Chapter 12
Climate Change

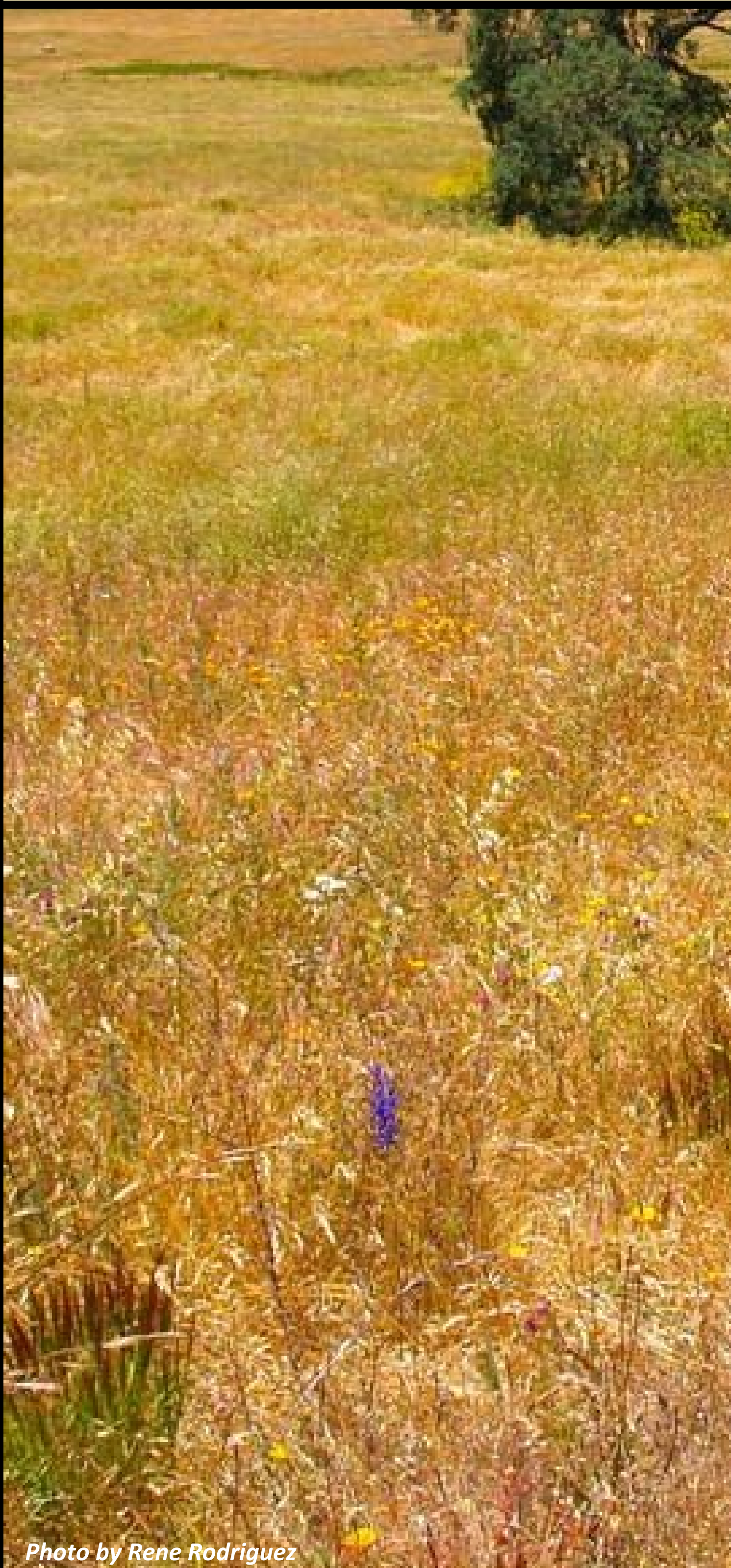

Photo by Rene Rodriguez

This chapter describes potential climate change effects that may occur due to global climate change and increases in greenhouse gas emissions within San Benito County.

This chapter is organized into the following sections:

- Climate Change (Section 12.1)
- Greenhouse Gas Emissions Inventory (Section 12.2)
- Effects of Climate Change and Adaptation (Section 12.3)

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SECTION 12.1 CLIMATE CHANGE

Introduction

This section summarizes the scientific basis for climate change and provides an overview of Federal, State, and local policies, regulations, and laws associated with climate change.

Key Terms

Black Carbon (BC). Black Carbon, commonly called soot, is formed through the incomplete combustion of fossil fuels, biofuel, and biomass (e.g., wood, waste, and alcohol fuels). Black Carbon warms the planet by absorbing heat in the atmosphere and by reducing the ability of snow and ice to reflect sunlight.

California Climate Action Registry (CCAR). The California Climate Action Registry is a nonprofit voluntary registry for sources and producers of greenhouse gas (GHG) emissions.

Carbon dioxide (CO_2). Carbon Dioxide is an odorless and colorless greenhouse gas. Outdoor levels of CO_2 are not high enough to result in negative health effects. CO_2 is emitted from natural sources (the decomposition of dead organic matter; respiration of bacteria, plants, animals, and fungus; evaporation from oceans; and volcanic out-gassing) and man-made sources (the burning of coal, oil, natural gas, and wood).

Carbon dioxide equivalent (CO_2e). A distinct measure for describing how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of CO_2 as the reference.

Carbon Sequestration. Carbon storage (sequestration) occurs in forests and soils, primarily through the natural process of photosynthesis. Atmospheric carbon dioxide is taken up through leaves and becomes carbon in the woody biomass of trees and other vegetation.

Chlorofluorocarbon (CFC). CFCs are gases formed synthetically by replacing all hydrogen atoms in methane or ethane (C_2H_6) with chlorine and/or fluorine atoms. CFCs are nontoxic, nonflammable, insoluble, and chemically unreactive in the troposphere (the layer of the atmosphere nearest the earth's surface).

Global Warming Potential (GWP). GWP is one type of simplified index based upon radiative properties that can be used to estimate the potential future impacts of emissions of different gases upon the climate system in a relative sense. The reference gas in this case is CO_2. One teragram of carbon dioxide equivalent (Tg CO_2 e) is essentially the emissions of the gas multiplied by the GWP.

Greenhouse Effect. The earth's natural warming process is known as the "greenhouse effect." Certain atmospheric gases that trap heat in the atmosphere, causing the greenhouse effect, are referred to as greenhouse gases (GHGs).

Greenhouse Gases (GHG). Gases that contribute to the greenhouse effect. Some GHGs such as carbon dioxide occur naturally, and are emitted to the atmosphere through natural processes and human activities. Other GHGs (e.g., fluorinated gases) are created and emitted solely through human activities. The principal GHGs that enter the atmosphere because of human activities include: water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Chlorofluorocarbons (CFCs), and fluorinated gases (hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)).

Greenhouse Gas (GHG) Inventory. A greenhouse gas (GHG) inventory is an accounting of the amount of greenhouse gases emitted to or removed from the atmosphere over a specific period of time (e.g., one year) for a specified area. Inventories may be global or local. A GHG inventory also provides information on the activities that cause emissions and removals, as well as background on the methods used to make the calculations. Policy makers use GHG inventories to track emission trends, develop strategies and policies, and assess progress in controlling GHG emissions.

Hydrofluorocarbons (HFC). HFCs are synthetic, man-made chemicals that are used as a substitute for CFCs. Of all the greenhouse gases, they are one of three groups with the highest global warming potential.

Intergovernmental Panel on Climate Change (IPCC). The IPCC assesses the scientific, technical, and socio-economic information relevant for the understanding of the risk of human-induced climate change.

Local Governments for Sustainability (ICLEI). ICLEI, now called ICLEI-Local Governments for Sustainability, is an international association of local governments, as well as national and regional local government organizations, that have made a commitment to sustainable development.

Methane (CH_4). CH_4 is highly flammable GHG, and may form explosive mixtures with air. Methane has both natural sources (such as in swamplands) and anthropogenic sources (such as growing rice, raising cattle, using natural gas, mining coal, fossil-fuel combustion, and biomass burning).

Nitrous oxide (N_2O). N_2O, also known as laughing gas, is a colorless greenhouse gas. Nitrous oxide is considered harmless in small doses, but heavy exposure can cause brain damage.

Perfluorocarbons (PFCs). Perfluorocarbons have stable molecular structures, and do not break down through chemical processes in the lower atmosphere. PFCs have very long lifetimes – between 10,000 and 50,000 years. Two common PFCs are tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6).

Sulfur hexafluoride (SF_6). Sulfur hexafluoride is an inorganic, odorless, colorless, nontoxic, nonflammable gas. It also has the highest GWP of any gas evaluated (23,900). In high concentrations in confined areas, the gas presents the hazard of suffocation because it displaces the oxygen needed for breathing.

Teragram (Tg). A teragram is equal to one trillion grams, or one billion kilograms.

Tonne. Also known as a “metric ton” (MT), a measurement equal to 1,000,000 grams (or 1,000 kilograms). One tonne converts to 2,204.62 pounds. By comparison, the standard ton used in the United States (a short ton) is equal to 2,000 pounds.

Water vapor (H_20). Water vapor (H_20) is the most abundant, important, and variable GHG in the atmosphere. Water vapor is not considered a pollutant; in the atmosphere it maintains a climate necessary for life.

Regulatory Setting

International Treaties

United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The UNFCCC entered into force in March of 1994. With 194 Parties, the UNFCCC has near universal membership, and is the parent treaty of the 1997 Kyoto Protocol. The Kyoto Protocol has been ratified by 190 of the UNFCCC Parties. Under the Protocol, 37 nations, including highly industrialized countries and countries undergoing the process of transition to a market economy, have legally binding emission limitation and reduction commitments. The ultimate objective of both the UNFCCC and the Kyoto Protocol is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system. The United States (U.S.), although a signatory to the Kyoto Protocol, has neither ratified nor withdrawn from the Protocol. The signature alone is merely symbolic, as the Kyoto Protocol is non-binding on the United States unless ratified.

The 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit, was held in Copenhagen, Denmark, in December 2009. The Copenhagen Accord, an agreement between the United States, China, India, South Africa, and Brazil that delegates agreed to "take note of," recognized that climate change is one of the greatest challenges of the present, and acknowledged that actions should be taken to keep any temperature increases to below two degrees Celsius. The document is not legally binding and does not contain any legally binding commitments for reducing CO_2 emissions. The Copenhagen Accord asks countries to submit emissions targets by the end of January 2010, and paves the way for further discussions to occur at the 2010 UN climate change conference in Mexico.

Federal Plans, Policies, Regulations, and Laws

The Federal government continues to actively develop a climate change program to reduce GHGs. The April 2, 2007, U.S. Supreme Court ruling that carbon dioxide (CO_2) is an air pollutant as defined under the Clean Air Act (CAA), and that EPA has the authority to regulate emissions of GHGs (*Massachusetts v. U.S. Environmental Protection Agency* [2007] 549 U.S. 05-1120) propels the development of new rules and regulations.

The American Clean Energy and Security Act (H.R. 2454). On May 21, 2009, the House of Representatives Energy and Commerce Committee approved H.R. 2454, "The American Clean Energy and Security Act." Also known as the Waxman-Markley comprehensive energy bill, this legislation amends the Public Utility Regulatory Policies Act of 1978 to establish a combined efficiency and renewable electricity standard that requires utilities to supply an increasing percentage of their demand from a combination of energy efficiency savings and renewable energy (6 percent in 2012, 9.5 percent in 2014, 13 percent in 2016, 16.5 percent in 2018, and 20 percent in 2021-2039). H.R. 2425 includes a cap-and-trade global warming reduction plan designed to reduce economy-wide GHG emissions 17 percent by 2020. Other provisions include: studies and incentives regarding new carbon capture and sequestration technologies; energy efficiency incentives for homes and buildings; and grants for green jobs. The House of Representatives passed H.R. 2454 by a vote of 219-212 on June 26, 2009. As of July 1, 2010, the Senate has not yet passed this proposed legislation nor their own version of a climate change bill.

