Invasive Mussel Prevention Plan

Sacramento Municipal Utility District

September 2025



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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
°C	degrees Celsius
CDFW	California Department of Fish and Wildlife
CCR	California Code of Regulations
eDNA	environmental deoxyribonucleic acid
ENF	Eldorado National Forest
FERC	Federal Energy Regulatory Commission
FGC	Fish and Game Code
Forest Service	U.S. Department of Agriculture, Forest Service
K	thousand
M	million
mg/L	milligram per liter
mm	millimeter
O&M	operations and maintenance
SMUD	Sacramento Municipal Utility District
s.u.	standard unit
UARP	Upper American River Project
WID	watercraft inspection and decontamination

1.0 INTRODUCTION AND BACKGROUND

1.1 REPORT PURPOSE

In 2009, the Sacramento Municipal Utility District (SMUD) drafted its first *Invasive Mussel Prevention Plan* (Prevention Plan) in compliance with California state law to prevent the inadvertent and unwanted introduction of invasive freshwater mussels[1] into SMUD-owned reservoirs and water supplies owned or under contract by SMUD. The plan was first implemented in 2009 and included a vulnerability assessment, plans for monitoring, and a description of public outreach (SMUD 2012). The plan and associated vulnerability assessment has since been reviewed and modified in accordance with the findings of previous years, and as new information on invasive mussels is known. Development of the Prevention Plan follows guidance provided by California Department of Fish and Wildlife (CDFW) (CDFW 2020). This updated Prevention Plan includes the following components:

- A description of SMUD's management areas.
- A discussion of invasive mussels including their biology, history, and current distribution in California.
- A summary of the current vulnerability assessment (SMUD 2025).
- SMUD's monitoring program detailing methods for early detection of invasive mussels.
- Descriptions of current and future management actions to control mussels.
- An introduction to the rapid response plans (SMUD 2019a, SMUD 2019b) developed to address detected infestations.
- Annual agency reporting requirements.

This Prevention Plan includes reservoirs and water supplies within three separate management areas: Upper American River Project (UARP), Chili Bar Project, and Rancho Seco Lake (Figure 1).

[1] For this report the term invasive mussel will be used to reference the two dreissenid mussel species (which include zebra mussels, *Dreissena polymorpha*, and quagga mussels, *Dreissena rostriformis bugensis*) and Golden mussels (*Limnoperna fortunei*).

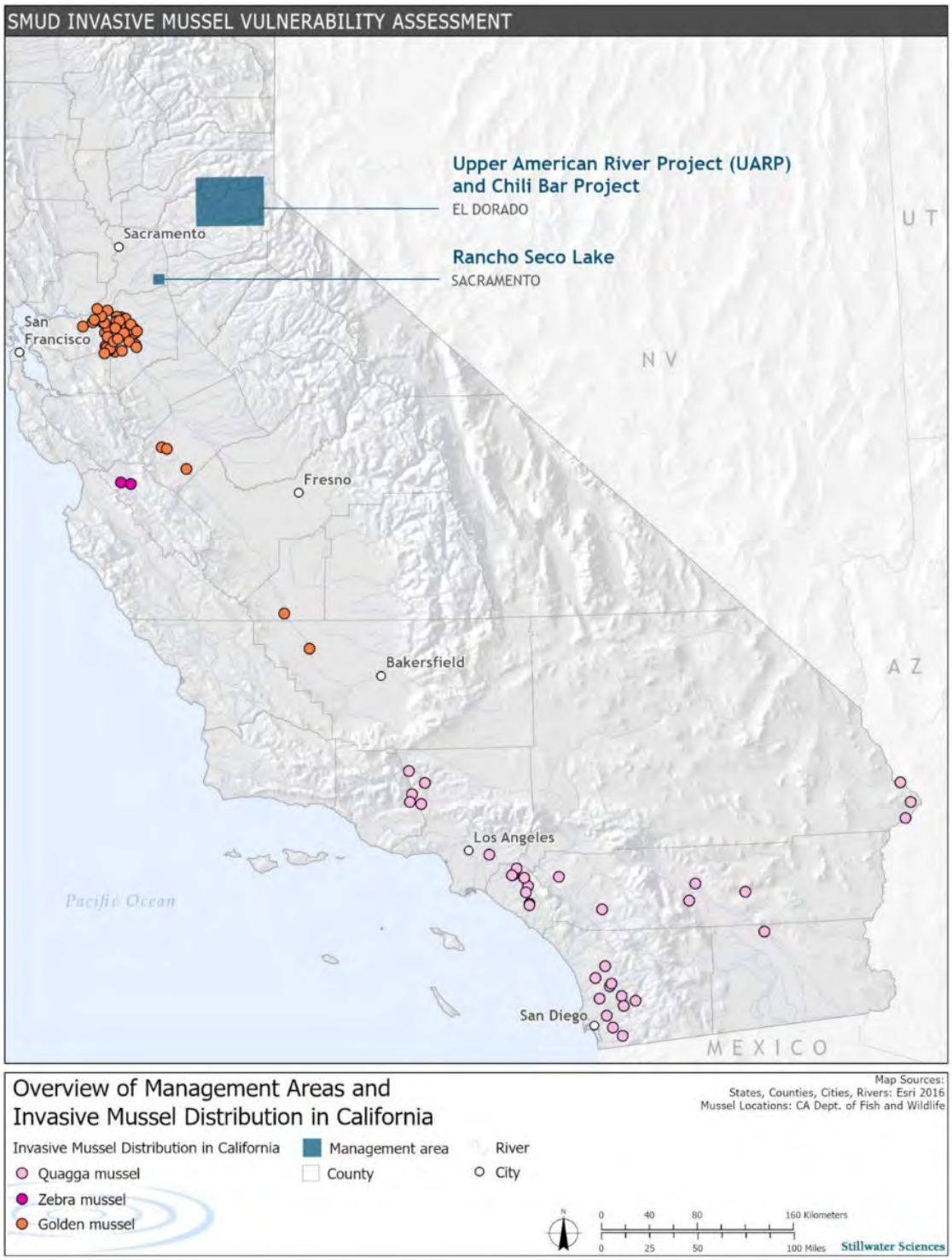


Figure 1. Location of Sacramento Municipal Utility District's management areas and proximity to invasive mussel-infested waterbodies in California as of June 2025.

1.2 REGULATORY CONTEXT

California Assembly Bill 2065, designed to stop the spread of non-native dreissenid mussels throughout California, was signed into law in September 2008. The bill added a new section to the California Fish and Game Code (FGC) Section 2302 mandating that:

> *(a) Any person, or federal, state, or local agency, district, or authority that owns or manages a Reservoir, as defined in Section 6004.5 of the Water Code, where recreational, boating, or fishing activities are permitted, except a privately-owned Reservoir that is not open to the public, shall do both of the following:*
>
> *(1) Assess the vulnerability of the Reservoir for the introduction of nonnative dreissenid mussel species.*
>
> *(2) Develop and implement a program designed to prevent the introduction of nonnative dreissenid mussel species.*
>
> *(b) The program shall include, at a minimum, all of the following:*
>
> *(1) Public education.*
>
> *(2) Monitoring.*
>
> *(3) Management of those recreational, boating, or fishing activities that are permitted.*

This Prevention Plan has been prepared to comply with the key elements of an invasive mussel prevention program as required by California Code of Regulations (CCR) Title 14 Section 672.1(b)(1), which include a monitoring program to detect the presence of dreissenid mussels, and management of recreational activities to prevent the introduction of mussels that includes public education and outreach. A vulnerability assessment of the SMUD managed waterbodies (SMUD 2023), also mandated under CCR Title 14 Section 672.1(b)(1), was completed, and is summarized in Section 4 and included in Attachment 1.

