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8 September 2014

California Department of Water Resources
Division of Integrated Regional Water Management
Financial Assistance Branch – Attn: Ted Daum
Post Office Box 942836
Sacramento, CA 94236-0001

Subject: Climate Change and Vulnerability Assessment submission as an addendum to the Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan (Kern IRWMP)

Dear Mr. Daum:

Enclosed please find the Climate Change and Vulnerability Assessment submission as an addendum to the Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan (Kern IRWMP). It is being submitted as a result of the June 6, 2014 IRWM Plan Review Process recommendations prepared by DWR. Members of the Kern IRWMP Executive Committee discussed the results of the Plan Review Process with you during a conference call on July 7, 2014, when it was determined that the Climate Change Standard and Vulnerability Assessment should be addressed so that the Kern IRWMP would be in compliance with the IRWM Guidelines. This will also enable the Kern IRWMP to meet the requirements of the Proposal Solicitation Package for Emergency Drought Funding; an application was submitted by project proponents on July 21, 2014.

The Kern IRWMP participants met on August 25, 2014 to conduct the Vulnerability Assessment and review the draft Climate Change submission (agenda and meeting notes attached). Comments were received and incorporated.

Your contact person for matters regarding this submittal is:

Ms. Lauren Bauer
Kern County Water Agency
PO Box 58
Bakersfield, CA 93302-0058
661/634-1411
lbauer@kcwa.com

We appreciate your assistance in this matter. Please feel free to contact Ms. Bauer with any questions or comments.

Very truly yours,

KENNEDY/JENKS CONSULTANTS

Mary Lou Cotton
Practice Leader, Water Resources

Attachments

cc: Joe Yun, DWR

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September 5, 2014

Technical Memorandum

To: Kern IRWMP Participants Group c/o Ms. Lauren Bauer, Water Resources Planner

From: Mary Lou Cotton

Subject: Vulnerability to Climate Change Technical Memorandum
K/J 1289035*01

Climate change refers to significant changes in temperature, precipitation, wind patterns and other weather that occur over several decades and beyond. Climatic changes observed in recent decades are occurring due to rising average global temperatures that are the result of elevated levels of gases released primarily by human activities, which trap heat in the atmosphere in a process known as the greenhouse effect. These so-called greenhouse gases (GHGs) include, among others, water vapor, carbon dioxide (CO_2) and methane (CH_4).

Climate change is impacting California water resources in many ways, including through rising sea levels, reduced snowpack, and more frequent and severe droughts. Impacts and vulnerabilities vary by region resulting in the need for tailored actions to ensure the viability of regional watersheds, including the Kern Region. These actions focus on reducing the intensity of climate change through mitigation measures and adapting to climate change effects.

This technical memorandum identifies the potential climate change vulnerabilities in the Kern Region as well as potential future actions to mitigate the vulnerabilities to climate change. The climate change vulnerability assessment presented in this section includes the checklist assessment in the Department of Water Resources (DWR's) *Climate Change Handbook for Regional Water Planning* and is consistent with climate change requirements in the Proposition 84 Integrated Regional Water Management Plan (IRWMP) Guidelines (June 2014).

1.1 Climate Change Projections Overview

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

Climate change has the potential to have significant impacts on the Kern IRWM Region. The U.S. Bureau of Reclamation (Reclamation), the State of California and others continue to study climate change and its potential impacts on water and other resources in the western states.

The primary climate variables projected by global climate models (GCMs) that are important for water resources planning in California are changes in air temperature, changes in precipitation patterns, and sea level rise. The State of California 2009 Climate Change Impacts Assessment (California Climate Change Center 2009) provides the scientific basis for developing statewide climate change impact projections. The 2009 assessment provided future climate projections to support water resources decision making in California. A set of six GCMs were run for two

GHG emissions scenarios, A2 and B1, selected from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). The IPCC report provides a family of common scenarios that cover a range of plausible trends in GHG emissions over the 21st century as a result of economic, technological, and population change (IPCC 2007). Scenario A2 assumes higher GHG emissions and high growth in population and represents a more competitive world that lacks cooperation in development (similar to business as usual), while B1 is a lower GHG emission scenario that represents social consensus for sustainable development. Each GCM was used to simulate a historical period from 1950-1999 and a future projection period from 2000 to 2100. The 1950-1999 period serves as a baseline or "present condition" for the models so that future conditions can be projected. Table 1 lists the six GCM models and their sponsoring organization, the combination of which were used to evaluate climate change impacts in the Kern Region.

Table 1: Summary of Global Climate Models

GCM	Sponsoring Organization and Model Name
NCAR-PCM1[(a)]	National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM)
GFDL-CM21[(a)]	National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluids Dynamics Laboratory (GFDL) model, version 2.1
NCAR-CCSM3[(a)]	NCAR Community Climate System Model (CCSM)
MPI-ECHAM5	Max Plank Institute ECHAM5/MPI-OM Used by DWR for its climate change analysis for the 2011 Reliability Report, but the 2013 Draft Report Update uses Bay Delta Conservation Plan (BDCP) LLT CC5 input hydrology.
MIROC32	MIROC 3.2 medium-resolution model from the Center for Climate System Research of the University of Tokyo and collaborators
CNRM-CM3[(a)]	French Centre National de Recherches Météorologiques (CNRM) models
Four Model Average[(a)]	Cal-Adapt website. Average of the following four GCMs: NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3. Used in this analysis for Kern River Region

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

DWR used the MPI-ECHAM5 model with the A2 emissions scenario when preparing the 2011 *State Water Project Delivery Reliability Report*. MPI-ECHAM5 represents the median of the six GCMs listed in Table 1. However, the 2013 *Draft Delivery Reliability Report* (December 2013) uses the climate change input hydrology developed for the Bay Delta Conservation Plan (BDCP) for the Late Long Term planning horizon and the 5th climate change region (BDCP LLT CC5 input hydrology). This had the effect of lowering State Water Project (SWP) long-term future reliability, from 60% to 58%.

The California Energy Commission's Public Interest Energy Research Program (PIER) recently established the Cal-Adapt website (http://cal-adapt.org/), whose purpose is to explore California's climate change research. In part, the website provides output from four climate models (NCAR-PCM1, GFDL-CM21, NCAR-CCSM3, and CNRM-CM3) and two GHG emission scenarios (A2 and B1) downscaled to any location in California. The four GCMs are a subset of the six GCMs identified in Table 1. Because the BDCP LLT CC5 GCM is not included in Cal-Adapt, an average of the four GCMs (also provided by Cal-Adapt) with the A2 emission scenario was used in this analysis for the Kern Region.

1.2 Kern Region Climate Change Projections

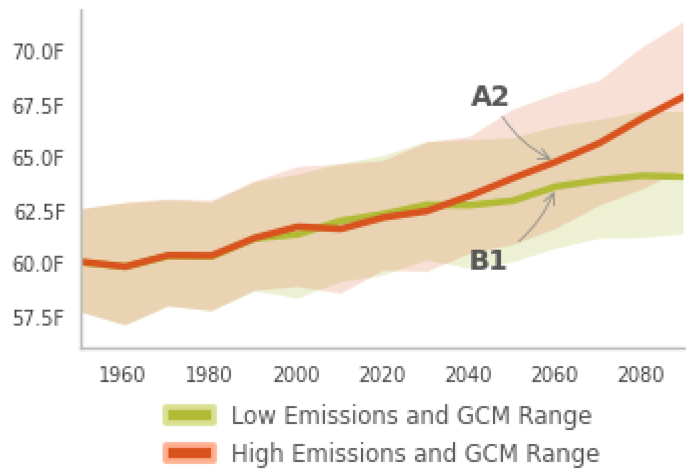
Climate change is expected to have various impacts on the Kern Region including: (1) changing hydrology, and the resultant impacts to conjunctive use operations, due to a shift from snow to rain precipitation, (2) higher wildfire risk due to warmer, drier conditions over the year, and associated impacts on water quality and flooding, (3) fluctuations in temperature resulting in longer and drier conditions over the year, and associated impacts on water quality and flooding, (4) longer and more severe multi-year droughts, (5) greater summer water demand from all categories of users and (6) impacts to habitats and species.

1.2.1 Temperature

Cal-adapt projects that locally, overall air temperatures are expected to rise from 1degree Fahrenheit (°F) to 2.3°F over the next few decades. The historical average annual temperature in the Kern region is 61.4°F; the A2 and B1 scenarios project increases of 3.5°F and 6.3°F by the end of the 21st century. Figure 1 shows the projected air temperature change for the four GCMs averaged from 2000 through 2100, compared with the historical baseline from 1950-2000. The projected temperature increases begin to diverge at mid-century so that, by the end of the century, the temperature increases projected in the higher emissions scenario A2 are almost twice as high as those projected in the lower emissions scenario B1.

