to the entire FCGMA jurisdiction, but some management programs apply to specific areas. In addition to programs and ordinances that require reporting and fees for groundwater use, FCGMA implements a groundwater storage credit program that provides groundwater credits for surface water or imported water delivered equal to the amount of water that was used in lieu of pumping groundwater and that could have been used for groundwater recharge (spreading or injection).

By Resolution 2014-01, FCGMA approved the Conejo Creek Water Pumping Program involving CWD and PVCWD using the Conejo Creek Diversion (Conejo Creek Project). The Conejo Creek Project provides for the use of recycled water produced by the Hill Canyon Wastewater Treatment Plant in Thousand Oaks within the PVCWD service area through CWD. CWD diverts recycled water discharged to Conejo Creek and delivers it to the PVCWD service area for use in lieu of pumping. The FCGMA resolution allows the PVCWD to transfer credits generated by using recycled water in lieu of groundwater pumping within its service area to CWD. If monitoring data indicate that the Subbasin will support it, the resolution provides for extraction of up to 4,500 acre-feet (AF) from CWD-owned wells in an amount equal to the volume of recycled water delivered by PVCWD in lieu of pumping. However, flows from the Hill Canyon WWTP have decreased in response to conservation programs and are expected to decrease further in the future, thus reducing the potential yield of the project. Diversions of surface water on Conejo Creek prior to 2002 were estimated to average 2,450 AFY from 1985 to 2002 (see Chapter 2 of this GSP).

FCGMA approved an ordinance to establish an allocation system for the Oxnard Subbasin and PVB on October 23, 2019. The purpose of this ordinance is to facilitate adoption and implementation of the GSP and to ensure that the Oxnard Subbasin and PVB are operated within their sustainable yields. It is not the purpose of the ordinance to determine or alter water right entitlements, including those ~~which~~that may be asserted pursuant to California Water Code ~~s~~Sections 1005.1, 1005.2, or 1005.4.~~ ~~ A copy of this ordinance is included in Appendix A.

1.6 LAND USE ELEMENTS OR TOPIC CATEGORIES OF APPLICABLE GENERAL PLANS

SGMA requires that the GSP include a description of the consideration given to the applicable county and city general plans and the various adopted water-resources-related plans and programs and an assessment of how the GSP may affect those plans (California Water Code, Section 10727.2[g]). In addition to these elements, the GSP may include processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity (California Water Code, Section 10727.2[g]). Several kinds of land use plans contain provisions that affect water use and sustainability within the Oxnard Subbasin. Sustainable management of the FCGMA basins and the SGMA legislation require that the provisions of these plans be considered and coordinated in the development of DWR requires that the GSP include a summary of these plans and a description of how these plans may change water demands or affect FCGMA's ability to achieve sustainability and how the GSP addresses these potential effects, and how the GSP may affect the water supply assumptions made in these plans (DWR 2016b, Sections 354.8[f] and 354.8[g]). The California Water Code requires that the GSP include processes to review land use plans and coordinate with planning agencies related to groundwater issues (California Water Code, Section 10727.2). Plan types relevant to FCGMA jurisdiction and individual basins within it include county and city General Plans and associated area-specific and community plans and urban water management plans (UWMPs). There are no agricultural water management plans applicable to the Oxnard Subbasin because none of the water purveyors serve more than 25,000 irrigated acres within the Subbasin (excluding recycled water deliveries). The CWD has a 2015 Agricultural Water Management Plan, and although the southern end of CWD's service area extends into the Oxnard Subbasin near California State University Channel Islands, its agricultural service area occurs outside the Subbasin (CWD 2017).

California state law requires that cities and counties prepare and adopt a "comprehensive long-term general plan for the physical development of the county or city" and that "elements and parts [of the plan] comprise an integrated, internally consistent and compatible statement of policies for the adopting agency" (California Government Code, Sections 65300 and 65300.5). Among the required elements of the plan is the conservation, development, and utilization of water developed in coordination with groundwater agencies such as FCGMA (California Government Code, Section 65302[d][1]).

The Urban Water Management Planning Act of 1983 requires urban water suppliers to report on water sources, deliveries, demand, and efficiency, as well as performing water shortage contingency planning. Such plans are to be updated every 5 years (in years ending in 0 and 5) and submitted to DWR. The Urban Water Management Planning Act applies both to urban retail suppliers that provide potable municipal water to more than 3,000 end users or 3,000 AFY and to urban wholesale water suppliers that provide more than 3,000 AFY at wholesale (DWR 2016c). The applicable codes have been modified multiple times to include various provisions for water-related reporting.

For more than three decades, FCGMA has participated in the management of water within its jurisdiction. Such management includes oversight of many aspects of groundwater production and use, as well as coordination with all other entities responsible for water supply and land use issues. Because of these long-term relationships, many of the plans described in this section are consistent with the goal of sustainable groundwater management over the planning and implementation horizon. Due to the high level of coordination among agencies within the Oxnard Plain and FCGMA jurisdiction, it is anticipated that water demand among land uses managed by City and County jurisdiction, as well as water customers served by water purveyors, will be monitored and managed in a manner consistent with the provisions of SGMA and this GSP.

The following sections contain a description of the land use and water management plans that are applicable to water planning within the Oxnard Plain, a discussion of the consideration given to the land use plans, and an assessment of how the GSP may affect those plans. The plans included were selected as the plans with the most salient information relating to sustainable management. However, this is not intended to be a comprehensive list; other plans that include information pertinent to water management in the Oxnard Subbasin include the City of Port Hueneme UWMP, PHWA UWMP, MWD UWMP, the City of Oxnard General Plan, and the Naval Base Ventura County Joint Land Use Study (City of Port Hueneme 2016b; PHWA 2016; MWD 2016; City of Oxnard 2011; NBVC 2015). These plans are discussed in brief in Section 1.6.3, Additional Plan Summaries.

1.6.1 General Plans

General plans are considered applicable to the GSP ~~if they have the potential to direct urban growth, zoning changes, or redevelopment anywhere~~ to the extent that they may change water demands within the Oxnard Subbasin or affect the ability of the GSA to achieve sustainable groundwater management over the planning and implementation horizon. General Plans applicable to the Oxnard Subbasin are (1) the Ventura County General Plan, (2) the City of Oxnard 2030 General Plan, and (3) the 2015 General Plan and Local Coastal Program for the City of Port Hueneme. Small parts of the City of Ventura and City of Camarillo partially overlap the Subbasin, but implementation of their general plans are expected to have a negligible effect on implementation of the GSP within the Oxnard Subbasin. The areas of Ventura and Camarillo that extend into the Subbasin are already built out or zoned as agriculture and open space.

FCGMA staff has participated on the Ventura County General Plan Update Water Element Focus Group and continues to work with Ventura County planning staff to ensure that the GSP and the General Plan Update are mutually consistent. Furthermore, the FCGMA Board includes a representative for both the County and all the incorporated cities within FCGMA's jurisdiction, ensuring representation and coordination between the GSA, the County, and the incorporated cities.

Based on the timing of the adoption of the General Plan Update and the GSP, the GSA will be subject to the following California Government Code sections pertaining specifically to the coordination of planning and SGMA-related documents:

- California Government Code, Section 65350.5 – requires that the planning agency review and consider GSPs prior to General Plan adoption.
- California Government Code, Section 65352 – requires that prior to adoption of a General Plan Update, the legislative body must refer the plan to the GSA for review.
- California Government Code, Section 65352.5 – requires that the GSA provide the current version of the GSP to planning agencies preparing to update or adopt the General Plan.

All existing general plans and future updates undergo an analysis of environmental impacts under the California Environmental Quality Act (CEQA). In addition, all discretionary projects proposed within the Oxnard Subbasin under municipal, County, and/or state jurisdiction are required to comply with CEQA. In 2019, the Governor's Office of Planning and Research released an update to the CEQA Guidelines that included a new requirement to analyze projects for their compliance with adopted GSPs. Specifically, the applicable significance criteria include the following:

- Would the program or project substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?
- Would the program or project conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?

Therefore, to the extent general plans allow growth that could have an impact on groundwater supply, such projects would be evaluated for their consistency with adopted GSPs and for whether they adversely impact the sustainable management of the Subbasin. Under CEQA, potentially significant impacts identified must be avoided or substantially minimized unless significant impacts are unavoidable, in which case the lead agency must adopt a statement of overriding considerations.

Ventura County General Plan

Plan Description

The Ventura County General Plan (VCPD 2015) applies to the County as a whole and includes area-specific plans for distinct unincorporated areas. For example, the El Rio/Del Norte Area Plan includes policies to (1) protect the Oxnard Forebay Basin and its recharge area within the El Rio/Del Norte area in order to protect groundwater resources and (2) ensure that sewage treatment facilities provide maximum feasible protection and/or enhancement of groundwater resources. The County General Plan was last amended in October 2015. However, the County Planning Department is now undertaking a comprehensive update of the plan, thereby providing an immediate opportunity for coordination between FCGMA (as the GSA) and the County Planning Department, as required by SGMA.

The comprehensive update of the County General Plan is due to be completed by mid-2020 and will have a planning horizon of 20 years.

How the Plan May Affect Sustainable Water Management

Because General Plans and the associated elements define long-term policy related to community growth, development, and land use, General Plans are integral to the implementation of sustainable water management. The County General Plan is in the process of undergoing a comprehensive update, which provides the opportunity for consistency in regard to the relevant areas of the County General Plan and the GSP. Areas where FCGMA will coordinate with the County include the following:

- The compatibility of County land use with the goals and requirements of SGMA and groundwater sustainability. This includes County programs and policies for the protection or redesignation of urban, agriculture, and open space for the purpose of reducing or adjusting groundwater use, recharge, or groundwater quality.
- The consistency of discretionary development as it pertains to the FCGMA basins' water resources.
- The development of thresholds by the County for development within available water supply limits as determined by the GSPs for the FCGMA basins.
- Coordinated water-related monitoring programs within the FCGMA basins.
- The inclusion of land subsidence, drought, and point-source pollution as "hazards," as identified in the County General Plan.
- The coordination of goals, policies, and programs of the Water Resources section of the General Plan.

- The coordination of goals, policies, and programs of the Water Resources section of the General Plan, which pertain to groundwater overdraft, environmental uses of surface water, groundwater and surface water quality, and demand management and reuse. The programs of the Water Resources section specifically address the coordination of water agencies and County support of FCGMA plans.
- The coordination of capital projects or programs proposed as part of the GSP to achieve sustainability within the FCGMA basins.
- The regulatory authority of the GSA as it relates to that of the County.

How the GSP May Impact the Water Supply Assumptions of the General Plan

Sections 1.3.1 through 1.3.3 of the General Plan (VCPD 2015) describe the goals, policies, and programs that apply to water resources. The goals outlined in Section 1.3.1 of the General Plan include monitoring water supply and quality, maintaining or restoring water quality and supply, balancing supply and demand, protection of aquifer recharge areas and protecting and restoring wetlands. The GSP includes specific provisions for each of these: the monitoring of water resources (Chapter 4), the definition and maintenance of groundwater-dependent ecosystems (wetlands), definition of sustainability as it pertains to water resources (Chapter 3), and projects and management actions by which these goals will be obtained (Chapter 5, Projects and Management Actions). The General Plan also has a resource appendix that describes in general terms the groundwater resources within Ventura County. The next time the general plan is updated, the information in the GSP will be used to provide information relevant to the groundwater resources appendix.

The General Plan policies listed in Section 1.3.2 (VCPD 2015) include provisions and requirements for discretionary development. Some of the projects of the GSP will likely constitute discretionary development and therefore require consistency with General Plan or demonstration of "overriding considerations." The GSAs within the Subbasin will encourage municipalities to consider the GSP in the implementation of each of their general plans, and incorporate groundwater management criteria, where applicable and relevant, from the GSP into future general plan updates. General Plan Section 1.3.3 lists specific programs that County divisions will support in the application of the General Plan. Programs (management actions) implemented by FCGMA as part of the GSP may be added to those supported by the General Plan.

The 1998 Save Open Space and Agricultural Resources ordinance generally requires an approval by the electorate for any General Plan Amendment that changes land use designations for agricultural, rural, or open-space-designated lands. This and similar ordinances are in effect for much of the FCGMA area, including the Cities of Camarillo, Oxnard, and Ventura and unincorporated County areas, through at least 2050 (VCPD 2015). Should implementation of the

GSP result in the conversion of agricultural, rural, or open space lands to other uses, either to accommodate GSP projects or as a result of management actions that reduce water demand, a vote of the electorate would be required.

It is not the role of a general plan to make water supply assumptions, but to take into consideration existing and anticipated water supply conditions in planning for growth. This includes FCGMA's water supply allocations, as incorporated into the 5-year UWMPs. General plan policies for all jurisdictions include provisions to maximize water conservation for both indoor use and outdoor irrigation/landscaping. Furthermore, the areas zoned for development are generally already built out, so growth, where it occurs, is likely to consist of redevelopment projects or small areas of new development. As all new development is subject to supply mitigation, which includes installing dual plumbing and the use of nonpotable water where feasible, any offset of or increase in the volume of water used on the land being developed or redeveloped is mitigated; land conversion and changes in land use planning are not anticipated to adversely affect implementation of the GSP. Furthermore, city and County officials make up part of the FCGMA Board, and like the SGMA process, both UWMPs and general plans are living documents subject to periodic updates and reviews.

1.6.2 Urban Water Management Plans

UWMPs are prepared by urban water suppliers every 5 years. These plans support the suppliers' long-term resource planning to ensure that adequate water supplies are available to meet existing and future water needs (California Water Code, Sections 10610–10656 and 10608). Every urban water supplier that either provides over 3,000 AF of water annually or serves more than 3,000 urban connections is required to submit a UWMP. Within UWMPs, urban water suppliers must:

- Assess the reliability of water sources over a 20-year planning time frame.
- Describe demand management measures and water shortage contingency plans.
- Report progress toward meeting a targeted 20% reduction in per-capita (per-person) urban water consumption by the year 2020.
- Discuss the use and planned use of recycled water.

The information collected from the submitted UWMPs is useful for local, regional, and statewide water planning. Besides annual review of the GSP, the 5-year evaluation interval required for GSPs under SGMA works well with the equivalent review interval for UWMPs, ensuring that information on water supply, and groundwater in particular, is updated appropriately. Water suppliers that operate groundwater wells within the jurisdiction of FCGMA and the other GSAs (County and CWD) in the Subbasin will update their water supply projections in accordance with the allocation of groundwater production available. Groundwater supply assumptions made by urban water suppliers in their 2015 UWMPs will be superseded by the groundwater allocation reduction management actions discussed in Chapter 5 of this GSP.

Calleguas Municipal Water District UWMP

Description/Summary of Agency and Plan

CMWD is an independent special district and a wholesale water provider, the service area of which includes significant parts of each of the basins and the Oxnard Subbasin within the FCGMA area (Figure 1-8, Ventura County Water Purveyors; FCGMA et al. 2007). Within the Oxnard Plain, CMWD supplies the Cities of Oxnard and Port Hueneme (Figure 1-8). It has been a member agency of MWD since 1960, and provides wholesale water to 19 retail water purveyors. CMWD supplies water mainly for M&I uses. Most of the water supplied by CMWD is water from the SWP purchased from MWD. Storage facilities available to CMWD include a surface water reservoir in Thousand Oaks and underground storage in the LPVB via the Las Posas Aquifer Storage and Recovery Project (see Table 1-11).

CMWD does not operate any wastewater treatment facilities but supports the use of recycled water through the ownership and operation of recycled water pipelines and pumping facilities. The Salinity Management Pipeline transfers salty water away from surface waters in the southwestern Ventura County region to other beneficial uses or the Pacific Ocean (Table 1-11). CMWD actively conducts water conservation programs. Such programs include rebate/incentive programs, school programs, social media campaigns, and workshops.

The UWMP, adopted June 15, 2016, has a planning horizon of 25 years. The production of the UWMP was coordinated with, and obtained information from, numerous water suppliers and management agencies, including CWD, City of Camarillo, City of Oxnard, City of Port Hueneme, City of Moorpark, Ventura County Waterworks District 1, Ventura County Waterworks District 19, FCGMA, MWD, and UWCD. CMWD notified the appropriate agencies and the public of the production of the UWMP, conducted a public hearing, and incorporated public comments prior to adopting the plan.

Coordination with SGMA and Other Agencies

The UWMP contains a section describing FCGMA and the programs that it implements (CMWD 2016, Section 6-2). The SGMA legislation and GSP requirements are also described in this section, including FCGMA's role as the GSA and its role in preparing the GSPs.

In January of 2016, the CMWD Board of Directors adopted a strategic plan, one of the provisions of which is to, "Work with FCGMA, United Water Conservation District, agricultural pumpers, purveyors, and other groundwater interests to encourage, support, and facilitate the development and implementation of groundwater sustainability plans within the service area that increase certainty in groundwater management and promote conjunctive use operations" (CMWD 2016, p. 7-13).

How the Plan May Change Water Demands within the Subbasin

Due to the extensive collaboration between FCGMA as the historical management agency and GSA and the CMWD as a major wholesale water supplier within the FCGMA basins, the UWMP incorporates and reflects water demand and sustainability issues that must be addressed under SGMA. Implementation of this GSP will require continued coordination between the many agencies and stakeholders within the Oxnard Subbasin and periodic adjustment of assumptions regarding climate, population, land use, environmental requirements, and other factors impacting water demand. The CMWD UWMP recognizes those factors and provides for adaptation where necessary.

Such adaptation includes support of Senate Bill (SB) X7-7 goals for conservation, an extensive demand management program, and participation in capital projects that provide for conjunctive use on a regional scale.

How the Plan May Affect Sustainable Groundwater Management within the Subbasin

For the reasons noted previously, the CMWD UWMP largely fosters the goals of sustainable management within the Oxnard Subbasin. Both CMWD and MWD have recognized and are pursuing remedies to improve the reliability of water supplies within their respective service areas. UWMP strategies to remediate reliability issues of water supplies include pursuing demand management programs and local water supply projects such as increased use of recycled and brackish groundwater. In regard to SWP supply reliability, MWD and CMWD support DWR in projects and strategies to increase reliability from the Sacramento/San Joaquin Delta. These programs include California WaterFix and California EcoRestore (CMWD 2016, p. 7-2).

How the GSP May Impact the Assumptions of the UWMP

The UWMP presents strategies for preparing for SWP reliability challenges, climate variability, and emergency shortages. For planning purposes, the UWMP considers demand to be the total demand within the service area after accounting for local supplies. The GSP anticipates groundwater extraction reductions for M&I and agricultural uses even if planned projects discussed in the 2015 UWMP are developed. The UWMP assumes an increase in imported normal year demand of 5% between 2020 and 2040. Therefore, the UWMP may underestimate the demand upon which supply calculations are made. The UWMP assumes future water projects and demand management measures in water demand and reliability calculations. Those assumptions may be modified by those projects and management actions included in the GSP.

United Water Conservation District UWMP (Oxnard–Hueneme Water System)

Description/Summary of Agency and Plan

UWCD is a wholesale water supplier that was established as a public agency in 1950; its predecessor agency, the Santa Clara Water Conservation District, had been in existence since 1927. UWCD is also a water conservation district established under the California Water Code. UWCD is tasked with managing, protecting, and supplying water within the Santa Clara River Valley and the Oxnard Plain. It provides potable water to several retail systems within the Oxnard Subbasin, including the City of Oxnard, PHWA, and several mutual water companies (Figure 1-8). Its service area encompasses the entire extent of the Oxnard Plain, as well as portions of the Las Posas Valley and Pleasant Valley, and part of the Santa Clara River Watershed (Figure 1-8). The UWCD UWMP applies only to the Oxnard–Hueneme Water System (OHWS) within the Oxnard Plain.

UWCD facilities include the OHWS, the Freeman Diversion, Lake Piru Reservoir, the Pumping Trough Pipeline, the Pleasant Valley Pipeline, and multiple recharge basins located in the Oxnard Forebay (see Table 1-11). Components of the OHWS include 12 extraction wells proximal to the recharge basins of the Oxnard Forebay, the El Rio Treatment Plant, and approximately 12 miles of transmission pipelines (UWCD 2016, p. 7). The OHWS supplies water mainly for residential, commercial, and industrial uses. The Pumping Trough Pipeline and Pleasant Valley Pipeline provide non-potable surface water or blended surface water and groundwater to agriculture in the central and southern portions of the Subbasin, thus offsetting groundwater pumping in the area in order to reduce the risk of seawater intrusion.

As a party to the SWP contract between Ventura County Flood Control District and DWR, UWCD purchased 1,260 AF of SWP water from Casitas Mutual Water District in 2012 and 1,890 AF of SWP water from the City of San Buenaventura in 2013. This water was released from Lake Piru into the Santa Clara River, from which it could be diverted at the Freeman Diversion, and served as a potential supply source for the OHWS (UWCD 2016, p. 17). The UWCD also routinely purchases Table A SWP water when available.

Potential UWCD projects to be implemented in the future could include the Full Advanced Treatment Program, which would entail a collaborative agreement between the City of Oxnard~~,~~ or another source, and several agricultural entities to deliver recycled water ~~from the City of Oxnard's AWPF~~ through UWCD's Pumping Trough Pipeline and the Pleasant Valley Pipeline for agricultural users in the Oxnard Plain. A study completed by UWCD indicated that desalination opportunities may be feasible. However, such a system would not supply water to the OHWS (UWCD 2016).

As a wholesale supplier, UWCD complies with demand management requirements through metering, public education, and stakeholder outreach. All components of the OHWS are fully metered, including the 12 supply wells at the El Rio Spreading Grounds. The UWCD conducts tours, lectures, workshops, and other outreach as part of their water conservation program. In addition, UWCD is subject to demand management and other programs instituted by FCGMA. The UWCD UWMP was adopted June 8, 2016, and included coordination with Ventura County and the Cities of Oxnard and Port Hueneme, among other entities.

Coordination with SGMA and Other Agencies

As a wholesale water provider located within the Oxnard Plain, UWCD is within the jurisdiction of, and therefore subject to the allocations and requirements of, FCGMA. A UWCD representative sits on the FCGMA Board of Directors.

UWCD conducts monitoring programs for groundwater levels, surface flow, and water quality and produces an annual report summarizing these data (Table 1-10). This information is vital for the implementation of monitoring and management programs within the Oxnard Plain. The UWCD Resolution 2014-01, adopted March 12, 2014, addresses cooperation among all of the water users within FCGMA jurisdiction and the Santa Clara River basins to undertake conservation measures, support the FCGMA emergency ordinance, and pursue alternative water supplies (UWCD 2016, Appendix E).

How the Plan May Change Water Demands within the Subbasin

Due to the high level of coordination among agencies within the Oxnard Plain and FCGMA jurisdiction, it is anticipated that water demand among users of the OHWS will be monitored and managed consistent with the provisions of SGMA and this GSP. In addition, UWCD conducts demand management programs and activities in conjunction with the other water agencies in the Oxnard Plain.

How the Plan May Affect Sustainable Groundwater Management within the Subbasin

Because UWCD takes an active role in FCGMA, the implementation of SGMA, and monitoring programs within the Oxnard Plain, this and future versions of the UWMP will continue to support sustainable groundwater management. The UWMP states that aquifer protection is mainly the responsibility of FCGMA and that, "As the designated Groundwater Sustainability Agency, FCGMA has the primary responsibility for aquifer protection … FCGMA has the legal authority to implement the GSP when adopted" (UWCD 2016, p. 34). Historically, the OHWS has had little reliance on imported water supplies and therefore is minimally subject to issues related to declining reliability of that source.

Water quality concerns within the Oxnard Subbasin include seawater intrusion, release of connate brines, nitrate concentrations, and salt accumulation. To the extent that UWCD operations allow for diversion of generally higher-quality surface water than that usually found in groundwater and offset pumping in coastal areas, the plan fosters sustainable management with respect to water quality. Nitrate concentrations in water extracted from UWCD shallow supply wells have been found to increase during periods of drought, when artificial recharge of diverted Santa Clara River water decreases. The UWMP recommends the deepening of existing wells in the vicinity of the El Rio Spreading Grounds in order to draw water from areas with lower nitrate concentrations.

How the GSP May Impact the Assumptions of the UWMP

The UWCD UWMP assumes a 75% reduction in groundwater extractions from historical levels. Those provisions are superseded by the yields determined in this GSP (see Chapter 2). In addition, the GSP proposes minimum thresholds for water levels in coastal wells that are significantly higher than those of the recent past in order to reduce the impacts of seawater intrusion (see Section 3.4.3, Seawater Intrusion). These provisions of the GSP will impact UWCD operations within the Subbasin, including groundwater extractions from UWCD wells, and deliveries through the OHWS.

The UWMP assumes future water projects and demand management measures in water demand and reliability calculations. Those assumptions may be modified by those projects and management actions included in the GSP.

City of Oxnard UWMP

Description/Summary of Agency and Plan

The City of Oxnard was incorporated in 1903. The City of Oxnard serves as a retail water purveyor, providing potable and recycled water for commercial, industrial, residential, and agricultural use. The City of Oxnard's water service area includes the City of Oxnard and limited unincorporated areas of Ventura County. Oxnard's water supplies include imported water from CMWD, groundwater from UWCD, and groundwater produced from local wells. These sources may be blended to meet water quality requirements and to optimize for cost and supply. The City of Oxnard also operates wastewater treatment facilities for its own service area and surrounding areas. The City of Oxnard conducts a water conservation program with public information, water efficiency rebates, and water waste patrols. It is also compliant with SB X7-7, requiring a 20% reduction in per-capita urban water use by the year 2020.

As part of its water supply infrastructure, the City of Oxnard owns and operates 10 groundwater wells and 6 blending stations within the Oxnard Subbasin boundary. In 2009, as part of its GREAT ~~p~~Program, the City constructed the AWPF, which produces recycled water. The GREAT ~~p~~Program also includes brackish water desalters, one of which currently operates at a production rate of 7,500 AFY, and is planned to expand to 15,000 AFY. The AWPF now has a capacity of 7,000 AFY and its use is expected to increase as consumers are identified and pipelines are constructed. The facility recycles effluent from, and is located near, the wastewater treatment plant in the southern part of the City of Oxnard. Consumers of this recycled water include PVCWD and some other agricultural operators. Potential consumers could include PHWA and UWCD (City of Oxnard 2015). In addition to recycling water for landscape and agricultural irrigation, the City of Oxnard plans to construct and operate an aquifer storage and recovery well program through which recycled water may be stored or extracted.

The City of Oxnard is considering future water projects, including expansion of the AWPF by 7,000 AFY for groundwater recharge and expansion of aquifer storage and recovery facilities to inject and store treated water in the LAS. A dozen or more wells may be constructed by the early 2030s as part of this program (City of Oxnard 2015). This program has the capacity to provide predictable quantities of reclaimed water to the region for a variety of conjunctive uses, without borrowing from existing sources of water. The project reclaims and reuses treated effluent that would otherwise be conveyed to the ocean.

Coordination with SGMA and Other Agencies

The UWMP was adopted June 20, 2016, and has a planning horizon of 25 years. The production of the UWMP was coordinated with, and obtained information from, numerous water suppliers and management agencies, including the CMWD, UWCD, MWD, PHWA, FCGMA, and the Ventura County Local Agency Formation Commission (LAFCo). The City of Oxnard notified the appropriate agencies and the public of the production of the UWMP, conducted a public hearing, and incorporated public comment prior to adopting the plan.

How the Plan May Change Water Demands within the Subbasin

The City of Oxnard is entirely within FCGMA jurisdiction. As such, it is subject to the FCGMA ordinances and groundwater management activities described in Table 1-11. Many of the City of Oxnard's plans for water project expansion have been developed with, and require approval by, FCGMA. Implementation of this GSP will require continued coordination between the agencies and stakeholders within the Oxnard Subbasin and periodic adjustment of assumptions regarding climate, population, land use, environmental requirements, and other factors impacting water demand. Currently, the City has a net-zero policy on new development, which requires a proposed development to provide their groundwater allocation to the City (subject to FCGMA approval) or contribute to City programs designed to offset potable water use. Because of the existing level of coordination with FCGMA, the Oxnard UWMP is not expected to affect the water demand within the Oxnard Subbasin.

How the Plan May Affect Sustainable Groundwater Management within the Subbasin

Due to the jurisdictional overlap of FCGMA and the City of Oxnard, the Oxnard UWMP largely fosters the goals of sustainable management within the Oxnard Subbasin. Because the City of Oxnard at times relies on imported water from MWD via CMWD, the declining reliability of that supply may affect future management decisions. MWD is strategically addressing issues related to source reliability (CMWD 2016). Assumptions within the UWMP that may impact sustainable management of the basin include the continuation of current pumping allocations and the future availability of potable reuse supplies.

How the GSP May Impact the Assumptions of the UWMP

The UWMP indicates consistency with FCGMA management actions, including extraction reductions in accordance with Ordinance 8, Ordinance E, and the 100,000 acre-foot (AF) basin maximum extraction target of the 2007 FCGMA Basin Management Plan. However, the GSP contemplates reductions in groundwater extractions as compared to the historical averages and maintaining increased groundwater elevations near the coast for the management of seawater intrusion (see Chapters 2 and 3). Because the City of Oxnard is a coastal city partially dependent on groundwater extractions and UWCD supplies, its UWMP will be impacted by these GSP components. The UWMP assumes future water projects and demand management measures in water demand and reliability calculations. Those assumptions may be modified by those projects and management actions included in the GSP.

City of Ventura UWMP

Description/Summary of Agency and Plan

The City of Ventura, which was originally incorporated in 1866, is located on the Pacific Coast to the north of the Oxnard Subbasin, with a small portion of the city extending into the Subbasin. The City of Ventura Water Department (VWD), a retail water provider, supplies water to the city and several unincorporated areas of Ventura County. Parts of the city's water system are within both Casitas Municipal Water District and UWCD jurisdictions. VWD provides potable water for commercial, industrial, residential, and irrigation customers. VWD also provides recycled water for the irrigation of parks and golf courses (City of Ventura 2016).

VWD's supplies are from ~~imported water~~Lake Casitas, the Ventura River, groundwater, and reclamation facilities. Although the City of Ventura has a 10,000 AFY allocation of SWP water, there are currently no facilities by which SWP water can be delivered to the city. VWD extracts groundwater from the Oxnard Subbasin for use within the City's service area. The City's full Historical Allocation (HA) was 5,472 AFY (in 1990) and has since been adjusted by FCGMA ordinances to 4,104 AFY (a 25% reduction of HA in 2013) and 3,862 AFY (20% reduced

Temporary Extraction Allocation in since 20182016). The City of Ventura has complied with Senate Bill (SB) X7-7, requiring 20% reduction in per-capita water use, and implements demand management programs, including wastewater a prohibition on water waste, conservation pricing, and public education.

Wells used by the City of Ventura for its municipal water supply that are located within the Oxnard Subbasin consist of three wells at the Buenaventura Golf Course (City of Ventura Well Nos. 5, 6, and 7) (City of Ventura 2016).

Coordination with SGMA and Other Agencies

The City of Ventura UWMP was adopted in June 2016, and has a planning horizon of 25 years. The production of the UWMP was coordinated with, and obtained information from, numerous water suppliers and management agencies, including FCGMA, CMWD, UWCD, City of Oxnard, and Ventura County LAFCo. The City of Ventura notified the appropriate agencies and the public of the production of the UWMP, conducted a public hearing, and incorporated public comments prior to adopting the plan.

How the Plan May Change Water Demands within the Subbasin

The City of Ventura UWMP will not likely change the water demand within the Oxnard Subbasin.

How the Plan May Affect Sustainable Groundwater Management within the Subbasin

Although the City of Ventura is located primarily outside the Oxnard Subbasin and the FCGMA area, the City extracts approximately 3,860 AFY of groundwater from the Subbasin that FCGMA has approved to be exported for use within the Mound Groundwater BasinCity's service area. To the extent that the UWMP assumes continuation of this exportation of groundwater, these continued extractions will need to be addressed as part of FCGMA's ongoing efforts to sustainably manage groundwater in the Oxnard Subbasin. However, the extraction has historically been subject to FCGMA management ordinances and will be subject to future FCGMA policies.

How the GSP May Impact the Assumptions of the UWMP

The UWMP assumes continued extractions from the Oxnard Subbasin. This assumption may be impacted by GSP management actions that reduce annual extractions within the Subbasin. These management actions would be undertaken to maintain coastal groundwater levels at higher than historic averages (see Chapters 2 and 3).

1.6.3 Additional Plan Summaries

Port Hueneme Water Agency UWMP

PHWA is a wholesale urban water supplier that delivers approximately 4,000 AFY of SWP water and groundwater to Naval Base Ventura County, the City of Port Hueneme, and the Channel Islands Beach Community Services District (PHWA 2016). Approximately 20% of the PHWA water supply is purchased SWP water from CMWD. The remaining 80% of the water supply is groundwater, provided to PHWA by UWCD as part of a 40-year supply agreement negotiated in 1996 (PHWA 2016). PHWA does not directly pump groundwater from the Oxnard Subbasin, but relies on the groundwater produced by UWCD.

City of Port Hueneme UWMP

The City of Port Hueneme is a retail water agency that supplies approximately 1,903 AFY of SWP water and groundwater purchased from PHWA (City of Port Hueneme 2016b). The City of Port Hueneme does not directly pump groundwater in the Oxnard Subbasin (City of Port Hueneme 2016b).

Metropolitan Water District UWMP

MWD is a public agency that delivers water from the Colorado River and the SWP to its member agencies (MWD 2016). The member agencies of MWD include 14 cities, 11 municipal water districts, and 1 county water agency (MWD 2016). Relevant to water supplies in the Oxnard Basin, PHWA purchases water from CMWD, which is a member agency of MWD. MWD supplies imported water to CMWD. MWD does not directly or indirectly pump groundwater in the Oxnard Subbasin.

City of Oxnard General Plan

The City of Oxnard owns and operates a municipal water supply system, providing both imported water and local groundwater in its service area. The General Plan addresses groundwater resources in both the Infrastructure and Community Services Goals section and the Environmental Resources Goals section of the General Plan. These goals include supporting the FCGMA policies that protect, enhance, and replenish the aquifers of the Oxnard Subbasin and adhering to recommendations regarding groundwater extractions and quality from the Ventura County Regional Water Quality Planning Program (City of Oxnard 2011, Goals ICS-11.5 and ICS-11.9). Additionally, Goal ER-5 states: "well managed water supply and wastewater treatment programs that together meet expected demand, prevent groundwater overdraft, and ensure water quality" (City of Oxnard 2011). Under this goal, reducing dependence on groundwater through development of the GREAT Ppprogram is specified as supporting the policies of FCGMA (City of Oxnard 2011). Specifically, Policy ER-5.3 states "The City shall maintain a minimal dependence on Basin 4A groundwater consistent with the Groundwater Resource Encroachment and Treatment (GREAT) Program and support the policies of the Fox Canyon

Groundwater Management Agency to protect, enhance, and replenish the aquifers underlying the Oxnard Plain" (City of Oxnard 2011).

The City of Oxnard General Plan includes several policies that address a range of water supply and groundwater resource issues. These include the following (City of Oxnard 2011):

- **Policies ICS-1.1 (Maintain Existing Service Levels), ICS-1.2 (Development Impacts to Existing Infrastructure), and ICS-1.3 (Funding for Public Facilities)** require the City to plan and ensure that a variety of funding methods (including developer fees, grants, and public facility fees) are used to expand the range of public services and utilities (including water supply infrastructure) consistent with community needs.
- **Policy ICS-11.4 "(GREAT Program Implementation)"** requires the City to continue supporting and implementing this program as a key way to meet the City's long--term water supply needs.
- **Policies ICS-11.2 and ICS-11.7** encourage the City to continue its promotion of a variety of water conservation measures (including landscaping and low--flow fixtures) as part of all future development.
- **Policy ICS-11.6 "(Sustainability of Groundwater)"** calls for the continued support of the various policies of the local groundwater management agency and **Policy ICS-11.9 "(Groundwater Extractions)"** calls for ~~the~~ continued adherence to the Ventura County Regional Water Quality Planning Program's recommendations regarding groundwater quality and extractions.
- **Policy ICS-11.12 "(Water for Irrigation")** encourages the use of non-potable water supplies for landscape irrigation.
- **Policy ICS-11.10 "(Water Supply Assessment for All Projects")** requires the preparation of water supply studies prior to the approval of future development projects.
- **Implementation Measure #No. 59** requires the City to maintain and periodically update water, wastewater, and drainage infrastructure master plans to ensure that sufficient levels of infrastructure are planned for and financed in the City.

The General Plan does not contain ~~any specific~~ water supply assumptions that would conflict with the sustainable management criteria or the projects and management actions proposed in this GSP. ~~Instead, t~~The City ~~of Oxnard's~~ General Plan recognizes the existing constraints water resources ~~present~~that exist in supporting future development, as evidenced through its various policies encouraging development of alternative water supplies, promoting conservation– and use of non-potable water~~strategies~~, and requiring completion of water supply assessments ~~as a precondition to approving future development~~for all projects prior to approval. In addition, the City has a net-zero policy on new development, which requires a proposed development to provide their groundwater allocation to the City (subject to FCGMA approval) or contribute to City programs designed to offset potable water use. The General Plan also includes policies that promote redevelopment of old and/or blighted areas, development of mixed-use urban villages, and/or expansion of existing business and attraction of new business. Such development and investments would undoubtedly require additional water resources to support, and implementation of this GSP is likely to increase existing limitations on water availability. However, as discussed in detail in Section 1.4.3, (Operational Flexibility Limitations) as well asand Chapter 5 (Projects and Management Actions) of the FCGMA, the City of Oxnard, and other jurisdictions within the Oxnard Plain continue to implement projects that increase operational flexibility within the Oxnard Subbasin.

Naval Base Ventura County

Naval Base Ventura County (NBVC) is composed of three main operating areas (Point Mugu, Port Hueneme, and San Nicolas Island) and eight special areas. NBVC Point Mugu is located in unincorporated Ventura County, and NBVC Port Hueneme is located in the City of Port Hueneme. NBVC plays a vital role in national security missions, supporting approximately 80 tenant commands and over 20,000 direct, indirect, and induced jobs within Ventura County. Water sustainability is critical to military sustainability, resiliency, and compatibility. NBVC's primary water supply is groundwater extracted from the Forebay by UWCD, blended with imported water from the CMWD, and delivered to NBVC Port Hueneme and NBVC Point Mugu via the Oxnard Hueneme Pipeline, contracted through and in partnership with the Port Hueneme Water Agency. NBVC also operates one groundwater well on Port Hueneme with limited pumping, listed as a back-up drinking water source, and used primarily for landscaping and water system operations. NBVC groundwater use currently represents approximately 1 percent of groundwater pumped in the Oxnard Subbasin and Pleasant Valley Basin.

The Channel Islands Air National Guard Station (ANGS) shares the airfield with NBVC Point Mugu, but is housed on property owned by the United States Air Force and is located in unincorporated Ventura County. Channel Islands ANGS supports missions for both the Federal government and the State of California. Channel Islands ANGS is supported by two water sources; a groundwater well, permitted through the County of Ventura, which is used for irrigation only; and a potable water pipeline that is part of the NBVC groundwater pipeline. All permitting, reporting and other requirements are provided as a matter of comity and in support of good water management.

The SGMA provides that the federal government, appreciating the shared interest in assuring the sustainability of groundwater resources, may voluntarily agree to participate in the preparation or administration of a groundwater sustainability plan, per Water Code Section 10720.3.

Recognizing this shared interest, NBVC has voluntarily engaged in the development of the GSP for the Oxnard Subbasin by FCGMA.

While welcoming federal government participation, SGMA recognizes Federal Reserve Water Rights (FRWR) as distinct from those water rights based in state law and directs that Federal Reserve Water Rights be respected in full, and in case of any conflict between federal and state law, federal law shall prevail. Water Code § 10720.3(d). SGMA also directs that the groundwater sustainability agency consider the interests of all beneficial uses and users of groundwater, listing the federal government, including, but not limited to, the military and managers of federal lands among those interests. Water Code § 10723.2.

Under U.S. Supreme Court case law defining the FRWR, federal agencies have an implied right to water to support the primary mission for which Congress and the Federal government have designated that land, including a provision of water for growth to support that mission.[4] It is well established in the Supremacy Clause of the U.S Constitution, Article VI, Clause 2, that the Federal Government is not subject to state regulation, unless Congress clearly and unambiguously waives this sovereign immunity.

Consistent with its proactive and cooperative engagement with FCGMA, NBVC has a vested interest in participating in the SGMA effort to support a groundwater basin that achieves a sustainable yield. NBVC may voluntarily agree to an allocation under the GSP less than its full FRWR. In recognition and acknowledgment of the limits on FCGMA to regulate the federal government, any such allocation shall be directly assigned to the federal agency and shall not be subject to the requirements of any allocation ordinance, including but not limited to allocation carryovers, borrowing, transfers, reductions and/or variances and fees.

Although not subject to formal regulation under SGMA, NBVC is committed to being a good steward of water resources and to exploring partnerships that help to achieve groundwater sustainability, including projects that benefit both the Navy and the community.

Naval Base Ventura County Joint Land Use Study

The NBVC prepared a Joint Land Use Study that includes a discussion of water supply and potential impacts to Naval Base Ventura County water quality and quantity (NBVC 2015). This report, which was prepared in cooperation with the Cities of Camarillo, Oxnard, and Port Hueneme and the County of Ventura, identifies saltwater intrusion and impacts to storm drain flows as potential concerns for adequate supplies of good quality water to Naval Base Ventura County. To

[4] The FRWR was first recognized by the U.S. Supreme Court in the context of tribal interests (*See Winters v. United States*, 207 U.S. 564 5090 (1908)) and subsequently expanded to federal agencies (*See Cappaert v. United States*, 426 U.S. 128 (1976)), *Federal Power Commission v. Oregon*, 349 US 435 (1955)).

avoid these potential impacts, the Joint Land Use Study suggests coordination with the FCGMA GSP efforts (NBVC 2015).

1.7 WELL PERMITTING POLICIES AND PROCEDURES

The three permitting agencies requiring well permits within FCGMA jurisdiction are FCGMA, Ventura County Public Works Agency, and the City of Oxnard. The FCGMA well permit requirements pertain to the entirety of FCGMA's jurisdiction. The Ventura County ordinances do not preclude or supplant any other agency requirements. To construct a well within the City of Oxnard, a permit is required from both FCGMA and the City of Oxnard.

Each well permitting agency, as a minimum standard, implements California's Water Well Standards, which include requirements to avoid sources of contamination or cross-contamination, proper sealing of the upper annular space (i.e., first 50 feet), disinfection of the well following construction work, use of appropriate casing material, and other requirements. The permitting agencies require wells to meet certain setback criteria (e.g., septic system setback) and specific construction and sealing requirements. In addition, well-drilling activities are required to reduce pollution to the maximum extent practicable using best management practices such as installing a sediment basin to contain runoff, using geotextile fabric to contain sediments and drilling mud, or eliminating the use of drilling foam.

The permitting agencies monitor and enforce these standards by requiring drilling contractors with a valid C-57 license to submit permit applications for the construction, modification, reconstruction (i.e., deepening), or destruction of any well within their jurisdiction. The processing and issuance of a water well permit is currently considered a ministerial action, meaning permits are issued to drillers meeting California Water Well Standards and County sealing requirements, and notwithstanding errors in the application. Certain circumstances, however, such as when installing a well could cause the spread of contaminants to uncontaminated water zones, may prevent FCGMA from issuing a well permit.

The passage of SB 252 added Article 5, Wells in Critically Overdrafted Groundwater Basins, to Chapter 10 of the California Water Code, requiring collection of specific information for water wells proposed in critically overdrafted groundwater basins. The provisions of SB 252 are effective until January 30, 2020.

1.7.1 FCGMA

Since its inception, FCGMA has implemented multiple ordinances and policies related to the extraction and use of groundwater. FGMA did not impose a permit requirement for the Oxnard Subbasin until 2010 (Ordinance 8.2). A complete list of historical policies and ordinances is kept and updated on the FCGMA website (FCGMA 2019c). Those currently pertaining to well permits are described here.

Emergency Ordinance E, adopted April 11, 2014, in response to severe drought, declining water levels, and seawater intrusion, prohibits the issuance of permits for new groundwater wells associated with new or increased groundwater use, and limits extractions from existing wells (FCGMA 2014b). The ordinance limits groundwater extractions for M&I and agricultural users.

Ordinance E temporarily replaced the then-in-use allocation systems (HA and Baseline Allocation [BA]) for M&I well operators with a Temporary Extraction Allocation that uses average annual extractions from the base period 2003 to 2012. The ordinance sets a series of allocation reductions from the base amount to take effect beginning July 1, 2014, with a 10% reduction. The ordinance requires an additional 5% reduction every 6 months through January 2016, resulting in a total reduction of 20%.

Ordinance E requires all agricultural well operators to apply for a 25% reduced Efficiency Allocation. An Efficiency Allocation is based on a well operator demonstrating that water used for agriculturally developed land is at least 80% efficient (FCGMA 2011, Resolution No. 2011-04). Ordinance E also contains provisions for the FCGMA Board to undertake additional adjustments to irrigation allowances by resolution.

Under Emergency Ordinance E, accounts that are solely associated with domestic wells operate well(s) using a 25% reduced HA (also known as an Adjusted Historical Allocation [AHA]) and/or a BA. An HA is an average of annual extractions from the base period 1985 to 1989. A BA is associated with a parcel and is based on new development after the close of the HA base period.

Since 1983, FCGMA ordinances have required registration of wells, reporting of extractions, and payment of pumping fees. Currently, the FCGMA Ordinance Code continues these requirements. Additionally, the code (Chapter 2) requires that permits be obtained from FCGMA for new wells prior to construction. For wells installed within the FCGMA area, the applicant must subsequently obtain a permit from the Ventura County Public Works Agency or the City of Oxnard if within the City's jurisdiction. The FCGMA Ordinance Code requires the installation and maintenance of flow meters, providing proof of flowmeter accuracy, and reporting of all extractions semi-annually (Table 1-11). In 2018, FCGMA adopted an ordinance that will require all wells within the Agency to be equipped with advanced metering infrastructure telemetry by October 1, 2020.

1.7.2 Ventura County

The ordinances relating to groundwater wells in Ventura County are contained in Ventura County Ordinances, Division 4, Chapter 8, Water, Article 1 – Groundwater Conservation, Sections 4811–4828 (County of Ventura 2016). These ordinances regulate the construction, maintenance, operation, modification, and destruction of groundwater wells. Ventura County requires well permits for any construction, modification, replacement, repair, or destruction of wells. Permit requirements include "information as the Agency may deem necessary in order to determine whether underground waters will be protected" (County of Ventura 2016, Chapter 8, 4813, C8). Ventura County requires that a well permit application from FCGMA be completed and authorized prior to consideration for a Ventura County permit. Ventura County well construction or destruction activity standards are required to comply with the DWR Well Standards Bulletins Nos. 74-81 and 74-90. New water wells must be equipped with a flow meter and calibrated every 3 years; however, de minimis extractors (those producing less than 2 AFY) are exempt from this requirement. Completion logs are required for all wells, and geophysical logs are required where necessary to prevent cross contamination of pumping zones.

Section 4826 pertains to the Aquifer Protection Program, the purpose of which is to require destruction or repair of wells that are causing groundwater pollution. The provision requires annual reporting of water extractions, time of operation, static water levels, and pump test data if available. Based on these data, all wells are classified with regard to location and operational condition.

Due to pervasive drought conditions, as of October 28, 2014, Section 4826.1 prohibited the construction of new wells within the unincorporated area of Ventura County except under specific circumstances. With the initiation of SGMA, the ordinance was modified to include only basins designated as high or medium priority by DWR, which includes all of the FCGMA basins in the Oxnard Subbasin except the Arroyo Santa Rosa Valley Basin.

1.7.3 City of Oxnard

Chapter 22, Article VII, of the Oxnard City Code includes requirements for the construction, repair, modification, and destruction of wells. The City of Oxnard requires a fee and permit for the construction of water wells. Notable among the permit requirements is a statement confirming that the aquifers underlying the City of Oxnard are no longer in a state of overdraft. Applications for new wells require a public hearing and are considered by City Council (Oxnard City Code, Section 22-101). Permits are also required for the repair, modification, or destruction of existing wells.

1.7.43 Additional Well Permitting Policies and Procedures

In addition to State of California, County of Ventura, and FCGMA well permitting policies and procedures, a permit in the form of a well agreement with the City of Ventura is required to construct a well within the City of Ventura's jurisdictional boundary.

1.8 NOTIFICATION AND COMMUNICATION

1.8.1 Notification and Communication Summary

Notification and communication regarding the development of the Oxnard Subbasin GSP takes place in the following four key phases:

1. Initial Notification
2. GSP Development
3. Draft GSP Review and Comment
4. GSP Implementation

The Initial Notification was completed with the FCGMA submittal of the Notice of Intent on February 24, 2017, to the DWR to develop a GSP for the Oxnard Subbasin. The GSP Development phase included extensive outreach and engagement with the stakeholders, including beneficial users, as described in more detail in Section 1.8.3, Public Meetings Summary, and Section 1.8.6, Communication.

The Draft GSP Review and Comment phase will include the formal public comment period for the Draft GSP and response to comments, as discussed in Section 1.8.4, Summary of Comments and Responses. The GSP Implementation notification and communication period will begin once FCGMA submits the final GSP to DWR and will include engagement with the public and beneficial users regarding the progress of monitoring and reporting updates on the GSP to DWR, establishment of fees, and the development and implementation of management strategies, including projects as needed.

1.8.2 Summary of Beneficial Uses and Users

Beneficial uses of groundwater from the Oxnard Subbasin include agricultural, M&I, ~~urban,~~ and environmental uses. As discussed in Section 1.3.2.3, Historical, Current, and Projected Land Use, land use on the Oxnard Plain is 47% agriculture, 47% urban, and 6% open space. Of the groundwater produced from the UAS and the LAS, approximately 60% is used for agriculture and the remaining 40% is used for M&I and urban uses. GDEs are the primary environmental users of groundwater in the Subbasin. The GDEs are connected to the semi-perched aquifer, which is separated from the underlying UAS by a clay layer throughout much of the Oxnard Subbasin, and from which there is limited groundwater production.

Beneficial users of groundwater and property interests potentially affected by the use of groundwater are described in the following paragraphs.

Surface Water Users. The primary surface water users within the Oxnard Subbasin are UWCD and CWD, which both operate conjunctive-use programs. The interests of UWCD and CWD are represented on the FCGMA Board, as discussed in Section 1.2.3, Organization and Management Structure. Consultation with UWCD and CWD staff has occurred formally and informally throughout the development of the GSP, including participation in public meetings and the Technical Advisory Group (TAG). UWCD has also contributed data from their monitoring programs. There are also environmental uses of surface water, as discussed in this section under Environmental Users. All identified surface water users in the Oxnard Subbasin were added to the interested parties list that is sent monthly electronic newsletters and meeting notices regarding the status of the GSP.

Municipal Well Operators and Public and Private Water Purveyors. There are over 40 public and private water purveyors in the Oxnard Plain, as shown on Figure 1-8. A detailed description of each purveyor is included in the VCWPD Inventory of Public and Private Water Purveyors (2006). All of the purveyors in the Oxnard Plain, including all municipal well operators, are supplied water by either UWCD or CMWD. The interests of both UWCD and CMWD are represented on the FCGMA Board, as previously discussed in Section 1.2.3. Staff from both UWCD and CMWD have provided groundwater monitoring data, have participated in public meetings, and regularly collaborate with FCGMA staff. The Cities of Oxnard and Port Hueneme also have direct representation on the FCGMA Board by the representative appointed to serve on behalf of the five incorporated cities within FCGMA jurisdiction. Several of the smaller water districts and mutuals have also participated in FCGMA public meetings and provided comments throughout the development of the GSP.

Agricultural Users. Agricultural users have been identified as key stakeholders since the creation of FCGMA in 1982 and have direct representation through one of five members on the FCGMA Board. The primary crops grown in the Oxnard Plain are strawberries, raspberries, celery, peppers, beans, cabbage, lettuce, spinach, kale, cut flowers, and nursery stock. Agricultural user interests are represented within the Oxnard Plain by the Ventura County Agricultural Commissioner, the Ventura County Farm Bureau, individual pumpers, and groups of pumpers that have organized to advocate for their interests during the GSP development process. The FCGMA Board directed staff to work with pumpers' groups on the development of proposed allocation systems that will be brought before the FCGMA Board for consideration. FCGMA maintains a database of well owners, including agricultural well owners. Email addresses in the database have been added to the list of interested parties who receive electronic newsletters regarding the status and development of the Oxnard Subbasin GSP.

Domestic Users. The majority of domestic groundwater users in the Subbasin are supplied water from a city, special district, or mutual water company. FCGMA maintains a database of well owners, including domestic well owners. Email addresses in the database have been added to the list of interested parties who receive electronic newsletters regarding the status and development of the Subbasin GSP.

Local Land Use Planning Agencies. FCGMA staff members have reached out to all local land use planning agencies with jurisdiction over the Oxnard Plain, including the County of Ventura, the City of Oxnard, and the City of Port Hueneme. The County of Ventura holds one of five seats on the FCGMA Board. The FCGMA Board also has a member appointed to represent the five incorporated cities, including the cities of Oxnard and Port Hueneme. As discussed in Section 1.6, Land Use Elements or Topic Categories of Applicable General Plans, FCGMA has established working relationships with the land use planning agencies. FCGMA staff has participated on the Ventura County General Plan Update Water Element Focus Group and continues to work with Ventura County planning staff to ensure that the GSP and General Plan Update are consistent.

Environmental Users. Environmental users of groundwater are concentrated in the four GDEs and two potential GDEs described further in Section 2.3.7, Groundwater-Dependent Ecosystems. These GDEs include aquatic habitat, in-channel wetlands, riparian forest, and coastal marshes. FCGMA has taken steps to incorporate the interests of environmental users in the development of the GSP through appointing an environmental representative to the TAG. The TAG held a special meeting focusing on potential groundwater-dependent ecosystems and accepted comments from the public on the potential impacts to surface water bodies. There are several non-governmental organizations with missions associated with environmental water uses on the list of interested parties who receive electronic newsletters regarding the status and development of the Oxnard Subbasin GSP.

The Federal Government. As discussed in Section 1.3.2.3, the federal government is a landowner and groundwater user in the Oxnard Basin through the Naval Base Ventura County. Representatives from the U.S. Navy have been coordinating with FCGMA staff regarding the development of the GSP, have participated in FCGMA public meetings, and are on the list of interested parties who receive electronic newsletters regarding the status and development of the Oxnard Subbasin GSP.

California Native American Tribes. According to the U.S. Bureau of Indian Affairs California Tribal Homelands and Trust Land Map, updated in 2011 and available from the DWR website, the entire Oxnard Subbasin is within the Chumash Tribal/Cultural area. There are not currently any federally recognized Indian Tribes, Indian land currently or historically held in trust by the U.S. government, or smaller Reservation or Rancheria areas in the Oxnard Plain. FCGMA recognizes that the Chumash culture and associated cultural resources are important in Ventura County. Several active local groups and individuals representing the interests of tribal communities in Ventura County have been added to the list of interested parties, including representatives from the Barbareno/Ventureno Band of Mission Indians (Chumash) and the Wishtoyo Chumash Foundation. FCGMA has reached out to the DWR Southern Region Office Tribal Liaison, Jennifer Wong, and added her to the list of interested parties. The San Gabriel Band of Mission Indians has also shown an interest in the groundwater sustainability planning process and has been added to the list of interested parties.

Disadvantaged Communities. The majority of the Disadvantaged Communities (DACs) within the Oxnard Plain receive water from cities, special districts, or mutual water companies. FCGMA works closely with these water agencies and mutuals that represent the interests of the DACs. The

Watersheds Coalition of Ventura County has established a DAC Involvement Committee to discuss DAC needs and project opportunities related to Integrated Regional Water Management. FCGMA staff participates in the DAC Involvement Committee. Representatives from Integrated Regional Water Management and the DAC Involvement Committee have participated in FCGMA public meetings and are on the list of interested parties who receive electronic newsletters regarding the status and development of the Subbasin GSP.

1.8.3 Public Meetings Summary

FCGMA has been discussing the development of a GSP since March 2015. Table 1-12 lists the FCGMA public meetings in which the participants discussed or took action on the Subbasin GSP. Note that the list will be updated as additional meetings occur.

1.8.4 Summary of Comments and Responses

The FCGMA Board approved release of a Preliminary Draft GSP in January 2018, with a 90-day comment period. An evening public workshop was held on February 8, 2018, to present the Preliminary Draft GSP, answer questions, and solicit comments. Formal comments were accepted in writing only. The comments were submitted in person at the public workshop and electronically via email to fcgma-gsp@ventura.org. A total of 32 comment letters were received by FCGMA on all three GSPs. A summary of the comments was presented to the FCGMA Board at the May 23, 2018, meeting. In consideration of these comments, FCGMA completed an independent peer review of the numerical groundwater models, completed additional analysis for the water quality approach, and extended the timeline for completion of the GSP. Comments on the Preliminary Draft GSP and direction from the FCGMA Board after consideration of public comments have been incorporated in the Draft GSP.

Before completing the Draft GSP, additional information was made available to the public to enhance understanding of the technical information and processes used for the development of the Draft GSP. The following documents were posted on the FCGMA website, discussed in public FCGMA meetings, and sent to the list of interested parties in electronic newsletters:

- Minimum Thresholds and Measurable Objectives Data, March 2019
- Peer Review of the United Water Conservation District and Calleguas Municipal Water District Models for the Oxnard Subbasin, Pleasant Valley Basin, and Las Posas Valley Basin, March 2019
- Approach for GSP Modeling of Future Conditions in the Oxnard Subbasin, Pleasant Valley Basin and Las Posas Valley Basin, January 2019

- Minimum Thresholds and Measurable Objectives in the Las Posas Valley Basin, Oxnard Subbasin, and Pleasant Valley Basin, January 2019
- Assessing the Sustainable Yield of the Oxnard Subbasin, Pleasant Valley Basin, and Las Posas Valley Basin, January 2019

A public workshop was held on March 15, 2019, to discuss the estimated sustainable yield, minimum thresholds, and measurable objectives proposed for the Draft GSP. Comments received at the public workshop have beenwere incorporated into this the Draft GSP. After theThe Draft GSP is was approved by the FCGMA Board, and released for a 60-day public comment period will be openedon July 29, 2019, during which time FCGMA will solicited formal comments on the Draft GSP.

Before completing this Final GSP, the public comments received on the Draft GSP were reviewed and where appropriate incorporated into this Final GSP. Public comments on the Draft GSP are included in Appendix A.

1.8.5 Summary of Initial Information on Relationships between State and Federal Regulatory Agencies

FCGMA has not entered into any formal agreements with the federal government regarding preparation or administration of this GSP or groundwater management pursuant to SGMA, Section 10720.3(c). The U.S. Navy is a current beneficial user of water within the Subbasin and has initiated informal coordination with FCGMA staff, including a presentation to the FCGMA Board on May 24, 2017, detailing the Navy's interests and operations related to water use within the FCGMA boundaries. There are no federally recognized Indian Tribes within the Subbasin boundaries.

FCGMA recognizes the need for both formal and informal consultation with state and federal regulatory agencies throughout the implementation of the GSP. FCGMA received a formal request from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) on October 11, 2016, to be added to the list of interested parties for the development of the GSP. FCGMA has added National Marine Fisheries Service NMFS to the list of interested parties, as well as the following state and federal regulatory agencies:

- Los Angeles Regional Water Quality Control Board
- U.S. Fish and Wildlife Service
- California Department of Fish and Wildlife
- California Department of Water Resources

1.8.6 Communication

A public outreach and engagement plan was developed for all of the GSPs that FCGMA is developing (included as Appendix B to this GSP). The purpose of the public outreach and engagement plan was to create a common understanding and transparency throughout the groundwater sustainability planning process, including fulfilling the requirements of SGMA as described in DWR 2016b, Section 354.10.d. The public outreach and engagement plan discusses the FCGMA decision-making process; identifies opportunities for public engagement and provides a discussion of how public input and response will be used; describes how FCGMA encourages the active involvement of diverse social, cultural, and economic elements of the population within the Subbasin; and describes the method FCGMA shall follow to inform the public about progress implementing the public outreach and engagement plan, including the status of projects and actions.

FCGMA has provided ongoing and innovative opportunities for stakeholders to engage in the GSP development process. FCGMA has provided regular updates to interested parties through monthly electronic newsletters highlighting monthly progress on the GSP development, upcoming meetings, and opportunities for engagement. Monthly updates and opportunities for public comment were provided at FCGMA Regular Board Meetings, FCGMA Special Board Meetings, and TAG Meetings. Meeting agendas and minutes, as well as video recordings of all FCGMA Board Meetings and Workshops, were made available on the FCGMA website. Additional technical information about the GSP development was made available on the FCGMA website including the Preliminary Draft GSP, Technical Memoranda, and TAG Meeting Materials. The Preliminary Draft GSP was available online for more than 120 days, including an official 90-day public comment period. FCGMA encouraged active participation from stakeholders through four public workshops (November 15, 2016; September 20, 2017; February 8, 2019; and March 15, 2019), a survey for input on sustainability indicators, and a public call for project ideas for incorporation into the GSP.

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Table 1-1
Estimate of Project Cost and Water Supply for First 5 Years

Proposed Project	Estimated Annual Costs	Estimated Acre-Feet of Water	Estimated Cost per Acre-Foot
Oxnard Groundwater Recovery Enhancement and Treatment Program Advanced Water Purification Facility	$7,000,000	2,000	$3,500
RiverPark–Saticoy Groundwater Replenishment Reuse Project Recycled Water Project	$6,885,000	4,500	$1,530
Freeman Diversion Expansion	$6,426,000	7,400	$870
Temporary Land Fallowing	$954,000	530	$1,800
Total	$21,265,000	14,430	—

Table 1-2
Groundwater Sustainability Plan Estimated Implementation Cost through 2040

Fiscal Year	Operations and Monitoring Costs	Management, Administration and Other Costs	5-Year GSP Evaluation[a]	10% Contingency	Total[b]
2020	$1,000,000	$1,455,000	$300,000	$275,500	$3,030,500
2021	$1,028,000	$1,495,740	$308,400	$283,214	$3,115,354
2022	$1,056,784	$1,537,621	$317,035	$291,144	$3,202,584
2023	$1,086,374	$1,580,674	$325,912	$299,296	$3,292,256
2024	$1,116,792	$1,624,933	$335,038	$307,676	$3,384,439
2025	$1,148,063	$1,670,431	$114,806	$293,330	$3,226,630
2026	$1,180,208	$1,717,203	$118,021	$301,543	$3,316,976
2027	$1,213,254	$1,765,285	$121,325	$309,986	$3,409,851
2028	$1,247,225	$1,814,713	$124,723	$318,666	$3,505,327
2029	$1,282,148	$1,865,525	$128,215	$327,589	$3,603,476
2030	$1,318,048	$1,917,759	$65,902	$330,171	$3,631,881
2031	$1,354,953	$1,971,457	$67,748	$339,416	$3,733,573
2032	$1,392,892	$2,026,658	$69,645	$348,919	$3,838,113
2033	$1,431,893	$2,083,404	$71,595	$358,689	$3,945,581
2034	$1,471,986	$2,141,739	$147,199	$376,092	$4,137,016
2035	$1,513,201	$2,201,708	$75,660	$379,057	$4,169,626
2036	$1,555,571	$2,263,356	$77,779	$389,671	$4,286,376
2037	$1,599,127	$2,326,730	$79,956	$400,581	$4,406,394
2038	$1,643,903	$2,391,878	$82,195	$411,798	$4,529,773
2039	$1,689,932	$2,458,851	$168,993	$431,778	$4,749,553
2040	$1,737,250	$2,527,699	$86,862	$435,181	$4,786,992
Total[b]	$28,067,603	$40,838,363	$3,187,009	$7,209,297	$79,302,272

Notes: GSP = Groundwater Sustainability Plan.
Costs are in 2020 dollars.

[a] The 5-year update costs include costs for the Oxnard Subbasin as well as the PVB and LPVB, for which FCGMA is the GSA.
[b] Amounts may not sum precisely due to rounding.

Table 1-3
Groundwater Sustainability Agencies in the Oxnard Subbasin

GSA Name	Total Area of GSA (Acres)	% of GSA area within Oxnard Subbasin	Acres Wwithin Oxnard Subbasin	% of Oxnard Subbasin
Fox Canyon Groundwater Management Area	117,280	46.0	53,941	94.1
Camrosa OPV Management Area (Camrosa Water District—Oxnard Subbasin)	3,880	4.4	171	0.3
Oxnard Subbasin Outlying Areas (Ventura County)	3,236	100	3,236	5.6
		Total	57,348	100

Notes: GSA = Groundwater Sustainability Agency; OPV = Oxnard Subbasin–Pleasant Valley Basin.

