6.0 GROWTH-INDUCING IMPACTS

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6.0 GROWTH-INDUCING IMPACTS

6.1. INTRODUCTION

While NEPA offers no specific guidance with respect to growth-inducing impacts, Section 15126(g) of the CEQA guidelines require an EIR to discuss how a project may "*foster economic or population growth, or the construction of additional housing . . . in the surrounding environment . . . [and] the characteristic of some projects which may encourage and facilitate other activities that could significantly affect the environment*."

Section 15126.2(d) of the CEQA Guidelines states that an EIR must, "…[d]iscuss the ways in which a proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment." Growth must not be assumed to be necessarily beneficial, detrimental or of little significance in an EIR. The EIR must address what, if any, obstacles to growth and development the project would remove, thereby inducing growth to occur. The project may have other characteristics, might foster economic or population growth that might affect the environment, and these too must be discussed in the EIR.

6.2. GROWTH CONCEPTS

Growth rates and patterns are influenced by various local, regional, and national forces that reflect ongoing social, economic, and technological changes. Ultimately, the amount and location of population growth and economic development that occur in a specific area are controlled, to some extent, by local and county governments through zoning, land use plans and policies, and decisions regarding development applications. Local government and other regional, State, and federal agencies also make decisions about infrastructure (such as roads, water facilities, and sewer facilities) that may influence growth rates and the location of future development.

Growth-inducing impacts fall into two general categories, direct and indirect. Direct growth inducing impacts are generally associated with the provision of urban services to an undeveloped area. The provision of these services to a site, and the subsequent development, can serve to induce other landowners in the vicinity to convert their property to urban uses. Indirect, or secondary growth-inducing impacts consist of growth induced in the region by the additional demands for housing, goods, and services associated with the population increase caused by, or attracted to, a new project. Typically, the purpose of a General Plan is to guide growth and development in a community and, accordingly, the General Plan is premised on the acknowledgement that a certain amount of growth will take place over a defined time horizon. The focus of the General Plan, then, is to provide a framework in which the growth can be managed and to tailor it to suit the needs of the community and surrounding area.

6.3. EL DORADO COUNTY GENERAL PLAN

The El Dorado County General Plan acknowledges that the County will continue to grow but will attempt to retain the qualities of its natural resource base, both consumptive and environmental, in order to maintain its custom and culture and to assure its long-term economic stability. The Plan acknowledges the ecological and historic values of these lands while saving and conserving the lands for future economic benefits for all purposes. The County and its Plan recognize that the rural character of the County is its most important asset. Accordingly, with careful planning and management, it is felt that the County can maintain this character while accommodating reasonable growth and achieving economic stability.

The vision for future growth in the County includes the following:

1. Maintain and protect the County's natural beauty and environmental quality, vegetation, air and water quality, natural landscape features, cultural resource values, and maintain the rural character and lifestyle while ensuring the economic viability critical to promoting and sustaining community identity.
2. Where appropriate, encourage clustered development as an option to maintain the integrity and distinct character of individual communities, while protecting open space and promoting natural resource uses.
3. Make land use decisions in conjunction with comprehensive transportation planning and pursuing economically viable alternative transportation modes, including light rail. Adopt a Circulation Element providing for rural and urban flows that recognize limitations of topography and natural beauty with flexibility of road standards.
4. Promote a better balance between local jobs and housing by encouraging high technology activities and value added activities tied directly to available resource based industries such as the timber industry, tourism, agriculture, mining, and recreation.
5. Increase the amount of affordable housing by providing a variety of housing types and encouraging residential projects to reflect affordability in light of the existing local job base and/or infrastructure.
6. Encourage efforts to locate a four-year college and support the ability of elementary, middle, and high schools to keep pace with population growth.
7. Improve and expand local parks and recreational facilities throughout the County.
8. Recognize that the General Plan is a living document which must be updated periodically, consistent with the desires of the public, and provide for public involvement in the planning process.

Various General Plan strategies have also been developed that help provide for methods of achieving the visions and goals and to carry forward the Plan's principle purposes. These include:

1. Recognize urban growth in Community Regions while allowing reasonable growth throughout the rural areas of the County.

2. Promote growth in a manner that retains natural resources and reduces infrastructure costs.
3. Encourage growth to reflect the character and scale of the community in which it occurs and recognize that planned developments are an effective planning tool to maximize community identity and minimize impact on the surrounding area.
4. Require new growth to fully fund its on-site services and apportioned share of off-site services.
5. Provide that Plan goals, objectives, and policies reflect the significant differences in characteristics between the principal land use planning areas of Community Regions, Rural Centers, and Rural Regions.
6. Provide sufficient land densities and land use designations throughout the County to accommodate the projected growth for all categories of development.
7. Support the ability of the private sector to create and provide housing for all residents regardless of income, race, sex, age, religion, or any other arbitrary factor to accommodate the County's projected share of the regional housing needs.
8. Recognize economic development as an integral part of the development of existing communities and new communities by allowing for a diverse mix of land use types which would facilitate economic growth and viability.

Guidance provided by the General Plan regarding interpretation of some of the major policies affecting or otherwise controlling "disorderly" growth, include the following:

- AG and Timberland Setbacks
  - Policy 8.1.3.2 AND 8.4.1.2 Interim Interpretive Guidelines (July 31, 2007)
- Development on 30 percent slopes
  - Policy 7.1.2.1 - Interim Interpretive Guidelines (October 24, 2006)
- Housing Element
  - Evaluating General Plan Consistency in Relation to Density and Affordable Housing Policies (September 28, 2006)
- Integrated Natural Resources Management Plan (INRMP)
  - INRMP Development & Supporting Documentation
- Oak Woodlands
  - Oak Woodlands Planning/Oak Woodlands Ordinance
- Riparian areas and wetlands - buffers and setbacks
  - Policy 7.3.3.4 Interim Interpretive Guidelines (June 22, 2006)

6.4. EL DORADO COUNTY POPULATION

El Dorado County's 2000 population was 156,299. Population within the county has grown approximately 2.4 percent annually since 1990; this can be compared with the State annual growth rate of nearly 1.4 percent. The net increase in number of jobs in El Dorado County was 59,939 (a

380 percent increase) between 1970 and 2000, with the service and professional sector generating 43,231 new jobs.

In March 2002, Economic & Planning Systems (EPS) completed a detailed land use forecast for the West Slope of El Dorado County. EPS estimated that, based on market research, historical growth patterns, and SACOG projections, El Dorado County could support an additional 78,000 persons by 2025. According to the EPS projections, it is expected that the West Slope population would increase 64 percent between 2000 and 2025.[217]

6.5. PROMOTION OF ECONOMIC EXPANSION

El Dorado County, through the Economic Development Element of its General Plan appreciates the importance of fostering new and sustainable economic development. Objective 10.1.5 of this Element: Business Retention and Expansion states that it is the County's objective to: [a]*ssist in the retention and expansion of existing businesses through focused outreach and public and private incentive programs and <u>target new industrie</u>s which diversify and strengthen our export base*. [Emphasis added]

Several policies are relevant in this context and confirm the County's genuine intent at promoting new economic development. Policy 10.1.5.1 provides for the assistance to industries to remain, expand, or to locate in El Dorado County. Programs under this policy include:

<u>Program 10.1.5.1.1</u>: Identify and attract selected targeted industries that are consistent with the County's goal of balancing economic vitality and environmental protection.

<u>Program 10.1.5.1.2</u>: Develop an action plan for each targeted industry to encourage retention and expansion of businesses including special needs of each targeted industry and location assistance for expansion or relocation. Incubator space within commercial/industrial parks is an important component of these action plans.

<u>Program 10.1.5.1.3</u>: The Economic Development Providers Network shall establish a system for annually inventorying existing industries and businesses in order to provide early warning of businesses that are at risk and are considering moving or expanding out of the County.

<u>Program 10.1.5.1.4</u>: Annually dedicate and budget County staff to implement programs under Objective 10.1.5 and/or coordinate County efforts with the private sector and Economic Development Providers Network.

<u>Program 10.1.5.1.5</u>: The County shall monitor land availability through five-year reviews of the General Plan to assure a sufficient supply of commercial and industrial designated lands.

<u>Program 10.1.5.1.6</u>: El Dorado County, in cooperation with the Economic Providers Network, shall develop a comprehensive regional economic development program to attract industry to the County at a rate higher than the Sacramento Area Council of Governments (SACOG) and/or County

217 El Dorado County Planning Department, *El Dorado County General Plan Draft Environmental Impact Report* (SCH #2001082030), May 2003, Chapter 4, Land Use Forecasts and Development Estimates.

employment forecasts. The economic development program should consider the employment needs of the resident labor force as well as more traditional measures of progress/stability as the jobs/housing balance.

Deliberate attempts at targeting specific industries and expanding value added industries are reflected in the following policies and programs:

Policy 10.1.5.3 Conduct outreach to targeted industries for potential location in El Dorado County.

Program 10.1.5.3.1: Develop an information system on significant potential vacancies in office, commercial, and industrial space to facilitate the movement of business from one facility to another. The information system should include data which characterizes the type and source of utilities available at each vacancy.

Policy 10.1.5.4 Recognize and promote agricultural based industries in El Dorado County and provide for the expansion of value added industries in an economically viable manner consistent with available resources.

Program 10.1.5.4.1: The Zoning Ordinance shall provide for agriculture dependent commercial and industrial uses on lands within Rural Regions.

Program 10.1.5.4.2: The Zoning Ordinance shall allow the sales and marketing of products grown in El Dorado County and crafts made in El Dorado County in areas designated for agricultural use.

Policy 10.1.5.5 Recognize and promote the need to create greater opportunities for El Dorado County residents to satisfy retail shopping demands in El Dorado County.

Program 10.1.5.5.1: Designate sufficient lands of a size and at locations to accommodate needed retail and commercial development.

Policy 10.1.5.6 Encourage the locating of new employment base industries that provide for additional employment opportunities for existing residents currently employed by industries with declining job potential to provide for a better employment future and business climate for the County.

Prior to approval of a General Plan amendment to Tourist Recreational or a zone change to implement this land use designation, when a site is adjacent to a residential, agricultural, or Natural Resource designation, a finding shall be made which concludes that the development project will have no significant growth inducement effect on adjacent lands.

It is important to note that it is the responsibility of public planning agencies to foresee future needs for development and to try to implement land use development strategies that, to the extent possible, meet those needs in a manner that is environmentally sound and takes into consideration other objectives and overall needs of the community. It is the responsibility of the County Board of Supervisors to adopt and uphold such policies.

6.6. WATER SUPPLY PROVISIONS – GENERAL PLAN CONTEXT

Regarding the availability of water supplies, the El Dorado County General Plan is premised on the following assumptions:

a) An adequate supply of water will be available to serve the County's current population.

b) Additional water supplies will be developed to support the projected growth.

c) Lack of water availability may change the period of time over which this Plan remains valid.

d) The designation of the American or Cosumnes Rivers as "Wild and Scenic" or their drainage basins as "National Recreation Areas" would be incompatible with the County's water storage objectives.

Pertaining to water supply, the Public Services and Utilities Element of the General Plan, GOAL 5.2: WATER SUPPLY states:

> The development or acquisition of an adequate water supply consistent with the geographical distribution or location of future land uses and planned developments.

A clear goal of the General Plan is the development or acquisition of an adequate water supply to meet future needs. Of particular relevance is Policy 5.2.1.15, which states:

> "The County shall support the efforts of the County Water Agency and public water providers to retain existing and <u>acquire new surface water supplies for planned growth</u> and existing and planned agricultural uses within El Dorado County. New surface water supplies may include wastewater that has been reclaimed consistent with state and federal law." [Emphasis Added]

Other notable policies within the Public Services and Utilities Element pertaining to water supply can be found in the following:

Policy 5.2.1.1	The El Dorado County Water Agency shall support a County-wide water resources development and management program which is coordinated with water purveyors and is consistent with the demands generated by the General Plan land use map.
Policy 5.2.1.13	The County shall encourage water purveyors to design water supply and infrastructure projects in a manner that avoids or reduces significant environmental effects to the maximum extent feasible in light of the water supply objectives of a given project.
Policy 5.2.1.14	The County, in cooperation with the Water Agency and water purveyors, shall collect and make available information on water supply and demand.

EDCWA has recently updated its final *Water Resources Development and Management Plan*. This Plan is designed to coordinate water planning activities within El Dorado County and provide a blueprint for actions and facilities needed to meet the County's water needs into the future. The major water agencies participating in development of the plan are: EDCWA, EID, GDPUD, Grizzly Flat Community Services District, South Tahoe Public Utility District and the Tahoe City Public Utility District. The Plan addresses the water supply needs of the entire County including those areas presently not served by a purveyor, and identifies potential technical, environmental and institutional constraints for each water resource alternative.

Existing water supply infrastructure and operations have been able to absorb substantial urban growth in western El Dorado County, primarily within the EID service area. However, water demand forecasts indicate that considerably more water will be needed to support approved growth in the County and projected increases in agricultural demands. Based on the approved 2004 General Plan and refinements made to the agricultural projections, the estimated total water demand in the County in 2025 will be roughly 125,445 AF. Most of this demand would occur on the western slope of the county, while about 10 percent of the future demand would be in the Tahoe Basin.

Buildout of the General Plan will require a total water supply of about 194,820 AF. Based on the 2004 General Plan and refinements made to the agricultural projections, the additional water supply needed by 2025 is calculated to be 34,276 AF, and a total of 103,518 AF of additional water supplies will be needed to meet projected buildout demands. Accordingly, without these new CVP contracts in place, an additional 34,000 AF of new water supplies are needed to meet the County's 2004 General Plan growth projections to 2025 and associated water needs.

6.7. GROWTH-INDUCING IMPACTS

Growth inducing impacts, both direct and indirect, have been thoroughly addressed in the El Dorado County General Plan, its supporting EIR, and the several policies and interpretive guidelines that have been prepared in support of specific General Plan Policies (e.g., INRMP, Oak Woodlands, Development of 30 percent Slopes, Riparian Areas and Wetland Buffers, etc.). The new CVP water service contracts authorized by P.L.101-514 are intended to meet, in part, the long-term water supply needs of El Dorado County. An inability to obtain this or, other water supplies, would inhibit and delay projected and approved growth within the County.

As noted in each of the secondary, or service area related resource impact discussions (i.e., non-diversion related) provided previously, anticipated impacts will occur within El Dorado County as the General Plan is fully implemented and growth continues, as planned and expected. Many such effects are, in fact unavoidable. As provided in the various General Plan Policies and, in particular, the mitigation measures identified and adopted by the County as part of its General Plan EIR, various means to avoid, offset, reduce or otherwise mitigate these significant adverse impacts have been made. Still, certain impacts, owing to their nature, existing baseline conditions, and lack of available technologies to address these effects on a broad scale imply that several impacts will remain significant and unavoidable. The County has made specific findings on what these impacts are and, in this EIS/EIR, references to those impacts have been provided in previous sections.

The implementation of the General Plan would likely result in or contribute to the following irreversible environmental changes:

- Relatively low-density (primarily residential) suburban land use patterns that would likely preclude future higher density development except where designated. This would likely preclude efficient, cost-effective full-service transit services.

- Conversion of existing undeveloped land and open vistas to developed land uses, thus precluding other alternate land uses in the future, and precluding preservation of the existing land use pattern and vistas.
- Irreversible loss of agricultural land and timberland.
- Commitment of water resources to serve development and degradation of water quality from suburban runoff.
- Commitment of municipal resources to the provision of services and operations of infrastructure for future suburban development.
- Surfacing of substantial areas of important soils and mineral resources with impermeable surfaces associated with semi-rural and suburban development.
- Increased ambient noise and background air emissions.
- Conversion of existing habitat and irreversible loss of wildlife.

In addition to these irreversible changes, other more general irreversible changes would be expected, and the magnitude would be generally tied to population growth. Population related, irreversible changes would be as follows:

- Irreversible consumption of goods and services associated with the future population.
- Irreversible consumption of energy and natural resources associated with the future population.
- Possible demand for and use of goods, services, and resources by the county to the exclusion of development in other locations in the region.

Various significant and unavoidable impacts of the General Plan alternatives were identified in the General Plan EIR. This assessment is consistent with NEPA (40 CFR 1502.16) requiring, in part, a discussion of the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. Such discussions should consider: (f) natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures; and (g) urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures.

Without this new water supply, future growth would be curtailed within the Subcontractor service areas of EID and GDPUD as defined by this Proposed Action. In this sense, the project is growth-inducing. Without the 15,000 AFA associated with the project, some of growth contemplated by the El Dorado County General Plan may not occur.

In summary, the significant and unavoidable impacts included the following, by resource category:

Land Use and Housing

5.1-2: Substantial Alteration or Degradation of Land Use Character in the County or Subareas.

Agriculture and Forestry

5.2-1: Potential for Conversion of Important Farmland, Grazing Land, or Land Currently in Agricultural Production or for Conflict that Results in Cancellation of a Williamson Act Contract.

Visual Resources

Impact 5.3-2: Degradation of Existing Visual Character or Quality of the Area or Region.

Traffic and Circulation

5.4-1: Potential Inconsistencies with LOS Policies. Depending on which mitigation is adopted, impact may or may not be mitigated to less than significant.

5.4-2: Increase in Daily and Peak Hour Traffic.

5.4-3: Short-Term Unacceptable LOS Conditions Related to Generation of New Traffic in Advance of Transportation Improvements.

5.4-4: Insufficient Transit Capacity.

Water Resources

5.5-1: Increased Water Demand and Likelihood of Surface Water Shortages Resulting from Expected Development.

5.5-2: Potential Environmental Impacts Associated with the Development of New Surface Water Supplies and Related Infrastructure.

5.5-3: Increase in Groundwater Demand and Related Impacts.

5.5-4: Increase in Wastewater Flows and Related Infrastructure Impacts.

5.5-7: Increase in Surface Water Pollutants from Additional Wastewater Treatment Plant Discharges.

Utilities

5.6-3: Potential Noncompliance with State-Mandated Solid Waste Diversion Rate.

5.6-5: Potential for Land Use Incompatibility and Other Impacts of New and Expanded Solid Waste and Hazardous-Waste Facilities.

5.6-6: Potential for Land Use Incompatibility and Other Impacts of New and Expanded Energy Supply Infrastructure.

5.6-7: Potential for Impacts Associated with New and Expanded Communications Infrastructure.

Public Services

5.7-3: Potential Land Use Incompatibility Associated with Development and Expansion of Public School Facilities.

Human Health and Safety

5.8-2: Increased Incidents of Illegal Dumping of Household Hazardous Wastes.

5.8-3: Increased Risk of Accidental Release of Hazardous Materials.

5.8-6: Risk of Exposure to Flood Hazards Inside Dam Inundation Area.

5.8-7: Exposure to Electromagnetic Fields Generated by New Electric Energy Facilities at School Locations.

5.8-10: Increased Potential for Fire Incidents and Fire Hazards.

Noise

5.10-1: Exposure of Noise-Sensitive Land Uses to Short-Term (Construction) Noise.

5.10-2: Exposure to Ground Transportation Noise Sources.

5.10-3: Exposure of Noise-Sensitive Land Uses to Fixed or Non-transportation Noise Sources.

5.10-4: Exposure to Aircraft Noise.

Air Quality

5.11-1: Construction Emissions of ROG, NOx, and PM10.

5.11-2: Long-Term Operational (Regional) Emissions of ROG, NOx, and PM10.

5.11-3: Toxic Air Emissions.

5.11-4: Local Mobile-Source Emissions of Carbon Monoxide (CO).

5.11-5: Odorous Emissions.

Biological Resources

5.12-1: Loss and Fragmentation of Wildlife Habitat.

5.12-2: Impacts on Special-Status Species.

5.12-3: Impacts on Wildlife Movement.

5.12-4: Removal, Degradation, and Fragmentation of Sensitive Habitats.

The Proposed Action is in informal consultation with the USFWS under Section 7 of the ESA for listed species within the Subcontractor Service Areas. In light of the relationship between the Biological Assessment and this EIS/EIR, the following is provided as it pertains to special-status species within El Dorado County.

The El Dorado County General Plan EIR concluded that development of and projected increases in urban, agricultural, and mined areas under the General Plan would lead to loss of habitat and loss of individuals of both special-status plants and animals. This impact was considered *significant* for all of the four equal-weight alternatives assessed under the General Plan Update CEQA review process.

To preserve and provide additional protection for special-status gabbro soil plants, the County, USFWS, and other State and federal agencies are currently attempting to conserve much of the remaining habitat for gabbro soil plants. Expansion of the Pine Hill Ecological Preserve is one of the goals of the USFWS recovery plan for gabbro soil plants. Implementation of the recovery plan is expected to reduce the possibility that gabbro soil plants would become extinct or extirpated from El Dorado County, but because USFWS has no specific legislative mandate to require federal and State agencies or private entities to comply with the goals of the recovery plan, some of the goals may not be reached.

Impacts on special-status plants and their habitat are expected to be most severe in the gabbro soil region outside of the protected Pine Hill Ecological Preserve, but direct and secondary impacts are also expected within designated preserve areas. There is already substantial development in the preserve area and more development is anticipated. By 2025 the preserve would likely be substantially more isolated because it is almost entirely surrounded by high- and medium-intensity land designations.

Several General Policies address protection of special-status species; each with varying degrees of anticipated effectiveness.

Policy 7.4.1.1 states that the gabbro soil plants will be protected in perpetuity through the establishment of five preserve sites and that these preserve site shall be integrated into the overall open-space plan.

Policy 7.4.1.3 limits land uses within established preserve areas to activities that are compatible with rare plant protection and requires the County to develop an educational and interpretive program on rare plants. This policy would also reduce impacts on gabbro soil plant populations, particularly secondary impacts, such as degradation of existing habitat caused by inappropriate recreational uses.

Policy 7.4.1.4 requires that approved preserves be designated as Ecological Preserve on the General Plan land use map. The effectiveness of this policy would be dependent upon the degree to which land use restrictions associated with the Ecological Preserve land use designation would protect special-status species.

