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June 2023

Salinas Valley Groundwater Basin Investigation

Prepared for:

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Prepared by:

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ACRONYMS & ABBREVIATIONS

AF ....acre-feet
AF/yr ....acre-feet per year
AMBAG.................................Association of Monterey Bay Area Governments
ASGSA ....Arroyo Seco Groundwater Sustainability Agency
ASR......................................aquifer storage and recovery
Basin ....Salinas Valley Groundwater Basin
County...................................County of Monterey
CSIP ....Castroville Seawater Intrusion Project
DOF......................................California Department of Finance
DWR ....California Department of Water Resources
EIR ....2008 Monterey County Environmental Impact Report
ET...evapotranspiration
FMMP ....Farmland Monitoring and Mapping Program
GEMS ....Monterey County Groundwater Extraction Management System
General Plan..........................2010 Monterey County General Plan
GSA ....Groundwater Sustainability Agency
GSP ....Groundwater Sustainability Plan
HCM ....hydrogeologic conceptual model
LID.......................................Low Impact Development
LUCAS ....USGS Land-Use and Climate Scenario Simulator
MCWD..................................Monterey County Water District
MCWRA...............................Monterey County Water Resources Agency
mg/L.....................................milligrams per liter
SCRBS ....Salinas and Carmel Rivers Basin Study
Settlement Agreement............Monterey County Case Number M109451
SGMA ....Sustainable Groundwater Management Act
SRDF....................................Salinas River Diversion Facility
Study Area ....Zone 2C
SVBGSA...............................Salinas Valley Basin Groundwater Sustainability Agency
SVIGSM ....Salinas Valley Integrated Groundwater and Surface-Water Model
SVIHM..................................Salinas Valley Integrated Hydrologic Model
SVOM ....Salinas Valley Operational Model
SVWP ....Salinas Valley Water Project
SWI Model............................Seawater Intrusion Model
USBR ....United States Bureau of Reclamation
U.S. Census Bureau ....United States Census Bureau
USGS ....United States Geological Survey
Zone 2C................................Monterey County Water Resources Agency Assessment Zone 2C

EXECUTIVE SUMMARY

The County of Monterey (County) entered into 2 settlement agreements in 2015 with petitioners to resolve a challenge to the certification of the Environmental Impact Report (EIR) for the 2010 Monterey County General Plan (General Plan) (Settlement Agreement; Monterey County Case Number M109434 and M109441). The Settlement Agreement requires the County conduct a study to evaluate existing and future groundwater level, seawater intrusion, and water demand conditions in Zone 2C of the Salinas Valley Groundwater Basin through 2030. The County completed a 3-phased Basin Investigation to satisfy the Settlement Agreement's terms. This document completes Phase 3 of the Basin Investigation study.

This study provides revised water demand, groundwater elevation, and seawater intrusion estimates for Monterey County through 2030, the planning horizon for the 2010 General Plan. It focuses on the 4 subareas of Monterey County Water Resources Agency (MCWRA) Zone 2C where most groundwater production occurs: the Pressure, Eastside, Forebay (including Arroyo Seco), and Upper Valley Subareas. Current conditions are evaluated relative to the EIR for the 2010 General Plan. An array of 2030 land use, population, and climate change projections from other recent regional studies are used to project future water demands. The Salinas Valley Operational Model (SVOM) and Salinas Valley Seawater Intrusion Model (SWI Model) are used to analyze how 2030 water demands impact groundwater levels and seawater intrusion.

This study develops 3 scenarios for estimating 2030 water demands and groundwater conditions. The medium growth scenario uses average estimates for 2030 population, urban efficiency, and land use change. Uncertainty in future land use and urban growth is evaluated with low and high growth scenarios. The low growth scenario has lower than expected population growth, more efficient urban water use, and no change to current land use. The high growth model assumes that population growth will be higher than expected, urban water use efficiency will not improve, and more land conversion will occur compared to the medium growth scenario.

Water demands in Zone 2C are summarized for urban and agricultural uses. The EIR projected that agricultural water demand would decrease by 2030 due to a combination of land contraction, a shift to crops that are less water intensive, and an increase in irrigation efficiency; it also projected that urban water demand would increase to accommodate population growth. In total, the EIR projected that water demand would decrease by the end of the 2030 planning horizon.

More recent data compiled in this study suggest that contrary to the EIR, total water demands have actually increased since the EIR was completed. As of 2020, urban water demands had remained about the same as the EIR baseline data, and agricultural water demands were greater than projected in the EIR. Table ES-1 shows how the EIR estimates compare to the current and projected population and water demands developed in this study.

Table ES-1. Population and Water Demands (Rounded to Nearest Thousand)

	Environmental Impact Report (EIR)		Basin Investigation	
	Baseline (Year)	2030 EIR Projection	Recent Estimate (Year)	2030 Medium Growth Projection
	Acre-feet	Acre-feet	Acre-feet	Acre-feet
Population*	264,000 (2000)	369,000	304,000 (2020)	332,000
Urban Water Demand	45,000 (1995)	85,000	39,000 (2017)	40,000
Agricultural Water Demand	431,300 (1995)	374,000	447,000 (2017)	479,000
Total Water Demands	476,000 (1995)	459,000	485,000 (2017)	518,000

* Estimated Zone 2C population from County population presented in the EIR

The result of greater than projected water demands is that more groundwater is being pumped than assumed in the EIR and General Plan, contributing to groundwater level decline and seawater intrusion. Groundwater levels have declined more on average in the Zone 2C Subareas closest to the coast (Eastside and Pressure Subareas) than in the Zone 2C Subareas further inland (Forebay and Upper Valley Subareas). All 4 of these Subareas experienced groundwater declines during and after the recent drought periods from 2012 to 2016 and from 2020 to 2021, with groundwater levels recovering after the 2012 to 2016 drought in the Forebay and Upper Valley, and groundwater levels not fully recovering in the Pressure or Eastside Subareas.

The analysis of projected 2030 water demands and groundwater conditions found that under average climate conditions groundwater level declines and seawater intrusion are likely to continue through 2030. The projected trends have some variability due to the assumptions of the low, medium, and high growth scenarios. Average groundwater level decline by Subarea from 2010 to 2021 was approximately 3 feet in the Upper Valley and 6 to 8 feet in the other subareas. The projected average groundwater level declines by Subarea from 2021 to 2030 are anticipated to be between 0.5 feet in Upper Valley Subarea and about 4.5 feet in Pressure and Eastside Subareas. Figure ES-1 shows the historical, current, and projected range of groundwater levels by Subarea. Seawater intrusion mainly impacts the Pressure Subarea and is projected to impact approximately 210 to 240 acres/year from 2020 to 2030, which is similar to the average rate of 283 acres/year from 2011 to 2020.

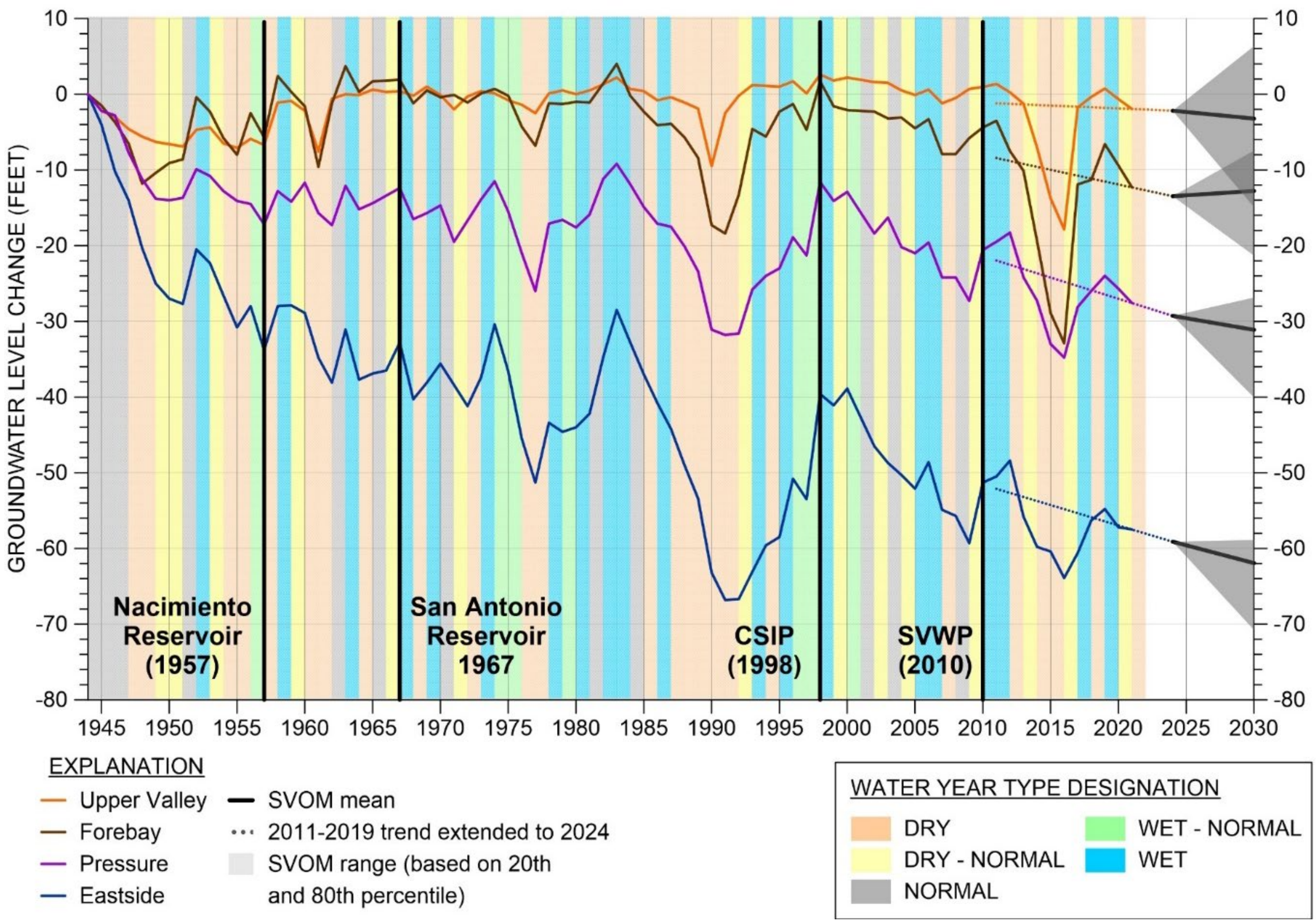

Figure ES-1. Projected Change in Groundwater Elevations in MCWRA Subareas from 2021 to 2030

Increasing projected water demands are not anticipated to have uniform impacts on groundwater conditions throughout Zone 2C. Some areas may see improved conditions even as average conditions decline. For example, seawater intrusion has slowed and groundwater levels have increased near Castroville since the Castroville Seawater Intrusion Project implementation began in 1998. However, greater rates of seawater intrusion have occurred in the 400-Foot Aquifer closer to the City of Salinas.

There are specific measures the County and/or other agencies could take to address groundwater level declines and seawater intrusion. This study recommends the following:

- Supporting groundwater sustainability efforts already underway
- Supporting further conservation
- Taking action to not exacerbate future conditions
- Coordinating land use planning with groundwater sustainability efforts to improve water supply projects, promote recharge and efficiency measures, and prevent future groundwater level declines and seawater intrusion.

1 INTRODUCTION

The County of Monterey (County) entered into 2 settlement agreements in 2015 with various petitioners to resolve a challenge to the certification of the Environmental Impact Report (EIR) for the 2010 Monterey County General Plan (General Plan) (Settlement Agreement; Monterey County Case Number M109434 and M109441). This study, referred to as the Basin Investigation, addresses specific terms of the Settlement Agreement. In particular, this study addresses items presented in Exhibit A, Section 1.c of the Settlement Agreement that requires the County conduct a study to show "…based on specific findings and supported by evidence…" that new development in Monterey County Water Resources Agency (MCWRA) Assessment Zone 2C has a "long-term, sustainable water supply, both in quality and quantity to serve the development."

Brown and Caldwell and the U.S. Geological Survey (USGS) completed the first 2 Phases of the Basin Investigation. On behalf of Monterey County, Brown and Caldwell executed Phase 1 of the Basin Investigation with delivery of the *2015, January 16 -State of the Salinas River Groundwater Basin – Hydrology Report* (hereafter referred to as *2015 State of the Basin Report*), which provided a near-term assessment of conditions in Zone 2C of the Salinas Valley Groundwater Basin (Brown and Caldwell, 2015). Phase 2 of the Basin Investigation is being conducted primarily by the USGS and entails a study of Zone 2C. Following multiple meetings of a Technical Advisory Committee from 2015 to 2017 to assist with assessment and selection of modeling tools, the USGS constructed an integrated groundwater-surface water model that can evaluate water budgets and groundwater elevations under historical and future conditions: the Salinas Valley Integrated Hydrologic Model (SVIHM), and its predictive version, the Salinas Valley Operational Model (SVOM).[1]

This study completes Phase 3 of the Basin Investigation by providing revised groundwater demand, groundwater elevation, and seawater intrusion estimates through 2030. This study uses land use, population, and climate change projections from other recent regional studies to estimate how local conditions may change by 2030. The SVOM and recently developed Salinas Valley Seawater Intrusion Model are used to evaluate how anticipated water demands may affect groundwater elevation and seawater intrusion through 2030. More recent data and projections are used to reassess the assumptions made in the General Plan and the associated EIR about future water use and conditions in MCWRA Zone 2C.

[1] These data (model and/or model results) are preliminary or provisional and are subject to revision. This model and model results are being provided to meet the need for timely best science. The model has not received final approval by the U.S. Geological Survey (USGS). No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the model and related material nor shall the fact of release constitute any such warranty. The model is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the model.

1.1 Purpose

This study has 2 main purposes. The primary purpose of this study is to reassess the assumptions made in the General Plan and EIR about future water use and conditions in MCWRA Zone 2C, as discussed in the previous section. A secondary purpose is to align the Basin Investigation, to the extent practicable, with other regional groundwater planning efforts.

Concurrent to this study, 4 groundwater sustainability agencies (GSAs), the Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA), Marina Coast Water District (MCWD) GSA, Arroyo Seco GSA (ASGSA), and County of Monterey GSA prepared Groundwater Sustainability Plans (GSPs) that include comprehensive analyses of recent basin conditions and establish strategies to reach and/or maintain groundwater sustainability. The GSAs developed the GSPs in response to the Sustainable Groundwater Management Act (SGMA) after the Basin Investigation commenced. Relevant work undertaken as part of GSP development is included as part of this Basin Investigation.

Likewise, the United States Bureau of Reclamation (USBR) began developing the Salinas and Carmel Rivers Basin Study (SCRBS) concurrent with the Basin Investigation. The SCRBS overlaps with this study in that it projects future water demands in the region considering climate change impacts and evaluates potential water projects and management actions to promote sustainability.

Coordinating this study with the other concurrent regional planning efforts provides both efficiency and an integrated approach to water management, while also satisfying the requirements of the Basin Investigation specified in the Settlement Agreement.

1.2 Study Objectives

The objectives of this study, paraphrased from the Settlement Agreement, include the following:

1. Present recent groundwater elevation and seawater intrusion data collected from wells.
2. Evaluate the total projected water demand in 2030 based on recent and anticipated future population, land use, and water use data and trends.
3. Assess the degree that water demand projections in the General Plan are likely to be reached or exceeded in 2030 based on reevaluated water demands.
4. Estimate groundwater elevations and the extent of seawater intrusion on an annual basis.
5. Evaluate and provide conclusions regarding future trends and expected changes in groundwater storage, groundwater elevations, and the extent of seawater intrusion.

6. Make recommendations on measures the County could take, should the study conclude that: 1) total water demand for all uses designated in the General Plan and EIR for the year 2030 is likely to be exceeded; or 2) groundwater elevations are likely to decline by the year 2030; or 3) the seawater intrusion boundary is likely to advance inland by the year 2030.

2 PROJECT BACKGROUND

The following sections provide an overview of Zone 2C (the Study Area) including general water demands, relevant published reports, and a description of the hydrogeologic conceptual model.

2.1 Study Area Overview

Zone 2C was established by MCWRA Ordinance 4203 as an Assessment Zone to implement the Salinas Valley Water Project (SVWP). The SVWP was developed "…to increase flood protection, address seawater intrusion, and assure a sufficient quantity and quality of water supplies to meet agricultural and urban needs within the Salinas Valley through the year 2030." The SVWP includes the following planned or completed projects:

- Re-operation and maintenance of Nacimiento and San Antonio Dams to improve water conservation and recharge;
- Modification of the spillway at Nacimiento Dam as necessary to meet relevant safety standards;
- Construction of the Salinas River Diversion Facility (SRDF) to provide surface water deliveries through the Castroville Seawater Intrusion Project (CSIP) for irrigation in an area with seawater intrusion with treated wastewater and supplemental groundwater pumping; and
- Implementation of general conservation measures with consideration given to recreation.

Zone 2C covers 436,000 acres of Monterey County, as shown on Figure 2-1. Zone 2C's extent is defined by the Salinas Valley alluvial basin extending from the Monterey County line to the Pacific Ocean, as well as the smaller alluvial basin surrounding the San Antonio River, and a buffer of land around Lake San Antonio near the Monterey and San Luis Obispo County line.

There are 7 MCWRA subareas in Zone 2C shown on Figure 2-1:

1. Pressure
2. Eastside
3. Forebay
4. Arroyo Seco
5. Upper Valley
6. Above Dam
7. Below Dam

The analyses detailed in this report cover the primary water-producing subareas in Zone 2C: Pressure, Eastside, Forebay (including the Arroyo Seco), and Upper Valley. These 4 subareas include most of the land area and account for nearly all groundwater pumping within Zone 2C (Brown and Caldwell, 2015).

Most of the land in Zone 2C is used for agriculture due to the region's unique combination of climate, soil, and water for growing high-value specialty crops such as strawberries, lettuce, cruciferous plants, and grapes (http://montereycfb.com/index.php?page=facts-figures-faqs). There is some undeveloped wetland, grassland, shrubland, and forest, mainly in the foothills surrounding the Salinas Valley.

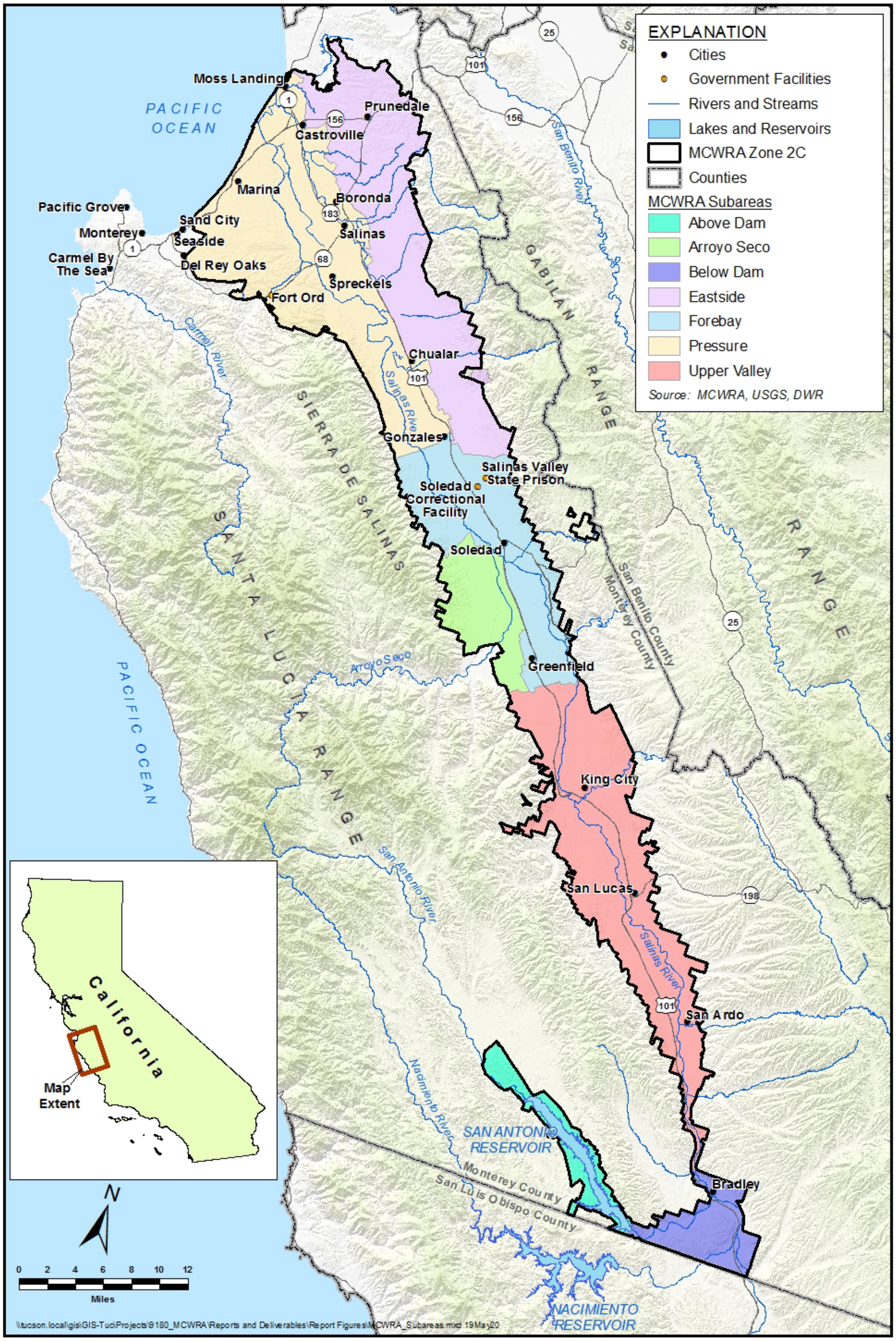

Figure 2-1. Zone 2C Study Area

Urban and residential areas scattered throughout the agrarian Salinas Valley are small, except for the City of Salinas (Figure 2-2). The following urban and residential areas comprise the populated land areas in Zone 2C:

- Cities:
  - City of Salinas, which has a current population of about 165,000 people;
  - Incorporated communities of 25,000 people or fewer, including Gonzales, Greenfield, King City, Marina, and Soledad; and
  - Other institutions near specific cities with significant populations including the California State University Monterey Bay in Marina, Soledad Correctional Facility, and Salinas Valley State Prison in Soledad. The former United States Army post at Fort Ord is not populated, other than portions of the former base within existing cities.
- Communities:
  - Unincorporated communities with populations between 1,000 and 20,000, including Boronda, Castroville, Chualar, and Prunedale; and
  - Unincorporated census designated places with populations less than 1,000 people, including Bradley, Moss Landing, San Ardo, San Lucas, and Spreckels.
- Rural areas:
  - Other unincorporated residences outside of cities and communities.

For simplicity, the terms cities, communities, and rural as described above are used throughout the report.

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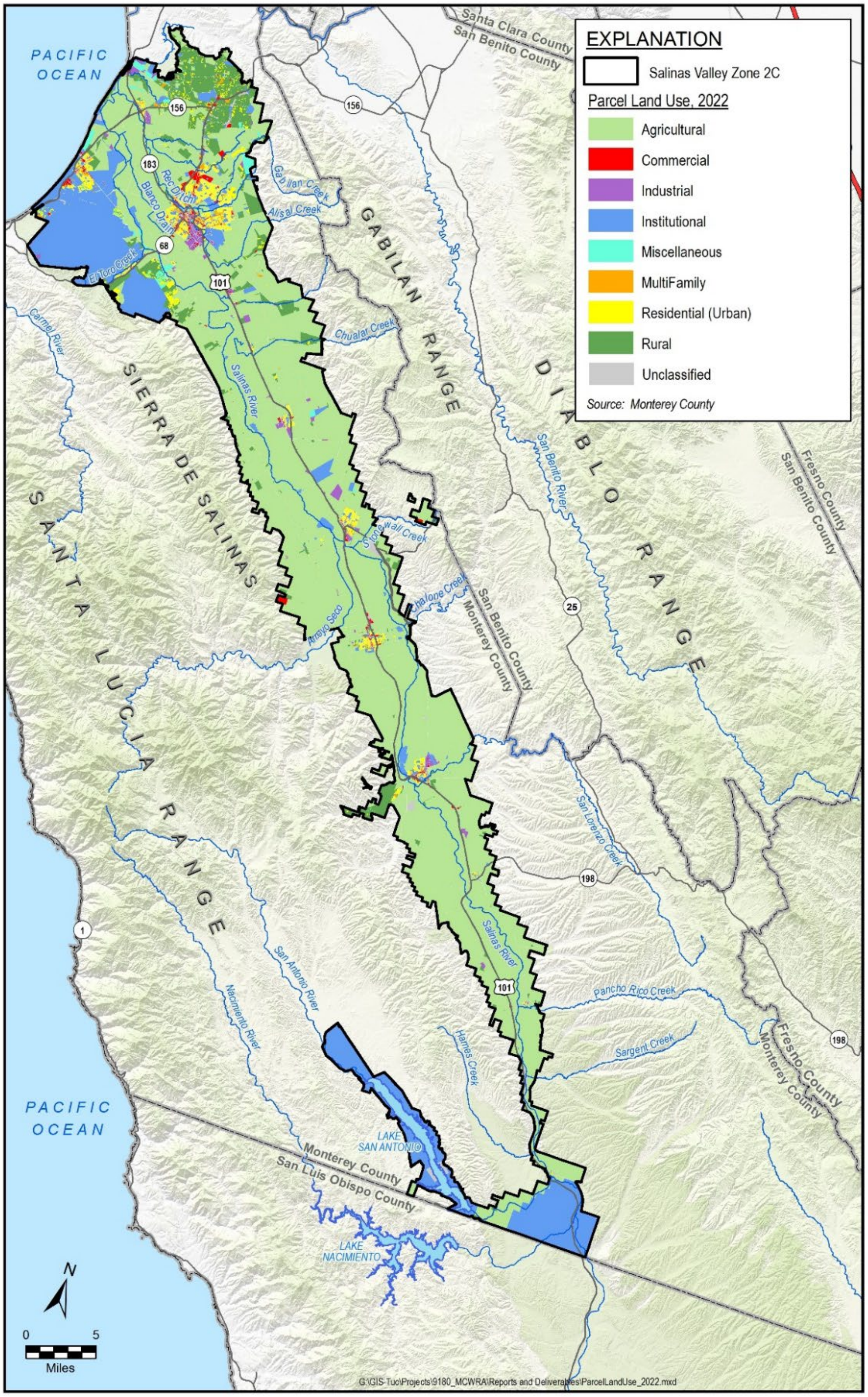

Figure 2-2. Zone 2C 2022 Land Use

2.2 Historical Water Demands and Supplies

Agricultural and urban water use accounts for most water demands in the region. Domestic supply, evapotranspiration from natural vegetation, and environmental beneficial use make up the remaining demands. Agricultural and urban water demand within Zone 2C has remained relatively stable since the 1970s (Brown and Caldwell, 2015).

Agricultural demands in Zone 2C are mainly met by groundwater, but surface water and recycled water meet agricultural demands in some small areas. Municipal water demands are met entirely with groundwater. Surface water sources in Zone 2C include diversions from the Salinas River and the Arroyo Seco, and recycled water is supplied by the Monterey County Water Recycling Projects, a combination of CSIP and the Salinas Valley Reclamation Project (Brown and Caldwell, 2015).

Groundwater pumping has been reported to MCWRA since 1994 through the Monterey County Groundwater Extraction Management System (GEMS). GEMS covers Zones 2, 2A, and 2B, which covers most of the areas in Zone 2C with groundwater pumping. The main areas in Zone 2C where groundwater pumping is not reported in GEMS are Prunedale, Corral de Tierra, and the Above Dam and Below Dam Subareas.

Estimated historical water demands from 1970 to 1994 have been estimated by the Salinas Valley Integrated Groundwater and Surface-Water Model (SVIGSM; MCWRA, 1997). The SVIGSM is a numerical model and precursor to the SVIHM and SVOM models used in Phase 3 of the Basin Investigation.

2.3 Previous Reports

The primary reports reviewed and used for this study include:

- The *2010 Monterey County General Plan* (General Plan; ICF International, 2010b);
- The Environmental Impact Report for the Monterey County 2010 General Plan (EIR; ICF International, 2010a);
- The *2015 State of the Basin Report* (Brown and Caldwell, 2015);
- Salinas and Carmel Rivers Basin Study: *Draft Technical Memorandum #3: Socioeconomic Scenarios* (Brown and Caldwell, 2019a) and *Draft Technical Memorandum #4: Model Tools and Inputs* (Brown and Caldwell, 2019b), being prepared for the USBR concurrently with this study; and

- Salinas Valley Basin GSPs and subsequent Annual Reports for the 180/400-Foot Aquifer, Eastside Aquifer, Forebay Aquifer, Langley Area, Monterey, and Upper Valley Aquifer Subbasins (MCWD GSA and SVBGSA 2022; SVBGSA 2022a, 2022b, 2022c, 2022d, and 2022e).

Table 2-1 summarizes the general information in each of the key reports listed above.

Table 2-1. Previous Reports Used to Develop the Basin Investigation

Study Name	Reference, Year	Plan or Study Timeframe	Study's Projected Data	Study Area	Zone 2C Data Available?
Monterey County 2010 General Plan	ICF International, 2010b	2010 through 2030	No quantitative data, relies on EIR	Monterey County	No quantitative data.
Monterey County EIR for 2010 General Plan	ICF International, 2010a	Generally, 2006 through 2030	Single estimate for water demands and population.	Monterey County	No, but some of the source data is available elsewhere.
Phase 1 Basin Investigation (2015 State of the Basin)	Brown and Caldwell, 2015	1959 through 2013	No projections.	Zone 2C	Yes
USBR – Salinas and Carmel Rivers Basin Study	Brown and Caldwell, 2019a; 2019b	2015 through 2100	Range of values for water demands and population.	Monterey County and San Luis Obispo County Groundwater Basins and Cities	No, but urban population and water use data is summarized by City and Community so can be estimated for Zone 2C with some assumptions.
Salinas Valley GSPs	Various GSAs, 2020, 2022	1950s through 2070	Range of hydrologic and climate conditions	6 Subbasins in Salinas Valley	Not specifically, data overlaps but is summarized by Bulletin 118 subbasins

2.3.1 2010 Monterey County General Plan

The 2010 General Plan serves as a blueprint for Monterey County's growth. It defines goals and policies that guide the County in future decision making. The General Plan planning horizon is 2030 and the buildout horizon is 2092. The 2030 planning horizon projected water demands are evaluated for this study.

The chapters of the General Plan reviewed for this study include:

- Chapter 1.0 – Land Use Element
- Chapter 3.0 – Conservation and Open Space Element
- Chapter 5.0 – Public Services Element (which addresses public water supply)

- Chapter 6.0 – Agriculture Element
- Chapter 8.0 – Housing Element

The goals and policies established by the General Plan address a wide range of planning topics. The main themes of the General Plan related to this study include:

- Assuring an adequate and safe water supply to meet the County's current and long-term needs;
- Ensuring that new development is assured a long-term sustainable water supply;
- Promoting the long-term protection, conservation, and enhancement of productive and potentially productive agricultural land;
- Establishing a development pattern centered on cities, community areas, and rural centers;
- Conserving agriculture and the agricultural economy; and
- Conserving sensitive natural areas.

Specific portions of the General Plan address development of new water supplies. For example, the Plan states in Policy PS-3.1, "…except as specifically set forth below, new development for which a discretionary permit is required, and that will use or require the use of water, shall be prohibited without proof, based on specific findings and supported by evidence, that there is a long-term, sustainable water supply, both in quality and quantity to serve the development." PS-3.1 goes on to state that this does not apply to development in Zone 2C until the Basin Investigation reaches a conclusion because there is a "rebuttable presumption that a Long Term Sustainable Water Supply exists within Zone 2C".

2.3.2 Environmental Impact Report for the Monterey County General Plan

Monterey County prepared a draft EIR that evaluated and disclosed the significant environmental impacts associated with implementation of the 2007 Draft General Plan through the 2030 planning horizon (ICF Jones & Stokes, 2008). The County received public comments, revised the EIR, and released a final version in 2010 (ICF International, 2010a). Together with the General Plan, the EIR formed the basis for the lawsuit that led to the Settlement Agreement that this study addresses. Sections of the EIR relevant to this study include:

- Section 4.1 – Land Use: urban and developed land use plans, impacts, and mitigation measures;

- Section 4.2 – Agricultural Resources: agricultural land use plans, impacts, and mitigation measures;
- Section 4.3 – Water Resources: water use plans, impacts, and mitigation measures;
- Section 4.15 – Population and Housing: population growth plans, impacts, and mitigation measures; and
- Section 3.2 of the response to public comments on the draft EIR – addressed public comments regarding projected agricultural land use changes by specific crops.

The EIR estimated future conditions in the County for both a 2030 planning horizon and a 2092 buildout horizon. The EIR used the following data sets to develop assumptions:

- Baseline land use was estimated using California Department of Conservation Farmland Monitoring and Mapping Program (FMMP) data. The FMMP maps farmland using a computer mapping system, aerial imagery, public review, and field reconnaissance. The 2030 agricultural land use was assumed to match the baseline acreage, with agricultural land conversion to accommodate urban growth in some areas being offset by agricultural land use growth at the margins of the Salinas Valley floor.
- Baseline population was estimated by Census Bureau counts. The 2030 population was projected by the Association of Monterey Bay Area Governments (AMBAG), *2004 Regional Growth Forecast* (AMBAG, 2004). AMBAG estimated future population growth from the 2000 Census Bureau baseline population, and used assumptions about likelihood and constraints for development of available land.
- Baseline and projected water demands referenced the SVWP's EIR, which were modeled using the SVIGSM. The 2030 agricultural water demands were assumed to be less than the 1995 baseline because of improved agricultural water use efficiency and a projected lower water demanding crop mixture. The 2030 urban water demand was scaled based on assumed population growth. Water demand estimates included recycled water use.

The quantitative historical information and projections from the EIR formed the basis for the policies and goals in the more qualitative General Plan document.

2.3.3 2015 State of the Basin Report

The *2015 State of the Basin Report* was completed in response to Monterey County Board of Supervisors referral 2014.01 to satisfy the need for a near term assessment of the groundwater basin and commence the Basin Investigation required by the Settlement Agreement. The report analyzed data from 1959 to 2013; the start date of the study aligns with the period when Nacimiento Reservoir began operation. The report provided a near-term assessment of conditions in Zone 2C. Data in the *State of the Basin Report* included summaries of groundwater conditions, water budgets, and seawater intrusion. The report approximated groundwater demand based on pumping data reported through GEMS since 1994 and the SVIGSM prior to 1994.

2.3.4 Salinas and Carmel Rivers Basin Study (SCRBS)

The USBR is overseeing the SCRBS concurrently with this study. Like this study, the SCRBS seeks to estimate the impact of projected population and land use changes on water demands in the Salinas and Carmel Rivers Basin.

Differences between this study and the SCRBS include the study areas, goals, time period, and SCRBS' evaluation of climate adaptation and mitigation strategies. The SCRBS study area includes almost all agricultural and urban lands in Monterey County in Zone 2C, the Carmel River Basin, and Monterey Peninsula, and also a portion of San Luis Obispo County. The relevant data presented in the SCRBS is divided by county so it can easily be parsed between the 2 counties and by areas overlapping the Basin Investigation. The goal of the Basin Investigation is to evaluate current and projected groundwater conditions in Zone 2C relative to the EIR and General Plan through the 2030 planning horizon. The goal of the SCRBS is to evaluate future water supply and demand to assess strategies for climate change adaptation and mitigation in the study area through the 2100 planning horizon.

The complete SCRBS report was not available in time for inclusion in this study; however, some of the SCRBS methodology was made available through a series of draft technical memoranda. The *Draft Technical Memorandum #3: Socioeconomic Scenarios* summarized various scenarios for population, urban land use, and urban water use projections (Brown and Caldwell, 2019a). Similarly, current and future agricultural land use were summarized in *Draft Technical Memorandum #4: Model Tools and Inputs* (Brown and Caldwell, 2019b). The methodologies used in the SCRBS for projecting future population growth, land use change, and urban water demands were reviewed and used, as appropriate, for this study.

The SCRBS estimated a range of urban water demands using population growth from the AMBAG *2018 Regional Growth Forecast* (AMBAG, 2018) and per-capita urban water demand data from recent Urban Water Management Plans. The AMBAG 2018 population projections only estimate an average population in the future. To assess potential variability in future urban water demands from population growth, the SCRBS developed a range of population growth estimates. The projected range of annual population growth is approximately 0.3% above and below the average annual population growth. The SCRBS study estimated that a 20% water use efficiency improvement to the baseline urban per capita water use in 2020 would be realized by 2030 and maintained through the 2100 planning horizon in the low, medium, and high urban water demand estimates.

The SCRBS also estimated how future land use may influence water demands. Historical land use data used in the SCRBS is from the FMMP and projected land use changes are from the USGS's Land-Use and Climate Scenario Simulator (LUCAS) Model for California's Fourth Climate Change Assessment (Sleeter *et al.*, 2017). The SCRBS uses low, medium, and high growth LUCAS scenarios to evaluate the changes to future land uses in 10-year intervals through 2100. Land use changes are incorporated into several integrated groundwater and surface water models in the SCRBS, including the SVIHM, the Salinas Valley Watershed Model, Carmel River Basin Groundwater Surface Water Flow Model, the Basin Characteristics Model, and the Paso Robles Basin Model. Since LUCAS simplifies the agricultural coverages into annual and perennial crop types, the baseline proportion of each annual and perennial crop in the models was used to map specific crops proportionately in projected land use simulations. The SCRBS agricultural water demand results were not available in time to include in this study.

2.3.5 Salinas Valley GSPs

Within Zone 2C, 4 GSAs manage groundwater: SVBGSA, MCWD GSA, ASGSA, and the County of Monterey GSA (the SVBGSA manages the County of Monterey GSA area according to an agreement between the agencies). The County of Monterey is a member of the SVBGSA Joint Powers Authority. The GSAs produced GSPs for each of the 6 Salinas Valley subbasins subject to SGMA within Monterey County: the 180-400-Foot Aquifer Subbasin, the Eastside Aquifer Subbasin, the Forebay Aquifer Subbasin, the Upper Valley Aquifer Subbasin, the Langley Area Subbasin, and the Monterey Subbasin. These subbasins do not align with the Monterey County subareas referenced within this study, though there is considerable overlap between many of the Subbasin and subarea boundaries.

Each GSP, each of which has been approved by the Department of Water Resources as required by SGMA, contains a hydrogeologic conceptual model for the respective subbasin that synthesizes available data into a description of the geologic and hydrologic framework to provide an understanding of the subsurface setting, how this affects groundwater flow, and surface water/groundwater interaction. Those syntheses are drawn on for the development of the hydrogeologic conceptual model for this study.

The GSPs include historical, current, and projected water budgets for each respective subbasin using the same groundwater model as used for this study. The projected water budgets do not make assumptions regarding future changes in land use, population, and efficiency, except for MCWD anticipated urban growth. Therefore, this study is complementary to the GSPs with respect to understanding potential future conditions.

The GSPs set out quantitative benchmarks for what constitutes sustainability according to 6 sustainability indicators: chronic lowering of groundwater levels, groundwater storage, seawater intrusion, subsidence, degradation of water quality, and depletion of interconnected surface water. This study reassesses the 2030 groundwater demand in the General Plan and models its impacts on groundwater levels and seawater intrusion. The 2030 conditions in this study are not compared to the GSPs directly, but both identify future conditions to inform whether, where, and what type of projects and management actions are needed.

Finally, the GSPs include projects and management actions that could be used to reach groundwater sustainability in each respective subbasin. Relevant projects and management actions were considered for inclusion in the recommendations of this report, along with measures in other reports and from other agencies and groups.

2.4 Hydrogeologic Conceptual Model

The hydrogeologic conceptual model (HCM) characterizes the geologic and hydrologic framework for Zone 2C and the Salinas Valley Groundwater Basin (Basin). It is based on best available data, technical studies, and maps that characterize physical components and surface water/groundwater interaction in the Basin. This HCM provides comprehensive written descriptions and illustrated representations of subsurface conditions. The HCM describes the Basin characteristics and processes which govern the flow of water across the Subarea boundaries and outlines the general groundwater setting that may be encountered in the subsurface environment.

2.4.1 Basin Setting

The Salinas Valley Groundwater Basin is an alluvial basin underlying the elongated, intermontane valley of the Salinas River. The Basin is oriented southeast to northwest, with the Salinas River draining towards the northwest into the Pacific Ocean at Monterey Bay (Figure 2-1). The Salinas River drains a watershed area of approximately 4,410 square miles, including the highlands of the Sierra de Salinas and Santa Lucia Range to the west and the Gabilan and Diablo Ranges to the east (Tetra Tech, 2015). The valley floor is approximately 90 miles long along its axis. The valley width is between 10 miles wide in the north near the City of Salinas and about 2 miles wide in the south near San Ardo.

2.4.2 Topography

The Basin slopes at an average grade of approximately 5 feet/mile, generally from the southeast to the northwest towards Monterey Bay. Land surface elevations range from approximately 1,800 feet along the Sierra de Salinas in the Forebay Subarea to sea level along the Pacific Coast.

2.4.3 Basin Boundaries

The Basin is laterally bounded by a combination of administrative and physical boundaries, shown on Figure 2-1.

2.4.3.1 Lateral Boundaries

The Study Area for this report is the MCWRA jurisdictional Zone 2C boundary, described in Section 2.1. It includes the main Salinas Valley alluvial basin. This boundary is based on administrative and hydrogeologic criteria. The Basin is bounded by the following physical features:

- **The Gabilan Range.** The northeastern boundary of the Basin is the contact between the unconsolidated alluvial fan deposits and the Gabilan Range, which is comprised mostly of granitic rocks. Groundwater flow across this boundary has not been studied extensively. Stream channels originating in the Gabilan Range provide groundwater recharge in the Basin. There are no published mapped faults or significant fracture sets that could contribute to mountain block recharge for the Basin.
- **The Sierra de Salinas.** The southwestern boundary of the Basin is the contact with the metamorphic and sedimentary rocks of the Sierra de Salinas. Groundwater flow across this boundary has not been studied extensively. However, in the northern portion of the Basin, Quaternary deposits occur on both sides of the King City Fault, which is a part of the Rinconada Fault Zone. In this area, the King City Fault is not a barrier to groundwater flow and the groundwater basin extends southwest of the structural trough.
- **The Pacific Ocean.** The northwestern basin boundary is defined by the Pacific Ocean. The Basin principal aquifers extend across this boundary and continue into the subsurface underlying Monterey Bay; there are no hydrogeologic barriers limiting groundwater flow across this coastal boundary.
- **Elkhorn Slough.** The northern boundary follows the current course of Elkhorn Slough that corresponds to a paleo-drainage of the Salinas River (California Department of Water Resources [DWR], 2003). The paleo-drainage is approximately 400-feet deep and buried beneath fine grained sediments that limit vertical groundwater flow (Durbin *et al*., 1978). This northern boundary of Elkhorn Slough is the Carneros Hills, a topographical divide that separates the Salinas Valley Groundwater Basin from the Pajaro Valley Groundwater Basin.

2.4.3.2 Vertical Boundaries

Other than the Basin margins where Alluvium is in contact with underlying granitic bedrock, the base, or bottom, of the Basin is not a sharp interface between permeable sediments and lower permeability basement rock. The usable portion of the Basin does not always include the full thickness of sedimentary sequences present. Previous investigations have estimated that the entire sedimentary sequence in the Salinas Valley Groundwater Basin might range between 10,000 and 15,000 feet thick (Brown and Caldwell, 2015). However, the productive freshwater principal aquifers are encountered at shallower depths.

With increasing depth, 3 factors limit the viability of the sediments as productive, principal aquifers:

1. Increased consolidation and cementation of the sediments decrease well yields.
2. Deeper strata contain poor-quality brackish water, unsuitable for most uses.
3. Discontinuous alluvial fan deposits interfingered with clay lenses impede vertical and horizontal groundwater flow.

Because these factors gradually change with depth, there is not a sharp, well-defined bottom of the principal/productive aquifers throughout the Basin.

2.4.4 Basin Geology

The Basin geology provides the physical framework through which groundwater occurs and moves. The geologic descriptions described here are derived from previously published scientific reports, and from investigations conducted by the USGS, State of California, or academic institutions. Figure 2-3 presents a geologic map of the Basin and vicinity. This geologic map was adopted from both the California Geologic Survey's 2010 statewide geologic map (Jennings *et al.*, 2010; Rosenberg, 2001). The figure legend presents the age sequence of the geologic materials from the youngest unconsolidated Quaternary sediments to the oldest pre-Cambrian basement rock.

The Basin was formed through periods of structural deformation and periods of marine and terrestrial sedimentation in a tectonically active area on the eastern edge of the Pacific Plate. The combination of tectonically driven land movement and climatically driven sea level changes has influenced the depositional environment in the Salinas Valley. Over time, the Salinas Valley has been filled with approximately 10,000 to 15,000 feet of both marine and continental sediments. The transitions between marine and terrestrial depositional environments have led to complex layering of coarse and fine-grained marine and continental materials in the subsurface as shown the cross sections in Section 2.4.4.2. This process created the variable hydrogeologic conditions encountered throughout the Salinas Valley Basin.