Figure 1: Historical and Projected Annual Average

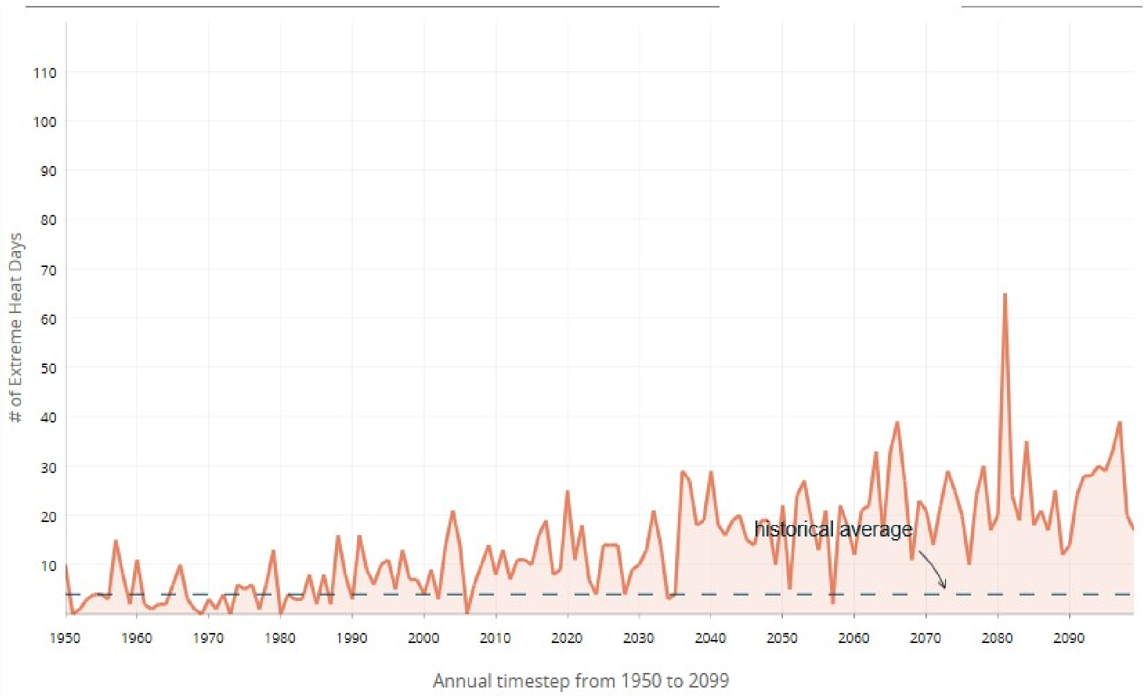
Air Temperature for Kern County



Source: Cal-adapt.org. Bakersfield Area

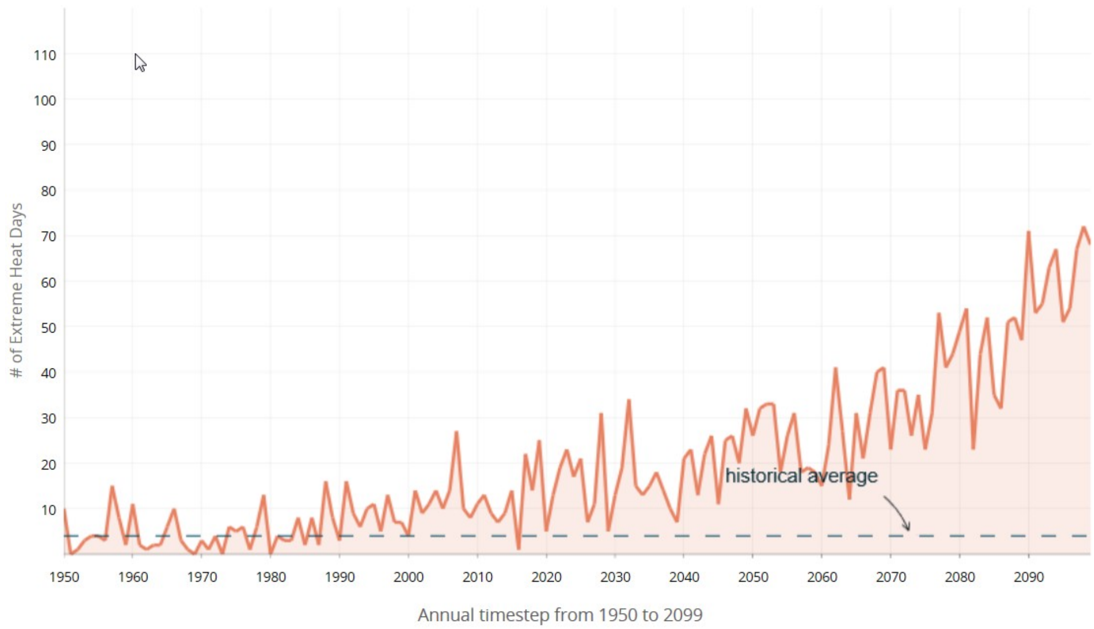
In addition to overall temperature increases, the region is projected to encounter higher incidences of extreme temperatures. Figure 2 and Figure 3 show the projected increases in extreme temperature days in Kern County for the B1 and A2 emission scenarios. This chart displays a count of the number of days that the selected area on the map is projected to exceed the area's calculated "extreme heat threshold" of 101 °F for each year 1950-2099. The historical annual average number of extreme heat days is four. Both scenarios project that number will increase to about 30 days by mid-century and either 40 or 70 days by the end of the century, depending on the emissions scenario. The increased temperatures will likely increase evaporation, leading to drier soils, increased crop evapotranspiration, and a longer growing season.

Figure 2: Number of Extreme Heat Days (Low Emission Scenario)



Source: Cal-adapt.org. Bakersfield Area

Figure 3: Number of Extreme Heat Days (High Emission Scenario)



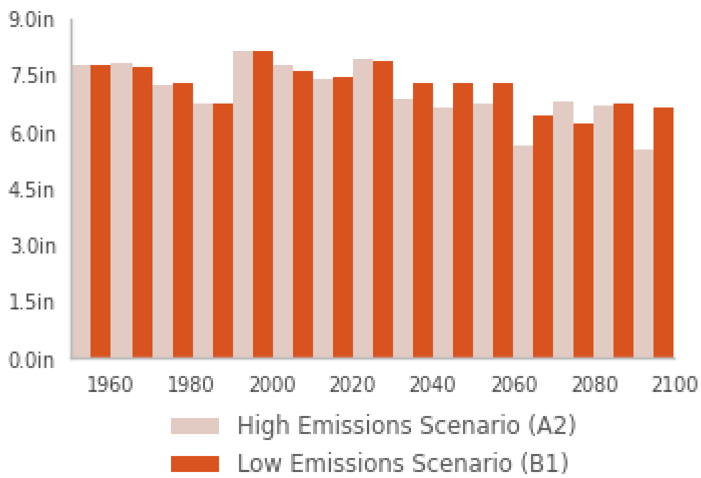
Source: Cal-adapt.org. Bakersfield Area

1.2.2 Precipitation

Precipitation in the Kern Region is essentially all in the form of rain, and significant shifts in the timing of precipitation are not expected to occur. On average the projections indicate little change in total annual precipitation in California. Furthermore, among several models, precipitation projections do not show a consistent trend during the next century. The Mediterranean seasonal precipitation pattern is expected to continue, with most precipitation falling during winter from North Pacific storms. One of the four climate models projects slightly wetter winters, and another projects slightly drier winters with a 10 to 20 percent decrease in total annual precipitation. However, even modest changes would have a significant impact because California ecosystems are conditioned to historical precipitation levels and water resources are nearly fully utilized.

Figure 4 shows the decadal precipitation projections from 1960 through 2100 for the Bakersfield area in Kern County. There appears to be continued variable precipitation over the next century, with an overall consistent decrease. Drier conditions may result in a reduction in effective precipitation for crop irrigation needs and higher wildfire risk in the Region.

