

California Water Plan

2023 UPDATE
TECHNICAL SERIES

Watershed Hub Resilience Indicators and Metrics

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Acronyms and Abbreviations

| Acronym | Definition |
|----------------|---|
| ACE | Areas of Conservation Emphasis |
| AF | acre-feet |
| Ag | agricultural |
| AWWA | American Water Works Association |
| AWWA 36 | <i>M36 Water Audits and Loss Control Programs, Fourth Edition</i> |
| BRIC | Baseline Resilience Indicators for Communities |
| CalEPA | California Environmental Protection Agency |
| CBI | Conservation Biology Institute |
| CCHVI | Climate Change and Health Vulnerability Indicator |
| CCHVlz | Climate Change and Health Vulnerability Index Visualization |
| CDFW | California Department of Fish and Wildlife |
| CEC | California Energy Commission |
| CEFF | California Environmental Flows Framework |
| CNRA | California Natural Resources Agency |
| CoSMoS | Coastal Storm Modeling System |
| CPUC | California Public Utilities Commission |
| CRAM | California Rapid Assessment Method |
| CRNA | California Natural Resources Agency |
| CSCI | California Stream Condition Index |
| CSCI | California Stream Condition Index |
| CVFPP | Central Valley Flood Protection Plan |
| CVP | Central Valley Project |
| CWP | California Water Plan |
| DAC | disadvantaged community |
| DDW | Division of Drinking Water |
| DFW | California Department of Fish and Wildlife |
| DHHS | US Department of Health and Human Services |
| DO | dissolved oxygen |
| DSC | Delta Stewardship Council |
| DWR | California Department of Water Resources |
| ECOS | Environmental Council of the States |
| EPA | US Environmental Protection Agency |
| EROS | Earth Resources Observation and Science Center |
| ESA | Endangered Species Act |
| eWRIMS | Electronic Water Rights Information Management System |
| FEMA | Federal Emergency Management Agency |

| Acronym | Definition |
|----------------|---|
| FRAP | Fire and Resource Assessment Program |
| GAMA | Groundwater Ambient Monitoring and Assessment |
| GAP | Gap Analysis Project |
| GPCD | gallon(s) per capita per day |
| GSA | groundwater sustainability agency |
| GSP | groundwater sustainability plan |
| GW | gigawatt |
| HHS | US Department of Health and Human Services |
| HIS | Indian Health Service |
| Hub | Watershed Hub |
| ID | identification |
| IPI | index of physical integrity |
| IRWM | Integrated Regional Water Management |
| K through 12 | kindergarten through grade 12 |
| LCMAP | Land Change Monitoring, Assessment and Projection |
| LHMP | local hazard mitigation plan |
| M&I | municipal and industrial |
| mg/L | milligram(s) per liter |
| MRLC | Multi-Resolution Land Characteristics Consortium |
| MW | megawatt(s) |
| NC | natural communities |
| NFHL | National Flood Hazard Layer |
| NMFS | National Marine Fisheries Service |
| OEHHA | California Office of Environmental Health Hazard Assessment |
| OPR | Governor’s Office of Planning and Research |
| PHAB | physical habitat |
| PHS 9 | Public Health and Safety ID 9 |
| RAPTR | Resources Agency Project Tracking and Reporting |
| Reclamation | US Department of the Interior Bureau of Reclamation |
| SCCWRP | Southern California Coastal Water Research Project |
| SDAC | severely disadvantaged community |
| sea-level rise | sea-level rise |
| SFEI | San Francisco Estuary Institute |
| SGMA | Sustainable Groundwater Management Act |
| SWP | State Water Project |
| SWRCB | State Water Resources Control Board |

| Acronym | Definition |
|----------------|---------------------------------|
| TBU | tribal beneficial use |
| TM | technical memorandum |
| TNC | The Nature Conservancy |
| UC | University of California |
| US | United States |
| USFWS | US Fish and Wildlife Service |
| USGS | US Geological Survey |
| UWMP | urban water management plan |
| WRP | Watershed Resilience Program |
| WSCP | water shortage contingency plan |

1. Overview

1.1 Purpose

This technical memorandum (TM) documents the development of a proposed set of indicators and metrics to assess current water resources conditions for watersheds across the State. This TM describes the methods used to evaluate a broad set of water-related indicators, and then documents the selection of a subset from those indicators as a recommended set to be used statewide across multiple watersheds. Indicators were evaluated for relevance, practicality, geographic coverage, applicability at the watershed scale, and availability of quality data to support their use over time. The selected set of indicators and metrics are in draft form and subject to further refinement based on discussion with the DWR team and further review of processed data sets.

2. Introduction

2.1 Relationship to the California Water Plan and Watershed Resilience Program

The California Water Plan (CWP) is the State's strategic plan for sustainably managing and developing water resources for current and future generations. Required by Water Code Section 10005(a), it presents the status and trends of California's water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios.

CWP Update 2023 (Update 2023) focuses on three themes that respond to current issues facing the State: climate change, watershed resilience, and equity.

CWP Update 2023 also introduces the Watershed Resilience Program (WRP), which seeks to support regional collaboration across water sectors, and in jurisdictions at the watershed scale (from headwaters to groundwater and associated outflows), to address the effects of climate change. The WRP seeks to improve regional climate resilience with a focus on watershed-scale planning, climate resilience, and equity using an outcomes-based approach.

The WRP has the following goals:

- Understand and track multi-water sector climate vulnerabilities at the watershed scale.
- Promote increased coordination across all water-related sectors (water supply, flood, groundwater, water quality, forest/fire, ecosystem, and land use sectors).
- Support locally led networks across California's diverse regions.
- Promote and achieve regional climate resilience at the watershed scale.
- Incorporate equity throughout the process.

The WRP is featured in CWP Update 2023 within Chapter 5: Focus on Supporting Watershed Resilience. In order to understand the current levels of resilience in watersheds throughout the State, performance tracking is a critical element of the WRP.

2.2 Watershed Hub

2.2.1 Purpose and Users

The primary purpose of the Watershed Hub (or Hub) will be to provide performance tracking for the WRP. The Hub is anticipated to have a range of users, including managers and watershed network participants at the watershed level, State agency executives, WRP managers and staff, and State legislators in addition to the interested public (see Table 2-1).

- Supporting watershed networks with data and collaboration tools.
- Tracking watershed conditions and trends over time.
- Evaluating watershed outcomes to inform future actions and investments.
- Supporting the identification and prioritization of future adaptations strategies, management actions, and investments.

Table 2-1 Watershed Hub Users and Uses

| User | Use |
|--|--|
| Regional/Watershed Water Resources Manager | <p>Track regional/watershed conditions and trends using Statewide metrics and indicators</p> <p>Develop and track watershed-specific performance indicators to better manage unique conditions</p> <p>Support watershed networks with data and collaboration tools</p> <p>Identify and prioritize cross-sector adaptive management actions</p> <p>Track the collective outcomes of past ongoing and future projects to inform future actions and investments. Show returns on watershed investments.</p> |
| State Program Manager | <p>Track regional/watershed and statewide conditions and trends using statewide metrics and indicators</p> <p>Provide information to support the formation of watershed networks</p> <p>Develop regional/watershed reports in compliance with Water Code</p> <p>Support local agencies in identifying and prioritizing cross-sector adaptation management actions</p> <p>Document success of previous investments statewide and at the watershed scale</p> |
| State Legislator/Executive | <p>Track regional/watershed and statewide conditions and trends using statewide metrics and indicators</p> <p>Consider outcomes of past investments to inform future investments</p> <p>Support policymaking and investment priorities</p> |

2.2.2 Building on Previous and Ongoing DWR Performance Tracking Efforts

DWR has long acknowledged the value of performance tracking across water management sectors and has been developing various approaches for tracking. Over the last several years, DWR has invested in its Sustainability Outlook (Outlook) (California Department of Water Resources 2019a) to develop metrics and indicators, and in the Water Sustainability Atlas (Atlas) (California Department of Water Resources 2019b), to track water resource projects throughout the state. Both tools and their associated efforts are foundational to the Hub and have been extensively leveraged as described below.

2.2.2.1 Sustainability Outlook

In 2010, DWR initiated development of metrics and indicators to track progress toward desired objectives initially associated with the effects of extended drought. That effort evolved to become the Outlook, which defines metrics and indicators using societal values as an organizational structure and pulls from other efforts such as SGMA, the 2012 *Central Valley Flood Protection Plan (CVFPP)* (California Department of Water Resources 2012) and the 2017 CVFPP Update (California Department of Water Resources 2017), among others. Additionally, the Outlook engaged multiple interested parties for CWP Update 2018 discussions and incorporated their input into a systematic approach to identifying and screening metrics and indicators.

This TM builds on the approach originated by the 2012 CVFPP, which was furthered in the Outlook and documented in *Sustainability Outlook Indicator Descriptions and Methodology* (California Department of Water Resources 2019a). The initial set of indicators and metrics selected for use in this TM focus on measuring and evaluating watershed vital signs for climate resiliency. They are organized by water resource sectors, and were selected in part, because of readily available and well-maintained data sets currently in use. The proposed indicators in the TM are now aligned by water resources sectors as opposed to the 2018 Outlook, which was organized by the Societal Values. However, many of the indicators and metrics initially identified in the Outlook are still relevant for this effort and are recommended for inclusion in the Hub. Appendix C, Table C-1 shows the alignment between the 2019 Sustainability Outlook indicators and the recommended indicators and metrics selected for the Hub.

2.2.2.2 Water Sustainability Atlas

In 2017, DWR worked closely with IRWM groups, at their request, to develop the Atlas, which is a geographically based compendium of IRWM region summaries. The Atlas listed completed, in progress, and proposed water-related projects occurring within each region. The Atlas was intended to communicate the value of past investments through the reporting of proposed and ongoing projects and to help facilitate potential partnerships for multi-benefit projects. The Atlas was conceived as a tool that would open the lines of communication among DWR and regional/local water management agencies to support better decision making and resource allocation by tracking sustainability, promoting partnerships, and characterizing return on investment of water resources management. The Atlas had been pilot tested with select IRWM regions, including the American River Basin, San Diego, Mojave, and Ventura County.

2.2.2.3 Central Valley Flood Protection Plan

The 2022 CVFPP Update advances the State's overall performance tracking and adaptive management for flood-planning efforts by introducing a comprehensive framework that integrates CVFPP and Conservation Strategy goals, societal values, and outcomes. Previously, the 2017 CVFPP Update introduced an outcome-based planning approach with objectives and metrics related to multi-benefit flood management that could be tracked over time. The 2022 CVFPP Update reinforces these initial identified societal values and adds equity and social justice as a new societal value. Additionally, specific outcomes contributing to these societal values have been formulated in the context of achieving CVFPP goals.

Progress toward achieving CVFPP goals and tracking the performance of flood-planning outcomes associated with the CVFPP are aligned to the following societal values:

- Provide public health and safety.
- Support ecosystem vitality.
- Support a healthy economy.
- Provide opportunities for enriching experiences.
- Support equity and social justice.

2.2.2.4 Hub as Watershed Resilience Support Tool

The Hub builds on the previous work of the Outlook and the Atlas to create a centralized source of information for users, and uses shown in Figure 2-2, in support

of the WRP. Fundamentally, the Hub will track current conditions and trends across a watershed, along with proposed and past projects.

This performance-tracking approach requires selection of specific indicators and metrics that monitor existing conditions and reflect changes that may occur over time as a reaction to a range of factors, including actions such as changing climatic or environmental conditions, investments, and projects. The Hub will not track the outcome of specific projects but will instead provide a comparison of watershed current conditions and trends over time. Figure 2-1 illustrates how the Hub will allow a comparison of proposed and completed projects with conditions and vulnerabilities shown by watershed.

Figure 2-1 Linking Projects and Investments to Watershed Vulnerabilities

Linking Projects and Investments to Watersheds and Areas of Vulnerability

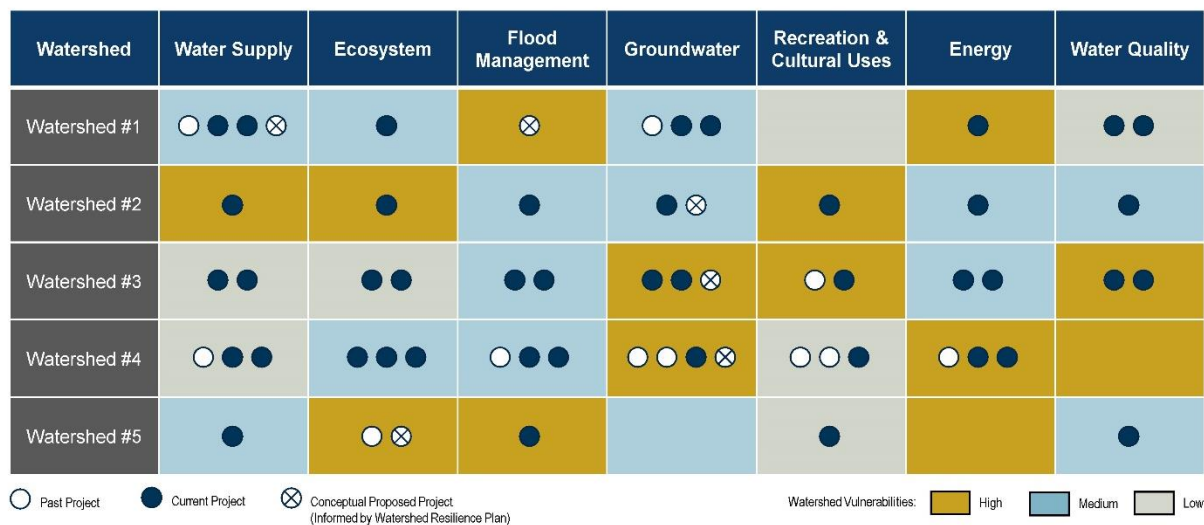
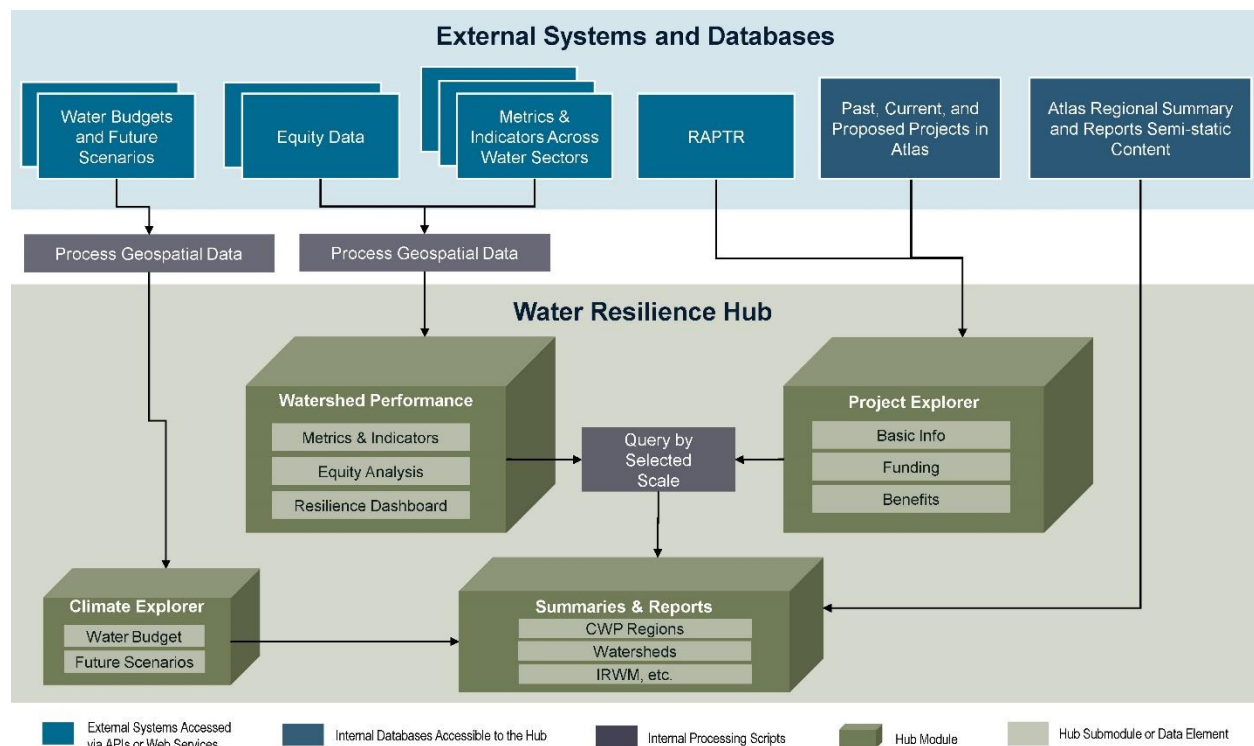


Figure 2-2 is a conceptual diagram of the Hub architecture. There are two central components that drive the core functionality of the Hub, (1) *Watershed Performance*, which houses the metrics and indicators that measure the vital signs of each watershed’s water resources, and (2) *Project Explorer*, which catalogs the water sector project inventories. Additional supporting components include the *Climate Explorer*, where future climate scenarios at a watershed scale will be housed and *Summaries & Reports*, where data from within the Hub and other sources will be integrated to provide Water Plan regional summaries in addition to reports requested by users. Each of these components relies on multiple external systems and databases, including the Atlas, RAPTR, several State data programs to provide the source data

for the indicators and metrics, and more. The Hub will include functionality to produce customized dashboards and summaries to allow analysis across metrics, future impacts, watersheds, and project inventories. The Hub is not intended to be a centralized repository of data but rather is integrated with external data sources, via application programming interfaces (APIs) or web services, that will be used to automate data processing, analysis, and visualization of relevant data to minimize management of the Hub.

Figure 2-2 Conceptual Diagram of Hub Architecture



2.2.3 Hub Development

It is anticipated that the Hub will be developed through a minimum of three phases alongside development of the WRP. The Hub will evolve over time as pilot studies are developed and user experience informs the appropriateness of metrics and indicators, and as desired and improved functionality can be added to the tool. The current plan for the initial three phases is summarized below.

Phase 1: Hub: Project Initiation

- Define Purpose and Need.
- Develop High-Level Use Cases.

CWP Update 2023

- Define Conceptual Architecture.
- Complete Initial Demonstration Buildout.
- Identify Initial Set of Metrics and Indicators.

Phase 2 Hub: Beta 1.0 User Launch

- Incorporate initial set of metrics and indicators.
- Build Statewide Resilience Dashboard.
- Identify watershed-specific metrics with Pilot Watersheds.
- Develop functionality for Regional Summaries.

Phase 3: Hub: Beta 2.0 Launch

- Adjust based on Beta 1.0 user experience.
- Integrate any additional metrics.
- Integrate additional desirable functionality and data.