Policy 7.4.1.5 addresses preparation of natural community preservation/conservation strategies. In most cases, however, Policy 7.4.1.5 would do little to reduce the potential for significant impacts on special-status species since under this policy, mitigation would be required only for special-status species restricted to areas where discretionary development is proposed; mitigation would not be required as long as the species was found and protected elsewhere on public land or private Natural Resources land.

Policy 7.4.1.6 directs the County to, under certain circumstances, require comprehensive habitat restoration and/or offsite mitigation plans. This policy also does not require impacts to be reduced to less-than-significant levels and applies only to discretionary projects; therefore, the policy would not be applicable to projects on nearly a third of the land open to ministerial development approvals in the county.

Policy 7.4.2.1 requires the County to protect, to the extent feasible, special-status species by developing biological conservation plans. This would also be mostly ineffective in mitigating impacts on special-status species. This policy is applicable only when federal or state plans do not provide adequate protection on lands outside County control. This policy could be effective in avoiding or delaying extirpation of a particular special-status species, but because few species have approved conservation plans, many special-status species would receive no consideration.

El Dorado County and EDCWA have worked with federal and State agencies in the continued development towards a long-term protection and preservation strategy for gabbro soil special status species. These have included the following:

- Contribution to development of the Pine Hill Preserve
  - Funding

    $2.1M toward purchase of 525 acres

    $2.9M toward purchase of land

    $5.7M toward purchase of 236 acres and a preserve manager salary
  - Long-Term Management

    Cooperative Management Agreement

    Fulfilling roles as part of the agreement
- Cooperation with USFWS
  - Development of MOA between USFWS, EDCWA, and El Dorado County regarding long-term protection of gabbro soils plants

7.0 CLIMATE CHANGE

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7.0 CLIMATE CHANGE

7.1. OVERVIEW

This chapter provides a discussion on the background of climate change science, its technical underpinnings, some of the implications to long-term California water resources management including CVP/SWP operations, and some of the recent policy and regulatory initiatives. It includes the most recent scientific literature and discusses some of the focused areas of research and their interim findings that will likely affect California's natural, socio-economic, and cultural environments in the future.

7.2. BACKGROUND

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP) to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. Several hundred experts from all over the world are involved in the drafting of the continuing series of IPCC reports. In addition, several hundred experts participate in the review process. The IPCC represents the preeminent body of technical experts on climate change and its potential effects on the environment in the world today.

The First IPCC Assessment Report was completed in 1990 and played an important role in establishing the Intergovernmental Negotiating Committee for a UN Framework Convention on Climate Change by the UN General Assembly. The UN Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and entered into force in 1994. It provides the overall global policy framework under which the issue of climate change can be addressed.

The IPCC has continued to provide scientific, technical and socio-economic advice to the world community, and in particular to the Parties to the UNFCCC through its periodic assessment reports and special reports. Its Second Assessment Report, Climate Change 1995, provided key input to the negotiations, which led to the adoption of the Kyoto Protocol to the UNFCCC in 1997. The Third Assessment Report (TAR), Climate Change 2001, was completed in 2001. It was submitted to the 7th Conference of the Parties to the UNFCCC and Parties agreed that it should be used routinely as a useful reference for providing information for deliberations on agenda items of the Conference of the Parties. The IPCC has continued to prepare comprehensive assessment reports and released the contribution from Working Group I to the Fourth Assessment Report of the IPCC in February, 2007 describing progress in our understanding of the human and natural drivers of climate change, observed climate change, climate processes and attribution, and estimates of future climate change. It effectively builds upon past IPCC assessments and incorporates new findings from the past six years of research. Scientific progress in the field of climate change since the TAR has been based upon large amounts of new and more comprehensive field and modeling data, more sophisticated means of data analyses, improvements in understanding the physical processes and their simulation in models, and more extensive exploration as to where the remaining uncertainties lie (IPCC, 2007).

Early interest in climate change focused on how rapidly increasing and intensifying human activities including industrial processes, fossil fuel combustion, and changes in land use, such as deforestation could alter the atmospheric radiative energy balance. Carbon dioxide, as well as water vapor and methane were known to be absorbers of emitted longwave radiation from the earth's surface. Without the ability of the atmosphere to allow emitted longwave radiation back out into space, air temperatures would increase along with all of the associated ecosystem and societal effects that such temperature rise would impart. The contemporary recognition of the atmospheric *greenhouse effect* was born. Thorough discussions of the greenhouse effect and its implications to climate change are provided in Karnosky et al., (2001); IPCC (2001c; 1994); and Bates (1990). It should be noted here that *global warming* is not the equivalent to climate change. Significant, societally important climate change, due to both natural- and human- climate forcings, can occur without any global warming or cooling.

7.2.1. Milankovitch Theory

While human-induced climate change factors have received the most focus and attention, astrophysical theories of planetary motion (with later inference to long-term climate change) date back to the nineteenth century. In the last century, variations in orbital eccentricity, axial obliquity, and precession (of the equinoxes) were advanced by Milutin Milankovitch, a Serbian mathematician, who developed a complex theory for long-term climate change based on earlier work by J.A. Adhemar and James Croll in the mid-1800's. Using these three orbital variations, Milankovitch, in his book, titled in translation as, "*Record of Radiation on Earth and Its Application to the Problem of Ice Ages*", strove to connect the cycles of ice ages on Earth to small changes in our planet's motions in space. He was able to formulate a comprehensive mathematical model that calculated latitudinal differences in hemispheric "insolation" and the corresponding surface temperature for 600,000 years prior to the year 1800.

Empirical evidence to test his theories, at the time, was difficult to obtain. With the advent of advanced sampling techniques, however, studies of paleoclimatology now often use the analysis of trapped gases in deep ice cores to reconstruct climate conditions that existed hundreds of thousands of years ago. Ratios between oxygen and nitrogen and between the stable isotopes of oxygen (i.e., O^{18} and O^{16}) provide an indication of air temperatures at the time the ice was formed. Our knowledge of oxygen fractionization in water vapor over time has helped develop present day paleoclimatological methodologies.

Some long-term events (glacials and inter-glacials) determined through ice core sampling match up with Milankovitch's theory, but others at shorter time intervals (e.g., 21,000 y.a. and 40,000 y.a.) are not as clear. Certainly, climatologists are aware that small changes in solar heating arise from cycles of planetary motion; more precisely, they can calculate the small variations that arise from differences in solar heating throughout the Milankovitch cycles. They cannot, however, as yet explain clearly how those variations can affect Earth's climate so strongly that an ice age arises or recedes (Goldsmith, 2007).

A corollary to the Earth's planetary motion is the periodic intensification of solar activity that occurs approximately every decade as the Sun enters a new phase of magnetic activity (peaking at what astronomers call the solar maximum) (Woods and Lean, 2007). This cycle creates significant observable effects on Earth. Total ozone concentration, for example, increase by a few percent during solar maximums. Solar activity also appears to alter the interactions between the atmosphere and surface that drive the Earth's fundamental circulation cells, especially in the north-south Hadley and Ferrell cells and the east-west Walker circulation. The predominant global wind patterns are governed by these cells.

Moreover, since the Sun's photons provide virtually all of the energy that warms the Earth's surface and atmosphere (which in turn drives atmospheric and oceanic circulations), even relatively small changes in the total radiative output of the Sun can affect the Earth's surface due to the amplifying effect in how the atmosphere responds to solar changes (Woods and Lean, 2007).

This 11-year solar cycle was first discovered by Samuel Heinrich Schwabe in 1843. A Swiss astronomer, Rudolf Wolfe, later used Schwabe's data to reconstruct solar cycles dating back to the middle 1700s. Scientists have labeled Wolfe's reconstruction of the 1755-1766 cycle as "solar-cycle 1". Today, we are in the solar minimum that effectively ends solar cycle 23 and marks the beginning of cycle 24 (Woods and Lean, 2007).

Clearly, while solar variability (solar cycles) compete with other natural processes such as volcanic eruptions and the El Nino-Southern Oscillation (ENSO), it will become increasingly important to better our knowledge of all "natural" forcings in the context of human activities such as greenhouse gas production, so that we may fully appreciate the wide range of terrestrial variations that can affect our weather and climate.

7.2.2. Climate Modeling

The first assessments of the potential climatic effects resulting from increased CO_2 were performed using simplified climate models, namely, energy balance models (EBMs) and radiative-convective models (RCMs). The feedback processes in RCMs include water vapor feedback, moist adiabatic lapse rate feedback, cloud altitude feedback, cloud cover feedback, cloud optical depth feedback, and surface albedo feedback. However, these feedbacks can be predicted credibly only by physically based models that include the essential dynamics and thermodynamics of the feedback processes. Such physically based models are represented by the general circulation models (GCMs) in use today (Schlesinger and Mitchell, 1987).

The GCM's purpose is to numerically simulate changes in climate as a result of slow changes in some boundary condition (such as the solar constant) or physical parameters (such as greenhouse gas, or GHG concentrations). State-of-the-art GCMs exist as coupled atmosphere-ocean models, that is, a model simulating surface and deep ocean circulations is 'coupled' to an atmospheric GCM. The interface is the ocean surface: this is where the transfers of water (evaporation/precipitation) and momentum occur. An accurate coupling of the *fast* atmosphere to the *slow* ocean (e.g., with longer memory) is essential to simulate such dynamic processes like ENSO. GCM's can further be coupled to dynamic models of sea ice and conditions on land (Hadley Center, 2007).

GCMs derive their utility from assumptions on the level of assumed future GHG emissions (and therefore, loadings in the atmosphere) that will occur at prescribed times into the future. In general, the various GCMs assume one of three levels of potential future emissions:

- The *lower emissions* scenarios are characterized an assumed doubling (560 ppm) of CO_2 concentrations in the atmosphere by the year 2100, relative to pre-industrial levels (280 ppm). Projected temperatures from GCMs associated with lower emission scenarios range from 3º to 5.5º F.
- The *medium-high* emissions scenarios are characterized by an assumed tripling (840 ppm) of CO_2 concentrations in the atmosphere by the year 2100, relative to pre-industrial levels (280 ppm). Projected temperatures from GCMs associated with medium-high emission scenarios range from 5.5º to 8º F.
- The *high* emissions scenarios are characterized by CO_2 concentrations in the atmosphere by the year 2100 that are in excess of three-times that of pre-industrial levels. Projected temperatures from GCMs associated with high emission scenarios range from 8º to 10º F.

Local climate change is influenced significantly by local features such as mountains, which are not well represented in global models because of their coarse resolution. Models of higher resolution, however, cannot practically be used for global simulation of long periods of time. To overcome this dichotomy, regional climate models, with a higher resolution (typically 50 km) are constructed for limited areas and run for shorter periods (20 years or so). RCMs (regional circulation model, not be confused with radiative convective models mentioned previously) take their input at their boundaries and for sea-surface conditions from the global coupled atmosphere-ocean general circulation models (AOGCMs). The Hadley Centre in the U.K., the leading world institution on climate change modeling, has run RCMs for three regions, Europe, the Indian subcontinent and southern Africa and has developed an RCM to run on PCs for any region as part of a regional climate modeling system, PRECIS (Hadley Centre, 2007).

As a result of the coarse resolution of traditional GCMs, downscaling techniques have emerged as a means of relating macro-scale atmospheric variables to grid- and sub-grid-scale surface variables or, from large-scale atmospheric variables to watershed- and sub-watershed-scale surface variables (Christensen et al., 2007; Schaer et al., 1996). The modeling process for climate change analysis on natural resources, therefore, requires a multi-step approach that downscales climate data (e.g., air temperature and precipitation) from large-scale GCMs, to more regionally-based models.

The matter of scale can also be applied in the temporal context. Hydrologic analyses and land-atmosphere interaction studies, in general, require the specification of rainfall forcing at time scales of the order of 1 hour or less. The resolution must be a suitably small fraction of the characteristic concentration time of the watershed since coarse rainfall observations (e.g., weekly or daily) average out short and intense rainfall events, thus often resulting in the underestimation of runoff due to the well accepted non-linearity of runoff-generating mechanisms (Philip, 1957). Today, there is a large and continually growing body of research aimed at the development of techniques allowing the disaggregation of rainfall at hydrological relevant scales (Marani and Zanetti, 2007).

The regionally-based models, depending on the particular resource issue of interest (e.g., water supply, water quality, vegetation, fisheries health, etc.) use climate data as inputs to drive their physically-based models, the latter defining process interactions characteristic of that particular resource. Downscaling techniques can range from simple interpolation of climate model output, through the use of empirical/statistical relationships between watersheds and regional climate, to the use of nested regional climate models (IPCC 2001).

Yet, despite all of the extensive work that has been undertaken with GCMs, the envelope of uncertainty which remains in climate projections has not narrowed appreciably over the past 30 years. Fully understanding the entire spectrum of highly coupled, and tightly interactive processes is an enormous undertaking that, when looked at objectively, will always lead to uncertainty. This has resulted, despite the tremendous increases in computer power, observations, and in the number of scientific specialists studying the problem. This continuing challenge might suggest that our underlying understanding of the climate system may still be incomplete in important areas (Roe and Baker, 2007).

Allen and Frame (2007) discuss a fundamental problem in the identification of *climate sensitivity*. They note that the IPCC's most recent climate sensitivity as that ranging between 2º to 4.5º C; with a one-in-three chance that it will be outside this range. While they point out that the lower boundary is slightly higher than earlier estimates of 1.6º C, made in the 1970s, progress on the upper bound has been minimal (in fact, they suggest that the upper bound of climate sensitivity has become a sort of *holy grail* in climate research). The problem, they claim, lies in the fact that the observable atmospheric properties today, do not, and cannot, distinguish between a climate sensitivity of 4º C and that greater than say 6º C. A warming of 4º C would result in conditions so different from anything we can currently observe, that it is almost impossible to gauge when this warming would stop. By showing how a symmetric constraint on the strength of the atmospheric feedback parameter (i.e., how much energy is radiated to space per degree of surface warming) results in a strongly asymmetrical constraint on climate sensitivity, Allen and Frame (2007) have captured this important relationship. Their hypothesis; as the atmospheric feedback parameter approaches 1, climate sensitivity approaches infinity.

7.2.3. Current State of Knowledge

As discussed previously (see Section 5.5.1, Milankovitch Theory), climate change can be driven by both natural and human forcings. Defining the natural state and variability of the earth's climate is important. Yet, as discussed previously, even natural climate changes are not well enough understood to constitute a baseline against which we might realistically measure human-induced effects. A broad spectrum of observations, including both instrumental records and paleoclimate data (the former possibly contaminated by anthropogenic change, the latter not) has revealed substantial variability in the earth's climate on time scales of decades to centuries. It should be noted that this natural variability alone has considerable socioeconomic impact, particularly with its potential to affect agriculture, fisheries, and water resources. The evidence of natural variations in the climate system, which was once assumed to be relatively stable, clearly reveals that our climate has changed, is changing, and will continue to do so with or without anthropogenic influences.

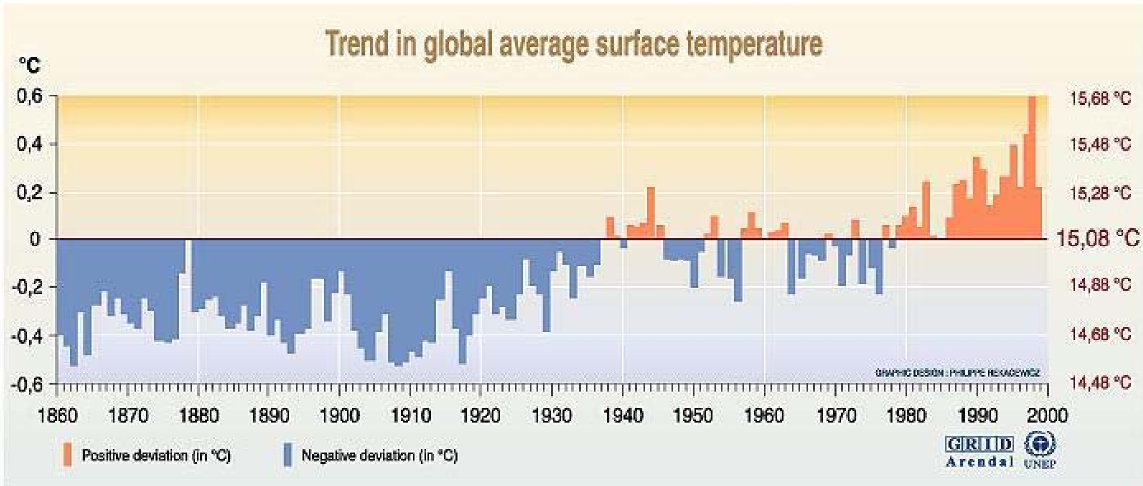
These changes will occur at decadal-century timescales and, accordingly, has been referred to as the Dec-Cen variability.

The climate record for the past 100,000 years indicates that the climate system has undergone periodic and often extreme shifts, sometimes in as little as a decade or less. The causes of abrupt climate changes have not been clearly established, but the triggering of events is likely to be the result of multiple natural processes. As alluded to previously, events or processes that may have led to these climate shifts include; solar energy variation (both direct and indirect), internal oscillations (e.g., Pacific Decadal Oscillation or El Nino Southern Oscillation), ocean variation (e.g., thermocline circulation), biospheric variation (e.g., carbon exchange), cryogenic variation (e.g., sea ice transport, land-ice interactions), surface versus atmospheric temperature interactions, and aerosol forcing mechanisms. Additionally, there are astrophysical explanations which were also discussed previously (see Milankovitch Theory).

Regarding human-induced climate change, there is a broad scientific consensus that this is a real phenomenon and that it is altering the natural air, sea, land and water cycles and their interactions in a variety of important ways (IPCC, 2007; 2001a; 2001b; 2001c; 1995). During the past decade, research on climate change induced impacts on the natural and human environments has grown considerably. The continually growing body of research has progressively added to what we now know regarding the potential vulnerabilities facing a wide range of ecological systems (e.g., forests, grasslands, wetlands, rivers, lakes and marine environments) as well as human systems (e.g., agriculture, water resources, coastal resources, human health, financial institutions, and human settlements) (Parker et al., 1994; Vose et al., 1992; Mitchell, 1989).

It is estimated that the temperatures at the earth's surface increased by an approximate 1.4°F (0.8°C) between the years 1900 and 2005. The past decade was the hottest of the past 150 years and perhaps the past millennium. The hottest 22 years on record have occurred since 1980, and 2005 was the hottest on record (Figure 7.1-1). As noted previously, the growing scientific consensus for this warming trend is based largely on the notion that increasing emissions of carbon dioxide and other GHGs have affected the earth's net radiative energy balance. Keeping in mind previous discussion on the limitations of climate sensitivity, projections of future warming suggest a global increase of as much as 2.5ºF (1.4ºC) to 10.4ºF (5.8ºC) by 2100, with warming in certain parts of the United States, for example, potentially even higher.

While changes in air temperature itself are noteworthy and have led to regional characterizations of changing long-term climate (e.g., a more arid U.S. southwest) (Seager et al., 2007), the related or affected changes in other natural processes and ecosystem functions are equally striking. Studies have shown the potential for shifting climatic regimes to alter snowpack accumulation in the western U.S. (Miller et al., 2003; Mote et al., 1995; Pupacko, 1993; Roos; 1991; 1990; and 1988) as well as the accumulation/ablation dynamics of high altitude glaciers, such as those in the Himalayas (Prasad and Singh, 2007).



Source: School of environmental sciences, climatic research unit, university of East Anglia, Norwich, United Kingdom, 1999.

FIGURE 7.1-1 TREND IN GLOBAL AVERAGE TEMPERATURE FROM 1860 TO 2000

The figure depicts global average combined land-surface air and sea surface temperatures from 1861 to 1998 relative to the average temperature between 1961 and 1990. The left vertical scale is in degrees Celsius. Source: United Nation's Environment Programmed Global Resource Information Database - Arendal website at: http://www.grida.no/climate/vital/17.htm.

Changing runoff hydrology from source area watersheds and their potential effects on downstream environments is an important consideration for many reasons. Knox (1993) showed a high sensitivity of flood events to climate change induced peak runoffs resulting from earlier snowpack melt coupled with warm winter rain-on-snow events. Peterson et al., (1995) addressed changing flow dynamics in estuaries and Inman et al., (2002) has modeled cliff and shoreline erosion due to changing sea levels. In fact, recent studies even suggest that data available for the period since 1990 raise concerns that the climate system, and in particular sea level, may be responding more quickly to climate change than our current generation of GCMs indicate (Rahmstorff et al., 2007). Such changes, if true, could have significant repercussions. Maury Roos (Chief Hydrologist, California Department of Water Resources) has shown that a modest 0.3 m rise in sea level would redefine the 100-year storm surge flood event in San Francisco Bay to a more frequent and disturbing, 10-year event.

More recent studies have, on the other hand, cautioned that at-risk areas have, on many occasions been identified on the basis of mean sea level, ignoring the effects of tides. The use of only mean sea level to determine flood risk represents a significant limitation to risk analyses primarily because the actual flooding process involves the level of high water, which is linked to tides and storm surges. Depending on the region, the level of high water can be several meters above mean sea level (Marbaix and Nicholls, 2007).

Warming of surface waters in the California Current since the 1950s has also coincided with significant declines in zooplankton production and volume. This has been explained by the relaxation of North Pacific anticyclonic gyre causing onshore movement of warmer, less saline waters, and reduced upwelling of cool, nutrient-rich waters (Weinheimer et al., 1999). The Pacific

Decadal Oscillation (PDO) has also been attributed to increasing water temperatures in watercourses draining to the Pacific Ocean. The Klamath River, in California, for example, showed water temperature increases of 0.5º C since the early 1960's potentially affecting the recovery of anadromous salmonids in that important north coast fishery (Bartholow, 2005).

In the Arctic polar region, enhanced transport of warmer air from lower latitudes has led to increased Arctic surface air temperatures. Concurrent reductions in Arctic ice extent and thickness have also been documented. The first evidence of warming in the intermediate Atlantic Water (defined as that between 150 and 900 meters) in the Arctic Ocean was noted in 1990. In 2004, another anomaly was observed suggesting that the Arctic Ocean is in a transition state towards a new, warmer state (Polyakov et al., 2007). The magnitude of this warming is unprecedented. The depth range and horizontal extent are exceptional, extending from the surface to almost 1,000 meters and occupying a vast area of the Barents Sea slope.

