Interconnected Surface Water and Groundwater Dependent Ecosystems Workplan: Napa Valley Subbasin

FINAL DRAFT

MARCH 2024

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INTERCONNECTED SURFACE WATER AND GROUNDWATER DEPENDENT ECOSYSTEMS WORKPLAN: NAPA VALLEY SUBBASIN

PREPARED FOR

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The Napa County Groundwater Sustainability Technical Advisory Group (TAG) is made up of five experts who provide guidance on the implementation of the Groundwater Sustainability Plan. The TAG has provided input on the direction, scope, and breadth of this Workplan. The Napa County Groundwater Sustainability Agency appreciates the contributions of the five members listed below:

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ORGANIZATIONS

During GSP implementation and throughout the development of multiple Workplans (including this Workplan), many organizations and individuals provided valuable input. The Napa County Groundwater Sustainability Agency appreciates the contributions of the organizations listed below:

California Department of Fish and Wildlife (CDFW)
California Sustainable Winegrowing Alliance
Napa County Farm Bureau
Napa County Resource Conservation District
Napa County Flood Control District
Napa Green
Napa Valley Grapegrowers Association
Napa Valley Vintners Association
National Marine Fisheries Service (NMFS)
Save Napa Valley Foundation
University of California Davis – Center for Watershed Sciences
University of California Berkley Extension
Winegrowers of Napa County

On behalf of the Napa County Groundwater Sustainability Agency, thank you to all of the community members who participated in public meetings, information sessions, and various outreach events. Your input was vital to shaping this Workplan

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Acronym	Meaning
AFY	acre-feet per year
amsl	above mean sea level
C&E	communications and engagement
CCC	Central California Coast
CDFW	California Department of Fish and Wildlife
CEFF	California Environmental Flows Framework
CEFWG	California Environmental Flows Working Group
CESA	California Endangered Species Act
cfs	cubic feet per second
CNDDB	California Natural Diversity Database
CNPPA	California Native Plant Protection Act
CRPR	California Rare Plant Rank
DO	dissolved oxygen
DPS	distinct population segment
DWR	Department of Water Resources
eDNA	Environmental DNA
EHCM	ecohydrologic conceptual model
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Unit
ET	evapotranspiration
GDE	Groundwater Dependent Ecosystem
gpm	gallons per minute
GSA	Groundwater Sustainability Agency

Acronym	Meaning
GSP	Groundwater Sustainability Plan
GSPAC	Groundwater Sustainability Plan Advisory Committee
HRTW	Human Right to Water
HSC	Habitat Suitability Criteria
ISW	interconnected surface water
LSCE	Luhdorff & Scalmanini, Consulting Engineers
LWD	large woody debris
MST	Milliken-Sarco-Tulucay
NAIP	National Agriculture Imagery Program
FCWCD	Flood Control and Water Conservation District
NCGSA	Napa County Groundwater Sustainability Agency
NDMI	Normalized Difference Moisture Index
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NVIHM	Napa Valley Integrated Hydrologic Model
NWI	National Wetlands Inventory
OVOK	Oak View/Oak Knoll
RCD	Resource Conservation District
RE	relative elevation
SFEI	San Francisco Estuary Institute
SGMA	Sustainable Groundwater Management Act
SMC	Sustainable Management Criteria
Subbasin	Napa Valley Groundwater Subbasin
SWGW	Surface Water Groundwater
TAG	Technical Advisory Group
TDS	total dissolved solids
UC Davis	University of California, Davis
USGS	United States Geological Survey
VES	Visual Encounter Surveys
WY	Water Year

EXECUTIVE SUMMARY

The Napa Valley Subbasin Groundwater Sustainability Plan (GSP) was submitted January 31, 2022 and approved January 26, 2023 by the California Department of Water Resources. The Napa County Groundwater Sustainability Agency (NCGSA) is responsible for implementing the GSP to ensure that the Napa Valley Subbasin (Subbasin) achieves and maintains sustainable groundwater conditions. This includes developing a series of Projects and Management Actions for implementation within the Subbasin to achieve the sustainability goal:

- To protect and enhance groundwater quantity and quality for all beneficial uses and users of groundwater and interconnected surface water in the Napa Valley Subbasin both now and in the future.
- The NCGSA will implement sustainable management criteria and an adaptive management approach supported by the best available information and best available science, resulting in the absence of undesirable results within 20 years from GSP adoption.

The GSP established sustainable management criteria (SMC), including measurable objectives and minimum thresholds, for the depletion of interconnected surface water (ISW) conditions based on the best available information and science. However, the GSP recognized data gaps in the available information on groundwater-dependent ecosystems (GDEs) and the relationship between ISW conditions and GDEs (GSP Section 5.11). The proposed action to address these data gaps within the Subbasin included the creation of a workplan that would "…leverage existing plans and knowledge about Subbasin conditions to provide a structured approach to evaluating the effect of groundwater conditions on interconnected surface waters and GDEs. Potential activities incorporated into the work plan could include biological field assessments to provide detailed site information for evaluating the potential effects on GDEs, investigating stream habitat conditions, and evaluating the status of rare, threatened, or endangered species." This Workplan is designed to provide a plan for data collection and evaluation to address these existing data gaps related to ISW and GDEs.

To better understand and quantify existing and historical streamflow characteristics and how they relate to GDE health in the Napa Valley Subbasin, the Workplan incorporates many aspects of the California Environmental Flows Framework (CEFF) (California Environmental Flows Working Group 2021, Stein et al. 2021). The information gathered during the development of this Workplan will be used to refine the sustainable management criteria for the depletion of ISW in the Subbasin.

CEFF Implementation

CEFF is an approach which aims to provide water managers with environmental flow recommendations that balance human and ecological water needs. CEFF is being widely applied throughout California and is a systematic approach to assessing ecological flow requirements based on ecological management goals, considering unimpaired hydrology, targeted species, and changes to the watershed that may have altered the flow-habitat relationships.

The overarching goal of the ISW and GDE Workplan is to use physical and biological data coupled with hydrologic modeling of groundwater levels and ISW to better understand the conditions required to protect and enhance healthy terrestrial and aquatic GDEs. In particular, the Workplan describes the steps needed to understand conditions necessary to:

1. Protect steelhead (*O. mykiss*) spawning, rearing, and migration in the watershed;
2. Support special status aquatic species; and
3. Protect terrestrial GDEs and special-status species.

ES-1. Background

In accordance with GSP regulations, SMCs established in the GSP should be evaluated as part of updates to the GSP required every five years. This Workplan is designed to address data gaps regarding ISW and GDEs to inform the refinement of SMC for ISW in the Subbasin, which would initially occur as part of the GSP updates in 2027 and 2032. **Figure ES-1** provides an overview of the Workplan organization and the relationship between key efforts completed during preparation of the Workplan and future Workplan implementation steps. **Figure ES-1** also highlights CEFF elements that were completed as part of Workplan development and CEFF steps to be completed during Workplan implementation. To address ISW and GDE data gaps, the Workplan summarizes existing information assembled from ongoing monitoring and studies and uses the Napa Valley Integrated Hydrologic Model (NVIHM) and other data to describe the physical and ecological setting in the Subbasin (**Section 3; Figure ES-1)**. The ecologic, hydrologic, and other setting characteristics were used to prioritize 21 sites for more focused and intensive site characterization (**Section 4; Figure ES-1)**. The basin setting information provides the foundation for ecohydrologic conceptual models of the highest priority sites (**Section 5; Figure ES-1).** The ecohydrologic conceptual models identify key landscape features and characteristics at the six intensive monitoring sites and describe what is known about the hydrology, observed special-status species, environmental stressors, and known data gaps at these sites. Results of **Sections 3 through 5** address several of the steps in CEFF.

The implementation of the ISW and GDE Workplan will begin in 2024 and is described in **Section 6.** The implementation of the Workplan couples ongoing hydrologic and ecologic data collection within the Subbasin with new Subbasin-wide data collection efforts and site-specific data collection at the highest priority intensive monitoring sites. New monitoring and data collection at intensive monitoring sites will include biological and hydrological data to develop flow-ecology relationships for key species. Information developed as part of preparation of this Workplan and implementation of additional steps outlined in the Workplan will address data and analysis requirements to complete the remaining steps in CEFF Section A and B in 2024 and 2025.

The completion of CEFF Sections A and B and implementation of other aspects of the Workplan will be used to inform the process for reviewing and establishing SMCs in the Subbasin as part of periodic updates to the GSP.

Stakeholder outreach and feedback described in **Section 7** will occur throughout implementation of the Workplan.

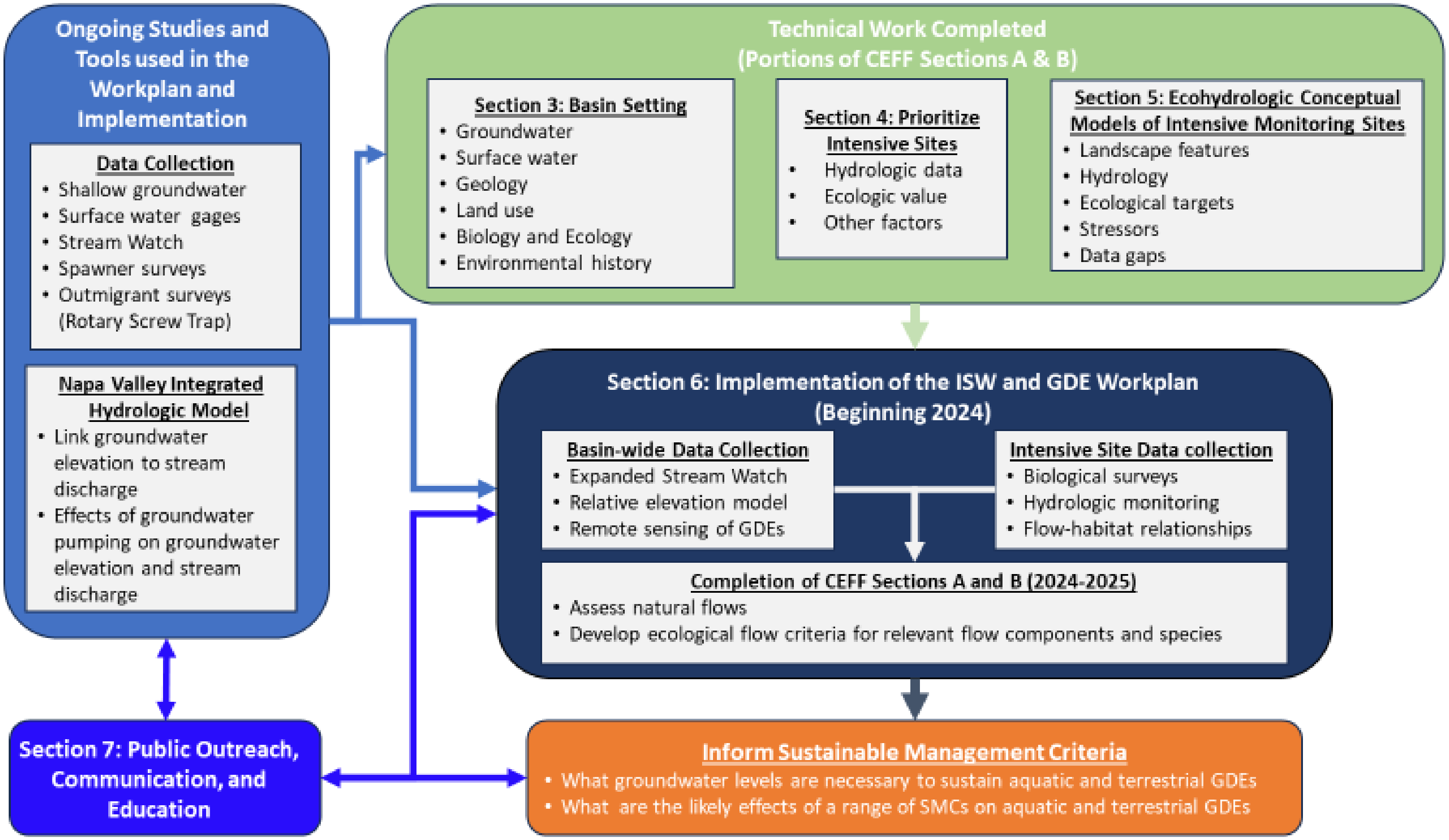


Figure ES-1. Overview of Workplan Approach

ES-2. California Environmental Flows Framework

To better understand the beneficial uses and users that may be impacted by depletions of ISW and refine and expand upon the SMC in the GSP, the CEFF process will be applied in the Subbasin. CEFF is a systematic approach to evaluating hydrologic and other environmental changes (e.g., river incision and sedimentation) and the effects of these changes on ecosystems within a watershed and is being widely applied throughout the state. CEFF is based on the concept of functional flows, which are components of the natural flow regime (i.e., expected flows in the absence of human activity similar to unimpaired flows) that support key ecological functions and ecological management goals. CEFF, however, acknowledges that other environmental changes, including changes to habitat, species distribution and temperature, may change the relationship between flows and habitats that naturally occur in the Subbasin. The CEFF process is divided into three sections, with 12 steps in total (**Source:** CEFWG 2021a, Figure ES-2).

CEFF Section A provides guidance for the development of ecological flow criteria using natural functional flows for the study area. CEFF identifies five components of the hydrograph that support key ecosystem functions (fall pulse flow, wet-season peak flows, wet-season baseflow, spring recession flow, and dry-season baseflow). CEFF Section B provides guidance for defining ecological flow criteria for functional flow components that may be impacted by non-flow alterations identified in Section A. Section B centers on the development of conceptual models, data compilation, and quantitative analyses to assess ecosystem responses to changes in these focal functional flow components, e.g., quantifying relationships between flow and habitat availability for relevant hydrograph components. CEFF Section C provides guidance on developing environmental flow recommendations and implementation strategies using stakeholder engagement. Sections A and B are incorporated into the ISW and GDEs Workplan, with Section C slated to be completed after the Workplan has been implemented.

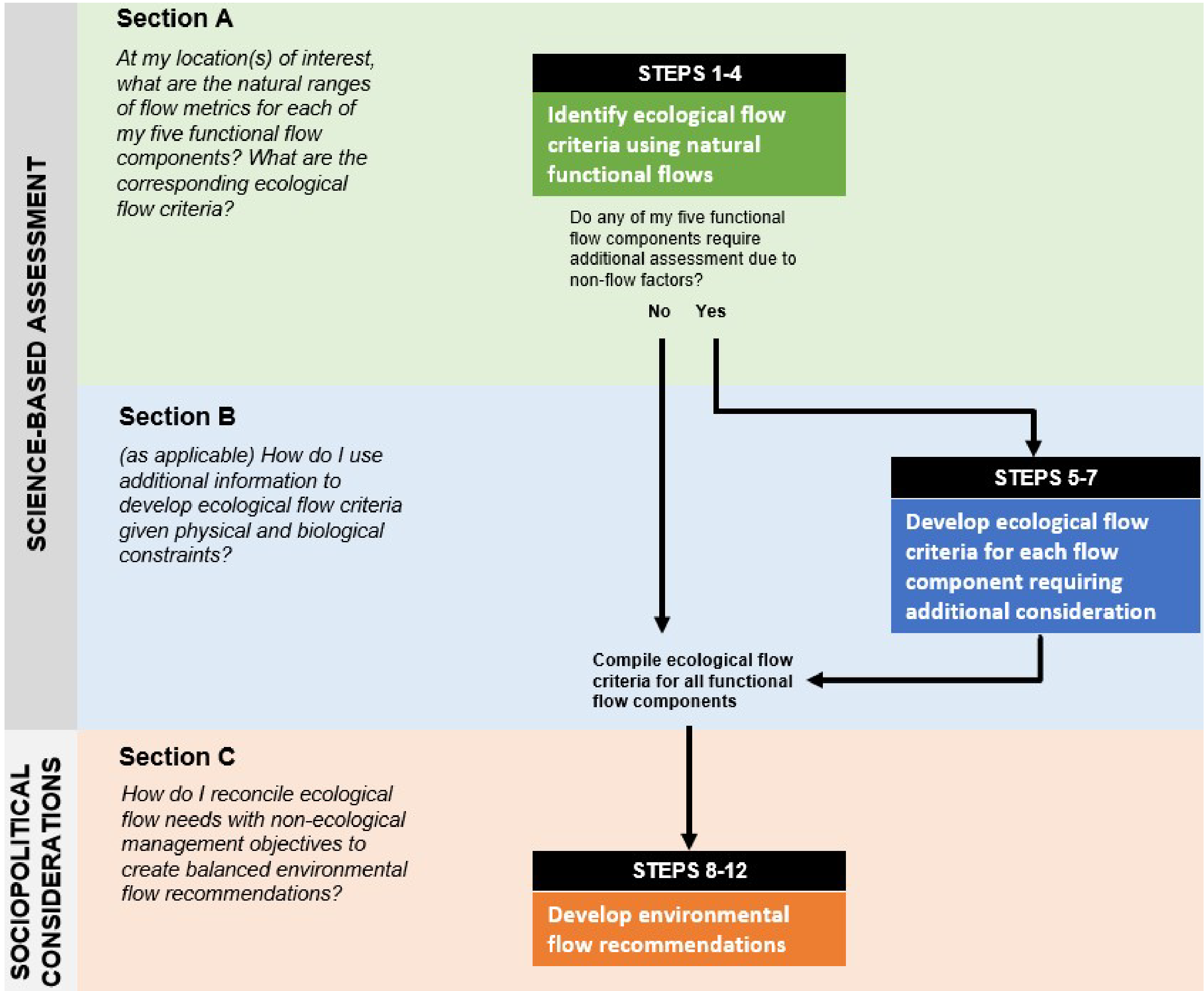


Figure ES-2. Overview of the California Environmental Flows Framework (from CEFWG, 2021a)

ES-3. Groundwater Dependent Ecosystems

GDEs in the Napa Valley Subbasin include natural communities associated with springs, riparian areas, and marshes, as well as aquatic communities that rely on interconnected surface water. Aquatic and terrestrial special-status species and terrestrial natural plant communities that are connected to groundwater through their roots are discussed below. The analyses in this Workplan assume that all streams and wetlands in the Subbasin are connected to groundwater at least some of the time. This assumption will be evaluated based on hydrologic data collected as part of the Workplan. Existing data were used to develop the monitoring recommendations described below (**Section ES 5**).

The mainstem Napa River provides approximately 29.8 miles of viable salmonid spawning habitat for Chinook salmon and steelhead (Napa RCD, 2016). Additionally, there are approximately 141 miles of tributary streams in the watershed that support salmonid spawning and freshwater rearing (Napa County RCD, 2016). Three special-status fish species (steelhead [*Oncorhynchus mykiss*], Pacific lamprey [*Lampetra tridentata, L. ayresi*], and longfin smelt [*Spirinchus thaleichthys*]) spawn and rear within the Napa Valley Subbasin. While not a listed species in the Napa Valley Subbasin, supporting Chinook salmon (*Oncorhynchus tshawytcha*) has been a long-term goal in Napa County, and numerous restoration and monitoring efforts support both Chinook salmon and steelhead.

Five special-status aquatic wildlife species were previously documented in the Napa Valley Subbasin; of these, four were identified as being likely to be associated with groundwater interconnected with surface water. These include one crustacean (California Freshwater Shrimp [*Syncaris pacifica*]), two amphibians (California giant salamander [*Dicamptodon ensatus*], foothill yellow-legged frog [*Rana boylii*]), and one reptile (northwestern pond turtle [Emys marmorata marmorata]). One amphibian species, the California Red-legged Frog [*Rana draytonii*]), historically occurred in the Subbasin but is currently extirpated (CDFW, 2023).

There were 12 vegetation communities identified as being likely associated with groundwater in the Napa Valley Subbasin. An additional eight vegetation communities were identified as possibly associated with groundwater. These vegetation communities are mostly affiliated with riparian areas along tributaries to the Napa River throughout the Subbasin.

Of the 37 special-status plant species documented previously in the Napa Valley Subbasin, two species were identified as being likely associated with groundwater, and an additional 13 species were identified as possibly associated with groundwater. These special-status plant species are mostly in the northernmost and southernmost ends of the Subbasin, near springs and the Napa River mainstem, respectively.

Six groundwater-dependent special-status terrestrial wildlife species were identified as likely occurring in the Subbasin, and three were identified as possibly occurring in the Subbasin. All nine were bird species indirectly dependent on groundwater (i.e., they occur in groundwater-dependent vegetation communities and/or used/fed on species that occur in ISW).

Taken together, these inventories of groundwater-dependent special status species demonstrate that the Napa Valley Subbasin supports a diverse range of aquatic and terrestrial species that rely on groundwater and interconnected surface water for at least part of their life history. Relationships between the health of these species and groundwater management in the Subbasin are not known and are the focus of the Workplan.

ES-4. Site Prioritization

A total of 21 sites were selected for evaluation based on the presence of special-status species, availability of hydrologic and ecological data, consideration of ecosystem characteristics, and spatial coverage and representation of the Subbasin (**Figure ES-3**). The 21 sites were then prioritized based on available hydrologic data, the ecological importance of the site, and other factors, including stream restoration, ongoing monitoring, and unique hydrologic characteristics (e.g., springs, tidal controls, etc.).

Hydrologic data were scored from zero to three points in accordance with the spatial coverage and amount of historical shallow groundwater and surface flow data. Ecological scores range from zero to six points based on the number of groundwater-dependent special-status species occurring near the site, the presence of salmonids, and the number of life stages that use the site (e.g., spawning and rearing versus just passage), and the presence of summer surface flow at the site. An additional priority point was assigned to sites with other important features, such as particularly important upstream habitat, stream restoration sites, or ongoing biological data collection that could be leveraged to assess GDE health or that are otherwise unique (i.e., tidal sections of the Napa River). Ecological importance scores had double the potential value of hydrologic scores because this Workplan is ultimately focused on sustaining ecology in the Napa Valley Subbasin. The results from the site prioritization are presented on **Figure ES-3**.

Based on the priority scoring, six sites (sites with scores of eight or greater) are recommended for further monitoring and characterization (**Figure ES-3**), hereby referred to as intensive monitoring sites. Five sites are located in the mainstem Napa River where the channel is generally perennial during normal water years (for the most part, tributaries are not perennial). These intensive monitoring sites include four ISW monitoring sites on the Napa River mainstem with dual completion monitoring wells installed in 2014 (Napa near Oak Knoll, Napa at Yountville, Napa at Napa, Napa near St. Helena), one site with the endangered California freshwater shrimp (Napa at Calistoga), and Sulphur Creek, which supports multiple life stages for steelhead and Chinook salmon and has foothill yellow-legged frogs.

Following methodology from The Nature Conservancy (Rhode et al., 2020), ecohydrologic conceptual models were developed for the six intensive monitoring sites (**Section 4**). The ecohydrologic conceptual models detail the known characteristics, including GDEs, surficial landscape features, groundwater and ISW dynamics, occurrence of listed species, known and likely stressors, preliminary assessment of streamflow depletion, and any data gaps.

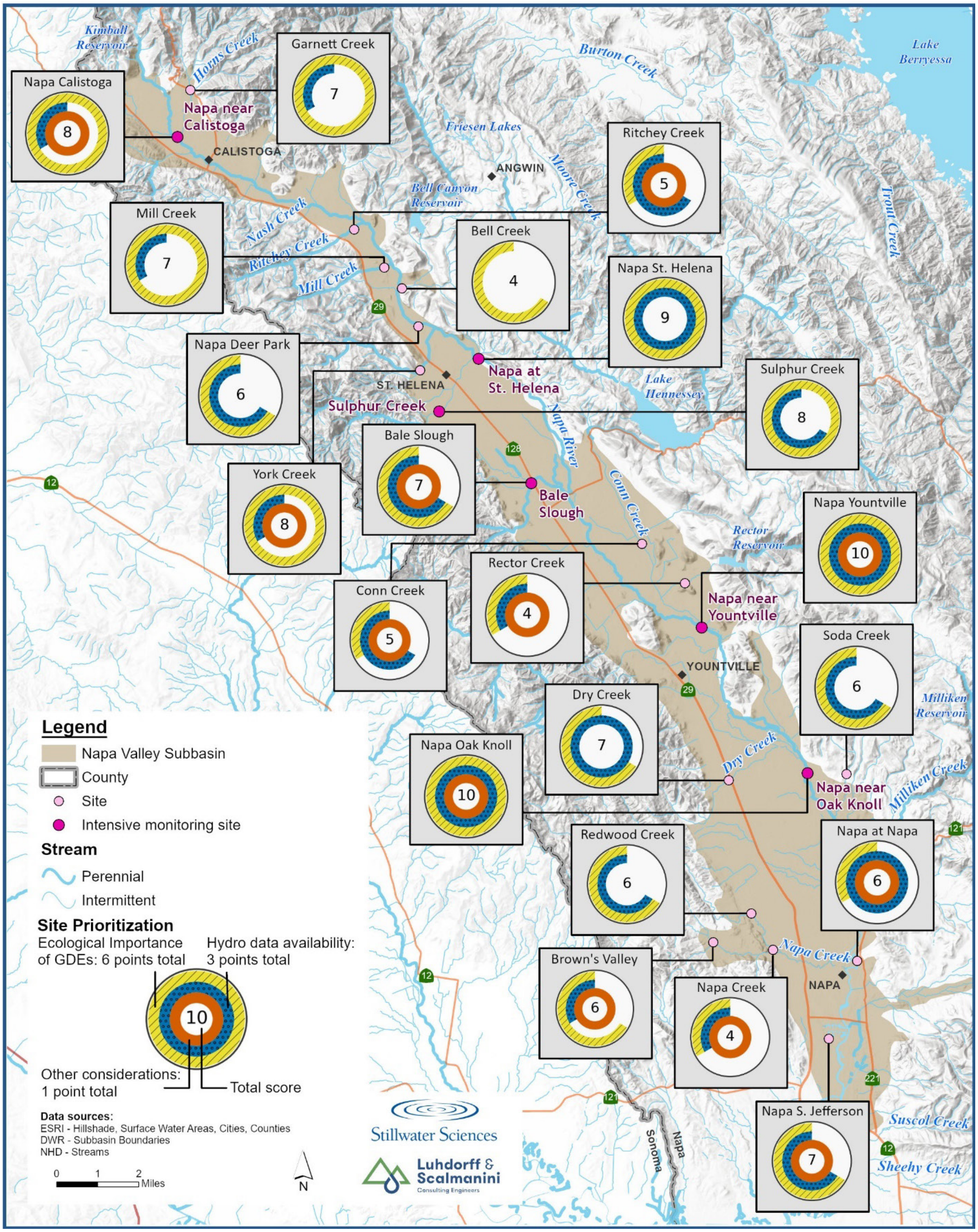


Figure ES-3. Site Prioritization for 21 Potential Study Sites in the Napa Valley Subbasin

ES-5. Workplan Implementation

Elements of the Workplan implementation include Subbasin-wide monitoring, intensive monitoring site data collection, and application of CEFF Section A and B. The Workplan includes implementation steps beginning in 2024 and outlined through 2030. Reports are scheduled for release annually with larger technical reports in 2026 and 2030 for inclusion in the 2027 and 2032 five-year GSP updates. Based on the initial results, specialized GDE-related monitoring may be modified or extended beyond 2030.

ES-5.1. Subbasin-Wide Monitoring

Data from existing ongoing monitoring by the NCGSA and other cooperating entities are key to supporting Workplan implementation. Ongoing Subbasin-wide monitoring and other GSP implementation efforts that will support the Workplan implementation include extensive groundwater monitoring by the NCGSA (including at existing ISW monitoring sites), qualitative observations of stream conditions through the Napa RCD Stream Watch program (**Section 3.2**), stream restoration monitoring, ongoing fish monitoring, including spawner surveys and outmigrant data from the rotary screw trap, and refinements to the NVIHM. Stream Watch is a unique volunteer-based program run by the Napa County RCD that tracks flow condition (flowing, isolated pools, and dry) at 39 active sites within the Subbasin. The groundwater monitoring includes five ISW monitoring sites installed in 2014 and at least eight additional ISW monitoring sites installed in 2023; these 13 sites provide a total of 26 monitoring wells for ISW monitoring.

Planned new and expanded Subbasin-wide monitoring includes using lidar data to map the elevation of riparian areas of the Subbasin relative to the nearby channel (relative elevation mapping), expansion of Stream Watch to include 20 additional sites, equipping high priority Stream Watch sites with additional monitoring technology, and remote sensing of GDEs. Relative elevation mapping was recommended by the TAG to assess the impact of channel incision on the stream network and to act as a proxy for shallow groundwater elevation. A subset of the expanded Stream Watch sites is proposed to be monitored using cameras and/or temperature monitoring.

ES-5.2. Intensive Monitoring Site Data Collection

Data collection at the six intensive monitoring sites will be used to assess the distribution of groundwater-dependent special-status species, develop linkages between flow and habitat or ecology, and extend these results to other parts of the Subbasin. Data to be collected at the intensive monitoring sites will include:

- Flow connectivity to assess connectivity within a reach, including up to four pools at five of the six sites and for the entire 1.5-mile reach of the Napa River at Calistoga that supports California freshwater shrimp. The connectivity surveys are intended to assess the degree to which Stream Watch observations can be extended over a longer reach and identify particularly sensitive reaches.
- Special-status fish habitat. Fish habitat will be assessed by mapping the distribution of habitat types within an intensive monitoring site with temperature and dissolved oxygen measurements.

- Fish occurrence in each reach will be assessed using methods appropriate to each site (e.g., electrofishing or snorkel surveys).
- Develop flow-discharge relationships for steelhead and other special-status species using hydraulic models coupled with site visits to assess the extent of suitable depth and velocity.
- The presence of special-status wildlife, including foothill yellow-legged frogs, northwestern pond turtles, and Pacific giant salamanders, during four site visits. The surveys will be a combination of visual encounter surveys and environmental DNA (eDNA) sampling. Water samples for eDNA can be used to assess the presence of species within 100 meters of the sample location. Combined visual encounter surveys and eDNA sample collection will occur during the initial survey in spring, with three additional visual encounter surveys during sampled years. Where habitat requirements are known, similar methods to those used for fish will be employed to determine habitat-flow relationships.
- Assessment of vegetation communities. The extent, composition, and vigor (i.e., health) of vegetation communities that make up the GDEs at each site will be monitored at plots, transects, and along the boundaries of the vegetation community. The presence and distribution of non-native species will be noted during the surveys. The surveys of vigor can be used to test whether remote sensing analyses used in the Subbasin-wide surveys are able to detect changes in the health of GDEs.
- Special-status plants will be assessed along transects at each site. The groundwater dependence of special-status species will be assessed using the literature, including the water source and habitat characteristics of the species.
- Special-status terrestrial wildlife species will be assessed in up to four surveys in combination with a deployed audio recording device at each site.

ES-5.3. Applications to CEFF

The steps described under CEFF Sections A and B will be completed for the six intensive monitoring sites during the first two years of Workplan implementation. The correspondence between the Workplan and CEFF is shown in **Table ES-1**. Some CEFF steps were completed as part of Workplan development, including site prioritization, describing the physical and ecological setting of each site, and the environmental history and history of landscape changes. Other CEFF steps are planned as part of Workplan implementation, including defining ecological management goals, assessing ecosystem function relative to the goals, assessing functional flow metrics at each intensive monitoring site, developing detailed conceptual models relating functional flow metrics to ecological management goals, quantifying flow-ecology relationships, and defining ecological flow criteria for functional flow components.

Table ES-1. Summary of CEFF Steps and Application of Workplan for CEFF Sections A and B		
Step	**Workplan Component**	**Schedule/Notes**
Section A: Identify ecological flow criteria using natural functional flows.		
Step 1: Define ecological management goals and locations of interest.	Ecological management goals (Section 1)	Goals will be refined during Workplan implementation
	Site prioritization (Section 4)	Completed
	Assess ecosystem functions relative to ecological management goals	To be completed Spring 2024
Step 2: Obtain natural ranges of flow metrics for five functional flow components.	Assess functional flow metrics using NVIHM and the Natural Flows Database (CEFWG, 2021b). Section 6	To be completed in 2024
Step 3: Evaluate if non-flow factors may affect the ability of natural ranges of functional flow metrics to achieve ecological management goals.	Physical and ecological setting	Completed
	Environmental history and landscape alteration (Section 5)	Completed
Step 4: Select ecological flow criteria for functional flow components not affected by non-flow factors.	Described in Section 6	To be completed after Workplan adoption
Section B: Develop ecological flow criteria for each flow component affected by non-flow factors.		
Step 5: Develop detailed conceptual model relating functional flow components to ecological management goals.	Described in Section 4	To be completed after Workplan adoption. Refined and updated as additional data are collected during Workplan implementation.
Step 6: Quantify flow-ecology relationships.	Special-status fish and aquatic wildlife (Sections 6)	
Step 7: Define ecological flow criteria for focal functional flow components.	Described in Section 6	

ES-5.4. Evaluation of Habitat Needs

CEFF Sections A and B, as well as the remainder of the Workplan steps outlined in **Table ES-1**, will be used to develop flow and groundwater elevation requirements for GDEs, including special-status species. These requirements will then be used to inform any reevaluation or development of SMCs at the intensive monitoring sites. The data from the intensive monitoring sites can then be extended to the Subbasin as a whole to identify potential areas where GDEs occur, but their habitat requirements are not being met.

ES-6. Schedule

The monitoring program outlined in this Workplan will begin in 2024 (following Workplan adoption) and continue through 2030 (**Table ES-2**). The frequency and timing of individual studies at intensive monitoring sites are summarized in **Section 6.3**. Surveys for terrestrial plants, wildlife, and GDEs will occur in 2024, 2025, and 2030 (indicated by an M in **Table ES-2**) and occur on an as-needed basis in other years (due to drought or floods). Some spring 2024 surveys may be postponed until spring 2025 depending on the timing of acceptance of the GSP (expected late March 2024) and the need for sufficient time to plan the surveys. Some elements of the monitoring program are anticipated to continue after 2030, but the approach and frequency will be evaluated in the 2030 Technical Report.

Data gathered during each year will be summarized in a technical memorandum to support the GSP Annual Reports. These memoranda will summarize the monitoring results and indicate any circumstances for consideration, such as site access or drought. More detailed technical reports will be prepared in 2026 and 2031(**Table ES-2**) for incorporation in GSP updates planned for 2027 and 2032.

Table ES-2. Monitoring Schedule for 2024 through 2031

Survey		2024	2025	2026	2027	2028	2029	2030	2031
Subbasin-wide monitoring	Terrestrial GDE remote sensing	Annual Assessments							
	Shallow groundwater wells	Continuous							
	Stream Watch (RCD)	Continuous							
Intensive site monitoring	Flow connectivity survey	M	M	M	M	M	M	M	M
	Natural community field surveys	M	M	AN	AN	AN	AN	M	AN
	Special-status plants	M	M	AN	AN	AN	AN	M	AN
	Terrestrial wildlife	M	M	AN	AN	AN	AN	M	AN
	Aquatic wildlife	M	M	AN	AN	AN	AN	M	AN
	Fish population	M	M	M	M	M	M	M	M
	Additional CEFF part A and B tasks	M	M						
ISW and GDE Reporting	Annual Technical Memo	TM	TM	TM	TM	TM	TM	TM	
	5-year update Technical Report			TR					TR
GSP Reporting	GSP Annual Report	AR	AR	AR	AR	AR	AR	AR	
	GSP Five-year Update				GSP				

<u>M</u> indicates the years where monitoring will be implemented.
<u>AN</u> indicates years where monitoring may occur on an as-needed basis.
<u>TM</u> indicates a technical memorandum deliverable summarizing the annual results of the ISW GDE surveys.
<u>TR</u> indicates technical report deliverables.
<u>AR</u> indicates GSP Annual Report submittal.
<u>GSP</u> indicates a five-year GSP Update submittal.

ES-7 Public Outreach and Education

The education and outreach component of the Workplan identifies options to accelerate and increase knowledge related to the river system and ecosystems in the Subbasin. A key strategy includes partnering with organizations to help develop material as well as host events and share material. Key partners in this outreach include the Napa County RCD, Environmental Flows Workgroup (as part of CEFF), the National Marines Fisheries Services, and California Department of Fish and Wildlife. The development of accessible and engaging outreach materials will be an integral part of outreach activities. These materials will be shared via events, social media, websites, and local press to raise the overall awareness of how groundwater and ecosystems interact.

1. INTRODUCTION

The Napa Valley Subbasin Groundwater Sustainability Plan (GSP) was submitted January 31, 2022 and approved January 26, 2023 by the California Department of Water Resources. The Napa County Groundwater Sustainability Agency (NCGSA) is now implementing the GSP to ensure that the Napa Valley Subbasin (Subbasin) achieves and maintains sustainable groundwater conditions. This includes developing a series of Projects and Management Actions for implementation within the Subbasin to achieve the sustainability goal:

- *To protect and enhance groundwater quantity and quality for all beneficial uses and users of groundwater and interconnected surface water in the Napa Valley Subbasin both now and in the future.*
- *The NCGSA will implement sustainable management criteria and an adaptive management approach supported by the best available information and best available science, resulting in the absence of undesirable results within 20 years from GSP adoption.*

The GSP established sustainable management criteria (SMC), including Measurable Objectives and Minimum Thresholds, for the depletion of interconnected surface water (ISW) conditions based on the best available information and science. However, the GSP recognized data gaps in the available information on groundwater-dependent ecosystems (GDEs) and the relationship between ISW conditions and GDEs (**GSP Section 5.11**). The proposed action to address these data gaps within the Subbasin included the creation of a workplan that would *"…leverage existing plans and knowledge about Subbasin conditions to provide a structured approach to evaluating the effect of groundwater conditions on interconnected surface waters and GDEs. Potential activities incorporated into the work plan could include biological field assessments to provide detailed site information for evaluating the potential effects on GDEs, investigating stream habitat conditions, and evaluating the status of rare, threatened, or endangered species."*

SGMA (State of California, 2021) defines ISW as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted" and GDEs as "ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface".

This Workplan is designed to implement recommendations from the GSP, including to address data gaps and better understand and quantify existing and historical streamflow characteristics and how they relate to GDE health in the Napa Valley Subbasin. The information gathered during the development of this Workplan will be used to refine the sustainable management criteria for the depletion of ISW in the Subbasin and initiate the California Environmental Flows Framework (CEFF) process (California Environmental Flows Working Group [CEFWG], 2021a; Stein et al., 2021).

The overarching goal of the ISW and GDEs Workplan is to use physical and biological data coupled with hydrologic modeling to better understand the conditions required to protect and enhance healthy terrestrial and aquatic GDEs. In particular, the Workplan describes the steps needed to understand what conditions are necessary to:

1) protect and enhance steelhead spawning, rearing, and migration in the watershed,
2) support special-status aquatic species, and
3) protect and enhance terrestrial GDEs and special-status species.