U.S. Environmental Protection Agency

Greenhouse Gas Reduction Initiatives. According to the U.S. Environmental Protection Agency (EPA), the United States government is using voluntary and incentive-based programs to reduce emissions, and has established programs to promote climate technology and science. This strategy has been developed to incorporate expertise from Federal agencies and the private sector. EPA's comprehensive policy to address climate change includes: energy efficiency, renewable energy, methane and other non-carbon dioxide (non-CO_2) gases, agricultural practices, and implementation of technologies to achieve GHG reductions. EPA administers multiple programs that encourage voluntary GHG reductions, including: Clean Energy-Environment State Partnership, Climate Leaders, Combined Heat and Power Partnership, ENERGY STAR, AgSTAR, EPA Office of Transportation and Air Quality Voluntary Programs, Green Power Partnership, High GWP Gas Voluntary Programs, Methane Voluntary Programs, and WasteWise (EPA 2009).

Endangerment and Cause or Contribute Findings. On December 7, 2009, the EPA Administrator signed two distinct findings regarding greenhouse gases under Section 202(a) of the Clean Air Act:

- Endangerment Finding: The Administrator finds that the current and projected concentrations of the six key well-mixed greenhouse gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) – in the atmosphere threaten the public health and welfare of current and future generations.

- Cause or Contribute Finding: The Administrator finds that the combined emissions of these well-mixed greenhouse gases from new motor vehicles and new motor vehicle engines contribute to the greenhouse gas pollution, which threatens public health and welfare.

These findings for GHGs do not include any specific rules. However, this action is a prerequisite to finalizing the EPA's proposed greenhouse gas emission standards for light-duty vehicles, described below. EPA's GHG "endangerment finding" implements the U.S. Supreme Court's landmark 2007 decision, which held that EPA has the authority to regulate GHGs.

Proposed Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards. On September 15, 2009, EPA and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) proposed a national program that would reduce greenhouse gas emissions and improve fuel economy for new cars and trucks sold in the United States. The standards that make up this proposed national program would apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years 2012 through 2016. They require these vehicles to meet an estimated combined average emissions level of 250 grams of carbon dioxide per mile, equivalent to 35.5 miles per gallon (MPG) if the automobile industry were to meet this carbon dioxide level solely through fuel economy improvements.

Proposed Prevention of Significant Deterioration/Title V Greenhouse Gas Tailoring Rule. On August 31, 2009, the EPA released the draft "Prevention of Significant Deterioration/Title V Greenhouse Gas Tailoring Rule." This proposed rule would limit Federal permitting requirements to industrial sources that emit 25,000 tonnes of CO_2 equivalent (CO_2e) per year.

Final Mandatory Reporting of Greenhouse Gas Rule. On September 22, 2009, the EPA administrator signed the Final Mandatory Reporting of Greenhouse Gas Rule to require large emitters and suppliers of GHGs to begin collecting data starting January 1, 2010 under a new reporting system. Under this rule, suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles or engines, and facilities that emit 25,000 tonnes or more per year of GHGs are now required to submit annual reports to EPA.

State of California Plans, Policies, Regulations, and Laws

The California Air Resources Board (CARB) is the agency responsible for coordination and oversight of State and local air pollution control programs in California, and for implementing the California Clean Air Act (CCAA). Various statewide and local initiatives have been established to reduce the State's contribution to GHG emissions, as well as to raise awareness about the various contributors to and consequences of climate change.

Statutes

Senate Bill 1771 (2000)–California Climate Action Registry (CCAR). Senate Bill (SB) 1771 (Chapter 1018, Statutes of 2000) established CCAR in 2000. In 2001, SB 527 (Chapter 769, Statutes of 2001) modified the CCAR as a nonprofit voluntary registry for GHG emissions. (SB 1771 enacted Sections 42800–42870 of the California Health and Safety Code and Public Resources Code Section 25730; SB 527 amended Sections 42810, 42821–42824, 42840–42843, 42860, and 42870 of the Health and Safety Code.) The purpose of the CCAR is to help companies and organizations with operations in the State establish GHG emissions baselines against which future GHG emissions reduction requirements may be applied. The CCAR has developed a general protocol and additional industry-specific protocols that provide guidance on how to inventory GHG emissions for participation in the registry.

Assembly Bill 1493 (2002). In 2002, then-Governor Gray Davis signed AB 1493 (Statutes 2002, Chapter 200; amending Health & Safety Code, Section 42823 and adding Health & Safety Code, Section 43018.5). AB 1493 requires that CARB develop and adopt, by January 1, 2005, regulations that achieve the maximum feasible reduction of GHGs emitted by passenger vehicles and light-duty trucks and other vehicles determined by CARB to be vehicles whose primary use is noncommercial personal transportation.

To meet the requirements of AB 1493, CARB approved amendments to the California Code of Regulations (CCR) in 2004 by adding GHG emissions standards to California's existing standards for motor vehicle emissions. Amendments to CCR Title 13, Sections 1900 and 1961 (13 CCR Section 1900, 1961), and adoption of Section 1961.1 (13 CCR Section 1961.1) require automobile manufacturers to meet fleet-average GHG emissions limits for all passenger cars, light-duty trucks within various weight criteria, and medium-duty passenger vehicle weight classes (i.e., any medium-duty vehicle with a gross vehicle weight rating less than 10,000 pounds (lb) that is designed primarily for the transportation of persons), beginning with the 2009 model year. Emissions limits are reduced further in each model year through 2016.

In December 2004, a group of car dealerships, automobile manufacturers, and trade groups representing automobile manufacturers filed suit against CARB to prevent enforcement of 13 CCR Sections 1900 and 1961 as amended by AB 1493 and 13 CCR 1961.1 (*Central Valley Chrysler-Jeep et al. v. Catherine E. Witherspoon, in Her Official Capacity as Executive Director of the California Air Resources Board, et al.*). The suit in the U.S. District Court for the Eastern District of California contended that California's implementation of regulations that, in effect, regulate vehicle fuel economy violates various Federal laws, regulations, and policies.

In January 2007, the judge hearing the case accepted a request from the State Attorney General's (AG) office that the trial be postponed until a decision was reached by the U.S. Supreme Court on a separate case addressing GHGs. In the Supreme Court case, *Massachusetts, et al., v. Environmental Protection Agency, et al.*, the primary issue in question was whether the CAA provides authority for EPA to regulate CO_2 emissions. EPA contended that the CAA does not authorize regulation of CO_2 emissions, whereas Massachusetts and 10 other States, including California, sued EPA to begin regulating CO_2. As mentioned above, the U.S. Supreme Court ruled on April 2, 2007, that GHGs are "air pollutants" as defined under the CAA, and EPA is granted authority to regulate CO_2 (*Massachusetts v. U.S. Environmental Protection Agency* [2007] 549 U.S. 05-1120).

On December 12, 2007, the U.S. Supreme Court found that if California receives appropriate authorization from EPA (the last remaining factor in enforcing the standard), these regulations would be consistent with and have the force of law, thus, rejecting the automakers' claim. This authorization to implement more stringent standards in California was requested in the form of a CAA section 209, subsection (b) waiver in 2005. EPA denied that waiver on March 6, 2008. In early 2009, CARB requested that EPA reconsider its waiver denial. On January 26, 2009, President Obama signed a Presidential Memorandum directing EPA to assess whether denial of the waiver based on California's application was appropriate in light of the Clean Air Act.

The EPA granted California the authority to implement GHG emission reduction standards for new passenger cars, pickup trucks, and sport utility vehicles on June 30, 2009. The Federal government will also be adopting California's "Pavley" auto emission standards nationwide, thereby establishing the country's first national auto emissions standard targeting greenhouse gases. In exchange for cooperation from the auto industry, however, both California and President Obama's administration will be implementing the standards on a slower time frame than that originally established by California. CARB held a public hearing on September 24, 2009, for proposed amendments to the "Pavley" regulations that reduce GHG emissions in new passenger vehicles from 2009 through 2016 (CARB 2009).

Senate Bill 1078 (2002). SB 1078 addresses electricity supply and requires that retail sellers of electricity, including investor-owned utilities and community choice aggregators, provide a minimum of 20 percent of their supply from renewable sources by 2017. SB 107 changed the target date to 2010.

Senate Bill 107 (2006). SB 107 (Chapter 464, Statutes of 2006) requires investor-owned utilities in the State, such as Pacific Gas and Electric Company (PG&E), to increase their total procurement of eligible renewable energy resources by at least an additional one percent of retail sales per year so that 20 percent of retail electricity sales come from renewable-energy sources by December 31, 2010. Previously, State law required achievement of this 20 percent requirement by 2017.

Assembly Bill 32 (2006), the California Global Warming Solutions Act of 2006. In September 2006, Governor Schwarzenegger signed AB 32, the California Global Warming Solutions Act of 2006 (Chapter 488, Statutes of 2006, enacting the California Health and Safety Code Sections 38500–38599). AB 32 establishes regulatory, reporting, and market mechanisms to achieve quantifiable reductions in GHG emissions and a cap on statewide GHG emissions. The goal of the legislation is to reduce California's GHG emissions to 2000 levels by 2010 and to 1990 levels by 2020. Executive Order S-3-05 (detailed below) creates a long-range goal of reducing GHG emissions to 80 percent below 1990 levels by 2050. Reducing GHG emissions to 1990 levels means cutting approximately 30 percent from business-as-usual emission levels projected for 2020, or about 10 percent from 2002-2004 levels. This reduction will be accomplished through an enforceable statewide cap on GHG emissions that will be phased in starting in 2012. To effectively implement the cap, AB 32 directs CARB to develop and implement regulations to reduce statewide GHG emissions from stationary sources. AB 32 specifies that regulations adopted in response to AB 1493 should be used to address GHG emissions from vehicles.

As required under AB 32, CARB approved the 1990 GHG emissions inventory on December 6, 2007, thereby establishing the emissions limit for 2020. The 2020 emissions limit was set at 427 million tonnes carbon dioxide equivalent (MMT CO_2e). The inventory revealed that in 1990, transportation, with 35 percent of the State's total emissions, was the largest single sector, followed by industrial emissions (24 percent); imported electricity (14 percent); in-state electricity generation (11 percent); residential use (7 percent); agriculture (5 percent); and commercial uses (3 percent).

In addition to the 1990 emissions inventory, CARB also adopted regulations requiring mandatory reporting of greenhouse gases for large facilities on December 6, 2007. All industrial facilities emitting over 25,000 tonnes of carbon dioxide equivalent (MT CO_2e) and any power generation facilities greater than or equal to one MW will be required to report their GHG emission to CARB, the lead air pollution control agency for the State. The largest facilities in the State account for 94 percent of GHG emissions from industrial and commercial stationary sources in California.

Senate Bill 1368 (2006). SB 1368 (Chapter 598, Statutes of 2006) is the companion bill to AB 32 and was signed by Governor Schwarzenegger in September 2006. SB 1368 required the California Public Utilities Commission (CPUC) to establish a GHG emissions standard for base-load generation from investor-owned utilities by February 1, 2007. Similarly, the California Energy Commission (CEC) was tasked with establishing a similar standard for local publicly owned utilities by June 30, 2007. These standards cannot exceed the emission rate from a base-load, combined-cycle natural-gas-fired plant. The legislation further requires that all electricity provided to California, including imported electricity, be generated from plants that meet the standards set by CPUC and CEC. In January 2007, CPUC adopted an interim GHG Emissions Performance Standard, which requires that all new long-term commitments for base-load generation entered into by investor-owned utilities have emissions no greater than a combined-cycle gas turbine plant (i.e., 1,100 lbs of CO_2 per megawatt-hour [MW-hour]). A "new long-term commitment" refers to new plant investments (new construction), new or renewal contracts with a term of five years or more, or major investments by the utility in its existing base-load power plants. In May 2007, CEC approved regulations that prohibit the State's publicly owned utilities from entering into long-term financial commitments with plants that exceed the standard adopted by CPUC of 1,100 lbs of CO_2 per MW-hour.