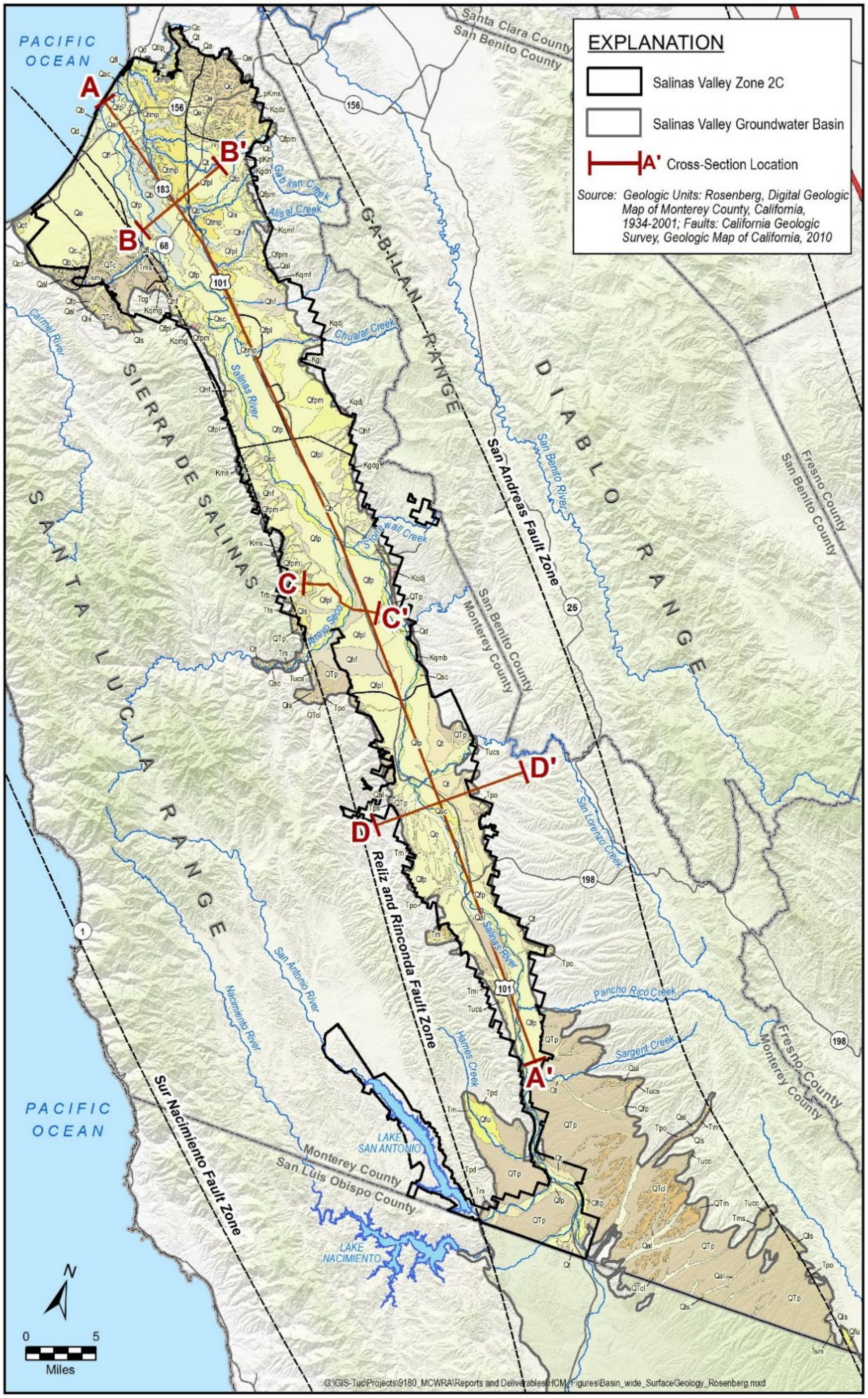

Figure 2-3. Salinas Valley Basin Geology and Cross Section Locations
(from Jennings *et al*., 2010; Rosenberg, 2001)

EXPLANATION

QUATERNARY

Qal	Alluvial deposits, undifferentiated
Qfl	Artificial fill
Qbs	Beach sand
Qd	Dune deposits
Qb	Basin deposits
Qhf	Alluvial fan deposits, Holocene
Qfp	Flood-plain deposits, undifferentiated?
Qsc	Stream channel deposits
Qc	Colluvium
Qls	Landslide deposits
Qe	Eolian deposits
Qfu	Pleistocene alluvial fans, undifferentiated
Qfpl	Alluvial fans, late Pleistocene
Qfpm	Alluvial fans, middle Pleistocene
Qt	Fluvial terrace deposits, undifferentiated
Qtlp	Fluvial terrace deposits, late Pleistocene
Qtmp	Fluvial terrace deposits, middle Pleistocene
Qct	Coastal terraces
Qa	Aromas Sand, undifferentiated

QUATERNARY-TERTIARY

QTp	Paso Robles Formation, undifferentiated
QTcl	Paso Robles Formation, clay
QTm	Paso Robles Formation, marl
QTpc	Paso Robles Formation, clay and gravel
QTc	Continental deposits

GEOLOGIC FEATURES

----- Fault Zone

TERTIARY

Tucc	Unnamed clastic sedimentary unit
Tucs	Unnamed clastic sedimentary unit
Tpo	Pancho Rico Formation, mudstone
Tpi	Pancho Rico Formation, siltstone
Tpd	Pancho Rico Formation, diatomite
Tps	Pancho Rico Formation, sandstone
Tsm	Santa Margarita Sandstone
Tmdi	Monterey Formation, diatomite
Tmi	Monterey Formation, siltstone
Tm	Monterey Formation, siliceous
Tml	Monterey Formation, semi-siliceous
Tmc	Monterey Formation, clay shale
Tms	Unnamed clastic sediments, marine sandstone
Tcg	Unnamed clastic sediments, sandstone and conglomerate
Tn	Unnamed clastic sediments, red beds
Tts	Marine sandstone
Trb	Red beds

CRETACEOUS

Kgj	Granite of Jacks Hill
Kqmf	Quartz monzonite of Fremont Peak
Kgdn	Granodiorite of Natividad
Kqmb	Quartz monzonite of Bickmore Canyon
Kqdv	Quartz diorite of Vergeles
Kqdj	Quartz diorite-granodiorite of Johnson Canyon
Kqdg	Gneissic quartz diorite of Stonewall Canyon
Kqmg	Garnetiferous quartz monzonite of Pine Canyon
Kms	Schist of Sierra de Salinas
pKqf	Quartzofeldspathic rocks
pKms	Mica schist (Gabilan Range)
pKm	Marble

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2.4.4.1 Geologic Formations

Major geologic units of the Basin are described below, starting at the ground surface and moving downwards through the strata from youngest to oldest. The surficial geologic formation designated on Figure 2-3 is provided in parenthesis.

- *Alluvium, Flood Plain Deposits, Landslide Deposits (Qal, Qfp, Qls)* – Holocene Alluvium deposits (Qal) are the most recent unconsolidated sedimentary layers in the Basin, formed by small streams and other surface processes. These sediments have gradational contacts the Floodplain Deposits (Qfp) that occur along El Toro Creek and its tributaries. The Floodplain Deposits consist predominately of unconsolidated layers of mixed sand, gravel, silt, and clay that were deposited in a fluvial environment by the Salinas River and its tributaries. Numerous landslide deposits (Qls) are present in upland portions of the subbasin such as San Benancio, Harper, and Corral de Tierra Canyons.
- *Dune Deposits (Qe)* – This Pleistocene unit blankets most of the northwestern portion of the Pressure Subarea. This unit only exists southwest of the Salinas River and is up to 250 feet thick. This sand is predominately fine- to medium-grained, with thin, gentle to moderate cross-bedding (Harding ESE, 2001).
- *Older Alluvial Fans (Qfu)* – This Pleistocene unit comprises alternating, interconnected beds of fine-grained and coarse-grained deposits, predominately associated with alluvial fan depositional environments. The Older Alluvium underlies coastal areas in Marina and Fort Ord but is not exposed at the ground surface. This unit underlies the Older Dune Sand, and in the Marina and Fort Ord area has been referred to in some reports as Valley Fill Deposits, which is described as including an estuarine clay layer (i.e. the Salinas Valley Aquitard) and an underlying sand and gravel fluvial sequence (Harding ESE, 2001).
- *Aromas Sand (Qa)* – This Pleistocene unit is composed of cross-bedded sands containing some clayey layers (Harding ESE, 2001). This unit was deposited in an eolian, high-energy alluvial, alluvial fan, and shoreline environments, with the predominant depositional environment being eolian (Harding ESE, 2001; Greene, 1970; Dupre, 1990). The Aromas Sand is exposed throughout the ridge and hilltops in the northern portions of the Eastside Subarea, while the unit is buried beneath Older Dune Sand and Alluvium in the Pressure Subarea. Thickness of the Aromas Sand varies within the Basin and is up to 300 feet thick (Harding ESE, 2001; Muir, 1982). Although a clayey or hard red bed is often observed at the basal contact with the underlying Paso Robles Formation, the stratigraphic relationship between the Aromas Sand and the Paso Robles Formation is difficult to discern due to lithologic similarities and the complex interface between them (Harding ESE, 2001; Dupre, 1990)
- *Paso Robles Formation (QTp)* – This Pliocene to lower Pleistocene unit is composed of lenticular beds of sand, gravel, silt, and clay from terrestrial deposition (Thorup, 1976;

Durbin *et al*, 1978). The depositional environment is largely fluvial but also includes alluvial fan, lake, and floodplain deposition (Durbin, 1974; Harding ESE, 2001; Thorup, 1976; Greene, 1970). The individual beds of fine and coarse materials typically have thicknesses of 20 to 60 feet (Durbin *et al*, 1978). Durham (1974) reports that the thickness of the Paso Robles Formation is variable due to erosion of the upper part of the unit. Formation thickness ranges from 500 feet to 2,000 feet and the formation outcrops in the central and southern portions of the Basin (Durbin *et al*, 1978).

- *Purisima Formation (Ppu)* – This Pliocene unit consists of interbedded siltstone, sandstone, conglomerate, clay and shale deposited in a shallow marine environment (Greene, 1977; Harding ESE, 2001). The Purisima Formation has been found in boreholes near the cities of Marina and Seaside; however, the unit is missing from the more inland portions of the Basin (Harding ESE, 2001; HydroMetrics, 2009; Geosyntec, 2007). The Purisima Formation ranges in thickness from 500 to 1,000 feet (Feeney and Rosenberg, 2003). This unit is not shown on the map as it does not crop out in the Salinas Valley Basin.
- *Santa Margarita Sandstone (Tsm)* – The Miocene Santa Margarita Sandstone is a friable, arkosic sandstone. In the northern portion of the Basin, the Paso Robles Formation conformably overlays the Purisima Formation, which interfingers with the Santa Margarita Sandstone (Durbin, 2007; Hydrometrics, 2009). Towards the boundaries with the Seaside Subbasin and the Corral de Tierra area, the Paso Robles unconformably overlays over the Santa Margarita Sandstone. Outcrops of the Santa Margarita Sandstone are found in the Corral de Tierra area of the Pressure Subarea.
- *Monterey Formation (Tmdi, Tmi, Tm, Tml, Tmc)* – The Monterey Formation (Miocene) is a shale or mudstone deposited in a shallow marine environment (Harding ESE, 2001; Greene, 1977). As discussed below, the Monterey Formation is relatively impervious. The top of the Monterey Formation is generally defined as the bottom of the Basin (Section 2.4.4.3).
- *Unnamed Miocene Sandstone (Tms, Tcg, Tn)* – An unnamed Miocene sandstone unit (Mus) underlies the Monterey Formation. The upper unit is marine arkosic sandstone and conglomerate; and the lower unit is continental sandstone and conglomerate (Wagner *et al*. 2002). This unit is exposed near the eastern and southern Basin boundaries in the Toro Park region of the Pressure Subarea. This unit is sometimes referred to as the Basal Sandstone in other reports (Geosyntec, 2007).

2.4.4.2 Cross Sections

Cross sections described below show the subsurface geologic interpretation in locations shown on Figure 2-3. The cross section name, location, and source are described below:

- Cross section A-A' on Figure 2-4 is adapted from the *2015 State of the Basin*. This cross section is parallel to the long axis of the Basin, encompassing the Pressure, Forebay, and Upper Valley Subareas.
- Cross section B-B' on Figure 2-5 is adapted from cross section E-E' from the 2004 *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley* by Kennedy-Jenks. This cross section is perpendicular to the long axis of the Basin within the Pressure and Eastside Subareas.
- Cross section C-C' on Figure 2-6 is adapted from cross section 5-5' from the 1994 *Hydrogeologic Investigation, Arroyo Seco Cone* by Staal, Gardner, & Dunne Inc. This cross section is perpendicular to the long axis of the Basin within the Forebay Subarea.
- Cross section D-D' on Figure 2-7 is adapted from the 2022 *Salinas Valley Groundwater Basin Upper Valley Subbasin Groundwater Sustainability Plan* by Montgomery & Associates. This cross section is perpendicular to the long axis of the Basin within the Upper Valley Subarea.

The generalized geologic interpretations shown on the cross sections are based on best available information from drilling logs and are an approximation for the complex and variable subsurface conditions. Hydrologic units shown on cross sections generally include the following:

- Fine-grained sediments such as clay, silt, sandy clay, and gravelly clay are shown as aquitards.
- Coarse-grained sediments such as sand, gravel, and sand-gravel mixtures are shown as aquifers.
- Sediments logged as gravel/clay, sand/clay, and sand/gravel/clay are interpreted to consist of interbedded coarse-grained and fine-grained deposits and are included with aquifer materials.

On the cross sections, the finer sediments are grouped in regions with hatch line, or the shaded regions for cross section A-A', and the coarser sediments have no hatching or shading.

The geologic units described in Section 2.4.4.1 do not align with geologic units shown in the cross sections. This is because downhole interpretations of lithology are imprecise compared to surficial mapping. In some cases, the logs may be old, the depth resolution poor, or the lithologic distinction suspect.

The subsurface geology in each of the primary MCWRA Subareas shown on the cross sections can be described as follows:

- <u>Pressure Subarea</u> is characterized by fluvial and marine deposits; namely alluvium, terrace deposits, the Paso Robles Formation, and the Aromas Sand (DWR, 2004). The upper 500 feet of sediments in the Pressure Subarea reflect the repeated sea level fluctuations that resulted from climatic changes in the Quaternary (Tinsley, 1975). This cycle of sea level rise and fall combined with the relationship with fluvial deposition in alternating periods created the sequence of aquifers and aquitards present today (Brown & Caldwell, 2015). This is illustrated on Figure 2-4 and Figure 2-5.

- Eastside Subarea is underlain by interconnected alluvial fan deposits (Kennedy/Jenks, 2004). Surface-water drainages originating in the Gabilan Range deposited a series of interconnected alluvial fans that extend from the Gabilan Range in the northeast to the fluvial and marine deposits that define the Pressure Subarea. This is illustrated on Figure 2-4 and Figure 2-5.
- Forebay Subarea is characterized by 2 intersecting geologic facies: the fluvial and marine dominated deposits of the main Salinas Valley, and the Arroyo Seco Cone alluvial fan originating in the Sierra de Salinas on the west side of the Basin. In general, the alluvial fan sediments encountered in the Arroyo Seco Cone are more coarse-grained than those found in the main Salinas Valley's fluvial and marine deposits. This is illustrated on Figure 2-4 and Figure 2-6.
- Upper Valley Subarea primarily consists of fluvial and marine deposits characterized as alluvium, terrace deposits, and the Paso Robles Formation (DWR, 2004). These features are in contact with the more consolidated sedimentary and crystalline rocks that comprise the Santa Lucia and the Gabilan Ranges which mark the western and eastern boundaries of the Subbasin, respectively. This is illustrated on Figure 2-4 and Figure 2-7.

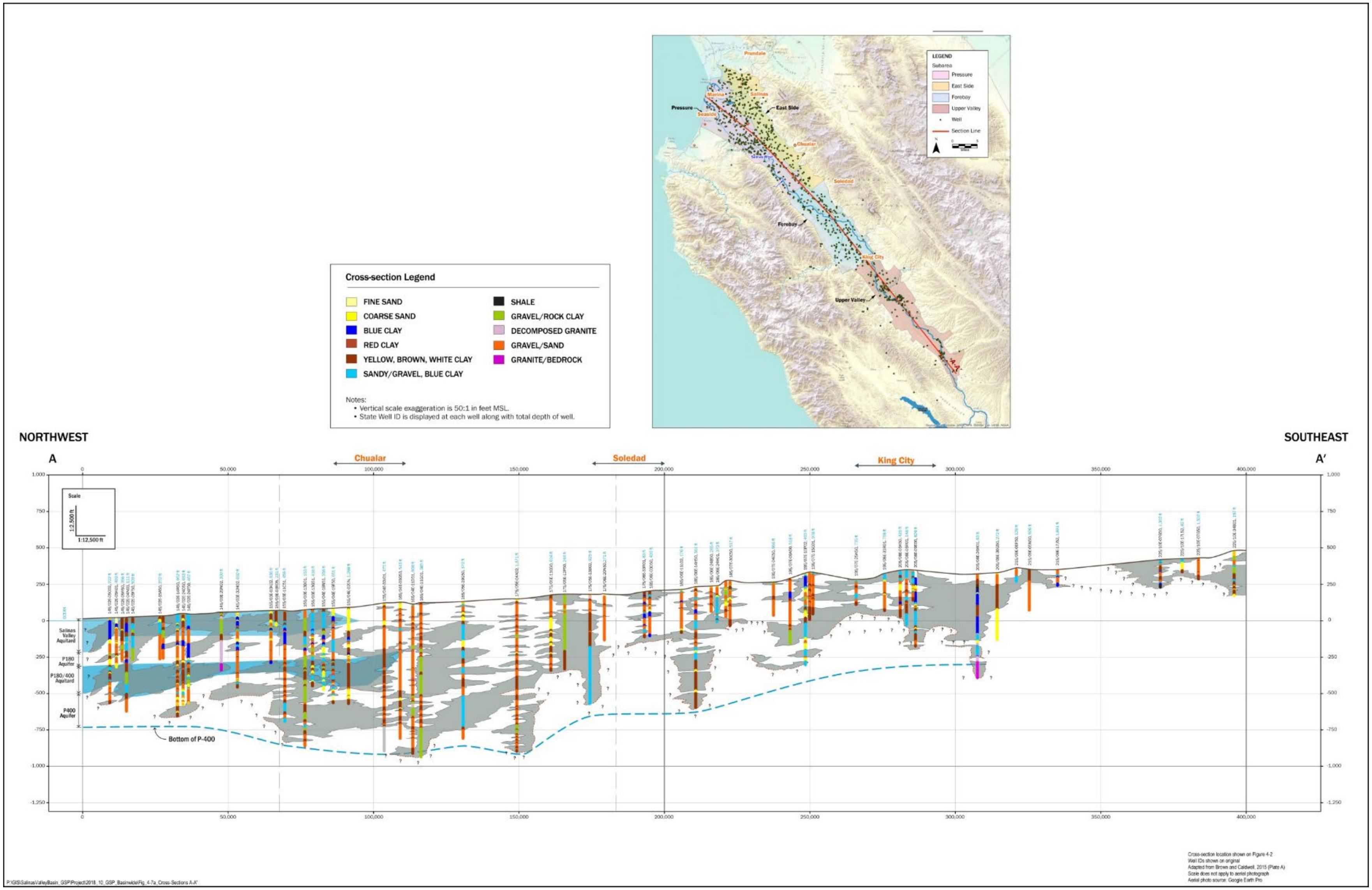

Figure 2-4. Cross Section A to A' Showing Principal Aquifers and Aquitards (Brown and Caldwell, 2015)

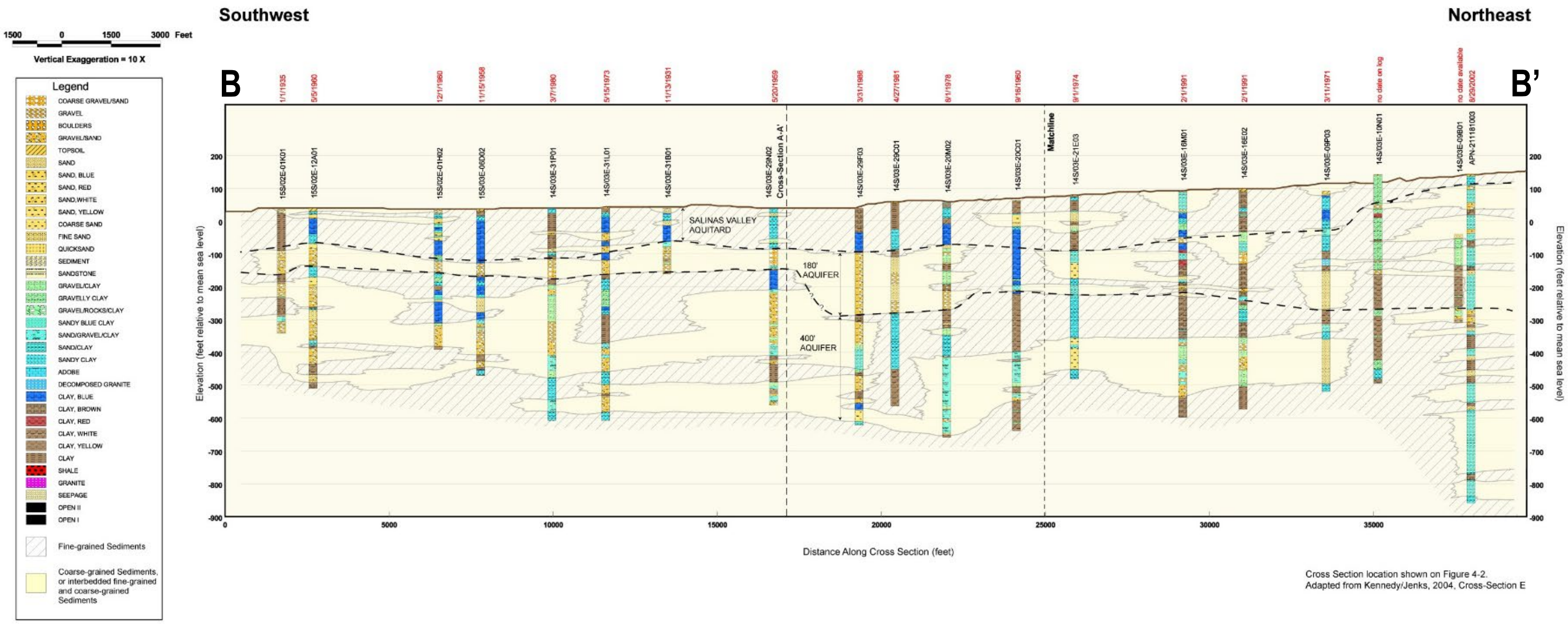

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Figure 2-5. Cross Section B-B' Showing Principal Aquifers and Aquitards (adapted from section E-E' from Kennedy/Jenks, 2004)

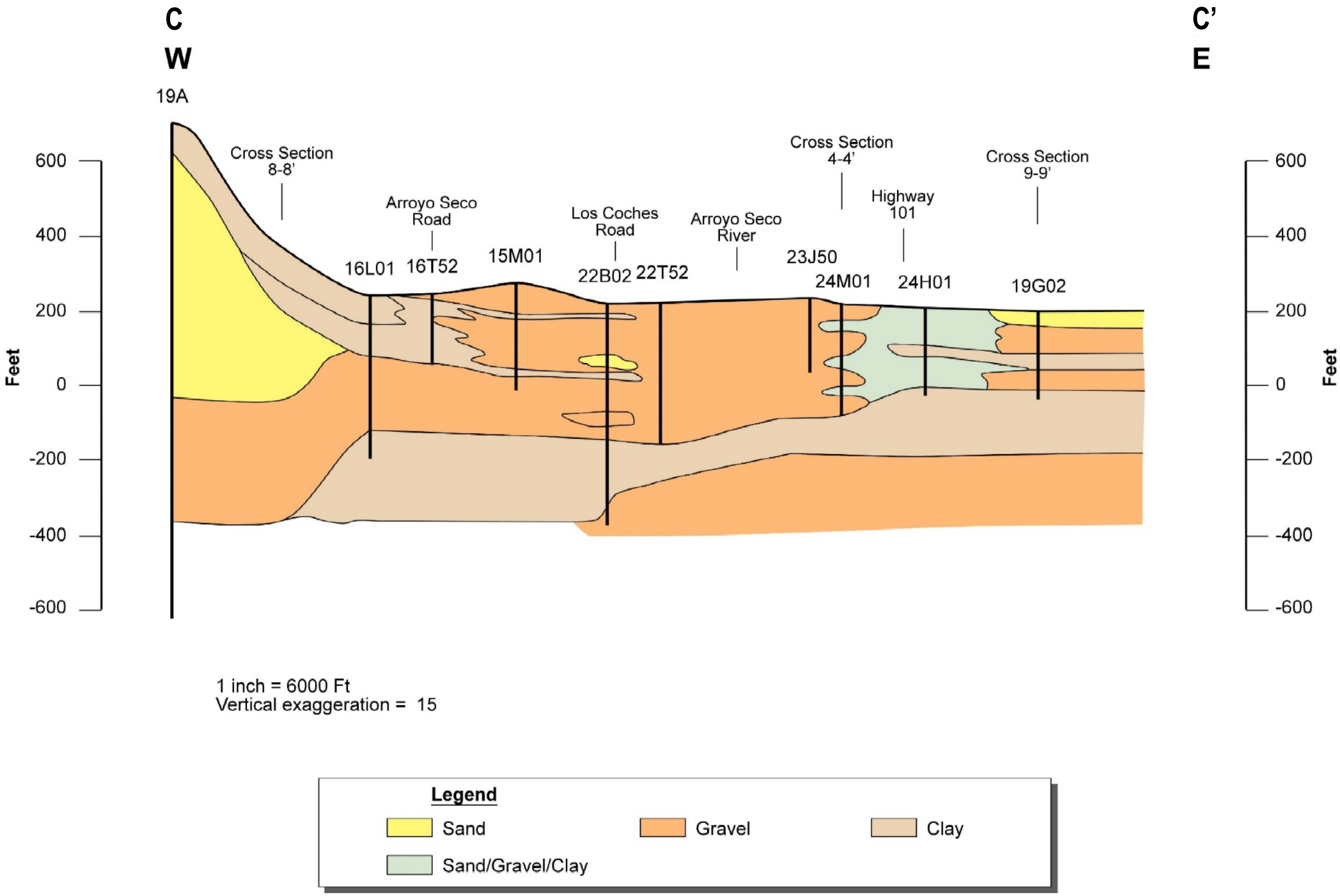

Figure 2-6. Cross Section C-C' (adapted from section 5-5' Staal, Gardner, & Dunne Inc, 1994)

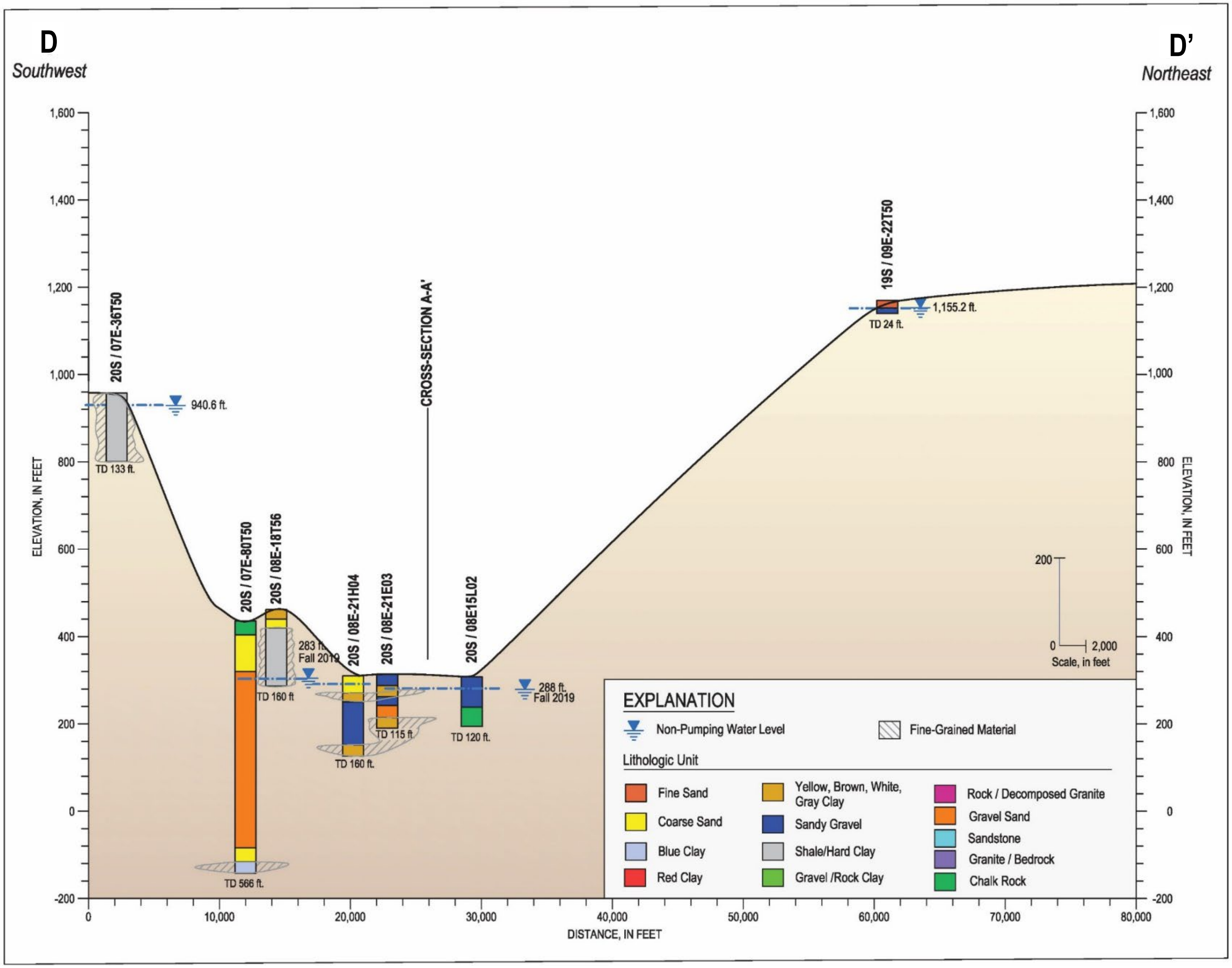

Figure 2-7. Cross Section D-D' (adapted from section C-C' from Montgomery & Associates, 2022)

2.4.4.3 Structure

The Salinas Valley is underlain by the Salinian tectonic block, a geologic basement terrane consisting of metamorphic and granitic rock of Paleozoic to Mesozoic age. The Salinian Block is bordered on both east and west by tectonic blocks of the Franciscan Complex. The boundaries between these tectonic blocks are large scale strike-slip faults: the San Andreas fault zone on the east, and the Sur-Nacimiento fault zone on the west (Figure 2-3).

2.4.4.4 Structural Restrictions to Flow

There are no known structural features that restrict groundwater flow within the Basin. However, lack of stratigraphic continuity associated with contrasting geologic depositional environments may impact groundwater flow between various Subareas, including:

- The transition from relatively layered fluvial and marine deposits in the Pressure Subarea to the alluvial fan deposits in the Eastside Subarea may restrict groundwater flow between the 2 subareas.
- The transition from a relatively homogeneous aquifer in the Forebay Subarea to the structured and layered aquifers in the Pressure Subarea may prevent some inter-subarea groundwater flow.

2.4.4.5 Soils

The Basin soils are derived from the underlying geologic formations and influenced by the historical and current patterns of climate and hydrology. Productive agriculture in the Basin is supported by deep, organic rich, loam soils. Soil types can also influence groundwater recharge rates. Figure 2-8 is a composite soil map based on soil taxonomy classification (U.S. Department of Agriculture, 2018). The Basin is dominated by mollisols, entisols, vertisols, and alfisols. Minor soils include histosols and inceptisols. The major soil orders are described in greater in Chapter 4 of the Salinas Valley GSPs.

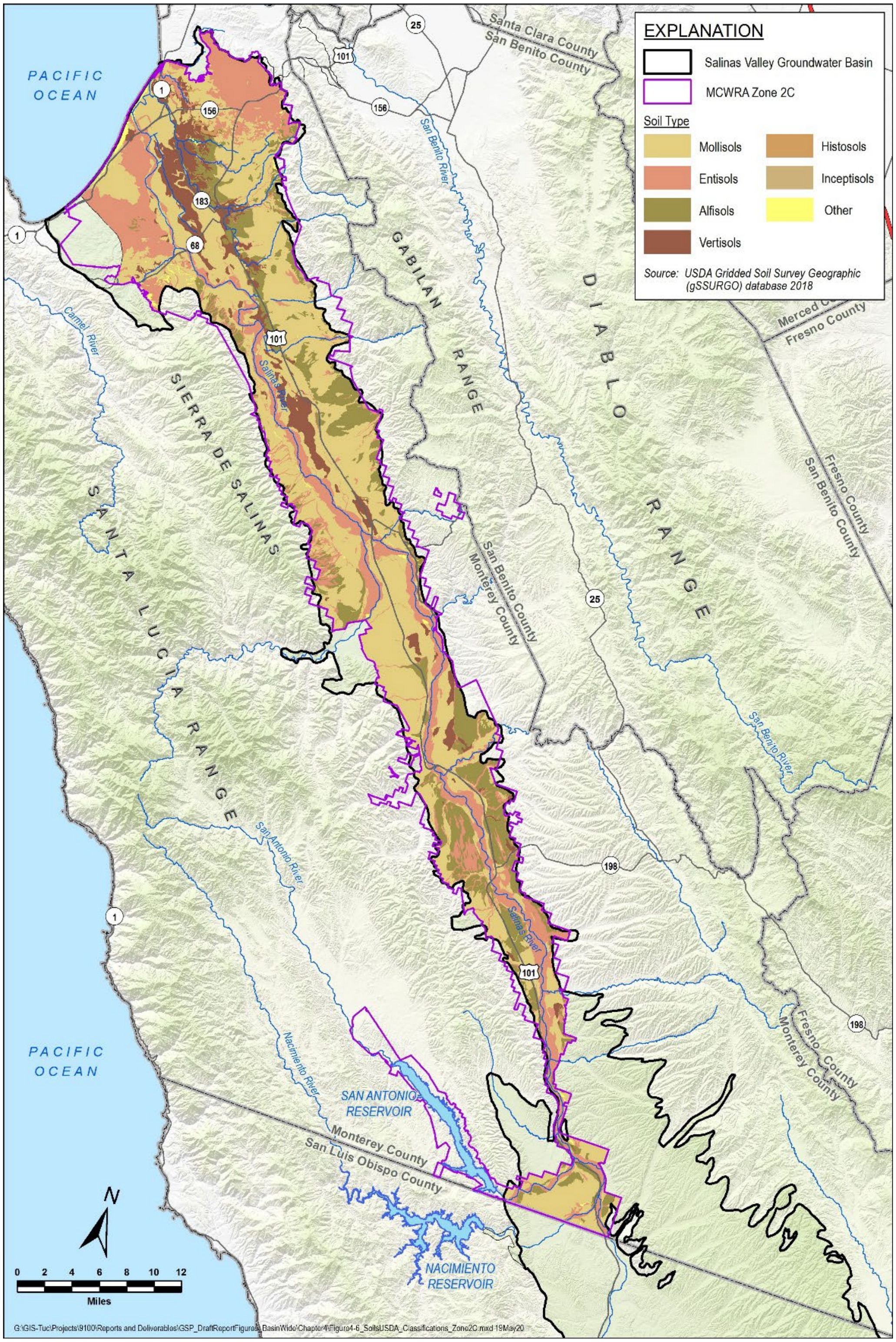

Figure 2-8. Composite Soils Map

2.4.5 Basin Hydrogeology

Groundwater production is primarily from the alluvium that fills the Salinas Valley structural trough. Throughout most of the southern two-thirds of the Basin, the groundwater system is in the alluvium. The alluvium does not include laterally continuous clay layers to restrict vertical flow and divide the alluvium into distinguishable aquifers. Rather, the alluvium is undifferentiated and groundwater production wells are screened in the shallowest productive sand and gravel intervals.

The presence of laterally continuous clay layers distinguishes the northern Pressure Subarea. As described in the following 2 subsections, the presence of continuous clay layers affects the following aspects of the basin hydrogeology:

- A near-surface clay layer, the Salinas Valley Aquitard, creates relatively shallow confined conditions in most of the Pressure Subarea, in contrast to the unconfined conditions over most of the Basin
- Deeper clay layers create definable aquifers in most of the Pressure Subarea, whereas most of the Basin includes only a single undifferentiated aquifer with interspersed, discontinuous clay layers.

While the Salinas Valley Aquitard is relatively continuous in the northern portion of the Basin, it is not monolithic. The clay layer is missing in some areas and pinches out in other areas.

Groundwater in the Eastside Subarea is often under semi-confined conditions due to the presence of multiple discontinuous clay and silt layers from the buildup of the alluvial fans over time.

2.4.5.1 Principal Aquifers

Groundwater production in the Basin is primarily from alluvial deposits belonging to 3 geologic units: the Holocene Alluvium (Qa), the Quaternary Older Alluvium (Qoa), and Pliocene Paso Robles Formation. Although these 3 geologic formations differ in age, they have similar distributions of sediment type and layering and in practice are difficult to distinguish during drilling.

For purposes of groundwater development in the Basin, these geologic units are not recognized as separate and individual aquifers, except in the Seaside portion of the Pressure Subarea. The principal aquifer in the Basin is simply referred to as alluvium, extending from the ground surface to the base of the groundwater basin. Other terminology, such as “Valley Fill” (Kennedy-Jenks, 2004) or “Basin Fill” (SVBGSA, 2022c) have also been assigned to the combined geologic units.

The local definition of multiple aquifers, or water-bearing zones within the alluvium is more a matter of practical resource development than of scientific analysis. The alluvium is split into 2 or more aquifers only where there is either a laterally continuous aquitard or a laterally continuous high-yield aquifer over a large area such that:

- The aquitard or aquifer is clearly recognized in many wells at approximately the same depth interval;
- The aquitard or aquifer has an observable impact on the groundwater hydrology – typically by a difference in water levels, water quality, or well yield above and below the aquitard; and
- There is practical value to well owners in recognizing the presence of the aquitard or aquifer in making well construction decisions based on that knowledge.

Based on the characteristics listed above, the alluvium transitions to a layered aquifer system separated by aquitards in the Pressure Subarea, where the Basin deepens and widens under the Salinas River towards the coast. Aquitards and high-yield aquifers are also recognized by local well owners throughout the Salinas Valley Basin. Although these local aquitards and aquifers may have practical importance to well owners at the local-scale, most of the discrete, local aquitards and aquifers do not influence groundwater flow at the Basin-scale.

Principal aquifers in the Salinas Valley Basin are described with slightly different names in the *2015 State of the Basin* report, GSPs, and other reports; however, they all describe the same general hydrostratigraphy. The subsections below describe the Salinas Valley hydrostratigraphy by Subarea, including aquitards and aquifers and the connectivity between Subareas.

2.4.5.1.1 Pressure Subarea

The shallowest water-bearing sediments are thin, laterally discontinuous, and do not constitute a significant source of water for the Subarea. These shallow sediments are therefore not considered a principal aquifer. These sediments are generally within 30 feet of the ground surface and are part of the Holocene Alluvium unit. Although these sediments are a minor source of water due to their poor quality and low yield, some small domestic wells draw water from this zone (Kennedy-Jenks, 2004; DWR, 2003; Showalter, 1984). Groundwater in these sediments is hydraulically connected to the Salinas River but is assumed to be relatively poorly connected to the underlying productive principal aquifers due to the presence of the underlying Salinas Valley Aquitard. In the Monterey Subbasin, the Dune Sands Aquifer is locally defined and overlies the Fort-Ord Salinas Valley Aquitard, which is an aquitard that pinches out near the coast, allowing the groundwater in the Dune Sands to flow into the 180-Foot Aquifer. However, while the Dune Sands Aquifer is locally designated, there are no major production wells in this aquifer, and it is impacted by Fort Ord contamination.

Beneath the shallow sediments, the following series of aquitards and principal aquifers have long been recognized in a multitude of studies and reports. They are the distinguishing hydrostratigraphic features of this Subarea.

- Salinas Valley Aquitard
- 180-Foot Aquifer
- 180/400-Foot Aquitard
- 400-Foot Aquifer
- 400-Foot/Deep Aquitard
- Deep Aquifers

2.4.5.1.1.1 Salinas Valley Aquitard

The Salinas Valley Aquitard is the shallowest, relatively continuous hydrogeologic feature in the Subbasin. The aquitard is composed of blue or yellow sandy clay layers with minor interbedded sand layers (DWR, 2003). The Salinas Valley Aquitard correlates to the Pleistocene Older Alluvium stratigraphic unit and was deposited in a shallow sea during a period of relatively high sea level.

2.4.5.1.1.2 180-Foot Aquifer

The Salinas Valley Aquitard overlies and confines the 180-Foot Aquifer. The 180-Foot Aquifer is the shallowest laterally extensive aquifer in the 180/400-Foot Aquifer Subbasin. This aquifer consists of interconnected sand and gravel beds that range from 50 to 150 feet thick. The sand and gravel layers are interlayered with clay lenses. This aquifer is correlated to the Older Alluvium or upper Aromas Sand formations (Harding ESE, 2001; Kennedy-Jenks, 2004). The 180-Foot Aquifer is exposed on the floor of the Monterey Bay (Todd Engineers, 1989).

The primary uses of the 180-Foot Aquifer are for domestic, irrigation, and municipal water supply.

2.4.5.1.1.3 180/400-Foot Aquitard

The base of the 180-Foot Aquifer is an aquitard consisting of interlayered clay and sand layers, including a marine blue clay layer similar to the Salinas Valley Aquitard (DWR, 2003). This aquitard is known as the 180/400-Foot Aquitard. It is widespread in the Subbasin but varies in thickness and quality, and areas of hydrologic connection between the 400-Foot and 180-Foot Aquifers are known to exist (Kennedy-Jenks, 2004). In areas where the 180/400-Foot Aquitard is thin or discontinuous, seawater in the 180-Foot Aquifer can migrate downward into the 400-Foot Aquifer in response to pumping or hydraulic gradient (Kennedy-Jenks, 2004).

2.4.5.1.1.4 400-Foot Aquifer

The 180/400-Foot Aquitard overlies and confines the 400-Foot Aquifer. The 400-Foot Aquifer is a hydrostratigraphic layer of sand and gravel with varying degrees of interbedded clay layers. It is usually encountered between 270 and 470 feet below ground surface. This hydrogeologic unit correlates to the Aromas Red Sands and the upper part of the Paso Robles Formation. Near the City of Salinas, the 400-Foot Aquifer is a single permeable bed approximately 200 feet thick; but in other areas the aquifer is split into multiple permeable zones by clay layers (DWR, 1973). The upper portion of the 400-Foot Aquifer merges and interfingers with the 180-Foot Aquifer in some areas where the 180/400-Foot Aquitard is missing (DWR, 1973).

The primary uses of the 400-Foot Aquifer are for domestic, irrigation, and municipal water supply.

2.4.5.1.1.5 400-Foot/Deep Aquitard

The base of the 400-Foot Aquifer is the 400-Foot/Deep Aquitard. The 400-Foot/Deep Aquitard is a series of clay layers that begin around 750 feet below land surface (Kennedy-Jenks, 2004). This aquitard can be several hundred feet thick (Kennedy-Jenks, 2004).

2.4.5.1.1.6 Deep Aquifers

The 400-Foot/Deep Aquitard overlies and confines the Deep Aquifers. The Deep Aquifers, also referred to historically as the 900-Foot and 1500-Foot Aquifers, are up to 900 feet thick and have alternating sandy-gravel layers and clay layers which do not differentiate into distinct aquifer and aquitard units (DWR, 2003). The Deep Aquifers correlate to the lower Paso Robles, Purisima, and Santa Margarita formations. The Deep Aquifers overlie the low permeability Monterey Formation. While the Deep Aquifers are relatively poorly studied, some well owners have indicated that there are different portions of the Deep Aquifers with different water qualities. No public data exists to substantiate these statements; however, SVBGSA, MCWRA, and other local entities began a Deep Aquifers Study in 2022 to better understand the Deep Aquifers in the Salinas Valley.

The Deep Aquifers are used primarily for irrigation and municipal water supply.

Within the Pressure Subarea, the Seaside Basin only recognizes the underlying, water-bearing geologic formations as principal aquifers. These are the Paso Robles Formation and the Santa Margarita Sandstone, which are typically designated ‘shallow’ and ‘deep’ in the well names. It is important to note that portions of the Paso Robles Formation form the basis of both the 400-Foot Aquifer, and Deep Aquifers elsewhere in the Pressure Subarea, and as such wells drawing from this geologic unit may be named as drawing from separate aquifers, but in fact are drawing from the same aquifer.

2.4.5.1.2 Eastside Subarea

There has been limited hydrogeologic analysis of individual Eastside Subarea aquifers. The most recent, detailed hydrostratigraphic analysis of the Eastside Subarea was published in 2004 with an update in 2015 (Kennedy/Jenks, 2004; Brown and Caldwell, 2015). The cross section on Figure 2-5 showing generalized relationships of finer or coarser sediments between boreholes should be interpreted with caution and an understanding the sediment structure of alluvial fans as it relates to the overall climatic setting over time.

Within the Eastside Subarea, 2 generalized water-bearing zones have been recognized within the alluvial fan aquifer system: the Eastside Shallow Zone and the Eastside Deep Zone. Many wells are screened across both zones, and are sometimes referred to using the terminology “Eastside Both”. While the designations of Deep and Shallow have been useful for geologic investigations into the morphology of the Subarea, they are not identified as distinct aquifers because unlike the Pressure Subarea, there is no continuous aquitard separating the layers. MCWRA identifies these as 2 distinct aquifers in many of their reports to correlate with generally time-stratigraphically equivalent zones as the 180-Foot and 400-Foot Aquifers. Additionally in the northern portion of the Subarea near Prunedale, the primary water-bearing zone is the Aromas Sands that overlie fractured granite. This unit is hydraulically connected to the 180- and 400-Foot Aquifers in the Pressure Subarea as the Aromas Sands comprise these aquifers as well.

The single aquifer in the Eastside Subarea appears to be somewhat hydraulically connected to the 180- and 400-Foot Aquifers in the Pressure Subarea, despite noted facies changes discussed in the 2004 *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley, (*Kennedy/Jenks, 2004). This connectivity is purportedly evidenced by the eastwardly decreasing groundwater elevations near Salinas (Brown and Caldwell, 2015). However, other than the very northern corner, seawater intrusion that is occurring in the Pressure Subarea has not been observed in most of the Eastside Subbarea, particularly where alluvial fans predominate, despite the eastward groundwater gradient. This suggests that the hydraulic connection between the 2 subareas may be limited in areas.

2.4.5.1.3 Forebay Subarea

Many previous studies have delineated the Arroyo Seco Subarea from the Forebay Subarea; however, this study no longer delineates this subarea due to the strong hydrologic connection between the sediments of each previously identified area. The Arroyo Seco Cone sediment fan is interfingered with the fluvial sediments of the greater Forebay Subarea, and recharge in the

Arroyo Seco Cone strongly influences groundwater elevations in the rest of the Forebay Subarea. Therefore, they are all combined into the generally unconfined Basin Fill Aquifer.

The Basin Fill Aquifer is the principal aquifer here and comprises sandy water-bearing layers that roughly correlate to, and are hydraulically connected to, the 180-Foot and 400-Foot Aquifers as defined in the neighboring Pressure Subarea (Kennedy/Jenks, 2004; Brown & Caldwell, 2015). The Salinas Valley Aquitard does not extend into this Subarea. The Basin Fill Aquifer includes the sediments which have built the Arroyo Seco Cone over time. The Arroyo Seco Cone covers approximately 22,000 acres on the west side of the Subbasin, near Greenfield (MCWRA, 2006). The interpreted extent of the Arroyo Seco Cone suggests that the Arroyo Seco Cone sediments are connected to sediments that cross almost the entire width of the Salinas Valley in the Forebay Subbasin. These sediments are deposited in thin beds, are laterally discontinuous, and may be locally perched due to the interbedded stratigraphy of the Arroyo Seco Cone and smaller alluvial fans where they occur in the Subarea. These sediments include intermittent clay layers which may act as locally confining units. These sediments also increase in confinement with depth throughout the Subarea.

The deepest sediments of the Basin Fill Aquifer in the Forebay Subarea are the same sediments as, and potentially hydraulically connected to, the Deep Aquifers in the Pressure Subarea (Brown & Caldwell, 2015). Some previous investigators have hypothesized that the Deep Aquifers present within the Pressure Subarea extend into the Forebay Subbasin (Green, 1970; Hanson *et al*, 2002; Brown & Caldwell, 2015; DWR, 2004); however, this deeper portion of the Basin Fill Aquifer has not been investigated or developed in a substantial way, and may not exist beneath the entirety of the Forebay Subarea.

2.4.5.1.4 Upper Valley Subarea

There has been limited hydrogeologic analysis of individual aquifers in the Subarea. The most recent, detailed hydrostratigraphic analysis of the Upper Valley Subbasin was published in 2015 (Brown and Caldwell, 2015).

Within the Upper Valley Subarea, the primary water-bearing units are similar to those found in the 180/400-Foot and Forebay Aquifer Subareas, as they are derived from the same sources. Due to the lack of extensive and traceable subsurface units, the Basin Fill Aquifer of the Upper Valley Subarea is generally unconfined and considered to be 1 unit (Brown and Caldwell, 2015). The Deep Aquifers present in other Subbasins are not present in the Upper Valley Subbasin because of the southward shallowing of the bottom of the Salinas Valley Basin.

2.4.5.2 Groundwater Elevation and Flow

Groundwater elevations in the Basin are generally highest at the southernmost end of the Upper Valley, and lowest between the City of Salinas and the coastline with Monterey Bay. Groundwater flow generally follows groundwater elevation contours from highs in the south to lows in the north, except for where localized depressions occur around pumping centers such as the City of Salinas.

2.4.6 Surface Water

The primary surface water body in the Basin is the Salinas River. This river runs through the entire length of the Salinas Valley and is fed by local tributaries that drain the western and eastern mountain ranges that bound the Basin as follows (Figure 2-9). Most of the tributaries are intermittent streams that only flow in the wet season. The following tributaries are found in Zone 2C:

- From Santa Lucia Range and Sierra de Salinas:
    - Arroyo Seco
    - San Antonio River
    - Nacimiento River
    - El Toro Creek
    - Hames Creek
- From Gabilan Range:
    - San Lorenzo Creek
    - Chalone Creek
    - Stonewall Creek
    - Pancho Rico Creek
    - Sargent Creek
- Valley Floor drainages:
    - Blanco Drain
    - Reclamation Ditch #1665 (Rec Ditch)

The following surface water bodies are located mostly outside of Zone 2C, but are important controls on the rate and timing of Salinas River flows:

- Two reservoirs constructed for flood protection, water conservation, and recreation include:
    - Nacimiento Reservoir, in San Luis Obispo County, was constructed in 1957 and has a storage capacity of 377,900 AF.