Table 1-4
Summary of Land Ownership in the Oxnard Subbasin

Ownership	Jurisdiction	Description	Acres within Subbasin	% of Total
Private Land				
Private	County of Ventura	Privately owned land under County jurisdiction, largely agriculture and open space.	31,825	55.5%
Private	City of Oxnard	Privately owned land under municipal jurisdiction, largely consisting of urban development.	15,959	27.8%
Private	Port Hueneme	Privately owned land under municipal jurisdiction, largely consisting of urban development.	1,134	2.0%
Private	City of Ventura	South edge of the City consisting of an office park/warehouse/retail/commercial district (water served by Ventura Water DistrictDepartment)	407	0.7%
Private	City of Camarillo	Consists of the western end of the Camarillo Airport and part of a commercial+mobile/pre-fab home subdivision	281	0.5%
		Subtotal (Private Land)	*49,606*	*86.5%*
Public Land				
Municipal	City of Oxnard, City of Ventura, City of Camarillo, Port Hueneme	Parks, and/or Golf Courses (Buenaventura Golf Course uses recycled water for irrigation)	663	1.2%
County	County of Ventura	Mandalay County Park	8	0.01%
State	California Department of Park and Recreation, California State University, California Department of Corrections and Rehabilitation	State Beaches (McGrath State Beach, Mandalay State Beach), California State University Channel Islands, Ventura Youth Correctional Facility	230	0.4%

Table 1-4
Summary of Land Ownership in the Oxnard Subbasin

Ownership	Jurisdiction	Description	Acres within Subbasin	% of Total
Federal	U.S. Navy	Naval Base Ventura County (Naval Construction Battalion Center Port Hueneme and Point Mugu Naval Air Station)	6,046	10.5%
Non-Profit	The Nature Conservancy	Lower Santa Clara River / Ormond Beach	795	1.4%
		Subtotal (Public Land)	*7,742*	*13.5%*
		Total	57,348	100%

Table 1-5
Oxnard Plain Stream Gauge Information

Station Number	Station Name	Record Start	Record End	Active?	Latitude	Longitude	Elevation (ft msl)	Station Type
Santa Clara River								
708	Santa Clara River at Montalvo Highway 101	1927	1993	No	34.241944	−119.189	70	Recording Stream Gauge
708A	Santa Clara River at Saticoy Highway 118	1967	2004	No	34.278889	−119.141	105	Recording Stream Gauge
723	Santa Clara River at Victoria Avenue	2007	N/A	Yes	34.234917	−119.217	62	Recording Stream Gauge
724	Santa Clara River at Freeman Diversion	2004	2005	No	34.299222	−119.108	161	Recording Stream Gauge
Revolon Slough Watershed								
776	Revolon Slough at Laguna Road	1979	2006	No	34.176072	−119.100	11	Recording Stream Gauge
776A	Revolon Slough at Pleasant Valley Road	2005	N/A	Yes	34.192592	−119.108	20	Recording Stream Gauge
780	Beardsley Wash at Central Avenue	1993	N/A	Yes	34.2305	−119.112	60	Recording Stream Gauge
782	Las Posas Estates Drain	1999	2008	No	34.230816	−119.106	76	Recording Stream Gauge
Calleguas Creek								
805	Calleguas Creek at California State University Channel Islands	1968	N/A	Yes	34.179028	−119.040	58	Recording Stream Gauge

Sources: VCWPD 2009, 2016.
Notes: ft msl = feet above mean sea level. N/A = not applicable, because gauge is active.

Table 1-6
Oxnard Plain Precipitation Station Information

Station Number	Station Name	Record Start	Record End	Active?	Latitude	Longitude	Elevation (ft msl)	Station Type	Mean Annual Rainfall (inches) for Period of Record
017	Hueneme Lighthouse near Port Hueneme	1890	1972	No	34.143333	−119.21	10	Standard Precipitation	13.4
017A	Port Hueneme–U.S. Navy	1972	1982	No	34.146389	−119.205	10	Standard Precipitation	15.6
017B	Port Hueneme–U.S. Navy	1982	1996	No	34.146389	−119.204	10	Standard Precipitation	14.9
017C	Port Hueneme–Oxnard Sewer Plant	1996	N/A	Yes	34.141684	−119.187	10	Recording Precipitation Gauge	11.4
032	Oxnard–Water Department	1902	2003	No	34.201389	−119.175	53	Standard Precipitation	14.7
032A	Oxnard Civic Center	2003	N/A	Yes	34.200087	−119.18	53	Recording Precipitation Gauge	10.0
168	Oxnard Airport	1956	N/A	Yes	34.201647	−119.208	34	Recording Precipitation Gauge	14.1
156	Oxnard CIMIS Station	2001	N/A	Yes	34.2233639	−119.196920	77	CIMIS Station	12.4
177	Camarillo–Pacific Sod	1956	2004	No	34.156446	−119.079	20	Standard Precipitation	12.7
177A	Camarillo–Pacific Sod	2004	N/A	Yes	34.155471	−119.073	20	Recording Precipitation Gauge	9.9
215	Channel Islands Harbor	1963	N/A	Yes	34.162042	−119.223	5	Standard Precipitation	13.4
215A	Channel Islands Harbor–Kiddie Beach	2015	N/A	Yes	34.158944	−119.222	15	Recording Precipitation Gauge	2.5
223	Point Mugu–U.S. Navy	1946	1976	No	34.118333	−119.107	5	Standard Precipitation Midnight	10.0
223A	Point Mugu–U.S. Navy	1976	N/A	Yes	34.112778	−119.119	12	Standard Precipitation Midnight	13.8
231	El Rio–County Yard	1966	2006	No	34.241111	−119.177	79	Standard Precipitation	16.7
231A	El Rio–Riverpark	2006	2008	No	34.245417	−119.181	Unknown (near sea level)	Recording Precipitation Gauge	8.8

Table 1-6
Oxnard Plain Precipitation Station Information

Station Number	Station Name	Record Start	Record End	Active?	Latitude	Longitude	Elevation (ft msl)	Station Type	Mean Annual Rainfall (inches) for Period of Record
239	El Rio–UWCD Spreading Grounds	1972	N/A	Yes	34.239405	−119.153	105	Recording Precipitation Gauge	15.2
257	Oxnard South–Vance	1979	1989	No	34.171944	−119.192	27	Standard Precipitation	15.7
261	Saticoy–Recharge Facility	1984	N/A	Yes	34.278889	−119.123	145	Standard Precipitation	16.0
267	Ormond Beach–Occidental Chemical	1989	1993	No	34.140556	−119.171	10	Standard Precipitation	14.1
273A	Oxnard NWS	2010	N/A	Yes	34.207207	−119.137	63	National Weather Service Site	8.6
403	Silverstrand Alert (Type B)	2008	N/A	Yes	34.15271	−119.219	18	Non-Standard Recorder	8.2
412	El Rio–Mesa School APCD	2012	N/A	Yes	34.252361	−119.143	131	Recording Precipitation Gauge	6.7
503	Oxnard Plain–Laguna Road (Type B)	2008	2010	No	34.176072	−119.1	28	Non-Standard Recorder	6.6

Notes: APCD = Air Pollution Control District; CIMIS = California Irrigation Management Information System; ft msl = feet above mean sea level; N/A = not applicable, because gauge is active; NWS = National Weather Service; UWCD = United Water Conservation District.

Table 1-7
Drought Periods in the Oxnard Plain

Drought Period	Duration (years)	Cumulative Deficit (inches)
1918–1936	18	−47.2
1944–1951	7	−31.5
1958–1964	6	−25.2
1969–1977	8	−24.8
1986–1991	5	−25.1
2011–2016	5	−27.7

Table 1-8
Past and Present Land Uses within the Oxnard Plain, 1990–2015

Land Use Category	1990		1993		2001		2005		2015	
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*
Agriculture										
Orchards and Vineyards	4,863	8%	5,088	9%	4,438	8%	2,491	4%	—	—
Cropland and Improved Pasture Land	23,080	40%	22,921	40%	21,917	38%	22,188	39%	—	—
Nurseries	698	1%	743	1%	1,343	2%	1,677	3%	—	—
Horse Ranches	9	0%	9	0%	5	0%	8	0%	—	—
Other Agriculture	252	0%	245	0%	271	0%	265	0%	—	—
Dairy/Livestock	66	0%	66	0%	37	0%	25	0%	—	—
Total	28,969	51%	29,073	51%	28,011	49%	26,654	47%	26,636	47%
Vacant/Open Space										
~~Vacant~~Open Space	5,070	9%	4,713	8%	4,247	7%	4,007	7%	—	—
Water	358	1%	472	1%	461	1%	533	1%	—	—
Total	5,429	9%	5,185	9%	4,707	8%	4,540	8%	3,662	6%
Urban/Built-Up										
Residential	8,061	14%	8,211	14%	8,810	15%	9,339	16%	—	—
Mixed Commercial and Industrial	2,399	4%	2,340	4%	2,403	4%	3,156	6%	—	—
Commercial and Services	8,136	14%	8,277	14%	8,556	15%	8,795	15%	—	—
Industrial	1,977	3%	1,835	3%	2,083	4%	2,111	4%	—	—
Transportation, Communication, and Utilities	2,335	4%	2,384	4%	2,734	5%	2,695	5%	—	—
Total	22,907	40%	23,047	40%	24,586	43%	26,096	46%	26,542	47%

Sources: SCAG 2005 (for 1990–2005); VCPD 2015 (for 2015).
Notes: Acres and percentages are rounded to the nearest whole number. The land use data for 2015 is based on the Ventura County General Plan land use map (VCPD 2015), which has a lower geographic resolution and uses fewer land use categories than data provided by SCAG for prior years; therefore, only the total amounts/percentages for the larger land use categories are provided for 2015.
The Naval Base Ventura County is primarily included in the "Commercial and Services" category.

Table 1-9
Past, Current, and Projected Population for Ventura County, the Cities of Oxnard and Port Hueneme, and the Oxnard Plain

Population	1990	2000	2010	2012	2015	2040
Ventura County	669,016	756,902	825,378	833,000	853,188	965,210
Oxnard	142,216	170,358	197,899	200,100	—206,908	237,300
Port Hueneme	20,322	21,845	21,723	21,800	22,399	22,400
Oxnard Plain	—	—	237,871	—	—	—

Sources: SCAG 2016 (for Ventura County 1990–2040, Oxnard 2012 and 2040, and Port Hueneme 1990–2012 and 2040); City of Oxnard 2011 (for Oxnard 1990–2010); City of Port Hueneme 2016a (Port Hueneme 2015); U.S. Census Bureau 2016 (Oxnard Plain 2010); U.S. Census Bureau 2015 (Oxnard 2015).
Note: — = not available or unknown.

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Table 1-10
Oxnard Subbasin Existing Water Resources Monitoring Programs

Program	Program Agency	Program Description	Parameter	Multi-Basin Program	Source	Link
Surface Water Monitoring Programs						
Ventura County Precipitation Monitoring	VCWPD	Collection of real-time and historical data from a network of precipitation gauges throughout Ventura County (approximately 22 within the Oxnard Subbasin). Data is available on the Web, along with some statistical reports. Gauge data are available in various time increments, depending on gauge type.	Precipitation	LPVB, PVB, ASRVB, Oxnard Subbasin	VCWPD. 2016. Hydrology Section Website. Accessed September 15, 2016.	http://vcwatershed.net/hydrodata/gmap.php?param=rain
Ventura County Streamflow Monitoring Program	VCWPD, in cooperation with USGS	Approximately 64 stream locations are monitored county wide (approximately 13 active and inactive gauges in the Oxnard Subbasin). Available data include average daily flow, event hydrographs, and peak flows.	Streamflow	LPVB, PVB, ASRVB, Oxnard Subbasin	VCWPD. 2016. Hydrology Section Website. Accessed September 15, 2016.	http://vcwatershed.net/hydrodata/gmap.php?param=rain
Ventura County Stream Gauging Program	USGS, UWCD	Approximately 64 stream locations are monitored county wide. Available data include average daily flow, event hydrographs, and peak flows.	Streamflow	Oxnard Subbasin, PVB	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 31).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Surface Water Quality Monitoring Program	UWCD	Monitoring of surface water quality at variable intervals. Parameters monitored include general minerals, temperature, and pH. Data are used to confirm that water quality is acceptable for groundwater recharge and agricultural irrigation.	Streamflow	Oxnard Subbasin, PVB	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 31).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Los Angeles Regional Water Quality Control Board Surface Water Quality Sampling	—	—	—	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 32).	—
Existing Groundwater Monitoring Programs						
California Statewide Groundwater Elevation Monitoring (CASGEM)	DWR program implemented by VCWPD	DWR-mandated program (Senate Bill X7-6) to track seasonal and long-term groundwater elevation trends.	Groundwater Elevation	LPVB, PVB, ASRVB, Oxnard Subbasin	DWR. 2016. California Statewide Groundwater Elevation Monitoring (CASGEM) Program. 2016. Accessed September 15, 2016.	http://www.water.ca.gov/groundwater/casgem/
Groundwater Ambient Monitoring and Assessment Program (GAMA)	SWRCB	SWRCB Program implemented in 2000 (modified by Assembly Bill 599 in 2001) to monitor and assess groundwater basins throughout the state.	Groundwater Quality	LPVB, PVB, ASRVB, Oxnard Subbasin	SWRCB. 2016. GAMA – Groundwater Ambient Monitoring and Assessment Program Website. Accessed September 22, 2016.	http://www.swrcb.ca.gov/gama/
Ventura County Groundwater Elevation Monitoring Program	VCWPD	Quarterly measurement of approximately 200 groundwater well elevations (approximately 38 within the Oxnard Subbasin) throughout Ventura County by VCWPD staff.	Groundwater Elevation	Oxnard Subbasin, LPVB, PVB, ASRVB	VCWPD. 2015. 2014 Annual Report of Groundwater Conditions (p. 12.)	http://pwaportal.ventura.org/WPD/docs/Groundwater-Resources/2014%20Annual%20Report-Web.pdf
Ventura County Groundwater Quality Monitoring Program	VCWPD	Approximately 150 wells sampled throughout the County (approximately 46 in the Oxnard Subbasin) and analyzed for general minerals and other constituents.	Groundwater Quality	Oxnard Subbasin, LPVB, PVB, ASRVB	VCWPD. 2015. 2014 Annual Report of Groundwater Conditions (p. 12).	http://pwaportal.ventura.org/WPD/docs/Groundwater-Resources/2014%20Annual%20Report-Web.pdf
UWCD Groundwater Quality Monitoring Program	UWCD	Measurement of groundwater water quality throughout the UWCD boundaries to comply with state standards for aesthetics and safety, monitor saltwater intrusion and saline migration, and track changes to water quality. Approximately 120 wells are sampled in the Oxnard Subbasin.	Groundwater Quality	Oxnard Subbasin, PVB	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 26).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
FCGMA Groundwater Extraction Reporting Program (1985)	FCGMA	Since 1985, FCGMA has collected extraction records from well operators on a semi-annual basis. Requirements include periodic calibration of meters.	Groundwater Extraction	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. 17).	http://www.fcgma.org/component/content/article/20-public-documents/plans/95-groundwater-management-plan

Table 1-10
Oxnard Subbasin Existing Water Resources Monitoring Programs

Program	Program Agency	Program Description	Parameter	Multi-Basin Program	Source	Link
Basin Management Objectives Monitoring	FCGMA	FCGMA has established a set of Basin Management Objectives that pertain to the overall health of the groundwater basins, including water levels and water quality. Each year, FCGMA publishes a report tracking the progress toward meeting the objectives.	Groundwater Conditions	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. iii).	http://www.fcgma.org/component/content/article/20-public-documents/plans/95-groundwater-management-plan
Other Existing Programs						
Ventura County Evaporation Monitoring	VCWPD	There is an evaporation gauge that records monthly evaporation from El Rio Spreading Grounds.	Evaporation	Oxnard Subbasin	VCWPD. 2016. Hydrology Section Website. Accessed September 15, 2016.	http://vcwatershed.net/hydrodata/gmap.php?param=rain
California Irrigation Management Information System (CIMIS)	DWR	CIMIS manages a network of over 145 automated weather stations in California.	Temperature, Precipitation, Evapo-transpiration	LPVB, PVB	CIMIS. 2018. CIMIS Data Website. Accessed January 15, 2018.	http://www.cimis.water.ca.gov
California Water Rights Permit 18908	UWCD, Water Rights Decision	Specifies conditions of release and diversion for habitat conservation.	Surface Water, Environmental	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 18).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Salt Nutrient Management Plans	VCWPD	Complies with the SWRCB Recycled Water Policy.	Water Quality	Oxnard Forebay	VCWPD. 2015. Lower Santa Clara River Salt and Nutrient Management Plan. Prepared by Larry Walker Associates. April 2015.	http://www.waterboards.ca.gov/losangeles/water_issues/programs/salt_and_nutrient_management/docs/2015/May/DraftSaltandNutrientManagementPlan/Section1IntroductionandGoals.pdf

Notes: ASRVB = Arroyo Santa Rosa Valley Basin; CIMIS = California Irrigation Management Information System; CMWD = Calleguas Municipal Water District; DWR = California Department of Water Resources; FCGMA = Fox Canyon Groundwater Management Agency; LPVB = Las Posas Valley Basin; PVB = Pleasant Valley Basin; SWRCB = State Water Resources Control Board; USGS = U.S. Geological Survey; UWCD = United Water Conservation District; VCWPD = Ventura County Watershed Protection District.

Table 1-11
Oxnard Subbasin Existing Water Resources Management Projects, Programs, and Strategies

Program/Project	Program Agency	Program Description	Parameter	Conjunctive Use Program?	Multi-Basin Program	Source	Link
Existing Surface Water Management Projects, Programs, and Strategies							
Ventura County Stormwater Quality Monitoring Program	Ventura County Watershed Protection District, Camarillo, Moorpark, Oxnard, Port Hueneme, and others.	Program meets the requirements of the Ventura County Stormwater Permits. Includes water quality sampling, watershed assessments, business inspections, and pollution prevention programs.	Surface Water Quality	No	Oxnard Subbasin, LPVB, PVB, ASRVB	Ventura Countywide Stormwater Quality Management Program Website. Accessed September 15, 2016.	http://www.vcstormwater.org/
State Water Project Importation	DWR, Ventura County, UWCD, CMWD, and City of Ventura	Purchase of up to 5,000 AFY of Ventura County's 20,000 AFY State Water Project allocation for release and percolation from Lake Piru, the Freeman Diversion, and surface deliveries to Pleasant Valley through the PTP. The water reaching the Freeman Diversion is considered a "foreign water supply" and is credited to UWCD.	Supplemental Water	Yes	Oxnard, LPVB, PVB, ASRVB	UWCD. 2014. Groundwater and Surface Water Conditions Report - 2013. UWCD Open-File Report 2014-12 (p. 36). FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. 50).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf

Table 1-11
Oxnard Subbasin Existing Water Resources Management Projects, Programs, and Strategies

Program/Project	Program Agency	Program Description	Parameter	Conjunctive Use Program?	Multi-Basin Program	Source	Link
Importation of Metropolitan Water District Water	CMWD	Import and deliver water from wholesaler Metropolitan Water District. Water purchased by water retailers such as the City of Oxnard to supplement water supply instead of pumping groundwater.	Supplemental Water	Yes	Oxnard Subbasin, PVB, LPVB	CMWD. 2015. Urban Water Management Plan – Final, pp. 1-1, 4-1, 4-2 (Figure 4-1), 6-1, 6-13.	http://www.mwdh2o.com/Who%20We%20Are%20%20.2007Fact%20Sheets/Member%20Agency%20Map.pdf http://www.mwdh2o.com/WhoWeAre/Member-Agencies/.2007Pages/default.aspx http://www.mwdh2o.com/WhoWeAre/History/Pages/default.aspx http://www.calleguas.com/images/docs-documents-reports/cmwdfinal2015uwmp.pdf
Salinity Management Pipeline	CMWD	A brine disposal pipeline that collects brine generated by desalting facilities in the LPVB, PVB, and Oxnard Subbasin and conveys it to an ocean outfall for disposal. Future construction of the pipeline is expected to serve additional facilities, including those in the ASRVB.	Surface Water	Yes	Oxnard Subbasin, LPVB, PVB, ASRVB	CMWD. 2015. Urban Water Management Plan – Final, p. 6-1.	http://www.calleguas.com/images/docs-documents-reports/cmwdfinal2015uwmp.pdf
Existing Groundwater Management Projects, Programs, and Strategies							
Basin Management Objective Program	FCGMA	FCGMA has established a set of Basin Management Objectives that pertain to the overall health of the groundwater basins, including water levels and water quality. Each year, FCGMA publishes a report tracking the progress toward meeting the objectives.	Groundwater Conditions	No	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. iii).	http://www.fcgma.org/component/content/article/20-public-documents/plans/95-groundwater-management-plan
FCGMA Groundwater Storage (including In-Lieu) Credit Program	FCGMA	This is a program by which credits are issued to the deliverer in equal amounts to the amount of delivered "newly available" water, imported water from outside the County, recycled water, or diverted surface water that would otherwise be wasted to the ocean. Delivered water used in lieu of pumping.	Groundwater	Yes	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA. 2015. Fox Canyon Groundwater Management Agency, Calendar Year 2014 Annual Report (p. 23).	http://www.fcgma.org/public-documents/reports
FCGMA Groundwater Injection Credit Program	FCGMA	This is a program by which credits are issued to operators that inject "newly available" water, water from outside the County, or recycled water.	Groundwater	Yes	LPVB, PVB, ASRVB, Oxnard Subbasin	FCGMA. 2015. Fox Canyon Groundwater Management Agency, Calendar Year 2014 Annual Report (p. 23).	http://www.fcgma.org/public-documents/reports
Salinity Management Pipeline	CMWD	A brine disposal pipeline that collects brine generated by desalting facilities in the LPVB, PVB, and Oxnard Subbasin and conveys it to an ocean outfall for disposal. Future construction of the pipeline is expected to serve additional facilities, including those in the ASRVB.	Groundwater	Yes	Oxnard Subbasin, LPVB, PVB, ASRVB	CMWD. 2015. Urban Water Management Plan – Final, p. 6-1.	http://www.calleguas.com/images/docs-documents-reports/cmwdfinal2015uwmp.pdf
Groundwater Supply Policy (Formerly Brackish Groundwater Policy)	FCGMA	The FCGMA Board of Directors adopted Resolution No. 2016-05, a policy for evaluating and authorizing proposals for groundwater supply projects. It allows for consideration of development of brackish groundwater for supply projects subject to monitoring requirements and other constraints and restrictions including compliance with SGMA.	Groundwater	Yes	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA. n.d. Draft Brackish Groundwater Project Pumping Policy.	http://www.fcgma.org/images/Erin/Draft%20Brackish%20Groundwater%20Project%20Pumping%20Policy%20revised%2020160720.pdf

Table 1-11
Oxnard Subbasin Existing Water Resources Management Projects, Programs, and Strategies

Program/Project	Program Agency	Program Description	Parameter	Conjunctive Use Program?	Multi-Basin Program	Source	Link
Extraction Fee Program	FCGMA	Groundwater extractors are assessed fees per acre-foot of extraction. Fees have been used by FCGMA to finance its management activities since its enabling legislation in 1983.	Groundwater	No	Oxnard Subbasin, LPVB, PVB, ASRVB	Assembly Bill No. 2995, Article 9.	http://www.fcgma.org/fcgma.old/publicdocuments/ordinances/ordinanceAB-2995.pdf
Groundwater Extraction Limitation Program	FCGMA	FCGMA has implemented a program of reduced allocations.	Groundwater	No	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. 45).	http://www.fcgma.org/component/content/article/20-public-documents/plans/95-groundwater-management-plan
Extraction Surcharge Program	FCGMA	FCGMA charges a fee to well operators for groundwater extractions in excess of annual allocation amounts	Groundwater	No	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. 45).	http://www.fcgma.org/component/content/article/20-public-documents/plans/95-groundwater-management-plan
Prohibition of export of groundwater	FCGMA	FCGMA Ordinance requires Board of Directors approval for the export of groundwater from within the FCGMA boundary for use outside of the boundary	Groundwater	No	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA Ordinance Code, Chapter 5, 5.2.2.1.	http://www.fcgma.org/images/ordinances_legislation/Ord_Code_FINAL_-_amended_01-09-2015.pdf
Other Existing Programs							
IRWM Program	WCVC	Initiated with Proposition 50 in 2006, the program provides competitive grant funds for projects and studies in accordance with a comprehensive IRWM Plan.	Groundwater, Surface Water	No	Oxnard Subbasin, LPVB, PVB, ASRVB	Ventura County Watersheds Coalition. 2016. WCVC. Accessed September 15, 2016.	http://www.ventura.org/wcvc/IRWMP/2014IRWMP.htm
Oxnard–Hueneme Pipeline (1954)	UWCD	Pumping of Oxnard Forebay wells to supply water to the Cities of Oxnard and Port Hueneme, thus avoiding coastal pumping and exacerbation of seawater intrusion.	Groundwater Quality	Yes	Oxnard Subbasin	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (pp. 7–8).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Pumping Trough Pipeline (1986)	UWCD	Supplies agriculture on the Oxnard Subbasin with a combination of surface water diverted from the Santa Clara River and groundwater, thus reducing the need for groundwater pumpage in the central Oxnard Plain pumping depression (1986).	Surface/ Groundwater	Yes	Oxnard Subbasin and PVB	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 5).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
The Freeman Diversion (1991)	UWCD	Diversion of Santa Clara River flood flows to Saticoy, El Rio, and Noble Basins for groundwater recharge and surface deliveries through the PTP and PVP. The Freeman Diversion allows for surface water supply in place of groundwater pumping, thus reducing the risk of seawater intrusion.	—	Yes	Oxnard Subbasin and PVB	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 39).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
The Noble Spreading Grounds (1995)	UWCD	Diversion of Santa Clara River flows to spreading grounds recharging both the UAS and LAS.	—	Yes	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 5).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Saticoy Well Field (2003)	UWCD	Draws from the mound beneath the Saticoy Spreading Grounds and allows for additional Santa Clara River recharge.	—	Yes	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 5).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf

Table 1-11
Oxnard Subbasin Existing Water Resources Management Projects, Programs, and Strategies

Program/Project	Program Agency	Program Description	Parameter	Conjunctive Use Program?	Multi-Basin Program	Source	Link
Rose and Ferro Spreading Grounds	UWCD	Diversion of Santa Clara River Water to former mining pits for the recharge of groundwater.	—	Yes	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 6).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
El Rio Spreading Grounds	UWCD	Diversion of Santa Clara River flows to spreading grounds recharging both the UAS and LAS.	—	Yes	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 5).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Pleasant Valley Pipeline	UWCD	Water diverted from Santa Clara River is provided to the PVCWD via a pipeline that terminates at the Pleasant Valley Reservoir. This water is supplied to agricultural users and offsets the need for groundwater pumping.	—	Yes	Oxnard Subbasin and PVB	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 8).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
Conejo Creek Diversion (2002)	CWD	PVCWD receives surface water from CWD's Conejo Creek Diversion.	Surface Water	Yes	—	UWCD. 2014. Groundwater and Surface Water Conditions Report – 2013. UWCD Open-File Report 2014-12 (p. 9).	http://www.unitedwater.org/images/stories/reports/GW-Conditions-Reports/2013%20GW%20and%20SW%20Conditions%20Report%20(UWCD%202014)%20FINAL.pdf
FCGMA M&I Allocation Program	FCGMA	The current M&I allocation program, also known as a Temporary Extraction Allocation, was implemented with the passage of Ordinance E in 2014. It was implemented for M&I users, replacing HA and BA.	Groundwater	Yes	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA. 2015. Calendar Year 2014 Annual Report (p. 10).	http://www.fcgma.org/public-documents/reports
FCGMA Irrigation Allocation Program	FCGMA	Requirement for agricultural irrigation efficiency as compared to FCGMA calculations for required irrigation for specific crop types with consideration of weather conditions.	Groundwater Extractions	Yes	Oxnard Subbasin, LPVB, PVB, ASRVB	FCGMA. 2015. Calendar Year 2014 Annual Report (p. 10).	http://www.fcgma.org/public-documents/reports
Groundwater Recovery Enhancement and Treatment (GREAT) Program – 2013 ~~(GREAT)~~	City of Oxnard	A desalination facility, recycled water system, ASR facility, and brine disposal line combine to provide non-potable M&I water and agricultural irrigation water, to reduce pumping of LAS groundwater.	Groundwater/ Surface Water	Yes	Oxnard Subbasin and Oxnard Forebay	FCGMA, UWCD, and CMWD. 2007. 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan. May 2007 (p. 54).	http://www.fcgma.org/component/content/article/20-public-documents/plans/95-groundwater-management-plan
Various Water Conservation Programs	Ventura County, Cities, and Water Districts	There are numerous conservation programs conducted by Cities, Ventura County, and other entities within FCGMA jurisdiction that provide education, incentives, and regulations to encourage water savings from both the M&I and agricultural sectors. The exact configuration of these programs change with climate and local and state requirements.	Surface Water, Groundwater	No	Oxnard Subbasin, LPVB, PVB, ASRVB	—	—

Notes: AFY = acre-feet per year; ASR = aquifer storage and recovery; ASRVB = Arroyo Santa Rosa Valley Basin; BA = Baseline Allocation; CMWD = Calleguas Municipal Water District; CWD= Camrosa Water District; DWR = California Department of Water Resources; FCGMA = Fox Canyon Groundwater Management Agency; HA = Historical Allocation; IRWM = Integrated Regional Water Management; LPVB = Las Posas Valley Basin; M&I = municipal and industrial; PTP = Pumping Trough Pipeline; PVB = Pleasant Valley Basin; PVCWD= Pleasant Valley County Water District; PVP = Pleasant Valley Pipeline; UWCD = United Water Conservation District; WCVC = Watersheds Coalition of Ventura County.

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Table 1-12
FCGMA Public Meetings on Oxnard Subbasin GSP

Meeting	Date
FCGMA Special Board Meeting	November 8, 2019
TAG Meeting	October 31, 2019
FCGMA Regular Board Meeting	August 28, 2019
GSP Work Shops	August 21,22, 2019
TAG Meeting	August 1, 2019
FCGMA Regular Board Meeting	July 24, 2019
FCGMA Regular Board Meeting	June 26, 2019
FCGMA Special Board Meeting	May 22, 2019
TAG Meeting	May 5, 2019
FCGMA Regular Board Meeting	April 24, 2019
FCGMA GSP Public Workshop No. 4	March 15, 2019
FCGMA Special Board Meeting	March 15, 2019
FCGMA Regular Board Meeting	February 27, 2019
Special TAG Meeting	February 19, 2019
FCGMA Special Board Meeting	February 8, 2019
Special TAG Meeting	February 6, 2019
FCGMA Regular Board Meeting	January 23, 2019
Special TAG Meeting	January 17, 2019
TAG Meeting	December 6, 2018
FCGMA Regular Board Meeting	December 5, 2018
FCGMA Special Board Meeting	November 20, 2018
TAG Meeting	November 1, 2018
FCGMA Regular Board Meeting	October 24, 2018
FCGMA Special Board Meeting	October 12, 2018
TAG Meeting	October 4, 2018
FCGMA Regular Board Meeting	September 26, 2018
FCGMA Special Board Meeting	September 14,2018
TAG Meeting	September 6, 2018
FCGMA Special Board Meeting	August 29, 2018
FCGMA Special Board Meeting Oxnard and Pleasant Valley Pumping Allocation Workshop	July 25, 2018
FCGMA Regular Board Meeting	July 25, 2018
TAG Meeting	July 5, 2018
FCGMA Special Board Meeting	June 20, 2018
Special TAG Meeting	June 19, 2018
TAG Meeting	June 14, 2018
FCGMA Regular Board Meeting	May 23, 2018
TAG Meeting	May 3, 2018
FCGMA Regular Board Meeting	April 25, 2018
TAG Meeting	April 5, 2018
FCGMA Regular Board Meeting	March 28, 2018

Table 1-12
FCGMA Public Meetings on Oxnard Subbasin GSP

Meeting	Date
FCGMA Special Board Meeting	March 9, 2018
TAG Meeting	March 1, 2018
FCGMA Regular Board Meeting	February 28,2018
FCGMA Special Board Meeting	February 26, 2018
FCGMA GSP Public Workshop No. 3	February 8, 2018
TAG Meeting	February 1, 2018
Special TAG Meeting	January 30, 2018
FCGMA Regular Board Meeting	January 24, 2018
TAG Meeting	January 4, 2018
FCGMA Special Board Meeting	January 3, 2018
Special TAG Meeting	December 14, 2018
FCGMA Special Board Meeting	November 13, 2017
TAG Meeting	November 2, 2017
TAG Meeting	October 6, 2017
FCGMA Special Board Meeting	October 13, 2017
FCGMA Regular Board Meeting	October 25, 2017
FCGMA Regular Board Meeting	September 27, 2017
FCGMA GSP Public Stakeholder Workshop No. 2A – Oxnard and Pleasant Valley	September 20, 2017
FCGMA Operations Committee Meeting	September 14, 2017
TAG Meeting	September 7, 2017
FCGMA Special Board Meeting	August 11, 2017
FCGMA Operations Committee Meeting	August 10, 2017
TAG Meeting	August 3, 2017
Special TAG Meeting – Sustainability Objective Concepts	July 27, 2017
FCGMA Regular Board Meeting	July 26, 2017
FCGMA Fiscal Committee Budget Workshop	July 25, 2017
Water Market Pilot Program Ad Hoc Committee Meeting	July 24, 2017
FCGMA Board Executive Committee Meeting	July 12, 2017
TAG Meeting	July 6, 2017
Special TAG Meeting – Groundwater-Dependent Ecosystems	June 29, 2017
FCGMA Regular Board Meeting	June 28, 2017
FCGMA Board Executive Committee Meeting	June 15, 2017
TAG Meeting	June 1, 2017
FCGMA Regular Board Meeting	May 24, 2017
TAG Meeting	May 4, 2017
Special TAG Meeting – Groundwater Models	April 27, 2017
FCGMA Regular Board Meeting	April 26, 2017
Special TAG Meeting	March 24, 2017
Special TAG Meeting – Groundwater Models	March 24, 2017
FCGMA Regular Board Meeting	March 22, 2017

Table 1-12
FCGMA Public Meetings on Oxnard Subbasin GSP

Meeting	Date
TAG Meeting	March 3, 2017
FCGMA Regular Board Meeting	February 22, 2017
TAG Meeting	February 2, 2017
FCGMA Regular Board Meeting	January 25, 2017
TAG Meeting	December 16, 2016
FCGMA Regular Board Meeting	December 9, 2016
TAG Meeting	November 18, 2016
FCGMA GSP Public Workshop No. 1	November 15, 2016
FCGMA Regular Board Meeting	October 26, 2016
TAG Meeting	October 7, 2016
FCGMA Executive Committee	October 3, 2016
FCGMA Regular Board Meeting	September 28, 2016
TAG Meeting	August 26, 2016
TAG Meeting	July 29, 2016
FCGMA Regular Board Meeting	July 20, 2016
FCGMA Regular Board Meeting	June 22, 2016
TAG Meeting	May 27, 2016
FCGMA Regular Board Meeting	May 25, 2016
FCGMA Special Board Meeting	May 13, 2016
TAG Meeting	April 29, 2016
FCGMA Regular Board Meeting	April 27, 2017
TAG Meeting	March 25, 2016
FCGMA Regular Board Meeting	March 23, 2016
FCGMA Special Board Meeting	March 11, 2016
TAG Meeting	February 26, 2016
TAG Meeting	January 29, 2016
FCGMA Regular Board Meeting	January 27, 2016
TAG Meeting	December 18, 2015
FCGMA Regular Board Meeting	December 11, 2015
TAG Meeting	November 20, 2015
FCGMA Special Board Meeting	November 13, 2015
TAG Meeting	October 30, 2015
FCGMA Regular Board Meeting	October 28, 2015
TAG Meeting	September 25, 2015
FCGMA Regular Board Meeting	September 23, 2015
TAG Meeting	August 28, 2015
FCGMA Special Board Meeting	August 13, 2015
TAG Meeting	July 30, 2015
FCGMA Regular Board Meeting	July 22, 2015
FCGMA Regular Board Meeting	June 24, 2015

Table 1-12
FCGMA Public Meetings on Oxnard Subbasin GSP

Meeting	Date
FCGMA Regular Board Meeting	May 27, 2015
FCGMA Regular Board Meeting	April 22, 2015
FCGMA Regular Board Meeting	March 25, 2015

Notes: FCGMA = Fox Canyon Groundwater Management Agency; GSP = Groundwater Sustainability Plan; TAG = Technical Advisory Group.

Figure 1-1 Vicinity Map for the Oxnard Subbasin

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Figure 1-2 Administrative Boundaries for the Oxnard Subbasin

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Figure 1-3 Weather Station and Stream Gauge Locations

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Figure 1-4 Average Daily Flows (ADF) and Monthly Minimum ADF in Oxnard Surface Waters

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Figure 1-5 Oxnard Plain Annual Precipitation

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Figure 1-6 Long-Term Precipitation Trends in the Oxnard Plain

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Figure 1-7 Land and Water Use

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Figure 1-8 Ventura County Water Purveyors

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CHAPTER 2
BASIN SETTING

2.1 INTRODUCTION TO BASIN SETTING

Physical Setting and Characteristics

The Oxnard Subbasin (Subbasin) of the Santa Clara River Valley Groundwater Basin is located near the western edge of the Transverse Ranges Geomorphic Province, which extends from the San Bernardino Mountains in the east to the San Miguel, Santa Rosa, and Santa Cruz Islands in the west (Figure 2-1, Oxnard Subbasin Vicinity Map; CGS 2002). The Transverse Ranges Geomorphic Province is characterized by a series of east-to-west-trending mountain ranges and valleys that are formed by north–south compression across a restraining bend in the San Andreas Fault (Hadley and Kanamori 1977; Bohannon and Howell 1982; Eberhart-Philips et al. 1990; Nicholson et al. 1994). Compression across this restraining bend is responsible for rapid, ongoing uplift of the mountain ranges (Yeats 1988; Feigl et al. 1993; Marshall et al. 2008) and extensive folding and faulting of the Pleistocene and older geologic formations in the province (Rockwell et al. 1988; Huftile and Yeats 1995).

The Oxnard Subbasin underlies the Oxnard Plain, an approximately 58,000-acre coastal plain formed by deposition of sediments from the Santa Clara River and Calleguas Creek, in southwestern Ventura County (DWR 1965, 2006). The northern boundary of the Oxnard Subbasin is the Oak Ridge Fault, and the southern boundary is the contact between permeable alluvium and semipermeable rocks of the Santa Monica Mountains (SWRCB 1956; DWR 2006). The eastern boundary of the Oxnard Subbasin lies against the Las Posas Valley Basin (LPVB) and Pleasant Valley Basin (PVB). The western boundary of the Oxnard Subbasin is the Pacific Ocean (SWRCB 1956; DWR 2006).

The stratigraphic sequence underlying the Oxnard Plain comprises an upper unit of younger and older alluvial deposits that unconformably overlies the San Pedro and Santa Barbara Formations (Table 2-1). The San Pedro Formation is a lower to middle Pleistocene shallow marine deposit that grades upward from a white-gray sand and gravel basal layer into an overlying series of interbedded silts, clays, and gravels. The Santa Barbara Formation is a lower Pleistocene marine sand and clay deposit (SWRCB 1956; Weber and Kiessling 1976; Turner 1975). The primary water-bearing units in the Oxnard Subbasin are the alluvial deposits that compose the Oxnard and Mugu Aquifers and the white-gray sand and gravel layer of the San Pedro Formation that composes the Fox Canyon Aquifer (FCA; Table 2-1). In addition, wells in the Oxnard Subbasin also produce water from the Hueneme Aquifer in the Upper San Pedro Formation and the Grimes Canyon Aquifer (GCA) in the Santa Barbara Formation.

The shallowest aquifer in the Oxnard Subbasin is a semi-perched aquifer comprising sands and gravels deposited by the Santa Clara River. This unit is underlain by a clay layer, commonly referred to as the "clay cap," that is nearly continuous throughout the Subbasin, with the notable exception of an approximately 10-square-mile area in the northeastern part of the Subbasin, adjacent to and south of the Santa Clara River, referred to as the "Forebay area" (Figure 2-1; Mukae and Turner 1975). In this region, the Oxnard and underlying Mugu Aquifers are unconfined. In the areas where the clay cap separates the semi-perched aquifer from the underlying Oxnard Aquifer, the Oxnard Aquifer is confined. The area in which the Oxnard Aquifer is confined is referred to as the "pressure plain area" of the Oxnard Subbasin (Figure 2-1; Mukae and Turner 1975).

The majority of the Oxnard Subbasin lies within the jurisdiction of the Fox Canyon Groundwater Management Agency (FCGMA), with two exceptions (Figure 2-1). These exceptions include an area in the northeastern corner of the Oxnard Subbasin, at the western end of South Mountain, and along the southeastern edge of the Oxnard Subbasin adjacent to the foothills of the Santa Monica Mountains. The reason for the discrepancy is that the FCGMA boundary was established based on a vertical projection of the FCA as defined by the Fox Canyon Groundwater Management Agency Act in 1982, whereas the Oxnard Subbasin boundary is based on the surface extent of the alluvium in the Oxnard Plain, and the location of both geologic structures and facies changes that impede flow between the Oxnard Subbasin and neighboring groundwater basins (DWR 2006). The geologic and hydrologic descriptions of the Oxnard Subbasin in this Groundwater Sustainability Plan (GSP) are based on the boundaries of the Oxnard Subbasin, including the areas to the northeast and southeast which are outside of the FCGMA jurisdictional boundaries.

2.2 HYDROGEOLOGIC CONCEPTUAL MODEL

The six commonly recognized water-bearing units in the Oxnard Subbasin are the semi-perched aquifer and the Oxnard, Mugu, Hueneme, Fox Canyon, and Grimes Canyon Aquifers (DWR 1965, 2006; Turner 1975). Of the six commonly recognized water-bearing units, five are considered primary aquifers in the Oxnard Subbasin. The semi-perched aquifer is a water-bearing unit, but is not considered a primary aquifer in the Subbasin. The five aquifers are grouped into an Upper Aquifer System (UAS) and Lower Aquifer System (LAS), with the Oxnard and Mugu Aquifers composing the UAS and the Hueneme, Fox Canyon, and Grimes Canyon Aquifers composing the LAS. The UAS primarily comprises recent to upper Pleistocene age alluvial deposits of the Santa Clara River system. The LAS is primarily composed of upper to lower Pleistocene age marine sediments.

The Forebay area is the primary recharge area for the primary aquifers in the Oxnard Subbasin. In this area, the UAS rests directly on the folded and eroded upper surface of the Hueneme Aquifer and FCA. Water that recharges the UAS in the Forebay area is able to migrate throughout the Subbasin. Both the lithologic units and geologic structures present in the Oxnard Subbasin affect the hydrology of the Subbasin. These features are discussed in more detail in Sections 2.2.1 through 2.2.5.

2.2.1 Geology

Geologic Units and Variation

Tertiary Sedimentary and Igneous Formations

Tertiary sedimentary and igneous rocks that underlie the Oxnard Subbasin are generally considered semipermeable or non-water-bearing (Turner and Mukae 1975). These tertiary formations include the Oligocene/Eocene-age Sespe Formation, the lower Miocene Conejo Volcanics, the upper Miocene Modelo and Monterey Formations, and the Pliocene Pico Formation (Table 2-1; Weber and Kiessling 1976; Dibblee 1992a, 1992b). These formations have been sampled in deep wells drilled in the Oxnard Subbasin (Figure 2-2, Geology of the Oxnard Subbasin; Turner 1975; Weber and Kiessling 1976). These formations are not considered an important source of groundwater in the Oxnard Subbasin (Turner 1975).

Quaternary Sedimentary Formations

Santa Barbara Formation (Lower Pleistocene; Marine)

The Santa Barbara Formation typically comprises laminated, poorly indurated blue-gray marine mud- and siltstone with sand and gravel (Table 2-1; Turner and Mukae 1975). The upper clay-rich sediments act as an aquitard between the Santa Barbara Formation and the overlying San Pedro Formation (Weber and Kiessling 1976). The localized basal conglomerate within the upper member of the Santa Barbara Formation hosts the GCA (Weber and Kiessling 1976).

San Pedro Formation (Lower to Middle Pleistocene; Marine and Nonmarine)

The San Pedro Formation is an interbedded, poorly lithified fine marine, silty sandstone, shale, and mudstone with local pebble conglomerate and an extensive basal sand unit that unconformably overlies the Santa Barbara Formation in the Oxnard Subbasin (Mukae and Turner 1975; Weber and Kiessling 1976).

The upper and lower parts of the San Pedro Formation are separated by a laterally extensive clay marker bed (Turner 1975). Overlying the clay marker bed are lenticular layers of sand, gravel, and silt (Mukae and Turner 1975). The lenticular deposits of sand and gravel in the Upper San Pedro Formation are known as the Hueneme Aquifer in the Oxnard Subbasin. The sediments of the Upper San Pedro Formation coarsen to the west, with a larger percentage of sand and gravel in the western part of the Subbasin and a larger percentage of fines in the eastern part of the Subbasin, particularly in the area adjacent to the boundary with the LPVB.

In contrast, the basal unit of the San Pedro Formation fines to the west. This unit comprises a 100- to 600-foot-thick continuous white or gray fine to medium marine sand with stringers of gravel and local silt and clay lenses (Turner 1975).[1] The lower part of the San Pedro Formation is the FCA, which is an important source of groundwater supply in the Oxnard Subbasin (Turner 1975).

Older Alluvium (Upper Pleistocene; Terrestrial)

The older alluvium, which comprises gravel, sand, silt, and clay, unconformably overlies the Upper San Pedro Formation. The older alluvium can be divided into two units: an upper clay zone and a lower sand and gravel zone (Mukae and Turner 1975). The Mugu Aquifer occurs in the sand and gravel zone at the base of the older alluvium (Mukae and Turner 1975).

Recent Alluvium (Holocene; Terrestrial)

The recent alluvium in the Oxnard Subbasin comprises sands and gravels interbedded with silt and clay (DWR 1965). These sediments, which unconformably overlie the older alluvium, reach a thickness of up to 300 feet. The basal unit includes coarse sands and gravels intercalated with clay layers (Mukae and Turner 1975). Overlying the basal unit throughout much of the Subbasin is a laterally continuous clay layer that reaches a thickness of up to 160 feet locally. The Oxnard aquifer occurs in the sand and gravel layer below the clay. Above the clay is the semi-perched aquifer.

Geologic Structure

Wright Road Fault

The Wright Road Fault is an active oblique right reverse fault that generally parallels the eastern jurisdictional boundary of the Oxnard Subbasin, separating the LPVB to the east from the Oxnard Subbasin to the west (Figure 2-2; DeVecchio et al. 2007). The fault trace is characterized by a 20-meter-high (66-foot-high) topographic scarp with up-to-the-east displacement along the north-northwest-trending fault (DeVecchio et al. 2007). There is no evidence that the Wright Road Fault impacts groundwater flow between the Oxnard Subbasin and the LPVB.

Oak Ridge and McGrath Faults

The Oak Ridge Fault is a high-angle, south-dipping, left-lateral reverse fault that juxtaposes water-bearing alluvium and older, semipermeable formations in the subsurface (Figure 2-2; SWRCB 1956). To the east of the Oxnard Subbasin, anticlinal folding in the hanging wall of the Oak Ridge Fault resulted in the Oak Ridge and South Mountain uplift (Yeats 1988). In the Oxnard Subbasin, the western extent of the Oak Ridge Fault is concealed beneath the recent alluvium (Mukae and Turner 1975).

[1] This marine sand has been identified as both the Saugus Formation (Kew 1924; Jakes 1979) and the Las Posas Sand (Pressler 1929, as cited in DeVecchio et al. 2012a.; Dibblee 1992a, 1992b; DeVecchio et al. 2012b). The term "San Pedro Formation" is used here for consistency with California Department of Water Resources nomenclature (DWR 2006).

The McGrath Fault, located approximately 1 mile south of the Oak Ridge Fault along the coast in the Oxnard Subbasin, is a branch of the Oak Ridge Fault system with the same sense of motion (Mukae and Turner 1975). The McGrath Fault defines the northerly limit of the Forebay area (Turner 1975). Together, the McGrath and Oak Ridge Faults limit hydraulic communication between the Oxnard Subbasin to the south and the Mound and Santa Paula Subbasins of the Santa Clara River Valley Groundwater Basin to the north.

Bailey Fault

Along the northern edge of the Santa Monica Mountains, the Bailey Fault Zone trends northeast–southwest through the Oxnard Subbasin (Figure 2-2; Turner 1975). The Bailey Fault is a near-vertical fault with up-to-the-south displacement in the subsurface that offsets quaternary sedimentary formations to the north with older formations to the south (Turner 1975). Groundwater elevation differences and chloride ion concentration differences across the fault suggest that it is a barrier to groundwater movement (Turner 1975). The FCA is absent to the south of the Bailey Fault.

Las Posas Syncline

The Las Posas syncline has resulted in thickening and downwarping of the San Pedro Formation and older formations in the central part of the Oxnard Subbasin (Figure 2-2). The axis of the Las Posas syncline trends northeast from its western mapped extent at the intersection of West 5th Avenue and Harbor Boulevard, through El Rio, and into the Las Posas Valley (Turner 1975). At the deepest part of the Las Posas syncline, the Upper San Pedro Formation reaches a thickness of approximately 1,150 feet (Mukae and Turner 1975).

Montalvo Anticline

Deformation in the hanging wall of the Oak Ridge and McGrath Faults has resulted in anticlinal structures on the northern boundary of the Oxnard Subbasin, including the Montalvo anticline (Figure 2-2). The Upper San Pedro Formation has been eroded away in the Forebay area of the Oxnard Subbasin along the axis of the anticline (Turner 1975). Erosion of the Upper San Pedro Formation results in direct communication between the alluvium and the white and gray marine sands of the Lower San Pedro Formation that compose the FCA.

2.2.2 Basin Bottom

The bottom of the Oxnard Subbasin generally corresponds to the base of the San Pedro Formation and the base of the FCA in the northern and western parts of the Subbasin, where the Santa Barbara Formation is absent (Figure 2-2 and Figure 2-3, Cross Section A–A′; Turner 1975). In the southern and eastern parts of the Subbasin, where the Santa Barbara Formation is present, the bottom of the

Subbasin is defined by the contact between the upper member of the Santa Barbara Formation, the GCA, and the underlying strata that have poor water quality (Figure 2-4, Cross Section B–B′).

In general, the bottom of the Oxnard Subbasin is shallower in the east and deeper in the west. Along the eastern margin of the Subbasin, the Subbasin bottom has been mapped at elevations between 0 feet above mean sea level (msl) and −1,200 feet msl (Turner 1975). Along the western edge of the Subbasin, the Subbasin bottom depth ranges from −400 to more than −1,800 feet msl (Turner 1975). The deepest part of the Subbasin occurs along the axis of the Las Posas syncline in the north-central part of the Subbasin.

2.2.3 Principal Aquifers and Aquitards

Semi-Perched Aquifer

River-deposited sands and gravels interbedded with minor silt and clay compose the semi-perched aquifer in the Oxnard Subbasin (DWR 1965; Turner 1975). The term “semi-perched aquifer” is used in this GSP as the name for the uppermost unit of the Oxnard Subbasin, which overlies the extensive clay cap in the pressure plain area of the Oxnard Subbasin (Figure 2-2 and Table 2-1). This name was used in the State Water Resources Control Board’s Bulletin 12 (SWRCB 1956) to distinguish the water-bearing sedimentary units in the pressure plain area from those in the Forebay area, and this terminology has been adopted by subsequent investigators (Mukae and Turner 1975; Turner 1975; Hanson et al. 2003; DWR 2006). Water-level data indicate that the sediments underlying the semi-perched aquifer are saturated. Therefore, the term “semi-perched aquifer” is used in this GSP to denote the limited migration of water from the uppermost aquifer to the underlying confined aquifer in the pressure plain area. It is not used to denote a discontinuity in saturation. Furthermore, there is limited groundwater production (<50 acre-feet per year [AFY]) from this unit (see Section 2.4, Water Budget). Therefore, although this unit is referred to as the “semi-perched aquifer,” it is not considered to be a principal aquifer in the Subbasin.

The semi-perched aquifer is part of the recent alluvium described in Section 2.2.1, Geology. This aquifer extends from the base of developed soil horizons to a depth of approximately 75 feet throughout most of the Subbasin (Turner 1975). Notably, this aquifer is absent in the Forebay area of the Oxnard Subbasin adjacent to and south of the present course of the Santa Clara River. The permeable sand and gravel deposits of the semi-perched aquifer tend to be continuous in a northeast–southwest orientation, which is similar to the present orientation of the Santa Clara River and lenticular to the northwest and southeast (Turner 1975).

The lenticular shape of the semi-perched aquifer deposits limits flow in the northwest–southeast direction and facilitates flow in the northeast–southwest direction. These deposits have not been affected by faulting or folding in the Subbasin, and there are no structural restrictions to flow through the semi-perched aquifer (UWCD Model Report [2018], provided as Appendix C to this GSP).

Agricultural return flows, saline connate water, and coastal flooding affect both groundwater quality and groundwater elevation in the semi-perched aquifer (Mukae and Turner 1975). The highest water levels in the aquifer, which are typically within a few feet of land surface, are found in heavily irrigated areas (Turner 1975). Tile drains are used throughout the Oxnard Subbasin to alleviate the high groundwater conditions. Agricultural return flows that cause the high water conditions have resulted in high concentrations of total dissolved solids (TDS) and chloride (as high as 23,000 milligrams per liter [mg/L]) in the semi-perched aquifer (Turner 1975; USGS 1996).

Clay Cap

Underlying the semi-perched aquifer is a clay layer that separates the semi-perched aquifer from the Oxnard Aquifer below (Turner 1975). The thickness of the clay cap is approximately 160 feet adjacent to the Pacific Ocean. The clay cap is absent in the Forebay area (DWR 1968; Mukae and Turner 1975). Although the clay cap functions as an aquitard, water can migrate vertically through the clay cap under conditions of differential head (Turner 1975), and in some cases, through casings of wells that have been improperly abandoned.

Oxnard Aquifer

The Oxnard Aquifer is a laterally continuous layer of upper Pleistocene and Holocene nonmarine gravel and cobbles (up to 6 inches in diameter); coarse to fine sand; and interbedded clay, silty clay, and silt lenses (Turner 1975). The deposits that compose this aquifer are part of the recent alluvium and are found beneath the entire Oxnard Subbasin and extend several miles offshore, where they are exposed in the walls of the Hueneme and Mugu submarine canyons (DWR 1965, 1968). The deposits tend to be finer near the coast and coarsen to the east (Turner 1975; DWR 2006). The local silty clay and silt lenses restrict both horizontal and vertical movement of water through the aquifer, and distinct permeable horizons have been identified in logs (DWR 1971).

The top of the Oxnard Aquifer has been shaped by differential erosion and sedimentation of the Santa Clara River (Turner 1975). Throughout much of the Oxnard Subbasin, a clay-rich aquitard that ranges in thickness from 10 to 100 feet separates the Oxnard Aquifer system from the underlying Mugu Aquifer (Mukae and Turner 1975). The basal surface of the clay is more uniform than the upper surface and generally deepens to the west–southwest (DWR 1968). The thickness of the Oxnard Aquifer also generally increases to the west-southwest, with a minimum thickness of less than 50 feet in the vicinity of the Forebay area and reaching a maximum thickness of greater than 150 feet in the vicinity of Point Mugu (DWR 1968; Turner 1975).

Flow of groundwater through the Oxnard Aquifer is controlled by lithologic variability. The only structural feature that restricts flow in this aquifer is the Bailey Fault, in the southern Oxnard Subbasin (Appendix C). The Oxnard Aquifer crops out offshore in the Hueneme and Mugu canyons, making it susceptible to seawater intrusion. The chloride concentration of native water in the Oxnard Aquifer is approximately 40 mg/L (similar to background values in the Mugu and Hueneme Aquifers), although this concentration varies with geographic location in the Subbasin (USGS 1996). In the vicinity of the Hueneme and Mugu submarine canyons, chloride concentrations have been affected by seawater intrusion. In 2016, the chloride concentration in the vicinity of Hueneme Canyon was as high as 4,800 mg/L, and in the vicinity of Mugu Canyon the chloride concentration was as high as 16,600 mg/L (FCGMA 2016).

The specific yield of the gravels of the Oxnard Aquifer is about 16% in the Forebay area where there are few clay deposits and the aquifer is unconfined (SWRCB 1956; DWR 2006). Wells screened in the Oxnard Aquifer are typically screened in multiple aquifers, including the underlying Mugu Aquifer. (For information on well construction requirements intended to prevent degradation of water quality of the aquifers in the LAS—referred to as requirements for "sealing zone"—see DWR 1968). The California Department of Water Resources (DWR) reports that the average well yield in the Oxnard Aquifer is about 900 gallons per minute (gpm; DWR 2006). Aquifer test results for two wells screened solely within the Oxnard Aquifer, however, have a higher average well yield, of approximately 1,500 gpm, with an average specific capacity of 47 gpm per foot (Hopkins, pers. comm. 2016). Storage coefficients of 6.18×10^{-4} and 3×10^{-4} were estimated from pumping test data at these two wells, and the transmissivity was estimated to be approximately 20,400 feet squared per day (Hopkins, pers. comm. 2016). The well yield and specific capacity were measured at three additional wells screened solely in the Oxnard Aquifer, although aquifer tests were not performed at these wells. The average well yield and specific capacity for these wells is 2,450 gpm and 108 gpm per foot. Based on these measurements, the average transmissivity is approximately 32,000 feet squared per day (Hopkins, pers. comm. 2016).

Water quality in the Oxnard Aquifer has been degraded by seawater intrusion and leakage of agricultural return flows through the clay cap separating the Oxnard Aquifer from the overlying semi-perched aquifer (UWCD 2016a). Seawater intrusion has been documented in both the Port Hueneme and Port Mugu areas (Turner 1975; UWCD 2016a). Water produced from this aquifer is used for agricultural and municipal and industrial (M&I) purposes.

Mugu Aquifer

The sediments that compose the Mugu Aquifer are upper Pleistocene age fine to coarse sands and gravels (DWR 1965; Turner 1975). These sand and gravel deposits are laterally extensive throughout the Subbasin and represent the basal deposits of the older alluvium. In general, the sediments of the Mugu Aquifer are finer near the coast and coarsen to the east (Turner 1975). A low-permeability clay deposit that ranges in thickness from 10 to 100 feet separates the Mugu Aquifer from the overlying Oxnard Aquifer throughout much of the Oxnard Subbasin. However, the clay layer is absent in the Forebay area of the Subbasin near the Santa Clara River (DWR 1965;

SWRCB 1979; Turner 1975). The Mugu Aquifer ranges in thickness from approximately 30 feet in the Forebay to approximately 270 feet in the vicinity of Point Mugu (DWR 1965; Turner 1975).

The Mugu Aquifer extends several miles offshore and crops out offshore in the Hueneme and Mugu canyons, making it susceptible to seawater intrusion. The chloride concentration of native water in the Mugu Aquifer is approximately 40 mg/L (USGS 1996). In the vicinity of the Hueneme and Mugu submarine canyons, however, chloride concentrations have been affected by seawater intrusion. In 2016, the chloride concentration in the vicinity of Mugu Canyon was as high as 3,200 mg/L (FCGMA 2016).

The base of the Mugu Aquifer was deposited over an irregular surface that has been affected by both folding and erosion (Turner 1975). The extensive folding of the aquifers underlying the Mugu Aquifer, however, has not been documented within the sediments of the Mugu Aquifer. Within the boundaries of the DWR Bulletin 118 basin, the only documented fault that acts as a barrier to flow is the Bailey Fault in the southern part of the Subbasin. Offshore, however, additional faults that act as barriers to flow exist in the vicinity of the Mugu submarine canyon (Hanson et al. 2003; Appendix C).

Wells screened in the Mugu Aquifer are typically screened in multiple aquifers, including the overlying Oxnard Aquifer. DWR does not report aquifer properties specifically for the Mugu Aquifer (DWR 2006). In the Forebay, Well 02N22W36E04S, screened solely within the Mugu Aquifer, has a well yield of 1,500 gpm, a specific capacity of 17.8 gpm per foot, and an estimated transmissivity of 7,900 feet squared per day (Hopkins, pers. comm. 2016). For wells screened in both the Oxnard and Mugu Aquifers, the average yield is 2,300 gpm, the average specific capacity is 110 gpm per foot, and the average estimated transmissivity is 29,000 feet squared per day (Hopkins, pers. comm. 2016). Water produced from this aquifer is used for agricultural and M&I purposes.

Hueneme Aquifer

The Hueneme Aquifer comprises a series of lenticular silts, sands, and gravels in the Upper San Pedro Formation. This aquifer is present in the northern part of the Oxnard Subbasin but is absent to the south of Hueneme Roads (Mukae and Turner 1975). Within the Oxnard Subbasin, the Hueneme Aquifer is up to 1,150 feet thick along the axis of the Las Posas syncline (Turner 1975). The Hueneme Aquifer extends several miles offshore and crops out in the Hueneme and Mugu submarine canyons.

Changes in lithologic composition, with the aquifer generally containing a higher percentage of fine materials adjacent to the LPVB and PVB, affect flow through the aquifer. The change in composition is accompanied by an increase in the lenticular nature of the deposits that compose the Hueneme Aquifer along the eastern boundary of the Oxnard Subbasin. These changes limit subsurface flow between the Oxnard Subbasin and the LPVB and PVB to the east.

In addition to changes in lithology, structural folding of the Hueneme Aquifer also affects subsurface flow (Turner 1975). Folding, subsequent erosion, and recent deposition have resulted in a direct hydraulic connection between the Hueneme Aquifer and the overlying Mugu Aquifer throughout much of the Oxnard Subbasin (Turner 1975). However, in the southwestern portion of the basin, where seawater intrusion has affected the Mugu Aquifer, the Mugu and Hueneme Aquifers are not in direct hydraulic communication. As a result, water quality in the Hueneme Aquifer has not been affected by seawater intrusion in this area (Turner 1975; Hanson et al. 2003). Offshore faulting in the Hueneme Aquifer also limits direct seawater intrusion into the aquifer in the vicinity of Mugu Canyon, and faulting along the northern and southern boundaries of the Oxnard Subbasin limit flow out of the Hueneme Aquifer to the Mound Basin or to the south of the Bailey Fault (Hanson et al. 2003; Appendix C).

The chloride concentration of native water in the Hueneme Aquifer is approximately 40 mg/L (USGS 1996). In the vicinity of Point Hueneme, the chloride concentration of the Hueneme Aquifer was as high as 9,900 mg/L in 2016 (FCGMA 2016).

Wells screened solely within the Hueneme Aquifer have an average yield of approximately 2,500 gpm and an average specific capacity of 38 gpm per foot (Hopkins, pers. comm. 2016). Storage coefficients of 2×10^{-4} and 3×10^{-4} were estimated from pumping test data at two wells and the transmissivity was estimated to be approximately 13,400 feet squared per day (Hopkins, pers. comm. 2016). Water produced from this aquifer is used for agricultural and M&I purposes.

Fox Canyon Aquifer

The FCA is a 100- to 600-foot-thick marine sand and gravel deposit in the Lower San Pedro Formation (Mukae and Turner 1975). The water-bearing deposits of the FCA fine toward the west (Turner 1975). This unit is laterally continuous throughout the Oxnard Subbasin except at the western tip of South Mountain, where the Santa Barbara Formation is in direct contact with the Mugu Aquifer, and in the southwestern part of the Subbasin, where uplift and erosion have removed the FCA (Turner 1975). In the northern and western parts of the Subbasin, the FCA defines the base of the freshwater zone.

In the Oxnard Subbasin, the FCA is thickest along the axis of the Las Posas syncline. In this area, the FCA reaches thickness in excess of 500 feet, and the base of the aquifer is below −2,000 feet msl (Turner and Mukae 1975; Turner 1975). The primary source of freshwater recharge to the FCA is infiltration through the Oxnard and Mugu Aquifer systems in the Forebay area (Turner 1975; FCGMA 2007).

As with the other primary aquifers in the Oxnard Subbasin, the FCA extends several miles offshore and water quality in the FCA has been impacted by seawater intrusion. The native water in the FCA had a chloride concentration of 40 mg/L (USGS 1996). Chloride concentration measured in 2002 from a well in the southeastern part of the Subbasin ranged from 183 to 367 mg/L (Izbicki et al. 2005). However, the concentration of chloride measured in Well 01N21W32Q04, located inland of Mugu Canyon in the southern part of the Subbasin, was 5,070 mg/L in 2015.

Offshore faulting in the vicinity of Mugu Canyon is thought to limit direct seawater intrusion into the FCA (Hanson et al 2003; Appendix C). Instead, increasing concentrations of chloride in the FCA near Mugu Canyon are thought to originate in the aquifers of the UAS and migrate vertically into the FCA.

There are no aquifer-specific hydraulic parameter measurements for the FCA. Several specific capacity aquifer tests have been conducted in the Oxnard Subbasin, but typically these tests occur in wells screened across multiple aquifers (Appendix C). More detail on the limitations of hydraulic parameter measurements is found in the UWCD model documentation report (Appendix C). Well 02N22W20J02S, in the northern Oxnard Subbasin, is screened in both the FCA and overlying Hueneme Aquifer. This well has a yield of 3,030 gpm, a specific capacity of 95.3 gpm per foot, and a transmissivity of 40,100 feet squared per day (Hopkins, pers. comm. 2016). Water produced from this aquifer is used for agricultural and M&I purposes.

Grimes Canyon Aquifer

The GCA comprises lower Pleistocene age sand with minor amounts of gravel. This aquifer corresponds with the basal conglomerate within the upper member of the Santa Barbara Formation and is only found underlying the southern and eastern parts of the Oxnard Subbasin (Turner 1975). In the southern part of the Subbasin, the GCA is found in a band approximately 5 miles wide along the base of the Santa Monica Mountains from the Pacific Ocean to the boundary with the PVB to the east (Turner 1975). Throughout the rest of the Subbasin, the Grimes Canyon member of the Santa Barbara Formation is absent. As with the other aquifers in the Subbasin, the GCA extends several miles offshore.

The GCA, where present in the Oxnard Subbasin, is in hydraulic communication with the overlying FCA, and there are no production wells perforated solely in the GCA (Turner 1975; VCWPD 2013). As a result, there is little information on the water quality or aquifer properties of the GCA. Water quality has been sampled in some basal portions of the aquifer, and has been found to have brackish water that is likely a result of limited flushing since deposition and upward migration of brines from underlying formations (Mukae and Turner 1975; Turner 1975; Hanson et al. 2003).[2, 3] In addition, seawater intrusion may have impacted some wells screened in the GCA (see Section 2.3.3, Seawater Intrusion). Direct seawater flow into the GCA in the vicinity of Mugu Canyon is thought to be limited by offshore faulting (Hanson et al 2003; Appendix C). Concentrations of chloride have been increasing in this area since the 1990s. In 2016 the groundwater concentration measured in a sample collected from Well 01S21W08L03S was 6,428 -mg/L (FCGMA 2016). Measured aAquifer properties data specific to the GCA are not currently available.

2.2.4 Data Gaps and Uncertainty in the Hydrogeologic Conceptual Model

The primary data gaps in the hydrogeologic conceptual model are as follows:

- Distributed measurements of aquifer properties from wells screened solely in a single aquifer
- Distributed measurements of groundwater quality from wells screened solely in a single aquifer
- Measurements of groundwater quality that distinguish the sources of high TDS concentrations in the FCA and the GCA
- Temporal limitations on groundwater elevation data
- Spatial limitations on groundwater elevation data
- The relative impacts of production from areas within the Subbasin on seawater intrusion
- Connection between the semi-perched aquifer and potential groundwater-dependent ecosystems (GDEs)
- Potential impacts of increased production in the semi-perched aquifer

The data gaps listed above create uncertainty in the understanding of the impacts of water level changes on change in storage in the aquifer and on the inland extent of seawater intrusion in the aquifers. Additional aquifer tests, groundwater elevations, and groundwater quality sampling in the future would help reduce the uncertainty associated with these data gaps. Closing the data gaps is discussed further in Chapter 4, Monitoring Networks, of this GSP.