Figure 4: Projected Annual Precipitation for the Bakersfield Area in Kern County



Source: Cal-adapt.org. Bakersfield Area

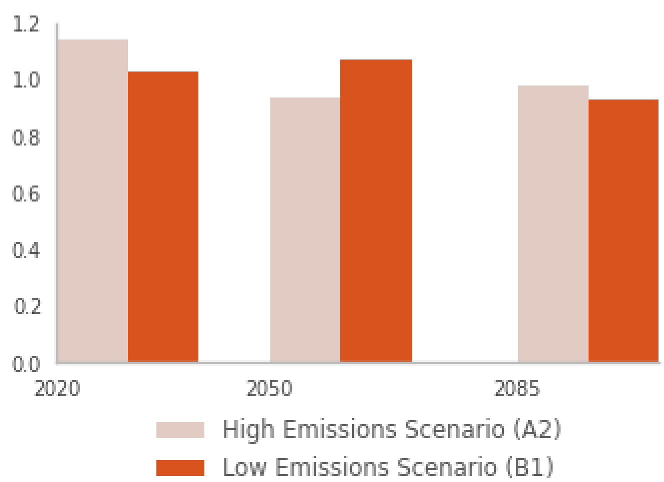
1.2.3 Wildfire

Fire is an important ecosystem disturbance. It promotes vegetation and wildlife diversity, releases nutrients into the soil, and eliminates heavy accumulation of underbrush that can fuel catastrophic fires. Statewide, the area projected to be burnt by wildfire toward the end of the century will increase substantially, especially in mountainous areas. As climate changes, it appears that summer dryness will begin earlier, last longer and become more intense. These changes may exacerbate fire occurrences, which have historically peaked in late summer and early fall. If temperatures rise into the medium warming range, the risk of large wildfires in California could increase by as much as 55 percent, which is almost twice the increase expected if temperatures stay in the lower warming range.

Because wildfire risk is determined by a combination of factors including precipitation, winds, temperature, landscape and vegetation conditions, future risks will not be uniform throughout the state. In years with wet winters, annual vegetation growth is plentiful. But accentuated dryness during summer would produce a hazardous fuel load that worsens the wildfire problem in some of Southern California wildlands. With expanding development into the urban/wildland interface, threats to human safety and property are even greater. The spread of invasive species that are more fire-prone, coupled with more frequent and prolonged periods of drought, all increase the risk of fires, and reduce the capacity of native species to recover. Wildfires are also bad news for the region in terms of air quality, human health, soil erosion and stress on watersheds.

Figure 5 shows projected increases in potential area burned in the Bakersfield area of Kern County. The y-axis represents the ratio of additional fire risk for an area compared to the expected burn area. These data are modeled solely on climate projections and do not take landscape and fuel sources into account. New wildfire risk projections are currently being produced that take more landscape information into account.

Figure 5: Projected Increase in Potential Area Burned in the Bakersfield Area of Kern County



Source: Cal-adapt.org. Bakersfield Area

Fire is an important process in maintaining a diverse ecosystem in the Region. It is unclear at this time whether projected increased wildfire risk will be beneficial or harmful to long term ecosystem health and habitat maintenance, but will likely negatively impact water quality with increased turbidity loading to water supplies.

1.3 Resources in the Kern Region Vulnerable to Climate Change

This section identifies the resources within the Kern Region, its related areas that are potentially affected, and their collective potential vulnerability to climate change. Table 2 provides a general overview of the water-related resources that are considered important in the Kern Region and potentially sensitive to future climate change. Resources that are likely to be vulnerable to climate change are considered for further analysis in the preceding subsections. Table 2 also highlights those resources in the Region that are unlikely to be affected by climate change and therefore they do not warrant further analysis and consideration at this time. The summary table provides the main categories applicable to water planning in the Kern Region with a general overview of the qualitative assessment of each category with respect to anticipated climate change impacts. Table 4 in Section 1.4 below provides the complete assessment of the regional vulnerability to the potential climate change impacts using the

'Vulnerability Assessment Checklist', found in the *Climate Change Handbook for Regional Water Planning* (DWR, 2011).

Table 2: Climate Change Vulnerability Assessment Overview

Watershed Characteristics	General Overview of Vulnerabilities
Water Demand	Urban and Agricultural Water Demand – Changes of hydrology in the Region as a result of climate change could lead to changes in water demand, both in quantities and patterns. Increased irrigation (outdoor landscape or agricultural) is anticipated to occur with temperature rise, increased evaporation losses with warmer temperature and longer growing season.
Water Supply	Imported Water – State Water Project (SWP) and Central Valley Project (CVP) water via the California Aqueduct and the Friant-Kern Canal are an important portion of the water resources available to the Region. Potential impacts on SWP and CVP water availability resulting from climate change directly affect the amount of imported water supply delivered to the Region, part of which will be delivered to recharge groundwater banking programs in the Kern Region. Groundwater – Changes in local hydrology could affect natural recharge to the local groundwater aquifers and the quantity of groundwater that could be pumped sustainably over the long-term. Decreased inflow from runoff, increased evaporative losses, warmer and shorter winter seasons can alter natural recharge of groundwater, as well as conjunctive use operations. Alternatively, if more precipitation occurs as rain, short-term high flows could result, and will require the Region to adapt to the faster runoff which will impact the timing of conjunctive uses. In addition, additional reductions in the imported water imposed by climate change would lead to more reliance on local groundwater, resulting in reductions in base flows, reduced groundwater outflows, increased depth to groundwater and increased land subsidence. .

Watershed Characteristics	General Overview of Vulnerabilities
Water Quality	Imported Water – Sea level rise could result in increases in chloride and bromide (a disinfection by product precursor), potentially requiring changes in drinking water treatment. Increased temperatures could result in an increase in algal blooms and taste and odor events. Regional Surface Water – Increased temperature could result in lower dissolved oxygen, increased algal blooms, and task and odor affect to the Kern River and its tributaries. Decrease in annual precipitation could result in higher concentrations of contaminants in these surface waters during droughts. Increased wildfire risk and flashier storms could increase turbidity loads for water treatment, irrigation filtration systems and spreading basins (sedimentation and loss of percolation rates). Return flows from groundwater banking programs have inherent water qualities. Increased use of banking projects is leading to replacement of higher quality snowmelt surface water (Kern River and Friant CVP), as these supplies are being diverted further upstream than historical diversions to effect transfers and exchanges, and replaced with groundwater supplies that are higher in salt constituents (TDS, nitrates, etc.).
Sea Level Rise	The Kern Region is not directly subject to sea level rise. However, potential effects of sea level rise would affect imported water supply conditions. As discussed above, the principal concern is the potential for sea water intrusion to increase Sacramento-San Joaquin Delta (Delta) salinity. While sea level rise is not a direct regional concern, pursuant to the California Ocean Protection Council Resolution adopted March 11, 2011, it should be considered in the project selection/prioritization process.
Flooding	Local surface flows could change as a result of more frequent and intense storm events, leading to more areas susceptible to flooding, and increasing risk of direct flood damage in the Kern Region.
Ecosystem and Habitat	Increased temperature and potential decreases in annual precipitation could put stress on sensitive ecosystems and alter habitats. Water-dependent recreation could also be affected by water quality impacts. In addition, the Kern Region may be subject to increased wildfire risk, which could alter habitat.
Hydropower	Hydropower production in the Kern Region is small, however power through the Western Area Power Administration operated by the BOR does provide power to the CVP. Because of the amount of hydropower used in comparison to the size of the Region is relatively small, climate change effects on hydropower are not considered to be significant.

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

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

1.3.1 Water Demand

Increasing air temperatures due to climate change will result in increased evaporation leading to drier soils, increased plant evapotranspiration (ET), and a longer growing season. All of these factors generally increase water demand however there are not sufficient data available to estimate a total volume.

The Cal-Adapt A2 emissions scenario projects an average temperature increase for the Kern Region of about 3.3°F by the mid-century (2050) and increase of about 6.3°F by the end of century (Figure 1). Characterizing the impacts of temperature rise on water demand is a difficult task and discussed on a qualitative basis. While water use varies considerably depending on other factors such as regional economy, population, and land use, a qualitative assessment of water demand increase can be noted based on the projected temperature increase from the Cal-Adapt emission scenarios.

Kern County is characterized by its traditional industries, agriculture, oil and gas production, as well as increasing urbanization and population growth. Total water demand for the region is projected to increase only slightly. Water use to meet municipal water needs are projected to increase significantly due to population growth - about 48 percent from approximately 189,162 acre-feet per year (AFY) in 2005 to 281,284 projected for 2030 (Kern IRWMP 2011). However most of the use in the Kern Region is agricultural. Although historically the trend of agricultural water use has been decreasing, for purposes of this report future agricultural water demands are assumed to stay the same at 2,669,713 AFY (Kern IRWMP 2011), although there are some current reports that forecast a decrease in overall usage within the Region. Total 2005 urban and agricultural demand for the Kern Region is estimated at around 2,857,755 AFY and projected 2030 total demand is estimated to be 2,938,818 AFY, a change of just under 3 percent (Kern IRWMP 2011.

An important effect of changing weather conditions is likely to be on landscape and agricultural demand. Higher temperature generally increases ET rates; but some research studies also suggest higher CO2 levels and higher temperature increase rates of plant growth, and can shorten the time to plant maturity (Hanak and Lund, 2008). This would reduce the overall plant water uptake, partially compensating for potential reductions in agricultural water supply. Thus, the net effect on agricultural crops is still uncertain (Kiparsky and Gleick, 2005) and remains an important area of on-going research.

