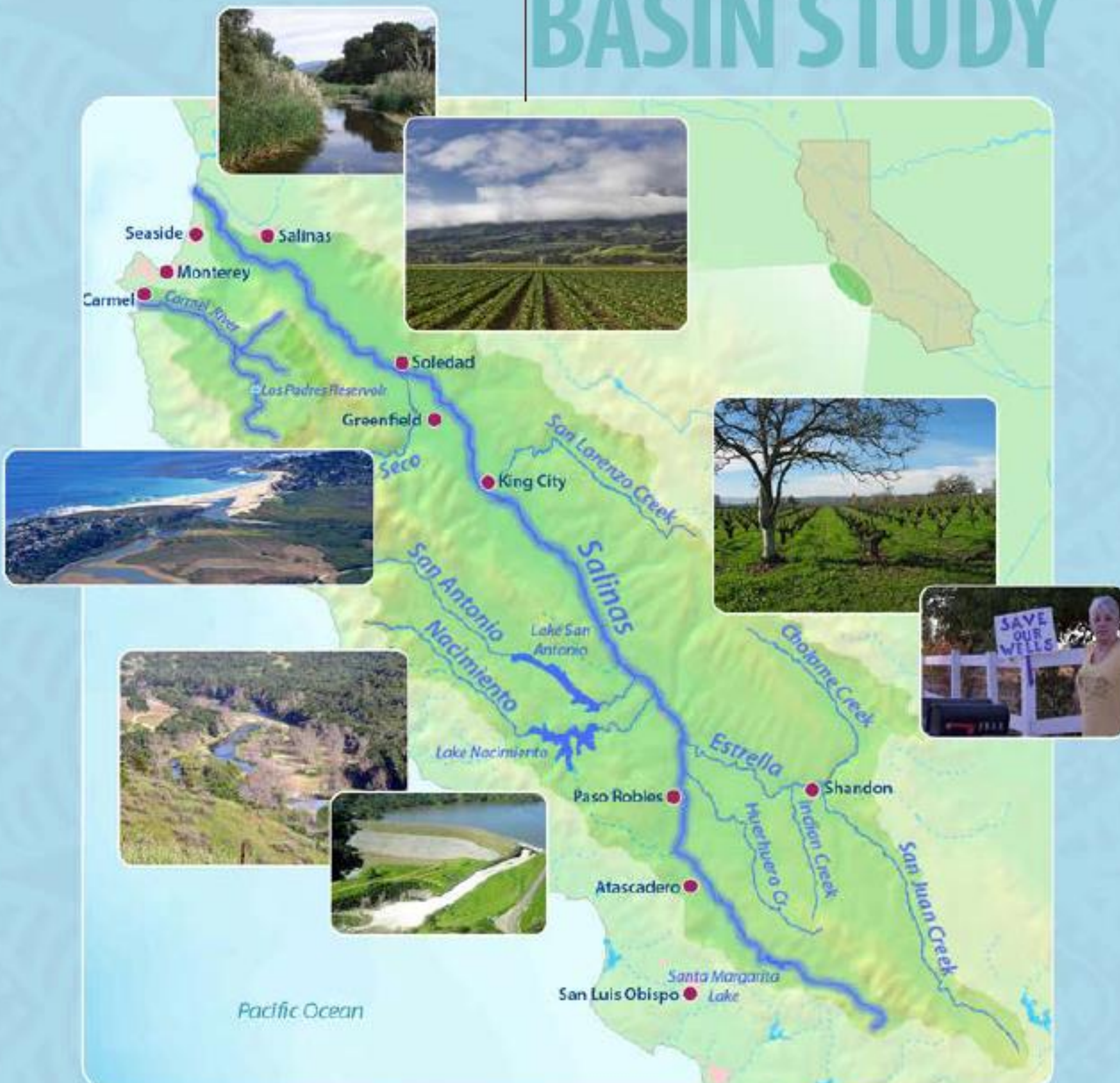
## Plan of Study

# SALINAS and CARMEL RIVERS BASIN STUDY




MRWPCA

PUBLIC WORKS
SAN LUIS OBISPO COUNTY

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

**Plan of Study**

# Salinas and Carmel Rivers Basin Study

**January 2017**

Bureau of Reclamation
Mid-Pacific Region

# Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation’s natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

# Table of Contents

## List of Tables



## List of Figures

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# Chapter 1 – Introduction

## 1.1 Purpose of the Basin Study

The purpose of the Salinas and Carmel Rivers Basin Study (Basin Study) is to inform and guide future courses of action in response to existing and potential future imbalances between water supplies and demands in the Salinas and Carson River Basins (CRB). This Basin Study is a collaborative effort between four local partner agencies, and is supported by two Federal agencies. It will identify existing water supplies and demands, model future water supplies and demands, accounting for uncertainties in future climate conditions, population growth, and other socioeconomic trends.

In response to identified imbalances between supplies and demands, the Basin Study will examine a variety of strategies that may be employed to reduce or mitigate these imbalances. Ultimately, this Basin Study will identify a portfolio of strategies to achieve long-term balance between supplies and demands in the Salinas and CRBs.

Four partner agencies (Partners) have proposed to collaborate with Reclamation to complete the Basin Study, with technical contributions to be made by each partner, Reclamation, and the U.S. Geological Survey (USGS). The four partner agencies are:

- San Luis Obispo County Flood Control and Water Conservation District (SLOCFCWCD)
- Monterey County Water Resources Agency (MCWRA)
- Monterey Peninsula Water Management District (MPWMD)
- Monterey Regional Water Pollution Control Agency (MRWPCA)

The Basin Study will be developed in coordination with the Monterey Peninsula Drought Contingency Plan (DCP), which is being managed by the MPWMD. Developed together and sharing hydrology, climate data and other common elements, these two studies will provide a robust view of how potential future climate conditions may impact water supplies and demands. Ultimately, these studies will be used to represent how imbalances between future water supplies and demands may be mitigated or reduced by implementing various actions and adaptation strategies.

## 1.2 Basin Study Goals and Objectives

The following are overarching goals for this Basin Study:

- To assist water managers in the Salinas and CRB to make sound decisions regarding water use
- Ensure that sufficient water supplies will be available in the future
- Propose adaptation strategies which address potential impacts to water supplies caused by projected climate change

- Improve water conservation and promote long-term sustainability
- Provide data and tools which can assist the non-Federal Partners in developing groundwater management plans which are consistent with the requirements of the State's sustainable groundwater management plan requirements

To meet these goals, the following general objectives of the Basin Study are:

1. Improve regional collaboration in the development of a comprehensive assessment of supplies and demands in each river basin and sub-basins
2. Identify a set of potential future climate conditions to year 2100 and assess the impacts of these future conditions to existing and projected future supplies and demands
3. Identify solutions and adaptation strategies which respond to the imbalances projected between supplies and demands

The Basin Study will include the following elements to achieve these objectives:

1. Projections of future water supply and demand within the basin, considering specific impacts resulting from climate change (as defined in Section 9503(b)(2) of the SECURE Water Act);
2. Analysis of how existing water and power infrastructure and operations will perform given any current imbalances between water supply and demand and in the face of changing water realities due to climate change (including extreme events such as floods and droughts) and population growth (as identified within Section 9503(b)(3) of the SECURE Water Act);
3. Development of appropriate adaptation and mitigation strategies to meet future water demands; and
4. An analysis of the adaptation and mitigation strategies identified, including analysis of all proposed strategies in terms of their ability to meet the study objectives, the extent to which they minimize imbalances between water supplies and demands and address the possible impacts of climate change, level o stakeholder support, the relative cost (when available), the potential environmental impacts, and other attributes common to the strategies.

## 1.3 Description of the Basin Study Area

The Basin Study encompasses the entire watersheds of the Salinas and CRBs, including the Monterey Peninsula (Figure 1). Together, the two basins encompass an area of approximately 4,500 square miles and have a combined population of roughly 370,000. Tourism brings an additional nine million people to these basins annually. Annual water demands for all uses in these two basins is approximately 600,000 acre-feet per year. The Salinas and CRBs include some of the world's most fertile agricultural lands and are internationally known for their natural beauty; ecological diversity; multi-national cultural history; and recreational opportunities such as fishing, auto racing, and golfing.

The area is oftentimes referred to as the "salad bowl of the world" or "America's salad bowl" because of the variety of crops grown. Agriculture represents a major economic driver for the local economy, with a combined annual agricultural production in Monterey and San Luis Obispo counties exceeding $5.5 billion per year in recent years. Approximately one third of the State's annual strawberry yield is grown in these basins. Wine grapes are so important and distinctive that there are three designated "American Viticultural Area" domains within the area. Monterey County is the fourth highest agricultural producing county in California. Combined with the agricultural production of San Luis Obispo County, the area proposed in this Basin Study is one of the most important agricultural areas in California and the western United States.

Figure 1. Map of Salinas and CRBs

In addition to their agricultural resources, these basins support important natural resources. National forest lands occupy a large portion of the upper watersheds, with runoff flowing to the Monterey Bay National Marine Sanctuary (MBNMS). The Salinas and Carmel watersheds also support the largest sustainable west coast run of *Oncorhynchus mykiss*, a salmonid species commonly referred to as South-Central California Coast (SCCC) steelhead trout, a Federally- listed threatened species. Numerous ongoing management activities for SCCC steelhead are currently focused on providing reliable water supplies, while improving the ability of SCCC steelhead trout to recover. For the purposes of the Basin Study, the geographic area is divided into four sub-areas: the San Luis Obispo County portion of the Salinas River watershed, the Monterey County portion of the Salinas River watershed, the Carmel River watershed in Monterey County, and the Monterey Peninsula watershed.

### 1.3.1 The Salinas River

The Salinas River is the largest river on California's central coast, originating in the center of San Luis Obispo County and flowing 170 miles north and northwest to its outfall in the MBNMS, about 80 miles south of San Francisco. The length of the Salinas River is about 170 miles (270 km); the watershed area encompasses approximately 4,160 square miles. The main stem Salinas River originates in San Luis Obispo County in the La Panza Range in the Los Padres National Forest and drains 4,160 square miles, from Santa Margarita Lake at 2,400 feet, it flows northwest to the Pacific Ocean. This watershed is more than twice the size of any other California central coastal river system from San Mateo to Santa Barbara (Funk and Morales 2002). Tributaries to the Salinas River include the Estrella, Nacimiento, San Antonio, Arroyo Seco, and San Lorenzo Rivers.

Santa Margarita Lake in San Luis Obispo County

The largest reservoirs in the Salinas basin include Lake Nacimiento, Lake San Antonio, and the smaller Santa Margarita Lake. Dams at the three reservoirs provide storage and flood protection and are operated to provide approximately 288,000 acre feet per year (AFY) for municipal water supplies, irrigation, recreation, groundwater recharge, and drought protection. The capacity of the hydroelectric power generation plant at Nacimiento Dam has a capacity of 4.3 Mw-hours per year.

The Salinas River's groundwater resources are used extensively to meet the water supply needs throughout the Salinas Valley. Agriculture in the watershed has been undergoing a transition from cattle-grazing to vineyards and other crops that require irrigation. The following sections provide a summary of land use patterns and water demands of the Salinas River Watershed in San Luis Obispo and Monterey counties.

***Salinas River Watershed in San Luis Obispo County***

The Salinas River headwaters region is located in the Los Padres National Forest in San Luis Obispo County, and is generally undeveloped open space. Land uses along the rest of the Salinas River Valley in San Luis Obispo County is predominantly agricultural or urban (Figure 2). Urban areas along the Salinas River Valley in San Luis Obispo County include Atascadero (29,000 approximate), Templeton (population 8,000 approximate), and Paso Robles (population 31,000 approximate). Strawberries, wine grapes, and cattle are the top agricultural producers for this region, and San Luis Obispo County is currently the third largest producer of wine in California. Cattle sales have increased in recent years as the lack of rangeland forage and the high cost of supplemental feed has forced the sale of livestock.

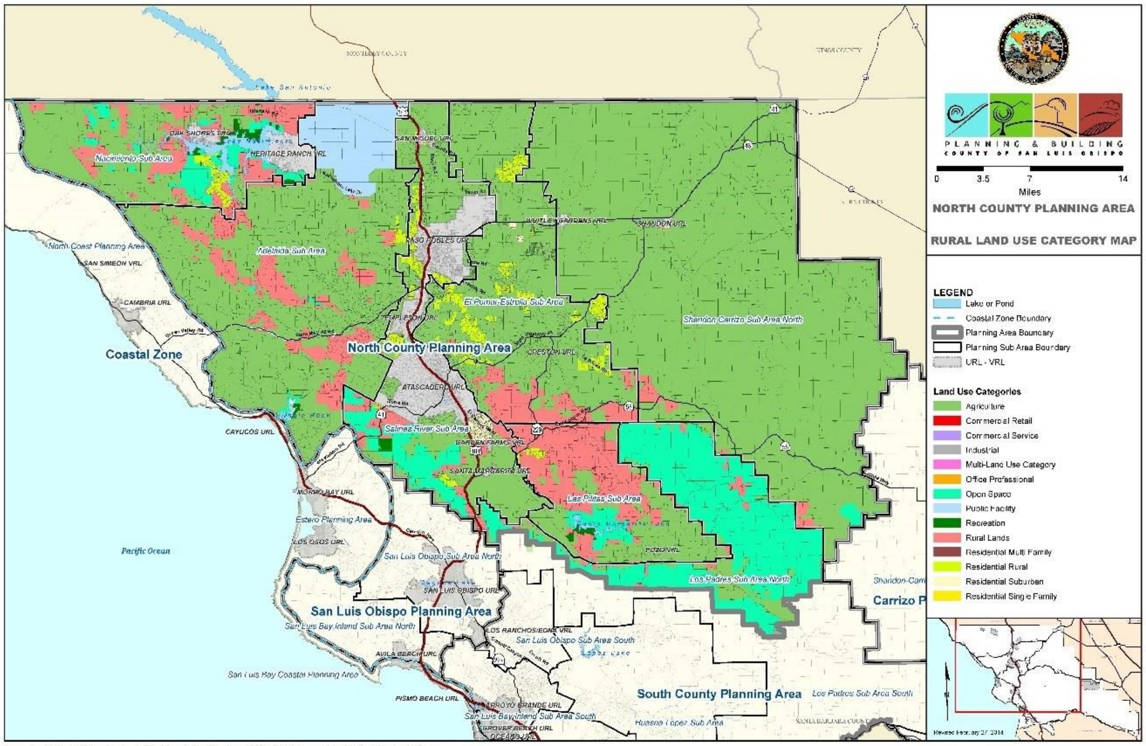


Figure 2. San Luis Obispo County Land Use

Groundwater is an important source of water supply to the region. Area groundwater basins are shown in Figure 3. San Luis Obispo County obtains nearly 80 percent of its water from groundwater sources and aboutt20 percent from surface sources including reservoirs.

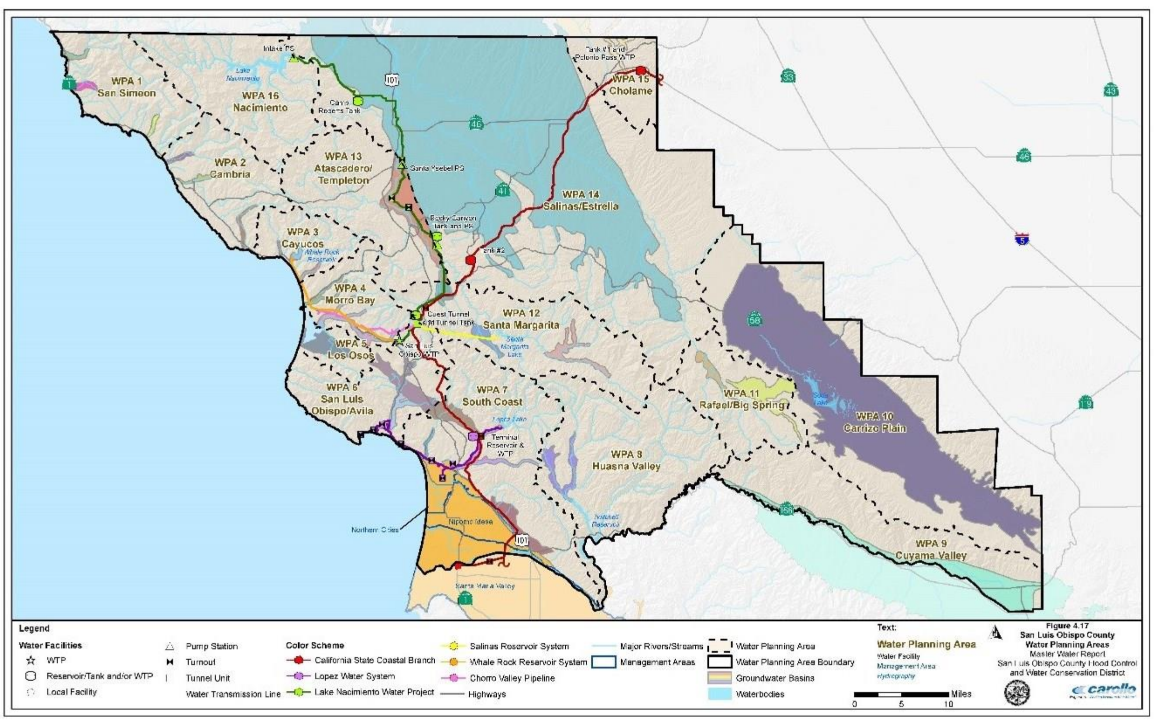

Figure 3. San Luis Obispo County Groundwater Basins

***Salinas River Watershed in Monterey County***

Much of Monterey County is located within the Basin Study area due to the extent of the Salinas River Basin's boundaries. Land uses in the Salinas River Valley in Monterey County is predominantly agricultural. The use of the Salinas River and its associated groundwater basin for irrigation has made the valley one of the most productive regions in the State. Monterey County is the fourth highest agricultural producing county in California, with 220,000 irrigated acres and 1.4 million acres total in agricultural production[1].

Notable crops include strawberries, artichokes, broccoli, cauliflower, celery, lettuce, spinach, carrots, peppers, potatoes, tomatoes, and wine grapes. Approximately one-third of California's

annual strawberry yield is grown in this area. Urban areas of the Salinas River Valley in Monterey County include King City (population 13,000 approximate), Greenfield (population 16,000 approximate), Soledad (population 25,000 approximate), and Salinas (population 155,000 approximate).

[1] UC Davis virtual tour: http://vric.ucdavis.edu/virtual_tour/salinas.htm

Figure 4. Salinas River in Monterey County

### 1.3.2 The Carmel River

The entire 255 square-mile CRB watershed lies within Monterey County. The basin originates in the Santa Lucia Mountains at 5,000 feet and merges with seven major stream tributaries along its 36-mile course before discharging to the Pacific Ocean. The Monterey Peninsula watersheds, which total about 85 square miles, and the adjacent Seaside Groundwater Sub-Basin (SGB), drain directly to the Pacific Ocean. The CRB and SGB are operated conjunctively to provide water to the Monterey Peninsula for municipal, commercial, and industrial use.

Typical view of the Carmel River in the Upper Watershed

Approximately 70 to 80 percent of the surface runoff in the Carmel River watershed comes from rain that falls in the Los Padres National Forest and Venanta Wilderness. According to the California Central Coast Integrated Water Management Plan update of 2009, the annual minimum instream flow of the Carmel River below the old San Clemente Dam site and

Reservoir is 3,620 acre-feet.[2] The Monterey Peninsula area currently relies heavily on the Carmel River and the Carmel Valley Aquifer for its water supply; however, the area is under a Cease-and Desist Order to reduce diversions to the Monterey Peninsula from this basin by about two-thirds by 2022.

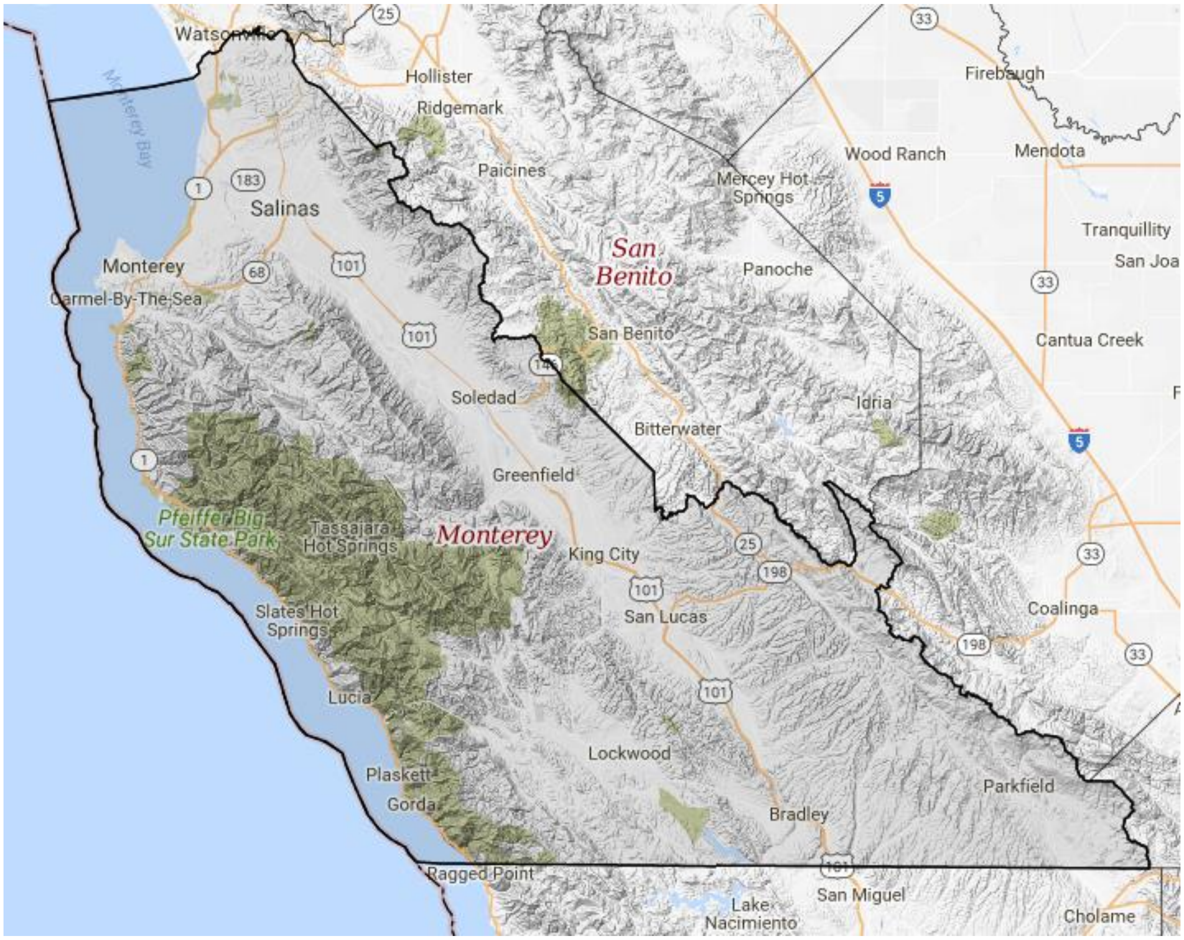


Figure 5. Monterey County Area Map

The Carmel River had two major dams and one minor dam located within its watershed. San Clemente Dam, constructed in 1921, was located 18.5 miles (29.8 km) upstream from the ocean, and once provided drinking water throughout the Monterey Peninsula. With the declaration of the dam as unsafe in a major flood or during a maximum credible earthquake and more than 90 percent loss of capacity due to sedimentation, the San Clemente Dam Removal Project was proposed and completed at the end of 2015. This project included removal of the San Clemente Dam and opening up of approximately 6.5 miles of historic steelhead habitat on the Carmel River with added access to three major tributary creeks for habitat and spawning. The Los Padres Dam, constructed in 1949, is located 25 miles upstream from the ocean. Its original capacity was 3,030 acre feet, but due to sedimentation, its storage capacity has been reduced to only about 1,700 acre feet. With only about 1,400 acre-feet actually available, the reservoir remains an important part of the local supply. The National Marine Fisheries Service has declared that the dam impacts habitat downstream for steelhead, is also a passage barrier, and should be studied to determine whether the dam should be removed.

The oldest dam on the Carmel River, commonly referred to as the “old Carmel River dam” or “Chinese dam” was a small turn-out dam about 15 feet high constructed about 1880 by Charles Crocker and the Pacific Improvement Company. This dam was constructed from hewn and mortared granite blocks with a labor force that included approximately 700 Chinese workers to build the dam and lay 25 miles of iron pipe to the Monterey Peninsula. The old Carmel River dam was designed to divert water supply to the first Del Monte Hotel on the Monterey Peninsula and was located approximately 2,000 feet downstream of the San Clemente Dam site. The San Clemente Dam was removed in 2016 due to sedimentation which significantly reduced its storage capacity and was a steelhead passage barrier.