Senate Bill 1505 (2006). SB 1505 (Chapter 877, Statutes of 2006) establishes environmental performance standards for the production and use of hydrogen fuel for transportation purposes in the State. In general, SB 1505 specifically requires the following:

- Hydrogen-fueled vehicles must reduce GHG emissions by at least 30 percent compared to emissions from new gasoline vehicles.
- At least one-third of the hydrogen produced or dispensed for transportation purposes in the State must be made from renewable sources of electricity.
- Well-to-tank emissions of smog-forming pollutants from hydrogen fuel dispensed in the State must be reduced by at least 50 percent when compared to gasoline.
- Emissions of toxic contaminants must be reduced to the maximum extent feasible compared to gasoline on a site-specific basis.

Senate Bill 97 (2007). SB 97, signed in August 2007 (Chapter 185, Statutes of 2007; Public Resources Code, Sections 21083.05 and 21097), acknowledges that climate change is a prominent environmental issue that requires analysis under the California Environmental Quality Act (CEQA). As a directive of the bill, the Governor's Office of Planning and Research (OPR) prepared Amendments to the CEQA Guidelines for greenhouse gas emissions and transmitted them to the California Natural Resources Agency on April 13, 2009. The Natural Resources Agency adopted the CEQA Guidelines Amendments on December 30, 2009.

On February 16, 2010, the Office of Administrative Law approved the Amendments, and filed them with the Secretary of State for inclusion in the California Code of Regulations. On March 18, 2010, the Natural Resources Agency adopted the proposed CEQA Guideline amendments as proposed by OPR. The adopted CEQA Guideline amendments require lead agencies to:

- Calculate or estimate the amount of GHGs produced by a project using either a quantitative modeling approach or a qualitative approach that includes performance standards,
- Use one or more of several approaches to determine the significance of emissions, including:
  - the amount of the project's emissions increase over existing conditions,
  - the level of emissions compared to a significance threshold, and/or
  - whether the project complies with an existing statewide, regional, or local plan to mitigate GHG emissions.

Climate Change Scoping Plan (2008). As indicated above, AB 32 requires CARB to adopt a scoping plan showing how reductions in significant GHG sources will be achieved through regulations, market mechanisms, and other actions. After receiving public input on its discussion draft of the Proposed Scoping Plan released in June 2008, CARB released the Climate Change Proposed Scoping Plan in October 2008, and adopted it on December 12, 2008.

The *Climate Change Scoping Plan* contains the main strategies California will implement to achieve a reduction of 169 million metric tonnes (MMT) of carbon dioxide equivalent (CO_2e) emissions, or approximately 30 percent, from the State's projected 2020 emission level of 596 MMT of CO_2e under a business-as-usual scenario (i.e., a reduction of 42 MMT CO_2e [10 percent from 2002-2004 average emissions]). The *Climate Change Scoping Plan* also includes a breakdown of the amount of GHG reductions CARB recommends for each emissions sector of the State's GHG inventory.

The key elements of the scoping plan to reduce California's GHG emissions to 1990 levels by 2020 include:

- Improved vehicle emission standards (reduction of 31.7 MMT CO_2e);
- Implementing low-carbon fuel standards (reduction of 15 MMT CO_2e);
- Expanding and strengthening energy efficiency measures in buildings and appliances (reduction of 26.3 MMT CO_2e);
- Expanding the renewable portfolio standard for electricity production to 33 percent (reduction of 21.3 MMT CO_2e); and
- Targeting fees to fund California's long-term commitment to AB 32 administration.

The *Climate Change Scoping Plan* also includes: establishing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system; and creating targeted fees, including a public goods charge on water use, fees on high global warming potential gases, and a fee to fund the administrative costs of the State's long-term commitment to AB 32 implementation.

CARB also recommends that reductions be achieved through local government actions and regional GHG targets; however, the exact amounts are still to be determined. The *Climate Change Scoping Plan* acknowledges that land use change will play an important role that affects various emission sectors including transportation, energy, water and wastewater, solid waste, and recycling. The ultimate assignments to local governments to achieve GHG reductions will become known as CARB finalizes the scoping plan. Also noteworthy is the fact that the *Climate Change Scoping Plan* does not include any direct discussion about GHG emissions generated by construction activity.

Senate Bill 375 (2008). SB 375, signed into law on September 30, 2008, aligns regional transportation planning efforts, regional GHG reduction targets, and land use and housing allocation. SB 375 requires Metropolitan Planning Organizations (MPO) to adopt a Sustainable Communities Strategy (SCS) or Alternative Planning Strategy (APS), which will prescribe land use allocation in that MPO's Regional Transportation Plan (RTP). CARB, in consultation with MPOs, will provide each affected region with reduction targets for GHGs emitted by passenger cars and light trucks in the region for the years 2020 and 2035. These reduction targets will be updated every eight years, but can be updated every four years if advancements in emissions technologies affect the reduction strategies to achieve the targets. CARB is also charged with reviewing each MPO's SCS or APS for consistency with assigned targets. If MPOs do not meet the GHG reduction targets, transportation projects would not be eligible for funding programmed after January 1, 2012.

SB 375 also extends the minimum time period for the Regional Housing Needs Allocation (RHNA) cycle from five years to eight years for local governments located within an MPO that meets certain requirements. City or county land use policies (e.g., General Plans) are not required to be consistent with the RTP (and associated SCS or APS). However, new provisions of CEQA would incentivize qualified projects that are consistent with an approved SCS or APS, categorized as "transit priority projects."

SB 375 only applies to the 18 Federally-designated MPOs in the State, which include 37 counties representing 98 percent of the statewide population. The Association of Monterey Bay Area Governments is the MPO for San Benito, Monterey, and Santa Cruz Counties and incorporated cities, and is subject to SB 375. Local governments such as San Benito County continue to exercise land use approval authority, but will be eligible for priority transportation funding or CEQA streamlining where plans or projects are consistent with a SCS or APS.

Executive Orders

Executive Order S-20-04 (2004). Governor Schwarzenegger signed Executive Order S-20-04, the California Green Building Initiative, on December 14, 2004, establishing the State's priority for energy and resource-efficient high-performance buildings. The executive order sets a goal of reducing energy use in State-owned and private commercial buildings by 20 percent in 2015, using nonresidential Title 20 and Title 24 standards adopted in 2003 as the baseline. The California Green Building Initiative also encourages retrofitting, construction, and operation of private commercial buildings in compliance with the Green Building Action Plan.

Executive Order S-3-05 (2005). Executive Order S-3-05, signed by Governor Schwarzenegger on June 1, 2005, proclaims that California is vulnerable to the effects of climate change. It declares that increased temperatures could reduce the Sierra Nevada's snowpack, further exacerbate California's air quality problems, and potentially cause a rise in sea levels. To combat those concerns, the Executive Order established targets for total GHG emissions. Specifically, emissions are to be reduced to the 2000 level by 2010, to the 1990 level by 2020, and to 80 percent below the 1990 level by 2050.

The Executive Order directed the secretary of the California Environmental Protection Agency (CalEPA) to coordinate a multi-agency effort to reduce GHG emissions to the target levels. The secretary will also submit biannual reports to the governor and legislature describing progress made toward reaching the emission targets; effects of climate change on California's resources; and mitigation and adaptation plans to combat these effects. To comply with the Executive Order, the secretary of CalEPA created the California Climate Action Team (CCAT), made up of members of various State agencies and commissions. CCAT released its first report in March 2006. The report proposed to achieve the targets by building on voluntary actions of California businesses and actions by local governments and communities, as well as through State incentive and regulatory programs.

Executive Order S-1-07 (2007). Governor Schwarzenegger signed Executive Order S-1-07, the Low Carbon Fuel Standard Program (LCFS), on January 18, 2007. It proclaims that the transportation sector is the main source of GHG emissions in California, at over 40 percent of statewide emissions. It establishes a goal that carbon intensity of transportation fuels sold in California should be reduced by a minimum of 10 percent by 2020. It instructed the CalEPA to coordinate activities between the University of California, the CEC, and other State agencies to develop and propose a draft compliance schedule to meet the 2020 target. Furthermore, it directed CARB to consider initiating regulatory proceedings to establish and implement the LCFS. In response, CARB identified the LCFS as an early action item pursuant to meeting the mandates in AB 32 with a regulation to be adopted and implemented by 2010.

Actions Taken by the Governor's Office of Planning and Research

In June 2008, OPR issued a Technical Advisory on CEQA and Climate Change (OPR 2008). This document recommends that for projects subject to CEQA, emissions be calculated and mitigation measures be identified to reduce those emissions. The OPR report does not identify emission thresholds for GHGs, but instead recommends that each lead agency develop its own thresholds.

On April 13, 2009, OPR submitted to the Secretary for Natural Resources its proposed amendments to the State CEQA Guidelines for GHG emissions, as required by Senate Bill 97 (Chapter 185, 2007). These proposed CEQA Guideline amendments would provide guidance to public agencies regarding the analysis and mitigation of the effects of GHG emissions in draft CEQA documents. The Natural Resources Agency adopted the CEQA Guidelines Amendments on December 30, 2009, to the Office of Administrative Law.

Actions Taken by the California Natural Resources Agency

On February 16, 2010, the Office of Administrative Law approved the Amendments, and filed them with the Secretary of State for inclusion in the California Code of Regulations. On March 18, 2010, the Natural Resources Agency adopted the proposed CEQA Guideline amendments as proposed by OPR. The adopted CEQA Guideline amendments require lead agencies to:

- Calculate or estimate the amount of GHGs produced by a project using either a quantitative modeling approach or a qualitative approach that includes performance standards,
- Use one or more of several approaches to determine the significance of emissions, including:
    - the amount of the project's emissions increase over existing conditions,
    - the level of emissions compared to a significance threshold, and/or
    - whether the project complies with an existing statewide, regional, or local plan to mitigate GHG emissions.

Actions Taken by California Attorney General's Office

The California Attorney General (AG) has filed comment letters under CEQA on a number of proposed projects regarding their identification and quantification of potential GHG effects, and the identification of mitigation programs and actions. The AG has also filed several complaints and obtained settlement agreements for CEQA documents covering general plans and individual programs that the AG found either failed to analyze GHG emissions or failed to provide adequate GHG mitigation. The AG's office has prepared a report that lists measures that local agencies should consider under CEQA to offset or reduce global warming impacts. The AG's office also has prepared a chart of modeling tools to estimate GHG emissions impacts of projects and plans. Information on the AG's actions can be found on the

California Department of Justice Office of Attorney General web site (California Department of Justice 2009).

California Air Pollution Control Officers Association Guidance

The California Air Pollution Control Officers Association (CAPCOA) released a report in January 2008 that describes methods to estimate and mitigate GHG emissions from projects subject to CEQA. The CAPCOA report evaluates several GHG thresholds that could be used to evaluate the significance of a project's GHG emissions. The CAPCOA report, however, does not recommend any one threshold. Instead, the report is designed as a resource for public agencies as they establish agency procedures for reviewing GHG emissions from projects subject to CEQA (CAPCOA 2008).

In June 2009, CAPCOA released its second document designed to serve as a guide and resource tool for local governments in addressing GHG emissions. This document, "Model Policies for Greenhouse Gases in General Plans," provides background information, examples, references, links, and a systematic worksheet to help local governments in moving toward GHG considerations in General Plan updates or in the development of specific Climate Action Plans (CAPCOA 2009).

Regional and Local Plans, Policies, Regulations, and Ordinances

The Monterey Bay Unified Air Pollution Control District (MBUAPCD), the regional air quality management agency for the North Central Coast Air Basin (NCCAB), and the agency with air permitting authority, has not yet adopted any significance thresholds for GHG emissions.

Major Findings

- San Benito County's regional air quality management agency, the Monterey Bay Unified Air Pollution Control District (MBUAPCD), has not yet adopted any significance thresholds for GHG emissions.

- Although MBUAPCD has developed on-road vehicular GHG emission inventories for Monterey and Santa Cruz counties based on the AMBAG travel model, they have yet (as of Summer 2010) to develop the on-road vehicular inventory for San Benito County.

