Central Valley Regional Water Quality Control Board

DRAFT Central Valley Region Climate Change Work Plan

Current State of Knowledge & Considerations for Addressing Climate Change

Authors

Contents

Acronyms and Abbreviations

AB 32	Assembly Bill 32
BMP	best management practice
CARB	California Air Resources Board
CDFA	California Department of Food and Agriculture
Central Valley Water Board	Central Valley Regional Water Quality Control Board
CNRA	California Natural Resources Agency
CUPA	Certified Unified Program Agencies
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
GHG	greenhouse gas
ILRP	Irrigated Lands Regulatory Program
NPDES	National Pollutant Discharge Monitoring Program
Regional Water Board	Regional Water Quality Control Board
SNMP	Salt and Nitrate Management Plan
State	state of California
State Water Board	State Water Resources Control Board
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
WDR	Waste Discharge Requirements
WQO	water quality objective
WWTP	wastewater treatment plants
%	percent
^{o}F	degrees Fahrenheit

1. Introduction

Over the last century, human activities have released large quantities of carbon dioxide and other greenhouse gases (GHGs) into Earth's atmosphere, which has driven changes to the global climate. Increased temperatures, reduced snowpack levels, increased frequency of extreme weather events, and rises in sea level have all been observed, and are expected to continue in the future. These changes are impacting water quality and water supply throughout the Central Valley Region.

While many studies have focused on the impact of climate change on water availability, little attention has been given to the impact of climate change on water quality. The observed and anticipated impacts of climate change will directly impact and potentially degrade the quality of surface water and groundwater. This problem deserves immediate attention, as we are beginning to understand that the impacts of climate change are already happening.

The State Water Resources Control Board (State Water Board) is taking an active role in responding to the effects of climate change. *State Water Board Resolution 2017-0012: Comprehensive Response Climate Change* was adopted on March 10, 2017. The resolution lays the foundation for a robust response to climate change that is integrated into all State Water Board actions. The planned climate change response includes actions aimed at reducing GHG emissions, improving ecosystem resilience, responding to climate change impacts, and employing sound modeling and analyses to guide decision-making.

This *Central Valley Region Climate Change Work Plan* (*Work Plan*) has been prepared to present current and proposed efforts that Central Valley Regional Water Quality Control Board (Central Valley Water Board) programs are undertaking in response to climate change. It will also prioritize major efforts that promote climate change resiliency. An approximate timeline is presented for implementation of major efforts.

2. Climate Change in California

The unique climate and topography of California, and the Central Valley in particular, influence how global climate trends are expressed at the regional level. The impacts of climate change on Central Valley Region climate, natural environment, and water resources are discussed in Section 2.1. Central Valley Region surface water and groundwater beneficial uses that may be vulnerable to climate change impacts are discussed in Section 2.2. Finally, State-wide climate change response measures being implemented to protect these beneficial uses are presented in Section 2.3.

2.1 Expected Impacts in the Central Valley

The impacts of climate change on the Central Valley Region climate, natural environment, and water resources are discussed below.

2.1.1 Temperature

Climate change models predict that California will experience higher ambient temperatures in the future, while extreme heat events are likely to increase in frequency and duration. The average annual surface temperature in California is projected to increase by between 2 and 5 degrees Fahrenheit (^{o}F) by 2050 and between 4 and 9 ^{o}F by 2100, depending on the GHG emissions scenario assumed (CNRA 2009). Within the Central Valley, a median increase in annual temperature of approximately 2 ^{o}F by 2025 and 4 ^{o}F by 2060 is projected. Climate models project a greater amount of warming during summer months, especially during nighttime, and in the interior regions of California (California Department of Water Resources [DWR] 2016). Heat waves are also expected to increase in frequency, with individual heat waves also showing a tendency towards becoming longer and extending over a larger area (Natural Resources Agency 2009).

2.1.2 Wildfires

Wildfire frequency and intensity is expected to grow as temperatures increase, snowpack level drop, and vegetation dries out. In one study, the middle 50 percent (%) of climate change projections showed State-wide burned area increases of 41% to 69% by 2085 (Westerling et al 2011). An increase in wildfire frequency and magnitude will accelerate the rates of soil erosion, pollutant runoff, and habitat loss. Wildfires are also a source of GHG emissions as well as fine particulates and other byproducts which impair air quality.

2.1.3 Precipitation and Snowpack

Most of California's precipitation falls in the winter as snow in the Sierra Nevada mountain range. California's water supply system is dependent on water stored as snowpack, as more than 60% of California's developed water supply originates in the Sierra Nevada mountain range. Up to 50% of the

flow entering the Sacramento-San Joaquin Delta (the Delta) also originates in the Sierra Nevada (Sierra Nevada Conservancy 2011).

Climate change is not anticipated to significantly alter Central Valley mean annual precipitation through 2100; however, the character of the precipitation is expected to change. It was projected that the Sierra Nevada snowpack will experience a 25% to 40% reduction from its historic average by the year 2050 (DWR 2008). Changes in snowpack and the timing of spring runoff have already been observed in the Sierra Nevada over the past century. Rising temperatures have resulted in more precipitation falling as rain instead of snow, and snowmelt occurring earlier in the spring (Moser et al 2009).

Historically, the most dangerous California storms have been warm and wet storms that occur during the winter and produce intense rainfall over large areas. Many of these storms are identified as "atmospheric rivers", which are characterized by narrow intense bands of water vapor transported in the lower atmosphere. Atmospheric rivers are increasingly understood to be a source of most of the largest floods in California. Over the next century, years with many atmospheric rivers are expected to become more frequent, as is the frequency of storm intensities characterized as "much-larger-than-historical-range" (Dettinger 2011).

2.1.4 Sea Level Rise

An overall rise in sea levels over time is expected as a function of the thermal expansion of seawater and the melting land-based ice. Sea level rise along the California coast is expected to accelerate during the 21st century. The National Research Council projected a sea level rise for the city of San Francisco at 4.8 to 23.9 inches by the year 2050, and 16.7 to 65.5 inches by the year 2100 (National Research Council 2012). Sea level rise has the potential to inundate previously dry areas, alter the salinity gradient of the Delta, and influence natural tidal variations along the coast (DWR 2016).

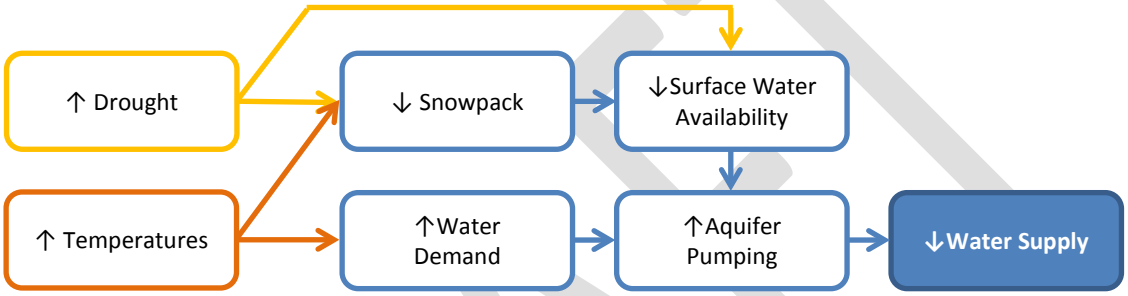
The Central Valley region is especially vulnerable to flooding from sea level rise, as much of the Delta land surface is below sea level (Moser et al 2009). Prior to agricultural development, Delta soils were water-logged and anaerobic. The drainage of Delta lands for agricultural purposes led to the soil aeration, oxidation of soil organic carbon to carbon dioxide, and subsequent subsidence of Delta lands (USGS 2000). Delta lands are protected from inundation by approximately 1,100 miles of earthen levees (DWR 2010), but rises in sea level would place added stress on the aging levee system. Sea level rise also exacerbates the problem of saltwater intrusion.

2.1.5 Water Supply

Most climate change projections show a general drying trend over California, resulting in reduced water deliveries from a decreasing Sierra Nevada snowpack. This trend may lead to water supply reliability risk for agriculture, and more competition among water users (CNRA 2009). To offset diminished surface water supplies, reliance may to shift toward groundwater sources. Two thirds of Californians receive at

least a portion of their drinking water from the Delta (USGS 2000). The majority of the Delta's land surface is devoted to agriculture, which is also dependent on a reliable freshwater supply (DWR 2017b).