2.0 SMUD MANAGEMENT AREAS

SMUD is a publicly owned municipal utility that generates, transmits and distributes electric power to a 900-square-mile service area that includes Sacramento County and a small portion of Placer and Yolo counties.

2.1 UPPER AMERICAN RIVER AND CHILI BAR PROJECTS

SMUD owns and operates the UARP and Chili Bar Projects located in El Dorado County, California (Figure 1 and Figure 2).

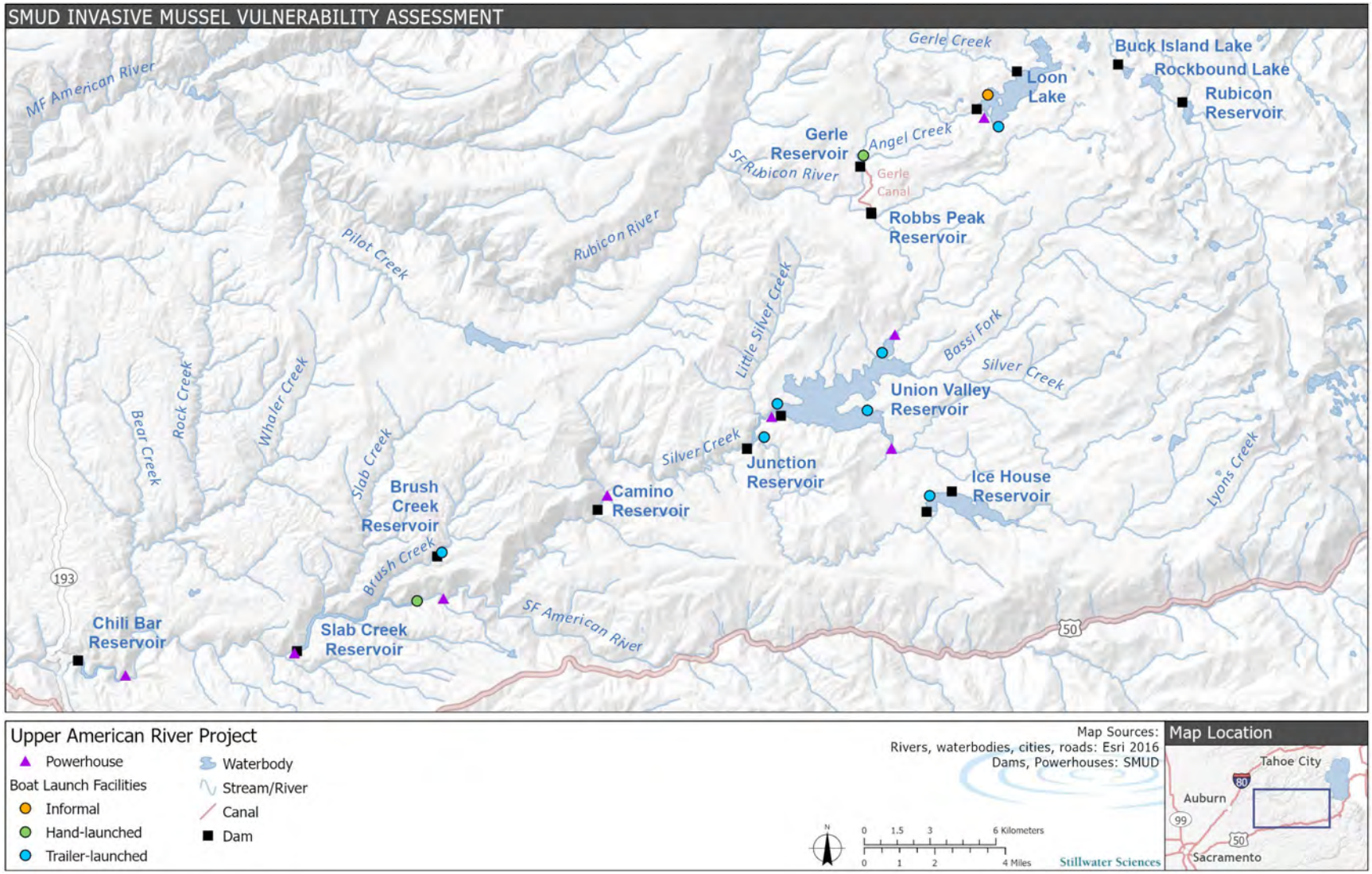


Figure 2. Overview of Upper American River Project and Chili Bar Project infrastructure and boat launch facilities.

2.1.1 Upper American River Project

The UARP was constructed between 1959 and 1985 and has an authorized capacity of 640 megawatts and an average annual generation of 1,835,000 megawatt-hours per year of energy. The annual generation plays an important part in meeting the capacity requirements of SMUD. The UARP is a significant power resource to the state of California and within the Northern California Assessment Area of the Western Electricity Coordinating Council—a regional entity of the North American Electric Reliability Corporation.

The UARP Federal Energy Regulatory Commission (FERC) Project boundary encompasses 6,375 acres of federally owned land administered by the U.S. Department of Agriculture, Forest Service (Forest Service), as part of the Eldorado National Forest (ENF), and 54 acres of United States-owned land administered by the Bureau of Land Management. The Project spans and uses water for power generation derived from surface runoff accumulated from approximately 674 square miles of drainage area in the Rubicon River, Silver Creek, and South Fork American River watersheds. The UARP watersheds flow generally in the westward direction with approximately 6,000 feet of elevation change throughout the Project. A snowpack of five to 10 feet is common in the higher elevations, with little or no snow in the lower elevations (below 2,000 feet).

The UARP consists of three major storage reservoirs (Loon Lake, Union Valley, and Ice House) with a combined capacity of approximately 379,000 acre-feet, eight smaller regulating or diversion reservoirs (Rubicon Reservoir, Buck Island Lake, Gerle Reservoir, Robbs Peak Reservoir, Junction Reservoir, Camino Reservoir, Brush Creek Reservoir, and Slab Creek Reservoir), and one 1.9-mile long canal (Gerle Canal) (Figure 2). The SMUD UARP power stairway, descending system of hydroelectric facilities, that includes additional information on reservoir elevations, diversions, and water flow is in Appendix A.

The UARP also includes recreation facilities containing over 700 campsites, seven developed boat launch facilities, hiking paths, and bicycle trails at the reservoirs. SMUD estimates that summer use at the UARP recreational facilities in the Crystal Basin, the mid-elevation range of the UARP at approximately 4,800 to 6,400 feet, is between 206,500 and 235,000 recreation-days.[2] There are approximately 24,000 recreation-days at the Project recreational facilities during the shoulder seasons (spring and fall). Campgrounds, day-use areas, boat launches, and trailhead parking areas are usually filled to capacity during peak times on holidays and some weekends during the summer; during the weekdays, occupancy at the recreational facilities is low.

[2] Recreational use of Forest Service sites, or areas of land or water, that aggregates 12 visitor-hours; may consist of one person for 12 hours, 12 persons for one hour, or any equivalent combination of continuous or intermittent recreation use by individuals or groups.

Reservoirs of the UARP receive a moderate level of recreational boating activity. Recreational boating is allowed on 10 of 11 UARP reservoirs, with only three reservoirs (Union Valley, Ice House, and Loon Lake) supporting larger trailer-launched motorized watercraft and boat docks (Figure 2, Table 1). Boating access to all UARP reservoirs occurs via federal lands and facilities managed by the ENF in partnership with SMUD per the terms contained in the federal license for the UARP.