The Workplan presented below will be implemented in 2024 and extends to 2030 with annual technical memoranda and larger technical reports in 2026 and 2030 for inclusion in the 2027 and 2032 five-year GSP updates. Based on the initial results of the data collection, GDE monitoring may be modified or extended beyond 2030. This Workplan is designed as an adaptive document that changes as new information is collected.

1.1. Approach

The goal of this ISW and GDEs Workplan is to address data gaps relative to the conditions needed to support ISW, GDEs, and groundwater dependent special-status species[1]. When completed, the Workplan will inform sustainable management criteria by quantifying relationships between biological requirements, habitat, groundwater elevations, and streamflow (**Figure 1-1**). To accomplish this, the Workplan used existing background hydrologic and biological data for the Napa Valley Subbasin to prioritize monitoring sites and recommend various monitoring techniques for further characterization of GDE and streamflow relationships. The Workplan includes ongoing monitoring of shallow groundwater at dual-completion monitoring sites, surface water monitoring at Napa County RCD's Stream Watch sites, fish surveys at the Napa Resource Conservation District (RCD) rotary screw trap, surveys of salmonid spawning, and remote sensing of GDEs. This ongoing monitoring will be supported by new basin-wide surveys, including the development of a relative elevation model and expansion of the Stream Watch network. Subbasin-wide data will be used to assess general trends across the Subbasin. Relationships between discharge and habitat and usage by GDEs and special-status species will be developed based on more detailed surveys at high priority sites. The high priority sites were identified using a ranking system that quantified hydrologic data, ecological importance, preliminary understanding of groundwater pumping effects on ISW during different water year types, and other factors that made sites unique. The highest ranked sites were selected for intensive monitoring and assessment. Surveys at each intensive site will include assessing the usage of the site by aquatic and terrestrial species using targeted surveys to assess the presence of different species and their life stage. At each site, the Workplan recommends the surveys and monitoring necessary to develop surface flow habitat relationships (or groundwater elevation-habitat relationships) for the species of interest based on their habitat needs. Field surveys will also explore flow connectivity (i.e., flowing, isolated pools, or dry). The intensive monitoring sites will be used as locations of interest in the CEFF analysis, with data gathered during the monitoring program. The flow-habitat relationships will be used with the Napa Valley Integrated Hydrologic Model (NVIHM), developed during the GSP, to evaluate the groundwater conditions necessary to support GDEs and their aquatic and terrestrial habitat requirements and to inform the refinement of sustainable management criteria (SMCs).

[1] Special-status species are plants and animals are legally protected under the Endangered Species Act (ESA), the California Endangered Species Act (CESA), or other federal, state, or local regulations, or are considered sufficiently rare by the scientific community to qualify for such protection (Napa County, 2007). The specific definitions used to determine special status species for plants and animals are given in Section 3.3.

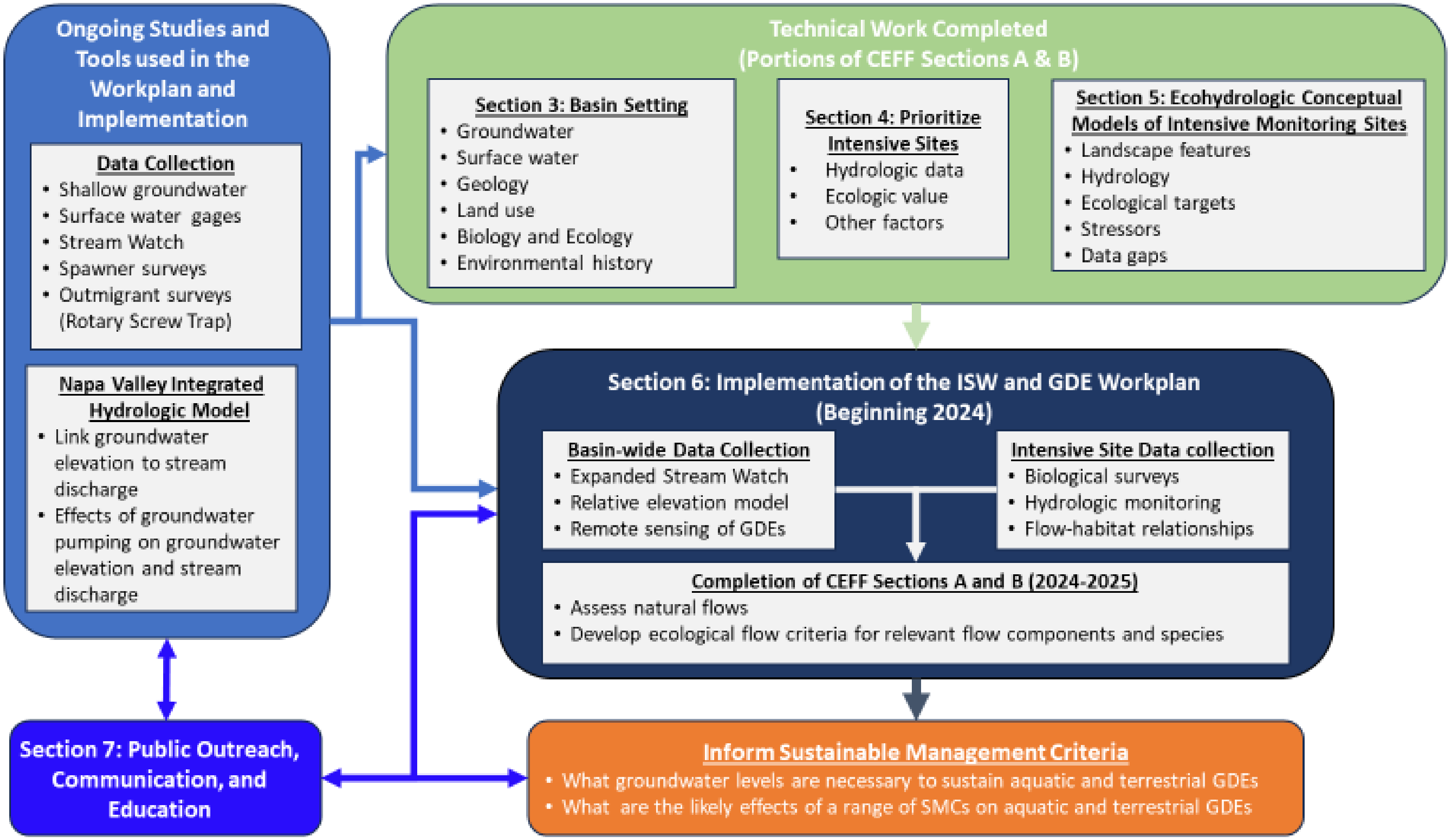


Figure 1-1. Overview of Workplan Approach

1.2. Structure of the ISW and GDEs Workplan

The ISW and GDEs Workplan is structured as follows.

- **Section 2** outlines background information, including previous studies, the Sustainable Groundwater Management Act (SGMA), and CEFF.
- **Section 3** provides the physical and ecological setting for the Napa Valley Subbasin. Specific data sources and data gaps are included.
- **Section 4** provides an overview of 21 sites evaluated based on existing ecological and hydrologic data and a prioritization process developed to select six high priority sites for further characterization.
- **Section 5** presents ecohydrologic conceptual models for the six intensive monitoring sites.
- **Section 6** provides recommendations for ongoing and new monitoring including: ongoing ISW monitoring, Stream Watch network expansion, fish monitoring, vegetation mapping, remote sensing, flow connectivity surveys, habitat field surveys, and environmental DNA sampling. Data assessment will incorporate CEFF analyses. Annual and other periodic reporting will be coordinated with GSP annual reports and five-year GSP updates.
- **Section 7** describes the community engagement and outreach plan.

2. BACKGROUND

2.1. Previous Studies

Many prior studies describe and delineate GDEs in the Napa Valley Subbasin. They help determine what is currently known about Subbasin GDEs and special-status species, the information needed to characterize GDEs and the conditions required to maintain GDE functions and a healthy status. The prior studies include: the GSP (LSCE, 2022a), annual reports (LSCE, 2022b and 2023), numerous fish habitat studies (e.g., Stillwater Sciences and Dietrich, 2002; Stillwater Sciences, 2007; 2019), benthic macroinvertebrate assessments for the Institute for Conservation Advocacy Research and Education (Dewberry, 2022), multiple fish monitoring reports by the Napa County RCD (e.g., Napa County RCD, 2011; 2018; 2020), studies on various tributaries in the Subbasin (e.g., Napa County RCD and PCI, 2012; Stillwater Sciences, 2020) and the environmental history of the basin (SFEI, 2012). Taken together, these studies indicate:

- With the arrival of Europeans, the Napa River and its tributaries were transformed from a multi-threaded anastomosing system with multiple channels lined with willows to an incised and primarily single-threaded stream. Consequently, a larger portion of the flow occurs in winter, and groundwater recharge is reduced relative to the natural condition.
- Streams that flow during the dry season are connected to groundwater and decreases in groundwater levels can cause the stream to go dry.
- There are several listed species in the Subbasin, many of which are dependent upon groundwater or interconnected surface water.
- Some streams (particularly tributaries to the mainstem Napa River) are naturally intermittent, but groundwater pumping may affect the duration or frequency of dry periods.
- Barriers to fish passage limit the extent of steelhead habitat in the watershed. Most of the current barriers are upstream of the Subbasin. The Napa County RCD is implementing a barrier removal plan to improve passage to upper reaches of the watershed (Napa County RCD, 2011).
- These factors, among others, have altered streams and the riparian zone and limited the success of native species.

These factors and their impacts are discussed in **Section 3**.

2.2. Legislative Framework

2.2.1. SGMA

In September 2014, Governor Jerry Brown signed SGMA, a three-bill legislative package now codified in Section 10720 et seq. of the California Water Code. Effective in California on January 1, 2015, SGMA provides a framework for the sustainable management of groundwater resources. SGMA encourages groundwater management at the local level. Local agencies form GSAs to develop and implement GSPs to guide sustainable management of state-defined groundwater basins and subbasins.

Under SGMA regulations, ISW is defined as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer, and the overlying surface water is not completely depleted." It is one of six sustainability indicators that provide a framework for evaluating sustainability within the Subbasin. Largely, the ISW sustainability indicator is informed based on the groundwater elevation and baseflow that are required by GDEs. GDEs, defined under SGMA, are ecological communities or species that depend on groundwater emerging from aquifers or groundwater occurring near the ground surface (GSP Regulation §351(m)). During the development of the Napa Valley Subbasin GSP, GDEs were evaluated using the guidance issued by The Nature Conservancy (Rohde et al., 2019).

The Department of Water Resources' (DWR's) approval of the Napa Valley Subbasin GSP (DWR, 2023) included three corrective actions to be completed by the first five-year evaluation. Recommended Correction Action 3 outlines the difficulty in estimating the location, quantity, and timing of stream depletion. The three items DWR recommended that the Napa County Groundwater Sustainability Agency (NCGSA) address concerning stream depletion are:

a) Consider utilizing the interconnected surface water guidance, as appropriate, when issued by the Department to establish quantifiable minimum thresholds, measurable objectives, and management actions.
b) Continue to fill data gaps, collect additional monitoring data, and implement the current strategy to manage depletions of interconnected surface water and define segments of interconnectivity and timing.
c) Prioritize collaborating and coordinating with local, state, and federal regulatory agencies as well as interested parties to better understand the full suite of beneficial uses and users that may be impacted by pumping induced surface water depletion within the GSA's jurisdictional area.

This Workplan is a substantial step to addressing items b and c above. DWR anticipates release of interconnected surface water guidance in Fall 2024 to Summer 2024.

2.2.2. Human Right to Water County Resolution

The Napa County Board of Supervisors passed Resolution 2022-178 on December 6, 2022, which incorporates the human right to water (HRTW) into Napa County policy. This addition to County policy recognizes general State policy, enacted on September 25, 2012, which declares that it *"be the established policy of the State that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes."* The Napa County policy goes further and states that the County will consider *"... the environment consistent with public trust principles, and all beneficial uses, to ensure prudent water resource management and efficient use, for the benefit of present and future generations."*

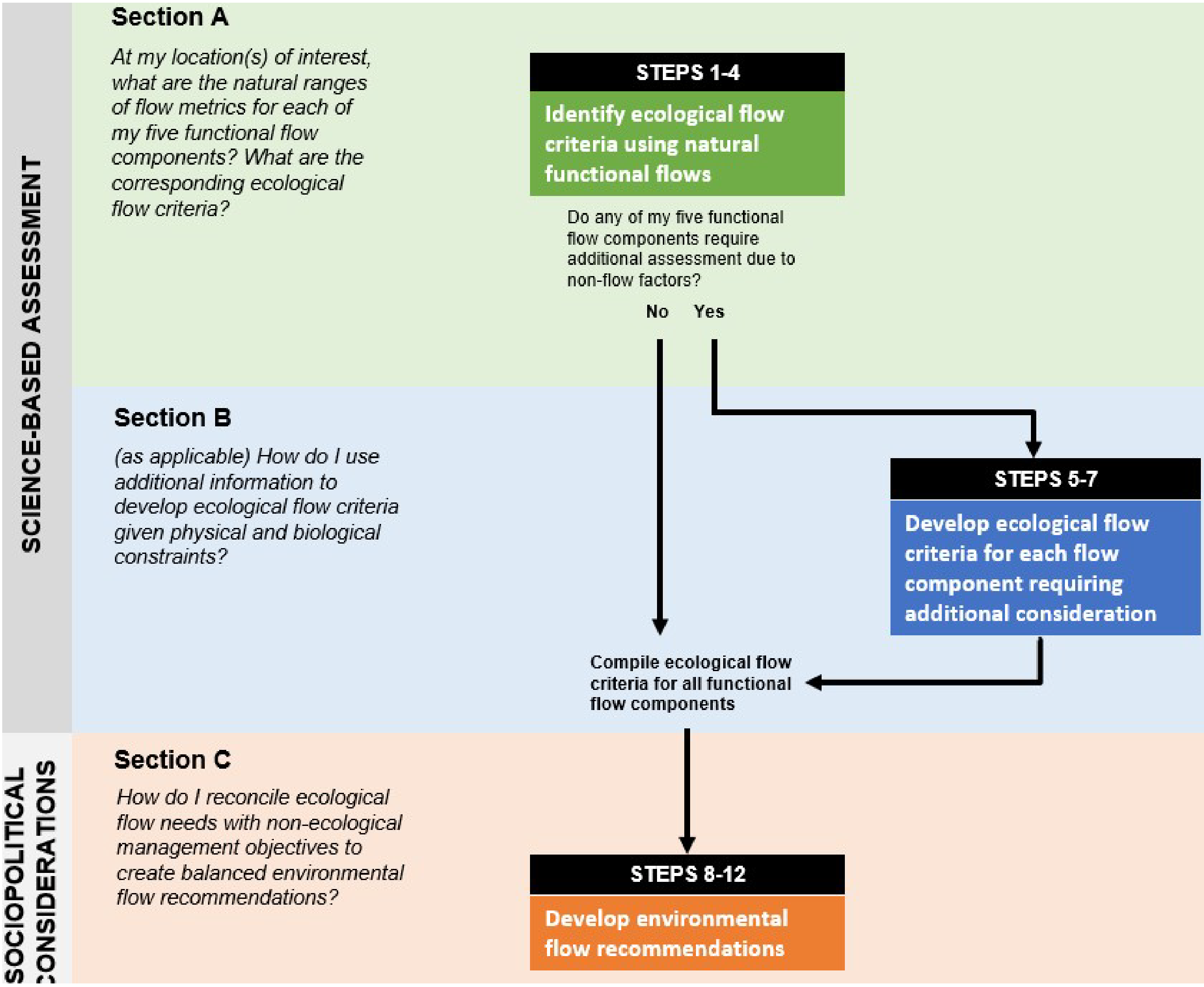
2.3. Environmental Flows

The Napa Valley Subbasin GSP identified ISW and GDE-related data gaps. To better understand the beneficial uses and users that may be impacted by depletions of ISW, and refine and expand upon the sustainable management criteria developed in the GSP, the ISW and GDEs Workplan will initiate development of scientifically defensible flow recommendations that balance human and ecosystem water needs. This analysis will be based on the Napa Valley Integrated Hydrologic Model (NVIHM), geomorphic analysis of stream corridors, historical analysis of past flows that supported the aquatic and riparian ecosystem, and an application of the California Environmental Flows Framework (CEFF) (CEFWG, 2021a).. CEFF is a systematic approach to evaluating hydrologic and other environmental changes (e.g., river incision and sedimentation) and the effects of these changes on ecosystems within a watershed. The natural environmental flows assessment of CEFF is often completed using the Natural Flows Database (e.g., CEFWG, 2021b; Grantham et al., 2022). This tool is designed to be applied statewide, so its application to a given system (such as the Napa River and floodplain) can provide a valuable reference but merits careful evaluation. The Natural Flows Database is most useful in river basins that lack locally specific information. River basins such as Napa with good current and historical surface water gaging data, observation well data, and an integrative model (such as NVIHM) should normally emphasize these data sources that are specific to the basin. A statewide model such as CEFF can provide valuable insights and merits application, but it should not be considered the only or even principal source of information on which to base environmental flows.

CEFF is based on the concept of functional flows, which are components of the natural flow regime (i.e., expected flows in the absence of human activity similar to unimpaired flows) that support key ecological functions and ecological management goals. Natural functional flow metrics are used as ecological flow criteria in CEFF based on the assumptions that the range of natural functional flows would maintain the physical, chemical, and biological functions needed by native freshwater species (Escobar-Arias and Pasternack, 2010; Yarnell et al., 2015) and that maintaining these functions would be broadly protective of ecosystem needs and achieve ecological management goals (Grantham et al., 2022). CEFF, however, acknowledges that other environmental changes, including changes to habitat, species distribution, and temperature, may change the relationship between flows and habitats that naturally occur in the Subbasin. The CEFF process is divided into three sections, with 12 steps in total (**Figure 2-1**, **Table 2-1**).

Functional flow metrics may be calculated from a locally calibrated hydrologic model such as the NVIHM (see Section 3.2.4), reconstructions of natural flow regimes based on geomorphology and historical data (e.g., Grossinger 2012, Kondolf and Vorster 1993), or application of CEFF, which quantifies functional flow metrics using statewide statistical models (Grantham et al., 2022; CEFWG, 2021b). One issue that arises with application of statewide models is the potential mismatch between the geomorphology and hydrology of the stream gages used to develop the CEFF flows and that of the streams to which they are applied. Many of the long-term stream gages in California are located on bedrock reaches, because these provide more stable “rating curves” (relations between stage, or river height, and flow). Bedrock reaches commonly have higher flow than nearby alluvial reaches because shallow groundwater flow is forced to the surface in bedrock reaches. Thus, applying a statewide model has predicted higher flows than actually measured in some alluvial reaches in Sonoma County (Kondolf, personal communication).

Another important factor is surface-groundwater interactions on alluvial fans. Most Napa River tributaries cross alluvial fans when they exit the mountains and enter the valley floor. At the head of the alluvial fan, the stream deposits coarser sediment (sand and gravel), which are more permeable. Streamflow infiltrates into the fan at the head of the fan, commonly emerging in wetlands at the base of the fan. Thus, the geomorphic setting of a gage or a point for which flows are modelled is critically important for a realistic assessment of flow.



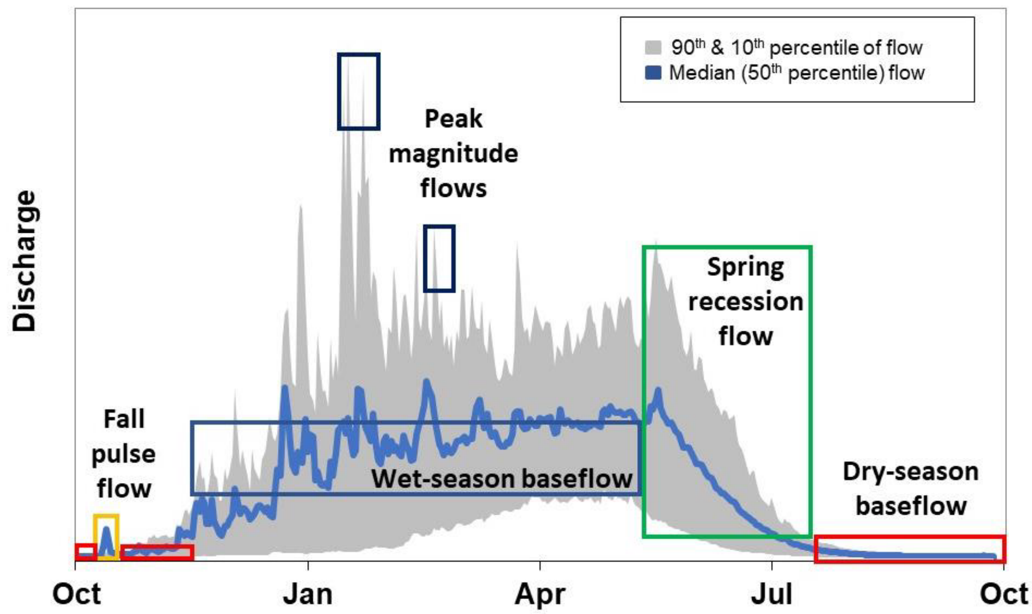
Source: CEFWG 2021a

Figure 2-1. Overview of the California Environmental Flows Framework

CEFF Section A provides guidance for the development of ecological flow criteria using natural functional flows for the study area. CEFF identifies five components of the hydrograph that support key ecosystem functions:

- fall pulse flow,
- wet-season peak flows,
- wet-season baseflow,
- spring recession flow, and
- dry-season baseflow (**Figure 2-2**).

Section A also provides guidance for determining whether non-flow alterations (e.g., physical habitat degradation, poor water quality, or invasive species) may limit the ability of the natural range of functional flow metrics to support key ecosystem functions. Under CEFF, natural functional flow metrics are used as ecological flow criteria unless a flow component may be impacted by other (non-flow) alterations, which occur to some degree in many rivers in California.



Source: CEFWG 2021a

Figure 2-2. A Representative Hydrograph with Functional Flow Components

CEFF Section B provides guidance for defining ecological flow criteria for functional flow components that may be impacted by non-flow alterations identified in Section A. Section B centers on the development of conceptual models, data compilation, and quantitative analyses to assess ecosystem responses to changes in these focal functional flow components, e.g., quantifying relationships between flow and habitat availability for relevant hydrograph components.

Once ecological flow needs have been determined (by geomorphological and historical analysis, detailed modeling such as NVIHM, and statewide model such as CEFF), the next step is integrating real-world constraints to develop environmental flow recommendations and implementation strategies. This requires analyzing tradeoffs to balance regulatory requirements, social values, and other non-ecological management objectives with the ecological flow needs, and typically involves stakeholder engagement.

Using CEFF, these final environmental flow recommendations are developed in Section C. The ISW and GDEs Workplan incorporates CEFF Sections A and B, with Section C slated to be completed after the Workplan has been implemented.

CEFF Section C provides guidance on developing environmental flow recommendations and implementation strategies. Tradeoff analyses are applied to balance regulatory requirements, social values, and other non-ecological management objectives with the ecological flow needs identified in Sections A and B. Stakeholder engagement also guides the development of a final set of environmental flow recommendations and an implementation plan for the study area. Sections A and B are incorporated into the ISW and GDEs Workplan, with Section C slated to be completed after the Workplan has been implemented.

Table 2-1. Discrete Steps Outlined in CEFF
California Environmental Flow Framework Steps
Section A: Identify ecological flow criteria using natural functional flows.
Step 1: Define ecological management goals and locations of interest (LOIs).
Step 2: Obtain natural ranges of flow metrics for five functional flow components.
Step 3: Evaluate if non-flow factors may affect the ability of natural ranges of functional flow metrics to achieve ecological management goals.
Step 4: Select ecological flow criteria for functional flow components not affected by non-flow factors (focal functional flow components).
Section B: Develop ecological flow criteria for each flow component affected by non-flow factors.
Step 5: Develop detailed conceptual model relating functional flow components to ecological management goals.
Step 6: Quantify flow-ecology relationships.
Step 7: Define ecological flow criteria for focal functional flow components.
Section C. Develop environmental flow recommendations (To be completed after the Workplan)
Step 8: Identify management objectives.
Step 9: Assess flow alteration.
Step 10: Evaluate management scenarios and assess tradeoffs.
Step 11: Define environmental flow recommendations.

Source: CEFWG 2021a

3. BASIN SETTING

The physical setting, data sources and gaps, and ecological setting of the Napa Valley Subbasin are described in this section. The information described in this section was used to evaluate different locations throughout the Subbasin. At each location, an ecohydrologic conceptual model (EHCM) was developed to assess the physical and ecological characteristics of each site (**Section 4**). EHCMs are conceptual models that provide an understanding of the physical and biological characteristics related to hydrology, land use, geology and geologic structure, water quality, and ecology of a particular site (Rohde et al., 2020).

3.1. Physical Setting

This section summarizes the physical setting relevant to groundwater and ISW and highlights environmental changes that would be considered in CEFF.

3.1.1. Geology

The Napa Valley Subbasin is within an active zone of complex tectonic deformation and down-warping generally associated with the San Andreas Fault Zone. Major rock types and deposits found in and near the Subbasin include surficial deposits of the Quaternary period, volcanic and sedimentary rocks of the Tertiary period, and volcanic and sedimentary rocks of the Mesozoic era (Cretaceous and Jurassic periods). As a result of extensive faulting, folding, erosion, and variable volcanic processes (e.g., lava flows, ash deposits), the surficial exposure of these formations is highly irregular.

The Quaternary (less than 2.5 million years [m.y] before present.) surficial deposits, collectively termed alluvium, cover most of the Napa Valley Subbasin. These deposits are highly heterogenous stemming in part from variable depositional processes, although, within the Subbasin, most are attributable to deposition by alluvial processes associated with rivers and streams. They have been divided into recent Holocene deposits (100,000 years to present) and Pleistocene deposits (2.5 m.y. to 100,000 years). The Holocene deposits include active stream channels, terraces, floodplains, and alluvial fans (**Figure 3-1**). South of Napa, Holocene bay muds (also known as sedimentary basin deposits) of marshland and estuary origin extend and merge with similar deposits of San Pablo Bay. Pleistocene deposits include older terraces, alluvial fans, and older alluvium.

Stream channel deposits in the Subbasin are composed of thicker beds of sand and gravel, which are lenticular and elongated in nature. They are interbedded with floodplain deposits of silt and clay with mixtures of sand and gravel and thin sheets of sand and gravel deposited by flood flows. Alluvial fans spreading out from the valley sides and tributaries tend to be broad, gravelly sandy silt and clay beds formed by flood flows with lenticular sand and gravel interbeds formed by the streams. The alluvial fan deposits tend to thin and become finer grained towards the valley center, merging into the floodplain deposits. The bay muds, as the name implies, are composed of fine-grained silts and clays. The bay muds tend to be blue or gray in color because of reducing conditions and constant saturation. Some interbedded lenses of finer sand beds occur, which were formed by streams or estuary channels. The Quaternary deposits are unconsolidated, becoming weakly consolidated with increasing age and deformed only by faulting.

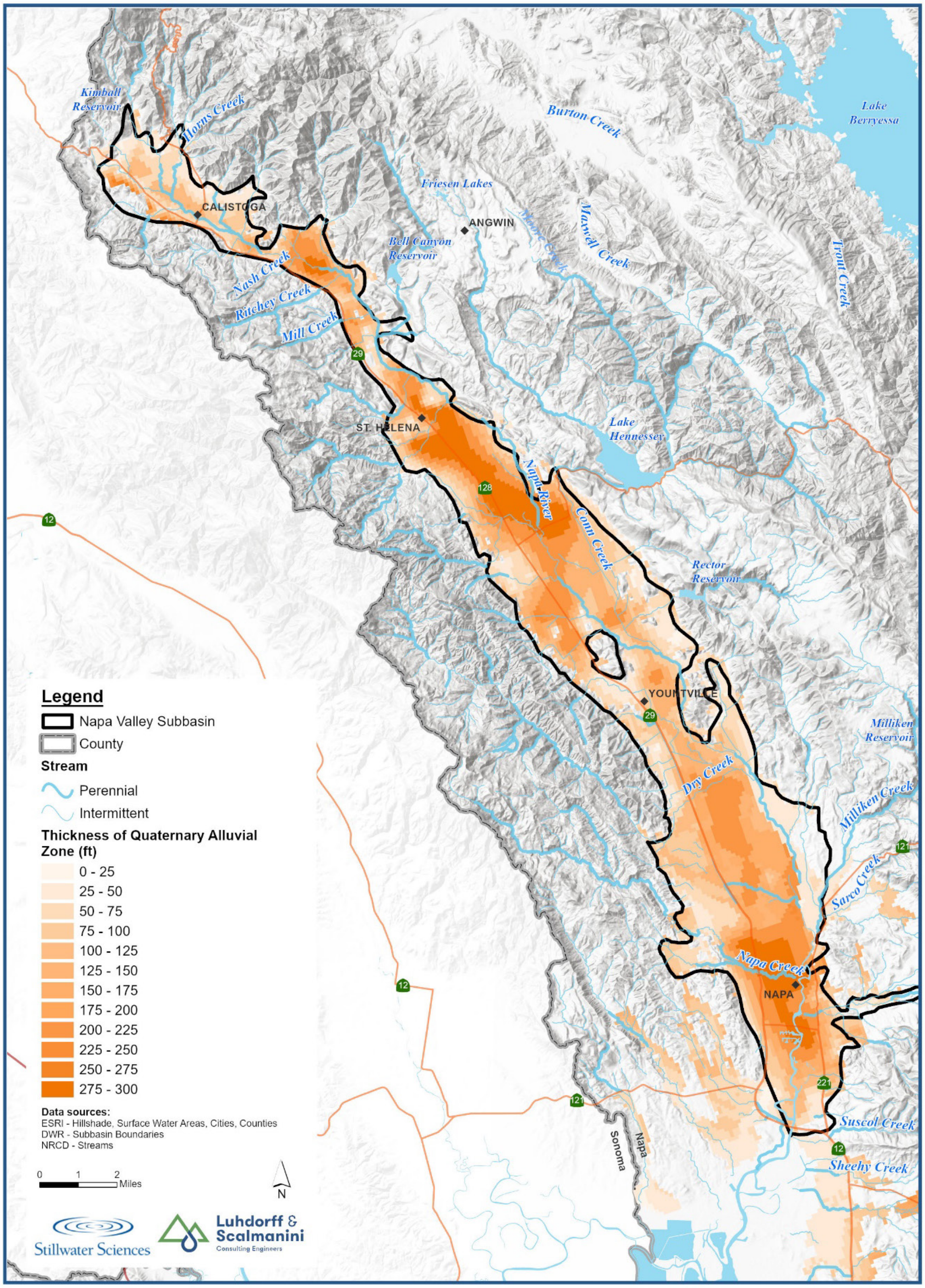


Figure 3-1. Distribution and Thickness of Quaternary Alluvium in the Napa Valley

3.1.2. Land Use

Characteristic land uses in the Napa Valley Subbasin include four incorporated municipalities, agricultural lands primarily supporting perennial vineyards, native vegetation and groundwater dependent ecosystems, wineries, and rural residences. The Subbasin is comprised of approximately 45 percent vineyards, followed by 28 percent urban land and 22 percent native vegetation (DWR, 2022). Land use mapping from 2019 is provided in **Figure 3-2**.

Wine grape production has long been a substantial component of land use in Napa Valley. The County's General Plan reports that Napa Valley supported 16,000 acres of vineyards as far back as the 1880s (Napa County, 2008). Detailed land use surveys of Napa County performed by DWR in 1987, 1999, and 2011 indicate that agricultural land uses overall and vineyard acreages were consistent over that 25-year period. More recent land use surveys (2014, 2016, 2018, 2019, 2020, 2021) show a similar and relatively consistent 21,000 acres of vineyards in the Subbasin since 1987.

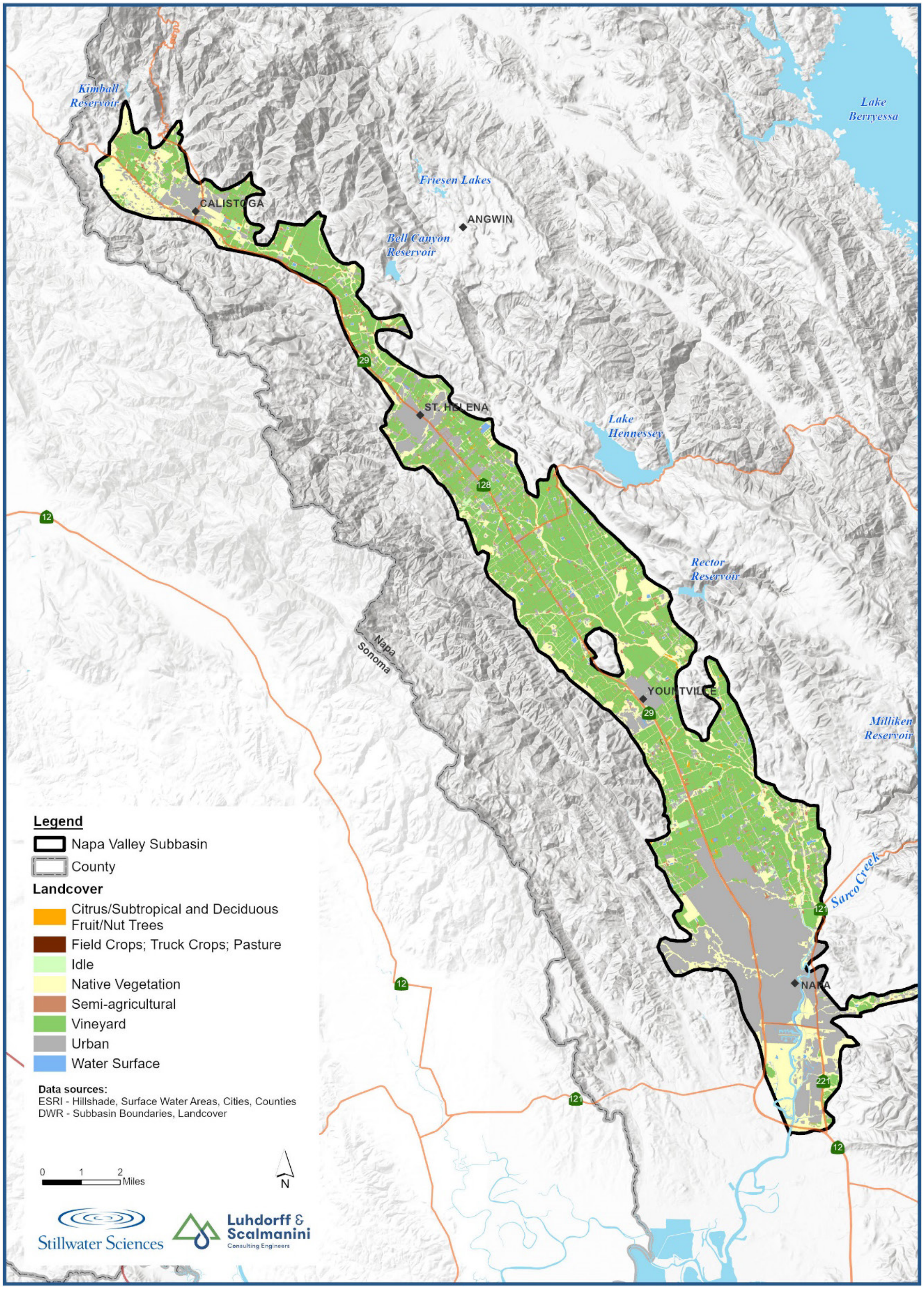


Figure 3-2. Napa Valley Subbasin Land Use in 2019

3.1.3. Groundwater

Groundwater in the Subbasin is contained in and moves primarily through the older and younger Quaternary alluvial formations from Calistoga to San Pablo Bay. These alluvial formations comprise the principal aquifer system of the Napa Valley Subbasin (LSCE, 2022a). Monitoring conducted since 2014 at dedicated monitoring wells along the Napa River and Dry Creek within Napa Valley and data from other wells show that within the Napa Valley alluvial formations, groundwater conditions range from unconfined to semi-confined throughout the Valley Floor and Napa Valley Subbasin. The degree of confinement in groundwater results from variations in the geologic materials, with more extensive and thicker areas of fine-grained, low-permeability materials leading to semi-confined conditions in underlying aquifer materials that can result in groundwater levels in deeper portions of the alluvium being offset from groundwater levels in shallower portions of the alluvium. These differences arise due to a difference in the resistance to vertical groundwater flow between unconfined and semi-confined areas.

Previous studies have identified groundwater recharge from deep percolation of rainfall across the land surface as a primary mechanism resulting in inflows to the Subbasin (Faye, 1973; Kunkel and Upson, 1960). Other means of groundwater recharge include deep percolation of applied irrigation water (including water applied for landscape irrigation), seepage of streamflow within the Subbasin, and mountain block recharge. Mountain block recharge refers to subsurface inflows of groundwater to the Subbasin from geologic formations adjacent to the Subbasin in the Napa River Watershed. Recharge by streamflow seepage is more likely to occur where stream channels cut through coarse alluvial fan deposits located where tributaries emerge into the valley floor.

Groundwater discharge occurs in the Subbasin through baseflow contributions to surface water systems, discharges at springs and wetlands in the Subbasin, and subsurface flows of groundwater to formations adjacent to the Subbasin. Not all discharge processes result in a net discharge or outflow from the Subbasin. For example, springs present in and near Calistoga discharge groundwater at the land surface. That discharged groundwater may re-enter the Subbasin groundwater system through infiltration or seepage along surface water channels.

Groundwater generally flows along the length of the Napa Valley through the older and younger alluvium from Calistoga to San Pablo Bay. Groundwater elevations from Spring 2022 range from about 380 feet above mean sea level (amsl) north of Calistoga to about 5 feet amsl near 1st Street in the vicinity of downtown Napa (**Figure 3-3**). The average horizontal hydraulic gradient in the alluvium is approximately 0.003 feet/feet, which is assumed to represent the unconfined portion of the aquifer system.

Groundwater trends and conditions in the Napa Valley Subbasin are largely dependent on the amount of precipitation and groundwater discharge; therefore, groundwater levels vary seasonally (spring and fall) and between WY types. Long-term groundwater level trends in the Napa Valley Subbasin are stable in the majority of wells with long-term groundwater level records. Recent drought effects (Water Years 2020, 2021, and 2022) resulted in significant groundwater level declines in the Subbasin. Some groundwater level recovery has occurred in response to wetter conditions in Water Year 2023.

Wells throughout the Milliken-Sarco-Tulucay (MST) have generally shown stable to declining groundwater levels over time, but wells with records extending back to the late 1970s better illustrate how climate and groundwater management impact groundwater conditions. Historically, groundwater levels in the northern MST were stable throughout the late 1970s until the mid-1980s (1986), at which time a decline of about 10 to 40 feet occurred (LSCE, 2021). Following this decline, groundwater levels stabilized until the late-1990s to early-2000s. After that time, groundwater levels experienced a gradual decline of about 10 to 30 feet until approximately 2009. Similar to historical conditions described for the northern MST, groundwater levels in the southern MST showed declines until about 2009 (LSCE, 2022a).

