# 2014 Climate Change Monitoring and Response Plan

East Bay Municipal Utility District

EBMUD

September 2014

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# 1.0 Introduction

## 1.1 Background

Climate change is a growing threat to the entire planet, and water resources are arguably already one of the first significant areas to be impacted. Although the full impact of climate change has not been felt, the District must plan for climate change to ensure that it can continue to provide reliable, high quality water and wastewater services to its customers. In 2008, a climate change objective was added to the Long Term Water Supply Goal in the District's Strategic Plan to ensure the District plans for the impacts of climate change and mitigates its own impact on climate change.

The District's work on climate change is an interdepartmental effort led by the Operations and Maintenance Department. Staff from Water and Natural Resources, Wastewater, and the Office of General Manager led the creation and update of this plan. This plan provides a 2014 update to the Climate Change Monitoring and Response Plan prepared in July 2010.

## 1.2 Purpose

The purpose of this document is to help the District understand potential climate change threats and prepare adaptation strategies, and to guide mitigation of District greenhouse gas emissions that contribute to climate change.

The science of climate change is still developing; consequently, the District's work to address climate change will continue to evolve as the science of climate change is better understood, and the District will adapt to changes in the environment.

## 1.3 Accomplishments

The District is a leader in the water industry in addressing climate change and has made many significant accomplishments. These include:

- Analysis of climate change impacts on the District's water supply.
- Producing renewable energy from several sources including hydropower, photovoltaic (PV) and biogas cogeneration at the District's main wastewater treatment plant
- Installed 776 kilowatts of new PV at five District facilities.
- Continued participation in industry committees, conferences, and workshops on climate change including the Climate Ready Water Utility Working Group and the EPA's Climate Change Risk Assessment and Awareness Tool Working Group.
- Reducing potable water demand through water conservation and water loss control.
- Maintaining a 57 vehicle hybrid-electric sedan fleet.
- Two plug-in electric hybrid vehicles

## 1.4 Action Plan Overview

The District's overall climate change strategy is to develop a plan to inform the District's future water supply, water quality, and infrastructure planning, and support resilient, durable infrastructure investment decisions, and mitigate District greenhouse gas emissions that contribute to climate change. This strategy will be accomplished through the following objectives:

- Assess climate change science and develop scenarios that illustrate a range of impacts from key variables including temperate rise, sea level rise, precipitation, snow pack and runoff

- Use the scenarios to identify critical infrastructure vulnerabilities and make cost-effective infrastructure investments adaptable to a range of foreseeable conditions (i.e., "no regrets" investments)
- Account for operational and infrastructure greenhouse gas emissions and participate in carbon credit generating programs
- Encourage and promote the cost-effective use and generation of renewable energy within the District's water and wastewater system operations consistent with District Policies 7.05 (Sustainability) and 7.07 (Energy).
- Educate policymakers on District and industry climate change concerns and interests, and advocate for reasonable legislation and regulatory changes
- Inform the public how the District is affected by and responding to climate change

## 1.5 Recommendations

The District continues to invest in climate change research, risk assessment, education and mitigation. The Climate Change Committee recommends the District focus on the following areas over the next two years:

- Incorporate climate change considerations into all level one (primary) and level two (sub-element) master plans. This includes, but is not limited to, identifying GHGs resulting from project construction and operations, and evaluating potential impacts of climate change when assessing facility sizing, location, operational flexibility, water quality, and water supply diversification.
- Complete the District's 2014 greenhouse gas emissions inventory.
- Investigate new renewable energy projects consistent with Policy 7.07 on renewable energy.
- Update the energy management strategy and publish an annual report on energy use and generation at the District.
- Compile key internal studies and memos on climate change
- Continue to monitor key parameters in our watersheds and around the state including temperature, precipitation, snow-covered area and runoff.
- Identify operational efficiencies and land-use practice changes to mitigate District emissions.
- Monitor, review, and, where warranted, actively participate in shaping legislation and proposed rules on climate change (Section 5).
- Review and update EBMUD's website information about climate change regularly.
- Inform the public on the District's response to climate change.
- Identify planned capital projects that would help the District respond to climate change.
- Participation on the EPA's Climate Resilience Evaluation and Awareness Working Group.
- Continue to participate in climate change activities at the national level to help guide the climate change research and policies related to the water and wastewater industry.

# 2.0 Science and Assessment

Information in this section is based on the findings in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), the 2014 US National Climate Assessment Report, the 2012 Third Assessment from the California Climate Change Center and other studies as noted in this report. Climate models have significantly improved since the Fourth Assessment Report (AR4). Models better reproduce observed continental-scale surface temperature patterns and trends over many decades and include the more rapid warming since the mid-20$^{th}$ century and the cooling immediately following large volcanic eruptions.

## 2.1 Observed Changes in the Climate System

Below is a summary of the observed changes in climate from the IPCC AR5. The observations are based on direct measurements and remote sensing from satellites and other platforms.

- Warming of the climate system is unequivocal and many of the observed changes since the 1950s are unprecedented over decades to millennia.
- Each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850.
- Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent.
- The rate of sea level rise since the mid-19$^{th}$ century has been larger than the mean rate during the previous two millennia.
- The largest contribution to total radiative forcing (the difference between the energy absorbed by the earth and the energy radiated back to space) is caused by the increase in the atmospheric concentration of $CO_2$ since 1750.
- The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. Carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification.

Below is a summary of the findings from the 2014 US National Climate Assessment Report.

- Global climate change is apparent across the United States and the warming in the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.
- Some extreme weather and climate events have increased in recent decades, and evidence confirms that some of these increases are related to human activities.
- Human-induced climate change will accelerate significantly if global emissions of heat-trapping gases continue to increase.
- Water quality and water supply reliability are jeopardized by climate change.
- The capacity of ecosystems to buffer the impacts of extreme events like fires, floods and severe storms is being overwhelmed.
- Current adaptation and mitigation efforts are insufficient to avoid increasingly negative social, environmental and economic consequences.

. . .

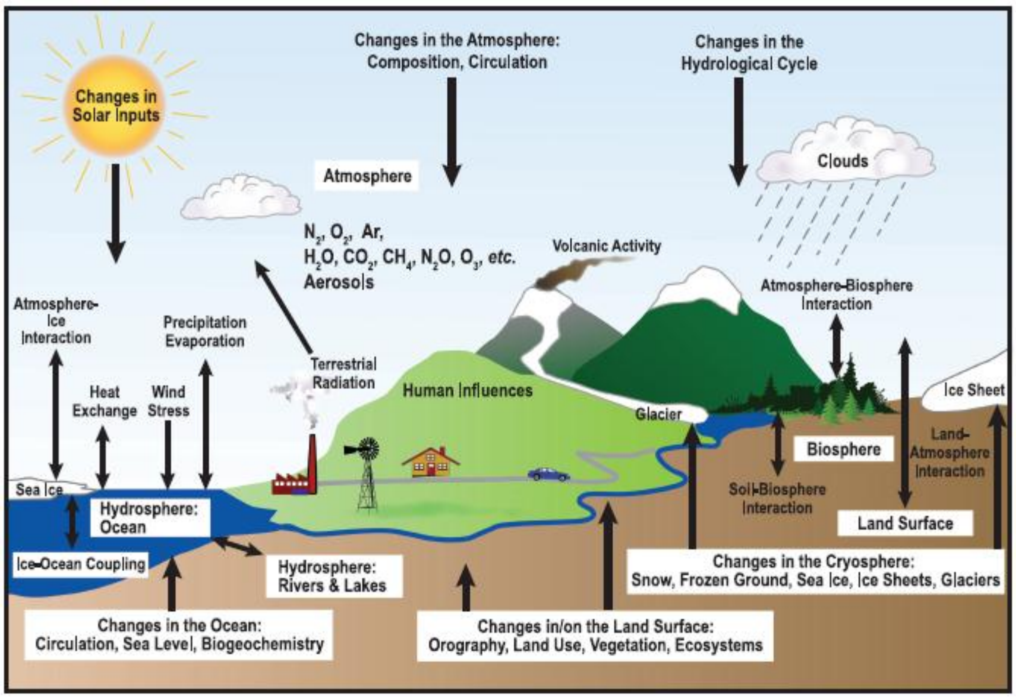
## 2.3 Relationship Between Climate Change and Weather

Chapter 1 of the IPCC AR4 provides a good description of the relationship between climate and weather. An excerpt from the chapter is summarized below.

*Climate is generally defined as average weather. Observations can show that there have been changes in weather, and it is the statistics of changes in weather over time that identifies climate change. A common confusion between weather and climate arises when people ask how climate can be predicted 50 years from now when we cannot predict the weather the next week. The chaotic nature of weather makes it unpredictable beyond a few days. Projecting changes in weather (i.e., long-term average weather) due to changes in atmospheric composition is a more manageable issue. As an analogy, it is impossible to predict the age at which any particular man will die; however, we can say with high confidence that the average age of death for men in industrialized countries is about 75 years.*

Figure 2.1 shows the components of the climate system, their processes and interactions.

**Figure 2.1:** Components of the Climate System[i]




## 2.1 Human and Natural Drivers of Climate Change

### CLIMATE CHANGE SCENARIOS

AR5 defined a set of four new scenarios called Representative Concentration Pathways (RCPs), which are identified by their approximate total radiative forcing in the year 2100 relative to 1750. These scenarios differ from the Special Report on Emissions Scenarios (SRES) scenarios used in the previous IPCC report.

The AR5 climate projections are based on a number of General Circulation Models (GCM) and RCPs (identified as RCP2.6, FCP4.5, RCP6 and RCP8.5). Each RCP provides spatially resolved data sets of land use change and sector-based emissions of air pollutants, and it specifies annual greenhouse gas (GHG) concentrations and anthropogenic emissions up to 2100. RCPs are based on a combination of integrated assessment models, simple climate models, atmospheric chemistry and global carbon cycle models. RCPs do not cover the full range of emissions in the literature, particularly for aerosols. The RCPs are described in Table 2.1 below.

**TABLE 2.1:** GHG Emissions Scenarios[ii]

| Scenario | Description |
|---|---|
| RCP2.6 | Very low forcing level. Radiative forcing peaks and declines by the year 2100. |
| RCP4.5 | Stabilizing forcing level. Radiative forcing stabilizes by the year 2100. |
| RCP6 | Stabilizing forcing level. Radiative forcing does not peak by the year 2100. |
| RCP8.5 | Very high GHG level. Radiative forcing does not peak by the year 2100. |

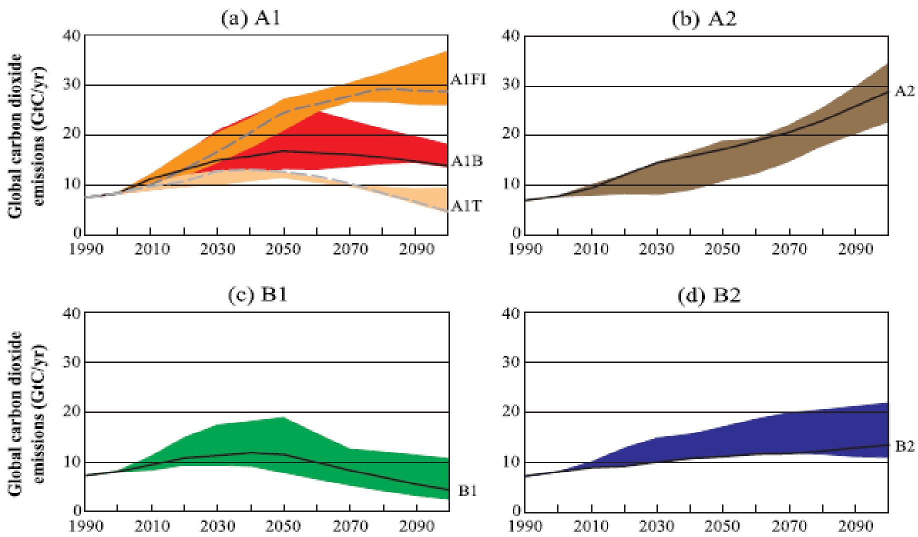
In 2000, the IPCC also prepared a report, “Special Report Emissions Scenarios”, which defined future emissions scenarios that are also used in other reports (Table 2.2). The SRES scenarios were developed to represent the range of driving forces and emissions to reflect the current understanding and knowledge about the uncertainties in future climate change emission scenarios.

**Table 2.2**: Special Report on Emission Scenarios Descriptions[iii]

| Scenario | Description |
|---|---|
| **A1** | A world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies |
| **A1fi** | Technology change is fossil-intensive |
| **A1t** | Non-fossil energy sources |
| **A1b** | Balance of fossil and non-fossil intensive |
| **A2** | Very heterogeneous world with high population growth, slow economic development and slow technological change |
| **B1** | A convergent world with the same global population as A1, but more rapid changes in economic structures toward a service and information economy |
| **B2** | A world with intermediate population and economic growth, emphasizing local solutions to economic, social and environmental sustainability |

Figure 2.2 shows each of the six emission scenarios from the IPCC SRES report. The A1fi and A2 scenarios are the most pessimistic and the A1t and B1 scenarios are the most optimistic.

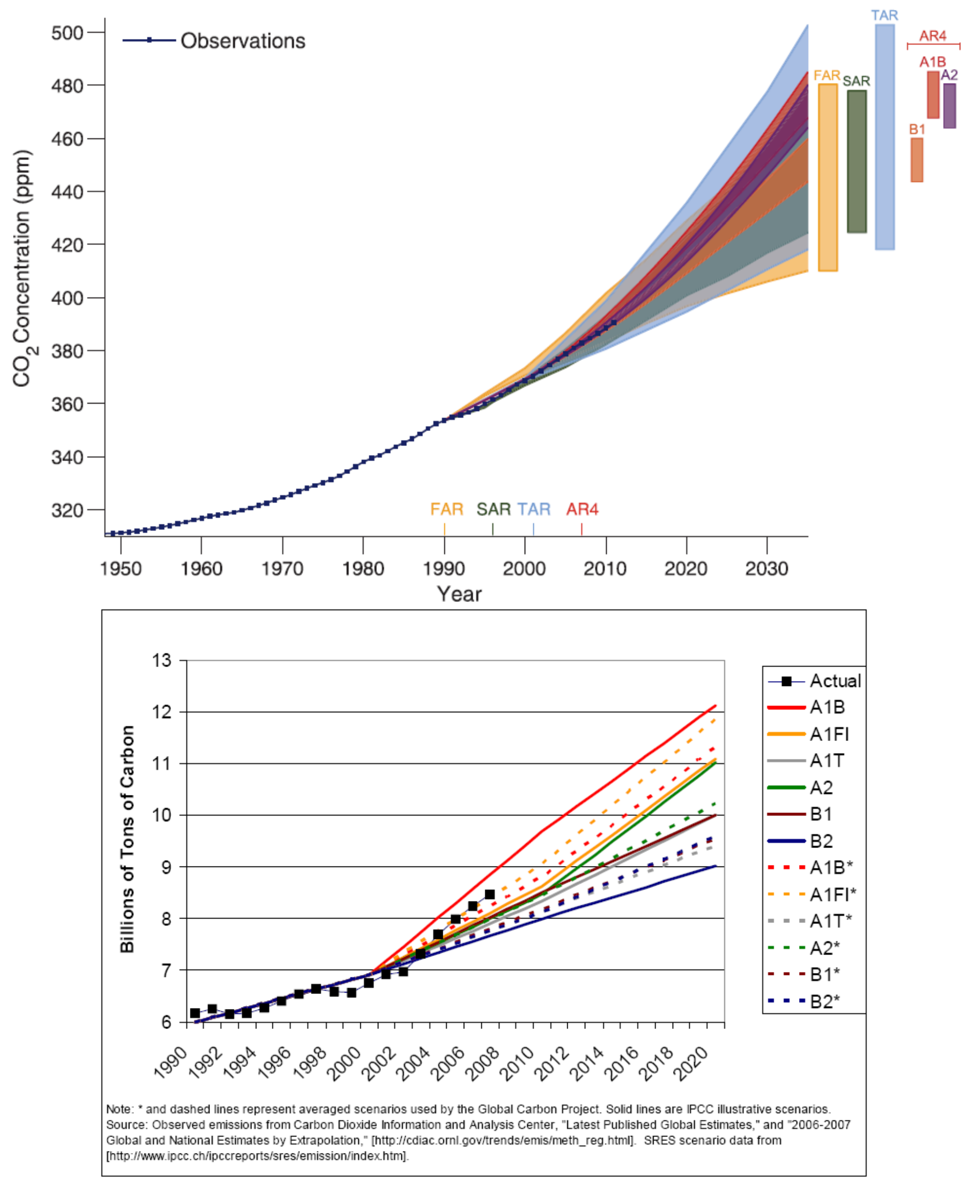
**Figure 2.2**: Total Global Annual $CO_2$ Emissions Scenarios

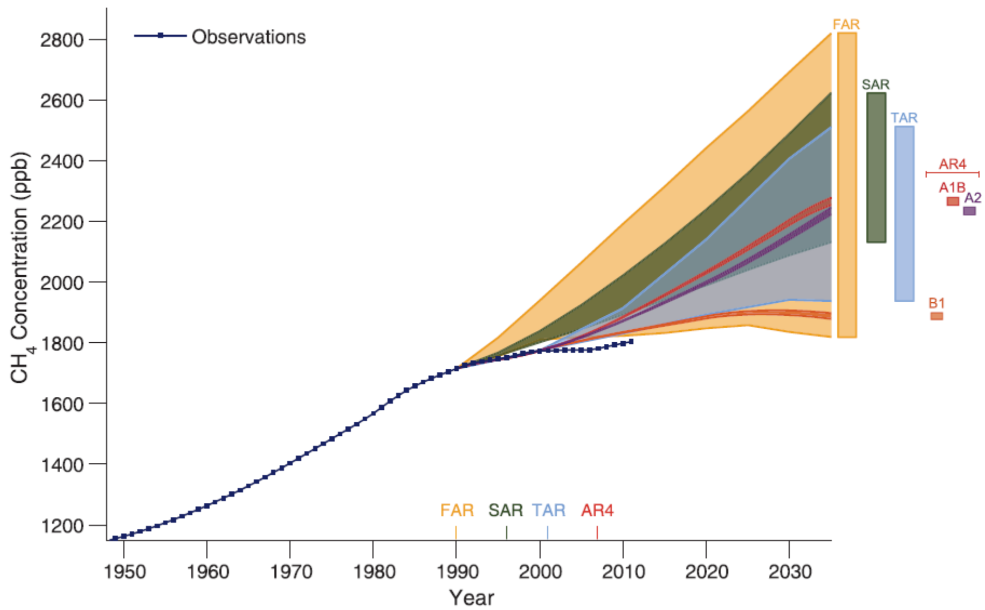


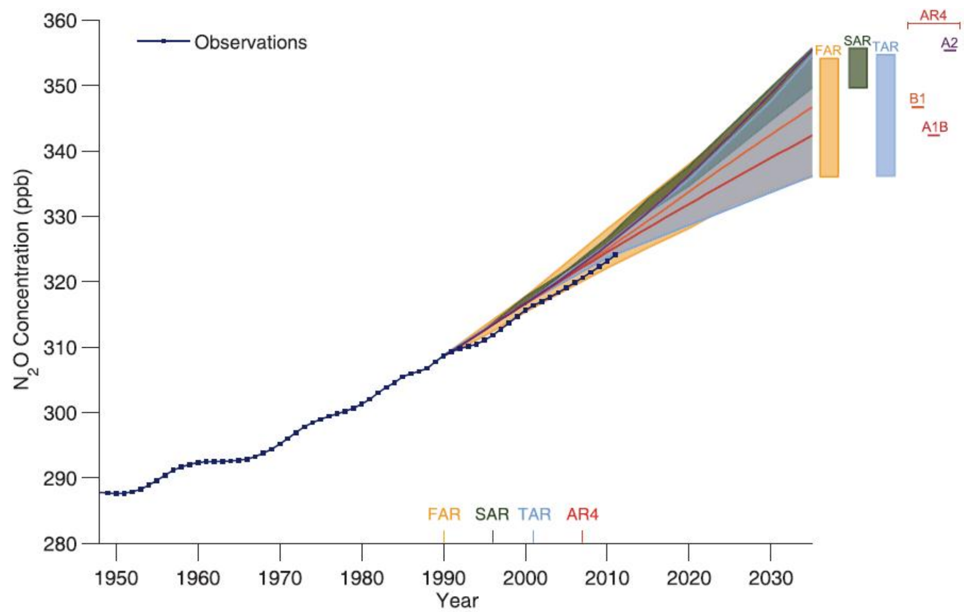

The RCPs represent a range of 21st century climate policies, as compared with the no-climate policy of the SRES scenarios used in the Third and Fourth Assessment Reports. The overall spread of projections for the high RCPs is narrower than for comparable scenarios used in AR4 because in contrast to the SRES emissions scenarios used in AR4, the RCPs are defined as concentration pathways and thus carbon cycle uncertainties affecting atmospheric $CO_2$ concentrations are not considered in the Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations. Projections of sea level rise are larger than in the AR4, primarily because of improved modeling of land-ice contributions.