2 Brackish water is typically defined as water with a concentration of total dissolved solids (TDS) between 3,000 and 10,000 mg/L.

3 Brines typically have concentrations of TDS greater than 35,000 mg/L.

2.3 GROUNDWATER CONDITIONS

2.3.1 Groundwater Elevation Data

Groundwater elevations in the Oxnard Subbasin were first measured in agricultural wells in the 1930s, and multiple entities, including the United Water Conservation District (UWCD), DWR, and the County of Ventura (the County), have recorded water elevations in the Oxnard Subbasin over the intervening decades. In the early 1990s, after the U.S. Geological Survey (USGS) installed a series of nested monitoring wells during the Regional Aquifer System Analysis (Densmore 1996), an annual groundwater monitoring program was initiated in the Subbasin by the County, UWCD, and USGS (FCGMA 2007). The groundwater monitoring programs conducted by the Ventura County Watershed Protection District and other agencies, including UWCD, include production wells and multiple-completion nested monitoring wells. Many of the production wells included in the monitoring program are screened across multiple aquifers. Historically, the FCGMA annual reports have included potentiometric surface maps for wells screened in the UAS and wells screened in the LAS since 2013 (FCGMA 2015).

To conform with the DWR GSP Regulations, Section 354.~~14~~16, the following discussion of groundwater elevation is limited to production and monitoring wells screened in a single aquifer. Water level measurements collected between March 2 and March 29, 2015, are used to represent groundwater elevations in spring 2015. Water level measurements collected between October 2 and 29, 2015, are used to represent groundwater elevations in fall 2015.

Because many production wells within the Subbasin are screened across multiple aquifers and there are a limited number of dedicated monitoring wells, the depiction of representative regional potentiometric surfaces in each aquifer is limited. Similarly, the depiction of groundwater trends is also limited by spatial and temporal constraints that are imposed when only using wells screened in a single aquifer. Groundwater pumping data for the year 2015 were mapped to provide context for interpreting the potentiometric surfaces presented in this section (see Figure 2-5, Upper Aquifer System 2015 Extraction [acre-feet] in Oxnard and Pleasant Valley and Figure 2-6, Lower Aquifer System 2015 Extraction [acre-feet] in Oxnard and Pleasant Valley). Self-reported groundwater extraction data for 2015 are shown in Figures 2-5 and 2-6 for wells screened in the UAS and LAS, respectively. In the UAS, the location of the greatest amount of extraction is within the Forebay, with additional extraction areas both west and southeast of the City of Oxnard (Figure 2-5). The majority of the production from the LAS is in the southeastern portion of the Subbasin (Figure 2-6). The volume of groundwater extracted from the LAS is greater than that extracted from the UAS.

Current and historical groundwater elevations are discussed below by aquifer. Full hydrographs for all Oxnard Subbasin wells in which five or more water level measurements have been recorded are included in Appendix D, Water Elevation Hydrographs. In general, climate cycles, management actions, and the construction of water conservation facilities have impacted water elevations in the Oxnard Subbasin. The Freeman Diversion, completed in 1991, allows UWCD to divert surface water from the Santa Clara River to spreading basins, where it can infiltrate into the aquifers of the UAS and be transported via pipelines to other areas. This additional recharge enhanced aquifer recovery in the 1990s after a period of drought (FCGMA 2007). Additionally, UWCD's Pumping Trough Pipeline (PTP), constructed in 1986, which delivers diverted Santa Clara River water to agricultural parcels on the Oxnard Plain in lieu of groundwater production from that area, resulted in rising groundwater elevations during the late 1980s. In 1991, Ventura County adopted Ordinance 3991, which provided a temporary prohibition on drilling of new wells in the UAS, which also contributed to water elevation recovery in the UAS in the 1990s.

2.3.1.1 Oxnard Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the Oxnard Aquifer wells ranged from −27.2 to 46.3 feet msl (Figure 2-7, Groundwater Elevation Contours in the Oxnard Aquifer, March 2–29, 2015). In the fall of 2015, recorded groundwater elevations ranged from −30.7 to 37.9 feet msl (Figure 2-8, Groundwater Elevation Contours in the Oxnard Aquifer, October 2–29, 2015).

Groundwater flows from areas of high groundwater elevation to areas of low groundwater elevation. The highest groundwater elevations in the Oxnard Aquifer are found in the Forebay in both the fall and spring of 2015 (Figures 2-5 and 2-7). The hydraulic gradient in the Forebay in the spring of 2015 was approximately 0.005 feet/feet with groundwater flowing to the south and southwest, toward the pumping centers west and southeast of the City of Oxnard. In the fall of 2015, the hydraulic gradient was approximately 0.005 feet/feet with groundwater flowing to the southwest and southeast.

Elsewhere in the Subbasin, groundwater elevations in the Oxnard Aquifer are higher on the western and eastern boundaries of the Subbasin than they are in the center of the Subbasin. In this central area, groundwater elevations are more than −20 feet msl in both the spring and fall of 2015, though the areal extent of lower elevations is much greater in fall than in spring (Figures 2-7 and 2-8). In general, elevations in the UAS in the central Oxnard Subbasin are above sea level during wet climatic periods and fall below sea level during droughts (UWCD 2016a). Artesian conditions can occur in the western Oxnard Subbasin during wet climatic cycles (UWCD 1999).

The central area of low elevations reflects the groundwater production from wells southeast of the City of Oxnard in the central Oxnard Subbasin (Figure 2-5). The hydraulic gradient, directed toward the production wells, was less than approximately 0.001 feet/feet in both the spring and fall of 2015. Coastal elevations were measured below or near sea level in both spring and fall of 2015, and consequently, the hydraulic gradient was generally landward at the coast (Figures 2-7 and 2-8).

There is uncertainty associated with the groundwater elevation contours, hydraulic gradient, and groundwater flow direction in the Oxnard Aquifer in the spring and fall of 2015. Fewer wells are screened solely within the Oxnard Aquifer than are producing groundwater from the Oxnard Aquifer. The majority of the wells that produce groundwater in the Oxnard Aquifer are screened across multiple aquifers. These wells were not used to create the contour maps in order to conform with the DWR GSP Regulations, Section 354.14. The uncertainty in hydraulic gradient, flow direction, and groundwater elevation within the Oxnard Aquifer is particularly pronounced in the southern Oxnard Subbasin, where there are few wells screened solely within the Oxnard Aquifer but several production wells screened in multiple aquifers (Figures 2-7 and 2-8).

Vertical Gradients

Groundwater elevations in the Oxnard Aquifer are higher than those in the underlying Mugu Aquifer, resulting in a downward vertical gradient from the Oxnard Aquifer to the Mugu Aquifer in all areas of the Oxnard Subbasin for which Mugu-specific elevation data are available (Table 2-2). The magnitude of the vertical gradient varies with distance from the coast. The downward vertical gradient between the Oxnard and Mugu Aquifers was calculated for five wells in the fall of 2015 (Table 2-2). The wells in Table 2-2 were selected from a larger group of nested groundwater monitoring wells to represent the vertical gradient at different geographic locations in the Subbasin.

In the spring of 2015, the vertical gradient from the Oxnard Aquifer to the underlying Mugu Aquifer ranged from 0.004 feet/feet at the coast near Port Hueneme to 0.278 feet/feet inland of Point Mugu (Table 2-2). In the fall of 2015, the vertical gradient from the Oxnard Aquifer to the underlying Mugu Aquifer ranged from 0.002 feet/feet at the coast near Port Hueneme to 0.468 feet/feet inland of Point Mugu (Table 2-2). The vertical gradients along the coast are lower than they are inland, possibly reflecting the influence of seawater in the aquifer, moderating water levels at the coast. Alternatively, the vertical gradients may be lower at the coast because there is less pumping near the coast (Figures 2-5 and 2-6), and gradients may be higher in some inland areas that are closer to the Forebay area, as recharge in the Forebay affects water pressure in the Oxnard Aquifer more than the other aquifers.

The vertical gradient between the Oxnard and Mugu Aquifers was higher in the fall than in the spring, except at the coast where it was the same in the spring and fall (Wells 01N22W20M02S and 01N22W20M03S), and in the Forebay where the gradient was higher in the spring than in the fall (Wells 02N22W23B07S and 02N22W23B08S). The vertical gradient in the Forebay was higher in the spring because of surface water spreading grounds in the Forebay that are primarily used during periods of higher flow in the Santa Clara River.

Vertical gradients within the Oxnard Aquifer were determined from monitoring well clusters 01N21W19L, 02N22W23B, and 01N22W28G, which have two screen intervals within the Oxnard

Aquifer (Table 2-2). For each of these locations, the vertical hydraulic gradient within the Oxnard Aquifer was directed downward. The downward vertical hydraulic gradient ranged from 0.009 to 0.278 feet/feet in the spring of 2015. In the fall of 2015, the downward vertical gradient ranged from 0.016 to 0.643 feet/feet. The downward vertical hydraulic gradient was larger in the fall than in the spring, and the largest downward vertical hydraulic gradient was in the Oxnard Forebay (Forebay). The smallest downward vertical hydraulic gradient within the Oxnard Aquifer was adjacent to the coast (Table 2-2; Figure 2-8).

Historical Groundwater Elevation Trends

Groundwater elevations in the Oxnard Aquifer have declined and recovered over climatic cycles since the 1930s (Figure 2-9a, Groundwater Well Hydrographs in the Oxnard Aquifer – Oxnard Plain). Management policies and the construction and operation of water conservation facilities have also impacted historical groundwater elevations (see Section 2.3.1, Groundwater Elevation Data). Full hydrographs for Oxnard Subbasin wells with five or more groundwater elevation measurements are included in Appendix D.

Groundwater elevation trends in Well 01N21W07H01S, the well with the longest historical groundwater elevation record in the Oxnard Subbasin, track with the trends observed in the record of cumulative departure from the mean precipitation on the Oxnard Plain (Figure 2-9a). Declines in groundwater elevation occurred between 1941 and 1966, 1970 and 1977, 1984 and 1990, and 2011 and 2016, coincident with periods of drought shown in the declining limb of the cumulative departure from the mean precipitation curve (Figure 2-9a). Groundwater elevations recovered after each historical drought period, but have not yet recovered from the drought beginning in 2011. The amount of historical recovery depended on the length of time between droughts and the amount of precipitation received in each of the water years between the droughts, as well as management measures, including surface water spreading and deliveries, operative during the various periods. By 1980, the groundwater elevation recovered to within 10 feet of the previous maximum measured in 1941, and by 1999, water levels exceeded the 1941 maximum (Figure 2-9a), likely due to several wet years during the 1990s and the influence of management actions taken, and water conservation facilities constructed, in the 1980s and 1990s (see Section 2.3.1). In the late 1990s, artesian conditions were documented in the western Oxnard Subbasin (UWCD 1999). Since 2011, groundwater elevations in this well have declined approximately 40 feet.

The patterns of water level decline and recovery observed in Well 01N21W07H01S are observed in Oxnard Aquifer wells throughout the Oxnard Subbasin, although absolute changes in water level vary geographically within the Oxnard Subbasin (Figure 2-9a and Figure 2-9b, Groundwater Well Hydrographs in the Oxnard Aquifer – Forebay Area). Wells in the Forebay area and northeastern Oxnard Subbasin have experienced water level declines of approximately 90 feet since 2011 (Figure 2-9b), while water levels in wells adjacent to the coast and in wells farther south have declined between 18 and 40 feet over the same period (Figure 2-9a). The larger water level changes observed in the northeastern Oxnard Subbasin reflect the influence of UWCD's managed aquifer recharge activities in the Forebay area; additionally, water level changes at the coast may be smaller due to the fact that seawater may be intruding and occupying volume within the aquifer as freshwater recedes.

Although groundwater elevations in the Oxnard Subbasin recover to some degree after each drought period, elevations in coastal wells do not always recover to mean sea level. Historical elevations of coastal wells over time in relation to sea level are discussed in Section 2.3.3.

2.3.1.2 Mugu Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the Mugu Aquifer in the Oxnard Subbasin ranged from −60.7 to 8.2 feet msl (Figure 2-10 Groundwater Elevation Contours in the Mugu Aquifer, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from −97.7 to −12.1 feet msl (Figure 2-11, Groundwater Elevation Contours in the Mugu Aquifer, October 2–29, 2015).

The highest groundwater elevations in the Mugu Aquifer are found in the Forebay in both the fall and spring of 2015 (Figures 2-10 and 2-11). The hydraulic gradient in the Forebay in the spring of 2015 was approximately 0.003 feet/feet with groundwater flowing to the south and southwest. In the fall of 2015, the hydraulic gradient was approximately 0.002 feet/feet with groundwater flowing to the south and southwest. These gradients are based on the wells that are screened solely within the Mugu Aquifer, which are primarily located in the eastern part of the Subbasin. Groundwater elevations in the Mugu Aquifer are lowest in the southeastern area of the Subbasin. In general, elevations in the UAS in the southernmost corner of the Subbasin tend to be lower than in the central Subbasin (by as much as 40 to 80 feet), regardless of climatic cycles (FCGMA 2013).

In the southeastern area of the Subbasin, groundwater elevations were −30 to −100 feet msl in 2015 (Figures 2-10 and 2-11). The hydraulic gradient, directed toward the area of low groundwater elevations, was approximately 0.002 feet/feet to the southeast in the spring of 2015. In the fall of 2015, the hydraulic gradient directed toward the area of low groundwater elevations ranged from approximately 0.004 to 0.009 feet/feet to the east-southeast. Coastal groundwater elevations were measured below or near sea level in both spring and fall of 2015, creating a presumably landward hydraulic gradient at the coast (Figures 2-10 and 2-11).

There is uncertainty associated with the groundwater elevation contours, hydraulic gradient, and groundwater flow direction in the Mugu Aquifer in the spring and fall of 2015. The gradient is unknown in the northwestern area of the Subbasin, where there are no wells screened solely within the Mugu Aquifer. Additionally, fewer wells are screened solely within the Mugu Aquifer than are producing groundwater from the Mugu Aquifer. The majority of the wells that produce groundwater in the Mugu Aquifer are screened across multiple aquifers. These wells were not used to create the contour maps, in order to conform with the DWR GSP Regulations, Section 354.14. For the central and eastern areas of the Subbasin in which there are well data in the Mugu Aquifer, the uncertainty in hydraulic gradient, flow direction, and groundwater elevation within the aquifer is particularly pronounced. In this area, groundwater appears to flow to the south-southeast from the Oxnard Subbasin to the PVB (Figures 2-10 and 2-11).

Vertical Gradients

Groundwater elevations in the Mugu Aquifer are lower than those in the overlying Oxnard Aquifer, resulting in a downward vertical gradient from the Oxnard Aquifer to the Mugu Aquifer throughout the Oxnard Subbasin (Table 2-2; Section 2.3.1.1, Oxnard Aquifer). Groundwater elevations in the Mugu Aquifer are higher than those in the underlying Hueneme Aquifer, resulting in a downward vertical gradient from the Mugu Aquifer to the Hueneme Aquifer in the Forebay and adjacent to Port Hueneme (Table 2-2). At monitoring well cluster 01N22W20M, adjacent to Port Hueneme, the downward vertical hydraulic gradient was 0.033 feet/feet in the spring of 2015 and 0.039 feet/feet in the fall of 2015. At monitoring well cluster 02N22W23B, in the Forebay, the downward vertical hydraulic gradient was 0.012 feet/feet in the spring of 2015 and 0.028 feet/feet in the fall of 2015.

Within the Mugu Aquifer, a downward vertical gradient of 0.365 feet/feet was calculated in the spring of 2015 between Wells 01N21W32Q07S and 01N21W32Q05S (Figure 2-10). In the fall of 2015, the downward vertical gradient was 0.560 feet/feet (Table 2-2; Figure 2-11).

Historical Groundwater Elevation Trends

Groundwater elevations in the Mugu Aquifer have declined and recovered over climatic cycles since the 1970s (Figure 2-12, Groundwater Well Hydrographs in the Mugu Aquifer). Management policies and the construction and operation of water conservation facilities have also impacted historical groundwater elevations (see Section 2.3.1). Full hydrographs for Oxnard Subbasin wells with five or more groundwater elevation measurements are included in Appendix D.

Groundwater elevation trends in Well 02N22W24P01S, the well with the longest historical groundwater elevation record in the Mugu Aquifer, track with the trends observed in the record of cumulative departure from the mean precipitation on the Oxnard Plain (Figure 2-12). Declines in groundwater elevation occurred between 1974 and 1977, 1984 and 1990, and 2011 and 2016, coincident with periods of drought shown in the declining limb of the cumulative departure from the mean precipitation curve (Figure 2-12). Groundwater elevations recovered after each historical drought period, but have not yet recovered from the drought beginning in 2011. The amount of historical recovery depends on the length of time between droughts and the amount of precipitation received in each of the water years between the droughts, as well as management measures, including artificial recharge and surface water deliveries, operative during the various periods. In 1996, water levels exceeded the previous maximum in 1980 (Figure 2-12), likely due to several wet years during the 1990s and the influence of management actions taken, and water conservation facilities constructed in the 1980s and 1990s (see Section 2.3.1). In the late 1990s, artesian conditions were documented in the western Oxnard Subbasin (UWCD 1999). Since 2011, groundwater elevations in this well have declined approximately 100 feet.

The patterns of water level decline and recovery observed in Well 02N22W24P01S are observed in Mugu Aquifer wells throughout the Oxnard Subbasin, although absolute changes in water level vary geographically within the Subbasin (Figure 2-12). Well 02N22W24P01S is located near the Forebay area. Other wells in the Forebay area experienced similar water level declines and recoveries to those observed in Well 02N22W24P01S (Figure 2-12). Water levels in wells adjacent to the coast and in wells farther south, however, tend to have larger intra-annual variation (variation that occurs within a single year) in groundwater level, but a smaller drought response (e.g., Wells 01N21W32Q05S and 01N21W19L11S; see Figure 2-12). The groundwater elevation in these wells declined between 20 and 80 feet between 2011 and 2015, whereas the groundwater elevation in wells in the Forebay area declined approximately 100 feet over the same period. The larger groundwater level changes observed in the northeastern Oxnard Subbasin likely reflect the influence of groundwater recharge from spreading basins in the Forebay area; additionally, groundwater level changes at the coast may be smaller due to the fact that seawater may be intruding and occupying volume within the aquifer as freshwater recedes.

Although groundwater elevations in the Oxnard Subbasin recover after each drought period, groundwater elevations in coastal Mugu-specific wells in the southern Subbasin typically remain below mean sea level. Historical elevations of coastal wells over time in relation to sea level are discussed in Section 2.3.3.

2.3.1.3 Hueneme Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the Hueneme Aquifer in the Oxnard Subbasin ranged from −89.4 to 10.2 feet msl (Figure 2-13, Groundwater Elevation Contours in the Hueneme Aquifer, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from −115.5 to 2.1 feet msl (Figure 2-14, Groundwater Elevation Contours in the Hueneme Aquifer, October 2–29, 2015). There are fewer wells screened solely in the Hueneme Aquifer than are screened in the Oxnard Aquifer, Mugu Aquifer, or FCA in the Oxnard Subbasin. The small number of wells screened solely within the Hueneme Aquifer creates uncertainty in the groundwater elevation contours, hydraulic gradient, and groundwater flow direction (Figures 2-13 and 2-14).

This aquifer is present in the northern part of the Oxnard Subbasin but is absent to the south of Etting and Hueneme Roads (Mukae and Turner 1975).

The highest groundwater elevations in the Hueneme Aquifer are found in the Forebay in both the fall and spring of 2015 (Figures 2-13 and 2-14). The hydraulic gradient in the Forebay in the spring of 2015 was approximately 0.008 feet/feet, with groundwater flowing to the southwest. In the fall of 2015 the hydraulic gradient was approximately 0.007 feet/feet, with groundwater flowing to the south-southwest.

Groundwater elevations in the Hueneme Aquifer are lowest south of the Forebay and west of Central Avenue (Figures 2-13 and 2-14). In this area, groundwater elevations were −80 to −100 feet msl in 2015 (Figures 2-13 and 2-14). This area of lower groundwater elevations coincides with the location of several production wells that are screened solely within the Hueneme Aquifer (Figure 2-6). The hydraulic gradient, directed toward the area of low groundwater elevations, ranged from approximately 0.003 feet/feet to the southeast in the spring of 2015 to approximately 0.008 feet/feet to the east-southeast in the fall of 2015. Coastal groundwater elevations were below or near sea level in both spring and fall of 2015, resulting in a landward hydraulic gradient at the coast (Figures 2-13 and 2-14).

Vertical Gradients

Groundwater elevations in the Hueneme Aquifer are lower than those in the overlying Mugu Aquifer, resulting in a downward vertical gradient from the Mugu Aquifer to the Hueneme Aquifer (Table 2-2; Section 2.3.1.2, Mugu Aquifer). Groundwater elevations in the Hueneme Aquifer were higher than those in the underlying FCA in both the spring and fall of 2015, except in the Forebay at Wells 02N22W23B03 and 02N22W23B04. In these wells, the groundwater elevation in the Hueneme Aquifer was higher than it was in the FCA in the spring of 2015, and lower than that in the FCA in the fall of 2015 (Table 2-2). In the spring of 2015, the downward vertical hydraulic gradient between the Hueneme Aquifer and FCA ranged from 0.014 feet/feet to 0.040 feet/feet. In the fall of 2015, the vertical hydraulic gradient between the Hueneme Aquifer and FCA ranged from 0.050 feet/feet downward adjacent to the coast, to 0.032 upward in the Forebay (Table 2-2).

Within the Hueneme Aquifer, a downward vertical gradient of 0.017 feet/feet was calculated for Wells 01N22W20M03S and 01N22W20M02S in the spring of 2015 (Figure 2-13). In the fall of 2015, the gradient in these wells was 0.019 feet, which is the same as it was in the spring. Farther north, in Wells 01N23W01C03S and 01N23W01C04S, the vertical gradient within the Hueneme Aquifer was similar to that calculated for Wells 01N22W20M03S and 01N22W20M02S. In the spring of 2015, the downward vertical hydraulic gradient was 0.009 feet/feet in Wells 01N23W01C03S and 01N23W01C04S. In the fall, the downward vertical hydraulic gradient was 0.010 feet/feet between Wells 01N23W01C03S and 01N23W01C04S (Table 2-2).

In Wells 02N22W23B07S and 02N22W23B08S, in the Forebay, the downward vertical gradient is greater in the upper Hueneme Aquifer than in the lower Hueneme Aquifer (Table 2-2). The gradients within the Hueneme Aquifer in the Forebay are similar to those within the Hueneme Aquifer along the coast.

Historical Groundwater Elevation Trends

Groundwater elevations in the Hueneme Aquifer have declined and recovered over climatic cycles (Figure 2-15, Groundwater Well Hydrographs in the Hueneme Aquifer). Management policies and the construction and operation of water conservation facilities have also impacted historical groundwater elevations (see Section 2.3.1). Full hydrographs for Oxnard Subbasin wells with five or more groundwater elevation measurements are included in Appendix D.

Groundwater elevation trends in Well 02N21W31P03S, the well with the longest historical groundwater elevation record in the Hueneme Aquifer, track with the trends observed in the record of cumulative departure from the mean precipitation on the Oxnard Plain (Figure 2-15). Declines in groundwater elevation occurred between 1974 and 1977, 1984 and 1990, and 2011 and 2016, coincident with periods of drought shown in the declining limb of the cumulative departure from the mean precipitation curve (Figure 2-15). Groundwater elevations largely recovered after each historical drought period, but have not yet recovered from the drought beginning in 2011. The amount of historical recovery depends on the length of time between droughts and the amount of precipitation received in each of the water years between the droughts, as well as the management measures, including artificial recharge and surface water deliveries, operative during the various periods. Since 2011, groundwater elevations in this well have declined approximately 60 feet (Figure 2-15).

The patterns of water level decline and recovery observed in Well 02N21W31P03S are also observed in Hueneme Aquifer Wells 01N22W03F05S and 01N22W26M03S, although the magnitude of the change in groundwater levels varies between the wells (Figure 2-15). Ignoring seasonal variations reflecting pumping, the spring high elevations between 1996 and 2010 were relatively stable in Well 01N22W26M03S and declined by approximately 32 feet in Well 01N22W03F05S. Between 2011 and 2015, during a period of drought, groundwater elevations declined approximately 47 feet in Well 01N22W26M03S and approximately 55 feet in Well 01N22W03F05S (Figure 2-15).

Although groundwater elevations in the Oxnard Subbasin recover after each drought period, groundwater elevations in coastal wells can remain below mean sea level, resulting in a landward gradient near the coast.

2.3.1.4 Fox Canyon Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the FCA in the Oxnard Subbasin ranged from −107.3 to 3.9 feet msl (Figure 2-16, Groundwater Elevation Contours in the Fox Canyon Aquifer, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from −156.3 to −24.6 feet msl (Figure 2-17, Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2–29, 2015).

The highest groundwater elevations in the FCA are found in the Forebay in both the fall and spring of 2015 (Figures 2-16 and 2-17). The lowest recorded groundwater elevations are found at Well 01N21W06J05S, south of 5th Street, west of Pleasant Valley Road (Figures 2-16 and 2-17). The low groundwater elevations in this well reflects the production from the FCA at this location (Figure 2-6). However, there are several wells in the surrounding areas that produced more groundwater in 2015, but are screened across multiple aquifers in the LAS. The hydraulic gradient in the FCA was directed toward Well 01N21W06J05S in both the spring and fall of 2015. In the spring of 2015, the hydraulic gradient was approximately 0.001 to 0.002 feet/feet. In the fall of 2015, the hydraulic gradient ranged from approximately 0.002 to approximately 0.005 feet/feet. These gradients may not fully depict the direction and magnitude of flow within the FCA because more production wells are screened across multiple aquifers in the LAS than are screened solely within the FCA, and consequently production is occurring in areas of the aquifer that lack aquifer-specific groundwater elevation data. Coastal groundwater elevations were measured below or near sea level in both spring and fall of 2015, resulting in a landward hydraulic gradient (Figures 2-16 and 2-17).

Vertical Gradients

Groundwater elevations in the FCA are generally lower than those in the overlying aquifers (Figures 2-16 and 2-17; Table 2-2). In the spring of 2015, the downward vertical gradient from the Mugu Aquifer to the FCA ranged from 0.012 feet/feet in the Forebay to 0.390 feet/feet adjacent to Highway 1 (Figure 2-16; Table 2-2). In the fall of 2015, the downward vertical gradient from the Mugu Aquifer to the FCA ranged from 0.620 feet/feet in the Forebay to 0.028 feet/feet south of Hueneme Road.

In the spring of 2015, the downward vertical gradient from the Hueneme Aquifer to the FCA was similar geographically, ranging from 0.014 feet/feet in the Forebay and along the coast north of Port Hueneme to 0.040 feet/feet adjacent to the coast at Port Hueneme (Table 2-2). In the fall of 2015, the vertical hydraulic gradient between the Hueneme Aquifer and FCA ranged from 0.050 feet/feet downward along the coast near Port Hueneme to 0.032 feet/feet upward in the Forebay (Table 2-2).

Within the FCA, a downward vertical gradient of 0.005 feet/feet was calculated for Wells 01N22W36K06S and 01N22W36K07S in the spring of 2015. The vertical hydraulic gradient in these wells, near Point Mugu, was 0.019 feet/feet downward in the fall of 2015. In the Mugu area the vertical flow to the FCA is a major mechanism for seawater intrusion. In the Forebay area, the vertical hydraulic gradient within the FCA was 0.014 feet/feet downward in the spring of 2015 and 0.022 feet/feet upward in the fall of 2015 (Table 2-2; Wells 02N21W07L04S and 02N21W07L06S).

Groundwater elevations in the FCA are higher than those in the underlying GCA, except adjacent to Port Hueneme in Wells 01N22W28G04S and 01N22W28G05S (Table 2-2).

Historical Groundwater Elevation Trends

Groundwater elevations in the FCA have declined and recovered over climatic cycles (Figure 2-18, Groundwater Well Hydrographs in the Fox Canyon Aquifer). Management policies and the construction and operation of water conservation facilities have also impacted historical groundwater elevations (see Section 2.3.1). Full hydrographs for Oxnard Subbasin wells with five or more groundwater elevation measurements are included in Appendix D.

Groundwater elevation trends in Well 01N22W26K04S, the well with the longest historical groundwater elevation record in the FCA, track with the trends observed in the record of cumulative departure from the mean precipitation on the Oxnard Plain (Figure 2-18). Declines in groundwater elevation occurred between 1974 and 1977, 1984 and 1990, and 2011 and 2016, coincident with periods of drought shown in the declining limb of the cumulative departure from the mean precipitation curve (Figure 2-18). Groundwater elevations recovered after each drought period prior to the most recent drought. Groundwater elevations have not yet recovered to pre-2011 levels.

The amount of historical recovery depends on the length of time between droughts and the amount of precipitation received in each of the water years between the droughts, as well as management measures, including artificial recharge and surface water deliveries, operative during the various periods. In 1999, water levels exceeded the previous maximum in 1983 (Figure 2-18), likely due to several wet years during the 1990s and the influence of management actions taken, and water conservation facilities constructed, in the 1980s and 1990s (see Section 2.3.1). In the late 1990s, artesian conditions were documented in the western Oxnard Subbasin (UWCD 1999).

The patterns of groundwater level decline and recovery observed in Well 01N22W26K04S are observed in FCA wells throughout the Oxnard Subbasin, although absolute changes in groundwater level vary geographically within the Oxnard Subbasin (Figure 2-18). Well 01N22W26K04S is located south of Hueneme Road. Other wells in this area experienced similar groundwater level declines and recoveries to those observed in Well 01N22W26K04S (Figure

2-18). Wells farther inland tend to have larger intra-annual variations in groundwater level (e.g., Wells 01N21W06J05S and 01N21W09C04S; see Figure 2-18). The groundwater elevation in these wells declines by 40 to 50 feet each year between the spring high and fall low groundwater levels. In contrast, Well 01N23W01C02S, adjacent to the coast, declines approximately 5 feet between the spring high and fall low groundwater level (Figures 2-16, 2-17, and 2-18). Groundwater level changes at the coast may be smaller due to the fact that seawater may be intruding and occupying volume within the aquifer as freshwater recedes.

Although groundwater elevations in the Oxnard Subbasin recover after each drought period, groundwater elevations in coastal FCA-specific wells in the southern Subbasin typically remain below mean sea level.

2.3.1.5 Grimes Canyon Aquifer

Spring and Fall 2015 Groundwater Elevations

The GCA is only found underlying the southern and eastern parts of the Oxnard Subbasin (Turner 1975). Only six wells in the Oxnard Subbasin are screened solely within the GCA. These wells are located in the southern part of the Subbasin, all located west of Revolon Slough (Figure 2-19, Groundwater Elevation Contours in the Grimes Canyon Aquifer, March 2–29, 2015). In the spring of 2015, recorded groundwater elevations in the GCA ranged from −31.3 to −75.6 feet msl (Figure 2-19). In the fall of 2015, groundwater elevations ranged from −38.6 feet msl to −114.2 feet msl (Figure 2-20, Groundwater Elevation Contours in the Grimes Canyon Aquifer, October 2–29, 2015).

Where measured, groundwater in the GCA flows to the east-northeast from the coast toward the Revolon Slough (Figures 2-19 and 2-20). In the spring of 2015, the hydraulic gradient in the vicinity of Point Mugu was approximately 0.003 feet/feet (Figure 2-19). In the fall of 2015, the hydraulic gradient was approximately 0.008 feet/feet (Figure 2-20).

There is a large degree of uncertainty associated with the groundwater elevation contours, hydraulic gradient, and groundwater flow direction in the GCA in the spring and fall of 2015 because so few wells are screened solely within the GCA. The direction of flow, as contoured by the wells that are screened within the GCA, likely reflects the LAS groundwater production south of Hueneme Road (Figure 2-6). However, no wells are screened solely within the GCA north of Hueneme Road; therefore, the groundwater elevation, hydraulic gradient, and direction of flow in the GCA is unknown for much of the Oxnard Subbasin. Coastal groundwater elevations were measured below or near sea level in both spring and fall of 2015, and consequently the hydraulic gradient was landward at the coast (Figures 2-19 and 2-20).

Vertical Gradients

Groundwater elevations in the GCA are generally lower than those in the overlying FCA, except adjacent to Port Hueneme in Wells 01N22W28G04S and 01N22W28G05S (Table 2-2). The downward vertical hydraulic gradient in the spring of 2015 ranged from 0.047 feet/feet downward at Wells 01N21W32Q04S and 01N21W32Q05S to 0.01 feet/feet upward Wells 01N22W28G04S and 01N22W28G05S (Table 2-2). Vertical hydraulic gradients were similar in the fall of 2015, ranging from 0.044 feet/feet downward to 0.019 feet/feet upward, in the same wells.

Only well cluster 01N21W32Q has two wells screened within the GCA (Wells 01N21W32Q02 and 01N21W32Q03; Figure 2-19). Within the GCA, the vertical hydraulic gradient was 0.084 feet/feet upward in both the spring and fall of 2015 (Table 2-2).

Historical Groundwater Elevation Trends

Groundwater elevations in the GCA have been measured since 1989. Similar to the water levels in the overlying FCA, the groundwater levels in the GCA recovered between 1990 and 1996 (Figure 2-21, Groundwater Well Hydrographs in the Grimes Canyon Aquifer). Between 1996 and 2010, groundwater elevations were relatively stable, with intra-annual variation of up to 80 feet per year, but with inter-annual variation (variation that occurs over a series of years) of 10 feet or less. Between 2011 and 2015 groundwater elevations in the GCA declined, coincident with a period of drought. Groundwater elevations in Wells 01N22W28G01S and 01N22W35E01S vary less than groundwater elevations in other GCA wells, potentially because they are relatively far from major centers of groundwater extraction or because they are adjacent to the coast, and the intrusion of seawater may moderate freshwater elevation changes (Figures 2-19 and 2-21).

Although groundwater elevations in the Oxnard Subbasin recover to some degree after each drought period, elevations in coastal GCA-specific wells in the southern Subbasin remain below mean sea level.

2.3.2 Estimated Change in Storage

Estimated monthly change in storage values for the Oxnard Subbasin were generated by the numerical groundwater flow model prepared by UWCD (Appendix C). Monthly data reported from the model was summed to get the annual change in storage for the period from water year 1986 to water year 2015. There are inherent uncertainties in using any numerical groundwater flow model. The uncertainty associated with the UWCD model estimates is explored in more detail in Appendix E, UWCD Model Peer Review. Model estimated change in storage for the aquifer, the UAS, and the LAS is presented below.

The annual change in storage in the semi-perched aquifer ranged from an increase of approximately 16,300 AF in water year 1995 to a decrease of approximately 11,000 AF in water year 2014. The average annual change in storage in the semi-perched aquifer was a loss of storage of approximately 410 AFY.

In the UAS, the annual change in storage ranged from an increase of approximately 63,000 AF in water year 2005 to a decrease of approximately 34,200 AF in water year 1987. The average annual change in storage in the UAS was a loss of approximately 2,800 AFY.

The LAS had a maximum annual increase in storage of approximately 7,300 AF in water year 2005 and a maximum annual decrease in storage of approximately 8,000 AF in water year 1987. The average annual change in the LAS was a loss of approximately 220 AFY.

Total average annual change in storage in the Oxnard Subbasin was a decrease in storage of approximately 3,400 AFY. For the entire Oxnard Subbasin, the annual change in storage ranged from an increase of approximately 81,000 AF in water year 2005 to a decrease of approximately 48,700 AF in water year 1987 (Figure 2-22, Oxnard Subbasin Annual Change in Storage).

The cumulative change in storage calculated by the model over the period of record, water years 1986 through 2015, is presented on Figure 2-23, Oxnard Subbasin Cumulative Change in Storage. For the semi-perched aquifer, the UAS, and the LAS, the cumulative change in storage was a loss of approximately 12,300 AF, 82,500 AF, and 6,600 AF, respectively. The total cumulative loss for the entire Oxnard Subbasin was approximately 101,400 AF (Figure 2-23). Groundwater extraction (pumping) in the FCGMA is reported on a calendar year basis, so pumping and artificial recharge in figures is per calendar year, while change in storage is per water year. Annual change in storage is not strongly correlated to groundwater pumping in the Oxnard Plain ($R^2 < 0.5$). In contrast, artificial groundwater recharge at the UWCD spreading grounds is correlated with change in storage ($R^2 > 0.8$; see Figures 2-22 and 2-23). Therefore, maintaining the ability to recharge groundwater via the UWCD spreading grounds is critical to maintaining groundwater production in the Subbasin.

The model results illustrated in Figures 2-22 and 2-23 represent the net change in groundwater storage in each of the aquifer systems in the Subbasin. These results, however, include flux of seawater into the coastal areas of the aquifer systems from offshore. The volume of seawater that intruded between 1986 and 2015 was calculated for the UAS and LAS. The volume of seawater calculated does not include coastal flux into or out of the semi-perched aquifer, as few production wells are screened solely in the semi-perched aquifer. In order to assess the change in freshwater storage in the Subbasin, the annual volume of seawater that intruded was subtracted from the annual total storage change discussed above.

In the UAS, the average annual change in freshwater storage is a loss of approximately 6,600 AFY, which is more than two times greater than the total average annual change in storage for the UAS (2,800 AFY), including seawater intrusion (Figure 2-24, Oxnard Subbasin Annual Change in Storage Without Coastal Flux). In other words, approximately 3,800 AFY of seawater intrusion occurred in the UAS between water years 1986 and 2015. The maximum annual increase in freshwater storage was approximately 61,500 AF in water year 2005 and the maximum annual decrease in freshwater storage was approximately 48,500 AF in water year 1990.

The average annual change in freshwater storage in the LAS is a loss of approximately 5,700 AFY, which is 26 times greater than the total average annual change in storage for the LAS (220 AFY), including seawater intrusion (Figure 2-24). Therefore, there was approximately 5,500 AFY of seawater intrusion into the LAS between water years 1986 and 2015. The maximum increase of freshwater in storage in the LAS was approximately 2,820 AF in water year 1998 and the maximum decrease of freshwater in storage was approximately 15,150 AF in water year 1990.

For the entire Oxnard Subbasin, there was an average decrease in freshwater storage of approximately 12,700 AFY, when coastal flux is removed, with a maximum increase in storage of approximately 74,700 AF in water year 2005 and a maximum decrease in storage of approximately 73,500 AF in water year 1990 (Figure 2-24). Cumulatively between 1986 and 2015, the loss of freshwater in storage in the UAS was approximately 197,200 AF and the loss of freshwater in storage in the LAS was approximately 170,200 AF. The cumulative change in freshwater storage for both the UAS and LAS was a loss of approximately 367,400 AF. The cumulative change in storage for the entire Oxnard Subbasin, including the semi-perched aquifer, calculated by the model over the period of record, was a loss of approximately 380,200 AF of freshwater in storage, excluding coastal flux (Figure 2-25, Oxnard Subbasin Cumulative Change in Storage Without Coastal Flux).

Estimates of model changes in storage have a level of uncertainty and are dependent on model input parameters. These parameters include groundwater pumping, artificial aquifer recharge, interbasin flows, recharge from precipitation and irrigation returns, stream leakage and groundwater discharge to streams, and inflows from the ocean. Numbers may also initially be biased due to assumptions about the initial groundwater levels used in the model, which are based on available well locations and measurements that may bias starting groundwater elevations modeled in the aquifers. These inputs were estimated using the best available data and calibrated to groundwater levels in the model to a reasonable extent (Appendix C). Changes in these input values from additional monitoring wells, the filling of data gaps, and model calibration and validation may result in changes in the modeled estimates of change in storage in the future.

2.3.3 Seawater Intrusion

Evidence of seawater intrusion in the Oxnard Subbasin was first documented in the 1930s in the vicinity of Port Hueneme and Point Mugu (DWR 1965). Since that time, the landward extent of the saline water impact front has been monitored and the causes and sources of increasing chloride concentrations have been studied. Table 2-3 lists historical seawater intrusion reports and studies on the Oxnard Subbasin.

An elevated risk of seawater intrusion has been found to exist near Port Hueneme and Point Mugu due to the near shore presence of the groundwater–seawater contact in deeply incised submarine canyons (UWCD 2016a).

Seawater intrusion has been documented in both aquifer systems, and in each primary aquifer, in the Oxnard Subbasin. Seawater preferentially intrudes the aquifers in permeable sand and gravel beds (UWCD 2016a). As a result, the eastward extent of the saline water impact front varies from north to south along the coastline and within each aquifer (UWCD 2016a). In the Oxnard Subbasin, seawater that has intruded the aquifers in the vicinity of Port Hueneme tends to flow southward toward Point Mugu even after groundwater elevations rise and the landward hydraulic gradient is reversed (UWCD 2016a). As a result, higher groundwater elevations in the aquifer do not tend to flush the seawater back out of the aquifer via the original intrusion pathway (UWCD 2016a). Consequently, impacts associated with seawater intrusion have not been eliminated during wetter-than-average climatic periods.

2.3.3.1 Causes of Saline Impacts in the Oxnard Subbasin

Under seaward groundwater gradients, groundwater in the Oxnard Subbasin generally flows south and west from the Oxnard Forebay area toward the Pacific Ocean and out to sea. When groundwater heads near the coast fall below sea level or, in confined aquifers, the sea-level-equivalent elevation according to the depth of the aquifer outcrop, the gradient reverses.[4]

In addition to seawater intrusion, low groundwater heads in confined zones in the Oxnard Subbasin can create conditions under which high-salinity waters from non-marine sources impact freshwater aquifers. These sources include connate (groundwater trapped in sedimentary rocks due their deposition) brines released during compaction of aquitards and older, higher-salinity groundwater upwelling from geologic formations deeper than the lower extent of the freshwater aquifers (Izbicki 1991, 1996; UWCD 2016a; Izbicki et al. 2005).

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4 Because seawater is approximately 1.025 times denser than freshwater (using the Ghyben-Herzberg theory [De Wiest 1998]), the elevation of confined freshwater necessary to counterbalance the pressure of the water in the sea can be several feet above sea level, and depends on the depth at which an aquifer crops out in the ocean (i.e., the deeper the outcrop, the higher the freshwater elevation necessary to counterbalance the pressure of seawater).

Thirdly, although the major aquifer units in the Oxnard Subbasin are commonly separated by low-permeability units, vertical gradients, long-screened wells, and areas of mergence between aquifers can result in vertical groundwater movement between major aquifers (UWCD 2016a). In particular, because water elevations are typically higher in the semi-perched aquifer than in the deeper confined aquifers, higher-salinity water from the semi-perched aquifer may reach confined aquifers via one or more of these mechanisms. Seawater intrusion also enters the FCA from vertical flow from the Mugu aquifer in the Mugu area.

Because zones of low groundwater head cause seawater intrusion and release of connate water from aquitards, and potentially influence non-marine brine migration into freshwater aquifers, distinguishing the source of salts in any given well is not always possible, particularly at chloride concentrations less than 500 mg/L (Izbicki 1996). In the southeastern Subbasin, near the Mugu submarine canyon, upward migration of brines can cause chloride concentrations to increase before the saline water impact front reaches a well (Izbicki 1996). Because the chloride concentration measured in wells near the Mugu submarine canyon reflect the combined effects of brine migration and seawater intrusion, it is difficult to define the leading edge of the saline water impact front using chloride concentrations in this area (Izbicki 1996). The USGS and UWCD models included faults in the Mugu Lagoon area that limit the hydraulic connection of the LAS in the Oxnard Basin to the Pacific Ocean (Hanson et al. 2003; Appendix C).

2.3.3.2 Current Extent of Seawater Intrusion

The known extent of saline water intrusion in the UAS and LAS in 2015 generally occurred near and southeast of Port Hueneme and in the area surrounding Mugu Lagoon. As of 2015, although seawater intrusion had been reduced in the Oxnard Subbasin due to management actions and wet climatic conditions in the 1990s and 2000s, TDS and chloride concentrations as high as 49,600 and 20,700 mg/L, respectively, were found in wells inland of the southern Oxnard coast (both measured in Well 01N22W07R05S; see Appendix F, Coastal Seawater Intrusion WL vs. CL Plots, and recent water quality data in Section 2.3.4, Groundwater Quality). The extent of saline water intrusion in the Oxnard Subbasin in 2015 is shown in cross section on Figure 2-26 (Approximate 2015 North–South Saline Water Intrusion Extent) and in plan view on Figures 2-27 through 2-32 (Coastal Chloride Concentrations, Fall 2015).[5] As discussed, chloride concentrations above 500 mg/L in the area of the Mugu Lagoon can be caused by both seawater intrusion and brine migration. Although this section focuses on areas that are known to be susceptible to seawater intrusion, the precise extent of current seawater intrusion impacts is difficult to separate from the areas that are impacted by release of saline water from connate brines. Therefore, the current area of seawater intrusion is smaller than the area of high chloride concentrations shown in Figures 2-27 through 2-32.

[5] Saline water is typically defined as groundwater with a TDS concentration between 10,000 and 35,000 mg/L.

Additionally, the inland extent of seawater intrusion varies by aquifer (see Figure 2-26). Between 1985 and 2015, UWCD groundwater model estimates suggest that approximately 1,800 AFY of groundwater flowed from the semi-perched aquifer to the Pacific Ocean. In the UAS (Oxnard and Mugu Aquifers), in years characterized by relatively high rainfall, groundwater flowed from the aquifers to the ocean in the spring, and the flow reversed in the fall; conversely, in dry years ocean water flowed into the aquifers in all seasons. On average, over the entire model period, there was approximately 3,900 AFY of seawater intrusion into the UAS in the Oxnard Subbasin. In the LAS, the direction of flow varied by aquifer. The direction of flow in the Hueneme Aquifer was primarily from the ocean to the aquifer, though there are some months in which the flow direction was seaward. In the FCA and the GCA, ocean water flowed into the aquifers in every month in the period of record. The average seawater intrusion in the LAS was approximately 5,500 AFY during the model period.

2.3.3.3 Historical Progression of Seawater Intrusion

Chloride concentrations were first measured in the Oxnard Subbasin in the 1920s. Between 1920 and 1929, the chloride concentration in three wells in the UAS ranged from 40 to 81 mg/L, with the lowest chloride concentration detected at the coast near Port Hueneme (FCGMA 2007). Groundwater elevations at this time ranged from 2 to 22 feet msl (FCGMA 2007). By 1934, when groundwater elevations in the UAS declined to −2 to 9 feet msl, the chloride concentration at a coastal well near Port Hueneme was 1,346 mg/L (FCGMA 2007). This was the first evidence of a potential saline water impact front in the vicinity of Port Hueneme. Between 1935 and 1940, chloride concentrations at the coast declined again and remained below 50 mg/L from 1934 to 1949 (FCGMA 2007). By 1954, however, as groundwater elevations in the UAS had declined to as much as −35 feet msl, seawater intrusion is interpreted to have affected an approximately 1-square-mile area near Port Hueneme, where two UAS wells had chloride concentrations of 1,070 and 1,925 mg/L.

This area of seawater intrusion expanded to the north and east between 1954 and 1959, and by 1959 an additional area of seawater intrusion was identified in the UAS north and east of Point Mugu (FCGMA 2007). Chloride concentrations near Port Hueneme reached 27,350 mg/L and those near Point Mugu reached 11,475 mg/L (FCGMA 2007). As groundwater elevations remained below sea level, the two areas of seawater intrusion continued to expand through the 1960s and 1970s, with the saline water impact front eventually reaching as much as 3 miles inland near Port Hueneme by the early 1980s (Izbicki 1996; FCGMA 2007).

The implementation of management strategies and pumping allocations by the FCGMA, along with increased rainfall in the late 1970s and early 1980s, reduced the area of the UAS affected by seawater intrusion, even as groundwater elevations remained below sea level throughout much of the Subbasin (FCGMA 2007). With the completion of the Freeman Diversion, which allowed for increased aquifer recharge at the spreading basins operated by UWCD, and additional above-average rainfall years, groundwater elevations in much of the UAS rose above sea level and the area of the UAS affected by seawater intrusion decreased in the 1990s (FCGMA 2007).

At the same time that seawater intrusion in the UAS was being managed and mitigated in the 1980s and 1990s, seawater intrusion began to affect the LAS (FCGMA 2007). By 1989, chloride was detected at a concentration of 6,700 mg/L at a well near Port Hueneme (FCGMA 2007). By 1994, chloride concentrations between 1,000 and 7,000 mg/L were detected near both Port Hueneme and Point Mugu (FCGMA 2007). The area impacted by seawater intrusion remained smaller in the LAS than in the UAS throughout the 1980s and 1990s.

Between 2000 and 2013, groundwater elevations in the UAS remained above sea level and there was little change in the extent of seawater intrusion near Port Hueneme (UWCD 2016a). As groundwater elevations dropped below sea level during the recent drought, however, chloride concentrations in UAS monitoring wells near the coast began to increase and the saline water impact front expanded eastward again (UWCD 2016a). Near the Mugu submarine canyon, the groundwater elevations in the UAS have remained below sea level and chloride concentrations in wells near the coast are close to those of seawater (UWCD 2016a). The current extent of saline water intrusion in both the UAS and the LAS is shown in Figures 2-27 through 2-32.

2.3.3.4 Relationships between Groundwater Elevation and Seawater Intrusion

The relationship between groundwater elevations and seawater intrusion, as measured by changes in chloride concentration, is complex. Since the 1950s, water levels in the Oxnard and Mugu Aquifers in coastal areas have historically fallen below sea level in response to increased production and drought cycles (Figures 2-9a and 2-12). Unlike areas farther inland, the water levels below sea level resulted in seasonal seawater intrusion during the fall irrigation season and during droughts in coastal wells in the vicinity of Point Hueneme and Point Mugu (Figure 2-33, Groundwater Flux along the Coast in the Upper Aquifer System). In contrast, as groundwater production increased in the LAS, water levels in the FCA and the GCA near the coast quickly fell below sea level and have remained there since the 1980s, even after periods of above-average precipitation (Figures 2-18 and 2-21). The UWCD model indicates continuous flux from the ocean into these aquifers since 1985 (Figure 2-34, Groundwater Flux along the Coast in the Lower Aquifer System).

Some wells located near Port Hueneme and screened in the Oxnard Aquifer and the Hueneme Aquifer have chloride concentrations that rise as groundwater elevations decline and that decline as groundwater elevations rise. This relationship is shown in Wells 01N22W20M05S and 01N22W29D03S on Figure 2-35 (Selected Historical Records of Water Elevation and Chloride Concentration). All the wells with chloride and groundwater measurements are shown on Figure 2-36 (Locations of Selected Coastal Wells with Historical Measurements of Chloride

Concentration and Water Elevation). It should be noted, however, that changes in chloride concentration in groundwater lag behind changes in groundwater elevation by up to 2 years in these wells. This response suggests that by the time the chloride response to declining groundwater elevations is measured, seawater intrusion has already begun.

The relationship between chloride concentration and groundwater elevation observed in Wells 01N22W20M05S and 01N22W29D03S is not universal throughout the Subbasin. In Well 01N22W29D02S, which is located in the same well cluster as Well 01N22W29D03S and is screened deeper in the Hueneme Aquifer, the concentration of chloride increased from 1995 through 2015, independent of groundwater elevation (Figures 2-35[C] and 2-36). The long-term increase in chloride concentration observed in this well suggests that groundwater elevations, even when above sea level, are not limiting the increasing chloride concentrations. A similar trend is observed in Well 01S21W08L03S, which is screened in the GCA and is located near Point Mugu; however, in this well groundwater elevations have remained below sea level since 1990 (Figures 2-35[D] and 2-36). One explanation is that the southern flow of groundwater along the coast from Port Hueneme discussed above may limit the ability to flush some areas of saltwater back out of Grimes Canyon.

A complete set of hydrographs for all wells from which both chloride and groundwater elevation data have been collected, showing the relationship between chloride concentration and groundwater elevation, is provided in Appendix F. A summary of the relationship between chloride concentration and groundwater elevation by region within the Oxnard Subbasin is provided below.

North Coast

In the north coastal Oxnard Plains, groundwater elevations in one nested well cluster (01N23W01C02S-05S) screened in the Oxnard Aquifer, the Hueneme Aquifer, and the FCA, were below sea level in the early 1990s, generally remained above or near sea level between the mid-1990s and early 2010s, and dropped below sea level between 2013 and 2015 (Appendix F). In spite of the low groundwater elevations in the historical record, the chloride concentration in the four nested wells 01N23W01C02S–01N23W01C05S (Figure 2-36) has not exceeded 55 mg/L since the wells were completed in 1990 (Appendix F). Additionally, recent chloride concentrations in both the UAS and the LAS are typically below 100 mg/L (see Section 2.3.4). ~~The hydrogeologic model and the chloride data both suggest that this area lacks a direct connection between the freshwater aquifers of the Oxnard Subbasin and the Pacific Ocean.~~ The aquifers of the Oxnard Subbasin are believed to crop out on the ocean floor where direct documentation of seawater intrusion cannot be measured.

Port Hueneme

In the vicinity of Port Hueneme, groundwater elevations in confined aquifers were below sea level in the early 1990s, recovered to elevations above sea level, remained there for two decades, and dropped below sea level between 2011 and 2014 after the onset of the recent drought. Records from nested wells 01N22W20M01 through 01N22W20M06 (which are screened in the semi-perched aquifer, the Oxnard Aquifer, the Mugu Aquifer, two zones in the Hueneme Aquifer, and the FCA; see Figure 2-36 and Appendix F) underscore the variability in the relationships between groundwater elevation and seawater intrusion in different water-bearing units. Despite the similarity in the five profiles of groundwater elevation over time, seawater preferentially intruded the Oxnard Aquifer in the past, and rising concentrations of chloride are observed in the Oxnard Aquifer, the Hueneme Aquifer, and the FCA in response to the recent decline in groundwater elevations. In this area, offshore outcrops of the older alluvium and the San Pedro Formation occur in the Hueneme submarine canyon. These outcrops provide a direct link between the Pacific Ocean and the freshwater aquifers of the Oxnard Subbasin. This region is susceptible to seawater intrusion, as demonstrated by chloride concentrations and groundwater elevations since the 1950s.

South Coast

In general, groundwater elevations in the Mugu Aquifer, FCA, and GCA in the South Coast Region have remained near or below sea level since the early 1990s (Figure 2-36 and Appendix F). Elevations in the Hueneme and Oxnard Aquifers largely remained above sea level between the mid-1990s and early 2010s. Within the upper Oxnard Aquifer, chloride concentrations have been decreasing, while rising chloride concentrations have been measured in the lower Oxnard Aquifer. In this area, elevated chloride concentrations in the Oxnard Aquifer likely result from southward migration of seawater that intruded the aquifer in the vicinity of Port Hueneme during earlier periods of low groundwater elevations (UWCD 2016a). This region does not typically experience direct seawater intrusion via offshore outcrops, but rather rising chloride concentrations indicate previous episodes of seawater intrusion via the Hueneme Canyon to the north.

Point Mugu

In all but one case, groundwater elevations in the vicinity of Mugu Lagoon have remained below sea level since the 1990s. Chloride concentrations exceeding 1,000 mg/L are measured in the majority of monitoring wells in this region (Figure 2-36; Appendix F). However, as noted above, some of the elevated chloride concentrations in this area are from the upwelling of connate water and the migration of groundwater to the LAS from the UAS.

2.3.4 Groundwater Quality

FCGMA adopted Basin Management Objectives (BMOs) for nitrate, chloride, and TDS in the Oxnard Subbasin for its 2007 Groundwater Management Plan Update (FCGMA 2007; Table 2-4). Additionally, the Water Quality Control Plan: Los Angeles Region (Basin Plan) specifies Water Quality Objectives (WQOs) for TDS, chloride, nitrate, sulfate (SO_4), boron, and nitrogen (mg/L nitrate) (LARWQCB 2013; Table 2-4). The current and historical distribution of these five constituents are discussed below. There are too few measurements of water quality in wells screened solely within a single aquifer to allow for meaningful discussion of water quality by aquifer. Additionally, as discussed in Section 2.3.1, the majority of the groundwater production in the Oxnard Subbasin occurs in wells that are screened across multiple aquifers. This production has the potential to impact water quality in multiple aquifers simultaneously. Therefore, impacts to groundwater quality in the Oxnard Subbasin are considered based on aquifer system.

Groundwater quality monitoring within the Oxnard Subbasin occurs on different schedules for different wells. In order to assess the current groundwater quality conditions within the Oxnard Subbasin, the most recent concentration of each of the five constituents listed above was mapped for samples collected between 2011 and 2015. Historical groundwater quality hydrographs are presented in Appendix G, Water Quality Hydrographs. Statistics on the most recent sample date, the maximum and minimum concentrations measured, the number of times sampled, and the number of samples whose concentration exceeded the relevant water quality threshold are presented in Appendix H, FCGMA Water Quality Statistics.

2.3.4.1 Total Dissolved Solids

Sources of high TDS water in the Oxnard Subbasin include seawater and brines migrating via faults or upwelling from older geologic formations (see Section 2.3.3). Additionally, in the UAS, improperly abandoned wells in the semi-perched aquifer and high chloride brines in fine-grained lagoonal deposits in the Oxnard and Mugu Aquifers, can contribute to high concentrations of TDS in the groundwater (Izbicki 1996). The water quality objective for TDS is 1,200 mg/L in the Forebay and confined aquifers, and 3,000 mg/L in the unconfined aquifers (LARWQCB 2013). The 2007 FCGMA BMO for TDS is 1,200 mg/L for the Forebay (FCGMA 2007). UAS wells with concentrations of TDS greater than 1,200 mg/L are found throughout the Oxnard Subbasin.

Upper Aquifer System

Concentration of TDS in groundwater in the UAS ranged from 652 mg/L to 49,600 mg/L between 2011 and 2015 (Figure 2-37a, Upper Aquifer System – Most Recent Total Dissolved Solids [mg/L] Measured 2011–2015, and Figure 2-37b, Upper Aquifer System, Forebay Area – Most Recent Total Dissolved Solids [mg/L] Measured 2011–2015). Water with TDS concentrations greater than 35,000 mg/L is considered brine. Both the highest and lowest concentrations of TDS were measured adjacent to the coast in Wells 01N22W27R05S and 01N22W27C02S, respectively (Figure 2-37a). The highest concentrations of TDS are found in coastal wells in areas known to be impacted by seawater intrusion (e.g., Well 01S21W08L04S) and release of connate brines from clay layers (e.g., Well 01N22W27R05S). The concentration of TDS in Well 01N22W27R05S has been increasing since 2013, while the concentration of TDS in Well 01S21W08L04S has remained stable over the last 5 years.

In the Forebay, Wells 02N22W23B02S and 02N22W23C05S have been used as BMO wells for TDS. In 2015, the concentration of TDS measured in a sample collected from Well 02N22W23B02S was 1,230 mg/L, and the concentration of TDS measured in a sample collected from Well 02N22W23C05S was 1,070 mg/L. The concentration of TDS in each of these wells has been increasing over the past 5 years (FCGMA 2016).

Lower Aquifer System

In general, TDS concentrations in the LAS are higher in the southern Oxnard Subbasin than in the northern part of the Subbasin (Figure 2-38, Lower Aquifer System – Most Recent Total Dissolved Solids [mg/L] Measured 2011–2015). Concentration of TDS in groundwater in the LAS ranged from 392 mg/L to 37,200 mg/L between 2011 and 2015 (Figure 2-38). The highest concentration was measured in Well 01N21W32Q03S, which is in the southern Oxnard Subbasin, inland from the coast, and is screened within the GCA (Figure 2-38). The higher concentration of TDS in this area likely resulted from upward migration of brines in deeper formations. This migration may have been induced or exacerbated by lowered groundwater elevations from groundwater production in the LAS, although the concentration of TDS in this well has increased steadily since 1995, even during periods when groundwater elevations were 40 to 100 feet higher than they were in 2015 (Izbicki 1991; Izbicki et al. 2005; UWCD 2016a).

The lowest concentration of TDS was measured in Well 01N22W35E03S, screened in the FCA south of Port Hueneme (Figure 2-38). The concentration of TDS in this well was 392 mg/L in 2015. TDS concentrations in this well have remained relatively stable over the last 5 years, neither increasing nor decreasing with the onset of the 2011 drought.

2.3.4.2 Chloride

Sources of water high in chloride in the Oxnard Subbasin include modern seawater, groundwater from the semi-perched aquifer, connate water from fine-grained lagoonal deposits in the Oxnard and Mugu formations, and brines migrating via faults or upwelling from older geologic formations (see Section 2.3.3). The UAS has a long history of seawater intrusion, with groundwater elevations below sea level measured as early as the 1930s (see Section 2.3.3; UWCD 2016a). Seawater intrusion affects a smaller area of the LAS than the UAS, and is more pronounced near Point Mugu than near Port Hueneme (UWCD 2016a). Brine migration along faults and from deeper geologic formations also affects the chloride concentration in the LAS (Izbicki 1991).

The water quality objective for chloride is 150 mg/L in the Forebay and confined aquifers, and 500 mg/L in the unconfined aquifers (LARWQCB 2013). The BMO for chloride is 150 mg/L for the UAS and LAS.

Upper Aquifer System

Concentration of chloride in groundwater in the UAS ranged from 23 mg/L to 20,700 mg/L between 2011 and 2015 (Figure 2-39a, Upper Aquifer System – Most Recent Chloride [mg/L] Measured 2011–2015, and Figure 2-39b, Upper Aquifer System, Forebay Area – Most Recent Chloride [mg/L] Measured 2011–2015). Chloride concentrations in the UAS are higher near the coast, from Point Hueneme south to Point Mugu, than inland or north of Port Hueneme (Figure 2-39a). The lowest concentration of chloride was measured in Well 01N22W11C02S in the central Oxnard Subbasin (Figure 2-39a). This well was only sampled one other time, in 1952, and the concentration of chloride measured at that time was 83 mg/L. Between 2011 and 2015, the concentration of chloride was less than 150 mg/L in the Forebay (Figure 2-39b).

The highest concentration of chloride (20,700 mg/L) was measured in Well 01N22W27R05S, adjacent to the coast south of Port Hueneme (Figure 2-39a). Groundwater from this well also had the highest concentration of TDS. The concentration of chloride in this well has been increasing since 2013. The concentration of chloride in Well 01S21W08L04S, a BMO well near Point Mugu, was 17,500 mg/L in 2015. The concentration of chloride in this well has been stable over the last 5 years (FCGMA 2016). Of the nine BMO wells with chloride concentration objectives in the UAS, three have had increasing chloride concentrations over the past 5 years (Wells 01N22W20J07S, 01N22W20J08S, and 01S22W01H03S), although all of the BMO wells have had water levels below their targets as a result of the drought.

Lower Aquifer System

In general, chloride concentrations in the LAS are higher in the southern Oxnard Subbasin than they are elsewhere in the Oxnard Subbasin (Figure 2-40, Lower Aquifer System – Most Recent Chloride [mg/L] Measured 2011–2015). In the Forebay, the concentration of chloride in groundwater is less than 100 mg/L, while concentrations of chloride south of Port Hueneme exceed 500 mg/L (Figure 2-40).

Concentration of chloride in groundwater in the LAS ranged from 33 mg/L to 14,300 mg/L between 2011 and 2015 (Figure 2-40). The lowest concentration of chloride was measured in Well 01N23W01C02S on the coast, north of Port Hueneme (Figure 2-40). The concentration of chloride in this well has remained stable since it was first measured in 1990.

The highest concentration of chloride was measured in Well 01N21W32Q03S, in the southern Oxnard Subbasin (Figure 2-40). In this well, the concentration of chloride has increased since it was first measured in 1991. At that time the concentration of chloride in the well was 340 mg/L. BMO Well 01S21W08L03S is also located in the southern Oxnard Subbasin, in the vicinity of Point Mugu. This is the only BMO well in the LAS that has had increasing concentrations of chloride over the past 5 years despite all of the BMO wells having water levels below their targets (FCGMA 2016).

2.3.4.3 Nitrate

Nitrate concentrations above WQOs and BMOs are present in the Forebay of the Oxnard Subbasin (UWCD 2008). These concentrations are likely a legacy of historical septic discharges and ~~historical~~ agricultural fertilizer application practices.[6] Historical discharges have resulted in concentrations that impact beneficial uses and users of the Oxnard Subbasin. In particular, not all municipal users of groundwater in this area have the ability to blend groundwater with nitrate exceeding the federal maximum contaminant level for nitrate as NO_3 of 45 mg/L.

Historical nitrate concentrations in the Forebay are most impacted by the quantity of surface water available for spreading from the Santa Clara River. The river water has lower concentrations of nitrate than the groundwater. Therefore, during periods when Santa Clara River water is used to recharge the Subbasin, groundwater concentrations of nitrate decrease. Conversely, during periods of drought, groundwater concentrations of nitrate in the Forebay tend to increase.

The BMO for nitrate is 22.5 mg/L in the Forebay (FCGMA 2007). The WQO for nitrate as NO_3 is 45 mg/L for the entire Oxnard Subbasin (LARWQCB 2013).

Upper Aquifer System

Between 2011 and 2015, concentrations of nitrate as NO_3 in groundwater in the UAS ranged from below the detection limit to 240 mg/L (Figure 2-41a, Upper Aquifer System – Most Recent Nitrate [mg/L as Nitrate] Measured 2011–2015, and Figure 2-37B). The highest concentration was measured in Well 02N22W26C01S in the Forebay (Figure 2-41b, Upper Aquifer System, Forebay Area – Most Recent Nitrate [mg/L as Nitrate] Measured 2011–2015). However, the concentration of nitrate measured in a sample collected from the same well in 2011 was only 4.9 mg/L. Similarly, nitrate concentrations in Wells 02N22W23B02 and 02N33W23C05S, which are both BMO wells, increased between 2011 and 2016. The concentration of nitrate in Well 02N22W23B02 was 4.1 mg/L in 2011 and was as high as 127 mg/L in 2015. The concentration of nitrate in Well 02N22W23C05 was 2.8 mg/L in 2011 and was as high as 31.9 mg/L in 2015.

