Appendix C
Qualitative Vulnerability Assessment

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American River Watershed Resilience Pilot Study Qualitative Vulnerability Assessment

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Contents

Attachments

DRAFT

Tables

Figures

DRAFT

Acronyms and Abbreviations

°F	degree(s) Fahrenheit
ARWRP	American River Watershed Resilience Pilot
CVP	Central Valley Project
DAC	Disadvantaged Communities
EID	El Dorado Irrigation District
N/A	not applicable
NID	Nevada Irrigation District
PCWA	Placer County Water Agency
PUD	Public Utility District
SMUD	Sacramento Municipal Utility District

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1. Introduction

The American River Watershed Resilience Pilot (ARWRP) Study evaluates climate-related risks and vulnerabilities across water-dependent sectors and land uses throughout the watershed. The vulnerability assessment is designed as a two-phased framework that integrates qualitative evaluation with quantitative analysis to support informed, risk-based decision-making.

Together, this approach allows stakeholders to identify where climate stressors intersect with high sensitivity, limited adaptive capacity, and far-reaching consequences. Systems are highlighted where early action, targeted investment, and deeper quantitative analysis can most effectively strengthen watershed resilience.

1.1 Qualitative Vulnerability Assessment

The first phase, qualitative vulnerability assessment, provides a structured, sector-specific evaluation of climate risks, capturing how different systems respond to stressors such as extreme heat, drought, flooding, and wildfire. This step emphasizes local context and planning-area nuance, recognizing that climate vulnerability varies significantly across the Upper and Lower American, Bear, and Cosumnes watersheds due to differences in hydrology, infrastructure, ecosystems, and community capacity.

Qualitative findings are then translated into standardized scores and a composite vulnerability index, forming the bridge to the second phase of analysis. This scoring framework enables consistent comparison across sectors and assets; supports prioritization of the most critical vulnerabilities; and informs where more detailed, scenario-based modeling is warranted.

1.2 Study Area

The study area for the ARWRP Study is presented on Figure 1-1. This area covers the entirety of the American River, Cosumnes River, and Bear River watersheds, as well as the North American, South American, and majority of the Cosumnes River Bulletin 118 groundwater basins. Land uses across the watershed are highly varied, with much of the urban and agricultural development consolidated in the lower elevation portions of the watershed to the west. As such, management of flood and water quality conditions (as well as surface water and groundwater supplies) are vital for preserving both the human and ecological communities in this area. While smaller, rural communities are present in the upper watershed areas to the east, much of this area provides hydropower generation and recreational opportunities, supplies the remaining watershed with surface water, and serves as protected forest.

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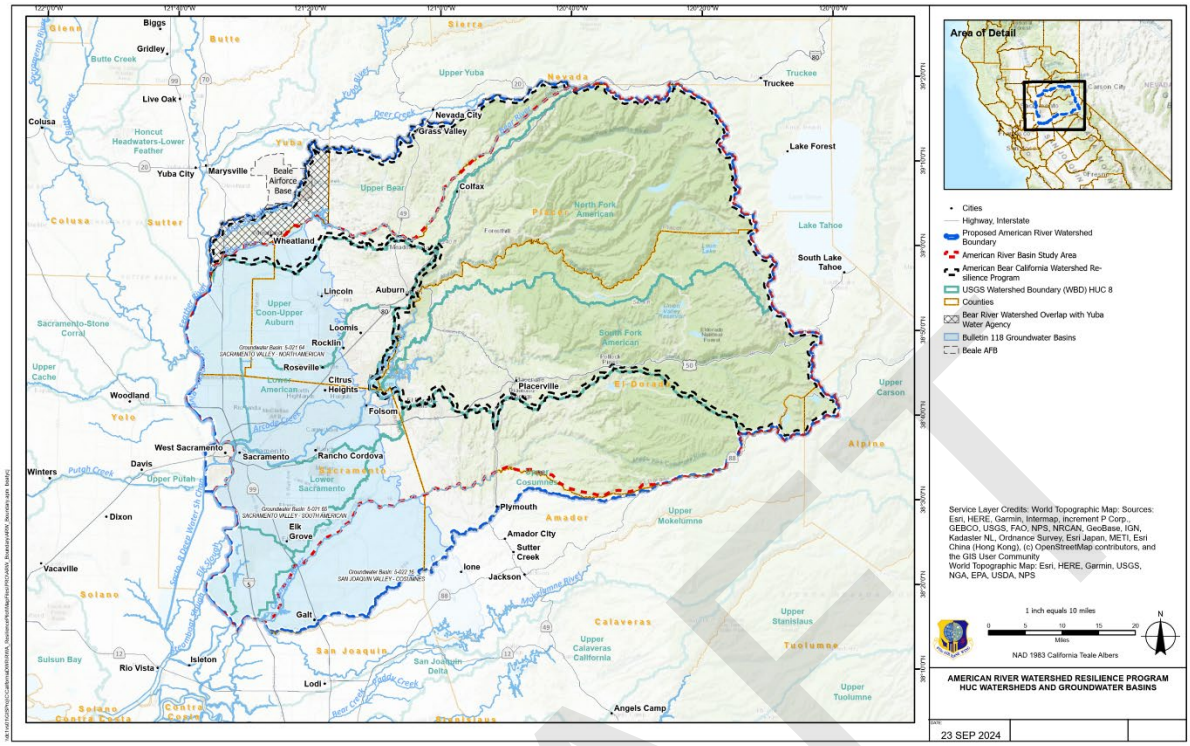

Figure 1-1. American River Watershed Resilience Pilot Study Area

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2. Qualitative Vulnerability Assessment

The qualitative vulnerability evaluation was conducted across eight sectors encompassing both built and natural systems:

- Agriculture
- Ecosystems
- Flood management
- Groundwater supply
- Hydropower
- Recreation and tourism
- Surface water supply
- Water quality

This qualitative assessment provides a foundational understanding of sector-specific sensitivities and adaptive capacities in the face of climate stressors. The ARWRP team developed a vulnerability assessment matrix that organizes key system components, such as reservoirs, levees, groundwater basins, aquatic habitats, water quality receptors, agricultural lands, and recreation assets, against major climate hazards including extreme heat, drought, extreme precipitation and flooding, wildfire, and sea-level rise where applicable.

For each system component, concise narrative statements describe the following:

- How the system is exposed to climate stressors
- Why it is sensitive to those stressors
- What limits or enhances its ability to adapt or recover

These narratives draw on existing watershed plans, agency studies, historical observations, and subject-matter expertise, confirming that local context and operational realities are reflected. Examples include the effects of snowpack loss and wildfire scars on upstream reservoir operations, and the heightened risk of levee overtopping in lower floodplain areas during atmospheric river events.

To better capture the unique geographic characteristics of the diverse areas in the watershed relative to physical conditions and institutional arrangements, the vulnerabilities in the watershed are assessed for six unique subregions, as illustrated on Figure 2-1: the upper and lower American, Bear, and Cosumnes subregions. The distinction between upper and lower portions of each basin was primarily based on the boundaries of the alluvial groundwater subbasins (i.e., the South Yuba, North and South American, and Cosumnes groundwater subbasins).

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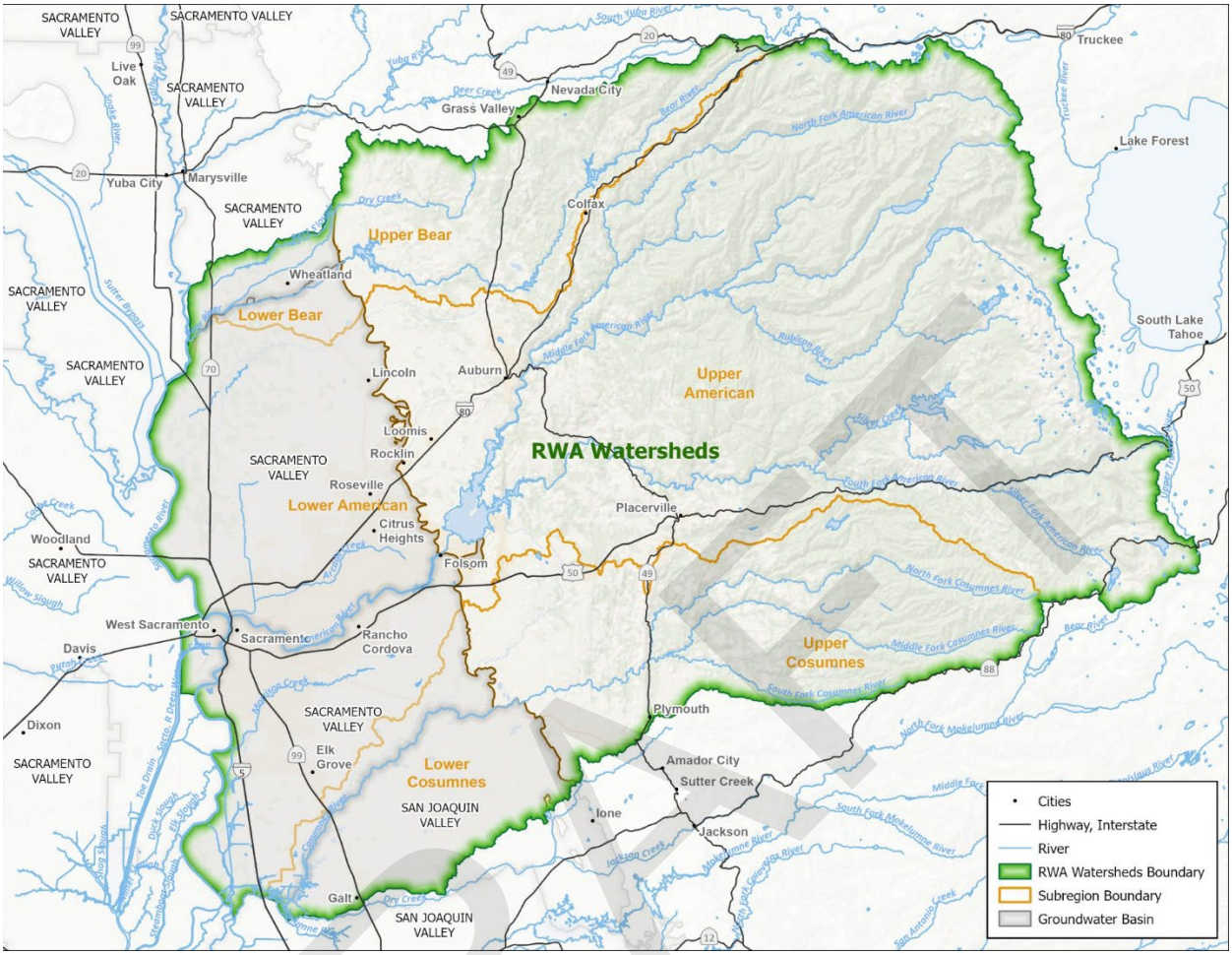

Figure 2-1. American River Watershed Sub-Regions Used in the Vulnerability Assessment

2.1 Methodology

The qualitative vulnerability assessment uses a structured framework to consistently translate expert judgment into comparable vulnerability ratings across systems, sectors, and planning areas. The approach is designed to be transparent, repeatable, and scalable; it allows diverse assets, from reservoirs and levees to ecosystems and communities, to be evaluated using a common logic.

At its core, the framework recognizes that vulnerability is not driven by exposure alone, but by the interaction between how sensitive a system is to climate stressors and how much capacity it has to adapt or recover. These two dimensions, Sensitivity and Adaptive Capacity, are assessed independently and then combined using a predefined lookup table to assign a Vulnerability Priority Rating.

2.1.1 Sensitivity Rating

Sensitivity describes how strongly a system component is affected when exposed to climate stressors such as extreme heat, drought, flooding, or wildfire. It reflects the degree to which climate conditions influence system performance, function, or integrity.

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Sensitivity is rated on a 5-point scale:

- 1 – Low Sensitivity:
  Climate variability and long-term climate change have little to no influence on the asset or its operations.
- 3 – Moderate Sensitivity:
  Climate stressors influence performance or operations, but impacts are generally manageable or intermittent.
- 5 – High Sensitivity:
  Climate stressors have a strong and direct influence on the asset or system, with high potential for performance degradation, failure, or loss of function.

Intermediate scores (2 and 4) are used to capture gradations between these conditions. Sensitivity ratings are informed by physical characteristics (e.g., storage size or ecological thresholds), operational constraints, and known climate-response relationships.

2.1.2 Adaptive Capacity Rating

Adaptive Capacity reflects a system's inherent ability to respond to, cope with, or recover from climate-related impacts. These include physical redundancy, operational flexibility, institutional authority, financial resources, regulatory protections, and the availability of alternative options.

Adaptive Capacity is also rated on a 5-point scale, but inversely, such that higher numeric values indicate lower capacity:

- 1 – High Adaptive Capacity: The system has substantial ability to adjust operations, recover quickly, or absorb climate impacts (e.g., multiple supply sources or strong institutional support).
- 3 – Moderate Adaptive Capacity: The system has some ability to adapt, but responses may be constrained by cost, governance, or infrastructure limitations.
- 5 – Low Adaptive Capacity: The system has little inherent capacity to adapt or recover, often due to single-source dependency, limited infrastructure, or institutional constraints.

This inverse scale verifies that high sensitivity combined with low adaptive capacity results in the highest vulnerability ratings, consistent with widely accepted climate risk frameworks.

2.1.3 Vulnerability Prioritization Logic

Rather than calculating vulnerability through a simple formula, the assessment uses a lookup table that explicitly defines how combinations of Sensitivity and Adaptive Capacity translate into a Vulnerability Priority Rating on a 5-point scale.

Key features of the lookup logic include the following:

- Systems with low sensitivity are assigned to low vulnerability even if adaptive capacity is limited, reflecting lower overall risk.
- Systems with high sensitivity and low adaptive capacity are assigned the highest vulnerability ratings (4 to 5), indicating priority concern.
- Systems with high sensitivity but strong adaptive capacity receive moderate vulnerability ratings, recognizing exposure but also resilience.

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- The lookup table avoids false precision and supports consistent expert interpretation across sectors.

A vulnerability score of 4 or 5 indicates high to very high vulnerability, signaling systems where climate stressors, sensitivity, and limited adaptive capacity converge to create elevated risk (Table 2-1).

Table 2-1. Vulnerability Prioritization Matrix

		Sensitivity Rating				
		Low (1)	Low-Moderate (2)	Moderate (3)	Moderate-High (4)	High (5)
Adaptive Capacity Rating	High (1)	1	1	1	1	3
	Moderate-High (2)	1	1	1	3	3
	Moderate (3)	1	2	3	4	5
	Low-Moderate (4)	1	2	4	5	5
	Low (5)	1	2	5	5	5

2.1.4 Scale of Effects Rating

To capture not only how vulnerable a system is, but also how far its impacts extend, the qualitative assessment includes a Scale of Effects rating. This metric describes the geographic and systemic reach of consequences associated with vulnerability.

The Scale of Effects is rated from 1 to 5, as follows:

1. Localized: Impacts are limited to a single facility, property, or small community.
2. Sub-regional: Impacts affect part of a planning area (e.g., a town, corridor, or subbasin).
3. Planning Area-wide: Impacts affect a substantial portion of a watershed or planning area.
4. Multi-watershed: Impacts cross planning boundaries and affect multiple interconnected basins.
5. Systemwide or Statewide: Impacts extend across the entire watershed system or have statewide implications (e.g., widespread snowpack loss, major reservoir operations, or large-scale disruptions to water supply or recreation).

This metric is critical for identifying cascading and compounding risks, where localized failures propagate into broader system consequences.

2.1.5 Composite Score of Vulnerability and Scale Effects

The Vulnerability Priority rating and Scale of Effects are combined to form a composite score that is weighted 2:1, respectively. This composite score provides for quick review and comparison of overall risks across sectors. However, the vulnerability assessment framework still retains the multi-dimensional view of climate risk provided by the Sensitivity rating, Adaptive Capacity rating, Vulnerability Priority rating, and Scale of Effects. This allows stakeholders to achieve the following:

- Compare vulnerabilities across different sectors and asset types.
- Distinguish between localized risks and systemwide threats.

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- Identify systems that warrant priority attention in quantitative modeling.
- Support transparent, defensible decision-making for adaptation planning.

This qualitative assessment serves as the first screening step of the ARWRP, confirming that subsequent quantitative analyses focus on the systems where climate impacts are most consequential and adaptive capacity is most constrained.

2.1.6 Stakeholder Input

The ARWRP team hosted agency-specific meetings to calibrate the qualitative findings with technical experts, agency representatives, and stakeholders, to ensure consistency in scoring across sectors and planning areas, particularly for interpreting adaptive capacity in relation to institutional, operational, and ecological constraints.

2.2 Results

Table 2-2 presents the results of the qualitative assessment of vulnerabilities. The details of the assessment are provided in Attachment 1. Table 2-2 summarizes the results of the qualitative vulnerability assessment across planning areas, sectors, and system components evaluated by the ARWRP. Each row represents a distinct system component or asset, with corresponding ratings for Sensitivity, Adaptive Capacity, Vulnerability, Scale of Effects, and a Composite Score that supports cross-sector comparison and prioritization.

Together, these results provide a comprehensive, watershed-wide snapshot of climate vulnerability, highlighting where climate stressors intersect with high sensitivity, limited adaptive capacity, and far-reaching consequences. The table is intended to be read both vertically (comparing vulnerability across sectors within a planning area) and horizontally (identifying system components that consistently rank among the highest priorities across the watershed). These findings form the basis for identifying high-priority assets and systems for further quantitative modeling and adaptation planning in subsequent phases of the study.