    - San Antonio Reservoir, in Monterey County, was constructed in 1967 and has a storage capacity of 335,000 AF.
- Arroyo Seco, a tributary with a 275 square mile drainage area that has no dams in its drainage basin and is characterized by both very high flood flows and extended dry periods.

Agricultural diversions and the construction of dams on the Salinas River and its tributaries have altered the river's hydrology, and the river no longer exhibits the seasonal variation in flows that were observed before the mid-20th century.

The mouth of the Salinas River forms a lagoon; and its outflow to Monterey Bay is blocked by sand dunes except during winter high-water flows. MCWRA operates a slide-gate to transfer water through a culvert from the lagoon into Old Salinas River during the wet season for flood control (MCWRA, 2014). The Old Salinas River discharges through tide gates at Potrero Road into Moss Landing Harbor and ultimately the Monterey Bay.

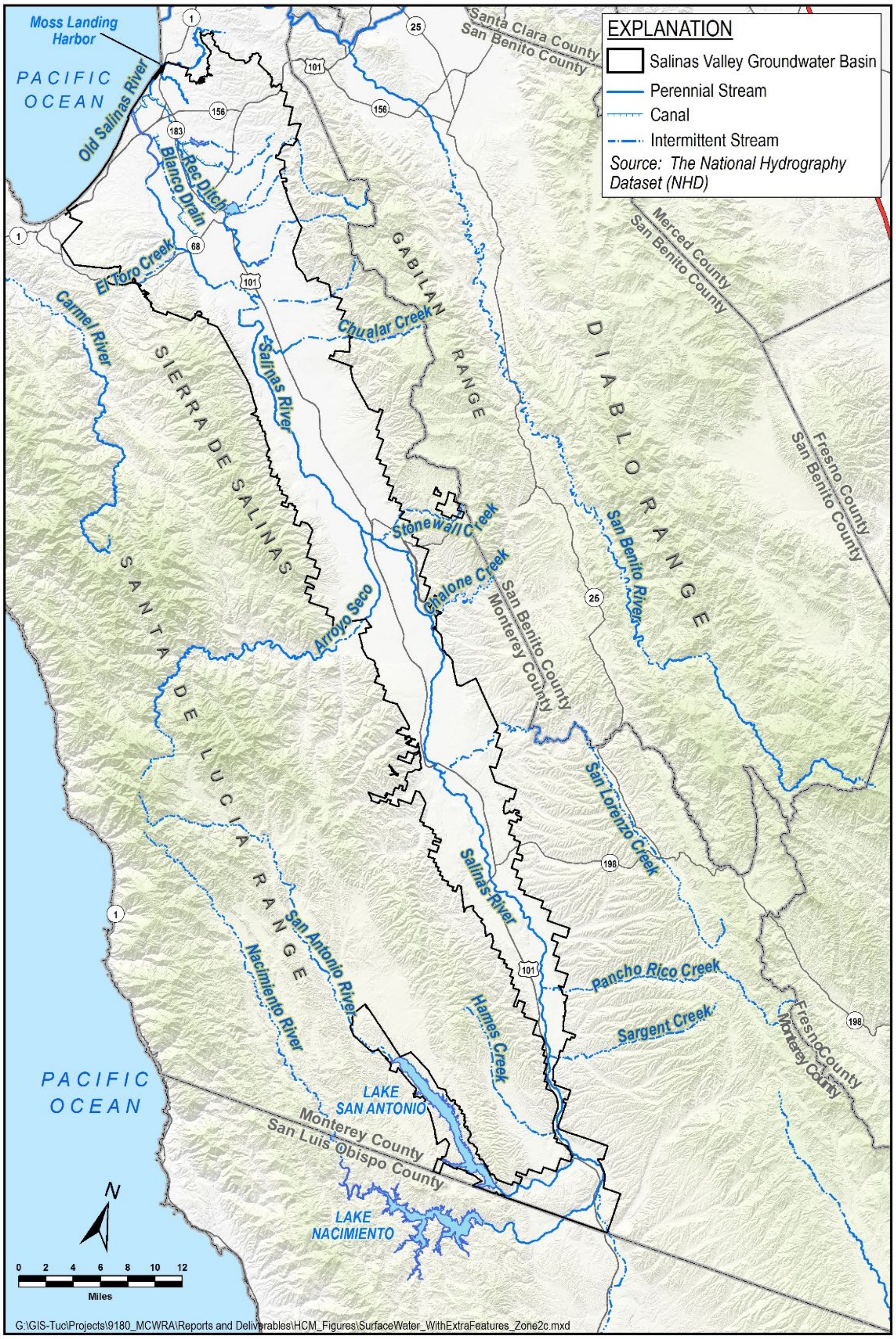

Figure 2-9. Salinas River and Tributaries

2.4.7 Natural Recharge Areas/Mechanisms

Natural recharge areas allow rainfall, local runoff, and streamflow to replenish aquifers by percolating through the subsurface. This section only identifies areas of natural recharge; anthropogenic recharge is not discussed here.

Natural groundwater recharge occurs through the following processes:

- Infiltration of surface water from the Salinas River and tributary channels
- Deep percolation of excess applied irrigation water
- Deep percolation of infiltrating precipitation
- Infiltration of water through mountain fronts and mountain blocks

Soil types can influence groundwater recharge. Recharge of surface water and deep percolation of precipitation are both surficial sources of natural groundwater recharge. An area's capacity for surficial groundwater recharge is dependent on a combination of factors, including steepness of grade, soil surface conditions such as paving or compaction, and ability of soil to transmit water past the root zone.

Areas with the highest potential for recharge are generally along the Salinas River and tributary streams. Actual recharge to the productive zones of the Basin could be limited because the discontinuous sediments throughout the Basin Fill may not provide a continuous path for recharge, and interfingering clay lenses may retard or prevent deep recharge. This demonstrates the limited utility of potential recharge maps that are solely based on surficial soil properties.

In addition to recharge through valley sediments, mountain front and mountain block recharge mechanisms help recharge the aquifers. Mountain front recharge occurs when water runs off the mountains and can infiltrate at the contact where the unconsolidated sediments of the Basin Fill meet the more consolidated or crystalline rocks of the mountains. Mountain block recharge occurs when water flows into the faults and cracks that frequently dissect mountains. These faults and cracks can allow water to flow down and meet the Basin Fill Aquifer at much deeper elevations, allowing for deep recharge. This mechanism is not well studied or easily modeled.

2.4.8 Natural Discharge Areas/Mechanisms

Natural discharge occurs where groundwater naturally leaves aquifers through flow to adjoining subareas or percolation to the ground surface. Natural groundwater discharge areas within the Basin include wetlands and other surface water bodies that receive groundwater discharge and evapotranspiration by vegetation types commonly associated with the sub-surface presence of groundwater. There are a few springs and seeps in the Basin. Natural groundwater discharge to streams – primarily, the Salinas River and its tributaries – has not been mapped to date.

2.4.9 Seawater Intrusion

Groundwater pumping has lowered groundwater elevations to a level that allows seawater to flow into the Basin from the Monterey Bay. Increased salt concentrations from seawater intrusion, measured as TDS or chloride concentration, are considered a nuisance for domestic or municipal uses rather than a health or toxicity concern. Additionally, increased salt concentrations from seawater intrusion may impact the ability to use groundwater for irrigation.

The impact of seawater intrusion on the beneficial uses of groundwater occurs at concentrations much lower than that of seawater. The TDS of seawater is approximately 35,000 mg/L. The State of California has adopted a recommended Secondary Maximum Contaminant Level (SMCL) for TDS of 500 mg/L, and a short term maximum SMCL of 1,500 mg/L. Groundwater with TDS of 3,000 mg/L or less, however, is considered to be suitable, or potentially suitable, for beneficial uses in accordance with SWRCB Resolution No. 88-63 as adopted in its entirety in the Central Coast Regional Water Quality Control Board's Basin Plan. The TDS limit for agricultural use is crop dependent: a 10% loss of yield in lettuce crops has been observed at a TDS of 750 mg/L; a 10% loss of yield in tomatoes has been observed at a TDS of 1,150 mg/L (Ayers and Westcot, 1985). The Monterey Subbasin GSP adopts 1,000 mg/L of TDS as a surrogate for 500 mg/L of chloride for the local groundwater (MCWD GSA and SVBGSA, 2022). MCWRA defines seawater intrusion in Ordinance No. 3790 as a concentration of chloride exceeding 500 mg/L.

Detailed characterization of seawater intrusion in the Basin can be found in multiple previous studies (Greene, 1970; DWR, 1973; Todd Engineers, 1989; Kennedy/Jenks, 2004). The primary reason seawater intrusion occurs is that the 180-Foot and 400-Foot Aquifers are in direct hydraulic contact with Monterey Bay. The secondary reason is that groundwater elevations in the 180-Foot and 400-Foot Aquifers are below sea level, resulting in a groundwater gradient that is landward. Groundwater elevation decline increases the gradient between seawater and groundwater, thus increasing the rate of seawater intrusion. A third reason for seawater intrusion is inter-aquifer flows; not only is the aquitard between the 180-Foot and 400-Foot Aquifers discontinuous in localized areas, but also poorly constructed or abandoned wells have facilitated downward migration of seawater from the 180-Foot Aquifer to the 400-Foot Aquifer.

The mechanisms that have facilitated seawater intrusion in the 180-Foot and 400-Foot Aquifers may also pose a risk of seawater intrusion into the Deep Aquifers. The formations that comprise the Deep Aquifers are also in contact with seawater in Monterey Bay, Deep Aquifer groundwater elevations have been declining with increased extraction over time, and the aquitard that separates the 400-Foot Aquifer from the Deep Aquifers is poorly studied and understood. Additionally, some wells completed in the deeper portions of the 400-Foot Aquifer may also be screened across the aquitard or in connection with the shallower portions of what is considered the Deep Aquifers.

3 TOOLS, DATA SOURCES, AND METHODS

This section details the tools, data sources, and methods used in this study to (1) summarize historical and current water demands and groundwater conditions, and (2) estimate 2030 water demands and groundwater conditions in Zone 2C.

This study assesses historical population, land use, and water demand for Zone 2C and compares it to the General Plan and EIR. First, the historical (1944 to 2013) groundwater levels and seawater intrusion extent data in the *2015 State of the Basin Report* is updated to include more recent observations through 2020. Then, population, land use, water demand, and climate projections developed using various methods are used to estimate how groundwater levels and seawater intrusion extent may change in Zone 2C by 2030, absent of any additional projects or management actions.

Tools used in this study include the SVIHM/SVOM, Seawater Intrusion Model (SWI Model), and LUCAS. Data used in this study is the most recent available. For the SVIHM/SVOM groundwater model the baseline data was from 2017, for the SWI Model the baseline data was from 2020, for population and seawater intrusion the most recent data was from 2020, and for water demands and groundwater elevations the most recent data was from 2021.

3.1 Tools

This Study uses 3 models: the SVOM, the SWI Model, and the LUCAS land use model. These are summarized in Table 3-1 and sections below. Projected water demands and groundwater conditions in 2030 are simulated using the SVOM and SWI Model. The LUCAS model is used to estimate a range of potential land use changes through 2030. A range of projected urban water demands, land use, and climate change conditions are developed for model simulations. Low, medium, and high growth scenarios provide a range of scenarios that helps account for uncertainty and potential variability in these estimates of expected conditions in 2030. The historical version of the SVOM, the SVIHM, and the historical SWI Model are used as the baselines for 2030 model projection scenarios. Appendix A summarizes the SVOM and SWI Model input and output data processing steps used for this study.

Table 3-1. Tools Used to Develop the Basin Investigation

Study Name	Reference, Year	Study Timeframe	Projected Data	Study Area
Phase 2 Basin Investigation (SVIHM/SVOM)	USGS, to be published in future	1967 through 2014	No projections.	Zone 2C
SWI Groundwater Model	Montgomery & Associates, 2023	1984 through 2020	No projections.	Coastal portion of Zone 2C mostly in Pressure Subarea
USGS - LUCAS Land Use Model	Sleeter *et al.*, 2017	2001 through 2100	Range of land use changes for variable growth rates.	State of California

3.1.1 SVOM Groundwater Model

The SVOM is a predictive integrated hydrologic model developed by USGS to complete Phase 2 of the Basin Investigation and for use in other regional groundwater planning efforts. Groundwater conditions are simulated with a finite difference numerical groundwater-surface water model using the MODFLOW-OWHM Version 2 code (Boyce *et al.*, 2020). This version of MODFLOW allows for a dynamic simulation of the balance between water consumption with supply and demand. The model extents are similar to the Zone 2C extent, shown on Figure 3-1.

The SVOM is a predictive version of another USGS model, the SVIHM. The SVIHM simulates historical conditions in the Salinas Valley, including reservoir and SRDF operations. The current SVIHM is calibrated to a historical time range from 1967 through 2014.

Agricultural water demands are estimated by the SVOM based on crop type and climate. Land use and crop type are inputs to the SVOM. Agricultural water demands are first met by precipitation, recycled water, and surface water diversions if available, and the remaining water demand is supplied by groundwater pumping. The Surface Water Operations package in the SVOM regulates releases from San Antonio and Nacimiento reservoirs based on MCWRA's existing operating policies.

Surface water and recycled water are used to satisfy some agricultural water demand in the model. The SVOM explicitly simulates only 2 stream diversions in the Salinas Valley – Clark Colony and the SRDF. The Clark Colony diversion is located along Arroyo Seco and diverts about 300 acre-feet per year (AF/yr) to an agricultural area nearby. The SRDF came online in 2010 and diverts water from the Salinas River to the CSIP area. SRDF diversions are made throughout the duration of the SVOM whenever reservoir storage and streamflow conditions allow during the period from April through October. Recycled water has been delivered to the

CSIP area as irrigation supply since 1998. The SVOM includes recycled water deliveries throughout the duration of the model.

For this study, agricultural water demands are simulated using 2030 projected land use and urban water demands are directly input into the SVOM. As explained in Section 3.2.2, pumping for 2030 urban use is based on historical public supply and industrial water use reported through GEMS, anticipated population growth, and anticipated changes in efficiency. The USGS determined that rural domestic water use in Zone 2C was negligible in comparison to municipal and agricultural pumping; therefore, rural domestic water use is not simulated in the models.

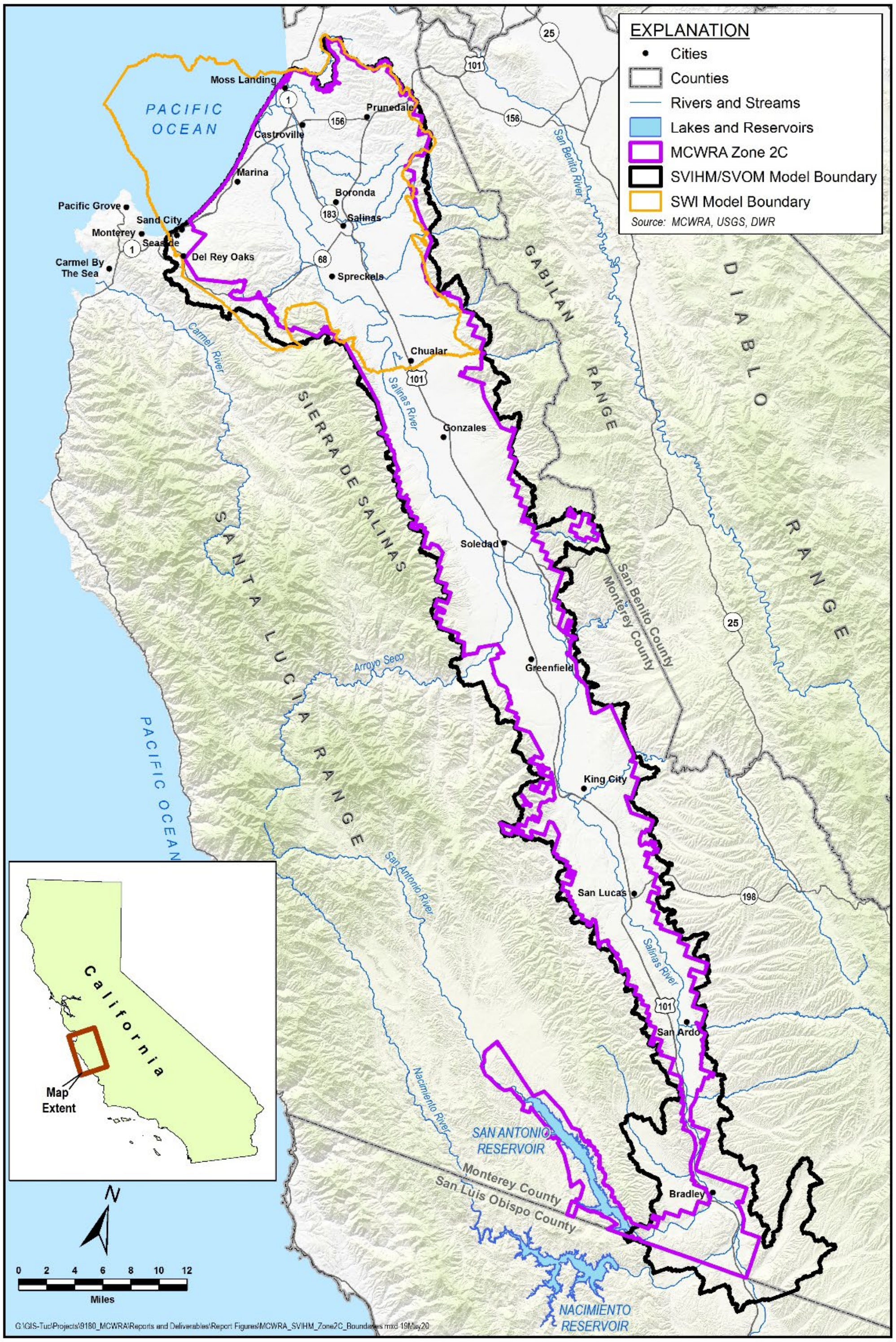

Figure 3-1. SVIHM, SVOM and SWI Model Extents

3.1.2 SWI Groundwater Model

The SWI Model is a coupled flow and transport groundwater model developed by Montgomery and Associates to simulate seawater intrusion in the Salinas Valley. Unlike other existing models of the Salinas Valley, such as the SVIHM and SVOM, the SWI Model numerically models density-dependent transport of chloride as an analogue for seawater intrusion. The SWI Model uses MODFLOW USG to numerically solve equations for groundwater flow and solute transport (Panday *et al*. 2022).

The purpose of the SWI Model is to assess projected seawater intrusion in the Salinas Valley and to predict the effectiveness of future projects at addressing further intrusion. A historical version of the SWI Model was developed to simulate processes that led to current seawater intrusion. The historical model simulates conditions between 1984 and 2020. A predictive version of the SWI model is used to simulate the impact of projected future land use, water demands, and climate on seawater intrusion from water year 2021 through 2030 (See Section 3.2.7). The groundwater elevations, chloride concentrations, and groundwater pumping at the end of the historical SWI Model are the initial conditions of the predictive SWI Model. Boundary conditions of the historical SWI Model are modified to extend the simulation period to 2030. Appendix A describes data processing steps in more detail.

The SWI Model study area includes the entire region of potential seawater intrusion in the Salinas Valley. The SWI Model boundaries are shown on Figure 3-1. The model is bounded by Elkhorn Slough and the Gabilan Mountains to the north/northeast, and the Santa Lucia Highlands to the south/southwest. The southern extent of the model is Chualar Creek. The SWI Model is built using existing groundwater models in this area, including the SVIHM, the Monterey Subbasin Groundwater Flow Model developed by EKI Environment & Water for Marina Coast Water District Groundwater Sustainability Agency (MCWD GSA and SVBGSA, 2022), the North Marina Groundwater Model (Hydrofocus, 2017), and the Seaside Basin Model (Hydrometrics, 2009; 2018). The SWI Model references the hydrogeology of multiple regional models, and the existing models supported development of several boundary conditions in the SWI Model.

Groundwater pumping is directly input into the SWI Model for urban and agricultural water demands. This is different than the SVOM, which uses the farm process to simulate agricultural pumping based on crop demand. MCWRA's GEMS data provided the SWI Model's pumping data since 1995 where collected. Other sources were relied upon for areas not covered by the GEMS program. Urban and agricultural pumping rates prior to 1995 are extracted from the SVIHM and other models. Surface water deliveries supplying CSIP are modeled as extracted water from the Salinas River at the SRDF at rates based on historical records. 2030 groundwater pumping for this study was input based on anticipated changes to historical urban and agricultural demand, as described in Section 3.2.2, 3.2.5, and Appendix A.

Sea level rise is particularly important for modeling seawater intrusion because it increases the hydraulic pressure of seawater flowing into the basin. Sea level rise was addressed in the model by increasing the specified head at the seawater interface in Elkhorn Slough. Per DWR guidance, 5.9 inches of sea level rise was added to the 2014 sea level surface used in the SWI Model to simulate 2030 projected sea level rise (DWR, 2018).

3.1.3 LUCAS Model

The LUCAS model projects land use changes for regional planning efforts and is used in this study to project 2030 land use. The LUCAS model land use projections were developed by the USGS for California's 4th Climate Change Assessment (Sleeter *et al.*, 2017). The LUCAS Model is used for projecting future land use in other regional land and water use studies in Monterey County, including a USGS and University of California Santa Cruz study of land use and future water demand in the California Central Coast region (Wilson *et al.*, 2020) and the SCRBS study (Brown and Caldwell, 2019b).

The LUCAS model incorporates historical and projected spatial land use change patterns to identify where land change is likely to occur in the future. LUCAS model results include land use maps on an annual time step between 2001 and 2100. The LUCAS model grid is composed of square kilometer cells (or 0.38 square mile) and each grid cell is assigned a unique land use for each annual time step. LUCAS estimates the probability of land use changes based on historical and projected data trends from the following sources:

- Population changes predicted in 2014 by the California Department of Finance [(DOF); Sharygin, 2016]
- Agricultural and urban expansion and contraction data from California Department of Conservation FMMP 2014 farmland data
- Perennial and annual agriculture crop mapping from the U.S. Department of Agriculture's National Agricultural Statistics Service
- Forest, land use, and land cover expansion and contraction from the USGS 2001 National Land Cover Database
- Additional land cover information from the Oregon State Landscape Ecology, Modeling, Mapping, and Analysis Team

There are 4 land use scenarios developed in the LUCAS model for California's 4th Climate Change Assessment: a "Business as Usual" scenario, and 3 scenarios incorporating low, medium, and high degrees of land use change from DOF projected population growth. The baseline land use in each LUCAS scenario is the 2001 land use shown on

Figure 3-2. The USGS compiled 10 replicate simulations for each scenario for model variability and uncertainty analysis. The SCRBS uses the same low, medium, and high growth scenario simulations selected for this study to project land use change. The amount of land use change in Zone 2C between 2001 and 2030 for the 4 LUCAS scenarios is shown on

Figure 3-3.

Annual and perennial agriculture, developed land, and grassland uses make up the largest percentage of total land use in Zone 2C as shown on

Figure 3-2 and change the most over time as shown on

Figure 3-3. Perennial agriculture and developed land uses have increasing trends and annual agriculture and grasslands have decreasing trends. Forest, wetlands, and shrublands remained relatively constant over time and barren, transportation, and water land uses had no change; for this reason and for consistency with the datasets in the EIR and SCRBS report, only annual, perennial, developed, and grassland land use types are reviewed in detail in this report.

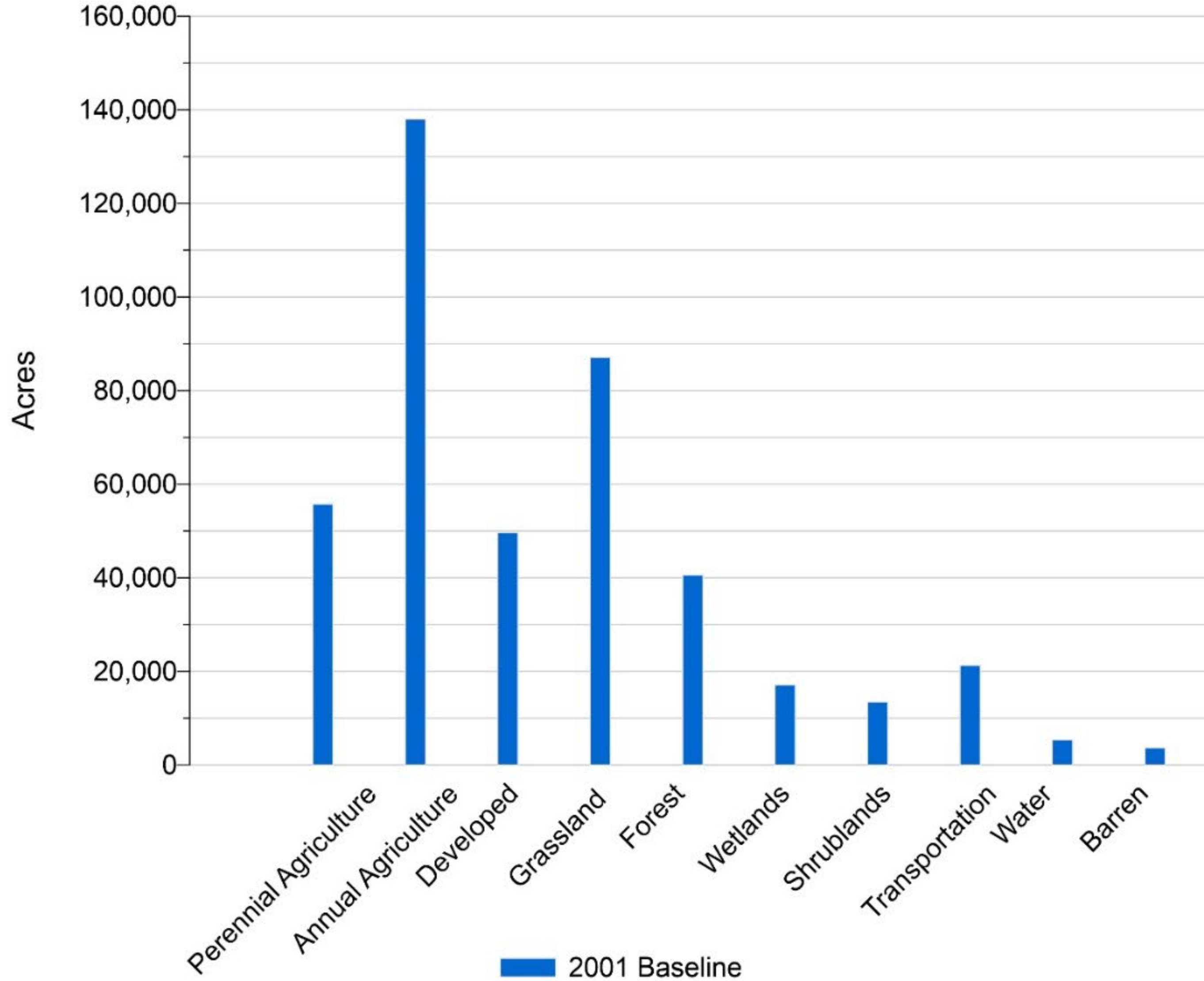

Figure 3-2. LUCAS Model Land Use in Zone 2C in 2001

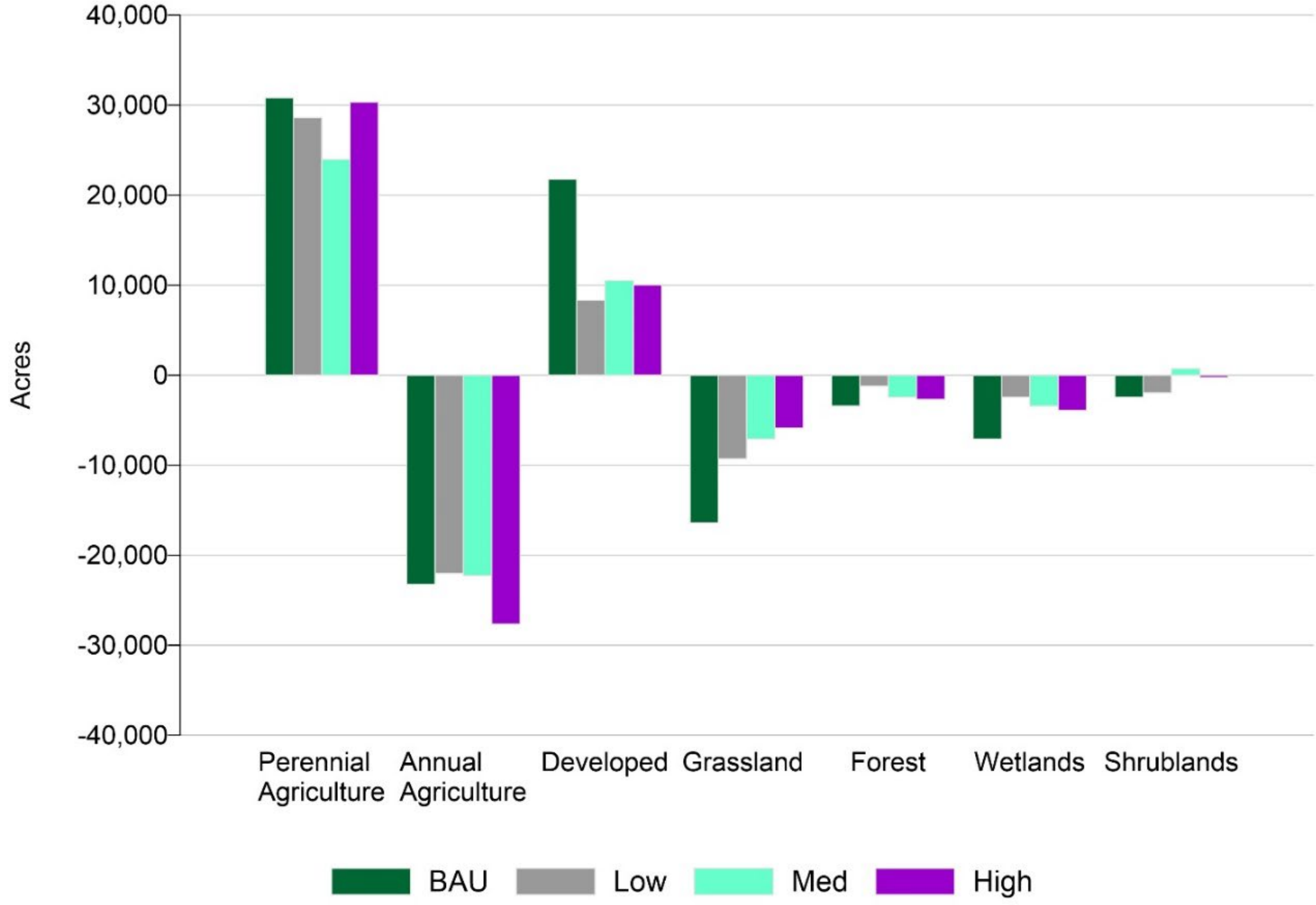

Figure 3-3. LUCAS Land Use Change in Zone 2C between 2001 and 2030

3.2 Data Sources and Methods

The following subsections describe the methods used to develop 2030 population, urban water use, land use, water demands, and water budget projections. The methodology relies upon vetted regional studies such as AMBAG population projections, DOF population counts, LUCAS land use projections, and use of the SVOM and SWI groundwater models.

This study includes low, medium, and high growth scenarios to account for uncertainty and potential variation in future conditions. A summary table of the main reports and the data sources used to develop their assumptions is included in Table 3-2.

Table 3-2. Investigation Methods for Previous Reports, Tools, and Phases of the Basin Investigation

Study Name	Population		Urban Water Demand		Land Use		Agricultural Water Demand	
	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected
Monterey County EIR for 2010 General Plan	DOF population counts	2004 AMBAG projections	MCWRA groundwater pumping data	Scaled based on projected population growth rate	FMMP	Not available	MCWRA groundwater pumping and recycled water diversion data and other unmeasured or unreported estimates	Estimated based on improved agricultural water use efficiency and a projected lower water demanding crop mixture
USBR - Salinas and Carmel River Basin Study	DOF population counts	2018 AMBAG projections	MCWRA groundwater pumping data	Scaled based on range of projected population and 20% efficiency improvement	FMMP	Urban: Population and population density. Farmland: LUCAS.	Estimated by groundwater model for aggregate crop mixture.	Estimated by groundwater model for projected crop mixture.
Phase 1 Basin Investigation (State of the Basin)	Not analyzed	Not applicable	1954-1994 – pumping in SVIGSM; 1994-2013 – MCWRA groundwater pumping (GEMS)	Not applicable	Not analyzed	Not applicable	1954-1994 – pumping in SVIGSM; 1994-2013 – MCWRA groundwater pumping (GEMS) and recycled and surface water diversions	Not applicable
Phase 2 Basin Investigation (SVIHM/SVOM)	Not applicable	Not applicable	1967-1994 – Estimated based on population 1994-2014 – MCWRA groundwater pumping data (GEMS)	Not applicable	USGS NLCD; Monterey County Ranch Maps; CalPIP	Not applicable	Estimated by groundwater model for aggregate crop mixture.	Not applicable

Study Name	Population		Urban Water Demand		Land Use		Agricultural Water Demand	
	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected
Phase 3 Basin Investigation (This Study)	DOF population counts	2018 AMBAG projections	2010-2021 MCWRA GEMS	Scaled based on range of projected population and range of efficiency improvement	2006 and 2017 SVIHM maps	2017 SVIHM map modified with 2017-2030 urban and agricultural land use change from LUCAS	2010-2021 MCWRA groundwater pumping data (GEMS) and recycled and surface water diversions	Estimated by groundwater model for projected crop mixture assuming climate change.
SWI Groundwater Model	Not applicable	Not applicable	1984-1995 – Extracted from SVIHM and other neighboring models 1995-2020 – MCWRA GEMS and other neighboring models	Scaled based on range of projected population and range of efficiency improvement	Extracted from other models for estimating surface recharge	No change to historical land use.	1984-1995 – Extracted from SVIHM and other neighboring models 1995-2020 – MCWRA GEMS and other neighboring models	Scaled based on range of projected agricultural water demands and climate change
USGS - LUCAS Land Use Model	DOF population counts	2014 DOF projections (Sharygrin, 2016)	Not applicable	Not applicable	2001 land use data from FMMP; USDA Nass; USGS NLCD; OSU LEMMA	Projected using land use change probability model	Not applicable	Not applicable

3.2.1 Population

This study updates the historical and current 2020 Zone 2C population and projects 2030 Zone 2C population using similar data as the General Plan and EIR. Projected population is used to derive the 2030 urban water demand.

3.2.1.1 Historical and Current Population

Historical data sources reviewed for this study include the following sources:

- United States Census Bureau (U.S. Census Bureau) population counts from 2000, 2010, and 2020; and
- DOF annual population estimates from summary reports in 1980, 1990, 2000, 2012, and 2021.

The U.S. Census Bureau performs nationwide population counts every 10 years and releases data for incorporated cities, unincorporated communities, and as a lump sum for the County. DOF estimates population annually in California counties and incorporated communities. The greater unincorporated population in the County is estimated as a lump sum. DOF predicts annual population changes using tax returns, birth rates, death rates, counts of drivers address changes, school enrollment, foreign and domestic migration, medical care enrollments, and student housing. The DOF adjusts their estimates every 10 years to be consistent with U.S. Census Bureau counts.

Historical and 2020 unincorporated community population is estimated for some lower population areas that do not have recent data available. At the time population data was gathered for this study, the U.S. Census Bureau only released unincorporated community population estimates for Castroville and Prunedale, the 2 largest communities in Zone 2C. Other smaller unincorporated communities are included in 2000 and 2010 U.S. Census Bureau counts. For smaller communities without 2020 population data, the 2010 to 2020 DOF unincorporated annual growth rate for Monterey County was used to project 2020 population from 2010 Census Bureau estimates.

The number of residents in rural areas in Zone 2C is not listed in recent DOF or U.S. Census Bureau counts. This study estimates Zone 2C rural population using County-wide unincorporated population estimates in DOF reports and an unincorporated population estimate compiled for the smaller portion of the County in the SCRBS study area.

3.2.1.2 Projected Population

This study compiles a range of 2030 population projection estimates for Zone 2C to estimate water demands. Population projections are based on the 2018 AMBAG report (AMBAG, 2018), historical U.S. Census Bureau and DOF population growth rates, and population growth projections used in the SCRBS report *Draft Technical Memorandum #3* (Brown and Caldwell, 2019a). AMBAG, U.S. Census Bureau, and DOF data are used to develop population projections for the EIR, General Plan, and SCRBS, making this approach consistent with other recent planning efforts in the County.

The 2018 AMBAG report is used in this study to project 2030 population. AMBAG population growth forecasts are released about every 5 years for local policy and resource allocation efforts in Monterey Bay area counties. The 2018 AMBAG report projects population every 5 years from 2015 through 2040. AMBAG population projections are modeled using DOF baseline 2015 population and U.S. Census Bureau data for gender, age, birth rates, death rates, and mobility. The 2018 AMBAG report projects population for individual cities and as a lump sum for unincorporated communities and rural areas. The 2018 AMBAG county unincorporated population growth rate was used to project 2030 population in Zone 2C communities and rural areas.

The medium growth scenario in the SVOM simulations is based on 2030 population projections. The potential range of variability in future population estimates was developed based on estimates in the SCRBS report (Brown and Caldwell, 2019a). Low and high population estimates for 2030 are calculated by adding and subtracting 0.3%, respectively, to the projected annual growth rate for each community between 2020 and 2030.

3.2.2 Urban Water Use

Urban water use is reported annually to MCWRA and is projected as an input for 2030 SVOM and SWI Model scenarios. Water for urban use is sourced by groundwater supply wells. Urban pumping has been reported in GEMS to MCWRA since 1994.

The historical pumping data and assumptions about future population growth and efficiency improvements are used to develop a range of projected 2030 urban groundwater pumping scenarios for this study. The 2017 GEMS urban pumping data is used as the baseline pumping data for 2030 projections. Urban water use is scaled proportionately with a range of population growth estimates, discussed in Section 3.2.1.2.

A range of 2030 urban water use efficiencies are used to scale pumping projections. The baseline water use coefficient in gallons per capita per day was calculated for each city using 2017 pumping and population data. Per capita water use has decreased in recent years as providers and customers improve efficiency (SCRBS, 2020). The California Senate introduced draft revised California Water Code language in February 2020 as Senate Bill 1217 that proposes a 9% reduction in target water use efficiency by 2030 as 1 of 4 potential methods that a water provider can use to show efficiency improvements (California S.B. 1217). The SCRBS study estimates that urban water use will decrease by 20% from 2017 levels by 2030, which could slightly overestimate required future reductions in urban water use. The SCRBS study also found that most water providers in Zone 2C were more efficient than their 2020 target water efficiency between 2015 and 2017, meaning they may not have to reduce per capita water use coefficients as much to meet future efficiency targets.

The following urban water use coefficients are used to project a range of 2030 urban water demands for this study:

- Low growth scenario – 2017 urban water use coefficients decreased by 20%, consistent with the SCRBS study projections.
- Medium growth scenario – 2017 urban water use coefficients decreased by 10%, consistent with language in proposed Senate Bill 1217.
- High growth scenario – 2017 urban water use coefficients remain the same as water providers are currently more efficient than required 2020 standards and might not need to reduce future water use in 2030.

Urban industrial water use is not easily projected using the methods for cities and communities since pumping data is not tied to specific population centers. The projected urban industrial water use is assumed to increase proportionally to overall population growth in Zone 2C. There are no efficiency changes estimated for urban industrial water use. Industrial uses include food processing, aggregate mining, business parks, and commercial landscape irrigation and community water uses are small and/or transient community water services, schools, and community centers.

Domestic groundwater pumping is used to supply water for residential use in rural areas. Domestic groundwater pumping is not tracked by the County and is not incorporated in the SVOM by USGS; therefore, 2030 groundwater pumping for rural residential use is not simulated in this study.

3.2.3 Land Use

Land use is directly related to agricultural, urban, and non-irrigated vegetation water demands, so changes in land use can influence water use. Historical water demands are measured by MCWRA and reported in GEMS so are not specifically tied to land use. However, for this study projected agricultural water demands are based on a range of 2030 land use projections in SVOM. The 2030 SVOM land use scenarios incorporate a range of expanding urban footprints, conversion from annual to perennial crops, and reduction in grazing and other non-irrigated lands.

3.2.3.1 Historical and Current Land Use

Historical and current land use mapping since the EIR is used to assess land use changes and the relationship between agricultural land use and water demands. The EIR used FMMP mapping to estimate land use coverage in the County. Agricultural water demands in the EIR were from GEMS pumping data, so FMMP land use did not factor into historical water demand estimation.

For this study, SVIHM 2017 land use map is the baseline for 2030 land use and water demand projections. The 2006 SVIHM land use map is also reviewed in this study to compare to the EIR baseline and establish rates of agricultural and urban land use change between 2006 and 2017.

A composite of multiple land use data sources are used by the USGS to develop historical SVIHM land use coverages. The land use classification system is based on USGS National Land Cover Dataset, local crop data from DWR and County Agricultural Commissioner Ranch Maps, and pesticide application permits to update recent land use maps. The maps used for this study are inputs to the model and are discretized on the model grid. Since the model grid resolution is coarser than the land use input map, the mapped land use coverage used for this study is not identical, but is close to the land use in SVIHM.

The SVIHM land use maps include detailed crop type classifications for estimating water demands in the SVIHM and SVOM. There are 22 unique land use classifications in SVIHM. Crop classifications shown on Figure 3-4 are simplified to show annual and perennial crop distribution. For this study, “barren” land was assumed to be “urban” or developed for residential, commercial, or industrial use because most of this land coincided with developed areas in Zone 2C. The SVIHM and SVOM crop classifications have unique coastal and inland water use coefficients because coastal crops require less water. The baseline map does not differentiate between coastal and inland crop locations, so the historical coastal and inland crop boundary in SVIHM is used to define coastal and inland locations for the SVIHM 2017 land use map, as shown on Figure 3-5.

Historical 2006 and recent 2016/2017 SVIHM and FMMP land use maps are compared to establish that the land use data used in this study is consistent with the source used for the EIR. The land use source comparison in Appendix B shows that SVIHM and FMMP map slightly different farmland and urban acreage, but the land use changes over time are similar. Since the SVIHM land use change is relatively consistent with FMMP, it is suitable for projecting land use and water demands relative to the EIR. The SVIHM map was selected instead of FMMP for this study because it is the historical SVIHM source file and is better suited for assigning unique crop types for estimating agricultural water demand in the SVOM.

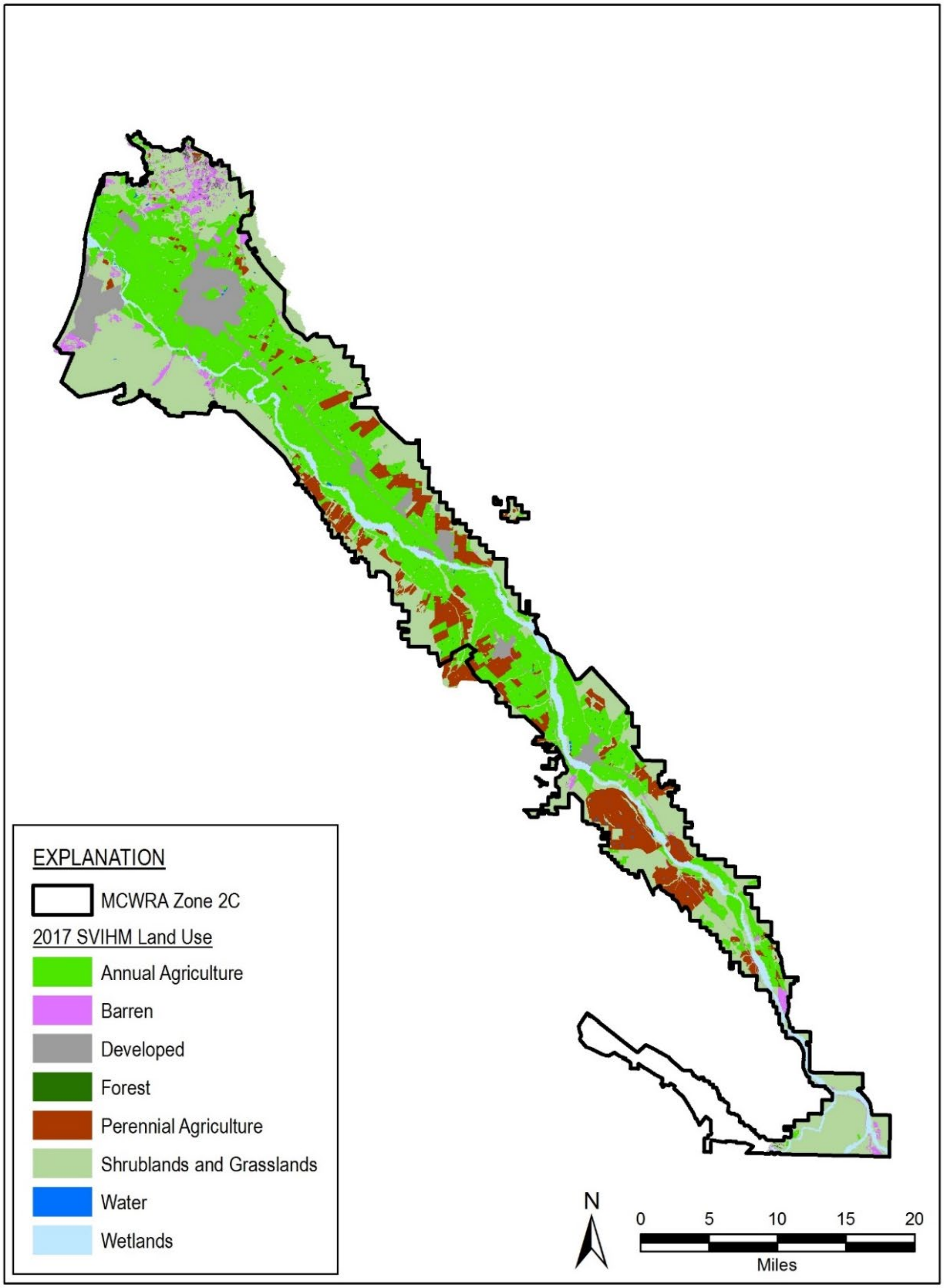

Figure 3-4. SVIHM 2017 Land Use

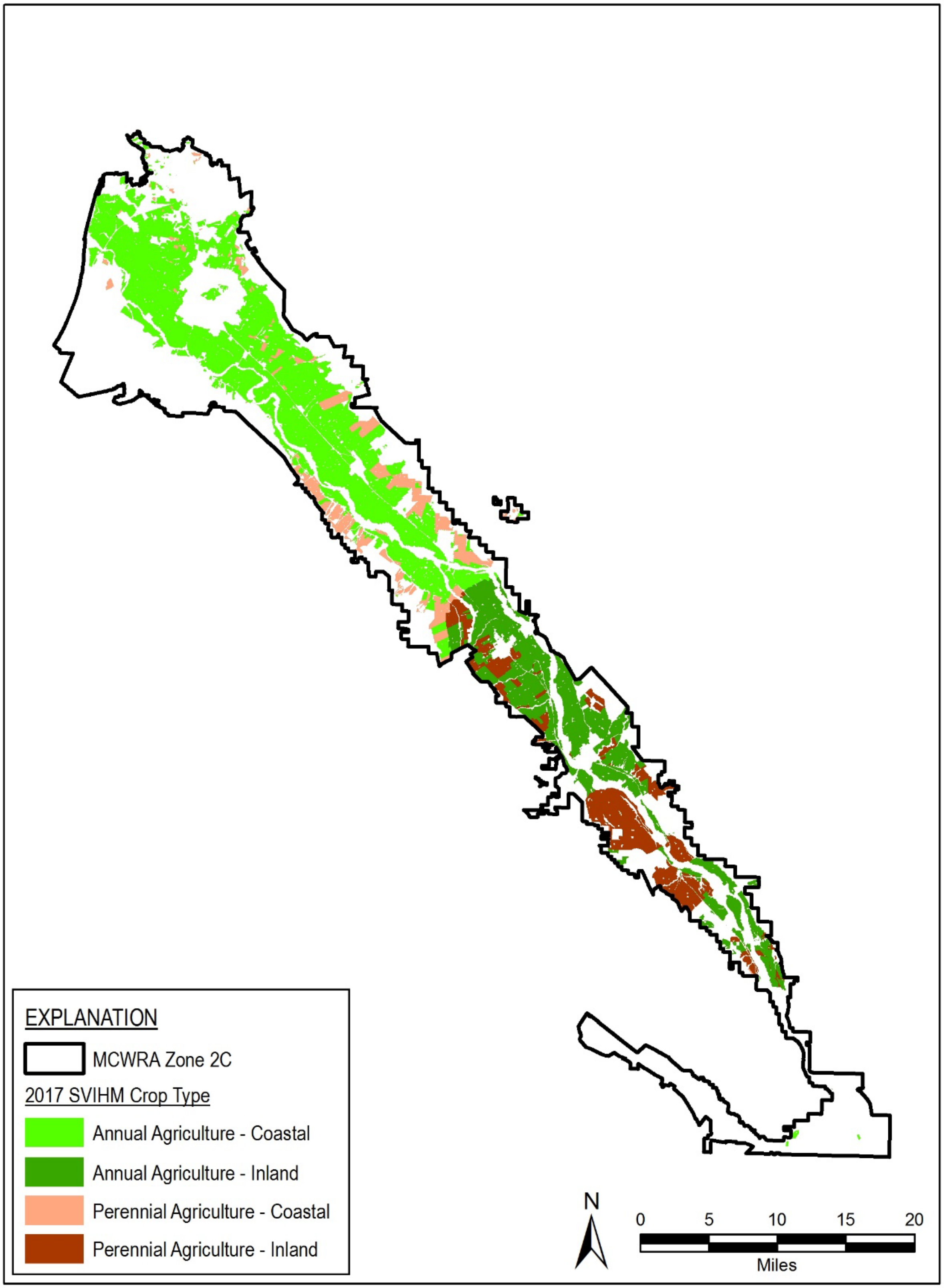

Figure 3-5. SVIHM Coastal and Inland Crop Distribution

3.2.3.2 Projected Land Use

Land use changes are projected for this study to estimate 2030 agricultural water demand with the SVOM. Projected land use changes from the LUCAS model are applied to the SVIHM 2017 baseline land use map to generate 2030 land use maps for model input.

