Appendix K

Climate Change

K.1 INTRODUCTION

During the last two decades "climate change" has received the continuing and increasing concern of the scientific community. Throughout the earth's geologic history, changes have occurred in the earth's climate as a result of normal, non-human related factors. Those factors (See Figure K-1) include extraterrestrial factors (solar input, the earth-sun relationship, and interstellar dust) as well as a range of naturally occurring phenomena on earth. All of the factors can and do influence the climate of the earth. Human activities have long played a part in climate change albeit that they have been had relatively slight impact when compared to the natural factors. However, through recent research, albeit controversial, it appears that human activities (anthropogenic sources of change) may have significant impacts on the earth's climates.
The actual effects of climate change predictions will not be known for years, possibly after it is too late to halt many of the temperature effects. However, credible estimates are being prepared by groups such as The Climate Change Center, with the support of the Governor, the Department of Water Resources, and other agencies, using hydrological and climate models. These predictions can help guide policy that supports research efforts into clean energy technologies for automobiles, electricity and other industries that currently rely on fossil-fuel technology. It also can help guide the County and the water purveyors in water resource planning and to identify possible future projects to ensure a safe and reliable supply.

Changes in the climate of the project area, whether caused by natural factors or anthropogenic factors, could indeed affect water management in El Dorado County and the surrounding areas of California. In addition, activities in the county could affect climate change. This chapter, therefore, is presented in two parts. Part I, sections K.2 through K.3, explores the possible effects OF changing global climatic conditions and periodic droughts on present and future El Dorado County water supplies. Part II, sections K.4 through K.8, presents a discussion of the possible effects of water- and land-use projects ON climate change.

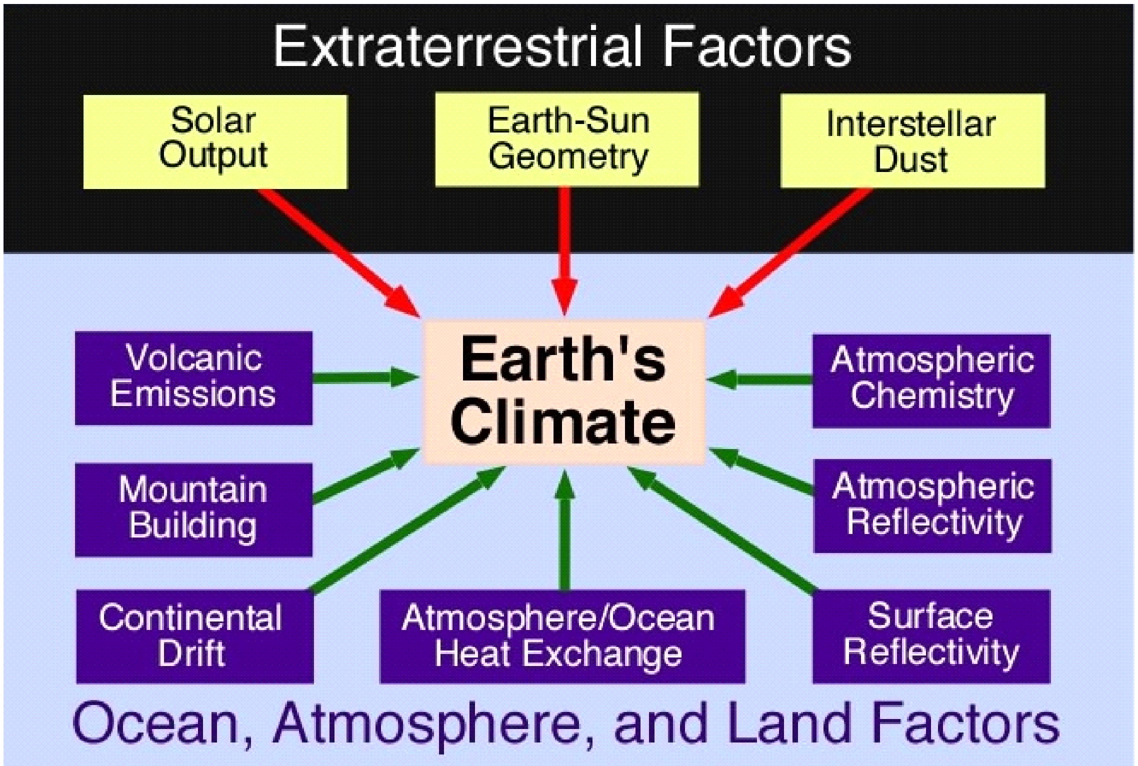


Figure K-1
Factors Affecting The Earth's Climate

Source: after Pidwirny, Michael, Ph.D.: *Fundamentals of Physical Geography,* Chapter 7, "Causes of Climate Change", University of British Columbia 2006.

PART I: EFFECTS OF CLIMATE CHANGE

K.2 CLIMATE CHANGE AND ITS EFFECT ON WATER RESOURCES

Climate change is affecting most of the world's resources. The effect that climate change or global warming has on temperature, sea levels, snow pack, agriculture, forests, and public health is a function of greenhouse gas emissions rates. As emissions rise, global temperatures rise. The effects are becoming more evident in rising sea levels, earlier snowmelt, and increasing atmospheric concentration of Ozone and CO_2, all of which indicate worldwide climate change.