Unfortunately, groundwater sources are already threatened in many parts of California. In 2016, DWR identified several Central Valley groundwater basins as being "critically overdrafted", indicating that continuation of current water management practices would likely result in significant adverse over-draft related impacts, including seawater intrusion, land subsidence, or chronic lowering of groundwater levels (DWR 2017a). Climate change impacts have the potential to accelerate the trend towards water supply depletion which is already being observed in many parts of the State. A simplified schematic summarizing the anticipated impacts of climate change on Central Valley water supplies is presented below.



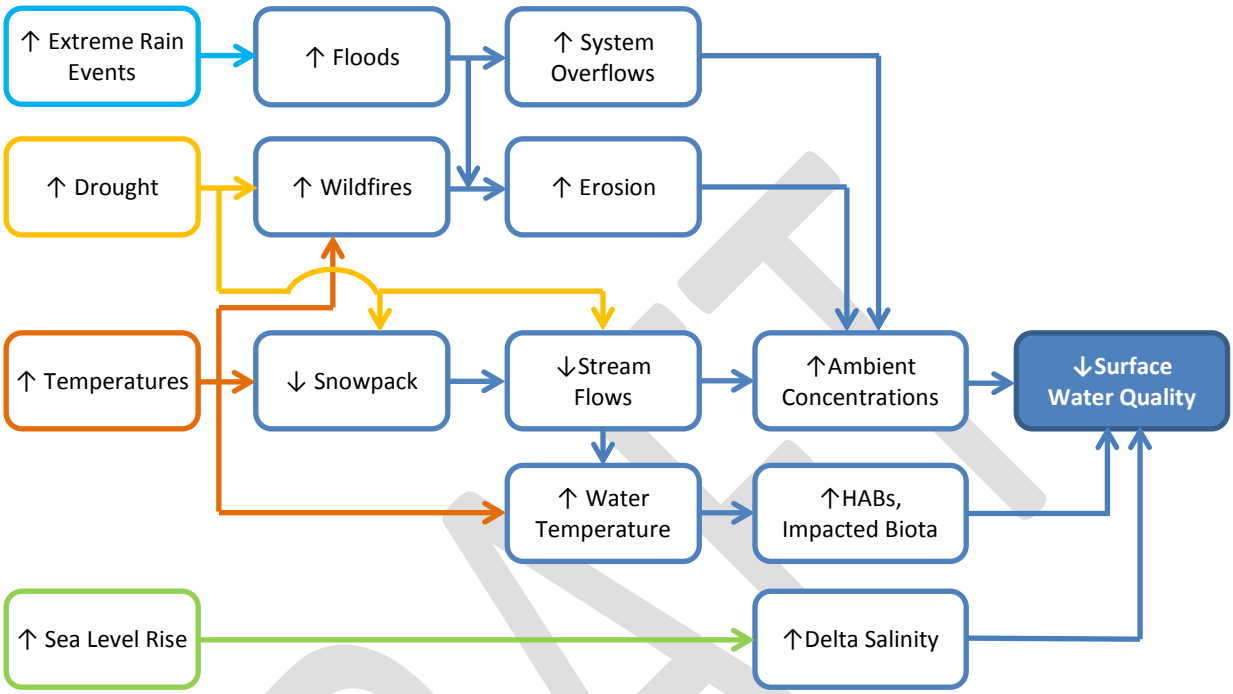
2.1.6 Water Quality

The possible consequences of climate change on California's water quality are numerous, complex, and often interconnected. The potential impacts of climate change on the physical, chemical, and biological characteristics of surface waters include:

- Higher temperatures and a greater fraction of Sierra Nevada precipitation falling as rain may reduce stream flows, especially during summer months, which could result in warmer waters, greater ambient concentrations, and loss of aquatic habitats. Within the Central Valley, the projected change in water temperature ranges from 1.3 to 2.5 ^{o}F by 2025, and 2.9 to 4.9 ^{o}F by 2060 (DWR 2016).
- Increased wildfire and flash flood occurrences could amplify soil erosion processes and the transport of sediment and contaminants to surface waters, impacting fish spawning and habitat.
- Heavy precipitation events could overload sewer systems and treatment plants, allowing wastewater to discharge into surface water bodies. Saturated soils could also limit infiltration both from percolation ponds and land application areas.
- Warmer surface waters would be conducive to algae growth, which could result in harmful algal blooms that threaten water quality by producing an undesirable odor, taste, and color.
- The lower oxygen solubility of warmer waters coupled with the proliferation, and subsequent decomposition, of algae may lead to anoxic surface water conditions which would threaten aquatic species.

- Sea level rise may lead to a loss of freshwater aquatic habitat within the Delta, and a shift towards more salt-tolerant plant and animal communities.

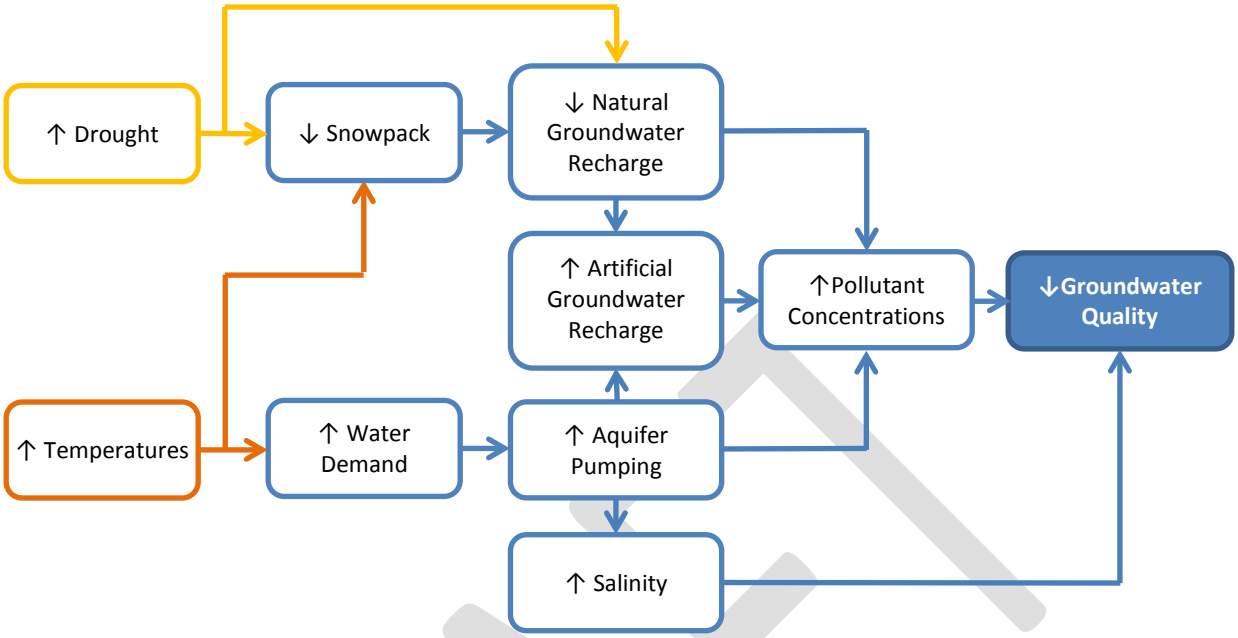
A simplified schematic summarizing some of the anticipated impacts of climate change on Central Valley surface water quality is presented below.



Climate change impacts on groundwater quality are sometimes unseen but no less prevalent than those on surface waters, and include:

- The combination of higher temperatures, periods of low precipitation, and the potential higher reliance on groundwater supplies may cause a drop in groundwater tables and concentrating of groundwater contaminants.
- The lowering of groundwater tables will increase the concentrations of salts.
- In an effort to recharge groundwater aquifers, increased application storm water and/or treated wastewater injection may alter groundwater quality.

A simplified schematic summarizing some of the anticipated impacts of climate change on Central Valley groundwater quality is presented below.



2.2 Beneficial Uses Vulnerable to Climate Change Impacts

Beneficial uses of groundwater and surface water are defined in water quality control plans (i.e., Basin Plans). Each Regional Water Board is required to prepare and adopt a Basin Plan pursuant to California Water Code (Section 13240) and supported by the federal Clean Water Act. The Central Valley Water Board has two Basin Plans, one for the Sacramento and San Joaquin River Basins, and one for the Tulare Lake Basin. The latest versions of these Basin Plans are:

- *The Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region, The Sacramento River Basin and The San Joaquin River Basin – Fourth Edition* (*Sacramento/San Joaquin River Basin Plan*; Central Valley Water Board 2016); and

- *Water Quality Control Plan for the Tulare Lake Basin – Second Edition* (*Tulare Lake Basin Plan*; Central Valley Water Board 2015).