Qualitatively, the ET projections with climate change suggest water demand for agriculture in the Region is anticipated to increase during months where ET is high and decrease in months where ET is low. As a result of increased ET, urban water demand is anticipated to increase as well because of greater outdoor water use for landscape irrigation and agriculture.

Demand management is an important adaptation given decreased water supply as a result of climate change. Agriculture has a variety of water demand management options including fallowing fields of annual crops and changing the crop itself to one that may be less water intensive, yet economically viable. Additionally, in some cases, farmers may be able to switch their water source from surface water to groundwater. Demand management options for the urban landscape sector range from climate appropriate plants to improved irrigation methods. Water demand management strategies are discussed in Section 11.2 in the November 2011 Kern IRWM Plan.

1.3.2 Water Supply

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

Climate change is expected to affect Regional imported water supplies as follows:

- Total precipitation is expected to decrease in the Sierra Nevada sources, reducing runoff to surface supplies.
- Snow pack projected to decrease as precipitation shifts toward more rain and less snow.
- Timing of runoff is expected to shift to earlier in the year, affecting reservoir storage especially in the spring and summer months, as well as groundwater recharge activities.
- Sea level rise may impact Delta water deliveries.

Climate change is expected to affect Regional surface and groundwater supplies as follows:

- Total precipitation is not projected to change significantly, however the trend is decreasing.
- Variability in annual precipitation is expected to continue, with vulnerability to droughts. This is especially important for the highly variable Kern River system.
- More intense storms anticipated that may affect surface water runoff, surface storage and groundwater recharge.

Climate change is expected to affect Regional oil and gas activities requiring supplies as follows:

Oil and gas drilling in the county could be impacted by decreasing water availability, particularly in times of drought by limiting the amount of water available for cooling, fuel extraction, and power generation. The effects of climate change and water availability on the oil and gas sector include a combination of potential direct and indirect impacts. Water is required in many different stages of the oil and gas value chain, from exploration to processing to transport, and the volume of water used in these activities varies, with the largest volume used in the refining process. Among exploration and production processes, the largest volume of water is used as a supplemental source.

Because the Kern Region relies heavily on imported supplies, any reduction or change in the timing or availability of those supplies could have negative impacts on the Region. Reductions in imported water supplies would lead to increased reliance on local groundwater, recycled water or other sources of supplies if demand was not reduced. Changes in local hydrology could affect surface storage of water and natural recharge to the local groundwater and the quantity of groundwater that could be pumped in a sustainable manner. The following sections describe potential climate change impacts to the region's water supplies.

1.3.2.1 Imported Supplies

Imported water deliveries to the Kern Region are from the SWP and CVP via the California Aqueduct, and the Friant-Kern Canal. Increasing development and environmental demands on water availability and quality for agricultural, municipal and industrial (M&I), and groundwater banking purposes, coupled with curtailments of imported SWP and CVP deliveries due to prolonged drought and regulatory restrictions, have intensified the competition for available water supplies in the Kern Region. It is estimated that due to drought and decreases in imported water supply, about 45,000 acres of farmland in the Region will be idled and an additional 100,000 acres will be under-irrigated. Climate change impacts are likely to exacerbate these challenges.

In an effort to assess the impacts of these varying conditions on SWP supply reliability, DWR issues its "*State Water Project Delivery Reliability Report*". DWR's long-term SWP delivery reliability analyses incorporate assumptions that are intended to account, among other impacts, for potential supply shortfalls related to global climate change. The long-term average delivery of contractual SWP Table A supply is projected to be 62 percent under current conditions and 58 percent under future conditions over the 20-year projection (DWR 2013). Within that long-term average, SWP Table A deliveries can range from 12 percent (single dry year) to 97 percent (single wet year) of contractual amounts under current conditions, and from 11 percent (single dry year) to 98 percent (single wet year) under future conditions. Contractual amounts are projected to be 31 percent during multiple-dry year periods (assuming a 4-year dry period), and from 81 to 85 percent during multiple wet periods (assuming a 4-year wet period). Table 3 shows SWP supplies projected to be available to the Region in average/normal years and summarizes estimated SWP supply availability in a single dry year and over a multiple dry year period. While detailed analysis of CVP supply reliability has not been performed, it is likely that similar impacts from climate change will also apply to the CVP.

Table 3: Kern County Water Agency (KCWA) Wholesaler Supply Reliability (AF)

Wholesaler (Supply Source)	2015	2020	2025	2030
Average Water Year				
DWR (SWP)				
KCWA Table A Supply	579,263	579,263	579,263	579,263
% of Table A Amount(a)	58%	58%	58%	58%
Single Dry Year				
DWR (SWP)				
KCWA Table A Supply	109,860	109,860	109,860	109,860
% of Table A Amount(a)	11%	11%	11%	11%
Multiple Dry Year				
DWR (SWP)				
KCWA Table A Supply	309,606	309,606	309,606	309,606
% of Table A Amount(a)	31%	31%	31%	31%

Note: (a) Percentages of Table A amount from DWR's *2013 SWP Delivery Reliability Report* and assumes future conditions. Also assumes Table A contract amount of 998,730 AFY.

1.3.2.2 Groundwater

The San Joaquin Valley groundwater basin covers the majority of the managed groundwater resources in the Kern Region. Other groundwater basins in the Kern Region include the Kern River Valley groundwater basin to the east; Walker Basin Creek Valley groundwater basin to the southeast; Cummings Valley and Tehachapi Valley West on the eastern side of the Region, Brite Valley to the southwest; and Cuddy Canyon Valley, Cuddy Ranch Area, Cuddy Valley; and

Mil Potrero Area basins to the south. All of these groundwater basin boundaries are within the watershed boundary of the Kern Region (see Figure 2-7 in the November 2011 Kern IRWM Plan for basin locations).

One of the longest-standing issues in the Kern Region is groundwater overdraft. Groundwater provides approximately 39 percent of local water needs; however it is estimated to be as much as 60 percent in dry years. Further, certain portions of the groundwater basin underlying the Kern Region have experienced overdraft conditions.

The Kern Region is well-known for its long-established and successful conjunctive use and banking programs. These programs overlie the major portions of the groundwater basin and can access surface supplies from the Kern River, the SWP, the Friant-Kern Canal, and more. In times of high flows, these surface supplies are recharged and stored to help to lessen the effects of dry period conditions when the Region relies on the groundwater basin.

The groundwater in the Kern Region may also be subject to decreasing reliability related to the extent and duration of longer drought periods that may occur due to climate change. There are limited data available to quantify the sustainable groundwater supplies and therefore to assess the resiliency of these supplies after drought events. A better understanding of groundwater supplies will be important to continued resiliency against climate change, as water supply management becomes a more important issue in the Region.

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

1.3.3 Water Quality

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

Surface waters in the Region are expected to be more directly vulnerable to water quality impacts of climate change, while water quality impacts to groundwater sources would be indirect, as conjunctive use and banking programs can increase the amount of salts in the underlying aquifer dependent on the source of the recharge water.

1.3.3.1 Imported Water Quality

SWP water currently meets or exceeds applicable standards (see Appendix D in the November 2011 Kern IRWM Plan for data). However, there is concern with some constituents that are approaching SWP acceptance criteria, particularly arsenic and selenium. SWP and CVP water is vulnerable to potential effects of climate change at the source in the Delta and in storage in Regional reservoirs. Sea-level rise will increase the intrusion of salinity into the Delta and its exported water. This will increase chloride and bromide (a disinfection byproduct [DBP] precursor that is also a component of sea water) concentrations in the SWP and CVP imported water. In addition, decreased freshwater flows into the Delta could increase the concentration of organic matter, which contribute to potentially higher DBP formation concentrations, in the SWP and CVP water. However, CVP water from the Friant system is of very high-quality as it originates from Sierra snowmelt and is similar in characteristics to Kern River supplies.

Extreme storm events, although rare, may cause quick response time thereof in canal flow rates, which may be more intense due to climate change and may present treatment challenges for source water and sedimentation issues in recharge basins because of increased turbidity. In the past, high turbidity events in reservoirs and conveyance facilities have required modification of the treatment processes (primarily additional chemical usage) for extended periods. In addition, an intense winter rainfall event after a wildfire in a watershed that burned the prior year can result in extremely high turbidities and fine organic matter in the water. The additional sludge production can overwhelm the treatment plants' solids handling equipment and require plants to be shut down or reduce their capacities for brief periods of time, or make capital investment to enlarge solids handling facilities. Similarly, turbidity events can negatively impact porosity in recharge basins, lessening their absorptive capacity. This combination of more intense rainfall events and increased wildfire risk is more likely under projected climate change conditions.