Governor Arnold Schwarzenegger signed Executive Order S-03-05 on June 1, 2005, which acknowledged the adverse effects that global warming will have on many of the States resources. The Order recognized the threat to the State's water supply, acknowledging that increased temperatures due to climate change threaten to significantly reduce Sierra snowpack, one of the State's primary sources of water. The Order states that green house emissions, including carbon dioxide, methane, nitrous oxide and hydrofluorocarbons be lowered by 2010 to 2000 levels, by 2020 reduced to 1990 levels, and by 2050 be reduced to 80 percent below 1990 levels[45].

The Order called for the California Environmental Protection Agency (CalEPA) to prepare biennial science reports on the potential impact of continued global warming on certain sectors of the California economy. CalEPA entrusted California Energy Commission's Public Interest Energy Research (PIER) and its California Climate Change Center (CCC) to lead this effort. The 2006 biennal report entitled "*Our Changing Climate, Assessing the Risks to California*" is the product of a multi-institutional collaboration between the California Air Resources Board, California Department of Water Resources, California Energy Commission, CalEPA, and the Union of Concerned Scientists. This report summarizes the effects of three possible climate change scenarios, which are described below. The CCC report was used to describe and quantify the possible climate change effects on El Dorado County's water resources.

- The **lower emissions** scenario is characterized by a mid-century population peak followed by a population decline and high economic and technological growth that drives industry to develop and produce resource-efficient products. This scenario is associated with a marked shift towards clean technologies. By the year 2100, atmospheric CO_2 concentration doubles, relative to pre-industrial levels. Projected temperature rises associated with a lower emissions scenario is 3 to 5.5 degrees Fahrenheit.

- The **medium high emissions** scenario projects continuous population growth, combined with irregular technological and economic growth. By the year 2100, CO_2 triples, relative to pre-industrial levels. Projected temperature rises associated with a medium high emissions scenario is 5.5 to 8 degrees Fahrenheit.

- Finally, the **high emissions** scenario is characterized by economic growth fueled by fossil-fuel driven technologies, and a mid-century peak in population followed by a decline. Compared to pre-industrial levels, atmospheric CO_2 more than triples in concentration. Projected temperature rises associated with a lower emissions scenario is 8 to 10.5 degrees Fahrenheit.

In general, California's current water distribution system relies on heavy winter snowpack in the Sierra Nevada to supply streams, rivers, and reservoirs with fresh water during the dry season, typically summer and fall. Rising temperatures predicted in the report would result in more winter precipitation falls as rain instead of snow, less snow accumulation and earlier yearly snow melt. Under a high emissions scenario, the snowpack in the Sierra could be reduced as much as 70 to 90 percent.

The detrimental effect on water resources from rising temperatures in California would be immediately felt on the water purveyors in El Dorado County. For instance the County relies on heavy winter snowfall in the Sierras for much of their water supplies to replenish flows in the American and Cosumnes watersheds when the snow melts in the spring, providing fresh clean drinking water, as well as cold, freshwater fish habitat. Rising temperatures due to global warming, under any of the aforementioned scenarios, could be devastating to the County's economy, hydropower production, agriculture, and freshwater supply.

K.2.1 WINTER RECREATION

Several ski resorts operate in El Dorado County, stimulating the regional economy during wintertime. The emissions scenarios analyzed by the CCC present a grim picture of winter tourism in the Sierras if greenhouse gases are not curbed. A high emissions scenario predicts a 70 to 90 percent reduction in snowpack by the end of the century. Under this scenario, winter tourism season at all except the highest elevation resorts would be shortened by as much as a month. By the end of the century, many years may have insufficient snow accumulations to support winter recreation in the Sierras.

K.2.2 HYDROPOWER

Several hydropower plants operating within the County and depend on river and stream flows originating in the Sierra Nevada mountain range. For instance, SMUD operates Loon Lake, Robbs Peak, Jones Fork, Union Valley, Jaybird, and Camino powerhouses as part of the UARP on the South Fork American River and the Rubicon River. Similarly, EID operates El Dorado Powerhouse as part of Project 184 on the South Fork of the American River. These large-scale hydropower projects generate energy that is then sold to California power customers. The sale of this power has important economic benefits to for EID. Hydroelectric power is a renewable source of renewable energy that supplies approximately 15 percent of California's electricity.

The possible impact to electricity resources in California caused in part by rising global temperatures is two-fold. The demand for energy demand in California will significantly increase if temperatures rise. This is particularly true for residents of the central valley, where summer temperatures often break triple digits. At the same time, the higher temperatures would negatively impact the snowpack that feed the rivers, decreasing the potential for hydroelectric power generation by as much as 30 percent if temperatures rise between 5.5 to 8 ºF.

K.2.3 AGRICULTURE

Agriculture is an important part of El Dorado County economics, open space, and recreation. Apple Hill, a rural area in Camino known for its apple orchards and Christmas tree farms, is a popular fall tourism spot. There are also many vineyards and boutique wineries in the Sierra Foothill region that depend on available water and predictable day-night temperatures during the spring and summer growing season.