- Although no GHG inventory has been completed for the county, because agricultural production and its associated farming operations account for a large percentage of the land uses within the county, agricultural operations associated with off-road farming equipment use, irrigation of cropland, and fertilizer applications are expected to be a large contributor to overall GHG emissions in the county.

- Because the majority of the county's population resides between two mountain ranges within a fertile valley floor, and is dependent on an agricultural livelihood, climate change may have the greatest effects on the county's agricultural operations, since over time climate change effects may reduce the suitability and productivity of agricultural lands.

- Increased drought, decreased rainfall, and changes in the county's vegetation cover and plant communities due to climate change could increase the risk of wildfire hazards to residential and agricultural uses within the wildland urban interface (WUI) as population increases and urban development encroaches into wildland interface areas over time.

- An increase in average annual temperatures, by itself, could affect San Benito County by increasing evapotranspiration rates that in turn, decrease reservoir levels (e.g., San Justo, San Luis), increase irrigation demand for cropland, and create potentially greater overall energy consumption to meet air conditioning demands of the growing population.
- Although global climate change models predict an increase in overall precipitation on a worldwide scale, there is no such consistency among the results of regional models that can be applied to San Benito County. Given the uncertainty associated with projecting the amount of annual precipitation, it would be too speculative to determine the reasonably foreseeable direct effects of climate change on physical conditions, specifically precipitation volumes, in the San Benito County.

Existing Conditions

The Greenhouse Effect

The earth's natural warming process is known as the "greenhouse effect." Certain atmospheric gases act as an insulating blanket that traps solar energy to keep the global average temperature in a suitable range. These gases are called GHGs because they trap heat like the glass walls of a greenhouse. The greenhouse effect raises the temperature of the earth's surface by about sixty degrees Fahrenheit. With the natural greenhouse effect, the average temperature of the earth is about 45 degrees Fahrenheit; without it, the average temperature of the earth plummets to approximately minus 15 degrees Fahrenheit (Pew Center 2009). It is normal for the earth's temperature to fluctuate over extended periods of time. Over the past one hundred years the earth's average global temperature has generally increased by one degree Fahrenheit. In some regions of the world, the increase has been as much as four degrees Fahrenheit (Brohan 2006).

Scientists studying the particularly rapid rise in global temperatures during the late twentieth century have determined that natural variability does not alone account for that rise (IPCC 2001). Rather, human activity spawned by the industrial revolution has resulted in increased emissions of carbon dioxide and other forms of GHGs, primarily from the burning of fossil fuels (during motorized transport, electricity generation, consumption of natural gas, industrial activity, manufacturing, etc.) and deforestation, as well as agricultural activity and the decomposition of solid waste. Carbon dioxide (CO_2) is the most common GHG and constitutes approximately 84 percent of all GHG emissions in California (CEC 2006). The State of California ranks as the 12th to 16th largest emitter of CO_2 (the most prevalent GHG) worldwide, and is responsible for approximately two percent of the world's CO_2 emissions (CEC 2006).

Scientists refer to the global warming context of the past century as the "enhanced greenhouse effect" to distinguish it from the natural greenhouse effect (PEW Center 2009). While the increase in temperature is known as "global warming," the resulting change in weather patterns is known as "global climate change." Global climate change is evidenced in changes to wind patterns, storms, precipitation, and air temperature.

According to overwhelming scientific consensus, climate change is a global problem (IPCC 2007). GHGs are global pollutants, unlike criteria air pollutants and toxic air contaminants (TAC), which are pollutants of regional and local concern. Whereas pollutants with localized air quality effects have relatively short atmospheric lifetimes (about one day), GHGs have long atmospheric lifetimes (one year to several thousand years). GHGs persist in the atmosphere for a long enough time to be dispersed around the globe. Although the exact lifetime of any particular GHG molecule is dependent on multiple variables and cannot be pinpointed, it is understood that more CO_2 is currently (2010) emitted into the atmosphere than is sequestered by ocean uptake, vegetation, and other forms of sequestration. Of the total annual human-caused CO_2 emissions, approximately 54 percent is sequestered through ocean uptake, uptake by northern hemisphere forest regrowth, and other terrestrial sinks within a year, whereas the remaining 46 percent of human-caused CO_2 emissions remains stored in the atmosphere (Seinfeld and Pandis 1998).

GHG Emission Components and Health Effects

GHGs are produced from: electricity generation, road transportation, and other energy sources; industrial processes; agriculture, forestry, and other land uses; solid waste disposal; and wastewater treatment and discharge. GHGs include water vapor, carbon dioxide, methane, nitrous oxide (N_2O), Chlorofluorocarbons (CFC), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF_6), and black carbon.

Much of the following discussion is adapted from the EPA's Emission Inventory Improvement Program, Estimating Greenhouse Gas Emissions, and EPA's website on Climate Change (EPA 2009 and 1999).

Water Vapor

Water vapor (H_20) is the most abundant, important, and variable GHG in the atmosphere. Water vapor is not considered a pollutant – in the atmosphere it maintains a climate necessary for life. Changes in its concentration are primarily considered to be a result of climate feedbacks related to the warming of the atmosphere rather than a direct result of industrialization. The feedback loop in which water is involved is critically important to projecting future climate change.

As the temperature of the atmosphere rises, more water is evaporated from ground storage (rivers, oceans, reservoirs, soil). Because the air is warmer, the relative humidity can be higher (in essence, the air is able to "hold" more water when it is warmer), leading to more water vapor in the atmosphere. As a GHG, the higher concentration of water vapor is then able to absorb more thermal indirect energy radiated from the Earth, thus further warming the atmosphere. The warmer atmosphere can then hold more water vapor, and so on, and so on. This is referred to as a "positive feedback loop." The extent to which this positive feedback loop will continue is unknown, as there are also dynamics that hold the positive feedback loop in check. As an example, when water vapor increases in the atmosphere, more of it will eventually also condense into clouds, which are more able to reflect incoming solar radiation - thus allowing less energy to reach the Earth's surface and heat it.

There are no health effects from water vapor itself. However, when some pollutants come in contact with water vapor they can dissolve, and the water vapor can then act as a pollutant-carrying agent. The main source of water vapor is evaporation from the oceans (approximately 85 percent). Other sources include: evaporation from other water bodies, sublimation (change from solid to gas) from sea ice and snow, and transpiration from plant leaves.

Carbon Dioxide

Carbon dioxide (CO_2) is an odorless and colorless GHG. Outdoor levels of CO_2 are not high enough to result in negative health effects. CO_2 is emitted from natural and manmade sources. Natural sources include: the decomposition of dead organic matter; respiration of bacteria, plants, animals, and fungus; evaporation from oceans; and volcanic out-gassing. Anthropogenic sources include: the burning of coal, oil, natural gas, and wood. CO_2 is naturally removed from the air by photosynthesis, dissolution into ocean water, transfer to soils and ice caps, and chemical weathering of carbonate rocks.

Since the industrial revolution began in the mid-1700s, the sort of human activity that increases GHG emissions has increased dramatically in scale and distribution. Data from the past 50 years suggests a corollary increase in global GHG levels and concentrations. As an example, prior to the industrial revolution, CO_2 concentrations were fairly stable at 280 parts per million (ppm). Today, they are around 370 ppm, an increase of more than 30 percent. Left unchecked, the concentration of carbon dioxide in the atmosphere is projected to increase to a minimum of 540 ppm by 2100 as a direct result of anthropogenic sources.

Short-term exposure to CO_2 at levels below 20,000 ppm does not cause harmful health effects. Higher concentrations can affect respiratory function and cause excitation followed by depression of the central nervous system. High concentrations of CO_2 can displace oxygen in the air, resulting in lower oxygen concentrations for breathing. Therefore, effects of oxygen deficiency may be combined with effects of CO_2 toxicity (Canadian Centre for Occupational Health and Safety 2009).

Methane

Methane (CH_4) is an extremely effective absorber of radiation, though its atmospheric concentration is less than carbon dioxide and its lifetime in the atmosphere is brief (10-12 years), compared to other GHGs. While methane is not toxic, it is highly flammable, and may form explosive mixtures with air. No health effects are known to occur from exposure to methane.

Methane has both natural and anthropogenic sources. It is released as part of the biological processes in low oxygen environments, such as in swamplands or in rice production (at the roots of the plants). Over the last 50 years, human activities such as growing rice, raising cattle, using natural gas, and mining coal have added to the atmospheric concentration of methane. Other anthropocentric sources include fossil-fuel combustion and biomass burning.

Nitrous Oxide

Nitrous oxide (N_2O), also known as laughing gas, is a colorless greenhouse gas. Nitrous oxide can cause dizziness, euphoria, and on some occasions, slight hallucinations. In small doses, it is considered harmless. However, in some cases, heavy and extended use can cause brain damage.

Concentrations of nitrous oxide also began to rise at the beginning of the industrial revolution. In 1998, the global concentration was 314 parts per billion (ppb). Microbial processes in soil and water produce nitrous oxide, including those reactions that occur in fertilizer containing nitrogen. In addition to agricultural sources, some industrial processes (fossil fuel-fired power plants, nylon production, nitric acid production, and vehicle emissions) also contribute to its atmospheric load. It is used as an aerosol spray propellant, e.g., in whipped cream bottles. It is also used in potato chip bags to keep chips fresh. It is used in rocket engines and in racecars. Nitrous oxide can be transported into the stratosphere, deposited on the earth's surface, and converted to other compounds by chemical reaction.

Chlorofluorocarbons

Chlorofluorocarbons (CFC) are gases formed synthetically by replacing all hydrogen atoms in methane or ethane (C_2H_6) with chlorine and/or fluorine atoms. CFCs are nontoxic, nonflammable, insoluble, and chemically unreactive in the troposphere (the level of air at the earth's surface). CFCs are no longer being used. It is therefore not likely that health effects would be experienced. Nonetheless, in confined indoor locations, working with CFC-113 or other CFCs is thought to result in death by cardiac arrhythmia (heartbeat frequency too high or too low) or asphyxiation.

CFCs have no natural source and were first synthesized in 1928. They were used for refrigerants, aerosol propellants, and cleaning solvents. With the discovery that they are able to destroy stratospheric ozone, a global effort to halt their production was undertaken, and has been extremely successful, so much so that levels of the major CFCs are now remaining steady or declining. However, their long atmospheric lifetimes mean that some of the CFCs will remain in the atmosphere for over 100 years.

Hydrofluorocarbons

Hydrofluorocarbons are synthetic, man-made chemicals that are used as a substitute for CFCs. Of all the GHGs, they are one of three groups with the highest global warming potential (GWP). The HFCs with the largest measured atmospheric abundances are (in order), HFC-23 (CHF3), HFC-134a (CF_3CH_2F), and HFC-152a (CH_3CHF_2). Prior to 1990, the only significant emissions were of HFC-23. HFC-134a emissions are increasing due to its use as a refrigerant. The EPA estimates that concentrations of HFC-23 and HFC-134a are now about 10 parts per trillion (ppt) each, and concentrations of HFC-152a are about one ppt. No health effects are known to result from exposure to HFCs, which are manmade for applications such as automobile air conditioners and refrigerants.

Perfluorocarbons

Perfluorocarbons have stable molecular structures, and do not break down through chemical processes in the lower atmosphere. High-energy ultraviolet rays, which occur about 60 kilometers above Earth's surface, are able to destroy the compounds. Because of this, PFCs have very long lifetimes, between 10,000 and 50,000 years. Two common PFCs are tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6). The EPA estimates that concentrations of CF_4 in the atmosphere are over 70 ppt.

No health effects are known to result from exposure to PFCs. The two main sources of PFCs are primary aluminum production and semiconductor manufacture.

Sulfur Hexafluoride

Sulfur hexafluoride (SF_6) is an inorganic, odorless, colorless, nontoxic, nonflammable gas. It also has the highest GWP of any gas evaluated (23,900). The EPA (2006) indicates that concentrations in the 1990s were about four ppt. In high concentrations in confined areas, the gas presents the hazard of suffocation because it displaces the oxygen needed for breathing.