Figure 6. Carmel River Confluence with the Pacific Ocean at Carmel

### 1.3.3 Monterey Peninsula Watershed

The Monterey Peninsula includes six incorporated cities and a portion of unincorporated Monterey County which collectively is home to over 100,000 people. Rainfall is the primary source for water supply recharge to the Carmel River and its aquifers and to the Seaside Basin aquifers. Annual rainfall in Monterey County ranges from just over 10 inches in the inland valleys to more than 70 inches at the peaks of the Santa Lucia mountain range adjacent to the coast. The annual average runoff from these local watersheds far exceeds use; however, the region lacks adequate infrastructure to capture the episodic runoff events and to treat and store the water. Annual minimum and maximum runoff has varied by orders of magnitude and resulted in both severe floods and droughts.


Figure 7. The Monterey Peninsula and Carmel River Watershed

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# Chapter 2 – Study Description

Basin studies are part of Reclamation's WaterSMART Program and are a key component of Reclamation's implementation of the SECURE Water Act (Public Law 111-11). The WaterSMART Program is specifically intended to address water supply challenges, including water supply shortages due to increased demands, climate change, and heightened competition for finite water supplies. Through Basin Studies, Reclamation engages with non-Federal partners and stakeholders to identify strategies to adapt to and mitigate current or future water supply and demand imbalances, including the impacts of climate change and other stressors on water and power facilities.

## 2.1 Project Background

The Basin Study provides a significant opportunity for the four non-Federal Partner agencies to work collaboratively with Reclamation to develop integrated strategies for managing regional water supplies which will benefit agricultural, urban, and environmental water demands. Strategies for adapting to climate change, including responses to changing precipitation patterns, runoff, and sea level rise are anticipated to be developed and potentially integrated into the management of the Salinas and CRBs. The Basin Study provides a scientific and collaborative basis for developing and implementing sound planning which is intended to guide future decisions for providing sustainable water supplies. This Basin Study provides opportunities to develop solutions and strategies to fill gaps in supply and demand planning, reduce risks to property and infrastructure associated with climate change, and improve sustainability of aquifers and surface flows in order to provide adequate water supplies for the benefit of all users well into the future.

One of the important characteristics of the proposed Basin Study is to identify what potential future climate conditions may be like. The climate analysis in the Basin Study will include a range of climate scenarios as well as consider increases in uncertainty. Water years 2012-15 stand as one of California's driest four-year periods since historical observations began, which occurred with record warming resulting in new temperature records set in 2014 and 2015 for statewide averages.

The basins and sub-basins included in the Basin Study are currently experiencing challenges in meeting demands and are projected to have insufficient water supplies in the future. Assuming that warming conditions continue, the Basin Study process is specifically designed to propose strategies which respond to potential impacts to surface and groundwater facilities, urban and agricultural demands, meeting water quality and temperature standards, riparian habitats and other environmental conditions.

The local agencies who are partnering with Reclamation in the Basin Study (MCWRA, MPWMD, MRWPCA, SLOCFCWCD) are responsible for stewardship of local water resources and have a significant interest to collaborate in the Basin Study with Reclamation. This Basin Study is anticipated to augment ongoing water planning by building a common understanding of potential future climate characteristics and planning for a range of possible responses to changing future conditions. By creating several different scenarios which represent potential future growth, agricultural demands and environmental conditions with different climate scenarios, the Basin Study provides a unique opportunity for Partners and Reclamation to evaluate possible adaptation strategies which are designed to moderate or mitigate uncertain future climate conditions.

The Basin Study will also evaluate risks to other environmental conditions such as fisheries and Endangered Species Act (ESA) habitats which may be degraded by the impacts of future climate change. The potential impacts of changes in flood frequency and magnitude will also be analyzed in the Basin Study. With substantial agricultural and urban development within the 100-year floodplains along the Salinas and Carmel Rivers, a large magnitude flood could place billions of dollars of urban and agricultural property at risk. Other resources which may be adversely impacted by climate change include forest areas which may experience increased fire risk. In essence, the Basin Study will provide each non-Federal Partner agency a “stress test” of each area’s ability to cope with potential future climate changes.

National forest lands are particularly susceptible to the impacts of climate change. The Los Padres National Forest is the only national forest along California’s Central coast and was originally established to prevent fires and protect the pristine water sources for the coastal communities surrounding the forest. The forest areas surrounding the Salinas and Carmel basins remain of high strategic importance since they provide most of the runoff within the basins. However, many of the adjacent forest areas now have high fuel loads. The recent Soberanes Fire, in the summer and fall of 2016, burned over 132,000 acres with more than 70 percent of the fire occurring within the Los Padres National Forest near Monterey. To protect firefighters, fire-fighting organizations mandated that private landowners clear fire-safe zones on access roads and around structures in order to be eligible for protection. The inaccessibility of the steep, rugged terrain contributed to the spread of the fire and in wilderness areas, fire managers and firefighting crews used MIST (Minimum Impact Suppression Tactics) as much as possible. Aircraft support was essential to controlling hotspots with helicopters dipping buckets into local ponds and reservoirs at a time when supplies were at critical lows as a result of ongoing drought.

This illustrates how outreach to the public about prevention of human caused fire and forest fuels management is now acknowledged to be critically important to maintain healthy watersheds. Improved forest management can directly reduce the risk of catastrophic fires and prevent significant amounts sedimentation which often fills reservoirs after these types of fires. The impacts of sea level rise and sea water intrusion will also be addressed in the Basin Study, particularly how these conditions may impact the aquifers and infrastructure which are adjacent to the MBNMS.

Water management in the Salinas and CRBs is also constrained under various regulatory restrictions on use of surface and groundwater supplies. Developing a sustainable balance between supplies and demands is vital for this region for long-term reliability in managing its water supply, as well as complying with legal mandates, coping with climate change, and improving economic and environmental conditions. Management of surface and groundwater resources in the study area is divided among multiple layers of local, regional, State, and Federal agencies, as well as for-profit entities such as private utilities. The Basin Study Partners are actively engaged in complying with sustainable groundwater management in accordance with the requirements of California's Sustainable Groundwater Management Act (SGMA).

Together, the Partners are proposing to develop plans for sustainable groundwater management plans in these basins. The Partners have implemented changes in conjunctive use programs to improve steelhead recovery and are (or will) participate in one another's public outreach processes. The Partners and Reclamation are dedicated to pursuing and evaluating the challenges of water resource management so that they will collectively ensure that future generations are provided with the tools to adapt available water supplies and demands.

## 2.2 Problems, Needs, and Opportunities

Consequences of water supply and demand imbalances in the Salinas and Seaside Basins have included declining groundwater levels, seawater intrusion into coastal aquifers and increased competition for limited groundwater supplies. Supply and demand imbalance in the CRB results in seasonal dewatering of up to eight miles of the Carmel River and a lowering of aquifer levels. Due to the limited capacity of the aquifer, it is fully recharged by runoff nearly every year. Legal and regulatory repercussions include adjudication of water rights in the Seaside Basin, designation of minimum in-stream environmental flows, and Dease and Desist Orders (CDO) from the State Water Board for reduction of groundwater pumping in portions of the CRB and and requirements from the California Department of Water Resources (DWR) to develop a plan for sustaibable use of parts of the Salinas River basin. The observed historical imbalances are likely to be further exacerbated by projected future climate conditions which may include more severe and longer drought periods.

### 2.2.1 Water Shortages

The primary water supply challenges in both Monterey and San Luis Obispo counties, which create or lead to imbalances between supply and demand, revolve around storage, distribution, and water quality. Within the Salinas and CRBs, an imbalance between water supplies and demands is being exacerbated by extended drought, increasing (and often competing) demands, and climate change. Understanding, anticipating, and adapting to these impacts by implementing various structural and non-structural strategies is one of the primary objectives of the Basin Study.

Due to extended droughts along California's Central Coast compounded by limited storage to capture runoff in years with abundant rainfall, the Salinas and CRBs have faced water supply and management challenges for over half a century. Monterey County is not a State Water Project contractor nor a Federal Central Valley Project contractor. Even though SLOCFCWCD is a State Water Project contractor, due to limited water available and uncertainty of receiving their full allocation, they have wisely decided to rely as much as possible on local supplies. Being virtually self-reliant on local water supplies, this region is substantially dependent on in-basin supplies. Drought conditions which affect all of California are especially difficult for this area due to reliance on limited local supplies.

The consequences of the historical imbalances between supply and demand have resulted in declining groundwater levels, seawater intrusion, impaired water supplies, regulatory actions in the form of a CDO on pumping, adjudication, and requirements for minimum in-stream flows to support ESA threatened steelhead. These historical imbalances and consequences are likely to be further exacerbated by climate change effects, with projections of possibly longer and more severe drought periods followed by periods of extreme precipitation events which may cause severe damage to property, infrastructure and critical habitats alike.

Although several recent studies have identified underlying problems and issues, the Basin Study will provide a forum for stakeholders and partner agencies to engage in providing a variety of possible solutions. Building on the hydrology model tools developed by the partners for the CRB and the Paso Robles and Salinas Valley sub-basins, the Basin Study will analyze how the various strategies will perform under various potential climate futures. This aspect of the Basin Study is unique and provides an informed picture of which strategies may perform best across various possible future climate conditions and also which would be the best investment.

The four Basin Study Partner agencies have participated in the development of State Integrated Regional Water Management (IRWM) plans to address water supplies and demands as well as climate change. The Partners have also prepared numerous individual studies on sub-areas of the basins. However, a basin-wide comprehensive study of the potential effects of climate change on water supplies, demands, and imbalances within the Salinas and CRBs has not yet been performed. More importantly, the Basin Study provides a structured opportunity and means to develop comprehensive and coordinated adaptive strategies to address climate change risk to the Basins' water supplies and demands. (Move Table 1 to this location…)

### 2.2.2 Basin Study Area Supplies and Demands

The Basin Study area is comprised of four major sub-basins: Salinas Valley Basin (SVB), CRB, SGB, and the Paso Robles Groundwater Basin (PRGB). All four of these sub-basins within the larger Salinas and Carmel basins are in a current state of imbalance between supply and demand, as demonstrated by seawater intrusion and groundwater level declines. While many studies and projects were conducted to find solutions to these issues, a projected imbalance remains that will be exacerbated by climate change. Table X below summarizes the current and projected future supply and demand imbalances for each sub-basin. Imbalances in the demands will be re-evaluated as a part of the Basin Study, in light of climate, population and other changes.

#### *Paso Robles Groundwater Basin*

The current water demand for the PRGB is largely estimated, as the only metered water users are within water purveyor boundaries. In 2014, an integrated watershed/basin model was utilized to estimate historical demands within the PRGB on an average annual basis for the period of 1980 through 2011, as well as the perennial yield. Due to the imbalance between water demand and supply within the PRGB, groundwater levels have been declining over the past 30 years. Declining groundwater levels have led to the need for deeper wells across the basin. Some water users located along the edge of the basin have lost access to the groundwater and are now drilling into fractured rock formations.

The Paso Robles Basin is an Important Wine Grape Region

Impacts to this aquifer have resulted in multiple conflicts and actions, and the formation of various stakeholder groups. Most recently, a two-year urgency ordinance (August 2013) followed by a permanent ordinance (October 2015) was adopted by the San Luis Obispo County Board of Supervisors requiring new development and irrigated agriculture within portions of the PRGB to offset new demands on the PRGB by a ratio of 1 to 1 (under the permanent ordinance, the offset requirements are in effect until a groundwater sustainability plan is adopted); formation of different types of water districts were and are being pursued; and several landowners within the PRGB have filed a quiet title action against public and private water suppliers within the PRGB (as well as the SLOFCWCD). Continuing declines in groundwater levels in the PRGB are anticipated to lead to the need for residential landowners to lower wells where possible, find alternate sources of water or vacate the area. Declining groundwater levels may also result in the loss of smaller agricultural operations unable to afford coping with recurring drought, or energy and treatment costs associated with pumping water from lower levels. The California DWR, in its 2016 update of Bulletin 118, determined that a portion of the Paso Robles Basin was sequestered from receiving groundwater from the Paso Robles basin due to the Rinconada Fault. This groundwater basin is called the Atascadero Basin and is located adjacent to and west of larger Paso Robles Basin. An integrated watershed/basin model prepared by the County of San Luis Obispo in 2014 projects that groundwater levels in the Atascadero Basin will remain stable beyond year 2040.

Table 1. Salinas and Carmel Basins Supply, Demands and Unmet Demand by Sub-Basins

| Basin Area | User | Supply (acre-feet) | Demand (acre-feet) | Unmet Demands |
|---|---|---|---|---|
| PRGB (Current) | Agriculture[1] | 89,600[4] | 76,000 | 3,600[5] |
| | M&I[1] | | 17,200 | |
| | Environmental[2] | 74,090 | 41,010 | No unmet demands |
| | Recreation[3] | Min pool: 2000 | Reached 1 time in 30 years | Est. 3 percent of the time |
| PRGB (2040) | Agriculture[1] | 89,600[4] | 91,072 | 17,344[5] |
| | M&I[1] | 6,250[6] | 22,122 | |
| | Environmental[2] | 74,090 | 41,010 | No unmet demands are projected |
| | Recreation[3] | Min pool: 2000 | Reached 1 time in 30 years | Est. 3 percent of the time |
| CRB and SGB (Future) | Agriculture[1] | Included in M&I | Included in M&I | |
| | M&I[1] | 8,500[7] | 20,000[8] | 11,500[8] |
| | Environmental[2] | Minimum instream flow and adjudication requirements are in effect | Minimum instream flow and adjudication requirements are in effect | Minimum instream flow and adjudication requirements are in effect |
| CRB and SGB (Current) | Agriculture[1] | Included in M&I | Included in M&I | Unknown |
| | M&I[1] | 5,000 (legal)[7] | 15,500[9] | 10,500 |
| | Environmental[2] | Basins are overappropriated and subject to cutbacks | Basins are overappropriated and subject to cutbacks | Basins are overappropriated and subject to cutbacks |
| SVB (Current) | Agriculture | 446,000[10] | 418,000[11] | 177,000[11] |
| | M&I | | 45,000[11] | |
| | Environmental | The need for allocations is mentioned but not quantified | The need for allocations is mentioned but not quantified | The need for allocations is mentioned but not quantified |
| SVB (Future) | Agriculture | 429,000[10] | 358,000[11] | 140,000[11] |
| | M&I | | 85,000[11] | |
| | Environmental | The need for allocations is mentioned but not quantified | The need for allocations is mentioned but not quantified | The need for allocations is mentioned but not quantified |

1. 1980-2011 Average Annual Basis; Paso Robles Groundwater Basin Model Update, Geoscience, 2014
2. Water Planning Area 13,Master Water Report, Carollo, 2009
3. Salinas Reservoir
4. Paso Robles Groundwater Basin estimated perennial yield; Geoscience Update
5. Unmet Demands for the purposes of the Paso Robles Sub Area means the extent to which demands exceed the perennial yield of the PRGB and Nacimiento water contract allocations ona an average annual basis, which results in sustained basin drawdown
6. Nacimiento Water Contracts = 6,250 AFY
7. Existing firm riparian, appropriative, and percolating rights determined by State Water Resources Control Board, SGB Adjudication, and annual well reports
8. Cal-Am estimate, CPUC Application A12-04-019 plus 2014 Monterey Peninsula IRWM Plan Update with estimate of 20-year General Plan build-out demand
9. Estimated demand within the Cal-Am service area as descirbed in testimony, CPUC A.12-04-019, Monterey

Peninsula Water Supply Project

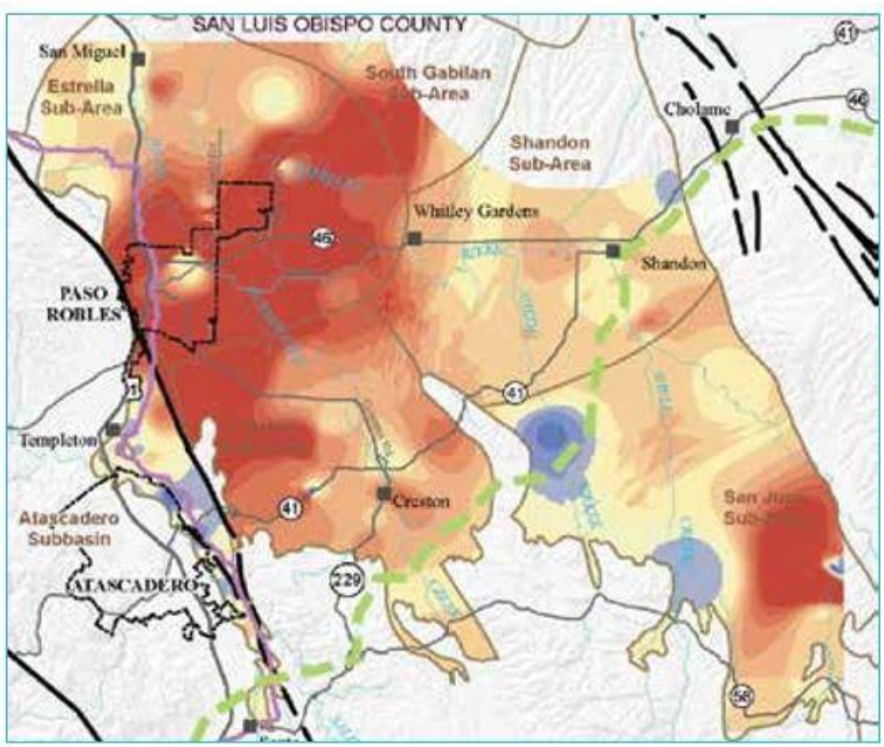


Figure 8. Paso Robles Groundwater Basin

### *Carmel River Alluvial Aquifer and Seaside Groundwater Basins*

More than 105,000 people reside in the MPWMD service area, which is dependent for water supplies from two sources: runoff from Carmel River Alluvial Aquifer in the CRB and groundwater from the SGB. The CRB currently supplies about 70 percent of domestic supply for the Monterey Peninsula; however, in 2009, the State Water Resources Control Board (SWRCB) issued a CDO to the local water provider, California American Water (Cal-Am). The CDO required Cal-Am to find replacement supplies for two-thirds of the annual diversions from the CRB by January 1, 2017. The SWRCB recently extended the deadline for compliance to Water Year 2022.

The SGB is at the northwest corner of the Salinas Valley, adjacent to Monterey Bay. Historical and persistent low groundwater elevations caused by pumping led to basin adjudication in 2006 and an amended court decision in 2007 that created the Seaside Basin Watermaster and ordered a ramp down in production from about 5,600 AFY to the Natural Safe Yield of 3,000 AFY by 2021. Cal-Am's right to appropriate water from the SGB will be reduced to less than half of the Natural Safe Yield by 2021. No seawater intrusion is occurring presently, but water levels are lower than those required to protect against seawater intrusion. Recharge into the basin aquifers will be beneficial for protection against seawater intrusion.

Both basins are being pumped in excess of legal rights to do so, which places the community at risk of heavy fines or severe rationing of up to 50 percent. Figure 3 shows that the estimated replacement need for the Monterey Peninsula is approximately 10,000 AFY. The MRWPCA's

Pure Water Monterey Groundwater Replenishment (GWR) Project would provide 3,500 AFY of highly treated recycled wastewater to the SGB and Cal-Am's proposed desalination plant on the coast south of the Salinas River would provide the balance of the replacement supplies. The GWR Project has received several approvals and is expected to begin delivering water as early as 2019. The desalination component of the replacement water supply project is currently under environmental review, with completion anticipated by 2020.

Habitat for steelhead in the CRB has been degraded and annual returns of adult steelhead have fallen below 10 percent of the estimated potential for the run. Years 2014 and 2015 show the lowest fish densities ever recorded and a rebound in returning adults from the 2012-2015 drought is extremely weak. Usable surface storage in the CRB is small (about 1,400 AF) and shrinking due to reservoir sedimentation.

It is anticipated that most of the climate change scenario conditions will occur over the entire study area; however, where local variations exist, additional evaluation will be conducted to determine local impacts. For example, sea level rise scenarios will be important to consider for the coastal portions of this study area and the adjacent aquifers, but would not be generally applicable in the upper Salinas River or CRB areas.

While multiple tools exist to evaluate future supply and demand conditions under future climate change scenarios, the Salinas and Carmel Basin Study is proposing to use the USGS and Reclamation’s technical support to better determine the interaction between basin sub-areas and to define how changes in one sub-basin can affect other sub-basins. With Reclamation’s oversight and USGS participation, predictive models and tools can be employed to evaluate each scenario on a basin-wide basis. The tools and models will be also be modified during the Basin Study to update temperature and precipitation assumptions as identified by Reclamation and USGS.

### 2.2.3 Instream Flows

Instream flow issues in the Carmel and Salinas Rivers include required cutbacks to Carmel River diversions, the variability of the natural flows of the Salinas River, the decline in steelhead fisheries and the ability of the region to meet the flow and temperature requirements of the National Marine Fisheries Service (NMFS) and the Regional Water Quality Control Board.

#### *Carmel River*

The Carmel River has long-served as the main water supply for the Monterey Peninsula. After finding that the Carmel River alluvial aquifer was declining through use as the primary water supply for the Monterey Peninsula community, the California SWRBC first ordered a 70 percent cutback in 1995 and then followed up in 2009 with a CDO to protect critical habitat for threatened species after little progress had been made to replace supplies. The pumping cutbacks were scheduled to begin on December 31, 2016, but the Monterey Peninsula requested an extension to December 31, 2021, which the SWRCB granted.

A coalition including the Monterey Peninsula Regional Water Authority, MPWMD, Cal-Am, Pebble Beach Company, and the City of Pacific Grove had asked for the extension on the most significant cutback to 2021 in order to advance progress on replacement water supplies before losing the current Carmel River water supply.

The coalition stated that the Monterey Peninsula is among the lowest per capita water users in the State and that a cutback of more than half of its current river water supply would have major public health and safety and economic impacts on the area. The proposed replacement water supplies include a groundwater replenishment project that could come online by 2018 and a proposed Cal-Am desalination plant which may be delayed until 2021.

### *Salinas River*

Another risk to water supplies is the timing and quantity of runoff in the Salinas River. As noted previously, many climate scientists now believe that future climate conditions will include longer drought periods with some occasional heavy rainfall events. Both reduced and increased runoff can create supply risks. The Salinas River is a "flashy" system, and increased runoff could result in increased flooding and damage to water supply infrastructure. Reduced runoff causing multi-year droughts would also reduce percolation and aquifer recharge resulting in reduced groundwater storage and potential declines in aquifer water levels.

### *Steelhead Fisheries in the Salinas and Carmel Rivers*

SCCC steelhead are an anadromous fish of the Salinas and Carmel rivers and their tributaries. They spend approximately the first two years of their life in the freshwater of these rivers and then migrate out to the Pacific Ocean. They return after several years to the rivers to spawn. Steelhead can live as long as eleven years, but many do not due to deteriorating river habitat conditions. The coastal steelhead is able to spawn more than once in a lifetime, but they typically only survive long enough to spawn once. Due to diversions in both basins, both rivers can be dewatered for long periods of time and may not open to the ocean during droughts. This has resulted in some anadromous steelhead becoming resident trout; however, it appears that the anadromous gene has not been eradicated in resident populations.

Coastal steelhead trout

The Study Area historically had a large population of steelhead, but changes in water quantity and quality and the course and speed of these rivers and their tributaries has negatively impacted steelhead's ability to survive. The headwaters were historically used for spawning and rearing while the lower waterways served primarily as migration corridors during times when flows were sufficient to reach the ocean. Only limited areas of the valley portions of these rivers currently provide suitable spawning and rearing habitat for steelhead. The substrates are sandy and silty as opposed to gravelly, and the water temperatures often exceed recommended maximums for good habitat conditions during warmer months. The construction of dams, changes in flows and timing due to reservoir releases, stream course straightening, diversions of stream flow, groundwater pumping, loss of riparian vegetation, and passage barriers to perennial headwaters have caused a dramatic decline to the point that NMFS believes SCCC steelhead are likely to become an endangered species within the foreseeable future in these rivers unless conditions are improved.

### 2.2.4 Groundwater

Groundwater issues in the area include declines in groundwater elevations, water quality reductions and seawater intrusion. A notable recent development in groundwater management efforts is, California's SGMA. These groundwater issues are described below:

#### *Seaside Groundwater Basin*

The Seaside Groundwater Basin provides about 30 percent of urban supplies for the Monterey Peninsula. It is recharged through percolation of rainfall and by excess winter flows in the Carmel River that are diverted and pumped into the local distribution system, and then injected into the basin for recovery in the dry season. The Seaside groundwater basin was adjudicated in 2006 and is subject to a series of production cutbacks in order to provide a sustainable yield by 2021. The cutback will result in native SGB water being about 15 percent of urban supplies.

#### *Seawater Intrusion in Aquifers Adjacent to Monterey Bay*

Seawater intrusion in the coastal groundwater basins is expected to be exacerbated with sea level rise associated with climate change. Seawater intrusion causes groundwater in those basins to become more saline and less desirable as a supply water source. Natural groundwater recharge and active injections of freshwater in the SGB by MPWMD and Cal-Am are occurring in several areas and are designed to keep seawater intrusion from advancing inland.