In the subsurface environment, responses in the vadose zone and groundwater to inter-annual, inter-decadal and multi-decadal climate variability has shown to exhibit important implications for long-term groundwater resource sustainability (Gurdak et al., 2007). In temperate climatic regions where snowmelt or springmelt represents the primary groundwater recharge event of the year, this can have significant repercussions to water resource management planning.

Climatic change has also been studied relative to its potential effects on biotic communities. Climate modeling suggests a long-term shift in ecotones in all hemispheres as species migrate to, and evolve in, more favorable ecosystems. Responses of both flora and fauna span an array of ecosystems and organizational hierarchies, and from the species to the community levels (Gian-Reto et al., 2002). In particular, ecosystems at high latitudes and altitudes are recognized as being very sensitive to climate change. Latitudinal tree-line advance as has been noted by Lloyd (2005) along with higher shrub density (Tape et al., 2006). While rising temperatures have shown to be responsible for increased plant growth in northern high latitudes (Myneni, et al., 1997), an upward shifting of plant species in high mountain systems has also been predicted for the near future. Under such conditions, the habitats of the alpine and nival vegetation could be restricted drastically, which may result in extinctions, particular of summit floras (Pauli, et al., 1996). More recently, Bunn et al., (2007) also referenced some non-intuitive responses, including those for tree-ring width decline in some locations, flat to declining trends in boreal forest greenness, and declines in terrestrial vegetation productivity.

While long-term mean temperature increases would certainly be influential, others submit that the potential effects of climate change on biotic communities may be due to changing maximum and minimum temperatures rather than annual means (Strachowic et al., 2002). From these changes, it is held that surviving species may reshuffle into entirely new combinations, creating completely new ecosystems or, as noted by Fox (2007) "no-analog" ecosystems.

Historically, increasing variability in moisture conditions (i.e., wet/dry oscillations promoting biomass growth, then burning), and/or a trend of increasing drought frequency, and/or warming temperatures have led to periods of increased wildfire activity. This transition was marked by a shift toward unusually warm springs, longer summer dry seasons, drier vegetation (which provoked more and longer burning large wildfires), and longer fire seasons. Reduced winter precipitation and an early spring snowmelt played an important role in this shift. Increases in wildfire were particularly strong in mid-elevation forests (Westerling et al., 2006). Robust statistical associations between wildfire and hydroclimate in western U.S. forests indicate that increased wildfire activity over recent decades reflects sub-regional responses to changes in climate. Historical wildfire observations exhibit an abrupt transition in the mid-1980s from a regime of infrequent large wildfires of short (average of 1 week) duration to one with much more frequent and longer burning (5 weeks) fires (Westerling, 2006).

7.2.4. Climate Change Effects on Water Resources

The potential effects of climate change on water resources have been extensively studied. Perhaps no other natural resource has been investigated as thoroughly. Globally, this effort is warranted when one considers that a large proportion of the world's population is currently experiencing water stress, a situation that will only become more challenging as the world’s population continues to grow. Comprehensive reviews of the effects on water resources across the scientific literature are provided in IPCC (2001) and, regarding water management, by Gleick (1998). Early recognition of the potential effects of climate change on U.S. water resources is provided in Waggoner (1990). A summarization of the potential impacts on western U.S. water resources has been prepared by Frost (2004) with Chalecki and Gleick (1999) providing a review of the existing data.

Since climate change is largely driven by changes in the net radiative energy balance (the solar incoming flux being constant, but for the astrophysical variations explained by Milankovitch), this can alter the magnitude and frequency of hydrologic cycling processes. It should be noted, however, that due to the complex interactions between the hydrologic cycle and general global circulation patterns as well as local weather systems, an increase in temperature would not necessarily translate into an increase in precipitation in all regions (IPCC, 2001). It is generally accepted that the difficulty in predicting future changes in regional precipitation patterns owes much to inherently high spatial variability of, and between, the factors causing precipitation (the issue of rainfall disaggregation was discussed previously).

Evaporation is generally driven by meteorological controls (e.g., air temperature, wind speed, gradient of saturation vapor pressure) whereas evapotranspiration, while influenced by those same factors, is also affected by soil moisture and vegetative water availability. Changes in meteorological controls may increase or offset rises in temperature, and it is possible that increased water vapor content and lowered net radiation could lead to lower evaporation demands. It is projected that in those areas where evaporation increases more than precipitation, soils will become drier, lake levels and reservoirs will drop, and river flows diminished.

Vegetation cover, type, and structural properties play an important role in evaporation. Interception of precipitation is very much influenced by vegetation type (i.e., canopy storage capacity). Differing vegetation types also generate different degrees of turbulence above the canopy; the greater the turbulence, the greater the evaporation. Climate induced changes in vegetation type and density, therefore, may directly or indirectly affect the water balance within watersheds. Coarse scale modeling has shown that soil moisture in the Northern Hemispheric mid-latitudes would experience reduced soil moisture during summer months (Gregory et al., 1997). For areas in agricultural production, this could have important implications. Duffy et al (2007), for example, in describing recent temperature trends in California, have noted the effect of soil moisture and their cooling affect on local summer daytime temperatures. They discuss the effect of irrigation practices which, by keeping the soil surface wet, can shut off a positive feedback in which atmospheric warming would otherwise reduce soil moisture and amplify warming.

Climate change effects on soil moisture will depend on not only the degree of climatic change, but also on soil structure characteristics. Changes in the frequency and duration of soil saturation, desiccation, and freeze-thaw cycles would have an affect on the long-term structural composition of some soils, possibly altering its hydraulic properties over time (e.g., infiltration capacity, percolation rate, transmissivity).

There is unfortunately, at present, a paucity of information regarding the effects of climate change on groundwater resources, at least relative to other water elements. Intuitively, a change in precipitation will alter potential groundwater recharge, but it can also alter the recharge season. Increased winter precipitation, as projected by most climate modeling scenarios for the mid-latitudes, is likely to increase. This will shift the recharge period for groundwater aquifers to earlier in the year. Overall recharge may be reduced if recharge potential exceeds soil infiltration and percolation rates; with a shorter more intense melt/rainy season, the overlying soil matrix must convey the same volume of water over a shorter period of time. If soil infiltration and/or percolation rates are exceeded, surface runoff or saturation overland flow would occur where, under a prolonged longer (and slower) melt/rainy season, this water flux would not have exceeded the soil's ability to infiltrate and transmit.

By far, the greatest number of studies on climate change induced effects on water resources have focused on runoff and streamflow. Under changing climatic conditions such as increases in temperature, the amount and duration of snow cover would be decreased which, in turn, can affect the timing of runoff. Peak streamflow, therefore, would shift from late spring, as is the general case currently in snow dominated regions, to early spring or late winter in those areas where the annual snowpack is an important component in the water balance.

Such hydrologic changes could increase competition for reservoir storage between hydropower and instream flow targets developed pursuant to Endangered Species Act requirements. Payne et al., (2004) for example, examined several alternative reservoir operating policies designed to mitigate reservoir system performance losses. In general, the combination of earlier reservoir refill with greater storage allocations for instream flow targets mitigated some of the negative impacts on flow, but only with significant losses in firm hydropower production (power forgone).

Shifts in the timing of peak flows, coupled with a magnification of water availability (i.e., more water is made available in winter, since a lesser proportion of winter precipitation would occur as snow) could exacerbate flood risk in those areas dependent on snow accumulation. Under such a situation, flood risk may increase even though overall precipitation in a particular area decreases (see Schreider et al., 1996). Alternatively, if overall precipitation increases, flood magnitudes can increase since, in larger watersheds, it is the total volume of precipitation over several days, not the peak intensity of rainfall that is important (IPCC, 2001).

While it is true that most large urban centers are protected from flooding by levees and upstream reservoir storage capacity, hydraulic and simple storage encroachments resulting from increased streamflow or reservoir inflow over shorter time intervals may also increase flooding risk. Rising sea levels also can impart increased flood risks to low lying estuarine areas and along coastal flatlands.

Increased drought risks resulting from climate change is considerably more difficult to quantitatively define than flooding since the criterion to establish droughts is more varied and discretionary. How is a drought defined? Does it refer to strict rainfall/runoff ratios, total rainfall, soil moisture deficits, low summer time instream flows, or lowered groundwater levels? Watersheds with large amounts of groundwater storage would tend to have higher summer flows under a changed climate because additional winter rainfall would tend to result in greater groundwater recharge (the additional rainfall offsetting the shorter recharge period). Summer flows in watersheds with little storage tend to be reduced because these watersheds do not experience the benefits of increased winter groundwater recharge. Watershed subsurface geology and storage can significantly influence the effects of climate change on summer flows. Proportionately, summer flows would be more prone to change than seasonal or annual flows (Dvorak et al., 1997).

Potential water quality impacts as a result of climate change are primarily related to streamflows. Chemical river quality is largely a function of the chemical loadings to the river, water temperature, and the flow volume. While the incipient chemical loading is a function of watershed geology and soil type, human activities such as mining, land use (residential, commercial and industrial) development, forestry, and agricultural practices have all shown to be more influential, especially over the last century. Each one of these human activities possesses feedback loops to river and reservoir water quality that would result from direct climate change effects.

Water temperature, as a water quality parameter, is a very important consideration in the evaluation of potential climate change effects on water resources. Numerous biological (e.g., fish spawning, rearing, holding, outmigration and emigration) and chemical/physical (e.g., eutrophication, nutrient transport and uptake, thermal stratification) processes in waterbodies are dictated by water temperature. Streamflow temperatures are projected to increase by a slightly lesser magnitude than air temperatures under a future warming climate. Elevated water temperatures in the future would lead to increases in certain concentrations of some chemical components and, at the same time, reductions in others. Dissolved oxygen concentrations, a key component to aquatic floral and faunal life would, however, be lower.

Changes in streamflow can have important implications for water and flood management, water quality, irrigation, and land use planning. If water supplies are reduced or their flow regime altered, the primary off-stream users of water such as urban/rural residents, industry, irrigated agriculture and in-stream users such as hydropower, recreation, and navigation, could be most directly affected (IPCC, 2001).

Gleick (1998) noted that while research continues, there is little absolute certainty about the form that many of these changes will take, or precisely when they will be unambiguously detected. As a result, while global climatic changes are likely to begin to appear in earnest within the next several decades, or even earlier, we are unable as of yet to *precisely* determine how such changes will affect water-supply systems or water demands. For example, changes in seasonal precipitation and intense rainfall frequency are difficult to predict because of, as was noted previously, the high degree of spatial and temporal variability associated with precipitation. Since precipitation, and precipitation forecasting drives so much of the water balance, accuracy in depicting this critical physical process becomes imperative.

7.2.5. Climate Change Effects on California Water Resources

Water resources are vital to California. The diverse and intricate character of the natural ecosystems and the importance of these systems to the economic viability, health, and livelihood of the nation's most populous State make sustainable long-term water resources a priority. A thorough summary and overview of potential climate change effects on California's water resources is provided by Kiparksy and Gleick (2003); see also Wilkinson, 2002. It is recognized that climatic warming will have a significant impact on water resources within the 20 to 90-year planning period of many water projects within the State. Semi-arid regions, especially those characteristic of Southern California are especially vulnerable to the anticipated negative impacts of future warming on water resources (Buehler, 2003).

Early recognition of the hydrological effects under the influence of climate change has been provided in Knox (1989) and Gleick (1986). Early water balance modeling associated with a climate change analysis for the Sacramento River watershed was conducted by Gleick in 1989. Water resources and their importance to California has, and continues to generate a number of climate change related studies (Vicuna et al., 2007; Vicuna, 2006; Vicuna et al., 2006; Zhu et al., 2007; Hanemann et al., 2006; Barnett, et al., 2004; Hayhoe et al., 2004; VanRheenen et al., 2004; Buehler, 2003; Lund et al., 2003; Roos, 1989).

The existing literature suggests that global warming is likely to have notable impacts on the hydrological cycle that can, in turn, affect many aspects of the California water system (Christy et al., 2006). Relative to preindustrial CO_2 conditions (280 ppm), doubled preindustrial CO_2 conditions (560 ppm) have shown to produce increased temperatures of up to 4°C on an annual average basis and of up to 5°C on a monthly basis. Temperature increases modeled are greatest in the central and northern regions of the State. On a monthly basis, the temperature response was greatest in February, March, and May for nearly all regions (Snyder et al., 2004). There is evidence that some changes in the magnitude of certain hydrological cycle components have already occurred, such as an earlier beginning date of spring snowmelt (Roos 1991; 1990; 1988), an increase in winter runoff as a fraction of total runoff, and a corresponding increase in winter flooding frequency.

Lettenmaier and Gan (1990) looked at four watersheds (in the Sacramento-San Joaquin basin) indexed to CO_2 doubling scenarios. Results showed a major seasonal shift in the snow accumulation pattern. Under alternative climate scenarios, more winter precipitation fell as rain instead of snow, and winter runoff increased while spring snowmelt runoff decreased. In addition, large increases in the annual flood maxima were simulated, primarily due to an increase in rain-on-snow events, with the time of occurrence of many large floods shifting from spring to winter. Such shifts in streamflow could significantly lower water deliveries from the CVP/SWP which traditionally ramps up in spring. Reduced deliveries could occur because of the increased winter spills from the reservoirs. Instead of winter precipitation being stored in the snowpack, operational reservoir flood control rules would dictate earlier spills. Such depletions in overall annual water availability could result even though the mean annual runoff increased slightly under some climate scenarios. While annual flows entering the Sacramento-San Joaquin Bay Delta would increase, the timing would be such that flows would be substantially increased in winter and somewhat decreased in spring and summer (Lettenmaier and Sheer, 1991). The modeling work of Chung et al., (2005) appears to confirm this conclusion. Modeled flows in the Feather River based on climate change induced elevation increases of the snowline revealed that peak runoff from winter storms increased by 23 percent, 83 percent and 131 percent, as the snowline rises from 4,500 feet msl to 5,000, 6,000, and 7,000 feet msl, respectively. Such increases in Feather River runoff could result in significant increased flood risk within the Sacramento Valley.

Alternatively, as noted by Brekke et al., (2004) separate modeling results in the San Joaquin basin showed that there could be decreased reservoir inflows, decreased storage and releases, and therefore, decreased deliveries from the reservoirs. Impacts under either climate change projection cannot be regarded as more likely than the other. As noted previously, most of the impact uncertainty is attributable to the divergence in the precipitation projections (Brekke et al., 2004). An equally valid explanation could lie in the selection of the physically-based watershed runoff model or in the temporal period of selection. Chung et al., (2005) in fact, showed that median inflows to Shasta, Oroville and Folsom reservoirs during the 2035-2064 modeled period were virtually identical with the historical record (1922-1994), however, when extended to the 2079-2099 period, median inflows for these reservoirs decreased by 15 percent, 25 percent and 33 percent, respectively.

Pupacko (1993) noted that, for the northern Sierra Nevada, the trend of increasing and more variable winter streamflow began as early as the mid-1960s. Mean monthly streamflow during December through March was substantially greater for water years 1965–1990 compared to the water years 1939–1964. Increased winter and early-spring streamflow during the later period is attributed to small increases in temperature, which increase the rain-to-snow ratio at lower altitudes and cause the snowpack to melt earlier in the season at higher altitudes. The timing of snowmelt runoff on the western slope of the Sierra Nevada is more sensitive than it is on the eastern slope to changes in temperature, owing to predominantly lower altitudes on the west side. This difference in sensitivity suggests that watersheds on the east side of the Sierra Nevada have, and could continue to have a more reliable water supply (as snow storage) than western-slope watersheds during future warming trends. An important conclusion that is generally supported for most snowmelt driven runoff watersheds in California, is that late winter snow accumulation could decrease by as much as 50 percent or more toward the end of this century (Miller et al., 2003).

Since about 1950, snow accumulation was already showing losses on the order of 10 percent in April 1 snow water equivalent (SWE) across the western U.S. (Mote et al., 2005). Over this period, the onset of the snowmelt spring freshet has shifted by 10-30 days, with the largest shifts in the western U.S. observed in the Pacific Northwest and in the Sierra Nevada. In California, the 100-

year, 3-day peak flows for rivers such as the American, Tuolumne, and Eel has more than doubled between the first and latter halves of the last century. Moreover, the annual peak 3-day mean discharges from these rivers are becoming more variable and larger for most sites in California (Hanemann et al., 2006).

With regard to flooding, in addition to rising sea level concerns, snowmelt-related streamflow represents a particular problem in California. As noted previously, modeling studies have indicated that there could be an approximate 50 percent decrease in snow pack by 2100. This potential deficit must be fully recognized and plans put in place well in advance to address this shortfall. In addition, with a warmer atmosphere capable of holding more water vapor and resulting in more intense warm winter-time precipitation events, the risk to flooding could increase substantially. Under our current reservoir infrastructure and operating rules, anticipated future high flow periods could impart significant downstream flood risks, since reservoirs are mandated to release water to maintain their structural integrity (Miller, 2003). With an altered hydrology, but no changes in physical infrastructure, how will current operating rules for flood control (e.g., encroachment curves) in CVP/SWP facilities adjust in the future in order to accommodate new flood risks?

Snyder et al., (2004) confirms that snow accumulation significantly decreases in all months and regions, with the greatest reduction occurring in the Sacramento River region under future modeling scenarios. However, their precipitation results indicate drier winters for all regions, with a large reduction in precipitation from December to April and a smaller decrease from May to November. The result is a wet season that is slightly reduced in length. These findings suggest that the total amount of water in the State will decrease. If water needs continually increase, the timing of water availability will be greatly perturbed (Snyder et al., 2004).

With changing precipitation, shifting snowlines, and altered inflows to source area reservoirs and primary CVP/SWP reservoirs, the potential effects of climate change on water supply obligations, both in the short- and long-term is a very important consideration. Modeled reductions in overall inflows to reservoirs have shown that the median delivery to SWP contractors (i.e., the quantity that is delivered at least 50 percent of the time) south of the Delta, declines by approximately 11 percent, relative to the historical record. Correspondingly, median deliveries to CVP contractors south of the Delta would fall by approximately 15 percent. These projections are for the more *moderate* climate change period 2035-2064. Under the 2070-2099 period, median deliveries to SWP contractors would decrease by 27 percent and CVP contractors by 31 percent (Hanemann et al., 2006; Chung et al., 2005). Any anticipated or ultimately realized shortfalls would likely be distributed unevenly, in deference to the variability and differences between contractor established water right priorities. The potential implications of such future shortfalls to CVP/SWP contractors can be put into perspective if one considers that in 1991, the CVP cut agricultural deliveries by 75 percent and M&I deliveries by 25 percent. At the same time, the SWP cut M&I deliveries by 70 percent and completely cut all deliveries to agricultural contractors.

The potential effects of climate change on the State's water resources and some of the expected consequences are presented in Table 7.1-1, created by the California Department of Water Resources (California Department of Water Resources, 2006).

TABLE 7.1-1

POTENTIAL EFFECTS OF CLIMATE CHANGE ON CALIFORNIA'S WATER RESOURCES AND EXPECTED CONSEQUENCES

Potential Water Resource Impact	Expected Consequence
Changes in the timing, intensity, location, amount, and variability of precipitation	• Potential increased storm intensity and increased potential for flooding • Possible increased potential for droughts
Long-term changes in watershed vegetation and increased incidence of wildfires	• Changes in the intensity and timing of runoff • Possible increased incidence of flooding and increased sedimentation
Sea level rise	• Inundation of coastal marshes and estuaries • Increased salinity intrusion into the Sacramento-San Joaquin River Delta • Increased potential for Delta levee failure • Increased potential for salinity intrusion into coastal aquifers (groundwater) • Increased potential for flooding near the mouths of rivers due to backwater effects
Increased water temperatures	• Possible critical effects on listed and endangered aquatic species • Increased environmental water demand for temperature control • Possible increased problems with foreign invasive species in aquatic ecosystems • Potential adverse changes in water quality, including the reduction of dissolved oxygen levels
Changes in urban and agricultural water demand	• Changes in demand patterns and evapotranspiration rates

Source:
1. From Table 3.1. California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources*, Technical Memorandum Report, July 2006.

Additionally, the possible effects of climate change on precipitation in California and its potential consequences are presented in Table 7.1-2 below.

7.2.6. Climate Change Modeling in El Dorado County

With EID, El Dorado County initiated a climate change investigation for its western slope purveyors in 2006 with a focus on analyzing the effects of a prolonged drought. The Shared Vision Model (SVM) was developed that incorporated water purveyor supplies and constraints, future anticipated water demands, and possible long-term climate change effects, taking into account needs and concerns voiced by members of the public. Staff from the El Dorado County Water Agency, El Dorado Irrigation District, Georgetown Divide Public Utility District, Grizzly Flat Community Service District and the City of Placerville also participated as stakeholders in this process.

Under a cooler and drier GCM scenario, available water supplies would be reduced by 11 percent for the El Dorado Irrigation District, 19 percent for Grizzly Flats Community Services District, and by 28 percent for the Georgetown Divide Public Utility District (El Dorado County Water, 2006).