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[6] Ventura County extended sewer lines into this area in the years between 2000 and 2011 to address additional discharges of nitrate.

Outside of the Forebay, the concentration of nitrate in the groundwater decreases rapidly and is not correlated with recharge from the spreading basins. In general, nitrate as NO_3 concentrations are highest in the southern Forebay and northeastern Oxnard Subbasin. The lowest concentrations are found in the southern Oxnard Subbasin, with the concentration of nitrate below the detection limit in the majority of the wells in the southern Subbasin (Figure 2-41a).

Lower Aquifer System

Concentrations of nitrate as NO_3 in groundwater in the LAS are lower than they are in the UAS. Between 2011 and 2015, the concentration of nitrate as NO_3 in wells screened in the LAS ranged from below the detection limit to 57 mg/L. The highest concentration was measured in Well 02N21W19A03S, in the northeastern Oxnard Subbasin. The concentration of nitrate in this well may be influenced by downward migration of water and is not representative of general nitrate concentrations within the LAS. The next-highest concentration of nitrate was measured in Well 01N22W23R02. The concentration of nitrate in the well was 22.1 mg/L (Figure 2-42, Lower Aquifer System – Most Recent Nitrate [mg/L as Nitrate] Measured 2011–2015). The majority of the wells in the LAS have nitrate as NO_3 concentrations below the detection limit. In the Forebay, the concentration of nitrate as NO_3 is lower in the LAS than it is in the UAS (Figures 2-41b and 2-42).

2.3.4.4 Sulfate

Sources of sulfate in the Oxnard Subbasin include mineral dissolution in groundwater and seawater intrusion. The majority of the wells in the Oxnard Subbasin have sulfate concentrations below 600 mg/L. Similar to nitrate, wells in the Forebay tend to have higher concentrations of sulfate than wells farther south, with the notable exception of Wells 01N22W27R05S and 01S21W08L04S (Figure 2-43a, Upper Aquifer System – Most Recent Sulfate [mg/L] Measured 2011–2015). The water quality objective for sulfate is 600 mg/L in the Forebay and confined aquifers, and 1,000 mg/L in the unconfined aquifers (LARWQCB 2013).

Upper Aquifer System

Concentrations of sulfate in the UAS ranged from 100 mg/L to 5,740 mg/L between 2011 and 2015 (Figure 2-43a and Figure 2-43b, Upper Aquifer System, Forebay Area – Most Recent Sulfate [mg/L] Measured 2011–2015). High concentrations of sulfate near the coast are generally indicative of seawater intrusion. The highest concentration was measured in Well 01N22W27R05S, which also had the highest concentration of chloride and TDS. The concentrations of each of these constituents has increased since 2013. The lowest concentration was measured in Well 01N22W36K09S in the southern Oxnard Subbasin.

Lower Aquifer System

Concentrations of sulfate in the LAS ranged from below the detection limit to 2,030 mg/L between 2011 and 2015 (Figure 2-44, Lower Aquifer System – Most Recent Sulfate [mg/L] Measured 2011–2015). High concentrations of sulfate near the coast are generally indicative of seawater intrusion. The highest concentration was measured in Well 01N21W32Q03S, which also had the highest concentration of chloride and TDS. Only four wells in the LAS had concentrations of sulfate that exceeded 600 mg/L. These wells are distributed throughout the Oxnard Subbasin and do not follow a clear geographic pattern. Similar to nitrate, LAS wells in the Forebay have lower concentrations of sulfate than UAS wells in the Forebay (Figure 2-44).

2.3.4.5 Boron

Sources of boron in the Oxnard Subbasin include seawater intrusion in coastal areas and release of anthropogenic (introduced by human activities) boron from past septic tank uses. The WQO for boron in the Oxnard Subbasin is 1 mg/L (LARWQCB 2013).

Upper Aquifer System

Concentrations of boron in the UAS ranged from 0.05 mg/L to 5.9 mg/L between 2011 and 2015 (Figure 2-45a, Upper Aquifer System – Most Recent Boron [mg/L] Measured 2011–2015, and Figure 2-45b, Upper Aquifer System, Forebay Area – Most Recent Boron [mg/L] Measured 2011–2015). The highest concentration was measured in Well 01N22W27R05S, which also had the highest concentrations of sulfate, chloride, and TDS. The lowest concentration was measured in Well 02N22W24A01S, in the northeastern Oxnard Subbasin (Figure 2-45a). Only seven wells in the UAS had boron concentrations greater than 1 mg/L between 2011 and 2015.

Lower Aquifer System

Concentrations of boron in the LAS ranged from 0.3 mg/L to 2.2 mg/L between 2011 and 2015 (Figure 2-46, Lower Aquifer System – Most Recent Boron [mg/L] Measured 2011–2015). The highest concentration was measured in Well 01N21W32Q03S, which also had the highest concentrations of sulfate, chloride, and TDS. Only five wells in the LAS had boron concentrations greater than 1 mg/L between 2011 and 2015.

2.3.4.6 Map of Oil and Gas Deposits

In the database maintained by the County of Ventura (2016), five oil fields entirely or partially fall within the Oxnard Subbasin: Montalvo, W.; Oxnard; El Rio; Santa Clara Avenue; and Saticoy (Figure 2-47, Oil Fields in the Vicinity of FCGMA Groundwater Basins). Petroleum extraction in the FCGMA basins occurs below the deepest freshwater aquifer (Hopkins 2013). While no evidence of impacts of petroleum extraction on beneficial use of groundwater in the FCGMA basins has been identified, there are limited available data. Few wells exist in deep aquifers near oil fields that could be monitored for potential impact. However, trace amounts of organic compounds have been found in deeper wells in southeastern Pleasant Valley (Izbicki et al. 2005), and there have been anecdotal reports of trace petroleum hydrocarbons observed in irrigation wells near some oil fields.

2.3.4.7 Maps of Locations of Impacted Surface Water, Soil, and Groundwater

Impacted surface water, soil, and groundwater have been documented in the Oxnard Subbasin, although these impairments tend to be limited to the semi-perched aquifer. This uppermost unit in the Oxnard Subbasin is underlain by a clay cap layer that limits the vertical migration of impaired water to the underlying UAS.

Impaired surface waters (i.e., 303(d) Listed Reaches) that overlie the Oxnard Subbasin include approximately 3 miles of the Santa Clara River, the Revolon Slough, Calleguas Creek, and a number of lined drains serving agricultural areas south of the City of Oxnard (Figure 2-48, Impaired Surface Waters in the Vicinity of FCGMA Groundwater Basins; SWRCB 2004). The names of the reaches used by the State Water Resources Control Board, and the impairments listed for each, are included in tabulated form in Appendix I, Oxnard 303(d) List Reaches.

Locations of impacted soil and groundwater were assessed on a basin-wide scale by reviewing information available on the SWRCB GeoTracker website and the California Department of Toxic Substances Control EnviroStor website. Cases that were closed by the supervisory agency were not considered.

Of the 290 open cases located within the boundaries of the Oxnard Subbasin and Pleasant Valley, groundwater was impacted in 77. Dudek reviewed and catalogued the constituents of concern (COCs) present on site in these 77 cases (Figure 2-49, Constituents of Concern at Open GeoTracker Cases with Impacted Groundwater within FCGMA Groundwater Basin Boundaries). Case details are included in Appendix J, GeoTracker Open Sites.

Of the 71 open cases in the Oxnard Plain in which groundwater is, or is potentially, impacted, the following COCs were identified as present at the following number of sites (Figure 2-49; Appendix J):

- Chlorinated volatile organic compounds (VOCs), including COCs marked as *solvents*, *VOCs*, and *chlorinated hydrocarbons*, were present at 34 sites.
- Gasoline and diesel, including COCs marked *TPH* and *petroleum*, were present at 32 sites.
- Metals were present at 27 sites.

- Polychlorinated biphenyls (PCBs) were present at 23 sites.
- Benzene, toluene, ethylbenzene, and/or xylenes (BTEX) were present at 18 sites.
- Pesticides were present at 12 sites.
- Methyl tert-butyl ethylene (MTBE) and/or tert-butyl alcohol (TBA) were present at seven sites.
- Two sites listed other COCs.

Many of these sites are located on land administered by the U.S. military (Figure 2-49). Outside of military bases, these sites tend to occur within the city limits of the Cities of Oxnard, Port Hueneme, and Camarillo.

The risk that contamination in the shallow groundwater of the Oxnard Subbasin would reach the UAS is somewhat mitigated by the presence of a confining layer that separates the semi-perched aquifer from the water-bearing units of the UAS throughout much of the Oxnard Plain (Turner and Mukae 1975). However, the vertical gradient is directed downward from the semi-perched aquifer to the underlying Oxnard Aquifer, indicating the potential for groundwater movement from the semi-perched aquifer to the Oxnard Aquifer.

Based on a review of open GeoTracker and EnviroStor cases with impacted groundwater, it does not appear that existing groundwater contamination in the semi-perched aquifer poses a substantial threat to beneficial use of groundwater in the UAS and the LAS. Based on a review of the files available on GeoTracker for each of the cases in the Oxnard Subbasin that fell outside the bounds of a military base, it appears that in none of the cases were any liable parties required to investigate deeper than 50 feet below ground surface (bgs), indicating that impacts to groundwater in the UAS were not a concern for regulatory agencies.

2.3.5 Subsidence

Inelastic, or irrecoverable, land subsidence (subsidence) can be a concern in areas of active groundwater extraction, including the Oxnard Subbasin. Active causes of land subsidence in the Oxnard Subbasin include tectonic forces, petroleum reservoir compaction, and clay compaction (Hanson et al. 2003). Significant water level declines in the FCGMA groundwater basins since the early 1900s suggest that fluid extraction, rather than tectonic activity, is the major cause of land subsidence (Hanson et al. 2003). Subsidence resulting from any of these sources can cause increased flood risk, well casing collapse, and a permanent reduction in the specific storage of the aquifer (Hanson et al. 2003).

Direct measurement of subsidence within the Oxnard Subbasin is limited. Elevation data from USGS benchmark (BM) E548 in the southern part of the Oxnard Plain indicate subsidence of about 1.6 feet (0.49 meters) during the period from 1939 to 1960, and an additional 1 foot (0.31 meters) of subsidence from 1960 to 1978 (Hanson et al. 2003). The average rate of subsidence for these two periods was similar, averaging approximately 0.07 feet (0.02 meters) per year from 1939 to 1960, and approximately 0.06 feet (0.02 meters) per year from 1960 to 1978 (Hanson et al. 2003). In contrast, elevation data from USGS BM Z901, located approximately 2.6 miles southeast of BM E548, indicate subsidence of approximately 0.3 feet (0.10 meters) between 1960 and 1978. The average rate of subsidence at BM E548 was 0.02 feet (0.01 meters) per year for this period. The rate of subsidence at BM Z901 decreased to approximately 0.01 feet per year from 1978 to 1992. Data are not available for BM E548 after 1978. The amount of subsidence measured at both BM E548 and BM Z901is the cumulative subsidence from all possible sources, including groundwater pumping, tectonic activity, and petroleum reservoir compaction.

In addition to direct measurement of subsidence in the southern part of the Oxnard Plain, potential subsidence was modeled for the entire Oxnard Plain for different future water production scenarios (Hanson et al. 2003). The scenarios included consideration of proposed water projects and ordinances for the FCGMA Basins. The model results suggest that areas within the Oxnard Plain may experience an additional 0.1 to 1 feet of subsidence by 2040 (Hanson et al. 2003). DWR classified the Subbasin as an area that has a medium to high potential for future subsidence. The amount of future subsidence will depend on whether future water levels decline below previous low levels and remain there for a considerable amount of time (Hanson et al. 2003). Maintaining water levels above the previous low water levels will limit the risk of future subsidence.

From March 2015 to June 2016, the Jet Propulsion Laboratory (JPL) analyzed interferometric synthetic aperture radar (InSAR) data from the European Space Agency's satellite-borne Sentinel-1A and NASA's airborne UAVSAR, along with similar previous studies from 2006 to 2015, to examine subsidence in areas of California. The study included the south-central coast of California in Ventura and Oxnard (Farr et al. 2017). The map generated from this study for this area of the south-central coast of California (Farr et al. 2017, Figure 23) showed less than 1 foot of subsidence for the Oxnard Subbasin.

2.3.6 Groundwater–Surface Water Connections

The Santa Clara River, Calleguas Creek, Revolon Slough, Mugu Lagoon, Ormond Beach, and McGrath Lake have all been identified as surface water bodies that may have a connection to the semi-perched aquifer in the Oxnard Subbasin (see Section 2.3.7, Groundwater-Dependent Ecosystems). However, groundwater elevation data for the semi-perched aquifer in the Oxnard Subbasin are extremely limited, with no monitoring sites near enough to surface water bodies to establish the extent of the connection between these surface water bodies and underlying groundwater (Figure 2-50, Groundwater Elevation Contours in the Semi-Perched Aquifer, March 2–29, 2015, and Figure 2-51, Groundwater Elevation Contours in the Semi-Perched Aquifer, October 2–29, 2015).The spatial extents of gaining, losing, and dry reaches in the Santa Clara River are seasonally variable (UWCD 2014, 2018).

The best available estimates for groundwater–surface water connections comes from the UWCD numerical model, which simulates the leakage from major surface water bodies in the Oxnard Subbasin using data from stream gauges and estimated aquifer properties (Appendix C). The UWCD model reports stream leakage from the Santa Clara River and Calleguas Creek into the underlying semi-perched aquifer. Numbers from the model represent net stream leakage and do not necessarily indicate direct connection between surface water bodies and groundwater in the semi-perched aquifer.

The UWCD model calculated stream percolation for water years from 1986 to 2015 (Table 2-5). The Santa Clara River had net recharge to groundwater in 26 of 30 water years, with an average net recharge to groundwater of approximately 5,700 AFY. The recharge to groundwater primarily occurs in the vicinity of the Forebay, where Santa Clara River water percolates into the UAS. Downstream of the Forebay, some reaches of the Santa Clara River are typically gaining in most years, generally from the semi-perched aquifer. Net groundwater discharge to the Santa Clara River was identified as occurring during 1999, 2002, 2006, and 2013. Calleguas Creek exhibited net recharge to groundwater in all years modeled, with an average net recharge to groundwater of approximately 3,450 AFY.

2.3.7 Groundwater-Dependent Ecosystems

Six potential GDE units, defined by dominant surface hydrologic features, were identified in the Oxnard Subbasin (Appendix C, UWCD Model Report; TNC 2017 [see Appendix K of this GSP]; Figure 2-52, Groundwater-Dependent Ecosystems for the Oxnard Subbasin). The potential GDE units were identified using the statewide potential GDE map (Appendix K). Of the six potential GDE units identified, the Lower Santa Clara River, McGrath Lake, Ormond Beach, and Mugu Lagoon units were validated using groundwater elevations measured in wells within or adjacent to the unit to confirm the potential hydrologic connection to groundwater in the semi-perched aquifer, as described in The Nature Conservancy's GDE Guidance Framework (Appendix K). Insufficient well data are available to confirm the depth to groundwater in the Revolon Slough unit or the Lower Calleguas Creek unit. Therefore, in the discussion below, these units remain as potential GDEs. Groundwater elevation in the vicinity of these units will be required in order to confirm whether or not the habitat is supported by groundwater (see Section 4.6.5, Shallow Groundwater Monitoring near Surface Water Bodies and GDEs).

Lower Santa Clara River GDE

The lower Santa Clara River GDE (located downstream of Highway 101 and upstream of the estuary) comprises approximately 750 acres of aquatic habitat, in-channel wetland, and a range of willow–cottonwood riparian forest (Figure 2-53, Lower Santa Clara River Groundwater-Dependent Ecosystems; Appendix K, The Nature Conservancy GDE Tech Memo). The GDE is located in the floodplain of the lower Santa Clara River, which undergoes substantial transformations in vegetation composition and distribution due to the dynamic nature of the river flows during winter. The lower Santa Clara River GDE supports habitat for several state- and federally listed species (Table 2-6).

Flow in the lower Santa Clara River downstream of Highway 101 has historically been perennial (SFEI 2011; City of Ventura 2016). The source of the perennial flow in this region is groundwater from the semi-perched aquifer, which is separated from the underlying UAS by a clay cap that limits groundwater migration and allows differences in groundwater elevation between the semi-perched aquifer and the Oxnard Aquifer. In the spring of 2015, groundwater elevations in the Oxnard Aquifer were below sea level (Figure 2-7).

Groundwater from the semi-perched aquifer provides the dry summer baseflow, if it exists, and a quarter of the winter flow (City of Ventura 2011). Groundwater flow direction between the semi-perched aquifer and the lower Santa Clara River, its estuary, and nearby McGrath Lake, depends on tidal conditions, river stage, and recharge rates due to agricultural irrigation (City of Ventura 2016). Groundwater levels from wells in the vicinity of the lower Santa Clara River GDE generally range between 7 and 11 feet bgs (Figure 2-53). The groundwater depths are within the range considered necessary for juvenile establishment (<10 feet) and mature vegetation growth (<20 feet) (City of Ventura 2016).

McGrath Lake GDE

The McGrath Lake GDE includes a coastal freshwater back-dune lake, arroyo willow riparian forest, freshwater emergent marsh, and saline emergent marsh (Figure 2-54, McGrath Lake Groundwater-Dependent Ecosystems). The McGrath Lake GDE supports critical habitat for several state- and federally listed endangered species as well as many special-status bird species (Table 2-6).

McGrath Lake is formed by shallow groundwater that remains perched above a clay layer in the semi-perched aquifer (ESA 2003). McGrath Lake operational water surface elevations are maintained between 2.7 and 3.6 feet msl (City of Ventura 2011). Groundwater flows toward the Santa Clara River during open-mouth conditions and towards McGrath Lake when the Santa Clara River Estuary fills following mouth closure (City of Ventura 2011). As measured since 2009, depths to groundwater around the McGrath Lake GDE range from ground surface to 10 feet bgs, depending on the well (Appendix K).

Ormond Beach GDE

The Ormond Beach GDE, which includes isolated patches of southern coastal salt marsh and coastal freshwater/brackish marsh that have been drained, filled, and degraded by past industrial and agricultural use, is part of a larger 1,500-acre coastal dune–marsh system of dunes, lakes, lagoons, and saltwater and freshwater marshes (WRA 2007; CCC 2017; Figure 2-55, Ormond Beach Groundwater-Dependent Ecosystems). The Ormond Beach GDE supports habitat for state- and federally listed species as well as 27 special-status plant species and 42 special-status wildlife species (Table 2-6).

The Ormond Beach GDE is hydrologically connected to the semi-perched aquifer. Shallow groundwater elevations are influenced by rainfall, tidal events, and the surface water elevations of the agricultural drains and flood control channels. Depth to groundwater ranges from ground surface to 15 feet bgs (Appendix K).

Mugu Lagoon GDE

Mugu Lagoon GDE is the largest salt marsh estuary in Southern California (USFWS 2016a). The GDE provides habitat for several state- and federally listed species (Table 2-6; Figure 2-56, Mugu Lagoon Groundwater-Dependent Ecosystems).

The estimated groundwater depth in the Mugu Lagoon GDE varies between ground surface and 6 feet bgs (Appendix K). Estimated depths to groundwater in the GDE, are based on interpolation of water elevation data from representative wells at Naval Base Ventura County Point Mugu to reference point locations within the Mugu Lagoon GDE. Mugu Lagoon receives groundwater discharge from the semi-perched aquifer along with freshwater from Calleguas Creek, the drainage ditches, primarily Oxnard Drainage Ditch No. 2, and salt water from tidal fluctuations.

Lower Calleguas Creek Potential GDE

The lower Calleguas Creek potential GDE includes aquatic habitat and mulefat and willow riparian forest. This potential GDE may support native special-status species (Table 2-6).

The Lower Calleguas Creek potential GDE overlies the semi-perched aquifer. The channel has been separated from the adjacent floodplain since the 1960s by a riprap and earthen levee countersunk about 3 feet below the surrounding grade. Thus, Calleguas Creek is a losing reach in the Oxnard Plain. Lower Calleguas Creek maintains a perennial streamflow due to a combination of wastewater effluent and pumped tile drain discharge from adjacent agricultural fields, with the addition of natural precipitation and stormwater runoff during winter months. The degree of groundwater recharge and/or discharge has not been studied and groundwater elevation data are not available for this area. Groundwater elevations at semi-perched aquifer monitoring wells (located approximately 1 mile to the southwest at Naval Base Ventura County Point Mugu) indicate typical groundwater elevations range from −1 to 6 feet msl. Extrapolated depths to groundwater at the downstream end of the Calleguas Creek GDE, at approximately 12 feet msl, are between 6 to 13 feet bgs. The extrapolated groundwater depths indicate the potential for the riparian vegetation to access shallow groundwater. Additional data need to be collected within the boundaries of the Calleguas Creek potential GDE in order to determine whether or not the riparian vegetation is accessing shallow groundwater.

Revolon Slough Potential GDE

The Revolon Slough potential GDE comprises aquatic habitat and willow riparian forest. This potential GDE may support native special-status species (Table 2-6). The riparian habitat within this potential GDE is considered “de minimis” because of its poor quality and limited extent adjacent to the waterway. Streamflow in lower Revolon Slough is considered to be a combination of agricultural return flow and precipitation and stormwater runoff. The degree of groundwater recharge and/or discharge has not been studied and groundwater elevation data are not available for this area. Groundwater elevations at semi-perched aquifer monitoring wells located approximately 1 mile to the southwest at Naval Base Ventura County Point Mugu indicate typical groundwater elevations range from −1 to 6 feet msl. Extrapolated depths to groundwater at the downstream end of the Revolon Slough potential GDE would be between 9 and 16 feet bgs. The extrapolated groundwater depths indicate the potential for the riparian vegetation to access shallow groundwater. Additional data need to be collected within the boundaries of the Revolon Slough potential GDE in order to determine whether or not the riparian vegetation is accessing shallow groundwater.

2.3.8 Potential Recharge Areas

To evaluate potential future recharge areas within the Oxnard Subbasin, soil types were obtained from the Web Soil Survey, available online at https://websoilsurvey.nrcs.usda.gov/ (USDA 2019). Soil Ksat rates (saturated hydraulic conductivity rates) for soils of 92 micrometers per second or greater were plotted. Figure 2-57, Oxnard Potential Recharge Areas, shows the results of this evaluation and areas with the most favorable soil recharge rates. The most favorable areas are near the current UWCD spreading grounds, along the Santa Clara River, in sands along the northern coastal areas, and in loamy sands, which may represent old Santa Clara River drainages.

2.4 WATER BUDGET

This section presents the current, historical, and simulated future water budget analysis for the Oxnard Subbasin. This water budget analysis has been completed in accordance with the DWR GSP Regulations. The historical water budget has been prepared for the 31-year period from the beginning of calendar year 1985 through 2015 (the current year for the Sustainable Groundwater Management Act [SGMA]) and is described in units of AF or AFY. The five commonly recognized aquifer units in the Oxnard Subbasin are the Oxnard, Mugu, Hueneme, Fox Canyon, and Grimes Canyon Aquifers (DWR 1965, 2006; Turner 1975). As described in Section 2.2, Hydrogeologic Conceptual Model, these aquifers are grouped into a UAS and an LAS, with the Oxnard and Mugu Aquifers composing the UAS and the Hueneme, Fox Canyon, and Grimes Canyon Aquifers composing the LAS. The UAS primarily comprises recent to upper Pleistocene age alluvial deposits of the Santa Clara River system.

UWCD (2018; Appendix C) developed the "Ventura Regional Groundwater Flow Model (VRGWFM)," a MODFLOW numerical groundwater flow model, for the Oxnard Subbasin, the Mound Basin, the western part of the LPVB, and the PVB. Details of the UWCD modeling effort are included in Appendix C. The groundwater budget analysis for the Oxnard Subbasin is based on the DWR Bulletin 118 basin boundary for the Oxnard Subbasin, and does not incorporate the remainder of the model domain. As with all groundwater flow models, the UWCD model has undergone several revisions and will continue to be revised as additional data are collected and the understanding of the hydrogeologic interactions in the model domain improves. This GSP uses the version of the model finalized in June 2018, which was developed to support the GSP process. This version of the model was used for the current and historical water budget analysis as well as for the future projected groundwater scenarios discussed in Section 2.4.5, Projected Future Water Budget and Sustainable Yield.

2.4.1 Sources of Water

Aquifer systems in the Oxnard Subbasin receive water from several sources. Native sources consist predominantly of rainfall infiltration within the Oxnard Subbasin and along its margins (mountain-front recharge), and subsurface inflows from the adjacent basins.

Water sources consist predominantly of streambed seepage from Calleguas Creek where it enters the Oxnard Subbasin from the adjoining PVB; streambed seepage from the Santa Clara River; artificial recharge by the UWCD; deep percolation of a portion of the irrigation water that is applied to agricultural, residential, and commercial lands, and to public open spaces; leakage from water distribution systems; septic system return flows; and wastewater treatment plant (WWTP) percolation ponds. Two small community WWTPs are located adjacent to the Santa Clara River in the Oxnard Subbasin. The Saticoy and the Montalvo WWTPs discharge treated effluent to percolation ponds.

Water supplies for the Oxnard Subbasin consist of locally pumped potable and nonpotable groundwater; imported water provided by UWCD (nonpotable) and Calleguas Municipal Water District (CMWD) (potable); nonpotable surface water provided by UWCD from its Freeman Diversion on the Santa Clara River and delivered to agricultural users in the Oxnard Subbasin via the PTP and to agricultural users in the Oxnard Subbasin and PVB via the Pleasant Valley Pipeline

(PVP); the Oxnard Subbasin portion of a nonpotable water supplied provided by the Camrosa Water District (CWD) to the Pleasant Valley County Water District (PVCWD) from a diversion on Conejo Creek; and fully advanced treated recycled water produced by the City of Oxnard (the Groundwater Recovery Enhancement and Treatment (GREAT) Pprogram) that began to be delivered to PVCWD and a few other agricultural users in early 2016.

The predominant municipal water suppliers in the Oxnard Subbasin are the City of Oxnard, the Port Hueneme Water Agency, the City of Ventura, and the Naval Base Ventura County. Water supplies for these municipal users include deliveries by UWCD via the Oxnard–Hueneme Pipeline, which obtains its water exclusively from wells located at the El Rio Spreading Grounds and along Rose Avenue. These municipal users may also receive imported water supplied by the CMWD. The City of Oxnard has wells within the Oxnard Subbasin. The City of Ventura also has wells in the Oxnard Subbasin, but uses water in their service areas inside and outside of the Oxnard Subbasin. Figure 1-8 shows a map of water purveyors with service areas within the Oxnard Subbasin.

In addition to groundwater pumping, agricultural water supplies are provided by UWCD via its PTP and PVP. The PTP services users in the Oxnard Subbasin, and the PVP services users in both the Oxnard Subbasin and the PVB. UWCD's water source for the PTP and PVP consists primarily of surface water obtained at the Freeman Diversion, which may include State Water Project water from Lake Piru. Groundwater is also extracted at five LAS wells located along the PTP pipeline in many years and is included in the water supplied by the PTP. Occasionally, temporarily stored recharge water is pumped from shallow wells at UWCD's Saticoy Spreading Grounds and included in water supplied by the PVP.[7]

2.4.1.1 Surface Water

Figure 2-58, Oxnard Subbasin Stream Gauges and Water Infrastructure, shows the locations of streams and primary drainage systems in and around the Oxnard Subbasin, as well as water infrastructure locations including WWTP ponds, stream gauge stations, and the two diversion structures (Freeman and Conejo Creek Diversions) that provide a portion of the water supply for the Oxnard Subbasin.

Santa Clara River

The Santa Clara River interacts with the groundwater system in the Oxnard Subbasin. Reaches of the Santa Clara River in the Oxnard Subbasin range from perennial to intermittent to ephemeral (Appendix C). The river flows through the adjoining Santa Paula Basin into the Oxnard Subbasin in the Forebay area, and then out of the Oxnard Subbasin to the Mound Basin. Climatic and

[7] UWCD extracts limited amounts of temporarily stored water from shallow wells at its Saticoy Spreading Grounds to the PVP during periods of mounding, as authorized by FCGMA Resolution 2011-02.

geologic characteristics of the Santa Clara River watershed result in an intermittent flow regime; however, flows can increase rapidly in response to high-intensity rainfall with the potential for severe flooding. During winter months, storm events may cause periods of continuous surface flow to the Pacific Ocean in the Santa Clara River.

Santa Clara River Recharge

The UWCD groundwater model used the MODFLOW STR stream package to simulate stream flow recharge. The stream flow discharge and percolation for the Santa Clara River were estimated using this stream package and the results are provided in Table 2-7a (for the semi-perched aquifer) Table 2-7b (for the UAS), and Table 2-7c (for the LAS). Except for 1998, 1999, and 2006, following the high rains in 1998 and 2005, the net effect of surface-water/groundwater interaction along the Santa Clara River was recharge to the UAS and the semi-perched aquifer in the Oxnard Subbasin (Appendix C). During these years, the net effect of surface-water/groundwater interaction was discharge from the UAS to the Santa Clara River. From 1985 to 2015, the average estimated recharge from the Santa Clara River to the semi-perched aquifer was 661 AFY, and the average estimated recharge to the UAS was 4,848 AFY (Tables 2-7a and 2-7b). These numbers do not include diversions from the Santa Clara River by the UWCD for artificial recharge at their spreading grounds or for direct use, which are discussed below.

Santa Clara River Diversions and Recharge

Table 2-8 summarizes the historical diversions of Santa Clara River water by UWCD and deliveries to both the Oxnard Subbasin and the PVB. On average, UWCD diverted 62,467 AFY from the Santa Clara River between 1985 and 2015, although diversion volumes, which depend on local climatic conditions, are highly variable (Table 2-8). These diversions may include State Water Project water held at Lake Piru and then delivered to the UWCD via the Santa Clara River. UWCD diverts surface water from the Santa Clara River in the Santa Paula Basin, just upstream of the Oxnard Forebay. The majority of this water, on average, is used for groundwater recharge in its spreading basins within the Oxnard Forebay (Table 2-8). Additionally, the water is used as supply for the PTP that services agricultural water users on the Oxnard Plain and as supply for the PVP agricultural water supply line that services agricultural water users in both the PVB and the Oxnard Subbasin. During drought periods, the relative percentage of diverted water used to recharge groundwater in the spreading basins declines, and the relative percentage of groundwater delivered through the PTP increases.

Table 2-9 provides the amounts of diverted water recharged by the UWCD in the three UWCD recharge grounds. Approximately 93% of the diverted water is recharged in the El Rio and Saticoy Spreading Grounds, on average, and the remaining 7% is recharged in the Noble Spreading Grounds (Table 2-9). Figure 2-59, Freeman Diversion and Uses in the Oxnard Subbasin, shows the amounts of diverted water by UWCD, and Figure 2-60, UWCD Groundwater Recharge, shows the annual recharge by UWCD. As shown in Table 2-10, the UWCD supply delivered in the PTP supply line is a mixture of surface water, and groundwater pumped by UWCD from their PTP wellfield, which pumps from the LAS, and less frequently, from their Saticoy wellfield.

Recharge from the UWCD groundwater recharge spreading grounds is included with recharge in Table 2-7a and Table 2-7b, but identified individually in Table 2-11. Of the total average annual recharge shown in Table 2-11 (73,669 AFY), UWCD groundwater recharge accounts for 48,306 AFY, or 65.6%. Recharge related to the PTP/PV system averaged 3,319 AFY from 1985 to 2015 as shown in Table 2-11, this is 4.5% of the total recharge. Of the average 62,467 AFY diverted from the Santa Clara River (Table 2-8), the average of 48,306 AFY (Table 2-11) recharged to the UWCD spreading grounds constitutes 77%.

The water delivered in the Oxnard–Hueneme Pipeline consists of groundwater pumped from the UAS and LAS near the El Rio Spreading Grounds. As shown in Table 2-10, deliveries from the Oxnard–Hueneme Pipeline are primarily used for municipal purposes, but small volumes are occasionally used for agricultural water supply along Hueneme Road on the southern part of the Oxnard Subbasin.

Calleguas Creek

Calleguas Creek enters the Oxnard Subbasin almost 2 miles upstream of its confluence with Revolon Slough and discharges to the Pacific Ocean at Mugu Lagoon. This reach of Calleguas Creek is perennial, with flow occurring primarily as maintenance flows provided by CWD (6 cubic feet per second required bypass flow at its diversion on Conejo Creek), inflows from agricultural field tile drains, inflows from Revolon Slough, and treated wastewater discharges into the lower reaches of Conejo Creek from the Camarillo Water Reclamation Plant (in the PVB) and the Hill Canyon WWTP in the City of Thousand Oaks. Table 2-12 summarizes the estimated flows in Arroyo Las Posas and Conejo Creek that enter Calleguas Creek, which then flows into the Oxnard Subbasin.

Table 2-12 summarizes the historical diversions of water from Conejo Creek by CWD at the Conejo Creek Diversion near Highway 101 that are supplied to the Oxnard Subbasin via PVCWD (Figure 2-58). The estimated diversions by CWD that are used in the Oxnard Subbasin are shown on Table 2-10. The source of water to Conejo Creek is mostly wastewater discharge from the Hill Canyon WWTP upstream of the Arroyo Santa Rosa Valley Basin. Table 2-10 shows only that portion of this water that is supplied to PVCWD and used in the Oxnard Subbasin.

Calleguas Creek Recharge

The UWCD (2018; Appendix C) groundwater model used the MODFLOW STR stream package to simulate recharge for Calleguas Creek in the Oxnard Subbasin. Calleguas Creek in the Oxnard Subbasin does not have hydraulic communication with the underlying UAS, but modeling indicates recharge to the semi-perched aquifer from 1985 to 2015 averaged 3,394 AFY (Table 2-7a).

Beardsley Wash/Revolon Slough

Beardsley Wash/Revolon Slough is a shallow drainage that captures shallow groundwater and stormwater from agricultural field tile drains and is lying at a similar elevation as the surrounding fields in its lower reaches where it is perennial. Consequently, it is not thought to be a recharge source.

2.4.1.2 Imported Water Supplies

Table 2-13 and Figure 2-61, Water Deliveries to the PVCWD and UWCD, show the historical volumes of water sold to the two water retailers (City of Oxnard and Port Hueneme Water Agency) that have historically purchased imported water from the CMWD. As shown in the table, sales to Port Hueneme Water Agency and to the City of Oxnard have occurred since 1996 and 1964, respectively. Sales have averaged approximately 1,564 AFY (from 1996 to 2015) and 13,500 AFY (from 1985 to 2015) to the Port Hueneme Water Agency and to the City of Oxnard, respectively.

As discussed in Section 2.4.1.1, Surface Water, the UWCD-diverted surface water from the Santa Clara River may include State Water Project water used for groundwater recharge in UWCD spreading basins or water directly delivered to water users by either the PVP or the PTP.

Percolation of Outdoor Irrigation (Urban Return Flows)

In the UWCD (2018; Appendix C) model, an assumed amount of M&I delivered water (5%) is estimated as groundwater recharge. This water is included as recharged water in Tables 2-7a and 2-7b and the total is provided in Table 2-11 by sources. Of the total annual recharge shown in Table 2-11 (73,669 AFY), percolation of applied water accounts for 928 AFY, or 1.3%.

2.4.1.3 Recycled Water Supplies

Two small community WWTPs are located adjacent to the Santa Clara River in the Oxnard Subbasin (Figure 2-58). The Saticoy WWTP and the Montalvo WWTP discharge treated effluent to percolation ponds. According the UWCD (Appendix C, p. 47), the average annual volumes of effluent discharged to the percolation ponds are approximately 80 and 200 AF, respectively, based on reports provided by California's State Water Resources Control Board online database, GeoTracker (http://geotracker.waterboards.ca.gov/). The Saticoy WWTP is within the Oxnard

Forebay, where percolating water can directly recharge the UAS. The Montalvo WWTP is farther downstream, in an area of the Oxnard Subbasin where percolating water recharges the semi-perched aquifer, which is not used for water supply. According to UWCD (Appendix C), the Montalvo WWTP ceased operating in 2016, subsequent to the model calibration period.

Recycled water by the City of Oxnard began to be provided to PVCWD and other agricultural users in early 2016. Wastewater effluent generated by the City of Oxnard historically has been treated at the Oxnard WWTP and discharged directly to the Pacific Ocean. However, the first phase of the GREAT pProgram's Advanced Water Purification Facility (AWPF) was recently completed in 2015, which provides this supply to PVCWD and other growers on the southern part of the Oxnard Subbasin.

Recycled Water Recharge

Recharge from the Saticoy and Montalvo WWTPs is simulated in the UWCD model using the recharge package. The monthly percolation volumes reported in the state's GeoTracker system were added to other areal recharge rates specified for the model grid cells corresponding to the WWTP percolation-pond sites (Appendix C, p. 83).

2.4.1.4 Percolation of Precipitation

Much of the rain that falls in the Oxnard Subbasin quickly returns to the atmosphere via evaporation, or runs off to creeks, storm drains, and ultimately the ocean; the remainder percolates into the soil where it is subject to evapotranspiration (ET), soil absorption, or for plant use. However, some precipitation can percolate into the soil and downward past the plant root zone and reach an underlying aquifer. This recharge process is referred to as deep infiltration (or percolation) of precipitation.

Deep percolation of precipitation depends on many factors, including: precipitation rate and duration, evaporation rate, ambient temperature, texture and slope of land surface, soil type and texture, antecedent soil moisture, vegetation cover, seasonal plant activity, and others is highly variable over time and location (Appendix C). Thus estimates of the percolation of precipitation is subject to substantial uncertainty.

UWCD downloaded monthly precipitation data for 180 rainfall gauge stations across the model domain from the Ventura County Watershed Protection District (http://www.vcwatershed.net/hydrodata/) (Appendix C, p. 80). UWCD used the Kriging method of geostatistical analysis to generate monthly precipitation distributions across model area, and the areal recharge from deep infiltration of precipitation was input to the model using the recharge package and was calculated as follows:

- If monthly precipitation is less than 0.75 inches, the precipitation is lost to evapotranspiration.

- If monthly precipitation is 0.75 to 1 inch, then recharge is assigned from 0% to 10% of precipitation (on a sliding scale).
- If monthly precipitation is 1 to 3 inches, then recharge is assigned from 10% to 30% of precipitation.
- If monthly precipitation is greater than 3 inches, then recharge is assigned as 30% of precipitation.
- Urban (non-agricultural) land use, including residential, commercial, and industrial areas: 5% of the total water precipitation.
- Undeveloped land: 10% of the total water precipitation.

Precipitation Recharge

Recharge from the percolation of precipitation is include with recharge in Tables 2-7a and 2-7b, but identified individually in Table 2-11. Of the total annual recharge shown in Table 2-11 (73,669 AFY), percolation of precipitation accounts for 8,947 AFY, or 12.1%.

2.4.1.5 Basin Groundwater Subsurface Inflow and Outflow

UWCD (Appendix C) provided model monthly groundwater inflows and outflows between the Oxnard Subbasin and the Pleasant Valley, Mound, west Las Posas Valley, and Santa Paula Basins, and unincorporated areas, as well as for three coastal segments adjacent to the Pacific Ocean. These inflows and outflows were combined to generate the annual estimates used for the groundwater budget. Additionally Table 2-7b shows the subsurface flows between the UAS and the semi-perched aquifer as well as the UAS and the LAS.

2.4.1.6 Mountain-Front Recharge

UWCD (Appendix C) used the MODFLOW WEL package to input mountain-front recharge specified flux amounts into model grid cells adjacent to each small drainage system (sub-watershed) along the margins of the model area, and to the base of elevated bedrock or mountains areas. In the Oxnard Subbasin, mountain-front recharge was applied at the base of the volcanic outcrops adjacent to the southwest side of the CWD Water Reclamation Plant shown on Figure 2-58, and along the Santa Monica Mountains. Recharge rates were calculated from monthly precipitation rates for the area receiving the precipitation. The monthly mountain-front-recharge rate inputs to the model followed the precipitation/recharge-percentage relationship used for agricultural return flows (Section 2.4.1.9, Percolation of Agricultural Irrigation Water [Agricultural Return Flows]). For the Oxnard Subbasin, mountain-front recharge from and to the volcanic outcrops and the Santa Monica Mountains (Unincorporated Areas) are shown in Tables 2-7a and 2-7b.

2.4.1.7 Septic Systems Recharge

The number and location of septic systems in the Oxnard Subbasin were estimated by DBS&A (2017) based on the Ventura County septic database. If septic systems were present within any parcel within a tract, it was assumed that all parcels in the tract contained septic systems. The number of septic systems in the Forebay decreased beginning in 2011 due to a County of Ventura program to phase out septic systems in the area. It was estimated that the number of systems in the Forebay decreased from 1,823 in 1985 to 485 in 2015 (DBS&A 2017).

Household water use and annual disposal was estimated to decrease from 0.21 AFY per household for 1985 to 1997, 0.20 AFY per household for 1988 to 2010, and 0.16 AFY per household from 1998 to 2015 based on DeOreo and Meyer (2012, as cited in DBS&A 2017). The resulting estimated percolation from all septic systems was estimated to decrease from 382 AFY in 1985 to 75 AFY in 2015 (DBS&A 2017). These values are small compared to known recharge values (UWCD spreading) and other estimated recharge values (Santa Clara River recharge; agricultural and municipal return flows).

The UWCD groundwater model assumed that septic system recharge was widespread and small relative to other recharge sources and incorporated septic system return flows implicitly as a component of agricultural and municipal return flows.

2.4.1.8 Distribution Systems Leakage

Distribution system losses from leakage of water-supply pipelines, sewer lines, and storm drains are included with M&I return flows in the UWCD model.

2.4.1.9 Percolation of Agricultural Irrigation Water (Agricultural Return Flows)

Groundwater pumping is discussed in Section 2.4.2.1; only recharge from agricultural return flow is discussed in this section. The UWCD groundwater model used the following water sources that were applied to irrigated land and assumed an agricultural return flow of 14%:

- Extracted groundwater from wells for agricultural use
- Groundwater and surface water delivered by the PVCWD pipeline
- Surface water diverted from Conejo Creek to PVCWD

If the precipitation is more than 1 inch per month, the agricultural return flow ratio is compared with precipitation recharge ratio. If the precipitation recharge ratio is larger than 14%, the agricultural return flow is replaced by the precipitation recharge ratio.

Agricultural Recharge

Recharge from the agricultural return flow is included with recharge in Tables 2-7a and 2-7b, and identified individually in Table 2-11. Of the total annual recharge shown in Table 2-11 (73,669 AFY), agricultural return flow accounts for 12,169 AFY, or 16.5%.

2.4.2 Sources of Water Discharge

Sources of groundwater discharge predominantly include groundwater pumping, tile drain discharges, and evapotranspiration. However, depending on groundwater levels (as noted in Section 2.4.1.1), groundwater/surface interactions can also discharge groundwater to surface water, which can then either be lost from the Subbasin or recharge elsewhere in the Subbasin. Likewise, groundwater pumped and used for agricultural, M&I, and domestic purposes can produce return flows (Section 2.4.1.2, Imported Water Supplies; Section 2.4.1.7, Septic Systems Recharge; Section 2.4.1.8, Distribution Systems Leakage; and Section 2.4.1.9). Subsurface groundwater flows (interbasin flows) can discharge groundwater from the Oxnard Subbasin to the adjacent groundwater basins, unincorporated areas, and the Pacific Ocean (Section 2.4.1.5, Basin Groundwater Subsurface Inflow and Outflow).

2.4.2.1 Groundwater Pumping

~~**Error! Reference source not found.Table** 2-14~~ Table 2-14 shows the amount of groundwater pumped for agricultural, M&I, and domestic uses by aquifer systems from the UWCD model results. UWCD modeled groundwater withdrawals using the multi-node well (MNW2) package. The extraction amounts in Table 2-14 were combined with well types from the FCGMA well database to distinguish the amounts extracted by type. Figure 2-62, Groundwater Pumping, shows the amounts of agricultural, M&I, domestic, and total groundwater pumped from the Oxnard Subbasin. Groundwater pumping is also shown in the Oxnard Subbasin groundwater budget in Tables 2-7a through 2-7c.

Available data indicate that during the calendar year 2015, a total of 80,814 AF (Table 2-14) of groundwater was extracted from the Oxnard Subbasin, of which, about 69% was for agricultural use (55,973 AF), 30% was for M&I use (24,648 AF), and about 0.2% was for domestic use (193 AF). For the Oxnard Subbasin, the FCGMA groundwater pumping database contains 732 known wells, of which 403 are currently listed as active use, 217 have been destroyed, 106 are inactive, and 6 could not be located. An additional 13 agricultural wells are in the UWCD database outside the FCGMA boundary.

Not all the groundwater produced in the Oxnard Subbasin remains in the Subbasin. Four agricultural users (PVCWD, Coastal Berry Co., Montalvo Water Co., Alta Mutual Water Co., and Guadalasca Mutual Water Co.) may export a portion of the groundwater that they pump from the

Oxnard Subbasin to areas inside the PVB. The PVCWD uses a combination of pumped groundwater from the Oxnard Subbasin and the PVB, delivered UWCD water from the PVP, CWD-delivered water from Conejo Creek, and other sources. FCGMA groundwater pumping records indicate that from 1985 to 2015, approximately 41% and 59% of PVCWD's pumped groundwater has come from the PVB and the Oxnard Subbasin, respectively. A geographic information system (GIS) calculation of the area of the PVCWD in Figure 1-8 indicates that approximately 56% of the PVCWD service area is in the Oxnard Subbasin, and the remaining 44% is in the PVB. For purposes of estimating PVCWD water deliveries, a ratio of 44% PVB and 56% Oxnard Subbasin area was assumed to be a reasonable basis for PVCWD water supplies between the two basins. As shown in Table 2-10, during some years, groundwater pumping by PVCWD in the Oxnard Subbasin is less than this ratio resulting in a net import from the PVB. Conversely, in some years, groundwater pumping in the Oxnard Subbasin is more than this ratio, resulting in a negative import (an export) to the adjacent PVB.

2.4.2.2 Tile Drain Recharge Losses

Tile drains are used beneath many agricultural lands in the Oxnard Subbasin to maintain a sufficiently deep groundwater table where poorly drained soils create shallow groundwater conditions that can negatively affect plant health and crop yields. These conditions prompted the installation of tile drains across most of the Oxnard Plain in the 1900s. Tile drains are present beneath many agricultural land parcels in the PVB as well. These drains discharge to local drainage ditches and then to surface water bodies Revolon Slough and Calleguas Creek. The flows in the tile drains are not metered.

Tile drains were implemented in the UWCD groundwater model using MODFLOW's drain package (DRN). Model grid cells with simulated tile drains in the uppermost active layer correspond with agricultural areas where tile drains are known or suspected to exist. The UWCD model has calculated losses to tile drains based on groundwater model simulated water levels and the results are provided in Tables 2-7a and 2-7b. Average annual loss to tile drains in the UWCD model is 10,752 AFY.

2.4.2.3 Evapotranspiration (ET)

The UWCD model used the U.S. Fish and Wildlife Service online "Wetlands Mapper" (https://www.fws.gov/wetlands/data/mapper.html) to indicate areas of riparian vegetation along stream channels. These areas, together with parts of the Santa Clara River (including its estuary), Revolon Slough/Beardsley Wash, McGrath Lake, Ormond Beach wetlands, and Mugu Lagoon wetlands were used to estimate evapotranspiration (ET) (Appendix C). ET is the discharge of groundwater from the saturated zone where the water table is present at very shallow depths. Such conditions mostly occur in the Oxnard Subbasin where the semi-perched aquifer interacts with surface water bodies, which is also where riparian vegetation is typically found in the Oxnard Subbasin. These areas are hydraulically connected to, and exchange fresh- to brackish-water with, the semi-perched aquifer near the coast. It should be noted that nearly all of the riparian vegetation that takes up groundwater in the Oxnard Subbasin occurs in land overlying the semi-perched aquifer, which is rarely, if ever, pumped as a source of agricultural or M&I water supply. Additional discussions about these areas are in Sections 2.3.6 and 2.3.7.

UWCD (Appendix C) applied USGS estimates for ET rates from 1.1 to 5.2 feet per year to calculated long-term annual average groundwater discharge as ET. UWCD implemented ET using MODFLOW's ET package, EVT. Model grid cells corresponding to areas of mapped wetlands with shallow groundwater were simulated. The maximum ET flux was 0.010 feet per day (3.65 feet per year) for model grid cells subject to ET over their entire area. The maximum ET flux is scaled down proportionally for grid cells that are only partially occupied by wetlands. The ET surface elevation was set at 3 feet bgs, and the ET extinction depth was set at 5 feet bgs (Appendix C, p. 84).

According to UWCD model results, the estimated annual loss from ET is 8,328 AFY, with most coming from the semi-perched aquifer (8,291 AFY, a shown in Table 2-7a) and a small amount from the UAS (37 AFY, as shown in Table 2-7b).

2.4.3 Current and Historical Water Budget Analysis

2.4.3.1 Water Year Types

Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined in this GSP as wet (≥ 150% of average), above normal (≥ 100% to <150% of average), below normal (> 75% to <100% of average), dry (> 50% to <75% of average), and critical (<50% of average). Figures 2-22 through 2-25 show the water year type from 1986 to 2015. The water type year for 2015 is dry.

2.4.3.2 Historical Water Budget Analysis

DWR has designated the Oxnard Subbasin as a high-priority basin. The DWR GSP Regulations, Section 354.18, Water Budget, states that, "If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions." According to the DWR Bulletin 118, "A basin is subject to critical overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts" (DWR 2006). Bulletin 118 Interim Update 2016 (October 18, 2016) lists the Oxnard Subbasin (Basin 4-004.02) as being in critical overdraft (DWR 2016).

Because of Bulletin 118's listing of the Oxnard Subbasin as being in critical overdraft, the DWR GSP Regulations, Section 354.18 (b)(5), requires a quantification of the overdraft over a period of years during which water years and water supply conditions approximated average conditions. Using the water year types discussed in Section 2.4.3.1, and the above normal (> 100% to <150% of average) and the below normal (> 75% to <100% of average) water year types to bracket water supply conditions approximating average conditions, the following years have near average conditions: 1988, 1991, 1992, 1994, 1996, 1997, 2000, 2001, 2003, 2006, 2008, 2010, and 2011.

The change in storage during these years was an increase of 6,045 AFY in the UAS and an increase of 1,029 AFY in the LAS (Tables 2-7b and 2-7c). However, the net seawater intrusion during these years was 4,189 AFY in the UAS, and 5,225 AFY in the LAS (Table 2-7c). Thus, the net change in groundwater storage for the UAS without seawater intrusion was an increase in 1,856 AFY in the UAS and the net change in storage without seawater intrusion in the LAS was a decrease of 4,196 AFY. Total groundwater pumping during these years averaged 47,080 AFY in the UAS and 28,893 AFY in the LAS for a total of 65,973 AFY (Tables 2-7b and 2-7c). This quantification of the overdraft over a period of years during which water years and water supply conditions approximated average conditions would indicate that the Oxnard Subbasin was in overdraft of about 2,340 AFY (4,196 AFY [LAS] − 1,856 AFY [UAS]). It should be noted that except for 2011, Tables 2-7b and 2-7c show net seawater intrusion for the UAS and LAS for each of the years that approximated average conditions. This seawater intrusion analysis suggests that based on the historical pumping patterns and pumping amounts, the Oxnard Subbasin was in overdraft by about 2,340 AFY during average water supply conditions.

GSP regulation Section 354.18 (c)(2) requires that the historical water budget information be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. Historically, the Oxnard Subbasin has received surface water supply deliveries directly from one main source: the Santa Clara River. Additionally, but to a lesser degree, Calleguas Creek, imported water delivered by the CMWD, and Conejo Creek water diversions have contributed surface water supplies to the Oxnard Subbasin. Table 2-8 shows that the diversion of Santa Clara River from 1985 to 2015 have averaged 62,467 AFY, and leakage from the Santa Clara River has averaged about 5,650 AFY (770 AFY [see Tables 2-7a and 2-7b] + 4,989 AFY [see Table 2-7b] – 109 AFY [see Table 2-7b]). This indicates a total Santa Clara River supply of approximately 68,117 AFY. In comparison, Calleguas Creek has supplied approximately 3,394 AFY (see Table 2-7a) to the semi-perched aquifer, CMWD has delivered 14,543 AFY of imported water (see Table 2-13), and Conejo Creek diverted flows have averaged 1,159 AFY (see Table 2-10). These last three sources total 19,096 AFY, or 22% of the total surface water deliveries (87,213 AFY) or only 28% of the total Santa Clara River. Tables 2-7a, 2-13, and 2-10 for Calleguas Creek, CMWD imported water, and Conejo Creek (starting in 2002), respectively, suggest that these sources are reliable and not significantly affected by the water year type. However, diversions from the Santa Clara River as shown in Table

2-8 and on Figure 2-59 vary widely depending on climate conditions. The high diversion years of 1993, 1998, and 2005 were wet years (Figures 2-22 and 2-59). The low diversion years of 1990, 2013 and 2014 were critical dry years, and 2015 was a dry year (Figures 2-22 and 2-59). Diversions of surface water by the UWCD from the Santa Clara River are critical to the surface water supplies of the Oxnard Subbasin.

2.4.3.3 Current (2015) Groundwater Conditions

Groundwater level data presented in Section 2.3, Groundwater Conditions, and the change in storage estimates for the calendar year 2015 from Tables 2-7a through 2-7c indicate that the Oxnard Subbasin had greater groundwater outflows than inflows in 2015. The estimated 2015 groundwater change in storage is a loss of about 38,703 AF (Tables 2-7a through 2-7c). This change in groundwater storage would be larger and groundwater storage declines greater if seawater intrusion had not replaced groundwater in the Oxnard Subbasin. Model results in Tables 2-7a through 2-7c indicate a net seawater intrusion in 2015 of approximately 19,200 AF. There was a net outflow of water to the Pacific Ocean in the semi-perched aquifer of approximately 504 AF (Table 2-7a), but a positive inflow (seawater intrusion) in the UAS of approximately 11,633 AF (Table 2-7b) and a positive inflow in the LAS of approximately 8,081 AF (Table 2-7c).

Tables 2-7a through 2-7c show that from 1985 to 2015, seawater intrusion has replaced freshwater in storage in the Oxnard Subbasin in the LAS every year, and 23 of 31 years in the UAS. Tables 2-7a and 2-7b indicate that seawater flows both in and out of the Oxnard Subbasin in the semi-perched aquifer and the UAS. However, groundwater generally flows out of the Subbasin from the semi-perched aquifer (which is not currently a usable aquifer), and seawater usually inflows to the UAS and LAS, which affects usable groundwater aquifers.

2.4.3.4 Estimates of Historical Sustainable Yield

Historical estimates for the Oxnard Subbasin sustainable yield[8] have also included the PVB. These historical sustainable yield estimates include the following:

- FCGMA, 1985, Groundwater Management Plan
- FCGMA, 2007, 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan
- UWCD and CMWD, 2012, Preliminary Draft Yield Analysis (UWCD 2016c)
- UWCD, 2016, Proposed Method for Estimating Sustainable Yield (UWCD 2016c)

[8] SGMA requires that an estimate of the "sustainable yield" be made for the Oxnard Subbasin based on historical data. However, as used in this section the sustainable yield does not address undesirable results, which are discussed in Chapter 3, Sustainable Management Criteria.

All of these historical estimates for the combined Oxnard Subbasin and PVB sustainable yield are about 65,000 AFY, but do not demonstrate that this groundwater pumping rate prevents seawater intrusion. The UWCD Open-File Report 2017-02 (UWCD 2017a) Scenario D estimated that seawater intrusion would be halted if: (1) there were no groundwater pumping in what the report refers to as an assumed future "seawater intrusion management area," (2) groundwater pumping were reduced by about 70% in LAS in the Oxnard Plain (excluding the Forebay) and in the PVB, and (3) there were no reduction in UAS pumping. However, this scenario assumed that groundwater for irrigation in the assumed future "seawater intrusion management area" would be supplied by a project to be implemented in the future. The combined estimated sustainable yield under Scenario D was 59,900 AFY for the Oxnard Subbasin (excluding the seawater intrusion management area) and the PVB.

To estimate the sustainable yield under historical conditions where no future project is implemented, the UWCD conducted Scenario F in Addendum Open-File Report 2017-02a (UWCD 2017b). In Scenario F, the assumed seawater intrusion management area was eliminated, and a uniform reduction in groundwater pumping was simulated to achieve sustainable yield. The scenario defined a sustainable yield as maintaining groundwater elevations along the coast at levels sufficiently high to prevent seawater intrusion and other forms of saline water intrusion. In the Port Hueneme area, where the UAS and LAS are believed to have direct hydraulic connection with the Pacific Ocean, UWCD assumed minimum thresholds[9] as defined in Open File Report 2017-02. However, under Scenario F, UWCD assumes a minimum threshold for the LAS near Mugu Lagoon to be −20 feet msl instead of 18.5 feet msl, as assumed in Open File Report 2017-02. This is because the most recent UWCD Saline Intrusion Update report (UWCD 2016b) interpreted the source of elevated chloride concentrations in the LAS near Mugu Lagoon to be saline water yielded from marine clays and/or from adjacent Tertiary-age sedimentary rocks, as a result of large declines in potentiometric head in the LAS over the past several decades, and not a direct result of current seawater intrusion. Additional discussion of saline water and seawater intrusion can be found in Section 2.3.3.

Based on the results from UWCD Scenario F (UWCD 2017b, Table 2-2), the sustainable yield under historical conditions with no changes from the current pumping locations (i.e., without water supply or infrastructure projects) for the Oxnard Subbasin would be a total of 39,000 AFY (27,000 AFY from the Oxnard Plain and 12,000 AFY from the Oxnard Forebay area). The results from UWCD Scenario F (2017b, Table 2-2) would indicate a total of 10,000 AFY for the PVB. Evaluation of the volume of water entering and leaving the model along the Pacific coastline under Scenario F indicated that there is a net outflow of water from the model to the Pacific Ocean over the 31-year simulation period. Groundwater left the model to the ocean in the UAS, while a smaller

9 "Minimum threshold" used here is in reference to the Open File Report 2017-02 usage and not to the minimum threshold discussed in Chapter 3 of this GSP.

amount of seawater intruded the LAS. This suggests that additional production may be possible from the Oxnard Subbasin by reducing groundwater pumping in the LAS and increasing it in the UAS. This shift in pumping may also better protect against seawater intrusion.

2.4.4 General Uncertainties in the Water Budget

There are several limitations and uncertainties associated with other water budget terms used for both the historical and future conditions due to necessary simplifying of assumptions and data gaps. Uncertainties about the groundwater models used are discussed in Section 2.4.5.8. Some of the general water budget limitations and/or uncertainties include the following:

1. The reporting of groundwater pumping outside the boundaries of the FCGMA is limited and there is a possibility of underreporting of pumping within the FCGMA boundaries due to non-reporting, inaccurate reporting, and equipment problems. Additional future data collection is needed to verify the existence and extent of and to eliminate this data gap. However, the amount of pumping outside the FCGMA boundary is expected to be minor given the limited number of wells (estimated at fewer than 12).
2. The hydrologic base period (calendar years 1985–2015, DWR's 31-year base period) may not necessarily be representative of long-term average conditions. As shown on Figure 1-6, Long-Term Precipitation Trends in the Oxnard Plain, this was a generally wetter-than-average period. However, the future water budget analysis in Section 2.4.5, which used a model 50-year period with an average precipitation period (1939 to 1979), does not suggest that the historical sustainable yield estimate based on this wetter-than-average period is too high. The combined UAS and LAS sustainable yield for the future water budget ranged from 30,000 AFY to 48,000 AFY (Section 2.4.5.9). The estimated historical sustainable yield using UWCD Scenario F (Section 2.4.3.4) of 39,000 AFY is within this range. The uncertainty associated with the future water budget sustainable yield is discussed in Section 2.4.5.8.
3. Conclusions regarding uncertainties in the UWCD model are discussed in Section 2.4.5.8, Uncertainty Analysis, and in the Dudek peer review of the UWCD model (Appendix E).
4. Subsurface inflows and outflows across basin boundaries are not measurable. The groundwater level data in these areas by themselves do not provide a clear indication of groundwater flow directions because of the limited water level measurements and the variation in time between measurements. The UWCD model provides a significantly improved understanding of these boundary fluxes and their variability under different pumping and recharge conditions in the region, but checking model values with observations and calculating the gradient with three-point groundwater flow problems should be considered to verify model estimates. Attempts to estimate inflows and outflows

across basin boundaries using well groundwater level data was attempted for this GSP, but data gaps and limited well locations screened in one aquifer made the results unreliable.

5. Some semi-perched groundwater in the Oxnard Subbasin is potentially captured by tile drains, rather than recharging the UAS. This uncertainty could be reduced through installation of instrumentation and measurement of discharges from the tile drains.
6. Currently, aquifer-specific water level maps are not reliable to estimate aquifer change in groundwater storage due to the limited number and distribution of aquifer-specific water wells. Dedicated monitoring wells could installed and equipped with water-level measuring data loggers in all of the aquifers. This would help decrease uncertainty in estimates of future changes in groundwater storage by enabling use of aquifer-specific water-level maps to check groundwater model change in storage calculations.

2.4.5 Projected Future Water Budget and Sustainable Yield

Several model scenarios were developed in accordance with SGMA guidelines to assess the future sustainable yield of the Oxnard Subbasin. Each future scenario covered a 50-year time frame, from 2020 to 2069. In this GSP, the period from 2020 to 2039 is referred to as the implementation period, and the period from 2040 to 2069 is referred to as the sustaining period. The sustainable yield was determined from the model scenarios that did not result in a net flux of seawater into either the UAS or the LAS in Oxnard Subbasin, within the level of the model uncertainty, during the 30-year sustaining period (Figure 2-63, Coastal Flux from the UWCD Model Scenarios).

Because the Oxnard Subbasin is hydraulically connected to the PVB and the WLPMA, the sustainable yield of the Oxnard Subbasin is influenced by groundwater production and projects in these adjacent basins. The UWCD model used to assess the sustainable yield of the Oxnard Subbasin includes both the PVB and the WLPMA in the model domain, and the modeling assumptions associated with each scenario discussed below include the assumptions made for these adjacent basins.

The model scenarios developed for Oxnard Subbasin, the PVB, and the WLPMA all included existing projects and the 2070 DWR climate-change factor applied to the 1930–1970 historical precipitation and hydrology base period. The model scenarios are the following:

- Future Baseline Simulation (2015–2017 average production rates adjusted by surface water deliveries);
- Future Baseline Simulation With Projects (2015–2017 average production rates adjusted by surface water deliveries; potential future projects that met the DWR conditions for incorporation in the GSP)

- Reduction With Projects (35% reduction of 2015–2017 average production rates adjusted by surface water deliveries for the UAS and LAS in the Oxnard Subbasin, 20% reduction for the UAS and LAS in PVB; and 20% in the LAS in the WLPMA; potential future projects that met the DWR conditions for incorporation in the GSP)
- Reduction Without Projects 1 (reduction of 2015–2017 average production rates adjusted by surface water deliveries by 25% in the UAS, 60% in the LAS, and 45% for wells screened in both aquifer systems in the Oxnard Subbasin; 25% reduction for the UAS and the LAS in the PVB; and 25% in the LAS in the WLPMA)
- Reduction Without Projects 2 (reduction of 2015–2017 average production rates adjusted by surface water deliveries by 55% in the UAS and the LAS in the Oxnard Subbasin; 20% reduction for the UAS and the LAS in the PVB; and 20% in the LAS in the WLPMA)
- Reduction Without Projects 3 (reduction of 2015–2017 average production rates adjusted by surface water deliveries by 55% in the UAS and the LAS in the Oxnard Subbasin; 0% reduction for the UAS and the LAS in the PVB; and 0% in the LAS in the WLPMA)

Two of the model scenarios listed above, the Future Baseline Simulation With Projects Scenario and the Reduction With Projects Scenario, incorporated projects that were approved for inclusion in the GSP model scenarios by the FCGMA Board. The Board's approval of these projects only indicates that they were sufficiently defined by the project proponent to be analyzed as part of the GSP. It does not indicate that these specific projects will necessarily be constructed or, conversely, that other projects will not be developed in the future. The projects included are discussed in more detail with the description of each scenario below.

An initial set of four modeling simulations were conducted using the future baseline conditions with two 50-year average climate cycles (1930–1979 and 1940–1989), and two DWR climate-change factors (2030 and 2070) applied to each of the 50-year periods. The 1930 to 1979 50-year period with the 2070 DWR climate-change factor was found to be the most conservative and was used for the comparison with the other modeling simulations conducted. Additional details about the selection of the two 50-year average climate cycles is provided in Section 2.4.5.7.

In addition to the initial set of four modeling simulations and the six model scenarios listed above, the Reduction Without Projects Scenario 1 was simulated with the DWR 2030 climate-change factor and with a historical precipitation and hydrology base period from 1940 to 1989. These simulations were conducted to better understand the potential impact of precipitation patterns and climate-change factors on the model results. While the results of these simulations were primarily used as a check on the minimum threshold groundwater elevations discussed in Chapter 3, the predicted impact on seawater intrusion is discussed in Section 2.4.5.7.

Over the next 5 years, as additional projects are developed the model assumptions discussed below will need to be altered and incorporated into the 5-year GSP evaluation.

2.4.5.1 Future Baseline Model Simulation

SGMA requires that the GSP include an assessment of the "future baseline" conditions. In the Future Baseline Scenario, in order to assess whether or not groundwater extractions from the Oxnard Subbasin, PVB, and WLPMA were sustainable at their current rates, the average annual 2015–2017 production rates, adjusted by surface water deliveries, were simulated. Future surface water deliveries were estimated by the UWCD using Santa Clara River flows for historical periods, the 1930— to 1979 climate period adjusted for future DWR climate-change factors, and estimated diversions based on similar historical Santa Clara River flows. UWCD also considered current allowable diversions, which accounts for current environmental restraints and diversion operating conditions, and optimization of water deliveries for the PVP and spreading basins. Additional details about the UWCD future model scenarios are included in Appendix L, UWCD GSP Model Documentation. For the Oxnard Subbasin, this rate is approximately 68,000 AFY without surface diversions, combined, for both the combined UAS and the LAS (Table 2-15).