#### *California's Sustainable Groundwater Management Act*

Groundwater basins are one of the most cost-effective and environmentally sustainable places to store water locally during wet years; and if managed well, can serve as a buffer against the impacts of climate change and drought. On September 16, 2014,
Governor Edmund G. Brown Jr. signed three bills that comprise the SGMA. This legislation created the framework for sustainable, local groundwater management for the first time in California history. The legislation requires local agencies to craft groundwater management plans that must incorporate long-term sustainability to meet their regional economic and environmental needs.

There are two key principles in the SGMA groundwater legislation. The first is that groundwater is best managed at the local or regional level and that local agencies should have the tools they need to sustainably manage their resources. Since some local and regional agencies may not have the tools necessary to manage their groundwater resources effectively; the SGMA emphasizes that groundwater management by a local authority is preferred when that entity has a desire to sustainably manage the resource and has sufficient technical information and the financial resources to do so.

The second principle is when local or regional agencies cannot or will not manage their groundwater sustainably, the State will intervene until the local agencies develop and implement a local governance entity to ensure the sustainability of a groundwater management plan. This limited State intervention would be temporary – until an adequate local program is established – to ensure the protection of the groundwater basin and its users from overdraft, subsidence, and other problems stemming from unsustainable uses of groundwater resources.

The SGMA also includes certain timeframes for compliance, with those basins designated as high priority being required to adopt a SGMA management plan earlier than other, lower priority basins. The PRGB which extends into Salinas Valley, and a portion of the Salinas Valley Groundwater Basin near the coast have been designated as high priority basins subject to critical overdraft by the State DWR and a SGMA sustainable management plan must be prepared by 2020. The Carmel basins have been deemed a high basin but is not currently subject to critical overdraft. The MPWMD is the designated Groundwater Sustainability Agency for the Carmel Basin. In the spring of 2016, DWR agreed with the SWRCB determination that surface water in the Carmel River flows through known and definite subterranean channels and is, therefore, not subject to SGMA requirements; however, DWR declined to remove the basin from the State Water Plan Bulletin 118.

## 2.3 Previous Work and Available Data

The Basin Study Partners have collected data and studied the basins for many decades. The breadth and extent of the data available is extensive. The SGMA requires consistent data (including groundwater elevation data, groundwater extraction date, surface water supply, total water use, change in groundwater storage, water budgets, sustainable yield) to be used in hydro-geologic analysis. The Basin Study Work Plan (Task 4) identifies processes and procedures to ensure the models are consistently utilized, particularly at watershed and basin model boundaries, prior to using the models to analyze the effect of various water supply and demand projections, and assessing the benefits and performance of various adaptation strategies.

Table 2- Existing Hydrology Models (see below) summarizes the models and studies relevant to the proposed Basin Study and identifies how they will be used in the development of the Basin Study.

The three major objectives regarding how the models are proposed to be used in the Basin Study are:

1. To evaluate and utilize existing hydrologic models developed for the Salinas and Carmel Basins, and to leverage the investments made previously by the Partner agencies in these models.
2. To develop a process or model tool(s) for both the upper and lower Salinas basins which leverages data from the existing sub-basin models including the Paso Robles Basin and the Carmel Valley models and others as appropriate.
3. To apply the most recent Coupled Model Intercomparison Project Phase 5 (CMIP5) Global Climate Models (GCM

4. ) which are appropriately downscaled to provide climate change impact data to the models developed for assessing the effects to supplies and demands across the Basin Study area.

### 2.3.1 Hydrology Models

The proposed model framework for the Basin Study would include enhancing these models by ensuring consistency, particularly at basin boundaries, and use the output from these local models for its climate change impact analyses. Incorporated in these simulations will be the magnitude and frequency of known or anticipated water shortages and all natural and anthropogenic supply components. The shortages will be quantitatively analyzed and evaluated based on the magnitude and timing of shortages. Since the Basin Study will address water supply and the related effects of potential climate change on future water supply, it is essential to have models that can simulate all the known and anticipated supply and demand conditions for all types of water uses (agricultural, municipal and industrial, environmental needs, and recreation). The modeling tools will be used to determine imbalances under certain conditions of quantity and quality of water supplies. In particular, the effects from sea-water intrusion will be simulated using increased demands and sea-level rise conditions. The potential consequences of not addressing imbalances in supply and demand will be shown through tables, graphs, and other figures. Also additional sources of water that are currently not captured or reused will be identified.

Specifically, for the upper/lower Salinas Valley, the simulations will include connections to San Antonio, Nacimiento, and Salinas Reservoirs. A review of the existing models will include providing input on the code selection used to develop the models. For example, MF-OWHM rev 2 is ideally suited as it will include the new Reservoir linkage Process (SWOPS) that simulates the reservoir inflows, outflows, charges, and credits and demand driven releases of agriculture. This approach has already been successfully used by Reclamation and USGS for the Lower Rio Grande project Environmental Impact Statement which also includes an analysis of potential climate change impacts. Incorporating these reservoirs will allow an analysis of how this existing infrastructure and operations will perform in the face of changing water drivers, such as population increases, changes in agricultural demands, and other conditions.

Table 2. Existing Hydrology Models Developed by the Partners in the Salinas and Carmel Basins

| Basin Area | User | Supply (acre-feet) |
|---|---|---|
| CRB/SGB | 2006 Carmel River Flood Insurance Study and HEC-RAS<br><br>CRBHM GSFLOW (PRMS linked to MODLFOW) – to be developed in 2015/16<br><br>2014 Canyon Del Ray HEC-HMS & HEC-RAS<br><br>Seaside Groundwater Basin Model | Predict flood elevations/areas of inundation along Carmel River<br><br>Simulate Carmel River flow, reservoir storage, aquifer storage, diversions, water system operation<br><br>Predict flood magnitudes, elevations, and areas of inundation<br><br>Simulate groundwater flow and contours with variable inputs/outputs to basin |
| PRGB | 1991 Salinas Reservoir Expansion Feasibility Study<br><br>2012 Groundwater Management Plan<br><br>2014 Integrated Watershed/Groundwater Basin Computer Model Update (HSPF/Modflow) 2016 Model Refinement, and 2016 Supplemental Water Supply Options Study<br><br>http://www.slocountywater.org/site/Water percent20 Resources/Water percent20Resources/Water percent20Forum/ | Established PRGB sustainability objectives<br><br>Used the model to assess impacts to groundwater supply by:<br><br>• Repeating the 1980-2011 hydrology and reservoir operation information for the simulation period 2012-2040<br>• Applying "no growth" and "growth" future demand pumping estimates to establish baselines for strategy comparison and compare to basin level stability objectives<br>• Identified and tested management strategies with the model and compared the degree of benefit tradeoffs |
| SVB | Integrated Groundwater Surface Water Model, Calibrated Baseline model (scheduled for complation early 2016)<br><br>Groundwater elevation contours Pressure 180 ft and Eastside shallow aquifers 1994-2013<br><br>Groundwater elevation contours Pressure 400 ft and Eastside deep aquifers 1994-2013 | Basin Sustainability:<br><br>• Evaluate seawater intrusion on annual basis through 2030/buildout<br>• Evaluate groundwater level elevations on annual basis through 2030/buildout<br>• Evaluate total water demand on annual basis through 2030/buildout<br>• Assess climate change effects and combined effects of groundwater pumping and rising sea level on the location of the freshwater-seawater interface over time and develop projects of changes in seawater intrusion volume |

### 2.3.2 Select Studies Which Support the Basin Study

Several local programs are working towards creating a sustainable framework for managing water supplies and demands. Selected examples are included below.

#### *San Luis Obispo County Flood Control and Water Conservation District, Paso Basin Supplemental Water Supply Options Study*

The PRGB encompasses a 790 square mile area in the upper Salinas River watershed in Central California. The Paso Basin is the primary water supply for North San Luis Obispo County, providing water for agricultural, urban, and rural users. Water extraction from the Paso Basin has increased with the growth and expansion of both urban and rural populations and particularly with agricultural use. The “perennial yield” point of the Paso Basin has been reached where basin outflows are equal to or greater than basin inflows, and groundwater elevations have been declining.

The San Luis Obispo County Board of Supervisors adopted an urgency ordinance in 2013 and a permanent ordinance in 2015 requiring all new development and agriculture to offset new water usage at a 1:1 ratio by either providing a new water supply or conserving water equal to what will be used by the new development (under the permanent ordinance, the offset requirements are in effect until a groundwater sustainability plan is adopted). In addition, to help ensure the sustainability of the Paso Basin water supply, the SLOFCWCD initiated a feasibility study to identify sources of water supply that could be obtained to supplement the Paso Basin. The study examines in-basin water supplies, State water supplies, and recycled water supplies to prioritize options and make recommendations for short and long-term water supply planning

#### *Monterey Peninsula, Carmel Bay, and South Monterey Bay (Monterey Peninsula) Integrated Regional Water Management Plan (IRWMP or IRWM Plan)*

Integrated regional water management in California is designed to increase regional self-sufficiency in solving water management problems. It encourages local water resource managers to take a proactive role in collaboration with other area stakeholders, and to craft innovative and effective strategies towards achieving water management objectives.

The 2014 IRWM Plan Update for the Monterey Peninsula, Carmel Bay, and South Monterey Bay is an expansion and modification of a former plan, the Monterey Peninsula, Carmel Bay, and South Monterey Bay IRWM Plan which was adopted in 2007. The IRWM Plan seeks to coordinate the actions of stakeholder entities involved in water resource protection, enhancement, and management in the region. The IRWM Plan lead agency is the MPWMD. The MPWMD works to ensure that project proponents, stakeholders, and the general public are well informed of IRWM activities.

The Monterey Peninsula Regional Water Management Group (RWMG) is the “working group” that is ultimately responsible for the development and implementation of the IRWM Plan. It includes seven local agencies and organizations. The RWMG members are expected to actively participate in RWMG meetings and ensure public involvement in the decision-making processes. Broad stakeholder involvement ensures that the IRWM Plan identifies local issues and needs; that it promotes the formation of partnerships, and encourages coordination with State and Federal agencies.

Beyond the 2014 update, the RWMG will meet on an ongoing basis to implement the IRWM Plan and to continue IRWM planning. The IRWM Plan is a long-term planning document with a minimum 20-year planning horizon. It will undergo periodic updates and revisions to reflect changing conditions, and a review of the IRWM Plan may occur with each IRWM Plan project solicitation. The review would be consistent with DWR IRWM Guidelines, which DWR designed to be consistent with the California Water Plan, and would reflect any significant changes that are relevant to the Region.

### *North Monterey County Drought Contingency Plan*

The North Monterey County DCP (DCP) is proposed to be initiated in December of 2016 and is intended to be conducted in parallel and in coordination with the Salinas and Carmel Basin Study. The managing agency for the DCP is the MPWMD. The DCP Plan Area encompasses North Monterey County, including part of the Salinas Valley from the southern edge of the City of Salinas to the Pacific Ocean, the western portion of Carmel Valley, and the urbanized Monterey Peninsula area between the Salinas and Carmel valleys. Although the study area for the DCP is a much smaller sub-region of the Basin Study area, this DCP sub-region is critically impacted by drought as a result of competing demands between agricultural, ecological, and urban water-users. The urbanized areas within the DCP Plan Area include Carmel, Monterey, Pacific Grove, Seaside, Marina, Salinas, Del Rey Oaks, and the Castroville area.

Key water supply challenges in the DCP Area include: (1) negative impacts to regional surface waters and groundwater through agricultural and rangeland water runoff, tail water, and percolation; (2) the flood risk, river channel congestion, seawater intrusion, nitrate contamination, and the distribution of water supplies in the Salinas River watershed; (3) water reliability for the Monterey Peninsula which must develop new water supplies due to a CDO to reduce water diversion from the Carmel River and an adjudication to reduce groundwater pumping of the Seaside Groundwater Basin in order to reduce the threat of seawater intrusion; and (4) the decline of area steelhead fisheries.

Both the Basin Study and DCP will use data created under the locally sponsored Salinas River Groundwater Basin Investigation. This will provide synergy and consistency between the studies while meeting the near-term drought response actions and organization needs of the DCP and the long-term planning needs of the Basin Study. The DCP will focus on how to predict the different stages or levels of severity of drought. It will identify and address near-term vulnerabilities; as well as actions and activities to establish long-term resiliency to drought, reducing the need for response actions.

The DCP will outline drought response actions and activities that can be implemented quickly during a drought, and develop an operational and administrative framework for identifying who is responsible for undertaking the actions necessary to implement plan elements. The MPWMD is the lead agency and fiscal agent for the North Monterey County DCP and convener of the Plan Task Force (Task Force). The Task Force includes MPWMD, MRWPCA, MCWRA, and Monterey County Office of Emergency Services.

# Chapter 3 – Study Approach and Management

The Basin Study is unique given the large amount of information that has already been developed and the strong collaborative foundation that has been created even before the Basin Study is initiated. The emphasis of this study will be on understanding basin conditions under various climate change scenarios and developing a range of adaptation strategies which will mitigate or alleviate identified water supply and demand imbalances. The water management strategies which are identified in the Basin Study will be evaluated using quantitative performance metrics and other qualitative measures developed in the early tasks of the basin study's work program.

The Basins Study will involve evaluation of a number of adaptation strategies which will be proposed at one or more stakeholder and Study Team meetings. The adaptation strategies will be grouped under broad categories (or portfolios) which will aid their review. The portfolios will then be evaluated to document changes in supply and demand if they were to be implemented and the efficacy of the portfolios to address identified water supply imbalances. Following a rigorous trade-off analysis, the project Partners and basin stakeholders will identify which portfolios are projected to perform in the most cost-effective manner over the duration of the analysis period. The results of this analysis will be included in the Summary Basin Study Report. A detailed description work plan for the Basin Study follows in Section 4.

## 3.1 Basin Study Management Structure

The total funding needed for the Basin Study is projected to be $1.66 million. Reclamation will provide funding as the Federal share, and the non-Federal cost-share Partners will match this amount ($1.66 million) with in-kind services contributions. The non-Federal Partners' contributions are listed in Appendix B of this Plan of Study (POS). Appendix B may be updated from time to time to reflect changes proposed, including, for example, additional funding needed for the basin study or additional sources of in-kind contributions as they become known during the duration of the Basin Study preparation.

The four non-Federal Partners participating in the Basin Study with Reclamation represent diverse geographic, economic and demographic regions throughout the Salinas and Carmel Basins. The Partners involvement in the study process is crucial to the success of the Basin Study as they provide local knowledge and guidance throughout the study development process, including development of scenarios, assisting in formulating strategies and communicating important results. The Partners are particularly important in working with the Study Team to communicate information to and from stakeholders including municipal, industrial, agriculture, environmental interests, and others as the Basin Study progresses.

The proposed organizational structure of the Basin Study is represented in Figure 9 . The proposed structure should be regarded as dynamic and may be adjusted by Reclamation and the Partners to add or change representatives or technical staff as needed. The over-arching purpose of the study management structure is to ensure completion of the Basin Study in an effective, technically-sound, cost-efficient, and timely manner. The study management structure is designed to facilitate direct communication among participating stakeholders and to provide for efficient decision-making by the non-Federal Partners within the management structure created by the Study Team.

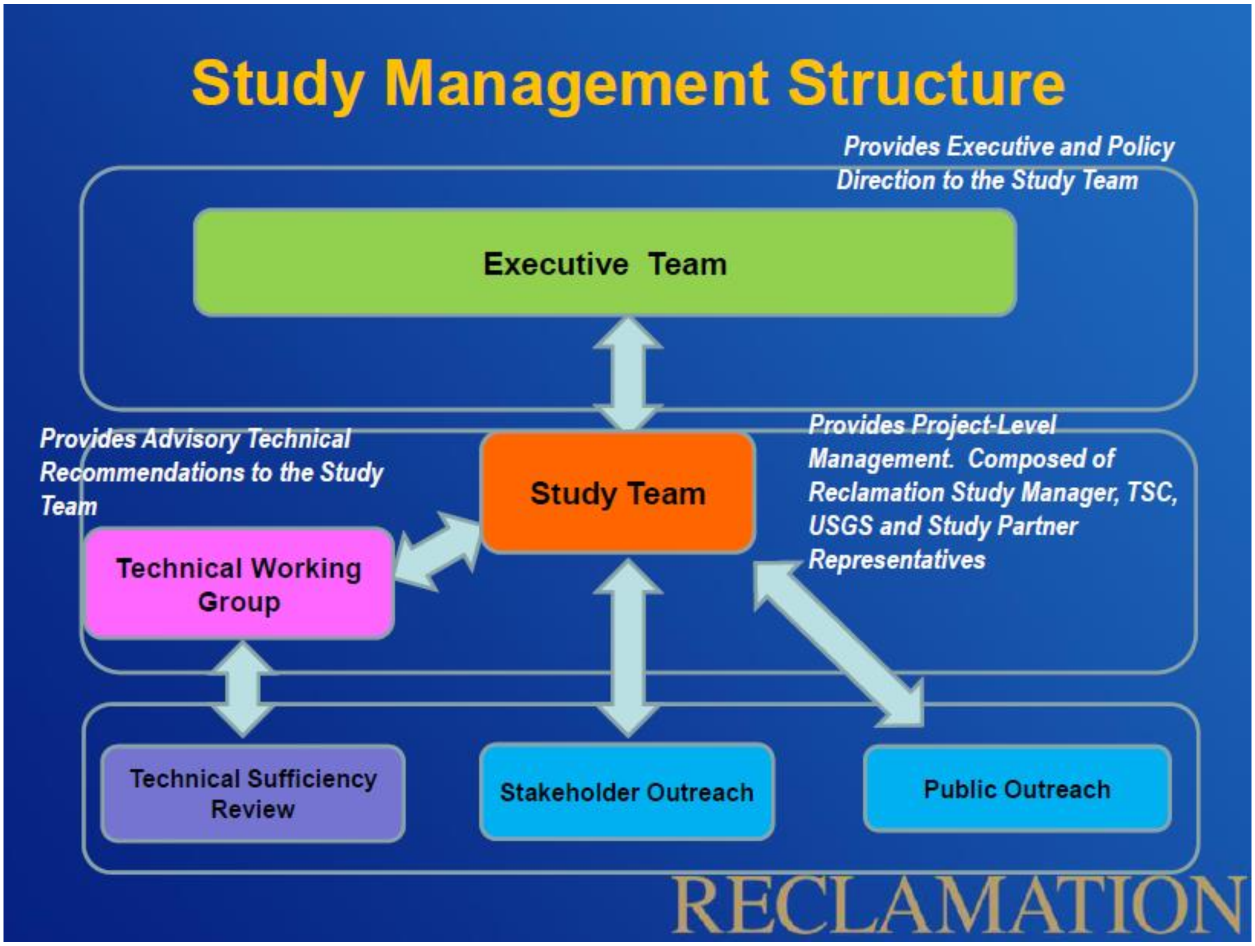


Figure 9. Basin Study Management Structure

## 3.2 Roles and Responsibilities of the Study Management Teams and Groups

### U.S. Bureau of Reclamation

Reclamation's Mid-Pacific Region will generally be responsible for overall management and completion of the Basin Study. Through an agreement with Reclamation's Technical Services Center in Denver and initiating work with a contractor and the USGS, Reclamation will ensure tasks identified in this POS are initiated and completed in a timely manner as guided by the overall Project Schedule. Reclamation's Project Manager will provide the day-to-day management of the Basin Study. Responsibilities of the Project Manager include acting as the executive manager of the Executive and Study Teams as well as maintaining regular communications between the Partners, Technical Working Group (TWG), Study Team, and Executive Team. The Project Manager, through the contractor, is also responsible for implementation of the Communication and Outreach Plan, and is responsible for organizing the technical sufficiency review (TSR) when Basin Study content has been prepared which warrants a review. Additional duties and responsibilities for Reclamation's Project Manager include maintaining required financial records, coordinating reports with Reclamation's Denver Policy Office, and working with the non-Federal cost-share Partners to provide periodic in-kind contribution reports to Reclamation when requested.

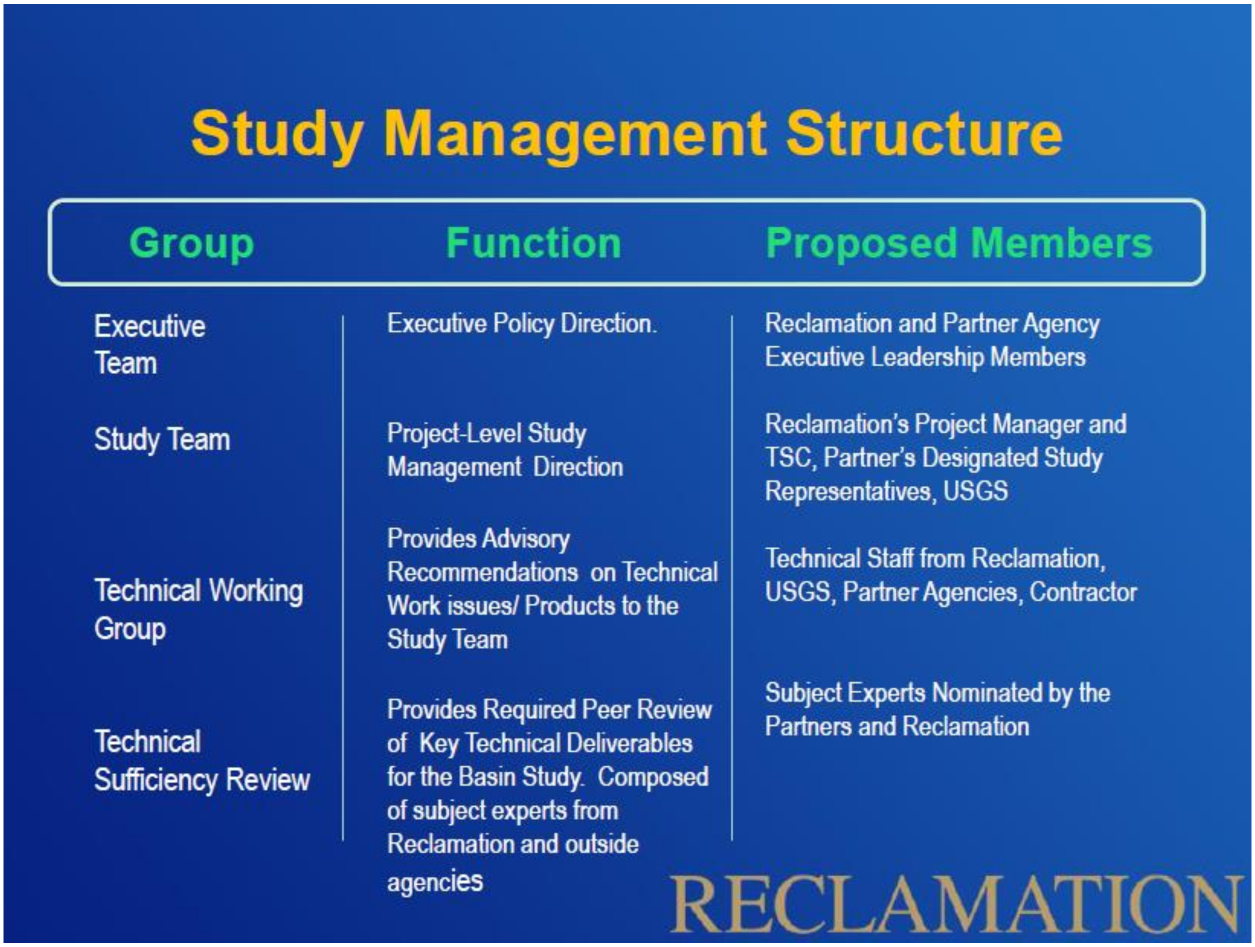


Figure 10. Basin Study Management Team Descriptions

### U.S Geological Survey

Reclamation will engage the USGS via an interagency agreement to assist in development of modeling and other technical work necessary for supporting the Basin Study. Specific tasks and assignments will generally be to coordinate the hydrology and climate model tools used in the Basin Study, and provide technical assistance to Reclamation and the non-Federal Partners as the Basin Study is developed. Other anticipated work with the USGS involves assisting in development of the climate scenarios, documentation of historical hydrology, and interpretation of modeling results. The detailed requirements for the USGS's work are identified in Appendix A.

## Executive Team

The Executive Team is composed of executive or policy-setting level representatives from Reclamation and each of the non-Federal cost-share partner agencies. The Executive Team determines all key and advanced policy issues (as may be elevated by the Project Manager) that may not be able to be resolved at either the Study Team or TWG level. The Executive Team also provides guidance on sensitive community and political issues and also provides interpretation of existing policies and preferences of participating Partner agencies.

This structure maximizes use of the experience and knowledge of the Executive Team members and provides a direct link to the Study Team and Project Manager to identify and resolve routine Basin Study issues as well as advanced policy, project direction, and Basin Study decision issues. The Executive Team will meet on an "as needed" basis as requested by the Project Manager and Study Team to provide direction on specific issues. Joint meetings between the Executive Team, TWG and other agencies may also be held from time to time on topic-specific issues and will be coordinated on an as-needed basis.