The AR5 RCPs are the basis for the temperature, precipitation, and sea level rise projection ranges used in this Monitoring and Response Plan. Figure 2.3 shows the observed globally and annually averaged $CO_2$ concentrations since 1950 compared with projections from previous IPCC assessments.

**Figure 2.3**: Comparison of Actual Emissions with Projections from Previous IPCC Assessments






**ATMOSPHERIC GHG CONCENTRATION AND RADIATIVE FORCING COMPONENTS**

Natural and anthropogenic processes that alter the Earth's energy budget are drivers of climate change. Radiative forcing (RF) quantifies the change in energy fluxes caused by changes in these drivers. A positive RF leads to surface warming and a negative RF leads to surface cooling. The AR5 report reported that the total RF is positive, and the largest contributor to the total RF is the increase in the atmospheric concentration of $CO_2$ since 1750.

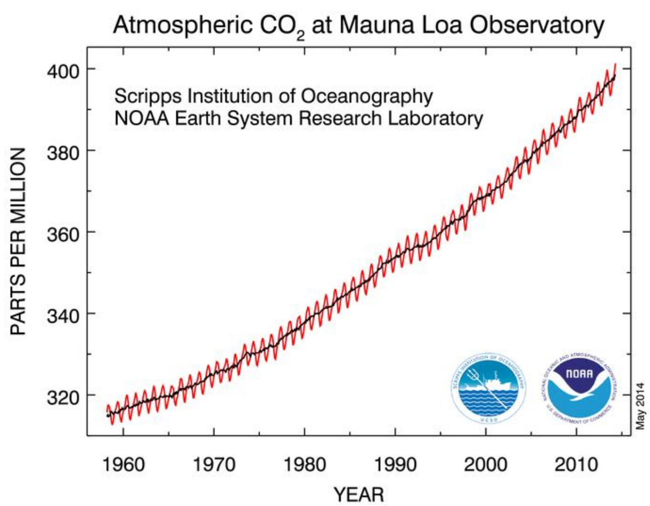
The AR5 report concluded that global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years, and that carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The following is a summary of the carbon and other biogeochemical cycles from the AR5 report.[iv]

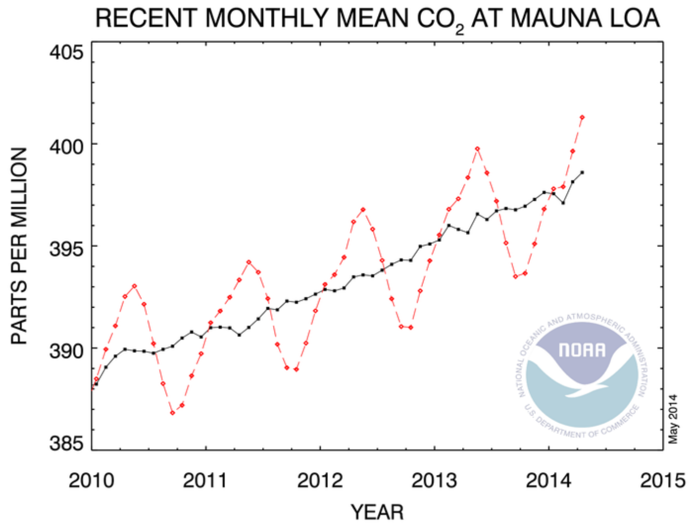
- Atmospheric concentrations of $CO_2$, methane ($CH_4$) and nitrous oxide ($N_2O$) have all increased since 1750 due to human activity. In 2011, the concentrations of these GHGs were 391 ppm, 1803 ppb and 324 ppb, and exceeded the pre-industrial levels by about 40%, 150% and 20%, respectively.
- Concentrations of $CO_2$, $CH_4$ and $N_2O$ now substantially exceed the highest concentrations recorded in ice cores during the past 800,000 years, and the mean rates of increase in atmospheric concentrations over the past century are, with very high confidence, unprecedented in the last 22,000 years.

In addition to GHGs, there are a number of other anthropogenic sources that contribute to radiative forcing including ozone, stratospheric water vapor, and surface albedo (surface reflection). Natural factors include solar irradiance and volcanic aerosols.

In April 2014, the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Lab reported that $CO_2$ levels exceeded 400 ppm in April for the first time in at least 800,000 years. The top graph in Figure 2.4 shows the atmospheric $CO_2$ levels at the Mauna Loa Observatory since the 1950's, and the bottom graph shows the monthly mean $CO_2$ levels at the Mauna Loa Observatory since 2010 (including the latest April 2014 reading over 400 ppm).

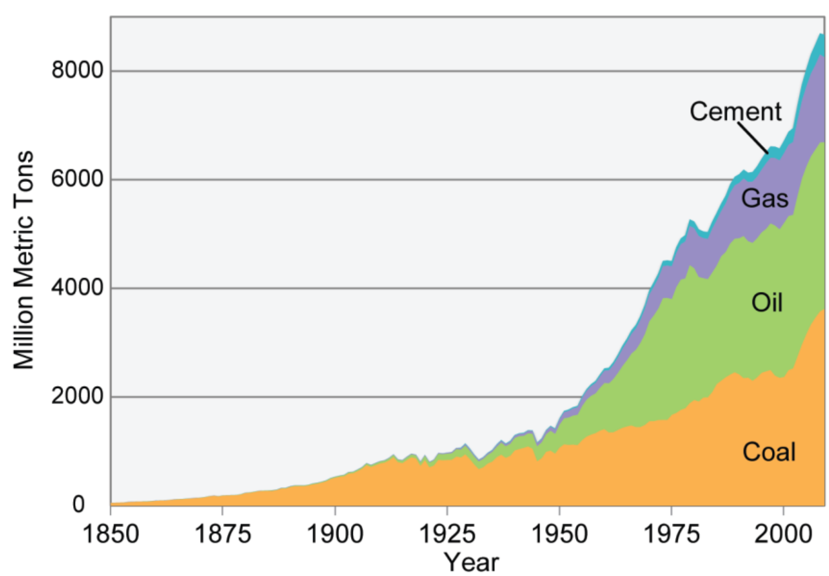
**FIGURE 2.4:** Atmospheric $CO_2$ at Mauna Loa Observatory (NOAA 2014)[v]






Past climate change was driven exclusively by natural factors such as volcanic eruptions, changes in energy from the sun, periodic variations in the Earth's orbit natural cycles that transfer heat between the ocean and the atmosphere, and slowly changing natural variations in heat-trapping gases in the atmosphere. [vi] The 2014 National Climate Assessment report noted that carbon emissions from burning coal, oil and gas, and producing cement accounted for 80% of the total emissions of carbon from human activities; land use changes (like cutting down forests) accounted for the other 20%. Figure 2.5 shows the carbon emissions from coal, oil gas and cement production since the 1850's.

**FIGURE 2.5:** Carbon Emissions in the Industrial Age[vii]




## 2.2 Observations of Recent Climate Change

The AR5 report concluded the warming of the climate is "unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia."

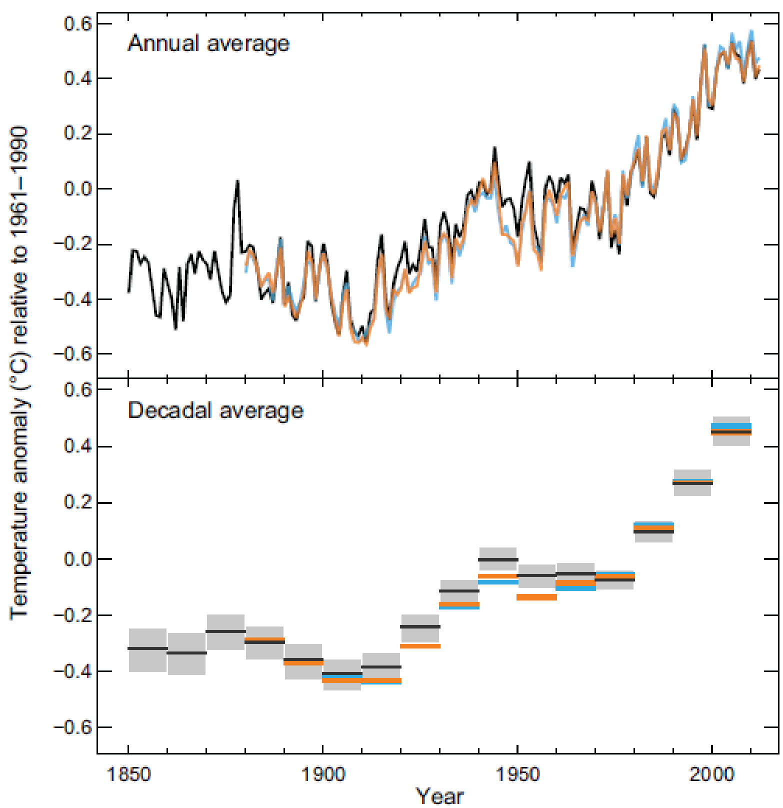
**TEMPERATURE AND PRECIPITATION**

Statewide average temperatures increased by about 1.7°F from 1895 to 2011, and warming has been greatest in the Sierra Nevada.[viii] The warmer temperatures and longer dry seasons over the last few decades have resulted in more severe and frequent wildfires. Some of the findings from the AR5 report are listed below.

- It is certain that global mean surface temperature has increased since the late 19th century. Each of the past three decades has been successively warmer at the Earth's surface than all the previous decades in the instrumental record, and the first decade of the 21st century has been the warmest.
- In the Northern Hemisphere, 1983-2012 was likely the warmest 30-year period of the last 1400 years.
- The globally averaged combined land and ocean surface temperature data shows a warming of 0.85°C over the period 1880 to 2012.
- It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on a global scale.
- Confidence in precipitation change averaged over global land areas since 1901 is low prior to 1951 and medium afterwards. Averaged over the mid-latitude land areas of the Northern Hemisphere, precipitation has increased since 1901.
- Changes in many extreme weather and climate events have been observed since about 1950. The frequency or intensity of heavy precipitation events has likely increased in North America.

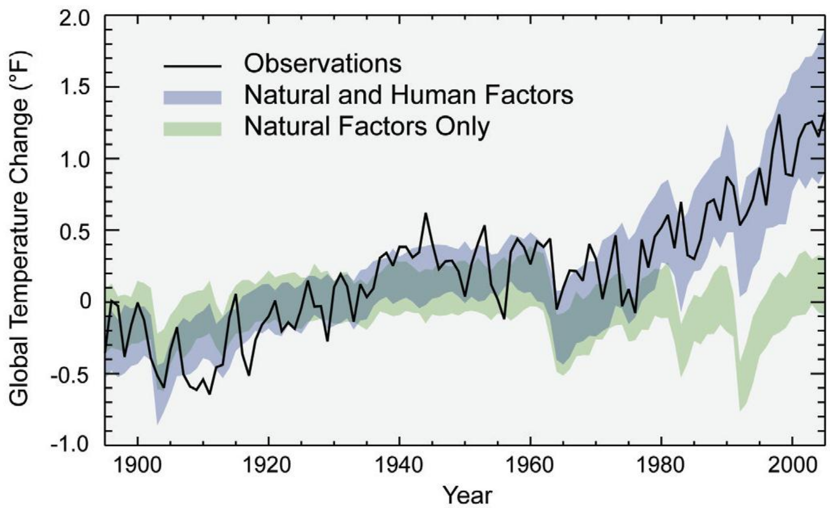
Figure 2.6 below from the AR5 report illustrates the observed increase in the globally averaged land and ocean temperature from 1850 to 2012.

**FIGURE 2.6**: Observed Globally Average combined Land/Ocean Surface Temperature 1850-2012[ix]



Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations. In fact, models show the increase in temperature across the globe over the land and in the ocean can primarily be attributed to anthropogenic forcings. Natural forcings alone cannot account for the observed increase in temperature.[x] Figure 2.7, from the 2014 US National Climate Assessment report, shows the observed and modeled global temperature change from 1900 to the present and separates natural and human factors driving the change.

**Figure 2.7**: Separating Human and Natural Influences on Climate[xi]




**RUNOFF**

The increased temperature has affected the snow water content and the spring runoff in the Western states. Some of the findings from the AR5 report are listed below.

- Mountain glaciers and snow cover on average have declined in both hemispheres
- There is high confidence some hydrological systems have been affected through increased runoff, earlier spring runoff and earlier spring peak discharge in many glacier-fed and snow-fed rivers and through effects on thermal structure and water quality of warming rivers and lakes

Spring runoff over the last century has decreased as shown in Figure 2.8. The figure shows the fraction of spring runoff in eight major rivers in the western Sierra Nevada (as a fraction of the water year total) has decreased approximately 10 percent over the last century.

**FIGURE 2.8**: April to July Spring Runoff as a Fraction of Water Year Total[xii]

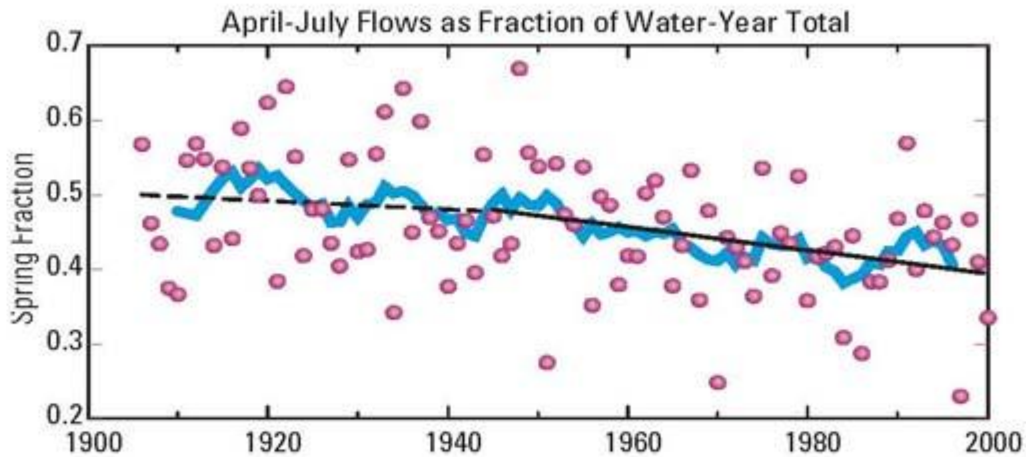
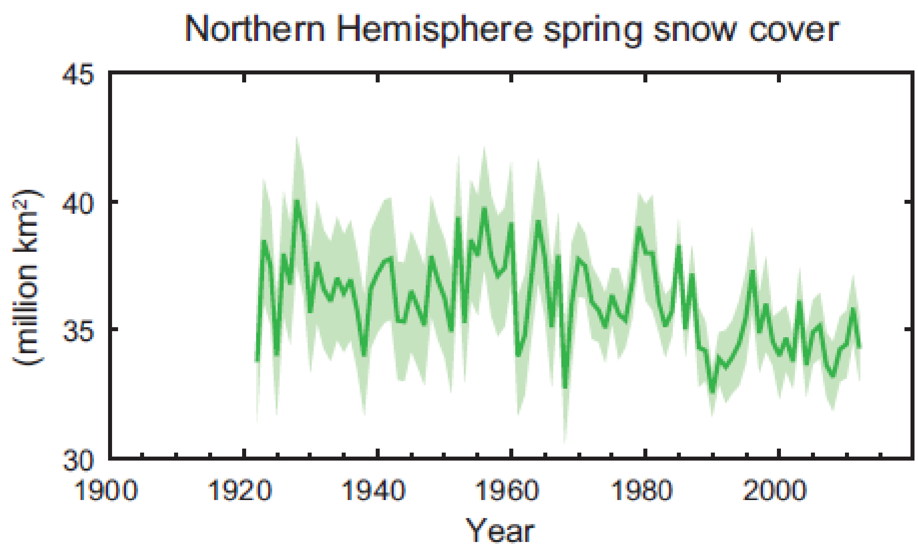



Figure 2.9 shows the change in the northern hemisphere spring snow cover from the AR5.

**FIGURE 2.9**: Northern Hemisphere Spring Snow Cover[xiii]




**SEA LEVEL RISE**

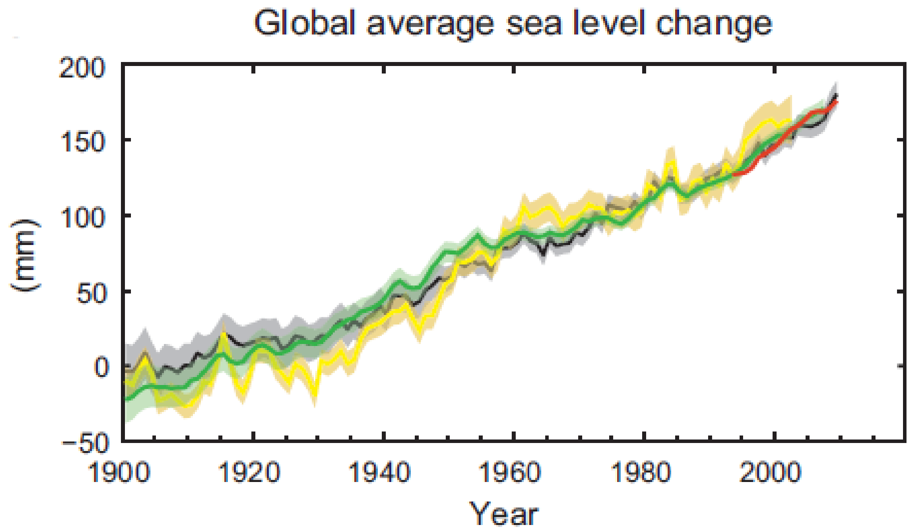
Sea level rise has also accelerated due to a number of factors including glacier mass loss and ocean thermal expansion. Some of the findings in AR5 report are listed below.

- Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass.
- The mean rate of global averaged sea level rise was 1.7 mm per year between 1901 and 2010, 2.0 mm per year between 1971 and 2010 and 3.2 mm per year between 1993 and 2010.
- The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia.

- There is very high confidence that maximum global mean sea level during the last interglacial period (129,000 to 116,000 years ago) was at least 5 meters higher than present, and there is high confidence that it did not exceed 10 meters above present.

Figure 2.10 shows the global average sea level change since 1900 (from the AR5 report).

**FIGURE 2.10**: Global Average Sea Level Change




## 2.3 Projections of Future Climate Change

The science of climate change is continuing to evolve and there are challenges in applying the projections to determine the impact to water utilities. These challenges include the difficulty in downscaling the GCMs to project regional effects, unknown future emission conditions and unknown future water demands. In addition, there are uncertainties and biases with all of the GCMs, which add to the challenges of interpreting the data and incorporating the results into planning studies.

However, it is generally agreed that climate change will alter precipitation and temperature in the future (with greater confidence in projections for temperature than for precipitation), which will likely affect water supply and, water demand, and the way in which water is managed.

The potential impacts to the District include:

- Increased demands for outdoor water use
- Increased challenges in reservoir management (balancing water supply and flood control)
- Increased drought frequency, intensity, and duration
- Increased flooding resulting in infrastructure impacts
- Decreased snowpack
- Changes in the timing of the Mokelumne River spring runoff

**TEMPERATURE**

The AR5 report concluded that, “continued emissions of GHGs will cause further warming and changes in all components of the climate system.” Below is a summary from the AR5 report.

- The global mean surface temperature change for the period 2016 to 2035 relative to 1986 to 2005 will likely be in the range of 0.3°C to 0.7°C.

- Increase of global mean surface temperatures for 2081 to 2100 relative to 1986 to 2005 is projected to likely be 0.3oC to 1.7oC (RCP2.6), 1.1oc to 2.6oC (RCP4.5) and

The 2012 California report "Our Changing Climate" concluded the following.

- By 2050, California is projected to warm by approximately 2.7°F (1.5°C) above 2000 averages, and by 4.1°F to 8.6°F (2.8°C 4.8°C) to by the end of the century.
- By 2100, average temperatures could increase by 4.1°F to 8.6°F, depending on emissions levels
- Springtime warming, a critical influence on snowmelt, will be particularly pronounced.
- Summer temperatures will rise more than winter temperatures, and the increases will be greater in inland California, compared to the coast
- Heat waves will be more frequent, hotter, and longer. There will be fewer extremely cold nights.

Table 2.3 shows the estimated global average surface warming from the AR5 report for the periods 2046-2065 and 2081-2100 (relative to 1986-2005).