LUCAS historical projections are evaluated for accuracy and consistency with other sources. LUCAS includes land use projections for 5 different growth scenarios. The maps project land use change at annual frequency from 2001 through 2100. LUCAS mapping has coarser discretization than other regional sources, so is not as accurate in mapping specific land uses at the local scale. However, the projected land use trends in the low and high growth LUCAS models between 2017 and 2030 align with historical changes, making it a suitable information source for projecting future land use changes. Historical, current, and projected LUCAS land use is discussed in more detail in Appendix B.

The following 2030 land use scenarios are developed for this study:

- Low growth scenario – Land use change in Zone 2C has slowed over the past few decades. Therefore, the low growth land use projection shows that 2030 land use is identical to the SVIHM 2017 baseline land use map.
- Medium growth scenario – The 2030 medium growth simulation applies land use changes from the low growth LUCAS model to the SVIHM 2017 baseline land use map.
- High growth scenario – The 2030 high growth simulation applies land use changes from the high growth LUCAS model to the SVIHM 2017 baseline land use map.

Creating future land use maps from the SVIHM and LUCAS datasets merges 2 maps with different refinement. The methodology for merging the SVIHM and LUCAS maps is described in Appendix A. Due to uncertainty about future cropping patterns, the 2030 land use projections only include 1 seasonal rotation, whereas the SVIHM has 2 seasonal crop rotations.

3.2.4 Climate

3.2.4.1 Historical Climate

The Basin has a Mediterranean climate, with generally mild summers and cool winters. Precipitation is primarily rain, with the majority falling between November and April in atmospheric river precipitation events. The highest portions of the Santa Lucia Range receive anywhere from 30 to 60 inches of precipitation per year, whereas the lowest portions of the valley floor received about 14 inches of precipitation per year (Brown & Caldwell, 2015). The Basin commonly experiences very dry years with multi-year droughts, such as the 8-year drought from 1984 to 1991, and the recent drought of 2012 to 2016 (Brown & Caldwell, 2015; Mount *et al*, 2021).

3.2.4.2 Projected Climate

Anticipated temperature and precipitation affect crop demand and agricultural pumping. There are many possible scenarios for future climate conditions in California. This study uses DWR's recommended 2030 central tendency scenario for use in GSPs to estimate the impact of future climate change on groundwater management (DWR, 2018). Generally, DWR anticipates 2030 regional climate conditions to be warmer than current conditions, with greater evapotranspiration, and more variable precipitation and streamflow. Precipitation, reference evapotranspiration, and streamflow historical records for 1967 through 2014 are scaled by the monthly factors provided by DWR to approximate a range of likely 2030 hydrologic and climate conditions.

3.2.5 Water Demands

Historical urban and agricultural water demands are reported to MCWRA. MCWRA has received data on urban and agricultural groundwater pumping using the GEMS database since 1994. MCWRA also records agricultural surface water diversion at the SRDF since 2010 and recycled water use by CSIP since 1998.

A range of 2030 scenarios are developed for this study to simulate water demands in SVOM and the SWI Model. Projected water demands are based on estimated 2030 population (Section 3.2.1), per capita urban water use (Section 3.2.2), land use (Section 3.2.3), and climate (Section 3.2.4). Urban water demands are input into the SVOM and SWI Model. Agricultural water demands are estimated by the SVOM based on land use mapping and input into the SWI Model based on metered pumping reported in GEMS. Appendix A provides water demand methods for both models.

Three SVOM and SWI Model scenarios, summarized in Table 3-3, are developed to simulate a range of potential agricultural and urban water demands in 2030. The medium growth scenario uses the average estimates for population growth, improved urban efficiency, and land use change. Uncertainty in future land use and urban growth is evaluated with 2 other scenarios that consider low or high growth. All 3 scenarios use hydrology and climate to account for climate change.

Table 3-3. Summary of SVOM Scenarios

2030 SVOM Scenario	Population	Urban Water Use Efficiency	Land Use	Climate Change
Low Growth	2030 AMBAG Projection, minus 3% of 2020-2030 projected population change	20% reduction in 2017 per capita water use	2017 land use from SVIHM	Historical hydrology with DWR 2030 scaling factors and sea level rise
Med Growth	2030 AMBAG Projection	10% reduction in 2017 per capita water use	2017 land use from SVIHM with 2017-2030 LUCAS low growth land use change	Historical hydrology with DWR 2030 scaling factors and sea level rise
High Growth	2030 AMBAG Projection, plus 3% of 2020-2030 projected population change	No change to 2017 per capita water use	2017 land use from SVIHM with 2017-2030 LUCAS high growth land use change	Historical hydrology with DWR 2030 scaling factors and sea level rise

3.2.6 Groundwater Elevation

Groundwater elevation data has been collected and analyzed by MCWRA since the agency was formed in 1947. MCWRA summarizes annual groundwater elevation change by Subarea on publicly available hydrographs (https://www.co.monterey.ca.us/government/government-links/water-resources-agency/programs/groundwater-level-monitoring/annual-groundwater-level-monitoring). The hydrographs show how groundwater levels rise and fall over time related to key water supply project implementation dates. The major projects include construction of the Nacimiento Reservoir in 1957, construction of the San Antonio Reservoir in 1967, completion of the CSIP in 1998, and completion of the Salinas Valley Water Project SRDF in 2010.

The MCWRA prepares fall groundwater elevation contour maps biennially since 1995, and annually since 2019. Contour maps are prepared for 2 general depth horizons comprising the following:

- Basin Fill, 180-Foot Aquifer, and Shallow Zone of the Eastside Subarea
- 400-Foot Aquifer in the Pressure Subarea and Deep Zone of the Eastside Subarea.

The Deep Aquifers below the 400-Foot Aquifer have only sparse groundwater level monitoring data. Since Deep Aquifers data are limited, groundwater conditions in these aquifers are a data gap that is being addressed as part of SVBGSA GSP implementation and are not analyzed in this report.

The SVOM is used to simulate future groundwater elevation changes under a range of future water demands and climate conditions. The SVOM groundwater elevation results are averaged for 2 model layers that correspond to the following principal aquifers: 1) Basin Fill Aquifer, 180-Foot Aquifer, and Shallow Zone of the Eastside Subarea and 2) 400-Foot Aquifer and Deep Zone of the Eastside Subarea. Mean groundwater level changes from the SVOM results are evaluated to assess how water demands influence groundwater elevations. The results are also evaluated for drier years and wetter years to assess how climate influences groundwater elevations. The 2030 SVOM groundwater level change results are averaged for each Subarea and appended to the MCWRA hydrograph to show how projected 2030 groundwater elevations compare to historical and current conditions. Areas around the model margins where the model is not well calibrated are clipped from the results. The SVOM groundwater elevation processing method is described in more detail in Appendix A.

3.2.7 Seawater Intrusion

Historical and current seawater intrusion is assessed using groundwater sampling of select monitoring wells at the seawater intrusion front. MCWRA produces 500 mg/L chloride isocontour maps for the 180 and 400-foot aquifers in the Pressure Subarea and a small area near the coast in the Eastside Subarea. Historically the isocontour maps were produced biennially, but they have been produced annually since 2019. The isocontour maps are used to show how the seawater/freshwater interface changes over time. Historical seawater intrusion data from MCWRA and other regional sources were used to calibrate the historical SWI Model described in Section 3.1.2.

Projected 2030 seawater intrusion is simulated using the SWI Model. The predictive SWI Model simulates seawater intrusion from the end of the historical SWI Model in 2020 through 2030. Predictive SWI Model simulations are developed to mimic the same 3 pumping and land use scenarios modeled with the SVOM in this study. The pumping and land use scenarios are adapted to the SWI Model from SVOM model inputs as described in Appendix A. The predictive SWI Model incorporates 5.9 inches of sea level rise, as described in Section 3.1.2.

The extent of seawater intrusion in 2030 is estimated in the 180-Foot and 400-Foot Aquifers using the modeled 500 mg/L chloride isocontour. The 2030 seawater intrusion area is compared to the 2020 SWI Model baseline, and the difference in intruded area is used to estimate the seawater intrusion rate in acres/year between 2020 and 2030. As discussed in Appendix A, the predictive SWI Model repeats the average annual hydrology and water demands so does not include results for wetter or drier than average conditions.

4 RESULTS

This section summarizes historical, current, and projected water demands, groundwater elevations, and seawater intrusion in Zone 2C. Historical data in the EIR and General Plan and current conditions are compared to projected 2030 conditions. Water demand projections for 2030 are based on anticipated population, land use, and water efficiency. Table 4-1 summarizes population, land use, and water demand data used in this study and other regional planning efforts.

The SVOM and SWI Model are used to estimate how groundwater elevations and seawater intrusion extent may change by 2030 under a range of potential future conditions. Average expected conditions in 2030 are simulated with the medium growth scenario discussed in Section 3.2.5. Uncertainty and potential variability in water demand estimates is simulated with the low and high growth scenarios discussed in the same section. The model simulations also provide annual results under a wide range of climate conditions that can be used to evaluate how drier or wetter than average climate may influence groundwater conditions.

MONTGOMERY & ASSOCIATES

Table 4-1. Summary of Results from Previous Reports, Tools, and Phases of the Basin Investigation

Study Name	Study Area	Population		Urban Land Use (acres)		Urban Water Demand (AF/yr)		Agricultural Land Use (acres)		Agricultural Water Demand (AF/yr)	
		Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected
Monterey County EIR for 2010 General Plan	County Population and Land Use; Zone 2C Water Demands	2000: 401,312 2020 (projected) : 527,069	2030: 602,731	2006: 55,951	Not projected	1995: 45,000	2030: 85,000	2006: 236,142	Not projected	1995: 431,300	2030: 373,900
USGS - LUCAS Land Use Model	Zone 2C	Not applicable	Not applicable	2017 Low Growth Projected: 55,534; 2020 High Growth Projected: 55,044	2030 Low Growth Projected: 58,959; 2030 High Growth Projected: 60,671	Not applicable	Not applicable	2017 Low Growth Projected: 200,606; 2020 High Growth Projected: 194,001	2030 Low Growth Projected: 201,340; 2030 High Growth Projected: 195,469	Not applicable	Not applicable
Phase 1 Basin Investigation (State of the Basin)	Zone 2C	Not analyzed	Not analyzed	Not analyzed	Not analyzed	Average 1995-2012: 50,000	Not applicable	Not analyzed	Not applicable	Average 1995-2012: 450,000	Not applicable
Phase 2 Basin Investigation (SVIHM/SVOM) *	Zone 2C	Not applicable	Not applicable	2014: 45,334	Not applicable	2017: 29,735	Not applicable	2014: 204,745	Not applicable	2014: 345,611	Not applicable

Study Name	Study Area	Population		Urban Land Use (acres)		Urban Water Demand (AF/yr)		Agricultural Land Use (acres)		Agricultural Water Demand (AF/yr)	
		Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected
Phase 3 Basin Investigation Low Growth (This Study)	Zone 2C	2010: 280,685 2020: 304,092	2030: 323,231	2006: 38,926 2017: 38,935	2030: 38,935	2017: 38,785	2030: 35,054	2006: 199,066 2017: 199,052	2030: 199,052	2017: 446,508	2030: 477,011
Phase 3 Basin Investigation Med Growth (This Study)	Zone 2C	2010: 280,685 2020: 304,092	2030: 332,289	2006: 38,926 2017: 38,935	2030: 41,462	2017: 38,785	2030: 39,896	2006: 199,066 2017: 199,052	2030: 199,568	2017: 446,508	2030: 478,556
Phase 3 Basin Investigation High Growth (This Study)	Zone 2C	2010: 280,685 2020: 304,092	2030: 341,347	2006: 38,926 2017: 38,935	2030: 43,664	2017: 38,785	2030: 44,987	2006: 199,066 2017: 199,052	2030: 200,145	2017: 446,508	2030: 476,446

* SVIHM/SVOM final model not available in time for inclusion in this study. Data is extracted from the preliminary model and input files. See Appendix A for more information.

4.1 Population

This study compiles a range of future population growth rates for estimating average expected conditions in 2030 (medium growth scenario), as well as uncertainty and potential variability in these estimates (low and high growth scenarios). Historical population counts and projections are compared to the EIR estimates used to develop the 2010 General Plan.

4.1.1 Historical and Current Population

Population growth in the EIR was overestimated compared to more recent population data. The EIR population projections were developed using 2000 baseline data in the 2004 AMBAG report. The population in Monterey County increased at a relatively consistent rate for decades prior to 2000 but slowed considerably after this time. The decline in the population growth rate likely contributed to the EIR overestimating current population.

Figure 4-1 shows historical and current population trends. The pink line and blue dashed lines are the County-wide historical data and projections used in the EIR, respectively, that show that since the EIR extended the historical trendline from 2000 to 2020, and the observed rate of population growth was lower, the EIR projected higher 2020 population than observed. The yellow line is the calculated Zone 2C historical population, which also shows that the rate of population growth slowed after 2000. As shown on Figure 4-1, Monterey County's population experienced a 20-year increase of about 110,000 people from 1980 to 2000 (DOF, 1980; DOF, 2000). The average annual population increase between 1980 and 2000 was about 1.9%, as shown on Figure 4-2. Citing 2004 AMBAG projections, the EIR projected that the population in Monterey County would continue to grow at an average annual rate of about 1.67%, resulting in a 2020 population of about 527,000 people.

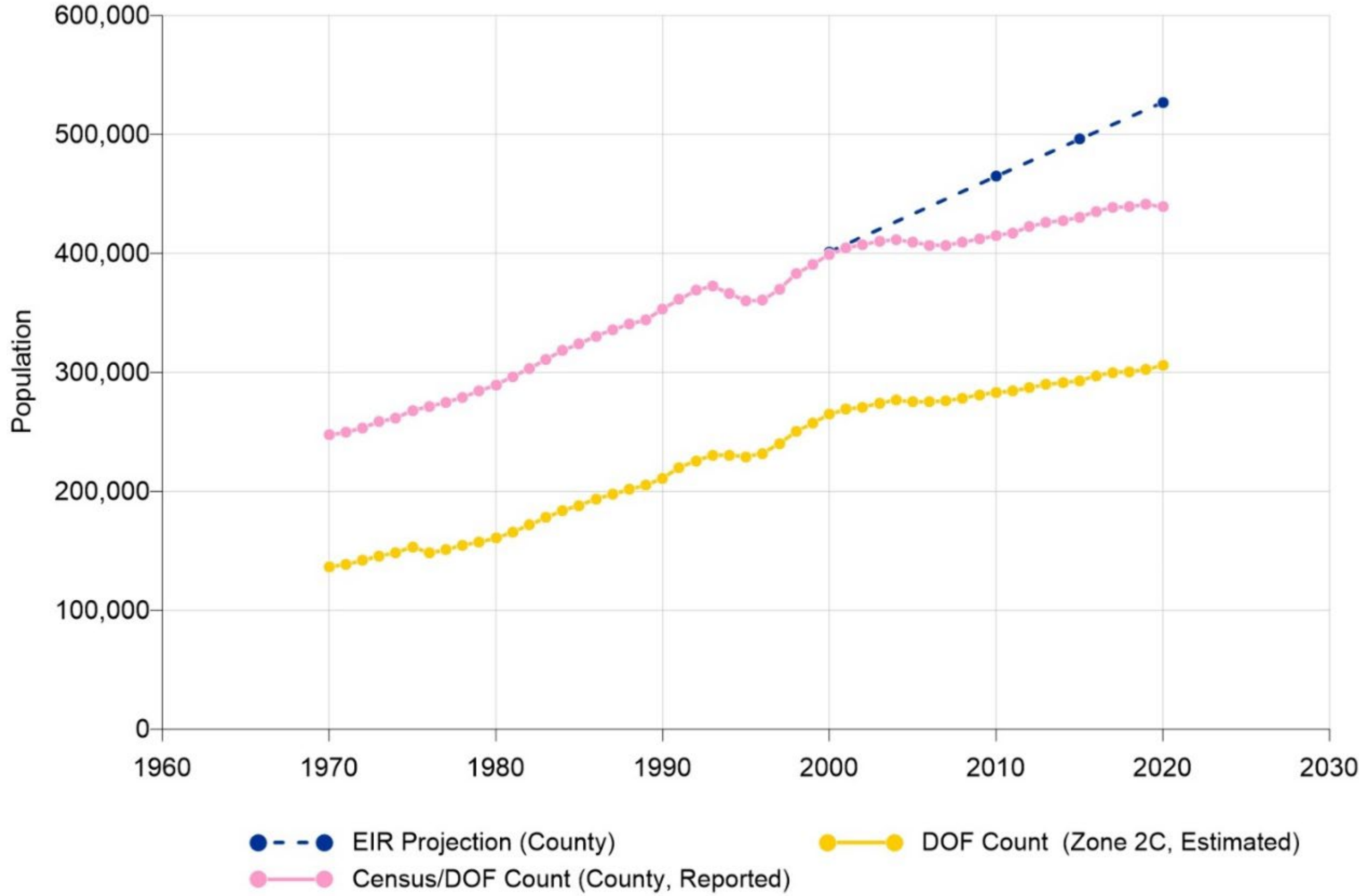

Figure 4-1. Historical and Current Population in County and Zone 2C

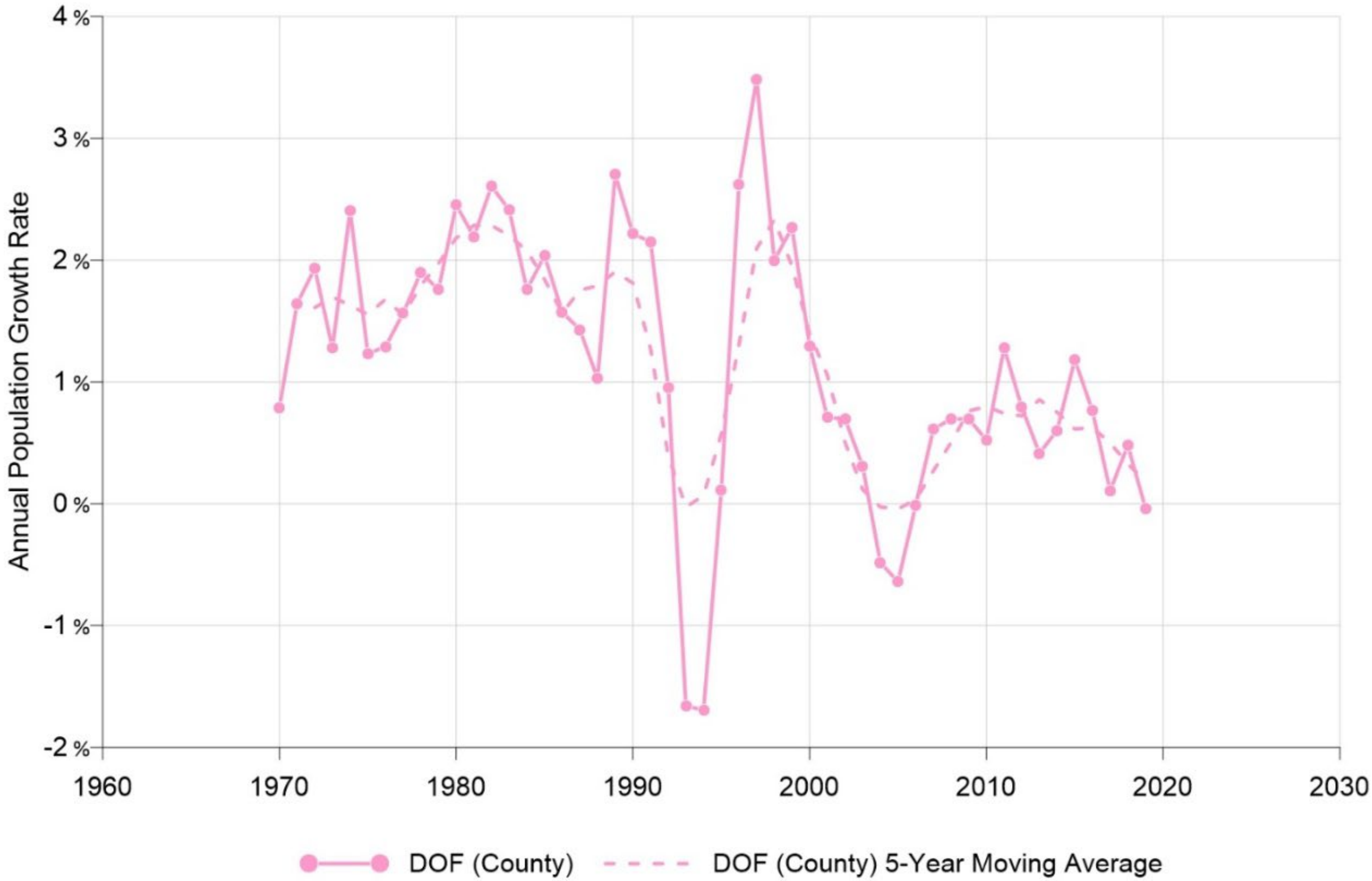

Figure 4-2. Annual Population Growth Rate in County

Between 2000 to 2020, population growth slowed from previous rates. The 2020 Monterey County population of 439,035 (U.S. Census Bureau, 2021), is about 88,000 people less than estimated in the EIR (Figure 4-1). Since 2000, annual population growth rates have ranged between -0.5% and 1.5% (Figure 4-2). Slowing population growth reflects an aging population and lower net migration into the region due to several factors including but not limited to water resource constraints, Fort Ord closure, housing cost increase, and economic recession (AMBAG, 2018). Since population growth began to slow prior to the EIR being completed, the EIR acknowledged that General Plan population assumptions were likely overestimated, but which resulted in conservative urban water demand projections.

This study estimates recent Zone 2C population to develop urban water demand projections for 2030. The Zone 2C population is estimated to be approximately 70% of the total population in the County based on city population counts and assumptions about community and rural populations detailed in Section 3.2.1. Zone 2C population increased from about 264,000 people in 2000 to about 304,000 people in 2020 (Figure 4-1). In 2017, the baseline for the groundwater model projections, the total population in Zone 2C was about 300,000 people. The Zone 2C population in 2017 included about 250,000 people in cities, 30,000 people in communities, and about 20,000 people in rural areas (Table 4-2). Over half of the people who live in Zone 2C reside in the City of Salinas with the remainder scattered throughout other cities and communities, particularly in areas closer to the coast. The 2010 to 2020 population growth rate in Zone 2C was about 0.83% per year, which is about half the rate assumed in the EIR.

Table 4-2. Historical and Current Population in Zone 2C

	2000	2010	2017	2020	% Annual Rate of Change (2010 to 2020)
Cities					
Gonzales	7,525	8,187	8,551	8,647	0.56%
Greenfield	12,583	16,330	18,013	18,937	1.60%
King City	11,094	12,874	14,214	13,332	0.36%
Marina	25,101	19,718	22,051	22,359	1.34%
Salinas	151,060	150,441	161,124	163,542	0.87%
Soledad	11,263	25,738	25,726	24,925	-0.32%
Total Cities	**218,626**	**233,288**	**249,679**	**252,742**	**0.84%**
Communities*					
Boronda	1,325	1,710	1,785	1,818	0.65%
Bradley	120	93	97	99	0.65%
Castroville	6,724	6,481	6,767	7,515	1.60%
Chualar	1,444	1,190	1,242	1,265	0.65%
Moss Landing	300	204	213	217	0.65%
Prunedale	16,432	17,560	18,334	18,885	0.75%
San Ardo	501	517	540	550	0.65%
San Lucas	419	269	281	286	0.65%
Spreckels	485	673	703	715	0.65%
Total Communities	**27,750**	**28,697**	**29,963**	**31,350**	**0.92%**
Rural**	**17,400**	**18,700**	**19,610**	**20,000**	**0.65%**
Total Zone 2C Population	**263,776**	**280,685**	**299,252**	**304,092**	**0.83%**

* 2000 and 2010 community populations are from Census Bureau counts. 2017 and 2020 community populations for Castroville and Prunedale are from 2020 Census and for other communities are estimated by interpolation based on the 2010 to 2020 DOF unincorporated population growth rate of 0.65% for all of Monterey County.

** 2020 population for rural areas in Zone 2C estimated from SCRBS report data. 2000, 2010, and 2017 rural population interpolated based on the 2010 to 2020 DOF unincorporated population growth rate of 0.65% for all of Monterey County.

4.1.2 Projected Population

The 2030 projected population in the County was likely overestimated in the EIR and General Plan. The EIR estimated the County's population would grow from 2000 to 2030 at an annual growth rate of 1.67% to 527,000 in 2020 and 602,731 in 2030 (Figure 4-3). However, population growth slowed after 2004, resulting in a 2020 County population of 439,035 (U.S. Census Bureau, 2021). The 2018 AMBAG report projected County population through 2040. The report used a 2015 population baseline and population growth rate of 0.64% per year to project that 476,588 people would live in the County in 2030 (Figure 4-3).

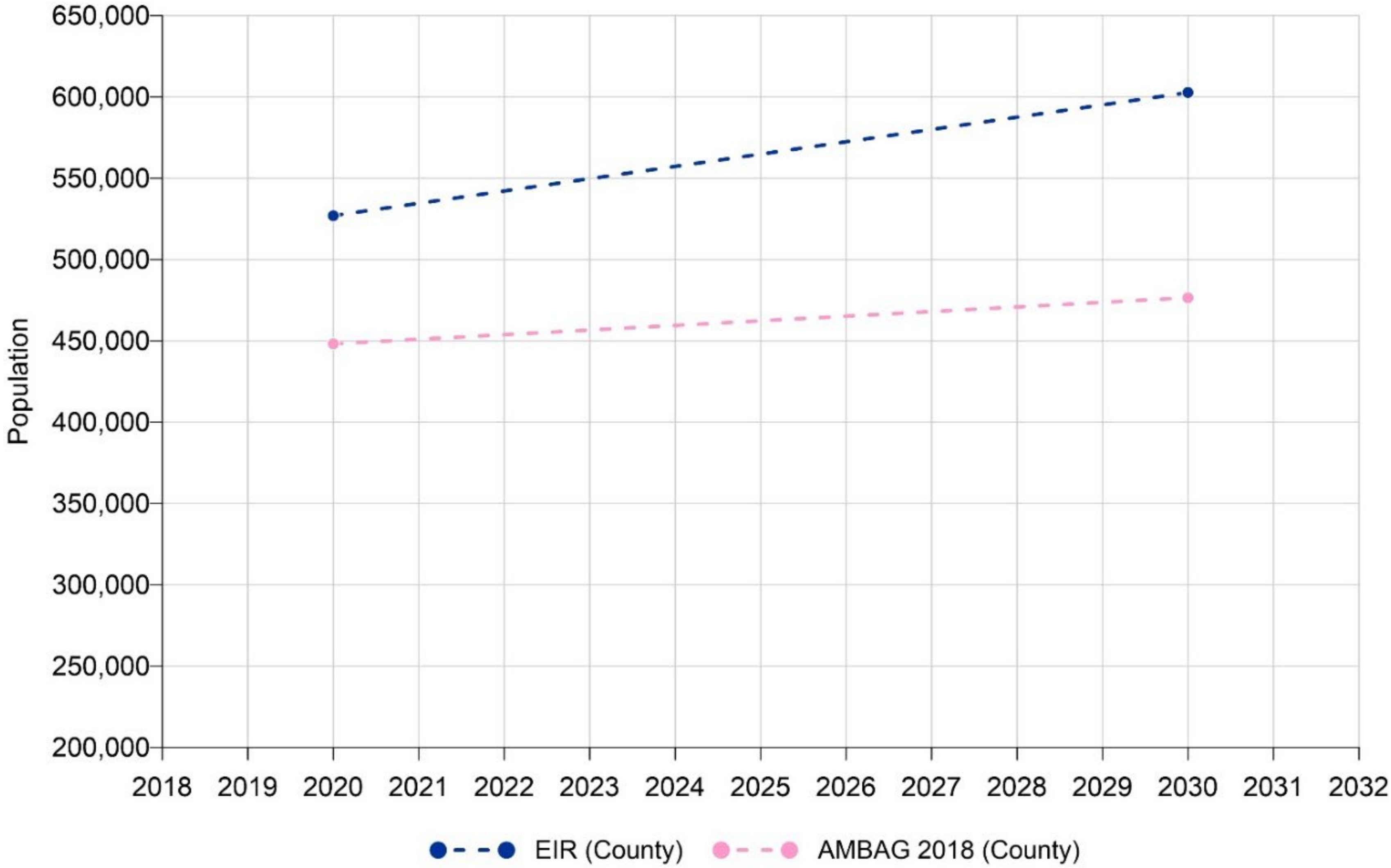

Figure 4-3. Projected Population in County

This study uses population projections from the 2018 AMBAG report to develop assumptions about population growth in Zone 2C. About 332,000 people are projected to live in Zone 2C in 2030, including about 281,000 people in cities (Table 4-3). The projected population growth equates to an annual average growth rate of about 1.2% in Zone 2C cities. Population growth in Gonzales and Marina is notably higher than the other cities because of planned developments in these areas. The annual population growth rates for Gonzales and Marina are about 5.3% and 2.8%, respectively, while the other cities are closer to the average annual growth rate of 0.64% projected by AMBAG.

The unincorporated population growth rate in the 2018 AMBAG report was used in this study to project 2030 populations in unincorporated communities and rural areas in Zone 2C. AMBAG does not specify population projections for specific unincorporated areas in Zone 2C. AMBAG projected an unincorporated County growth rate of 0.06% per year between 2020 and 2030. Applying this growth rate to 2020 population estimates suggests about 31,000 people are expected to live in Zone 2C communities and 20,000 are expected to live in Zone 2C rural areas in 2030 (Table 4-3). Population growth is less certain in unincorporated portions of Zone 2C that do not have specific population projections in the AMBAG report. However, this information is not as critical for this study because cities make up most of the urban water demands.

This study estimates a range of low and high growth scenario populations by adding and subtracting 0.3% from the annual growth rate for each individual city and community, based on the SCRBS projections of reasonable low and high urban growth. The resulting low and high 2030 population estimates for Zone 2C are about 323,000 and 341,000 people, respectively (Table 4-3; Figure 4-4). Low and high 2030 population estimates for Zone 2C cities are about 274,000 and 289,000 people, respectively (Table 4-3).

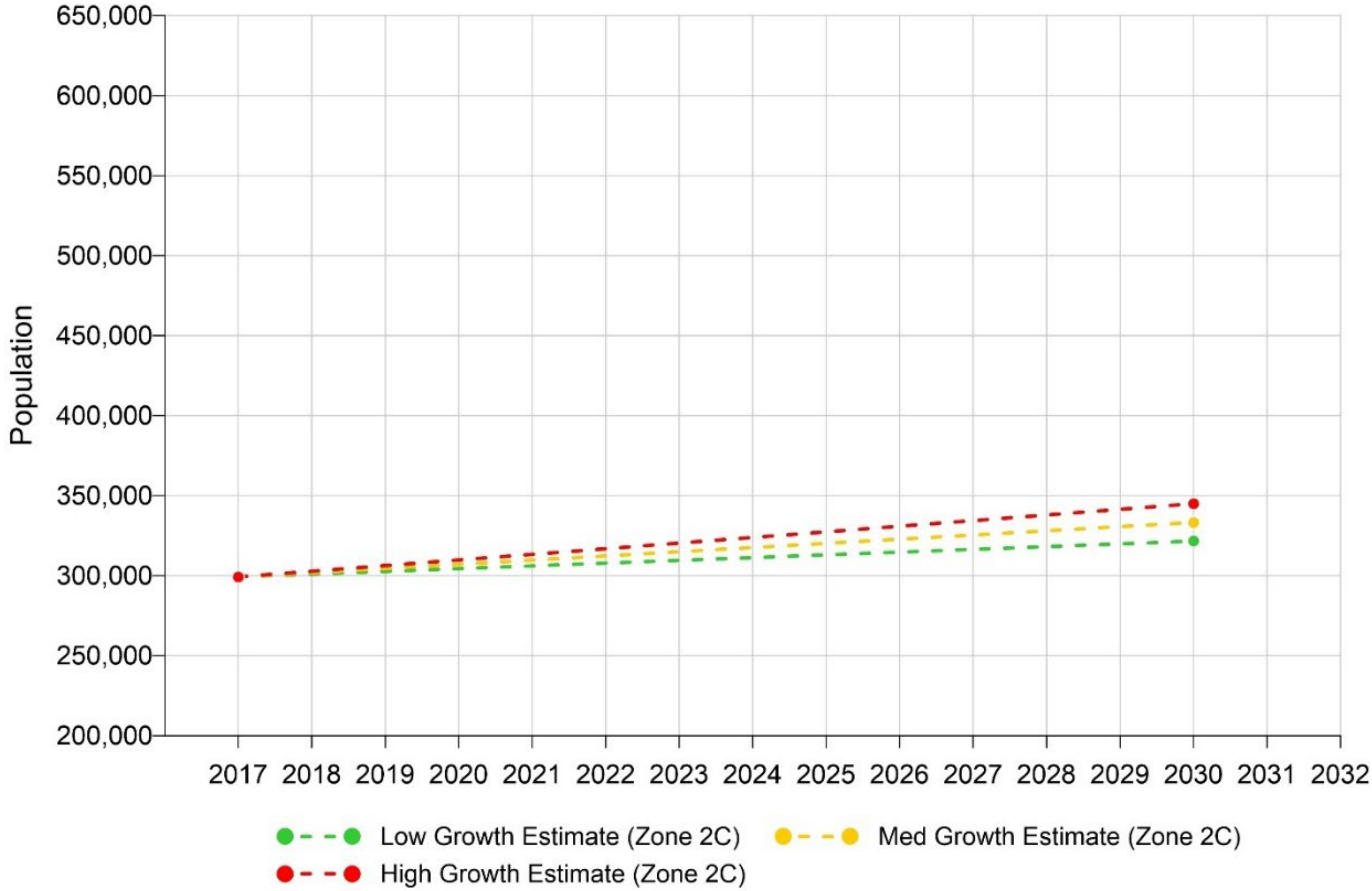

Figure 4-4. Projected Population in Zone 2C

Table 4-3. Population Projection in Zone 2C

	Low Growth Rate (% annual rate of change)	Med Growth Rate (% annual rate of change)	High Growth Rate (% annual rate of change)	Low Growth 2030 Estimated Population	Med Growth 2030 Estimated Population	High Growth 2030 Estimated Population
Cities						
Gonzales	4.99%	5.29%	5.59%	12,751	13,006	13,261
Greenfield	0.87%	1.17%	1.47%	19,875	20,424	20,973
King City	0.38%	0.68%	0.98%	15,362	15,806	16,250
Marina	2.47%	2.77%	3.07%	27,845	28,515	29,185
Salinas	0.51%	0.81%	1.11%	170,575	175,442	180,309
Soledad	0.88%	1.18%	1.48%	27,526	28,285	29,044
Total Cities	**0.90%**	**1.20%**	**1.50%**	**273,935**	**281,478**	**289,021**
Communities						
Boronda	-0.24%	0.06%	0.36%	1,774	1,829	1,883
Bradley	-0.24%	0.06%	0.36%	97	100	103
Castroville	-0.24%	0.06%	0.36%	6,724	6,930	7,137
Chualar	-0.24%	0.06%	0.36%	1,235	1,273	1,311
Moss Landing	-0.24%	0.06%	0.36%	212	218	225
Prunedale	-0.24%	0.06%	0.36%	18,218	18,778	19,338
San Ardo	-0.24%	0.06%	0.36%	537	553	570
San Lucas	-0.24%	0.06%	0.36%	279	288	296
Spreckels	-0.24%	0.06%	0.36%	698	719	741
Total Communities	**-0.24%**	**0.06%**	**0.36%**	**29,773**	**30,688**	**31,603**
Rural	**-0.24%**	**0.06%**	**0.36%**	**19,523**	**20,123**	**20,723**
Total Zone 2C Population	**0.71%**	**1.01%**	**1.31%**	**323,231**	**332,289**	**341,347**

4.1.3 Historical and Projected Population Summary

Figure 4-5 summarizes historical, current, and projected population in the County and Zone 2C. The pink and blue lines are the County-wide data and projections in the EIR and 2018 AMBAG report. The yellow line and attached dashed lines are the Zone 2C historical and projected populations estimated in this study.

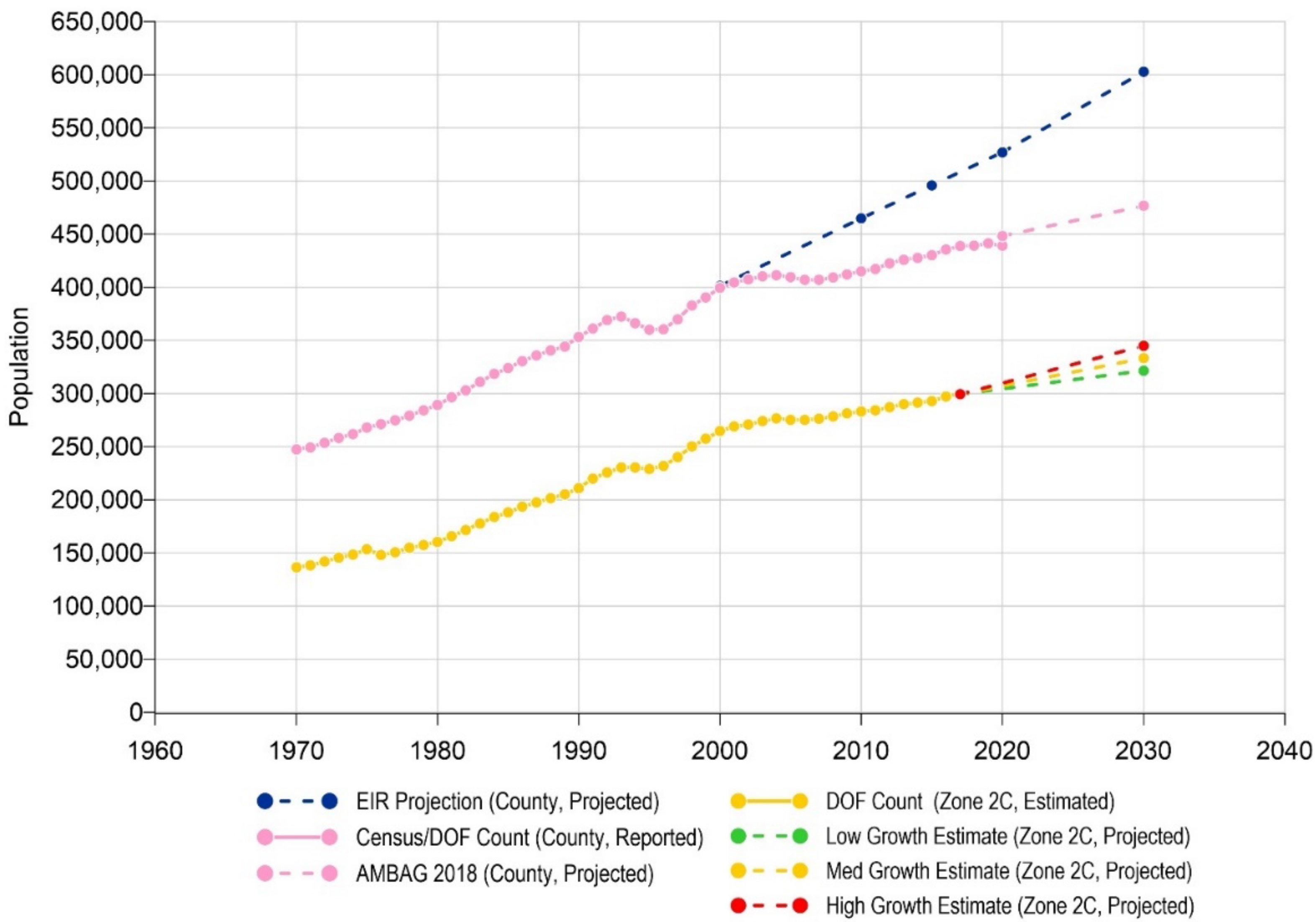

Figure 4-5. Historical, Current, and Projected Population in County and Zone 2C

4.2 Land Use

Land use in Zone 2C is used by the SVOM to estimate agricultural water demand. This study compiles a range of future land use changes for estimating average expected 2030 water demands (medium growth scenario), as well as potential variability in these estimates (low and high growth scenarios).

4.2.1 Historical and Current Land Use

Zone 2C includes a majority of the County's irrigated farmland and about half of the County's urban land. The total area of Zone 2C is about 436,000 acres, which is about 18% of the 2,410,000 acres of land in Monterey County. In 2006, Zone 2C included about 212,000 acres of farmland and 32,000 acres of urban land, which corresponds to about 90% of the irrigated farmland and about 57% of the urban land in the County (FMMP, 2006). The EIR assumed that urban land would continue to expand to accommodate population growth and that farmland expansion and contraction would occur simultaneously in Zone 2C. Although not specified explicitly, the assumptions in the EIR and proportion of developed lands in Zone 2C suggests that about 284 acres/year of farmland expansion and 350 acres/year of urban expansion could occur in Zone 2C from the EIR 2006 baseline through 2030. The following subsections present historical and current farmland and urban land use data from the SVIHM.

4.2.1.1 Historical and Current Farmland Land Use

Acreage used for farmland in Zone 2C has remained relatively consistent over the past several decades as the Salinas Valley floor is nearly completely developed (Brown and Caldwell, 2015). However, there has been a notable shift in agricultural cropping patterns in the region since the 1980s with more perennial vineyards and fewer annual crops. Cropping trends reflect slowly expanding farmland cultivation into the undeveloped margins of the agricultural basin that are suitable for vineyards but not many other annual crops (ICF International, 2010a; Wilson *et al*., 2020). Agricultural land displacement by urban growth has mostly been offset by agricultural expansion at the undeveloped margins of Zone 2C. Land developed for urban use is also more likely to displace annual crops than perennial vineyards based on the locations of these crops relative to existing cities and the more permanent nature of vineyards.

SVIHM maps of actual land use show minimal farmland contraction since 2006. SVIHM's mapped rate of land use change is verified with more recent FMMP land use maps, which show a slow farmland expansion rate (Appendix B). Historical Zone 2C farmland acreage from SVIHM is summarized in Table 4-4.

Table 4-4. Historical Farmland Acreage in Zone 2C

Time Period	Units	Farmland
2006	Acres	199,066
2017	Acres	199,052
2006-2017	Acres/Year	-1

4.2.1.2 Historical and Current Urban Land Use

Urban land has increased gradually over time in Zone 2C, generally growing in area at rates proportional to population growth (ICF International, 2010a; Brown and Caldwell, 2015; SCRBS, 2020). Urban land in Zone 2C is expanding into agricultural and other non-developed lands, mostly near the City of Salinas and other smaller communities.

SVIHM's 2006 and 2017 land use maps show very little urban expansion, despite some population growth. Urban land is not used in this study to simulate water demands, so the limited urban area expansion is inconsequential. Historical urban land use is summarized in Table 4-5.

Table 4-5. Historical Urban Land Acreage in Zone 2C

Time Period	Units	Urban Land
2006	Acres	38,926
2017	Acres	38,935
2006-2017	Acres/Year	1

4.2.2 Projected Land Use

This study projects 2030 land use for estimating agricultural water demands in SVOM and the SWI Model. The 2017 SVIHM baseline land use map is modified with land conversion predicted by the LUCAS model between 2017 and 2030 to simulate a range of likely 2030 land use conditions.

4.2.2.1 Projected Farmland Land Use

Projected farmland conversion in the models effects agricultural water demands. The low growth SVOM scenario assumes that 2017 land use remains the same in 2030. Medium and high growth land use scenarios incorporate LUCAS low and high growth land use change from 2017 to 2030, respectively. The land use projections result in an increase in SVOM farmland between 2017 and 2030 of 516 acres in the medium growth scenario and 1,093 acres in the high growth scenario, which equates to annual growth rates of 40 and 84 acres/year, respectively. Projected farmland expansion is summarized in Table 4-6 and shown on Figure 4-6.

Table 4-6. Projected Farmland Acreage in Zone 2C

Time Period	Units	SVOM Low	SVOM Med	SVOM High
2017	Acres	199,052	199,052	199,052
2030	Acres	199,052	199,568	200,145
2017-2030	Acres/Year	0	40	84

Despite little net change to total farmland, the LUCAS model projects significant farmland conversion from annual to perennial crops (Figure 4-7). Land use changes between 2017 and 2030 are described in more detail in Appendix A and B. The 2030 SVOM low, medium, and high growth land use maps are shown on Figure 4-8, Figure 4-9, and Figure 4-10, respectively. These maps are relatively similar because the land conversion in the low growth and high growth scenarios are relatively similar, as shown on Figure 4-7..