2.1.2 Chili Bar Project

SMUD built the Chili Bar Project to compensate Pacific Gas and Electric Company (PG&E) for the loss of Project No. 78, which was inundated when SMUD built Slab Creek Dam. SMUD transferred the ownership of the Chili Bar Project to PG&E on September 2, 1966. SMUD subsequently purchased the Chili Bar Project from PG&E in 2021. The Project has an installed capacity of 7 megawatts and an average annual energy generation of 32,291 megawatt-hours per year. It is located within the Northern California Assessment Area of the Western Electricity Coordinating Council. The Northern California Assessment Area has a significant summer peak demand, and the Chili Bar Project meets part of the existing load requirements within a system in need of energy resources.

The Chili Bar Project is located near the community of Placerville in El Dorado County, California in the foothills of the Sierra Nevada Mountains. The Project is on the South Fork American River (SF American River) immediately downstream of SMUD's UARP. The Project encompasses approximately 3.2 river miles and encloses a total of 254.63 acres, including 47.81 acres of federal land administered by the Bureau of Land Management, 15.06 acres of private land, and 191.76 acres of SMUD land. The Chili Bar Project consists of one reservoir (Chili Bar) that is currently not open to the boating public (Figure 2,Table 1). Recreation facilities include a parking area off Rock Creek Road and a trail that leads from Rock Creek Road to Chili Bar Reservoir.

Table 1. Summary of Recreational Boating on Upper American River Project and Chili Bar Project Reservoirs.

Reservoir	Accessible Public Boating	Number of Developed Boat Ramps	Boat ramps Accommodate, Motorized Boats	Number of Boat or Fishing Docks	Angling Permitted	Fish Stocked
Rubicon	Yes	--	No	--	Yes	No
Buck Island	Yes	--	No	--	Yes	No
Loon Lake	Yes	2	Yes	1	Yes	Yes
Gerle Creek	Yes	--	No (non-motorized)	--	Yes	No
Robbs Peak Forebay	No[1]	--	No	--	Yes	No
Union Valley	Yes	4	Yes	1	Yes	Yes
Ice House	Yes	1	Yes	1	Yes	Yes
Junction	Yes	1	Yes (small, motorized)	--	Yes	No
Camino[1]	No	1	Yes	--	Yes	No
Brush Creek	Yes	1	Yes (small, motorized)	--	Yes	No
Slab Creek	Yes	1	No (non-motorized)	--	Yes	No
Chili Bar[1]	No	1	Yes	--	Yes	No

[1] Boating limited to non-public watercraft required for operations and maintenance or license implementation studies.

2.2 RANCHO SECO LAKE AND FOLSOM SOUTH CANAL

Rancho Seco Lake, located in Sacramento County (Figure 3), was originally a small pond and was expanded into a 160-acre lake during the early 1970s to serve as an emergency backup water supply for the Rancho Seco Nuclear Generating Station. The Rancho Seco Nuclear Generating Station was closed June 7, 1989, and operation and management of the recreational area including Ranch Seco Lake was assumed by SMUD in 1992. Rancho Seco Lake is surrounded by the 400-acre Rancho Seco Recreational Area that includes campgrounds and hiking trails. It is open to the public year-round for recreation including boating, fishing, and swimming. There is a designated swimming beach located at the south-eastern side of the lake near the group picnic areas. There are two boat launch facilities for hand-launching boats, one located at each end of the dam (Figure 3). Trailer launched vessels are prohibited on the lake. New boating restrictions were implemented on March 25, 2025[3] including watercraft inspection and no live aquatic bait.

Folsom South Canal is an approximately 26.7-mile-long aqueduct that diverts water from the American River at Nimbus Dam in Sacramento County southward to near the town of Clay. Water is diverted by underground pipes from Folsom South Canal into Rancho Seco Lake via the Consumnes Power Plant Pumping Plant. The canal is operated by the U.S. Bureau of Reclamation as part of the Auburn-Folsom South Unit of the Central Valley Project. It is contracted for irrigation, industrial and municipal water supply. It is also connected to the Mokelumne Aqueduct, which provides water supply to the East Bay Municipal Utility District in the San Francisco Bay Area. Rancho Seco Lake has been used as an emergency backup water supply in case water delivery from the Folsom South Canal becomes temporarily halted. Boating and human contact are not allowed on the canal.

[3] Rancho Seco Recreational Area implements new boat restrictions to protect lake

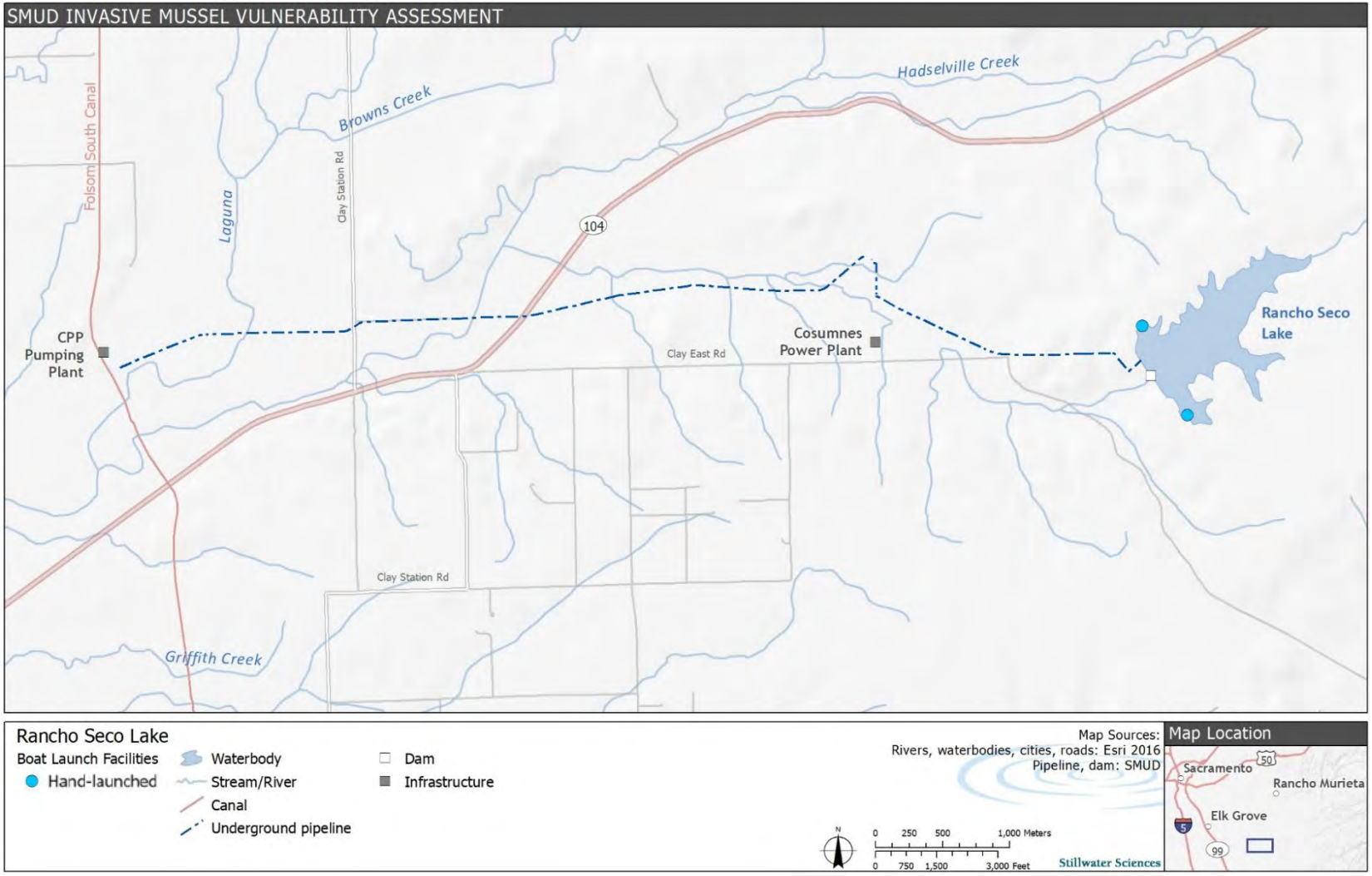


Figure 3. Overview of Rancho Seco Lake and Folsom South Canal infrastructure and boat launch facilities.