## Study Team

The Study Team is the primary Basin Study management and advisory group who will work closely with Reclamation's Project Manager to assist in the preparation of the Basin Study with Reclamation, USGS, and the non-Federal Partners. The Study Team provides guidance to Reclamation, USGS, Partners, and the contractor at key points in the preparation of the Basin Study. Composed of members from each of the four non-Federal Partner agencies, as well as the USGS and the contractor's team, the Study Team provides consistent direction and guidance and acts as a sounding board for ideas, information, and problem solving suggestions during the preparation of the Basin Study. The Study Team will meet regularly as identified in a meeting schedule which will be coordinated with the production of the Basin Study.

A charter for the Study Team will be prepared which is anticipated to include directives to the Study Team members to be open and inclusive, to consider alternative viewpoints and to employ a best science approach when considering how to resolve issues and problems. The Study Team generally operates by consensus under its charter and is expected to provide suggestions throughout development of the Basin Study, including when certain technical issues need to be referred to the TWG or elevated to the Executive Team.

## Technical Working Group

The TWG is formed to provide advisory technical recommendations to the Study Team and Project Manager. The TWG is composed of management-level or senior technical staff from Reclamation, the non-Federal cost-share partners and other agencies and organizations involved in water management in the Salinas and CRBs.

The Project Manager or Study Team may refer technical concerns or issues identified in the preparation of the Basin Study to the TWG for their review and recommendation. The TWG will generally operate by consensus. However, the TWG Charter provides that members of the TWG may provide a minority report. The Project Manager and TWG will provide status updates and inform the Project Manager and Study Team of any issues they should be aware of in their recommendations relating to the preparation of the Basin Study.

### Technical Sufficiency Review Team(s)

Reclamation's Directives and Standards require that all Basin Studies undergo a peer-level TSR prior to the Basin Study being transmitted by the Mid-Pacific Region's Director to the Director of Policy and Administration. Section 3.4 identifies how the TSR process will be managed as the Basin Study's technical memoranda are prepared. In general, Reclamation's Project Manager will be generally responsible for transmittal of the technical memoranda to the TSR team members. The TSR team members may be nominated by Reclamation, Study Partners, or others. The Project Manager will inform the Study Team of the proposed members of the TSR team.

The TSR team members will be contacted at the start of the Basin Study to determine if they can serve on the TSR. At the time of nomination, a general schedule will be provided to the prospective TSR team members which specifies when their particular TSR is anticipated to start. Two technically-qualified TSR members are desired to review each technical memoranda. The TSR team is anticipated to have different members for the various technical memoranda and will, therefore, have a flexible organizational structure which is agile and adaptive and can respond to changing conditions.

## 3.3 Change Management Plan

Change occurs on all projects as additional information is obtained and when conditions differ or change from those assumed during project scoping and as described in this POS. The procedures to be followed for documenting and executing change are described in this section.

A potential need for change in scope, schedule, and/or budget may be identified by members of the Study Team. Identified issues will be raised to the Reclamation Project Manager who will assess the relevance of the proposed change and develop a proposed approach for resolution. Minor adjustments that can be accommodated without affecting scope, schedule, and/or budget for major tasks may be approved by the Project Manager.

More significant changes that could affect scope, schedule, or budget for major tasks will be documented in a change justification memorandum which will be reviewed by Reclamation management. Where additional budget is needed, Reclamation Policy and Administration Office/Basin Study Program Analyst will also be contacted if additional budget is requested.

For any change request that is proposed by the Study Team and/or by the Basin Study Project Manager, an associated change justification memorandum will be prepared to document:

- The nature of the requested change (changes will be numbered and dated)
- Amount of budget impact, if any
- Length of schedule impact, if any
- Reason for change
- Associated impacts and risks

Change justification memorandums will be retained in the Basin Study's project records by the Project Manager and tracked through to completion. Upon approval of change requests by Reclamation, the Project Manager will update relevant project documents and will communicate the change to the Study Team members. A change justification memorandum that involves deviation from scope, schedule, or approved budget as set out in established in the Memorandum of Agreement (MOA) and POS will be documented in a memorandum from Reclamation's Regional Director (or his/her representative) to the Director, Policy and Administration. Budget or scope changes approved by Policy and Administration will be included in an amendment to the POS and MOA, as appropriate.

## 3.4 Risk Management Plan

New projects like the preparation of the Basin Study involve considerable uncertainties associated with developing new and unique model approaches, analyzing complex data, and developing various types of scenarios which represent potential future conditions. In undertaking the Basin Study, Reclamation and its Partners will make judgments about relevant uncertainties which result in varying types of risk to the project's budget, schedule, and scope. In project terms, a risk is an uncertain event or condition that, if it occurs, has an effect (usually negative) on one or more project objectives. The purpose of risk management plan is to establish a framework for identification of risks and development of strategies to mitigate or avoid those risks. The scope, schedule, and budget described in this POS provides the basis for developing a risk management approach.

The approach for the Basin Study will be to implement a process for the Study Team to proactively identify and assess various risks in order to implement mitigation strategies as early as possible. The most likely and highest impact risks will follow a mitigation process in which the risk is identified, accepted, removed via adjustment to the study framework, or mitigated utilizing a risk response. Risk management will generally involve the following steps:

- Include an agenda item for discussing risk at Study Team meetings.
- Document identified risks in the Basin Study's administrative records.
- Utilize the experience of the Study Team to review the history of similar projects in order to determine common risks and strategies used to mitigate those risks.
- For identified risks, the Project Manager will work with the Study Team members to assess probability and impact for each risk. This process will allow the Study Team to prioritize risks based on the effect they may have on the project.
- Risks determined to be most likely and to have the greatest potential impact will be reported to the Study Team and monitored during the time the project is exposed to each risk. Risk monitoring will be a continuous process throughout the term of the project.
- The Project Manager and the Study Team will develop responses to each identified risk. Responses may involve: avoidance (choose a different approach); mitigation (take action to reduce probability and/or impact); or acceptance (carry the risk and develop a contingency plan, if needed).

## 3.5 Technical Sufficiency Review Plan

Reclamation's Directives and Standards require that a basin study must undergo a TSR before it may be publicly released. In Section 3.2, the general process for nomination of the TSR team members is identified. This section outlines the approach and methods for reviewing technical information, data, models, analyses, and conclusions of the Basin Study in compliance with the Directives and Standards. The TSR plan involves:

- **Timing** – Individual reviews on each technical memoranda prepared for the Basin Study will be conducted at several steps, as reviewed with the Study Team, during preparation of the seven major study tasks, i.e., to correspond to key modeling and analytical phases of the work such as: (1) climate change and surface water analysis; (2) groundwater modeling and analysis; and (3) water resource management modeling.
- **Scope** – The TSR will focus on a review of the technical information, data, models, analyses, and conclusions as developed for each of the relevant study tasks. The volume and detail of information relevant for each phase of the TSR will vary in accordance with the specific content of the corresponding technical report/memorandum.
- **Process** – Reviews will be conducted largely through email transmittals of draft technical reports and associated data. Review comments will be requested within a specific time frame, as agreed to in advance with TSR reviewers, with the objective of maintaining progress and meeting schedule targets. Reviewers will also be requested to clearly identify and characterize scientific uncertainties and limitations. Comments received from reviewers will be recorded along with descriptions of how each comment was resolved, and any remaining technical uncertainties will be documented in the Final Basin Study Report. All results from the TSR will be documented and made available to Reclamation and the Study Team members. It is possible that previously completed peer reviews and/or comparable review processes completed by contractors and/or non-Federal parties may be sufficient for some portions of the Basin Study information and/or analyses; such reviews will be documented and, thereby, incorporated into the TSR record.
- **Number and Selection of Reviewers** – It is anticipated that two TSR reviewers will be designated for review of each technical memoranda prepared. If feasible, one reviewer will be from within Reclamation and one from outside Reclamation. Potential TSR reviewers with appropriate technical expertise and experience may be suggested by Study Team members. Individuals to be considered should not have been directly involved with conducting the specific analyses under review. The proposed composition of the TSR team will be confirmed by Reclamation and the Study Team.

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# Chapter 4 – Basin Study Work Plan

This section details the tasks that will be completed to achieve the Basin Study objectives (see Section 1.2) and describes the technical approach that will be used to complete each task. This section also describes the deliverable (work product) to be completed for each task and outlines the roles and responsibilities of each partner under each task, including Reclamation, USGS, and non-Federal study Partners, as well as a contractor to be retained by Reclamation.

In addition to the Basin Study, MPWMD is developing a DCP for northern Monterey County. The DCP is being led by MPWMD, with financial support from Reclamation and with technical participation from MCWRA, MRWPCA, and other local entities. The DCP encompasses a portion of the Basin Study area in the northern Salinas Valley and Monterey Peninsula. The DCP and Basin Study are being developed in tandem in order to leverage data, methods, and modeling tools between the two studies, including future climate scenarios and corresponding projections of future water supplies and demands.

Developing the studies in tandem will also improve stakeholder outreach, as the stakeholder groups for the two studies are anticipated to overlap. The Summary Work Plan, provided below in Section 4.2, includes a brief description of where information developed in each Basin Study task will be shared with the DCP, or where information from the DCP will be shared with the Basin Study.

## 4.1 Basin Study Requirements

A basin study must include four key elements, as detailed in the Reclamation Manual Directives and Standards WTR TRMR-65[3]. These elements include:

- Projections of future water supply and demand, considering specific impacts resulting from climate change, including any risk related to changes in snowpack; changes in the timing and quantity of runoff; changes in groundwater recharge and discharge; and any increase in the demand for water or the rate of reservoir evaporation as a result of increasing temperatures.
- Analysis of how existing water and power infrastructure and operations will perform given any current imbalances between water supply and demand, and in the face of changing water realities due to climate change (including extreme events such as floods and droughts) and population growth. Analysis must consider the extent to which changes in water supply will impact Reclamation operations and facilities, including: water deliveries; hydropower generation; recreation; fish and wildlife habitat; species or habitats protected under the ESA; water quality; flow-dependent ecological resiliency; and flood control.

[3] Reclamation Manual Directives and Standards (D&S) WTR TRMR-65 establishes the Bureau of Reclamation's requirements for reviewing, conducting, and approving Basin Studies under the WaterSMART (Sustain and Manage America's Resources for Tomorrow) Basin Study Program. D&S WTR TRMR-65 is available at the following URL: http://www.usbr.gov/recman/temporary_releases/wtrtrmr-65.pdf

- Development of appropriate adaptation and mitigation strategies to meet current and future water demands. Adaptation and mitigation strategies may include, but are not limited to, modification of existing reservoir or operating guidelines; new management, operating, or habitat restoration plans; water conservation and demand reduction strategies; new water infrastructure; new or improved models and decision support systems; and monitoring plans and data acquisition to support future analysis.
- Quantitative or qualitative trade-off analysis of identified adaptation and mitigation strategies. Trade-off analysis must examine proposed strategies in terms of their ability to meet the study objectives, the extent to which they minimize imbalances between water supply and demand and address the possible impacts of climate change, the level of stakeholder support, the relative costs (when available), the potential environmental impacts, and other attributes common to the strategies.

## 4.2 Summary Work Plan

The Basin Study will address the four required Basin Study elements through eight technical tasks. These tasks are outlined below and detailed in Sections 4.1-4.8. The technical approaches, study partner roles and responsibilities, and deliverables for each task are discussed below and summarized in Appendix A, Basin Study Task Assignment Table. A schedule for each task is included in Section 5, along with a table which includes projected budgets for each Task for each agency participating in the Basin Study.

Tasks 1-7 will each be documented in a technical memorandum to be prepared by the contractor with assistance from the USGS and Reclamation. Results from Tasks 1-7 will then be compiled and summarized in a final Summary Basin Study which includes an Executive Summary. Technical memoranda will undergo TSR as outlined in Section 3.4. The final study report and executive summary will undergo TSR as outlined in Section 3.4 and as further determined by Reclamation and the Study Team.

### Task 1: Develop Study Metrics

Task 1 will define a suite of metrics to quantify and characterize current and future climate conditions and water supplies, demands, and operations in the study area. Water supply and demand metrics will address timing and quantity of runoff and reservoir outflow; groundwater recharge, discharge, and aquifer levels; crop evapotranspiration and net irrigation requirement; indoor and outdoor municipal water use; reservoir evaporation rates; and other relevant supply and demand metrics identified by the study partners. Water operations metrics will address the quantity and reliability of surface water and groundwater deliveries, flood control, and hydropower generation, along with metrics or indicators associated with recreation, fish and wildlife habitat, species or habitats protected under ESA, water quality, and flow-dependent ecological resiliency.

***DCP Interface***

*Water supply, demand, and operations metrics developed for the Basin Study will be shared with the DCP, and vice versa, to facilitate consistency between the studies.*

### Task 2: Characterize Climate Change and Sea Level Rise

Task 2 will characterize historical and projected variability and trends in climate and sea level within the study area based on paleoclimate data, historical observations, and projections of future climate and sea levels. Analysis of climate will focus on aspects of climate variability and change that are likely to impact water supplies, demands, and operations in the study area, including, but not limited to, precipitation, temperature, and humidity. Analysis of sea level will focus on changes in mean sea level, with limited analysis of tidal fluctuation and storm surges. Analysis will consider climate and sea level projections from multiple GCMs and emissions scenarios, and may consider multiple downscaling methods.

***DCP Interface***

*Initial work for the DCP will use available data to characterize climatic and hydrologic variability over the DCP study area, including droughts. Additional data and information regarding historical and projected climate and hydrology will be developed by the Basin Study and incorporated into the DCP when available.*

### Task 3: Develop Study Scenarios

Task 3 will develop the set of planning scenarios that will be used to evaluate water supplies, demands, and operations under current and future conditions. Each scenario will represent the broad spectrum of factors that affect water supplies, demands, and operations, including physical factors such as climate and sea levels as well as socioeconomic factors such as population and per capita water use; industrial water use; agricultural practices, including cropping and irrigation patterns; and land use change throughout each sub-area. A baseline scenario will be developed to represent current climate, sea level, and socioeconomic conditions within the study area consistent with conditions in the year 2015. A suite of future scenarios will be developed to represent the range of projected changes in climate, sea level, and socioeconomic conditions within the Salinas Basin and CRBs. Future climate scenarios will be based on projections of climate change (Task 2) and corresponding projections of sea level rise. Future socioeconomic scenarios will be developed consistent with existing projections of population, land use, and other socioeconomic factors developed by the study partners as part of other recent or concurrent planning efforts. Future scenarios will represent transient changes in climate, sea level, and socioeconomic conditions through the end of the 21st century.

***DCP Interface***

*The Basin Study will leverage existing data and projections of population, land use, and other socioeconomic factors compiled and/or developed for the DCP, as applicable.*

### Task 4: Develop Modeling Tools and Inputs

Task 4 will develop the modeling tools and related input datasets that will be used to evaluate current and future water supplies, demands, and operations. Hydrologic and/or water operations models will be developed for each sub-area of the study area (see Section 1.1). Default (historical) model input datasets will then be modified to represent projected changes in climate, sea level, and socioeconomic conditions under each scenario considered in the Basin Study (see Task 3). Where applicable, Task 4 will leverage existing modeling tools and datasets developed by the study partners as part of other recent or concurrent efforts.

***DCP Interface***
*The DCP will leverage modeling tools and input datasets developed for the Basin Study, as applicable.*

### Task 5: Evaluate Water Supplies, Demands, and Operations (No Action Scenario)
Task 5 will evaluate and characterize water supplies, demands, and operations under current and future conditions in the absence of any change in surface water or groundwater management, i.e., assuming no change in water resources infrastructure or operations within the study area, often referred to as the No Action Alternative. The models and inputs developed in Task 4 will be used to simulate current and future conditions within each sub-area. Study metrics will then be calculated from model results to characterize current and future supplies, demands, and operations and to evaluate potential risks from climate change, sea level rise, and socioeconomic factors.

***DCP Interface***
*In addition to observed historical climate and hydrology data, the DCP will utilize simulations of current and future water supplies, demands, and operations developed for the Basin Study in evaluating drought risks and vulnerabilities within the DCP area, as applicable.*

### Task 6: Develop Adaptation and Mitigation Strategies
In Task 6, study partners will work together and with local stakeholders to identify adaptation and mitigation strategies to address current or projected imbalances in supplies and demands in the study area. Adaptation and mitigation strategies may include, but are not limited to, changes to the operation of existing infrastructure, development of new infrastructure, and/or water conservation and demand reduction measures. Where applicable, Task 6 will leverage strategies and alternatives developed by the study partners and/or local stakeholders as part of other recent or concurrent efforts.

***DCP Interface***
*The Basin Study will consider drought-related projects, actions, and strategies identified and evaluated by the DCP as potential adaptation strategies in Task 6 of the Basin Study, as applicable.*

### Task 7: Evaluate Adaptation and Mitigation Strategies
In Task 7, the Study Team will evaluate selected adaptation and mitigation strategies. Strategies developed in Task 6 will undergo initial review and screening, potentially including initial analysis based on simulation results from Task 5 and simplified representation of a given strategy. Selected strategies will then be evaluated in detail using the modeling tools developed in Task 4.

Strategies will be simulated by modifying the configuration of modeling tools and/or input datasets to represent water resources infrastructure and operations under proposed strategies, or by post-processing model outputs to represent proposed strategies. Study metrics will then be calculated from the model results and compared to study metrics from the No Action model results (Task 5). A bracketing approach will be used to evaluate uncertainties regarding future climate and socioeconomic conditions.

***DCP Interface***

*The DCP will conduct preliminary analysis of drought-related projects, actions, and strategies identified by the DCP; the Basin Study will leverage this preliminary analysis to streamline the initial review and screening of adaptation and mitigation strategies as part of Task 7. The Basin Study will then carry out detailed modeling and evaluation of selected strategies; the DCP will leverage modeling tools and analysis of selected strategies, as applicable.*

### Task 8: Prepare Basin Study Report

Finally, results from Tasks 1-7 will be compiled and summarized in a final study report and executive summary. Technical memoranda detailing the data, methods, and results of each previous task will be included as appendices to the final study report.

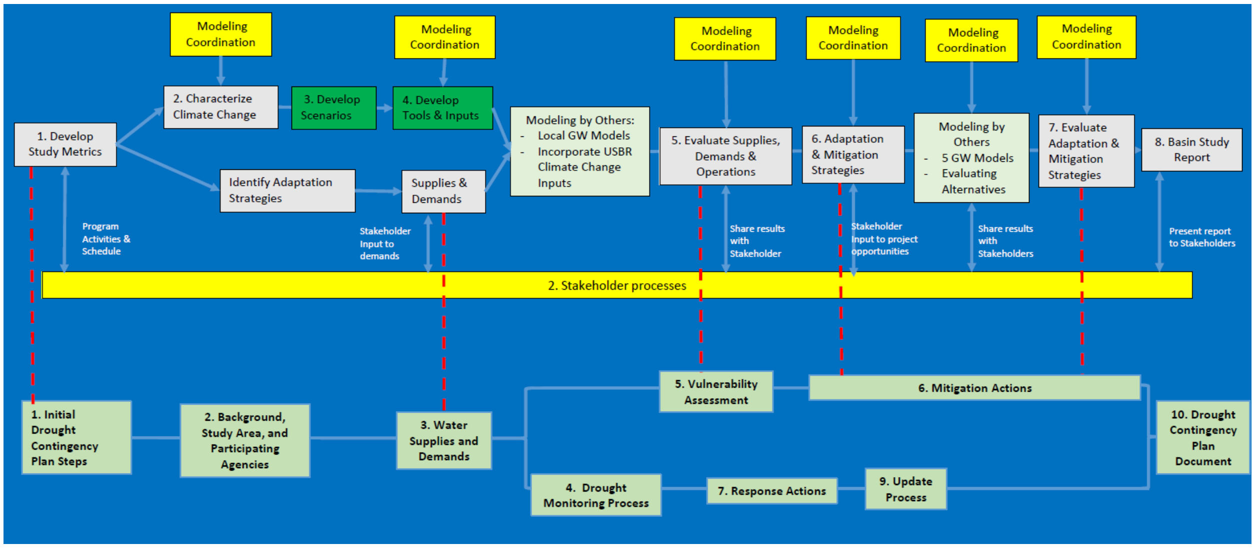


Figure 11. Relationship Diagram for the Salinas- Carmel Basin Study and the Monterey DCP

## 4.3 Detailed Work Plan

### Task 1: Develop Study Metrics

In order to meet the study objectives of evaluating current and future water supplies, demands, and operations, the Study Team, with support from the TWG, will first define a set of metrics to quantify and characterize conditions within the study area. For the purposes of the Basin Study, a metric is a measure, statistic, or indicator that can be used to quantify and/or characterize relevant conditions, as well as changes in those conditions, in response to climate variability and change, and in response to changes in socioeconomic drivers, water management practices, or other factors.

Quantitative metrics will be developed to characterize current water supplies and demands and to assess specific impacts from climate change, including risks related to changes in timing and quantity of runoff and streamflow including flood risk associated with extreme runoff events; changes in groundwater recharge, reservoir outflow, discharge, storage, and aquifer levels; changes in site-specific groundwater criteria such as seawater intrusion, land subsidence, streamflow capture, or water quality degradation; and increases in water demand or reservoir evaporation rates as a result of increasing temperatures.

Quantitative metrics will also be developed to characterize current and future operations, including water deliveries and flood control (including tidal gates and inundation from storm surge and sea-level rise). Additional quantitative or qualitative metrics will be developed to characterize current and future hydropower generation; recreation; fish and wildlife habitat; endangered, threatened, or candidate species and/or designated critical habitat; and water quality. Metrics will be developed for each sub-area, and metrics may differ between sub-areas due to differences in water supplies, demands, and operations throughout the Basin Study area.

The Study Team and TWG will consider key components of water supply and demand in developing the study metrics for each sub-area, including, but are not limited to:

- Surface water supply
- Groundwater supply
- Reclaimed (recycled) water supply
- Agricultural water demand (crop evapotranspiration and/or net irrigation requirement)
- Indoor municipal water demand
- Outdoor municipal water demand
- Industrial water demand
- Environmental water demand

In addition to key components of supply and demand, the Study Team and contractor will define metrics to characterize imbalances between water supply and demand. For the purposes of the Basin Study, the term ***imbalance*** refers to two general situations:

- **Water supply deficit**, defined as situations where the quantity, quality, timing, and/or location of available water supplies is not sufficient to meet water demands.
- **Water supply excess**, defined as situations where the quantity of available water supply at a given time and location exceeds corresponding water demands and available water storage capacity.

Imbalances depend on the relative magnitudes of supply and demand within a given sub-area. Imbalances also depend on the ability of water resources institutions, infrastructure, and management practices to convey available water supplies to beneficial uses, as well as to control excess supplies to avoid flooding and other adverse impacts. It is important to note that water supply deficits and excesses may occur simultaneously within a given sub-area.

For example, high runoff in one part of the sub-area may result in water supply excess. These could include reservoir spills, excess outflow from the sub-area, and/or localized flooding. Meanwhile, water supply deficits may occur in another part of the sub-area due to a lack of infrastructure to capture and convey water to the locations where water is needed.

It is also important to note that water supply deficits and excesses are often transient in nature. For example, a given sub-area may experience regular and recurring water supply excesses or deficits on a seasonal basis, e.g., excesses during the wetter winter season and deficits during the drier summer season. Similarly, a sub-area may experience water supply deficits that persist multiple seasons or years during severe drought events, with no deficit under normal conditions. The metrics developed for this study will allow for consideration of the frequency, duration, and magnitude of water supply deficits and excesses in each sub-area.

Water operations metrics will consider primary operating objectives within the basin. Surface water metrics will focus on the reliability of surface water deliveries, flood control and management, and reliability of meeting target environmental flows, along with other objectives identified by the Study Team and TWG.

Water operations metrics may also consider indicators related to groundwater management and aquifer conditions, such as groundwater elevations at specified locations, frequency of groundwater levels falling below target elevations, and indicators related to sea water intrusion in coastal aquifers. As noted above, study partners will identify additional quantitative or qualitative metrics to characterize important conditions in the basin that are affected by water operations, including hydropower generation; recreation; fish and wildlife habitat; ESA species and critical habitat; and water quality.

Metrics will ultimately be used to evaluate potential impacts of climate, sea level, and socioeconomic changes on water supplies, demands, and operations. For example, metrics characterizing water supply deficits will be used to identify where adaptation and mitigation strategies are needed to meet current and future water demands. Metrics characterizing water supply excesses, in turn, will be used to identify areas where excess water may be available and thus where there may be opportunities for adaptation and mitigation strategies to capture and/or convey excess water to alleviate water supply deficits.

