ATTACHMENT 1

LICENSEES' RESPONSE TO SCHEDULE A - ADDITIONAL INFORMATION

Exhibit A

1. FERC-1 Comment:

Exhibit A, section 3.1.3, page 3-7 states: "An ungated emergency overflow weir is located on the north side of Lower Quail Canal. If an unplanned release occurs, water can be discharged over the ungated weir into a detention basin located to the west and adjacent to the southernmost section of Lower Quail Canal." The following text (or similar that relays this information) should be added after these statements: "This detention basin is created by the Quail Detention Embankment, an existing structure, that is proposed to be included in the licensed project. The Quail Detention Dam is a zoned earth embankment dam designed to capture the contents of the Lower Quail Canal in the event of an overtopping or failure. The dam is normally a dry dam with an uncontrolled box-culvert outlet." All directional information (e.g. north, west, etc.) in the above statements should be verified for accuracy to ensure the text is correct before adding to Exhibit A.

Licensees' Response:

The Licensees have verified the directional information and concur. In addition, the Licensees propose that the following statement be added to Exhibit A after the existing sentence from Section 3.1.3, page 3-7, quoted above:

> "The embankment is a zoned earth embankment designed to capture the contents of the Lower Quail Canal in the event of an overtopping or failure. Section 5.2 of this Exhibit A describes the Quail Detention Embankment in detail and the Licensees' Proposal to include the Quail Detention Embankment in the new license."

2. FERC-2 Comment:

Exhibit A, section 3.2.5, page 3-19 states that the Elderberry Forebay Dam is 1,990 feet long and 200 feet high. We note that the Supporting Technical Information Document filed in conjunction with the Part 12 safety inspection reports lists the length as 1,935 feet and the height as 179 feet. Please review this information and resolve this discrepancy.

Licensees' Response:

The information in the Supporting Technical Information Document is correct. The correct length and height of the Elderberry Forebay Dam on Page 3-19 in Exhibit A should be revised to show the length and height as 1,935 feet and 179 feet, respectively.

Exhibit D

3. FERC-3 Comment:

In Exhibit D, section 3.0, page 3-1, you correctly state that the license being pursued is a new license, not an initial license, and therefore you are not required to provide original cost information that would include the net investment value of the project. While this is true, in our developmental analysis of the project, we use the net investment value as the basis for depreciation computations as part of the annual cost. Therefore, please provide the net investment value for the project as of December 31, 2019.

Licensees' Response:

The net investment value for the Project as of December 31, 2019 is approximately \$616,487,000. A total of approximately \$122,754,000 is related to the Warne Power Development and approximately \$493,733,000 is related to the Castaic Power Development.

4. FERC-4 Comment:

Exhibit D, table 6.1-1 on pages 6-2 and 6-3, provides costs for proposed cost measures to be implemented as part of the new license. However, the discussion in sections 6.1.1 and 6.1.2 indicate that the costs in table 6.1-1 include both existing measures and their associated costs that will be continued through the new license term, and new measures and costs that are new and/or different than the existing measures and costs. We are unable to separate those measures and costs based only on the information provided. Therefore, please: (a) revise section 6.1.1 to include a separate table (new table 6.1-1) comparable to the content of the current table 6.1-1 that provides only the measures and associated costs that are being continued; and (b) revise section 6.1.2 to include a new table (new table 6.1-2) comparable to the content of the current table 6.1-1 that only includes new measures and their associated costs and/or other additional measures and costs above and beyond what is provided in the new table for section 6.1.1 that would constitute only those additional costs associated with the DWR proposed project.

Licensees' Response:

Table 6.1-1 in revised Section 6.1.1, included here as Appendix A, provides a list of existing environmental and recreation measures and their costs that the Licensees propose be continued in the new license. Table 6.1-2 in revised Section 6.1.2, included here as Appendix A, provides a list of new measures and existing measures the Licensees propose for inclusion in the new license. Table 6.1-2 shows the Licensees' estimated cost to implement the new measures that go above and beyond the costs shown in Table 6.1-1.

5. FERC-5 Comment:

As discussed in the preceding AIR, Exhibit D, table 6.1-1 on pages 6-2 and 6-3, provides costs for proposed cost measures to be implemented as part of the new license. We also note that the implementation schedule in table 4.0-1 of the Recreation Management Plan includes several proposed measures and facility site enhancements that are supposed to correspond to the costs for measure RR1 in Exhibit D, table 6.1-1 of the FLA. When you revise Exhibit D, sections 6.1.1 and 6.1.2, please provide a table showing how the costs for recreation measure RR1 will be implemented each year of the first 30 years of the new license term, consistent with the schedule provided in the Recreation Management Plan table 4.0-1.

Licensees' Response:

Table 6.1-3 in revised Section 6.1.2, included here as Appendix A, provides the Licensees' estimated annual cost during each of the first 30 years of the new license for new measures in the Licensees' proposed Recreation Management Plan.

6. FERC-6 Comment:

Exhibit D, table 6.2-1 provides the annual capacity value for the Warne powerhouse ($1,382,000), as well as the installed capacity (74,290 kW) and dependable capacity (60,400 kW). Similarly, the table provides the annual capacity value for the Castaic powerhouse ($51,146,000), as well as the installed capacity (71,275,000 kW) and dependable capacity (201,600 kW). Please provide the capacity rate in $/kW-year and capacity in kW used to compute the annual capacity value for each powerhouse.

Licensees' Response:

For the Warne Powerplant, the capacity rate used to compute the annual capacity value in Table 6.2-1 of Exhibit D under the No Action Alternative is $3.48/kW-month. This rate is provided in the California Public Utilities Commission's (CPUC) 2017RAReport.pdf report file. This rate is converted to $/kW-year by multiplying it by 12 to arrive at $41.76/kW-year. The CPUC's Resource Adequacy (RA) program requires load serving entities, such as DWR, to procure capacity so that capacity is available to the California Independent System Operator when and where needed. The dependable capacity is calculated using five years of DWR's reported RA data for the Warne Powerplant. Capacity data submitted for each month through monthly filings were averaged for the calendar years 2013 through 2017. A five-year average of these data was then used to arrive at the yearly RA capacity. The yearly RA capacity was then multiplied by the local Los Angeles Basin area RA price ($3.48/kW-year) found in CPUC's 2017RAReport.pdf report file to calculate a yearly benefit. These values are shown in Appendix A.

Castaic Powerplant is located in LADWP's Balancing Authority which does not have the same Resource Adequacy requirements or market. For consistency across the facilities, LADWP has decided to use the same capacity rate and calculation methodology as used for Warne Powerplant. The previous valuation methodology being updated in Table 6.2-1 was provided after a misinterpretation of the term "capacity rate" and is not reflective of the value of Castaic Powerplant's value of installed capacity.

Exhibit E

Water Quality

7. FERC-7 Comment:

In section 5.1.1.7 Castaic Power Development, you discuss sediment removal practices, conducted under a Corps of Engineer's section 404 permit and a California State Water Resources Control Board (Water Board) water quality certification, at the Storm Bypass Check-Dam basins and Elderberry Forebay. You provide the quantity of sediment removed from each of the check-dam basins since 2005 in table 5.1-1. In addition, you state that periodic removal of sediment from the Elderberry Forebay is conducted on 10-year intervals and that approximately 500,000 cubic yards of sediment were removed, drained, and stockpiled in 2016. Although the water quality certification for these activities requires water quality monitoring if surface flows are present and inclusion of these monitoring results in Annual Mitigation Monitoring Reports to be submitted to them, you do not indicate whether surface flows were present during these activities or provide any related water quality measurement results. To provide Commission staff an understanding of the water-quality effects of these maintenance activities, please provide each annual report for maintenance activities that you submitted to the Water Board since 2005.

Licensees' Response:

Appendix B to this attachment provides copies of annual reports that LADWP has provided to the California State Water Resources Control Board (SWRCB) for maintenance activities related to the removal of sediment at the check-dam basins and in Elderberry Forebay.

8. FERC-8 Comment:

In sections 5.2.1.2 and 5.3.1.2, you discuss the inter-connectedness of invasive aquatic vegetation, harmful algae blooms (HABs), taste and odor, and use of algaecides and aquatic herbicides. Your discussion addresses your sampling of taste and odor compounds (i.e., geosim and 2-methylisoborneol) and cyanotoxins, your approach to determine the need to use algaecides, how treatment areas are selected (p. 5-175), and the use of your Aquatic Pesticides

Application Plan to guide your application of algaecides and aquatic herbicides and associated monitoring.

You state that when sampling results indicate taste and odor compounds exceed a pre-determined level, DWR and/or MWD determines the source and DWR manages the algal bloom to prevent further production of geosmin and 2-methylisoborneol. You also state that when concentrations of cyanotoxins are at or reaching a level of concern, DWR water quality staff determine the location of the source (in-lake production versus upstream production) and feasibility of control. Then, DWR staff develop a plan for applying aquatic herbicides to control the HAB if the location of the algal source is identified and cyanotoxin levels threaten water supply and recreational safety. You summarize your use of aquatic herbicides in 2016 to 2018 on page 5-119, and state that you have not conducted an algicide treatment for taste and odor in Project reservoirs. However, you do not provide: (1) measured concentrations of cyanotoxins, geosim, or 2-methylisoborneol; (2) which events had cyanotoxins at or reaching a level of concern or taste and odor compounds that exceeded a pre-determined level; (3) the source(s) identified for each of these events; (4) physical and chemical data associated with these events; (5) treatment and effectiveness of each application. To enable Commission staff to have a more complete understanding of the available information, please provide each annual report that you submitted to the Water Board to address these issues.

Licensees' Response:

In the interest of FERC's request, Appendix C to this attachment provides the results of DWR's cyanotoxin monitoring in Pyramid Lake from 2015 through 2019, and DWR's geosmin and 2-methylisoborneol (MIB) monitoring in Pyramid Lake from 2012 through part of 2020. Refer to the appended files titled:

20200505_DWR_P2426_SSWP_Cyanotoxin_results_2015
20200505_DWR_P2426_SSWP_Cyanotoxin_results_2016
20200505_DWR_P2426_SSWP_Cyanotoxin_results_2017
20200505_DWR_P2426_SSWP_Cyanotoxin_results_2018
20200505_DWR_P2426_SSWP_Cyanotoxin_results_2019
20200505_EAB_P2426_SSWP_Cyanotoxin_Advisory_Levels.pdf
20200505_MWD_P2426_SSWP_Pym_Lake_TO_Data_2012-2020

Taste and odor problems are generally considered an aesthetic nuisance in finished drinking water. Consumers can detect levels of geosmin and MIB as low as 5 nanograms per liter (ng/L) (5 parts per trillion) and 10 ng/L (10 parts per trillion), respectively. State and national secondary maximum contaminant levels for finished drinking water, considered as consumer acceptance contaminant levels (secondary drinking water standards set on the basis of aesthetic concerns that are not considered to present a risk to human health), provide thresholds that are designed to assist in the management of public water systems for aesthetic considerations and are applicable to treated drinking water sources.

The U.S. Environmental Protection Agency and the SWRCB established a level of 3 threshold odor units for odor in finished drinking water (EPA 2020; Title 22 of the California Code of Regulations, Section 64449).[1]

Although Project water from Pyramid Lake is considered a source of raw water supply, DWR conducts routine water quality monitoring as part of the larger SWP for multiple water quality constituents, including taste and odor, but is not required to meet treated drinking water standards. When raw water sources are delivered to State Water Contractors' member agencies, the water is treated to State and federal drinking water standards by the member agencies at their respective water treatment plants to ensure that water delivered to their respective customers complies with those standards.

DWR coordinates with Metropolitan Water District of Southern California (MWD) for water quality monitoring at Pyramid Lake, including taste and odor monitoring and laboratory analyses. MWD conducts the laboratory analysis for taste and odor compounds and these results for geosmin and MIB in Pyramid Lake from 2012 through part of 2020 are available. When applying a drinking water standard to raw water for the purpose of responding to FERC's AIR, of the 969 samples analyzed for geosmin, MWD's laboratory results indicate that the threshold odor units caused by geosmin for 387 (40 percent) were non-detect, 343 (35 percent) were 3 threshold odor units or less, and 239 (25 percent) were greater than 3 threshold odor units. Of the 969 samples analyzed for MIB, 653 (67 percent) were non-detect, 172 (18 percent) were 3 threshold odor units or less, and 144 (15 percent) were greater than 3 threshold odor units. The data are provided in the appended file:
20200505_MWD_P2426_SSWP_Pyramid_Lake_T_O_Data_2012-2020

The Los Angeles Regional Water Quality Control Board's (RWQCB) Basin Plan includes a taste and odor narrative water quality objective that specifies, "Waters shall not contain taste or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible aquatic resources, cause nuisance, or adversely affect beneficial uses." There are no documented taste and order impacts to this narrative water quality objective.

On a voluntary basis, DWR coordinates with the SWRCB and the California Water Quality Monitoring Council, which includes the California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network for which DWR is a participating member, and provides them with the results of monitoring for harmful algal blooms in SWP reservoirs, including Pyramid Lake. The data is posted to the California Water Quality Monitoring Council's mywaterquality.ca.gov website. DWR also will be coordinating on a statewide level with other State and federal agencies and Native American tribes under the State Freshwater and Estuarine

[1] U.S. Environmental Protection Agency (EPA). National Secondary Drinking Water Regulations. Available online: https://www.epa.gov/sdwa/drinking-water-regulations-and-contaminants. Accessed: June 13, 2020.

Harmful Algal Bloom Program that was established under Assembly Bill 834 (Statutes of 2019, Chapter 354) to collaborate on monitoring, reporting, and incident response for protecting public health from harmful algal blooms.

California cyanotoxin advisory levels were established in the *California Voluntary Guidance for Response to HABs in Recreational Inland Waters* that was prepared by the SWRCB, the California Office of Environmental Health Hazard and Assessment (OEHHA), and the California Department of Public Health (DPH) through the CCHAB Network. The cyanotoxin advisory levels use a three-tiered system as shown in Table 1 below.

Table 1. Cyanotoxin Trigger Levels for Posting Public Advisories

Criteria	No Advisory	Caution (TIER 1)	Warning (TIER 2)	Danger (TIER 3)
Total Microcystins (sum of all measured congeners)	< 0.8 µg/L	0.8 µg/L	6 µg/L	20 µg/L
Anatoxin-a	Non-detect	Detected	20 µg/L	90 µg/L
Cylindrospermopsin	< 1 µg/L	1 µg/L	4 µg/L	17 µg/L

Source: California Water Quality Monitoring Council (https://mywaterquality.ca.gov/habs/resources/habs_response.html). Accessed: June 13, 2020.
Key:
µg/L = micrograms per liter

DWR's voluntary sampling for cyanotoxins is conducted at the Emigrant Landing and Vaquero swim beach areas in Pyramid Lake weekly from Memorial Day to Labor Day, or following a cyanotoxin detection at the standard water quality station locations in Pyramid Lake. In instances when cyanotoxins are detected, this monitoring may continue past Labor Day on a weekly basis until cyanotoxin levels are no longer detected following multiple sampling events. Additional sampling and monitoring may occur in response to visual observation of algal blooms.

In 2015, microcystin levels in Pyramid Lake exceeded the Caution advisory level between mid-May and mid-October, with at least one of the four sampling locations, including two samples in June, categorized as "Danger" (79.5 micrograms per liter [µg/L] and 81.5 µg/L). In 2016, levels in Pyramid Lake generally exceeded the Caution advisory level from July through September, with one sample in the Danger advisory level (26 µg/L). In 2017, microcystin levels in Pyramid Lake exceeded the Caution advisory level from July through September. In 2018, levels in Pyramid Lake exceed the Caution advisory level from mid-June through mid-September, including one "Danger" sample in July (22.8 µg/L). Finally, in 2019, microcystin levels in Pyramid Lake exceeded the Caution advisory level from July through mid-September. The complete dataset is provided in Appendix C. Increased monitoring and issuances of public advisories occurred throughout those time periods, including corresponding public advisory signage, closures of swim beach areas, warnings to anglers on fish caught from the lake, cautions for pet owners, and other information.

The Project does not contribute concentrations of cyanotoxins, geosmin, or MIB to surface waters. The outside source contributing to cyanobacteria blooms during the above events is unknown.

DWR does not typically apply algaecide to Pyramid Lake to manage lake-wide algal blooms. Algaecides are typically applied on an as-needed basis consistent with a SWRCB-issued National Pollutant Discharge Elimination System (NPDES) permit to manage aquatic weeds and algae (such as filamentous green algae that are typically *Spirogyra* spp., *Cladophora* spp., and *Hydrodictyon* spp.) in nearshore shallow water areas to protect public safety and minimize recreational hazards.

DWR does not apply treatments in Pyramid Lake to control blooms producing taste and odor compounds. Management measures consist of monitoring and reporting to downstream water purveyors. The Licensees' existing permits issued by the SWRCB and the Los Angeles RWQCB do not include requirements for filing formal annual reports regarding geosmin and MIB for Pyramid Lake.

For cyanobacteria blooms, DWR coordinates with the SWRCB and DPH, and follows the voluntary guidance document that provides reservoir managers and operators with guidance on managing algal blooms, and includes a decision matrix for responding to algal blooms. Based on the results of the laboratory analyses and DWR's completion of an environmental assessment, DWR, in cooperation with OEHHA and DPH, posts public signage if cyanotoxins are detected. The health advisory signs notify the public of unsafe water activities associated with each threshold trigger level. Recreational activities are managed through issuance of recreational health advisories that include outreach and education, press releases, swim beach closures (when needed), recommendations to not eat the fish caught in Pyramid Lake, and other public protection measures. These advisories increase as the category of exposure danger increases. When the criteria for "No Advisory" is met for a minimum of two weeks, DWR has discretion over whether to continue posting public advisory signs.

The Licensees file annual monitoring reports with the SWRCB under the aquatic pesticide NPDES permit for Pyramid Lake, and the reports include physical and chemical data gathered during the course of monitoring prior to, during, and after the application of algaecides. Copies of the 2016 to 2019 annual monitoring reports covering Pyramid Lake are attached. Note that although the 2016 annual report (p. 16) states that the Licensees had attempted to treat for taste and odor in Pyramid Lake, DWR has never treated for taste and odor in Pyramid Lake, and this statement is incorrect per DWR staff. In communication with SWRCB, DWR staff verified that the July 13, 2016 copper treatment was applied to the shoreline and boat dock areas, and concentrations of taste and odor compounds were extremely low (i.e., nondetectable to 2 ng/L), and that the harmful algal bloom was being managed with recreation advisory signs and swim beach closures.

9. FERC-9 Comment:

On page 5-173, you state that mussel planktonic veligers are sampled with vertical plankton tows that occur on a monthly basis year-round at the outlet works in Pyramid Lake near the Angeles Tunnel Intake and as needed at the inlet near Emigrant Landing Day Use Area and cite DWR (2018, 2019). However, you do not explain the process for determining the need for monitoring at the inlet near Emigrant Landing Day Use Area, and it is not clear what documents you are citing. Therefore, please explain the process for determining the need for sampling planktonic veligers at the inlet near Emigrant Landing Day Use Area and provide the supporting documents. Also, provide DWR's Bulletin 132 for calendar years 2017, 2018, and 2019 or the information typically provided for quagga and zebra mussel monitoring and assessment in Chapter 3 Environmental Programs of Bulletin 132.

Licensees' Response:

The early detection monitoring program, which includes the use of plankton veliger and substrate sampling in Pyramid Lake, is not a requirement under any existing permit or State and federal mandate. Given the potential risk of zebra mussels invading SWP waters, DWR voluntarily began early detection monitoring for zebra mussel in the Central Valley Watershed in 1999 with the goal of detecting mussels during the early stages of colonization. Early detection monitoring increases the likelihood of eradicating a population when it is small and isolated; improves the feasibility and opportunity to control the spread of the mussel to other waterbodies; and provides an early warning to water managers (DWR 2005). Due to limited resources, waterbodies in the watershed were prioritized based on habitat suitability and likelihood of introduction, with priority given to high risk waterbodies (DWR 2005)[2]. The likelihood of mussel introduction into a waterbody was determined to be based on a lake's popularity and visitation level with recreational boaters because the primary vector of zebra mussels at the time was overland transport of trailered watercraft containing larval or adult mussels (DWR 2005). Under this premise, monitoring locations with a waterbody were selected near boat ramps where mussels could be dislodged while a boat was being launched near a gas dock, or convenience store that attracted boaters, had low flow conditions that retained the plankton veligers in the vicinity, and had protection from vandalism on sampling equipment (DWR 2005).

[2] California Department of Water Resources. 2005. Zebra Mussel Early Detection and Public Outreach Program. Final Report. September. Prepared for California Bay-Delta Authority (CALFED) and U.S. Department of the Interior, Fish and Wildlife Service by Messer, C. and Veldhuizen, T.

The experience and knowledge gained from the early detection monitoring activities were later applied to Pyramid Lake, where settlement plate and plankton net tow sampling occurs annually. Settlement plates deployed in the lake are inspected periodically, at a minimum of two times during the mussel spawning period, with increased sampling once a month following the detection of mussel settlement. Sampling typically occurs downstream of the inlet to the lake to detect any mussels coming from upstream sources, and near the Emigrant Landing boat dock to detect mussels dislodged by watercraft entering the lake. The purpose of monitoring at the inlet is to detect isolated or small founding populations. Since watercraft are a potential vector of quagga and zebra mussels, founding populations are likely to begin at or near boat launch areas where veligers would be ejected out of motor cooling systems and bilges upon start-up. To detect mussel populations established within the lake, sampling occurs mid-lake near Chumash Island, and near the lake outlet at Pyramid Dam. Plankton net tow sampling is conducted every two weeks near Pyramid Dam. However, sampling locations can be added, moved or removed at any location within the lake where necessary, as determined by DWR staff with experience in mussel management. As discussed, planktonic veliger sampling is routinely conducted near Pyramid Dam; however, in 2018, additional planktonic veliger sampling was conducted at the inlet and west of Chumash Island to collect more robust data in other lake locations.

Following the detection of deceased adult mussels in the Angeles Tunnel in 2016 and in response to State mandates for mussel control, DWR implemented its rapid response plan and expanded its early detection monitoring program in Pyramid Lake to include a combination of settlement plates, plankton net tow sampling, remote operated vehicle (ROV) surveys of available substrate, and infrastructure inspections during scheduled maintenance shutdowns. A ROV survey in 2016 at the Angeles Tunnel Intake structure identified one adult near the center of the trashrack that was also observed in the same location in a 2018 ROV survey; the 2018 ROV survey observed a second, single similar sized adult mussel on the north side of the trashrack that may have been present in 2016, but was not detected. It is anticipated that the two adult mussels are near the end of their life span (i.e., the life span of quagga mussel is typically five years [Richter 2008][3]).

Routine and continual monitoring as part of the response to the 2016 mussel detections are ongoing. No mussel veligers or young sub-adults have been detected to date. Based on the results of DWR's monitoring, there is no evidence of mussel reproduction in Pyramid Lake.

[3] Richter, Andrew. 2008. Pacific Northwest Aquatic Invasive Species Profile, Quagga Mussel (Dreissena bugensis). December 3, 2008. Available online: https://depts.washington.edu/oldenlab/wordpress/wp-content/uploads/2013/03/Dreissena-bugensis_Richter.pdf. Accessed: June 13, 2020.

Appendix D to this attachment includes additional information from Messer and Veldhuizen (2005) regarding the selection of monitoring sites (i.e., file named: 20050900_DWR_P2426_SSWP_Zebra_Mussel_Early_Detection_Public_Outreach_Program.pdf).

In addition, DWR, in consultation with other State agencies such as the California Department of Fish and Wildlife, is in the process of developing a Quagga and Zebra Mussel Vector Management Plan for the SWP, which will include Pyramid Lake. The purpose of the plan is to prevent the introduction of dreissenid mussel species into the SWP, and it includes management of mussel vectors, regulation of vector points-of-entry, early detection monitoring, and public education. The vector control program will consist of mandatory inspection and quarantine, and decontamination of potentially contaminated equipment and vessel inspections prior to launching within a SWP waterbody. The plan will provide guidelines for the inspection and restriction of those potential vectors and will provide the public with information on the impacts of dreissenid mussels, DWR's clean vessel requirements, watercraft cleaning, decontamination, and other procedures for reporting any mussel sightings.

Appendix E to this attachment includes Bulletin 132 for 2017. Bulletin 132 for 2018 and 2019 are still in development and are not available at this time. However, when published, the bulletins will report that DWR did not find any quagga mussel veligers in Pyramid Lake in 2018 and 2019, nor did DWR detect any mussels in other sampling (e.g., substrate sampling) in the lake in those years. Those corresponding bulletins will be posted on DWR's website (www.water.ca.gov) when they become available.

Aquatic Resources

10. FERC-10 Comment:

You conducted a desktop fish entrainment study that did not entirely follow your approved study plan, as modified by the June 14, 2017, Study Plan Determination (SPD), which required an evaluation of rainbow trout (juveniles and adults) and largemouth bass (all life stages) for potential risk of entrainment under both stratified and non-stratified lake conditions. However, in your final Field Results and Data Summary dated April 30, 2018, and in the FLA, your evaluation of intake velocities versus fish swimming speeds is limited to adult life stages of rainbow trout and largemouth bass, and you present no analysis of the potential risk of entrainment under both stratified and non-stratified lake conditions. To allow staff to complete its analysis of potential entrainment effects on a wider range of fish life stages and project operating conditions, please complete your analysis of potential fish entrainment as you proposed in your final study plan.

Licensees' Response:

Appendix F to this attachment includes an analysis of potential entrainment for juvenile rainbow trout and larval and juvenile largemouth bass under both stratified and non-stratified lake conditions. The analysis is also provided for volitional entrainment, as requested in FERC-11; juvenile and adult Sacramento hitch and striped bass, as requested in FERC-12; and related velocity calculations and drawings, as requested in FERC-13.

11. FERC-11 Comment:

Your analysis concluded that the potential for entrainment of adult rainbow trout and largemouth bass (i.e. recreational species) into the intake structures for the Pyramid Dam Low-Level Outlet and the Angeles Tunnel is low because both species are not likely to normally occur at the depths of the intakes, and the intake approach velocities are less than documented burst swim speeds for both species. This indicates that it is highly unlikely that these species would be involuntarily "swept" into the intake structures, but the study does not address potential entrainment of fish that volitionally pass through the intake structures in an attempt to move downstream out of Pyramid Lake. It is generally agreed that O. mykiss in Upper Piru Creek are related genetically to anadromous Southern California steelhead, so there is the potential for juvenile O. mykiss to attempt a seaward movement. Other resident species such as largemouth bass may also attempt downstream movements in response to population pressures and the need to seek out new habitat. To allow staff to complete its analysis of potential entrainment effects on fishes that may volitionally move out of Pyramid Lake, please describe the potential entrainment survival/mortality of both juvenile and adult life stages of rainbow trout and all life stages of largemouth bass that may volitionally enter both the Pyramid Dam Low-Level Outlet and the Angeles Tunnel, and identify the primary sources of mortality for each passage route.

Licensees' Response:

Appendix F to this attachment describes the potential entrainment survival/mortality of juvenile and adult life stages of rainbow trout and all life stages of largemouth bass that may volitionally enter the Pyramid Dam Low-Level Outlet and the Angeles Tunnel, and identifies the primary sources of mortality for each passage route.

12. FERC-12 Comment:

In Scoping Document 2, we listed aquatic resource issues that would be addressed in our NEPA document including, "effects of ongoing fish entrainment at the Warne powerplant, Castaic pump-generating station, and the outflow pipe and radial gate at Pyramid dam, including effects on special status species." As noted, your desktop entrainment analysis only focused on adult rainbow trout and largemouth bass entrainment from Pyramid Lake and did not include other *special status species. The FLA describes that Sacramento hitch, a state species of concern, occurs within Pyramid Lake as a probable introduced species but was not included in your entrainment analysis. In addition, the striped bass, also an introduced species but important to the sport fishery in both Quail Lake and Pyramid Lake, was not included in your analysis. To allow staff to complete its analysis of potential entrainment effects on special status species, please expand your entrainment analysis to include Sacramento hitch and striped bass, and include the analysis requested by item 9 above regarding volitional passage of these species.*

Licensees' Response:

Appendix F to this attachment includes an analysis of potential entrainment for juvenile and adult Sacramento hitch and striped bass under both stratified and non-stratified Pyramid Lake conditions.

13. FERC-13 Comment:

The FLA did not include the calculations for determining intake velocities used to compare to fish swimming speeds in your entrainment analysis, although the South SWP Hydropower Relicensing website (http://south-swp-hydropower-relicensing.com/studies/) includes an Excel spreadsheet entitled "20180405_dwr_sswp_p2426_Intake_Entrainment _Velocity_Calculations" that provides a summary of the calculations made. The spreadsheet does not clearly describe how the calculations were made, making it difficult for staff to verify the velocities used in the entrainment analysis. For example, in some cases staff is unable to duplicate the calculations shown in the spreadsheet. In addition, it is unclear how velocity dissipation with distance from the trashrack is modeled and calculated, and the FLA does not include drawings of the intake screens, which would help to understand the calculations. Therefore, to allow staff to verify the intake velocities used in the entrainment analysis, please provide a detailed step-by-step summary of how these velocities were calculated for both the Pyramid Dam Low-Level Outlet and the Angeles Tunnel Intake, including drawings showing the details of each trashrack analyzed (overall dimensions, and dimensions of the bar racks, their spacing, and any support structures), and a clear explanation of how velocity dissipation with distance from the trashrack is calculated.

Licensees' Response:

Appendix F to this attachment provides a summary of how velocities were calculated for both the Pyramid Dam Low-Level Outlet and the Angeles Tunnel Intake and an explanation of how velocity dissipation with distance from the trashrack was calculated. Appendix F to this attachment shows the details of each trashrack analyzed. These drawings show Critical Energy Infrastructure Information (CEII), and thus, Appendix G and the enclosed drawings are appropriately marked as such.

Terrestrial Resources

14. FERC-14 Comment:

In staff's comments on the draft license application, we requested additional information be provided in the FLA on the project's 11.4-mile-long, 230-kilovolt Castaic Transmission Line. The FLA does not include this information. The project transmission line could pose a collision and electrocution hazard to birds flying through the area and birds that might nest on the towers. Please provide the following information:

a) *any records of dead or injured birds that may have been found underneath the line, use of the towers by nesting birds, and any bird-related outages or other issues caused by birds;*

b) *the number of towers, whether the line includes a shield wire, and a description of any existing avian protection measures you have implemented relevant to the transmission line including any design and/or retrofitting equipment to minimize hazards to birds (e.g., per Avian Power Line Interaction Committee guidelines), the locations of all retrofitted sections; and*

c) *identify any sections along the length of the 11.4-mile-long transmission line that potentially pose a greater risk to birds traversing the area including water crossings and other nearby water bodies, ridgelines, suitable habitat for larger-bodied species, and other features that increase the risk of collision and electrocution.*

Licensees' Response:

LADWP is unaware of any bird-related issues on the Castaic Transmission Line. There have been no outages on the line caused by bird strikes. Although LADWP does not keep records of dead birds found under the line, LADWP is unaware of any reports of dead or injured birds associated with the transmission line. Similarly, there are no known reports of birds nesting on the line.

There are 51 towers on the Castaic Transmission Line, and the line includes static/shield wires. There are no additional avian protection measures on the line, nor have any areas been retrofitted at this time. Per the Licensees' proposed Sensitive Aquatic and Terrestrial Wildlife Management Plan, Avian Power Line Interaction Committee guidelines will be implemented for future pole repairs and replacements, and new construction on the line.

There are two areas along the Castaic Transmission Line that present somewhat higher risk of bird collisions based on existing site conditions and nearby features such as ridges or bodies of water: one 4.3-mile stretch that borders the southwest shore of Elderberry Forebay and Castaic Lake along a ridgeline, and a

1.3-mile stretch that crosses between Castaic Lake and Castaic Lagoon near the dam face. Figure 1 shows the location of these two sections of line.

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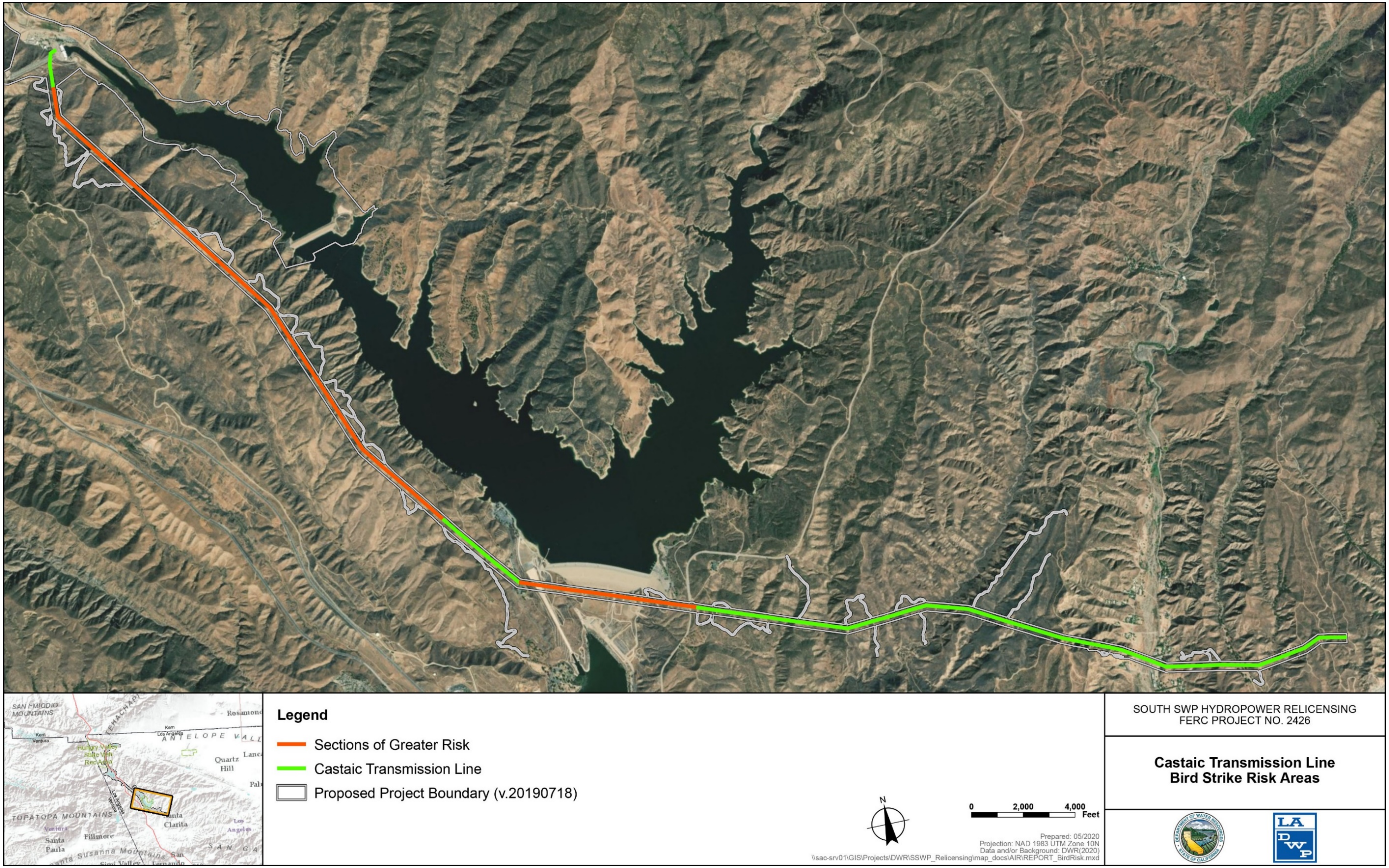

Figure 1. Bird Strike Risk Areas on the Castaic Transmission Line

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15. FERC-15 Comment:

The tricolored blackbird is state-listed as endangered in California. The species has been documented around Quail Lake and suitable nesting habitat occurs around the perimeter of the lake. Fluctuating water levels in Quail Lake could impact nesting habitat (e.g. cattail stands, wetland vegetation) for tricolored blackbird by inundating vegetation or lowering water levels that allow predators easier access to nests. Section 5.4.1.1, Existing Environment, under subsection Tricolored Blackbird, states "that the reservoir level [i.e., Quail Lake] is kept relatively constant throughout the year." However, it does not provide any further information on the timing, magnitude, and duration of water level fluctuations. The section also states that "the Licensees will generally avoid areas of breeding/nesting" for the tricolored blackbird. However, it does not specifically identify where breeding/nesting areas for this species occur. In order for staff to evaluate potential project effects on the tricolored blackbird including water level fluctuations in Quail Lake please address the following:

a) *provide quantitative information about water level fluctuations by season in Quail Lake and any project operations and/or environmental factors that cause the water levels to change;*

b) *describe the potential for water level changes to affect nesting habitat surrounding Quail Lake; and*

c) *identify locations of breeding/nesting areas for tricolored blackbird that you propose to avoid when performing project activities that could potentially disturb nesting blackbirds.*

Licensees' Response:

The Licensees analyzed Quail Lake daily elevation data from January 2006 through December 2018. On a day-to-day basis, the average fluctuation in reservoir elevation was 0.87 feet. Occasionally, the elevation would change 5 to 10 feet between days, but these are rare events and do not occur during any particular season. When elevation rose or lowered significantly, these changes usually occurred over weeks or months.

There is a slight difference per season in the mean elevation of Quail Lake. From 2006 through 2018, the fluctuations in that mean elevation per season, as measured by the standard deviation, are all over 2 feet above and below the 3,319 feet mean elevation (Table 2.)

Table 2. Mean Elevation of Quail Lake By Season

Season	Mean (feet)	Standard Deviation (feet)
Winter	3,319.42	2.42
Spring	3,319.17	2.55
Summer	3,319.07	2.28
Fall	3,319.86	2.37

The relatively small changes that occur are not anticipated to affect nesting habitat, as the elevation does not change enough or for long enough periods to either inundate or dry the vegetation around the perimeter of the lake.

Tricolored blackbirds have been reported nesting along the edges of Quail Lake in emergent vegetation, including cattail (*Typha latifolia*) and bulrush (*Schoenoplectus californicus*). A map of potential tricolored blackbird habitat and nest occurrences is provided in Appendix H to this attachment. The Licensees have included in their revised Sensitive Aquatic and Terrestrial Wildlife Management Plan, which is in Appendix I to this attachment, avoidance measures while performing Project operations and maintenance that could impact vegetation that may support breeding tri-colored blackbirds or disturb nesting birds along Quail Lake during the nesting season. The measures include conducting nesting bird surveys and establishing protective buffers around nests. Additionally, any Project-related activities that could potentially impact tricolored blackbirds would not be performed without the appropriate regulatory permits.

16. FERC-16 Comment:

The FLA defines what events qualify as emergencies to explain under what conditions how some measures would be implemented or altered in emergency situations. Some measures also include the caveat “to the extent possible,” “to the extent feasible, ”and other similar statements (e.g., Sensitive Aquatic and Terrestrial Wildlife Management Plan, Section 2.1). Please explain such non-emergency conditions, with examples, that could arise and would potentially affect the implementation of any proposed measures.

Licensees’ Response:

The Licensees understand the confusion this wording may cause. Therefore, the Licensees have removed the wording from its revised Sensitive Aquatic and Terrestrial Wildlife Management Plan, which is in Appendix I to this attachment.

17. FERC-17 Comment:

You describe several proposed environmental measures that would be implemented to minimize effects associated with non-routine project activities. Please describe which project activities could fall under that category of non-routine project activities.

Licensees’ Response:

The Licensees consider non-routine Project activities to include activities conducted outside of day-to-day routine operations and maintenance including: major transmission pole replacements (i.e., more than five consecutive poles replaced in a single area); re-conductoring multiple transmission line spans in a non-emergency situation; emergency road and facility construction or repair;

ground-disturbing activities of greater than 0.5 acres; vegetation management/removal projects outside of areas described in the Licensees' Application for New License; and other activities not described in Section B of the Licensees' Application for New License. The Licensees have included this list of activities in the Licensees' revised Sensitive Aquatic and Terrestrial Wildlife Management Plan, which is in Appendix I to this attachment.

18. FERC-18 Comment:

In Section 2.2.2 of the proposed Integrated Vegetation Management Plan (IVMP) (FLA, Attachment 4) you propose to identify new areas colonized by non-native invasive plant species by conducting surveys every 10 years for the term of the license. However, the plan does not specify where the surveys would be conducted. For staff to evaluate this measure, please state where you propose to conduct the surveys and how the survey areas would be selected.

Licensees' Response:

On a 10-year basis, the Licensees will conduct surveys for non-native invasive plant species, as defined in the Final License Application (FLA). Surveys will follow the protocols outlined in the FLA, which include a target list of species to be surveyed that will be reviewed and updated prior to field surveys. Surveys for non-native invasive plants will include the immediate vicinity around the Licensees' facilities as well as a 50-foot buffer around such facilities, in addition to areas of disturbance due to operation and maintenance activities (i.e., the 50-foot buffer applies to these areas as well). Areas that are known to contain non-native invasive plant occurrences will not be resurveyed.

19. FERC-19 Comment:

In order for staff to fully understand and evaluate proposed measures, please answer the following questions regarding the proposed Sensitive Aquatic and Terrestrial Wildlife Management Plan (FLA, Attachment 5):

a) *In Section 2.1, you propose to establish a mobile- and heavy-equipment exclusion zone within 100 feet of perennial streams and permanent bodies of water, and 50 feet of intermittent streams and ponds. Please explain the rationale and technical basis for the two distances you selected for the exclusion zones including any relevant citations.*

b) *You propose to conduct pre-construction surveys for federal and state-listed species, other sensitive species, sensitive habitats, and nesting birds in and within a reasonable buffer of proposed work areas prior to non-routine project activities. Please provide more specific information as to what distance(s) constitute a "reasonable buffer." Typically, such buffers should be specific to the proposed activity and potential for disturbance, location, species potentially affected, and season. In addition, please state* *the number of days prior to the initiation of any project activity that you would conduct surveys.*

Licensees' Response:

The Licensees' proposed buffers for perennial streams and permanent bodies of water, as well as for intermittent streams and ponds, are an amalgamation of buffers recommended for riparian, wetland, and other waters of the United States and/or State in other technical documents. Generally, buffer zones for waters and wetlands of the United States and State need to be at least 50 to 150 feet to protect them from human activities (Washington State Department of Ecology 1992[4]; Coati Municipal Code 2020[5]; New Hampshire Department of Environmental Services 2017[6]). For intermittent waters of the United States and/or State, the proposed buffer of 50 feet would be sufficient for their protection. Perennial streams and waters of the United States and/or State are more likely to have established vegetation, so buffers for riparian zones were considered for these areas. The National Resources Conservation Service considers the optimal buffer for a riparian zone to be between 35 and 150 feet, so a 100 foot buffer falls in the optimal zone (NRCS 2011[7]).

Buffers for all sensitive species, habitats, and nesting birds, as well as survey timing, have been added to the Licensees' revised Sensitive Aquatic and Terrestrial Wildlife Management Plan, which is in Appendix I to this attachment. These buffers are informed by guidance from resources agencies and are similar to buffers in similar management plans and measures for FERC licenses that have been approved by resource agencies (YCWA 2016[8]), as well as buffers used in California for non-FERC projects (PG&E 2015[9]).

[4] Washington State Department of Ecology. 2012. Wetland Buffers: Use and Effectiveness. February 2012. Available online: https://fortress.wa.gov/ecy/publications/publications/92010.pdf.
[5] City of Coati. 2020. Wetland Protection and Restoration. April 2020. Available online: https://www.codepublishing.com/CA/Cotati/html/Cotati17/Cotati1756.html.
[6] New Hampshire Department of Environmental Services. 2017. Wetlands Bureau: Frequently Asked Questions. 2017. Available online: https://www.des.nh.gov/organization/divisions/water/wetlands/categories/faq.htm.
[7] United States Department of Agriculture, National Resources Conservation Service. 2011. Plants for Riparian Buffers. November 2011. Available online: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/ nrcs144p2_043594.pdf.
[8] Yuba County Water Agency. 2016. Bald Eagle and American Peregrine Falcon Management Plan. Yuba River Development Project. Filed with FERC October 26, 2016.
[9] Pacific Gas and Electric Company. 2015. Nesting Birds: Species-Specific Buffers for PG&E Activities. November 2015. Available online: https://www.cpuc.ca.gov/Environment/info/panoramaenv/Fulton-Fitch/Application/Appendix_E_ Birds.pdf.

Cultural Resources

20-29. FERC-20 through -29 Comments:

FERC's AIR requests are not repeated here.

Licensees' Response:

As discussed with FERC staff, DWR anticipates filing the final Historic Properties Management Plan (HPMP) with FERC, including responses and appropriate updates relative to the nine Schedule A additional information requests (i.e., FERC-20 through FERC-29 Comments) pertaining to the HPMP, by September 30, 2020.

<u>Exhibit F</u>

30. FERC-30 Comment:

The Quail Lake embankment along the south side of Quail Lake is shown on Exhibit F, sheet F-02. The limits and alignment of the Quail Lake embankment along Rt. 138 should be reviewed and revised to reflect as-built conditions based on changes made in 1982 to enlarge the lake and to raise and rebuild Rt. 138. The existing Quail Detention Embankment that is proposed to be included as part of the licensed project is shown on Exhibit F, sheet F-07. However, the location of the embankment is not shown on any of the drawings for Quail Lake or the Lower Quail Canal. Please revise the appropriate drawings to clearly show the location of the embankment, the spillway, and the outlet tunnel. Also, review Exhibit F, sheet F-07 for accuracy and as-built conditions. The Exhibit F text states that the Quail Detention Embankment is shown on sheets F-07 and F-08. It does not appear that the embankment is shown on sheet F-08. Please resolve this discrepancy.

Licensees' Response:

Appendix J to this attachment includes revised Exhibit F, Sheets F-01, F-07, and F-08, that accurately show the Quail Detention Embankment. These drawings include CEII, and the appendix and drawings are appropriately marked as such. The title of Exhibit F drawing F-08 should be updated in Table 2.0-1 to "Quail Canal – Typical Sections to be consistent with the revised drawing title.

31. FERC-31 Comment:

Since the Quail Detention Embankment is proposed to be included in the licensed project, please provide stability analyses for the embankment under seismic and hydraulic loading conditions. The Supporting Design Report should also address the hazard potential of the embankment in order to justify the design flood for the structure.

Licensees' Response:

Appendix K to this attachment includes a stability analysis for the Quail Detention Embankment. The analysis includes CEII, and the appendix and drawings are appropriately marked so.

Exhibit G

32. FERC-32 Comment:

The Exhibit G maps do not show the location of the Quail Detention Embankment proposed to be included in the licensed project. Please revise the Exhibit G map(s) to clearly show the embankment within the project boundary.

Licensees' Response:

Appendix L to this attachment includes the revised Exhibit G map depicting the Quail Detention Embankment.

Attachment 1, Appendix A

Exhibit D, Revised Sections 6 and 7

ATTACHMENT 1

APPENDIX A

EXHIBIT D, REVISED SECTIONS 6 AND 7

6.0 ANNUAL COST OF OPERATIONS AND VALUE OF PROJECT POWER UNDER THE NO ACTION ALTERNATIVE AND LICENSEES' PROPOSAL

Section 6.0 is divided into two major sections, each of which addresses the No Action Alternative and the Licensees' Proposal. Section 6.1 discusses the Licensees' annual cost of operations. Section 6.2 discusses the value of Project power.

6.1. ANNUAL COST OF OPERATIONS

6.1.1. No Action Alternative

The Licensees estimate that, based on historical expenditures, the average annual operations and maintenance (O&M) cost under the No Action Alternative is approximately $42,226,000. The estimated average annual cost includes three components. The first component is $38,547,000 annually for O&M, station power, annual renewals and replacements, major infrastructure repairs/improvements unrelated to recreation or environmental activities. Some $19,776,000 of this total is related to DWR's O&M of the Warne Power Development and $18,771,000 is related to LADWP's O&M of the Castaic Power Development, of which $4,361,000 is for electricity to pump water from Elderberry Forebay to Pyramid Lake.

The second component is $2,524,000 annually related to recreation and environmental actions. This includes $502,000 for DWR's operation related to environmental activities of the Warne Power Development and recreation at Quail and Pyramid Lakes, and $2,022,000 related to LADWP's operation of the Castaic Power Development for activities such as hazardous waste management, Certified Unified Program Agency permits, biotic assessments and sensitive resource surveys, biological assessment reporting, sediment removal projects, annual laboratory support sampling and analysis, annual NPDES, and permitting relative to Section 401 of the Clean Water Act for the Elderberry Forebay, check dams, and Elderberry Forebay Spillway.

The third component is $1,155,000 annually. Under the No Action Alternative, the Licensees intend to recover their costs to obtain a new license for the Project. DWR estimates this cost is $24,669,000, or $822,000 annually, over 30 years; and LADWP estimates this cost is $10,000,000, or $333,000 annually, over 30 years (see Section 8 of this Exhibit D).

DWR does not have shareholders and therefore does not finance projects, including the relicensing, with equity capital. Any new construction, as well as the relicensing, is financed through various financial instruments, mainly the issuance of Revenue Bonds. DWR has maintained an exceptional bond rating throughout the years, including maintaining an AAA Standard and Poor's rating since 2001. Costs of borrowings for new construction that has taken place since the original Project facilities were completed are reported in Bulletin 132, an annual publication produced by DWR and available on the following website: https://water.ca.gov/.

LADWP is the largest municipal utility in the United States and is a proprietary department of the City of Los Angeles. The revenues from sale of electricity to LADWP customers are used to pay for LADWP's Power System O&M. LADWP's Power System is responsible for providing the electric service almost entirely within the LADWP service territory. The majority of the Power System capital improvements and new construction is financed primarily with the issuance of tax-exempt, long-term revenue bonds. The Power System has maintained strong bond ratings in the double A category throughout the years. Currently, the bonds are rated AA by both Standard & Poor's and Fitch Ratings, and Aa2 by Moody's Investor Service, with a stable outlook.

The Licensees anticipate that all their current average annual costs related to recreation and environmental actions, $1,524,000, would go forward under the Licensees' proposal. However, some of these costs would be components of some of the Licensees' proposed PM&E measures. Table 6.1-1 provides a breakdown of estimated environmental and recreational costs under the No Action Alternative that the Licensees anticipate would continue under the Licensees' Proposal for the new license.

Table 6.1-1. Estimated Costs to Implement Environmental and Recreational Measures in Licensees' Existing License That Are Likely to Continue Under the New License

Existing License	Proposed for Continuation in Some Part under DWR's Proposed Measure	Total Capital Cost Over 30 Years (2018 U.S. Dollars)	Total O&M Cost Over 30 Years (2018 U.S. Dollars)	Annualized Cost Over 30 Years[1] (2018 U.S. Dollars)
Article 19, Water Quality	ER2, Implement Hazardous Materials Management Plan	$0	$150,000	$5,000
Article 50, Exhibit R, Recreation Facilities	RR1, Implement Recreation Management Plan	$0	$2,700,000	$90,000
Article 51, Exhibit S, Fish Stocking in Pyramid Lake	AR2, Implement Pyramid Lake Fish Stocking Measure	$0	$8,820,000	$294,000
Article 51, Exhibit S, Wildlife Protection	TR2, Implement Sensitive Aquatic and Terrestrial Wildlife Management Plan	$0	$540,000	$18,000
Article 52, Stream Releases into Piru Creek	AR1, Implement Flow Releases into Pyramid Reach	$0	$90,000	$3,000

Table 6.1-1. Estimated Costs to Implement Environmental and Recreational Measures in Licensees' Existing License That Are Likely to Continue Under the New License (continued)

Existing License	Proposed for Continuation in Some Part under DWR's Proposed Measure	Total Capital Cost Over 30 Years (2018 U.S. Dollars)	Total O&M Cost Over 30 Years (2018 U.S. Dollars)	Annualized Cost Over 30 Years[1] (2018 U.S. Dollars)
Article 57, Revegetation	TR1, Implement Integrated Vegetation Management Plan Integrated	$0	$600,000	$20,000
Article 58, Maintain Pyramid Lake for Recreation	WR1, Maintain Pyramid Lake Elevations	$0	$450,000	$15,000
Articles 59, 60 & 402, Public Safety	LU3, Develop and Implement Project Safety Plan	$0	$2,400,000	$80,000
	Subtotal	*$0*	*$15,750,000*	*$525,000*
	Other Recreation/Environmental-Costs Expended by the Licensees for Operations of the Project[2]	**$0**	**$59,970,000**	**$1,999,000**
	Total	**$0**	**$75,720,000**	**$2,524,000**

Notes:
[1]Total annualized costs are calculated by summing Capital Cost and Total O&M Cost, and dividing the sum by 30.
[2]These include activities such as obtaining permits, biotic assessments and sensitive resource surveys, biological assessment reporting, sediment removal projects, annual laboratory support sampling and analysis, and NPDES-related activities.
Key:
O&M = operations and maintenance
U.S. = United States

6.1.2. Licensees' Proposal

The Licensees estimate that the average annual O&M cost under the Licensees' Proposal is approximately $43,808,000. Under the Licensees' Proposal, the normal average annual O&M cost of $38,547,000 would continue, as would the Licensees' recovery of the relicensing costs, annualized at $1,155,000. The environmental and recreational average annual cost of $2,524,000 under the No Action Alternative, shown in Table 6.1-1, would continue under the new license.

In addition, the Licensees estimate that their proposal would cost on average an additional $1,582,000 annually – costs that go above and beyond the costs related to the No Action Alternative shown in Table 6.1-2, and need to be added to the expected cost under the new license. These incremental costs are due to an expansion of some articles in the existing license or proposed new measures. Refer to Appendix E of Exhibit E for the full text of each of the Licensees' proposed measures, and to the resource sections in Exhibit E for a description of how each measure was developed. Table 6.1-2 provides for each Licensees' proposed new measures, costs that that go above and beyond the costs for the existing measures shown in Table 6.1-1.

Table 6.1-2. Estimated Costs to Implement the Licensees' Proposed Measures Beyond Those Costs Shown in Table 6.1-1

Licensees' Proposed Measure[1]		Total Capital Cost Over 30 Years (2018 U.S. Dollars)	Total O&M Cost Over 30 Years (2018 U.S. Dollars)	Annualized Cost Over 30 Years[2] (2018 U.S. Dollars)
Designation	Description			
GS1	Implement Erosion and Sediment Control Plan	$0	$0	$0
WR1	Implement Pyramid Lake Water Surface Elevation Restrictions	$0	$0	$0
WR2	Implement Hazardous Materials Management Plan	$0	$0	$0
AR1	Implement Flow Releases into Pyramid Reach	$0	$360,000	$12,000
AR2	Implement Pyramid Lake Fish Stocking Measure	$0	$0	$0
TR1	Implement Integrated Vegetation Management Plan	$0	$330,000	$11,000
TR2	Implement Sensitive Aquatic and Terrestrial Wildlife Management Plan	$0	$1,110,000	$37,000
RR1	Implement Recreation Management Plan	$10,040,000	$31,500,000	$1,385,000
LU1	Implement the Fire Prevention and Response Plan	$0	$450,000	$15,000
LU2	Develop and Implement Project Safety Plan	$0	$0	$0
VR1	Implement Visual Resources Management Plan	$0	$150,000	$5,000
CR1	Implement Historic Properties Management Plan (HPMP)	$0	$3,510,000	$117,000
	Total	**$10,040,000**	**$37,410,000**	**$1,582,000**

Notes:
[1]Refer to Appendix E of Exhibit E in this Application for New License for the complete text of each of DWR's proposed measures.
[2]Total annualized costs are calculated by summing Capital Cost and Total O&M Cost, and dividing the sum by 30.
Key:
DWR = California Department of Water Resources
O&M = operations and maintenance
U.S. = United States

The Licensees normally include costs related to erosion and sediment control in the costs for new projects as they are developed. Since no such projects are known at this time, Table 6.1-2 shows no costs related to the Licensees' Proposed Measure GS1.

Costs related to maintaining water surface elevations in Pyramid Lake, managing of hazardous material, stocking fish in Pyramid Lake, and maintaining safety overlap entirely with Articles 19, 51 and 58, and the combination of Articles 59, 60, and 402, in the existing license shown in Table 6.1-1. Therefore, there are no incremental costs shown in Table 6.1-2 for the Licensees' Proposed Measures WR1, WR2, AR2, and LU2, since these are continuation of articles and costs shown in Table 6.1-1.

The Licensees' proposed measure related to managing flow releases into Pyramid reach, managing vegetation and protecting sensitive species go above and beyond those measures in Articles 51, 52 and 57 in the existing license. Therefore, the costs shown in Table 6.1-2 for these measures are in addition to those costs shown in Table 6.1-1 to cover the additional new measure in the Licensees' Proposed Measures AR1, TR1, and TR2.

Costs related to fire prevention and response, and scenic integrity have historically been minor and covered under normal O&M. However, the Licensees propose specific measures for each of these with costs that are beyond those minor historical costs. Therefore, the costs for Licensees' Proposed Measures LU1, and VR1 shown in Table 6.1-2 are entirely new.

In addition, the costs related to the protection of cultural resources through the implementation of an HPMP are entirely new costs, since these measures are not included in the existing license, except for minor costs related to consultation for new projects. Costs in Table 6.1-2 for the Licensees' Proposed Measure CR1 are entirely new.

The costs shown in Table 6.1-2 for recreation are new costs for the recreation improvements identified in the Recreation Management Plan that are above and beyond the costs for recreation shown in Table 6.1-1.