3.0 INVASIVE MUSSELS

Three invasive mussel species have been identified in California, quagga mussel (*Dreissena rostriformis bugensis*), zebra mussel (*Dreissena polymorpha*), and golden mussel (*Limnoperna fortunei*). Both quagga and zebra mussels are within the same genera, Dreissena, and are known as Dreissenid mussels.

3.1 DREISSENID MUSSELS

3.1.1 History and Biology

The quagga mussel (*Dreissena rostriformis bugensis*) and zebra mussel (*Dreissena polymorpha*) are invasive bivalves that were introduced to North America from the Black and Caspian Seas in Europe. These mussels were discovered in North America in the 1980's and have caused considerable economic and environmental damage in the Great Lakes, Mississippi River Basin, eastern United States and have started to spread into the Western United States. Both zebra and quagga mussels occupy freshwater habitats and typically colonize hard surfaces; quagga mussels can also live on sand and silt substrates. These mussels have the capacity to spread rapidly causing fouling of infrastructure such as pipes and pumps, thus threatening hydropower infrastructure and operations. Both species are efficient selective filter feeders and have been shown to displace native species due to disruption of the aquatic food web and increase the possibility of cyanobacteria blooms (Vanderploeg et al. 2001, Knoll et al. 2008).

In order for dreissenid mussels to survive and reproduce, conditions need to be suitable for all life stages including spawning, juvenile growth and development, and adult survival. Establishment of dreissenid mussels has been shown to be limited by calcium concentrations, pH, and water temperature (Whittier et al. 2008, Cohen and Weinstein 1998 and 2001). Calcium concentrations less than 15 milligrams per liter (mg/L) have been demonstrated to be associated with decreased growth rates, loss of shell material, and poor larval production, all leading to low population growth (Cohen and Weinstein 2001). These effects can be compounded due to low pH values because the solubility of calcium carbonate increases as pH decreases, resulting in thin shells (Claudi and Prescott 2011). Spawning is limited at colder temperatures and mortality of individuals can be caused by freezing temperatures (Cohen 2008).

3.1.2 Current California Distribution

In early 2007, quagga mussels were detected for the first time in the Colorado River Basin, and by late 2007, the mussels were found in a reservoir in Southern California. The following year, zebra mussels were detected at San Justo Reservoir in San Benito County. As of 2025, quagga and zebra mussels have been confirmed in 44 locations, which are primarily quagga mussel infestations in southern California counties including San Diego, Riverside, Orange, Los Angeles, and Ventura (Figure 1; CDFW 2025a). Most of these reservoirs are separated from the UARP and Chili Bar Project, and Rancho Seco Lake by a large geographic distance (>350 miles). The closest

established dreissenid mussel population is in San Benito County, greater than 120 miles from the UARP, Chili Bar Project, and Rancho Seco (Figure 1).

A 1998 study evaluated the risk of California waterbodies to dreissenid colonization, the results of which suggested that the Sierra Nevada Mountain and the Sacramento River mainstem regions are unsuitable for the establishment of dreissenid mussel based on calcium thresholds (Cohen 2008). Variations in local water quality conditions within regions may alter the risk factors for invasive mussel colonization.

3.2 GOLDEN MUSSEL

3.2.1 History and Biology

The golden mussel is an invasive mussel to North America and native to the Pearl River Basin in China. Primarily through ship traffic, golden mussels were introduced to several countries in Asia and South America. The first confirmed detection in North America was in California in October 2024. Golden mussels can survive in most freshwater environments, attaching to rough stable substrates forming dense “reefs” (Xu et al. 2015a, Liu et al. 2024). Once established, populations of golden mussels have been shown to adhere extensively to hydraulic facility infrastructure, clogging valves and gates, reducing flow capacity, and deteriorating concrete (Xu et al. 2015a). For example, Yacyreta and Itaipu hydroelectric plants in South America have both underwent extensive unplanned outages due to fouling by invasive golden mussels (Liu et al. 2024). Golden mussels can also negatively affect local aquatic diversity by filtering phytoplankton, thereby reducing food resources for native mussels and other native planktivorous species (Boltovoskoy and Correa 2015, Liu et al. 2024).

This species is highly adaptive and can tolerate a wide range of freshwater conditions. Adult individuals can tolerate cold and warm water temperatures (<5–35 degrees Celsius[°C]), low-calcium concentrations (≤ 3 milligram per liter [mg/L]), slightly acidic and basic pH conditions (4.1–10 standard units [s.u.]), and low dissolved oxygen concentrations (< 1 mg/L) (Andrade 2018, Boltovoskoy et al. 2006, Cataldo et al. 2004, Liu et. al. 2020, Montalto and Marchese 2003, Oliveira et al. 2011, Ricciardi 1998, Xia et al. 2021). Larval stages are less resilient and require water temperatures between approximately 16 to 28°C to survive (Ricciardi 1998, Nakuano et. al. 2010). Calcium, which is essential for growth of calcium-carbonate-based shells, can be as low as 1 mg/L for adults to survive, but successful larval development likely requires greater concentration.

Golden mussels can also survive out of water for extended periods, though survival out of water is temperature dependent, and greater survival rates occur in cool, humid environments. In laboratory studies, adult individuals withstood desiccation for 11 days, 6 days, and 3 days at 10°C, 20°C, and 30°C, respectively (Andrade 2020). Juveniles and adults are observed in greater densities at depths of 1 to 2.5 meters in depth, and densities begin to decline at 4 meters in depth (Xu et al. 2015a, Liu et al. 2024). Optimal water velocity for all life stages is between 0.3 to 0.9 meter per second, and velocities

greater than 1 meter per second negatively affect food acquisition and adhesion to substrates (Xu et al. 2015b, Liu et al. 2024). Golden mussels' tolerance to broad water quality conditions and desiccation means they are a considerable invasive threat by translocation, particularly by trailered vessels that are often in standing water and are moved within and between waterbodies.

Adults can reach lengths up to 42 millimeters (mm) and achieve sexual maturity at approximately 5 mm in length (Darrigran et al. 2011, Liu et al. 2024). Reproduction primarily occurs during warmer months (>16°C), typically spring and summer in the northern hemisphere. Spawning temperatures reported from Asia and South America range from 16 to 28°C with an optimal spawning temperature of 16 to 17°C (Ricciardi 1998, Liu et al. 2024). Golden mussels can also have multiple reproductive periods within a year, ranging from one to three depending on suitable temperature windows (Xu et al. 2015b, Liu et al. 2024). Larvae are planktonic for 5 to 20 days at 20°C and 28°C, respectively, before settling on the benthos. Average larvae settlement counts range from 4,000 to 7,000 individuals per cubic meter, and densities as high as 44,000 individuals per square meter (Boltovoskoy and Cataldo 1999, Liu et al. 2024). Growth rates of juvenile golden mussels are temperature and food dependent but generally average up to 3.5 mm per month in water temperatures above 21.5°C (Xu et al. 2015b, Liu et al. 2024).