#### *Roles and Responsibilities*

Reclamation and USGS will identify metrics to characterize climate conditions within each sub-area and throughout the Basin Study area, with input and review from the contractor and non-Federal study partners. Reclamation, supported by USGS and the contractor, will work with local study partners to identify metrics to characterize water supplies, demands, and operations relevant to each sub-area. Reclamation will prepare a brief technical memorandum describing the study metrics; USGS, the contractor, and all non-Federal partners will review the technical memorandum.

#### *Task 1 Deliverable*

Task 1 will be documented in a brief memorandum defining the metrics that will be used to quantify and characterize water supplies, demands, and imbalances in each sub-area. Reclamation and the contractor will develop an outline and template for the Task 1 technical memorandum. The memorandum will then be prepared by the contractor and reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14[4] and the TSR plan

[4] Reclamation Manual Policy CMP P14 establishes Reclamation's policy for review of scientific information. Policy CMP P14 is available from the following URL: http://www.usbr.gov/recman/cmp/cmp-p14.pdf

(see Section 3.4). The draft memorandum, review comments from each study partner, and final memorandum will be included in the study's administrative record.

### Task 2: Characterize Climate Change and Sea Level Rise

Projections of water supplies and demands under future climate conditions are a required element of all Basin Studies. Weather and climate are two of the primary drivers of water supply and demand. Reclamation, with support from the TWG, will, therefore, evaluate and characterize historical and projected variability and trends in weather and climate over the study area as the first step in evaluating future water supplies and demands.

Analysis will focus on climate variables that are most likely to affect water supplies and demands, including, but not limited to, precipitation, temperature, and humidity. Historical and current climate conditions over the study area will be characterized based on a combination of weather station records and a gridded observational dataset.

In addition to historical and current climate conditions, historical and current hydrologic conditions will be characterized based on available streamflow and groundwater records, including relationships between climate and hydrologic variability within the Basin Study area. Paleoclimate data, including reconstructions of historical climate and streamflow, will also be evaluated to characterize long-term climate and hydrologic conditions in study area. Projected changes in climate conditions over the 21st century will be analyzed based on an ensemble of downscaled global climate projections. Climate projections analyzed in Task 2 will subsequently serve as the basis for developing future climate scenarios in Task 3.

Current weather and climate will be characterized based on the 30-year period from 1980-2010. Historical climate variability, including decadal variability and multi-decadal trends, will be characterized based on the period of record of available weather and climate datasets for the basin. Historical data will be obtained for weather stations within the study area, including but not limited to weather stations from the California Irrigation Management Information System, Remote Automated Weather Stations, and National Weather Service Cooperative Observer Network observation networks. In addition to weather station data, streamflow and groundwater data will be compiled in order to characterize hydrologic conditions and relationships between climate and hydrologic variability within the study area.

Analysis will include consideration of large-scale climate and hydrologic teleconnections, including relationships between climate and hydrologic variability and standard indices of the El Niño-Southern Oscillation and the Pacific Decadal Oscillation. Weather station, streamflow, and groundwater elevation data will be reviewed for quality assurance and corrected as needed prior to use in analysis. In addition to station data, a high-resolution gridded observational dataset will be used to characterize spatial and temporal variability over the study area.

Several gridded observational datasets are available that encompass the study area; a gridded dataset will be selected for use in this study based on the spatial and temporal resolution, period of record, and climate variables included in the dataset. Several observational datasets will be considered for analysis, including the PRISM dataset developed by Daly et al. (2008), the METDATA dataset developed by Abatzoglou et al. (2012), and the gridded climate datasets developed by Maurer et al. (2002) and by Livneh et al. (2013), respectively.

Analysis of future climate conditions will consider projected climate change over the study area for the period 2015-2100. Analysis will be based on an ensemble of downscaled global climate projections from the CMIP5 Multi-Model Dataset (Taylor et al. 2012). CMIP5 is a large-scale effort by the international climate science community to coordinate a set of global climate model simulations.

The primary objectives of CMIP5 are to improve scientific understanding of the global climate system and to provide projections of future climate change for use in evaluating climate change impacts by scientists, policy makers, and decision makers (Taylor et al. 2012, Intergovernmental Panel on Climate Change (IPCC) 2013 [Physical Science]). CMIP5 simulations of 20th century climate and projections of 21st century climate served as the primary scientific basis for the IPCC Fifth Assessment Report and constitute the most current resource for global climate projection information.

The CMIP5 Multi-Model Dataset includes simulations of 20th century climate and projections of 21st century climate from a total of 61 GCMs from 27 modeling centers representing 15 different countries (PCMDI 2015). Simulations were carried out with state-of-the-art GCMs that simulate the physical processes governing large-scale weather and climate, including processes and interactions between the atmosphere, ocean, land, and cryosphere.

GCMs were used to simulate weather and climate conditions under different scenarios representing historical and projected atmospheric compositions, including one scenario based on observed historical greenhouse gas and aerosol concentrations over the 20th century and several scenarios representing a range of plausible trajectories of atmospheric composition over the 21st century.

GCM simulations require substantial computer resources. Due to computational constraints, GCM simulations in the CMIP5 Multi-Model Dataset were run at relatively coarse spatial resolution, with model grid cells typically on the order of roughly 150km north-south by 150km east-west over North America.

Local weather and climate conditions, by contrast, exhibit substantial variability over a distance of 150 km due to variations in topography, land cover, and many other factors that affect local climate. As a result, the spatial resolution of GCMs is too coarse to use in most regional or basin-scale analyses. Applying GCM-based climate projections to support regional and basin-scale planning and decision making thus requires that GCM results are downscaled to finer spatial resolutions (Wood et al. 2004, Fowler et al. 2007, and IPCC 2013).

Numerous methods have been developed to downscale coarse-resolution GCM projections to finer spatial resolutions for local and basin-scale analysis, planning, and decision making. Downscaling methods fall into two broad categories: dynamical methods and statistical (non-dynamical) methods. Dynamical downscaling methods use finer-resolution regional climate models (RCM) to simulate the local-scale atmospheric response to global climate change.

The RCM is nested inside the GCM over a selected region; the RCM then simulates weather and climate conditions over the selected region at a finer resolution that is more applicable to a planning and decision making. Statistical (non-dynamical) downscaling methods rely on relationships between observed (historical) large-scale and finer-scale weather and climate conditions. These relationships are applied to the large-scale GCM results to develop GCM-based projections at the finer spatial scale.

Three options will be considered to obtain downscaled climate projections for the study area:

- Statistical downscaling – Bias Correction and Spatial Disaggregation (BCSD) Method
- Statistical downscaling – Multivariate Adaptive Constructed Analogs (MACA) Method
- Statistical downscaling – Localized Constructed Analogs (LOCA) Method

All three options rely on existing datasets of statistically-downscaled GCM projections. The BCSD dataset (Maurer et al. 2007, Reclamation 2013), MACA dataset (Abatzoglou et al. 2015), and LOCA dataset (Pierce et al. 2015) were developed by statistically downscaling GCM projections from the CMIP5 Multi-Model Dataset to finer spatial resolution over the continental United States. The BCSD dataset provides monthly values of projected precipitation and temperature for the full 21st century; the MACA and LOCA datasets provide daily values of projected precipitation, temperature, humidity, and other atmospheric variables for the full 21st century.

BCSD projections are provided at a grid resolution of 1/8° latitude by 1/8° longitude (approximately 12 km by 12 km); MACA projections are provided at a grid resolution of 1/24° latitude by 1/24° longitude (approximately 4 km by 4 km); and LOCA projections are provided on at a grid resolution of 1/16° latitude by 1/16° longitude grid (approximately 6 km by 6 km). The BCSD downscaling method uses a quantile-mapping bias correction[5] approach to remove GCM biases, followed by a simple mapping technique to spatially disaggregate GCM projections to finer resolution.

By contrast, both the MACA and LOCA downscaling methods utilize a constructed analog[6] approach to relate coarse-resolution GCM projections to finer-resolution weather and climate conditions. Both the MACA and LOCA datasets also incorporate bias correction of GCM projections prior to downscaling. The MACA and LOCA datasets differ primarily in the statistical procedure by which analogs are constructed, as well as the gridded observational dataset used to construct daily analogues.

Each dataset contains a large number of individual projections from different GCMs and emissions scenarios; the BCSD dataset also contains multiple projections from a given

[5] For the purpose of this Basins Study, the term *bias correction* refers to the use of a statistical procedure to adjust GCM projections to remove differences between the probability distributions of simulated and observed climate conditions.

[6] The constructed analogs approach involves identifying a set of observed daily climate patterns at the GCM resolution such that a weighted linear combination of observed daily patterns closely approximates the bias corrected GCM pattern. For any given day in the GCM record, downscaling is achieved based on the corresponding weighted linear combination of observed daily conditions at the target downscaling resolution. See Hidalgo et al. (2008) and Reclamation et al. (2013) for additional details.

combination of GCM and emissions scenario, where projections differ only in the GCM's initial condition at the start of the projection. The Basin Study will compare projected climate change between the three downscaled datasets to evaluate uncertainties in future projections resulting from different downscaling methods. Reclamation, in coordination with the TWG, will then select one dataset as the basis for analysis of future water supplies and demands for this study.

The Basin Study will consider all projections in the selected dataset in order to characterize uncertainty in projected future climate conditions. It should be noted that secondary downscaling will be applied to the selected dataset in Task 4 to develop model inputs for the CRB, MPW, and SVB sub-area models. Secondary downscaling is needed to develop future climate inputs at the spatial resolution of the hydrologic models that will be used in this study.

Analysis of sea levels will be based on historical observations and projections of sea level for the central coast of California. Analysis of historical trends will be based on records from a network of tidal gages along the California coast. The National Oceanic and Atmospheric Administration operates and maintains a network of more than 15 tidal gages along the California coast, including one gage located in Monterey Bay. Observed tidal gage records will be analyzed to characterize recent variability and trends in sea levels along the central coast of California.

Analysis of sea level projections will consider projections from empirical models (NRC 2012) and from process-based dynamical models (IPCC 2013 [Physical Science Basis]). Analysis will characterize the range of projected change in mean sea level along the central coast region. Projected changes in sea level variability, including storm surges, will be considered qualitatively based on a review of recent scientific literature.

#### *Roles and Responsibilities*

Local study partners will provide Reclamation with any historical weather, climate, or sea level data that the partner agencies typically use for planning and/or management purposes. In addition to data provided by the partners, Reclamation will obtain a gridded observational climate dataset and available sea level data for the study area. Reclamation will also obtain climate projections for the study area from the datasets discussed above.

Reclamation will then characterize historical and projected climate conditions based on the climate metrics defined in Task 1, including historical and projected averages, seasonal and inter-annual, and long-term trends. USGS, the contractor, and non-Federal partners will provide input and review through the TWG regarding data selection and statistical methods to characterize historical and future climate.

#### *Task 2 Deliverable*

Task 2 will be documented in a technical memorandum detailing observed and projected changes in climate over the study area. The Task 2 memorandum will be prepared by Reclamation and reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14 and the TSR plan (see Section 3.4). The draft memorandum, review comments, and final memorandum will be included in the Basin Study's administrative record.

### Task 3: Develop Study Scenarios

In order to evaluate water supplies, demands, and operations under current and future conditions, the Study Team, with coordination and support from the TWG, will develop a set of planning scenarios representing the broad range of factors that affect water supplies and demands in the study area, including factors related to climate, sea level, and socioeconomic conditions. One baseline scenario will be developed to represent current climate and sea level conditions in the study area. This task will also be conducted in a way that meets Groundwater Sustainability Plan regulations if reasonably feasible.

A suite of future scenarios will be developed to represent the range of projected changes over the 21st century. Future climate and sea level scenarios will be developed based on projections analyzed in Task 2. Future socioeconomic scenarios will be developed to reflect a range of potential population, per capita water use, industry, agricultural practices, and land uses in the basin. A total of five future climate scenarios, five future sea level scenarios, and three future socioeconomic scenarios are anticipated for this Basin Study.

Developing and analyzing multiple scenarios is a widely used approach to planning and decision-making in situations characterized by a high level of uncertainty, where it is not possible to accurately predict the most likely set of future conditions. Future water supplies and demands will depend on a broad range of factors, including future weather and climate conditions, sea levels, population and demographics, agricultural cropping and irrigation practices, commercial and industrial development, and changes in land use, among others. The evolution of each of these factors over the 21st century is highly uncertain.

When faced with such uncertainty, planners and decision makers commonly consider a suite of scenarios that represent a range of plausible and equally likely future conditions, rather than attempting to predict the actual or most likely trajectory of future conditions. By considering a broad range of scenarios, planners and decision makers can address relevant “what if” questions and develop robust and effective strategies despite large uncertainty in future conditions.

Future climate conditions, for example, will depend on future emissions of greenhouse gases and aerosols. Future emissions, in turn, will depend on a number of factors, including regional and global demographics, technological and socioeconomic developments, and potential national and international efforts to limit or reduce emissions. The evolution of future emissions is thus highly uncertain (IPCC 2000 [SRES Summary]).

As a result, it is not possible to accurately predict the actual or most likely trajectory of future emissions, i.e., the quantity of emissions each month or year over the next century. Instead, the climate science community has developed a suite of emissions scenarios (IPCC 2000 [SRES Summary]) and representative concentration pathways (van Vuuren et al. 2010) that represent “alternative images of how [future emissions] might unfold” (IPCC 2000 [SRES Summary]).

GCMs are then used to develop projections of future climate under a range of different emissions scenarios, where each emissions scenario or representative concentration pathway is considered equally likely.

Three types of scenarios will be developed for the Basin Study: climate scenarios, sea level rise scenarios, and socioeconomic scenarios. Climate scenarios will specify transient (time-varying) sequences of precipitation, temperature, and other climate variables relevant to water supplies and demands. Climate scenarios will be used to develop inputs to hydrology and water operations models in order to simulate future surface-water and groundwater supplies, demands, and management within each sub-area (see Tasks 4-5). Similarly, sea level scenarios will specify transient sequences of sea levels, and will be used to develop inputs to groundwater models of coastal aquifers (e.g., Seaside Groundwater Basin).

Because changes in global sea level are strongly linked to global mean temperature, each sea level scenario will be paired with a corresponding climate scenario. Socioeconomic scenarios will specify transient sequences of population, land use, commercial and industrial conditions, irrigated acreage and cropping patterns, and other non-climate factors that affect water demand and use within the study area. Similar to climate scenarios, socioeconomic scenarios will be used to develop inputs to hydrology and water operations models in order to simulate water supplies, demands, and management under current and future conditions.

In order to ensure that projections of future water supplies, demands, and operations are carried out consistently across the four sub-areas within the Basin Study area, the Study Team, with coordination and support from the TWG, will develop a common set of scenarios for the Basin Study. In particular, climate and socioeconomic scenarios will represent spatial and temporal changes, including long-term trends, specific to each sub-area, but will be based on a common set of climate projections and common set of assumptions regarding future socioeconomic trends, respectively.

#### *Baseline Scenarios*

Baseline scenarios will be developed to represent conditions consistent with the 2015 water year. The baseline socioeconomic scenario will essentially represent a snapshot in time consistent with water demands and uses for the year 2015. The baseline socioeconomic scenario will be developed from the best available data regarding population, municipal and industrial water demands, agricultural cropping and irrigation practices, and other socioeconomic factors that affect water demand and use within the study area. Similarly, the baseline sea level scenario will be developed based on the best available data regarding average sea level adjacent to the study area during the year 2015.

The baseline climate scenario, by contrast, will represent time-varying weather and climate conditions, with the general characteristics of weather and climate, e.g., monthly and seasonal averages and inter-annual variability, consistent with recent historical conditions over the period from approximately 1975-2015. Observations from outside this period may be included to provide a longer period of record for the baseline climate scenario; where historical observations exhibit significant trends, trends may be removed to ensure consistent climate conditions over the duration of the baseline climate scenario. If trends are removed, care will be taken to ensure that low frequency climate variability such as the Pacific Decadal Oscillation is not removed from the baseline climate scenario.

***Future Scenarios***

Future socioeconomic scenarios will be developed to represent projected trends in population, land use, commercial and industrial development, irrigated acreage and cropping patterns, and other non-climate factors that affect water demand and use within the study area over the 21st century. Given the considerable uncertainty regarding how socioeconomic factors will evolve over the next century, it is anticipated that three socioeconomic scenarios will be developed for each sub-area, including a slow growth, moderate growth, and aggressive growth scenario.

In order to ensure that future socioeconomic conditions are represented consistently across the study area, scenarios will be developed for each sub-area using a common set of methods and assumptions regarding future growth. Where practicable, socioeconomic scenarios will leverage existing population and land use projections, such as projections developed for County (or City) General Plans and other recent planning efforts, including IRWM plans. Other studies, reports, and documents identified by the Study Team or TWG as relevant to developing future scenarios will also be considered.

Future climate scenarios will specify transient sequences of precipitation, temperature, and other climate variables that will be used to evaluate water supplies, demands, and operations in each sub-area over the 21st century. The IPCC describes climate scenarios as follows:

> *"A climate scenario is a plausible representation of future climate that has been constructed for explicit use in investigating the potential impacts of anthropogenic climate change. Climate scenarios often make use of climate projections (descriptions of the modelled response of the climate system to scenarios of greenhouse gas and aerosol concentrations), by manipulating model outputs and combining them with observed climate data."* (IPCC 2001 [Physical Science])

Climate scenarios will be developed by combining downscaled climate projection from Task 2 with observed historical climate data for the study area. A set of five climate scenarios will be developed for the Basin Study to represent the range of uncertainty in projected precipitation and temperature. Scenarios will include:

- Hot-Wet (90th percentile temperature, 90th percentile precipitation)
- Hot-Dry (90th percentile temperature, 10th percentile precipitation)
- Central Tendency (50th percentile temperature, 50th percentile precipitation)
- Warm-Dry (10th percentile temperature, 10th percentile precipitation)
- Warm-Wet (10th percentile temperature, 90th percentile precipitation)

Where percentiles[7] are calculated based on the projected change in annual mean temperature and precipitation for each ensemble member over the 21st century. Each scenario will incorporate projected changes in precipitation, temperature, and other climate variables from one or more downscaled climate projections. Several methods are available to construct climate scenarios based on a combination of historical observations and climate projections.

The technical method used to develop climate scenarios for the Basin Study will be selected by the Study Team, in coordination with the TWG, as part of this task. Several of the methods available to develop future climate scenarios involve applying projected changes in the statistical characteristics of precipitation, temperature, and other climate variables onto the observed historical record of each variable.

These methods essentially combine projected climate change with historically observed climate variability, while preserving the year-to-year sequencing of historical climate record. In many cases, however, the reliability of surface water and groundwater supplies is sensitive to changes in both the magnitude and sequencing of climate variability, including the timing and duration of wet and dry periods. If a climate scenario method is selected that preserves the year-to-year sequencing of historical climate variability, additional analysis will be carried out to evaluate sensitivity of water supplies, demands, and operations to the sequencing of climate variability.

Five future sea level scenarios will be developed to represent the projected range of sea level rise along the central coast of California during the 21st century. Scenarios will be based on projections derived from empirical as well as process-based models. Trends in sea level are strongly correlated with trends in global mean temperature (Cayan et al. 2009, NRC 2012). Each sea level scenario will, therefore, be paired with a corresponding climate scenarios based on projected change in temperature.

### *Roles and Responsibilities*

Development of socioeconomic scenarios will be led by the contractor, with support from non-Federal study partners and coordination and review from Reclamation and USGS. The contractor will help to identify socioeconomic factors that must be considered in developing scenarios and will coordinate discussion among the Study Team and TWG to identify existing socioeconomic projections, reasonable assumptions, and plausible ranges of the identified factors. Once the contractor and non-Federal partners have developed the conceptual scenarios and corresponding assumptions, Reclamation will provide technical support to the study partners in quantifying relevant socioeconomic factors under each scenario.

Development of climate and sea level scenarios will be led by Reclamation, with input and review from USGS regarding the data and methods used to construct scenarios.

### *Task 3 Deliverable*

Task 3 will be documented in two technical memoranda, one that details the baseline and future climate and sea level scenarios developed for the Basin Study and one that details the baseline

[7] In statistics, a *percentile* is a measure used to indicate the percentage of observations out of a group that fall below a given value. For example, if 20 of the values in a group of observations fall below the value 10.5, then 10.5 is the $20^{th}$ percentile of the distribution of observations.

and future socioeconomic scenarios.  Each technical memorandum will discuss the data, methods, and assumptions used to develop each scenario for each sub-area.  Reclamation and the contractor will develop an outline and template for each of the Task 3 technical memoranda. The Task 3 memorandum detailing climate and sea level scenarios will then be prepared by Reclamation, with support and review from USGS.

The Task 3 memorandum detailing socioeconomic scenarios will be prepared by the contractor, with support from the non-Federal partners.  Both technical memoranda will be reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14 and the TSR plan (see Section 3.4).  The draft memoranda, review comments, and final memoranda will be included in the administrative record.

### Task 4: Develop Modeling Tools and Inputs

The Basin Study will use hydrologic and water operations models to simulate water supplies, demands, and operations under climate, sea level, and socioeconomics scenarios representing current (baseline) and future conditions within the study area (see Task 3).  Due to the diversity of hydrologic conditions and complexity of water management strategies across the study area, modeling will be carried out for five sub-areas, as described below.

Model results will be analyzed in detail for each sub-area and integrated across sub-areas to allow for basin-scale analysis.  Development of scenarios (Task 3) and corresponding inputs (this task) will be coordinated across sub-areas to ensure that the sub-area modeling approach allows for coherent analysis of current and future water supplies and demands at both sub-area and basin scales.

The Basin Study area will be modeled as five sub-areas, listed below, and illustrated in Figure XX below:

- Paso Robles Sub-Area (PRB)
- Salinas Valley Sub-Area (SVB)
- Carmel River Sub-Area(CRB)
- Seaside Groundwater Sub Basin (SGB)
- Monterey Peninsula Watershed Sub-Area (MPW)

The study partners are currently developing or updating modeling tools for the PRB, SVB, CRB, and SGB sub-areas.  These models are briefly summarized below.  In addition to the four existing sub-area models, a new land surface hydrology model (rainfall-runoff model) will be developed to simulate runoff within the MPW sub-area under current and future climate conditions.  If needed to achieve the study objectives, additional modeling tools may be developed to simulate landscape and household water demands within the MPW sub-area.

Inputs to each of these models will be modified to represent each of the baseline and future scenarios considered in the Basin Study, as summarized below.  Model inputs may be modified directly based on the scenarios developed in Task 3.  For example, precipitation and temperature inputs will be modified to represent future climate scenarios, and model inputs representing municipal groundwater pumping will be modified to represent municipal water demands in future socioeconomic scenarios. In some cases, additional modeling tools may be required to develop modified inputs.

For example, crop demand models may be required to calculate irrigation-related inputs for future climate scenarios. Similarly, soil water balance models may be required to calculate recharge inputs to groundwater models for future climate scenarios. Urban water demand models may also be required to calculate municipal and industrial water demands for future scenarios. Where applicable, modeling tools used to develop modified inputs to sub-area models will be determined by the Study Team and contractor as part of this task.