Like all GCM application and forecasting exercises, reliance on a singular scenario has notable risks and must be viewed with caution. Leaving aside the hydrometeorological functions within the model (which have their own confidence limits), other parameters must be set; assumptions for wind speed, storm track vector, changes in ground cover (affecting surface albedo), changes in ground

TABLE 7.1-2

POSSIBLE EFFECTS OF CLIMATE CHANGE ON PRECIPITATION IN CALIFORNIA AND POTENTIAL CONSEQUENCES

Possible Changes in Precipitation	Potential Consequences
Amount	Increased precipitation could benefit water supplies and improve environmental conditions in some areas, especially where water supply diversions have significantly affected streamflow. Increased precipitation could also increase the incidence of flooding, depending on the timing and intensity of precipitation. Decreased precipitation could have serious consequences for water supplies and the environment.
Form	Climate warming is expected to increase minimum snow elevations in California's mountains and cause more precipitation to fall in the form of rain rather than snow. This will result in reductions of annual snowpack and reduce effective water storage for maintaining spring and summer streamflow/water supply diversions. Reductions in snowpack could also negatively affect hydroelectric power generation and flood control operations.
Intensity, Duration, and Timing of Precipitation Events	Increased intensity or duration of precipitation events could increase the frequency and severity of flooding. Decreases could reduce flooding. Climate change could affect the incidence of precipitation events where rain falls on accumulations of snowpack. If the incidence or severity of such events increase, it could have serious flood control and water supply implications.
Variability	Increased variability in annual precipitation could present significant challenges for water managers in meeting water demands and providing flood control. Increased surface storage capacity, operational changes for reservoirs and additional use of groundwater storage could be required. Decreased variability could benefit water management.
Location	Shifts in the annual average distribution of precipitation in the State, due to possible changes in regional circulation patterns or other possible causes, could benefit some regions and negatively affect others. California's major water storage and conveyance systems are located and designed in accordance with the historic distribution of precipitation. Significant shifts in the distribution of precipitation could pose serious water management challenges, jeopardize the effectiveness of the State's existing water supply infrastructure and alter ecosystems.

Source:
1. From: Table 2.3 California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources*, Technical Memorandum Report, July 2006.

roughness (affecting the turbulent exchanges), degree-days, and the gradient for saturation vapor pressure, to name but a few. Moreover, a base hydrological record must be selected upon which these assumptions, collectively representing a climatological *perturbation factor*, must be applied. Depending on the scenario of interest, differing hydrological periods can be selected. In water supply planning, it is common to use historic drought periods (e.g., 1928-1932, 1977, or 1991-1992). The SVM, for example, used the 1977 water year, applied a second identical 1977 (to create a highly conservative boundary condition) and increased overall mean air temperatures.

Numerous combinations of scenario permutations are possible in climate change modeling depending on element of interest. More recently, EID has worked with the Stockholm Environmental

Institute (SEI) in applying the WEAP model, an interactive, user-friendly modeling platform in addressing watershed and hydrological changes. The model is also being used in the IRWMP for the Cosumnes, American, Bear and Yuba rivers (CABY). As previously described, CALSIM II is a system-wide reservoir routing model designed to integrate CVP/SWP operations, including all regulatory controls (e.g., Biological Opinions and water quality provisions). It uses hindcasted hydrology to predict changes in system-wide hydrology resulting from changes to various elements of CVP/SWP operation. WEAP has been used on a smaller scale, has a more physically based runoff logic than CALSIM II, and is intended for completely different purposes than CALSIM II.Its intention, developed originally for watershed planning purposes, is to observe changes in hydrology within a watershed based on user-developed alterations in watershed infrastructure and instream restoration activities.

Some of the possible drought mitigation measures implemented by the various water purveyors would have the following effects (EDCWA 2007 Water Resources Development and Management Plan, Chapter 10: Long-Term Outlook and Recommendations):

- El Dorado Irrigation District could almost completely offset projected 2030 water supply shortfalls under the modeled design drought conditions by, 1) fully utilizing the new CVP water service contract water under this Proposed Action and that identified under the Supplemental Water Supply Project such that 92 percent reliability would be achieved, or, 2) fully utilizing the new CVP water service contract water under this Proposed Action, groundwater banking, and implement the Alder Creek Reservoir Project where, 94 percent would be achieved;
- Georgetown Divide Public Utility District could expect shortfalls in meeting demands about 5 percent of the time with drought conditions being prevalent about 50 percent of the time. These conditions would occur despite a new Rubicon River diversion and fully utilizing the new CVP water service contract water under this Proposed Action; and
- Grizzly Flats Community Services District could almost completely offset projected 2030 shortfalls under the modeled design drought conditions with the use of a 350 TAF off-stream storage reservoir that was 50 percent full at the time of drought onset. This would provide 97.8 percent reliability under the design drought condition assumed by the SVM modeling.

7.2.7. Climate Change Effects on CVP/SWP

As the primary water storage and delivery system in California, the coordinated CVP/SWP represents a critical component within the State's overall water resources management structure. Any potential effects on the hydrology upon which CVP/SWP operation rely will have important implications to virtually all sectors of the California economy.

Effects on CVP/SWP operations are noteworthy in that they represent the third step in a multi-step hydrological assessment process of climate change. As described earlier, the first step involves development of coarse scale GCM generated atmospheric data (e.g., temperature and precipitation); these data are input into watershed snowmelt/runoff models at the regional or sub-regional level. Watershed models, primarily simulated in headwater catchments upstream of CVP/SWP reservoirs provide the inflow data that then can be input into hydrologic routing models (e.g., CALSIM II) for the entire coordinated CVP/SWP system.

Various studies on the effects of climate change on the CVP/SWP and the water dependent resources that rely on its operations have been undertaken. Climate change effects on the salinity of San Francisco Bay (also Sacramento-San Joaquin river system) was investigated by Smith and Tirpak (1989); Central Valley agriculture, by Hanemann et al., (2006); levees and the joint effects of climate change, economic costs, and regional growth by Zhu et al., (2007). Climate induced hydrological changes and their long-term implications to irrigated agriculture (Schlenker et al., 2007), perennial crops (Lobell et al., 2006), and on flood control, hydropower generation, and low flow augmentation at Folsom Reservoir (Carpenter and Georgakakos, 2001) are also included in the literature on CVP/SWP effects resulting from climate change.

A comprehensive study by Lund et al., (2003) using the integrated economic-engineering optimization model of California's inter-tied water system, CALVIN (CALifornia Value Integrated Network), looked at how well the water infrastructure of California could adapt and respond to changes in climate, in the context of higher future populations, changes in land use, and changes in agricultural technology. CALVIN is unconstrained by current day operational rules for the CVP/SWP.

The main conclusions of Lund et al., (2003) are as follows:

1. Methodologically, it is possible, reasonable, and desirable to include a wider range of hydrologic effects, changes in population and water demands, and changes in system operations in impact and adaptation studies of climate change than has been customary. Overall, including such aspects in climate change studies provides more useful and realistic results for policy, planning, and public education purposes.

2. A wide range of climate warming scenarios for California shows significant increases in wet season flows and significant decreases in spring snowmelt. This conclusion, confirming many earlier studies, is made more generally and quantitatively for California's major water sources. The magnitude of the climate's warming effect on water supplies can be comparable to water demand increases from population growth in the coming century.

3. California's water system can adapt to the population growth and climate warming modeled, which are fairly severe. This adaptation will be costly in absolute terms, but, if properly managed, should not threaten the fundamental prosperity of California's economy or society, although it can have major effects on the agricultural sector. The water management costs are a tiny proportion of California's current economy.

4. Agricultural water users in the Central Valley are the most vulnerable to climate warming. While wetter hydrologies could increase water availability for these users, the driest climate warming hydrology would reduce agricultural water deliveries in the Central Valley by about a third. Some losses to the agricultural community in the dry scenario would be

compensated by water sales to urban areas, but much of this loss would be an uncompensated structural change in the agricultural sector.

5. Water use in Southern California is likely to become predominantly urban in this century, with Colorado River agricultural water use being displaced by urban growth and diverted to serve urban uses. This diversion is limited only by conveyance capacity constraints on the Colorado River Aqueduct deliveries of Colorado River water and California Aqueduct deliveries of water from the Central Valley. Given the small proportion of local supplies in southern California, the high willingness-to-pay of urban users for water, and the conveyance-limited nature of water imports, this region is little affected by climate warming. Indeed, even in the dry scenario, Southern California cannot seek additional water imports. Population growth, conveyance limits on imports, and high economic values lead to high use of wastewater reuse and lesser but substantial use of seawater desalination along the coast.

6. Flooding problems could be formidable under some wet warming climate scenarios flood flows indicated by the HCM2100 scenario would be well beyond the control capability of existing, proposed, and probably even plausible reservoir capacities. In such cases, major expansions of downstream floodways and changes in floodplain land uses might become desirable.

7. While adaptation can be successful overall, the challenges are formidable. Even with new technologies for water supply, treatment, and water use efficiency, widespread implementation of water transfers and conjunctive use, coordinated operation of reservoirs, improved flow forecasting, and the close cooperation of local, regional, state, and federal government, the costs will be high and there will be much less “slack” in the system compared to current operations and expectations. The economic implications of water management controversies will be greater, motivating greater intensity in water conflicts, unless management institutions can devise more efficient and flexible mechanisms and configurations for managing water in the coming century.

8. The limitations of this kind of study are considerable, but the qualitative implications seem clear. It behooves us to carefully consider and develop a variety of promising infrastructure, management, and governance options to allow California and other regions to respond more effectively to major challenges of all sorts in the future.

9. Further climate change work on water in California should be expanded from this base to include flood damage costs, sea level rise, other forms of climate change, such as various forms of climate variability, some refinements in hydrologic representation, and some operations model improvements discussed in the report.

10. Tanaka et al., (2006) used this same approach (i.e., a state-wide economic-engineering optimization model of water supply management) and modeled two climate warming scenarios to determine the effects on California’s water supply system. The results showed 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

large changes in the operation of California's large groundwater storage capacity, significant transfers of water among water users, and some adoption of new technologies.

The current operations and planning model relied upon by the U.S. Bureau of Reclamation and California Department of Water Resources is CALSIM II (see previous description in Subchapter 5.3.1, CALSIM II Model). Climate change effects on water CVP/SWP water resources using CALSIM II have been undertaken in several studies (California Department of Water Resources, 2006; 2005; 2003a; 2003b; Easton et al., 2006; and Vicuna, 2006). These results corroborate recurring trends; lower summer and late-spring runoff for practically all watersheds, higher mid-winter streamflows, and under the higher emission scenarios, up to 50 percent of the future years would be categorized as critically-dry, relative to the historical record of 18 percent, whereas, under the lower emission scenarios, little or no change in the frequency of critically-dry years would be expected (Vicuna, 2006). Chung et al., (2005) provide prior clarification, noting that while the shift in distribution between wet or above normal water years and dry or critically dry years only changes slightly (shifting towards drier) during the 2035-2064 modeled period, a significant shift towards drier years is modeled for the 2070-2090 period.

Vicuna (2006) goes on to note that reservoir storage levels, water supply deliveries, and variables that can document key environmental parameters in the Bay-Delta and elsewhere, could be used as performance indicators to better gauge the effects of climate change on California's water resource system.

Modeling of potential climate change effects in the Sacramento-San Joaquin River basin showed that progressive reductions in winter, spring, and summer streamflow were less severe in the northern part of the Central Valley than in the south. In the south (i.e., south of Delta), a distinct seasonality shift in streamflows was apparent. Results from the water resources system model indicated that achieving and maintaining status quo (control scenario climate), system performance in the future would be nearly impossible, given the altered climate scenario hydrologies. The most comprehensive of the mitigation alternatives examined, satisfied only 87–96 percent of environmental targets in the Sacramento system, and less than 80 percent in the San Joaquin system. Van Rheenen et al., (2004) concluded that demand modification and system infrastructure improvements will be required to account for the volumetric and temporal shifts in flows predicted to occur with future climates in the Sacramento–San Joaquin River basins.

In 2006, the California Department of Water Resources (2006) completed a climate change study using CALSIM II. Streamflows were generated using the University of Santa Clara developed, macro-scale hydrologic model, Variable Infiltration Capacity (VIC) model for watershed runoff. VIC converted the GCM precipitation data into runoff data at a 1/8th degree grid (quite large for watershed-level studies, but appropriate for macro-scale analyses). Both rainfall and snowmelt runoff were represented in this model. The runoff data was further processed to produce regional scale streamflow data centered on the following locations:

- Smith River at Jedediah Smith State Park
- Sacramento River at Shasta Reservoir

- Feather River at Oroville Reservoir
- Yuba River
- North Fork American River
- American River at Folsom Reservoir
- Stanislaus River at New Melones Reservoir
- Tuolumne River at New Don Pedro Reservoir
- Merced River at Lake McClure
- Kings River at Pine Flat Reservoir

While streamflow data were available, the regional scale of the data was still too coarse for direct CALSIM II input. Miller, et al., (2003) has used perturbation ratios to transfer regional scale climate change behavior to local scale historic data. This technique was used to transfer average climate change effects observed in VIC regional runoff to historic CALSIM II reservoir inflows.

The projected time references were selected – 1976 and 2050 respectively. VIC monthly streamflows were averaged around these years. To adequately represent the effects of climate change, the period of average was thirty years - a recognized climatological time-scale – centered on the reference year; 1976 average monthly streamflows were calculated using the 1961-1990 VIC data, and 2050 average monthly streamflows were calculated using the 2035-2064 VIC data. Finally, perturbation ratios were calculated by dividing the 2050 VIC average monthly streamflows by their respective 1976 VIC average monthly streamflows. The climate change perturbations generally resulted in higher flows in the winter and lower in the spring and early summer as expected.

Current research has alluded to some interesting findings. As with any scientific endeavor, while the results of an investigation are important, its future recommendations are just as valuable. The California Department of Water Resources (2005) has identified some areas of interest for future research, including:

- the accuracy of forecasts for higher elevation watersheds,
- the statistical correlation between snowpack and forecast accuracy,
- the difference in the range of forecasts between higher elevation watersheds and lower elevation watersheds,
- the faster and more uniform convergence of forecasts for higher elevation watersheds as compared to those for lower elevation watersheds, and
- the discrepancy in the 50 percent exceedance forecasts, which show that these forecasts tend to slightly underestimate actual deliveries for higher elevation watersheds and overestimate deliveries for lower elevation watersheds.

As part of its evaluation in the Biological Assessment for the CVP-OCAP, Reclamation has more recently conducted an analysis of the potential implications of climate change for the CVP and SWP that was intended to examine the sensitivity of CVP/SWP operations and system conditions to a range of future climate conditions. A detailed explanation of the methodology and assumptions is provided in Appendix R to the Biological Assessment; *Sensitivity of Future CVP/SWP Operations to Potential Climate Change and Associated Sea Level Rise*. The description and summary that follows is the most current summarization available; it is taken from the *Draft Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations and Criteria Plan*, by NOAA Fisheries, dated December 11, 2008.

The study develops four climate change scenarios intended to bookend the range of possibilities arising from available climate projection information. The bookends span the range of outcomes developed under the assumptions of the future cumulative condition with respect to two variables: precipitation and temperature. All four scenarios are based on the assumptions, derived from published sources, that sea level will rise approximately 30 cm by 2030, and that the tidal range will increase by 10 percent. Since this evaluation was implemented for the CVP-OCAP Biological Assessment, it was designed to address the possibility that changes in habitat and entrainment rates might affect listed salmonids and green sturgeon under possible change scenarios. Four climate change scenarios were used and this evaluation consisted of six separate model runs. These runs were:

Study 9.0 Baseline conditions without sea level rise (SLR). Conditions are based on Study 8 but with only D1641 regulatory constraints.

Study 9.1 Baseline conditions with 1 foot SLR.

Study 9.2 Climate projection #1 “Wetter, less warming” climate with SLR.

Study 9.3 Climate projection #2 “Wetter, more warming” climate with SLR.

Study 9.4 Climate projection #3 “Drier, less warming” climate with SLR.

Study 9.5 Climate projection #4 “Drier, more warming with SLR.

The purpose of Study 9.1 is to convey information on the impact of SLR on the future of OCAP operations before addressing climate change scenarios.

The general results of the models indicate that future warming is expected to cause a greater fraction of the annual runoff from the Central Valley watersheds to occur during winter and early spring and a reduced fraction of the annual runoff to occur during late spring and summer. This reflects the predicted change from less snowmelt derived runoff to greater precipitation driven runoff in the region’s watersheds, particularly those watersheds originating in lower elevations (*i.e.*, northern Sierra and Cascade mountain ranges) and is consistent with other studies. The climate change models predict that factors affecting the annual precipitation levels, rather than changes in air temperature, would have a greater effect on annual runoff. The models also predicted that changes in the mean-annual deliveries and carryover storage were more sensitive to the annual precipitation changes than the changes in air temperature. SLR created greater salinity intrusion into the western delta which created significant decreases in the amount of CVP and SWP deliveries. Although the salinity intrusion created more variability in the X2 position, this intrusion was mitigated in the “wetter” scenarios by increased upstream runoff and delta outflow.

The climate modeling for the four different combinations of air temperature and precipitation indicated that for the “wetter” climates (Studies 9.2 and 9.3), the frequency of “wet” hydrological years increased over the baseline conditions, while dry and critically dry years were reduced. Hydrologic year types classified as above normal increased marginally over the baseline conditions, while years classified as below normal were essentially unchanged. Conversely, the climate models for drier climates (Studies 9.4 and 9.5) showed a substantial decrease in “wet” years and a substantial increase in “critically dry” years. Above normal year types were slightly more frequent in the drier climate scenarios than in the baseline conditions, while below normal year types were significantly lower in the drier, less warming climates compared to the control baseline.

The results from the climate modeling show that climate change typically had more effect on Delta flows during wetter years than during drier years. This result seems related to how CVP and SWP operations occur with more flexibility during wet years, within the constraints of flood control requirements, compared to drier years when the CVP and SWP operations may be more frequently constrained to maintain in-stream flows and other environmental objectives. For key locations in the Delta, the following results were apparent:

Head of Old River Flows

- Remained positive (oceanward) for all scenarios
- Decreased in winter and spring of wetter years for the drier climate change scenarios (Studies 9.4 and 9.5)
- Increased in winter of wetter years for the wetter climate change scenarios (Studies 9.2 and 9.3)
- Changes were minor during drier years for all climate change scenarios

Old and Middle River Flows

- Flows were typically negative (landward) except for a flow reversal in winter of wetter years for the wetter, less warming scenario (Study 9.2)
- Fall and winter flows are the most sensitive to climate change
- Negative winter flows decreased for the wetter scenarios and increased for the drier scenarios
- Negative fall flows increased for the wetter scenarios and decreased for the drier scenarios

QWEST Flows [westward flows from the Delta towards the ocean]

- Magnitude and direction of QWEST is affected by climate change scenario and season
- Flow direction is typically positive during wetter water years except for summer

  - for the drier climate change scenarios always positive in the spring
  - typically negative in the summer of drier years except for the drier, more warming scenario
  - positive in the fall of drier years for the drier climate change scenarios and negative in fall of drier years for the wetter climate change scenarios
- Winter flows are the most sensitive to climate change and response varies by scenario

Cross Delta Flows

- Winter flows were the most sensitive to climate change, flows decreased for the drier climate scenarios and increased for the wetter climate scenarios
- Results show that climate change typically had more effect on Delta velocities during wetter years than during drier years. This result is consistent with the Delta flow results

Head of Old River Velocities

- Are positive (oceanward) for all scenarios
- Increased in winter and spring of wet years for the wetter climate change scenarios
- Decreased in winter and spring of wet years for the drier climate change scenarios
- Changes were typically less than 0.05ft/s during drier years for all climate change scenarios

Middle River at Middle River Velocities

- Are negative (landward) for all scenarios except for a slight reverse flow in winter of the wetter, less warming scenario
- During wetter years, negative winter velocities decreased for the wetter climate change scenarios and increased for the drier climate change scenarios
- Changes were typically less than 0.05ft/s for drier climate change scenarios

San Joaquin River at Blind Point Velocities

- Are positive (oceanward) for all scenarios
- Changes were typically less than 0.05ft/s

Cross Delta Velocities (Georgiana Slough)

- Are positive (oceanward) for all scenarios
- Increased in winter for the wetter climate change scenarios and decreased in winter for the drier climate change scenarios

The fall and winter periods appear to have the most sensitivity to climate changes. In general, the pattern of study results suggests that OMR flow during January through June becomes more negative during dry years in the drier/less warming and drier/more warming scenarios, but with some substantial changes that are mostly either an increase in negative flow or a decrease in positive flow compared to the other scenarios. In other words, in the drier climate change scenarios, it is expected that fish in the channels surrounding the CVP and SWP projects will be exposed to higher entrainment risks during the January through June time frame than under projected future conditions without climate change.

Wetter climate patterns appear to present less entrainment risk during the January through June period in wet and above normal water year types, but elevated risks during the below normal, dry and critically dry water year types. The late fall period (October through December) also had consistently higher risks of entrainment in the wetter climate scenarios than the base case modeled in Study 9.0 for the future climate change models.

Table 7.1-3 shows the modeled trends for average changes in flow for the simulated climate change scenarios, relative to the base case. Trends and flow directions are based on 50 percent values with tends rounded to nearest 250 cfs. No shading (white) indicates locations with positive (oceanward) flows. Dark shading (blue) indicates locations with negative (landward) flows. Light shading (yellow) indicates locations with mixed flow regimes (sometimes positive and sometimes negative). Seasons are defined as winter is Jan-Mar, spring is Apr-Jun, summer is Jul-Sep, and fall is Oct-Dec. Wetter year types are those classified as wet or above normal. Drier year types are those classified as below normal, dry or critically dry.

TABLE 7.1-3

TRENDS FOR AVERAGE CHANGES IN FLOW FOR CLIMATE CHANGE SCENARIOS RELATIVE TO THE BASE CASE

Name	Year Type	Wetter, Less Warming	Wetter, More Warming	Drier, Less Warming	Drier, More Warming
		Flow	Flow	Flow	Flow
Head of Old River	Wetter	Increased by 1750cfs in spring, 1000cfs in summer, 250cfs in fall, and 750cfs in winter	Increased by 500cfs in winter, decreased by 1500cfs in spring, decreases were less than 250cfs in summer and fall	Decreased by 3500cfs in winter and spring, and decreased by 250cfs in summer and fall	Decreased by 2750cfs in winter and 3000cfs in spring, decreases were less than 250cfs in summer and fall
	Drier	Changes were less than 250cfs	Changes were less than 250cfs	Changes were less than 250cfs	Changes were less than 250cfs
	Wetter	In winter flows changed from negative 3200cfs (landward) to positive 100cfs (oceanward). The rest of the year, negative (landward) flows decreased by 750cfs in spring, 250cfs in summer, and increased by 500cfs in fall	Negative (landward) flows decreased by 2500cfs in winter, 750cfs in spring, and 250cfs in summer. Negative flows increased by 750cfs in fall.	Negative (landward) flows increased by 3250cfs in winter, 500cfs in spring and 1000cfs in summer. Negative flows decreased by 500cfs in fall.	Negative (landward) flows increased by 1250cfs in winter. Negative flows decreased by 250cfs in spring and by 1750cfs in fall. Summer flow changes were less than 250cfs.