State law defines beneficial uses of California's water that may be protected against quality degradation to include (and not be limited to) "…domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment, navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves". Protection and enhancement of existing and potential beneficial uses are primary goals of water quality planning. Surface water and groundwater beneficial uses that may be vulnerable to climate change impacts are presented below. Beneficial use definitions are provided in Appendix A.

2.2.1 Surface Waters

Existing and potential beneficial uses of Sacramento River Basin and San Joaquin River Basin surface waters are presented in Figure II-1 and Table II-1 of the *Sacramento/San Joaquin River Basin Plan*. Similarly, Tulare Lake Basin surface water beneficial uses are identified in Table II-1 of the *Tulare Lake Basin Plan.* Anticipated climate change impacts and surface water beneficial uses threatened by these impacts are described below. Along with the beneficial uses identified below, the MUN (Municipal and Domestic Supply) and AGR (Agricultural Supply) beneficial uses would be threatened by many climate change impacts, as these beneficial uses are sensitive to changes in both surface water supply and quality, and have been designated for surface waters throughout the Central Valley.

- The expected increase in surface water temperatures may endanger fish populations that thrive in cold waters, impacting the COLD (Cold Freshwater Habitat) designation.
- The combination of lower surface water flows, increasing pollutant and sediment concentrations, and increasing algae growth (which could bring a decrease in surface water dissolved oxygen levels) could potentially affect the hydrological and chemical quality of the region's streams, lakes and wetlands. These changes would impact several beneficial uses such as MUN, AGR, COLD, WARM (Warm Freshwater Habitat), WILD (Wildlife Habitat), and SPWN (Spawning, Reproduction, and/or Early Development) throughout the Central Valley Region. In the Sacramento and San Joaquin River Basins, the BIOL (Preservation of Biological Habitats) and MIGR (Migration of Aquatic Organisms) beneficial uses would also be impacted.
- Increasing algae growth, potential harmful algal blooms, and decreased surface water flow could impact recreational beneficial uses such as MUN, REC-1 (Water Contact Recreational Use) and REC-2 (Non-contact Recreational Use).
- Increasing pollutant and sediment loadings and increasing algae growth could affect beneficial uses designated to protect human activities that rely on water quality, such as MUN, AGR, PRO (Industrial Process Supply), and IND (Industrial Service Supply).
- Decreasing surface water flows could result in water depths that no longer support NAV (Navigation) uses in the Sacramento and San Joaquin River Basins. Decreasing surface water flows would also influence reservoir water management, which could impact the hydropower generation (POW) beneficial use throughout the Central Valley Region.
- Increasing surface water salinity, combined with lower stream flows limiting the amount of freshwater coming into Delta zones may cause conversions of habitat types (e.g., estuarine habitats to marine habitats) and/or loss of freshwater wetland habitats. These ecological changes could impact beneficial uses such as WILD and SPWN throughout the Central Valley Region, along with the BIOL and MIGR beneficial uses in the Sacramento and San Joaquin River Basins.
- In the Tulare Lake Basin, the RARE (Rare, Threatened, or Endangered Species) beneficial use is also expected to be impaired by the anticipated surface water and habitat impairments described above.

- In the Tulare Lake Basin, changes to water quality and supply are also expected to impair the GWR (Ground Water Recharge) and FRSH (Freshwater Replenishment) beneficial uses.

A summary of anticipated climate change impacts and surface water beneficial uses threatened by these impacts is presented in the table below.

BENEFICIAL USES	Increased Temperature	Reduced Flow Rates	Increased Discharge Concentration	Increased Algae Growth	Increased Salinity
ENTIRE CENTRAL VALLEY					
MUN	X	X	X	X	X
AGR	X	X	X	X	X
IND			X	X	X
PRO			X	X	
POW		X			
REC-1		X	X	X	
REC-2		X	X	X	
COLD	X	X	X	X	
WARM		X	X	X	
WILD	X	X	X	X	X
SPWN	X	X	X	X	X
SACRAMENTO AND SAN JOAQUIN RIVER BASIN ONLY					
BIOL		X	X	X	X
MIGR		X	X	X	X
NAV		X			
TULARE LAKE BASIN ONLY					
RARE		X	X	X	X
GWR		X	X	X	X
FRSH		X	X	X	X

2.2.2 Groundwater

Existing and potential beneficial uses of Sacramento River Basin and San Joaquin River Basin groundwater are presented in Chapter II of the *Sacramento/San Joaquin River Basin Plan*. Unless otherwise designated by the Regional Water Board, all groundwater in the Sacramento River Basin and San Joaquin River Basin is considered suitable or potentially suitable, at a minimum, for municipal and domestic water supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO). All of these beneficial uses are dependent on groundwater supply. In many climate change scenarios, drought conditions are expected to become more frequent, and diminishing

surface water supplies are expected to result in increased groundwater pumping. These conditions would threaten groundwater supplies, and consequently, the MUN, AGRI, IND, and PRO beneficial uses. As discussed in Section 2.1.4, climate change impacts are also expected to influence groundwater quality by reducing groundwater recharge, and concentrating pollutants. The MUN, AGR, and PRO beneficial uses are dependent on water quality, and therefore would be impaired by these changes.

Tulare Lake Basin groundwater beneficial uses are presented in Chapter II and Table II-2 of the *Tulare Lake Basin Plan.* Along with the MUN, AGR, IND, and PRO beneficial uses, the REC-1, REC-2, and WILD beneficial uses have been identified for groundwater within portions of the Tulare Lake Basin.

A summary of anticipated climate change impacts and groundwater beneficial uses threatened by these impacts is presented in the table below.

BENEFICIAL USES	Declining Water Tables	Increased Salinity	Increased Artificial Recharge
ENTIRE CENTRAL VALLEY			
MUN	X	X	X
AGR	X	X	
IND	X	X	X
PRO	X	X	X
TULARE LAKE BASIN			
REC-1	X	X	X
REC-2	X	X	X
WILD	X	X	X

2.3 State-Wide Climate Change Response Measures

State Water Board Resolution 2017-0012 was adopted on March 7, 2017 to lay the foundation for a robust response to climate change that is integrated into all State Water Board actions. The planned climate change response includes actions aimed at reducing GHG emissions, improving ecosystem resilience, responding to climate change impacts, and ensuring that decisions are made using sound modeling and analyses. Resolution 2017-0012 compels response actions from the State Water Board with support from the Regional Water Boards. These response actions include collaboration with, and support of, climate change response efforts being driven by other agencies including the United States Environmental Protection Agency (USEPA), California Air Resources Board (CARB), Department of Resources Recycling and Recovery, and others. Ongoing climate change response initiatives are presented below.

2.3.1 Greenhouse Gas Reduction

Select State-wide initiatives aimed at mitigating the impacts of climate change by reducing GHG emissions are summarized below.

2.3.1.1 Assembly Bill 32

Assembly Bill 32 (AB 32), also known as the California Global Warming Solutions Act of 2006, requires California to reduce its GHG emissions to 1990 levels by the year 2020. This emissions level would represent approximately a 15% reduction as compared to the GHG emission level under the "business as usual" scenario. Pursuant to AB 32, the CARB must adopt regulations to achieve the maximum technologically feasible and cost-effective GHG emission reductions. The CARB's strategy for reducing emissions is outlined in a scoping plan which is updated every five years. The first scoping plan, titled *Climate Change Scoping Plan: A Framework for Change* (CARB 2008) was finalized in December 2008, and the first update was approved in May 2014. The scoping plan proposed to reduce GHG emissions through a combination of policies, planning, direct regulations, market approaches, incentives, and voluntary efforts.

2.3.1.2 Healthy Soils Program

In September 2016, the California Department of Food and Agriculture (CDFA) appropriated $7.5 million from the Greenhouse Gas Reduction Fund to develop and administer the Healthy Soils Program. The Healthy Soils Program will be designed to provide incentives to farmers and ranchers to build soil carbon and reduce GHG emissions from agricultural land. The program will provide growers with a list of practices that have quantified GHG reductions so growers can choose which practice to implement and obtain financial incentives for its implementation. GHG reduction practices will be approved by the United States Department of Agriculture Natural Resources Conservation Service. The framework for the program is being developed in 2017.

