
CHAPTER 8.0 CLIMATE CHANGE

8.1 Introduction

The act of planning requires an estimate of future conditions. Traditionally, resource managers have assumed that the past is a good indicator of the future, and have used historical measurements as best estimates for future conditions. Per Proposition 84 and California Department of Water Resources (DWR) requirements, this chapter considers an Upper Feather River (UFR) watershed that, as a result of climate change, may have substantially different climate conditions than historically witnessed in the planning area.

This chapter begins with a description of climate change regulations and requirements related to the integrated regional water management planning process, as well as an overview of the resources used to support chapter analysis and findings. The chapter then provides a brief explanation of how temperature and precipitation could change in the planning area, and how those changes could cause regional impacts. Based on these impacts, the chapter provides the findings of the climate change vulnerability assessment. The chapter concludes with a prioritized list of vulnerabilities in the planning area and a description of how climate change is integrated into the plan's resource management strategies and project selection process.

8.1.1 Regulatory Framework

The primary guidelines for the Upper Feather River Integrated Regional Water Management Plan (IRWMP) are in the DWR's *Integrated Regional Water Management Proposition 84 and 1E Guidelines*.¹ DWR's guidelines establish the general process, procedures, and criteria to implement the IRWMP Implementation Grant Program, funded by Proposition 84 (The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006) and the related Stormwater Flood Management Grant Program, funded by Proposition 1E (The Disaster Preparedness and Flood Protection Bond Act of 2006). The guidelines present 16 IRWMP Standards. Standard 16 (Climate Change) notes:

The IRWM Plan must address both adaptation to the effects of climate change and mitigation of GHG emissions. The IRWM Plan must include the following items:

- A discussion of the potential effect of climate change on the IRWM region, including an evaluation of the IRWM region's vulnerabilities to the effects of climate change and potential adaptation responses to those vulnerabilities. The evaluation of vulnerabilities must, at a minimum, be equivalent to the vulnerability assessment contained in the Climate Change Handbook for Regional Water Planning (December, 2011)
- A process that considers GHG emissions when choosing between project alternatives.
- The IRWM Plan must include a list of prioritized vulnerabilities based on the vulnerability assessment and the IRWM's decision making process.
- The IRWM Plan must contain a plan, program, or methodology for further data gathering and analysis of the prioritized vulnerabilities.

¹ DWR. 2012. *Integrated Regional Water Management Proposition 84 and 1E Guidelines*.

When assessing and evaluating climate change impacts and vulnerabilities, DWR's guidelines encourage IRWMP regions to bear in mind four documents in particular. These documents are briefly described below:

1. **Climate Change Handbook for Regional Water Planning.**² The Climate Change Handbook for Regional Water Planning (Handbook) assists IRWMP regions in incorporating climate change analysis and methodologies into their planning efforts. As noted above, Proposition 84 guidelines require that the climate change evaluation in this plan be equivalent to the vulnerability assessment contained in the Climate Change Handbook for Regional Water Planning. The climate change work completed for this chapter follows the suggested guidelines laid out in the Handbook.
2. **"Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water."**³ This white paper published by DWR urges a new approach to managing California's water and other natural resources in the face of climate change. The document emphasizes IRWM as the mechanism for fostering a collaborative regional approach to water management. The recommendations from the white paper are incorporated into Volume 1 Chapter 7 of California Water Plan.
3. **Safeguarding California.**⁴ The CNRA's *Safeguarding California* (2014) updated the California Climate Adaptation Strategy (2009) and discusses statewide and sector-specific vulnerability assessments, looking in particular at which climate factors will be driving impacts in each sector and how impacts interact across sectors. By identifying these inter-relationships, the document highlights opportunities to implement adaptation strategies across sectors. The report also provides comprehensive lists of adaptation by sector.
4. **Climate Change Scoping Plan.**^{5,6} CARB's Climate Change Scoping Plan describes different statewide greenhouse gas (GHG) emissions sectors, including water management, and recommends specific strategies that may help reduce GHG emissions. The 2014 update provides strategies for important GHG emissions sectors in the UFR Region, including agriculture, water, and natural and working lands.

8.1.2 Chapter Resources

This chapter is supported by numerous resources ranging from scholarly journals to local insights. The published resources used to support the analysis in this chapter are listed in (Section 8.7). It is important to note that the UFR watershed is incredibly diverse and has different climate and hydrological conditions throughout. The watershed is also remote and has limited data availability for some of the basins and sub basins. Due to its importance to state water and energy resources, the majority of available reliable data focuses on the North Fork of the Upper Feather River.

In addition to published resources, the planning team obtained local expertise through questionnaires administered via e-mail and in person to the Regional Water Management Group (RWMG); phone

² DWR, USEPA, and USACE. 2011. *Climate Change Handbook for Regional Water Planning*. http://www.water.ca.gov/climatechange/docs/Climate_Change_Handbook_Regional_Water_Planning.pdf.

³ DWR. 2008. "Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water." <http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf>.

⁴ CNRA (California Natural Resources Agency). 2014. *Safeguarding California: Reducing Climate Risk*. http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf.

⁵ CARB (California Air Resources Board). 2008. *Climate Change Scoping Plan*. http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.

⁶ CARB. 2014. *First Update to the Climate Change Scoping Plan*. http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf

interviews with staff from the counties located in the planning area; a climate change workshop in Quincy, CA in August 2015; and a presentation of this chapter to the RWMG in October 2015. The written and human resources used to develop this chapter ensure the proper balance of rigorous research and on-the-ground local knowledge.

8.2 Climate Change Trends

8.2.1 Introduction

Observed warming of the global climate system is unequivocal. Since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased; these observed global changes are expected to continue and accelerate into the foreseeable future.⁷ Scientists use models to project future climate conditions. Although models are imperfect and include assumptions and uncertainty, they provide the best available estimate of future conditions.

The local effects of global climate warming vary greatly depending on location. The state of California provides the Cal-Adapt data portal, a website that offers the best available local climate projections for a variety of variables under different climate change scenarios. The data used in the Cal-Adapt tools has been gathered from California's scientific community and represents the most current data available. The planning team used Cal-Adapt's Community Climate System Model 3.0 (CCSM3) to gather climate projections in the planning area for temperature and precipitation under a high and low emissions scenario.

The CCSM3 model is a coupled climate model for simulating the earth's climate system and is composed of one central coupler component and four separate models that simultaneously simulate the earth's atmosphere, ocean, land surface, and sea ice. The CCSM3 model is the default model when selecting data from Cal-Adapt.

Among the primary drivers of climate projections are GHG emissions scenarios. The Intergovernmental Panel on Climate Change (IPCC) has developed a set of possible future GHG emissions based on different scenarios of global population growth, economic growth, and government regulations of GHGs. Cal-Adapt projections are available for two IPCC emissions scenarios, A2 or B1:

- ◆ A2 is the medium-high emissions scenario. The A2 emissions scenario assumes continuous population growth and uneven economic and technological growth. It also assumes that heat-trapping emissions increase through the 21st century and that atmospheric carbon dioxide (CO₂) concentration approximately triples, relative to preindustrial levels, by 2100.
- ◆ B1 is the lower emissions scenario. The B1 emissions scenario assumes a world with high economic growth and a global population that peaks by mid-century and then declines. Under this scenario, there is a rapid shift toward less fossil fuel-intensive industries and the introduction of clean and

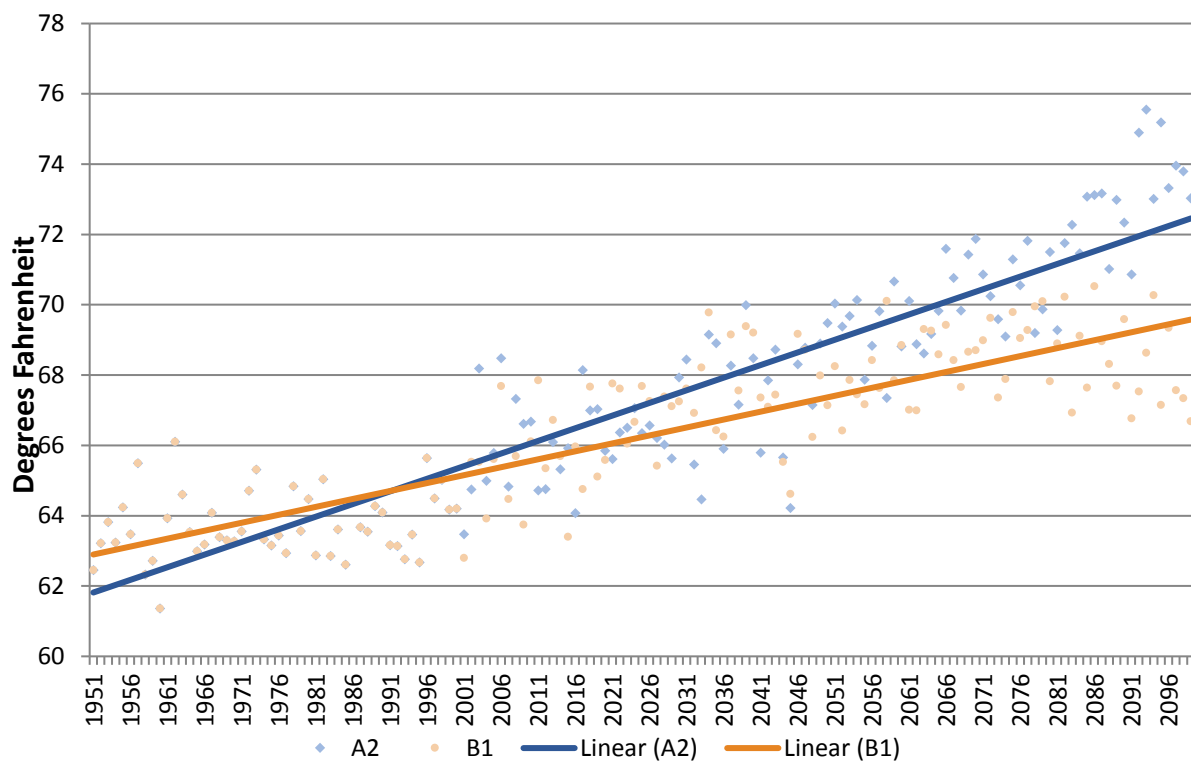
⁷ IPCC (International Panel on Climate Change). 2013. "Summary for Policymakers." In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf.

resource-efficient technologies. Heat-trapping emissions peak about mid-century and then decline; CO₂ concentration approximately doubles, relative to preindustrial levels, by 2100.

The planning team reviewed temperature and precipitation projections in the planning area through the 21st century. The figures below show the outputs for mean annual high temperature (Figure 8-1) and average annual precipitation per decade (Figure 8-2). For both emissions scenarios, temperature is expected to increase over the next century. Under the more extreme A2 scenario, the models show that temperatures would be expected to increase on average by approximately 5°F between 2000 and 2100. These averages smooth out temperature anomalies such as extreme heat and heat waves, which are also expected to increase as a result of climate change. Additionally, minimum temperatures are expected to increase through 2100, which could impact snowpack levels.