TABLE 7.1-3

TRENDS FOR AVERAGE CHANGES IN FLOW FOR CLIMATE CHANGE SCENARIOS RELATIVE TO THE BASE CASE

Name	Year Type	Wetter, Less Warming	Wetter, More Warming	Drier, Less Warming	Drier, More Warming
		Flow	Flow	Flow	Flow
	Drier	Negative (landward) flows increased by less than 250cfs in winter, 750cfs in spring, 1000cfs in summer and 1750cfs in fall.	Negative (landward) flows increased by 500cfs in winter, spring, fall, and 750cfs in summer.	Changes were less than 250cfs in spring and fall. Negative (landward) flows decreased by 750cfs in summer and increased by 500cfs in winter.	Negative (landward) flows decreased by 250cfs in winter, 500cfs in spring, 1000cfs in summer and 750cfs in fall
QWEST	Wetter	Increased by 4000cfs in winter, 3000cfs in spring, 1500cfs in summer and 500cfs in fall	Increased by 3750cfs in winter, changes were less than 250cfs in spring, increased by 250cfs in summer, and decreased by 500cfs in fall	Positive (oceanward) flows decreased by 6500cfs in winter, 1750cfs in spring, 750cfs in summer, and 250cfs in winter.	Positive (oceanward) flows decreased by 4250cfs in winter and 1250cfs in spring, 250cfs in summer. Positive fall flows increased by 250cfs.
	Drier	Negative (landward) winter flows of 0cfs changed to positive (oceanward) flows of 400cfs. Positive spring flows increased by 250cfs. Summer flow changes were less than 250cfs. Positive flows of 200 fall flows changed to negative flow of 300cfs.	Changes were less than 250cfs	Flow changes were less than 250cfs in winter. Positive flows increased by 250cfs in spring and fall, 750cfs in summer.	Flow changes were less than 250cfs in winter. Positive (oceanward) flows increased by 750cfs in spring, summer, and fall.
Cross Delta	Wetter	Increased by 1000cfs in winter, decreased by 250cfs in spring and summer, changes were less than 250cfs in fall	Increased by 2000cfs in winter, 750cfs in spring, and decreased by 750cfs in summer and 500cfs in fall	Decreased by 1250cfs in winter, 500cfs spring and fall, increased by 250cfs in summer	Decreased by 2250cfs in winter, 500cfs in spring, 250cfs in summer and 1000cfs in fall
	Drier	Increased by 250cfs in winter and summer, 750cfs in fall, changes were less than 250cfs in spring	Increased by 500cfs in winter, 250cfs in fall, changes were less than 250cfs in spring and summer	Decreased by 250cfs in winter, summer and fall, decreased by 500cfs in spring	Decreased by less than 500cfs in winter, spring and fall, decreased by 750cfs in summer

Notes: No shading (white) indicates locations with positive (oceanward) flows. Dark shading (blue) indicates locations with negative (landward) flows. Light shading (yellow) indicates locations with mixed flow regimes (sometimes positive and sometimes negative).

Source: From Table 6-21. Trends for Average Changes in Flow for Climate Change Scenarios Relative to the Base Case, Draft Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations and Criteria Plan, NOAA Fisheries, December 11, 2008.

From a fisheries perspective in the Sacramento River, NOAA Fisheries reported that in comparing climate change scenarios (Study 9.0 base vs Study 9.5 drier, more warming) average winter-run and fall-run mortality increased from 15 percent to 25 percent, and average spring-run mortality increases from 20 percent to 55 percent. Reclamation's mortality model was not run for Central Valley steelhead. However, if late-fall run Chinook salmon is used as a surrogate for Central Valley steelhead (since they spawn at similar times in the winter), late-fall mortality increases in Study 9.5 (drier, more warming) and Study 9.3 (wetter, more warming) under all water year types on average 4 percent over baseline (Study 9.0).

September carryover storage is less than 1.9 MAF during average dry years (1928 to 1934) in all scenarios except Study 9.2 wetter, less warming. Under these conditions, winter-run and spring-run would experience a loss of spawning habitat as water temperatures below dams become harder to control and the coldwater pool in Shasta diminishes. Central Valley steelhead would experience less of a loss on the Sacramento River since they spawn in the late winter when water temperatures are not as critical to incubation. However, resident forms of *O. mykiss* spawn in May when water temperatures exceed 56ºF at Bend Bridge in 25 percent of future water years. It is likely that given warmer water temperatures resident *O. mykiss* would move upstream closer to Keswick Dam where temperatures are cooler, or into smaller tributaries like Clear Creek.

Water temperatures in the Sacramento River at Balls Ferry increase under all climate change scenarios except for Study 9.2 (wetter, less warming). Temperatures exceed the 56ºF objective at Balls Ferry in July, August, September, and October. The highest water temperatures approach 60ºF in September in Study 9.5 (drier, more warming), which is when spring-run salmon begin spawning.

The climate change scenarios do not incorporate day-to-day adaptive management decisions. Given the current prioritization of using cold water first for winter-run salmon during the summer, it would be logical to assume that spring-run and fall-run would experience greater impacts then those modeled. In order to overcome the impacts of climate change, NOAA Fisheries concluded that new operating criteria needs to be developed that allows for greater storage of water earlier in the year. This would involve the cooperation of the U.S. Corps of Engineers in developing new flood control curves and integration with State and federal reservoirs. DWR has recommended investigating the feasibility of fish passage over dams to access colder water at higher elevations.

7.2.8. Uncertainties in Future Climate Change Projections

Previous discussions have touched on this issue. Clearly, there has been an increasingly robust effort directed towards investigating the potential effects of climate change over the past several decades. Yet even today, there is continuing investigative work being undertaken to better understand atmospheric processes that govern the interactions and relationships between GHG (both natural and human-induced) and our climate. Some of this work has pointed to possible shortcomings in past GCM development theories. Work by Schwartz and Andrea (1996) and, more recently, by Kerr (2007) have noted the seeming omission of aerosols in the consideration of GCM simulations. Most GCMs also focus exclusively on the troposphere (up to 10 km in altitude) but neglect the stratosphere (between 10 and 50 km) which supports the critical ozone layer. The ozone layer is particularly important in any assessment of climate change in that it affects the energy balance of the lower atmosphere (Baldwin, et al., 2007). In fact, there is admittedly a less than perfect understanding of the mechanisms by which stratospheric circulation changes are communicated with the surface. This is important since any long-term changes in stratospheric winds and temperatures are likely to affect surface climate variability (Baldwin et al., 2007). Still other investigations have noted that while GCMs provide a solid basis for generalized temperature prediction, projected precipitation levels do not necessarily match with projected future atmospheric moisture modeling (Wentz et al., 2007) – as has been noted previously.

Some of the countervailing evidence has included the fact that the stratosphere has in fact cooled since 1979, the year in which the Montreal Protocol was ratified (WMO/UNEP 2007). The Montreal Protocol was signed in an effort to control aerosol emissions to the upper atmosphere. Consequently, other documentation has identified an overall cooling in the upper atmosphere in the high latitudes, over the polar region. One can hope that as climate change research continues, sensitivity will be encouraged in how these results are conveyed. It is important that we strive to avoid coming to hard and fast conclusions based solely on what Huntingford and Lowe (2007) refer to as “overshooting scenarios”. Caution must be continually exercised when applying what we know today and assuming that it is universal and unconstrained.

Others maintain, however, that the complexity of the climate system, its influencing factors, and the delicate balance that exists, in fact, warrants an <u>overly</u> cautious approach. There may exist fine, though as yet undefined, thresholds which, once crossed, can not be reversed. This is what Schellnhuber et al., (2006) refer to as “dangerous climate change”. The balance of taking action now compared to the future, although uncertain of the consequences of no action, is an area of active and increasing debate (see Stern, 2007). Still, with climate change research at the forefront of many hydrometeorological disciplines and pursuits and, propelled by the public’s ever increasing concern over this issue, we can expect even more studies in the future focusing on the various limitations, boundary conditions, drivers, and interactive processes that define climate change. Fewer and fewer studies will be drawn to testing countervailing hypotheses.

In the midst of our uncertainties, however, current climate change modeling projections exhibit some key commonalities that demand near-term attention from California’s resource management communities. First, even the most benign of the projected climate-change scenarios are sufficient to significantly alter the California’s landscape, hydrology, and land and water resources. Second, those alterations are likely to become significant within roughly the next 25 years (Barnett et al. 2004; Dettinger et al. 2004; van Rheenen et al. 2004). Thus, California, like the rest of society, is faced with a variety of possible climate changes that are likely to develop within the same time frames as the resource-management decisions necessary to respond to them. In fact, even if we are able to reduce emissions of GHGs locally at their source, further changes in the climate that we will experience are unavoidable.

The Pew Center (2007) maintains that action is needed now in order to adapt to the changes that will be apparent as the climate continues to change. Most projections of future climate change do not address what could happen if changes (e.g., warming) continues beyond 2100, which is inevitable if steps to reduce emissions (worldwide) are not taken, or if the rate of change accelerates. Furthermore, the longer warming persists and the greater its magnitude, the greater the risk of climate “surprises” such as abrupt or catastrophic changes in the global climate (Pew Center, 2007; Schellnhuber et al., 2006).

7.2.9. Climate Change Management Implications

To date, technical responses to this dilemma of how to best manage for climate change has primarily involved the development and preliminary applications of tools for assessing the potential climate-change impacts. The efficacy of various possible adaptation or accommodation strategies has not received as much attention as the tools developed to define the problem. In part, this response has been motivated by the assumption that projection uncertainties will be reduced sufficiently in the near term to justify postponing more intensive and detailed assessments until later. A comprehensive overview of GHG and climate change relationships along with cost-effective control technologies and the issues related to their implementation is provided by CALEPA (2004). Bosello et al., (2007) describe the economic effects of climate change in this future context. Cox and Stephenson (2007) discuss the role of mitigation banking credits.

The projected changes to our environment include sufficiently important near-term impacts, and the chances that projection uncertainties will decline precipitously in the near term are small enough, so that delays may not be warranted. For example, two highly respected climate modelers, David Randall and Akio Arakawa, recently opined that "*a sober assessment suggests that with current approaches the cloud parameterization problem [the most vexing aspect of climate and climate-change modeling at present] will not be 'solved' in any of our lifetimes*" (Randall et al. 2003). Thus, we should not assume that large reductions of projection uncertainty will arrive in time to allow confident planning of responses to climate change. Consequently, new strategies for more completely accommodating projection uncertainties are needed (Dettinger, 2005).

There has been long-standing acknowledgment that policy decisions, in some capacity, will have to address climate change (Dowlatabadi and Morgan, 1993; Jackson 1995), yet even as early as the late 1980's, at least a few researchers were becoming aware of the challenges for water managers to account for climate change within traditional management approaches. The dynamic qualities of maturing water systems, socially imposed constraints, and climate extremes made this unique for its time. A dual pattern of crisis/response and gradual adjustment emerges, and specific mechanisms for effecting adjustment of water management systems are being identified. The broader trends in U.S. and California water development, suggest that oversized structural capacity, the traditional adjustment to climate variability in water resources, may prove less feasible in the future as projects become smaller and new facilities are delayed by economic and environmental concerns (Riebsame, 1988). In light of these uncertainties, policy-makers should consider expanding research into abrupt climate change, improving monitoring systems, and taking actions designed to enhance the adaptability and resilience of ecosystems and economies (Alley et al., 2003).

As noted by Chalecki and Gleick at the turn of this century, while considerable progress had been made in the modeling of climate change effects on first-order systems such as regional hydrology, significant work remained to be done in understanding subsequent effects on the second-, third-, and fourth-order economic and social systems (e.g., agriculture, trade balance, and national economic development) that are affected by water resources. They go on; however, to maintain that in order to remedy a recently-revealed lack of understanding about climate change on the part of the public, climate and water scientists should collaborate with social scientists (Chalecki and Gleick, 1999). It was deemed important to illuminate the effects of climate change and variability on a variety of systems that affect how and where most people live. So, while the effects of climate change on water resources, for example, are noteworthy, rising water demands resulting from anticipated future population growth, greatly outweighs any climate warming in defining the state of global water systems to 2025 (Vorosmarty et al., 2003).

Finally, with the global changing socio-political environment, climate change should also be looked at within the context of future national security issues. Potential increases in violence and disruption stemming from the stresses created by abrupt changes in the climate pose a different type of threat to national security than we are accustomed to today. Military confrontation may be triggered by a desperate need for natural resources such as energy, food and water rather than by conflicts over ideology, religion, or national honor. The shifting motivation for confrontation would alter which countries are most vulnerable and the existing warning signs for security threats (Schwartz and Randall, 2003).

7.2.10. California Actions

On June 1, 2005, Governor Arnold Schwarzenegger issued Executive Order S-3-05 establishing GHG emissions targets for California and requiring biennial reports on potential climate change effects on several areas, including water resources. The Governor established a Climate Action Team (CAT) to guide the reporting efforts. The CAT selected four climate change scenarios that reflect two GHG emissions scenarios represented by two Global Climate Models (GCMs). The CAT requested that those four climate change scenarios be used whenever possible in the climate change reporting efforts.

As September 2006 drew to a close, Governor Schwarzenegger signed three pieces of legislation intended to reduce overall California GHG emissions. Governor Schwarzenegger signed the most comprehensive of the new laws, the landmark Global Warming Solutions Act (AB 32) on September 27. This law caps the State's GHG emissions at 1990 levels by 2020. This emissions target is approximately equal to a 25 percent reduction from current levels and is the first state-wide program in the country to mandate an economy-wide emissions cap that includes enforceable penalties.

AB 32 requires the State Air Resources Board to establish a program for state-wide GHG emissions reporting and to monitor and enforce compliance with this program. It also authorizes the State board to adopt market-based compliance mechanisms including emissions cap-and-trade, and allows a one-year extension of the targets under extraordinary circumstances. Two days later, on September 29, Governor Schwarzenegger signed SB 1368, authored by State Senator Don Perata. This new law directs the California Energy Commission to set a GHG performance standard for electricity procured by local publicly owned utilities, whether it is generated within state borders or imported from plants in other states, and will apply to all new long-term electricity contracts. The standard will discourage the purchasing of electricity produced from high-emissions sources, whether in-state or out-of-state. It will push utilities to rely more on clean sources, including coal with carbon capture and sequestration, and renewables.

Earlier that same week, on September 26, Governor Schwarzenegger signed SB 107, which requires California's three major utilities – Pacific Gas & Electric, Southern Edison, and San Diego Gas & Electric – to produce at least 20 percent of their electricity using renewable sources by 2010.

On January 9, 2007, Governor Schwarzenegger pledged that he would establish the world's first Low Carbon Fuel Standard (LCFS). It will apply to all transportation fuels sold in California, with the goal of reducing the carbon intensity of California's passenger vehicle fuels at least 10 percent by 2020. The LCFS includes provisions for market-based mechanisms, such as carbon credit trading that will allow fuel providers to meet the new requirements in the most cost-effective manner. The standard is expected to substitute low-carbon fuels for up to 20 percent of current vehicle gasoline consumption and greatly expand the number of alternative and hybrid vehicles in California.

California Energy Commission

The California Energy Commission (CEC) develops and implements both building and appliance energy efficiency standards, prepares California's GHG inventory, develops transportation fuel policy and programs, and manages climate change research programs. In conjunction with the California Public Utility Commission, the CEC also coordinates the Renewable Portfolio Standard and a variety of energy efficiency programs.

A significant program undertaken by the CEC is its Public Interest Energy Research (PIER) Program. It is intended to support public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Under the PIER Program, up to $62 million are awarded annual for the most promising public interest energy research. This is facilitated through partnerships with various research and development organizations, including individuals, businesses, utilities, and public or private research institutions.

The California Climate Change Center (CCCC) is sponsored by the PIER Program and coordinated by one of its Energy-Related Environmental Research areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies

The Center is managed by the CEC, Scripps Institution of Oceanography at the University of California at San Diego, and the University of California at Berkeley. The Scripps Institution of Oceanography conducts and administers research on climate change detection, analysis, and modeling; and the University of California at Berkeley conducts and administers research on economic analysis and policy issues. The Center also supports the Global Climate Change Grant Program, which offers competitive solicitations for climate research.

California Public Utilities Commission

In addition to coordinating with the CEC on energy efficiency programs and the Renewable Portfolio Standard, the California Public Utilities Commission (CPUC) requested that its regulated energy utilities address key issues pertaining to climate change. The CPUC requires regulated utilities to employ a “greenhouse gas adder” when evaluating competitive bids to supply energy. This adder is designed to capture the financial risk of emitting GHGs. The CPUC is also investigating the creation of a “carbon cap” on each regulated facility.

California Climate Change Registry

The Registry is a public/private partnership created by the State of California to encourage companies, governmental agencies and other organizations that do business in California to voluntarily measure and report their GHG emissions. To date, Registry has over 45 members including all major utilities, a number of California companies, cities, government entities and non-governmental organizations.

Sustainable Silicon Valley

The group of Silicon Valley manufacturers, including ALZA, Calpine Hewlett-Packard, Lifescan, Lockheed, Oracle, and PG&E, has pledged to reduce GHG emissions in Santa Clara County to 20 percent below 1990 levels by 2010.

California Cities

The Cities for Climate Protection Campaign goal is to reduce GHG emissions resulting the burning of fossil fuels and other human activities. Over 25 California cities have joined the campaign including Los Angeles, Sacramento, San Francisco and Chula Vista.

7.2.11. U.S. Support and Progress

In the future, the U.S., together with other international partners will need to continue our aggressive pursuit at addressing and filling-in both the technical gaps (i.e., physical sciences) as well as the social implications (i.e., impacts on the natural, social, cultural, and financial environments) of climate change. Clearly, this will continue to be multi-faceted endeavor; bringing together all aspects of our national and international societies. Notwithstanding these pressing needs, the National Academies’ National Research Council (NRC) have recently expressed serious concern about the management, funding and emphasis of the $1.7 billion-a-year Climate Change Science Program (CCSP) here in the U.S. To date, only two of the 21 synthesis and assessment reports due from the CCSP have been produced. According to the CCSP Chair, the program has demonstrated only “limited success” in assessing climate change impacts on human well-being and their adaptive capacities. More effort is needed to support both the modeling spatiality issues as well as the social science studies necessary to gauge human adaptive change.

7.2.12. Potential Effects of the Proposed Action on Climate Change

Much has been written about the potential effects of climate change on a variety of natural and human-related resources including those specific to California. The previous discussions focus on this particular aspect of the climate change issue. Equally important, however, are the potential effects of projects and human activities, either specifically, or collectively, <u>on</u> climate change. As a potential indirect impact on the "environment", such a discussion is noteworthy in the context of this EIS/EIR.

Water diversion projects, *per se*, have virtually no direct effect on *climate change*, as it has been <u>defined</u> in this subchapter. Even a potentially large water diversion project with the capability of significantly depleting a reservoir will have no discernible direct effect on regional changes in climate. This is because climate change is driven primarily by the net radiative energy balance of the atmospheric layers (e.g., troposphere and stratosphere), whose interactive processes are unaffected by the singular action of diverting water at the ground surface. Assuming that a residual water supply remains in the waterbody after diversion, the continued presence of ongoing exchange mechanisms (e.g., gradient of saturated vapor pressure) between the water surface and atmosphere will remain. By all of the atmospheric, hydroclimatological and climatological processes known and accepted, water diversions, in and of themselves, cannot affect global climatic forcings.

For this Proposed Action, a 15,000 AFA maximum diversion from Folsom Reservoir or, from points upstream, will have no direct measurable effect on local climate.

The energy balance in the atmosphere controls, interacts, and manifests itself with other meteorological, hydrological, biological, vegetative, and pedological processes at the surface. This fact, as discussed at length earlier in this subchapter is the driving mechanism by which climate change effects on natural systems can be investigated. Climate, as defined, is a system involving the oceans, land, atmosphere and continental ice sheets with interfacial fluxes between these components (National Research Council, 2005). It must include and consider, therefore, these other physical processes. In the example provided, a water diversion, while depleting the overall storage within a waterbody cannot, by itself, alter the exchange mechanisms between the water surface and the atmosphere. The gradient of saturated vapor pressure exists prior to, during, and after diversions.

However, when considering the matter of the *indirect* effects of water diversion projects on climate, the issue becomes more intriguing and certainly not as clear. As an action that can been viewed as accommodating approved growth (i.e., development, urbanization, land clearing, etc.), the indirect effects of water diversions can be *tied,* at least in some manner, to a variety of land activities to which it serves. These can include:

- Removal of vegetation (land conversions)
- Soil disturbance
- New highways, roads, and parking lots
- Commercial/retail development

- Residential development
- Recreational facilities
- Industrial development
- Institutional development

These activities can, by their influence on the net radiative energy balance and the exchange mechanisms with the overlying atmosphere, have a collective effect on climate in varying degrees. In El Dorado County, each of these land uses are controlled, for the most part, by the Community and Development Department of El Dorado County as part, and through its standard land use designation and project approval processes. The El Dorado County Water Agency, El Dorado Irrigation District, or the Georgetown Divide Public Utility District, do not control, direct, propose, or otherwise influence large scale land use changes associated with development. In the case of the two purveyors, individually small infrastructure facility projects are periodically constructed, but in terms of land area conversions, these are insignificant, relative to county and city approved development initiatives.

As land uses change, the physical processes between the land and atmosphere (e.g., evaporation, sensible heat exchange, latent heat exchange) will change. This is largely due to changing net radiation at the surface (i.e., solar shortwave reflectivity), surface roughness, moisture availability, and momentum uptake. Different surfaces also emit longwave radiation in varying amounts as per the Stefan-Boltzmann law. With land use changes, the entire net radiative energy balance is altered.