2.3.1.3 Water - Energy Nexus

In the water sector, fossil fuel-based energy is typically used for water and wastewater conveyance and treatment. GHG emissions can be reduced by replacing fossil fuels with renewable energy, improving system efficiency, and enhancing water conservation. Many water and wastewater agencies have already reduced their carbon footprint by utilizing renewable sources of energy and encouraging their users to be water efficient. The use of recycled water, increased system efficiency, and energy capture from wastewater streams have the potential to further reduce GHG emissions in the water sector.

Climate change has the potential to impact both the supply of, and demand for, energy in California. As discussed in Section 2, the Central Valley climate is expected to become warmer and have fewer "wet" years in the future. These changes may reduce the average stream flow entering reservoirs upstream of hydroelectric power stations, which in turn would reduce the long-term rate of power generation.

Concurrently, a warmer climate may increase the demand for water and power, further intensifying our reliance on fossil fuels and other non-hydroelectric forms of energy. Water managers must consider the effect of climate change on stream flows and energy demands to optimize the operation of hydroelectric systems.

2.3.2 Adaptation

The *Work Plan* builds on several ongoing initiatives to adapt to the impacts of climate change and ensure protection of human health and the environment. Existing adaptation-focused initiatives are summarized in the following sections.

2.3.2.1 Safeguarding California

Executive Order S-13-08, which was issued in November 2008, directed the California Natural Resources Agency (CNRA) to develop a state climate adaptation strategy in coordination with local, regional, state, and federal public and private entities. In response to Executive Order S-13-08, the CNRA issued the *2009 California Climate Adaptation Strategy* (CNRA 2009), which established a proactive foundation for climate change adaptation and prioritized specific vulnerabilities and adaptation needs. In July 2014, the CNRA issued its first update of this report, titled *Safeguarding California: Reducing Climate Risk* (CNRA 2014). This report highlighted climate risks for nine sectors of California, including agriculture, public health, energy, and water. The report also discussed climate change impact mitigation progress to date, and proposed realistic sector-specific recommendations for future work. A 2017 update to this plan is currently being prepared. In addition to these documents, CNRA issued the 2016 *Safeguarding California: Implementation Action Plans* (CNRA 2016) which consisted of ten implementation plans to serve as a blueprints for executing the actions recommended in the 2014 *Safeguarding California: Reducing Climate Risk* report.

2.3.2.2 Cal-Adapt

Cal-Adapt is a web-based resource for visualizing local risks posed by the projected consequences of climate change, including extreme heat, sea level rise, snowpack, wildfire, and drought. Cal-Adapt was developed by the University of California at Berkeley's Geospatial Innovation Facility with funding and advisory oversight by the California Energy Commission. The Cal-Adapt climate tools are supported by peer-reviewed research which has been downscaled to California's geography to allow planners to identify potential climate impacts in their particular area, and assess local vulnerabilities to those impacts.

3. Regional Water Board Considerations for Addressing Climate Change

This section presents current and proposed efforts that Central Valley Water Board programs are undertaking in response to climate change. Additional program information, including each program's goals, staffing, and performance targets may be found in the annual program fact sheets, which are available on the Central Valley Water Board website.

3.1 Planning

The planning program involves various activities that include: planning, data collection, and stakeholder engagement to ultimately support the development of surface water and groundwater regulatory standards, policies and guidance documents. Climate change adaptation and mitigation will be considered as part of future planning and guidance efforts.

3.1.1 Basin Planning

Basin Plans provide the foundation for all Central Valley Water Board regulatory actions by identifying surface water and groundwater beneficial uses, water quality objectives (WQOs), implementation actions to achieve WQOs, and monitoring programs to ensure that implementation actions are effective. The Central Valley Water Board has two Basin Plans, one for the Sacramento and San Joaquin River Basins, and one for the Tulare Lake Basin. The current versions of these Basin Plans are identified in Section 2.2.

The current Basin Plans do not explicitly address climate change; however, future Basin Plan amendments must evaluate climate change as part of the environmental review process. Also, climate change will make outdated some of the data used to evaluate beneficial uses. Climate change impacts will be considered during the next triennial Basin Plan review which is scheduled for 2017. The triennial review is a public review process that is conducted once every three years to identify and prioritize actions needed to address water quality concerns and maintain the effectiveness of the Basin Plan. Examples of climate change-related concerns that may be considered for future action as part of the Basin Plan review process include:

- Encouraging the incorporation of wetlands and riparian areas in groundwater recharge basin projects;
- Redefinition of background conditions;
- Accounting for flood safety measures and associated changes in flow and storage capacities;
- Accounting for the impacts of drought and water conservation in setting of objectives;
- Evaluation of temperature criteria to determine achievable conditions leading to changes in basin plan requirements including development of temperature objectives;
- Streamlining the permitting and review process for groundwater recharge projects;
- Re-designating certain beneficial uses if climate change impacts alter the beneficial uses that can be supported in a given basin; and

- Protecting certain beneficial uses that are especially climate-sensitive, such as COLD; if pursued, this amendment would involve coordination with other agencies that control water rights and flow, along with the development of numeric temperature water quality objectives.

3.1.2 Total Maximum Daily Loads

The Total Maximum Daily Loads (TMDL) program establishes maximum allowable pollutant loading rates (i.e., TMDLs) for impaired water bodies to ensure that WQOs are achieved and beneficial uses are protected. The program also allocates the allowable pollutant load among dischargers to the water body.

As discussed in Section 2, average surface water flows may decrease in the future, and changes to surface water temperature, dissolved oxygen, and turbidity are also possible. Observed changes in surface water characteristics may require TMDL program staff to:

1. Update the definition of "background conditions" based on observed changes in ambient surface water characteristics; or
2. Expand of the list of water bodies classified as "impaired" based on current program guidelines.

If changes to surface water body conditions are observed over time, updates to TMDL values may be needed to maintain WQOs, or site specific objectives would need to be considered to improve program responsiveness to changing environmental conditions, "re-opener clauses" may be adopted. Planning assessment periods would likely be lengthened so that observed environmental variability can be better understood and incorporated into TMDL planning. Collaboration with the Surface Water Ambient Monitoring Program (SWAMP) will be needed to ensure that the appropriate monitoring is conducted to fully understand changes to ambient surface water body conditions.

3.1.3 Delta Program

Central Valley Water Board Delta Program staff work with staffs of the San Francisco Bay Water Board and State Water Board to develop a strategies for addressing impacts to beneficial uses in the Delta. In 2008, the State Water Board, San Francisco Bay Water Board, and Central Valley Water Board jointly adopted the *Strategic Workplan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (State Water Board 2008) which described the actions the Water Boards would complete to protect beneficial uses of water in the San Francisco Bay/Sacramento-San Joaquin Delta, and provided timelines and resource needs for implementation. In 2014, the Central Valley Water Board prepared the *2014 Delta Strategic Work Plan* (Central Valley Water Board 2014) to provide updates on work proposed in 2008, and to present new projects recommended by the Central Valley Water Board and Delta Stewardship Council.

Anticipated climate change impacts to surface water (Section 2.2.1) including changes in water temperature, dissolved oxygen, and algae growth, will impact the Delta. Sea level rise will inundate new

areas and influence salinity gradients. Sea level rise coupled with more extreme coastal storms will result in increased flooding in the Delta. Also, potential changes in precipitation patterns will influence the timing and flow rates of freshwater inputs to the Delta. In response to these changes, the Delta Program will promote wetland restoration projects to protect areas serving as wetland habitat and GHG sinks. This effort would be linked to mitigation measures in the water quality certification program. The Delta Program will also focus monitoring resources more on the drivers of harmful algal blooms so that their occurrences can be better predicted and mitigated. The Delta Nutrient Research Plan, which is currently being developed by the San Francisco Bay Water Board and the Central Valley Water Board, is considering uncertainties related to climate change within its research recommendations. Ultimately, the document will propose the development of mathematical models that will assist in further testing climate change scenarios and possible management strategies.