Table 6.1-3 provides DWR's anticipated annual cost (i.e., sum of new costs in Table 6.1-2) over each of the first 30 years of the new license for implementation of the Licensees' proposed Recreation Management Plan, consistent with the schedule of implementation provided in Table 4.0-1 of the plan. To determine the total cost of implementing the Recreation Management Plan, the Article 50, Exhibit R, costs in Table 6.1-1 must be added to the total cost shown in Table 6.1-3.

Table 6.1-3. Anticipated Annual Cost for Implementation of the Proposed Recreation Management Plan Over the First 30 Years of the New License (Estimated Cost for Each Year after License Issuance)

Year	Dollars	Year	Dollars	Year	Dollars
1	$2,253,334	11	$1,290,000	21	$1,050,000
2	$2,253,333	12	$1,290,000	22	$1,050,000
3	$2,218,333	13	$1,290,000	23	$1,050,000
4	$2,095,000	14	$1,290,000	24	$1,050,000
5	$1,970,000	15	$1,290,000	25	$1,050,000
6	$1,970,000	16	$1,090,000	26	$1,050,000
7	$1,970,000	17	$1,090,000	27	$1,050,000
8	$1,470,000	18	$1,090,000	28	$1,050,000
9	$1,470,000	19	$1,090,000	29	$1,050,000
10	$1,470,000	20	$1,090,000	30	$1,050,000
				Total	**$41,540,000**

6.2. VALUE OF PROJECT POWER

6.2.1. No Action Alternative

The Project's installed and dependable capacity under the No Acton Alternative are 1,349,290 kilowatts (kW), excluding one pump-starting unit at the Castaic Powerplant, and 1,292,400 kW, respectively. DWR estimates the dependable capacity of the Warne Powerplant is 60,400 kW by multiplying the Warne Powerplant's average monthly Resource Adequacy (RA) data for 2013 through 2017 by the yearly RA capacity. DWR used the Commission's 2017RAReport.pdf report file and multiplied the local Los Angeles Basin area RA price by the annual RA average capacity to estimate the yearly benefit of dependable capacity. LADWP estimates the dependable capacity of the Castaic Powerplant is 1,232,140 kW. The Licensees estimate the value of capacity is $25,101,000: $1,382,000 for the Warne Power Development and $23,719,000 for the Castaic Power Development. (Table 6.2-1.)

In addition, the Licensees estimated average annual energy production of the Project under the No Action Alternative is 824,803 MWh: 304,464 MWh for the Warne Power Development and 520,339 MWh for the Castaic power Development. The Licensees estimate that 93,775 MWh (30.8 percent) of the Warne Powerplant average total annual energy production and 484,748 MWh (93.2 percent) of the Castaic Powerplant average total annual energy production occurs as peak power. The Licensees estimate that the remaining 210,689 MWh (69.2 percent) of the Warne Powerplant average total annual energy production and the remaining 35,591 MWh (6.8 percent) of the Castaic Powerplant average total annual energy production is off-peak power. The average annual values of the peak and off-peak power for Warne Powerplant are $2,625,000 and $5,898,000, respectively, and the average annual values of the peak and off-peak power for the Castaic Powerplant are $18,961,000 and $1,070,000, respectively. The total Project average annual energy production value is $28,554,000. (Table 6.2-1.)

Castaic Powerplant is a crucial asset to LADWP. As a load serving entity, LADWP utilizes the Castaic Powerplant to store hundreds of megawatts, which facilitates load leveling and peak shaving. Castaic Powerplant provides valuable ancillary services to LADWP as a balancing authority, including the ability to: (1) help balance load with generation, (2) integrate intermittent energy resources, and (3) provide reactive power support, regulation and frequency support service, and operating reserve services (both spinning and supplemental). These ancillary benefits enable LADWP to promote the dependability of its Power System, especially when power demand is high (i.e., hot summers). (LADWP 2014). Though LADWP utilizes Castaic Powerplant's unique functionality to provide these ancillary services, data are not explicitly logged individually as the facility is operated as a group within the Los Angeles System resources for the Balancing Authority. For this reason, LADWP estimates the value of these ancillary services is $51,146,000. The Warne Powerplant does not provide ancillary services. (Table 6.2-1.)

Table 6.2-1 summarizes the annual capacity of the Project, the total average annual value of capacity, the total average annual value of energy and ancillary services for the Project, and the total Project power value.

Under the No Action Alternative, the Warne Powerplant's capacity rate is $41.76/kW-year. To provide a comparable valuation this same capacity rate was also used to value the Castaic Powerplant. The Project's generation rate, based on an average annual cost of production of $42,226,000 and an average annual generation of 824,703,000 kWh, is $0.051/kw.

Table 6.2-1. Average Annual Project Power and Value Under the No Action Alternative

Value	No Action Alternative		
	Warne Power Development	**Castaic Power Development**	**Total Project**
Annual Capacity			
Installed (kW)	74,290	1,275,000	1,349,290
Dependable (kW)	60,400	1,232,140	1,292,540
Value ($)	$1,382,000	$23,719,000*	$25,101,000
Annual Generation			
Peak Energy (MWh)	93,775	484,748	578,523
Off-Peak Energy (MWh)	210,689	35,591	246,280
Subtotal (MWh)	304,464	520,339	824,803
Value ($)	$8,523,000	$20,031,000	$28,554,000
Annual Ancillary Services			
Reserves (MWh)	0	8,470,433	8,470,433
Value ($)	0	$51,146,000**	$51,146,000
Total Project Power Value (2018 U.S. Dollars)	**$104,801,000**		

Key:
kW = kilowatt
kWh = kilowatt hour
MW = megawatt
MWh = megawatt hour
U.S. = United States
** Castaic Powerplant's valuation uses the same capacity rate methodology as Warne Powerplant*
*** Estimated values are provided due the lack of an ancillary service market and data granularity at resource-level*

6.2.2. Licensees' Proposal

The Licensees do not propose to add or remove generation facilities from the Project, and propose to operate the Project as it has been operated historically. Therefore, under the Licensees' Proposal, the amount and value of the Project's capacity, energy, and ancillary services would not change from the amounts and values under the No Action Alternative shown in Table 6.2-1. The Project's capacity, capacity rate, and generation would not change from the No Action Alternative. The Project's generation rate, based on an average annual cost of production of $43,808,000 and an average annual generation of 824,803,000 kWh, is $0.053/kw.

7.0 CHANGES IN PROJECT COST, POWER, AND VALUE

Table 7.0-1 compares the average annual power benefits and average annual costs of the No Action Alternative and the Licensees' Proposal.

Table 7.0-1. Comparison of Average Annual Power Benefits, Costs, and Net Benefits of the No Project Alternative and the Licensees' Proposal

Value	No Action Alternative	Licensees' Proposal	Change[1]
Average Annual Power Benefits			
Capacity			
Installed (kW)	1,349,290	1,349,290	$0
Dependable (kW)	1,292,540	1,292,540	$0
Value (2018 U.S. Dollars)	**$25,101,000**	**$25,101,000**	**$0**
Generation			
Peak Energy (MWh)	578,523	578,523	$0
Off-Peak Energy (MWh)	246,280	246,280	$0
Subtotal (MWh)	824,803	824,803	$0
Value (2018 U.S. Dollars)	**$28,554,000**	**$28,554,000**	**$0**
Ancillary Services			
Reserves (MWh)	8,470,433	8,470,433	$0
Value (2019 U.S. Dollars)	**$51,146,000**	**$51,146,000**	**$0**
Total Benefits (2019 U.S. Dollars)	**$104,801,000**	**$104,801,000**	**$0**
Average Annual Costs			
Non-Environmental / Non-Recreation O&M Costs (2018 U.S. Dollars)	$38,547,000	$38,547,000	$0
Recovery of Relicensing Costs (2018 U.S. Dollars)	$1,155,000	$1,155,000	$0
Environmental and Recreational Cost (2018 U.S. Dollars)	$2,524,000[2]	$4,106,000	$1,582,000
Total Costs (2018 U.S. Dollars)	**$42,226,000**	**$43,808,000**	**$1,582,000**
Average Annual Net Benefits			
Value (2018 U.S. Dollars)	**$62,575,000**	**$60,993,000**	**-$1,582,000**

[1]Calculated by subtracting the No Action Alternative values from the values for the Licensees' Proposal.
[2]Related to Existing Environmental Expenditures.
Key:
kWh = kilowatt hour
MWh = megawatt hour
U.S. = United States

In summary, under both the No Action Alternative and the Licensees' Proposal, the Project's installed and dependable capacity would be 1,349,290 kW and 1,292,540 kW, respectively, and the Project would generate on average 824,803,000 kWh of energy annually. No change would occur in the Project's ancillary services, or the total benefits from the Project's capacity, energy and ancillary services sales. However, under the Licensees' Proposal, the Project's average annual cost would increase from $42,226,000 to $43,808,000, and increase of $1,582,000 (3.8 percent), resulting in an overall reduction of 2.5 percent in average annual net benefits from $62,575,000 to $60,993,000. In terms of cost of power, the Licensees' Proposal would increase the cost of the Project's generation from $0.051/kWh to $0.053/kWh.

Attachment 1, Appendix B

Annual Reports Submitted to California State Water Resources Control Board

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Department of Water and Power the City of Los Angeles

ANTONIO R. VILLARAIGOSA
Mayor

Commission
LEE KANON ALPERT, *President*
EDITH RAMIREZ, *Vice President*
FORESCEE HOGAN-ROWLES
JONATHAN PARFREY
THOMAS S. SAYLES
BARBARA E. MOSCHOS, *Secretary*

S. DAVID FREEMAN
Interim General Manager
RAMAN RAJ
Chief Operating Officer

December 31, 2009

Ms. Tracy Egoscue, Executive Officer
Los Angeles Regional Water Quality Control Board
320 West 4TH Street, Suite 200
Los Angeles, California 90013

Attention: Dana Cole, 401 Certification Unit

Dear Ms. Egoscue:

Subject: Castaic Creek Maintenance Annual Monitoring Report for Los Angeles Department of Water and Power (LADWP) Water Quality Certification

The Los Angeles Department of Water and Power (LADWP) is submitting the enclosed Annual Monitoring Report for the Castaic Creek Maintenance Project as required per LADWP Water Quality Certification (File No. 05-146).

This Annual Monitoring Report is required under the 401 water quality certification conditions of certification. The Castaic Creek Maintenance Project commenced September 8, 2009, and ceased on December 4, 2009. LADWP removed a total of 241,475 cubic yards (CY) of sediment from the three debris basins upstream of each check dam. 134,450 CY was removed from Basin 1: 70,345 CY from Basin 2, and 40,370 CY from Basin 3. (Attachment 1). Surface Water monitoring begun September 28, 2009, upon the detection of water in Check Basin 2. The first Monitoring Report was submitted to the Regional Board on October 15, 2009.

In compliance with conditions of certification 14: LADWP submits the following documentation:

(a) Color photo documentation of the pre-and-post project and site conditions

- See attachment 1 (pg 1 through pg 3)

(b) Geographical Positioning System (GPS) coordinates in decimal-degrees format outlining the boundary of the project and mitigation areas

  - See attachment 2 (pg 1 through pg 3)

(c) The overall status of the project including a detailed schedule of work

- The LADWP commenced the Castaic Creek Maintenance of its check dams, September 8, 2009. The work included clearing and grubbing existing spoil pile, removing tamarisk and other vegetation from the worksite and removing sediment from the basins. The maintenance also involved hauling the excavated materials to the existing spoil piles. All work was done in compliance with the 401 certification as well as the United States Army Corps of Engineers Regional General Permit (RGP) No. 47

(d) Copies of all permits revised as required in Additional condition 1

- There were no revisions to any of the permits listed above for this project

(e) Water quality monitoring results for each reach (as required) compiled in an easy to interpret format

- There was no monitoring for Check Basins 1 and 3. Water was diverted from Check Basin 2 only. See attachment 3

(f) A certified Statement of "no net loss" of wetlands associated with this project

- The maintenance activities of the Castaic Creek Check Bypass channel including Basins 1, 2 and 3 resulted in "no net loss" to the body of the channel and the wetlands associated within.

(g) Discussion of any monitoring activities and exotic plant control efforts

- The maintenance project required the removal of invasive plant species, including the giant reed (*Arundo donax*), castor bean (*Ricinus communis*) and tamarisk (*Tamarix spp*) along with monitoring of the Arroyo Toad (*Bufo californicus*). All monitoring efforts were in compliance with the Regional General Permit (RGP) No. 47 for Permit Number 2002-01534-AOA-RGP 47 of the United States Army Corps of Engineers.

- Surface water was detected within check basin 2. Implementation of the Surface Water Diversion plan started September 28, 2009 with sampling upstream and downstream of the ponded water. Surface water diversion ceased October 28, 2009. Results of the monitoring activities are located in Attachment 3.

- There is no compensatory mitigation associated with this project

(h) A certified statement from the permittee or his/her representative that all conditions of this certification have been met.

- See attachment 4

If you have any questions or require further assistance, please contact Charlynn Rachell of the Wastewater Quality and Compliance Group at (213) 367-2976.

Sincerely,

Katherine Rubin

Katherine Rubin
Manager of Wastewater Quality and Compliance

CR:rp
Enclosures
c/enc: Ms. Charlynn Rachell

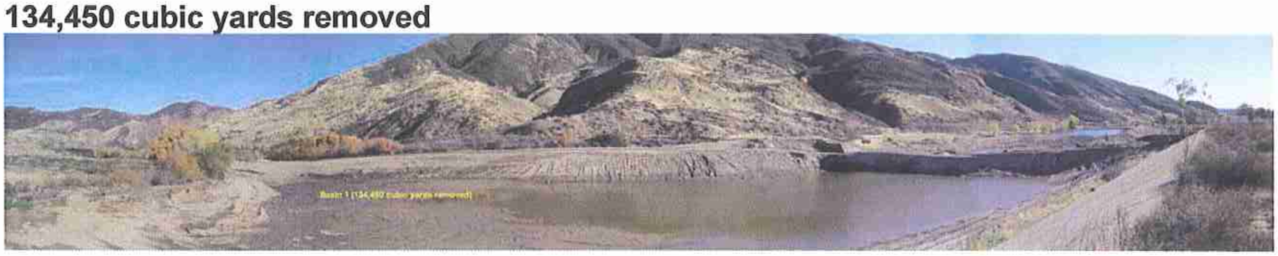
Castaic Creek Maintenance
Surface Water Diversion Plan
401 water certification
File no. 05-146

Attachment 1
Pre-Post Site Conditions

Castaic Bypass Channel
Sediment Removal

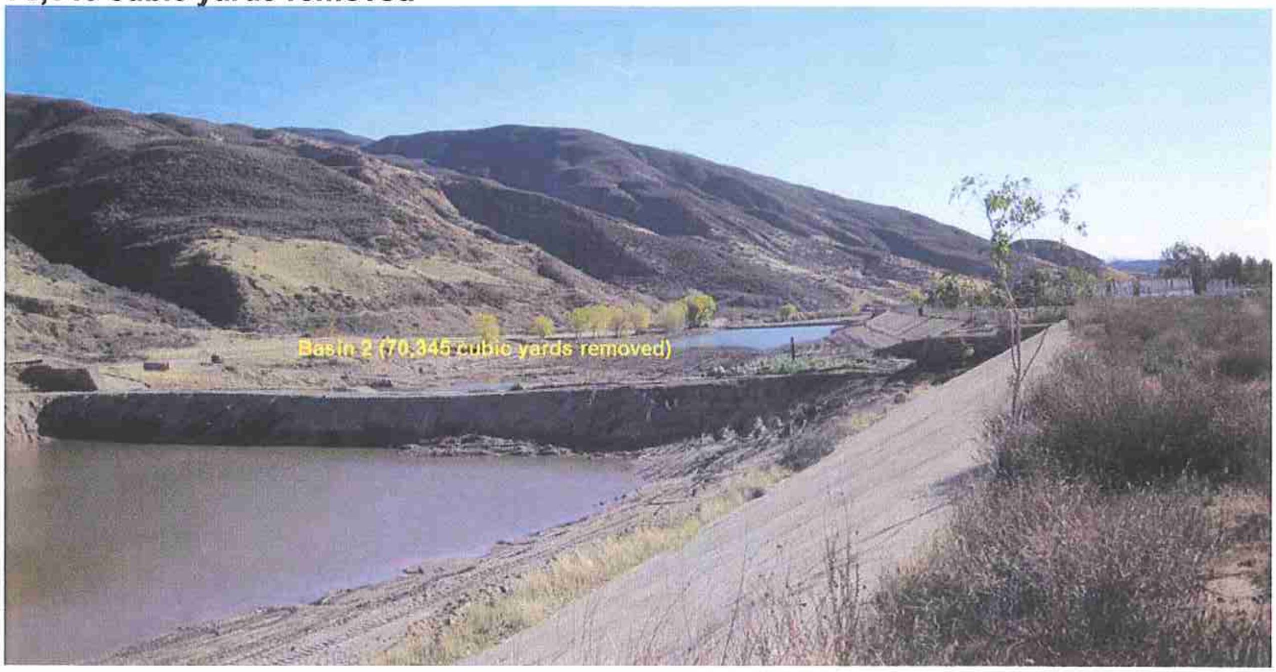
Preconstruction Basin 1

Post Construction Basin 1
134,450 cubic yards removed



Preconstruction Basin 2

Post Construction Basin 2
70,345 cubic yards removed



Preconstruction Basin 3

Post Construction Basin 3
40,370 cubic yards removed

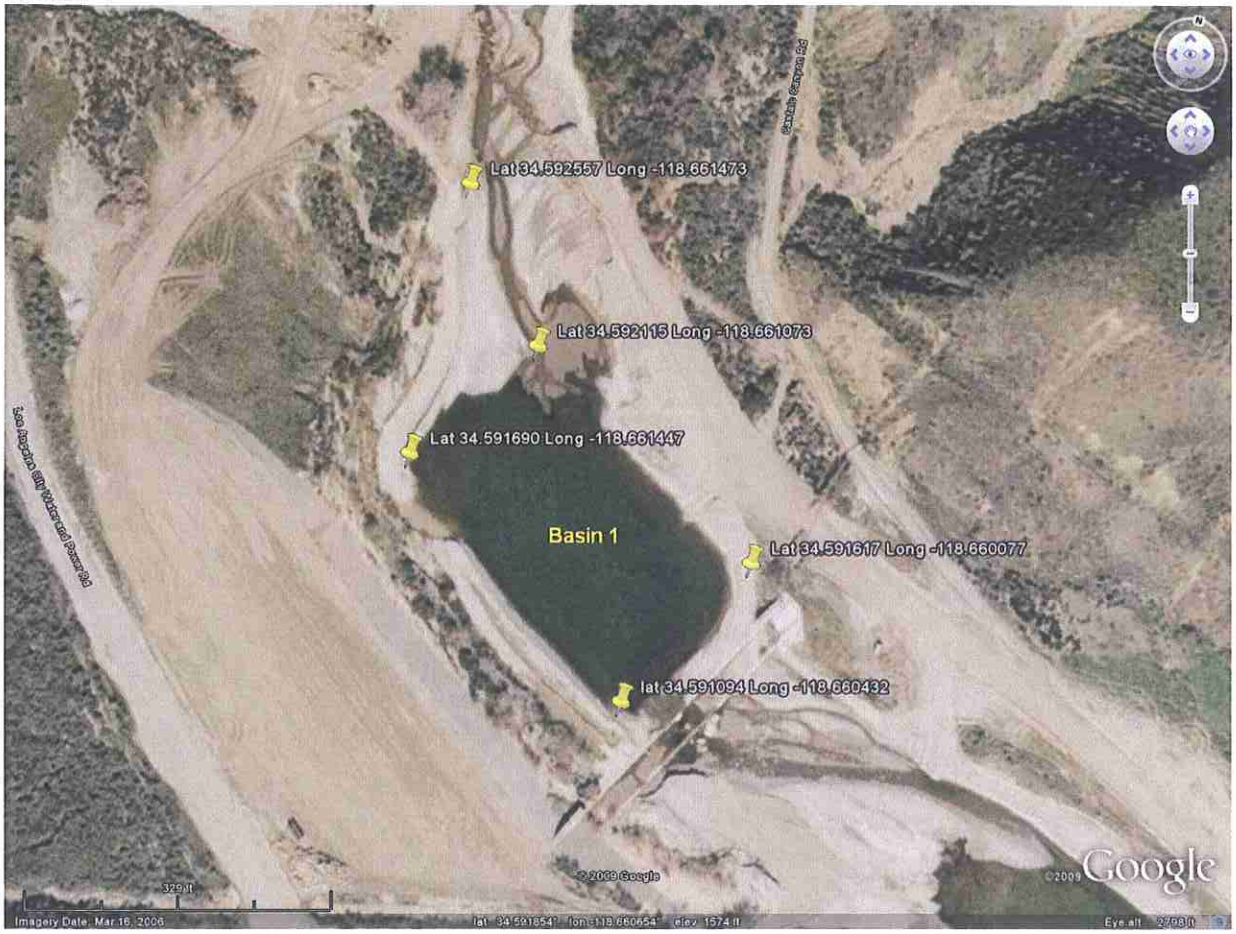
Total volume removed from the three basins 241,475.
Completed on December 04, 2009

Castaic Creek Maintenance
Surface Water Diversion Plan
401 water certification
File no. 05-146

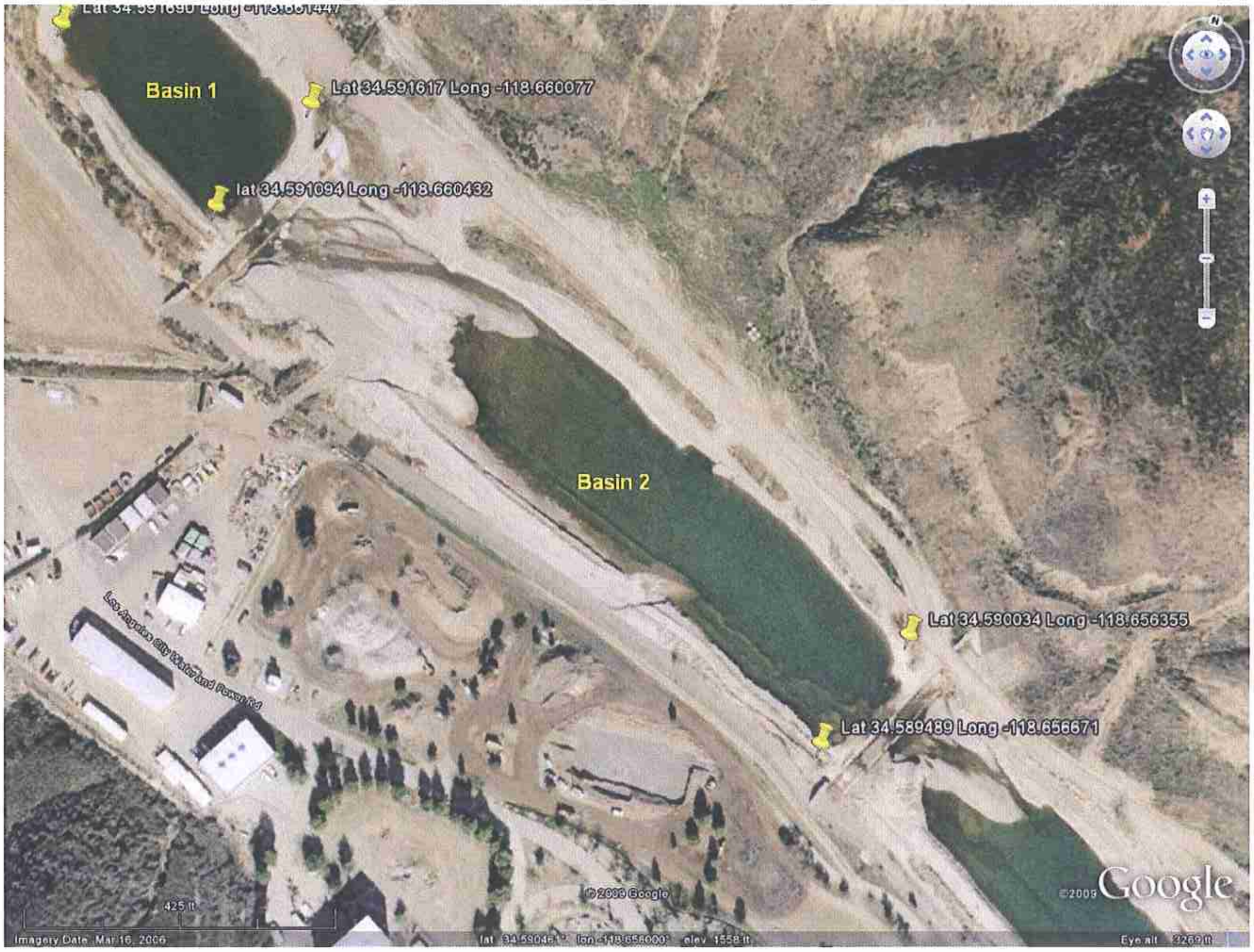
Attachment 2
GPS Coordinates

The following aerial pictures are from Google earth with Latitudes and Longitudes coordinates along the corners of the basins.

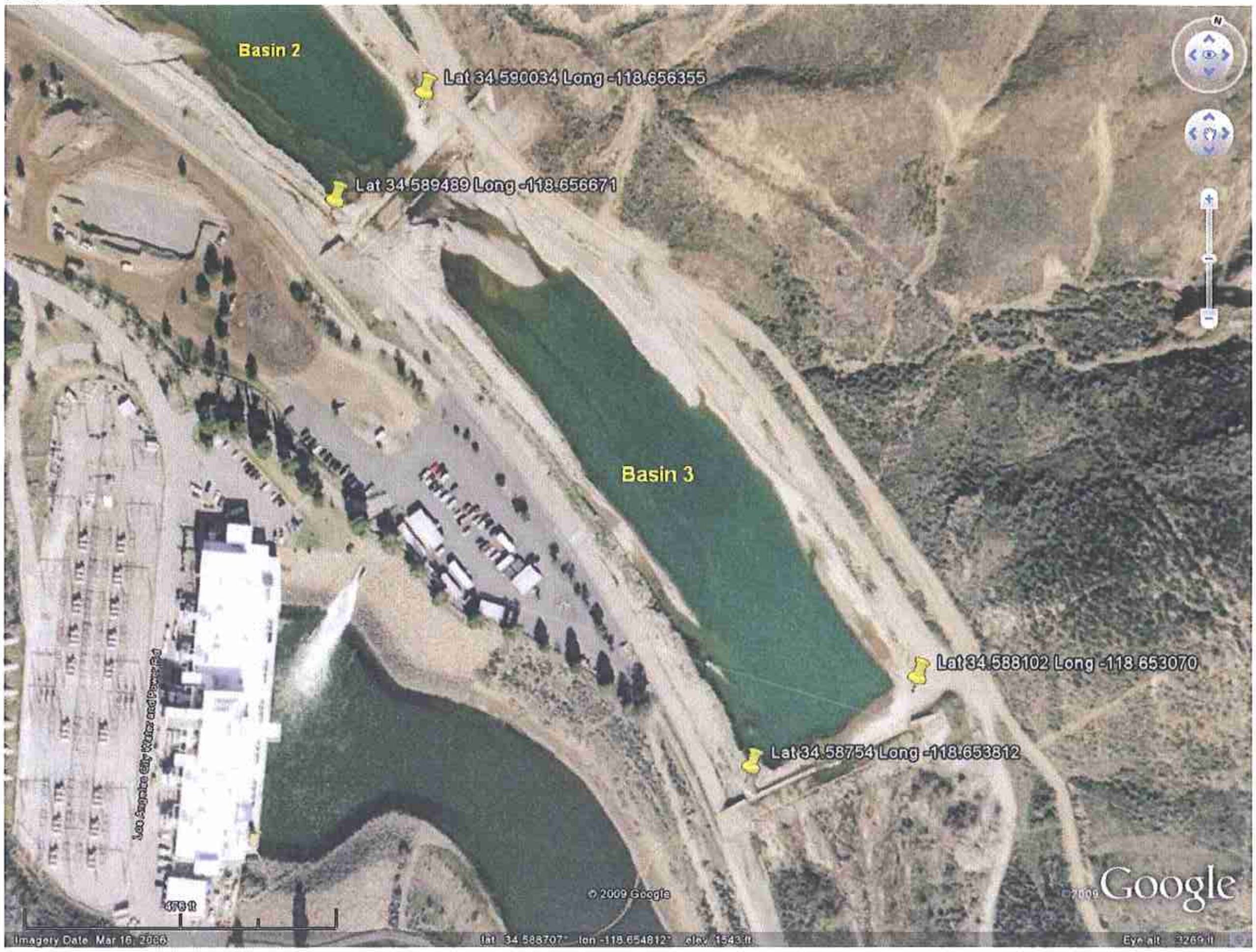
Basin 1



Basin 2


Basin 1
Lat 34.591617 Long -118.660077
lat 34.591094 Long -118.660432
Basin 2
Lat 34.590034 Long -118.656355
Lat 34.589489 Long -118.656671
Los Angeles City Water and Power Rd
425 ft
© 2009 Google
©2009 Google
Imagery Date: Mar 16, 2006
elev 1558 ft

Basin 3



Basin 2
Lat 34.590034 Long -118.656355
Lat 34.589489 Long -118.656671
Basin 3
Lat 34.588102 Long -118.653070
Lat 34.58754 Long -118.653812
Los Angeles City Water and Power Rd
© 2009 Google
Google

Castaic Creek Maintenance
File No. 05-146

Annual Summary

Basin 2 Upstream

Constituent	Unit	9/28/2009	9/29/2009	9/30/2009	10/1/2009	10/2/2009	10/7/2009	10/14/2009	10/21/2009	10/28/2009	Method of Analysis
pH		6.89	6.85	6.92	7.04	7.27	6.91	NS	6.61	ND	SM 4500-H+B
Temperature	°F	68.9	65.7	61.9	61.7	60.8	60.3	NS	71.2	ND	SM 2550B
Dissolved Oxygen	mg/l	5.7	3.9	6.9	7	6.8	5.7	NS	3.4	ND	SM 4500-O C
Turbidity	NTU	3.1	1.5	5.0	1.9	1.5	2.5	NS	346	ND	EPA 180.1
Total Suspended Solids	mg/l	15.9	1.0	8.6	2.1	1.9	2.2	NS	600	ND	SM 2540D

Basin 2 Downstream

Constituent	Unit	9/28/2009	9/29/2009	9/30/2009	10/1/2009	10/2/2009	10/7/2009	10/14/2009	10/21/2009	10/28/2009	Method of Analysis
pH		6.95	6.97	6.90	6.95	7.12	6.77	NS	7.03	7.02	SM 4500-H+B
Temperature	°F	70.3	67.5	63.0	62.4	65.3	64.9	NS	61.7	61.2	SM 2550B
Dissolved Oxygen	mg/l	1.7	4.6	2.2	9.5	10.9	6.8	NS	7.6	16	SM 4500-O C
Turbidity	NTU	2.0	50.0	1.8	168	57	69.5	NS	79	325	EPA 180.1
Total Suspended Solids	mg/l	3.2	71.0	3.0	538	661	116	NS	127	463	SM 2540D

NS= No Sample due to Rain   ND=NO Discharge

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 05-146

I certify under penalty of law that this document and all enclosures were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person(s) who manage the system or those directly responsible for data gathering, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Executed on the _31__day of December, 2009 at Los Angeles, California.

Signature ____________

Name Katherine Rubin_

Title Manager of Wastewater Quality and compliance

December 30, 2011

Mr. Sam Unger
Executive Officer
Los Angeles Regional Water Quality Control Board
320 West 4TH Street, Suite 200
Los Angeles, California 90013

Attention: Valerie Carrillo, 401 Certification Unit

Dear Mr. Unger:

Subject: Castaic Creek Maintenance Annual Monitoring Report for
Los Angeles Department of Water and Power (LADWP)
Water Quality Certification

The Los Angeles Department of Water and Power (LADWP) is submitting the enclosed Annual Monitoring Report for the Castaic Creek Maintenance project as required per LADWP Water Quality Certification (File No. 11-137).

This Annual Monitoring Report is required under the 401 water quality certification file No. 11-137 conditions. The Castaic Creek Maintenance Project commenced October 03, 2011 and ceased on December 02, 2011. LADWP removed a total of 50,960 cubic yards (CY) of sediment from the three debris basins upstream of each check dam. 32,340 CY was removed from Basin 1: 8,170 CY from Basin 2, and 10,450 CY from Basin 3. (Enclosure 1). Surface Water monitoring begun October 06, 2011 upon the detection of water in Check Basin 2. All monitoring data was submitted to the Regional Board on December 28, 2011.

In compliance with conditions of certification 14:

"The applicant shall submit to this Regional Board Annual Monitoring Reports by January 1st of each year for a minimum period of five (5) years after planting or until mitigation success has been achieved. The report shall describe in detail all of the project/ construction activities performed during the previous year and all restoration and mitigation efforts; including percent survival by plant species and percent cover. This report shall include as a minimum, the following documentation":

(a) Color photo documentation of the pre- and post project and site conditions.

- See Enclosure 1

(b) Geographical Positioning System (GPS) coordinates in decimal-degrees format outlining the boundary of the project and mitigation areas.

- See Enclosure 2

(c) The overall status of the project including a detailed schedule of work.

- LADWP commenced the Castaic Creek Maintenance of check dams, October 03, 2011. The work included clearing and grubbing existing spoil pile, removing tamarisk and other vegetation from the worksite and removing sediment from the basins. The maintenance also involved hauling the excavated materials to existing spoil piles. The Check Dam 2 repair commenced on October 25, 2011 and was completed November 29, 2011. All work was done in compliance with the 401 certification, the United States Army Corps of Engineers Regional General Permit (RGP) No. 47, and the Department of Fish and Game Stream Bed Alteration ordinance as submitted with the 401 application. All work was completed by December 02, 2011.

(d) Copies of all permits revised as required in Additional condition 1.

- There were no revisions of permits for this project

(e) Water quality monitoring results in a tabular summary format for each basin (as required).

- See Enclosure 3

(f) A certified Statement of "no net loss" of wetlands associated with this project.

- The maintenance activities of the Castaic Creek Check Bypass channel including Basins 1,2 and 3 resulted in "no net loss" to the body of the channel and the wetlands associated within.

(g) Discussion of any monitoring activities and exotic plant control efforts.

- The maintenance project required the removal of invasive plant species, including tamarisk (*Tamarix spp*) along with monitoring of the Arroyo Toad (*Bufo californicus*) and Southwestern Pond Turtle. All monitoring efforts were in compliance with the United States Army Corps of Engineers permit SPL-2011-00879-GS.

- Surface water was detected within check basin 2. Implementation of the Surface Water Diversion plan started October 06, 2011 with sampling upstream and downstream of the ponded water. Surface water diversion ceased October 24, 2011. Results of the monitoring activities are located in Enclosure 3. The sample results indicate that the beneficial uses of the Castaic Creek basins have not been harmed.

- The lower third of Debris Basin 3 was untouched as per the compensatory mitigation.

(h) A certified statement from the permittee or his/her representative that all conditions of this certification have been met.

- See Enclosure 4

If you have any questions or require further assistance, please contact Ms. Charlynn Rachell of the Wastewater Quality and Compliance Group at (213) 367-2976.

Sincerely,

Katherine Rubin

Katherine Rubin
Manager of Wastewater Quality and Compliance

CR:lr
Enclosure
c: Ms. Charlynn Rachell

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

Pre-Post Conditions

Enclosure 1

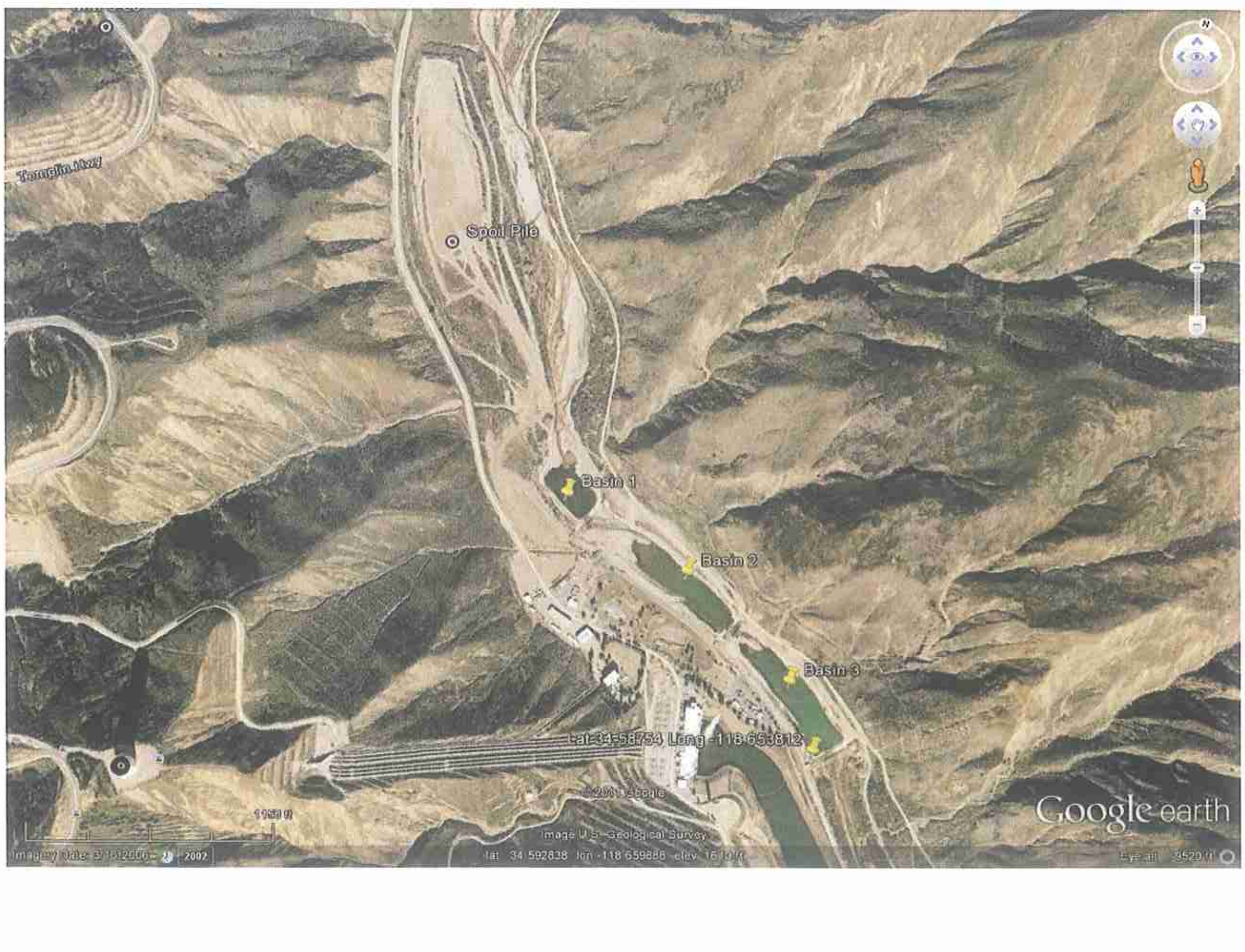
Castaic Bypass Channel Sediment Removal Project 2011

Bypass Channel Sediment Removal
Construction Start Date: **October 03, 2011**
Construction End Date: **December 02, 2011**

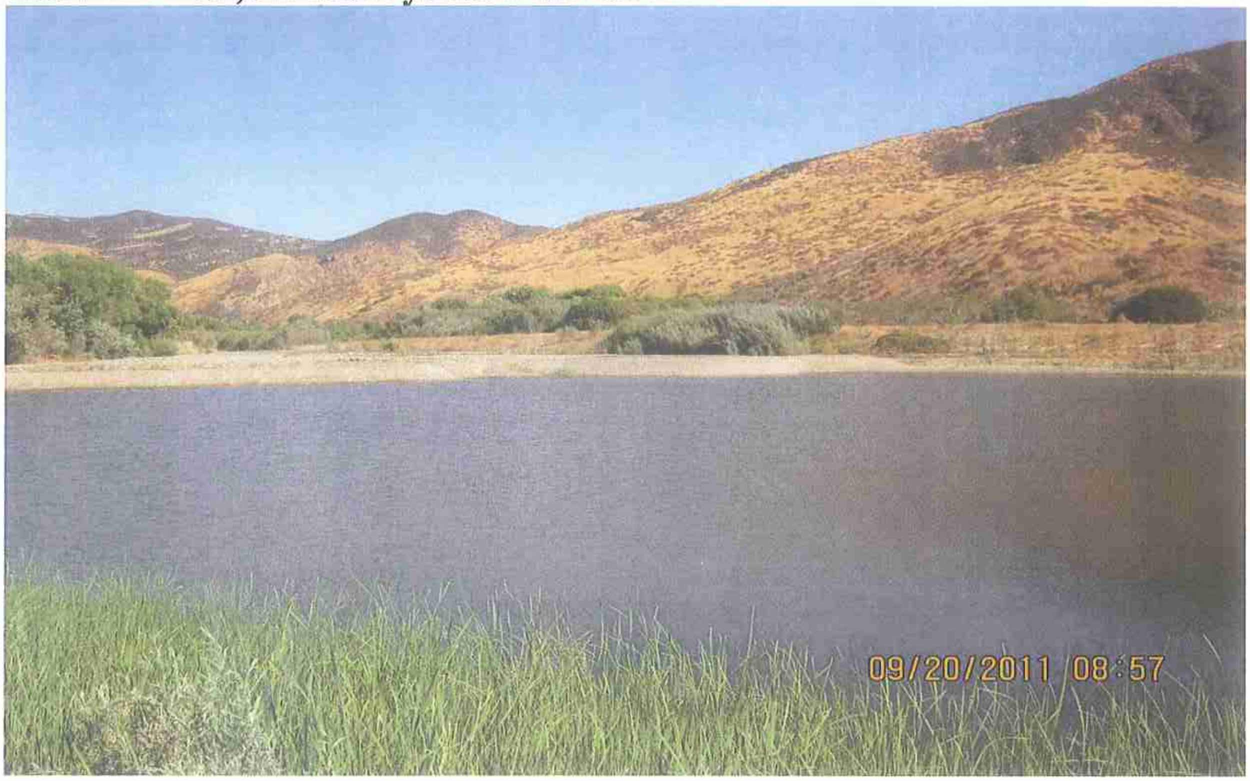
Check Dam 2 Repair
Construction Start Date **October 25, 2011**
Construction End Date **November 29, 2011**

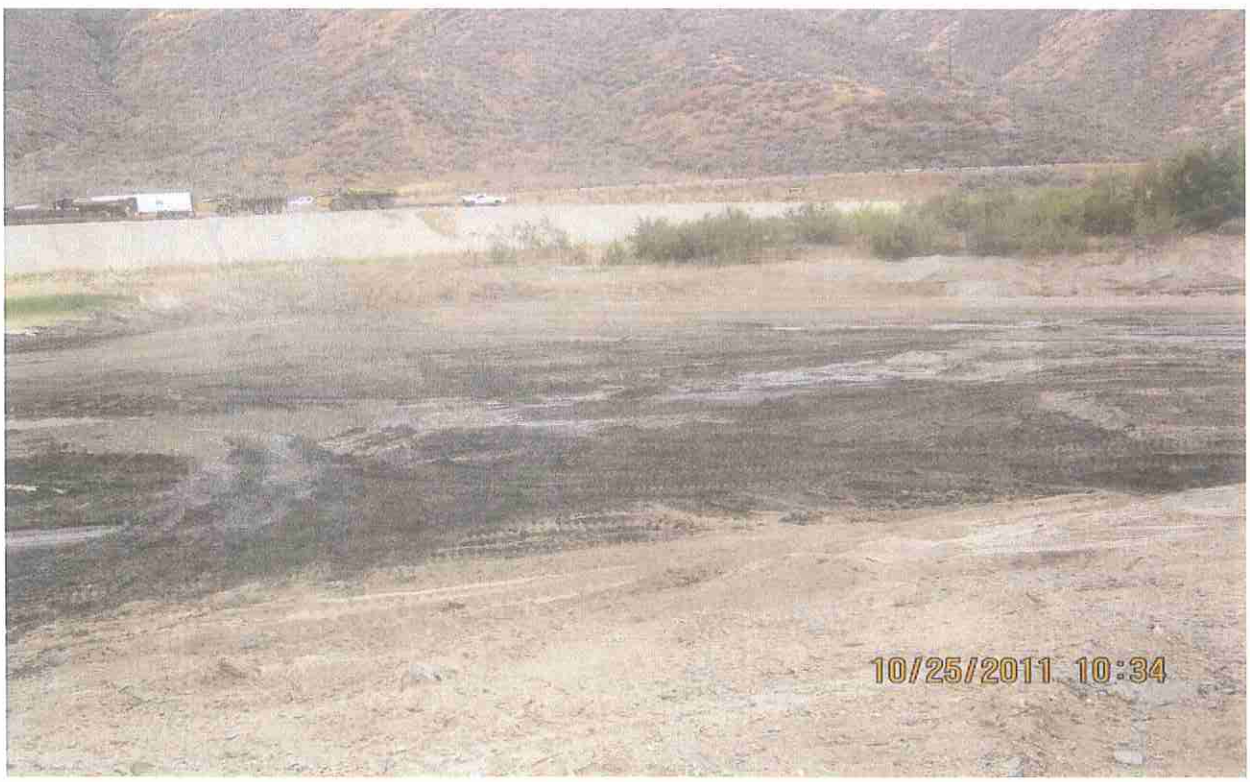
Material Hauled to Stockpile (Cubic Yards): FINAL

Basin 1	**32,340**
Basin 2	**8,170**
Basin 3	**10,450**
Total	**50,960 cubic yards**



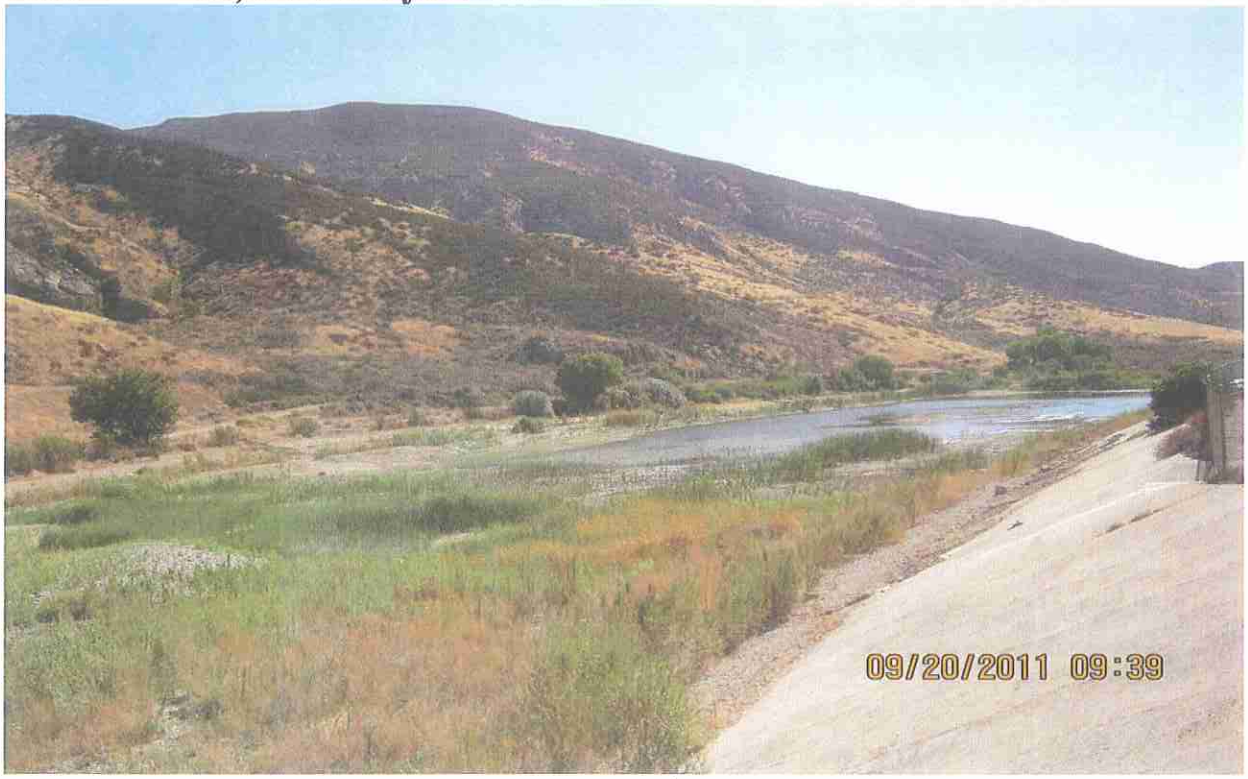
Basin 1 32,340 cubic yards removed





Basin 2 8,170 cubic yards removed

Basin 3 10,450 cubic yards removed



Check Dam 2 Repair

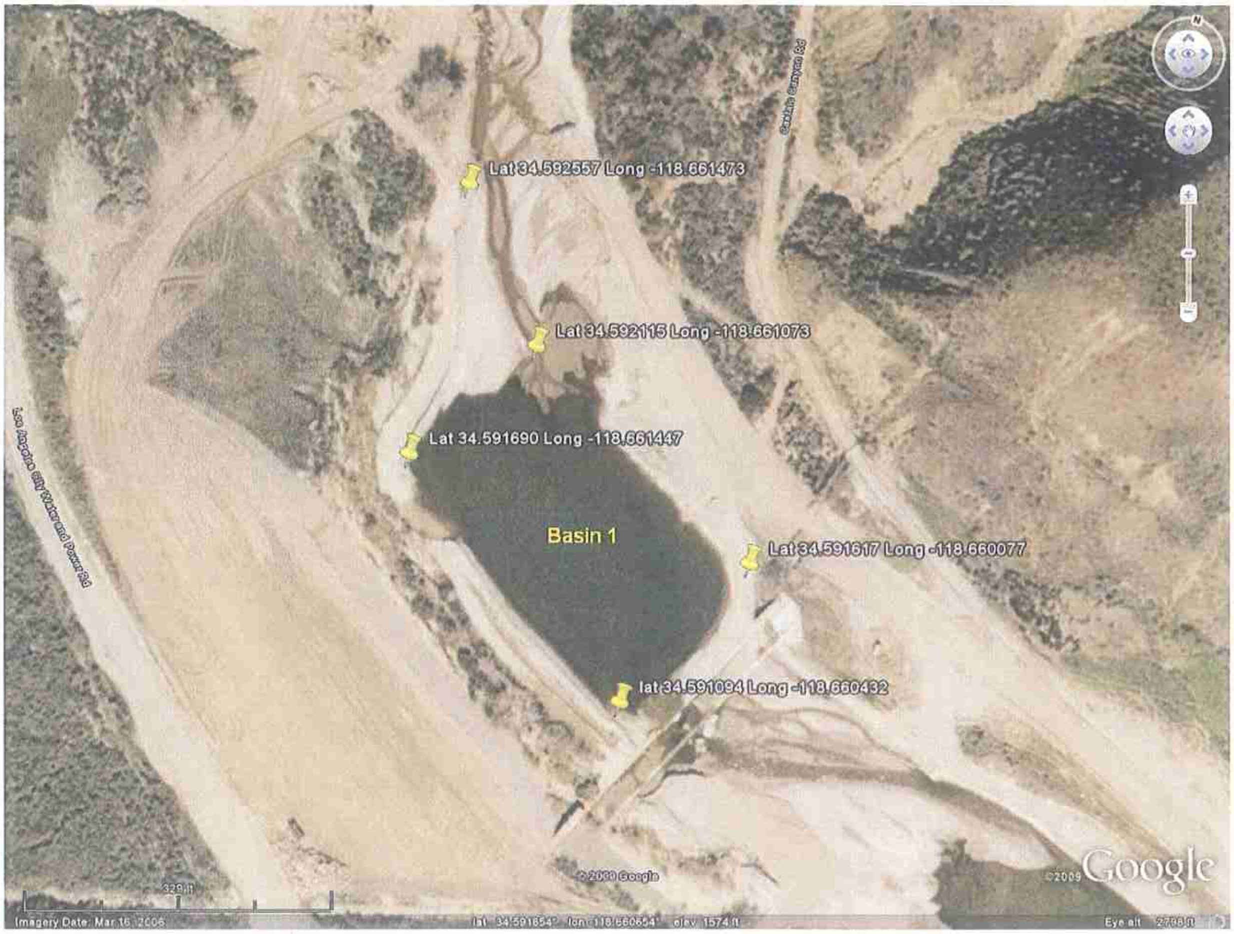
Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

Basin Locations

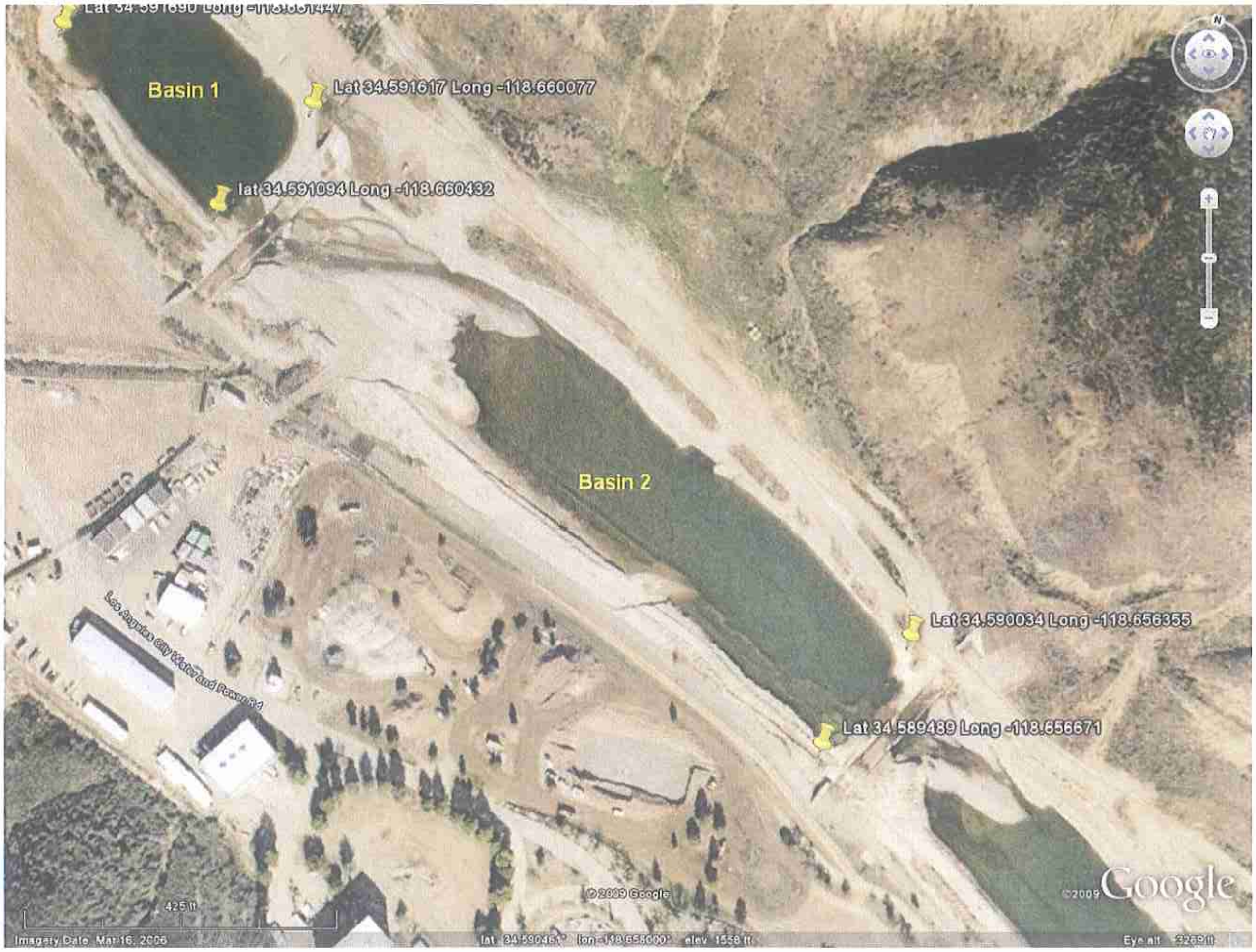
Enclosure 2

The following aerial pictures are from Google earth with Latitudes and Longitudes coordinates along the corners of the basins.

