Section 5: Climate Change

5.1 Climate Change

This climate change section was developed to be consistent with the following Proposition 84 IRWMP Guidelines (October 2012):

- Describe, consider, and address the effects of climate change on the region and disclose, consider, and reduce where possible greenhouse gas (GHG) emissions when developing and implementing projects
- Identify climate change impacts and address adapting to changes in the amount, intensity, duration, timing, and quality of runoff and recharge
- Consider the effects of sea level rise on water supply conditions and identify suitable adaptation measures
- Describe policies and procedures that promote adaptive management

This section is intended to focus on climate change adaptation and instill climate change adaptation as an overarching theme throughout the Plan. The recently issued *Climate Change Handbook for Regional Water Planning* dated November 2011 (Schwarz et al 2011) was used for guidance in developing this Plan section.

5.1.1 Legislative and Policy Context

5.1.1.1 Current Regulatory Constraints

5.1.1.1.1 US EPA Mandatory Reporting of Greenhouse Gases Rule

The US EPA Reporting Rule, which started in 2011, requires reporting for 2010 emissions for sources or single facilities with more than 25,000 metric tons carbon dioxide equivalent ($MTCO_2e$) annually. The rule can be found at: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html.

5.1.1.1.2 Title V of the Clean Air Act

Title V of the federal Clean Air Act reauthorization (1990) requires each state to develop a permit-to-operate system and emission fee program for major sources of air pollution. Title V only applies to "major sources." US EPA defines a major source as a facility that emits, or has the potential to emit (PTE) any criteria pollutant or hazardous air pollutant (HAP) at levels equal to or greater than the Major Source Thresholds (MST). The MST for criteria pollutants may vary depending on the attainment status (e.g., marginal, serious, extreme) of the geographic area and the criteria pollutant or HAP in which the facility is located.

Title V permit holders must incorporate GHG requirements when renewing or revising a permit. EPA has continued to pursue regulations to address issues related to climate change. The EPA already requires large emissions sources (greater than 25,000 MTCO2e) to annually report their emissions. As well, the EPA has published rules to start directly regulating GHG emissions

under the Clean Air Act. Under the EPA's Tailoring Rule, facilities responsible for nearly 70 percent of the nation's GHG emissions will be subject to GHG emissions permits.

None of the water utilities in the Region are currently subject to these federal regulations because none own or operate a single facility that meets the current emissions thresholds of 25,000 $MTCO_2e$ per year.

5.1.1.1.3 AB 32 Global Warming Solutions Act and Executive Order S-3-05

California continues to lead the nation in developing public policy responses to address issues related to climate change and GHG emissions — most notably through the implementation of Assembly Bill 32 (AB 32). AB 32 established GHG reduction targets for California, put the California Air Resources Board (ARB) in charge of implementation and rulemaking through the development of the "Scoping Plan." AB 32 aims to reduce statewide GHG emissions to 1990 levels (427 million $MTCO_2e$) by 2020. California is currently at about 469 million $MTCO_2e$, and under the business-as-usual case, most recently updated in 2010, 2020 emissions are expected to be about 507 million $MTCO_2e$. In order to meet the 2020 target, California will need to reduce GHG emissions by about 80 million $MTCO_2e$, an approximate 16 percent reduction from the state's projected 2020 emissions, by 2020. To meet these targets a two percent reduction is needed each year for the next ten years. To accomplish the goal the state is pursuing a number of direct regulations and market-based mechanisms that have been laid out in a Scoping Plan. The core measures of the Scoping Plan are tailpipe standards, transportation and land-use changes, low carbon fuel standard, enhanced energy efficiency, a Renewables Portfolio Standard (RPS) of 20 percent by 2010 and 33 percent by 2020, and a Cap & Trade program. More information about the Scoping Plan can be found at: http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

5.1.1.1.4 California ARB's Mandatory Greenhouse Gas Reporting Regulation

ARB's Mandatory Reporting Rule requires the state's largest emitters (single sources with GHG emissions greater than 25,000 $MTCO_2e$ per year) to annually report and verify their GHG emissions. The rules were revised to harmonize the state's reporting rules with the US EPA's Mandatory Reporting Rule and streamline the reporting and verification process for sources with GHG emissions between 10,000 and 25,000 $MTCO_2e$. ARB finalized the proposed changes in 2011. The rule can be found at: http://www.arb.ca.gov/cc/ccei.htm.

5.1.1.1.5 Cap-and-Trade Rule and Compliance Offsets

The most far-reaching regulatory action to emerge from AB 32 is the development of rules implementing a cap-and-trade program for California. Under cap-and-trade, an overall limit on GHG emissions from capped sectors will be established and lowered every year until 2020. Facilities subject to the cap will be able to trade permits to emit GHGs or acquire offsets from uncapped sectors. Starting in 2012, entities with GHG emissions greater than 25,000 $MTCO_2e$ in process and combustion emissions (not indirect electricity emissions) will be subject to cap. Water utility facilities in the Upper SCR are below this threshold for their facilities and will not be included in the Cap and Trade regulation. More information about the Cap and Trade regulation can be found at: http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

"The regulation will cover 360 businesses representing 600 facilities and is divided into two broad phases: an initial phase beginning in 2012 that will include all major industrial sources

along with utilities; and, a second phase that starts in 2015 and brings in distributors of transportation fuels, natural gas and other fuels.

Companies are not given a specific limit on their greenhouse gas emissions but must supply a sufficient number of allowances (each covering the equivalent of one ton of carbon dioxide) to cover their annual emissions. Each year, the total number of allowances issued in the state drops, requiring companies to find the most cost-effective and efficient approaches to reducing their emissions. By the end of the program in 2020 there will be a 15 percent reduction in greenhouse gas emissions compared to today, reaching the same level of emissions as the state experienced in 1990, as required under AB 32.

To ensure a gradual transition, ARB will provide significant free allowances to all industrial sources during the initial period (2012-2014). Companies that need additional allowances to cover their emissions can purchase them at regular quarterly ARB auctions, or buy them on the market. Electric utilities will also be given allowances and they will be required to sell those allowances and dedicate the revenue generated for the benefit of their ratepayers and to help achieve AB 32 goals.

Eight percent of a company's emissions can be covered using credits from compliance-grade offset projects, promoting the development of beneficial environmental projects in the forestry and agriculture sectors. Included in the regulation are four protocols, or systems of rules, covering carbon accounting rules for offset credits in forestry management, urban forestry, dairy methane digesters, and the destruction of existing banks of ozone-depleting substances in the U.S. (mostly in the form of refrigerants in older refrigeration and air-conditioning equipment)."[1]

California is coordinating the development of its program with the Western Climate Initiative (WCI). WCI is a multi-jurisdictional initiative to develop regional market-based mechanisms (i.e., cap-and-trade program) to reduce GHGs. The rationale for a broader regional approach is that it could provide greater flexibility for emitters in how, when and where to achieve emissions reductions; and create a more fluid and robust marketplace for trading.

The cap-and-trade program will effectively put a price on GHG emissions and implicitly on energy (transportation fuel and electricity) prices. So, while water utilities in the Region may not be directly subject to a cap on its emissions they may be subject to higher prices for fossil fuels and electricity. Water utilities may also see carbon prices manifested in its supply chain as suppliers pass their compliance and higher energy costs onto their customers.

5.1.1.1.6 South Coast Air Quality Management District (SCAQMD) Guidance for CEQA Greenhouse Gas Significance Thresholds

Consistent with Senate Bill (SB) 97, projects subject to CEQA review must estimate GHG emissions and consider potential impacts, and projects with potential significant impacts must consider mitigating project related emissions. SCAQMD draft interim guidance significance thresholds are: 10,000 $MTCO_2e$/year for industrial projects (SCAQMD lead agency), and 3,000 $MTCO_2e$/year (proposed) for commercial/institutional projects. SCAQMD guidance does not distinguish between biogenic (naturally occurring) and anthropogenic (human caused) emissions. Wastewater plant emissions are considered biogenic. More information about the

[1] ARB press release dated December 16, 2010. The full press release can be found at: http://www.arb.ca.gov/newsrel/newsrelease.php?id=170.

Guidance can be found at: http://www.aqmd.gov/ceqa/handbook/GHG/GHG.html, http://www.water.ca.gov/climatechange/docs/CEQA_GHG_Guidance.pdf and http://www.ceres.ca.gov/ceqa/docs/Final_Statement_of_Reasons.pdf.

In 2007, the California Legislature directed the Natural Resources Agency to develop specific guidelines for lead agencies on how to quantify, evaluate and mitigate a project's potential GHG emissions and climate change impacts. Under the guidelines, finalized in February 2010, a lead agency must calculate GHG emissions from a project, assess the impacts of these emissions, make a significance determination, and if necessary consider mitigation measures. The definitions of significant impacts and determination of significance thresholds are subject to interpretation of pre-existing CEQA guidelines and jurisprudence.

SCAQMD has developed interim draft guidance establishing a process for evaluating whether or not GHG emissions from an industrial project (i.e., stationary source) are significant where SCAQMD is the lead agency. SCAQMD is currently considering expanding its guidelines for use by other local lead agencies. The proposal includes a significance threshold for commercial and institutional land use projects (e.g., new construction).

5.1.1.1.7 Executive Order S-13-08

By Executive Order S-13-08, the California Governor directed the California Natural Resources Agency, DWR, the Office of Planning and Research, the California Energy Commission, State Water Resources Control Board, and other State agencies to research and advance California's ability to adapt to the impacts of climate change. Results of this work include the California Sea Level Rise Assessment and the California Climate Change Adaptation Strategy.

5.1.1.1.8 California Ocean Protection Council Resolution

The California Ocean Protection Council Resolution adopted March 11, 2011 requires that projects or programs funded by the State of California consider sea level rise.

5.1.1.2 Future Regulatory Constraints

5.1.1.2.1 US EPA Greenhouse Gas Tailoring Rule

US EPA is considering rules targeting sources below 50,000 short tons CO_2e (about 45,000 $MTCO_2e$) by 2016. The current rule applies to sources greater than 75,000 short tons CO_2e (about 68,000 $MTCO_2e$). US EPA is also reviewing an accounting approach for biogenic emissions sources.

In its final Tailoring Rule, US EPA committed to exclude sources with GHG emissions below 50,000 short tons CO_2e (about 45,000 $MTCO_2e$) per year from new permitting requirements through at least 2016. During this period, US EPA plans to conduct a study of the permitting burdens that would exist if the Tailoring Rule were to be applied to smaller sources. Based on the outcome of the study US EPA may expand the tailoring rule to include additional small sources or permanently exclude them from a GHG permitting system. Given the political constraints facing the agency, including efforts in the U.S. Congress to repeal or delay US EPA's authority to enact the rules, it is unlikely that the agency will pursue aggressive regulation of small sources such as those operated by CLWA.

As currently adopted, the Tailoring Rule does not distinguish between GHG emissions from fossil and biologically derived fuels. US EPA concluded a public comment period in September

2010 seeking information on approaches to account for GHG emissions from bioenergy and other biogenic sources. US EPA is under considerable political pressure to revisit the decision to treat emissions from biomass the same as emissions from fossil fuels. No decision has yet been made on this issue.

5.1.1.2.2 Federal Cap-and-Trade Program or other Market-Based Mechanism to Create a Price for GHGs or Carbon

While the Clean Air Act allows US EPA to use economic incentives, including emissions trading programs, to control emissions; the prospects for legislation establishing a national economy wide cap-and–trade program, or alternative carbon pricing policies such as a carbon tax, are highly unlikely in the near-term. Congress may act to increase incentives for energy efficiency and renewable energy production. The most likely mechanism for renewable resources incentives is through a federal clean energy standard that would include nuclear energy resources. Enactment of a federal clean energy standard is unlikely to impact the Region as none of the current federal policy proposals would preempt California's far more ambitious renewable energy portfolio standard.

5.1.1.2.3 AB 32 Scoping Plan Water Sector Recommendations

In addition to regulatory approaches to meet the state GHG emissions reduction goals; the ARB Scoping Plan calls for the "water sector" to implement six voluntary measures to achieve 4.8 million $MTCO_2e$ in emissions reductions by the year 2020. The measures include: increased water use efficiency, broader implementation of water recycling, improvements to the energy efficiency of the state's water and wastewater infrastructure, low impact development techniques, development of in-conduit hydroelectric and wastewater treatment renewable energy resources, and instituting a public goods charge to finance investments in water conservation and water sector energy efficiency. More information about these measures can be found at: http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf.

Both the Association of California Water Agencies and the California Association of Sanitation Agencies have active programs to track and monitor the development of any legislation or regulatory initiatives to mandate these measures.

5.1.1.2.4 City of Santa Clarita Climate Action Plan

Consistent with requirements by the State of California, the City of Santa Clarita completed a CAP, outlining how emissions reduction goals required under AB 32 will be achieved (see also Section 2.3.1.1). The CAP will serve as a component of the general plan document for the City to address GHG Emissions. Based on the goals, objectives, and policies of the recently adopted General Plan, the CAP identified measurable mitigation strategies that will enable the City of Santa Clarita to meet and even exceed the 2020 GHG emissions targets. Mitigation measures included in the CAP focus actions in four categories.

- Energy
    - Installation of higher efficiency public street and area lighting
    - Replacement of traffic lights with LED traffic lights
    - Establishment of onsite renewable energy systems – Solar Power

- Transportation
    - Overall land use/locations measures, which include reducing total vehicle miles travelled and improving traffic flow by increasing density of in-City development and diversity of mixed use developments, increasing location efficiency, destination and transit accessibility, integrating affordable and below market rate housing, improving the transit system, and improving the pedestrian network.
- Water
    - Use of reclaimed water
    - Installation of low-flow water fixtures
    - Use of water-efficient landscape irrigation systems
- Vegetation
    - Urban tree planting
    - Creation of new vegetated open space

Implementation of these CAP measures is anticipated to reduce GHG emissions in the City of Santa Clarita by 193,000 $MTCO_2e$ per year.

5.1.2 Vulnerability to Climate Change

This section identifies the potential climate change vulnerabilities of the Region's water resources. The climate change assessment presented in this section is at least equivalent to the checklist assessment in DWR's *Climate Change Handbook for Regional Water Planning* and consistent with climate change requirements in the Proposition 84 IRWMP Guidelines (October 2012).

5.1.2.1 Climate Change Scenarios

Climate change assessment is performed using the output of computer models that project future conditions from inputs on GHG emissions. These models are not predictive, but provide projections of potential future climate scenarios that can be used for planning purposes.

The primary climate variables projected by global climate models (GCMs) that are important for water resources planning in California are changes in air temperature, changes in precipitation patterns, and sea level rise. The State of California 2009 Climate Change Impacts Assessment prepared by DWR (DWR 2009) provides the scientific basis for developing statewide climate change impact projections. The 2009 assessment provided future climate projections to support water resources decision making in California. A set of six GCMs were run for two GHG emissions scenarios, A2 and B1, selected from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). The IPCC report provides a family of common scenarios that cover a range of plausible trends in GHG emissions over the 21st century as a result of economic, technological, and population change (IPCC 2007). Scenario A2 assumes higher GHG emissions and high growth in population and represents a more competitive world that lacks cooperation in development (similar to business as usual), while B1 is a lower GHG emission scenario that represents social consensus for sustainable development. Each GCM was used to simulate a historical period from 1950-1999 and a future

projection period from 2000 to 2100. The 1950-1999 period serves as a baseline or "present condition" for the models so that future conditions can be projected. Table 5.1-1 lists the six GCM models and their sponsoring organization.