**TABLE 2.3**: Projected Global Mean Surface Temperature Warming

| Case | Best Estimate | |
|---|---|---|
| | **2046-2065 (°C)** | **2081-2100 (°C)** |
| RCP 2.6 | 0.4 to 1.6 | 0.3 to 1.7 |
| RCP 4.5 | 0.9 to 2.0 | 1.1 to 2.6 |
| RCP 6.0 | 0.8 to 1.8 | 1.4 to 3.1 |
| RCP 8.5 | 1.4 to 2.6 | 2.6 to 4.8 |

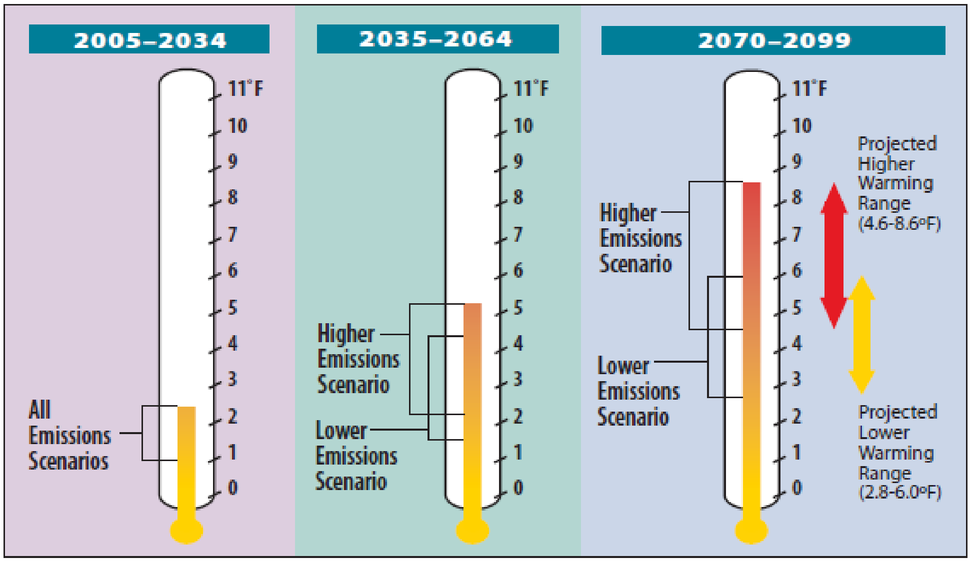
For the Western United States, average temperatures could rise 2 to 7.5°C by the end of the century depending on the emissions scenario by the end of the century, which is higher than the average global increase in surface temperature. Table 2.4 shows the projected warming (2090-2099 temperatures relative to 1980-1999) for Western North America.

**TABLE 2.4**: Projected Average Surface Warming for Western North America from 2090 to 2099[xiv]

| Low Emissions | Medium Emissions | High Emissions |
|---|---|---|
| Likely Range: 2-5°C | Likely Range: 3-7°C | Likely Range: 4-8°C |

Figure 2.11 from "Our Changing Climate" report projects temperatures to increase significantly this century. The California Climate Change Center concluded the following:[xv]

**Figure 2.11**: Projected Average Temperature in California



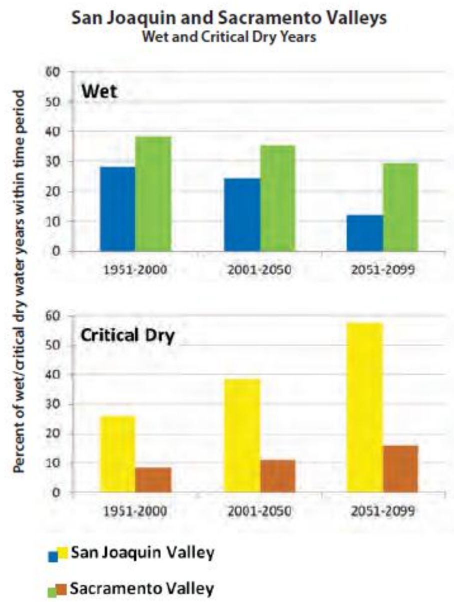

The AR5 report concluded that "changes in the global water cycle in response to the warming over the 21st century will not be uniform." . For North America there is a trend toward greater precipitation with the ensemble mean projecting a 20 percent increase. For Central California, however, there is a weak trend towards greater precipitation, and depending on the model possibly a decrease in precipitation.[xvi]

Some other findings from the AR5 report are summarized below.

- The high latitudes and the equatorial Pacific Ocean are likely to experience an increase in annual mean precipitation by the end of the century under the RCP8.5 scenario.
- Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will very likely become more intense and more frequent by the end of the century.
- There is high confidence that the El Nino-Southern Oscillation will remain the dominant mode of interannual variability in the tropical Pacific, with global effects in the 21st century.

Studies from the 2012 Our Changing Climate report found that by the latter half of the 21st century, critically dry years could occur substantially more often (8 percent more frequently in the Sacramento Valley and 32 percent more often in the San Joaquin Valley) compared to the historical period from 1951 to 2000. [xvii] Figure 2.12 shows the percent of wet/critically dry years through the end of the century.

**Figure 2.12**: Projection of Wet and Critically Dry Years[xviii]




## SEA LEVEL RISE

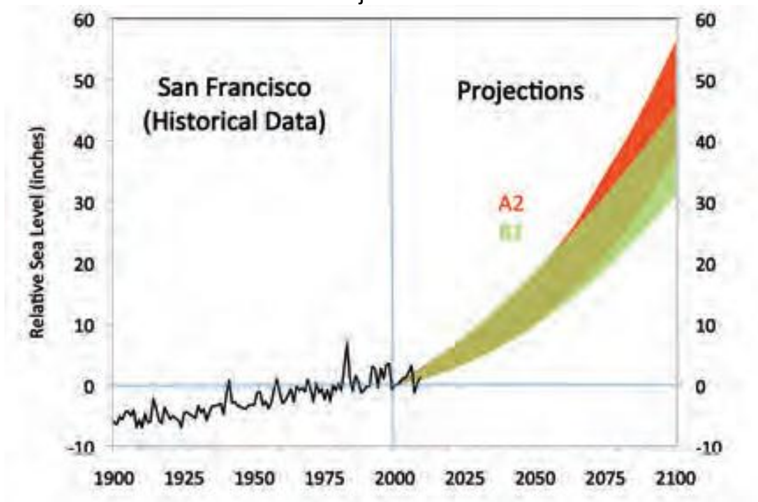
Global mean sea level will continue to rise during the 21st century. Under all emission scenarios, the rate of sea level rise will very likely exceed that observed during the 1971 to 2010 period due to increased ocean warming and increased loss of mass from glaciers and ice sheets. . Table 2.5 summarizes the projected sea level rise from the AR5 report.. The projections in the table exclude future rapid dynamical changes in ice flow and do not include the full effects of changes in ice sheet flow. The projections include a contribution due to increased ice flow from Greenland and Antarctica at rates observed from 1993 to 2003, but these rates could increase or decrease in the future. Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper-bound for sea level rise.

**TABLE 2.5**: Projected Sea Level Rise[xix]

| Case | Sea Level Rise (measured at 2090-2099 relative to 1980-1999) |
|---|---|
| Constant Year 2000 Concentrations | NA |
| RCP2.6 | 0.32 to 0.63 meters |
| RCP4.5 | 0.33 to 0.63 meters |
| RCP6.0 | 0.45 to 0.82 meters |
| RCP8.5 | 0.52 to 0.98 meters |

Sea level along California's coast has risen approximately 7 inches in the last century and is expected to accelerate in the future.[xx] In 2050, the sea level could be 10 to 18 inches higher than in 2000 and 31 to 55 inches higher by the end of the century. Figure 2.13 shows the projected sea level rise in the San Francisco Bay Area from the 2012 Our Changing Climate report.

**FIGURE 2.13**: Projected Sea Level Rise[xxi]




## APRIL 1 SNOW COVERED AREA

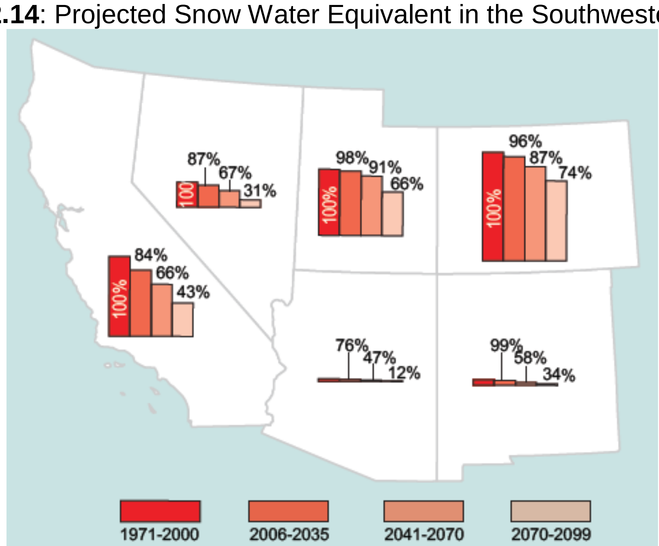
The California Department of Water Resources concluded for a 4°C rise in temperature, the April 1 snow-covered area in the Mokelumne Watershed could decrease to 26 percent (compared to the current April 1 snow-covered area of 50 percent) as shown in Table 2.6. This represents 52 percent reduction in the snow covered area when compared to the current April 1 snow covered area. This estimate is based on a projected rise of 500 feet in the snow level for every 1°C rise in temperature.

**TABLE 2.6:** Snow Covered Area Changes with Temperature (Mokelumne Basin)[xxii]

| Mean Elevation (feet) | Avg Apr 1 Snow line (feet) | Total Area (sq mi) | Snow Covered Area | 1°C Rise | 2°C Rise | 3°C Rise | 4°C Rise | 5°C Rise |
|---|---|---|---|---|---|---|---|---|
| 5030 | 5000 | 575 | 50% | 43% | 38% | 31% | 26% | 20% |

Figure 2.14 shows the projected snow water equivalent in the Southwest from the 2014 US National Climate Assessment report (assuming the A2 scenario). These declines are strongly correlated with early timing of the runoff and decreases in the total runoff.

**Figure 2.14**: Projected Snow Water Equivalent in the Southwestern US[xxiii]



## HEAT WAVE DURATION AND FREQENCY

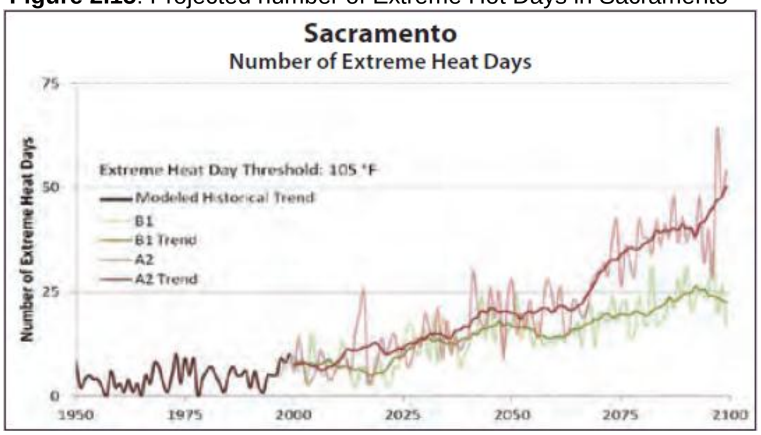
Heat waves, defined by the IPCC as at least five consecutive days with a maximum temperature higher than the average by at least 5°C, are projected to become more frequent. The AR4 report projected by the end of the 21st century, the heat wave durations for the Western United States could increase from approximately 5 days today to 85 days in the worse-case scenario by 2100.[xxiv] Table 2.6 summarizes the projected increase in heat wave duration for the Western United States.

**TABLE 2.6:** Heat Wave Duration

| Scenario | 2050 | 2100 |
|---|---|---|
| Low Emissions | 20 days | 40 days |
| Medium Emissions | 30 days | 70 days |
| High Emissions | 35 days | 85 days |

Figure 2.15 shows the projected number of extreme hot days in Sacramento, which are defined as days when the air temperature is at least 105°F. In this example, by the end of the century, the number of extreme heat days is double the historic average.

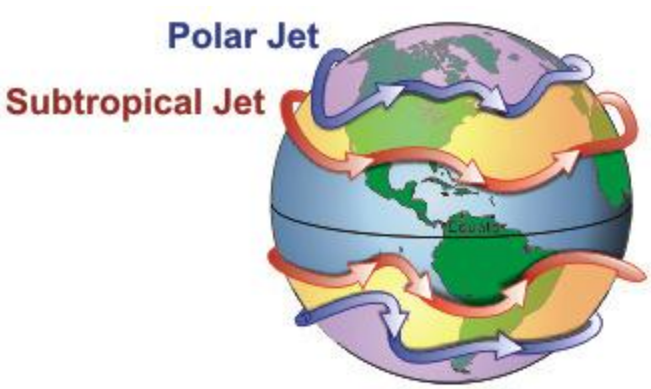
**Figure 2.15**: Projected number of Extreme Hot Days in Sacramento[xxv]




## JET STREAM

Recent research describes how the jet stream may be affected by climate change. The studies find the troposphere (the lowest level of the atmosphere) is warming and moving higher in elevation (by about 900 feet).[xxvi] [xxvii] Since the troposphere is where most of the weather occurs and the difference in the temperature between the troposphere and the stratosphere is the main factor in what creates the jet stream, the warming and rising of the troposphere is being linked to the poleward shift and weakening of the jet stream.

The mechanisms behind the wind circulation and the jet stream are complex; the graphic below illustrates the subtropical and polar jet streams in both the northern and southern hemispheres.



Both the subtropical and polar jet streams have been observed moving poleward according to the recent research. Previous computer models showed the tropical zone (the region of the earth between the Tropic of Cancer and the Tropic of Capricorn) would expand approximately 2 degrees (125 miles) by the end of the 21st century due to the poleward shift of the jet stream resulting from climate change,. However, recent studies show that the zone has already expanded more than this prediction – approximately 2 to 4.8 degrees of latitude (125 miles to 300 miles). Therefore, if the tropical climate is heading poleward, the typically drier subtropical zones (areas immediately north and south of the tropical zone) may be moving poleward as well. And with the jet stream moving poleward, presumably so would the storm tracks.

The latest research reports poleward movement on the order of 12 miles per decade; however, previous studies indicate the poleward movement may be as high as 30 miles per decade. By the middle of the century (in the next 40 years), the jet streams may shift anywhere from 48 to 120 miles, which may make our current Bay Area climate more like Central California's.

**ENERGY DEMAND AND GENERATION**

The Third Assessment report from the California Climate Change Center concluded that climate change will increase demand for cooling in the increasingly hot and longer summer season and decrease demand for heating in the cooler season. The following is a summary of the conclusions from the report.

- In the near term, higher temperatures in the next decade could increase demand by up to 1 Gigawatt during hot summer months.
- Energy supply from hydropower from the more than 150 high-elevation hydropower plants (above 1000 feet) could be impacted. These hydropower plants supply about 75% of all the hydropower produced in California, and their small size allows little flexibility in operations and might make these facilities more vulnerable to climate change and reduced snowpack.
- Electricity generation would be substantially reduced in the summer when hydropower generation is needed most to meet peak demands.
- Transmission of electricity will be affected due to reduced efficiency in the electricity generation process, transmission lines lose 7% to 8% of transmitting capacity in high temperatures.
- Key transmission corridors are vulnerable to wildfires.

**FOREST FIRES**

Wildfire risk in California will increase as a result of climate change. Earlier snowmelt, higher temperatures, and longer dry periods over a longer fire season will directly increase wildfire risk. Research estimated that the long-term increase in fire occurrence associated with a higher emissions scenario is substantial, with increases in the number of large fires statewide ranging from 58 percent to 128 percent above historical levels by 2085.[xxviii] Under the same emissions scenario, estimated burned area will increase by 57 to 169 percent, depending on the scenario.[xxix]

Recent studies conclude the increase in wildfire activity can be correlated with rising seasonal temperatures and the earlier arrival of spring. In a review of 1,166 forest wildfires from 1970 to 2003 in the Western United States, researchers compared the number and potency of wildfires to spring and summer temperatures and the timing of snowmelts.[xxx]

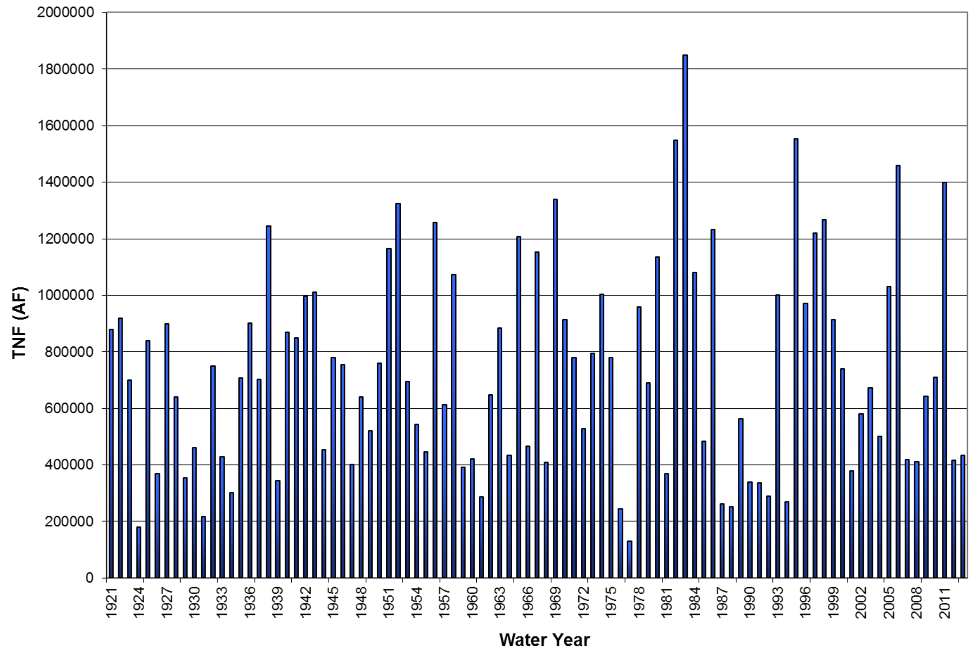
The study found in the mid 1980's there was a jump of four times the average number of wildfires in the West compared with the early 1980's and 1970's. The total area burned was six-and-a-half times greater in the mid 1980's than the earlier years examined. The wildfire season also has extended by 78 days in the more recent period of 1987 to 2003 compared to 1970 through 1986.

## 2.4 District Climate Observations

### MOKELUMNE RIVER TRUE NATURAL FLOW

Figure 2.16 shows the Mokelumne River true natural flow (TNF) since water year 1921.