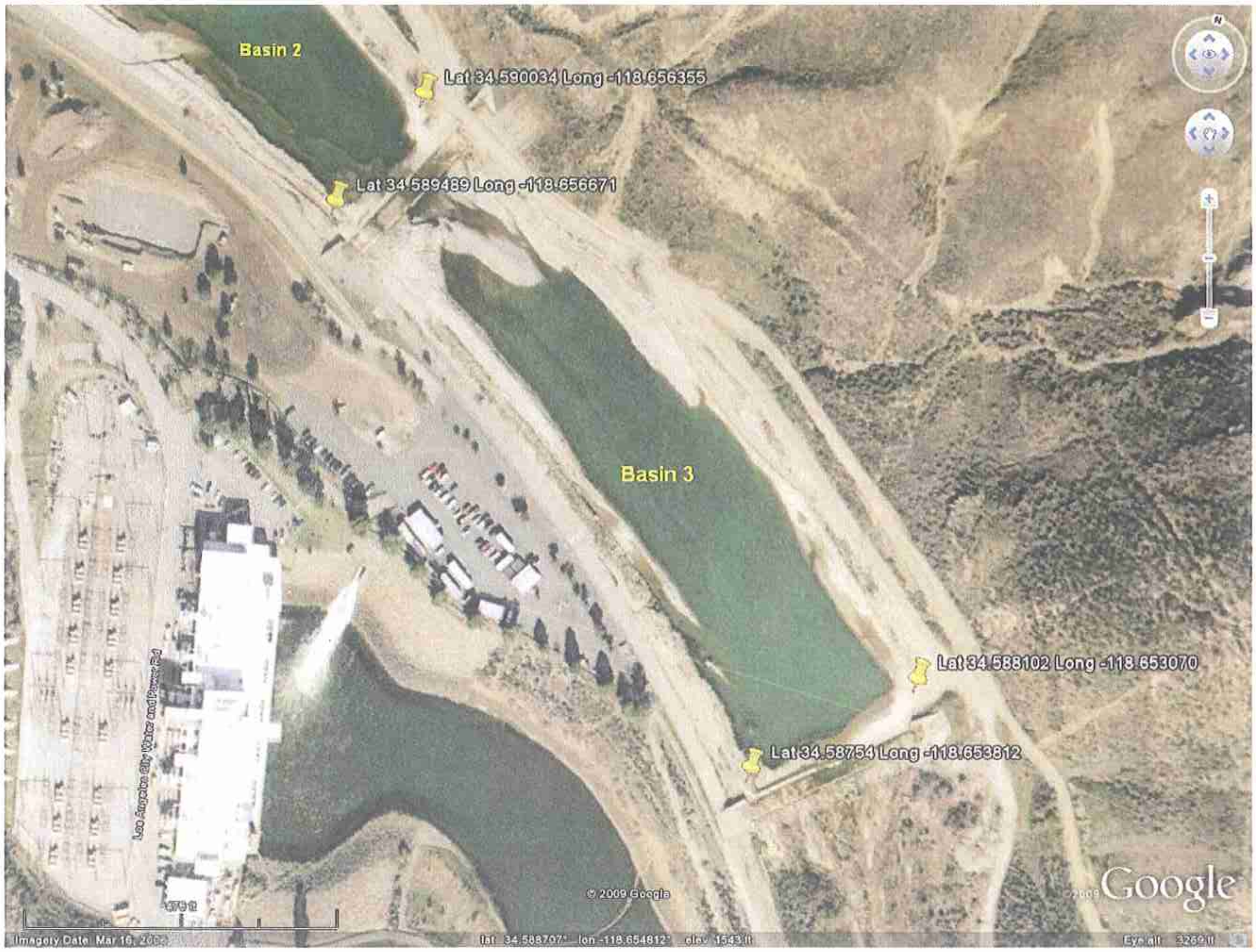
Basin 1



Basin 2


Basin 1
Lat 34.591617 Long -118.660077
lat 34.591094 Long -118.660432
Basin 2
Lat 34.590034 Long -118.656355
Lat 34.589489 Long -118.656671
Los Angeles City Water and Power Rd
425 ft
© 2009 Google
©2009 Google
Imagery Date Mar 16, 2006

Basin 3


Basin 2
Lat 34.590034 Long -118.656355
Lat 34.589489 Long -118.656671
Basin 3
Lat 34.588102 Long -118.653070
Lat 34.58754 Long -118.653812
© 2009 Google
Google
lon -118.654812° elev 1543 ft

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

Annual Tabular Summary

Enclosure 3

Castaic Creek Maintenance
File No. 11-137
Annual Summary

Basin 1 Baseline

Constituent	Unit	*10-6-11 baseline
pH		8.56
Temperature	°F	60.8
Dissolved Oxygen	mg/l	6
Turbidity	NTU	2.7
Total Suspended Solids	mg/l	15.9

Basin 2 Baseline

Constituent	Unit	*10-6-11 baseline
pH		8.07
Temperature	°F	62.1
Dissolved Oxygen	mg/l	5.8
Turbidity	NTU	4
Total Suspended S	mg/l	4.6

Basin 3 Baseline

Constituent	Unit	*10-6-11 baseline	Method of Analysis
pH		8.37	SM 4500-H+B
Temperature	°F	60.6	SM 2550B
Dissolved Oxygen	mg/l	6.4	SM 4500-O C
Turbidity	NTU	6.2	EPA 180.1
Total Suspended	mg/l	17	SM 2540D

Basin 2 downstream

Constituent	Unit	10/7/2011	10/11/2011	10/12/2011	10/13/2011	10/14/2011	10/17/2011	10/24/2011	Method of Analysis
pH		7.99	8.26	ns	ns	ns	ns	ns	SM 4500-H+B
Temperature	°F	62.2	62.6	ns	ns	ns	ns	ns	SM 2550B
Dissolved Oxygen	mg/l	5.8	5.8	ns	ns	ns	ns	ns	SM 4500-O C
Turbidity	NTU	1.4	<1	ns	ns	ns	ns	ns	EPA 180.1
Total Suspended Solids	mg/l	1.1	1.0	ns	ns	ns	ns	ns	SM 2540D

Basin 3 Upstream

Constituent	Unit	10/7/2011	10/11/2011	10/12/2011	10/13/2011	10/14/2011	10/17/2011	10/24/2011	Method of Analysis
pH		7.89	8.05	8.14	8.3	8.3	8.14	7.93	SM 4500-H+B
Temperature	°F	63.5	66.0	67.8	66.9	68.7	74.1	63.9	SM 2550B
Dissolved Oxygen	mg/l	6.9	6.0	6.7	6.2	7.3	7.2	6.4	SM 4500-O C
Turbidity	NTU	1.1	1.4	2.0	2.2	1.8	1.8	2.4	EPA 180.1
Total Suspended Solids	mg/l	1.5	1.6	1.6	1.7	2	2.4	2.8	SM 2540D

Basin 3 Downstream

Constituent	Unit	10/7/2011	10/11/2011	10/12/2011	10/13/2011	10/14/2011	10/17/2011	10/24/2011	Method of Analysis
pH		8.45	8.48	8.38	8.31	8.35	8.31	7.98	SM 4500-H+B
Temperature	°F	61.7	65.3	66.7	69.4	68.7	73.9	63.5	SM 2550B
Dissolved Oxygen	mg/l	7.0	7.8	5.8	8	6.7	6.8	6.8	SM 4500-O C
Turbidity	NTU	2.5	2.8	1.8	2.7	1.8	1.1	<1	EPA 180.1
Total Suspended Solids	mg/l	2.9	4.6	1.7	4	2	0.9	1	SM 2540D

*** baseline before diversion began**

NS=No Sample Basin Dry

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

Certification Statement

Enclosure 4

Enclosure 4

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

I certify under penalty of law that this document and all enclosures were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person(s) who manage the system or those directly responsible for data gathering, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Executed on the 20th day of December, 2011 at Los Angeles, California.

Signature Katherine Rubin

Name Katherine Rubin

Title Manager of Wastewater Quality and compliance

Los Angeles Department of Water & Power

December 31, 2013

Mr. Sam Unger, Executive Officer
Los Angeles Regional Water Quality Control Board
320 West 4[TH] Street, Suite 200
Los Angeles, California 90013

Attention: Valerie Carrillo, 401 Certification Unit

Dear Mr. Unger:

Subject: Castaic Creek Maintenance Annual Monitoring Report for
Los Angeles Department of Water and Power (LADWP)
Water Quality Certification (File No. 11-137)

The Los Angeles Department of Water and Power (LADWP) is submitting the enclosed Annual Monitoring Report for the Castaic Creek Maintenance project as required per LADWP Water Quality Certification (File No. 11-137).

This Annual Monitoring Report is required under the 401 water quality certification conditions of certification. The Castaic Creek Maintenance Project commenced October 03, 2013 and ceased on October 25, 2013. LADWP removed a total of 13,160 cubic yards (CY) of sediment from the three debris basins upstream of each check dam. 3,900 CY was removed from Basin 1: 3,420 CY from Basin 2, and 5,840 CY from Basin 3. (Enclosure1). There was no Surface Water monitoring as the basins were dry.

In compliance with conditions of certification 14: "The applicant shall submit to this Regional Board Annual Monitoring Reports by January 1[st] of each year for a minimum period of five (5) years after planting or until mitigation success has been achieved. The report shall describe in detail all of the project/ construction activities performed during the previous year and all restoration and mitigation efforts; including percent survival by plant species and percent cover. This report shall include as a minimum, the following documentation:

(a) Color photo documentation of the pre- and post project and site conditions

- See Enclosure 1

(b) Geographical Positioning System (GPS) coordinates in decimal-degrees format outlining the boundary of the project and mitigation areas

- See Enclosure 2

(c) The overall status of the project including a detailed schedule of work

- The LADWP commenced the Castaic Creek Maintenance of check dams, October 03, 2013. The work included clearing and grubbing existing spoil pile, removing tamarisk and other vegetation from the worksite and removing sediment from the basins. The maintenance also involved hauling the excavated materials to the existing spoil piles. All work was done in compliance with the 401 certification, the United States Army Corps of Engineers Regional General Permit (RGP) No. 47, and the Department of Fish and Game Stream Bed Alteration Agreement as submitted with the 401 application.

(d) Copies of all permits revised as required in Additional condition 1

- United States Army Corps of Engineers permit SPL-2013-00659-GS. Issued October 02, 2013. See Enclosure 3

(e) Water quality monitoring results for each reach (as required) compiled in an easy to interpret format

- There was no monitoring data as the basins were dry.

(f) A certified Statement of "no net loss" of wetlands associated with this project

- The maintenance activities of the Castaic Creek Check Bypass channel including Basins 1, 2 and 3 resulted in "no net loss" to the body of the channel and the wetlands associated within.

(g) Discussion of any monitoring activities and exotic plant control efforts

- The maintenance project required the removal of invasive plant species, including tamarisk (*Tamarix spp*) along with monitoring of the Arroyo Toad (*Bufo californicus*) and Southwestern Pond Turtle. All monitoring efforts were in compliance with the United States Army Corps of Engineers permit SPL-2013-00659-GS.

- The lower third of Debris Basin 3 was untouched as per the compensatory mitigation per the 401.

(h) A certified statement from the permittee or his/her representative that all conditions of this certification have been met.

- See Enclosure 4

If you have any questions or require further assistance, please contact Ms. Charlynn Rachell of the Wastewater Quality and Compliance Group at (213) 367-2976.

Sincerely,

Katherine Rubin
Manager of Wastewater Quality and Compliance

CR:lr
Enclosure
c: Ms. Charlynn Rachell

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

Pre-Post Conditions

Enclosure 1

Castaic Bypass Channel Sediment Removal Project
Access Road Shoulder Fill 2013 (MRS81/1165612)

Bypass Channel Sediment Removal

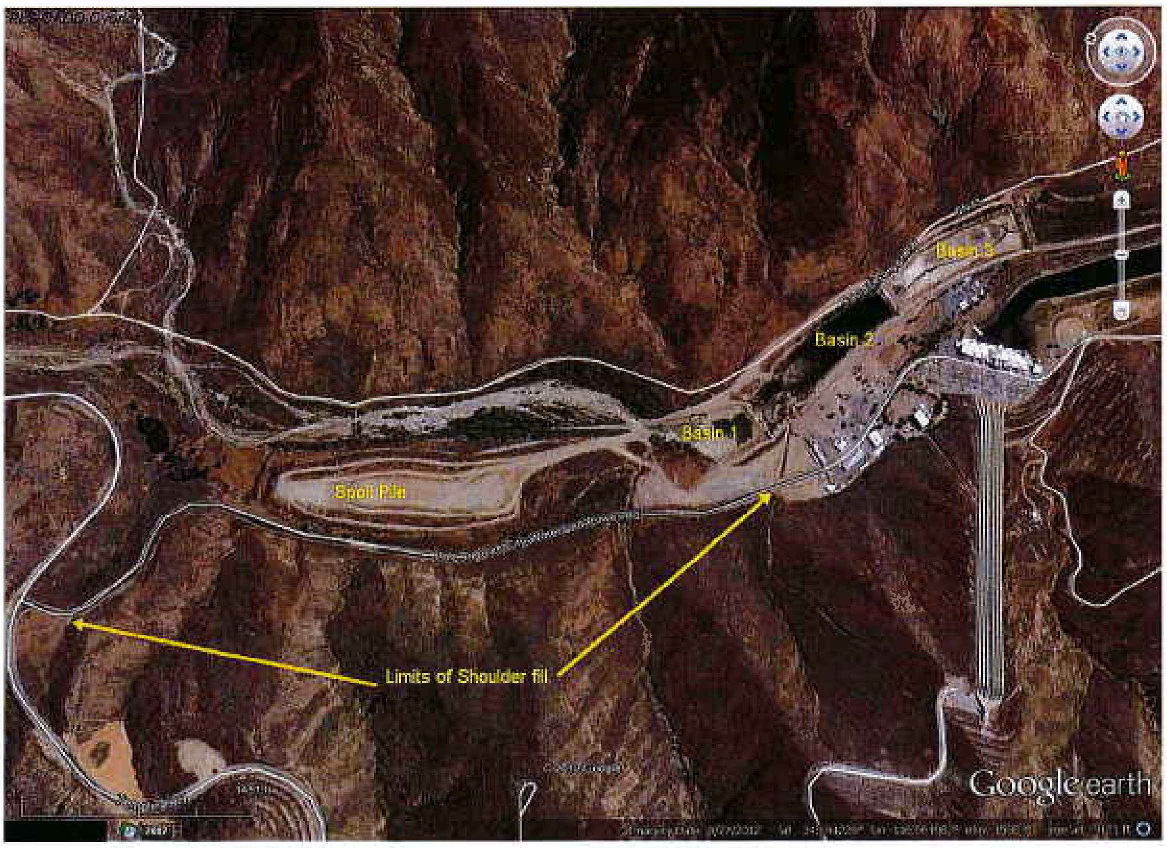
Construction Start Date:	October 03, 2013
Construction End Date:	October 25, 2013

Material Hauled to Stockpile (Cubic Yards): FINAL

Basin 1	3,900 cubic yards (cy)
Basin 2	3,420
Basin 3	5,840
Total	**13,160 cy**

Access Road Shoulder Fill

Construction Start Date	October 28, 2013
Construction End Date	November 15, 2013



BASIN 1


Basin 1
Looking south

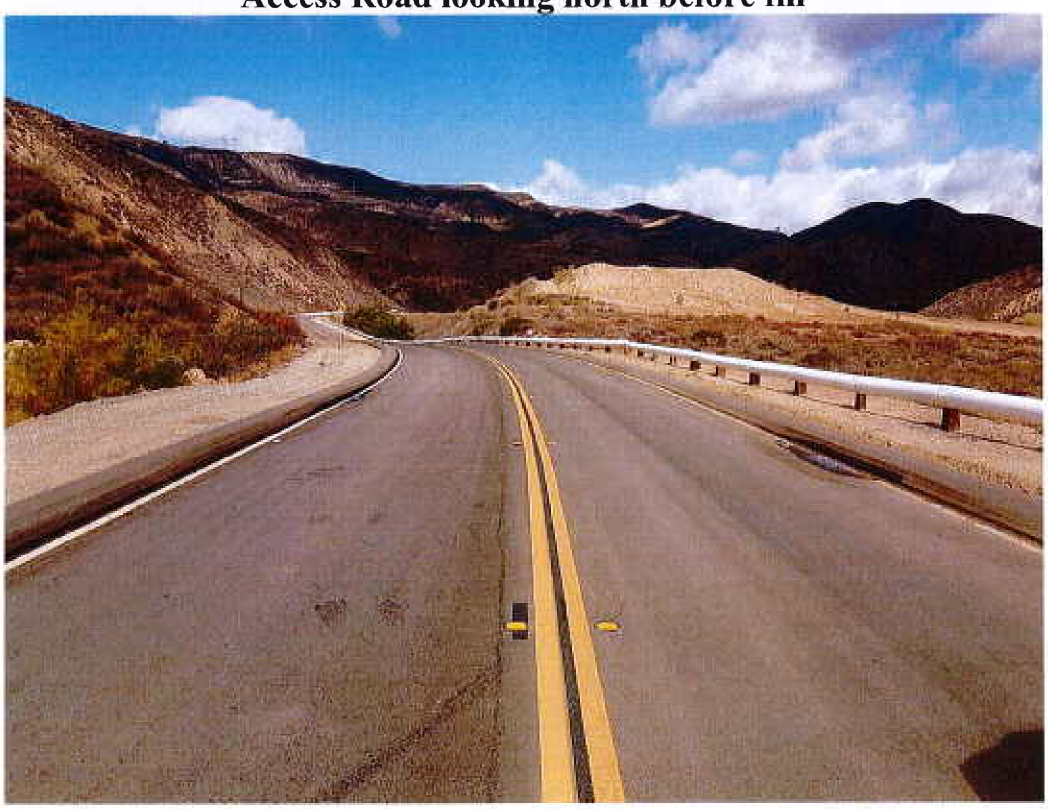

Basin 1
looking north 3,900 cubic yards removed

BASIN 2

BASIN 3

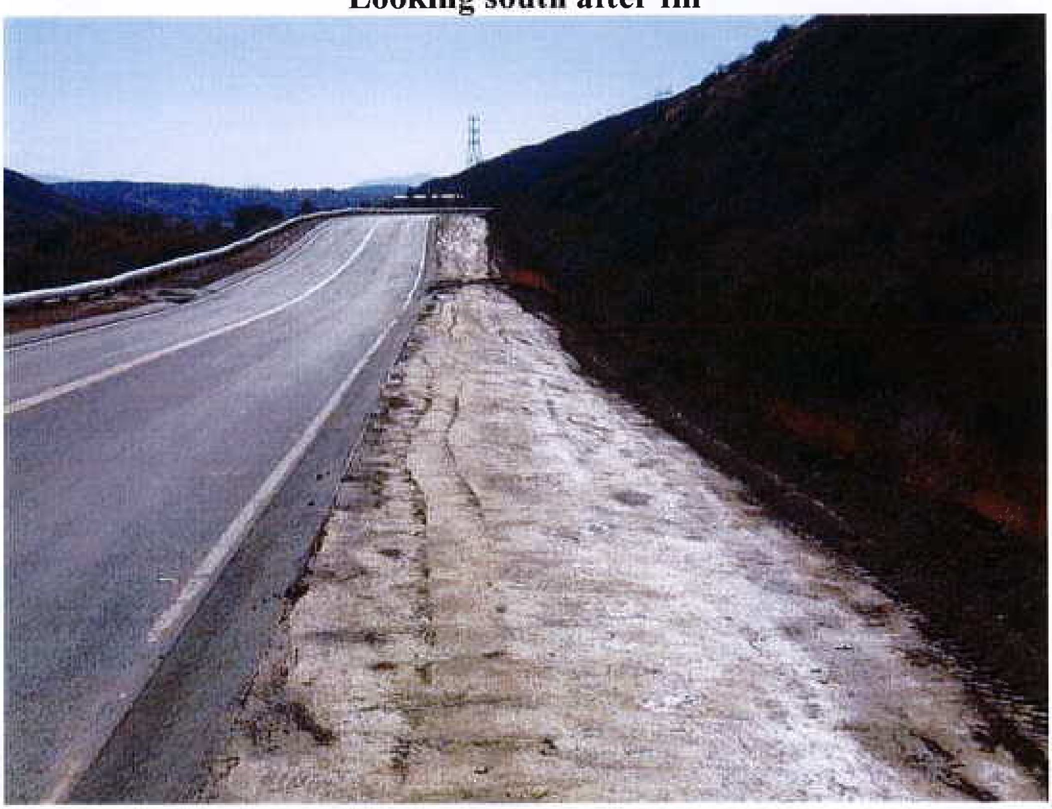
Access Road looking south before fill

Access Road looking north before fill



Looking north after fill

Looking south after fill



Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

GPS coordinates of basin

Enclosure 2

GPS coordinates in decimal-degrees format outlining the boundary of the Debris Basins. Imagery is from 08/2012
At the time of the 2013 maintenance clean-out, the basins were dry.

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

U.S. Army Corps of Engineers permit

Enclosure 3

LOS ANGELES DISTRICT
U.S. ARMY CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY PERMIT

Permittee: Los Angeles Department of Water and Power; Charles Holloway

Permit Number: SPL-2013-00659-GS

Issuing Office: Los Angeles District

Note: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description:
To temporarily discharge fill onto 14.7 acre(s) of non-wetland waters of the U.S. pursuant to Section 404 of the Clean Water Act of 1972, in association with the L.A. Department of Water and Power Castaic Plant Emergency Individual Permit Project as shown on the attached drawings.

Specifically, you are authorized to:

1. Temporarily discharge fill onto 14.7 acre(s) of non-wetland waters of the U.S. for the emergency excavation of approximately 80,000 cubic yards of accumulated sediment from within Check Dams 1-3;

2. Inspect and make minor repairs to Check Dams 1-3 in the Bypass Channel to ensure the structural integrity and proper function of the structures. The work would include clearing rocks, vegetation and debris in the area behind and around the sills and check dams, filling the area behind or in front of sills with rip rap, and adding as-needed shotcrete to the area between the check dams and the sills.

Project Location: In Castaic Creek, at Los Angeles Department of Water and Power (LADPW) Castaic Power Plant, near the City of Castaic, Los Angeles County, California (34.5904 Latitude, -118.6577 Longitude), as shown on the attached figures.

Permit Conditions:

General Conditions:

1. The time limit for completing the authorized activity ends on March 31, 2014. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification from this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished with the terms and conditions of your permit.

Special Conditions:

1. Pursuant to 36 C.F.R. section 800.13, in the event of any discoveries during construction of either human remains, archeological deposits, or any other type of historic property, the Permittee shall notify the Corps' Archeology Staff within 24 hours (Steve Dibble at 213-452-3849 or John Killeen at 213-452-3861). The Permittee shall immediately suspend all work in any area(s) where potential cultural resources are discovered. The Permittee shall not resume construction in the area surrounding the potential cultural resources until the Corps Regulatory Division re-authorizes project construction, per 36 C.F.R. section 800.13.

2. The applicant shall implement all terms and conditions stipulated in the U.S. Fish and Wildlife Service's Final BO (1-8-96-F-55) dated March 7, 1997.

3. Within 45 calendar days of completion of authorized work in waters of the U.S., the Permittee shall submit to the Corps Regulatory Division a post-project implementation memorandum including the following information:

A) Date(s) work within waters of the U.S. was initiated and completed;
B) Summary of compliance status with each special condition of this permit (including any noncompliance that previously occurred or is currently occurring and corrective actions taken or proposed to achieve compliance);
C) Color photographs (including map of photopoints) taken at the project site before and after construction for those aspects directly associated with permanent impacts to waters of the U.S. such that the extent of authorized fills can be verified;
D) One copy of "as built" drawings for the entire project. Electronic submittal (Adobe PDF format) is preferred. All sheets must be signed, dated, and to-scale. If submitting paper copies, sheets must be no larger than 11 x 17 inches; and
E) Signed Certification of Compliance (attached as part of this permit package).

4. No later than one month following completion of authorized work in waters of the U.S., the permittee shall ensure all sites within waters of the U.S. subject to authorized, temporary impacts are restored to pre-project alignments, elevation contours, and conditions to the maximum extent practicable to ensure expeditious resumption of aquatic resource functions. No later than 45 calendar days following completion of authorized work in waters of the U.S., the permittee shall submit a memorandum documenting compliance with this special condition.

Further Information:

1. Congressional Authorities. You have been authorized to undertake the activity described above pursuant to:

( ) Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403).

(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).

( ) Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 U.S.C. 1413).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data. The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measure ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give you favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

Charles C. Holloway 10/4/2013

PERMITTEE CHARLES HOLLOWAY DATE

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

______________________________ ______________________

DATE

Daniel P. Swenson, D. Env.
Chief, L.A. & San Bernardino Section
North Coast Branch
Regulatory Division

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

______________________________ ______________________

TRANSFEREE DATE

LOS ANGELES DISTRICT
U.S. ARMY CORPS OF ENGINEERS

NOTIFICATION OF COMMENCEMENT OF WORK FOR DEPARTMENT OF THE ARMY PERMIT

Permit Number: *SPL-2013-00659*
Name of Permittee: *City of Los Angeles Department of Water and Power; Charles Holloway*
Date of Issuance: *October 2, 2013*

Date work in waters of the U.S. will commence: 10/4/2013
Estimated construction period (in weeks): 8 weeks
Name & phone of contractor (if any): N/A

Please note that your permitted activity is subject to a compliance inspection by an Army Corps of Engineers representative. If you fail to comply with this permit you may be subject to permit suspension, modification, or revocation.

I hereby certify that I, and the contractor (if applicable), have read and agree to comply with the terms and conditions of the above referenced permit.

Charles A. Holloway
Signature of Permittee

10/4/2013
Date

At least ten (10) days prior to the commencement of the activity authorized by this permit, sign this certification and return it using any ONE of the following three (3) methods:

(1) E-MAIL a statement including all the above information to: Gerardo.Salas@usace.army.mil

OR

(2) FAX this certification, after signing, to: 213-452-4196

OR

(3) MAIL to the following address:

U.S. Army Corps of Engineers
Regulatory Division
ATTN: CESPL-RG-SPL-2013-00659
LOS ANGELES DISTRICT CORPS OF ENGINEERS
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

LOS ANGELES DISTRICT
U.S. ARMY CORPS OF ENGINEERS

NOTIFICATION OF COMPLETION OF WORK AND CERTIFICATION OF COMPLIANCE WITH DEPARTMENT OF THE ARMY PERMIT

Permit Number: *SPL-2013-00659*
Name of Permittee: *City of Los Angeles Department of Water and Power; Charles Holloway*
Date of Issuance: *October 2, 2013*

Date work in waters of the U.S. completed: ____________________
Construction period (in weeks): ____________________
Name & phone of contractor (if any): ____________________

Please note that your permitted activity is subject to a compliance inspection by an Army Corps of Engineers representative. If you fail to comply with this permit you may be subject to permit suspension, modification, or revocation.

I hereby certify that the work authorized by the above referenced permit has been completed in accordance with the terms and conditions of said permit.

____________________ ____________________
Signature of Permittee Date

Upon completion of the activity authorized by this permit, sign this certification and return it using any ONE of the following three (3) methods:

(1) E-MAIL a statement including all the above information to: Gerardo.Salas@usace.army.mil

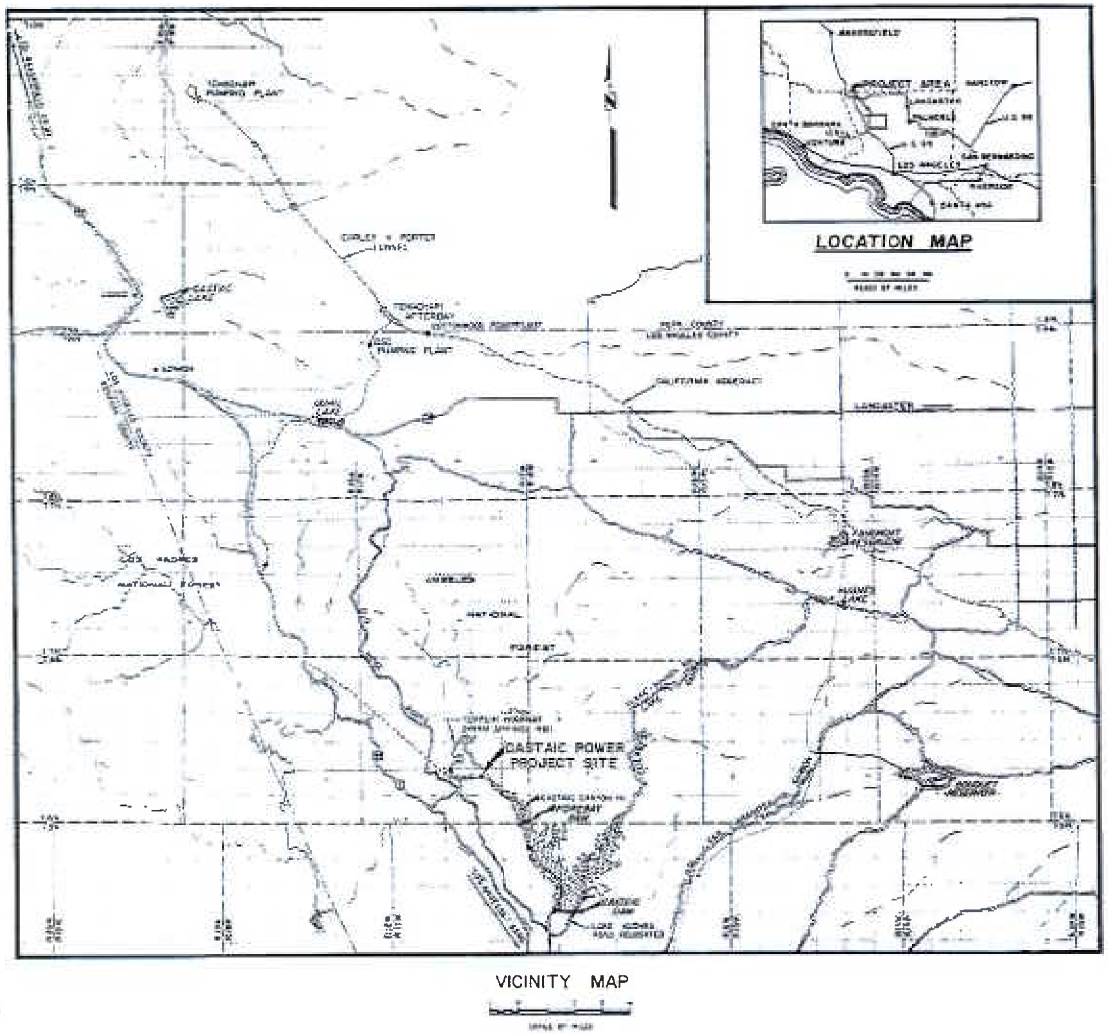
OR

(2) FAX this certification, after signing, to: 213-452-4196

OR

(3) MAIL to the following address:

U.S. Army Corps of Engineers
Regulatory Division
ATTN: CESPL-RG-SPL-2013-00659
LOS ANGELES DISTRICT CORPS OF ENGINEERS
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325



CITY OF LOS ANGELES
DEPARTMENT OF WATER & POWER
POWER SYSTEM

CASTAIC POWER PROJECT
OUTLET WORKS & SERVICE SPILLWAY & GRADING OF RIGHT ABUTMENT FOREBAY DAM

SPECIFICATION NO. 7727

LIST OF DRAWINGS

CIVIL

GENERAL

PA-CA165	LOCATION MAP AND LIST OF DRAWINGS
[illegible]	LIST OF DRAWINGS
[illegible]	PROJECT MAP-NORTHERLY AREA
[illegible]	PROJECT MAP-SOUTHERLY AREA
[illegible]	SITE DEVELOPMENT

RIGHT ABUTMENT

[illegible]	GRADING PLAN - RIGHT ABUTMENT
[illegible]	SECTIONS - RIGHT ABUTMENT
[illegible]	CORE TRENCH PLAN
[illegible]	PLAN AND PROFILE - PATROL ROAD
[illegible]	[illegible] - PATROL ROAD
[illegible]	SECTIONS - PATROL ROAD

OUTLET WORKS AND SERVICE SPILLWAY

[illegible]

[illegible]	PLAN AND PROFILE
[illegible]	PLAN AND PROFILE - [illegible] DIVERSION AND LOW LEVEL OUTLET
[illegible]	EXCAVATION PLAN
[illegible]	SECTIONS - EXCAVATION PLAN
[illegible]	GRADING PLAN - TOWER AREA - PHASE I
[illegible]	GRADING PLAN - SPILLWAY BASIN AREA - PHASE I
[illegible]	SECTIONS - OUTLET WORKS AND SERVICE SPILLWAY
[illegible]	FENCING - ACCESS [illegible]

SPECIFICATION 7727

REVISIONS

LOCATION MAP AND LIST OF DRAWINGS
FOREBAY DAM
CASTAIC POWER PROJECT

POWER SYSTEM
DEPARTMENT OF WATER & POWER CITY OF LOS ANGELES

PA CA165

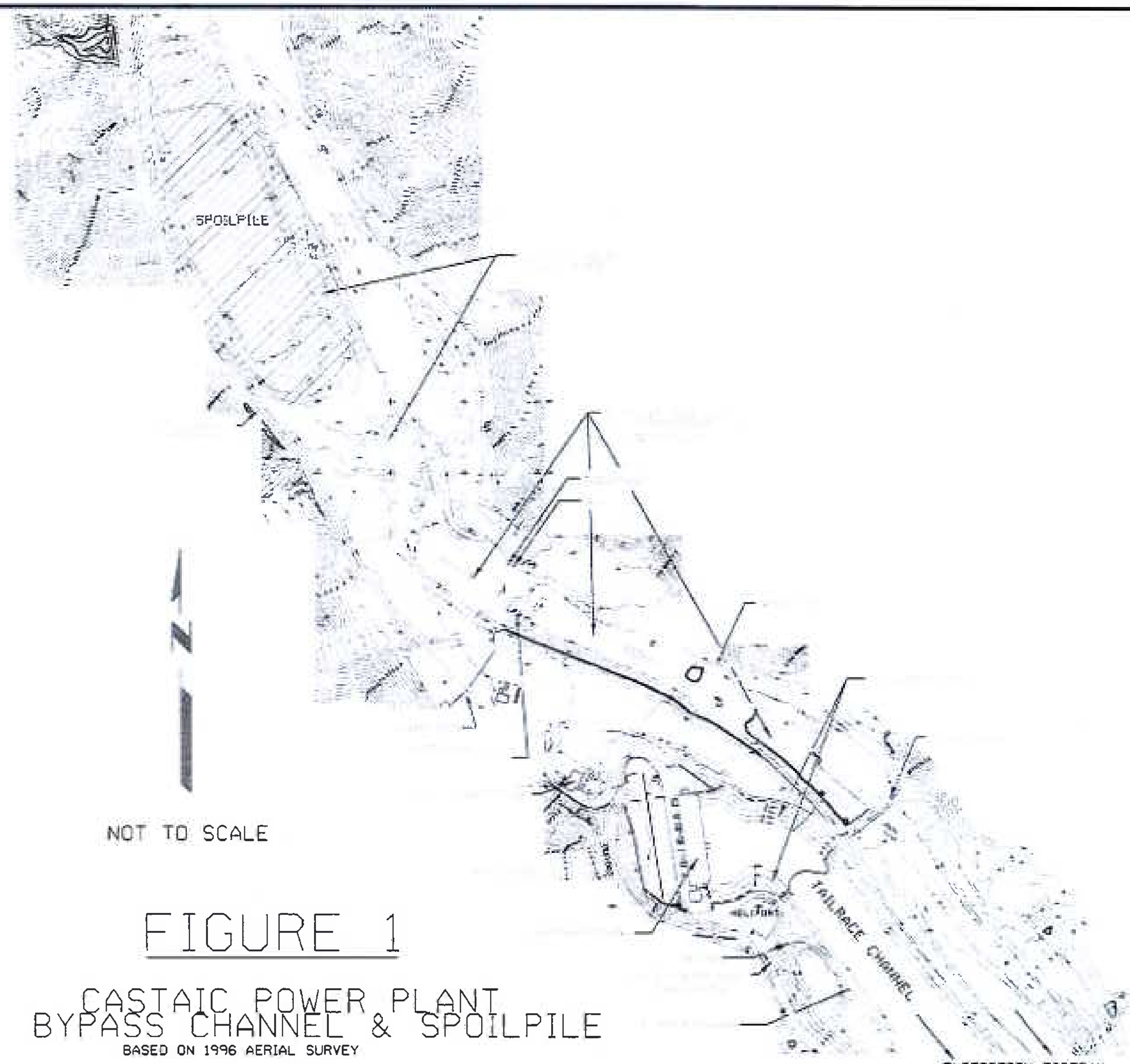


FIGURE 1

CASTAIC POWER PLANT
BYPASS CHANNEL & SPOILPILE
BASED ON 1996 AERIAL SURVEY

FILE NAME: BYPASS CHANNEL SITE MAP.DGN


BASIN 2
BASIN 3

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

Certification Statement

Enclosure 4

Enclosure 3

Los Angeles Department of Water and Power
Castaic Creek Maintenance Project
401 Water Quality Certification
File no. 11-137

I certify under penalty of law that this document and all enclosures were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person(s) who manage the system or those directly responsible for data gathering, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Executed on the 31st day of December, 2013 at Los Angeles, California.

Signature Katherine Rubin

Name Katherine Rubin

Title Manager of Wastewater Quality and compliance

Los Angeles LA DWP Department of Water & Power

ERIC GARCETTI
Mayor

Commission
MEL LEVINE, *President*
WILLIAM W. FUNDERBURK JR., *Vice President*
JILL BANKS BARAD
MICHAEL F. FLEMING
CHRISTINA E. NOONAN
BARBARA E. MOSCHOS, *Secretary*

DAVID H. WRIGHT
General Manager

December 29, 2016

Mr. Samuel Unger, Executive Officer
California Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Room 200
Los Angeles, CA 90013

Attention: Mr. Dana Cole, Section 401 Program

Dear Mr. Unger:

Subject: 2016 Annual Monitoring Report for the Castaic Creek Maintenance and Elderberry Forebay Sediment Removal Section 401 Water Quality Certification (File No. 16-082)

The Los Angeles Department of Water and Power (LADWP) submit the enclosed Annual Monitoring Report for the Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, and Spillway Repair Work Project, as required by the Clean Water Act 401 Water Quality Certification issued on October 26, 2016.

If you have any questions, please contact Ms. Andrea N. Yip of my staff at (213) 367-4230.

Sincerely,

Katherine Rubin

Katherine Rubin
Manager of Wastewater Quality and Compliance

AY:lct
Enclosure
c: Ms. Andrea N. Yip

Los Angeles Department of Water and Power
Castaic Creek Maintenance and Elderberry Forebay Sediment Removal
2016 CWA 401 Annual Monitoring Report
File No. 16-082

A. Color Photo Documentation of Pre- and Post- Project Site Conditions

See Attachment 1 for photos of pre-project and current project site conditions.

B. Geographical Positioning System (GPS) Coordinates Outlining the Boundary of the Project

See Attachment 2 for GPS coordinates outlining the boundary of the work area.

C. Overall Status of Project

Maintenance activities consisted of draining Elderberry Forebay, removing sediment and vegetation from the bypass channel leading into Elderberry Forebay, removal of debris and sediment from the tailrace channel and Elderberry Forebay, grading for temporary access into the bypass channel and tailrace channel, and deposition of excavated sediment and debris to designated spoil pile area. The sediment removal work in Elderberry Forebay started on October 31, 2016. In total, 480,110 cubic yards of sediment was removed from Elderberry Forebay. Work on Elderberry Forebay was completed by December 21, 2016, which is the date that the Forebay started refilling.

Maintenance activities to remove sediment and vegetation from settling basins (Basin 1, 2, and 3) of the Castaic Creek Bypass Channel started on October 31, 2016. To date, a total of 2,860 cubic yards of sediment was removed from Basin 1. The remaining sediment removal in Basin 1, 2, and 3, is expected to be completed in January 2017.

In addition, the existing boat ramp into Elderberry Forebay was extended due to safety concerns with boat launching in low water elevation. Work on the boat ramp started on December 5, 2016 and was completed on December 14, 2016.

D. Copies of Revised Permits

No permits for this project were revised in 2016.

E. Water Quality Monitoring Results

There was no monitoring data since there were no dewatering activities or surface waters present during maintenance work.

F. Certified Statement of "No Net Loss" of Wetlands

The maintenance work resulted in no net loss of wetlands associated with this project.

G. Discussion of Any Monitoring Activities and Exotic Plant Control Efforts

Biological monitoring has been conducted during the ongoing sediment removal work at Castaic Power Plant per the Streambed Alteration Agreement and Biological Opinion issued for the maintenance activities. Authorized biological monitors have been present during initial ground disturbance activities, exclusionary fence installation, vegetation clearing activities and invasive plant removal. Following the completion of the aforementioned activities, biological monitors have remained on site for a minimum of two days a week during the remaining maintenance work.

The primary species of concern in the project area is the endangered arroyo toad (Anaxyrus californicus). Other species of concern in the area include the two-striped garter snake (Thamnophis hammondii), southwestern pond turtle (Actinemys marmorata pallida), and the coast horned lizard (Phrynosoma coronatum). No arroyo toads have been observed within or in the vicinity of a work area during monitoring activities. Two sensitive species that have been observed by biological monitors are a loggerhead shrike (Lanius ludovicianus) and a bald eagle (Haliaeetus leucocephalus). Neither of these individuals was present in the immediate vicinity of an active work area or affected by the maintenance activities.

Invasive plant species that have been identified in the vicinity of the maintenance activities that have been removed as part of the ongoing maintenance effort include giant reed (Arundo donax) and saltcedar (tamarix ramosissima).

H. Certification Statement

"I declare under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system or those directly responsible for gather the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Executed on the 3rd day of January, 2017, at Los Angeles, California.

Katherine Rubin

Katherine Rubin, Manager of
Wastewater Quality and Compliance

Attachment 1

Project Site Conditions

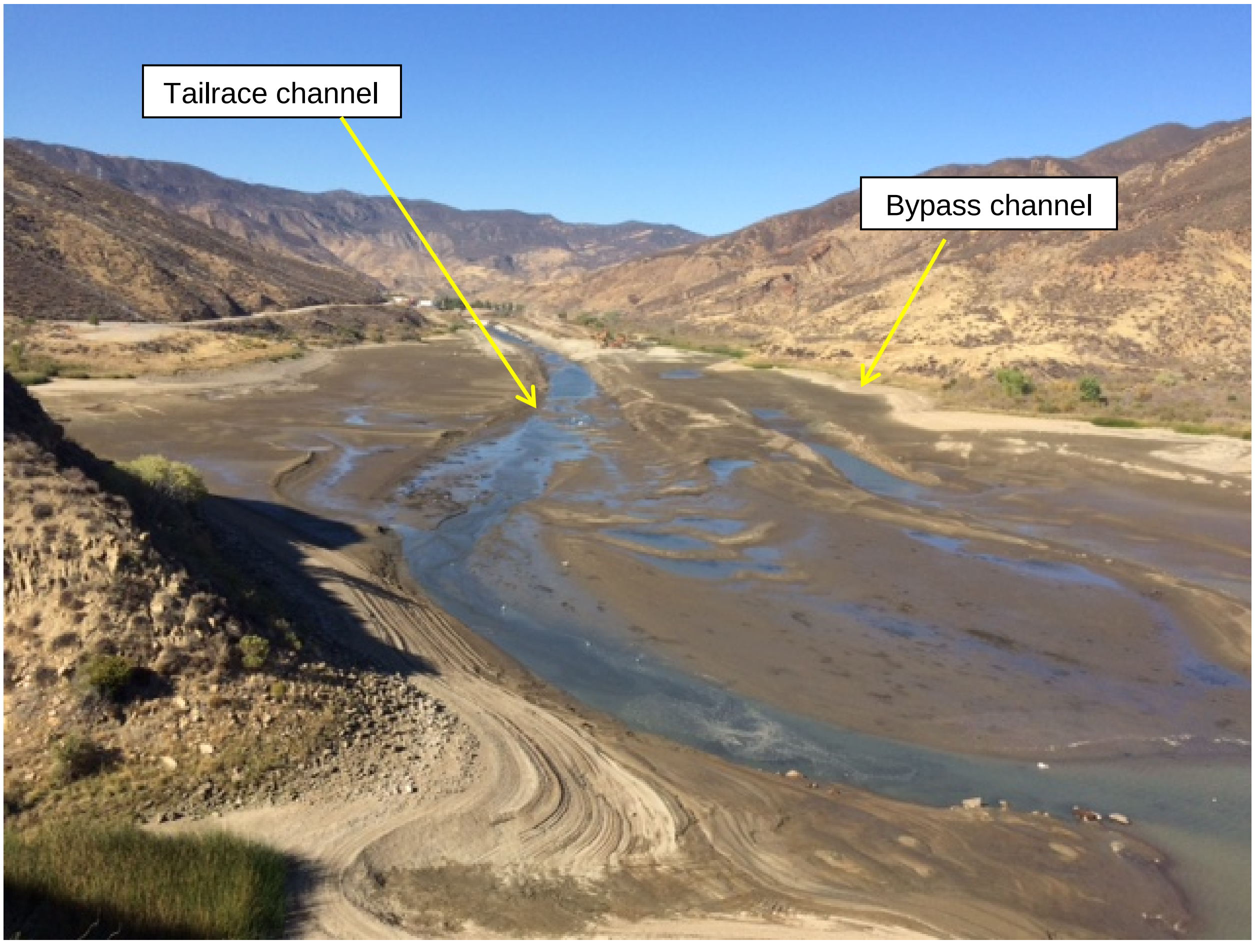


Figure 1. Aerial photo of drained Elderberry Forebay before sediment removal

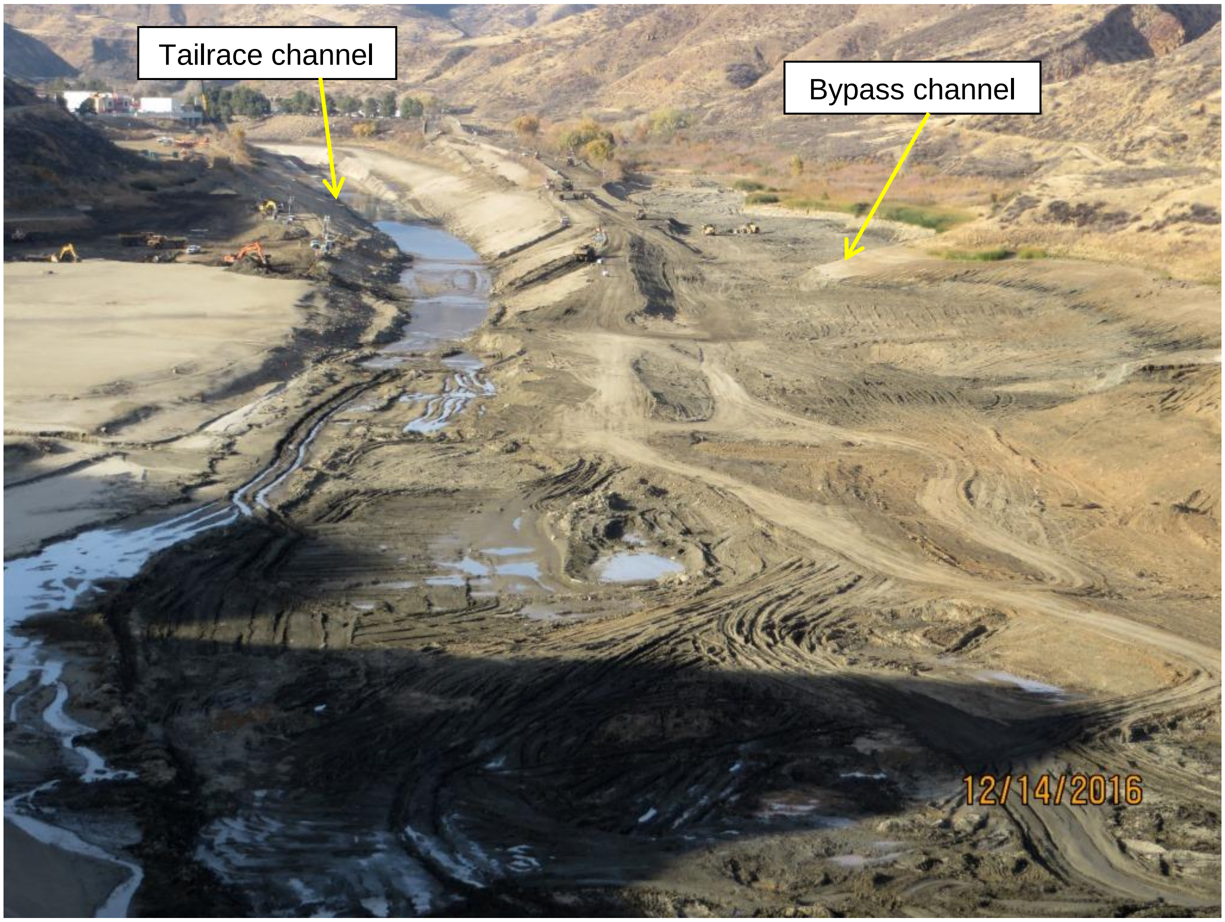


Figure 2. Aerial photo of drained Elderberry Forebay after sediment removal

Figure 3. Castaic Creek Basin 1 before sediment removal

Figure 4. Castaic Creek Basin 1 during sediment removal (not yet completed)

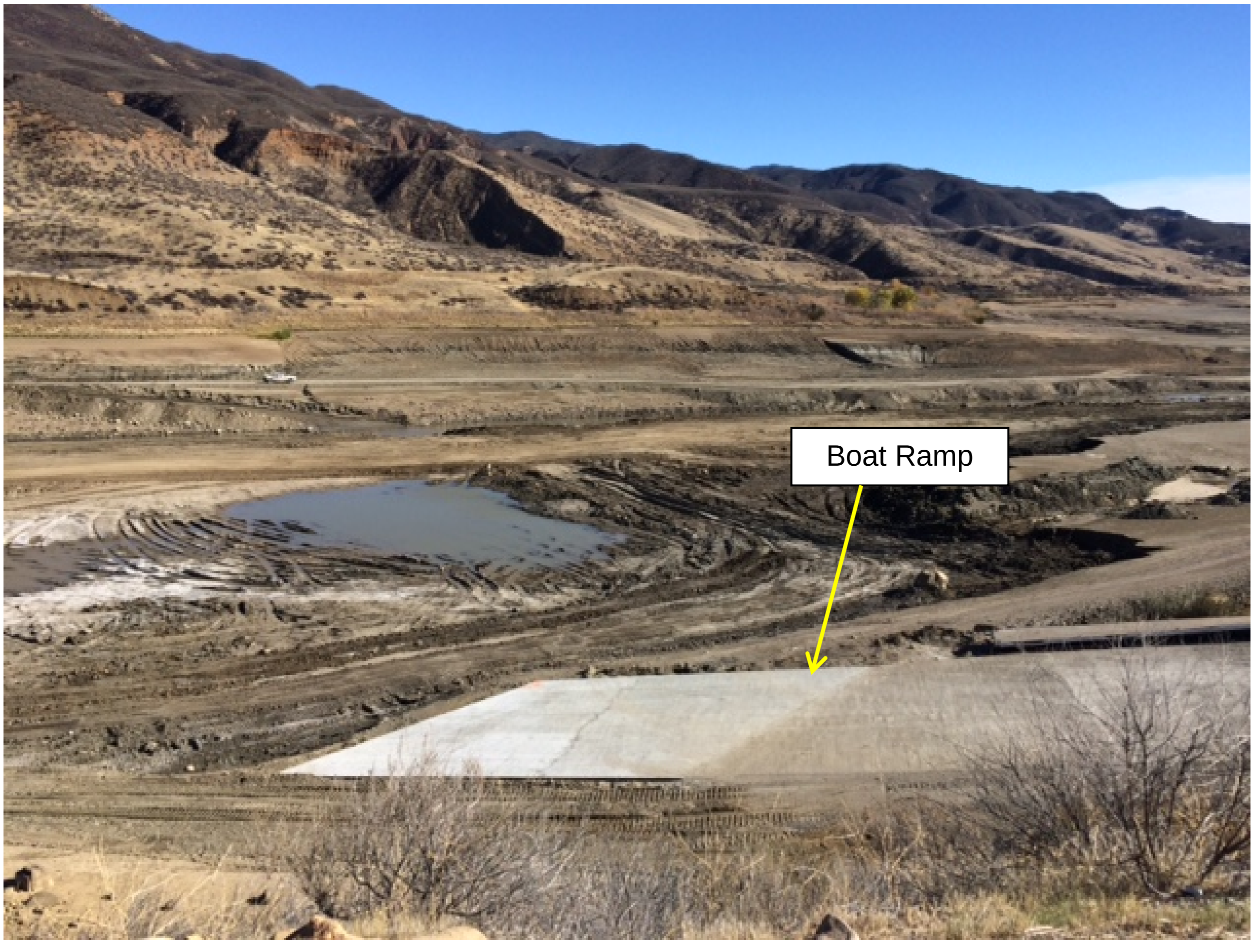


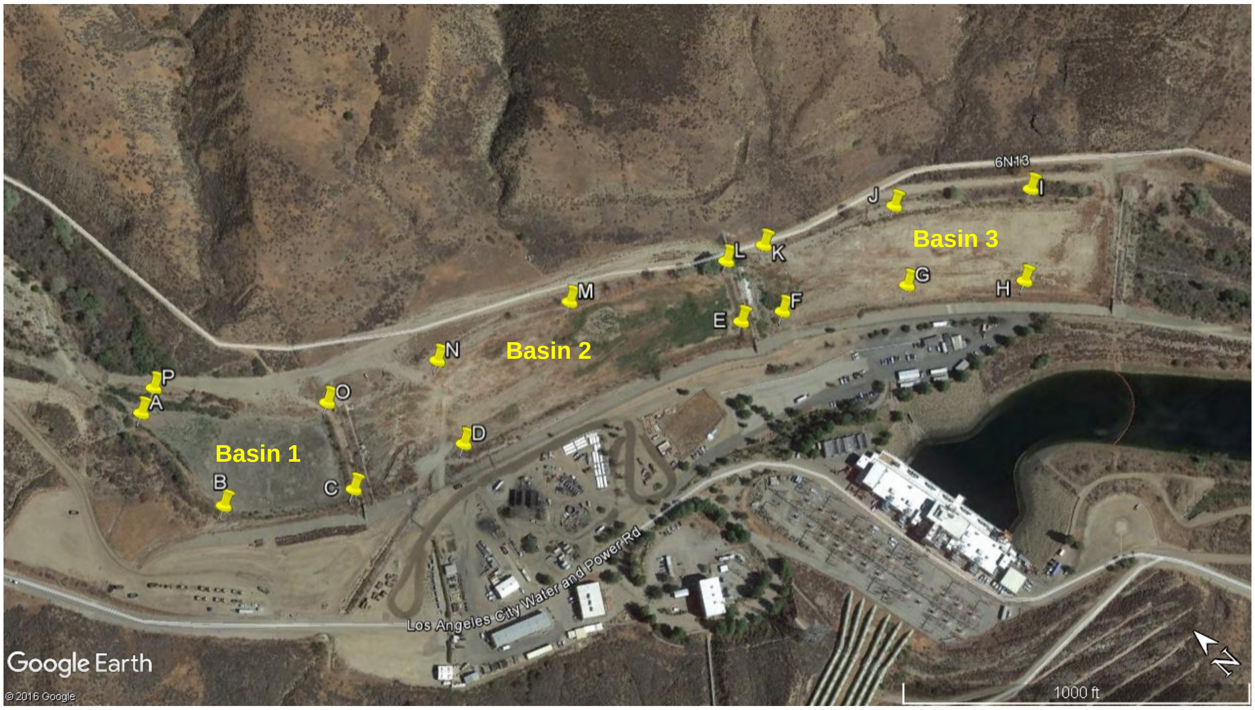
Figure 5. Extended boat ramp into Elderberry Forebay

Attachment 2

GPS Coordinates of Project Boundary

GPS Coordinates of Project Boundary

Castaic Creek Maintenance:



Pin	Latitude	Longitude
A	34.59260	-118.66149
B	34.59158	-118.66159
C	34.59090	-118.66058
D	34.59051	-118.65950
E	34.58955	-118.65670
F	34.58935	-118.65634
G	34.58876	-118.65528
H	34.58808	-118.65443
I	34.58856	-118.65371
J	34.58929	-118.65479
K	34.58985	-118.65598
L	34.58998	-118.65636
M	34.59068	-118.65774
N	34.59114	-118.65908
O	34.59155	-118.66014
P	34.59267	-118.66122

Elderberry Forebay Sediment Removal:

Pin	Latitude	Longitude
1	34.58798	-118.65284
2	34.58740	-118.65376
3	34.58775	-118.65623
4	34.58674	-118.65604
5	34.58116	-118.65020
6	34.57892	-118.64879
7	34.57995	-118.64694
8	34.58441	-118.65005

Los Angeles Department of Water & Power

CUSTOMERS FIRST

December 27, 2018

Ms. Deborah J. Smith, Executive Office
California Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Room 200
Los Angeles, CA 90013

Attention: Mr. Dana Cole

Dear Ms. Smith:

Subject: 2018 Annual Monitoring Report for the Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, and Spillway Repair Work Project Water Act Section 401 Water Quality Certification (File No. 16-082)

The California Regional Water Quality Control Board, Los Angeles Region, issued to the Los Angeles Department of Water and Power (LADWP) the Clean Water Act Section 401 Water Quality Certification for the Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, and Spillway Repair Work Project on October 26, 2016. The Clean Water Act Section 401 requires the submittal of an annual report for a minimum period of five years following the issuance of the certification or until mitigation success and project completion have been achieved and documented. Enclosed is the Annual Report for the 2018 reporting year.

The report includes:

- Overall Status of Project
- Discussion of any Monitoring Activities
- Certification Statement

If you have any questions, please contact Mr. Edgar Gomez, of the Wastewater Quality and Compliance Group, at (213) 367-4425.

Sincerely,

Katherine Rubin
Manager of Wastewater Quality and Compliance Group

EG:th
Enclosure
c/enc: Mr. Edgar Gomez

Enclosure 1:

Annual Monitoring Report File No. 16-082

Los Angeles Department of Water and Power
Castaic Creek Maintenance and Elderberry Forebay Sediment Removal
2018 CWA 401 Annual Monitoring Report
File No. 16-082

A. Color Photo Documentation of Pre- and Post- Project Site Conditions

No Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, or Spillway Repair work was performed in 2018.