Groundwater level hydrographs for the southern MST area show a greater response to changing conditions in 2015, after a dry period from 2012 to 2014. Following a recovery in water levels during 2015, groundwater levels have been in decline up until spring 2023. These trends across the MST can be closely correlated with trends in precipitation and groundwater management practices. The consistent water levels from the late 1970s to the mid-1980s correspond to four very wet years and one wet year**.** The continual decline in water levels up until the late 1990s and early 2000s was likely due to several dry and below-average years followed by multiple wet and very wet years and the adoption of the County's Groundwater Conservation Ordinance 1162 in 1999 to limit pumping in the MST. From 2006 to 2017, conditions were generally below average, with just two wet years.

In the northern part of the Northeast Napa Management Area and west of the Soda Creek Fault, groundwater level trends are similar to wells located in the MST. Groundwater levels declined historically until about 2009, generally stabilized between 2009 and 2018 (with some decline in response to dry conditions in 2013 and 2014), and then declined again in response to recent dry years.

Seasonally, groundwater levels are typically higher in response to precipitation in the winter and spring and lower in the summer and fall in response to pumping and other groundwater discharge. Groundwater levels at wells located within the center of the Subbasin are generally more stable than levels observed at wells near the Subbasin margin, where they generally exhibit greater variability between the spring and fall. The difference in groundwater level responses is likely due to wells at the Subbasin margin being constructed largely, if not entirely, in older deposits underlying the alluvium.

Groundwater elevation data, including hydrographs and well locations, are available on the NCGSA interactive web map[2].

[2] https://experience.arcgis.com/experience/fa5d7cef2a884f12b90689f6029ab040/

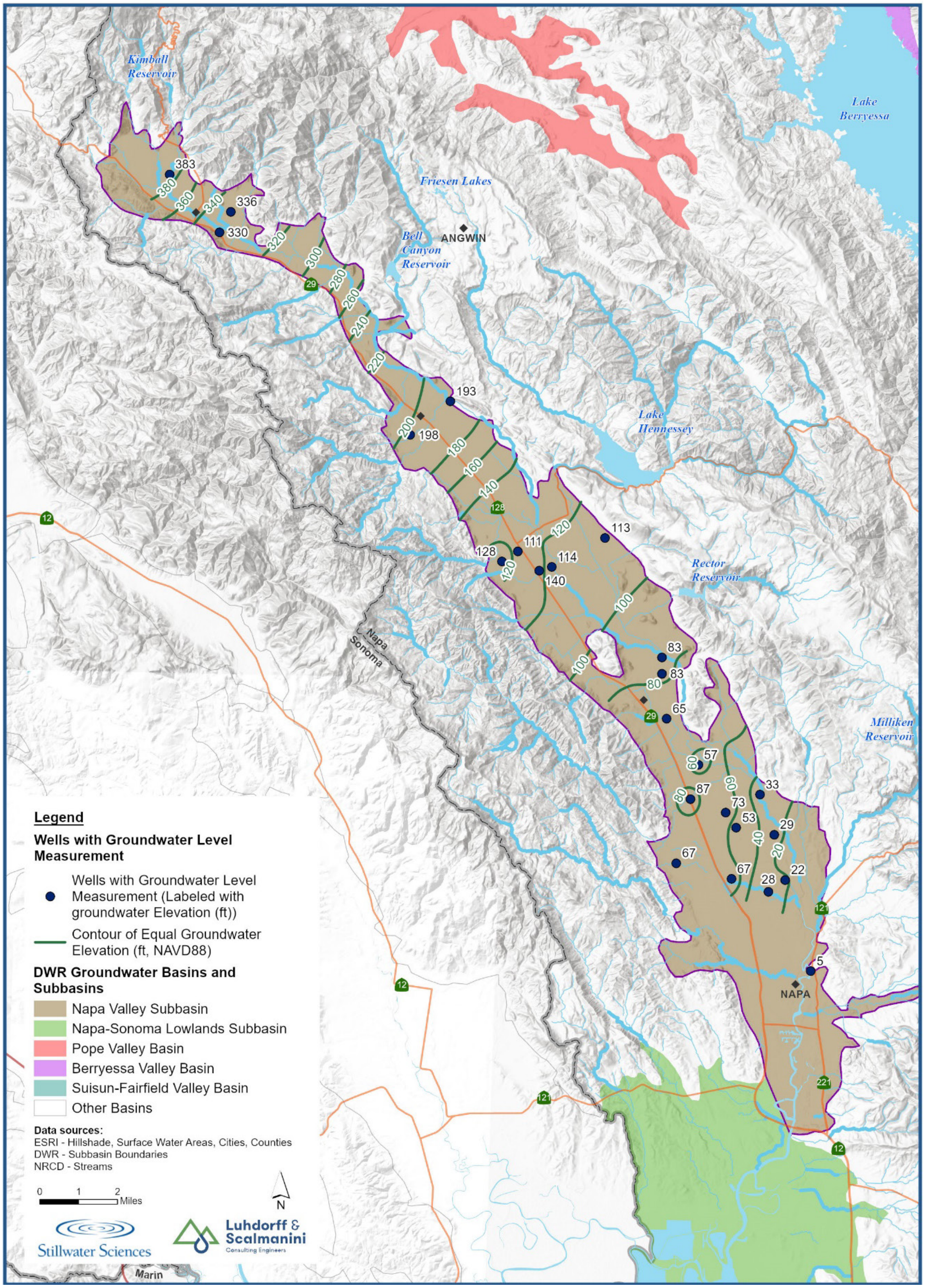


Figure 3-3. Napa Valley Subbasin Groundwater Elevation Contours from Spring 2022

Groundwater extraction within the Subbasin occurs from agricultural, rural domestic residential, municipal water users, and wineries. Groundwater pumping is estimated by water year for these sectors from 2015 through 2022 (**Figure 3-4**). During this period, estimated annual groundwater extraction ranged from 14,340 to 22,840 acre-feet per year (AFY). Agricultural pumping accounts for the majority (76 percent) of pumping in the Subbasin. Rural residential groundwater extraction accounts for about 18 percent of all groundwater pumping in the Subbasin. Of this, outdoor water use for landscape irrigation is estimated to account for over 90 percent of the groundwater pumped for rural residential use. Municipal pumping accounts for approximately 2 percent of total groundwater extraction in the Subbasin and averages 350 AFY. Winery extraction accounts for approximately 4 percent of total groundwater extraction in the Subbasin.

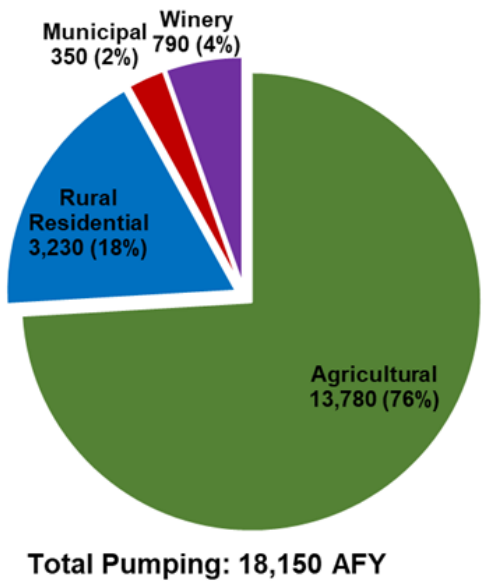


Figure 3-4. Average Estimated Groundwater Pumping (WY 2015-2022)

Available information compiled for the GSP indicates that approximately 76 percent of production wells in the Subbasin have screened intervals completely or partially within the alluvium, while 24 percent of production wells are screened entirely within older Tertiary units, including the Huichica formation and Sonoma Volcanics. Although wells produce groundwater from the older Tertiary units, the dominant fraction of groundwater production likely occurs from the alluvium because of the greater water-yielding characteristics of the materials in the alluvium. Groundwater production from the alluvium is variable, with yields ranging from less than 10 gallons per minute (gpm) near the East and West mountainous areas to more than 2,000 gpm in some areas where the alluvium thickness exceeds 200 feet.

3.1.4. Surface Water

The Napa River flows southeast from the Coast Ranges through the Napa Valley Subbasin and Napa- Sonoma Valley Lowlands Subbasin before entering San Pablo Bay at Vallejo. Several intermittent and perennial streams flow through the Napa Valley Subbasin and feed into the Napa River (**Figure 3-5**). These tributaries contribute recharge to the Napa Valley Subbasin, some of which likely support low-flow conditions in the Napa River as dry season baseflow. Shallow groundwater within the alluvial deposits generally shows complex hydrologic interactions with the Napa River streambed along its reaches at multiple time scales.

Surface waters, or groundwater discharging to the land surface, that support GDEs in the Subbasin include springs and surface water channels mapped by the USGS, U.S. Fish and Wildlife Service, and Napa County RCD (**Figure 3-5**). These include springs in the vicinity of Calistoga and estuarine and riverine tidal channels in the southern portion of the Subbasin, extending to within the City of Napa. Additional mapping and evaluation of GDEs in the Subbasin are provided in the GSP.

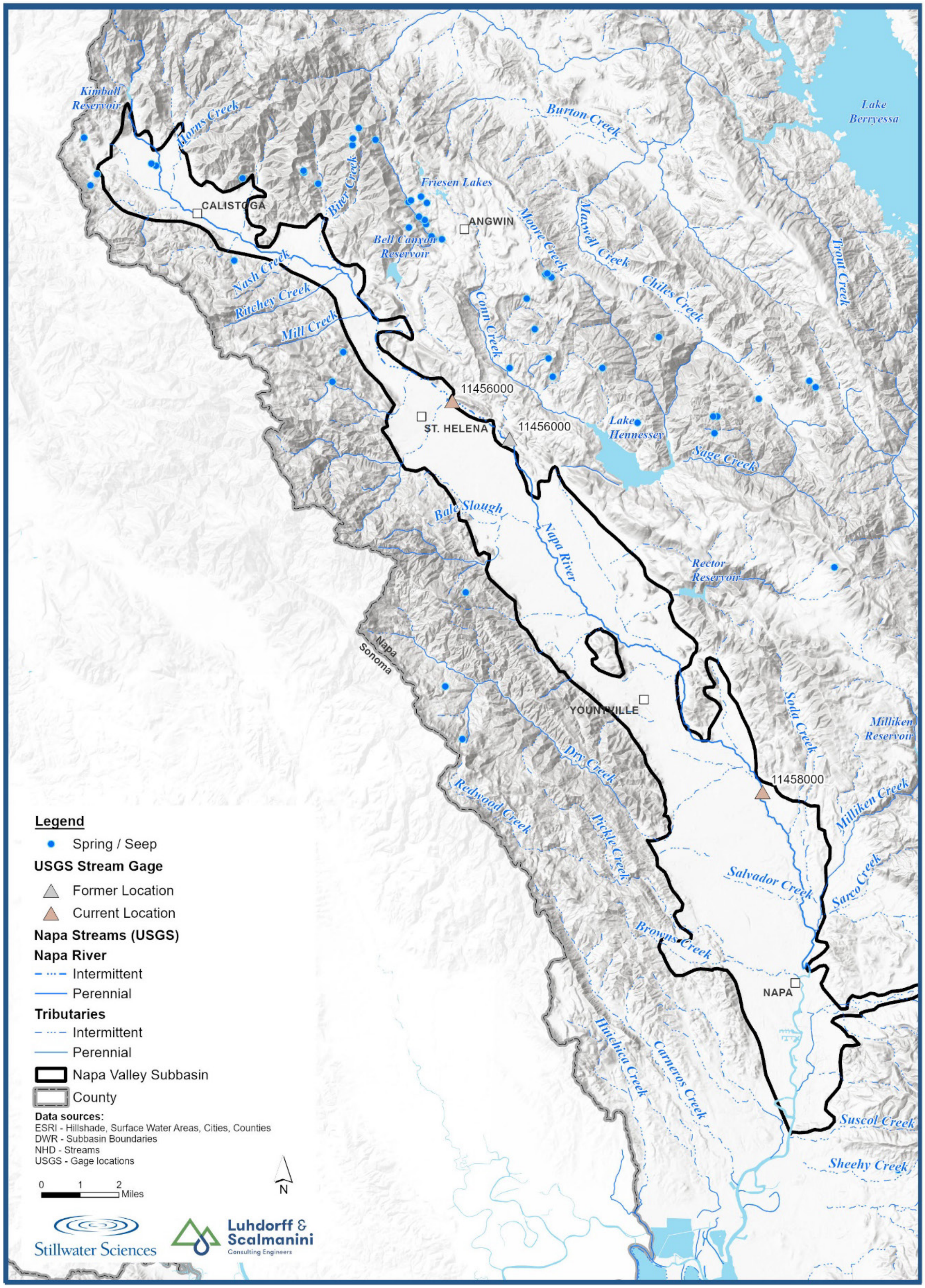


Figure 3-5. National Hydrography Dataset: Streams, Springs, Seeps, and USGS Stream Gages

Surface water monitoring efforts within the Napa Valley commenced in 1929 with United States Geological Survey (USGS) stream gaging stations at the Napa River near St. Helena (Station ID 1145600) and the Napa River near Napa (Station ID 1145800) (**Table 3-1**, **Figure 3-5**). The Napa River near St. Helena gage recorded stage only (no discharge) from 7/1/1995-5/31/2000 (**Table 3-1**). The Napa River near St. Helena gage was moved approximately 1.75 miles upstream in January 2005 to its current location to improve data accuracy. The Napa River at Napa gage was operational from 1929-1932 and from 1960-present. Stream stage (i.e., water surface elevation) is monitored continuously at these gages, and volumetric flow rates (i.e., stream discharge) are calculated using rating curves developed by the USGS. These gages, now supported with funding from the USGS and DWR, provide long-term data useful for characterizing surface water flows in the Subbasin.

Table 3-1. Period of record of currently active USGS stream gages in the Napa Valley Subbasin

Gage Name	Gage Number	Period of Record
Napa River near St. Helena	1145600	10/1/1929-9/30/1932 10/1/1939-7/1/1995, 5/31/2000-present
Napa River near Napa	1145800	10/1/1929-9/30/1932 10/1/1960-present

Figure 3-6 shows the Napa River annual water year (WY) average streamflow by water year calculated from USGS surface water stations near St. Helena and Napa. These annual averages are calculated from raw discharge data and, therefore, capture flashy, high-volume surface water flows associated with winter storms. Water year types can be generally observed from relative differences between the annual average stream flows in **Figure 3-6;** however, the seasonal lows, or the number of days with little to no streamflow, are not well represented by an annual water year average. **Figure 3-7** shows the monthly average of streamflow calculated from raw USGS surface water station data near St. Helena and Napa to compare the timing and magnitude of seasonal surface water declines between historical water years. Average monthly flows indicate the Napa River typically approaches little to no-flow conditions during the fall in the vicinity of St. Helena and Napa, with notable differences between recession curves associated with late summer precipitation events, groundwater recharge, groundwater discharge, and baseflow development (**Figure 3-7**).

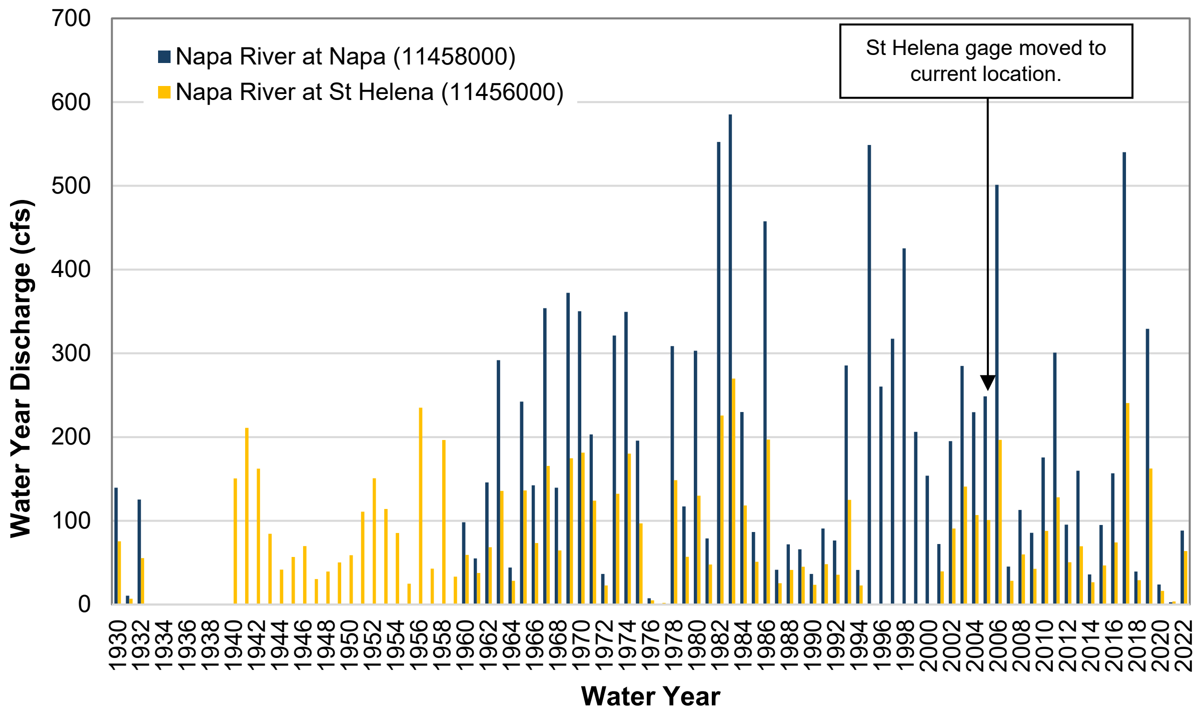


Figure 3-6. Mean Water Year Discharge in the Napa River (WY 1930-2022)

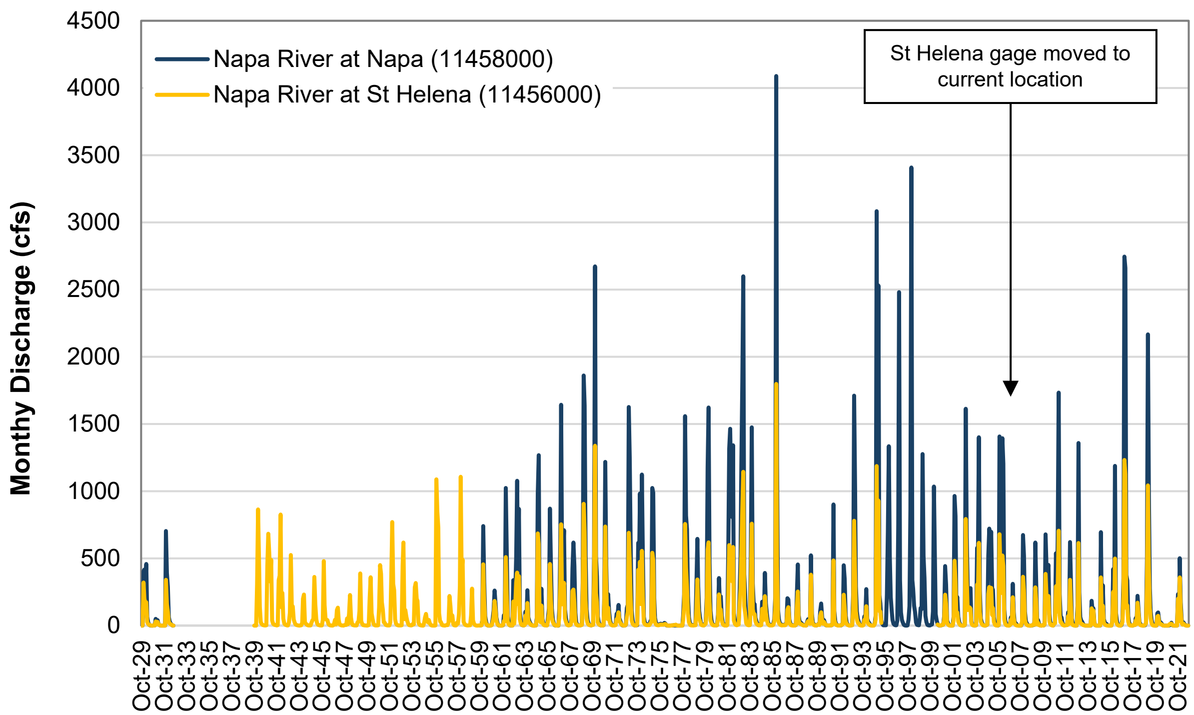


Figure 3-7. Mean Monthly Discharge in the Napa River (WY 1930-2022)

Historically, the annual streamflow hydrograph for both the Napa River near Napa and the Napa River near St. Helena gages exhibited periods of low or no streamflow conditions during dry years(Faye 1973). Faye (1973) highlights that the Napa River did not flow for a significant amount of time during the 1930 and 1931 water years because of low precipitation and groundwater levels. Steep seasonal recession in Napa River flows were observed in 1910-1911 (SFEI, 2012). The number of days in each year of the historical records at the USGS Napa River near St. Helena and Napa River near Napa gages during which measured flows less than 0.1 cubic feet per second (cfs) from 1960 through 2022 are presented in **Figure 3-8**. These data illustrate the historical occurrence of seasonal low-flow conditions. During drier years, the low/no flow conditions typically start in early summer (June) with a greater number of days with low or no streamflow, whereas during wetter years, such low or no flow conditions tend to first occur in October, and there are no or relatively fewer days experiencing low or no streamflow.

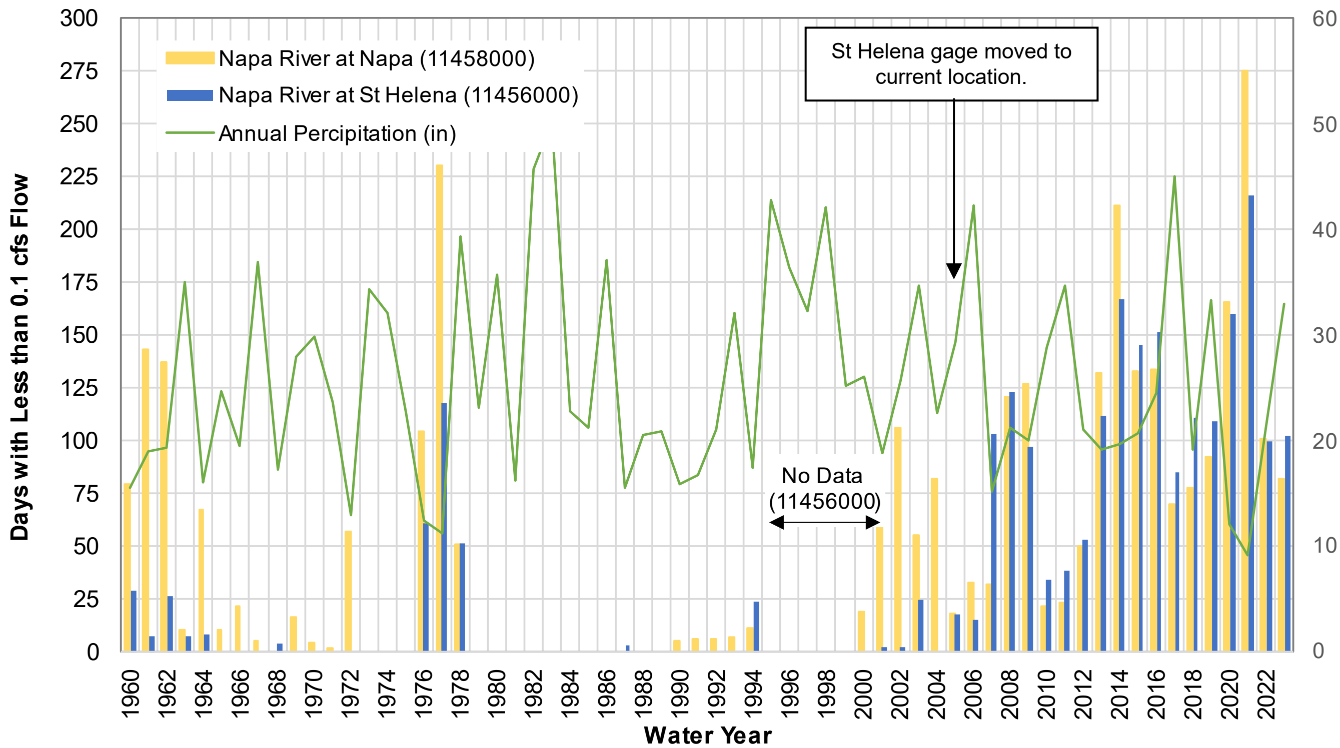


Figure 3-8. Annual Zero Flow Days Napa River (WY 1960-2022)

A recent statewide analysis of streamflow characteristics by Lane and others (2018) systematically evaluated stream gage data from 229 reference stream gages across the state to "generate baseline hydrologic archetypes of regional stream classes for California." The resulting nine stream classes "represent distinct hydrologic landscapes, with distinct flow patterns, flow sources, (and) hydrologic characteristics" (Lane et al., 2018). The resulting classification designates the Napa River and its tributaries as Winter Storm class streams, which are characterized by a concentration of streamflow during the wet season that transitions to a dry season of minimal streamflow over a relatively brief spring recession period.

Interactions between groundwater and surface water in the Subbasin are temporally and spatially variable and, as in many settings, challenging to quantify. Monitoring efforts have, for many decades, observed groundwater levels to be very near the land surface and in contact with surface water channels in the Subbasin (Faye, 1973; LSCE and MBK, 2013; LSCE, 2020). Hydraulic connections between groundwater and surface water occur when groundwater under unconfined conditions reaches elevations very near to or above surface water features. Such connections vary spatially and temporally in the Subbasin (LSCE and MBK, 2013; LSCE, 2020). Interconnections between groundwater and surface water also vary by the rate and direction of flow of groundwater to or from surface waters.

When unconfined groundwater elevations are above surface water elevations, the direction of flow is towards the surface water channel, and the surface water channel is referred to as a gaining reach. When unconfined groundwater elevations are below surface water elevations, the direction of flow is away from the surface water channel, and the surface water channel is referred to as a losing reach. Losing reaches are further characterized as connected or disconnected according to whether a continuous zone of saturation is present between the streambed and the unconfined groundwater body. The rate of flow between groundwater and surface water in gaining reaches and connected losing reaches depends on the difference in their respective water level elevations and the physical properties of the streambed through which the flow exchange occurs. The rate of streamflow depletion in disconnected losing reaches is not dependent on the difference in groundwater and surface water elevations but is instead controlled by the surface water elevation and the physical properties of the streambed.

Surface waters with a perennial hydraulic connection to groundwater in the Subbasin are assumed to include perennial reaches of the Napa River and its tributaries (**Figure 3-5**). Surface waters with an intermittent hydraulic connection to groundwater in the Subbasin include some intermittent reaches of the Napa River and its tributaries. Reaches of some tributaries, including Dry Creek from the Subbasin margin to at least Highway 29, may be hydraulically disconnected from groundwater (LSCE, 2020). Results from hydrologic modeling suggest the hydraulic connections between surface water and groundwater are dynamic and vary spatially and temporally.

3.1.5. Environmental History

San Francisco Estuary Institute (SFEI) (2012) investigated the environmental history of the Napa River Watershed, including the Napa Valley Subbasin. Prior to European settlement, multi-threaded channels flowed across the Napa Valley Subbasin. Tributaries exited the uplands and flowed over alluvial fans toward the Napa River, with larger alluvial fans forming the western side of the Subbasin where rainfall and sediment supply were higher than tributaries on the eastern side of the Subbasin. Some of the tributaries did not connect to the Napa River, but all available flow infiltrated into the groundwater system, at least during low flows (SFEI, 2012). Once these tributaries were connected to the mainstem, the amount of water flowing out of the Napa Valley and into the marsh dramatically increased, and groundwater recharge decreased (SFEI, 2012). The historical channel network was much more complex than the current channel network, and side channels and sloughs along the Napa River likely supported expansive willow forests (SFEI, 2012).

Channel simplification, including channel straightening and bank armoring, increased the stress on the channel bed, causing at least six to nine feet of channel incision in most of the Subbasin (SFEI, 2012). As the Napa River continued to incise, the banks were able to confine more water, and the channels in the Subbasin further incised. Consequently, the extensive stands of native willows that made up the riparian zone were replaced in many locations by much deeper-rooted oak trees, which border many of the channels today. Because the channel network is more connected and there are less extensive floodplains, peak flows are higher and occur more rapidly than they did under historical conditions.

In addition to the changes to channel morphology, direct changes to flow through flow diversions, groundwater pumping, and drainage tiles have further altered the natural flow regime. Hundreds of small dams were constructed throughout the Subbasin, mostly for water supply (Stillwater Sciences and Dietrich 2002; SFEI, 2012). Notable water supply dams include Hennessey, Bell Canyon, Rector, and Milliken, located in the hills east of the Subbasin (but within the watershed), and Kimball Reservoir, located north of Calistoga. The dams and other infrastructure in the Napa River Watershed created numerous migration barriers for salmonids and other aquatic species (Napa County RCD, 2011). The Napa County RCD has identified many of these barriers and has been working to remove them and increase accessible upstream habitat for Chinook salmon and steelhead (Napa County RCD, 2011). Groundwater pumping has contributed to lowered groundwater levels and decreased ISW in the Subbasin, but the degree to which these changes have affected flow in different parts of the watershed remains an active area of monitoring and modeling. In some places, drainage tiles were installed underground to speed groundwater drainage below agricultural fields (SFEI, 2012). Watershed modeling suggests that changes such as increased network connectivity and changes in land coverage have caused peak flows to increase and baseflows to decrease relative to natural conditions (SFEI, 2012).

With changes to habitat and flow, there has been a large decline in fish populations, including the extirpation of coho salmon (*Oncorhynchus kisutch*) in the 1960s [Leidy et al., 2005] and a decline in steelhead population. The degree to which Chinook salmon were historically found in the watershed is not known (Stillwater Sciences and Dietrich, 2002). Nevertheless, the Napa River Watershed continues to support a diverse population of native fish and other aquatic species.

In 1990, the California Regional Water Quality Control Board listed the Napa River as impaired by fine sediment deposition, with fine sediment reducing bed cover and impacting spawning gravels throughout the watershed. The effects of fine sedimentation and other impacts that are unrelated to groundwater management will be considered during CEFF as part of the evaluation of flow effects on spawning and rearing habitat.

To increase available habitat for fish and increase fish populations, numerous stream restoration projects have been implemented throughout the watershed. These include restoration of vegetation, floodplain connectivity, habitat complexity, and dam removal. Planned and completed restoration projects on the Napa River mainstem and tributaries, include the Napa River/Napa Creek Flood Protection Project, Napa Salt Marsh, and Napa Plant Site restoration projects, several sediment reduction and habitat enhancement projects, and numerous bridge replacement and fish barrier removal projects.

3.2. Data Sources

The data sources related to the physical basin setting used to develop the preliminary EHCMs include shallow and deep monitoring wells, surface water-groundwater sites, Stream Watch, and the NVIHM. These sources are described below.

3.2.1. Shallow Monitoring Wells and Surface Water-Groundwater Sites

The GSP ISW monitoring network includes 13 dual-completion monitoring wells, for a total of 26 wells (**Table 3-2**). Dual-completion wells separately monitor groundwater conditions in shallow and deep alluvium at the same site (**Figure 3-9**), allowing for the measurement of vertical hydraulic gradients to better understand how groundwater and surface water interact. Five sites were installed in 2014 in the mainstem Napa River and at one site on Dry Creek and eight additional sites were installed in 2023. Groundwater levels are recorded at 4-hour intervals at these sites, along with stream stage and water quality data (**Sections 3.2.5** and **3.2.6; Figure 3-9**). Stream stage data at the eight sites installed in 2023 are still being evaluated for monitoring. It is expected stream monitoring will be installed in 2024.

Table 3-2. Dual Completion Monitoring Well Sites

Surface Water-Groundwater Monitoring Well	General Location	Installation Date
NapaCounty-214s/215d	Napa River at 1st St (Napa)	Fall 2014
NapaCounty-216s/217d	Napa River at Hwy 29 (Napa)	Fall 2014
NapaCounty-218s/219d	Napa River at Oak Knoll Ave (Napa)	Fall 2014
NapaCounty-220s/221d	Napa River at Yountville Cross Road (Yountville)	Fall 2014
NapaCounty-222s/223d	Napa River at Pope Street (St Helena)	Fall 2014
NapaCounty-247s/248d	Ritchy Creek at Bale Lane (Calistoga)	Spring 2023
NapaCounty-245s/246d	Napa River at Rutherford Rd. (Rutherford)	Spring 2023
NapaCounty-243s/244d	Soda Creek at Petra Dr. (Napa)	Spring 2023
NapaCounty-241s/242d	Napa River at S. Jefferson St. (Napa)	Spring 2023
NapaCounty-249s/250d	Redwood Creek at Redwood Rd (Napa)	Fall 2023
NapaCounty-251s/252d	Conn Creek at Oakville Cross Rd (Napa)	Fall 2023
NapaCounty-253s/254d	Sulphur Creek at Cemetery (St Helena)	Fall 2023
NapaCounty-255s/256d	Napa River at Deer Park Rd (St Helena)	Fall 2023

3.2.2. Deeper Groundwater Wells

Groundwater elevation is also monitored in approximately 96 (as of Spring 2023) deeper wells in the Subbasin, which can be used to track longer-term trends (LSCE, 2022b).

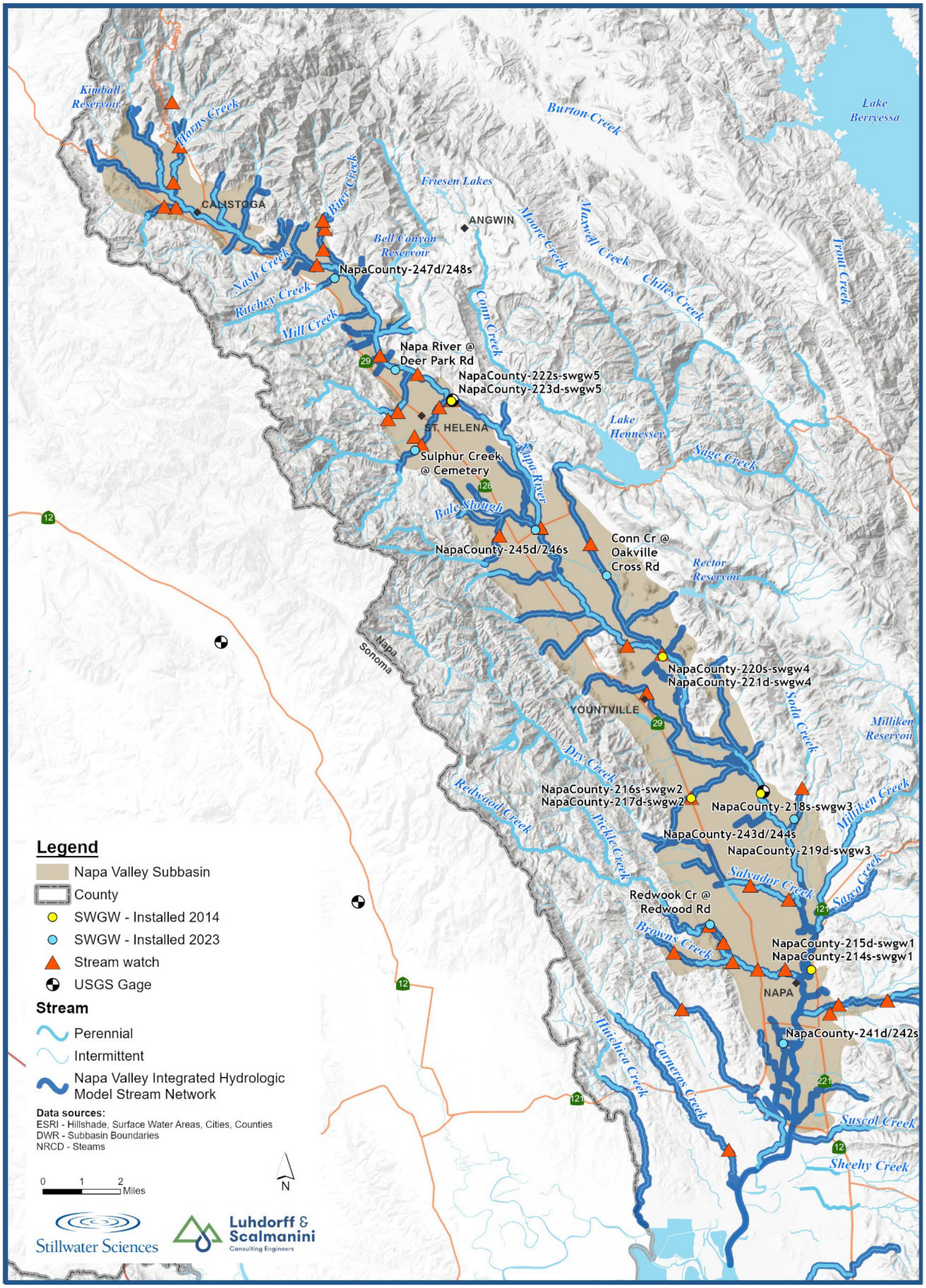


Figure 3-9. Map of SWGW Monitoring Locations, Stream Watch Sites, and NVIHM Stream Network Cells

3.2.3. Stream Watch

Since 2017, the Napa County RCD, in cooperation with the Napa County Watershed Information and Conservation Council, has collected streamflow observations through the Stream Watch community science program[3]. Trained volunteers collect data at 39 active Stream Watch sites, 35 of which are located within the Subbasin (**Figure 3-9**; note that the active Newell Creek and Murphy Creek sites are outside the map area). Volunteers record the site number, date, location, degree of litter, and flow condition and photograph the site at a set point. Flow condition is classified as "dry," "isolated pools," or "flowing." Initially, the program began with 10 Stream Watch sites, with gradual program expansion in 2019 and further program expansion in 2020 and 2022. Between 2016 and January 31, 2023, 3,528 observations were recorded in the Stream Watch database, with 1,147 observations in WY 2022. Although observations are episodic, Stream Watch data, combined with shallow groundwater monitoring data at the stream reach, help inform the understanding of interconnected surface water and surface flow response to changes in groundwater elevation.

3.2.4. Napa Valley Integrated Hydrologic Model

NVIHM was developed to simulate surface and near-surface farm-related processes and groundwater movement in the Napa Valley Groundwater Subbasin. The development of a calibrated model is intended to support water resources management and GSP development and implementation for the Subbasin. NVIHM has been developed to be used as a platform to evaluate historic hydrologic conditions and develop predictive modeling scenarios aimed at evaluating the impact of future management actions, projects, and adaptive management strategies.