According to predictions from the Climate Change Center, wine grapes are expected to be particularly hard-hit by increasing temperatures, which can cause premature ripening of the grapes. This effect will be most noticeable by the end of the century when rising temperatures could cause grapes to ripen up to two months earlier, which will affect grape quality.

Fruit trees are likely to suffer from rising temperatures as well. The development of many fruit crops depend on a consistent number of heat accumulation (between 45 and 95º F) and chill hours (less than 45º F) for proper bud and fruit development. Chill hours are diminishing in the state, and temperatures increase in the 5.5 to 8º F range, chill hour requirements for some crops in the Central Valley could reach a critical threshold [44].

K.2.4 WATER SUPPLY

A reliable water supply cycle is critical to California’s current water system. Rising temperatures threaten to reduce Sierra snowpack by 25 percent by the year 2050 44 . The risk of flooding will increase as less water is stored as snowpack because more precipitation will fall as rain. This will necessitate the need for more storage reservoirs to serve as flood control and water storage. This need is recognized by policy makers in California. For instance, in a January 9, 2007 press release Governor Schwarzenegger proposed a $4.5 million Strategic Growth Plan to invest in storage and conveyance infrastructure in California, in response to current trends and climate research. The proposal provides up to three million acre-feet of additional surface storage, which would supply

500,000 acre-feet of annual water supply. Also part of the proposal is 500,000 acre-feet per year available from groundwater storage, and water conservation projects that would save 200,000 acre-feet per year [46].

K.3 DROUGHT & CLIMATE CHANGE CONSIDERATIONS (WESTERN SLOPE)

K.3.1 DROUGHT CYCLES

Dr. David Jones, professor emeritus, Department of Geology and Geophysics, University of California at Berkeley, working with the Citizens for Water group in El Dorado County has investigated hydrologic cycles affecting the American River during the past century and compared this historic record with information from past centuries derived from tree ring studies. This comparison shows that droughts in past centuries were more severe and of longer duration than any drought experienced during the last century. The historic data show a period of declining rainfall followed by 30 years of normal rainfall, with the remaining part of the century characterized by highly variable conditions. Tree ring data substantiate a similar cyclical pattern extending back to 1600, but with longer periods of drought. These data show that long-term drought is part of the normal climate pattern and suggest the need to plan for drought emergencies by providing additional storage for drought protection. A copy of Dr. Jones' paper is included in Appendix G.

K.3.2 THE SHARED VISION MODEL (SVM) ANALYSIS

The El Dorado County Western Slope Drought Analysis presents the key outcomes of the first phase of drought analysis effort including: a consensus-based, collaborative stakeholder process, the development of a Shared Vision Model (SVM), and input from a team of veteran experts. The second phase of the drought analysis will establish drought preparedness plans for each of the purveyors participating in this study. Phase 2 is expected to be completed by the end of 2006. Agencies involved with this drought planning analysis are the El Dorado County Water Agency (EDCWA), El Dorado Irrigation District (EID), Georgetown Divide Public Utility District (GDPUD), Grizzly Flats Community Services District (GFCSD) and the City of Placerville. These stakeholders participated in the analysis by serving as Drought Advisory Committee members.

The drought analysis incorporates water purveyor supply constraints, stakeholder needs and concerns, future water demands, and possible long-term climate change into a Shared Vision Model (SVM). The Microsoft© Excel based SVM was built with stakeholders as a framework for creating a dynamic, consensus-based view of each purveyor’s water system. The SVM uses drought simulation to translate the science of drought into practical solutions for water purveyors. The SVM computer drought simulator includes analysis of historical runoff hydrology, reservoir storage capacities under current operating rules, water demand projected through year 2030, and additional new water supply that could offset predicted water shortfalls.

The project's overall goal is to provide the tools necessary to complete individual preparedness plans and the response plans unique to each of the purveyors. The Shared Vision Model Conclusions Summary are based on the following assumptions:

- Purveyor historical record: GDPUD (1966-1980), GFCSD (1911-1987), EID (1922-2004)
- Design drought conditions refer to 1976, 1977, 1977 (repeated) hydrology
- Reliability refers to the volume of water supplied divided by volume demanded in the simulation period (historical or design drought). This value is weighted so that a month with a small shortfall does NOT count as much as a month with a large shortfall.
- Shortfall refers to the amount of water demand a purveyor cannot supply. Average shortfall is the average value of all months with shortfall; months with no shortfall are not included. For example, if two months out of 36 months have shortfalls and one month's shortfall is 10 acre feet, the other 20 acre feet, the average shortfall is 15 acre feet. (This note is important when it seems as though average shortfalls should decrease; they may not for instance when reliability increases due to fewer months of shortfalls being averaged)
- All the following scenarios assume purveyor contracts in place as of January 2005. These also incorporate each purveyor's drought plan including drought indicators and triggers (i.e. EID's Sly Park monthly volume matrix).
- Source: *El Dorado County Western Slope Drought Analysis - Phase I Report* and February 5, 2007 SVM. See these resources for further details.