The warmer temperatures could also lead to increased taste and odor events triggered by algal blooms; which are characterized by water quality changes during the spring and summer such as increases in DO and DO saturation, pH and fluorescence. Water treatment plants can be designed to address taste and odor events through pre-ozonation but use of higher ozone dosages to control taste and odor events must also consider the need to control bromate formation (from the oxidation of bromide), which could increase due to greater bromide levels in the imported SWP and CVP water affected by climate change. Local canals would have to deal with the algae and effects thereof with higher treatment cost (i.e. copper sulfate).

1.3.3.2 Regional Surface Water Quality

The primary regional surface water in the Kern Region is the Kern River. Local minor streams, many of which are ephemeral, provide additional local surface water. A very small percentage of minor stream runoff is collected and used as irrigation for agriculture; the majority of these irregularly-occurring flows serve to recharge local groundwater basins. However, the Kern River serves as a major source of supply to groundwater banking programs in the Region.

The Kern River and its tributaries, while generally considered a high quality supply, are vulnerable to potential water quality impacts due to climate change as a result of increased temperature, more frequent heavy rainfall events, increased wildfire risk, and longer periods of low natural stream flow from decreased annual precipitation. Increased water temperature generally reduces DO and can promote algal blooms if nutrients are available in the source. The storm events can transport sediments and other pollutants along the river, while long periods of low flow can increase concentrations of pollutants from wastewater plant and non-point discharges. Increased wildfires may contribute to the turbidity events. Key water quality constituents of concern are nitrogen and chloride, in addition to reduced DO and increased algae growth, turbidity and sedimentation. Taken together these can impact drinking water supplies as well as supplies utilized for groundwater recharge.

Imported water stored in Isabella Reservoir will also be vulnerable to climate change when considering reduced runoff volumes which could affect turbidity and increasing water temperatures, dissolved oxygen (DO) levels, and pH.

1.3.3.3 Groundwater Quality

Groundwater quality throughout the region is typically suitable for most urban and agricultural uses with only localized impairments including high TDS (salts), sodium chloride, sulfate, nitrate, organic compounds, boron and arsenic. High TDS, arsenic, boron, and nitrates are the primary groundwater quality issues. Various constituents can impact agricultural uses and M&I uses in different ways.

Any water quality impacts to groundwater sources due to climate change are expected to be indirect, primarily due to decreased recharge from lower precipitation, increased periodic recharge from earlier/faster snowmelt runoff and increased use of groundwater to make up loss of imported or local surface water supplies. Decreased recharge and increased groundwater pumping may allow concentrations of groundwater contaminants such as perchlorate and volatile organic compounds to increase, which may trigger additional treatment requirements and increase groundwater treatment costs. Increased use of lower quality groundwater may also have some concerns associated with soil properties over a long period.

1.3.4 Flooding

Flooding is one of the most costly and destructive natural disaster; thus, a change in flood risk is a potential significant effect of climate change that could have great implications for the Kern Region. Local minor streams are the second-largest source of local surface water to the Region after the Kern River. Streams with measurable runoff are grouped into four separate watershed areas: Poso, Caliente, El Paso, and San Emigdio. Under certain hydrologic conditions, some of these streams carry very large flows that can be quite damaging. Examples include flooding in the Kelso Creek area, and in the area around the cities of Arvin and Lamont. Regional efforts to address flooding and to better manage such flow events have been initiated among various parties in the Region, including the County of Kern, KCWA and the affected areas.

The FEMA Flood Insurance Rate Map for the Kern Region designates multiple areas as “High Risk,” areas with a 1 percent or greater risk of flooding in any year and a 26 percent chance of flooding over the life of a 30-year mortgage. The area at greatest flood risk is the area surrounding the communities of Lamont, Weedpatch, and the city of Arvin. The area is also prone to wildfires, which impact water quality when rain washes fire debris into waterways. Other large flood area includes the Buena Vista lakebed as well as areas in the historic Tulare lakebed and nearby drainage areas. Areas along the Kern River and other local streams like Tejon, El Paso and Grapevine in the southern region are also considered to have a high flood risk. These areas are depicted in Figure 2-8 in the November 2011 Kern IRWM Plan.

Regional efforts to address flooding and to better manage such flow events have been initiated among various parties in the Kern Region, including the County of Kern, KCWA and the affected areas. For more information on flood management see Section 10.2 in the November 2011 Kern IRWM Plan.

While the Cal-Adapt climate change model projects precipitation decrease of 10 percent by 2050 on the long-term basis, research data suggest that there is a risk of increased flooding in California (Kiparsky and Gleick 2005). Flooding depends not only on average precipitation but on the timing and intensity of precipitation. Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms would occur. This could present larger areas susceptible to flooding and increase the risk of direct flood damage in the Region.

1.3.5 Ecological Health and Habitat

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

Environmental resources of the Kern Region include the Kern River, Sequoia National Forest, several wildlife refuges, and the unique flora and fauna of the Tejon Pass area and Transverse Ranges. The riparian forest along the South Fork Kern River in the vicinity of Onyx and Weldon is one of the highest quality and most extensive stands of that vegetation type in California. This section of the river has the largest populations of Southwestern willow flycatchers and yellow-billed cuckoos in California. Much of this forest is conserved in the USFS South Fork Wildlife Area, Audubon California's Kern River Preserve, and California Department of Fish and Game's (CDFG's) Canebrake Ecological Reserve. For more detail on the Kern Region's ecological resources, see Section 2.4 in the November 2011 Kern IRWM Plan. All of these species and habitats have acclimated to the historical climate and water resources and may or may not to adapt to potential changes due to future climate change.

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

Ackerly *et al.* (2012) summarizes existing research on the relationship between climate and biodiversity and how changes in climate historically have and will in the future impact habitat. In terrestrial systems, the impacts of rising temperature and changing precipitation patterns have the largest effect and that in estuarine and intertidal areas, sea-level rise results in the most important direct impact. These habitats may be affected directly by habitat loss through erosion, or indirectly via human responses such as coastal armoring (e.g., construction of sea walls) and other infrastructural changes.

1.4 Regional Vulnerability Assessment

Table 4 provides an assessment of the regional vulnerability to the potential climate change impacts using the 'Vulnerability Assessment Checklist', found in the 'Climate Change Handbook for Regional Water Planning' (DWR, 2011). This checklist provides a further evaluation of the effects on regional water demands and supplies, as well as water quality, flooding events, environmental and ecosystems, and hydropower systems within the Kern Region.

In addition to the assessment of vulnerabilities provided in Table 4, the Kern Region prioritized the identified vulnerabilities during a Stakeholder meeting in August 2014. The results are displayed in the Climate Change Vulnerabilities Prioritization Table provided in Appendix A. Meeting minutes from the August Stakeholder meetings are also included with Appendix A, documenting the planning efforts of the Region.

Table 4: Vulnerability Assessment Checklist

Resource Checklist Item	Kern Regional Condition
Water Demand	
Are there major industries that require cooling/process water in your planning region?	Kern County is characterized by its traditional industries, agriculture, oil and gas production, as well as increasing urbanization and population growth. Oil and gas drilling in the county could be impacted by decreasing water availability, particularly in times of drought by limiting the amount of water available for cooling, fuel extraction, and power generation. Additionally, process water is required in packing plants and other locations for processing crops harvested from the field, further contributing to the significance of the use.
Does water use vary by more than 50% seasonally in parts of your region?	Yes. A significant amount of water in the Kern Region is used for agricultural purposes, the demand for which fluctuates greatly in the summer compared to the winter.
Are crops grown in your region climate-sensitive? Would shifts in daily heat patterns, such as how long heat lingers before night-time cooling, be prohibitive for some crops?	Yes. The Kern Region is the second largest agricultural county in the state in economic value, and produces over 250 different crops, including over 30 types of fruits and nuts, over 40 types of vegetables, over 20 field crops, lumber, nursery stock, livestock, poultry and dairy products. Many of these are climate-sensitive and could be prohibitively affected by shifts in daily heat patterns.
Do groundwater supplies in your region lack resiliency after drought events?	With only six (6) inches per year of average rainfall, groundwater is necessary to maintain a sufficient water supply in the semi-desert climate of the Region. It is estimated that on average groundwater accounts for 39 percent of total water supply to the Region; however, it is estimated to be as much as 60 percent during dry years. Long-established and successful conjunctive use and banking programs. These programs overlie the major portions of the groundwater basin and can access surface supplies from the Kern River, the SWP, the Friant-Kern Canal, and more. In times of high flows, these surface supplies are recharged and stored to help to lessen the effects of dry period conditions when the Region relies on the groundwater basin.