3.2.2 Current California Distribution

Golden mussels were first discovered in California during October 2024 in the Sacramento–San Joaquin Delta (Port of Stockton, California) and O'Neill Forebay (CDFW 2025b). This California occurrence of golden mussels was the first in North America and is believed to have been introduced from international ships to the Port of Stockton. In early 2025, golden mussels were found in the lower San Joaquin River and upper Sacramento–San Joaquin Delta region, encompassing Contra Costa, Sacramento, San Joaquin, and Alameda counties (Figure 1). Their presence in the State Water Project allowed rapid translocation from Merced County to western King and Kern counties. As of June 2025, golden mussels have been confirmed in approximately 30 locations throughout the Sacramento-San Joaquin Delta and the California Aquaduct (Figure 1; CDFW 2025b). As of June 2025, 661 surveys have been conducted throughout California, including the Sacramento River, by the California Department of Fish and Wildlife (CDFW) and other local agencies, and these surveys have not detected golden mussels outside waterbodies associated with the Sacramento-San Joaquin Delta and California State Water Project. Survey results were reported to the CDFW Invasive Species Program (CDFW 2025b). At the time of this report, golden mussels have been observed approximately 27 miles from Rancho Seco Lake and approximately 60 to 96 miles from the Chili Bar Project and UARP reservoirs.

4.0 POTENTIAL INTRODUCTION PATHWAYS

The risk of invasive mussel introduction and establishment in the UARP and Chili Bar Project reservoirs and Rancho Seco Lake were evaluated in SMUD's 2025 Invasive Mussel Vulnerability Assessment (Attachment 1) by considering the potential pathways

of introduction of mussels through natural processes and human activities associated with the waterbodies. The systematic method recommended by CDFW for describing each pathway was used by breaking each pathway down into its fundamental parts: “who,” “what,” “where,” and “when” (CDFW 2017). All activities that involve movement of water and contact with the water as potential means by which invasive mussels may be introduced were listed and analyzed for the potential as a vector for introduction.

4.1 UARP AND CHILI BAR PROJECT RESERVOIRS

Six potential pathways for invasive mussel introduction were identified in the UARP and Chili Bar Project: upstream water diversion, recreation, fish stocking, operations and maintenance, natural resource management and research, and wildfire operations. The pathway considered to have the greatest potential for transporting invasive mussels is recreation, specifically trailered motorized watercraft. The 2025 vulnerability assessment describes the analysis of these potential pathways by which invasive mussels may be introduced into the UARP and Chili Bar Project reservoirs in greater detail.

4.2 RANCHO SECO LAKE AND FOLSOM SOUTH CANAL

Six potential pathways for invasive mussel introduction were identified in the Vulnerability Assessment for Rancho Seco Lake and Folsom South Canal (the water source for Rancho Seco Lake): water diversions, recreation, fish stocking, operations and maintenance, natural resource management and research, and wildfire operations. The pathway considered to have the greatest potential for transporting invasive mussels is through water diversion.

5.0 WATER QUALITY

Invasive mussels require suitable water quality conditions (e.g., calcium, water temperature, pH, dissolved oxygen, and salinity) for all life stages to survive and successfully colonize. Water quality data from the UARP, Chili Bar, and Rancho Seco reservoirs were compared with CDFW guidance (CDFW 2024) and literature-based values (e.g., Cohen and Weinstein 1998) to determine the risk of invasive mussel colonization.

5.1 DREISSENID MUSSELS

5.1.1 Upper American River Project and Chili Bar Project Reservoirs

Water quality conditions in UARP and Chili Bar Project reservoirs are such that there is low risk of colonization of dreissenid mussels due to the following:

- Calcium concentrations are low (0.8–3.3 mg/L) in all UARP and Chili Bar Project reservoirs.
- pH concentrations are generally low in the UARP and Chili Bar Project reservoirs - 96% of pH measurements collected between 2017 to 2024 were within the low risk of colonization range for dreissenid mussels (<7.3 s.u.).

- Seasonal water temperature suitability for dreissenid mussel colonization between fall and spring are low to moderate and high throughout summer.

Table 2 summarizes the ranges of water quality conditions in UARP and Chili Bar Project reservoirs along with the associated relative risk level of dreissenid mussel colonization. Detailed water quality data are presented in the Invasive Mussel Vulnerability Assessment (Attachment 1).

Table 2. Water Quality Conditions for Upper American River Project and Chili Bar Project Reservoirs and Associated Risk of Dreissenid Mussel Colonization Based on Literature Values.[1]

Parameter	UARP and Chili Bar Reservoir Water Quality Results[2]			
	All Depths			Colonization Potential Dreissenid Mussels[2]
	Range	Mean[3]	n	
Calcium (mg/L)	0.8–3.3	1.2–2.7	249	Low (<15)
pH (s.u.)	4.6–9.2	6.4–7.1	7,408	Low (<7.3)
Summer water temperature[4] (ºC)	5.2–23.7	8.6–18.3	1,173	Moderate (9–15) to high (15–31)
All seasons water temperature (ºC)	1.8–23.7	9.3–14.2	7,229	Low (<10) to moderate (10–31)
Dissolved oxygen (mg/L)	0.6–13.0	8.1–10.7	7,404	Moderate (4–8) to high (>8)

Notes: °C= degrees Celsius
s.u. = standard unit
mg/L = milligram per liter
UARP = Upper American River Project

[1] Literature values from Cohen and Weinstein (1998) and Cohen (2008).
[2] Data sources: SMUD (2025); invasive mussel monitoring water quality data collected between 2023–2024.
[3] Data presented are the calculated means for UARP and Chili Bar reservoirs. See Appendix B for data presented by reservoir.
[4] Summer *in situ* profiles were collected between June and August during 2017 through 2024.

5.1.2 Rancho Seco Lake and Folsom South Canal

Water quality data (calcium, pH, water temperature, and dissolved oxygen) were analyzed for Rancho Seco Lake. Surface water samples were collected throughout summer during invasive mussel inspections between 2011 and 2025. In general, water chemistry parameters (pH, water temperature, and dissolved oxygen) have a moderate to high suitability for dreissenid mussel colonization, and calcium concentrations (6.3–10.0 mg/L) are low (Table 3). Detailed water quality data are provided in Attachment 1.

Table 3. Summer Water Quality Conditions for Rancho Seco Lake and Associated Risk of Dreissenid Mussel Colonization Based on Literature Values.[1]

Parameter	Reservoir Water Quality Results			Colonization Potential Dreissenid Mussels
	Range	Mean	n	
Calcium (mg/L)	6.3–10.0	7.5	22	Low (<15)
pH (s.u.)	6.7–9.0	8.3	17	Moderate (7.3–7.5 or 8.7–9.0) to high (7.5–8.7)
Water temperature (ºC)	20–28	25	18	high (15–31)
Dissolved oxygen (mg/L)	7.7–10.2	8.5	16	Moderate (4–8) to high (>8)

Notes: °C= degrees Celsius
s.u. = standard unit
mg/L = milligram per liter
[1] Literature values from Cohen and Weinstein (1998), Cohen (2008).