K.3.3 CLIMATE CHANGE FACTORS

Projections of future climate change are represented by changes in seasonal river flow patterns. This assumes lessening amounts of water stored in snow pack, reductions in average annual precipitation amounts, and an increase in the extent and frequency of drought. In order to incorporate the potential for climate change, various climate scenario factors were applied to each purveyor's actual hydrological record as well as the design drought scenario, base 1976, 1977, 1977 (repeated) hydrology. These factors shown in Tables **K-1**, **K-2**, **K-3**, and **K-4** represent the relationship between actual hydrology and four types of shifts in projected hydrologic runoff conditions. These shifts are based on regionally derived scenarios developed by Dr. Jay Lund and his research analysis team at UC Davis. These are the same data sets used in the forecasting tools for the Department of Water Resources, Bulletin 160: California Water Plan and the California Energy Commission Climate Change Report (Vicuna, 2005). Dr. Lund's information for American River watershed inflows to Folsom Lake under four different scenarios was used to index the runoff hydrology and reflect the possible impact due to climate change. The four scenarios consist of (1) HCM 2050 Scenario, a warmer and wetter climate in year 2050, (2) PCM 2050 Scenario, a cooler and drier climate by year 2050, (3) HCM 2100 Scenario, a warmer and wetter climate by year 2100, and (4) PCM 2100 Scenario, a cooler and drier climate year 2100. PCM 2100 Scenario represents the potential "worst case" climate change scenario for drought. Additional information on how these climate change scenarios were created is provided in the Appendix E of the April 2006 *El Dorado County Western Slope Drought Analysis - Phase I Report*.

K.3.4 SVM Modeled Scenarios (as of January 31, 2007)

Current Conditions (Default Conditions)

This scenario consists of:

- 2004 demands;
- Contracts (*including current water shortage contingency policies*) in place as of January 2005;
- Operating rules for surface supplies as defined for 2005; and
- Historical hydrologic record conditions (no climate change).

Table K-1
Current Conditions (Default Conditions)

	Historical record		**Design drought**	
	Reliability	**Average Shortfall (AF/mo)**	**Reliability**	**Average Shortfall (AF/mo)**
GDPUD	100%	0	100%	0
GFCSD	98.12%	4	82.25%	9
EID	99.74%	113	100%	0

Future without Action

This scenario consists of:

- Projected 2030 demands;
- Contracts (*including water shortage contingency policies*) in place as of January 2005;
- Operating rules for surface supplies as defined for 2005; and
- Historical hydrologic record conditions (no climate change).

Table K-2
Future without Action

	Historical record		**Design drought**	
	Reliability	**Average Shortfall (AF/mo)**	**Reliability**	**Average Shortfall (AF/mo)**
GDPUD	80%	1,970	64%	1,258
GFCSD	90.72%	14	80.55%	11
EID	95.01%	791	80%	2,368

Future With Action

This scenario consists of:

- Projected 2030 demands;
- Contracts (including water shortage contingency policies) in place as of January 2005;
- Operating rules for surface supplies as defined for 2005;
- Historical hydrologic record conditions (no climate change); and
- Modeled water efficiency projects planned to reduce water demands. Water efficiency projects refer to water conservation and water loss reduction measures for EID; using their existing well for GFCSD; and water conservation for GDPUD.

Table K-3
Future with Action

	Historical record		Design drought	
	Reliability	Average Shortfall (AF/mo)	Reliability	Average Shortfall (AF/mo)
GDPUD	81%	1,858	67%	1,266
GFCSD	91.53%	14	80.55%	11
EID	95.82%	756	83%	2,032

Future with Action and Climate Change

This scenario consists of:

- Projected 2030 demands;
- Contracts (including water shortage contingency policies) currently in place as of January 2005;
- Operating rules for surface supplies as defined for 2005;
- Modeled water efficiency projects planned to reduce water demands. Water efficiency projects refer to water conservation and water loss reduction measures for EID; using their existing well for GFCSD; and water conservation for GDPUD; and
- Worst case cooler and drier "Climate Scenario - PCM 2100" hydrologic conditions enacted.

Table K-4
Future with Action and Climate Change

	Historical record		Design drought	
	Reliability	Average Shortfall (AF/mo)	Reliability	Average Shortfall (AF/mo)
GDPUD	66%	1,928	58%	987*
GFCSD	86.14%	14	68.63%	10*
EID	95%	742*	78%	2,355

* Average shortfall values decrease with climate change due to a longer more moderate drought duration (additional months with more moderate shortfall amounts are being averaged). For example for GDPUD's future with action scenario under design drought conditions, the average drought duration was 6.5 months. The average duration extended to 9.5 months with the cooler and drier PCM 2100 climate change conditions.

By 2030 under the cooler and drier PCM2100 climate scenario water supplies will be reduced by 11% for EID, 19% for GFCSD, and 28% for GDPUD.