Resource Checklist Item	**Kern Regional Condition**
Are water use curtailment measures effective in your region?	Stakeholders of this IRWMP have identified water use efficiency as an important component of water supply planning. One of the stated objectives of this IRWMP is to "Pursue and implement cost effective water use efficiency programs." In addition to direct water use efficiency, stakeholders have expressed a desire to improve system operation, reduce system water loss, and decrease energy use related to water infrastructure. Another objective of this IRWMP is to "Replace aging infrastructure to reduce system water losses, improve operational efficiencies, and reduce service interruptions." Lastly, implementation of agricultural land fallowing programs within the Region also help to curtail water use.
Are some instream flow requirements in your region either currently insufficient to support aquatic life, or occasionally unmet?	No. However, since 1994, the two large projects that import water into the Kern Region, the CVP and the SWP, have been incrementally impacted by environmental and regulatory requirements that have served to diminish the ability of the projects to reliably deliver water supplies. A large proportion of recent imported water cutbacks has stemmed from fishery issues in the Sacramento-San Joaquin Delta, where the pumping plants for the CVP and SWP are located, as well as San Joaquin River Settlement or Public Law 111-111 where water previously supplied to the CVP Friant Division for M&I and agricultural irrigation is being diverted into the San Joaquin River for in-stream flows.
Water Supply	
Does a portion of the water supply in your region come from snowmelt?	Yes. The Kern River is fed by annual snowmelt from the Southern Sierra Nevada, including Mount Whitney. The SWP, CVP and Friant system are also fed by Sierra snowmelt.

Resource Checklist Item	Kern Regional Condition
Does part of your region rely on water diverted from the Delta, imported from the Colorado River, or imported from other climate-sensitive systems outside your region?	Yes. The Kern Region receives SWP and CVP water delivered through the Delta, which is affected by climate change. Friant CVP also has a Delta connection with the San Joaquin River Restoration Program as well as San Joaquin River Exchange Contractor rights.
Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past?	The Kern Region does not rely on coastal aquifers. While salt intrusion from coastal aquifers is not applicable, salt management is still an issue in the region with regard to increasing salinity in groundwater. Salt in imported water supplies such as the SWP and CVP is the major source of salt which circulates throughout the groundwater in Kern County.
Would your region have difficulty in storing carryover supply surpluses from year to year?	There is limited carryover available for SWP and CVP water in San Luis Reservoir. Carryover of Friant CVP water in Millerton Lake/Friant Dam has limited capacity. Carryover of Kern River water in Isabella Reservoir is limited by the Reservoir's flood control purpose and US Army Corps of Engineers Regulations. However, there are opportunities to expand the Region's groundwater storage capabilities.
Has your region faced a drought in the past during which it failed to meet local water demands?	No. Water demands have been met through the use of groundwater which, during drought, can result in significant declines in groundwater levels. To the extent that surface water supplies are reduced in the future (as a result of climate change and/or regulatory constraints), recharge will be reduced, which will affect the availability of groundwater for meeting local water demands.

Resource Checklist Item	Kern Regional Condition
Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas?	Yes. Aquatic pests, including invasive plants have been fought on the Kern River for decades. Prevention and control of invasive species is an ongoing battle by many resource agencies such as the Kern River Preserve Audubon Society, and the Kern River Ranger District. Canal operators treat aquatic weeds, mainly with use of copper sulfate.
Water Quality	
Are increased wildfires a threat in your region? If so, does your region include reservoirs with fire-susceptible vegetation nearby which could pose a water quality concern from increased erosion?	Yes. Parts of the Kern Region are prone to wildfires, which impact water quality when rain washes fire debris into waterways. In July 2008, the Piute Fire burned a significant area in the region. It was soon followed by a summer thunderstorm, which washed fire debris into the South Fork and ultimately down the Kern River. Many water purveyors were forced to switch from Kern River water to alternate sources to avoid contamination of settling ponds and costly treatment of the water.
Does part of your region rely on surface water bodies with current or recurrent water quality issues related to eutrophication, such as low dissolved oxygen or algal blooms? Are there other water quality constituents potentially exacerbated by climate change?	Yes. The Kern River, the primary native surface supply in Region, is generally considered a high quality supply. However, Isabella Lake which serves as the source for the lower Kern River is listed on the 303(D) list for dissolved oxygen and pH. Climate change could exacerbate these water quality conditions from increased temperatures. Banking return flows result in replacement of higher quality snowmelt water with groundwater.
Are seasonal low flows decreasing for some waterbodies in your region? If so, are the reduced low flows limiting the waterbodies' assimilative capacity?	Possibly. Annual Kern River flows and flows in local ephemeral streams could be decreasing through time.

Resource Checklist Item	**Kern Regional Condition**
Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues?	No. Water is intended for many beneficial uses including agricultural water supplies, groundwater recharge, water replenishment, recreation, wildlife habitat, rare and endangered species, and wetland ecosystems. Most of these are met within the Kern Region; however there are two TMDLs for Lake Isabella with regard to DO and pH.
Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation?	No.
Sea Level Rise	
Has coastal erosion already been observed in your region?	No. The Kern Region is located in the Southern San Joaquin Valley, and concerns regarding coastal regions are not applicable.
Are there coastal structures, such as levees or breakwaters, in your region?	No.
Is there significant coastal infrastructure, such as residences, recreation, water and wastewater treatment, tourism, and transportation) at less than six feet above mean sea level in your region?	No.
Are there climate-sensitive low-lying coastal habitats in your region?	No.
Are there areas in your region that currently flood during extreme high tides or storm surges?	No.
Is there land subsidence in the coastal areas of your region?	No.
Do tidal gauges along the coastal parts of your region show an increase over the past several decades?	No.
Flooding	
Does critical infrastructure in your region lie within the 200-year floodplain?	Yes. The FEMA Flood Insurance Rate Map for the Kern Region designates multiple areas as “High Risk”, areas with a 1 percent or

Resource Checklist Item	Kern Regional Condition
	greater risk of flooding in any year and a 26 percent chance of flooding over the life of a 30-year mortgage. Figure 2-8 (in the November 2011 Kern IRWM Plan) shows the areas that are within the 100- and 500-year floodplain. Flooding can result in the inundation of structures, causing water damage to structural elements and contents, as well as impact damage to structures, roads, bridges, culverts, and other features from high velocity flows and from debris carried by floodwaters.
Does part of your region lie within the Sacramento-San Joaquin Drainage District?	No.
Does aging critical flood protection infrastructure exist in your region?	Yes. In general, many Kern County communities are older and the physical components of their water systems are aging and outdated. Aging infrastructure is a particular issue for rural communities and DACs.
Have flood control facilities (such as impoundment structures) been insufficient in the past?	Yes. The primary flood control facility in the Region is Isabella Dam on the Kern River. The dam protects the urban Bakersfield area and about 350,000 acres of agricultural land and oilfields. Kern River had an unregulated flow until 1954 when the Isabella Dam and Reservoir were constructed by the Army Corps of Engineers. Unfortunately, due to seepage and earthquake concerns, the flood control capacity of the reservoir has recently been limited. Other areas near Lamont in the southern portion of the Region also have infrastructure that could be impacted.
Are wildfires a concern in parts of your region?	Yes. Parts of the Kern Region are prone to wildfires, which impact water quality when rain washes fire debris into waterways.
Ecosystem and Habitat Vulnerability	
Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues?	Coastal aquatic habitats are not applicable to the Region. However,

Resource Checklist Item	**Kern Regional Condition**
	aquatic pests, including invasive plants have been fought on the Kern River for decades. Prevention and control of invasive species is an ongoing battle by many resource agencies such as the Kern River Preserve Audubon Society, and the Kern River Ranger District.
Does your region include estuarine habitats which rely on seasonal freshwater flow patterns?	No.
Do climate-sensitive fauna or flora populations live in your region?	Environmental resources of the Region include the Kern River, Sequoia National Forest, several wildlife refuges, and the unique flora and fauna of the Tehachapi Mountains, Tejon Pass area and Transverse Ranges. The riparian forest along the South Fork Kern River in the vicinity of Onyx and Weldon is one of the highest quality and most extensive stands of that vegetation type in California. This section of the river has the largest populations of Southwestern willow flycatchers and yellow-billed cuckoos in California. All of these resources could be potentially affected by climate change.
Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region?	Yes. There are threatened and endangered species in the Kern Region including the bald eagle, burrowing owl, California condor, California red-legged frog, least bell's vireo, and the San Joaquin kit fox to name a few. Whether or not changes in species distribution have occurred is unknown.