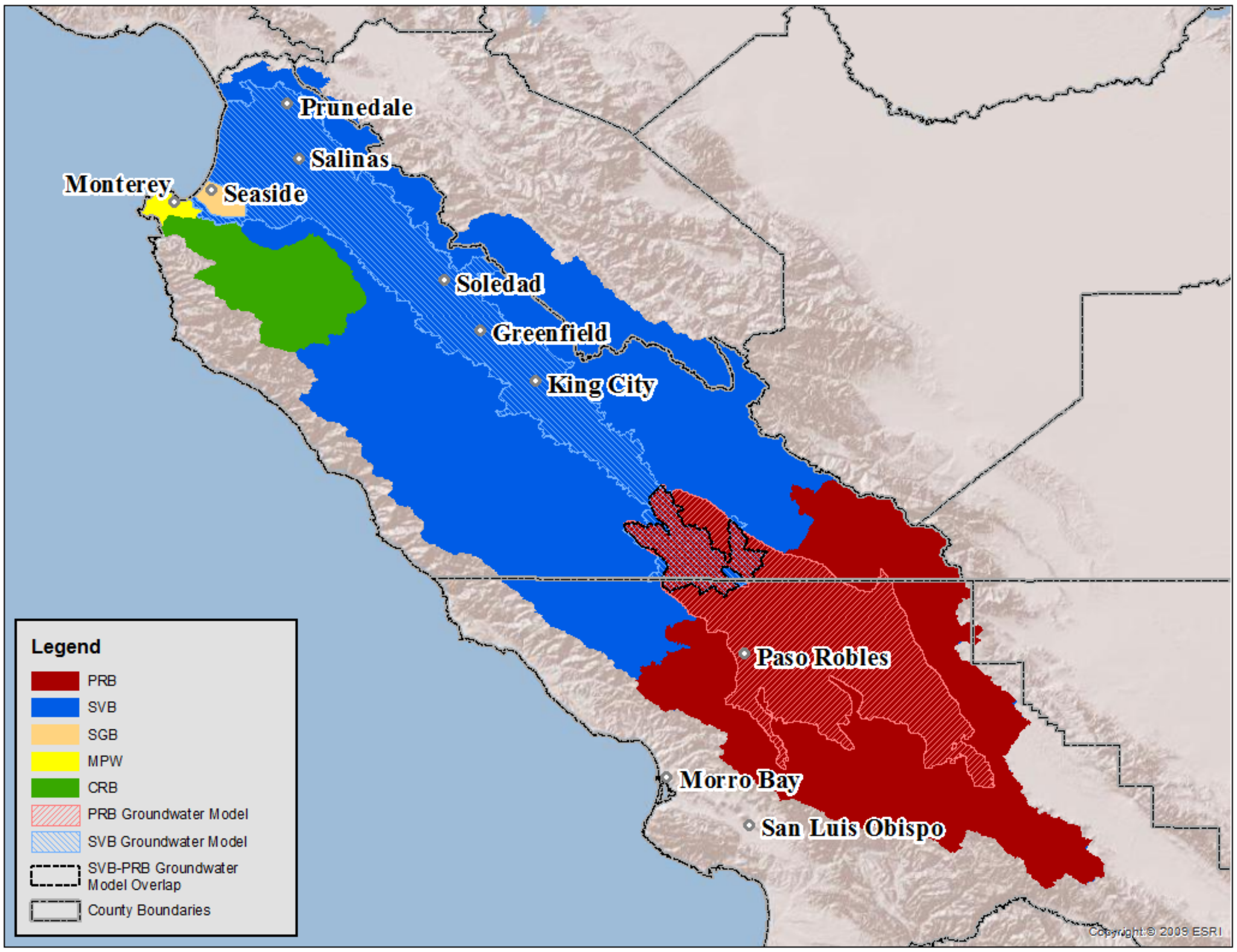


Figure 12. Map of Salinas and CRBs sub-areas. See text for discussion. *(PRB is Paso Robles Groundwater Basin Sub-Area; SVB is SVB Sub-Area; SGB is Seaside Groundwater Basin Sub-Area; MPW is Monterey Peninsula Watershed Sub-Area; CRB is CRB Sub-Area)*

### *Overview of Sub-Area Models*

The Salinas and CRBs will be modeled as five sub-areas, as noted above. The PRB, SVB, and SGB sub-areas all lie within the Salinas River Basin. The PRB sub-area encompasses the upper portion of the Salinas River Basin in San Luis Obispo County and southern Monterey County.

The PRB sub-area includes the Paso Robles Area sub-basin of the Salinas Valley Groundwater Basin (see California DWR 2003), along with the surrounding watersheds that contribute runoff and recharge to the groundwater sub-basin.

The SVB sub-area encompasses the lower portion of the Salinas River basin in Monterey County and northern San Luis Obispo County, and includes the remaining sub-basins of the Salinas Valley Groundwater Basin and the surrounding watersheds that contribute to the groundwater basin. The Seaside Groundwater Basin lies within the overall extent of SVB sub-area and encompasses the adjudicated Seaside Groundwater Basin. The CRB sub-area encompasses all watersheds and drainages that contribute to the Carmel River, and the MPW sub-area encompasses several smaller watersheds and drainages that lie between the Salinas River and CRBs and drain from the Monterey Peninsula directly to the Pacific Ocean.

The PRB and SVB sub-areas will be modeled using a combination of watershed and groundwater models: Watershed models will be used to evaluate rainfall-runoff processes throughout each sub-area, including runoff to streams and recharge to groundwater; groundwater models will then be used to simulate groundwater storage, water table fluctuations, and groundwater/surface-water interactions within the primary groundwater basins in each sub-area. The CRB sub-area will be modeled using an integrated groundwater/surface-water model, and the MPW watershed will be modeled using a land surface hydrology model (rainfall-runoff model).

It should be noted that the SVB sub-area encompasses the SGB sub-area. The SGB sub-area will, therefore, be modeled as part of the SVB sub-area; however, the groundwater model of the adjudicated Seaside Groundwater Basin developed by the California-American Water Company and later adopted by the Seaside Groundwater Basin Watermaster may be used by the Basin Study if needed.

#### *Paso Robles Sub-Area (PRB)*

The PRB sub-area will be modeled using a combination of land surface (watershed) and groundwater models. SLOCFCWCD contracted to develop a groundwater model of the PRGB for use as a quantitative tool to evaluate future hydraulic conditions in the basin. SLOCFCWCD subsequently contracted with Geoscience Support Services, Inc. and Todd Groundwater to update the original groundwater model and to develop a watershed model to calculate inflow components to the groundwater model. The resulting watershed model and updated groundwater model will be used to model the PRB sub-area for the Basin Study.

The watershed model of the PRB sub-area encompasses the entire sub-area, which includes the upper portion of the Salinas River watershed in San Luis Obispo County and portions of southern Monterey County. The PRB watershed model uses the Hydrologic Simulation Program-Fortran (HSPF) modeling software to simulate the land surface water balance throughout the sub-area, including runoff, infiltration, evapotranspiration, and groundwater recharge.

Simulated runoff, recharge, and evapotranspiration are subsequently used to develop inputs to the PRB groundwater model. The PRB groundwater model uses the USGS Modular Groundwater Flow Model (MODFLOW) to simulate groundwater storage, aquifer levels, and groundwater/surface-water interactions for the major aquifers within the sub-area. Details of the updated model are provided by Geoscience Support Services and Todd Groundwater (2014).

#### *Salinas Valley Sub-Area (SVB)*

The SVB sub-area will be modeled using an integrated hydrologic model of surface water and groundwater in the Salinas Valley Groundwater Basin combined with a land surface (watershed) model to simulate runoff and recharge from the surrounding drainages. MCWRA has contracted with USGS to develop the combined modeling approach in order to support long-term planning and management of groundwater and surface-water resources in the Salinas Valley Groundwater Basin and throughout the SVB sub-area, including evaluation of water demands for existing and future uses and analysis of groundwater levels and sea water intrusion.

The watershed model component of the combined modeling approach encompasses the entire SVB sub-area and the an integrated hydrologic model component encompasses all major aquifers of the Salinas Valley Groundwater Basin except for the Paso Robles Area sub-basin, which falls within the PRB sub-area (California DWR 2003).

The watershed component of the SVB modeling approach simulates the land surface water balance in the drainages surrounding the major aquifers, including surface runoff and recharge from these drainages into the aquifers, as well as the movement and use of water across the landscape of the Salinas Valley. Watershed processes will be simulated using two land surface hydrology models (i.e., rainfall-runoff models), the Basin Characterization Model (BCM) and the HSPF.

Both BCM and HSPF simulate surface runoff, infiltration and soil moisture, evapotranspiration, and groundwater recharge. The two models use different approaches to representing individual hydrologic processes; the use of two models thus allows for consideration of model uncertainties in simulating runoff and recharge reaching the Salinas Valley aquifers.

The groundwater component of the SVB modeling approach, referred to as the Salinas Valley Integrated Hydrologic Model (SVIHM), is being developed to delineate and characterize the major aquifers of the Salinas Valley Groundwater Basin, with the exception of the Paso Robles Area sub-basin, and to simulate groundwater flow and storage in all of the major aquifers above the Monterey Formation.

SVIHM will use the integrated hydrologic modeling platform MODFLOW-OWHM (Hanson and others, 2014), which allows for simulation of streamflow, reservoir operations, landscape processes (e.g., land surface water balances for agricultural areas and native vegetation), groundwater flow, and seawater intrusion, among other processes. SVIHM will simulate hydrologic conditions in the Salinas Valley using monthly stress periods and bimonthly time steps.

The model is calibrated to observed historical conditions over the period October 1967 through December 2014, including measured groundwater heads, vertical head differences between aquifers, streamflows, streamflow differences, streamflow diversions, estimates of seawater intrusion, and reported agricultural pumpage. Because MODFLOW-OWHM calculates water supplies and demands internally (as opposed to supplies and demands being provided as model inputs), model inputs become relatively fundamental.

Model inputs include climate (precipitation and potential evapotranspiration), municipal and industrial groundwater pumping, stream inflows and recharge along aquifer boundaries, changes in sea level, and land use. Simulated conditions include groundwater recharge, surface runoff and streamflow, reservoir storage and releases, surface water diversions and deliveries, agricultural pumpage, agricultural return flows, actual evapotranspiration, and spatially-distributed changes in groundwater storage and heads.

#### *Carmel River Sub-Area (CRB)*

The CRB sub-area will be modeled using the CRB Hydrologic Model (CRBHM). MPWMD has contracted with USGS and Huntington Hydrologic to develop CRBHM as a replacement for the district's outdated Carmel Valley Simulation Model. Once completed, MPWMD will use CRBHM as the primary planning tool to optimize water supply operations in the CRB, including analysis of changes in river flows, groundwater storage, and groundwater/surface-water interactions in response to changes in operation of Los Padres Dam and changes in municipal groundwater pumping within the basin. CRBHM will also be used to evaluate and compare the effects of various proposed water supply projects on aquifer storage, river flows, and steelhead habitat in the CRB sub-area.

CRBHM will use the coupled groundwater and surface-water flow model GSFLOW. GSFLOW is based on the integration of the USGS Precipitation-Runoff Modeling System, which simulates the land surface water balance including infiltration, evapotranspiration, runoff, and recharge, and the USGS MODFLOW, which simulates groundwater storage and movement, aquifer levels, groundwater/surface-water interactions, and related processes. CRBHM will use GSFLOW to simulate the entire CRB sub-area at a uniform horizontal grid resolution of 100m by 100m.

Model inputs include precipitation, municipal groundwater pumping from the Carmel Valley Alluvial Aquifer by the California-American Water Company, and private groundwater pumping from within the alluvial aquifer and surrounding mountain block aquifers. CRBHM is being calibrated over the period 1995-2005 based on available observations of streamflow and groundwater levels throughout the basin.

#### *Seaside Groundwater Basin Sub-Area*

The SGB sub-area encompasses the adjudicated Seaside Groundwater Basin, which is located adjacent to and beneath the Monterey Bay in the vicinity of Seaside, California. The SGB sub-area lies within the extent of the SVB sub-area. For the purposes of evaluating current and future water supplies, demands, and operations as part of the Basin Study, the SGB sub-area will be modeled as part of the SVB sub-area groundwater model, SVIHM, described above. If warranted for the purpose of evaluating proposed mitigation and adaptation strategies, additional analysis of the SGB sub-area may be carried out using the existing groundwater flow and transport model of the adjudicated Seaside Groundwater Basin, referred to here as the SGB model.

The SGB model was initially developed by the California-American Water Company and later adopted by the Seaside Groundwater Basin Watermaster (Timothy J. Durban, Inc. 2007). The SGB model uses a modified version of the USGS groundwater and solute transport modeling software FEMFLOW3D (Durban and Bond 1998). The model simulates groundwater storage, movement, and elevations within the SGB sub-area. The model also simulates the concentration and movement of salinity within the groundwater system based on specified salinities at each boundary (e.g., salinity at the freshwater-seawater interface and salinity of recharge from precipitation). Key inputs to the SGB model include average annual recharge over the model domain (spatially and temporally uniform); specified groundwater heads, fluxes, and salinities at the model boundaries; and groundwater pumping rates throughout the model domain.

#### *Monterey Peninsula Watershed Sub-Area (MPW)*

There is no existing hydrologic model of the Monterey Peninsula Watershed sub-area. A rainfall-runoff model of the MPW sub-area will be developed as part of the Basin Study in order to evaluate hydrologic changes in the sub-area, such as changes in streamflow, infiltration and recharge, and evapotranspiration. Three options will be considered to develop the MPW model:

- Extend SVB watershed model (HSPF) to encompass MPW sub-area
- Extend SVB watershed model (BCM) to encompass MPW sub-area
- Utilize the Central Coast stormwater model (TELR) for the MPW sub-area

As summarized above, USGS is working with MCRWA to develop a new model of the SVB sub-area. This model includes a groundwater model of the SVB along with a watershed model of the surrounding tributary watersheds. USGS is developing two independent versions of the watershed models for the SVB sub-area, one version using the HSPF and one using the BCM. Either of these watershed models could be extended to encompass the MPW sub-area.

Alternatively, MRWPCA and MPWMD are currently participating in a project to develop a collaborative regional Stormwater Resource Plan for the Monterey Peninsula, Carmel Bay, and South Monterey Bay IRWM (RWM) planning area. This study will use a Stormwater Tools to Estimate Load Reductions (TELR) model that encompasses the MPW sub-area. The TELR model simulates runoff volumes within the MPW sub-area using a catchment-based approach. This model will be reviewed and considered as a potential option for use in the Basin Study.

The software and modeling approach used to represent the MPW sub-area will ultimately be determined by the study team as part of this task.

#### *Development of Model Inputs for Basin Study Scenarios*

Each of the modeling tools that will be used in this Basin Study has a unique set of input requirements that depend on the model software and configuration. Default input datasets for each model were developed in conjunction with model development, calibration, and verification. These input datasets, referred to here as historical or calibration input datasets, were developed based on historical data sources and represent observed historical conditions within each sub-area, including historical weather and climate, water demands and uses, and water management.

In order to simulate current and future water supplies, demands, and operations for the Basin Study, calibration input datasets will be modified to represent the scenarios developed in Task 3. While the input requirements of each model are unique, the Study Team, with support from the TWG, will coordinate closely to ensure that the data and methods used to modify calibration input datasets for each scenario are as consistent as possible across all sub-areas.

***Climate and Sea Level Scenarios***

Reclamation and USGS will coordinate with each non-Federal partner through the Study Team and TWG to identify model inputs related to climate and sea level, and to modify or perturb default (historical) inputs as needed to represent the baseline and future climate scenarios developed in Task 3. For each sub-area, the partner who developed the modeling tool(s) for that sub-area will provide all available model input datasets related to climate and sea level, along with a detailed description of the data, methods, and assumptions used to develop the calibration inputs.

Reclamation and USGS, with input and review from the TWG, will then develop and apply technical methods to modify the calibration inputs to represent changes in climate and sea level under the baseline and future climate scenarios.

Baseline climate and sea level inputs will likely be equal to historical inputs. In some cases, however, long-term trends may be removed from historical inputs to ensure that baseline inputs are consistent with climate and sea levels over the period 1980-2015. If trends are removed, care will be taken to ensure that low frequency climate variability such as the Pacific Decadal Oscillation is not removed from the baseline climate scenario.

Historical inputs will subsequently be modified to represent each of the future climate and sea level scenarios developed in Task 3. Inputs will be modified by perturbing the statistical distribution of historical inputs to reflect the transient change in weather and climate conditions and sea levels under each future scenario. The data and methods used to develop climate-related model inputs for future scenarios will be as consistent as possible across all sub-areas, and study partners will have the opportunity to review the data and methods used to develop model inputs for each scenario.

As noted above under Task 3, if future climate scenarios preserve the year-to-year sequencing of observed historical climate variability, additional simulations will be carried out to evaluate sensitivity of water supplies, demands, and operations to the sequencing of climate variability. Model inputs for these simulations will be developed in a similar manner to climate scenario inputs.

***Socioeconomic Scenarios***

Reclamation and USGS will coordinate with the contractor and non-Federal partners through the Study Team and the TWG to identify model inputs that reflect socioeconomic conditions within each sub-area, including inputs that relate to water demands for agricultural, municipal, and industrial uses. Reclamation and USGS will then work together to develop methods to modify or perturb historical socioeconomic inputs as needed to represent the baseline and future socioeconomic scenarios developed in Task 3. Perturbations applied to historical socioeconomic inputs in order to represent the baseline socioeconomic scenario may include adjusting historical inputs based on time-varying historical water uses to be consistent with the population and per capita water demand, agricultural conditions, and industrial water uses in each sub-area for the year 2015.

Perturbations applied to represent future socioeconomic scenarios may include imposing trends or changes in input values to reflect projected changes in socioeconomic conditions over the simulation period. Similar to development of climate-related inputs, the data and methods used to develop socioeconomic-related model inputs for baseline and future scenarios will be as consistent as possible across all sub-areas, and Reclamation and the study partners will have the opportunity to review the data and methods used to develop inputs for each scenario.

It should be noted that agricultural water demands depend on a combination of socioeconomic factors—e.g., irrigated acreage, crop selection, irrigation methods, etc.—as well as weather and climate conditions that affect crop water use. The socioeconomic components of agricultural water demand under baseline and future scenarios will be led by the contractor, with support from the non-Federal partners. The climate-related component of agricultural water demand will be led by Reclamation, in close coordination with the Study Team and TWG. In addition to socioeconomic factors and climate conditions, water quality may also affect irrigation demand.

For example, irrigation demand increases with salinity as additional water is required to flush salts from the root zone. Effects of salinity on irrigation demand will be considered in this study if identified as an important consideration by the Study Team, TWG, or stakeholders. The methods used to consider salinity impacts on irrigation demand will depend on the sub-area where those impacts are considered.

#### *Roles and Responsibilities*

The non-Federal partners will provide completed and calibrated sub-area models to USGS for the CRB, SVB, PRB, and SGB sub-areas, including the model source code and/or executable(s), as applicable, as well as all model configuration and input files required to simulate historical conditions (i.e., all inputs required to run the model over its calibrated historical simulation period).

Non-Federal partners will also provide documentation of climate-related or socioeconomic-related model inputs to USGS, along with relevant data, scripts, and/or tools used to develop those inputs. The Study Team, with coordination and support from the TWG, will subsequently review the methods developed by Reclamation and USGS to incorporate the climate and socioeconomic scenarios developed in Task 3 into each sub-area model.

USGS and Reclamation will coordinate with the non-Federal partners, through the Study Team and TWG, to gain a detailed understanding of the configuration and inputs to sub-area models for the CRB, SVB, PRB, and SGB sub-areas and the data, methods, and assumptions used to construct climate-related and socioeconomic-related inputs. USGS will work with Reclamation and the Study Team to identify any configuration parameters and model inputs that must be revised to simulate water supplies, demands, and operations under the future climate and socioeconomic scenarios developed in Task 3. USGS will work with Reclamation to develop technical methods to modify relevant model inputs for each sub-area model as needed to simulate future scenarios.

USGS will then prepare model inputs for each combination of climate and socioeconomic scenario.[8] The Study Team and TWG will provide preliminary review of the data and methods used to develop scenario inputs and final review of the modified input datasets.

#### *Task 4 Deliverable*

Task 4 will be documented in a technical memorandum describing the modeling tools and inputs developed and/or used in the Basin Study. The boundary conditions across each model will be described in a way intended to help meet groundwater sustainability plan requirements regarding inter-and intra-basin data and methodology consistency to the extent possible. Reclamation and the contractor will develop an outline and template for the Task 4 technical memorandum. For each sub-area, the non-Federal partner who developed the modeling tools for that sub-area will provide a detailed description of the modeling tools and the corresponding historical model inputs. USGS will then provide a detailed description of the datasets and methods used to develop modified inputs for each future scenario.

The contractor will prepare the Task 4 technical memorandum based on the detailed descriptions of models, default (historical) inputs, and modified inputs provided by USGS and non-Federal partners. The Task 4 technical memorandum will be reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14 and the TSR plan (see Section 3.4). The draft memorandum, review comments, and final memorandum will be included in the administrative record.

### Task 5: Evaluate Water Supplies, Demands, and Operations (No Action Scenario)

Task 5 focuses on evaluating current and projected supplies, demands, and operations under the baseline and future scenarios considered in this study and in the absence of any adaptation or mitigation strategies. Water supplies, demands, and operations will be evaluated using the study metrics developed in Task 1, and the modeling tools and inputs developed in Task 4. Study metrics representing current conditions will be calculated for each sub-area from simulations of the baseline scenario, and metrics representing future conditions will be calculated from simulations of future climate, sea level, and socioeconomic scenarios.

Results will be used to characterize water supplies, demands, and operations within each sub-area under each scenario. Results from baseline and future scenarios will be compared to evaluate risks and impacts of projected changes in climate, sea level, and socioeconomic conditions, and results will be compared among future scenarios to characterize future uncertainties.

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[8] As discussed in Section 4.5, it is anticipated that simulations will be carried out for all combinations of future climate conditions (five scenarios) and future socioeconomic conditions (three scenarios) for a total of 15 future scenarios.

Task 5 involves four primary steps:

- Simulation of baseline and future scenarios
- Calculation of study metrics
- Characterization of current and future water supplies, demands, and operations
- Comparison of water supplies, demands, and operations between current and future scenarios

For each sub-area, USGS will carry out transient simulations under baseline and future scenarios using the modeling tools and inputs developed in Task 4. Simulations will be carried out by running the sub-area model or models with the model input datasets corresponding to each baseline scenario and each future scenario, respectively. Simulations of future conditions will be carried out for all combinations of the five future climate scenarios and three future socioeconomic scenarios, for a total of 15 future scenarios.

As discussed in Section 4.3, future sea level scenarios are associated with future climate scenarios and, therefore, do not increase the number of combined scenarios. USGS will coordinate with Reclamation and non-Federal partners to address interactions and dependencies between sub-areas. In general, where the model(s) for one sub-area depend on conditions in an adjacent sub-area—e.g., inputs to one sub-area include streamflow out of an adjacent upstream sub-area—inputs will be based on results from the adjacent sub-area model(s) under the corresponding scenario.

USGS will post-process simulation results and compute study metrics for each sub-area under each combined climate and socioeconomic scenario (see Task 1). Study metrics will typically be calculated at the same timescale as the corresponding model's time step; all metrics will then be aggregated to seasonal and annual timescales to allow for consistent evaluation and comparison across sub-areas.

Reclamation, in coordination with USGS and non-Federal partners, will then characterize water supplies, demands, and operations in each sub-area under baseline and future scenarios. Characterization will be based on descriptive statistics and time series analysis of study metrics (see Task 1), including but not limited to consideration of averages, percentiles, inter-annual variability, and trends. Characterization will include analysis of projected changes in flood risk at selected locations using the approach developed by Condon et al (2015).

In addition, characterization may also consider the frequency with which a given metric crossing a specified threshold value, such as the frequency of water supplies falling below a specified level or frequency of water demands exceeding supplies. Finally, the contractor, in coordination with non-Federal partners and with support from Reclamation and USGS, will interpret the effects of projected changes in climate, sea level, and socioeconomic conditions on water supplies, demands, and operations, including risks, impacts, and uncertainties associated from climate and socioeconomic changes. The contractor will work with Reclamation, USGS, and non-Federal partners to identify and interpret the potential risks and impacts of climate change in each sub-area and within the study area as a whole.

### *Roles and Responsibilities*

USGS will carry out simulations of all sub-areas under all combinations of future climate, sea level, and socioeconomic scenarios. USGS will then post-process model results and calculate the study metrics identified in Task 1 for each sub-area and scenario combination. Reclamation will analyze the resulting study metrics to quantitatively characterize water supplies, demands, and operations under each scenario combination, including analysis of future flood risk at selected locations.

The contractor, in coordination with non-Federal partners and with support from Reclamation and USGS, will qualitatively interpret projected changes in water supplies, demands, and operations within each sub-area and for the Basin Study area as a whole, including consideration of important conditions affected by water operations, including hydropower generation; recreation; fish and wildlife habitat; ESA species and critical habitat; and water quality. The Study Team and TWG will provide interim review and feedback regarding the approaches used by USGS and Reclamation to simulate and characterize future water supplies, demands, and operations.

### *Task 5 Deliverable*

Task 5 will be documented in a technical memorandum describing current (baseline) and future water supplies, demands, and operations within each sub-area and within the study area as a whole. Reclamation and the contractor will develop an outline and template for the Task 5 technical memorandum. For each sub-area, USGS will provide a detailed summary of the model simulations and the study metrics calculated from model results. Reclamation will then provide a detailed summary of quantitative evaluation and characterization of study metrics under each scenario and a comparison of study metrics between scenarios, including evaluation and characterization of flood risks at selected locations.

Finally, the contractor will provide qualitative discussion and interpretation of the study results. Discussion and interpretation will consider imbalances between water supplies and demands, as well as important conditions in the basin that are affected by water operations, including hydropower generation; recreation; fish and wildlife habitat; ESA species and critical habitat; and water quality. Qualitative discussion will focus on identifying and describing the projected risks, impacts, and uncertainties resulting from projected changes in climate, sea level, and socioeconomic conditions.

The contractor will prepare the Task 5 technical memorandum by compiling detailed summaries of each sub-area and the comparison of study metrics between scenarios. The Task 5 technical memorandum will be reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14 and the TSR plan (see Section 3.4). The draft memorandum, review comments, and final memorandum will be included in the administrative record.