B. Geographical Positioning System (GPS) Coordinates Outlining the Boundary of the Project

No Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, or Spillway Repair work was performed in 2018.

C. Overall Status of Project

No Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, or Spillway Repair work was performed in 2018.

Past maintenance activities have consisted of draining Elderberry Forebay, removing sediment and vegetation from the bypass channel leading into Elderberry Forebay, removal of debris and sediment from the tailrace channel and Elderberry Forebay, grading for temporary access into the bypass channel and tailrace channel, and deposition of excavated sediment and debris to designated spoil pile area. The sediment removal work in Elderberry Forebay started on October 31, 2016. In total, 480,110 cubic yards of sediment was removed from Elderberry Forebay. Work on Elderberry Forebay was completed by December 21, 2016.

Maintenance activities to remove sediment and vegetation from settling basins (Basin 1, 2, and 3) of the Castaic Creek Bypass Channel started on October 31, 2016 and was completed by December 21, 2016. A total of 2,860 cubic yards of sediment was removed from Basin 1.

In addition, the existing boat ramp into Elderberry Forebay was extended due to safety concerns with boat launching in low water elevation. Work on the boat ramp started on December 5, 2016 and was completed on December 14, 2016.

Future planned activities include repairs to the Elderberry Forebay Emergency Spillway and maintenance of the spoil pile area. These activities are anticipated to occur in the 1st Quarter of 2019.

D. Copies of Revised Permits

No permits for this project were revised in 2018.

E. **Water Quality Monitoring Results**

There is no monitoring data since there was no maintenance work, or dewatering activities during 2018.

F. **Certified Statement of "No Net Loss" of Wetlands**

The maintenance work resulted in no net loss of wetlands associated with this project.

G. **Discussion of Any Monitoring Activities and Exotic Plant Control Efforts**

As required, biological monitoring has been conducted during past sediment removal work at Castaic Power Plant for the maintenance activities. Authorized biological monitors have been present during initial ground disturbance activities, exclusionary fence installation, vegetation clearing activities and invasive plant removal. Following the completion of the aforementioned activities, biological monitors have remained on site for a minimum of two days a week during the remaining maintenance work.

The primary species of concern in the project area is the endangered arroyo toad (Anaxyrus californicus). Other species of concern in the area include the two-striped garter snake (Thamnophis hammondii), southwestern pond turtle (Actinemys marmorata pallida), and the coast horned lizard (Phrynosoma coronatum). To date, no arroyo toads have been observed within or in the vicinity of a work area during monitoring activities. Two sensitive species that have been observed by biological monitors are a loggerhead shrike (Lanius ludovicianus) and a bald eagle (Haliaeetus leucocephalus). Neither of these individuals was present in the immediate vicinity of past active work areas or affected by previously performed maintenance activities.

Invasive plant species that have been identified in the vicinity of the maintenance activities that have been removed as part of the ongoing maintenance effort include giant reed (Arundo donax) and saltcedar (tamarix ramosissima).

The above monitoring activities will be conducted prior to any maintenance activities planned in 2019.

H. Certification Statement

"I declare under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system or those directly responsible for gather the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Executed on the 27th day of December, 2018, at Los Angeles, California.

Katherine Rubin

Katherine Rubin, Manager of
Wastewater Quality and Compliance

Los Angeles Department of Water & Power

CUSTOMERS FIRST

December 20, 2019

Ms. Renee Purdy, Executive Officer
Los Angeles Region
California Regional Water Quality Control Board
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Attention: Mr. Dana Cole

Dear Ms. Purdy:

Subject: 2019 Annual Monitoring Report for the Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, and Spillway Repair Work Project Water Act Section 401 Water Quality Certification (File No. 16-082)

The California Regional Water Quality Control Board, Los Angeles Region, issued to the Los Angeles Department of Water and Power (LADWP) the Clean Water Act Section 401 Water Quality Certification for the Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, and Spillway Repair Work Project on October 26, 2016. The Clean Water Act Section 401 requires the submittal of an annual report for a minimum period of five years following the issuance of the certification or until mitigation success and project completion have been achieved and documented. Enclosed is the Annual Report for the 2019 reporting year.

The report includes:

- Overall Status of Project
- Discussion of any Monitoring Activities
- Certification Statement

If you have any questions, please contact Mr. Edgar Gomez, of the Wastewater Quality and Compliance Group, at (213) 367-4425.

Sincerely,

Katherine Rubin
Manager of Wastewater Quality and Compliance Group

EG:mh
Enclosure
c/enc: Mr. Edgar Gomez

Enclosure 1:

Annual Monitoring Report File No. 16-082

Los Angeles Department of Water and Power
Castaic Creek Maintenance and Elderberry Forebay Sediment Removal
2019 CWA 401 Annual Monitoring Report
File No. 16-082

A. Color Photo Documentation of Pre- and Post- Project Site Conditions

See Attachment 1 for photos of pre-project and current project conditions.

B. Geographical Positioning System (GPS) Coordinates Outlining the Boundary of the Project

See Attachment 2 for GPS coordinates outlining the boundary of the work area.

C. Overall Status of Project

Maintenance work began in Basin 1 on October 21, 2019. Maintenance activities included re-establishing the haul route to and around the spoil pile area, the removal of sediment and vegetation from Basin 1, the hauling of excavated materials to existing the existing spoil pile, the removal of invasive species (see Section G), and grading/stabilization of the spoil pile. Excavation work in Basin 1 was completed the week of December 11, 2019 and resulted in the removal of 52,580 cubic yards of sediment. Maintenance work was planned for Basins 2 and 3, but it was ultimately decided that this work would not be conducted. Demobilization and site stabilization will occur through the rest of the year and is expected to be completed within the first few weeks of January 2020.

Past maintenance activities have consisted of draining Elderberry Forebay, removing sediment and vegetation from the bypass channel leading into Elderberry Forebay, removal of debris and sediment from the tailrace channel and Elderberry Forebay, grading for temporary access into the bypass channel and tailrace channel, and deposition of excavated sediment and debris to designated spoil pile area. The sediment removal work in Elderberry Forebay started on October 31, 2016. In total, 480,110 cubic yards of sediment was removed from Elderberry Forebay. Work on Elderberry Forebay was completed by December 21, 2016.

Maintenance activities to remove sediment and vegetation from settling basins (Basin 1, 2, and 3) of the Castaic Creek Bypass Channel started on October 31, 2016 and was completed by December 21, 2016. A total of 2,860 cubic yards of sediment was removed from Basin 1.

In addition, the existing boat ramp into Elderberry Forebay was extended due to safety concerns with boat launching in low water elevation. Work on the boat ramp started on December 5, 2016 and was completed on December 14, 2016.

D. Copies of Revised Permits

The California Department of Fish and Wildlife Streambed Alteration was amended on August 21, 2019. A copy of the amended permit is enclosed as Attachment 3.

E. Water Quality Monitoring Results

There was no monitoring data since there were no dewatering activities or surface waters flows in the project work areas which resulted in a discharge to receiving water.

F. Certified Statement of "No Net Loss" of Wetlands

The maintenance work resulted in no net loss of wetlands associated with this project.

G. Discussion of Any Monitoring Activities and Exotic Plant Control Efforts

As required, biological monitoring has been conducted during past sediment removal work at Castaic Power Plant for the maintenance activities. Authorized biological monitors have been present during initial ground disturbance activities, exclusionary fence installation, vegetation clearing activities and invasive plant removal. Following the completion of the aforementioned activities, biological monitors have remained on site for a minimum of two days a week during the remaining maintenance work.

The maintenance project required the removal of invasive plant species, along with the monitoring of the Arroyo Toad and Southwestern Pond Turtle. All monitoring efforts were in compliance with United States Army Corps of Engineers permit SPL-2007-01230 and California Department of Fish and Wildlife Streambed Alteration Agreement No. 1600-2010-0001-R5.

Certification Statement

"I declare under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system or those directly responsible for gather the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Executed on the 27th day of December, 2019, at Los Angeles, California.

Katherine Rubin

Katherine Rubin, Manager of
Wastewater Quality and Compliance

Attachment 1

Pre- and Post-project Photographs

Figure 1. Castaic Creek Basin 1 Pre-maintenance work (facing east)

Figure 2. Castaic Basin 1 Pre-maintenance work (facing south)

Figure 3. Castaic Creek Exclusionary Fence Installation (facing south-east)

Figure 4. Castaic Creek Basin 1 during beginning of sediment removal (facing west)

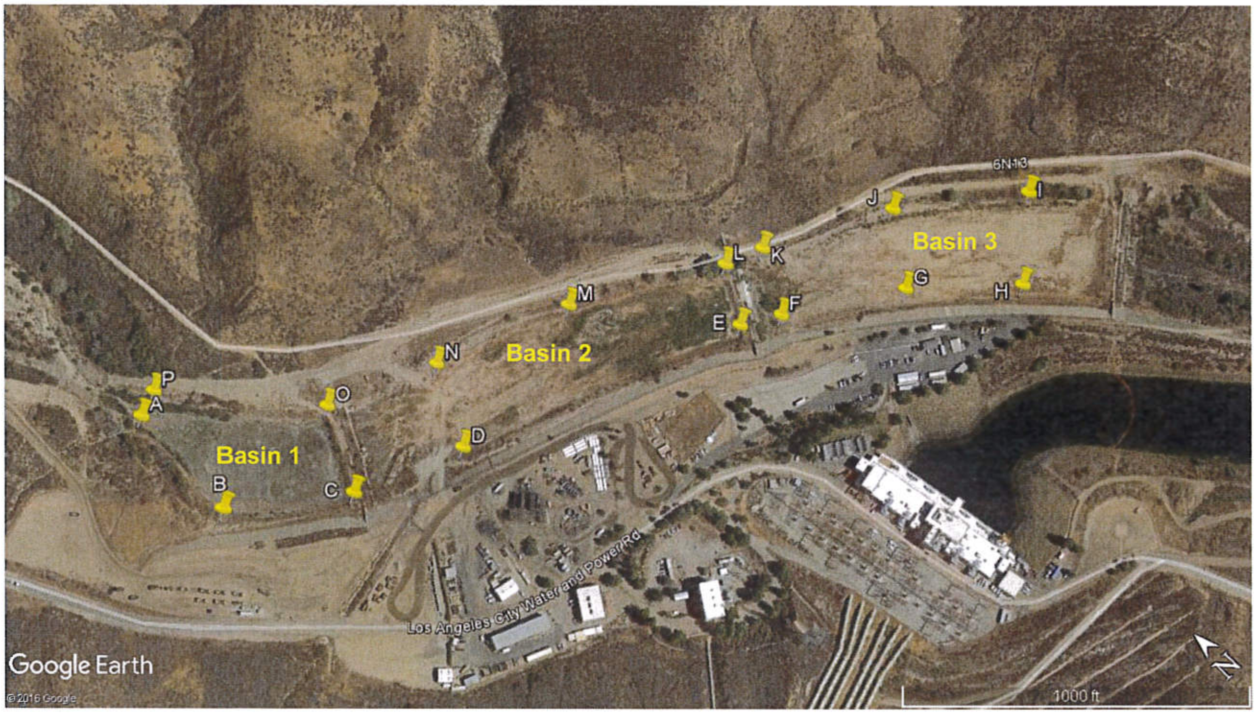
Figure 5. Castaic Creek Basin 1 sediment removal near completion (facing west)

Attachment 2

Geographical Positioning System (GPS) Coordinates Outlining the Boundary of the Project

GPS Coordinates of Project Boundary

Castaic Creek Maintenance:



Pin	Latitude	Longitude
A	34.59260	-118.66149
B	34.59158	-118.66159
C	34.59090	-118.66058
D	34.59051	-118.65950
E	34.58955	-118.65670
F	34.58935	-118.65634
G	34.58876	-118.65528
H	34.58808	-118.65443
I	34.58856	-118.65371
J	34.58929	-118.65479
K	34.58985	-118.65598
L	34.58998	-118.65636
M	34.59068	-118.65774
N	34.59114	-118.65908
O	34.59155	-118.66014
P	34.59267	-118.66122

Attachment 3

Copies of Revised Permits

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
South Coast Region
3883 Ruffin Road
San Diego, CA 92123
(858) 467-4201
www.wildlife.ca.gov

***GAVIN NEWSOM**, Governor*
CHARLTON H. BONHAM, Director

August 21, 2019

Charles C. Holloway
City of Los Angeles Department of Water and Power
111 North Hope Avenue, Room 1044
Los Angeles, CA 90012
Charles.holloway@ladwp.com

Dear Mr. Holloway:

Amendment of Lake or Streambed Alteration Notification No. 1600-2010-0001-R5; Castaic Basin Sediment Removal; Los Angeles County

The California Department of Fish and Wildlife (CDFW) has determined it is necessary to amend Lake or Streambed Alteration Agreement 1600-2010-0001-R5 (Agreement). This Amendment to the Agreement includes updating the project description to include relocation of the debris/sediment stockpile and the addition of a measure related to the reporting requirements. This Amendment will address those requested changes as well as clarify and revise some of the existing measures of our Agreement. Language removed from these conditions is shown in ~~red with a strikethrough~~. Language added to these conditions is shown in ***bold, italicized*** text).

PROJECT DESCRIPTION

The project is limited to the alteration of Castaic Creek by conducting long-term maintenance activities at three debris basins located at the Castaic Power Plant.

The Castaic Power Plant maintenance consists of sediment removal within the bypass channel within Check Dams Basins #1, #2 and #3. This activity usually occurs once every ~~1-2~~ ***3*** years ***to allow approximately 10 acres of vegetation to re-establish***, but may occur more often due to frequent storm events. Basin #1 measures 250 feet wide by 400 feet in length; Basin #2 measures 250 feet wide by 1200 feet in length; Basin #3 measures 250 feet wide by 1100 feet in length. The total temporary impact area for the three basins is 15.5 acres. The sediment is removed and stored at a permanent storage area located within the property. Sediment removal activities should be planned to occur after September 1st and prior to March 1st, to avoid impacts to nesting birds and at a time that will maximize the temporary relocation and protection efforts for the reptile and amphibian species that utilize these pond areas.

The Permittee proposes to remove the existing sediment stockpile which contains 1.8 million cubic yards of sediment from the Castaic Power Plant to off-site disposal or reuse locations. Removed soil material would be hauled from the sediment stockpile, along Templin Highway to Interstate 5 (I-5), where it would then be hauled and disposed of by the selected contractor at various locations. The estimated 5-year period to remove the stockpile assumes that a mixture of dump trucks with a 10-24 cubic yard capacity, with associated necessary off-road equipment, are utilized during sediment removal each year. Excavated sediment would be loaded into trucks and hauled to off-site locations.

The Permittee and its contractor will first seek to recycle excavated material as feasible, likely for use on other municipal projects within the Santa Clarita and surrounding areas. All disposal, storage, or use locations of the removed material will be previously disturbed (not containing sensitive biological species or habitat) and be permitted, zoned, or otherwise authorized to accept such material for storage/use. The stockpile will include Best Management Practices (BMPs) straw waddles to contain and divert storm water and prevent drainage into the creek area.

2.14 Protection Plans for Sensitive Species. The Permittee has developed and submitted plans to address potential impacts to a host of sensitive species that have either been observed at the project site or have a probability to occur within the project site. Should any other additional sensitive or rare species be observed, the Permittee shall provide CDFW with an addendum to the existing plan(s) to address these additional species. Two existing sensitive species protection plans have been submitted, reviewed, and approved by CDFW. These plans are:

a) The ***Permittee shall submit an updated*** 'Southwestern Pond Turtle Protection Plan' ~~(dated September 29, 2010) was developed~~ to avoid and minimize project impacts to this species. The plan ~~includes~~ ***should include*** pre-project surveys and trapping, collection of individuals out of harms way, biological monitoring ***of debris basins and stockpile site, proper BMPs to exclude pond turtle from stockpile area,*** temporary relocation sites (returning the individuals to adjacent and appropriate habitat once project activities have been completed), and established off-site relocation areas ***that do not contain unarmored threespine stickleback. This plan shall be submitted 30 days prior to initiation of work.***

3.10 Submittal of Observation Forms to the California Natural Diversity Database. If any special status species are observed at the project site, the Permittee or designated representative shall submit an observation form to the Natural Diversity Data Base (NDDB) within ten working days of the sightings. CDFW staff assigned to the project shall be included on any e-mail or letter that is sent for this purpose. The only exception to the above is that sensitive bird species must have a nesting or breeding component as part of the observation. Burrowing owl, due to burrowing in the winter, does not need to be verified that nesting or breeding is occurring. ***Prior to CDFW signature of this Amendment, all CNDDB observations to date must be submitted to https://www.wildlife.ca.gov/Data/CNDDB and a copy of the observation form to R5LSACompliance@wildlife.ca.gov. Instructions for completing and submitting the form are available at: https://www.wildlife.ca.gov/Data/CNDDB/Submitting-Data.***

4.5 Post-Project Annual Report. Permittee shall submit a post-project annual report detailing all projects and related activities that have taken place that year by December 31 of each year. This report shall also include the Annual Maintenance Fee described in Measure 4.4 of this Agreement. Should no project related activities take place during a calendar year, by the end of said calendar year, Permittee shall submit written notification describing the absence of activities via e-mail R5LSACompliance@wildlife.ca.gov, Reference # 1600-2010-0001-R5.

All other conditions in the Agreement remain in effect unless otherwise noted herein.

Please sign and return one copy of this letter to acknowledge the Amendment. Copies of the Agreement and this Amendment must be readily available at project worksites and must be presented when requested by a CDFW representative or agency with inspection authority.

If you have questions regarding this letter, please contact Joseph Stanovich, Environmental Scientist, at (562) 430-7642 or Joseph.Stanovich@wildlife.ca.gov.

Sincerely,

Erinn Wilson
Environmental Program Manager

ACKNOWLEDGEMENT

I hereby agree to the above-referenced Amendment.

Print Name: Charles C. Holloway Date: 8/22/2019

Signature: Charles C. Holloway

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
South Coast Region
3883 Ruffin Road
San Diego, CA 92123
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

November 07, 2014

Charles C. Holloway
City of Los Angeles Department of Water and Power
111 N. Hope Avenue, Room 1044
Los Angeles, CA 90012

Subject: Final Lake or Streambed Alteration Agreement
Notification No. 1600-2010-0001-R5
Castaic Power Plant and Castaic Creek Maintenance Program

Dear Mr. Holloway,

Enclosed is the final Streambed Alteration Agreement (Agreement) for the Castaic Power Plant and Castaic Creek Maintenance Project (Project). Before the California Department of Fish and Wildlife (Department) may issue an Agreement, it must comply with the California Environmental Quality Act (CEQA). In this case, the Department, acting as a responsible agency, filed a notice of exemption (NOE) on the same date it signed the Agreement.

Under CEQA, the filing a NOE starts a 35-day period within which a party may challenge the filing agency's approval of the project. You may begin your project before the 30-day period expires if you have obtained all necessary local, state, and federal permits or other authorizations. However, if you elect to do so, it will be at your own risk.

If you have any questions regarding this matter, please contact Jeff Humble, Environmental Scientist at 805-652-1868 or Jeff.Humble@wildlife.ca.gov

Sincerely,

Christe Beard-Gadbo

for Betty J. Courtney
Environmental Program Manager I

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE SOUTH COAST REGION 3883 Ruffin Road San Diego, CA 92123 **STREAMBED ALTERATION AGREEMENT** NOTIFICATION NO. 1600-2010-0001-R5 REVISION 2 CASTAIC CREEK CITY OF LOS ANGELES DEPARTMENT OF WATER AND POWER CASTAIC POWER PLANT AND CASTAIC CREEK MAINTENANCE PROGRAM	

This Streambed Alteration Agreement (Agreement) is entered into between the California Department of Fish and Wildlife (CDFW) and the City of Los Angeles Department of Water and Power (Permittee), 111 N. Hope Street, Room 1044, Los Angeles, CA 90012, as represented by Mr. Charles C. Holloway, (213) 367-0285.

RECITALS

WHEREAS, pursuant to Fish and Game Code (FGC) section 1602, Permittee notified CDFW on January 5th, 2010 that Permittee intends to complete the project described herein.

WHEREAS, pursuant to FGC section 1603, CDFW has determined that the project could substantially adversely affect existing fish or wildlife resources and has included measures in the Agreement necessary to protect those resources.

WHEREAS, Permittee has reviewed the Agreement and accepts its terms and conditions, including the measures to protect fish and wildlife resources.

NOW THEREFORE, Permittee agrees to complete the project in accordance with the Agreement

PROJECT LOCATION

The project is located at The Permittees facility, located at Castaic Creek (Castaic Creek Storm Bypass Channel), a tributary to the Santa Clara River, Los Angeles County, California. Latitude N 34.59°, Longitude W 118.66°.

PROJECT DESCRIPTION

The project is limited to the alteration of Castaic Creek by conducting long-term maintenance activities at three debris basins located at the Castaic Power Plant.

The Castaic Power Plant maintenance consists of sediment removal within the bypass channel within Check Dams Basins #1, #2 and #3. This activity usually occurs once every 1-2 years, but may occur more often due to frequent storm events. Basin #1 measures 250 feet wide by 400 feet in length; Basin #2 measures 250 feet wide by 1200 feet in length; Basin #3 measures 250 feet wide by 1100 feet in length. The total temporary impact area for the three basins is 15.5 acres. The sediment is removed and stored at a permanent storage area located within the property. Sediment removal activities should be planned to occur after September 1st and prior to March 1st, to avoid impacts to nesting birds and at a time that will maximize the temporary relocation and protection efforts for the reptile and amphibian species that utilize these pond areas.

Other minor repairs may include repairs of the check dams, embankments, and other facilities. Substantial repairs that require project design and planning will require the submittal of new notification for a Lake or Streambed Alteration Agreement or the submittal of an amendment request.

Project activities described in this Agreement were previously conducted under Streambed Alteration Agreements 5-664-92, and 1600-2004-0288-R5.

PROJECT IMPACTS

Based on project documentation and site visits conducted by CDFW (Betty J. Courtney, Tim Hovey, and Jeff Humble) CDFW has determined that such operations may substantially adversely affect existing fish and wildlife resources specifically including: amphibians: coast range newt (*Taricha torosa torosa*), western spadefoot toad (*Spea hammondii*), foothill yellow-legged frog (*Rana boylii*), California red-legged frog (*Rana aurora*), arroyo toad (*Bufo californicus*); reptiles: coast patch-nosed snake (*Salvadora hexalepis*), coastal rosy boa (*Lichanura trivirgata roseofusca*), San Diego horned lizard (*Phrynosoma coronatum blainvillii*), two-striped garter snake (*Thamnophis hammondii*), southwestern pond turtle (*Actinemys marmorata pallida*), coastal western whiptail (*Cnemidophorus tigris*), silvery legless lizard (*Anniella pulchra pulchra*); birds: yellow warbler (*Dendroica petechia brewsteri*), least Bell's vireo (*bellii pusillus*), coastal California gnatcatcher (*Polioptila californica californica*), osprey (*Pandion haliaetus*), California condor (*Gymnogyps californianus*), southwestern willow flycatcher (*Empidonax traillii extimus*), burrowing owl (*Athene cunicularia*), Southern California rufous-crowned sparrow (*Aimophila ruficeps canescens*), Bell's sage sparrow (*Amphispiza belli*), horned lark (*Eremophila alpestris*), coastal cactus wren (*Campylorhynchus brunneicapillus sandiegensis*); mammals: western mastiff bat (*Eumops perotis*), pallid bat (*Antrozous pallidus pacificus*), San Diego desert woodrat (*Neotoma lepida intermedia*), San Diego black-tailed jackrabbit (*Lepus californicus deserticola*), southern grasshopper mouse (*Onychomys torridus ramona*), ringtail cat (*Bassariscus astutus*), American badger (*Taxidea taxus*); Fish: unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*); plants: fragrant pitcher sage (*Lepichinia rossii*), Parry's spineflower (*Chorizanthe parryi* var. *parryi*), Ross' pitcher sage (*Lepechinia rossii*), slender-horned spineflower (*Dodecahema leptoceras*), Davidson's bushmallow (*Malacothamnus davidsonii*), Greata's aster (*Symphyotrichum greatae*), Nevin's barberry (*Berberis nevinii*), Los Angeles sunflower (*Helianthus nuttallii* ssp. *parishii*), Ojai navarretia (*Navarretia ojaiensis*), Plummer's mariposa lily (*Calochortus plummerae*), slender mariposa lily (*Calochortus clavatus var. gracilis*), round-leaved filaree (*Erodium macrophyllum*), San Gabriel bedstraw (*Galium grande*), Palmer's grappling hook (*Harpagonella palmeri*), short-joint beavertail (*Opuntia basilaris* var. *brachyclada*), chaparral ragwort (*Senecio aphanactis*), Peirson's morning glory (*Calystegia peirsonii*); and all other aquatic and wildlife resources in the area, including the riparian vegetation which provides habitat for such species in the area.

The adverse effects the project could have on the fish or wildlife resources identified above include: the temporary impacts of an estimated 15.5 acres of riparian habitat, associated disturbances related to construction activities, and the temporary relocation of amphibian and reptile species.

MEASURES TO PROTECT FISH AND WILDLIFE RESOURCES

1. Administrative Measures

Permittee shall meet each administrative requirement described below.

1.1 Documentation at Project Site. Permittee shall make the Agreement, any extensions and amendments to the Agreement, and all related notification materials and California Environmental Quality Act (CEQA) documents, readily available at the project site at all times and shall be presented to CDFW personnel, or personnel from another state, federal, or local agency upon request.

1.2 Providing Agreement to Persons at Project Site. Permittee shall provide copies of the Agreement and any extensions and amendments to the Agreement to all persons who will be working on the project at the project site on behalf of Permittee, including but not limited to contractors, subcontractors, inspectors, and monitors.

1.3 Notification of Conflicting Provisions. Permittee shall notify CDFW if Permittee determines or learns that a provision in the Agreement might conflict with a provision imposed on the project by another local, state, or federal agency. In that event, CDFW shall contact Permittee to resolve any conflict.

1.4 Project Site Entry. Permittee agrees that CDFW personnel may, upon approval, enter the project site at any time to verify compliance with the Agreement.

1.5 Personnel Compliance On Site. If the Permittee or any employees, agents, contractors and/or subcontractors violate any of the terms or conditions of this agreement, all work shall terminate immediately and shall not proceed until CDFW has been contacted and the issue remedied, or CDFW has taken all of its legal actions.

1.6 Pre-project briefing. A pre-maintenance meeting/briefing shall be held involving all the contractors and subcontractors, concerning the conditions in this Agreement.

1.7 Notification of Start of Work. The Permittee shall notify CDFW at least five days prior to the start of any maintenance activities within CDFW jurisdictional areas. Notification shall be either: a) submitted to CDFW Regional Office, at 3883 Ruffin Road, San Diego, CA, 92123, Attn: Streambed Alteration Staff, b) sent electronically to CDFW inbox via email at: R5LSACompliance@wildlife.ca.gov or, c) using one of the two options above, can also be sent simultaneously to the local CDFW staff working on this project. For these notifications, please reference, Agreement No. 1600-2010-0001-R5, in the subject line.

1.8 Future Project Documents Submitted to CDFW. All required reports, survey results, and other project documentation shall be shall be submitted with the reference Streambed Alteration Agreement Number 1600-2010-0001-R5, to the CDFW regional office, at 3883 Ruffin Road, San Diego, CA, 92123, Attn: Streambed Alteration Staff, or, may be sent electronically to the CDFW streambed program inbox via email at: R5LSACompliance@wildife.ca.gov

1.9 Time Sensitive Documents Submitted to CDFW. For time sensitive documents/information, please ensure the information is simultaneously submitted to the local CDFW staff/contact for this Agreement via the most appropriate and agreed upon method.

2. Avoidance and Minimization Measures

To avoid or minimize adverse impacts to fish and wildlife resources identified above, Permittee shall implement each measure listed below.

Aquatic and Wildlife Species Protection and Surveys

2.1 Avoidance of Nesting and/or Breeding (non-raptor) Birds. When possible, the Permittee shall not remove or otherwise disturb vegetation on the project site during the period from March 1st to September 15th to avoid impacts to breeding/nesting birds. If work cannot be avoided during these times, then prior to project-related activities, the Permittee shall have a qualified biologist survey the project site and areas adjacent to the project site to determine if breeding/nesting birds are present.

2.2 Presence/Absence Surveys for Non-Sensitive Nesting and/or Breeding Bird Species. If surveys are conducted to determine if nesting and breeding bird activity is present within the work area, the Permittee shall have a qualified wildlife biologist conduct these surveys. Surveys shall be conducted every two to three days over a two-week period with the final survey conducted within 72 hours prior to the initiation of project activities. Survey results shall be provided to CDFW within 24 hours of completing the survey(s). If results are time sensitive, then an email summary to the local CDFW staff working on this project (with a letter report to follow) may be submitted to expedite CDFW review. If any nesting is observed during the survey(s), then CDFW shall be contacted immediately to discuss the potential for work to occur.

2.3 Raptor Nesting Surveys. Prior to project activities during the raptor nesting season, which is estimated to be January 31st to September 1st, a qualified biologist shall conduct a single survey for raptor nests within and adjacent to the project area. This survey shall take place within a three week period prior to any scheduled maintenance activity. If an inactive raptor nest is located, the Permittee shall contact CDFW to discuss measures should the nest become active during the project term. Survey results shall include species identification as well as the location of the nesting site. If any inactive raptor nest is to be removed, the Permittee shall contact CDFW to get approval. It is recommended that an initial survey take place as soon as possible during this seasonal time period so that the Permittee can get an idea of potential raptor nest locations.

2.4 Presence/Absence Survey Guidelines for Bird Species Listed as State Threatened, Endangered, or Species of Special Concern. If suitable habitat is present for any bird species that is listed as State Threatened, Endangered, and/or Species of Special Concern, then surveys for these species may include protocol level survey methodology. Existing protocol survey guidelines shall be adhered to in order to determine the presence and/or absence of that species during the bird nesting season. Protocol level surveys shall take place within said suitable habitat for that species as well as a 500 foot buffer around the suitable habitat area. Coordination with CDFW shall take place prior to the implementation of any protocol level survey to ensure the accuracy of these surveys.

2.5 Observed Breeding and/or Nesting for Non-Listed Bird Species. If any bird nesting and/or breeding activities are observed during the required surveys, the Permittee shall contact CDFW immediately. If work is proposed within 500 feet of the observation areas, then the Permittee shall be required to draft a plan for CDFW approval that includes avoidance and minimization measures to ensure the nesting/breeding area(s) are not impacted in any manner.

2.6 Migratory Bird Protection. Be advised, migratory nongame native bird species are protected by international treaty under the Federal Migratory Bird Treaty Act (MBTA) of 1918 (50 C.F.R. Section 10.13). Sections 3503, 3503.5 and 3513 of the California Fish and Game Code that prohibit take of all birds and their active nests including raptors and other migratory nongame birds (as listed under the Federal MBTA).

2.7 Pre-Project Surveys. The Permittee shall have a qualified wildlife biologist conduct three surveys of the work area, to be spaced out over a two-week period with the last survey being conducted within a five-day period prior to the start of work. Pre-project surveys shall include general surveys for botanical and wildlife resources within and adjacent to the project area, as well as:

a. Surveys shall be conducted to determine the presence of burrows that may be utilized by the American badger, San Diego black-tailed jackrabbit, southern grasshopper mouse, and burrowing owl. Potential burrow sites should be recorded and monitored for species observation or signs that the burrow is active. For burrow sites determined to be active, these areas shall be mapped and it shall be determined if they will be impacted by project activities.

b. Surveys shall include locating, mapping, and surveying seasonal pond areas. These locations shall be generally surveyed and may be used for species-specific surveys at the appropriate time of year.

c. Channels with flowing or standing water within as well as adjacent to the work area shall be surveyed for aquatic species, such as the coast range newt, foothill yellow-legged frog, California red-legged frog, arroyo toad, two-striped garter snake, and southwestern pond turtle.

d. Suitable habitat for the silvery (or, California) legless lizard shall be surveyed by raking the leaf litter and upper layers of soil to determine if this species is present.

e. Surveys shall be conducted to locate any woodrat nests, or middens. Active nest sites shall be mapped and it shall be determined if they will be impacted by project activities.

f. Pre-determined, multiple relocation areas for any species encountered during surveys or monitoring that can be relocated safely out of harms way.

2.8 Pre-Project Survey Letter Report. Survey results shall be briefly summarized in a letter report to include biologist recommendations regarding potential impacts and minimization measures to species. This report shall be provided to CDFW at least 48 hours prior to the start of said project activities. An electronic copy of the report shall be sent to the CDFW project contact with the letter report to follow. If sensitive species are observed during the surveys, the Permittee shall contact CDFW immediately to discuss the implementation of avoidance and minimization measures. Identified sensitive species/habitats, and other notable sightings shall be recorded and submitted on a map that will be updated and added to with each subsequent survey (the map to be used for future survey staff and to avoid and minimize wildlife and botanical issues at the project site).

2.9 Focused Surveys for Wildlife and Botanical Species. A host of sensitive or rare species have either been observed at the project site or have the probability to occur due to the presence of suitable habitat. Surveys shall be conducted over the term of the Agreement in order to determine the presence/absence of these species from the project area and potential impacts to these species. These surveys are discussed in detail in Section 3, the 'Mitigation Measures' portion of this Agreement.

2.10 On-Site Biological Monitoring Duration. A qualified biological monitor (with all required collection permits) shall be on-site during all project operations that involve vegetation removal, grading (removal of the first 24" of soil), water diversions, de-watering, exposed (excavated) work areas, and work within sensitive habitats or areas where sensitive species may be present. After the previously specified work activities have been completed that require a monitor to be on-site, the monitor shall then remain on-site for the remainder of the project term (as work occurs within jurisdictional areas) for no less than two days a week, for a minimum four-hour period per day. Dependent upon work conditions and/or prolonged project activities, the Permittee may contact CDFW to discuss a potential decrease for biological monitoring.

2.11 On-Site Biological Monitor Responsibilities. The biological monitor shall also be responsible for: a) the installation and maintenance of devices to prevent species entrapment within excavated work areas; b) on randomly selected days, to survey the work area prior to the start of work; c) relocate any vertebrate species encountered to a safe and pre-determined relocation area that is suitable for the host of species that may be encountered; d) locating any ground dwelling or dormant species by sorting through the first 24-inches of sediment removed from the basins; e) with permission from the Permittee and with coordination from the on-site contractor, have the authority to temporarily stop work activities to resolve any biological issues; f) educate the contractors and equipment operators regarding the conditions of this Agreement; g) install exclusionary devices, where necessary, to prevent the migration of species into the work area(s); and h) report any species mortality to CDFW.

2.12 Sensitive Species Observations During the Work Term. If any state threatened or endangered, are observed within the work area, the Permittee shall implement a 500-foot 'work-free' buffer zone around the location of the sighting. If any other rare species or species of special concern are observed within the work area, the Permittee shall implement a 100-foot 'work-free' buffer zone around the location of the sighting. The Permittee shall then contact CDFW to determine if and when work may commence.

2.13 California Condor Protection. The project area is within the range of the California condor. Most of the Condors in the wild are fitted with GPS devices, but if Permittee should observe a Condor in the area, or determine that a condor may be distressed or injured, the U.S. Fish and Wildlife Service shall be contacted. Please report any unusual condor activity or Condor observations in the area to Jesse Grantham of the U.S. Fish and Wildlife Hopper Mountain National Wildlife Refuge, (805) 644-5185, extension 294. Permittee shall not approach a Condor in any situation but rather call the U.S Fish and Wildlife for professional advice. Care shall be taken to keep the area clean of trash. Condors will ingest many types of small shiny objects and have been known to ingest oil-saturated cloths and trash as well. Therefore, the project area shall be kept clean of trash, contaminated water pools (which a Condor may use to bathe), etc. If a large carcass (i.e. deer, cow, etc.) is found within the area, then contact shall be made with the Fish and Wildlife Service to determine if these carcasses shall be removed or left in place for Condor feeding.

2.14 Protection Plans for Sensitive Species. The Permittee has developed and submitted plans to address potential impacts to a host of sensitive species that have either been observed at the project site or have a probability to occur within the project site. Should any other additional sensitive or rare species be observed, the Permittee shall provide CDFW with an addendum to the existing plan(s) to address these additional species. Two existing sensitive species protection plans have been submitted, reviewed, and approved by CDFW. These plans are:

a. The 'Southwestern Pond Turtle Protection Plan' (dated September 29, 2010) was developed to avoid and minimize project impacts to this species. The plan includes pre-project surveys and trapping, collection of individuals out of harms way, biological monitoring, temporary relocation sites (returning the individuals to adjacent and appropriate habitat once project activities have been completed), and established off-site relocation areas.

b. The 'Castaic Creek Species Protection Plan' (dated January, 2013) was developed to avoid and minimize impacts to a host of sensitive species. The plan addresses species which have either been observed at the project area, or have the potential to occur due to the presence of suitable habitat. The plan addresses the two-striped garter snake, arroyo toad, coast horned lizard, western spadefoot toad, burrowing owl, coastal western whiptail, California legless lizard, and the coast patch-nosed snake. The plan also addresses various plant species, which include, but are not limited to, mariposa lilies species, Peirson's morning glory, San Gabriel bedstraw, and the Ojai navarretia.

2.15 Threatened and/or Endangered Species. An Incidental Take Permit (ITP) from CDFW may be required if the project, project construction, or any project-related activity during the life of the project will result in "take," as defined by the Fish and Game Code, of any species protected by the California Endangered Species Act (CESA) (Fish & G. Code, §§86, 2080, 2081, subd. (b), (c)). This Agreement does not authorize take of any rare, threatened or endangered species that may occur within or adjacent to the proposed work area. If there is a potential for take, the Permittee may request consultation with CDFW and obtain the necessary state permits and/or submit plans to avoid any impacts to the species. Consultation with federal agencies would be required to receive take authority for federal threatened and endangered species.

2.16 Environmental Education Program. Educational materials shall be created and incorporated into an environmental training to be conducted for all project personnel entering the project area. Educational materials may be brief and concise but should illustrate potential sensitive native species and their habitat, discuss any specific measures to protect the species, what to do if the species is observed, and how to coordinate with the on-site biological monitor, etc. Educational information is also encouraged to be posted in office areas or other common areas.

2.17 Night Work Restriction. Permittee activities shall be limited to the period of daylight hours to limit disturbances on wildlife activity; no night work is authorized unless deemed an emergency situation as described within Fish and Game Code, Section 1610.

2.18 Rodent Control Measures (Rodenticides). CDFW strongly discourages the use of rodent bait (rodenticides) as a method of rodent control within or adjacent to open space areas. If a method of rodent control is used at the project site, then an integrated pest management plan shall be developed that includes the frequent collection of rodent carcasses, keeping clean and frequently checked bait stations, use of bait stations that exclude non-target species from entering them, as well as using a less harmful or toxic products. These types of toxic chemicals used in rodenticides can get in the local water supply, accumulate in the food chain, harm other non-target species, and are unsafe for humans and their pets.

2.19 Wildlife Secure Trash Cans. In the project areas, as well as throughout the overall site/facility, the Permittee shall install and use fully covered trash receptacles with secure, wildlife proof lids to contain all food, food scrapes, food wrappers, beverage and other miscellaneous trash. This will also deter wild animals from entering areas where unsecured trash cans are present and create the potential for public safety issues.

In-Stream Structures and Water Diversion

2.20 Structures Within Fish Habitat. Any structure and/or culvert placed within a stream where fish do or may occur, shall be designed, constructed and maintained such that it does not constitute a barrier to upstream or downstream movement of aquatic life. This includes the proper placement of a structure so that downstream areas receive an appropriate supply of water at an appropriate depth, temperature, and velocity. The structure shall also facilitate the movement of fish and aquatic wildlife resources from upstream and downstream areas.

2.21 Culvert Placement. The addition or replacement of any culverts within a stream shall be placed slightly below the stream grade. Culvert replacement shall be completed by installing a similar culvert pipe of the same size or larger. Culverts may be designed and installed in a manner that minimizes any excess erosion or sedimentation. This may include the installation of energy dissipaters placed at the end of culverts to minimize bank erosion. Energy dissipaters shall not include the use of grouted material, and where possible, allow for minimal growth of vegetation.

2.22 Water Diversion and De-Watering. If deemed necessary to divert or obstruct water for the purposes of conducting project activities, a water diversion shall: a) have measures to control sedimentation, b) allow water to reach downstream areas, c) include measures to ensure the protection of aquatic species (proper fittings, screening on pump intakes, etc.), d) make preparations to conduct the relocation of aquatic species that may be stranded in de-watered areas, including sufficient staff and a pre-determined relocation area, and e) have biological monitoring oversight. Mortality of any native species during these activities shall be recorded in the field and included in a subsequent report to CDFW. Any non-native aquatic species encountered during these activities shall not be relocated, but rather shall be disposed of (sacrificed).

Vegetation Removal and Impacts

2.23 Vegetation Removal Limits. Removal of vegetation within the project areas shall not exceed the limits proposed. To avoid excess vegetation removal, it is recommended that the work area be flagged or marked to identify the limits of vegetation removal. Specific trees can also be flagged with a colored ribbon to ensure that it is not removed.

2.24 Temporary Impacts to Vegetation. In areas of temporary disturbance, where vegetation must be temporarily removed, and no earth work will occur, native trees and shrubs should be cut to ground level using other methods than by grading. Therefore, in areas where grading will not occur, native trees and shrubs shall be cut to ground level with hand operated power tools to promote faster re-growth of this vegetation. This said method will compensate for the temporary impacts associated with the removal of these types of vegetation.

2.25 In-Place Protection of Tree Species. All oaks, walnuts, and sycamore trees within the work area shall be clearly marked, fenced off, or flagged to prevent equipment from operating within the drip line of these trees.

2.26 Vegetation Removal as Routine Maintenance. If native vegetation is removed as part of the maintenance program for the overall facility in order to maintain access roads, conduct fuel modification, etc., then this work should be done without or with a limited use involving herbicide application. If the removal of native vegetation is required within the bed, bank, or channel of a stream, and the application of herbicides is necessary, only herbicides approved for aquatic contact shall be used.

2.27 Non-Native Vegetation Removal. Non-native vegetation may be removed from the work area as well as throughout the facility property. If non-native vegetation removal is conducted, it shall be done using the correct methodology in order to prevent the reestablishment of that non-native vegetation. Non-native vegetation removed from a work area shall be disposed of properly so that it shall not become re-established in other areas. Prevalent non-native species, such as tree tobacco, pampas grass, castor bean, giant cane, myoporum, pepper tree, and tamarisk, shall be removed from the work area and treated with an approved herbicide using current and species specific methodologies to control and eradicate these non-native plant species.

2.28 Landscaped Plant Species. Non-native plants shall not be planted in common areas and around developed areas. For a list of native species that can be used, please consult with CDFW.

2.29 Stockpiled Vegetation Debris. Vegetation that is removed for project activities shall not be stockpiled in a channel or in areas where it can enter a channel or drainage. If possible, and as determined by the Permittee, vegetation stockpiling may occur in upland and open space areas, where wildlife can utilize these materials. Native plant material that is removed from the work area can also be salvaged for any restoration or re-vegetation efforts.

Vehicle and Equipment Access, Usage, and Maintenance

2.30 Equipment Maintenance and Vehicle Check. Any equipment or vehicles driven and/or operated adjacent to a stream or drainage shall be checked prior to work and then maintained daily, to prevent fluid leaks or contamination of the stream area. No equipment maintenance shall occur within or near any stream channel, where petroleum products or other pollutants from the equipment may enter these areas.

2.31 Staging and Vehicle Storage. Staging/storage areas for equipment and materials shall be located outside any stream or drainage channel. Equipment operation will be limited to the top of a stream bank whenever feasible.

Pollution Prevention and Erosion Control Measures

2.32 Rain Events and Work Schedule. If measurable rain is predicted (chance of 50% or greater) during the following work day, then, if not already present, sediment control devices shall be installed and maintained at the work area. No work shall be conducted during rain events.

2.33 Deleterious Materials. No debris, soil, silt, sand, bark, slash, sawdust, rubbish, construction waste, cement or concrete or washings thereof, asphalt, paint, oil or other petroleum products or any other substances which could be hazardous to aquatic life shall be allowed to contaminate the soil and/or enter into or placed where it may be washed by rainfall or runoff into, waters of the State. Any of these materials, placed within or where they may enter a stream, by the Permittee or any party working under contract, or with the permission of the Permittee, shall be removed immediately.

2.34 Post Work Site Clean-Up. When project-related activities are completed, any excess materials or debris shall be removed from the work area and within 150 feet of the high water mark of any stream or lake. The Permittee shall comply with all litter and pollution laws. All contractors, subcontractors and employees shall also obey these laws and it shall be the responsibility of the Permittee to insure compliance.

2.35 Wet Concrete/Cement. Cement and concrete shall not be poured within 150 feet of areas where surface water is present. The Permittee shall monitor the 24-hour weather forecast and cement or concrete materials shall only be poured if a 24-hour 'no rain' window is predicted. Wet concrete and cement can have significant adverse impacts to the stream, water quality, and aquatic organisms.

2.36 Spill Containment for Equipment. Stationary equipment such as motors, pumps, generators, and welders, located within or adjacent to the stream/lake shall be positioned over drip pans. Stationary heavy equipment shall have suitable containment to handle a catastrophic spill/leak. Spill clean-up equipment shall be on-site prior to the start of project-related activities. The clean-up of all spills shall begin immediately. CDFW shall be notified immediately by the Permittee of any spills and shall be consulted regarding clean-up procedures.

2.37 Storm Drain Signage. If storm drains are present within the project site or facility, the Permittee shall mark/sign/stencil all storm drains warning that dumping is illegal and that all storm water drains to Castaic Lake and/or the Santa Clara River.

2.38 Sediment and Erosion Prevention. Runoff from steep, erodible surfaces will be diverted into stable areas with little erosion potential. Water checks shall be placed along dirt access roads to divert stormwater with a higher sediment load away from stream and drainages. Appropriate erosion control measures shall be installed and maintained to prevent or remove eroded material and reduce excess sedimentation. These measures include, but are not limited to, temporary soil stabilization (mulching, hydroseeding, mats, etc.), sediment control devices (fiber rolls, silt fencing, sand bags, catchment basins, etc.), and wind erosion control (watering, paving, etc.).

Fill Materials and Spoil Sites

2.39 Fill Storage and Spoil Areas. Any spoil or fill storage sites shall be located in areas where these materials cannot be washed back into any stream or drainage under any condition. These areas shall also have measures to control excess siltation during a rain event. Devices used for this purpose shall be installed around the perimeter of the spoil storage site as soon as possible and maintained. These areas shall be maintained in a vegetation free state unless the establishment of vegetation is not deemed problematic.

2.40 Use of Fill. Fill will be limited to the minimal amount necessary to accomplish the agreed activities. Where fill is used and total compaction is not deemed necessary, the upper two feet of fill will not be compacted to allow for the establishment of vegetation, unless this practice will lead to excessive erosion. Fill compaction shall not occur in areas where vegetation is expected to become re-established (i.e. temporary work areas).

Sedimentation and Turbidity Control

2.41 Precautions to Minimize Work Related Turbidity. Measures shall be included in project planning (including water diversion and de-watering plans) and implemented to prevent any excess siltation or turbidity of the work area, areas downstream of the work area, or areas that are re-watered. This may include the installation and maintenance of sediment control devices, construction of silt catchment basins and silt settling basins, etc. Any turbid water that is to be released into a natural stream or drainage must first be settled, filtered, or otherwise treated prior to discharge.

2.42 Silt Catchment Basin Usage. If silt catchment basins are used, the basins must be constructed across the stream immediately downstream of the project site. Catchment basins shall be constructed of materials that are free from mud and silt. Upon completion of the project, all basin materials along with the trapped sediments shall be removed from the stream to prevent sediment from entering the stream.

2.43 Silt Settling Basins. Silt settling basins, if used, must be located away from the stream to prevent discolored, silt-bearing water from reaching the stream or lake during any flow regime.

2.44 Off-Stream Siltation Ponds. If an off-stream siltation ponds are used to control sediment, the ponds must be constructed in a location, or must be designed, such that potential spills into a flowing stream during periods of high water levels/flow are precluded.

2.45 CDFW Inspection. CDFW shall be allowed to inspect the above measures used to reduce excess sedimentation. If CDFW determinations that turbidity/siltation levels resulting from project related activities constitute a threat to aquatic life, activities associated with the turbidity/siltation must halt until effective approved control devices are installed, or abatement procedures are initiated.

3. **Mitigation Measures**

To compensate for adverse impacts to fish and wildlife resources identified above that cannot be avoided or minimized, Permittee shall implement each measure listed below.

3.1 Compensatory Mitigation Required. The Permittee will be temporarily impacting habitats that include mulefat and willow riparian scrub and associated riparian buffer, or transitional vegetation. Impacts are temporary in nature and only occur, on an average, once every 2 to 5 years. The total impact area is an estimated 15.0 acres. Due to the low frequency of this maintenance activity, mitigation will be required at a 0.2 to 1 mitigation to impact ratio. Therefore, the resulting mitigation required for this project totals 3.0 acres.

3.2 Utilizing a Third Party. Mitigation may include the involvement of a third party entity, which will carry out the mitigation requirements at an off-site location. The entity, location, and the general mitigation strategy shall be approved by CDFW prior to the Permittee entering into a formal agreement with that third party. All supporting documentation between the Permittee and the third party shall be submitted to CDFW within one week after these documents have been finalized.

3.3 Mitigation Parameters and Timing. Mitigation shall occur within the upper Santa Clara River watershed. The Permittee shall present the conceptual mitigation strategy, or alternatives, to CDFW for approval prior to initiation. Mitigation can be satisfied by the purchase of credits at an approved mitigation bank, utilizing a third party to carry out the mitigation requirements, and may also be a combination of the former. Mitigation may be satisfied by conducting restoration, enhancement, creation, and preservation of riparian habitat types. Compensatory mitigation shall be initiated no later than 1-year after this Agreement has been executed. Therefore any third party fee transfers and a draft habitat mitigation monitoring plan will have been completed/finalized and submitted to CDFW for review. The mitigation site shall have little to no future recreational use and have a legal instrument in place for the permanent protection of the site.

3.4 Mitigation as Preservation and/or Acquisition. The Permittee has the option to provide fees to a third party entity that is pursuing an open space acquisition for the purposes of benefiting fish and wildlife resources. The acquisition parcel or property shall contain a minimum of 3.00 acres of CDFW related streambed habitat. Fees for this mitigation option shall include all or a portion of the acquisition cost, a one-time fee to cover the basic maintenance needs of the site over a five-year term as well as to conduct enhancement at the site. Enhancement shall consist of the removal of non-native vegetation, trash and debris, and signage. This one-time fee shall be determined by the third-party and presented to CDFW and an itemized manner. The minimum fee required for acquisition will be based on an estimate from the third party entity for the restoration of 3.0 acres of riparian habitat (excluding clerical fees and fees involved with reporting requirements). CDFW shall approve the entity and location of the potential acquisition prior to the finalization of any documents. In this scenario, the third party entity shall have specified land(s) to be acquired upon receipt of the fees. CDFW may require, by way of our third-party beneficiary template, to be listed as a third-party beneficiary for the acquired lands. CDFW shall approve any mechanism for the permanent protection of the site, any conditions related to the use of the site, and the future maintenance and management program/plan.

3.5 Utilizing a CDFW Approved Mitigation Bank. The Permittee has the option to purchase credits at a CDFW approved mitigation bank. If credits are purchased at the Santa Paula Creek Mitigation Bank, then a minimum 5.0 acres of riparian habitat credits must be purchased due to the preservation only nature of this bank.

3.6 Mitigation and/or Restoration Plan. If mitigation involves the active restoration and/or enhancement of an area, then a habitat mitigation and monitoring plan shall be developed for CDFW review after CDFW has approved the conceptual mitigation strategy. The plan should identify the location of the mitigation area, entities involved, goals of the mitigation, habitats to be restored or established, initial maintenance schedule, irrigation methodology (if required), and plant species to be used. Plant material shall be derived from local sources and may consist of seed mix, container stock, and cuttings and may also consist of plant material salvaged from project activities. The mitigation plan shall establish goals for the success of the mitigation/restoration efforts.

3.7 Success Criteria for Restoration. In order to deem the restoration activities complete, the site shall have met the following criteria. This includes: a) monitoring, maintenance, and reporting of the mitigation area for a period of five years, or until the mitigation efforts are deemed successful; b) if a single plant species constitutes more than 60% of the vegetative cover at the end of a three-year term, then additional efforts shall take place to create more plant diversity; c) at the end of the monitoring term, no woody invasive species shall be present, and herbaceous invasive species shall not exceed five percent cover, d) based on adjacent reference areas and the habitat types to be restored, estimated percent cover requirements shall be suggested for native vegetation to be met at the end of monitoring years three and five; d) replacement plantings shall occur for any significant plant mortality; and f) the mitigation area shall be without supplemental irrigation for a minimum period of two years. Success criteria may also be reiterated in the original habitat mitigation and monitoring plan. The Permittee has the option to suggest a separate or complementary set of success criteria through data collection of an adjacent reference site. This reference site shall be undisturbed and consist of the same habitat types to that which are being restored.

3.8 Mitigation Monitoring Reports. Annual monitoring reports shall be submitted to CDFW for a total of five years for mitigation that involves a restoration, enhancement, or creation component. In some scenarios, and with CDFW concurrence, the monitoring term may be reduced if the goals of the mitigation can be met within an agreed upon and reduced term. The first monitoring report shall be submitted one year after the completion of initial mitigation activities. Mitigation monitoring reports, at a minimum, shall include: a) survival rates for planting and seeding areas; b) percent cover of native and non-native vegetation; c) composition or diversity of plant species; d) reference any plant mortality and number of plants used for replacement in these areas; e) non-native vegetation control efforts; f) photos from designated photo stations to show the progress of the mitigation efforts; g) biologist and/or restoration ecologist recommendations for the success of the mitigation area to be implemented the following monitoring year; and h) a list of any wildlife observations at the mitigation site.

3.9 Final Mitigation Monitoring Report. After the final monitoring year, if the mitigation site has met the success criteria identified in the mitigation plan, CDFW shall request a site visit to determine if the mitigation efforts are deemed complete. The mitigation site should be free of trash and the irrigation infrastructure should be removed. If the mitigation site is deemed successful by CDFW, documentation will be submitted to the Permittee to acknowledge this.

3.10 Submittal of Observation Forms to the California Natural Diversity Database. If any special status species are observed at the project site, the Permittee or designated representative shall submit an observation form to the Natural Diversity Data Base (NDDB) within ten working days of the sightings. CDFW staff assigned to the project shall be included on any e-mail or letter that is sent for this purpose. The only exception to the above is that sensitive bird species must have a nesting or breeding component as part of the observation. Burrowing owl, due to burrowing in the winter, does not need to be verified that nesting or breeding is occurring.

3.11 Non-Native Aquatic Species Eradication Program. A qualified biologist shall remove any non-native aquatic animals from the work area as they are encountered. Target animals include bullfrog, African clawed frog, non-native turtles, and crayfish.

4. Long-Term Agreement Requirements, Reporting, and Fees

4.1 Status Reports. The California Fish and Game Code Section 1605 (g), requires Four-Year Status Reports to be submitted over the duration of the Agreement. However, this requirement can be fulfilled with the continuation of post-project reports, to be submitted each time a basin clean-out activity has been conducted. In order to comply with the California Fish and Game Code Section 1605 (g), these reports shall include the following information: a) a copy of the original Agreement, b) the status of the activity covered by the Agreement, c) an evaluation of the success or failure of the measures in the Agreement to protect the fish and wildlife resources that the activity may substantially adversely affect, d) a discussion of any factors that could increase the predicted adverse impacts on fish and wildlife resources, and a description of the resources that may be adversely affected, e) photo documentation consisting of "before and after" photos of representative work areas in which maintenance was completed with hand tools, and all areas in which work involving heavy equipment occurred. The reports shall also include, as an appendix, copies of the California Natural Diversity Database (CNDDB) observation forms completed for sightings of special status species from the period of the last report.

4.2 CDFW Actions After Report Submittal. Upon receipt of the post-project activity report, CDFW will contact Permittee to schedule, if needed, an on-site inspection by CDFW staff, to confirm that Permittee is in compliance with the terms of this Agreement, and that the Agreement is adequately protecting fish and wildlife resources. Following review of this report and the on-site inspection, and if CDFW determines that the measures in the Agreement no longer protect the fish and wildlife resources that are being substantially adversely affected by the activity, CDFW, in consultation with Permittee, and within 45 days of receipt of the report, shall impose one or more new measures to protect the fish and wildlife resources affected by the activity.

4.3 Additional Long-Term Agreement Requirements. In addition to the above requirements, pursuant to the California Fish and Game Code Section 1605 (g), the Permittee shall: a) immediately notify CDFW in writing if monitoring reveals that any of the protective measures were not implemented during project activities, or if measures will not be implemented within the time period specified, b) immediately notify CDFW if any of the protective measures are not providing the level of protection that is appropriate for the impact that is occurring, and recommendations, if any, for alternative protective measures, c) CDFW shall verify compliance with protective measures to ensure the accuracy of the Permittee mitigation, monitoring and reporting efforts. CDFW may, at its sole discretion, may review relevant documents maintained by the Permittee, interview the Permittee employees and agents, inspect the work site, and take other actions to assess compliance with, or effectiveness of, protective measures in this Agreement.