TABLE 5.1-1
SUMMARY OF GLOBAL CLIMATE MODELS

GCM	Sponsoring Organization and Model Name
NCAR-PCM1[(a)]	National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM)
GFDL-CM21[(a)]	National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluids Dynamics Laboratory (GFDL) model, version 2.1
NCAR-CCSM3[(a)]	NCAR Community Climate System Model (CCSM)
MPI-ECHAM5	Max Plank Institute ECHAM5/MPI-OM Used by DWR for its climate change analysis for the 2009 Reliability Report and 2011 update.
MIROC32	MIROC 3.2 medium-resolution model from the Center for Climate System Research of the University of Tokyo and collaborators
CNRM-CM3[(a)]	French Centre National de Recherches Météorologiques (CNRM) models
Four Model Average[(a)]	Cal-Adapt website. Average of the following four GCMs: NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3. Used in this analysis for Upper Santa Clara River Region

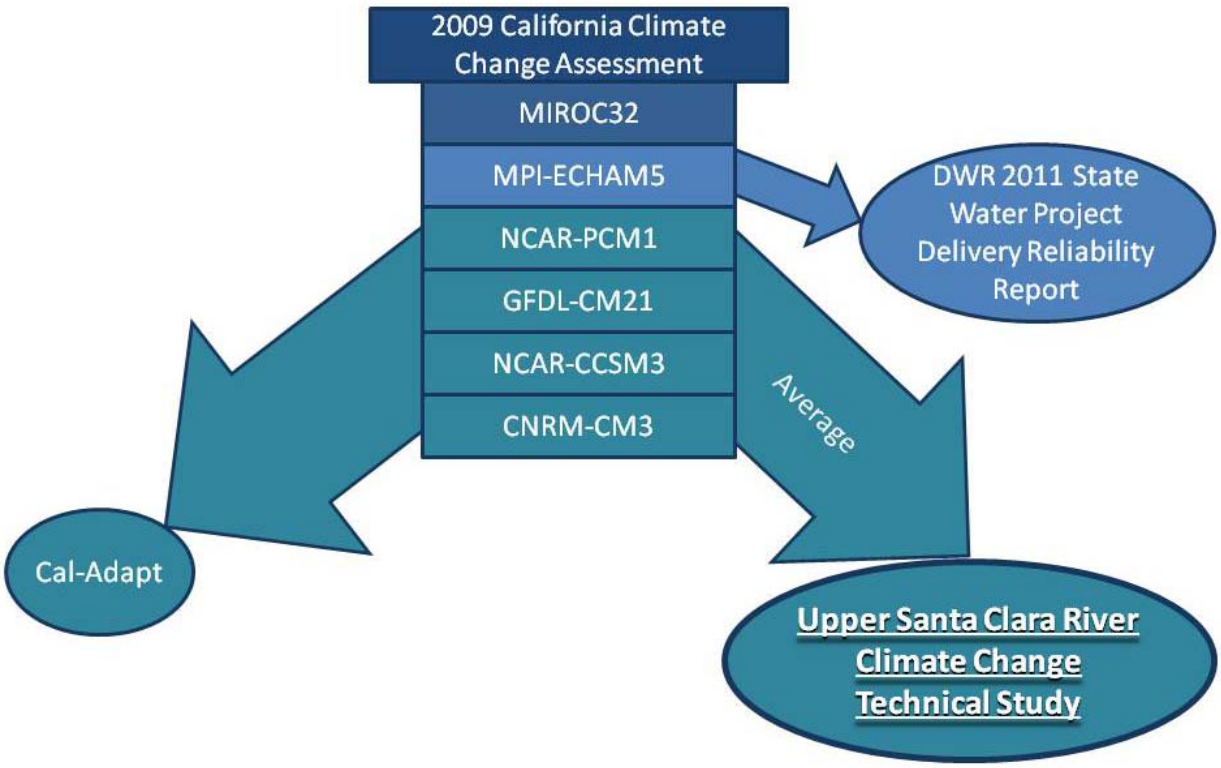
Note: (a) Model used by Cal-Adapt.

DWR used the MPI-ECHAM5 model with the A2 emissions scenario when preparing the 2011 *State Water Project Delivery Reliability Report*. MPI-ECHAM5 represents the median of the six GCMs listed in Table 5.1-1.

The California Energy Commission's Public Interest Energy Research Program (PIER) recently established the Cal-Adapt website (http://cal-adapt.org/), whose purpose is to explore California's climate change research. In part, the website provides output from four climate models (NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3) and two GHG emission scenarios (A2 and B1) downscaled to any location in California. The four GCMs are a subset of the six GCMs used in DWR's climate change assessments. Because the MPI-ECHAMP5 GCM is not included in Cal-Adapt, an average of the four GCMs (also provided by Cal-Adapt) with the A2 emission scenario was used in this analysis for Upper Santa Clara River Region to be consistent with the DWR analysis.

Figure 5.1-1 provides a visualization of which global climate change models were used in the above-mentioned climate change assessments and assessment tools.

FIGURE 5.1-1
GLOBAL CLIMATE CHANGE MODELS USED IN ASSESSMENT OF WATER RESOURCES



5.1.2.1.1 Statewide Climate Change Projections

Statewide climate change projections, based on the 2009 Scenarios Project assessment, were used to assess Regional vulnerabilities described in Table 5.1-2. All of the models show increased warming throughout the 21st century, with average annual air temperature increasing about 2°F to 5°F by 2050. The Mediterranean seasonal precipitation pattern is expected to continue during the 21st century, with most of the precipitation occurring during winter from North Pacific storms. The hydro-climate is expected to be influenced by the El Niño-Southern Oscillation (ENSO) with alternating periods of wet and dry water years. In the Sierra Nevada Mountains, there will be some shift to more winter precipitation occurring as rain instead of snow, with a reduction in snowpack accumulation and shifts in runoff patterns, especially during the summer and fall.

5.1.2.1.2 USCR Region Climate Change Projections

Overall air temperatures are expected to rise from 1°F to 2.3°F over the next few decades. The historical average annual temperature in the Upper Santa Clara River region is 61.9°F; the A2 and B1 scenarios project increases of 6.9°F and 4.3°F by the end of the 21st century. Figure 5.1-2 shows the projected air temperature change for the four GCMs averaged from 2000 through 2100, compared with the historical baseline from 1950-2000 used for the initial

conditions for the models (see Section 5.1.2.1) The temperature projections begin to deviate between the A2 and B1 scenarios around mid-century, with the A2 scenario increase about twice the B1 scenario by 2100. For purposes of this analysis, an air temperature increase of 4°F has been assumed.

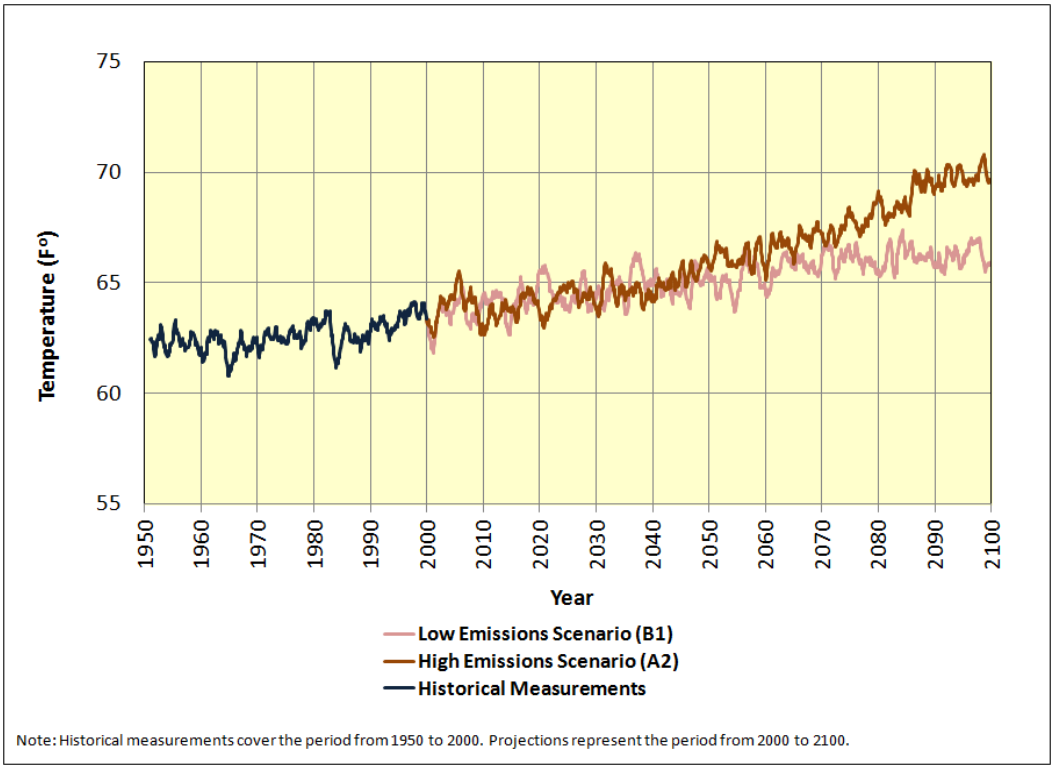
Precipitation in the Region is essentially all due to rain, and significant shifts in the timing of precipitation are not expected to occur. One of the four climate models projects slightly wetter winters, and others project slightly drier winters with a 10 to 20 percent decrease in total annual precipitation. The drier conditions projected may result in a higher wildfire risk in the Region. Figure 5.1-3 shows the decadal precipitation projections from 1960 through 2100. There appears to be continued variable precipitation over the next century, with overall decrease. For purposes of this analysis, a 10 percent decrease in annual precipitation has been assumed.

5.1.2.2 Vulnerable Watershed Characteristics

Identification of watershed characteristics that could potentially be vulnerable to future climate change is the first step in assessing the climate change vulnerabilities in the Region. In the context of this analysis, vulnerability is defined as the degree to which a system is exposed to, susceptible to, and able to cope with and adapt to, the adverse effects of climate change, consistent with the definition in the recently issued *Climate Change Handbook for Regional Water Planning*.

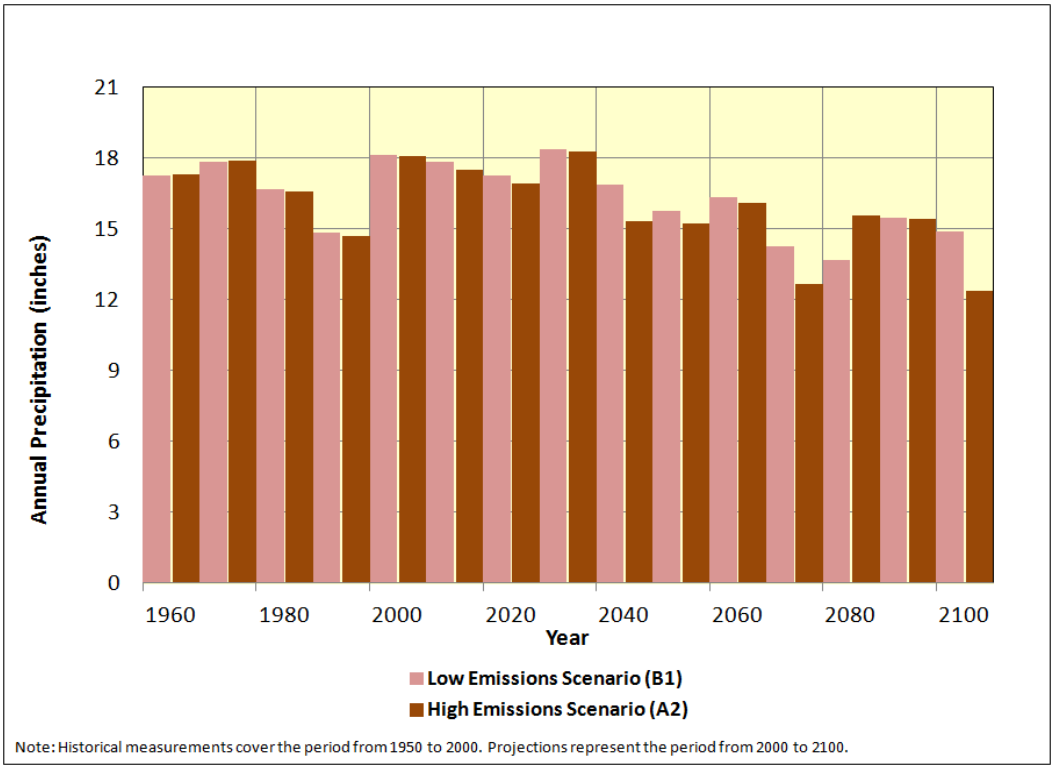
Table 5.1-2 provides a summary list of water-related resources that are considered important in the Region and potentially sensitive to future climate change. The summary table provides the main categories applicable to water planning in the Region with a general overview of the qualitative assessment of each category with respect to anticipated climate change impacts. The main categories follow the climate change vulnerability checklist assessment as defined in the *Climate Change Handbook for Regional Water Planning*. These categories also reflect a combination of the IRWMP requirements and are consistent with Proposition 84 requirements.

FIGURE 5.1-2
HISTORICAL AND PROJECTED ANNUAL AVERAGE AIR TEMPERATURE FOR THE USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

FIGURE 5.1-3
PROJECTED ANNUAL PRECIPITATION FOR USCR REGION:
AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

Table 5.1-2 identifies the anticipated climate change impacts on these identified resources only qualitatively. It should be noted that resources that are likely to be vulnerable to climate change are considered for further analysis in the following subsections. Table 5.1-2 also highlights those resources in the Region that are unlikely to be affected by climate change and therefore they do not warrant further analysis and consideration at this time.

5.1.2.3 Vulnerability Sector Assessment

Climate change processes are supported by extensive scientific research and are based on a vast number of peer-reviewed and published technical literature. Much of the available literature presents general information, but there is relatively little information that presents specific tools on how to apply impacts in the context of addressing climate change impacts on water resources. In addition, far less information is available on smaller geographic areas and the spatial resolution of the existing climate change models is still quite low. One additional challenge is that precipitation projections cannot be easily converted directly into surface runoff and groundwater recharge to connect with the local water resources planning activities.

TABLE 5.1-2
CLIMATE CHANGE VULNERABILITY ASSESSMENT OVERVIEW

Watershed Characteristics	General Overview of Vulnerabilities
Water Demand	**Urban and Agricultural Water Demand** – Changes of hydrology in the Region as a result of climate change could lead to changes in water demand, both in quantities and patterns. Increased irrigation (outdoor landscape or agricultural) is anticipated to occur with temperature rise, increased evaporation losses with warmer temperature, and longer growing season.
Water Supply	**SWP Imported Water** – SWP water is an important portion of the water resources available to the Region. Potential impacts on SWP water availability resulting from climate change directly affect the amount of imported water supply delivered to the Region. **Groundwater** – Changes in local hydrology could affect natural recharge to the local groundwater aquifers and the quantity of groundwater that could be pumped sustainably over the long-term. Decreased inflow from runoff, increased evaporative losses, warmer and shorter winter seasons can alter natural recharge of groundwater. In addition, additional reductions in the SWP imported water imposed by climate change would lead to more reliance on local groundwater.
Water Quality	**SWP Imported Water** – Sea level rise could result in increases in chloride and bromide (a disinfection by product precursor), potentially requiring changes in drinking water treatment. Increased temperature could result in increase in algal blooms and taste and odor events. **Regional Surface Water** – Increased temperature could result in lower dissolved oxygen in streams. Decrease in annual precipitation could result in higher concentrations of contaminants in streams during droughts. Increased wildfire risk and flashier storms could increase turbidity loads for water treatment.
Sea Level Rise	The Region is not directly subject to sea level rise. However, potential effects of sea level rise would affect SWP water supply conditions. As discussed above, the principal concern is the potential for sea water intrusion to increase Delta salinity. As sea level rise is not a direct regional concern, it is not discussed further in this vulnerability assessment.
Flooding	Local surface flows could change as a result of more frequent and intense storm events, leading to more areas susceptible to flooding, and increasing risk of direct flood damage in the Region.
Ecosystem and Habitat	Increased temperature and potential decreases in annual precipitation could put stress on sensitive ecosystems and alter habitats. In addition, the Region may be subject to increased wildfire risk, which could alter habitat.
Hydropower	Currently, the Region produces only minimal hydropower; thus, climate change effects on hydropower are not likely to be considerable and were not considered further in the analysis at the time of this IRWMP update.