Sulfur hexafluoride is used for insulation in electric power transmission and distribution equipment, in the magnesium industry, in semiconductor manufacturing, and as a tracer gas for leak detection.

Black Carbon

Black Carbon (BC) is formed through the incomplete combustion of fossil fuels, biofuel, and biomass (e.g., wood, waste, and alcohol fuels), and is emitted in both anthropogenic and naturally occurring soot. BC warms the planet by absorbing heat in the atmosphere and by reducing the ability to reflect sunlight when deposited on snow and ice. Black carbon is often transported over long distances, mixing with other aerosols along the way. The aerosol mix can form transcontinental plumes of atmospheric brown clouds, with vertical extents of approximately two to three miles (three to five kilometers). BC has emerged as the second largest contributor to global warming after carbon dioxide (V. Ramanathan 2007). Decreasing BC emissions could be a relatively inexpensive way to significantly slow climate change in the short-term. Inhalation of soot is a major public health issue. Between 25 percent and 35 percent of BC in the global atmosphere comes from China and India, emitted from the burning of wood and cow dung in household cooking and through the use of coal to heat homes. Countries in Europe and elsewhere that rely heavily on diesel fuel for transportation also contribute large amounts of BC. The developed nations have reduced their BC emissions from fossil fuel sources by a factor of five or more since the 1950s. The technology exists for a drastic reduction of fossil fuel related BC (V. Ramanathan 2007).

Global Warming Potential

Global Warming Potential (GWP) is one type of simplified index based upon radiative properties that can be used to estimate the potential future impacts of emissions of different gases upon the climate system in a relative sense. GWP is based on a number of factors, including the radiative efficiency (heat-absorbing ability) of each gas relative to that of carbon dioxide, as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of carbon dioxide.

GWP is the amount of radiative forcing that would result from the emission of one kilogram of a non-CO_2 GHG that is equivalent to that from the emission of one kilogram of carbon dioxide over a fixed period of time. One teragram (one trillion grams or one billion kilograms or one million tonnes) of carbon dioxide equivalent (Tg CO_2e) is essentially the emissions of the gas multiplied by the GWP. A summary of the atmospheric lifetime and GWP of selected gases is presented in Table 12-1. As indicated, GWP ranges from one to 23,900.

TABLE 12-1 ATMOSPHERIC LIFETIMES AND GLOBAL WARMING POTENTIALS Worldwide		
Gas	**Atmospheric Lifetimes (Years)**	**Global Warming Potential (100 Year Time Horizon)**
Carbon Dioxide	50-200	1
Methane (CH_4)	12 (+/- 3)	21
Nitrous Oxide (N_2O)	120	310
HFC-23	264	11,700
HFC-134a	14.6	1,300
HFC-152a	1.5	140
PFC: Tetrafluoromethane (CF_4)	50,000	6,500
PFC: Hexafluoroethane (C_2F_6)	10,000	9,200
Sulfur Hexafluoride (SF_6)	3,200	23,900
Black Carbon	days to several weeks	680

Source: Environmental Protection Agency, EIIP Technical Report Series, Volume VIII, Estimating Greenhouse Gas Emissions, 2006.

GWPs were developed by the Intergovernmental Panel on Climate Change (IPCC) to quantify the globally averaged relative radiative forcing effects of a given GHG, using carbon dioxide as the reference gas. In 1996, the IPCC published a set of GWPs for the most commonly measured greenhouse gases in its Second Assessment Report (SAR) (IPCC 1996). In 2001, the IPCC published its Third Assessment Report (TAR), which adjusted the GWPs to reflect new information on atmospheric lifetimes and an improved calculation of the radiative forcing of carbon dioxide (IPPC 2001). However, SAR GWPs are still used by international convention and the United States to maintain the value of the carbon dioxide “currency.” To maintain consistency with international practice, the California Climate Action Registry requires participants to use GWPs from the SAR for calculating their emissions inventory. For this reason, this GHG inventory uses the SAR GWPs (Table 12-2).

TABLE 12-2 GLOBAL WARMING POTENTIAL FOR THE COMMON GHG POLLUTANTS Worldwide		
Greenhouse Gas	**SAR GWP (IPCC 1996)**	**TAR GWP (IPCC 2001)**
Carbon Dioxide (CO_2)	1	1
Methane (CH_4)	21	23
Nitrous Oxide (N_2O)	310	296

Source: Intergovernmental Panel on Climate Change, Guidelines for National Greenhouse Gas Inventories, Volumes 1,2, and 3, 1996; and Intergovernmental Panel on Climate Change, Climate Change 2001 Synthesis Report, 2001.

Reductions of Greenhouse Gas Emission Sources

Statewide

The GHG emission sectors described below would experience varying degrees of State regulation and would be reduced overall on a statewide level under existing regulations. As discussed above, legislation already in effect will achieve statewide reductions of GHG emissions associated with electricity production, industry, vehicle miles travelled (VMT), and motor vehicles.

Local Government

Projects implemented on a local level could generate GHG emissions associated with each of the emission sectors described above; however, the ability of local governments to reduce those GHG emissions would vary by sector. Certain GHG emission sectors will be regulated by the implementation of statewide emission reduction programs (e.g., vehicle emissions standards and renewable energy portfolios). Local governments, including San Benito County, have the ability to reduce vehicle miles traveled (VMT) through sustainable land use regulations, which in turn can help reduce transportation-related GHG emissions. However, local governments do not have control over vehicle emissions technology or fuel economy standards. Both of these parameters are important components for achieving the emission reductions mandates set in AB 32.

Local governments such as San Benito County will play a role in achieving the emission reduction goals mandated in AB 32 and SB 375. The ability to influence land use decisions, provide services to the population (e.g., recycling service, waste management, and waste water treatment), and provide public education and incentives (e.g., energy conservation, agricultural practices) to citizens are options for local governments to reduce GHG emissions generated within their jurisdictions. As discussed above, for SB 375, CARB will assign each MPO a GHG emissions reduction target for passenger cars and light trucks. The County, in coordination with the Association of Monterey Bay Area Governments, will need to develop a SCS or APS to achieve the allocated reduction target.

Land use decisions and development projects are not their own GHG emissions sectors. In other words, land use development projects can generate GHG emissions from several sectors (e.g., transportation, electricity, and waste) as described in more detail below. Therefore, land use decisions and development projects can affect the generation of GHG emissions from multiple sectors that result from their implementation. Development projects can result in direct or indirect GHG emissions that would occur on- or off-site. For example, electricity consumed in structures within a project would indirectly cause GHGs to be emitted at a utility provider. The people who reside in and the visitors to a development project would drive vehicles that generate off-site GHG emissions, which are associated with the transportation sector. The following sections describe the major GHG emission sectors that can and cannot be affected by local government actions. In addition, a description of the existing state of climate change science is provided for informational purposes.

Greenhouse Gas Emission Sectors

The Climate Change Scoping Plan, adopted by the California Air Resources Board (CARB) in 2008, identifies the main GHG emission sectors that account for the majority of GHG emissions generated within California:

- **Transportation.** This sector represents the GHG emissions associated with on-road motor vehicles, recreational vehicles, aviation, ships, and rail.
- **Electricity.** This sector represents the GHG emissions associated with use and production of electrical energy. Approximately 25 percent of electricity consumed in California is imported, thus, GHG emissions associated with out-of-state electricity production are also included as part of this sector.
- **Industry.** This sector represents the GHG emissions associated with industrial land uses (e.g., manufacturing plants and refineries). Industrial sources are predominately comprised of stationary sources (e.g., boilers and engines) associated with process emissions.
- **Commercial and Residential.** Commercial and residential GHG emission sources include area sources such as landscape maintenance equipment, fireplaces, and natural gas consumption for space and water heating.
- **Agriculture.** This sector represents the GHG emissions associated with agricultural processes. Agricultural sources of GHG emissions include off-road farm equipment, irrigation pumps, residue burning, livestock, and fertilizer volatilization.
- **High Global Warming Potential.** This sector represents the generation of high GWP GHGs. Examples of high GWP GHG sources include refrigerants (e.g., hydrofluorocarbons [HFCs], chlorofluorocarbons [CFCs]) and electrical insulation (e.g., sulfur hexafluoride). Although these GHGs are typically generated in much smaller quantities than CO_2, their high GWP results in considerable CO_2e.
- **Recycling and Waste:** This sector represents the GHG emissions associated with waste management facilities and landfills.

SECTION 12.2 GREENHOUSE GAS EMISSIONS INVENTORY

Note: Information for this section is currently (2010) being prepared by the Association of Monterey Bay Area Governments and will be included in the Final Background Report.

SECTION 12.3 EFFECTS OF CLIMATE CHANGE AND ADAPTATION

Introduction

This section identifies indirect effects of climate change on the earth, California, and San Benito County under existing and future conditions. Several general categories of potential effects of climate change are discussed in this section:

- Increased temperature
- Reduced snowpack storage and water supply
- Increased sea levels
- Decreased water quality
- Altered precipitation volumes, types, and intensities
- Extreme weather events
- Reduction of agriculture
- Reduction of water supply

Key Terms

See section 12.1 above.

Regulatory Setting

See section 12.1 above.

Major Findings

- The California Department of Water Resources (DWR) projects that approximately 50 percent of the statewide snowpack will be lost by the end of the century. Although current forecasts are uncertain, it is evident that this phenomenon could lead to significant challenges in securing an adequate water supply for a growing population.
- Average runoff from melting snowpack is usually about 20 percent of the total annual natural runoff and roughly 35 percent of the total usable annual surface water supply in California. The snowpack is estimated to contribute an average of about 15 million acre-feet (MAF) of runoff each year, about 14 MAF of which is estimated to flow into the Central Valley.
- Based on the results of a variety of regional climate models, it is reasonably foreseeable that some increase in annual average temperatures, in the range of 2 to 5°C (3.6 to 9.0°F), will occur in California, and in the county, during the next 100 years.
- Snow is expected to be a smaller part of overall precipitation but will also melt and runoff earlier in the year. This change will occur as overall precipitation will likely increase slightly. These two

trends will most likely cause reduced summer flows, reduced summer soil moisture, and increased winter flows and flood potential.

- A 15 percent increase in land fallowing is expected to occur under a dry and warm climate scenario. Land fallowing would reduce agricultural productivity and affect the agricultural economy as well as the rural support economies.

Existing Conditions

Global average ambient concentrations of CO_2 have increased dramatically since preindustrial times, from approximately 280 parts per million (ppm) to approximately 353 ppm in 1990, and approximately 380 ppm in 2000. Global average temperature has risen approximately 0.76 degree Celsius (°C) since 1850. If global CO_2 emissions were to be eliminated today, global average temperatures would continue to rise an additional 0.5°C by the end of this century. This phenomenon is caused by the inertia of the climate system and time scale of the main sequestration mechanism in the carbon cycle – the ocean. In other words, global temperatures will rise an additional 0.5°C due to human activities that have already occurred. Because GHG emissions associated with fossil fuel combustion, population growth, technological advances, and current standards of living will continue to occur, a more likely range of scenarios for global average temperature rise would be 1.8–4.0°C by the end of the century, depending on the global emissions scenario that ultimately occurs.

Effects associated with the incremental increase in global temperature have already begun to occur. Such effects are projected to occur in numerous forms: sea level rise, reduction in the extent of polar and sea ice, changes to ecosystems, changes in precipitation patterns, reduced snowpack, agricultural disruption, increased intensity and frequency of storms and temperature extremes, increased risk of floods and wildfires, increased frequency and severity of drought, effects on human health from vector borne disease, species extinction, and acidification of the ocean.