4.4 Annual Maintenance Fees. The CDFW fee schedule requires that additional fees be paid per maintenance activity per year. Therefore, the Permittee shall submit a single maintenance fee (in accordance with the current CDFW Fee Schedule) with the post-project report for the maintenance of the basins. Other maintenance activities conducted at the site, as described within this Agreement, shall require the submittal of additional maintenance fees per maintenance activity conducted.

CONTACT INFORMATION

Any communication that Permittee or CDFW submits to the other shall be in writing and any communication or documentation shall be delivered to the address below by U.S. mail, fax, or email, or to such other address as Permittee or CDFW specifies by written notice to the other.

To Permittee:
City of Los Angeles Department of Water and Power
Charles C. Holloway
111 N. Hope Avenue, Room 1044
Los Angles, CA 90012
Office (213) 367-0285
Email: charles.holloway@ladwp.com

To CDFW:
Department of Fish and Wildlife
South Coast Region
3883 Ruffin Road
San Diego, CA 92123
Attn: Lake and Streambed Alteration Program
Notification #1600-2010-0001-R5
Region 5 Streambed Alteration Program Inbox: R5LSACompliance@Wildlife.ca.gov

LIABILITY

Permittee shall be solely liable for any violations of the Agreement, whether committed by Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents or contractors and subcontractors, to complete the project or any activity related to it that the Agreement authorizes.

This Agreement does not constitute CDFW's endorsement of, or require Permittee to proceed with the project. The decision to proceed with the project is Permittee's alone.

SUSPENSION AND REVOCATION

CDFW may suspend or revoke in its entirety the Agreement if it determines that Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, is not in compliance with the Agreement.

Before CDFW suspends or revokes the Agreement, it shall provide Permittee written notice by certified or registered mail that it intends to suspend or revoke. The notice shall state the reason(s) for the proposed suspension or revocation, provide Permittee an opportunity to correct any deficiency before CDFW suspends or revokes the Agreement, and include instructions to Permittee, if necessary, including but not limited to a directive to immediately cease the specific activity or activities that caused CDFW to issue the notice.

ENFORCEMENT

Nothing in the Agreement precludes CDFW from pursuing an enforcement action against Permittee instead of, or in addition to, suspending or revoking the Agreement.

Nothing in the Agreement limits or otherwise affects CDFW's enforcement authority or that of its enforcement personnel.

OTHER LEGAL OBLIGATIONS

This Agreement does not relieve Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, from obtaining any other permits or authorizations that might be required under other federal, state, or local laws or regulations before beginning the project or an activity related to it.

This Agreement does not relieve Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, from complying with other applicable statutes in the FGC including, but not limited to, FGC sections 2050 et seq. (threatened and endangered species), 3503 (bird nests and eggs), 3503.5 (birds of prey), 5650 (water pollution), 5652 (refuse disposal into water), 5901 (fish passage), 5937 (sufficient water for fish), and 5948 (obstruction of stream).

Nothing in the Agreement authorizes Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, to trespass.

AMENDMENT

CDFW may amend the Agreement at any time during its term if CDFW determines the amendment is necessary to protect an existing fish or wildlife resource.

Permittee may amend the Agreement at any time during its term, provided the amendment is mutually agreed to in writing by CDFW and Permittee. To request an amendment, Permittee shall submit to CDFW a completed CDFW "Request to Amend Lake or Streambed Alteration" form and include with the completed form payment of the corresponding amendment fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5).

TRANSFER AND ASSIGNMENT

This Agreement may not be transferred or assigned to another entity, and any purported transfer or assignment of the Agreement to another entity shall not be valid or effective, unless the transfer or assignment is requested by Permittee in writing, as specified below, and thereafter CDFW approves the transfer or assignment in writing.

The transfer or assignment of the Agreement to another entity shall constitute a minor amendment, and therefore to request a transfer or assignment, Permittee shall submit to CDFW a completed CDFW "Request to Amend Lake or Streambed Alteration" form and include with the completed form payment of the minor amendment fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5).

EXTENSIONS

In accordance with FGC section 1605(b), Permittee may request one extension of the Agreement, provided the request is made prior to the expiration of the Agreement's term. To request an extension, Permittee shall submit to CDFW a completed CDFW "Request to Extend Lake or Streambed Alteration" form and include with the completed form payment of the extension fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5). CDFW shall process the extension request in accordance with FGC 1605(b) through (e).

If Permittee fails to submit a request to extend the Agreement prior to its expiration, Permittee must submit a new notification and notification fee before beginning or continuing the project the Agreement covers (Fish & G. Code, § 1605, subd. (f)). .

EFFECTIVE DATE

The Agreement becomes effective on the date of CDFW's signature, which shall be: 1) after Permittee's signature; 2) after CDFW complies with all applicable requirements under the California Environmental Quality Act (CEQA); and 3) after payment of the applicable FGC section 711.4 filing fee listed at http://www.CDFW.ca.gov/habcon/ceqa/ceqa_changes.html.

TERM

This Agreement shall expire on December 31st, 2027, unless it is terminated or extended before then. All provisions in the Agreement shall remain in force throughout its term. Permittee shall remain responsible for implementing any provisions specified herein to protect fish and wildlife resources after the Agreement expires or is terminated, as FGC section 1605(a)(2) requires.

AUTHORITY

If the person signing the Agreement (signatory) is doing so as a representative of Permittee, the signatory hereby acknowledges that he or she is doing so on Permittee's behalf and represents and warrants that he or she has the authority to legally bind Permittee to the provisions herein.

AUTHORIZATION

This Agreement authorizes only the project described herein. If Permittee begins or completes a project different from the project the Agreement authorizes, Permittee may be subject to civil or criminal prosecution for failing to notify CDFW in accordance with FGC section 1602.

CONCURRENCE		
The undersigned accepts and agrees to comply with all provisions contained herein.		
FOR CITY OF LOS ANGELES-DEPARTMENT OF WATER AND POWER		
Charles C. Holloway		
Charles C. Holloway		Date 9/22/2014
Title: Manager, Environmental Affairs		
FOR DEPARTMENT OF FISH AND WILDLIFE		
Christa Leard-Jackson		
Betty J. Courtney		Date November 10, 2014
Environmental Program Manager		

Prepared by: Jeff Humble, Environmental Scientist

Los Angeles Department of Water & Power

CUSTOMERS FIRST

December 27, 2019

Ms. Renee Purdy, Executive Officer
Los Angeles Region
California Regional Water Quality Control Board
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Attention: Mr. Dana Cole

Dear Mr. Cole:

Subject: 2017 Annual Monitoring Report for the Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, and Spillway Repair Work Project Water Act Section 401 Water Quality Certification (File No. 16-082)

Per your December 27, 2019 email request, please find enclosed a copy of the Annual Report for the 2017 reporting year.

The report includes:

- Overall Status of Project
- Discussion of any Monitoring Activities
- Certification Statement

If you have any questions, please contact Mr. Edgar Gomez, of the Wastewater Quality and Compliance Group, at (213) 367-4425.

Sincerely,

Katherine Rubin
Manager of Wastewater Quality and Compliance Group

EG:
Enclosure
c/enc: Mr. Edgar Gomez

Enclosure 1:

Annual Monitoring Report File No. 16-082

Los Angeles Department of Water and Power
Castaic Creek Maintenance and Elderberry Forebay Sediment Removal
2017 CWA 401 Annual Monitoring Report
File No. 16-082

A. Color Photo Documentation of Pre- and Post- Project Site Conditions

No Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, or Spillway Repair work was performed in 2017.

B. Geographical Positioning System (GPS) Coordinates Outlining the Boundary of the Project

No Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, or Spillway Repair work was performed in 2017.

C. Overall Status of Project

No Castaic Creek Maintenance, Elderberry Forebay Sediment Removal, or Spillway Repair work was performed in 2017.

Past maintenance activities have consisted of draining Elderberry Forebay, removing sediment and vegetation from the bypass channel leading into Elderberry Forebay, removal of debris and sediment from the tailrace channel and Elderberry Forebay, grading for temporary access into the bypass channel and tailrace channel, and deposition of excavated sediment and debris to designated spoil pile area. The sediment removal work in Elderberry Forebay started on October 31, 2016. In total, 480,110 cubic yards of sediment was removed from Elderberry Forebay. Work on Elderberry Forebay was completed by December 21, 2016.

Maintenance activities to remove sediment and vegetation from settling basins (Basin 1, 2, and 3) of the Castaic Creek Bypass Channel started on October 31, 2016 and was completed by December 21, 2016. A total of 2,860 cubic yards of sediment was removed from Basin 1.

In addition, the existing boat ramp into Elderberry Forebay was extended due to safety concerns with boat launching in low water elevation. Work on the boat ramp started on December 5, 2016 and was completed on December 14, 2016.

D. Copies of Revised Permits

No permits for this project were revised in 2017.

E. **Water Quality Monitoring Results**

There is no monitoring data since there was no maintenance work, or dewatering activities during 2017.

F. **Certified Statement of "No Net Loss" of Wetlands**

The maintenance work resulted in no net loss of wetlands associated with this project.

G. **Discussion of Any Monitoring Activities and Exotic Plant Control Efforts**

As required, biological monitoring has been conducted during past sediment removal work at Castaic Power Plant for the maintenance activities. Authorized biological monitors have been present during initial ground disturbance activities, exclusionary fence installation, vegetation clearing activities and invasive plant removal. Following the completion of the aforementioned activities, biological monitors have remained on site for a minimum of two days a week during the remaining maintenance work.

The primary species of concern in the project area is the endangered arroyo toad (Anaxyrus californicus). Other species of concern in the area include the two-striped garter snake (Thamnophis hammondii), southwestern pond turtle (Actinemys marmorata pallida), and the coast horned lizard (Phrynosoma coronatum). To date, no arroyo toads have been observed within or in the vicinity of a work area during monitoring activities. Two sensitive species that have been observed by biological monitors are a loggerhead shrike (Lanius ludovicianus) and a bald eagle (Haliaeetus leucocephalus). Neither of these individuals was present in the immediate vicinity of past active work areas or affected by previously performed maintenance activities.

Invasive plant species that have been identified in the vicinity of the maintenance activities that have been removed as part of the ongoing maintenance effort include giant reed (Arundo donax) and saltcedar (tamarix ramosissima).

The above monitoring activities will be conducted prior to any future maintenance activities.

H. Certification Statement

"I declare under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system or those directly responsible for gather the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Executed on the 22nd day of December, 2017, at Los Angeles, California.

Katherine Rubin

Katherine Rubin, Manager of
Wastewater Quality and Compliance

Attachment 1, Appendix C

California Department of Water Resources' Cyanotoxin Monitoring in Pyramid Lake from 2015 through 2019, and DWR's geosmin and 2-methylisoborneol [MIB] Monitoring in Pyramid Lake from 2012 through part of 2020

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ATTACHMENT 1

APPENDIX C

California Department of Water Resources' Cyanotoxin Monitoring in Pyramid Lake from 2015 through 2019, and DWR's geosmin and 2-methylisoborneol [MIB] Monitoring in Pyramid Lake from 2012 through part of 2020

Appendix C includes the California Department of Water Resources' (DWR) cyanotoxin monitoring in Pyramid Lake from 2015 through 2019 and DWR's geosmin and 2-methylisoborneol (MIB) monitoring in Pyramid Lake from 2012 through part of 2020.

Appendix C will be filed separately with the Federal Energy Regulatory Commission (FERC) as Excel files.

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Attachment 1, Appendix D

Additional Information Regarding California Department of Water Resources' Selection of Monitoring Sites for Planktonic Veliger Sampling

Zebra Mussel Early Detection and Public Outreach Program
Final Report

September 2005

by
Cindy Messer and Tanya Veldhuizen

California Department of Water Resources
Division of Environmental Services
3251 S Street
Sacramento, CA 95816

Report for:
California Bay-Delta Authority (CALFED)
and
U.S. Department of the Interior,
Fish and Wildlife Service

CBDA Project No. 99-F07,
Zebra Mussel Detection and Outreach Program

For information regarding this report or its contents, please contact:

Tanya Veldhuizen
Environmental Scientist
California Department of Water Resources
Division of Environmental Services
3251 S Street
Sacramento, CA 95817

Email: tanyav@water.ca.gov
Phone: (916) 227-2553

Acknowledgements

Many people contributed to the success of this program and to the completion of this report. Program management, report review and comments, and numerous ideas for enhancing this program were provided by Kim Webb (USFWS), Erin Williams (USFWS), Lia McLaughlin (USFWS), Jeff Herod (USFWS), David Bergendorf (USFWS) and Susan Ellis (DFG). Program management, guidance and support for this effort were provided by Steve Ford (DWR), Rich Breuer (DWR), Ted Sommer (DWR) and Zach Hymanson (formally DWR). Extensive review of earlier drafts of the rapid response plan was provided by Marion Ashe (DFG-OSPR) and Lars Anderson (UC Davis). Assistance with contracting and budgeting was provided by Gloria Pacheco (DWR). Assistance with data collection, data management and graphics was provided by Jody Sears, Eric Santos, Tom Willadson, Anthony Kwong, Alicia Seesholtz, and Chris Fox. Technical advice was provided by Dr. Robert McMahon (University of Texas at Arlington) and Toni Pennington. Funding for this program was provided by DWR and the California Bay-Delta Authority (CALFED) and administered by U.S. Fish and Wildlife Service.

A volunteer-based monitoring program could not get off the ground without the efforts of its volunteers. The authors thank the many people, agency staff and private citizens alike, who dedicated time and resources and provided access to property to help establish this program.

The authors would especially like to thank Barbara McDonnell (DWR) for her enduring support and for believing that this program will make a difference.

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Chapter 1

Introduction

Impetus for Protecting the San Francisco Estuary and the Central Valley Watershed from the Zebra Mussel

The San Francisco Estuary (Estuary), which includes San Francisco Bay, San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin Delta (Delta) is the largest estuary on the western coast of North America (Cohen and Carlton 1995). This estuary encompasses approximately 1600 square miles of waterways and drains over 40 percent of the fresh water in California (CDWR 1995). The Sacramento and San Joaquin rivers flow from inland valleys into the Delta, an elaborate system of islands, sloughs, canals and channels. Before exiting the Delta, fresh water from these rivers mixes with saline water from the bay to create a highly variable and complex aquatic habitat (Hymanson 1994). The Estuary has historically provided habitat for commercially important species such as Dungeness crab, sturgeon, striped bass, salmon, steelhead, otter, mink, fur seals and whales (Skinner 1962). Today the Estuary continues to support several commercial species such as crabs, crayfish, sturgeon, striped bass and salmon on a small scale. The freshwater portion of the Estuary provides recreational anglers and hunters with many prized game species such as sunfish, catfish, small and largemouth bass, and a variety of water fowl.

Along with its distinction as the largest estuary on the west coast of North America, this estuary is also the most highly invaded aquatic ecosystem in North America (Cohen and Carlton 1998). The Estuary has experienced 150 years of intense commercial activity that has drastically altered the ecosystem creating large areas of disturbed habitat. Since 1850, one nonnative species has been introduced every 36 weeks on average; this number increased to one species every 15 weeks starting in 1970 (Cohen and Carlton 1995, SEP 1998). In certain parts of the Estuary, entire aquatic communities are comprised of introduced species. There are an estimated 250 introduced species of aquatic animals and plants inhabiting this region (Cohen and Carlton 1995). Of these introduced species, 69% are invertebrates, 15% are fish, 12% are vascular plants, and 4% represent protists (Cohen and Carlton 1995, Dill and Cardone 1997). Non-native aquatic invertebrate species constitute one of the largest groups of organisms found in the Estuary (Nichols and Thompson 1985, Cohen and Carlton 1995). For the benthic community, it is estimated that introduced species may account for 40-100% of species found in a given community and as much as 95% of the biomass (SEP 1998). Introduced species may pose the largest threat to native biodiversity in the Estuary (SEP 1998, Mack et al. 2000).

Introduced species can impose a multitude of impacts on an aquatic ecosystem once established (Carlton et al. 1990, Noonburg 2003, Karatayev 2003). These impacts include limiting the range of competing species, reducing food resources, localized habitat alteration, accumulation of contaminants, and further disturbance of impaired aquatic systems, possibly allowing new introductions to take place (Gardner 1976, O'Neill 1996, Greenwood 2001, Mayer 2001, Vanderploeg 2001). In addition, some introduced aquatic species, such as water hyacinth (*Eichornia crassipes*), Brazilian waterweed (*Egeria densa*), cyanobacteria (*Microcystis* species), and Chinese mitten crab (*Eriocheir sinensis*), have negatively impacted municipal and recreational uses of water in this system by clogging waterways, biofouling of water intake and conveyance systems, producing biotoxins, and eating fishing bait (Pimental et al. 2000, Rudnick et al. 2000).

Because of their numerous and far-reaching effects, introduced aquatic species impact restoration, safe drinking water and water conveyance objectives in the Estuary. In recent years, the CALFED Ecosystem Restoration Program (ERP) has committed significant resources to restoring functional habitats (e.g., aquatic, riparian and floodplain habitats) within the Estuary and its tributaries for native species of fish, birds, and vegetation to thrive (CALFED 2001, 2004). These efforts have resulted in 100,000 acres of habitat being protected or restored (CALFED 2003). However, these habitats are prevented from reaching a truly restored or preserved status due, in large part, to the presence of non-native species. CALFED has also established goals for providing safe, reliable, and affordable drinking water to Californians as it comes out of the Delta (CALFED

2004). Safety and quality goals can be jeopardized by harmful algal blooms such as *Microcystis* blooms. Invasive species, such as zebra mussels, have the ability to create *Microcystis* blooms by selectively rejecting this blue-green alga while reducing competing species of green algae (Cotner et al. 1995, Gu and Mitchell 2002, Dionisio et al. 2003). Lastly, CALFED has developed goals and milestones for improving the movement of water through Delta channels and water projects while continuing to support the ecosystem (CALFED 2004). Operations of these facilities are already rigidly controlled to reduce the take of listed species, and the presence of a large population of non-native aquatic species (e.g., zebra mussels, Chinese Mitten crabs) can further hinder reliability of water exports.

The CALFED ERP has also funded monitoring, research, management-oriented and outreach projects (e.g., Purple Loosestrife Prevention, Detection and Control; Effects of Introduced Clams on the Food Supply of Bay-Delta Fishes; Evaluation of Potential Impacts of the Chinese Mitten Crab on the Benthic Community in the Sacramento-San Joaquin Delta; Non-native Invasive Species Advisory Council; and Reducing Risk of Importation and Distribution on Non-native Invasive Species through Outreach and Education) focused on reducing the negative impacts of introduced species on native species and on water conveyance reliability and quality (CALFED 2003). Collectively, these projects examined the distribution and impacts of introduced species, conducted public outreach activities, and established multi-agency committees to discuss and act cooperatively to further understand the role of introduced species in this system.

Funded by CALFED and implemented by the California Department of Water Resources (DWR), the Zebra Mussel Early-Detection and Outreach Project (ZMEDOP) began in 2000 and established an early-detection monitoring program and public outreach campaign in California's Central Valley watershed, including the Sacramento-San Joaquin Delta, for zebra mussels. The risk of zebra mussel invasion into California and subsequent impacts were documented in 1998 by Cohen and Weinstein and more recently by Drake and Bossenbroek

(2004). The potential range of zebra mussels in California is not wide-spread, but does include areas critical for native fish habitat and water storage, supply and conveyance for municipal and agricultural needs. The areas at greatest risk of invasion by zebra mussels include the Sacramento-San Joaquin Delta and the State and Federal water projects.

Zebra Mussel Life History and Distribution

The zebra mussel, *Dreissena polymorpha*, is a small (< 2 inches), freshwater mussel which usually has alternating dark and light brown stripes, but can also be solid light or dark brown. These mussels are only found in freshwater (< 2 parts per thousand salinity) usually at depths of 2 to7 meters (Berg et al. 1996, Horgan and Mills 1996, McMahon 1996). Zebra mussels can live up to four to five years and become reproductively mature within their second year. Females are capable of producing over one million eggs within a spawning season (Ram and McMahon 1996). Zebra mussels are filter feeders consuming a variety of phytoplankton and zooplankton species and can filter about one liter of water per individual per day (Bunt 1993, Sprung 1995). Like the mussels found clinging to the rocks along the California coastline, the zebra mussel attaches onto hard surfaces (e.g., pipes, screens, rock, logs, boats, etc) and form colonies made up of many individuals attached to a single object.

The zebra mussel is native to the Aral, Black, and Caspian Sea region near Russia and the Ukraine. It was first discovered in North America in Lake St. Clair, a small water body connecting Lake Huron and Lake Erie, in June 1988 (Johnson and Padilla 1996, McMahon 1996). Within months of its discovery, large numbers began to appear in Lake St. Clair and along the northern shoreline of western Lake Erie. The distribution of the zebra mussel now covers most of the Great Lakes region of the United States and Canada and the northern portion of the mid-West, and is expanding into the Eastern and Central regions (Miller and Payne 1997, 100th Meridian Initiative 2005). Scientists and resource managers have determined that zebra mussels can thrive throughout most of the

United States, including California (McMahon 1996). The Sacramento-San Joaquin Delta is prime habitat for the zebra mussel, as are other lakes and rivers in the central valley watershed (Cohen and Weinstein 1998; Drake and Bossenbroek 2004).

Initial introduction of the zebra mussel into North America was most likely from ballast water from ships originating in from freshwater European ports (Carlton 1985). The dispersal mechanism of the zebra mussel within a water body, such as the Great Lakes, includes water currents (carrying planktonic larvae called veligers), floating vegetation (transporting attached juvenile and adult mussels) and local boat and barge traffic (transporting veligers and attached mussels) (Tyus et al. 1994, Horvath 1997, Cohen and Weinstein 1998). Long-distance dispersal has mostly been due to the transport of recreational watercraft harboring: 1) veligers in residual water in live wells, bilges, bait buckets, and cooling systems; 2) adult mussels attached to hulls, anchors, intake systems and ropes; and 3) adults attached to aquatic macrophytes entangled on the trailer or boat exterior (Johnson and Padilla 1996). Boats harboring live veliger and adult zebra mussels are then either navigated or trailered to other waterbodies within and between watersheds and states.

Movement of the zebra mussel into western states has been accomplished exclusively through trailered or commercially transported recreation boats and houseboats (Padilla 1996). Under cool and humid conditions, zebra mussels can survive out of water for several days and endure the cross-country transit to California (Tyus et al. 1994, USFWS 2001). At California Stateline crossings, agricultural inspectors have discovered over 20 boats with live and dead adult zebra mussels attached to boat hulls or in the engine compartments (Susan Ellis, pers. comm.). Since May 2004, live and dead zebra mussels were discovered on three boats that were attempting to launch at Lake Mead in Nevada (Wen Baldwin, pers. comm.). California annually hosts numerous large fishing tournaments organized and/or promoted by national organizations, such as

B.A.S.S., attracting many out-of-state boaters. Trailer surveys and interviews with marina managers conducted by investigators for ZMEDOP have shown that boaters from Nevada, Oregon, and Washington are frequent visitors to California. Boats and houseboats purchased from zebra mussel-infested states are also common place here. All of these factors increase the likelihood of zebra mussel introduction into California.

Economic, Ecological, and Recreational Impacts

Impacts from zebra mussels are well documented and based on the experience of zebra mussel invasions in the United States, Canada, and Europe; they can be categorized as ecological, economic and recreational. Ecological impacts in the Estuary would include changes in water clarity and phytoplankton availability. Zebra mussels are filter feeders and remove planktonic organisms, which are essentially the basis of the aquatic food web, from the water column. Studies have shown that zebra mussels have increased water clarity in Lake Erie up to six times what it was prior to their arrival (USGS 1999). The increase in water clarity has resulted in an increase in the growth and expanse of aquatic plants many of which are also unwanted introduced pests. Zebra mussels can alter physical and chemical parameters in aquatic habitats, and accumulate contaminants (Botts et al. 1996, Johannsson 2000, Reed-Andersen 2000, Kolar et al. 2002). The alteration of the aquatic food web and aquatic habitats in the Sacramento-San Joaquin Delta and upstream environment through the establishment of the zebra mussel could negatively affect key fish species, such as Chinook salmon, delta smelt, and splittail.

Economic impacts would occur because of biofouling, a result of the mussel's ability to firmly attach to hard substrates and to form dense colonies. These colonies of mussels encrust and clog steel and concrete pipes, fish screens, water intakes, agricultural irrigation systems, and numerous other components of water storage and conveyance systems, water treatment plants and power generation plants (O'Neill 1996, Cohen and Weinstein 1998). Dense mussel colonies have reduced or stopped operations at these types of facilities. When treatment facilities conduct major eradication of zebra mussels in their infrastructure using chemical applications, localized fish kills occur and drinking water quality is impacted. In addition, mass quantities of dead mussels impart a foul taste and odor on drinking water that is detectable by consumers (O' Neill 1996, G. Smythe, pers. comm.). Zebra mussels have caused billions of dollars in damage to water intake structures and delivery systems such as those used for power and municipal water treatment plants in the eastern United States from the Great Lakes into the Mississippi drainage (Pimental et al. 1999, Pimental et al. 2005, Lovell and Stone 2005). Similar damage and operation impacts would be seen in California due to the intensive water storage and conveyance systems present (Peterson and Janik 1997).

Zebra mussels also affect vessel owners. Impacts to vessels (e.g., fishing boats, water ski boats, sailboats, houseboats, and research vessels) include attachment to hulls and outboard motors, clogging of engine cooling systems, and impairment of steering mechanisms (USFWS 2001). These impacts result in increased fuel consumption, maintenance costs, and inability to moor vessels in freshwater for long periods of time. Frequent cleaning, maintenance and replacement of motors will directly impact boaters, marinas, boat dealers, and businesses (e.g., restaurants, hotels, bait shops, and boating supply stores) in the small communities located near popular boating destinations and dependent on this recreational activity.

Potential Invasion of Western States

Scientists agree it is a matter of when, not if, zebra mussels become established in all West Coast states, including California. There is a national effort, coordinated through the 100th Meridian Initiative, to stop the spread of the zebra mussel beyond the 100th meridian. The 100th meridian is located east of the

Continental Divide, which forms a natural barrier to zebra mussel dispersal through connective waterways. Despite this effort, the zebra mussel continues to threaten the safety of the western states, because of: 1) the low level of funding to provide adequate public education, early detection monitoring, and boat cleaning education and inspections; 2) the ability of adult zebra mussels to attach onto boats and live out of water for several days; 3) the ability of zebra mussel veligers to live in boat livewells, bilge pumps, and other water reservoirs for several days; and 4) the occurrence of overland transport of boats between waterbodies and states.

Further evidence of this very real threat to California is the fact that live and dead zebra mussels have been found on boats being transported into California (K. Webb, pers. comm., S. Ellis, pers. comm.). When the agricultural inspection stations began inspecting trailered boats entering California in October 1993, inspectors found zebra mussels on a boat within six weeks (Peterson and Janik 1997). Zebra mussels have been found on 24 boats between 1993 and April 2000. This is a very high number considering that the inspections are not mandatory and the inspection stations are not open at all times. Currently, 7 out of the 16 stations are not open full-time because of California's budget crisis. With this limited line of defense, California needs to increase public awareness efforts and become vigilant about monitoring for zebra mussels. In addition, 3 boats harboring live and dead zebra mussels were found in summer 2004 attempting to launch into Lake Mead (W. Baldwin, pers. comm., 100^{th} Meridian Initiative 2005). The discoveries were made after a public education campaign began in the region a few years prior. It is unknown how many infested boats have launch into Lake Mead, or California waters for that matter, because routine inspections of high risk boats (boats originating from states that have established zebra mussel populations) does not occur.

Other West Coast states, which are currently zebra mussel-free, have taken serious steps to prevent the introduction of this species. Like California, Washington State declared the zebra mussel an injurious species. It is proactively monitoring waterbodies and has established regulations for fishing tournaments (Washington Administrative Code 232-12-168). Tournament organizers are required to inspect and certify the cleanliness of all boats and trailers before boats are launched. Boats harboring zebra mussels must undergo decontamination. Oregon is also actively monitoring for zebra mussels. Portland State University, Center for Lakes and Reservoirs (PSU-CLR) received funding to establish a volunteer-based zebra mussel monitoring system in Arizona, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming (Pennington and Sytsma 2002). Both Oregon and Washington states, with coordination from the 100th Meridian Initiative, are conducting a major campaign to educate participants of the re-enactment of the Lewis and Clark Expedition about the zebra mussel and how to prevent its spread. The bicentennial celebration and re-enactment of the expedition is occurring from 2004 though 2007, with participants boating from the zebra mussel infested waters of the Mississippi and lower Missouri rivers to the zebra mussel free waters of the upper Missouri, Snake, and Columbia rivers. Thousands of people are expected to participate in the re-enactment. Once the boaters reach the Columbia River, there is a high probability of zebra mussels being introduced into that river. Numerous boaters from Oregon and Washington visit California lakes and rivers each year, especially the easily accessible Lake Shasta. Therefore, if the zebra mussel becomes established in the Columbia River, the probability of it reaching California will be great.

Zebra Mussel Early-Detection and Outreach Project

In response to the threat of zebra mussels, the California Department of Water Resources (DWR), with funding from the California Bay-Delta Authority (CALFED), implemented a comprehensive program to protect California's Central

Valley watershed and water supply. The “Zebra Mussel Early-Detection and Outreach Project” was a multi-year project that began in 2000 and ended in 2005. The project entailed a public outreach and education program, a risk assessment for California, an early detection monitoring program, a centralized reporting system, and a rapid response plan.

The objectives of the public outreach and education program were to provide information materials to all interested parties on how to identify zebra mussels, how to prevent their introduction (e.g., how to properly clean boats), and what to do if zebra mussels were found in California. This program focused on several specific counties (Sacramento, San Joaquin, Butte, Fresno, Merced, Glen, Colusa and Tehama), but information was circulated to other areas of California.

The risk assessment involved determining which waterbodies in California had a high risk of zebra mussel establishment. High risk areas were identified by suitable zebra mussel habitat (e.g., substrate, pH, mineral availability), appropriate water temperatures for spawning, adequate food supplies, and high levels of boating activity.

Early detection monitoring was conducted at high risk waterbodies in the Central Valley watershed. Sampling consisted of suspending an artificial substrate for zebra mussels to settle onto and then checking this substrate for the presence of zebra mussels every month. The artificial substrate monitoring was conducted by private citizens, marina staff, DWR staff, and staff from other agencies.

A centralized system was established for reporting zebra mussel sightings. This system consisted of a toll-free “zebra mussel hotline”, a website, and an email address. Key information about zebra mussel sightings could be distributed via email, the Internet and phone to all necessary agencies, organizations, and facilities. A list of appropriate personnel from these agencies, organizations and facilities was compiled and continually updated as new parties expressed interest in being notified.

A rapid response plan was developed to provide guidelines for zebra mussel sighting confirmation and appropriate eradication measures. This plan provided a list of regulatory agencies to contact in the event of zebra mussel detection, outlined containment measures, and listed available control and eradication strategies.

Chapter 2

Zebra Mussel Risk Assessment: Risk of Introduction and Subsequent Establishment in Waterbodies in California's Central Valley Watershed

Introduction

The invasive zebra mussel, *Dreissena polymorpha*, poses a real threat to California's water supply, the integrity and reliability of the water conveyance systems, aquatic ecosystems, and aquatic recreation and associated economy. In response to this threat, the California Department of Water Resources, with funding from CALFED, implemented the Zebra Mussel Early Detection and Outreach Program in 1999. A component of the program was to establish an early detection monitoring program for the zebra mussel in waterbodies at risk of invasion and located in the Central Valley watershed.

The objective of the early detection monitoring program was to detect the presence of zebra mussels during the early stages of colonization in a waterbody. The benefits of early detection are increased likelihood of eradicating the population when it is small and isolated, increased feasibility of and the opportunity to control the spread of zebra mussels to other waterbodies within California, and provide an early warning system to water resource managers. To prioritize the establishment of study sites for a zebra mussel early-detection monitoring program, we evaluated waterbodies in the Central Valley for risk of inoculation and colonization of the invasive zebra mussel.

Cohen and Weinstein (1998) evaluated and rated 160 sites throughout California for their potential level of risk of colonization and abundance of zebra mussels. The level of risk was based on known zebra mussel tolerance limits for five environmental variables: salinity, dissolved calcium, pH, temperature, and dissolved oxygen, with greater weight given to calcium and pH. The waterbodies were classified as having high, moderate, or low-to-no colonization potential. Based on these criteria, Cohen and Weinstein determined 44% of the sites had high potential for colonization by zebra mussels, 2% of the sites had moderate potential, and 54% of the sites had low-to-no potential. Of the 160 sites examined, 78 were located within the Central Valley watershed. Cohen and

Weinstein concluded that the high risk sites were concentrated in three areas of the Central Valley watershed: the west side of the Sacramento Valley, the San Joaquin River and southern portion of the Sacramento-San Joaquin Delta, and the water projects with intakes located in the southern portion of the delta. Sites in the northern and central regions of the Sierra Nevada Mountains were categorized as no-to-low risk for zebra mussel colonization.

In addition to the Cohen and Weinstein report on environmental variables important for zebra mussel introduction and persistence, a thorough review of all pertinent literature on this subject was conducted and the findings summarized by Cohen (2005) for the purpose of this report (Table 2.1; Appendix A). In his report, Cohen provides a detailed discussion on calcium since it can be a critical limiting factor for zebra mussel persistence in a given waterbody.

McMahon (pers. comm.) found a correlation between the presence of the Asian clam, *Corbicula fluminea*, and the zebra mussel, indicating a similarity of environmental requirements (Table 2.2). This suggests that an established population of *C. fluminea* in a waterbody can be an indicator of environmental suitability for the zebra mussel. When the presence of *C. fluminea* is included as a predictive variable, the level of risk assigned to some waterbodies in the Central Valley by Cohen and Weinstein is too conservative. They categorized some lakes and river reaches as low risk for zebra mussel colonization, yet these same sites support *C. fluminea* populations. For example, Lake Don Pedro, Lake Almanor, Millerton Lake, Folsom Lake and Shasta Lake were categorized as low-to-no risk for zebra mussel establishment. These same lakes and reservoirs all support *C. fluminea* populations. Given the widespread geographic distribution of *C. fluminea* in the Central Valley, the potential distribution of zebra mussels could be greater than predicted by Cohen and Weinstein.

An important factor for an early detection monitoring program is predicting where zebra mussels will first appear. Given that the primary vector of the zebra

Table 2.1. Distribution and/or survival of zebra mussels based on environmental requirements (adapted from Cohen 2005, Cohen and Weinstein 1998, O'Neill 1996, McMahon 1996 and 1991).

	High	Moderate	Low	Low - None
Salinity (ppt or mg/l)	<4-8 ppt (adults); <6 ppt (veligers) (McMahon) <2 ppt (Cohen/Weinstein) 0-1 ppt (O'Neill) <5 mg/l (Cohen)	2-8 ppt (stable env.) (Cohen/Weinstein) 1-4 ppt (O'Neill) 5-10 mg/l (Cohen)	2-8 ppt (rapid changes) (Cohen/Weinstein) 4-10 ppt (O'Neill) >10 mg/l (Cohen)	>8 ppt (Cohen/Weinstein) >10 ppt (O'Neill) >10 mg/l (Cohen)
Water Temp (°C) (Lower Limit)	10 – 26 (larval fertilization/development) (McMahon) >15 s (Cohen/Weinstein) 16 - 25 (Cohen)	0 - 15 (Cohen/Weinstein) 12 – 16 (Cohen)	<10 (Cohen/Weinstein) 9 - 15 (O'Neill) 6 – 10 (Cohen)	<8 (O'Neill) 0 – 6 (Cohen)
Water Temp (°C) (Higher Limit)	12-24 (McMahon) 15 - 31 and 10 ≤ (max) ≤31 (Cohen/Weinstein) 18-25 (O'Neill) 15 - 24 (Cohen)	10-26 (McMahon) 0 - 15 and 10 ≤ (max) ≤31 (Cohen/Weinstein) 25-28 (O'Neill) 25 (Cohen)	28-30 (O'Neill) >28 (Cohen)	>30 (McMahon) (max)<10 or >31 (Cohen/Weinstein) >30 (O'Neill) >30 (Cohen)
Calcium (mg/l)	≥25 (adults) ≥34 (veligers) (McMahon) >25 (Cohen/Weinstein) 25 - >125 (O'Neill) >20 (Cohen)	15-25 (Cohen/Weinstein) 20-25(O'Neill)	15 (lower limit adults) 12 (lower limit veligers) (McMahon) <15 (Cohen/Weinstein) 9-20 (O'Neill) 12 – 15 (lower limit) (Cohen)	<9 (O'Neill)
pH	≥ 6.5, >8 (adults) 7.4 – 9.4, optimal 8.4 (veligers) (McMahon) 7.5 - 8.7 (Cohen/Weinstein) 7.5 – 8.7 (O'Neill) 7.4 – 9.4, optimal 8.4 (Cohen)	7.3 – 7.5 or 8.7 – 9.0 (Cohen/Weinstein) 7.2 – 7.5 or 8.7 – 9.0 (O'Neill)	<7.3 or >9.0 (Cohen/Weinstein) 6.5 – 7.2 or 9.0 (O'Neill) 6.5 - 7.3 or 9.0-9.5 (Cohen)	<6.5 or >9 (O'Neill) <6.5 or >9.5 (Cohen)

Table 2.1, continued. Distribution and/or survival of zebra mussels based on environmental requirements (adapted from Cohen 2005, Cohen and Weinstein 1998, O'Neill 1996, McMahon 1996 and 1991).

	High	Moderate	Low	Low - None
Dissolved Oxygen (mg/l)	>8 (Cohen/Weinstein) 8 – 10 (O'Neill) >6 (Cohen)	6 – 8 (Cohen/Weinstein) 6 – 8 (O'Neill) 4 - 6 (Cohen)	<6 (Cohen/Weinstein) 4 – 6 (O'Neill) 0 – 4 (Cohen)	 <4 (O'Neill) ≤1.5 or 4 @ 18 ^{o}C (lethal to adults) (Cohen)
Velocity (m/sec)	0.1 – 1.0 (Cohen/Weinstein, Cohen) 0.1 – 1.0 (O'Neill)	>1.0 – 1.5 (Cohen/Weinstein, Cohen) 0.09 – 0.1 or 1.0 – 1.25 (O'Neill)	>1.5 – 2.0 (Cohen/Weinstein, Cohen) 0.075 – 0.09 or 1.25 – 1.5 (O'Neill)	>1.5 – 2.0 (Cohen/Weinstein, Cohen) >0.075 or >1.5 (O'Neill)
Total Hardness (mg $CaCO_3$/l)	90 - >125 (O'Neill)	45 – 90 (O'Neill)	25 – 45 (O'Neill)	<25 (O'Neill)
Turbidity (NTU)	Upper limit unknown, >160 (McMahon) 40 – 200 (O'Neill)	20 – 40 (O'Neill)	10 – 20 or 200 - 250 (O'Neill)	<10 or > 250 (O'Neill)
Conductivity (µSiemens)	83 - >110 (O'Neill)	37 – 82 (O'Neill)	22-36 (O'Neill)	<22 (O'Neill)
Substrate	Hard substrates needed for settlement. Can settle on sticks, logs, shells, vegetation and other mussels. (Cohen)	Not available	Not available	Not available
Size and Depth of Waterbody	Well oxygenated, moderately eutrophic lakes, slow changes in salinity and temperature. (McMahon) Highly dependant on lake depth and hardness. More common in relatively large and deep lakes with low to moderate levels of algae and nutrients. (Cohen)	Small, shallow and productive lakes (<0.3 km^2). (Cohen)	Not available	Not available
Nutrients (µm)	< 1µm up to planktonic rotifers and crustaceans (adults) Algae 1-4 µm in diameter (veligers) Algal concentration req. 0.1 – 0.7 mg C liter $^{-1}$ (depending on age/size) (McMahon) Moderate levels of nutrients needed for successful population. (Cohen)	Not available	Not available	Not available

Table 2.2. Environmental requirements and life history traits for *Corbicula fluminea* and *Dreissena polymorpha* (adapted from Gleason 1984, McMahon 1991, Hornbach 1992, O'Neill 1996, and Karatayev 2003).

	Corbicula fluminea	***Dreissena polymorpha***
Water Temperature (^oC) (upper limit)	36	30
Water Temperature (^oC) (lower limit)	2	10
Spawning Temperature (^oC)	18 - 35	12 - 30
Calcium (mg/l)	2	>25
Salinity (ppt)	Up to 10-14 (will survive long-term exposure at this level)	2 - 8
Velocity (m/sec)	1.2 – 1.5 (optimal for settling juveniles)	0.1 – 1.0 (optimal for growth of juveniles)
Depth (meters)	Up to 12m if deeper water is well oxygenated	Shallow (≤2m), adults can occur up to 60m if well oxygenated
pH	≥7	7.5 – 8.7
Dissolved Oxygen (mg/l)	>6	>6
Habitat	Unstable conditions, higher velocity, tolerates rapid changes in salinity, highly oxygenated areas	Stable conditions, moderate velocity, stable salinity, highly oxygenated areas
Substrate	Unstable (clean sand, mud, gravel)	Stable, hard substrates (includes aquatic vegetation, other mussels)
Feeding	Filter feed or pedal feed	Filter feed only
Life span (years)	1-5	4-7
Age at Maturity (years)	0.25 – 0.75	1-2
Reproductive Mode	Hemaphroditic	Gonochoristic
Fecundity (average # young/ adult/breeding season)	35,000	30,000 -40,000/female
Juvenile size at release	250µm (w/shell formed)	40-70 µm (planktonic)
Relative juvenile survivorship	Extremely low	Extremely low
Relative adult survivorship	2 - 41%/year (low)	26 – 88%/year (moderate)
# reproductive efforts/year	2	1 (2-8 months long)

mussel is overland transport of recreational vessels harboring live zebra mussels (Strayer 1991, Carlton 1993), the zebra mussel will most likely be introduced into waterbodies that are popular boating destinations. Waterbodies that are popular with boaters are at higher risk of zebra mussel invasion than waterbodies that are less popular or have boating restrictions, primarily because of the increase in potential inoculation frequency. The risk of inoculation greatly increases for waterbodies that are frequented by boaters that visit waterbodies in States with established zebra mussel populations or States that are at high risk for invasion by zebra mussels (i.e., states located within the Colorado and Columbia River basins). Cohen and Weinstein did not use potential inoculation frequency or boater popularity in their evaluation.

For this assessment, we evaluated waterbodies in the Central Valley watershed for risk of zebra mussel invasion. We based risk on zebra mussel inoculation frequency and habitat suitability. This information was used to prioritize the establishment of study sites for a zebra mussel early detection monitoring program.

Methods

The study area was restricted to reservoirs, lakes and rivers located in the Central Valley watershed of California. The Central Valley watershed extends from Shasta and Trinity counties in the north, the western slope of the Sierra Nevada Mountain Range, the eastern slope of the coast range, and San Joaquin County to the south, and drains into the Sacramento-San Joaquin Delta. We evaluated 68 waterbodies within the watershed, including 46 waterbodies previously evaluated by Cohen and Weinstein.

The waterbodies were evaluated to determine the probability of zebra mussel introduction and the ability of the zebra mussel to become established in a particular waterbody. The probability was categorized as high, moderate,

moderate to low, low, low to none, and none. Risk of introduction and establishment was based on five criteria. These criteria were:

1) risk of introduction/inoculation based on the popularity of the waterbody with boaters;
2) risk of introduction/inoculation based on the popularity of the waterbody with out-of-state resident boaters;
3) risk of colonization based on water chemistry as provided in the report by Cohen and Weinstein (1998);
4) risk of colonization based on water chemistry collected from other data sources or extrapolated from Cohen and Weinstein (1998); and
5) risk of colonization based on the presence of *C. fluminea*.

Greater weight was given to boater popularity and presence of C. fluminea, because of the uncertainty around the water chemistry requirements of the zebra mussel.

The popularity of a waterbody was used to estimate the frequency of inoculation. The overall popularity of a waterbody was based on level of boater usage, number of boat ramps, number and size of marinas, availability of houseboat rentals, number of fishing tournaments, length of boating season, and boating restrictions. Information was obtained through site visits, interviews with regional staff, internet research, and boat trailer counts.

Because data on interstate waterbody usage is unavailable, we used out-of-state boater popularity as a surrogate for translocation of zebra mussels between invaded and zebra mussel-free areas. Out-of-state boater popularity was used to estimate potential inoculation frequency from boats coming from states with established zebra mussel populations. Out-of-state boater popularity was based on:

1) the percentage of boat trailers with out-of-state license plates;
2) the scale (local, regional, national) and number of fishing tournaments; and

3) the relative amount of out-of-state residents compared to California residents using the waterbody according to local staff.

The data were gathered from interviews with regional staff, internet research, and boat trailer license plate surveys. We assumed that waterbodies with national fishing tournaments received more out-of-state boaters than waterbodies with local tournaments or no tournaments. At some waterbodies, we counted the number of boat trailers parked at a launch site by State of origin. The State of origin was determined by the license plate. Through these counts, we determined the percent of out-of-state boaters using the waterbody.

Risk of colonization was based on water chemistry requirements of the zebra mussel, as presented by McMahon (1996), O'Neill (1996), Cohen and Weinstein (1998) and Cohen (2005) (Table 2.1). We utilized risk level categories presented by Cohen and Weinstein (1998) for most of the waterbodies. We also utilized other sources of water quality data and information such as expert opinions of DWR water quality monitoring staff and other regional agency staff. For sites not evaluated by Cohen and Weinstein, we extrapolated the water quality data and ranking provided in Cohen and Weinstein (1998) for waterbodies sharing the same water source, where feasible. For example, risk level based on water chemistry at Lake McClure, a reservoir on the Merced River, was extrapolated from Cohen and Weinstein's assessment of the Merced River.

The presence of *C. fluminea* in a waterbody was determined by visual surveys (presence of live or dead clams in shallow water or along the shoreline), interviews with regional staff, and published reports of *C. fluminea* distribution in California (Eng 1977, Thompson pers. comm.).

Results

We evaluated 68 waterbodies in the Central Valley watershed for risk of zebra mussel introduction and subsequent establishment. We determined that 8 waterbodies were at high risk, 13 were at moderate risk, 10 were at moderate to low risk, 23 were at low risk, 7 were at no to low risk, and 7 were at no risk (Table 2.3).

Waterbodies ranked as high risk for inoculation and establishment of zebra mussels were popular boating destinations for California resident and out-of-state boaters. Most of the sites had confirmed populations of *C. fluminea*. These 6 sites were Clear Lake, New Bullards Bar Reservoir, Sacramento-San Joaquin Delta, Shasta Lake, Trinity Lake, and Whiskeytown Reservoir.

Eighteen waterbodies ranked as moderate risk; these were Antelope Lake, Black Butte Reservoir, Camanche Reservoir, Collins Lake, Englebright Lake, Folsom Lake, Lake Almanor, Lake Berryessa, Lake Davis, Lake Don Pedro, Lake McClure, Lake Natoma, Lake Oroville, Millerton Lake, New Hogan Reservoir, Pardee Reservoir, Sacramento River, and San Luis Reservoir. California resident boater popularity was high to moderate, while out-of-state boater popularity was moderate to low. The presence of *C. fluminea* was confirmed at most of these waterbodies.

Moderate to low risk waterbodies had high to moderate-low levels of usage from California resident boaters, but had low levels of usage from out-of-state boaters. Five of the 6 sites had established populations of *C. fluminea*. Sites within this ranking included American River, East Park Reservoir, Feather River, Frenchmen Lake, Lake Del Valle, and Stony Gorge Reservoir.

Waterbodies that had relatively low levels of boater activity were ranked as low risk. The 23 sites were Bethany Reservoir, Bucks Lake, Butt Valley Reservoir,

Table 2.3. Survey results and risk categorization for Central Valley waterbodies. (*) indicates waterbodies not evaluated in Cohen and Weinstein (1998). (--) indicates risk level from Cohen and Weinstein (1998) was used.

Waterbody	Risk Level - colonization based on H2O chemistry (Cohen and Weinstein 1998)	Risk Level - colonization based on H2O chemistry (other data sources)	Risk Level - colonization based on presence of *Corbicula fluminea*	Risk Level - inoculation based on CA-resident boater popularity	Risk Level - inoculation based on out-of-state boater popularity	Overall Level of Risk-inoculation and colonization
American River	low-to-no	--	yes	high	low	moderate-low
Antelope Lake	low-to-no	--	unknown	moderate	moderate	moderate
Bethany Reservoir	*	high	yes	low	low	low
Black Butte Lake	high	--	yes	moderate	low	moderate
Bucks Lake	*	moderate	native species present, *C. fluminea* presence unknown	low	low	low
Butt Valley Reservoir	*	low	unknown	moderate-low	low	low
Butte Creek	low-to-no	--	unknown	low-none	low-none	low-none
Cache Creek	high	--	unknown	low-none	low-none	low-none
California Aqueduct	high	--	yes	none	none	none
Camanche Reservoir	low-to-no	--	unknown	high	moderate-low	moderate
Cherry Lake	*	unavailable	unknown	low	low	low
Chowchilla River below dam	high	--	unknown	none	none	low-none
Clear Lake	high	--	yes	high	moderate	high
Clifton Court Forebay	high	--	yes	none	none	none
Collins Lake	*	unavailable	yes	moderate	moderate-low	moderate
Contra Loma Reservoir	high	--	unknown	low	low	low

Table 2.3, continued. Survey results and risk categorization for Central Valley waterbodies. (*) indicates waterbodies not evaluated in Cohen and Weinstein (1998). (--) indicates risk level from Cohen and Weinstein (1998) was used.

Waterbody	**Risk Level - colonization based on H2O chemistry (Cohen and Weinstein 1998)**	**Risk Level - colonization based on H2O chemistry (other data sources)**	**Risk Level - colonization based on presence of *Corbicula fluminea***	**Risk Level - inoculation based on CA-resident boater popularity**	**Risk Level - inoculation based on out-of-state boater popularity**	**Overall Level of Risk- inoculation and colonization**
Cosumnes River	low-to-no	--	yes	low	low	low
Delta Mendota Canal	high	--	yes	none	none	none
East Park Reservoir	*	high	yes	moderate-low	low	moderate-low
Eastman Lake	*	high	unknown	low	low	low
Englebright Lake	*	low-to-no	unknown	moderate	low	moderate
Feather River	low-to-no	--	yes	high	low	moderate-low
Folsom Lake	low-to-no	--	yes	high	moderate-low	moderate
Frenchman Lake	low-to-no	--	unknown	moderate-low	unknown	moderate-low
Fresno River	moderate	--	unknown	none	none	low-none
Friant-Kern Canal	low-to-no	--	unknown	none	none	none
Hensley Lake	*	moderate	unknown	low	low	low
Hetch Hetchy Reservoir	low-to-no	--	unknown	none	none	none
Indian Valley Reservoir	high	--	yes	low	low	low
Keswick Reservoir	*	low	unknown	low	unknown	low
Lake Almanor	low-to-no	--	yes	moderate	moderate	moderate
Lake Berryessa	moderate	--	yes	high	moderate-low	moderate

Table 2.3, continued. Survey results and risk categorization for Central Valley waterbodies. (*) indicates waterbodies not evaluated in Cohen and Weinstein (1998). (--) indicates risk level from Cohen and Weinstein (1998) was used.

Waterbody	Risk Level - colonization based on H2O chemistry (Cohen and Weinstein 1998)	Risk Level - colonization based on H2O chemistry (other data sources)	Risk Level - colonization based on presence of *Corbicula fluminea*	Risk Level - inoculation based on CA-resident boater popularity	Risk Level - inoculation based on out-of-state boater popularity	Overall Level of Risk-inoculation and colonization
Lake Davis	low-to-no	moderate	unknown	moderate	moderate	moderate
Lake Del Valle	high	--	yes	high	low	moderate-low
Lake Don Pedro	low-to-no	--	yes	high	moderate-low	moderate
Lake Eleanor	*	low-to-no	unknown	none	none	low-none
Lake McClure	*	low-to-no	yes	moderate	low	moderate
Lake Natoma	low-to-no	--	yes	high	moderate-low	moderate
Lake Oroville	*	moderate	yes	high	moderate-low	moderate
Lewiston Lake	*	low	unknown	low	low	low
Little Grass Valley Reservoir	*	moderate	unknown	low	low	low
Mariposa Reservoir	high	--	unknown	low-none	none	low-none
Merced River	low-to-no	--	yes	low	low	low
Millerton Lake	low-to-no	--	yes	high	moderate-low	moderate
Mokelumne River	low-to-no	--	yes	low	low	low
New Bullards Bar Reservoir	*	low-to-no	unknown	high	moderate	high
New Hogan Reservoir	*	moderate	yes	moderate	low	moderate
North Bay Aqueduct @ Barker Slough	high	--	yes	none	none	none

Table 2.3, continued. Survey results and risk categorization for Central Valley waterbodies. (*) indicates waterbodies not evaluated in Cohen and Weinstein (1998). (--) indicates risk level from Cohen and Weinstein (1998) was used.

Waterbody	**Risk Level - colonization based on H2O chemistry (Cohen and Weinstein 1998)**	**Risk Level - colonization based on H2O chemistry (other data sources)**	**Risk Level - colonization based on presence of *Corbicula fluminea***	**Risk Level - inoculation based on CA-resident boater popularity**	**Risk Level - inoculation based on out-of-state boater popularity**	**Overall Level of Risk-inoculation and colonization**
O'Neill Forebay	*	high	yes	low	low	low
Pardee Reservoir	low-to-no	--	unknown	moderate	low	moderate
Putah Creek below Monticello Dam	high	--	unknown	low	low	low
Sacramento River	low-to-no	--	yes	high	moderate-low	moderate
Sacramento-San Joaquin Delta	ranges from low to high	high	yes	high	moderate	high
San Joaquin River @ Friant Dam	low-to-no	--	unknown	low	low	low
San Luis Reservoir	high	--	yes	moderate	low	moderate
Shasta Lake	low-to-no	--	yes	high	high	high
Sly Creek Reservoir	*	moderate	unknown	low	low	low
South Bay Aqueduct	high	--	yes	none	none	none
Spicer Meadow Reservoir	*	moderate	unknown	low	low	low
Stanislaus River @ Ripon	low-to-no	--	yes	low	low	low
Stanislaus River, middle fork	low-to-no	--	unknown	low	unknown	low
Stony Gorge Reservoir	*	high	yes	moderate-low	low	moderate-low
Thermolito Afterbay	low-to-no	moderate	yes	low	low	low
Thomes Creek	low-to-no	--	unknown	none	none	low-none

Table 2.3, continued. Survey results and risk categorization for Central Valley waterbodies. (*) indicates waterbodies not evaluated in Cohen and Weinstein (1998). (--) indicates risk level from Cohen and Weinstein (1998) was used.

Waterbody	**Risk Level - colonization based on H2O chemistry (Cohen and Weinstein 1998)**	**Risk Level - colonization based on H2O chemistry (other data sources)**	**Risk Level - colonization based on presence of *Corbicula fluminea***	**Risk Level - inoculation based on CA-resident boater popularity**	**Risk Level - inoculation based on out-of-state boater popularity**	**Overall Level of Risk- inoculation and colonization**
Tracy Fish Collection Facility	high	--	yes	none	none	none
Trinity Lake	*	high	yes	high	high	high
Whiskeytown Reservoir	low-to-no	--	unknown	high	moderate	high
Yuba River, lower	low-to-no	--	unknown	low	low	low

Cherry Lake, Contra Loma Reservoir, Cosumnes River, Eastman Lake, Hensley Lake, Indian Valley Reservoir, Keswick Reservoir, Lewiston Lake, Little Grass Reservoir, Merced River, Mokelumne River, O’Neill Forebay, Putah Creek below Monticello Dam, San Joaquin River below Friant Dam, Spicer Meadow Reservoir, middle fork of the Stanislaus River, Stanislaus River at Ripon, Sly Creek Reservoir, Thermolito Afterbay, and lower Yuba River.

Seven waterbodies were at low to no risk of inoculation and subsequent establishment, because the water was too shallow for motorized-boating or there was no accessibility (i.e., lack of roads and boat ramps). These waterbodies were Butte Creek, Cache Creek, Chowchilla River below dam, Fresno River, Lake Eleanor, Mariposa Reservoir, and Thomes Creek.

Eight waterbodies were at no risk of inoculation of zebra mussels because boating was not permitted. These sites were California Aqueduct, Clifton Court Forebay, Delta Mendota Canal, Fraint-Kern Canal, Hetch Hetchy Reservoir, North Bay Aqueduct at Barker Slough, South Bay Aqueduct, and Tracy Fish Collection Facility.

In addition to the 68 waterbodies within the Central Valley watershed evaluated, we also evaluated 3 sites outside of this watershed. These were Eagle Lake, San Antonio Reservoir, and San Leandro Reservoir (Table 2.4). These waterbodies were evaluated because of their proximity to sites slated for evaluation within the Central Valley watershed. Eagle Lake was at high risk of inoculation of zebra mussels due to its popularity with out-of-state and California boaters. San Leandro and San Antonio Reservoirs were at no risk of inoculation of zebra mussels because boating was not permitted at either site.

Table 2.4. Survey results and risk categorization for waterbodies outside of the Central Valley watershed. (--) indicates risk level from Cohen and Weinstein (1998) was used.