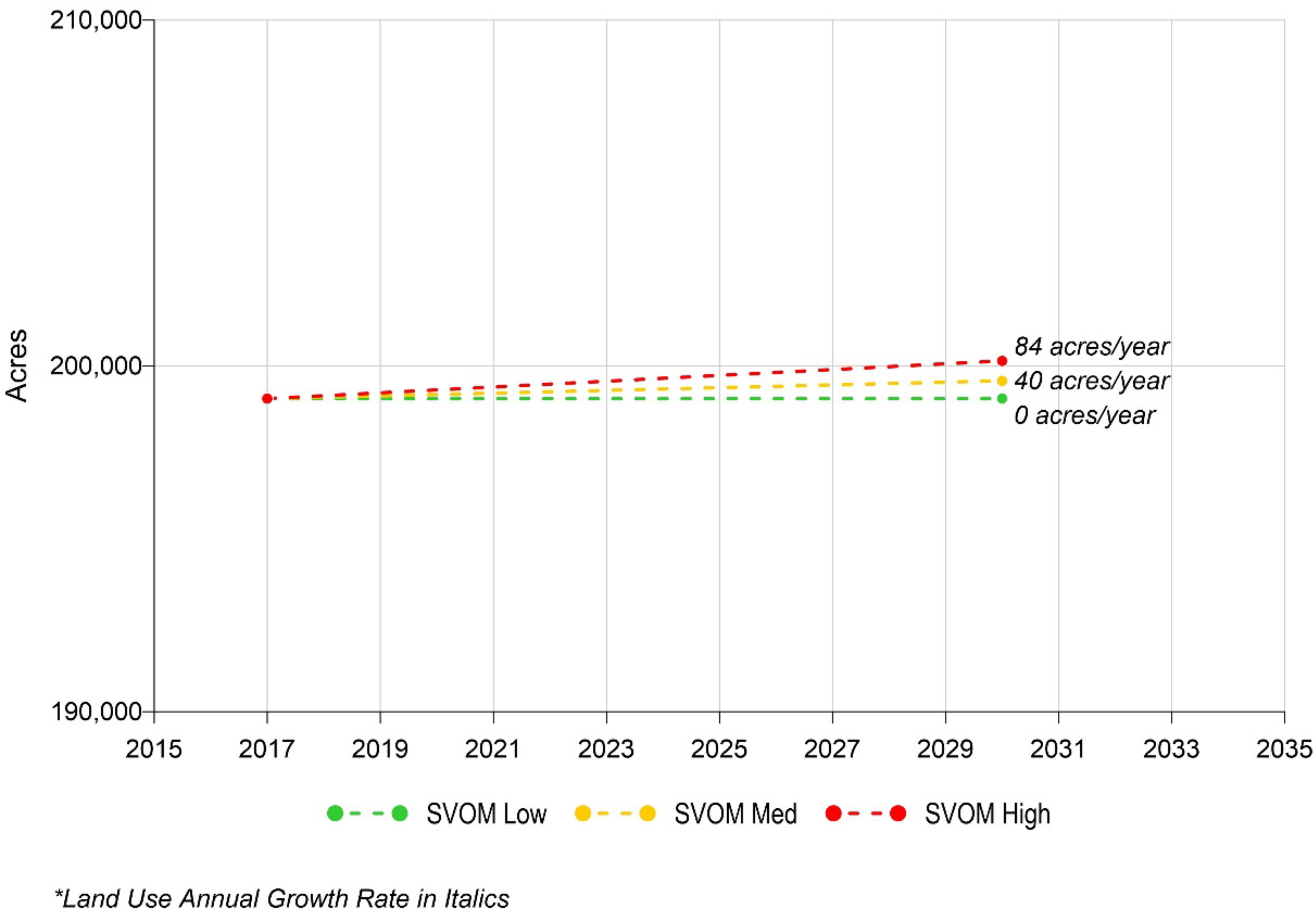

Figure 4-6. Projected Farmland Acreage in Zone 2C

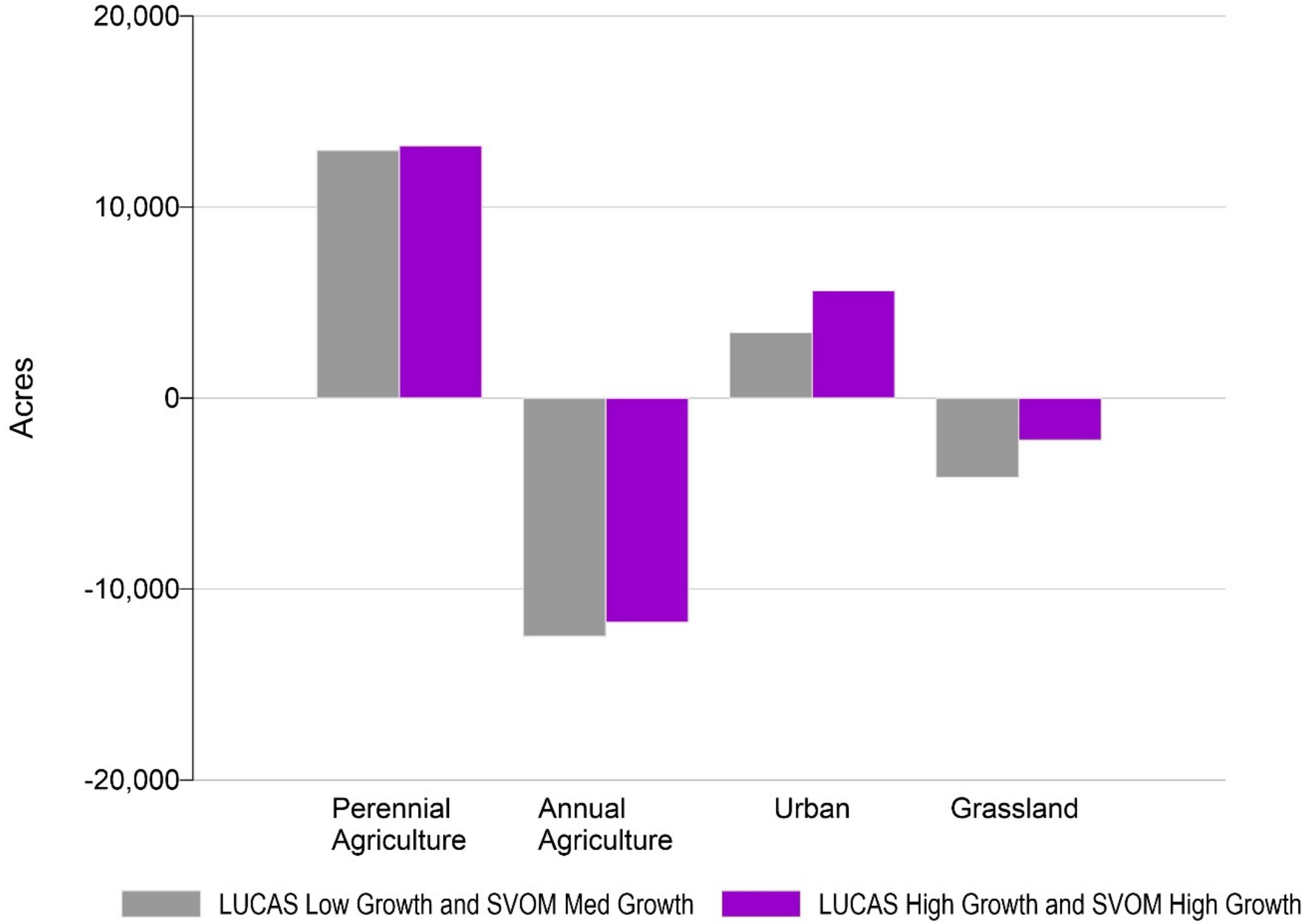

Figure 4-7. Projected Land Use Change in Zone 2C Between 2017 and 2030

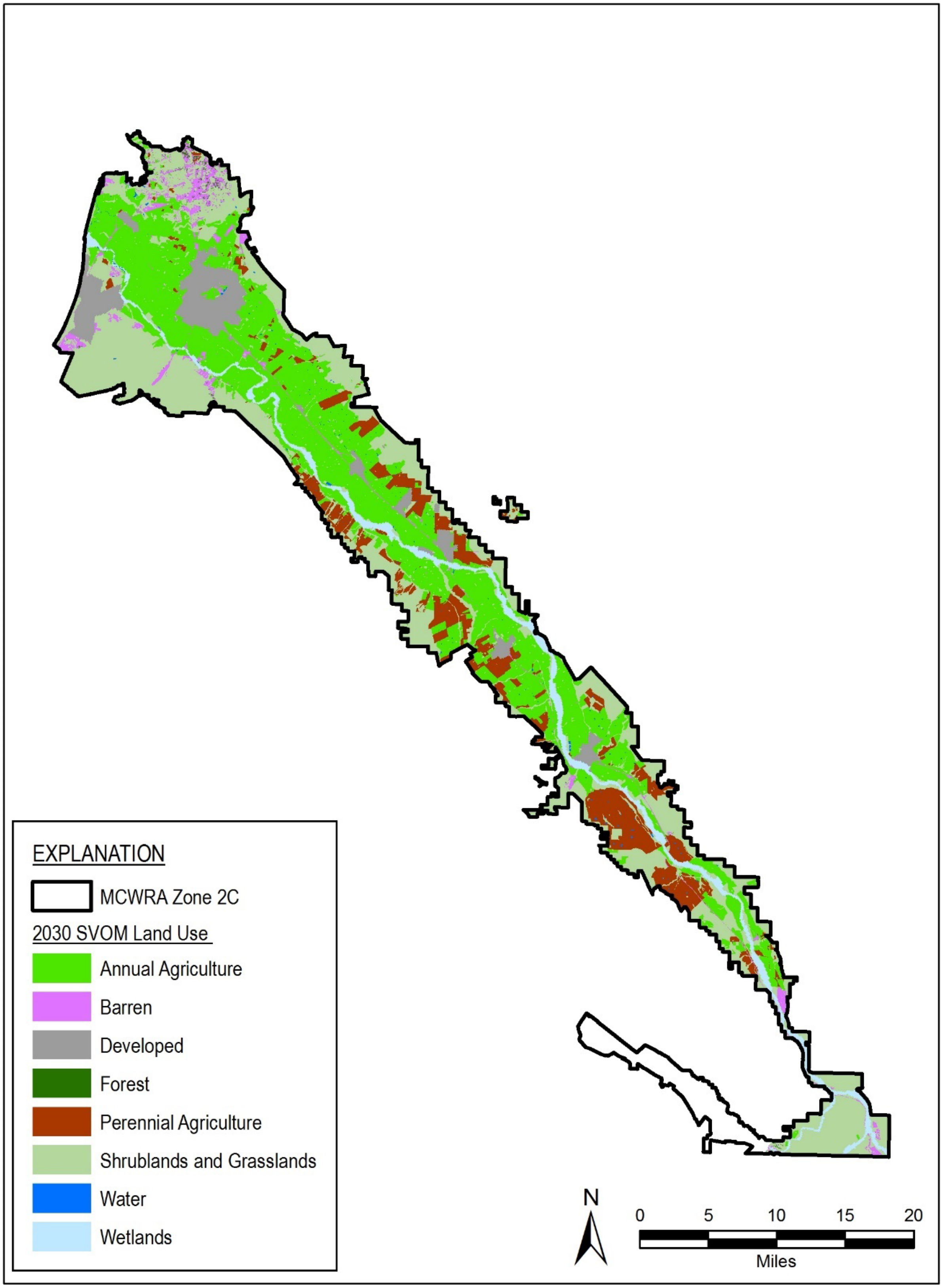

Figure 4-8. 2030 SVOM Low Growth Land Use

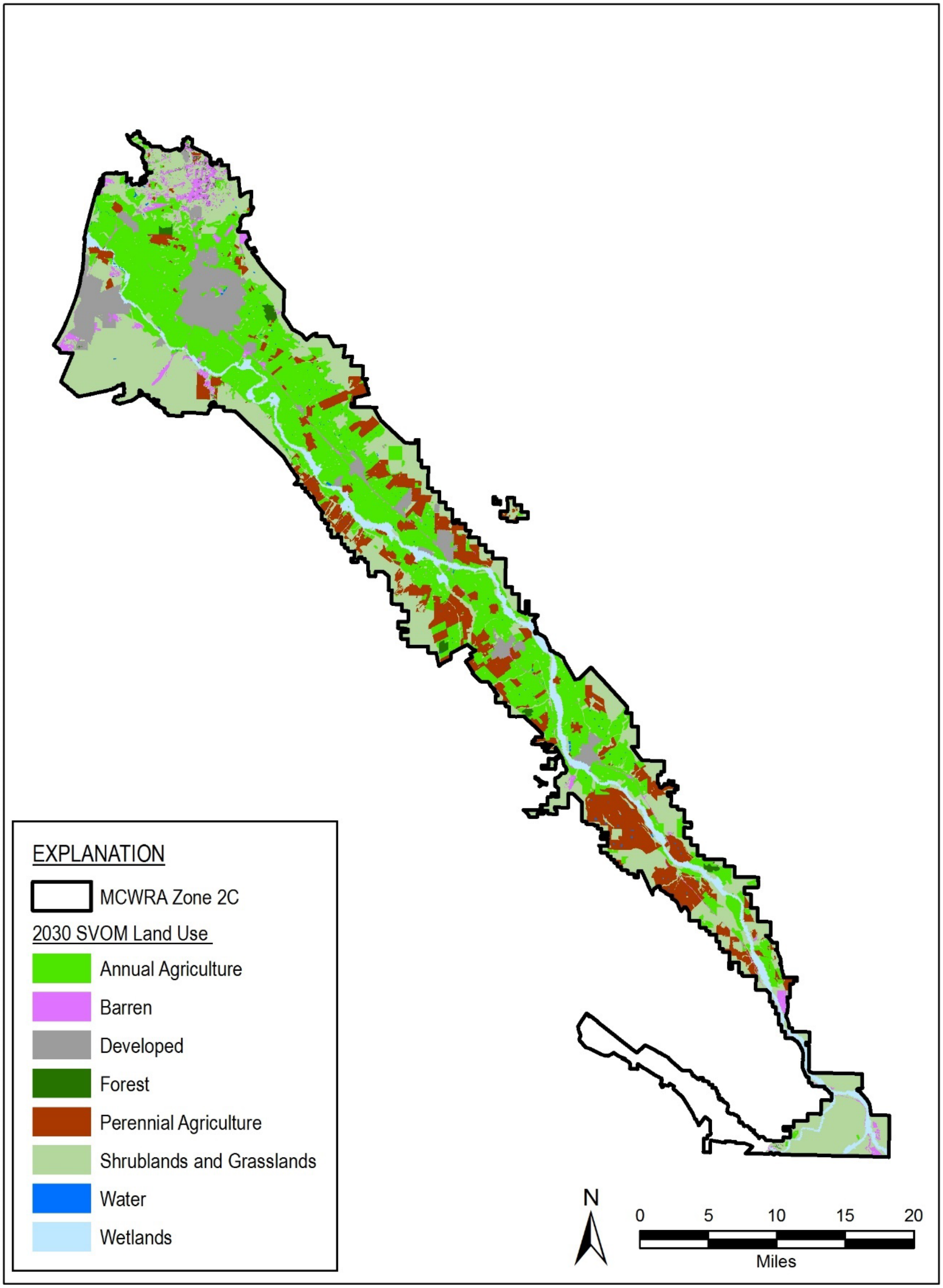

Figure 4-9. 2030 SVOM Medium Growth Land Use

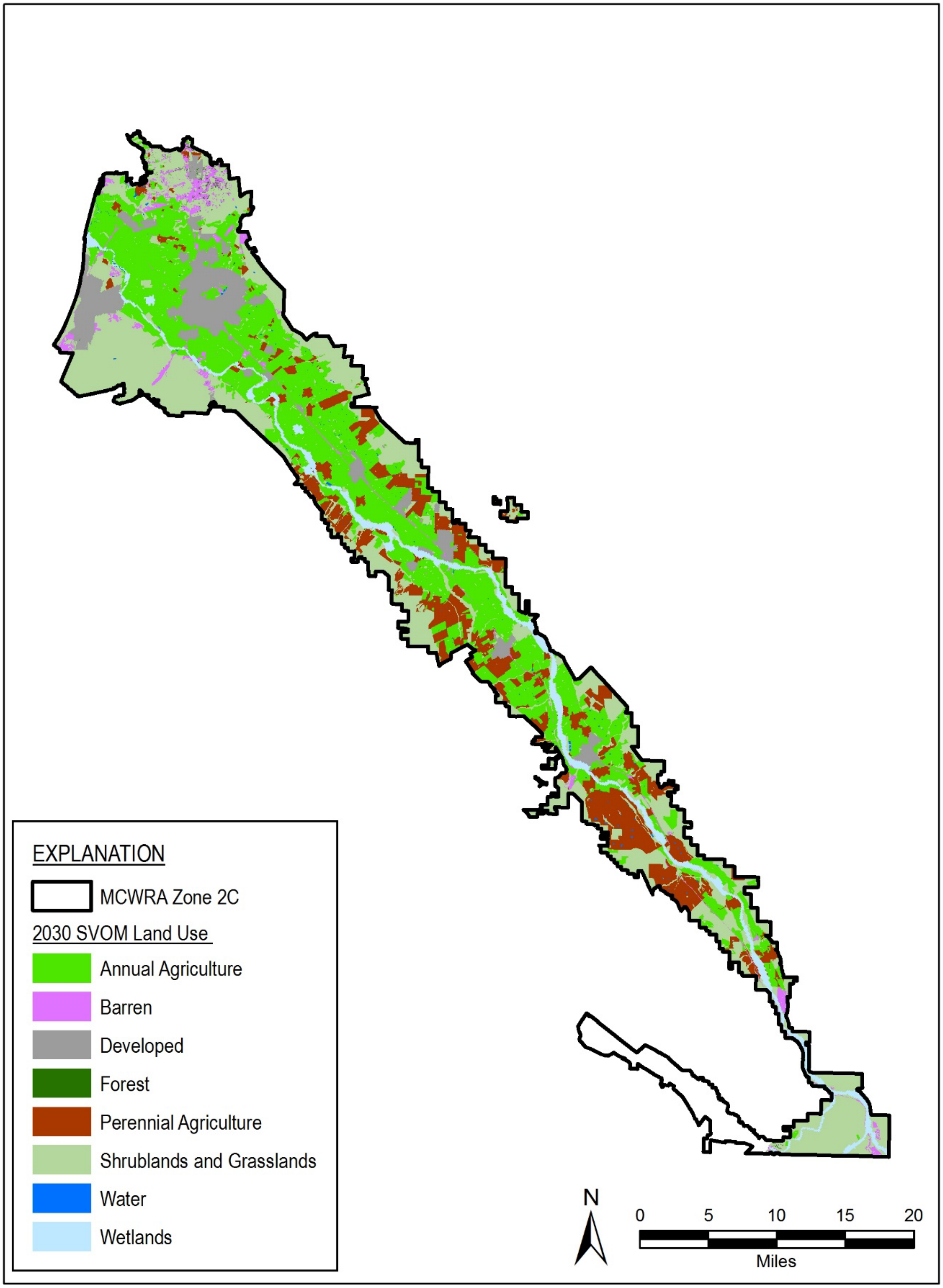

Figure 4-10. 2030 SVOM High Growth Land Use

4.2.2.2 Projected Urban Land Use

This study uses LUCAS model results to project urban land use changes as described in Section 4.2.2.1. The SVOM medium and high growth scenarios include about 256 and 436 acres/year of urban land expansion, respectively (Table 4-7; Figure 4-11). The urban land use growth estimates from LUCAS appear to be overestimated since population growth has slowed since 2020 but are within a reasonable margin of error. Any error is inconsequential because urban land area is not used in the SVOM for simulating water demands; rather urban water demand is calculated directly using groundwater pumping from municipal supply wells. Urban land cover in the groundwater model can limit groundwater recharge from precipitation relative to more permeable land uses. Groundwater recharge impediment by urban land growth is a minor component in the groundwater budget and therefore has little to no effect on the groundwater simulation results.

Table 4-7. Projected Urban Land Acreage in Zone 2C

Time Period	Units	SVOM Low	SVOM Med	SVOM High
2017	Acres	38,935	38,935	38,935
2030	Acres	38,935	42,268	44,598
2017-2030	Acres/year	0	256	436

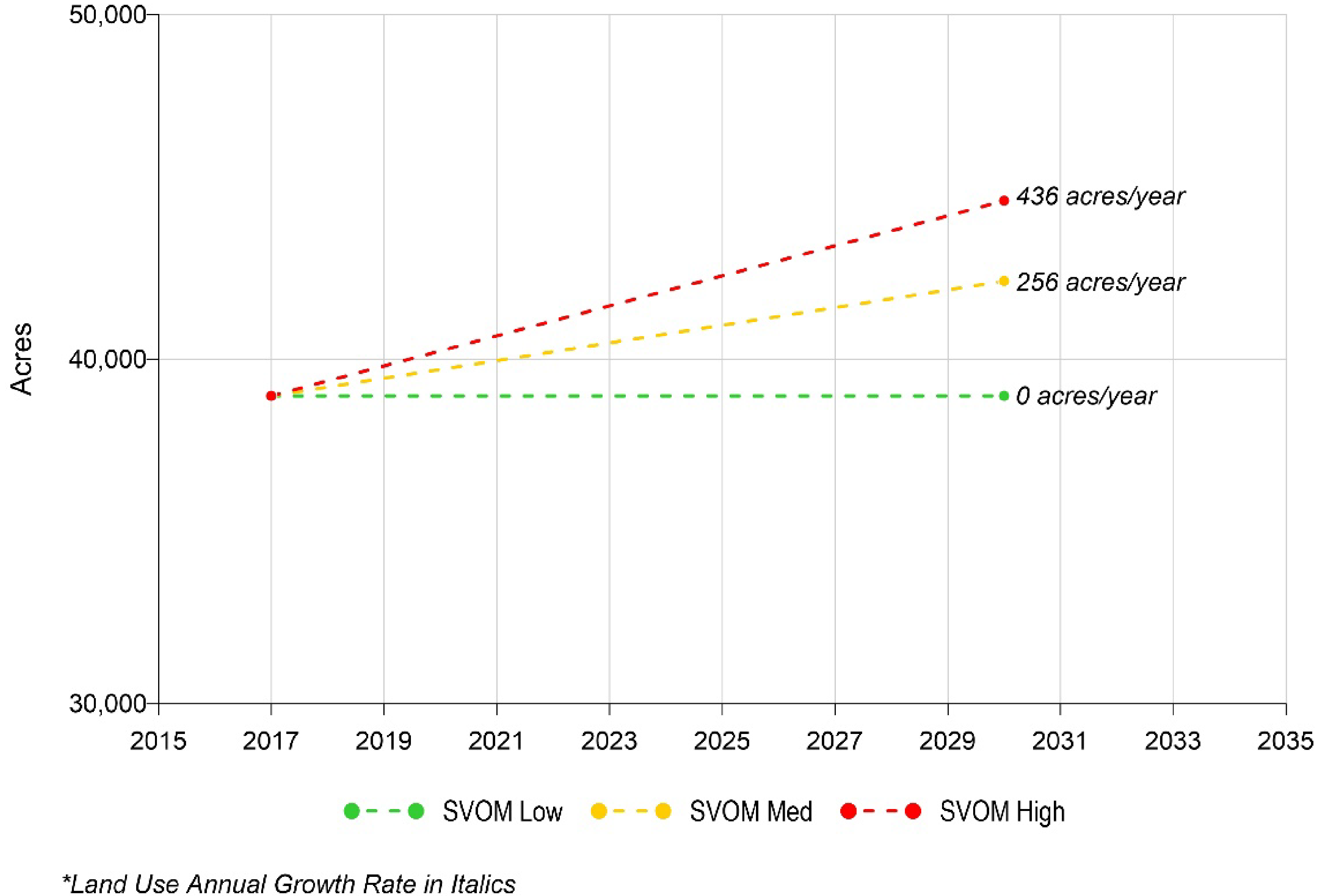

Figure 4-11. Projected Urban Land Acreage in Zone 2C

4.3 Water Demand

This study uses the previously discussed population and land use estimates to compile a range of 2030 agricultural and urban water demands for SVOM simulations. Historical, current, and projected water demands are compared to the information in the EIR.

Currently, about 90% of water demands in Zone 2C are for agricultural irrigation and 10% are for urban uses. Groundwater is used to supply almost all water demands except for a relatively small amount of recycled water and surface water used for agricultural irrigation. Some agricultural water demand is satisfied by precipitation, which is accounted for in the SVOM simulations. This study only addresses water demand from groundwater pumping for urban and agricultural use, surface water diversion, and recycled water use.

4.3.1 Historical and Current Water Demand

Historical water demands in the EIR and General Plan are compared to recent groundwater pumping data available from GEMS, recycled water use by CSIP, and surface water diversions from SRDF for use by CSIP.

4.3.1.1 Historical Water Demand in the EIR

The EIR used 1995 water demand from SVIGSM as the baseline to develop assumptions for the General Plan. The 1995 baseline water demand was 476,300 AF, including 431,300 AF for agriculture irrigation and 45,000 AF for urban use. The EIR baseline conditions assumed groundwater pumping supplied approximately 463,000 AF for urban and agricultural uses and the Salinas Valley Reclamation Plant supplied about 13,300 AF of recycled water for irrigation.

Water demands in Salinas Valley fluctuate annually due to differences in precipitation and temperature. The years with high water use coincide with dry and hot years and the years with low water use coincide with wet and cool years. The EIR included supplemental 1995 to 2005 water demand data, reported to the GEMS program, to show pumping variability over time. During the 11-year period, agricultural groundwater pumping had a range of about 157,000 AF, and urban groundwater pumping had a range of about 15,000 AF.

4.3.1.2 Historical and Current Water Demand in GEMS

MCWRA's GEMS data is used in this study to establish baseline groundwater pumping. Although more recent data is available, the 2017 GEMS data was used as the baseline to be consistent with the most recent SVIHM land use and pumping input files available when this study was prepared. GEMS only includes pumping measured in Zone 2, 2A, and 2B, so underreports Zone 2C pumping slightly by omitting pumping in Prunedale, Corral de Tierra, and the Above and Below Dam Subareas. 1995 GEMS pumping data is 504,049 AF, which is about 6% more pumping than the EIR modeled baseline conditions for 1995.

Agricultural pumping reported to GEMS has fluctuated between about 400,000 AF/yr and 550,000 AF/yr since 1995. Despite fluctuation with climate, agricultural groundwater pumping has remained relatively stable over time with more pumping in dry years and less pumping in wet years. The 2017 baseline agricultural pumping is 432,036 AF. Figure 4-12 graphs the historical groundwater extraction data relative to water year type with a solid black line, as well as the EIR's projected agricultural pumping with a dashed blue line. The 2017 total agricultural water demand was 446,508 AF.

GEMS urban pumping consists mostly of municipal supply. In 2017, total urban pumping was about 38,785 AF, including 30,225 AF for city supply, 6,916 AF for industrial use, and 1,644 AF for community supply. Rural domestic pumping is not included in these estimates. Figure 4-13 shows the Zone 2C population with a yellow line, the measured urban pumping with a solid black line and the EIR estimated growth in urban pumping with a dashed blue line. Urban pumping has decreased from a peak in 2004, despite a slowly increasing population. Urban pumping is decreasing because efficiency and conservation improvements are outpacing population growth.

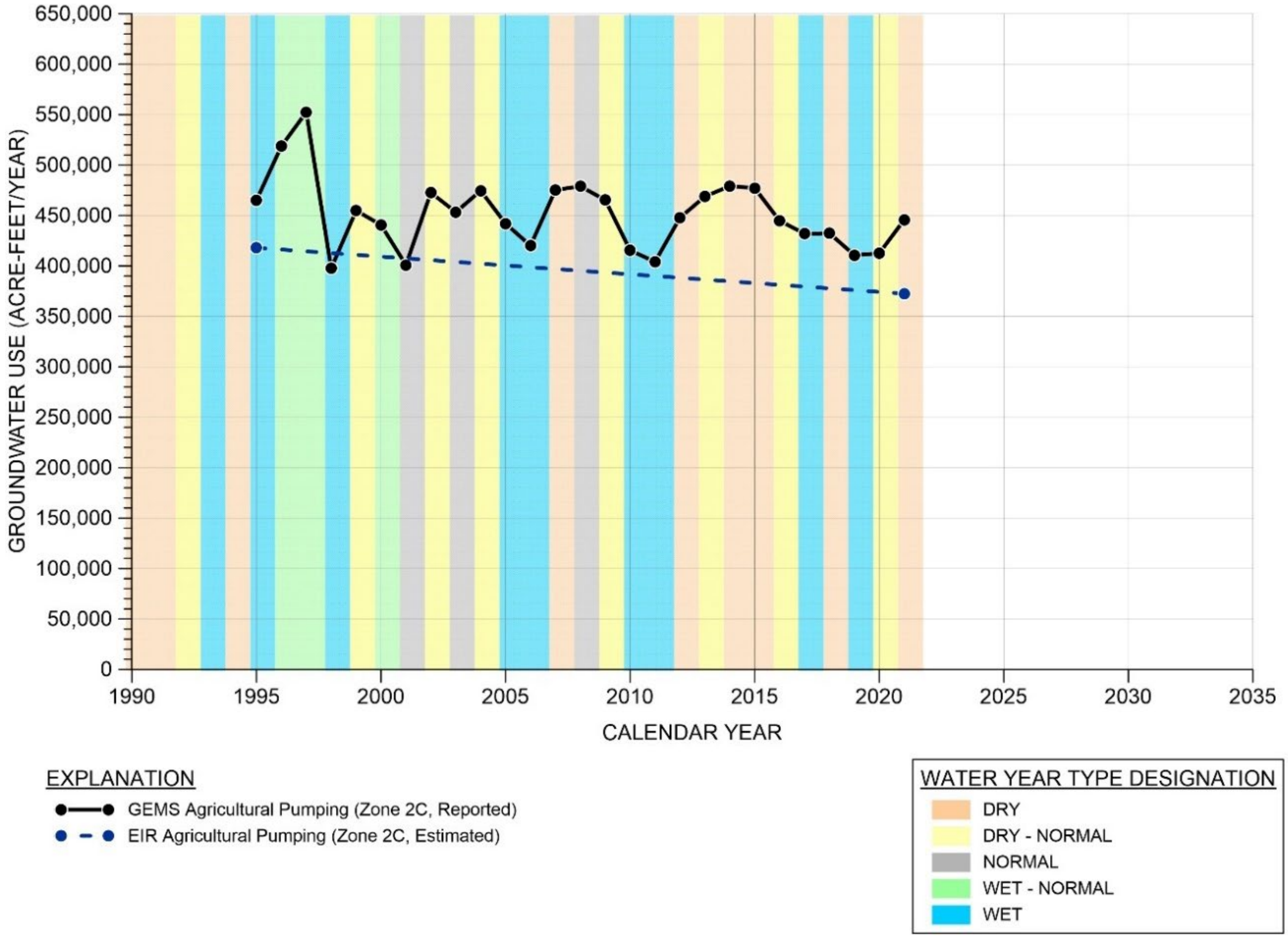

Figure 4-12. Historical and Estimated Agricultural Pumping in Zone 2C

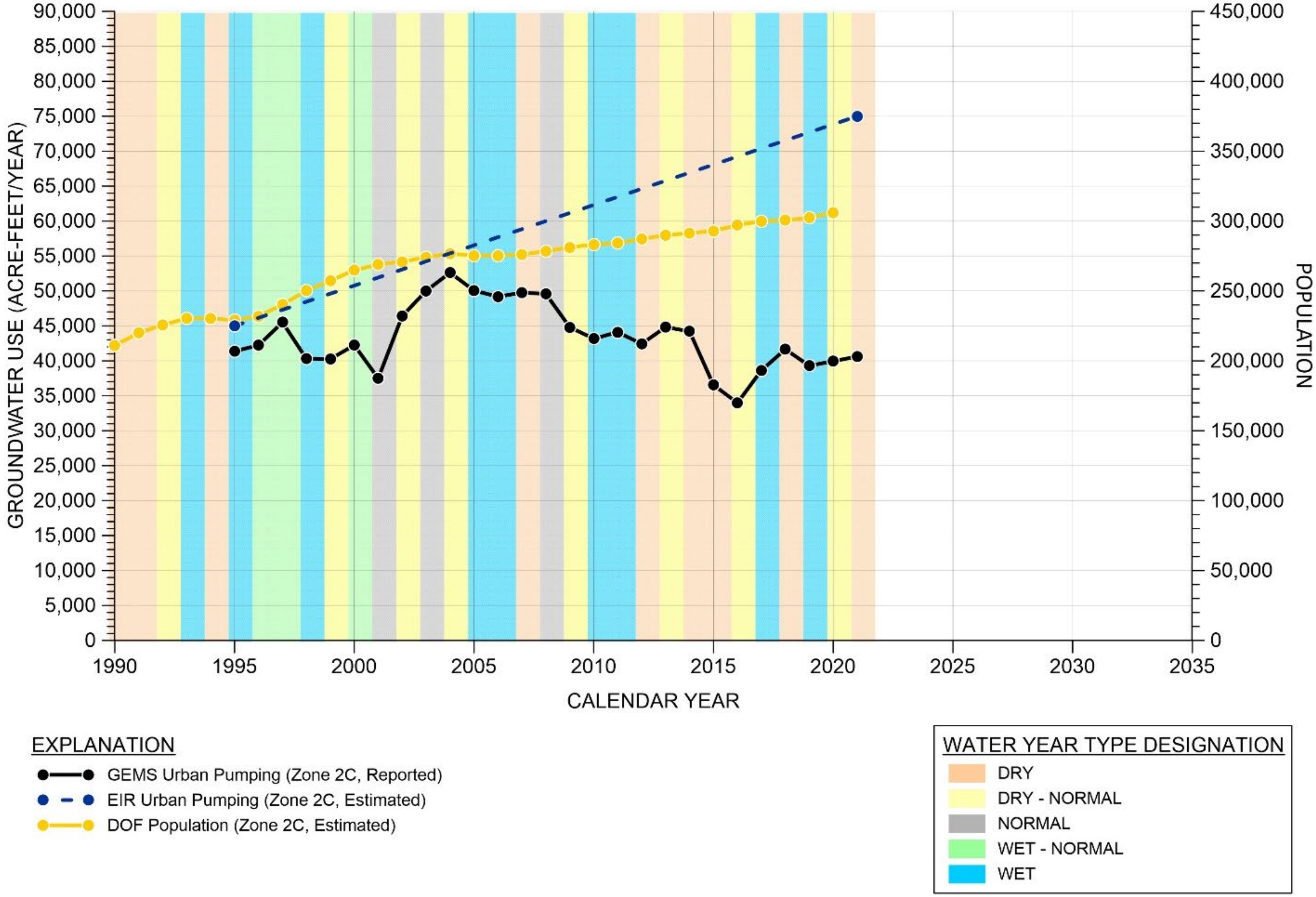

Figure 4-13. Historical and Estimated Urban Pumping and Population in Zone 2C

4.3.1.3 Historical Surface and Recycled Water Demand

MCWRA tracks surface water diversion at the SRDF since 2010 and recycled water use by CSIP since 1998. Both water sources are used to irrigate agriculture and offset groundwater pumping. Total surface and recycled water diversions average about 16,000 AF/yr since 2010 and were about 14,500 AF in 2017, the baseline year for water demands in this study.

Between 2010 and 2020, SRDF diversions average 3,700 AF/yr, ranging from no diversions in the dry years of 2014 through 2016, to 7,600 AF diverted in the wet year of 2019. The 2017 diversion was 4,150 AF. Between 1999 and 2020 CSIP recycled water deliveries averaged 12,400 AF/yr, with more recycled water used in dry years like 2014 (16,500 AF), and less recycled water used in wet years like 2019 (8,500 AF). The 2017 recycled water use totaled 10,322 AF. Historical surface and recycled water demand is summarized in Table 4-8.

Table 4-8. Historical Surface and Recycled Water Demand in Zone 2C

			Historical Water Demand (AF)			
Project	Years	Water Source	2017	Average	Min	Max
SRDF	2010-current	Salinas River	4,150	3,700	0 (2014 through 2016)	7,600 (2019)
CSIP	1998-current	Recycled Water	10,322	12,400	8,500 (2019)	16,500 (2014)

4.3.2 Projected Water Demand

This study updates and refines the projected water demand estimates in the EIR with more recent water demand from the SVOM groundwater model simulations. Projected 2030 water demands for agricultural and urban use are shown on Figure 4-14. The data are discussed in detail in the subsections below.

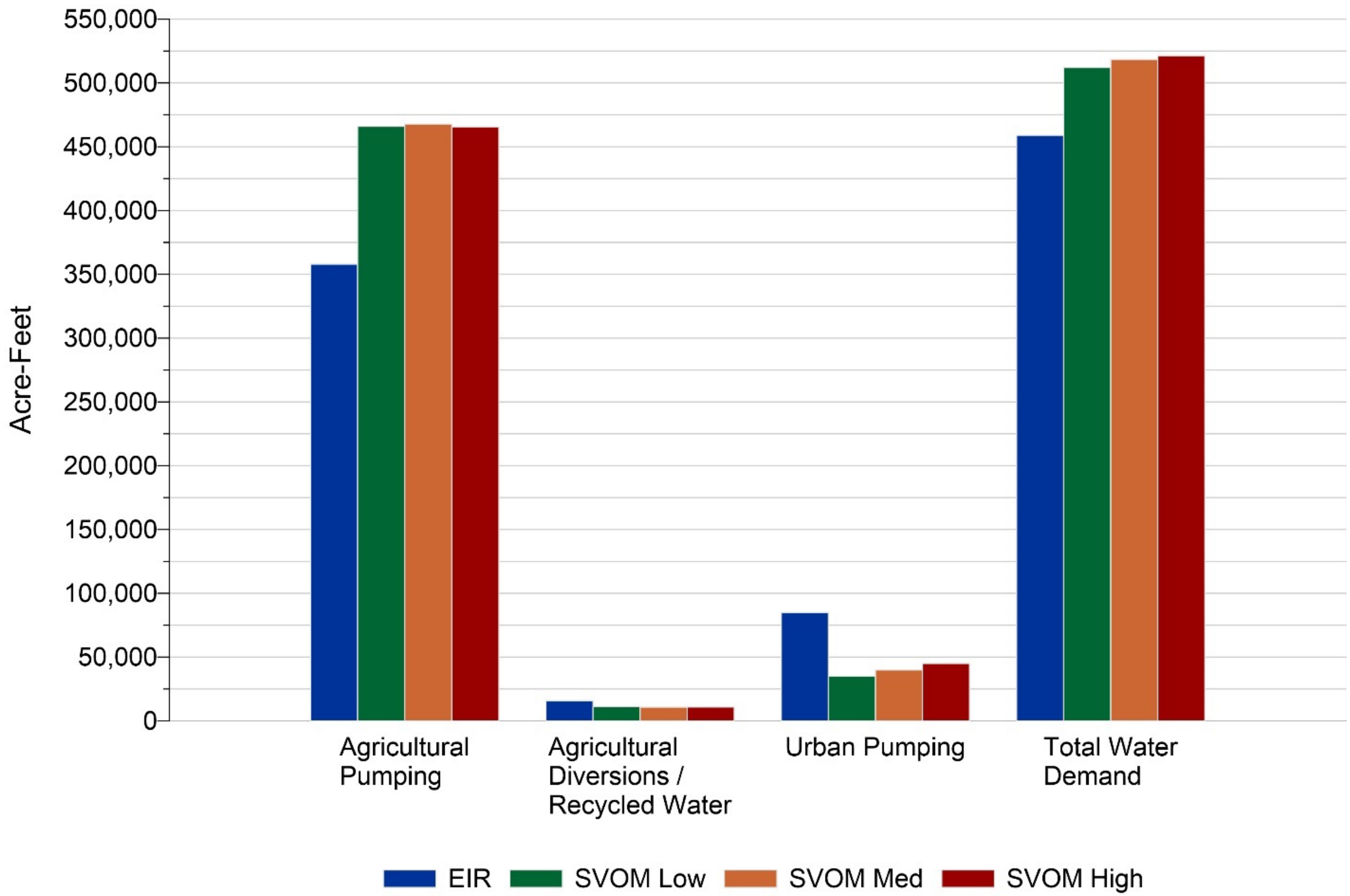

Figure 4-14. Projected Water Demand in Zone 2C

4.3.2.1 Projected Water Demand in the EIR

The EIR projected that 2030 water demands in the Salinas Valley would remain relatively similar to the 1995 baseline. The EIR total water demand in 1995 was 476,300 AF and the EIR projected 2030 water demand was 458,900 AF. The EIR projection assumed that in 2030, 443,000 AF of total water demand would be met by groundwater pumping, 15,900 AF of total water demand would be met by CSIP recycled water deliveries, and no surface water would be supplied from the SRDF.

The EIR projected that agricultural water demand in Salinas Valley would decrease from 431,300 AF in 1995 to 373,900 AF in 2030, of which 358,000 would come from groundwater pumping. The projected decrease in agricultural water demand assumed improved irrigation efficiency, crop conversion from higher water use annual crops to lower water use vineyards, and urbanization of former agricultural lands.

The EIR projected urban water demand in Salinas Valley would increase from 45,000 AF in 2006 to 85,000 AF in 2030. The projected increase in urban water demand was based on assumed population growth and no urban efficiency improvement.

4.3.2.2 Projected Water Demand in SVOM

The 2030 total projected water demands for this study are greater than projected water demands in the EIR by 42,000 to 52,000 AF. The average 2030 water demands from the SVOM are relatively similar for the low, medium, and high growth scenarios. The low growth scenario total water demand, including diversions, is 512,065 AF; the medium growth scenario demand is 518,452 AF; and the high growth scenario demand is 521,433 AF. Total projected water demand is summarized and compared to EIR projections in Table 4-9 and shown on Figure 4-14.

Agricultural water demand is consistent between the 3 SVOM scenarios and is greater than projected in the EIR. The EIR assumed that water demands would decrease significantly by 2030 despite a slightly increasing farmland acreage. The 2030 agricultural pumping projected in the EIR is 358,000 AF, which is much less than agricultural pumping between 465,000 and 468,000 AF in the SVOM scenarios. Recycled and surface water deliveries for agriculture are projected to be about 15,900 AF by the EIR, which is greater than average diversions between 10,805 and 11,019 AF in the SVOM scenarios. Projected agricultural water demand from SVOM simulations is summarized in Table 4-9 and shown on Figure 4-14.

Urban water demand fluctuates between SVOM scenarios and is less than projected in the EIR. Urban water demands have decreased over time despite slow population growth. The 2030 projected urban water demand in the EIR is 85,000 AF, which is more than double the medium growth scenario 2030 urban water demand of 39,896 AF. Projected urban water demand in the low and high growth SVOM scenarios are35,054 and 44,987 AF. Projected 2030 urban water demand is summarized in Table 4-9 and shown on Figure 4-14.

Table 4-9. Projected Water Demand in Zone 2C

Water Demand Component	2017 Baseline	2030 Low Growth	2030 Med Growth	2030 High Growth
	AF	AF	AF	AF
Gonzales	1,575	1,868	2,156	2,457
Greenfield	1,795	1,572	1,832	2,105
King City	1,632	1,401	1,633	1,878
Marina	3,176	3,186	3,696	4,231
Salinas	18,809	15,798	18,432	21,214
Soledad and prisons	3,238	2,747	3,204	3,686
Cities Total Water Demand	30,225	26,316	30,666	35,253
Communities Total Water Demand	1,644	1,314	1,536	1,771
Industrial Total Water Demand	6,916	7,424	7,694	7,964
Urban Water Demand	**38,785**	**35,054**	**39,896**	**44,987**
Agricultural Pumping	432,036	465,992	467,751	465,580
SRDF Diversion and CSIP Recycled Water	14,472	11,019	10,805	10,866
Agricultural Water Demand	**446,508**	**477,011**	**478,556**	**476,446**
Total Water Demand	**485,293**	**512,065**	**518,452**	**521,433**

4.3.3 Historical and Projected Water Demand Summary

Figure 4-15 compares the EIR-projected agricultural pumping, the blue dashed line, with the historical agricultural pumping from GEMS data, the black solid line. This figure additionally shows the SVOM predicted agricultural pumping for the low, medium, and high growth scenarios using colored dashed lines beginning in 2021.

The EIR projected a significant decrease in agricultural pumping and a significant increase in urban pumping by 2030. By contrast, agricultural pumping has been relatively stable since the EIR was drafted, although annual variations in climate result in large fluctuations year to year. Independent of land use changes, this study projects agricultural pumping to increase slightly on average from current conditions because 2030 conditions are projected to be warmer with more erratic precipitation. Taking into account climate change and anticipated land use changes, this study projects 2030 agricultural water demands to be about 100,000 AF more than the EIR assumed.

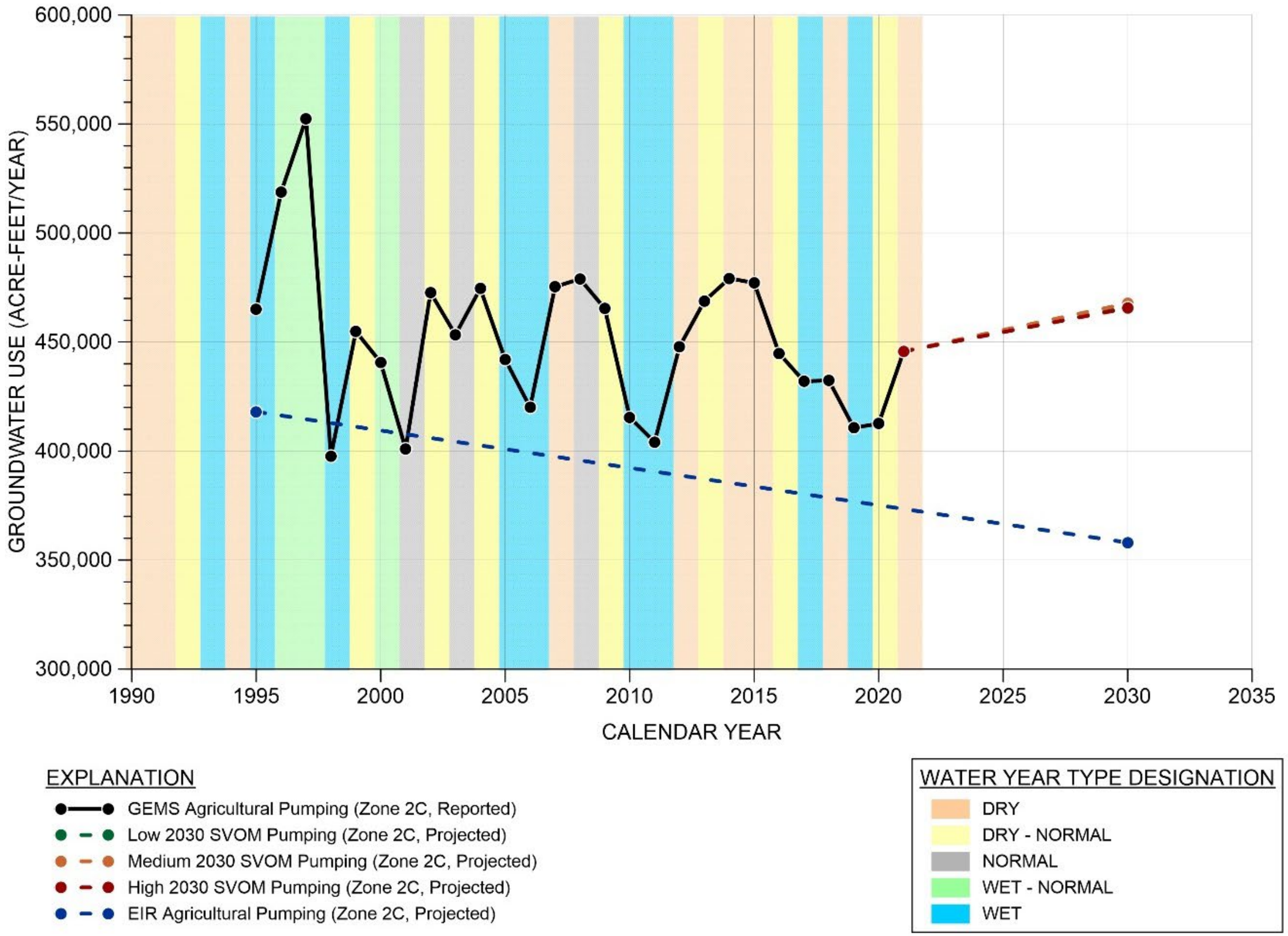

Figure 4-15. Historical and Projected Agricultural Groundwater Pumping in Zone 2C

Figure 4-16 graphs historical and predicted population. The yellow solid line is historical data, and the dashed red, yellow, and green lines are projected data. The EIR projected urban pumping demand is shown as a blue dashed line. Historical urban pumping from the GEMS database is shown as a black solid line. Urban pumping projected by the low, medium, and high growth scenarios are shown with dark green, dark yellow, and dark red dashed lines.

Urban water demands are more consistent on an annual basis than agricultural water demands and reflect stable or decreasing water use due to improved efficiency and conservation which offsets slow population growth. Urban water demand in 2030 is projected to be about 45,000 AF less than the EIR assumed.