This section presents the vulnerability of each sector identified in Table 5.1-2 with respect to climate change projections given the existing tools and available data. This is an initial attempt using projections specific to the Region for the vulnerability assessment in support of the IRWMP. The outcome of this initial assessment is intended to help understand the potential impacts, to integrate climate change into long-term planning, and to improve understanding of the uncertainties associated with climate change effects. Consistent with the water resources planning horizon in the Region through 2050, the vulnerability analysis considers projections for mid-21st century (2050), consistent with DWR's modeling approach to climate change.

5.1.2.3.1 Water Demand

Demand management is an important adaptation given the loss of water supply as a result of climate change. A simple methodology was used to relate historical water demand with temperature. Reasonable projections were made for potential variations in water demand, based on anticipated temperature increase as a result of climate change.

The Cal-Adapt A2 emissions scenario used to project temperature and precipitation with climate change and the MPI-ECHAM5-MPI model used by DWR for SWP reliability analysis are similar with respect to the level of future projected emissions. The Cal-Adapt A2 emissions scenario projects a temperature increase for the Region of about 4°F by the mid-century (2050) and increase of about 7°F by the end of century. The projected average annual air temperature rise of 4°F by 2050 appears small against the background historical annual variability and characterizing the impacts of temperature rise on water demand is a difficult task and discussed on a qualitative basis. While water use varies considerably depending on other factors such as regional economy, population, and land use, a qualitative assessment of water demand increase can be noted based on the projected temperature increase from the Cal-Adapt A2 emission scenario. Limited historical temperature data are available for the Region from the Castaic Dam Evaporation Station (Site 252CE), provided by the LADPW. Based on 20 years of limited data between 1991 and 2011, the average of the maximum temperature varied from 62.9°F in February to 95.1°F in August, with the highest temperature of 98.4°F measured in August 1998. The average of the minimum temperature over the same historical period varied from 43.8°F in February to 62.6°F in August, with the lowest temperature of 39.1°F measured in March 2006. Although data records are limited covering a relatively short period of time, significant seasonal and annual variations are noted.

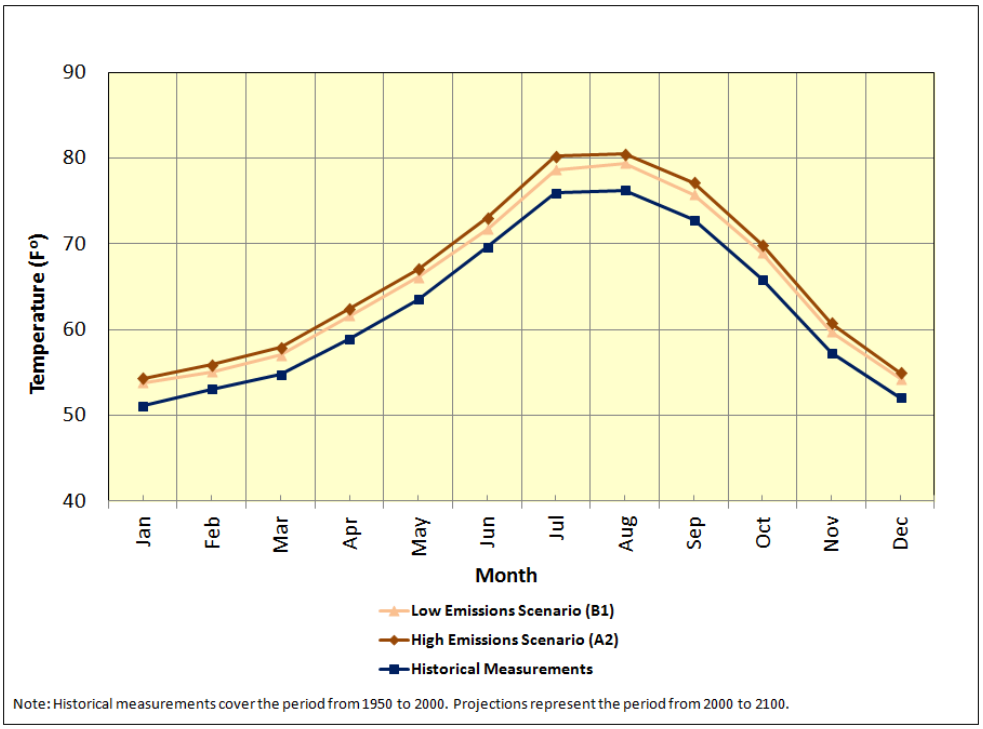
Historical water demand shows an increasing trend since 1995 with a downturn in recent years, likely due to response by customers to conservation efforts and the economic downturn. Water use to meet municipal water needs increased from approximately 45,700 AF in 1995 to nearly 77,500 AF in 2007, and was about 70,000 AF in 2009. Water demand is projected to gradually increase from almost 95,000 AF in 2015 to nearly 141,000 AF in 2050 (Section 3.3.1). This projection accounts for projected land use changes and conservation to comply with SBX7-7.

Weather affects water demand in the Region. The largest water use occurs during the end of summer and the beginning of fall months (July, August, and September) and water is used least in cooler months leading into spring (February and March). Total water use can vary more than 50 percent seasonally, indicating a significant monthly and seasonal variation in water use with weather conditions.

Higher temperature is likely to increase water demands. While the ten percent increase of water demand per capita has been assumed to account for dry years in the *2010 Santa Clarita Valley*

UWMP, there are not sufficient data available to quantify the effect from increasing temperature resulting from climate change. For a qualitative discussion, the projected increases in temperature and evapotranspiration (ET) have been evaluated to show seasonal changes in projections with climate changes compared with historical trends. Figure 5.1-4 shows the projected average monthly air temperature change for the four GCMs averaged from the present (1950-2000) through 2100 for the Region. The temperature projections are higher for the A2 and B1 emissions scenarios than the historical observed data and the A2 scenario projections are consistently higher than the B1 scenario projections. Based on the monthly average temperature, the projections with climate change show increase in temperature throughout the year with higher temperature increase in dry or summer months than wet or winter months. Under the A2 scenario, the projected temperature increase would be about 4°F during summer months compared with about 3°F during winter months. Qualitatively, these projections suggest water demand in the Region is likely to increase as a result of the projected higher temperature with a higher temperature increase anticipated during dry months compared to wet months.

FIGURE 5.1-4
PROJECTED AVERAGE MONTHLY TEMPERATURE FOR USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



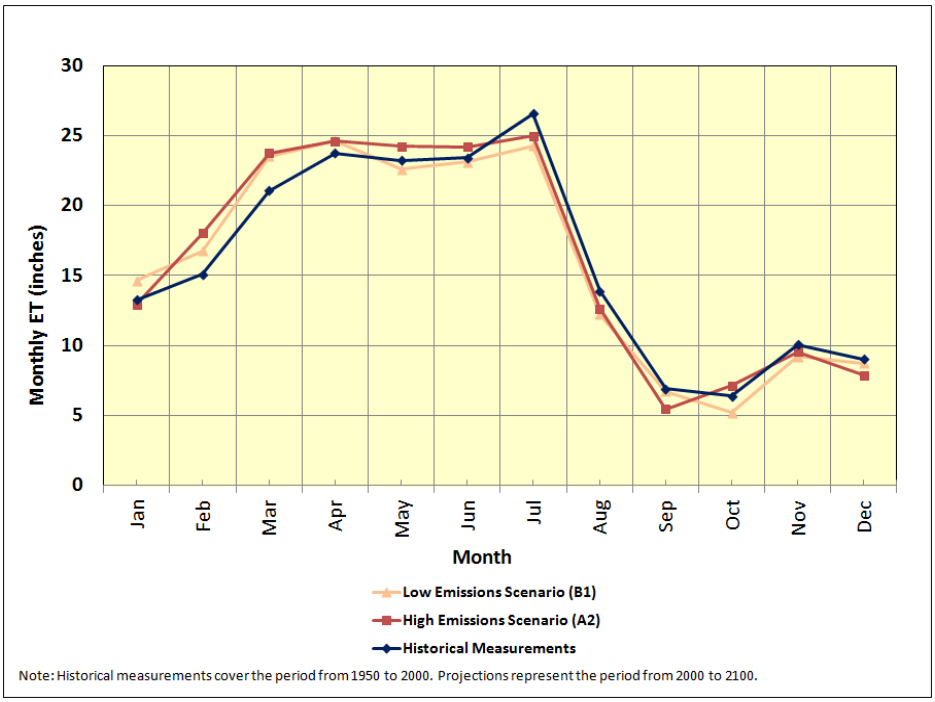
Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

The most important effect of changing weather conditions is likely to be on agricultural demand. Higher temperature generally increases ET rates, but some research studies also suggest higher CO_2 levels and higher temperature increase rates of plant growth and can shorten the time to plant maturity (Hanak and Lund, 2008). This would reduce the overall plant water uptake, partially compensating for potential reductions in agricultural water supply. Thus, the net effect on agricultural crops is still uncertain (Kiparsky and Gleick, 2005) and remains an

important area of ongoing research. Figure 5.1-5 shows the projected average monthly ET change for the four GCMs averaged from the present (1950-2000) through 2100 for the Region. In general, both the background historical and projections with climate change show higher ET during dry months (March through July) with a sharp decline in ET during August and September. The ET projections are generally higher for the A2 and B1 emissions scenarios than the historical observed data during months of the year where ET tends to be higher (January through June months). For months where ET is generally lower, a shift is anticipated between the background historical data and projections, where the historical data become slightly higher than the A2 and B2 scenario projections.

Qualitatively, the ET projections with climate change suggest water demand for agriculture in the Region is anticipated to increase during months where ET is high and decrease in months where ET is low. As a result of increased ET, urban water demand is anticipated to increase with greater outdoor water use for landscape irrigation. The temperature and ET projections with climate change as shown in Figures 5.1-4 and 5.1-5 demonstrate the effects of climate change on the future water demand based on seasonal variations; however, the projected water demand increase with population growth and land use changes is large in the Region and these factors are likely to be more significant drivers of outdoor water use than the effect of climate change alone.

FIGURE 5.1-5
PROJECTED AVERAGE MONTHLY EVAPOTRANSPIRATION FOR USCR REGION: AVERAGE OF FOUR GCMS FOR TWO EMISSIONS SCENARIOS



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

5.1.2.3.2 Water Supply

For long-term water supply planning, coping with variability is a challenge. With potential additional changes imposed by climate change, there will be a heightened need to evaluate and respond to increased water supply variability.

A broad range of impacts could be produced by climate change in the Region, yet some of the most significant impacts of climate change are anticipated to occur on water resources. An analytical approach was used to identify and describe water supply availability under climate change, and includes DWR's modeling analysis of SWP imported water reliability.

SWP delivery to the Region comprises about 54 percent of total existing water supplies projected through 2050 in the Region in normal/average years (Table 3.1-1). Groundwater pumping from local aquifers and additional sources from groundwater banking activities make up the remaining major water sources used to meet the Region's municipal and agricultural water demand. The Region relies on imported SWP supplies and any reduction or change in the timing or availability of those supplies could have negative impacts on the Region. Reductions in the SWP imported water would lead to increased reliance on local groundwater or other sources of supplies. Changes in local hydrology could affect natural recharge to the local groundwater and the quantity of groundwater that could be pumped in a sustainable manner. Reductions in SWP imported water as a result of climate change could lead to increased groundwater production.

Although SWP supply is mainly controlled by hydrologic conditions in the northern part of the state, the groundwater resources would be affected by local conditions, whereby climate change effects on these resources could occur at the same time. Therefore, the combined effects on SWP imported water and groundwater resources can exert more magnified stress on the Region's water supply planning than the effects on individual resources.

The following is an assessment of climate change on SWP imported water and groundwater resources. The SWP imported water assessment is presented first to identify potential reductions in SWP deliveries. The outcome of the SWP assessment is tied to the groundwater assessment as SWP reductions may lead to increased reliance on local groundwater.

5.1.2.3.3 SWP Imported Water

Availability of future SWP imported water supplies to the Region was assessed within the context of climate change impacts. The methodology used for the vulnerability assessment includes a comparison of estimated future SWP deliveries with and without climate change to evaluate the potential vulnerability of the SWP imported water. Future projections of SWP deliveries are based on the modeling analysis performed by DWR, as reported in the recently issued *2011 Reliability Report* (DWR 2012). DWR conducted an assessment of the impacts of climate change on the state's water supply using MPI-ECHAMPS Global Climate Model. As described earlier, the model output is based on the A2 emission scenario with mid-century (2050) projections. The assumption used for the emissions level in the DWR modeling analysis is consistent with the Cal-Adapt A2 emissions scenario used for forecasting temperature, precipitation, ET, and runoff projections with climate change.

DWR's modeling analysis is based on the 82 years of hydrologic data (water years 1922-2003) and uses forecast levels of climate change through year 2050, with 2020 land use levels. The analysis accounts for potential hydrologic changes that could result from climate change and the

effects of sea level rise on water quality, but does not incorporate the probability of catastrophic levee failure (DWR 2012).

On a qualitative basis, DWR's climate change modeling analysis indicates increased temperature, decreased water availability with reduced Sierra Nevada snowpack, early snow melt, and a rise in sea level (DWR 2012). DWR's *2011 Reliability Report* provides SWP system-wide deliveries expressed as a percentage of total maximum Table A amounts for future conditions with climate change. These percentages do not reflect the differing allocations to individual contractors. In the absence of detailed results for each contractor, this vulnerability assessment assumed that changes in total SWP Table A deliveries resulting from climate change are a reasonable representation of future SWP imported water supply to the Region. The underlying assumption is that future reductions in SWP imported water to the Region would be proportional to projected reductions in total SWP deliveries.

DWR's modeling analysis provides future projections of SWP deliveries both with and without climate change, each using the 82 years of hydrologic data. Using DWR's modeling analysis for the assessment of climate change is consistent with the ongoing long-term water planning in the Region. In addition, results from DWR's climate change analysis allows for a direct comparison of SWP supply vulnerability of future conditions with and without climate change on a quantitative basis.

As described above, the climate change model MPI-ECHAMPS with the A2 emission scenario was used by DWR in the *2011 Reliability Report* for the future SWP delivery projections with climate change. The maximum SWP Table A demands for deliveries to SWP contractors from the Delta is 4,133 thousand acre feet (TAF) based on the current demands developed by DWR. In the *2011 Reliability Report*, the maximum SWP Table A demands for deliveries from the Delta are assumed to be the same as 4,133 TAF under future conditions, both with and without climate change effects. In other words, the maximum annual SWP Table A demand of 4,133 TAF is assumed in all 82 years of the simulation (note there is no variation in demand due to different annual hydrologic conditions). In the context of evaluating the climate change effects in this study, reductions in SWP deliveries with and without climate change are presented as percentages of the maximum SWP Table A delivery amount of 4,133 TAF annually.