K.3.5 SUMMARY OF THE EFFECTS OF CLIMATE CHANGE

Independent of climate change, the SVM derived tables presented previously demonstrate that demand cutbacks (as adopted in each purveyors water shortage contingency plans) and conservation efforts alone will not decrease drought shortfall magnitudes. A few examples of the effects of enacted drought mitigation measures under projected 2030 demands are summarized below.

- EID can ALMOST completely mitigate projected 2030 shortfalls under design drought conditions and historical hydrological flow patterns with Scenario C action summarized above and (1) PL101-514 and the White Rock Diversion Project (92% reliability in a design drought), or (2) PL101-514, groundwater banking and Alder Creek Reservoir (94% reliability in the design drought).

- GDPUD can expect shortfalls about 5% of the time, with a drought being called and policies enacted almost 50% of time under Scenario C actions and Rubicon River 1B UARP PL101-514 enacted in design drought conditions.

- GFCSD can ALMOST completely mitigate design drought conditions (97.8% reliability) with the use of a 350 AF off-stream storage reservoir that is half full at the beginning of the drought. Under historical record-based conditions and the use of an off-stream reservoir the system reliability is 99.7%.

PART II: PROJECT EFFECTS ON CLIMATE CHANGE

K.4 INTRODUCTION AND BACKGROUND

Much has been written about the effects of climate change on the environment, particularly on the potential effect of climate change on water resources and their management. The previous section provides detailed information on the potential effects of climate change on the hydrology of the American River and the management of the resources of the river. Despite that plethora of information on the potential effects OF climate change on water resources, much less has been written to date on the effects of water- and land-use projects ON climate change. The purpose of this section, therefore, is to introduce and address some of the potential effects of supplying water for future land use on climate change. Some of the effects will exacerbate the potential problems which might be caused by climate change; some may actually reduce the effects of climate change.

Water projects, per se, have limited potential for direct impacts on climate change. The direct effects that they might have could come from:

- removal of vegetation which could reduce the sequestration[1] of carbon dioxide (CO_2);
- disturbance of soil which could release CO_2 or methane (CH_4) into the atmosphere;
- construction of dams and appurtenant structures which might change the albedo in a given area; or
- creation of impoundments which might in fact enhance the sequestration of CO_2 in the stored water. These activities could cause the release of greenhouse gases (GHG) or they could enhance the storage of those gases.

Water projects that would result in potential land use changes could result in indirect impacts on climate change. The following discussion is certainly not the "end-all/be-all" related to the subject. On the contrary; it is intended to serve as an introduction and initial assessment of an issue, a set of issues, for which appropriate standards of practice will evolve as others expand and develop appropriate research and specific recommendations. Just as NEPA and CEQA practices have evolved over time, so will the assessment of the potential effects of water- and land-use on climate change evolve.

The discussion is divided into five additional sections:

The Carbon Cycle (K.5),
Greenhouse Gas Generation (K.6),
Potential Regional Carbon Sinks (K.7),
Other Potential Mitigation Measures (K.8), and
Conclusions (K.9).

K.5. THE CARBON CYCLE

For an adequate base of understanding the potential effects of projects on climate change, it is necessary to examine the carbon cycle. K. Kimball[2] writes that:

[1] *Sequestration*: the process of increasing the carbon content of a carbon pool (e.g. living vegetation) other than the atmosphere.
[2] Kimball, J: The Carbon Cycle (undated), http://users.rcn.com/jkimball.ma.ultranet/Biology Press/C/CarbonCycle.html.

Carbon returns to the atmosphere and water by:

- *Respiration (as CO_2),*
- *Burning,* (and)
- *Decay (producing CO_2 if oxygen is present, methane (CH_4) if it is not).*

The concentration of carbon in living matter (18%) is almost 100 times greater that its concentration in earth (0.19%)." So living things extract carbon from their nonliving environment. For life to continue, this carbon must be recycled.

Carbon exists in the nonliving environment as:

- *Carbon dioxide (CO_2) in the atmosphere and dissolved in water (forming HCO_3),*
- *Carbonic rocks (limestone and coral = $CaCO_3$),*
- *Deposits in coal, petroleum, and natural gas derived from once-living things, and*
- *Dead organic matter, e.g., humus in the soil.*

Carbon enters the biotic world through the action of autotrophs[3]:

- *Primarily photoautotrophs, like plants and algae, that use the energy of light to convert carbon dioxide to organic matter, and*
- *To a small extent, chemoautotrophs – bacteria and archaea[4]that do the same but use the energy derived from an oxidation of molecules in their substrate.*