3. Selecting Indicators and Metrics

This section documents the approach to selecting the recommended set of primary and secondary indicators and metrics for the Hub during the Beta 1.0 and 2.0 phases of development. It includes a step-by-step methodology used to select indicators and specific metrics by water resource category. This section also includes definitions of terms used throughout the technical memo.

3.1 Review of Previous Efforts and Available Data

To inform the process and assure that the overall framework, indicators, and metrics identified for the Hub are consistent with other approaches, multiple State and federal resources were reviewed. The Hub's performance-tracking approach will build upon and align with existing State and federal guidance, frameworks, and planning processes for watershed resilience and climate adaptation. The primary resources relied upon for this effort are as follows:

- California DWR: Sustainability Outlook Indicator Descriptions and Methodology (California Department of Water Resources 2019a).
- California DWR: Appendix H, Climate Change Adaptation for the CVFPP Conservation Strategy Update Memorandum in CVFPP Conservation Strategy 2022 Update (California Department of Water Resources 2022a).
- California DWR: 2022 CVFPP Update (California Department of Water Resources 2022b).
- California DWR: CVFPP Conservation Strategy 2022 Update (California Department of Water Resources 2022c).
- California DWR: Report on the Water Sustainability Atlas Pilot Project with Recommendations (California Department of Water Resources 2019c).
- California Governor's Office of Emergency Services (Cal OES): *California Adaptation Planning Guide* (California Governor's Office of Emergency Services 2020).
- California Natural Resources Agency (CNRA): *2021 California Climate Adaptation Strategy* (California Natural Resources Agency 2021).
- CNRA, California Environmental Protection Agency (CalEPA), and California Department of Food and Agriculture (CDFA): *2020 California Water Resilience Portfolio* (California Natural Resources Agency, California Environmental Protection Agency, and California Department of Food and Agriculture 2020).

- California Water Quality Monitoring Council: *Healthy Watersheds Partnership Assessment* (California Water Quality Monitoring Council 2023).
- University of South Carolina College of Arts and Sciences: *BRIC: Baseline Resilience Indicators for Communities* (College of Arts and Sciences, University of South Carolina 2023).
- Federal Emergency Management Agency (FEMA): *National Risk Index for Natural Hazards* (Federal Emergency Management Agency 2023).
- National Oceanic and Atmospheric Administration (NOAA): *US Climate Resilience Toolkit* (National Oceanic and Atmospheric Administration 2023).
- Governor’s Office of Planning and Research (OPR): *Planning and Investing for a Resilient California: A Guidebook for State Agencies* (Governor’s Office of Planning and Research 2018).
- Resilient CA Adaptation Planning Map (RAP-Map) (Governor’s Office of Planning and Research 2023).
- US Army Corps of Engineers (USACE): *Engineering with Nature* (US Army Corps of Engineers 2023a).
- USACE: *International Guidelines Natural and Nature Based Features for Flood Risk Management* (US Army Corps of Engineers 2023b).
- US Environmental Protection Agency (EPA): *Integrated Assessment of Healthy Watersheds* (US Environmental Protection Agency 2023).
- University of California (UC) Berkeley and the California Energy Commission (CEC): *Cal-Adapt* (UC Berkeley and California Energy Commission 2023).

In addition to the planning guidance documents and programs listed above, additional resources were reviewed to understand the availability of data sets that could potentially be used for the Hub. Sources for these data include State and federal agencies and programs, non-governmental organizations, and academic institutions. Table 3-1 lists the data owners/managers by water resources category and provides a link to databases reviewed along with the name of the owner or manager of those data.

Table 3-1 Data Resources to Inform Development of Water Resource Indicators and Metrics

| Water Resource Category | Database and Link (If Available) | Data Owner/Manager |
|--------------------------------|--|---------------------------|
| All Categories | 2018 Sustainability Outlook | DWR |
| Water Supply | California Urban Water Use Map | Pacific Institute |

| Water Resource Category | Database and Link (If Available) | Data Owner/Manager |
|--------------------------------|---|--|
| | Urban Water Management Plans (UWMPs) | DWR |
| | California Public Utilities Commission–Water Division | California Public Utilities Commission |
| | Division of Drinking Water (DDW) | State Water Resources Control Board (SWRCB) |
| | Urban Water Loss | DWR |
| | Water Loss Control | SWRCB |
| Flood Management | National Flood Hazard Layer | FEMA |
| | National Risk Index | FEMA |
| | Census Data | US Census Bureau |
| Groundwater | SGMA Data Viewer | DWR |
| | GSPs Status Summary | DWR |
| | GeoTracker | SWRCB |
| | SGMA Basin Prioritization Dashboard | DWR |
| | Dry Well Reporting System | DWR |
| Ecosystems | Areas of Conservation Emphasis | DFW |
| | Data Basin | Conservation Biology Institute |
| | California Natural Flows Database | The Nature Conservancy (TNC) and the US Geological Survey (USGS) |
| | California Integrated Assessment of Watershed Health | EPA |
| | RePlan: Regional Conservation and Development Planning Tool | California Strategic Growth Council |
| | California Aquatic Resource Inventory | San Francisco Estuary Institute |
| | Surface Water Ambient Monitoring Program | SWRCB |

| Water Resource Category | Database and Link (If Available) | Data Owner/Manager |
|--------------------------------|--|---|
| Water Quality | Impaired Water Bodies | SWRCB |
| | California Water Sustainability | UC Davis |
| | Drinking Water Systems with Violations Tool | SWRCB |
| | Impaired Water Bodies | SWRCB |
| | Electronic Water Rights Information Management System (ERWIMS) | SWRCB |
| | California Environmental Data Exchange Network (CEDEN) | SWRCB |
| Recreation | My Water Quality | California Water Quality Monitoring Council |
| | 30x30 California–Access Explorer | CRNA |
| Hydropower | Hydroelectric Power | CEC |
| Equity | Disadvantaged Communities Mapping Tool | DWR |
| | California Office of Environmental Health Hazard Assessment (OEHHA) | California OEHHA |
| | Climate Change and Health Vulnerability Indicators (CCHVIz) for California | California Department of Public Health |
| | Climate and Economic Justice Screening Tool | US Council on Environmental Quality |

Note:

The Sustainability Outlook was consulted for indicators in all water resource categories.

CCHVI = Climate Change and Health Vulnerability Indicator.

CRNA = California Natural Resources Agency.

DDW = Division of Drinking Water.

DFW = California Department of Fish and Wildlife.

DWR = California Department of Water Resources.

EPA = US Environmental Protection Agency.

FEMA = Federal Emergency Management Agency.

GSP = groundwater sustainability plan.

OEHHA = Office of Environmental Health Hazard Assessment.

SGMA = Sustainable Groundwater Management Act.

TNC = The Nature Conservancy.

USGS = US Geological Survey.

3.2 Key Terms

Several key terms are used in the process described in this TM.

- **Resilience** is the capacity of natural and built systems to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience.
- **Sustainability** of California’s water systems means meeting current needs – expressed by water stakeholders as public health and safety, healthy economy, ecosystem vitality, and opportunities for enriching experiences – without compromising the needs of future generations.
- **Indicator** is an observable phenomenon that can be used to monitor progress toward achieving a goal or intended outcome (e.g., reduced population risk in the floodplain).
- **Metric** is a method of measuring results from a specific and measurable process or action that can be evaluated.
- **Outcome** is the result of an action taken.

3.3 Process for Selecting Indicators and Metrics

The process for selecting indicators and metrics across water sectors and equity is described below:

1. Define the purpose of indicators and metrics (what is being measured?)
2. Identify water resource categories and preliminary indicators and metrics.
3. Develop criteria for indicators and metrics selection.
4. Screen indicators and metrics against developed criteria and select the recommended indicators and metrics.

The following subsections describe the results of each step.

3.3.1 Step 1. Define Purpose

The desired overall outcomes for the WRP are resilient watersheds that can equitably, safely, and sustainably deliver a full range of water resources and ecological services. The standard method to measure and communicate progress is using relevant and specific indicators and metrics. The focus of this TM is the development of metrics and indicators that serve as vital signs that assess current water resources conditions for watersheds across the State. This approach seeks to identify bellwether indicators that, when taken together, broadly characterize the current conditions and trends for each water sector within each watershed.

The focus in this TM is on indicators and metrics that are applicable to watersheds throughout the state. Later phases of the Hub (version 2.0 and beyond) are expected to add functionality that will allow watershed networks to supplement unique indicators and metrics specific to their individual watersheds.

The development of metrics and indicators is dynamic, collaborative, and ongoing. Although this TM includes a set of recommended metrics and indicators for initiating the Hub, metrics and indicators are expected to evolve over time. Some datasets initially selected may become obsolete, and others that were not available previously may become available.

3.3.2 Step 2. Identify Water Resource Categories and Preliminary Indicators

All resources for which water is managed should be included in the performance tracking approach. The seven water related sectors used included:

- Water supply.
- Ecosystems.
- Flood management.
- Groundwater.
- Water quality.
- Recreation and cultural uses.

In the following subsections, each of the water-dependent resource categories is briefly described, including the rationale for selecting the identified preliminary set of

metrics and indicators. Each water resources category also includes a table listing intended outcomes, indicators, metrics, and data sources.

3.3.2.1 Water Supply

Table 3-2 lists preliminary indicators and metrics for water supply. These reflect Governor Newsom’s goals for increasing supplies and reducing demand while also measuring affordability and reliability. These indicators can be used at the watershed scale throughout the state and can be applied to affect agricultural, municipal, industrial, and ecosystem uses for water. Equity metrics are presented separately in Section 3.2.3.

Table 3-2 Water Supply – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|---|---|--|---|
| Efficient use of water | Reuse of water supply (advanced treatment) | Annual volume of recycled water (AF) | Clean Water State Revolving Fund |
| Efficient use of water | Average annual municipal and industrial water use | Average annual M&I per capita water use (GPCD) | SWRCB and Pacific Institute |
| Efficient use of water | System (M&I and Ag) leaks and losses | Undetermined | UWMPs; AWWA M36; DWR Water Loss Audit Reporting Website; DWR Water Audit Manual; SWRCB Water Loss Control |
| Affordability of water | Cost of municipal and industrial water | Cost of water to end user (\$/AF) | CPUC |
| Affordability of water | Cost of agricultural water | Cost of water to end user (\$/AF) | CPUC |
| Reliability of water supply for beneficial uses | Delivery reliability of SWP, CVP, and Colorado River Aqueduct systems | Delivery allocation of full contract (%) | DWR/Reclamation |
| Reliability of water supply for beneficial uses | Domestic water supply reliability | Population with Failing, At-Risk Water Systems as defined by the Safer Program | SWRCB Safer Dashboard- (2023 Drinking Water Needs Assessment) |

| Outcome | Indicator | Metric | Data Source |
|---|---|---|-----------------------------|
| Reliability of water supply for beneficial uses | Municipal and industrial water supply reliability | Undetermined | UWMPs; SWRCB; DDW; US HHIHS |
| Reliability of water supply for beneficial uses | Agricultural water supply reliability | Average annual actual agricultural water deliveries compared to full allocation | — |
| Reliability of water supply for beneficial uses | Ecosystem water supply | Annual volume of water dedicated for ecological flows/ecosystem purposes | — |
| Resilience of water supply to climatic hydrologic, and other external stressors | Diversification of water supplies | Percent of supply from primary source(s) | — |
| Resilience of water supply to climatic hydrologic, and other external stressors | Redundancy of water | Percent of population reliant on water from Delta-based projects | UWMPs |
| Resilience of water supply to climatic hydrologic, and other external stressors | Water Shortage Contingency Plans | Percent of population covered by WSCPs in each hydrologic region | UWMPs |
| Resilience of water supply to climatic hydrologic, and other external stressor | Short-term transfers of water | Volume of water transfers versus cost of transfer water | SWRCB; DWR; Water Agencies |

Note:

\$ = dollars.

AF = acre-feet.

Ag = agricultural.

AWWA = American Water Works Association.

AWWA 36 = *M36 Water Audits and Loss Control Programs, Fourth Edition* (American Water Works Association 2015).

CPUC = California Public Utilities Commission.

GPCD = gallons per capita per day.

HHS = US Department of Health and Human Services.

HIS = Indian Health Service.

M&I = municipal and industrial.

US = United States.

UWMP = urban water management plan.

3.3.2.2 Flood Management

Growing populations and aging infrastructure make the flood system increasingly vulnerable; this vulnerability will be exacerbated as warming and extreme precipitation intensify, even under projections that indicate overall drier conditions. The preliminary indicators and metrics for a resilient flood management system consider the extent of population and asset exposure for a range of flood events in addition to the ability for at-risk populations to evacuate during a flood event. Table 3-3 lists a preliminary set of indicators and metrics for flood management.

Table 3-3 Flood Management – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|--|---|--|--|
| Flood risk for people in the floodplain | Population exposure to 100- and 500-year flood events | Population at risk in 100-year and 500-year floodplain | FEMA NFHL Maps and Census Data |
| Flood risk for people in the coastal flood zones | Asset exposure to 100-year flood events | Value of assets in 100-year floodplain | FEMA NFHL Maps and Asset Data |
| Flood risk for assets in the floodplain | Urban population without State-mandated urban level of flood protection | Percent of population without State-mandated urban level of flood protection | Sustainability Outlook Public Health and Safety (PHS 9) |
| Flood risk for assets in the coastal flood zones | Population vulnerability to coastal flooding impacts | Population at risk for coastal flooding | USGS CoSMoS and Census Data |

| Outcome | Indicator | Metric | Data Source |
|---|--|--|--|
| Flood risk for assets in the coastal flood zones | Asset vulnerability to coastal flooding impacts | Assets at risk for coastal flooding | USGS CoSMoS and Asset Data |
| Flood risk for assets in the coastal flood zones | Current status of FEMA flood mapping | Most recent date of flood risk mapping at regional level | FEMA NFHL Maps |
| Ability of people to evacuate or otherwise avoid harm | Population served by local hazard mitigation or emergency evacuation plans | Percent of population served by plans | LHMPs |

Note:

CoSMoS = Coastal Storm Modeling System.

FEMA = US Federal Emergency Management Agency.

LHMP = local hazard mitigation plan.

NFHL = National Flood Hazard Layer.

PHS 9 = Public Health and Safety Item 9, from the Sustainability Outlook Indicator Descriptions and Methodology.

USGS = US Geological Survey.

3.3.2.3 Groundwater

During an average year, California's 515 alluvial groundwater basins and subbasins contribute approximately 38 percent toward the state's total water supply. During dry years, groundwater contributes up to 46 percent (or more) of the statewide annual supply and serves as a critical buffer against the impacts of drought and climate change. Many municipal, agricultural, and disadvantaged communities rely on groundwater for up to 100 percent of their water supply needs (California Department of Water Resources 2023). In some regions, the unsustainable use of groundwater has caused negative impacts, such as land subsidence (with damage to infrastructure), reduced streamflow, and reduced water quality. As groundwater is over-pumped, water tables drop, and many domestic wells run dry.

The preliminary list of groundwater indicators and metrics (Table 3-4) use selected datasets related to SGMA to characterize groundwater levels and storage, land subsidence, groundwater quality, irrigated acreage that depend on groundwater, numbers of dry wells, seawater intrusion, and other characteristics.

Table 3-4 Groundwater – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|---|---|--|---|
| Groundwater levels | Groundwater level trends over a representative monitoring network | Changes in median water elevation (ft) | SGMA—Levels |
| Groundwater storage | Total volume of in storage | Acre-feet | SGMA—Sustainability Plan Annual Reports |
| Seawater intrusion | Rate and extent of seawater intrusion based on movement of chloride iso contours in affected aquifers | Extent of seawater intrusion (miles) | SGMA—Sustainability Plan Annual Reports |
| Land subsidence | Rate and extent of land subsidence over a representative monitoring network | Feet | SGMA—Land subsidence |
| Interconnected surface water depletions | Volume and rate of surface water depletion from interconnected streams | Volume of depletion | SGMA |
| Water quality | Groundwater quality trends over a representative monitoring network | Varies | SGMA—Sustainability Plan Annual Reports and USGS GAMA—Public supply Well, Inorganic Data and Trends |
| Water quality | Migration of contaminant plumes | Total area of contamination | SGMA—Sustainability Plan annual Reports and SWRCB—Geo Tracker |
| Potential disruption in agricultural, and environmental supply during drought | Irrigated acres dependent on ground water for production | Acre | SGMA—Basin Prioritization Dashboard |

| Outcome | Indicator | Metric | Data Source |
|--|---|---------------------|--|
| Potential disruption in municipal, agricultural, and environmental supply during drought | Number of dry wells | Number of dry wells | DWR—Dry well |
| Potential disruption in municipal, agricultural, and environmental supply during drought | Population served solely by groundwater | Population | SGMA—Basin Prioritization Dashboard |
| Potential disruption in municipal, agricultural, and environmental supply during drought | Acreage of groundwater dependent ecosystems | Acre | TNC and NC Dataset Viewer |
| Safe groundwater supply for drinking water | Number of wells exceeding the water quality standards (primary and secondary) | Number of wells | SGMA—Sustainability Plan Annual Reports and SWRCB—GAMA |
| Safe groundwater supply for drinking water | Population served by wells that are not compliant to drinking water quality standards | Population at risk | SWRCB—GAMA and US Census Bureau |

Note:

DWR = California Department of Water Resources.

GAMA = Groundwater Ambient Monitoring and Assessment.

NC = Natural Communities.

SGMA = Sustainable Groundwater Management Act.

SWRCB = State Water Resources Control Board.

TNC = The Nature Conservancy.

USGS = US Geological Survey.

3.3.2.4 Ecosystems

Many of California's watersheds' natural functions and water-dependent habitats have been altered or lost. These changes have impacted ecosystems, threatened the

extinction of multiple species, impaired water bodies, and have degraded watershed health.

Preliminary indicators (Table 3-5) were selected to be consistent with the Healthy Watersheds Program general framework (California Water Quality Monitoring Council 2023). Developed by the EPA, the Healthy Watersheds Program conceptual framework is a systems-based approach toward identifying and protecting healthy watersheds based on the dynamics and interconnectedness of aquatic ecosystems through six essential ecological attributes to describe ecosystem conditions, or outcomes. These include:

- Landscape condition.
- Biotic condition.
- Chemical and physical characteristics.
- Ecological processes.
- Hydrologic and geomorphic condition.
- Natural disturbance regimes.