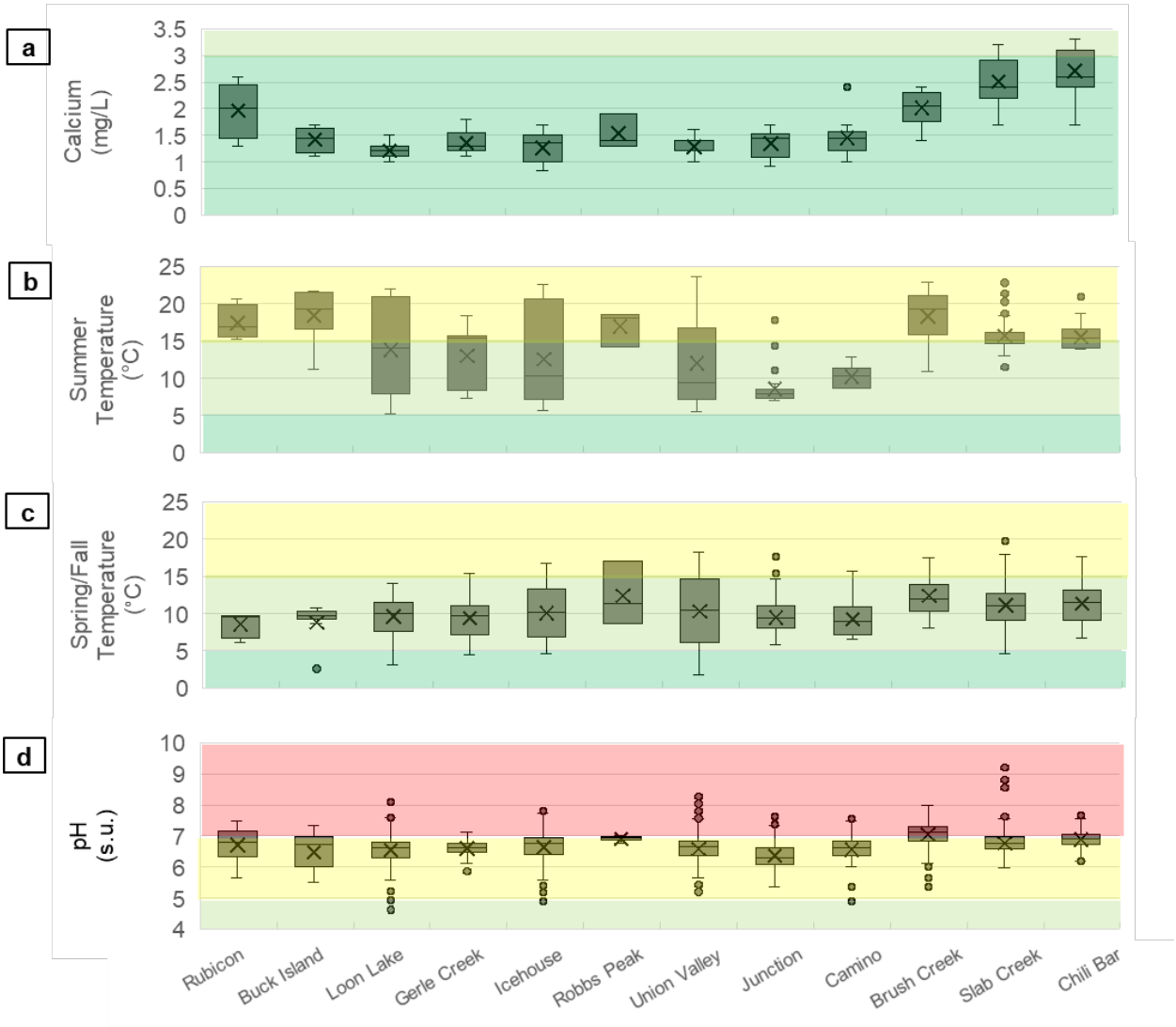
5.2 GOLDEN MUSSEL

5.2.1 Upper American River Project and Chili Bar Project Reservoirs

The potential for colonization was evaluated by comparing water quality data for three parameters (calcium, water temperature, and pH)[4] from reservoirs in the UARP and Chili Bar Project to current CDFW guidelines (CDFW 2024, 2025c; Figure 4). Based on these guidelines, water quality conditions in the UARP and Chili Bar Project indicate a very low-to-moderate risk for golden mussel colonization for the following reasons:

- Reservoir calcium concentrations range from 0.8 to 3.3 mg/L which is categorized as very low to low.
- Summer water temperatures are categorized as low-to-moderate colonization risk, whereas spring and fall water temperatures are cooler and generally low risk.
- Reservoir pH concentrations and range from 4.6 to 9.2 which is categorized as moderate colonization risk based on golden mussel calcification.

[4] Salinity and dissolved oxygen were not included in the analysis. Golden mussels are a freshwater species and limited by high salinity outside the range found in SMUD reservoirs. Golden mussels are able to survive in very low (<1 mg/L) dissolved oxygen concentrations.



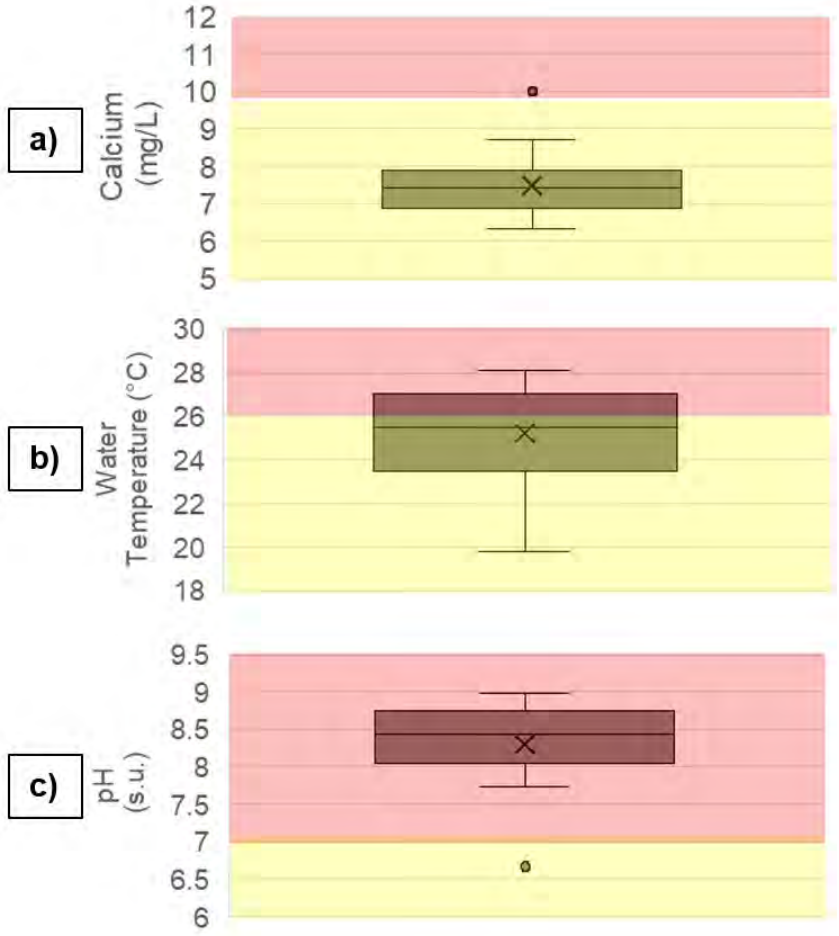
Notes: Box and whisker plots show the data distribution by reservoir: mean = x within the box, median (50th percentile) = black line in the center of box; upper quartile (75th percentile) = top of the boxes; lower quartile (25th percentile) = bottom of the boxes; whiskers drawn to the farthest point within 1.5 x interquartile range. Outliers for box and whisker plots shown as individual points.

Risk of golden mussel colonization (CDFW 2024, 2025c) is indicated by colored shading: dark green = very low risk, light green = low risk, yellow = moderate risk, and red =high risk).

Figure 4. Water quality and vulnerability of golden mussel colonization for (a) calcium concentrations, (b) summer water temperatures, and (c) spring/fall water temperatures, and (d) pH in Upper American River Project and Chili Bar Project reservoirs during 2019–2024.

5.2.2 Rancho Seco Lake and Folsom South Canal

Water quality data from Rancho Seco Lake indicate suitable habitat conditions for golden mussel colonization based on CDFW guidelines (CDFW 2024; Figure 5). Calcium concentrations and water temperatures were within the moderate-to-high category. Water temperatures (>16°C) supporting larvae development could occur for at least 7 months of the year, and survival is not limited by calcium (>5 mg/L). Overwinter water temperature data is not available at this location but based on regional climate and the lower elevation (247 ft above sea level), it is likely that adults and larvae could survive year-round.



