

Appendix I

Climate Change Vulnerability Assessment

I. Water Demand

- Are there major industries that require cooling/process water in your planning region?*
 - As average temperatures increase, cooling water needs may also increase.
 - Identify major industrial water users in your region and assess their current and projected needs for cooling and process water.

- Does water use vary by more than 50% seasonally in parts of your region?*
 - Seasonal water use, which is primarily outdoor water use, is expected to increase as average temperatures increase and droughts become more frequent.
 - Where water use records are available, look at total monthly water uses averaged over the last five years (if available). If maximum and minimum monthly water uses vary by more than 25%, then the answer to this question is "yes"
 - Where no water use records exist, is crop irrigation responsible for a significant (say >50%) percentage of water demand in parts of your region?

- 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?*
 - Fruit and nut crops are climate-sensitive and may require additional water as the climate warms.

- Do groundwater supplies in your region lack resiliency after drought events?*
 - Droughts are expected to become more frequent and more severe in the future. Areas with a more hardened demand may be particularly vulnerable to droughts and may become more dependent on groundwater pumping.

- Are water use curtailment measures effective in your region?*
 - Droughts are expected to become more frequent and more severe in the future. Areas with a more hardened demand may be particularly vulnerable to droughts.

- Are some instream flow requirements in your region either currently insufficient to support aquatic life, or occasionally unmet?*
 - Changes in snowmelt patterns in the future may make it difficult to balance water demands. Vulnerabilities for ecosystems and municipal/agricultural water needs may be exacerbated by instream flow requirements that are:
 1. not quantified,
 2. not accurate for ecosystem needs under multiple environmental conditions including droughts, and
 3. not met by regional water managers.

II. Water Supply

- Does a portion of the water supply in your region come from snowmelt?*
 - Snowmelt is expected to decrease as the climate warms. Water systems supplied by snowmelt are therefore potentially vulnerable to climate change.
 - Where watershed planning documents are available, refer to these in identifying parts of your region that rely on surface water for supplies; if your region contains surface water supplies originating in watersheds where snowpack accumulates, the answer to this question is "Yes."
 - Where planning documents are not available, identify major rivers in your region with large users. Identify whether the river's headwaters are fed by snowpack.

- 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?*
 - Some imported or transferred water supplies are sources from climate-sensitive watersheds, such as water imported from the Delta and the Colorado River.

- Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past?*
 - Coastal aquifers are susceptible to salt intrusion as sea levels rise, and many have already observed salt intrusion due to over-extraction, such as the West Coast Basin in southern California.

- Would your region have difficulty in storing carryover supply surpluses from year to year?*
 - Droughts are expected to become more severe in the future. Systems that can store more water may be more resilient to droughts.

- Has your region faced a drought in the past during which it failed to meet local water demands?*
 - Droughts are expected to become more severe in the future. Systems that have already come close to their supply thresholds may be especially vulnerable to droughts in the future.

- Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas?*
 - As invasive species are expected to become more prevalent with climate change, existing invasive species issues may indicate an ecological vulnerability to climate change.

III. 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?*
 - Some areas are expected to become more vulnerable to wildfires over time. To identify whether this is the case for parts of your region, the California Public Interest Energy Research (PIER) Program has posted wildfire susceptibility projections as a Google Earth application at: <http://cal-adapt.org/fire/>. These projections are only the results of a single study and are not intended for analysis, but can aid in qualitatively answering this question. Read the application's disclaimers carefully to be aware of its limitations.
- 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?*
 - Warming temperatures will result in lower dissolved oxygen levels in water bodies, which are exacerbated by algal blooms and in turn enhance eutrophication. Changes in streamflows may alter pollutant concentrations in water bodies.
- Are seasonal low flows decreasing for some waterbodies in your region? If so, are the reduced low flows limiting the waterbodies' assimilative capacity?*
 - In the future, low flow conditions are expected to be more extreme and last longer. This may result in higher pollutant concentrations where loadings increase or remain constant.
- Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues?*
 - In the future, low flows are expected decrease, and to last longer. This may result in higher pollutant concentrations where loadings increase or remain constant.
- Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation?*
 - While it is unclear how average precipitation will change with temperature, it is generally agreed that storm severity will probably increase. More intense, severe storms may lead to increased erosion, which will increase turbidity in surface waters. Areas that already observe water quality responses to rainstorm intensity may be especially vulnerable.