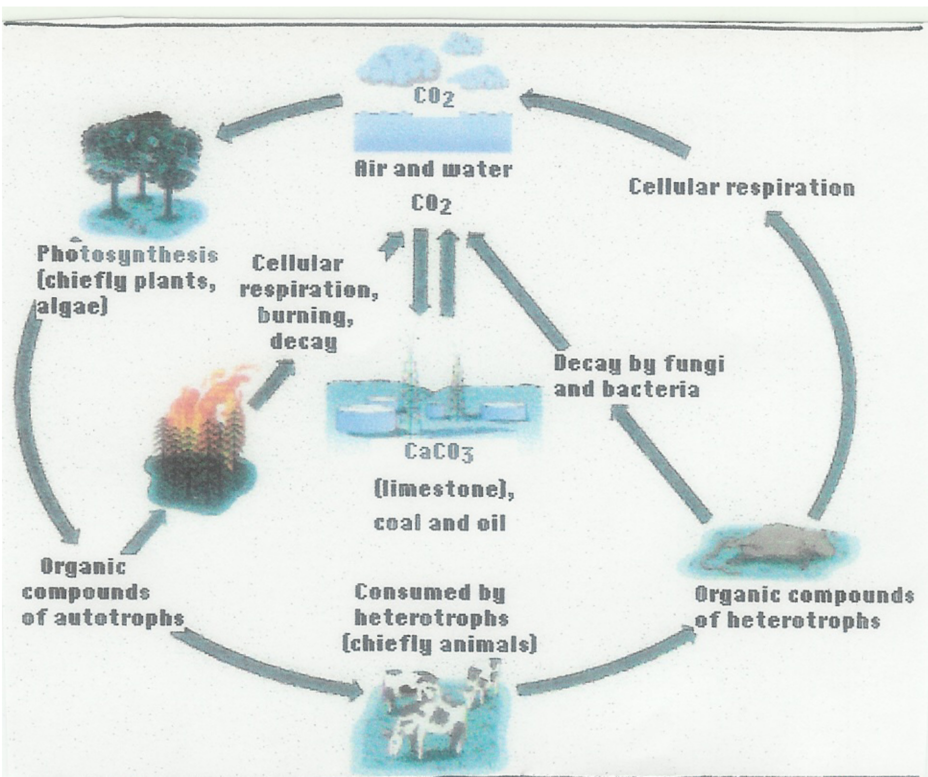
From this discussion, as in Figure K-2, it can be seen that there are a great number of stages in the cycle where water- and land-uses could potentially affect the carbon cycle. As affects on the cycle, those uses could contribute to the creation of greenhouse gases that are currently recognized as the primary contributors to climate change. Let us now look at some of the land uses which could cause the generation of greenhouse gases.

[3] *Autotophs:* Webster's New College Dictionary, Fourth edition, provides the following definition: "Autotrophic: making its own food by photosynthesis, as a green plant does, or by chemosynthesis, as any of certain bacteria do."

[4] *Archaea:* Webster's, op cit: "… any of a large group of primitive bacteria having unusual cell walls, membrane lipids, ribosomes, and RNA sequences, and having the ability to produce methane and to live in anaerobic extremely hot, salty, or acidic conditions."

K.6. GREENHOUSE GAS GENERATION

In essence, greenhouse gases (GHGs) are those gaseous components of the atmosphere that block the re-radiation of incoming solar radiation (insolation) causing the atmosphere to heat. This heating is the principal contributor to what may be causing climate change. The greenhouse gases are water vapor, carbon dioxide, methane, and ozone, all of which occur naturally in the atmosphere. Two questions which are particularly pertinent to this discussion are: "Which of these naturally occurring gases can be affected by the activities of humans (*anthropogenic* greenhouse gases)? [and] What else might contribute to the greenhouse gas effect?"



Source: J. Kimball:
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/C/CarbonCycle.html

Figure K.2

The Carbon Cycle

K.6.1 WHICH OF THESE NATURALLY OCCURRING GASES CAN BE AFFECTED BY THE ACTIVITIES OF HUMANS (ANTHROPOGENIC GREENHOUSE GASES)?

The most dramatic – and clearly the largest – contributor to GHG is the burning of fossil fuels. Of those, emissions from vehicles are currently the greatest contributor of CO_2 in El Dorado County and the adjacent areas. The Draft Environmental Impact Report (DEIR)/ Draft Environmental Impact Statement (DEIS) for the Rio Del Oro Specific Plan (Rancho Cordova area) notes (p.3-15-9) that "Transportation is responsible for 41 percent of the state's GHG emissions, followed by electricity generation. Emissions of CO_2 and NO_x are byproducts of fossil fuel combustion[5]. Methane, a highly potent GHG results from off-gassing associated with agricultural practices and landfills." Additionally, chlorofluorocarbons (CFCs)[6] are of concern.

All of these sources can be found in El Dorado County. Land use plans that result in increases in these gases should be evaluated carefully to determine their potential effects on climate change. But there are other potential sources which should also be examined. Each should be examined carefully, because what may seem to be an adverse affect might well be a beneficial effect.

As illustrated in the Rio Del Oro document:

> *Because GHG are global, a project that shifts the location of where someone lives or works, by itself, may or may not contribute a new GHG. For example, someone may move from Southern California (and from the South Coast Air Quality Management District) to the project site, and while this would likely increase emissions within the Sacramento Metropolitan Air Quality Management District, it is not conclusive that this would result in generation of more GHG globally. In fact, if a person moves from one location, where they have long commutes and a land use pattern that requires substantial energy use, to a project that promotes shorter and fewer vehicle trips, more walking and less energy use, it could be argued that the new project would result in a potential reduction in generation of global GHG.* (p. 3.15-19)

Regarding the potential impact of transportation on GHG, the previous section referenced the recently passed AB 32 that which provides for controlling GHG emissions from stationary sources.