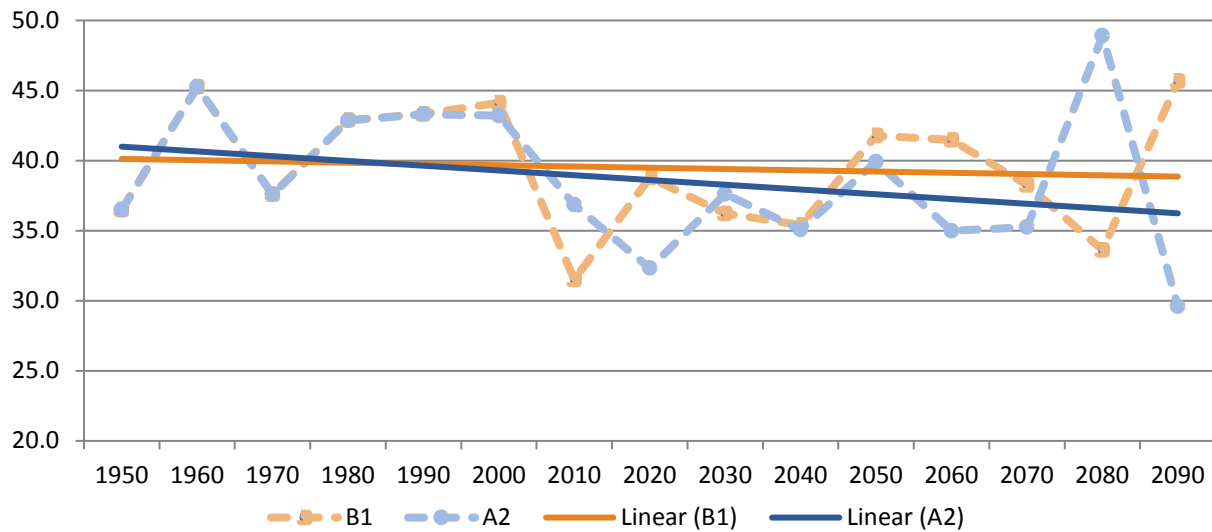
The trend is less clear with the model outputs for precipitation. The A2 scenario shows a slightly larger decrease in annual precipitation across the region; however, the decrease is not substantial under either scenario. What is shown is increasing variability in the amount of precipitation over time. The RWMG should continue to monitor precipitation projections as they become more refined and accurate. In the meantime, the planning area should expect the recent phenomenon of prolonged drought occasionally interspersed by intense downpour events to continue.

Figure 8-1. Mean Annual High Temperature (Fahrenheit)



Source: Cal-Adapt 2015

Figure 8-2. Annual Average Inches of Precipitation per Decade (A2 and B1)



Source: Cal-Adapt 2015

The changes in temperature and variability in precipitation are consistent with changes expected throughout the state. As a result of these changes, the state of California expects numerous climate change impacts to occur and worsen through the next century, including increased wildfires, decreased snowpack and snowmelt runoff, increasingly severe droughts, shifting habitat and threats to biodiversity, damage to forest health, and impacts on energy demand and energy production.⁸ The following discusses specific impacts that are expected to occur as a result of expected climate change including increased wildfire, decreased water supply, changes to water demand, poorer water quality, increased flooding, and changes to ecosystem habitat.

8.2.2 Wildfire

Rising temperatures and longer dry seasons, both of which are expected in the UFR watershed as a result of climate change, increase the risk of wildfire.⁹ Rising temperatures and earlier snowmelt are shown to increase the frequency, size, and severity of wildfires, trends which align with wildfire activity in the Sierra Nevada since the early 1980s.¹⁰ According to the Cal-Adapt Wildfire: Fire Risk Map (2015), the UFR watershed may experience a one- to twofold increase in burned area by 2050 and a two- to threefold increase in burned area by 2085.

⁸ CNRA (California Natural Resources Agency). 2014. *Safeguarding California: Reducing Climate Risk*. http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf.

⁹ DWR. 2015. *California Climate Science and Data for Water Resources Management*.

http://www.water.ca.gov/climatechange/docs/CA_Climate_Science_and_Data_Final_Release_June_2015.pdf

¹⁰ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests*.

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

In addition to the increased risk of wildfires from higher temperatures and ongoing drought, increasing fuel supply exacerbates the issue. As carbon dioxide supply increases with ongoing emissions and winter snows are replaced by heavy rain, the growth of plants is expected to accelerate.¹¹ Grasslands and brush species are positioned to flourish in this scenario, as they require less water and can rebound quickly from wildfires. The Region's existing coniferous forests will be increasingly vulnerable due to slower growth, difficulty of migration, and increased dryness.

While severity of wildfire is typically inversely related to frequency, research in the Sierra Nevada region indicates that fuel growth described above (more fuel-rich and drier) will likely increase both the frequency and the severity of fires. This will reduce the ability of large trees, such as conifers, to continue to migrate upslope and rebound from past events, as grassland will be quicker to rebound and provide adequate fuel for the next fire.¹²

These projected patterns for wildfires pose a serious threat to water quality in the UFR. Decreased forest and vegetation area as a result of catastrophic wildfire reduces the stability of soils, increasing erosion rates and runoff. If a heavy rain event occurs after a fire, soil, ash, and sediment flow into surface water resources in the UFR watershed, degrading water quality.¹³ Climate projections estimate that when precipitation does occur, it will be in the form of heavy rains, increasing the volume of water to carry sediment over burned areas into streams and waterbodies.¹⁴

8.2.3 Water Supply

The most significant water supply concern in the UFR associated with climate change is the reduction in precipitation, winter snowpack accumulation, and aquifer outflow from springs. Precipitation, occurring as both rain and snow, supply water for the residents of the region as well as runoff to Lake Oroville, a key feature of the State Water Project.

Climate change can directly affect the volume, timing, and type of precipitation (rain or snow) which affects the hydrologic cycle in the UFR basin and impacts the availability of water for beneficial use. The climate within the watershed is Mediterranean, with most of the annual precipitation occurring during the winter (November through March). Because the basin includes large areas that are near the average snowline, rainfall and rain-snow mixtures are common during winter storms. Consequently, the overall timing and rates of runoff from the basin are highly sensitive to winter temperature fluctuations.¹⁵ This

¹¹ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests.*

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

¹² USDA. 2013b. *Ecological Restoration Implementation Plan.*

<http://featherriver.org/catalog/files/EcologicalRestorationImplementationPlan.pdf>.

¹³ Sierra Nevada Conservancy. 2014. *The State of the Sierra Nevada's Forests.*

<http://www.sierranevada.ca.gov/our-work/docs/StateOfSierraForestsRptWeb.pdf>

¹⁴ DWR. 2015. *California Climate Science and Data for Water Resources Management.*

http://www.water.ca.gov/climatechange/docs/CA_Climate_Science_and_Data_Final_Release_June_2015.pdf

¹⁵ USGS (US Geological Survey). 2005. *Precipitation-Runoff Processes in the Feather River Basin, Northeastern California, and Streamflow, Predictability, Water Years 1971-97.*

<http://pubs.usgs.gov/sir/2004/5202/>

increases the potential for climate change effects associated with a reduced low elevation snowpack and a decrease in the annual watershed runoff.

As described in the vulnerability assessment, below, the interactions between climate, weather, and geology related to water resources in the UFR watershed are complex. A historical declining trend of unimpaired runoff was found for the North, Middle, and South Forks of the Feather River. Potential climate change impacts appear to be pronounced on the North Fork where permeable volcanic bedrock composition tends to contribute larger fractions of groundwater flow to streams than other parts of the Feather River basin.

Runoff from the North Fork is affected by annual reductions in rainfall and snowpack accumulation and melt, and the prolonged dry period which has significantly reduced flow from springs that provide baseline flows. The UFR watershed is experiencing some of the largest impacts in California from the decline of low elevation snowfall and early snowmelt.¹⁶ These observed impacts are expected to be exacerbated by future climate change. Models predict that by the end of the century, the Sierra snowpack may experience a 48–65 percent loss from the 1961–1990 average.¹⁷ Less snow predicted in the UFR watershed due to climate change coinciding with natural dry cycles (as evidenced from recent volcanic aquifer decline) will cause the resultant runoff impact to be more significant than otherwise anticipated.¹⁸

Increased evapotranspiration in the UFR watershed is likely taking place in the mixed conifer forests due to rising air temperatures. Increased forest growth and higher temperatures are the two key factors contributing to the increased evapotranspiration that has taken place in recent years. Forest management adaptations to precipitation variability, higher temperatures, and more extreme weather events are paramount to how the UFR, surrounding regions, and much of Northern California adapts to climate change with respect to water supply and ecological needs. Because the UFR is the source water area for Lake Oroville, which provides water supply to the State Water Project, understanding how specific management strategies affect the forests' responses to climate change will continue to grow in importance.

8.2.4 Water Demand

As water supply becomes increasingly tenuous, even steady levels of demand can put stress on the watershed. As surface water resources are diminished by decreased snowmelt, water users who previously depended on water from streams may turn to groundwater resources, extracting water at a faster rate than can be recharged. While currently groundwater makes up only a small amount of the watershed's overall water supply, it is the major supply source for rural single-family homes as well as public and private water supply systems. In rural areas, many homes are not connected to a municipal water system and are entirely dependent upon private wells for domestic use. As both groundwater and surface water resources diminish during drought period, these wells can be impacted by sedimentation, contaminants, or decreases in aquifer levels. Portions of the Sierra Valley, the largest groundwater aquifer in the

¹⁶ Freeman, Gary. 2010. *Tracking the Impact of Climate Change on Central and Northern California's Spring Snowmelt Subbasin Runoff*.

<http://www.plumascorporation.org/uploads/4/0/5/5/40554561/freeman2010.pdf>

¹⁷ DWR. 2015. *California Climate Science and Data for Water Resources Management*.

http://www.water.ca.gov/climatechange/docs/CA_Climate_Science_and_Data_Final_Release_June_2015.pdf

¹⁸ Freeman, Gary. 2015. *Planning Beyond California's Three Year Drought – A 2015 Hydroelectric Planning Perspective*. Presented at the 2015 Western Snow Conference.

<http://featherriverorg.alias.strange.com/wp-content/uploads/2014/10/3.FreemanComp.pdf>

watershed, have experienced declining water levels in recent decades.¹⁹ The population of the Sacramento River Basin, which includes the UFR watershed, is expected to double in the next 50 years, placing more demand from urban uses on the diminishing water supply although effects are expected to be less significant in the UFR Region of the Sacramento River Basin.²⁰

8.2.5 Water Quality

Water quality in the UFR is generally considered to be good. The primary threats to water quality in the UFR are from impacts related to common land and water use practices in this watershed, (e.g., ranching, mining, timber harvest, road construction/maintenance, and rural residential development).²¹

While it is unclear how average precipitation will specifically change with climate change, it is generally agreed that storm severity will probably increase. More intense, severe storms may lead to increased erosion, thus increasing turbidity in surface waters. Warming temperatures will result in lower dissolved oxygen levels in waterbodies, which are exacerbated by potential algal blooms and in turn enhanced eutrophication. Climate-induced increases in storm intensity may alter pollutant concentrations in waterbodies and produce increased turbidity. This could, in turn, decrease water quality. Stakeholders noted that issues related to eutrophication, such as low dissolved oxygen or algal blooms, are limited to reservoirs and that reservoir water temperature is relatively elevated under existing conditions, with increasing potential risks from temperature increases anticipated with climate change.

The increased risk of catastrophic wildfire associated with higher temperatures, and prolonged periods of drought, followed by significant storm events, may result in runoff and sedimentation that pose a significant threat to water quality in portions of the UFR such as the Feather River Canyon.