Waterbody	**Risk Level - colonization based on H2O chemistry (Cohen and Weinstein 1998)**	**Risk Level - colonization based on H2O chemistry (other info sources)**	**Risk Level - inoculation based on CA-resident boater popularity**	**Risk Level - inoculation based on out-of-state boater popularity**	**Overall Level of Risk- inoculation and colonization**
Eagle Lake	low-to-no	high	high	high	high
San Antonio Reservoir	high	--	none	none	none
San Leandro Reservoir	high	--	none	none	none

We conducted boat trailer surveys at 17 sites (Table 2.5). Based on these surveys, out-of-state boater percentages ranged from 24% to 0% depending on the waterbody surveyed. Shasta Lake had the highest percent of out-of-state boaters (24%) and the highest number of states of origin (4). Total counts

Table 2.5. Popularity of selected waterbodies with out-of-state boaters based on boat trailer license plate counts.

Waterbody	Total boats	California boats	out-of-state boats	% out-of-state boats
Bullards Bar Reservoir	19	18	1	5
Camanche Reservoir	10	10	0	0
Collins Lake	58	57	1	2
Don Pedro Lake	74	74	0	0
Englebright Dam	17	17	0	0
Lake Almanor	10	8	2	20
Lake Berryessa	30	29	1	3
Lake Del Valle	7	7	0	0
Lake Oroville	18	18	0	0
Little Grass Valley Reservoir	5	5	0	0
Millerton Lake	18	18	0	0
New Hogan Reservoir	21	20	1	4.7
Pardee Reservoir	20	20	0	0
Sacramento River (at Red Bluff)	5	5	0	0
San Luis Reservoir	6	6	0	0
Shasta Lake	189	152	37	24
Trinity Lake	4	4	0	0

ranged from 189 trailers at Shasta Lake to 4 trailers at Trinity Lake. States of origin for out-of-state boaters were Arizona, Colorado, Minnesota, Montana, Nevada, Oregon, and Washington (Table 2.6).

Table 2.6. Number of out-of-state boats by waterbody and State.

Waterbody	Arizona	Colorado	Minnesota	Montana	Nevada	Oregon	Washington	Total out-of-state boats
Bullards Bar Reservoir	0	0	0	0	1	0	0	1
Collins Lake	0	0	0	0	1	0	0	1
Lake Almanor	0	0	0	0	2	0	0	2
Lake Berryessa	0	0	1	0	0	0	0	1
New Hogan Reservoir	0	1	0	0	0	0	0	1
Shasta Lake	3	0	0	1	0	23	10	37

Discussion

Cohen and Weinstein did not use potential inoculation frequency in their evaluation. Based on our criteria, some of Cohen and Weinstein's high risk sites are at low risk for introduction because of boater restrictions. For example, San Leandro and San Antonio Reservoirs were ranked as high risk by Cohen and Weinstein. However, the risk of inoculation is extremely low because aquatic recreation, including boating, is not permitted at these reservoirs.

Waterbodies on eastern slope of the coast range had high mineral content appropriate for zebra mussels, but boater popularity was relatively low and tended to be frequented by local residents, with the exception of Clear Lake. Because of the relatively low boater usage, these sites were ranked as moderate, moderate to low, or low risk. Clear Lake attracted out-of-state boaters with its world class fishing and nationally advertised fishing tournaments; therefore it is at high risk for zebra mussel inoculation and establishment.

Waterbodies on the western slope of the Sierra Nevada Mountains had less suitable water chemistry compared to coastal range lakes due to lower water temperatures, lower eutrophication, and lower primary production (Cohen and Weinstein 1998). However, boater popularity, including out-of-state boater popularity, was relatively higher at most of these sites. Shasta Lake, Trinity Lake, and Whiskeytown Reservoir were frequented by boaters from Oregon and Washington, while Lake Almanor, New Bullards Bar Reservoir, and Englebright Reservoir were visited by boaters from Nevada.

Zebra mussel inoculation potential was based on preliminary estimates of boater popularity. However, these data were not readily available or did not exist prior to our assessment. To accurately determine risk of zebra mussel inoculation, we recommend conducting an expansive boater survey at each waterbody.

Not all waterbodies had evidence of *C. fluminea* populations, such as Bucks Lake and Whiskeytown Reservoir. Additional sampling is recommended for these sites to confirm the presence or absence of *C. fluminea*. Current distributional information on C. fluminea is very limited and not readily available in the published literature, especially for rivers and reservoirs. An intensive field study is required to produce this data.

Although many sites were not considered high risk for zebra mussel inoculation and establishment based on our assessment criteria, this does not mean that the waterbody could not support a zebra mussel population. The majority of these sites could support zebra mussels; however, the population may come from upstream sources. For example, no boating is allowed in the Delta Mendota Canal and California Aqueduct so risk of inoculation is low. However, these aqueducts provide prime habitat for zebra mussels. If zebra mussels become established in the Sacramento-San Joaquin Delta, larval zebra mussels would be transported into the aqueducts. Larval mussels would also be transported into downstream diversions and reservoirs (e.g., Bethany and San Luis Reservoirs, South Bay Aqueduct, Lake Del Valle), irrigation canals, and drinking water treatment plants. While these sites were not a high priority for installing early detection monitors in this phase of the program, we strongly recommend that these areas be monitored.

Chapter 3

Zebra Mussel Early Detection Monitoring Program

Purpose and Benefits of Early Detection Monitoring

The objective of field monitoring is to detect zebra mussels during the initial stage of establishment. To increase the possibility of eradicating zebra mussels from a waterbody, control measures should be implemented while the population is small and isolated. Early detection of zebra mussel populations is the key to successful eradication. The ability to successfully eradicate or control an infestation of zebra mussels is more feasible and less costly if the population is isolated to a single lake as opposed to widespread in the watershed. Therefore, containing new zebra mussel populations is extremely important.

Early detection provides water facility and power generation managers with an early warning system. They would have some time to retrofit facilities to ensure uninterrupted water and power deliveries. Facility managers will need to change facility operating procedures to adapt to and minimize the impacts of zebra mussels. Such measures may include retrofitting intake valves with customized filters designed to screen out mussels, painting irritant coatings on surfaces to prevent mussels from settling, periodically flushing the system with high concentrations of chemicals (such as chlorine) to kill attached mussels, or periodically pressure washing all surfaces with hot water to kill and remove attached mussels (O'Neill 1996). All of these measures are very costly and may require temporary facility shutdowns.

Early detection of zebra mussels is also useful for resource managers, including those responsible for recreational activities such as fishing and boating. The early detection of zebra mussels provides managers with time to initiate rapid response actions, including establishing inspection and cleaning stations for boats leaving the infected waterbody. These actions will be necessary to prevent spread of zebra mussels into other areas. Private marina operators will also be alerted and given adequate time to prepare for additional maintenance and inspection activities associated with the presence of zebra mussels.

Field monitoring in California is part of a network of early detection monitoring programs taking place in the western United States. Other states included in this network are Arizona, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming (Pennington and Sytsma 2002). By forming this network, neighboring states can provide each other with early warning of zebra mussel presence, thus allowing states not yet infested to increase monitoring activities and border inspections and prepare for rapid response actions.

Overview of the Monitoring Program

The monitoring program for California consisted of sampling for settling veliger (juvenile) and adult zebra mussels using a substrate sampling device (described below) and visually inspecting structures present within the waterbody. This was a volunteer-based program that utilized federal, state and local agency staff as well as private marina staff to monitor for zebra mussels. ZMEDOP staff monitored sites in the Sacramento-San Joaquin Delta. Volunteers monitored sites in the other waterbodies. Monitoring took place at 49 sites in 28 waterbodies within the Central Valley watershed (Figure 3.1). Monitoring occurred year-round at most sites. Sites that were subject to freezing, becoming snow-bound, or otherwise closed in the winter months, were monitored late spring through fall. Substrate sampling devices were visually inspected monthly (where possible) and results reported via faxed or mailed datasheets, email, or phone. Collaboration was formed during 2004 between the DWR program and Portland State University's Center for Lakes and Reservoirs' program to expand monitoring in California to areas outside of the Central Valley watershed.

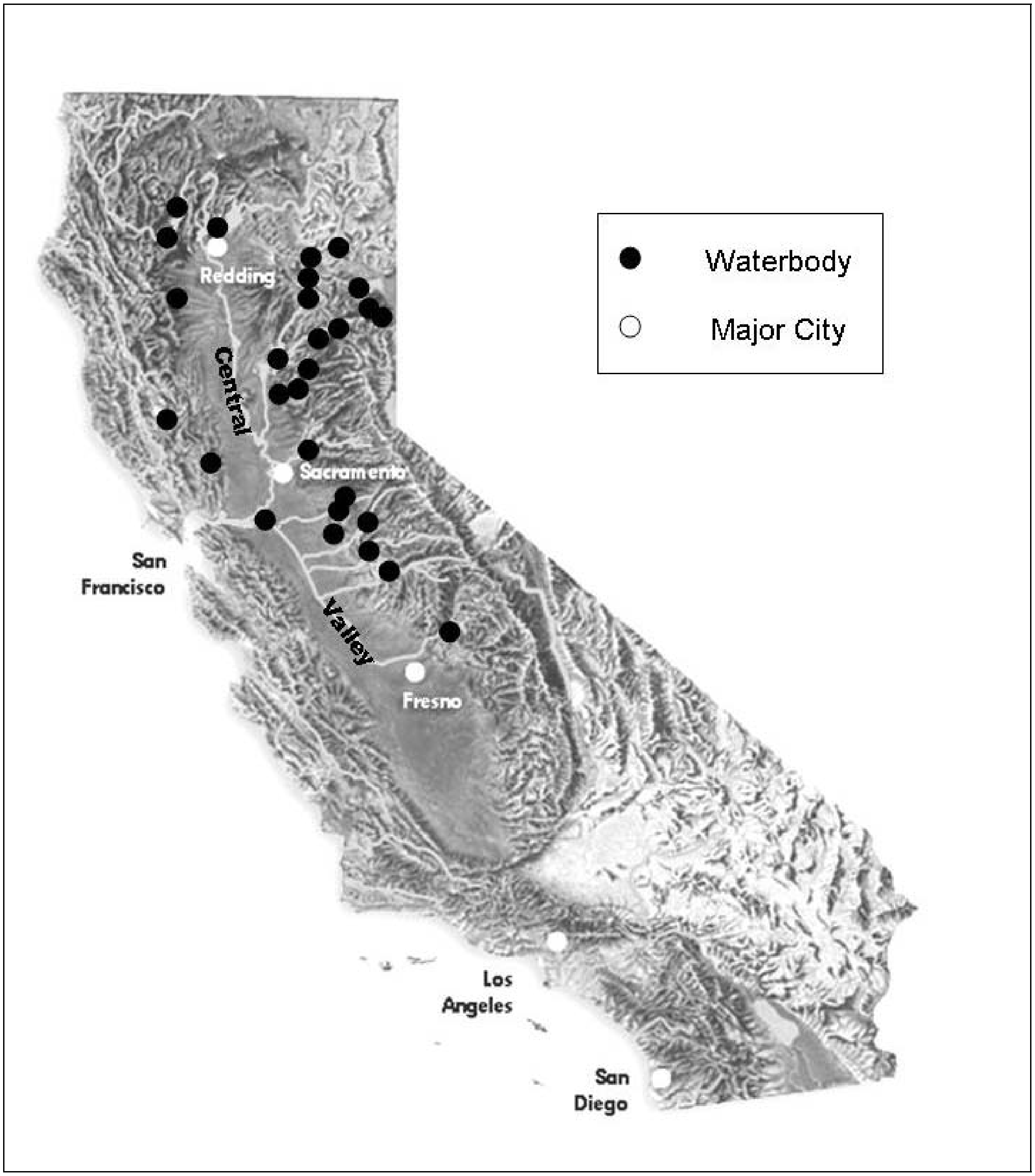


Figure 3.1. Map of waterbodies that contain zebra mussel early detection monitoring sites.

Description of Sampling Device

The design of the zebra mussel substrate sampling device was based on sampling gear used by other zebra mussel monitoring programs (USACE 1992, USACE 1994, Marsden 1992, Pennington and Sytsma 2002). The sampling device consisted of two white Polyvinylchloride (PVC) tubes (2x8 inch) and a clear acrylic plate (6x6 inch) (Figure 3.2). Each PVC tube was constructed from 2-inch diameter Schedule 40 PVC and was 8-inches long. Multiple holes (½-inch diameter) were drilled into the PVC for water circulation. Each tube contained white or cream-colored tulle fabric (4 x 6 inches), a stiff nylon open-mesh fabric, secured in place with a ziptie at each end of the tube to keep the fabric from floating out of the tube. The top PVC tube was 1 m (3 ft) below the surface. The lower PVC tube was 1 m (3 ft) below the top PVC tube. The acrylic plate was 1 m (3 ft) below the lower PVC tube. A lead weight (8 to 12 ounces) was secured at the end of the sampling line. The lowest sampling component was a minimum of 0.66 m (2 ft) above the bottom substrate. The entire device was secured by a line tied to a stable structure, such as a boat dock (Figure 3.3).

Planktonic larval mussels, or veligers, become entrapped in the fabric mesh inside of the PVC tubes. Juvenile mussels settle out and attach onto the outside of the PVC tubes and the acrylic plate (“settling plate”).

Selection of Monitoring Sites

Waterbodies were selected based on the findings of the risk assessment (see Chapter 2). The level of risk was based on suitable water chemistry, presence of *Corbicula fluminea* (an indicator species), and boater popularity. High risk sites were a priority. Waterbodies ranked from moderate through low were included in the monitoring program as volunteers were identified.

We conducted on-site surveys to select the optimal location for deploying the sampling device. Because the primary vector of zebra mussels being introduced into California was the overland transport of trailered vessel harboring larval or adult mussels, we selected sites near boat ramps where zebra mussels would be dislodged while the boat was launched. Best sites were in close proximity to a boat ramp, a gas dock or convenience store that attracted boaters, had low flow, and had protection from vandalism. Marinas tended to offer all of these factors, in addition to people willing to check the sampling device. If a marina was not located on a waterbody, we looked for alternative locations. These included boat houses of lake management staff and water quality monitoring structures. We avoided placing the sampling devices at unsupervised boat ramps because of the potential for boat propellers to become entangled in the sampler rope and tampering by the general public.

Volunteer Selection, Training, and Follow-up

After all monitoring sites were selected, we conducted searches using the Internet on each waterbody to determine appropriate agency and marina staff to contact regarding monitoring at the site. Individuals were contacted either by phone or in person, were presented with information about this program, and then were asked to assist with the monitoring.

In general, volunteers were either agency personnel or staff from private marinas. Individuals were selected based on authority at a given site, proximity and attendance at the site (e.g., work at the marina, check the site regularly as part of other monitoring duties), and interest and capacity to monitor on a long-term basis.

Presentations about the Zebra Mussel Watch Program were given to larger watershed and agency groups as requested (see Chapter 4, Table 4.2), and volunteers were often selected or recommended as a result of these meetings.

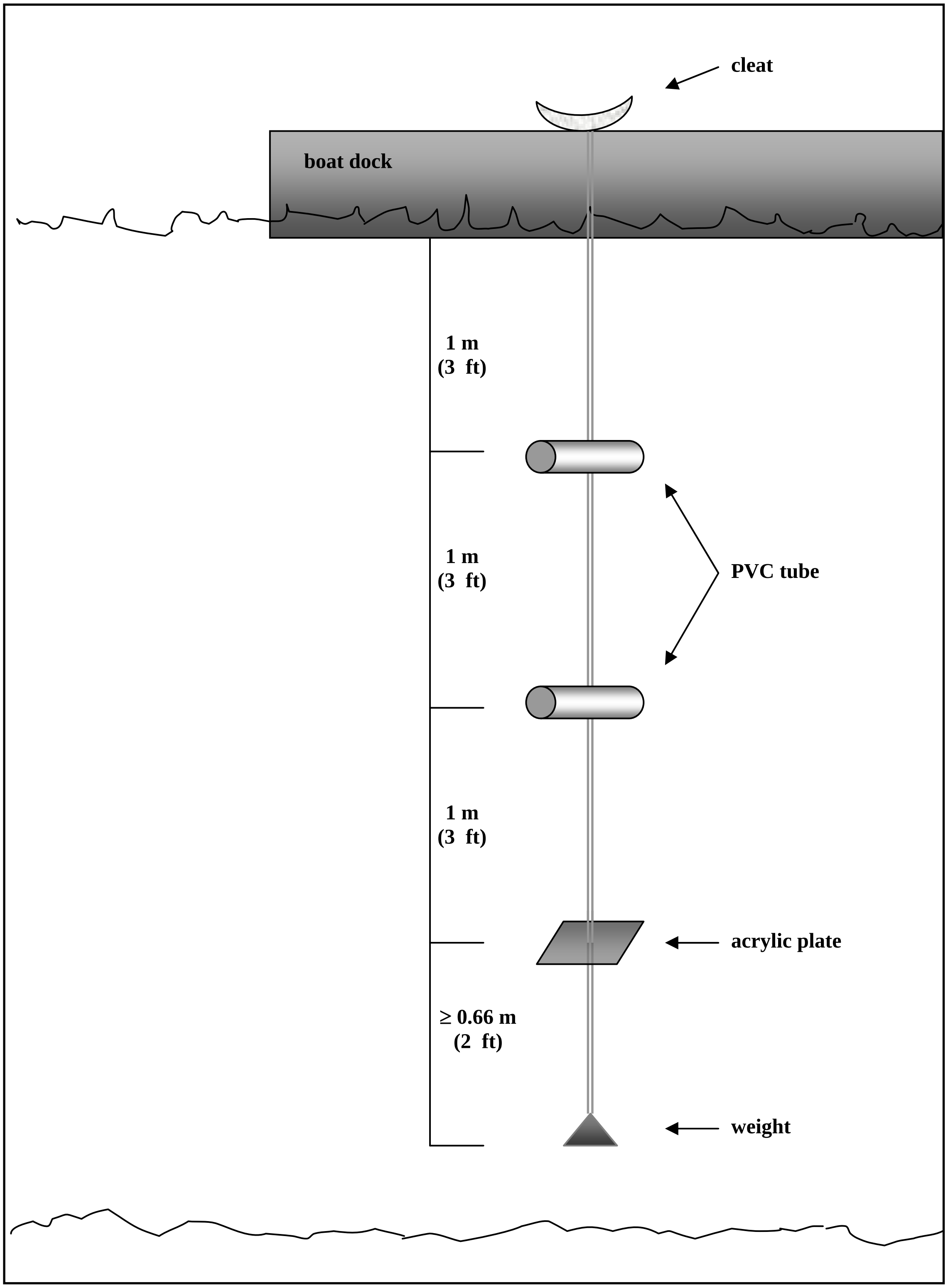


Figure 3.2. Diagram of the zebra mussel substrate sampling device.

Figure 3.3. Zebra mussel substrate sampling device suspended in a boat slip at a marina.

Each volunteer received verbal and written instructions on sampling protocol, including zebra mussel identification, visual inspection methodology, recording and reporting data, deploying and retrieving the sampling device, preserving samples, and reporting potential sightings (Figure 3.4). Each volunteer was given a packet containing written sampling instructions, 12 monitoring datasheets, and a sheet containing 15 sample tags for preserved samples (Appendix B). In addition, they received an zebra mussel information packet that contained a business card for the Zebra Mussel Watch Program, a “Stop Aquatic Hitchhikers!” sticker, a “Zap the Zebra” pamphlet, a “Not Wanted: Zebra Mussel Outlaws” poster, a copy of “Program Implemented to Prevent the Establishment of the Invasive Zebra Mussel into California” (Veldhuizen and Messer 2003a), a copy of “Protect your Watershed from Zebra Mussels, Become a Volunteer Monitor” (Veldhuizen and Messer 2003b), a copy of the Washington Department of Fish and Wildlife news release “Zebra Mussels Discovered at Washington-Idaho Border”, a “Zebra Mussels in North America: The Invasion and its Implications” pamphlet, and a “Zebra Mussel: Questions and Answers for Inland Lake Managers” pamphlet (Appendix C). We tried to personally meet with all volunteers. On a few occasions, we were unable to meet the volunteer, but were able to talk with them over the phone. In most cases, we personally deployed the substrate sampling device under the observation of the volunteer.

Arrangements were made with each volunteer as to the frequency of reporting the data, as per the volunteer’s convenience (Appendix D). Some volunteers mailed or faxed in the datasheets on a monthly basis while others did so on a 6-month basis. For those volunteers behind schedule on their reporting, we reminded them via phone. We attempted to interest volunteers in reporting results via email like other monitoring programs have done, but found volunteers had little interest in doing this (Pennington and Sytsma 2002). Overall, we had only two individuals report results using this method.

Zebra Mussel Monitoring Instructions

Placement of Sampler

Place sampler in low flow areas where there is frequent boat traffic, such as boat ramps and docks. Hide or disguise the sampler to prevent theft, vandalism, or disturbance. Tie off in a discrete location or use a plastic milk carton as a floation device.

The upper PVC tube should be about 1 meter (3 feet) below the surface. If the plexiglass plate is touching the bottom, then raise the sampler 1 to 2 feet or find a deeper location. If a deeper location cannot be found, then shorten the length of rope between the PVC tubes and the plexiglass plate. Record any modifications to the sampler in the "comments" section of the datasheet.

At time of placement, fill out all requested information on the datasheet. Please use a pencil. Under "Set Data", record the information when the sampler is placed in the water. Under "Retrieval Data", record the information when the sampler is removed from the water.

Sample Retrieval

Check the sampler monthly and year-round (or as long as the boat docks are in place and winter-time conditions allow access to the entrance roads).

- Visually inspect each component of the sampler (PVC tubes, mesh, and plexiglass plate) for juvenile mussels. *Immediately* report potential mussel sightings or if the PVC pipes or plexiglass plate feel "bumpy" to the touch.

If you suspect zebra mussels:

- Call the Zebra Mussel Watch staff at 1-888-840-8917.
- You may be instructed to:
  - Return the sampler to the water. Zebra Mussel Watch staff will retrieve it within 1 day.

  Or:
  - Detach the PVC tubes and plexiglass plate from the float and weight.
  - Remove the mesh from the PVC tubes. Place the mesh in a jar, along with a sample tag. Preserve the sample with isopropyl (rubbing) alcohol.
    Note: If it is not possible to preserve the mesh in alcohol, leave the mesh in the PVC tubes.
  - Place the PVC tubes and plexiglass plate in a ziplock bag, along with a sample tag. Leave the bag open and allow to air dry for 2-3 days or until contents are dry. Seal bag closed when dry.

Sample Pick-up

______ Sample to be picked up by Zebra Mussel Watch staff.

______ Mail sample to Zebra Mussel Watch staff in the provided envelope.

Other arrangements:

____

____

____

____

Other Activities

Conduct monthly inspections of your waterbody for living and dead zebra mussels. Look for live attached zebra mussels on boat docks, pilings, bouys, boats (propeller, hull, trim tabs, anchor), driftwood, tree snags, aquatic plants, and rocks. Look for zebra mussel shells on the shore (especially after water level drops), boat ramp areas, parking lots near boat ramps, etc.

Spread the word. Teach others how to prevent zebra mussels and other exotics from invading your lake or stream.

Contact Us for More Information

Zebra Mussel Watch Program
Coordinators: Tanya Veldhuizen
Cindy Messer

Hotline: 1-888-840-8917 (tollfree)

E-mail: mussel@water.ca.gov

Address: California Department of Water Resources
Division of Environmental Services
3251 S Street
Sacramento, CA 95816
Attn: Zebra Mussel Watch Program

Figure 3.4. Zebra mussel monitoring instructions provided to each volunteer.

Within one month of meeting a volunteer, we mailed a personalized thank you letter to them (Figure 3.5). The letter reiterated any special arrangements agreed upon and our contact information. We also mailed a letter to upper management, if appropriate, informing them of the Zebra Mussel Watch Program and of the volunteer monitoring arrangement.

To increase the volunteers' accessibility to DWR staff, we developed several mechanisms by which volunteers could ask questions, request additional materials and supplies, and express concerns. These mechanisms included a program website (www.des.water.ca.gov/zmwatch/), a toll-free hotline (1-888-840-3917), and an email address (mussel@water.ca.gov).

In July 2004, a letter was sent to each volunteer requesting them to submit all datasheets by January 2005 for inclusion in the final report (Figure 3.6). If necessary, postage was paid using self-addressed stamped envelopes to retrieve datasheets. Approximately half of the volunteers chose to fax datasheets to us. In the same letter, we also requested them to contact us if they no longer wanted to be a volunteer monitor.

Data Collection

Each substrate sampling device was visually examined for zebra mussels on a monthly basis. Each month, data was collected and recorded on a datasheet (Figure 3.7). Types of data included location of the monitoring site, name of volunteer or data recorder, dates the sampling device was set and retrieved, sample number, latitude and longitude, water temperature (if known), water depth (if known), presence/absence of zebra mussels, density (thick, sparse, none) and type of aquatic vegetation (if present), condition of sampling device, and action taken by the volunteer after inspecting the sampling device.

STATE OF CALIFORNIA – THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
DIVISION OF ENVIRONMENTAL SERVICES
3251 S STREET
SACRAMENTO, CA 95816-7017

June 25, 2004

Marcel Moranton
Ranger Supervisor
East Bay Municipal Utility District
Mokelumne Watershed and Recreation Division
4900 Stony Creek Road
Ione, CA 95640

Dear Mr. Moranton,

Thank you for taking time to talk with us about the Department of Water Resources' Zebra Mussel Watch Program.

As you now know from our discussion and from the literature we left with you, there is good reason to be concerned about zebra mussels reaching the lakes, streams and reservoirs of California.

We also wanted to thank you for offering to assist us with monitoring for zebra mussels at Pardee Reservoir. Periodically, we will contact you to make sure you have all of the supplies and information you need. We appreciate your interest in this project, as it will require a great effort to get the word out to boaters on the importance of preventing the invasion of zebra mussels in California. We definitely could not do it without assistance from individuals like you.

Please feel free to contact us if you have any questions about monitoring, need replacement equipment, additional posters, or if you would like more zebra mussel literature. We can be reached by phone at 1-(888)-840-8917 or by email at mussel@water.ca.gov.

Sincerely,

Cindy Messer and Tanya Veldhuizen
CA Department of Water Resources

Figure 3.5. Example of a thank you letter mailed to a new volunteer.

STATE OF CALIFORNIA – THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
DIVISION OF ENVIRONMENTAL SERVICES
3251 S STREET
SACRAMENTO, CA 95816-7017

July 26, 2004

Dear Volunteer,

The end of your first year of monitoring for zebra mussels is rapidly approaching. We greatly appreciate your assistance with this effort. We hope it has gone smoothly for you. If you have encountered any problems, please contact us so we can provide assistance. If you resolved the issue yourself and think your experience may benefit others, please let us know and we will pass the word on to our other volunteers. We are always looking for ways to improve the program.

Enclosed is another year's supply of datasheets. We have a report due to our funding source in Spring 2005. Therefore, we ask that you please mail in all of the completed datasheets by January 2005 for inclusion in the report. We have provided a pre-addressed stamped envelop for this purpose.

We revised the monitoring instructions and have enclosed an updated copy. You may recall we originally stated that during the cooler months the sampling device was going to be visually inspected, and during the warmer months (when conditions are right for the mussels to spawn) the device was going to be returned to us and inspected under the microscope. Due to the State budget and contracting constraints, we are unable to afford the high cost of hiring an outside entity to examine all of the sampling devices in the laboratory. Therefore, we ask that you continue to visually inspect your sampling device year-round or for the duration of your operating season.

If you need new mesh or a replacement sampling device, please call us at 1-888-840-8917 (toll-free). If you are noticing excessive algal growth on the sampler, please do not clean it. You may unknowingly wash off baby mussels. Please notify us and we will make arrangements to pick up your sampler and replace it with new one. We will examine the "dirty" sampler underneath the microscope.

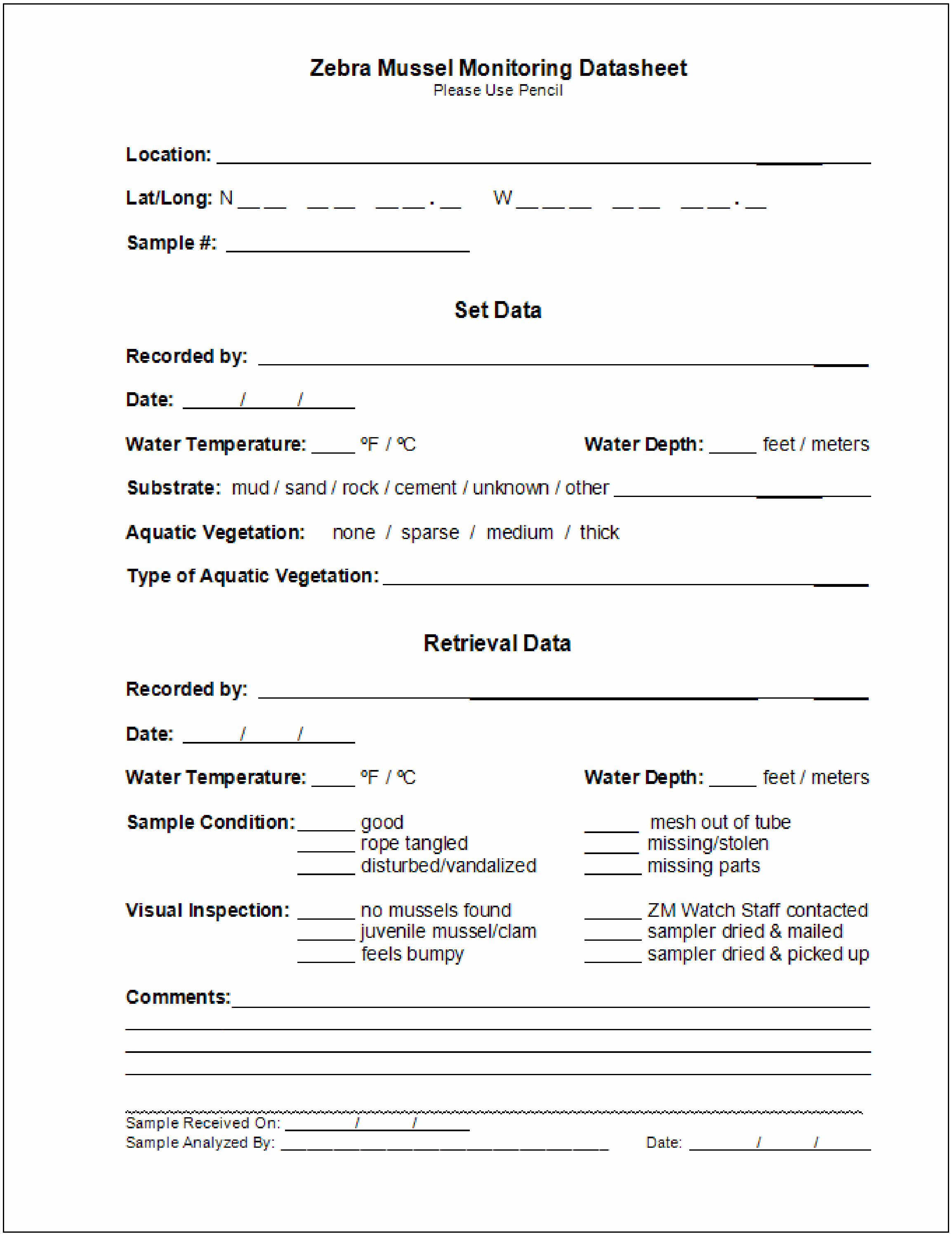
We are also providing you with posters that can be placed around your marina to increase the public's awareness of this very real threat. Hopefully, all of our hard work will pay off in keeping our waters zebra mussel-free.

As always, if you need any assistance or have any questions, please contact us at 1-888-840-8917 (toll-free) or at mussel@water.ca.gov. And if there comes a time when you no longer wish to be a volunteer monitor, please contact us immediately so we can find a replacement.

Sincerely,

Tanya Veldhuizen and Cindy Messer
Environmental Scientists
CA Department of Water Resources

Figure 3.6. Letter sent to volunteer monitors to remind them to return datasheets.



Zebra Mussel Monitoring Datasheet

Please Use Pencil

Location: ____________________

Lat/Long: N __ __ __ __ __ __ __ . __ W __ __ __ __ __ __ __ __ . __

Sample #: ____________________

Set Data

Recorded by: ____________________

Date: ____/____/____

Water Temperature: ____ °F / °C **Water Depth:** ____ feet / meters

Substrate: mud / sand / rock / cement / unknown / other ____________

Aquatic Vegetation: none / sparse / medium / thick

Type of Aquatic Vegetation: ____________________

Retrieval Data

Recorded by: ____________________

Date: ____/____/____

Water Temperature: ____ °F / °C **Water Depth:** ____ feet / meters

Sample Condition:
- _____ good
- _____ rope tangled
- _____ disturbed/vandalized
- _____ mesh out of tube
- _____ missing/stolen
- _____ missing parts

Visual Inspection:
- _____ no mussels found
- _____ juvenile mussel/clam
- _____ feels bumpy
- _____ ZM Watch Staff contacted
- _____ sampler dried & mailed
- _____ sampler dried & picked up

Comments: ____________________

Sample Received On: ____/____/____

Sample Analyzed By: ____________________ Date: ____/____/____

Figure 3.7. Datasheet used to record sampling data for the zebra mussel sampling devices.

If present, juvenile mussels would theoretically settle out and attach onto the outside of the PVC tubes and the acrylic plate (“settling plate”). Reportedly, newly settled juvenile mussels are difficult to see with the naked eye, but they feel “bumpy” or “gritty” to the touch (USACE 1992). Therefore, volunteers were asked to inspect the substrate sampler by feeling the outside of the PVC tubes and the acrylic settling plate to determine whether they felt “bumpy” or “gritty,” even if mussels were not visually apparent.

For select monitoring sites, the substrate sampling devices were retrieved by DWR staff and sent to a private consultant for processing. Mr. Wayne Fields of Hydrozoology identified and enumerated all collected macroinvertebrates (>0.5mm) to the lowest possible taxon, paying close attention to any mollusc (clams, mussels) species present. All organisms collected on the sampling devices were preserved and retained by DWR staff. They will be house in long-term storage at DWR-DES office.

When a substrate sampling device was removed from the water, the line and weight were detached and the remaining parts were immediately placed in a 3-gallon bucket with tight fitting lid containing just enough buffered formalin (10% formaldehyde) to cover the device (approximately 5 - 6 inches). A new substrate sampling device was deployed at that time as a replacement. The preserved sampling device was transported in the back of a pick-up truck to the DWR-DES office. After 24 hours, DWR staff transferred the sampling device into 70% ethanol for long-term storage. Mr. Fields retrieved the sampling device within 72 hours of collection.

To prevent any possibility of contamination between monitoring sites (should zebra mussels be present and not yet detected), sampling devices were never taken from one site to a different site even within a single waterbody. Sampling devices lost or broken were replaced with new ones, and volunteers were instructed not to move the sampling devices outside of the immediate area where they were originally placed.

Water quality data was collected by various federal, state and local agencies on a regular basis at all monitoring sites. Volunteers were not asked to collect this data to minimize time spent collecting zebra mussel presence/absence data each month. We felt most volunteers would not commit to adding this task to their monthly visual inspections (if this sampling was not part of their regular duties), and marina staff would require equipment be provided to them to conduct water quality sampling. Instead of using a single discrete water quality sample each month to determine whether a given waterbody was conducive to zebra mussels, long-term water quality data was available from on-line databases (such as STORET, USGS NWIS Web Data, Bay-Delta and Tributaries Database (BDAT)), DWR water quality monitoring databases, and the published literature (Cohen and Weinstein 1998).

<u>Sample Processing</u>

In the laboratory each component of the sampling device was gently rinsed and scraped over a 0.5 mm screen to retain all macroinvertebrates. Using a stereoscopic dissecting microscope (70-120x), all organisms retained by the screen were sorted and identified to the lowest possible taxon. When taxonomic features were too small for identification under the dissecting scope, the organism was permanently mounted on a slide and examined under a compound microscope. Individuals of the same taxon were placed in ½ dram shell vials and then all taxa from a single sample were placed into a larger vial (16 – 32 oz.) containing 70% ethanol for long-term storage. All enumeration and identification information was recorded on a datasheet and later entered into the Program's database (Figure 3.8). Laboratory identification and enumeration of macro-benthic organisms in each sample was performed under contract by Hydrozoology Laboratory, P.O. Box 682 Newcastle, CA 95658.

Sacramento-San Joaquin Delta Benthos Data Sheet

Department of Water Resources, Environmental Services Office

Lab Sample Number	Site	Bank	Grab Number	Sample Date	Sub Sample Size
E _ _ _ _ _ _	_ _ _ _	_	_	_ _ / _ _ / _ _ (M M D D Y Y)	_

Comments:

Sample Volume ________ mL:

% Vegetable Detritus: ____ % Peat: ____ % Hard Clay Particles: ____

% Shell Fragment: ____ % Mica: ____ % Worm Tubes: ____

% Sand: ____ % Gravel: ____ % Other: ____

	PHYLUM	FAMILY	GENUS	SPECIES	ORG.#	tally	COUNT
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							
21.							
22.							
23.							
24.							
25.							

Specimen Count: ________ x 4 = ________ + ________ = ________

Entered By: ________

QA/QC'd By: ________

Figure 3.8. Datasheet for recording data for the laboratory identification and enumeration of macro-benthic organisms collected in the zebra mussel sampling device.

Program Database and Data Entry

As described in Chapter 5, a Microsoft Access database was designed specifically for the Zebra Mussel Watch Program. All collected data, including waterbody information (Appendix E), early-detection monitoring data (Appendix F), volunteer contact information[1], and macroinvertebrate data (Appendix G), was entered into the database.

Monitoring information was entered into the database using the main form and selecting “Monitor” and “Add/Edit” under “Sample Data” to either retrieve existing data or add new data (see Chapter 5). A sub-form was generated that was similar to the field datasheet. Entry fields included sample number, site location, date, contact name (with a link to contact information), water temperature, water depth, substrate type (e.g., mud, sand, vegetation), aquatic vegetation type and density, sample condition, visual inspection results and any actions taken.

This database, as well as the original datasheets, is currently housed with DWR staff at 3251 S Street, Sacramento, CA 95816. Copies of the database format can be obtained from DWR staff upon request. With the exception of volunteer contact and personal information, all data was uploaded from the Zebra Mussel Watch Program’s database to the Bay-Delta and Tributaries Database (BDAT) managed by the Interagency Ecological Program (IEP). This comprehensive database houses monitoring data from numerous agency studies and is available to the general public (http://bdat.ca.gov/).

Response to Potential Zebra Mussel Sightings

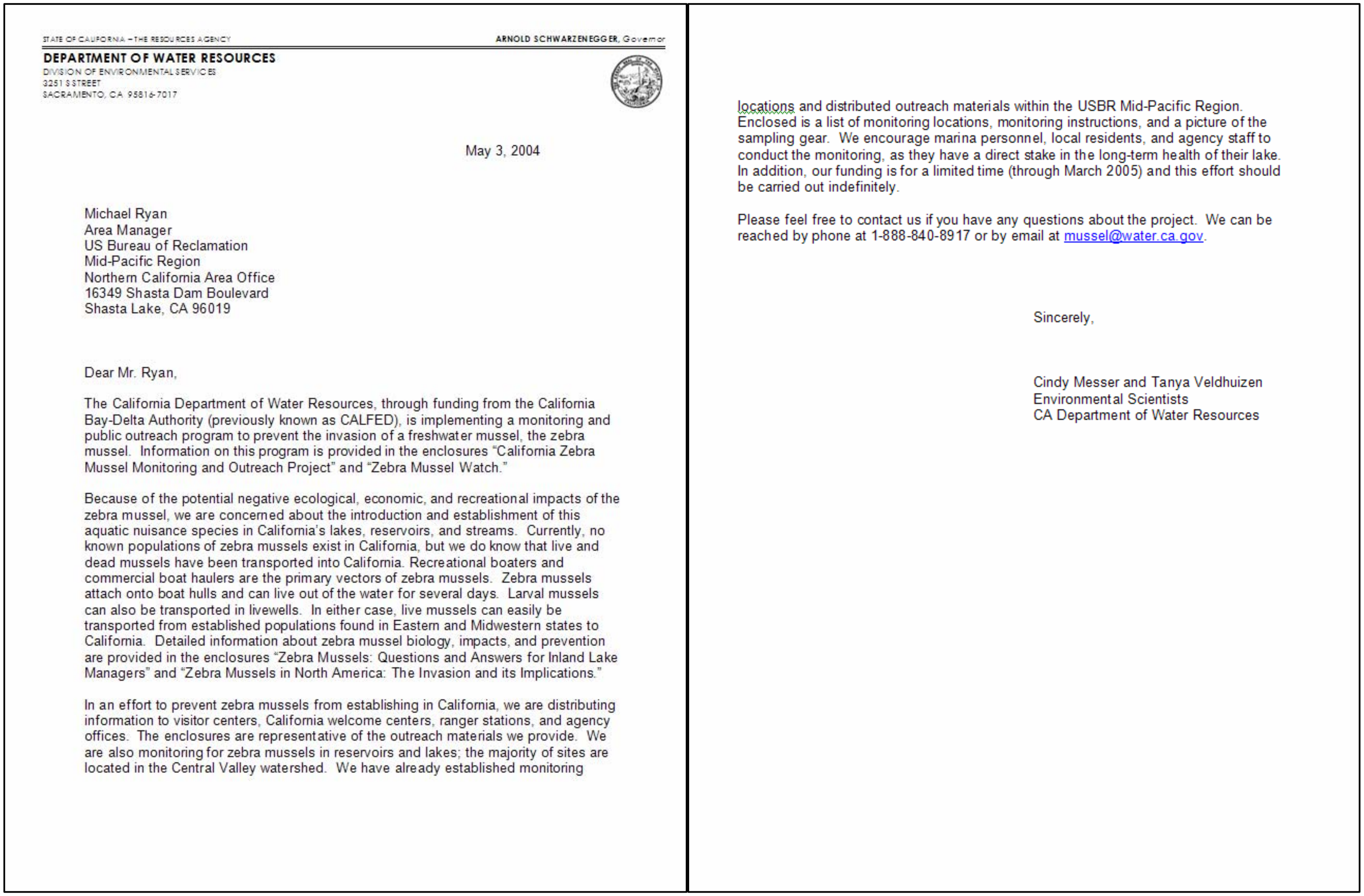
Calls regarding potential zebra mussel sightings were received directly by ZMEDOP staff via the zebra mussel hotline located at the DWR-DES office in

[1] Volunteer contact information is confidential and was not provided in this report. This information was provided to CALFED and USFWS in a separate document; access to that document is restricted.

Sacramento. Emails were routed directly to ZMEDOP staff personal computers. Calls were answered as they came in; email and voicemail messages were returned within 24 hours. Several DWR staff shared the task of responding to calls and emails to ensure coverage during vacation and sick leave. In the event a suspected sighting was reported, we were to notify appropriate staff at the California Department of Fish and Game in Sacramento and U.S. Fish and Wildlife Service in Stockton. Initial rapid response actions entail traveling to the monitoring site (when possible) to confirm zebra mussel presence/absence and to collect samples for laboratory and expert identification. If the monitoring site was remote and/or weather conditions did not permit travel to the site, volunteers were asked to send the sampler to us at DWR-DES office in Sacramento using UPS or Fed-Ex mail service (DWR had an established account with both carriers and would pay for shipping). If the volunteer was sending the entire sampling device, they were instructed to enclose it in a large Zip-loc bag and place it on ice. If individual organisms were being sent, the volunteer was asked to place the organism in a plastic vial provided to them, fill it with ambient water or rubbing alcohol, and enclose it in a Zip-loc bag for shipping. (A detailed description of rapid response actions, including contact information, is described in Chapter 6.)

Notification of Waterbody Authority(ies)

For each waterbody included in the monitoring program, we informed the State, federal, and local agencies with jurisdiction over that waterbody about our program. The agency was provided with information regarding zebra mussel biology, impacts, and early detection monitoring, locations of monitoring sites in waterbodies under its jurisdiction, and the Zebra Mussel Watch Program (Figure 3.9).



STATE OF CALIFORNIA – THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
DIVISION OF ENVIRONMENTAL SERVICES
3251 S STREET
SACRAMENTO, CA 95816-7017

May 3, 2004

Michael Ryan
Area Manager
US Bureau of Reclamation
Mid-Pacific Region
Northern California Area Office
16349 Shasta Dam Boulevard
Shasta Lake, CA 96019

Dear Mr. Ryan,

The California Department of Water Resources, through funding from the California Bay-Delta Authority (previously known as CALFED), is implementing a monitoring and public outreach program to prevent the invasion of a freshwater mussel, the zebra mussel. Information on this program is provided in the enclosures "California Zebra Mussel Monitoring and Outreach Project" and "Zebra Mussel Watch."

Because of the potential negative ecological, economic, and recreational impacts of the zebra mussel, we are concerned about the introduction and establishment of this aquatic nuisance species in California's lakes, reservoirs, and streams. Currently, no known populations of zebra mussels exist in California, but we do know that live and dead mussels have been transported into California. Recreational boaters and commercial boat haulers are the primary vectors of zebra mussels. Zebra mussels attach onto boat hulls and can live out of the water for several days. Larval mussels can also be transported in livewells. In either case, live mussels can easily be transported from established populations found in Eastern and Midwestern states to California. Detailed information about zebra mussel biology, impacts, and prevention are provided in the enclosures "Zebra Mussels: Questions and Answers for Inland Lake Managers" and "Zebra Mussels in North America: The Invasion and its Implications."

In an effort to prevent zebra mussels from establishing in California, we are distributing information to visitor centers, California welcome centers, ranger stations, and agency offices. The enclosures are representative of the outreach materials we provide. We are also monitoring for zebra mussels in reservoirs and lakes; the majority of sites are located in the Central Valley watershed. We have already established monitoring locations and distributed outreach materials within the USBR Mid-Pacific Region. Enclosed is a list of monitoring locations, monitoring instructions, and a picture of the sampling gear. We encourage marina personnel, local residents, and agency staff to conduct the monitoring, as they have a direct stake in the long-term health of their lake. In addition, our funding is for a limited time (through March 2005) and this effort should be carried out indefinitely.

Please feel free to contact us if you have any questions about the project. We can be reached by phone at 1-888-840-8917 or by email at mussel@water.ca.gov.

Sincerely,

Cindy Messer and Tanya Veldhuizen
Environmental Scientists
CA Department of Water Resources

Figure 3.9. Example of letter to regional authority notifying them that zebra mussel monitoring is occurring in waterbodies under their jurisdiction.

Monitoring Sites

We established 49 early detection monitoring sites in 28 waterbodies (Appendix D). Using the findings of our risk assessment as a guide, we established monitoring sites in all high risk waterbodies and most of the moderate risk waterbodies. Twenty-four of these waterbodies were actively monitored. We had difficulty maintaining volunteer commitment at the remaining four waterbodies. Thirty-nine percent of the sites were monitored by private marina staff, 24% by Federal agency staff, 24% by State agency (DWR) staff, 6% by public utility staff, and 2% by local (city) government staff.

For some of the waterbodies, there was a discrepancy between the date we first contacted the volunteer and the date monitoring commenced. The discrepancy was due to one or more of the following situations:

1) there was a lack of staff available to monitor;
2) there was a change in staff, and the new staff were not informed of the commitment to monitor;
3) weather-related conditions, such as snow and high water levels, prevented access to the site and delayed installation of the sampling device;
4) we contacted the volunteer at the end of their field sampling season, so deployment of the sampling device was postponed field sampling resumed in the spring; or
5) we contacted the volunteer at the end of the recreation season, the docks were to be removed and/or the resort closed for the winter season, so deployment of the sampling device was postponed until the next season.

One of the waterbodies, Eagle Lake, was outside of the Central Valley watershed. We included this lake in our monitoring program because DWR staff offered to monitor it as Eagle Lake was already part of their existing water quality monitoring program. The inclusion of waterbodies outside of the Central Valley watershed was critical to protecting our water resources within the Central Valley and throughout California.

Below is a list of the waterbodies with number and location of monitoring sites, type of volunteer monitor, and monitoring start date. Status of each monitoring site was current as of May 2005.

Antelope Lake

DWR-Northern District (DWR-ND) monitors the water quality of this lake, and agreed to inspect the sampling device during their water quality monitoring field season that runs from spring (after snowmelt) through October. We initially contacted DWR-ND in September 2003, at the end of their field season. Substrate deployment occurred at the start of the next field season in spring 2004. Sites were established at two locations in the reservoir. During summer 2004, staff changes occurred, samplers were not maintained, and datasheets were not returned. New staff resumed the project in January 2005. One site was reestablished in May 2005 (at the start of the 2005 field season) and was located at the DWR water quality station.

Black Butte Reservoir

One monitoring site was established at this small reservoir in May 2004. The sampler was secured to the water quality monitoring tower, simply known as the "Tower", which is located near the dam. USACE staff checked the sampler year-round, when accessible. After January 2005, the water level rose above the height of the tether rope and the sampler was inaccessible. As of May 2005, the sampler was still not reachable.

Bucks Lake

In August 2003, a biologist from Plumas National Forest Service Mount Hough Ranger District offered to establish three monitoring sites at the lake; two at the marinas and one at a private residential dock. We deployed a sampler at Bucks

Lakeshore Resort Marina in August 2003. That fall, the sampler became entangled in the dock cables as the lake level dropped. In the spring, after snowmelt, the sampler was to be replaced and the other two samplers were to be installed by the district biologist. However, the district biologist left without notifying us. We have not found a replacement volunteer.

Butt Valley Reservoir

DWR-ND monitors the water quality of this lake, and agreed to inspect the sampling device during their water quality monitoring field season that runs from spring (after snowmelt) through October. The sampling device was deployed in May 2005 (at the start of the 2005 field season) and was located at the DWR water quality station. This small reservoir had no marinas, and the single boat ramp had a small floating platform that did not provide a secure location for sampling gear.

Camanche Reservoir

In May 2004, two sites were established at both marinas located on the reservoir. The sites were Camanche North Shore Marina and Camanche South Shore Marina. Both sites were maintained by marina staff year-round.

Clear Lake

Four monitoring sites were established at this large natural lake. The sites were Braitos Buckingham Marina, City of Lakeport’s marina located at 3rd Street, City of Lakeport’s marina located at 5th Street, and Holiday Harbor Marina. The sampler at Braitos Buckingham Marina was deployed in December 2004. As of May 2005, the water was too high at both of the City marinas and Holiday Harbor Marina to install the samplers.

Collins Lake

This was a small privately owned lake. A monitoring site was established at the marina in August 2004. The sampling device was checked by the staff year-round.

Eagle Lake

DWR-ND monitors the water quality of this natural lake, and agreed to inspect the sampling device during their water quality monitoring field season that runs from spring (after snowmelt) through October. The sampler was located at the water quality monitoring station.

We initially contacted DWR-ND in September 2003, at the end of their field season. Substrate deployment occurred at the start of the next field season in spring 2004. Sites were established at two locations in the reservoir. During summer 2004, staff changes occurred, samplers were not maintained, and datasheets were not returned. New staff resumed the project in January 2005. One site was reestablished in May 2005 (at the start of the 2005 field season) and was located at the DWR water quality station.

Englebright Reservoir

One site was established in August 2004 at the USACE Boat House in the region of the reservoir called the "Narrows". The sampling device was checked year-round by USACE staff.

Folsom Lake

USBR-Central California Area Office monitors water quality for this reservoir and agreed to deploy one sampling device and inspect it year-round. USBR staff biologists were given a sampling device in August 2004, but did not deployed it due to permitting requirements from the Department of Parks and Recreation and high water levels during spring 2005. USBR and DWR staff completed the forms to request a permit to monitor in March 2005. The sampling device will be deployed in early summer 2005 when water levels stabilize.

Frenchman Lake

DWR-Northern District monitors the water quality of this natural lake, and agreed to inspect the sampling device during their water quality monitoring field season that runs from spring (after snowmelt) through October. The zebra mussel early detection monitoring site was located at the DWR water quality monitoring station.

We initially contacted DWR-ND in September 2003, at the end of their field season. The sampling device was installed at the start of the next field season in spring 2004. During summer 2004, staff changes occurred, the sampling device was not maintained, and datasheets were not returned. New staff resumed the project in January 2005. The sampling device was redeployed May 2005 (at the start of the 2005 field season) and was located at the DWR water quality station.

Lake Almanor

One site was established at the marina at Plumas Pines Resort in August 2003. Contact was made with the USFS Almanor Ranger District biologist regarding coordination of sampling efforts at the lake. An additional monitoring site was supposed to be established at a marina on the opposite side of the lake, and sampling devices were supplied in September 2003. Despite positive reception during our in person meeting, we received no further assistance or communication from the biologist.

Lake Berryessa

In June 2004, early detection monitoring sites were established at two marinas, Lake Berryessa Marina Resort and Spanish Flat Resort. At both locations, marina staff checked the sampling devices on a year-round basis.

Lake Davis

In August 2003, a biologist from Plumas National Forest Service Mount Hough Ranger District offered to establish a monitoring site at the lake. However, the biologist never deployed the sampling gear and left without notifying us. We did not find a replacement volunteer.

Lake Don Pedro

One sampling site was established at Don Pedro Marina at Fleming Meadows in July 2004. The sampling device was maintained by marina staff on a year-round basis.

Lake McClure

Lake McClure is owned and operated by Merced Irrigation District. In July 2004, the park ranger agreed to set and check two sampling devices on a year-round basis. The monitoring sites were the marinas at Barrett Cove Park and McClure Point. By late summer 2004, both sampling devices disappeared and we were not notified. Replacement gear was supplied summer 2005.

Lake Natoma

USBR-Central California Area Office monitors water quality for this reservoir and agreed to deploy one sampling device and inspect it year-round. USBR staff biologists were given a sampling device in August 2004, but did not deployed it due to permitting requirements from the Department of Parks and Recreation and high water levels during spring 2005. USBR and DWR staff completed the forms to request a permit to monitor in March 2005. A sampling device will be deployed in early summer 2005 when water levels stabilize.

Lake Oroville

One site was established at Bidwell Marina in August 2003. It was checked by DWR-Oroville staff on a monthly basis. We recommend another site be established at the Lime Saddle Boat Launch when it reopens. The marina was closed for flood damage repair.

Little Grass Valley Reservoir

DWR-Northern District monitors the water quality of this reservoir, and agreed to inspect the sampling device during their water quality monitoring field season that runs from spring (after snowmelt) through October. The zebra mussel early detection monitoring site was located at the DWR water quality monitoring station. This small reservoir had no marinas, and the boat ramps had small floating platforms that did not provide secure locations for the sampling gear.

We initially contacted DWR-ND in September 2003, at the end of their field season. Substrate deployment occurred at the start of the next field season in spring 2004. Sites were established at two locations in the reservoir. During summer 2004, staff changes occurred, samplers were not maintained, and datasheets were not returned. New staff resumed the project in January 2005. One sampler will be deployed this year at the water quality monitoring station. As of May 2005, the reservoir was not accessible due to snow.

Millerton Lake

One monitoring site was established at Millerton Lake Marina at Winchell Cove in June 2004. The harbor master checked the sampling device on a year-round basis. We recommend establishing a second site at the boat house owned by California Department of Parks and Recreation, located near the dam. Onsite park staff were in favor of this, and we obtained permission from the State Parks Four Rivers District research ecologist. He was arranging to have seasonal park staff check the sampling device, but never finalized this plan. He did not respond to our letters and phone calls.

New Bullard's Bar Reservoir

In August 2004, we met with USFS Downieville Ranger Station staff to establish zebra mussel monitoring sites in the reservoir. One sampling device was installed at Emerald Cove Resort & Marina in August 2004. Another sampling device was to be deployed at Dark Day boat launch in Spring 2005, after repairs were made to the floating dock at the boat launch. USFS staff checked the sampler year-round.

New Hogan Lake

In May 2004, a monitoring site was established at the USACE boat house, located at the dam. USACE staff checked the sampling device year-round. This small reservoir had no marinas, and the boat ramps had small floating platforms that did not provide secure locations for the sampling gear.

Pardee Reservoir

One site was established in this reservoir in May 2004. The sampler was installed at the EBMUD boat house, located near the marina and public boat launch. The park ranger checked the sampler year-round.

Sacramento-San Joaquin Delta

Six sites were established in the delta. These sites were Bridgehead Marina, Eddos Harbor and RV Park, Herman and Helens Marina and Resort, Holland Riverside Marina, River Point Landing Marina and Resort, and Tracy Fish Collection Facility. The site at the Tracy Fish Collection Facility was established in September 2004 and was monitored by USBR staff year-round. The other five delta sites were established in December 2004 and were checked by DWR-DES staff year-round.

Shasta Lake

In August and September 2004, six monitoring sites were established in this large reservoir. The sites were Bridge Bay Resort, Digger Bay Resort, Jones

Valley Resort, Holiday Harbor Resort and Marina, Lake View Resort, and Sugar Loaf Resort. Samplers were checked by marina staff on a year-round basis. The aquatic biologist for the USFS Shasta-Trinity National Forest Ranger District oversaw these sites by providing assistance, equipment, and information to volunteers, and acting as first responder to reported sightings.

Sly Creek Reservoir

DWR-Northern District monitors the water quality of this reservoir, and agreed to inspect the sampling device during their water quality monitoring field season that runs from spring (after snowmelt) through October. The zebra mussel early detection monitoring site was located at the DWR water quality monitoring station. This small reservoir had no marinas, and the boat ramps had small floating platforms that did not provide secure locations for the sampling gear.