Future Baseline Scenario Model Assumptions

The Future Baseline model simulation included the following:

- Constant pumping at the 2015–2017 average rate of approximately 68,000 AFY adjusted for surface water deliveries in the Oxnard Subbasin (39,000 AFY in the UAS; 29,000 AFY in the LAS), 13,000 AFY in the WLPMA, and approximately 14,000 AFY in the PVB
- Starting water levels equal to the final 2015 water levels from the historical simulations
- Precipitation and streamflow for two 50-year periods (1930–1979 and 1940–1989), with an average precipitation that equaled the average precipitation for the entire historical record
- Estimates of Santa Clara River surface water available for diversion prepared by UWCD staff using climate-change factors provided by DWR and historical measured flow in the river for the 50-year periods
- East Las Posas Management Area outflows to Arroyo Las Posas to the PVB from the CMWD model
- Projects that are currently operating in the Subbasin or currently under development

The historical measurements of precipitation for the two 50-year periods were modified using the DWR 2030 and 2070 climate-change factors. Stream flows were estimated using the adjusted rainfall. UWCD estimated Santa Clara River flow and the volume of water diverted to direct delivery and spreading. Pumping was decreased where the water is delivered to account for the surface water delivered. Future streamflow in Conejo and Calleguas Creeks in Pleasant Valley was estimated by regression.

No projects currently under development were identified in the Oxnard Subbasin, but two projects under development in the PVB were incorporated into the future baseline simulation because these projects affect inflows to the Oxnard Subbasin. The two projects in PVB are the City of Camarillo's North Pleasant Valley Desalter (desalination) Project and Conejo Creek Diversion deliveries to Pleasant Valley County Water District. The North Pleasant Valley Desalter Project was simulated by dividing the total project pumping of 4,500 AFY between project extraction wells 02N20W19L05 and 02N20W19F04. Additionally, pumping from Well 02N21W34C01 increased by 1,300 AFY to reflect a shift in areas of production.

In this scenario, Conejo Creek diversions will increase deliveries to agriculture by an additional 2,200 AFY to make the total deliveries in the PVB 4,500 AFY starting in 2020. The Conejo Creek Project allows CWD to increase pumping by up to 4,500 AFY based on credits for surface water delivered to PVCWD. However, in running the future simulations, it became apparent that the model area identified for production from the CWD wells was not able to extract the full amount. The amount of simulated CWD pumping that was achievable in the future baseline simulation was therefore limited to 2,816 AFY.

It is important to remember that groundwater extractions are not the only source of water to the Oxnard Subbasin. Surface water deliveries vary between the model scenarios because the model adjusts the deliveries of Santa Clara River water based on simulated groundwater elevations in the Oxnard Subbasin Forebay. Therefore, the total water available to the Oxnard Subbasin in the Future Baseline Scenario is approximately 72,000 AFY. Additionally, although the model calculates the groundwater extractions and surface water deliveries with precision, the values reported in Table 2-15 have been rounded to the nearest 1,000 AFY to reflect the uncertainty in the model calculations.

Future Baseline Scenario Model Results

Both the modeled flux of seawater and the particle tracks from the Future Baseline Scenario indicate that continuing the 2015–2017 extraction rate for the next 50 years would cause net seawater intrusion in both the UAS and LAS as well as ongoing inland migration of the saline water impact front (Figure 2-63 and Figure 2-64a through 2-64e, UWCD Model Particle Tracks, Future Baseline). The average annual flux of seawater into the UAS during the sustaining period was 4,400 AFY and the average annual flux of seawater into the LAS during the sustaining period was 5,300 AFY. The saline water impact front continued to migrate landward throughout the sustaining period, even during wetter than average climate periods. Based on these factors, the current areal and aquifer-system distribution of groundwater production at the extraction rates modeled in the Future Baseline Scenario was determined not to be sustainable.

2.4.5.2 Future Baseline With Projects Model Simulation

Future Baseline With Projects Scenario Model Assumptions

Modeling of future conditions included all of the assumptions incorporated into the Future Baseline simulation, and also incorporated potential future projects approved for inclusion by the FCGMA Board. Incorporation of the potential future projects in the Future Baseline With Projects Scenario neither represents a commitment by FCGMA to impose pumping reductions in the amounts specified at the wells identified below nor a commitment to move forward with each project included in the future model scenarios. Assumptions about projects and project implementation may have changed since the modeling was conducted and will continue to change over the next 5 years. These changes should be incorporated into the modeling for the 5-year GSP evaluation.

In the Oxnard Subbasin simulated future projects included delivery of 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road, expansion of the GREAT Ppprogram to increase groundwater recharge by 4,500 AFY in the Saticoy Spreading Grounds, and a 504 AFY reduction of pumping through temporary fallowing. These projects are discussed in detail in Chapter 5 of this GSP.

To simulate the delivery of 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road, pumping from wells near the coast in the pumping depression area (UWCD model parameter zone 4; Figure 2-65, UWCD Model Zones) was reduced uniformly and proportionally by 4,600 AFY. Additionally, pumping from Wells 02N22W23C05S and 02N22W23C07S in the Forebay was adjusted to allow the City of Oxnard to pump up to 8,000 AFY of accumulated credits for 2,600 AF recycled agricultural water delivered annually from the GREAT Ppprogram (FCGMA 2018).

To simulate the expansion of the GREAT pPProgram, spreading recharge was increased by 4,500 AFY starting in 2025. To simulate the 504 AFY reduction of pumping through fallowing, pumping from Wells 01N22W26K04S, 01N22W27H02S, 01N22W26M03S, 01N22W26K03S, 01N22W26P02S, 01N22W26Q03S, and 01N22W26D05S was reduced uniformly and proportionally by 504 AFY. It should be noted that these wells were selected for modeling purposes only and use of these wells in the model simulations was not intended to represent any planned pumping restrictions or limitations on these wells.

In the PVB, a proposed temporary fallowing project was simulated near the pumping depression (in model parameter zone 11; Figure 2-65). This project would generate a 2,407 AFY reduction in pumping, however, actual simulated fallowing totaled 2,234 AFY due to considerations of existing contracts for the delivery of surface water from the Santa Clara River. Pumping was preferentially reduced in wells in the LAS within the PVB to the extent possible.

In the WLPMA, future projects included the purchase of 1,762 AFY of water to be delivered to the eastern portion of the WLPMA in lieu of groundwater extraction. Simulated pumping was reduced in Zone Mutual Water Company Wells 02N20W07R03, 02N20W07R02, 02N20W08M01, 02N20W08E01, and 02N20W08F01, as well as Ventura County Waterworks District No. 19 Wells 02N20W06R01 and 02N20W08B01. The pumping reductions of 1,762 AFY were applied uniformly and proportionally across the wells.

After incorporating the potential future projects, the average groundwater production rate for the UAS in the Oxnard Subbasin was 41,000 AFY and the average groundwater production rate for the LAS in the Oxnard Subbasin was 24,000 AFY for the Future Baseline With Projects Scenario. In the PVB, the average groundwater production rate was 4,300 AFY in the UAS and 7,600 AFY in the LAS. In the WLPMA, the average production rate in the LAS was 11,200 AFY.

Because the projects that were incorporated into the Future Baseline With Projects Scenario included reduction of approximately 500 AFY from temporary fallowing in Oxnard, and deliveries of recycled water from the GREAT Ppprogram, the groundwater extractions in the LAS decreased by approximately 4,000 AFY, relative to the Future Baseline Scenario. At the same time, the groundwater extractions from the UAS increased by approximately 2,000 AFY, relative to the Future Baseline Scenario, in the Future Baseline With Projects Scenario (Table 2-15). Consequently, the effect of incorporating the projects was to shift groundwater extraction from the LAS to the UAS, and reduce overall groundwater extraction by approximately 2,000 AFY. The total water available to the Oxnard Subbasin in the Future Baseline With Projects Scenario was approximately 73,000 AFY, with the reduction in groundwater production being offset by the addition of approximately 3,000 AFY of project water.

Future Baseline With Projects Scenario Model Results

Although the shift in groundwater extractions from the LAS to the UAS and reduction in the total extractions helped reduce the flux of seawater into the Oxnard Subbasin, overall the Future Baseline With Projects Scenario resulted in approximately 3,000 AFY of seawater flux into the UAS and 2,700 AFY into the LAS during the sustaining period (Figures 2-66a through 2-66e, UWCD Model Particle Tracks, Base Case with Projects). Particle tracks for the Future Baseline With Projects Scenario also showed net landward migration of the saline water impact front during the sustaining period (Figures 2-66a through 2-66e). Based on these factors, the current areal and aquifer-system distribution of groundwater production at the extraction rates modeled in the Future Baseline With Projects Scenario was determined not to be sustainable.

2.4.5.3 Reduction With Projects Scenario

Reduction With Projects Scenario Model Assumptions

The Reduction With Projects Scenario included all of the assumptions incorporated into both the Future Baseline simulation and the Future Baseline With Projects Scenario. The Reduction With Projects Scenario also included a 35% reduction of 2015–2017 average production rates for the UAS and LAS in the Oxnard Subbasin, 20% reduction for the UAS and LAS in the PVB, and 20% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period. In the Oxnard Subbasin UAS, the simulated groundwater production rate in model year 2020 was 40,000 AFY. The production rate in model year 2040 at the beginning of the sustaining period was 24,300 AFY.[10] The average production from the UAS for the sustaining period was 26,500 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 28,500 AFY and the simulated groundwater production rate in model year 2040 was 14,000 AFY. The average production rate from the LAS for the sustaining period was 12,800 AFY.

Reduction With Projects Model Scenario Results

Reducing groundwater production in the UAS and LAS, and shifting some groundwater extractions from the LAS to the UAS via the potential future projects in the Reduction With Projects Scenario, resulted in an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 3,300 AFY during the sustaining period. In the LAS, the Reduction With Projects Scenario resulted in an average flux of approximately 1,200 AFY of seawater into the LAS during the sustaining period (Figures 2-67a through 2-67e, UWCD Particle Tracks, Reduction With Projects Simulation). Particle tracks for the Reduction With Projects Scenario indicate that the location of the 2015 saline water impact front would likely migrate toward the Pacific Ocean in the UAS as freshwater diluted saline concentrations, while it would experience some landward migration in the LAS (Figures 2-67a through 2-67e). The continued landward migration of the saline water impact front in the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in this model scenario, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

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10 Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the UAS in 2040 is 39% of the extraction rate in 2020 rather than the 35% specified in the model scenario description.

2.4.5.4 Reduction Without Projects Scenario 1

Reduction Without Projects Scenario 1 Model Assumptions

The Reduction Without Projects Scenario 1 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects Scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 1 also included a 25% reduction of 2015–2017 average production rates for wells screened solely in the UAS, a 60% reduction of the 2015–2017 average production rates for wells screened solely in the LAS, and a 45% reduction of the 2015–2017 average production rates for wells screened in both aquifer systems. The 2015–2017 average pumping rate was reduced by 25% in the UAS and LAS in the PVB, and 25% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period.

In the Oxnard Subbasin UAS, the simulated groundwater production rate in model year 2020 was 40,300 AFY. The production rate in model year 2040 at the beginning of the sustaining period was 27,300 AFY.[11] The average production from the UAS for the sustaining period was 27,200 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 33,100 AFY and the simulated groundwater production rate in model year 2040 was 13,000 AFY. The average production rate from the LAS for the sustaining period was 11,600 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 39,000 AFY for the 30-year sustaining period (Table 2-15).

Reduction Without Projects Scenario 1 Model Results

The fluxes in the UAS and LAS in the Reduction Without Projects Scenario 1 were similar to those simulated in the Reduction With Projects Scenario (Figures 2-68a through 2-68e, UWCD Model Particle Tracks, Reduction Without Projects Scenario (1) Simulation). There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 2,800 AFY during the sustaining period in the Reduction Without Projects Scenario 1. In the LAS, the Reduction Without Projects Scenario 1 resulted in an average flux of approximately 1,300 AFY of seawater into the LAS during the sustaining period. Particle tracks for this scenario indicate that the 2015 saline water impact front would likely migrate toward the Pacific Ocean in the UAS as freshwater diluted saline concentrations in the UAS, while it would migrate farther landward in the LAS than in the Reduction With Projects Scenario (Figures 2-68a through 2-68e). As in the Reduction With Projects Scenario, the continued landward migration of the saline water impact front in the LAS

[11] Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the UAS in 2040 is 32% of the extraction rate in 2020 rather than the 25% specified in the model scenario description.

suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 1, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.5 Reduction Without Projects Scenario 2

Reduction Without Projects Scenario 2 Model Assumptions

The Reduction Without Projects Scenario 2 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects Scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 2 also included a 55% reduction of 2015–2017 average production rates for the UAS and LAS. The 2015–2017 average pumping rate was reduced by 20% in the UAS and LAS in the PVB, and 20% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period.

In the Oxnard Subbasin UAS, the simulated groundwater production rate in model year 2020 was 40,000 AFY. The production rate in model year 2040 at the beginning of the sustaining period was 17,600 AFY.[12] The average production from the UAS for the sustaining period was 17,600 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 33,100 AFY and the simulated groundwater production rate in model year 2040 was 12,800 AFY. The average production rate from the LAS for the sustaining period was 11,500 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 29,000 AFY for the 30-year sustaining period (Table 2-15).

Model results indicate that under this scenario the groundwater flux in the LAS between the PVB and the Oxnard Subbasin is mostly reversed from the above scenarios from model year 2027 to 2055. The groundwater flow during this period (2027 to 2055) in the LAS is from the Oxnard Subbasin to the PVB. This increased the seawater intrusion in the LAS in the Oxnard Subbasin, exacerbating Oxnard Subbasin's seawater intrusion problem.

Reduction Without Projects Scenario 2 Model Results

There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 4,700 AFY during the sustaining period in the Reduction Without Projects

[12] Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the UAS in 2040 is 56% of the extraction rate in 2020 rather than the 55% specified in the model scenario description.

Scenario 2 and an average flux of approximately 900 AFY of seawater into the LAS. As in the Reduction Without Projects Scenario 1, the continued inflow of seawater into the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 2, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.6 Reduction Without Projects Scenario 3

Reduction Without Projects Scenario 3 Model Assumptions

The Reduction Without Projects Scenario 3 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects Scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 3 also included a 55% reduction of 2015–2017 average production rates for the UAS and LAS. The 2015–2017 average pumping rate was not reduced in the UAS and LAS in the PVB or in the LAS in the WLPMA. Groundwater production rates were reduced in the Oxnard Subbasin linearly over the implementation period and held constant during the sustaining period.

In the Oxnard Subbasin UAS, the simulated groundwater production rate in model year 2020, at the beginning of the implementation period, was 40,000 AFY. The production rate in model year 2040 at the beginning of the sustaining period was 18,100 AFY. The average production from the UAS for the sustaining period was 18,100 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 33,200 AFY and the simulated groundwater production rate in model year 2040 was 13,700 AFY. The average production rate from the LAS for the sustaining period was 12,300 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 30,000 AFY for the 30-year sustaining period (Table 2-15).

Reduction Without Projects Scenario 3 Model Results

There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 3,700 AFY during the sustaining period in the Reduction Without Projects Scenario 3 and an average flux of approximately 1,400 AFY of seawater into the LAS. As in the Reduction Without Projects Scenarios 1 and 2, the continued inflow of seawater into the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 3, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

Model results indicate that under this scenario the groundwater flux in the LAS between the PVB and the Oxnard Subbasin is reversed from model year 2027 to the end of the model period (2070). The groundwater flow during this period (after 2027) in the LAS is from the Oxnard Subbasin to the PVB. This significantly increases the seawater intrusion in the LAS in the Oxnard Subbasin exacerbating Oxnard Subbasin's seawater intrusion problem.

2.4.5.7 Alternative Climate and Rainfall Patterns

To assess the potential impacts on model predictions from alternate climate-change assumptions and precipitation patterns, two additional simulations were conducted using the Reduction Without Projects Scenario 1. These additional simulations changed the scenario assumptions in two ways. First, the Reduction Without Projects Scenario 1 was simulated using the DWR 2030 climate-change factor, rather than the more conservative 2070 climate-change factor. This revised scenario is referred to as the Reduction Without Projects Scenario 1a. Second, the Reduction Without Projects Scenario 1a was simulated with the DWR 2030 climate-change factor applied to the historical precipitation and hydrology period from 1940 to 1989, rather than the original period from 1930 to 1979. This revised scenario is referred to as the Reduction Without Projects Scenario 1b.

The 50-year periods from 1930 to 1979 and 1940 to 1989 were selected because they were the two periods from the entire historical record with the closest mean, or average, precipitation to the mean precipitation for the entire historical record of 14.4 inches. The mean precipitation for the historical period from 1930 to 1979 is also 14.4 inches and the mean precipitation from the historical period from 1940 to 1989 is 14.6 inches. These periods also have a similar distribution of precipitation years to the historical record and a similar average drought length to the average drought length in the historical record. The primary difference between the two periods is the timing of the dry periods in the records. The period from 1930 to 1979 begins with a 7-year dry period from 1930 to 1936 (model years 2020–2026), while the period from 1940-1989 begins with a 5-year wetter than average period (model years 2020–2024). The differences between these scenarios are discussed below.

Reduction Without Projects Scenario 1a

The Reduction Without Projects Scenario 1a had approximately 2,200 AFY of freshwater flowing out of the UAS to the Pacific Ocean and 1,500 AFY of seawater intrusion into the LAS during the sustaining period. Compared to the Reduction Without Projects Scenario 1, there was approximately 600 AFY less flow out of the UAS and approximately 200 AFY more flow into the LAS from the Pacific Ocean (Figure 2-63). This is the result of lower water levels in the UAS and LAS under this scenario than the Reduction Without Projects Scenario 1. The 2030 climate-change factor showed lower potential water levels and more seawater intrusion than the 2070 climate-change factor; however, the difference between the simulated fluxes in the two scenarios is within the uncertainty of the model predictions and is not significant compared to other uncertainties in the future simulations, including the actual precipitation pattern that will prevail over the period from 2020 to 2069.

Reduction Without Projects Scenario 1b

The Reduction Without Projects Scenario 1b had approximately 4,300 AFY of freshwater flowing out of the UAS to the Pacific Ocean and 760 AFY of seawater intrusion into the LAS during the sustaining period. Compared to the Reduction Without Projects Scenario 1a, the Reduction Without Projects Scenario 1b had 2,100 AFY more freshwater leaving the UAS and 800 AFY less seawater intrusion in the LAS during the sustaining period (Figure 2-63). The reduced seawater intrusion and increased freshwater outflow are the result of higher simulated groundwater levels during the sustaining period than in the Reduction Without Projects Scenario 1a. The groundwater elevations in the Reduction Without Projects Scenario 1b rise faster in response to the wetter than average precipitation pattern that occurs at the beginning of the model period (model years 2020–2024) and remain higher during the sustaining period (model years 2040–2069) than they do in the Reduction Without Projects Scenario 1a. The differences in seawater intrusion and water levels between the Reduction Without Projects Scenarios 1a and 1b show that the model is more sensitive to actual precipitation patterns than it is to the predicted relative changes in climate between 2030 and 2070. The actual climate and precipitation patterns over the next 5 years should be used to revise the model simulations and refine the estimated potential for net seawater intrusion during the sustaining period.

2.4.5.8 Uncertainty Analysis

A review of the UWCD model was conducted to provide an independent evaluation of the model for use in the context of developing a GSP and to quantify the uncertainty associated with the modeling estimates of the sustainable yield for the basins in the model domain (Appendix E). UWCD conducted a *local* sensitivity analysis of its model prior to this review, in order to evaluate how the model input parameters obtained via the model calibration affect the model outputs. The peer review conducted an additional *global* sensitivity analysis that keys off of their local sensitivity analysis, and allows for a quantitative assessment of uncertainty in seawater flux and sustainable yield.

General Results

Results of the model scenarios discussed above indicate that changes to groundwater production rates or to extraction locations for the Oxnard Subbasin are needed to avoid seawater intrusion in the LAS during the sustaining period. Understanding the uncertainties in the model predictions underscores the desirability of making gradual changes in production rates while additional monitoring and studies help to reduce these uncertainties.

The largest potential sources of uncertainty in the model were found to be hydraulic properties, for a given precipitation pattern. As discussed in Section 2.4.5.7, Alternative Climate and Rainfall Patterns, precipitation and surface water availability are a critical input parameter for predictive simulations. Critical areas of hydraulic properties were constrained in the historical simulations by aquifer testing. In particular, the model parameters that accounted for the most variance (approximately 37% of total variance) in minimizing error between observed groundwater levels and model simulated heads throughout the model were the horizontal hydraulic conductivities assigned to the Oxnard and Mugu Aquifers in the Forebay. The values assigned in the model were consistent with horizontal hydraulic conductivities determined from aquifer testing in that area. The fact that the most sensitive parameter assignments were well constrained by observations reduces uncertainty and provides good confidence in model predictions of groundwater levels overall.

Additionally and importantly, these same zones of horizontal hydraulic conductivity accounted for approximately 24% of total variance in model calculations of seawater flux across the ocean boundary. In contrast, the conductance of the ocean general head boundaries only accounted for approximately 3% of the variance in seawater flux. This indicates that the movement of artificially recharged groundwater from the Forebay to the coast is key in seawater flux. Additionally, the amount of Forebay recharge that enters the WLPMA rather than moving toward the coast was found to affect the seawater flux more than the conductance of the general head boundaries representing the ocean outcrops at the model boundary.

Stream infiltration, a parameter that was estimated based on the correlation between predicted and observed water levels accounted for approximately 5% of the variance in seawater flux and horizontal and vertical hydraulic conductivity of the aquitard separating Layer 5 (Mugu Aquifer) from Layer 7 (the Hueneme Aquifer) in the PVB accounted for approximately 3% of the variance in seawater flux. This sensitivity is associated with the flux across the basin boundary and flow between the UAS and the LAS. Again, these parameters in the PVB accounted for more seawater flux than that accounted for by the conductance of the aquifer outcrops beneath the ocean.

Quantifying Uncertainty

The uncertainty associated with model simulations of seawater flux was calculated by determining the relationship between simulated groundwater levels in wells near the coast and simulated seawater flux at the ocean boundary for the six model scenarios described in Section 2.4.5. This relationship was established by calculating the mean errors between observed and simulated groundwater levels at the coastal wells and applying the relationship between simulated groundwater levels and seawater flux to determine what the flux would have been had the model exactly reproduced observed groundwater levels. This analysis was conducted for both the entire model period from 2020 to 2069 and the sustaining period from 2040 to 2060. In general the analysis indicated that there is approximately 2,000 AFY uncertainty due to model error in simulated total seawater flux, though this varies depending on which time frame is analyzed.- Alternatively, using calculated seawater flux from the 121 realizations in thea global sensitivity analysis yielded a comparable result of approximately 3,000 AFY uncertainty in seawater flux. The global sensitivity analysis is discussed in Appendix E. For the sustaining period, the relationship between seawater flux and pumping gives a confidence interval for the sustainable yield of approximately ± 6,000 AFY for the UAS and ± 3,600 AFY for the LAS. For the entire model period from 2020 to 2069, the relationship between seawater flux and pumping gives a confidence interval for the sustainable yield of approximately ± 4,100 AFY for the UAS and ± 2,300 AFY for the LAS. The relationship between seawater flux and water levels will continue to be refined through data collection and analysis over successive 5-year periods for the GSP evaluations, and these uncertainty estimates are anticipated to contract accordingly.

2.4.5.9 Estimates of Future Sustainable Yield

The sustainable yield for Oxnard Subbasin was assessed by examining the modeled flux of seawater into the Subbasin over the 50-year model period and 30-year sustaining period predicted by the UWCD model for the Subbasin, the PVB, and the WLPMA. Only theThe sustaining period was assessed because SGMA recognizes that undesirable results may occur during the 20-year implementation period, as basins move toward sustainable groundwater management. In addition to the flux of seawater, particle tracks from the model runs were analyzed to evaluate the potential migration of the current extent of saline water impact in the UAS and the LAS. The particles were placed along the approximate inland extent of the zone of saline water impact in 2015. Scenarios that minimize the net flux of seawater into the Oxnard Subbasin and the landward migration of the saline water impact front over the 30-year sustaining period are sustainable for Oxnard, while those that allow for net seawater intrusion and landward migration of the saline water impact front are not.

None of the model scenarios described in Section 2.4.5 successfully eliminated seawater intrusion in the LAS during the 50-year model period, or the 30-year sustaining period, while the majority of the model scenarios resulted in net freshwater loss from the UAS to the Pacific Ocean. Therefore, none of the direct model scenarios was used to determine estimate the sustainable yield of the Oxnard Subbasin. Instead, the relationship between seawater flux and groundwater production from each of the model scenarios for both the 50-year period and the 30-year periods was were plotted graphically and the linear relationship between the seawater flux and groundwater production was used to predict the quantity of groundwater production that would result in no net seawater intrusion over the sustaining periods in either the UAS or the LAS. This method is also discussed in Appendix E, Section 2.3.2.2, and the seawater flux and groundwater production plots are provided in Appendix E as Figures 4 and 5.- In order to provide separate estimates for the two aquifer systems, independent relationships between groundwater production and seawater intrusion were developed for the UAS and LAS. It was possible to develop relationships for each aquifer within the UAS and LAS, but in general wells in the Oxnard

Subbasin are screened in multiple aquifers in each aquifer system. Therefore, for management purposes, the sustainable yield estimates were developed for the aquifer systems rather than for independent aquifers.

The sustainable yield of the UAS was calculated to be approximately 32,000 AFY for both the entire 50-year model period and the 30-year sustaining period. The uncertainty in the estimated sustainable yield for the UAS is lower if only the sustaining period is used. For the entire model period, the uncertainty in the sustainable yield is approximately ± 6,000 AFY, whereas for the sustainable period the uncertainty in the sustainable yield is approximately ± 4,100 AFY. Consequently, this analysis suggests that the sustainable yield of the UAS may be as high as 38,000 AFY or as low as 26,000 AFY.

The sustainable yield of the LAS was calculated to be approximately 7,000 AFY for both the entire 50-year model period and the 30- year sustaining period. The uncertainty in the estimated sustainable yield for the LAS is lower if the entire model period is used. For the entire model period, the uncertainty in the sustainable yield of the LAS is approximately ± 2,300 AFY, whereas for the sustainable period the uncertainty in the sustainable yield is approximately ± 3,600 AFY. Consequently, this analysis suggests that the sustainable yield of the LAS may be as high as 10,600 AFY or as low as 3,400 AFY.

It is anticipated that the analysis for the 5-year update to the GSP will focus on differential extractions on the coast and inland, particularly in the LAS. Additional modeling is recommended for the 5-year update process to understand how changes in pumping patterns can increase the overall sustainable yield of the Oxnard Subbasin. As this understanding improves, projects to support increases in the overall sustainable yield can be developed.

2.5 MANAGEMENT AREAS

In order to sustainably manage the groundwater resources of the Oxnard Subbasin, the Subbasin has been divided into five management areas (Figure 2-69, Oxnard Subbasin Management Areas). These areas are the Forebay Management Area, the West Oxnard Plain Management Area, the Oxnard Pumping Depression Management Area, the Saline Intrusion Management Area, and the East Oxnard Plain Management Area (EOPMA). These areas are separated by hydrogeologic and water quality characteristics.

The Forebay Management Area is in the northeastern Oxnard Subbasin. In this area of the Subbasin, the semi-perched aquifer and clay cap are absent, resulting in direct communication between the alluvium and the underlying aquifer systems. The majority of surface water recharge to the Oxnard Subbasin occurs within the UWCD spreading grounds located in the Forebay Management Area.

The West Oxnard Plain Management Area lies within the Oxnard Subbasin jurisdictional boundaries. The West Oxnard Plain Management Area, which includes the City of Oxnard, is south and west of the Forebay Management Area.

The Oxnard Pumping Depression Management Area is south and east of the West Oxnard Plain Management Area. The boundaries of the Oxnard Pumping Depression Management Area include are Highway 101 to the north, North Rice Avenue and North Rose Avenue to the west, East Hueneme Road and Highway 1 to the south, and the Bailey Fault and the PVB to the east. This management area was established based on the low groundwater elevations historically recorded in both the UAS and the LAS in the area.

The Saline Intrusion Management Area lies to the west of the Oxnard Pumping Depression Management Area, and south of the West Oxnard Plain Management Area. The Saline Intrusion Management Area includes both Port Hueneme and Point Mugu, where saline intrusion has occurred historically and has impacted wells in both the UAS and LAS.

The EOPMA lies to the east of the Bailey Fault and is predominantly within the jurisdiction of the County of Ventura., although the service area of CWD overlies a A small area on the northern boundary between the EOPMA and the PVB is covered by the Camrosa Water District ––Oxnard Subbasin GSA (see Figure 1-2)., and TheThe the FCGMA jurisdictional boundary extends into the EOPMA along the boundary with the Oxnard Pumping Depression Management Area (Figure 2-69). This management area was established based on groundwater elevation and chloride concentration differences across the Bailey Fault, which acts as a barrier to groundwater flow (Turner 1975; Section 2.2.1).

This GSP has been prepared for the entire Oxnard Subbasin and management areas defined in this GSP will be managed by the FCGMA. The minimum thresholds and measurable objectives developed in Chapter 3 are based on the data available in the Forebay Management Area, the West Oxnard Plain Management Area, the Oxnard Pumping Depression Management Area, and the Saline Water Intrusion Management Area. Comparable historical data on groundwater elevation, storage, production, and quality are not available for the EOPMA. Therefore, the minimum thresholds and measurable objectives for the West Oxnard Plain and Oxnard Pumping Depression Management Areas, which are adjacent to the EOPMA, will be applied to age and/or depth equivalent hydrostratigraphic units in the EOPMA. As additional data are collected in the EOPMA, separate minimum thresholds and management objectives may be developed. If changes to the minimum thresholds and management objectives are warranted, justification will be provided in the 5-year GSP updates.

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Table 2-1
Oxnard Subbasin Stratigraphic and Hydrostratigraphic Nomenclature

<table>
<tr><th rowspan="2">Geologic Period</th><th rowspan="2">Geologic Epoch</th><th>Mukae and Turner (1975)</th><th>Kew (1924); Bailey (1951)[a]</th><th>Weber and Kiessling (1976)</th><th>Dibblee (1992a, 1992b)</th><th colspan="3">Mukae and Turner (1975); DWR (2006)</th></tr>
<tr><th colspan="4">Lithologic Units and Formations</th><th colspan="3">Hydrostratigraphy</th></tr>
<tr><td rowspan="8">Quaternary</td><td>Holocene</td><td rowspan="2">Alluvium: Active stream deposits, sand, and gravel; stream, swamp, and lagunal deposits of clay, sand, and gravel</td><td colspan="3">Recent Alluvium: Active lagoonal, beach, river, and floodplain and alluvial deposits</td><td rowspan="2">Oxnard</td><td>Semi-Perched</td><td rowspan="4">Upper Aquifer System</td></tr>
<tr><td rowspan="4">Upper Pleistocene</td><td rowspan="2">Terrace deposits: Deformed river deposits</td><td colspan="2" rowspan="2">Older Alluvium: Deformed beach, river, floodplain, and terrace deposits</td><td>Oxnard</td></tr>
<tr><td rowspan="3">Older Alluvium: Clays silts, sands, and gravels from the Santa Clara River</td><td colspan="2" rowspan="2">Mugu</td></tr>
<tr><td rowspan="5">Saugus Formation: Terrestrial and marine sand and gravel</td><td>Saugus Formation: Terrestrial fluvial</td><td rowspan="2">Saugus Formation: Terrestrial</td></tr>
<tr><td rowspan="3">San Pedro Formation: Marine clays and sand and terrestrial sediment</td><td colspan="2" rowspan="2">Hueneme</td><td rowspan="4">Lower Aquifer System</td></tr>
<tr><td rowspan="3">Lower Pleistocene</td><td rowspan="2">San Pedro Formation: Marine and nonmarine clay, sand, and gravel</td><td rowspan="3">Las Posas Sand: Shallow marine sand</td></tr>
<tr><td colspan="2">Fox Canyon</td></tr>
<tr><td>Santa Barbara Formation: Marine clay, sand, and gravel</td><td>Santa Barbara Formation: Shallow marine sand</td><td colspan="2">Grimes Canyon (upper member)</td></tr>
<tr><td rowspan="4">Tertiary</td><td>Pliocene</td><td>Pico Formation: Shale, sandstone, and conglomerate</td><td>Fernando Group</td><td colspan="2"></td><td colspan="3" rowspan="4">Non-Freshwater Bearing</td></tr>
<tr><td rowspan="2">Miocene</td><td>Santa Margarita and Modelo Formations</td><td colspan="2">Modelo Formation: Marine mudstones</td><td>Monterey Formation</td></tr>
<tr><td>Topanga Formation and Volcanics</td><td colspan="3">Conejo Volcanics: Terrestrial and marine extrusive and intrusive igneous rocks</td></tr>
<tr><td>Oligocene/ Eocene</td><td>Older Rocks</td><td colspan="3">Sespe Formation: Sandstone and cobble conglomerate</td></tr>
</table>

Note:
[a] As cited in DeVecchio et al. 2012a.

Table 2-2
Vertical Gradient

Location	Nested Group (First 9 Digits of SWN)	Well (Penultimate 2 Digits of SWN)	Screen Interval		Spring 2015 Elevation (ft msl)	Spring 2015 Gradient (ft/ft)[a]	Fall 2015 Elevation (ft msl)	Fall 2015 Gradient (ft/ft)[a]	Aquifer[b]
			Top	*Bottom*					
Forebay	02N22W23B	09	75	95	NA	—	10.41	−0.643	Oxnard
		08	135	155	−13.06	−0.057	−28.19	−0.019	Oxnard
		07	260	300	−20.72	−0.012	−30.81	−0.028	Mugu
		06	460	500	−23.2	−0.114	−36.43	−0.107	Hueneme
		05	830	870	−65.53	−0.036	−75.84	−0.039	Hueneme
		04	1,1 10	1,150	−75.59	−0.014	−86.77	0.032	Hueneme
		03	1,2 10	1,250	−77	—	−83.55	—	Fox
Forebay	02N21W07L	06	135	155	8.2	−0.012	−12.07	−0.042	Mugu
		04	500	540	3.88	−0.014	−27.9	0.022	Fox
		03	640	700	1.84	—	−24.59	—	Fox
North - Coastal	01N23W01C	05	120	145	1.18	−0.040	−0.92	−0.048	Oxnard
		04	630	695	−20.03	−0.009	−26.52	−0.010	Hueneme
		03	965	1,065	−23.24	−0.014	−29.95	−0.010	Hueneme
		02	1,3 90	1,490	−29.31	—	−34.34	—	Fox
Port Hueneme	01N22W20M	06	50	70	1.27	−0.071	1.8	−0.131	Semi-Perched
		05	150	170	−5.78	−0.004	−11.27	−0.002	Oxnard
		04	280	300	−6.26	−0.033	−11.55	−0.039	Mugu
		03	520	560	−14.6	−0.017	−21.3	−0.019	Hueneme
		02	700	740	−17.57	−0.040	−24.8	−0.048	Hueneme
		01	900	940	−25.65		−34.47		Fox

Table 2-2
Vertical Gradient

Location	Nested Group (First 9 Digits of SWN)	Well (Penultimate 2 Digits of SWN)	Screen Interval		Spring 2015 Elevation (ft msl)	Spring 2015 Gradient (ft/ft)[a]	Fall 2015 Elevation (ft msl)	Fall 2015 Gradient (ft/ft)[a]	Aquifer[b]
			Top	*Bottom*					
Port Hueneme	01N22W28G	5	180	200	−7.4	−0.009	−12.4	−0.016	Oxnard
		4	255	275	−8.1	−0.030	−13.6	−0.032	Oxnard
		3	720	760	−22.3	−0.039	−28.8	−0.051	Hueneme
		2	995	1,095	−34.2	0.010	−44.2	0.019	Fox
		1	1,2 95	1,395	−31.3	—	−38.6	—	GCA
Point Mugu	01N22W36K	09	175	195	−13.07	−0.110	−24.14	−0.156	Oxnard
		08	310	330	−27.89	−0.220	−45.17	−0.561	Mugu
		07	410	450	−52.06	−0.005	−106.82	−0.019	FCA
		06	540	580	−52.71	−0.025	−109.32	−0.014	FCA
		05	680	720	−56.26	—	−111.34	—	GCA
South/ Central	01N21W19L	14	18	38	11.97	−0.278	10.1	−0.331	Semi-Perched
		13	110	130	−13.63	−0.048	−20.33	−0.096	Oxnard
		12	200	220	−17.93	−0.109	−28.96	−0.119	Oxnard
		11	300	320	−28.85	−0.390	−40.87	−0.620	Mugu
		10	394	414	−65.55	—	−99.19	—	FCA
South	01N21W32Q	06	275	285	−41.21	−0.278	−65	−0.468	Oxnard
		07	180	220	−12.7	−0.356	−20.24	−0.560	Mugu
		05	330	370	−60.7	−0.021	−97.74	−0.028	Mugu
		04	600	640	−66.3	−0.047	−105.38	−0.044	FCA
		03	800	840	−75.6	0.084	−114.17	0.084	GCA
		02	930	970	−64.7	—	−103.2	—	GCA

Notes: FCA = Fox Canyon Aquifer; ft/ft = feet per feet; ft msl = feet above mean sea level; GCA = Grimes Canyon Aquifer; SWN = State Well Number.

[a] Negative gradients are directed downward.

[b] The Oxnard and Mugu Aquifers compose the UAS, and the Hueneme, Fox, and Grimes Aquifers compose the LAS. Aquifer designations were provided by UWCD.

Table 2-3
Seawater/Saline Water Historical Reports and Studies

Title	Author/Agency	Date
Sea Water Intrusion, Oxnard Plain Ventura County	California Department of Water Resources	October 1965
Sea-Water Intrusion: Aquitards in the Coastal Ground Water Basin of Oxnard Plain, Ventura County	California Department of Water Resources, Bulletin No. 63-4	September 1971
Oxnard Plain Groundwater Study	State Water Resources Control Board	March 1979
Chloride Sources in a California Aquifer	John A. Izbicki, U.S. Geological Survey	July 1991
A Study of Seawater Intrusion Using Direct-Current Soundings in the Southeastern Part of the Oxnard Plain, California	U.S. Geological Survey, Open File Report 93-524	1993
Use of δ18O and δD to Define Seawater Intrusion	John A. Izbicki, U.S. Geological Survey	1996
Simulation of Ground-Water/Surface-Water Flow in the Santa Clara–Calleguas Ground-Water Basin, Ventura County, California	Hanson et al., U.S. Geological Survey; Water Resources Investigation Report 02-4136	2003
Mugu Seawater/Saline Water Intrusion Monitoring Program: AB303 Grant, Agreement No. 4600004100	United Water Conservation District	April 2007
2007 Update to the Fox Canyon Groundwater Management Agency Management Plan	Fox Canyon Groundwater Management Agency	2007
Oxnard Plain Time Domain Electromagnetic Study for Saline Intrusion	United Water Conservation District, Open-File Report 2010-003	2010
Saline Intrusion Update, Oxnard Plain and Pleasant Valley Basins	United Water Conservation District	October 2016

Table 2-4
Basin Plan and FCGMA Water Quality Thresholds for Groundwater in the Oxnard Subbasin

Threshold Source	Sub-Area/Zone Description	Threshold Concentration (mg/L)				
		TDS	*Chloride*	*Nitrate*	*Sulfate*	*Boron*
LARWQCB Basin Plan WQO	Oxnard Forebay and Confined Aquifers	1,200	150	45	600	1
	Unconfined and Perched Aquifers	3,000	500	45	1,000	—
FCGMA 2007 BMO	Oxnard Forebay	1,200	—	22.5	—	—
	Oxnard Plain	—	150	—	—	—

Sources: LARWQCB 2013; FCGMA 2007.
Notes: BMO = Basin Management Objective; FCGMA = Fox Canyon Groundwater Management Agency; LARWQCB = Los Angeles Regional Water Quality Control Board; mg/L = milligrams per liter; TDS = total dissolved solids; WQO = Water Quality Objective.

Table 2-5
Modeled Surface Water Percolation from Streams in the Oxnard Subbasin

Water Year[a]	Santa Clara River Percolation (acre-feet)[b]	Calleguas Creek Percolation (acre-feet)
1986	8,466	4,423
1987	115	2,586
1988	10,402	3,572
1989	780	3,308
1990	943	2,140
1991	11,306	2,357
1992	18,255	5,290
1993	19,821	6,274
1994	3,303	3,468
1995	9,085	5,846
1996	560	3,687
1997	3,386	3,953
1998	3,922	6,760
1999	−4,404	3,699
2000	2,973	3,707
2001	4,225	4,770
2002	−521	3,341
2003	10,382	3,571
2004	3,913	1,873
2005	17,975	6,536
2006	−890	3,184
2007	47	1,802
2008	7,073	3,159
2009	4,281	2,617
2010	14,173	2,732
2011	10,803	3,763
2012	3,023	1,890
2013	−268	968
2014	5,821	819
2015	1,520	1,476
Average	5,682	3,452

Notes:

a Results presented are in water years, and will not match values presented in Section 2.4 text and Tables 2-7a through 2-7c, which are presented in calendar years.

b Negative numbers represent discharge of groundwater to the stream.

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Table 2-6
Ecological Assets

Ecological Assets	Lower Santa Clara River	McGrath Lake	Ormond Beach Wetlands	Mugu Lagoon and Wetlands	Lower Calleguas Creek	Revolon Slough
Locally important, special-status, rare, threatened, or endangered plants or animals supported by the GDE	• Santa Ana sucker • western pond turtle • tidewater goby • coast horned lizard • white rabbit-tobacco • southern riparian scrub • least Bell's vireo *(CDFW 2016)* • steelhead	• Belding's savannah sparrow • burrowing owl • California least tern • least Bell's vireo • salt marsh bird's-beak • sandy beach tiger beetle • silvery legless lizard • Ventura Marsh milk-vetch *(CDFW 2016)* • sandy beach tiger beetle • brown pelican • western least bittern • white-faced ibis • osprey • white-tailed kite • northern harrier • sharp-shinned hawk • Cooper's hawk • light-footed clapper rail • western snowy plover • long-billed curlew • California least tern • western yellow-billed cuckoo • burrowing owl • southwestern willow flycatcher • loggerhead shrike • least Bell's vireo • yellow warbler • yellow-breasted chat • Belding's savannah sparrow • California red-legged frog • southwestern pond turtle • silvery legless lizard • San Diego horned lizard • two-striped garter snake • south coast garter snake • Townsend's big-eared bat *(ESA 2003, Table 3-2)*	• Belding's savannah sparrow • California least tern • Coulter's goldfields • California brackish water snail • salt marsh bird's-beak • tidewater goby • western snowy plover *(CDFW 2016)* • western snowy plover • California least tern • California brown pelican • light-footed clapper rail • least Bell's vireo • Southern California saltmarsh shrew • San Diego black-tailed jackrabbit • double-crested cormorant • American bittern • great blue heron • great egret • snowy egret • black-crowned night heron • white-faced ibis • white-tailed kite • northern harrier • Cooper's hawk • sharp-shinned hawk • merlin • mountain plover • long-billed curlew • western burrowing owl • loggerhead shrike • yellow warbler • California horned lark • tricolored blackbird • south coast garter snake • tiger beetle • sandy beach tiger beetle • wandering skipper • globose dune beetle • red sand-verbena • spiny rush • woolly seablite *(WRA 2007)*	• arroyo chub • Belding's savannah sparrow • burrowing owl • California brown pelican • California least tern • Coulter's goldfields • estuary seablite • ferruginous hawk • globose dune beetle • least Bell's vireo • light-footed clapper rail • salt marsh bird's-beak • sandy beach tiger beetle • senile tiger beetle • southern coastal salt marsh • tidewater goby • wandering (=saltmarsh) skipper • western snowy plover *(CDFW 2016)* • peregrine falcon	• arroyo chub • two-striped gartersnake • least Bell's vireo *(CDFW 2016)*	• arroyo chub *(CDFW 2016)* • least Bell's vireo *(Appendix K)*

Table 2-6
Ecological Assets

Ecological Assets	Lower Santa Clara River	McGrath Lake	Ormond Beach Wetlands	Mugu Lagoon and Wetlands	Lower Calleguas Creek	Revolon Slough
Important or critical habitat provided for native species (USFWS 2016b)	• southwestern willow flycatcher critical habitat (569 acres) • tidewater goby critical habitat (22 acres) • western snowy plover critical habitat (35 acres) • steelhead critical habitat • Audubon California Important Bird Area	• southwestern willow flycatcher critical habitat (32 acres) • tidewater goby critical habitat (18 acres) • Ventura Marsh milk-vetch critical habitat (78 acres) • Audubon California Important Bird Area	• tidewater goby critical habitat (88 acres) • western snowy plover critical habitat (26 acres) • Audubon California Important Bird Area	• western snowy plover critical habitat (51 acres) • Wetland of Regional Importance in the Western Hemisphere Shorebird Reserve Network • Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) are designated for Pacific Coast groundfish and coastal pelagic species in the nearshore marine and estuarine habitats • Laguna Point to Latigo Point Area of Special Biological Significance • Audubon California Important Bird Area	None	None
Portion of GDE that is a recognized wetland (USFWS 2016a; Appendix K)	1,180 acres (93%)	197 acres (71%)	207 acres (96%)	5,943 acres (93%)	6 acres (4%)	2 acres (8%)
Protected area, locally important conservation or wildlife corridor plan areas within the GDE	• The Nature Conservancy (160 acres) • City of Ventura (1.2 acres)	• McGrath State Beach (56 acres) • Mandalay State Beach (29 acres) • Mandalay County Park (0.7 acres)	• The Nature Conservancy (129 acres) • Port Hueneme Beach Park (1.3 acres)	• Point Mugu State Park (0.1 acres)	None	None
List any environmental beneficial uses designated in the RWQCB Basin Plan for the surface water found in the groundwater basin.	• Wildlife Habitat (WILD) • Rare, Threatened, or Endangered Species (RARE) • Migration of Aquatic Organisms (MIGR) • Spawning, Reproduction, and/or Early Development (SPWN) • Wetlands (WET) Also REC1, REC2	• Estuarine Habitat (EST) • Wildlife Habitat (WILD) • Rare, Threatened, or Endangered Species (RARE) • Wetlands (WET) Also REC1, REC2	• Estuarine Habitat (EST) • Wildlife Habitat (WILD) • Rare, Threatened, or Endangered Species (RARE) • Wetlands (WET) Also, REC1, REC2	• Estuarine Habitat (EST) • Marine Habitat (MAR) • Wildlife Habitat (WILD) • Preservation of Biological Habitats of Special Significance (BIOL) • Rare, Threatened, or Endangered Species (RARE) • Migration of Aquatic Organisms (MIGR) • Spawning, Reproduction, and/or Early Development (SPWN) • Shellfish Harvesting (SHELL) • Wetlands (WET) Also REC1 (potential), REC2	Reach 2: • WARM • COLD • Wildlife Habitat (WILD) • Rare, Threatened, or Endangered Species (RARE) • Wetlands (WET) Also REC1, REC2	Reach 4 (Revolon Slough): • WARM • Wildlife Habitat (WILD) • Wetlands (WET) Also REC1, REC2
Is the GDE area composed of >30% native vegetation? (Appendix K)	Yes	Yes	Yes	Yes	Yes	Yes

Sources: CDFW 2016; GreenInfo Network 2016; USFWS 2016a, 2016b; Appendix K; WRA 2007; ESA 2003.

Table 2-7a
Groundwater Recharge and Discharge in the Semi-Perched Aquifer

Calendar Year[a]	Groundwater Recharge (AF)										Groundwater Discharge (AF)											Storage Change (AF)
	Stream Leakage (Santa Clara River in Oxnard Forebay)	*Recharge*	*Subsurface Inflow from PVB*	*Unincorporated Areas*	*Subsurface Inflow from West LPVB*	*Subsurface Inflow from the UAS*	*Sum of Coastal Flux from Arnold Road to Point Mugu*	*Coastal flux from Channel Islands Harbor to Arnold Road*	*Stream Leakage Calleguas Creek*	*Total Inflow*	*Pumping*	*Tile Drains*	*Subsurface Outflow to UAS*	*Groundwater Discharge to Streams (Santa Clara River in Oxnard Forebay)*	*Evapotranspiration*	*Unincorporated Areas*	*Subsurface Outflow to West LPVB*	*Coastal Flux North to Channel Islands Harbor*	*Coastal flux from Channel Islands Harbor to Arnold Rd*	*Subsurface Outflow to Mound Basin*	*Total Outflow*	*Change in Groundwater Storage[b]*
1985	0	23,081	1,525	152	0	0	843	0	2,592	28,192	−44	−2,983	−15,889	−404	−5,765	0	−374	−2,076	−266	−1,247	−29,050	857
1986	1,133	28,960	1,720	59	0	0	632	0	4,243	36,748	−65	−6,579	−13,989	0	−8,312	0	−66	−1,789	−235	−844	−31,879	−4,869
1987	0	24,587	1,780	16	0	0	672	0	3,097	30,153	−65	−5,886	−18,182	−407	−7,100	0	−335	−1,628	−243	−626	−34,472	4,319
1988	1,021	23,162	1,758	0	0	0	658	0	3,236	29,836	−61	−5,715	−17,824	0	−7,138	−25	−72	−1,442	−206	−622	−33,105	3,269
1989	0	20,613	1,641	0	0	0	667	0	3,146	26,068	−73	−4,848	−19,673	−245	−6,582	−57	−10	−1,315	−188	−451	−33,441	7,373
1990	0	18,731	1,312	0	0	0	701	0	1,901	22,645	−141	−3,032	−22,805	−136	−5,008	−89	0	−1,076	−176	−362	−32,825	10,180
1991	1,857	26,208	1,074	0	0	0	652	0	2,526	32,316	−128	−2,856	−23,955	0	−5,207	−107	−2	−854	−119	−470	−33,698	1,382
1992	4,382	28,816	1,448	0	0	0	567	0	5,661	40,875	−92	−5,605	−19,636	0	−7,684	−84	−47	−773	−25	−645	−34,589	−6,285
1993	3,165	29,069	2,161	0	8	0	552	21	6,209	41,186	−70	−8,637	−8,873	0	−9,404	−25	0	−950	0	−594	−28,553	−12,633
1994	42	21,586	2,249	0	0	0	668	0	3,240	27,784	−89	−7,101	−6,674	0	−7,680	−5	−349	−1,219	−12	−607	−23,735	−4,048
1995	1,563	31,175	3,070	53	105	2,351	558	0	6,037	44,912	−55	−13,095	0	0	−10,618	0	0	−1,449	−85	−609	−25,912	−19,001
1996	521	25,153	3,281	58	0	0	650	0	4,168	33,831	−27	−12,061	−1,148	0	−9,283	0	−223	−1,592	−105	−892	−25,332	−8,498
1997	0	26,109	3,628	69	0	0	652	0	4,050	34,508	−20	−14,177	−6,733	−187	−9,647	0	−266	−1,821	−200	−855	−33,905	−602
1998	598	32,461	4,336	134	811	5,986	542	0	6,184	51,052	−6	−20,912	0	0	−12,445	0	0	−2,006	−257	−575	−36,199	−14,852
1999	0	19,869	4,254	94	0	0	680	0	3,506	28,404	−10	−15,444	−3,958	−585	−9,755	0	−392	−2,008	−244	−975	−33,371	4,967
2000	0	22,718	4,259	69	0	0	660	0	3,706	31,412	−11	−15,051	−8,528	−360	−9,840	0	−342	−2,128	−321	−836	−37,418	6,006
2001	0	27,888	4,414	87	0	0	611	0	4,974	37,974	−8	−17,135	−3,472	−18	−10,797	0	−41	−2,073	−324	−720	−34,589	−3,385
2002	0	19,479	4,219	60	0	0	686	0	3,562	28,007	0	−12,918	−10,775	−199	−8,925	0	−455	−1,944	−299	−779	−36,294	8,287
2003	624	20,846	4,207	62	0	0	664	0	2,610	29,012	0	−13,054	−9,433	0	−9,096	0	−125	−1,897	−290	−755	−34,649	5,637
2004	1,268	23,658	4,131	50	0	0	683	0	3,262	33,052	0	−11,527	−13,653	0	−8,265	0	−59	−1,791	−293	−646	−36,234	3,182
2005	2,113	26,133	4,668	91	430	0	581	0	5,453	39,468	0	−16,632	−625	0	−10,950	0	0	−1,681	−232	−548	−30,668	−8,800
2006	406	22,032	4,622	75	56	2,744	681	0	2,975	33,590	0	−14,711	0	0	−9,156	0	0	−1,697	−189	−794	−26,547	−7,043
2007	0	17,401	4,673	40	0	0	726	0	1,982	24,822	0	−12,812	−9,238	−533	−7,984	0	−626	−1,809	−222	−812	−34,036	9,213
2008	595	21,781	4,791	45	0	0	680	0	3,613	31,505	0	−13,449	−9,365	0	−8,859	0	−156	−1,812	−254	−689	−34,584	3,079
2009	789	19,847	4,711	46	0	0	696	0	2,370	28,458	0	−12,256	−10,893	0	−8,129	0	−157	−1,685	−235	−622	−33,978	5,521
2010	1,851	27,065	4,706	72	0	0	652	0	2,737	37,083	0	−13,439	−10,338	0	−8,689	0	−59	−1,613	−229	−655	−35,022	−2,060
2011	1,022	20,056	4,774	85	0	0	644	0	3,648	30,229	0	−14,172	−3,689	0	−9,306	0	−10	−1,513	−177	−638	−29,506	−723
2012	115	17,308	4,651	59	0	0	720	0	1,813	24,665	0	−11,317	−7,982	0	−7,644	0	−203	−1,498	−166	−622	−29,431	4,766
2013	0	14,694	4,237	23	0	0	745	0	437	20,136	0	−8,415	−13,937	−234	−6,478	0	−17	−1,483	−212	−539	−31,316	11,180
2014	809	18,636	3,467	−9	0	0	720	0	1,489	25,112	0	−6,185	−19,272	0	−5,952	−9	0	−1,358	−257	−534	−33,567	8,446
2015	0	13,543	2,760	−36	0	0	721	0	801	17,790	−2	−4,451	−18,043	−80	−5,322	0	0	−1,048	−177	−401	−29,524	11,734

Table 2-7a
Groundwater Recharge and Discharge in the Semi-Perched Aquifer

Calendar Year[a]	Groundwater Recharge (AF)										Groundwater Discharge (AF)											Storage Change (AF)
	Stream Leakage (Santa Clara River in Oxnard Forebay)	*Recharge*	*Subsurface Inflow from PVB*	*Unincorporated Areas*	*Subsurface Inflow from West LPVB*	*Subsurface Inflow from the UAS*	*Sum of Coastal Flux from Arnold Road to Point Mugu*	*Coastal flux from Channel Islands Harbor to Arnold Road*	*Stream Leakage Calleguas Creek*	*Total Inflow*	*Pumping*	*Tile Drains*	*Subsurface Outflow to UAS*	*Groundwater Discharge to Streams (Santa Clara River in Oxnard Forebay)*	*Evapotranspiration*	*Unincorporated Areas*	*Subsurface Outflow to West LPVB*	*Coastal Flux North to Channel Islands Harbor*	*Coastal flux from Channel Islands Harbor to Arnold Rd*	*Subsurface Outflow to Mound Basin*	*Total Outflow*	*Change in Groundwater Storage[b]*
Maximum	4,382	32,461	4,791	152	811	5,986	843	21	6,209	51,052	0	**−2,856**	0	0	**−5,008**	0	0	**−773**	0	**−362**	**−23,735**	11,734
Minimum	0	13,543	1,074	**−36**	0	0	542	0	437	17,790	**−141**	**−20,912**	**−23,955**	**−585**	**−12,445**	**−107**	**−626**	**−2,128**	**−324**	**−1,247**	**−37,418**	**−19,001**
Average	770	22,989	3,372	47	45	357	663	1	3,394	31,639	**−31**	**−10,531**	**−10,600**	**−109**	**−8,291**	**−13**	**−141**	**−1,582**	**−201**	**−676**	**−32,175**	535

Notes: AF = acre-feet; LPVB = Las Posas Valley Basin; PVB = Pleasant Valley Basin; UAS = Upper Aquifer System.

a Results from these tables are in calendar years, and will not exactly match data in Table 2−5 and Sections 2.3.2 and 2.3.6, which are presented in water years.

b A negative number indicates that water entered storage.

Table 2-7b
Groundwater Recharge and Discharge in the Upper Aquifer System

Calendar Year[a]	Groundwater Recharge (AF)													Groundwater Discharge (AF)														Storage Change (AF)
	Stream Leakage (Santa Clara River in Oxnard Forebay)	*Volcanic Outcrops*	*Recharge*	*Subsurface Inflow from PVB*	*Unincorporated Areas*	*Subsurface Inflow from the Semi-Perched Aquifer*	*Subsurface Inflow from Santa Paula Basin*	*Subsurface Inflow from West LPVB*	*Coastal Flux north to Channel Islands Horbor*	*Coastal flux from Channel Islands Harbor to Arnold Rd*	*Sum of Coastal Flux from Arnold Rd to Point Mugu*	*Subsurface Inflow from the Mound Basin*	*Total Inflow*	*Pumping*	*Tile Drains*	*Subsurface Outflow to the Semi-Perched Aquifer*	*Subsurface Outflow to LAS*	*Subsurface Outflow to West LPVB*	*Groundwater Discharge to Streams (Santa Clara River in Oxnard Forebay)*	*Evapotranspiration*	*Unincorporated Areas*	*Subsurface Outflow to the Santa Paula Basin*	*Subsurface Outflow to PVB*	*Coastal Flux north to Channel Islands Harbor*	*Coastal flux from Channel Islands Harbor to Arnold Rd*	*Subsurface Outflow to Mound Basin*	*Total Outflow*	*Change in Groundwater Storage[b]*
1985	737	5	36,262	0	430	15,889	0	963	742	1,415	2,408	3,014	61,865	−71,157	−356	0	−21,581	0	0	0	0	−1,020	−1,551	0	0	0	−95,665	33,800
1986	6,880	17	63,061	0	0	13,989	0	0	1,254	1,454	2,316	2,227	91,198	−64,234	0	0	−20,735	−2,629	0	0	−52	−968	−613	0	0	0	−89,230	−1,968
1987	1,271	8	35,362	0	431	18,182	0	0	3,076	2,312	3,128	4,181	67,951	−67,347	0	0	−23,240	−137	0	0	0	−744	−15	0	0	0	−91,483	23,532
1988	9,147	8	42,938	142	136	17,824	2,145	0	3,434	2,458	3,150	1,233	82,614	−63,663	0	0	−24,847	−2,053	0	0	0	0	0	0	0	0	−90,563	7,949
1989	530	2	19,007	588	412	19,673	0	0	5,376	2,977	3,402	3,046	55,012	−61,443	0	0	−26,103	−778	0	0	0	−524	0	0	0	0	−88,848	33,835
1990	1,095	2	11,112	1,153	397	22,805	544	0	7,476	3,914	4,095	2,259	54,853	−57,820	0	0	−30,731	−109	0	0	0	0	0	0	0	0	−88,661	33,807
1991	10,696	15	42,247	956	0	23,955	2,244	0	7,221	3,974	4,092	463	95,863	−49,646	0	0	−27,671	−2,705	0	0	−9	0	0	0	0	0	−80,031	−15,832
1992	16,092	22	104,442	0	0	19,636	3,089	0	4,412	2,769	3,084	0	153,544	−45,853	0	0	−24,091	−7,151	0	0	−592	0	−73	0	0	−4,193	−81,953	−71,591
1993	13,448	19	97,426	0	0	8,873	2,372	0	287	1,145	2,051	0	125,620	−47,504	0	0	−25,390	−8,460	0	0	−194	0	−2,107	0	0	−5,603	−89,259	−36,360
1994	2,931	6	52,967	0	394	6,674	837	0	221	857	1,768	0	66,656	−49,868	0	0	−24,598	−4,155	0	0	0	0	−1,808	0	0	−422	−80,853	14,197
1995	8,600	25	102,350	0	0	0	1,039	0	0	133	1,212	0	113,359	−39,520	−292	−2,351	−24,364	−7,649	0	−127	−384	0	−1,346	−1,750	0	−4,568	−82,352	−31,008
1996	2,598	15	56,775	0	128	1,148	310	0	0	0	960	0	61,935	−35,068	−734	0	−22,583	−4,454	0	−119	0	0	−1,375	−2,233	−202	−401	−67,168	5,233

Table 2-7b
Groundwater Recharge and Discharge in the Upper Aquifer System

Calendar Year[a]	Groundwater Recharge (AF)													Groundwater Discharge (AF)														Storage Change (AF)
	Stream Leakage (Santa Clara River in Oxnard Forebay)	*Volcanic Outcrops*	*Recharge*	*Subsurface Inflow from PVB*	*Unincorporated Areas*	*Subsurface Inflow from the Semi-Perched Aquifer*	*Subsurface Inflow from Santa Paula Basin*	*Subsurface Inflow from West LPVB*	*Coastal Flux north to Channel Islands Horbor*	*Coastal flux from Channel Islands Harbor to Arnold Rd*	*Sum of Coastal Flux from Arnold Rd to Point Mugu*	*Subsurface Inflow from the Mound Basin*	*Total Inflow*	*Pumping*	*Tile Drains*	*Subsurface Outflow to the Semi-Perched Aquifer*	*Subsurface Outflow to LAS*	*Subsurface Outflow to West LPVB*	*Groundwater Discharge to Streams (Santa Clara River in Oxnard Forebay)*	*Evapotranspiration*	*Unincorporated Areas*	*Subsurface Outflow to the Santa Paula Basin*	*Subsurface Outflow to PVB*	*Coastal Flux north to Channel Islands Harbor*	*Coastal flux from Channel Islands Harbor to Arnold Rd*	*Subsurface Outflow to Mound Basin*	*Total Outflow*	*Change in Groundwater Storage[b]*
1997	2,300	14	54,861	0	221	6,733	0	0	0	181	1,231	1,123	66,666	−52,122	−532	0	−23,393	−3,560	0	−30	0	−387	−407	−1,139	0	0	−81,568	14,902
1998	0	26	122,199	0	0	0	0	0	0	0	509	0	122,734	−43,078	−967	−5,986	−21,766	−8,501	−663	−420	−625	−4,282	−67	−2,733	−589	−1,247	−90,925	−31,809
1999	0	5	37,762	0	529	3,958	0	0	0	0	639	1,413	44,305	−48,269	−1,180	0	−18,830	−1,847	−2,309	−131	0	−1,162	−106	−2,688	−590	0	−77,113	32,807
2000	3,677	9	54,044	1,084	0	8,528	0	0	0	90	1,047	749	69,228	−45,561	−454	0	−20,784	−2,743	0	0	−38	−500	0	−852	0	0	−70,931	1,704
2001	3,944	19	77,935	1,233	0	3,472	0	0	0	9	949	0	87,561	−42,551	−457	0	−20,746	−4,589	0	0	−69	−1,091	0	−1,447	0	−2,070	−73,019	−14,543
2002	3,129	7	22,151	1,150	432	10,775	1,237	0	0	427	1,191	861	41,360	−44,571	−191	0	−21,202	−1,420	0	0	0	0	0	−319	0	0	−67,703	26,344
2003	7,334	10	36,230	1,803	120	9,433	3,016	0	156	476	1,098	0	59,677	−47,327	0	0	−18,335	−2,591	0	0	0	0	0	0	0	−342	−68,596	8,919
2004	9,742	15	25,471	2,485	149	13,653	3,421	0	1,766	1,170	1,513	86	59,471	−46,670	0	0	−19,410	−2,397	0	0	0	0	0	0	0	0	−68,477	9,006
2005	8,009	18	121,368	1,757	0	625	0	0	0	219	937	0	132,932	−41,034	−222	0	−23,873	−10,233	0	−86	−615	−1,174	0	−1,101	0	−5,909	−84,247	−48,685
2006	0	10	82,755	1,283	72	0	0	0	0	0	665	0	84,785	−42,858	−1,041	−2,744	−22,640	−6,474	−1,416	−244	0	−3,135	0	−2,273	−301	−3,285	−86,411	1,626
2007	1,031	3	31,445	2,419	404	9,238	0	0	0	107	901	828	46,376	−54,564	−430	0	−18,531	−1,122	0	0	0	−683	0	−786	0	0	−76,116	29,740
2008	6,446	11	58,687	3,135	0	9,365	0	0	71	537	1,138	0	79,389	−51,775	−5	0	−21,473	−4,242	0	0	−52	−25	0	0	0	−405	−77,978	−1,412
2009	7,141	7	24,406	3,515	283	10,893	2,661	0	960	815	1,174	259	52,114	−51,431	0	0	−18,696	−1,734	0	0	0	0	0	0	0	0	−71,861	19,748
2010	12,155	20	48,796	3,938	32	10,338	3,016	0	834	785	1,134	0	81,048	−44,145	0	0	−17,864	−3,033	0	0	0	0	0	0	0	−1,365	−66,407	−14,641
2011	5,847	8	73,711	3,049	0	3,689	0	0	0	301	930	0	87,535	−41,608	0	0	−20,530	−6,136	0	0	−216	−244	0	−758	0	−2,941	−72,434	−15,101
2012	2,878	4	22,461	3,162	348	7,982	1,122	0	0	401	1,067	905	40,330	−43,460	0	0	−19,728	−2,338	0	0	0	0	0	−278	0	0	−65,803	25,472
2013	0	0	4,132	3,767	342	13,937	0	0	2,121	1,383	1,803	2,546	30,032	−44,900	0	0	−20,628	−1,388	0	0	0	−27	0	0	0	0	−66,943	36,911
2014	6,504	6	4,860	4,552	229	19,272	2,448	0	4,573	2,641	2,793	2,205	50,084	−43,012	0	0	−24,557	−1,603	0	0	0	0	0	0	0	0	−69,172	19,089
2015	506	1	3,843	4,639	186	18,043	357	0	5,641	3,037	2,955	2,145	41,354	−42,177	0	0	−21,886	−1,304	0	0	0	0	0	0	0	0	−65,367	24,013
Maximum	16,092	26	122,199	4,639	529	23,955	3,421	963	7,476	3,974	4,095	4,181	153,544	**−35,068**	0	0	**−17,864**	0	0	0	0	0	0	0	0	0	**−65,367**	36,911
Minimum	0	0	3,843	0	0	0	0	0	0	0	509	0	30,032	**−71,157**	**−1,180**	**−5,986**	**−30,731**	**−10,233**	**−2,309**	**−420**	**−625**	**−4,282**	**−2,107**	**−2,733**	**−590**	**−5,909**	**−95,665**	**−71,591**
Average	4,989	11	50,680	1,478	183	10,600	963	31	1,601	1,161	1,785	953	74,434	**−49,169**	**−221**	**−357**	**−22,284**	**−3,469**	**−142**	**−37**	**−92**	**−515**	**−305**	**−592**	**−54**	**−1,056**	**−78,295**	3,861

Notes: AF = acre-feet; LAS = Lower Aquifer System; LPVB = Las Posas Valley Basin; PVB = Pleasant Valley Basin.

a Results from these tables are in calendar years, and will not exactly match data in Table 2-5 and Sections 2.3.2 and 2.3.6, which are presented in water years.

b A negative number indicates that water entered storage.