NVIHM incorporates many types of data, including climate, surface water and recycled water supply, crop properties, soil type, surface water, and subsurface geology. The NVIHM also relies on estimates of evapotranspiration (ET) to calculate irrigation demand based on consumptive use for agriculture and landscaping. Since NVIHM accounts for interdependencies between landscape, climate, surface water, and groundwater, it can simulate the dynamics between different components of the hydrologic system and how they affect streamflow and stream-aquifer interaction.

Model simulations can also be used to evaluate stream depletion from groundwater pumping. This analysis relies on the development of synthetic scenarios where groundwater pumping from one or more water use sectors is removed. The difference in simulated streamflow in the synthetic model relative to the calibrated model is a measure of the stream depletion. The scenarios presented in this Workplan only assess depletion occurring from agricultural pumping. Additional scenarios to assess stream depletion by other groundwater users in the Subbasin are being developed.

[3] https://naparcd.org/streamwatch/

3.2.5. *Stream Stage and Discharge*

The stream stage and discharge monitoring network includes 37 sites in the Napa Valley Subbasin (**Figure 3-10**). The monitoring network includes two active USGS stream gages described in **Section 3.1.4**, one on the Napa River at Oak Knoll Avenue and another at Pope Street, both of which report stage and discharge. Seasonal streamflow depletion is calculated at these gages using the NVIHM. Napa County maintains five transducers that collect stream stage data adjacent to the SWGW sites (**Section 3.2.1**) at four-hour intervals. An additional eight stage monitors will be deployed in 2024 located at the shallow monitoring well sites installed in 2023 (**Table 3-1**). The Napa County Flood Control and Water Conservation District maintains 22 sites. In total, six sites monitor stage and discharge, and sixteen sites monitor stage only (LSCE, 2023). The Napa County Flood Control gages are not designed to track low flows. Upgrades to this system to monitor low flows is not feasible at this time.

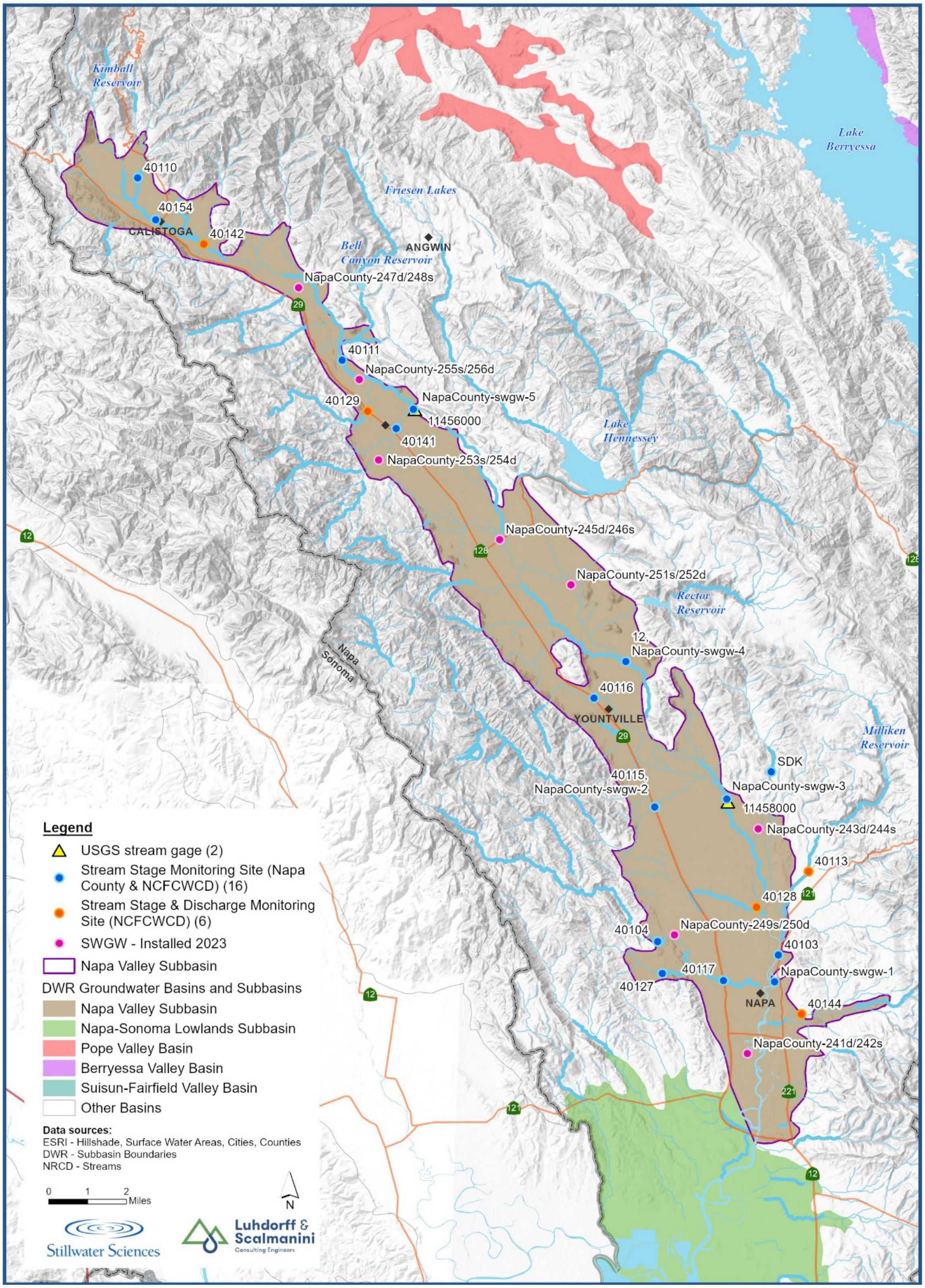


Figure 3-10. Stream Stage and Discharge Monitoring Network

3.2.6. Water Quality

Napa County monitors surface water temperature, conductivity, salinity, and total dissolved solids (TDS) at transducers adjacent to the five SWGW sites (**Section 3.2.1**) at one-hour intervals. These constituents will also be monitored at the eight SWGW sites installed in 2023. Surface water quality was historically measured at USGS gage on Napa Creek (USGS 11458300) from 1976-2018.

3.3. Ecological Setting

GDEs in the Napa Valley Subbasin include natural communities associated with springs, riparian areas, and marshes, as well as aquatic communities that rely on interconnected surface water. Aquatic and terrestrial special-status species and terrestrial natural plant communities that are connected to groundwater through their roots are discussed below. The analyses assume that all surface water in the Subbasin is potentially connected to groundwater at least some of the time. This assumption is explored further for intensive monitoring sites in **Section 5** and is based on NVIHM, shallow groundwater monitoring, Stream Watch, and stream stage and discharge data. The data in this section was used to develop the monitoring workplan outlined in **Section 6**.

The Napa River Subbasin contains 23 miles of critical habitat for steelhead (*Oncorhynchus mykiss*) and 230 acres of critical habitat for Contra Costa goldfields (*Lasthenia conjugens*) (**Figure 3-11**). Although critical habitat for Contra Costa goldfields lies within the Subbasin, it is not included in the analysis below because it is a vernal pool species and not groundwater dependent.

The Napa River and its tributaries are listed as impaired for sediment (RWQCB, 2009), and studies of benthic macro invertebrates in the watershed indicate a high diversity of taxa in the forested streams with declining diversity in streams bounded by agricultural fields and urban areas (Dewberry, 2022).

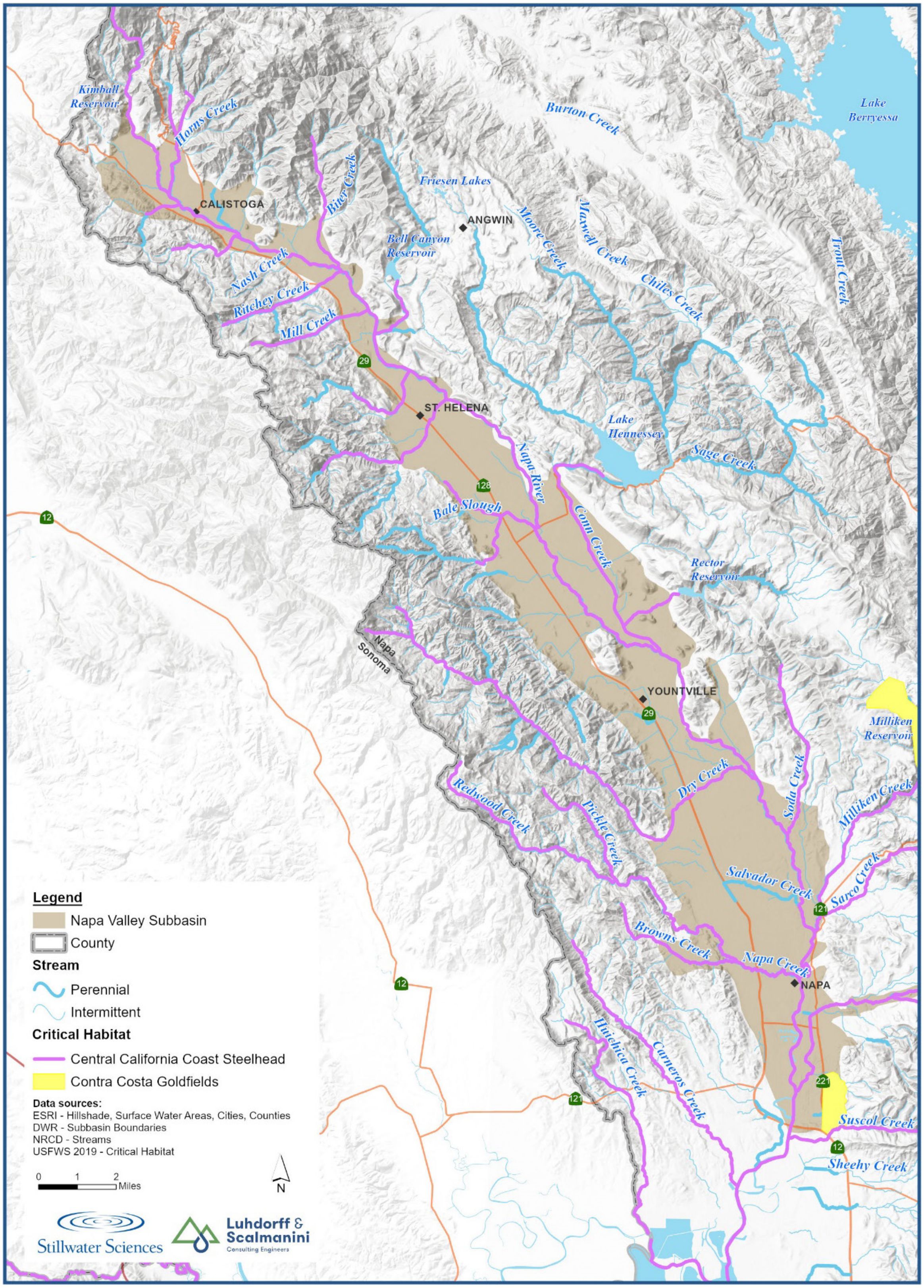


Figure 3-11. Critical Habitat in the Napa Valley Subbasin

3.3.1. Aquatic Species

3.3.1.1. Methods

The GSP *Napa Valley Subbasin Groundwater Sustainability Plan* (LSCE, 2022a) summarized the presence of special-status aquatic species observations in the Subbasin. This workplan includes additional review of existing special-status fish and aquatic wildlife species and aquatic habitat requirements. Wildlife species that were classified as aquatic include amphibians and reptile species that require waterbodies for breeding and/or spend the majority of their life cycle in water.

In this document, special-status aquatic species are defined as those:

- Listed, proposed, or under review as endangered or threatened under the Federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA);
- Designated by the California Department of Fish and Wildlife (CDFW) as a Species of Special Concern; and/or
- Designated by CDFW as Fully Protected under the California Fish and Game Code (Sections 3511, 4700, 5050, and 5515).

In addition to the GSP, existing data sources included:

- California Natural Diversity Database (CNDDB) (CDFW, 2023a);
- eBird (2023); and
- Literature review

Wildlife species were evaluated for potential groundwater dependence using determinations from the Critical Species Lookbook (Rohde et al., 2019) or by evaluating known habitat preferences, life histories, and diets in the literature. Aquatic wildlife species in the Napa Valley Subbasin are all directly dependent on interconnected surface water. Special-status species are summarized in **Table 3-3**.

3.3.1.2. Fish

The Napa Valley Subbasin supports a predominantly native fish assemblage consisting of a diverse community of sixteen native fish species, including steelhead, fall-run Chinook salmon (*Oncorhynchus tshawytcha*), Pacific and river lamprey (*Lampetra tridentata, L. ayresi*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), tule perch (*Hysterocarpus traski*), and Sacramento splittail (*Pogonichthys macorlepidotus*) (Leidy 1997). Salmonid habitat and usage were estimated based on the Napa County RCD's ongoing work to characterize stream segments in the Napa River watershed. Chinook salmon primarily use the mainstem Napa River, while steelhead use the mainstem Napa and its tributaries (**Figure 3-12**). The mainstem Napa River provides approximately 29.8 miles of viable salmonid spawning habitat (**Figure 3-13**). Additionally, there are approximately 141 miles of tributary streams in the watershed that support salmonid spawning and freshwater rearing (Napa County RCD 2016), with extensive habitat upstream of the Subbasin (**Figure 3-11**). Three special-status fish species (steelhead, Pacific Lamprey and longfin smelt *[Spirinchus thaleichthys]*) spawn and rear within the Napa Valley Subbasin. While not a listed species in the Napa Valley Subbasin, supporting Chinook salmon has been a long-term goal in Napa County, and numerous restoration and monitoring efforts support Chinook and steelhead.

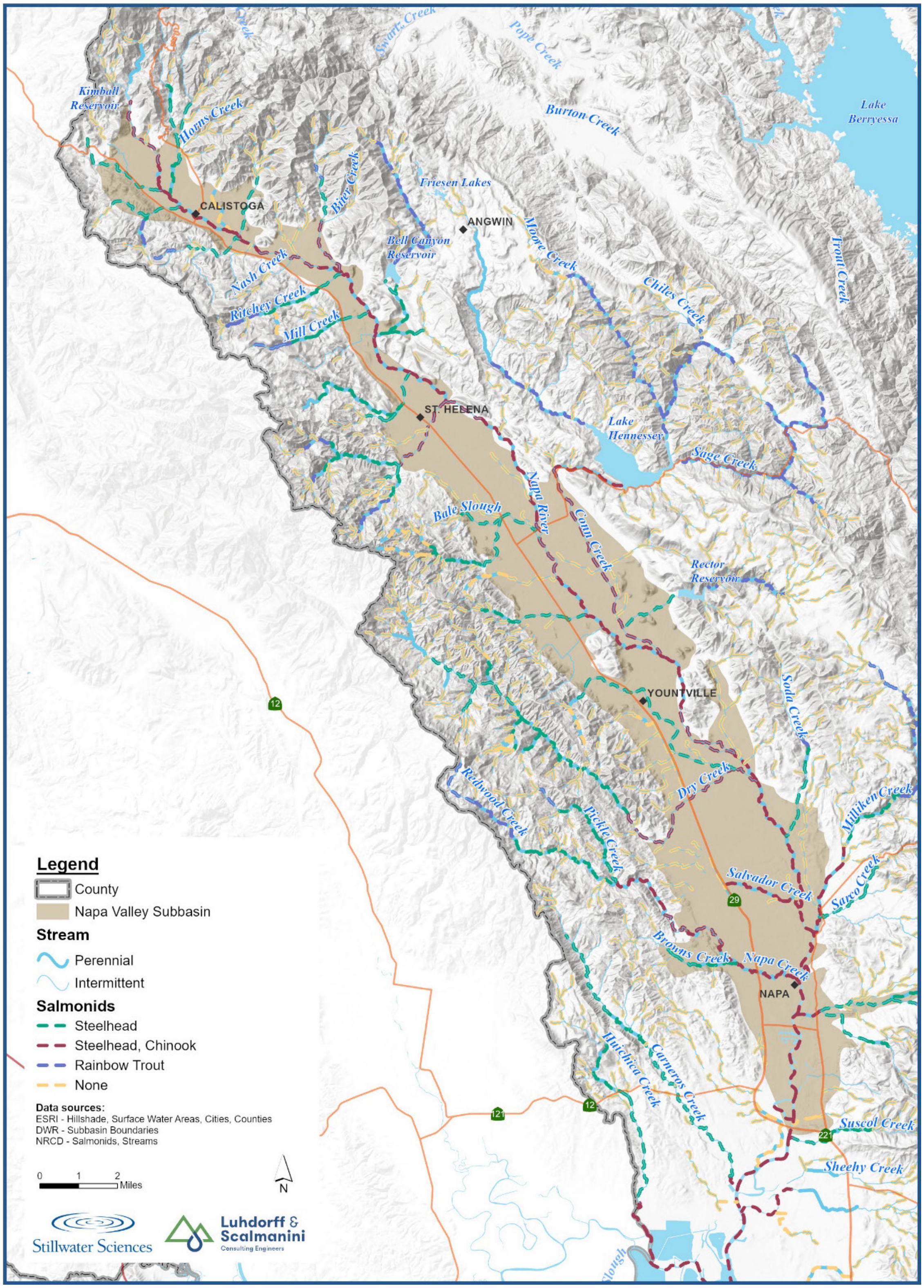


Figure 3-12. Salmonid usage in the Napa Valley Watershed Mapped by the Napa County RCD

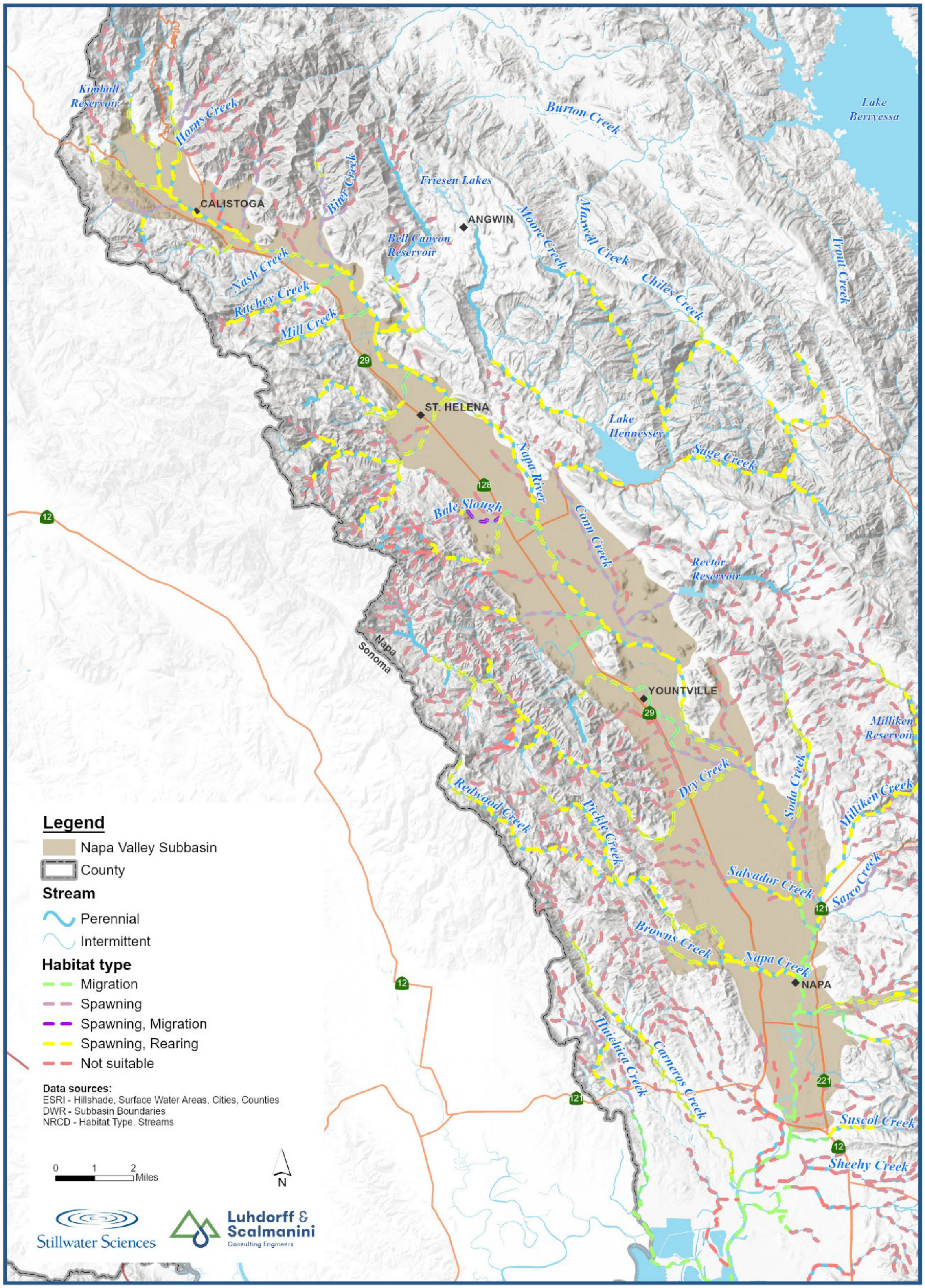


Figure 3-13. Salmonid Habitat Type in the Napa Valley Subbasin mapped by the Napa County RCD

Steelhead

Steelhead in the Napa River and its tributaries are part of the Central California Coast (CCC) distinct population segment (DPS), which is listed as Threatened under the ESA. Juvenile steelhead spend between one and four years rearing in freshwater and, therefore, require adequate year-round habitat. Generally, juvenile steelhead in central California coast streams spend two years in freshwater and, during that time, may travel within and between streams to seek out suitable habitat at higher flows. Environmental conditions during spring, including invertebrate production, water volume, and water temperature, are likely the key factors affecting steelhead growth in Napa River tributaries (Stillwater Sciences 2007). Juvenile steelhead have been documented in 26 streams in the Napa River drainage, in tributaries to the east and west of the mainstem Napa River (Stillwater Science 2006). Juveniles begin to smolt and migrate downstream to seek out foraging opportunities when they reach about 100 mm in length (National Oceanic and Atmospheric Administration [NOAA], 2016; Moyle, 2002). Between March and May, steelhead smolts migrate from their rearing grounds to the mainstem Napa River and San Pablo Bay. When flow conditions permit, out migrating smolts are counted at the Napa County RCD's rotary screw trap between Oak Knoll Avenue and Trancas Street (Napa County RCD, 2012; 2020).

Adult steelhead typically return to spawn in the Napa River and its tributaries between January and March. Migratory pulses are associated with high outflow events. Individuals that arrive when low flows make upper tributaries inaccessible may hold in deeper pools or the river mainstem until winter storm events facilitate passage into spawning reaches (Moyle, 2002). Steelhead typically spawn in tributaries with perennially flowing, cool, well-oxygenated water. In the Napa River Watershed, designated critical habitat for CCC steelhead includes sections of the mainstem Napa River and several of its tributaries (**Figure 3-11**). Limited information is available on adult steelhead movement patterns. The Napa River historically supported a run of 6,000-8,000 steelhead (USFWS 1968); however, the run had declined to an estimated 2,000 adults by the late 1960s (USFWS, 1968). The current run of steelhead is estimated to range from hundreds up to perhaps one thousand fish (Napa County RCD, 2016).

Temperature tolerance for steelhead is often reported as 19-20°C. A recent data compilation by Drenner et al. (in preparation) found that steelhead can occur in high density at temperatures in excess of 20°C, suggesting that *O. mykiss* in this region have increased thermal tolerance compared to more northern populations.

Chinook Salmon

The Napa River Watershed supports a population of fall-run Chinook salmon. Chinook salmon in the watershed are not included in the nearby Central Valley Fall/late Fall Evolutionarily Significant Unit (ESU) or the California Coastal Chinook Salmon ESU and, therefore, are not a special-status species. Chinook primarily spawn and rear in the mainstem Napa River but also use some tributaries, including Redwood Creek, Dry Creek, Conn Creek, Napa Creek, Salvador Creek, and Sulphur Creek (**Figure 3-12**).

Juvenile Chinook rear in the Napa River for between two and five months after emerging. Juvenile Chinook have been observed as late as August in Redwood Creek (Stillwater Sciences, 2011). Chinook salmon smolt outmigration typically occurs during the spring and peaks in May (Napa County, RCD 2016).

Spawning migration timing is dependent on rainfall patterns but typically occurs between late September and early October. Peak Chinook spawning in the Napa River generally occurs from November through early January (Napa County, RCD 2016). Annual spawning is well documented and occurs throughout the 25 miles of the mainstem Napa River between Calistoga and Oak Knoll Avenue (Napa County, RCD 2020).

Longfin Smelt

Longfin smelt have been observed in the vicinity of the Napa Valley Subbasin and are listed as Threatened under the California Endangered Species Act. Most longfin smelt exhibit a two-year life cycle, spawning and dying during their second year. However, during good growth years, longfin smelt can spawn at the end of their first year, and three-year-old smelt have also been observed (Moyle, 2002). Spawning occurs in freshwater during the winter to early spring (February through April) over sandy or gravel substrate. Most smelt die after spawning, but a few (mostly females) may live another year. The eggs are adhesive and hatch in 40 days when water temperatures are 7°C. Newly hatched larvae are 5-8 millimeters (mm) long. Larvae can be moved downstream to estuaries by high flows but may also spend considerable time in fresh water. It takes almost three (3) months for longfin smelt to reach the juvenile stage (USFWS, 2012). CNDDB occurrences of longfin smelt in the watershed are restricted to the lower sections of the mainstem Napa River downstream of the Riverside Drive Boat Ramp. Longfin smelt were detected at Station 349 (near the Riverside Drive Boat Ramp) as part of the Interagency Ecologic Program (IEP) surveys (Merz et al., 2013, IEP, 2024) near the southern extent of the Subbasin.

Pacific Lamprey

The Napa River Watershed is one of seven Bay Area watersheds with Pacific lamprey (Boyce et al., 2022). Over the last 50 years, the population of Pacific lamprey has declined due to barriers to upstream migration, habitat loss and modification, and a decrease in channel connectivity. Consequently, they are listed as a California State Species of Special Concern and a USFWS Species of Concern (CDFW, 2023a). The Pacific lamprey is an anadromous species that spends its adult life in the open ocean, parasitizing salmon and other fish before migrating to freshwater streams. Once they enter the stream, Pacific lamprey can spend a few months migrating upstream to spawn. Lamprey spawn in gravels (25-75 mm) and die soon after depositing and fertilizing their eggs. Larval lamprey, or ammocoetes, spend time in slower moving water with fine substrate, and as they mature into juveniles, they begin their migration back to the open ocean, where they spend as long as five years growing before repeating their life cycle and returning to freshwater (CDFW, 2023a). Lamprey in the Napa River Watershed are not as limited by instream barriers to migration compared to populations in other locations, but instead, they are limited by water quality and stream connectivity (Boyce et al., 2022). Pacific lamprey have been observed at the Napa County RCD rotary screw trap every year of its operation (Napa County RCD, 2020). In 2020, 964 juveniles, two ammocoetes, and no adults were observed over the 11 days the trap was operating (Napa County RCD, 2020).

3.3.1.3. Wildlife

Five special-status aquatic wildlife species were previously documented in the Napa Valley Subbasin; of these, four were identified as being likely to be associated with groundwater interconnected with surface water. These include one crustacean (California Freshwater Shrimp [*Syncaris pacifica*]), two amphibians (California giant salamander [*Dicamptodon ensatus*], foothill yellow-legged frog *Rana boylii*]), and reptile (northwestern pond turtle [*Emys marmorata marmorata*]). One amphibian species, California Red-legged Frog [*Rana draytonii*]), historically occurred in the Subbasin but is currently extirpated (CDFW, 2023a). **Table 3-3** summarizes the special-status fish and wildlife species that are associated with groundwater, including groundwater association, location within the Subbasin, general habitat characteristics, and aquatic habitat requirements.

Table 3-3. Special-status Aquatic Wildlife, Fish Species, and Sensitive Natural Communities Associated with Groundwater in the Napa Valley Subbasin					
Common Name ***Scientific Name***	**Status1 Federal/State**	**Associated with groundwater[2]**	**Potential to Occur within the Subbasin[3]**	**General Habitat**	**Aquatic Habitat Requirements**
Fish					
Steelhead *Oncorhynchus mykiss*	FT/–	Direct; thermal refuge during warm months	Likely; known occurrences in the Napa River and 26 streams in the Napa Valley drainage and in tributaries to the east and west of the mainstem Napa River (NCRD, 2011)	Anadromous forms use perennial streams and rivers from the ocean to the upper reaches of watersheds.	Cool, deep pools and riparian canopy cover act as important thermal refuges in the summer months. Juveniles require high flow refuge in the form of undercuts, side channels, and floodplains in the winter months. A recent data compilation by Drenner et al. (in preparation) found that steelhead can occur in high density at temperatures in excess of 20 deg. C, suggesting that O. mykiss in this region have increased thermal tolerance compared to more northern populations (which have an upper limit of thermal tolerance at 19-20°C.
Longfin smelt *Spirinchus thaleichthys*	–/ST	Direct; breeding may occur in waterbodies associated with groundwater and interconnected surface water	Likely; known occurrences in the lower section of the Napa River mainstem (CDFW, 2023c)	Inhabits a wide range of salinities, from bays and estuaries to brackish and freshwater, and is also found in wetlands and marshlands.	While this species is mainly known to inhabit estuaries, recent evidence suggests the use of freshwater as a part of their life cycle. Little information exists for their specific use and the phenological timing of freshwater movements.
Pacific Lamprey *Entosphenus tridentatus*	FSC/SSC	Direct; breeding may occur in waterbodies associated with groundwater and interconnected surface water	Likely; known occurrences in the mainstem Napa River and lower reaches of connected tributaries (Napa County RCD, 2020)	Anadromous; adults migrate from open ocean to rivers and tributaries to lay eggs. After hatching, juveniles reside in freshwater for 3-7 years before migrating to the open ocean.	Adults require cool, clean water and gravel substrate for spawning; juveniles require finer substrate for burrowing and calmer waters found in stream margins and off channel habitats.
Crustaceans					
California Freshwater Shrimp *Syncaris pacifica*	FE/SE	Direct (interconnected surface water)	Likely; known occurrences in Napa River and Garnett Creek in Calistoga (CDFW 2023c)	Low-elevation, low-gradient perennial or intermittent freshwater streams with perennial pools and structurally diverse banks	Within streams, this species occupies edge habitats, including glides, pools, and, to a lesser extent, riffles. The limited studies on this species have found it associated with areas of low flow, mid-channel depths of 1 to 4 feet, water temperatures of 7 to 16°C, dissolved oxygen levels of 3.3 to 12.3 mg per liter, and pH values between 5.9 to 9.1. In streams with these qualities, the shrimp is found in undercut banks that have exposed root material, woody debris, and/or overhanging vegetation. These habitat characteristics are required to prevent the shrimp from being washed away during high-flow events.
Amphibian					
California giant salamander *Dicamptodon ensatus*	–/SSC	Direct; breeding may occur in waterbodies associated with groundwater and interconnected surface water	Likely; historical occurrences in Sulphur Creek in St. Helena and population assumed extant (CDFW 2023c)	Wet coastal forests in or near clear, cold, permanent and semi-permanent streams and seepages.	This species reproduces in perennial, cold water streams. Eggs are thought to be deposited between October and March underneath instream objects like logs and rocks. Females will stay and guard the nest until it hatches. Larvae can take up to three years to undergo metamorphosis, with the average time being 18 to 24 months. Neotenic individuals have been documented in this species, though it is rare.

Table 3-3. Special-status Aquatic Wildlife, Fish Species, and Sensitive Natural Communities Associated with Groundwater in the Napa Valley Subbasin					
Common Name ***Scientific Name***	**Status1 Federal/State**	**Associated with groundwater[2]**	**Potential to Occur within the Subbasin[3]**	**General Habitat**	**Aquatic Habitat Requirements**
Foothill yellow-legged frog (northwest/north coast clade) *Rana boylii*	–/SSC	Direct (interconnected surface water)	Likely; known occurrences in tributaries to Napa River (Sulphur Creek and Dry Creek) in St. Helena and Yountville (CDFW 2023c)	Shallow tributaries and mainstems of perennial streams and rivers, typically associated with cobble or boulder substrate; occasionally found in isolated pools, vegetated backwaters, and deep, shaded, spring-fed pools; the frog is reliant on surface water that may be fed by groundwater.	This species deposits egg masses from March through June along cobble bars, under boulders, or in pools. The physical characteristics at deposition sites include low flows (<.3 ft/sec), depths of 2 to 12 inches (when measured from the surface of the water to the top of the egg mass), and water temperatures between 9 to 21.5°C. Eggs hatch in 5 to 37 days after laying. Larvae are typically found next to their egg mass for the first week or two after hatching before moving into shallow warm water habitats with an abundance of algae. They undergo metamorphosis 3 to 4 months after hatching.
California Red-legged Frog *Rana draytonii*	FT/SSC	Direct (interconnected surface water)	Unlikely; historic observation in Calistoga, population presumed extirpated[4] (CDFW 2023c)	Breeds in still or slow-moving water with emergent and overhanging vegetation, including wetlands, wet meadows, ponds, lakes, and low-gradient, slow-moving stream reaches with permanent pools; uses adjacent uplands for dispersal and summer retreat.	This species deposits egg masses from November through May, typically in ponds or pools along intermittent streams. They require slow moving water, with boulders, vegetation, or woody debris used as a deposition substrate for their egg masses. While egg masses are frequently located within four feet of shore and at depths less than one and a half feet, they can be laid 40 feet from shore and at depths of 10 feet. Larvae may undergo metamorphosis four to eight months after hatching but can overwinter.
Reptile					
Northwestern Pond Turtle *Emys marmorata marmorata*	–/SSC	Direct (interconnected surface water)	Likely; known occurrences include Napa River and tributaries in Napa, Yountville, MST, St. Helena, and Calistoga (CDFW 2023c)	Ponds, lakes, rivers, streams, creeks, marshes, and irrigation ditches with basking sites; feeds on aquatic plants, invertebrates, worms, frog and salamander eggs and larvae, crayfish, and occasionally frogs and fish; relies on surface water that may be supported by groundwater (Rohde et al. 2019)	These turtles typically inhabit ponds and slower moving, deep sections of streams with emergent objects to bask on. Underwater objects are also important habitat features. In warmer areas, shallow edge water habitat can offer underwater basking sites. Backwater habitat and side channels offer refuge during high flow events. This species nests in the upland around their aquatic habitat, up to 0.6 miles away.

1. Status codes

   Federal
   - FE = Listed as endangered under the federal ESA
   - FT = Listed as threatened under the federal ESA
   - FSC = USFWS Species of Concern

   State
   - SE = Listed as Endangered under CESA
   - ST = Listed as Threatened under CESA
   - SSC = CDFW Species of Special Concern

2. Groundwater Dependent Ecosystem (GDE) association:

   Direct: Species directly dependent on groundwater for some or all water needs

   Indirect: Species dependent upon other species that rely on groundwater for some or all water needs

3. Potential to Occur:

   Likely: the species has documented occurrences, and the habitat is high quality or quantity

   None: no potential to occur due to lack of habitat and/or the population is assumed extirpated

4. Ongoing efforts to reintroduce this species to Napa County, with the latest set of egg mass relocations occurring in 2023.

3.3.2. Terrestrial Species and Ecosystems

Terrestrial GDEs are analyzed below using vegetation communities, special-status plants, and terrestrial wildlife.

3.3.2.1. Vegetation Communities

The GSP identified potential GDE units in the Napa River (LSCE, 2022a). This Workplan summarizes the additional review of existing vegetation communities and outlines methods for monitoring surveys. Available information on vegetation communities and groundwater dependence was reviewed to refine groundwater dependency assessments and inform field-based monitoring methodology.

In addition to the GSP, existing data sources were reviewed, including but not limited to:

- iGDE database (Klausmeyer et al. 2018),
- Napa County Vegetation Map (2016 update) (University of California, Davis [UC Davis] 2016),
- National Wetlands Inventory (NWI) (USFWS, 2023), and
- National Agriculture Imagery Program (NAIP) (USDA, 2022) Napa County: Imagery date: 2022; Resolution: 1 meter.

The steps for defining GDEs outlined in Rohde et al. (2018) were used as a guideline for this process. A decision tree was applied to determine when species or biological communities were considered groundwater-dependent based on definitions found in the 23 California Code of Regulations (CCR) § 351(m) (State of California, 2021) and Rohde et al. (2018). This decision tree, created to systematically and consistently address the range of conditions encountered, is summarized below; the term "unit" refers to an area with consistent vegetation and hydrology.

The unit is a GDE if groundwater is likely:

- Interconnected with surface water in a stream channel;
- An important hydrologic input to the unit during some time of the year;
- Important to survival and/or natural history of inhabiting species; and
- Associated with a principal aquifer used as a regionally important source of groundwater.

The unit is not a GDE if its hydrologic regime is primarily controlled by:

1. Surface discharge or drainage from an upslope human-made structure(s) with no connection to a principal aquifer (such as irrigation canals, irrigated fields, reservoirs, cattle ponds, or water treatment ponds/facilities); or
2. Precipitation inputs directly to the unit surface (this excludes vernal pools from being GDEs where units are hydrologically supplied by direct precipitation and very local shallow subsurface flows from the immediately surrounding area).

For the Napa Valley Subbasin, the aquifers relevant to GDEs include the alluvial sediments that directly underlie the channel bed, as well as smaller outcroppings of volcanic units. Volcanic outcroppings generally occur in the southern Calistoga area between the Napa River and Silverado Trail and near the confluence of Napa and Biter Creeks. Some riparian species may use perched groundwater or disconnected surface water, but both of these sources are limited during the growing season in the Napa Valley.

Results

There were 12 vegetation communities identified as being likely associated with groundwater in the Napa Valley Subbasin. An additional eight vegetation communities were identified as possibly associated with groundwater. These vegetation communities are mostly affiliated with riparian areas along tributaries to the Napa River throughout the Subbasin. These vegetation communities are shown in **Figure 3-14** and summarized in **Table 3-4**.