We initially contacted DWR-ND in September 2003, at the end of their field season. The sampling device was installed at the start of the next field season in spring 2004. During summer 2004, staff changes occurred, the sampler was not maintained, and datasheets were not returned. New staff resumed the project in January 2005. The sampling device was redeployed May 2005 (at the start of the 2005 field season) and was located at the DWR water quality station.

Trinity Lake

In April 2004, three monitoring sites were established in this reservoir at Cedar Stock Resort and Marina, Trinity Alps Marina, and Trinity Center Marina. Marina staff volunteered to examine the sampling devices year-round.

Whiskeytown Reservoir

We contacted National Park Service staff at the reservoir in April 2004. Three monitoring sites were established at Brandy Creek Marina, Whiskey Creek Boat Launch, and Oak Bottom Marina. Sampling devices were deployed in May 2004. A biologist from the National Park Service Whiskeytown National Recreation

Area volunteered to check the samplers year-round, weather-permitting. The samplers were not checked December through January due to weather-related conditions. The docks at Oak Bottom Marina were pulled ashore for the winter season, and the sampler was destroyed. A new sampler is to be deployed in early summer 2005, when the docks are reinstalled.

Waterbodies Not Monitored

We surveyed other waterbodies but did not include them in the current early detection monitoring program for several reasons. These waterbodies did not have secure locations to leave the sampling device unattended, had no permanent accessible structures, and/or lacked staff to check the samplers. Based on the results of our risk assessment (see Chapter 2), we ranked the following waterbodies as moderate to moderate-low risk of zebra mussel inoculation and establishment, and we recommend monitoring occur at them. These waterbodies are American River, East Park Reservoir, Feather River, Lake Del Valle, Sacramento River, San Luis Reservoir, and Stony Gorge Reservoir.

Although ranked as low, low to no, or no risk of zebra mussel inoculation and establishment, we recommend early detection monitoring be established at the following Central Valley waterbodies because of their importance to California's water supply system: Bethany Reservoir, O'Neill Forebay, California Aqueduct, Clifton Court Forebay, Delta Mendota Canal, North Bay Aqueduct at Barker Slough, and South Bay Aqueduct.

Discussion

Monitoring Sites

The number of monitoring sites established at a waterbody varied between waterbodies due to differences in level of risk of zebra mussel inoculation, the number of marinas present, the size of the waterbody, popularity of the waterbody with boaters, availability of volunteer monitors, availability of secure monitoring sites if marinas not present, whether or not property access was granted, and connectivity with other waterbodies.

Monitoring sites were established at all waterbodies ranked high risk and at the majority of waterbodies ranked moderate risk in the risk assessment report (see Chapter 2). In this phase of the program, monitoring sites were not established at waterbodies ranked at ‘moderate to low’ or lower risk level, except where volunteers were willing to sample multiple sites or were easily identified (e.g., Bucks Lake, Butt Valley Reservoir, Sly Creek Reservoir). One site outside of the Central Valley watershed was also established (i.e. Eagle Lake) as a volunteer contacted us.

Although many sites were not considered high risk, this does not mean that the waterbody could not support a zebra mussel population. The majority of these sites could support zebra mussels; however, the population may come from upstream sources. In most of these cases, the source waters are being monitored for zebra mussels. For example, the State Water Project and Central Valley Project aqueducts provide prime habitat for zebra mussels, and the monitoring sites were established upstream in the delta and at the fish facilities. The lower American River could support a zebra mussel population; however suitable monitoring sites are not present within the river. Monitoring sites were established upstream in Folsom Lake and Lake Natoma.

Because of the interconnectivity of the Central Valley watershed and our water delivery system, to some it may see impossible to control zebra mussels once they become established in the watershed. For example, some argue that if zebra mussels are introduced into the delta, it will not be economically or environmentally feasible to eradicate or control them. Thus, it does not make sense to initiate actions for controlling them or continuing to monitor for them.

However, the monitoring program will remain valuable as an early warning system for resource managers both upstream and downstream of infested waterbodies. Upstream areas can only be infected if zebra mussels are transported upstream or overland by people (e.g., boats, bait buckets, jet skis, research gear, etc). If contacted regarding potential zebra mussel introduction, resources managers at these areas should increase vigilance and implement quarantine/control measures. Control measures include boat inspections and cleanings, controlled boat launching, and controlled upstream movement of boats. Downstream waterbodies will need to monitor at water intake sites to determine whether zebra mussel veligers are present. Facility managers will need to retrofit facilities to ensure uninterrupted water and power deliveries, and change facility operating procedures to adapt to and minimize the impacts of zebra mussels. Resource managers of infested waterbodies and those located downstream will also need to increase boater awareness regarding transporting zebra mussels and may need to implement boat inspections and cleanings for boats leaving the waterbody(ies).

Monitoring Protocol

During the formative years of this program, the State of California experienced a hiring freeze and seasonal staff could not be hired to implement the monthly monitoring. In order to resolve this and to begin early detection monitoring, we opted to establish a volunteer monitoring program. Substrate sampling was selected at the primary means of monitoring, because it is less labor intensive, less costly in terms of training volunteers and providing sampling equipment, and it can be done successfully by non-biologists. Substrate sampling gives a good indication of zebra mussel presence/absence. It does not however detect veligers as early as zooplankton sampling (O'Neill 1996).

Data generated on zebra mussel presence/absence by this program came largely from monthly visual inspections by volunteers and DWR staff. Two of the substrate sampling devices were collected from Lake Berryessa and the

Sacramento-San Joaquin Delta and analyzed in a laboratory. The purpose of this exercise was to establish a protocol for field collection of the devices, sample analysis, preservation and long-term storage. We found the protocol outlined in this report to work effectively with minimal use of staff time and resources. Laboratory analysis was straightforward and easily repeatable. Based on the number and identification of the species collected by these sampling devices, we feel that substrate sampling is a valuable means of collecting baseline data on macroinvertebrate species (> 0.5mm in size) present in a given waterbody pre-zebra mussel invasion. Additional sampling devices were not collected because of the extensive time needed by DWR staff to establish early detection monitoring sites in other waterbodies, conduct subsequent follow-up activities with volunteers, and meet other work-related commitments. A lack of seasonal staff available to travel to sites to collect sampling devices also contributed to the small number of devices analyzed.

Volunteers are a valuable resource for monitoring an extremely large geographic region (i.e. the state of California). For this monitoring program, we worked almost exclusively with volunteers from local, state and federal agencies and from private marinas. Overall, our experience was a positive one allowing us to monitor most of the Central Valley watershed and seldom did we encounter individuals not willing to help us. There are several issues that arose from using volunteers which includes the need for extensive follow-up activities (i.e. phone calls and letters to ensure sampling was being conducted and that datasheets were being completed), inconsistencies in sampling protocol, lack of reports to DWR staff regarding loss of sampling devices, and volunteer turn-over.

Data Storage and Reporting

All data generated by this program (with the exception of volunteer personal contact data) will be available to the public via the Bay-Delta and Tributaries Database (BDAT) (http://bdat.ca.gov/). DWR staff will continue to post monthly monitoring data from established sites indefinitely.

Centralized Reporting System and Suspected Sightings

DWR staff will continue to maintain and update the current reporting and information system (i.e., website, toll-free hotline, email address, outreach material dissemination) and will implement or assist in responding to reports of suspected sightings.

Recommendations and the Future of the CA Zebra Mussel Watch Program

While it is our opinion that the monitoring program described in this report is a successful initial effort to establish early detection monitoring for zebra mussels in California, we have several recommendations that will assist in the development of a more comprehensive and long-term monitoring program for the State.

Management

A successful long-term monitoring program should be managed by as few as possible (1-3) organizations (i.e. government agencies, academic programs, or consulting firms) to eliminate duplication of sampling effort, confusion among volunteers and the general public, and to ensure that lines of communication between lead investigators and responsible agencies remain open and current.

If more than one agency or program is involved in this effort, it is imperative that the centralized reporting system for suspected sightings established by this program remain intact and staff from one of the organizations be assigned to respond to these reports. We also recommend that a single source (i.e. website, phone number, email address, etc.) for California-related program information and outreach materials be used to reduce confusion and subsequent disinterest among volunteers and the general public. Maintaining the current program's website, email address, toll-free phone line and list serve will serve this purpose.

Rapid response is essential for early detection monitoring, and therefore at least one of the agencies and/or organizations should be located in California and have a budget for staff to respond to suspected sightings. Appropriate rapid response actions for California are outlined in the Zebra Mussel Rapid Response Plan for California (see Chapter 6).

Long-Term Funding

CALFED funding of the monitoring program ended June 2005. DWR staff currently responsible for the California Zebra Mussel Watch Program will continue to maintain the volunteer-based monitoring program at established sites (Appendix D), the program's website, toll-free hotline, email address and list-serve as needed. Long-term funding for early detection monitoring has not been secured, but potential sources are being investigated at this time. Long-term funding (>3 years) is required to ensure continuity in monitoring and personnel and to detect zebra mussels as soon as possible after they have been introduced into this State.

Monitoring Protocol

To truly detect zebra mussels in the early stages of establishment within a waterbody, a combination of planktonic veliger sampling and artificial substrate sampling is needed. While substrate sampling can be conducted by volunteer monitors and is inexpensive, planktonic veliger sampling requires a greater level of expertise (training in biological sampling, identification of larval zebra mussels) and resources (labor hours and money for sample collection and analysis).

If funding and/or staff are limited, then the majority of resources should be spent on planktonic veliger sampling because this monitoring takes place at the life stage when spread is most likely (Stangel 2004). The frequency of this sampling can be adjusted to maximize sampling effort with existing funds, and should be concentrated during the warmer months of the year (i.e. April through October) when spawning occurs. Sampling can either take place monthly or at the beginning and end of the season. Waterbodies that are at high risk of inoculation due to recreational boating activities and have suitable environmental conditions for zebra mussels should be sampled monthly, while sites that have a moderate to low risk level can be sampled twice per season.

Volunteer-Based Monitoring

As other zebra mussel volunteer-based monitoring programs have concluded, retaining volunteer interest in monitoring activities requires sampling protocol be easy and sampling frequency be low (Pennington 2002, Shaw 2003). The use of volunteer monitors should be limited to substrate sampling only. Planktonic veliger sampling should only be conducted by agency personnel. The use of seasonal staff dedicated to this task will ensure that sampling is conducted on a regular basis using approved protocol.

For a long-term monitoring program that involves using volunteer monitors, a substantial portion of the program's budget must be allocated for time and resources needed to maintain volunteer interest, ensure sampling consistency and prevent turn-over.

The most efficient option is to use seasonal staff to check and/or collect artificial substrate samplers in addition to conducting planktonic veliger sampling. The use of seasonal staff will greatly reduce time spent conducting follow-up activities with volunteers and will increase consistency of sampling frequency and protocol. However, even if early detection monitoring is conducted by agency personnel, relationships with local agency staff, marina staff and the general public must be established as a public outreach and education effort, to obtain permission to access the waterbody and surrounding property, and to get local residents' approval of the monitoring program.

Chapter 4

Public Outreach and Information Dissemination

The assumptions of this program component were extensive outreach and education efforts modify behaviors, increase the chance of zebra mussel early-detection, and generate public support for zebra mussel control measures. Investigators believed that Agency and public response to a zebra mussel invasion and implementation of control and eradication measures would be efficient and widely supported by conveying how detrimental zebra mussels would be to the Central Valley watershed, to the Sacramento-San Joaquin Delta ecosystem, to State and Federal water conveyance systems, to regional and local facility infrastructure (e.g., water treatment plants, hydroelectric plants, and agricultural water intake and delivery systems), and to the recreational boating community and businesses. Working under these assumptions, zebra mussel outreach information was provided to public agency staff, stakeholder groups, businesses, and the general public. Public outreach and education efforts included development of the California Zebra Mussel Watch Program (CZMWP), the CZMWP website, a centralized reporting and information system, slide shows, posters, a "watch card", a newsletter, and articles. Numerous oral and poster presentations were developed and given by lead investigators to various stakeholder groups. Informational literature from other organizations (e.g., 100th Meridian Initiative, Sea Grant) was also distributed through this program.

Web-based Information Exchange

The centralized reporting and information system consisted of a toll-free zebra mussel "hot line" phone number, an email address, an email list serve, a website, and an Access database (see Chapter 4) for storing outreach activity records.

The toll-free phone number (1-888-840-8917) and email address (mussel@water.ca.gov) were used to receive reports of zebra mussel sightings, reports of substrate sampling results, requests for monitoring equipment, and requests for educational materials. They were also used for general communication purposes, as the general public was able to call and email project staff directly. The toll-free number and email address were provided on all outreach materials developed by project staff.

The website provided a mechanism for the public and agency staff to report zebra mussel sightings and to readily obtain information about zebra mussels and zebra mussel activities in California (Appendix H). The website contained zebra mussel identification information, detail instructions for reporting potential zebra mussel sightings, and sample collection and preservation techniques. The website was hosted on the DWR Division of Environmental Services web server. The web address was http://www.des.water.ca.gov/zmwatch/.

An email reflector containing the email addresses of interested parties/persons was established to readily exchange information regarding sightings and provide updates on the status of zebra mussels in California. The email reflector address was zmwatch@water.ca.gov. The email reflector contained the email addresses of the members of the California Zebra Mussel Action Team Incident Coordinators, Incident Action Team members, and Stakeholder Group members, who are listed in the California Zebra Mussel Rapid Response Plan (Chapter 6, Appendix N).

ZMEDOP and CDWR Information Technology staff maintained the website, email address, the list serve, and the Access database.

<u>Outreach Materials Developed by ZMEDOP</u>

Outreach materials were constructed using information gathered from an extensive literature review, consultation with experts from other States, and referencing materials developed by other invasive species outreach programs. The result was the development of educational materials specific to California and the California Zebra Mussel Watch Program. Materials included a website, a newsletter, a wallet-sized “watch card”, slide shows, posters, and articles.

The website provided information on zebra mussel identification, life history, impacts, volunteer-based early detection monitoring program, and rapid response plan (Appendix H). It also provided information on ZMEDOP, the activities of the California Zebra Mussel Watch program (CZMWP), available outreach materials, and clean-boating practices.

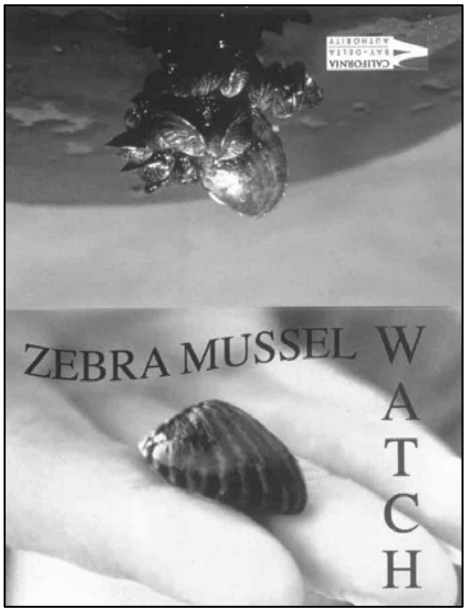
A newsletter was published in summer 2004. It was distributed to all volunteer monitors and was posted on the website. The format could be used for future editions. Two articles on the Zebra Mussel Watch Program were published in *Pisces* and the *Interagency Ecological Program Newsletter* (Table 4.1).

Zebra mussel watch cards have been used extensively in the United States as an important education tool and field reference guide. The watch cards provide information on zebra mussel identification and preservation, and how to report potential sightings. A zebra mussel watch card was developed with reporting information specific to the California Zebra Mussel Watch Program (Figure 4.1).

Table 4.1. Citations for zebra mussel publications.

Citation
Veldhuizen, T. and C. Messer. 2003. Program implemented to prevent establishment of the invasive zebra mussel into California. *Pisces*, 32(4):7-9.
Veldhuizen, T. and C. Messer. 2003. Protect your watershed form zebra mussels, become a volunteer monitor. *Pisces*, 32(4):10-11.
Veldhuizen, T. and C. Messer. 2004. Program implemented to prevent establishment of the invasive zebra mussel into California. *Interagency Ecological Program Newsletter*, 17(1) Winter issue.
Veldhuizen, T. and C. Messer. 2004. Protect your watershed form zebra mussels, become a volunteer monitor. *Interagency Ecological Program Newsletter*, 17(1) Winter issue.

A.



B.

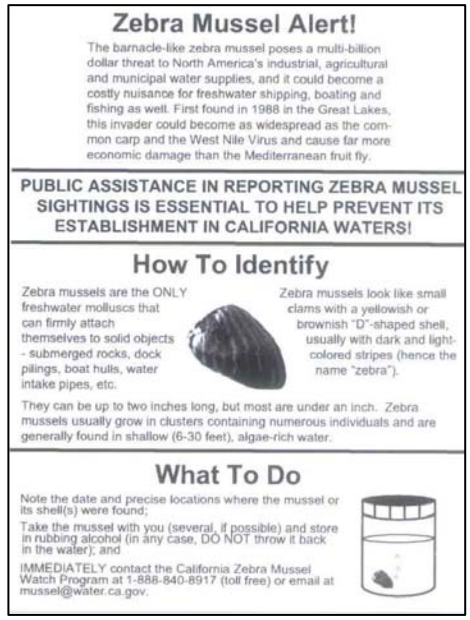


Figure 4.1. The zebra mussel watch card. A) Outside of watch card. B) Inside of watch card.

A poster was developed to educate the public in a quick and captive format (Figure 4.2). The poster provided information on zebra mussel identification and impacts, described clean boating practices, requested assistance with early detection monitoring, and provided instructions for reporting potential sightings. It also contained images of zebra mussel impacts.

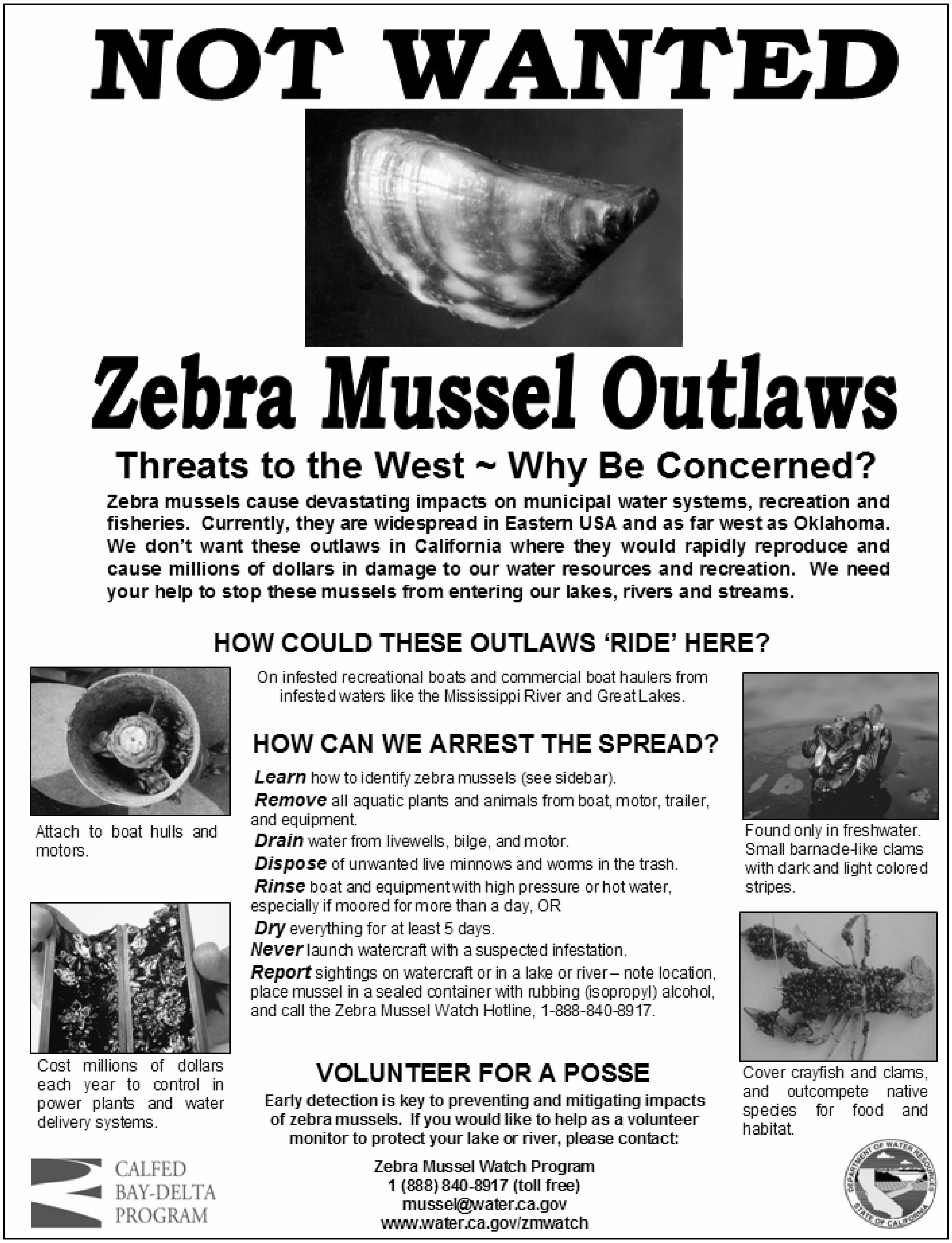


Figure 4.2. The zebra mussel poster.

Presentation of Zebra Mussel Information at Conferences, Workshops, and Meetings

ZMEDOP staff attended conferences, workshops, and meetings to obtain and exchange current information and give presentations. Information regarding all aspects of the program was presented at 20 local, regional and national conferences and meetings (e.g., International Conference on Aquatic Invasive Species, 100th Meridian Initiative Annual Meeting, American Fisheries Society Western Division Conference, Marine Bioinvasions Conference, and CALFED Science Conference) as oral or poster presentations (Table 4.2). Oral presentations were usually accompanied by a slideshow.

Table 4.2. List of conferences, workshops, and meetings where information about the zebra mussel program was presented. Information was provided as oral presentation (oral), oral presentation accompanied by slide show (oral with slides), or poster presentation (poster).

Conference/Meeting	Type(s) of Presentation	Date	Location
11th International Conference on Aquatic Invasive Species	poster	February 2002	Alexandria, VA
CALFED Nonnative Invasive Species Advisory Council	oral with slides	April 2002	Sacramento, CA
DWR Environmental Scientist Workshop	poster	September 2002	Fallen Leaf Lake, CA
CALFED Nonnative Invasive Species Advisory Council	oral with slides	December 2002	Sacramento, CA
CALFED Science Conference	poster	January 2003	Sacramento, CA
Interagency Ecological Program Annual Meeting	poster	February 2003	Asilomar, CA
Marine Bioinvasions Annual Conference	poster	March 2003	La Jolla, CA
100th Meridian Initiative Annual Meeting	oral with slides	June 2003	Atchison, KS

Table 4.2, continued. List of conferences, workshops, and meetings where information about the zebra mussel program was presented. Information was provided as oral presentation (oral), oral presentation accompanied by slide show (oral with slides), or poster presentation (poster).

Conference/Meeting	Type(s) of Presentation	Date	Location
CALFED Nonnative Invasive Species Advisory Council	oral with slides	July 2003	Sacramento, CA
DWR Environmental Scientist Workshop	oral with slides, poster	September 2003	Davis, CA
Wildlife Society Annual Meeting	poster	October 2003	Sacramento, CA
6th Biennial State of the Estuary Conference	poster		Oakland
Cache-Putah Creeks Watershed Bioregional Outreach Meeting	oral	January 2004	Winters, CA
Interagency Ecological Program Annual Meeting	poster	February 2004	Lodi, CA
Carmel River Watershed Conservancy Group	oral with slides	February 2004	Carmel, CA
American Fisheries Society Western Division Conference	poster	March 2004	Salt Lake City, UT
Annual Meeting of California-Nevada Chapter of the American Fisheries Society	poster	April 2004	Redding, CA
DWR Environmental Scientist Workshop	poster	September 2004	Fallen Leaf Lake, CA
Clear Lake Advisory Subcommittee meeting	oral with slides	August 2004	Lakeport, CA
Association of California Water Agencies 2005 Spring Conference	oral with slides, poster	May 2005	San Jose, CA

Distribution of Materials

Informational materials were supplied to all interested groups, including volunteer monitors, water agency staff, marina staff, State and Federal agency staff, visitor centers, educators, and attendees of meetings and conferences (Appendix I). Materials consisted of those developed by ZMEDOP staff and by other organizations and were assembled into an “Information Packet” (Table 4.3, Appendix C). The “Volunteer Packet” provided to volunteer monitors included the “Information Packet.” Larger quantities of some materials were supplied to some individuals for further distribution, such as visitor center staff and educators (Appendix I). Materials were re-supplied, as needed, to groups already receiving them.

Beginning in 2003, ZMEDOP staff collected data on the quantity of materials distributed (Table 4.4). ZMEDOP staff distributed 58 information packets and 40 volunteer packets to individuals. In addition, staff provided individuals and visitor centers with additional materials for distribution to colleagues, other agency staff, and/or the general public. Distributed materials included over 850 “Zap the Zebra” pamphlets, 340 zebra mussel watch cards, 167 “Not Wanted – Zebra Mussel Outlaws” posters, 100 “Zebra Mussels in North America – The Invasion and its Implications” pamphlets, 80 “Zebra Mussels: Questions and Answers for Inland Lake Managers” pamphlets, and 40 “Program Implemented to Prevent the Establishment of the Invasive Zebra Mussel into California” articles. Materials distributed at conferences, workshops, and meetings were not quantified.

Table 4.3. Outreach materials included in the zebra mussel information packet.

Outreach Material	Developed by:
"Zebra Mussel Watch Program" business card	ZMEDOP/DWR
"Not Wanted – Zebra Mussel Outlaws" poster	ZMEDOP/DWR
"Protect your Watershed from Zebra Mussel, Become a Volunteer Monitor" article	ZMEDOP/DWR
"Program Implemented to Prevent the Establishment of the Invasive Zebra Mussel into California" article	ZMEDOP/DWR
"Zebra Mussels: Questions and Answers for Inland Lake Managers" pamphlet	Illinois-Indiana Sea Grant College Program, Illinois Natural History Survey, and UIUC Department of Natural Resources and Environmental Sciences
"Zebra Mussels Discovered at Washington-Idaho Border" WDFW news release (WDFW 2004)	Washington Department of Fish and Wildlife
"Zebra Mussels in North America – The Invasion and its Implications" pamphlet	Ohio Sea Grant College Program
"Zap the Zebra" pamphlet	BOAT/US Clean Water Trust
"Stop Aquatic Hitchhikers!" sticker	USFWS

Table 4.4. Quantity of zebra mussel outreach materials distributed in 2003 and 2004. Quantities do not include amount distributed at conferences, meetings and workshops.

Outreach Material	Quantity
Information Packet	58
Volunteer Packet	40
"Zap the Zebra" pamphlet	847
Zebra Mussel Watch Card	340
"Not Wanted – Zebra Mussel Outlaws" poster	167
"Zebra Mussels in North America – The Invasion and its Implications" pamphlet	100
"Zebra Mussels: Questions and Answers for Inland Lake Managers" pamphlet	80
"Program Implemented to Prevent the Establishment of the Invasive Zebra Mussel into California" article	40

Training of Volunteer Monitors

Each volunteer monitor was provided with an information packet and a monitoring packet. We trained the majority of the volunteers in person. A few were trained over the phone. Training involved explaining the impacts of zebra mussels and the benefits of early detection monitoring; how zebra mussels differed from native mussels and clams and the introduced Asian clam, *C. fluminea*; zebra mussel life history as it pertains to early detection monitoring; how to check the substrate sampling device for veligers and newly settled juvenile mussels; how to record and report data; and how to report potential sightings (see Chapter 3 for further information).

We trained 55 individuals how to monitor for zebra mussels using the substrate sampler. A list of individuals who received training for monitoring and conducted monitoring is provided in Appendix J.

Chapter 5

Zebra Mussel Watch Database

Purpose of the Database

All information collected as part of the Zebra Mussel Watch Program, except the boater survey data[1], is stored in an Access database designed specifically for this Program. The database contains data on volunteers, early detection monitoring sites, waterbodies, zebra mussel monitoring results, and collected macroinvertebrates. Queries can be used to access and combine the various types of data stored in this database. Though data are different in nature (i.e., waterbody information versus invertebrate identification and/or catch), the results of these combinations can be used to yield information on zebra mussel introductions and movement, to generate lists of agencies/organizations involved in monitoring, and to organize baseline data on aquatic invertebrates and zooplankton.

All data, except personal contact data of volunteers, stored in this database will be made accessible to the public at the completion of this phase of the Program. This database is part of a two-step process for transferring data from DWR staff computers to the Internet (see Data Accessibility Section).

Components of the Database

The database consists of multiple tables that are related to each other or to a subset of tables through unique identifiers or common data fields (Figure 5.1).

Contact Information

Data collected on all persons and organizations contacted was recorded on the 'Zebra Mussel Contact Information' datasheet (Appendix K), entered into the database using the 'Zebra Mussel Contact Information' form (Figure 5.2), and was stored in the 'ContactsLookUp' table. Data on the type and quantity of public

[1] The boater survey data was entered into an Excel database and the datasheets were mailed to David Britton (US Fish and Wildlife Service, Region 2) for inclusion in the 100th Meridian boater usage pattern database. The results of our survey are presented in Chapter 1.

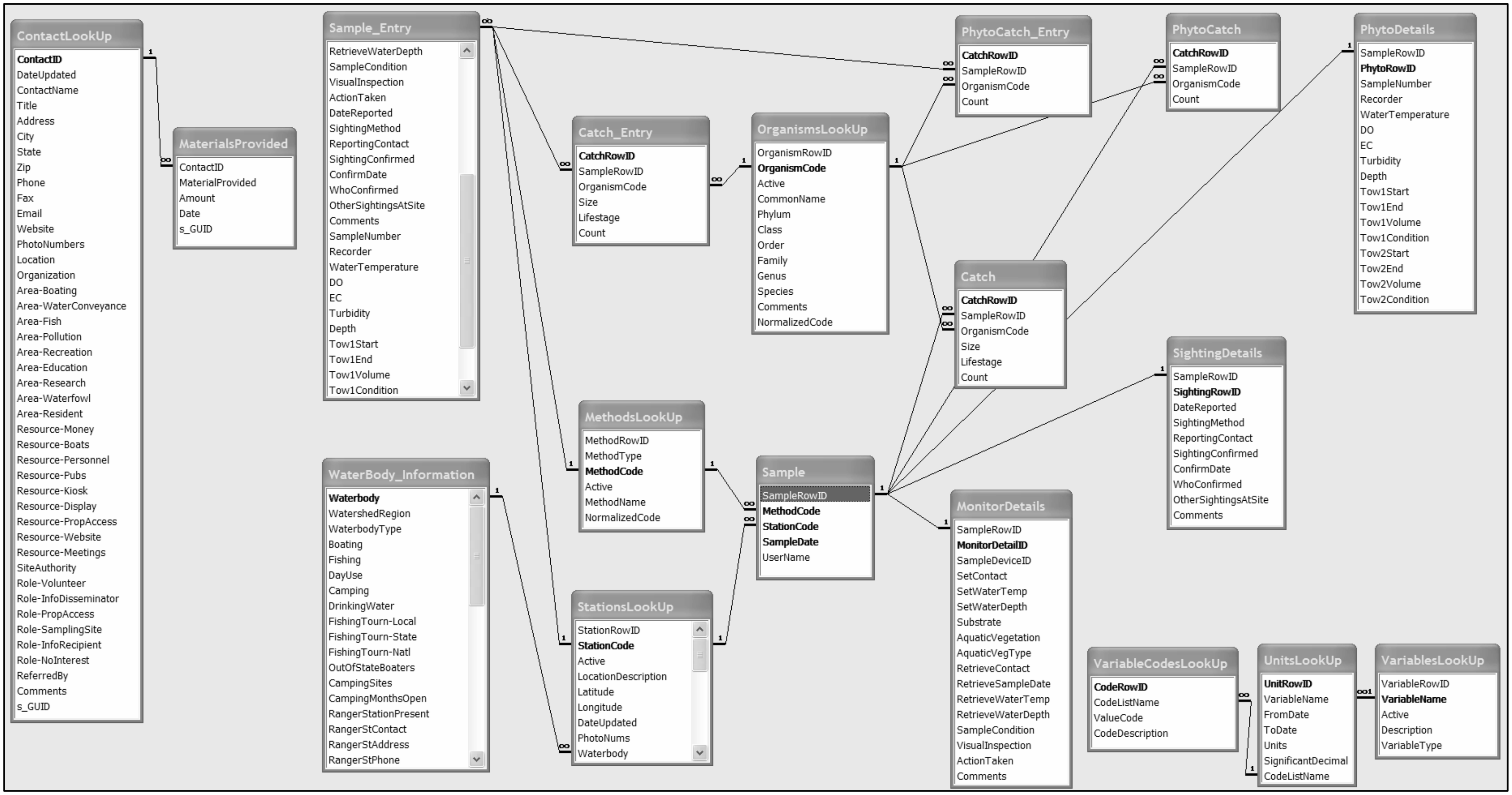


Figure 5.1. Data tables and their relationships in the Zebra Mussel Watch Program database. The connecting lines represent links between data tables. The bold-faced data fields are the fields that are linked to other tables.

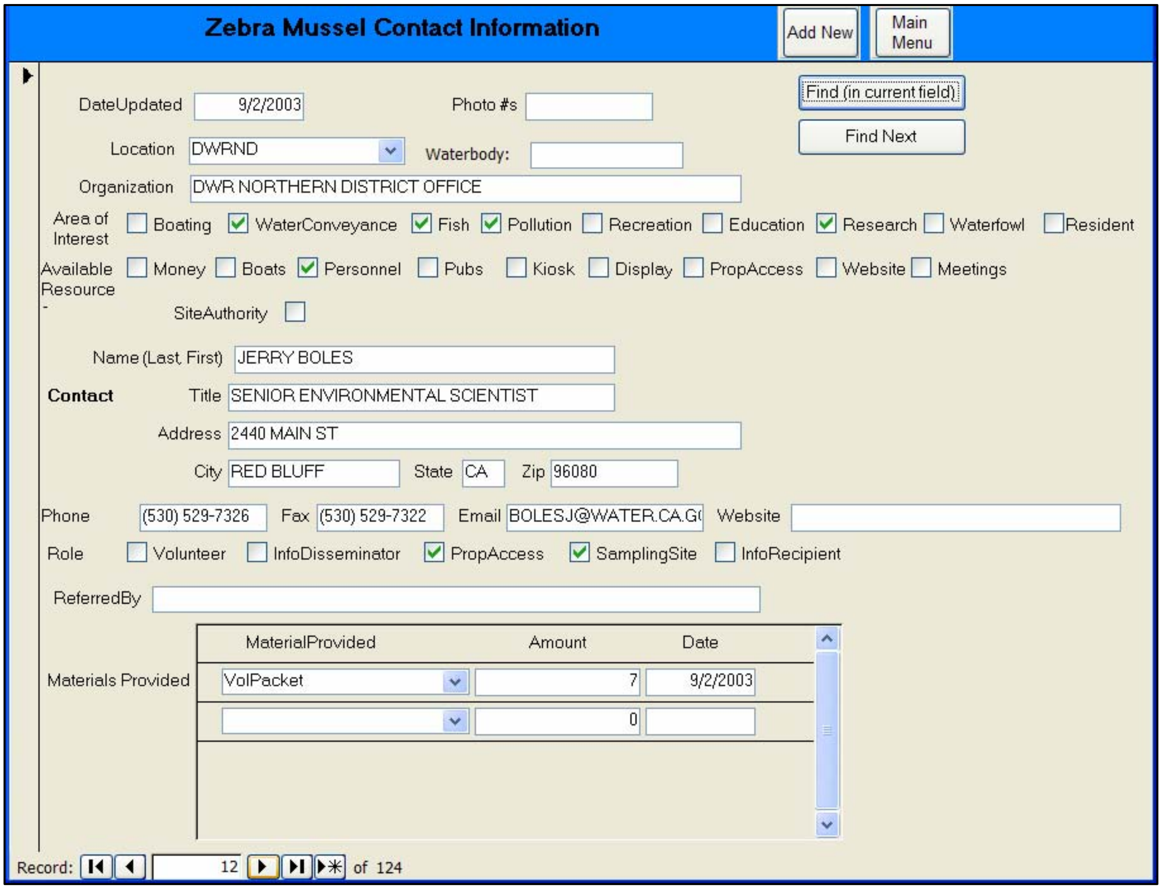


Figure 5.2. The form for entering data collected on each person or organization contacted and provided with outreach materials.

outreach materials provided to each person is stored in the 'MaterialsProvided' table. Data collected includes name, organization, address, phone number, email address, area of interest, the types of resources the person or organization offered to the Program, the role or level of involvement of the person or organization, and the type and quantity of outreach materials provided to them.

Waterbody Information

Data was collected on each waterbody surveyed and recorded on the 'Zebra Mussel Waterbody Information' datasheet (Appendix K). The data was entered into the database using the 'Zebra Mussel Water Body Information' form (Figure 5.3) and was stored in the 'WaterBody_Information' table. Collected data included waterbody name and type (e.g., reservoir, lake, river, aqueduct), types

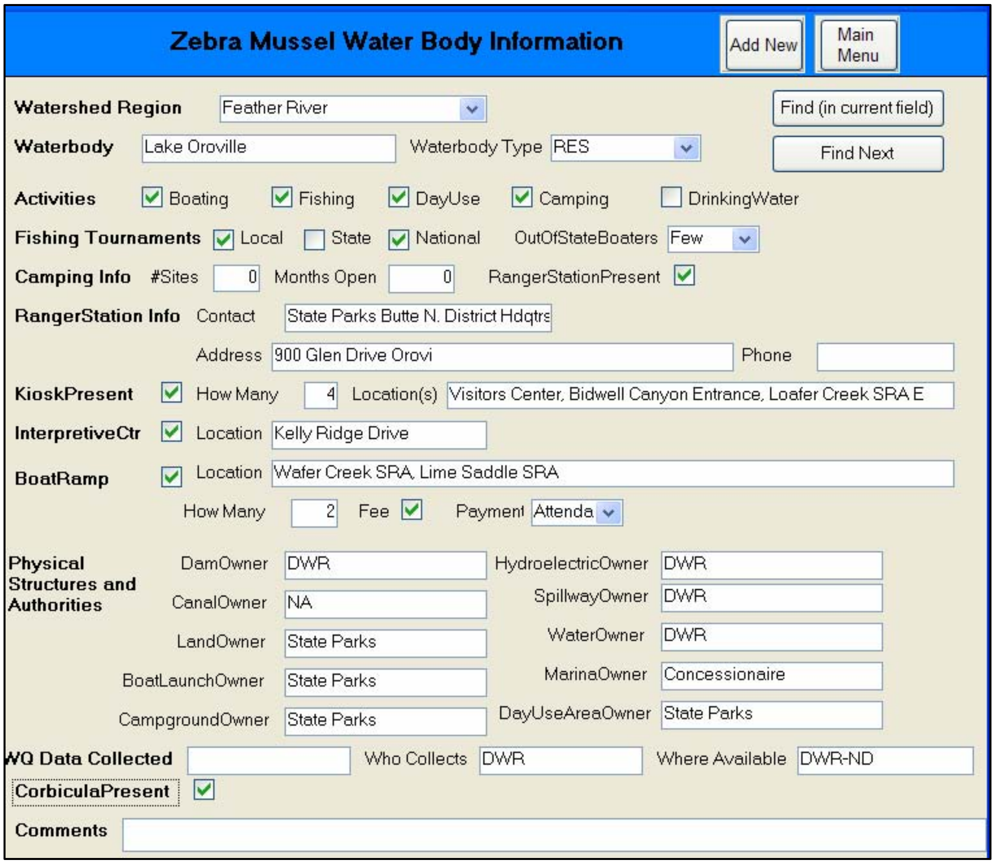


Figure 5.3. The form for entering data collected on each waterbody.

of activities available (e.g., boating, camping, fishing), ranger station information, presence and location of structures for displaying public outreach materials (e.g., kiosks, interpretive centers), and owners or authorities of any physical structures (including the water and surrounding land).

Monitoring Site Information

Data on each monitoring site was recorded on the 'Zebra Mussel Monitoring Site' datasheet (Appendix K), and entered into the database using the 'Sites/Locations' form (Figure 5.4). The data was stored in the 'StationsLookUp' table. Types of data collected include name of location, description of the location, sample site landmarks and GPS coordinates, sample number, site access information, and name of the volunteer monitor. Contact information for the volunteer monitor is stored in the 'ContactLookUp' table.

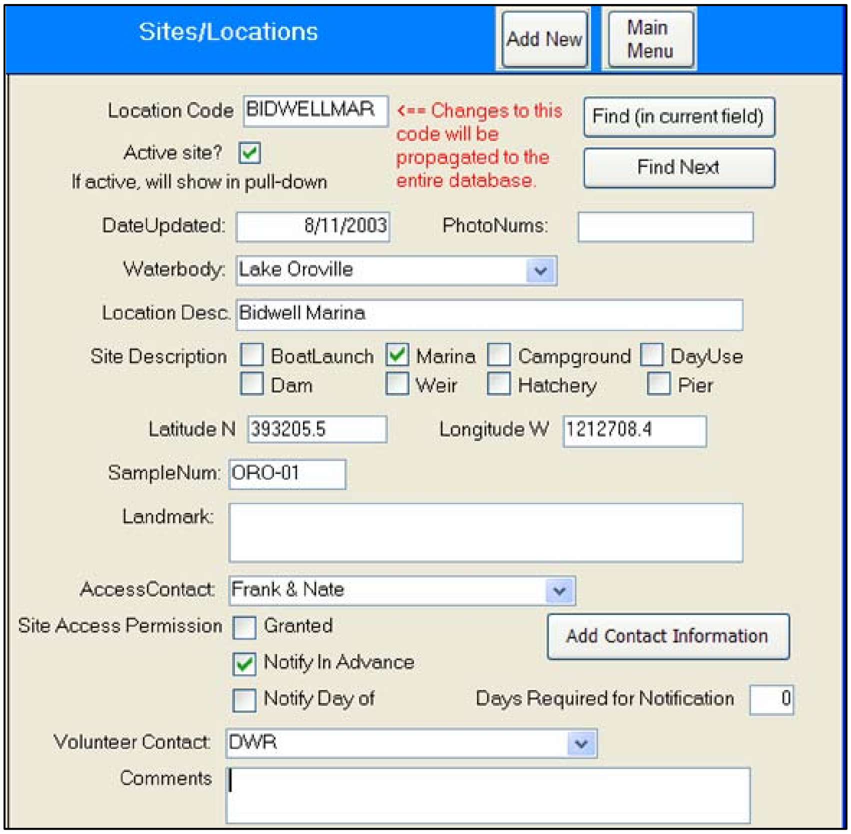


Figure 5.4. Form for entering early detection monitoring site data.

Early Detection Monitoring Data

Data from the zebra mussel substrate sampler devices was recorded on the 'Zebra Mussel Early Detection Monitoring' datasheet (Appendix K). Data is entered into the database using the 'Entry Monitor data' form (Figure 5.5) and is stored in the 'MonitorDetails' table. Data collected by the volunteer monitor includes name of monitoring site location, sample number, set and retrieval dates, water temperature and depth at time of sampler deployment (set) and retrieval, presence and type of aquatic vegetation, condition of the sampler upon retrieval, and the presence or absence of zebra mussels based on visual inspection.

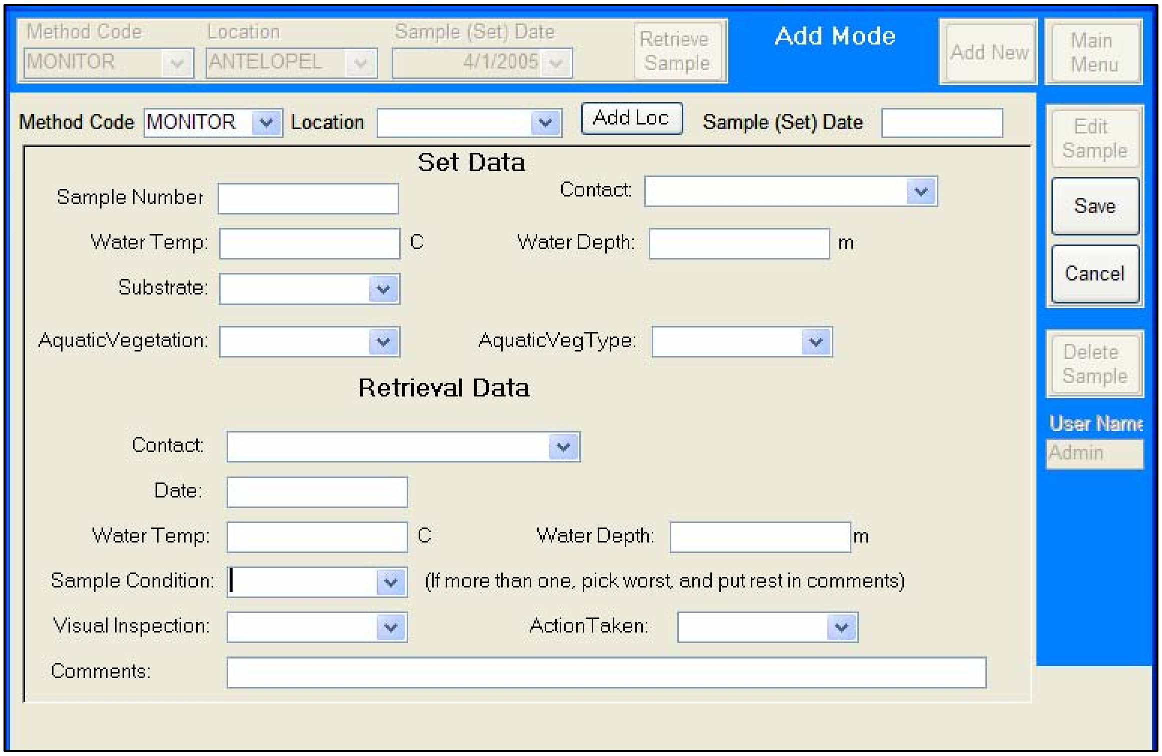


Figure 5.5. Form for entering early detection monitoring sampling data.

Reported Zebra Mussel Sightings Data

All reported zebra mussel sightings, including false sightings, were entered into the database using the ‘Entry Sighting data’ form (Figure 5.6). Data recorded included date of the reported sighting, where the organism was sighted, name and contact information of the person making the report, the date the sighting was confirmed by a biologist, name of the confirming biologist, and any other sightings made at this location. Additional data was collected on the organism type (i.e. species), life stage, size, and quantity. The data was stored in the ‘SightingDetails’ and ‘Catch’ tables.

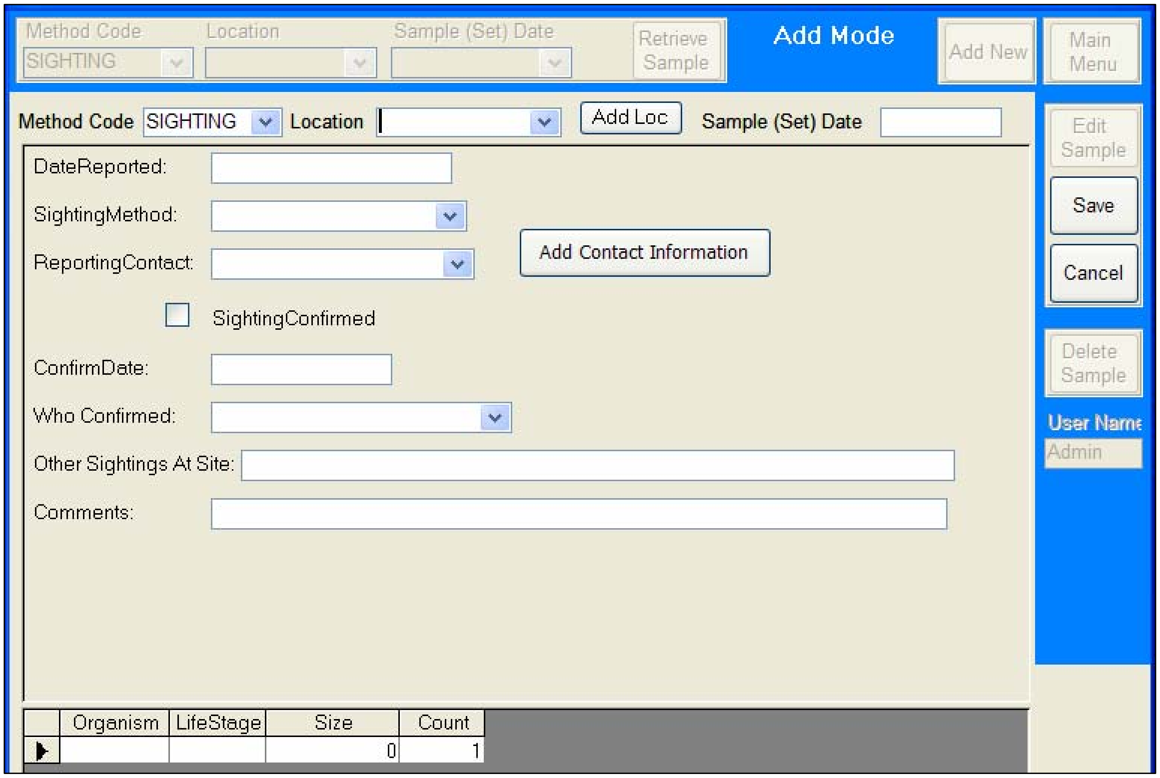


Figure 5.6. Form for entering reported zebra mussel sightings data and confirmation follow-up data.

Plankton Tow Data

Veliger or phytoplankton tows were not conducted during the course of this Program, but the database can accommodate these data. Sample description and catch data is entered into the database using the ‘Entry Phyto Tow data’ form (Figure 5.7). The data is stored in the ‘PhytoDetails’ and ‘PhytoCatch’ tables. Available data fields include tow duration and volume, sample date, tow start and end times, water quality parameters, and catch data (i.e. taxonomy and quantity of organisms).

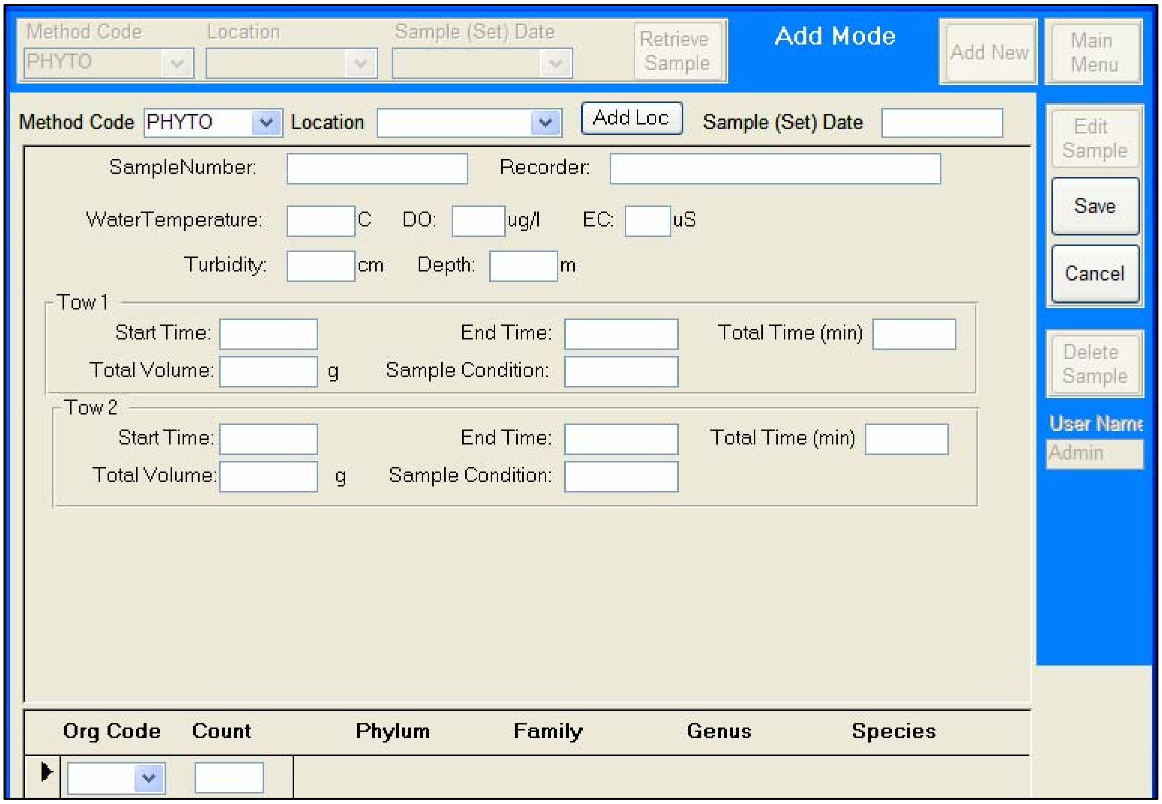


Figure 5.7. Entry form for the plankton tow data.

Description of Data Variables

A description of each data variable was included in the database and is found in the 'Data Dictionary' (Figure 5.8). The Data Dictionary is accessed from the main page of the Zebra Mussel Monitoring Database. To access the dictionary, select 'Data Dictionary' under 'Lookup Tables' (Figure 5.9).

Data Entry

New monitoring, plankton (veliger) and sighting data is added to the database and existing data is edited from the main form (Figure 5.10). Select either 'monitor', 'phytoplankton' or 'sighting' and click 'Add/Edit' under the 'Sample Data' heading on the main form. A sub-form similar to the field datasheet is generated at this point (Figures 5.5, 5.6, 5.7). New data is entered into the subform or existing samples are retrieved for editing.

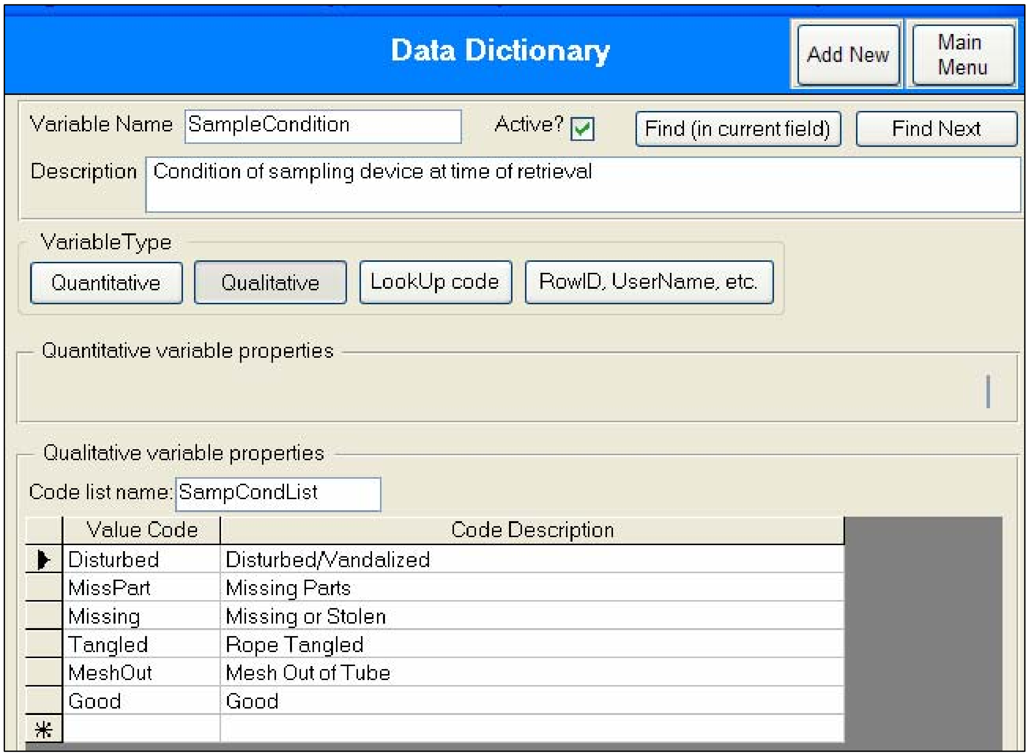


Figure 5.8. Form for the 'Data Dictionary.'

To add new contact, location, waterbody, organism (species) and data dictionary information or to edit existing data, select the appropriate category from the 'Lookup tables' and click on 'Edit' on the main form (Figure 5.9). A subform is generated allowing changes to be made to the appropriate table (Figures 5.2, 5.3, 5.4, 5.8).

<u>Data Accessibility</u>

This database, as well as the original datasheets, is currently housed with DWR staff at 3251 S Street, Sacramento, CA 95816. Copies of the database format can be obtained from DWR staff upon request. With the exception of volunteer contact and personal information, all data is uploaded from the Zebra Mussel Watch Program's database to the Bay-Delta and Tributaries Database (BDAT) managed by the Interagency Ecological Program (IEP). This comprehensive

Figure 5.9. Subforms for entering or editing data on collected organisms, monitoring or surveyed locations, contacts, waterbodies, organism life stages, or the Data Dictionary are accessed from the Main Menu under 'Lookup tables.'

Figure 5.10. Data entry subforms for entering monitoring data, zebra mussel sighting data, and plankton tow data are accessed from the Main Menu under 'Sample data.'

database houses monitoring data from numerous agency studies and is available to the general public (http://bdat.ca.gov/).