Climate change has the potential to affect environmental conditions in California through a variety of mechanisms. Resource areas other than air quality and atmospheric temperature could be indirectly affected by the accumulation of GHG emissions. For example, an increase in the global average temperature is expected to result in a decreased volume of precipitation falling as snow in California and an overall reduction in snowpack in the Sierra Nevada. Snowpack in the Sierra Nevada provides both water supply (runoff) and storage (within the snowpack before melting), which is a major source of supply for the State. According to the CEC (2006a), the snowpack portion of the water supply could potentially decline by 30-90 percent by the end of the 21st century. A study cited in a report by the California Department of Water Resources (DWR) projects that approximately 50 percent of the statewide snowpack will be lost by the end of the century (Knowles and Cayan 2002). Although current forecasts contain varying levels of uncertainty, it is evident that this phenomenon could lead to significant challenges in securing an adequate water supply for a growing population. An increase in precipitation falling as rain rather than snow could also lead to increased potential for floods, because water that would normally be held in the Sierra Nevada snowpack until spring could flow into the Central Valley concurrently with winter storm events. This scenario would place more pressure on California's levee/flood control system (DWR 2006).

Another mechanism for indirect effects on the environment in California is sea level rise. Sea levels rose worldwide approximately seven inches during the last century (CEC 2006b), and it is predicted to rise an additional 7–22 inches by 2100, depending on the future levels of GHG emissions (IPCC 2007). However, the Governor-appointed Delta Vision Blue Ribbon Task Force has recommended that the State plan for a scenario of 16 inches of sea level rise by 2050, and 55 inches by 2100 (CARB 2008). Resultant effects of sea level rise could include increased coastal flooding, saltwater intrusion, and disruption of wetlands (CEC 2006b). Water delivery to the county from sources in the Delta could be adversely affected.

As California's climate changes over time, the ranges of various plant and wildlife species could shift or be reduced, depending on the favored temperature and moisture regimes of each species. In the worst cases, some species would become extinct or be extirpated from the State if suitable conditions are no longer available. An additional concern associated with climate change is an increased risk of wildfire caused by changes in rainfall patterns and plant communities.

Increased Temperature

An increase in average annual temperatures, by itself, would minimally affect San Benito County except for adjustments in operations in response to warmer temperatures, such as increased evapotranspiration rates affecting reservoir levels, agriculture, and landscaped areas, resulting in an increased irrigation demand, and potentially greater overall energy consumption to meet air conditioning demands of a growing population.

An increase in annual average temperature is a reasonably foreseeable effect of future climate change. This change (i.e., increase in global average temperature) alone would lead to an increase in ozone formation and an increase in aggravated health conditions for the elderly and those with respiratory disorders (Environmental Literacy Council 2008).

Status and Trends

The Earth's climate has had numerous periods of cooling and warming in the past. Significant periods of cooling have been marked by massive accumulations of sea- and land-based ice extending from the Earth's poles to as far as the middle latitudes. Periods of cooling have also been marked by lower sea levels because of the accumulation of ice and the cooling and contraction of the oceans. Periods of warming caused recession of the ice toward the poles, warming and thermal expansion of the oceans, and rise in sea levels (DWR 2006; IPCC 2007).

Average temperatures in the Northern Hemisphere appear to have been relatively stable from about the year 1000 to the mid-1800s based on temperature proxy records from tree rings, corals, ice cores, and historical observations (IPCC 2007). However, there is a significant amount of uncertainty related to proxy temperature records, especially those extending far back into the past.

IPCC stated that the Earth's climate has warmed since the preindustrial era and that it is very likely that at least some of this change is attributable to the activities of humans (IPCC 2007). Global average near-surface air temperatures and ocean surface temperatures increased by 0.74°C ± 0.18°C (1.33°F ± 0.32°F) during the 20th century (IPCC 2007).

Temperature measurements, apparent trends in reduced snowpack and earlier runoff, and other evidence such as changes in the timing of blooming plants, indicate that temperatures in California and elsewhere in the western U.S. have increased during the past century (NOAA 2005; Mote et al. 2005; Cayan et al. 2001).

Projections

Modeling results from general circulation models (GCM) are consistent in predicting increases in temperatures globally with increasing concentrations of GHGs resulting from human activity. Climate change projections can be developed on a regional basis using techniques to downscale from the results of global models (although increased uncertainty results from the downscaling). In 2005, a relatively large group of model projections for California projected a temperature rise of approximately 2.5°C to 9°C (4.5°F to 16.2°F) for Northern California by 2100 (Dettinger 2005). An analysis of the distribution of the projections generally showed a central tendency at about 3°C (5.4°F) of rise for 2050, and about 5°C (9°F) for 2100 (Dettinger 2005).

Work by Snyder et al. (2002) has produced the finest-scale temperature and precipitation estimates to date. Resulting temperature increases for a scenario of doubled CO_2 concentrations are 1.4°C to 3.8°C (2.5°F to 6.8°F) throughout California. This is consistent with the global increases predicted by the IPCC (2007). In a regional model of the western United States, Kim et al. (2002) projected a climate warming of approximately 3°C to 4°C (5.4°F to 7.2°F). Of note in both studies is the projection of uneven distribution of temperature increases. For example, regional climate models show that the warming effects are greatest in the Sierra Nevada, with implications for snowpack and snowmelt (Kim et al. 2002; Snyder et al. 2002).

Effect on the County

Based on the results of a variety of regional climate models, it is reasonably foreseeable that some increase in annual average temperatures will occur in San Benito County during the next 100 years. Although a temperature increase is expected, the amount and timing of the increase is uncertain. In general, predictions put an increase in the range of 2°C to 5°C (3.6 to 9°F) over the next 50–100 years (IPCC 2007; Kim et al. 2002; Snyder et al. 2002; Dettinger 2005).

Increasing temperatures in California would indirectly affect the county through changes in water supply, sea levels, water quality, agriculture, and energy consumption rates. Indirect effects of climate change on the physical conditions in the county are discussed later in this section. Direct effects of increased temperatures in the county would lead to an increase in aggravated health conditions for the elderly and those with respiratory disorders (Environmental Literacy Council 2008).

Precipitation Volume, Type, and Intensity

Climate change can affect precipitation in a variety of ways, such as by changing the following:

- overall amount of precipitation
- type of precipitation (rain vs. snow)
- timing and intensity of precipitation events

Each of these effects on precipitation patterns is discussed in the following paragraphs.

Status and Trends

Worldwide precipitation is reported to have increased about two percent since 1900. Although global average precipitation has been observed to increase, changes in precipitation over the past century vary in different parts of the world. Some areas have experienced increased precipitation while other areas have experienced a decline (IPCC 2007; NOAA 2005). An analysis of trends in total annual precipitation in the western U.S. by the National Weather Service's Climate Prediction Center provides evidence that annual precipitation has increased in much of California, the Colorado River Basin, and elsewhere in the West since the mid-1960s (DWR 2006). In another study evaluating trends in annual November-through-March precipitation for the western U.S. and southwest Canada, the data indicate that for most of California and the Southwest, there was increasing precipitation during the period of 1930–1997 (Mote et al. 2005).

Former State Climatologist James Goodridge compiled an extensive collection of longer-term precipitation records from throughout California. These data sets were used to evaluate whether there has been a changing trend in precipitation in the State over the past century (DWR 2006). Long-term runoff records in selected watersheds in the State were also examined. Based on a linear regression of the data, the long-term historical trend for statewide average annual precipitation appears to be relatively flat (no increase or decrease) over the entire record. However, it appears that there might be an upward trend in precipitation toward the latter portion of the record.

When these same precipitation data are sorted into three regions–northern, central, and southern California–trends show that precipitation in the northern part of the State appears to have increased slightly from 1890 to 2002, and precipitation in the central and southern portions of the State show slightly decreasing trends. All changes were in the range of one to three inches annually (DWR 2006).

Although existing data indicate some level of change in precipitation trends in California, more analysis is needed to determine whether changes in California's regional annual precipitation totals have occurred as the result of climate change or other factors (DWR 2006).

Projections

IPCC predicts that increasing global surface temperatures are very likely to result in changes in precipitation. Global average precipitation is expected to increase during the 21st century as the result of climate change, based on global climate models for a wide range of GHG emissions scenarios. However, global climate models are generally not well-suited for predicting regional changes in precipitation because of their coarse level of outputs compared to the scale of regionally important factors that affect precipitation (e.g., maritime influences or effects of mountain ranges) (IPCC 2007).

Therefore, while increasing precipitation on a global scale is generally an expected effect of climate change, significant regional differences in precipitation trends can be expected. Some recent regional modeling efforts conducted for the western U.S. indicate that overall precipitation will increase (Kim et al. 2002; Snyder et al. 2002), but considerable uncertainty remains because of differences among larger-scale GCMs. In California, precipitation is projected to increase in the northern part of the State (Kim et al. 2002; Snyder et al. 2002) and in the winter months.

Various California climate models provide mixed results regarding changes in total annual precipitation in the State through the end of this century. Models predicting the greatest amount of warming generally predict moderate decreases in precipitation; on the other hand, models projecting smaller increases in temperature tend to predict moderate increases in precipitation (Dettinger 2005). In addition, an IPCC review of multiple global GCMs identifies much of California as an area where less than 66 percent of the models evaluated agree on whether annual precipitation would increase or decrease; therefore, no conclusion on an increase or decrease can be provided (IPCC 2007), and California climate could be either warmer-wetter or warmer-drier. Considerable uncertainties about the likely effects of climate change on California hydrology and water resources will remain until there is more precise and consistent information about how precipitation patterns, timing, and intensity will change (Kiparsky and Gleick 2005; DWR 2006).

Effect on the County

Although global climate change models generally predict an increase in overall precipitation on a worldwide scale, there is no such consistency among the results of regional models applied to California. Based on the model and input assumptions, both increases and decreases in annual precipitation are predicted. There is also variability in the results for different parts of the State. Given the uncertainty associated with projecting the amount of annual precipitation, it would be too speculative to determine the reasonably foreseeable direct effects of climate change on physical conditions, specifically precipitation volumes, in San Benito County.

Snowpack Storage and Water Supply

The county relies primarily on groundwater from local private wells, and on surface water deliveries from the Central Valley Project (CVP) for water supply purchased by the San Benito County Water District (SBCWD). Though little of the county's water supply is derived directly from snowmelt, surface supplies imported into the county do rely on snowmelt sources and the local surface water that does fall within the county is captured and stored in the Hernandez and Paicines reservoirs. Because much of the county is not served by public water purveyors, groundwater overdraft has been a long-term problem in certain areas in the county.

Status and Trends

California's annual snowpack, on average, has the greatest accumulations from November though the end of March. The snowpack typically melts from April through July. Snowmelt provides significant quantities of water to streams and reservoirs for several months after the annual storm season has ended. The length and timing of each year's period of snowpack accumulation and melting varies based on temperature and precipitation conditions (DWR 2006).

California's snowpack is important to the annual water supply because of its volume and the time of year that it typically melts. Average runoff from melting snowpack is usually about 20 percent of the total annual natural runoff, and roughly 35 percent of the total usable annual surface water supply. The snowpack is estimated to contribute an average of about 15 million acre-feet (MAF) of runoff each year, about 14 MAF of which is estimated to flow into the Central Valley. In comparison, total reservoir capacity serving the Central Valley is about 24.5 MAF in watersheds with significant annual accumulations of snow (DWR 2005).

California's reservoir managers (including State Water Project [SWP] and Central Valley Project [CVP] facilities) use snowmelt to help fill reservoirs once the threat of large winter and early spring storms and related flooding risks have passed. These systems include water management infrastructure within watersheds, where additional water is stored in reservoirs and used to help meet downstream water demands after flows from snowmelt begin to recede. Some of the annual runoff collected in California's reservoirs is held from one year to the next because California's annual precipitation and snowpack can vary significantly from year to year. There may also be decade-scale variation in precipitation over the Sierra Nevada (Freeman 2002), and possibly other parts of California. Carryover storage can help meet water demand in years when precipitation and runoff is low.

Because the importance of the Sierra snowpack is tied to both the volume of water it holds and the timing of water releases (spring and early summer), simply assessing the amount of precipitation that falls as snow does not convey the full value of the snowpack and the potential effects of climate change on water supply. Measurements of the amount of Sierra runoff occurring from April to July are a better indicator of the combined interaction between the volume of the snowpack and the time of year that it melts.