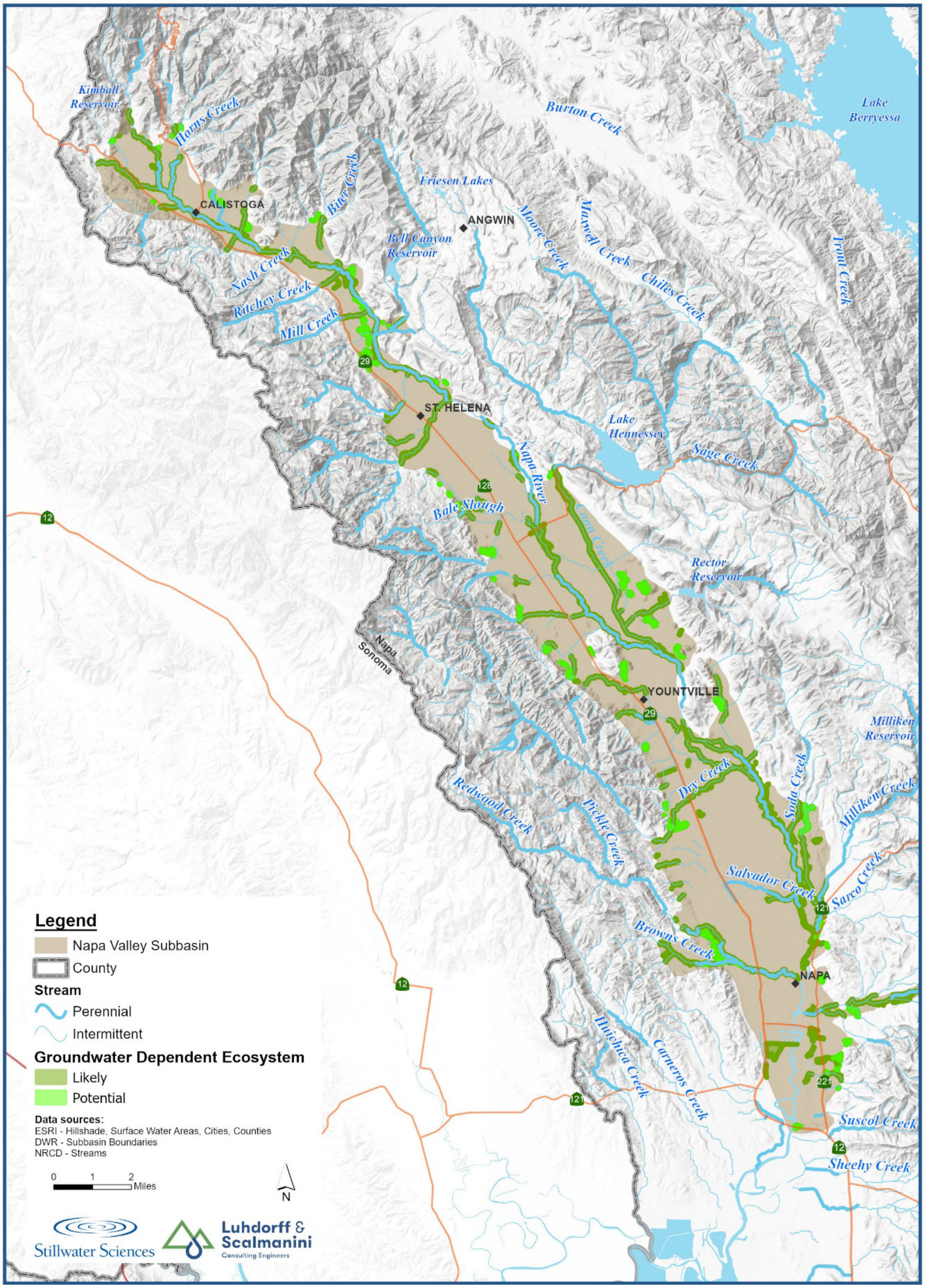


Figure 3-14. Terrestrial Groundwater Dependent Ecosystems in the Napa Valley Subbasin

Table 3-4. Potential GDEs Identified in the Napa Valley Subbasin				
Vegetation Community	**Associated with Groundwater**	**State Rarity[1]**	**Location within the Subbasin**	**Acres**
(Bulrush–Cattail) Fresh Water Marsh *Typha* spp.	Likely	S5	Near the Old Faithful Geyser; lower end of Napa River/floodplain	133
Blue Oak *Quercus douglasii*	Likely	S4	Along tributaries	226
California Bay–Leather Oak–(Rhamnus spp.–Foothill Pine) Mesic Serpentine *Umbellularia californica–Quercus durata–Rhamnus* spp. *Pinus sabiniana*	Possible	S3	Few populations along the west edge of the Subbasin	21.4
California Bay–Madrone–Coast Live Oak–(Black Oak–Big Leaf Maple) *Umbellularia californica–Arbutus menziesii–Quercus agrifolia–Quercus kelloggii–Acer macrophyllum*	Possible	S3	Many populations throughout the Subbasin; some riparian, some not	519
Coast Live Oak *Quercus agrifolia*	Likely	S4	Along tributaries; in patches on north-facing slopes	1213
Coast Live Oak–Blue Oak–(Foothill Pine) *Quercus agrifolia–Quercus douglasii*	Likely	S4	Along tributaries; in patches on north-facing slopes	832
Coast Redwood *Sequoia sempervirens*	Likely	S3	Two small populations along tributaries on the west side of Subbasin	15.6
Coast Redwood–Douglas-fir / California Bay *Sequoia sempervirens–Pseudotsuga menziesii–Notholithocarpus densiflorus*	Likely	S3	One small population along the road above a tributary	0.11

Table 3-4. Potential GDEs Identified in the Napa Valley Subbasin				
Vegetation Community	**Associated with Groundwater**	**State Rarity[1]**	**Location within the Subbasin**	**Acres**
Eucalyptus *Eucalyptus* spp.–*Ailanthus altissima–Robinia pseudoacacia*	Possible	SNA	Throughout the Subbasin, occasionally near tributaries	53.1
Leather Oak–California Bay–Rhamnus spp. Mesic Serpentine Chaparral *Quercus durata–Umbellularia californica–Rhamnus* spp.	Possible	S4	One small population near a small reservoir	0.19
Leather Oak–White Leaf Manzanita–Chamise Xeric Serpentine *Quercus durata–Arctostaphylos viscida–Adenostoma fasciculatum*	Possible	S4	Three small populations along tributaries	6.26
Mixed Oak *Quercus* (*agrifolia, douglasii, garryana, kelloggii, lobata, wislizeni*)	Possible	S4	Many populations throughout the Subbasin except along the Napa River mainstem; riparian and not	652
Mixed Willow *Salix* spp.	Likely	N/A	Riparian areas, including near Napa River mainstem	92.5
Oregon White Oak *Quercus garryana*	Likely	S3	On slopes of the west side of the Subbasin; occasionally near tributaries	90.2
Riverine, Lacustrine, and Tidal Mudflats	Possible	N/A	One small population at Napa Marsh	18.9
Serpentine Grasslands	Possible	N/A	One small population on a slope on the west side of the Subbasin	4.55
Valley Oak *Quercus lobata*	Likely	S3	Along tributaries; remnant patches among agricultural land	245

Table 3-4. Potential GDEs Identified in the Napa Valley Subbasin				
Vegetation Community	**Associated with Groundwater**	**State Rarity[1]**	**Location within the Subbasin**	**Acres**
Valley Oak–(California Bay–Coast Live Oak–Walnut–Ash) Riparian Forest *Quercus lobata–Umbellularia californica–Quercus agrifolia–Juglans californica–Fraxinus* spp.	Likely	S3	Lining most tributaries and Napa River mainstem south to the City of Napa	1965
Valley Oak–Fremont Cottonwood–(Coast Live Oak) Riparian Forest *Quercus lobata–Populus fremontii–*(*Quercus agrifolia*)	Likely	S3	Along tributaries, especially at the southern end of the Subbasin	269
Water	Possible	N/A	Typically, small ponds associated with agriculture (does not include interconnected surface water that makes up the Napa River and its tributaries)	751
White Alder (Mixed Willow–California Bay–Big Leaf Maple) Riparian Forest *Alnus rhombifolia–Salix* spp.*–Umbellularia californica–Acer macrophyllum*	Likely	S4	Along tributaries in the upper watershed; one in the lower watershed along Spencer Creek	27.2

NOTE: This Table does not include interconnected surface water ecosystems

1. State Rarity Rank

   S1 Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.

   S2 Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

   S3 Vulnerable—At moderate risk of extinction or elimination due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.

   S4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.

   S5 Demonstrably Secure—Common; widespread and abundant.

   SNA Not Applicable

3.3.2.2. Special-status Plants and Sensitive Natural Communities

Methods

The GSP (LSCE, 2022a) identified special-status plant species and sensitive natural communities that have the potential to occur within the Subbasin. In this document, special-status plant species are defined as those:

- Listed, proposed, or under review as endangered or threatened under ESA or CESA;
- Designated as endangered or rare under the California Native Plant Protection Act (CNPPA); and/or
- Taxa that meet the criteria for listing as described in Section 15380 of the CEQA Guidelines, including species listed on CDFW's (CDFW, 2023b) or plants with a California Rare Plant Rank (CRPR) of 1, 2, 3, or 4.

A query of existing data from the CNDDB (CDFW, 2023a) was performed, including the Napa Valley Subbasin plus a one-mile buffer. This buffer accounts for spatial uncertainty in the data sources.

Database query results were reviewed for special-status plant species and sensitive natural communities that may occur within or be associated with, terrestrial or aquatic potential GDEs. These special-status plant species and sensitive natural community types were then consolidated into a list, along with summaries of habitat preferences, potential groundwater dependence, and reports of any known occurrences.

Sensitive natural communities were classified as either likely or unlikely to depend on groundwater based on species composition using the same methodology as vegetation communities (**Section 2.1**). Plant species were evaluated for potential groundwater dependence based on their habitat (Jepson Flora Project 2023) and association with terrestrial or aquatic communities classified as potential GDEs. Special-status plant GDE associations were assigned one of three categories: likely, possible, or unlikely. The "possible" category was included to classify plant species with limited habitat data or where a species may have an association with a vegetation community identified as a GDE.

Results

Of the 37 special-status plant species previously documented in the Napa Valley Subbasin, two species were identified as being likely associated with groundwater, and an additional 13 species were identified as possibly associated with groundwater. These special-status plant species are mostly in the northernmost and southernmost ends of the Subbasin, near springs and the Napa River mainstem, respectively. **Table 3-5** summarizes the special-status plant species and sensitive natural communities that are associated with groundwater, including habitat and occurrence information.

Table 3-5. Special-status Plant Species and Sensitive Natural Communities Associated with Groundwater in the Napa Valley Subbasin

Common name *Scientific name*	Status (Federal/State/ CRPR)[1]	Association with groundwater	Habitat and occurrence
Special-status plants			
Pappose tarplant *Centromadia parryi* subsp. *parryi*	–/–/1B.2	Possible, occurs in seeps, which may be associated with groundwater	Often in alkaline soils in chaparral, coastal prairie, coastal salt marshes and swamps, meadows and seeps, vernally mesic areas of valley and foothill grassland; known occurrences observed in Calistoga in seasonal wetlands. Historical records are associated with hot springs.
San Joaquin spearscale *Extriplex joaquinana*	–/–/1B.2	Possible, occurs in seeps, which may be associated with groundwater	Alkaline soils in chenopod scrub, meadows and seeps, playas, valley and foothill grassland; known occurrence observed in wet areas adjacent to the Napa River in the southern end.
Burke's goldfields *Lasthenia burkei*	FE/CE/1B.1	Possible, occurs in seeps, which may be associated with groundwater	Mesic soils in meadows and seeps, vernal pools; known occurrence is near the Old Faithful geyser in Calistoga.
Delta tule pea *Lathyrus jepsonii var. jepsonii*	–/–/1B.2	Possible, habitat may be associated with groundwater	Brackish and freshwater marshes and swamps; known occurrences are adjacent to the Napa River at the southern end of the Subbasin.
Mason's lilaeopsis *Lilaeopsis masonii*	–/CR/1B.1	Possible, habitat may be associated with groundwater	Brackish and freshwater marshes and swamps, riparian scrub; known occurrences are along the Napa River in the southern end of the Subbasin.
Sebastopol meadowfoam *Limnanthes vinculans*	FE/CE/1B.1	Possible, occurs in seeps, which may be associated with groundwater	Vernally mesic soils in meadows and seeps, valley and foothill grassland, and vernal pools; known occurrences are in seasonally wet areas, including at the Yountville Ecological Reserve.
Baker's navarretia *Navarretia leucocephala* subsp. *bakeri*	–/–/1B.1	Possible, occurs in seeps, which may be associated with groundwater	Mesic soils in cismontane woodland, lower montane coniferous forest, meadows and seeps, valley and foothill grassland, and vernal pools; known occurrence was in a vernal pool near Calistoga and has been extirpated.
Calistoga popcornflower *Plagiobothrys strictus*	FE/CT/1B.1	Likely, occurrence associated with a GDE	Alkaline areas near thermal springs in meadows and seeps, valley and foothill grassland, and vernal pools; known occurrence information is non-specific within the Calistoga USGS Quad, in geyser-fed grassland swales.
Napa blue grass *Poa napensis*	FE/CE/1B.1	Likely, occurrence associated with a GDE	Alkaline areas near thermal springs in meadows and seeps and valley and foothill grassland; known occurrences are near hot springs in Calistoga.
California alkali grass *Puccinellia simplex*	–/–/1B.2	Possible, occurs in seeps, which may be associated with groundwater	Alkaline soils, flats, lake margins, vernally mesic soils in chenopod scrub, meadows and seeps, valley and foothill grassland, and vernal pools; known occurrence is near hot springs in Calistoga.
California beaked-rush *Rhynchospora californica*	–/–/1B.1	Possible, occurs in seeps, which may be associated with groundwater	Bogs and fens, lower montane coniferous forest, freshwater marshes and swamps, and seeps; known occurrence is in a spring-fed marsh on Mount George.
Sanford's arrowhead *Sagittaria sanfordii*	–/–/1B.2	Possible, habitat may be associated with groundwater	Shallow freshwater marshes and swamps; known occurrence is in a swampy area in Yountville.
long-styled sand-spurrey *Spergularia macrotheca* var. *longistyla*	–/–/1B.2	Possible, occurs in seeps, which may be associated with groundwater	Alkaline soils in marshes and swamps, meadows and seeps; known occurrences are near hot springs in Calistoga.
Suisun Marsh aster *Symphyotrichum lentum*	–/–/1B.2	Possible, habitat may be associated with groundwater	Brackish and freshwater marshes and swamps; known occurrence is along a ruderal railroad berm on the west edge of Napa Municipal Golf Course.
Saline Clover *Trifolium hydrophilum*	–/–/1B.2	Possible, habitat may be associated with groundwater	Marshes and swamps, mesic and alkaline soils in valley and foothill grassland, and vernal pools; known occurrences are various wet habitats, including spring-fed marsh and stream, and one occurrence has been extirpated by development.

Table 3-5. Special-status Plant Species and Sensitive Natural Communities Associated with Groundwater in the Napa Valley Subbasin			
Common name *Scientific name*	**Status (Federal/State/ CRPR)[1]**	**Association with groundwater**	**Habitat and occurrence**
Sensitive natural communities			
Coastal and Valley Freshwater Marsh	S2.1	Likely, occurrence associated with a GDE	Known occurrence is east of Tubbs Lane and adjacent to the Old Faithful Geyser of California; CNDDB record indicates geyser fed swale habitat
Coastal and Valley Freshwater Marsh	S2.1	Likely, occurrence associated with a GDE	Known occurrence is east of Tubbs Lane and adjacent to the Old Faithful Geyser of California; CNDDB record indicates geyser fed swale habitat

1. Status Codes (CNPS, 2023):

Federal

FE = Listed as endangered under the federal Endangered Species Act

State

CE = Listed as Endangered under the California Endangered Species Act

CT = Listed as Threatened under the California Endangered Species Act

CR = Listed as Rare under the Native Plant Protection Act

S = Sensitive

Rank

2 Imperiled, at high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

California Rare Plant Rank (CRPR)

1B Plants rare, threatened, or endangered in California and elsewhere

2B Plants rare, threatened, or endangered in California but more common elsewhere

3 More information needed about this plant, a review list

CRPR Threat Ranks:

0.1 Seriously threatened in California (high degree/immediacy of threat)

0.2 Fairly threatened in California (moderate degree/immediacy of threat)

0.3 Not very threatened in California (low degree/immediacy of threats or no current threats known)

Sources: Habitat Information: CNPS, 2023; Occurrence Information: CNDDB (CDFW, 2023a)

3.3.2.3. Special-status Terrestrial Wildlife

Results

Six groundwater-dependent special-status terrestrial wildlife species were identified as likely occurring in the Subbasin, and three were identified as possibly occurring in the Subbasin (**Table 3-6**). All nine were indirectly dependent on groundwater (i.e., they occur in groundwater-dependent vegetation communities and/or used/fed on species that occur in ISW. All nine species were birds (American white pelican [*Pelecanus erythrorhynchos*], bald eagle [*Haliaeetus leucocephalus*], bank swallow (*Riparia riparia*), redhead [*Aythya americana*], saltmarsh common yellowthroat (*Geothlypis trichas sinuosa*), summer tanager (*Piranga rubra*), tricolored blackbird (*Agelaius tricolor*), yellow-breasted chat (*Icteria virens*), and yellow warbler (Setophaga petechia). **Table 3-6** summarizes the special-status terrestrial wildlife species that are associated with groundwater, including groundwater association, location within the Subbasin, and habitat.

Table 3-6. Special-status Terrestrial Wildlife Associated with Groundwater in the Napa Valley Subbasin

Common name *Scientific name*	Status[1] federal/State	Associated with groundwater[2]	Potential to Occur within the Subbasin[3]	Habitat
American white pelican *Pelecanus erythrorhynchos*	–/SSC (nesting colonies)	Indirect	Likely, occurrences throughout the Napa Valley Subbasin (eBird 2023)	Salt ponds, large lakes, and estuaries; loafs on open water during the day; roosts along water's edge at night; forages for small fish in shallow water on inland marshes.
Bald eagle *Haliaeetus leucocephalus*	FD, BGEPA/SE, SFP	Indirect	Likely, occurrences throughout the Napa Valley Subbasin (eBird 2023)	Large bodies of water or rivers with abundant fish, uses snags or other perches; nests in advanced-successional conifer forest near open water (e.g., lakes, reservoirs, rivers); bald eagles are reliant on surface water that may be supported by groundwater and/or groundwater-dependent vegetation (Rohde et al. 2019).
Bank swallow *Riparia riparia*	–/ST	Indirect	Possible, one occurrence in the vicinity of Napa Valley Subbasin (eBird 2023)	Nests in vertical bluffs or banks, usually adjacent to water (i.e., rivers, streams, ocean coasts, and reservoirs) where the soil consists of sand or sandy loam; feeds on caterpillars, insects, frog/lizards, and fruit/berries; relies on surface water that may be supported by groundwater (Rohde et al. 2019).
Redhead *Aythya americana*	–/SSC	Indirect	Possible, occurrences in the vicinity of Napa Valley Subbasin (eBird 2023)	Freshwater emergent wetlands with dense stands of cattails (spp.) and bulrush (spp.) interspersed with areas of deep, open water; forages and rests on large, deep bodies of water.
Saltmarsh common yellowthroat *Geothlypis trichas sinuosa*	–/SSC	Indirect	Likely, known occurrences include Napa River in Napa Valley Floor-Napa and MST (CDFW, 2023a)	Brackish marsh, riparian woodland/swamp, freshwater marsh, and salt marsh, often near upland habitats
Summer tanager *Piranga rubra*	–/SSC	Indirect	Possible, one occurrence in the vicinity of Napa Valley Subbasin (eBird 2023)	Open mixed lowland forests, nesting in mature riparian cottonwood forests; feeds on bees, wasps, and other insects.
Tricolored blackbird *Agelaius tricolor*	–/ST	Indirect	Likely; known occurrences in Napa River in MST (CDFW, 2023a)	Feeds in grasslands and agriculture fields; nesting habitat components include open, accessible water with dense, tall emergent vegetation, a protected nesting substrate (including flooded or thorny vegetation), and a suitable nearby foraging space with adequate insect prey; relies on GDEs for breeding and roosting (Rohde et al., 2019).
Yellow-breasted chat *Icteria virens*	–/SSC	Indirect	Possible, occurrences in the Napa Valley Subbasin (eBird 2023)	Early successional riparian habitats with a dense shrub layer and an open canopy.
Yellow warbler *Setophaga petechia*	–/SSC	Indirect	Likely, occurrences throughout the Napa Valley Subbasin (eBird 2023)	Open canopy, deciduous riparian woodland close to water, along streams or wet meadows

1. Status Codes
   - Federal
     - FD = Federally delisted
     - BGEPA = Federally protected under the Bald and Golden Eagle Protection Act
   - State
     - SE = Listed as Endangered under CESA
     - SSC = CDFW species of special concern
     - SFP = CDFW fully protected species
     - ST = Listed as Threatened under the CESA
2. Groundwater Dependent Ecosystem (GDE) association:
   - Direct: Species directly dependent on groundwater for some or all water needs
   - Indirect: Species dependent upon other species that rely on groundwater for some or all water needs
3. Potential to Occur
   - *Likely:* the species has documented occurrences and the habitat is high quality or quantity
   - *Possible*: no documented occurrences and the species' required habitat is moderate to high quality or quantity
   - *Unlikely*: no documented occurrences and the species' required habitat is of low to moderate quality or quantity
   - *None:* no potential to occur due to lack of habitat and/or the population is assumed extirpated

3.4. Basin Setting Data Gaps

With the addition of the new monitoring wells in 2023, the shallow monitoring network is well-distributed along the Mainstem Napa River south of St. Helena with the exception of the Napa River between Pope Street and the Rutherford Stream Watch site. The Napa River flows along the eastern boundary of the valley and is outside the Subbasin through much of this reach. There are only two sites north of St. Helena (Ritchey Creek and the Napa River at Deer Park Road). This gap is at least partially filled by Stream Watch data, which covers most of the mainstem and tributaries in this area. There is another data gap for the Napa River near Calistoga. Stream Watch Site 11 was located at Berry Street, in Calistoga but was retired in 2022 because the site was consistently flowing even when many other reaches were dry (Paul Blank, personal communication).

While there has been extensive stream temperature monitoring in the past (e.g., Stillwater Sciences and Dietrich 2002), recent stream temperature data are currently limited to the dedicated SWGW sites. The expanded shallow groundwater monitoring network as of the end of 2023, in combination with Stream Watch, NVIHM, and the surface water monitoring network, provides a robust physical monitoring database. For all stream reaches, the linkage between flow and habitat Stream Watch and NVIHM can be used to assess groundwater dynamics north of Ritchey Creek, but more data in the northern portion of the Subbasin should be a target of future shallow groundwater and/or surface water monitoring.

Several tributaries support salmonids and lack either a SWGW well or a Stream Watch site. These tributaries include:

- Mill Creek
- Diamond Mountain Creek
- Simmons Creek
- Blossom Creek
- Bell Creek
- To Kalon Creek
- Bella Oaks Creek
- Milliken Creek
- Sarco Creek

Perhaps the largest data gap from a biological perspective is the Napa River near Calistoga, which is within the reported extent of California freshwater shrimp, a state and federally endangered organism. The extent of connected streamflows through the 1.5-mile reach of the Napa River from Highway 29 to Greenwood Ave and the lower 0.5 miles of Garnett Creek. A Stream Watch site near the downstream end of the California freshwater shrimp habitat (Site 11) was retired in 2022. This site was flowing during all 99 observations from November 2018 to January 2022.

Another gap includes linking streamflow to habitat and fish survival and linking groundwater to terrestrial GDE health. The physical monitoring and modeling network can be used to assess when reaches go dry, which is obviously detrimental to aquatic ecosystems, but the degree to which groundwater pumping affects habitat and water quality (including temperature) at low (but not zero) flows is not known. Developing relationships between streamflow and habitat extent for different life stages is crucial for understanding targeted flows to support specific species and life stages.

Linking groundwater elevations and the health of terrestrial GDEs (e.g., vegetation communities) is crucial when considering GDEs as part of developing minimum thresholds and measurable objectives. Often, the rooting depth of species, along with the elevation of GDEs relative to groundwater, are used to assess potential impacts. These data can be used in combination with remote sensing of vegetation health, including Normalized Difference Moisture Index (NDMI) or Normalized Difference Vegetation Index (NDVI), to better assess the health and/or impacts to the ecosystem. This analysis is somewhat complicated in the Napa Valley Subbasin because the width of GDEs is often one or two pixels using 30-meter resolution Landsat data usually used to assess NDVI (TNC, 2022), which makes NDVI analysis uncertain. Higher resolution multi-spectral imagery could help to resolve this uncertainty, but these data are not publicly available and have shorter periods of record than Landsat data. Moreover, the rooting depths reported in the literature that are used to develop rooting depth databases are often a function of the local groundwater depth and can have a large variation and uncertainty (Fan et al. 2017). Field studies can be used to assess linkages between groundwater and GDE health, which can then be used to assess the accuracy of NDVI (or other remote sensing data) and infer rooting depths. Field studies can also help assess other pressures on GDEs, including invasive species, disease, and fire.

3.5. Basin Setting Summary

Streams in the Napa Valley Subbasin are generally connected with groundwater for at least part of the year. Streams that flow during the dry season are sustained by groundwater. Within the Subbasin, tributaries flow over alluvial fans and are generally intermittent (Napa RCD, 2019). The Napa River is intermittent in places, particularly during dry years. Even when it goes dry in places, the mainstem Napa remains connected later into the year than its tributaries. The pools in some reaches become isolated during the dry season as the riffles become disconnected from groundwater. The Napa River is tidally influenced in its downstream reaches from the City of Napa to its outlet in San Pablo Bay. NVIHM modeling results suggest that groundwater pumping has no noticeable effect on the timing and frequency of dry conditions in tributaries.. Upstream of the Subbasin, tributaries are intermittent in their upstream reaches and often become perennial as their drainage area increases. The perennial tributary reaches upstream of the Subbasin provide extensive cool-water habitat for steelhead and other aquatic species, and the connection between the mainstem Napa River and the tributaries is important for salmonid migration and other aquatic organisms.

Habitat in the Napa River has been altered by widespread channel incision that has disconnected the Napa River and its tributaries from their floodplains. In areas with connected river and groundwater system, typically the groundwater elevation can be inferred by the depth of the river channel. The incision of the channel could have caused lowering of regional groundwater levels. Flows have also been altered by dams and groundwater pumping. The largest reservoir in the watershed is Lake Hennesey on Conn Creek, with smaller reservoirs on Rector Creek and tributaries upstream of Calistoga. Numerous small dams are used for short-term storage of water throughout the watershed (Stillwater Sciences and Dietrich 2002). Other water uses include surface water diversions for agriculture and municipal water supplies.

The Napa Valley Subbasin supports three special-status fish and four special-status aquatic wildlife species. All the special-status aquatic species were dependent upon ISW for at least part of their life history. There were 12 vegetation communities identified as being likely associated with groundwater, and eight vegetation communities were identified as possibly associated with groundwater. These communities are mostly affiliated with riparian areas along tributaries to the Napa River throughout the Subbasin. Two special-status plant species were likely dependent upon groundwater, and 13 were possibly dependent on groundwater.

4. INTENSIVE MONITORING SITE PRIORITIZATION

This Workplan uses Subbasin-wide data in combination with data collected at intensive monitoring sites to consider flow needs and NVIHM model results to assess the effect of groundwater pumping on ISW and GDEs and inform SMCs. Potential intensive monitoring sites were identified based on information from **Section 3**.

4.1. Potential Intensive Monitoring Site Identification

Twenty-one sites were identified as potential intensive monitoring sites. An initial list of 17 potential sites was developed based on hydrologic monitoring and included tributaries (12 sites) and the mainstem Napa River (5 sites). Four additional sites were included based on discussions with the Napa County RCD, which identified important tributaries for steelhead and Chinook salmon (including Ritchey Creek, Browns Valley Creek, and Bell Creek). Existing and planned hydrologic monitoring, salmonid habitat mapped in a GIS data set provided by the Napa County RCD, and the presence of special-status species and GDEs were assessed for each site.

4.2. Summary of Prioritization Criteria

The 21 sites were prioritized based on available hydrologic data, the ecological importance of the site, and other factors, including stream restoration, ongoing monitoring, and unique hydrologic characteristics (e.g., springs, tidal controls, etc.). A preliminary EHCM was developed for each site to support the prioritization. These parameters were quantified and summed to prioritize the sites. Extending observations during the monitoring period will produce a more robust dataset at sites with longer duration shallow groundwater and/or surface flow data. Moreover, longer historical records aid the refinement of the NVIHM, which informs the assessment of groundwater pumping effects on ISW and streamflow depletion.

Table 4-1 summarizes hydrologic conditions and data availability at each of the 21 sites. Sixteen of the sites have some surface water monitoring, including 2 USGS sites, 5 original SWGW sites (these are also referred to as ISW monitoring sites), and 13 Stream Watch sites. The Napa River at Calistoga had a Stream Watch that was discontinued in 2022 because it was always flowing. Five sites had shallow groundwater monitoring (dual completion) wells installed in 2014, four sites had dual completion wells installed in Spring 2023, and four sites had dual completion wells installed in Fall 2023. Flow conditions (e.g., perennial, intermittent) were based on data from Napa County RCD (2019) and Stream Watch results. Seven of the 21 sites were mapped as having perennial flow, including one tributary (Bell Creek). The remaining sites were intermittent, typically going dry during the summer months. There are numerous small dams throughout the Napa River Watershed. Larger dams are noted in **Table 4-1** and include Hennessey Dam, Rector Dam, Kimball Dam, and Bell Canyon Dam. Hennessey Dam, the largest dam in the watershed, affects flow in Conn Creek and mainstem sites downstream of the Conn Creek confluence, including Napa near Yountville, Napa near Oak Knoll, Napa at Napa (First Street), and Napa at S. Jefferson St.

Hydrologic data availability was scored on the following scale:

- 0 points: No data.
- 1 point: Deep groundwater wells and/or Stream Watch.
- 2 points: Planned or recently implemented SWGW/ISW sites and Stream Watch.
- 3 points: SWGW/ISW sites installed in 2014. The longer-term SWGW/ISW sites were given higher priority because they have already captured a range of hydrologic conditions and can be used to track groundwater changes through time.

Table 4-1. Hydrologic Data Summary at Potential Intensive Sites

Site	Tributary/ Mainstem	Surface Water Monitoring	Shallow Groundwater Monitoring	Flow Condition	Notes	Hydrology ranking
Bale Slough	Tributary, West Side	Stream Watch; stage (planned 2024)	Installed Spring 2023	Intermittent	Groundwater Recharge potentially affected by Hennessey and Rector Reservoirs	2
Bell Creek	Tributary, East Side	None	None	NVIHM suggests that reach is connected to groundwater.	Unknown	0
Browns Valley	Tributary, West Side	Stream Watch	None	Intermittent		1
Conn Creek	Tributary, East Side	Stream Watch; stage (planned 2024)	Installed Fall 2023	Intermittent	Unknown	2
Dry Creek	Tributary, West Side	Stream Watch; stage (2015 - Present)	Installed 2014	Intermittent		3
Garnett Creek	Tributary, West Side	Stream Watch	None	Intermittent		1
Mill Creek	Tributary, West Side	None	None	Intermittent	Small diversions	1
Napa Creek	Tributary, West Side	Stream Watch	None	Intermittent		1

Table 4-1. Hydrologic Data Summary at Potential Intensive Sites						
Site	**Tributary/ Mainstem**	**Surface Water Monitoring**	**Shallow Groundwater Monitoring**	**Flow Condition**	**Notes**	**Hydrology ranking**
Napa River at Napa	Mainstem	Stage (2015 - Present)	Installed 2014	Perennial, Tidal		3
Napa River near Calistoga	Mainstem	Stream watch site retired 2022[1]	None	Perennial at Stream Watch Site	Kimball Dam, springs near Calistoga	1
Napa River near Oak Knoll	Mainstem	USGS Gage; stage (2015 - Present)	Installed 2014	Perennial, intermittent in dry years	Henessey Dam upstream	3
Napa River near St. Helena	Mainstem	Stream Watch, USGS Gage; stage (2015 - Present)	Installed 2014	Perennial, intermittent in dry years		3
Napa River near Yountville	Mainstem	Stream Watch; stage (2015 - Present)	Installed 2014	Perennial, intermittent in dry years	Henessey Dam upstream	3
Napa River at Deer Park Road	Mainstem	Stage (planned 2024)	Installed Fall 2023	Perennial		2
Napa River at S. Jefferson St.	Mainstem	Stage (planned 2024)	Installed Spring 2023	Perennial, Tidal		2
Rector Creek	Tributary, East Side	None	None	Intermittent		1
Redwood Creek	Tributary, West Side	Stream Watch; stage (planned 2024)	Installed Fall 2023	Intermittent		2

Table 4-1. Hydrologic Data Summary at Potential Intensive Sites						
Site	Tributary/ Mainstem	Surface Water Monitoring	Shallow Groundwater Monitoring	Flow Condition	Notes	Hydrology ranking
Ritchey Creek	Tributary, West Side	Stream Watch; stage (planned 2024)	Installed Spring 2023	Intermittent		2
Soda Creek	Tributary, East Side	Stream Watch; stage planned 2024	Installed Spring 2023	Perennial	Bell Canyon Reservoir upstream	2
Sulphur Creek	Tributary, West Side	Stream Watch; stage (planned 2024)	Installed Fall 2023	Intermittent		2
York Creek	Tributary, West Side	None	None	Intermittent		1

1. The Stream Watch site for the Napa River at Calistoga was retired in 2022, because it supported flowing conditions even during severe drought.

Table 4-2 summarizes the ecological conditions at each site and other factors that were considered in the prioritization. Salmonid presence and lifestages in each reach were taken from Napa RCD (2019). Other aquatic special-status species near the intensive sites were noted if the observations occurred near the site in the Napa River or were noted in a nearby tributary in CNDDB. Because their observations occur throughout the Subbasin, special-status birds were not considered. Most of the potential sites support at least one lifestage of steelhead and/or Chinook salmon. Eleven of the sites support steelhead and Chinook salmon spawning and rearing, and seven of the sites support steelhead spawning and rearing. For intermittent streams, support for steelhead rearing is short-lived because the streams are dry near the end of the spawning period. These tributaries consequently get lower scores for those lifestages. GDEs are present at all the potential sites except Napa River at Napa, which has no mapped GDEs. Special-status species that occur at two or fewer sites include California freshwater shrimp at Napa River near Calistoga and Garnett Creek and northwestern pond turtles on Conn Creek. Foothill yellow-legged frogs occurred at four of the sites. Other factors considered in the ranking include stream restoration at Bale Slough and four of the mainstem sites (Napa River near S. Jefferson St., Napa near Napa, Napa River near Oak Knoll, Napa River near Yountville).

The ecological importance of GDEs was scored based on the following scale:

- 0 points: No ecological importance (no terrestrial or aquatic GDEs).
- 2 points: One special-status species lifestage and/or a terrestrial GDE.

- 4 points: Two special-status species or lifestages (e.g., spawning and rearing).
- 6 points: Multiple special-status species lifestages (spawning and rearing). The reach has isolated pools and/or flow for part of the summer, and groundwater is important.

Ecological importance scores had double the potential value of hydrologic scores because this Workplan is ultimately focused on sustaining ecology in the Napa Valley Subbasin.

Other considerations:

- An additional point was given to sites with other features, such as particularly important upstream habitat, stream restoration sites, or ongoing biological data collection that could be leveraged to assess GDE health, or that are otherwise unique (i.e., tidal sections of the Napa River).

Table 4-2. Special-status Species and Other Considerations Components and Scores

Site	Special-status aquatic species	Terrestrial GDEs	Special-status Species/GDE Score	Notes on Other Factors	Other Factors Score
Bale Slough	Steelhead spawning and rearing, foothill yellow-legged frog	Present	4	Restoration	1
Bell Creek	Steelhead spawning and rearing	Present	4		0
Browns Valley	Steelhead spawning and rearing	Present	4	Recommended by Napa RCD, relatively unpumped	1
Conn Creek	Steelhead spawning, northwestern pond turtle	Present	2		1
Dry Creek	Steelhead and Chinook salmon spawning and rearing	Present	4		0
Garnett Creek	California freshwater shrimp, steelhead spawning and rearing	Present	6		0
Mill Creek	Steelhead migration, rainbow trout	Present	6		0
Napa Creek	Steelhead spawning and rearing	Present	2	Little pumping	1
Napa River at Napa	Passage for steelhead, Chinook salmon, longfin smelt	Not Present	2	Tidal, restoration, ongoing	1

Table 4-2. Special-status Species and Other Considerations Components and Scores					
Site	**Special-status aquatic species**	**Terrestrial GDEs**	**Special-status Species/GDE Score**	**Notes on Other Factors**	**Other Factors Score**
				vegetation monitoring	
Napa River near Calistoga	California freshwater shrimp, steelhead and Chinook salmon spawning and rearing, Calistoga popcornflower	Present	6	Unique setting, springs	1
Napa River near Oak Knoll	Steelhead and Chinook salmon spawning and rearing	Present	6	Restoration site	1
Napa River near St. Helena	Steelhead and Chinook salmon spawning and rearing	Present	6		0
Napa River near Yountville	Steelhead and Chinook salmon spawning and rearing, northwestern pond turtle	Present	6	Restoration downstream	1
Napa River at Deer Park Road	Steelhead and Chinook salmon spawning and rearing	Present	4		0
Napa River near S. Jefferson St.	longfin smelt downstream, steelhead passage	Present	4	Tidal, restoration, nearby vegetation surveys	1
Rector Creek	Steelhead, foothill yellow-legged frog	Present	2	Extensive data	1
Redwood Creek	Steelhead and Chinook salmon spawning and rearing	Present	4		0
Ritchey Creek	Steelhead migration	Present	2	Relatively pristine upstream	1
Soda Creek	Steelhead spawning and rearing, fish passage artificially blocked upstream	Present	2		0

Table 4-2. Special-status Species and Other Considerations Components and Scores					
Site	**Special-status aquatic species**	**Terrestrial GDEs**	**Special-status Species/GDE Score**	**Notes on Other Factors**	**Other Factors Score**
Sulphur Creek	Steelhead and Chinook salmon spawning and rearing, foothill yellow-legged frog	Present	6		0
York Creek	Steelhead spawning and rearing in upper reaches, steelhead migration in lower reaches	Present	6	Dam removal project upstream of Subbasin	1

4.3. Prioritization of Potential Intensive Sites

Sites were prioritized for the monitoring network based on the availability of groundwater and surface water data (including shallow wells, surface water wells, Stream Watch, and deeper wells), the usage of the site by special-status species, and other factors (mainstem versus tributary, the importance of groundwater, stream restoration, or existing monitoring). The importance of each site was assessed by adding the hydrologic, ecologic, and other factors' scores (**Figure 4-1**, **Table 4-3**). The symbols used in **Figure 4-1** show the total score for each site as well as concentric circles, which show the score for hydrologic data availability (the degree to which the blue circle is filled), ecological importance (the degree to which the green circle was filled), and whether or not a bonus score was given (shown as a filled orange circle).