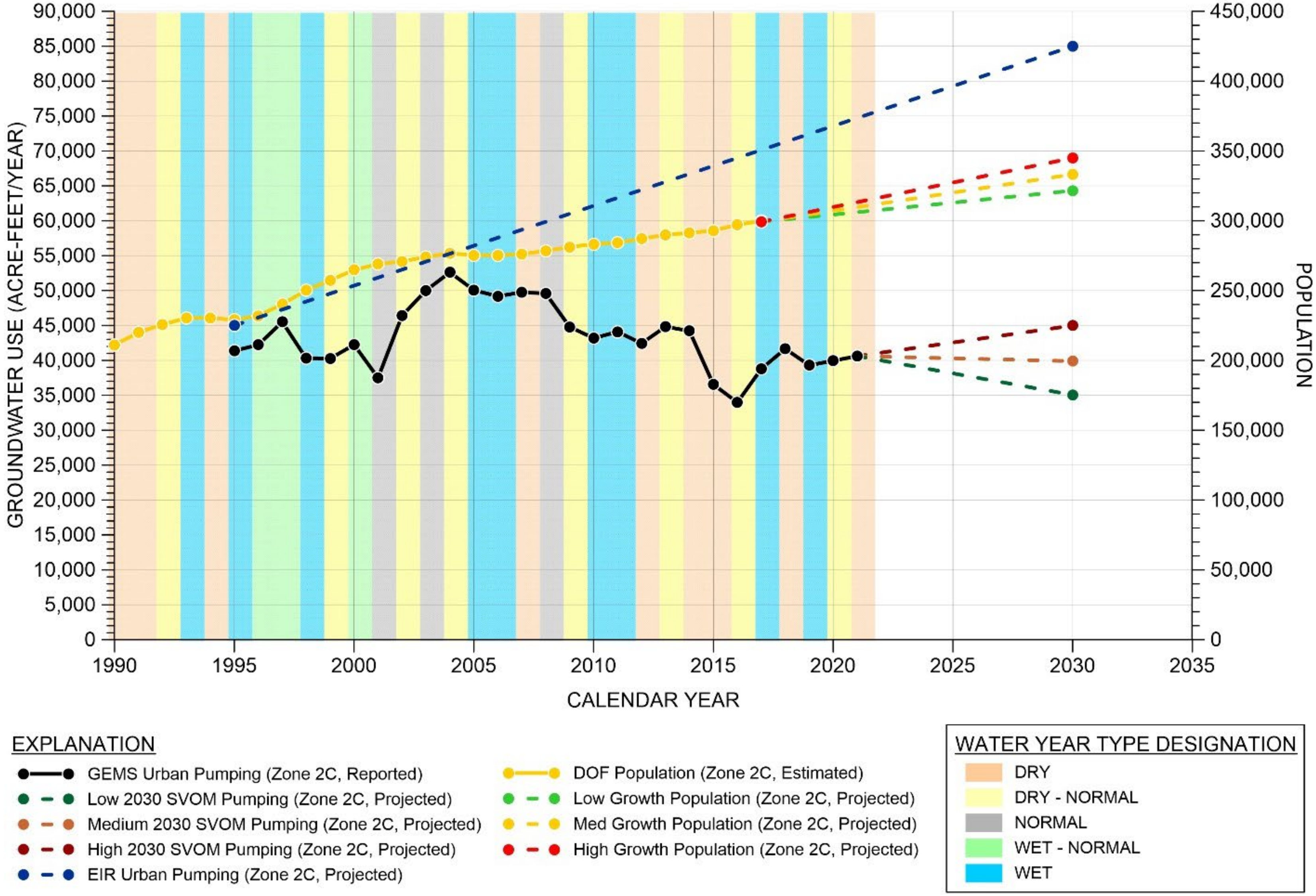

Figure 4-16. Historical and Projected Urban Groundwater Pumping in Zone 2C

4.4 Groundwater Elevations

The following sections summarize historical and current groundwater elevation data as well as groundwater elevation projections. Recent groundwater elevation data collected since 2010 is summarized to demonstrate how conditions have changed since the EIR and General Plan. The 2030 SVOM results demonstrate the influence that future water demand and climate may have on groundwater elevations. Groundwater elevations in the Deep Aquifers are included in this analysis; however, there is insufficient data to produce groundwater elevation contours for the Deep Aquifers.

4.4.1 Historical and Current Groundwater Elevations

Groundwater elevations fluctuate over time with changes in water supply, water demand, and climate. Figure 4-17 and Table 4-10 show the cumulative change in groundwater elevations between 1944 and 2021 in the Upper Valley, Forebay, Eastside, and Pressure Subareas; the years that key water supply projects were completed; and water year type. This figure and table are derived from MCWRA data and graphics. Water year type is correlated with water demands as more groundwater is extracted in drier years than wetter years.

Over the historical record, there is a net groundwater level decline in the Eastside, Pressure, and Forebay Subareas. The Upper Valley has little net groundwater level change. Between 1944 and 2021 groundwater levels declined by an average of 58 feet in the Eastside Subarea, 28 feet in the Pressure Subarea, 12 feet in the Forebay Subarea, and 2 feet in the Upper Valley Subarea.

The rate of groundwater level decline has increased since about 2000 in all Subareas, primarily because the climate has been drier than average. Notable groundwater level declines are observed during the droughts from 2012 to 2016 and 2020 to 2021. Table 4-10 shows average cumulative change in groundwater elevations for 4 time periods: the historical records from 1944 to 2021 and 2000 to 2021; 2011 to 2019, which is used to develop the recent groundwater level trends; and 2010 to 2021, which is the change since the EIR. Between 2011 and 2019, average groundwater levels declined by approximately 4.3 feet in the Eastside Subarea, 4.5 feet in the Pressure Subarea, 3.1 feet in the Forebay Subarea, and 0.6 feet in the Upper Valley Subarea, as shown by the dotted trendlines on Figure 4-17 and in Table 4-10. Between 2010 and 2021, average groundwater levels declined by approximately 6.2 feet in the Eastside Subarea, 7 feet in the Pressure Subarea, 7.9 feet in the Forebay Subarea, and 2.9 feet in the Upper Valley Subarea.

Table 4-10. Cumulative Change in Historical Groundwater Elevations in MCWRA Subareas

Subarea	MCWRA Average Groundwater Elevation Change (ft)			
	Historical Record: 1944 to 2021	Recent Historical: 2000 to 2021	Recent Trend: 2011 to 2019	Change Since EIR: 2010 to 2021
Eastside	-57.5	-18.6	-4.3	-6.2
Forebay	-12.3	-10.2	-3.1	-7.9
Pressure	-27.6	-14.7	-4.5	-7.0
Upper Valley	-2.0	-4.2	-0.6	-2.9

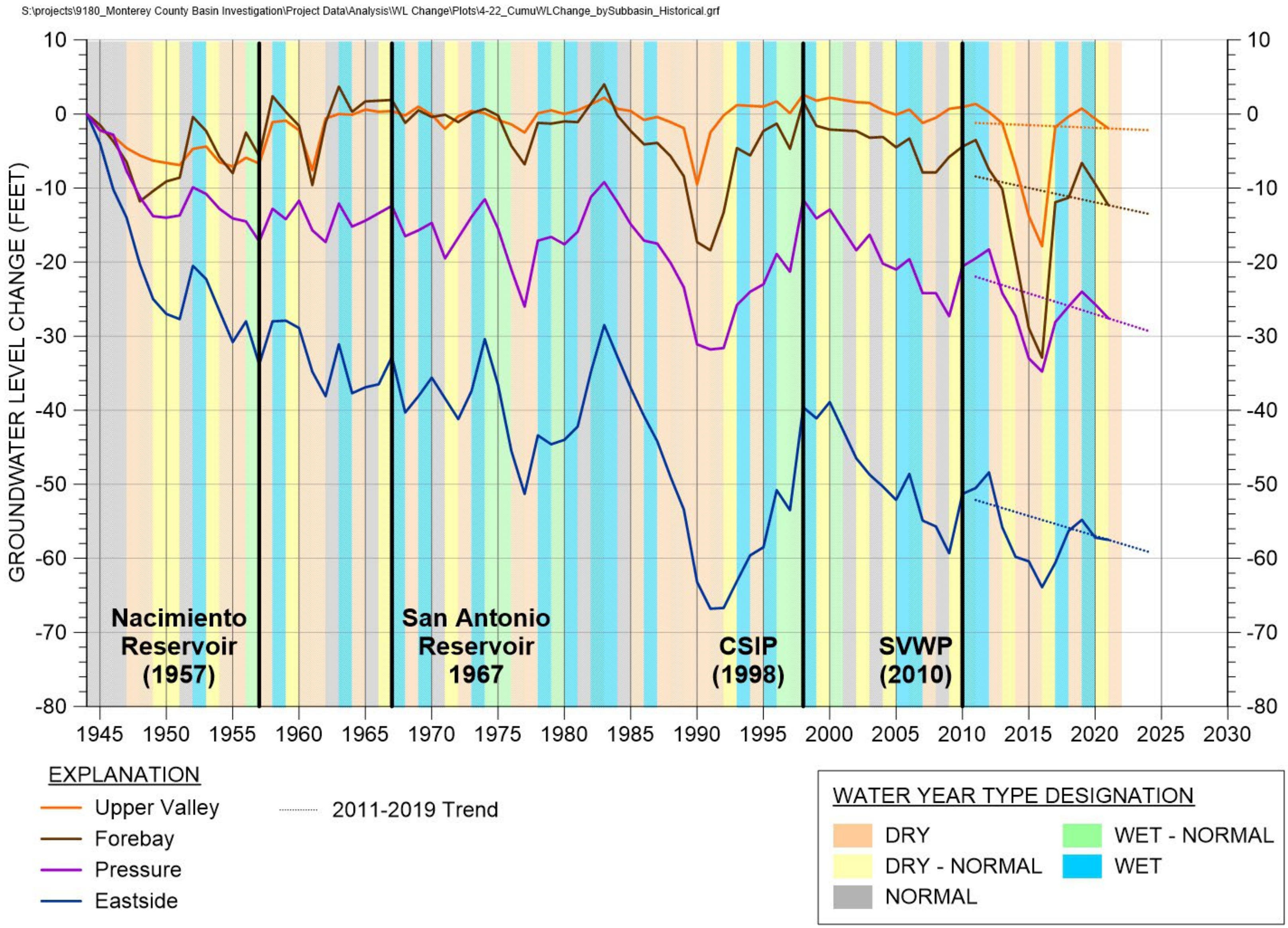

Figure 4-17. Cumulative Change in Groundwater Elevations in MCWRA Subareas from 1944 to 2021

Groundwater elevation contours maps for the Salinas Valley primary aquifers are used to assess groundwater flow directions and conditions in the Basin. Change in groundwater elevation maps show where groundwater level increases and decreases are occurring. MCWRA prepares 2 fall groundwater elevation contour maps: 1 shallow zone map for the Basin Fill Aquifer, 180-Foot Aquifer and Eastside Shallow Zone, and 1 deeper zone map for the 400-Foot Aquifer and Eastside Deep Zone. No groundwater elevation contour maps are produced for the Deep Aquifers due to insufficient data, however groundwater levels are generally declining in the Deep Aquifer wells that are monitored. The 2011 and 2021 contour maps are used to assess groundwater level changes since the EIR was developed instead of 2010 and 2021 maps because MCWRA prepared biennial contour maps in odd years until 2019, and annual contour maps thereafter.

Figure 4-18 and Figure 4-19 show the shallow zone MCWRA generated groundwater elevation maps for 2011 and 2021. Generally, groundwater levels follow topography, with higher groundwater levels in areas of higher land surface elevation. The notable exception is the depression to the east of the City of Salinas, where groundwater elevations are notably below sea level.

Figure 4-20 shows the change in groundwater elevation between 2011 and 2021 for the shallow zone. In the Basin Fill Aquifer, 180-Foot Aquifer, and Eastside Shallow Zone, there are areas of groundwater level increase and decrease between 2011 and 2021. During this period, there were increases in groundwater elevation along several streams flowing off the Gabilan Range, such as where San Lorenzo Creek flows into the Upper Valley Subarea near King City and downstream of where Stonewall Creek flows into the Forebay Subarea near Soledad. There were notable groundwater elevation declines just southeast of the City of Salinas, along the Salinas River near Chualar, and along the Arroyo Seco. Relatively stable groundwater elevations are found in the Upper Valley Subarea and closer to the coast where alternative water sources are used and seawater has intruded into the shallower aquifers.

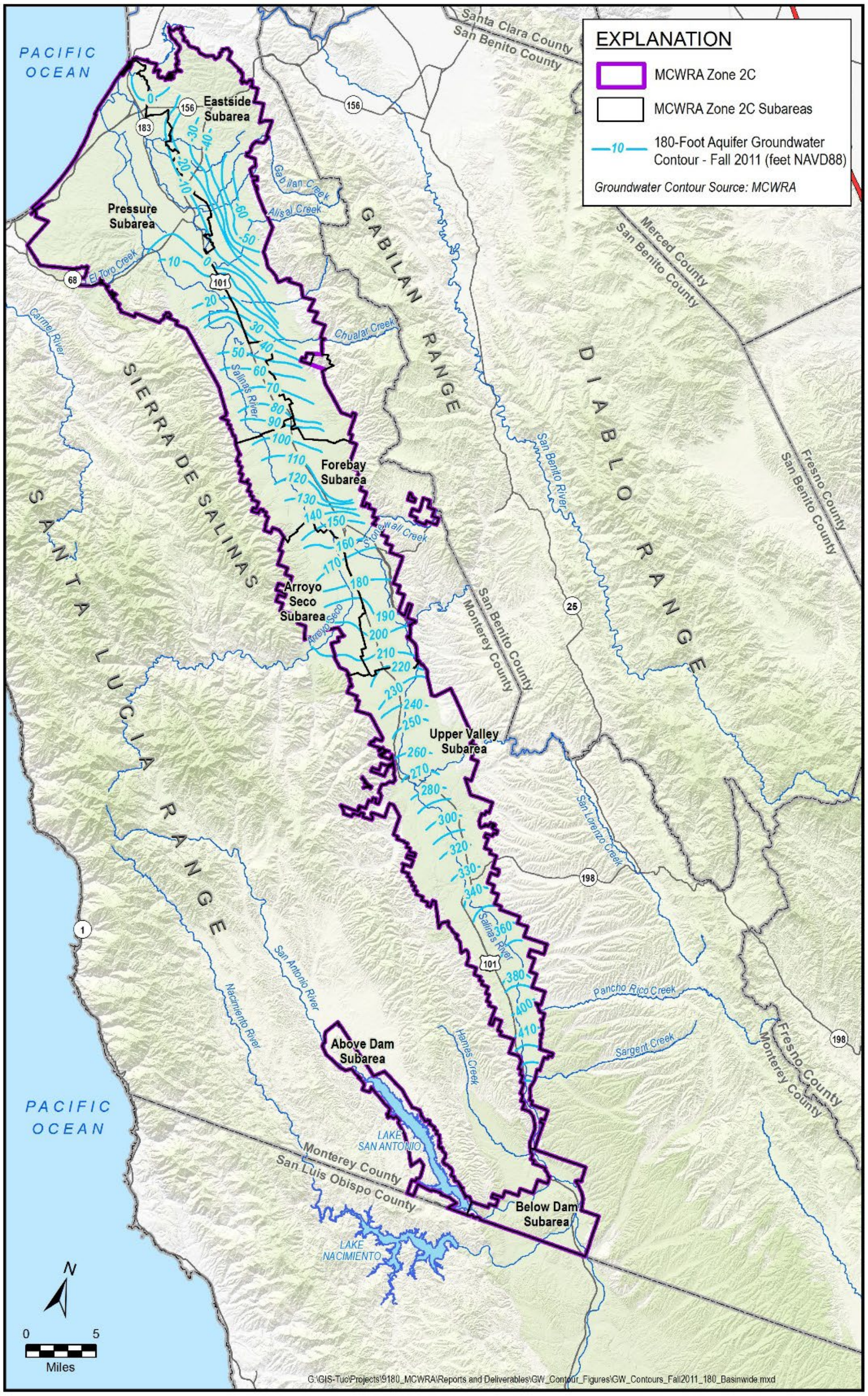

Figure 4-18. Fall 2011 Groundwater Elevation in Basin Fill Aquifer, 180-Foot Aquifer, and Shallow Zone of the Eastside Subarea

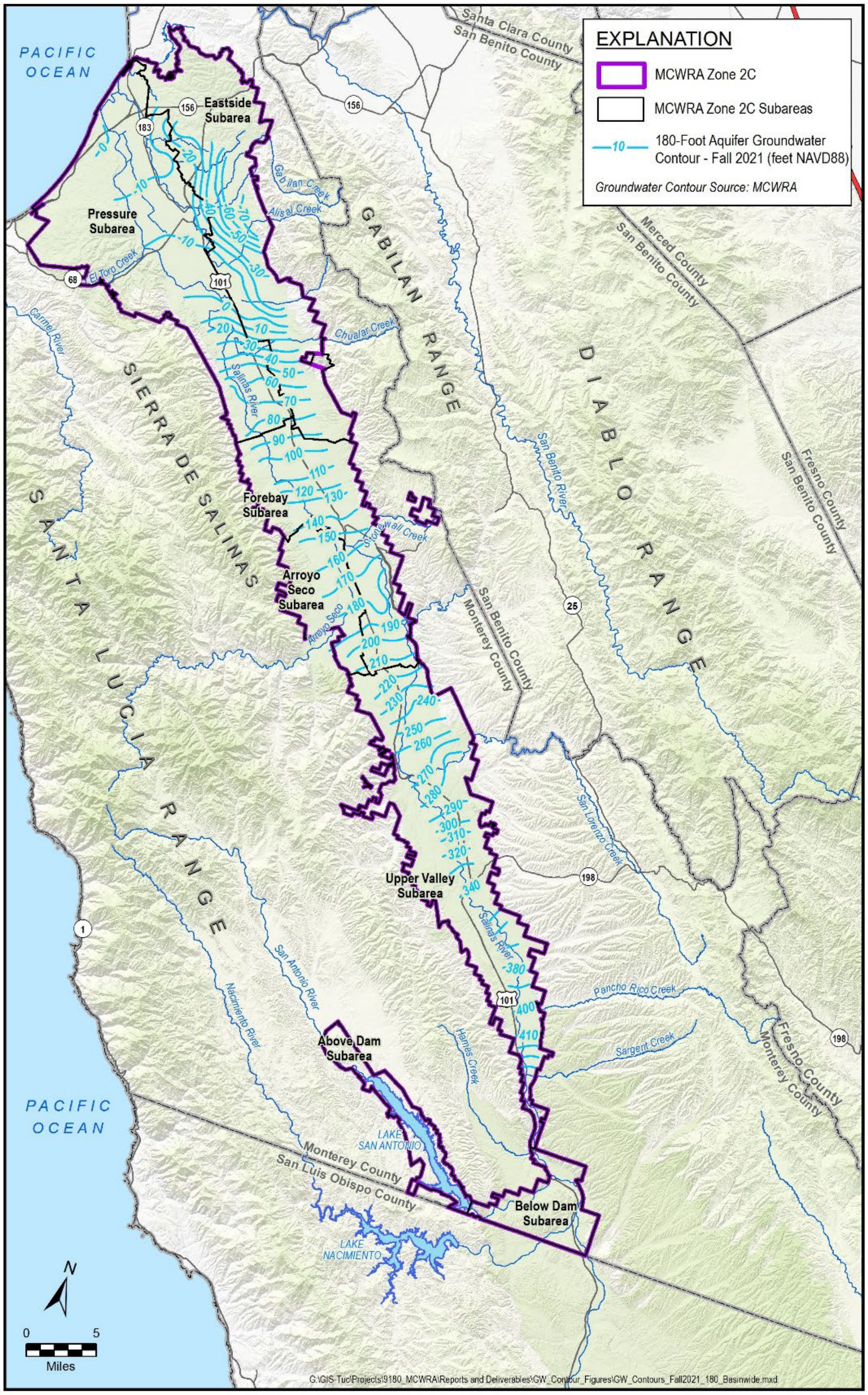

Figure 4-19. Fall 2021 Groundwater Elevation in Basin Fill Aquifer, 180-Foot Aquifer and Shallow Zone of the Eastside Subarea

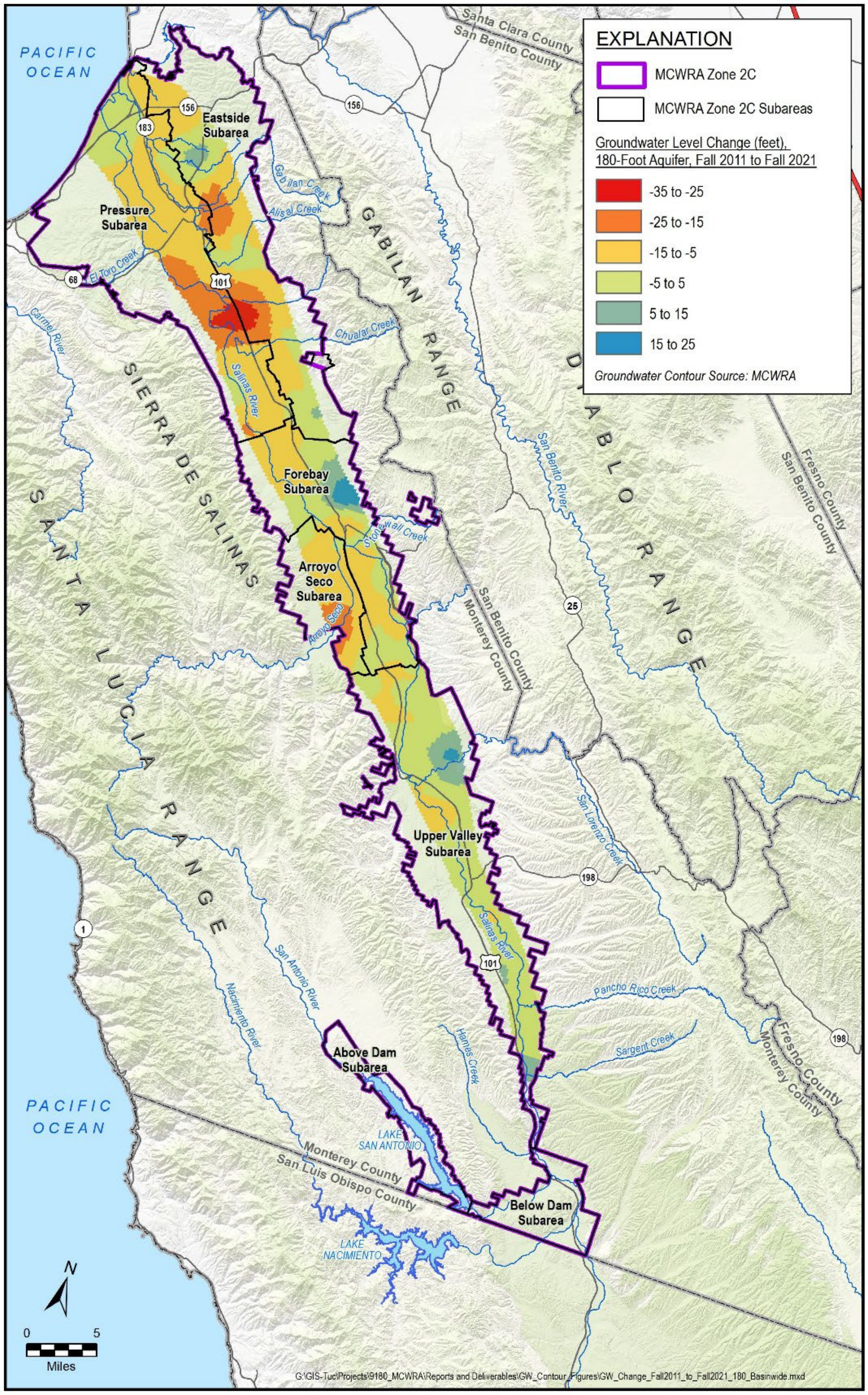

Figure 4-20. Fall 2011 to 2021 Groundwater Elevation Change in Basin Fill Aquifer, 180-Foot Aquifer, and Shallow Zone of the Eastside Subarea

Figure 4-21 and Figure 4-22 show groundwater elevation contours for the 400-Foot and Deep Zone of the Eastside Subarea Aquifers in Fall 2011 and 2021, respectively. Groundwater elevations in the 400-Foot Aquifer are typically lower than groundwater elevations in the 180-Foot Aquifer. Similarly, groundwater elevations in the Deep Zone of the Eastside Subarea are generally lower than the Shallow Zone. The change in groundwater elevation between 2011 and 2021 is shown on Figure 4-23.

Since the EIR, groundwater elevations in the 400-Foot and Deep Zone of the Eastside Subarea Aquifer have slightly declined over time in most areas in the Eastside and Pressure Subareas. Groundwater elevation declines are greatest, ranging up to 40-feet, south of Chualar Creek and at the upgradient aquifer extent near Gonzales. Even though a groundwater depression is still found east of Salinas, the groundwater elevation increased up to 15 feet in this area in the 400-Foot Aquifer and Deep Zone of the Eastside Subarea. The 400-Foot Aquifer and Deep Zone of the Eastside Subarea have little fluctuation at the coast interface because pumping in areas with seawater intrusion has decreased.

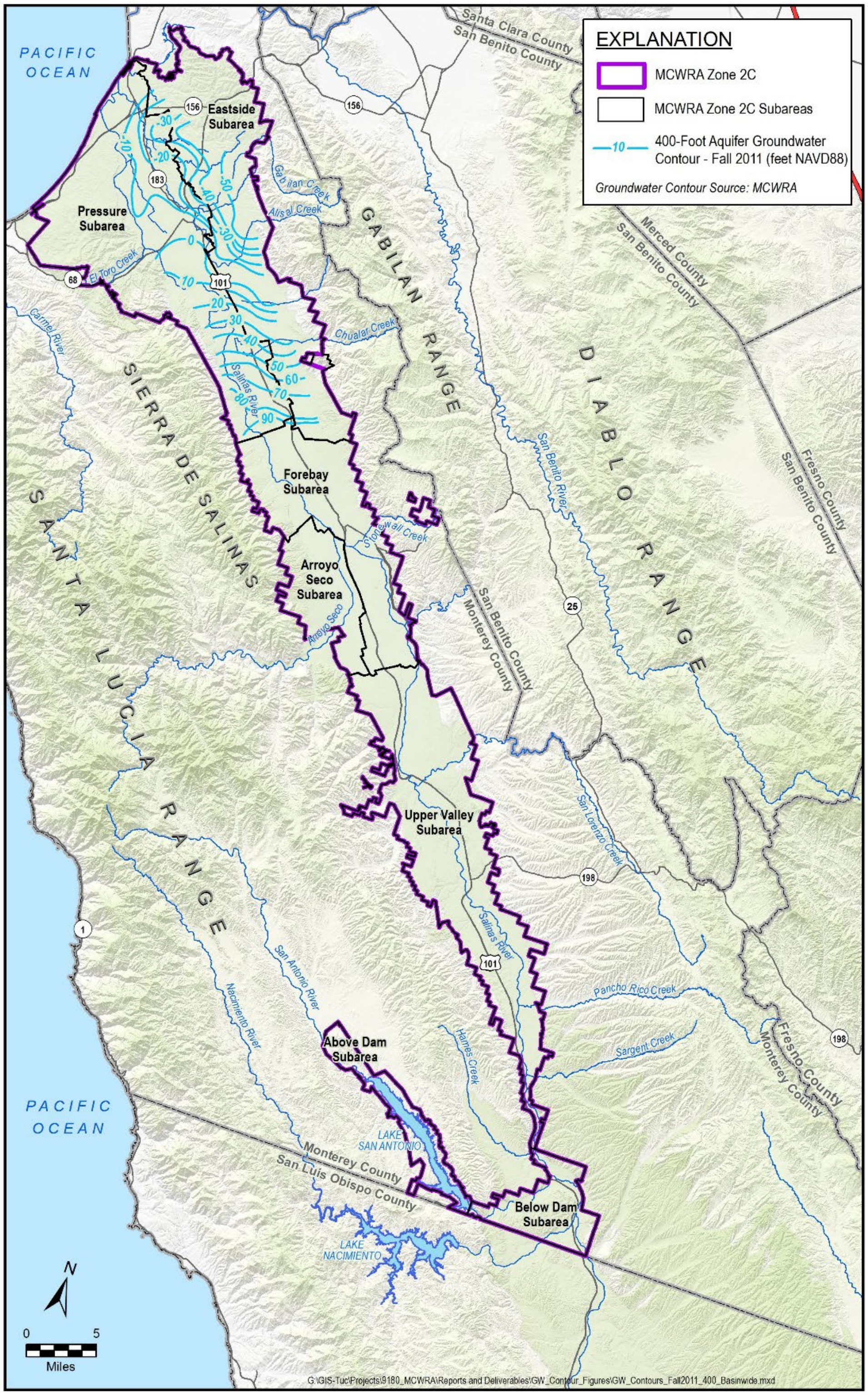

Figure 4-21. Fall 2011 Groundwater Elevation in 400-Foot Aquifer and Deep Zone of the Eastside Subarea

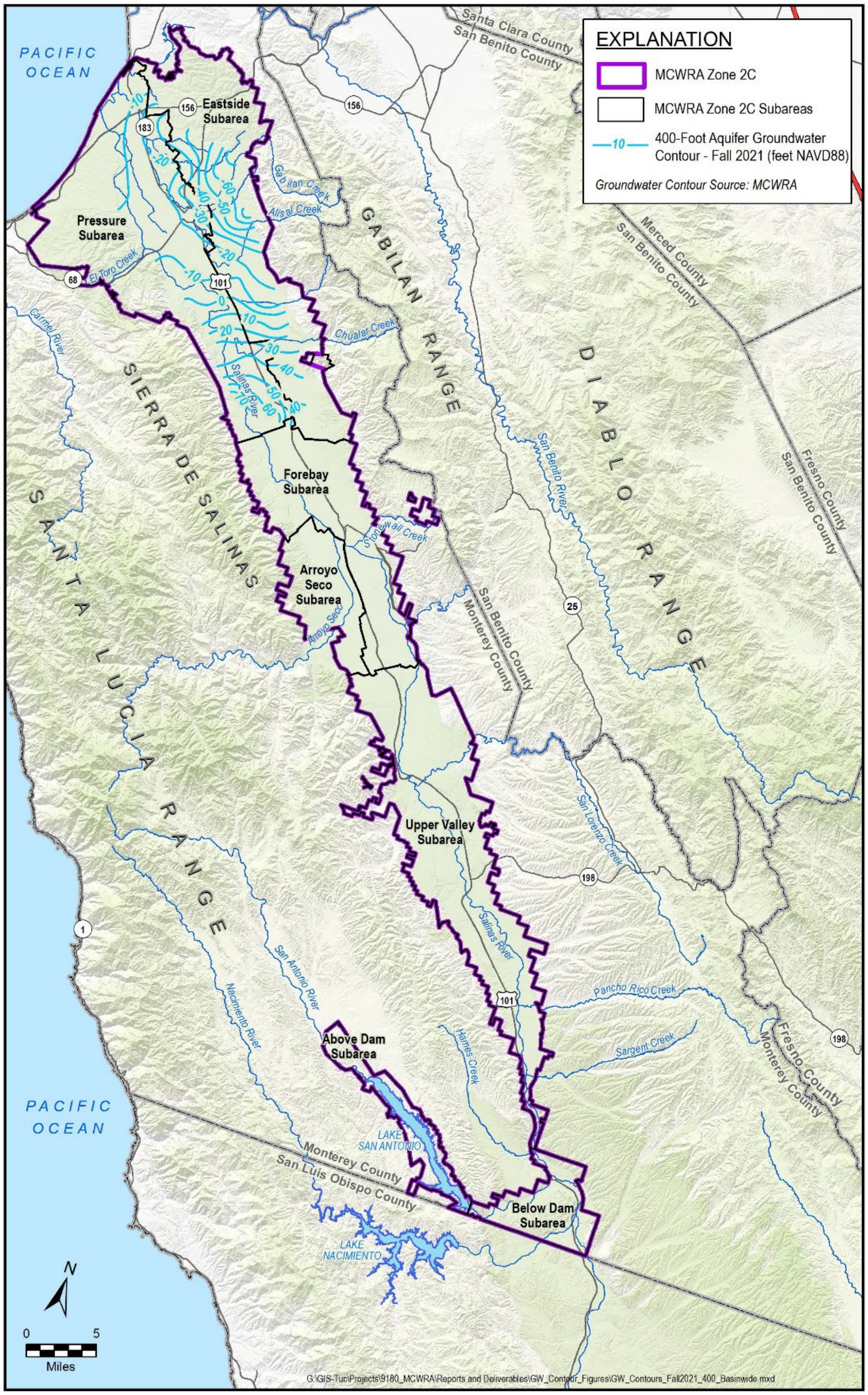

Figure 4-22. Fall 2021 Groundwater Elevation in 400-Foot Aquifer and Deep Zone of the Eastside Subarea

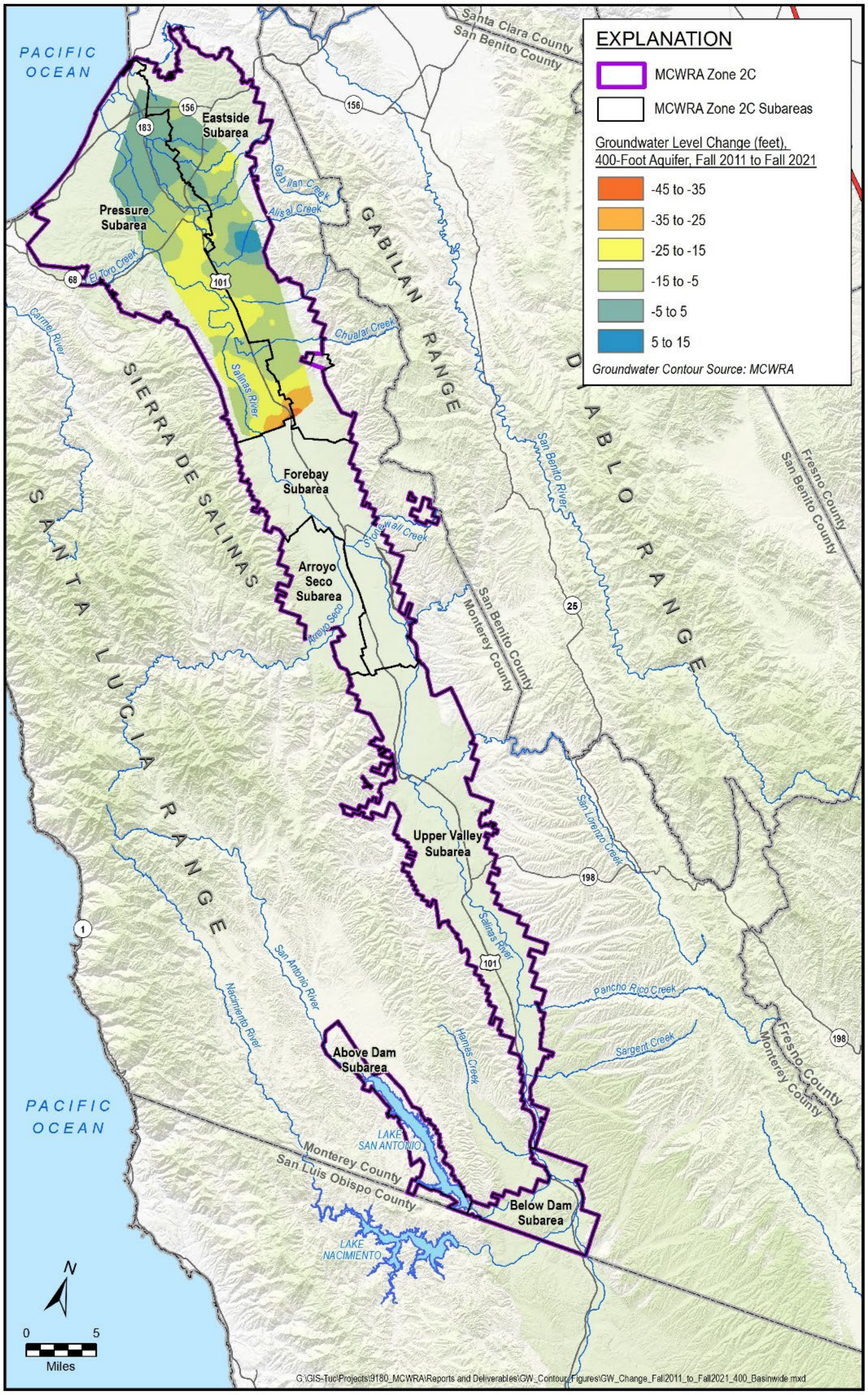

Figure 4-23. Fall 2011 to 2021 Groundwater Elevation Change in 400-Foot Aquifer and Deep Zone of the Eastside Subarea

4.4.2 Projected Groundwater Elevations

The SVOM low, medium, and high growth simulations show that the rate of groundwater elevation change through 2030 under average anticipated climate is not anticipated to deviate much from recent observed changes in Zone 2C. Projected groundwater level change from 2021 through 2030 is shown on Figure 4-24. The projected groundwater level change is a combination of extension of the 2011-2019 trend and the average 2030 SVOM model results, as further detailed in Appendix A. The grey shaded area around each projected groundwater level trend represents projected groundwater level trends in wetter or dryer than average conditions.

Groundwater elevations in 2030 are projected by the SVOM to be slightly lower than 2021 levels on average in the Eastside, Pressure, and Upper Valley Subareas, and increase slightly in the Forebay Subarea. The average groundwater elevation decline for the 3 SVOM scenarios is between 0.4 and 0.5 feet/year in the Eastside Subarea, between 0.2 to 0.3 feet/year in the Pressure Subarea, and 0.2 feet/year in the Upper Valley Subarea (Table 4-11). The rate of average groundwater elevation increase is 0.1 feet/year in the Forebay Subarea.

Rates modeled by the SVOM were combined with the 2011-2019 trend extended to 2024 to estimate groundwater elevations in 2030. Groundwater elevations between 2021 and 2030 are projected to decrease by 4.3 to 4.5 feet in the Eastside Subarea, by 3.1 to 3.6 feet in Pressure Subarea, 1.1 to 1.2 feet in the Upper Valley, and 0.4 to 0.5 feet in Forebay (Table 4-12). These groundwater elevation changes were estimated using average expectations for unknown future climate conditions. In general, long-term average groundwater levels are expected to change at rates similar to those observed in the last decade shown on Figure 4-20 and Figure 4-23 and summarized in Table 4-10.

Actual groundwater elevations will be impacted by the occurrence of wet and dry years. Groundwater elevations fluctuate much more with climate than anticipated changes to future water demands. Under drier than average (20th percentile) climate, projected groundwater elevation declines are more substantial than average conditions. The projected rate of average groundwater elevation decline is 1.9 feet/year in the Eastside Subarea, between 1.8 feet/year in the Pressure Subarea, 1.3 feet/year in the Forebay Subarea, and 2.1 feet/year in the Upper Valley Subarea. Under wetter than average (80th percentile) climate, groundwater elevation is projected to increase compared to average conditions. The rate of average groundwater elevation increase is 0.1 feet/year or less in the Eastside Subarea, 0.4 feet/year in the Pressure Subarea, 1.0 foot/year in the Forebay Subarea, and 1.4 to 1.5 feet/year in the Upper Valley Subarea.

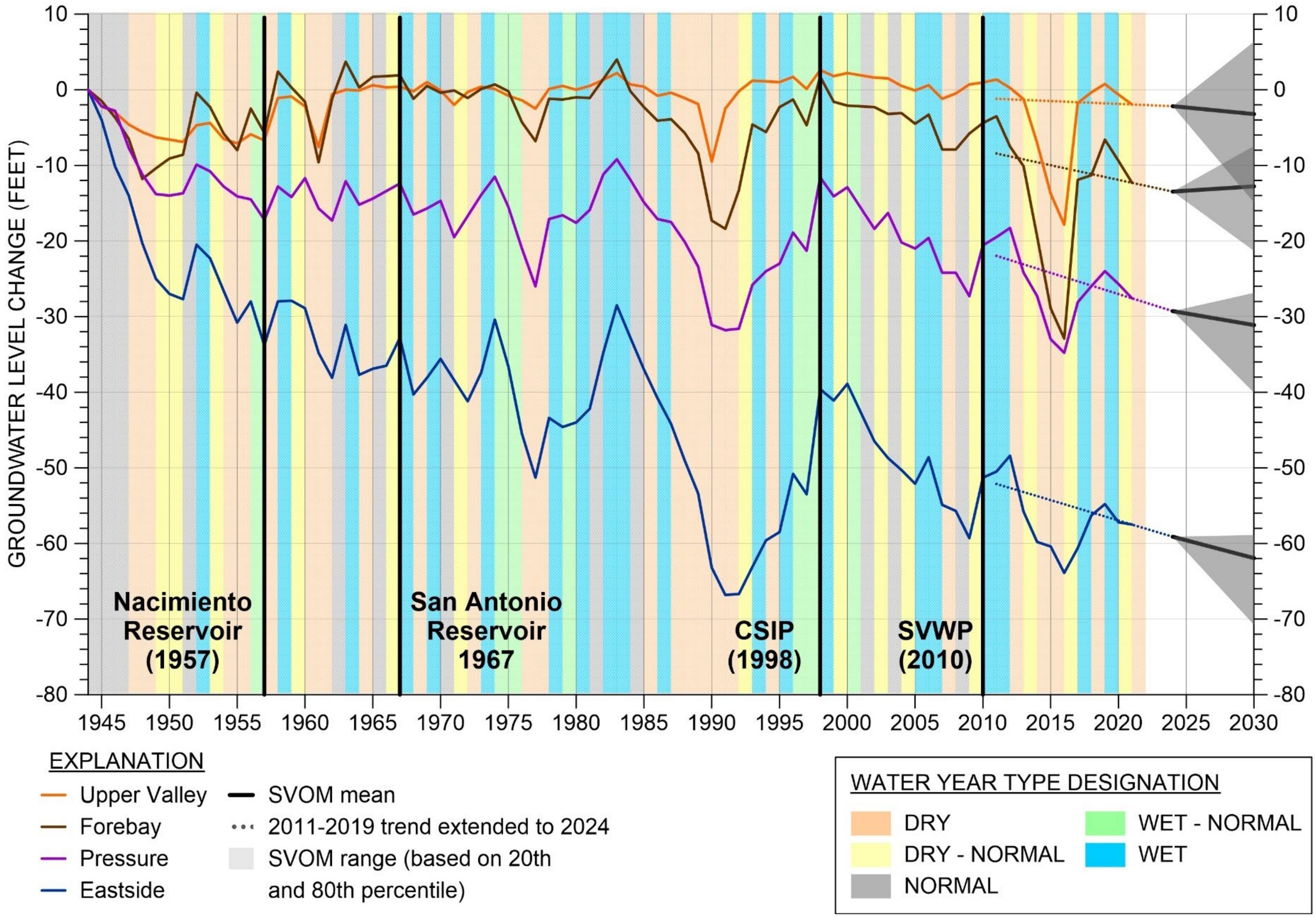

Figure 4-24. Projected Change in Groundwater Elevations in MCWRA Subareas from 2021 to 2030

Table 4-11. Projected Average Groundwater Elevation Change in SVOM Scenarios

Subarea	Groundwater Elevation Change (feet/year)									
Model Scenario	2011 – 2019 Trend Extended From 2021 to 2024	Low Growth Scenario			Medium Growth Scenario			High Growth Scenario		
Statistic		20%	Mean	80%	20%	Mean	80%	20%	Mean	80%
Eastside	-0.5	-1.9	-0.4	0.0*	-1.9	-0.5	0.0*	-1.9	-0.5	0.1
Forebay	-0.4	-1.3	0.1	1.0	-1.3	0.1	1.0	-1.3	0.1	1.0
Pressure	-0.6	-1.8	-0.2	0.4	-1.8	-0.3	0.4	-1.8	-0.3	0.4
Upper Valley	-0.1	-2.1	-0.2	1.4	-2.1	-0.2	1.4	-2.1	-0.2	1.5

*Groundwater elevation change greater than zero but less than +0.1 feet.

Table 4-12. Projected Average Groundwater Elevation Change 2021 to 2030

Subarea	Total Groundwater Elevation Change 2021 to 2030 (feet)			Rate of Groundwater Elevation Change 2021 to 2030 (feet/year)		
	Low Growth	Medium Growth	High Growth	Low Growth	Medium Growth	High Growth
Eastside	-4.3	-4.5	-4.4	-0.43	-0.45	-0.44
Forebay	-0.4	-0.5	-0.5	-0.04	-0.05	-0.05
Pressure	-3.1	-3.6	-3.5	-0.31	-0.36	-0.35
Upper Valley	-1.1	-1.2	-1.2	-0.11	-0.12	-0.12

4.5 Seawater Intrusion

The following sections summarize historical and current data and projections of seawater intrusion from 2010 through 2030. Historical seawater intrusion data through 2010 from the *2015 State of the Basin Report* is updated with more recent seawater intrusion extents through 2020 from MCWRA. Seawater intrusion rates from 2020 through 2030 are projected using the SWI Model. Seawater intrusion occurs in the 180-Foot and 400-Foot Aquifers. It has not been found in the Deep Aquifers to date; however, groundwater elevations in the Deep Aquifers are lower than historically recorded and on average are lower than in the 400-Foot Aquifer, indicating the potential for seawater intrusion in the future.

4.5.1 Historical and Current Seawater Intrusion

Seawater intrusion occurs in the Pressure Subarea and northeast corner of the Eastside Subarea near the Elkhorn Slough, where groundwater elevations are at or below sea level. Seawater intrusion is found in different extents and advances inland at variable rates in the 180-Foot and 400-Foot Aquifers. The EIR references a baseline seawater intrusion rate from 1995 of 8,900 AF/yr across the coastal boundary for the 2 aquifers combined and points towards implementation of the CSIP and SVWP projects as having the potential to halt seawater intrusion. However, despite the EIR saying seawater intrusion may be halted by these 2 projects, the 2030 projected future conditions indicate a seawater intrusion increase of 10,300 AF/yr. The EIR approach for estimating seawater intrusion rates is different than the more recent approach in the *2015 State of the Basin* and recent MCWRA estimates, so information is not easily compared. The EIR references an annual volume of seawater flowing into the groundwater basin from the ocean, while the more recent sources use an area impacted by intrusion. For simplicity, the area impacted by seawater intrusion from the *2015 State of the Basin* and MCWRA is discussed in this section, as it better describes usable groundwater.

The rate of seawater intrusion expansion in 180-Foot Aquifer has slowed since the early 2000s, particularly since 2010, as shown in Table 4-13 and Figure 4-25. The rate of seawater intrusion expansion in the 400-Foot Aquifer also slowed since the early 2000s, but expanded faster between 2010 and 2015 as shown in Table 4-13 and Figure 4-26. Recent seawater intrusion in the 400-Foot Aquifer is related to higher salinity 'islands' that developed within the 400-Foot Aquifer from hydraulic connection with the overlying 180-Foot Aquifer where seawater intrusion had already occurred. This downward migration is driven by the downward head gradient between the 2 aquifers (Figure 4-18 through Figure 4-22). The rate of seawater intrusion expansion in the 400-Foot Aquifer has slowed since 2017.