IV. Sea Level Rise

- Has coastal erosion already been observed in your region?*
 - Coastal erosion is expected to occur over the next century as sea levels rise.
- Are there coastal structures, such as levees or breakwaters, in your region?*
 - Coastal structures designed for a specific mean sea level may be impacted by sea level rise.
- 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?*
 - Coastal flooding will become more common, and will impact a greater extent of property, as sea levels rise. Critical infrastructure in the coastal floodplain may be at risk.
 - Digital elevation maps should be compared with locations of coastal infrastructure.
- Are there climate-sensitive low-lying coastal habitats in your region?*
 - Low-lying coastal habitats that are particularly vulnerable to climate change include estuaries and coastal wetlands that rely on a delicate balance of freshwater and salt water.
- Are there areas in your region that currently flood during extreme high tides or storm surges?*
 - Areas that are already experiencing flooding during storm surges and very high tides, are more likely to experience increased flooding as sea levels rise.
- Is there land subsidence in the coastal areas of your region?*
 - Land subsidence may compound the impacts of sea level rise.
- Do tidal gauges along the coastal parts of your region show an increase over the past several decades?*
 - Local sea level rise may be higher or lower than state, national, or continental projections.
 - Planners can find information on local tidal gauges at http://tidesandcurrents.noaa.gov/sltrends/sltrends_states.shtml?region=ca

V. Flooding

- Does critical infrastructure in your region lie within the 200-year floodplain? DWR's best available floodplain maps are available at: http://www.water.ca.gov/floodmgmt/lra/mo/fmb/fes/best_available_maps/*
 - While it is unclear how average precipitation will change with temperature, it is generally agreed that storm severity will probably increase. More intense, severe storms may lead to higher peak flows and more severe floods.
 - Refer to FEMA floodplain maps and any recent FEMA, US Army Corps of Engineers, or DWR studies that might help identify specific local vulnerabilities for your region. Other follow-up questions that might help answer this question:
 1. What public safety issues could be affected by increased flooding events or intensity? For example, evacuation routes, emergency personnel access, hospitals, water treatment and wastewater treatment plants, power generation plants and fire stations should be considered.
 2. Could key regional or economic functions be impacted from more frequent and/or intense flooding?

- Does part of your region lie within the Sacramento-San Joaquin Drainage District?*
 - The SSJDD contains lands that are susceptible to overflows from the Sacramento and San Joaquin Rivers, and are a key focus of the Central Valley Flood Protection Plan. (<http://www.water.ca.gov/cvfmpp/program.cfm>).

- Does aging critical flood protection infrastructure exist in your region?*
 - Levees and other flood protection facilities across the state of California are aging and in need of repair. Due to their overall lowered resiliency, these facilities may be particularly vulnerable to climate change impacts.
 - DWR is evaluating more than 300 miles of levees in the San Joaquin and Sacramento Rivers Valleys and the Delta (<http://www.water.ca.gov/levees/>).

- Have flood control facilities (such as impoundment structures) been insufficient in the past?*
 - Reservoirs and other facilities with impoundment capacity may be insufficient for severe storms in the future. Facilities that have been insufficient in the past may be particularly vulnerable.

- Are wildfires a concern in parts of your region?*
 - Wildfires alter the landscape and soil conditions, increasing the risk of flooding within the burn and downstream areas. Some areas are expected to become more vulnerable to wildfires over time. To identify whether this is the case for parts of your region, the California Public Interest Energy Research Program (PIER) has posted wildfire susceptibility projections as a Google Earth application at: <http://cal-adapt.org/fire/>. These projections are the results of only a single study and are not intended for analysis, but can aid in qualitatively answering this question. Read the application's disclaimers carefully to be aware of its limitations.

VI. Ecosystem and Habitat Vulnerability

- Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues?*
 - Erosion is expected to increase with climate change, and sedimentation is expected to shift. Habitats sensitive to these events may be particularly vulnerable to climate change.
- Does your region include estuarine habitats which rely on seasonal freshwater flow patterns?*
 - Seasonal high and low flows, especially those originating from snowmelt, are already shifting in many locations.
- Do climate-sensitive fauna or flora populations live in your region?*
 - Some specific species are more sensitive to climate variations than others.
- Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region?*
 - Species that are already threatened or endangered may have a lowered capacity to adapt to climate change.
- Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities?*
 - Economic values associated with natural habitat can influence prioritization.
- Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life?*
 - Constrained water quality and quantity requirements may be difficult to meet in the future.
- Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region?*
 - Storm surges are expected to result in greater damage in the future due to sea level rise. This makes fragile coastal ecosystems vulnerable.
- Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change (<http://www.itsgettinghotoutthere.org/>)?*
 - These ecosystems are particularly vulnerable to climate change.

- 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?*

- These ecosystems are particularly vulnerable to climate change.

VII. Hydropower

- Is hydropower a source of electricity in your region?*

- As seasonal river flows shift, hydropower is expected to become less reliable in the future.

- 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?*

- Energy needs are expected to increase in many locations as the climate warms. This increase in electricity demand may compound decreases in hydropower production, increasing its priority for a region.