The prioritization score shown in the figure and table can be used to prioritize intensive sites but also to identify sites where additional hydrologic data are needed (e.g., sites with high ecological importance scores and low hydrologic information scores). Eight of the 21 sites had the highest ecologic score. These sites included four mainstem sites (Napa near Calistoga, Napa near St. Helena, Napa near Oak Knoll, and Napa at Yountville) and four tributaries (Sulphur Creek, Garnett Creek, Mill Creek, and York Creek). The latter sites could be targeted for Stream Watch expansion, monitored for connectivity and water temperature, and/or prioritized for monitoring well network expansion. Details of initially selected intensive sites, including ecohydrologic conceptual models, are described in **Section 5**.

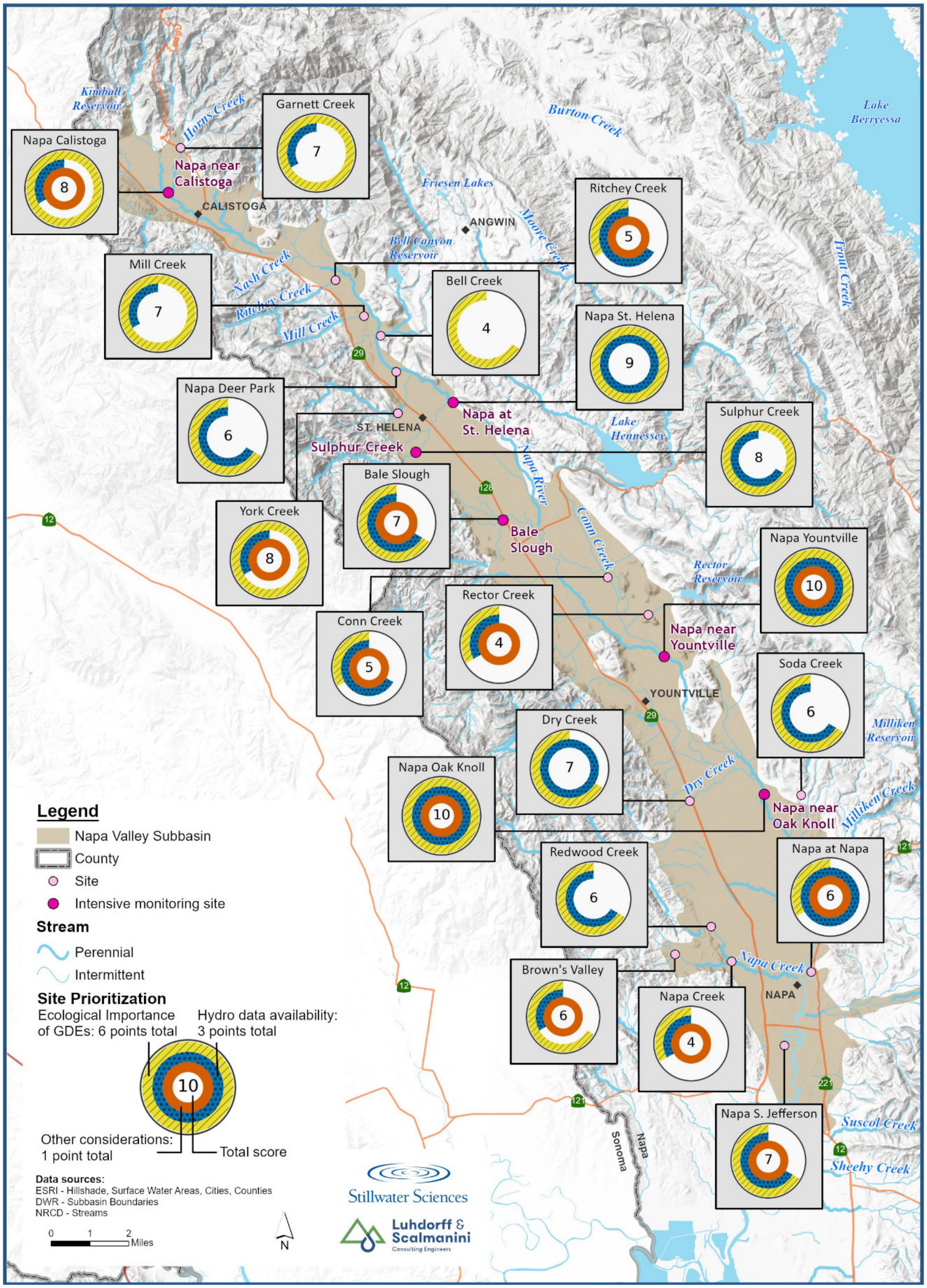


Figure 4-1. Site Prioritization

Table 4-3. Site Prioritization Scores				
Site Factors	**Ecological importance of GDEs**	**Hydrologic Data Availability**	**Other**	**Total**
Bale Slough	4	2	1	7
Bell Creek	4	0	0	4
Browns Valley	4	1	1	6
Garnett Creek	6	1	0	7
Conn Creek	2	2	1	5
Napa River near S. Jefferson St.	4	1	1	6
Mill Creek	6	1	0	7
Napa River at Napa*	2	3	1	6
Napa River near Calistoga*	6	1	1	8
Dry Creek	4	3	0	7
Napa Creek	2	1	1	4
Napa River near Oak Knoll*	6	3	1	10
Napa River near Yountville*	6	3	1	10
Rector Creek	2	1	1	4
Ritchey Creek	2	2	1	5
Napa River near St. Helena*	6	3	0	9
Redwood Creek	4	2	0	6
Napa River at Deer Park Road	4	2	0	6
Soda Creek	4	2	0	6
Sulphur Creek*	6	2	0	8
York Creek	6	1	1	8

* indicates intensive monitoring site

There were 2 sites with the 10 points maximum score (Napa River near Oak Knoll, Napa River near Yountville)), 1 site with nine points (Napa River near St. Helena), and 3 sites with 8 points (York Creek, Napa River near Calistoga, and Sulphur Creek) and four sites with 7 points (Mill Creek, Dry Creek, Garnett Creek, and Bale Slough) (**Tables 4-3 and 4-4**).

Table 4-4. Distribution of Prioritization Scores	
Total Score	**Number of Sites**
10	2
9	1
8	3
7	5
6	5
5	2
4	3

Based on the rankings in **Figure** 4-1 **4-1** and **Table 4-3**, six sites are recommended initially for Intensive monitoring (sites with scores of 8 or greater). These include the three mainstem sites with dual completion wells installed in 2014 (Napa near Oak Knoll, Napa at Yountville, Napa near St. Helena), one site with the endangered California freshwater shrimp (Napa River at Calistoga), Sulphur Creek which supports multiple lifestages for steelhead and Chinook salmon and has foothill yellow-legged frogs, and Bale Slough which is part of an ongoing restoration project. Despite having a higher priority score than the other tributaries (except Sulphur Creek), Bale Slough was selected as an intensive survey site rather than York Creek to avoid having 3 of the 6 sites within a 2 square mile area. Additionally, Bale Slough will provide a monitoring within the subbasin between St. Helena and Yountville.

The sites shown in **Figure 4-2** are co-located with either SWGW/ISW monitoring wells or Stream Watch sites.

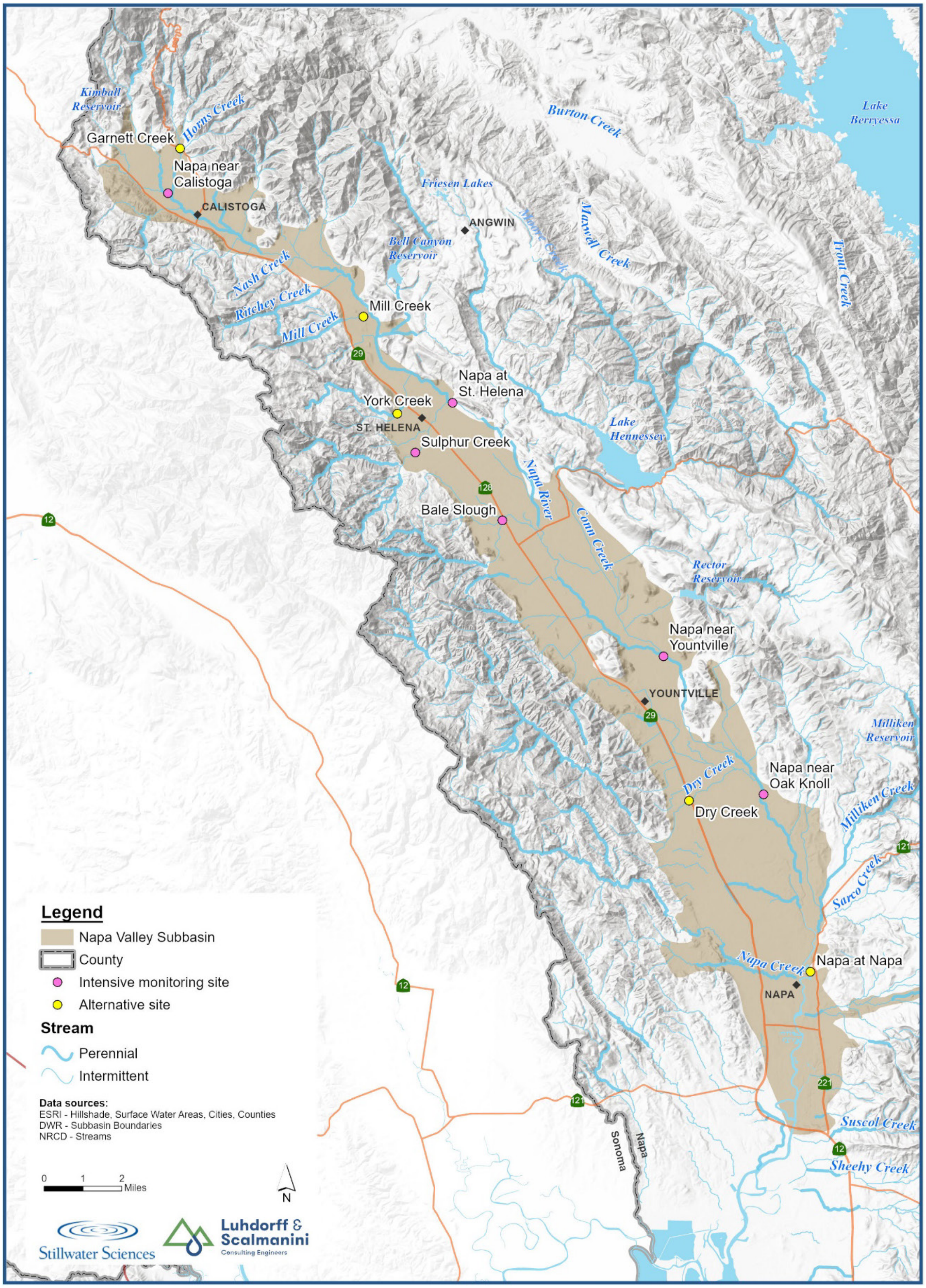


Figure 4-2. Proposed Intensive Monitoring Sites and Alternative Sites

4.4. Alternative sites

The rankings shown in **Figure 4-2** and **Table 4-3** can be used to identify alternative sites to the intensive sites selected above. Alternative sites could be selected after one year of monitoring. This has the advantage of more spatial coverage than only conducting biological monitoring at the six sites but has the disadvantage that it becomes more difficult to evaluate future trends. The sites selected for the second year of monitoring will be assessed in coordination with the TAG. Given their high prioritization scores (7-8) potential alternative sites include York Creek (which had a recent dam removal), Dry Creek, Garnett Creek, and Mill Creek would be the highest priority alternative sites.

5. ECOHYDROLOGIC CONCEPTUAL MODELS FOR INTENSIVE MONITORING SITES

EHCMs for the six recommended intensive sites are described in this section and summarized in **Table 5-1**. These EHCMs were developed following Rohde et al. (2020) and include GDEs, surficial landscape features, groundwater and ISW dynamics, listed species occurring near the intensive sites (ecological targets), known and likely stressors, preliminary assessment of streamflow depletion, and any data gaps. Each of these intensive sites is also referred to by CEFF as a “Location of Interest” (**Section 2.3**). These locations will be used to develop the CEFF ecology-flow metrics.

Table 5-1. Summary of Ecohydrologic Conceptual Models for Intensive Monitoring Sites

Site	GDE Type	Surficial Landscape Features	Groundwater and ISW Dynamics	Ecological Targets	Known and likely stressors	Data gaps
Napa River at Calistoga	Riparian oaks along tributaries and Napa mainstem and some palustrine wetlands.	Upstream-most Napa River reach within the Subbasin. Springs and seeps create freshwater emergent marsh habitat.	Reach is generally connected with groundwater and baseflow is sustained throughout the year.	Steelhead, Chinook salmon, California freshwater shrimp, northwestern pond turtle, Calistoga popcornflower.	Urbanization and channel simplification and incision. Tile drains may reduce groundwater elevation during dry season.	Channel conditions. Long-term shallow groundwater monitoring. Habitat-flow linkages. Stream Watch (site retired in 2022).
Napa River at Pope St. (St. Helena)	Riparian oaks and willows.	Land cover is primarily urban. Reach is located near the eastern edge of the Subbasin at the downstream end of St. Helena.	Reach is frequently disconnected from groundwater.	Steelhead, Chinook salmon. Foothill yellow-legged frog presumed extant.	Urbanization and channel simplification and incision. Groundwater pumping contributes to stream depletion.	Channel conditions. Long-term shallow groundwater monitoring. Habitat-flow linkages.
Bale Slough	Riparian oaks near Napa River confluence	Bale Slough is a historical wetland complex that drains to the Napa River from the west. The channel is currently incised. Restoration site: Bale Slough – Bear Creek Sediment Reduction and Habitat Enhancement	Intermittent reach, which may be connected to groundwater a few weeks per year during wet years. NVIHM indicates depth to groundwater between 10 and 15 feet in spring, which may not support a connection to groundwater.	Steelhead, chinook salmon, foothill yellow-legged frog.	Summer water temperatures warm enough to potentially stress steelhead. Channel simplification.	Long-term shallow groundwater monitoring. Habitat-flow linkages.
Napa River near Yountville	Riparian oaks.	Land cover is primarily vineyards outside of the Ecological Reserve. The alluvial basin is constricted in this reach.	Groundwater levels indicate consistent to intermittent direct hydraulic connection. Stream Watch observations indicate that the isolated pools are maintained when groundwater levels drop below the thalweg.	Steelhead, Chinook salmon, northwestern pond turtle.	Historic channel simplification, but the reach is located in the OVOK restoration project. Groundwater pumping contributes to stream depletion.	Habitat-flow linkages.
Napa River at Oak Knoll	Riparian oaks.	Land cover is primarily agricultural. The reach is near the eastern edge of the alluvial basin, which is constrained to the west by an alluvial fan associated with Dry Creek.	Groundwater levels indicate consistent to intermittent direct hydraulic connection and gaining stream conditions. Lake Hennesey and Rector Reservoir operations affect surface flow in this reach.	Steelhead and Chinook salmon.	Channel simplification. Groundwater pumping contributes to stream depletion.	Influence of Hennessey Dam on flows in this reach is uncertain.
Napa River near First Street	No mapped terrestrial GDEs, but oaks occur upstream.	The Napa River is tidal and perennial in this reach. Reach is located within the Napa River Flood Control Project, which includes planted vegetation and setback levees.	Lake Hennesey and Rector Reservoir operations affect surface flow in this reach. Exchange between groundwater and surface water is unlikely based on fine sediment that make up the riverbed and electrical conductivity measurements. Tidal variation in surface water elevation is 5-7 feet.	Migration corridor for steelhead and Chinook salmon. Longfin smelt have been observed downstream.	Levee development. Urbanization. Channel simplification. Upstream dams. Groundwater pumping contributes to stream depletion.	Habitat-flow linkages. Use by fish other than salmonids not well known.
St. Helena Area – Sulphur Creek	Riparian oaks and willows.	Sulphur Creek is a west-side tributary with a high sediment supply. Sulphur Creek has supported a consistently braided channel morphology near the Valley View Bridge but is incised near the Napa River confluence.	Sulphur Creek is intermittent, with flows in winter and spring. NVIHM indicates that Sulphur creek is typically disconnected from groundwater in this reach, except during wet winters.	Steelhead, chinook salmon, foothill yellow-legged frog.	Groundwater pumping has little effect on Sulphur Creek but contributes to depletion downstream (Napa River at Napa).	Long-term shallow groundwater monitoring. Habitat-flow linkages.

Napa River at Calistoga

GDE Type:

Ecosystems associated with ISW. Oaks along tributaries and Napa River mainstem. Some palustrine wetlands in the vicinity of Old Faithful geyser and neighboring springs and seeps.

Surficial Landscape Features:

The site is located in the upstream-most reach of the Napa River in the Napa Valley Subbasin (**Figure 4-1**). This reach is near the northernmost portion of the Subbasin. The alluvium is approximately 100 feet thick along the mainstem in this reach, pinching out into volcanics north of Calistoga. Deeper wells in the area may produce groundwater from the underlying Sonoma Volcanics. Seeps and springs are mapped in the area near the Old Faithful geyser. Several other springs are mapped in the uplands and on alluvial fans surrounding the area. The presence of seeps and springs is unique to the Calistoga area, and these create freshwater emergent marsh habitat.

Groundwater and ISW Dynamics and Hydrologic Fluxes:

Flows could be affected by upstream water management, including dams (Kimball Dam and numerous small dams) and groundwater pumping. The influence of dams on flow through the Calistoga reach is included in the NVIHM but has not been explored. The USGS collected discharge data at a gage on the Napa River at Calistoga from 1975 to 1983. From the Natural Flows Database, median summer flows were 0.41-6.5 cfs (10th-90th percentile) during these years. The Natural Flows Database suggests that median unimpaired summer flows were 0-22.5 cfs (10th-90th percentile) during dry years.

Groundwater levels in the Calistoga area are generally within 10 feet of the ground surface in the spring and exhibit seasonal declines of approximately 10 feet in the fall (**Figure 5-1**). No long-term trends in groundwater levels are apparent. There are tile drains in the area that may affect local groundwater recharge and discharge.

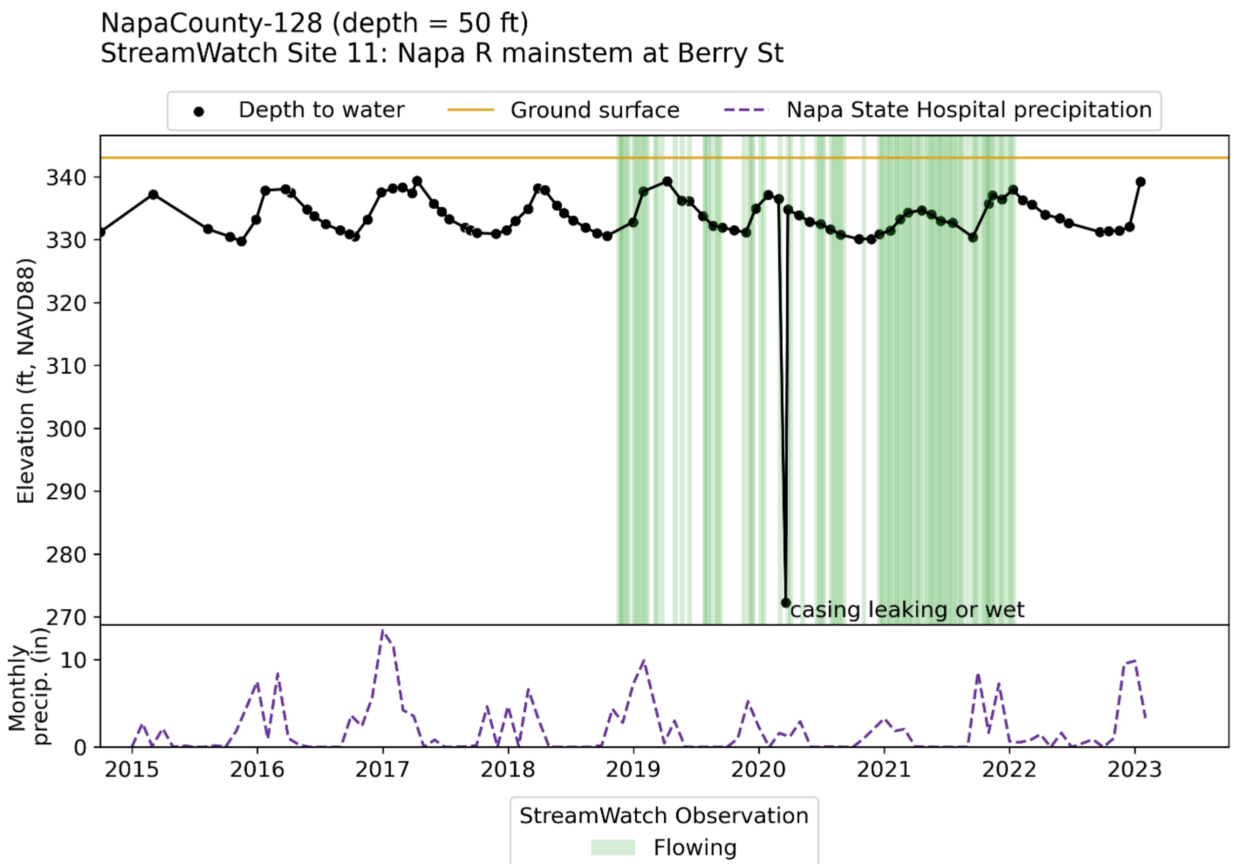


Figure 5-1. Groundwater levels in NapaCounty-128 monitoring well, observations at Stream Watch Site 11, and monthly precipitation at Napa State Hospital

The NVIHM results indicate that this reach is generally connected with groundwater throughout the year. Stream Watch observations also suggest that baseflows are sustained in this reach throughout the year; all observations from Stream Watch Site 11 (Napa River at Berry Street) reported flowing conditions. Stream Watch Site 11 was retired in 2022. Disconnected flows may occur upstream of Stream Watch Site 11 (Paul Blank, Pers. Comm). The NVIHM results also suggest that groundwater pumping is sufficient to decrease Napa River flows in this reach and increase the frequency and duration of dry conditions for the Napa River mainstem. Monthly discharge typically increases under the No Pumping scenario compared with the Baseline scenario (**Table 5-2**).

Table 5-2. Estimated Stream Depletion by Water Year Type (Napa River at Calistoga)									
Month	Dry Years			Normal Years			Wet Years		
	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	18.2	0.5	3%	31.6	1.0	3%	68.8	1.6	2%
Feb	28.6	0.8	3%	40.6	1.0	3%	76.0	1.1	1%
Mar	28.7	0.8	3%	35.0	0.9	2%	46.9	0.7	1%
Apr	14.8	0.5	3%	11.7	0.5	4%	20.6	0.4	2%
May	1.3	0.1	12%	1.1	0.1	9%	3.8	0.1	3%
Jun	0.6	0.1	25%	0.7	0.1	20%	1.0	0.1	7%
Jul	0.4	0.2	40%	0.5	0.2	34%	0.7	0.1	20%
Aug	0.3	0.2	57%	0.4	0.2	54%	0.5	0.2	31%
Sep	0.3	0.2	64%	0.5	0.3	57%	0.5	0.2	40%
Oct	1.4	0.3	18%	2.4	0.3	15%	2.8	0.3	12%
Nov	1.9	0.3	14%	5.4	0.4	7%	4.7	0.4	8%
Dec	9.2	0.5	5%	27.9	1.2	4%	31.9	1.3	4%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the ‘No Pumping scenario’.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

Ecological Targets:

The Napa River at Calistoga is a critical habitat for Central California Coast Steelhead and provides spawning and rearing habitat for steelhead and Chinook salmon. Special-status species include the California freshwater shrimp (which is endangered), northwestern pond turtle, and Calistoga popcorn flower. California freshwater shrimp occur in a 1.5-mile-long reach upstream of Highway 29. The Calistoga popcorn flower is associated with alkaline areas near thermal springs in meadows and seeps. NDVI of GDEs is typically stable. However, because the wetland GDEs are small compared to the 30-m LANDSAT pixel, NDVI may not be a robust metric for GDE health.

Known and Likely Stressors:

The reach is impacted by urbanization and channel simplification and incision. Tile drains may affect runoff relative to groundwater recharge and discharge and thus may reduce groundwater elevation during the dry season. The reduced groundwater levels may impact aquatic areas and wetlands dependent on groundwater. Dams upstream of the reach may reduce coarse sediment input.

Data Gaps:

Channel conditions, including slope, are not well characterized in this reach. Long-term shallow groundwater monitoring is limited in the area. Linkages between flow and habitat for steelhead and Chinook salmon are not well understood. The nearest active mainstem Napa River Stream Watch site is located approximately 3.5 miles downstream at Larkmead Lane.

Napa River at Pope Street (St. Helena)

GDE Type:

Ecosystems associated with ISW and riparian valley oaks.

Surficial Landscape Features:

The site is located at the downstream end of St. Helena on the Napa River (**Figure 4-1**). The reach is near the eastern edge of the Subbasin, and the alluvium is just over 100 feet thick at the NapaCounty-222s-swgw5/NapaCounty-223d-swgw5 site. Urbanization impacts this reach.

Groundwater and ISW Dynamics and Hydrologic Fluxes:

Depth to groundwater is typically 10 to 15 feet in spring. Groundwater levels decline by approximately 5 to 10 feet during the dry season and fell below the Minimum Threshold during the 2020 and 2021 dry seasons (**Figure 5-2**). The ground surface in this figure is the ground surface adjacent to the groundwater well. Dynamic river stage values below the streambed elevation at this site reflect conditions where water is present but below the surveyed thalweg elevation because the thalweg location and gage location are not exactly co-located. Stable stage measurements in the dry season likely represent isolated pool or dry conditions at the site as suggested by Stream Watch data. NapaCounty-222s-swgw5 is the only shallow monitoring well near the site; shallow groundwater data have been available since 2014 to assess longer-term trends. Dual-completion monitoring well data (NapaCounty-222s-swgw5 and NapaCounty-223d-swgw5) exhibit a downward vertical head gradient.

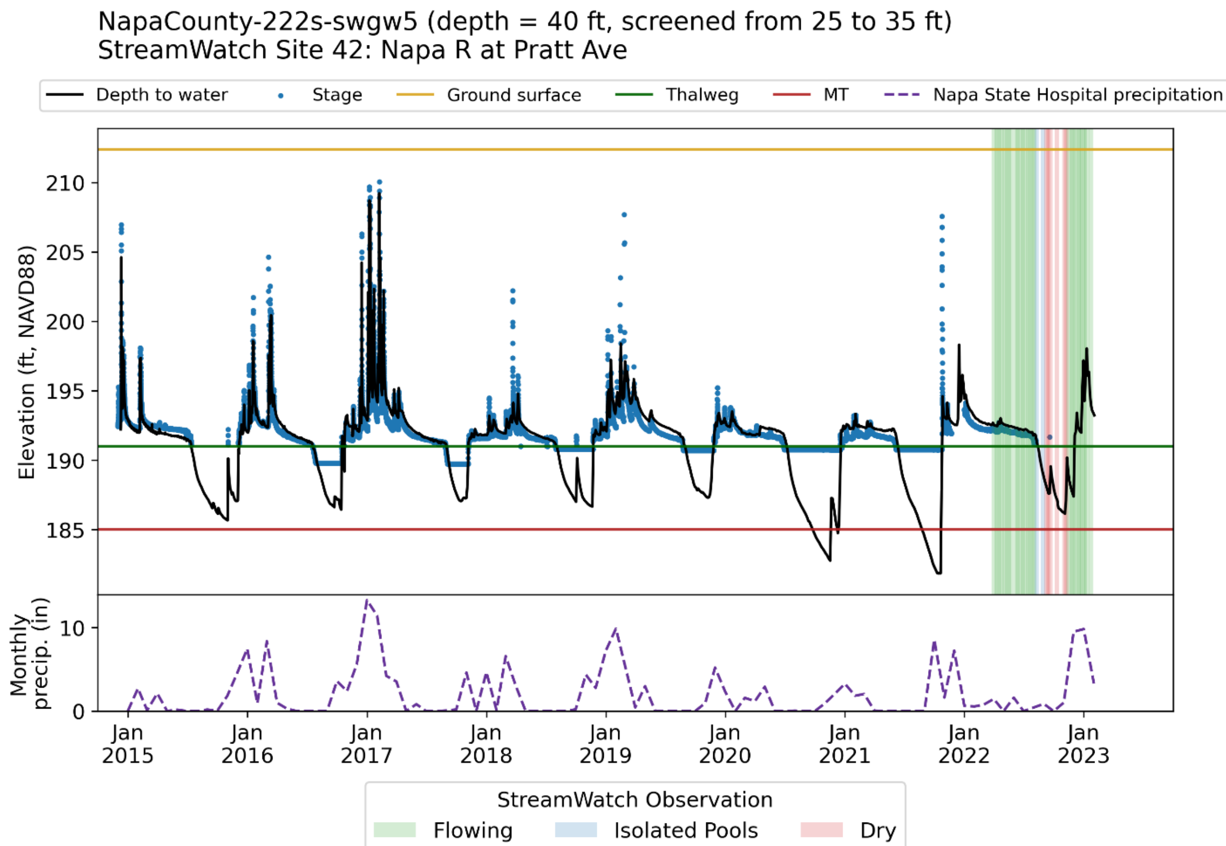


Figure 5-2. NapaCounty-222s-swgw5 groundwater levels and stage, observations from Stream Watch Site 2, monthly precipitation at Napa State Hospital, thalweg elevation near monitoring well, and Minimum Threshold for monitoring well.

The NVIHM results indicate that the Napa River is disconnected from groundwater more frequently in this reach than in most other mainstem reaches. The model indicates that groundwater pumping for agriculture causes this reach to go dry (or nearly dry) in July through September in Dry to Normal water year types from 1988 to 2014. Stream Watch data support the modeled results showing that dry conditions occur in fall in in 5 of the 6 years from 2017-2023 (**Figure 5-2**). Isolated pools do not persist for long at this site, with aperiodic observations spanning a few days to up to a month. The channel goes dry when the shallow groundwater elevation is approximately equal to the thalweg elevation.

The NVIHM results indicate groundwater pumping contributes to decreases in Napa River flows in this reach and increases the frequency and duration of dry conditions for the Napa River mainstem. Monthly discharge typically increases under the No Pumping scenario compared with the Baseline scenario, and the frequency of low/no-flow days is lower under the No Pumping scenario, particularly during the dry season (**Table 5-3**). Flow in this reach may also be affected by upstream water management, including Kimball and Bell Canyon dams, as well as in-channel diversions.

Table 5-3. Estimated Stream Depletion by Water Year Type (Napa River at Pope Street)									
Month	Dry Years			Normal Years			Wet Years		
	Streamflow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Streamflow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Streamflow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	52.4	3.6	7%	126.7	5.1	4%	445.2	5.7	1%
Feb	108.5	4.0	4%	192.2	4.5	2%	465.3	4.3	1%
Mar	97.4	3.7	4%	139.5	3.6	3%	303.0	2.9	1%
Apr	36.6	2.6	7%	39.4	2.4	6%	122.2	2.0	2%
May	12.7	2.2	17%	15.1	2.4	16%	42.6	1.4	3%
Jun	5.9	3.0	51%	9.1	3.7	40%	17.8	2.5	14%
Jul	4.0	3.4	87%	6.5	4.6	71%	12.0	4.2	35%
Aug	2.8	2.6	96%	4.7	4.3	91%	8.8	5.0	57%
Sep	2.7	2.6	95%	5.1	4.4	86%	7.6	4.9	64%
Oct	11.0	3.8	35%	17.5	5.1	29%	20.8	4.7	23%
Nov	15.1	3.5	23%	36.2	5.3	15%	33.8	4.5	13%
Dec	35.3	4.2	12%	146.2	6.5	4%	205.4	5.8	3%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the 'No Pumping scenario'.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

Ecological Targets:

The site supports critical habitat for steelhead and Chinook salmon and steelhead spawning and rearing. Foothill yellow-legged frogs are presumed extant in this area but have been observed only along Sulphur and Conn Creeks, not along the mainstem.

GDE vegetation is primarily riparian oaks and willows. GDEs upstream of the site showed a decline in NDVI during 2021 due to a fire that encroached into the riparian zone. Otherwise, no long-term trends in NDVI are apparent at this site.

Known and Likely Stressors:

Groundwater pumping in the vicinity, including the municipal pumps for St. Helena, as well as pumping upstream, contributes to stream depletion at St. Helena. Channel simplification and incision are also likely stressors in the system, driven by urbanization in and upstream of the reach.

Data Gaps:

Channel conditions, including slope, are not well characterized in this reach. Long-term shallow groundwater monitoring is limited in the area. Linkages between flow and habitat for steelhead and Chinook salmon are not well understood.

Bale Slough

GDE Type:

Riparian valley oaks at the Napa River confluence.

Surficial Landscape Features:

Bale Slough is a historical wetland complex (SFEI 2012) that drains to the Napa River from the west. As a result of land use changes and agricultural development over the last century, the channel is currently confined in this reach. Bear Creek, which is perennial east of the subbasin in the Mayacamas Mountains and intermittent within the subbasin, drains into Bale Slough.

Bale Sough overlies an alluvial fan. Land use is predominately vineyards, and upslope areas are forested. There are drainage tiles near the site.

Groundwater and ISW Dynamics and Hydrologic Fluxes:

NVIHM indicates that most of the reach is disconnected from groundwater, with the exception of the lowermost reach, which may be connected to groundwater a few weeks per year during wet years. As a result, the NVIHM results indicate that groundwater pumping has little impact on streamflow in this reach (Table 5-4)

Table 5-4. Estimated Stream Depletion by Water Year Type (Bale Slough)									
Month	Dry Years			Normal Years			Wet Years		
	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	-	-	-	1.4	0.0	1%	12.4	0.0	0%
Feb	0.6	0.0	1%	4.4	0.0	0%	15.9	0.0	0%
Mar	0.8	0.0	0%	2.5	0.0	1%	9.8	0.0	0%
Apr	-	-	-	-	-	-	2.2	0.0	0%
May	-	-	-	-	-	-	-	-	-
Jun	-	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-
Sep	-	-	-	-	-	-	-	-	-
Oct	-	-	-	-	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-	-
Dec	-	-	-	1.3	0.0	1%	2.5	0.0	1%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the 'No Pumping scenario'.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

NVIHM also indicates that depth to groundwater is between 10 and 15 feet in spring, which is sufficiently shallow to support some woody vegetation but may not support a connection between the stream and groundwater.

Stream Watch data show that dry conditions occur in summer and fall in most years and in spring in some years (**Figure 5-3**). Stream Watch observations at Bale Slough near Highway 29 reported flowing water 43 percent, and 55 percent reported dry conditions. Isolated pools were only observed on two occasions. The The Natural Flows Database suggests that median unimpaired summer flows were 0-0.53 cfs (10th-90th percentile) during dry years.

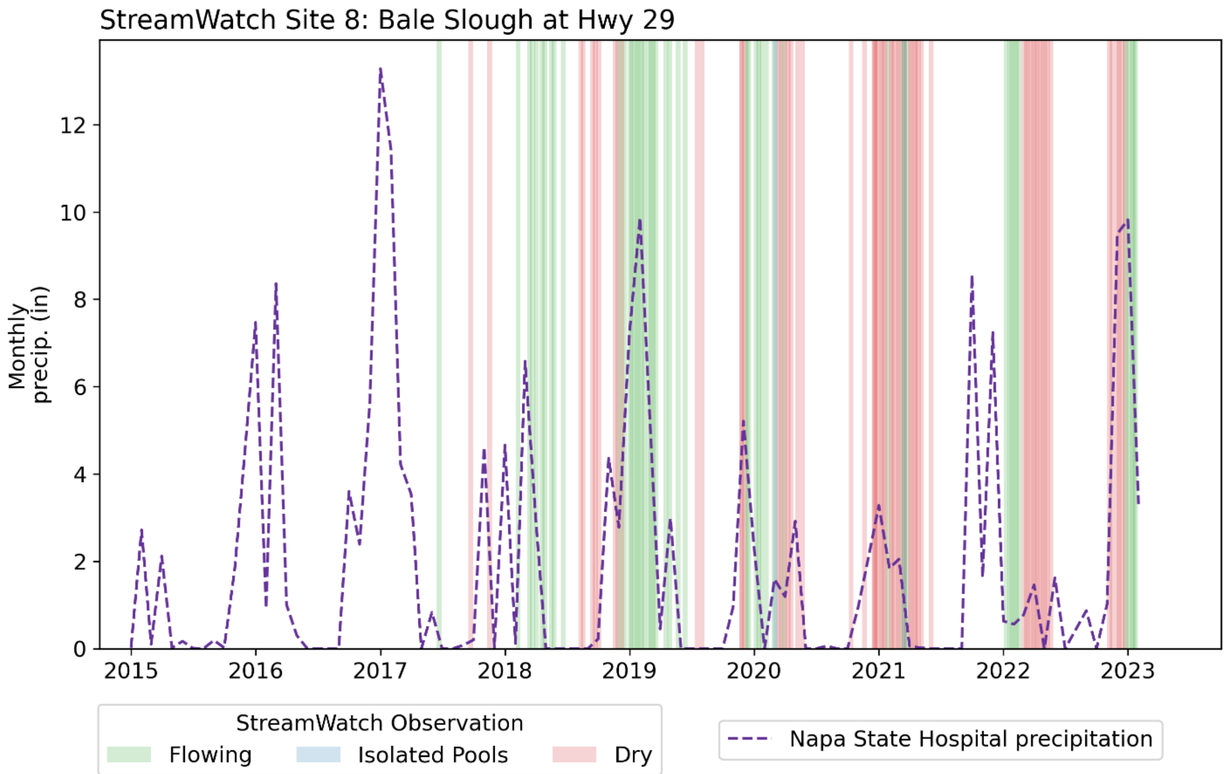


Figure 5-3. Observations from Stream Watch Site 8, monthly precipitation at Napa State Hospital

Ecological Targets:

Bale Slough is critical habitat for steelhead. The reach is mapped as spawning habitat and a migration corridor for Chinook salmon and steelhead, with a small reach of rearing habitat at the western edge of the subbasin. One of the goals of the Bale Slough restoration project is to improve rearing habitat in the reach. Foothill yellow-legged frog have been observed in Bear Creek upstream of the reach.

Known and Likely Stressors:

Summer water temperatures are warm enough to potentially stress steelhead, and groundwater inputs may not be sufficient to maintain low stream temperature (Stillwater and Dietrich 2002). Channel simplification and incision have decreased available rearing habitat in the reach, but the Bale Slough – Bear Creek Sediment Reduction and Habitat Enhancement restoration project is designed to reduce stream bank erosion and channel incision and enhance salmonid habitat. Project construction began in 2023.

Data Gaps:

Shallow groundwater monitoring has been absent historically, but monitoring will begin at a newly installed dual-completion monitoring well in Fall 2023 (NapaCounty-245d/246s). The relative importance of groundwater in winter/spring flows is not well-known and linkages between flow and habitat are unknown.