It should be noted that SWP supplies to CLWA, as reported in the *2010 Santa Clarita Valley UWMP*, are based on DWR's more detailed, contractor-specific delivery data from its analyses for the *2009 Reliability Report*. In the *2010 UWMP*, DWR's analysis of current (2009) conditions was used to estimate 2010 SWP supplies and its analysis of future (2029) conditions was used to estimate 2030-2050 SWP supplies. SWP supply to CLWA by 2050 is projected to be at 57,400 AFY (60 percent of CLWA's 95,200 AFY Table A amount) in average/normal years, 9,100 AFY (10 percent of Table A amount) in a single dry year and 33,000 AFY over a multi-year dry period.

<u>Average, Maximum, and Minimum Annual SWP Table A Deliveries</u>

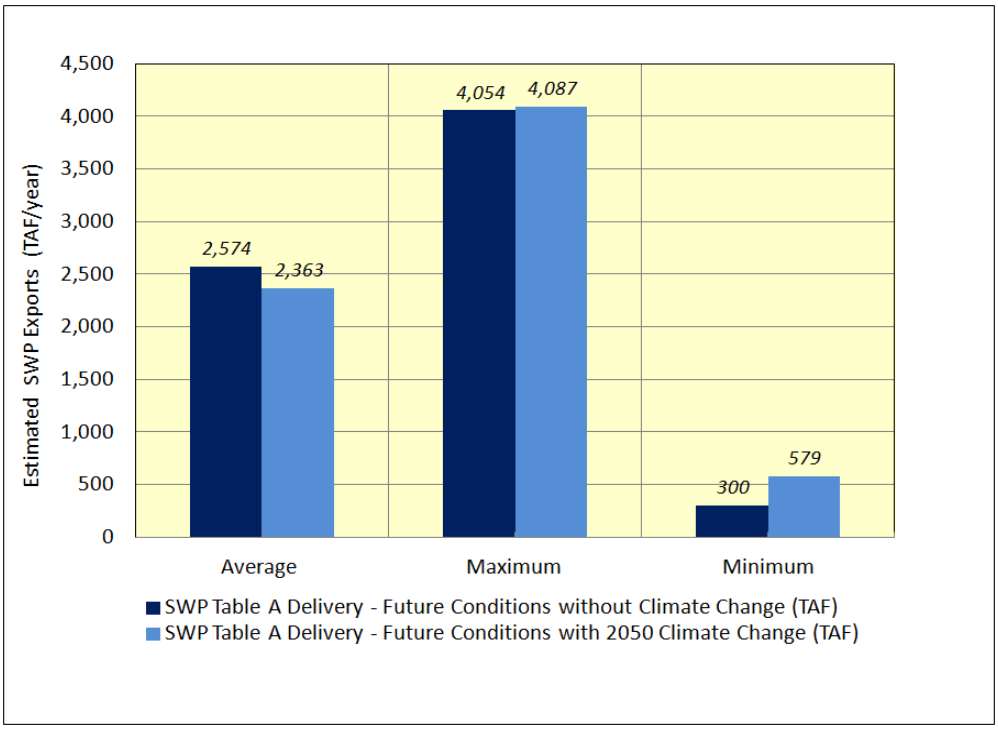
Figure 5.1-6 presents the estimated long-term average, maximum, and minimum annual SWP Table A deliveries for the future conditions with and without climate change. The long-term average is based on the projections for the 82 years of hydrologic period (1922 to 2003) modified to reflect climate change. Based on the future conditions with climate change, SWP Table A deliveries range from an annual minimum of 579 TAF to a maximum of 4,087 TAF, with

the long-term average of 2,363 TAF. These estimates show that the maximum annual delivery increases by 33 TAF per year (1 percent) under the future conditions with 2050 climate change, relative to the future conditions with no climate change effects.

Estimated minimum annual delivery is 279 TAF (48%) higher with climate change than without climate change. However, the average annual deliveries decrease from 2,574 TAF under the future conditions without climate change to 2,363 TAF under the future conditions with climate change. This is a reduction of 211 TAF annually at the system-wide level.

In assessing the future SWP delivery reliability, the long-term average SWP delivery from the *2011 Reliability Report* is directly applicable to individual contractors. The long-term average of future SWP deliveries with climate change is lower than the long-term average without climate change, as depicted in Figure 5.1-6. The average value represents the long-term trend over the entire 82 years of the hydrologic data. This decreasing trend in the average SWP delivery projections with climate change is consistent with the expected reduction in the reliability of the SWP water supply system due to climate change impact (DWR 2009). SWP future projections associated with any particular year (i.e., the minimum and maximum values) or over a short period of time (i.e., a single dry period or single wet period) should be viewed carefully because these results are dependent upon the rainfall that has occurred in previous years. In addition, reservoir storage for the beginning of any year varies depending upon the weather conditions in the previous year. Therefore, the results for any single year, such as the minimum and maximum values as shown in Figure 5.1-6, should be interpreted with caution as they may be affected by the amount of water assumed to be available from the previous year. While the long-term SWP future projections with climate change indicate reduction in deliveries, SWP projections for a single year (or over a short period of time) does not follow the decreasing trend. As described above and shown in Figure 5.1-6, the minimum and maximum values are projected to be higher with climate change. Since they represent projected deliveries in a single year, the increasing trend with climate change could be attributed to the factors that occur in the previous years, such as weather and or reservoir storage conditions, that affect deliveries.

FIGURE 5.1-6
ESTIMATED AVERAGE, MAXIMUM, AND MINIMUM ANNUAL SWP EXPORTS – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE



Source: Figure based on Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12.

Long-term average SWP Table A deliveries are estimated to be 57 percent of Table A amount for the future conditions with climate change; without climate change long-term deliveries are expected to be 62 percent of Table A amounts. Assuming available SWP supply to the Region would be proportional to the SWP system-wide supply conditions, projected SWP imported water delivery to CLWA with climate change corresponds to about 54,500 AF (or 57 percent of Table A amount based on CLWA's annual contract amount of 95,200 AF of SWP water) and 59,300 AF (or 62 percent of Table A amount) without climate change.

The *2010 Santa Clarita Valley UWMP,* based on the *2009 Reliability Report,* assumed SWP supply of 57,400 AFY. The new modeling in the *2011 Reliability Report* suggests that CLWA SWP average supply could be 2,900 AFY less (about 3%) than assumed in the *2010 Santa Clarita Valley UWMP*. For the purpose of this analysis, results from the *2011 Reliability Report* were used consistently for future projections with and without climate change. In light of the long-term water supply availability, this reduction appears small and comprises a relatively small portion of the Region's total water supply.

It should also be noted that the current assumptions used in DWR's *2009* and *2011 Reliability Report* present a conservative projection of SWP delivery reliability. Several emerging factors related to the biological opinions on the Delta operations, issued by US FWS and the National Marine Fishery Service (NMFS), have the potential to affect the availability of SWP supplies, supporting higher estimates of average annual SWP deliveries than projected in the *2009* and

2011 Reliability Report. Therefore, the projections presented herein also present conservative estimates concerning the long-term delivery reliability of SWP supplies.

SWP Table A Deliveries by Water Year Types

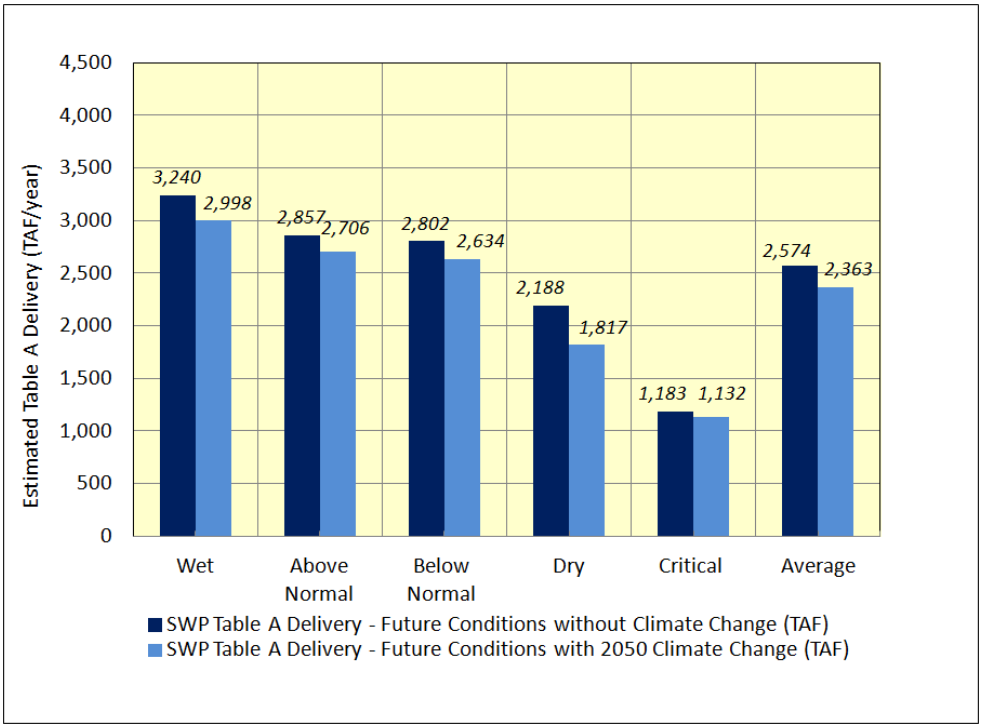
Figure 5.1-7 and Table 5.1-3 show estimated SWP Table A deliveries by water year type under future conditions with and without climate change. In Figure 5.1-7 and Table 5.1-3, estimated SWP exports reported by DWR for the 82 years of hydrologic data (water years 1922 to 2003) were averaged according to water year type. This representation shows how the estimated SWP exports would vary by hydrologic year types over the entire 82 years of the modeling analysis. Overall, the future conditions with climate change forecast lower deliveries under all water year types, with the largest difference for dry years. Deliveries decrease by as little as 51 TAF (5%) during critical years to as much as 371 TAF (20%) during dry years under the future conditions with climate change relative to no climate change.

TABLE 5.1-3
ESTIMATED SWP EXPORTS BY WATER YEAR TYPE – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE

Water Year Type	Future Conditions (2050) with Climate Change (TAF)	Future Conditions (2050) without Climate Change (TAF)	Difference, Future with and without Climate Change	
			TAF	%
Wet	2,998	3,240	-242	-8
Above Normal	2,706	2,857	-152	-6
Below Normal	2,634	2,802	-168	-6
Dry	1,817	2,188	-371	-20
Critical	1,132	1,183	-51	-5
Average	2,363	2,574	-211	-9

Source: Estimated SWP exports are based on the 82 years of hydrologic data (water years 1922-2003) from Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12 SWP Table A Deliveries for Future Conditions. Hydrologic data were averaged according to water year types based on DWR's Sacramento Valley water year index (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST).

FIGURE 5.1-7
ESTIMATED SWP TABLE A DELIVERY BY WATER YEAR TYPE – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE



Source: Estimated SWP exports are based on the 82 years of hydrologic data (water years 1922-2003) from Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12 SWP Table A Deliveries for Future Conditions. Hydrologic data were averaged according to water year types based on DWR's Sacramento Valley water year index (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST).

Dry-Year SWP Table A Deliveries

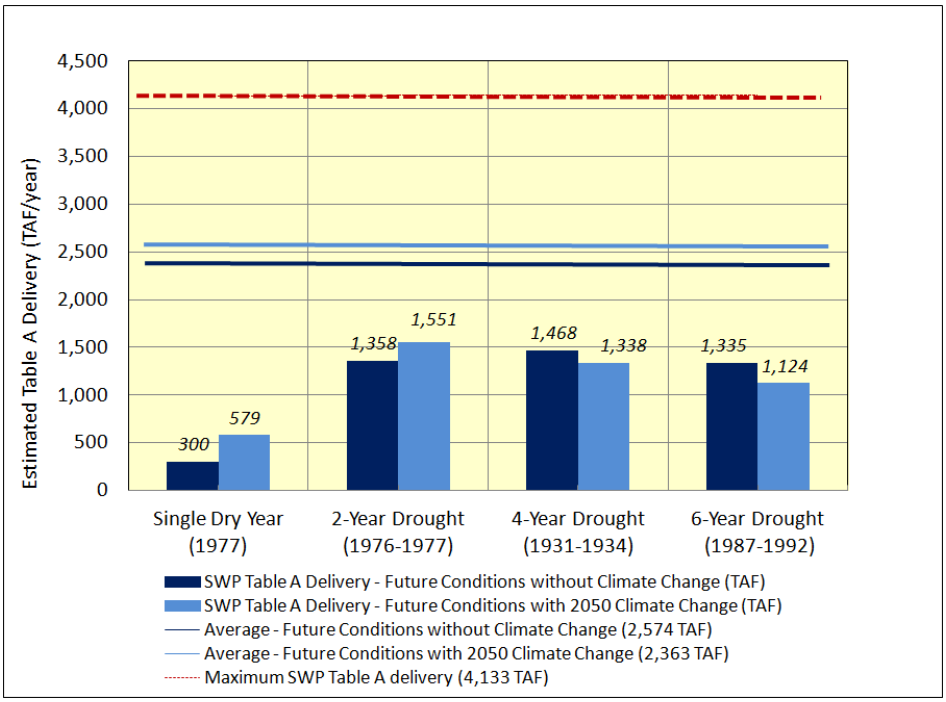
Figure 5.1-8 shows a comparison of estimated SWP Table A deliveries under future conditions with and without climate change during possible drought conditions. Unlike Figure 5.1-7 that shows the average of dry and critical years over the entire 82 years of hydrologic period, Figure 5.1-8 shows estimates of SWP exports for a single dry year, or the average of the consecutive dry years. Droughts are analyzed using historical drought-period precipitation and runoff patterns from 1922 through 2003. Future conditions with land use and climate change are also accounted for. As shown in Figure 5.1-8, estimated annual SWP deliveries can be expected to range from 579 TAF to 1,551 TAF under the future conditions with climate change, relative to 300 TAF to 1,468 TAF without climate change effects. This indicates a 12% to 48% increase for the single dry year and 2-year drought, respectively, with climate change. Under both future conditions, the single year drought (1977) is the most intense dry period, with the lowest delivery. As shown in Figure 5.1-8, the increasing trend for the single dry and 2-year drought with climate change is different than the overall decreasing trend seen in SWP projections with climate change. As discussed above, the long-term average SWP delivery is projected to be lower with climate change (Figure 5.1-6). Similarly, a decreasing trend is seen for the average deliveries by water year types where the future conditions with climate change forecast lower

deliveries under all water year types (Figure 5.1-7). However, as discussed above, the minimum and maximum values are projected to be higher with climate change (Figure 5.1-6), similar to the increasing trend seen for the single-dry year and 2-year drought projections with climate change (Figure 5.1-8). As discussed earlier, the projections over a single year (i.e., minimum, maximum, or a single dry period) or over a short period of time (i.e., 2-year drought) should be interpreted carefully because the results for the beginning of any year are dependent upon the rainfall and reservoir storage conditions in the previous year. While the increasing trend with climate change does not follow the overall expected trend for decreasing SWP deliveries with climate change, it could be attributed to the factors that occur in the previous years, such as weather and or reservoir storage conditions that affect deliveries.

While SWP supplies are anticipated to increase during short period drought conditions, as depicted in Figure 5.1-8 for the single dry year and 2-year drought, during the multi-year (4-year and 6-year) drought projections under future conditions are lower with climate change than without climate change. This is consistent with the decreasing trend seen with climate change for the long-term average and the average deliveries during different water year types. For the 4-year and 6-year drought, SWP Table A deliveries with climate change decrease by 10% to 19%, respectively, compared with future conditions without climate change. For the 6-year drought, SWP supply to the Region is anticipated to be reduced by 4,900 AF per year, as a result of decrease in SWP Table A delivery from 36% of Table A amount without climate change to 32% of Table A amount with climate change.