3.1.4 Surface Water Ambient Monitoring Program (SWAMP)

SWAMP was created to fulfill the legislative mandate for a unifying program that would coordinate all surface water quality monitoring conducted by the State Water Board and Regional Water Boards. SWAMP conducts water quality monitoring directly and through collaborative partnerships. Surface water monitoring data collected by SWAMP will be a critical component in monitoring climate change impacts on surface water conditions. In 2016, SWAMP staff was trained in identifying and sampling toxic algae such as cyanobacteria. SWAMP staff will work with the State Water Board to conduct initial algal bloom response monitoring, as needed, in the future. During 2017 and 2018, SWAMP is also planning to deploy continuous temperature loggers in several headwater streams to monitor temperature trends and evaluate whether the streams are protective of cold water habitat.

Climate change will have an impact on reference and background conditions of surface waters. SWAMP's monitoring approach will need to be adjusted in the future to ensure that any changes in key climate change indicators (e.g., temperature, flow rate, salinity, dissolved oxygen, etc.) are captured in their dataset. This data will help planners better quantify how background conditions are evolving and what impact these changes might have on beneficial uses. At this time, however, there are no specific contract or laboratory resources available to monitor climate change impacts. SWAMP will need to expand available laboratory resources so that chemical and biological surface water changes can be examined more thoroughly.

3.1.5 Central Valley Salinity Alternatives for Long-Term Sustainability Program (CV-SALTS)

Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) initiative is a stakeholder-driven effort that was initiated in 2006 to develop a sustainable Salt and Nitrate Management Plan (SNMP) for the entire Central Valley. The SNMP addresses the legacy of salt and nitrate accumulation in soil, groundwater, and surface water in the region. The SNMP was submitted to the Central Valley Water Board in December 2016, and ultimately will be incorporated into the Basin Plan as an amendment. The SNMP has three primary goals:

1. Ensure a safe drinking water supply;
2. Achieve balanced salt and nitrate loading; and
3. Implement managed aquifer restoration.

Salt and nutrient management will become especially critical in the future if decreases in water supply continue to be observed. As a long term program, CV-SALTS will be considering climate change as part of its planning process. Climate change impacts that are expected to influence CV-SALTS planning include the potential increased drought frequency and reduced freshwater flows. In response to potential drought conditions, CV-SALTS prepared a Conservation and Drought Policy to guide salt and nitrate management during drought years. CV-SALTS also developed an AGR Policy which includes numerical guidance to facilitate more rapid and consistent interpretation of the Basin Plan AGR beneficial use narrative related to groundwater salinity objectives. The AGR Policy recommended modifications to the Basin Plans to clarify how salinity will be managed within each groundwater basin and sub-basin. Both of these policies were included in the SNMP as attachments. Changes in temperature regimes and length of growing seasons will likely lead to increased use of fertilizers and changes in pesticide and herbicide usage, both of which will impact salt loading from agriculture.

3.2 Surface Water Regulation

As discussed in Section 2, the potential impacts of climate change on surface water bodies are varied, and interconnected. Across surface water programs, there may be tension between state and federal interpretations of if and how to account for climate change. The following sections discuss how climate change is impacting surface water regulatory programs, how the programs are adapting to these impacts, and steps that may be taken to enhance program response.

3.2.1 National Pollutant Discharge Elimination System (NPDES)

The National Pollutant Discharge Elimination System (NPDES) program is a federal program that has been delegated to the State for implementation by the State Water Board and the Regional Boards. The NPDES program regulates point sources that discharge pollutants to surface waters of the United States. Discharges are regulated via individual and general permits which include requirements related to discharge flow rate, pollutant concentrations, and discharge monitoring.

Climate change impacts are expected to influence the flow rate, temperature, turbidity, salinity and other characteristics of Central Valley surface waters. This will boost the importance of the data collected by the Delta Regional Monitoring Program. Additionally permits may need to be updated based on the findings from the Delta Nutrient Research Plan. Shifts in precipitation patterns may reduce surface water flows, especially during summer months when Sierra Nevada snowpack has been depleted. At the same time, increased focus on water conservation and recycling may result in lower flow rate, higher concentration discharges to surface waters. Permit requirements may need to be updated in response to these trends. Future permits would need to incorporate a higher degree of

adaptability, such as a weather-dependent component whereby the discharge requirements vary based on surface water flow characteristics. Contingencies may also be written into permits to modify discharge requirements during extreme weather events. In the future, dischargers will also be required to prepare climate change action plans outlining their efforts towards reducing GHG emissions and improve operational efficiency. In the short-term, voluntary action plans will be requested. Dischargers will need to re-evaluate flood hazards and their potential impacts on facility operations. ` Additionally, there will be a need to reconsider dilution in order to account for increased stream flow variability. There will be more NPDES facilities that will reduce or eliminate surface water discharges as recycled water use becomes more prevalent. Changes in background concentrations coupled with changes in aquatic species present in surface water may necessitate changes in testing criteria related to toxicity.

3.2.2 Storm Water

The Storm Water Program regulates storm water discharges from industrial facilities, construction sites, and municipal systems through the NPDES permitting system. As discussed in Section 2, the frequency of large storms, including atmospheric rivers, may increase in the future, potentially resulting in increased rates of erosion and sediment discharge. In response to these issues, facility best management practices (BMPs) will need to become more robust, including more frequent use of engineered products and "Low Impact Development" (LID) techniques. "Low Impact Development" refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of storm water in order to protect water quality and associated aquatic habitat (USEPA 2017). In the Municipal Separate Storm Sewer System (MS4) program, more permits will require the use of LID. Additional research and regulatory development is needed for "Low Impact Development" applications such as the use of permeable pavements or dry wells to enhance groundwater recharge. With an increase in precipitation falling as rain (as opposed to snow), there will also be the need for more robust BMPs both permanent, such as at industrial facilities and temporary, such as at construction sites. In order to prepare for more precipitation falling as rain and more extreme rain events, sites may need to construct larger storm water detention systems. Given the large changes expected in rainfall frequency and severity, program requirements will need to change in order to appropriately protect beneficial uses.

3.2.3 Water Quality Certification

The Water Quality Certification Program regulates the removal or placement of materials (e.g., dredging, levee construction, etc.) in wetlands and waterways of the State. These projects generally require a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers. The State's Water Quality Certification is issued pursuant to Section 401 of the Clean Water Act to certify that the project approved by the Corps will also meet State water quality requirements.

Climate change is expected to impact Water Quality Certification Program in a similar fashion to how it may impact the Storm Water Program. With the potential for more frequent and greater intensity storms in the future, vigorous BMPs and the use of engineered products may be needed to control

erosion during dredging and material placement projects. The number of Water Quality Certifications may also increase in the future if more flood control projects are constructed in response to changing storm patterns. Sea level rise may also prompt new projects related to bridge piers, docks, and shoreline infrastructure, many of which may also require Water Quality Certifications. Climate change impacts may also lead to increased focus and value being placed on wetlands, which are regulated by the 401 Water Quality Certification Program, as ecological habitat and carbon sinks. This will result in the need for more wetlands and reduction in the loss of wetlands associated 401 projects.

3.2.4 Forest Activities Program

The Forest Activities Program permits storm water discharges from timber harvesting and fuels management activities. Climate change is expected to negatively impact forest resiliency. More frequent and intense forest fires are projected in the future. Severe storm events may increase erosion. Alternatively, the warmer climate and reduced snowpack may allow for forest growth at higher elevations than are currently observed. Concurrently, a trend towards timber harvesting at higher elevations may be observed if reductions in snowpack allow for road access to areas that were previously obstructed by snow.

Currently, the Forest Activities Program is assessing the Battle Creek Watershed-Based Management Plan to assess whether a more holistic approach to watershed management is beneficial to water quality, and whether this approach can be used to accelerate management actions in a pre-fire or post-fire scenario. This type of approach may be beneficial in addressing climate change impacts Implementation of these activities may be expanded in the future to further mitigate wildfire risk, especially if public acceptance of climate change enhances the perceived value of forests as GHG sinks. The program will need to evolve as other regulations related to AB32 evolve, including potentially links to forestry offset protocols. This work will be coordinated with the Air Resources Board, CalFire and the Board of Forestry. The Forest Activities Program should also consider enhanced surface water monitoring and protection measures in response to the risk of more frequent and intense precipitation events. General Orders will allow for greater flexibility in the future such that they may be more easily updated in response to new research or BMPs. With an increase in wild fires, there will be a greater need for staff participation in post-fire response activities. Increased wild fire occurrences will lead to a greater focus on Emergency and Exempted plans for harvests, with lower CEQA and NEPA requirements.