Changes in patterns of runoff reveal declining water storage in the form of snowpack. Runoff volumes for April–July have declined when evaluated as "unimpaired" runoff, meaning that the effects of runoff detention in reservoirs are removed. Data indicate that although overall precipitation volumes (represented by runoff amounts) showed no change, more runoff occurred as a result of rain during the winter months, and less runoff could be attributed to the melting of accumulated snowpack during the spring and early summer. These trends suggest less accumulation of snowpack and earlier runoff of snow melt.

Projections

As early as the mid-1980s and early 1990s, regional hydrologic modeling of the effects of climate change has suggested with increasing confidence that higher temperatures will affect the timing and magnitude of snowmelt and runoff in California (Gleick 1986; Lettenmaier and Gan 1990; Lettenmaier and Sheer 1991; Nash and Gleick 1991; Hamlet and Lettenmaier 1999). Over the past two decades, this has been one of the most persistent and well-established findings on effects of climate change for water resources in the U.S. and elsewhere, and it continues to be the major conclusion of regional water assessments (Knowles and Cayan 2002).

By delaying runoff during the winter months when precipitation is greatest, snow accumulation in the Sierra Nevada acts as a massive natural reservoir for California. Despite uncertainties about how increased concentrations of GHGs may affect precipitation, there is very high confidence that higher temperatures will lead to dramatic changes in the dynamics of snowfall and snowmelt in watersheds dominated by substantially more snowfall (Kiparsky and Gleick 2005; DWR 2006). An analysis of the effect of rising temperatures on snowpack conducted by DWR (2006) shows that a 3°C (5.4°F) rise in average annual temperature would likely cause snowlines to rise approximately 1,500 feet. This would result in an annual loss of approximately five MAF of water storage in snowpack. Simulations conducted by N. Knowles and D. R. Cayan (Knowles and Cayan 2002) project a loss in April snowpack in the Sierra Nevada of approximately five percent with a 0.6°C (1.1°F) increase in average annual temperature, an approximately 33 percent loss with a 1.6°C (3.4°F) rise, and an approximately 50 percent loss in April snowpack with a 2.1°C (4.9°F) average annual temperature rise. Loss of snowpack was projected to be greater in the northern Sierra Nevada and the Cascades than in the southern Sierra Nevada because of the greater proportion of land at the low and mid-elevations in the northern ranges. With a temperature increase of 2.1°C, the northern Sierra Nevada and the Cascades were projected to lose 66 percent of their April snowpack, while the southern Sierra Nevada was projected to lose 43 percent of its April snowpack (Knowles and Cayan 2002).

Future predictions confirm that not only will snowpack form a smaller part of overall precipitation, but it will also melt and run off earlier in the year (Gleick and Chalecki 1999). This change will occur as overall precipitation will likely increase slightly. These two trends will most likely cause reduced summer flows, reduced summer soil moisture, and increased winter flows and flood potential. Higher snowlines will cause a greater proportion of winter runoff and earlier snowmelt times will lengthen the duration of peak winter flows and flood potential.

Effect on the County

Based on the results of a variety of regional climate models and literature, it is reasonably foreseeable that snowpack will be reduced and/or will melt earlier or more rapidly in watersheds that feed the Central Valley Project. Consequently, changes in snowpack could affect the county indirectly by altering the timing and volume of runoff that feeds the Central Valley Project, which supplies much of the northern portion of San Benito County's water supply. As a result, CVP deliveries to the county may decrease over time.

Extreme Weather Events

Variability and extreme weather events are a natural part of any climatic system. The extent of climatic stability or variability is dependent in large part on the time frame examined. Climatic conditions may be characterized as relatively stable over periods of hundreds or thousands of years, but within that time frame there may be severe droughts or flood events that vary widely beyond the overall average condition.

Status and Trends

Paleoclimatic evidence from tree rings, buried stumps, and lakebed sediment cores suggests that in California, the past 200 years have been relatively wet and relatively constant when compared with older records (DWR 2006). These older records reveal greater variability than the historical record, in particular in the form of severe and prolonged droughts, but are not likely to be as reliable as more recent records. Most identified climatic averages and extremes for California are based on the historical climate record since 1900, and cannot be considered fully representative of past or future conditions (DWR 2006).

Extreme weather events are expected to be one of the more important indicators of climate change. Phenomena such as the El Niño/Southern Oscillation, which is the strongest natural inter-annual climate fluctuation, affect the entire global climate system and the economies and societies of many regions and nations. Direct effects of this climate fluctuation occur in California. The El Niño/Southern Oscillation for example, strongly influences storms and precipitation patterns. It is unclear how increases in global average temperatures associated with global warming might affect the El Niño cycles. However, the strong El Niños of 1982–83 and 1997–98 and associated flood events, along with the more frequent occurrences of El Niños in the past few decades, have forced researchers to try to better understand how human-induced climate change may affect inter-annual climate variability (Trenberth and Hoar 1996; Timmermann et al. 1999).

In addition to possible long-term changes in precipitation trends, increased variability of annual precipitation is a possible outcome of climate change. Based on a statistical analysis of California precipitation records, there appears to be an upward trend in the variability of precipitation over the 20th century, with variability values at the end of the century about 75 percent larger than at the beginning of the century. This indicates that there tended to be more extreme wet and dry years at the end of the century than there were at the beginning of the century (DWR 2006). However, as stated above, paleoclimatic evidence suggests that weather patterns in California have been relatively constant over the last 200 years, which identifies the variable weather patterns toward the latter part of this period as more pronounced. As identified previously in the "Precipitation" discussion, there has been little change in the average amount of annual precipitation in California over the last 100 years. Therefore, the increased variability between wet and dry years in recent decades appears to oscillate around the same annual average established over a longer time frame.

Projections

While variability is not well modeled in large-scale GCMs, some modeling studies suggest that the variability of the hydrologic cycle increases when mean precipitation increases, possibly accompanied by more intense local storms and changes in runoff patterns (DWR 2006). However, the results of another long-standing model point to an increase in incidents of drought, resulting from a combination of increased temperature and evaporation along with decreased precipitation (DWR 2006). Based on the first model mentioned, this decrease in precipitation would lead to reduced variability in hydrologic cycles.

A study that analyzed 20 GCMs in use worldwide suggests that the West Coast may be less affected by extreme droughts than other areas; instead, the region would experience increased average annual rainfall (Meehl et al. 2000). A separate study that reviewed several GCM scenarios showed increased risk of large storms and flood events for California (Miller et al. 1999). Conflicting conclusions about climatic variability and the nature of extreme weather events (e.g., droughts, severe storms, or both) support the need for additional studies with models featuring higher spatial resolution (Kiparsky and Gleick 2005; DWR 2006).

Effect on the County

Although various climate change models predict some increase in variability of weather patterns and an increasing incidence of extreme weather events, there is no consistency among the model results, with some predicting increased incidents of droughts and others predicting increased frequency of severe storm events. Given the uncertainty associated with projecting the type and extent of changes in climatic variability and the speculative nature of predicting incidents of extreme weather events, the effect on the county of changing patterns of storms and other extreme weather remains unclear.

Increased risk of drought presents increased risk of wildfire hazards. However, most urbanized areas of the county are bounded by agricultural land that is actively farmed or fallow, and are not generally adjacent to any wildlands. As the county continues to grow and development encroaches further into wildland interface areas, the potential for wildland fires will increase.

Sea Level Rise

Status and Trends

One of the major areas of concern related to global climate change is rising sea level. Worldwide average sea level appears to have risen about 0.4 to 0.7 foot over the past century based on data collected from tide gauges around the globe, coupled with satellite measurements taken over approximately the last 15 years (IPCC 2007). Various gauge stations along the coast of California show an increase similar to the global trends. Data specific to the San Francisco tide gauge near the Golden Gate Bridge shows that the 19-year mean tide level (the mean tide level based on 19-year data sets) has increased by approximately 0.5 foot over the past 100 years. Rising average sea level over the past century has been attributed primarily to warming of the world's oceans and the related thermal expansion of ocean waters, and the addition of water to the world's oceans from the melting of land-based polar ice. Some researchers have attributed most of the worldwide rise to thermal expansion of water, although there is some uncertainty about the relative contributions of each cause (Munk 2002).

Projections

A consistent rise in sea level has been recorded worldwide over the last 100 years. Recorded rises in sea level along the California coast correlate well with the worldwide data. Based on the results of various global climate change models, sea level rise is expected to continue. Based on the consistency in past trends, the consistency of future projections, and the correlation between data collected globally and data specific to California, it is reasonably foreseeable that some amount of sea level rise will occur along the California coast over the next 100 years. Although sea level rise is expected to occur, the amount and timing of the increase is uncertain.

Various global climate change models have projected a rise in worldwide average sea level of 0.6–1.9 feet by 2099 (IPCC 2007). Although these projections are on a global scale, the rate of relative sea level rise (SLR) experienced at many locations along California's coast is relatively consistent with the worldwide average rate of rise observed over the past century. Therefore, it is reasonable to expect that changes in worldwide average sea level through this century will also be experienced by California's coast (DWR 2006). For example, the Governor-appointed Delta Vision Blue Ribbon Task Force has recommended the State plan for a scenario of 16 inches of sea level rise by 2050, and 55 inches by 2100 (California Resources Agency 2008).

Effect on the County

For California's water supply, the largest effect of sea level rise would likely be in the Delta (DWR 2005). Increased intrusion of salt water from the ocean to the Delta could degrade the quality of the fresh water that is pumped out for municipal, industrial, and agricultural purposes. This could lead to increased releases of water from upstream reservoirs or reduced pumping from the Delta to maintain compliance with water quality standards. Increased demand for stored surface water could affect other surface water supplies within the applicable watershed; however, until specific demands occur, the effect on regional supplies, especially those dependent on the CVP, remains speculative.

While climate change-induced sea level rise is reasonably certain, with respect to the county, even the high-range projections would not directly affect low-lying areas of the county due to the county's location between two mountain ranges and its overall higher elevation compared to sea level. For example, projected seawater rise associated with global climate change is in the range of 0.6–1.9 feet or up to 55 inches (4.6 feet) by the year 2099 (IPCC 2007; CARB 2008). Minimum ground surface elevations within the county are near 80 feet in the northwest county at the Pajaro River.

Water Supply

Status, Trends, and Projections

Several recent studies have shown that existing water supply systems are sensitive to climate change (Wood 1997). Potential effects of climate change on water supply and availability could directly and indirectly affect a wide range of institutional, economic, and societal factors (Gleick 1998). Much uncertainty remains, however, with respect to the overall effect of global climate change on future water supplies. For example, models that predict drier conditions (i.e., parallel climate model [PCM]) suggest decreased reservoir inflows and storage and decreased river flows, relative to current conditions. By comparison, models that predict wetter conditions project increased reservoir inflows and storage and increased river flows (Brekke 2004). Both projections are equally probable based on which model is chosen for the analyses (Brekke 2004). Much uncertainty also exists with respect to how climate change will affect future demand on water supply (DWR 2006). Still, changes in water supply are expected to occur, and many regional studies have shown that large changes in the reliability of water yields from reservoirs could result from only small changes in inflows (Kiparsky and Gleick 2005; Cayan et al. 2006).

Little work has been performed on the effects of climate change on specific groundwater basins or groundwater recharge characteristics (Kiparsky and Gleick 2005). Changes in rainfall and changes in the timing of the groundwater recharge season would result in changes in recharge. Conversely, warmer temperatures could lead to higher evaporation or shorter rainfall seasons, which could mean that soil deficits would persist for longer time periods, shortening recharge seasons. Warmer, wetter winters would increase the amount of runoff available for groundwater recharge. This additional winter runoff, however, would be occurring at a time when some basins, particularly in Northern California, are being recharged at their maximum capacity. Reductions in spring runoff and higher evapotranspiration, on the other hand, could reduce the amount of water available for recharge. However, the specific extent to which various meteorological conditions will change and the effect of that change on groundwater are both unknown. A reduced snowpack, coupled with increased rainfall, could require a change in the operating procedures for California's existing dams and conveyance facilities (Kiparsky and Gleick 2005).