Table 3-5 Ecosystems – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|-----------------------------|------------------------------------|--|-------------------------------------|
| Hydrology | Natural/ecological flows | Percent deviation from natural flow regime | TNC, Natural Flows |
| Hydrology | In-stream barriers | Percent of stream network disconnected | CDFW |
| Environmental water quality | Stream condition index | CSCI score | SWRCB |
| Habitat | California Rapid Assessment Method | Multiple parameters | SFEI, CRAM Wetlands |
| Habitat | PHAB | Multiple parameters | SCCWRP |
| Environmental water quality | Algal Stream Condition Index | ASCI Score | SWRCB, SMC, CEDEN |

| Outcome | Indicator | Metric | Data Source |
|----------------------|-------------------------------|---|--|
| Habitat | Wetland amount | Percent wetlands | SFEI |
| Geomorphology | Road crossing density | Number of road-stream crossings in the catchment/catchment area | CBI |
| Geomorphology | Impervious surfaces | Percent impervious | UC Davis |
| Biological condition | Biodiversity values | Terrestrial and aquatic biodiversity ranks | CDFW—Aquatic CDFW—Terrestrial |
| Biological condition | USFWS designated habitat | Percent of region with designated habitat (ESA) | USFWS |
| Biological condition | Rare and endemic fish species | Number of rare and endemic fish species | RePlan |
| Landscape condition | Fire threat | Fire threat class | FRAP |
| Landscape Condition | Natural land cover | Percent of region in native vegetation/land cover | USGS, MRLC, LCMAP |
| Landscape condition | Landscape integrity | degree of intactness (fragmentation index) | CBI |

Note:

CBI = Conservation Biology Institute.

CEDEN = California Environmental Data Exchange Network.

CDFW = California Department of Fish & Wildlife.

CRAM = California Rapid Assessment Method.

ESA = Endangered Species Act.

PHAB = Physical Habitat.

SCCWRP = Southern California Coastal Water Research Project.

SFEI = San Francisco Estuary Institute.

SMC = Stormwater Monitoring Coalition.

SWRCB = State Water Resources Control Board.

TNC = The Nature Conservancy.

UC = University of California.

USFWS = US Fish and Wildlife Service.

3.3.2.5 Water Quality

While most Californians have access to clean drinking water, more than 1 million residents still lack access to safe drinking water (California Natural Resources Agency 2020) despite ongoing and significant investments. Similarly, the number of impaired water bodies throughout the state continues to grow despite regulations and enforcement efforts. The preliminary list of indicators and metrics (Table 3-6) for water quality considers populations affected by drinking water system violations, water supplies that depend on impaired water bodies, and level of impairment of water bodies.

Table 3-6 Water Quality – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|-----------------------------|--|--|---|
| Drinking water quality | Public water systems not in compliance with drinking water standards | Populations affected by drinking water system violations | SWRCB |
| Drinking water quality | Water supplies derived from Clean Water Act Section 303(d) impaired water bodies | Water supply | SWRCB , eWRIMS |
| Environmental water quality | Water quality impairments | Designated temperature, DO impairments | SWRCB |

Note:

CSCI = California Stream Condition Index.

eWRIMS = Electronic Water Rights Information Management System.

SWRCB = State Water Resources Control Board.

3.3.2.6 Recreational and Cultural Uses

In 2017, the SWRCB established and defined two beneficial uses unique to California Tribes, and a third beneficial use unique to people and communities who engage in subsistence fishing. These beneficial uses were developed in collaboration with California Tribes and the public. Together, these three beneficial uses are generally referred to as “Tribal Beneficial Uses” and are defined as follows:

- Tribal Tradition and Culture (CUL) – Uses of water that support the cultural, spiritual, ceremonial, or traditional rights or lifeways of California Tribes, including, navigation, ceremonies, fishing, gathering, or other consumption of

natural aquatic resources (including fish, shellfish, vegetation, and abiotic materials).

- Tribal Subsistence Fishing (T-SUB) – Uses of water involving the non-commercial catching or gathering of natural aquatic resources, including fish and shellfish, for consumption by individuals, households, or communities of California Tribes to meet needs for sustenance.
- Subsistence Fishing (SUB) – Uses of water involving the non-commercial catching or gathering of natural aquatic resources, including fish and shellfish, for consumption by individuals, households, or communities to meet needs for sustenance.

Water-based recreation and Tribal Beneficial Uses are already, and will continue to be, impacted by climate change. Climate change will reduce flows and affect the water quality in rivers, impacting fisheries and thus subsistence fishing, reducing snowpack, and resulting in conditions such as poor air quality or extreme heat that prevents or limits outdoor activity.

The preliminary list of indicators and metrics for recreation and cultural uses (Table 3-7) focuses on both access and usage data. Recreational uses of rivers, lakes, snow, and coastal areas are evaluated through indirect measures of boating use/day, usable surface area, total snow in designated areas, and existing coastal recreation public spaces.

With respect to access, while many Californians enjoy nature frequently, millions never have the opportunity. 1 in 4 Californians do not have a public park or open space within walking distance of their home, and 6 in 10 live in a park-poor neighborhood with fewer than three acres of park and open spaces. California's recently launched *30 x 30 California* (California Natural Resources Agency 2023a) and *Outdoors for All* (California Natural Resources Agency 2023b) initiatives will provide crucial information on Californians' accessibility to open spaces. (*30X30 Access Explorer*). Information from these programs is available from the *30 x 30 California Access Explorer*.

With respect to measuring Tribal Beneficial Uses, indicators and metrics that characterize the health of water bodies are currently the most relevant and available. However, as the SWRCB incorporates Tribal Beneficial Uses into their Basin Plans (State Water Resources Control Board 2023a) throughout the state, additional relevant data sets may become available in the future.

Table 3-7 Recreation and Cultural Land Uses – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|---------------------------------|--|--|--|
| Amount of recreational benefits | Riverine recreational uses | Boating use per day during May through September | Computed from approaches described in CWP Watershed Resilience Assessment |
| Amount of recreational benefits | Lake recreational uses | Usable surficial lake area | Computed from approaches described in CWP Watershed Resilience Assessment |
| Amount of recreational benefits | Lacustrine recreational uses | Usable surficial lake area | Computed from approaches described in CWP Watershed Resilience Assessment |
| Amount of recreational benefits | Snow recreational uses | Number of days of snow in designated areas November through June | Computed from approaches described in CWP Watershed Resilience Assessment |
| Amount of recreational benefits | Intracoastal recreational uses | Existing coastal recreation areas | Computed from approaches described in CWP Watershed Resilience Assessment |
| Accessibility to open spaces | Access to Open Space | Population within half-mile radius of GAP code 1 or 2 open space | 30x30 Access Explorer https://data.ca.gov/dataset/access-explorer1 |
| Tribal Beneficial Uses | (Placeholder for future measurement of Tribal Tradition and Culture) | | |
| Tribal Subsistence Fishing | Water quality of water bodies used for Subsistence Fishing | Impaired Water bodies within or adjacent to Tribal Lands | Intersection of Impaired Water Bodies Dataset and Digital Atlas of California Native Americans |

Note:

CWP = California Water Plan.

GAP = Gap Analysis Project.

TBU = tribal beneficial use.

3.3.2.7 Hydropower

Hydropower is a renewable resource and an essential component of California’s renewable energy portfolio. The amount of hydroelectricity produced in California changes each year because of the variability of snowmelt runoff and rainfall. Hydropower averages 15% of California’s electricity generation, from 7% in dry years to over 20% in wet years. For example, in 2006, large hydroelectrical facilities produced 40,952 gigawatts (GW); in 2011, they produced 35,682 GW; and in 2021 they produced 12,036 GW (California Energy Commission 2023). Data for hydropower energy production is tracked separately for large facilities (those producing more than 30 megawatts [MWs]) and small facilities (those producing less than 30 MW). The hydropower indicators and metrics for both types of facilities are listed in Table 3-8.

Table 3-8 Hydropower – Preliminary List of Indicators and Metrics

| Outcome | Indicator | Metric | Data Source |
|---------------------------------|---|---|---------------------|
| Hydropower, energy productivity | Hydropower generation efficiency — large facilities | Average generation, lowest generation, and highest generation — annually, OR over a multiyear period (large facilities > 30 MW) | CEC |
| Hydropower, energy productivity | Hydropower generation efficiency — small facilities | Average generation, lowest generation, and highest generation — annually, OR over a multiyear period (small facilities < 30 MW) | CEC |

Note:

CEC = California Energy Commission.

MW = megawatt.

3.3.3 Overlaying a Water Equity Lens

While State and local governments have worked to invest in safe, reliable, and affordable water supply for all Californians, inequities remain for vulnerable communities. These communities often bear the brunt of certain risks, such as flooding, environmental pollution, and contaminated or insufficient water supplies (State Water Resources Control Board 2023b).

The Water Equity category is intended to crosscut the other seven water resource categories. Water equity indicators and metrics help to better understand how vulnerable communities are disproportionately impacted by water quality

contaminants, flood risks, drinking water shortages, dry wells, access to open spaces, and other water resource sectors.

Social equity and environmental justice in water seeks access and affordability to clean and safe water and improved safety from flood and fire hazards. It also strives for equal access to community investments, participation in decision-making, and representation in water management leadership. This initial list of equity metrics and indicators primarily focuses on how vulnerable communities are affected by impacts across water sectors. As additional datasets become available related to investments, representation, and participation in decision-making, additional metrics and indicators can be integrated into the Hub to provide a fuller assessment of equity at both the State and watershed scale.

Multiple indices have been developed by federal, State, and local agencies that have defined vulnerable communities using an array of available demographic data. This demographic data is intersected with various climate and environmental risk factors. Each of these metrics is developed through a slightly different methodology and many overlap (Table 3-9). Additional equity metrics and indicators are shown on Table 3-10.

Table 3-9 Water Equity – Preliminary List of Potential Indices of Impacted Vulnerable Communities

| Index or Outcome | Indicator | Metric | Data Source |
|---|---|--|--------------------------------------|
| CalEnviroScreen | 20 indicators across exposure, environmental effects, sensitivity and socioeconomic factors | Multiple parameters | OEHHA |
| Climate Change and Health Vulnerability—Factors | 19 indicators across environmental exposure, population sensitivity, and adaptive capacity (note: does not include flood) | Multiple parameters | CCHViz |
| Disadvantaged Communities Mapping | Median income household income less than 80% and 60% of the statewide average | % of total population in DACs or SDACs | DWR—DAC Mapping Tool |
| Delta Social Vulnerability Index | Delta vulnerability index | Compound indicator of vulnerability | DSC—Delta Adapts |

Note:

CCHViz = Climate Change and Health Vulnerability Index Visualization.

DAC = disadvantaged community.

DSC = Delta Stewardship Council.

OEHHA = California Office of Environmental Health Hazard Assessment.

SDAC = severely disadvantaged community.

Table 3-10 Preliminary List of Equity Indicators and Metrics

| Outcome | Indicators | Metric | Source |
|--|---|--|-------------------------|
| Equitable Availability of Water Supply | Intersect selected vulnerable community demographic data with population-based water supply indicators and metrics | | |
| Equitable Risk of Flood | Intersect selected vulnerable community demographic data with population based selected flood indicators and metrics | | |
| Access to Clean Water | Intersect selected vulnerable community demographic data with population-based water quality indicators and metrics | | |
| Availability of Groundwater | Intersect selected vulnerable community demographic data with population-based groundwater indicators and metrics | | |
| Cultural Land and Water Uses | Intersect selected vulnerable community demographic data with selected cultural land use and recreation access indicators and metrics | | |
| Equitable Investments | Funding in Vulnerable Communities | Dollars granted for water resources projects in areas with majority vulnerable population | Not currently available |
| Equitable Participation in decision-making | Community engagement designed to meet needs of vulnerable communities | Members of vulnerable communities participating in water resource project decision-making at the local, regional and State level | Not currently Available |
| Equitable Representation | Vulnerable community members represented on boards and in leadership positions | % of boards and leadership positions with water resources and project and funding decisions | Not currently available |

3.3.4 Step 3. Develop Criteria for Selection of Statewide Indicators and Metrics

A preliminary list of over 60 potential indicators and metrics were identified through the review of other frameworks and data sources. Criteria was developed to narrow this initial list to a focused set of metrics and indicators appropriate for the Hub. The

criteria were created by the development team in consultation with DWR staff and subject matter experts. The criteria were informed by previous State efforts such as the Outlook. The criteria included the following:

- **Relevance:** Indicators and metrics are closely connected and reflective of current water resource sector conditions and are expected to change over time.
- **Practicality:** Indicators and metrics should be able to be tracked over time and should provide easily interpreted and meaningful data.
- **Update Frequency and Ease:** Data sources for the indicators and metrics should be easily obtainable, consistently available, well maintained, updated frequently, and provide quality data. Data collection efforts have durable funding and support. Additionally, accessing and uploading the data to the Hub should be readily achievable.
- **Coverage and Scale:** Data sets are available statewide and applicable at the watershed scale. Data is at a resolution that provides meaningful information at both watershed and statewide scales.
- **Quality:** Data is collected and processed by trusted and well-known sources with rigor and commitment to high data management standards.

3.3.5 Step 4. Screen Indicators and Metrics

Each indicator was evaluated for the criteria presented in the previous section using a scale of 1 to 3, with 1 being a low potential and a poor linkage with the criteria, 2 implying a medium potential and/or requiring supplemental processing of the data to meet the criteria, and 3 indicating a high potential and strong linkage.

Scores for each criterion were averaged to produce an overall score for each indicator. Each indicator was classified as either Tier 1 or Tier 2 based on these overall scores. Tier 1 indicators were determined to provide useful primary information for the resource condition and likely have higher quality data to support statewide tracking. Tier 2 indicators were identified as useful, or supporting indicators, but often had lower quality data statewide.

Table A-1, in Appendix A provides ratings for each indicator and metric against each criterion. Additionally, for each indicator and metric, Table A-1 shows the total score and assigns a Priority Tier of 1 or 2 and a brief rationale.

4. Recommended Indicators and Metrics

Based on the scoring of indicators and metrics outlined in Table A-1 with the criteria described in the previous section, the development team recommended advancing the following Tier 1 indicators across the seven water resource categories listed in Table 4-1. Acknowledging the abundance of indicators available to select from in Table A-1, the team recognized the importance of streamlining, managing, and evaluating a diverse but focused set of indicators. The quality of each indicator and metric was taken into account and the overall mix of recommended indicators and metrics within each water sector category to reduce redundancy.

It's important to note that the metrics and indicators listed in Table 4-1 are intended as an initial set for use in the Beta 1.0 version of the Hub. As users and interested parties provide feedback on the tool, new indicators, metrics, and datasets will be considered. This iterative process allows for continuous improvement and adaptation to better address evolving needs.

Table 4-1 Tier 1 Recommended Water Resource Indicators and Metrics to Advance for the Beta 1.0 Hub

| Category | Number | Condition or Outcome | Indicator | Metric | Reference (Trend, If Applicable) |
|--------------|--------|--|---|--|---|
| Water Supply | 1 | Reliability of water supply for beneficial uses | Delivery reliability of SWP, CVP, and Colorado River Aqueduct systems | Percent difference of actual water deliveries to long-term average | Percent difference of actual water deliveries to long-term average |
| | 2 | Reliability of water supply for beneficial uses | Domestic water supply reliability | Population with failing or at-risk water systems as defined by SAFER Dashboard | Percent of watershed population affected (decrease, 0%) |
| | 3 | Water conservation and efficient use of water | Average annual urban water use | Average annual GPCD | Relative to historical (decreasing) |
| Flood | 4 | Flood risk for people in the floodplain | Population exposure to 100-year flood events | Population at risk in 100-year floodplain | Percentage of watershed population at risk to 100-year flood events (target = decrease) |
| | 5 | Flood risk for people in the coastal flood zones | Population exposure to 100- year flood events | Population at risk in 100-year coastal flood zones | Percentage of watershed population within 100-year flood zones (decrease) |
| | 6 | Flood risk for assets in the floodplain | Asset exposure to 100-year flood events | Value of assets in 100-floodplain (\$M) | Relative to historical (decrease) |

| Category | Number | Condition or Outcome | Indicator | Metric | Reference (Trend, If Applicable) |
|-----------------|---------------|--|---|--|---|
| | 7 | Flood risk for assets in the coastal flood zones | Asset exposure to 100- r flood events | Value of assets in 100- floodplain (\$M) | Relative to historical (decrease) |
| Groundwater | 8 | Groundwater levels | Groundwater level trends over a representative monitoring network | Changes in median water elevation (ft) | Groundwater level percentile compared to previous 20-years from DWR's Groundwater Live reporting. |
| | 9 | Land subsidence | Rate and extent of land subsidence over a representative monitoring network | Feet | Subsidence rate (decrease) |
| | 10 | Potential disruption in municipal, agricultural, and environmental supply during drought | Number of dry wells | Number of dry wells | Number of dry wells (decrease) |
| Ecosystem | 11 | Environmental water quality and biological condition | CA Stream Condition Index | CSCI score | CSCI score (positive or increasing positive) |
| | 12 | Environmental water quality and biological condition | Algal Stream Conditions Index | ASCI Score | ASCI score (positive or increasing positive) |
| | 13 | Environmental water quality and biological condition | CA Rapid Assessment Method | CRAM Score | CRAM score (positive or increasing positive) |
| Landscape | 14 | Landscape condition | Fire threat | Fire threat class | Fire threat class (reduction) |
| Water Quality | 15 | Drinking water quality | Public water systems not in compliance with drinking water standards | Populations affected by drinking water system violations | Populations affected by drinking water systems not in compliance (decrease, zero) |

| Category | Number | Condition or Outcome | Indicator | Metric | Reference (Trend, If Applicable) |
|------------|--------|--------------------------------|--|--|---|
| | 16 | Drinking water quality | Water supplies derived from Clean Water Act Section 303(d) impaired water bodies | Percent of Water supplies listed as impaired | Percent of water supplies derived from Clean Water Act Section 303(d) listed sources (decrease, zero) (increase or decrease) |
| Hydropower | 17 | Hydropower energy productivity | Hydropower generation efficiency—large facilities | Average generation, lowest generation, and highest generation—annually OR over a multiyear period (large facilities > 30 MW) | |
| Equity | 18 | CalEnviroScreen | 20 indicators across exposure, environmental effects, sensitivity, and socioeconomic factors | Multiple parameters | Relative to 1990 levels |

Note:

AF = acre-feet.

DAC = disadvantaged community.

DO = dissolved oxygen.

ESA = Endangered Species Act.

GAP = Gap Analysis Project.

GPCD = gallons per capita per day.

CWP Update 2023

MW = megawatt.

SDAC = severely disadvantaged community.

USFWS = US Fish and Wildlife Service.

5. Testing of Selected Indicators and Metrics in Watersheds

Initial development of the Hub tool has included constructing the basic architecture and functionality of the Hub, including a draft dashboard, and landing pages for each water sector category, including equity.

To date, five data sets have been imported into the Hub as proxies to test the optimal approach for analyzing and displaying information. These data sets are as follows:

- Equity (Cal Enviroscreen, and disadvantaged community).
- Population exposure to 100-year flood events.
- Clean water act section 303d impaired water bodies.
- Terrestrial biodiversity.
- Wetlands.