**Figure 2.16: Mokelumne River TNF – Water Years 1930 to 2010**



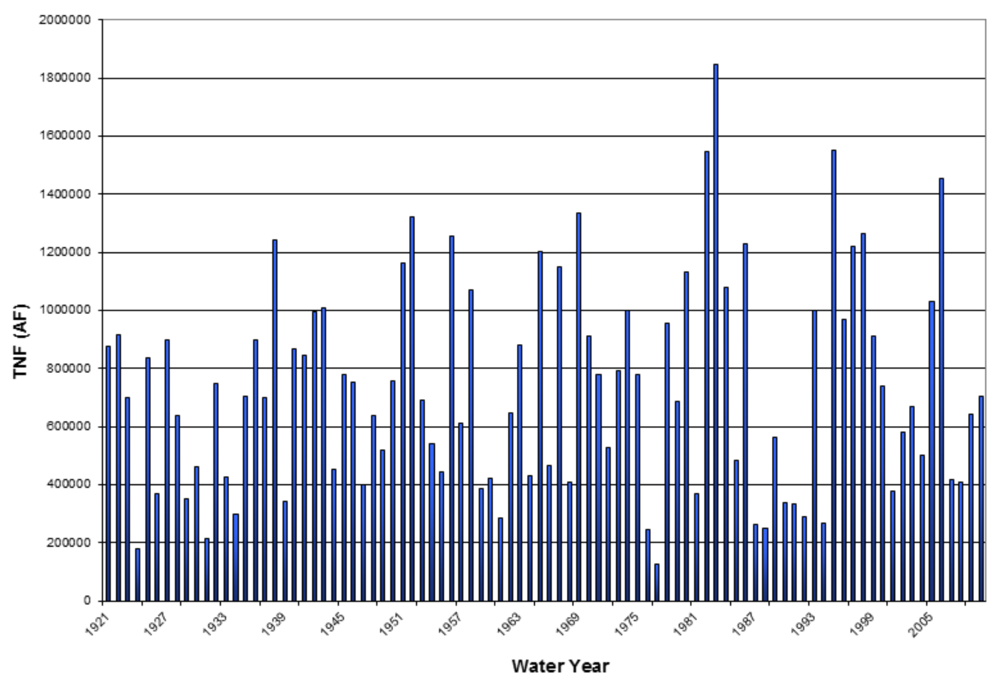
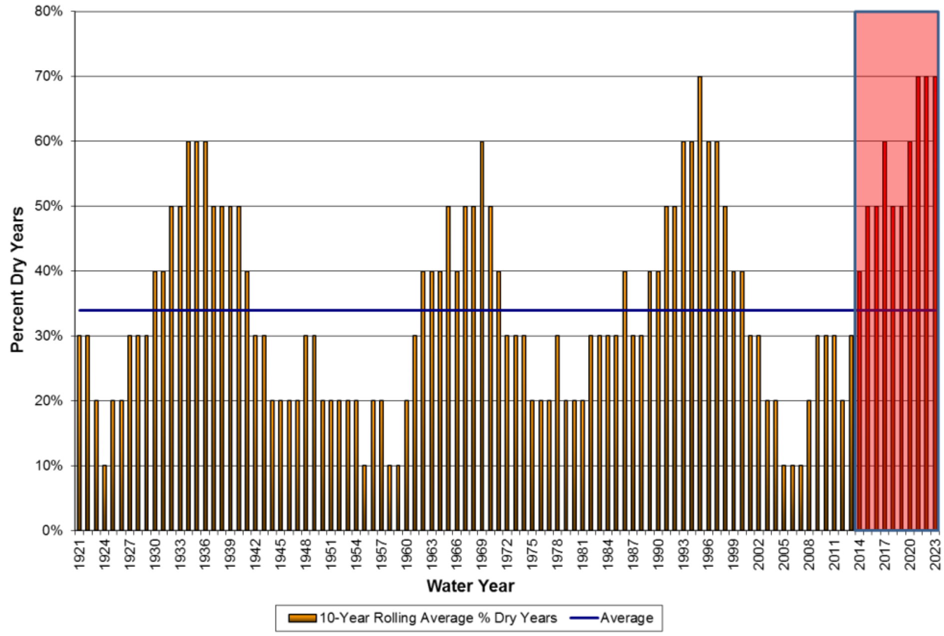
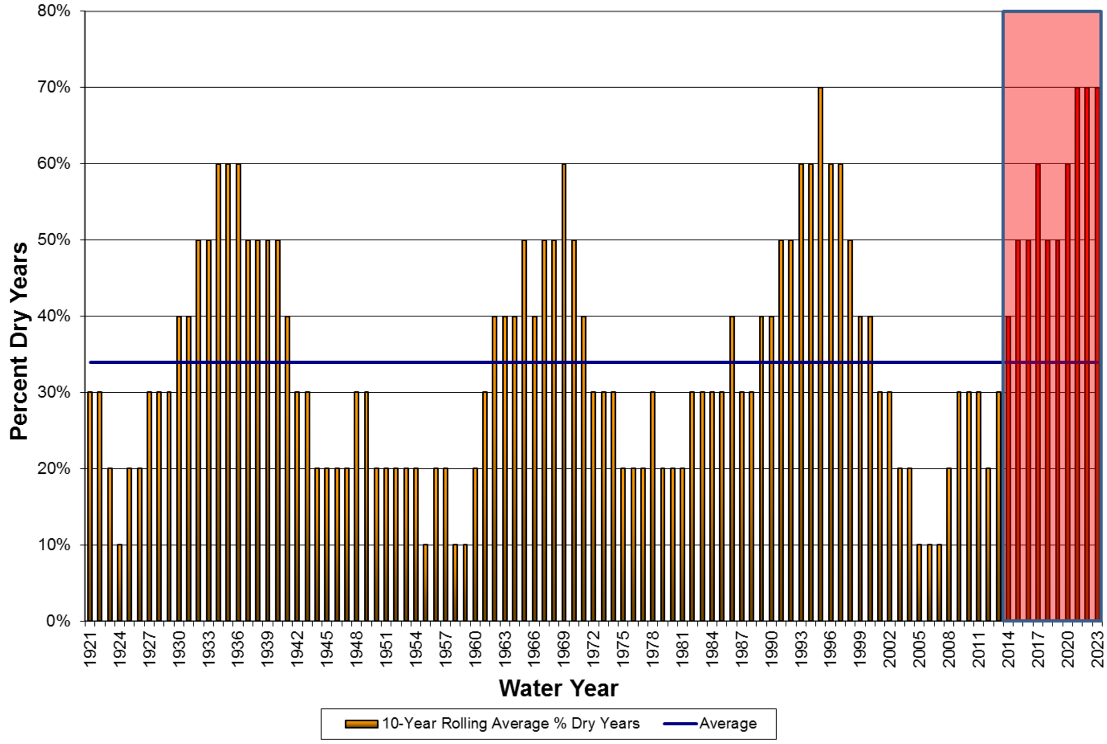




Figure 2.17 shows the rolling 10-year average of the percent of dry years and the projected percent dry years through 2023 assuming runoff follows a similar pattern for the next 10 years. For this graph, a dry year is defined as any year when the annual TNF is less than 500 TAF.

**Figure 2.17: Rolling 10-year Average Percent of Dry Years**





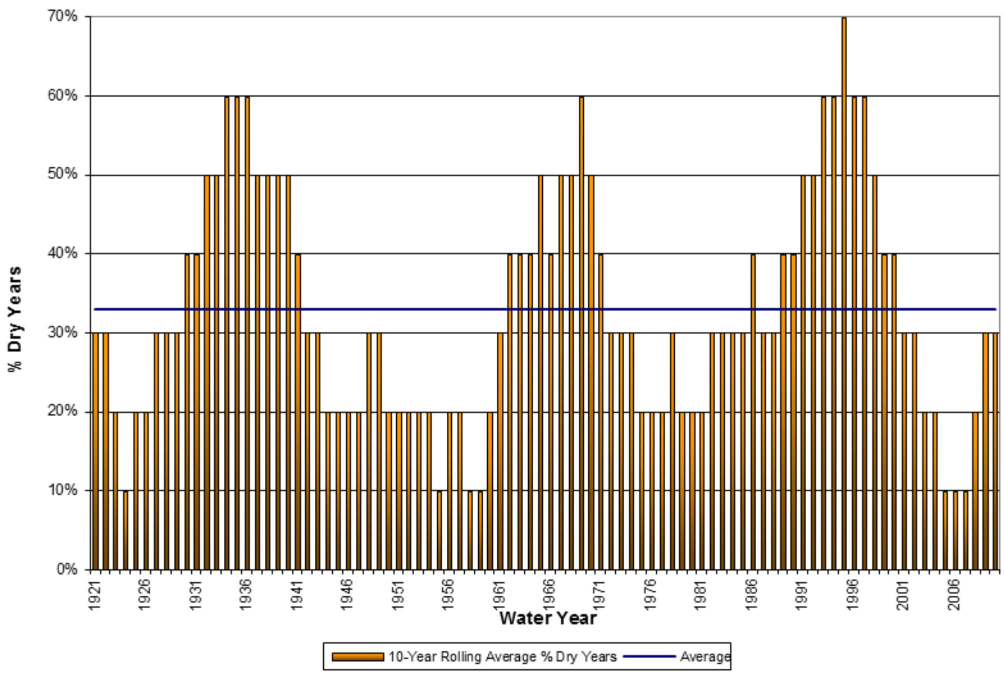
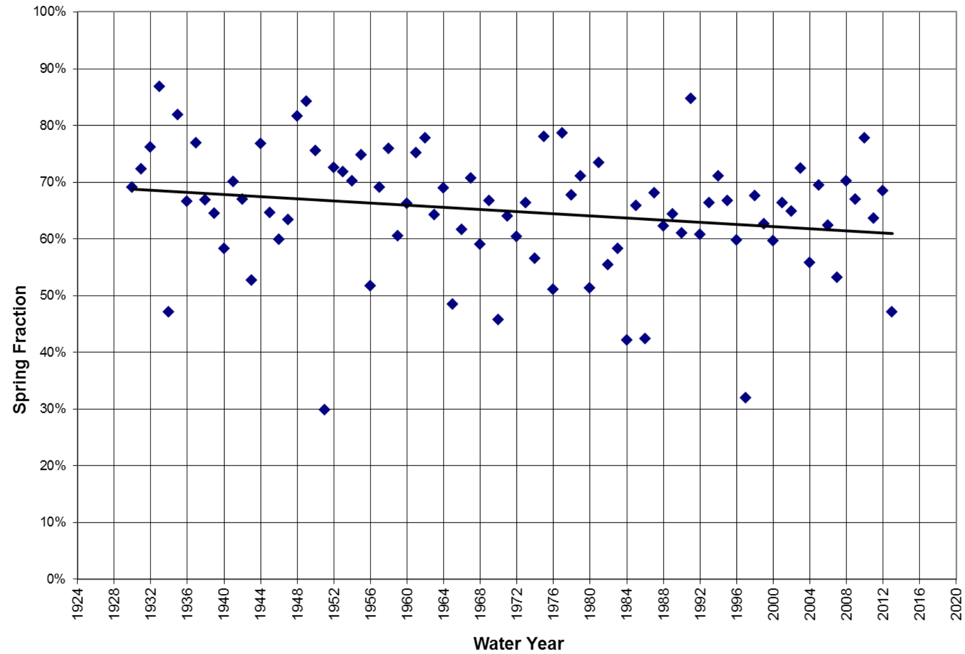
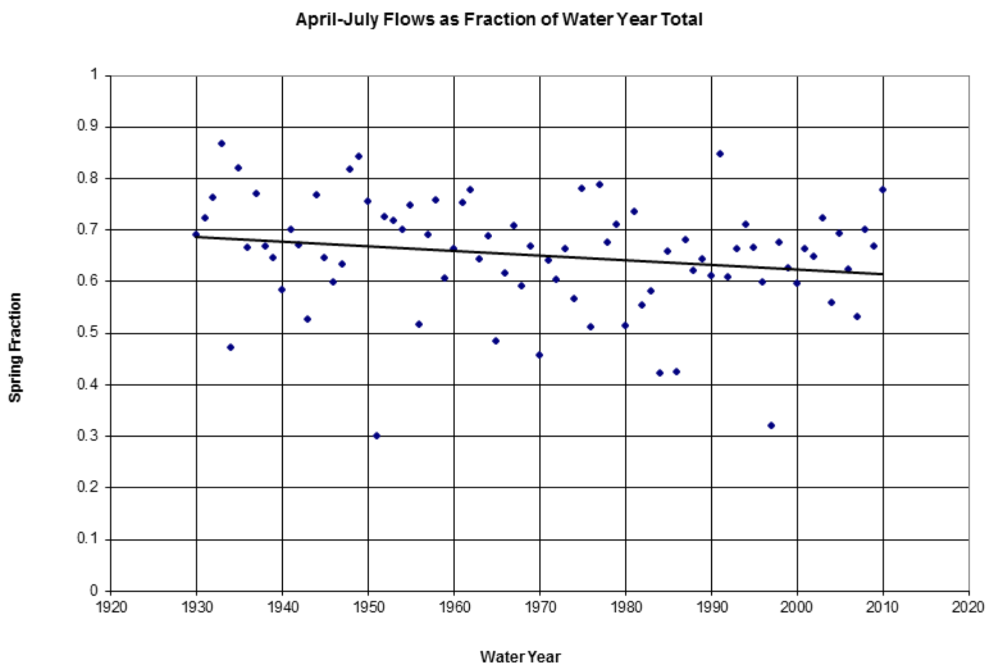




Figure 2.18 shows the percent spring runoff versus the total annual runoff since water year 1930 for the Mokelumne River.

**Figure 2.18: April to July Flows as Fraction of Water Year Total**

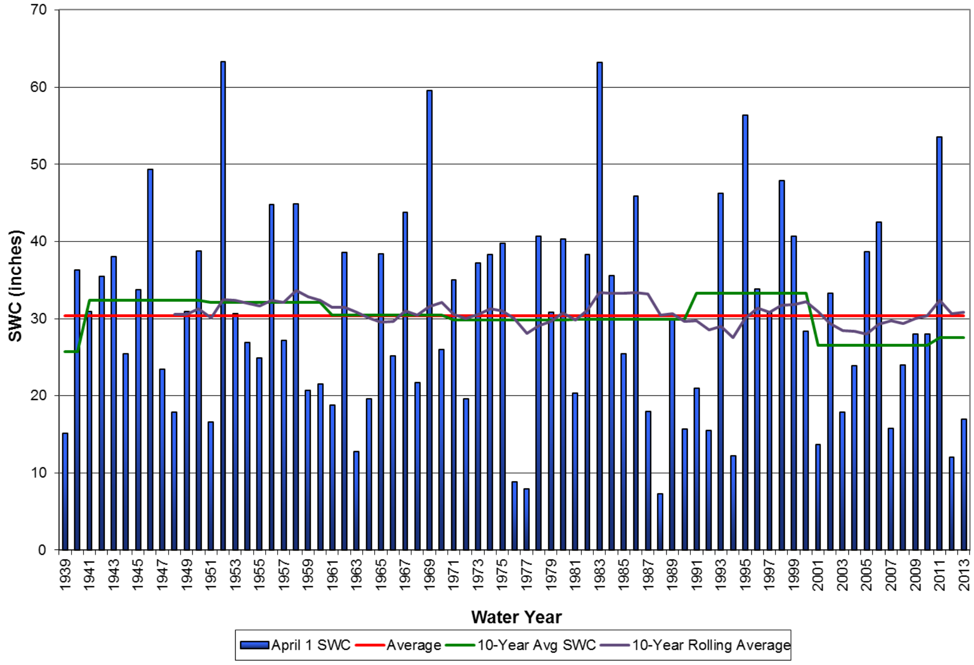



## SNOW WATER CONTENT

Figures 2.19 and 2.21 show the snow water content (SWC) on April 1 at Caples Lake (elevation 8000 feet), Silver Lakes (Elevation 7100 feet), and Hams Station (Elevation 5500 feet) since the 1930’s. Also shown each plot is the long-term and 10-year rolling averages.

**Figure 2.19: Caples Lake April 1 Snow Water Content (Elevation 8000 feet)**



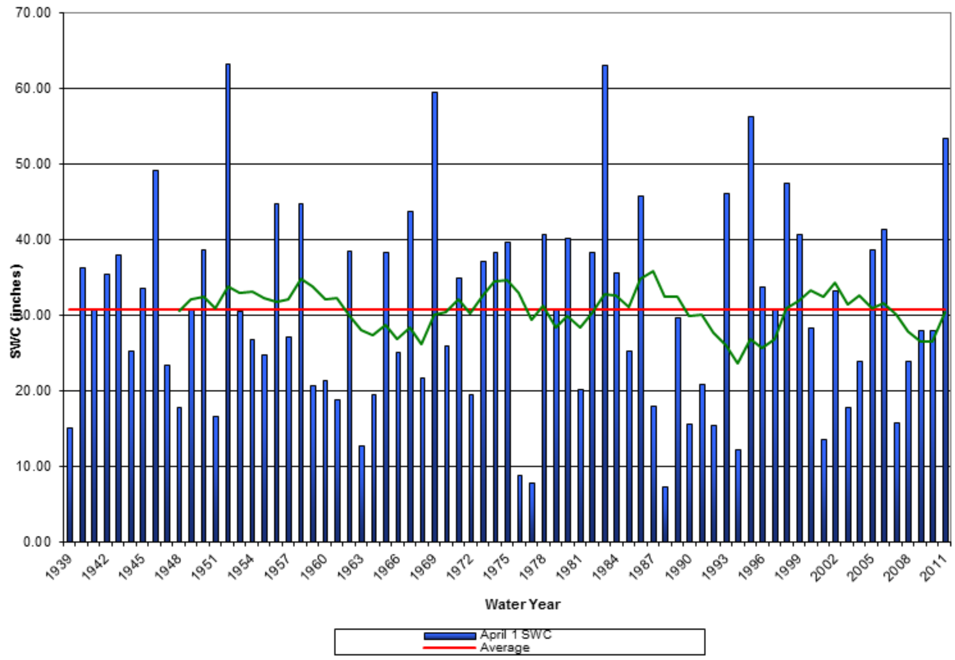



**Figure 2.20: Silver Lakes April 1 Snow Water Content (Elevation 7100 feet)**

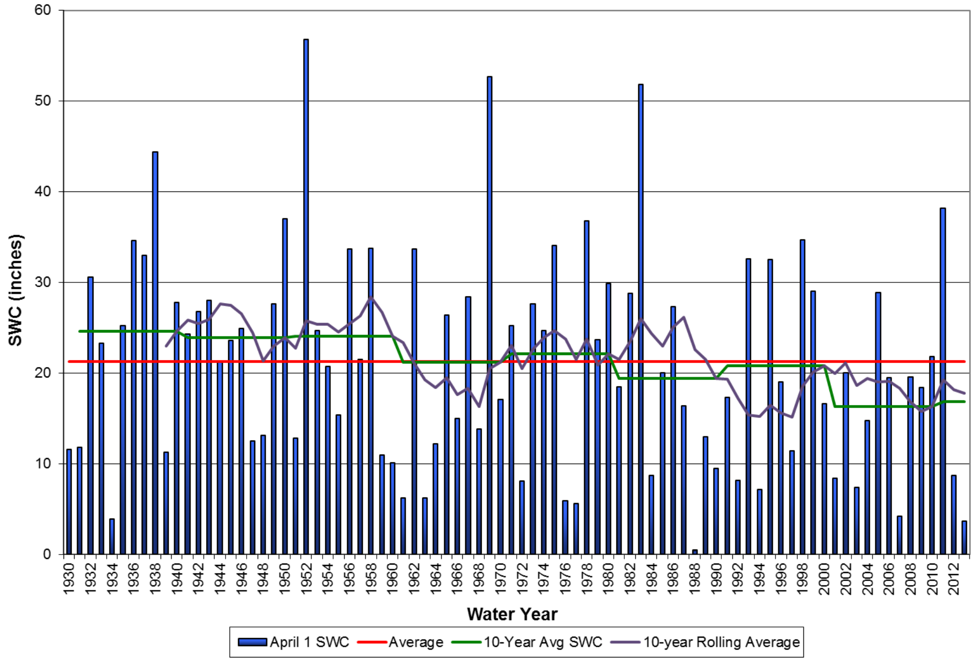
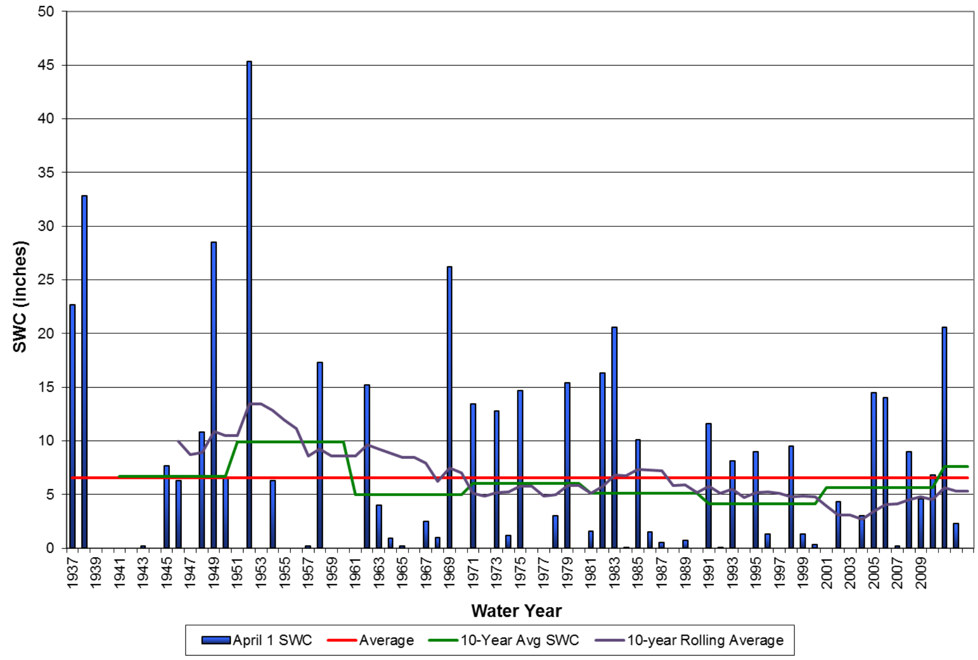
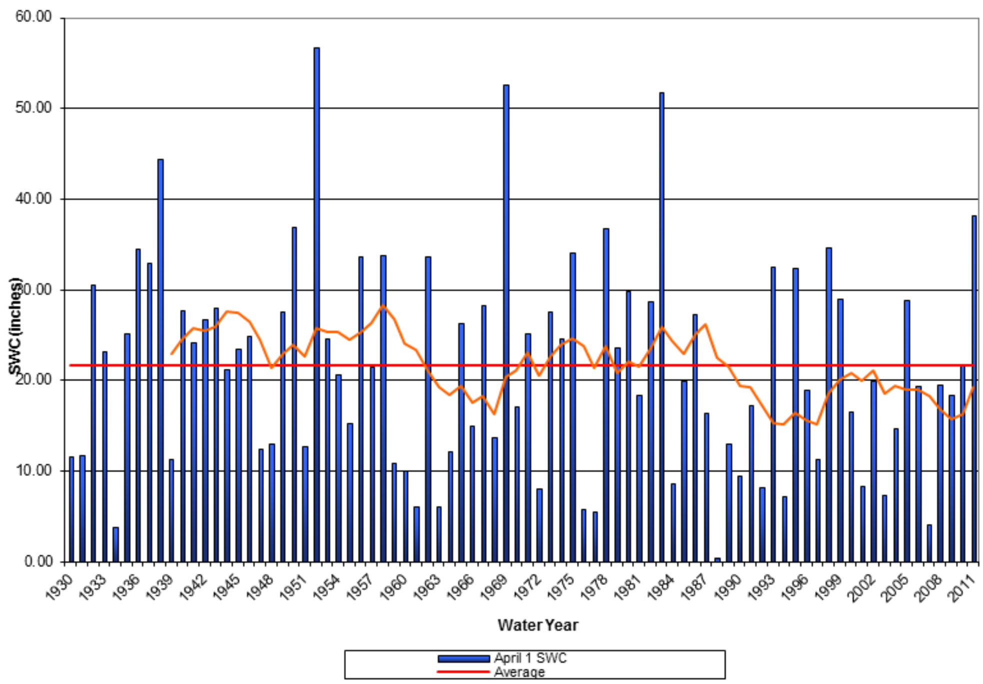