Table 4-13. Historical Seawater Intrusion Rates in Zone 2C

Reference	Start Date	End Date	180-Foot Rate (acres/yr)	400-Foot Rate (acres/yr)
2015 State of the Basin	1944	1959	-	1.5
	1959	1965	-	-
	1965	1975	397	370
	1975	1985	458	380
	1985	1993	-	103
	1993	1997	451	224
	1997	1999	1,200	272
	1999	2001	381	250
	2001	2005	442	90
	2005	2007	213	61
	2007	2009	96	47
	2009	2011	176	238
MCWRA Data	2011	2015	29	778
	2015	2017	25	610
	2017	2019	10	163
	2019	2020	33	219

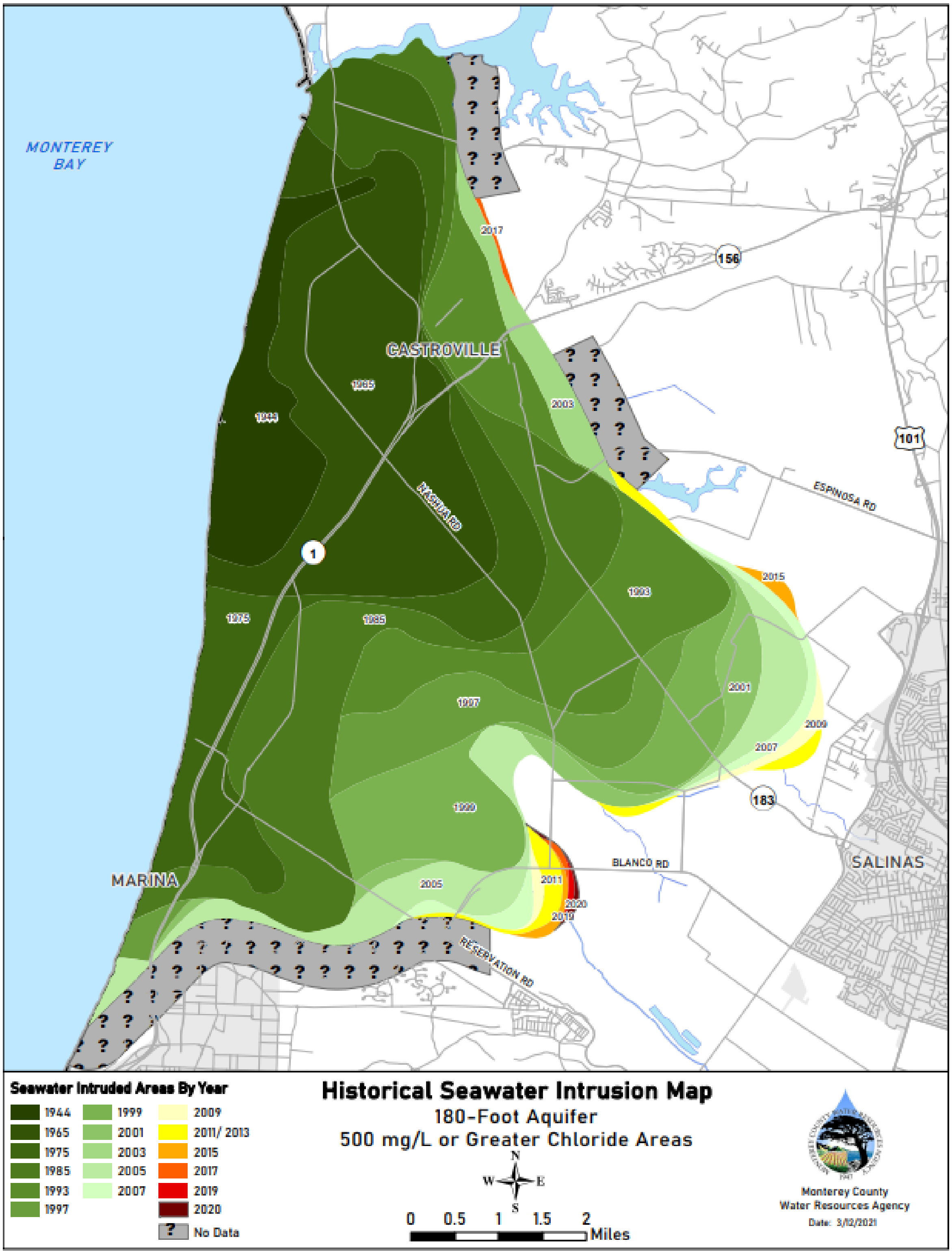

Figure 4-25. Historical Seawater Intrusion in the 180-Foot Aquifer, 1959-2020

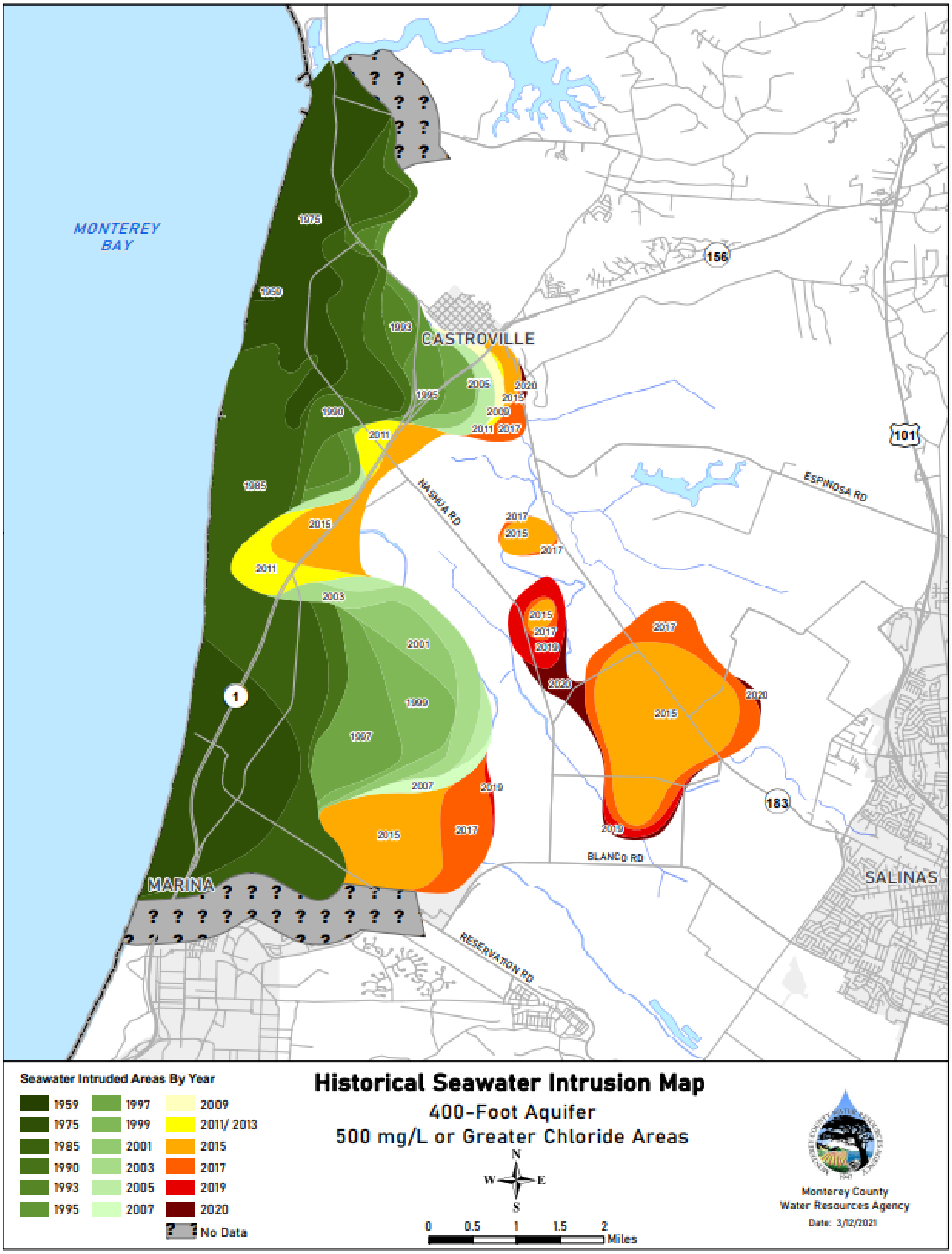

Figure 4-26. Historical Seawater Intrusion in the 400-Foot Aquifer, 1959-2020

4.5.2 Projected Seawater Intrusion

Seawater intrusion is projected to continue advancing inland through 2030, as shown in Table 4-14 and on Figure 4-27 and Figure 4-28. Projected seawater intrusion includes areas where modeled chloride concentrations in groundwater are at least 500 mg/L. In the 3 modeled scenarios, the leading edge of the seawater intrusion area approaches the city limits of Salinas in the 180-Foot Aquifer. Seawater intruded 'islands' of high salinity in the 400-Foot Aquifer which existed prior to 2020, appear to have dispersed to include a larger, but more contiguous, area. Projected seawater intrusion should be considered an average, not by aquifer. Land use changes in this study were derived from the regional LUCAS model projections so are not associated with the likelihood of land use changes at specific farms. Actual land use changes may occur in slightly different areas than projected changes that use wells installed in other aquifers. Therefore, projected land use changes cannot reliably be used to project changes to pumping by aquifer, but rather this assessment of projected seawater intrusion should be considered total intrusion regardless of aquifer.

Estimated rates of projected seawater intrusion in the Basin Fill and 180-Foot Aquifers ranges from 131 acres/year (low growth scenario) to 204 acres/year (high growth scenario). In the 400-Foot Aquifer, seawater intrusion is projected to advance at rates ranging from 221 acres/year (high growth scenario) to 350 acres/year (low growth scenario). Seawater intrusion rates in the 180 and 400-Foot Aquifers in the medium growth scenario fall between the low and high growth scenarios but are more like the high growth scenario. Projected seawater intrusion rates in the 180-Foot Aquifer are slightly more than recent estimates by MCWRA for 2011 through 2020. Projected seawater intrusion rates in the 400-Foot Aquifer are slightly less than recent estimates from MCWRA data between 2011 and 2020 (Table 4-14). Average projected seawater intrusion from 2020 to 2030 in the 2 aquifers is slightly less than estimated between 2011 and 2020 (Table 4-13).

Table 4-14. Projected Seawater Intrusion Rates in SWI Model Scenarios

		Seawater Intrusion Rates (acres/year)		
Model Scenario	**Time Period**	**180-Foot Aquifer**	**400-Foot Aquifer**	**Average of 180-Foot and 400-Foot Aquifers**
Historical	2011 - 2020	24	542	283
Low Growth	2020 - 2030	131	350	241
Medium Growth	2020 - 2030	200	222	211
High Growth	2020 - 2030	204	221	213

In the low growth scenario, the seawater plume in the 180- and 400-Foot Aquifers is drawn towards agricultural areas to the southeast, while in the medium and high growth scenarios it advances towards Salinas. The location of advancement is affected by the amount and location of pumping. Since more or less intrusion may occur in each aquifer depending on where land use changes occur and which aquifer overlying farms pump from, the rate of intrusion for the aquifers combined should be more representative of projected intrusion than the individual aquifer rates. The low growth scenario features the lowest urban pumping volumes and most of the total reduction occurs near Salinas. Also, after accounting for pumping reductions due to declining water levels, total pumping in the medium and high growth scenarios for the area within the SWI Model was similar (<1,000 AF/yr difference), while it was lower for the low growth scenario (about 5,000 AF/yr less).

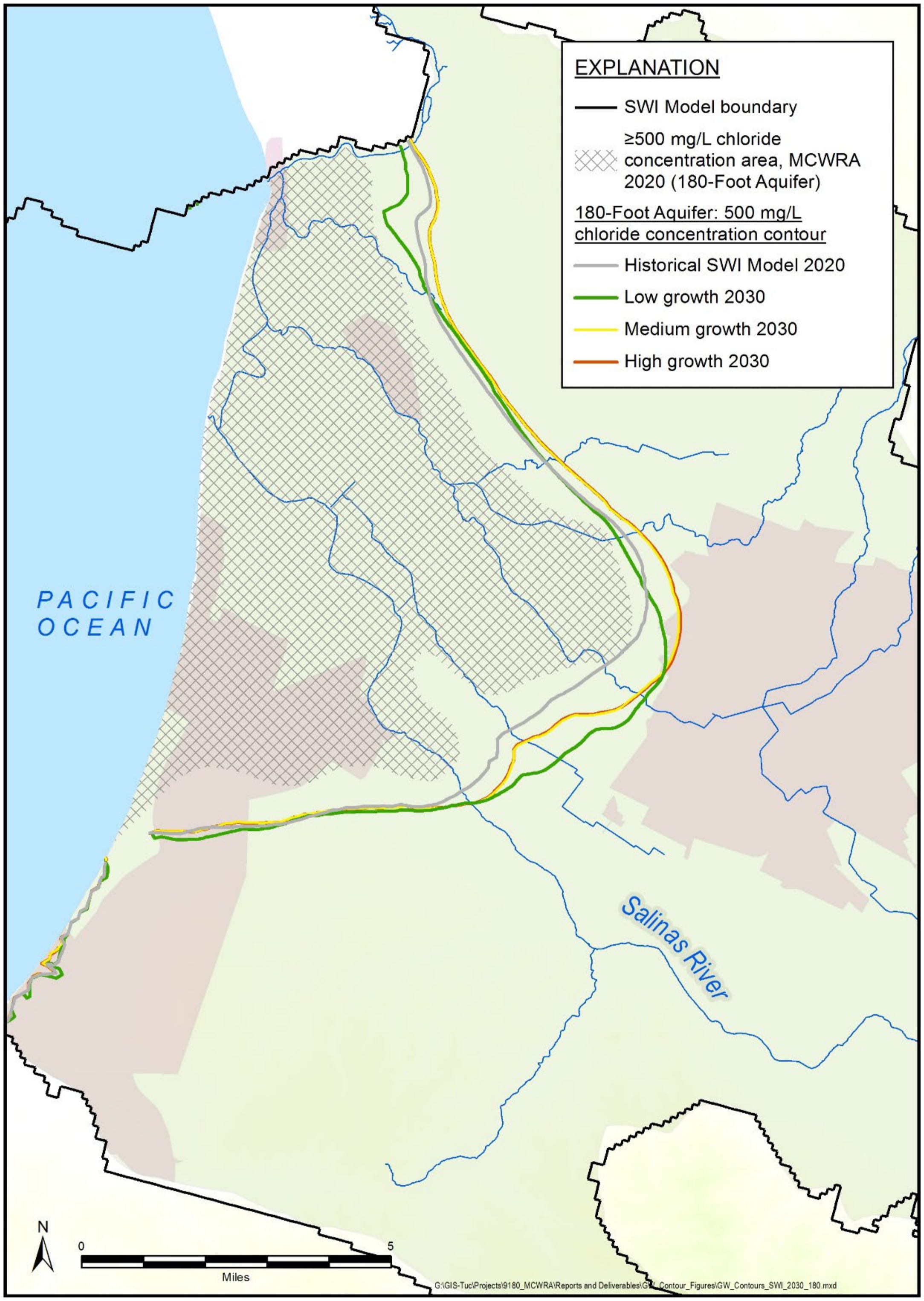

Figure 4-27. Projected Seawater Intrusion in the 180-Foot Aquifer, 2020-2030

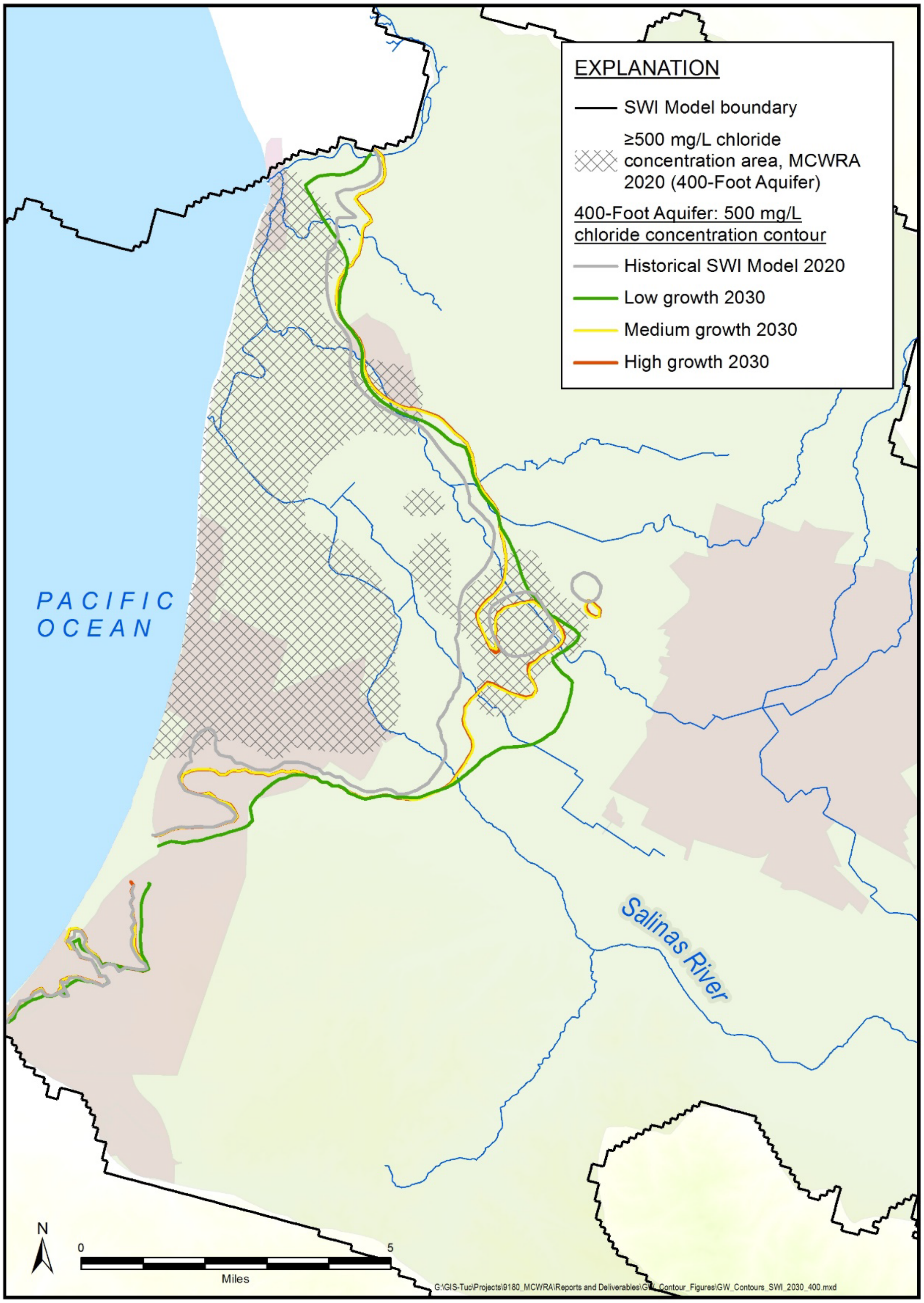

Figure 4-28. Projected Seawater Intrusion in the 400-Foot Aquifer, 2020-2030

5 DISCUSSION

This study re-evaluates assumptions about 2030 water demands, groundwater levels, and seawater intrusion in the EIR and General Plan. A range of projected 2030 water demands are developed based on projected population growth, urban efficiency improvements, and land use changes. The SVOM and SWI groundwater models are used to assess the impacts that 2030 water demands may have on groundwater levels and seawater intrusion in Zone 2C. The projected 2030 water demand and groundwater conditions are compared to assumptions in the Monterey County 2010 General Plan and EIR to assess the degree to which total water demands projected in the General Plan are expected to be exceeded.

The EIR projected future water demands in the Salinas Valley for the General Plan based on assumed changes to population, land use, and water efficiency. During the 10 years prior to the EIR population growth in the County had decreased to about half the pre-2000 rate of growth. The EIR used conservative population growth assumptions from before 2000 to project future urban water demands. Leading up to the EIR, net farmland expansion was relatively minimal, with vineyard growth at the margins of the valley generally being offset by annual crop contraction for urban development around existing cities and communities. The EIR assumed that further irrigation efficiency improvements, conversion of farmland to lower water use vineyards, and farmland contraction around urban areas would result in a significant decrease in agricultural water demand.

This study uses more recent data and trends to develop 3 scenarios for estimating a range of 2030 water demands and groundwater conditions. The medium growth scenario uses the average estimates for population growth, improved urban efficiency, and land use change. Uncertainty in future land use and urban growth is evaluated with low and high growth scenarios that consider lower or higher than average expected changes. The low growth scenario has lower than expected population growth, more efficient urban water use, and no change to current land use. The high growth model assumes that population growth will be higher than expected, urban water use efficiency will not improve, and that more land conversion will occur compared to the medium growth scenario. All 3 growth scenarios use the same climate change assumptions including warmer temperatures, greater evapotranspiration, more variable precipitation and streamflow, and sea level rise. The scenarios typically use 2017 baseline data to project conditions in 2030.

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Table 5-1. Projected Population, Land Use, and Water Demand in Zone 2C

Study	Population		Urban Land Use (acres)		Urban Water Demand (AF/yr)		Agricultural Land Use (acres)		Agricultural Water Demand (AF/yr)	
	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected	Historical and Current	2030 Projected
EIR with Zone 2C Assumptions*	2000: 264,000	2030: 397,000	2006: 32,319	Not projected	1995: 45,000	2030: 85,000	2006: 211,728	Not projected	1995: 431,300	2030: 373,900
Low Growth Scenario	2010: 280,685 2020: 304,092	2030: 323,231	2006: 38,926 2017: 38,935	2030: 38,935	2017: 38,785	2030: 35,054	2006: 199,066 2017: 199,052	2030: 199,052	2017: 446,508	2030: 477,011
Medium Growth Scenario	2010: 280,685 2020: 304,092	2030: 332,289	2006: 38,926 2017: 38,935	2030: 41,462	2017: 38,785	2030: 39,896	2006: 199,066 2017: 199,052	2030: 199,568	2017: 446,508	2030: 478,556
High Growth Scenario	2010: 280,685 2020: 304,092	2030: 341,347	2006: 38,926 2017: 38,935	2030: 43,664	2017: 38,785	2030: 44,987	2006: 199,066 2017: 199,052	2030: 200,145	2017: 446,508	2030: 476,446

*Assumptions made about EIR population and land use data to summarize by Zone 2C instead of County

Table 5-1 summarizes historical and projected data in the EIR, compared to the low, medium, and high growth scenarios for this study. Recent land use trends show that urban land is continuing to grow faster than farmland. However, urban growth rates appear to have slowed since the EIR to accompany a slowing population growth rate. Net farmland expansion is minimal but there is expansion and contraction of farmland occurring in different areas. As projected in the EIR, vineyard growth at the margins of the valley is generally being offset by annual crop contraction for urban development around existing cities and communities.

The EIR projected that 2030 total water demand would be less than the 1995 baseline. The EIR projected that urban water demand would increase significantly to accommodate population growth and that agricultural water demand would decrease significantly due to land contraction, shift to lower water use crops, and increased irrigation efficiency.

More recent data and projections in this study suggest that total water demands are increasing and in 2030 will likely be greater than projected in the EIR. Urban water demands remain about the same as the EIR baseline data, and agricultural water demands are greater than projected. Although the agricultural footprint has been stable and there has been a shift to more water efficient crops, there is no evidence of significant increased efficiency. Furthermore, warmer temperatures and more erratic precipitation since the EIR has likely led to greater current and projected agricultural water demand.

The result of greater than projected water demands is that more groundwater is being pumped than assumed in the EIR and General Plan. Groundwater pumping that exceeds groundwater recharge causes groundwater level decline and seawater intrusion near the coast. Groundwater levels are declining more on average in the Eastside and Pressure Subareas than in the Forebay and Upper Valley Subareas, which are more stable during average conditions. The Forebay Subarea has experienced slower groundwater level declines historically and the Upper Valley Subarea has been relatively stable, however all Subareas including the Forebay and Upper Valley experience groundwater declines during and after recent drought periods. Forebay and Upper Valley groundwater levels recover more quickly after droughts than the Pressure or Eastside Subareas.

The average changes in groundwater levels and seawater intrusion observed from 2010 to 2021 are projected to roughly continue through 2030. Groundwater levels declined in all Zone 2C Subareas since 2010 by 3 to 8 feet on average. The projected average groundwater level changes from 2021 to 2030 are anticipated to decline up to 4.5 feet. The highest projected groundwater level variability between the 3 scenarios is in the Pressure Subarea near the City of Salinas, where there is a difference of about 0.5-foot in the 3 scenarios' groundwater levels.

Seawater intrusion mainly impacts the Pressure Subarea and is projected to occur at average rates of about 210 to 240 acres/year from 2020 to 2030, which is similar to the average rate of 283 acres/year from 2011 to 2020.

Increasing projected water demands are not anticipated to have uniform impacts on groundwater conditions throughout Zone 2C. Some areas may see improved conditions even as conditions on average degrade. For example, seawater intrusion has slowed and groundwater levels have increased near Castroville since CSIP implementation began. However, greater rates of seawater intrusion have occurred in the 400-Foot Aquifer closer to Salinas. In general, greater groundwater elevation declines are projected to continue in the Pressure and Eastside Subareas, while the Forebay and Upper Valley Subareas are projected to remain relatively similar to current conditions.

Projected water demand, groundwater elevation, and seawater intrusion in this study are based on a near-term extension of current trends. Variable climate through 2030 could result in higher or lower groundwater levels and rates of seawater intrusion than average. Recent climate has been more extreme than past weather records, with a drought from 2012 to 2016 followed by wet years in 2017 and 2019 and another drought from 2020 to 2021. Drier than average conditions will result in greater groundwater level declines, and wetter than average conditions will result in groundwater level increases relative to average conditions. Increasing or decreasing groundwater levels within and near the seawater intrusion edge have a direct relationship to the amount of further seawater intrusion.

The interplay between urban and agricultural land use, changes between crop types, and efficiency gains all affect future conditions. This study incorporates current conditions and recent trends to project urban growth, crop conversion, and climate change to develop a range of water demand, groundwater level, and seawater intrusion projections for 2030. However, groundwater use will also be affected by commodity markets, water projects and management actions, and other factors. Given uncertainty regarding future projects and management actions currently under development, this study shows anticipated 2030 water demand and groundwater conditions with existing infrastructure and reservoir operations. The following section describes additional projects and management actions that may be implemented to address impacts caused by lowering groundwater levels and seawater intrusion.

6 MEASURES TO ADDRESS GROUNDWATER LEVELS AND SEAWATER INTRUSION

There are measures the County and/or other agencies could take to address groundwater level declines and seawater intrusion. Measures are broken down into 3 groups: general measures that prevent further degradation of groundwater conditions, measures to address groundwater level declines, and measures to address seawater intrusion. The groups are not mutually exclusive; because seawater is drawn inland by low groundwater levels, some groundwater level recommendations will also help slow seawater intrusion, or some projects could use water either for direct use or groundwater recharge. Furthermore, some measures may only assist part of the Valley depending on where and how they are implemented. In some cases, measures may improve groundwater conditions in 1 area while contributing directly or indirectly to declining conditions elsewhere, so evaluation of project benefits and trade-offs is needed prior to implementation. Finally, lack of water access is more acute in drought periods, so consideration of temporal variation in groundwater needs throughout the year and across water years should be taken into consideration. This study does not recommend that all measures be implemented. Rather, it recommends that these measures be considered and some combination of them be implemented.

6.1 General Measures

Maintain Current Infrastructure

The Nacimiento and San Antonio Reservoirs are critical to providing water to most of the Salinas Valley by promoting groundwater recharge and delivering surface water to be used in lieu of groundwater in the seawater intruded coastal area. The DWR Division of Safety of Dams requires replacement of the San Antonio spillway to continue to operate at planned levels. Without improvements, less water will be able to be stored in the San Antonio reservoir, which may reduce groundwater recharge along the Salinas River or reduce surface water deliveries. Reducing surface water deliveries could increase CSIP groundwater extractions, negatively affecting groundwater levels throughout the Valley and seawater intrusion in the coastal area.

CSIP provides a combination of recycled water, Salinas River water, and groundwater to the Zone 2B coastal area, most of which has seawater intrusion in either or both of the 180-Foot and 400-Foot Aquifers. Since CSIP began operation in 1998, groundwater extraction in this area declined, which helped slow seawater intrusion. CSIP remains critical for addressing seawater intrusion while enabling continued agricultural production in this area. The system is now over 20 years old and should continue to receive maintenance and improvements to continue to function. When there is inadequate pressure or no water deliveries, growers rely on their private wells. Further, to help address groundwater level declines and seawater intrusion, the system should be operated to maximize reliance on recycled and surface water and minimize groundwater extraction from its supplemental wells.

Consider Groundwater Conditions in Land Use Planning

Groundwater conditions vary across the Valley. While urban growth and agricultural land use changes are driven by many factors, land use planning should take into account water availability and the impact extraction has on groundwater conditions, and work collaboratively with the GSAs. This will help ensure adequate water supply for new communities and farms, and it will not increase the effort needed for Salinas Valley subbasins to be sustainable under SGMA.

Well permits are approved by the Monterey County Health Department, and groundwater conditions are monitored and managed by MCWRA, SVBGSA, ASGSA, MCWD GSA, Monterey Peninsula Water Management District, and the Seaside Watermaster. Local land use agencies should consider GSPs and consult these agencies relevant to the specific area when revising or adopting policies, such as amending general plans and approving regulations or criteria. Consideration of water availability and groundwater conditions is important, albeit not the only factor given other pressures on land use planning, such as the need for more housing that is affordable and the state's Regional Housing Needs Assessment goals. Agencies should work collaboratively to proactively identify how to manage future growth without compromising long-term water supplies or groundwater sustainability, such as through zoning changes that accommodate development of new water supplies, enhance groundwater recharge, encourage water conservation efforts, and promote water recycling projects.

Prevent Declines in Groundwater Recharge

Groundwater recharge is important for replenishing water within the aquifers. Land use affects soil health and recharge capabilities. Areas of high recharge exist, such as in the Arroyo Seco Cone and along the Salinas River south of Chualar. Areas of high recharge potential should be protected from land use activities that would reduce recharge. If development is necessary, it should be done in a manner that continues to support recharge, such as through including Low Impact Development (LID) or green infrastructure that assists with recharge. This could include LID standards for new or retrofitted construction, or stormwater and dry weather runoff capture projects.

Support Conservation to Reduce Groundwater Demand

Reducing demand from existing and new sources can help reduce groundwater extraction. Urban and agricultural conservation, including adopting more efficient technologies, should continually be supported. California state policies for urban conservation have driven water purveyors to offer conservation programs, such as incentivizing the use of low flow toilet fixtures, laundry-to-landscape greywater reuse systems, and lawn replacement with drought tolerant landscaping. Technology advancements continue to develop more efficient devices, and continued outreach, support, and incentives is critical for installation of these devices and water-efficient behavioral changes. Existing water conservation measures should be continued, and new water conservation measures promoted for residential users.

Agricultural water conservation measures in the Salinas Valley have increased substantially over the past few decades. Additional conservation will further reduce agricultural groundwater demand. Agricultural extension work, such as offered through University of California Cooperative Extension and Resource Conservation District of Monterey County, could help growers identify and tailor conservation practices and reach small growers. Installation of more CIMIS stations to develop more accurate Evapotranspiration (ET) data could provide a useful tool to help growers determine the exact amount of irrigation needed. The use of ET data with soil moisture sensors, soil nutrient data, and flow meter data can help inform more efficient irrigation practices. The development and use of these tools could be supported through securing funding or coordinating with existing local agricultural extension specialists who conduct research and provide technical assistance to growers.

Prevent Seawater Intrusion Leakage Between Aquifers

A portion of the existing seawater intrusion in the 400-Foot Aquifer results from vertical flow from the overlying 180-Foot Aquifer. The Deep Aquifers are additionally at risk of intrusion from overlying aquifers. Historically, groundwater elevations were lower in the 400-Foot Aquifer than the Deep Aquifers, which resulted in an upward hydraulic pressure gradient that prevented downward flow from overlying aquifers. Groundwater elevations have lowered in the Deep Aquifers, resulting in a downward gradient in the coastal area, increasing the risk of seawater intrusion from the overlying 400-Foot Aquifer.

Downward flow of seawater intrusion should be reduced through well destruction, well design restrictions, and pumping management in the coastal area. Older wells in the seawater intruded area should be properly destroyed to remove potential conduits for vertical flow. Under the Protection of Domestic Drinking Water Supplies for the Lower Salinas River Valley project, MCWRA has already destroyed 19 wells. Wells within Zone 2B, or in or near the defined area around seawater intrusion, should be evaluated and considered for destruction to prevent leakage of seawater intrusion between aquifers. Monterey County Code 15.08 should continue to be implemented, as it requires new wells in or near the seawater intruded area to be screened in 1 aquifer to prevent seawater intrusion leakage between aquifers. Any pumping controls should address vertical gradients between aquifers.

Continually Optimize Reservoir Operations and Undertake Reservoir-related Projects to Balance Multiple Needs

Reservoir operations must balance multiple needs, including groundwater recharge in the Salinas Valley, providing surface water to the SRDF, protecting endangered species, flood control, and recreation. MCWRA is working with the National Marine Fisheries Service to develop a Habitat Conservation Plan to meet Endangered Species Act requirements for activities associated with water operations and management activities. Reservoir operations must comply with laws, regulations, and water rights and diversion permits.

Under certain drought conditions MCWRA convenes the Drought Technical Advisory Committee to help develop a release schedule aimed at mitigating negative effects from droughts, including from surface water flows and groundwater recharge. Release schedules depend on the specific conditions encountered, but aim to operationalize key guiding principles, such as maintaining geographic equity, avoiding adverse impacts to Valley-wide agricultural operations, and avoiding, to the extent possible, consecutive years where only minimum releases are made from the reservoirs. Annual reservoir releases could help recharge the aquifers in the Basin, which prevents declines in groundwater elevations and aquifer storage during drought periods. However, there may be trade-offs in the ability to continue to deliver water throughout multi-year droughts since releases reduce water in storage. Projects such as MCWRA's proposed Interlake Tunnel that increase storage may help prevent groundwater level declines in the Salinas Valley during droughts.

Any reservoir related projects or optimization actions should be designed to maximize the benefits for multiple water users including ecological water users, current and future surface water diverters, and groundwater users that rely on Salinas River recharge. Reservoir operations should be regularly reviewed and adjusted to ensure address changes in water needs as they evolve.

6.2 Measures to Address Groundwater Level Decline

Declining groundwater levels can either be addressed by reducing extraction or recharging more water into the aquifer system. Along with direct measures, reducing extraction can be supported through providing alternative supplies that are used in lieu of groundwater.

Reduce Groundwater Extraction

Along with conservation and efficiency gains, as noted above, demand management could require regulatory action, such as extraction controls or reductions. Demand management can be structured in different ways, such as through pumping allocations. Determination of allocation distribution and pumping reductions typically involves careful planning, sound data, extensive engagement of interested parties, consideration of fairness, and foresight regarding future changes. To increase flexibility, extraction limits or controls may be paired with a market-based system where extraction can go above limits in 1 place if it is reduced in another place; however, the heterogeneity of the groundwater basin and groundwater conditions requires careful attention to where such exchanges occur. Extraction limits could also be implemented in conjunction with providing alternative water supplies to meet demand.

Provide Alternative Supplies

There are several types of alternative supply projects that could provide water supplies to be used in lieu of groundwater in the Salinas Valley. Monterey One Water already produces recycled water that is distributed to CSIP growers. There are opportunities to optimize CSIP that are being pursued, such as reducing shut-down time needed for maintenance. Additional storage near the CSIP system through tanks or ponds could add flexibility that would enable reduction of groundwater extraction. Additionally, expanding CSIP to provide irrigation water to additional farmland would reduce current dependence on extraction if the additional source water for expansion did not come from groundwater. There may also be opportunities to develop smaller recycled water plants, such as a local wastewater scalping plant, to recycle water from future Salinas expansion or King City's efforts to recycle its wastewater. The potential impact of these projects depends on where they occur, how much water is recycled, and the recycled water end use.

Surface water may also be diverted for use instead of groundwater. Several such projects have been identified in the Salinas Valley. For example, MCWRA's 11043 surface water diversion permit would enable Salinas River water to be diverted and delivered to the Eastside Subarea or other areas when flows are over the historical 90th percentile for that day of the year. For this conceptual project, surface water could be delivered directly or recharged; however, direct delivery would likely require additional storage, as the water would likely be diverted over a small period of time. Other options for surface water diversions include Gabilan Creek or Watson Creek. Stormwater may also be diverted for direct irrigation use, depending on the quality of the water.

A third type of alternative supply is desalinated ocean water or desalted brackish groundwater. Desalinated water could be used for either drinking water, irrigation, or groundwater recharge.

Increase Groundwater Recharge

Approaches to increasing groundwater recharge vary within the Salinas Valley. The Salinas River generally recharges the primary groundwater aquifers south of Chualar. The Salinas Valley Aquitard inhibits direct recharge along most of the Salinas River north of Chualar; however, gaps in the aquitard may exist, such as nearby Somavia Road. There may be ways to operate the reservoirs to increase recharge; however, as noted above, reservoir operations must comply with regulations and meet multiple goals.

Additional recharge along the Salinas River where there is no aquitard present could be enhanced by removing dense native and non-native vegetation, providing vegetation free channel bottom areas for infiltration, and managing sediment. This would increase groundwater recharge and reduce evapotranspiration, with additional flood mitigation and ecosystem co-benefits. The Salinas River's natural river geomorphology has been impacted by the construction of the San Antonio and Nacimiento Dams and flood control levees, resulting in sediment build up and vegetation encroachment that has increased flood risk, decreased direct groundwater recharge, and contributed to increased ET through vegetation build-up. Targeted, geomorphically-informed stream maintenance and floodplain enhancement could improve stream function both morphologically and biologically. The existing Salinas River Stream Maintenance Program and removal of the invasive species *Arundo donax* (arundo) and *Tamarix sp.* (tamarisk) could be furthered to take a 3-pronged approach to stream channel improvements: removing perennial native and non-native vegetation in designated maintenance channels and removing arundo and tamarisk throughout the river corridor; reducing the height of sediment bars that have been identified to meet criteria for impeding flow; and adding floodplain enhancement to increase groundwater recharge.

Recharge could also be enhanced along the tributaries and streams that drain into the Salinas River through floodplain enhancement and recharge. For example, enhancing areas along Gabilan Creek and other streams that run into the Valley could help slow stormwater runoff and recharge the aquifers. Floodplain restoration efforts could be focused on lands directly adjacent to streams, so as not to interfere with active farming, or incorporate features such as check dams to encourage greater recharge.

Even with floodplain enhancement efforts, significant amounts of stormwater will continue to flow to the ocean during storm events. Some stormwater could be captured and infiltrated before it reaches a stream through managed aquifer recharge of overland flow and stormwater runoff. This could be done through agricultural landowners dedicating a portion of their land to recharge ponds, and directing overland flood flows into the ponds. Collecting runoff before it enters a local stream and allowing it to infiltrate could help recharge the aquifers and raise groundwater levels.

Finally, smaller scale efforts to increase rain and stormwater infiltration could yield local groundwater level benefits, particularly in areas such as Prunedale where the subsurface consists of fractured granite. Anticipated climate change may bring more frequent and extreme precipitation events. When rainfall is concentrated in a short time period rather than spread out, more stormwater runs off rather than infiltrates, which reduces groundwater recharge. Recharge features can capture and recharge a portion of the stormwater by infiltration management techniques like LIDs, dry wells, or rain gardens. Larger scale projects in areas where the groundwater table is high will likely have the greatest impact. Small scale or disperse efforts are unlikely to have substantial impacts on groundwater levels in areas where groundwater table is lower or where extraction far exceeds the amount recharged.

6.3 Measures to Address Seawater Intrusion

Seawater intrusion currently occurs in the 180-Foot and 400-Foot Aquifers. It has not yet been detected in the underlying Deep Aquifers. Three main approaches for addressing seawater intrusion: reducing extraction near seawater intrusion, increasing groundwater recharge near seawater intrusion, or developing a seawater extraction barrier. In addition, as noted in Section 6.1 General Measures, it is also important to prevent seawater intrusion leakage between aquifers.

Reduce Groundwater Extraction Near Seawater Intrusion

Reducing extraction near seawater intruded areas would help raise groundwater levels by increasing hydraulic pressure against seawater intrusion. However, reducing extraction in some areas will have a greater effect than in other areas. Reduced extraction would need to be significant and continued over time to not only slow but stop seawater intrusion.

CSIP has already slowed the rate of seawater intrusion by providing irrigation water to be used in lieu of individual growers extracting groundwater in and near the seawater intruded area. Further reduction in extraction in this area could help address seawater intrusion.

Increase Groundwater Recharge Near Seawater Intrusion

Recharging groundwater inland increases hydraulic pressure against intruding seawater. Recharge is generally most beneficial closer to the seawater intrusion front. Confined aquifers, like those in the Pressure Subarea, can be recharged by direct injection through the aquitard into the relevant aquifer. Given that most of the seawater intrusion occurs in an area confined by the Salinas Valley Aquitard, injection with no recovery, indirect potable reuse, or aquifer storage and recovery (ASR) are 3 options that would inject water into the underlying aquifers. Injection with no recovery provides a permanent hydraulic barrier, but it requires a source of water that can be injected and never used. Both indirect potable reuse and ASR effectively use aquifers as a reservoir for storage of water that will be extracted in the future. More water would need to be injected than recovered to effectively address seawater intrusion. All recharge requires a source of water, and injected water would need to be treated to meet regulatory requirements.

Install Seawater Extraction Barrier

One approach to addressing seawater intrusion is to install a hydraulic extraction barrier to seawater intrusion. Extracting groundwater from a line of wells creates a hydraulic barrier of low pressure that captures seawater intrusion and prevents seawater from moving inland of the wells. Brackish groundwater extracted from the barrier wells could be desalted and then used for municipal or agricultural use instead of groundwater.

6.4 Examples of Measures

Table 6-1 includes specific examples of the measures that can be taken to address groundwater level declines and seawater intrusion in the Salinas Valley. These are examples and are not exhaustive, nor do they constitute a recommendation of which projects or management actions are most appropriate. All examples have been or are being considered by a local agency or group within the Salinas Valley.

Table 6-1. Example Management Actions and Projects to Address Groundwater Level Decline and Seawater Intrusion in Zone 2C

Subcategory	Management Action or Project (associated agency)	Description
GENERAL MEASURES		
Maintain Current Infrastructure	MCWRA Capital Asset Management Program (MCWRA)	Complete required San Antonio Dam spillway replacement and other high priority projects to comply with federal and state regulatory requirements, restore full operational functionality, and ensure public and/or employee safety.
Consider Groundwater Conditions in Land Use Planning	Land Use Jurisdiction Coordination Program (SVBGSA)	Increase coordination between agencies that manage groundwater and land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity
Prevent Declines in Groundwater Recharge	Low Impact Development Projects (County of Monterey, Housing and Community Development)	Construct or require construction of systems and practices that manage stormwater and encourage infiltration in urban areas
Support Conservation to Reduce Groundwater Demand	Conservation and Agricultural Best Management Practices (SVBGSA)	Promote agricultural best management practices and support use of ET data as an irrigation management tool for growers
Prevent Seawater Intrusion Leakage Between Aquifers	Protection of Domestic Drinking Water Supplies for the Lower Salinas River Valley (MCWRA)	Destroy wells that could facilitate seawater intrusion leakage between aquifers. Grant-funded, concludes in 2023.
Continually Optimize Reservoir Operations and Undertake Reservoir-related Projects to Balance Multiple Needs	Drought Technical Advisory Committee (MCWRA)	When triggered by drought conditions, convene this committee of experts that develops and recommends plans for how to manage reservoir releases during drought to meet all needs
MEASURES TO ADDRESS GROUNDWATER LEVEL DECLINE		
Reduce Extraction	Fallowing, Fallow Bank, and Agricultural Land Retirement (SVBGSA)	Fallow agricultural land that currently relies on groundwater, such as through voluntary fallowing, a fallow bank whereby anybody fallowing land can draw against the bank to offset lost profit from fallowing, or retirement of agricultural land
Provide Alternative Supplies	CSIP Expansion (SVBGSA)	Expand service area of CSIP to provide a combination of Salinas River water, recycled water, and, when needed, groundwater in lieu of groundwater extraction
Increase Recharge	Multi-benefit Stream Channel improvements (SVBGSA)	Prune native vegetation and remove non-native vegetation, manage sediment, and enhance floodplains for recharge. Includes 3 components: Stream Maintenance Program, Invasive Species Eradication, and Floodplain Enhancement and Recharge
MEASURES TO ADDRESS SEAWATER INTRUSION		
Reduce Groundwater Extraction Near Seawater Intrusion	Demand Planning (SVBGSA)	Proactively determines how extraction should be controlled and planned for
Increase Groundwater Recharge Near Seawater Intrusion	Seasonal Release with ASR (SVBGSA)	Release flows from reservoirs during the winter/spring, for groundwater recharge and then diversion at the SRDF. Treat diverted water and then inject into the 180-Foot and 400-Foot Aquifers for seasonal storage, extracting a lesser amount for delivery to CSIP during the peak irrigation season
Install Seawater Extraction Barrier	Seawater Intrusion Extraction Barrier (SVBGSA)	Install a series of wells in the 180-Foot and 400-Foot Aquifers to extract groundwater and form a hydraulic barrier that prevents seawater intrusion from advancing inland of the wells

6.5 Conclusion

This study reassesses the anticipated 2030 water demand in the 2010 Monterey County General Plan and the associated EIR and assesses its potential impact on groundwater levels and seawater intrusion in MCWRA Zone 2C. It does so through assessing observed and reported data through 2020, projecting various 2030 water demands, and modeling 2030 groundwater levels and seawater intrusion under low, medium, and high growth scenarios. The study finds that on average groundwater demand will remain higher than anticipated in the EIR at a level that is about the same as current (2021) extraction, with the possibility of being higher or lower depending on changes to population, land use, and urban efficiency. The impact on groundwater conditions varies by MCWRA Subarea, as extraction is not sustainable in several parts of Zone 2C at current rates. In places such as the Eastside and Pressure Subareas, extraction at current rates will continue to cause groundwater level declines and draw seawater further inland, unless additional action is taken. The aquifers within the Valley are hydrologically connected, so extraction farther from locations of decline or seawater intrusion could have an impact; however, groundwater movement is slow, and impact is greater when extraction occurs closer to the seawater intrusion front.

In 2014, California passed SGMA and local agencies created GSAs to help locally manage groundwater through GSPs. GSPs have been developed and approved, and they are now being implemented. Efforts by the GSAs and County to achieve sustainable groundwater levels and minimize seawater intrusion should reinforce one another. The GSPs contain numerous options for addressing groundwater level decline and seawater intrusion that are appropriate for each respective subbasin. The stratigraphy and groundwater system varies throughout the Salinas Valley, and how changes in demand will affect groundwater levels varies. Fewer options exist to address seawater intrusion than groundwater levels.

This study recommends supporting groundwater sustainability efforts underway, supporting further conservation, and taking action to not exacerbate future conditions. This study shows that land use, and therefore land use planning, greatly affects groundwater demand in the Salinas Valley. Land use planning should be better coordinated with groundwater sustainability efforts to prevent future groundwater levels decline and seawater intrusion in the County.

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Appendix A

Groundwater Model Data Processing

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1 GROUNDWATER MODEL DATA PROCESSING

This appendix describes groundwater model data processing steps used in this phase of the Basin Investigation. The purpose of the report is to (1) summarize historical and current water demands and groundwater conditions, and (2) estimate 2030 water demands and groundwater conditions in Zone 2C. Low, medium, and high growth model scenarios were developed to simulate a range of potential 2030 groundwater conditions using the SVOM and SWI Model. The baseline model data used to develop 2030 projections are the most recent complete datasets available at the time of the study. The baseline data for the SVOM is from 2017; the baseline data for the SWI Model is from 2020. This appendix describes data processing to create land use and pumping model inputs, evaluate water demand results, and process groundwater elevation and seawater intrusion data.

1.1 Land Use

Agricultural water demands are estimated in SVOM using land use mapping and the farm process package. This section describes how projected land use changes from LUCAS are incorporated into the SVIHM baseline land use map and incorporated into the model. See Appendix B for details on the land use data comparison and mapping that provided the base for the SVOM modeling.

The 2030 SVOM land use maps are created using 2017 SVIHM baseline land use and land use changes estimated by the LUCAS low and high growth models. The provisional 2017 SVIHM baseline land use was not input into the SVIHM preliminary version used for this study, which is only calibrated and run through 2014. The 2017 SVIHM land use data is similar to 2014 SVIHM land use data. The following steps were taken to incorporate LUCAS land use changes into the SVIHM map:

- GIS was used to select areas in the 2017 SVIHM baseline map that are predicted by LUCAS to change land use by 2030.
- Parcels in the SVIHM baseline map were selected if they were centered in cells projected to change in LUCAS; selected parcels were changed to the future land use predicted by the LUCAS model.
- Additional parcels in the SVIHM baseline map were manually selected and changed as needed to balance the acreage change projections in LUCAS with the actual changes made to the SVIHM map. For example, if a changed area in the LUCAS model showed a different baseline land use than the SVIHM baseline, a nearby area with the correct baseline land use was selected to incorporate the land use change.