Notes: Box and whisker plots show the data distribution by reservoir: mean = x within the box, median (50th percentile) = black line in the center of the two shaded boxes; upper quartile (75th percentile) = top of the boxes; lower quartile (25th percentile) = bottom of the boxes; whiskers drawn to the furthest point within 1.5 x interquartile range. Outliers for box and whisker plots shown as individual points.

Golden mussel colonization risk levels (CDFW 2024, Liu et al. 2020) are indicated by colored shading: yellow = moderate and red = high colonization risk.

Figure 5. Water quality and vulnerability of colonization for (a) calcium concentrations (b) water temperatures, and (c) pH in Rancho Seco during 2011–2025.

6.0 VULNERABILITY ASSESSMENT SUMMARY

The *Invasive Mussel Vulnerability Assessment* (SMUD 2025) (Attachment 1) evaluates the risk of invasive mussel introduction and establishment in UARP Reservoirs and Rancho Seco Lake based on the following:

- A discussion of invasive mussels including their current distribution in California;
- An evaluation of the potential pathways of invasive mussel introduction into the management areas through both natural processes and human activities;
- An assessment of aquatic habitat quality based on water quality conditions (calcium, pH, temperature, and dissolved oxygen) known to affect mussel colonization;
- A review of the early detection monitoring program results; and
- A short summary of the invasive mussel prevention program that has been implemented thus far.
- A list of future potential management actions including early detection monitoring, preventative controls, and post-infestation mitigation.

The vulnerability of SMUD reservoirs to invasive mussel introduction and colonization is low to moderate based on current CDFW guidelines and available scientific literature. All SMUD reservoirs remain at a low risk to quagga and zebra mussel infestation due to the absence of nearby populations and unfavorable water chemistry (i.e., calcium concentrations below species-specific thresholds). Golden mussels pose a greater threat because of nearby populations and the species ability to tolerate wider ranges of water quality chemistry (i.e., lower calcium concentrations). Water chemistry in Rancho Seco Lake and Folsom South Canal is favorable to golden mussels; however, introduction into Rancho Seco through recreation is low due to current watercraft restrictions. Loon Lake, Union Valley, Ice House, Junction, and Brush Creek reservoirs have the highest risk of golden mussel introduction through recreational motorized watercraft; however, water chemistry and overwinter conditions in these reservoirs may limit their ability to successfully colonize.

The following preventative actions would further inform or reduce the risk of invasive mussel infestation:

- Monitoring: Continue water quality and early detection mussel monitoring, including environmental deoxyribonucleic acid (eDNA) sampling at boat launches.
- Recreation Controls: Implement a Watercraft Inspection and Decontamination (WID) program for motorized watercraft. Continue boating restrictions at Rancho Seco Lake.
- Infrastructure Modifications: Establish a decontamination station in a location where traffic could easily be managed, clean and contaminated equipment could be separated, and hot water and electricity can be provided.

The vulnerability assessment should be periodically updated as reservoir management plans change; more scientific information becomes available; or if invasive mussels are detected in the Sierra Nevada regions, Sacramento region, or reservoirs that contain low calcium concentrations.

7.0 EARLY DETECTION MONITORING PROGRAM

Early detection of invasive mussels allows managers to implement rapid responses to reduce the spread of these mussels, such as restrictions on watercraft movement and management of water diversions. In 2009 SMUD developed an Invasive Mussel Prevention Plan which included monitoring for the presence/absence of adult mussels at Rancho Seco Lake and at the UARP. Chili Bar Reservoir monitoring started after SMUD took ownership from PG&E in 2021. Monitoring at these locations began in 2009 and 2011, respectively. Invasive mussel monitoring methods at SMUD reservoirs include the following:

- Surface water quality data (calcium, pH, water temperature, and dissolved oxygen) are collected during mussel surveys to monitor reservoir conditions.
- Surface surveys conducted for adult and juvenile mussels on hard substrates located around the reservoirs (e.g., boat launches, docks, concrete structures, shorelines).
- Artificial substrates deployed to provide a substrate for juvenile mussels to attach (Figure 6).

In 2025, SMUD began voluntarily collecting invasive mussel eDNA. Monitoring methods and suitable locations for the artificial substrates were identified in consultation with CDFW. Additional details on the survey locations and frequency of monitoring efforts are included in Table 4.

Environmental DNA sampling from water samples can detect the presence of the mussel even at low abundances. Biologists conduct eDNA sampling at thirteen accessible boat launches throughout the UARP, Chili Bar, and Rancho Seco Reservoirs:

- Loon Lake Boat Ramp
- Gerle Creek Reservoir (Hand Launch)
- Union Valley Reservoir-Sunset Boat Dock
- Union Valley Reservoir-Yellowjacket Boat Ramp
- Union Valley Reservoir-West Point Campground Boat Ramp
- Union Valley Reservoir-SMUDEA Power Pines
- Ice House Reservoir Boat Ramp
- Junction Boat Ramp
- Brush Creek Boat Ramp
- Slab Creek East Hand Launch
- Chili Bar Boat Launch (administrative only)

- Ranch Seco Boat Launch

Samples are collected bi-annually, coinciding with existing invasive mussel monitoring. Samples are analyzed for golden mussel and quagga/zebra mussels DNA using assays provided by a qualified laboratory. Rainbow trout (UARP and Chili Bar Reservoirs) and largemouth bass (Ranch Seco) are analyzed as internal positive controls. Negative controls are collected by filtering 1 liter of distilled water prior to sample collection.

At each monitoring location, triplicate samples (i.e., three filters) are collected. Water is collected using a peristaltic pump and filters. At least 1 liter of water is filtered per sample collected. To prevent contamination, eDNA samples are collected from the shore and surveyors wear single-use latex gloves. Laboratory personnel follow best practices for eDNA extraction and create and analyze an extraction negative and quantitative polymerase chain reaction (qPCR) negative with every extraction batch and qPCR plate (Miya et al. 2016).

Samples are analyzed in triplicate (i.e., three filters) and with internal positive control to ensure samples are not inhibited (i.e., a negative result signified DNA was not detected, not an indication of a failed qPCR reaction). A laboratory report describing results, methods, and references to the published assays is provided approximately 2 weeks from the date samples are received by the qualified laboratory.



Figure 6. Photographs of artificial substrates deployed at the Upper American River Project, Rancho Seco Lake, and Folsom South Canal.

Table 4. Invasive mussel monitoring methods, frequencies, and locations at Upper American River Project Reservoirs and Chili Bar Project Reservoirs, and Rancho Seco Lake.

Reservoir	Artificial Substrate[1]	Surface Survey[2]	Water Chemistry[3]	eDNA	Location
Upper American River Project					
Rubicon	N/A	Bi-annually	Bi-annually	N/A	Lakeshore
Buck Island	N/A	Bi-annually	Bi-annually	N/A	Lakeshore
Loon Lake	Monthly (June–Oct)	Monthly (May–Oct)	3 times / year	Bi-annually	Boat dock
				Bi-annually	Boat ramp
Gerle Creek Reservoir	Monthly (June–Oct)	Monthly (May–Oct)	3 times / year	Bi-annually	Fishing pier
Robbs Peak Forebay	N/A	Monthly (May–Oct)	3 times / year	Bi-annually	Lakeshore
Union Valley	Monthly (June–Oct)	Monthly (May–Oct)	3 times / year	Bi-annually	Sunset boat dock
				Bi-annually	Yellowjacket boat ramp
				Bi-annually	West Point boat ramp
Ice House	Monthly (June–Oct)	Monthly (May–Oct)	3 times / year	Bi-annually	Boat dock
Junction	N/A	Monthly (May–Oct)	3 times / year	Bi-annually	Boat ramp
Camino	N/A	Monthly	3 times / year	Bi-annually	Boat ramp
Brush Creek	N/A	Monthly	3 times / year	Bi-annually	Boat ramp
Slab Creek[4]	N/A	Monthly	3 times / year	Bi-annually	Boat ramp—east
Chili Bar Project					
Chili Bar	N/A	Monthly	3 times / year	Bi-annually	Boat ramp
Rancho Seco Lake					
Rancho Seco Lake	Monthly	Monthly	3 times / year	Bi-annually	Rental boat dock[5]
					North boat ramp
					South boat ramp
					North fishing dock

Notes: eDNA = environmental deoxyribonucleic acid

[1] Monthly artificial substrate monitoring is conducted when boat docks are deployed at the boat launching facilities. The period of monitoring may vary by year based on access and water levels. Artificial substrates are polyvinyl chloride (PVC) plates or tubes deployed in the reservoir water column.