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Table 2-2. Summary of Qualitative Vulnerability Assessment

Planning Area	System	System Component (Asset)	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects	Composite Score
Lower American River	Agriculture	Placer County (West Placer)	3	3	3.0	4.0	3.3
Lower American River	Agriculture	Sacramento County	3	2	1.0	4.0	2.0
Lower American River	Community & Equity	Walnut Grove and Isleton Communities	4	3	4.0	2.0	3.3
Lower American River	Community & Equity	Sacramento Metro East	4	3	4.0	2.0	3.3
Lower American River	Community & Equity	Urban Core and Floodplain Communities	4	3	4.0	2.0	3.3
Lower American River	Ecosystem	Aquatic Ecosystems	4	4	5.0	5.0	5.0
Lower American River	Ecosystem	Forest Health and Ecosystem Services	3	3	3.0	3.0	3.0
Lower American River	Ecosystem	Riparian and Groundwater Dependent Ecosystems	3	3	3.0	3.0	3.0
Lower American River	Flood Management	Floodplain and Local Drainage	4	2	3.0	3.0	3.0
Lower American River	Flood Management	Folsom Reservoir	4	4	5.0	5.0	5.0
Lower American River	Flood Management	Lower American & Sacramento Levee System	4	4	5.0	4.0	4.7
Lower American River	Flood Management	Sacramento Weir & Yolo Bypass	3	1	1.0	4.0	2.0
Lower American River	Groundwater Supply	Built System - Landowner groundwater wells	4	3	4.0	1.0	3.0
Lower American River	Groundwater Supply	Built System - Municipal systems	3	1	1.0	2.0	1.3
Lower American River	Groundwater Supply	Natural System - North American Subbasin	4	3	4.0	4.0	4.0
Lower American River	Groundwater Supply	Natural System - South American Subbasin	4	3	4.0	4.0	4.0
Lower American River	Hydropower	Folsom Reservoir	4	3	4.0	5.0	4.3

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Planning Area	System	System Component (Asset)	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects	Composite Score
Lower American River	Recreation	Recreational Uses - Access/use of forested recreation zones, camping/hiking activities, access to water activities	3	2	1.0	4.0	2.0
Lower American River	Recreation	Tourism - Impacts on businesses, quantity of visitors	3	2	1.0	4.0	2.0
Lower American River	Surface Water Supply	Built Conveyance (e.g., canals, pipelines, and intakes)	3	1	1.0	4.0	2.0
Lower American River	Surface Water Supply	Folsom Reservoir	5	3	5.0	5.0	5.0
Lower American River	Surface Water Supply	Natural Conveyance - River system	4	3	4.0	4.0	4.0
Lower American River	Water Quality	Drinking Water Source Quality	4	2	3.0	3.0	3.0
Lower American River	Water Quality	Ecological	4	3	4.0	3.0	3.7
Lower American River	Water Quality	Regulatory Standards	4	3	4.0	3.0	3.7
Lower Bear River	Flood Management	Bear Levee System	4	3	4.0	4.0	4.0
Lower Bear River	Flood Management	Floodplain and Local Drainage	4	3	4.0	3.0	3.7
Lower Bear River	Groundwater Supply	Built System - Landowner groundwater wells	4	3	4.0	1.0	3.0
Lower Bear River	Groundwater Supply	Built System - Municipal systems	3	3	3.0	1.0	2.3
Lower Bear River	Groundwater Supply	Natural System - Groundwater basin	4	3	4.0	4.0	4.0
Lower Bear River	Surface Water Supply	Natural Conveyance - River system	4	3	4.0	3.0	3.7
Lower Bear River	Water Quality	Drinking Water Source Quality	4	3	4.0	2.0	3.3
Lower Bear River	Water Quality	Ecological	3	3	3.0	2.0	2.7
Lower Bear River	Water Quality	Regulatory Standards	4	3	4.0	3.0	3.7
Lower Bear River	Agriculture	Valley	3	3	3.0	4.0	3.3
Lower Bear River	Agriculture	Valley	3	3	3.0	4.0	3.3
Lower Bear River	Community & Equity	Wheatland and Agricultural Edge	4	3	4.0	2.0	3.3
Lower Cosumnes River	Agriculture	Valley	3	3	3.0	4.0	3.3

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Planning Area	System	System Component (Asset)	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects	Composite Score
Lower Cosumnes River	Community & Equity	Galt South and Delta Edge	4	3	4.0	2.0	3.3
Lower Cosumnes River	Ecosystem	Aquatic Ecosystems	3	3	3.0	3.0	3.0
Lower Cosumnes River	Ecosystem	Riparian and Groundwater Dependent Ecosystems	3	4	4.0	3.0	3.7
Lower Cosumnes River	Flood Management	Floodplain and Local Drainage	5	3	5.0	3.0	4.3
Lower Cosumnes River	Flood Management	Levee System	5	5	5.0	4.0	4.7
Lower Cosumnes River	Groundwater Supply	Built System - Landowner groundwater wells	4	3	4.0	1.0	3.0
Lower Cosumnes River	Groundwater Supply	Built System - Municipal systems	3	2	1.0	2.0	1.3
Lower Cosumnes River	Groundwater Supply	Natural System - Groundwater basin	4	3	4.0	3.0	3.7
Lower Cosumnes River	Recreation	Recreational Uses - Access/use of forested recreation zones, camping/hiking activities, access to water activities	2	3	2.0	4.0	2.7
Lower Cosumnes River	Recreation	Tourism - Impacts on businesses, quantity of visitors	2	3	2.0	4.0	2.7
Lower Cosumnes River	Surface Water Supply	Built Conveyance (e.g., canals, pipelines, and intakes)	3	3	3.0	2.0	2.7
Lower Cosumnes River	Surface Water Supply	Natural Conveyance - River system	3	3	3.0	3.0	3.0
Lower Cosumnes River	Water Quality	Drinking Water Source Quality	3	3	3.0	3.0	3.0
Lower Cosumnes River	Water Quality	Ecological	4	3	4.0	4.0	4.0
Lower Cosumnes River	Water Quality	Regulatory Standards	3	3	3.0	3.0	3.0
Upper American River	Agriculture	El Dorado County	3	4	4.0	4.0	4.0
Upper American River	Agriculture	Placer County (Foothills)	3	3	3.0	4.0	3.3
Upper American River	Community & Equity	Foothill Towns along Highway Corridors (Placerville or Auburn)	4	3	4.0	3.0	3.7

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Planning Area	System	System Component (Asset)	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects	Composite Score
Upper American River	Community & Equity	Upper Watershed Rural Communities (Foresthill or Quintette)	5	4	5.0	2.0	4.0
Upper American River	Ecosystem	Aquatic Ecosystems	3	3	3.0	2.0	2.7
Upper American River	Ecosystem	Forest Health and Ecosystem Services	5	3	5.0	5.0	5.0
Upper American River	Ecosystem	Riparian and Groundwater Dependent Ecosystems	3	3	3.0	2.0	2.7
Upper American River	Flood Management	Built Reservoirs and Dams	2	3	2.0	4.0	2.7
Upper American River	Flood Management	Floodplain and Local Drainage	4	3	4.0	1.0	3.0
Upper American River	Groundwater Supply	Built System - Landowner groundwater wells	4	3	4.0	1.0	3.0
Upper American River	Groundwater Supply	Built System - Small water systems	4	4	5.0	1.0	3.7
Upper American River	Groundwater Supply	Natural System - Fractured rock aquifers	3	3	3.0	2.0	2.7
Upper American River	Hydropower	EID (Project 184)	3	3	3.0	5.0	3.7
Upper American River	Hydropower	Foresthill PUD (Sugar Pine Reservoir)	3	4	4.0	2.0	3.3
Upper American River	Hydropower	Georgetown Divide PUD (Stumpy Meadows Reservoir)	3	4	4.0	2.0	3.3
Upper American River	Hydropower	PCWA (Middle Fork Project)	3	3	3.0	5.0	3.7
Upper American River	Hydropower	SMUD (Upper American River Project)	3	3	3.0	5.0	3.7
Upper American River	Recreation	Recreational Uses - Access/use of forested recreation zones, camping/hiking activities, access to water activities	5	2	3.0	5.0	3.7
Upper American River	Recreation	Tourism - Impacts on businesses, quantity of visitors	5	2	3.0	5.0	3.7
Upper American River	Surface Water Supply	Built Reservoirs	3	3	3.0	4.0	3.3
Upper American River	Surface Water Supply	Built System - Small water systems	3	4	4.0	1.0	3.0

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Planning Area	System	System Component (Asset)	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects	Composite Score
Upper American River	Surface Water Supply	Conveyance Systems (e.g., canals and other conduits)	5	3	5.0	2.0	4.0
Upper American River	Surface Water Supply	Natural Reservoirs - Snowpack	5	4	5.0	5.0	5.0
Upper American River	Water Quality	Drinking Water Source Quality	2	3	2.0	2.0	2.0
Upper American River	Water Quality	Ecological	3	2	1.0	2.0	1.3
Upper American River	Water Quality	Regulatory Standards	3	2	1.0	2.0	1.3
Upper Bear River	Ecosystem	Forest Health and Ecosystem Services	4	4	5.0	5.0	5.0
Upper Bear River	Flood Management	Reservoirs	3	3	3.0	3.0	3.0
Upper Bear River	Hydropower	Nevada Irrigation District	3	3	3.0	3.0	3.0
Upper Bear River	Hydropower	Nevada Irrigation District	3	3	3.0	3.0	3.0
Upper Bear River	Recreation	Recreational Uses - Access/use of forested recreation zones, camping/hiking activities, access to water activities	3	3	3.0	3.0	3.0
Upper Bear River	Recreation	Tourism - Impacts on businesses, quantity of visitors	3	3	3.0	2.0	2.7
Upper Bear River	Recreation	Recreational Uses - Access/use of forested recreation zones, camping/hiking activities, access to water activities	3	3	3.0	3.0	3.0
Upper Bear River	Recreation	Tourism - Impacts on businesses, quantity of visitors	3	3	3.0	2.0	2.7
Upper Bear River	Surface Water Supply	Built Conveyance (e.g., canals, pipelines, and intakes)	4	3	4.0	4.0	4.0
Upper Bear River	Surface Water Supply	Built Reservoirs	4	3	4.0	4.0	4.0
Upper Bear River	Water Quality	Drinking Water Source Quality	4	3	4.0	2.0	3.3
Upper Bear River	Water Quality	Ecological	4	3	4.0	3.0	3.7
Upper Bear River	Water Quality	Regulatory Standards	4	3	4.0	2.0	3.3

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Planning Area	System	System Component (Asset)	Sensitivity Rating	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects	Composite Score
Upper Bear River	Agriculture	Foothill	3	3	3.0	4.0	3.3
Upper Bear River	Agriculture	Foothill	3	3	3.0	4.0	3.3
Upper Bear River	Community & Equity	Foothill Communities	4	3	4.0	2.0	3.3
Upper Cosumnes River	Agriculture	Foothill	3	4	4.0	4.0	4.0
Upper Cosumnes River	Ecosystem	Forest Health and Ecosystem Services	4	4	5.0	5.0	5.0
Upper Cosumnes River	Ecosystem	Aquatic Ecosystems	3	3	3.0	2.0	2.7
Upper Cosumnes River	Groundwater Supply	Natural System - Fractured rock aquifers	3	3	3.0	2.0	2.7
Upper Cosumnes River	Groundwater Supply	Built System - Small water systems	4	4	5.0	1.0	3.7
Upper Cosumnes River	Groundwater Supply	Built System - Landowner groundwater wells	4	3	4.0	1.0	3.0
Upper Cosumnes River	Recreation	Tourism - Impacts on businesses, quantity of visitors	5	2	3.0	3.0	3.0
Upper Cosumnes River	Recreation	Recreational Uses - Access/use of forested recreation zones, camping/hiking activities, access to water activities	5	2	3.0	3.0	3.0
Upper Cosumnes River	Surface Water Supply	Natural Reservoirs - Snowpack	4	3	4.0	4.0	4.0
Upper Bear River	Surface Water Supply	Natural Reservoirs - Snowpack	4	3	4.0	4.0	4.0

Notes:

PCWA = Placer County Water Agency
PUD = Public Utility District
SMUD = Sacramento Municipal Utility District

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2.2.1 Highest-priority Vulnerabilities (Vulnerability Rating = 5; Composite often 4.0 to 5.0)

This section discusses the results of the qualitative analysis, in terms of high, moderate, and low vulnerability categories. The following seven system components stand out as "very high vulnerability," because they combine high sensitivity with limited adaptive capacity and often have systemwide or multi-watershed impacts:

6. Lower American River – Folsom Reservoir (Surface Water Supply): Sensitivity 5, Adaptive Capacity 3, Vulnerability 5, Scale 5, Composite 5.0.
   The reservoir's vulnerability is both high and systemwide, reflecting its central role in supply, flood operations, and downstream environmental constraints.

7. Upper American River – Natural Reservoirs (Snowpack): Sensitivity 5, Adaptive Capacity 4, Vulnerability 5, Scale 5, Composite 5.0.
   Snowpack loss is both highly climate-driven and difficult to "adapt around," and its effects propagate across the watershed.

8. Upper American River / Upper Cosumnes River – Forest Health & Ecosystem Services: Sensitivity 5 (Upper American) and 4 (Upper Cosumnes), Adaptive Capacity 3–4, Vulnerability 5, Scale 5, Composite 5.0.
   These results highlight that forest stress and wildfire-driven change are treated as watershed-wide vulnerabilities with cascading effects on runoff timing, erosion, water quality, and habitat.

9. Lower American River – Aquatic Ecosystems: Sensitivity 4, Adaptive Capacity 4, Vulnerability 5, Scale 5, Composite 5.0.
   This indicates that aquatic habitat is not only sensitive (temperature/flow thresholds) but also limited in adaptive options under future extremes.

10. Lower Cosumnes River – Levee System: Sensitivity 5, Adaptive Capacity 5, Vulnerability 5, Scale 4, Composite 4.7.
    This indicates a high exposure with limited ability to adapt the system, and which includes multiple highly vulnerable and affected communities and land uses.

11. Lower American River – Lower American & Sacramento Levee System: Sensitivity 4, Adaptive Capacity 4, Vulnerability 5, Scale 4, Composite 4.7.
    This reinforces the notion that levee risk is both high and geographically consequential.

12. Lower Cosumnes River – Floodplain & Local Drainage: Sensitivity 5, Adaptive Capacity 3, Vulnerability 5, Scale 3, Composite 4.3.
    This reflects high hazard sensitivity even if impacts are more planning-area focused than systemwide.

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2.2.2 High Vulnerabilities (Vulnerability Rating = 4; Composite commonly 3.3 to 4.0)

The following three broad middle tier of high vulnerabilities appear across all planning areas, especially in groundwater, community/equity, and flood management:

1. Groundwater and water **reliability**

- Lower American River – North American & South American Subbasins (Groundwater basins): Sensitivity 4, Adaptive 3, Vulnerability 4, Scale 4, Composite 4.0.
  These represent regional-scale vulnerability where pumping and recharge dynamics affect long-term sustainability.
- Lower Bear River – Groundwater Basin: Sensitivity 4, Adaptive 3, Vulnerability 4, Scale 4, Composite 4.0.
- Private/landowner wells repeatedly score Vulnerability 4 with low Scale of Effects (1).
  This means they are high-risk for households but typically localized in consequence unless failures cluster.

2. Flood management

- Lower Bear River – Bear Levee System: Sensitivity 4, Adaptive 3, Vulnerability 4, Scale 4, Composite 4.0.
- Lower Bear River – Floodplain & Local Drainage: Vulnerability 4, Scale 3, Composite 3.7.
- These results indicate consistent concern that increased flood intensity and frequency interacts with aging infrastructure and limited expansion options.

3. Community and equity

- Many community components in the Lower American and Lower Cosumnes (e.g., Walnut Grove/Isleton, Sacramento Metro East, Galt South/Delta Edge, Urban Core/Floodplain communities) show Sensitivity 4 / Adaptive 3 / Vulnerability 4 with Scale 2 and Composite 3.3. This pattern suggests high vulnerability is widespread, but often subregional in extent—unless tied to levee systems or major supply nodes.

2.2.3 High Vulnerability but Localized Effects

Some results are important because they show high vulnerability despite small geographic footprints, often because the systems lack redundancy:

- Upper American River – Small Water Systems (Groundwater): Sensitivity 4, Adaptive 4, Vulnerability 5, Scale 1, Composite 3.7.
- Upper Cosumnes River – Small Water Systems (Groundwater): same pattern (5 vulnerability, 1 scale, 3.7 composite).
  This communicates a key equity finding: small systems can be extremely vulnerable even when impacts do not immediately cascade watershedwide.

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2.2.4 Moderate to Lower Vulnerabilities

Several components score lower vulnerability (1 to 3), usually because adaptive capacity is relatively strong (e.g., large municipal systems or certain managed floodways), or because sensitivity is moderate:

- Lower American River – Built conveyance systems show low vulnerability in some entries (e.g., Sensitivity 3, Adaptive 1, Vulnerability 1, Scale 4, Composite 2.0).
  This implies that, while climate impacts may be widespread, these systems have high operational and institutional capacity to respond.
- Sacramento Weir & Yolo Bypass shows a low vulnerability score (1) with high scale (4) and low composite (2.0).
- This reflects that it is a systemwide asset designed to manage extremes, with strong adaptive function built into the system.