Resource Checklist Item	**Kern Regional Condition**
Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities?	Yes. Water-dependent recreation includes a wide variety of outdoor activities that can be divided into two (2) categories. The first category includes fishing, boating, swimming, and rafting, which occur on lakes, reservoirs, and rivers. The second category includes recreation that is enhanced by water features but does not require actual use of the water, such as wildlife viewing, picnicking, camping, and hiking.
Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life?	No.
Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region?	There are several wildlife refuges within the Kern Region including the Kern National Wildlife Refuge that manages some wetlands. Coastal storms are not possible in the Region, due to its location in the southern San Joaquin Valley.
Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change	Yes, the Kern Region's eastern boundary is the southern Sierra Nevada, which is listed on the Top 10 habitats list.
*Are there areas of fragmented estuarine, aquatic, or wetland wildlife habitat within your region? Are there movement corridors for species to naturally migrate? Are there infrastructure projects planned that might preclude species movement**?***	Yes. There are many wildlife habitats in the Kern Region. Most notably is the Kern National Wildlife Refuge which provides habitat for wintering and migrating waterfowl, shorebirds, and marsh birds and also provides habitat for upland and riparian bird species. However, there are no infrastructure projects planned in the Region that are known to preclude species movement.

Resource Checklist Item	**Kern Regional Condition**
Hydropower	
Is hydropower a source of electricity in your region?	Yes. Within the Kern Region is the Rio Bravo Hydro Project Hydro Power Plant which has a design capacity of 14 mega watts (MWe). However, most of the energy provided in the Kern Region comes from its 37 high-efficiency cogeneration facilities that produce two sources of energy in the form of steam and electricity.
Are energy needs in your region expected to increase in the future? If so, are there future plans for hydropower generation facilities or conditions for hydropower generation in your region?	Yes. Energy needs in the Region will increase in the future as a result of several factors, which include changes in land use from agricultural uses to urban uses, increasing population and increases in groundwater pumping. However, the Kern Region has a variety of efforts planned to reduce energy use, and to develop local energy supply sources. These efforts include utilization of renewable resources, such as wastewater treatment plant digester gas recovery, hydropower, and solar power.

1.4.1 Vulnerability Prioritization

This section discusses a list of prioritized vulnerabilities based on stakeholder input on the importance of these sectors to the Kern Region. The watershed vulnerability assessment identifies the water resource characteristics for each sector most vulnerable to potential climate change projections. The Region can use the assessment results to prioritize the sectors with vulnerabilities and develop adaptive strategies to respond to potential climate change impacts. The sector vulnerability prioritization is defined as follows (1 being the sector most prioritized [high risk] and 4 being the sector least prioritized [low risk] with respect to climate change vulnerability):

1. Water Supply; Water Quality

2. Water Demand; Flooding

3. Ecosystem and Habitat

4. Sea Level Rise and Hydropower

The vulnerability assessment and prioritization was conducted based on the *Climate Change Vulnerability Checklist* provided as Table 4, data currently available and inputs from the stakeholders involved in the preparation of this study for the Kern Region. This assessment can be improved in the future with further data gathering and analyzing of the prioritized vulnerabilities.

1.5 Climate Change Adaptations

The Kern IRWMP (Plan) identifies strategies to address adapting and mitigating the general effects of climate change. The objectives for the Kern Region address adapting and mitigating the general effects of climate change, including changes in the amount, intensity, timing, quality, and variability of runoff and recharge. These "no regrets" adaptations recognize the current water management context for the region. In addition, mitigation strategies addressed by the objectives for the Kern IRWMP include energy efficiency improvements, emissions reductions, and carbon sequestration through vegetation growth. The Climate Change Handbook (DWR, 2011) was used to help develop these adaptation and mitigation strategies, which are listed in Table 10-2 in the November 2011 Kern IRWM Plan.

For this technical memorandum, potential adaptation strategies have been grouped by water resource and priorities developed in the climate change vulnerability analysis. This approach will allow the Kern Region to incorporate climate change adaptation and GHG mitigation measures in projects developed and evaluated as part of the IRWMP process. While the focus of this discussion is adaptation, some of the adaptation strategies will overlap with and enhance GHG mitigation measures.

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

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

1.5.1.1 Water Supply

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

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

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

1.5.1.2 Water Quality

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

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

- Consider water quality improvements associated with water transfers and water banking on Regional water supply.

- Encourage projects (ex. conjunctive use) that improve water quality of contaminated groundwater sources.
- Increase implementation of low impact development (LID) techniques to improve stormwater management.
- Comply with NPDES permits to ensure water quality protection.

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

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

1.5.2.1 Water Demand

Climate change projections suggest increases in average annual air temperature by mid-century and increased evaporative losses are expected to increase both urban and agricultural water demand. Suggested Regional adaptation strategies to address potential increases in water demand include the following:

- Aggressively increase cost effective water use efficiency.
- Encourage agricultural users to adopt efficient water management practices.
- Encourage landscape water users to adopt efficient water management practices, including xeriscaping.

1.5.2.2 Flooding

Climate change projections are not sensitive enough to assess short term extreme events such as flooding, but the general expectation is that more intense storms will occur. Suggested Regional adaptation strategies to address potential increases in flood risk include:

- Improve emergency preparedness and response capacity in anticipation of potential increases in extreme events.
- Practice and promote integrated flood management among water and flood management agencies.
- Flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands.
- Avoid significant new development in areas that cannot be adequately protected from flooding.

- Encourage land use policies including LID that maintain or restore historical hydrological characteristics.
- Development of a Kern Region Flood Protection Plan.

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

Ecosystem Health and Habitat was identified as the third highest priority sector category that could potentially be impacted by climate change. The potential impacts due to climate change and the suggested regional adaptation strategies are summarized below. Climate change projections of increasing annual average temperature suggest potential environmental stressors that may affect the sustainability of existing ecosystems and habitat. Suggested Regional adaptation strategies to address potential Ecosystem Health and Habitat impacts include the following:

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

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

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

1.5.4.1 Sea Level Rise

Climate change projections suggest sea level rise off most of the California Coast of over half a meter by mid-century and by about one meter by the end of the century. Suggested Regional adaptation strategies to address potential reductions in water supply include the following:

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

1.5.4.2 Hydropower

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

- Support alternative economically viable energy projects within the region including solar energy and wind energy.

1.6 Data Gaps and Next Steps

1.6.1 Data Improvement

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

This section describes potential areas of future data gathering efforts for the priority sectors identified earlier. The recommendations focus on the top four priority sectors; namely, water supply, water quality, water demand, and flooding. The lower priority sectors include ecosystem health and habitat and fire, which require a lesser degree of data collection. Climate change vulnerability of ecosystem health and habitat is difficult to quantify, and reliance on generalized studies will likely satisfy the Region's needs. Thus, the Kern Region should prioritize data gathering efforts for the sectors most vulnerable to climate change impacts.

1.6.1.1 Climate Change Models and Scenarios

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

1.6.1.2 Updates on Climate Change Research

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

1.6.1.3 Vulnerability Assessment Update

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

1.6.1.4 Water Demand

Cal-Adapt projections suggest water demand in the Region is likely to increase as a result of higher temperature with the greatest temperature increase anticipated during dry months compared to wet months. Historical records of annual water demand data currently available are not specific enough to quantify the effects from increasing temperature. As discussed earlier in the vulnerability assessment, the most important effect of changing weather conditions is likely to be on agricultural demand, but the overall effects on agricultural water demand is uncertain.

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

- Collect and analyze historical monthly records of water demand data for the Region to quantify the weather effects on water use and seasonal variations in response to changes in historical temperature.
- Collect and analyze historical monthly records of water demand data for each purveyor in the Region to demonstrate purveyor-specific patterns in response to changes in climate.
- Based on the water demand and temperature data, develop a regression analysis correlating water demand to temperature on a monthly or seasonal basis for the Region and each purveyor. The historical response can be used to infer future response with the projected changes in temperature with climate change.
- Characterize the variations in indoor and outdoor water use, both for the Region and each purveyor. Future data gathering should focus on the seasonal and monthly patterns both in indoor and outdoor usage to evaluate the effects of weather conditions on each use category.
- Collect and analyze historical agricultural water demand to quantity the weather effects on water use and seasonal variations in response to changes in historical temperature.
- Identify the major industries in the Region that require cooling and/or process water. As water temperature increases, cooling water needs may also increase.

1.6.1.5 Water Supply

Future assessment of water supply climate change vulnerability will incorporate the most up-to-date data available from DWR and the most current groundwater supply availability. Suggestions for future data gathering efforts to quantify the climate change effects on water supply include the following:

- Update DWR SWP Delivery Reliability Report projections - DWR provides an updated analysis and report every two years.
- Review or request other reports (e.g., USBR, Army Corp of Engineers, etc).
- Update available groundwater supply projections – Groundwater production in a given year varies depending on hydrologic conditions. Changes in local hydrology and natural recharge are anticipated to have a direct impact on available groundwater storage and may affect current safe operating ranges. Updates on the groundwater safe operating ranges will be needed when further assessments of water supply vulnerability to climate change are performed for future Plan updates.
- Evaluate the effects of reduction in precipitation from climate change on the groundwater operational ranges and quantify the potential reduction in groundwater supply due to reduction in precipitation from climate change.