8.2.6 Flooding

Flooding poses numerous risks to critical facilities and infrastructure including roads or railroads blocked or damaged during flood events, bridges washed out or blocked, backed-up drainage systems, drinking water contamination, sewer systems backed up, and damage to underground utilities.²² In the UFR, flooding is of greatest concern during rain-on-snow events that increase the probability of high runoff. Increasing temperatures and reduced and earlier snowmelt are shown to increase the frequency of wildfires. Avalanche chutes, debris chutes, and alluvial fans can be extremely active in flood events that occur after wildfires, which can degrade the quality of the habitat and threaten aquatic species. Unmitigated forest growth without the intervention of a fuels reduction programs increase the risk of catastrophic fire which may intensify flooding impacts.

¹⁹ DWR. 2013. *California Water Plan Update 2013. Volume II: Regional Report, Mountain Counties Overlay Area*. http://www.waterplan.water.ca.gov/docs/cwpu2013/Final/Vol2_MountainCountiesRR.pdf

²⁰ Sacramento River Watershed Program. 2010. *A Roadmap to Watershed Management*. http://www.sacrivier.org/files/documents/roadmap/SRWP_ExecSummary.pdf

²¹ Ibid.

²² County of Plumas. 2013. *Plumas County Hazard Mitigation Plan*. <http://www.countyofplumas.com/DocumentCenter/View/10019>

8.2.7 Ecosystem Habitat

Impacts of climate change such as rising temperatures and changing precipitation patterns can have a lasting impact on the unique habitats and native species found in the UFR watershed.²³ In the mountainous parts of the watershed, temperature increases have led to thermal stress for species acclimated to a cooler climate. Forced upslope migrations and upward latitude changes have been observed in recent years, a trend that is expected to continue with increased climate-change related warming.²⁴ These forced migrations can cause thermal or other stress on native species, increasing the vulnerability of the watershed's habitats. Species that are found only in the UFR watershed are especially vulnerable to temperature increases or changes in water availability, as upward migration may not be physically possible in the time needed. Diversions and dams throughout the watershed fragment the habitat and inhibit the ability of thermally stressed inhabitants to access higher altitude and latitude environs more suitable to their biological requirements.

These changes can also have a dramatic effect on the balance of species in the watershed. As some native species struggle to adapt or move as a result of warming temperatures, "habitat generalists" including invasive plants, insects, and pathogens may find it easier to survive and further reduce habitat availability for natives. Heat-tolerant species will be especially positioned to take habitat from native species.²⁵ Warming and snowmelt earlier in the year may not only impact the habitats of species native to the watershed, but could also mismatch timing or distribution among species. For example, disruptions to normal hatching patterns may shift so that insect-eating species may be present before or after the hatching of their insect prey. This unbalanced distribution of species presence and patterns can further endanger species that depend on annual cycles for food, and allow the unchecked growth of another population.²⁶

The increasing risk of wildfire, as discussed above, also has the potential to disrupt habitats. As frequency and intensity of fires increases, habitats and plant and animal populations will have less time to recover, increasing vulnerability.²⁷ Shifting precipitation patterns toward more winter rain is expected to increase grass biomass in the watershed, which serves as increased fuel for fires. After wildfires are extinguished, invasive vegetation, grasslands and brush species will be far faster to recover than trees, fostering a burn and regrowth cycle that reduces and eventually eliminates habitat availability for tree species. This can decrease both the number of old-growth forest trees and threaten old-growth dependent flora and fauna.²⁸

²³ DWR. 2015. *California Climate Science and Data for Water Resources Management*.

http://www.water.ca.gov/climatechange/docs/CA_Climate_Science_and_Data_Final_Release_June_2015.pdf

²⁴ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests*.

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

²⁵ Hoshovsky, Marc. 2013. *Potential Impacts of Climate Change to California's Wildlife and Habitats*.

http://www.parks.ca.gov/pages/24772/files/01-mhoshovsky-cc_and_impacts_to_ca_habitat_and_wildlife.pdf

²⁶ Ibid.

²⁷ Ibid.

²⁸ USDA. 2013b. *Ecological Restoration Implementation Plan*.

<http://featherriver.org/catalog/files/EcologicalRestorationImplementationPlan.pdf>.

8.3 Regional Climate Change Vulnerabilities

Assets in the UFR watershed have varying capacity to respond to different climate change impacts. This section examines major climate change vulnerabilities related to water resources in the UFR watershed. This section presents the *Climate Change Handbook for Regional Water Planning* Vulnerability Assessment Checklist, per Proposition 84 guidelines. The checklist is presented by categories and provides key questions to assess vulnerability in each category. The responses to each question include cross-references to resource management strategies that could be employed to enhance regional adaptation to climate change impacts. As noted earlier in this chapter, the answers to each question below were derived using published resources, via questionnaires filled out by members of the RWMG and each of the working groups, and in a three-hour in-person working session with RWMG and working group members. The section concludes with a summary and prioritization of climate change vulnerabilities.

8.3.1 Water Demand

1) Are there major industries that require cooling/process water in your planning region?

☒ Yes ☐ No ☐ Perhaps/Uncertain

Agriculture, forestry, wood products, agricultural crops, energy production, and tourism are the main economic activities in the planning region. Some of these activities in the UFR Region require cooling water. Collins Pine Company operates a wood products manufacturing and co-generation electricity generating facility in Chester. Sierra Pacific Industries, in Quincy, also uses a cooling tower for a co-generation plant. These facilities are critical for handling biomass during wildfire prevention and response activities. Additionally, some timber mills in the Region require cooling water for log decks to avoid wood drying and staining.

2) Does water use vary by more than 50 percent seasonally in parts of your region?

☒ Yes ☐ No ☐ Perhaps/Uncertain

The largest change in variability as a result of climate change is a longer forest growing season and higher rates of evapotranspiration. Crop irrigation for hay and small fruit and nut operations, which have high seasonal variability, is also a substantial source of water demand in the UFR Region, with some suggesting it exceeds 50 percent of total anthropogenic water use. Additionally, the regional population grows significantly in the summer, with an influx of seasonal residents and tourists. These factors create seasonal water use patterns that depend on increased water availability in the summer months. Drought, earlier snowmelt, and decreased flows are expected to continue and worsen in the future, making this high demand period increasingly vulnerable to water shortages.

3) 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 ☐ No ☐ Perhaps/Uncertain

Timber production is an important regional commodity. While the UFR watershed's coniferous forests are more resilient to temperature fluctuations than many crops, decreases in precipitation may weaken the productive capacity of this sector. Climate impacts would be prohibitive for a small number of other crops in the region. A majority of the field crops in the region are hay (alfalfa, meadow, and grain) and pasture

(irrigated, nonirrigated, and range). In 2011, these crops were valued at \$9,591,000 in Plumas County and \$3,200,363 in Sierra County. Miscellaneous crops (nursery, apiary, seed, fruit, potatoes, and grains) accounted for \$250,000 of agricultural output in Plumas County and \$35,000 in Sierra County.²⁹ While these crop types represent a very small portion of the region's economy and land use, fruit and nut crops are some of the most sensitive to climate change impacts, specifically changes in precipitation and temperature.³⁰ Warming has been greatest in the Sierra Nevada foothill and mountain region, where the UFR watershed is located, increasing the vulnerability of temperature impacts to agricultural operations.³¹

4) Do groundwater supplies in your region lack resiliency after drought events?

☒ Yes ☐ No ☐ Perhaps/Uncertain

Much of the region's drinking water comes from groundwater supplies. Drought conditions prevent aquifers from recharging, a problem that is exacerbated when groundwater withdrawal exceeds infiltration. In the Upper North Fork Feather River, aquifer outflow has decreased 36 percent, a possible result of an earlier spring snowmelt period.³² In sustained drought conditions, any existing use of surface waters may be curtailed, shifting even more consumption to groundwater basins. This potentially increases vulnerability to subsidence, groundwater depletion, and decreased water supply for other essential water uses. The Sierra Valley Aquifer, the largest in the UFR watershed, has demonstrated a downward trend in water levels from 2005. All wells monitored by the Sierra Valley Groundwater Management District (SVGMD) had lower water levels in 2015 than they did in 2005, with some water levels nearly 20 feet deeper.³³ Previously, increases in groundwater pumping for irrigation and extreme drought conditions in the late 1970s led to a steady decline in Sierra Valley Aquifer water levels. Levels were slowly restored, reaching earlier 1970 levels by the late 1990s.³⁴ This suggests a slow recharge pattern in a decade-long drier precipitation pattern that may require additional management to conserve aquifer resiliency with continued growth in water demands and prolonged drought conditions.

The region is geographically and hydrologically diverse. Because of this, drought events impact the regions of the watershed differently. For example, a 2006 study for the Lake Front at Walker Ranch development, located on the west shore of the Lake Almanor Peninsula on the northeast side of the lake, determined that the Lake Almanor Groundwater Basin and the Mountain Meadows Valley Groundwater Basin were not in risk of overdraft. These basins are identified to have high capacity for recharge,

²⁹ County of Plumas. 2011. *Plumas and Sierra Counties' Annual Crop Report*.

<http://www.countyofplumas.com/ArchiveCenter/ViewFile/Item/1582>

³⁰ CDFA (California Department of Food and Agriculture). 2013. *Climate Change Consortium for Specialty Crops: Impacts and Strategies for Resilience*. www.cdfa.ca.gov/environmentalstewardship/pdfs/ccr-report.pdf.

³¹ Ibid.

³² Freeman, Gary. 2012. *Analyzing the Impact of Climate Change on Monthly River Flows in California's Sierra Nevada and Southern Cascade Mountain Ranges*.

<http://www.westernsnowconference.org/sites/westernsnowconference.org/PDFs/2012Freeman.pdf>

³³ SVGMD (Sierra Valley Groundwater Management District). 2015. *Technical Report on 2012-14 Hydrogeologic Evaluation for Sierra Valley*. <http://sierravalleygmd.org/2012-2014TechnicalReport.pdf>

³⁴ DWR (Department of Water Resources). 2004. *California Bulletin 118: Sierra Valley Groundwater Basin, Sierra Valley Groundwater Subbasin*.

<http://www.water.ca.gov/groundwater/bulletin118/basindescriptions/5-12.01.pdf>

increasing their resiliency to drought.³⁵ Groundwater monitoring data to sufficiently measure drought resiliency is not available for all basins and sub basins.

5) *Are water use curtailment measures effective in your region?*

☐ Yes ☐ No ☒ Perhaps/Uncertain

Plumas County proclaimed a local drought emergency on August 19, 2014.³⁶ These exemptions provide necessary relief to water users who depend on dwindling resources, but continued reliance may increase vulnerability. A sustained drought may increase hardships on the over 1,000 riparian and appropriative water rights holders in the region.³⁷ The State Water Resources Control Board (SWRCB) has extended mandatory curtailments on all water rights, including senior water rights holders. These curtailments vary in severity across the watershed but have especially impacted post-1914 water rights holders in the region. As of June 2015, the region had reduced metered residential water use by 22 percent, achieving SWRCB targets. In this regard, curtailment measures have effectively met state requirements. However, these curtailments have been challenging, especially for small and isolated communities in the UFR Region without access to other water sources. Although curtailment measures have met SWRCB requirements, if drought conditions persist or worsen, it is unclear how additional curtailments can be achieved in economically distressed communities with rapidly diminishing water supplies and no access to alternative water supplies.