Table 2-7c
Groundwater Recharge and Discharge in the Lower Aquifer System

Calendar Year[a]	Groundwater Recharge (AF)										Groundwater Discharge (AF)					Storage Change (AF)
	Subsurface Inflow from PVB	*Subsurface Inflow from the UAS*	*Unincorporated Areas*	*Subsurface Inflow from Santa Paula Basin*	*Subsurface Inflow from West LPVB*	*Coastal Flux north to Channel Islands Harbor*	*Coastal flux from Channel Islands Harbor to Arnold Road*	*Sum of Coastal Flux from Arnold Road to Point Mugu*	*Subsurface Inflow from the Mound Basin*	*Total Inflow*	*Pumping*	*Subsurface Outflow to West LPVB*	*Subsurface Outflow to Santa Paula Basin*	*Subsurface Outflow to PVB*	*Total Outflow*	*Change in Groundwater Storage[b]*
1985	0	21,581	81	0	292	2,954	1,763	1,016	2,014	29,702	−34,579	0	−123	−100	−34,802	5,100
1986	285	20,735	162	0	0	2,900	1,689	899	2,482	29,151	−28,475	−292	−162	0	−28,929	−223
1987	1,146	23,240	71	0	1,091	4,005	2,176	1,185	2,687	35,601	−38,471	0	−1	0	−38,473	2,872
1988	710	24,847	109	0	470	4,187	2,203	1,183	2,272	35,981	−37,023	0	−53	0	−37,076	1,094
1989	43	26,103	77	6	1,569	4,989	2,386	1,210	3,279	39,663	−44,754	0	0	0	−44,754	5,091
1990	1,027	30,731	93	130	1,838	6,233	2,890	1,450	3,174	47,566	−51,926	0	0	0	−51,926	4,359
1991	0	27,671	132	133	911	5,865	2,811	1,392	2,356	41,272	−37,084	0	0	−491	−37,575	−3,698
1992	0	24,091	223	120	0	4,288	2,198	1,070	1,033	33,023	−23,641	−1,474	0	−1,073	−26,188	−6,835
1993	0	25,390	217	63	0	2,764	1,733	964	1,829	32,960	−25,392	−2,170	0	−1,205	−28,767	−4,192
1994	0	24,598	121	48	0	2,964	1,763	952	1,937	32,383	−32,806	−719	0	−263	−33,789	1,406
1995	0	24,364	161	57	0	2,126	1,476	848	2,150	31,184	−24,584	−1,393	0	−235	−26,212	−4,972
1996	0	22,583	125	16	0	1,763	1,351	772	2,031	28,642	−27,440	−866	0	−117	−28,423	−220
1997	167	23,393	118	0	0	2,273	1,604	885	2,679	31,120	−32,248	−557	−28	0	−32,832	1,712
1998	109	21,766	194	0	0	1,114	1,130	656	3,186	28,156	−21,883	−2,093	−13	0	−23,989	−4,167
1999	116	18,830	89	0	0	977	1,132	742	1,285	23,171	−26,844	−834	−77	0	−27,755	4,584
2000	546	20,784	90	0	0	1,814	1,392	886	1,856	27,368	−27,819	−450	−27	0	−28,295	927
2001	1,030	20,746	118	0	0	1,784	1,388	882	1,361	27,310	−23,661	−620	−2	0	−24,282	−3,028
2002	913	21,202	63	14	470	2,483	1,631	875	1,961	29,612	−33,324	0	0	0	−33,324	3,712
2003	210	18,335	61	59	36	2,124	1,444	814	1,906	24,989	−24,017	0	0	0	−24,017	−972
2004	353	19,410	59	39	529	3,060	1,796	888	1,917	28,052	−30,513	0	0	0	−30,513	2,461
2005	819	23,873	211	0	0	1,959	1,426	733	2,961	31,983	−25,225	−1,799	−9	0	−27,033	−4,950
2006	1,430	22,640	120	0	0	1,436	1,284	696	2,672	30,278	−28,316	−999	−83	0	−29,398	−880
2007	1,266	18,531	57	0	0	1,565	1,299	705	2,349	25,772	−27,854	−55	−108	0	−28,016	2,244
2008	1,608	21,473	133	0	195	2,139	1,482	751	2,862	30,643	−30,891	0	−41	0	−30,933	290
2009	1,657	18,696	67	8	772	2,338	1,538	715	2,727	28,519	−30,458	0	0	0	−30,458	1,940
2010	1,162	17,864	103	126	0	2,171	1,402	660	2,719	26,208	−23,680	−136	0	0	−23,816	−2,393
2011	1,618	20,530	143	21	0	1,785	1,359	699	2,725	28,881	−26,984	−1,115	0	0	−28,099	−782
2012	1,431	19,728	71	9	463	2,032	1,405	666	2,864	28,670	−31,169	0	0	0	−31,169	2,500
2013	1,499	20,628	56	0	1,061	3,111	1,853	857	2,921	31,986	−39,159	0	−1	0	−39,160	7,175
2014	1,346	24,557	63	109	1,681	4,593	2,441	1,060	3,150	39,000	−39,905	0	0	0	−39,905	905
2015	1,420	21,886	86	113	1,264	4,690	2,343	1,038	2,838	35,679	−38,635	0	0	0	−38,635	2,956
Maximum	1,657	30,731	223	133	1,838	6,233	2,890	1,450	3,279	47,566	**−21,883**	0	0	0	**−23,816**	7,175
Minimum	0	17,864	56	0	0	977	1,130	656	1,033	23,171	**−51,926**	**−2,170**	**−162**	**−1,205**	**−51,926**	**−6,835**
Average	707	22,284	112	35	408	2,854	1,735	908	2,393	31,436	**−31,250**	**−502**	**−24**	**−112**	**−31,888**	452

Notes: AF = acre-feet; LPVB = Las Posas Valley Basin; PVB = Pleasant Valley Basin; UAS = Upper Aquifer System.
[a] Results from these tables are in calendar years, and will not exactly match data in Table 2-5 and Sections 2.3.2 and 2.3.6, which are presented in water years.
[b] A negative number indicates that water entered storage.

Table 2-8
UWCD Diversions and Usage of Santa Clara River Water (AF)

Calendar Year	Freeman Diversion	Recharge in Oxnard Forebay Spreading Grounds	PTP Supply Line Deliveries (To Oxnard Subbasin Only)	PVP Supply Line Deliveries to Oxnard Subbasin and Pleasant Valley Basin[a]
1985	42,802	33,837	0	8,738
1986	69,805	59,810	35	9,851
1987	37,638	32,825	2,492	4,560
1988	49,128	40,571	3,709	6,922
1989	24,123	16,920	6,653	5,702
1990	9,553	8,892	9,762	319
1991	44,646	39,289	7,827	1,674
1992	118,151	101,421	7,622	9,320
1993	117,937	94,241	8,462	15,294
1994	71,238	50,588	9,005	12,336
1995	121,235	98,952	8,616	14,014
1996	70,280	54,047	9,513	9,356
1997	71,115	52,006	9,631	11,375
1998	142,279	118,672	7,681	16,064
1999	56,401	35,816	9,017	12,856
2000	71,868	51,793	9,155	11,682
2001	97,061	75,176	6,223	15,635
2002	31,144	20,209	8,632	6,055
2003	47,630	34,111	7,464	6,311
2004	34,160	23,166	8,389	5,245
2005	138,246	118,629	6,470	13,047
2006	101,592	80,554	8,125	12,495
2007	46,430	29,703	8,806	9,908
2008	71,933	56,433	9,639	11,333
2009	40,872	22,438	9,180	14,589
2010	64,005	46,228	7,177	11,555
2011	92,119	71,959	8,700	12,672
2012	37,036	20,816	8,129	10,182
2013	8,941	2,686	8,691	3,230
2014	4,501	2,900	6,644	199
2015	2,607	2,516	5,476	0
Maximum	142,279	118,672	9,762	16,064
Minimum	2,607	2,516	0	0
Average	62,467	48,297	7,320	9,114

Note:
[a] For water supplied by the UWCD PVP to PVCWD, 56% is used in the Oxnard Subbasin and 44% in the Pleasant Valley Basin; only the 56% used in the Oxnard Subbasin is shown in this table.

Table 2-9
United Water Conservation District Water (AF)

Calendar Year	Recharge to Saticoy	Recharge to Noble	Recharge to El Rio	Total Recharge
1985	19,909	0	13,928	33,837
1986	43,407	0	16,403	59,810
1987	16,152	0	16,673	32,825
1988	21,496	0	19,075	40,571
1989	9,729	0	7,192	16,920
1990	3,308	0	5,584	8,892
1991	23,306	0	15,982	39,289
1992	55,606	0	45,815	101,421
1993	45,064	0	49,177	94,241
1994	17,982	0	32,606	50,588
1995	35,419	10,657	52,876	98,952
1996	25,608	3,806	24,633	54,047
1997	22,323	4,412	25,271	52,006
1998	56,935	18,710	43,027	118,672
1999	16,539	1,285	17,992	35,816
2000	28,620	0	23,173	51,793
2001	26,918	8,824	39,434	75,176
2002	5,291	32	14,886	20,209
2003	7,158	44	26,909	34,111
2004	8,105	0	15,061	23,166
2005	46,872	19,490	52,267	118,629
2006	29,005	10,709	40,840	80,554
2007	11,404	99	18,200	29,703
2008	28,631	8,562	19,240	56,433
2009	9,215	0	13,223	22,438
2010	15,108	995	30,125	46,228
2011	23,435	10,679	37,845	71,959
2012	3,985	538	16,293	20,816
2013	34	263	2,389	2,686
2014	387	578	1,935	2,900
2015	1,231	0	1,285	2,516
Maximum	56,935	19,490	52,876	118,672
Minimum	34	0	1,285	2,516
Average	21,232	3,216	23,850	48,297

Table 2-10
Summary of Water Deliveries

Calendar Year	PVCWD (AF)[a]			United Water Conservation District (AF)											Total UWCD and PVCWD Water Deliveries in Oxnard Subbasin (AF)
				PTP (Oxnard Subbasin Only)					*O-H Supply Line (Oxnard Subbasin Only)*			*PVP (Oxnard Subbasin and Pleasant Valley Basin)*[c]			
	Conejo Creek Flows Delivered by CWD for Agriculture[b]	*Pumped Groundwater from Oxnard Subbasin Basin*	*Total PVCWD Water Delivered*	*PTP Wells 1–5 (LAS)*	*Saticoy Wells (UAS)*	*Total PTP Groundwater Pumpage*	*Total PTP Surface Water*	*Total PTP Water*	*Municipal Deliveries*	*Agriculture Deliveries*	*Total O-H Water*	*Diversions of Santa Clara River Water Used in the Oxnard Subbasin for Agriculture*	*Recharged Spreading Water Pumped and Used in the Oxnard Subbasin for Agriculture (Saticoy Wells)*[d]	*Total PVP Water*	
1985	0	−170	−170	0	0	0	0	0	13,901	0	13,901	4,893	0	4,893	18,624
1986	0	−282	−282	0	0	0	35	35	14,096	0	14,096	5,517	0	5,517	19,366
1987	0	−231	−231	2,321	0	2,321	171	2,492	15,364	0	15,364	2,554	0	2,554	20,179
1988	0	387	387	2,184	0	2,184	1,525	3,709	15,513	0	15,513	3,876	0	3,876	23,486
1989	0	121	121	5,301	0	5,301	1,352	6,653	14,494	0	14,494	3,193	0	3,193	24,462
1990	0	273	273	9,506	0	9,506	256	9,762	14,757	0	14,757	179	0	179	24,971
1991	0	708	708	5,042	0	5,042	2,785	7,827	12,644	0	12,644	938	0	938	22,117
1992	0	−604	−604	989	0	989	6,633	7,622	12,669	0	12,669	5,219	0	5,219	24,906
1993	0	−197	−197	825	0	825	7,637	8,462	14,977	0	14,977	8,565	0	8,565	31,807
1994	0	−369	−369	1,564	0	1,564	7,441	9,005	13,092	0	13,092	6,908	0	6,908	28,635
1995	0	−308	−308	1,128	0	1,128	7,488	8,616	8,664	0	8,664	7,848	0	7,848	24,820
1996	0	−1,007	−1,007	3,264	0	3,264	6,249	9,513	6,881	0	6,881	5,239	0	5,239	20,627
1997	0	−425	−425	2,389	0	2,389	7,242	9,631	17,776	0	17,776	6,370	0	6,370	33,351
1998	0	107	107	511	0	511	7,170	7,681	16,784	0	16,784	8,996	0	8,996	33,567
1999	0	−119	−119	2,142	0	2,142	6,875	9,017	17,671	0	17,671	7,200	0	7,200	33,769
2000	0	−376	−376	1,341	0	1,341	7,814	9,155	14,043	79	14,122	6,542	0	6,542	29,442
2001	0	−484	−484	423	0	423	5,800	6,223	13,337	0	13,337	8,756	0	8,756	27,832
2002	1,468	−145	1,323	4,120	0	4,120	4,512	8,632	14,132	786	14,918	3,391	0	3,391	28,264
2003	3,364	−298	3,066	758	0	758	6,706	7,464	16,759	0	16,759	3,534	0	3,534	30,823
2004	2,995	−767	2,228	2,682	0	2,682	5,276	7,958	11,644	431	12,075	2,937	0	2,937	25,197
2005	3,115	−1,051	2,064	59	0	59	6,411	6,470	9,796	0	9,796	7,307	0	7,307	25,636
2006	3,607	2	3,609	105	0	105	8,020	8,125	9,906	0	9,906	6,997	0	6,997	28,637
2007	3,382	−41	3,342	898	696	1,594	7,211	8,806	22,763	0	22,763	5,245	303	5,548	40,459
2008	2,718	−213	2,505	2,936	1,452	4,388	5,251	9,639	17,304	51	17,356	5,534	813	6,347	35,846
2009	2,239	−218	2,021	2,995	685	3,680	5,500	9,180	18,160	68	18,228	7,179	990	8,170	37,598
2010	2,733	77	2,810	512	382	894	6,283	7,177	15,709	19	15,727	6,260	211	6,471	32,185
2011	3,598	164	3,762	817	254	1,071	7,629	8,700	10,747	0	10,747	6,826	271	7,096	30,305
2012	2,415	−5	2,410	929	1,031	1,960	6,169	8,129	14,210	0	14,210	5,389	313	5,702	30,451
2013	1,822	101	1,923	4,647	349	4,996	2,696	7,692	12,854	998	13,852	1,737	72	1,809	25,276

Table 2-10
Summary of Water Deliveries

Calendar Year	PVCWD (AF)[a]			United Water Conservation District (AF)											Total UWCD and PVCWD Water Deliveries in Oxnard Subbasin (AF)
				PTP (Oxnard Subbasin Only)					O-H Supply Line (Oxnard Subbasin Only)			PVP (Oxnard Subbasin and Pleasant Valley Basin)[c]			
	Conejo Creek Flows Delivered by CWD for Agriculture[b]	*Pumped Groundwater from Oxnard Subbasin Basin*	*Total PVCWD Water Delivered*	*PTP Wells 1–5 (LAS)*	*Saticoy Wells (UAS)*	*Total PTP Groundwater Pumpage*	*Total PTP Surface Water*	*Total PTP Water*	*Municipal Deliveries*	*Agriculture Deliveries*	*Total O-H Water*	*Diversions of Santa Clara River Water Used in the Oxnard Subbasin for Agriculture*	*Recharged Spreading Water Pumped and Used in the Oxnard Subbasin for Agriculture (Saticoy Wells)*[d]	*Total PVP Water*	
2014	1,151	−287	864	7,027	0	7,027	22	7,049	10,773	0	10,773	112	0	112	18,798
2015	1,319	−876	443	5,476	0	5,476	0	5,476	10,920	0	10,920	0	0	0	16,839
Maximum	3,607	708	3,762	9,506	1,452	9,506	8,020	9,762	22,763	998	22,763	16,064	990	8,996	40,459
Minimum	0	−1,051	−1,007	0	0	0	0	0	6,881	0	6,881	0	0	0	16,839
Average	1,159	−211	948	2,351	156	2,508	4,779	7,287	13,947	78	14,025	9,113	96	5,104	27,364

Notes: AF = acre-feet; CWD = Camrosa Water District; LAS = Lower Aquifer System; O-H = Oxnard–Hueneme; PTP = Pumping Trough Pipeline; PVCWD = Pleasant Valley County Water District; PVP = Pleasant Valley Pipeline; UAS = Upper Aquifer System; UWCD = United Water Conservation District.

[a] Negative value indicates groundwater pumped in the Oxnard Subbasin and used in Pleasant Valley.

[b] For water supplied by Camrosa Water District to PVCWD, 56% is used in the Oxnard Subbasin and 44% in the Pleasant Valley Basin; only the 56% used in the Oxnard Subbasin is shown in this table.

[c] For water supplied via the UWCD PVP to PVCWD, 56% is used in the Oxnard Subbasin and 44% in the PVB; only the 56% used in the Oxnard Subbasin is shown in this table.

[d] UWCD extracts limited amounts of temporarily stored water from shallow wells at its Saticoy Spreading Grounds to the PVP during periods of mounding, as authorized by FCGMA Resolution 2011-02.

Table 2-11
Recharge by Type (AF)

Calendar Year	UWCD Spreading	Precipitation	Pumped Groundwater	Applied water (M&I and Domestic)	PTP/PVP System	Total Recharge
1985	33,837	4,937	18,562	753	1,254	59,343
1986	59,810	14,048	16,017	747	1,399	92,021
1987	32,825	7,149	17,878	744	1,353	59,949
1988	40,579	6,096	16,719	771	1,934	66,100
1989	16,920	2,130	17,158	869	2,542	39,620
1990	8,904	1,502	16,449	939	2,051	29,844
1991	39,289	11,869	14,044	745	2,510	68,455
1992	101,421	15,752	11,886	863	3,336	133,258
1993	94,241	15,461	11,778	784	4,230	126,494
1994	50,588	6,173	12,936	853	4,003	74,553
1995	98,952	19,121	10,501	874	4,075	133,525
1996	54,047	12,566	10,908	635	3,771	81,928
1997	52,261	10,592	13,396	725	3,995	80,970
1998	118,672	21,656	9,555	755	4,022	154,660
1999	35,816	4,927	11,928	846	4,114	57,631
2000	51,793	8,733	11,216	1,113	3,906	76,762
2001	75,176	15,715	10,105	1,079	3,748	105,823
2002	20,209	5,728	11,440	1,116	3,137	41,630
2003	34,111	8,670	9,949	1,003	3,343	57,076
2004	23,166	10,322	10,642	1,342	3,658	49,129
2005	118,629	14,794	8,733	1,292	4,053	147,501
2006	80,554	8,575	9,855	1,239	4,564	104,786
2007	29,703	2,704	11,588	779	4,072	48,846
2008	56,433	7,548	10,761	1,036	4,689	80,468
2009	22,438	6,057	10,135	932	4,690	44,252
2010	46,228	16,086	8,695	954	3,899	75,861
2011	71,959	6,759	9,425	1,079	4,544	93,767
2012	20,816	3,695	10,640	975	3,643	39,768
2013	2,686	735	11,663	1,044	2,698	18,825
2014	2,900	6,182	11,404	1,011	1,999	23,496
2015	2,516	1,064	11,278	857	1,671	17,386
Maximum	118,672	21,656	18,562	1,342	4,690	154,660
Minimum	2,516	735	8,695	635	1,254	17,386
Average	48,306[a]	8,947	12,169	928	3,319	73,669

Notes: AF = acre-feet; M&I = municipal and industrial; PTP = Pumping Trough Pipeline; PVP = Pleasant Valley Pipeline; UWCD = United Water Conservation District.

[a] The difference between 48,306 AFY in this table and 48,279 AFY in Table 2-9 is caused by how UWCD tracks monthly spreading. The UWCD hydrologist entered a negative number in some of the monthly records to reconcile their percolation total. So for the following 3 months, Table 2-7 has:

- August 1988 recharge to Saticoy is −8 acre-feet.
- April 1990 recharge to Saticoy is −11.34 acre-feet.
- September 1997 recharge to Saticoy is −255.06 acre-feet.

Table 2-12
Stream Flows in Arroyo Las Posas and Conejo Creek, and Conejo Creek Diversion and Deliveries to the Pleasant Valley County Water District (AF)

Calendar Year	Arroyo Las Posas Flows Measured at Stream Gauge 806 until 1997 and 806A to 2005	Conejo Creek Flows Measured at Stream Gauge 800 until 2011 and 800A to 2012	Conejo Creek Water Delivered by CWD for Agriculture (AF)[a]	Conejo Creek Flows Delivered by CWD for Agriculture In PVCWD[b]	Conejo Creek Flows Delivered by CWD for M&I	Total CWD Conejo Creek Flows Diversions
1985	1,174	14,265	2,450	0	0	2,450
1986	11,707	25,621	2,450	0	0	2,450
1987	3,487	16,851	2,450	0	0	2,450
1988	3,256	16,922	2,450	0	0	2,450
1989	840	14,785	2,450	0	0	2,450
1990	1,068	12,608	2,450	0	0	2,450
1991	9,715	20,227	2,450	0	0	2,450
1992	26,792	44,305	2,450	0	0	2,450
1993	27,749	52,306	2,450	0	0	2,450
1994	2,956	16,195	2,450	0	0	2,450
1995	26,984	45,909	2,450	0	0	2,450
1996	9,919	22,862	2,450	0	0	2,450
1997	10,742	22,905	2,450	0	0	2,450
1998	47,361	49,704	2,450	0	0	2,450
1999	923	16,479	2,450	0	0	2,450
2000	4,884	18,000	2,450	0	0	2,450
2001	18,819	28,092	2,450	0	0	2,450
2002	3,003	16,744	2,450	2,621	0	5,071
2003	12,973	21,592	1,249	6,008	256	7,513
2004	13,757	23,522	1,345	5,348	276	6,969
2005	54,549	46,396	1,639	5,562	336	7,537
2006	NA	23,175	1,457	6,441	298	8,196

Table 2-12
Stream Flows in Arroyo Las Posas and Conejo Creek, and Conejo Creek Diversion and Deliveries to the Pleasant Valley County Water District (AF)

Calendar Year	Arroyo Las Posas Flows Measured at Stream Gauge 806 until 1997 and 806A to 2005	Conejo Creek Flows Measured at Stream Gauge 800 until 2011 and 800A to 2012	Conejo Creek Water Delivered by CWD for Agriculture (AF)[a]	Conejo Creek Flows Delivered by CWD for Agriculture In PVCWD[b]	Conejo Creek Flows Delivered by CWD for M&I	Total CWD Conejo Creek Flows Diversions
2007	NA	17,048	3,288	6,040	674	10,002
2008	NA	25,254	2,895	4,854	358	8,107
2009	NA	19,099	3,225	3,998	673	7,896
2010	NA	20,293	2,554	4,880	594	8,028
2011	NA	17,518	2,359	6,425	533	9,317
2012	NA	7,612	2,603	4,312	653	7,568
2013	NA	NA	2,999	3,253	754	7,006
2014	NA	NA	2,858	2,055	854	5,767
2015	NA	NA	2,555	2,355	794	5,704
Maximum	54,549	52,306	3,288	6,441	854	10,002
Minimum	840	7,612	1,249	0	0	2,450
Average	13,936	24,153	2,423	2,069	227	4,720

Notes: AF = acre-feet; CWD = Camrosa Water District; M&I = municipal and industrial; NA = not applicable; PVCWD = Pleasant Valley County Water District.

[a] 2,450 AFY between 1985 and 2002 accounts for riparian water rights holders' use of Conejo Creek water prior to development of CWD's Diversion Facility and non-potable surface water system. Between 2003 and 2006, deliveries are less than previous assumptions as not all riparian customers had connected to the CWD non-potable system. It is fair to assume the difference between those volumes and 2,450 were still applied to land.

[b] For water supplied by CWD to PVCWD, 56% is used in the Oxnard Subbasin and 44% in the PVB.

Table 2-13
Sales and Usage of Imported Water Supplied by the Calleguas Municipal Water District (AF)

Calendar Year	Delivered and Used by the City of Oxnard for M&I	Delivered and Used by Port Hueneme Water Agency for M&I	Total Imported Water Supplied
1985	14,094	0	14,094
1986	14,023	0	14,023
1987	14,422	0	14,422
1988	14,565	0	14,565
1989	15,026	0	15,026
1990	16,853	0	16,853
1991	12,705	0	12,705
1992	15,576	0	15,576
1993	14,799	0	14,799
1994	11,441	0	11,441
1995	14,513	0	14,513
1996	12,392	64	12,456
1997	13,615	641	14,256
1998	12,675	2,234	14,909
1999	14,721	2,615	17,336
2000	14,487	2,935	17,422
2001	13,201	1,731	14,932
2002	13,591	3,054	16,645
2003	12,858	1,072	13,930
2004	13,742	1,595	15,337
2005	12,447	1,590	14,037
2006	11,994	2,067	14,061
2007	14,008	2,221	16,229
2008	15,150	1,197	16,347
2009	10,431	1,278	11,709
2010	11,238	838	12,076
2011	11,506	1,072	12,578
2012	13,474	1,047	14,521
2013	15,331	2,011	17,342
2014	13,550	1,483	15,033
2015	11,116	556	11,672
Maximum[a]	16,853	3,054	17,422
Minimum[a]	10,431	64	11,441
Average[a]	13,534	1,565	14,543

Notes: AF = acre-feet; M&I = municipal and industrial.
[a] Maximum, minimum, and average values are calculated for the period over which water deliveries occurred.

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Table 2-14
Oxnard Subbasin Groundwater Used

Calendar Year	Agricultural Pumpage (AF)				M&I Pumpage (AF)				Domestic Pumpage (AF)				Totals (AF)			
	Pumpage (UAS)	*Pumpage (LAS)*	*Pumpage (Semi-Perched)*	*Total Agricultural*	*Pumpage (UAS)*	*Pumpage (LAS)*	*Pumpage (Semi-Perched)*	*Total M&I*	*Pumpage (UAS)*	*Pumpage (LAS)*	*Pumpage (Semi-Perched)*	*Total Domestic*	*Pumpage (UAS)*	*Pumpage (LAS)*	*Pumpage (Semi-Perched)*	*Total Pumpage*
1985	42,652	27,990	26	70,669	23,578	5,996	15	29,589	4,926	593	3	5,522	71,157	34,579	44	105,780
1986	36,285	23,167	37	59,489	24,196	5,038	24	29,258	3,752	270	4	4,026	64,234	28,475	65	92,773
1987	39,028	33,285	38	72,350	25,198	5,004	24	30,226	3,122	182	3	3,307	67,347	38,471	65	105,883
1988	34,505	31,938	33	66,476	26,475	4,574	25	31,074	2,683	511	3	3,196	63,663	37,023	61	100,746
1989	34,238	35,435	41	69,713	24,548	8,521	29	33,098	2,657	798	3	3,458	61,443	44,754	73	106,269
1990	34,082	42,137	83	76,302	23,000	9,780	56	32,837	738	8	2	748	57,820	51,926	141	109,887
1991	25,830	30,008	67	55,905	19,682	7,068	51	26,801	4,134	7	11	4,152	49,646	37,084	128	86,858
1992	24,076	20,070	48	44,194	21,286	3,562	43	24,892	491	9	1	501	45,853	23,641	92	69,587
1993	23,621	19,757	35	43,413	23,294	5,626	34	28,954	589	8	1	598	47,504	25,392	70	72,966
1994	26,820	23,981	48	50,849	22,505	8,818	40	31,363	544	7	1	552	49,868	32,806	89	82,764
1995	21,580	17,759	30	39,369	17,335	6,818	24	24,177	605	7	1	613	39,520	24,584	55	64,159
1996	21,642	22,211	17	43,870	12,866	5,221	10	18,096	560	8	0	568	35,068	27,440	27	62,535
1997	25,190	25,725	10	50,925	26,612	6,515	10	33,138	320	8	0	327	52,122	32,248	20	84,390
1998	20,263	15,279	3	35,545	22,611	6,597	3	29,211	204	7	0	211	43,078	21,883	6	64,966
1999	23,082	23,765	5	46,852	24,871	3,073	5	27,949	316	5	0	322	48,269	26,844	10	75,123
2000	21,982	21,027	5	43,014	23,380	6,788	6	30,174	199	4	0	203	45,561	27,819	11	73,390
2001	19,046	17,194	4	36,244	23,292	6,460	5	29,757	212	6	0	219	42,551	23,661	8	66,220
2002	20,837	24,502	0	45,338	23,555	8,819	0	32,374	179	3	0	182	44,571	33,324	0	77,895
2003	17,772	17,645	0	35,417	29,374	6,368	0	35,742	182	4	0	186	47,327	24,017	0	71,345
2004	19,299	21,732	0	41,031	27,091	8,775	0	35,866	280	6	0	286	46,670	30,513	0	77,183
2005	16,464	15,140	0	31,604	24,213	10,080	0	34,292	357	5	0	362	41,034	25,225	0	66,258
2006	18,290	16,268	0	34,558	24,405	12,044	0	36,449	163	4	0	168	42,858	28,316	0	71,174
2007	24,110	20,802	0	44,912	30,289	7,047	0	37,336	165	5	0	170	54,564	27,854	0	82,418
2008	23,618	22,853	0	46,471	27,999	8,034	0	36,033	159	5	0	163	51,775	30,891	0	82,667
2009	20,027	22,784	0	42,811	31,272	7,670	0	38,942	132	5	0	137	51,431	30,458	0	81,890
2010	17,056	16,767	0	33,822	26,963	6,890	0	33,853	126	23	0	150	44,145	23,680	0	67,825
2011	18,648	18,253	0	36,901	22,832	8,725	0	31,558	128	6	0	134	41,608	26,984	0	68,592
2012	20,914	22,376	0	43,290	22,415	8,790	0	31,205	131	3	0	134	43,460	31,169	0	74,629
2013	22,514	29,341	0	51,855	22,202	9,816	0	32,018	184	2	0	186	44,900	39,159	0	84,059
2014	22,536	32,236	0	54,772	20,224	7,667	0	27,891	252	2	0	254	43,012	39,905	0	82,917
2015	23,102	32,870	1	55,973	18,884	5,762	1	24,648	191	3	0	193	42,177	38,635	2	80,814
Maximum	42,652	42,137	83	76,302	31,272	12,044	56	38,942	4,926	798	11	5,522	71,157	51,926	141	109,887
Minimum	16,464	15,140	0	31,604	12,866	3,073	0	18,096	126	2	0	134	35,068	21,883	0	62,535
Average	24,487	24,010	17	48,514	23,756	7,160	13	30,929	925	81	1	1,007	49,169	31,250	31	80,450

Notes: AF = acre-feet; LAS = Lower Aquifer System; M&I = municipal and industrial; UAS = Upper Aquifer System.
Pumping amounts are from the UWCD model and usage type is from the FCGMA well database.

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Table 2-15
Modeled 2040–2069 Groundwater Extraction Rates and Surface Water Deliveries for the Oxnard Subbasin

Model Scenario	Upper Aquifer System Groundwater Extractions (AFY)	Lower Aquifer System Groundwater Extractions (AFY)	Total Groundwater Extractions (AFY)
Future Baseline	39,000	29,000	68,000
Future Baseline With Projects	41,000	25,000	66,000
Reduction With Projects	27,000	13,000	40,000
Reduction Without Projects Scenario 1	27,000	12,000	39,000
Reduction Without Projects Scenario 2	18,000	12,000	30,000
Reduction Without Projects Scenario 3	18,000	12,000	30,000

Notes: AFY = acre-feet per year.

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Figure 2-1 Oxnard Subbasin Vicinity Map

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Figure 2-2 Geology of the Oxnard Subbasin

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Figure 2-3 Cross Section A–A′

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Figure 2-4 Cross Section B–B′

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Figure 2-5 Upper Aquifer System 2015 Extraction (acre-feet) in Oxnard and Pleasant Valley

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Figure 2-6 Lower Aquifer System 2015 Extraction (acre-feet) in Oxnard and Pleasant Valley

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Figure 2-7 Groundwater Elevation Contours in the Oxnard Aquifer, March 2–29, 2015

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Figure 2-9a Groundwater Well Hydrographs in the Oxnard Aquifer – Oxnard Plain

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Figure 2-10 Groundwater Elevation Contours in the Mugu Aquifer, March 2–29, 2015

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Figure 2-11 Groundwater Elevation Contours in the Mugu Aquifer, October 2–29, 2015

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Figure 2-12 Groundwater Well Hydrographs in the Mugu Aquifer

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Figure 2-13 Groundwater Elevation Contours in the Hueneme Aquifer, March 2–29, 2015

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Figure 2-14 Groundwater Elevation Contours in the Hueneme Aquifer, October 2–29, 2015

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Figure 2-15 Groundwater Well Hydrographs in the Hueneme Aquifer

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Figure 2-16 Groundwater Elevation Contours in the Fox Canyon Aquifer, March 2–29, 2015

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Figure 2-17 Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2–29, 2015

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Figure 2-18 Groundwater Well Hydrographs in the Fox Canyon Aquifer

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Figure 2-19 Groundwater Elevation Contours in the Grimes Canyon Aquifer, March 2–29, 2015

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Figure 2-21 Groundwater Well Hydrographs in the Grimes Canyon Aquifer

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Figure 2-22 Oxnard Subbasin Annual Change in Storage

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Figure 2-23 Oxnard Subbasin Cumulative Change in Storage

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Figure 2-24 Oxnard Subbasin Annual Change in Storage Without Coastal Flux

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Figure 2-25 Oxnard Subbasin Cumulative Change in Storage Without Coastal Flux

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Figure 2-26 Approximate 2015 North–South Saline Water Intrusion Extent

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Figure 2-29 Mugu Aquifer Coastal Chloride Concentrations, Fall 2015

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Figure 2-41a Upper Aquifer System – Most Recent Nitrate (mg/L as Nitrate) Measured 2011–2015

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Figure 2-42 Lower Aquifer System – Most Recent Nitrate (mg/L as Nitrate) Measured 2011–2015

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Figure 2-43a Upper Aquifer System – Most Recent Sulfate (mg/L) Measured 2011–2015

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Figure 2-43b Upper Aquifer System, Forebay Area – Most Recent Sulfate (mg/L) Measured 2011–2015

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Figure 2-44 Lower Aquifer System – Most Recent Sulfate (mg/L) Measured 2011–2015

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Figure 2-45a Upper Aquifer System – Most Recent Boron (mg/L) Measured 2011–2015

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Figure 2-45b Upper Aquifer System, Forebay Area – Most Recent Boron (mg/L) Measured 2011–2015

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SUSTAINABLE MANAGEMENT CRITERIA

3.1 INTRODUCTION TO SUSTAINABLE MANAGEMENT CRITERIA

In the Oxnard Subbasin, significant and unreasonable seawater intrusion is the primary undesirable result that occurs when groundwater production exceeds the sustainable yield. This undesirable result can occur even if groundwater production from the Subbasin as a whole is less than the freshwater recharge to the Subbasin, as seawater intrusion is closely related to groundwater production from coastal wells. Infrastructure projects and management actions undertaken in the Oxnard Subbasin have at times limited and even reversed the progress of seawater intrusion (see Section 2.3.3, Seawater Intrusion). However, groundwater elevations declined in all aquifers in the Subbasin in response to the statewide drought that began in 2011. These groundwater elevation declines exacerbated the impacts of seawater intrusion in the Subbasin.

On October 28, 2015, after several consecutive years of drought, the Fox Canyon Groundwater Management Agency (FCGMA) Board of Directors (Board) adopted planning goals for the Oxnard Subbasin, as well as the other basins within its jurisdiction. These goals are as follows:

- Control saline water impact front at its current position.
- Do not allow groundwater quality to further degrade without mitigation.
- No net subsidence due to groundwater withdrawal.
- Promote water levels that mitigate or minimize undesirable results (including pumping trough depressions, surface water connectivity, and chronic lowering of water levels).

These goals guide the definition of undesirable results, minimum thresholds, and measurable objectives in the subsequent sections.

Groundwater elevations are the primary metrics by which progress toward meeting the sustainability goal in the Oxnard Subbasin will be measured. Sustainable management of the Oxnard Subbasin does not necessarily mean, however, that springtime high groundwater levels in the Subbasin remain the same year after year. Rather, sustainability can be achieved over cycles of drought and recovery, so long as the impacts to the Subbasin that may occur during periods of drawdown are not significant or unreasonable. Thus, year over year, groundwater levels may decline during a drought, but sustainable management will result in groundwater levels—and, by extension, chloride concentrations and land surface elevations—returning to pre-drought levels in the wet years after a drought.

3.2 SUSTAINABILITY GOAL

The primary sustainability goal in the Oxnard Subbasin is to increase groundwater elevations inland of the Pacific coast in the aquifers that compose the Upper Aquifer System (UAS) and the Lower Aquifer System (LAS) to elevations that will prevent the long-term, or climatic cycle net (net), landward migration of the 2015 saline water impact front (see Section 3.3.3); prevent net seawater intrusion in the UAS; and prevent net seawater intrusion in the LAS.

The use of net landward migration, and net seawater intrusion in the sustainability goal reflects that climatic cycles influence groundwater elevations over multi-year periods and requires that assessment of seawater impacts to the Subbasin be tied to a time period over which net impacts are measured. This Groundwater Sustainability Plan (GSP) assesses net impacts to the Oxnard Subbasin over both a 50-year period beginning in 2020, and a 30-year period beginning in 2040. Undesirable results may occur in the Subbasin between 2020 and 2039, as progress is made toward sustainable management. By 2040, however, management of the Subbasin should achieve the sustainability goal. The 30-year period from 2040 through 2069 is referred to as the sustaining period in this GSP, as it is the period on which the evaluation of sustainability is based.

In order to achieve the sustainability goal, groundwater production will need to be reduced relative to historical groundwater production rates. At the same time, groundwater production inland from the coast may be allowed to increase as infrastructure is developed to convey inland production to agricultural users on the coast. During the first 5 years following GSP adoption, it is anticipated that the combined groundwater production from both the UAS and the LAS will begin to be reduced toward the estimated sustainable yield, accounting for the uncertainty assessed in the model water budget and sustainable yield predictions (Section 2.4, Water Budget).

Proposed reductions in groundwater production must take into account ~~both~~ the potential economic disruption to the agricultural industry in the Subbasin, the interference with municipal water supply planning and rate setting, and the uncertainty in the estimated sustainable yield of the Subbasin. The estimated sustainable yield of the Subbasin is 42,000 acre-feet per year (AFY) with an uncertainty estimate of ±9,000 AFY (see Section 2.4.4, General Uncertainties in the Water Budget). The average 2015 groundwater production rate was 69,000 AFY. The difference between the upper estimate of the sustainable yield, 51,000 AFY, and the 2015 production rate is 18,000 AFY. If production is reduced linearly between 2020 and 2040, the estimated groundwater production reduction necessary throughout the geographic extent of the Oxnard Subbasin ~~over the first 5 years~~ is approximately ~~4,500~~900 AFY. However, the sustainability goal allows for operational flexibility, as groundwater production patterns are anticipated to change during the 20-year GSP implementation period from 2020 through 2039. Progress toward the sustainability goal will be evaluated throughout the 20-year implementation period.

The following sections describe the undesirable results that have occurred and may occur within the Subbasin, the minimum thresholds developed to avoid undesirable results, and the measurable objectives that account for the need to continue groundwater production during drought cycles and the associated interim milestones to help gauge progress toward sustainability over the next 20 years.

3.3 UNDESIRABLE RESULTS

Under the Sustainable Groundwater Management Act (SGMA), undesirable results occur when the effects caused by groundwater conditions occurring throughout the Subbasin cause significant and unreasonable impacts to any of the six sustainability indicators. These sustainability indicators are as follows:

- Chronic lowering of groundwater levels
- Reduction of groundwater storage
- Seawater intrusion
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water

The definition of what constitutes a significant and unreasonable impact for each sustainability indicator is determined by the Groundwater Sustainability Agency, which is FCGMA in the Oxnard Subbasin, using the processes and criteria set forth in the GSP. Each of the sustainability indicators is discussed in this section in the context of undesirable results.

3.3.1 Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels resulting in a significant and unreasonable depletion of supply is an undesirable result applicable to the Oxnard Subbasin. Seawater intrusion occurs in the Subbasin as groundwater levels fall below threshold elevations that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater elevations differ between the aquifers of the UAS and the LAS, as well as with geographic location in the Subbasin. Groundwater elevation declines can also induce release of connate water brines, reduce the quantity of freshwater in storage, and cause land subsidence in the Subbasin.

The primary cause of groundwater conditions in the Subbasin that would lead to chronic lowering of groundwater levels is groundwater production in excess of natural and artificial recharge. Groundwater production from the Subbasin may result in significant and unreasonable lowering of groundwater levels if the groundwater levels were lowered to an elevation at which they allow net seawater intrusion in the UAS and LAS over climate cycles of drought and recovery. Historically, this condition has occurred within the Oxnard Subbasin.

In the past, groundwater levels in the UAS have declined during periods of drought and recovered during wet periods (Section 2.3.1, Groundwater Elevation Data). In fact, flowing artesian conditions were observed in UAS wells after multiple-year periods of above-average precipitation (UWCD 2016; Appendix C, UWCD Model Report, to this GSP). Groundwater levels in the LAS have also declined during drought and risen during wet periods, although the water levels in many wells in the LAS have remained below sea level since the 1980s (Section 2.3.1). One factor that contributed to the recovery of water levels following periods of drought was the amount of surface water that was diverted from the Santa Clara River and infiltrated through spreading basins to recharge the aquifers. Surface-water flows are available during wetter-than-average precipitation periods. These surface-water diversions and spreading are controlled by the United Water Conservation District (UWCD), which anticipates maintaining the historical volume of water diverted from the Santa Clara River over the next 50 years (UWCD 2018).

In addition to surface-water spreading, seawater intrusion into the aquifers of the Oxnard Subbasin has also sustained groundwater levels. Unlike surface-water spreading, seawater intrusion sustains groundwater levels at the expense of freshwater storage in the Subbasin (Section 2.3.3). Water levels in the aquifers of the LAS have remained below sea level even during drought recovery periods, thereby continuing to allow migration of seawater into the Subbasin near the Mugu and Hueneme Submarine Canyons (Section 2.3, Groundwater Conditions). Continued seawater intrusion has reduced the amount of freshwater in storage in the Subbasin.

Based on the sustainability goals for the Oxnard Subbasin, the criterion used to define undesirable results for chronic lowering of groundwater levels is landward migration of the 2015 saline water impact front during the sustaining period from 2040 through 2069. It is expected that there will be some landward migration of this front between 2020 and 2040 as the FCGMA Board and stakeholders in the Subbasin undertake the necessary projects and management actions toward achieving sustainability in 2040. The minimum thresholds metric against which chronic lowering of groundwater levels will be measured is groundwater levels that were selected to prevent net landward migration of the 2015 saline water impact front, and net seawater intrusion over the 30-year sustaining period from 2040 through 2069. These groundwater elevations are higher than previous historical low water levels, many of which were measured in the fall of 2015 (Table 3-1; Figures 3-1 through 3-5, Minimum Thresholds and Groundwater Elevation Contours).

In order to effectively manage the groundwater resources of the Oxnard Subbasin, the Subbasin has been divided into five management areas (see Section 2.5, Management Areas; Figure 2-69, Oxnard Subbasin Management Areas). These areas are defined by differences in their hydrogeologic properties, groundwater quality, or historical groundwater elevations. Groundwater elevations within each management area will be used to determine whether significant and unreasonable chronic lowering of groundwater levels is occurring. All of the management areas except the East Oxnard Plain Management Area (EOPMA) have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the water level thresholds set for the wells closest to the EOPMA are presumed to be protective for the EOPMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Chronic lowering of groundwater levels in the Oxnard Subbasin has the potential to impact the beneficial uses and users of groundwater in the Subbasin by (1) exacerbating seawater intrusion in the Subbasin, (2) reducing the volume of freshwater in storage, (3) potentially causing land subsidence, (4) impacting areas of interconnected surface water and groundwater, and (5) causing groundwater levels to drop below current well screens.

3.3.2 Reduction of Groundwater Storage

Significant and unreasonable reduction of groundwater storage is an undesirable result that applies to the Oxnard Subbasin. Seawater intrusion occurs in the Subbasin as groundwater levels fall below threshold levels that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater levels differ between the UAS and the LAS, and differ with geographic location in the Subbasin.

The primary cause of groundwater conditions in the Subbasin that would lead to reduction in groundwater storage is groundwater production in excess of recharge over a cycle of drought and recovery. Groundwater production from the Subbasin may result in a significant and unreasonable reduction of groundwater in storage if the volume of water produced from the Subbasin exceeds the volume of freshwater recharging the Subbasin over cycles of drought and recovery. Changes in groundwater in storage can be tracked using groundwater elevations and would become significant and unreasonable if groundwater levels were lowered to an elevation below which they allow landward migration of the 2015 saline water impact front over cycles of drought and recovery, which would cause a long-term decline in groundwater storage.

Numerical groundwater model simulations indicate that there has been approximately 101,000 acre-feet (AF) of storage loss in the Oxnard Subbasin over the 31 years from 1985 to 2015 (Section 2.3.2, Estimated Change in Storage; Appendix C). The model results also indicate that between 1985 and 2015, approximately 380,000 AF of seawater intruded into the UAS and LAS under the Oxnard Subbasin. The replacement of freshwater with seawater is a reduction in freshwater storage and is an undesirable result that has already occurred within the Subbasin.

Based on the sustainability goals for the Oxnard Subbasin, the criterion used to define undesirable results for reduction in groundwater storage is landward migration of the 2015 saline water impact front after 2040. The minimum thresholds metric against which reduction of groundwater storage will be measured is water levels that were selected to prevent net landward migration of the 2015 saline water impact front, and net seawater intrusion after 2040. These groundwater elevations are higher than previous historical low water levels (Table 3-1).

Groundwater elevations within each management area of the Oxnard Subbasin will be used to determine whether significant and unreasonable reduction of groundwater in storage is occurring. All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the water level thresholds set for the wells closest to the EOPMA are presumed to be protective for the EOPMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Reduction of groundwater storage in the Oxnard Subbasin has the potential to impact the beneficial uses and users of groundwater in the Subbasin by limiting the volume of groundwater available for agricultural, municipal, industrial, domestic, and environmental. These impacts will affect all users of groundwater in the Subbasin.

3.3.3 Seawater Intrusion

Significant and unreasonable seawater intrusion is an undesirable result that is present or likely to occur in the Oxnard Subbasin. Seawater intrusion is the primary sustainability indicator in the Oxnard Subbasin. Seawater intrusion occurs in the Subbasin as groundwater levels fall below threshold levels that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater levels differ between the UAS and the LAS, and differ with geographic location in the Subbasin.

The primary cause of groundwater conditions in the Subbasin that would lead to seawater intrusion is groundwater production. Currently, the area of the Subbasin impacted by concentrations of chloride greater than 500 milligrams per liter (mg/L) is generally west of Highway 1 and south of Hueneme Road. Sources of water high in chloride in the Oxnard Subbasin include modern seawater as well as non-marine brines and connate water in fine-grained sediments (see Section 2.3.3). Therefore, this area is referred to as the “saline water impact area,” rather than the “seawater intrusion impact area,” to reflect all the potential sources of chloride to the aquifers in this area. The saline water impact area was already impacted before 2015, when SGMA was implemented. As a result, the goal of this GSP is not to reverse historical impacts, but rather to limit seawater intrusion to the area that has already been impacted. Therefore, significant and unreasonable seawater intrusion is defined as seawater intrusion that results in a net landward migration of the 2015 saline water impact front beyond the already impacted area west of Highway 1 and south of Hueneme Road from 2040 through 2069.

Chloride concentrations in the Oxnard Subbasin indicate that seawater intrusion has occurred historically, and is currently occurring, in the vicinity of Point Hueneme and Point Mugu. However, seawater is not the only source of chloride to the groundwater of the Oxnard Subbasin (Section 2.3.3, Groundwater Conditions, and Section 2.3.4, Groundwater Quality). Chloride concentrations exceeding 500 mg/L have been measured in the southeastern part of the Subbasin, where there is no direct connection between the inland freshwater aquifer and the Pacific Ocean. Stable isotope studies of the groundwater in these wells have shown that the chloride concentrations are likely not a result of seawater intrusion, but rather originated from release of connate water in the fine-grained lagoonal deposits in the Oxnard and Mugu Aquifers (Izbicki 1996). The connate water is released as groundwater head in the aquifer declines and the fine-grained deposits compress. Additionally, chloride concentrations in the UAS are also impacted by downward migration of brackish water from the semi-perched aquifer via improperly abandoned wells (Izbicki 1996). In the LAS, chloride concentrations above 500 mg/L result from seawater intrusion, as well as from upward migration of brines from the geologic formations that underlie and surround the Subbasin (Izbicki 1991).

The minimum thresholds metric against which seawater intrusion will be measured is water levels that were selected to prevent lateral seawater intrusion. These groundwater elevations are equal to, or higher than, previous historical low water levels (Table 3-1). Some of the minimum threshold groundwater elevations in the LAS are below sea level. These elevations were selected based on model results that indicate groundwater elevations could be this low and still limit seawater intrusion. They were also selected in concert with groundwater elevations in adjacent management areas, and are not expected to negatively impact the ability of the adjacent management areas to meet their sustainability goals.

The groundwater elevations selected in each of the management areas of the Oxnard Subbasin will be used to determine whether seawater intrusion is occurring in the Saline Intrusion Management Area and the West Oxnard Plain Management Area (WOPMA) of the Subbasin (Figure 2-69). Until a monitoring well is installed in the EOPMA, the water level thresholds set for the wells closest to the EOPMA in the WOPMA and the Oxnard Pumping Depression Management Area are presumed to be protective for the EOPMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Seawater intrusion in the Oxnard Subbasin has the potential to impact the beneficial uses and users of groundwater in the Subbasin by limiting the volume of non-brackish groundwater available for agricultural, municipal, industrial, and domestic use. These impacts will affect all users of groundwater in the Subbasin and continued seawater intrusion could result in changing land use as agricultural land is fallowed due to reduced groundwater supplies.

3.3.4 Degraded Water Quality

3.3.4.1 Chloride and TDS

Significant and unreasonable degraded water quality related to groundwater production is an undesirable result that has the potential to occur in the Oxnard Subbasin. Increases in chloride and total dissolved solids (TDS) have been observed in coastal areas of the Oxnard Subbasin including parts of the WOPMA and the Saline Intrusion Management Area. These increases are associated with seawater intrusion as well as connate water in fine-grained lenses, downward migration of brines from improperly abandoned wells, and upward migration of brines from deeper geologic formations (Izbicki 1991, 1996; UWCD 2016).

Degradation of groundwater quality from increased concentrations of chloride and TDS has the potential to impact the beneficial uses and users of groundwater in the Subbasin by (1) limiting the volume of groundwater available for agricultural, municipal, industrial, and domestic use or (2) requiring construction of treatment facilities to remove the constituents of concern.

The primary cause of groundwater conditions in the Subbasin that would lead to degradation of water quality from increased concentrations of TDS and chloride is groundwater production. If groundwater production from the Subbasin results in expansion of areas of the Subbasin impacted by chloride and TDS concentrations that limit agricultural and potable use, significant and unreasonable degradation of water quality may occur.

Based on the sustainability goals for the Oxnard Subbasin, the criterion used to define undesirable results for degraded water quality is the migration of the 2015 saline water impact front during the sustaining period from 2040 through 2069. The minimum thresholds metric against which degradation of water quality will be measured is groundwater levels that were selected to prevent net landward migration of the 2015 saline water impact front. The minimum thresholds metric against which seawater intrusion will be measured is groundwater levels that were selected to prevent net landward seawater migration. These groundwater elevations are equal to, or higher than, previous historical low water levels (Table 3-1).

Water quality will continue to be monitored at monitoring well locations identified by FCGMA and its partner agencies, as identified in Chapter 4, Monitoring Networks. As additional data are collected, the effectiveness of applying a water level proxy to groundwater quality degradation will continue to be assessed.

3.3.4.2 Nitrate

In the Oxnard Forebay area of the Oxnard Subbasin, nitrate concentrations above the water quality objectives (WQOs) and basin management objectives (BMOs) are routinely detected in groundwater (UWCD 2008). These concentrations have resulted in significant and unreasonable impacts to beneficial uses and users of the Oxnard Subbasin, as not all municipal users of groundwater in this area have the ability to blend groundwater with nitrate exceeding the federal maximum contaminant level (MCL) with other water to sufficiently reduce the nitrate concentration for municipal use. Although nitrate concentrations in the Forebay have impacted municipal users of groundwater, the concentrations of nitrate in the Forebay are not caused by groundwater conditions occurring throughout the Subbasin. Rather, nitrate concentrations above WQOs and BMOs in the Forebay are likely a legacy of historical septic discharges and ~~historical~~ agricultural fertilizer application practices.[1]

Although nitrate concentrations decrease when water levels are high, the decreases are not a result of regional groundwater production patterns. Instead, the reduction in nitrate concentration results from dilution of nitrate in groundwater by lower nitrate concentration surface-water recharge from the Santa Clara River. Operationally, in years when surface-water diversions are lower than the overall demand, UWCD prioritizes surface-water recharge in areas where nitrate concentrations in the groundwater exceed the MCL over deliveries to areas with lower concentrations of nitrate in the groundwater. UWCD currently anticipates maintaining and potentially increasing surface-water recharge from the Santa Clara River in the future. Increases in surface-water recharge, combined with the cessation of septic discharges and modern agronomic fertilization practices, are anticipated to result in long-term declines in nitrate concentration in the Forebay.

Because nitrate concentrations are not impacted by local or regional groundwater production, and the currently impacted area is not anticipated to get larger in the future, the concentration of nitrate is not considered to be a SGMA sustainability indicator in the Subbasin. Because nitrate impacts are not a sustainability indicator, no minimum threshold concentration for nitrate is proposed at this time. Nitrate concentrations will continue to be monitored and the relationship between groundwater production and nitrate concentrations will be reevaluated during the 5-year evaluation.

3.3.5 Land Subsidence

The undesirable result associated with land subsidence in the Oxnard Subbasin is subsidence that substantially interferes with surface land uses. The FCGMA Board resolution discussed in Section 3.1, Introduction to Sustainable Management Criteria, calls for groundwater management that will not result in net subsidence due to groundwater withdrawal. Subsidence related to groundwater withdrawal can occur as groundwater elevations decline below previous historical low water levels, because the groundwater acts to reduce the effective stress, or pressure, on the sediments in the aquifers. As water levels decline, the pressure on the sediment matrix increases, and the pore structure of the sediment can collapse, resulting in subsidence. The minimum thresholds metric

[1] Ventura County extended sewer lines into this area in the years between 2000 and 2011 to address additional discharges of nitrate.

against which subsidence will be measured is water levels that were selected to prevent lateral seawater intrusion. These groundwater elevations are equal to, or higher than, previous historical low water levels, which will limit the potential for future land subsidence in the Subbasin resulting from groundwater withdrawal (Table 3-1).

Groundwater production is only one cause of subsidence in the Oxnard Subbasin. In addition to groundwater production, tectonic forces and oil and gas production can also result in subsidence in the Oxnard Subbasin (Section 2.3.5, Subsidence). Currently there are no monitoring stations that separate the effects of groundwater withdrawal from those of the other causes of subsidence.

Groundwater production from the Subbasin may result in significant and unreasonable land subsidence if the subsidence "substantially interferes with surface land uses" (California Water Code, Section 10721(x)(5)). Using this definition, historical records of land subsidence in the Subbasin do not indicate that land subsidence as a result of groundwater production has caused or is likely to cause undesirable results. Parts of the Oxnard Plain have experienced 2 to 3 feet of subsidence in the past, and future projections of subsidence indicate that areas within the Oxnard Plain may experience an additional 0.1 to 1 feet of subsidence by 2040 (Hanson et al. 2003; DWR 2014).

Land subsidence related to groundwater production has the potential to impact the beneficial uses and users of groundwater in the Oxnard Subbasin by interfering with surface land uses in a way that causes additional costs for releveling fields, replacing surface infrastructure, and otherwise interfering with surface land uses. Additional subsidence of 0.1 to 1 feet is not anticipated to substantially interfere with surface land uses in the Subbasin.

Even though substantial interference with land surface uses is not anticipated, actions to reduce groundwater production to a rate that avoids net seawater intrusion will mitigate future seawater intrusion as well as reducing the potential for additional subsidence in the Subbasin related to groundwater production.

3.3.6 Depletions of Interconnected Surface Water

The undesirable result associated with depletion of interconnected surface water in the Oxnard Subbasin is loss of groundwater-dependent ecosystem (GDE) habitat.

The primary cause of groundwater conditions in the Subbasin that would lead to depletion of interconnected surface water is groundwater production from the semi-perched aquifer. This unit is not currently considered a principal aquifer of the Oxnard Subbasin (Section ~~2.2.4~~2.2.3, Principal Aquifers and Aquitards). Groundwater production from the semi-perched aquifer may result in depletion of interconnected surface water with significant and unreasonable adverse effects on beneficial uses of surface water if the groundwater levels were lowered to an elevation below which the vegetation in the existing GDEs could not access groundwater over a length of time that negatively affected the health of the GDE. Historically, this condition has not occurred within the Oxnard Subbasin, because there has been very minor (<31 AFY) groundwater production from the semi-perched aquifer (Section 2.4.1.2, Imported Water Supplies).

Depletion of interconnected surface water in the Oxnard Subbasin is not currently occurring, as evidenced by lack of production, relatively stable groundwater elevations, and the need for tile drains in the semi-perched aquifer. Groundwater elevations will continue to be monitored in the semi-perched aquifer.

Depletion of interconnected surface water in the Oxnard Subbasin has the potential to impact the uses and users of groundwater in the Subbasin by lowering the groundwater table and negatively impacting the health of GDEs. If future projects involve the use of water from the semi-perched aquifer, depletion of interconnected surface water is possible, and significant and unreasonable impacts may occur. Reevaluation of the effects on existing and potential GDEs should be conducted in conjunction with the project approval process for any such future projects.

3.3.7 Defining Subbasin-Wide Undesirable Results

In order to better manage groundwater production and projects within the Oxnard Subbasin, the Subbasin has been divided into four management areas (Section 2.5, Management Areas). Groundwater production in each of the management areas occurs in both the UAS and LAS (Table 2-14, Oxnard Subbasin Groundwater Used). Although there are groundwater production wells screened in both the UAS and the LAS in the Oxnard Subbasin, there are a sufficient number of wells screened only in one of the two aquifer systems to be able to manage groundwater production in the Subbasin by aquifer system. In contrast, there are few production wells screened only within an individual aquifer in the Subbasin. Therefore, the discussion of Subbasin-wide undesirable results that follows has been separated by aquifer system, but not by individual aquifer.

Upper Aquifer System

Fifteen wells were selected as key wells in the UAS (Table 3-1).[2] Of these, three are in the Forebay Management Area, three are in the West Oxnard Plain Management Area, and nine are in the Saline Intrusion Management Area. None of the UAS key wells are located in the Oxnard Pumping Depression Management Area.

Undesirable results are defined in three ways for the UAS in the Oxnard Subbasin. The first is based on the total number of wells, independent of management area or aquifer. Under this definition, the

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2 Well 02N21W07L05 is screened in multiple aquifers, and has been assigned to the UAS for the purpose of defining undesirable results.

UAS will be determined to be experiencing undesirable results if, in any single monitoring event, water levels in six of the 15 key wells are below their respective minimum thresholds.

The second definition of undesirable results for the UAS is based on the degree to which a single well exceeds a minimum threshold. Under this definition, the UAS would be determined to be experiencing an undesirable result if the groundwater elevation at any individual key well is below the historical low water level for that well.

The third definition of undesirable results for the UAS is based on the time over which a well may exceed the minimum threshold. Under this definition, the UAS would be determined to be experiencing an undesirable result if the water level in any individual key well was below the minimum threshold for either three consecutive monitoring events or three of five consecutive monitoring events. Monitoring events are scheduled to occur in the spring and fall of each year.

If conditions in the UAS meet any of the definitions of undesirable results listed above, the UAS would be considered to be experiencing undesirable results.

Lower Aquifer System

Nineteen wells were selected as key wells in the LAS (Table 3-1).[3] Of these, six are in the Forebay Management Area, five are in the West Oxnard Plain Management Area, six are in the Saline Intrusion Management Area, and two are in the Oxnard Pumping Depression Management Area.

Undesirable results are defined in three ways for the LAS in the Oxnard Subbasin. The first is based on the total number of wells, independent of management area or aquifer. Under this definition, the LAS will be determined to be experiencing undesirable results if, in any single monitoring event, water levels in 8 of the 19 key wells are below their respective minimum thresholds.

The second definition of undesirable results for the LAS is based on the degree to which a single well exceeds a minimum threshold. Under this definition, the LAS would be determined to be experiencing an undesirable result if the groundwater elevation at any individual key well is below the historical low water level for that well.

The third definition of undesirable results for the LAS is based on the time over which a well may exceed the minimum threshold. Under this definition, the LAS would be determined to be experiencing an undesirable result if the water level in any individual key well were below the minimum threshold for either three consecutive monitoring events or in three of five consecutive monitoring events. Monitoring events are scheduled to occur in the spring and fall of each year.

[3] Wells 02N21W07L03, 01N21W07J02, and 01N21W07L03 are screened in multiple aquifers and have been assigned to the LAS for the purpose of defining undesirable results.

If conditions in the LAS meet any of the definitions of undesirable results listed above, the LAS would be considered to be experiencing undesirable results.

3.4 MINIMUM THRESHOLDS

The following sections and discussion set forth the minimum thresholds for each of the six sustainability indicators. These thresholds discussed below are the proposed minimum groundwater elevations that would prevent undesirable results, defined as net landward migration of the 2015 saline water impact front, net seawater intrusion in the UAS, or net seawater intrusion in the LAS. When groundwater elevations drop below the proposed minimum threshold, the Subbasin may experience undesirable results (Section 3.3.7, Defining Subbasin-Wide Undesirable Results).

The minimum thresholds for chronic lowering of water levels, change in groundwater storage, seawater intrusion, groundwater quality, and land subsidence are based on the historical record of groundwater elevation in individual aquifers, the documented impacts of seawater intrusion, and the hydrogeologic conceptual model developed for the Oxnard Subbasin. All of these undesirable results are interrelated, and each is directly tied to seawater intrusion. Because groundwater elevations, change in storage, and groundwater quality are directly tied to seawater intrusion, the minimum threshold groundwater levels selected to mitigate the effects of seawater intrusion are also used for the other undesirable results as well (Table 3-1).

The minimum threshold groundwater levels selected to prevent seawater intrusion were based on a review of the historical groundwater elevation data and an analysis of the potential for seawater intrusion under multiple future groundwater production scenarios. Predicted groundwater levels were simulated over a 50-year period from 2020 to 2069 (Section 2.4.5, Projected Future Water Budget and Sustainable Yield). The future climate simulated in the model recreated the observed climate from 1930 to 1979, with adjustments to precipitation and streamflow based on climate change factors provided by the California Department of Water Resources (DWR). The historical period from 1930 to 1979 includes periods of drought and periods of above-average precipitation, but has the average precipitation of the entire climate record for the Oxnard Subbasin (Section 2.4.5). The 50-year future simulations were used to assess the rate of groundwater production that results in no net seawater intrusion in either the UAS or the LAS in the Oxnard Subbasin after 2040.

Two simulations were found to minimize net seawater intrusion after 2040 (Figures 2-67a through 2-67e, UWCD Model Particle Tracks for the Reduction With Projects Simulation, and Figures 2-68a through 2-68e, UWCD Model Particle Tracks for the Reduction Without Projects Simulation 1; Section 2.4). Groundwater production in the first simulation, referred to as the Reduction With Projects Scenario (Section 2.4.5.3), averaged approximately 40,000 AFY, with 27,000 AFY of production in the UAS, and 13,000 AFY in the LAS. This simulation incorporated projects, including temporary fallowing of approximately 500 AFY in the Oxnard Subbasin, and deliveries of approximately 4,000 AFY of recycled water from the City of Oxnard's Groundwater Recovery Enhancement and Treatment (GREAT) pProgram for irrigation in the coastal area. Groundwater production in the second simulation, referred to as the Reduction Without Projects Scenario 1 (Section 2.4.5.4), averaged approximately 39,000 AFY, with 27,000 AFY of production in the UAS, and 12,000 AFY in the LAS (Section 2.4.5). In general, the simulated groundwater elevations in the model scenario with projects were close to those in the scenario without projects, with any observed difference between the two limited to less than approximately 10 feet (Figures 3-6 through 3-11, Key Well Hydrographs).

The minimum threshold groundwater elevations selected to protect against net seawater intrusion in the UAS and LAS are based on the lowest simulated groundwater elevation after 2040 for the two model simulations in which net seawater intrusion was minimized. To account for some of the uncertainty in the simulated future groundwater elevations, the lowest simulated value in either of the two simulations was used as a starting point for selecting the minimum thresholds. The lowest simulated value was then rounded down to the nearest 5-foot interval to further account for uncertainty in the future simulated groundwater elevations. The rounded groundwater elevation was then raised by 2 feet to account for predicted sea level rise by 2070. The minimum thresholds for each well are presented in Table 3-1 and Figures 3-6 through 3-11.