Existing functionality for these data sets includes an interface that allows navigation and display of information on each water resource category, individual watersheds, and summary data that allows comparison across watersheds. Equity data sets have been intersected with water sector data sets to understand potential disproportionate impacts on vulnerable populations. Screenshots of the test landing pages for these indicators and metrics are in Appendix C.

6. Next Steps

To maintain momentum on Hub development, the following next steps are recommended:

1. Continue State agency engagement on Hub indicators and metrics.
2. Process and import remaining required data sets into the Hub. Associated data sets can be imported into the Hub for analysis and viewing.
3. Finalize beta version functionality of the Hub. Review approach to analysis and display of metrics/data and collaboratively design additional features.
4. Test Beta 1.0 Hub. Develop a functional Hub Beta 1.0 with an initial first set of data for the metrics and indicators.

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Appendix A

Preliminary List of Indicators and Metrics and Scoring

Table A-1 Scoring of Preliminary List of Indicators and Metrics

| Category | Outcome | Indicator | Metric | Source | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | Notes | |
|--------------|--|---|---|---|-----------|--------------|------------------|----------|---------|---------------|---------------|--|---|
| | | | | | | | | | | | | | |
| Water Supply | Ensure reliability of water supply for beneficial uses | Domestic (urban) water supply reliability | Population with Failing, At-Risk Water Systems as defined by the Safer Program | SAFER Dashboard, 2023 Drinking Water Needs Assessment (SWRCB) | 3 | 3 | 3 | 3 | 3 | 3 | 1 | Key water supply reliability indicator for smaller systems. | |
| | | Municipal and industrial water supply reliability | Undetermined | UWMPs; SWRCB; DDW; US DHHS; IHS | 3 | 1 | 3 | 2 | 2 | 2.2 | 2 | Information for major water suppliers exists, but unclear whether consistent data sets exist for complete watersheds. Could score higher if synthesized data were available. | |
| | | Agricultural water supply reliability | Average annual actual agricultural water deliveries compared to full allocation | Undetermined | | 3 | 1 | 1 | 1 | 1 | 1.4 | 2 | Data coverage and availability are unclear. |
| | | Delivery reliability of SWP, CVP, and Colorado River Aqueduct systems | % difference of actual water deliveries to long-term average | DWR; Reclamation | | 3 | 3 | 3 | 2 | 3 | 2.8 | 1 | Water reliability indicator of major backbone systems that provide water to many regions of the State. |
| | | Ecosystem water supply | Annual volume of water dedicated for ecological flows/ecosystem purposes | Undetermined | | 3 | 2 | 3 | 1 | 2 | 2.2 | 2 | Ecological flows are the flows necessary to sustain aquatic and riparian ecosystems throughout the river corridor. The CEFF is a stepwise process for developing ecological flow criteria for California streams using functional flows. A complete and detailed dataset is unavailable at this time and would require development. |
| | Ensure affordability of water | Cost of M&I water | Cost of water to end user (dollar per acre-foot or dollar per gallon) | California Public Utilities Commission | 2 | 2 | 3 | 2 | 3 | 2.4 | 1 | The end user cost might not be directly comparable across all regions. Source of water, conveyance, treatment, distribution, pricing structures all vary for each water supplier and watershed. Cost reflects water affordability but are also driven by regional supply and demand. | |
| | | Cost of agricultural water supply | Cost of water to end user (dollar per acre-foot or dollar per gallon) | California Public Utilities Commission | 2 | 2 | 3 | 2 | 3 | 2.4 | 1 | The end user cost might not be directly comparable across all regions. Source of water, conveyance, treatment, distribution, pricing structures all vary for each water supplier and watershed. Cost reflects water affordability but are also driven by regional supply and demand. | |
| | Achieve efficient use of water | Average annual urban water use | Average annual GPCD | SWRCB and Pacific Institute | 3 | 3 | 3 | 3 | 2 | 2.8 | 1 | The indicator reflects water conservation practices on a per capita basis | |

| Category | Outcome | Indicator | Metric | Source | | | | | | | | Notes |
|----------|---|--|--|---|-----------|--------------|------------------|----------|---------|---------------|---------------|---|
| | | | | | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | |
| | | System (M&I and Ag) leaks and losses | Undetermined | UWMPs; AWWA M36; DWR Water Loss Audit Reporting Website; DWR Water Audit Manual; SWRCB Water Loss Control | 2 | 0 | 0 | 0 | 0 | 0.4 | 2 | Estimating losses and leaks would clearly show the gaps and opportunities for improvement of a given system. It is uncertain the quality, coverage, and consistency of data. |
| | | Reuse of water supply (advanced treatment) | Annual volume of recycled water (million acre-feet) | Clean Water State Revolving Fund | 2 | 2 | 3 | 3 | 3 | 2.6 | 1 | Water recycling reduces vulnerability by diversifying water sources. There are also many reasons water suppliers don't recycle water, including: lack of conveyance or treatment infrastructure, sufficient existing water supplies, and lack of demand for recycled water. |
| | Ensure resilience of water supply to climatic, hydrologic, and other external stressors | Redundancy of water supply | % of population reliant on water from Delta-based projects | UWMPs | 2 | 2 | 3 | 3 | 3 | 2.6 | 1 | Diversifying water sources and avoiding dependence on a single water source could reduce vulnerability. There are limitations of this indicator by focusing solely on Delta-based supplies. For instance, many non-Delta based supplies may also rely on a single water source. |
| | | Water Shortage Contingency Plans | % of population covered by WSCPs in each hydrologic region | UWMPs | 3 | 1 | 1 | 1 | 2 | 1.6 | 2 | Data is not readily available and synthesized across the state. Could become priority resilience metric if synthesized. |
| | | Short-term transfers of water | Volume of water transfers versus cost of transfer water | SWRCB; DWR; Water Agencies | 2 | 1 | 2 | 1 | 2 | 1.6 | 2 | Inconsistent coverage across the state and inconsistent updates of quality. |
| Flood | Flood risk for people and property in the floodplain | Population exposure to 100-year flood events | Population at risk in 100-year floodplain | FEMA NFHL Maps and Census Data | 3 | 3 | 1 | 3 | 2 | 2.4 | 1 | FEMA produces the National Flood Hazard Layer, which supports the National flood Insurance Program and the flood risk level of a given location; the analysis against the census database provides the population at risk. |
| | | Asset exposure to 100-year flood events | Value of assets in 100-year floodplain | FEMA NFHL Maps and Asset Data | 3 | 1 | 1 | 3 | 2 | 2.0 | 1 | FEMA produces the National Flood Hazard Layer, which supports the National flood Insurance Program and the flood risk level of a given location. The update frequency of the Asset database, and the census data is not optimal. |

| Category | Outcome | Indicator | Metric | Source | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | Notes |
|-------------|---|--|--|---|-----------|--------------|------------------|----------|---------|---------------|---------------|---|
| | | | | | | | | | | | | |
| | | Urban population without State-mandated urban level of flood protection | % of population | Sustainability Outlook Public Health and Safety (PHS) 9 | 3 | 2 | 1 | 3 | 2 | 2.2 | 2 | Identifying areas that have developed or responded to frameworks and criteria to enhance flood protection for their communities may be used as an indicator of resilience in their improved ability to prevent, anticipate, respond, resist, maintain and recover to incidents of different magnitude or trends. While the Urban Level of flood Protection Criteria has been established by DWR (November 2013), it only applies to the Central Valley. |
| | | Population vulnerability to coastal flooding | Population at risk to coastal flooding | USGS CoSMoS and Census Data | 3 | 2 | 1 | 3 | 2 | 2.2 | 1 | Derived from the CoSMoS developed by USGS allows more detailed predictions of coastal flooding due to both sea-level rise and storm projections using wind and pressure global climate models. |
| | | Asset vulnerability to coastal flooding impacts | Assets at risk for to coastal flooding | USGS CoSMoS and Asset Data | 3 | 1 | 1 | 3 | 2 | 2.0 | 1 | Derived from the CoSMoS developed by USGS allows more detailed predictions of coastal flooding due to both sea-level rise and storm projections using wind and pressure global climate models. The update frequency of the Asset database, and the census data is not optimal. |
| | | Current status of FEMA flood mapping | Most recent date of flood risk mapping at regional level | FEMA NFHL Maps | 3 | 1 | 1 | 2 | 2 | 1.8 | 2 | Indicator of flood risk understanding and exposure. Several areas of California are unmapped or have outdated mapping. Supporting Tier 2. |
| | Ability of people to evacuate or otherwise avoid harm | Population served by local hazard mitigation or emergency evacuation plans | % of population | LHMPs | 3 | 2 | 1 | 2 | 1 | 1.8 | 2 | Data is not readily available. Local hazard mitigation plans, or emergency response and evacuation plans contribute to a community's resilience capacity. |
| Groundwater | Groundwater levels | Groundwater level trends over a representative monitoring network in a groundwater basin | Changes in median water elevation | SGMA—Levels | 3 | 3 | 3 | 3 | 2 | 2.8 | 1 | Groundwater levels trends is a real-time indicator of the health of groundwater basins. Identifying trends improves the ability to identify, anticipate, prepare, and respond to disruptive events. |

| Category | Outcome | Indicator | Metric | Source | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | Notes |
|----------|--------------------------------|---|-----------------------------|---|-----------|--------------|------------------|----------|---------|---------------|---------------|--|
| | | | | | | | | | | | | |
| | Groundwater storage reductions | Total volume of reduction in storage over a representative period (e.g., 10 year) | Acre-feet | SGMA—Sustainability Plan Annual Reports | 3 | 2 | 2 | 2 | 3 | 2.4 | 1 | Similar to groundwater level trends as a real-time indicator of the health of groundwater basins. |
| | Seawater intrusion | Rate and extent of seawater intrusion based on movement of chloride iso contours in affected aquifers | mg/L chloride | SGMA—Sustainability Plan Annual Reports | 2 | 1 | 2 | 2 | 2 | 1.8 | 2 | Data is not readily available across the coastal areas, |
| | Water quality degradation | Groundwater quality trends over a representative monitoring network in a groundwater basin | Varies | SGMA—Sustainability Plan Annual Reports and USGS GAMA-Public supply Well, Inorganic Data and Trends | 2 | 2 | 2 | 2 | 2 | 2.0 | 1 | 85% of California residents depend on groundwater for some portion of their water supply; while groundwater quality is important, there are a wide range of constituents to monitor that vary by groundwater basin. |
| | | Migration of contaminant plumes | Total area of contamination | SGMA—Sustainability Plan annual Reports and SWRCB—Geo Tracker | 2 | 2 | 0 | 0 | 0 | 0.8 | 2 | Data is not available statewide; the quality and update frequency are uncertain. Legacy contaminant plumes are widespread and represent an important component of health and safety monitoring. |
| | Land subsidence | Rate and extent of land subsidence over a representative monitoring network | Feet | SGMA—Land subsidence | 3 | 3 | 3 | 2 | 3 | 2.8 | 1 | The main cause of subsidence is groundwater pumping (followed by peat loss and oil extraction). Water distribution and aquifer recovery has successfully decreased land subsidence in some areas; in others it continues with rates of more than 1 foot per year. The effects include damage to buildings and infrastructure, increased flood risk and lasting damage to groundwater aquifers and aquatic ecosystems in areas of known subsidence. |

| Category | Outcome | Indicator | Metric | Source | | | | | | | | Notes |
|----------|--|---|---------------------|--|-----------|--------------|------------------|----------|---------|---------------|---------------|---|
| | | | | | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | |
| | Interconnected surface water depletions | Volume and rate of surface water depletion from interconnected streams | Volume of depletion | SGMA | 2 | 0 | 0 | 0 | 0 | 0.4 | 2 | Uncertain the quality and consistency of the data. Indicator to is useful in understanding the overall water balance and inform accurate water planning and management across watersheds. |
| | Potential disruption in municipal, agricultural, and environmental supply during drought | Number of dry wells | Number of wells | DWR—Dry well | 3 | 2 | 3 | 2 | 2 | 2.4 | 1 | Indicator focused on private (self-managed) wells; Dry wells reflect the overall condition of an aquifer and the unsustainable use of its waters against its recharge capacity. This can also serve as a key equity metric for vulnerable populations dependent on wells. |
| | | Population served solely by groundwater | Population | SGMA—Basin Prioritization Dashboard | 2 | 1 | 0 | 0 | 0 | 0.6 | 2 | Very low update frequency, inconsistent quality, and limited coverage across the state. |
| | | Acreages supplied by groundwater | Acre | SGMA—Basin Prioritization Dashboard | 3 | 2 | 2 | 2 | 2 | 2.2 | 2 | Limited update frequency, coverage, and quality. |
| | | Acreage of groundwater-dependent ecosystems | Acre | TNC and NC Dataset Viewer | 3 | 2 | 1 | 3 | 3 | 2.4 | 2 | Data quality is robust and relatively new. The update frequency is uncertain. |
| | Safe groundwater supply for drinking water | Number of wells exceeding the water quality standards (primary and secondary) | Number of wells | SGMA—Sustainability Plan Annual Reports and SWRCB—GAMA | 3 | 1 | 1 | 1 | 1 | 1.4 | 2 | Availability, updating frequency, and quality of data are uncertain. |
| | | Population served by wells that are not compliant to drinking water quality standards | Population at risk | SWRCB—GAMA and US Census Bureau | 3 | 1 | 2 | 2 | 2 | 2.0 | 2 | Availability, updating frequency, and quality of data are uncertain. Groundwater Live may improve score in the future. |

| Category | Outcome | Indicator | Metric | Source | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | Notes |
|-----------------------------|---------------------------|---|---|-------------------------------------|-----------|--------------|------------------|----------|---------|---------------|---|---|
| | | | | | 1 | 2 | 3 | 3 | 3 | 2.4 | 1 | |
| Ecosystem | Landscape condition | Natural land cover | % of region in native vegetation/land cover | USGS, MRLC, LCMAP | 1 | 2 | 3 | 3 | 3 | 2.4 | 1 | Increment of native vegetation relative land cover. The natural landcover is a direct indicator of landscape condition, but also unlikely to change significantly over time. The EROS program now includes the LCMAP initiative, which provides the capacity to plot land cover change in the United States. |
| | | Landscape integrity | degree of intactness (fragmentation index) | CBI | 2 | 2 | 1 | 3 | 3 | 2.2 | 1 | Update frequency is low |
| | | Fire threat, compound indicator or fuel rank and fire rotation rate | % of fire threat | FRAP | 3 | 3 | 1 | 3 | 3 | 2.6 | 1 | Reduction of Fire Threat Class The fire threat indicator combines the Fuel Rank (based on live and dead fuel material and its capacity to support high-intensity fire) and Fire rotation (the burning rate over the previous 30 years). It represents a hazard and, indirectly, an indicator of forest and rangelands' health and general condition. |
| | Habitat | CRAM | Multiple parameters | SFEI, CRAM Wetlands | 3 | 3 | 2 | 2 | 3 | 2.6 | 1 | Functional assessment of existing wetlands |
| | | PHAB | Multiple parameters | SCCWRP | 3 | 3 | 1 | 1 | 3 | 2.2 | 2 | Limited data coverage across the state and update frequency. IPI score reflecting physical integrity across streams. |
| | Hydrology | Wetland amount | % wetlands | SFEI | 2 | 2 | 2 | 3 | 3 | 2.4 | 1 | Tracks recovery and increase of wetlands. |
| | | Natural/ecological flows | % deviation from natural flow regime | TNC, Natural Flows | 1 | 1 | 3 | 3 | 3 | 2.2 | 2 | Tracks relative deviation from natural hydrograph distribution. Method similar to California Environmental Flows Framework. |
| | | In-stream barriers | % of stream network disconnected | CDFW | 3 | 3 | 2 | 1 | 3 | 2.4 | 2 | Fish barrier related metric. Fish barriers impede the migration of priority species and the natural distribution of aquatic communities. |
| | Geomorphology | Road crossing density | Number of road-stream crossings in the catchment/catchment area | CBI | 2 | 3 | 1 | 2 | 3 | 2.2 | 2 | Road crossing inventory and assessment metric. The current dataset covers the redwood region and is an old survey. |
| | | Impervious surfaces | % impervious | UC Davis | 2 | 2 | 1 | 3 | 1 | 1.8 | 2 | The greater the proportion of watershed with impervious surfaces, the greater the likelihood of geomorphic processes and conditions being degraded. |
| Environmental water quality | Water quality impairments | Designated temperature, DO impairments | SWRCB | 2 | 2 | 3 | 2 | 3 | 2.4 | 1 | Reduction and delisting of waterbodies in the Clean Water Act Section 303(d) lists. The temperature and dissolved oxygen are comparable measurements across waterbodies and track overall aquatic health. | |

| Category | Outcome | Indicator | Metric | Source | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | Notes |
|------------------------------|--|--|--|--|-----------|--------------|------------------|----------|---------|---------------|---------------|--|
| | | | | | | | | | | | | |
| | Environmental water quality and biological condition | Stream condition index | CSCI score | SWRCB | 3 | 3 | 2 | 2 | 3 | 2.6 | 1 | The biological scoring tool is a proven method to translate direct surveys of key species and translate them into a measure of stream health. The current coverage and updated could be improved. It is a predictive index that has statewide applicability. |
| | Biological condition | Biodiversity values | Terrestrial and Aquatic Biodiversity Ranks | CDFW—Aquatic CDFW—Terrestrial | 2 | 2 | 3 | 3 | 3 | 2.6 | 1 | The terrestrial and aquatic Biodiversity ranks are the best available information on California's terrestrial and aquatic species biodiversity. Combines richness, rarity, and irreplaceability. Identify areas of highest biodiversity across the state, considering rare and endemic species. |
| | Environmental water quality and biological condition | Algal stream condition | ASCI Score | SWRCB , SMC , CEDEN | 3 | 3 | 2 | 2 | 3 | 2.6 | 1 | Algae is a direct link to water chemistry and nutrient stressors. ASCI is a predictive index that uses a consistent tool that can be applied across the state. It also features a large dataset that spans California ecoregions. Provides information complimentary to the CSCI score. |
| | | USFWS Designated Habitat | % of region with Designated Habitat (ESA) | USFWS | 2 | 2 | 3 | 2 | 3 | 2.4 | 1 | Recovery of threatened and endangered species and removal of critical habitat designation. The ECOS critical habitat on-line mapper includes (some, but not all) the proposed and final critical habitat for species listed as Threatened and Endangered by the UFWS, or that are jointly managed by USFWS/NMFS. |
| | | Rare and endemic fish species | Number of rare and endemic fish species | RePlan | 2 | 2 | 2 | 3 | 3 | 2.4 | 2 | |
| Water Quality | Drinking water quality | Public water systems not in compliance with drinking water standards | Populations affected by drinking water system violations by county | SWRCB | 3 | 1 | 3 | 3 | 3 | 2.6 | 1 | Direct water-related impact on people's health and well-being. |
| | | Water supplies derived from 303(d) impaired water bodies | Water supply volume | SWRCB , eWRIMS | 2 | 1 | 2 | 3 | 3 | 2.2 | 1 | The eWRIMS is a computer database developed by the SWRCB to track information on water rights in California. |
| Recreation and Cultural Uses | Amount of recreational benefits | River recreational uses | Boating use per day (during a specific time period) | CWP Watershed Resilience Assessment | 3 | 2 | 1 | 3 | 2 | 2.2 | 2 | Broad metric using observed river flows. |