2.3 Summary of Findings

The qualitative vulnerability assessment reveals that climate risk in the American River watershed is concentrated in a limited number of highly consequential systems, where strong climate sensitivity coincides with constrained adaptive capacity and where impacts extend well beyond individual sites. While vulnerabilities are present across all sectors and planning areas, the results clearly distinguish system-defining risks from those that are more localized or manageable.

2.3.1 Systemwide Vulnerabilities Dominate Highest Risk Category

The assessment identifies several assets and systems with very high vulnerability (rating of 5) and systemwide or multi-watershed effects (Scale of Effects 4 to 5). These include Folsom Reservoir; natural snowpack systems; forest health and ecosystem services; lower American River aquatic ecosystems; and major levee systems in the Cosumnes and Lower American Rivers. These systems consistently score at the top of the composite ranking (4.7 to 5.0), indicating that even moderate additional climate stress could result in cascading impacts across water supply, flood management, ecosystems, recreation, and communities. Their importance lies not only in their sensitivity, but in their central role within the watershed's interconnected systems.

2.3.2 Severe and Far-reaching Ecosystem and Forest Health Vulnerabilities

Ecosystem-related components, especially forest health and ecosystem services and aquatic ecosystems in the Lower American River, consistently rank among the highest vulnerabilities. Forest health systems in the Upper American, Upper Bear, and Upper Cosumnes Rivers score at the maximum vulnerability level with systemwide effects, reflecting the compounding influence of drought, wildfire, pests, and heat. These vulnerabilities have implications well beyond ecology; they affect erosion, sediment transport, water quality, reservoir operations, and long-term hydrologic function across the watershed.

2.3.3 Flood Management: a Critical and Widespread Vulnerability

Flood-related assets, particularly levee systems, floodplains, and local drainage networks, emerge as a dominant vulnerability across the Lower American, Lower Cosumnes, and Lower Bear River planning areas. Levee systems in the Lower Cosumnes and Lower American Rivers are rated at the highest vulnerability level, reflecting high exposure to extreme precipitation and atmospheric rivers, combined with limited options for structural adaptation. These systems also exhibit high scale-of-effects scores, underscoring

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that flood failures would affect entire communities, transportation corridors, and agricultural areas, rather than isolated locations.

2.3.4 Surface Water Supply Vulnerabilities Driven by Snowpack Loss and Key Storage Constraints

Surface water supply systems show elevated vulnerability where they depend on snowpack-driven hydrology or single, critical storage facilities. Natural snowpack in the Upper American, Upper Bear, and Upper Cosumnes Rivers consistently ranks as highly vulnerable with systemwide consequences, reflecting the foundational role of snowpack as the watershed's largest natural reservoir. Folsom Reservoir, assessed under both surface water supply and flood management, stands out as one of the most consequential vulnerabilities in the entire assessment due to its sensitivity to runoff timing shifts and regulatory constraints that limit operational flexibility.

2.3.5 Groundwater Vulnerabilities Reflecting both Regional Sustainability and Localized Water Insecurity

Groundwater systems display two distinct but equally important vulnerability patterns. At the regional scale, groundwater basins in the Lower American and Lower Bear River areas score high vulnerability with large scales of effect, indicating risks to long-term groundwater sustainability and regional water reliability. At the local scale, small water systems and private landowner wells, particularly in the upper watershed and Cosumnes areas, show very high vulnerability despite having localized impacts. These systems lack redundancy and financial capacity, making them especially sensitive to drought and wildfire, and highlighting equity concerns even when impacts do not immediately cascade watershedwide.

2.3.6 Widespread but Often Subregional-scale Community and Equity Vulnerabilities

Community and equity components show consistently high vulnerability scores (rating of 4) across multiple planning areas, including Delta-edge communities, Sacramento Metro East, floodplain communities, foothill towns, and upper watershed rural communities. While many of these impacts are subregional in scale, they represent concentrated risk to populations with limited adaptive capacity, particularly in areas facing overlapping hazards such as flooding, heat, wildfire, and water insecurity. Upper watershed rural communities stand out with the highest vulnerability scores, reflecting isolation, limited redundancy, and constrained institutional capacity.

2.3.7 Lower Vulnerability but not Low Importance

Some systems, such as large conveyance infrastructure, major managed floodways, and certain municipal water systems, show lower vulnerability ratings due to higher adaptive capacity, even when exposed to climate stressors. These findings do not indicate absence of risk, but rather reflect that institutional strength, operational flexibility, and system design play a meaningful role in moderating climate impacts.

2.4 Key Vulnerability Drivers

Key drivers of vulnerability are the underlying climatic, physical, institutional, and operational factors that explain why certain systems, assets, or communities experience disproportionately high risk under climate stress. They describe the mechanisms through which climate hazards translate into real impacts by increasing system sensitivity, creating single points of failure, or constraining adaptive capacity.

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These drivers go beyond the presence of a hazard to capture dependencies, infrastructure limitations, and institutional constraints, as well as the compounding effects of multiple stressors.

Identifying key drivers provides the analytical link between vulnerability ratings and actionable responses, allowing planners to distinguish whether risks are best addressed through infrastructure investment, operational changes, policy reforms, ecosystem restoration, or institutional capacity building.

Table 2-3 summarizes the key drivers of vulnerability identified across the six sub-regions evaluated in this qualitative assessment. These drivers synthesize the results of the vulnerability analysis and highlight the underlying factors most responsible for high vulnerability ratings. Together, they provide a structured basis for prioritizing adaptation strategies and targeting actions where they will be most effective.

Table 2-3. Key Drivers of Vulnerability

Planning Area	Vulnerability Driver
Upper Watersheds (American, Bear, Cosumnes)	**Forest health** – Increasing frequency and intensity of wildfires are degrading watershed resilience and reducing critical ecosystem services.
Upper Watersheds (American, Bear, Cosumnes)	**Snowpack loss** –Natural water storage declines with local and statewide impacts; fractured rock aquifers offer little reliable backup for local communities.
Upper Watersheds (American, Bear, Cosumnes)	**Community and economic resilience** – Increasing stress impacts are felt in rural and resource-dependent communities.
Upper Watersheds (American, Bear, Cosumnes)	**Infrastructure exposure challenges** – Aging and vulnerable infrastructure is exposed to intensifying climate hazards.
Upper Watersheds (American, Bear, Cosumnes)	**Agricultural vulnerability** – Variable surface water supply, limited groundwater, and aging irrigation systems heighten drought risk.
Lower American River	**Forest health** –Water quality, air quality, and runoff regulation are affected.
Lower American River	**Snowpack loss** –Water supply, runoff timing and flood risks, and cold water availability are affected.
Lower American River	**Folsom Reservoir constraints** – Limited storage capacity and complex operational and regulatory trade-offs (e.g., supply, flood, temperature, Delta, and Central Valley Project [CVP]) may exist.
Lower American River	**Flood management challenges** – Few levee setback options exist; performance uncertainty results from more extreme events.
Lower Cosumnes Watershed	**Minimal flood protection** – Increasing stress on farms and small communities exists due to increasing frequency of extreme precipitation.
Lower Cosumnes Watershed	**Floodplain management challenges** – Increasing intensity of extreme events with no regulation facilities exasperates the dual stress of recurrent flooding and droughts.
Lower Bear River	**Forest health and fire risk** – Increasing wildfire frequency and severity degrade watershed function, reduce snowpack, and threaten water quality and hydropower assets.
Lower Bear River	**Limited storage and flood control** –Small reservoir capacity and limited flood infrastructure reduce flexibility to manage growing flood and drought extremes.

DRAFT

3. References

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Appendix A. Qualitative Vulnerability Assessment for American River Watershed

System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Agriculture	Lower American River	Placer County (West Placer)	Heat waves stress walnuts, rice, and livestock; irrigation demand increases.	Storm-driven flooding may inundate rice fields and rural roads.	N/A	Rice is highly vulnerable to cutbacks; groundwater pumping costly.	Smoke exposure during wildfire events affects grapes and labor.	Moderate - Rice production is sensitive to water shortages. - Other crops (walnuts, grapes) are also temperature- and water-dependent.	3	Moderate - Irrigation districts (PCWA, NID) provide some resilience - High water intensity of rice limits flexibility.	3	3	4
Agriculture	Lower American River	Sacramento County	Dairy, pears, grapes are sensitive to extreme heat; higher irrigation needs.	Urban/riverine floods; Delta levee breaches threaten orchards.	Delta lands exposed to backwater flooding + salinity intrusion.	Reduced surface deliveries; higher reliance on groundwater.	Smoke taint on grapes; grassfires possible.	Moderate - Diverse, high-value crops are climate sensitive - Delta flood/levee risks increase overall exposure.	3	Moderate-High - Strong institutional support - Larger-scale irrigation infrastructure - Access to multiple water sources improve adaptive capacity.	2	1	4
Community & Equity	Lower American River	Walnut Grove and Isleton Communities	Outdoor laborers and mobile housing residents face extreme heat and poor air quality.	Levee-protected communities face flood risk from Delta surges and high tides.		Heavy reliance on agriculture and water-dependent industries creates drought vulnerability. Reduced crop yields and job insecurity.	Vegetated levees and surrounding agricultural lands pose fire hazards, threatening community safety and air quality.	Moderate-high sensitivity - Economically vulnerable, linguistically diverse populations. - Agricultural labor increases exposure to extreme heat and poor air quality; - Housing stock is often unregulated and unsafe.	4	Moderate adaptive capacity - Strong community networks and place-based knowledge are strong; - Formal resilience planning and infrastructure are lacking. - Emergency support services have challenges reaching unincorporated populations	3	4	2
Community & Equity	Lower American River	Sacramento Metro East	Foothill communities experience increasing heat stress, with limited tree canopy and aging infrastructure compounding risks for outdoor workers, low-income households, and the elderly.	Localized flooding and stormwater overflow impact unincorporated and under-resourced areas, particularly those adjacent to creeks, canyons, or steep terrain with inadequate drainage systems.	N/A	Extended drought strains small water systems and domestic wells, particularly for households outside of major service districts or reliant on aging infrastructure.	Communities face severe wildfire exposure due to their proximity to wildland-urban interface zones, with many residents living in areas with single evacuation routes and limited defensible space.	High-moderate sensitive - Socioeconomic vulnerability, rural isolation, aging populations - Reliance on limited public services. - Populations with limited mobility, outdoor-based employment, or fixed incomes face heightened exposure to both acute events (fire, flood) and chronic stressors (heat, water scarcity).	4	Moderate - Uneven adaptive capacity. Some communities benefit from strong local organizing or fire-safe councils, while others lack adequate emergency planning, financial resources, or accessible public cooling and relief services. - Infrastructure gaps - Jurisdictional fragmentation limit coordinated adaptation responses.	3	4	2

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Community & Equity	Lower American River	Urban Core and Floodplain communities	Exposure to multiple urban heat islands, particularly in lower-income neighborhoods with limited tree cover, older buildings, and limited access to indoor cooling. Populations most affected includes children, elderly, and low-income renters.	localized flooding due to aging stormwater infrastructure. Increasing impermeable surfaces and intensifying rainfall events challenge drainage systems.	N/A	Local landscaping, parks, and green spaces face cutbacks during droughts, disproportionately affecting outdoor cooling and recreation for low-income families.	Zone is exposed to smoke, power shutoffs, and fire-related emergency shelter burdens due to proximity to Wildland Urban Interface zones. The Parkway corridor faces growing vegetation and ignition risks.	High-moderate sensitivity - Urban and suburban neighborhoods with overlapping vulnerabilities related to heat exposure, housing insecurity, and aging infrastructure. - Mobile home parks, subsidized housing, and communities of color are disproportionately impacted by heat stress and flooding. - Linguistic isolation, - Limited public transit, and exposure to traffic-related pollution compound climate impacts.	4	Moderate - Some well-resourced areas like Fair Oaks - DAC-designated census tracts and older urban cores have lower adaptive capacity. - Municipal services exist - Not all residents benefit equitably due to renter displacement, underinvestment in shade and stormwater infrastructure, and public health disparities. - Community organizations, local governments, and public agencies are increasingly engaged in adaptation - Targeted capacity-building and inclusive planning remain needed.	3	4	2
Ecosystem	Lower American River	Aquatic Ecosystems	Water temperatures frequently exceed salmon survival thresholds (~68°F), particularly during heat waves.	Extreme storm events cause rapid water releases from Folsom, impacting aquatic habitat downstream.	Sea level rise pushes Delta salinity upstream and may alter aquatic habitat suitability along the lower Sacramento River.	Reduced flows during drought limit aquatic habitat, causing critical stress to salmon populations.	Wildfires disrupt stream habitats by increasing sedimentation, turbidity, erosion (from lost vegetation roots), and altering water chemistry (higher pH), degrading water quality and aquatic habitats.	High sensitivity - Extreme heat and drought conditions, exacerbated by urban heat island effects. - Salmon and steelhead populations acutely vulnerable to thermal stress and reduced managed-flow availability during drought.	4	Moderate-low adaptive capacity - Actively managed flows from Folsom Reservoir providing periodic cold-water releases. - Adaptive management limited by finite cold-water supply during severe droughts and urban pressures restricting habitat connectivity	4	5	5
Ecosystem	Lower American River	Forest Health and Ecosystem Services	Warmer temperatures accelerate drought stress, increasing tree susceptibility to pests and disease, and increase risk of wildfires.	Heavy rainfall events erode soil, destabilizing slopes and increasing tree fall risk.	N/A	Extended drought conditions reduce oak woodland resilience, increasing mortality risk.	Wildfires cause extensive tree mortality, erosion, habitat loss, shifts in species composition, increased vulnerability to invasive species, and substantial biodiversity loss by eliminating critical habitats and native species.	Moderately sensitive - Drought-tolerant but vulnerable in prolonged drought. - Moderately sensitive oak woodlands experiencing stress and mortality from prolonged drought and invasive species. - Urban forests vulnerable to extreme heat events and urban heat island effects, reducing ecological function.	3	Moderate adaptive capacity - Protected areas like parks and urban forestry initiatives. - Constrained by fragmented landscapes, limited natural regeneration opportunities, - Restricted connectivity for species migration or range shifts under sustained climatic stress.	3	3	3

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Ecosystem	Lower American River	Riparian and Groundwater Dependent Ecosystems	Hotter summers increase riparian evapotranspiration demand on groundwater, dry out riparian soils faster, stressing vegetation.	Severe flooding can erode riparian zones.	Higher Delta salinity affects groundwater near riparian areas along the lower Sacramento River, impacting vegetation.	Drought lowers groundwater levels and baseflows, stressing riparian trees, cause die-offs, and may limit regeneration.	Wildfires damage riparian forests by reducing soil moisture, limiting regeneration, increasing habitat fragmentation, and significantly reducing biodiversity by harming sensitive aquatic and terrestrial species dependent on stable moisture conditions	Moderate-high sensitivity - Reliance on stable groundwater tables and periodic flooding for riparian regeneration. - Urban encroachment and reduced flood frequency diminish habitat quality and regeneration potential, especially during prolonged drought.	3	Moderate adaptive capacity, - Protected riparian corridor management (e.g., American River Parkway). - Limited by inability to fully mimic natural flooding regimes necessary for riparian forest recruitment.	3	3	3
Flood Management	Lower American River	Floodplain and Local Drainage	Urban heat and dry soils reduce infiltration and increase stormwater runoff temperatures.	Local drainage systems are overwhelmed by intense storms, causing flash flooding in urban areas.	Tidal backflow into storm drains increases flood risk in low-lying neighborhoods.	Prolonged dry periods reduce soil permeability, increasing runoff during subsequent storms.	Post-fire debris and ash clog storm drains, reducing drainage efficiency and increasing flood risk.	High sensitivity - Vulnerable to extreme precipitation, wildfire impacts - Impervious surfaces amplify localized flooding risks	4	Moderate to high adaptive capacity - Effective stormwater management, - Infrastructure redundancy, - Proactive management	2	3	3
Flood Management	Lower American River	Folsom Reservoir	Earlier snowmelt and warmer inflows reduce cold water pool availability, affecting downstream temperature management for fish.	High-intensity storms require rapid drawdowns, challenging flood control operations and increasing downstream risk.	N/A	Reduced inflows limit water supply, hydropower generation, and cold water pool management.	Increased sediment and nutrient loading from upstream fires degrade water quality and reduce storage.	Moderate to high sensitivity - Limited storage increases spill risk; - Extreme storms challenge flood management capabilities. - Increased post-fire sedimentation and debris flows	4	Moderate-low adaptive capacity - Small size relative to watershed runoff - Auxiliary spillway - Dam raise - Coordinated flood management - Potential for FIRO and coordination with upstream reservoirs	4	5	5
Flood Management	Lower American River	Lower American & Sacramento Levee System	Higher temperatures increase evapotranspiration and urban heat island effects, stressing levee-adjacent vegetation and soils.	High flows from upstream reservoirs combined with local stormwater can exceed levee design capacity, especially during atmospheric rivers.	N/A	Prolonged dry periods lead to increased soil desiccation, impacting structural integrity and increasing likelihood of failure during flood events.	Urban-interface fires can damage levee-adjacent infrastructure and increase erosion risk.	High sensitivity - Highly vulnerable to overtopping and erosion from intense flood events - High-flow releases from Folsom risk downstream earthen levee erosion - Limited capacity during prolonged dry periods due to levee erosion	4	Moderate-low adaptive capacity - Strong investment, oversight, real-time flood modeling - Strong levee infrastructure, ongoing upgrades, - Coordinated agency oversight and management - Capacity uneven across segments due to localized low points, - Urban encroachment that limits rooms for adaptation.	4	5	4