Assuming that the Region's SWP supply reliability would be proportional to SWP system-wide supply reliability, there is potential for slightly increased SWP supply to the Region during a single year and 2-year drought with climate change assumptions compared with no climate change effects. In the worst-case single critically dry year (1977), estimated SWP Table A delivery increases from 7% of total maximum Table A amount without climate change to 14% of Table A amount with climate change. This represents a 7% increase and corresponds to about 6,500 AF additional SWP supply to the Region (based on the annual contract amount of 95,200 AF of SWP water). During the 2-year drought, the projected increase in SWP supply is about 5% of total Table A amount or 4,500 AF more of SWP supply.

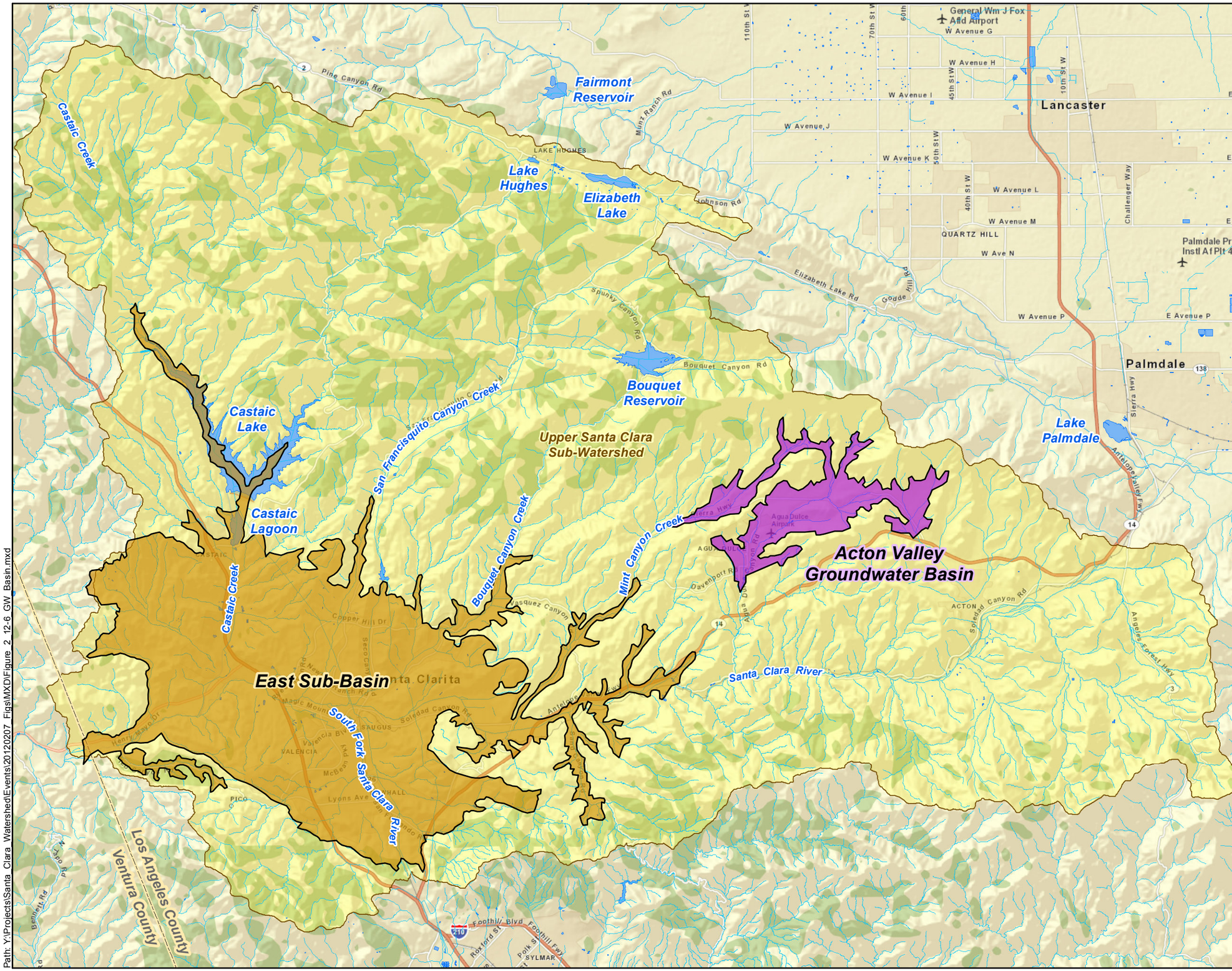
FIGURE 5.1-8
ESTIMATED SWP TABLE A DELIVERY DURING DRY PERIODS – FUTURE CONDITIONS WITH AND WITHOUT CLIMATE CHANGE



Source: Figure based on Draft Technical Addendum to the State Water Project Delivery Reliability Report 2011, Table 12 SWP Table A Deliveries for Future Conditions.

5.1.2.3.4 Groundwater

As discussed in the Water Supplies and Water Demand Section (see Section 3.1-1 and Table 3.1-1), the Region relies on groundwater mainly in two groundwater basins: Acton Valley Basin and Santa Clara River Valley Basin, East Subbasin. The boundaries of the basins are shown in Figure 5.1-9, as defined by DWR Bulletin 118 (DWR, 2003). There are also groundwater areas that are recognized locally (Agua Dulce Basin and Soledad Canyon Alluvial Channel) and used for pumping, but they are not designated as a groundwater basin by DWR. Groundwater extraction data, groundwater storage, and yield data for these locally recognized



Legend

- Acton Valley Groundwater Basin
- East Sub-Basin (Santa Clara River GW Basin)
- Upper Santa Clara Sub-Watershed
- Water Body
- Streams

N

0 1.5 3

Miles

Kennedy/Jenks Consultants

CLWA IRWMP Grant Application
Los Angeles County, California

Groundwater Basin Boundaries in the Region

1189057*00
February 2012

Figure 5.1-9

Path: Y:\Projects\Santa_Clara_Watershed\Events\20120207_Figs\MXD\Figure_2_12-6_GW_Basin.mxd

basins are not currently available. A detailed description of the hydrogeologic characteristics of the basins, groundwater flow and water quality conditions, and storage capacity of the aquifers is presented in the previous sections and additional details can be found in other existing reports (CH2MHill 2005; LSCE 2011).

Groundwater basins in the Region are recharged largely by infiltration of surface water flows in the Santa Clara River channel and deep percolation of precipitation and runoff in its tributaries. Surface water flows percolate through the alluvial deposits along the stream channels, recharging the Alluvium, and the underlying Saugus Formation. Groundwater in the Santa Clara River Valley Basin is produced from the Alluvium and Saugus Formation.

Based on the groundwater operating plan for the Santa Clara River Valley East Subbasin, total groundwater production in a given year varies depending on the hydrologic conditions. Based on the existing and planned pumping, groundwater is anticipated to provide about 43,600 AF through year 2050 (35,225 AF existing and 8,375 AF planned) (see Table 3.1-1). With the existing (24,950 AF) and planned (20,000 AF) banking programs, total (maximum) capacity of the banking program withdrawals would reach 44,950 AF annually through 2050, but this banking water is typically used only in dry years. The projections of pumping are well within the available groundwater supply for the Region. Total combined groundwater available from the Alluvium, Saugus Formation, and Acton Basin ranges from 71,900 AFY to 89,000 AFY during normal and above normal years and reduces to 60,400 AFY to 74,900 AFY during dry years (see Table 3.1-2).

While the basins have supply exceeding the future projected pumping levels, in light of the basin characteristics and natural recharge processes in the basins, changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage. Warmer winters would increase the amount of runoff available for groundwater recharge, but reductions in inflow from runoff and increased evaporative losses could reduce the amount of natural recharge. While the extent to which climate change will change the natural recharge processes and the impact of that change are not exactly known and are difficult to quantify, simplifying assumptions were applied to provide initial estimates.

For this analysis, precipitation reduction of 10 percent was assumed to occur in the Region on a long-term basis. Assessment of climate change impacts on groundwater resources is presented in two parts. The first part of the analysis uses a “what if” scenario to evaluate if groundwater aquifers could make up for SWP supplies impacted by climate change while staying within a safe operating range. The underlying assumption was that reduced SWP supplies would be solely made up by groundwater pumping and that future pumping levels could be potentially higher than the future pumping projections reported in the *2010 Santa Clarita Valley UWMP*. The second part of the analysis is based on a “what if” scenario to evaluate the combined effects of climate change on SWP supplies, in conjunction with potential climate change effects on groundwater resources. In this scenario, it was assumed that 10 percent precipitation reduction would result in 10 percent reduction in the current safe groundwater pumping operational range. This is considered as an initial assessment of climate change effect on groundwater resources and further analysis may be warranted.

Following is a brief discussion of historical and operational range of pumping from the Alluvium, Saugus Formation, and Acton Basin, as this information is pertinent to the assessment of future pumping projections with climate change effects.

Santa Clara River Valley East Subbasin – Alluvium

Pumping from the Alluvium in a given year is governed by local hydrologic conditions in the eastern Santa Clara River watershed. Therefore, changes in local hydrologic conditions resulting from climate change are anticipated to directly affect the available supply in the Alluvium.

Groundwater production from the Alluvium is projected to range from 38,100 AFY to 38,600 AFY through year 2050 under normal years (CLWA, et al. 2011). Future projections of pumping account for land-use changes including a decrease in agricultural land use and decrease in agricultural pumping and the equivalent amount of increased pumping for municipal water supply. Future pumping projections are consistent with the long-term sustainable pumping operations and are within pumping capacity and historical ranges of pumping in the Alluvium. The Alluvium can supply groundwater on a long-term sustainable basis in the overall range of 30,000 to 40,000 AFY during normal and above-normal years, with a probable reduction in dry years to 30,000 to 35,000 AFY. In terms of pumping capacity, the combined maximum pumping capacity of the three retail water purveyors with Alluvium wells (NCWD, SCWD, and VWC) is approximately 67,000 AFY (CLWA, et al. 2011), which is more than sufficient to meet the potential future groundwater supply from the Alluvium. However, as a result of the groundwater operating plan, pumping to full capacity is not permitted. Historical pumping data show that since the beginning of SWP deliveries to the Region in 1980, total pumping from the Alluvium ranged from 20,000 AFY (in 1983) to slightly more than 43,000 AFY (in 1999). During recent years between 2005 and 2009, pumping from the Alluvium was at the upper end of the operating plan range, from nearly 38,700 AF (in 2005) to slightly over 43,000 AF (in 2006).

The groundwater modeling analysis, prepared by CH2M Hill and LSCE (2005), was used to examine the yield and sustainability of the Alluvium in response to pumping in the 30,000 to 40,000 AFY range under average/normal and wet conditions, and in the 30,000 to 35,000 AFY range under locally dry conditions. The model was based on a 78-year hydrologic period from historical precipitation and considered a number of hydrologic conditions expected to affect groundwater pumping and recharge. The modeling analysis showed no evidence of long-term decline in groundwater levels or storage. The updated basin yield analysis (LSCE & GSI 2009) resulted in similar findings as the original modeling analysis, providing further evidence that the operating plan reflects the ongoing sustainable groundwater supply rates. On an overall basis, projected groundwater production from the Alluvium is intended to remain within the sustainable ranges in the groundwater operating plan (CLWA, et al. 2011).

Santa Clara River Valley Basin - Saugus Formation

Pumping from the Saugus Formation in a given year is tied directly to the availability of other water supplies, particularly from SWP. Therefore, reductions in the SWP imported water from climate change impacts would lead to more reliance on the Saugus Formation.

Based on the future projections of groundwater pumping through year 2050, the Saugus Formation would supply water from 11,500 AFY to 12,500 AFY in normal years (CLWA, et al. 2011). On an overall basis, projected groundwater production from the Saugus Formation remains well within the sustainable ranges defined in the groundwater operating plan (CLWA, et al. 2011). Based on the historical operating ranges and recent modeling analyses (2005 and 2009), the Saugus Formation can supply groundwater on a long-term sustainable basis in the overall range of 7,500 to 15,000 AFY during normal years, but has the capacity to produce more

in dry years. As presented earlier in Table 3.1-2, planned dry-year pumping from the Saugus Formation ranges between 15,000 and 25,000 AFY during a drought year and can increase to between 21,000 and 25,000 AFY if SWP deliveries are reduced for two consecutive years and between 21,000 and 35,000 AFY if SWP deliveries are reduced for three consecutive years.

Based on a combination of historical operating experience and recent groundwater modeling analysis in 2005 and 2009, the Saugus Aquifer can be considered a sustainable water supply source to meet the Saugus portion of the operating plan for the groundwater subbasin. The operating plan for the Saugus, with fairly low pumping in wet/normal years and increased pumping through dry periods, reflects sustainable groundwater supply rates. Limited data exists regarding groundwater levels in the Saugus Formation; however, the existing data indicate no trend toward a sustained decline in water levels or storage indicative of overdraft.

Acton Groundwater Basin

The Acton Basin consists of alluvial and stream terrace deposits and is under unconfined conditions. The basin is drained by the Santa Clara River and recharged largely by deep percolation of direct rainfall runoff captured in the valley floor, and Santa Clara River and tributaries. As seen in Table 3.1-2, availability of groundwater from the Acton Basin is estimated to range from 14,900 AF for a relatively dry period to 34,400 AF for a relatively wet period. Based on the historical data, groundwater levels declined during the 1950s through the mid-1970s, rose during the late 1970s to the mid-1980s, and continued to decline after the 1980s (Slade 1990).

"What If" Scenario 1: Projected Future Groundwater Pumping with Reduced SWP Supplies

This scenario assumes (1) SWP supplies with climate change as reported in the 2011 Reliability Report and (2) groundwater supplies consistent with the 2010 Santa Clarita Valley UWMP.

This section presents the first part of the analysis where future groundwater pumping volumes are projected to accommodate the reduced SWP supplies as a result of climate change effects on SWP supplies. The future projections of pumping from the Alluvium, Saugus Formation, and Acton Basin, as reported in the *2010 Santa Clarita Valley UWMP*, were evaluated in light of the operating plan pumping range and reduced SWP supplies resulting from climate change based on the vulnerability assessment of SWP supplies presented above. This is a qualitative analysis to evaluate if the basins have the potential to make up for reduced SWP supplies resulting from climate change without long-term effects on groundwater levels and storage. The current analysis is mainly based on the long-term average trends to capture the long-term response from climate change. Conditions during a multi-year (6-year) drought were also assessed as a conservative approach.

Based on DWR's modeling analysis of climate change effects on SWP supplies, CLWA's SWP imported water supply is estimated to decrease by 4,900 AFY both on the long-term average basis and during the multi-year (6-year) drought, relative to future projections without climate change. In average/normal years, the future pumping projections of 38,100 AFY to 38,600 AFY in the Alluvium, as described in the *2010 Santa Clarita Valley UWMP* (CLWA, et al. 2011), would be in the upper range of the operating plan (up to 40,000 AFY, Table 3.1-2). Additional pumping from the Alluvium to accommodate the reduced SWP delivery of 4,900 AFY would exceed the sustainable yield. In addition, pumping higher than the estimated sustainable Alluvium yield at 38,600 AFY could potentially result in both short-term and long-term

groundwater levels and storage depletion in this basin. For the purpose of this assessment, it was assumed that the Alluvium could potentially produce 38,600 AFY on the long-term average. During a multi-year drought, the potential for the basin to support additional pumping of 4,900 AFY is low, given that the basin operating yield decreases to 34,850 AFY (CLWA, et al. 2011).