Napa River near Yountville

GDE Type:

Ecosystems associated with ISW, oak woodlands (riparian)

Surficial Landscape Features:

This site includes the confluence with Conn Creek and the Yountville Ecological Reserve. Land cover is agriculture (vineyards) outside of the Ecological Reserve. This reach overlies alluvium, with outcrops of Sonoma Volcanics in the Yountville hills and the hillsides along the valley. The river flows along the Yountville hills approximately 1.1 miles upstream of the Napa County-220s-SWGW4 site. The valley slope upstream at Rutherford is approximately 0.002. There are drainage tiles near the site (LSCE, 2022a) that likely decrease recharge and increase peak flows. The reach is in the middle of the Oak View/Oak Knoll (OVOK) restoration project. The reach immediately below the Ecological Reserve was part of the restoration project and included bank stabilization, creation of floodplain benches, and removal of invasive species. Cross-sections were surveyed in this reach as part of the restoration monitoring program.

Groundwater and ISW Dynamics and Hydrologic Fluxes:

Flows are affected by upstream water management and use, including dams, groundwater pumping, and flow diversions. Despite relatively low groundwater well density near this site, the area near the site had an intermediate volume of groundwater pumping in 2022 relative to the rest of the Subbasin (LSCE, 2023). The site is near the confluence with Conn Creek, which makes up 40 percent of the drainage area at the site. Conn Creek and its tributary, Rector Creek, are both regulated by dams. Lake Hennessey on Conn Creek was built in 1948, and Rector Dam was built in 1946. Lake Hennessey is the largest reservoir in the Napa River Watershed. Flow in Conn Creek is affected by Lake Hennessy and Rector Dam and is likely disconnected from groundwater for most of its length until it nears the Napa River. Hennessey and Rector dams do not affect flows upstream of the confluence but likely affect the timing of groundwater recharge.

Conn Creek is likely disconnected from groundwater within the Subbasin until it nears the Napa River. The Natural Flows Database suggests that Lake Hennessey decreases flows relative to unimpaired conditions from October through June and increases flows from July through September. Releases from Lake Hennessey were monitored by the USGS at gage 11456500 from 1929-1959 and 1970-1975. The Natural Flows Dataset suggests that median unimpaired summer flows were 5 cfs, with periodic disconnection during dry years.

The NVIHM results suggest this site is disconnected from the water table beginning in the early to mid-summer through the late fall or early winter. This reach reconnects to the aquifer system in winter when groundwater levels recover due to recharge from precipitation.

Stream Watch Sites are located at the Napa River Ecological Reserve (Site 1) and Napa River at Cook Road (Site 24). Since 2017, the Napa River at the Ecological Reserve has had flowing water during approximately

79 percent of the observations and isolated pools during the remaining 21 percent (**Figure 5-3**). The spatial resolution of the NVIHM is not sufficient to differentiate between isolated pools and dry conditions. Site 24 is slightly drier with dry conditions during 2 percent of the observations, isolated pools in 35 percent of the observations, and flowing the remaining 63 percent of the observations.

Groundwater levels at Napa County-220s-SWGW4 are typically above or near thalweg elevation, indicating connectivity between groundwater and surface water as well as gaining stream conditions in the reach (**Figure 5-4**). The ground surface in this figure is the ground surface adjacent to the groundwater well. Dynamic river stage values below the streambed elevation at this site reflect conditions where water is present but below the surveyed thalweg elevation because the thalweg location and gage location are not exactly co-located. Groundwater levels dropped below the thalweg in 2020 and 2021. Groundwater levels in the shallower monitoring well indicate “consistent to intermittent direct hydraulic connection.” Groundwater levels in Napa County-220s dropped below the Minimum Threshold during the summers of 2020-2022. In all three years, the channel maintained isolated pools and the thalweg elevation is a reasonable approximation of the groundwater elevation at which the pools become isolated. In contrast to sites upstream and downstream, this site did not go dry. The role of releases from Lake Hennessey during this period is not known.

Deeper monitoring wells (NapaCounty-133 and 134) show relatively steady groundwater levels that fluctuate 10-15 feet between spring and fall. The summer/fall groundwater levels decreased during the dry years in the mid-2010s but recovered during the wetter period in 2019.

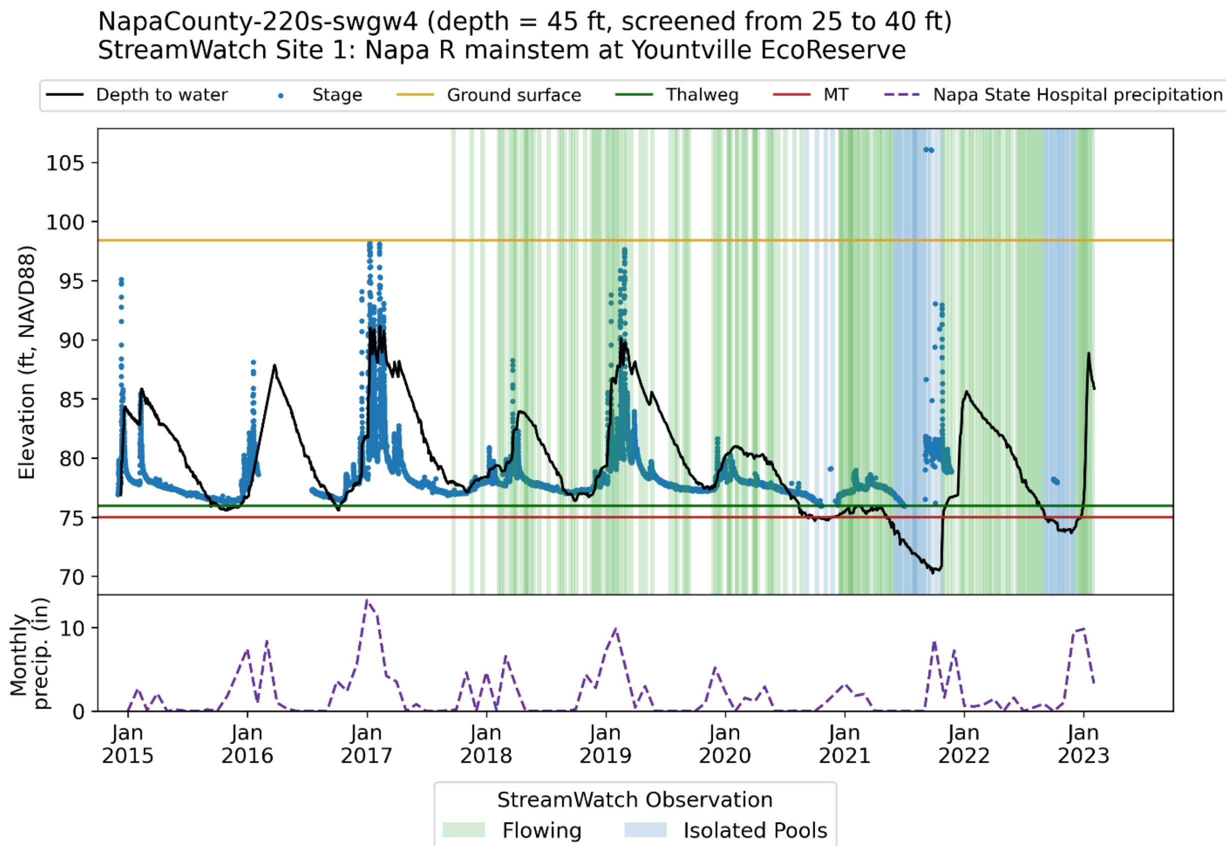


Figure 5-4. NapaCounty-220s-swgw4, groundwater levels and stage, observations from Stream Watch Site 1, monthly precipitation at Napa State Hospital, thalweg elevation near monitoring well, and the Minimum Threshold for monitoring well.

Groundwater pumping at this site has a small effect on flows in the winter and spring (10-15 cfs or less than 25 percent of the discharge). In summer, the difference between existing flows and flows without pumping has a lower magnitude (5-7 cfs) but reduces flows by a greater percentage (**Table 5-5**) than in the wet season. The modeling shows that in the absence of groundwater pumping, the minimum flow would be just over 4 cfs, while under existing conditions from 1988 through 2022, the channel has zero flow for nearly 30 percent of the low-flow season.

Table 5-5. Estimated Stream Depletion by Water Year Type (Napa River at Yountville)									
Month	Dry Years			Normal Years			Wet Years		
	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	111.5	9.4	8%	236.8	12.4	5%	855.3	14.3	2%
Feb	228.2	10.5	5%	367.6	11.9	3%	936.4	13.0	1%
Mar	186.9	9.4	5%	273.8	10.2	4%	616.9	10.5	2%
Apr	72.6	7.8	11%	84.5	7.9	9%	304.0	7.2	2%
May	26.8	6.5	24%	28.1	6.8	24%	102.8	5.9	6%
Jun	8.9	6.1	68%	13.1	7.2	55%	33.5	6.1	18%
Jul	6.1	5.9	96%	9.3	7.7	82%	17.1	7.2	42%
Aug	4.4	4.3	98%	7.1	6.8	96%	12.8	8.4	66%
Sep	4.7	4.6	98%	8.2	7.6	93%	11.7	8.5	72%
Oct	20.3	8.0	40%	38.1	10.9	29%	42.9	11.4	27%
Nov	31.2	8.1	26%	73.4	12.7	17%	73.2	11.3	16%
Dec	68.5	10.9	16%	275.0	15.5	6%	396.2	13.9	4%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the 'No Pumping scenario'.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

Ecological Targets:

GDE vegetation is primarily Riparian valley oak. NDVI has generally been stable, with a drop in 2021 (followed by recovery). This reach is listed as critical habitat for steelhead and provides spawning and rearing habitat for steelhead and Chinook salmon (Napa County RCD, 2019). Northwestern pond turtles have been observed in the Napa River nearby and Conn Creek.

Known and Likely Stressors:

Groundwater pumping causes significant streamflow depletion during the summer (**Table 5-3**). Channel incision and simplification occurred historically, but the Oakville to Oak Knoll restoration project (completed 2021) includes restoration activities upstream and downstream of the Ecological Preserve.

Data Gaps:

Relationships between discharge and habitat for salmonids and other aquatic species have not been defined in this reach. Water quality, particularly temperature and dissolved oxygen levels in pools in the reach are unknown.

Napa River at Oak Knoll

GDE Type:

Ecosystems associated with ISW; riparian zones (mostly oaks).

Surficial Landscape Features:

The Napa River is close to the eastern edge of the Subbasin here, with a large alluvial fan associated with Dry Creek to the west. Quaternary alluvium thickness ranges from about 30 to 100 feet. Land use near the site is primarily agricultural, with numerous vineyards surrounding the site.

The channel gradient at Oak Knoll is approximately 0.001. The Napa River has a high-flow secondary channel downstream of the site. This reach is the southern end of the OVOK Restoration Project. This site is downstream of the Napa River confluence with Conn Creek and is, therefore, influenced to some degree by Hennessey Dam operations.

Groundwater and ISW Dynamics and Hydrologic Fluxes:

Flows are affected by upstream water management and use, including dams and groundwater pumping. Several tributaries (To Kalon, Yount Mill, Conn, Chase, and Dry creeks) join the Napa River upstream of the reach. Conn Creek substantially increases the drainage area at this reach compared with upstream sites. Operation of Lake Hennessey and Rector Reservoir (which lie within the Conn Creek drainage) affects surface flow in this reach. Irrigation water sources near the site include groundwater and surface water diversions (LSCE, 2022a).

The Natural Flows Dataset suggests that median unimpaired summer flows on the Napa River at Oak Knoll are 0.22/5.75/19.7 cfs (10^{th}-50^{th}-90^{th} percentile). The observed median discharge is 2.6 cfs. The USGS Dry Creek gage (gage 11457000), near Dry Creek Rd. west of Hwy 29, was “relatively unimpaired” from 1951 to 1966 and was used as training data for the natural flow model (CEFWG, 2021b). From the Natural Flows Dataset: median unimpaired summer flows on Dry Creek in the Oak Knoll reach are 0.05/0.29/1.1 cfs (10^{th}-50^{th}-90^{th} percentile).

Groundwater levels at Napa County SWGW3 are typically above or near thalweg elevation (**Figure 5-4**), indicating connectivity between groundwater and surface water as well as gaining stream conditions in the reach. The ground surface in this figure is the ground surface adjacent to the groundwater well. Dynamic river stage values below the streambed elevation at this site reflect conditions where water is present but below the surveyed thalweg elevation because the thalweg location and gage location are not exactly co-located. Stable stage measurements in the dry season (e.g., summer and fall 2020 and 2021) likely represent isolated pool or dry conditions. Groundwater levels dropped below the thalweg in 2020 and 2021 (**Figure 5-5**). Groundwater levels in the Napa County-218s-SWGW3 (shallower monitoring well) indicate “consistent to intermittent direct hydraulic connection.”

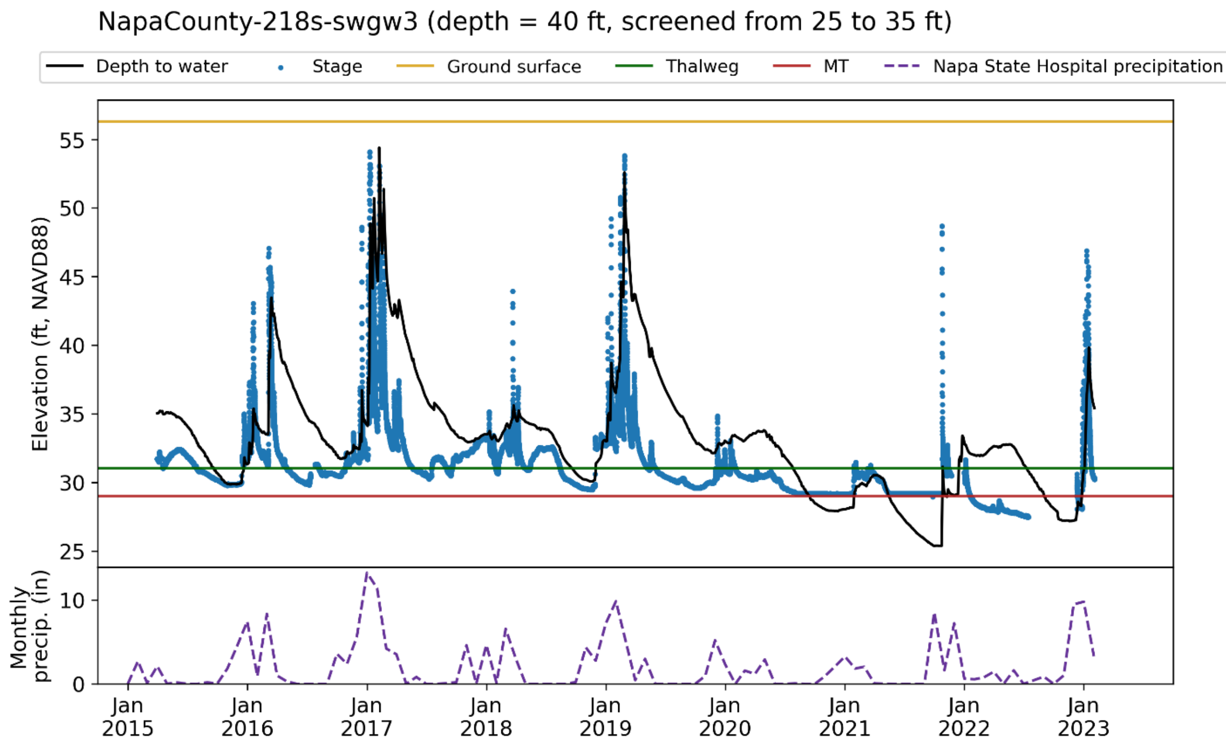


Figure 5-5. NapaCounty-218s-swgw3, groundwater levels and stage, monthly precipitation at Napa State Hospital, thalweg elevation near monitoring well, and the Minimum Threshold for monitoring well.

The USGS Napa River near Napa gage (Gage 11458000) is located at the Oak Knoll Bridge. The gage recorded flow of 0 cfs about 13 percent of the time from 10/1/1959-present, but no flow conditions were closer to 34 percent from 10/1/2014-7/1/2023. The NVIHM suggests that 0 cfs flow in the summer would be very rare in the absence of groundwater pumping, but stream depletion greater than 95 percent occurs in dry and normal years during August and September (**Table 5-6**).

Table 5-6. Estimated Stream Depletion by Water Year Type (Napa River at Oak Knoll)

Month	Dry Years			Normal Years			Wet Years		
	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	127.6	13.2	10%	290.0	17.9	6%	1061.9	21.5	2%
Feb	273.7	15.3	6%	447.8	17.1	4%	1138.0	18.7	2%
Mar	221.2	13.6	6%	325.6	14.5	4%	740.3	15.0	2%
Apr	79.3	10.0	13%	93.2	10.2	11%	348.7	10.4	3%
May	29.6	7.8	26%	30.4	8.2	27%	116.6	8.4	7%
Jun	9.6	7.2	75%	13.9	8.4	61%	35.3	7.2	20%
Jul	6.3	6.2	98%	9.6	8.4	87%	17.5	8.5	49%
Aug	4.3	4.2	98%	7.1	6.9	97%	13.4	10.0	74%
Sep	4.8	4.7	98%	8.7	8.4	96%	12.7	10.2	80%
Oct	22.8	9.7	42%	44.8	13.8	31%	49.9	14.4	29%
Nov	36.6	10.1	28%	86.8	16.6	19%	88.9	15.2	17%
Dec	80.8	14.4	18%	342.4	22.5	7%	502.2	21.6	4%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the ‘No Pumping scenario’.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

Ecological Targets:

GDE vegetation is primarily Riparian Valley Oak. NDVI was historically stable, with a decrease in 2021 followed by recovery. The site supports steelhead and Chinook salmon spawning and rearing (Napa County RCD, 2019).

Known and Likely Stressors:

Stressors include groundwater pumping, upstream dams, and channel simplification. The Oakville to Oak Knoll restoration project (completed in 2021) may have enhanced habitat in this reach.

Data Gaps:

The influence of Hennessey Dam on flows in this reach is uncertain.

Napa River near First Street

The prioritization of the Napa River at Napa was changed to account for the source of summer flows. Because of the relatively impermeable substrate at the site, a local connection to groundwater is unlikely, freshwater inputs to the reach are supplied by upstream ISW. The Napa River at Napa site was changed from a high priority site to an alternative site based on comments to the Public Draft of the Workplan.

GDE Type:

Ecosystems associated with ISW.

Surficial Landscape Features:

This Napa River at Napa site is monitored at Napa County-214s-swgw1. The Napa River is tidal and perennial in this reach; the thalweg elevation is -18 feet mean sea level. The Napa River is dredged for navigation downstream of the confluence with Tulucay Creek (downstream of this site). The site is located within the Napa River Flood Control Project Contract 3 Area, which includes planted vegetation and setback levees. The project is a multi-purpose flood protection and floodplain reconnection project. Vegetation is monitored as part of the Napa River Flood Protection Project. The upstream-most vegetation transect is downstream near the Third Street Bridge (Rincon, 2022; Stillwater Sciences, 2017).

Groundwater and ISW Dynamics and Hydrologic Fluxes:

Flows are affected by upstream water management and use, including dams and groundwater pumping. Surface flow to the Napa River near First Street site is influenced by dams (including Hennessey and Rector dams) which block about 30 percent of the drainage area at First Street (SFEI 2012).

The Natural Flows Dataset suggests that unimpaired summer flows on the Napa River at Napa are 0/6.7/22 cfs (10^{th}-50^{th}-90^{th} percentile).

Groundwater levels at Napa County-214s-SWGW1 are typically above the thalweg elevation and are closely linked with surface water elevation (**Figure 5-6**). Based on the fine sediments that make up the riverbed and electrical conductivity measurements, it is unlikely that there is an exchange between surface water and groundwater at this site (LSCE, 2022a). The tidal variation in surface water elevation is 5-7 feet (LSCE, 2022a). Because the channel is perennial, there is no Stream Watch site in this reach.

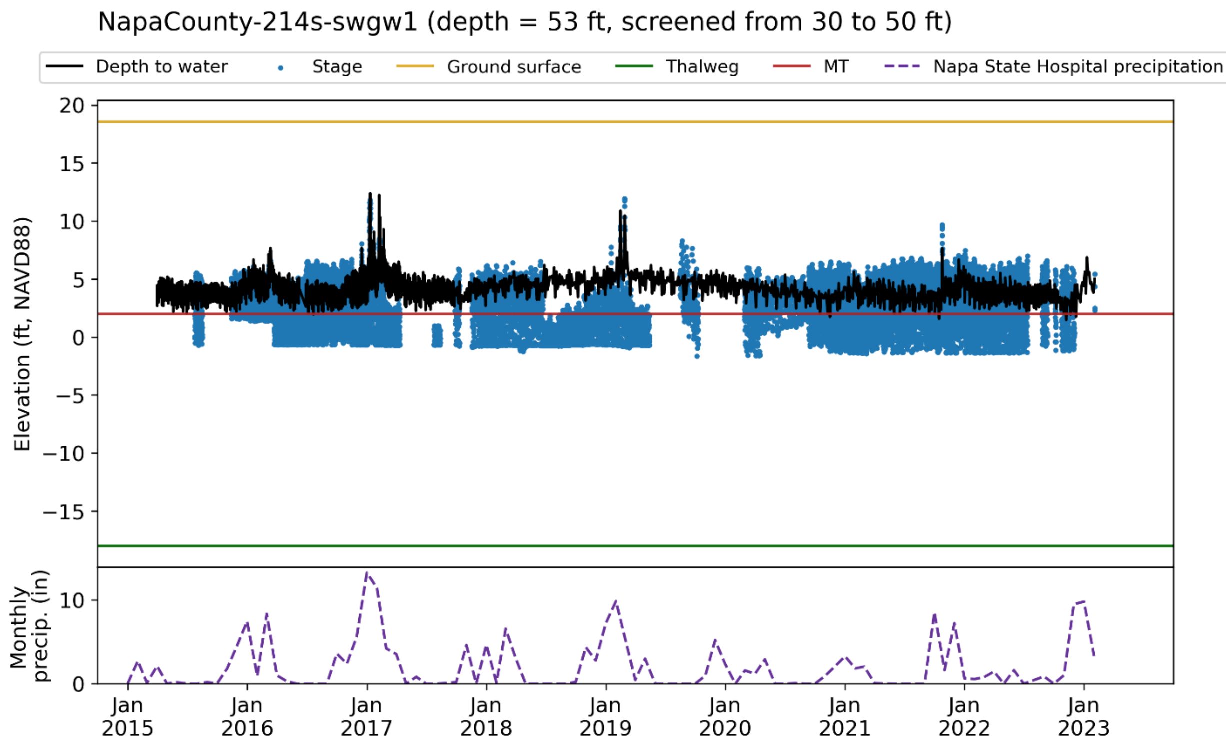


Figure 5-6. NapaCounty-214s-swgw1, groundwater levels, monthly precipitation at Napa State Hospital, thalweg elevation near monitoring well, and Minimum Threshold for monitoring well

Although the channel is always flowing, groundwater pumping has affected flows during summer (**Table 5-7**). Under existing conditions from 1988 through 2022, the NVIHM results suggest that the Napa River flows perennially at this site, however groundwater pumping reduces streamflow by between 55 to 70 percent during low flows in Dry and Normal water year types.

Table 5-7. Estimated Stream Depletion by Water Year Type (Napa River at Napa)

Month	Dry Years			Normal Years			Wet Years		
	Streamflow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Streamflow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Streamflow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	162.7	15.5	10%	352.7	21.4	6%	1235.7	26.1	2%
Feb	329.4	18.7	6%	520.3	20.8	4%	1283.3	23.1	2%
Mar	262.0	16.7	6%	371.1	17.6	5%	833.3	19.0	2%
Apr	92.7	12.1	13%	105.6	12.3	12%	387.8	13.2	3%
May	36.3	9.3	26%	35.9	9.6	27%	134.1	10.6	8%
Jun	14.0	8.6	61%	18.0	9.7	54%	42.0	8.6	20%
Jul	11.3	7.6	68%	14.7	9.8	67%	23.6	10.0	42%
Aug	9.4	5.7	60%	12.3	8.3	67%	19.6	11.7	59%
Sep	10.2	6.3	62%	15.0	10.2	68%	19.4	12.0	62%
Oct	29.1	11.7	40%	58.8	16.1	27%	65.1	17.0	26%
Nov	49.4	12.3	25%	111.9	19.7	18%	119.5	18.1	15%
Dec	103.1	16.9	16%	417.4	26.7	6%	615.1	26.3	4%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the 'No Pumping scenario'.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

Ecological Targets:

There are no mapped GDEs at this site. There is a patch of Valley Oak (*Quercus lobata*) just upstream in the Oxbow Preserve; more Valley Oaks occur just upstream of the Preserve on the west side of the Napa River.

The reach is mapped as a migration corridor for steelhead and Chinook salmon. Longfin smelt have been observed about 1.4 miles downstream of the site near the Riverside Drive boat ramp.

Known and Likely Stressors:

This site is influenced by:

- Levee development
- Urbanization
- Channel simplification
- Upstream dams
- Groundwater pumping

The NVIHM results indicate that groundwater pumping upstream of this reach, north of Yountville to St. Helena, is the most significant contributor to stream depletion in the Napa River at Napa reach.

Data Gaps:

Linkages between habitat and flow at this site are not known. Flow and substrate conditions are not suitable for salmonid spawning but use by other fish is less well known.

St. Helena Area – Sulphur Creek

GDE Type:

Riparian Valley Oaks and mixed willow alliance along Sulphur Creek to the confluence with Napa River mainstem.

Surficial Landscape Features:

Sulphur Creek emerges from the hills west of the Napa Valley Subbasin and flows toward the Napa River through St. Helena. Sulphur Creek is noted for a high sediment supply attributed to the Franciscan formation bedrock in its watershed (Grossinger et al. 2004). Sulphur Creek has supported a consistently braided channel morphology near the Valley View Bridge but has incised in its lower reaches near the Napa River confluence (Pearce and Grossinger 2004). Both sides of the channel are urbanized for the lower mile of the creek, with the north bank urbanized for most of the rest of its length in the Subbasin. Sulphur Creek is wider than many other tributaries in the Subbasin and supports large gravel and sand bars in its upstream reaches (upstream of Crane Avenue).

Groundwater and ISW Dynamics and Hydrologic Fluxes:

Sulphur Creek is intermittent, with flows in winter and spring. NVIHM results suggest the lower portions of the channel are connected 25-75 percent of the time in March and disconnected in summer.

LSCE (2022a) suggests that there is low to moderate groundwater extraction near Sulphur Creek, although the well density is higher than most of the Subbasin. LSCE (2022a) did not map any flow diversions in the Creek and there are no large upstream dams.

Stream Watch data show that dry conditions occur in summer and fall in most years and in spring in some years (**Figure 5-7**). The Natural Flows Database finds the median unimpaired summer flows (dry-season baseflow) were 0.43 cfs (0.09-1.24 cfs, 10^{th}-90^{th} percentile).

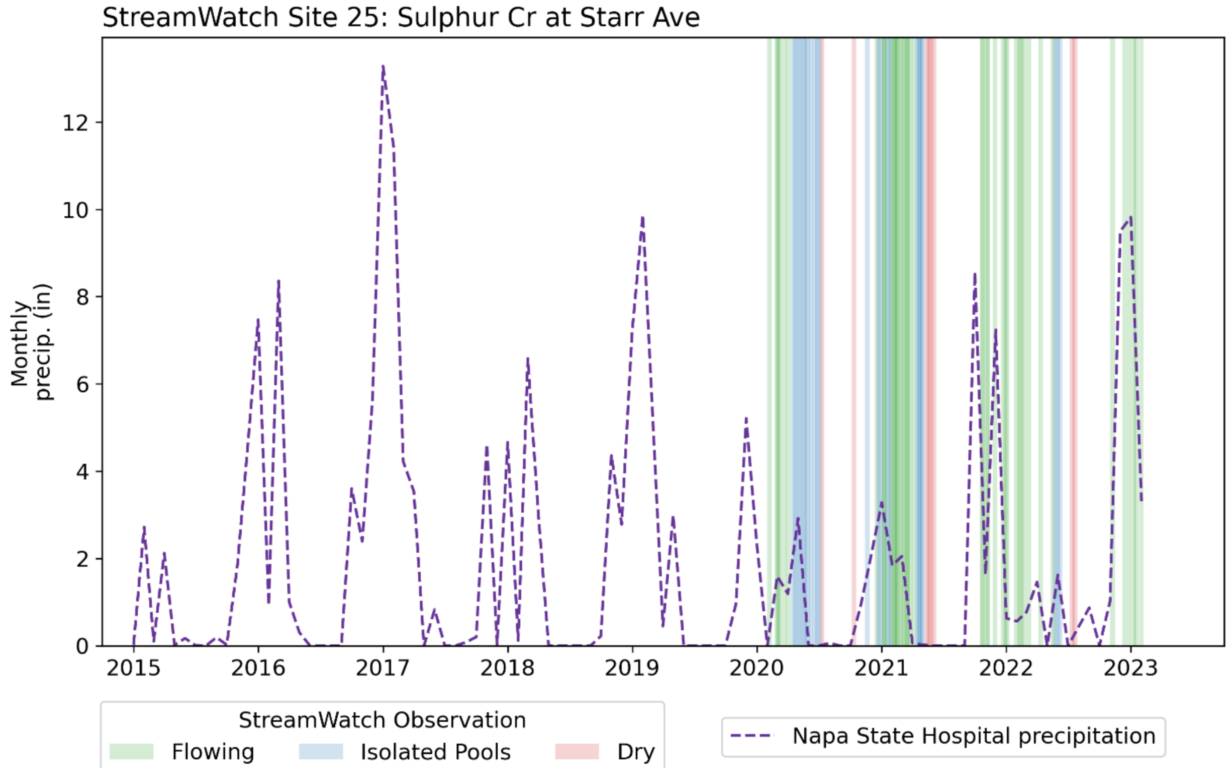


Figure 5-7. Observations from Stream Watch Site 25, monthly precipitation at Napa State Hospital

The NVIHM results show that Sulphur Creek is typically disconnected from the water table in this reach, with the exception of wet winters. As a result, the NVIHM results indicate that groundwater pumping has little impact on streamflow in this reach (**Table 5-8**). Monthly discharge in the calibrated model does not differ significantly from the scenario with no groundwater pumping.

Table 5-8. Estimated Stream Depletion by Water Year Type (Sulphur Creek at Starr Ave)

Month	Dry Years			Normal Years			Wet Years		
	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion	Stream-flow (cfs)[1]	Stream Depletion (cfs)[2]	Percent Stream Depletion
Jan	1.6	0.0	1%	11.1	0.0	0%	47.5	0.1	0%
Feb	8.5	0.0	0%	19.4	0.1	0%	50.7	0.1	0%
Mar	8.0	0.0	0%	13.5	0.1	0%	32.7	0.1	0%
Apr	1.0	0.0	1%	1.5	0.0	1%	11.0	0.1	1%
May	-	-	-	-	-	-	1.6	0.0	3%
Jun	-	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-
Sep	-	-	-	-	-	-	-	-	-
Oct	-	-	-	0.3	0.0	2%	-	-	-
Nov	-	-	-	0.4	0.0	2%	0.1	0.0	2%
Dec	0.5	0.0	1%	11.8	0.0	0%	18.1	0.0	0%

1. Streamflow is the simulated flow, from the NVIHM, when all irrigation pumping has been removed from the simulation, typically referred to as the 'No Pumping scenario'.
2. Stream depletion is calculated as the difference between all agricultural pumping removed (No Pumping) and the Baseline model scenario. The Baseline scenario includes agricultural pumping. Stream depletion occurs in winter months due to the time it takes for pumping effects to move through the hydrogeologic system.

Ecological Targets:

Sulphur Creek is a critical habitat for steelhead and provides spawning and rearing habitat for steelhead and Chinook salmon (Napa County RCD, 2019). Foothill yellow-legged frogs have been recorded along intermittent reaches of Sulphur Creek. Habitat conditions and population are recorded in good condition.

GDE vegetation is riparian Valley Oaks and mixed willow alliance. No long-term trends in NDVI are apparent (LSCE, 2023).

Known and Likely Stressors:

While groundwater pumping has little effect on Sulphur Creek, the NVIHM results indicate that groundwater pumping in this area contributes to stream depletion downstream (Napa River at Napa). The effect of channel incision and aggradation on rearing habitat has not been explored.

The lower reaches of Sulphur Creek flow through St. Helena. The degree to which levees and other flood protection have influenced the site is not known.

Sulphur Creek has a large sediment supply and historically built a large alluvial fan that helped push the Napa River to the eastern boundary of the Napa Valley. The creek was mined for gravel until 2002, and the relative elevation of the floodplain suggest that the channel is currently close to its historical elevation near the cemetery (SFEI 2012).

Data Gaps:

Shallow groundwater monitoring has been absent historically, but monitoring will begin at a newly installed dual-completion monitoring well in Fall 2023. The relative importance of groundwater in winter/spring flows is not well-known and linkages between flow and habitat are unknown.

6. WORKPLAN IMPLEMENTATION

This section presents recommendations for assessing the ecological health of GDEs in the Napa Valley Subbasin. Workplan implementation includes: (1) evaluation of ongoing monitoring from other programs or agencies, (2) collection of hydrologic and remote sensing data throughout the basin to assess the effects of groundwater pumping on GDEs, (3) collection of biological and hydrologic data at the six intensive monitoring sites, and (4) incorporation of CEFF steps. Ongoing and new workplan activities throughout the Subbasin and at intensive monitoring sites are described in this section and summarized in Table 6-X.

Initial studies are designed to assess baseline habitat and habitat-flow relationships at intensive monitoring sites, with subsequent monitoring focused on assessing trends in ecosystem health to inform groundwater management. The results of these assessments will be used to assess the ecohydrological condition of the site as a whole using NVIHM and Subbasin-wide data (e.g., Stream Watch). The relationships between discharge and habitat and information on usage by a variety of special-status species at the intensive monitoring sites will be used in combination with NVIHM to assess other reaches with similar hydrology and ecosystems and to identify additional data gaps to be addressed. This Workplan is intended to be a living document with prioritization of sites and measurements evolving through time based on input from the Technical Advisory Group (TAG) and the NCGSA. Data gathered during Workplan implementation will be used to assess additional data needs and inform Minimum Thresholds and Measurable Objectives that consider ISW and GDEs.

Explicit ecological management goals include:

1. Protect and enhance habitat for groundwater-dependent aquatic and terrestrial special-status species in the Subbasin;
2. Protect and enhance GDEs and natural communities;
3. Protect and enhance habitat connectivity with aquatic habitat upstream of the Subbasin; and
4. Develop discharge-habitat relationships for special-status species, where possible.

The goals will be revisited annually at the completion of Workplan implementation. Inherent in meeting each of these goals is monitoring ISW, including shallow groundwater and surface flow throughout the Subbasin, and the use of the NVIHM to assess the effects of groundwater pumping on ISW throughout the Subbasin.

Table 6-1. Ongoing and New Workplan Monitoring Activities		
Period	**Location**	**Activity**
Ongoing	Subbasin	Shallow groundwater monitoring
		Surface water monitoring
		Stream Watch
		Restoration monitoring
		Napa County RCD fish monitoring
		NVIHM refinements and updates
New with Workplan implementation	Subbasin	Relative elevation mapping
		Stream Watch expansion
		Remove sensing of GDEs
	Intensive monitoring sites	Flow connectivity survey
		Special-status fish monitoring
		Special-status aquatic wildlife monitoring
		Vegetation monitoring
		Special-status plants and sensitive natural communities monitoring
		Special-status terrestrial wildlife monitoring
		Additional CEFF part A and B tasks

6.1. Subbasin-Wide Monitoring and Evaluation

6.1.1. Ongoing Subbasin Monitoring

This section describes ongoing monitoring from other programs or agencies that will be evaluated as part of this Workplan.

6.1.1.1. Shallow Groundwater Monitoring

Shallow groundwater monitoring includes continuous monitoring with transducers at the five SWGW/ISW sites installed in 2014 and the eight additional SWGW/ISW sites installed in 2023 (**Figure 3-9**). Transducer data are downloaded on a quarterly basis. Five of the six recommended intensive monitoring sites have nearby SWGW/ISW sites. The data from these and other monitoring wells in the Subbasin will be used to evaluate shallow groundwater conditions and ISW at the intensive monitoring sites and elsewhere in the Subbasin.

6.1.1.2. Surface Water Monitoring

Surface water monitoring includes continuous stage monitoring with transducers at the five SWGW/ISW sites installed in 2014 and will include the eight additional SWGW/ISW sites installed in 2023 with surface water stage data to be installed in 2024 (**Figure 3-10**). Transducer data are downloaded on a quarterly basis. Five of the six recommended intensive monitoring sites have nearby SWGW/ISW sites. The data from these and other surface water monitoring sites will be used to evaluate ISW conditions at the intensive monitoring sites and elsewhere in the Subbasin.

6.1.1.3. Stream Watch

The shallow groundwater and surface water monitoring data will be supplemented by the ongoing Stream Watch program outlined in **Section 3.2.3**.

The hydrological monitoring results can be compared with results from the NVIHM to inform the model and assess model performance in determining connectivity.

6.1.1.4. Restoration Monitoring

There are several ongoing monitoring programs associated with stream restoration projects in the Subbasin that can be leveraged to assess ecological conditions throughout the Subbasin. Monitoring for three restoration projects on the mainstem Napa River, conducted or coordinated by Napa County RCD and/or Napa County Flood Control and Water Conservation District, is described below. Following the implementation of the Napa River Flood Protection Project, ecological response to the restoration has been monitored using repeated habitat mapping of vegetation types and assessment of vegetation along 15 transects. These surveys have occurred every five years since 2012 (Napa County Napa County Flood Control and Water Conservation District [FCWCD] 2022, Stillwater Sciences 2018, and Stillwater Sciences 2013a). The Rutherford Reach restoration project, completed in 2012, includes habitat rehabilitation, floodplain creation, and vegetation planting along a 4.5-mile reach from south of St. Helena to Oakville Cross Road. Monitoring conducted by the Napa County RCD includes channel thalweg surveys, 16 cross-section surveys, assessment of large woody debris, and mapping eroding banks (Napa County FCWCD and Napa County RCD 2023a). Vegetation monitoring includes 22 vegetation transects first surveyed in the first three years after project implementation and then in years 5 and 10. The transects were surveyed in 2020 and will be resurveyed in 2025. The OVOK Restoration Project included restoration along 8.4 miles of the Napa River. Monitoring includes topographic surveys of 19 cross sections throughout the reach and thalweg surveys (2020 and 2022) that covered about half of the project reach. The cross sections were surveyed in 2012 prior to the project and in 2022 after project completion. Vegetation surveys include assessment of invasive species and survival of vegetation planted as part of the restoration project in 2020-2022 (Napa County FCWCD and Napa County RCD, 2023b). The OVOK monitoring includes annual spawner surveys conducted by the Napa County RCD.