System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Flood Management	Lower American River	Sacramento Weir & Yolo Bypass	Hotter summers increase evapotranspiration in bypass wetlands, affecting habitat and water balance.	High flows trigger weir operation more frequently, stressing bypass capacity and maintenance.	N/A	Prolonged drought reduces sediment and nutrient flow through the bypass, resulting in ecosystem impacts.	Fire-prone due to vegetated floodplain and agricultural land, particularly during extended drought periods	Moderate sensitivity - Vegetation overgrowth, prolonged dryness increases fire risk - Extreme precipitation complicates weir operations	3	High adaptive capacity - Large area allows flexible management strategies - Constrained by fixed flow thresholds and manual gate operations	1	1	4
Groundwater Supply	Lower American River	Built System - landowner groundwater wells	Increased demand for irrigation and domestic use during heat waves	Flooding damages shallow wells and septic systems	N/A	Shallow wells may fail; increased pumping costs	Fire-related power outages and contamination risks	Moderate-high vulnerability: - Individual wells susceptible to drought-induced quality issues and drying.	4	Moderate adaptive capacity: - Most wells are shallow - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure. - Presence of drought contingency plans and access to state/federal funding, and regional groundwater planning	3	4	1
Groundwater Supply	Lower American River	Built System - municipal systems	Increased cooling and irrigation demand stresses municipal supply	Flooding damages pump stations and treatment infrastructure	N/A	Increased reliance on groundwater; supply shortfalls	Fire damage to infrastructure; degraded source water quality	Moderate vulnerability: - Increased demand and potential water quality degradation during drought conditions.	3	High adaptive capacity: - Well-integrated municipal systems with redundancy, - Active groundwater banking, conjunctive use - Treatment capabilities. - Municipal financial resources	1	1	2
Groundwater Supply	Lower American River	Natural System - North American Subbasin	Increased evapotranspiration reduces recharge; higher temperatures increase irrigation demand	Flooding mobilizes contaminants; reduces recharge efficiency	N/A	Overdraft risk; land subsidence potential	Post-fire runoff degrades recharge water quality	Moderate-highly sensitive: -Large agricultural and urban groundwater use with increased reliance on groundwater during drought conditions; - Potential contamination risks. - Highly reliant on consistent recharge from interconnected surface waters	4	Moderate-high adaptive capacity: - Large aquifer system is with substantial storage. - Active groundwater management through SGMA, conjunctive use, and coordinated management - Regional Water Bank provides good redundancy. - Recharge constrained by urbanization that limits natural recharge zones.	3	4	4

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Groundwater Supply	Lower American River	Natural System - South American Subbasin	Similar to North American Subbasin: reduced recharge and increased demand	Flooding overwhelms recharge basins; contaminant mobilization	N/A	Chronic overdraft risk; reduced aquifer recovery	Fire-related debris and ash degrade recharge quality	Moderate-Highly sensitive: - Agricultural and urban groundwater use with increased reliance on groundwater during drought conditions; - Potential contamination risks. - Highly reliant on consistent recharge from interconnected surface waters - History of groundwater overdraft and thick alluvial zones makes the system more prone to drawdowns.	4	Moderate-high adaptive capacity: - Large aquifer system is with substantial storage. - Active groundwater management through SGMA, conjunctive use, and coordinated management - Regional Water Bank provides good redundancy. - Recharge constrained by urbanization that limits natural recharge zones.	3	4	4
Hydropower	Lower American River	Folsom Reservoir	- Reduced snowpack and earlier snowmelt decrease reservoir inflows, reducing hydropower output in late summer and fall, coinciding with peak energy demand. - Increased evaporation further reduces reservoir storage.	- Increased flood risks from intense atmospheric river storms, necessitating earlier releases, lost generation opportunities, and potentially damaging infrastructure.	-Sea level rise pushes Delta salinity upstream, requiring higher freshwater outflows from Folsom, limiting storage available for hydropower generation and increasing operational complexity.	Extended droughts significantly reduce reservoir storage and hydropower generation capability, limiting energy production substantially during multi-year dry periods.	increased wildfire risks in upper watersheds lead to sedimentation and debris flows, impairing reservoir water quality, reducing storage capacity, and potentially damaging hydropower infrastructure.	High sensitivity: - Heavy reliance on snowpack-dependent inflows - Limited storage capacity relative to inflows and demand - Operational constraints during drought and heatwaves.	4	Moderate adaptive capacity - Integration with broader CVP/SWP water supply and power generation networks. - Coordinated releases with other CVP facility provide some operational flexibility - Existing infrastructure redundancy - Constrained by regulatory requirements, - Limited cold-water storage	3	4	5

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Recreation	Lower American River	Recreational Uses - access/use of forested recreation zones, camping/hiking activities, access to water activities	Urban heat and limited shade reduce the usability of river trails and increase health risks for vulnerable populations engaging in outdoor activities.	Flooding along the American River Parkway leads to temporary closures of trails, picnic areas, and public access points.	N/A	Drought reduces water quality and flow levels in the river, impacting swimming, wading, and boating conditions.	Regional smoke from nearby wildfires limits recreational use of river parks and trail systems, even without direct fire exposure.	Moderate sensitivity – Recreation is mostly urban and tied to well-used trail systems (e.g., American River Parkway) that flood frequently during storms – Heat exposure along paved or unshaded segments disproportionately impacts vulnerable users, including the elderly, children, and unhoused individuals – Water-based recreation such as swimming or wading is sensitive to both water quality degradation and lower flows during drought periods – Year-round use leads to cumulative wear and pressure on park and trail infrastructure	3	High-moderate adaptive capacity – Managed by well-resourced entities (e.g., Sacramento County Regional Parks), with established emergency response and communication systems – Infrastructure such as shade structures, signage, and bike patrols support safe recreation during moderate hazard conditions – Cooling centers and public messaging systems are in place and activated during heat and smoke events – Strong interagency partnerships and funding pipelines improve resilience across city-managed green space	2	1	4
Recreation	Lower American River	Tourism - Impacts on businesses, quantity of visitors	High summer temperatures discourage tourism at riverfront parks, outdoor festivals, and walking tours, especially during peak afternoon hours.	Extreme storms flood riverfront paths and disrupt events, reducing tourist activity and damaging infrastructure.	N/A	Low water levels and poor river aesthetics during drought conditions deter water-based tourism and degrade visitor experience.	Widespread smoke from regional wildfires affects air quality, deters travel, and results in event cancellations or reduced turnout.	Moderate sensitivity – Tourism is tied to seasonal events and accessible green spaces, which are impacted by flooding, heatwaves, and poor air quality – Riverfront trails and outdoor festivals are disrupted by climate stressors but are not the sole driver of tourism to the area – Sensitive to smoke, trail closures, and heat during peak summer months when tourism peaks	3	High-moderate adaptive capacity – Sacramento's diversified tourism economy includes indoor, cultural, and historic attractions that provide fallback options – Investment in flood resilience and green infrastructure buffers some climate-related disruptions – Air quality alerts and visitor advisories are integrated into broader public communication platforms	2	1	4
Surface Water Supply	Lower American River	Built Conveyance (e.g., Canals, pipelines, intakes)	Higher temperatures increase water losses from evaporation; thermal expansion stresses infrastructure	Flooding can damage intakes and pump stations; sediment clogs infrastructure	N/A	Water supply availability sharply curtailed; stress on aging pipelines.	Post-fire sedimentation and turbidity clog and damage intake screens and pumps. Fire-related power outages have impacts on pump stations and SCADA systems.	Moderate vulnerability: - Urban infrastructure susceptible to flood damage, - Increased pollutant load in extreme precipitation events, - Potential impacts from sediment and wildfire runoff	3	High adaptive capacity: - Redundant infrastructure, - Multiple source options (e.g., groundwater, Sacramento River), - Proactive maintenance and management.	1	1	4

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Surface Water Supply	Lower American River	Folsom Reservoir	Rising temperatures accelerate snowmelt timing in the Sierra Nevada, Folsom Reservoir fills earlier than peak summer demand resulting in increased evapotranspiration loss, higher risk of midsummer shortages, compromised ecosystem flow targets and greater volatility in reservoir operations.	Sudden inflows from atmospheric rivers or rapid snowmelt trigger emergency releases (Jan 2017, heavy rainfall led to high inflows triggering controlled flood releases)	N/A	Loss of snowmelt timing affects storage for drought supplies, surface flow reductions reduce delivery reliability; Reduced reliability during drought; 2022 shortfalls projected at 117,000 acre-feet/year	Post-fire hydrophobic soils reduce infiltration; ash and debris degrade water quality	High Sensitivity: - Small reservoir size relative to watershed increases flood spill and drought shortage risk; - Warm temperatures exacerbate evaporation losses and reduce cold-water pool. - Sedimentation and water quality risks from wildfire runoff.	5	Moderate adaptive capacity: - Auxiliary spillway and reservoir raise increase flood management effectiveness - Multi-agency management (Water Forum) - Conjunctive use and groundwater availability provide operational flexibility. - Strict regulatory constraints, CVP operations, and minimum flow requirements limit adaptation options	3	5	5
Surface Water Supply	Lower American River	Natural Conveyance - River System	Elevated temperatures reduce cold-water habitat for salmonids; increased algal blooms and thermal stress	Flashier flows increase erosion, sedimentation, and bank instability	N/A	Reduced reservoir inflows limit summer baseflows; water quality impacts resulting from concentration of nutrients; low flow volumes lead to higher water temperatures impacting cold-water species.	Runoff causes water quality impacts; increased erosion. Debris flows destabilize riverbanks and infrastructure.	Highly sensitive - Flow dependency, ecological thresholds critical for fish survival. - Reduced summer flows, elevated water temperatures, turbidity from storms, and degraded aquatic habitats.	4	Moderate adaptive capacity: - Managed flow standards (Modified Flow Management Standard), - Coordinated management and strong institutional oversight (Water Forum, Reclamation, Sacramento Area Flood Control Agency). - Habitat restoration efforts.	3	4	4
Water Quality	Lower American River	Drinking Water Source Quality	Higher source water temperatures causing DBP management challenges; potential algal toxins from HABs.	Potential water intake disruptions and treatment issues from high turbidity and pollutant influx during floods.	Moderate indirect effects due to Delta operations potentially influencing water availability & quality.	Increased concentration of pollutants; challenges in maintaining drinking water quality standards; reliance on groundwater blending or alternate sources.	Treatment complexity increases from turbidity and contaminants from upstream wildfire runoff events.	High sensitivity - Higher pollutant concentrations in low flows. - Elevated water temperatures, algal blooms, turbidity spikes, potential DBPs affecting treatment processes.	4	High capacity - Advanced water treatment capabilities, - Redundant supply sources (Sacramento River, groundwater) - Inter-agency collaboration.	2	3	3
Water Quality	Lower American River	Ecological	Reduced habitat suitability (high temperature, low dissolved oxygen) threatens salmonids; frequent algal blooms.	High turbidity and pollutant spikes degrade aquatic ecosystems, impact fish spawning habitats.	Moderate indirect impacts due to possible increased freshwater release demands affecting ecological flows.	Extreme stress due to reduced flows and increased contaminant concentrations.	Severe sedimentation, nutrient inputs from upstream wildfire runoff, damaging riparian and aquatic habitats.	High sensitivity - Reduced flows, elevated temperatures significantly stress salmon habitat -Higher pollutant concentrations in low flows and degraded DO levels stress aquatic life.	4	Moderate-high capacity - Habitat restoration efforts - Coordinated management across agencies. - Effective management (Modified Flow Management Standard) - Folsom storage can assist with temperature management.	3	4	3

System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Water Quality	Lower American River	Regulatory Standards	Difficulty achieving temperature and dissolved oxygen standards critical for salmon; increased frequency of water quality exceedances.	Difficulty maintaining turbidity, bacteria, nutrient standards after extreme floods/stormwater runoff.	Moderate (regulatory obligations for Delta salinity could reduce freshwater allocations).	Challenges meeting flow and water quality standards for ecosystem protection, especially during extreme drought.	Difficulty meeting turbidity and nutrient standards due to wildfire debris flows from upper watershed.	High sensitivity - Challenges in consistently meeting temperature and water quality standards due to climate extremes and reduced flows.	4	High capacity - Strong institutional framework - Multiple water sources to offset reliance on lower American - Effective regional coordination.	3	4	3
Ecosystem	Lower Bear River	Aquatic Ecosystems	Increased temperatures raise water temperatures above native trout thermal tolerance for extended durations (75-77°F).	Extreme rainfall causes significant flooding that scour streambeds, destroying eggs, displacing species, and mobilizing legacy mercury contamination.	N/A	Extended drought conditions significantly reduce habitat and degrade water quality (low oxygen, algal blooms).	Wildfires disrupt stream habitats by increasing sedimentation, turbidity, erosion (from lost vegetation roots), and altering water chemistry (higher pH), degrading water quality and aquatic habitats.	Moderately sensitive - Rising stream temperatures, extended drought-induced low-flow conditions, - Flooding events that mobilize legacy mercury. - Small watershed size quickly pushes habitats beyond ecological thresholds. - Cold-water trout severely threatened.	3	Moderate-low adaptive capacity - Fragmented habitats from dams and diversions. - Legacy mercury contamination exacerbates vulnerability. - Minimal opportunities for species migration or natural refugia, exacerbated by limited management interventions and resources.	3	3	4
Ecosystem	Lower Bear River	Riparian and Groundwater Dependent Ecosystems	Hotter summers increase riparian evapotranspiration demand on groundwater, dry out riparian soils faster, stressing vegetation.	Intense flooding events severely erode riparian zones and destabilize banks, altering vegetation communities.	N/A	Extended drought periods critically lower groundwater levels, causing riparian trees diebacks, converting habitat to drought-tolerant species.	Wildfires damage riparian forests by reducing soil moisture, limiting regeneration, increasing habitat fragmentation, and significantly reducing biodiversity by harming sensitive aquatic and terrestrial species dependent on stable moisture conditions	Moderately sensitive - Prolonged drought-driven groundwater declines and extreme flooding-induced erosion. - Moisture-dependent communities (wet meadows, riparian corridors) rapidly degrade and transition to drought-tolerant vegetation under persistent dry conditions.	3	Moderate adaptive capacity - Constrained by fragmented riparian corridors, loss of connectivity due to historical development. - Institutional and resource constraints impede restoration and conservation efforts significantly.	3	3	3
Flood Management	Lower Bear River	Bear Levee System	Prolonged heat dries levee soils and accelerates embankment cracking, weaking levee integrity	Intense rainfall events cause rapid runoff and localized flooding that increase overtopping and erosion risk.	Indirect impacts may occur where Delta backwater effects alter flood stages in the lower reaches	Drought hardens soils, reducing infiltration and increasing flash flood risk during storms.	Post-fire runoff increases sediment loads and accelerates erosion on levee-adjacent waterways	High sensitivity - Vulnerable to drought-related soil cracking and wildfire sedimentation - Increased erosion risk and reduced levee integrity	4	Moderate adaptive capacity - Recent improvements and flood control planning efforts - Limited resources, steep terrain, legacy development constraints limit large-scale adaptations	3	4	4

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Flood Management	Lower Bear River	Floodplain and Local Drainage	Hotter temperatures reduce soil moisture and evapotranspiration patterns, shifting runoff timing and reducing seasonal groundwater recharge	Short, intense storms overwhelm local drainages and floodplains, increasing surface runoff and erosion into downstream channels.	N/A	Drought dries out soils, reducing infiltration and increasing flash flood potential during later storms	Wildfire removes vegetation and destabilizes slopes, increasing sediment runoff and clogging local drainage systems	Moderate to high sensitivity - Vulnerable to intense rainfall, post-fire erosion - Increased flash flooding, sediment buildup and culvert overflows	4	Moderate adaptive capacity - Floodplain has capacity - Rural drainage system limited by poorly maintained culverts, ditches - Infrastructure capacity is limited to manage peak flows and debris	3	4	3
Groundwater Supply	Lower Bear River	Built System - land owner groundwater wells	Increased demand for agricultural/domestic use	Flooding damages wellheads and access roads	N/A	Reduced reliability; increased maintenance	Fire-related debris and power loss disrupt operations	Moderate-High vulnerability: - Individual wells susceptible to drought-induced quality issues and drying. - Highly sensitive to prolonged droughts. - High summer temperatures tax irrigation and outdoor domestic use.	4	Moderate adaptive capacity: - Most wells are shallow - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure. - Presence of drought contingency plans and access to state/federal funding, and regional groundwater planning - Inconsistent GSA coverage and limited regional recharge projects.	3	4	1
Groundwater Supply	Lower Bear River	Built System - municipal systems	Increased demand for cooling and irrigation	Flooding damages infrastructure; sediment increases treatment needs	N/A	Emergency operations during drought; supply stress	Fire damage to infrastructure; degraded water quality	Moderate vulnerability: - Increased pumping in drought risks groundwater depletion and contamination. - Drought and wildfire risk causes system-wide stress.	3	Moderate-High adaptive capacity: - Limited redundancy and financial resources for infrastructure improvements for small communities; - Moderate operational flexibility. - Presence of drought contingency plans and access to state/federal funding, and regional groundwater planning. - Inconsistent GSA coverage and limited regional recharge projects.	3	3	1