Tanaka et al. (2006) explored the ability of California's water supply system to adapt to long-term climatic and demographic changes using the California Value Integrated Network (CALVIN), a statewide economic-engineering optimization model of water supply management. The results show that agricultural water users in the Central Valley are the most sensitive to climate change, particularly under the driest and warmest scenario (i.e., PCM 2100), predicting a 37 percent reduction of Central Valley agricultural water deliveries and a rise in Central Valley water scarcity costs by $1.7 billion. Although the results of the study are only preliminary, they suggest that California's water supply system appears "physically capable of adapting to significant changes in climate and population, albeit at a significant cost." Such adaptation would entail changes in California's groundwater storage capacity, water transfers, and adoption of new technology.

Based on the conclusions of current literature regarding California's ability to adapt to global climate change, it is reasonably expected that over time the State's water system will be modified to be able to address the projected climate changes (e.g., under dry and/or warm climate scenarios) (DWR 2006). Although coping with climate change effects on California's water supply could come at a considerable cost, based on a thorough investigation of the issue, it is reasonably expected that statewide implementation of some, if not several, of the wide variety of adaptation measures available to the State will likely enable California's water system to reliably meet future water demands. For example, traditional water supply reservoir operations may be used, in conjunction with other adaptive actions, to offset the effects of climate change on water supply (Medellin et al. 2006; Tanaka et al. 2006; Lund et al. 2003). Other adaptive measures include better urban and agricultural water use efficiency practices, conjunctive use of surface and ground waters, desalination, and water markets and portfolios (Medellin et al. 2006; Lund et al. 2003; Tanaka et al. 2006). More costly statewide adaptation measures could include construction of new reservoirs and enhancements to the State's levee system (CEC 2003). As described by Medellin et al. 2006, with adaptation to the climate, the water deliveries to urban centers are expected to decrease by only 1 percent, with southern California shouldering the brunt of this decrease.

Medellin et al. (2006) used the CALVIN model under a high-emissions "worst-case" scenario, called a dry-warming scenario. The study found that climate change would reduce water deliveries by 17 percent in 2050. The reduction in deliveries, however, was not equally distributed between urban and agricultural areas. Agricultural areas would see their water deliveries drop by 24 percent while urban areas would see a reduction of only one percent. There was also a geographic difference: urban water scarcity was almost absent outside of Southern California.

In 2003, CEC's Public Interest Energy Research (PIER) program established the California Climate Change Center (CCCC) to conduct climate change research relevant to the State. Executive Order S-3-05 called on CalEPA to prepare biennial science reports on the potential effects of continued climate change on certain sectors of California's economy. CalEPA entrusted PIER and its CCCC to lead this effort. The climate change analysis contained in its first biennial science report concluded that major changes in water management and allocation systems could be required to adapt to the change. As less winter precipitation falls as snow, and more as rain, water managers would have to balance the need to construct reservoirs for water supply with the need to maintain reservoir storage for winter flood control. Additional storage could be developed, but at high environmental and economic costs.

Lund et al. (2003) examined the effects of a range of climate warming estimates on the long-term performance and management of California's water system. The study estimated changes in California's water availability, including effects of forecasted changes in 2100 urban and agricultural water demands using a modified version of the CALVIN model. The main conclusions are summarized as follows:

- Methodologically, it is useful and realistic to include a wide range of hydrologic effects, changes in population and water demands, and changes in system operations in climate change studies.

- A broad range of climate warming scenarios show significant increase in wet-season flows and significant decreases in spring snowmelt. The magnitude of climate change effects on water supplies is comparable to water demand increases from population growth in the 21st century.
- California's water system would be able to adapt to the severe population growth and climate change modeled. This adaptation would be costly, but it would not threaten the fundamental prosperity of the State, although it could have major effects on the agricultural sector. The water management costs represent only a small proportion of California's current economy.
- Under some wet-warming climate scenarios, flooding problems could be substantial. In certain cases, major expansions of downstream floodways and alterations in floodplain land use could become desirable.
- California's water system could economically adapt to all of the climate warming scenarios examined in the study. New technologies for water supply, treatment, and water use efficiency, implementation of water transfers and conjunctive use, coordinated operation of reservoirs, improved flow forecasting, and the cooperation of local, regional, State, and Federal governments can help California adapt to population growth and global climate change. Even if these strategies are implemented, however, the costs of water management are expected to be high and there is likely to be less "slack" in the system than under current operations and expectations.

Effect on the County

As described by the projections above, overall, climate change is expected to have the largest effect on southern California and on agricultural users. Most water scarcity would be felt by agricultural users in southern California. However, it is expected that southern California urban water users, especially in the Coachella Valley, would also experience some scarcity. By the year 2050, almost no urban water scarcity would exist north of the Tehachapi Mountains; however, agricultural water scarcity could increase in the Central Valley (Medellin et al. 2006; Tanaka et al. 2006; and Lund et al. 2003).

To the extent that available data and projections suggest that climate change would intensify existing wet and dry patterns, resulting in more precipitation during the wet season and less during the dry season, if the appropriate infrastructure is developed to capture winter rainfall, the county could be less affected by these changes than the current agricultural water use regime. However, there is uncertainty with respect to the effects of climate change on future water availability in California, in terms of whether and where effects will occur, and the timing and severity of any such potential effect.

Water Quality

Status and Trends

Water quality depends on a wide range of interacting variables such as water temperatures, salinity, flows, runoff rates and timing, waste discharge loads, and the ability of watersheds to assimilate wastes and pollutants. The water quality of the county has experienced substantial adverse affects from human activities, including contaminant inputs from urban, industrial, and agricultural sources. Various water bodies in the county are considered impaired in their ability to provide beneficial uses (e.g., ecological habitat, recreation, irrigation, drinking water) because of the presence of a variety of pollutants and stressors. Existing water quality problems in the county may generally be placed in the categories of toxic materials, suspended sediments and turbidity, dissolved oxygen fluctuations and low dissolved oxygen levels, and bacteria.

Projections

Climate change could alter numerous water quality parameters in a variety of ways. Higher winter flows could reduce pollutant concentrations (through dilution) or increase erosion of land surfaces and stream channels, leading to higher sediment, chemical, and nutrient loads in rivers (DWR 2006). Increases in water flows can also decrease chemical reactions in streams and lakes, reduce the flushing time for contaminants, and increase export of pollutants to coastal areas (Jacoby 1990; Mulholland et al. 1997; Schindler 1997). Decreased flows can exacerbate temperature increases, increase the concentration of pollutants, increase flushing times, and increase salinity (Schindler 1997; Mulholland et al. 1997). Decreased surface-water flows can also reduce nonpoint-source runoff (Mulholland et al. 1997). Increased water temperatures can enhance the toxicity of metals in aquatic ecosystems (Moore et al. 1997). Increases in water temperature alone are often likely to lead to adverse changes in water quality, even in the absence of changes in precipitation (Kiparsky and Gleick 2005).

A review performed by Murdoch et al. of the potential effects of climate change on water quality concluded that significant changes in water quality are known to occur as a direct result of short-term changes in climate (Murdoch et al. 2000). The review notes that water quality in ecological transition zones and areas of natural climate extremes is vulnerable to climate changes that increase temperatures or change the variability of precipitation. However, it is also argued that changes in land and resource use will affect water quality comparable to or even greater than those from changes in temperature and precipitation. A separate study performed by Kiparsky and Gleick in 2005 concluded that the net effect on water quality for rivers, lakes, and groundwater in the future is dependent not just on how climatic conditions might change, but also on a wide range of other human actions and management decisions (Kiparsky and Gleick 2005).

Effect on the County

Although there are various ways in which climate change could affect water quality, effects could be positive or negative depending on a variety of conditions. Current water quality conditions in regional surface waters depend in large part on human activities which would continue to be the case in the future. The effects of climate change on water quality could be alleviated or exacerbated by localized human actions. Given the uncertainty associated with projecting the types and extent of changes in water quality attributable to climate change, along with the variability of effects due to human activities, this potential climate change effect is too speculative to draw a conclusion regarding any direct effect on physical conditions throughout the county.

Agriculture

Status, Trends, and Projections

Numerous studies indicate that climate change may have a profound effect on agriculture in California (Tanaka et al. 2006; Howitt 2003). Many of the climate change forecasting models used in the studies predict a variety of direct and indirect effects on the sector's agronomic and economic conditions. The degree to which climate change will affect agriculture depends on a variety of factors. Although there remains uncertainty about what form of climate change will occur in California, the majority of research on the subject has focused on the likelihood that a climate warming pattern will occur (DWR 2006; Lund 2003). Although both dry-warm or wet-warm forms of climate warming would affect California agriculture, dry-warm climate scenarios are expected to be the most problematic (Tanaka et al. 2006).

Potential effects of climate change include reductions in water supply and water supply reliability, increased evapotranspiration, changes in growing season, and altered crop choices (DWR 2006). As discussed in the previous sections, substantial changes may occur in terms of water supply. As a primary consumer of surface water and groundwater, the agricultural sector will face significant challenges in the event of supply reductions. Higher levels of evapotranspiration would result from the increased temperatures and decreased humidity of a dry-warm climate scenario (Hildalgo 2005). In turn, evapotranspiration would cause increases in water demand, salt accumulation on plants, soil salinity, and additional water use for reducing saline soils (DWR 2006). Such effects could reduce productivity and create adverse economic repercussions for farmers and ranchers in the State (DWR 2006). Changes to the growing season and altered crop choices may negatively or positively affect productivity, water supply, and profitability, depending on the adaptations farmers choose (Tanaka et al. 2006).

Most year-2100 models indicate increased market water transfers from agriculture to urban users (Tanaka et al. 2006). Sector productivity could be maintained if water transfers were balanced with irrigation efficiency improvements.

Although a dry-warm climate scenario would reduce agricultural water deliveries (24 percent statewide), models demonstrate that agricultural income will be reduced by only six percent and irrigated lands will be reduced by only 15 percent. It is expected that farmers will adopt changes in crop mix, cropping systems, and irrigation technology. These adaptations are likely to reduce the effect of reduced water deliveries on agriculture (Tanaka et al. 2006).

Increased evapotranspiration rates could have a considerable effect on agricultural water demand in the State (DWR 2006). The IPCC expects a 3°C increase in temperature over the next century (IPCC 2007). Research demonstrates that such an increase in temperature will likely result in a five percent increase in plant transpiration, assuming no change in solar radiation (cloudiness) levels and other related variables (wind, humidity, and minimum temperature) (Hildalgo 2005). Therefore, evapotranspiration alone could create a five percent increase in agricultural water consumption over the next 100 years, or a 0.5 percent increase per decade. Projected increases in CO_2 concentrations are expected to increase plant growth by up to 20 percent and in turn lead to increased evapotranspiration (Long 2004). A caveat to this is that increased atmospheric CO_2 concentrations may work to decrease plant stomata transpiration rates and thus reduce overall evapotranspiration rates (Long 2004). More research is needed to understand this relationship.

Effect on the County

How climate change affects agricultural operations on private land is a matter of public concern. Climate change may reduce the suitability of lands for agricultural uses. However, while climate change effects may occur, adaptation is also expected that would allow farmers and ranchers to minimize any potential negative effect on agricultural incomes. Adoption of new cropping systems and improved irrigation techniques are expected to allow agriculture to continue in the region. Although costly to farmers, implementation of more efficient irrigation techniques and systems would reduce the amount of water required to achieve the same crop yields, which would reduce overall agricultural water demand and GHG emissions associated with water conveyance. Other less expensive agricultural practices that may be implemented to lessen the impact of climate change include introduction of later-maturing crop varieties and species, switching crop sequences, sowing earlier, adjusting the timing of field operations, and conserving soil moisture through different tillage methods, among others. However, the extent to which these farming practices will be implemented is dependent on the individual farmers. No regulations currently (2010) exist that would require agricultural operators to implement less GHG intensive practices. Because of the significant uncertainty in projecting future conditions, it would be too speculative to determine the reasonably foreseeable direct effects of climate change on physical conditions in San Benito County.