## Task 6: Develop Adaptation and Mitigation Strategies

Task 6 will focus on development of adaptation and mitigation strategies to address current or projected imbalances between water supplies and demands. The Basin Study may consider potential infrastructure strategies involving the development of new infrastructure or modification of existing infrastructure, as well as potential operational strategies involving modification of surface water or groundwater management or operating criteria without changes to existing infrastructure. In addition, strategies may involve a single project or element, or may combine multiple projects or elements to form a coordinated portfolio. Project and elements included in adaptation and mitigation strategies may include, but are not limited to:

- Modification of an existing reservoir or operating guideline(s)
- Development of new water management, operating, or habitat restoration plans
- Development of water conservation and demand reduction strategies or projects
- Development of new water infrastructure
- Development or improvement of hydrologic models and other decision support systems
- Development of a monitoring plan to acquire and maintain water resources data to strengthen understanding of water supply and assist in future assessments and analyses

Adaptation and mitigation strategies will be identified and developed for each sub-area based on the specific needs and conditions within that sub-area; some projects and elements may not apply to all sub-areas, or may be developed differently for different sub-areas. Development of adaptation and mitigation strategies for each sub-area will be led by the contractor, with support from non-Federal partners with management responsibilities in that sub-area.

Reclamation and USGS will provide review and support to the contractor and non-Federal partners in identifying and developing potential adaptation and mitigation strategies. Reclamation and USGS will also provide coordination and technical support with respect to developing potential adaptation strategies in sufficient detail to allow for simulation and/or evaluation of proposed strategies.

Development of adaptation and mitigation strategies will be guided by analysis of current and future supplies, demands, and operations carried out under Task 5, as well as results of previous analyses of historical or current imbalances carried out as part of other planning efforts within the Basin Study area. Strategies considered in the Basin Study may include adaptation and mitigation strategies developed through the Basin Study as well as strategies developed as part of other planning efforts.

#### *Roles and Responsibilities*

Identification of potential adaptation and mitigation strategies will be led by the contractor, with significant input from local study partners. The contractor will coordinate and facilitate discussion of adaptation and mitigation strategies among stakeholders, the Study Team, and TWG; both Reclamation and USGS will provide technical support and review in identifying and developing potential strategies.

#### *Task 6 Deliverable*

Task 6 will be documented in a technical memorandum summarizing adaptation and mitigation strategies considered in the Basin Study. For each strategy or portfolio of strategies, the technical memorandum will summarize the purpose and objectives of the strategy and the area affected by the strategy. The technical memorandum will then provide a detailed description of all new infrastructure, changes to existing infrastructure, and/or changes to water management and operations that would be implemented as part of the proposed strategy. Reclamation and the contractor will develop an outline and template for the Task 5 technical memorandum.

The description of each adaptation or mitigation strategy will be prepared by the contractor, with input and review from the non-Federal partners involved in identifying and developing that strategy. The contractor will then prepare the Task 6 technical memorandum by compiling these descriptions of proposed strategies. The Task 6 technical memorandum will be reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14 and with the TSR plan (see Section 3.4). The draft memorandum, review comments, and final memorandum will be included in the Basin Study's administrative record.

### Task 7: Evaluate Adaptation and Mitigation Strategies

Adaptation and mitigation strategies considered in the Basin Study will be evaluated through a combination of quantitative and qualitative analysis. Strategies identified in Task 6 will undergo initial review and screening by the Study Team, with input and support from the TWG. Initial review and screening will be coordinated and facilitated by the contractor, with significant input from the non-Federal partners and review and feedback from Reclamation and USGS. Initial review and screening will involve qualitative evaluation of the anticipated benefits of each strategy with respect to water supplies, demands, and operations, as well as anticipated challenges, including technical, environmental, legal, and cost considerations.

Initial review and screening may also involve the use of simplified methods to estimate changes in water supply, demand, or operations under a given strategy. Strategies will be selected for further analysis based on results of initial screening and review. Strategies which have similar characteristics, or those which are expected to perform synergistically if implemented together, may be grouped into one or more portfolios to reduce the number of model runs needed for detailed quantitative analysis under varying climate and socioeconomic conditions.

For strategies or portfolios selected for further analysis, detailed quantitative analysis will be carried out based on simulation of water supplies, demands, and operations under proposed adaptation and mitigation strategies. For each strategy or portfolio selected, the model (or models) and corresponding input datasets for the sub-areas directly affected by that strategy will be updated to represent proposed changes in infrastructure and/or operations under that strategy. The model will then be used to simulate hydrologic conditions and/or water operations with the strategy in place.

Similar to Task 5, model results will be processed to calculate study metrics. Effects of proposed changes in infrastructure and/or operations on water supplies, demands, and operations will then be quantified and evaluated by comparing study metrics between simulations with the strategy in place (i.e., simulations carried out in Task 7) and simulations representing current infrastructure and operations (i.e., simulations carried out in Task 5). Evaluation will consider water supply and demand metrics, as well as metrics that characterize important conditions in the basin that are affected by water operations, including hydropower generation; recreation; fish and wildlife habitat; ESA species and critical habitat; and water quality.

If for any reason it is not feasible to represent a given strategy or portfolio directly using the corresponding sub-area model(s), proposed changes in infrastructure and/or operations will be evaluated through reanalysis of simulations representing current infrastructure and operations (i.e., simulations carried out in Task 5). Reanalysis may include modifying simulated reservoir releases, river diversions, and/or streamflow to represent proposed changes in surface water infrastructure and/or operations, and estimating corresponding changes in seepage and recharge.

It should be noted that reanalysis methods may not be applicable for evaluating some strategies involving desalination, water recycling and reuse, and groundwater management, including strategies involving artificial or augmented recharge, or corresponding changes in groundwater/surface-water interactions. If needed, evaluation of strategies or portfolios using a reanalysis approach will be carried out by Reclamation, with input and support from the contractor.

If a strategy or portfolio is evaluated by reanalysis, the analysis will be carried out by Reclamation with input and support from the non-Federal partner(s) with management responsibilities in the affected sub-area(s). The Study Team and TWG will be given an opportunity to review the proposed reanalysis methodology to ensure that it provides a reasonable representation of proposed changes.

In addition to quantitative analysis of changes in water supply, demand, and operations, adaptation and mitigation strategies will be evaluated to identify potential effects on environmental and socioeconomic conditions within the Basin Study area. Evaluation of environmental conditions may consider, either quantitatively or qualitatively, potential effects on recreation, fish and wildlife habitat, endangered species, water quality, and ecological resilience. Where sufficient information is available, evaluation of socioeconomic effects may consider relative costs and potential socioeconomic impacts of proposed changes in infrastructure and operations.

In addition, qualitative evaluation may consider potential legal issues associated with proposed strategies. Qualitative evaluation will be based on review of existing information, including previous planning documents, environmental assessments, and appraisal studies, as well as the knowledge and expertise of the Study Team; no new information or quantitative analysis of environmental and socioeconomic conditions will be developed under the Basin Study.

Uncertainties in future climate and socioeconomic conditions will be considered in evaluating adaptation and mitigation strategies through the use of a bracketing approach. Rather than simulating all combinations of future climate and socioeconomic scenarios as done in Task 5, simulations will be carried out for one scenario combination representing the central tendency or median from Task 5 and two scenarios bracketing the lower and upper range of simulations from Task 5. As noted above, the study team may also decide to combine individual adaptation and mitigation strategies into portfolios, rather than simulating each selected strategy individually.

#### *Roles and Responsibilities*

Initial review and screening will be coordinated and facilitated by the contractor, with significant input from the non-Federal partners and review and feedback from Reclamation and USGS. Detailed analysis of selected strategies or portfolios will be carried out by USGS and

Reclamation, in coordination with the contractor and with input and review by non-Federal partners. USGS will modify model configurations and/or inputs as needed to represent each strategy or portfolio selected for detailed analysis. USGS will then simulate water supplies, demands, and operations with selected strategies in place and post-process model results, including calculation of relevant metrics from Task 1.

Reclamation will quantitatively characterize water supplies, demands, and operations based on the simulated metrics provided by USGS. The contractor will then coordinate and facilitate qualitative interpretation of evaluation results. The Study Team and TWG will provide input and review throughout this task to ensure that strategies are simulated and evaluated in a manner that supports local planning and decision making within the basin.

#### *Task 7 Deliverable*

Task 7 will be documented in a technical memorandum describing the simulated change in water supplies, demands, and operations under each of the adaptation strategies or portfolios evaluated in this task. Reclamation and the contractor will develop an outline and template for the Task 7 technical memorandum. For each strategy, USGS and Reclamation will provide a summary of the model simulations and calculated study metrics developed under Task 7 and a summary of changes in study metrics under the proposed strategy (i.e., change in study metrics between simulations carried out under Task 7 compared to those under Task 5).

The contractor, with input from the affected non-Federal partner(s), will provide qualitative discussion and of interpretation of evaluation results, including important conditions in the basin that are affected by water operations, including hydropower generation, recreation, fish and wildlife habitat, ESA species and critical habitat, and water quality.

The contractor will then prepare the memorandum by compiling the summaries and descriptions for all strategies. The Task 7 technical memorandum will be reviewed by the Study Team and TWG consistent with Reclamation Manual Policy CMP P14 and with the TSR plan (see Section 3.4). The draft memorandum, review comments, and final memorandum will be included in the administrative record.

### Task 8: Prepare Basin Study Summary Report

The Contractor, with support from Reclamation, will prepare the final Basin Study summary report and executive summary. The final summary report and executive summary will provide a detailed summary of the study data, methods, and results of each study task, including key findings and conclusions regarding current and projected water supplies, demands, and operations, and potential mitigation and adaptations strategies to address the impacts of climate change. The technical memoranda prepared under Tasks 1-7 will be included as appendices to the final study report. The final study report and executive summary will be reviewed by the Study Team and the USGS.

#### *Roles and Responsibilities*

The contractor will prepare a draft-final Basin Study summary report document which includes an Executive Summary. The Study Team and Executive Team will provide a detailed review and comment on the report outline and on the final report.

### *Task 8 Deliverable*

The draft-final Basin Study Summary Report and Executive Summary will serve as the deliverables for this task. Both documents will be reviewed by the Study Team and Executive Team consistent with Reclamation Manual Policy CMP P14. The draft documents, review comments, and final documents will be included in the administrative record.

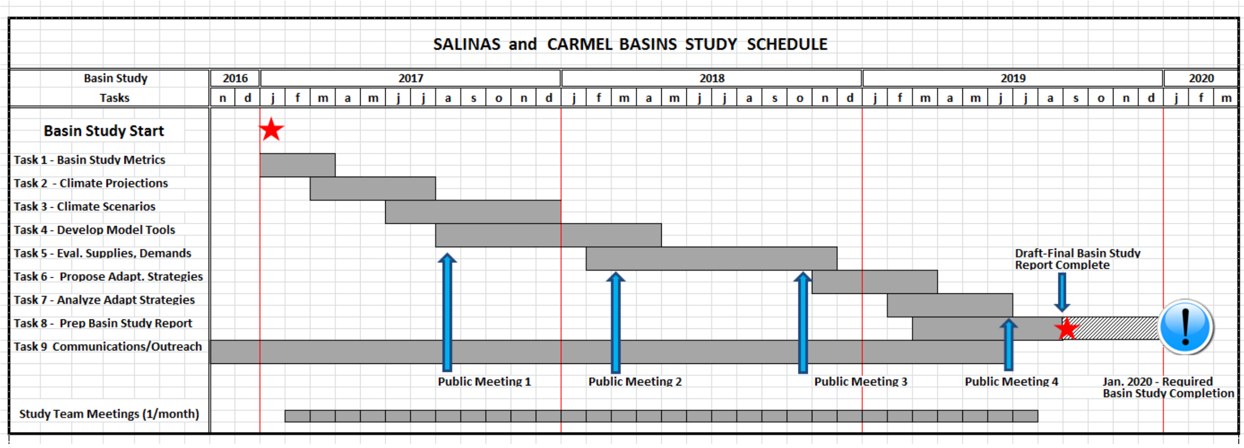


Figure 13. Salinas and Camel Basin Study Schedule

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# Chapter 5 – Communications and Outreach Plan

## 5.1 Goal and Objectives of the Communications and Outreach Plan

This Communications and Outreach Plan (COP) outlines how Reclamation, the Study Team (including the contractor) will communicate with and involve diverse stakeholders and the interested public during the development and review of the Basin Study. In general, the contractor is responsible for coordination and management of the COP and implementation of the communication and outreach processes described in this section to support all meetings, the website and other elements of the COP.

The Goal of the COP is to support the preparation of the Basin Study Report which: (1) is broadly understood, and; (2) solicits and incorporates stakeholder input where feasible and appropriate. Federal partners involved with Reclamation intend to create a variety of participation opportunities to involve stakeholders, which include Federal agencies, State agencies, and local government agencies including water districts, flood control agencies, as well as scientific research groups, environmental groups, and agricultural groups.

The participation and outreach strategy for the Basin Study will focus on the following objectives:

- Reclamation will provide stakeholders with multiple, meaningful opportunities to learn about and provide input on the content of the Basin Study
- Reclamation will keep stakeholders well informed throughout the Basin Study development process regarding the development of technical reports and the opportunities for stakeholders to review and provide input for consideration
- Opportunities for stakeholder participation through public workshops and meetings
- Potential connections and linkages between the Basin Study, the DCP, and related efforts
- Information about the Basin Study will be accessible and easy to understand; Reclamation and Study Team representatives will be available to answer stakeholder questions
- Reclamation will, to the extent possible, work to integrate interests, needs, and expectations from multiple stakeholder groups during the development of the Basin Study
- Reclamation will identify and, as appropriate, address key stakeholder concerns and issues during the Basin Study development process

## 5.2 Approach

Several participation and outreach methods will be employed to maintain communication with the Study Partners and interested stakeholders to provide and receive information.

In order to achieve the objectives articulated in this Chapter, Reclamation intends to utilize an approach that is flexible and adaptive to the Basin Study development process and stakeholder needs. The communications and outreach approach will:

- Recognize that there are various stakeholders and audiences interested in the Basin Study, and that each group will require a distinct approach
- Identify the most effective and efficient activities to inform and engage stakeholders in order to achieve participation and outreach objectives
- Provide clear, timely information on how interested stakeholders can be involved; and adhere to the following principles:
  - The Basin Study will be developed in a transparent way
  - Public outreach will begin early in the Basin Study development process and will proceed in a timely and consistent manner
  - Reclamation will avoid making redundant requests of stakeholders or communicating inconsistent messages

The Basin Study will be developed in phases and stakeholder outreach will be planned around milestones corresponding to these phases. As the Study progresses, the effectiveness of the public involvement process will be assessed periodically, and adjustments will be made as necessary to ensure that appropriate communication and feedback are occurring.

## 5.3 Study Audiences

A broad range of stakeholders have an interest in the development of the Basin Study. This COP organizes Basin Study stakeholders into four main audiences: (1) internal/Study Partners; (2) technical experts; (3) key stakeholders; and (4) the general public, recognizing that there will be different levels of interest and decision-making, and that the communication and outreach strategy should be designed to accommodate these audiences. Below are descriptions of the four stakeholder audiences.

### Reclamation and Basin Study Partners

The study partners include Reclamation and the following agencies: MCWRA, SLOFCWCD, MPWMD, and the MRWPCA. The partners are contributing resources to support the development of the Basin Study; their staff will be contributing time to the Basin Study on a variety of levels (policy, technical, etc.). The partners contribute information and data to the process. Partner agencies are also responsible for ensuring their respective constituencies are appropriately informed about the Basin Study process and have the opportunity to provide input.

### Technical Experts

Technical experts include recognized researchers and scientists in the earth sciences, including climatology/meteorology, hydrology, geology, and other fields. Technical experts will provide independent expert input and peer review of content for the Basin Study.

### Key Stakeholders

A number of stakeholder groups have a keen interest in the Basin Study and its outcomes. These key stakeholders, made up of local and regional entities and non-governmental groups, are familiar with the landscape of water resources management in the Salinas and CRB area, and are interested in providing input into specific technical aspects or the entirety of the Basin Study. Key stakeholder groups may include:

- Federal, State and local government agencies
- Elected officials
- Groundwater Sustainability Agencies
- Flood control agencies
- Reclamation districts
- Water districts
- Scientific research groups
- Hydropower agencies and other representatives of the energy industry
- Environmental groups
- Agricultural groups
- Representatives of the recreational industry
- Related programs and initiatives such as the California Water Plan 2018 Update, local IRWM Plans, groundwater plan updates and others

### General Public

The general public includes California residents and organizations that are not likely to closely track the technical details of the Basin Study but would like to be updated periodically and receive information that is easy to understand and helps explain what implications the Basin Study will have on their lives and livelihoods.

## 5.4 Outreach Activities

Various coordinated activities will be conducted in order to inform and engage a variety of stakeholder audiences. Activities will include regular internal meetings among Reclamation and Study Partners, technically focused meetings, public meetings, coordination meetings with related efforts, and briefings with key stakeholder groups. In addition, the contractor will distribute regular email updates, allow for public review of draft documents, and share information broadly through the Basin Study website and other outreach materials. These activities support the outreach Goal and Objectives identified in Section 6.1.

Section 9.1 of the POS contains a project master schedule with important milestones. The Master Schedule will be updated by the contractor to include indicators which illustrate when specific outreach activities are proposed to be implemented in relation to the development of Basin Study content. The Master Schedule will be revisited and updated as appropriate throughout the development of the Basin Study.

### Executive Team Meetings

The Executive Team, comprised of Reclamation and Study Partner executives and senior officials, will meet as needed when requested by the Study Team to provide high-level policy direction.

### Study Team Meetings

Reclamation, USGS, and Study Partner representatives and consultant team staff compose the Study Team. The Study Team will hold regular meetings to manage and provide policy and technical direction throughout the Basin Study process. External stakeholders, including members of the public, will not participate in these meetings.

### Technical Working Group Meetings

The TWG is comprised of technical staff from Reclamation, USGS, Study Partners and the consultant team, will meet as needed requested by the Study Team to recommend or review key technical work products. Examples of where the TWG may provide review or recommendations include the following: metrics, water supply, water demand, and adaptation strategies.

### Technical Sufficiency Review

The TSR will involve both Reclamation and other experts in the earth sciences, including climatology/meteorology, hydrology, geology, and other fields. The TSR will involve professionals who are not directly engaged in the preparation of the Basin Study. The TSR, as required by Reclamation's Basin Study Directives and Standards, provides a "best science" perspective and expert-level peer review of Basin Study methodology and work products. The TSR team provides their review comments directly to Reclamation. A copy of the review findings will also be submitted to Study Team. The TSR team will be convened by the Project Manager and meet on an as-needed basis when there are technical memoranda available or other recommendations are needed.

### Stakeholder and General Public Meetings

Meetings with stakeholders and the general public will be scheduled around milestones in the Basin Study development process.

### Public Outreach and Information Meetings

Public meetings will be held at strategic points throughout the Basin Study, beginning with an initial meeting in the spring/summer of 2017. The exact dates of these meetings will be determined by the Study Team after work on the overall Basin Study is initiated and the contractor is retained. The general concept in the COP is that prior to completion of certain key major Basin Study phases, public meetings will be held to provide a summary of the results of the previous phase(s) and to inform participants on the upcoming phases of the Basin Study. This allows consideration of information and suggestions by the public for incorporation into the Basin Study.

Public meetings are currently envisioned as follows:

- Public Meeting #1 will focus on a presentation of information developed in Tasks 1, 2, and 3. This includes study metrics, characterization of climate change and sea level rise, and proposed study scenarios.
- Public Meeting #2 will present an overview of Task 4, the model tools used for the Basin Study, and Task 5, the information developed for water supplies, demands and operations.
- Public Meeting #3 will focus on the findings of Task 6, development of adaptation strategies (includes receiving input (or nominations)) for certain adaptation strategies; and, Task 7, the process for and analysis of the adaptation strategies proposed.
- Public Meeting #4 will focus on presenting the findings and results from the analysis of the adaptation strategies proposed and receiving public input on options and strategies.
- Public Meeting #5 will focus on presentation of the findings and the results of the Basin Study, includes the key vulnerabilities and the most robust and promising strategies. Includes presentation of potential next steps and follow-up investigations to promote long term sustainability.
- Public meetings will generally be held via webinar in order to make them time and resource efficient for the Study Team, Partners, and stakeholders, and to allow participation from remote locations. The meetings will be recorded and archived for future reference.

### Coordination Meetings with Related Efforts

Some of the stakeholders and general public interested in the Basin Study will overlap with those engaged and involved in other related processes, such as the Drought Contingency Planning and Groundwater Sustainability Plan preparation which are proposed to run concurrently with the preparation of the Basin Study. Over the duration of the preparation of the Basin Study, there may be opportunities to leverage related program meetings or interactions with these shared stakeholders. Cross promotion and leveraging existing groups of engaged stakeholders can assist in promoting the purpose of the COP and Basin Study outreach process in achieving the goals of the communications plan without adding significant costs of additional meetings.

As part of the implementation of the COP, Reclamation and the contractor will coordinate with other agencies and organization which are involved in programs which will inform the development of the Basin Study. These include:

- The California Water plan 2018 Update
- The Monterey Peninsula DCP

- Groundwater Sustainability Plan Development Entities
- Stormwater Resource Plans
- Other…TBD

In addition to coordinating project-specific efforts, Reclamation will also coordinate with broader engagements, particularly where appropriate such as the Statewide Water Analysis Network, which is a statewide network of stakeholders and experts convened by DWR to improve California's analytical capabilities in support of water management decisions and investments.

### Additional Meetings with Interested Stakeholders

During the course of the Basin Study, additional meetings will be held with interested stakeholder groups to solicit additional input, expertise, data, and information. As appropriate, representatives of key stakeholder groups may participate in specific Basin Study tasks to facilitate incorporation of their input into the Basin Study.

### Study Information and Updates

The Study Team and contractor will develop outreach materials to inform and educate stakeholders; tailoring materials for specific audiences when appropriate. What follows is a list of materials and systems that are proposed to be developed to support stakeholder communication and outreach. This list will be revisited after outreach activities are initiated and updated accordingly.

### Study Website

The Basin Study website will be one of the most important outreach tools and the most important outlet for communication and engagement with the general public.

A dedicated Basin Study website will be the repository for up-to-date information, including upcoming opportunities for stakeholders to provide input. Website content will be updated periodically, particularly at major milestones and prior to public meetings. In addition, the website will function as a tool for stakeholders to contribute input and ideas to the Basin Study process.

### Outreach Materials

Reclamation will develop informational materials that convey clear, consistent, and timely information that helps members of the public to understand the Basin Study and how it relates to their interests, and informs them on how to get involved. Outreach materials will be easy-to-understand and visually appealing.

### Stakeholder Mailing List/Study Updates

Basin Study updates will be sent to stakeholders on the Basin Study mailing list (either physically, electronically, or both) in anticipation of Basin Study milestones, including public meetings. The updates will inform stakeholders of the Basin Study status, provide opportunities for input, and provide meeting information including dates and locations of upcoming public meetings

Individuals can request to be included on the mailing list through the Basin Study email address or through attendance at a public meeting captured on the sign-in sheet. An initial mailing will be made to a list of stakeholders provided by the Study Partners and stakeholders from similar prior studies.

### Designated Point-of-Contact

The Basin Study will have designated point(s)-of-contact whom stakeholders can contact for additional information, questions, or comments. The point-of-contacts' information will be posted on the Basin Study website, and will be included in outreach materials.

### Review of Draft Study Documents

The project work plan anticipates preparation of a series of technical reports linked to tasks in the Performance Work Statement including:

- Metrics, sea level rise and climate scenarios
- Study scenarios
- Hydrologic models
- Water supply, demands and operations
- Adaptation strategy development
- Adaptation strategy performance analysis
- Findings (in the Summary Basin Study Report and Executive Summary)

The Study Team may provide opportunities for stakeholders to review and provide input on content of the Basin Study’s technical reports at certain intervals. All reviews will occur after the TSR review has been completed. The Study Team may review the TSR comments (and involve the TWG as appropriate) and may incorporate pertinent comments into the technical reports as appropriate, but will not respond to individual comments. All technical reports will be considered interim drafts until they are released by Reclamation in the final Basin Study Report.