| Category | Outcome | Indicator | Metric | Source | | | | | | | | Notes |
|------------|---|--|--|--|-----------|--------------|------------------|----------|---------|---------------|---------------|---|
| | | | | | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | |
| | | Lake recreational uses | Usable surficial lake area | CWP Watershed Resilience Assessment | 3 | 2 | 1 | 3 | 2 | 2.2 | 2 | Broad metric using observed lake water surface area. |
| | | Snow recreational uses | Number of days on snow in designated areas November through June | CWP Watershed Resilience Assessment | 3 | 2 | 1 | 3 | 2 | 2.2 | 2 | Broad metric using observed snow days. |
| | | Coastal recreational uses | Change in coastal recreational areas | CWP Watershed Resilience Assessment | 3 | 2 | 1 | 3 | 2 | 2.2 | 2 | Broad metric using mean sea levels |
| | Tribal Beneficial Uses (Tribal Tradition and Culture) | Placeholder for future measurement of TBUs by SWRCB | TBD | SWRCB | 3 | 0 | 0 | 0 | 0 | 0.6 | 2 | Data sets do not yet exist that map these uses of water by Tribes. SWRCB or other entities could possibly develop them in the future. |
| | Tribal Beneficial Uses (Tribal Subsistence Fishing) | Water quality of water bodies used for Subsistence Fishing | Impaired Water bodies within or adjacent to Tribal Lands | Intersection of Impaired Water Bodies Dataset and Digital Atlas of California Native Americans | 2 | 2 | 1 | 3 | 3 | 2.2 | 2 | Functions more as a water quality metric than a recreation and cultural uses metric |
| Hydropower | Hydropower energy productivity | Hydropower generation efficiency—large facilities | Average generation, lowest generation, and highest generation—annually OR over a multiyear period (large facilities > 30 MW) | CEC | 3 | 2 | 3 | 3 | 3 | 2.8 | 1 | Hydropower production varies yearly depending on rainfall and reservoir levels. |
| | | Hydropower generation efficiency—small facilities | Average generation, lowest generation, and highest generation—annually OR over a multiyear period (small facilities < 30 MW) | CEC | 3 | 2 | 3 | 3 | 3 | 2.8 | 1 | Hydropower production varies yearly depending on rainfall and reservoir levels. |
| Equity | CalEnviroScreen | 20 indicators across exposure, environmental effects, sensitivity, and socioeconomic factors | Multiple parameters | OEHHA | 3 | 3 | 3 | 3 | 3 | 3.0 | 1 | |

| Category | Outcome | Indicator | Metric | Source | | | | | | | | Notes |
|----------|--|---|---|---|-----------|--------------|------------------|----------|---------|---------------|---------------|--|
| | | | | | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier | |
| | Climate Change and Health Vulnerability Indicators | 19 indicators across environmental exposure, population sensitivity, and adaptive capacity (note: does not include flood) | Multiple parameters | CCHViz | 2 | 1 | 3 | 3 | 3 | 2.4 | 2 | While this index is substantial, it is also similar to CalEnviroScreen, the standard currently in use across State agencies therefore not recommended as Priority 1. |
| | DAC Mapping | Median income household income less than 80% of the statewide average | % of total population in DACs | DWR—DAC Mapping Tool | 3 | 3 | 3 | 3 | 3 | 3.0 | 1 | |
| | Delta Social Vulnerability Index | Delta vulnerability Index | Compound indicator of vulnerability | DSC—Delta Adapts | 2 | 2 | 1 | 1 | 3 | 1.8 | 2 | This is limited to the Delta and therefore not a Priority for the Statewide metrics for the Hub. Watersheds that include areas within the Delta may wish to include this data set for watershed specific analysis. |
| | Equitable Availability of Water Supply | Population Based Water Supply Indicators X Vulnerable Communities | Disproportionate effects of water supply impacts to vulnerable communities | OEHHA-Cal EnviroScreen DWR—DAC Mapping Tool And Tier 1 Water Supply Sources | 3 | 3 | 3 | 3 | 3 | 3 | 1 | Intersect selected vulnerable community demographic data with population-based water supply indicators and metrics. |
| | Equitable Risk of Flood | Tier 1 Population Based Flood Indicators X Vulnerable Community Indicators | Disproportionate effects of flood impacts to vulnerable communities | OEHHA DWR—DAC Mapping Tool And Tier 1 Flood Risk Sources | 3 | 3 | 3 | 3 | 3 | 3 | 1 | Intersect selected vulnerable community demographic data with population-based selected flood indicators and metrics. |
| | Access to Clean Water | Tier 1 Population based Water Quality Indicators X Vulnerable Community Indicators | Disproportionate effects of water quality impacts to vulnerable communities | OEHHA DWR—DAC Mapping Tool And Tier 1 Water Quality Sources | 3 | 3 | 3 | 3 | 3 | 3 | 1 | Intersect selected vulnerable community demographic data with population-based water quality indicators and metrics. |

| Category | Outcome | Indicator | Metric | Source | Notes | | | | | | |
|----------|--|--|---|---|-----------|--------------|------------------|----------|---------|---------------|---------------|
| | | | | | Relevance | Practicality | Update Frequency | Coverage | Quality | Overall Score | Priority Tier |
| | Availability of Groundwater | Tier 1 Population based Groundwater Indicators X Vulnerable Community Indicators | Disproportionate groundwater impacts to vulnerable communities | OEHHA DWR—DAC Mapping Tool And Tier 1 Groundwater Sources | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| | Recreational and Cultural Uses | Tier 1 Population Based Recreation Indicators X Vulnerable Community Indicators | Disproportionate recreation impacts on to vulnerable communities. | OEHHA DWR—DAC Mapping Tool And Tier 1 Recreation Sources | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| | Equitable Investments | Funding in Vulnerable Communities | Dollars granted for water resources projects in areas with majority vulnerable population | OEHHA DWR—DAC Mapping Tool Plus TBD Source on investments. | 3 | 2 | 0 | 0 | 0 | 1 | 2 |
| | Equitable Participation in decision-making | Community engagement designed to meet needs of vulnerable communities | Members of vulnerable communities participating in water resource project decision-making at the local, regional, and State level | OEHHA DWR—DAC Mapping Tool Plus, TBD Source on Participation in Decision Making | 3 | 2 | 0 | 0 | 0 | 1 | 2 |
| | Equitable Representation | Vulnerable community members represented on boards and in leadership positions | % of boards and leadership positions with water resources and project and funding decisions | OEHHA DWR—DAC Mapping Tool Plus, TBD Source on Equitable Representation | 3 | 2 | 0 | 0 | 0 | 1 | 2 |

Note:

< = less than.

> = greater than.

Ag = agricultural.

ASCI = Agal Stream Condition Index.

AWWA = American Water Works Association.

AWWA M36 = *M36 Water Audits and Loss Control Programs* (American Water Works Association 2015).

CBI = Conservation Biology Institute.

CCHViz = Climate Change and Health Vulnerability Index Visualization.

CDFW = California Department of Fish and Wildlife.

CEC = California Energy Commission.

CEDEN = California Environmental Data Exchange Network.

CEFF = California Environmental Flows Framework.

CoSMoS = Coastal Storm Modeling System.

CRAM = California Rapid Assessment Method.

CSCI = California Stream Condition Index.

CVP = Central Valley Project.

CWP = California Water Plan.

DAC = disadvantaged community.

DDW = Division of Drinking Water.

DHHS = US Department of Health and Human Services.

DO = dissolved oxygen.

DSC = Delta Stewardship Council.

DWR = California Department of Water Resources.

ECOS = Environmental Council of the States.

ESA = Endangered Species Act.

eWRIMS = Electronic Water Rights Information Management System.

FEMA = Federal Emergency Management Agency.

FRAP = Fire and Resource Assessment Program.

GAMA = Groundwater Ambient Monitoring and Assessment.

GPCD = gallon(s) per capita per day.

HIS = Indian Health Service.

Hub = Watershed Hub.

IPI = index of physical integrity.

LCMAP = Land Change Monitoring, Assessment and Projection.

LHMP = local hazard mitigation plan.

M&I = municipal and industrial.

mg/L = milligram(s) per liter.

MRLC = Multi-Resolution Land Characteristics Consortium.

MW = megawatt(s).

NC = natural communities.

NFHL = National Flood Hazard Layer.

NMFS = National Marine Fisheries Service.

OEHHA = California Office of Environmental Health Hazard Assessment.

PHAB = physical habitat.

PHS 9 = Public Health and Safety.

Reclamation = US Department of the Interior Bureau of Reclamation.

SDAC = severely disadvantaged community.

SFEI = San Francisco Estuary Institute.

SGMA = Sustainable Groundwater Management Act.

Southern California Coastal Water Research Project.

SWP = State Water Project.

SWRCB = State Water Resources Control Board.

TNC = The Nature Conservancy.

UC = University of California.

US = United States.

USFWS = US Fish and Wildlife Service.

USGS = US Geological Survey.

UWMP = urban water management plan.

WSCP = water shortage contingency plan.