**Figure 2.21: Hams Station April 1 Snow Water Content (Elevation 5500 feet)**

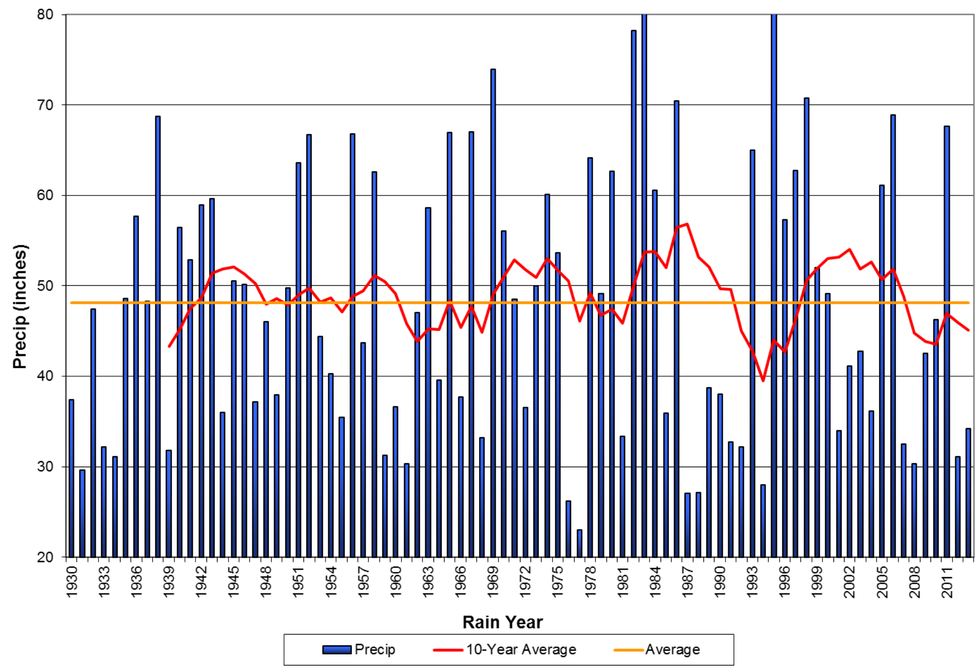


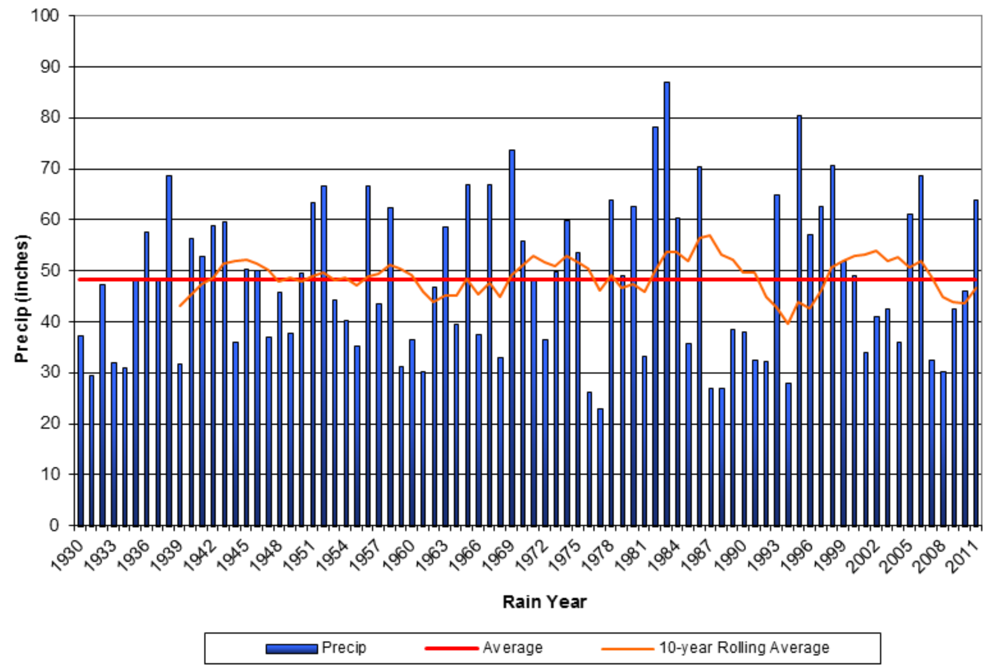




## PRECIPITATION

Figure 2.22 shows the Mokelumne 4-Station annual precipitation since 1930. Also shown on the figure are the average precipitation and the 20-year standard deviation from the average.

**Figure 2.22: Mokelumne 4-Station Annual Precipitation**

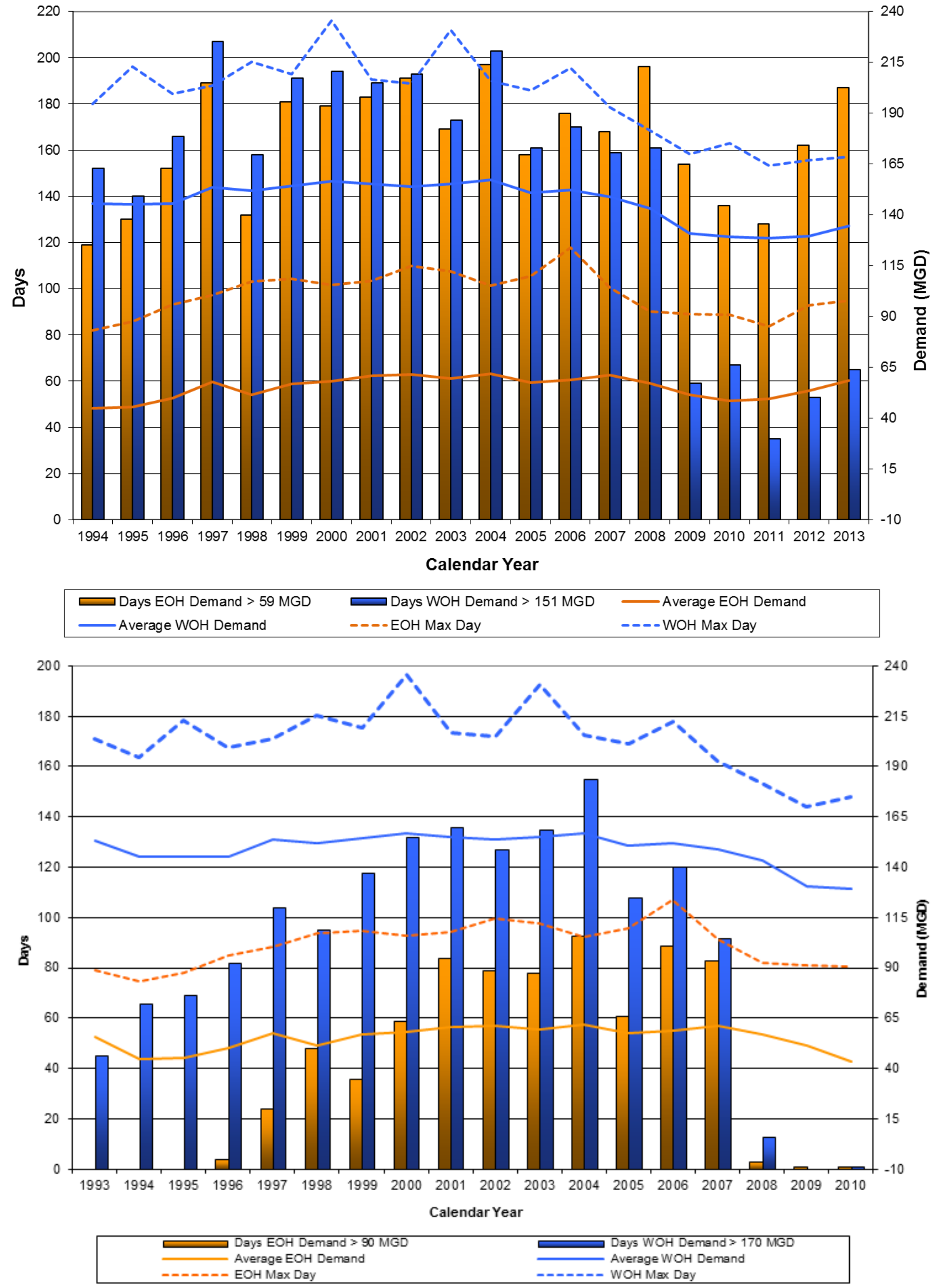



## WATER DEMAND

Figure 2.23 shows gross water production (GWP) East- and West-of-Hills since 1993. The bar chart shows the number of days East-of-Hills production was greater than 59 MGD and West-of-Hills production was greater than 151 MGD (2005 to 2007 average).. The graph also shows the average production and max day GWP East- and West-of-Hills.

**Figure 2.23: East and West-of-Hills Gross Water Production**




## 2.5 Assessment of Climate Change Impacts

Climate change is projected to have many impacts on the District. This section provides a brief assessment of the potential impacts to the District and is covered in greater detail in Section 3 of this plan.

### WATER SUPPLY AND DEMAND

- **Water Supply.** Impacts to carryover storage as a result of decreased runoff and the timing of the runoff.

- **Water Demand.** Increase in water usage as a result of a warmer climate.
- **Water Rationing.** Increase in frequency and severity of water rationing as a result of water shortages.

**WATER QUALITY AND THE ENVIRONMENT**

- **Water Quality.** Decrease in water quality as a result of warmer water temperatures, shift in spring runoff, and increasing peak runoff.
- **Cold Water Management.** Challenges managing cold water pool in Camanche and Pardee Reservoirs as a result of increasing frequency of dry water year types and warming rivers and reservoirs.
- **Fishery Impacts.** Challenges managing fisheries in the Mokelumne River.
- **Wastewater.** Challenges managing more extreme and/or concentrated flows, increased risk of flooding and infiltration and inflow associated with sea level rise.

**FLOOD CONTROL**

- **Flooding.** Increase in storm surge flood events as a result of sea level rise.
- **Flood Control Management.** Challenges managing flood control as a result of the timing of the runoff and increasing peak runoff.

**INFRASTRUCTURE**

- **Infrastructure Impacts.** Impacts to infrastructure in the Delta and near the shore due to sea level rise. Primary concerns for EBMUD include the potential inundation of the Mokelumne Aqueducts from levee failure/overtopping in the Delta, and flooding of the Main Wastewater Treatment Plant (MWWTP).

**ENERGY**

- **Hydropower Generation.** Impact to generation as a result of changes in runoff timing and patterns, and management of cold water pool.
- **Electricity Transmission.** Transmission lines lose 7 to 8 percent of transmitting capacity in high temperatures. There is a 40 percent increase in the probability of wildfire exposure for some major transmission lines.[xxxi]
- **Energy Demand.** Climate change will increase the demand for heating in the cooler season and cooling in the warmer season.

# 3.0 Impacts, Vulnerabilities, and Adaptation

This section evaluates the District services and operations that could potentially be impacted by climate change, identifies potential vulnerabilities to District's critical facilities, and identifies possible adaptation measures.

## 3.1 Potential Impacts

This section provides an overview of the services and operations the District provides, the potential effects that climate change may have, and how these effects could potentially impact the services provided by the District.

### OVERVIEW OF OPERATIONS AND SERVICES PROVIDED BY THE DISTRICT

The District provides a number of services including water supply, water treatment and distribution, wastewater treatment, power generation, and recreation. As part of the impact evaluation, these water services are grouped into Demand and Supply, and wastewater services are divided into Collection, Treatment, and Discharge as shown in Figure 3.1.

### POTENTIAL IMPACTS OF CLIMATE CHANGE ON SERVICES PROVIDED BY THE DISTRICT

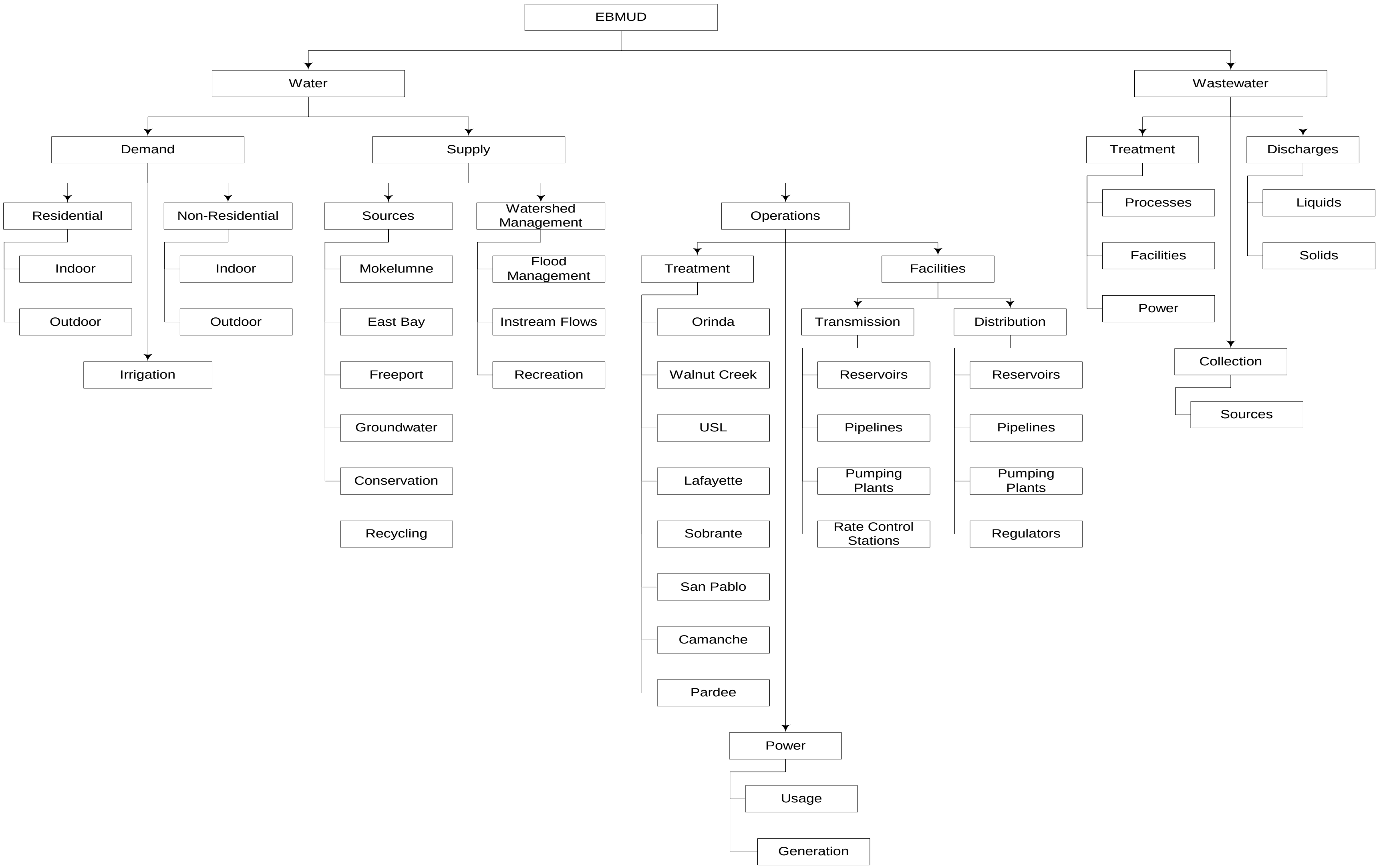
As identified in the Science and Assessment chapter, climate change may have the following impacts:

- Increasing average atmospheric temperature
- Increasing or decreasing precipitation
- Sea level rise
- Reduced April 1 snow-covered area
- Increased variability in runoff patterns
- Increasing heat wave duration, frequency, and intensity
- Increase in water demand
- Increasing growing season length
- Shifting jet stream
- Increasing forest fires

These effects may result in the following changes:

- Increased average annual atmospheric temperatures and heat wave days
- Increased water temperatures
- Increased ratio of rain to snow (R/S), delayed onset of the snow season, accelerated rate of spring snowmelt, and shortened overall snowfall season
- Changes in the timing, intensity, location, and amount of precipitation
- Increased evaporation
- Long-term changes in watershed vegetation
- Changes in source water quality

**Figure 3.1:** Overview of Operations and Services Provided By EBMUD



The potential changes can significantly impact water supply regionally and locally. Regionally, the potential impacts of climate change on California's water resources are identified in the Progress on Incorporating Climate Change into Management of California's Water Resources Technical Memorandum issued by Department of Water Resources (DWR) in July 2006[xxxii]. The potential local climate change impacts on District operations and services are identified and summarized in Tables 3.1 and 3.2.

**Table 3.1:** Potential Water Resource Impacts and Local Expected Consequences

| Potential Water Resource Impact | Expected Consequences |
|---|---|
| Increased temperatures and heat wave days | • Increased water demand<br>• Increased power demand<br>• Increased water-based recreation demand |
| Increased ratio of rain to snow, delayed onset of the snow season, accelerated rate of spring snowmelt, and shortened overall snowfall season | • Potential annual water storage loss in the EBMUD's snowpack<br>• Increased challenges for reservoir management and balancing the competing concerns of flood protection and water supply |
| Changes in the timing, intensity, location, and amount of precipitation | • Potential increased storm intensity and increased potential for flooding; increased stormwater flows in wastewater system<br>• Possible increased frequency, intensity and duration of droughts<br>• Increase in the number of critically dry years<br>• Possible reduced reservoir storage levels<br>• Possible significant fluctuations in reservoir storage levels |
| Increased evaporation | • Decrease in water supply<br>• Increase in water demand<br>• Increase in fire hazard |
| Long-term changes in watershed vegetation | • Changes in the intensity and timing of runoff<br>• Possible increased incidence of flooding and increased sedimentation<br>• Possible critical effects on listed and sensitive plant and animal species<br>• Potential changes in source water quality<br>• Upslope migration of deciduous vegetation and potentially decreased runoff |
| Sea level rise | • Inundation of coastal marshes and estuaries<br>• Increased salinity intrusion into the Sacramento-San Joaquin River Delta<br>• Increased potential for Delta levee failures<br>• Increased potential for salinity intrusion into coastal aquifers (groundwater)<br>• Increased potential for flooding near the mouths of river due to backwater effects<br>• Impacts on wastewater outfalls/backflow<br>• Potential impact on customer base |
| Increase in water temperatures | • Possible critical effects on listed and sensitive aquatic species<br>• Increased environmental water demand for temperature control<br>• Possible increased problems with foreign invasive species in aquatic ecosystems<br>• Potential adverse changes in water quality, including the reduction of dissolved oxygen levels and increased nutrients |
| Increased frequency and intensity of wildfires | • Potential adverse changes in water quality, including increased sediment and nutrients<br>• Increased water demand |

**Table 3.2:** Potential Impacts and Consequences to Operations and Services provided by the District

| Potential Impacts | Expected Consequences | |
|---|---|---|
| | **Operations & Services** | **Expected Consequences** |
| Increased temperatures & heat wave days | Demand - Non-residential | Increases in commercial landscape irrigation (golf courses, outdoor commercial usages such as golf courses, cemeteries, etc.) and commercial and industrial cooling<br><br>Changes in season demand patterns (food processing, irrigation) |
| | Demand - Residential | Increases in water demand (due to increased net evapotranspiration)<br><br>Changes in seasonal demand patterns (primarily irrigation) |
| • Increased ratio of R/S, delayed onset of the snow season, accelerated rate of spring snowmelt & shortened overall snowfall season.<br>• Increased evaporation<br>• Long-term changes in watershed vegetation<br>• Change in the timing, intensity, location & amount of precipitation | Sources | Loss of annual water supply from the Sierra snowpack<br><br>Increase in drought frequency<br><br>Increase in potential for invasive species<br><br>Increase in adverse changes in water quality (physical and biological)<br><br>Increase in erosion/sedimentation |
| • Increased temperatures & heat wave days<br>• Long-term changes in watershed vegetation<br>• Increased frequency & intensity of wildfires<br>• Increased ratio of R/S, delayed onset of the snow season, accelerated rate of spring snowmelt & shortened overall snowfall season<br>• Change in the timing, intensity, location & amount of precipitation | Watershed Management | Increase in flooding incidence<br><br>Increase in needs to balance between flood protection and water supply<br><br>Increase in difficulty maintaining instream flows<br><br>Increase in environmental water demand for instream temperature control<br><br>Increased difficulty in maintaining recreational quality |
| • Increased temperatures & heat wave days<br>• Increased ratio of R/S, delayed onset of the snow season, accelerated rate of spring snowmelt & shortened overall snowfall season<br>• Increased water temperatures<br>• Increased frequency and intensity of wildfires<br>• Change in water quality<br>• Increased evaporation | Operations | Increased difficulty and cost in treatment due to degraded water quality (taste& odor; sediment)<br><br>More stringent regulations<br><br>Increase in O&M cost to prevent/treat invasive species<br><br>Increase in potential for salinity intrusion into coastal aquifers (groundwater)<br><br>Greater challenges for reservoir management and balancing the competing concerns of flood protection and water supply |

**Table 3.2:** Potential Impacts and Consequences to Operations and Services provided by the District

| Potential Impacts | Expected Consequences | |
|---|---|---|
| | **Operations & Services** | **Expected Consequences** |
| • Change in the timing, intensity, location & amount of precipitation<br>• Sea level rise | | Shorten facility life cycles due to higher usage - to treat and to deliver - to meet higher demands<br><br>Changes in demand patterns potentially offsetting storage to demand ratio<br><br>Increase in energy usage and costs to meet higher seasonal demands |
| • Sea Level Rise<br>• Change in the timing, intensity, location & amount of precipitation | Wastewater Collection | Increase in energy usage due to increased infiltration and inflow<br><br>Increase in corrosion rates due to lower wastewater flows and longer residence times in collection systems<br><br>Increased vulnerability to sanitary sewer overflows due to increased intensity of precipitation events |
| • Increased temperatures<br>• Change in the timing, intensity, location & amount of precipitation | Wastewater Treatment | Increase in wastewater contaminant concentrations, possibly impacting biological treatment processes, due to reduction in wastewater flows caused by decreased runoff and water conservation under drought conditions<br><br>Increase in stormwater infiltration and inflow, caused by increases in rainfall intensity during wet weather, resulting in higher peak flows at treatment plants |
| • Increased temperatures<br>• Change in the timing, intensity, location & amount of precipitation<br>• Sea level rise | Wastewater Discharge | More stringent discharge requirements and higher pollutant reduction rates due to lower freshwater flows, under drought conditions, to receiving waters<br><br>Increase in saltwater infiltration for collection systems in low-lying areas which may cause an increase in wastewater total dissolved solids concentration and potential for plant upsets.<br><br>Increased pumping energy required at outfall |

## 3.2 Vulnerability

While it is generally accepted that average temperature will increase in California over the next century, other predictions are less certain. EBMUD reviewed the state of climate change science and concluded that it was not advisable to take one of many global climate change models and try to estimate temperature and precipitation at the watershed level. Instead, the District took a bottom-up approach by evaluating the vulnerability of the District supply system. A sensitivity analysis was completed to determine how the system would be most vulnerable to changing climatic parameters.