6) *Are some instream flow requirements in your region either currently insufficient to support aquatic life, or occasionally unmet?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

The UFR has a breadth of users and cannot always support the flows needed by each sector especially during the summer and fall "low flow" seasons. Hydropower, timber manufacturing, agriculture, and tourism all make separate demands on the watershed. Aquatic species in the UFR that are already vulnerable to periods of low flow may become increasingly susceptible to harm as snowmelt patterns change. Although environmental water law in California reserves surface water resources for aquatic species, diminished flow magnitude from reduced runoff and sustained withdrawal from agricultural and urban users can significantly reduce biological integrity of aquatic communities.³⁸ Because river flow plays such an integral part in aquatic ecosystems, even moderate changes in magnitude can disrupt fish and macroinvertebrates.³⁹ In the last half-century, high-flow periods have occurred earlier as a consequence of

³⁵ Kleinfelder. 2007. *Supplemental Water Resources Assessment, Lake Front at Walker Ranch Development, Lake Almanor, Plumas County, California.*

³⁶ County of Plumas. 2014. *Proclamation of Local Emergency Due to Drought Conditions throughout Plumas County.* <http://www.countyofplumas.com/DocumentCenter/View/11735>.

³⁷ Ecosystem Sciences. 2005. *Integrated Regional Water Management Plan, Upper Feather River Watershed, California, Volume 1.* http://featherriver.org/wp-content/uploads/docs/IRWMP_063005.pdf.

³⁸ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests.*

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

³⁹ Carlisle, D., Wolock, D. and Meador, M. 2010. *Alteration of streamflow magnitudes and potential ecological consequences: a multiregional assessment.*

http://water.usgs.gov/nawqa/pubs/Carlisleetal_FlowAlterationUS.pdf.

warmer spring temperatures and the resulting snowmelt. This spring peak runoff creates a lower flow period in the summer. These shifting flows create extended, extreme wet and dry periods, which are difficult to manage and can disrupt the delivery of necessary flows for economic, recreational, and environmental needs.⁴⁰ The current drought has significantly reduced flows across the UFR watershed, especially in the North Fork, damaging Coldwater fish populations as a result.

Resource Management Strategies (RMS) for adapting to water demand vulnerabilities:

- ◆ Agricultural water use efficiency
- ◆ Urban water use efficiency
- ◆ Conveyance – regional/local
- ◆ System reoperation
- ◆ Water transfers
- ◆ Conjunctive management
- ◆ Precipitation enhancement
- ◆ Drinking water treatment and distribution
- ◆ Matching water quality to water use
- ◆ Agricultural land stewardship
- ◆ Land use planning and management
- ◆ Economic incentives
- ◆ Outreach and engagement
- ◆ Water and culture

8.3.2 Water Supply

1) *Does a portion of the water supply in your region come from snowmelt?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

According to the California Water Plan Regional Report for the Mountain Counties Area, the majority of water originates as surface water flows from the Sierra Nevada.⁴¹ The Upper Feather River watershed receives water runoff from snowmelt, with the amount of snowfall largely dependent on the location and topography within the UFR watershed.⁴² In Plumas County, snowpack at high elevations serves as a natural water reservoir that drains into the water system throughout the year.⁴³ Plumas County includes approximately 72 percent of the UFR watershed. A study by Gary Freeman (2010) showed that sub basins within the UFR watershed that are either in a rain shadow or behind topographic barriers are more likely to be impacted by climate change due to reduced snowpack and spring runoff, resulting in reduced

⁴⁰ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests.*

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

⁴¹ DWR. 2013. *California Water Plan Update 2013. Volume II: Regional Report, Mountain Counties Overlay Area.* http://www.waterplan.water.ca.gov/docs/cwpu2013/Final/Vol2_MountainCountiesRR.pdf

⁴² Freeman, Gary. 2012. *Analyzing the Impact of Climate Change on Monthly River Flows in California's Sierra Nevada and Southern Cascade Mountain Ranges.*

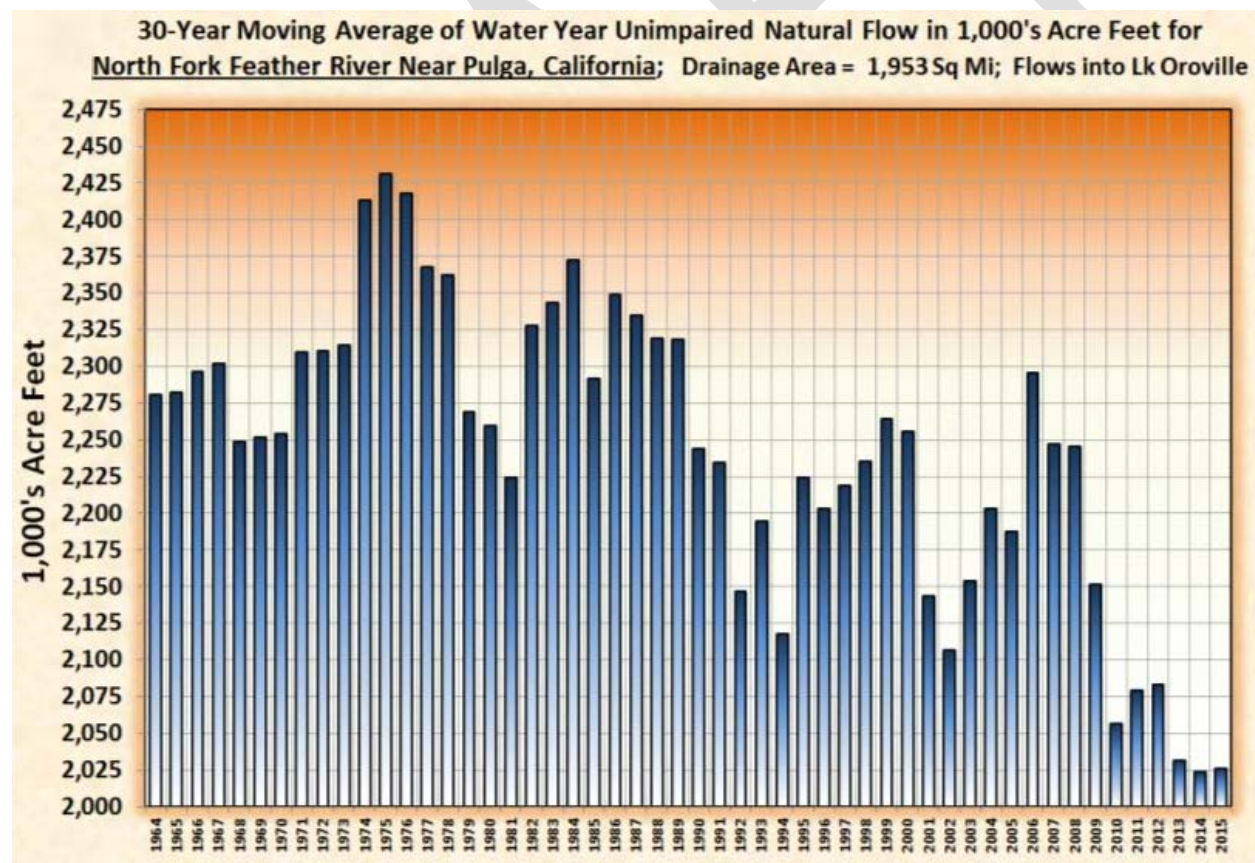
<http://www.westernsnowconference.org/sites/westernsnowconference.org/PDFs/2012Freeman.pdf>

⁴³ County of Plumas. 2012b. *2035 Plumas County General Plan Update Draft Environmental Report.* <http://www.countyofplumas.com/DocumentCenter/View/9351>

runoff for the water year. Highly impacted sub basins within the UFR watershed include the Lake Almanor sub basin and the East Branch North Fork Feather River sub basin. An analysis of the unimpaired natural flow of the Middle Fork and the South Fork of the Feather River (similar to the analysis shown in Figure 8-3) indicates that flows in the Middle Fork and South Fork have been impacted to a lesser degree than the North Fork. Additionally, the UFR watershed is experiencing some of the largest impacts in California from the decline of low elevation snowfall and early snowmelt.⁴⁴ Less snow predicted in the UFR watershed due to climate change coinciding with natural dry cycles (as evidenced from recent volcanic aquifer decline) will cause the resultant runoff impact to be more significant than otherwise anticipated.⁴⁵

Figure 8-3 illustrates the 30-year moving average (ex. data point 1964 is the average of 1935 through 1964) of the Water Year (October 1 through September 30) unimpaired natural flow for the North Fork Feather River near Pulga for the period 1964 through 2015. The declining trend indicates that over this period, 1935 through 2015, the North Fork Feather River has experienced a reduction in annual runoff restricting the ability to meet water demands.

Figure 8-3. North Fork Feather River Water Year (October 1–September 30) Runoff



⁴⁴ Freeman, Gary. 2010. *Tracking the Impact of Climate Change on Central and Northern California's Spring Snowmelt Subbasin Runoff*.

<http://www.plumascorporation.org/uploads/4/0/5/5/40554561/freeman2010.pdf>

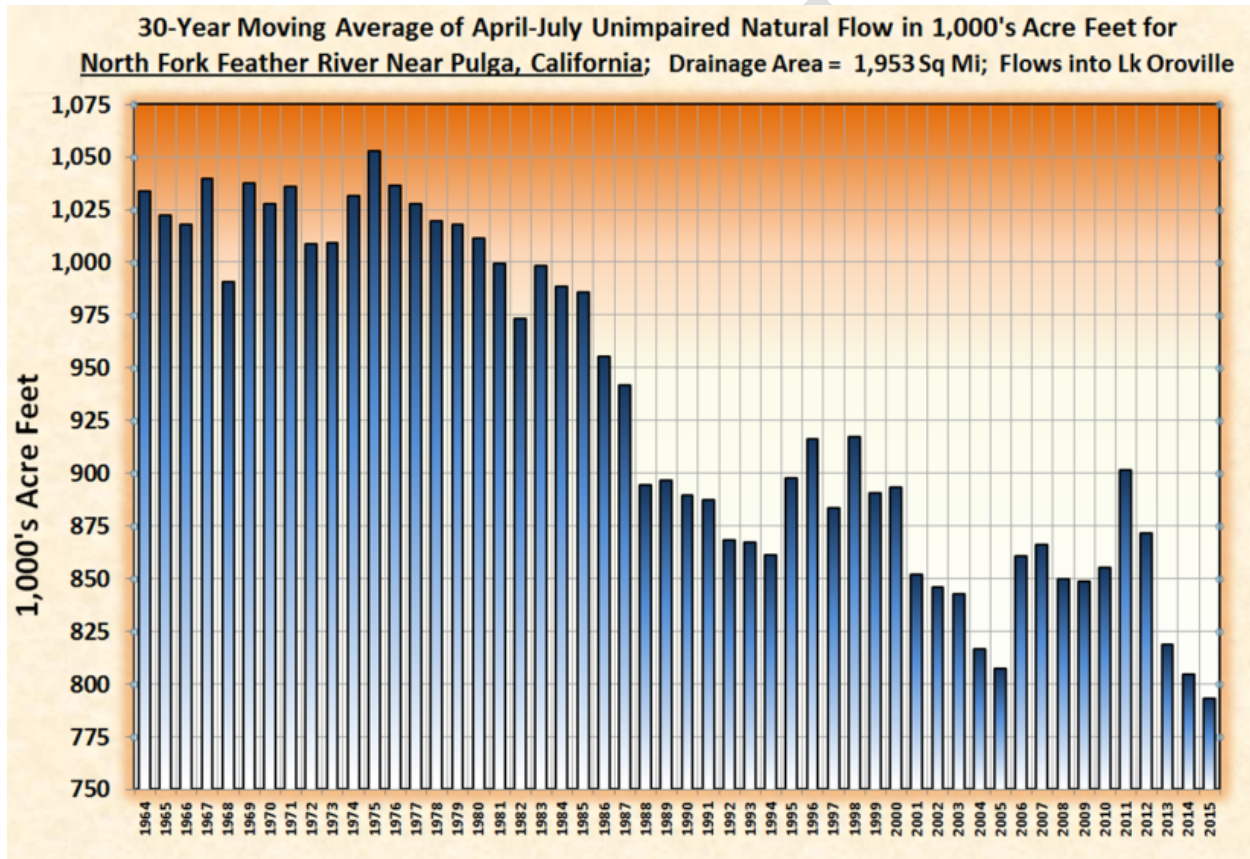
⁴⁵ Freeman, Gary. 2015. *Planning Beyond California's Three Year Drought – A 2015 Hydroelectric Planning Perspective*. Presented at the 2015 Western Snow Conference.