System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Groundwater Supply	Lower Bear River	Natural System - Groundwater Basin	Higher temperatures reduce recharge efficiency; increased irrigation demand	Flooding reduces infiltration; increases surface runoff	N/A	Limited storage heightens drought vulnerability	Post-fire erosion and sedimentation reduce recharge quality	Moderate-High vulnerability: - Groundwater basin is a combination of fractured bedrock aquifers upland and disconnected alluvial systems in the lowland areas - Recharge is heavily dependent on snowmelt and increased precipitation. - Sensitive to drought-induced depletion, - Contamination from surface contaminants.	4	Moderate adaptive capacity: - Some conjunctive use, - Limited active management and recharge projects in place.	3	4	4
Surface Water Supply	Lower Bear River	Natural Conveyance - River System	Warmer temperatures reduce cold-water refugia; thermal stress on aquatic species	Channel scouring and sedimentation from high flows. Reduced accumulation and earlier melt limit reliable downstream water delivery; 2021 Sierra snowpack peaked early, reducing Bear River inflows	N/A	Prolonged drought reduces baseflow contributions from snowmelt, springs, etc. Decreased sediment transport causes stagnation in low-flow areas; aquatic habitat impacts and loss of riparian vegetation	Post-fire erosion, sedimentation, and debris flows. Aquatic habitat and fish impacts.	Moderate-High sensitivity: - Fragmented by impoundments. - Susceptible to sedimentation and mercury contamination from historic mining, - Increased turbidity from intense storms, and reduced flow during drought.	4	Moderate adaptive capacity - Natural buffers are limited - No large-scale restoration or flow-protection policies currently present. - Limited control over river system conditions; - Basic operational flexibility	3	4	3
Water Quality	Lower Bear River	Drinking Water Source Quality	Increased temperatures causing HABs; potential DBP formation.	Extreme turbidity events complicating water treatment; potential damage to conveyance infrastructure (canals, flumes).	N/A	Increased treatment challenges from higher contaminant concentration; limited ability to blend or switch sources.	High turbidity and contaminants post-wildfire requiring complex and costly treatment; potential infrastructure damage.	Moderate-High sensitivity: - Severe turbidity events and contaminants (mercury, nutrients) post-wildfire; - Water quality significantly impacted by drought conditions.	4	Moderate: - Basic redundancy, - Moderate treatment flexibility, - constrained by aging infrastructure & vulnerability, - Limited financial and operational resources.	3	4	2
Water Quality	Lower Bear River	Ecological	Habitat degradation for native species from high water temperatures, HABs, and reduced dissolved oxygen.	Severe turbidity and mercury contamination from historic mining mobilized by floods.	N/A	Severe ecological stress from very low flows, concentrated pollutants, elevated nutrient concentrations.	Post-fire sedimentation, turbidity, and mercury contamination severely impacting aquatic ecosystems.	Moderate sensitivity - High vulnerability to wildfire-induced erosion, sedimentation, and contaminants affecting aquatic habitats and biodiversity. - Severe wildfire risk and flooding can mobilize legacy mercury contamination	3	Moderate capacity; - Small-scale habitat restoration and sediment management. - Constrained by financial resources and infrastructure	3	3	2

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Water Quality	Lower Bear River	Regulatory Standards	Challenges maintaining water temperature and dissolved oxygen standards during heat events.	Increased turbidity, mercury mobilization challenging compliance with water quality standards.	N/A	Difficulty maintaining regulatory compliance for instream flows, turbidity, and temperature criteria during drought.	Increased regulatory compliance difficulty due to post-fire sediment, mercury, and turbidity spikes.	Moderate-High sensitivity - Difficulties meeting turbidity, temperature, mercury, and dissolved oxygen standards due to legacy mining and climate-driven events.	4	Moderate; - Limited capacity due to financial constraints - Limited regulatory flexibility and few resources to enhance compliance strategies. - Small-scale infrastructure.	3	4	3
Agriculture	Lower Bear River	Valley	Hotter summers increase evapotranspiration and irrigation demand, straining both surface and groundwater. Energy costs rise for pumping.	Farms exposed to Bear River overflow and storm-driven flooding; soil erosion and sedimentation increase recovery costs.	N/A	Irrigated agriculture suffers during drought as surface deliveries shrink; shallow groundwater aquifers are quickly depleted.	Smoke and ash deposition reduce crop quality; power outages disrupt irrigation and post-harvest handling.	Moderate - Crops and soils are sensitive to both drought and flooding - Limited buffer capacity. - Agricultural lands are sensitive due to limited storage and shallow aquifers - Narrow crop base (walnuts, pasture, vineyards) - Soils prone to erosion. - Buffer capacity against prolonged drought/flood is minimal.	3	Moderate - Irrigation districts (PCWA, NID) provide some water flexibility - Redundancy is limited, and infrastructure cannot easily absorb long-duration climate shocks.	3	3	4
Agriculture	Lower Bear River	Valley	Hotter summers increase evapotranspiration and irrigation demand, straining both surface and groundwater. Energy costs rise for pumping.	Farms exposed to Bear River overflow and storm-driven flooding; soil erosion and sedimentation increase recovery costs.	N/A	Irrigated agriculture suffers during drought as surface deliveries shrink; shallow groundwater aquifers are quickly depleted.	Smoke and ash deposition reduce crop quality; power outages disrupt irrigation and post-harvest handling.	Moderate - Crops and soils are sensitive to both drought and flooding - Limited buffer capacity. - Agricultural lands are sensitive due to limited storage and shallow aquifers - Narrow crop base (walnuts, pasture, vineyards) - Soils prone to erosion. - Buffer capacity against prolonged drought/flood is minimal.	3	Moderate - Irrigation districts (PCWA, NID) provide some water flexibility - Redundancy is limited, and infrastructure cannot easily absorb long-duration climate shocks.	3	3	4

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Community & Equity	Lower Bear River	Wheatland and Agricultural Edge	Field laborers experience prolonged sun exposure without sufficient protections. Residences often lack air conditioning. High health risks for elders and outdoor workers, especially undocumented populations who may avoid seeking medical help.	Levee-protected agricultural areas face flood risk from intense storms and backwater effects, with potential to disrupt crop production and worker transportation.		Dependence on irrigation-dependent agriculture creates heightened risk during drought, threatening both employment and food supply chains.	Vegetated levees, dry agricultural lands, and interface areas create moderate wildfire risk, exposing outdoor workers to smoke and disruption during harvest periods.	High-Moderate sensitivity -Rural isolation, unincorporated governance, and inadequate infrastructure. - Many residents face language barriers, immigration-related fear of engagement, and lack reliable access to transportation, healthcare, or insurance. - Agricultural labor patterns increase direct exposure to extreme heat and poor air quality - Housing stock is often unregulated and unsafe.	4	Moderate adaptive capacity. - Strong community networks and place-based knowledge - Formal resilience infrastructure and planning support are lacking. - County services often struggle to reach unincorporated populations. - Emergency communication and climate adaptation initiatives remain inaccessible for non-English speakers, undocumented workers, and those living in informal housing.	3	4	2
Agriculture	Lower Cosumnes River	Valley	Rising heat increases irrigation demand, lowers water-use efficiency, and stresses grapes, walnuts, and orchards. Higher temperatures degrade soils and increase pest pressures.	Floodplain agriculture highly exposed to seasonal inundation and atmospheric river flooding. Floods prolong saturation, cause root damage, delay operations, and alter recharge patterns.	Small Delta backwater risk.	Heavy dependence on variable surface flows and shallow groundwater. During droughts, groundwater overdraft accelerates aquifer depletion.	Wildfire smoke affects grapes and orchard products, reducing marketability; poor air quality threatens farm labor during harvest.	Moderate sensitivity - Dual exposure to both flooding and drought creates severe stress. - Vineyards and orchards are especially vulnerable to root damage from flood and to water scarcity during drought. - Farms depend on highly variable floodplain water and over drafted groundwater	3	Moderate - Some adaptive capacity through conservation easements, restoration projects (Cosumnes Preserve), and state/federal programs. - Infrastructure is minimal, floodplain farms lack protective levees - Overdraft risks constrain resilience.	3	3	4
Community & Equity	Lower Cosumnes River	Galt South and Delta Edge	Outdoor agricultural workers and rural residents experience extreme heat stress due to insufficient protections and limited access to cooling infrastructure. Elders, children, and undocumented residents are especially vulnerable.	Levee-protected rural communities face significant risk of backflow flooding and storm surges. Unincorporated areas are exceptionally vulnerable with limited emergency resources.		Reliance on irrigation-dependent agriculture and private wells. Drought impacts threaten water supply reliability and agricultural livelihoods.	Vegetated levees and nearby agricultural fields are fire hazards, exposing workers and rural homes to smoke and access disruptions.	Moderate-High sensitivity - Rural isolation and aging infrastructure; - Limited defensible space; - Dependence on private wells and small systems; - Populations with limited mobility face evacuation challenges	4	Moderate adaptive capacity - Community networks and place-based knowledge are strong; - Formal resilience planning and infrastructure are lacking. - Emergency support services have challenges reaching unincorporated populations	3	4	2

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Ecosystem	Lower Cosumnes River	Aquatic Ecosystems	High temperatures intensify low-flow periods, causing severe aquatic habitat loss and thermal stress.	Extreme rainfall causes significant flooding, increasing sediment loads, affecting stream channel stability, reshaping river channels and aquatic habitats.	Sea level rise exacerbates tidal influence, increasing habitat variability for aquatic species along the lower reaches.	Prolonged drought leads to extended drying of river reaches, severely impacting aquatic life.	Wildfires disrupt stream habitats by increasing sedimentation, turbidity, erosion (from lost vegetation roots), and altering water chemistry (higher pH), degrading water quality and aquatic habitats.	Moderate sensitivity - Subject to natural hydrologic extremes (drying in drought, flood-driven erosion). - Aquatic habitats dependent on seasonal flow variability threatened by prolonged drought and extreme floods. - Native fish, particularly salmon, vulnerable to altered timing and magnitude of flows.	3	Moderate adaptive capacity - Preserved floodplain connectivity providing natural habitat resilience. - Lack of upstream reservoirs to buffer extreme drought conditions significantly limits capacity. - Groundwater depletion reduces available aquatic refugia during dry periods.	3	3	3
Ecosystem	Lower Cosumnes River	Riparian and Groundwater Dependent Ecosystems	Increasing heat significantly reduces groundwater recharge and stresses riparian vegetation.	Intense storms regularly inundate riparian zones, reshaping ecosystems, and groundwater recharge patterns.	Increased salinity intrusion from sea level rise affects groundwater availability and riparian health along the lower reaches.	Drought lowers groundwater levels and baseflows, stressing riparian trees, cause die-offs, and may limit regeneration.	Wildfires damage riparian forests by reducing soil moisture, limiting regeneration, increasing habitat fragmentation, and significantly reducing biodiversity by harming sensitive aquatic and terrestrial species dependent on stable moisture conditions	Moderate sensitivity - Dependence on natural flooding cycles for regeneration and sustained groundwater for vegetation survival. - Severe droughts and altered flood timing significantly threaten riparian forest regeneration and wetland health.	3	Moderate-high adaptive capacity - Preserved floodplain connectivity allowing natural habitat regeneration and groundwater recharge. - Adaptive capacity constrained by groundwater overdraft during drought and absence of reservoir-backed flow management.	4	4	3
Flood Management	Lower Cosumnes River	Floodplain and Local Drainage	Heat shortens wet cycles, reducing floodplain storage and groundwater recharge.	Storms cause fast inundation in non-maintained channels, flooding infrastructure.	N/A	Dry soils reduce floodplain function and alter seasonal flow timing	Upland fires increase sediment loads, clogging local drainage and ecological features	High sensitivity - Highly vulnerable to hydrologic variability, flood events, and sediment from wildfire - Frequent flooding impacts agricultural runoff and pollutant mobilization.	5	Moderate adaptive capacity - Natural floodplain capacity provides some resilience - Local drainage infrastructure inadequate for extreme flooding conditions, reducing overall capacity to manage intense flood scenarios	3	5	3

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Flood Management	Lower Cosumnes River	Levee System	Prolonged heat dries levee soils, increasing the risk of shrinkage, cracking, and embankment failure	Extreme precipitation events generate peak flows that exceed levee capacity, increasing risk of overtopping and erosion (1997, 2006 flood)	N/A	Dry conditions weaken levee soils and reduce riparian vegetation, leaving embankments more exposed to erosion during storms	Wildfire removes vegetation and destabilizes slopes, increasing sediment runoff and clogging local drainage systems	High sensitivity - No upstream dams for flow regulation; - Highly vulnerable to atmospheric river flooding and overtopping - Proximity to tidal backwater areas increases risk - Sediment and pollutant mobilization.	5	Low adaptive capacity - Limited levee infrastructure and no reservoir control; - Fully dependent on natural floodplain management. - Recent infrastructure upgrades and regional planning efforts - Limited by aging infrastructure, multi-jurisdictional governance complexity	5	5	4
Groundwater Supply	Lower Cosumnes River	Built System - land owner groundwater wells	Increased demand during heat waves	Flooding damages wells and access	N/A	Reduced reliability; increased groundwater depletion	Fire-related disruptions to power and water quality	Moderate-High vulnerability: - Individual wells susceptible to drought-induced quality issues and drying. - Highly sensitive to prolonged droughts. - High summer temperatures tax irrigation and outdoor domestic use.	4	Moderate adaptive capacity: - Most wells are shallow - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure. - Presence of drought contingency plans and access to state/federal funding, and regional groundwater planning - Limited regional recharge projects	3	4	1

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Groundwater Supply	Lower Cosumnes River	Built System - municipal systems	Increased municipal demand	Flooding damages infrastructure; increases treatment needs	N/A	Supply shortfalls; increased treatment and pumping needs	Fire damage to infrastructure; degraded source water quality	Moderate sensitivity - Municipal systems such as Galt, Clay Water district depend on single source of groundwater - Increased pumping in drought risks groundwater depletion and contamination. - Drought and wildfire risk causes system-wide stress.	3	Moderate-high adaptive capacity: - Limited redundancy - Moderate operational flexibility. - Presence of drought contingency plans and access to state/federal funding, and regional groundwater planning. - Cosumnes Subbasin Provides framework for coordinated adaptive management	2	1	2
Groundwater Supply	Lower Cosumnes River	Natural System - Groundwater Basin	Higher temperatures reduce recharge; increased evapotranspiration	Flash flooding reduces infiltration; increases erosion	N/A	Already stressed basin becomes more vulnerable	Post-fire runoff introduces sediment and contaminants	High sensitivity: - Overdraft conditions due agricultural pumping - Limited upstream inflows that are subject to variable precipitations - River dries out during low flow seasons limiting recharge - Depends largely on seasonal recharge and floodplain overflow.	4	Moderate adaptive capacity: - Active SGMA management, - Limited groundwater recharge and conjunctive use projects ongoing.	3	4	3
Recreation	Lower Cosumnes River	Recreational Uses - access/use of forested recreation zones, camping/hiking activities, access to water activities	Heat limits safe access to unshaded riparian areas, reducing visitation during peak afternoon hours.	Seasonal flooding renders popular recreation areas inaccessible and damages trails and access roads.	N/A	Drought dries up seasonal wetlands and creeks, limiting wading, paddling, and wildlife observation opportunities.	Surrounding grassland fires create closures and safety hazards that limit recreation even in unburned zones.	Moderate-Low sensitivity – Tourism is low-density and highly dependent on landscape quality, clean air, and water-based activities, all vulnerable to climate stressors – Small lodging operators and nature-based experiences are particularly impacted by fire risk, road closures, and drought – Scenic routes and rural hospitality offerings face long-term reputational damage following major climate events	2	Moderate adaptive capacity – Limited formal coordination among tourism operators, with most businesses operating independently or seasonally – Few marketing or contingency strategies are in place for post-disaster recovery or visitor redirection – Emergency alert systems and climate-adaptive business planning are not well integrated into tourism sector management – Some potential exists for increased resilience through agritourism and seasonal diversification, but this remains largely untap	3	2	4