## CLIMATE CHANGE SENSITIVITY ANALYSES

A number of parameters were varied in a model of the EBMUD water supply system to determine the sensitivity of the District's operations and services to climate change. As part of the sensitivity analysis, assumptions were varied one at a time and not compounded for the following cases:

- Changes in customer demands resulting from a 4°C increase in air temperature
- Changes in the timing of Mokelumne River runoff corresponding to 2°C, 3°C, and 4°C increases in air temperature
- Reductions in Mokelumne River runoff corresponding to 10% and 20% reductions in precipitation

The following is a summary of the District's sensitivity analyses.

- **Supply.** Carryover storage is susceptible to earlier springtime runoff because winter storage capacity is reduced during winter to provide flood control reserve, making it more likely that some runoff cannot be captured in the District's reservoirs in the spring. The District analysis found that carryover storage was more likely to be reduced and to a greater degree as temperature increases and runoff occurs earlier. For example, for 4°C of warming, carryover storage was reduced in 56 percent of the years modeled, with an average decrease of 6 percent during those years. Carryover storage is even more sensitive to a decrease in annual runoff. In approximately 70 percent of years analyzed in the hydrologic record, carryover storage is reduced by 12 percent and 24 percent for the 10 percent and 20 percent annual decrease in runoff scenarios, respectively. This likely would result in a severe shortage of water.
- **Demand.** A warmer climate is projected to increase water demand. EBMUD estimated that water demand will increase by 10 MGD if average temperature in the service district increases by 4°C.
- **Flood Control Management.** The volume of flood control releases in winter and spring are significantly reduced when annual runoff is reduced. Annual flood volumes decrease, on average, by 43 percent for the 10 percent reduction scenario and decrease by almost 75 percent for the 20 percent reduction scenario. The volume of flood releases in winter and spring are affected by earlier spring runoff. November through March flood control release volumes increased by 66 percent, 81 percent, and 89 percent, on average, for the 2°C, 3°C, and 4°C scenarios, respectively. For the April through July period, releases decreased by slightly smaller magnitudes.
- **Water Temperature**. Simulations were run to evaluate the anticipated changes in water temperature flowing into Pardee Reservoir as a result of 2°C, 3°C, and 4°C increases in ambient air temperature. The results show that minimum, average and maximum water temperatures would be expected to increase as a result of increasing ambient temperature. In a dry year, water temperature increases ranged from 0.3°C to 1.5°C. In a below normal year, water temperature increases ranged from 1.0°C to 3.5°C. In an above normal year, water temperature increases ranged from 1.1°C to 2.5°C.

Historically, three out of ten years are dry years in the Mokelumne basin. Runoff is strongly correlated with precipitation and spring snow water content. With a 10 percent reduction in precipitation, the number of dry years is projected to increase to four out of ten years, and with a 20 percent reduction in precipitation, the number of dry years is projected to increase to five out of ten years.

## VULNERABILITY ASSESSMENT

The Impacts, Vulnerability, and Adaptation (IVA) Working Group is comprised of representatives from Water Distribution Planning, Water Supply Operations, Wastewater Planning, Legislative

Affairs, Water Supply Improvements, Natural Resources, and Water Treatment and Distribution. The IVA Working Group identified the following as high-priority areas of vulnerability:

***Water Supply & Demand***

Reduced precipitation would greatly impact water supplies and the need for supplemental supplies to meet increased demand.

***Watershed Management***

- A recent report showed that 1 foot rise in sea level changes a “1 in 100” storm surge flood event into a “1 in 10” storm surge flood event.
- Increases in water temperature may also affect the water system because of its fishery responsibilities, which include maintaining a “cold water” pool in reservoirs to manage downstream river temperatures. Temperature management is a vital part of the reservoir operation plans so the District can provide cold water during fish migration periods.
- As a result of the ocean upwelling conditions in 2005, there were significant reductions in returns of fall-run Chinook salmon to the Central Valley in 2007 (including the Mokelumne River). The upwelling provides food to juvenile salmon that enter the ocean in March-July. Delayed early-season upwelling is consistent with predictions of the influence of climate change. Stream temperatures are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods.
- Increase in intensity and frequency of wildfires will tax the limited resources available to respond to wildfires.
- Current District policies and management plans do not address the fire risk mitigation associated with climate change consequences.
- Source water quality protection measures to address possible increases in nutrients and sediments associated with climate change consequences not currently identified.
- Significant reservoir fluctuations conflict with water-based recreation services and impact source water quality.
- Increased temperatures and heat wave days will affect ability to meet water-based recreation demands.

***Operations***

- Reduced ability to regulate reservoir release temperatures, particularly at Camanche Dam
- Increase in intensity and frequency of wildfires will increase water demand for suppression
- Increased temperature leads to increased demands, which then would require additional infrastructure improvements, especially to meet peak demands.
- Increases in the severity of storms could increase turbidity levels in raw water supplies. Severe storms can dramatically increase turbidity and slow the District’s ability to treat water. Simultaneously, this will also increase the cost of treatment. In addition, increasing water temperature may affect water quality by promoting algae growth and result in increased taste-and-odor compounds.
- Rising sea levels may pose a threat to low lying infrastructure including the Delta levees and the Mokelumne Aqueducts.
- The California Climate Change Center reported in 2006 a warmer climate would not only increase the demand for energy but also increase the demand for peak energy use by 4.1 percent to 19.3 percent by the end of the century. In addition, if precipitation deceases or runoff patterns change significantly, hydropower generation may correspondingly decrease between 10 to 30 percent. For the District, this would result in a reduction of 18 to 54 GW hours in energy production resulting in a loss of revenue.

***Wastewater***

- Vulnerable to high storm flows if rainfall intensity increases: remote pumping stations, remote wet weather treatment facilities, influent pump station, effluent pump station, and interceptor capacity (resulting in sanitary sewer overflows).
- Vulnerable to lower sewage flows during droughts: wastewater interceptor system (due to increased corrosion) and biological wastewater treatment processes (e.g., secondary activated sludge due to more concentrated contaminants).
- Vulnerable to higher sea levels: low lying facilities (main wastewater treatment plant, dechlorination facility, overflow structures and wet weather facilities are susceptible to inundation) and biological wastewater treatment processes (e.g., secondary activated sludge or clarifier upsets due to higher dissolved solids concentrations).

## 3.3 Adaptation

The District is developing many adaptation strategies to address climate change. This section discusses some initial adaptation ideas being considered. These strategies will be revised over time as our understanding of climate change and its impacts are better understood.

**WATER SUPPLY PLANNING**

The recommended adaptation approach to climate change is to adjust the District's water supply portfolio as the impact of climate change manifests itself over time. The Board has identified a preferred portfolio approach with a rationing target of up to 15 percent. By reducing the rationing target from 25 percent, the District will have more flexibility to respond to changing conditions related to climate change or any other emergency, because it will have the ability to increase rationing if the emergency is more severe than planned. In addition, on-going water conservation and recycling programs will further reduce demand and lessen impacts on supplies impacted by climate change.

Furthermore, the preferred portfolio includes several supplemental supply projects that would be pursued on parallel tracks in the event that one (or more projects) is not able to produce the expected dry-year yield. These projects include water transfers, recycling, groundwater storage, desalination, and surface storage.

This gives the District a number of projects to develop as the impacts of climate change are better understood.

**OTHER DISTRICT ADAPTATION NEEDS**

***Short-term measures***

- Incorporate climate change considerations in all level one and two master plans
- Incorporate potential climate change impacts in watershed management plans
- Evaluate the feasibility of selective withdrawal system for Camanche and Pardee reservoirs to manage release water temperatures
- Continue to monitor influent total dissolved solids concentrations to prevent impacts to the secondary treatment process at the wastewater treatment plant
- Collaborate with other agencies on assessing vulnerabilities and adaptation strategies developing (e.g., BCDC and NOAA Adapting to Rising Tides project)

***Long-term measures***

- Implement the District's long-term plan for water supply reliability

- Develop regional partnerships including water system interties and exchanges to improve regional water supply reliability
- Improve fire protection measures to reduce demand for fire suppression
- Implement measures at District reservoirs to maintain water-based recreation services (e.g., extended boat ramps and shoreline access)
- Employ measures to reduce sediment/nutrient influx resulting from reservoir fluctuations and wildfires
- Evaluate Army Corps flood control guidelines in Mokelumne watershed to add flexibility to fill our reservoirs based on an earlier runoff scenario while still maintaining adequate flood control space
- Reduce inflow and infiltration to the collection system in order to reduce the impact of high intensity precipitation events on the wastewater collection and treatment systems
- Develop corrosion prevention plans, which may include chemical addition in the interceptor system
- Coordinate with other agencies on long-term protection strategies for the wastewater collection system, main wastewater treatment plant and wet weather facilities

# 4.0 Mitigation

The sources of GHG emissions are primarily related to electrical energy generation, transportation, industrial and agricultural processes, and land use practices (e.g., deforestation). According to the IPCC Fifth Assessment Report, mitigation, in the context of climate change, is human intervention to reduce the sources or enhance the sinks of GHGs. The goal is to achieve the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Total global anthropogenic GHG emissions have risen more rapidly from 2000 to 2010 than in the previous three decades. Emission growth has occurred despite the presence of a wide array programs and national policies aimed at mitigating emissions. From 2000 to 2010, global GHG emissions grew on average 2.2 percent per year compared to 1.3 percent per year over the entire period from 1970 to 2000. The global economic crisis 2007/2008 temporarily reduced global emissions, but did not change the longer-term trend. In order to reverse that trend, a combination of mandatory and voluntary actions will be required. Adaptation and mitigation are closely linked. Adaptation efforts will be more difficult, more costly, and less likely to succeed if significant mitigation actions are not implemented.

Over the next 20 years or so, even the most aggressive climate policy can do little to prevent warming already ”loaded” into the climate system. In other words, the climate is changing and will continue to change over time due to the persistence of GHGs in the atmosphere.. The benefits of avoided climate change will only accrue beyond the near future. Emissions reductions and carbon sequestration have a time value (i.e., early actions have a greater long term benefit). Over longer time frames, beyond the next few decades, mitigation investments have a greater potential to reduce climate change damage. In addition, emissions reductions can lead to new technologies which will help improve efficiencies and reduce operating costs.

## 4.1 EBMUD Mitigation Goals

The District’s emissions are very small compared to those of many other industries, and compared to state, national, and global emissions; therefore, by itself, the District cannot have a significant or measurable impact on global climate change. Nevertheless, EBMUD will take steps to reduce its carbon footprint because:

1. EBMUD is an environmentally responsible company and as such should minimize its impact on the environment,
2. The District has policies on water efficiency, sustainability and renewable energy to minimize and mitigate our environmental impacts.
3. Mitigating climate change primarily involves reducing energy use or making operations more efficient which ultimately reduces operating costs,

The first step in effectively managing emissions is establishing a measurable goal. Setting goals can lead to innovation and improved performance. There are two basic kinds of goals:  absolute and intensity based.

**ABSOLUTE TARGETS**

Absolute targets reduce total emissions over a specific time period. The advantage of this kind of goal is it defines a specific quantity of emissions that is measurable and unambiguous. The disadvantage is it can indicate a reduction in emissions just by reducing production and not necessarily due to gains in efficiency. For example, the District’s overall emissions in some years (i.e., 2007 through 2009) went down primarily because water demands also went down, which resulted in fewer indirect emissions. However, there are external factors out of the District’s control that may drive up emissions even though overall production is lower (e.g., use of Freeport in a drought).

**GHG INTENSITY**

GHG intensity allows an agency to account for changes in production over time. GHG intensity is the ratio of GHG emissions divided by a normalizing factor (e.g., million gallons potable water delivered or million gallons of wastewater treated). The advantages of GHG intensity are the goal is independent of production and is a measure of efficiency. The disadvantages are the goal does not indicate whether total emissions are increasing overall and the quantity of emissions generated must be related to GHG emitting activities for the goal to be relevant.

Selection of a goal must be pertinent to the District's operations and meet the organizational needs. The sectors that describe our emissions have different characteristics. Emissions from some operations (Water Treatment and Distribution and Wastewater) are directly related to production and the District has some control over the outcome. However, the many operations only have an indirect relationship (Raw Water) or no relationship to production (Buildings and Fleet). Consequently, GHG intensity is a more appropriate method to evaluate the Water Treatment and Distribution and Wastewater sectors and absolute goals are more appropriate for Fleet and Buildings sectors. The District has little control over the Raw Water emissions, so a goal is not necessarily relevant.

**DISTRICT GOALS AND EVALUATING PROGRESS**

District Policy 7.05, Sustainability includes an objective to identify projects and plans that mitigate climate change impacts and reduce greenhouse gas emissions, In November 2013, the Board of Directors approved a revised Energy Policy (Policy 7.07) that established the following goals:

1. Be carbon free for indirect emissions by 2040, and
2. Achieve a 50 percent reduction in direct emissions compared to 2000 levels by 2040.

Carbon free means the organization has reduced its indirect GHG emissions to the maximum extent feasible, and offset any unavoidable emissions by purchasing GHG offsets or Renewable Energy Credits (RECs). Staff will annually report progress towards these goals to the Board of Directors, management, and staff as required under the Sustainability Policy (Policy 7.05).

## 4.3 Emissions Inventories

In general, GHG emissions are not measured directly. Emissions estimates are derived from protocols that provide guidance on estimating emissions based on energy use (e.g., electricity, gasoline, natural gas, etc.) and operations (e.g., water and wastewater treatment). The use of protocols provides a level of transparency, consistency, and credibility for reporting GHG emissions and offsets.

Emissions are generally divided according to an internationally recognized standard into three groups. Direct emissions (Scope 1) are emissions from sources within the organizational boundary that the District owns or controls. These emission are primarily from stationary combustion, mobile combustion, process related emissions, or fugitive emission. Indirect emissions (Scope 2) are those emissions occurring outside the District from the production of electricity that is used by the District. The third group of emissions (optional indirect emissions or Scope 3) is emissions over which the District exerts significant influence or control like raw material transport or waste removal. The District does not track Scope 3 emissions.

## VOLUNTARY EMISSIONS REPORTING

The District was among the first water agencies to take membership in the California Climate Action Registry (the California Registry or CCAR), in March 2006. CCAR (www.climateregistry.org) was established by California statute in 2000 as a non-profit voluntary registry for GHG emissions. CCAR members voluntarily measure, verify, and publicly report their GHG emissions.

The Climate Registry (TCR) is the sister organization of CCAR and was formed to continue voluntary reporting throughout North America. The Climate Registry (www.theclimateregistry.org) is a nonprofit collaboration among North American states, provinces, territories and Native Sovereign Nations to set consistent and transparent standards for the calculation, verification and public reporting of greenhouse gas emissions into a single registry.

CCAR accepted its last emissions inventory reports and officially closed in December 2010. CCAR has been transitioning its members to The Climate Registry. CCAR will continue to maintain emissions data from members' pioneering voluntary early action commitments in perpetuity on its website.

The District is no longer a member of CCAR or TCR because it did not realize a significant benefit from membership. However, the District still uses the General Reporting & Verification Protocols to complete its emissions inventories because they provide value for calculating inventories that can be used for comparison with other entities. CCAR developed a number of protocols to assist in the process of calculating, reporting and verifying an emissions inventory. The protocols provide rigorous standards for emissions reporting that are consistent across jurisdictions and in line with international standards.

### *Emissions Inventory Boundary*

The first step in completing a GHG emissions inventory is to determine the content of the inventory. The District will only report emissions created by operation of facilities and equipment that are 100 percent owned and operated by the District. For example, emissions created by operation of the Freeport Regional Water Authority JPA are not included in the District's inventory because the District does not necessarily control the power purchase or use. However, emissions created by operating the Folsom South Canal Connection facilities are included in the District's inventory because it is directly managed by the District.

### *Greenhouse Gases*

As established in the Kyoto Protocol developed by the United Nations Convention on Climate Change, the following gases are generally included in an emission inventory:

1. Carbon Dioxide ($CO_2$)
2. Methane ($CH_4$)
3. Nitrous Oxide ($N_2O$)
4. Hydrofluorocarbons (HFCs)
5. Perfluorocarbons (PFCs)
6. Sulfur Hexafluoride ($SF_6$)

Each gas has a different ability to trap heat in the atmosphere. This characteristic is represented by the Global Warming Potential (GWP) relative to $CO_2$. For example, methane has approximately 25 times more capacity to trap heat in the atmosphere than carbon dioxide. Therefore, the GWP for methane is 25. The GWP is used to convert the amount of each gas (usually in tons) to a carbon dioxide equivalent ($CO_2$-e) for ease of comparison.

The District's inventory only includes carbon dioxide for the following reasons:

- In order to be consistent with the District's baseline and early inventories. Carbon dioxide was the only gas required in our inventory as part of the CCAR protocols until the 2008 reporting period.
- Collecting additional data to report on all six gases (e.g., vehicle mileage by type, location and maintenance history for refrigerants, and location and maintenance history for SF6) is labor intensive and would not likely yield significant changes in our inventories.

Future inventories may include all six gases should we determine or suspect GHGs other than carbon dioxide will make a significant contribution to our inventory.

### *Anthropogenic Versus Biogenic Emissions*

Anthropogenic emissions result from carbon released in fossil fuels that have been trapped in geologic formations for millennia. Biogenic emissions are from carbon in biomass recently contained in living organic matter, such as combustion of biogas at the Main Wastewater Treatment Plant. Biogenic emissions will be tracked and reported separately from anthropogenic emissions. Because of this difference, the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories requires that CO2 emissions from biogenic sources be reported separately.

### *Emissions Calculations*

The District participated in CCAR for three years and calculated, verified, and publicly-reported its District-wide CO2 emissions inventories for calendar years 2005, 2006, and 2007. As noted above, the District ended its participation in CCAR but it continues to quantify and track District-wide GHG emissions using TCR protocols.

Although there are some minor emissions from process activities and fugitive emissions, the District's Scope 1 or direct emissions are primarily from stationary and mobile combustion. Direct emissions from combustion are calculated using the total annual fuel consumption multiplied by an emissions factor for that specific fuel (natural gas, gasoline or diesel).

The District's indirect emissions result from the use of electricity. To calculate the emissions from electrical use, the annual electrical use is multiplied by an electrical emissions factor for the electricity source. The emissions factor is derived based on the electrical utility's mix of generation.

## 2013 GREENHOUSE GAS INVENTORY

In 2013, the District's Scope 1 and 2 GHG emissions totaled 31,244 Metric Tons (MT) of carbon dioxide which represents a 31 percent reduction from year 2000 levels, and nearly identical to the 2012 emissions inventory (31,106 MT).

### *Emissions Sectors*

A GHG inventory for a water utility is more meaningful if the data are broken down into sectors associated with specific activities or sectors. The following five sectors allow more detailed analysis of the emissions, comparison with other water agencies, and comparison of emissions over time:

- Raw Water – emissions resulting from activities associated with water intake and transport to a treatment facility.
- Water Treatment and Distribution – all emissions resulting from treating raw water for potable use and distributing the treated water to customers.