Land use changes (e.g., clearing land for logging, ranching, and agriculture), lead to varying amounts of carbon dioxide emissions, depending on the intensity of the land use change. Vegetation contains carbon that is released as carbon dioxide when the vegetation decays or burns. Under natural regeneration, lost vegetation would normally be replaced by re-growth with little or no net emission of carbon dioxide, however, over the past several hundred years, deforestation and other land use changes in many countries have contributed substantially to atmospheric carbon dioxide increases. Land use changes are responsible for 15 to 20 percent of current carbon dioxide emissions.

Methane (natural gas) is the second most important of the GHGs resulting from human activities. It is produced by rice cultivation, cattle and sheep ranching, and by decaying material in landfills. Methane is also emitted during coal mining and oil drilling, and by leaky gas pipelines. Human activities have increased the concentration of methane in the atmosphere by about 145 percent above what would be present naturally.

Nitrous oxide is produced by various agricultural and industrial practices. Human activities it is estimated have increased the concentration of nitrous oxide in the atmosphere by about 15 percent above what would be present naturally.

Chlorofluorocarbons (CFCs) have been used in refrigeration, air conditioning, and as solvents. However, the production of these gases is being eliminated under existing international agreements (i.e., Montreal Protocol), rationalized because of their effect on the stratospheric ozone layer. Other fluorocarbons that are also GHGs are being used as substitutes for CFCs in some applications, for example in refrigeration and air conditioning. Although currently very small, their contributions to climate change are expected to rise in the future.

Ozone in the troposphere is another important GHG resulting from industrial activities. It is, however, also created naturally and also by reactions in the atmosphere involving gases resulting from human activities, including nitrogen oxides from motor vehicles and power plants. Based on current data, tropospheric ozone is an important contributor to an enhanced greenhouse effect. However, in part because ozone is also produced naturally, and because of its relatively short atmospheric lifetime, the magnitude of this contribution remains uncertain.

The most dramatic of the human activities in terms of being the largest contributor to GHGs is the burning of fossil fuels. Of that category of emissions, those generated from fossil fuel run automobiles and other vehicles represent the most significant contribution. It is estimated that in California, approximately 41 percent of the GHG emissions result from transportation (see Rio Del Oro Specific Plan, DEIS/DEIR). Together, the burning of fossil fuels and land use changes, have increased the abundance of small airborne particles in the atmosphere. These particles can change the amount of energy that is absorbed and reflected by the atmosphere; and hence, the net radiative energy balance. Particulates are also believed to modify the properties of clouds, changing the amount of energy that they absorb and reflect.

It is evident that changes in land use and land cover are important contributors to climate change and variability. Reconstructions of past land-cover changes and projections of possible future land-cover changes are needed to better understand past climate changes and to more accurately project possible future climate changes. Additionally, changes in land use and land cover can affect ecosystems, biodiversity, and the many important goods and services they provide to society, including carbon sequestration. Land-cover characteristics, therefore, are important inputs to climate models.

Determining the effects of land-use and land-cover change on the Earth’s ecosystems depends on an understanding of past land-use practices, current land-use and land-cover patterns, and projections of future land use and cover, as affected by human activities, population size and distribution, economic development, technology, and other factors.

Dietz et al. (2001) provide a compelling argument regarding growth of the human population and consumption as a principal factor affecting climate change. Their findings suggest the impact of these two environmental stressors is so profound that they may, in fact, outpace any potential environmental benefits from industrial modernization and improving technologies. Through the creation of a research program called STIRPAT, a highly refined way of systematically and empirically assessing the human-generated factors that drive adverse environmental impacts, they examined various GHGs and their "ecological footprints." This represented a quantitative measurement of the stress placed on the environment by demands for available lands and resources to meet the need for food, housing, transportation, consumer goods and services. Urbanization, economic, age of population, and other analyzed factors have little effect, according to their research. Population growth and consumption were the principal factors affecting climate change.

Other studies (see Changnon, 1992) maintained that the rate and amount of urban climate change approximate those being predicted globally using climate models. Large metropolitan areas in North America, home to 65 percent of the nation's population, have created major changes in their climates over the past 150 years. Urbanization, in this case, was a major factor in localized climate change. It is difficult, however, to clearly differentiate between the effects of urbanization, per se, relative to population growth since the two are inextricorably linked.

While most environmental impact research use single indicators of impact, such as CO_2 emissions or deforestation rates, a sound measure of impact must take account of several factors. As noted by Dietz et al., (2001), first, there can be tradeoffs among impacts. GHG emissions will be lower for nations that make substantial use of hydroelectric power and nuclear power, but each of those energy sources have their own environmental impacts. Second, environmental impacts can be “off-shored” in the sense that consumption in one part of the world is linked via world trade to changes in the biophysical environmental in another part of the world. In accounting for impacts, it is difficult to know how much of such impacts should be attributed to the site where the impacts occur and how much to the site where the consumption occurs.

This latter point is an important one. A significant complicating factor when assessing the potential effects of existing or planned activities on climate change is that, given current impact metrics (e.g., GHG loadings), it is virtually impossible to ascribe the increment of impact from a single activity to potential climate change effects either at that location, regionally, or in some transboundary context. The highly complex nature of atmospheric dynamics are such that GHG emissions in one location may, depending on a multitude of variables, spatially (in three-dimensions) and temporally, contribute to or affect a climate change related parameter (e.g., temperature or precipitation) that may be observed, but more likely that not, remain unobserved.

8.0 ENVIRONMENTAL JUSTICE

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8.0 ENVIRONMENTAL JUSTICE

8.1. BACKGROUND

Environmental Justice refers to the inequitable environmental burdens born by groups such as racial minorities, women, residents of economically disadvantages areas, or residents of developing nations. Environmental justice proponents generally view the environment as encompassing “where we live, work and play” (in some instances, “pray” and “learn” are also included). Proponents seek to redress inequitable distributions of environmental burdens (e.g., pollution, industrial facilities, crime, etc.) and equitably distribute access to environmental goods such as nutritious food, clean air and water, parks, recreation, health care, education, transportation, safe jobs, etc. Self-determination and participation in decision-making are key components of environmental justice. Root causes of environmental injustices are long-standing and include institutional racism: the commodification of land, water, energy and air; unresponsive, unaccountable government policies and regulation; and a lack of resources and power in affected communities. Critics contend that any such “unjust” effects are unintentional and area due to a variety of other factors.

In the early 1980s, environmental justice emerged as a concept in the United States. On February 11, 1994, President Clinton issued Executive Order 12898 entitled, “*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*”. This Executive Order was designed to focus the attention of federal agencies on the human health and environmental conditions in minority and low-income communities. It required federal agencies to adopt strategies to address environmental justice concerns within the context of agency operations. In an accompanying Presidential Memorandum, the President emphasized existing laws, including NEPA as providing the opportunities for federal agencies to address environmental hazards in minority and low-income communities.

In April 1995, the U.S. Environmental Protection Agency released the document titled, “*Environmental Justice Strategy: Executive Order 12898*”. In August 1997, the EPA Office of Environmental Justice released the “*Environmental Justice Implementation Plan*”. The Implementation Plan supplements the EPA environmental justice strategy. It provides estimated time frames for undertaking revisions, identifying the lead agents and determining the measures of success for each action item. Several EPA offices have since developed more specific plans and guidance to implement Executive Order 12898.

The National Environmental Policy Act of 1969 (42 U.S.C. §4321 et seq.) serves as the nation’s basic environmental protection charter. A primary purpose of NEPA is to ensure that federal agencies consider the environmental consequences of their actions and decisions as they conduct their respective missions. For major federal actions significantly affecting the quality of the human environment, the federal agency must prepare a detailed environmental impact statement (EIS) that assesses the Proposed Action and all reasonable alternatives. These documents are required to be broad in scope, addressing the full range of potential effects of the Proposed Action on human health and the environment. Regulations established by both the Council on Environmental Quality (CEQ) and EPA require that socio-economic impacts associated with significant physical environmental effects also be addressed in the EIS. The Memorandum accompanying the Executive Order identifies four important ways to consider environmental justice under NEPA:

1. Each Federal Agency should analyze the environmental effects, including human health, economic and social effects of federal actions, including effects on minority populations, low-income populations, and Indian tribes, when such analysis is required by NEPA;

2. Mitigation measures identified as part of an Environmental Assessment (EA), or a Record of Decision (ROD), should, wherever feasible, address significant and adverse environmental effects of proposed federal actions on minority populations, low-income populations, and Indian tribes;

3. Each Federal agency must provide opportunities for effective community participation in the NEPA process, including identifying potential effects and mitigation measures in consultation with affected communities and improving the accessibility of public meetings;

4. Review of NEPA compliance must ensure that the Lead Agency preparing NEPA analyses and documentation has appropriately analyzed environmental effects on minority populations, low-income populations, or Indian tribes, including health, social, and economic effects.

The Office of Secretary's Office of Environmental Policy and Compliance (OEPC) provides national leadership and direction in the coordination and development of environmental policy and program evaluation. It provides for a coordinated and unified approach and response to environmental issues that affect multiple bureaus in order to ensure that the U.S. Department of Interior speaks as one entity with respect to these important issues. It provides guidance for the Department's compliance with the full range of existing environmental statutes, executive orders, regulations and other requirements.

The principles of environmental justice considerations under NEPA recognize that environmental justice issues may arise at any step of the NEPA process and, that agencies should consider these issues at each and every step of the process, as appropriate. Environmental justice issues cover a broad range of impacts covered under NEPA, including impacts on the natural or physical environment and interrelated social, cultural and economic effects. Environmental justice concerns may arise from any of these concerns. Agencies should recognize that the question of whether an agency's action raises environmental justice issues is highly sensitive to the history or circumstances of a particular community or population, the particular type of environmental or human health impact, and the nature of the Proposed Action itself. There is no standard formula for how environmental justice issues should be identified or addressed. However, six principles provide general guidance:

- Agencies should consider the composition of the affected area, to determine whether minority populations, low-income populations, or Native American tribes are present in the area affected by the Proposed Action and, if so, whether there may be disproportionately high and adverse human health or environmental effects on these populations;

- Agencies should consider relevant public health data and industry data concerning the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards to the extent such information is reasonably available. For example, data may suggest that there are disproportionately high and adverse human health or environmental effects on a minority population, low-income population, or Native American tribe from an agency action. Agencies should consider these multiple, or cumulative effects, even if certain effects are not within the control or subject to the discretion of the agency proposing the action;
- Agencies should recognize the interrelated cultural, social, occupational, historical, or economic factors that may amplify the natural or physical environmental effects of the proposed agency action. These factors should include the physical sensitivity of the community or population to particular impacts; the effects of any disruption on the community structure associated with the Proposed Action; and the nature and degree of impact on the physical and social structure of the community;
- Agencies should develop effective public participation strategies. Agencies should, as appropriate, acknowledge and seek to overcome linguistic, cultural, institutional, geographic, and other barriers to meaningful participation, and should incorporate active outreach to affected groups;
- Agencies should assure meaningful community representation in the process. Agencies should be aware of the diverse constituencies within any particular community when they seek community representation and should endeavor to have complete representation of the community as a whole. Agencies should also be aware that community participation must occur as early as possible if it is to be meaningful; and,
- Agencies should seek tribal representation in the process in a manner that is consistent with the government-to-government relationship between the United States and tribal governments, the federal government's trust responsibility to federally-recognized tribes, and any treaty rights.

It is important for agencies to recognize that the impacts within minority populations, low-income populations, or Native American groups may be different from impacts on the general population due to a community's distinct cultural practices. For example, data on different patterns of living, such as subsistence fish, vegetation, or wildlife consumption and the use of well water in rural communities may be relevant to the analysis. Where a proposed agency action would not cause any adverse environmental impacts, and therefore would not cause any disproportionately high and adverse human health or environmental impacts, specific demographic analysis of these sensitive groups may not be warranted. However, where environments or Native American tribes may be affected, agencies must consider pertinent treaty, statutory, or executive order rights and consult with tribal governments in a manner consistent with the government-to-government relationship.

8.2. U.S. BUREAU OF RECLAMATION

Within the context of the special relationships between the United States and various Indian tribes, Reclamation has Native American Affairs Offices in Washington, D.C, the Regions, and many Area offices. These offices are primarily concerned with making Reclamation services readily available to tribes and, to ensure that Native American concerns are considered by Reclamation in their various programs. Reclamation has implemented numerous procedures to ensure that its actions do not adversely affect Indian trust assets. Reclamation staff produces and review all NEPA and related documents in order to ensure their clarity and ready accessibility to all affected parties. Notices of public meetings are published in news media and through electronic media (e.g. radio and television) as well as the Federal Register. NEPA documents requiring public review are made available for display in public libraries and distributed to all upon request.

Reclamation's four goals pertaining to environmental justice issues include the following:[218]

> **Goal 1**
>
> The Department will involve minority and low-income communities as we make environmental decisions and assure public access to our environmental information.
>
> **Goal 2**
>
> The Department will provide its employees environmental justice guidance and with the help of minority and low-income communities develop training which will reduce their exposure to environmental health and safety hazards.
>
> **Goal 3**
>
> The Department will use and expand its science, research, and data collection capabilities on innovative solutions to environmental justice-related issues (for example, assisting in the identification of different consumption patterns of populations who rely principally on fish and/or wildlife for subsistence).
>
> **Goal 4**
>
> The Department will use our public partnership opportunities with environmental and grassroots groups, business, academic, labor organizations, and Federal, Tribal, and local governments to advance environmental justice.

While some highly specialized technical work such as hydraulic and hydrologic modeling have been referred to universities, Reclamation tends to use its own personnel in research, technical development, communication, and leadership efforts. To further augment environmental justice, Reclamation has partnered with the Bureau of Indian Affairs and Hispanic-serving institutions throughout the U.S.

218 U.S. Department of the Interior, Office of Environmental Policy and Compliance, Environmental Justice Strategic Plan, 1995. website: http://www.doi.gov/oepc/ej_goal1.html; http://www.doi.gov/oepc/ej_goal2.html; http://www.doi.gov/oepc/ej_goal3.html; http://www.doi.gov/oepc/ej_goal4.html.

8.3. PRINCIPLES OF ANALYSIS

When a disproportionately high and adverse human health or environmental effect on a low-income population, minority population, or Native American tribe has been identified, agencies should analyze how environmental and health effects are distributed within the affected community. Displaying available data spatially, through a GIS platform for example, can provide the agency and the public with an effective visualization of the distribution of health and environmental impacts among demographic populations. This type of data should be analyzed in light of any additional qualitative information gathered through the public participation process.

Where a potential environmental justice issue has been identified, the agency should state clearly in the EIS or EA whether, in light of all of the facts and circumstances, a disproportionately high and adverse human health or environmental impact on minority populations, low-income populations, or Native American tribe is likely to result from the Proposed Action and any alternatives. This statement should be supported by sufficient information for the public to understand the rationale for the conclusion. The underlying analysis should be presented as concisely as possible, using language that is understandable to the public and that minimizes the use of technical acronyms or jargon.

Agencies should encourage the members of the communities that may suffer a disproportionately high and adverse human health or environmental effect from a proposed agency action to help develop and comment on possible alternatives to the proposed agency action as early in the process as possible.

8.3.1. P.L.101-514 Effects

The Congressionally mandated new CVP water service contract authorized by P.L.101-514 was granted to the El Dorado County Water Agency and would be facilitated through Reclamation. This new water service contract was intended to represent a new federal long-term water supply. The legislation did not, by design, specify the manner of delivery, locations of use, intended recipients or other restrictions pertaining to its implementation. El Dorado County interests were identified and accommodated insofar as the legislation only stipulated that the new water supply be used in El Dorado County. This was consistent with the overarching intent of P.L.101-514 (Section 206[b]) which, as early as 1990, focused on the immediate new water needs of El Dorado County. No preference was placed on socio-economic standing, racial, cultural, historic, or ethnic special-status peoples.

The Agency, acting as the prime contractor with Reclamation will enter into subcontracts with both EID and GDPUD for each of the latter's share of the new CVP M&I contract water. An equitable distribution of the 15,000 AFA between EID and GDPUD was originally assumed, proposed, and implemented as part of the NEPA.CEQA analysis. The Proposed Action, in fact, as defined within this EIS/EIR is designed to equally share the 15,000 AFA between EID and GDPUD. While shifted allocations (e.g., via NEPA/CEQA alternatives) of the 15,000 AFA between EID and GDPUD were identified as procedural alternatives and thoroughly reviewed as part of the environmental review, they were only analyzed and presented in this EIS/EIR in order to address the potential environmental benefits of such partitioning as required under NEPA/CEQA. No pre-judged allocation of this new CVP water was made; moreover, no specific entities, neighborhoods, commercial enterprises, special interest groups, or industries were designated as recipients of this new federal water supply.

The Agency, under the edicts of both (the State) Water Code and Reclamation Law (as a new CVP contractor) is compelled to ensure that the maximum beneficial use of this new water supply as envisioned by P.L.101-514 is maintained; this has temporal implications. As water demands grow within the County, the two intended recipient water purveyors (i.e., EID and GDPUD) will differ in their anticipated and realized growth rates. This is due to the fact that within El Dorado County, it is acknowledged that growth is not spatially uniform. Growth follows numerous stimuli; available infrastructure, transportation access and efficiency, industrial/commercial opportunities, workforce availability, and physical/geographic constraints or barriers, among others. EID's service area, in particular its El Dorado Hills, Bass Lake, Cameron Park, and Shingle Springs areas have, and continue to represent the high growth epicenters of the County. Facilitated by ready access to State Highway 50, these areas are situated along a major commercial/economic corridor that provides an effective linkage with the greater Sacramento metropolitan area, South Lake Tahoe and, more distantly, the Central Valley and Bay Area. As a ready commuter source for the employment-diverse Sacramento region, this area has experienced considerable growth over the past decade.

The GDPUD service area, by contrast, is located more remotely: centered on the Georgetown Divide between the South and Middle/North forks of the American River. More rural in character, this area is not as easily accessible as the western areas of the EID service area. Accordingly, anticipated growth opportunities within the GDPUD service area are significantly more constrained.

As noted, the new water made available under this contracting action will be put to beneficial use as required by State and Reclamation water law. Since this new CVP water cannot be sold out of County, the Agency will exercise control over how its use will best meet existing and foreseeable future needs within the County, as new demands are generated. For certain areas, this may occur over a period of time, relative to other areas which may have a more pressing immediate need. As long as a verifiable in-County demand exists, the Agency, together with Reclamation will make these supplies available to EID and GDPUD on a long-term annual basis.

As previously described, there exists no pre-condition on the use of this water other than its defined use for municipal and industrial purposes (as set forth in Reclamation contracting) and, its limitations within certain portions of the EID and GDPUD service areas (i.e., Subcontractor service areas). The new surface water supply (diverted from Folsom Reservoir and/or exchanged with upper Middle Fork water rights) will have no effect on those rural communities relying on local area groundwater wells, nor will it affect any rivers or waterbodies relied upon for subsistence fish, vegetation or wildlife. Unimpaired inflow to Folsom Reservoir (the source of this new CVP water allocation) does not affect these resources. Moreover, use of this new water supply is not restricted to or prohibited from any one particular socio-economic, ethnic, or cultural group; water supplies held by both EID and GDPUD are managed in a commingled fashion. Service extensions, connection fees, hook-up charges, etc. are administered uniformly, without bias or preference, and on a first come first served basis. Finally, the implementation of this new water service contract does not require facility or construction activities that would remove, displace, cause to disrupt or otherwise adversely affect minority, low-income, or Native American groups or communities.

Accordingly, this action poses no deliberate or inadvertent adverse effect upon minority, low-income, or Native American communities, groups, or persons. Human health or environmental impacts associated with these groups or, their practices and livelihoods are not anticipated to be affected by this action or its alternatives.

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9.0 INDIAN TRUST ASSETS

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9.0 INDIAN TRUST ASSETS

9.1. AFFECTED ENVIRONMENT

Indian Trust Assets (ITAs) are legal interests in property held in trust by the U.S. for federally-recognized Indian tribes or individual Indians. An Indian trust has three components: (1) the trustee, (2) the beneficiary, and (3) the trust asset. ITAs can include land, minerals, federally-reserved hunting and fishing rights, federally-reserved water rights, and in-stream flows associated with trust land. Beneficiaries of the Indian trust relationship are federally-recognized Indian tribes with trust land; the U.S. is the trustee. By definition, ITAs cannot be sold, leased, or otherwise encumbered without approval of the U.S. The characterization and application of the U.S. trust relationship have been defined by case law that interprets Congressional acts, executive orders, and historic treaty provisions.

Consistent with President William J. Clinton's 1994 memorandum, "Government-to-Government Relations with Native American Tribal Governments," Bureau of Reclamation (Reclamation) assesses the effect of its programs on tribal trust resources and federally-recognized tribal governments. Reclamation is tasked to actively engage federally-recognized tribal governments and consult with such tribes on government-to-government level (59 Federal Register 1994) when its actions affect ITAs. The U.S. Department of the Interior (DOI) Departmental Manual Part 512.2 ascribes the responsibility for ensuring protection of ITAs to the heads of bureaus and offices (DOI 1995). Reclamation will comply with procedures contained in Departmental Manual Part 512.2, guidelines, which protect ITAs.

Further, DOI is required to "protect and preserve Indian trust assets from loss, damage, unlawful alienation, waste, and depletion" (DOI 2000). It is the general policy of the DOI to perform its activities and programs in such a way as to protect ITAs and avoid adverse effects whenever possible (Bureau of Reclamation 2000.

A review of the Proposed Action was conducted to determine whether the Proposed Action has potential to affect ITAs. The Proposed Action is to execute a new long-term water service contract between the El Dorado County Water Agency (EDCWA) and Reclamation to implement those parts of Public Law 101 514, Section 206, pertaining specifically to EDCWA. Under this contract, up to 15,000 AFA of CVP water would be provided to EDCWA for diversion from Folsom Reservoir or for exchange on the American River upstream from Folsom Reservoir (Proposed Project). The contract would provide water that would serve M&I water needs in El Dorado County. EDCWA would, in turn, make water available to EID and GDPUD for M&I use within their respective service areas. Based on the information provided it is determined the Proposed Action does not have a potential to affect Indian Trust Assets. The nearest ITA's to the proposed project site is the Auburn Rancheria which is approximately 11miles NW of the project location and the Shingle Springs Rancheria which is approximately 12 miles east of the project location.