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Recreation	Lower Cosumnes River	Tourism - Impacts to businesses, quantity of visitors	Rising temperatures reduce the seasonal appeal of nature tourism tied to birding and habitat viewing.	Flooded preserves and trail systems reduce eco-tourism access and visitor safety during wet seasons.	N/A	Loss of wetland habitat and low stream flows reduce the draw for seasonal visitors, birders, and eco-tour groups.	Fire and smoke from nearby uplands reduce visibility, impact air quality, and diminish the experience of open-space tourism.	Moderate-Low sensitivity – Small lodging operators and nature-based experiences are particularly impacted by fire risk, road closures, and drought	2	Moderate adaptive capacity – Limited formal coordination among tourism operators, with most businesses operating independently or seasonally – Emergency alert systems and climate-adaptive business planning are not well integrated into tourism sector management – Some potential exists for increased resilience through agritourism and seasonal diversification, but this remains largely untapped	3	2	4
Surface Water Supply	Lower Cosumnes River	Built Conveyance (e.g., Canals, pipelines, intakes)	Higher temperatures increase water demand and stress on delivery systems	Flooding damages infrastructure and increases sediment load	N/A	Loss of snowmelt timing affects storage for drought supplies, surface flow reductions reduce delivery reliability	Debris and sediment from fire runoff degrade aquatic ecosystems and clog channels; loss of riparian vegetation reduces bank stability; post-fire runoff leads to flashier flows and elevated flood risks.	Moderate vulnerability: - Limited conveyance infrastructure at risk from floods and drought-driven low flows; - Minimal redundancy.	3	Moderate adaptive capacity: - Infrastructure limited in scope; - Minimal emergency or backup options available.	3	3	2
Surface Water Supply	Lower Cosumnes River	Natural Conveyance - River System	Elevated temperatures increase evapotranspiration and reduce baseflows	Flash floods increase erosion and channel instability	N/A	Flow impacts - disconnected streams, diminished baseflows and impaired ecological connectivity	Debris and sediment from fire runoff degrade aquatic ecosystems and clog channels	Moderate sensitivity: - No regulating reservoirs - Severe flooding risk, extreme low-flow conditions in drought, - High turbidity and sediment loads during floods.	3	Moderate-high adaptive capacity: - Some floodplain capacity to absorb and filter sediment, - Groundwater recharge provides limited base flow in drought.	3	3	3
Water Quality	Lower Cosumnes River	Drinking Water Source Quality	Limited direct surface water treatment; primarily groundwater wells. Increased groundwater quality risk (salinity, contaminants).	Potential contamination from agricultural runoff during flooding; groundwater impacts from flooded fields.	Moderate-long term risk to groundwater quality (salinity intrusion near delta).	Severe drought reduces groundwater recharge, risking groundwater quality decline; wells at risk of drying.	Potential groundwater contamination post-wildfire; increased organic carbon, nutrients from ash/debris flows.	Moderate sensitivity - Reliance on groundwater wells - Potential contamination from salinity intrusion, agriculture runoff, wildfire events.	3	Moderate; - Groundwater dependency, - No alternative water sources, or advanced treatment infrastructure,	3	3	3

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Water Quality	Lower Cosumnes River	Ecological	Severe ecological stress (very high temperatures, frequent drying events, algal blooms, and low dissolved oxygen) causing near-total ecosystem collapse in drought periods.	Significant sediment/nutrient pulses from flooding degrading downstream habitats.	Moderate future impact on lower reaches and delta wetlands (increased salinity intrusion).	Extreme ecological degradation due to river drying and habitat loss; near-total collapse of aquatic habitats in drought.	Severe habitat damage from sediment, ash, nutrients post-wildfire; high turbidity severely impacting aquatic ecosystems.	Moderate-High sensitivity: - Minimal redundancy, - Free-flowing river highly susceptible to drought drying, extreme water temperature, severe biodiversity loss during low-flow events.	4	Moderate: - Natural floodplain resilience provides some buffering; - Minimal management infrastructure to actively mitigate risks.	3	4	4
Water Quality	Lower Cosumnes River	Regulatory Standards	Difficulty maintaining temperature and dissolved oxygen standards due to frequent low flows and high water temperatures.	Frequent exceedances of turbidity and nutrient standards during flooding; limited ability to control pollutants.	Moderate (potential future salinity challenges in lower watershed).	Nearly impossible to maintain instream flow standards; severe challenges meeting regulatory objectives in drought.	Severe sedimentation and nutrient influx post-wildfire complicating compliance with water quality standards.	Moderate sensitivity: - Frequent inability to meet flow, temperature, dissolved oxygen, turbidity standards; - Vulnerability in drought and low-flow periods.	3	Moderate: - Minimal management infrastructure, - No reservoir or flow control measures, - Severely constrained capacity to comply with regulatory standards.	3	3	3
Agriculture	Upper American River	El Dorado County	Apples and wine grapes highly sensitive to extreme heat and reduced chill hours; livestock stress.	Heavy storms cause soil erosion, orchard damage, and access loss.	N/A	Many farms outside irrigation districts; wells and flumes vulnerable; water scarcity worsens in drought.	Very high wildfire exposure (Caldor Fire showed direct crop/infrastructure losses).	Moderate - Apples and grapes are extremely sensitive to late frost, heat, and smoke. - Fragmented, non-district water systems increase climate vulnerability.	3	Low–Moderate - Adaptive capacity constrained by reliance on vulnerable flumes/wells and lack of redundancy. - Agritourism economy magnifies exposure to disruptions.	4	4	4
Agriculture	Upper American River	Placer County (Foothills)	Heat stress reduces mandarin quality/marketability; walnuts and livestock productivity decline. Reduced snowpack lowers streamflow.	Flash floods/erosion damage soils, terraces, irrigation.	N/A	Reduced seasonal flows limit irrigation for specialty crops and rangeland; reliance on small-scale systems.	High wildfire exposure; rangeland, orchards, and vineyards threatened.	Moderate - Specialty crops (mandarins, walnuts) and livestock are highly climate-sensitive. - Water availability depends almost entirely on seasonal surface runoff, increasing exposure to heat/drought variability.	3	Moderate - Some adaptive capacity from PCWA and irrigation districts. - However, smaller-scale farms and foothill topography limit water storage, reducing redundancy in extreme years.	3	3	4

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Community & Equity	Upper American River	Foothill Towns along Highway Corridors (Placerville, Auburn,	Tree loss from wildfire has increased solar exposure and heat stress for mobile and temporary housing residents. Aging populations face higher health risks. Many homes lack AC or have poor insulation.	Post-fire landscapes are highly vulnerable to debris flows and landslides. Hydrophobic soils increase surface runoff, and culverts are often undersized. Road failures and erosion are recurrent risks.	N/A	Communities rely on private wells, small mutual water companies, and forest-fed water systems with little redundancy. Reduced snowpack and dry years strain water reliability and affordability.	This zone lies entirely within VHFHSZ. The Caldor Fire caused severe infrastructure damage, loss of homes, and persistent re-burn risk. Long-term impacts to health, housing, and landscape recovery persist.	High-Moderate sensitivity - Aging or mobile housing stock - Populations face additional barriers related to income constraints, aging, and rural isolation, with high risk for being underserved by emergency or resilience programs.	4	Moderate adaptive capacity - Strengthened by post-Caldor Fire recovery efforts - Increased community awareness, and emerging partnerships with Tribal governments. - Formal emergency management systems are still strained, - Housing reconstruction remains incomplete, - Institutional access to climate resilience funding is limited. - Many communities fall into jurisdictional gaps due to unincorporated status or fragmented service delivery.	3	4	3
Community & Equity	Upper American River	Upper Watershed Rural Communities (Foresthill, Quintette)	Increasingly frequent heatwaves impact rural residents, exacerbated by their elevation. Aging populations are more sensitive due to lack of air conditioning and off-grid power.	Homes on slopes and mobile structures are especially vulnerable due to steep terrain that leads to flash flooding and road washouts.	N/A	Widespread reliance on private wells and fragmented water systems. Many residents lack the financial means to drill deeper or install backup storage.	Entire region falls within a VHFHSZ	High sensitivity - Many residents are elderly, live alone, or rely on fixed incomes. - Mobile homes and aging structures lacking defensible space are common. - Broadband and cellular coverage remain limited in many areas, reducing access to emergency alerts and services. - Includes lands of cultural importance to the United Auburn Indian Community and Nisenan peoples, whose cultural and spiritual connections to the watershed are threatened by fire, drought, and access barriers.	5	Moderate. - Strong local cohesion and Fire Safe Councils offer some community-level preparedness - Absence of incorporated municipal governments reduces access to resilience funding and coordinated planning - Water governance is highly fragmented - Emergency services are limited	4	5	2

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Ecosystem	Upper American River	Aquatic Ecosystems	Water temperatures can exceed trout tolerance thresholds (~68°F).	Increased rain-on-snow events cause rapid runoff and potential erosion in headwater streams, and increase sedimentation.	N/A	Drought reduces summer streamflows, limiting aquatic habitats.	Wildfires disrupt stream habitats by increasing sedimentation, turbidity, erosion (from lost vegetation roots), and altering water chemistry (higher pH), degrading water quality and aquatic habitats.	Moderate sensitivity - Reduced snowpack and altered streamflow timing. - Cold-water streams and alpine aquatic habitats can be impacted by increased drought and warming. - Species such as native trout and amphibians are vulnerable to declining flows and rising temperatures	3	Moderate adaptive capacity - Extensive forested headwaters potentially providing habitat diversity. - Severely constrained by high-severity wildfires and erosion in certain areas that fragmented habitats and limit connectivity. - Limited human intervention reduces opportunities for targeted adaptive management.	3	3	2
Ecosystem	Upper American River	Forest Health and Ecosystem Services	Warmer temperatures accelerate drought stress, increasing tree susceptibility to pests and disease, and increase risk of wildfires. Increase the threat of opportunistic invasives and upward shift of ecotones.	Intense precipitation increases runoff and erosion potential, negatively impacting soil health.	N/A	Extended droughts greatly exacerbate forest mortality, increasing susceptibility to pests and wildfire.	Wildfires cause extensive tree mortality, erosion, habitat loss, shifts in species composition, increased vulnerability to invasive species, and substantial biodiversity loss by eliminating critical habitats and native species.	High sensitivity - Loss of snowpack, prolonged drought, beetle outbreaks, and massive high-severity wildfires. - Forest ecosystems transitioning from conifer-dominated to shrub-dominated habitats. - Increased biodiversity loss. - Ecosystem services are affected by degradation of forests leading to diminished water retention, reduced carbon sequestration, erosion control, habitat provision, biodiversity, lower recreational value, and disrupted cultural uses.	5	Moderate adaptive capacity - Ongoing forest management (prescribed burns, thinning) intended to enhance resilience. - Severely constrained by vast wildfire scars, overstocked stands from historical fire suppression, and inadequate resources for forest restoration at necessary scales. - Insufficient integration of ecosystem service valuation into water and land management - Lack of sustained funding and inter-agency coordination to support resilience investments	3	5	5
Ecosystem	Upper American River	Riparian and Groundwater Dependent Ecosystems	Hotter summers increase riparian evapotranspiration demand on groundwater, dry out riparian soils faster, stressing vegetation.	Flash flooding events increase erosion, damaging riparian corridors.	N/A	Drought lowers groundwater levels and baseflows, stressing riparian trees, cause die-offs, and may limit regeneration.	Wildfires damage riparian forests by reducing soil moisture, limiting regeneration, increasing habitat fragmentation, and significantly reducing biodiversity by harming sensitive aquatic and terrestrial species dependent on stable moisture conditions	Moderate sensitivity - Shifts in snowmelt timing, drought-induced groundwater declines, and wildfire-induced erosion. - Riparian forests and meadows significantly affected by declining groundwater and altered seasonal water availability.	3	Moderate adaptive capacity - Relatively intact high-elevation riparian zones allowing some natural recovery. - Constrained by wildfire severity, fragmented riparian corridors, and slow vegetation regeneration following disturbance.	3	3	2

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Flood Management	Upper American River	Built Reservoirs and Dams	Warmer temperatures accelerate snowmelt, reducing spring storage and increasing early-season inflows, challenging reservoir operations.	Rain-on-snow events and intense storms increase inflow volumes, stressing dam safety and spillway capacity.	N/A	Multi-year droughts reduce snowpack and runoff, limiting reservoir recharge and downstream allocations.	Post-fire erosion and debris flow from steep slopes increase sedimentation in reservoirs, reducing capacity and requiring costly dredging.	Moderate-High sensitivity - Potential overtopping and spillway damage from intense precipitation; - Heavily forested, fire-prone watershed can damage infrastructure - Sedimentation from wildfires.	2	Moderate adaptive capacity - Managed reservoir operations, ongoing flood management projects, - Aging infrastructure - Regulatory constraints reduce management flexibility during extreme drought and flood events	3	2	4
Flood Management	Upper American River	Floodplain and Local Drainage	Reduced snowpack and drier soils alter runoff timing and reduce infiltration.	Steep terrain and limited floodplain storage lead to rapid runoff and flash flooding in tributaries.	N/A	Dry soils reduce infiltration, increasing flash flood potential during intense storms.	Burn scars reduce vegetation cover, increasing runoff and debris flow risk, overwhelming local drainage.	Moderate-High sensitivity - Heavily forested, fire-prone watershed - Minimal functional floodplains due to steep terrain - Undersized stormwater infrastructure vulnerable to atmospheric rivers	4	Moderate adaptive capacity - Robust interagency cooperation - Aging infrastructure and regulatory constraints limit response during extreme events	3	4	1
Groundwater Supply	Upper American River	Built System - land owner groundwater wells	Increased pumping demand during heat waves; stress on small-scale systems	Flood damage to wellheads and electrical systems	N/A	Wells may run dry; increased maintenance and energy costs	Power outages disrupt pumping; contamination from ash and debris	High sensitivity: - Wells susceptible to drying or quality degradation during prolonged drought.	4	Moderate adaptive capacity: - Most wells are shallow - Fractured rock system limit options for deepening wells - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure	3	4	1
Groundwater Supply	Upper American River	Built System - Small Water Systems						High sensitivity: - Wells susceptible to drying or quality degradation during prolonged drought	4	Moderate-Low adaptive capacity: - Only source of water for many isolated rural communities - Most wells are shallow - Fractured rock system limit options for deepening wells - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure	4	5	1

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Groundwater Supply	Upper American River	Natural System - Fractured rock aquifers	Reduced recharge due to higher evapotranspiration and post-fire hydrophobic soils; sediment and ash may clog fractures, limiting aquifer recovery and reducing water availability.	Limited infiltration due to rapid runoff; sediment and ash may clog fractures	N/A	Low storage capacity increases drought sensitivity	Post-fire hydrophobic soils reduce infiltration; ash and debris degrade water quality	Moderate sensitivity: - Limited storage capacity and slow recharge - Highly dependent on seasonal snowmelt and infiltration from precipitation	3	Moderate adaptive capacity: - Few artificial options for recharge - Lack of coordinated monitoring hamper ability to make adaptive management decisions - Low demand and dependency on groundwater	3	3	2
Hydropower	Upper American River	EID (Project 184)	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperature increase irrigation and outdoor water demands that compete with hydropower releases. - Rising temperatures exacerbate peak energy demand during heatwaves, straining resources.	- Increased frequency and intensity of storms can damage the extensive system of canals, small dams, and flumes are (e.g., storm events after Caldor Fire that caused substantial operational disruptions and expensive emergency repairs).	- Increased Delta salinity affect statewide water management, possibly influencing upstream operational flexibility.	-Extended drought conditions reduce water availability and hydropower generation forcing prioritization of water supply and environmental flow compliance over energy production (e.g., during recent droughts all hydropower generation was halted).	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	Very High Sensitivity: - Severe wildfire impacts (Caldor Fire); critical damage to canal/flume infrastructure causing prolonged disruptions - Extreme vulnerability to storms, landslides, mudslides, especially following wildfires - Limited reservoir capacity and high dependency on declining snowpack, significantly heightening drought sensitivity	3	Moderate adaptive capacity: - High financial burden from infrastructure rebuilding post-disasters; insufficient FEMA financial support - Limited redundancy in critical infrastructure; single points of failure significantly disrupt water delivery systems - Workforce attraction and retention hindered by hazardous conditions, high wildfire risks, and expensive living environments	3	3	5

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Hydropower	Upper American River	Foresthill PUD (Sugar Pine Reservoir)	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperature increase irrigation and outdoor water demands.	- Increased frequency and intensity of storms, flooding, and landslides can damage pipeline and road access infrastructure.	- No direct and minimal indirect impacts due to limited linkage to Delta operations.	-Extended drought conditions reduce water availability and hydropower generation forcing prioritization of water supply over energy production.	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	Moderate-High Sensitivity: - High sensitivity due to reliance on a single small reservoir (Sugar Pine Reservoir); minimal redundancy makes it highly vulnerable to drought conditions and decreased snowpack - Extreme wildfire risk demonstrated by proximity to major fires (e.g., Mosquito Fire); dense forest environment significantly elevates infrastructure risk - Moderate vulnerability to intense storms causing potential pipeline disruptions, landslides, and road access issues affecting critical water supply infrastructure	3	Moderate adaptive capacity: - limited water storage, absence of alternative water supply sources or interconnections, and severely limited infrastructure redundancy - Minimal financial resources and limited insurance coverage severely constrain emergency preparedness, disaster recovery, and proactive infrastructure investments - Significant workforce constraints due to hazardous living conditions, limited housing availability, and high insurance costs, severely limiting effective emergency response	4	4	2
Hydropower	Upper American River	Georgetown Divide PUD (Stumpy Meadows Reservoir)	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperature increase irrigation and outdoor water demands that compete with hydropower releases. - Rising temperatures exacerbate peak energy demand during heatwaves, straining resources.	- Increased frequency and intensity of storms, flooding, and landslides can damage canal, pipeline distribution, and road access infrastructure.	- No direct and minimal indirect impacts due to limited linkage to Delta operations.	-Extended drought conditions reduce water availability and hydropower generation forcing prioritization of water supply over energy production.	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	Moderate-High sensitivity: - Single-reservoir system (Stumpy Meadows) creates minimal redundancy, making the system highly vulnerable to drought conditions - Extreme wildfire risks (Mosquito Fire), severe threat to infrastructure and water quality - Infrastructure vulnerable to severe storms, landslides, pipeline disruptions due to steep terrain and aging assets	3	Moderate adaptive capacity: - Limited storage capacity - Negligible infrastructure redundancy - Constrained financial resources - Insurance coverage challenges for critical assets - Inadequate FEMA reimbursement support	4	4	2