Historical pumping in the Saugus Formation, on the other hand, has been fairly low and increased pumping up to about 15,000 AFY over a four-year period showed short-term water level impacts but produced no long-term depletion of the substantial groundwater storage. While the future projection of pumping from the Saugus Formation ranges from 11,500 AFY to 12,500 AFY, the basin has the potential to pump additional amounts in the short-term, as high as 35,000 AFY during a single dry year and up to 32,550 AFY during a multi-year drought in the case of reduced SWP deliveries. For the purposes of this assessment, it was assumed that, both on the long-term basis, and multi-year drought conditions, the entire amount of reduced SWP supplies could be potentially made up by pumping in the Saugus Formation. If the reduced SWP supply was made up solely by groundwater pumping in the Saugus Formation, pumping would increase by an equivalent amount of reduced SWP delivery, or 4,900 AFY. This would result in pumping in the range of 16,400 AFY to 17,400 AFY on the long-term average. This range is slightly higher than the upper end of the planned use of the aquifer in normal years, but lower than the upper range of pumping in dry years when reduced SWP deliveries occur during consecutive years (up to 35,000 AFY). As discussed earlier, the full Saugus Formation supply of 35,000 AFY in certain dry years would require restoration of perchlorate impacted wells with additional wells, but pumping in the range of 16,400 AFY to 17,400 AFY is not anticipated to be affected by well capacity. Overall, additional pumping from the Saugus to make up for reduced SWP supplies is within the range of pumping identified in the recent basin analysis found to protect long-term groundwater sustainability. Groundwater levels could potentially go below historical levels in response to greater long-term use of the aquifer, but the basin is anticipated to show recovery of groundwater levels and storage after cessation of higher pumping.

Given that the Acton Basin is under unconfined conditions and shows historical groundwater level declines, the basin is anticipated to be most vulnerable to local changes in hydrology and reduced natural recharge. For the purpose of this assessment, no additional pumping from the Action Basin was assumed to occur to respond to reduced SWP deliveries resulting from climate change.

<u>“What If” Scenario 2: Projected Future Groundwater Pumping with Reduced SWP Supplies and Reduced Precipitation</u>

This scenario assumes (1) SWP supplies with climate change as reported in the 2011 Reliability Report and (2) groundwater supplies reduced to reflect anticipated reductions in recharge with climate change.

For the purpose of this part of the analysis, SWP projections with climate change remain the same as discussed in the “What If” Scenario 1. However, the groundwater operating range was modified based on the simplifying assumption that a 10 percent reduction in precipitation would lead to a 10 percent reduction in the operational range. This is done on a long-term basis and does not account for year-to-year variations in precipitation change or any resulting annual changes in groundwater resources. The intent is to evaluate if the basins can still support the additional pumping in the long-term without adverse long-term effects in groundwater storage

and levels when SWP deliveries are reduced because of climate change effects on SWP supplies.

Given a 10 percent reduction in the operational yield, available pumping from the Alluvium is assumed to decline to 27,000 AFY to 36,000 AFY, less than the current operating range of 30,000 AFY to 40,000 AFY. Future projected groundwater production from the Alluvium (without climate change) ranges from 38,100 AFY to 38,600 AFY, which exceeds the modified operational yield. While the 10 percent reduction assumption is very broad and conservative, this suggests that, the Alluvium may not have the capacity to support future projections of pumping in the long-term, and may not support additional pumping that may be required when SWP supplies are reduced. In addition, future pumping of 38,100 AFY to 38,600 AFY may require further analysis of the operational range to maintain the long-term sustainability of the basin.

Assuming a 10 percent reduction in the operational yield, the Saugus Formation could potentially range from 6,750 to 31,500 AFY, compared with the current range of 7,500 AFY to 35,000 AFY. If the reduced SWP supply of 4,900 AFY was made up solely by groundwater from the Saugus Formation, pumping would range from 16,400 AFY to 17,400 AFY on the long-term average, compared with future pumping projection of 11,500 AFY to 12,500 AFY without climate change. This increased pumping is higher than the upper end of the modified operating range in normal years (13,500 AFY), but still lower than the upper range of the modified operating use in consecutive dry years (22,500 AFY for a dry year 2 and 31,500 AFY for dry year 3). With the modified (reduced) operating range, it appears that the Saugus Formation could potentially support pumping up to 13,500 AFY in the long-term without affecting the long-term stability of the basin. Therefore, the Saugus Formation has the potential to make up for a portion of the additional pumping when SWP deliveries are reduced with climate change, but a combination of other sources should be considered to make up the difference and meet the water demand in the Region.

5.1.2.3.5 Water Quality

Improving water quality is a Plan objective that may be impacted by climate change. Studies of potential climate change impacts on water quality exist, but few trends in relationships between hydroclimate (hydrology and weather variables) have been identified. Key climate vulnerabilities potentially important to the Region include increasing temperature and changes in precipitation patterns. Increased wildfire risk is another potential factor that could affect water quality in the Region. Outside the Region, sea level rise in the Sacramento-San Joaquin Delta is expected to impact water quality of imported SWP water.

Surface waters in the Region are expected to be more directly vulnerable to water quality impacts of climate change, while water quality impacts to groundwater sources would be indirect. Key surface water sources include imported SWP water stored in Castaic Lake and flowing water in the Upper Santa Clara River and its tributaries such as Bouquet Creek.

<u>SWP Imported Water</u>

SWP water is vulnerable to potential effects of climate change at the source in the Delta and in storage in Castaic Lake. The effect in the Delta would be due to sea level rise which increases the intrusion of salinity into the exported SWP water. This will increase chloride and bromide (a disinfection byproduct precursor that is also a component of sea water) concentrations in the

SWP imported water. In addition, decreased freshwater flows into the Delta could increase organic matter, which contribute to disinfection byproduct formation, in the SWP water. Water stored in Castaic Lake will also be vulnerable to climate change. A prior study of potential climate change impacts on the water quality of Lake Cachuma near Santa Barbara found that water quality parameters related to rainfall-runoff (turbidity and apparent color) during the wet season, winter, and/or spring could be evaluated by looking at total precipitation while water parameters related to taste and odor (increasing water temperature, dissolved oxygen (DO), threshold odor number (TON), pH, and percent DO saturation) during the dry season, spring, and summer could be evaluated by looking at air temperature parameters and/or evaporation (Drago and Brekke 2005).

Extreme storm events, although rare, may be more intense under climate change and may present treatment challenges for source water with increased turbidity. In the past, high turbidity events in Castaic Lake during 1998 and 2005 required modification of the treatment processes (primarily additional chemical usage) for extended periods. In 2005, an intense winter rainfall event after a wildfire in the watershed the prior year resulted in extremely high turbidities (peak over 80 NTU) in the lake. Although the treatment plants were able to treat the water, the additional sludge production overwhelmed the solids handling equipment and the plants had to be shut down for a brief time. This combination of more intense rainfall events and increased wildfire risk is more likely under projected climate change conditions.

The warmer temperatures could lead to increased taste and odor events triggered by algal blooms, which are characterized by water quality changes such as increases in DO and DO saturation, pH, and TON, during the spring and summer. CLWA's two surface water treatment plants are designed to address taste and odor events through preozonation, although use of higher ozone dosages to control taste and odor events must also consider the need to control bromate formation (from the oxidation of bromide), which could increase due to greater bromide levels in the imported SWP water affected by climate change.

Regional Surface Waters

The primary Regional surface water is the Upper Santa Clara River and its tributaries, including Bouquet Creek. The Upper Santa Clara River is largely defined as ephemeral with highly variable flows, depending on precipitation levels. Water quality impacts to rivers due to climate change include increased temperature, more frequent heavy rainfall events, and longer periods of low natural stream flow due to decreased annual precipitation. A prior study of 43 rivers found that surface water temperatures increased 0.4 to 0.6°F for each 1°F rise in air temperature (Morrill, Bales, and Conklin 2005). Increased water temperature generally reduces dissolved oxygen and can promote algal blooms if nutrients are available in the source. The storm events can transport sediments and other pollutants along the river, while long periods of low flow can increase concentrations of pollutants from wastewater plant and non-point discharges. Increased wildfires may contribute to the turbidity events.

Key water quality considerations are nitrogen concentrations and chlorides in stretches of the river, both of which may be impacted by climate change. Nitrogen concentrations can be influenced by low stream flows and increased temperatures that may promote eutrophication.

Regional Groundwater

Any water quality impacts to groundwater sources due to climate change are expected to be indirect, primarily due to decreased recharge from lower precipitation and increased use of groundwater to make up loss of SWP imported water. Decreased recharge and increased groundwater pumping may allow concentrations of groundwater contaminants such as perchlorate and volatile organic compounds to increase, which may trigger additional treatment requirements and increase groundwater treatment costs.

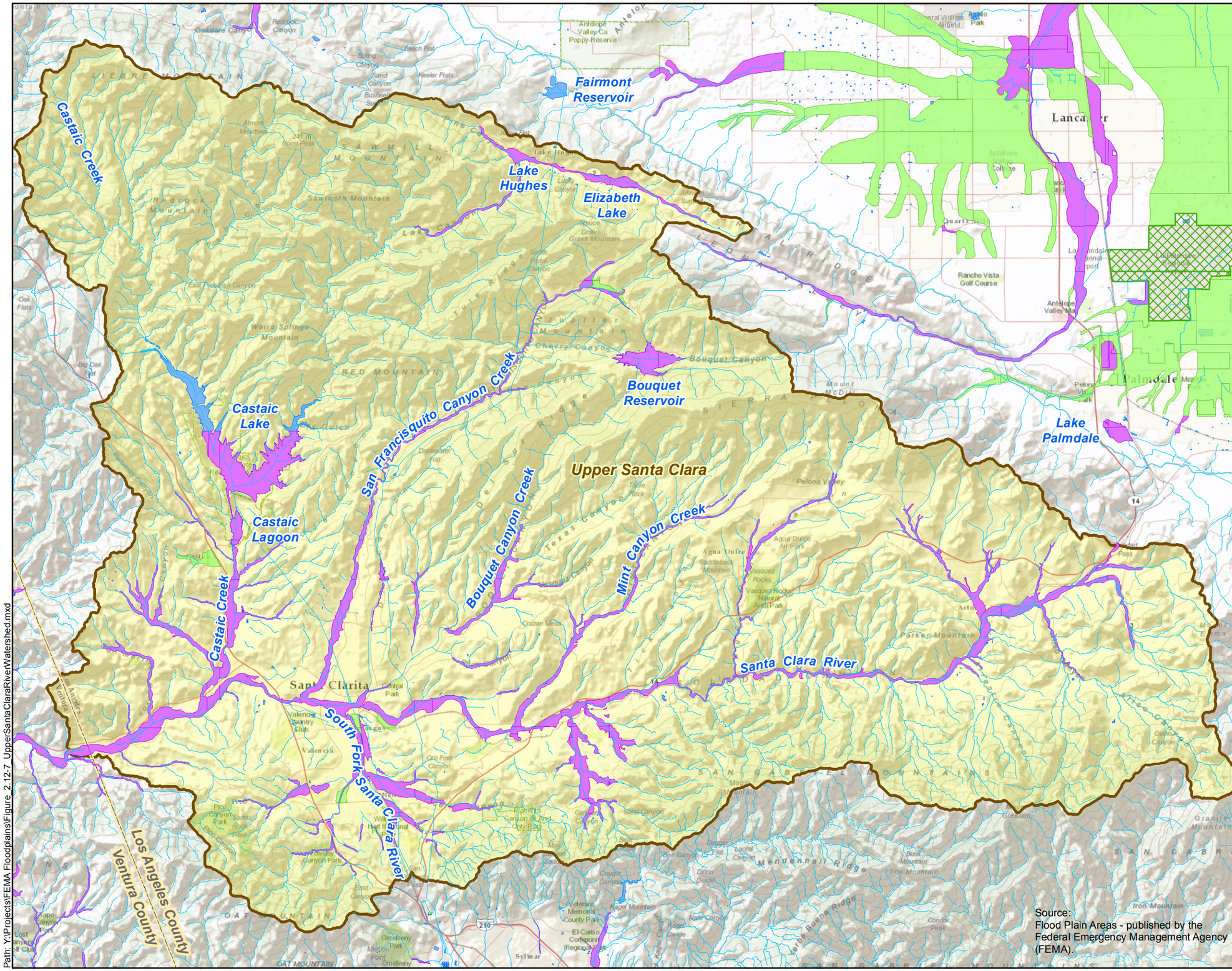
5.1.2.3.6 Flooding

Flooding is the most costly and destructive natural disaster; thus, a change in flood risk is a potential significant effect of climate change that could have great implications for the Region.

Figure 5.1-10 present the 100-year and 500-year floodplains within the Upper Santa Clara River Watershed, showing areas that would be most vulnerable to flooding, based on data available from FEMA. It should be noted that the 200-year floodplain maps were unavailable. In general, the floodplains are primarily located along the Santa Clara River and its major tributaries and correspond to surface water bodies such as Castaic Lake and Bouquet Reservoir. As expected, the 500-year floodplains appear in much smaller areas than the 100-year floodplains. In general, land use within the floodplains typically includes residential, commercial, industrial, and agricultural areas.

While the Cal-Adapt climate change model projects precipitation decrease of 10 percent by 2050 on the long-term basis, research data suggest that there is a risk of increased flooding in California (Kiparsky and Gleick 2005). Flooding depends not only on average precipitation but on the timing and intensity of precipitation. For the purpose of the assessment of future flooding from climate change, Cal-Adapt model results for runoff were used to make a general assessment for the likelihood of future flooding events in the Region. Cal-Adapt provides projections of monthly and annual runoff for the Santa Clarita region for the period 1950 to 2099, based on the four different models. Monthly runoff from the four climate change models were averaged to provide an estimate for the Region. Historical monthly averages were compared with future projections to provide an indication of future changes in runoff due to climate change.

Figure 5.1-11 shows results of the annual runoff for the historical period (1950 to 2000 base period) and projections (2000 through 2099), based on the average of results from the four different climate models under A2 emissions scenario. Overall, future runoff projections are slightly higher than historical trends. On the long-term average, monthly runoff is slightly higher for the future projections (0.26 inches/month from 2000 through 2050) than the historical period (0.24 inches/month for 1950-2000). Similarly, the maximum monthly runoff is also higher for future projections (7.32 inches//month) than historical data (4.62 inches/month). Future projections generally suggest the possibility of increased amount and intensity of runoff than historically observed, in addition to more variable runoff with climate change.