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# Appendix A – Basin Study – Agency and Partner Tasking Table

# APPENDIX A

## SALINAS AND CARMEL BASINS STUDY

### Task Assignments by Reclamation, USGS, Contractor and Local Agency Partners

| Task | Reclamation | Contractor | USGS | MPWMD | MCWRA | SLOCPWD | MRWPCA |
|---|---|---|---|---|---|---|---|
| **1. Develop Study Metrics** | | | | | | | |
| **1(a) Develop Climate Metrics** | • Co-lead | • Coordinate / Support | • Co-lead | • Review | • Review | • Review | • Review |
| **1(b) Develop Supply Metrics** | • Coordinate / Support | • Coordinate / Support | • Limited Support / Review | • Co-lead (MP, CRB, SGB) | • Co-lead (SVB, SGB) | • Co-lead (PRB) | • Review |
| **1(c) Develop Demand Metrics** | • Coordinate / Support | • Coordinate / Support | • Limited Support / Review | • Co-lead (MP, CRB, SGB) | • Co-lead (SVB, SGB) | • Co-lead (PRB) | • Review |
| **1(d) Develop Operations Metrics** | • Coordinate / Support | • Coordinate / Support | • Limited Support / Review | • Co-lead (MP, CRB, SGB) | • Co-lead (SVB, SGB) | • Co-lead (PRB) | • Review |
| **1(e) Task 1 Tech Memo** | • Lead | • Review / Support Study Team | • Review | • Review | • Review | • Review | • Review |
| **2. Characterize Climate Change and SLR** | | | | | | | |
| **2(a) Compile Climate Data – Observed Climate** | • Lead | • Coordinate / Support Study Team w/ data | • Limited support (provide available data) | • Provide available data | • Provide available data | • Provide available data | • Provide available data |
| **2(b) Compile Climate – Global Projections** | • Lead | N/A | • Review | • N/A | • N/A | • N/A | • N/A |
| **2(c) Compile Climate – Downscaled Proj.** | • Lead | N/A | • Review | • N/A | • N/A | • N/A | • N/A |
| **2(d) Characterize Current Climate** | • Lead | N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **2(e) Characterize Climate Trends – Observed** | • Lead | N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **2(f) Characterize Climate Trends – Projected** | • Lead | N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **2(g) Compile Sea Level Data – Observed Climate** | • Lead | N/A | • Review | • N/A | • N/A | • N/A | • N/A |
| **2(h) Compile Sea Level – Projections** | • Lead | N/A | • Limited support (discuss data options) | • N/A | • N/A | • N/A | • N/A |
| **2(j) Characterize Current Sea Level** | • Lead | N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **2(k) Characterize Sea Level Trends – Observed** | • Lead | N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **2(l) Characterize Sea Level Trends – Projected** | • Lead | N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **2(m) Task 2 Tech Memo** | • Lead | • Review / Support Study Team | • Review | • Review | • Review | • Review | • Review |
| **3. Develop Study Scenarios** | | | | | | | |
| **3(a) Develop Climate Scenarios** | • Lead | • N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **3(b) Develop Sea Level Scenarios** | • Lead | • N/A | • Limited support (discuss method options) | • N/A | • N/A | • N/A | • N/A |
| **3(c) Develop Socioeconomic Scenarios** | • Coordinate / Support | • Lead | • Review | • Co-lead (MP, CRB, SGB) | • Co-lead (SVB, SGB) | • Co-lead (PRB) | • Co-Lead (SGB) |
| **3(d) Task 3 Tech Memo** | • Lead – outline/template<br>• Lead – climate<br>• Lead – sea level<br>• Co-Lead – socio/econ | • Lead – socio/econ scenarios<br>• Support Study Team | • Review | • Review – climate<br>• Review – sea level<br>• Co-lead – socio/econ (MP, CRB, SGB) | • Review – climate<br>• Review – sea level<br>• Co-lead – socio/econ (SVB, SGB) | • Review – climate<br>• Review – sea level<br>• Co-lead – socio/econ (PRB) | • Review – climate<br>• Review – sea level<br>• Review – socio/econ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **4. Develop Modeling Tools and Inputs** | | | | | | | |
| **4(a) Develop modeling tools** | • Coordinate / Support | • Coordinate / Support Study Team<br>• Assist model tool transfer and documentation from Partners to USGS as needed. | • Lead (all sub-areas)<br>• Obtain models and inputs from partners<br>• Identify model updates for basin study<br>• Implement updates (if any) | • Support (MP, CRB, SGB)<br>• Provide calibrated model and default inputs<br>• Provide documentation of model and inputs<br>• Provide data/tools used to develop selected inputs<br>• Discuss model updates required for basin study | • Support (SVB, SGB)<br>• Provide calibrated model and default inputs<br>• Provide documentation of model and inputs<br>• Provide data/tools used to develop selected inputs<br>• Discuss updates required for basin study | • Support (PRB)<br>• Provide calibrated model and default inputs<br>• Provide documentation of model and inputs<br>• Provide data/tools used to develop selected inputs<br>• Discuss updates required for basin study | • Review |
| **4(b) Develop model inputs – baseline** | • Coordinate / Support | • N/A | • Lead (all sub-areas)<br>• Identify updates to inputs for baseline<br>• Implement updates | • Support (MP, CRB, SGB)<br>• Identify and discuss input updates for baseline | • Support (SVB, SGB)<br>• Identify and discuss input updates for baseline | • Support (PRB)<br>• Identify and discuss input updates for baseline | • Review |
| **4(c) Develop model inputs – future climate** | • Support<br>• Provide climate scenarios, collaborate on method to develop model inputs for scenarios | • N/A | • Lead (all sub-areas)<br>• Identify update to inputs for all scenarios<br>• Implement updates | • Support (MP, CRB, SGB)<br>• Identify and discuss input updates for future scenarios | • Support (SVB, SGB)<br>• Identify and discuss input updates for future scenarios | • Support (PRB)<br>• Identify and discuss input updates for future scenarios | • Review |
| **4(d) Develop model inputs – future sea level** | • Support<br>• Provide sea level scenarios, collaborate on method to develop model inputs for scenarios | • N/A | • Lead (all sub-areas)<br>• Identify updates to inputs for all scenarios<br>• Implement updates | • Support (CRB, SGB)<br>• Identify and discuss input updates for future scenarios | • Support (SVB, SGB)<br>• Identify and discuss input updates for future scenarios | • Review | • Review |
| **4(e) Develop model inputs – future socio/econ** | • Coordinate / Support / Review | • N/A | • Lead (all sub-areas)<br>• Identify updates to inputs for all scenarios<br>• Implement updates | • Support (MP, CRB, SGB)<br>• Identify and discuss input updates for future scenarios<br>• Support USGS in implementing updates | • Support (SVB, SGB)<br>• Identify and discuss input updates for future scenarios<br>• Support USGS in implementing updates | • Support (PRB)<br>• Identify and discuss input updates for future scenarios<br>Support USGS in implementing updates | • Review |
| **4(f) Task 4 Tech Memo** | • Lead – outline/template<br>• Review – model development / updates<br>• Co-Lead – climate inputs<br>• Co-Lead – sea level inputs<br>• Review – socio/econ inputs | • Support Study Team Review | • Co-Lead – model development / updates<br>• Co-Lead – climate inputs<br>• Co-Lead – sea level inputs<br>• Co-Lead – socio/econ inputs | • Review – climate inputs<br>• Review – sea level inputs<br>• Co-Lead – socio/econ inputs (MP, CRB, SGB) | • Review – climate inputs<br>• Review – sea level inputs<br>• Co-Lead – socio/econ inputs (SVB, SGB) | • Review – climate inputs<br>• Review – sea level inputs<br>• Co-Lead – socio/econ inputs<br>(PRB) | • Review – climate inputs<br>• Review – sea level inputs<br>• Review – socio/econ inputs |
| **5. Evaluate supplies, demands, and operations** | | | | | | | |
| **5(a) Simulate Baseline Conditions** | • Coordinate / Support | • N/A | • Lead (all sub-areas)<br>• Carry out simulations of baseline conditions using models and inputs developed in Task 4 | • Support | • Support | • Support | • Review |
| **5(b) Simulate Future Conditions** | • Coordinate / Support | • N/A | • Lead (all sub-areas)<br>• Carry out simulations of future conditions under future climate, socioeconomic, and sea level scenarios using models and inputs developed in Task 4 | • Support | • Support | • Support | • Review |

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| **5(c) Compute Study Metrics** | • Co-Lead (all sub-areas)<br>• Compute study metrics – historical (Compute from observations)<br>• Discuss method options to compute study metrics for baseline + future scenarios | • Coordinate / Support Study Team | • Co-Lead (all sub-areas)<br>• Discuss method options to compute study metrics for baseline + future scenarios<br>• Compute study metrics – baseline + future<br>(Computed from model simulations carried out under Task 5(a-b)) | • Support (MP, CRB, SGB)<br>• Provide historical data to compute metrics<br>• Discuss method options to compute study metrics for baseline + future scenarios | • Support (SVB, SGB)<br>• Provide historical data to compute metrics<br>• Discuss method options to compute study metrics for baseline + future scenarios | • Support (PRB)<br>• Provide historical data to compute metrics<br>• Discuss method options to compute study metrics for baseline + future scenarios | • Support (SGB)<br>• Provide historical data to compute metrics<br>• Discuss method options to compute study metrics for baseline + future scenarios |
| **5(d) Evaluate/Characterize Historical Conditions** | • Lead<br>• Quantitatively evaluate / characterize historical water supplies, demands, and operations based on study metrics from Task 5(c) | • Co-Lead<br>• Qualitatively interpret and discuss historical water supplies, demands, and operations based on quantitative evaluation / characterization | • Support<br>• Discuss approach to evaluating / characterizing historical conditions | • Support<br>• Discuss approach to evaluating / characterizing historical conditions | • Support<br>• Discuss approach to evaluating / characterizing historical conditions | • Support<br>• Discuss approach to evaluating / characterizing historical conditions | • Support<br>• Discuss approach to evaluating / characterizing historical conditions |
| **5(e) Evaluate/Characterize Baseline Conditions (without adaptation/mitigation)** | • Lead<br>• Quantitatively evaluate / characterize baseline water supplies, demands, and operations based on study metrics from Task 5(c) | • Co-Lead<br>• Qualitatively interpret and discuss baseline water supplies, demands, and operations based on quantitative evaluation / characterization | • Support<br>• Discuss approach to evaluating / characterizing baseline conditions | • Support<br>• Discuss approach to evaluating / characterizing baseline conditions | • Support<br>• Discuss approach to evaluating / characterizing baseline conditions | • Support<br>• Discuss approach to evaluating / characterizing baseline conditions | • Support<br>• Discuss approach to evaluating / characterizing baseline conditions |
| **5(f) Evaluate/Characterize Future Conditions (without adaptation/mitigation)** | • Lead<br>• Evaluate / characterize future water supplies, demands, and operations based on study metrics from Task 5(c) | • Co-Lead<br>• Qualitatively interpret and discuss future water supplies, demands, and operations based on quantitative evaluation / characterization | • Support<br>• Discuss approach to evaluating / characterizing future conditions | • Support<br>• Discuss approach to evaluating / characterizing future conditions | • Support<br>• Discuss approach to evaluating / characterizing future conditions | • Support<br>• Discuss approach to evaluating / characterizing future conditions | • Support<br>• Discuss approach to evaluating / characterizing future conditions |
| **5(g) Evaluate/Characterize Projected Change (without adaptation/mitigation)** | • Lead – Compare baseline vs. historical (historical vs. future w/o climate change, effects of socio/econ change)<br>• Lead – Compare future vs. baseline (baseline vs. future climate scenarios, effects of climate change) | • Co-Lead<br>• Qualitatively interpret and discuss projected effects of climate change and socioeconomic change on water supplies, demands, and operations | • Support<br>• Discuss approach to evaluating / characterizing projected changes/effects<br>• Discuss approach to evaluating / characterizing climate and socioeconomic uncertainties | • Review | • Review | • Review | • Review |
| **5(h) Task 5 Tech Memo** | • Lead – outline/template<br>• Lead – historical conditions<br>• Lead – baseline conditions<br>• Lead – future conditions<br>• Lead – projected change | • Co-Lead – historical conditions (qualitative interpretation)<br>• Co-Lead – baseline conditions (qualitative interpretation)<br>• Co- Lead – future conditions (qualitative interpretation)<br>• Co-Lead – projected | • Lead – simulations / results<br>• Review – historical conditions<br>• Review – baseline conditions<br>• Review – future conditions<br>• Review – projected change | • Review – all | • Review – all | • Review – all | • Review – all |

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| | | change (qualitative interpretation) | | | | | |
| **6. Develop mitigation/adaptation strategies** | | | | | | | |
| **6(a) Define mitigation/adaptation objectives** | • Coordinate / Support (all sub-areas)<br>• Discuss/review imbalances<br>• Discuss/review adaptation objectives | • Lead- Identify adaptation / mitigation objectives | • Support (all sub-areas)<br>• Discuss/review imbalances<br>• Discuss/review adaptation objectives) | • Co-Lead (MP, CRB, SGB)<br>• Identify adaptation / mitigation objectives | • Co-Lead (SVB, SGB)<br>• Identify adaptation / mitigation objectives | • Co-Lead (PRB)<br>• Identify adaptation / mitigation objectives | • Co-Lead (SGB)<br>• Identify adaptation / mitigation objectives |
| **6(b) Develop non-structural strategies (optional)** | • Coordinate / Support (all sub-areas)<br>• Discuss/review non-structural strategies<br>• Help as needed to develop concepts in sufficient detail to simulate/evaluate alternatives | • Lead - Develop non-structural adaptation / mitigation strategies with Study Team | • Support (all sub-areas)<br>• Discuss/review non-structural strategies<br>• Help as needed to develop concepts in sufficient detail to simulate/evaluate alternatives | • Co-Lead (MP, CRB, SGB)<br>• Develop non-structural adaptation / mitigation strategies | • Co-Lead (SVB, SGB)<br>• Develop non-structural adaptation / mitigation strategies | • Co-Lead (PRB)<br>• Develop non-structural adaptation / mitigation strategies | • Co-Lead (SGB)<br>• Develop non-structural adaptation / mitigation strategies |
| **6(c) Develop structural strategies (optional)** | • Coordinate / Support (all sub-areas)<br>• Discuss/review structural strategies<br>• Help as needed to develop concepts in sufficient detail to simulate/evaluate alternatives | • Lead - Develop structural adaptation / mitigation strategies with Study Team | • Support (all sub-areas)<br>• Discuss/review structural strategies<br>• Help as needed to develop concepts in sufficient detail to simulate/evaluate alternatives | • Co-Lead (MP, CRB, SGB)<br>• Develop structural adaptation / mitigation strategies | • Co-Lead (SVB, SGB)<br>• Develop structural adaptation / mitigation strategies | • Co-Lead (PRB)<br>• Develop structural adaptation / mitigation strategies | • Co-Lead (SGB)<br>• Develop structural adaptation / mitigation strategies |
| **6(f) Task 6 Tech Memo** | • Lead – outline/template<br>• Review – strategies (all sub-areas) | • Co-lead -- section(s) describing proposed strategies | • Review (all sub-areas) | • Co-lead (MP, CRB, SGB)<br>• Contribute section(s) describing proposed strategies | • Co-lead (SVB, SGB)<br>• Contribute section(s) describing proposed strategies | • Co-lead (PRB)<br>• Contribute section(s) describing proposed strategies | • Co-lead (SGB)<br>• Contribute section(s) describing proposed strategies |
| **7. Evaluate adaptation/mitigation strategies** | | | | | | | |
| **7(a) Initial Screening or Evaluation of Proposed Adaptation / Mitigation Strategies** | • Coordinate / Support<br>• Discuss screening criteria (qualitative)<br>• Discuss method options for initial evaluation via simplified approach (quantitative)<br>• Provide support in carrying out initial screening / evaluation | • Lead – Facilitate discussion to identify and select screening criteria and method options for initial evaluation, including developing draft criteria and method options<br>• Lead – Perform initial screening and evaluation w/ Study Team | • Support<br>• Discuss screening criteria (qualitative)<br>• Discuss method options for initial evaluation via simplified approach (quantitative) | • Co-Lead (MP, CRB, SGB)<br>• Identify and select initial screening criteria<br>• Identify and select option(s) for initial evaluation<br>• Carry out initial screening and evaluation | • Co-Lead (SVB, SGB)<br>• Identify and select initial screening criteria<br>• Identify and select option(s) for initial evaluation<br>• Carry out initial screening and evaluation | • Co-Lead (PRB)<br>• Identify and select initial screening criteria<br>• Identify and select option(s) for initial evaluation<br>• Carry out initial screening and evaluation | • Co-Lead (SGB)<br>• Identify and select initial screening criteria<br>• Identify and select option(s) for initial evaluation<br>• Carry out initial screening and evaluation |
| **7(b) Modify model configuration and/or inputs as needed to simulate adaptation / mitigation strategies** | • Coordinate / Support<br>• Discuss method options to represent strategies in sub-area models | • Co-Lead<br>• Facilitate w/ Study Team - discuss options to represent strategies in sub-area models | • Co-Lead<br>• Discuss method options to represent strategies in sub-area models<br>• Implement selected options | • Co-Lead<br>• Discuss method options to represent strategies in sub-area models | • Co-Lead<br>• Discuss method options to represent strategies in sub-area models | • Co-Lead<br>• Discuss method options to represent strategies in sub-area models | • Co-Lead<br>• Discuss method options to represent strategies in sub-area models |
| **7(c) Simulate Baseline Conditions (with adaptation/mitigation** | • Coordinate / Support | • Facilitate review and discussion, including | • Lead<br>• Carry out simulations of baseline | • Review | • Review | • Review | • Review |

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| **strategies)** | | dissemination of simulation results to Study Team | conditions with adaptation/mitigation strategies in place using models/inputs developed in Task 7(a) | | | | |
| **7(d) Simulate Future Conditions (with adaptation/mitigation strategies)** | • Coordinate / Support<br>• Identify future climate scenarios to be simulated with adaptation/mitigation strategies (bracketing approach) | • Facilitate, review and discussion, including dissemination of simulation results to Study Team | • Lead<br>• Carry out simulations of future conditions with adaptation/mitigation strategies in place using models/inputs developed in Task 7(a) | • Review | • Review | • Review | • Review |
| **7(e) Evaluate/Characterize Baseline Conditions (with adaptation/mitigation strategies)** | • Lead<br>• Quantitatively evaluate / characterize baseline water supplies, demands, and operations based on study metrics with adaptation / mitigation strategies | • Co-Lead<br>• Qualitatively interpret and discuss baseline water supplies, demands, and operations based on quantitative evaluation / characterization | • Support<br>• Provide study metrics from simulations carried out in Task 7(c)<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies |
| **7(f) Evaluate/Characterize Future Conditions (with adaptation/mitigation strategies)** | • Lead<br>Quantitatively evaluate / characterize future water supplies, demands, and operations based on study metrics with adaptation / mitigation strategies | • Co-Lead<br>Qualitatively interpret and discuss future water supplies, demands, and operations based on quantitative evaluation / characterization | • Support<br>• Provide study metrics from simulations carried out in Task 7(d)<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies | • Support<br>• Discuss method options to evaluate / characterize conditions with strategies |
| **7(g) Evaluate Adaptation/Mitigation Strategies** | • Co-Lead<br>• Compare water supplies, demands, and operations between simulations with and without adaptation/mitigation strategies<br>• Quantify effects of adaptation/mitigation strategies on water supplies, demands, and operations based on simulated change in study metrics<br>• Compare effects of each adaptation / mitigation strategy to corresponding strategy objectives | • Lead<br>• Interpret results with the Study Team (with vs. without strategy) (MP, CRB, SGB, SVB, PRB)<br>• Consider trade-offs<br>• (quantitative trade-off with respect to water supply/demand; qualitative trade-off with respect to environmental and other considerations) | • Support<br>• Discuss method options for quantifying effects of adaptation / mitigation strategies | • Co-Lead<br>• Interpret results (with vs. without strategy) (MP, CRB, SGB)<br>• Consider trade-offs (quantitative trade-off with respect to water supply/demand; qualitative trade-off with respect to environmental and other considerations) | • Co-Lead<br>• Interpret results (with vs. without strategy) (SVB, SGB)<br>• Consider trade-offs (quantitative trade-off with respect to water supply/demand; qualitative trade-off with respect to environmental and other considerations) | • Co-Lead<br>• Interpret results (with vs. without strategy) (PRB)<br>• Consider trade-offs (quantitative trade-off with respect to water supply/demand; qualitative trade-off with respect to environmental and other considerations) | • Co-Lead<br>• Interpret results (with vs. without strategy) (SGB)<br>• Consider trade-offs (quantitative trade-off with respect to water supply/demand; qualitative trade-off with respect to environmental and other considerations) |
| **7(h) Task 7 Tech Memo** | • Lead – outline/template<br>• Co-Lead – initial screening/evaluation<br>• Lead – evaluation results<br>• Co-Lead – interpretation and trade-off analysis | • Co-Lead w/ Study Team<br>• Co-Lead – interpretation and trade-off analysis<br>• Review – all other | • Lead – modeling methods/results<br>• Review – all other | • Co-Lead – initial screening/evaluation<br>• Co-Lead – interpretation and trade-off analysis<br>• Review – all other | • Co-Lead – initial screening/evaluation<br>• Co-Lead – interpretation and trade-off analysis<br>• Review – all other | • Co-Lead – initial screening/evaluation<br>• Co-Lead – interpretation and trade-off analysis<br>• Review – all other | • Co-Lead – initial screening/evaluation<br>• Co-Lead – interpretation and trade-off analysis<br>• Review – all other |
| **8. Final Study Report and Executive Summary** | | | | | | | |
| **8(a) Prepare draft-final Summary Report** | • Support – Contractor Prep of Summary Report<br>• Lead – review | Lead – Prepare Summary Report & Executive Summary | • Support – review | • Support – limited writing<br>• Support – review | • Support – review | • Support – review | • Support – review |
| **8(b) Prepare draft-final Executive Summary (positioned in Summary** | • Support – Contractor Prep of Summary Report & Executive | Lead – Prepare Summary Report & Executive | • Support – review | • Support – limited writing<br>• Support – review | • Support – review | • Support – review | • Support – review |

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| **Report)** | Summary<br>• Lead – review | Summary | | | | | |

**NOTES:**

(1) Abbreviations … CRB = Carmel River Basin; SVB = Salinas Valley Basin; PRB = Paso Robles Basin; SGB = Seaside Groundwater Basin; MP = Monterey Peninsula watersheds (area between CRB and SVB model domains)

(2) Responsibilities for modeling Tasks 4, 5, and 7 are assigned based on study partner. It should be noted that actual work will likely be carried out under contract – e.g., USGS will conduct modeling of SVB under contract with MCWRA; USGS will conduct modeling of CRB under contract with MPWMD; and MPWMD may contract with USGS to conduct modeling of MP.

**SHADING:**

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|---|---|---|
| GREEN: | Task / sub-task funded by partner | (partner cost share) |
| BLUE: | Task / sub-task funded by Reclamation | (Federal cost share) |
| BROWN: | Not applicable | (No cost) |

# Appendix B – Table of Major Study Tasks, Budgets w/Projected Timelines

| Basin Study Task | Task Number | Summary Description | Mid-Pacific Region, TSC & Contractor Budget | USGS Budget | Totals x Task | Deliverables | Non-Federal Cost Share Required | Timeline |
|---|---|---|---|---|---|---|---|---|
| ***Develop Basin Study Metrics*** | **1** | Define a suite of metrics to quantify and characterize current and future climate conditions and water supplies, demands, and operations | $39,647 | $12,701 | $52,348 | Task 1 and 2 Technical Memorandum | $52,348 | Complete - April 2017 |
| ***Develop Climate Projections and sea level rise data*** | **2** | Characterize variability and trends in climate based on paleoclimate data, historical observations, and projections of future climate and sea levels | $73,440 | $15,935 | $89,375 | Task 1 and 2 Technical Memorandum | $89,375 | Complete - July 2017 |
| ***Prepare climate and socioeconomic scenarios*** | **3** | Develop planning scenarios that will be used to evaluate water supplies, demands, and operations under current and future conditions | $86,253 | $13,032 | $99,285 | Task 3 Technical Memorandum | $99,285 | Complete - January 2018 |
| ***Develop Modeling Tools and Strategies for Integration of Sub-Basin Models*** | **4** | Develop modeling tools and related input datasets to evaluate current and future water supplies, demands, and operations | $107,078 | $253,750 | $360,828 | Task 4 and 5 Technical Memorandum | $360,828 | Complete - May 2018 |
| ***Evaluate Supplies, Demands and Operations*** | **5** | Evaluate and characterize water supplies, demands, and operations under current and future conditions assuming no change in surface water or groundwater management | $155,501 | $234,975 | $390,476 | Task 4 and 5 Technical Memorandum | $390,476 | Complete - December 2018 |
| ***Develop and Analyze Adaptation Strategies*** | **6** | Study partners and stakeholders identify adaptation and mitigation strategies to address current or projected imbalances in supplies and demands | $159,508 | $36,148 | $195,656 | Task 6 and 7 Technical Memorandum | $195,656 | Complete - March 2019 |
| ***Evaluate Proposed Adaptation Strategies*** | **7** | USGS and the Study Team will evaluate selected adaptation and mitigation strategies. | $107,433 | $157,452 | $264,885 | Task 6 and 7 Technical Memorandum | $264,885 | Complete - July 2019 |
| ***Basin Study Summary Report and Executive Summary*** | **8** | Information developed in Tasks 1-7 will be summarized in a final basin study summary report. Technical memoranda detailing the data, methods, and results of each previous task will be included as appendices to the final study report | $109,545 | $13,346 | $122,891 | Summary Basin Study Report w/ Executive Summary | $122,891 | Complete - September 2019 |
| ***Public Outreach & Communication Plan Implementation*** | **9** | Contractor provides continuous public outreach. Includes Project website, meeting management and coordination, email regarding project status, | $84,400 | 0 | $84,400 | Implements the Basin Study's Communications and Outreach Plan | $84,400 | Continuous Impementation Throughout During Preparation |
| **GRAND TOTALS** | | | **$922,805** | **$737,339** | **$1,660,144** | | **Total Cost Share Req'd.= $1,660,144** | |

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