<http://featherriverorg.alias.strangeocode.com/wp-content/uploads/2014/10/3.FreemanComp.pdf>

Source: Freeman 2015.

Figure 8-4 illustrates the 30-year moving average of April through July unimpaired natural flow for the North Fork Feather River near Pulga. Although similar to the Water Year chart above, we see an even starker declining trend indicating not only a reduction in overall flow, but also a reduction of that flow occurring as snowmelt which typically makes up the bulk of the flow occurring during the April through July period.

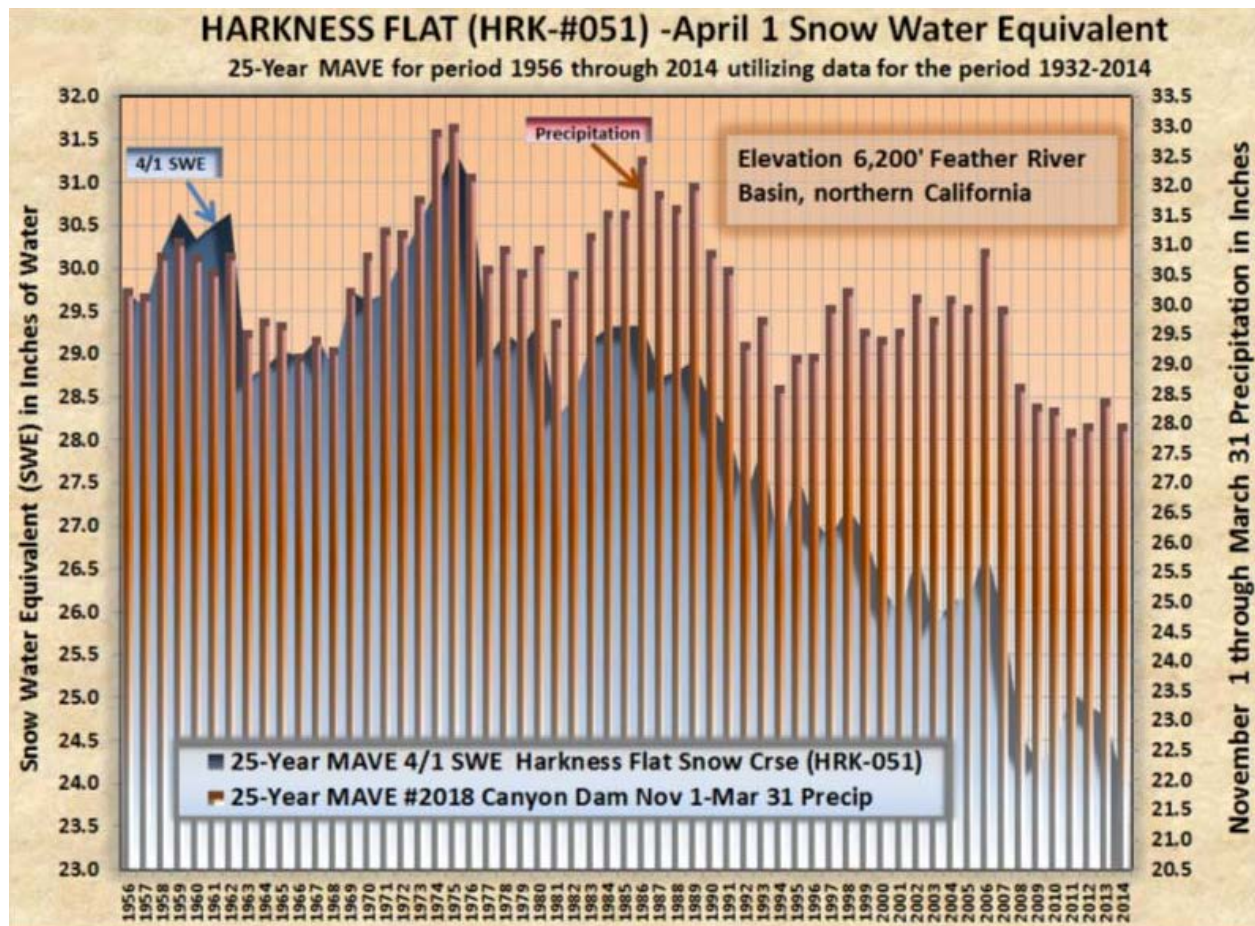
Figure 8-4. North Fork Feather River April–July Runoff



Source: Freeman 2015.

Figure 8-5 illustrates the 25-year moving average of the April 1 Harkness Flat Snow Course located on the Upper North Fork Feather River utilizing the period 1932 through 2014. This snow course is a permanent site that represents snowpack conditions in snow water equivalent. Snow water equivalent is the depth, in inches, of the water that would form if the snow were to melt. There is a declining trend suggesting a reduced snowpack over time. This matches the conclusion discussed above of a reduced snowpack over time. The figure also charts the 25-year moving average of the November 1 through March 31 precipitation at Canyon Dam (Lake Almanor). This, too, indicates a trend of reduced precipitation over time.

Figure 8-5. Harkness Flat Snow Course April 1 Snow Water Equivalent and November 1 through March 31 Precipitation at Canyon Dam



Source: Freeman 2015.

2) 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 ☐ No ☐ Perhaps/Uncertain

Water is diverted by canal from Little Truckee River, a primary tributary to the Truckee River, into Webber Creek for supplemental irrigation use in portions of the Sierra Valley. These waters eventually flow into the Feather River Basin. The maximum diversion rate is 60 cubic feet per second during the growing season (March 15 through September 30). This interbasin water diversion varies from about 1,500 acre-feet per year to 10,000 acre-feet per year with an average of about 5,700 acre-feet per year.⁴⁶

⁴⁶ Nevada Division of Environmental Protection, Bureau of Water Quality Planning. 1997. *Truckee River Chronology: A Chronological History of Truckee River and Related Water Issues*. <http://truckeeriver.org/wp-content/uploads/2013/11/Truckee-River-Chronology-1997.pdf>

3) Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past?

☐ Yes ☒ No ☐ Perhaps/Uncertain

The region is not located near the coast. Salt intrusion is not an issue for the region.

4) Would your region have difficulty in storing carryover supply surpluses from year to year?

☒ Yes ☐ No ☐ Perhaps/Uncertain

Reservoirs in the UFR historically spill frequently during the spring when inflow exceeds both the available usable capacity of the seasonal reservoirs and the capacity of releasing inflow through outlets.⁴⁷ Rain-shadowed sub basins in the watershed are experiencing earlier snowmelt, an increased proportion of precipitation occurring as rain with less snowfall overall, and reduced aquifer outflow from springs. The filling of mountain reservoirs from snowmelt earlier in the year and an increasing dependence on rainfall for filling is anticipated to eventually lead to an increased likelihood for spill from reservoirs in the UFR watershed.⁴⁸ Under these conditions, reservoirs without mandated flood reservations are expected to be operated to hold storage higher than historical practice to help meet late summer and fall water demands, which will increase the risk of reservoir spills. As snowpack reduces, there is likely to be increased motivation to hold water in storage. According to stakeholders, meadows in the basin have been impacted reducing their capacity to store water and relax the natural flow hydrograph. Stakeholders also noted that there is unused groundwater storage, primarily in the North Fork Feather River basin, and that stormwater capture could be a source of water.

5) Has your region faced a drought in the past during which it failed to meet local water demands?

☒ Yes ☐ No ☐ Perhaps/Uncertain

According to the Plumas County General Plan, adequate water supply is currently available for water purveyors in Plumas County and all have reported sufficient supply to meet projected water demands until 2030.⁴⁹ The majority of potable water supply in Plumas County is provided by a variety of individual Community Service Areas (CSA), Community Services Districts (CSDs), and Public Utility Districts (PUDs) that serve the various communities located throughout the region. During water years 2014 and 2015, due to statewide drought conditions, the State Water Resources Control Board (SWRCB) curtailed post-1914 water rights tributary to the Sacramento-San Joaquin Delta, including the UFR watershed. This curtailment reduced the ability to divert water, impacting water supply availability. In response, water purveyor demand management plans have been effective in balancing available water supply with demand. Climate change impacts could lead to more severe, frequent, and prolonged drought conditions, reducing the reliability of the local water supply. According to stakeholders, during times of drought, some agricultural water supplies are not considered adequate and residential wells have gone dry,

⁴⁷ Freeman, Gary. 2012. *Analyzing the Impact of Climate Change on Monthly River Flows in California's Sierra Nevada and Southern Cascade Mountain Ranges*.

<http://www.westernsnowconference.org/sites/westernsnowconference.org/PDFs/2012Freeman.pdf>

⁴⁸ Ibid.

⁴⁹ County of Plumas. 2012a. *2035 Plumas County General Plan Update*.

<http://www.countyofplumas.com/DocumentCenter/View/9356>

requiring drilling deep wells and the trucking of water to homes. Low-income well owners are particularly vulnerable to dry wells or surface water curtailments.

6) Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas?

☒ Yes ☐ No ☐ Perhaps/Uncertain

According to the Environmental Impact Report (EIR) prepared for the Upper North Fork Feather River Hydroelectric Project (UNFFR Project), several invasive and noxious weeds have been introduced to the UFR watershed. Surveys conducted by Garcia and Associates in 2000 found nine species of invasive and noxious weeds occurring in disturbed areas around the reservoirs and along roads and the river within the UNFFR Project area.⁵⁰ The EIR also identified a risk of spreading invasive plants or noxious weeds with increased ground disturbance in the areas surrounding the reservoirs, roads, and along the river, which could have an adverse effect on special-status plants that may occur within the UFR watershed.⁵¹

Certain invasive species are expected to be favored as a result of warming and drying conditions. Additional invasive species act as stressors on native species that, when combined with lower flows or erratic flow regimes more likely with greater climate variability, can cause decreased viability for desired species. Stakeholders noted the existence of yellow star thistle (*Centaurea solstitialis*) in the UFR basin and the concern for introduction of quagga and zebra mussels, which exist in the region, both invasive species that could be advantaged through climate change.