Appendix B

Screenshots of Preliminary Watershed Hub Dashboard

Figure B-1 Draft Splash Screen of Watershed Hub

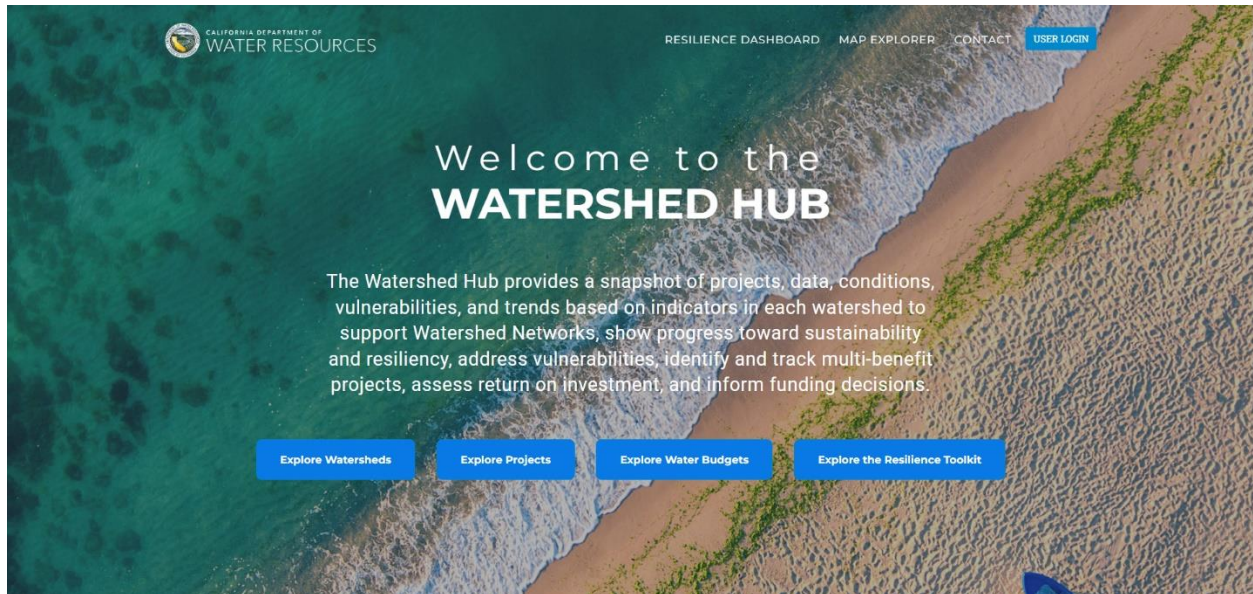


Figure B-2 Draft Map Explorer View Showing Water Resource Resilience Categories

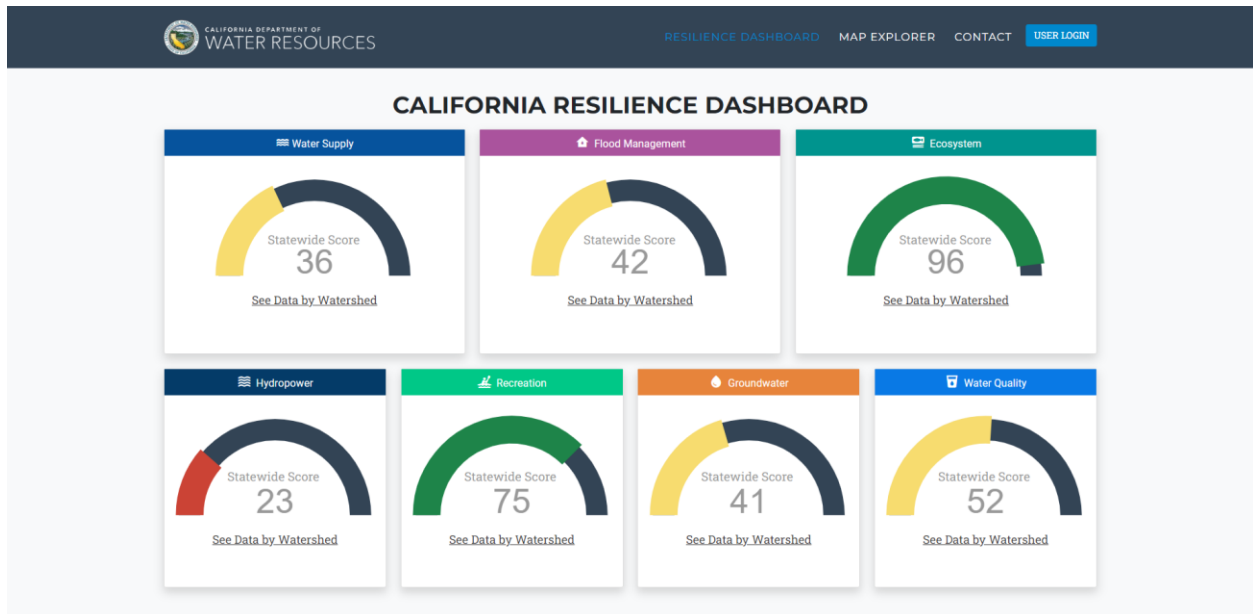


Figure B-3 Draft Map Explorer View Showing Flood Indicators

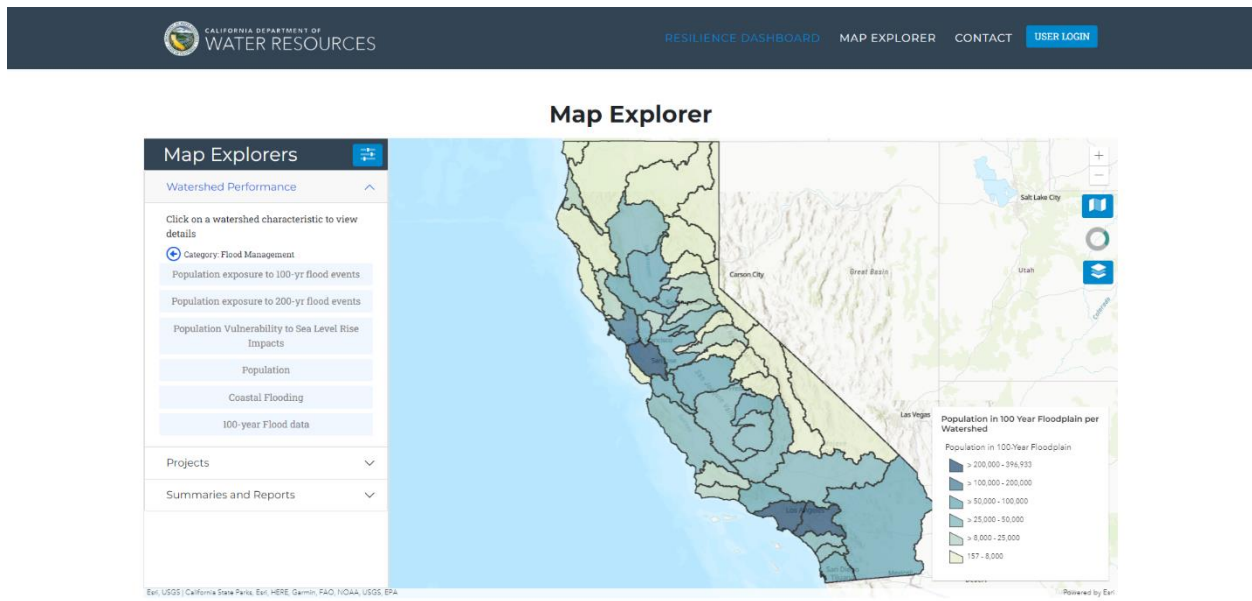


Figure B-4 Draft Watershed View Showing Flood Indicator and Equity Lens

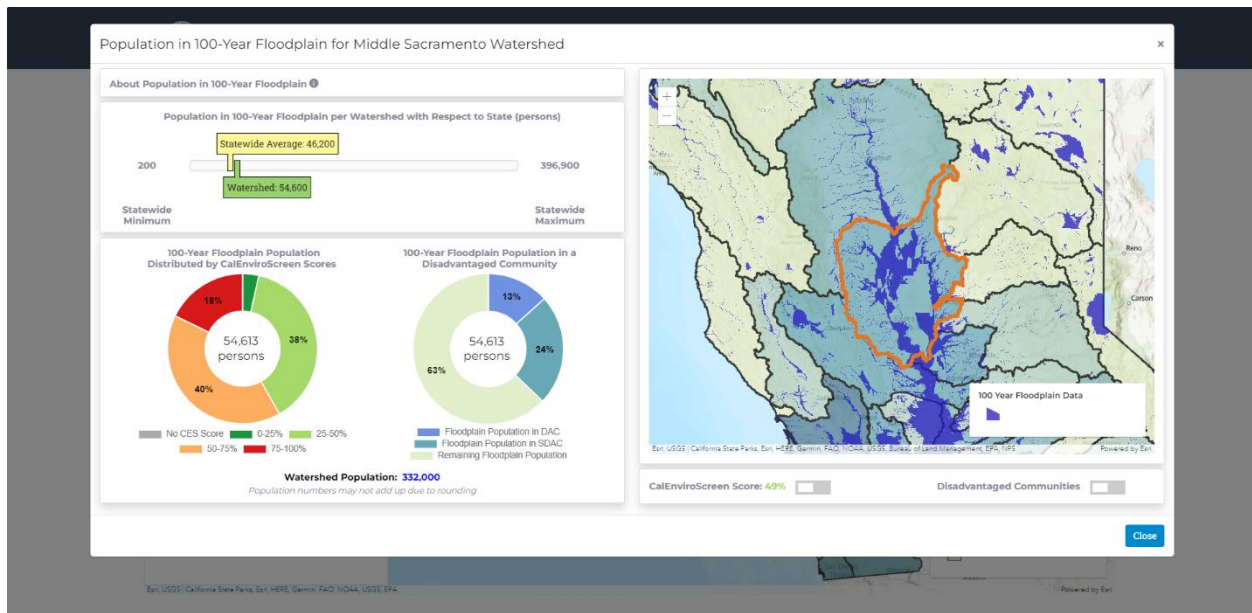


Figure B-5 Draft Statewide Summary of Flood Indicator and Equity Lens

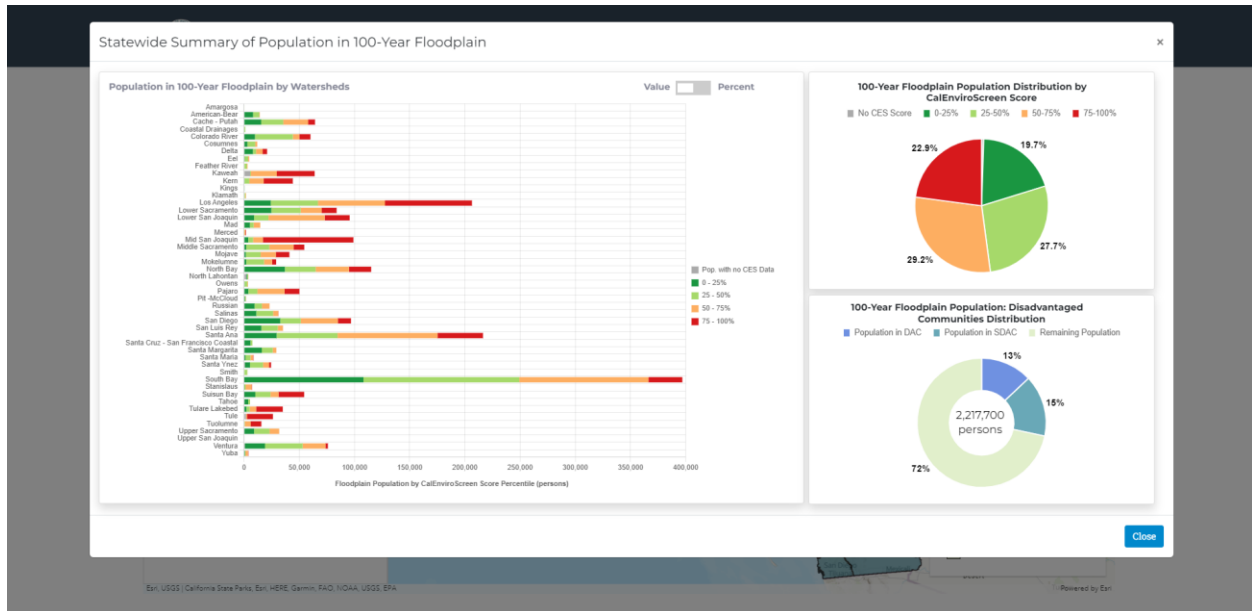


Figure B-6 Draft Map Explorer View Showing Ecosystem Indicators (Biodiversity)

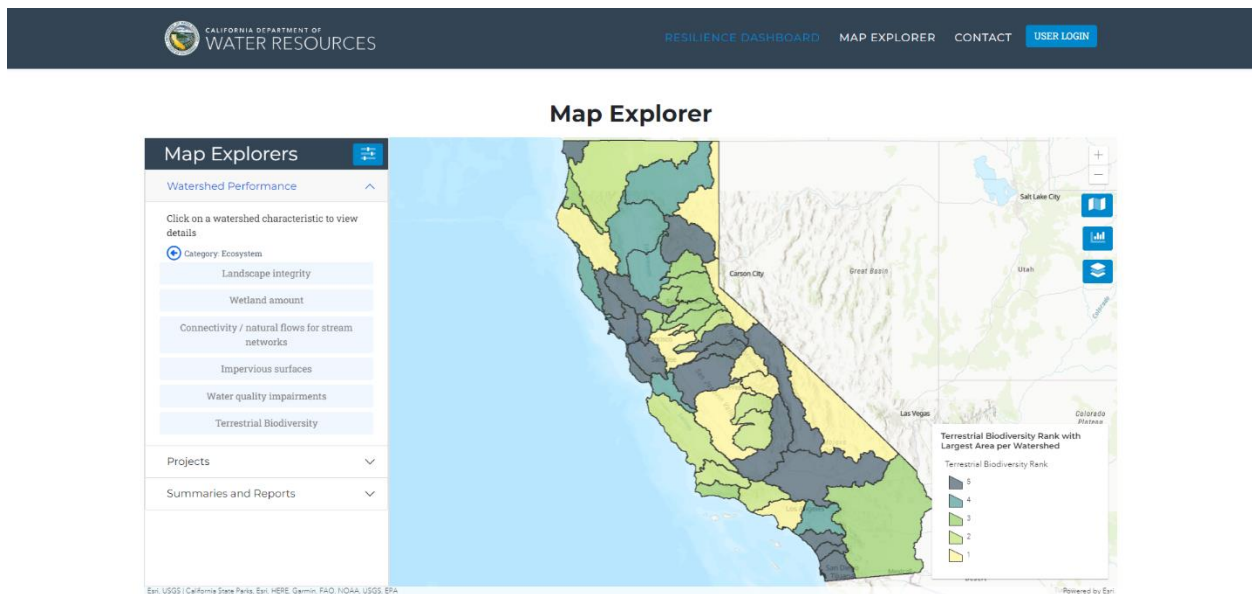


Figure B-7 Draft Watershed View of Ecosystem Indicators (Biodiversity)

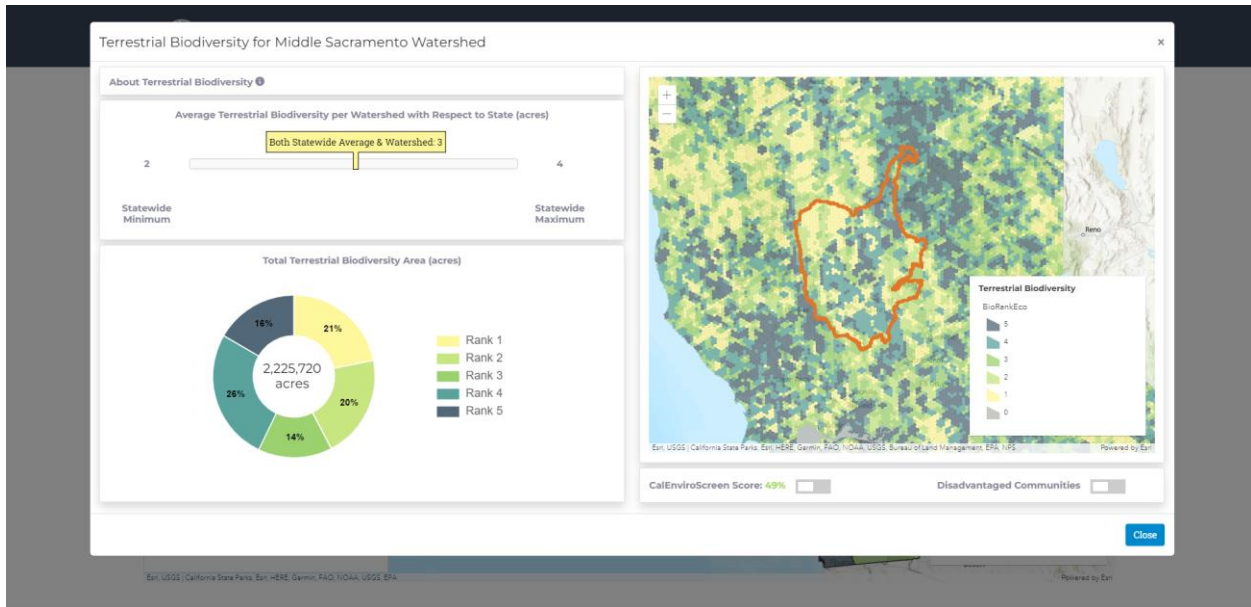


Figure B-8 Draft Statewide Summary of Ecosystem Indicator (Biodiversity)

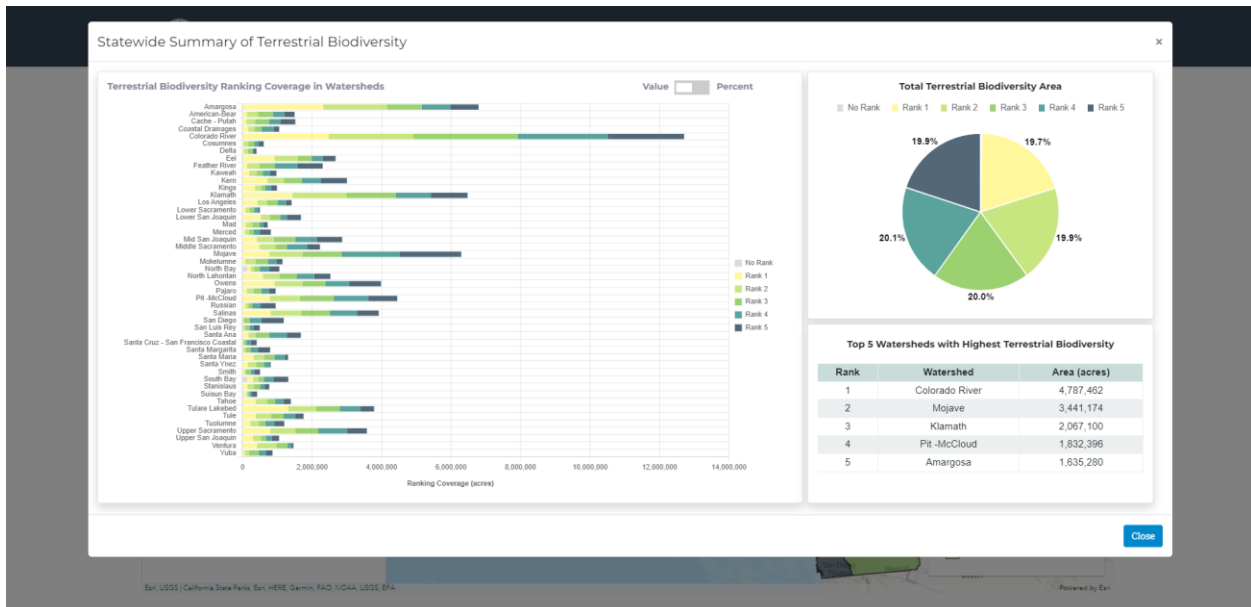


Figure B-9 Draft Map Explorer View Showing Ecosystem Indicators (Wetland Area)

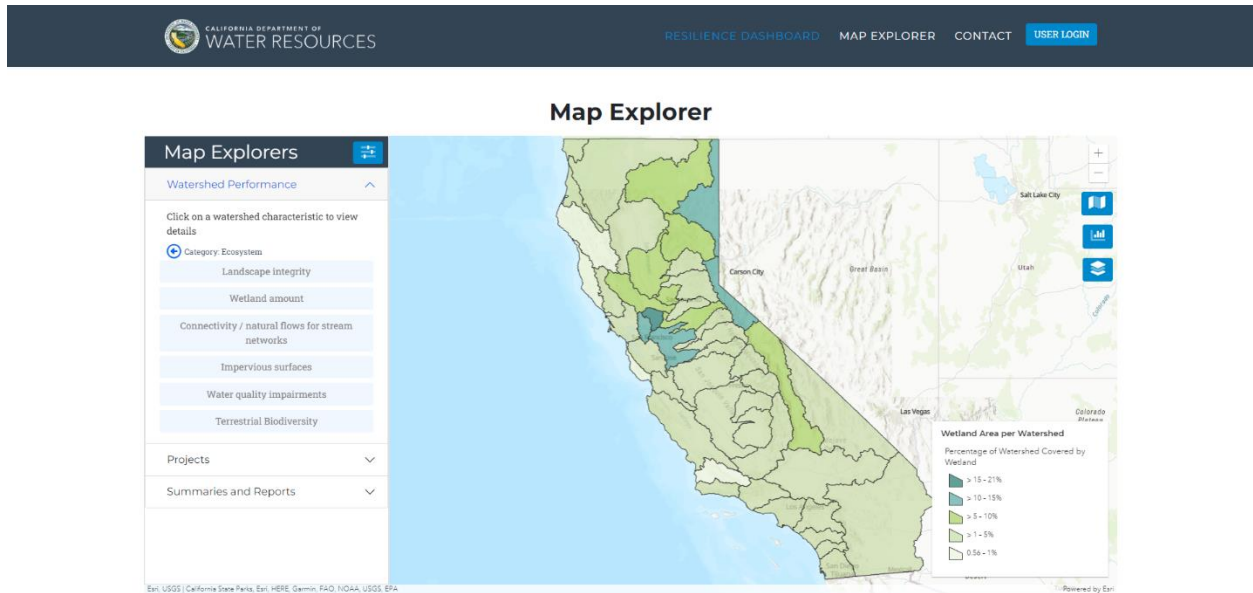


Figure B-10 Draft Watershed View Showing Ecosystem Indicators (Wetland Area)

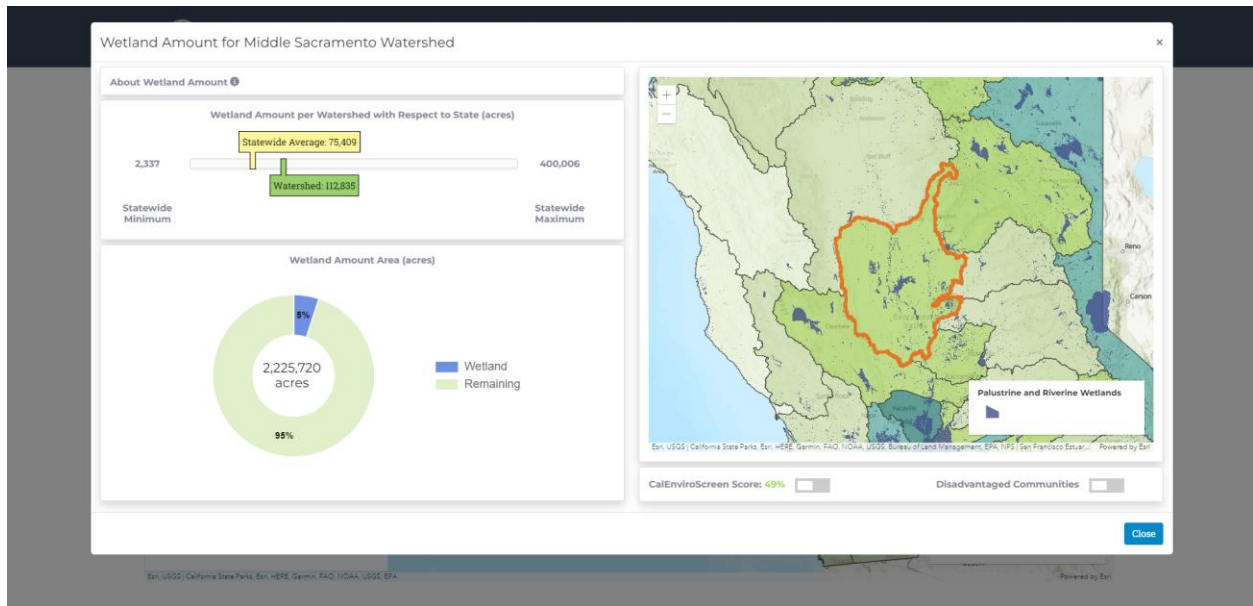


Figure B-11 Draft Statewide Summary of Wetland Areas by Watershed

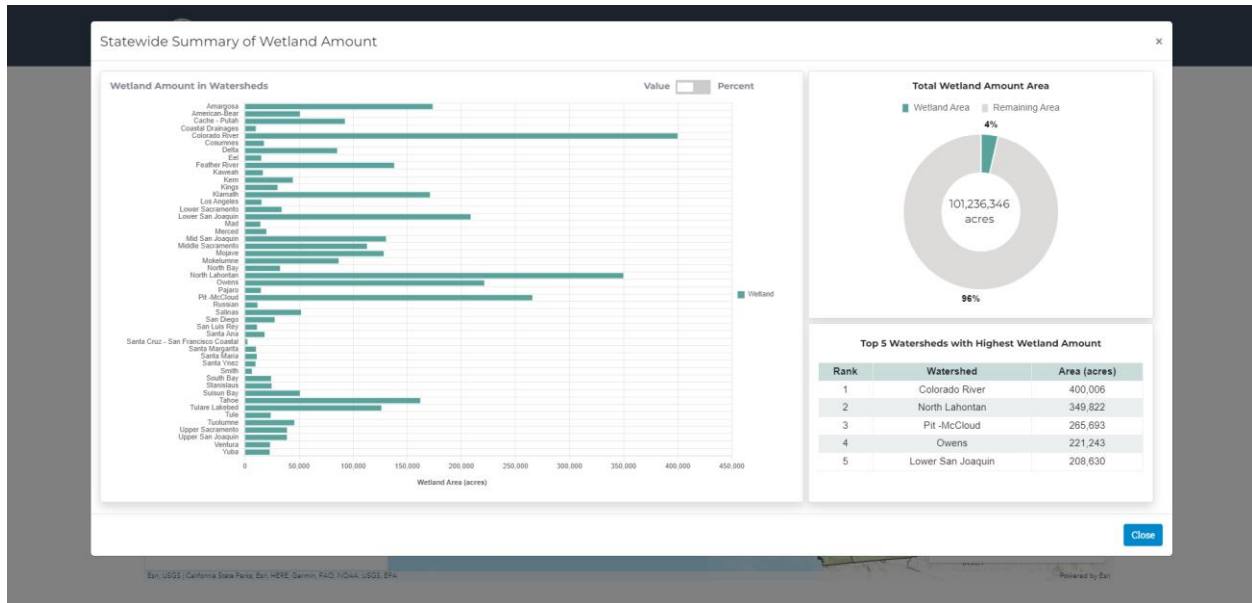


Figure B-12 Draft Map Explorer View Showing Water Quality Indicators (303d Streams)