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Hydropower	Upper American River	PCWA (Middle Fork Project)	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperature increase irrigation and outdoor water demands that compete with hydropower releases. - Rising temperatures exacerbate peak energy demand during heatwaves, straining resources.	- Increased frequency and intensity of future atmospheric river storms could exceed spillway capacities, causing forced spills and lost generation opportunities.	- Increased Delta salinity affect statewide water management, possibly influencing upstream operational flexibility.	-Extended drought conditions reduce water availability and hydropower generation, forcing prioritization of water supply and environmental flow compliance over energy production (e.g., recent droughts in 2012-2016, 2020-2022),	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	Moderate-High sensitivity: - Significant exposure to wildfire; extensive infrastructure risk and damage - High vulnerability to geotechnical failures (e.g., Bear River Canal) - High dependence on snowpack; significant impacts from warmer storms, evaporation losses, and reduced runoff timing	3	Moderate-High adaptive capacity: - Limited flexibility to shift generation seasonally - Large reservoir storage provide flexibility - Active forest management (French Meadows Restoration) - Diversified water resources - Workforce attraction difficulties due to fire risk and housing availability and insurance issues - Insurance coverage challenges for critical assets (e.g., tunnels) - Inadequate FEMA reimbursement support - Constraints financial resources	3	3	5

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Hydropower	Upper American River	SMUD (Upper American River Project)	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperatures exacerbate peak energy demand during heatwaves, straining resources.	- Increased frequency and intensity of future atmospheric river storms pose potential risks, potentially exceeding historical design parameters.	- No direct and minimal indirect impacts due to limited linkage to Delta operations.	-Extended drought conditions reduce water availability and hydropower generation forcing prioritization of water supply and environmental flow compliance over energy production.	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	Moderate-High sensitivity: - Significant dependence on snowpack; reduced snowpack and altered runoff timing significantly affect hydroelectric generation, especially in late summer when energy demand peaks - High wildfire exposure; critical transmission infrastructure vulnerable (e.g., King Fire, Caldor Fire), causing substantial outages and costs - Increased frequency and intensity of extreme storms may exceed historical infrastructure design parameters, threatening dam safety and operational integrity	3	Moderate-High adaptive capacity: - High adaptive capacity due to diversified energy portfolio, large reservoir storage capacity, and substantial infrastructure redundancy - Strong governance and proactive forest and vegetation management (fuels reduction projects, infrastructure hardening) - Robust emergency planning, operational flexibility, and ability to purchase alternative power sources during disruptions	3	3	5
Recreation	Upper American River	Recreational Uses - access/use of forested recreation zones, camping/hiking activities, access to water activities	Extreme heat reduces the comfort and safety of hikers, swimmers, and campers in exposed alpine and foothill recreation areas during peak summer months.	Heavy precipitation events increase trail erosion, landslide risks, and periodic access closures in high-use forested recreation zones.	N/A	Prolonged drought reduces reservoir and river levels, limiting swimming, paddling, and shoreline recreation while degrading trail conditions.	Frequent wildfires and persistent smoke events lead to widespread trail and campground closures, reduce recreational access, and deter local and regional visitors.	Moderate sensitivity: – Activities such as hiking, swimming, paddling, and climbing are directly impacted by smoke, low water levels, or trail damage – Access points are often remote and single-threaded, making them more susceptible to disruption from landslides, fire closures, or weather damage	5	Moderate-high adaptive capacity: – Federal land management (e.g., Eldorado National Forest) provides some planning capacity, but response is often under-resourced or delayed – Trail signage and closures exist but real-time communication to visitors is limited in remote areas – Infrastructure (e.g., roads, restrooms, shaded areas) is aging or minimal, though regional coordination has improved post-fire events – Recreation-based nonprofits and user groups (rafting, climbing, hiking) are engaged but operate independently without a unified response strategy	2	3	5

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Recreation	Upper American River	Tourism - Impacts to businesses, quantity of visitors	Increasing summer temperatures discourage tourism in outdoor lodging and guided adventure services, especially during heat advisories and red flag warnings.	Intense storms disrupt access to remote resorts and nature-based tourism destinations, reducing seasonal revenue	N/A	Low river flows and snowpack reductions shorten the rafting and fishing season, directly impacting tourism operators and water-dependent businesses.	Recurring wildfire activity and poor air quality contribute to cancellations, reduced bookings, and negative perceptions of the region as a safe summer destination.	Moderate sensitivity: – Tourism is heavily seasonal and dependent on natural assets like snowpack, river flow, and clean air, all of which are climate-sensitive – Wildfire and poor air quality have increasingly led to cancellations of summer and fall bookings for cabins, rafting trips, and outdoor tours – Road access to lodges, trailheads, and forest roads is frequently disrupted by storm washouts, downed trees, or fire damage – Economic reliance on a narrow summer window means even short hazard events have outsized business impacts	5	Moderate-high adaptive capacity: – Many operators are small-scale and lack financial resilience to adapt offerings or pivot operations during hazard seasons – Emergency communications and air quality alerts exist but rely on self-monitoring by visitors and businesses – Coordination among outfitters, lodges, and tourism boards is limited, though a few collaborative efforts (e.g., fire-safe business networks) are emerging – Infrastructure upgrades and diversified tourism offerings (e.g., shoulder-season events) remain underdeveloped	2	3	5
Surface Water Supply	Upper American River	Built Reservoirs	Decreased snow accumulation reduces recharge; elevated temperatures reduce summer inflows; potential storage shortfalls	Increased inflow variability threatens storage predictability; reservoir spill risk increases under extreme runoff conditions.	N/A	Storage shortfalls during prolonged dry periods	Increased sediment and nutrient loading in reservoirs reduce storage capacity and water quality. Post-fire erosion worsens turbidity and nutrient levels, impacting downstream operations. Fire-related power outages impair dam operations and SCADA systems.	Moderate sensitivity: - Reduced inflows from earlier snowmelt - Increased flood risks from intense storms - Sedimentation risks from wildfire runoff	3	Moderate adaptive capacity: - Some operational flexibility via reservoir storage - Existing coordinated management - Constrained by limited water source redundancy in extreme drought - Passive spillways limits ability to manage downstream floods - Strict regulatory constraints and minimum flow requirements limit adaptation options	3	3	4
Surface Water Supply	Upper American River	Built System - Small Water Systems							3		4	4	1

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Surface Water Supply	Upper American River	Conveyance Systems (e.g., Canals and other conduits)	Prolonged dry periods increase pressure on canals to deliver water over longer distances with higher loss rates due to evaporation and seepage	Intense rainfall or rapid snowmelt events overwhelm canal capacity, leading to overtopping or washouts	N/A	Small, isolated, or rural systems lack treatment or conveyance redundancy.	Post-fire hydrophobic soils reduce infiltration; ash and debris degrade water quality	High vulnerability: - Susceptible to damage from intense precipitation, flooding, landslides, and post-wildfire erosion, impacting water delivery	5	Moderate adaptive capacity: - Aging infrastructure - Infrastructure redundancy limited - Relies on ongoing maintenance, proactive repair programs, and operational flexibility	3	5	2
Surface Water Supply	Upper American River	Natural Reservoirs - Snowpack	Increased precipitation in the form of rain vs snow; less snow accumulation (reduced snowpack); earlier snowmelt leading to shifts in runoff timing	Increased flood risk from earlier snowmelt and high-flow events; erosion and sediment loading into rivers.	N/A	Loss of snowmelt timing affects storage for drought supplies, surface flow reductions reduce delivery reliability. For example,. in 2021, total surface water deliveries for Central Valley and North Coast farms decreased by about 5.5 million acre-feet, which is 41% below the average between 2002 and 2016.	High-intensity fires degrade forested watersheds and impair runoff quality and storage capacity. The 2021 Caldor Fire burned over 220,000 acres including key headwaters of the Upper American River, introducing ash and debris into downstream reservoirs and reducing infiltration	High: - Peak runoffs occur up to 35 days earlier by late century - Total runoff from watershed expected to decrease by 5%	5	Moderate: - Natural system has sufficient adaptive capacity as it is not significantly affected by minor reduction in runoff due to its size - Natural system has limited adaptive capacity to the loss of snowpack due to lack of groundwater aquifer to stem runoff, or sufficient forest cover and wetland resources to act as storage basins	4	5	5
Water Quality	Upper American River	Drinking Water Source Quality	Increased organic carbon and algal toxins leading to challenges managing DBPs.	High turbidity events requiring treatment adjustments; potential infrastructure damage (canals, intakes).	N/A	Reduced inflow and higher contaminants concentration increase treatment complexity; potential DBP formation.	Turbidity, organic loads, and debris severely challenge treatment plant operations and capacity.	Moderate-Low sensitivity: - Increased temperatures, turbidity, organic carbon, and DBPs; severe water quality impacts following wildfire events -Small systems lack advanced treatment and are vulnerable to wildfire disruptions	2	Moderate capacity: -Inadequate source water protection in fire-prone zones - Fragmented postfire water quality response planning -Limited real-time monitoring	3	2	2
Water Quality	Upper American River	Ecological	Severe stress to cold-water fisheries (salmon/trout) from elevated river temperatures and reduced dissolved oxygen. Increased HABs.	Increased sedimentation damaging spawning habitats; turbidity spikes reduce aquatic biodiversity.	N/A	High stress due to low streamflow, reduced habitat connectivity, concentrated contaminants.	Severe sedimentation, nutrient loads, turbidity; habitat degradation from ash and debris flow.	Moderate sensitivity: - Reliant on cold-water habitat - Vulnerable to increased temperatures, sedimentation from wildfire erosion, altered hydrology affecting aquatic biodiversity	3	Moderate-high capacity: - Forest management to reduce wildfire risks and erosion - Reservoir management and habitat restoration efforts - Constrained by financial resources and regulatory barriers	2	1	2

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Water Quality	Upper American River	Regulatory Standards	Difficult to meet Basin Plan water temperature and dissolved oxygen objectives; increased risk of harmful algal blooms.	Difficulty meeting turbidity standards after major storms; increased regulatory non-compliance risk due to stormwater runoff impacts.	N/A	Challenges meeting minimum instream flow and temperature regulations.	Regulatory challenges due to severe post-fire sediment and turbidity spikes affecting compliance.	Moderate sensitivity: - Difficulty meeting temperature, dissolved oxygen, turbidity standards, especially post-wildfire and flood events	3	Moderate-high capacity: - Proactive reservoir operations and sediment management plans - Capacity strained in extreme events	2	1	2
Ecosystem	Upper Bear River	Forest Health and Ecosystem Services	Warmer temperatures accelerate drought stress, increasing tree susceptibility to pests and disease, and increase risk of wildfires.	Heavy rainfall events erode soil, destabilizing slopes and increasing tree fall risk.	N/A	Extended droughts greatly exacerbate forest mortality, increasing susceptibility to pests and wildfire.	Wildfires cause extensive tree mortality, erosion, habitat loss, shifts in species composition, increased vulnerability to invasive species, and substantial biodiversity loss by eliminating critical habitats and native species.	Moderate sensitivity: - Drought and wildfire, compounded by invasive species proliferation and ecological fragmentation - Forest ecosystems rapidly approach ecological tipping points under sustained climate stress -Ecosystem services are affected by degradation of forests leading to diminished water retention, reduced carbon sequestration, erosion control, habitat provision, biodiversity, lower recreational value, and disrupted cultural uses	4	Moderate adaptive capacity: - Fragmented landscapes and restricted migration pathways - Significant barriers include limited active management, funding constraints, governance hurdles impeding large-scale forest resilience interventions - Insufficient integration of ecosystem service valuation into water and land management - Lack of sustained funding and inter-agency coordination to support resilience investment	4	5	5

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Flood Management	Upper Bear River	Reservoirs	Warmer winters reduce snowpack and increase evaporation, limiting reservoir recharge.	Small reservoirs are quickly overwhelmed by intense storms, increasing spill risk.	N/A	Multi-year droughts reduce inflows and impair water supply reliability.	Burned areas contribute sediment and legacy mercury to reservoirs, degrading water quality.	Moderate to high sensitivity: - Limited reservoir capacities susceptible to flooding, high spill potential, and sedimentation risk - Variable snowpack-fed inflows - High sedimentation from wildfires (Rollins, Camp Far West) - Limited flexibility during drought and extreme events	3	Moderate adaptive capacity: - Active reservoir management by water districts - Aging infrastructure limits adaptive capacity during extreme events - Limited redundancy and financial resources for substantial improvements	3	3	3
Hydropower	Upper Bear River	Nevada Irrigation District	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperature increase irrigation and outdoor water demands that compete with hydropower releases. - Rising temperatures exacerbate peak energy demand during heatwaves, straining resources.	- Increased frequency and intensity of storms can damage the extensive system of canals, small dams, and flumes (e.g., damage to PG&E's South Yuba Canal in 2023).	- Increased Delta salinity affect statewide water management, possibly influencing upstream operational flexibility.	-Extended drought conditions reduce water availability and hydropower generation forcing prioritization of water supply and environmental flow compliance over energy production.	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	High sensitivity: - Infrastructure highly susceptible to floods, landslides, and canal failures (Bear River, PG&E canals) - High wildfire exposure causing extensive infrastructure damage and significant recovery costs - Aging infrastructure requiring extensive and costly maintenance due to increased drought and storm events	3	Moderate adaptive capacity: - Financial limitations and inadequate insurance severely restrict proactive investment and disaster recovery - Workforce attraction/retention issues exacerbated by high insurance costs and severe fire risks - Ineffective FEMA reimbursement limits financial resilience post-disaster	3	3	3

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Hydropower	Upper Bear River	Nevada Irrigation District	- Rising temperature reduce snowpack, cause earlier snowmelt shifting reservoir inflow timing, increasing evaporation from reservoirs. - Rising temperature increase irrigation and outdoor water demands that compete with hydropower releases. - Rising temperatures exacerbate peak energy demand during heatwaves, straining resources.	- Increased frequency and intensity of storms can damage the extensive system of canals, small dams, and flumes (e.g., damage to PG&E's South Yuba Canal in 2023).	- Increased Delta salinity affect statewide water management, possibly influencing upstream operational flexibility.	-Extended drought conditions reduce water availability and hydropower generation forcing prioritization of water supply and environmental flow compliance over energy production.	-Wildfires threaten infrastructure, causing extended power and water outages, expensive emergency repairs - Cause degraded reservoir water quality, loss of storage capacity, and costly sediment management issues.	High sensitivity: - Infrastructure highly susceptible to floods, landslides, and canal failures (Bear River, PG&E canals) - High wildfire exposure causing extensive infrastructure damage and significant recovery costs - Aging infrastructure requiring extensive and costly maintenance due to increased drought and storm events	3	Moderate adaptive capacity: - Financial limitations and inadequate insurance severely restrict proactive investment and disaster recovery - Workforce attraction/retention issues exacerbated by high insurance costs and severe fire risks - Ineffective FEMA reimbursement limits financial resilience post-disaster	3	**3**	3
Recreation	Upper Bear River	Recreational Uses - access/use of forested recreation zones, camping/hiking activities, access to water activities	Extended heatwaves make forest and foothill recreation less accessible, particularly for heat-sensitive individuals and families.	Flash flooding and storm runoff damage trails and small recreation sites, reducing safety and usability.	N/A	Dry conditions lower stream levels and reservoir access, impacting fishing, swimming, and informal day-use recreation.	Recreation areas face high wildfire risk, frequent closures, and long recovery times that limit seasonal outdoor access.	Moderate sensitivity: – Users engage in informal or dispersed recreation (fishing, swimming, hiking) without formal infrastructure or management presence – Environmental degradation from fire or drought can take multiple seasons to recover, impacting both recreation quality and safety; Areas are prone to fire closures, flooding, and prolonged access disruption due to road damage or lack of redundancy	3	Moderate adaptive capacity: – Managed by a mix of counties and special districts, with variable capacity across jurisdictions – Limited formal planning for recreation-specific climate adaptation, though fire-safe councils and user groups play an informal role – Some areas benefit from stewardship by local volunteers or associations, but coordination is inconsistent – Infrastructure improvements are sporadic and underfunded; signage, emergency access, and evacuation planning are minimal	3	3	3

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Recreation	Upper Bear River	Tourism - Impacts to businesses, quantity of visitors	Heat extremes limit outdoor tourism appeal and shorten the seasonal window for nature-based travel.	Localized flooding and debris flows block rural roads, reducing access to lodging and guided tour areas	N/A	Reduced reservoir and stream volume curtail boating, fishing, and eco-tourism opportunities, impacting local businesses.	Frequent fire events disrupt travel, degrade scenic quality, and lead to negative visitor perceptions of fire-prone destinations.	Moderate sensitivity: – Tourism is low-density and dependent on landscape quality, clean air, and water-based activities, all vulnerable to climate stressors – Small lodging operators and nature-based experiences are particularly impacted by fire risk, road closures, and drought; face long-term reputational damage following major climate events	3	Moderate adaptive capacity: – Limited formal coordination among tourism operators, with most businesses operating independently or seasonally – Emergency alert systems and climate-adaptive business planning are not well integrated into tourism sector management – Some potential exists for increased resilience through agritourism and seasonal diversification, but this remains largely untapped	3	3	2
Recreation	Upper Bear River	Recreational Uses - access/use of forested recreation zones, camping/hiking activities, access to water activities	Extended heatwaves make forest and foothill recreation less accessible, particularly for heat-sensitive individuals and families.	Flash flooding and storm runoff damage trails and small recreation sites, reducing safety and usability.	N/A	Dry conditions lower stream levels and reservoir access, impacting fishing, swimming, and informal day-use recreation.	Recreation areas face high wildfire risk, frequent closures, and long recovery times that limit seasonal outdoor access.	Moderate sensitivity: – Users engage in informal or dispersed recreation (fishing, swimming, hiking) without formal infrastructure or management presence – Environmental degradation from fire or drought can take multiple seasons to recover, impacting both recreation quality and safety; Areas are prone to fire closures, flooding, and prolonged access disruption due to road damage or lack of redundancy	3	Moderate adaptive capacity: – Managed by a mix of counties and special districts, with variable capacity across jurisdictions – Limited formal planning for recreation-specific climate adaptation, though fire-safe councils and user groups play an informal role – Some areas benefit from stewardship by local volunteers or associations, but coordination is inconsistent – Infrastructure improvements are sporadic and underfunded; signage, emergency access, and evacuation planning are minimal	3	3	3