RMS for adapting to water supply vulnerabilities:

- ◆ Urban water use efficiency
- ◆ Conveyance – regional/local
- ◆ System reoperation
- ◆ Water transfers
- ◆ Conjunctive management
- ◆ Precipitation enhancement
- ◆ Municipal recycled water
- ◆ Surface storage – regional/local
- ◆ Drinking water treatment and distribution
- ◆ Groundwater remediation/aquifer remediation
- ◆ Forest management
- ◆ Recharge area protection
- ◆ Economic incentives
- ◆ Outreach and engagement
- ◆ Water-dependent recreation

⁵⁰ SWRCB. 2014. *Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact Report*. http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/upper_feather_ferc2105/eir2014nov/unffr_6_6.pdf.

⁵¹ Ibid.

8.3.3 Water Quality

1) 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 ☐ No ☐ Perhaps/Uncertain

According to a report prepared by the Sierra Nevada Conservancy (2014), *The State of the Sierra Nevada's Forests*, the Sierra Nevada (including the UFR watershed) are at a high risk for uncharacteristically large and damaging wildfires. After fires, burn areas can experience increased erosion rates due to the increases in runoff and lack of vegetation to stabilize the soil. According to the Cal-Adapt Wildfire: Fire Risk Map (2015), the UFR watershed may experience a one- to twofold increase in burned area by 2050 and a two- to threefold increase in burned area by 2085. The fire season has extended in recent years, according to stakeholders. Increased fire frequency, intensity, and season may impact vegetative species composition, especially the size and extent of old-growth forest habitat and related fauna; threaten critical facilities located in fire-prone areas; and increase chances for human and economic loss due to development in fire-prone areas. Reservoir water quality has been adversely affected by increased post-fire erosion. According to stakeholders, mercury is a concern as well increasing risks associated with forest densification combined with decades of fire suppression policy and activities. Numerous communities lack adequate water supplies for firefighting, although with the absence of CALFIRE stations in the Region, communities are their own first responders to wildfire for considerable periods of time during large or widespread forest fire events.

2) Does part of your region rely on surface waterbodies 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 ☐ No ☐ Perhaps/Uncertain

Water quality in the UFR watershed in Plumas County is generally considered to be good; however, there are general concerns including temperature, dissolved oxygen, sediment, and bacteria. Additionally, several waterbodies are listed on the Clean Water Act's 303(d) list of impaired waters for mercury, copper, temperature, and toxicity. These waters include Feather River, North Fork (below Lake Almanor); and Feather River, South Fork (Little Grass Valley Reservoir to Lake Oroville).⁵²

Water quality in the UFR watershed is heavily influenced by Lake Almanor, as the majority of its water flows through several reservoirs and into Lake Oroville. According to the UNFFR Project EIR, Lake Almanor generally meets water quality objectives set by the SWRCB in the Sacramento Basin Plan. Water temperature in Butt Valley Reservoir is heavily influenced by Lake Almanor and the operation of hydropower facilities. In general, Butt Valley Reservoir, just downstream of Almanor, shows similar dissolved oxygen (DO) concentrations as Lake Almanor, which currently meets water quality objectives. Other reservoirs in the UFR watershed include Belden Forebay, Seneca Reach, and Belden Reach, all of which are directly or indirectly influenced by Lake Almanor and reservoir operations. Thus, water quality is

⁵² County of Plumas. 2012b. *2035 Plumas County General Plan Update Draft Environmental Report*. <http://www.countyofplumas.com/DocumentCenter/View/9351>

relatively similar to Lake Almanor and Butt Valley Reservoir; however, water temperature fluctuates depending on hydropower operations, and DO can be slightly elevated depending on the time of year.⁵³

Warming temperatures will result in lower dissolved oxygen levels in waterbodies, which are exacerbated by potential algal blooms and in turn enhanced eutrophication. Climate-induced increases in storm intensity may alter pollutant concentrations in waterbodies and produce increased turbidity. This could, in turn, decrease water quality.

Stakeholders noted that issues related to eutrophication, such as low dissolved oxygen or algal blooms, are limited to reservoirs and that reservoir water temperature is relatively elevated under existing conditions, increasing potential risk from climate change.

3) Are seasonal low flows decreasing for some waterbodies in your region? If so, are the reduced low flows limiting the waterbodies' assimilative capacity?

☒ Yes ☐ No ☐ Perhaps/Uncertain

UFR watershed flows are largely regulated by a series of hydroelectric projects located on the North Fork Feather River above Oroville Dam. Lake Almanor is the start of the system and was constructed to store water in the winter and spring and release flows throughout the summer and fall for hydropower generation.⁵⁴

As stated above under the Water Supply subsection, the rain-shadowed sub basins in the UFR watershed (the Lake Almanor sub basin and the East Branch North Fork Feather River sub basin) are experiencing earlier snowmelt, an increased proportion of precipitation occurring as rainfall with less snowfall overall, and reduced aquifer outflow from springs. This change in precipitation timing and type has resulted in the filling of mountain reservoirs from snowmelt earlier in the year. An increasing dependence on rainfall for filling is anticipated to eventually lead to an increased likelihood for spill from reservoirs.⁵⁵ It is likely that streamflow will increase in some areas of the UFR watershed during the spring. The Freeman 2012 study considered the possible side effects of climate change on runoff by comparing two consecutive 35-year periods (1942–1976 and 1977–2011). Trend analyses over a moving 30-year average show reductions in flow on tributaries to the Feather River watershed at about 4.5 percent. This would suggest that overall seasonal low flows are decreasing in the UFR watershed. Additionally, these low-flow conditions are expected to be more extreme and last longer. Decreased flows in some waterbodies will likely result in higher concentrations of pollutants and reduced assimilative capacity.

An analysis of the unimpaired natural flow of the Middle Fork and the South Fork of the Feather River (similar to the analysis shown in Figure 8-3) indicates that flows in the Middle Fork and South Fork have been impacted to a lesser degree than the North Fork. The risks to seasonal low flows are also expected to be lesser in the Middle Fork and South Fork.

⁵³ SWRCB. 2014. *Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact Report*. http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/upper_feather_ferc2105/eir2014nov/unffr_6_6.pdf.

⁵⁴ Ibid.

⁵⁵ Freeman, Gary. 2012. *Analyzing the Impact of Climate Change on Monthly River Flows in California's Sierra Nevada and Southern Cascade Mountain Ranges*. <http://www.westernsnowconference.org/sites/westernsnowconference.org/PDFs/2012Freeman.pdf>

4) Are there beneficial uses designated for some waterbodies in your region that cannot always be met due to water quality issues?

☒ Yes ☐ No ☐ Perhaps/Uncertain

According to the Basin Plan, the North Fork Upper Feather River provides several beneficial uses including municipal and domestic water supply, hydropower generation, water contact recreation, water non-contact recreation, cold freshwater habitat, spawning habitat, and wildlife habitat.⁵⁶ The Basin Plan indicates the Middle Fork Feather River provides the following beneficial uses: agricultural, recreation, warm and cold water freshwater habitat, spawning habitat, and wild habitat. Beneficial uses for the South Fork Feather River are not listed in the Basin Plan. In addition to hydropower generation, the UNFFR Project provides approximately 30,920 acres of reservoirs and tributaries that provide water contact and water non-contact recreational opportunities.⁵⁷ The SWRCB has not reported any water quality issues in connection with beneficial uses.

Overall climate drying and warming could exacerbate elevated water temperatures, a reduced capacity for dilution, potential for eutrophication and total organic carbons related to increased algae presence, sediment and non-point source pollution from more intense storm events and higher peak flows, and the potential for wastewater runoff into receiving waters.

5) Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation?

☒ Yes ☐ No ☐ Perhaps/Uncertain

While it is unclear how average precipitation will change with climate change, 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. The region's water treatment needs are met in several ways, including through on-site septic systems, community septic systems, and community wastewater treatment plants (County of Plumas 2012b; Sierra County 2015).^{58,59} At least one system in the watershed has experienced overflows due to excessive inflow, which is exacerbated by rainfall.⁶⁰ According to stakeholders, there is a potential risk to water treatment and wastewater treatment facility operation during severe rain events, which could be exacerbated with climate change.

⁵⁶ Central Valley RWQCB (Regional Water Quality Control Board). 2011. *The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region Fourth Edition, the Sacramento River Basin and the San Joaquin River Basin*.

http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr.pdf

⁵⁷ SWRCB. 2014. *Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact Report*.

http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/upper_feather_ferc2105/eir2014nov/unffr_6_6.pdf

⁵⁸ County of Plumas. 2012b. *2035 Plumas County General Plan Update Draft Environmental Report*.

<http://www.countyofplumas.com/DocumentCenter/View/9351>

⁵⁹ Sierra County. 2015. *Liquid Waste & Onsite Sewage Disposal*.

<http://www.sierracounty.ca.gov/index.aspx?NID=236>

⁶⁰ SWRCB (State Water Resources Control Board). 2009. *RESCISSION OF CEASE AND DESIST ORDER No. 93-068 for City of Portola*.

http://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/plumas/r5-2009-0094.pdf

RMS for adapting to water supply vulnerabilities:

- ◆ Flood management
- ◆ Conveyance – regional/local
- ◆ System reoperation
- ◆ Precipitation enhancement
- ◆ Drinking water treatment and distribution
- ◆ Groundwater remediation/aquifer remediation
- ◆ Matching water quality to water use
- ◆ Pollution prevention
- ◆ Salt and salinity management
- ◆ Urban stormwater runoff management
- ◆ Ecosystem restoration
- ◆ Forest management
- ◆ Recharge area protection
- ◆ Sediment management
- ◆ Watershed management

8.3.4 Flooding

1) Does critical infrastructure in your region lie within the 200-year floodplain?

☒ Yes ☐ No ☐ Perhaps/Uncertain

The Federal Emergency Management Agency (FEMA) has developed best available floodplain maps with delineated 100- and 500-year flood zones for Plumas County. The DWR has not delineated the 200-year flood zones in Plumas County. The majority of the 100-year flood zones are associated with local watercourses.⁶¹ Development in the region is discouraged within the 100-year flood zones.

Because the 200-year floodplain is not delineated, it is not known if critical infrastructure lies within the 200-year floodplain. The Plumas County Hazard Mitigation Plan indicates that there are 69 critical facilities (out of 720) at risk from flooding. Critical facilities data were overlaid with flood hazard data to determine the type and number of facilities within the 100- and 500-year floodplain. Flooding poses numerous risks to critical facilities and infrastructure including roads or railroads blocked or damaged, bridges washed out or blocked, backed-up drainage systems, drinking water contamination, sewer systems backed up, and damage to underground utilities.⁶²

Localized drainage problems with flooding do occasionally occur. In Plumas County, flooding may result from rainfall and runoff exceeding the capacity of local watercourses, rainfall and runoff to depressions causing localized areas of shallow flooding, or flooding from failure of a dam. Some communities are at risk to flooding from dam failure and inundation.⁶³ Additionally, and according to stakeholders, the

⁶¹ County of Plumas. 2012a. *2035 Plumas County General Plan Update*.

<http://www.countyofplumas.com/DocumentCenter/View/9356>

⁶² County of Plumas. 2013. *Plumas County Hazard Mitigation Plan*.

<http://www.countyofplumas.com/DocumentCenter/View/10019>

⁶³ County of Plumas. 2012a. *2035 Plumas County General Plan Update*.

<http://www.countyofplumas.com/DocumentCenter/View/9356>

wastewater plant and fire departments are susceptible to flooding that could be increased from climate change.

2) *Does part of your region lie within the Sacramento-San Joaquin Drainage District?*

☐ Yes ☒ No ☐ Perhaps/Uncertain

The UFR watershed is north of the Sacramento-San Joaquin Drainage District.