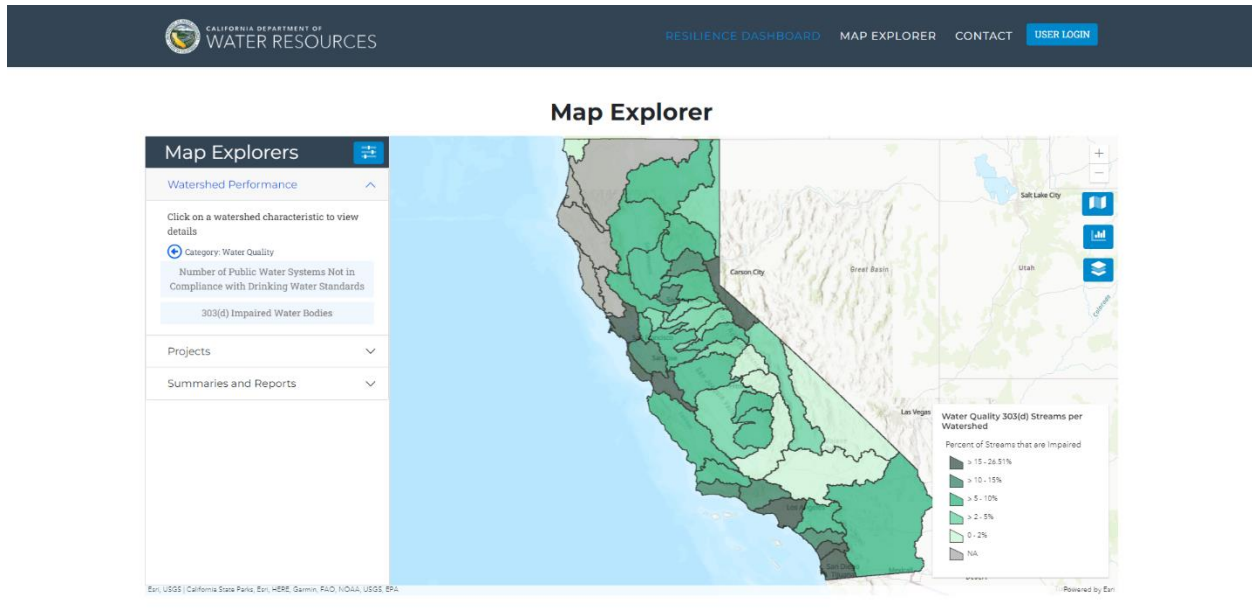


Figure B-13 Draft Watershed View Showing Water Quality Indicators (303d Streams)

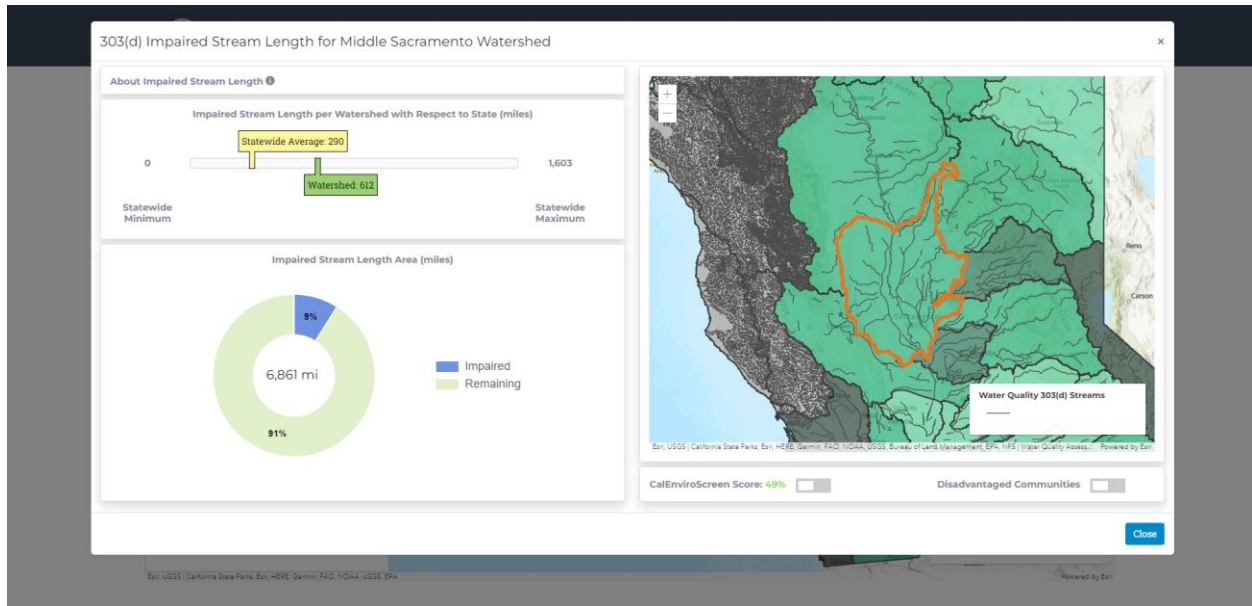


Figure B-14 Draft Statewide Summary of Impaired Stream Miles by Watershed

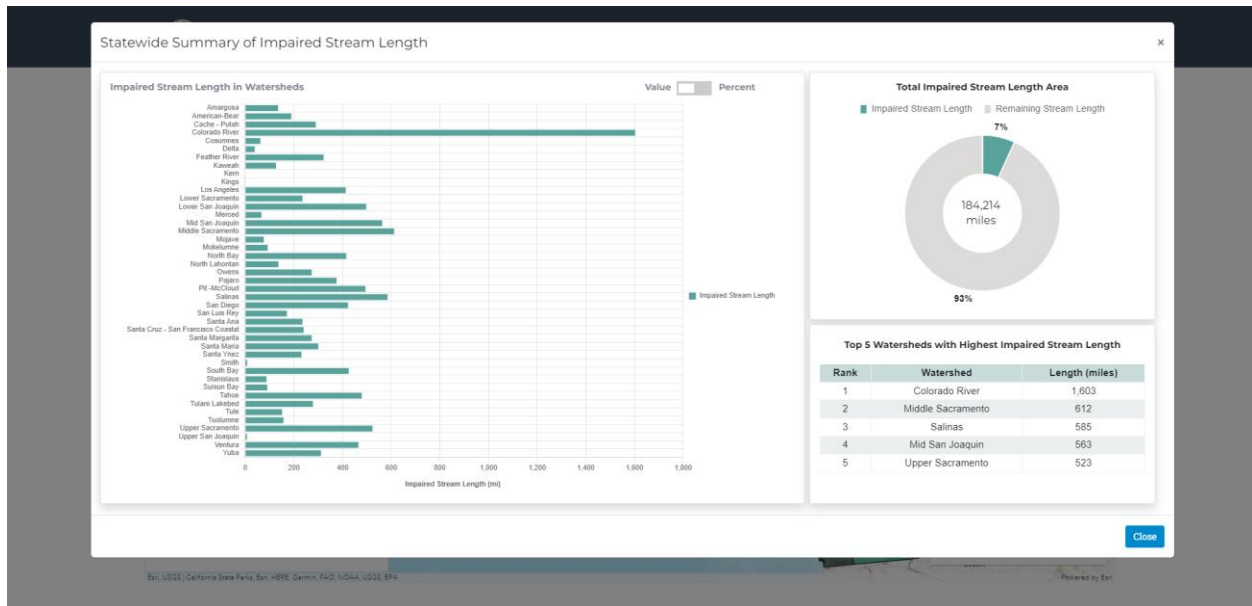


Figure B-15 Draft Map Explorer View Showing Equity Indicator (CalEnviroScreen)

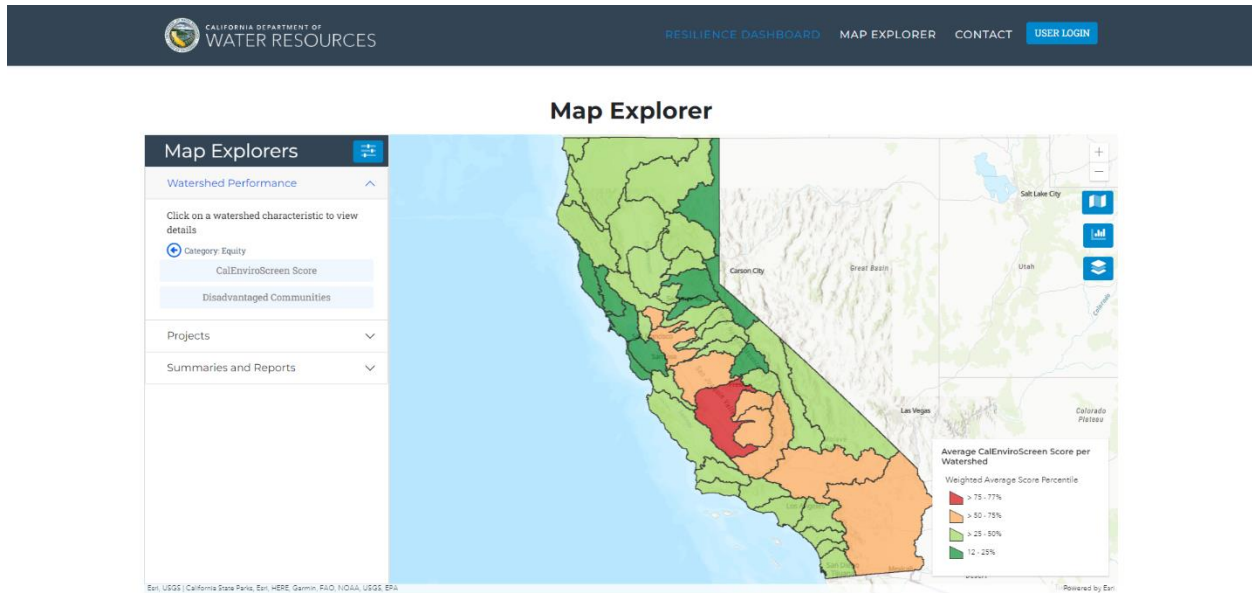


Figure B-16 Draft Watershed View Showing Equity Indicators (CalEnviroScreen)

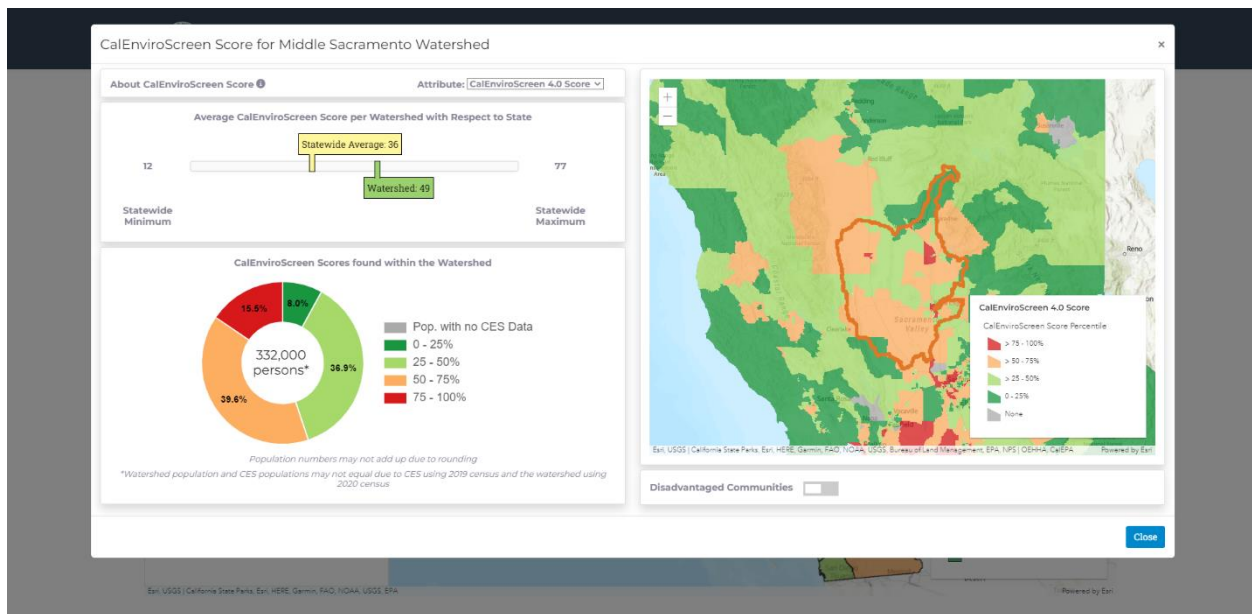


Figure B-17 Draft Statewide Summary of Equity Score (CalEnviroScreen) by Watershed

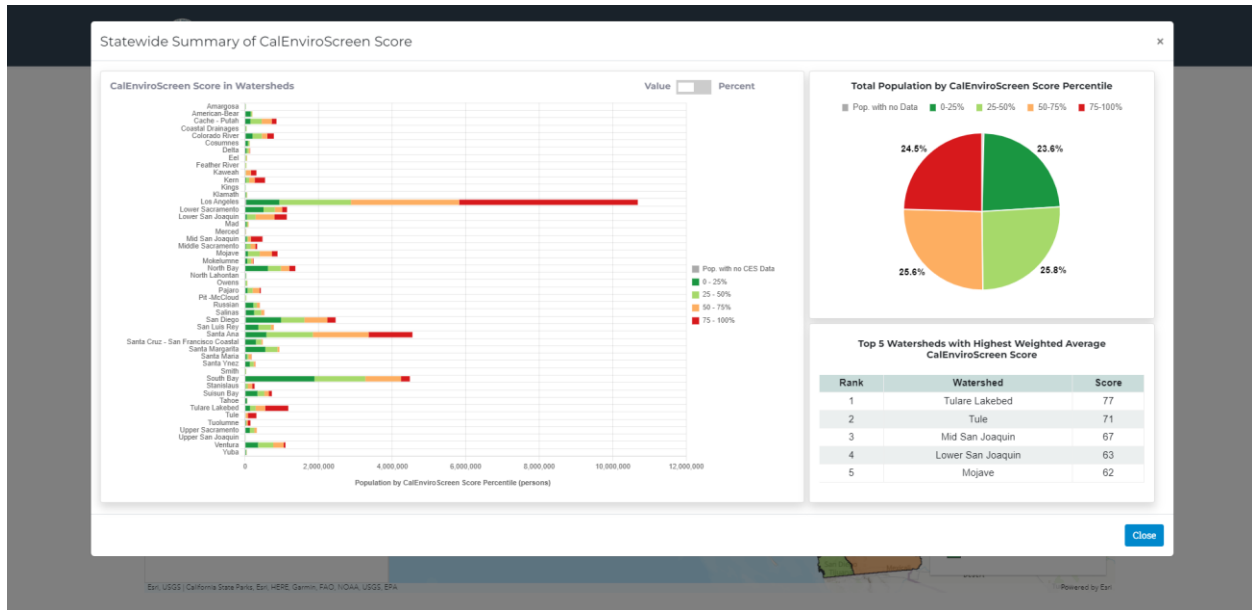


Figure B-18 Draft Map Explorer View Showing Equity Indicator (DAC)

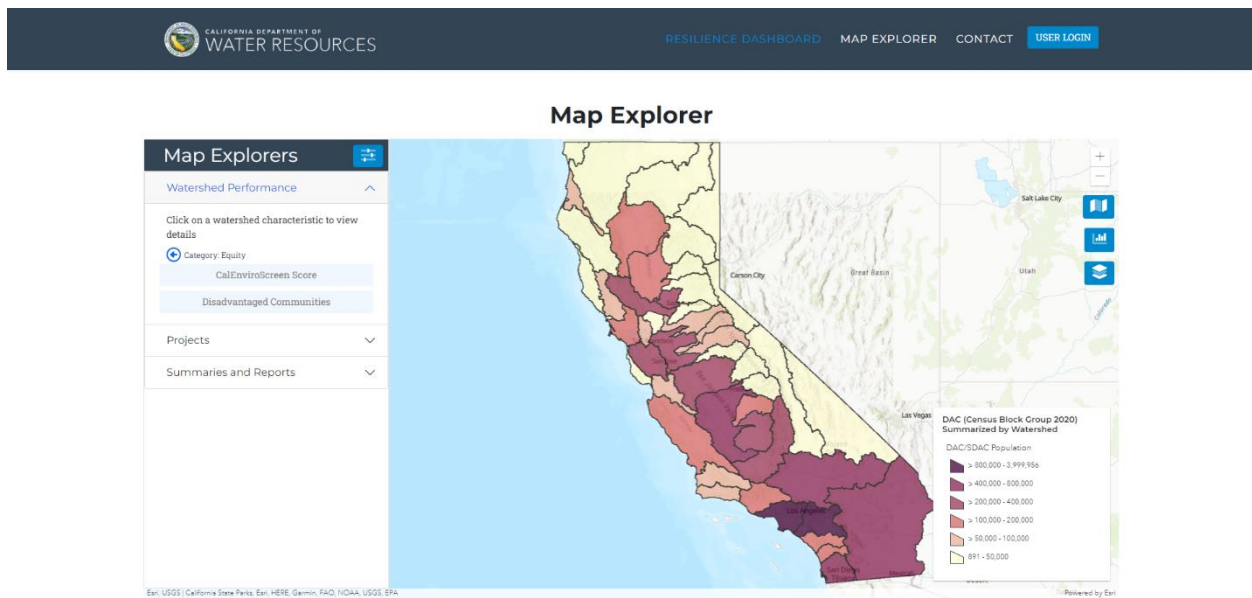


Figure B-19 Draft Watershed View Showing Equity Indicators (DAC)