3.2.5 Mining

The Mining Program oversees the discharge of mining waste to land for approximately 95 mine sites with known or potential water quality impacts. Discharges from active mines are regulated through the issuance of WDRs and will usually regulate all of the surface impoundments, tailing ponds, and waste piles or overburden waste rock dumps. Mining Program staff conducts inspections, review compliance reports, and identify potential responsible parties for mines that have been abandoned. Program objectives are achieved through collaboration with the Land Disposal Program, NPDES, Site Cleanup, and others.

Climate change will impact the Mining Program primarily through the increased extreme precipitation events and floods. If flood zones are expanded in response to observed large flood events, some mine operations may no longer meet current siting criteria. Existing mine operations may also require upgrades, including expansion of surface impoundment storage capacity, to control runoff during large precipitation events. At mines where groundwater is being monitored, deeper monitoring wells may need to be installed in response decreases in water table elevation during drought periods. Higher rainfall will also increase acid mine drainage, potentially increase the water pressure behind bulkheads and similar mine features, and potentially mobilize contaminants from tailings piles and the like.

3.2.6 Cannabis Cultivation Waste Discharges

The Cannabis Cultivation Waste Discharge Program was created to reduce the environmental damage caused by cannabis cultivation. Program resources are focused on improving process efficiency, pursuing enforcement actions, and enrolling cultivators in the General Order for Discharges of Waste Associated with Medicinal Cannabis Cultivation Activities. The primary concerns of cannabis cultivation include illicit grading activity, illegal water diversion, and chemical/nutrient discharges to waters of the State.

Similar to other crops, cannabis grows best within a specific range of environmental conditions. Changes in temperature and/or precipitation patterns will impact cannabis watering and nutrient needs. There will likely be changes in locations where cannabis is cultivated. In an extreme drought scenario, growers may move their operations to locations that are more conducive to cannabis growth (e.g., from northern counties to the Valley floor). The Cannabis Cultivation Waste Discharge Program will encourage or require water conservation/recycling at cannabis operations if drought conditions persist for an extended period. Growers may also proactively implement water conservation/recycling measures into their operations to mitigate the impact of drought conditions on regional water supplies. Similar to other regulated discharges, water conservation/recycling applications at cannabis operations may concentrate pollutant discharges, which may have unintended consequences on receiving waters. As the industry and regulations evolve over the next several years, changes in regulations and in cultivation locations make it difficult to predict some of the approaches water quality protection.

3.2.7 Nonpoint Sources

The goal of the Nonpoint Source Program is to restore waters impacted by nonpoint source pollution and to protect unimpaired water bodies by assessing nonpoint source pollution problems and implementing management programs. The Nonpoint Source Program implements the State-wide *California Nonpoint Program Implementation Plan for 2014-2020* (State Water Board 2015), which focuses on improving the State's ability to effectively manage nonpoint source pollution and conform to the requirements of the federal Clean Water Act and the federal Coastal Zone Act Reauthorization Amendments of 1990. Sources of nonpoint pollution include timber harvests, abandoned mines, agricultural areas, and development projects.

Similar to other programs, the Nonpoint Source Program would be directly impacted by increases in extreme precipitation events and floods. Frequent extreme precipitation events will necessitate updates to existing erosion control BMPs, and increase the need for new BMPs in instances where currently none are required. Additional time and funding may also be needed to optimize BMPs to ensure that TMDLs are consistently achieved under new conditions. There will be a need to develop criteria to deal with increased uncertainty in monitoring events used for effectiveness assessments.

Alternatively, under a future drought scenario, it may be difficult to assess erosion control BMP performance due to the more variable nature of storms. The Nonpoint Source Program should consider lengthening the grant period, which currently allows three years for characterization of baseline conditions and BMP effectiveness, in response to a prolonged period of drought conditions. There will be an increased need for projects with vegetative cover to reduce erosion risks. Drought conditions may also increase the risk of wildfire and vegetation loss, which would amplify the risk of sediment and pollutant runoff. Higher surface water temperatures may increase the potential for harmful algal blooms, which could prompt changes in TMDLs and necessitate more robust BMPs to mitigate this risk. Additional resources may be needed to evaluate site background conditions, BMP effectiveness monitoring, and BMP adaptation over the life of the project. Research is needed on the site-specific causes of harmful algal blooms and optimal BMPs to reduce erosion and runoff.

3.2.8 Irrigated Lands

The Irrigated Lands Regulatory Program (ILRP) was initiated in 2003 to regulate the discharge to surface water of irrigated land wastes including pesticides, fertilizers, salts, pathogens, and sediment (section 3.3.6 addresses the ILRP groundwater program). The ILRP regulates discharges using General Orders for agricultural growers that are part of third-party groups (coalitions). Currently there are 14 coalitions helping growers comply with the General Orders. The goal of the ILRP is to prevent irrigated lands discharges from causing or contributing to exceedances of water quality objectives.

Future changes in temperature and/or precipitation patterns may impact the use of water, fertilizer, pesticides, and other amendments at agricultural operations. An increase in the use of these amendments may have a corresponding increase in amendment loading to surface water and groundwater. The impact on surface water quality could be amplified if other climate change-related trends (e.g., increased erosion or reduce streamflow) were also observed. Current ILRP General Orders include requirements related to sediment control, pesticide use, and surface water monitoring; these requirements may need to be updated if a greater degree of surface water impairment is observed.

To more proactively address potential climate change impacts, the ILRP will collaborate with planning programs to anticipate future changes in background surface water quality, and modify General Orders accordingly. There will need to be changes in Management Practices Evaluation Programs to address the need for robust BMPs in light of climate change. Increased rainfall intensity and severe weather occurrences will necessitate more robust storm water management practices. The ILRP will work with

the Healthy Soils Initiative (Section 2.3.1.2) to encourage growers to build soil carbon and consequently reduce GHG emissions and erosion. In an effort to promote the use of compost as an alternative to fertilizers, the ILRP, along with State Water Board, is pursuing research related to the nitrogen content of various forms of compost.

3.3 Groundwater Regulation

As discussed in Section 2, the higher temperatures and shifting precipitation patterns associated with climate change are expected to negatively impact the quantity and quality of available groundwater resources. At the same time, increased groundwater pumping could further impair groundwater quality by concentrating pollutants resulting in recharge with poorer quality water. Within all groundwater/land disposal programs, there will be a need to evaluate potential impacts of climate change. The following sections discuss how climate change is impacting groundwater regulatory programs, how the programs are adapting to these impacts, and what additional steps may be undertaken to enhance program response.

3.3.1 Title 27 – Non-Hazardous Waste Land Disposal

The Title 27 Program protects water quality by regulating non-hazardous waste discharge to land for treatment, storage and disposal in waste management units, pursuant to Title 27 of the California Code of Regulations. Wastes regulated by this program include municipal solid wastes, designated wastes such as petroleum impacted soils and auto shredder waste, and inert solid wastes. Typical discharge sites include landfills, industrial surface impoundments, and waste piles.

Future design and operation of landfills will be influenced by the observed impacts of climate change. Landfill covers could be more susceptible to erosion during extreme weather events. Extended periods of drought will negatively impact the performance of vegetative covers, leading to increased maintenance. These trends will prompt new regulations and/or BMPs to maintain landfill cover performance. Changes in groundwater levels will mean that some sites would no longer be able to meet siting criteria. Groundwater monitoring would need to be relocated or rescreened as water table depths change. More extreme rainfall events will necessitate larger surface impoundments and potential changes in storm water management systems. There will also be flood related issues associated with closed landfills in flood plains and adjacent to rivers

Landfills also present opportunities for climate change mitigation. The Title 27 Program currently requires landfill gas capture only at locations where a gas leak has been confirmed. The program may encourage the use of fully enclosed digesters, bioreactors, and treatment cells, as opposed to “dry tomb” containment cells, to further promote methane generation and capture. Anaerobic digester requirements are currently being incorporated into some WDRs, and the Title 27 Program is collaborating with the CARB and local air districts to increase the collection and treatment of landfill gases. Additional collaboration is planned with CARB and CalRecycle to encourage the application of landfill digesters and use of landfill gas as an energy source.

3.3.2 Waste Discharge Requirements (Non-15)

The WDRs, or Non-15, Program regulates point discharges to land that are exempt from Title 27 of the California Code of Regulations, pursuant to Subsection 20090 of Title 27. The WDRs Program primarily regulates wastewater treatment plants (WWTPs), wastewater recycling operations, food processing industries, and other industries that discharge non-hazardous wastes.