3) *Does aging critical flood protection infrastructure exist in your region?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

Stakeholders indicated that the Taylorsville Mill Race Farmers Dam is in need of repair.

4) *Have flood control facilities (such as impoundment structures) been insufficient in the past?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

Flood control facilities, including the Big Ditch flood control channel in Chester, have historically provided adequate levels of flood protection. According to stakeholders, local flooding risk is present at road crossing and culverts and the Taylorsville Mill Race Farmers Dam has been insufficient in the past.

5) *Are wildfires a concern in parts of your region?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

Rising temperatures and earlier snowmelt are shown to increase the frequency of wildfires, especially in Northern California. Fire size and intensity have already increased significantly in the Sierra Nevada since the early 1980s.⁶⁴ Increasing fuel supply has also led to the regional increase in wildfires, a product of increased winter rains in place of snowfall.⁶⁵ The Plumas County Hazard Mitigation Plan indicates that the highest fuel hazard is along the Feather River Canyon.⁶⁶ According to the Cal-Adapt Wildfire: Fire Risk Map (2015), the UFR watershed may experience a one- to twofold increase in burned area by 2050 and a two- to threefold increase in burned area by 2085. This increased risk of severe wildfires poses a significant risk to water quality in the Upper Feather River by increasing sedimentation and runoff that disrupt the river's normal and healthy function. Avalanche chutes, debris chutes, and alluvial fans can be extremely active in flood events that occur after wildfires, which can degrade the quality of the habitat and threaten aquatic species. Unmitigated forest growth without the intervention of a fuels reduction program may increase this risk.

⁶⁴ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests.*

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

⁶⁵ Ibid.

⁶⁶ County of Plumas. 2013. *Plumas County Hazard Mitigation Plan.*

<http://www.countyofplumas.com/DocumentCenter/View/10019>

RMS for adapting to flooding vulnerabilities:

- ◆ Flood management
- ◆ Conveyance – regional/local
- ◆ System reoperation
- ◆ Precipitation enhancement
- ◆ Urban stormwater runoff management
- ◆ Land use planning and management
- ◆ Watershed management

8.3.5 Ecosystem and Habitat Vulnerability

1) *Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

The region features complex topography and multiple waterways, as well as highly erodible granitic and sedimentary soils. Grazing and timber production in the region's riparian zones have decreased vegetation and increased the amount of sedimentation and runoff in adjacent waterbodies.⁶⁷ In the past, these activities were the leading causes of erosion in the UFR watershed. While these sectors still cause issues of erosion in some portions of the watershed, stakeholders noted that current management practices have significantly decreased their impacts on aquatic habitats. As noted earlier, the growing threat of wildfires will consequently increase the amount of erosion and sedimentation in the watershed, increasing the region's vulnerability to negative habitat impacts as a result. Additionally, roads in the watershed are understood to exacerbate erosion and sedimentation issues.

A variety of aquatic habitats, including lakes, rivers, streams, and reservoirs, exist in the watershed. Aquatic species in the region, including rainbow and brown trout, landlocked Chinook salmon, large- and small-mouth bass, green sunfish, Sacramento perch, channel catfish, and brown bullhead catfish, can be negatively impacted by increased turbidity from sedimentation and erosion (Sierra Institute for Community and Environment 2009).

2) *Does your region include estuarine habitats which rely on seasonal freshwater flow patterns?*

☐ Yes ☒ No ☐ Perhaps/Uncertain

The region does not encompass any estuarine habitats.

3) *Do climate-sensitive fauna or flora populations live in your region?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

Although all flora and fauna can be impacted by climate-caused habitat changes, plant and animal species that can live in a broad range of conditions are more resilient to these changes than those that can only survive in a very narrow habitat. Because of an inability to migrate to another habitat, the species that are

⁶⁷ PCFCWCD (Plumas County Flood Control and Water Conservation District). 2004. *Feather River Watershed Management Strategy*. <http://featherriver.org/wp-content/uploads/docs/FeatherRiverStrategy.pdf>.

found only in the Upper Feather River Region are especially sensitive to climate-related changes. The most recent State Wildlife Action Plan identified no fish or invertebrate species as focal species of conservation strategies in the Sierra Nevada Foothills and Sierra Nevada regions, but does identify many amphibian, reptile, and bird species.⁶⁸ The UFR watershed is diverse and complex, and changes in habitat factors such as temperature or precipitation can impact a wide range of species. In the Sierra Nevada region, 60 percent of coniferous forest bird species are expected to experience significant range reduction, narrowing the amount of acceptable habitat and increasing vulnerability.⁶⁹ Decreased stream flow and rising water temperatures in the Sierra Nevada are likely to increase thermal stress on salmonids and decrease ranges for sensitive species such as rainbow trout.⁷⁰ Even decreasing winter snowfall can increase grazing by deer and elk throughout the winter, which in turn reduces the growth of certain tree species, damaging essential habitat for songbirds in the region.⁷¹ The interconnectedness of the region's climate with all of the species that live there means that shifts in normal temperature and precipitation closely impact many of the native species.

4) Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region?

☒ Yes ☐ No ☐ Perhaps/Uncertain

Chapter 3 *Region Description* provides an overview of existing endangered and threatened species conditions in the UFR Region. A majority of the existing research on changes in species distribution in the region shows that upslope movement into higher elevations of the Sierra Nevada has been and will continue to be the trend in regional habitat movement.⁷² A pattern of climate-driven changes in fire activity, which has the potential to further disrupt species distribution, has also already been observed.⁷³

5) Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities?

☒ Yes ☐ No ☐ Perhaps/Uncertain

Fishing, boating, kayaking, swimming, hunting, bird-watching, agritourism, and agriculture are all integral parts of the economic prosperity of the UFR Region. The Plumas County Visitors Bureau promotes outdoor recreation as a popular tourist attraction for the region in every season. Cross-country skiing, longboard racing, snowmobiling, and snowshoeing are winter attractions that may also be negatively

⁶⁸ CDFW (California Department of Fish and Wildlife). 2015. State Wildlife Action Plan, Province-Specific Conservation Categories – Central Valley and Sierra Nevada.

<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=100045&inline>

⁶⁹ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests.*

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

⁷⁰ Ibid.

⁷¹ Ibid.

⁷² Ibid.

⁷³ Ibid.

impacted by a reduced snowpack.⁷⁴ Agricultural and wood processing industries, rely on the watershed for irrigation and milling.

6) Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life?

☒ Yes ☐ No ☐ Perhaps/Uncertain

Pacific Gas and Electric Company (PG&E) manages a number of dams along the North Fork Feather River and releases water to meet minimum flow requirements for aquatic species along the Seneca and Belden reaches.⁷⁵ Diminished flow is an integral predictor of fish and macroinvertebrate community health.⁷⁶ Stakeholders noted that water has been released from Lake Almanor to reduce issues associated with diminished flows, but high water temperatures and low dissolved oxygen in these releases can be uninhabitable for aquatic species. If sustained drought or increased water temperature continues to exacerbate existing conditions, reduced flow could diminish both the quality and the quantity of habitat for aquatic species.⁷⁷ As mentioned above, flows in the Middle Fork and South Fork have been impacted to a lesser degree than the North Fork.

7) Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region?

☐ Yes ☒ No ☐ Perhaps/Uncertain

There are no estuaries, coastal dunes, wetlands, marshes, or exposed beaches in the region. Coastal storms are not a concern.

8) 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 ☐ No ☐ Perhaps/Uncertain

Most of the UFR Region in California's Sierra Nevada range, which is identified by the Endangered Species Coalition as one of the top 10 most vulnerable habitats to climate change. The region has a diverse ecosystem, which is dependent on snowmelt from the Sierra Nevada and Cascade ranges to regulate the water cycle and vibrancy of the habitat. Nearly 200 species in the habitat are on California's Special

⁷⁴ Plumas County Visitors Bureau. 2015. *Outdoor Recreation*. <http://plumascounty.org/Recreation-in-Plumas-County>.

⁷⁵ SWRCB. 2014. *Upper North Fork Feather River Hydroelectric Project Draft Environmental Impact Report*. http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/upper_feather_ferc2105/eir2014nov/unffr_6_6.pdf.

⁷⁶ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen, Modoc, and Plumas National Forests*. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

⁷⁷ Ibid.

Animals List, which tracks threatened and endangered species in the state. As rains replace winter snows, the annual spring snowmelt will continue to move earlier, disrupting ecosystem function.⁷⁸

The importance of the watershed is underscored by its listing as an Audubon Important Bird Area. The region supports over 1 percent of the global and 10 percent of the state population of one or more sensitive species, supports more than nine sensitive bird species, hosts 10,000 or more observable shorebirds in one day, and hosts 5,000 or more observable waterfowl in one day. The Important Bird Area surrounding Lake Almanor and Mountain Meadows Reservoir is notable for supporting one of the largest populations of willow flycatchers in the state, which breed in meadows with willow thickets in and around Westwood and Chester.⁷⁹

9) 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 ☐ No ☐ Perhaps/Uncertain

The chain of dams in the Upper Feather River Region fragments aquatic habitat and prevents movement of fish and other aquatic wildlife to varying degrees. Additionally, extensive road systems, fencing, and historic mining have damaged the watershed and disrupted natural movement corridors.⁸⁰ Catastrophic wildfire can also destroy habitat and disrupt natural migration corridors across the UFR watershed.

Integrated planning efforts in the Plumas National Forest have led to significant improvements in forest-wide restoration of habitat connectivity for fish and other aquatic organisms. These aquatic organism passage (AOP) programs, when paired with overall watershed restoration, help to decrease the number of fragmented movement corridors.⁸¹ At the time of this writing, no known infrastructure projects are planned that might preclude species movement.

RMS for adapting to ecosystem and habitat vulnerabilities:

- ◆ Agricultural water use efficiency
- ◆ Conveyance – regional/local
- ◆ System reoperation
- ◆ Conjunctive management
- ◆ Pollution prevention
- ◆ Salt and salinity management
- ◆ Urban stormwater runoff management
- ◆ Agricultural land stewardship
- ◆ Ecosystem restoration
- ◆ Forest management
- ◆ Land use planning and management
- ◆ Sediment management

⁷⁸ Endangered Species Coalition. 2010. *It's Getting Hot Out There: Top 10 Places to Save for Endangered Species in a Warming World*. <http://www.endangered.org/its-getting-hot-out-there/>.

⁷⁹ California Audubon Society. 2015. *Important Bird Areas*. <http://ca.audubon.org/important-bird-areas-9>.

⁸⁰ USDA. 2013b. *Ecological Restoration Implementation Plan*. <http://featherriver.org/catalog/files/EcologicalRestorationImplementationPlan.pdf>.

⁸¹ Ibid.

- ◆ Watershed management
- ◆ Water-dependent recreation

8.3.6 Hydropower

1) *Is hydropower a source of electricity in your region?*

☒ Yes ☐ No ☐ Perhaps/Uncertain

The region's electricity is provided by the Plumas-Sierra Rural Electric Co-op (PSREC) and PG&E. As of 2014, PSREC generated 0.5 percent of its grid-wide energy from small hydroelectric and 33.2 percent from large hydroelectric.⁸² In 2012, PG&E procured 2 percent of its total electricity from small hydroelectric and 11 percent from large hydroelectric.⁸³ This hydropower production may become vulnerable to decreased production capacity if flow volume decreases. All together, the dams on the Upper Feather River produce 9–30 percent of California's power.⁸⁴

In the lower North Fork Feather River, PG&E owns a series of reservoirs known as the "stairway of power" for hydropower production.⁸⁵ Seven dams regulated by the Federal Energy Regulatory Commission (FERC), listed below, are located in the region, five of which are owned and operated by PG&E.