- Buildings – emissions resulting from operation of all facilities not associated water or wastewater operations like the Administration Building, Adeline Maintenance Center, and service yards.
- Fleet – emissions associated with energy use in District vehicles and mobile equipment including cars, trucks, heavy equipment, and portable pumps and generators.
- Wastewater – all anthropogenic (i.e., caused by humans) emissions resulting from operation of the District's wastewater collection and treatment facilities. Emissions from combustion of digester gas are considered biogenic (i.e., part of the normal carbon cycle) and, therefore, not included in the inventory.

Each sector has different drivers for emissions. In 2013, the District's emissions were allocated among the sectors as follows:

**Table 4.1: 2013 Emissions by Sector**

| Sector | Direct GHG Emissions (MT) | Indirect GHG Emissions (MT) | Percentage of Total |
|---|---|---|---|
| Raw Water | 0 | 1337 | 4 |
| Water Treatment and Distribution | 32 | 15,775 | 51 |
| Buildings | 2783 | 1406 | 13 |
| Fleet | 6701 | 0 | 22 |
| Wastewater | 722 | 2488 | 10 |
| **Total** | **10,238** | **21,006** | **100** |

***Evaluation of Emission Sectors***

There are many different factors that influence the District's emissions. Some items can be managed by the District and some are external to the District. In a drought year for example, the District may utilize its alternate water supply from the Sacramento River. This water supply requires much more energy to move the water from Sacramento to the service area since most of the Mokelumne River supply flows to Bay Area via gravity. In addition, the Sacramento River water must be treated in the conventional treatment plants (USL and Sobrante) which require much more energy mostly for production of ozone.

California's Renewable Portfolio Standard (RPS) requires the electric utilities to incorporate additional renewable energy in their mix of generation. PG&E is currently using 17.7 percent renewables. The RPS requires 33 percent renewables by 2020. The increased use of renewable energy will drive down the emissions factor for electrical use. The electric emissions factor peaked at 878.71 lbs. $CO_2$/MWh in 2007 and dropped to 681.01 $CO_2$/MWh in 2010.

Biofuels (e.g., digester gas, biodiesel or ethanol) can be carbon neutral; however, that condition is dependent on the net life-cycle carbon impact of the production, transportation, and use of the biofuel. Some biofuels such as corn-based ethanol are not carbon neutral.

The Water Treatment and Distribution and Wastewater sectors are driven primarily by indirect emissions from electrical energy use. The RPS program will continue to drive increased use of renewables which will drive the emissions factor even lower in future years. As water treatment and distribution production and wastewater treatment volume will vary from year to year and therefore influence the corresponding emissions, the emissions should be reviewed based on the intensity.

Fleet emissions are direct emissions and currently result from combustion of diesel and gasoline. Based on the goals established in Policy 7.07, direct emissions must be less than 9,777 MT in 2013. Actual direct emissions in 2013 were 10,238 MT. So, the District did not meet its goal.

However, staff has made efforts to reduce direct emissions including purchasing more efficient vehicles, alternative fueled vehicles and reducing vehicle miles traveled.

The District is performing pilot programs for use of alternate-fuel vehicles and more efficient vehicles for supervisory personnel. The Alternative Fuel Vehicle Pilot is utilizing the Chevrolet Volt, an electric/gas vehicle, to evaluate its fuel efficiency and effectiveness for District staff. The Volt gets a 98 miles per gallon equivalent for electric only operation, and 37 miles per gallon for gasoline-only. However, users must start and end their day in the same place for a fast charge.

As vehicles are replaced, the individual workgroup needs are evaluated to determine the availability of alternative-energy or more fuel-efficient vehicles as alternatives. In FY14, the District replaced 28 vehicles to improve fuel efficiency. Overall, the new vehicles are 34 percent more efficient than the vehicles they replaced.

Staff is also working with District units and outside agencies to reduce the vehicle miles traveled for the District's fleet. The District presently has a central location in the city of Oakland where the majority of maintenance services and repairs for the District's fleet are performed. There is an identified cost associated with transporting these vehicles to and from this central location. Staff is working to establish a satellite location east of the hills to provide the same level of servicing and repair to reduce the miles traveled for vehicles and equipment on that side of the hills.

Finally, the District is installing a new fuel management system to effectively measure and manage fuel use throughout the organization. Fuel is an expensive commodity which has an impact on the environment. Managing the District's fuel use is good financial sense and supports our sustainability goals.

The emissions in the Buildings category are mostly driven by electrical use for heating and lighting. This category could have an intensity based goal based on number of people in the buildings or square footage. However, those numbers are not changing significantly. Reporting based on absolute emissions would be appropriate and easily measurable.

As mentioned above, the Raw Water sector emissions are highly variable based on the amount of pumping required and whether an alternate water supply is employed

## MANDATORY EMISSIONS INVENTORY REPORTING

Based on the requirements of AB32, CARB has established mandatory reporting regulations requiring annual reporting from the largest facilities in the state which account for 94 percent of greenhouse gas emissions from industrial and commercial stationary sources in California. Transportation sources, which account for 38 percent of California's total greenhouse gas emissions, are not covered by these regulations but will continue to be tracked through other means. The standards and approaches to reporting were developed in close consultation with the California Climate Action Registry, as required by the law.

There are about 800 separate sources that fall under the new reporting rules and include electricity generating facilities, electricity retail providers and power marketers, oil refineries, hydrogen plants, cement plants, cogeneration facilities and industrial sources that emit more than 25,000 tons of carbon dioxide each year from on-site stationary source combustions such as large furnaces. Backup generators, schools and hospitals are excluded from the requirements. Although most of the MWWTP's emissions are biogenic, the cogeneration facility falls under this requirement.

Affected facilities began tracking their emissions in 2008, which were reported beginning in 2009. Emissions for 2008 could be based on best available emission data. Beginning in 2010, however, emissions reports were required to be more rigorous and are subject to third-party verification. Verification takes place annually or every three years, depending on the type of facility. District staff is collecting fuel quantity and quality data for both biogas and diesel to comply with CARB requirements.

At the federal level, the EPA has issued the Mandatory Reporting of Greenhouse Gases Rule. The rule requires reporting of greenhouse gas (GHG) emissions from large sources and suppliers in the United States, and is intended to collect accurate and timely emissions data to inform future policy decisions. Under the rule, suppliers of fossil fuels or industrial greenhouse gases, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions are required to submit annual reports to the EPA. The rule became effective December 29, 2009. Emissions from the MWWTP must be reported under this rule.

## 4.4 Emissions Reductions and Offsets

Reductions in the District's GHG emissions are accomplished primarily through the following actions:

- Energy Efficiency: Adoption of more energy-efficient components and systems including buildings, vehicles, manufacturing processes, and equipment;
- Low-Carbon Energy Sources: Use of energy that generates fewer or no emissions such as renewables (e.g., wind, solar, and bioenergy), and nuclear energy, and
- Non-CO2 Emission Reductions: Reduction of emissions of non-CO2 greenhouse gases and black carbon (soot); for example, moving to climate-friendly alternatives to HFCs, cutting nitrous oxide emissions by improving combustion efficiency and particulate capture.
- Carbon sequestration: Removal of carbon containing substances, in particular carbon dioxide (CO2) from the atmosphere to terrestrial or marine reservoirs. Biological sequestration includes direct removal of CO2 from the atmosphere through land-use change (LUC), afforestation, reforestation, revegetation, carbon storage in landfills, and practices that enhance soil carbon in agriculture

The District has already implemented a number of measures that reduce GHG emissions including converting to a hybrid sedan fleet, installing microturbine cogeneration systems at the Administration Building and Adeline Maintenance Center, installing photovoltaic arrays at the Sobrante Water Treatment Plant and Adeline Administration Center, and expanding the biogas cogeneration capacity by adding a new turbine at the Main Wastewater Treatment Plant. Further reductions will be accomplished by reducing GHG emissions from routine operations through energy and water conservation, use of additional energy efficiency methods, and new alternative energy sources. In addition, the District could consider purchasing offsets accomplished through conservation easements and improved watershed practices through afforestation or reforestation. These further reductions are particularly important given the anticipated significant impact of operating the Folsom South Canal Connection (FSCC) and contemplated future energy-intensive projects such as desalination.

In dry years when a supplemental water supply is needed, the energy required to operate the FSCC will constitute a substantial portion of the District's overall energy demand. The corresponding GHG emissions also will be large. During an average year of operation, the two pumping plants in the FSCC will require approximately 35 million kWh of electric power, with associated emissions of 9,800 metric tons (MT) of CO2. Using historical records, the FSCC facilities are only expected to operate for three years out of every ten. However, climate change could increase drought frequencies and thus increase the need to operate the FSCC.

## INDIRECT EMISSIONS REDUCTIONS

The majority of the District's emissions are indirect from use of electrical energy. Power is one of the largest controllable operating costs and sources of GHG emissions. The process of managing electrical energy use is best handled by a plan-do-check-act process. The basic process is:

- **Plan.** Establish and prioritize energy conservation targets
- **Do.** Implement specific practices to meet these targets
- **Check.** Monitor and measure energy performance improvements and cost savings
- **Act.** Periodically review progress and make adjustments to energy programs

The District evaluates individual projects to conserve water and energy or create renewable energy. The District adopted Policy 7.07 to encourage and promote the cost-effective use of renewable energy. The District has developed opportunities to serve its facilities with onsite renewable generation under a net energy metering agreement such as the Sobrante Photovoltaic (PV) Project.

Examples of projects that will be evaluated to reduce the District's indirect emissions include:

- Reducing energy consumption in office buildings by installing motion activated light switches, installing more efficient lighting, and adding window films to reduce heat gain
- Installing submetering at process facilities (e.g., water and wastewater treatment facilities) to better manage larger electrical loads
- Regularly performing pump efficiency tests to evaluate efficiency degradation over time
- Replace low efficiency pumps/motors with higher efficiency equipment
- Install variable frequency drive units where applicable
- Institute operational changes to reduce energy consumption at the main wastewater treatment plant
- Include minimizing GHG emissions as a goal in planning new projects
- Reduce water use at District facilities through equipment upgrades and metering
- Reviewing the District's master equipment specifications to ensure energy efficient systems are appropriately procured.

## DIRECT EMISSIONS REDUCTIONS

Fleet operations (vehicles and portable equipment) produce 22 percent of EBMUD's total emissions which are most of the direct emissions. Other sources of direct emissions include the natural gas-powered microturbines at the AB and AMC and stationary generators. .

The natural gas powered microturbines currently installed are a best practice for controlling emissions because they are relatively clean burning and are used in a cogeneration facility to generate heating and cooling (i.e., relatively high thermal efficiency). Therefore, the focus for direct emissions reductions should be on fleet operations.

Examples of actions that will be considered to reduce the District's direct emissions are:

- Procuring alternative fueled (e.g., LNG, CNG, biodiesel) engines, hybrid electric vehicles, plug-in hybrid vehicles
- Downsizing vehicles/engines/fleet size
- Partnering with agencies/companies/etc. to develop new applications for existing technology (e.g., hybrid electric drives for service trucks)
- Employee outreach programs to promote best practices for operating efficiencies (e.g., proper tire inflation and minimized idling)
- Actions that reduce the vehicle miles traveled such as carpooling to meetings, webinars, and webcast conferences.

The result of this review should be reduced fuel use and fewer direct emissions.

**CARBON OFFSETS AND RENEWABLE ENERGY CREDITS**

A carbon offset is reduction of GHG emissions typically measured in metric tons of carbon dioxide that occur as a result of a discrete project or activity. The project or activity results in less carbon dioxide or other greenhouse gases in the atmosphere than would otherwise occur under “business as usual”. Carbon offsets allow an organization to forgo reducing its own emissions by paying another party to reduce its emission or investing in a project to reduce or sequester carbon emissions. Offsets can be created by renewable energy projects, energy efficiency, and land use and agriculture-based projects, such as methane abatement.

In order to be valid, offsets must be, unique (i.e. not counted elsewhere), additional (i.e., go beyond business as usual), not part of a regulatory requirement, permanent, verifiable, and real. Since the emissions are additional and unique, they can be applied to Scope 1, Scope 2, or Scope 3 emissions.

Future District offset projects could include:

- Purchase offsets through an offset provider (e.g., myclimate.org, etc.) for District business travel
- Afforestation or reforestation of District watershed property
- Further expansion of the cogeneration facility at the MWWTP using biogenic gas
- Further diversion of organic wastes from landfill to the anaerobic digesters at the MWWTP for increased renewable energy generation
- Enhancement of the hydro-power facilities at Camanche and Pardee

Renewable Energy Credits (RECs) represent the environmental and other non-power attributes of renewable electricity generation and are a component of all renewable electricity products. RECs are measured in single megawatt-hour increments and are created at the point where the electricity is generated. A REC, including its associated attributes and benefits, can be sold separately from the electricity generated by a renewable power source. This is called a Tradable REC or TREC. Buyers can select RECs based on the generation resource (e.g., wind, solar, geothermal), when the generation occurred, as well as the location of the renewable generator.

Renewable energy reduces GHG emissions by displacing emissions from other generation sources. A REC represents zero carbon emissions for one MWh of electricity enabling the purchaser to claim the benefits of renewable electricity. RECs provide electrical consumers a choice in terms of sources of electricity regardless of their location and the local mix of electrical generation sources.

Both RECs and carbon offsets can reduce an organization’s carbon footprint, but RECs can only reduce the GHG emissions from electrical use (i.e., Scope 2 emissions). A REC represents buying zero emission electricity from a renewable source. Renewable energy projects are not necessarily additional. Determining additionality requires application of additional tests. RECs are not required to be additional. Therefore, the reductions cannot be transferred to other emissions sources. Consequently, RECs will only be used to reduce Scope 2 emissions and carbon offsets will be used to reduce Scope 1 emissions if the District cannot meet its goals by reducing emissions directly.

Expansion of the cogeneration facilities at the MWWTP was completed in 2012 with the installation of a 4.5-MW gas turbine. The facility produces more than 100 percent of the electricity required to operate the MWWTP, on an annual basis. Excess renewable power with bundled RECs is sold to the Port of Oakland. The RECs from this facility may be sold with the power, sold separately, or retained by the District to offset District emissions.

The Camanche and Pardee hydropower facilities are older facilities that were constructed before carbon markets were established. Therefore, the Camanche and Pardee power plants are not additional and cannot be used to generate carbon credits. However, they can be used to create RECS.

# 5.0 Legislation and Regulations

## 5.1 Introduction

The California Global Warming Solutions Act of 2006 (AB 32), is far and away the dominant legislative initiative on climate change both statewide and nationally. While California's greenhouse gas (GHG) emissions constitute only about 1.4 percent of the global total (and 6.2 percent of the U.S. total), the Legislature and Governor have determined that California should take a leadership role in advancing technological and political solutions that could be adopted later by other states and nations. In 2010, the voters ratified the state's policy on climate change action by soundly rejecting Proposition 23, which would have suspended AB 32 until California's unemployment rate dropped to 5.5% or below for four consecutive quarters.

AB 32 was intended to take California beyond the terms of the Kyoto Protocol, which was negotiated in 1997. The protocol, which was adopted by 183 countries, required industrial countries to reduce GHG emissions 5.2% (1990 baseline) over 10 years, beginning in 2005. However, the Clinton administration acknowledged that the treaty failed to meet a condition within Senate Resolution 98, requiring a meaningful participation by developing countries in binding commitments limiting greenhouse gases; therefore, the treaty was never brought to the Senate for ratification.

AB 32 goes further than the Kyoto Protocol in establishing the first comprehensive program of regulatory and market mechanisms to achieve real, quantifiable, cost-effective reductions in GHG emissions by major industrial sources in California.

AB 32 built on previous state legislation (AB 1493, passed in 2002) which requires automakers to reduce greenhouse gas emissions from new cars and trucks sold in the state beginning in 2009. EBMUD was among the few water agencies that played an active role in supporting both of these bills in the Legislature. More than a year before AB 32 was signed into law, the Governor took action on climate change with an Executive Order establishing goals to reduce California's GHG emissions to:

- 2000 levels by 2010 (11 percent below business as usual)
- 1990 levels by 2020 (25 percent below business as usual)
- 80 percent below 1990 levels by 2050

The second of these goals became the centerpiece of AB 32.

The federal government, by contrast, has been much slower to require efforts by businesses and public agencies intended to reduce GHG emissions. Despite the passage through the House of Representatives of the Waxman-Markey (cap and trade) bill in 2009, the Senate declined to advance similar legislation and the prospects for comprehensive federal legislation now appear increasingly remote. The most significant actions at the federal level have been in the executive and judicial branches.

In his 2014 State of the Union address, President Obama promised executive action in pursuing GHG emission reductions to mitigate climate change. Executive branch actions for regulating power plant GHG emissions stem from EPA's 2010 regulations imposing permitting requirements on new and significantly modified large industrial sources of GHGs under the Clean Air Act's Prevention of Significant Deterioration (PSD) provision (also known as the Tailoring Rule). Utility and industry groups are challenging this authority in the Supreme Court, arguing that PSD covers only pollutants affecting ambient air quality. Pursuant to PSD, the EPA proposes to permit GHG emissions from fossil-fueled power plants. An important point within the Tailoring Rule discussion includes treatment of biogenic GHG emissions, such as those from the Power Generation Station (PGS) at EBMUD's Main Wastewater Treatment Plant (MWWTP).

## 5.2 AB 32 Implementation

AB 32 requires the state to achieve a reduction in GHGs emitted in California to 1990 levels by 2020; in quantitative terms, this is 174 million metric tons of CO2 equivalent (174 MMT CO2E). This reduction will be accomplished through an enforceable statewide cap on GHGs that began implementation in January 2012. Under the authority of AB 32, the California Air Resources Board (ARB) is developing appropriate regulations and has established a mandatory reporting system to track and monitor GHG emissions levels. Currently the Main Wastewater Treatment Plant (including PGS) is the only District facility required to report GHG emissions to ARB under the mandatory reporting system; however, because PGS emissions are biogenic, the Main Wastewater Treatment Plant is not subject to the cap.

In January 2009, ARB adopted the AB 32 Scoping Plan, which serves as the state's policy blueprint containing the broad overview of the programs, measures, and approaches to comply with AB 32. In developing the Plan, ARB was advised by the Climate Action Team (CAT), comprised of 14 state agencies and divided into 11 subgroups that address specific issue areas. The Water/Energy subgroup (WETCAT) is dedicated to examining the GHG reduction benefits from increased water use efficiency, given the energy demands of treating and distributing water; however, other subgroups such as the Land Use subgroup are also evaluating actions that could have a bearing on water/wastewater industry operations.

In December 2011 the CPUC issued a final decision in the Renewable Portfolio Standard (RPS) proceedings regarding renewable energy credits (RECs). The RPS requires investor-owned and publicly-owned utilities to procure at least 33% of their energy from qualified renewable energy sources by the year 2020. RECs are an accounting tool the utilities use to demonstrate compliance with the RPS and there are three REC categories. The final decision made some important distinctions among REC categories, including the third category for Tradable RECs or TRECs. The final decision clearly defines TRECs as being unbundled and limits their use for utility compliance with the RPS. This has the effect of reducing their value compared to bundled, or Category 1 RECs, and reduces potential revenue from PGS because much of the renewable energy generated there is used on site to power the Main Wastewater Treatment Plant. During the CPUC RPS proceeding, objections to including in-state renewable distributed energy generation in Category 3 were raised but ultimately overruled, and it does not appear that this ruling will change any time in the near future.

The Cap-and-Trade Rule became effective in 2012 and since that time there have been eight auctions, the most recent held on August 18, 2014. Currently the rule covers electricity (including imports) and large industrial facilities emitting more than 25,000 MTCO2e per year. Cap and trade is expected to expand and include transportation fuel suppliers in 2015. Capped facilities will be allocated a certain amount of emissions per year and will be required to either reduce their emissions or purchase offsets annually. The current emissions limit for large industrial facilities excludes emissions from biogenic sources. The majority of the District's emissions, in particular at the MWWTP, result from the use of digester gas, considered a biogenic source. Therefore, the District is currently excluded from the cap. Although the Rule has been active for several years and is well established, it continues to be challenged in courts but it is not likely that these challenges will be successful in halting cap and trade in California. There are also legislative efforts to introduce a carbon tax in the transportation fuel sector but its likelihood of success is uncertain at this time.

In February 2014, the ARB released its "Proposed First Update to the Climate Change Scoping Plan: Building on the Framework", as required by AB 32 on a recurrent five-year cycle. The Update notes that the state is on track to meet the goal of a 20% reduction in GHG emissions by 2020, and asserts that this progress is "evidence of California's ability to show that it is possible to break the historical connection between economic growth and associated increases in energy demand, combustion of carbon-intensive resources, and pollution." The Update also reaffirms the

State's commitment to an 80% reduction in GHG emissions by 2050, and warns that achieving this goal could be much more difficult, particularly with anticipated population growth.

Similar to the previous Scoping Plan, the Update gives only limited attention to the water sector. With the passage of SB X7 7 (Steinberg) in 2009, requiring a 20% per capita reduction in urban water use consumption by 2020, this bill has become the focal point for state efforts to advance water conservation, dovetailing with the aims of AB 32. In addition, the Update discusses current State efforts underway in water recycling and with its Integrated Regional Water Management Plan (IRWMP) program, which funds numerous water efficiency projects.