5 NO_X = a mixture of nitrogen monoxide and nitrogen dioxide.

6 Chlorofluorocarbons are chemical compounds developed in the 1930s as safe, non-toxic, non-flammable alternatives for use in refrigerants and sprays.

However, it only pertains to stationary emission sources. As just noted, transportation emissions account for the greatest single source of GHGs. In the Rio Del Oro Specific Plan DEIR/DEIS a means is suggested to estimate per capita emissions which could also be applied to projects proposed for El Dorado County. It reads:

> *A possible metric that could be used to determine if this project* (the project for which the DEIR/DEIS was prepared) *would contribute to global GHG would be to determine if, on a per capita basis, this project would generate more GHG than a benchmark level based on a policy, in this case AB 32. Although AB 32 would only directly apply to stationary sources of emissions, mobile- and area-source emissions generated by a project can be addressed on a per capita basis, in order to be consistent with statewide goals to reduce global warming impacts. A project would increase GHG above the 1990 goal it would result in generation of more than 2 tons of* CO_2 *per capita annually. This figure is the calculated per-capita CO2 emissions level generated in California in 1990, discounted because the state's population has grown considerably since 1990 and is projected to continue to grow. …* (p.3-15-19)

The basis for this specific number is further explained in the DEIR/DEIS:

> *GHG emissions associated with the project were estimated using* CO_2 *emissions as a proxy for all GHG emissions. This is consistent with the current reporting protocol of the California Climate Action Registry.* CO_2 *emissions associated with vehicle miles traveled* (VMT) *are the best indicator of GHGs associated with a land development project. However, it is important to note that other GHGs have a higher Global Warming Potential (GWP) that* CO_2*. For example, 1 pound of methane has an equivalent GWP of 21 pounds of* CO_2*. In other words, as a GHG, methane is 21 times as efficient as* CO_2*. Nonetheless, emissions of other GHGs would be low relative to* CO_2*, and would be roughly proportional to VMT as well. Annual VMT/person for the year 1990 was estimated based on 1989 census data, and this rate corresponds to an annual rate of 8,703 VMT/person. Based on a fleetwide emission factor for the year 1990, this would result in a statewide annual emission rate of approximately 3.5 tons* CO_2*/person associated*

with vehicle miles traveled. In addition, population growth must also be considered, in order to obtain the 1990 emissions target. The population of the state is forecast to grow to 43,851,741 people by the year 2020. In order to achieve the mass of emissions that occurred in 1990, the emission rate per capita must be further reduced to compensate for the increased VMT associated with the increased population growth. Thus, the annual rate must be reduced by approximately 33% below the 1990 rate, to approximately 2 Tons CO_2/person, in order to achieve the 1990 baseline promulgated by AB 32. [p. 3.15-20]

[Editors note: specific references provided in the Rio Del Oro DEIR/DEIS are omitted here. It should also be noted that there is some question about the suitability of this metric. It has been suggested that an alternative standard of significance might be simply a "substantial increase". Considerable research is on-going at the present time to develop a metric that would be suitable to meet the needs of the California Environmental Quality Act (CEQA).]

Some of the other potential sources of GHG are listed below. Each should be carefully considered in the assessment of the potential effects of a land use project on climate change because each releases sequestered CO_2 or creates Methane (CH_4) or in some cases, both. They are:

Soils and sub-surface vegetation related:

Exposing below ground biomass,

Soil clearing, or

Tilling.

Surface vegetation related:

Above ground decaying biomass,

Litter and woody debris,

Harvest residues,

Fungi & bacterial decay,

Methane from plant decay,

Insect pests (which could decrease a forest's sequestration capacity), and

Forest- and grass-burning;

Industrial/Commercial related:

Energy generation (from fossil fuel burning facilities),

Cement production,

Chlorofluorocarbon (CFCs release from):

Refrigerators,

Solvents,

Propellants, and

Plastic foam manufacturing;

Heating and cooling of office buildings,

Mining (particularly surface mining and soil washing), and

Vehicle maintenance facilities; [and]

Other Activities:

Stationary construction equipment operation,

Residential heating,

Cattle raising (particularly feed lots),

Growing paddy rice, and

Stationary construction equipment.

This list is certainly not all-inclusive; there are undoubtedly other activities which could affect the production of GHGs. The list is intended as an indication of the range of land- use activities that could have direct impact on climate change. As such, they illustrate the need to analyze proposed projects to evaluate their potential to create or release GHGs and the attendant impact on climate change.

K.6.2 WHAT ELSE MIGHT CONTRIBUTE TO THE GREENHOUSE GAS EFFECT?

While the previous list of potential contributors is long, it does not include all of the land use related factors which could impact on climate change. Some of them are:

Increases in the size and mass of urban areas: which could increase the heat- island effect[7] of urban areas;

[7] The *heat-island effect* is the increase of the heat of the atmosphere over urban areas as compared to adjacent rural or natural environments. Again, considerable research is going in to the assessment of the magnitude of this factor.