Demand for water recycling will increase in the future in response to water supply changes (Section 2.1.5). Many wastewater agencies are already recycling wastewater by collaborating with other agencies to apply a portion of treated wastewater to landscaping, agricultural fields, or groundwater aquifers. This trend is expected to become more common in the future, which may prompt more use of the statewide water recycling General Order. Anaerobic digesters, which are currently employed at a subset of WWTPs, are also expected to become more common as a means of renewable energy generation. Anaerobic digestion of organic waste produces methane gas, which can be captured and used as an energy source while also preventing its release to the atmosphere. Municipal waste water systems will also have to deal with increased inflow and infiltration (I&I) into their systems due to saturated soils. This may necessitate recalculation of water balances and potential design changes for treatment systems. Changes in underlying groundwater quality related to increasing salt concentrations will result in changes to permit requirements. The program will also need to assess how to work with facilities that may be at greater risk of flood water inundation.

To further accelerate the adoption of anaerobic digester technology, incentive programs administering grants and/or low-interest loans may be considered. Additional General Orders may also be adopted for non-dairy industries (e.g., food processors and wineries) that may benefit from anaerobic digester technology.

3.3.3 Site Cleanup

The Site Cleanup Program regulates and oversees the investigation and cleanup of contaminated sites that are polluting, or threaten to pollute, surface water and/or groundwater. Site Cleanup Program sites include military bases, railyards, oil refineries, and smaller facilities such as dry cleaners and plating shops.

Climate change is expected to impact the Site Cleanup Program primarily through potential decreases in groundwater table elevation and greater emphasis on the use of “green” remediation technologies. Drought may lead to decreases in groundwater table elevations, causing wells to become dry, contaminants to be transferred from the saturated zone to the vadose zone, and the effectiveness of existing remedial technologies to potentially be reduced. Concurrently, the Site Cleanup Program may encourage the use of “green” remediation technologies such as passive systems (e.g., permeable reactive barriers), biological approaches, in-situ remedies, and remedies utilizing renewable energy sources such as solar panels. On 6 February 2015, the Central Valley Water Board adopted *Resolution R5-2015-0017: Waste Discharge Requirements General Order for In-Situ Groundwater Remediation and*

Discharge of Treated Groundwater to Land to expedite the approval of in-situ remedy proposals and provide more consistent regulation of their implementation. The Site Cleanup Program, statewide, could also pursue an incentive program to encourage the use of renewable energy sources at cleanup sites. Greenhouse gas reduction strategies will result in increasing incentives for infill and brownfield development and the need to expedite putting properties back into productive use. This will put pressure on the site cleanup program and will likely result in more requests for agreements to only partially remediate these sites. The need for more low impact development and storm water management may also impact urban areas with contaminated groundwater and potentially affect groundwater cleanups.

3.3.4 Underground Storage Tanks (USTs)

The goal of the Underground Storage Tank (UST) Program is to protect the beneficial uses of water and human health from the effects of fuel hydrocarbon releases from UST systems. The two main components of the program are the permitting of operating USTs, which is run by local Certified Unified Program Agencies (CUPAs), and cleanup of UST releases, which is shared by select CUPAs and the nine Regional Water Boards.

The climate change considerations presented above for the Site Cleanup Program will also apply to the UST Program. Additionally, potential climate change-related shifts in the transportation industry may lead to changes in fuel composition, the use of smaller USTs, and possibly a reduction in the total number of services stations with petroleum fuels. These changes would all have subtle impacts on the UST Program's approach towards regulation and cleanup. Flooding coupled with saturated soils will put increased pressure on USTs and could result in tanks becoming unsecured and floating to the surface.

3.3.5 Confined Animal Facilities

Confined animal facilities are characterized by farms or ranches where livestock are held for a significant period of time and provided with food. Most confined animal facilities in the Central Valley are dairies; however, there are also many feedlots and poultry facilities. The primary objective of Confined Animal Facilities Program is to prevent impairment of surface water and groundwater by controlling the discharge of manure, wastewater, and storm water runoff.

Climate change is expected to impact confined animal facilities primarily through an increased focus on water conservation and recycling. Water conservation efforts could result in more concentrated waste streams which may be more harmful to surface and ground waters, especially during low flow periods. If strict limits are placed on water use, facility managers may also choose to change cropping patterns or import feed. Recently, a number of dairies located near surface waters have had issues related to flooding. It will be necessary to determine methods to mitigate these risks. Existing and future general orders will need to account for changes in water availability and implications for fodder crops. This issue coupled with statewide efforts related to compost and Healthy Soils, has implication for nutrient management. There is also a potential for funding to address some of the issues that have a nexus to

reduction in short lived climate pollutants, through greenhouse gas reduction funds. The Central Valley Water Board adopted Order No. R5-2011-0039, *General Order for Centralized Dairy Manure Anaerobic Digester or Centralized Dairy Manure Co-digester Facilities* in 2011 to streamline the permitting process for centralized dairy manure digester and co-digester facilities. Anaerobic digester use may become more common in the future as a means of treating manure waste and generating methane gas for use as an energy source. Research is ongoing to optimize manure digester gas production and produce an easily transportable solid fertilizer as a digester end product.

3.3.6 Irrigated Lands

As discussed in Section 3.2.8, the ILRP was initiated in 2003 to regulate waste discharges from irrigated lands using General Orders. Groundwater regulations were added to the ILRP in 2012, and continue to be developed. Growers in areas where groundwater is vulnerable to contamination or is known to be impacted by nitrate or other agriculture constituents will be required to have a certified nitrogen management plan and provide nitrogen summary reports to their coalitions. Growers will also be required to monitor wells on their property in accordance with the appropriate General Order.

To ensure protection of groundwater quality, the ILRP requires development of Model Performance Evaluation Programs to identify appropriate management practices. An initiative is also underway to protect groundwater from nitrate leaching, which could become increasing harmful to groundwater under drought and/or limited groundwater recharge conditions in the future. Agricultural coalitions in the Tulare Lake Basin were awarded a $2,000,000 United States Department of Agriculture grant to implement an innovative program to quantify and minimize nitrate leaching from farming operations. The project is producer-led, but involves a broad range of technical partnerships and collaborators, including local universities and the CDFA. Similar to other programs involved in monitoring groundwater, monitoring wells used for ILRP reporting may become dry under future climate conditions, necessitating the installation of deeper wells. Climate change will lead to changes in irrigation practices, especially if obtaining water becomes more difficult. These changes will affect contaminant concentrations and contaminant transport in soils. Changing temperature regimes will also lead to changes in pest prevalence which could lead to changes in the use of pesticides and herbicides. All of these impacts of climate change will need to be addressed in management plans and evaluation of management practices. Efforts related to enhanced compost use and the Healthy Soils Initiative may necessitate changes in how nutrients are managed. Regulations will need to evolve to address increased use of recycled water and potential groundwater recharge efforts on farms. The program will also be working with CV_SALTS to tackle issues related to increasing salt concentrations.

3.3.7 Oil Fields

The purpose of the Oil Field Program is to properly regulate oil field discharges and oversee monitoring activities to ensure the protection of surface water, groundwater, and human health. The Oil Field Program regulates four primary activities related to oil production:

- Generation of drilling muds during well development;
- Generation of wastewater during oil production;
- Wastewater injection into disposal wells; and
- Well stimulation under Senate Bill 4.

Extreme precipitation and flood events will negatively impact operations at oil fields. Wastewater facilities, specifically ponds, may require re-evaluation and/or upgrades to effectively handle wet-weather flows. Dischargers are currently pursuing water conservation and recycling applications in response to reductions in freshwater supplies. Wastewater treatment research aimed at increasing the fraction of oil field wastewater that can be recovered is also ongoing. The Oil Field Program will encourage or require water efficiency and/or recycling applications in the future. These applications would result in lower, more concentrated, discharge flow rates. WDRs will need to be updated to ensure that allowable discharges continue to be protective of surface water and groundwater. Dependent on the outcome of the Region's Food Safety Panel efforts, there may be more permitting related to the use of recycled water from oil fields and associated advanced treatment systems.