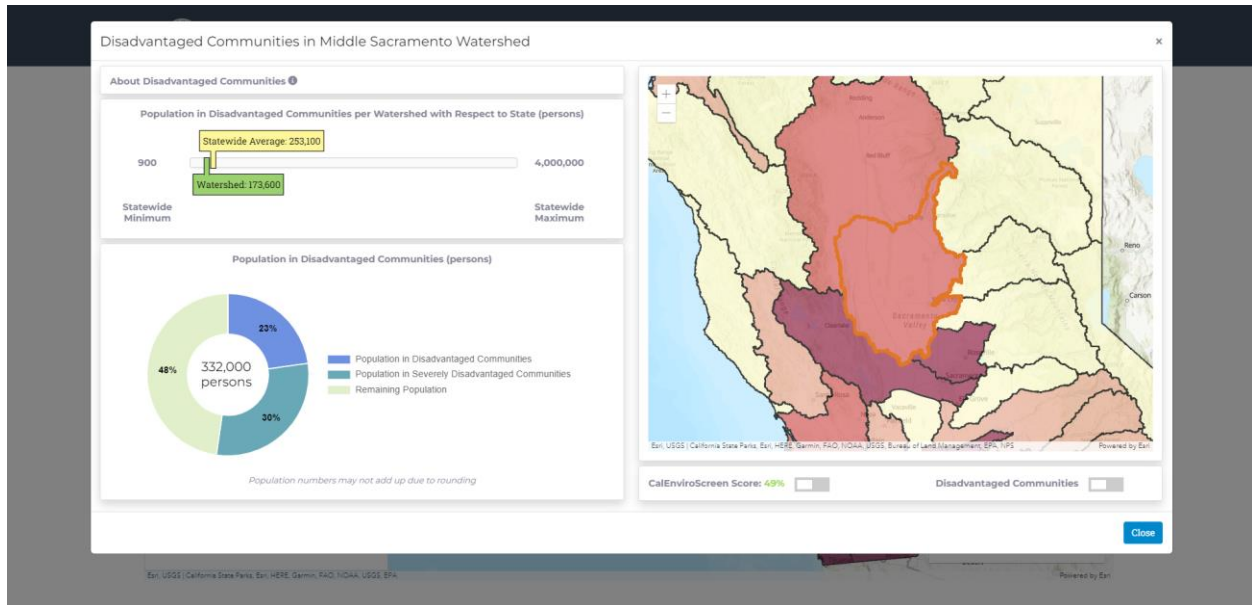


Figure B-20 Draft Statewide Summary of Equity Score (DAC) by Watershed

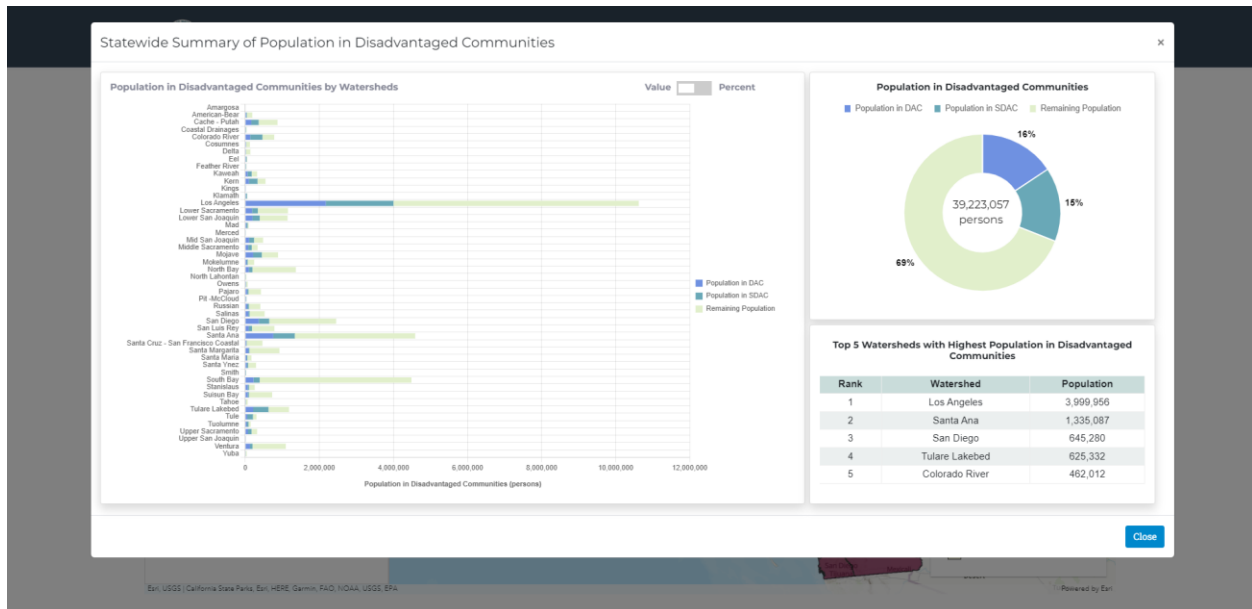


Figure B-21 Draft Map Explorer Showing Hydrological Regions



Figure B-22 Draft View of Regional Report (Central Coast)

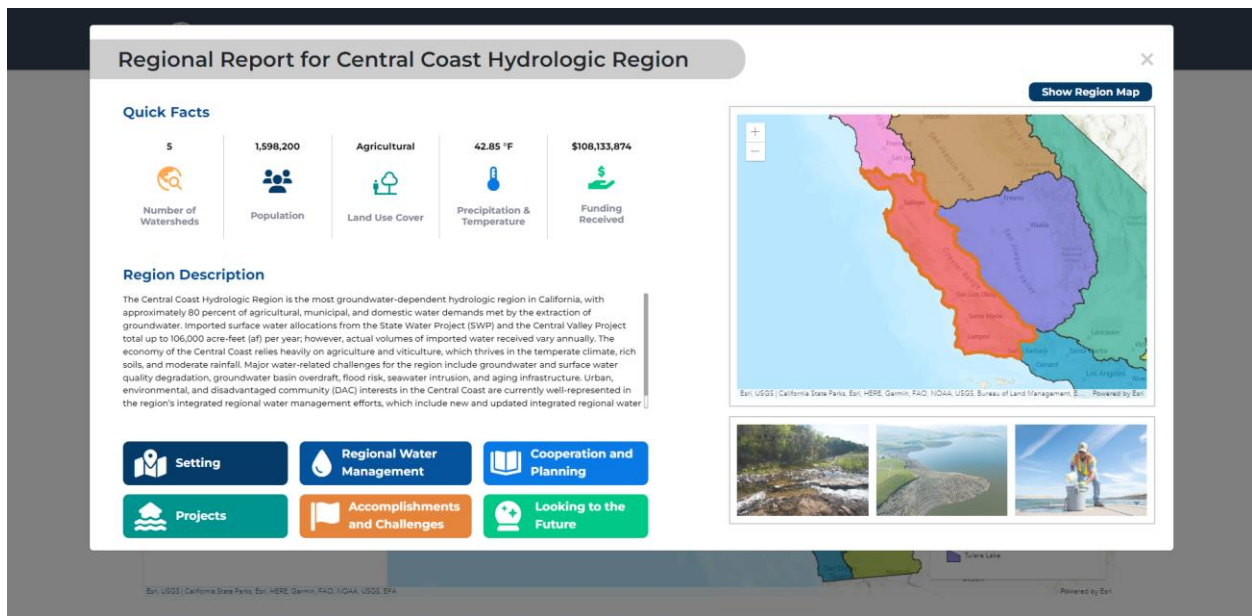


Figure B-23 Draft View of Regional Report Project Tracking (Central Coast)

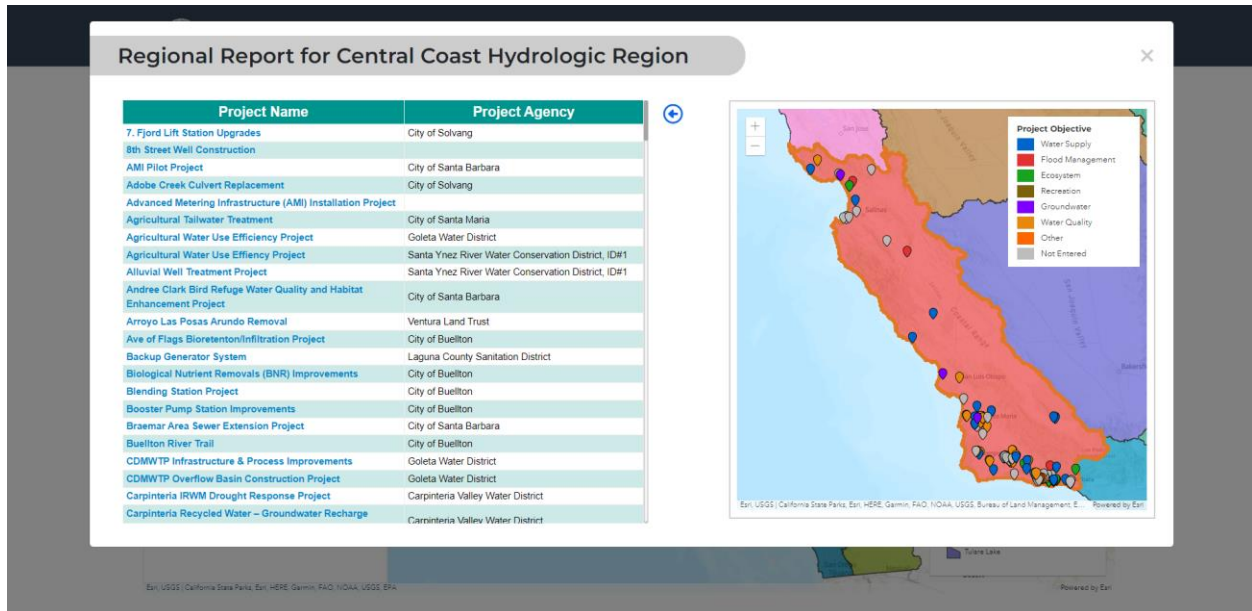


Figure B-24 Draft View of Selected Projects Overlain with Watershed Flood Risks

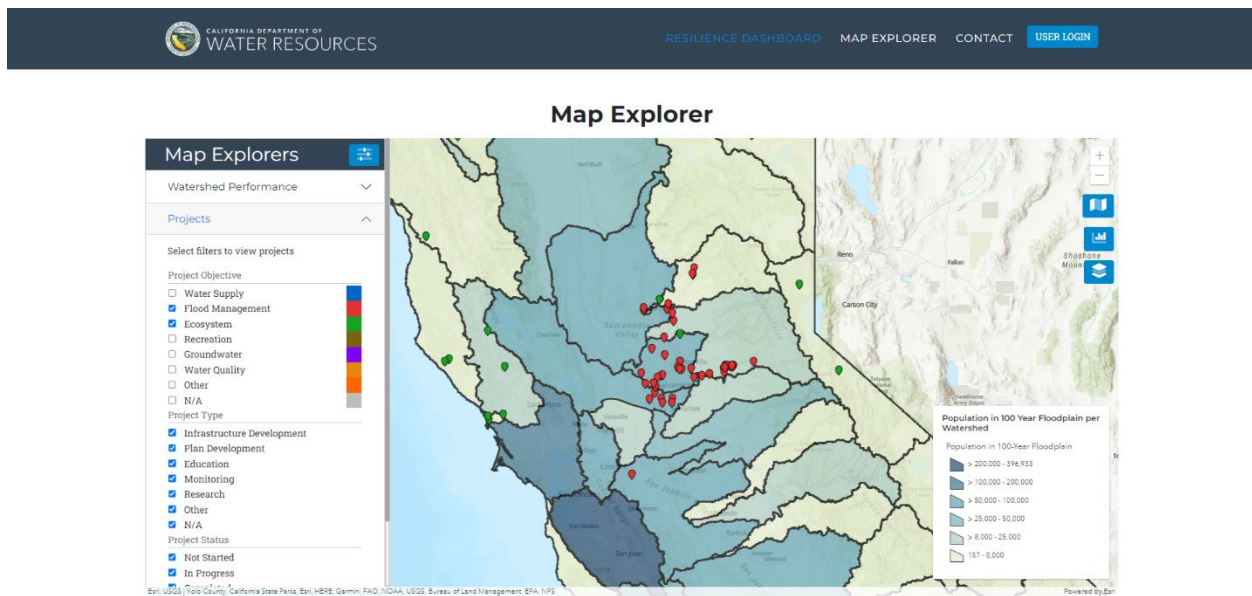


Figure B-25 Draft View of Project Report

Project Name: Upper Reach of Three Creeks Parkway Restoration Project

Contra Costa County Flood Control and Water Conservation District

Project Description

This project will widen approximately 1,600 linear feet of Marsh Creek in Brentwood from Dainty Avenue to its confluence from Deer Creek, part of an important ecological corridor linking Mount Diablo to the Delta Shoreline. Approximately 450 acres of developed land will be protected against a 100-year flood event. This project will reduce flood risks by excavating approximately 9,000 cubic yards (CY) of soil from the channel banks and creating a wider floodplain area. This widening will help achieve the following near-term outcomes: attenuate flood peaks and provide flood

Project Status: Completed
Project Cost: \$1,977,437

Location | **Gallery** | **Investments**
Contact | **Project Benefits** | **Status**
Expenditures

Map: A map of Brentwood, CA, showing the project location marked with a red pin. The map includes street names such as Little Tree Way, Knight, San Jose Ave, and Concord Ave. A legend on the right side of the map shows floodplain elevation ranges: 0-25,000, >25,000-50,000, >50,000-75,000, >75,000-100,000, and >100,000-125,000.

Appendix C

Relationship Between 2018 Sustainability Outlook and Indicators and Metrics Considered for Watershed Hub

Table C-1 shows the relationship between the Sustainability Outlook Indicators and recommended Tier 1 Hub Indicators and Metrics. For each of the Sustainability Outlook Indicators, the table indicates the following in relationship to the recommended Tier 1 Hub Indicators and Metrics:

- Yes – Metric included
- Yes (modified) – Similar or modified metric is included
- No – Metric not included

Table C-1 Relationship Between Sustainability Outlook Indicators and Tier 1 Hub Indicators and Metrics

| Societal Value | Intended Outcome | ID | Indicator | Category of Proposed CWP Resilience Indicator | Included as a Priority Indicator? |
|--------------------------|---|------|---|---|-----------------------------------|
| Public Health and Safety | A reliable water supply for domestic needs, sanitation, and fire suppression | PHS1 | Population and Percentage of Population with Reliable Domestic Water Supplies | Water Supply | Yes (modified) |
| | | PHS2 | Population and Percentage of Population without Access to Reliable Sanitation | Water Quality | No |
| | | PHS3 | Number of Public Water Systems Not in Compliance with Drinking Water Standards | Water Supply/Water Quality | Yes |
| | Reduced number of people exposed to waterborne health threats such as contaminants or infectious agents | PHS4 | Percentage of Beaches with Safe Coliform Bacteria Levels | Water Quality | No |
| | | PHS5 | Water Supplies Derived from Clean Water Act Section 303(d) Impaired Water Bodies | Water Supply/Water Quality | Yes |
| | | PHS6 | Potential for Consumption of Mercury-contaminated Fish | Water Quality | No |
| | | PHS7 | Population Served by Local Hazard Mitigation Plans, Emergency Response Plans, or Equivalent | Flood | No |
| | | PHS8 | Population Covered by Water Shortage Contingency Plans | Water Supply | Yes (Tier 2) |

| Societal Value | Intended Outcome | ID | Indicator | Category of Proposed CWP Resilience Indicator | Included as a Priority Indicator? |
|-----------------------|--|-----------|---|--|--|
| Ecosystem Vitality | Reduced loss of life, injuries and health risks caused from extreme hydrologic conditions, catastrophic events, and system failures (including infrastructure) | PHS9 | Urban Population without State-mandated Urban Level of Flood Protection | Flood | Yes (Tier 2) |
| | | PHS10 | Population in Floodplains with Equal to or Greater than a 1% Chance of Flooding in any Given Year | Flood | Yes |
| | Maintained and increased ecosystem and native species distributions in California while sustaining and enhancing species abundance and richness | EV1 | Native Fish Diversity Index | Eco | Yes (modified) |
| | | EV2 | Non-native Invasive Species Distribution and Status | Eco | No |
| | | EV3 | Acreage of Wetlands | Eco | Yes |
| | | EV4 | Degree of Aquatic Fragmentation | Eco | Yes (Modified) |
| | | EV5 | Impaired Water Bodies—by Hydrologic Region | Eco | Yes |
| | | EV6 | California Stream Condition Index | Eco | Yes |
| | | EV7 | Impaired Water Bodies—Count by Watershed | Water Quality | Yes |

| Societal Value | Intended Outcome | ID | Indicator | Category of Proposed CWP Resilience Indicator | Included as a Priority Indicator? |
|-----------------------|--|-----------|--|--|--|
| Healthy Economy | Achieved designated beneficial uses for waterbodies throughout the state | EV8 | Number of Harmful Algae Blooms | Water Quality | No |
| | | HE1 | Delivery Reliability of SWP, CVP, and Colorado River Aqueduct Systems | Water Supply | Yes |
| | | HE2 | Comparison of Actual Water use to Proposed Statewide Water Use Targets | Water Supply | Yes (modified) |
| | Reliable water supplies of suitable quality for a variety of productive uses, and productive water uses are based on a reliable supply | HE3 | Distribution System Leaks and Losses | Water Supply | Yes (Tier 2) |
| | | HE4 | Groundwater Basins with Stable or Recovering Groundwater Levels | Groundwater | Yes (modified) |
| | | HE5 | Groundwater Extraction Rates and Subsidence Rates | Groundwater | Yes (modified) |
| | | HE6 | Change in Groundwater Storage | Groundwater | Yes (modified) |
| | | HE7 | Percentage of Groundwater Basin Areas in Compliance with SGMA | Groundwater | No |
| | | HE8 | Contaminated Groundwater Wells | Groundwater | Yes |
| | | HE9 | Socioeconomic Vulnerability to sea-level rise Impacts | Flood | Yes (modified) |
| HE10 | Areas Covered by Local Coastal Program Vulnerability Assessments Updated for sea-level rise | Flood | No | | |

| Societal Value | Intended Outcome | ID | Indicator | Category of Proposed CWP Resilience Indicator | Included as a Priority Indicator? |
|-----------------------|--|-----------|--|--|--|
| | More benefits from economics activities, including from reduced costs to provide a given level of service (including transaction and permitting costs) Reduced likelihood or occurrence of significant social disruption following a disaster | HE11 | Regional Trend in Cost of Water for Municipal and Industrial, Agricultural, and Other Purposes; Cost Compared to State Average for these Same Supplies | Water Supply | Yes (modified) |
| | | HE12 | Volume of Water Transferred on the Open Market; Cost of Water on the Transfer Market | Water Supply | Yes (Tier 2) |
| | | HE13 | % of Average Annual Power Demand Satisfied by Hydropower | Hydropower | Yes (modified) |
| | | HE14 | Value of Assets within Floodplains with Equal to or Greater than a 1% Chance of Flooding in any Given Year | Flood | Yes |

| Societal Value | Intended Outcome | ID | Indicator | Category of Proposed CWP Resilience Indicator | Included as a Priority Indicator? |
|---|--|------|--|---|-----------------------------------|
| Opportunities for Enriching Experiences | Preserved or enhanced culturally or historically significant sites and communities, including continued and enhanced access to water and land used for sacred ceremonies or cultural practices | OEE1 | Number of Historically and Culturally Significant Sites at Risk of Flooding or sea-level rise | Flood/Recreation | No |
| | Preserved and increased natural areas with aesthetic or intrinsic value (including viewshed) | OEE2 | Change in Natural Area | Recreation | No |
| | Continued and enhanced access to resources that support education and learning | OEE3 | Number of School Districts Using Water and Environmental Curriculum in K through 12 Programs | Recreation | No |
| | | OEE4 | Number of Students Enrolled in Water and Environmental Resources Management Programs within the University of California and California State University Systems | Recreation | No |

| Societal Value | Intended Outcome | ID | Indicator | Category of Proposed CWP Resilience Indicator | Included as a Priority Indicator? |
|-----------------------|--|-----------|---|--|--|
| | Continued and enhanced recreational opportunities in waterways, reservoirs, or natural and open spaces | OEE5 | Number of Water Agencies that Have Educational Programs for Customers | Recreation | No |
| | | OEE6 | Change in Visitor Days at Water-related Park Lands | Recreation | No |

Note:

CVP = Central Valley Project

ID = identification

K through 12 = kindergarten through grade 12

sea-level rise = sea-level rise

SGMA = Sustainable Groundwater Management Act

SWP = State Water Project