- Projected 2030 land use maps were created by defining crops for new agricultural land. There are numerous annual crops grown in Zone 2C. The most common annual crop in the SVIHM map in each Subarea was used to classify new annual agriculture land. The designated crops for new annual agriculture land are lettuce in Pressure and Eastside Subareas and crucifers in Forebay and Upper Valley Subareas. The only significant perennial crop grown in Zone 2C is vineyards, so all land changed to perennial crops was assigned the vineyard classification.
- The 3 GIS maps used for this study were input into the SVOM by calculating and applying an equivalent acreage of each crop type in the GIS map to 6.4-acre model grid cells. For example, if the area in a 6.4-acre model grid cell had dispersed fields totaling 3.2 acres of lettuce, 1.6 acres of broccoli, and 1.6 acres of vineyards dispersed throughout, then blocks covering half the grid cell would be classified as lettuce, a quarter as broccoli, and a quarter as vineyards.

1.2 Water Demands

Projected 2030 water demands were developed for groundwater model simulations to evaluate groundwater elevations and seawater intrusion. The baseline water demand for projections is GEMS reported pumping, SRDF surface water diversion, and CSIP recycled water diversion. The 2030 water demand projections were scaled based on 3 scenarios with a range of population growth, urban water efficiency, land use change, and climate. The historical and 2030 projected water demands required pre- and post-processing for consistent groundwater model simulation and reporting.

Urban pumping is input to both groundwater models. The SVIHM and SVOM have different urban supply well numbers, locations, and pumping volumes than the GEMS reported pumping. The SWI Model uses GEMS locations and pumping for wells that fall within the SWI Model domain, with some wells aggregated in the Model. Projected 2030 urban pumping inputs were developed for the well locations in both models that are consistent with the 2030 projected urban pumping estimates for GEMS, described in the report.

Agricultural pumping is a model output from the SVOM and a model input for the SWI Model. In the SVOM, agricultural pumping is based on crop type, availability of land surface water sources, and climate. Agricultural pumping rates in the SWI Model are from GEMS. The 2030 projected agricultural pumping results in SVOM are scaled based on the ratio between SVIHM and GEMS pumping. Pumping in the 2030 projected SWI Model scenarios are scaled from the historical SWI Model based on the ratio between the SVIHM baseline and 2030 SVOM projected pumping to reflect change from current (2020) GEMS pumping to 2030 based on the assumptions in the low, medium, and high scenarios.

The following sections describe the groundwater pumping pre- and post-processing in more detail.

1.2.1 Urban Pumping in SVOM

Groundwater pumping to meet urban water demands is simulated as specified rates in the SVOM. Pumping for urban use is based on public supply and industrial water use reported to MCWRA in GEMS. The provisional SVIHM 2017 baseline pumping was provided by USGS but is not input into the SVIHM preliminary version used for this study, which is only calibrated and run through 2014. The 2017 data is similar to 2014 because it is a continuation of a subset of GEMS time series data using the same wells. The projected 2030 urban pumping is repeated each year in the SVOM.

The SVIHM and SVOM have fewer numbers of supply wells and pumping volumes than the GEMS database. Urban pumping in the SVIHM is 76% of the urban pumping in GEMS. The 2017 GEMS baseline includes 179 wells used to pump 38,785 AF of groundwater for urban use including the following:

- 87 wells used to pump 30,225 AF of groundwater for public supply
- 58 wells used to pump 6,916 AF for industrial use
- 17 wells used to pump 1,644 AF for small water systems

The 2017 SVIHM baseline includes 115 wells used to pump about 29,735 AF of groundwater for urban use including the following:

- 53 wells used to pump 22,798 AF for public supply
- 36 wells used to pump 5,389 AF for industrial use
- 15 wells used to pump 1,548 AF for small water systems

The scaling factors applied to 2017 GEMS baseline to project 2030 low, medium, and high growth urban water demands are discussed in Section 3.2.2 of the report. The same scaling factors were applied to 2017 SVIHM baseline data to create 2030 SVOM low, medium, and high growth pumping inputs for the model. Pumping is scaled based on city, community, and industrial use. The 2017 baseline SVIHM and 2030 GEMS and SVOM urban pumping is summarized in Table A-1. SVOM pumping inputs that are scaled to be lower than GEMS pumping were intended to produce a more accurate groundwater level response given the construction and calibration of the model. The 2030 GEMS pumping volumes are used to describe the projected urban water demands in the report.

Table A-1. GEMS and SVIHM/SVOM Urban Water Demand

	GEMS Pumping (AF)				SVIHM Baseline and SVOM Input Pumping (AF)			
Urban Water Demand Component	2017 GEMS Baseline	2030 GEMS Low Growth	2030 GEMS Med Growth	2030 GEMS High Growth	2017 SVIHM Baseline	2030 SVOM Low Growth	2030 SVOM Med Growth	2030 SVOM High Growth
Gonzales	1,575	1,868	2,156	2,457	909	1,444	1,660	1,884
Greenfield	1,795	1,572	1,832	2,105	1,007	875	1,012	1,155
King City	1,632	1,401	1,633	1,878	1,632	1,355	1,568	1,792
Marina	3,176	3,186	3,696	4,231	2,425	2,419	2,787	3,170
Salinas	18,809	15,798	18,432	21,214	15,855	13,331	15,425	17,615
Soledad	3,238	2,747	3,204	3,686	971	845	977	1,115
Cities Total Water Demand	**30,225**	**26,316**	**30,666**	**35,253**	**22,798**	**20,269**	**23,430**	**26,729**
Communities Total Water Demand	**1,644**	**1,314**	**1,536**	**1,771**	**5,389**	**3,998**	**4,567**	**5,315**
Industrial Total Water Demand	**6,916**	**7,424**	**7,694**	**7,964**	**1,548**	**1,657**	**1,703**	**1,823**
Total Urban Water Demand	**38,785**	**35,054**	**39,896**	**44,987**	**29,735**	**25,926**	**29,701**	**33,643**

1.2.2 Agricultural Pumping in SVOM

Agricultural pumping is a model output from the SVIHM and SVOM. Similar to urban pumping, the preliminary versions of SVIHM and SVOM used in this study underestimate agricultural groundwater pumping compared to GEMS. SVIHM is only run through 2014 by USGS in the preliminary model, so a direct comparison with baseline 2017 MCWRA GEMS data used elsewhere in this study is not possible. Agricultural pumping in 2014 SVIHM is 345,611 AF and agricultural pumping in 2014 GEMS is 523,563 AF. In 2014, SVIHM includes 66% of reported agricultural pumping in GEMS.

Projected 2030 SVOM low, medium, and high growth scenarios result in average pumping between 307,336 and 308,769 AF for the 3 scenarios over the 14-year representative hydrologic period. Dividing the SVOM scenario pumping by 66% results in an average adjusted 2030 pumping between 465,992 and 467,751 AF. The adjusted 2030 SVOM pumping is presented as the projected agricultural water demands in the report. GEMS reported, modeled, and adjusted projected pumping is summarized in Table A-2.

Table A-2. GEMS, SVIHM, and SVOM Pumping

Agricultural Water Demand	2014 GEMS (AF)	2014 SVIHM (AF)*	2030 SVOM Low Growth (AF)	2030 SVOM Med Growth (AF)	2030 SVOM High Growth (AF)
Actual Pumping	523,563	--	--	--	--
Simulated Pumping	--	345,611	307,608	308,769	307,336
Adjusted Pumping	--	523,563	465,992	467,751	465,580

* provisional data subject to change.

1.2.3 SVOM to SWI Model Pumping Adjustment

Urban and agricultural pumping are both inputs to the SWI Model. Pumping inputs for 2030 projections were prepared to be consistent with the 2030 SVOM scenarios described above. For both urban and agricultural areas, the combined scaling factor was applied to a year of monthly average SWI Model pumping rates from 2016 to 2020. This recent period was identified as representative of recent basin conditions and includes both wet and dry years. The resulting average year of monthly rates was multiplied by the scaling factor and repeated for 10 years from 2020 through 2030.

A direct comparison with baseline SVOM conditions was necessary to adjust SWI Model agricultural pumping inputs. New SVOM model runs were compiled using 2017 land use and urban pumping and run both with and without climate change. Since agricultural land use is not changing rapidly, 2017 SVOM land use was comparable to 2020 SWI Model land use.

1.2.4 Urban Pumping in SWI Model

Urban pumping in the projected 2030 SWI Model was scaled based on reported data for various water system types. To scale projected urban pumping in the SWI Model, urban wells were categorized as part of either City of Marina, City of Salinas, Small Community, or Industrial water systems. This approach is similar to the SVOM projections, just for a smaller area and different set of wells. Other cities in Zone 2C are outside the model domain for the SWI Model. Scaling factors for urban pumping are developed by comparing the pumping totals listed in Table A-1 for the baseline SVIHM and 2030 SVOM low, medium, and high growth scenarios. Table A-3 lists the scaling factors used to project 2030 SWI Model urban pumping.

Table A-3 Urban Pumping Scaling Factor by Water System

Water System	2030 Low Growth Scaling Factor	2030 Med Growth Scaling Factor	2030 High Growth Scaling Factor
Marina	100%	115%	131%
Salinas	84%	97%	111%
Communities Total Water Demand	71%	82%	97%
Industrial Total Water Demand	107%	110%	113%

1.2.5 Agricultural Pumping in the SWI Model

The 2030 SWI Model agricultural pumping was scaled from the historical baseline SWI Model pumping to account for changes in agricultural land use and climate change. Agricultural pumping is adjusted to account for changes in land use applied to the SVOM. For each water balance subregion, sometimes referred to as "Farms," a land use scaling factor is calculated by comparing pumping rates modeled in the 2030 low, medium, or high growth SVOM scenarios to a baseline SVOM model run with 2017 land use and pumping and 2030 climate change. To incorporate the effects of climate change, the land use scaling factors were also scaled by comparing pumping and recharge from the baseline SVOM no climate change scenario to the baseline SVOM with 2030 climate change. These scaling factors were applied to the SWI Model agricultural pumping.

1.3 Groundwater Elevation

Modeled groundwater elevation trends are combined with recent observations to estimate future changes in groundwater elevation expected by 2030. MCWRA reports observed annual change in groundwater elevation by subarea.[1] This hydrograph figure is used to summarize recent groundwater elevation results in Section 4.4.1 of the report and updated to show projected groundwater elevation results in Section 4.4.2.

Assuming average climate, recent groundwater elevation trends are likely to continue for the next few years while GSPs establish funding and implementation plans. Groundwater elevation change trends over the past decade are estimated from the MCWRA hydrograph data by calculating an annual average groundwater elevation change from 2011 and 2019 data. Groundwater level data between 2012 and 2018 is not included in this calculation because water levels during those years are strongly impacted by a drought that occurred between 2012 and 2016. The recent annual average groundwater level decline is approximately 0.5 foot per year in the Pressure, Eastside, and Forebay Subareas and 0.1 foot per year in Upper Valley Subarea. The 2011 to 2019 annual average groundwater level change trends in Table A-4 are used to project near-future groundwater level changes from 2021 through 2024. The trend lines are shown on the historical groundwater elevation hydrograph in Section 4.4.1 of the report.

Table A-4. Recent Observed Trends in Annual Average Groundwater Level Change

Subarea	2011-2019 trend (feet per year)
Pressure	-0.6
Eastside	-0.5
Forebay	-0.4
Upper Valley	-0.1

The projected groundwater elevation change from SVOM low, medium, and high growth scenarios is calculated and shown on the hydrograph in Section 4.4.2. The groundwater elevation results are extrapolated from a representative timeframe in the model, using hydrology and weather from 1996 to 2014. Model years 1996 to 2014 are selected as a representative timeframe because groundwater elevations in the SVIHM on which the SVOM is based are better calibrated to these years than earlier timeframes, and there is greater certainty in the data inputs. The result is a timeseries of average groundwater level change by subarea for a sequence of 19 years with climate and hydrology similar to 1996-2014.

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[1] available at https://www.co.monterey.ca.us/government/government-links/water-resources-agency/programs/groundwater-level-monitoring/annual-groundwater-level-monitoring

Groundwater head simulated in SVOM model cells each fall is subtracted from the head simulated in the same model cell in the subsequent year to approximate the annual groundwater elevation change. Groundwater level changes are averaged across model cells within each Subarea. Only annual groundwater level change simulated in model layers 3 and 5 are used in calculations. This is because layers 3 and 5 are equivalent to the 180- and 400-foot aquifers in the Pressure Subarea, Shallow Zone and Deep Zone in the Eastside Subarea, and basin fill aquifers in the Forebay and Upper Valley Subareas.

Groundwater level changes in the Monterey Subbasin area (39,451 acres) and parts of the basin margins (17,761 acres) were excluded from the total MCWRA Zone 2C area in the model (432,406 acres). The preliminary version of the SVOM used for this study appears to not be as well calibrated in the Monterey Subbasin. Also, the SVOM simulated more extreme groundwater level changes within small areas along the sloped basin margins, which would skew subarea average water level changes.

Groundwater elevation statistics are used to project groundwater level change under average conditions as well as wetter and dryer than average conditions. Groundwater level change tends to be more positive following wet years, and more negative after dry years. Thus, the mean groundwater level change across the timeseries represents groundwater level changes expected across a range of wet and dry climate conditions. The 20th percentile groundwater level change is selected to represent groundwater level changes under drier than average climate, while the 80th percentile groundwater level change is selected to represent wetter than average conditions.

The MCWRA hydrograph is updated to project 2030 groundwater levels. The current groundwater level for each Subarea is extended from 2021 through 2024 with the recent trendline. The 2030 SVOM average, 20th, and 80th percentile annual groundwater level change for each subarea is extended from 2024 to 2030 to project how groundwater elevations may change in Zone 2C under average, drier than average (20th percentile), and wetter than average (80th percentile) conditions.

1.4 Seawater Intrusion

Projected 2030 seawater intrusion is simulated using the SWI Model. The predictive SWI Model simulates seawater intrusion from the end of the historical SWI Model in 2020 through 2030. The groundwater elevations and chloride concentrations at the end of the historical SWI Model are the initial conditions of the predictive SWI Models. Boundary conditions of the historical SWI Model are modified to extend the simulation period to 2030. The modifications are made to be consistent with the 3 SVOM scenarios in this study, including pumping, land use, climate, and sea level rise. Water demand and climate adjustments in the predictive SWI Model are described in Section 1.2

Sea level rise is particularly important for modeling seawater intrusion because it increases the hydraulic pressure of seawater flowing into the basin. Per DWR guidance, 5.9 inches of sea level rise was added to the 2014 sea level surface used as specified heads in the SWI model to simulate 2030 projected sea level rise (DWR, 2018).

Specified heads along the inland far-field model boundary at Chualar Creek are extracted from the equivalent model cells in the respective SVOM models from 1996 to 2006. This set of years was selected because it represents climate diversity and comes before the 2012 to 2016 drought. Likewise, stream inflows for the Salinas River, mountain streams, and diversions at the SRDF are extracted from the respective SVOM models for the same set of years. Surface water deliveries used for irrigation in the CSIP area are modeled as extracted water from the Salinas River at the SRDF. Groundwater recharge return flows from irrigation and urban pumping were adjusted similarly to pumping inputs described above.

The 500 mg/L groundwater chloride concentration contour at the end of the simulation is extracted from the SWI Model results to represent seawater intrusion in 2030. The 500 mg/L chloride contour in layer 5 of the SWI Model is extracted to represent seawater intrusion in the 180-Foot Aquifer. The 500 mg/L chloride contour in layer 7 of the SWI Model is extracted to represent the 400-Foot Aquifer. In the SWI Model, layers 3 and 5 represent the upper and lower portions of the 180-Foot Aquifer. Layer 5 was selected to represent seawater intrusion in the 180-Foot Aquifer conservatively, because the 500 mg/L contour has advanced inland more in the lower portion of the aquifer.

Appendix B

Land Use Data Comparison

1 LAND USE DATA COMPARISON

Various land use data sources are used for the Basin Investigation to establish historical, current, and projected conditions. The 3 primary land use sources, FMMP, SVIHM, and LUCAS, are used for the following purposes:

- FMMP data is used in the EIR to establish baseline land use conditions for assumptions in the General Plan. The FMMP 2006 and 2016 data for Zone 2C is reviewed for this study to establish how the EIR land use compares and contrasts with the Basin Investigation land use.
- The 2006 and 2017 SVIHM land use maps are used as a model input for SVIHM. The SVIHM land use is used for this study to compare to the EIR and establish a baseline for projecting 2030 land use and agricultural water demands.
- LUCAS is used to project a range of land use changes between 2017 and 2030 for estimating 2030 agricultural water demands.

1.1 FMMP Land Use Mapping

FMMP mapping was used to develop assumptions in the EIR. The historical FMMP maps are publicly available so are clipped to Zone 2C for comparison to this study. More recent FMMP land use from 2016 is compared to the 2006 EIR baseline data to assess how land use has changed in Zone 2C since the EIR. Historical and more recent data are compared with SVIHM and LUCAS land use maps used in this study. The 2016 FMMP land use map is shown for example on Figure B-1. The change in FMMP farmland acreage between 2006 and 2016 is portrayed on a land use comparison map on Figure B-2.

The EIR assumed that about 284 acres/year farmland expansion could occur in Zone 2C by 2030. FMMP mapping in 2006 and 2016 showed that the farmland expansion rate was much slower averaging 86 acres/year (Figure B-3).

Despite very little net change in farmland acreage in the County and Zone 2C, FMMP data shows that farmland is still going into and out of production in different areas. In general, there is some farmland being converted to urban land around existing cities and communities, and some areas where farmland is expanding into previously undeveloped land at the margins of the Salinas Valley floor. The 2016 FMMP Conversion cites a minimal net farmland acreage increase of about 100 acres in the County between 2014 and 2016 despite about 3,000 acres of farmland going into and out of production in different areas (Department of Conservation, 2016).

Urban land expansion in Zone 2C leading up to the EIR was about 350 acres/year. The EIR assumes that urban land would continue to expand at similar rates through 2030 to accommodate population growth. The more recent FMMP data between 2006 and 2016 corresponds to an annual urban land use conversion rate of 130 acres/year in Zone 2C (Figure B-4). Urban land expansion has slowed since 2006 because population growth has been slower than assumed in the EIR. Recent urban land development in Zone 2C has occurred near existing cities and communities (Figure B-4).

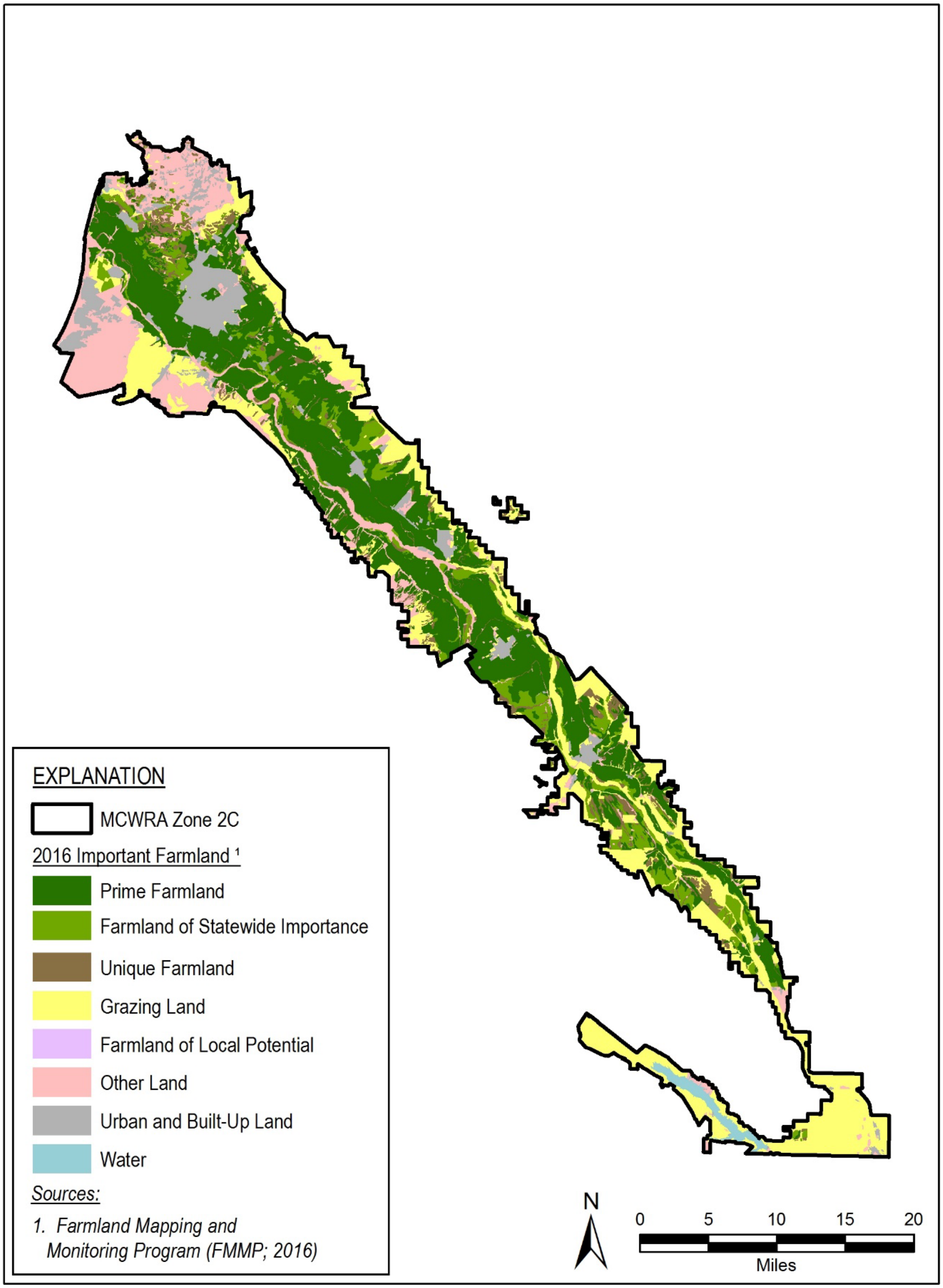


Figure B-1. FMMP 2016 Land Use

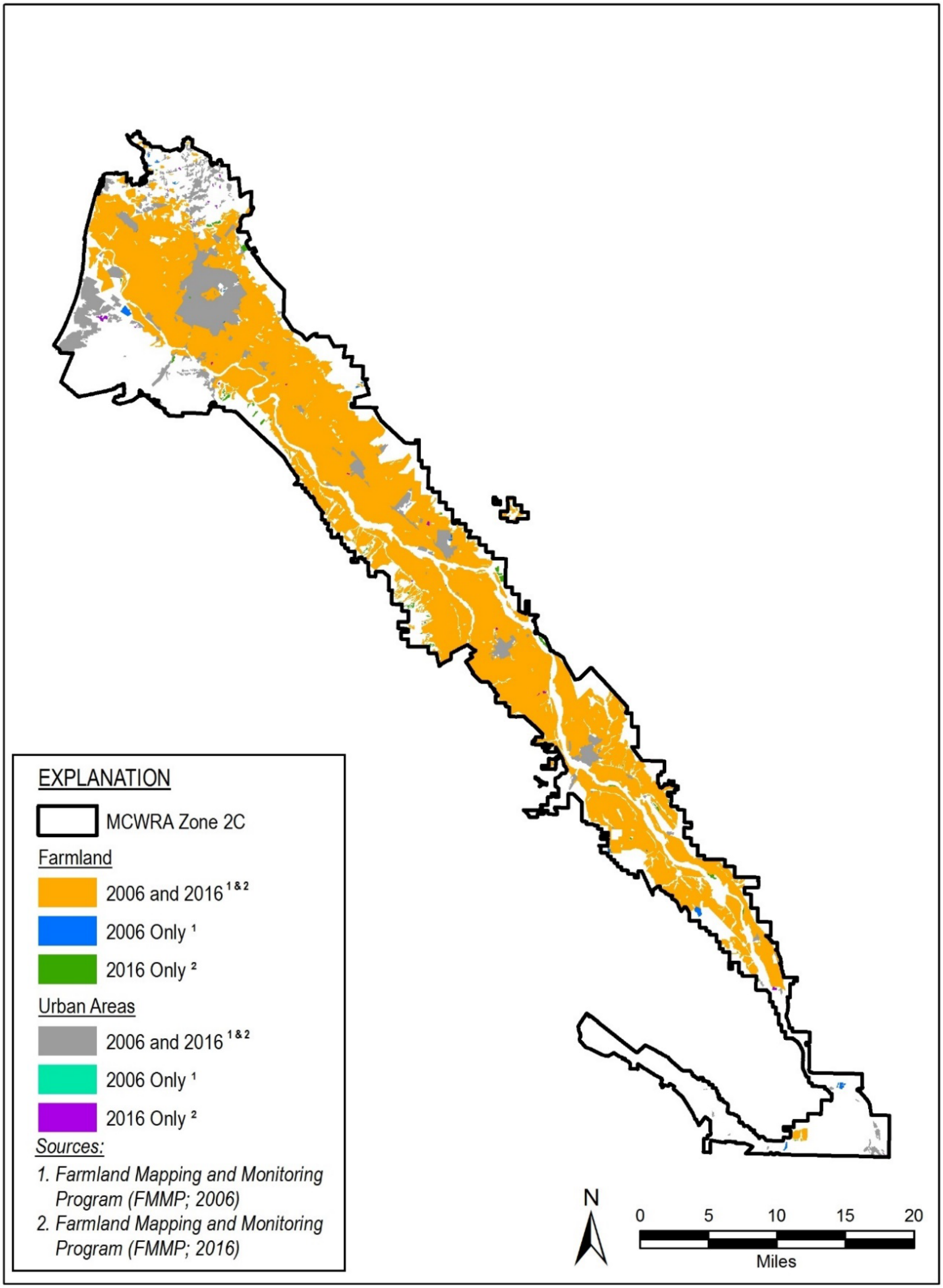
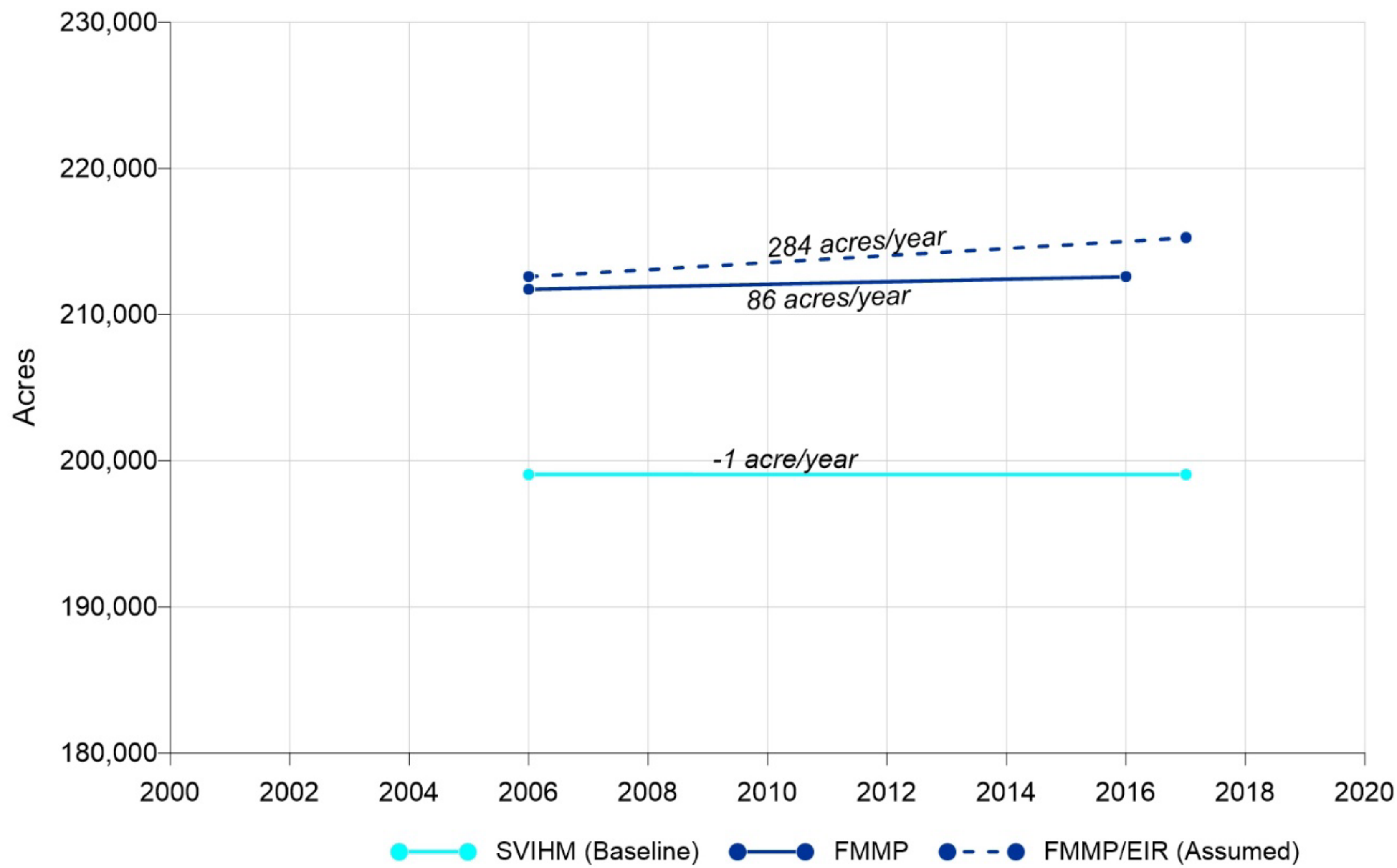
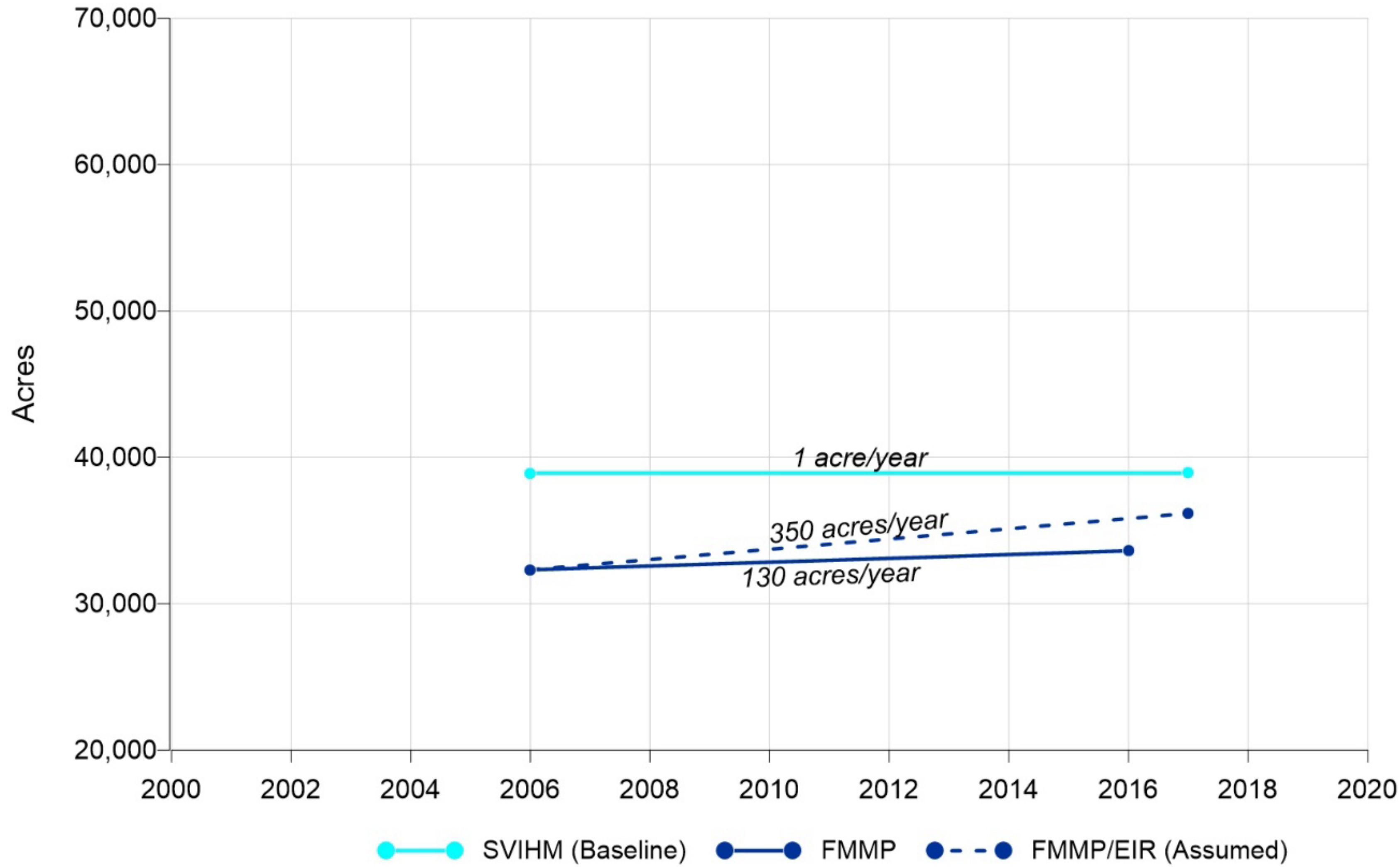


Figure B-2. FMMP Land Use Change 2006 to 2016



*Land Use Annual Growth Rate in Italics

Figure B-3. Historical Zone 2C Farmland Acreage



**Land Use Annual Growth Rate in Italics*

Figure B-4. Historical Zone 2C Urban Land Acreage

1.2 SVIHM Land Use Mapping

The 2017 SVIHM land use map is the baseline to develop 2030 land use assumptions for this study. The 2006 SVIHM land use map is also reviewed to evaluate land use changes for SVIHM source maps since the EIR. There are nominal differences of about 1 acre/year between the 2006 and 2017 SVIHM land use acreage for farmland and urban land uses (Figure B-3 and Figure B-4, respectively). The SVIHM land use change since the EIR is compared to FMMP to evaluate how the model source files compare and contrast to the EIR and General Plan source files. As discussed in the previous section, FMMP land use also remained relatively stable since the EIR, though more acres were converted to farmland and urban land than the SVIHM.

Spatial land use interpretations by FMMP and SVIHM sources are also reviewed to determine where the maps agree and where they are different. Figure B-5 shows the land use comparison between 2016 FMMP and 2017 SVIHM land use maps. FMMP and SVIHM maps generally include similar agricultural and urban footprints. However, there are some differences in how the maps identify farmland and urban areas. For example, the FMMP map includes about 4,000 acres of prime farmland that SVIHM maps as non-irrigated pasture or grassland, mostly in the Upper Valley Subarea south of King City and Forebay Subarea southwest of Soledad. Another difference is that the SVIHM map includes about 5,300 more urban acres than FMMP, mainly in areas developed for commercial and industrial uses outside of the major urban centers. The general agreement in historical and current land use coverage makes the 2017 SVIHM land use map a suitable dataset to compare to the EIR and General Plan and use as a baseline for projecting 2030 water demands. The dispersed differences between the FMMP and SVIHM maps lessens the impact that land use classification errors, if any, might have on the groundwater model simulation results.

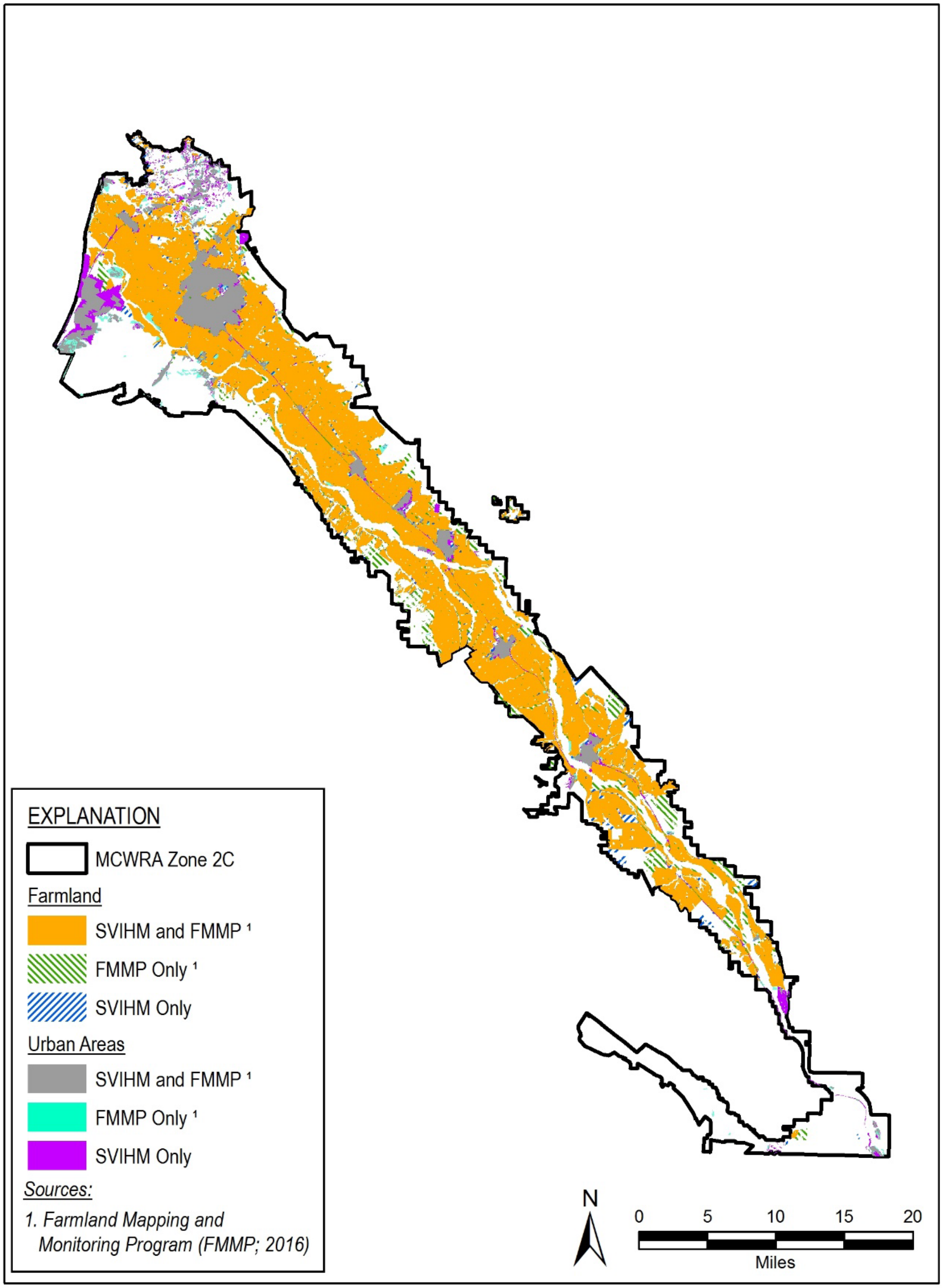


Figure B-5. SVIHM and FMMP 2016/2017 Land Use Comparision

1.3 LUCAS Land Use Mapping

The LUCAS model low and high growth 2017 to 2030 land use change is used to develop 2030 land use maps for SVOM simulations. Projected farmland data in the LUCAS model was reviewed and compared with information in the other sources in Section 4.2.2 of the report. This appendix includes some additional comparisons to other sources and example land use maps from the 2017 LUCAS low and high growth models (Figure B-6 and Figure B-7).

The LUCAS model was initialized using 2001 land use, after which it estimated future land use annually through 2100. This means the 2017 land use from LUCAS is a projection and is therefore less accurate than FMMP and SVIHM which map actual conditions. The coarser discretization for the statewide LUCAS model compared to other local sources also likely leads to some error in land use acreages. However, since LUCAS was only used to project land use change over time, only land use changes between 2017 and 2030 are relevant to this study. LUCAS farmland expansion rates of 48 to 84 acres/year between 2017 and 2030 are consistent with recent conversion rates mapped by the SVIHM (-1 acre/year) and FMMP (86 acres/year) and less than assumed in the EIR (284 acres/year). LUCAS urban expansion of 256 and 436 acres/year was slightly more than SVIHM (1 acre/year) and FMMP (130 acres/year), but similar to the assumed rate in the EIR (350 acre/year). The LUCAS land conversion data show that it is similar to other recent data and reasonable for projecting land use in Zone 2C.

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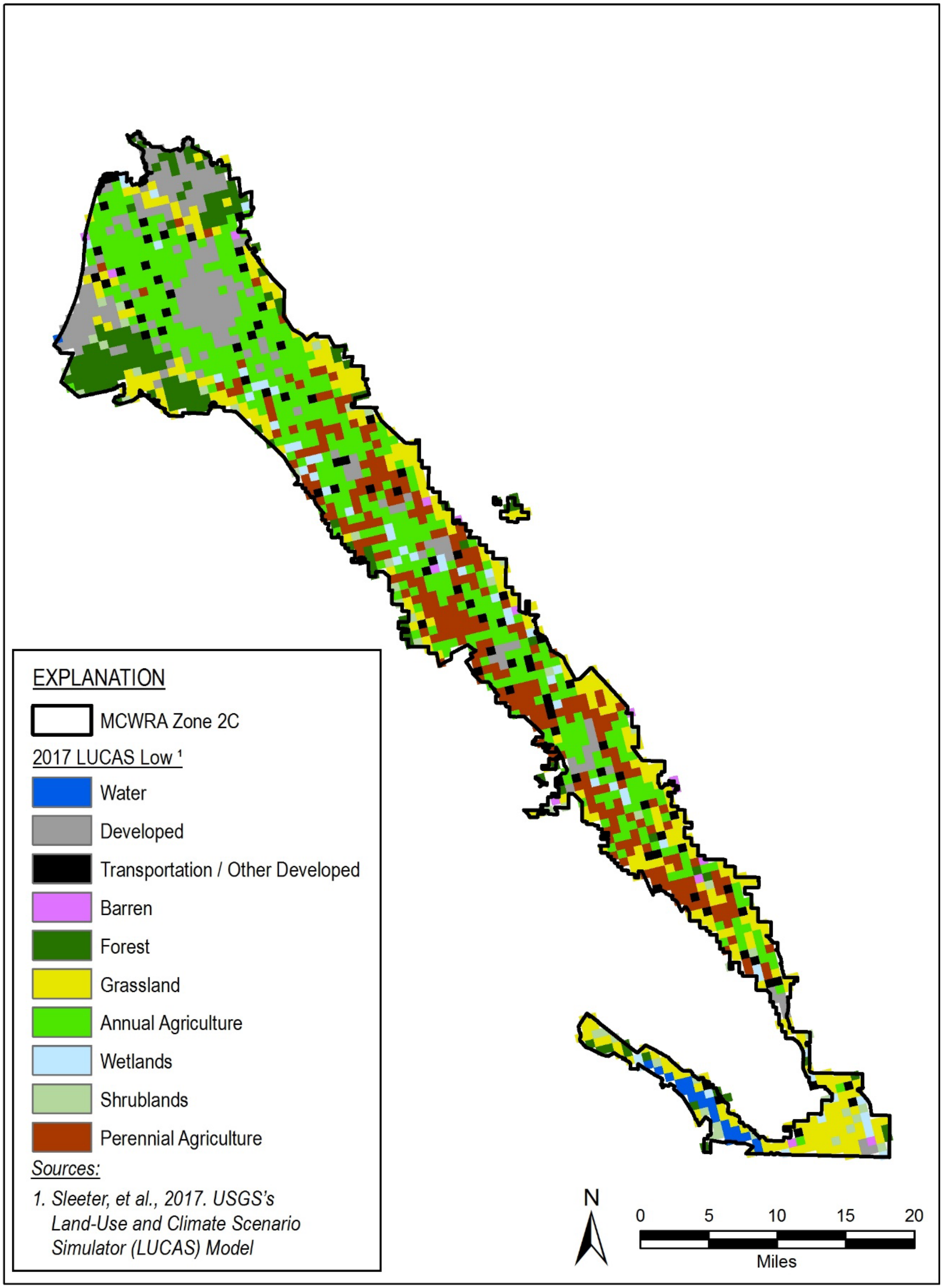

Figure B-6. 2017 LUCAS Low Growth Land Use

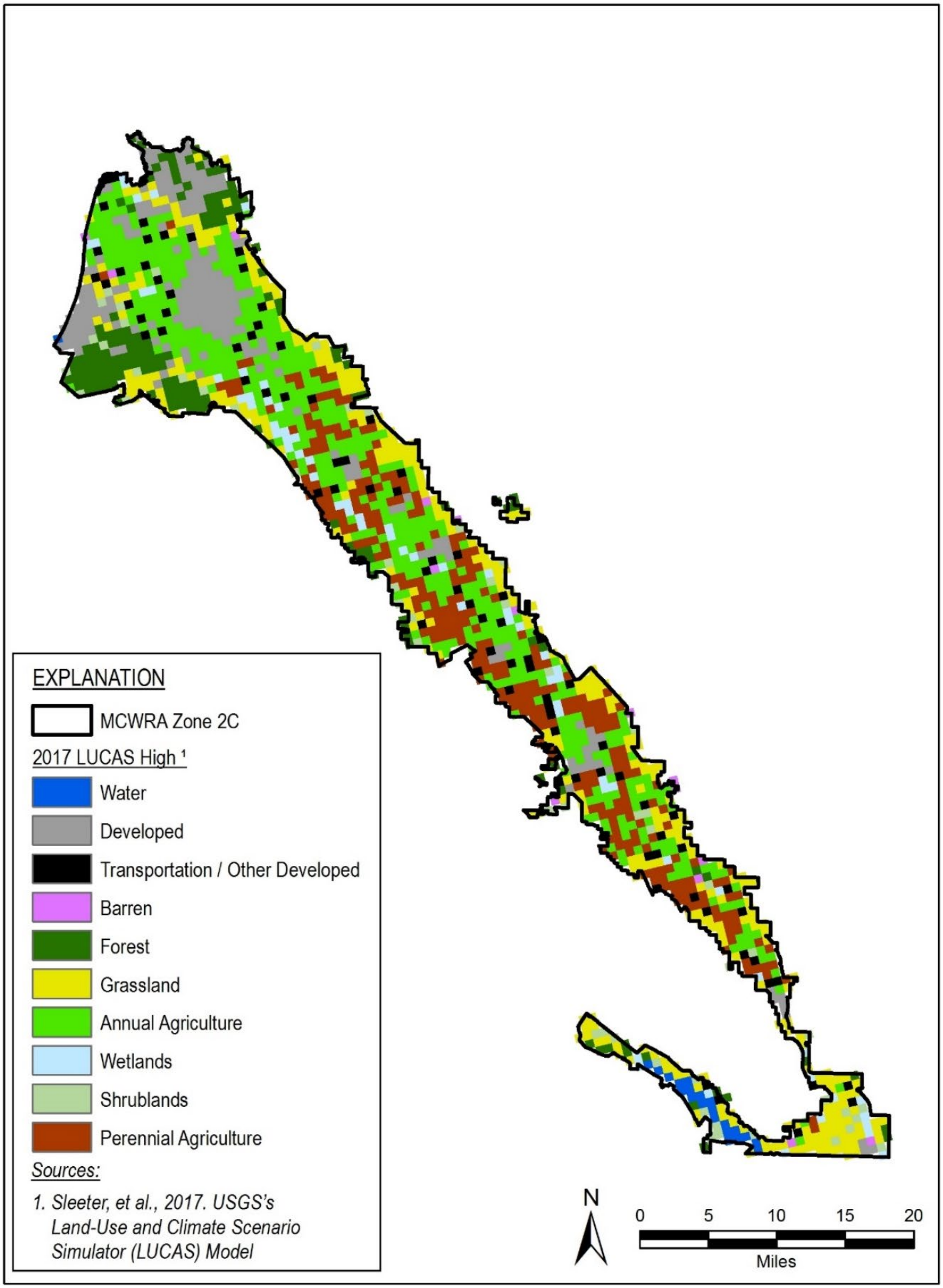

Figure B-7. 2017 LUCAS High Growth Land Use

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