The Update emphasizes incentive approaches for the water sector including: preference for funding IRWMP projects that achieve water use efficiency, with numeric targets; development of green infrastructure permits by the Water Boards to treat and capture urban runoff for local use; and development of a comprehensive groundwater management strategy by the SWRCB. No specific new regulations are proposed in this Update which now makes no reference to advocating a "public goods charge" on water, as it advocated in the previous version. There is a proposal for the CPUC to complete water-energy nexus rulemaking by 2016 and to continue implementation of joint water-energy utility efficiency programs and partnerships; however, this is more intended to facilitate co-funding opportunities between the electricity and water sectors for efficiency projects that achieve both energy and water savings. There is a reference to the concept of a "loading order", based on CPUC requirements for the electricity sector that prioritizes investments in energy efficiency ahead of developing new power supplies. The Update states that "the conservation-first policy could be implemented through legislation or joint-agency action". Such a mandate runs counter to the integrated resources portfolio planning widely practiced in the water industry and would be highly controversial.

## 5.3 Coordination with State and National Associations

EBMUD has been working both independently and in collaboration with various associations to monitor, assess, and comment on proposals coming out of the AB 32 process. On the water side, California Urban Water Agencies (CUWA) has an active Climate Change Committee which has adopted Climate Change Policy Principles:
http://cuwa.org/pubs/Climate_Change_Policy_Principles.pdf

In addition, CUWA has collaborated with the California Municipal Utilities Association and jointly adopted "Cap and Trade General Auction Revenues for Water-Related Purposes": http://cuwa.org/pubs/CapAndTradeCMUA_CUWA.pdf

In 2009, CUWA completed a greenhouse gas emission inventory and management guide for water utilities, in cooperation with the Water Research Foundation.

In 2007, EBMUD became one of the first members of the California Wastewater Climate Change Group (CWCCG). The CWCCG represents over 40 wastewater agencies that treat approximately 90 percent of the municipal wastewater in the state of California. The primary purpose of the CWCCG is to respond to climate change and forthcoming regulations and to provide a unified voice for the California wastewater industry. District staff actively engages in CWCCG activities, which include tracking regulatory and legislative developments, participating in proceedings, meetings, and workshops of the CPUC and California Energy Commission (CEC), and providing industry information to the appropriate decision makers.

EBMUD is represented at the national level by a number of associations including AMWA, AWWA, the Western Urban Water Coalition, NACWA, and others. These organizations, and particularly AMWA, have been intensifying their focus on climate change and are seeking to ensure that the water and wastewater industries' perspectives are included in future legislation.

## 5.4 Other State Climate Change Legislation

AB 32 was preceded by two bills that established the California Climate Action Registry in 2001 (SB 527), and the regulation of tailpipe $CO_2$ emissions in 2002 (AB 1493). The first law that explicitly addressed climate change was AB 4420, passed in 1988, that directed the Energy Commission to prepare and maintain the state's inventory of greenhouse gas (GHG) emissions and to study the effects of GHGs.

In 2008, another major bill relating to climate change policy was enacted. SB 375 (Steinberg) requires the ARB to set regional targets for the purpose of reducing greenhouse gas emissions from passenger vehicles, for 2020 and 2035. If regions develop integrated land use, housing and transportation plans that meet the SB 375 targets, new projects in these regions can be relieved of certain review requirements of the California Environmental Quality Act.

Table 5.1 summarizes state legislation relevant to EBMUD that addresses climate change either directly or indirectly.

**Table 5.1:** California Legislation on Climate Change

| Bill (Author) | Subject | Impact on EBMUD |
|---|---|---|
| AB 1493 (Pavley)* 2002 | Requires regulation of CO2 emissions from noncommercial vehicles | Indirect benefit of increased fuel efficiency |
| AB 32 (Núñez)* 2006 | Creates a cap and trade regime for GHG emissions statewide. | Increased costs for fuel and electricity. |
| AB 118 (Núñez) 2007 | Creates Alternative and Renewable Fuel and Vehicle Technology Program, to transform fuel and vehicle types | $120M in state grants available – could provide future funding for EBMUD fleet replacements. |
| AB 236 (Lieu) 2007 | Requires the State to revise criteria for purchasing motor pool vehicles to rank environmental and energy benefits. | Potential impact on developing market for EBMUD fleet vehicles. |
| AB 662 (Ruskin)* 2007 | Requires cost-effective operating efficiency standards for appliances related to energy and water. | Assists EBMUD in meeting water conservation goals. |
| AB 1109 (Huffman) 2007 | New standards for lighting efficiency and hazardous components | Beneficial impact on energy consumption at District facilities |
| AB 1470 (Huffman)* 2007 | Sets goal of 200,000 solar water heating systems by 2017. | Advances use of renewable energy. |
| AB 1560 (Huffman)* 2007 | Prescribes water efficiency and conservation standards for new buildings | Supports District goals for conservation and supply reliability. |
| AB 1613 (Blakeslee) 2007 | Requires capturing waste heat to improve electrical generating efficiency | No direct impact |
| SB 97 (Dutton) 2007 | Requires CEQA evaluation of GHGs for projects. | Additional analysis of District project impacts |
| SB 7X 7 (Steinberg) 2009** | Requires 20% per capita reduction in urban water use by 2020. | Consistent with EBMUD's water conservation goals |
| SB 104 (Oropeza) 2009 | Adds nitrogen trifluoride to the state list of regulated GHGs. | No direct impact. |
| SB 535 (De Leon) 2012 | Directs funding from Greenhouse Gas Reduction Fund to disadvantaged communities. | May provide funding for projects within EBMUD service area. |
| SB 726 (Lara) 2013 | Requires ARB to report on state expenditures related to Western Climate Initiative. | No direct impact. |

*EBMUD supported **EBMUD support if amended

## 5.5 National Regulations

In October 2009, EPA adopted its Mandatory Greenhouse Gas Reporting Rule, which establishes mandatory greenhouse gas (GHG) reporting requirements for owners and operators of certain facilities that directly emit GHG as well as for certain fossil fuel suppliers and industrial GHG suppliers. It is similar to ARB reporting rule but excludes biogenic emissions, therefore the District's wastewater facility is not subject to reporting.

In May 2010, EPA issued its "Tailoring Rule" which regulates GHG emissions under the Clean Air Act (CAA) through New Source Review (NSR) and Title V Operating Permits. The rule is called the Tailoring Rule because EPA had to tailor or modify the typical threshold used for conventional pollutants. Under the CAA, facilities that emit over 100 to 250 tons per year of traditional pollutants (e.g., SOx, NOx) are regulated. However, applying the same threshold to GHG emissions is not feasible, since GHGs are emitted at much greater quantities. Under this rule, facilities with GHG emissions exceeding certain thresholds will be subject to Prevention of Significant Deterioration (PSD) under NSR and Title V permitting under the CAA. Facilities that are subject to PSD will be required to install "best available control technology", which is still being identified, to control GHG emissions. Facilities subject to Title V will be subject to monitoring and record keeping requirements for GHGs. Initially, the EPA deferred the inclusion of biogenic emissions under the PSD ("Deferral Rule") for three years (2011-2014). The effect of this deferral was that no new wastewater facilities would be subject to PSD or Title V. In 2013 an appeals court ruled the Deferral Rule to be invalid ("vacature") and the Deferral Rule has been appealed to the Supreme Court. If the Supreme Court decides not to hear the case the vacature will be automatically affirmed and a decision by the court is expected in the summer of 2014. NACWA is monitoring and working closely with the EPA on this issue.

In 2011, the Obama Administration finalized the first-ever fuel economy standards for Model Year 2014-2018 for heavy-duty trucks, buses, and vans. The Administration is now working with industry and other key stakeholders to develop post-2018 fuel economy standards for heavy-duty vehicles to further reduce fuel consumption through the application of advanced cost-effective technologies.

On April 18, 2012, EPA finalized regulations to reduce air pollution from the oil and natural gas industry, while allowing continued growth in U.S. oil and natural gas production. The final rules rely on proven technologies and best practices to reduce emissions of smog-forming volatile organic compounds (VOCs). The final rules are expected to yield a nearly 95 percent reduction in VOC emissions from more than 11,000 new hydraulically fractured gas wells each year. This reduction would be accomplished primarily through capturing natural gas that currently escapes into the air, and making that gas available for sale. The rules also will reduce air toxics, which are known or suspected of causing cancer and other serious health effects, and emissions of methane, a potent greenhouse gas.

On September 20, 2013, the U.S. Environmental Protection Agency announced its first steps under President Obama's Climate Action Plan to reduce carbon pollution from power plants. EPA is proposing carbon pollution standards for new power plants built in the future, and is kicking off the process of engagement with states, stakeholders, and the public to establish carbon pollution standards for existing power plants.

# 6.0 Public Education and Industry Participation

## 6.1 Public and Employee Education

EBMUD continues to work to inform the public and ratepayers about climate change, potential impacts to the District, and actions the District is taking. The District website includes pages on climate change. EBMUD also promotes employee awareness of climate change issues by sharing information and activities using a climate change Wiki on its Intranet and by sponsoring presentations about climate change for staff.

## 6.2 Industry Participation

EBMUD is participating on a number of working groups to address the impact of climate change on water utilities. Below is a brief summary of each of the working groups. More information can be found on the Wiki (http://wiki/water_ops/index.php5/EBMUD_Climate_Change_Portal).

**CLIMATE READY WATER UTILITIES WORKING GROUP**

In the fall 2009, EPA convened a Climate Ready Water Utility (CRWU) Working Group under the National Drinking Water Advisory Council (NDWAC). Senior EBMUD staff participated in the working group including a number of face-to-face meetings. The charge of the CRWU Working Group is to evaluate the concept of “Climate Ready Water Utilities” and provide recommendations to the full NDWAC on the development of an effective program for drinking water and wastewater utilities, including recommendations to

- Define and develop a baseline understanding of how to use available information to develop climate change adaptation and mitigation strategies, including ways to integrate this information into existing complementary programs such as the Effective Utility Management and Climate Ready Estuaries Program
- Identify climate change-related tools, training, and products that address short-term and long-term needs of water and wastewater utility managers, decision makers, and engineers, including ways to integrate these tools and training into existing programs
- Incorporate mechanisms to provide recognition or incentives that facilitate broad adoption of climate change adaptation and mitigation strategies by the water sector into existing EPA Office of Water recognition and awards programs or new recognition programs

The final NDWAC report was delivered to the EPA Administrator in January 2011 and included eleven findings and twelve recommendations, an adaptive response framework to guide climate ready activities, and identification of resources and incentives to support and encourage utility climate readiness. A full copy of the report is available on the EPA’s Climate Ready Water Utilities website at http://water.epa.gov/infrastructure/watersecurity/climate/.

**EPA CLIMATE RESILIENCE EVALUATION AND AWARENESS TOOL**

As part of the CRWU Program, the EPA developed a Climate Resilience Evaluation and Assessment Tool (CREAT) to assist drinking water and wastewater utility owners and operators in understanding potential climate change impacts and in assessing the related risks at their utilities. EBMUD staff participated served on the Working Group assisting the EPA with the development of CREAT.

The charge of the working group was to assist in the evaluation of whether the framework for the existing Vulnerability Self Assessment Tool (VSAT) could be revised to address climate change issues and provide input and inform tool development throughout all phases of the process. VSAT was developed to assess vulnerabilities regarding man-made threats and natural disasters. The Working Group completed the evaluation of the VSAT tool and completed the framework for the climate change risk assessment and awareness tool in early 2010. CREAT is a stand-alone application that allows utilities to assess vulnerabilities related to climate change impacts with the purpose of elevating awareness and generating provisional adaptation options.

EBMUD and the New York Department of Environmental Protection hosted pilots for the CREAT software. EPA incorporated comments from these pilots and released CREAT version 1 to the public in December 2010. EPA is planning new functionality for CREAT version 2.0 including supporting multiple climate change scenarios, extreme events, energy efficiency and climate change analysis comparison. EBMUD is participating in version 2 and attended a face-to-face meeting in June 2011 with EPA's technical team.

## VULNERABILITY ASSESSMENT AND RISK MANAGEMENT TOOL FOR CLIMATE CHANGE

EBMUD staff is participating on the Project Advisory Committee for the Water Research Foundation's Project, Vulnerability Assessment and Risk Management Tools for Climate Change: Assessing Potential Impacts and Identifying Adaptation Options. This project is being funded by the Climate Change Strategic Initiative and by a partnership between the Water Research Foundation and the New York State Energy Research and Development Authority. The objective of this project is to develop tools to assist water utilities in identifying and managing risks associated with potential impacts from climate change.

In 2009, the Stockholm Environment Institute (SEI) was selected to develop this tool. The first phase of the work will synthesize existing knowledge on climate change risk identification and assessment. In 2010, SEI reviewed the literature and prepared a draft synthesis of the state of current knowledge related to climate risk identification and assessment. As part of this task, SEI has developed a draft survey instrument to seek more targeted information. In 2011, SEI plans to complete their synthesis report, develop their risk management approach, and continue with the pilot studies with New York City and Colorado Springs.

## ADAPTING TO RISING TIDES

EBMUD staff participated in a sub-regional working group for the Adapting to Rising Tides Project, a joint effort of the Bay Conservation and Development Commission (BCDC) and NOAA to conduct a vulnerability and risk assessment and develop adaptation strategies to address rising sea levels associated with climate change. The Vulnerability and Risk Assessment Report details the impacts of 16 inches and 55 inches of sea level rise on key EBMUD assets, including the MWWTP. EBMUD staff will continue to participate in related efforts led by BCDC to further define the vulnerabilities and start to develop regional, multi-agency adaptation strategies.

# Appendix A – Glossary and Acronyms

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| **AB32** | Assembly Bill 32 (California Global Warming Solutions Act) |
| **Adaptation** | Initiatives and measures to reduce the vulnerability of natural and human systems to actual or expected climate change effects. Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc. |
| **Afforestation** | Direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. See also Re- and Deforestation. |
| **AMWA** | Association of Metropolitan Water Agencies |
| **Anthropogenic** | Resulting from or produced by human actions |
| **AR4** | IPCC Fourth Assessment Report |
| **AWWA** | American Water Works Association |
| **BCDC** | Bay Conservation and Development Commission |
| **Biofuel** | Any liquid, gaseous, or solid fuel produced from plant or animal organic matter e.g. soybean oil, alcohol from fermented sugar, black liquor from the paper manufacturing process, wood as fuel, etc. Second-generation biofuels are products such as ethanol and biodiesel derived from ligno-cellulosic biomass by chemical or biological processes. |
| **Biogenic** | Resulting from or produced by biological processes. |
| **Biomass** | The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass. |
| **Cap** | Mandated restraint as an upper limit on emissions. The Kyoto Protocol mandates emissions caps in a scheduled timeframe on the anthropogenic GHG emissions released by Annex B countries. By 2008-2012 the EU e.g. must reduce its $CO_2$-equivalent emissions of six greenhouse gases to a level 8 percent lower than the 1990-level. |
| **Carbon Cycle** | The set of processes such as photosynthesis, respiration, decomposition, and air-sea exchange, by which carbon continuously cycles through various reservoirs, such as the atmosphere, living organisms, soils, and oceans. |
| **Carbon Offset** | A carbon offset represents a quantity of GHG emissions reductions, measured in units (usually metric tons) of carbon dioxide–equivalent (CO2e) that occur as a result of a discrete project. |
| **CARB** | California Air Resources Board |
| **CAT** | Climate Action Team |
| **CCAR** | California Climate Action Registry |
| **CCX** | Chicago Climate Exchange |

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| **CFC** | Chlorofluorocarbon |
| **$CH_4$** | Methane |
| **CFI** | Carbon Financial Instrument |
| **Climate Change** | As defined in the IPCC AR4 report, climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. |
| **CNG** | Compressed Natural Gas - Natural gas that has been compressed under high pressures, typically between 2000 and 3600 psi, and held in a container |
| **$CO_2$ Equivalent** | The amount of $CO_2$ emission that would cause the same radiative forcing as an emitted amount of a well mixed greenhouse gas, or a mixture of well mixed greenhouse gases, all multiplied with their respective Global Warming Potentials to take into account the differing times they remain in the atmosphere. |
| **Deforestation** | The natural or anthropogenic process that converts forest land to non-forest. See afforestation and reforestation. |
| **De Minimis** | So small or minimal in difference that it does not matter or the law does not take it into consideration |
| **DWR** | Department of Water Resources |
| **Emissions Trading** | A market-based approach to achieving environmental and air quality objectives. It allows those reducing GHG emissions below their emission cap to use or trade the excess reductions to offset emissions at another source inside or outside the country. In general, trading can occur at the intra-company, domestic, and international levels. The Second Assessment Report by the IPCC adopted the convention of using permits for domestic trading systems and quotas for international trading systems. Emissions trading under Article 17 of the Kyoto Protocol is a tradable quota system based on the assigned amounts calculated from the emission reduction and limitation commitments listed in Annex B of the Protocol. |
| **ENSO** | El Nino-Southern Oscillation |
| **FSCC** | Folsom South Canal Connection |
| **GCM** | General Circulation Model |
| **GHG** | Greenhouse Gas - Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapor ($H_2O$), carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$) and ozone ($O_3$) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Besides carbon dioxide, nitrous oxide and methane, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons. |

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| **Global Warming** | Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions. |
| **Greenhouse Effect** | Greenhouse gases effectively absorb infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus, greenhouse gases trap heat within the surface-troposphere system. This is called the greenhouse effect. Thermal infrared radiation in the troposphere is strongly coupled to the temperature at the altitude at which it is emitted. In the troposphere, the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, –19°C, in balance with the net incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, +14°C. An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing that leads to an enhancement of the greenhouse effect, the so-called enhanced greenhouse effect. |
| **GWP** | Global Warming Potential |
| **HCFC** | Hydrochlorofluorocarbon |
| **Inertia** | In the context of climate-change mitigation, inertia relates to the difficulty of adaptive change resulting from pre-existing conditions within society such as physical man-made capital, natural capital and social non-physical capital, including institutions, regulations and norms. Existing structures lock in societies, making change more difficult. |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IRWMP** | Integrated Regional Water Management Plan |
| **JSA** | Joint Settlement Agreement |
| **LNG** | Liquified Natural Gas - Natural gas liquified either by refrigeration or by pressure |
| **Market Based Regulation** | Regulatory approaches using price mechanisms (e.g., taxes and auctioned tradable permits), among other instruments, to reduce GHG emissions. |
| **MGD** | Millions Gallons per Day |
| **Mitigation** | Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks. |
| **MMT** | Million Metric Tons |
| **MT** | Metric Tons |
| **MWWTP** | Main Wastewater Treatment Plant |

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| **NOAA** | National Oceanic and Atmospheric Administration |
| **$NO_2$** | Nitrous Oxide |
| **No Regrets Investment** | Investment that is expected to provide a positive benefit during the useful life of the investment with minimal risk of impacts from climate change. |
| **NOx** | Reactive nitrogen oxides (the sum of NO and $NO_2$) |
| **PDO** | Pacific Decadal Oscillation |
| **ppm** | Parts per Million |
| **PV** | Photovoltaic |
| **Radiative Forcing** | As defined in the IPCC AR4 report, radiative forcing is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcings tend to cool the surface. |
| **REC** | Renewable Energy Credit is a commodity representing proof that one megawatt-hour (MWh) of electricity was generated from a renewable energy source. |
| **Reforestation** | Direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was previously forested but converted to non-forested land. See also afforestation and deforestation. |
| **Relative Sea Level** | Sea level measured by a tide gauge with respect to the land upon which it is situated. Mean sea level is normally defined as the average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides. See Sea level change. |
| **Sea Level Change** | Sea level can change, both globally and locally, due to (i) changes in the shape of the ocean basins, (ii) changes in the total mass of water and (iii) changes in water density. Sea level changes induced by changes in water density are called steric. Density changes induced by temperature changes only are called thermosteric, while density changes induced by salinity changes are called halosteric. See also Relative Sea Level; Thermal expansion. |
| **Sequestration** | Carbon storage in terrestrial or marine reservoirs. Biological sequestration includes direct removal of $CO_2$ from the atmosphere through land-use change, afforestation, reforestation, carbon storage in landfills and practices that enhance soil carbon in agriculture. |
| **SimClim** | SimClim is an integrated modeling software used to assess climate change impacts and adaptation. |
| **Snow Line** | The lower limit of permanent snow cover, below which snow does not accumulate. |
| **SWC** | Snow Water Content |

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| **Thermal Expansion** | In connection with sea level, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level. See Sea level change. |
| **TNF** | True Natural Flow |
| **TREC** | A Tradable Renewable Energy Credit (TREC) is a transaction in which an entity procures only a REC (and not the underlying energy) from another entity |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **VMT** | Vehicle Miles Traveled |
| **VOC** | Volatile Organic Compound |
| **WSMP 2040** | EBMUD’s Water Supply Management Program plan to ensure adequate and reliable high-quality water supplies that will meet our customers’ water needs up to year 2040 |

# Appendix B – References

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