9.2. ENVIRONMENTAL CONSEQUENCES

9.2.1. No Action

Under the no action alternative, there are no impacts on Indian Trust Assets, as no new facilities would be constructed and existing operations would continue to operate as has historically occurred.

9.2.2. Proposed Action

There are no tribes possessing legal property interests held in trust by the United States in the water involved with this action, nor is there such a property interest in the lands designated to receive the water proposed in this action. The nearest ITA to the proposed project site is the Auburn Rancheria which is approximately 11miles NW of the project location and the Shingle Springs Rancheria which is approximately 12 miles east of the project location.

9.2.3. Cumulative Effects

There are no impacts on Indian Trust Assets as a result of the Proposed Action therefore the Proposed Action would not contribute to cumulative impacts on Indian Trust Assets.

10.0 CONSULTATION/COORDINATION AND APPLICABLE LAWS

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10.0 CONSULTATION/COORDINATION AND APPLICABLE LAWS

10.1. OVERVIEW

This chapter describes the consultation and coordination activities undertaken as part of the preparation of this joint EIS/EIR. Starting in late 1991, after the passing of P.L.101-514 (on November 4, 1990), Reclamation and EDCWA began discussions on the scope of the effort to be implemented in developing this EIS/EIR. Extensive public scoping followed the early noticing of the project in 1993. The project was put on hold during the late 1990s until 2005 when the El Dorado County General Plan Update was suspended. Since 2006, public scoping and agency consultation were re-initiated, and new technical work (i.e., CALSIM II modeling) was incorporated into this EIS/EIR.

10.2. BACKGROUND

A Notice of Preparation (NOP) for this EIS/EIR was prepared for the Proposed Action and circulated in April 1993 (with an assigned State Clearninghouse Number; SCH#1993052016). A Notice of Intent (NOI) was also prepared for the action and published in the Federal Register (Vol. 58, No.90, May 12, 1993). Subsequently, new information regarding potential project alternatives was identified and made available, warranting issuance of another revised NOP distributed on May 22, 1998. Since 1998, a number of events transpired that prompted EDCWA to issue a Supplemental NOP in September 2006. Specifically, in 1999, the El Dorado County General Plan Update was suspended by a Writ of Mandate, and additional environmental review of the General Plan was required. El Dorado County completed the supplemental environmental review, and approved the General Plan in July 2004; in March 2005, El Dorado County voters approved the referendum on the General Plan adopted by the Board of Supervisors. In September 2005, the Sacramento County Superior Court discharged the Writ of Mandate that previously limited development approvals in El Dorado County pending completion of the new General Plan. Additionally, water needs for this region of the County have been re-verified, and focused information on the potential alternatives, including the intended service areas have been established. Through the alternatives development process, key public trust resource agencies have been identified as potential Responsible Agencies under CEQA; these include the State Water Resources Control Board (SWRCB) and the Placer County Water Agency (PCWA). As of the result of these latter developments and, in deference to the amount of elapsed time since the previous public scoping efforts, Reclamation and EDCWA opted to re-initiate public scoping in 2006. A new NOP/NOI was prepared and released on September 15, 2006. This EIS/EIR has undergone several public scoping and stakeholder outreach efforts over the past 20 years; the lead agencies have maintained duly diligent in keeping abreast of new policy, technical, and legal changes that, at the time, may affected the environmental analysis of this joint document. This current EIS/EIR reflects all of those earlier concerns and includes, adopts, and/or incorporates changes and advances that have occurred since the passing of the original legislation in 1990.

10.3. EARLY PUBLIC OUTREACH

An initial scoping phase was developed to help refine the Proposed Action and identify the major issues of concern. In August 1994, a list of organizations, public trust resource agencies, and interested stakeholders was developed. A questionnaire was prepared covering 13 standard questions to be asked at a series of interviews with the identified parties. A series of interviews was conducted in September, 1994. The interviewees included:

- Fisheries Resource Agencies: California Department of Fish & Game, U.S. Fish & Wildlife Service, and National Marine Fisheries Service;
- PG&E
- El Dorado County Business Community (A. Hazbun, Murray & Downs, K. Russell)
- Friends of the River/CA Sportfishing Alliance
- American River Land Trust
- El Dorado County Parks and Recreation Division
- Western States Endurance Run
- California Department of Boating and Waterways
- El Dorado County Assessor's Office
- El Dorado County River Management Advisory Committee
- American Whitewater Association

The questionnaire and interview responses are included in Appendix A in this Draft EIS/EIR.

10.4. PUBLIC SCOPING MEETINGS

Subsequent to the May 22, 1998 NOP/NOI, two public scoping meetings were held on August 6, 1998 and August 7, 1998 to formally solicit comment on the EIS/EIR. These sessions were lightly attended by the public; oral comment by only one member of the public was tendered at these meetings. Written comments were received by: the U.S. Environmental Protection Agency (Region IX), The Center for Sierra Nevada Conservation, and a joint submittal from the El Dorado County Taxpayers for Quality Growth and Sierra Club – Maidu Group, Mother Lode Chapter.

In September, 2006, subsequent to the supplemental NOP/NOI distributed on September 15, 2006, two additional public scoping meetings were held; on September 26 and 27. These meetings were also lightly attended. Comment letters were received from the Planning and Conservation League, Westlands Water District, El Dorado County, Environmental Management Department – Air Quality Management District, Regional Water Quality Control Board, and the California Native Plant Society in response to the NOP/NOI. Appendix B of this Draft EIS/EIR contains the comment letters.

10.4.1. 2006/2007 Outreach Efforts

As part of the 2006/2007 scoping efforts (see Appendix C in this Draft EIS/EIR for noticing materials and responses), additional briefing meetings were held with various agencies to provide updates of the revised Proposed Action and solicit comments that would help guide preparation of the environmental review documentation. Meetings were held with: California Department of Fish & Game, California Department of Parks & Recreation, California Department of Water Resources, CALFED, Sacramento Area Water Forum, State Water Resources Control Board, U.S. Environmental Protection Agency – Region IX, Sierra Nevada Conservancy, and the Planning and Conservation League.

The Planning and Conservation League provided extensive and thorough comments and suggested actions. In particular, discussion of the potential effects of climate change has been incorporated into this EIS/EIR. An extensive scientific literature review, discussion of current trends, and cited reference analyses on climate change; its effects on California water resources, the CVP/SWP, upper basin ecosystem function, snowpack and wildlife, Bay-Delta, and sea level changes was prepared and included in this EIS/EIR. The new discussion includes an explanation of climate change modeling, the various scaling considerations (i.e., spatiality) that govern climate modeling application at the watershed scale, what the State has committed to in addressing part of the climate change challenge, and ongoing risks, issues, and challenges for the future.

10.5. CONSULTATIONS/COORDINATION AND APPLICABLE LAWS

Numerous laws and regulations at the federal, State and local levels apply to this Proposed Action. As described previously and, as defined by the Proposed Action itself, there are two elements that make up the environmental analysis for this action and, therefore, the regulatory framework upon which its approval is predicated. First, is the execution and approval of the new CVP M&I water service contract. Second, is the future likelihood that new facilities and/or infrastructure will be required by the contractors to fully implement (i.e., divert, convey, treat and distribute treated water) the Proposed Action. In an effort to fully disclose all of the potentially likely laws and regulations that are, or may be associated with this Proposed Action and its implementation, a broad discussion is provided.

10.6. FEDERAL LAWS

10.6.1. National Environmental Policy Act

The National Environmental Policy Act (NEPA, 42 USC 4321; 40 CFR 1500.1) was established in 1969 to ensure that Federal agencies consider potential environmental effects of their actions, cooperate with other agencies, and disclose potential effects in a public forum. NEPA requirements always include the preparation of the appropriate environmental document, and may also include:

- Publishing public notice of hearings, public meetings, and availability of environmental documents;
- Holding public hearings or meetings;
- Soliciting comment and input from the public; and

- Making documents and comments available to the public according to the Freedom of Information Act.

The U.S. Bureau of Reclamation serves as the federal lead agency under NEPA. Reclamation will use this joint EIS/EIR to comply with NEPA requirements.

Section 46.100 of Subtitle A of Title 40 of the CFR

CEQ regulations provide that federal agencies review their NEPA regulations and procedures and, in consultation with CEQ, revise them as necessary to ensure full compliance with the purposes and provisions of NEPA (40 CFR 1507.3). The CEQ reviewed the proposed conversion of the Department of Interior's (DOI) NEPA procedures from Chapters 1-6 of Part 516 of the Department Manual to regulations at a new Part 46 to Subtitle A of Title 43 of the Code of Federal Regulations. The proposed changes and conversion of the procedures as regulations was published in the Federal Register for comment on January 2, 2008 (73 FR 126). The final rule was published in the Federal Register on October 15, 2008.

In relevant part, Section 46.100 addresses the incorporation of consensus-based management as part of the Department of Interior's NEPA process. While the DOI acknowledges that neither NEPA nor the CEQ regulations require consensus, and that consensus may not always be achievable or consistent with policy decisions, it requires the *use* of consensus-based management whenever practicable. Consensus-based management is not inconsistent with the intent of NEPA and the CEQ regulations. Recognizing that consensus-based management may not be appropriate in every case, the final rule does not set consensus-based management requirements; timelines or documentation of when parties must become involved in the process. Similar to collaborative processes, consensus-based management, like public involvement and scoping, will vary depending on the circumstances surrounding a particular proposed action.

This EIS/EIR, including its primary components, the Proposed Action and alternatives underwent extensive public outreach and community input efforts (see Subchapter 10.2 and following, provided earlier) in their development. Consistent with Section 46.100, the alternatives identification and development process provided full opportunity for the evaluation of reasonable alternatives presented by persons, organizations or communities who may have had (or have) interest in the Proposed Action. Limited by the number of authorized points of diversion, legal water permit conditions (e.g., water right and CVP), and the physical constraints of moving water from one point to another based on geography, a set number of alternatives were possible. Still, the alternatives identification process identified, described, screened, and ultimately evaluated the widest range of alternatives across several broad categories (see Chapter 3.0). These included completely new alternative water supplies to those authorized under this congressional action, variations in the amounts, allocations, and diversion patterns of those supplies, and potential demand reduction or water supply offsetting actions (e.g., reclaimed water use) up to and including possible growth moratoriums.

Under Section 46.100, the Responsible Official (RO) as defined by the Department of Interior, was intimately involved in all steps of the alternatives identification, screening criteria selection, screening process, and impact evaluation framework development for the alternatives (e.g., correlating alternatives with the use of CALSIM II hydrologic modeling simulations).

10.6.2. Federal Endangered Species Act

Reclamation's Long-Term Coordinated Operations of the CVP and SWP will dictate how CVP, SWP, and related actions will be managed, controlled, and implemented. CVP water service contracts are an important part of CVP operations. Any new CVP water service contract must take into account how it could affect or otherwise be integrated into Reclamation's existing contracting program, including any environmental effects. For this reason, the current deliberations and ultimate outcome of the ESA consultations having regard to the Long-Term Coordinated Operations of the CVP and SWP are relevant to the Proposed Action.

In February 2005, the USFWS issued a Biological Opinion (BiOp) that analyzed the potential effects of the coordinated, long-term operation of the CVP and SWP, as part of Reclamation's revised CVP-OCAP action on delta smelt, and referred to as the Long-Term Coordination Operations of the CVP and SWP. As part of the litigation in the matter of *Natural Resources Defense Council et al., v. Dirk Kempthorne, San Luis & Delta Mendota Water Authority et al.,* (Case No. 05-CV-01207 OWW), the court held, on May 25, 2007, that the BiOp was "arbitrary and capricious" and "contrary to law". The court maintained that an appropriate interim remedy must be implemented. The court ordered that the USFWS issue a new BiOp by September 15, 2008 (and later postponed to December 15, 2008). The USFWS issued its final BiOp on December 15, 2008. After reviewing the current status of the delta smelt, the effects of the Proposed Action and the cumulative effects, it was the USFWS's biological opinion that the long-term coordinated operations of the CVP and SWP, as proposed, are likely to jeopardize the continued existence of the delta smelt.

On October 22, 2004, NOAA Fisheries issued its Opinion on the proposed long term CVP and SWP CVP-OCAP. Within that document was a consultation history that dated back to 1991, which is incorporated here by reference. On April 26 and May 19, 2006, Reclamation requested reinitiation of consultation on the CVP-OCAP based on new listings and designated critical habitats. In a June 19, 2006, letter to Reclamation, NOAA Fisheries stated that there was not enough information in Reclamation's request to initiate consultation. NOAA Fisheries provided a list of information required to fulfill the initiation package requirements [50 CFR 402.14(c)]. From May 2007, until May 29, 2008, NOAA Fisheries participated in the following interagency forums, along with representatives from Reclamation, DWR, USFWS, and CDFG, in order to provide technical assistance to Reclamation in its development of a Biological Assessment and initiation package.

- Biweekly interagency OCAP meetings;
- Biweekly five agencies management meetings;
- Weekly directors' meetings; and
- Several modeling meetings.

In addition, NOAA Fisheries provided written feedback on multiple occasions:

- Multiple e-mails from the USFWS (submitted on behalf of USFWS, NOAA Fisheries, and CDFG) providing specific comments on various chapters of the CVP-OCAP Biological Assessment, including the legal setting (Chapter 1.0, Introduction) and project description (Chapter 3.0, Alternatives Including the Proposed Action and Project Description);
- February 15, 2008, e-mails from NOAA Fisheries to Reclamation, transmitting comments on species accounts for the anadromous salmonid species and green sturgeon (Chapters 3.0-5.0, and 10.0);
- A February 21, 2008, letter providing comments with regard to the development of the CVP-OCAP Biological Assessment, and in particular, the draft project description; and
- An April 22, 2008, species list.

On May 19, 2008, NOAA Fisheries received Reclamation's May 16, 2008, request to initiate formal consultation on the CVP-OCAP. On May 30, 2008, Reclamation hand-delivered a revised Biological Assessment containing appendices and modeling results. On June 10, 2008, NOAA Fisheries issued a letter to Reclamation indicating that an initiation package was received, and that it would conduct a 30-day sufficiency review of the Biological Assessment received on May 30, 2008. On July 2, 2008, NOAA Fisheries issued a letter to Reclamation, indicating that the Biological Assessment was not sufficient to initiate formal consultation. In that letter, NOAA Fisheries described the additional information necessary to initiate consultation. In addition, on July 17, 2008, NOAA Fisheries offered additional comments on the CVP-OCAP Biological Assessment via e-mail.

Throughout July 2008, NOAA Fisheries continued to participate in the interagency forums listed above to continue to provide technical assistance to Reclamation on its development of a final Biological Assessment and complete initiation package. In addition, meetings were held between NOAA Fisheries and Reclamation staff on August 8, September 9, and September 19, 2008, to discuss and clarify outstanding concerns regarding the modeling, Essential Fish Habitat (EFH), and project description information contained in the draft Biological Assessment. On August 20 and September 3, 2008, NOAA Fisheries received additional versions of the draft Biological Assessment, hand delivered to the NOAA Fisheries Sacramento Area Office on DVD.

On October 1, 2008, the Sacramento Area Office received a hand-delivered letter from Reclamation, transmitting the following documents: (1) final Biological Assessment on a DVD, (2) Attachment 1: Comment Response Matrix, (3) Attachment 2: errata sheet; (4) Attachment 3: Additional modeling simulation information regarding Shasta Reservoir carryover storage and Sacramento River water temperature performance and exceedances; and (5) Attachment 4: American River Flow Management Standard 2006 Draft Technical Report. The letter and enclosures were provided in response to our July 2, 2008, letter to Reclamation, indicating that the Biological Assessment was not sufficient to initiate formal consultation.

In its October 1, 2008, letter, Reclamation also committed to providing, by mid-October 2008: responses to comments and initiating consultation related to Pacific Coast Salmon EFH within the

Central Valley, and (2) a request for conferencing and an analysis of effects of the continued long-term operation of the CVP and SWP on proposed critical habitat for green sturgeon. On October 20, 2008, Reclamation provided to NOAA Fisheries via e-mail the analysis of effects on the proposed critical habitat of Southern DPS of green sturgeon. In addition, on October 22, 2008, Reclamation provided to NOAA Fisheries via e-mail supplemental information regarding the EFH assessment on fall-run Chinook salmon. On November 21, 2008, NOAA Fisheries issued a letter to Reclamation, indicating that Reclamation had provided sufficient information to initiate formal consultation on the effects of the CVP-OCAP, with the understandings that: (1) Reclamation is committed to working with NOAA Fisheries staff to provide any additional information determined necessary to analyze the effects of the proposed action; and (2) NOAA Fisheries was required to issue a final Opinion on or before March 2, 2009.

On December 11, 2008, NOAA Fisheries released its Draft BiOp on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan in accordance with Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). The request for formal consultation was received on October 1, 2008. The final version of the Draft BiOp will supersede the 2004 CVP-OCAP BiOp. The Draft BiOp was based on (1) the initiation package provided by Reclamation, including the CVP-OCAP Biological Assessment, received by NOAA Fisheries on October 1, 2008; (2) the supplemental analysis of effects on the proposed critical habitat of Southern DPS of green sturgeon and supplemental information regarding the EFH assessment on fall-run Chinook salmon; (3) other supplemental information provided by Reclamation; (4) declarations submitted in court proceedings pursuant to Pacific Coast Federation of Fishermen Association (PCFFA) *et al*. v. Gutierrez *et al*.; and (5) scientific literature and reports.

The purpose of the Draft BiOp was to determine, based on the best scientific and commercial information available, whether the Central Valley Project and State Water Project Operations Criteria and Plan, as proposed by Reclamation, is likely to jeopardize the continued existence of the following species: Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*, hereafter referred to as winter-run); Central Valley spring-run Chinook salmon (*O. tshawytscha*, hereafter referred to as spring-run); Central Valley (CV) steelhead (*O. mykiss*); Central California Coast (CCC) steelhead (*O. mykiss*); Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*, hereafter referred to as Southern DPS of green sturgeon); and Southern Resident killer whales (*Orcinus orca*, hereafter referred to as Southern Residents) or, destroy or adversely modify the designated critical habitat of the above salmon and steelhead species, or proposed critical habitat for Southern DPS of green sturgeon.

NOAA Fisheries concluded that, as proposed, the long-term continued operation of the CVP and SWP is not likely adversely affect Central California Coast steelhead and their designated critical habitat. However, the long-term CVP and SWP OCAP is likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern DPS of North American green sturgeon. The long-term CVP and SWP OCAP is also likely to destroy or adversely modify critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, and proposed critical habitat for the Southern DPS of green sturgeon. The consultation on the effect of that proposed action on Southern Resident killer whales is ongoing. Therefore, no conclusion was reached for that species.

The final BiOp with the required Reasonable and Prudent Alternatives, Incidental Take Statements, and associated conservation recommendations were released on June 4, 2009.

Reclamation, while continuing to have concerns, has provisionally accepted the RPA contained in the Biological Opinion on the long-term coordinated operations of the CVP and SWP dated, June 4, 2009. Reclamation will immediately implement the near- term elements of the RPA by modifying the operations as required and continue with the planning and implementation associated with several major actions called for in the RPA, including construction of the Red Bluff Pumping Plant, replacement of the Whiskeytown Reservoir temperature curtain and fish passage improvements on Battle Creek. The provisional acceptance is conditioned on the need to further evaluate and develop many of the longer term actions. These actions are subject to future appropriations, and may be beyond Reclamation's authority, or require agreements from outside parties to implement, which are outside of Reclamation's control. Accordingly, Reclamation anticipates that re-initiation of Section 7 consultation may be needed as these actions are further developed.

Specifically, for the American River, the NOAA Fisheries Biological Opinion RPA identified a flow management standard for implementation. Reclamation is still evaluating this flow standard. The RPA also includes a requirement to develop a genetic management plan for Nimbus Fish Hatchery, a new target temperature objective of 65°F at Watt Avenue and a flow threshold of 4,000 cfs. Specific cold water pool temperature management facilities and actions have been identified in the RPA for study and implementation as well as the planning and implementation of fish passage facilities at both Nimbus and Folsom Dams. Reclamation is working to better understand, in detail, how all of the RPA requirements CVP wide, may affect the CVP and its operations.

Reclamation has been informally consulting with the USFWS and NOAA Fisheries on the Proposed Action. Staff of the USFWS and NOAA has been meeting independently with Reclamation and its project team to determine the scope of the consultation and develop an appropriate approach framework to address listed and proposed species as part of the Section 7 requirements under this statute. These consultations, however, have been delayed pending Reclamation’s ongoing consultations with USFWS and NOAA Fisheries on the CVP-OCAP. The Proposed Action, as defined in the CALSIM II modeling for the CVP-OCAP Biological Assessment was included and, therefore, represents an assumed part of the long-term CVP/SWP operation by Reclamation action. The two current CVP-OCAP BiOps have been prepared and issued inclusive of the P.L.101-514 new CVP water service contract proposed under this action.

Separate meetings have been held with USFWS staff that focused on the listed terrestrial species within the Subcontractor service areas proposed under this action. A Biological Assessment for these species has been prepared and is included in Appendix G of this Draft EIS/EIR.

10.6.3. Fish and Wildlife Coordination Act

Under the Fish and Wildlife Coordination Act (16 USC 661-666c), Reclamation is required to consult with USFWS and NOAA Fisheries before approving water projects that will affect surface water bodies supporting fish and wildlife species. As noted previously, Reclamation has been engaged in informal consultation with USFWS and NOAA Fisheries on this Proposed Action; the reports and recommendations of these agencies, if determined to be necessary, will be integrated into any document prepared.

While the USFWS did prepare a Coordination Act Report (CAR) for the Sacramento County Water Agency (SCWA) portion of the P.L.101-514 new CVP water service contract EIS/EIR, there is no intention of preparing a CAR for this Proposed Action.