Legend

- 500-Year Flooding (Zone x500)
- 100-Year Flooding (Zone A)
- An area that is located within a community or county that is not mapped on any published FIRM.
- Upper Santa Clara Sub-Watershed
- Streams
- Water Body

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Kennedy/Jenks Consultants

CLWA IRWMP Grant Application
Los Angeles County, California

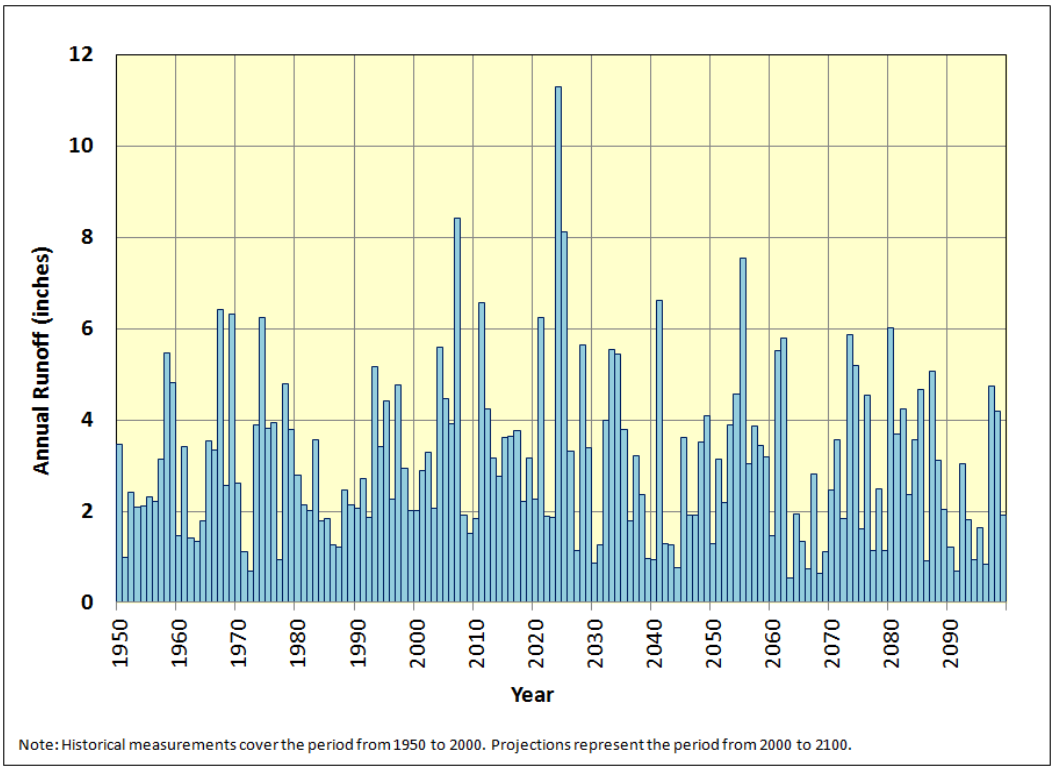
Upper Santa Clara River Sub-Watershed Flood Plain Areas

1189057*00
February 2012

Figure 5.1-10

Path: Y:\Projects\FEMA Floodplains\Figure_2.12-7_UpperSantaClaraRiverWatershed.mxd

FIGURE 5.1-11
HISTORICAL AND PROJECTED RUNOFF FOR SANTA CLARITA REGION



Source: Source data are based on Cal-Adapt website for the Santa Clarita area.

These projections are intended to provide general trends for future projections and are considered reasonable when compared to historical trends over a long-period of time. However, these are runoff estimates over large areas and considered relatively straightforward evaluations of changes in large scale precipitation patterns. The climate change model results may not capture the timing and intensity of runoff and the model resolution is insufficient to account for small-scale watershed characteristics that play a significant role in flooding events.

Historical runoff data used in the climate change models were analyzed for the periods of historical flooding events in the Region to demonstrate if Cal-Adapt model results are able to capture the site specific trends that occurred historically. As presented earlier (Section 4.1), major floods in the Region occurred during the winters of 1969 (January and February) and 1983 (in February and March). Historical runoff data from Cal-Adapt model are 0.68 inches/ month for January 1969 and 3.7 inches/month for February 1969, which are considerably higher than the long-term monthly average runoff of 0.24 inches/month. For the 1983 flood event, runoff of 1.8 inches/month for February and 0.76 inches/month for March predicted by Cal-Adapt are also much greater than the historical long-term averages. While the comparison was done for only limited flood occurrences, Cal-Adapt seems to generally respond to site conditions with anticipated runoff. Therefore, results from Cal-Adapt could be used as a general guidance for potential occurrence of future floods in the Region.

In some ways, risk of flood from climate change could be more problematic than for water supply. Water supply issues usually arise over a period of months to years, allowing time to respond to changes. In contrast, while large floods are relatively rare, they are swift and devastating if preparations are insufficient. There is no window to prepare for a flood once the flood waters arrive; floods must be addressed through advanced preparation and quick response in the course of an event. Greater flood risk should be considered when evaluating new development in the 500-year floodplain.

5.1.2.3.7 Ecological Health and Habitat

Ecosystem health and habitat protection are important to the Region. Increased temperature, changes in precipitation patterns, and increased wildfire risk projected for potential climate change scenarios are potential stressors to ecosystems and habitat in the Region.

Principal features in the Region include the Upper Santa Clara River and several canyons that provide complex topography that support diverse ecosystems and habitat (see Section 2.4 for a detailed description of ecological processes and environmental resources in the Region). These include at least 26 special status plant species, 45 special status wildlife species, several significant habitats (native grasslands, forests, fresh water marshes, vernal ponds, wetland habitat, and wildlife corridors), and five significant ecological areas (Cruzan Mesa Vernal Ponds SEA, Santa Clara River SEA, Santa Felicia SEA, Santa Susanna Mountains/Simi Hills SEA, and Valley Oak Savannah SEA). All of these species and habitats have acclimated to the historical climate and water resources and may or may not to adapt to potential changes due to future climate change.

Increased air temperature will increase water temperature in rivers, tributary streams, ponds, and lakes, with resulting decreases in DO. This combination may stress fish and biota that depend on higher DO levels and colder water which may impact their sustainability. The increased annual average air temperatures may also alter plant habitat by changing the length and timing of the growing season and/or allowing non-native species to outcompete native species and disrupt ecosystems that depend on the present habitats. Thus, measures to control non-native species may be needed to maintain habitats. Water available for plant habitat could be impacted by potential decreases in annual precipitation and increases in ET due to projected increases in temperature. Decreased precipitation could also directly affect formation of vernal ponds.

Fire is an important process in maintaining a diverse ecosystem in the Region. Projected increases in wildfire risk due to climate change are not well understood, but it appears that summer dryness could begin earlier and fires could burn longer and affect more land area. It is unclear at this time whether projected increased fire risk will be beneficial or harmful to long term ecosystem health and habitat maintenance, but will likely negatively impact water quality as discussed in Section 5.1.2.3.3.

5.1.2.4 Vulnerability Prioritization

This section discusses a list of prioritized vulnerabilities based on the vulnerability assessment presented in the earlier subsections. The watershed vulnerability assessment (Section 2.12.2.3) identifies the water resources characteristics for each sector most vulnerable to potential climate change projections. The Region can use the assessment results to prioritize the sectors with vulnerabilities and develop adaptive strategies to respond to potential climate change impacts. Based on the inputs from the stakeholders in the Region, the sector

vulnerability prioritization is defined as follows (1 being the sector most prioritized and 4 being the sector least prioritized with respect to climate change vulnerability):

1. Water Supply; Water Quality
2. Water Demand; Flooding
3. Ecosystem and Habitat
4. Sea Level Rise; Hydropower

Table 5.1-4 summarizes the climate change vulnerability based on the results of the vulnerability assessment.

With respect to climate change effects, the vulnerability prioritization is intended to identify if existing sectors can handle the impacts that would occur under future climate change, and to evaluate alternative water management options and projects. This also assists IRWMP's decision making process as part of proposed measures for adapting to climate change (see Section 5.1.3).

The vulnerability assessment and prioritization was conducted based on data currently available and inputs from the stakeholders involved in the preparation of this study for the Region. This assessment can be improved in the future with further data gathering and analyzing of the prioritized vulnerabilities.

5.1.3 Adaptation to Climate Change

Adaptation to climate change involves adjustments in natural and human systems that occur in response to projected impacts of climate change. The goal of adaptation is to minimize risks associated with anticipated impacts and take advantage of beneficial opportunities that may arise from climate change. Adaptation strategies are developed in conjunction with GHG mitigation strategies, which may overlap. For example, promoting water and energy efficiency are both GHG mitigation and climate change adaptation strategies. Adaptation strategies discussed in this section provide the Region with guidance related to projects that will enhance the Region's preparedness to plan and react to these potential impacts.

5.1.3.1 Statewide Adaptation Strategies for the Water Sector

The California Natural Resources Agency (CNRA), working through the Climate Action Team, is responsible for leading the effort to develop adaptation strategies for California. Strategies were published as a report to the Governor entitled *2009 California Climate Adaptation Strategy* (CNRA 2009) and will be updated approximately every two years. Specific adaptive water management strategies for the water sector were developed by DWR. The statewide adaptation strategies target fundamental improvements in water management systems and enhancements in ecosystem sustainability.

TABLE 5.1-4
CLIMATE CHANGE VULNERABILITY ASSESSMENT

Watershed Characteristics	General Overview of Vulnerabilities
Water Supply	**Potential Climate Change Vulnerability** – Climate change projections suggest continued highly variable annual precipitation with a slightly drier climate by mid-century. The overall impact on SWP imported water and groundwater supplies would be significant and can affect the long-term planning. **Sector Response in Context of Regional Planning** **SWP Imported Water** - SWP supply to the Region is projected to be impacted by climate change on a long-term basis, based on DWR's latest analysis of SWP delivery reliability with climate change effects. Based on the future conditions with 2050 climate change, the long-term average SWP system-wide deliveries are projected to be reduced by 5%, from 62% of Table A amount without climate change to 57% of Table A amount with climate change. Assuming the Region's SWP supply would be proportional to SWP's system-wide supply reliability, this represents a reduction of 4,900 AFY, of CLWA's SWP Table A amount. While this appears to be a small impact and comprises a small portion of future water supply in the Region, it should be viewed in light of the cumulative effects of climate change on other water resources, such as the local groundwater availability. **Groundwater** – Natural recharge to the local groundwater aquifers is likely to be affected by projected changes in precipitation pattern and amount (a long-term reduction of about 10% by 2050), increased evaporative losses, and warmer and shorter winter seasons. The overall impact on groundwater resources could be significant. Reduced natural recharge would affect the amount of groundwater available in the long-term. Reductions in the SWP imported water imposed by climate change would lead to more reliance on local groundwater. With potential reduction in natural recharge to groundwater, groundwater can make up for a portion of reduced SWP supply. Future planned projects need to meet the water demand to accommodate the effects of climate change on water demand and water supplies. **IRWMP Objective Impacted** – Increase Water Supply **Performance Metric Development** – Performance metrics should be based on SWP delivery and groundwater operation range limitations and quantities of new supply development (reclaimed water, water baking, etc.).

Watershed Characteristics	General Overview of Vulnerabilities
Water Quality	**Potential Climate Change Vulnerability** – Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. **Sector Response in Context of Regional Planning** **SWP Imported Water** – SWP imported water stored in Castaic Lake is potentially vulnerable to water quality changes from climate change, mainly because of the vulnerability of SWP source water in the Delta, resulting from sea level rise and increased salinity of SWP water. Extreme storm events could also result in increased turbidity. Potential changes in the water quality of Castaic Lake could present challenges at the surface water treatment plants in the Region and may require modifications to treatment processes. **Regional Surface Water** – The Upper Santa Clara River and its tributaries are vulnerable to potential water quality impacts due to climate change as a result of increased temperature, more frequent heavy rainfall events, increased wildfire risk, and longer periods of low natural stream flow from decreased annual precipitation. Key water quality constituents of concern are nitrogen and chloride, in addition to reduced DO and increased algae growth, turbidity and sedimentation. **Regional Groundwater** – Groundwater aquifers in the Region are subject to indirect water quality impacts, primarily due to decreased natural recharge under future conditions of decreased precipitation and increased use of groundwater to make up for reduced SWP supply. Increased groundwater pumping may present challenges with the management of perchlorate in groundwater, leading to additional treatment or treatment cost. **IRWMP Objective Impacted** – Improve Water Quality **Performance Metric Development** – Performance metrics should be based on source water quality exceedances (e.g., consecutive days with turbidity exceeding a trigger value, frequency of algal blooms) and frequency of meeting water quality standards (e.g., chloride, nitrogen).

Watershed Characteristics	General Overview of Vulnerabilities
Water Demand	**Potential Climate Change Vulnerability** – Projected increase in average annual air temperature by mid-century and increased evaporative losses are expected to increase both urban and agricultural water demand. **Sector Response in Context of Regional Planning** **Urban Water Demand** – Water demand in the Region is affected by weather and shows large seasonal variations, with the largest water use in the summer months and the least in cooler months. Water demand is likely to increase in the Region as a result of projected increase in annual average air temperature due to climate change (about 4°F by 2050). However, water demand increase resulting from this projected temperature increase appears minor relative to other major factors, such as population growth and land use conversion from agriculture to urban. Urban outdoor landscape is expected to be impacted most from climate change, with temperature rise, increased evaporation losses with warmer temperature, and longer growing season. **Agricultural Water Demand –** Climate change is expected to increase agricultural demand, as a result of projected increased annual average temperature, increased evaporation losses with warmer temperature, and longer growing season. The Region's agricultural demand is projected to decrease over time as a result of land use conversion from agriculture to urban. Thus, any climate change effects on agricultural demand are likely to be outweighed by decrease in agricultural activities. **IRWMP Objective Impacted** – Reduce Water Demand **Performance Metric Development** – To be determined. It is unclear that sufficient information is available to develop a performance metric unless a correlation between air temperature and water demand for the Region can be developed (data gap).
Flooding	**Potential Climate Change Vulnerability** – Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms would occur. **Sector Response in Context of Regional Planning** The Region could be potentially subject to more frequent and intense storm events as a result of increased projected annual runoff with climate change. This could present larger areas susceptible to flooding and increase the risk of direct flood damage in the Region. **IRWMP Objective Impacted** – Promote Resource Stewardship. **Performance Metric Development** – Consider excluding placement of critical infrastructure within the 500 year (or 200 year, if defined) floodplain.

Watershed Characteristics	General Overview of Vulnerabilities
Ecosystem and Habitat	**Potential Climate Change Vulnerability** – Climate change projections of increasing annual average temperature suggest potential environmental stressors. **Sector Response in Context of Regional Planning** The Upper Santa Clara River and several canyons in the Region support diverse ecosystems and habitat that may need to adapt to potential changes due to future climate change. Increased air temperature, increased ET, decreased precipitation and resulting water temperature, in addition to decreased DO may impact the sustainable habitat of fish and biota. Increased air temperature, increased ET, and decreased precipitation may also change water available to plant habitat, resulting in habitat alteration. Increased risk of wildfire is projected, but the impact is unclear. **IRWMP Objective Impacted** – Promote Resource Stewardship **Performance Metric Development** – Consider use of metrics such as acres of habitat maintained.
Sea Level Rise	**Potential Climate Change Vulnerability** – Climate change projections used by DWR suggest sea level rise of one foot due to temperature increase by mid-century. **Sector Response in Context of Regional Planning** The Region is not directly subject to sea level rise. However, potential effects of sea level rise would affect SWP water supply conditions, mainly because of the potential for sea water intrusion to increase Delta salinities (see water quality above). **IRWMP Objectives Impacted** – Improve Water Quality **Performance Metric Development** – No performance metric is recommended because the climate change response will be undertaken by DWR.
Hydropower	**Potential Climate Change Vulnerability** – Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. **Sector Response in Context of Regional Planning** Currently, the Region does not produce hydropower; thus, climate change effects on hydropower are not likely to occur. However, DWR operates hydropower projects as part of the SWP and any decreases in hydropower production would result in higher energy costs to the Region. **IRWMP Objective Potentially Impacted** – Increase Water Supply **Performance Metric Development** – Performance metrics should be based on energy charges from DWR.

DWR developed the following 10 statewide adaptation strategies for the Water Management Sector:

- Strategy 1: Provide sustainable funding for statewide and integrated regional water management
- Strategy 2: Fully develop the potential of integrated regional water management
- Strategy 3: Aggressively increase water use efficiency
- Strategy 4: Practice and promote integrated flood management
- Strategy 5: Enhance and sustain ecosystems
- Strategy 6: Expand water storage and conjunctive management of surface and groundwater resources
- Strategy 7: Fix Delta water supply, quality, and ecosystem conditions
- Strategy 8: Preserve, upgrade and increase monitoring, data analysis and management
- Strategy 9: Plan for, and adapt to, sea-level rise
- Strategy 10: Identify and fund focused climate change impacts and adaptation research and analysis

These statewide strategies provide guidance specifically aimed at addressing the impacts of climate change. Some of DWR's strategies can be directly applied to Regional management strategies, while others are supportive of Regional efforts that are discussed in the following section.