Changes in albedo: changes in the reflective surfaces of the built environment could add to the heat-island affect in urban areas;

Release of aerosols: which could reflect sunlight into space;

Release dust and other particulates: which could potentially decrease the amount of re-radiation of incoming solar energy thereby increase the heating of the atmosphere; or

Release of Nitrous Oxide (N_2O) and other gases: which could also decrease the re-radiation of incoming solar energy.

As for the previous question, this list is not all-inclusive. It too is intended to illustrate some of the ways in which land uses could contribute to the generation GHG or other activities that could have affects on climate change. But what are some of the activities that could mitigate these effects?

K.6.3 ACTIVITIES TO REDUCE POTENTIAL IMPACTS

This section presents discussions of several ways that can reduce carbon and thereby reduce the potential impacts on climate change.

K.7 POTENTIAL REGIONAL CARBON SINKS

Human activities, specifically, land use activities, do not all create adverse impacts on climate. Some of the activities which could increase the sequestration of carbon and thereby decrease the effects of climate change include:

Forests: living storage of carbon (albeit that carbon is stored in daylight hours and lost at night when the process of photosynthesis stops and carbon is respirated back into the atmosphere as CO_2 but the net of the full day is an increase in the naturally stored carbon). This is particularly true in polyculture forests where there is a natural mix of growth at different levels as opposed to monoculture forests (e.g.: tree farms) which are managed to produce a single species of vegetation;

Wood products: sequestration of carbon in wood products (yes, even in one's home in the wood used for building as well as the furniture and art objects);

Urban planting and gardens: as with natural or tree-farmed forests, urban planting can increase the regional sequestration of carbon;

Algae production: natural or human-caused eutrophication of water bodies stores carbon (albeit often at the expense of stored oxygen necessary for successful fish life); and

Water bodies: the natural capacity of water to store carbon.

Again, this list is not all-inclusive. It simply provides an indication of the types of land uses and attendant human activities that could mitigate the affects of water- and land-use projects on climate change.

K.8 SOME OTHER POTENTIAL MITIGATION MEASURES

One measure that is receiving careful world-wide consideration is "Carbon Credits" or carbon banking. *Wikipedia* describes carbon credits as follows:

> ***Carbon credits*** *are certificates awarded to countries that are successful in reducing the emissions that cause global warming. For trading purposes, one credit is considered equivalent to one ton of carbon dioxide emission reduced. Such a credit can be sold in the international market at a prevailing market rate. The trading can take place in open market. Developed countries that have exceeded the levels can either cut down (their) emissions, or borrow or buy credits from developing countries. However there are two exchanges for carbon credit viz Chicago Climate Exchange and the European Climate Exchange.*

Just as wetlands mitigation banking has become a potential mitigation tool, so may carbon banking become a future mitigation tool. The basic requirement is that a forest planted and managed on land that has been previously disturbed or a change from one type of vegetative cover (e.g.: grassland) to a suite of vegetation, including a mix of shrubs and trees, could become a viable "carbon bank". Needless to say, much needs to be done before this concept could become a viable local or regional mitigation measure.

Some additional measures that might reduce the effects of land use on GHG production and climate change are:

> *Aforestation*: converting grasslands to trees (which often has the added benefit of reducing dust caused by erosion);
>
> *Conservation tillage*: tilling of land that minimizes the exposure of the natural soil to reduce the release of sequestered carbon;
>
> *Fuelwood forests*: growing of forest materials to be used for fire-wood to reduce the dependency on other forests for heating;
>
> *Restriction on fire places*: while not always a popular measure, elimination of in-home fireplaces could reduce the release of carbon dioxide;
>
> *Wooded parks*: creation or retention of naturally vegetated parklands in urban or rural areas;
>
> *Restoration of disturbed lands*: revegetation after mining activities or other uses which have stripped the natural vegetation form an area could enhance the sequestration of carbon; and

Expanded development and use of non-fossil fuel alternative forms of energy: solar, wind, tidal, and geothermal.

Yet again, these are not the entire list of what might be done to mitigate the potential impacts of water- and land-use on the production of GHG and the attendant climate change. They, too, are illustrations.

K.9 CONCLUSIONS REGARDING IMPACTS ON CLIMATE CHANGE

From the preceding information, it would appear that:

Water projects of themselves may have some direct impacts on climate change: they could be both adverse and beneficial;

Water projects could have indirect impacts on climate change: by enabling changes in uses of the land that in themselves have the potential to impact the production of GHGs could impact climate change;

Many types of land-uses can affect climate change: the list of human activities that could affect climate change is not limited to transportation alone;

Land use activities don't necessarily all have adverse effects on climate change: as noted, a project which might itself have adverse consequences could replace a project or activity that has even greater consequences; and

Increasing sequestration of carbon is one of the keys to reducing GHGs: by increasing the amount of carbon that is actually stored in living materials, in wood products, in the soil or deeply underground, or in water bodies could decrease the amount of CO_2 released to the atmosphere.

Much more can and should be done to determine the effects of water- and land-use activities on the production of GHGs. Research and development are needed in each of the areas described above.