There are no proposed minimum thresholds in the EOPMA because there are no suitable monitoring wells in the EOPMA (Figure 2-69). The thresholds for the Saline Intrusion Management Area and Oxnard Pumping Depression Management Area, both of which border the EOPMA, are presumed to protect the EOPMA, which has considerably less groundwater production than the adjoining management areas (see Section 2.5). This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

It is important to remember that there are several sources of uncertainty in the model predictions. These sources of uncertainty include, but are not limited to, the prediction of future climate, future diversions from the Santa Clara River, groundwater model assumptions and assigned values, and future groundwater production distribution in the Subbasin. The uncertainty in each of these factors is anticipated to decrease with time. As these factors are better understood, the minimum thresholds should be reassessed, and adjustments should be made, when warranted by the assessment.

3.4.1 Chronic Lowering of Groundwater Levels

The selected minimum thresholds for chronic lowering of groundwater levels are presented in Table 3-1. These minimum thresholds are water levels that were selected based on future groundwater model simulations that limit migration of the 2015 saline water impact front after 2040, limit net seawater intrusion into the UAS and LAS, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall.

These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by limiting seawater intrusion and chronic lowering of groundwater levels. This allows for long-term use of groundwater supplies in the Subbasin without ongoing loss of storage that would cause economic harm to the users of groundwater in the Subbasin and impair the beneficial uses of groundwater in the Subbasin.

These minimum thresholds may impact groundwater users in the Subbasin by requiring both an overall reduction in groundwater production relative to historical levels, and potentially by requiring a redistribution of groundwater pumping within the Subbasin. A redistribution of groundwater production to shift groundwater production inland may require inland users to deepen existing wells, or replace wells, and may require adjustment of the currently proposed minimum thresholds in the future. Furthermore, the minimum threshold groundwater elevations may result in a return to artesian conditions in wells screened in the UAS and LAS adjacent to the coast. In these areas, improperly abandoned wells can act as conduits for flow from the aquifer systems to land surface. Additional efforts may need to be undertaken by FCGMA and stakeholders in the Subbasin to prevent negative impacts from rising water levels and improperly abandoned wells.

The minimum thresholds for chronic lowering of groundwater levels are water levels that will be measured at the monitoring wells listed in Table 3-1. Groundwater levels in these wells, which are referred to as “key wells,” will be reported to DWR in the annual reports that will follow the submittal of this GSP. Additionally, as funding becomes available, it is recommended that each of these monitoring wells be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.2 Reduction of Groundwater Storage

The minimum thresholds for reduction in groundwater storage are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the Subbasin, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall (Table 3-1). The minimum thresholds impacts to groundwater users for reduction of groundwater storage are the same as those for chronic lowering of groundwater levels. These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by allowing for long-term use of groundwater supplies in the Subbasin without replacing freshwater in the UAS and LAS with seawater. Such a replacement would lead to a loss of storage that would cause economic harm to the users of groundwater in the Subbasin and impair the beneficial uses of groundwater in the Subbasin.

The minimum thresholds for reduction of groundwater storage are water levels that will be measured at the key wells two times per year. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.3 Seawater Intrusion

Because the concentration of chloride is ~~a poor~~not necessarily the best indicator of modern seawater intrusion, the relationship between seawater intrusion and groundwater elevation was investigated using a numerical groundwater model (Appendix C). Groundwater levels in the Oxnard and Mugu Aquifers in coastal areas have historically fallen below sea level in response to increased production and drought cycles since the 1950s (Figure 2-9a, Groundwater Well Hydrographs in the Oxnard Aquifer – Oxnard Plain, and Figure 2-12, Groundwater Well Hydrographs in the Mugu Aquifer). The groundwater levels below sea level resulted in seasonal seawater intrusion during the fall irrigation season and during droughts in coastal wells in the vicinity of Point Hueneme and Point Mugu (Figure 2-35, Selected Historical Records of Water Elevation and Chloride Concentration).

Modeling by UWCD (2018; see Appendix C to this GSP) indicates that there was flux from the ocean into the Oxnard and Mugu Aquifers in the vicinity of the offshore Mugu and Hueneme Submarine Canyons when the coastal groundwater levels in the UAS fell below 5 to 10 feet above mean sea level. In 1990, FCGMA directed pumpers to decrease production in these aquifers to mitigate seawater intrusion. As a result, production in coastal areas shifted from the Oxnard and Mugu Aquifers to the deeper Hueneme Aquifer, the Fox Canyon Aquifer (FCA), and the Grimes Canyon Aquifer (the aquifers that compose the LAS). Water levels in the FCA and the Grimes Canyon Aquifer near the coast quickly fell below sea level and have remained there since the 1980s, even after periods of above-average precipitation (Figure 2-18, Groundwater Well Hydrographs in the Fox Canyon Aquifer, and Figure 2-21, Groundwater Well Hydrographs in the Grimes Canyon Aquifer). The UWCD model indicates continuous flux from the ocean into these aquifers since 1985 (Figure 2-34, Groundwater Flux along the Coast in the Lower Aquifer System).

Because the model indicates a strong relationship between groundwater elevation and seawater intrusion, the minimum thresholds for addressing seawater intrusion are water levels that were selected based on future groundwater model simulations that limited seawater intrusion in the UAS and LAS (Table 3-1). The model simulations suggest that if water levels fall below the minimum threshold elevations, the Subbasin is likely to experience net landward migration of the 2015 saline water impact front after 2040. These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by limiting seawater intrusion. This allows for long-term use of groundwater supplies in the

Subbasin without ongoing loss of storage that would cause economic harm to the users of groundwater in the Subbasin and impair the beneficial uses of groundwater in the Subbasin.

Groundwater users in the Subbasin may be impacted by the minimum thresholds in several ways. First, an overall reduction in groundwater production relative to historical levels will be required to achieve the minimum thresholds. Such a reduction may impact the value of agricultural land, drive changes in crop types, result in temporary fallowing of agricultural acreage, and cause economic disruption to the regional economy. Second, a redistribution of groundwater pumping may be required to optimize water management in the Subbasin. If groundwater production is reduced at the coast and shifted inland, additional infrastructure may be needed to convey water from the inland areas to the coast, inland users may be required to deepen existing wells, and the currently proposed minimum thresholds may need to be lowered for inland areas in the future. Third, as the minimum thresholds are achieved in the coastal areas, additional economic impacts may occur as improperly abandoned wells may need to be properly sealed so they do not act as a conduit for flow from the underlying aquifers.

The minimum thresholds were selected for each aquifer system in the Oxnard Subbasin, primarily using wells screened in a single aquifer. These wells will be used to monitor groundwater elevations in each aquifer system in the Subbasin. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.4 Degraded Water Quality

Water quality impacts to the aquifer systems of the Oxnard Subbasin are limited to high concentrations of nitrate, chloride, and TDS. The sources and mechanisms controlling the concentration of these constituents differs throughout the Subbasin (Section 2.3). Nitrate concentrations in the Forebay exceed the federal MCL in some wells. However, these concentrations cannot be reduced by altering groundwater production in the Subbasin. For these concentrations, the recharge source water should be of the highest quality possible to maintain or improve future groundwater quality (Section 3.3.4, Degraded Water Quality). Although FCGMA cannot control the quality of the recharge water, the groundwater elevations minimum thresholds to prevent net migration of seawater after 2040 are higher than the historical low groundwater elevations at which nitrate concentrations were observed to exceed the federal MCL. These groundwater elevations will be used as the minimum thresholds to prevent further degradation of groundwater quality in the Forebay until such time that a separate concentration minimum threshold is found to be necessary.

In contrast to concentrations of nitrate in the Forebay, the concentration of chloride and TDS in coastal wells is influenced by groundwater production. Concentrations of chloride and TDS exceed federal, state, and local standards in some wells in the Subbasin (Section 2.3). Groundwater production near the coast induces seawater intrusion, and lowered groundwater elevations induce compaction of fine-grained sediments that release connate brines into the aquifers. Because both of these processes are tied to groundwater elevations in the Subbasin, minimum thresholds for groundwater elevation, rather than concentration, were set to control the additional impacts from seawater and brine migration in the aquifers (Section 3.4.3, Seawater Intrusion). The minimum thresholds selected are the same as the water level thresholds selected to prevent net migration of the 2015 saline water impact front after 2040. These groundwater elevations are higher than historical low elevations, which will prevent further compaction of fine-grained sediments and brine release. They are also designed to prevent further degradation of water quality from direct seawater intrusion.

As discussed previously, the minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by increasing the overall amount of freshwater storage in the Subbasin and limiting the further intrusion of seawater. The minimum thresholds impacts to groundwater users for degraded water quality are anticipated to be the same as those for seawater intrusion, which are described in Section 3.4.3.

The minimum thresholds for degraded water quality are water levels that will be measured at the monitoring wells listed in Table 3-1. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.5 Land Subsidence

The minimum thresholds for land subsidence are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the Subbasin, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall (Table 3-1). As groundwater withdrawals will be reduced to avoid further seawater intrusion, groundwater elevations in the aquifer systems will rise, and the resulting minimum thresholds are higher than historical low water levels. Because groundwater elevations must be maintained above the minimum threshold in order to avoid undesirable results for seawater intrusion and loss of freshwater storage, water levels in the Subbasin will remain above historical low water levels after 2040. Therefore, water levels in the Subbasin will not induce inelastic subsidence in the Subbasin. If the distribution of pumping is altered to mitigate seawater intrusion by reducing pumping near the coast and increasing pumping in the Forebay, the potential subsidence risk may have to be revisited in inland areas. This risk evaluation should be tied to areas in which the minimum thresholds are lowered below previous historical low water levels.

As discussed previously, the minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by increasing the overall amount of freshwater storage in the Subbasin and limiting the further intrusion of seawater. These minimum thresholds also will limit future subsidence because currently they are greater than the historical low groundwater elevation. The minimum thresholds impacts to groundwater users for land subsidence are anticipated to be the same as those for seawater intrusion, which are described in Section 3.4.3.

The minimum thresholds for subsidence are water levels that will be measured at the monitoring wells listed in Table 3-1. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.6 Depletions of Interconnected Surface Water

The minimum thresholds for depletions of interconnected surface water are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the Subbasin, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall (Table 3-1). The areas of interconnected surface water and groundwater and associated GDEs described in Section 2.3.6, Groundwater–Surface Water Connections, and Section 2.3.7, Groundwater-Dependent Ecosystems, are connected to the semi-perched aquifer, from which there is little current groundwater production. Because the semi-perched aquifer is not considered a principal aquifer, specific minimum thresholds were not selected for this unit. Instead, results of the numerical groundwater model scenarios that prevent net landward migration of the 2015 saline water impact front after 2040 indicate that groundwater elevations in the semi-perched aquifer will be supported by groundwater elevations in the underlying Oxnard Aquifer. The Oxnard Aquifer is the uppermost aquifer of the UAS. The simulated minimum threshold water levels in the Oxnard Aquifer that prevent net migration of the 2015 saline water impact front after 2040 were found to result in higher water levels in the semi-perched aquifer. Therefore, the minimum thresholds for depletions of interconnected surface water are water levels in the Oxnard Aquifer that also prevent net migration of the 2015 saline water impact front after 2040. The minimum thresholds are equal to or higher than the lowest groundwater elevation measured at these wells. The selected groundwater elevations are anticipated to protect against depletion of interconnected surface water, because historical groundwater elevations in the semi-perched aquifer have maintained the documented and potential GDEs in the Subbasin (Section 2.3). ~~These groundwater elevations will~~

~~not impact the sustainable management of adjacent basins, because the semi-perched aquifer does not extend into either the Las Posas Valley Basin or the Pleasant Valley Basin.~~

As discussed previously, the minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by increasing the overall amount of freshwater storage in the Subbasin and limiting the further intrusion of seawater. The minimum thresholds set will maintain the existing beneficial uses of the semi-perched aquifer by maintaining groundwater elevations equal to or higher than historical lows. The minimum thresholds impacts to groundwater users for interconnected groundwater and surface water are anticipated to be the same as those for seawater intrusion, which are described in Section 3.4.3.

Currently there is very little groundwater production from the semi-perched aquifer. If water levels in this aquifer rise as a result of reduced groundwater production in the underlying UAS, additional projects may investigate producing water from the semi-perched aquifer. Such projects will have to evaluate the potential impact to interconnected surface water and GDEs as part of the feasibility and permitting process. Additionally, if projects that produce groundwater from the semi-perched aquifer are implemented, the need for specific water level minimum thresholds in the semi-perched aquifer should be reevaluated.

The minimum thresholds for interconnected surface water are water levels that will be measured at the monitoring wells listed in Table 3-1. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.5 MEASURABLE OBJECTIVES

The measurable objectives are quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted GSP to achieve the sustainability goal. For the Oxnard Subbasin, the measurable objective is the water level—measured at each of the key wells throughout the Subbasin—at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS. If water levels in the Subbasin remained at the measurable objective in perpetuity, no groundwater would flow from the aquifer systems into the Pacific Ocean, and no ocean water would flow into the aquifer systems. This is the theoretical ideal water level for managing the aquifer systems of the Subbasin, because seawater intrusion would be prevented while maintaining the maximum freshwater use from the aquifer systems. However, because groundwater elevations in the Oxnard Subbasin respond to climatic cycles, actual groundwater levels in the Subbasin cannot be maintained at the measurable objective indefinitely. Therefore, to allow for operational flexibility while still preventing net migration of the 2015 saline water impact front after 2040, the measurable objectives were selected to work with the minimum thresholds in the Oxnard Subbasin.

To allow for operational flexibility during drought periods, water levels in the Subbasin are allowed to fall below the measurable objective, so long as they remain above the minimum threshold. As water levels fall below the measurable objective, seawater will flow toward the freshwater aquifer systems in the Subbasin, even if the water levels remain above the minimum threshold. The longer groundwater elevations remain between the measurable objective and the minimum threshold the greater the volume of seawater that will migrate into the aquifer systems. In order to prevent net seawater intrusion over periods of drought and recovery, the periods during which seawater intrusion occurs must be offset by periods when the groundwater elevations are higher.

There are two components to balancing groundwater levels over climate cycles to prevent net migration of the 2015 saline water impact front after 2040. The first is not allowing groundwater levels to decline below an elevation at which net seawater intrusion will occur. This elevation is the minimum threshold. The second is ensuring that periods during which groundwater levels are above the minimum threshold but below the measurable objective are offset by equal periods during which groundwater levels are above the measurable objective. Therefore, the measurable objectives were selected based on the median groundwater elevation between 2040 and 2070, simulated for each well, in model simulations that prevented net landward migration of the 2015 saline water impact front after 2040.

The median groundwater elevation was rounded down to the nearest 5-foot interval to account for uncertainty in the model simulated future groundwater elevations. In order to account for future sea level rise, the rounded groundwater elevations were increased by 2 feet. The median simulated groundwater elevation (from 2040 to 2070) at each well after rounding and accounting for sea level rise is the measurable objective (Table 3-1). In order to prevent net seawater intrusion in the Subbasin after 2040, observed groundwater levels should be above the measurable objective 50% of the time. Ideally, the periods during which the water levels are above the measurable objectives will coincide with periods of above-average precipitation. If this occurs, additional reductions in groundwater production are not anticipated to be required to offset seawater intrusion. If, however, prolonged periods of drought limit the ability to recharge the groundwater aquifers in the Oxnard Subbasin, additional reductions in groundwater production may be required to offset seawater intrusion.

3.5.1 Chronic Lowering of Groundwater Levels

The measurable objective for the chronic lowering of groundwater levels is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. The measurable objective groundwater level was selected for each of the key wells

(Table 3-2). At each of these wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the Subbasin.

Groundwater elevations within each management area of the Oxnard Subbasin will be used to determine whether chronic lowering of groundwater levels is occurring. All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells in the Saline Intrusion Management Area and Oxnard Pumping Depression Management Area, closest to the EOPMA, are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the WOPMA and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Interim Milestones for Chronic Lowering of Groundwater Levels

Interim milestones, which are target groundwater levels in 2025, 2030, and 2035 at key wells, will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040. The interim milestones for chronic lowering of groundwater levels are the same as the interim milestones for seawater intrusion, because the interim milestones measure progress toward groundwater elevations in the Subbasin that prevent the net migration of the 2015 saline water impact front after 2040.

Two sets of interim milestones were determined for the key wells in the Subbasin (Table 3-2). The first set of interim milestones was calculated using linear interpolation between the fall 2015 low groundwater elevation and measurable objective (Figure 3-12, Interim Milestones for Dry and Average Conditions – Linear Interpolation). The second set was calculated using linear interpolation between the fall 2015 low groundwater elevation and the minimum threshold (Figure 3-12).

Two sets of interim milestones were calculated because the actual groundwater elevation in 2040 will depend both on groundwater production from the Subbasin and the climatic conditions between 2020 and 2040. Groundwater model simulations of future groundwater levels show that groundwater levels throughout the Subbasin vary by tens of feet at constant groundwater production rates over 5-year periods. This variability reflects the variability in annual precipitation, flow in the Santa Clara River, and groundwater recharge through the UWCD spreading grounds. Just as annual climate conditions vary from the calculated long-term historical mean conditions, so do 5-year average climate conditions (Figure 3-13, Distribution of 5-Year Average Climate Conditions in the Historical Record of Precipitation on the Oxnard Plain). Therefore, progress toward the measurable objective, which is the anticipated median groundwater level necessary to prevent net migration of the 2015 saline water impact front after 2040, must be evaluated in the context of the climate that occurred during the preceding 5 water years.

If, for example, the average precipitation from water years 2020 through 2024 (October 1, 2019, through September 30, 2024) equals the long-term historical average precipitation for the Oxnard Subbasin, then, as groundwater production is reduced, the groundwater level at each key well should reach the interim milestone for average climate conditions shown in Table 3-2. Under these conditions, groundwater levels in the Subbasin would be expected to reach the measurable objective by 2040. If, however, the precipitation from water years 2020 through 2024 is less than 70% of the average long-term historical precipitation, as has occurred six times in the historical record (Figure 3-13), reductions in groundwater production anticipated as part of this GSP would not be sufficient for groundwater elevations to reach the interim milestone for average climate conditions. In order for the Subbasin to be sustainable in 2040 under ongoing dry climate conditions, the interim milestones should reflect progress toward the minimum threshold at each key well, rather than progress toward the measurable objective (Figure 3-13). Five-year climate conditions that fall between average and less than 70% of average would be expected to produce interim milestone groundwater elevations between those listed in Table 3-2.

Although specific interim milestones were not selected at each key well for above-average climate conditions, a similar analysis should be performed as part of the 5-year assessment process. For example, if the average precipitation from water years 2020 through 2024 exceeds 140% of the average long-term historical precipitation, as has occurred six times in the historical record (Figure 3-13), groundwater elevations in the fall of 2024 should be higher than the interim milestone groundwater elevation for average conditions listed in Table 3-2. Further, although Table 3-2 provides interim milestone groundwater elevations for the years 2030, 2035, and 2040, these interim milestones should be reassessed as part of the 5-year GSP evaluation process because of their climate dependence. The linear interpolation and resultant interim milestones should be updated based on the measured water level in the fall of 2024, 2029, and 2034 at each key well.

3.5.2 Reduction of Groundwater in Storage

The measurable objective for reduction of groundwater in storage is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the Subbasin.

All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells in the Saline Intrusion Management Area and Oxnard Pumping Depression Management Area, closest to the EOPMA, are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the WOPMA and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Interim Milestones for Reduction of Groundwater in Storage

Interim milestones for reduction of groundwater in storage are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for reduction of groundwater in storage are the same as the interim milestones for seawater intrusion.

3.5.3 Seawater Intrusion

The measurable objective for seawater intrusion is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the Subbasin.

All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Saline Intrusion Management Area and the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the adjoining management areas and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Interim Milestones for Seawater Intrusion

Interim milestones for seawater intrusion are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced.

3.5.4 Degraded Water Quality

The measurable objective for degraded water quality is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the Subbasin.

Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Saline Intrusion Management Area and the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the adjoining management areas and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Interim Milestones for Degraded Water Quality

Interim milestones for degraded water quality are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for degraded water quality are the same as the interim milestones for seawater intrusion.

3.5.5 Land Subsidence

The measurable objective for land subsidence is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). This groundwater level is higher than the historical low water level in each key well. Therefore, it will protect against land subsidence related to groundwater withdrawal. The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the Subbasin.

Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Saline Intrusion Management Area and the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the adjoining management areas and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Interim Milestones for Land Subsidence

Interim milestones for land subsidence are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for land subsidence are the same as the interim milestones for seawater intrusion.

3.5.6 Depletions of Interconnected Surface Water

The measurable objective for depletions of interconnected surface water is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). This groundwater level is higher than the historical low water level in each key well. Therefore, it will protect against depletions of interconnected surface water related to groundwater withdrawal. The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the Subbasin.

Currently there is very little groundwater production from the semi-perched aquifer. If water levels in this aquifer rise as a result of reduced groundwater production in the underlying UAS, additional projects may investigate producing water from the semi-perched aquifer. Such projects will have to evaluate the potential impact to interconnected surface water and GDEs as part of the feasibility and permitting process. Additionally, if projects that produce groundwater from the semi-perched aquifer are implemented, the need for specific water-–level measurable objectives in the semi-perched aquifer should be reevaluated.

Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the Oxnard Pumping Depression Management Area and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Interim Milestones for Depletions of Interconnected Surface Water

Interim milestones for depletions of interconnected surface water are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for interconnected surface water are the same as the interim milestones for seawater intrusion.

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Table 3-1
Minimum Threshold Groundwater Elevations by Well, Management Area, and Aquifer for Key Wells in the Oxnard Subbasin

State Well Number	Management Area	Aquifer	Perforations (ft bgs)	Top Perforations (ft msl)	Bottom Perforations (ft msl)	Historical Water Level Low (ft msl) and Date Measured		2015 Spring Water Level (ft msl) and Date Measured		GSP Undesirable Result	Proposed Minimum Threshold (ft msl)
01N21W32Q06S	Saline Intrusion Management Area	Oxnard	180–220	−172.7	−212.7	−25.8	11/22/1991	−12.7	March 2015	SWI, reduction in groundwater storage	2
01N22W20J08S	Saline Intrusion Management Area	Oxnard	155–195	−143.8	−183.8	−14.8	09/28/1991	−7.6	March 2015	SWI, reduction in groundwater storage	7
01N22W26J04S	Saline Intrusion Management Area	Oxnard	185–205	−170.2	−190.2	−28.3	10/26/1990	−14.3	March 2015	SWI, reduction in groundwater storage	2
01N22W27C03S	Saline Intrusion Management Area	Oxnard	175–195	−162.8	−182.8	−18.6	12/13/1990	−9.0	March 2015	SWI, reduction in groundwater storage	7
01N23W01C05S	West Oxnard Plain Management Area	Oxnard	120–145	−105.8	−130.8	−6.9	11/18/1991	1.2	March 2015	SWI, reduction in groundwater storage	7
02N22W36E06S	West Oxnard Plain Management Area	Oxnard	230–320	−211.7	−251.7	−25.0	10/28/2015	−15.3	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	12
01N21W32Q05S	Saline Intrusion Management Area	Mugu	330–370	−322.7	−362.7	−107.4	11/30/2015	−60.7	March 2015	SWI, reduction in groundwater storage	2
01N21W32Q07S	Saline Intrusion Management Area	Mugu	275–285	−268.2	−278.2	−72.5	11/30/2015	−41.2	March 2015	SWI, reduction in groundwater storage	2
01N22W20J07S	Saline Intrusion Management Area	Mugu	310–350	−298.8	−338.8	−16.5	11/13/1991	−10.7	March 2015	SWI, reduction in groundwater storage	7
01N22W26J03S	Saline Intrusion Management Area	Mugu	524–620	−509.2	−605.2	−52.6	10/26/1990	−33.1	March 2015	SWI, reduction in groundwater storage	2
01N22W27C02S	Saline Intrusion Management Area	Mugu	275–295	−262.8	−282.8	−27.3	12/13/1990	−14.3	March 2015	SWI, reduction in groundwater storage	7
02N21W07L06S	Forebay Management Area	Mugu	135–155	11.9	−8.1	−12.2	12/03/2015	8.3	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	25
02N22W23B07S	Forebay Management Area	Mugu	260–300	−150.2	−190.2	−40.8	12/15/1992	−20.7	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N22W36E05S	West Oxnard Plain Management Area	Mugu	360–420	−288.4	−348.4	−21.0	11/04/2015	−13.6	February 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	10
01N22W20J05S	Saline Intrusion Management Area	Hueneme	640–680	−628.8	−668.8	−29.9	11/30/2015	−19.9	March 2015	SWI, reduction in groundwater storage	2
01N23W01C03S	West Oxnard Plain Management Area	Hueneme	965–1,065	−950.8	−1,050.8	−39.7	01/07/1991	−23.2	March 2015	SWI, reduction in groundwater storage	7
01N23W01C04S	West Oxnard Plain Management Area	Hueneme	630–695	−615.8	−680.8	−34.9	01/07/1991	−20.0	March 2015	SWI, reduction in groundwater storage	7
02N22W23B04S	Forebay Management Area	Hueneme	1,110–1,150	−1,000.2	−1,040.2	−147.1	10/28/2014	−75.6	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−5
02N22W23B05S	Forebay Management Area	Hueneme	830–870	−720.2	−760.2	−121.0	10/12/1991	−65.5	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−5

Table 3-1
Minimum Threshold Groundwater Elevations by Well, Management Area, and Aquifer for Key Wells in the Oxnard Subbasin

State Well Number	Management Area	Aquifer	Perforations (ft bgs)	Top Perforations (ft msl)	Bottom Perforations (ft msl)	Historical Water Level Low (ft msl) and Date Measured		2015 Spring Water Level (ft msl) and Date Measured		GSP Undesirable Result	Proposed Minimum Threshold (ft msl)
02N22W23B06S	Forebay Management Area	Hueneme	460–500	−350.2	−390.2	−41.7	02/03/1993	−23.2	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N22W36E03S	West Oxnard Plain Management Area	Hueneme	195–285	−123.1	−213.1	−51.8	12/03/2014	−30.5	June 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	10
02N22W36E04S	West Oxnard Plain Management Area	Hueneme	130–170	−58.9	−98.9	−32.11	11/04/2015	−32.1	November 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	10
01N21W32Q04S	Saline Intrusion Management Area	FCA	600–640	−592.7	−632.7	−116.9	11/30/2015	−66.3	March 2015	SWI, reduction in groundwater storage	−23
01N22W20J04S	Saline Intrusion Management Area	FCA	870–930	−858.8	−918.8	−40.7	11/30/2015	−28.1	March 2015	SWI, reduction in groundwater storage	2
01N22W26K03S	Saline Intrusion Management Area	FCA	470–580	−456.9	−566.9	−71.8	06/16/2015	−65.6	March 2015	SWI, reduction in groundwater storage	−18
01N23W01C02S	West Oxnard Plain Management Area	FCA	1,390–1,490	−1,375.8	−1,475.8	−50.4	01/07/1991	−29.3	March 2015	SWI, reduction in groundwater storage	7
02N21W07L04S	Forebay Management Area	FCA	500–540	−353.1	−393.1	−32.0	10/14/2015	3.9	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N22W23B03S	Forebay Management Area	FCA	1,210–1,250	−1,100.2	−1,140.2	−128.7	02/28/1991	−77.0	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−5
01N21W32Q02S	Saline Intrusion Management Area	GCA	930–970	−922.7	−962.7	−115.2	11/30/2015	−64.7	March 2015	SWI, reduction in groundwater storage	−23
01N21W32Q03S	Saline Intrusion Management Area	GCA	800–840	−792.7	−832.7	−125.8	11/30/2015	−75.6	March 2015	SWI, reduction in groundwater storage	−23
01N21W07J02S	Oxnard Pumping Depression Management Area	Multiple	590–1,280	−555.4	−1,245.4	−145.4	10/21/2014	−96.2	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−40
01N21W21H02S	Oxnard Pumping Depression Management Area	Multiple	503–863	−484.3	−844.3	−149.4	10/20/2014	−101.1	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−70
02N21W07L03S	Forebay Management Area	Multiple	640–700	−493.1	−553.1	−24.6	10/15/2015	1.8	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N21W07L05S	Forebay Management Area	Multiple	270–310	−1,23.1	−163.1	−7.4	12/30/2015	20.5	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	25

Notes: FCA = Fox Canyon Aquifer; ft bgs = feet below ground surface; ft msl = feet mean sea level; GCA = Grimes Canyon Aquifer; GSP = Groundwater Sustainability Plan; SWI = seawater intrusion; WL = water level.
Interim milestones are proposed for wells with spring 2015 groundwater elevations that are lower than the minimum threshold groundwater elevation. Wells with spring 2015 groundwater elevations that are higher than the minimum threshold are currently in compliance with the goals of this GSP and do not require milestones to assess progress toward sustainability.

Table 3-2
Measurable Objectives and Interim Milestones

Well Number	Aquifer	Minimum Threshold (ft msl)	Measurable Objective (ft msl)	Fall 2015 Water Level Low (ft msl) and Date Measured		Interim Milestone Average Climate (ft msl)				Interim Milestone Dry Climate (ft msl)			
						2025	*2030[a]*	*2035[a]*	*2040[a]*	*2025*	*2030[a]*	*2035[a]*	*2040[a]*
01N21W32Q06S	Oxnard	2	17	−23.12	11/30/2015	−15	−5	6	17	−18	−11	−4	2
01N22W20J08S	Oxnard	7	17	-14.56	11/2/2015	−7	1	9	17	−10	−5	1	7
01N22W26J04S	Oxnard	2	17	−23.31	10/16/2015	−15	−5	6	17	−18	−11	−4	2
01N22W27C03S	Oxnard	7	17	−14.83	10/6/2015	−7	1	9	17	−10	−5	1	7
01N23W01C05S	Oxnard	7	17	−1.94	11/2/2015	4	8	12	17	2	4	6	7
02N22W36E06S	Oxnard	12	37	−25.03	10/28/2015	−10	6	22	37	−16	−7	2	12
01N21W32Q05S	Mugu	2	17	−107.36	11/2/2015	−78	−46	−14	17	−82	−54	−26	2
01N21W32Q07S	Mugu	2	17	−72.50	11/30/2015	−52	−29	−6	17	−56	−37	−18	2
01N22W20J07S	Mugu	7	17	−16.21	11/2/2015	−7	1	9	17	−10	−5	1	7
01N22W26J03S	Mugu	2	17	−44.39	10/16/2015	−30	−15	1	17	−33	−21	−9	2
01N22W27C02S	Mugu	7	17	−22.57	10/6/2015	−15	−5	6	17	−17	−9	−1	7
02N21W07L06S	Mugu	27	62	−12.21	12/3/2015	8	26	44	62	−1	8	17	27
02N22W23B07S	Mugu	17	47	−31.59	12/30/2015	−11	8	27	47	−18	−6	6	17
02N22W36E05S	Mugu	12	37	−21.01	11/4/2015	−6	8	22	37	−12	−4	4	12
01N22W20J05S	Hueneme	2	17	−29.87	11/30/2015	−18	−6	6	17	−22	−14	−6	2
01N23W01C03S	Hueneme	7	22	−32.26	11/30/2015	−17	−4	9	22	−21	−12	−3	7
01N23W01C04S	Hueneme	7	22	−28.36	11/4/2015	−17	−4	9	22	−21	−12	−3	7
02N22W23B04S	Hueneme	−3	17	−95.68	12/3/2015	−67	−39	−11	17	−72	−49	−26	−3
02N22W23B05S	Hueneme	−3	17	−83.59	12/3/2015	−60	−35	−10	16	−65	−45	−25	−4
02N22W23B06S	Hueneme	17	47	−37.35	12/3/2015	−15	6	27	47	−22	−9	4	17
02N22W36E03S	Hueneme	12	37	−51.77	12/3/2014	−28	−6	16	37	−35	−20	−5	11
02N22W36E04S	Hueneme	12	37	−32.12	11/4/2015	−13	4	21	37	−20	−10	1	12

Table 3-2
Measurable Objectives and Interim Milestones

Well Number	Aquifer	Minimum Threshold (ft msl)	Measurable Objective (ft msl)	Fall 2015 Water Level Low (ft msl) and Date Measured		Interim Milestone Average Climate (ft msl)				Interim Milestone Dry Climate (ft msl)			
						2025	*2030*[a]	*2035*[a]	*2040*[a]	*2025*	*2030*[a]	*2035*[a]	*2040*[a]
01N21W32Q04S	FCA	−23	2	–116.94	11/30/2015	−86	−57	−28	2	−92	−69	−46	−23
01N22W20J04S	FCA	2	17	–40.72	11/30/2015	42	34	26	17	38	26	14	2
01N22W26K03S	FCA	−18	2	–71.84	6/16/2015	−52	−34	−16	2	−57	−44	−31	−18
01N23W01C02S	FCA	7	22	–37.63	11/30/2015	−25	−10	6	22	−28	−16	−4	7
02N21W07L04S	FCA	17	42	–32.02	10/14/2015	−12	6	24	42	−18	−6	6	17
02N22W23B03S	FCA	−3	17	–94.26	12/3/2015	−67	−39	−11	17	−72	−49	−26	−3
01N21W32Q02S	GCA	−23	2	–115.19	11/30/2015	−86	−57	−28	2	−92	−69	−46	−23
01N21W32Q03S	GCA	−23	2	–125.76	11/30/2015	−93	−61	−29	2	−100	−75	−50	−24
01N21W07J02S	Multiple	−38	2	–140.02	10/25/2015	−105	−70	−35	1	−115	−90	−65	−39
01N21W21H02S	Multiple	−68	-8	–137.09	9/30/2015	−103	−71	−39	−7	−118	−101	−84	−67
02N21W07L03S	Multiple	17	37	–24.59	10/15/2015	−10	6	22	37	−15	−5	6	17
02N21W07L05S	Multiple	27	57	–7.41	12/30/2015	11	27	43	58	3	11	19	27

Notes: FCA = Fox Canyon Aquifer; ft msl = feet mean sea level; GCA = Grimes Canyon Aquifer.

[a] Interim milestones for 2030, 2035, and 2040 will depend on climate conditions and Subbasin water level recoveries between 2020 and 2025. These thresholds are proposed for the current GSP but will be reviewed and revised with each 5-year evaluation.

Figure 3-1 Minimum Thresholds and Groundwater Elevation Contours in the Oxnard Aquifer, October 2–29, 2015

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Figure 3-2 Minimum Thresholds and Groundwater Elevation Contours in the Mugu Aquifer, October 2–29, 2015

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Figure 3-3 Minimum Thresholds and Groundwater Elevation Contours in the Hueneme Aquifer, October 2–29, 2015

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Figure 3-4 Minimum Thresholds and Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2–29, 2015

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Figure 3-5 Minimum Thresholds and Groundwater Elevation Contours in the Grimes Canyon Aquifer, October 2–29, 2015

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Figure 3-6a Key Well Hydrographs for Wells Screened in the Oxnard Aquifer

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Figure 3-6b Key Well Hydrographs for Wells Screened in the Oxnard Aquifer

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Figure 3-7a Key Well Hydrographs for Wells Screened in the Mugu Aquifer

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Figure 3-7b Key Well Hydrographs for Wells Screened in the Mugu Aquifer

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Figure 3-8a Key Well Hydrographs for Wells Screened in the Hueneme Aquifer

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Figure 3-8b Key Well Hydrographs for Wells Screened in the Hueneme Aquifer

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Figure 3-9a Key Well Hydrographs for Wells Screened in the Fox Canyon Aquifer

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Figure 3-9b Key Well Hydrographs for Wells Screened in the Fox Canyon Aquifer

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Figure 3-10 Key Well Hydrographs for Wells Screened in the Grimes Canyon Aquifer

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Figure 3-11 Key Well Hydrographs for Wells Screened in Multiple Aquifers

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Figure 3-12 Interim Milestones for Dry and Average Conditions – Linear Interpolation

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Figure 3-13 Distribution of 5-Year Average Climate Conditions in the Historical Record of Precipitation on the Oxnard Plain

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CHAPTER 4
MONITORING NETWORKS

4.1 MONITORING NETWORK OBJECTIVES

The overall objective of the monitoring network in the Oxnard Subbasin (Subbasin) is to track and monitor parameters that demonstrate progress toward meeting the sustainability goals. In order to accomplish this objective, the monitoring network in the Subbasin must be capable of the following:

- Monitoring changes in groundwater conditions (in six sustainability indicator categories)
- Monitoring progress toward minimum thresholds and measurable objectives
- Quantifying annual changes in water budget components

The existing network of groundwater wells includes both monitoring wells and production wells. This network is capable of delineating the groundwater conditions in the Subbasin and has been used for this purpose in the past. The current groundwater well network will be used to monitor groundwater conditions moving forward, in order to continue to assess long-term trends in groundwater elevation and groundwater quality in the Subbasin.

In the future, to the extent possible, additional dedicated monitoring wells will be incorporated into the existing monitoring network. These wells will provide information on groundwater conditions in geographic locations where data gaps have been identified, or where a dedicated monitoring well would better represent conditions in the aquifers than a production well currently used for monitoring.

4.2 DESCRIPTION OF EXISTING MONITORING NETWORK

The existing monitoring network for groundwater and related surface conditions in the Subbasin includes groundwater production wells, dedicated groundwater monitoring wells, stream gauges, and weather stations. The components of the monitoring network are discussed in Section 4.2.1, Groundwater Monitoring, and Section 4.2.2, Surface Conditions Monitoring, in the context of their ability to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions and of the ability of the network to provide representative conditions in the Subbasin. A discussion of how the monitoring network relates to each of the sustainability criteria follows this discussion in Section 4.3, Monitoring Network Relationship to Sustainability Indicators.

4.2.1 Groundwater Monitoring

Groundwater Elevation

Data collected from more than 150 wells in the Subbasin have been used to demonstrate historical groundwater elevation conditions in the Upper Aquifer System and Lower Aquifer System (Figures 4-1 through 4-6, Monitoring Wells Screened in the Oxnard Subbasin (by aquifer)). The groundwater well monitoring network contains wells that are located in every management area of the Subbasin except the East Oxnard Plain Management Area (EOPMA) and that are screened in every primary aquifer in the Subbasin. Although the network of groundwater wells includes agricultural, municipal and industrial, and domestic production wells, the majority of the wells used to determine groundwater elevations are designated as monitoring wells in the Ventura County Watershed Protection District (VCWPD) database of groundwater elevation and groundwater quality data collected in the Subbasin.

The United Water Conservation District (UWCD) collects groundwater elevation data from more than 100 monitoring and agricultural wells in the Subbasin. These wells are monitored either monthly or bimonthly (once every two months). Water levels are measured both manually and with pressure transducers, which record the pressure of water (or height of the water column) above the transducer in the well. Pressure transducers have been installed in 65 of these wells. These transducers record the height of the water column in the well every 4 hours, thereby providing high temporal resolution data on groundwater conditions in the aquifers. Data are downloaded from the transducers quarterly, in a rotating pattern. Transducer records are subject to quality control review before being added to UWCD databases and reported to VCWPD.

Manual groundwater elevation measurements are collected monthly or bimonthly from the UWCD network of groundwater wells. These data are used to assess seasonal and long-term trends in groundwater elevation in the Subbasin, where groundwater elevations were first measured in the 1930s. Seasonal and long-term groundwater elevation trends have been assessed based on the data collected from the existing network of groundwater monitoring wells, and are discussed in Section 2.3, Groundwater Conditions, of this Groundwater Sustainability Plan (GSP).

The spatial and temporal coverage of the existing groundwater monitoring network is sufficient to provide an understanding of representative conditions in the Upper Aquifer System and Lower Aquifer System throughout the Subbasin, and this network will be used to demonstrate progress toward the sustainability goals for the Subbasin. Although evaluation of the current network suggests that the network is sufficient to document groundwater conditions in the Subbasin, areas for future improvement of the network are identified in Section 4.6, Potential Monitoring Network Improvements.

Groundwater Quality

The majority of the wells in the groundwater elevation monitoring network in the Subbasin are also monitored for groundwater quality. UWCD conducts the majority of the water quality monitoring in the Subbasin. UWCD water quality monitoring is conducted in a rotating pattern such that each well is monitored at least once per year. Annual monitoring of groundwater quality is sufficient to demonstrate long-term trends in groundwater quality, because the physical processes that drive changes in groundwater quality operate on a longer timescale. Currently, groundwater elevations are the primary metric by which progress toward sustainability will be measured. However, groundwater quality data will continue to be collected and analyzed to assess whether groundwater elevation thresholds are sufficiently protective of groundwater conditions in the Subbasin. Recommendations for improvement of the groundwater quality monitoring network are identified in Section 4.6.

Groundwater Extraction

The Fox Canyon Groundwater Management Agency (FCGMA) has required reporting of groundwater extraction from the Subbasin since 1983. Historically, groundwater extraction data from wells within the FCGMA jurisdictional boundary have been self-reported by well owners semi-annually (Figure 2-5, Upper Aquifer System 2015 Extraction [acre-feet] in Oxnard and Pleasant Valley, and Figure 2-6, Lower Aquifer System 2015 Extraction [acre-feet] in Oxnard and Pleasant Valley). In 2018, FCGMA adopted an ordinance that required installation of advanced metering infrastructure (AMI) telemetry on wells that were equipped with flowmeters (FCGMA 2018). All agricultural wells were required to install AMI by December 31, 2018; municipal and industrial wells are required to install AMI by October 1, 2019; and all other metered wells are required to install AMI by October 1, 2020. Requiring AMI on all metered wells within FCGMA jurisdiction will provide for broader simultaneous reporting of groundwater extractions, improve FCGMA's ability to monitor and manage groundwater use, and facilitate implementation of this GSP.

4.2.2 Surface Conditions Monitoring

The primary surface conditions that impact groundwater conditions in the Oxnard Subbasin are surface water flows and precipitation. The monitoring networks for both surface conditions are discussed in this section.

Surface Water

Surface flows in the Subbasin are monitored by a network of gauges that are maintained by the VCWPD (Table 4-1). The network includes three types of gauges:

1. Recording Stream Gauges (also known as Daily and Peak Stations). These stream gauges record daily average flowrates as well as "peak" flowrates during rain events.

2. Peak Only (Event) Gauges. This type of stream gauge records only “peak” flowrates during rain events (the threshold over which a flowrate is considered to be part of a rain event is site-specific).
3. ALERT Peak Gauges. These stream gauges serve only as a flood warning system. These stations register high flows but are not used to measure numerical flow rates.

The recording stations at the Freeman Diversion Channel near Saticoy, Santa Clara River at Victoria Avenue, Beardsley Wash at Central Avenue, and the Revolon Slough at Pleasant Valley Road are recording gauges that provide the primary data on surface flows. These gauges collect daily data, while the other gauges in the basin only record flows during precipitation events.

In addition to the surface flow monitoring network in the Subbasin, UWCD monitors and reports diversions from the Santa Clara River. These diversions are used to deliver surface water to agricultural users in lieu of groundwater production and are used for recharge, via UWCD’s spreading grounds, to the groundwater aquifers in the Subbasin.

Surface water flows have been recorded in the Subbasin since the 1930s (Figure 1-4, Average Daily Flows (ADF) and Monthly Minimum ADF in Oxnard Surface Waters). Daily flows on Calleguas Creek and in the Revolon Slough have been recorded since the 1970s. There are currently gauges on the major surface water bodies in the Subbasin (Figure 4-7, Active Surface Water Monitoring Network for the Oxnard Subbasin). The historical and existing spatial and temporal coverage from the surface water flow gauge network provides adequate coverage for the short-term, seasonal, and long-term surface flow conditions in the Subbasin. Although the current network is sufficient to document surface flow conditions in the Subbasin, areas for improvement are identified in Section 4.6.

Precipitation

Thirteen precipitation gauges currently monitor precipitation in the Subbasin (Table 4-2; Figure 4-8, Active Precipitation Monitoring Network for the Oxnard Subbasin). The precipitation gauges are maintained, and data are collected, by VCWPD and the National Weather Service.

Precipitation in the Subbasin has been recorded for more than a century (Figure 1-5, Oxnard Plain Annual Precipitation). Although the locations of individual precipitation gauges have changed through time, with some gauges being removed from service and others added, there is overlap between the records collected from the various gauges. Therefore, a continuous precipitation record can be constructed for the Subbasin to demonstrate long-term trends. More recent data, collected with greater frequency, can be used to demonstrate short-term and seasonal trends in precipitation.

In addition to providing adequate temporal coverage of the Subbasin, the current network of precipitation gauges includes sites in every management area of the Subbasin except the EOPMA. This is sufficient spatial coverage to document precipitation in the Subbasin and to connect the precipitation measurements to both streamflow and groundwater conditions. Additional precipitation monitoring locations are not currently recommended for characterizing surface conditions in the Oxnard Subbasin.

4.3 MONITORING NETWORK RELATIONSHIP TO SUSTAINABILITY INDICATORS

To document changes in groundwater conditions related to each of the six sustainability indicators, monitoring will be conducted using the existing network of groundwater wells (Figures 4-1 through 4-6). This network includes a greater number of wells than the list of key wells provided in Chapter 3, Sustainable Management Criteria, of this GSP (see Tables 4-3 and 4-4). Minimum thresholds and measurable objectives have been selected for the set of key wells but have not been selected for every well used to monitor groundwater conditions in the Subbasin. Conditions measured in the key wells will be used to document progress toward the sustainability goals. Groundwater conditions measured in the broader network of wells, which includes the key wells, will be used to document conditions in the Subbasin at a greater spatial coverage than is provided by the key wells. Recommendations and findings based on the key well data will be supported by the data collected by the broader well network.

4.3.1 Chronic Lowering of Groundwater Levels

To monitor conditions related to chronic lowering of groundwater levels, the groundwater monitoring network must be structured to accomplish the following:

- Track short-term, seasonal, and long-term trends in water elevation.
- Demonstrate groundwater elevations in mid-March and mid-October for each primary aquifer or aquifer system.
- Record groundwater elevations in key wells in which minimum thresholds and measurable objectives have been identified to track progress toward the sustainability goals for the Subbasin.

Spatial Coverage by Aquifer

The Subbasin monitoring well density for groundwater elevations varies by aquifer (Tables 4-3 and 4-4). Of the primary aquifers in the Subbasin identified in Chapter 2, Basin Setting, the Grimes Canyon Aquifer has the lowest density of active wells in which groundwater elevations can be measured. The density of wells in the Grimes Canyon Aquifer is approximately 1 well per 13 square miles (the Oxnard Subbasin area is approximately 90 square miles). There is no definitive rule for the density of groundwater monitoring points needed in a basin; however, for comparison, the monitoring well density recommended by CASGEM Groundwater Elevation Monitoring Guidelines ranges from 1 to 10 wells per 100 square miles (DWR 2010). Additional California Department of Water Resources (DWR) guidelines recommend a well network with a density of 1 observation per 16 square miles (DWR 2010, 2016b). Therefore, the density of wells in the Grimes Canyon Aquifer meets the criteria for adequate coverage to accomplish the objectives of the monitoring well network for determining chronic lowering of groundwater levels.

In addition to the Grimes Canyon Aquifer, the density of wells in the other primary aquifers in the Subbasin is also greater than the recommended well density provided in the DWR and CASGEM guidelines. The density of active monitoring wells in the Fox Canyon Aquifer (FCA) and the Hueneme Aquifer is approximately 1 well per 4 square miles. The density of active monitoring wells in the Mugu Aquifer is approximately 1 well per 3 square miles, and the density of active monitoring wells in the Oxnard Aquifer is approximately 1 well per square mile.

Groundwater elevations are also monitored in the semi-perched aquifer, although the semi-perched aquifer is not a primary aquifer in the Subbasin. These elevations are measured to document interactions between the semi-perched aquifer and the surface water bodies in the Subbasin, as well as to document potential gradients between the semi-perched aquifer and the underlying Oxnard Aquifer. The density of monitoring wells in the semi-perched aquifer is approximately 1 well per 13 square miles. This density meets the DWR and CASGEM criteria for documenting groundwater elevations in the semi-perched aquifer.

Although the active network of wells used to document chronic lowering of groundwater levels in the Subbasin has sufficient spatial density on the Subbasin scale, in some aquifers, there are local areas in which coverage can be improved. Potential improvements in local coverage are discussed in Section 4.6.

Temporal Coverage by Aquifer

Groundwater elevation data will be collected from the network of groundwater wells to provide groundwater elevation conditions in the spring and fall of each year. Further discussion of the monitoring schedule is provided in Section 4.4, Monitoring Network Implementation.

4.3.2 Reduction of Groundwater Storage

To monitor conditions related to reduction of groundwater storage, the groundwater monitoring network must be structured to accomplish the following:

- Demonstrate groundwater elevations in mid-March and mid-October for each primary aquifer or aquifer system.
- Calculate year-over-year (mid-March to mid-March) change in storage by aquifer.
- Provide data from which lateral and vertical hydraulic gradients within and between aquifers can be calculated.
- Record groundwater elevations in key wells in which minimum thresholds and measurable objectives have been identified to track progress toward the sustainability goals for the Subbasin.

The requirements for documenting reduction in groundwater storage are similar to those for chronic lowering of groundwater levels (see Section 4.3.1), because these two sustainability indicators are interrelated. The primary difference between the two sets of requirements is the need to document potential gradients between aquifers. These gradients influence the movement of water between aquifers, which in turn influences storage in the aquifer.

Historically, the change in groundwater stored in freshwater aquifers in the Subbasin has been modeled by UWCD. After GSP adoption, modeled volumes of annual change in storage will be reported by aquifer and by year in annual reports. A standardized method to calculate the change in storage that relies solely on water elevations within each aquifer, rather than on a numerical model, may also be developed as a check on the model predictions.

The spatial and temporal density of groundwater elevation data necessary to document groundwater storage changes in the aquifers of the Subbasin is the same as that necessary to document groundwater elevation changes. The current network of wells is capable of documenting changes to both sustainability indicators. Specific recommendations for potential improvements to local coverage are discussed in Section 4.6.

4.3.3 Seawater Intrusion

To monitor conditions related to seawater intrusion, groundwater elevations will be measured, and water quality samples will be collected, in such a way as to accomplish the following:

- Track short-term, seasonal, and long-term trends in water elevation.
- Demonstrate groundwater elevations in mid-March and mid-October for each primary aquifer or aquifer system.

- Record groundwater elevations in key wells in which minimum thresholds and measurable objectives have been identified to track progress toward the sustainability goals for the Subbasin.

These goals are the same as those for chronic lowering of groundwater levels (see Section 4.3.1). Groundwater elevations are the metric by which seawater intrusion will be assessed (see Section 3.3.3).

Spatial Coverage by Aquifer

A network of nested monitoring wells was installed in the early 1990s by the U.S. Geological Survey for the Regional Aquifer System Analysis, which includes 16 wells in the Oxnard Subbasin (USGS 1996). Fourteen of these well sites are located within an approximately 28-square-mile area adjacent to the Pacific Ocean. Thus, the density of dedicated monitoring wells adjacent to the coast is approximately 1 well per 2 square miles. The current network of wells is capable of documenting groundwater elevations that could induce seawater intrusion. No additional coastal monitoring wells are proposed.

Water Quality Constituents

Groundwater samples will continue to be collected and analyzed for total dissolved solids (TDS) and chloride in order to assess trends in groundwater quality related to seawater intrusion. The network of existing wells is capable of providing an adequate assessment of groundwater quality trends for these constituents.

Temporal Resolution

Historically, groundwater quality samples have been collected with sufficient temporal resolution to identify seawater intrusion in the aquifers of the Subbasin (see Section 2.3.3, Seawater Intrusion, of this GSP). The temporal resolution of the data has varied through time and depends on the entity monitoring a given well. UWCD has collected annual groundwater samples from the network of monitoring wells along the Subbasin coastline since the late 1980s (UWCD 2016). These samples have documented long-term trends in chloride concentration for the coastal wells. Because the degradation of water quality associated with seawater intrusion is a process that occurs over a longer time than changes in groundwater elevation associated with groundwater production, annual groundwater quality sampling is adequate for documenting changes in chloride and TDS concentration associated with seawater intrusion.

4.3.4 Degraded Water Quality

To monitor conditions related to degraded water quality, water quality samples will be collected in such a way as to track long-term trends in water quality that may impact beneficial uses and users of groundwater in the Subbasin. Specifically, these water quality samples should be targeted to constituents of concern and areas of the Subbasin that have documented degradation, or the potential for degradation, in water quality related to groundwater production from the Subbasin.

Spatial Coverage by Aquifer

The network of wells currently used to monitor groundwater elevation conditions in each aquifer is sufficient to determine trends in groundwater quality as well. The primary areas of concern for groundwater quality degradation relating to groundwater elevations in the Subbasin are the Forebay Management Area, the Saline Intrusion Management Area, and the Oxnard Pumping Depression Management Area. Monitoring groundwater quality changes associated with seawater intrusion is discussed in Section 4.3.3. The spatial density of groundwater elevation monitoring wells is discussed in Section 4.3.1. The spatial coverage provided by the existing monitoring network is sufficient to document changes in groundwater quality.

Water Quality Constituents

Monitoring and annual reporting has occurred for constituents that are associated with a water quality threshold adopted by the FCGMA Board of Directors or by the Los Angeles Regional Water Quality Control Board. These constituents are TDS, chloride, nitrate, sulfate, and boron. The network of existing wells is capable of providing an adequate assessment of groundwater quality trends for these constituents.

Temporal Resolution

Degradation of groundwater quality occurs on a longer timescale than changes in groundwater elevation. Historically, UWCD has collected water quality samples on a quarterly basis and VCWPD has collected samples annually, although more frequent sampling can occur in some wells. These samples have provided information on trends in groundwater quality throughout the Subbasin. Samples from coastal wells have been used to document seawater intrusion, and samples from wells in the Oxnard Forebay have been used to document degradation of water quality related to increasing nitrate concentrations (see Section 2.3). The temporal resolution of the data collection is adequate to document trends in groundwater concentration for the constituents identified by the FCGMA Board of Directors and the Los Angeles Regional Water Quality Control Board.

4.3.5 Land Subsidence

To monitor conditions related to land subsidence, groundwater elevations will be measured to determine if water levels fall below historical lows. Groundwater elevations are being used as a proxy for land subsidence in the Subbasin. The minimum thresholds identified at the key wells are above the historical low groundwater elevation. Therefore, it is not anticipated that specific land subsidence monitoring will be required for the Subbasin. Instead, the network of groundwater monitoring wells discussed in Sections 4.2.1 and 4.3.1 will be used to determine if land subsidence related to groundwater production may occur.

4.3.6 Depletions of Interconnected Surface Water

To monitor conditions related to depletions of interconnected surface water, surface water flows and shallow groundwater will be measured in such a way as to accomplish the following:

- Track short-term, seasonal, and long-term trends in groundwater elevation in the semi-perched aquifer.
- Demonstrate groundwater elevations in mid-March and mid-October for the semi-perched aquifer.
- Record groundwater elevations in key wells in which minimum thresholds and measurable objectives have been identified to track progress toward the sustainability goals for the Subbasin.

Surface water flows in the Revolon Slough, Calleguas Creek, and the Santa Clara River downstream of, but not including, the Freeman Diversion are connected to water levels in the semi-perched aquifer, rather than the underlying confined aquifers of the Upper Aquifer System and Lower Aquifer System. In turn, the groundwater elevation in the semi-perched aquifer is effectively regulated by the height of the agricultural tile drains installed throughout the Oxnard Plain (UWCD 2016).

Although the active network of wells used to document groundwater conditions in the semi-perched aquifer has sufficient spatial density at the Subbasin scale, there are local areas in which coverage can be improved. Potential improvements in local coverage are discussed in Section 4.6.

4.4 MONITORING NETWORK IMPLEMENTATION

4.4.1 Groundwater Elevation Monitoring Schedule

To reduce uncertainty associated with hydraulic gradients, and to follow guidance documents produced by DWR (DWR 2016b), water level measurements used in the evaluation of seasonal high and seasonal low groundwater conditions should be collected in a 2-week window in mid-March and mid-October (specifically, March 9–22 and October 9–22 of any given calendar year).

Short-term trends in groundwater elevation are currently, and will continue to be, monitored using transducers that are operated and maintained by UWCD. Data from these transducers are downloaded quarterly and stored in a central database.

Seasonal and long-term trends in groundwater elevation are monitored using the transducer data and manual measurements made by UWCD on a monthly or bimonthly basis, and manual measurements made by VCWPD on a quarterly basis. Additional manual water level measurements made by other partner agencies (e.g., the City of Oxnard or mutual water districts) are typically sent to VCWPD annually.

4.4.2 Groundwater Storage Monitoring Schedule

Groundwater storage is directly related to, and calculated from, groundwater elevations. Consequently, the schedule for monitoring groundwater storage is the same as that for monitoring groundwater elevations.

4.4.3 Seawater Intrusion Monitoring Schedule

Groundwater Elevation

Twice-yearly comprehensive evaluations (in mid-March and mid-October) of groundwater elevations in each aquifer will be used to assess progress toward minimum thresholds designed to avoid seawater intrusion.

Groundwater Quality

Annual groundwater quality samples for each coastal well will be used to monitor water quality trends related to seawater intrusion.

4.4.4 Water Quality Monitoring Schedule

UWCD conducts monthly or quarterly monitoring of groundwater quality in many wells throughout the Oxnard Subbasin. Wells with stable water quality are sampled annually or twice annually by ~~the~~ UWCD. Groundwater quality monitoring should continue on the same schedule in order to document groundwater quality trends in the Subbasin. Annual reviews of the groundwater quality trends will be used to assess whether sampling frequency or the spatial density of samples needs to be adjusted.

4.4.5 Groundwater Extraction Monitoring Schedule

Monitoring of groundwater extraction rates will take place continuously, using flowmeters and telemetry equipment installed on individual wellheads, and monthly totals of pumped water will be transmitted to a central database maintained by FCGMA.

4.5 PROTOCOLS FOR DATA COLLECTION AND MONITORING

Protocols for collecting groundwater level measurements and water quality samples, as well as downloading transducers and logging the boreholes of newly drilled wells, are included in the Monitoring Protocols Best Management Practices (BMPs) produced by DWR (DWR 2016a). FCGMA plans to work with agency partners to ensure that future data collection is conducted according to relevant protocols in the BMP. Current practices used by VCWPD and UWCD are described in this section.

VCWPD Protocols

VCWPD technicians collect water levels using steel tapes. For a well that is too deep for the tape, an acoustical sounder or an air pressure gauge is used, and the measurement is stored in the database with a Questionable Measurement Code, indicating that alternate equipment was used.

VCWPD technicians collect water quality samples from production wells using the installed pump equipment. A three-volume purge, or a testing of groundwater parameters including pH, temperature, and electrical conductivity, is conducted to determine whether the water at the wellhead is representative of groundwater in the aquifer. Water quality samples are then sent to an analytical laboratory, where they are filtered and preserved.

UWCD Protocols

UWCD technicians collect water levels using a variety of equipment, including dual-wire and single-wire sounders and metal tapes. In the event that the well contains a pump, the technician manually tests the approximate temperature of the pump housing. If the pump housing is warm, the water level that is entered into the database is qualified with a Questionable Measurement Code, indicating recent pumping. ~~The~~ UWCD also considers other indicators, such as wet conditions at wells and in nearby fields, to evaluate if water levels may not be static.

UWCD technicians collect water quality samples using the three-volume purge method, and follow U.S. Geological Survey guidelines for groundwater quality sampling. For shallow wells, a Grundfos Redi-Flo pump is used to purge and sample the groundwater. For deeper wells, a compressor is used to airlift the groundwater for purging and sampling. On rare occasions, a bailer is used to purge and sample.

4.6 POTENTIAL MONITORING NETWORK IMPROVEMENTS

The existing monitoring network in the Subbasin is sufficient to document groundwater conditions in the Subbasin, and can be used to document progress toward the sustainability goals for the Subbasin. Analysis of the monitoring network, however, also indicates that there are local areas in which data coverage and monitoring efforts can be improved in the future. Areas for improvement of the existing monitoring network and data infrastructure system, are described in the following sections.

4.6.1 Water Level Measurements: Spatial Data Gaps

Additional monitoring wells could be used to improve spatial coverage for groundwater elevation measurements in the West Oxnard Plain Management Area, the Oxnard Pumping Depression Management Area, and the EOPMA. Wells that are added to the network should be dedicated monitoring well clusters, with individual wells in the cluster screened in a single aquifer. The potential improvements to the monitoring network in each aquifer are shown on Figures 4-9 through 4-14 (Existing and Potential New Wells for Monitoring Groundwater Conditions, by aquifer).

The groundwater monitoring network in the Subbasin could be improved by adding monitoring wells in the Oxnard Pumping Depression Management Area (Figures 4-9 through 4-14). An additional well, or wells, in this area would provide aquifer-specific groundwater elevations in an area that does not have local wells screened solely in the Mugu Aquifer or the Hueneme Aquifer, and does not have a dedicated monitoring well screened in any of the primary aquifers. Groundwater elevation measurements in this well would help constrain groundwater gradients across the boundary between the Subbasin and the Pleasant Valley Basin. Additionally, a well in this management area could be used to assess groundwater conditions in the semi-perched aquifer adjacent to the Revolon Slough. FCGMA has applied for funding through a DWR Technical Support Services monitoring well funding grant to add a monitoring well in the Oxnard Pumping Depression Management Area.

In the West Oxnard Plain Management Area, the groundwater monitoring network could be improved by adding a monitoring well to the area north of Highway 101 and south of the Oxnard Forebay. Currently, there are no dedicated monitoring wells in this area (Figures 4-9 through 4-14). Adding a monitoring well in this area would provide for aquifer-specific water levels adjacent to the West Las Posas Management Area boundary. These groundwater levels could be used to constrain the gradient between the West Las Posas Management Area and the Subbasin.

The monitoring network in the West Oxnard Plain Management Area could also be improved by adding a monitoring well to the area north of 6th Street and west of Ventura Road. This area has dedicated monitoring wells in the Oxnard Aquifer, but does not have a dedicated monitoring well in the Mugu or Hueneme Aquifer or the FCA. A monitoring well in this area would help constrain groundwater gradients in the northwest~~ern~~ part of the Oxnard Subbasin.

There are currently no monitoring wells in the EOPMA, which has minimal known groundwater production. Addition of a monitoring well in the vicinity of Calleguas Creek in the EOPMA would improve understanding of groundwater conditions in this management area. It would also provide data to help constrain the relationship between groundwater elevations in the EOPMA and groundwater conditions in the adjacent Oxnard Pumping Depression and Saline Intrusion Management Areas.

New wells will be constructed to applicable well installation standards set in California DWR Bulletins 74-81 and 74-90, or as updated (DWR 2016b). It is recommended that, where feasible, new wells be subjected to pumping tests to collect additional information about aquifer properties in the vicinity of new monitoring locations.

Proposed locations are approximate and subject to feasibility review (accounting for infrastructure, site acquisition, and site access, among other factors) after GSP submittal. The schedule for new well installation will be developed in conjunction with feasibility review.

4.6.2 Water Level Measurements: Temporal Data Gap

The DWR Monitoring Protocol BMP (DWR 2016a) states the following:

> Groundwater elevation data … should approximate conditions at a discrete period in time. Therefore, all groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1 to 2 week period.

The DWR Monitoring Networks BMP (DWR 2016b) states the following:

> Groundwater levels will be collected during the middle of October and March for comparative reporting purposes.

Currently, groundwater elevation measurements are not scheduled according to these criteria. To minimize the effects of this type of temporal data gap in the future, it will be necessary to coordinate the collection of groundwater elevation data so it occurs within a 2-week window during the key reporting periods of mid-March and mid-October. The recommended collection windows are October 9 to 22 in the fall and March 9 to 22 in the spring (see Section 4.4).

Additionally, as funding becomes available, pressure transducers should be added to wells in the groundwater monitoring network. Pressure transducer records provide the high temporal resolution data that allows for a better understanding of water level dynamics in the wells related to groundwater production, groundwater management activities, and climatic influence.

4.6.3 Groundwater Quality Monitoring

To improve the existing groundwater quality monitoring in the Subbasin, the current analyte list could be expanded to include a full general minerals suite. Stiff or Piper diagrams could then be created to fully characterize the geochemical characteristics of the groundwater and track changes over time. ~~The~~ UWCD currently gets a general mineral analysis at least annually for most monitoring wells in the Oxnard Subbasin.

4.6.4 Subsidence Monitoring

Currently, neither FCGMA nor its partner agencies in the region monitor land subsidence. The U.S. Geological Survey maintained one benchmark in the southern part of the Oxnard Plain between 1939 and 1978 (see Section 2.3.5, Subsidence, of this GSP), but it is not currently operational. Subsidence related to groundwater production is not anticipated to occur in the Subbasin in the future because the minimum threshold groundwater elevations are higher than the historical low groundwater elevations in the Subbasin. Preexisting GPS-based benchmarks could be used for monitoring land subsidence in the event that groundwater elevations drop below historical low levels for an extended period, and the potential for land subsidence to substantially interfere with surface land uses is determined (see Section 3.3.5, Land Subsidence). Additionally, historical InSAR and LIDAR records exist for the Oxnard Plain and could be used for comparison to future conditions if groundwater production causes water levels that are below the historical lows.

4.6.5 Shallow Groundwater Monitoring near Surface Water Bodies and GDEs

Currently, there are relatively few wells that can be used to monitor the shallow groundwater in the semi-perched aquifer that may be interconnected with surface water bodies and sustain GDEs or potential GDEs in the Subbasin. To improve the existing monitoring network and to assist with understanding the potential connectivity between shallow groundwater and potential GDEs, a dedicated shallow monitoring well within the boundaries of the potential GDE along the Revolon Slough and an additional dedicated shallow monitoring well in the vicinity of Lower Calleguas Creek could be added to the monitoring network, independent of an additional nested well cluster (Figure 2-52, Groundwater Dependent Ecosystems for the Oxnard Subbasin).

Additional shallow monitoring wells are not proposed for the coastal GDEs (Lower Santa Clara River, McGrath Lake, Ormond Beach, and Mugu Lagoon) described in Section 2.3.7, Groundwater-Dependent Ecosystems, of this GSP (see Figures 2-52 through 2-56). The coastal GDEs are sustained by groundwater in the semi-perched aquifer, which is rarely used for water supply in the Subbasin (FCGMA 2007). However, if future projects propose to produce water from the semi-perched aquifer, depletion of interconnected surface water is possible, and significant and unreasonable impacts may occur. Therefore, additional monitoring wells may be necessary and should be installed in conjunction with the planning for those projects.