1.6.1.6 Water Quality

Collection of historical water quality data within the Region would greatly improve the understanding of Regional water quality and how it may be impacted by climate change. For imported SWP water, the vulnerability analysis relied on DWR projections of water quality impacts in the Delta due to sea level rise and increases in salinity. Future analyses will incorporate updated DWR or other agency studies on the potential impacts of climate change on SWP quality.

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

- Monitor future and collect historical water quality data within the Region during storm events.
- Develop a long-term water quality record for the Kern River that would assist in improving the understanding of Regional water quality.
- Collect long-term weather records associated with air temperature, precipitation, and ET to assess potential correlations with seasonal water quality.
- Develop, to the extent possible, a long term surface/ground/aerial deposition model that can be continuously updated and refined with newly available data. Model should be ready accessible to stakeholders and in a user-friendly format to allow better understanding of trends over time.

1.6.1.7 Flooding

A quantitative assessment of the potential impacts of climate change on flooding cannot be performed as climate projections are not sensitive enough to project short-term extreme events such as flooding. Rather, the 100-year and 500-year floodplains were used to define flooding risk zones that should be considered in location of water infrastructure.

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

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

As recommended by DWR's Climate Change Handbook for Regional Water Planning, future work should focus on gathering the 200-year floodplain maps for the Region after DWR develops them under the authorization of Senate Bill 5 (SB 5) enacted in 2007. Currently, the 100-year and 500-year floodplain maps are available from FEMA. Additional information on the DWR's Best Available Maps (BAM) program can be found at the following website: http://gis.bam.water.ca.gov/bam/.

- Coordinate with the Region stakeholders for advanced flood preparation and quick response and document the protocol(s).
- Perform an inventory of critical infrastructure located in floodplains, especially those that were impacted during the historical flood events in 1969 and 1983.
- Update the projections of runoff with climate change as updates from Cal-Adapt become available.
- Work with local flood plain managers and/or equivalent to determine areas of concern as information from FEMA evolves.

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Appendix A

Climate Change Vulnerabilities Prioritization

August 2014 Kern Region Stakeholder Meeting Minutes

Climate Change Vulnerabilities Prioritzation

Kern IRWMP Objectives	Climate Change Vulnerabilities	Prioritization (High, Medium, Low)
Increase Water Supply		
Through cooperation and collaboration with other regions restore water supplies to levels that will mitigate for water lost from the region and eliminate overdraft	Water Supply	H
Pursue and implement cost effective water use efficiency programs	Water Demand	M
Increase water storage capacity in the region by increasing recharge acreage and expanding groundwater banking programs before all prime recharge land has been developed	Water Supply, Sea Level Rise	H
Integrate management of water banking facilities to maximize conjunctive use over the planning horizon	Water Supply	H
Increase/augment water supplies to meet region demands (e.g., M&I, agricultural, environmental) by 2050.	Water Supply, Sea Level Rise	H
Improve Operational Efficiency		
Increase transfers and exchanges flexibility over the planning horizon	Water Supply	H
Create tools to re-regulate water supplies within the region, including storage, storm flows, and operational flows over the planning horizon	Water Supply	H
Increase distribution efficiencies and reduce energy usage over the planning horizon	Water Demand	M
Increase the use of alternate energy sources (e.g., solar)	Hydropower	M
Replace aging infrastructure to reduce system water losses, improve operational efficiencies, and reduce service interruptions	Water Supply, Flooding	M
Increase the use of recycled water for direct reuse within the Kern Region	Water Supply, Water Demand, Water Quality	M
Optimize local management of water resources to improve water supply reliability over the planning horizon	Water Supply	H
Increase pool of qualified candidates to operate water and wastewater systems	Water Quality	L
Improve Water Quality		
Monitor and/or manage headwaters/areas of origin, natural streams, and recharge areas to prevent or mitigate contamination	Ecosystem and Habitat, Water Quality	M
Identify and preserve prime recharge areas in the Kern fan area and other areas	Water Supply, Water Quality	H
Improve water quality for DACs and the watershed over the planning horizon	Water Supply, Water Quality	H
Continue to provide drinking water that meets or exceeds water quality standards; and support efforts to attain appropriate standards throughout the planning horizon	Water Supply, Water Quality	H
Maximize the use of lesser quality water for appropriate uses (landscaping, certain ag crops, "aesthetic" projects) throughout the planning horizon	Water Supply, Water Quality	M
Coordinate and enhance aquatic pest control efforts from this point forward	Ecosystem and Habitat, Water Quality, Water Supply	M
Promote Land Use Planning and Resource Stewardship		
Promote stewardship of the Kern River by applying appropriate measures in various reaches of the river from this point forward	Ecosystem and Habitat	M
Encourage the removal of non-native invasive plant species that affect water quality, reliability, and operations	Ecosystem and Habitat, Water Supply, Water Quality	M
Identify and promote the regeneration and restoration of native riparian habitat	Ecosystem and Habitat	M
Coordinate agricultural and urban water suppliers to more effectively address land use planning issues from this point forward	Habitat, Water Demand, Water Supply	M
Improve the linkage between land use planning and water supply in the region throughout the planning horizon	Ecosystem and Habitat, Water Supply	H
Increase educational opportunities to improve public awareness of water supply, conservation, and water quality issues throughout the planning horizon	Ecosystem and Habitat, Water Supply, Water Demand, Water Quality	H
Improve and coordinate integrated land use planning to support stewardship of environmental resources, such as the Kern River and Kern Fan, and integrate with habitat conservation plans and other ongoing planning efforts from this point forward	Ecosystem and Habitat, Water Supply	M
Preserve and improve ecosystem/watershed health throughout the planning horizon	Ecosystem and Habitat	M
Improve Regional Flood Management		
Improve regional flood management by addressing preparedness, response, and post flood actions throughout the planning horizon	Flooding	M
Reduce the effects of poor quality runoff throughout the planning horizon	Flooding. Water Quality	M
Identify and promote innovative flood management projects to protect vulnerable areas	Flooding	H
Plan new developments to minimize flood impacts from this point forward	Ecosystem and Habitat, Flooding	M

Tulare Lake Basin Portion of Kern County
Integrated Regional Water Management Plan

August 25, 2014 - 1:00 pm – 3:00 pm
Kern County Water Agency
Stuart T. Pyle Water Resources Center
3200 Rio Mirada Drive, Bakersfield, CA 93308

Meeting Objectives:

- Recommendations from DWR Plan Review Process:
- Climate Change Vulnerability Assessment Prioritization

PARTICIPANTS MEETING AGENDA

1:00	**I**	**Welcome and Introductions – Executive Committee Chair** Meeting purpose and agenda *A quorum of the EC was present as follows: Bill Taube, Chair, Regina Houchin, Jon Curry, Greg Fenton, and Lauren Bauer.*
1:05	**II**	**General Information Items** A. Revised/Updated Participant Funding Agreement – Lauren Bauer *Lauren described the process for obtaining indications from all signatories that they would be willing to execute the "First Amendment to the Agreement with KCWA for IRWM Plan Management Services." An email request for comments on the form of the agreement is currently being conducted; comments are due by COB September 1, 2014. After the Amendment is finalized, an email poll of signatories regarding their wiliness to execute will be conducted.*
1:20	**III**	**Funding Opportunities - KJ/P&P Team** A. Water Energy Draft PSP - $19M B. Update on Emergency Drought Funding Application *Mary Lou Cotton of Kennedy/Jenks Consultants gave a brief update on these items and referred to a handout of DWR's compiled list of applicants for the Emergency Drought Funding.*
1:30	**IV**	**IRWM Plan Status – KJ** ***A.*** Kern IRWM Plan DWR Plan Review Recommendations: Climate Change Vulnerability Assessment Prioritization – KJ and EC Members *Mary Lou described the draft Climate Change Technical Memo and Vulnerability Assessment table that were sent to the participants on August 20. She then described the Vulnerability Assessment and prioritization process, and led the group through a discussion of the vulnerabilities that could potentially impact the Tulare Lake Basin Portion of Kern County Region. The group collectively discussed and agreed upon the prioritization of the vulnerabilities, and directed Mary Lou to include it as part of the Climate Change package to be submitted to DWR by September 9, 2014.*
2:00	**V.**	**Public Comment** *Representatives from the Community Water Center reported that the Tulare Lake Basin Disadvantaged Community Study is ready and will be presented to the Tulare County Board of Supervisors on September 9. A draft of the report (prepared by Provost & Pritchard) is available on the Tulare County website. The report contains recommendations regarding DACs for various IRWM Regions.*
		Close