5.1.3.2 Regional Adaptation Strategies

In this analysis, potential adaptation strategies have been grouped by watershed characteristics (or sector) and priorities developed in the climate change vulnerability analysis. This approach will allow the Regional Management Group and other stakeholders to incorporate climate change adaptation and GHG mitigation measures in projects developed and evaluated as part of the IRWMP process. While the focus of this discussion is adaptation, some of the adaptation strategies will overlap with and enhance GHG mitigation measures.

5.1.3.2.1 Vulnerability Priority 1 (Highest) Sectors: Water Supply and Water Quality

Water supply and water quality were identified as the highest priority sectors that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

5.1.3.2.2 Water Supply

Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century. The overall impact will include reductions in SWP imported water and greater reliance on groundwater supplies with the potential to affect long-term planning.

Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

- Expand water storage and conjunctive management of surface and groundwater resources.
- Reduce reliance on imported SWP water, which depends on the Sierra snowpack for water supply.
- Enhance use of recycled water for appropriate uses as a drought-proof water supply.
- Enhance practices of water exchanges and water banking outside the Region to supplement water supply.
- Encourage local agencies to develop and implement AB 3030 Groundwater Management Plans as a fundamental component of the IRWM plan.
- Develop plans for local agencies in the Region to monitor the elevation of their groundwater basins.
- Encourage cities and the county agencies in the Region to adopt local ordinances that protect the natural functioning of groundwater recharge areas.

5.1.3.2.3 Water Quality

Climate change projections suggest increased temperature and continued highly variable annual precipitation with slightly drier climate by mid-century that could degrade water quality.

Suggested Regional adaptation strategies to address potential water quality impacts include the following:

- Support DWR strategies that protect or enhance water quality delivered by the SWP.
- Consider coordination with DWR to improve water quality in Castaic Lake through lake aeration practices.
- Consider water quality improvements associated with water transfers and water banking on Regional water supply.
- Consider riparian forest projects that provide cooling for habitat (see Ecosystem Health and Habitat).
- Encourage projects that improve water quality of contaminated groundwater sources.
- Increase implementation of LID techniques to improve stormwater management
- Comply with NPDES permits to ensure water quality protection

5.1.3.2.4 Vulnerability Priority 2 (Second Highest) Sectors: Water Demand and Flooding

Water demand and flooding were identified as the second highest priority sectors that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

5.1.3.2.5 Water Demand

Climate change projections suggest increases in average annual air temperature by mid-century and increased evaporative losses are expected to increase both urban and agricultural water demand.

Suggested Regional adaptation strategies to address potential increases in water demand include the following:

- Aggressively increase water use efficiency
- Encourage agricultural users to adopt efficient water management practices
- Encourage landscape water users to adopt efficient water management practices

5.1.3.2.6 Flooding

Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms will occur.

Suggested Regional adaptation strategies to address potential increases in flood risk include:

- Improve emergency preparedness and response capacity in anticipation of potential increases in extreme events.
- Practice and promote integrated flood management among water and flood management agencies.
- Flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands
- Avoid significant new development in areas that cannot be adequately protected from flooding
- Encourage land use policies including low impact development (LID) that maintain or restore historical hydrological characteristics.

5.1.3.2.7 Vulnerability Level 3 (Third Highest) Sector: Ecosystem and Habitat

Ecosystem Health and Habitat was identified as the third highest priority sector category that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below.

Climate change projections of increasing annual average temperature suggest potential environmental stressors that may affect the sustainability of existing ecosystems and habitat.

Suggested Regional adaptation strategies to address potential Ecosystem Health and Habitat impacts include the following:

- Promote water resources management strategies that restore and enhance ecosystem services.
- Provide or enhance connected "migration corridors" for animals and plants to promote increased biodiversity and allow the plants and animals to move to more suitable habitats to avoid serious impacts and support increased biodiversity.
- Consider projects that provide seasonal aquatic habitat in streams and support corridors of native riparian forests that create shaded riverine and terrestrial habitat.

5.1.3.2.8 Vulnerability Priority 4 (Lowest) Sectors: Sea Level Rise and Hydropower

Sea level rise and hydropower were identified as the lowest priority sectors for the Region.

5.1.3.2.9 Sea Level Rise

Climate change projections used by DWR suggest sea level rise of one foot due to temperature increase by mid-century. Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

- Support DWR strategies that minimize the impact of sea level rise on salinity intrusion into the Delta and impact water quality deliveries in the SWP.
- Support DWR strategies for protecting levees in the Delta from the potential effects of projected sea level rise.

5.1.3.2.10 Hydropower

Climate change projections suggest continued highly variable annual precipitation with slightly drier climate by mid-century, affecting hydropower generation. Strategies to address potential reductions in hydropower generated by the SWP include the following:

- Support DWR strategies to maximize hydropower in SWP facilities that reduce energy charges to the Region.

5.1.4 Next Steps for Future IRWMP Updates

5.1.4.1 Data Improvement

The climate change assessment conducted in this Plan update is qualitative in some areas due to limited data, high level of uncertainty, and, in some cases, because impacts to a given sector are not expected to be severe. The intent of future data gathering is to address gaps in the current vulnerability assessment, to improve the understanding of climate change impacts and vulnerabilities, and to enable a more quantitative analyses. Recommended future data gathering efforts should include data that facilitate more quantitative analysis of the vulnerability, as described in the following sections. Data gathering efforts should be also be considered in the context of the current and proposed projects and funding available.

This section describes potential areas of future data gathering efforts for the priority sectors identified earlier. The recommendations focus on the top four priority sectors; namely, water supply, water quality, water demand, and flooding. The lower priority sectors include ecosystem health and habitat, sea level rise, and hydropower, which require a lesser degree of data collection. Climate change vulnerability of ecosystem health and habitat is difficult to quantify, and reliance on generalized studies will likely satisfy the Region's needs. As previously noted, sea level rise and hydropower vulnerabilities are not directly applicable to the Region and are only indirectly important to the imported SWP water supply that is a responsibility of DWR. Thus, the Region should prioritize data gathering efforts for the sectors most vulnerable to climate change impacts.

5.1.4.1.1 Climate Change Models and Scenarios

Cal-Adapt modeling results for the Santa Clarita Region were used for projections of temperature, ET, precipitation, and runoff for the Region. The California Energy Commission maintains the Cal-Adapt site and will update the modeling tools as new climate change modeling results, based on more refined data, become available from the ICCC. Thus, the available climate change tools and projections for the Region should be reviewed periodically and the vulnerability assessment updated in future versions of the Plan.

5.1.4.1.2 Updates on Climate Change Research

Research on the climate change impacts on water resources is ongoing and continues to evolve with further analysis and more refined methodologies. During the preparation of this Plan update, key literature resources on climate change have been reviewed. New scientific findings should be reviewed periodically and incorporated into the climate change vulnerability assessment, especially the findings pertinent to the sectors most vulnerable to the climate change in the Region.

5.1.4.1.3 Vulnerability Assessment Update

As noted above, a goal of further data collection is to enable a more quantitative analysis of the high priority watershed sectors that are more vulnerable to climate change in future Plan updates. Water supply and water quality were identified as the highest priority sectors and water demand and flooding were identified as the second highest priority sectors that could potentially be impacted by climate change.

<u>Water Supply</u>

In this Plan update, the assessment of the vulnerability of water supply to potential climate change impacts is presented for the SWP imported water delivery to CLWA and groundwater pumping. As discussed earlier, climate change impacts on the SWP imported water supply were based on the future projections of SWP deliveries from DWR's modeling analysis reported in the *2011 Reliability Report* (DWR 2012). The assessment of groundwater supply vulnerability is based on existing and planned pumping and the current capacity of the water banking programs to respond to reductions in imported SWP water deliveries. Future assessment of water supply climate change vulnerability should incorporate the most up-to-date data available from DWR and the most current groundwater supply availability.

Suggestions for future data gathering efforts to quantify the climate change effects on water supply include the following:

- Update DWR SWP Delivery Reliability Report projections - DWR provides updated analysis and report every two years.

- Update available groundwater supply projections – Groundwater production in a given year varies depending on hydrologic conditions. Changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage and may affect current safe operating ranges. Updates on the groundwater safe operating ranges will be needed when further assessments of water supply vulnerability to climate change are performed for future Plan updates.

- Evaluate the effects of reduction in precipitation from climate change on the groundwater operational ranges - A simplifying assumption was used for a 10 percent reduction in the operational range in response to the 10 percent reduction in precipitation. Further analysis is suggested to refine this assumption and quantify the potential reduction in groundwater supply due to reduction in precipitation from climate change.

Water Quality

The assessment of the vulnerability of water quality to potential climate change impacts is qualitative due to the limited Regional monthly and seasonal weather information related to air temperature and precipitation over long time periods and limited access to long-term water quality data. The vulnerability assessment instead relied on Cal-Adapt model outputs for annual air temperature increases and precipitation changes and prior studies of how water quality in the Region may be affected by these climate change impacts. Key water quality changes identified for the Region include potential increases in taste and odor events due to increased likelihood of algal blooms and short-term high turbidity events due to storms, especially following wildfires. Collection of historical water quality data within the Region (e.g., Castaic Lake and other locations) would greatly improve the understanding of Regional water quality and how it may be impacted by climate change. For imported SWP water, the vulnerability analysis relied on DWR projections of water quality impacts in the Delta due to sea level rise and increases in salinity. Future analyses should incorporate updated DWR studies on the potential impacts of climate change on SWP quality.

Suggestions for future data gathering efforts to quantify the climate change effects on water quality include:

- Monitor and collect historical water quality data within the Region during storm events.

- Develop a long-term water quality record for Castaic Lake that would assist in improving the understanding of Regional water quality.

- Collect long-term weather records associated with air temperature, precipitation, and ET to assess potential correlations with seasonal water quality.

- Develop, to the extent possible, a long term surface/ground/aerial deposition model that can be continuously updated and refined with newly available data. Model should be ready accessible to stakeholders and in an user-friendly format to allow better understanding of trends over time.

Water Demand

The assessment of the effect of climate change on water demand is based on the Cal-Adapt projections for ET and temperature. Cal-Adapt projections suggest water demand in the Region is likely to increase as a result of higher temperature with the greatest temperature increase anticipated during dry months compared to wet months. The ten percent increase of water demand per capita has been assumed to account for dry years in the *2010 Santa Clarita Valley UWMP*, but historical records of annual water demand data currently available are not specific enough to quantify the effects from increasing temperature. As discussed earlier in the vulnerability assessment (Section 5.1.2), the most important effect of changing weather conditions is likely to be on agricultural demand, but the overall effects on agricultural water demand is uncertain.

Suggestions for future data gathering efforts to quantify the climate change effects on municipal and agricultural water demand include the following:

- Collect and analyze historical monthly records of water demand data for the Region to quantify the weather effects on water use and seasonal variations in response to changes in historical temperature.

- Collect and analyze historical monthly records of water demand data for each purveyor in the Region to demonstrate purveyor-specific patterns in response to changes in climate.

- Based on the water demand and temperature data, develop a regression analysis correlating water demand to temperature on a monthly or seasonal basis for the Region and each purveyor. The historical response can be used to infer future response with the projected changes in temperature with climate change.

- Characterize the variations in indoor and outdoor water use, both for the Region and each purveyor. Future data gathering should focus on the seasonal and monthly patterns both in indoor and outdoor usage to evaluate the effects of weather conditions on each use category.

- Collect and analyze historical agricultural water demand to quantity the weather effects on water use and seasonal variations in response to changes in historical temperature.

- Identify the major industries in the Region that require cooling and/or process water. As water temperature increases, cooling water needs may also increase.

Flooding

A quantitative assessment of the potential impacts of climate change on flooding cannot be performed as climate projections are not sensitive enough to project short-term extreme events such as flooding. Rather, the 100-year and 500-year floodplains were used to define flooding risk zones that should be considered in location of water infrastructure. The Cal-Adapt model runoff outputs appear to represent the historical runoff record available. In examining the historical runoff record, there are data gaps as recording stations have started and stopped operation.

Suggestions for future data gathering efforts to address the potential climate change effects on flooding include the following:

- Perform an inventory of runoff monitoring stations in the Region to see if a more robust runoff record can be developed. Those data may allow an analysis of historical storm events correlated with precipitation events as well as annual precipitation to provide a better understanding of conditions that may lead to more extreme flooding conditions.

- Future work should focus on gathering the 200-year floodplain maps for the Region after DWR develops them. Currently, the 100-year and 500-year floodplain maps are available from FEMA.

- Coordinate with the Region stakeholders for advanced flood preparation and quick response and document the protocol(s).

- Perform an inventory of critical infrastructure located in floodplains, especially those that were impacted during the historical flood events in 1969 and 1983.

- Update the projections of runoff with climate change as updates from Cal-Adapt become available.

- Work with local flood plain managers and/or equivalent to determine areas of concern as information from FEMA evolves.

5.1.4.2 Future Actions – Create a GHG Baseline

To be accurate in the estimation of each agency's GHG emissions; an agency-specific comprehensive GHG inventory should be developed. The City of Santa Clarita Climate Action Plan recently completed this baseline for their general plan items, which could serve as a reference. A comprehensive inventory would use a well established protocol to calculate all of the GHG emissions created by each agency. It is recommended that each agency eventually conduct a GHG inventory, but in the absence of agency specific GHG inventories, gross GHG emissions can be calculated by developing agency-specific GHG intensity factors. An agency-specific GHG intensity factor calculates the estimated metric tons of CO_2 per acre foot of water delivered or million gallons of wastewater treated by the agency (MT CO_2/AF). Knowing this will enable an estimation of the GHG emission baseline for a particular agency and the Region. It will also allow for the estimation of the GHG emission reductions associated with an individual project or strategy that reduces water demand.

For each of the RWMG water or wastewater entities data will need to be collected for actual annual electricity, natural and fleet fuel used, as well as the amount of imported water from DWR and other suppliers. Using known GHG intensity factors for DWR water supplies, electrical supplies, natural gas and fleet fuel and applying these factors to the amount an agency uses, GHG emissions (MT CO_2/year) can be estimated for each agency. By dividing the total emissions by the total AF of water delivered or the million gallons of wastewater treated, agency-specific GHG intensity factors (MT CO_2/AF) can be developed. The calculation should use data from the same year. While not as precise and accurate as a comprehensive GHG inventory, a GHG intensity factor will create an estimated baseline of GHG emissions for each agency and the Region.

5.1.4.3 Future Actions – Quantify Adaption and Mitigation Strategies at the Project Level

As part of this Plan update, the climate change impacts of specific projects proposed for implementation are being considered (see Section 8). Future Plan updates may have the data available to further quantify climate change adaptation and mitigation strategies and apply them at the project level. For each proposed project it may be desirable to identify GHG emissions and to identify and evaluate GHG mitigation. Proposed projects could be evaluated against the GHG Baseline and evaluated for their ability to reduce agency-specific GHG intensity factors.

5.1.4.4 Future Actions – Develop Performance Metrics

As part of future Plan updates the Region may choose to develop performance metrics specific to water and wastewater projects and climate change. Proposed IRWMP projects would be evaluated against these metrics and these metrics would provide a measure of Plan performance. Table 5.1-4, shown above, provides a starting point for the development of performance metrics.