4.6.6 Surface Water: Flows in Agricultural Drains in the Oxnard Plain

Discharge flows are currently unmeasured in the drainage system, frequently referred to as the "tile drains," that was installed throughout the Oxnard Plain in the 1950s (Isherwood and Pillsbury 1958). The tile drains were installed to support the development of land in the Oxnard Plain, which was formerly affected by high soil salinity levels, for agriculture (Isherwood and Pillsbury 1958). The drains are typically located 6 to 7 feet below ground surface, though the depth varies and is not well documented in most areas. Shallow groundwater entering the drains discharges to central drainage ditches, and from there flows into local surface waters, such as the Revolon Slough, or directly to the ocean, such as at Port Hueneme.

Metering flow in the tile drains would provide an important check on numerical groundwater results and would also provide valuable information about the water resource potential of the semi-perched aquifer. The tile drain system is extensive, and in much of the Oxnard Plain its current state of repair is currently unknown. A feasibility study is recommended to identify the best locations in the drainage system for installing flowmeters.

4.7 REFERENCES CITED

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Table 4-1
Network of Stations Monitoring Surface Flows in the Vicinity of the Oxnard Subbasin

Station Number	Station Name	Latitude	Longitude	Elevation (ft msl)	Station Type	USGS ID
A639	Freeman Diversion Weir ALERT	34.299111	−119.108417	187	ALERT Stream Gauge	—
724A	Santa Clara River at Freeman Diversion (ALERT)	34.299222	−119.108	—	ALERT Stream Gauge	—
793	J Street Drain at Lagoon (ALERT)	34.140944	−119.188028	15	ALERT Stream Gauge	—
778	Nyeland Acres Drain	34.225099	−119.126788	46	Peak Only (Event) Gauge	—
779	Rice Rd Drain at Wooley Rd	34.189448	−119.151126	24	Peak Only (Event) Gauge	—
781	Santa Clara Drain	34.242678	−119.113763	79	Peak Only (Event) Gauge	—
719	Freeman Diversion Channel near Saticoy	34.292778	−119.116389	—	Recording Stream Gauge	11113900
723	Santa Clara River at Victoria Ave	34.234917	−119.216611	62	Recording Stream Gauge	—
780	Beardsley Wash at Central Ave	34.2305	−119.112028	60	Recording Stream Gauge	—
776A	Revolon Slough at Pleasant Valley Rd	34.192592	−119.107875	20	Recording Stream Gauge	—

Notes: ft msl = feet above mean sea level; USGS = U.S. Geological Survey.
This table shows results from active gauges only (as of August 2016).

Table 4-2
Network of Stations Monitoring Precipitation in the Vicinity of the Oxnard Subbasin

Station Number	Station Name	Latitude	Longitude	Elevation (ft msl)	Station Type	USGS ID
273A	Oxnard NWS	34.207207	−119.137384	63	National Weather Service Site	—
403	Silverstrand Alert (Type B)	34.15271	−119.218965	18	Non-Standard Recorder	—
017C	Port Hueneme–Oxnard Sewer Plant	34.141684	−119.18665	10	Recording Precipitation Gauge	—
032A	Oxnard Civic Center	34.200087	−119.180278	53	Recording Precipitation Gauge	46569
168	Oxnard Airport	34.201647	−119.207685	34	Recording Precipitation Gauge	—

Table 4-2
Network of Stations Monitoring Precipitation in the Vicinity of the Oxnard Subbasin

Station Number	Station Name	Latitude	Longitude	Elevation (ft msl)	Station Type	USGS ID
175A	Saticoy–County Yard	34.281214	−119.141018	150	Recording Precipitation Gauge	—
177A	Camarillo–Pacific Sod	34.155471	−119.073003	20	Recording Precipitation Gauge	—
215A	Channel Is Harbor–Kiddie Beach	34.158944	−119.222338	15	Recording Precipitation Gauge	—
239	El Rio–UWCD Spreading Grounds	34.239405	−119.153009	105	Recording Precipitation Gauge	—
412	El Rio–Mesa School APCD	34.252361	−119.143056	131	Recording Precipitation Gauge	—
223A	Point Mugu–USN	34.112778	−119.119444	12	Standard Precipitation Midnight	—
215	Channel Islands Harbor	34.162042	−119.222717	5	Standard Precipitation	—
261	Saticoy–Recharge Facility	34.278889	−119.123056	145	Standard Precipitation	—

Notes: APCD = Air Pollution Control District; ft msl = feet above mean sea level; NWS = National Weather Service; USGS = U.S. Geological Survey; USN = U.S. Navy; UWCD = United Water Conservation District.
This table shows results from active gauges only.

Table 4-3
VCWPD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored by VCWPD[a]	Water Quality Samples Collected by VCWPD[a]	Water Level Sampling Schedule after GSP Adoption	Water Quality Sampling Schedule after GSP Adoption
01N21W04D04S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W04N02S	Monitoring	Multiple	Unassigned	Yes	—		—
01N21W06L04S	Agricultural	Oxnard	UAS	Yes	—		—
01N21W07H01S	Agricultural	Oxnard	UAS	Yes			—
01N21W08R01S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W09C04S	Agricultural	FCA	LAS	Yes	—		—
01N21W16A04S	Agricultural	Multiple	LAS	Yes	—		—
01N21W16M01S	Agricultural	Multiple	Both	Yes	—		—

Table 4-3
VCWPD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored by VCWPD[a]	Water Quality Samples Collected by VCWPD[a]	Water Level Sampling Schedule after GSP Adoption	Water Quality Sampling Schedule after GSP Adoption
01N21W16M03S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W16P03S	Agricultural	Multiple	LAS	Yes	—		—
01N21W17D02S	Agricultural	Oxnard	UAS	Yes	—		—
01N21W19J05S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W20K03S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W20N07S	Domestic	Multiple	UAS	Yes	—		—
01N21W21H02S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W21H03S	Agricultural	Unassigned	LAS	—	Yes		Annual
01N21W21K03S	Agricultural	Unassigned	Both	—	Yes		Annual
01N21W21N01S	Agricultural	Mugu	UAS	Yes	—		—
01N21W22C01S	Agricultural	Multiple	LAS	—	Yes		Annual
01N21W28D01S	Agricultural	Multiple	LAS	Yes	Yes		Annual
01N21W28G01S	Agricultural	Unassigned	UAS	—	Yes		Annual
01N21W28H03S	Agricultural	Unassigned	Both	—	Yes		Annual
01N21W29B03S	Agricultural	Multiple	UAS	Yes	Yes		Annual
01N21W32K01S	Municipal	FCA	LAS	Yes	—		—
01N22W03F05S	Municipal	Hueneme	LAS	—	Yes		Annual
01N22W03F07S	Municipal	Oxnard	UAS	—	Yes		Annual
01N22W06B01S	Domestic	Unassigned	UAS	—	Yes		Annual
01N22W12M01S	Agricultural	Unassigned	UAS	—	Yes		Annual
01N22W12N03S	Agricultural	Multiple	LAS	Yes	—		—
01N22W12R01S	Agricultural	Multiple	LAS	Yes	—		—
01N22W14K01S	Agricultural	Oxnard	UAS	Yes	—		—
01N22W16D04S	Municipal	Hueneme	LAS	—	Yes		Annual
01N22W19A01S	Municipal	Hueneme	LAS	—	Yes		Annual
01N22W21B03S	Municipal	Multiple	LAS	Yes	—		—
01N22W21B06S	Municipal	Multiple	LAS	—	Yes		Annual
01N22W23R02S	Agricultural	Unassigned	LAS	—	Yes		Annual
01N22W24B04S	Agricultural	Multiple	LAS	—	Yes		Annual
01N22W24C02S	Agricultural	Multiple	UAS	Yes	—		—
01N22W24C03S	Agricultural	Unassigned	Both	—	Yes		Annual
01N22W25K01S	Agricultural	Unassigned	UAS	—	Yes		Annual
01N22W25K02S	Agricultural	FCA	LAS	—	Yes		Annual

Table 4-3
VCWPD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored by VCWPD[a]	Water Quality Samples Collected by VCWPD[a]	Water Level Sampling Schedule after GSP Adoption	Water Quality Sampling Schedule after GSP Adoption
01N22W26K03S	Agricultural	Multiple	LAS	Yes	—	Twice yearly	—
01N22W26M03S	Agricultural	Hueneme	LAS	Yes	Yes		Annual
01N22W26P02S	Agricultural	Unassigned	LAS	—	Yes		Annual
01N22W26Q01S	Agricultural	Unassigned	Both	—	Yes		Annual
01N22W36B02S	Agricultural	Multiple	LAS	Yes	—		—
02N21W07P04S	Agricultural	Multiple	LAS	Yes	Yes		Annual
02N21W19A01S	Domestic	Multiple	UAS	—	Yes		Annual
02N21W19A03S	Agricultural	Multiple	LAS	Yes	—		—
02N21W19B02S	Agricultural	Oxnard	UAS	Yes	—		—
02N21W20F02S	Domestic	Multiple	Unassigned	Yes	—		—
02N21W20M03S	Agricultural	Multiple	UAS	—	Yes		Annual
02N21W20M06S	Agricultural	Multiple	LAS	Yes	—		—
02N21W31P02S	Monitoring	Multiple	Unassigned	Yes	—		—
02N21W31P03S	Monitoring	Hueneme	LAS	Yes	—		—
02N22W23H03S	Agricultural	Unassigned	UAS	—	Yes		Annual
02N22W24P01S	Agricultural	Mugu	UAS	Yes	Yes		Annual
02N22W24P02S	Agricultural	Multiple	LAS	—	Yes		Annual
02N22W24R02S	Domestic	Unassigned	UAS	—	Yes		Annual
02N22W25A02S	Agricultural	Unassigned	UAS	—	Yes		Annual
02N22W25F01S	Industrial	Unassigned	UAS	—	Yes		Annual
02N22W26E01S	Municipal	Multiple	UAS	Yes	—		—
02N22W27M02S	Municipal	Unassigned	UAS	—	Yes		Annual
02N22W30F03S	Agricultural	Unassigned	LAS	—	Yes		Annual
02N22W30K01S	Agricultural	Oxnard	UAS	Yes	—		—
02N22W31A01S	Agricultural	Multiple	Unassigned	Yes	—		—
02N22W31D02S	Agricultural	Unassigned	UAS	—	Yes		Annual
02N22W32C04S	Agricultural	Multiple	UAS	—	Yes		Annual
02N22W32Q03S	Agricultural	Multiple	UAS	Yes	—	Twice yearly	—
02N22W36E02S	Municipal	Hueneme	LAS	—	Yes		Annual
02N22W36E03S	Municipal	Hueneme	UAS	—	Yes		Annual
02N22W36F01S	Domestic	Unassigned	Unassigned	—	Yes	Twice yearly	Annual
02N22W36F02S	Agricultural	Unassigned	UAS	—	Yes		Annual

Table 4-3
VCWPD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored by VCWPD[a]	Water Quality Samples Collected by VCWPD[a]	Water Level Sampling Schedule after GSP Adoption	Water Quality Sampling Schedule after GSP Adoption
02N23W25G02S	Industrial	Multiple	Unassigned	Yes	Yes		Annual
02N23W25M01S	Agricultural	Unassigned	UAS	—	Yes		Annual
02N23W36C04S	Domestic	Oxnard	UAS	Yes	—		—

Notes: FCA = Fox Canyon Aquifer; GSP = Groundwater Sustainability Plan; LAS = Lower Aquifer System; UAS = Upper Aquifer System; VCWPD = Ventura County Watershed Protection District.
[a] As of October 2017.

Table 4-4
UWCD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
01N21W04D04S	Agricultural	Multiple	LAS			Yes			Quarterly	
01N21W06J05S	Agricultural	FCA	LAS				Yes			
01N21W06R01S	Monitoring	Oxnard	UAS			Yes			Quarterly	
01N21W07J02S	Agricultural	Multiple	LAS				Yes		Twice yearly	
01N21W10G01S	Agricultural	Multiple	LAS			Yes			Quarterly	
01N21W12D01S	Agricultural	Multiple	UAS	Yes					Bimonthly	
01N21W15J04S	Agricultural	Multiple	LAS	Yes	Yes				Monthly	
01N21W17C02S	Agricultural	Unassigned	UAS			Yes			Quarterly	
01N21W17G03S	Agricultural	Multiple	LAS	Yes					Bimonthly	
01N21W18A04S	Agricultural	Unassigned	UAS	Yes	Yes				Bimonthly	
01N21W18L05S	Agricultural	Unassigned	LAS			Yes			Quarterly	
01N21W19C01S	Agricultural	Oxnard	UAS	Yes					Bimonthly	
01N21W19J05S	Agricultural	Multiple	LAS	Yes					Bimonthly	
01N21W19L10S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W19L11S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W19L12S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W19L13S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W19L14S	Monitoring	Semi-Perched	Semi-Perched	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W20C05S	Agricultural	Mugu	UAS	Yes					Bimonthly	
01N21W20K03S	Agricultural	Multiple	LAS	Yes					Bimonthly	
01N21W21H02S	Agricultural	Multiple	LAS			Yes			Quarterly	
01N21W28D01S	Agricultural	Multiple	LAS			Yes			Quarterly	
01N21W28G04S	Agricultural	Multiple	LAS	Yes					Bimonthly	

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State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
01N21W31A05S	Monitoring	FCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N21W31A06S	Monitoring	FCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N21W31A07S	Monitoring	Mugu	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N21W31A08S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N21W31A09S	Monitoring	Oxnard	UAS	Yes				Yes	Bimonthly	Quarterly
01N21W32Q02S	Monitoring	GCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W32Q03S	Monitoring	GCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W32Q04S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W32Q05S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W32Q06S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N21W32Q07S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W01M03S	Agricultural	Multiple	LAS				Yes		Quarterly	
01N22W02A02S	Monitoring	Mugu	UAS	Yes	Yes	Yes			Monthly	
01N22W03F05S	Municipal	Hueneme	LAS			Yes			Quarterly	
01N22W03F09S	Monitoring	Unassigned	Unassigned	Yes	Yes			Yes	Monthly	Twice yearly
01N22W03F11S	Monitoring	Unassigned	Unassigned	Yes	Yes			Yes	Monthly	Twice yearly
01N22W03F13S	Municipal	Oxnard	UAS			Yes			Quarterly	
01N22W11C03S	Agricultural	Unassigned	Unassigned	Yes	Yes				Monthly	
01N22W13D03S	Agricultural	Multiple	LAS				Yes		Quarterly	
01N22W14R02S		Oxnard	UAS	Yes					Bimonthly	
01N22W16D04S	Municipal	Hueneme	LAS	Yes	Yes				Monthly	
01N22W17C03S	Municipal	Multiple	LAS			Yes			Quarterly	
01N22W18L02S	Municipal	Unassigned	LAS	Yes					Bimonthly	

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State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
01N22W19A01S	Municipal	Hueneme	LAS	Yes					Bimonthly	
01N22W20J04S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W20J05S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W20J06S	Monitoring	Mugu–Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W20J07S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W20J08S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W20M01S	Monitoring	FCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W20M02S	Monitoring	Hueneme	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W20M03S	Monitoring	Hueneme	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W20M04S	Monitoring	Mugu	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W20M05S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W20M06S	Monitoring	Semi-Perched	Semi-Perched	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W21B03S	Municipal	Multiple	LAS	Yes					Bimonthly	
01N22W21B06S	Municipal	Multiple	LAS	Yes					Bimonthly	
01N22W24B04S	Agricultural	Multiple	LAS	Yes					Bimonthly	
01N22W24C02S	Agricultural	Multiple	UAS	Yes					Bimonthly	
01N22W24M03S	Agricultural	Unassigned	Both	Yes					Bimonthly	
01N22W26J03S	Monitoring	Mugu	UAS	Yes				Yes	Bimonthly	Quarterly
01N22W26J04S	Monitoring	Oxnard	UAS	Yes				Yes	Bimonthly	Quarterly
01N22W26J05S	Monitoring	Semi-Perched	Semi-Perched	Yes				Yes	Bimonthly	Quarterly
01N22W27C02S	Monitoring	Mugu	UAS	Yes				Yes	Bimonthly	Quarterly

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State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
01N22W27C03S	Monitoring	Oxnard	UAS	Yes				Yes	Bimonthly	Quarterly
01N22W27C04S	Monitoring	Semi-Perched	Semi-Perched	Yes				Yes	Bimonthly	Quarterly
01N22W27R03S	Monitoring	Mugu	UAS	Yes				Yes	Bimonthly	Quarterly
01N22W27R04S	Monitoring	Oxnard	UAS	Yes				Yes	Bimonthly	Quarterly
01N22W27R05S	Monitoring	Oxnard	UAS	Yes				Yes	Bimonthly	Quarterly
01N22W28G01S	Monitoring	GCA	LAS	Yes	Yes			Yes	Monthly	Quarterly
01N22W28G02S	Monitoring	FCA	LAS	Yes	Yes			Yes	Monthly	Quarterly
01N22W28G03S	Monitoring	Hueneme	LAS	Yes	Yes			Yes	Monthly	Quarterly
01N22W28G04S	Monitoring	Oxnard	UAS	Yes	Yes			Yes	Monthly	Quarterly
01N22W28G05S	Monitoring	Oxnard	UAS	Yes	Yes			Yes	Monthly	Quarterly
01N22W29D01S	Monitoring	FCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W29D02S	Monitoring	Hueneme	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W29D03S	Monitoring	Hueneme	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W29D04S	Monitoring	Mugu	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W35E01S	Monitoring	GCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W35E02S	Monitoring	FCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W35E03S	Monitoring	FCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W35E04S	Monitoring	Mugu	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W35E05S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01N22W36K05S	Monitoring	GCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W36K06S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W36K07S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N22W36K08S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly

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State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
01N22W36K09S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N23W01C02S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N23W01C03S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N23W01C04S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01N23W01C05S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Quarterly
01S21W08L03S	Monitoring	GCA	LAS	Yes		Yes		Yes	Bimonthly	Quarterly
01S21W08L04S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Quarterly
01S22W01H01S	Monitoring	Multiple	LAS					Yes		Quarterly
01S22W01H02S	Monitoring	FCA	LAS					Yes		Quarterly
01S22W01H03S	Monitoring	Mugu	UAS					Yes		Quarterly
01S22W01H04S	Monitoring	Oxnard	UAS					Yes		Quarterly
02N21W06P01S	Agricultural	Multiple	Unassigned	Yes					Bimonthly	
02N21W07F01S	Agricultural	Multiple	UAS	Yes					Bimonthly	
02N21W07L03S	Monitoring	Multiple	Unassigned	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W07L04S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W07L05S	Monitoring	Multiple	Unassigned	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W07L06S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W07L07S	Municipal	Multiple	UAS				Yes		Bimonthly	
02N21W07M04S	Municipal	Multiple	UAS				Yes		Bimonthly	Twice yearly
02N21W07N02S	Agricultural	Multiple	LAS	Yes					Bimonthly	
02N21W07P03S	Agricultural	Multiple	LAS	Yes					Bimonthly	
02N21W07P04S	Agricultural	Multiple	LAS	Yes					Bimonthly	
02N21W07Q01S	Agricultural	Multiple	LAS			Yes				

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UWCD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
02N21W07R01S	Monitoring	Multiple	LAS	Yes					Bimonthly	
02N21W08D01S	Monitoring	Multiple	Unassigned	Yes					Bimonthly	
02N21W16J03S	Agricultural	Multiple	LAS	Yes					Bimonthly	
02N21W17F05S	Agricultural	FCA	LAS	Yes					Bimonthly	
02N21W18B01S	Agricultural	Multiple	UAS	Yes				Yes	Bimonthly	Twice yearly
02N21W19P01S	Agricultural	Multiple	LAS	Yes	Yes				Bimonthly	
02N21W20A02S	Agricultural	Unassigned	Unassigned	Yes					Bimonthly	
02N21W22G01S	Municipal	GCA	LAS	Yes					Bimonthly	
02N21W28A02S	Municipal	GCA	LAS	Yes					Bimonthly	
02N21W29L04S	Agricultural	Multiple	LAS	Yes	Yes				Monthly	
02N21W29M02S	Agricultural	Unassigned	Unassigned	Yes	Yes				Monthly	
02N21W30A01S	Agricultural	Unassigned	LAS	Yes	Yes				Monthly	
02N21W31P06S	Agricultural	Hueneme	LAS	Yes					Bimonthly	
02N21W32E01S	Agricultural	Multiple	LAS				Yes		Quarterly	
02N21W34G02S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W34G03S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W34G04S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W34G05S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N21W34G06S	Monitoring	Unassigned	Unassigned	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W01P02S		Oxnard	UAS			Yes		Yes	Quarterly	
02N22W01R02S	Monitoring	Multiple	Unassigned			Yes		Yes	Quarterly	Twice yearly
02N22W02R05S	Agriculture	Multiple	Both	Yes					Bimonthly	
02N22W11G01S		Oxnard	UAS			Yes		Yes	Quarterly	

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State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
02N22W11J01S	Monitoring	Multiple	Unassigned	Yes		Yes		Yes	Bimonthly	Twice yearly
02N22W11J02S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W11Q01S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Twice yearly
02N22W12A01S	Monitoring	Oxnard	UAS	Yes		Yes			Bimonthly	
02N22W12A02S	Agricultural	Oxnard	UAS	Yes					Bimonthly	
02N22W12B08S	Agricultural	Multiple	UAS	Yes		Yes			Bimonthly	
02N22W12E04S	Industrial	Multiple	Both			Yes			Quarterly	
02N22W12F03S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W12F04S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W12G03S	Industrial	Oxnard	UAS	Yes					Bimonthly	
02N22W12H01S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W12J02S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W12J04S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W12K05S	Industrial	Unassigned	UAS			Yes			Quarterly	
02N22W12N03S	Agricultural	Hueneme	LAS	Yes					Bimonthly	
02N22W12Q06S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W12R03S	Agricultural	Multiple	Both	Yes					Bimonthly	
02N22W12R04S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W12R05S	Agricultural	Unassigned	Both	Yes					Bimonthly	
02N22W13C01S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W13N02S	Municipal	Multiple	LAS				Yes		Quarterly	
02N22W13N05S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W13N06S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly

Table 4-4
UWCD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
02N22W13N07S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W14A09S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Twice yearly
02N22W14B01S	Agricultural	Multiple	LAS	Yes	Yes				Monthly	
02N22W14D01S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W14F03S	Monitoring	Oxnard	UAS	Yes		Yes		Yes	Bimonthly	Twice yearly
02N22W14G04S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W14G05S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W14G06S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W14G07S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W14G08S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W14P02S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W14P03S	Municipal	Multiple	UAS	Yes				Yes	Bimonthly	
02N22W15L01S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W15P01S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W15R02S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W16R02S	Monitoring	Oxnard	UAS			Yes		Yes	Quarterly	Twice yearly
02N22W22Q05S	Municipal	Multiple	LAS	Yes	Yes				Monthly	
02N22W22R02S	Municipal	Multiple	Unassigned	Yes	Yes				Monthly	
02N22W23B02S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W23B03S	Monitoring	FCA	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23B04S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23B05S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23B06S	Monitoring	Hueneme	LAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly

Table 4-4
UWCD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
02N22W23B07S	Monitoring	Mugu	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23B08S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23B09S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23C02S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W23C05S	Agricultural	Multiple	UAS			Yes	Yes		Quarterly	
02N22W23C06S	Municipal	Unassigned	UAS				Yes		Quarterly	
02N22W23D06S	Agricultural	Multiple	UAS	Yes					Bimonthly	
02N22W23G03S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W23G04S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W23H04S	Municipal	Multiple	LAS				Yes		Quarterly	
02N22W23H06S	Monitoring	Oxnard	UAS	Yes	Yes	Yes		Yes	Monthly	Twice yearly
02N22W23K05S	Municipal	Multiple	UAS				Yes		Quarterly	
02N22W24A01S	Agricultural	Multiple	UAS	Yes				Yes	Bimonthly	Twice yearly
02N22W24P02S	Agricultural	Multiple	LAS	Yes					Bimonthly	
02N22W25J01S	Municipal	Multiple	LAS	Yes					Bimonthly	
02N22W25L03S	Municipal	Multiple	UAS			Yes			Quarterly	
02N22W26B03S	Municipal	Hueneme	LAS				Yes		Quarterly	
02N22W26E01S	Municipal	Multiple	UAS					Yes		Twice yearly
02N22W26H02S	Agricultural	Multiple	LAS	Yes					Bimonthly	
02N22W27A02S	Municipal	Unassigned	Unassigned					Yes		Twice yearly
02N22W27A03S	Municipal	Unassigned	Unassigned					Yes		Twice yearly
02N22W27K01S	Municipal	Unassigned	UAS					Yes		Twice yearly
02N22W27L01S	Municipal	Unassigned	UAS					Yes		Twice yearly

Table 4-4
UWCD Monitoring Schedule of Wells in the Oxnard Subbasin

State Well Number (SWN)	Main Use	Screened Aquifer	Screened Aquifer System	Manual Water Levels Monitored Bimonthly[a]	Manual Water Levels Monitored Monthly[a]	Standard Transducer and Manual Water Level[a]	O&M Transducer and Manual Water Level[a]	Water Quality Samples Collected Monthly or Quarterly[a]	Water Level Sampling Schedule after GSP Adoption[a,b]	Water Quality Sampling Schedule after GSP Adoption[a]
02N22W27M02S	Municipal	Unassigned	UAS					Yes		Twice yearly
02N22W28H02S	Domestic	Unassigned	UAS					Yes		Twice yearly
02N22W30K01S	Agricultural	Oxnard	UAS	Yes					Bimonthly	
02N22W31A01S	Agricultural	Multiple	Unassigned			Yes			Quarterly	
02N22W32C04S	Agricultural	Multiple	UAS	Yes					Bimonthly	
02N22W36E04S	Monitoring	Hueneme	LAS						Twice yearly	
02N22W36E05S	Monitoring	Mugu	UAS						Twice yearly	
02N22W36E06S	Monitoring	Oxnard	UAS			Yes			Twice yearly	
02N22W36E07S	Monitoring	Mugu	UAS			Yes			Twice yearly	
02N22W36E08S	Monitoring	Hueneme	LAS			Yes			Twice yearly	
02N22W36M02S	Monitoring	Unassigned	Unassigned	Yes						

Notes: FCA = Fox Canyon Aquifer; GCA = Grimes Canyon Aquifer; GSP = Groundwater Sustainability Plan; LAS = Lower Aquifer System; O&M = operations and maintenance; UAS = Upper Aquifer System; UWCD = United Water Conservation District.

[a] As of October 2017.

[b] Although sometimes used to mean twice a month (i.e., semimonthly), *bimonthly* as used here means once every 2 months.

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Figure 4-1 Monitoring Wells Screened in the Semi-Perched Aquifer in the Oxnard Subbasin

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Figure 4-2 Monitoring Wells Screened in the Oxnard Aquifer in the Oxnard Subbasin

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Figure 4-3 Monitoring Wells Screened in the Mugu Aquifer in the Oxnard Subbasin

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Figure 4-4 Monitoring Wells Screened in the Hueneme Aquifer in the Oxnard Subbasin

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Figure 4-5 Monitoring Wells Screened in the Fox Canyon Aquifer in the Oxnard Subbasin

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Figure 4-6 Monitoring Wells Screened in the Grimes Canyon Aquifer in the Oxnard Subbasin

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Figure 4-7 Active Surface Water Monitoring Network for the Oxnard Subbasin

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Figure 4-8 Active Precipitation Monitoring Network for the Oxnard Subbasin

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Figure 4-9 Existing and Potential New Wells for Monitoring Groundwater Conditions in the Semi-Perched Aquifer

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Figure 4-10 Existing and Potential New Wells for Monitoring Groundwater Conditions in the Oxnard Aquifer

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Figure 4-11 Existing and Potential New Wells for Monitoring Groundwater Conditions in the Mugu Aquifer

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Figure 4-12 Existing and Potential New Wells for Monitoring Groundwater Conditions in the Hueneme Aquifer

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Figure 4-13 Existing and Potential New Wells for Monitoring Groundwater Conditions in the Fox Canyon Aquifer

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Figure 4-14 Existing and Potential New Wells for Monitoring Groundwater Conditions in the Grimes Canyon Aquifer

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CHAPTER 5
PROJECTS AND MANAGEMENT ACTIONS

5.1 INTRODUCTION TO PROJECTS AND MANAGEMENT ACTIONS

Projects and management actions have been developed to meet the sustainability goal, measurable objectives, and undesirable results identified for the Oxnard Subbasin (Subbasin) in Chapter 3, Sustainability Management Criteria, of this Groundwater Sustainability Plan (GSP). Seawater intrusion in the aquifers of the Upper Aquifer System (UAS) and Lower Aquifer System (LAS) has been identified as the undesirable result that will impact beneficial uses of groundwater in the Subbasin.

To address potential impacts to beneficial uses and users of groundwater in the Subbasin resulting from groundwater production in excess of the current sustainable yield, several projects were developed for the Subbasin. The projects listed below were suggested by stakeholders, selected for inclusion in the GSP through a process by the Operations Committee of the Fox Canyon Groundwater Management Agency (FCGMA) Board of Directors (Board), and approved for inclusion in the GSP by the FCGMA Board. The criteria for including a project in the GSP included the following:

- Sufficient project information is available for evaluation and modeling.
- Project increases sustainable yield, or reduces groundwater demand.
- Project implementation is planned within 20 years.
- Project meets GSP Emergency Regulations Section 354.44 criteria.
- There is an agency proponent for the project.
- Funding for the project is identified.

In the Oxnard Subbasin, five projects were determined by the Operations Committee to meet the above criteria. These five projects were incorporated into the future model scenarios to the extent possible (see Section 2.4.5, Projected Future Water Budget and Sustainable Yield). The inclusion of these projects does not constitute a commitment by the FCGMA Board to construct or fund the projects, but rather signals that these projects were sufficiently detailed to be included in groundwater modeling efforts that examined the quantitative impacts of the projects on groundwater elevations and the sustainable yield of the Subbasin. As currently envisioned, the projects in this GSP would be implemented by the project proponent or sponsoring agency. However, FCGMA may opt to implement projects in the future as necessary to achieve sustainability in the Subbasin. Additionally, all projects undertaken in the Subbasin will need to be approved and permitted by all relevant regulatory agencies. These agencies may include, but are not limited to, the Regional Water Quality Control Board and the State Water Resources Control Board.

In addition to the projects discussed in this chapter, the FCGMA Board has the authority to implement management actions to ensure that the Subbasin does not experience undesirable results. The primary management action that can be implemented by the FCGMA Board is restrictions on groundwater production. This authority was granted to the FCGMA Board in the enabling legislation that formed the FCGMA, and this action has been undertaken in the past to eliminate overdraft.

As discussed in Chapter 2, Basin Setting, groundwater modeling was used to evaluate projected water budget conditions and potential impacts to beneficial uses and users of groundwater in the basin.– Without the type of projects described below, substantially greater reductions in groundwater production will be needed to meet the sustainability goal for the basin, which would lead to significant economic disruption and prevent groundwater in the basin from being put to beneficial use to the fullest extent possible. It is anticipated, and recommended, that FCGMA will evaluate, model, and conduct feasibility studies of other projects for achieving sustainable groundwater management for the 5-year update to this GSP to optimize basin management and minimize extraction restrictions.

5.2 PROJECT NO. 1 – GREAT PROGRAM ADVANCED WATER PURIFICATION FACILITY

5.2.1 Description of Project No. 1

The Groundwater Recovery Enhancement and Treatment (GREAT) Program's Advanced Water Purification Facility (AWPF) is part of the City of Oxnard's GREAT Program, which focuses on using existing water resources more efficiently. The AWPF provides the City of Oxnard with a source of reclaimed water that can be used for landscape irrigation, agricultural, industrial process water, and groundwater recharge. The AWPF is designed to initially treat approximately 8 to 9 million gallons per day (mgd) of secondary effluent from the Oxnard Wastewater Treatment Plant and produce 6.25 mgd of product water for reclaimed water uses. This is equivalent to 7,000 acre-feet per year (AFY) of product water that can be delivered through existing infrastructure. The AWPF is currently producing up to 4,600 AFY. Advanced purified water was first delivered to agricultural operators in 2016. The portion of the project that is being considered for inclusion in GSP is the additional water that is being purchased by FCGMA to reduce groundwater extractions for which no Recycled Water Pumping Allocation is issued.

5.2.2 Relationship of Project No. 1 to Sustainability Criteria

GREAT Program AWPF Project water was included in future groundwater modeling scenarios to examine the impact that the project may have on the sustainability criteria. This project was incorporated in the modeling along with the expansion of the GREAT Program AWPF (see Section 5.3, Project No. 2 – GREAT Program Advanced Water Purification Facility Expansion Project) and the temporary fallowing of agricultural land (see Section 5.6, Project No. 5 – Temporary Agricultural Land Fallowing Project). Therefore, the relationship between the impact of this project alone and the sustainability indicators has not been quantified. Rather, the potential effect of this project in the context of all three of these projects is presented in this discussion.

Relationship to Minimum Thresholds

The minimum thresholds for both the UAS and the LAS in the Oxnard Subbasin are higher than the historical low water levels and the spring 2015 water levels (see Chapter 3). In the UAS, the minimum thresholds are approximately 41 feet higher than historical low water levels and 25 feet higher than spring 2015 water levels. In the LAS, the minimum thresholds are approximately 70 feet higher than historical low water levels, and 38 feet higher than spring 2015 water levels.

The numerical groundwater model simulation of the Future Baseline With Projects scenario, which incorporates potential future projects including the GREAT Program AWPF Project, results in higher groundwater elevations than the Future Baseline scenario, which does not incorporate projects (see Section 2.4). Incorporation of the projects resulted in groundwater elevations at the end of the 50-year model simulation that were, on average, approximately 2 feet higher in the UAS and approximately 8 feet higher in the LAS. This suggests that the projects will assist with water level recovery in the Subbasin, a necessary first step to avoid exceedance of the minimum thresholds. Although implementation of the projects increases water levels in the Subbasin, these projects alone did not provide sufficient recycled water or redistribution of groundwater production to avoid exceedance of the minimum thresholds.

As modeled, the GREAT Program AWPF Project supplied approximately 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road (Chapter 2~~, Basin Setting~~). This accounts for approximately half of the water delivered in the Future Baseline With Projects scenario. Because groundwater elevations were higher in the Future Baseline With Projects scenario than they were in the Future Baseline scenario, and because the GREAT Program AWPF Project supplied approximately half of the project water modeled this project is anticipated to result in measurably higher groundwater elevations in the Oxnard Subbasin. Therefore, the GREAT Program AWPF Project is anticipated to benefit the Subbasin and assist with raising groundwater elevations above the minimum thresholds in the future.

Relationship to Measurable Objectives

The relationship of the GREAT Program AWPF Project to the measurable objectives is similar to the relationship with the minimum thresholds. By measurably increasing water levels in the Subbasin, the GREAT Program AWPF Project water will help the Oxnard Subbasin meet the measurable objective water levels defined in Chapter 3.

5.2.3 Expected Benefits of Project No. 1

The AWPF product water that will be put to use in the Oxnard Subbasin is secondary wastewater effluent that is currently discharged to the Pacific Ocean. Therefore, this project provides a new source of water for use in the Subbasin. This additional water is expected to benefit the Oxnard Subbasin by providing water that would otherwise be pumped from the Subbasin to farmers in the vicinity of Hueneme Road, an area that is currently threatened by the inland migration of the saline water impact front (see Section 2.3, Groundwater Conditions).

5.2.4 Timetable for Implementation of Project No. 1

Phase 1 of the GREAT Program AWPF Project has already been permitted and constructed, and the AWPF Project is currently operating in the Subbasin. Under the current program, AWPF water is being delivered to farmers. The City of Oxnard receives a Recycled Water Pumping Allocation for delivered water used by farmers in lieu of groundwater production. Implementation of the project relative to the GSP will depend on the timetable necessary to deliver the GREAT Program AWPF water to farmers for in-lieu groundwater production for which no allocation or credits are provided to the City of Oxnard. Therefore, if the GREAT Program AWPF Project is incorporated into management of the Oxnard Subbasin for the purpose of increasing groundwater elevations to meet the sustainability criteria, the time for implementing the GREAT Program AWPF Project will depend on acquiring the necessary agreements between FCGMA and the City of Oxnard. This is anticipated to require less than 1 year.

5.2.5 Metrics for Evaluation of Project No. 1

Evaluation of the GREAT Program AWPF Project will be based on the quantity of water delivered to farmers in the vicinity of Hueneme Road and the associated reduction in groundwater production from this area. Groundwater producers in the Oxnard Subbasin have been required to report groundwater production to FCGMA since 1983. The GREAT Program AWPF water delivered to farmers will also have to be reported to FCGMA if this project is implemented as part of the GSP.

5.2.6 Economic Factors and Funding Sources for Project No. 1

The capital to construct the GREAT Program AWPF Project facilities has already been funded by City of Oxnard bonds and federal grant money (FCGMA 2018). Ongoing operations and maintenance are anticipated to equal approximately $300 per acre-foot (AF) of water generated by the project (FCGMA 2018). Funding for operations and maintenance has not been identified; however, as proposed, funding may come from a replenishment fee implemented by the FCGMA Board. ~~The cost of the water produced by the GREAT Program AWPF Project is approximately $3,100 per AF.~~

Any action taken by the FCGMA Board, acting as the Groundwater Sustainability Agency for the portion of the ~~LPVB~~ Oxnard Subbasin in its jurisdiction, to impose or increase a fee shall be taken by ordinance or resolution. Should the FCGMA Board decide to fund a project through imposition of a replenishment fee, FCGMA will hold at least one public meeting, at which oral or written presentations may be made. Notice of the meeting will include an explanation of the fee to be considered and the notice shall be published pursuant to Section 6066 of the Government Code.[1] At least 20 days prior to the meeting, the Groundwater Sustainability Agency will make the data on which the proposed fee is based available to the public.

5.3 PROJECT NO. 2 – GREAT PROGRAM ADVANCED WATER PURIFICATION FACILITY EXPANSION PROJECT

5.3.1 Description of Project No. 2

The GREAT Program's AWPF is part of the City of Oxnard's GREAT Program, which focuses on using existing water resources more efficiently. The purpose of the GREAT Program AWPF Expansion Project is to increase the production of high-quality recycled water within the City of Oxnard, the Oxnard Subbasin, and the Pleasant Valley Basin. This project will provide additional reclaimed water for Subbasin recharge. The AWPF Expansion Project is predicated on the availability of secondary effluent from the Oxnard Wastewater Treatment Plant or other available and appropriate source water. The main project components include purchase and installation of additional microfiltration, reverse osmosis, and ultraviolet/advanced oxidation equipment. Additionally, the project will require construction of influent flow equalization facilities. The AWPF Expansion Project could occur in phases, which would be dictated by the availability of source water, recycled water uses and needs, and project funding.

5.3.2 Relationship of Project No. 2 to Sustainability Criteria

GREAT Program AWPF Expansion Project water was included in future groundwater modeling scenarios to examine the impact that the project will have on the sustainability criteria. This project was incorporated in the modeling along with the GREAT Program AWPF Project (see Section 5.2, Project No. 1 – GREAT Program Advanced Water Purification Facility) and the temporary fallowing of agricultural land (see Section 5.6). Therefore, the relationship between the impact of this project alone and the sustainability indicators has not been quantified. Rather, the potential effect of this project in the context of all of three of these projects is presented in this discussion.

[1] Publication of notice pursuant to Section 6066 of the Government Code: "shall be once a week for two successive weeks. Two publications in a newspaper, published once a week or oftener, with at least five days intervening between the respective publication dates not counting such publication dates are sufficient."

Relationship to Minimum Thresholds

The numerical groundwater model simulation of the Future Baseline With Projects scenario, which incorporates potential future projects including the GREAT Program AWPF Expansion Project, results in higher groundwater elevations than the Future Baseline scenario, which does not incorporate projects (see Section 2.4, Water Budget). Incorporation of the projects resulted in groundwater elevations at the end of the 50-year model simulation that were, on average, approximately 2 feet higher in the UAS and approximately 8 feet higher in the LAS. This suggests that the projects will assist with water level recovery in the Subbasin, a necessary first step to avoid exceedance of the minimum thresholds. Although implementation of the projects increases water levels in the basin, these projects alone did not provide sufficient recycled water or redistribution of groundwater production to meet the minimum thresholds.

The AWPF Expansion Project water accounts for approximately half of the water delivered in the Future Baseline With Projects scenario. Because groundwater elevations were higher in the Future Baseline With Projects scenario compared to the Future Baseline scenario, and because the AWPF Expansion Project supplied approximately half of the project water modeled, the AWPF Expansion Project is anticipated to result in measurably higher groundwater elevations in the Oxnard Subbasin. Therefore, this project is anticipated to benefit the Subbasin and assist with raising groundwater elevations above the minimum thresholds in the future.

As modeled, the GREAT Program AWPF Expansion Project supplied approximately 4,500 AFY of recycled water to the United Water Conservation District (UWCD) Saticoy Spreading Grounds (see Section 2.4.5). This would be a recharge, rather than an in-lieu, program. However, the exact use of the AWPF Expansion Project water is not currently specified. It can be used for groundwater recharge, but it can also be used as part of an in-lieu program or for indirect potable reuse.

Relationship to Measurable Objectives

The relationship of the GREAT Program AWPF Expansion Project to the measurable objectives is similar to the relationship with the minimum thresholds. By measurably increasing water levels, the GREAT Program AWPF Expansion Project will help the Oxnard Subbasin meet the measurable objective water levels defined in Chapter 3.

5.3.3 Expected Benefits of Project No. 2

The AWPF Expansion Project product water that will be put to use in the Oxnard Subbasin is secondary wastewater effluent that is currently discharged to the Pacific Ocean. Therefore, this project provides a new source of water for use in the Subbasin. This additional water is expected to benefit the Oxnard Subbasin by providing additional recharge via the Saticoy Spreading Grounds (see Section 2.3).

5.3.4 Timetable for Implementation of Project No. 2

The City of Oxnard has already constructed and already operates the GREAT Program AWPF. As discussed in Section 5.3.1, Description of Project No. 2, the AWPF Expansion Project will require purchase and installation of additional equipment, as well as construction of influent flow equalization facilities. The expansion can occur in phases; therefore, the timetable for implementing the project is not fixed at this time. The implementation timetable for expansion of the AWPF is not dependent on permits or completion of California Environmental Quality Act (CEQA) documentation, which has already been obtained. The City of Oxnard estimates that the construction timetable for implementation of the AWPF Expansion Project is approximately 1 year.

The timetable for incorporating the GREAT Program AWPF Expansion Project water into sustainable management programs will also depend on how the water will be used. If, for example, the water will be conveyed to the Saticoy Spreading Grounds, the necessary infrastructure to convey the water will need to be constructed, in addition to construction of the expanded facility. Depending on the permitting required and construction time frames, it is anticipated that the timetable for incorporation of the AWPF Expansion Project water in sustainable management programs may take an additional 1 to 5 years beyond what was estimated by the City of Oxnard for construction of the expanded AWPF alone.

5.3.5 Metrics for Evaluation of Project No. 2

Evaluation of the GREAT Program AWPF Expansion Project will be based on the quantity of water delivered by the project. This water will be metered and the quantity of water delivered will be reported to FCGMA annually.

5.3.6 Economic Factors and Funding Sources for Project No. 2

Expansion of the AWPF can occur in phases, and the degree to which the AWPF is expanded will depend on the quantity of water available and the demand for the water produced. Therefore, the exact cost of expanding the GREAT Program AWPF is not currently known. Under one potential expansion scenario, the facility upgrades are anticipated to cost approximately $16,600,000 (FCGMA 2018). Under this scenario, the water produced by the facility would cost approximately $1,900 per AF. Operations and maintenance costs for the expanded AWPF would be approximately $440 per AF. Funding sources have not yet been identified for this project, although a portion of the project may be funded by replenishment fees implemented by the FCGMA Board. Any action taken by the FCGMA Board to impose or increase a fee shall be taken by ordinance or resolution, and notice shall be provided of any meeting at which imposition of the ordinance or resolution will be discussed (see Section 5.2.6, Economic Factors and Funding Sources for Project No. 1).

5.4 PROJECT NO. 3 – RIVERPARK–SATICOY GRRP RECYCLED WATER PROJECT

5.4.1 Description of Project No. 3

The RiverPark–Saticoy Groundwater Replenishment and Reuse Project (GRRP) Recycled Water Project will convey water produced by the GREAT Program AWPF Expansion Project (see Section 5.3) to the Saticoy Groundwater Recharge Facility and El Rio Groundwater Recharge Facility operated by UWCD (FCGMA 2018). In 2016, the City of Oxnard completed the northernmost portion of its 9.5-mile north–south Recycled Water Backbone Pipeline, which terminates at the RiverPark development adjacent to the Santa Clara River, north of Highway 101. This pipeline does not currently reach UWCD's groundwater recharge facilities. Under the GRRP Recycled Water Project, the Recycled Water Backbone Pipeline will be extended by 3 miles to convey water from the AWPF Expansion Project to UWCD groundwater recharge facilities. The 3-mile pipeline extension is called the RiverPark–Saticoy Pipeline. Up to 4,800 AFY of water will be conveyed to the UWCD recharge facilities via the Recycled Water Backbone and RiverPark–Saticoy Pipelines. It should be noted that this project does not provide water in addition to Project No. 2; rather, it provides the infrastructure to deliver the GREAT AWPF expansion water to the Saticoy Spreading Grounds.

5.4.2 Relationship of Project No. 3 to Sustainability Criteria

The RiverPark–Saticoy GRRP Recycled Water Project, using the AWPF Expansion Project product water to recharge groundwater in the Oxnard Forebay, was included in future groundwater modeling scenarios to examine the impact that the project will have on the sustainability criteria. The RiverPark–Saticoy GRRP Recycled Water Project is the same as the GREAT Program AWPF Expansion Project, as incorporated into the numerical groundwater model simulations, because the RiverPark–Saticoy GRRP Recycled Water Project simply provides the infrastructure to convey the water. It does not provide additional water to the Subbasin beyond what was modeled for the GREAT Program AWPF project. As discussed in Section 5.2.2, Relationship of Project No. 1 to Sustainability Criteria, and Section 5.3.2, Relationship of Project No. 2 to Sustainability Criteria, the relationship between the impact of this project alone and the sustainability indicators has not been quantified. Rather, the potential effect of this project in the context of all three of these projects is presented in this discussion.

Relationship to Minimum Thresholds

As modeled, the RiverPark–Saticoy GRRP Recycled Water Project provided the infrastructure to supply approximately 4,500 AFY of recycled water to the UWCD Saticoy Spreading Grounds (see Section 2.4.5). This would be a recharge, rather than an in-lieu, program. The numerical groundwater model simulation of the Future Baseline With Projects scenario, which incorporates potential future projects including the RiverPark–Saticoy GRRP Recycled Water Project, results in higher groundwater elevations than the Future Baseline scenario, which does not incorporate projects (see Section 2.4). This suggests that the projects will assist with water level recovery in the Subbasin, a necessary first step to avoid exceedance of the minimum thresholds. Although implementation of the projects increases water levels in the basin, these projects alone did not provide sufficient recycled water or redistribution of groundwater production to avoid the exceedance of the minimum thresholds.

The AWPF Expansion Project water, delivered via the RiverPark–Saticoy GRRP Recycled Water Project, accounts for approximately half of the water delivered in the Future Baseline With Projects scenario. Because groundwater elevations were higher in the Future Baseline With Projects scenario than they were in the Future Baseline scenario, and because the RiverPark–Saticoy GRRP Recycled Water Project supplied approximately half of the project water modeled, the RiverPark–Saticoy GRRP Recycled Water Project is anticipated to result in measurably higher groundwater elevations in the Oxnard Subbasin. Therefore, the RiverPark–Saticoy GRRP Recycled Water Project is anticipated to benefit the Subbasin and assist with raising groundwater elevations above the minimum thresholds in the future.

Relationship to Measurable Objectives

The relationship of the RiverPark–Saticoy GRRP Recycled Water Project to the measurable objectives is similar to the relationship with the minimum thresholds. By measurably increasing water levels, the RiverPark–Saticoy GRRP Recycled Water Project will help the Oxnard Subbasin meet the measurable objective water levels defined in Chapter 3.

5.4.3 Expected Benefits of Project No. 3

The RiverPark–Saticoy GRRP Recycled Water Project is expected to benefit the Oxnard Subbasin by providing the infrastructure to take secondary treated wastewater from the Oxnard Water Treatment Plant and using it for groundwater recharge (FCGMA 2018). Currently, this water is being discharged to the Pacific Ocean. The RiverPark–Saticoy Pipeline and the GRRP will help ensure that excess flows from the AWPF will be used for groundwater recharge. In addition, the product water from the AWPF Expansion Project is of higher quality than groundwater in the Oxnard Forebay. Therefore, by using this water to recharge groundwater in the Forebay, implementation of the GRRP Recycled Water Project is expected to improve groundwater quality in the Forebay (FCGMA 2018).

5.4.4 Timetable for Implementation of Project No. 3

UWCD estimates that the RiverPark–Saticoy GRRP Recycled Water Project could be implemented in 18 to 24 months. The project is already in the preliminary design phase and a draft initial study/mitigated negative declaration has been prepared. The required project permits (a groundwater replenishment reuse permit and a California Department of Transportation (Caltrans) permit) are anticipated to take 12 to 18 months to obtain, and the likelihood of obtaining these permits is anticipated to be high (FCGMA 2018).

5.4.5 Metrics for Evaluation of Project No. 3

The metric for evaluation of the RiverPark–Saticoy GRRP Recycled Water Project will be the quantity of water delivered to UWCD's groundwater recharge facilities. UWCD will meter the deliveries and will report these to FCGMA for incorporation in the annual and periodic GSP evaluation process.

5.4.6 Economic Factors and Funding Sources for Project No. 3

Funding sources for the RiverPark–Saticoy GRRP Recycled Water Project is proposed to come from either UWCD Zone B or FCGMA funds (FCGMA 2018). UWCD proposes funding assistance from FCGMA for the capital cost of the project, which is estimated to be $6.4 million, with an annual operations and maintenance cost of approximately $5 million to $7.5 million. The resulting water cost would be approximately $1,000 to $1,500 per AF. These operating costs are anticipated to be provided by a pump charge administered ~~either~~ by ~~UWCD or by~~ FCGMA. The timeline necessary to secure funding for the project is anticipated to be the same as the construction timeline.

Any action taken by the FCGMA Board to impose or increase a fee shall be taken by ordinance or resolution, and notice shall be provided of any meeting at which imposition of the ordinance or resolution will be discussed (see Section 5.2.6).

5.5 PROJECT NO. 4 – FREEMAN EXPANSION PROJECT

5.5.1 Description of Project No. 4

UWCD currently operates the Freeman Diversion on the Santa Clara River, which diverts surface water flows from the river into recharge facilities for the purpose of providing additional recharge to the Oxnard Subbasin, and for direct delivery to growers via UWCD pipelines. Through time, more restrictive environmental regulatory requirements have lessened the amount of Santa Clara River surface water available to be diverted at the Freeman Diversion. The Freeman Expansion Project proposes constructing facilities capable of diverting surface water at higher flow rates and with higher sediment loads than the currently diverted flows (FCGMA 2018). Using the higher flows, which are less conducive to fish migration, has been encouraged by both regulatory agencies and non-governmental organizations (FCGMA 2018).

The Freeman Expansion Project would expand the recharge facilities, using two former gravel mines located adjacent to UWCD's Noble Basin recharge facility that have not previously been used for groundwater recharge, and would increase the capacity of UWCD's diversion system (FCGMA 2018). The project would also include modification and expansion of existing fish screens, modifications to the existing desilting basin, and construction of a high-capacity conveyance to the former Ferro aggregate mining pit. Although the exact capacity of the project is not currently known, UWCD anticipates that at full project build-out, the expanded facility could provide an additional 7,400 AF of diversions relative to the current diversion capacity (FCGMA 2018).

5.5.2 Relationship of Project No. 4 to Sustainability Criteria

Historically UWCD has diverted over 62,000 AFY from the Freeman Diversion (see Table 2-8). The Freeman Expansion Project would provide up to an additional 7,400 AF. Although expansion of UWCD's diversion capabilities at the Freeman Diversion was not explicitly modeled in the GSP future projects scenarios, historical groundwater elevations are strongly and positively correlated with the quantity of surface water diverted by UWCD. Therefore, increased surface water diversions that will be delivered directly to agricultural users, thereby offsetting groundwater production, or that will be recharged via UWCD's recharge facilities will help increase water levels in the Subbasin.

Relationship to Minimum Thresholds

Groundwater elevations in the Oxnard Subbasin are currently below the minimum thresholds proposed in Chapter 3 of this GSP. Increased recharge of surface water that currently flows to the Pacific Ocean will help water levels recover to elevations above the proposed minimum thresholds. The magnitude of the groundwater level rise will depend on the quantity of additional recharge available via the expanded diversion facilities.

Relationship to Measurable Objectives

The relationship of the Freeman Expansion Project to the measurable objectives is the same as the relationship with the minimum thresholds. By increasing water levels in the Subbasin, the Freeman Diversion Project will help the Oxnard Subbasin meet the measurable objective water levels defined in Chapter 3.

5.5.3 Expected Benefits of Project No. 4

The Freeman Expansion Project will provide an additional source of water to the Oxnard Subbasin by diverting high flows, which are not as suitable for fish migration, from the Santa Clara River and using those flows to provide additional groundwater recharge. The surface water flows in the Santa Clara River are lower in total dissolved solids and nitrate concentration compared to the groundwater in the Oxnard Forebay. Therefore, this project will reduce the concentrations of these constituents in the groundwater. Additionally, replenishing the groundwater will reduce pump lift, and therefore energy consumption, for municipal and agricultural pumpers (FCGMA 2018).

5.5.4 Timetable for Implementation of Project No. 4

The timetable for implementation of the Freeman Expansion Project is estimated to be between 2 and 10 years (FCGMA 2018). The required modifications to the conveyance system needed to deliver turbid water have been analyzed, and this project was included in the UWCD Habitat Conservation Plan (FCGMA 2018). However, the project has not yet undergone environmental review, engineering design, or permitting.

5.5.5 Metrics for Evaluation of Project No. 4

The metric for evaluation of the Freeman Expansion Project would be the quantity of surface water diverted at flow rates that are higher than the current maximum flow rate that can be diverted. UWCD meters diversions from the Santa Clara River and would report these to FCGMA.

5.5.6 Economic Factors and Funding Sources for Project No. 4

Improvements to the conveyance system, fish screens, and desilting basin inlet are estimated to cost $31 million (FCGMA 2018). The annual operations and maintenance cost is estimated to be $700,000. The combined capital and operations and maintenance cost of the water is estimated to be approximately $4,300 AFY. Funding sources for the project are anticipated to include grant money, UWCD rate payers, and replenishment fees from FCGMA.

Any action taken by the FCGMA Board to impose or increase a fee shall be taken by ordinance or resolution, and notice shall be provided of any meeting at which imposition of the ordinance or resolution will be discussed (see Section 5.2.6).

5.6 PROJECT NO. 5 – TEMPORARY AGRICULTURAL LAND FALLOWING PROJECT

5.6.1 Description of Project No. 5

The Temporary Agricultural Land Fallowing Project would use replenishment fees to lease and temporarily fallow agricultural land (FCGMA 2018). This would result in decreased groundwater production on the parcels or ranches that are fallowed, and an overall reduction in groundwater demand in the Subbasin. Parcels or ranches in areas susceptible to seawater intrusion would be targeted with this project (FCGMA 2018).

5.6.2 Relationship of Project No. 5 to Sustainability Criteria

Temporary fallowing of agricultural land was included in future groundwater modeling scenarios to examine the impact that the project will have on the sustainability criteria (see Section 2.4.5). As discussed in Sections 5.2.2 and 5.3.2, the relationship between the impact of this project alone and the sustainability indicators has not been quantified. Rather, the potential effect of this project in the context of all three of these projects is presented in this discussion.

Relationship to Minimum Thresholds

As modeled, the Temporary Agricultural Land Fallowing Project reduced production from the Subbasin by approximately 500 AFY (see Section 2.4.5). The numerical groundwater model simulation of the Future Baseline With Projects scenario, which incorporates potential future projects including the Temporary Agricultural Land Fallowing Project, results in higher groundwater elevations than the Future Baseline scenario, which does not incorporate projects (see Section 2.4). This suggests that the projects will assist with water level recovery in the Subbasin, a necessary first step to meet the minimum threshold. Although implementation of the projects increases water levels in the basin, these projects alone did not provide sufficient supplemental water or redistribution of groundwater production to meet the minimum thresholds. Additionally, the Temporary Agricultural Land Fallowing Project accounted for approximately 7% of the total volume of water delivered or saved by all of the projects in the Oxnard Subbasin that were incorporated into the future groundwater model scenarios. The effect of this project on groundwater elevations is likely smaller than that of other projects incorporated into the future model scenarios. However, the value of this project is more directly connected with the location of the land that would be fallowed. If the project can target areas that are prone to seawater intrusion, the impact of this project will be greater than would be indicated by a comparison of the volume of water supplied.

Relationship to Measurable Objectives

The relationship of the Temporary Agricultural Land Fallowing Project to the measurable objectives is similar to the relationship with the minimum thresholds. By increasing water levels and fallowing agricultural land prone to seawater intrusion, the Temporary Agricultural Land Fallowing Project will help the Oxnard Subbasin meet the measurable objective water levels defined in Chapter 3.

5.6.3 Expected Benefits of Project No. 5

Temporary fallowing is a quick way to reduce demand with no capital costs or infrastructure needed. Because it is inexpensive, it is envisioned that temporary fallowing could be implemented early, while other long-term solutions are investigated and implemented. The Temporary

Agricultural Land Fallowing Project will benefit the Oxnard Subbasin by mitigating seawater intrusion in the Subbasin. This project would complement a water market that is currently being developed for the Subbasin by providing an alternative method for landowners to monetize pumping allocations (FCGMA 2018).

5.6.4 Timetable for Implementation of Project No. 5

The project is currently in the planning phase but does not require construction of new facilities and is unlikely to require permitting. CEQA compliance has not yet been initiated but the project proponents anticipate that a negative declaration or a mitigated negative declaration may be sufficient (FCGMA 2018). The project could be implemented when FCGMA is able to collect replenishment fees, and willing lessors are found to participate.

5.6.5 Metrics for Evaluation of Project No. 5

The metric for evaluation of the Temporary Agricultural Land Fallowing Program will be the volume of groundwater that is not produced from wells that supply the fallowed acreage. FCGMA has required groundwater production reporting since 1983. Groundwater production rates from before the project is implemented will be compared to groundwater production rates when the parcel or ranch has been fallowed. If the project is implemented, the historical production rates and associated base period for calculating those rates will be determined.

5.6.6 Economic Factors and Funding Sources for Project No. 5

The funding source for this project is anticipated to be replenishment fees collected by FCGMA. The cost of water under this project is estimated to be $1,200 to $1,800 per acre-foot. Any action taken by the FCGMA Board to impose or increase a fee shall be taken by ordinance or resolution, and notice shall be provided of any meeting at which imposition of the ordinance or resolution will be discussed (see Section 5.2.6)

5.7 MANAGEMENT ACTION NO. 1 – REDUCTION IN GROUNDWATER PRODUCTION

5.7.1 Description of Management Action No. 1

The primary management action proposed under this GSP is a Reduction in Groundwater Production from the Oxnard Subbasin. FCGMA has had the authority to monitor and regulate groundwater production in the Oxnard Subbasin since 1983. The FCGMA Board has used its authority to reduce groundwater production from the Subbasin in the past, and will continue to exert its authority over groundwater production as the Groundwater Sustainability Agency for the Subbasin.

The estimated long-term rate of groundwater production in the UAS that will prevent net seawater intrusion after 2040 is approximately 32,000 AFY ± 4,100 to 6,000 AFY (see Section 2.4.5). The estimated long-term rate of groundwater production in the LAS that will prevent net seawater intrusion after 2040 is approximately 7,000 AFY ± 2,300 to 3,600 AFY (see Section 2.4.5). Reductions in groundwater production were modeled as a linear decrease from the 2015–2017 production rates. The exact reductions that will be implemented in the Subbasin over the next 5 years will be determined by the FCGMA Board based on the data collected and analyzed for this GSP. These reductions will be evaluated based on the potential paths to reaching sustainability discussed in Chapter 3.

5.7.2 Relationship of Management Action No. 1 to Sustainability Criteria

Reducing groundwater production in the Oxnard Subbasin has a measurable impact on groundwater elevations. Groundwater elevations, in turn, control seawater intrusion. Seawater intrusion occurs in the Subbasin when groundwater elevations fall below threshold elevations that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The relationship between seawater intrusion and groundwater elevation is impacted by groundwater production throughout the Subbasin, but is strongest in wells adjacent to the coast.

The effect of Reduction in Groundwater Production on groundwater level elevations was simulated using a numerical groundwater model (see Section 2.4.5). The results of the model and the relationship between Reduction in Groundwater Production and the sustainability criteria is discussed below.

Relationship to Minimum Thresholds

In the absence of additional projects, purchase of imported water, and shifting groundwater production locations, Reduction in Groundwater Production in the Subbasin is a critical component of achieving sustainability. When groundwater production was reduced from the 2015–2017 average production rates, simulated future groundwater elevations in the Subbasin recovered to elevations that remained above the minimum threshold after 2040 (see Section 2.4.5). The long-term production rate necessary to maintain groundwater elevations above the minimum threshold depended on several factors, including the simulated future climate, the quantity of surface water available to recharge the Subbasin, and the number of projects undertaken. Therefore, the numerical groundwater simulation results suggest a range of potential reductions in groundwater production that will maintain groundwater elevations above the minimum thresholds. This range is anticipated to change as additional data are collected and additional projects are implemented over the next 5 years. Therefore, any reductions implemented by the FCGMA Board over the initial 5-year period after the GSP is adopted will be evaluated and may be changed as warranted by future conditions in the Subbasin.

Relationship to Measurable Objectives

The relationship between Reduction in Groundwater Production and the measurable objectives is similar to the relationship between Reduction in Groundwater Production and the minimum thresholds. Numerical groundwater model simulations suggest a range of potential groundwater production rates that would result in groundwater elevations that are higher than the measurable objective half of the time and lower than the measurable objective half of the time (see Section 3.5, Measurable Objectives). As discussed previously, this range is anticipated to change as additional data are collected and additional projects are implemented over the next 5 years. Therefore, any reductions implemented by the FCGMA Board over the initial 5-year period after the GSP is adopted will be evaluated and may be changed as warranted by future conditions in the Subbasin.

5.7.3 Expected Benefits of Management Action No. 1

The primary benefit related to Reduction in Groundwater Production is recovery of groundwater elevations that have historically allowed for seawater intrusion in the Oxnard Subbasin. Reduction in Groundwater Production can be used to close any differential between groundwater elevations that can be obtained through implementation of projects and the groundwater elevations necessary to prevent future net seawater intrusion in the UAS and the LAS.

5.7.4 Timetable for Implementation of Management Action No. 1

The FCGMA Board already has the authority to reduce groundwater production in the Subbasin. Therefore, reductions can be implemented within months of GSP adoption, once the proposed reductions have gone through the FCGMA Board approval process.

5.7.5 Metrics for Evaluation of Management Action No. 1

The metric for evaluation of Reduction in Groundwater Production will be groundwater elevations in the UAS and the LAS. As groundwater elevations recover, additional projects are developed, and basin management is optimized, groundwater production rates will continue to be evaluated and adjusted accordingly.

5.7.6 Economic Factors and Funding Sources for Management Action No. 1

Program administration, investigations, inspections, compliance assistance, and enforcement of the Reduction in Groundwater Production management action will rely on funding from pumping fees imposed by FCGMA. Economic factors that will affect Reduction in Groundwater Production include impacts to the users of groundwater in the Subbasin. Potential economic impacts to stakeholders will be considered in the decision process for selecting future groundwater production rates and reductions necessary to meet the sustainability goal for the Subbasin.

5.7.7 Management Action No. 1 Uncertainty

Groundwater production from the Oxnard Subbasin has resulted in historical seawater intrusion, and groundwater model simulations indicate that sustainable groundwater production rates will need to be lower than historical rates to prevent net seawater intrusion in each aquifer system after 2040. Nevertheless, uncertainty remains regarding the exact reductions in groundwater production required to achieve the sustainability goals for the Subbasin. Uncertainty in the hydrogeologic conceptual model and the numerical groundwater model is discussed in Chapter 2 of this GSP. Uncertainty in the minimum thresholds and measurable objectives is discussed in Chapter 3. Chapters 2 and 3 also discuss uncertainty associated with the future location of groundwater production and impacts of projects that will optimize management of the Subbasin.

Because of the existing uncertainty associated with future conditions in the Subbasin, a plan for exact reductions and groundwater elevation triggers for those reductions has not been developed as part of this GSP. Instead, FCGMA will work to develop this plan over next 20 years, as the level of uncertainty is reduced. FCGMA recognizes that a specific long-term plan that incorporates stakeholder feedback and the need for flexibility in groundwater management will have to be adopted by 2040 to provide users of groundwater in the Subbasin with the tools necessary to plan for sustainable groundwater production into the future.

~~5.9~~5.8 MANAGEMENT ACTION NO. ~~3~~ 2 – WATER MARKET PILOT PROGRAM

A Water Market Pilot Program is currently being conducted by the FCGMA as a means of increasing operational management of groundwater in the Subbasin. The pilot program will run through July 2019 and may be extended to October 2019 (FCGMA 2019). The program is open to agricultural operators in the Oxnard Subbasin who are authorized by FCGMA to participate. Participants are able to submit anonymous bids and offers to an electronic trading desk that matches potential buyers and sellers. Matching takes place at 4:00 p.m. on Friday each week of the pilot program (FCGMA 2019). Transfer of extraction allocation will be reported to FCGMA by the Exchange Administrator.

Trades are limited by both geography and quantity. Transfers that result in a net increase in the total market allocation for participants in the Saline Water Intrusion Management Area or Pumping Depression Management Areas are not allowed. Additionally, participants with a well located in the Saline Water Intrusion Management Area may receive a transfer of market allocation only from another participant with a well in the Saline Water Intrusion Management Area. The same is true for participants in the Pumping Depression Management Areas.

Analysis of the Water Market Pilot Program will be conducted and its suitability for incorporation as a management action for the Subbasin will be determined after the pilot program is completed in July 2019.

~~5.10~~5.9 REFERENCES CITED

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