[2] Survey conducted 50 to 100 yards on both sides of boat ramps where safely accessible pending access and safety (e.g., wildfire, AQI, weather).

[3] Water chemistry sampling (calcium, pH, water temperature, and dissolved oxygen).

[4] Slab Creek-West monitoring ceased in 2025 due to safety concerns via access road. No boat launch is currently being used by the public at this location.

[5] Surface survey only, no artificial substrate at rental boat dock and no water chemistry collected at this location.

8.0 PREVENTION PROGRAM

The SMUD invasive mussel prevention program consists of public education and outreach designed to help visitors understand the biology of invasive mussels, the risk they pose to water users, and steps that can be taken for mussel prevention. Educational programs at UARP and Chili Bar Project reservoirs and Rancho Seco Lake focus on recreational boaters. These programs include posted signs with the message: "Don't Move a Mussel - Clean, Drain, Dry!" (Figure 7). These educational materials include instructions on how to clean, drain and dry watercraft between launches. Additionally, recreational boating on Rancho Seco Lake is restricted to only hand-launched watercraft and trailered watercraft with electric motors. These watercrafts have a lower probability of transporting mussel larvae or adults from mussel contaminated reservoirs because they are less likely to contain standing water in live wells, bilges, and outboard motors.

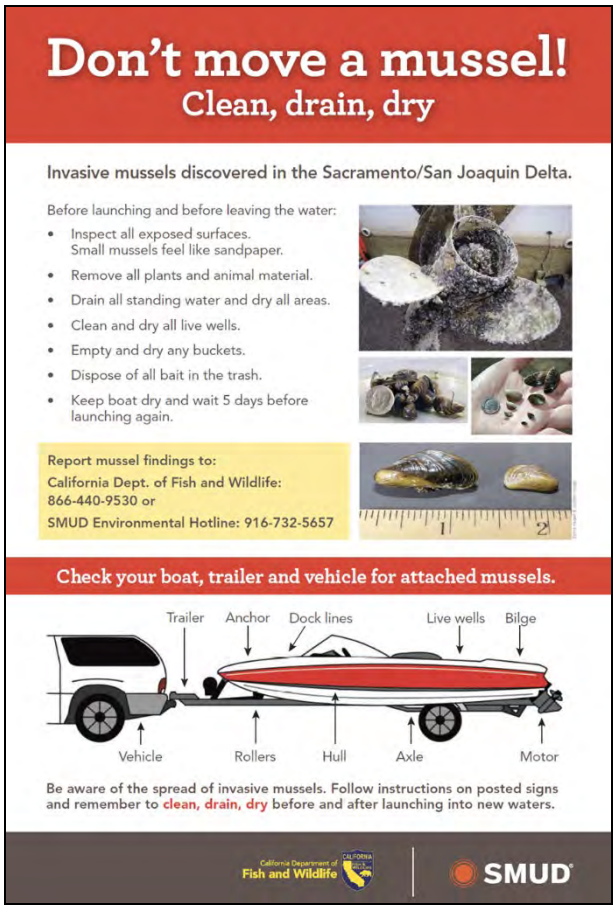


Figure 7. Example of posted educational signs

In August 2025, SMUD was awarded a Sport Fishing Restoration Boating Access (SFRBA) Grant for Invasive Mussel Response. This funding supports projects that help prevent the introduction and spread of invasive mussels in lakes, reservoirs and waterways, ensuring the long-term health of state waters. Funds made available to SMUD through the SFRBA will support the purchase and installation of a self-service waterless cleaning system at Rancho Seco Lake. A self-service waterless cleaning system will reduce the spread of invasive plants in boats by up to 95% and will facilitate the removal of contaminated water trapped in vessels by up to 96%.

8.1 FUTURE MANAGEMENT ACTIONS

Potential future management actions were identified in the vulnerability assessment to allow water managers to evaluate options to consider in the future based on site-specific conditions (Attachment 1). The completion of a Watercraft Inspection and Decontamination Station Feasibility and Logistics Plan is being considered by SMUD. If adopted in the future, this Decontamination Stations Feasibility and Logistics Plan would identify and evaluate potential inspection/decontamination station locations, identify agencies that would need to participate, identify possible months of operation, identify the triggers for installation of stations, evaluate program tracking options, and develop cost estimates for installing and operating a station. Due to the low vulnerability of SMUD Reservoirs, no additional management actions are currently being considered.

9.0 RAPID RESPONSE PLAN

Once invasive mussels are introduced into a waterbody, managing the infestation is extremely expensive and eradication is nearly impossible. If mussels are detected in a waterbody, a rapid response must be implemented to be effective at controlling and/or eradicating the invasive mussel population while it is still small and localized (Attachment 2 & 3). Detection response plans were developed for the UARP (SMUD 2019a) and Rancho Seco Lake (SMUD 2019b) and are provided in Attachments C and D, respectively. These response plans are consistent with guidelines outlined in *the Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide* (NPS 2007), which includes the following response planning steps:

1. **Pre-plan**: organize for a response before an initial detection in the management area;
2. **Initial Response**: immediate actions to take in the first days to weeks after the initial detection;
3. **Extended Response**: actions to implement for the upcoming visitor and boating season in the weeks or months after initial response; and
4. **Long-term Response**: actions to implement as part of day-to-day management actions and into facility designs in the first few years after an extended response.

The detection response plans focus on pre-plan and initial response actions SMUD should implement if invasive mussels are detected in the SMUD management areas. Additional planning and coordination should be developed with partner agencies if the

vulnerability of SMUD Reservoirs increases, as well as new invasive mussel infestations in the Sierra Nevada or Sacramento regions. Upon the report of an invasive mussel, the SMUD Invasive Mussel Coordinator must immediately notify CDFW Invasive Species Program headquarters[5] and CDFW Region 2 -North Central Regional Coordinator[6]. If mussels are detected in a SMUD waterbody, an Incident Response and Control Plan is required for submittal to CDFW within 60 days.

10.0 ANNUAL REPORTING

Annual reports (for January 1–December 31) will be submitted to CDFW each year to document the prevention program's implementation, as required under CCR Title 14 Section 672.1 (b)(5). These reports will summarize any changes to the waterbody's vulnerability, the results of monitoring, and any management activities implemented. Annual reports will be submitted by SMUD Mussel Coordinator or designated biologist to the CDFW Region-2 North Central Regional Scientist no later than March 31 of each year.

[5] CDFW Invasive Species Program headquarters contact email: invasives@wildlife.ca.gov; 1-866-440-9530; or submit an Observation Report form at https://www.wildlife.ca.gov/Conservation/Invasives/Quagga-Mussels/Observation-Report

[6] CDFW Regional Scientist contact information: Angie Montalvo (email: Angie.Montalvo@wildlife.ca.gov; phone: 530.333.7749)

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