3.4 Overarching Considerations

Several common themes are evident throughout the Central Valley Water Board program climate change considerations presented in the previous sections, including:

- Potential changes to the characterization of "background conditions" will be needed over time as new data is obtained and long-term environmental trends are better understood;
- Meeting regulatory requirements will become more difficult, and result in the need for flexible, adaptable regulatory mechanisms;
- BMPs and surface water management infrastructure design will need to be reevaluated in response to potential changes in extreme weather patterns may be necessary;
- Expanded use of water conservation and recycling will result in lower flow rates, more concentrated discharges;
- There will be increased sensitivity of surface water bodies to pollutant loadings due to lower stream flows and higher water temperatures; and
- There will be more incentives to implement environmentally friendly solutions, including "green" groundwater remedies, "low impact development" storm water systems, and anaerobic digestion applications to exploit organic waste resources.

Since these themes affect multiple programs, collaboration and knowledge-sharing between programs will be critical for ensuring that program policies and procedures adapt to changing conditions. Inter-program collaboration, especially with planning program staff, will prepare staff to better handle these changes and enable them to more proactively and effectively implement new policies.

4. Work Plan for Addressing Climate Change and Water Quality in the Central Valley

This section presents an approximate timeline for the implementation of major Central Valley Water Board initiatives discussed in Section 3. The section has been organized by the projected timeframe for initiative implementation, as follows:

- Short-Term: 0 to 3 years;
- Medium-Term: 3 to 5 years; and
- Long-Term: greater than 5 years.

In many cases, the timing for of these initiatives is dependent upon funding availability, agency approvals, and other factors that cannot by readily and easily predicted. In these instances, the steps needed to commence initiative activities are briefly discussed.

4.1 Short-Term

Central Valley Water Board initiatives that are expected to be conducted within the next three years are discussed below.

4.1.1 Permitting

As new permits are issued and existing permits are renewed, permit requirements will be updated in response to conclusions drawn from ongoing data collection and research activities. Permitting changes include:

- Incorporation of greater permit adaptability, such as a weather-dependent component whereby the discharge requirements could vary based on surface water flow characteristics;
- Requests for voluntary climate change action plans outlining dischargers' efforts to reduce GHG emissions, improve operational resiliency, and/or enhance water recycling; and
- Requests for the voluntary review of BMPs and storm water management systems to better prepare facilities for extreme weather events.

In the short-term, it is anticipated that climate change response actions will be requested of dischargers only on a voluntary basis until permits requirements are changed. In the medium- to long-term, climate change response plans will be included as permit requirements.

4.1.2 Data Collection

SWAMP surface water data collection and collaborative partnerships will become increasingly focused on climate change-related parameters over the next three years. During 2017 and 2018, SWAMP is planning to deploy continuous temperature loggers in several headwater streams to evaluate

temperature trends and determine whether streams are protective of cold water habitat. SWAMP staff was recently trained in identifying and sampling toxic algae. Staff will work with the State Water Board to conduct initial algal bloom response monitoring in the coming years. Subsequent monitoring may be completed to evaluate algal bloom trends, and collaborate with other programs on appropriate mitigation measures. Collaboration with the Department of Water Resources and other agencies on data collection will provide benefits for water quality monitoring.

4.2 Medium-Term

Central Valley Water Board initiatives that are planned for approximately the next three and five years are discussed below.

4.2.1 Central Valley Salinity Alternatives for Long-Term Sustainability Program (CV-SALTS)

CV-SALTS submitted the SNMP for Central Valley Water Board consideration on 31 December 2016. Ultimately, the SNMP will be incorporated into the Basin Plan as an amendment. The SNMP represents a comprehensive plan for managing Central Valley salts and nitrates in a manner that is environmentally and economically sustainable. Included in the SNMP is a Conservation and Drought Policy to guide salt and nitrate management during drought years. The SNMP and related basin planning efforts under CV-SALTS will account for climate change impacts as they related to salt and nutrient management. They will also provide a template for other future basin planning efforts related to climate change.

A public comment period for the SNMP was completed in January 2017, and a general information workshop was held with the Central Valley Water Board in March 2017. A specific timeframe for adoption of the SNMP as a Basin Plan amendment has not been developed; however, within three to five years it is projected that the Basin Plan amendment will be adopted and the early phase of SNMP policy implementation will be ongoing. This work will have benefits for addressing climate change the basin plans.

4.2.2 Modelling

The Central Valley Water Board plans to support climate change-related modelling and analysis initiatives being conducted by state and federal agencies. Collaboration on these efforts will allow for better coordination between the Central Valley Water Board and other agencies on climate change-related issues in the future. Additionally, these tools will also enhance the ability of technical staff to forecast climate change impacts and their effect on water resources. Initiatives that Central Valley Water Board plan to support include:

- California Department of Fish and Wildlife temperature modeling for the Sacramento River;
- CNRA water security and agricultural resilience modelling being conducted as part of the Fourth California Climate Change Assessment;

- USEPA Better Assessment Science Integrating Point and Non-Point Sources (BASINS) environmental analysis system for watershed- and water quality-based studies;
- USEPA's WEPPCAT tool for assessing the potential impacts of climate change on sediment loading to streams; and
- USEPA's Water Quality Analysis Simulation Program (WASP) model for predicting water quality responses to natural phenomena and manmade pollution.

The Central Valley Water Board will work with the State Water Board on contracts and other collaborative efforts for modeling the impacts of climate change on water quality.

4.2.3 Guidance / Policy Development

Development of a Central Valley Water Board comprehensive climate change response policy is anticipated to begin within approximately three to five years. Such policy would outline the Central Valley Water Board's overall strategy for adapting to, and mitigating, climate change impacts. The policy would be informed by ongoing data collection, planning, and modelling being conducted by federal and state agencies in collaboration with the Central Valley Water Board.

4.3 Long-Term

Central Valley Water Board initiatives that are expected to begin between three and five years from now are discussed below.

4.3.1 Basin Planning

Climate change impacts will be considered during the next Basin Plan triennial review which is scheduled for 2017. The triennial review is a public review process that is conducted once every three years to identify and prioritize actions needed to address water quality concerns and maintain the effectiveness of the Basin Plan. After public input is received, the Central Valley Water Board develops and adopts by resolution a priority list of potential issues that may result in Basin Plan amendments.

The priority list guides development of a work plan for each Basin Plan which describes the actions the Central Valley Water Board may take to investigate and respond to issues. Many of the issues have not been investigated by staff and detailed information was not provided in comments. These issues are described in broad conceptual terms. Before an issue can result in a Basin Plan amendment, staff must investigate the issue to identify the scope of potential Basin Plan amendment in conformance with applicable federal and state laws and regulations. After determining that a Basin Plan amendment is the appropriate means to address the issue, information, including the development of scientific justification, is prepared to support the amendment. Then the potential amendment undergoes a structured public participation process before it can be presented to the Central Valley Water Board for its consideration.

The *Issue List and Work Plan for the 2014 Triennial Review of the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (*2014 Triennial Review Work Plan*; Central Valley Water Board 2015) was adopted on 16 April 2015. The *2014 Triennial Review Work Plan* identified 14 issues that could potentially be developed into Basin Plan amendments. For each issue, the work plan presented ongoing actions and resources, along with longer-term actions and resources to needed to adequately address the issue. It is anticipated that the next triennial review work plan will be finalized in 2018, and address Central Valley Water Board response to climate change-related issues. Climate change response actions may be formalized as Basin Plan amendments to outline the Central Valley Water Board's plan for achieving WQOs and protecting beneficial uses under changing environmental conditions.

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APPENDIX A

Beneficial Use Definitions

AGR - Agricultural Supply
Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

BIOL - Preservation of Biological Habitats
Uses of water that support designated areas or habitats, such as Areas of Special Biological Significance, established refuges, parks, sanctuaries, ecological reserves, or other areas where the preservation or enhancement of natural resources requires special protection.

COLD - Cold Freshwater Habitat
Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

GWR - Ground Water Recharge
Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

IND - Industrial Service Supply
Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

MIGR - Migration of Aquatic Organisms
Uses of water that support habitats necessary for migration, acclimatization between fresh and saltwater, or other temporary activities by aquatic organisms, such as anadromous fish.

MUN - Municipal and Domestic Supply
Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

NAV - Navigation
Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

POW - Hydropower Generation
Uses of water for hydropower generation.

PRO - Industrial Process Supply
Uses of water for industrial activities that depend primarily on water quality.

RARE – Rare, Threatened, or Endangered Species
Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

REC-1 - Water Contact Recreation
Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

REC-2 - Non-Contact Water Recreation
Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

SPWN - Spawning, Reproduction, and/or Early Development
Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

WARM - Warm Freshwater Habitat
Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

WILD - Wildlife Habitat
Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.