6.1.1.5. Ongoing fish monitoring

The Napa County RCD monitors fish throughout the Napa River Watershed, including spawner surveys in the fall and winter and salmonid trapping at the rotary screw trap in the spring. RCD intends to continue operation of the rotary screw trap in its current location indefinitely if funding can be secured; however, due to significant downtime in recent years due to extreme high and low flows, the smolt monitoring program in the future with additional methods and/or locations (Paul Blank, personal communication). Additionally, there is extensive monitoring of vegetation (including GDEs), channel morphology, and fish habitat at restoration sites in the Napa River Watershed. These monitoring programs have data collection frequency and extent outlined in their respective monitoring programs; these are generally publicly available. Data collected by the Napa County RCD will be incorporated into annual technical memoranda.

6.1.1.6. NVIHM Refinements and Updates

The NVIHM is currently updated every year to include the latest climate and land use. Annual estimates of applied water, stream flow, and interconnected surface water will be ongoing.

Additional refinements to the NVIHM will occur during GSP implementation. Currently, the stream network is being refined to better reflect mapped cross-section geometry. Updates to the cross-section geometry will improve the representation of the wetted area of the stream and provide more realistic flow-depth relationships.

Additional updates planned for the NVIHM include (1) refinements to the upper watershed model approach, Including land use changes, as well as fire effects and the manner in which streamflow entering the Subbasin is modeled; (2) soil moisture refinements will be made with further development of the USGS MODFLOW code; and (3) total volume and timing of applied water in relation to different vineyard management decisions are being evaluated. These updates may affect how pumping is distributed across the Subbasin. Updates will be documented in the Napa County Groundwater Sustainability Annual Report.

6.1.2. New Subbasin Monitoring

6.1.2.1. Relative Elevation Mapping

The TAG recommended assessing the relative elevation of the near-channel areas of the Subbasin. Relative elevation maps identify the elevation relative to baselevel of near channel areas using lidar data. The 2018 USGS lidar will be used as the input topography for the relative elevation mapping. The baselevel is typically defined based on riffle crest elevation in the lidar. Relative elevation can be used as a proxy for depth to water for GDEs, particularly where the stage is known. Moreover, relative elevation modeling can be used to quantify stream incision throughout the basin and the extent of floodplain habitat. The results can be used to evaluate potential riparian habitat, assess floodplain refugia, and identify sites for floodplain restoration. In the Napa Valley Subbasin, a relative elevation map can assess the degree of incision and help to link shallow groundwater elevations with the range of elevation for GDEs.

6.1.2.2. Stream Watch Expansion

Gaps in the hydrologic monitoring network identified in **Section 3.3** will also be addressed through expansion of the volunteer Stream Watch network and/or installation of cameras and/or temperature loggers at up to 20 sites. These will be used to track when the loggers are submerged and may be able to identify when the stream is flowing and/or transitions to isolated pools. These sites would be identified and implemented by the Napa County RCD in coordination with the NCGSA.

6.1.2.3. Remote sensing of GDEs

LSCE (2022b; 2023) assessed changes to vegetation indices (e.g., NDVI and NDMI) of GDEs within the Napa Valley Subbasin using the GDE Pulse Tool (TNC, 2022). This remote sensing will continue during Workplan implementation, but it will be adapted to better reflect the growing season in the Napa Valley Subbasin and use the latest GDE maps. The NDVI and NDMI would be averaged for each GDE over the growing season in the Napa Valley (likely April through September) adapted for the Napa Valley Subbasin, where the growing season is longer than for California as a whole. In addition, NDVI and NDMI of updated GDE maps (**Figure 3-12**) will be tracked rather than the 1999 vegetation map used in TNC (2022).

6.2. Intensive Monitoring Site Data Collection

This section describes surveys associated with the six intensive monitoring sites identified in **Sections 4** and described in **Section 5**. Data collected near the intensive monitoring sites will be incorporated into the analyses described below. The extent of each site will be determined during Workplan implementation based on access and proximity to shallow groundwater monitoring and will include areas of similar dimensions. The extent of the monitoring may vary based on the type of monitoring at each site, but ideally it will include 2-3 pools.

6.2.1. Flow Connectivity Survey

Where access permits, dry-season flow connectivity will be assessed at each intensive monitoring site. Flow connectivity will be mapped at least four times annually, starting in spring and continuing through the dry season (as long as wet conditions persist within the reach) and will include the extent of connected flow, any dry reaches, and the locations of isolated pools. These surveys are intended to increase the extent of the Stream Watch network to assess the degree to which the Stream Watch site is representative of the reach as a whole. Because there are no active shallow wells or Stream Watch sites in the Napa River near Calistoga, flow connectivity will be mapped over the 1.5-mile reach of the Napa River and Garnett Creek upstream of Highway 29, where California freshwater shrimp occur. At other sites, flow connectivity surveys will be measured of a distance of 20 channel widths where access permits that length of stream survey (i.e., 2,000 feet where the bankfull channel width is 100 ft). Additional connectivity surveys may be identified in reaches where the transition from flowing conditions to isolated pools and dry conditions is uncertain.

6.2.2. Special-status Fish

6.2.2.1. Monitoring Methods

At each intensive monitoring site used by fish, monitoring will include a combination of habitat assessment and fish surveys. Habitat assessments will focus on the habitat present, the connectivity of that habitat, and the extent of habitat changes under different flow conditions. In addition, continuous temperature sampling and dissolved oxygen (DO) sampling will occur at a representative pool in each intensive site. The habitat surveys will occur at up to 10-15 channel widths to encompass 2-3 pools.

The fish population and usage surveys are intended to assess the species present (including any invasive predators) and how habitat is being used throughout the year. The type of fish survey depends on the conditions at the time of the survey. Surveys are likely to include:

- Multiple pass backpack electrofishing where possible (wadable depth <4ft);
- Three repeat snorkel passes through each habitat unit.; and
- Beach seine pools where turbidity is too high to snorkel.

The repeat pass surveys allow for bounded count population estimates (Routledge 1982) as well as to account for variability between observations. In addition, DO and temperature will be monitored using continuous data loggers at least one pool per reach.

The relationship between fish habitat and discharge at selected intensive monitoring sites will be analyzed using 2-D hydraulic modeling at a variety of representative flows with a focus on summer rearing habitat for steelhead. The modeled depth and velocity can be paired with proximity to cover field surveys to assess the available habitat. The extent of habitat at each site will be quantified by fisheries biologists for the life stages of steelhead and Chinook salmon during two to three field visits in spring and summer. The extent of high-quality habitat availability will be assessed by mapping instream occurrences of large woody debris (LWD), canopy cover, and dominant substrate throughout the reach. In addition, the dimensions of each pool in the reach will be recorded. These habitat metrics will be assessed using the CDFW Habitat Inventory Methods Protocol (Flosi et al., 2002). The habitat mapping will be coupled with the stream temperature, DO, and connectivity monitoring. **Table 6-2** shows example Habitat Suitability Criteria ranges for fry and juvenile steelhead based on CDFW (2014). Baseline fish habitat and population surveys would occur in 2024 and 2025. Follow up surveys would occur annually through 2030.

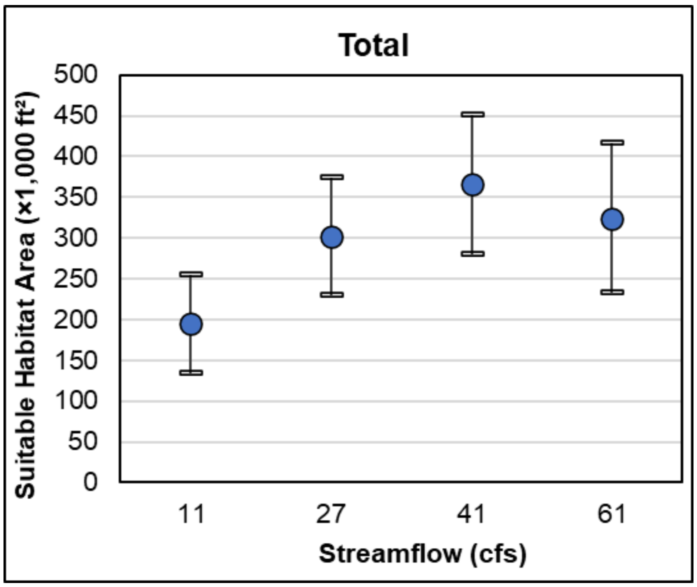
Table 6-2. Example Habitat Suitability Criteria (HSC) for Steelhead

Life Stage	Depth (ft)	Velocity (ft/s)	Proximity to cover (ft)[1]
Fry Rearing (< 2-6 cm)[2]	0.1-0.2	0.0.9	<2.4
Juvenile Rearing (6-15 cm)[3]	0.4-5.0	0.1-2.5	<4.8

1. CDFW (2014) defines cover as crevices among cobbles and boulders, ledges, aquatic vegetation, submerged overhanging branches of riparian vegetation, submerged organic debris, bent-over emergent sedges, low-hanging branches of riparian vegetation, high-flow debris clinging to overhanging riparian vegetation, and riverbank features.2. Criteria for fry steelhead 20–59 mm based on HSI ≥0.5 (CDFW 2014).
3. Criteria for juvenile steelhead 60–150 mm (CDFW 2014). Maximum depth for juvenile rearing based on USFWS (2011).

6.2.2.2. Analysis

Habitat availability at the intensive monitoring sites will be evaluated for a range of flows to develop a habitat discharge relationship (**Figure 6-1**). In **Figure 6-1**, 41 cfs corresponds to the maximum extent of suitable habitat for a reach within Coyote Creek in Santa Clara County. Because the range of natural flows may be small in a given year, field observations can be supplemented by 2-D hydraulic modeling, which can assess the changes in depth and velocity for a variety of flows. This requires topography from existing lidar supplemented by topographic surveys. A range of surface flows will be determined for each site based on the Natural Flows Database, NVIHM, and pro-rated flow data from nearby USGS gages. Flows would include fall peak flows, winter baseflow, spring recession, and dry season baseflows. Groundwater management may affect fall peak flows if antecedent low-flow conditions increase stream losses to groundwater thereby reducing peak magnitudes. Floodplain refugia during high flows can also be important for salmonid survival. This habitat is not related to groundwater management, unless groundwater levels drop below the rooting depth of vegetation that provides cover in these reaches. The extent of floodplain habitat at each site can be assessed using the relative elevation model and field assessment during other fish monitoring assessments.



Source: Stillwater Sciences 2021a

Figure 6-1. Example of Discharge Versus Habitat Area for Coyote Creek, Santa Clara County

6.2.3. Special-status Aquatic Wildlife

6.2.3.1. Monitoring Methods

Limited data are available for aquatic wildlife species in the Napa Valley Subbasin. Special-status species surveys will be conducted to determine the current spatial distribution of these species. Field surveys for aquatic wildlife will occur in 2024 and 2025 at intensive monitoring sites to establish baseline conditions, with follow-up surveys planned for 2030. Additional surveys may occur during years of exceptional drought or following floods. During 2024, habitat suitability for listed aquatic species will be assessed at each of the intensive monitoring sites, including aquatic breeding habitat for California giant salamander and all aquatic habitat for California freshwater shrimp, foothill yellow-legged frogs, and northwestern pond turtles. If suitable habitat is not available at the intensive monitoring site, a desktop analysis of habitat suitability will be used to determine suitable replacement sites for the special-status aquatic wildlife. The habitat suitability assessment will focus on areas with the highest potential for breeding, specific to each species' life history requirements, to target locations with the highest potential for species detection and the potential for the waterbody to be located within a GDE. Final survey site selection will include areas with moderate to high breeding habitat suitability where there is a high likelihood the breeding habitat is associated with groundwater, habitat where species have historically been detected, and locations with the potential for multiple species occurrences.

If suitable habitat is available, surveys will include Visual Encounter Surveys (VESs) and environmental DNA sampling (eDNA sampling). No targeted visual encounter field surveys are included for the California Freshwater Shrimp, northwestern pond turtle, or California giant salamander. For these species, eDNA and surface water connectivity at each site will be used to assess the species' presence.

Foothill Yellow-legged Frog

VESs for foothill yellow-legged frogs will be conducted to determine the timing and life stages utilizing GDEs. VESs will be conducted following standard visual survey protocols for foothill yellow-legged frogs outlined in Peek et al. (2017). Up to four surveys will be conducted at each site: two in the spring, one in the early summer, and one at the end of summer/early fall. Specific survey timing will be determined based on species' breeding seasons and environmental conditions for that year (e.g., streamflow, temperature, and accessibility). Surveys will document all life stages: adults, subadults, egg masses, and tadpoles. Surveys will generally consist of slowly walking or wading the perimeter of each site or stream reach while counting all life stages observed. Surveyors will take care to scan ahead to detect basking post-metamorphic individuals, and dip nets may be used to sweep habitat.

6.2.3.2. Environmental DNA Sampling

Sampling for eDNA will be conducted for foothill yellow-legged frogs at all suitable aquatic sites surveyed (sites with low suitability for foothill yellow-legged frogs would be selected for eDNA sampling only if high or moderately suitable sites are not identified). eDNA is an effective tool for detecting cryptic and rare species in stream systems, including foothill yellow-legged frogs. Species detection using eDNA methods is accomplished by the collection of water samples and identification of trace DNA particles, thought to originate from shed skin cells, feces, etc., that are extracted from the samples. The range of detection using eDNA methods is species-specific and related to environmental characteristics (e.g., water temperature, pH, ultra-violet light, etc.). Studies conducted in similar environments have found foothill yellow-legged frog DNA does not travel far in moving water and is not detected after about 328 feet (100 meters) from the source (Bedwell and Goldberg, 2020), which is consistent with other stream eDNA transport studies.

Water samples will be collected during one VES survey. eDNA field collection methods will be based on current eDNA sample collection literature and protocols (e.g., Kieran et al. 2020, Halstead et al. 2017, Bedwell and Goldberg 2019; Goldberg et al., 2016; Carim et al., 2016; Laramie et al., 2015; Pilliod et al., 2014). A minimum of two liters will be filtered at each sampling site and water samples will be collected every 328 feet within the sampling area. Surveyors will collect all samples from the water's surface and target sampling locations in habitats/micro-habitats that appear high quality foothill yellow-legged frog habitat (e.g., backwaters, rocky slow-moving streams). To prevent downstream contamination, surveyors will collect all samples from downstream to upstream, and where possible, surveyors will avoid entering the riverine system. All boots, equipment, and other materials that come in contact with the water will be decontaminated with a 10 percent bleach solution for 10 minutes prior to fieldwork and when changing sampling sites.

Site-specific eDNA sample design (e.g., number of samples collected and locations) and detailed methodologies (e.g., filter pore size and sample volume) will be developed based on habitat characteristics to maximize the likelihood of species detection within the sample site.

The eDNA samples will be frozen or stored in ethanol or desiccant and analyzed by an eDNA laboratory with validated assays for foothill yellow-legged frogs. Results will be reported as detection or non-detection for each species, respectively.

6.2.3.3. Special-status Aquatic Wildlife Analysis

Habitat mapping and field survey data (including eDNA) will be utilized to determine the presence of special-status species within the Napa Valley Subbasin. For intensive monitoring sites where flow connectivity may occur, the impact of dry conditions on habitat extent and quality will be assessed based on the timing of disconnected flow and the portion of the site that goes dry. At intensive monitoring sites, where field visits indicate habitat may be flow dependent and flows extend through critical lifestages, hydraulic modeling can be used to link habitat availability to flow. Hydraulic modeling (to assess depth and velocity) for special-status wildlife species would be considered pending recommendations after the baseline assessment. The baseline assessment is anticipated to be performed in 2024.

6.2.4. Vegetation Communities

6.2.4.1. Monitoring Methods

Vegetation monitoring will be performed in spring/summer within a portion of each intensive monitoring site assessment reach identified for field surveys. The vegetation assessment area will be selected to include groundwater dependent vegetation communities, special-status plants, and sensitive natural communities. Initial surveys in 2024 and 2025 will serve to establish baseline vegetation conditions. Follow up monitoring will occur in 2030 so the results can be included in the 2032 5-year GSP update. Interim monitoring may occur if triggered by exceedance of Minimum Thresholds for groundwater elevation or major fires or floods that alter the vegetation. Monitoring transects and/or plots will be established to assess vegetation composition, cover, and vigor of groundwater dependent vegetation communities. For communities dominated by woody species (e.g., oaks, riparian trees), transects will be established, and data will be collected using line point intercept methodology. Communities dominated by herbaceous species (e.g., wetlands, marsh habitats) will be assessed using plots. Plant vigor will be monitored by visually assessing foliage for each plant using qualitative categories detailed in **Table 6-3**.

Up to four monitoring locations (i.e., plots or transects) will be established within the vegetation assessment area and will be placed to capture a range of the GDEs present. Each transect will be monumented and surveyed with a GPS to facilitate repeat surveys. The location, extent, and number of monitoring locations at each intensive monitoring site will be established in the field. Monitoring locations will be paired with groundwater monitoring sites, as feasible, to relate species composition and overall health with known groundwater patterns.

Table 6-3. Woody Plant Vigor Categories for the Project	
Category	**Description**
1	Less than 25% of foliage appears to be healthy
2	25 to 50% of foliage appears to be healthy
3	51 to 80% of foliage appears to be healthy
4	81% (or greater) of foliage appears to be healthy

In addition to vegetation monitoring at plots and/or transects, vegetation community types and boundaries will be monitored within a portion of each intensive monitoring site assessment reach. The composition and/or extent of vegetation communities could vary through time as a result of floods, droughts, fire, and disease. Groundwater-dependent vegetation community mapping will be updated as a part of the field surveys, with the 2016 vegetation mapping (UC Davis, 2016) as a starting place for baseline surveys.

Vegetation community mapping will include boundaries for sensitive natural communities, which are defined as those natural community types (e.g., legacy natural communities in CDFW's CNDDB, vegetation alliances and/or associations) with a state ranking of S1 (critically imperiled), S2 (imperiled), S3 (vulnerable), or an unranked association that is considered sensitive on CDFW's California Sensitive Natural Communities List (CDFW, 2023c) or in the CNDDB (CDFW, 2023a).

6.2.4.2. Analysis

Vegetation community data collected during monitoring will be used to establish baseline conditions. Rooting depth reported in the literature (e.g., TNC, 2018; Fan et al., 2017) and wetland indicator status for observed species (USACE, 2022) will be used to support understanding of groundwater dependency and inform rationale for interpreting future changes to vegetation composition, cover, vigor, and community type.

Mapping of groundwater-dependent vegetation communities' extent over time will support an understanding of the effect of groundwater use or other environmental factors on groundwater-dependent vegetation. Declines in the extent or health of groundwater communities associated with changes in groundwater elevation can be used to update groundwater requirements for GDEs and inform the identification of Minimum Thresholds.

At intensive monitoring sites, changes to GDE health measured in the field can be linked with changes in NDVI and NDMI (and other remote sensing indices) to evaluate the degree to which NDVI and NDMI are useful metrics of vegetation health. Because the width of the riparian zone can be as small as one or two pixels in the satellite data, standard NDVI and NDMI analyses might not capture changes in vegetation health. If NDVI and NDMI values do not reflect changes in the extent or health of terrestrial GDEs measured during the monitoring period, higher spatial resolution remote sensing data may be considered for the intensive monitoring sites and Subbasin-wide surveys.

6.2.5. Special-status Plants and Sensitive Natural Communities

6.2.5.1. Monitoring Methods

A targeted special-status plant species survey will be conducted within the intensive assessment reaches. Targeted surveys will be focused on special-status plant species with the potential to be groundwater dependent (as listed in **Table 3-4**) and will be performed in May, which is within the blooming period of the groundwater-dependent special-status plant species with a likelihood to occur in the Subbasin. Surveys in 2024 and 2025 will serve to establish baseline population size and extent, with subsequent monitoring occurring every five years or sooner if remote sensing shows changes to vegetation health or if groundwater elevations fall below the trigger criteria defined for the site.

Within the vegetation assessment area of each intensive monitoring site, special-status plant surveys will target habitats where species are expected to occur. The extent of each population will be mapped using GPS and population information, including population counts, and will be collected using a CNDDB occurrence form. Vigor (**Table 6-3**) and plant associates (non-dominant plant species found within the mapped vegetation unit) will also be recorded. Observations of potential water sources (e.g., spring, tributary) will be noted and, where feasible, observed rooting depth will be recorded.

6.2.5.2. Analysis

Special-status plant species population data will be combined with existing information (i.e., CNDDB results) to establish baseline conditions. Species population extent (e.g., acreage, number of individuals) will be compared to the established baseline in subsequent surveys. Where possible, rooting depths observed in the field will be compared to known depths in the literature.

Vigor and plant associate species will be reviewed to support an understanding of site dynamics, such as an increase in non-native species cover or change in wetland indicator status of dominant plant associates through time. These surveys will be linked with physical parameters that could affect vegetation health (shallow groundwater data, the extent of floods, fires, and rainfall) to better understand vegetation dynamics at intensive monitoring sites.

6.2.6. Special-status Terrestrial Wildlife

6.2.6.1. Monitoring Methods

The special-status wildlife birds listed in **Table 3-5** use a variety of environments ranging from marshes to ISW to dense riparian vegetation. To establish a baseline survey, one acoustic logger will be deployed at each site to supplement up to four bird surveys that will occur at the proposed intensive monitoring study sites when listed birds are likely present in 2024 and 2025. Bird surveys will focus on any nesting near the site. Counts of each species observed at intensive monitoring sites will be recorded to provide an estimate of species richness and use of the site (including nesting). In addition, public databases such as ebird and iNaturalist will be used to track changes through time. Proxy surveys of habitat include the timing and duration of surface flow when birds are present, changes to riparian vegetation observed during the plant and natural community surveys, and the extent of wetlands and marshlands observed during the surveys, which will be used to supplement the bird surveys. Follow-up surveys would occur in 2030 prior to submission of the 2032 five-year GSP update.

6.2.6.2. Analysis

Changes to habitat, including the duration of surface flow and changes to riparian habitat, will be used in combination with the bird surveys to assess the potential effects of groundwater use. If habitat is declining, annual bird surveys targeted to their preferred habitat may be implemented.

6.3. Developing Environmental Flows

The information gathered during the development and implementation of the ISW and GDEs Workplan will be used to develop environmental flows. The following section describes the application of CEFF, which is one approach to developing environmental flows (but not the only approach).

To develop conceptual models of the surface and near-surface hydrology and ecological processes, the GSA will draw upon geomorphological and historical data, NVIHM modeling, and the statewide natural flow estimates from CEFWG (2021b) and Grantham et al. (2022). Descriptions of the physical and ecological setting, site prioritization, and monitoring data will inform the refinement of ecological management goals and ecosystem functions. The magnitude of summer base flow from the Natural Flows Databases has already been assessed for the intensive monitoring sites as part of their EHCMs; the other flow components will be assessed during Workplan implementation. Widespread incision has altered channel morphology across the Subbasin, which is an important factor to consider in conceptual models of ISW.

While CEFF is based on the idea that the ecosystem evolved to a natural flow condition, it also recognizes that landscape changes such as groundwater pumping and stream incision can alter the relationship between flow and habitat. As discussed in Section 3 of this document, there have been numerous changes in the Napa Valley Subbasin that have altered flows, including channel connectivity and channel simplification that have led to widespread channel incision. Many of these changes occurred soon after European settlement and predate systematic collection of hydrologic data. Thus, natural hydrographs in the Natural Flows Database do not necessarily correspond to what were likely the natural hydrographs prior to European settlement (which were not measured) due in part to widespread channel incision in the Subbasin and similar settings throughout the state. Another critical factor is the effect of groundwater pumping on streamflow, which can be evaluated with the NVIHM. In addition, other hydrologic effects (e.g., flow diversions, geomorphology, and the effects of smaller dams) are integrated into NVIHM.

In the CEFF framework, Sections A and B will provide guidance on flows required to support targeted species and will be used to inform SMC for the Subbasin. In Section C, other beneficial uses of water are also considered. The application of CEFF in the Workplan will follow the steps summarized in **Table 6-4**.

Table 6-4. Summary of CEFF Steps and Application of Workplan for Sections A and B.		
Step	**Workplan component**	**Schedule/Notes**
Section A: Identify ecological flow criteria using natural functional flows.		
Step 1: Define ecological management goals and locations of interest.	Ecological management goals (Section 1)	Goals will be refined during Workplan implementation
	Site prioritization (Section 4)	Completed
	Assess ecosystem functions relative to ecological management goals	To be completed Spring 2024
Step 2: Obtain natural ranges of flow metrics for five functional flow components.	Assess functional flow metrics using NVIHM and the Natural Flows Database (CEFWG, 2021b). Section 6	To be completed in 2024
Step 3: Evaluate if non-flow factors may affect the ability of natural ranges of functional flow metrics to achieve ecological management goals.	Physical and ecological setting	Completed
	Environmental history and landscape alteration (Section 5)	Completed
Step 4: Select ecological flow criteria for functional flow components not affected by non-flow factors.	Described in Section 6	To be completed after Workplan Adoption
Section B: Develop ecological flow criteria for each flow component affected by non-flow factors.		
Step 5: Develop detailed conceptual model relating functional flow components to ecological management goals.	Described in Section 4	To be completed after Workplan adoption
Step 6: Quantify flow-ecology relationships.	Special-status fish and aquatic wildlife (Sections 6)	To be completed after Workplan adoption
Step 7: Define ecological flow criteria for focal functional flow components.	Described in Section 6	To be completed after Workplan adoption

6.3.1. Monitoring and Analyses for CEFF

Tasks slated for completion during Workplan implementation are outlined in **Table 6-4** and described below.

Step 1.1: Develop ecological management goals. Preliminary ecological management goals are described in **Section 4.1**. These goals may be refined based on baseline data collected in the first year after the Workplan is implemented.

Step 1.2 was completed as part of this Workplan.

Step 1.3: Assess ecosystem functions relative to ecological management goals will be completed as part of the CEFF analysis in 2024-2025 and included in the 2027 five-year GSP update.

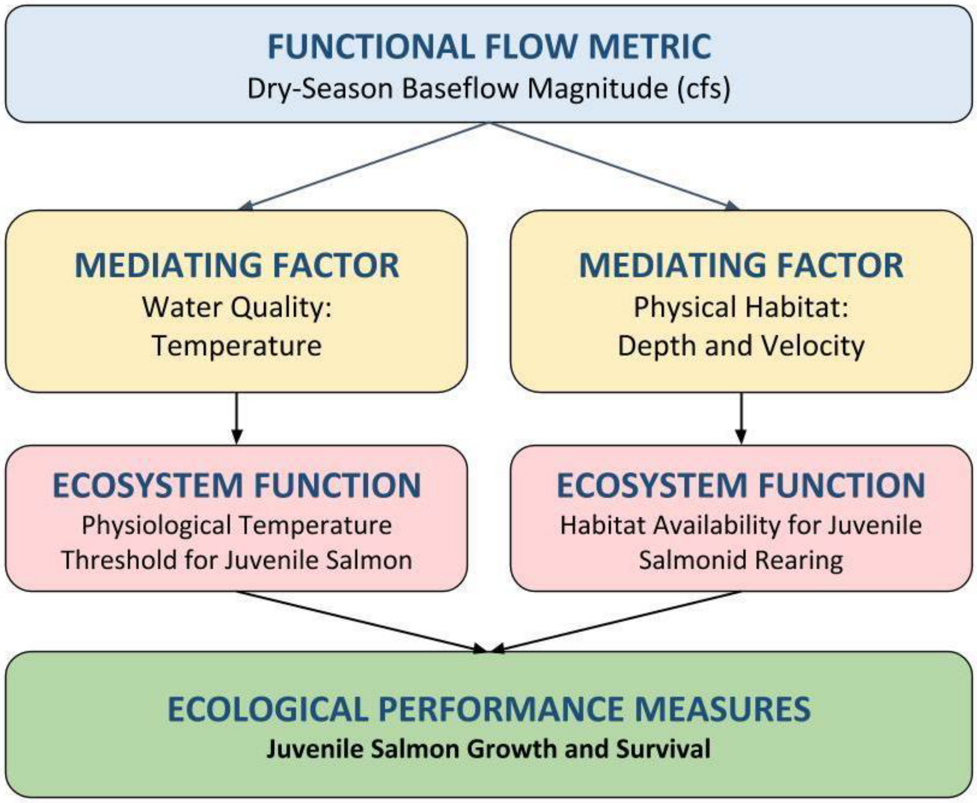
Step 2: Obtain natural ranges of flow metrics for five functional flow components will be completed in 2024 using NVIHM and the Natural Flows Database (CEFWG, 2021b) and included in the 2027 five-year GSP update. A preliminary assessment of the summer low flows is provided in **Section 6**.

Steps 3.1 and 3.2 were completed and are included in this Workplan.

Step 4 Select ecological flow criteria for functional flow components not affected by non-flow factors will be completed in 2024and includes assessing the ecological function of each flow component, the relevance of each flow component to groundwater pumping, and the potential impact of non-flow related factors on the ecological function of each flow component. An example of how non-flow factors will be assessed is provided in Table 6.X. following Yarnell et al. (2022).

Table 6-5. Preliminary Assessment of Aon-flow Factors for the Napa River at St. Helena			
Functional Flow Component	**Example Ecosystem Function**	**Potential non-flow limiting factor**	**Relevance to groundwater management**
Fall Pulse Flow	Ecological management goals (Section 1)	Reduced channel complexity and changes to channel morphology	Low summer groundwater levels may affect pulse magnitude
Wet Season Peak Flows	Transport sediment, alter channel morphology	Reduced floodplain extent	Not relevant
Wet Season Base flows	Spawning and rearing for steelhead, (ANY FROG?)	Channel simplified, reduced cover in places	Outside of pumping season, flows may be slightly decreased
Spring Recession Flow	Riparian vegetation establishment, potential spawning, rearing, and migration	Channel simplification	Limited
Dry-season Base Flow	Steelhead rearing, shrimp habitat	Changes to riparian zone (reduced willows, etc.). Potential simplification of habitat. Sedimentation	Dependent on ISW and altered by groundwater management

Step 5: Develop detailed conceptual models. The conceptual models relate functional flow components to ecological management goals. Conceptual models will be developed following examples from CEFWG (2021a) (**Figure 6-2**) with a focus on spring recession flow and dry season baseflow because they are closely related to groundwater. For example, in the Napa Valley Subbasin dry season, baseflows are likely to affect steelhead rearing habitat (depth and velocity), flow connectivity, and water quality (stream temperature). These components will be quantified where possible in subsequent steps.



Source: CEFWG 2021a

Figure 6-2. Example Conceptual Model for Salmonid Growth and Survival

Step 6: Quantify flow-ecology relationships. These will be assessed for steelhead, Chinook salmon, and frogs, as described in **Section 3.3**. The linkage between flow and habitat extent can be quantified by tracking the change in the extent of steelhead rearing habitat based on **Table 6-2** following the example in **Figure 6-2**. The change in conditions can be quantified in the field or using a 2D hydraulic model to assess flow velocity and depth under a range of conditions. Changes to stream temperature and DO could also occur during low flows and will be evaluated based on data collection described in **Section 5**.

Step 7: Define ecological flow criteria for focal functional flow components. In this step, the flow-ecology relationship for each of the ecosystem goals (Step 6) will be used to develop flow criteria for the relevant functional flow components. Using NVIHM and monitoring data, flow criteria will then be related to groundwater elevations at the locations of interest.

6.4. Implementation Recommendations and Schedule

The monitoring program outlined in this Workplan will begin in 2024 (following Workplan adoption) and continue through 2030 (**Table 6-6**). The frequency and timing of individual studies at intensive monitoring sites are summarized in **Section 6.3**. Surveys for terrestrial plants, wildlife, and GDEs will occur in 2024, 2025, and 2030 (indicated by an M in **Table 6-6**) and occur on an as-needed basis in other years (due to drought or floods). Some spring 2024 surveys may be postponed until spring 2025 depending on the timing of acceptance of this Workplan (expected late March 2024) and the need for sufficient time to plan the surveys. The methods will be evaluated in the field and adapted to meet site conditions, where necessary. The implementation of the Workplan will be reevaluated in the 2026 Technical Report and will discuss data gaps addressed and/or newly identified data gaps and other findings to incorporate in the five-year GSP update. Some elements of the monitoring program are intended to continue after 2031, but the approach and frequency will be evaluated in the 2026 Technical Report, 2027 GSP update, and the 2031 Technical Report.

The technical memoranda and reports will evaluate the degree to which existing sites are suitable for biological and hydrological monitoring and the degree to which additional sites may be required to address gaps in the hydrological and biological monitoring networks. For example, if amphibian surveys find that species are not present at a given site, relocating the monitoring to fill in data gaps in other parts of the basin may be recommended. Similarly, if groundwater levels are sufficient to maintain surface flow, the RCD may determine that a Stream Watch site should be relocated.

Table 6-6. Monitoring Schedule for 2024 Through 2031

Survey		2024	2025	2026	2027	2028	2029	2030	2031
Subbasin-wide monitoring	Terrestrial GDE remote sensing	M	M	M	M	M	M	M	M
	Shallow groundwater wells	Continuous							
	Stream Watch (RCD)	Continuous							
Intensive site monitoring	Flow connectivity survey	M	M	M	M	M	M	M	M
	Natural community field surveys	M	M	AN	AN	AN	AN	M	AN
	Special-status plants	M	M	AN	AN	AN	AN	M	AN
	Terrestrial wildlife	M	M	AN	AN	AN	AN	M	AN
	Aquatic wildlife	M	M	AN	AN	AN	AN	M	AN
	Fish population	M	M	M	M	M	M	M	M
	Additional CEFF part A and B tasks	M	M						
ISW and GDE Reporting	Annual Technical Memo	TM	TM	TM	TM	TM	TM	TM	
	5-year update Technical Report			TR					TR
GSP Reporting	GSP Annual Report	AR	AR	AR	AR	AR	AR	AR	
	GSP Five-year Update				GSP				

M indicates the years where monitoring will be implemented.
AN indicates years where monitoring may occur on an as-needed basis.
TM indicates a technical memorandum deliverable summarizing the annual results of the ISW GDE surveys.
TR indicates technical report deliverables.
AR indicates GSP Annual Report submittal.
GSP indicates a five-year GSP Update submittal.

6.5. Reporting

Data gathered during each year will be summarized in a technical memorandum to support the GSP annual reports. These memoranda will summarize the monitoring results and indicate any issues with the monitoring plan (e.g., site access, drought, etc.). More detailed technical reports will be prepared in mid-2026 and 2030. These reports will summarize the monitoring results through the previous year. These reports will include more interpretation than the annual technical memoranda and will suggest changes as needed to improve the effectiveness of the monitoring program. The technical reports will be submitted in time for inclusion in the five-year GSP updates. The results of CEFF Sections A and B will be included in the 2026 Technical Report. This report will recommend future monitoring frequency and be published as an appendix to the 5-year GSP update. Recommended monitoring frequency and locations will be carried conducted from 2027-2030. Collected data through 2030 will be compiled and analyzed, and included in the ten-year GSP update in January 2032. Outcomes from CEFF will support the refinement of SMCs for the Napa Valley Subbasin.

6.6. Adjustments to the Monitoring Plan

Adjustments to the monitoring plan will be made in consultation with the TAG. Adjustments could include moving some or all of the biological surveys from one site to another, expansion of the biological or hydrological monitoring network, changes to survey protocols, or adjustments to survey frequency. Consultation with the TAG will be done during the monthly public meetings and documented in either the annual reports or the five-year GSP updates.

7. COMMUNICATION AND ENGAGEMENT

Communications and engagement (C&E) are an essential element of the Workplan. The C&E strategies aim to achieve a broad understanding and acceptance of the Workplan's ongoing work and characterization of ISW and GDEs approach and to facilitate actions leading to successful plan implementation. This Workplan targets outreach focused on understanding ISW and GDEs throughout the Subbasin.

7.1. Background

During the development of the GSP, a 25-member Groundwater Sustainability Plan Advisory Committee (GSPAC) for the Napa Valley Subbasin provided broad stakeholder representation for the NCGSA. The GSPAC was charged with advising the NCGSA on matters related to the preparation of the Napa Valley Subbasin GSP, including policies and recommendations for groundwater management and identification of any data gaps. As part of their final deliberations, the GSPAC unanimously approved a recommendation for the formation of a TAG as a successor body to aid in the implementation of the Napa Valley Subbasin GSP.

The TAG's core charge is to provide well-informed, practical recommendations to the NCGSA as the NCGSA carries out GSP implementation, taking into account the best available scientific information and best practices in groundwater management. The TAG's charge includes consideration of groundwater conditions where some GSP representative monitoring sites are exhibiting exceedances of GSP-defined SMC or triggers and invoking adaptive management approaches, including analyses and response actions to address SMC exceedances or triggers, and identifying potential projects and/or management actions to avoid undesirable results.

The TAG meetings have been the primary point of stakeholder engagement during the initial phases of GSP implementation and the development of the ISW and GDE Workplan. The TAG will continue to serve as an important source of guidance for implementation of the Workplan and provide a standing, formal process for public input on the ISW and GDE Workplan implementation and results.

7.2. Documentation

All forms of C&E will be documented. Documentation will include the date and type of C&E that occurred, the venues and participants involved, and any key outcomes.

7.3. Education and Outreach

The education and outreach component of the Workplan identifies options to accelerate and increase knowledge related to the river system and ecosystems in the Subbasin. Messages will focus on key questions which are important to consider when communicating the importance of natural systems. Some key questions include:

- How is groundwater connected to streams?
- What can I do to protect streams?
- What can I do to protect groundwater?
- How is GSA tracking health of GDEs over time?
- Why do local streams dry up and how do I know if it's related to groundwater pumping?

Partner Approach. A key strategy includes partnering with organizations to help develop material as well as host events and share material. A key partner in outreach is the Napa County RCD. Other community partners include Napa County University of California Cooperative Extension, Firesafe Councils, industry groups, schools, and service clubs. Due to the importance of the ecosystems and habitat present in the Subbasin, partnerships will also span outside of Napa County to include the National Marines Fisheries Service, California Department of Fish and Wildlife and the California Environmental Flows Workgroup. Collaboration with these entities will allow the NCGSA to benefit from and leverage their deep knowledge and well-developed community relationships. Further, because each of these entities is a trusted messenger for the communities they serve, their engagement enhances the legitimacy of the NCGSA's efforts.

Outreach Materials. The development of accessible and engaging outreach materials will be an integral part of outreach activities. These materials will be developed in English and Spanish and shared via events, social media, websites, and local press to raise the overall awareness of how groundwater and ecosystems interact.

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