10.6.4. Magnuson-Stevens Fishery Conservation and Management Act

This legislation requires consultation with NOAA Fisheries regarding actions that may adversely affect “essential fish habitat”, by way of a reduction in quantity or quality of habitat needed for spawning, breeding, feeding or maturation. Reclamation has been in informal consultation with NOAA Fisheries on this Proposed Action, and will continue consultations, in compliance with the Magnuson-Stevens Fishery Conservation and Management Act.

10.6.5. Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 makes it unlawful to “take” (i.e., kill, harm, or harass) any migratory bird listed in 50 CFR 10, including their nests, eggs, or products. Migratory birds include geese, ducks, shorebirds, raptors, songbirds, and many others. The Migratory Bird Executive Order of January 11, 2001, directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act, and defines the responsibilities of each federal agency taking actions that have, or are likely to make, a measurable affect on migratory bird populations. Reclamation has been in informal consultation with the USFWS on the terrestrial species potentially affected by the Proposed Action and have considered the Migratory Bird Treaty Act.

10.6.6. National Historic Preservation Act

“Cultural resources” is a term used to describe both archaeological sites depicting evidence of past human use of the landscape; and the built environment, which is represented in structures such as dams, roadways, and buildings. The National Historic Preservation Act (NHPA) of 1966 is the primary federal legislation which outlines the federal government’s responsibility for cultural resources. Section 106 of the NHPA requires the federal government to take into consideration the effects of an undertaking on cultural resources listed in or eligible for inclusion in the National Register of Historic Places (National Register); such resources are referred to as “historic properties.”

The Section 106 process is outlined in the federal regulations at 36 CFR Part 800. These regulations describe the process that the federal agency (Reclamation) takes to identify cultural resources and the level of effect that the proposed undertaking will have on historic properties. In summary, Reclamation must first determine if the action is the type of action that has the potential to affect historic properties. If the action is the type of action to affect historic properties, Reclamation must identify the area of potential effects (APE), determine if historic properties are present within that APE, determine the effect that the undertaking will have on historic properties, and consult with the State Historic Preservation Office, to seek concurrence on Reclamation’s findings. In addition, Reclamation is required through the Section 106 process to consult with Indian Tribes concerning the identification of sites of religious or cultural significance, and consult with individuals or groups who are entitled to be consulting parties or have requested to be consulting parties. Consultation correspondence is included in Appendix J in this Draft EIS/EIR.

A Class I survey of the area of potential effects was conducted in 2008. This survey consisted of a literature review and records search; no field reconnaissance was conducted for the action described in this EIS/EIR. This Class I survey does not qualify as full compliance with the NHPA, but serves to aid in the initial stages of identification of cultural resources. Relevant information from this document is summarized in Subchapter 4.9 (Water-Related Cultural Resources).

Project-level analyses of future facilities projects, not a part of this Proposed Action may, however, require additional SHPO coordination at the time they are undertaken, including Class III (on-ground examination) surveys to further investigate the potential for impact on cultural resources on a project level. Such project-level, facilities-oriented consultations are premature at this time and, accordingly, have not been initiated.

10.6.7. Archaeological Resources Protection Act

The Archaeological Resources Protection Act of 1979 defines archaeological resources; requires federal permits for excavation; provides for curation of materials, records, and other data; provides for confidentiality of archaeological site locations; and, in the 1988 amendment, requires the inventorying of public lands for archaeological resources. In addition, Section 110 of the NHPA specifies that archaeological resources must be taken into consideration before implementing any federal action. Reclamation, as part of its NHPA Section 106 consultation, has incorporated requirements under the Archaeological Resources Protection Act into its approval process.

10.6.8. American Indian Religious Freedom Act

The American Indian Religious Freedom Act of 1979 (PL 95-341) directs that Native American groups, who might use or have direct or indirect interest in the project be invited to participate in the planning process. Reclamation has coordinated with the Bureau of Indian Affairs and solicited input and comments from various rancherias and Native American groups as part of its consultation process under the NHPA.

10.6.9. Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act of 1990 (PL 101-601; 104 Stat. 3049) as amended, outlines the federal government’s responsibility for the treatment and ultimate disposition of human burials and grave-related materials. The Act requires consultation with certain Native American communities if circumstances regarding human remains, associated artifacts, or objects of cultural patrimony arise.

10.6.10. Indian Trust Assets and Native American Consultation

Reclamation is undertaking compliance procedures and documentation of the new P.L.101-514 CVP water service contract consistent with Section 106 of the NHPA. A Class I survey report has been prepared and will be used by Reclamation in its consultation with the State Office of Historical

Preservation (SOHP). Reclamation has solicited input and comment from Native American Heritage Commission (NAHC) and will review the federal action area for Indian Trust Assets.

10.6.11. Clean Water Act

As noted previously, the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Board (RWQCB), are responsible for ensuring implementation and compliance with the provisions of the federal Clean Water Act (CWA) and California's Porter-Cologne Water Quality Control Act. Along with the SWRCB and RWQCB, water quality protection is the responsibility of numerous water supply and wastewater management agencies, as well as city and county governments, and requires the coordinated efforts of these various entities.

A Section 401 CWA Water Quality Certification or waiver from the RWQCB is required before a Section 404 permit becomes valid. Associated with possible future facilities and infrastructure needs, the specific CWA requirements may apply at such time as these facilities/infrastructure projects are proposed.

10.6.12. Other Federal Statutes and Regulations of Relevance

Various laws, directives and orders have been promulgated over time, which collectively, serve to guide the operations of the CVP. These include:

- Rivers and Harbors Act (1935, 1937, 1940)
- Reclamation Project Act (1939)
- Flood Control Act (1944)
- CVP Water Service Contracts (1944)
- Water Rights Settlement Contracts (1950)
- Grasslands Development Act (1954)
- Trinity River Act (1955)
- Reclamation Project Act (1956, 1963)
- Auburn-Folsom South Unit Authorization Act (1965)
- Power Contract 2948A (1967)
- SWRCB Decision 1485 (1978)
- Energy and Water Development Appropriation Act (1980)
- Suisun Marsh Development Appropriation Act (1980)
- Corps of Engineers Flood Control Manuals for Shasta (1977), Folsom (1959) and New Melones (1980)
- Reclamation Reform Act (1982)
- Coordinated Operating Agreement (COA) (1986)

- The Proposed Action is consistent with each of these federal statutes. As noted earlier, potential future actions associated with implementation of the Proposed Action and delivery of the P.L. 101-514 contract water, such as facilities construction, may require additional federal permits or compliance at the project-level at the time they are undertaken.

10.7. Executive Orders

10.7.1. Executive Order 12898 (Environmental Justice)

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” directs federal agencies to assess whether their actions have disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. This is discussed in greater detail in Chapter 8.0 (Environmental Justice).

10.7.2. Executive Order 11988 (Floodplain Management)

Executive Order 11988 directs federal agencies to enhance floodplain values, to avoid development in floodplains whenever there is a practicable alternative, and to avoid to the extent possible adverse impacts associated with occupancy or modification of floodplains. The Proposed Action, as defined, does not involve any new development activities. In the future, if any of the potentially required facilities or infrastructure were to traverse floodplain areas under Reclamation ownership or easements, the provisions of this Executive Order would apply.

10.7.3. Executive Order 11990 (Protection Of Wetlands)

Executive Order 11990 directs federal agencies to enhance wetlands values, to avoid development in wetlands whenever there is a practicable alternative, and to avoid to the extent possible adverse impacts associated with occupancy or modification of wetlands. The Clean Water Act regulatory process requires compliance with Federal “no net loss of wetlands” policies, and includes a public and agency review process and a Clean Water Act Section 404 (b)(1) alternatives analysis that would in practice be likely to require avoidance of impacts on aquatic habitats or compensation for losses in extent and values. The Proposed Action, as defined, does not purport to alter any existing land areas. Existing wetlands, therefore, would not be affected by this action. Similar to Executive Order 11988, in the future, if any of the potentially required facilities or infrastructure were to affect wetland areas under Reclamation ownership or easements, the provisions of this Executive Order would apply.

10.7.4. Executive Order 11593 (Historic Properties)

Executive Order 11593 and Section 110 of the NHPA) provide direction for inventorying and evaluation of historic properties, and for initiating measures and procedures to provide for the maintenance, through preservation, rehabilitation, or restoration, of federally owned and registered sites at professional standards prescribed by the Secretary of the Interior. Reclamation, in its preparation of a Class I Survey has fully complied with this Executive Order.

10.8. STATE LAWS

10.8.1. California Environmental Quality Act

Under the California Environmental Quality Act (CEQA), El Dorado County Water Agency is the Lead Agency preparing the EIR; it is a joint EIS/EIR. EDCWA intends this joint EIS/EIR to be consistent with CEQA Guidelines. When this Draft EIS/EIR is completed, EDCWA will provide public notice in accordance with Section 15087 of the CEQA Guidelines. Upon certifying the Final EIS/EIR, EDCWA will adopt a reporting or monitoring program for the implementation of mitigation measures which were adopted, as necessary, and to record any changes to the project that it is considering. The program will be designed to ensure compliance during project implementation. The public record for the Final EIS/EIR will be completed by the filing of a Notice of Determination (NOD) and appropriate disposition of the Final EIS/EIR (CEQA Guidelines, Sections 15094-15095.)

10.8.2. California Endangered Species Act

The California Department of Fish and Game (CDFG) is responsible for implementation of the California Endangered Species Act (CESA). The Lead Agencies have been in informal consultation with CDFG, to keep it appraised of the project and environmental document progress. Upon review of the environmental documentation, CDFG will issue a written Finding of its determination of whether the Proposed Action poses a threat to survival of any species that CDFG lists as endangered, through adverse modification or destruction of the specie's essential habitat. Also included in the CDFG finding will be a determination of whether the Proposed Action will result in take of any of threatened or endangered species (as listed by CDFG).

The CDFG findings will also be given to the SWRCB for review with the petition for a change in place of use for El Dorado County's Middle Fork Project water, an action to be taken by PCWA before the Proposed Action can be fully implemented on behalf of GDPUD.

10.8.3. Porter-Cologne Water Quality Control Act

In 1969, the California Legislature enacted the Porter-Cologne Water Quality Control Act (the Act) to preserve, enhance and restore the quality of the State's water resources. The Act established the State Water Resources Control Board and nine Regional Water Quality Control Boards as the principal State agencies with the responsibility for controlling water quality in California. Under the Act, water quality policy is established using Water Quality Control Plans (also known as Basin Plans); using standards described in these plans, water quality standards are enforced for both surface and ground water and the discharges of pollutants from point and non-point sources are regulated. Under State law, the permit is officially called waste discharge requirement. Under federal law, the permit is officially called a NPDES permit. In the future, where new facilities or infrastructure are necessary to take, convey, treat or distribute the new water made available under this Proposed Action, close review of the requirements under this Act will be forthcoming. Any facilities requiring a waste discharge requirement will be acquired by the project proponent.

10.8.4. Section 1602 of the Fish and Game Code

CDFG regulates work that will substantially affect resources associated with rivers, streams, and lakes in California, pursuant to Fish and Game Code Sections 1600–1607. Any action from a public project that substantially diverts or obstructs the natural flow or changes the bed, channel, or bank of any river, stream, or lake or uses material from a streambed must be previously authorized by CDFG in a Lake or Streambed Alteration Agreement under Section 1602 of the Fish and Game Code. This requirement may, in some cases, apply to any work undertaken within the 100-year floodplain of a body of water or its tributaries, including intermittent streams and desert washes. As a general rule, however, it applies to any work done within the annual high-water mark of a wash, stream, or lake that contains or once contained fish and wildlife or that supports or once supported riparian vegetation.

Activities indirectly associated with this project that could require Section 1602 authorization and a Streambed Alteration Agreement include the eventual construction or alteration of diversion facilities, service-area related development that could have impacts on streams or drainages in El Dorado County, and potential conveyance improvements. These actions would result in the alteration of the flow within water bodies and occur within the annual high-water mark of water bodies that contain wildlife and support riparian vegetation. Prior to any activities that could affect rivers, streams or lakes, applications will submitted to CDFG for authorization of activities under a new Streambed Alteration Agreement (California Fish and Game Code 1600 et seq.). In the future, where certain facilities or infrastructure are proposed that intend to cross a stream or waterbody, the project proponent at the time, will facilitate discussions with CDFG to acquire the necessary approvals under this Section of the Fish & Game Code.

10.8.5. Natural Community Conservation Planning Act

In 1991, the State's Natural Community Conservation Planning Act (NCCPA) was passed. The NCCPA is broader in its orientation and objectives than the California and Federal Endangered Species Acts, and is designed to identify and protect individual species that have already declined in number significantly. The primary objective of the NCCP program is to conserve natural communities at the ecosystem scale while accommodating compatible land use. The program seeks to anticipate and prevent the controversies and gridlock caused by species' listings by focusing on the long-term stability of wildlife and plant communities and including key interests in the process.

An NCCP identifies and provides for the regional or area-wide protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. El Dorado County is currently in the process of developing an HCP/NCCP document, the Integrated Natural Resources Implementation Plan (INRMP) which has, and continues to include wide-ranging interagency support including Reclamation, Bureau of Land Management, and the USFWS.

10.8.6. Government Code Section 65040.12(e), Environmental Justice

State law defines environmental justice in Government Code Section 65040.12(e) as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation and enforcement of environmental laws, regulations and policies. Government Code Section 65040.12(a) designates the Governor’s Office of Planning and Research (OPR) as the coordinating agency in State government for environmental justice programs, and requires OPR to develop guidelines for incorporating environmental justice into general plans. There is currently no State requirement that environmental justice be addressed as a part of the CEQA review process for individual projects; however, this statute may be applicable to future facility-construction projects that could occur during the implementation of the Proposed Action.

10.8.7. Williamson Act (California Land Conservation Act)

The California Legislature passed the Williamson Act in 1965 to preserve agricultural and open space lands by discouraging premature and unnecessary conversion to urban uses. The Act creates an arrangement whereby private landowners contract with counties and cities to voluntarily restrict land to agricultural and open-space uses. The vehicle for these agreements is a rolling term 10 year contract (i.e. unless either party files a "notice of non-renewal" the contract is automatically renewed annually for an additional year). In return, restricted parcels are assessed for property tax purposes at a rate consistent with their actual use, rather than potential market value. Currently, nearly 16.9 million of the State's 29 million acres of farm and ranch land are protected under the Williamson Act. Williamson Act provisions are embodied in the land use zoning, allocation and development process. They are not part of the approval process for new CVP water service contracts. However, in the future, where new facilities and/or infrastructure are planned that may affect certain land uses and land areas, the provisions contained in the Williamson Act would be part of those environmental review and approval processes.

10.9. Notification and Distribution

During the preparation of this EIS/EIR and, specifically, regarding the public noticing that has occurred, an extensive list of contacts including; public trust resource agencies, non-governmental organizations, local and regional politicos, environmental groups, and other special interest associations and individual stakeholders were notified.

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11.0 EIS/EIR AUTHORS AND PERSONS/AGENCIES CONTACTED

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El Dorado Business Community

California Department of Boating and Waterways

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13.0 LIST OF ABBREVIATIONS

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13.0 LIST OF ABBREVIATIONS

AF	acre-feet
AFA	acre-feet per annum
AFRP	Anadromous Fish Restoration Program
Ag	Agricultural
ANN	Artificial Neural Network
AOGMCs	atmosphere-ocean general circulation models
APCD	Air Pollution Control District
APE	Area of Potential Effect
AQMD	Air quality Management District
ARFCP	American River Flood Control Project
AROG	American River Operations Group
ASR	Aquifer Storage and Recovery
BDCP	Bay Delta Conservation Plan
BGEPA	Bald and Golden Eagle Protection Act
BiOp	Biological Opinion
BMP	Best Management Practice
CABY	Cosumnes, American, Bear, and Yuba rivers
CALSIM II	California Simulation II Model
Caltrans	California Department of Transportation
CALVIN	California Value Integrated Network
CAR	Coordination Act Report
CARB	California Air Resources Board
CAT	Climate Action Team
CCAO	Central California Area Office
CCC	Central California Coast
CCCC	California Climate Change Center
CCSP	Climate Change Science Program
CDFG	California Department of Fish & Game
CDPR	California Department of Parks & Recreation
CEC	California Energy Commission
CEQ	Council on Environmental Quality

CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFC	Chlorofluorocarbon
cfs	cubic feet per second
CGS	California Geological Survey
CIP	Capital Improvement Program
CNPS	California Native Plant Society
COA	Coordinated Operations Agreement
CPMM	Coldwater Pool Management Model
CPUC	California Public Utilities Commission
CRF	Code of Federal Regulations
CRHP	California Register of Historic Places
CRLF	California red-legged frog
CUWCC	California Urban Water Conservation Council
CV	Central Valley
CVP	Central Valley Project
CVP CPOU	CVP Consolidated Place of Use
CVPIA	Central Valley Project Improvement Act
CVP-OCAP	Central Valley Project Operations Criteria and Plan
CWA	Clean Water Act
DMC	Delta Mendota Canal
DMMs	Demand Management Measures
DOC	Dissolved Organic Carbon
DOE	Department of Energy
DPS	distinct population segments
DSA	Drainage Service Areas
DWR	California Department of Water Resources
E/I	export-to-inflow
EA	Environmental Assessment
EBMs	energy balance models
EC	Electrical Conductivity
EDCTA	El Dorado County Transit Authority
EDCWA	El Dorado County Water Agency
EDWAPA	El Dorado Water & Power Authority
EFH	Essential Fish Habitat

EID	El Dorado Irrigation District
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ENSO	El Nino-Southern Oscillation
EPA	Environmental Protection Agency
EPS	Economic & Planning Systems
ERP	Ecological Restoration Program
ERPP	Ecosystem Restoration Program Plan
ESA	Endangered Species Act
ET	Evapotranspiration
EWA	Environmental Water Account
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FIRMs	Flood Insurance Rate Maps
FMS	Flow Management Standard
FMS	Flow Management Standard
GCM	Global (or General) circulation model
GCMs	Global Climate Models
GDPUD	Georgetown Divide Public Utility District
GHG	Greenhouse gases
GIS	Graphic Information System
GPCD	gallons-per-capita-per-day
GWh	Gigawatt Hour
HCM	Highway Capacity Manual
INI	Impaired Nimbus Inflow Index
INRMP	Integrated Natural Resources Implementation Plan
IPCC	International Panel on Climate Change
km	kilometer
kW	kilowatts
LAFCO	Local Agency Formation Commission
LAR FMS	Lower American River Flow Management Standard
LAROPs	Lower American River Operations Groups
LCFS	Low Carbon Fuel Standard
M&I	Municipal & Industrial
MAF	million acre-feet

MCAB	Mountain Counties Air Basin
MES	mass emission strategy
MFP	Middle Fork Project
-MR	Mineral Resource
msl	mean sea level
MTP	Metropolitan Transportation Plan
MW	Megawatt
MWh	Megawatt Hour
NAHC	Native American Heritage Commission
NCCPA	Natural Community Conservation Planning Act
NDA	National Defense Authorization
NEMDC	Natomas East Main Drainage Canal
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMWC	Natomas Mutual Water Company
NOAA	National Oceanic and Atmospheric Administration
NOC	Notice of Completion
NOD	Notice of Determination
NOI	Notice of Intent
NOP	Notice of Preparation
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRDC	Natural Resources Defense Council
NRHP	National Register of Historic Places
OCAP	Operations Criteria and Plan
OEPC	Office of Environmental Policy and Compliance
OPR	Office of Planning and Research
PAH	Polynuclear aromatic hydrocarbon
PCFFA	Pacific coast Federation of Fishermen Association
PCWA	Placer County Water Agency
PDO	Pacific Decadal Oscillation
PEIS	Programmatic Environmental Impact Statement
PG&E	Pacific Gas and Electric Company
PIER	Public Interest Energy Research

POD	Pelagic Organism Decline
POTW	Publicly Owned Treatment Works
POU	Place of Use
PPD	Pollutant Policy Document
ppt	parts per thousand
PROSIM	Project Simulation Model
PSA	Purveyor Specific Agreement
PZEV	Partial and zero-emission vehicles
RCM	Regional circulation model
RCMs	radiative-convective models
RIF	Road Impact Fees
RM	River Mile
ROD	Record of Decision
ROG	Reactive Organic Gas
RPA	Reasonable and Prudent Alternative
RWQCB	Regional Water Quality Control Board
SACOG	Sacramento Area Council of Governments
SAFCA	Sacramento Area Flood Control Agency
SCWA	Sacramento County Water Agency
SDIP	South Delta Improvement Program
SEI	Stockholm Environmental Institute
SFAR	South Fork American River Project
SHPO	State Historic Preservation Officer
SJWD	San Juan Water District
SMUD	Sacramento Municipal Utility District
SOFAR	South Fork American River
SRA	State Recreation Area
SRAC	Shaded Riverine Aquatic Cover
SRFCP	Sacramento River Flood Control Project
SRI	Sacramento River Index
SRWRS	Sacramento River Water Reliability Study
SSWD	Sacramento Suburban Water District
SVM	Shared Vision Model
SWE	snow water equivalent
SWP	State Water Project

SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TAR	Third Assessment Report
TCD	Temperature Control Device
TDS	Total Dissolved Solids
THM	trihalomethanes
TIM	Traffic Impact Mitigation
TMDLs	total maximum daily loads
TOC	Total Organic Carbon
TRD	Trinity River Division
TSM	Transportation Systems Management
TUs	thermal units
UARM	Upper American River Model
UARP	Upper American River Project
UCCE	University of California cooperative Extension
UNEP	United Nations environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USFWS	U.S. Fish & Wildlife Service
UWMP	Urban Water Management Plan
VAMP	Vernalis Adaptive Management Plan
VIC	Variable Infiltration Capacity
WAPA	Western Area Power Administration
WBAs	water budget area boundaries
WMO	World Meteorological Organization
WNA	Water Needs Assessment
WOMT	Water Operations Management Team
WTP	Water Treatment Plant
WY	Water Year
X2	Two- part per thousand near bottom isohaline line
YCWA	Yuba County Water Agency

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