- ◆ Bucks Creek (PG&E – Bucks Lake)
- ◆ Rock Creek/Cresta (PG&E – North Fork Feather River)
- ◆ South Feather (South Feather Water & Power – Little Grass Valley)
- ◆ Lake Oroville (California Department of Water Resources)
- ◆ Upper North Fork Feather River (PG&E – Almanor/Butt Valley)
- ◆ Poe (PG&E – North Fork Feather River)
- ◆ Hamilton Branch powerhouse (PG&E – Lake Almanor)

Climate change has the potential to alter the ability of all of the operational hydroelectric facilities in the region to produce power due to shifting temperatures, altered stream flow, and higher rates of evaporation and transpiration in the feeder watersheds.⁸⁶ While trends in precipitation and temperature can vary significantly across the region, decreases in snowfall and the consequent impacts will be more evenly distributed. Significant declines in snowfall over the past century have been observed in the watershed.⁸⁷ The watershed depends on Sierra snowmelt for much of its flow. Because of this, the dams

⁸² PSREC (Plumas-Sierra Rural Electric Co-op). 2014. Power Content Label.

http://www.psrec.coop/downloads/Power%20Content%20Label/2014_PSREC_PCL.pdf.

⁸³ CEC (California Energy Commission). 2012. *Utility Annual Power Content Labels for 2012 – Investor Owned Utilities*. http://www.energy.ca.gov/sb1305/labels/2012_index.html#iou

⁸⁴ USDA. 2013b. *Ecological Restoration Implementation Plan*.

<http://featherriver.org/catalog/files/EcologicalRestorationImplementationPlan.pdf>.

⁸⁵ Sacramento River Watershed Program. 2015. *Upper Feather River Watershed*.

<http://www.sacriver.org/aboutwatershed/roadmap/watersheds/feather/upper-feather-river-watershed>.

⁸⁶ Bryan, L., and T. Thaler, G. Griffith, J. Morris, T. Crossett, and R. Rasker, eds. 2013. *Forest and Water Climate Adaptation: A Plan for Shasta County, California*. http://www.mfpp.org/wp-content/uploads/2013/05/Shasta-County-Forest-Water-Climate-Adaptation-Plan-Final_v4-2013.pdf.

⁸⁷ USDA (US Department of Agriculture Forest Service). 2013a. *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Lassen,*

along the UFR and its many tributaries are vulnerable to decreased generation as a result of the decreased availability of water resources.

2) *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 ☐ No ☐ Perhaps/Uncertain

Limited population growth and rising temperatures have the potential to increase demand for energy in the UFR Region. Currently, large-scale hydropower (presented above as the stairway of power) is built-out in the watershed. The region's electricity is primarily provided by the Plumas-Sierra Rural Electric Cooperative, as well as PG&E and the Lassen Municipal Utility District. As of July 2015, FERC has not issued any permits for a new dam. Although some potential exists for smaller hydropower generation facilities, decreases in overall hydropower productivity and increased challenges to building hydropower (such as few undammed rivers, little unallocated water, and growing environmental, economic, and political constraints) may strongly limit facility development.⁸⁸

RMS for adapting to hydropower production vulnerabilities:

- ◆ Conveyance – regional/local
- ◆ Land use planning and management
- ◆ Water and culture

8.3.7 Vulnerability Assessment Summary

Table 8-1 summarizes the climate change vulnerabilities and relevant resources management associated with each category of water use and resources, as described in the text above.

Modoc, and Plumas National Forests.

http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3820062.pdf.

⁸⁸ Pacific Institute. 2015. *Impacts of California's Ongoing Drought: Hydroelectricity Generation.*

<http://pacinst.org/wp-content/uploads/sites/21/2015/03/California-Drought-and-Energy-Final1.pdf>.

Table 8-1. Climate Change Vulnerability Summary

Category	Vulnerabilities	Resource Management Strategies
Water Demand	Seasonal variability, climate-sensitive crops, drought-sensitive groundwater supplies, in-stream flow requirements	<ul style="list-style-type: none"> ◆ Agricultural water use efficiency ◆ Urban water use efficiency ◆ Conveyance – regional/local ◆ System reoperation ◆ Water transfers ◆ Conjunctive management ◆ Precipitation enhancement ◆ Drinking water treatment and distribution ◆ Matching water quality to water use ◆ Agricultural land stewardship ◆ Land use planning and management ◆ Economic incentives ◆ Outreach and engagement ◆ Water and culture
Water Supply	Decreased snowfall, worsening of natural dry cycles, decreased water supply	<ul style="list-style-type: none"> ◆ Urban water use efficiency ◆ Conveyance – regional/local ◆ System reoperation ◆ Water transfers ◆ Conjunctive management ◆ Precipitation enhancement ◆ Municipal recycled water ◆ Surface storage – regional/local ◆ Drinking water treatment and distribution ◆ Groundwater remediation/aquifer remediation ◆ Forest management ◆ Recharge area protection ◆ Economic incentives ◆ Outreach and engagement ◆ Water-dependent recreation

Category	Vulnerabilities	Resource Management Strategies
Water Quality	Lower dissolved oxygen levels in waterbodies, potential algal blooms and eutrophication, altered pollutant concentrations in waterbodies, increased turbidity, decreased water quality	<ul style="list-style-type: none"> ◆ Flood management ◆ Conveyance – regional/local ◆ System reoperation ◆ Precipitation enhancement ◆ Drinking water treatment and distribution ◆ Groundwater remediation/aquifer remediation ◆ Matching water quality to water use ◆ Pollution prevention ◆ Salt and salinity management ◆ Urban stormwater runoff management ◆ Ecosystem restoration ◆ Forest management ◆ Recharge area protection ◆ Sediment management ◆ Watershed management
Flooding	Runoff exceeding the capacity of local watercourses, rainfall, and runoff to depressions causing localized areas of shallow flooding, sedimentation resulting from wildfire	<ul style="list-style-type: none"> ◆ Flood management ◆ Conveyance – regional/local ◆ System reoperation ◆ Precipitation enhancement ◆ Urban stormwater runoff management ◆ Land use planning and management ◆ Watershed management
Ecosystem and Habitat Vulnerability	Aquatic habitat erosion and sedimentation, climate-sensitive fauna or flora, endangered or threatened species, aquatic habitats used for economic activities, quantified environmental flow requirements, climate-sensitive habitats, fragmented habitat and movement corridors	<ul style="list-style-type: none"> ◆ Agricultural water use efficiency ◆ Conveyance – regional/local ◆ System reoperation ◆ Conjunctive management ◆ Pollution prevention ◆ Salt and salinity management ◆ Urban stormwater runoff management ◆ Agricultural land stewardship ◆ Ecosystem restoration ◆ Forest management ◆ Land use planning and management ◆ Sediment management ◆ Watershed management ◆ Water-dependent recreation
Hydropower	Hydropower facilities, regional energy needs	<ul style="list-style-type: none"> ◆ Conveyance – regional/local ◆ Land use planning and management ◆ Water and culture ◆ Other strategies

8.4 Prioritizing Vulnerabilities

All of the vulnerabilities listed above represent important issues and considerations for the planning region as a whole. Some vulnerabilities will be of high priority to a certain suite of stakeholders because of

their area of expertise, interests, or employment; another stakeholder group's priorities will likely differ for the same reasons. Identifying vulnerabilities for such a diverse group of stakeholders and issues is an exercise in assessing how soon that vulnerability may occur, if it's not already (urgency), and the degree of probability that the vulnerability will become a hazard, if it's not already (risk).

In August 2015, approximately 28 local stakeholders attended a climate change-focused meeting in Quincy, California, and participated in a vulnerability prioritization activity. Table 8-2 displays the results of that activity in terms of urgency and risk, and sorts by priority based on those findings. It is important to make the distinction that these priorities are relative to responding to climate change and not IRWM project prioritization.

Table 8-2. UFR Climate Change Priorities

Priority	Category	Topic	Urgency	Risk
1	Water Demand	Seasonal water use variability	High	High
1	Water Supply	Snowmelt	High	High
1	Water Supply	Unmet local water demands (drought)	High	High
1	Water Supply	Invasive species	High	High
1	Water Quality	Water quality (wildfires)	High	High
1	Water Quality	Eutrophication water quality issues	High	High
1	Water Quality	Seasonal low flows and assimilative capacity	High	High
1	Water Quality	Treatment facility operations	High	High
1	Flooding	Aging critical flood protection	High	High
1	Flooding	Wildfires	High	High
1	Ecosystem and Habitat Vulnerability	Climate-sensitive fauna or flora	High	High
1	Ecosystem and Habitat Vulnerability	Recreation and economic activity	High	High
1	Ecosystem and Habitat Vulnerability	Quantified environmental flow requirements	High	High
1	Ecosystem and Habitat Vulnerability	Top habitat vulnerable to climate change	High	High
2	Water Demand	Unmet in-stream flow requirements	Medium	High
3	Water Demand	Climate-sensitive crops	Medium	Medium

Priority	Category	Topic	Urgency	Risk
3	Water Demand	Groundwater drought resiliency	Medium	Medium
3	Water Demand	Water curtailment effectiveness	Medium	Medium
3	Water Quality	Unmet beneficial uses	Medium	Medium
3	Flooding	Critical infrastructure in a floodplain	Medium	Medium
3	Flooding	Insufficient flood control facilities	Medium	Medium
3	Ecosystem and Habitat Vulnerability	Erosion and sedimentation	Medium	Medium
3	Ecosystem and Habitat Vulnerability	Endangered or threatened species	Medium	Medium
3	Ecosystem and Habitat Vulnerability	Fragmented habitat	Medium	Medium
3	Hydropower	Electricity source	Medium	Medium
4	Water Supply	Supply surplus carryover	Low	Medium
5	Water Demand	Cooling/process water for industry	Low	Low
5	Water Supply	Climate-sensitive water supply	Low	Low
5	Hydropower	Growing energy needs	Low	Low

8.5 Further Data Gathering and Analysis of the Prioritized Vulnerabilities

Proposition 84 guidelines requires that this IRWMP “contain a plan, program, or methodology for further data gathering and analysis of the prioritized vulnerabilities.” The method to fulfill this requirement is located in Chapter 11 *Plan Performance, Monitoring, and Data Management*.

8.6 Greenhouse Gas Emissions and UFR Project Development and Selection

In addition to addressing climate change vulnerability, Proposition 84 guidelines require this IRWMP to describe how GHG emissions are mitigated and how adaptation actions are addressed. As part of the project evaluation process (Chapter 9 *Project Development and Review Process*), each project was required to identify if it addressed climate change issues. In order to say that a project had addressed climate change issues, project sponsors were required to respond to a checklist that provided high-level GHG emissions estimates for construction- and annual project operation-related GHG emissions, as well as state how the project contributed to regional resiliency as new projects are implemented over the 20-year planning horizon.

Climate change adaptation strategies are also included in this IRWMP as part of the RMS chapter. As noted above, each climate change vulnerability topic was assessed for relevant RMS. Where an RMS was

identified as being relevant to climate change, the project team provided climate change considerations and further analysis. See Chapter 6 *Resource Management Strategies* for more information.

DRAFT