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System	Planning Area	System Component (Asset)	Rising Temperatures & Extreme Heat	Extreme Precipitation & Flooding	Sea Level Rise	Drought	Wildfires	Sensitivity	Sensitivity Rating	Adaptive Capacity	Adaptive Capacity Rating	Vulnerability Rating	Scale Effects
Recreation	Upper Bear River	Tourism - Impacts to businesses, quantity of visitors	Heat extremes limit outdoor tourism appeal and shorten the seasonal window for nature-based travel.	Localized flooding and debris flows block rural roads, reducing access to lodging and guided tour areas	N/A	Reduced reservoir and stream volume curtail boating, fishing, and eco-tourism opportunities, impacting local businesses.	Frequent fire events disrupt travel, degrade scenic quality, and lead to negative visitor perceptions of fire-prone destinations.	Moderate sensitivity: – Tourism is low-density and dependent on landscape quality, clean air, and water-based activities, all vulnerable to climate stressors – Small lodging operators and nature-based experiences are particularly impacted by fire risk, road closures, and drought; face long-term reputational damage following major climate events	3	Moderate adaptive capacity: – Limited formal coordination among tourism operators, with most businesses operating independently or seasonally – Emergency alert systems and climate-adaptive business planning are not well integrated into tourism sector management – Some potential exists for increased resilience through agritourism and seasonal diversification, but this remains largely untapped	3	3	2
Surface Water Supply	Upper Bear River	Built Conveyance (e.g., Canals, pipelines, intakes)	Increased evaporation losses, thermal expansion and stress on plastic and metal pipelines; water quality impacts, which trigger algal growth especially in slow or stagnant canal stretches	Due to hilly terrain even modest flash floods cause significant service interruptions for small aging conveyance assets. Causes erosion, landslides and debris flows that block or damage canals.	N/A	Loss of snowmelt timing affects storage for drought supplies, surface flow reductions reduce delivery reliability	Post-fire debris flows disrupt conveyance lines. Power outages disrupt automated TIGs and pump stations.	High sensitivity: - Conveyance system is aging and exposed - Susceptible to damage from flooding, landslides, wildfires, and intense precipitation events	4	Low-Moderate adaptive capacity: - Topographic constraints limit adaptive capacity despite extensive local knowledge and some modernization upgrades - Limited redundancy - Reliant on ongoing maintenance and emergency response capabilities - Infrastructure resilience constrained by financial resources	3	4	4
Surface Water Supply	Upper Bear River	Built Reservoirs	Earlier and faster snowmelt reduces spring and summer inflows. Higher evaporation losses and increased irrigation demand. Inability to maintain cool water releases for aquatic habitat. Relatively small and shallow reservoirs are susceptible to seasonal drawdown.	Flooding and debris overload cause structural stress and service interruptions. For example, Placer County storm events damaged canal headworks in 2017.	N/A	Insufficient recharge result in below average reservoirs levels. (e.g., 2014, 2021). Impacts on water quality due to thermal stratification an algal growth in low-volume conditions.	Post-fire runoff carries sedimentation and debris into reservoirs, reducing storage capacity and degrading water quality (e.g., 2021 River Fire).	Moderate-High sensitivity: - Reservoirs are relatively small and shallow, therefore especially prone to snowpack variability, inflows and wildfire events - Drought-induced water quality degradation	4	Moderate adaptive capacity: - Regional coordination present - Limited redundancy due to small reservoir size - Infrastructure is aging and capital improvements may not implement within timeframe necessary	3	4	4

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Water Quality	Upper Bear River	Drinking Water Source Quality	Increased temperatures causing HABs; potential DBP formation.	Extreme turbidity events complicating water treatment; potential damage to conveyance infrastructure (canals, flumes).	N/A	Increased treatment challenges from higher contaminant concentration; limited ability to blend or switch sources.	High turbidity and contaminants post-wildfire requiring complex and costly treatment; potential infrastructure damage.	Moderate-High sensitivity: - Severe turbidity events and contaminants (mercury, nutrients) post-wildfire - Water quality significantly impacted by drought conditions	4	Moderate: - Basic redundancy - Moderate treatment flexibility - Constrained by aging infrastructure & vulnerability - Limited financial and operational resources	3	4	2
Water Quality	Upper Bear River	Ecological	Habitat degradation for native species from high water temperatures, HABs, and reduced dissolved oxygen.	Severe turbidity and mercury contamination from historic mining mobilized by floods.	N/A	Severe ecological stress from very low flows, concentrated pollutants, elevated nutrient concentrations.	Post-fire sedimentation, turbidity, and mercury contamination severely impacting aquatic ecosystems.	Moderate-High sensitivity: - High vulnerability to wildfire-induced erosion, sedimentation, and contaminants affecting aquatic habitats and biodiversity - Severe wildfire risk and flooding can mobilize legacy mercury contamination	4	Moderate capacity: - Small-scale habitat restoration and sediment management - Constrained by financial resources and infrastructure	3	4	3
Water Quality	Upper Bear River	Regulatory Standards	Challenges maintaining water temperature and dissolved oxygen standards during heat events.	Increased turbidity, mercury mobilization challenging compliance with water quality standards.	N/A	Difficulty maintaining regulatory compliance for instream flows, turbidity, and temperature criteria during drought.	Increased regulatory compliance difficulty due to post-fire sediment, mercury, and turbidity spikes.	Moderate-High sensitivity: - Difficulties meeting turbidity, temperature, mercury, and dissolved oxygen standards due to legacy mining and climate-driven events	4	Moderate; - Limited capacity due to financial constraints - Limited regulatory flexibility and few resources to enhance compliance strategies - Small-scale infrastructure	3	4	2
Agriculture	Upper Bear River	Foothill	Extreme heat reduces forage availability, stresses livestock, and affects orchards.	Flash flooding and slope failures damage irrigation, fencing, and access roads.	N/A	High drought exposure: small-scale farms face forage shortages and unreliable irrigation.	Wildfire risk is extremely high due to steep terrain and fuel-rich forests; fires cause direct crop/livestock losses and degrade soils through erosion.	Moderate sensitivity: - Foothill agriculture is acutely exposed to wildfire, drought, and flash flooding - Small farms lack the capacity to buffer these events - Livestock and small-scale crops are highly exposed to drought and wildfire - Vulnerability compounded by steep topography	3	Moderate: - Weak emergency resources - Minimal water storage, limited infrastructure - Poor emergency preparedness reduces resilience - Reliance on surface-only flows magnifies exposure	3	3	4

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Community & Equity	Upper Bear River	Foothill Communities	Heatwaves disproportionately impact hillside communities because homes lack modern cooling. Many residents are elderly or medically fragile. Limited access to emergency cooling centers. Long distances to health care amplify heat-related risks.	Steep slopes and limited stormwater infrastructure heighten risk of flash flooding and erosion. Remote access delays emergency response and complicates recovery.		Private wells and small, decentralized systems are vulnerable to drought-induced supply reductions; impact household reliability and increasing water costs.	Limited evacuation routes and frequent smoke exposure during fire season disrupt air quality and community health.	Moderate-High sensitivity: - Dispersed rural population with limited services - Dependence on private wells and small systems - Low mobility populations face evacuation challenges	**4**	Moderate capacity: - Strong social networks support informal response - But limited funding and lack of formal systems for coordination	**3**	**4**	**2**
Agriculture	Upper Cosumnes River	Foothill	High heat lowers crop resilience, stresses livestock, and accelerates wildfire ignition risk.	Steep slopes prone to erosion and debris flows during extreme rainfall, damaging soils and irrigation.	N/A	Limited water storage and drying streams force reliance on hauled or emergency water supplies.	High exposure to wildfire due to vegetative cover and limited access routes.	Moderate: - Small-scale foothill farms highly sensitive to heat, drought, and wildfire - Specialty farms and ranches rely on surface-only flows - Shallow soils are highly sensitive to climate extremes	**3**	Low-moderate: - Adaptive capacity constrained by isolation - Limited storage - Minimal institutional support - Lack of water infrastructure severely constrain adaptive capacity	**4**	**4**	**4**

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Ecosystem	Upper Cosumnes River	Forest Health and Ecosystem Services	Warmer temperatures accelerate drought stress, increasing tree susceptibility to pests and disease, and increase risk of wildfires.	Heavy rainfall events erode soil, destabilizing slopes and increasing tree fall risk.	N/A	Extended droughts greatly exacerbate forest mortality, increasing susceptibility to pests and wildfire.	Wildfires cause extensive tree mortality, erosion, habitat loss, shifts in species composition, increased vulnerability to invasive species, and substantial biodiversity loss by eliminating critical habitats and native species.	Very High sensitivity: - Drought stress and large-scale, severe wildfires, exacerbated by warmer temperatures and invasive species - High-severity wildfires have dramatically reshaped forest composition, reducing long-term resilience - Ecosystem services are affected by degradation of forests leading to diminished water retention, reduced carbon sequestration, erosion control, habitat provision, biodiversity, lower recreational value, and disrupted cultural uses	4	Low to moderate adaptive capacity: - Forest regeneration hindered by severe wildfire impacts and drought-driven soil moisture deficits - Efforts at restoration and reforestation limited in scale, resulting in slow ecosystem recovery and constrained adaptive response - Insufficient integration of ecosystem service valuation into water and land management - Lack of sustained funding and inter-agency coordination to support resilience investment	4	5	5
Ecosystem	Upper Cosumnes River	Aquatic Ecosystems	Water temperatures can exceed trout tolerance thresholds (~68°F).	Increased rain-on-snow events cause rapid runoff and potential erosion in headwater streams, and increase sedimentation.	N/A	Drought reduces summer streamflows, limiting aquatic habitats.	Wildfires disrupt stream habitats by increasing sedimentation, turbidity, erosion (from lost vegetation roots), and altering water chemistry (higher pH), degrading water quality and aquatic habitats.	Moderate sensitivity: - Reduced snowpack and altered streamflow timing - Cold-water streams and alpine aquatic habitats can be impacted by increased drought and warming - Species such as native trout and amphibians are vulnerable to declining flows and rising temperatures	3	Moderate adaptive capacity: - Extensive forested headwaters potentially providing habitat diversity - Severely constrained by high-severity wildfires and erosion in certain areas that fragmented habitats and limit connectivity - Limited human intervention reduces opportunities for targeted adaptive management	3	3	2
Groundwater Supply	Upper Cosumnes River	Natural System - Fractured rock aquifers	Reduced recharge due to higher evapotranspiration and post-fire hydrophobic soils; sediment and ash may clog fractures, limiting aquifer recovery and reducing water availability.	Limited infiltration due to rapid runoff; sediment and ash may clog fractures	N/A	Low storage capacity increases drought sensitivity	Post-fire hydrophobic soils reduce infiltration; ash and debris degrade water quality	Moderate sensitivity: - Limited storage capacity and slow recharge - Highly dependent on seasonal snowmelt and infiltration from precipitation.	3	Moderate adaptive capacity: - Few artificial options for recharge - Lack of coordinated monitoring hamper ability to make adaptive management decisions. - Low demand and dependency on groundwater	3	3	2

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Groundwater Supply	Upper Cosumnes River	Built System - Small Water Systems						High sensitivity: - Wells susceptible to drying or quality degradation during prolonged drought.	4	Moderate-Low adaptive capacity: - Only source of water for many isolated rural communities - Most wells are shallow - Fractured rock system limit options for deepening wells - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure.	4	5	1
Groundwater Supply	Upper Cosumnes River	Built System - land owner groundwater wells	Increased pumping demand during heat waves; stress on small-scale systems	Flood damage to wellheads and electrical systems	N/A	Wells may run dry; increased maintenance and energy costs	Power outages disrupt pumping; contamination from ash and debris	High sensitivity: - Wells susceptible to drying or quality degradation during prolonged drought.	4	Moderate adaptive capacity: - Most wells are shallow - Fractured rock system limit options for deepening wells - Lack of detailed monitoring hampers effective management - Individual landowner dependency with potentially limited resources -Variable capacity to maintain well infrastructure.	3	4	1

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Recreation	Upper Cosumnes River	Tourism - Impacts to businesses, quantity of visitors	Increasing summer temperatures discourage tourism in outdoor lodging and guided adventure services, especially during heat advisories and red flag warnings.	Intense storms disrupt access to remote resorts and nature-based tourism destinations, reducing seasonal revenue	N/A	Low river flows and snowpack reductions shorten the rafting and fishing season, directly impacting tourism operators and water-dependent businesses.	Recurring wildfire activity and poor air quality contribute to cancellations, reduced bookings, and negative perceptions of the region as a safe summer destination.	Moderate sensitivity – Tourism is heavily seasonal and dependent on natural assets like snowpack, river flow, and clean air, all of which are climate-sensitive – Wildfire and poor air quality have increasingly led to cancellations of summer and fall bookings for cabins, rafting trips, and outdoor tours – Road access to lodges, trailheads, and forest roads is frequently disrupted by storm washouts, downed trees, or fire damage – Economic reliance on a narrow summer window means even short hazard events have outsized business impacts	5	Moderate-high adaptive capacity – Many operators are small-scale and lack financial resilience to adapt offerings or pivot operations during hazard seasons – Emergency communications and air quality alerts exist but rely on self-monitoring by visitors and businesses – Coordination among outfitters, lodges, and tourism boards is limited, though a few collaborative efforts (e.g., fire-safe business networks) are emerging – Infrastructure upgrades and diversified tourism offerings (e.g., shoulder-season events) remain underdeveloped	2	3	3
Recreation	Upper Cosumnes River	Recreational Uses - access/use of forested recreation zones, camping/hiking activities, access to water activities	Extreme heat reduces the comfort and safety of hikers, swimmers, and campers in exposed alpine and foothill recreation areas during peak summer months.	Heavy precipitation events increase trail erosion, landslide risks, and periodic access closures in high-use forested recreation zones.	N/A	Prolonged drought reduces reservoir and river levels, limiting swimming, paddling, and shoreline recreation while degrading trail conditions.	Frequent wildfires and persistent smoke events lead to widespread trail and campground closures, reduce recreational access, and deter local and regional visitors.	Moderate sensitivity – Activities such as hiking, swimming, paddling, and climbing are directly impacted by smoke, low water levels, or trail damage – Access points are often remote and single-threaded, making them more susceptible to disruption from landslides, fire closures, or weather damage	5	Moderate-high adaptive capacity – Federal land management provides some planning capacity, but response is often under-resourced or delayed – Trail signage and closures exist but real-time communication to visitors is limited in remote areas – Infrastructure (e.g., roads, restrooms, shaded areas) is aging or minimal, though regional coordination has improved post-fire events – Recreation-based nonprofits and user groups (rafting, climbing, hiking) are engaged but operate independently without a unified response strategy	2	3	3

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Surface Water Supply	Upper Cosumnes River	Natural Reservoirs - Snowpack	Minimal snowpack; warming reduces any remaining snow accumulation	Watershed's low elevation and lack of build flood control infrastructure compound runoff impacts and overwhelm floodplain storage capacity, exacerbating flood impacts.	N/A	Prolonged dry periods reduce baseflows, impair ecological function and limit recharge, leaving system with low buffering capacity against multi-year droughts	Reduced vegetation cover, accelerated snowmelt, and degraded floodplain and wetland storage; impacts ability to retrain water, recharge groundwater and regulate flows, increasing likelihood of drought-related impacts and post-fire flooding	High sensitivity: - Variable snowpack; - Extreme exposure to climate variability, drought, and flooding.	4	Low adaptive capacity: - No infrastructure or management options for snowpack variability; - Fully dependent on rainfall.	3	4	4
Surface Water Supply	Upper Bear River	Natural Reservoirs - Snowpack	Reduced snow accumulation and earlier melt reduce seasonal storage	Increased runoff variability and erosion	N/A			High vulnerability: - Highly susceptible to changes in precipitation patterns and earlier runoff timing.	4	Moderate adaptive capacity: - No management options for snowpack; - Relies entirely on natural variability.	3	4	4

Notes:

CVP = Central Valley Project
DAC = Disadvantaged Communities
DBP = disinfection byproduct
FEMA = Federal Emergency Management Agency
FIRO = Forecast-Informed Reservoir Operations
HAB = harmful algal bloom
N/A = not applicable
NID = Nevada Irrigation District
PCWA = Placer County Water Agency
PUD = Public Utility District
SCADA = supervisory control and data acquisition
VHFHSZ = Very High Fire Hazard Severity Zone

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