For questions regarding database format and design please contact:

Maureen McGee
Interagency Information Systems Service
Department of Water Resources
(916) 227-1308, mmcgee@water.ca.gov

Chapter 6

Zebra Mussel Rapid Response Plan for California

Introduction

As part of the Zebra Mussel Early-Detection Monitoring and Outreach Program and the California Zebra Mussel Watch Program (CZMWP), this rapid response plan was developed to outline necessary actions and resources needed to respond to a confirmed introduction of zebra mussels into this state. The goals of this rapid response plan are to provide information necessary to facilitate the eradication and/or control of zebra mussels in waters within the "CALFED area of interest" (Central Valley watershed), and to serve as the template for a state rapid response plan that includes all water bodies within California.

This plan outlines available options for eradication and/or control of zebra mussels. This plan is a guideline for resource managers and agency personnel and does not advocate any one eradication or control technique over another. Included is a list of potential zebra mussel infestation scenarios with possible treatment and post-treatment monitoring techniques.

The Zebra Mussel Rapid Response Plan for California is a working document that requires additional information, which will be incorporated as it becomes available, regarding funding sources, permitting requirements, specific roles of agency personnel, legal information, and infestation site specific information. This draft plan will serve as the template for a statewide plan which staff from the Department of Water Resources will continue to develop.

It should be noted that agencies will not be required to commit funds, staff or resources beyond an amount that is reasonable for the size and level of involvement of the agency. All actions taken in response to zebra mussel introduction into this state (e.g., eradication/control, preventing spread, education/outreach, detection and enforcement) will require an extensive and highly creative system of sharing resources and staff among all agencies and stakeholder groups involved. Several agencies or individuals may be assigned specific roles in this plan; these assignments reflect the agency's or individual's capacity and/or expertise to initiate and/or authorize certain actions (e.g., boat inspections, temporary closure of water bodies for recreational use) and may or may not involve providing funding, resources or staff. As with other eradication and control actions taken against newly introduced species in California (e.g., *Caulerpa taxifolia,* Northern Pike), specific roles, available funding, resources and staff may not be determined until the official state response plan is developed or until zebra mussels are detected in the State's waters.

Definitions and Acronyms

CAZMAT - California Zebra Mussel Action Team

CZMWP - California Zebra Mussel Watch Program

Control - actions taken to restrain a current zebra mussel population within a given waterbody once it is determined that complete removal is not an option.

Establish - successful introduction and persistence of a population of zebra mussels in a given waterbody beyond one year.

Eradicate - to exterminate a population of zebra mussels in a given waterbody.

HACCP - Hazard Analysis and Critical Control Point

Vector - means by which zebra mussels are transported overland and by water between waterbodies

Veliger - a free-swimming larval stage of mollusks characterized by the presence of a ciliated velum utilized for swimming and feeding.

Rapid Response Participants

To implement this plan, three groups will be utilized at various stages of the rapid response actions. Individuals and agencies may belong to more than one group.

These groups and their associated tasks are:

1) California Zebra Mussel Watch Program (CZMWP) (Appendix L)

Staff for the CZMWP are currently employed in the Division of Environmental Services at the Department of Water Resources (DWR). Responsibilities of this group include maintaining early-detection monitoring in the CALFED-California Bay Delta Authority (CALFED) area of interest, maintaining contact with other groups conducting monitoring for zebra mussels in California, and maintaining the program’s database, toll-free hotline, email address and website. This group serves as the first point of contact for receiving zebra mussel sighting reports and will conduct sighting confirmation and specimen identification. Rapid response actions will be initiated by this group in response to a confirmed zebra mussel identification. CZMWP staff will serve as members of the California Zebra Mussel Action Team (CAZMAT) once mussels are detected in California.

2) California Zebra Mussel Action Team (CAZMAT) (Appendices M-O)

Purpose

CAZMAT will serve as an advisory council in the event of a zebra mussel introduction in California, will coordinate and implement rapid response actions and will continue post-introduction monitoring, treatment, and information dissemination efforts indefinitely.

Members

The CAZMAT will consist of representatives from federal, state and local agencies, special interest groups and the general public. The core team will be small (approximately 8-15 individuals), but all interested organizations will be invited to regular meetings to discuss pertinent information about the introduction such as current distribution, potential for spread, proposed treatment plans, enforcement, detection, monitoring actions, and impacts to industrial, agricultural, municipal and recreational activities. Formation of the CAZMAT will depend on the available funding, resources and staff provided by the various agencies and interest groups. This effort will entail extensive and creative cost and resource-sharing efforts from all interested organizations. Appendix M lists potential organizations that will either participate as core members of CAZMAT, be continually provided with information on CAZMAT activities via email, and/or will be invited to attend public meetings. The list may not contain all organizations and groups interested in zebra mussels. New groups will be added as they are identified.

Structure and Tasks

The CAZMAT will consist of 4 main groups or “teams” including the Incident Coordinators, Incident Action Team, Information Dissemination Team and the Stakeholder Group (Appendix N). The Incident Coordinators, Incident Action and Information Dissemination Teams will coordinate and implement all rapid response-related actions. The Stakeholder Group will participate in meetings and be provided with information regarding all rapid response actions. Stakeholders may provide a variety of items including property access, support for treatment/eradication options, funding, resources and staff.

The Incident Action and Information Dissemination Teams are comprised of sub-groups with specific functions (e.g., funding procurement and contracting, field operations, securing permits, and public outreach). A detailed description of the Teams and sub-groups is provided in Appendix O.

Depending on the particular circumstances involved with an introduction of zebra mussels into California, all or some of the CAZMAT teams and their associated sub-groups will be utilized. Individuals may serve as core members of several groups if the listed tasks are such that this does not present an unreasonable workload for one staff person.

3) Zebra Mussel Science Panel (Appendix P)

This panel will be made up of experts of: 1) zebra mussel biology, impacts, monitoring, and control; 2) water projects and water issues in CA; 3) freshwater mollusks; 4) agricultural pest control; and 5) CA invasive species issues and regulations. Panel members may be located locally or from out-of-state and may or may not also serve as members of CAZMAT. A partial list of panel members, their contact information and area of expertise is listed in Appendix P. Additional members will be added as they are identified.

Rapid Response Actions (Appendix Q - U)

A flow chart of the rapid response actions outlined below is provided in Appendix Q.

Action 1. Zebra mussel sighting reported to CZMWP staff

Currently, CZMWP staff are employed by the CA Department of Water Resources, Division of Environmental Services (DWR-DES). The current lead investigators for this project are:

Tanya Veldhuizen
Environmental Scientist
Phone: 1 (916) 227-2553 or 1 (888) 840-8917
Email: tanyav@water.ca.gov or mussel@water.ca.gov
Fax: 1 (916) 227-7554

and

Cindy Messer
Senior Environmental Scientist
Phone: 1 (916) 651-9687 or 1 (888) 840-8917
Email: cmesser@water.ca.gov or mussel@water.ca.gov
Fax: 1 (916) 651-9653

The following instructions are for an initial response to a potential zebra mussel sighting. CZMWP staff may receive reports via the Program's toll free "hot line", email address or website (see below).

> Phone: (toll free "zebra mussel hot line") - 1 (888) 840-8917
> Email: mussel@water.ca.gov
> CA Zebra Mussel Watch Program website: www.water.ca.gov/zmwatch

Instructions for initial response to reported sightings:

A. Zebra Mussel Hotline

Calls regarding potential zebra mussel sightings are received directly by CZMWP staff via the zebra mussel hotline located at the DWR-DES office in Sacramento. Calls are answered as they come in; voicemail messages are returned within 24 hours.

Cindy Messer and Tanya Veldhuizen share the task of responding to calls to ensure coverage during vacation and sick leave. When Cindy and Tanya are off duty at the same time and for longer than 2 days, a third DWR staff person is assigned the task of checking for voicemail messages twice per day and recording information into a call log. If a sighting is reported, the DWR staff person is to contact the following agency personnel by phone (in order):

Susan Ellis
Invasive Species Coordinator
California Department of Fish and Game
Central Valley Bay-Delta Branch
Phone: (916) 653-8983
Email: sellis@dfg.ca.gov
Fax: (916) 653-8256

and

Jeffrey J. Herod
U.S. Fish and Wildlife Service
Supervisory Fishery Biologist
Phone: 209.946.6400 X 321
Fax: 209.946.6355
Email: Jeffrey_Herod@fws.gov

If no verbal contact is made with Susan and Jeffrey or if both are unavailable to respond to the sighting within 24 hours, the DWR staff person will then contact both**:**

David Bergendorf	and	Lia McLaughlin
Aquatic Nuisance Species		Non-native Invasive Species Program
Program Assistant		Watershed Coordinator
US Fish and Wildlife Service		US Fish and Wildlife Service
Phone :(209) 946-6400 ext. 342		Phone (209) 946-6400 x 337
Email: david_bergendorf@fws.gov		Email: lia_McLaughlin@fws.gov
Fax (209) 946-6355		Fax: (209) 946-6355

In the event that all agency contacts listed above are not available to respond to a zebra mussel sighting report, the DWR staff person will contact:

Kim Webb
Deputy Project Leader
U.S. Fish and Wildlife Service
209-946-6400 x 311
Fax 209-946-6355
kim_webb@fws.gov

B. Email

Email messages are received directly by both Cindy Messer and Tanya Veldhuizen. Emailed reports of zebra mussel sightings are responded to within 24 hours and preferably by phone. If no phone number is provided by the reporter, an emailed response is made. Email is checked regularly throughout the business day by both lead investigators.

If Tanya and Cindy are out of the office at the same time and for longer than 2 days, all messages received at this email address are forwarded to a third DWR staff person. This person is instructed to check email regularly throughout the day, to save all incoming messages, and to contact the agency personnel (by phone and by forwarding the emailed report) as described above.

C. Website

Instructions for reporting a zebra mussel sighting on the website include calling the zebra mussel hotline and/or sending the information via the program's email address. Reported sightings will be handled as described above.

D. Additional Comments

To minimize the risk of losing reports due to complicated reporting instructions, persons reporting a suspected zebra mussel sighting ***will not*** be instructed to contact other agencies when CZMWP lead staff are out of the office. All reported sightings will be initially handled by CZMWP/DWR staff and reported to other appropriate agency staff as outlined above.

In addition to reports received by CZMWP staff, sightings may also be reported to the California Department of Fish and Game, U.S. Fish and Wildlife Service, and the 100^{th} Meridian Initiative via phone and email addresses obtained from these agencies websites.

Action 2. Zebra Mussel Sighting Report Response

All individuals reporting a suspected zebra mussel sighting will be asked for the following information by either CZMWP staff or other agency staff (as listed in Action 1):

Location: Exact location zebra mussel(s) or shell(s) was found (e.g., latitude/longitude, water body name, landmarks such as the name of the marina, boat launch, beach or campground where mussel was found, and whether the mussel(s) or shell(s) found on a boat, in the water or on the beach).

Date: when mussel(s) or shell(s) was found.

Contact Information: Name and contact information of individual reporting the sighting.

The individual reporting the sighting will be asked to preserve the zebra mussel(s) or shell(s) in rubbing alcohol or in a freezer. The individual will be instructed not to return the specimen(s) to the water. Arrangements will be made between CZMWP staff (or agency staff listed above) and the reporting individual for pick-up of the mussel(s) or shell(s). If possible, the reporting individual will be asked to show agency staff where the specimen(s) was found.

Action 3. Zebra Mussel Sighting Validation

A. Confirm specimen identification

1. CZMWP staff (or staff listed above in Action 1) will pick-up specimens from the individual reporting the sighting at the location where they were found and conduct an initial visual inspection of the site for additional signs of zebra mussel presence. The visual inspection will consist of searching for and collecting additional zebra mussels and photographing zebra mussels if attached to objects such as boats or docks.

2. A specimen will immediately be sent to CDFA for official identification and will be treated as a “High Priority" item.
   - Dr. Rosser W. Garrison
Associate Insect Biosystematist
Plan Pest Diagnostics
CA Department of Food & Agriculture
3294 Meadowview Road
Sacramento, CA 95832-1448
Phone: (916) 262-1167
Fax: (916) 262-1190
Email: rgarrison@cdfa.ca.gov

3. Send alternate specimen to The University of Texas at Arlington for expert identification.
   - Dr. Robert "Bob" McMahon
Associate Dean, College of Science
The University of Texas at Arlington
Box 19047
Arlington, Texas 76019
Phone: 817-272-3492   Fax: 817-272-3511
E-mail: r.mcmahon@uta.edu

4. Send alternate specimen to CZMWP staff at DWR for rapid preliminary identification.
   - Tanya Veldhuizen
     Zebra Mussel Watch Program
     California Department of Water Resources
     Division of Environmental Services
     3251 S Street
     Sacramento, CA 95816
     Phone: (916) 227-2553 or 1-888-840-8917 Fax: (916) 227-7554
     Email: mussel@water.ca.gov

5. Send alternate specimen for rapid preliminary identification
   - Wayne Fields
     Aquatic Invertebrate Taxonomist
     Hydrozoology
     P.O. Box 682
     Newcastle, CA 95658
     Phone: (916 663-1900

Zebra mussel identification will be conducted using well-established methods such as cross-polarized light for larval zebra mussels (veligers) and the use of taxonomic keys for adult zebra mussels (McMahon 1991, Mardsen 1992, Conn 1993, Johnson 1995).

B. Confirm presence of zebra mussels in the waterbody

If zebra mussel identification is confirmed, CZMWP staff (or agency staff listed in Action 1) will contact CAZMAT Incident Coordinators directly to initiate the following actions:

1. Convene CAZMAT – Assistant Incident Coordinator will contact all Incident Action Team (IAT) members listed in Appendix M. CAZMAT Incident Coordinators will select and coordinate a small group to conduct fieldwork to determine if a population of zebra mussels is established at the site.

   Establishment is defined as either the presence of a colony of juvenile/adult mussels and/or presence of veligers in zooplankton samples taken at the site. Incident Coordinators working with the Funding Team will seek assistance from cooperating stakeholder groups. The waterbody authority will be requested to secure staff, resources and property access.

2. Information Dissemination – In addition to fieldwork, information regarding the positive identification of a zebra mussel in CA will be relayed to the media, to appropriate state government officials, to the

CAZMAT Stakeholder Group, and to other zebra mussel and aquatic invasive species programs outside of the state. The CAZMAT Information Dissemination Team working with the Incident Coordinators will be responsible for completing this task.

Action 4. Initiate Rapid Response Plan Actions

A. If a population of zebra mussels is **not** found to have established at the waterbody, the following actions will be conducted:

1. The CAZMAT Incident Coordinators will be notified and monitoring will be conducted, short-term (e.g. 6 months) at the waterbody to ensure zebra mussels are not present. Updates on information regarding this action will be provided as described in Action 3. Data collected from the monitoring will be stored in the CZMWP database. If no zebra mussels are found after 6 months, rapid response actions will cease and a monthly volunteer monitoring program will commence.

B. If a population of zebra mussels **is** established at the waterbody, the Assistant Incident Coordinator and Information Dissemination Team will conduct the following actions:

1. Convene an emergency meeting of all CAZMAT members and the Zebra Mussel Science Panel.

2. The Information Dissemination Team will continue to update information regarding the incident to all entities listed in Action 3, using the same methods as listed above.

3. Incident Coordinators and the Funding subgroup will work directly with the Stakeholder Group and State and Federal government officials to secure emergency (and long-term) funding, resources and staff to initiate rapid response actions.

Action 5: Notification of Eradication Plan and Public Education

The Information Dissemination Team (including the Public Outreach subgroup) and the Regulatory subgroup (with assistance from the Operations subgroup and the Stakeholder Group) will complete the following tasks:

A. Land ownership assessment.

1. Determine who owns the land

2. Notify landowner(s)

3. Educate landowner(s) and obtain support for eradication plan

4. Obtain permission from landowner(s) to enter property

B. Water user assessment.

1. Identify water users and water rights holders

2. Notify water users

3. Educate water users and obtain support for eradication plan

C. Resource management.

1. Identify all resources managers at site (not included above) and notify about public meetings and available information regarding zebra mussel impacts

D. Public notification

Incident Coordinators and any available CAZMAT members will attend public meetings.

1. Provide press release and information packets to media.
   a) press release available from CAZMAT
   b) information packets available from the CZMWP; contact: Cindy Messer or Tanya Veldhuizen, DWR

2. Hold town meetings.

3. Inform and educate landowners and water users.
   a) impacts of zebra mussel, control options, deciding factors, risks
   b) PowerPoint presentation is available from the CZMWP; contact: Cindy Messer or Tanya Veldhuizen, DWR

Action 6. Obtain Permits

The Regulatory subgroup will be responsible for completing the tasks described below.

A. Secure permits required for selected eradication method. Permits required will vary according to eradication method selected.

B. The Regulatory subgroup will work with representative from regulatory agencies (preferably already a part of the Stakeholder Group) to facilitate permit approval in a timely manner within their respective agency. Permits must be obtained in a timely manner to allow the implementation of the eradication procedures to commence prior to the spawning season and while environmental conditions are most suitable for successful eradication.

C. Obtain a Federal Crisis Exemption if the known or accepted methods of eradication are not useable in our situation and we need to take more extreme measures.

Action 7. Site Assessment and Vector Control

A. Delineate population

The Technical Expertise and Operations subgroups will lead with assistance from the Logistics and Detection/Enforcement subgroups to conduct the following tasks:

1. Use detection methodology: plankton tows, visual, substrate sampling, SCUBA, snorkeling.

2. Inspect physical structures within waterbody: boat ramps, launches, moorings, marinas, pumping structures, etc.

3. Inspect entire waterbody, downstream waterbodies/rivers, and neighboring waterbodies.

4. Survey potentially inoculated waterbodies.
    a) Survey all adjoining waterbodies
    b) Survey waterbodies with high boat usage

5. Determine circulation patterns in waterbody.
    a) Allows for prediction of spreading pattern within the waterbody
    b) Use dyes, particle tracking, and/or floating objects

6. Implement HACCP methodology for "clean" sampling practices.

B. Containment of veligers and movement of adults.

The Operations subgroup will lead with assistance from the Technical Expertise, Logistics, Regulatory, Detection/Enforcement teams to conduct the following tasks:

1. Assume veligers are present.

2. Stop or slow water release.
    a) draw water from below thermocline
    b) reduce amount released

3. Install a physical barrier.

C. Vector control

The Detection/Enforcement and Regulatory subgroups will lead with assistance from the Technical Expertise, Operations, Logistics, and Public Outreach subgroups to conduct the following tasks:

1. Enforce “No boat entry” policies.
    a) Sacramento-San Joaquin Delta closure (must prove "protection from major disaster")
    b) Work with local governments to close local waterbodies

2. Wash and inspect all removed boats and equipment.

3. Track all boats that recently used the infested waterbody.

4. Inspect other waterbodies used by the infested boat.

5. Post “Zebra Mussel Alert” signs.

D. Eradicate source of zebra mussel inoculation (e.g., infested boat)

The Detection/Enforcement team will lead with assistance from the Technical Expertise, Regulatory teams to complete this task.

E. Attempt to prevent spread of veligers via overland transport to other waterbodies

The Detection/Enforcement subgroup will lead with assistance from the Technical Expertise, Public Outreach, Regulatory, and Operations subgroups to complete the following tasks (where feasible, especially in waterbodies adjacent to the infested area):

1. Survey all boaters regarding previous waterbodies visited.

2. Inspect all boats before launching into waters not infested.

3. Quarantine boats that recently used the infested waterbody.

4. Close all unattended boat ramps in areas not infested.

F. Conduct Public Outreach Activities

The Public Outreach Team will lead with assistance from other appropriate CAZMAT teams to conduct the following tasks:

1. Develop/publish/disseminate literature to assist with and explain

detection, vector control, containment, and eradication/control activities.

2. Assist Information Dissemination Team with development of an extensive broadcast (radio, television, newspaper advertisements) of CAZMAT activities.

Action 8: Selection of Eradication Method

A. Convene meeting of all members of CAZMAT and the Zebra Mussel Science Panel to specifically discuss control/eradication efforts.

B. Determine control/eradication method.

   1. Chemical, physical, other.

   2. Consult Appendix R - Summary of zebra mussel eradication options.

   3. Consult Appendix S – Table of eradication and control options based on infestation scenario.

   4. Consult Appendix T – Table of chemical treatment options.

   5. Consult Appendix U – Methods for in situ evaluation method of effective applied chemical concentration and determination of zebra mussel death.

C. Determining factors in selecting eradication method(s):

   1. Type of waterbody – contained lake, on-stream reservoir, off-stream reservoir, small stream, large river, delta, water diversion.

   2. Extent of population distribution – isolated vs. widespread.

   3. Life stage(s) present.
      a) Assume veligers and adults are present

   4. Time of year in relation to spawning season.
      a) Is spawning occurring now?
      b) How many months until spawning?

   5. Relate spawning season to historical monthly temperature patterns for waterbody (spawning at 12+ °C).

   6. Amount of water in reservoir/waterway.
      a) Does reservoir need to be drawn down before treatment?
      b) Is river flow low enough for effective treatment?

7. Circulation patterns in waterbody.
    a) Determine spreading pattern of population within the waterbody
    b) Determine inflow rates and sources
        1) If water release is stopped, how fast will reservoir fill up and water level reach the spillway?
        2) If drawdown needs to occur, what is the feasibility given input source(s)?
    c) Determine rate of outflow and distance of veliger dispersal

8. Presence of T & E species.

9. Special status of waterbody.
    a) Water use designation (e.g. drinking water)
    b) “Wild and scenic” designation
    c) Wilderness area
    e) Potential impact to cultural resources

10. Special training or permits required to use method(s).

11. Cost of method(s).

Action 9: Approve Control/Eradication Plan

CAZMAT Incident Coordinators to approve a plan after public meetings are held and public comments/concerns are sufficiently addressed.

Action 10: Eradication Implementation

A. CAZMAT Incident Coordinators to implement control/eradication program.

1. Technical Expertise, Operations, Logistics, Detection/Enforcement and Regulatory subgroups will conduct on-sight implementation and monitoring of post- treatment effects.

B. Implement control/eradication methods.

1. Follow guidelines provided in Appendix R.

2. Eradication procedures must be carried out and completed as soon as possible, especially when environmental conditions are most suitable for successful eradication.

3. Monitor eradication progress.
    a) Percent mortality of zebra mussels in test cages

4. Monitor impacts of eradication method on water quality and aquatic organisms.

5. Adjust eradication method based on new information.
   a) Adjust to improve effectiveness
   b) Adjust to minimize impacts

Action 11: Post-treatment Monitoring and Follow-up Treatments

A. Evaluate success of treatment

Technical Expertise subgroup in consultation with Zebra Mussel Science Panel will evaluate success of treatment method and report to other CAZMAT members at post-treatment meeting(s).

1. Successful treatment = 100% mortality of zebra mussels in treatment test cages.

2. Determine monitoring methodology in advance.

3. Conduct post-eradication treatment monitoring for all life-stages of zebra mussels.
   a) Monitoring will commence within one week after the eradication treatment is completed
   b) Monitoring will continue through the next spawning and settlement seasons

4. If eradication treatment is determined to be successful, quarantine on the waterbody will be lifted.

5. Evaluate impacts of treatment method.

B. Follow-up treatment

1. Failure = less than 100% mortality of zebra mussels in treatment test cages.

2. CAZMAT Incident Coordinators to provide justification for follow-up treatment to Stakeholder Group and other interested parties.

3. Quarantine remains in effect.

4. Determine follow-up treatment method.

5. Conduct follow-up treatment prior to the spawning season and while conditions are suitable for successful eradication.

6. Conduct post-treatment monitoring.
   a) Monitoring will commence within one week after the eradication treatment is completed
   b) Monitoring will continue through the next spawning and settlement seasons

C. Dissemination of treatment results (Information Dissemination Team).

1. Weekly reports of the implemented eradication procedure will be distributed to interested parties.

2. A summary of activities and final results of the eradication procedure will be disseminated to all interested parties within 1 month of completion.

D. Pursue long-term funding.

Convene meeting of all CAZMAT members to discuss long-term funding, resources and staff for monitoring post-treatment site.

Incident Coordinators and Funding subgroup work together to secure additional resources.

Recommendations for the State Rapid Response Plan

The following items should be addressed and included in the State's rapid response plan:

A. Identify and provide information on all required permits and regulations that must be considered, the agencies responsible for each permit/regulation, procedures for obtaining permits and contact information for agency staff issuing permits.

B. Information packets containing all information for completing permits should be assembled in advance and made readily available.

C. Determine and pursue long-term funding for early detection monitoring activities and identify sources of funds for rapid response actions.

D. Provide a detailed description of all possible scenarios requiring rapid response actions, including political actions and processes, needed for control and/or eradication of zebra mussels.

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Appendix A

A Review of Zebra Mussel's Environmental Requirements
by Andrew N. Cohen

A Review of Zebra Mussel's Environmental Requirements

a report for the

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Many studies have investigated the potential distribution of zebra mussels in different regions based on a variety of environmental factors, including temperature, chemical characteristics, sediment size and turbidity (Table 1). The four sections of this report provide (1) background on the zebra mussel's life cycle; (2) a summary of potential distribution studies, (3) a factor by factor review of the environmental characteristics that are most frequently cited as controlling zebra mussel distribution and abundance, and (4) a more detailed review of the available data regarding calcium requirements.

1. The Zebra Mussel's Life Cycle

Different developmental stages of the zebra mussel have different environmental requirements, and both environmental factors and the presence of different developmental stages vary seasonally. An understanding of the zebra mussel's life cycle and its seasonal pattern of development is therefore useful in considering how environmental factors may affect the mussel's distribution.

Gametogenesis generally begins in the fall or winter, with spawning starting in the spring (Mackie *et al.* 1989; Sprung 1993; Mackie & Schloesser 1996; Nichols 1996; McMahon 1996). The spawning period is often prolonged, continuing in pulses to late summer or early fall. In some regions and circumstances the process be considerably delayed, with the synthesis of gametes peaking in the spring and spawning beginning in late summer Wang *et al.* 1993, 1994. During spawning large quantities of eggs and sperm are released into the water where fertilization occurs, with a single spawning female potentially releasing tens of thousands to millions of eggs (Mackie *et al.* 1989; Sprung 1993; Mackie & Schloesser 1996; Nichols 1996).

After an initial non-feeding phase, the larvae develop intestines and a swimming organ known as the velum, and begin a feeding phase in 2-9 days after fertilization. The larvae are then called veligers, and they develop progressively through a stage with a D-shaped shell, a veliconcha stage with a more rounded shell, and a pediveliger stage with the initial development of a foot. After a week to a month or more of growth they attain shell lengths of around 200-240 µm and settle to the bottom (Mackie *et al.* 1989;

Sprung 1993; Ackerman *et al.* 1994; Mackie & Schloesser 1996). Development times are longer at lower temperatures and with lower food availability. Larvae that are produced in the fall may overwinter by delaying development for several months (Nichols 1996; McMahon 1996).

Settling larvae attach by byssal threads to hard substrates and metamorphose into juveniles. They reach sexual maturity at 1-2 years and shell lengths of 5-12 mm (Mackie *et al.* 1989; Smirnova & Vinogradov 1990; Mackie & Schloesser 1996; Nichols 1996). They live for 2-9 years, reaching maximum shell lengths of over 40 mm (Mackie *et al.* 1989; Smirnova & Vinogradov 1990; Mackie & Schloesser 1996).

2. Summary of Potential Distribution Studies

In the earliest attempt at assessing potential distribution of zebra mussels in North American, Strayer (1991) first analyzed the mussels' distribution in Europe relative to climate variables. Based on his results (Table 2 and discussion in Section 3 below), he mapped zebra mussels' potential North American distribution to cover areas with mean annual air temperatures between 0° and 18° C, and areas with monthly mean air temperatures between ⁻15° and 27° C. These ranges include most of the United States (including most of California except for the hot southeastern portion of the state) and much of southern Canada. Strayer further argued that zebra mussels' range in Europe was probably not limited by climate factors, and so the potential North American range he estimated should be considered a minimum range rather than a limiting range. He did, however, note that calcium levels might be too low to support zebra mussels in parts of this range.

Neary and Leach (1992) mapped the potential occurrence of zebra mussels in Ontario, using criteria based on Sprung's (1987) assessment of the calcium concentrations and pH needed for larval survival (Fig. 1, Table 3); though they noted that the critical values that they derived for calcium (12 and 20 mg/l) were lower than the level that Ramcharan *et al.* (1991) had estimated was limiting zebra mussel distribution in Europe (28 mg/l), and that their analysis might therefore overestimate the area at risk. They started their analysis with data on 6,151 lakes (out of an estimated 262,000 lakes in the province that are over 1 hectare in size) from the Ontario Acid Sensitivity Data Base. Most of these data were based on a single mid-lake grab sample taken in winter. For 3,950 lakes, the data included both pH and calcium measurements; for 2,201 additional lakes that lacked calcium measurements, conductivity values were converted to calcium values using a regression derived from the first set of lakes (calcium (in mg/l) = 0.141 x conductivity (in µS) – 1.175 (r^2=0.88, n=3950)). Using these values and the criteria in Table 3, they then mapped the water quality suitability of areas within 10 km each of the data points; and extended this mapping to additional areas with maps of terrain types based on the potential of soil and bedrock to reduce acidity, using two of the terrain classifications that correlated well with the lake data for calcium and pH. Summary data provided for 6,147 lakes, combined with the strong correlation of high pH with high calcium concentrations, indicate that zebra mussel larval survival would be classified as unlikely in about 78% of the lakes, possible in 10% and probable in 20%. However, since these lakes in the Acid Sensitivity database may have been selected for inclusion based on characteristics that correlate with lower calcium concentrations, these percentages may underestimate the overall susceptibility of Ontario lakes.

Murray *et al.* (1993), using the same calcium criteria as used by Neary and Leach (1992) (Table 4), estimated that a successful invasion is unlikely at 73%, possible at 19% and probable at 8% of the 230 lakes, ponds and river sites that they examined in Connecticut.[1]

Baker *et al.* (1993b), used criteria for pH and calcium which Baker *et al.* (1993a) developed from a literature review (Table 5), with maximum reported monthly mean measurements for May-September, to classify 14 lakes and the tidal freshwater portions of 7 major estuaries in Virginia in terms of their susceptibility to zebra mussels. They classified 24% of lakes and estuaries as having low susceptibility (successful reproduction unlikely), 28% as moderate (successful reproduction and large populations expected in some periods), and 43% as high (expected rapid growth to sustained large populations).[2]

Strayer and Smith (1993) reviewed distributional data relative to salinity in Europe, and based on a salinity tolerance of 2 ppt predicted that zebra mussels could colonize the Hudson River estuary from its head at Troy down to 80 km above the Battery, with an estimated 50-250 billion zebra mussels in this area.

Koutnik and Padilla (1994) estimated the potential distribution and abundance of zebra mussels in Wisconsin lakes, using 3 models developed by Ramcharan *et al.* (1992) from European lake data. These models are: (1) an occurrence model derived from a discriminant function analysis using pH and calcium concentration as parameters; (2) a categorical density model derived from a discriminant function analysis using pH, calcium, nitrate and phosphate concentrations; and (3) an abundance or numerical density model derived from a multiple regression using pH, nitrate and phosphate concentrations. The occurrence model showed a potential for zebra mussels to establish in 48% of the lakes examined, while the categorical density and numerical density models indicated a potential for establishment in 84-85% of the lakes.

Armistead (1995) assessed the potential for zebra mussels to colonize down the length of the Mississippi River, comparing 5-year monthly mean water temperatures to laboratory results regarding upper incipient lethal temperatures. He concluded that while southern sites from Louisville, Kentucky to New Orleans, Louisiana exceeded lethal

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1 These percentages are based on the calcium data in the appendices in Murray *et al.* (1993), except that Wononpakook Lake is taken from Table 4 (the value in the appendix apparently being an error—Nancy Balcom, Connecticut Sea Grant, pers. comm. 2000). However, the discussion and tables in Murray *et al.* (1993) suggest a lesser degree of susceptibility, with about 12% sites ranked as possible and 5% probable.

2 Although the text in Baker *et al.* (1993b) reports the Mattaponi/Pamunkey river system as having moderate susceptibility, Table 1 and the calcium values reported in that paper indicate a rank of low susceptibility, which was used to calculate these percentages.

limits at some time during the 5-year period, in some cases exceedances were of short duration and probably would produce little mortality. At New Orleans, however, exceedances were lengthy, and he concluded these water are unsuitable for zebra mussels. He cautioned, however, that the data used were from surface measurements, and that deeper and potentially colder water might provide suitable habitat.

Tammi *et al.* (1995a) used the same calcium and pH criteria as used by Neary and Leach (1992) in Ontario to analyze 5 rivers[3] in Rhode Island (Table 3). They estimated that the potential for colonization is unlikely at 93% of these sites, possible at 7% and probable at none. Tammi *et al.* (1995b) used calcium concentrations alone to analyze 78 lakes, ponds reservoirs and rivers in Rhode Island (Table 6), and estimated no chance of survival at 74% of the sites, low survival at 13%, poor-to-moderate growth at 12% and very good growth at 1%.[4]

Duke Power (1995) used calcium concentration, pH, turbidity and the abundance of another exotic clam, *Corbicula fluminea*, to assess the potential for zebra mussel infestations at 16 water bodies in its service area in North and South Carolina. It concluded that infestation is unlikely at 19% of sites, possible at 44% of sites and probable at 37% of sites.

Doll (1997) ranked habitat suitability at 338 sites in North Carolina based on calcium, pH, mean summer temperature (June-September), dissolved oxygen and salinity (Table 7). The calcium data used were the averages of all recorded measurements in 1953-1995 from the U.S. geological Survey, while temperature data (average of 1988-1994 data) and data for pH, oxygen and salinity (average of monthly measurements in 1989-1994) were from the North Carolina Division of Water Quality. Doll did not combine the individual rankings for these five parameters into an overall ranking for each site; however, the individual parameter rankings indicate that most inland waters are too calcium-poor, and most coastal waters too salty, to support zebra mussels.

Janik (1997), using data from the California Department of Water Resources, found calcium, pH and temperature to be suitable for zebra mussels at three sites along the California Aqueduct.

Sorba and Williamson (1997) used calcium, total hardness (as $CaCO_3$), pH, mean summer (June-September) temperature, dissolved oxygen, conductivity and turbidity (Secchi disk depth) to assess Manitoba's waters (Table 8). They estimated overall rankings based on the lowest potential for any single parameter, finding very low colonization potential at 34% of sites, low potential at 19%, moderate potential at 22% and high potential at 25%.

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3 Though the text stated that 52 lakes and ponds and 5 rivers were analyzed, Tammi *et al.* (1995) only reported ratings for 51 lakes & ponds. The percentages here are based on the 51 rated sites.

4 They note, however, that the 1% of water bodies rated as having very good growth potential for zebra mussels consists of a single pond connected to Narragansett Bay, with salinities levels that may make it uninhabitable for zebra mussels.

Based on a review of the scientific literature, Hayward and Estevez (1997) constructed habitat suitability index (HSI) curves for zebra mussels ranging from 0.0 (perfectly unsuitable or lethal) to 1.0 (perfectly suitable or optimal) for each of seven parameters: temperature, salinity, calcium, pH, dissolved oxygen, turbidity (Secchi disc depth) and sediment size (phi). They accumulated tidal, diurnal, lunar and seasonal variation, and information on larval and adult stages, into single, annualized, life-cycle HSI curves for each parameter. They then used these curves to calculate HSI values for 281,780 data records from 9,028 Florida sites in the US EPA's STORET database. They calculated composite HSI values for each sample at each site, and took the median of sample HSI values to represent that site. These were above 0.5 for 21% of the sites, and above 0.8 for 3% of the sites. Most waters appeared to be too turbid and too low in calcium and pH to support zebra mussels. They also calculated and mapped HSI values aggregated by U.S. Geologic Survey Hydrologic Units.

Cohen & Weinstein (1998) used April-September data on calcium, pH, mean and maximum temperature, dissolved oxygen and salinity to assess colonization potential at 160 sites in California, including rivers, lakes, reservoirs, aqueducts and canals (Table 9). They used STORET data supplemented by water quality data from other agencies and researchers. They combined the rankings for individual factors to produce overall rankings of low-or-no colonization potential at 54% of sites, moderate potential at 2% of sites and high potential at 44% of sites (Table 10). They concluded that most coastal watersheds, the west side of the Sacramento Valley, the San Joaquin River and the southern part of the Delta provide suitable habitat for zebra mussels, including many critical water supply facilities such as the California Aqueduct (as Janik (1997) had concluded earlier), the South Bay Aqueduct, the Delta-Mendota Canal, the Los Angeles Aqueduct, the Colorado River Aqueduct, the All American Canal, and the reservoirs associated with these systems. They found that colonization would be prevented throughout most of the Sierra Nevada and the upper Sacramento River watershed by low calcium, sometimes in combination with low pH; at many southern California sites by warm summer water temperatures; in some inland brackish waters by high salinity; and in some northeastern California lakes by periodic desiccation, possibly combined with high or fluctuating salinities.

Ashby *et al.* (1998) evaluated the potential for zebra mussel infestation at 453 U.S. Army Corps of Engineers projects across the U.S., based on alkalinity, pH, temperature and dissolved oxygen, and concluded that more than half the sites have suitable water quality for zebra mussels.

3. Review of Factors

<u>Temperature</u>

Zebra mussels do not survive freezing (McMahon 1996), but Strayer (1991) noted that even if temperatures are not low enough to kill zebra mussels outright, their establishment may be prevented by a growing season that is too short to allow growth and reproduction. In Europe, zebra mussels have become abundant where average winter temperatures are as low as 6° C, but are less common in colder environments (Stanczykowska and Lewandowski 1993). Strayer (1991) reported zebra mussels to be less common in Europe at sites within 100 km of weather stations with mean annual air temperatures below 3-6° C (Table 2). Various studies in Europe and North America have reported lower temperature limits for adult growth that are in the range of 10-12° C (Morton 1969; Stanczykowska 1977; Mackie 1991), but Bij de Vaate (1989) report growth at temperatures down to 6° C in the Netherlands (Table 11). In North America, zebra mussels normally begin to spawn at 12° C and above, and spawning thresholds of 12° have also been reported in Germany (Borcherding 1991; Neumann *et al.* 1992), but limited spawning has been reported at 10° C in the Great Lakes and Europe (Sprung 1993; Nichols 1996; McMahon 1996). Spawning peaks at about 12-18° C, which is also roughly the optimum temperature for larval development (Sprung 1993).

Strayer (1991) reported that zebra mussels are absent from European sites within 100 km of weather stations with mean annual air temperatures above 18° C or highest mean monthly air temperatures above 27° C (Table 2) (based, however, on very few stations). Baker *et al.* (1993b) noted that it may not be possible to determine the zebra mussel's upper temperature limit from its Old World distribution, since the Mediterranean Sea acts as a southern barrier. Laboratory experiments and field observations suggest that water temperatures above 22-26° C are unsuitable for reproduction or spawning (Table 12), however, Baker *et al.* (1993a) argue that in temperate regions seasonal temperature fluctuations will usually result in some period each year with temperatures that allow successful reproduction, so that adult temperature tolerances are probably more critical in setting range limits. Strayer (1991, citing McMahon & Tsou 1990) noted that temperatures greater than 26-32° C can kill larvae or adults, and further noted (citing Walz 1978) that respiratory costs can exceed assimilation rates at high temperatures, resulting in loss of body mass, which could prevent the establishment zebra mussels without necessarily killing them outright.

Stanczykowska (1977, cited by Baker *et al.* 1993a) reports 26-33° C as the upper temperature range for adult growth. Several authors have reported 30° C as the upper limit for efficient feeding and adult growth, and 31-33°C as the upper limit for short-term survival (Table 12). In southern U.S. waters, juveniles and adults have been reported growing at temperatures up to about 30° C, with massive die-offs occurring at 31° C.

Smirnova and Vinogradov (1990) and Smirnova *et al.* (1993) note that Volga River populations of zebra mussels vary in their heat tolerance, with the southernmost population (at Astrahan) and a population living in waters heated by power plant discharges (at Kostromo) being the most tolerant of high temperatures.

Salinity

Zebra mussels' salinity limits depend not only on salinity levels, but also on the rate of change of salinity and on the composition of the salt. Zebra mussels can only tolerate low levels of salinity in waters with short-term salinity fluctuations (such as estuaries), but can handle higher levels of stable salinity. Laboratory studies reflect this, showing greater tolerance to higher salinity levels when the increase in salinity is gradual rather than abrupt (Strayer & Smith 1993). Some researchers have argued that zebra mussels can tolerate higher salinity in waters that contain higher proportions of divalent ions (Ca^{++} and Mg^{++}) and sulfates relative to monovalent ions (Na^{+} and Cl^{-}), or that chloride content rather than total salinity is the critical factor (Strayer & Smith 1993). Others have suggested that temperature may affect salinity tolerance (with higher tolerance in colder water), and that different populations may have different genetic capacities to tolerate salinity (*e.g.* Baker *et al.* 1993a). For example, Volga River populations of zebra mussels vary in their salt tolerance, with the population nearest the sea (at Astrahan) tolerating the highest salinities, and the population furthest from the sea (at Rybinsk) being the least tolerant; and this is mirrored by their cellular response to high salinities (Smirnova & Vinogradov 1990; Smirnova *et al.* 1993).

Zebra mussels occur up to a mean salinity of 0.6 ppt in Netherlands estuaries, up to <1 ppt in the eastern Gulf of Riga, and up to <2 ppt in the extreme eastern Gulf of Finland and in estuaries bordering the Black Sea (Wolfe 1969; Strayer & Smith 1993). It has been collected in stunted populations in the saltiest portions of the Vistula estuary and lagoon at up to 4.8 ppt, and in the Kiel Canal at 3.8 and 6.2 ppt (Strayer & Smith 1993). In the Hudson River estuary it was found at high densities at sites with maximum salinities up to 3 ppt, and at lower densities at sites with maximum salinities up to 6 ppt (Baker *et al.* 1993a).

Zebra mussels are present in ponds in the Netherlands delta region with stable salinities up to 4 ppt (Wolff 1969). They are abundant in the northern Caspian Sea at salinities of 6-9 ppt, but are not present in the main body of the sea at 13 ppt (Strayer & Smith 1993). They were abundant throughout the Aral Sea at salinities of 10 ppt; as water diversions raised the salinity of the sea, mussel populations began to decline at around 12 ppt and had virtually disappeared when salinities reached 14 ppt (Stayer & Smith 1993). Stable salinity levels, or proportionally higher concentrations of calcium and magnesium, may be among the factors enabling zebra mussels to live in these relatively salty waters (Stayer & Smith 1993).

Laboratory studies, conducted at a range of temperatures and with different acclimation procedures, have produced disparate results. Barber (1992) reported that adult mussels and exposed to salinity levels rising slowly from 0 to 2.7 ppt in 15° C water had all died after 52 days. In contrast, Mackie & Kilgour (1992) reported 85% survival of adult mussels that were slowly acclimated to 8 ppt salinity over 42 days in 4° C and 10° C water (Table 13). Vinogradov *et al.* (1993) noted one study that reported 100% mortality after 168 days in 5 ppt, another that reported the lethal concentration to be 5-7 ppt, and a third that reported the lethal concentration using stepwise acclimation to be 10-12 ppt, while Strayer and Smith (1993) noted earlier studies that reported 10 ppt as the limit for long-term survival of gradually acclimated mussels

pH

Ramcharan *et al.* (1992) analyzed 76 European lakes and found that zebra mussels are absent from those with pH below 7.3. Vinogradov *et al.* (1993) found that loss of sodium and calcium exceeded uptake at pH levels below 6.8-6.9, and that zebra mussels were generally more vulnerable than other freshwater bivalves to disruption of ion metabolism from reductions in pH level. Sprung (1993) reported that in laboratory experiments a pH of 7.4 to 9.4 is needed for veliger development, with peak success at around pH 8.4 in 18-20° C. Baker and Baker (1993) reported that the "preponderance of evidence" suggests that pH levels below about 7.0 will not sustain large zebra mussel populations. Different authors reviewing the literature have selected minimum pH requirements ranging from 6.5 to 7.5 (Table 14) and maximum pH requirements ranging from 9.0 to 9.5 (Table 15).

Calcium and Hardness[5]

Strayer (1991) noted that most European surface waters are hard with > 20 mg/l of calcium, while many North American waters are soft, and suggested that water hardness could limit zebra mussel distribution in North America. Reviewing data for 70 European lakes, he found zebra mussels mainly reported in lakes with calcium levels above 20-40 mg/l, and absent from lakes with < 20 mg/l. In a discriminant analysis of 30 lakes with and without zebra mussels, he found that hardness and lake depth (primarily), and lake area and transparency (to a lesser extent) accounted for 52% of the variation ($F=14.67$, $p<0.01$). Strayer noted that many species of freshwater mollusks are restricted to relatively hard waters, and that Sprung's (1987) studies suggested that zebra mussel larvae needed hard water with a minimum of about 20 mg/l of calcium (Fig. 1). Smirnova and Vinogradov (1990), noting the inability of zebra mussels to live in soft waters, suggested that this is related to the species origin in the Caspian Sea in water with high concentrations of calcium and magnesium sulfates.

Ramcharan *et al.* (1992) analyzed 76 European lakes and found that zebra mussels are present only where calcium concentrations are at least 28.3 mg/l. Padilla (1997) found

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5 Standard analytical methods define "dissolved calcium" as calcium measured in a sample after filtration through a 0.45 μm membrane filter, and "total calcium" as calcium measured in an unfiltered sample after vigorous digestion (US EPA 1983; Eaton *et al.* 1995). In practice these measures are likely to be close unless total calcium levels are quite high, and in some cases the same data is reported both as dissolved and as total calcium (Pederson pers. comm. 1998; J. Kirschner pers. comm. 1998; also observed by the author in STORET data). In this report, I treat concentrations reported as dissolved calcium or total calcium as equivalent measures and report them simply as calcium concentrations.

"Calcium hardness" is sometimes reported, in milliequivalents per liter (meq/l) of calcium ion (Ca^{++}). This can be converted to calcium concentration as 1 meq= 20.05 mg of calcium (Masters 1991). Many sample measures also include "total hardness," which is the concentration of all multivalent metallic cations in solution, primarily consisting of calcium and magnesium (Mg^{++}) in natural waters, with much smaller quantities of other cations such as iron (Fe^{++}), manganese (Mn^{++}), strontium (Sr^{++}) and aluminum (Al^{+++}) sometimes present (Masters 1991). Because of the varying proportions of these ions, total hardness cannot be simply converted to calcium hardness or calcium concentration. However, in the majority of fresh waters where ionic concentrations are not too high (*i.e.* carbonate-dominated waters), the proportions do not vary too much (*e.g.* Ca:Mg ratios of ≈3-6 by weight in the mean composition of river waters for the world and individual continents exclusive of Australia—Wetzel 1983), such that 1 meq of total hardness translates to about 13-16 mg/l of calcium.

similar results for over 500 lakes in the former Soviet Union. In North America, however, zebra mussels have been reported as present and sometimes abundant at calcium levels ranging from 12 to 25 mg/l (Mellina & Rasmussen 1994; Cusson & Lafontaine 1997; Vermont Department of Environmental Conservation 1998; S. Nichols, pers. comm. 1998) (Table 16).

In laboratory studies, zebra mussels did not survive calcium levels below 15 mg/l, where metabolic equilibrium was lost (Vinogradov *et al.* 1993). In tests of rearing success, the lowest number of deformed larvae occurred at over 35 mg/l of calcium (Figure 1; Sprung 1987). In general, laboratory studies have shown that zebra mussels are less able than other freshwater bivalves to regulate hemolymph ion levels and acid/base levels in waters with moderate acidity and calcium concentrations. Thus we might expect them to be restricted to waters with higher pH and calcium levels compared to most other freshwater bivalves.

Most studies of potential zebra mussel distribution have used values of 12 or 15 mg/l as the minimum calcium threshold below which the establishment of a population is unlikely, though threshold values of 2, 7 and 9 mg/l have also been used (Table 16).

Potassium

Vinogradov *et al.* (1993) reported that zebra mussels are well adapted to waters with extremely low potassium levels, with equilibrium concentrations (where uptake = loss) determined in laboratory assays ranging from about 10-100 µM/l.

Doll (1997) noted that zebra mussels are generally not found in waters with potassium concentrations greater than 39 mg/l. Fisher and Stromberg (1992, cited by Baker *et al.* 1993a) report that the 24-hr LC_{50} for potassium (as KCl) is about 100 mg/l.

Dissolved Oxygen

The lethal lower limit for adult zebra mussels is apparently about 4 mg/l of oxygen at 18° C (Sprung 1987; Table 17). In anoxic conditions, zebra mussels survived a maximum of 6 days at 17-18°C and a maximum of 3 days at 23-24° C (Baker *et al.* 1993a). Boelman *et al.* (1997) report that zebra mussels are usually found where dissolved oxygen is over 90% of saturation and become stressed at levels of 40-50% of saturation. Smirnova and Vinogradov (1990) report 80-85% oxygen saturation as optimal. Lower oxygen requirements in colder water may allow overwintering mussels to survive under ice. However, low oxygen levels in severely polluted waters reportedly eradicated zebra mussels from much of the Rhine River during the 1970s (Neumann *et al.* 1993), and low oxygen may in part account for their poor success in eutrophic lakes (McMahon 1996).

Turbidity

In a discriminant function analysis of 30 lakes with and without zebra mussels, Strayer (1991) determined that hardness and lake depth (primarily), and lake area and transparency (to a lesser extent) accounted for 52% of the variation ($F=14.67$, $p<0.01$). He found that zebra mussels were uncommon in lakes with Secchi disk depths under 1 meter, and at least one researcher has suggested that high turbidity may control zebra mussel distributions by interfering with feeding (Strayer & Smith 1993). However, Doll (1997) noted that zebra mussels don't appear to be inhibited by high turbidity, having been found in parts of the Mississippi River with > 80 NTU of total suspended solids.

Substrate

Zebra mussel larvae need hard substrates to settle on. Mellina and Rasmussen (1994) found that substrate availability explained between 38% to 91% of the variability in density of zebra mussels in the Hudson and St. Lawrence rivers and Oneida Lake and explained 75% of the variability in 72 other lake sites described in the literature, with mussels being more abundant in coarser substrate. However, in lakes with little hard substrate, zebra mussels may initially settle on sticks, logs, shells or plants, or sometimes attach directly to sand grains, and later settle onto each other, eventually forming large mats (Ramcharan *et al.* 1992, Mellina & Rasmussen 1994; Nichols 1996; Berkman *et al.* 1998).

Water Velocity

Water velocities affect larval settlement and fertilization. Zebra mussel larvae are unable to settle from water that is flowing faster than about 1.5-2.0 m/sec, which limits their distribution in many rivers (Boelman *et al.* 1997). Flowing river waters also lower fertilization success by washing gametes downstream, and associated turbulence can damage or kill fragile larvae (Sprung 1993; Horvath *et al.* 1996). Smirnova and Vinogradov (1990) report velocities of 0.1-1.0 m/sec as favorable, and that feeding declines above 1.0-1.5 m/sec as fast flowing water deforms the zebra mussel's siphon. These factors probably account for zebra mussel densities being lower in rivers than in lakes (Strayer 1991; Horvath *et al.* 1996). In Europe, zebra mussels are rarely found in rivers less than 30 m wide (Table 18), perhaps due to the higher velocities found in smaller rivers (Strayer 1991).

Size or Depth of Waterbody

In a discriminant function analysis of 30 European lakes with and without zebra mussels, Strayer (1991) found that hardness and lake depth (primarily), and lake area and transparency (to a lesser extent) accounted for 52% of the variation ($F=14.67$, $p<0.01$). Reviewing data for 73 European lakes, Strayer (1991) found that zebra mussels were less common in lakes smaller than 0.3 km^2, and suggested that zebra mussels' absence from shallow, productive lakes could be due either to periods of anoxia, or to intense predation by water birds. Stanczykowska and Lewandowski (1993) similarly found that relatively large and deep European lakes that have low to moderate levels of algae and nutrients have higher densities of mussels than relatively small and shallow lakes that are higher in algae and nutrients.

In a review of 16 European studies, Strayer (1991) found that zebra mussels occurred more commonly in wider streams, and were rarely found in streams less than 30 m wide (Table 18).

Precipitation

Strayer (1991) analyzed the distribution records of zebra mussels relative to weather data at 110 weather stations across Europe. He found that zebra mussels were less frequently recorded within 100 km of weather stations that reported strong seasonal patterns of precipitation (*i.e.* those stations with the lowest mean monthly precipitation being < 0.3 of the highest mean monthly precipitation).

Nutrients

In general, zebra mussels seem to do best in waters with moderate levels of nutrients, with mussels being absent, or present only at low densities, in eutrophic and oligotrophic waters.

Strayer (1991, citing Walz 1978) suggested that lakes with low productivity might not provide enough food for zebra mussels. Ramcharan *et al.* (1992), in a study of 76 European lakes, found that waters that are exceptionally low in algal nutrients tend to lack or have very low densities of zebra mussels. Doll (1997) noted that zebra mussels are generally not found in waters with nitrate concentrations below 0.009 mg/l. Ramcharan *et al.* (1992) reported that zebra mussels were absent from European lakes with phosphate concentrations below 0.05 mg/l, but Baker *et al.* (1993a) stated that zebra mussels have been reported in lakes with no measurable free phosphate, and Doll (1997) noted that they have been found at phosphate levels as low as 0.001 mg/l.

Stanczykowska *et al.* (1983) found zebra mussels to be absent from most hypereutrophic lakes in Poland, and Stanczykowska and Lewandowski (1993) found that Polish lakes with high or very high levels of nutrients and algae had no or low densities of zebra mussels, while lakes with medium to low levels of nutrients and algae tended to have medium to high densities of zebra mussels. Also, zebra mussels declined or disappeared as lakes became more eutrophic. Strayer (1991) suggested that zebra mussels' absence from shallow, productive lakes in Europe could be due to periods of anoxia, or to intense predation by water birds. Ramcharan *et al.* (1992) found that zebra mussel density was negatively correlated with phosphate and nitrate in European lakes, and that they were absent where phosphate levels exceeded 18 mg/l, which also suggests that eutrophic lakes are less suitable habitats. Ramcharan *et al.* (1992) speculate that this may be due to lower oxygen levels, or to dense algae clogging the mussels’ gills. Doll (1997), however, noted that zebra mussels are fairly tolerant of polluted waters and survive organic enrichment except when oxygen levels are depleted.

4. Further Assessment of Calcium Requirements

Complicating Factors

Calcium levels can vary substantially in some water bodies, changing with location, depth or time (Table 19). Calcium generally varies more in hardwater than in softwater lakes, in part because when calcium is near saturation levels increased photosynthetic activity can substantially increase the precipitation of calcium carbonate from the epilimnion (Wetzel 1975). This variation must be kept in mind when assessing calcium data relative to zebra mussel distributions.

A further complexity is that zebra mussels' calcium requirements vary with changes in other environmental factors. Several studies conclude that zebra mussels' calcium threshold varies with pH, mainly declining with increasing pH (Ramcharan *et al.* 1994; Hincks & Mackie 1997; Nierzwicki-Bauer, pers. comm. 2001). Zebra mussels' higher survival in waters with naturally high calcium concentrations may possibly be due to higher magnesium levels, rather than higher calcium levels *per se* (Nichols, pers. comm. 2001). Zebra mussels may also obtain some calcium from their diet: mollusks typically meet between 70-80% of their calcium needs by absorption through their gills and mantle, and the rest from their food (Vinogradov *et al.* 1993). Finally, zebra mussels may be able to reabsorb some calcium from their shells in order to meet metabolic requirements.

Reported Distributions and Calcium Limits

The calcium requirements for zebra mussels estimated by various studies or determined from reviews of the scientific literature vary widely (Table 16). In general , studies based on European distributions have indicated that relatively high calcium concentrations are needed for establishment (above ≈25 mg/l), while studies based on North American distributions have generally concluded that the mussels can establish at lower concentrations (ca. 7-15 mg/l). For example, as noted above, Ramcharan *et al.* (1992) found that zebra mussels were found only in lakes with calcium concentrations greater than 28 mg/l in Europe, and Padilla (1997) reached similar conclusions for lakes in the former Soviet Union. However, zebra mussels have been reported as abundant in North America at calcium levels of 20-25 mg/l (Mellina and Rasmussen 1994; Vermont Department of Environmental Conservation 1998), and present at calcium levels of 4-19 mg/l (Mellina and Rasmussen 1994; Cusson and Lafontaine 1997; Vermont Department of Environmental Conservation 1998; S. Nichols, pers. comm. 1998) (Tables 20, 22).

Cohen and Weinstein (2001) investigated whether the main low calcium populations reported in North America (Table 20) might consist of "sink" populations of mussels that are able to grow but not reproduce at those sites, and which had arrived as larvae or drifting juveniles from higher calcium, up-river sites where reproduction is possible. They found that the populations in the St. Lawrence River, Lake Champlain and Richelieu River in waters with less than 28 mg/l of calcium all have possible sources of larvae and juveniles in higher calcium waters upstream (Table 21). In Duluth Harbor at the western end of Lake Superior, zebra mussels were reported in low numbers since

1989, with calcium concentrations of 13-23 mg/l reported in 1994-95. The mussels could have arrived as larvae in the approximately 800,000 metric tons of ballast water from the lower Great Lakes that is discharged into Duluth Harbor each year. Larger numbers of mussels reported in Duluth Harbor since 1998 probably indicate establishment, but calcium levels during that period are unknown. Cohen and Weinstein (2001) concluded that the few records of zebra mussels at other sites in Lake Superior, whose open waters have calcium concentrations of 12-15 mg/l, do not represent established populations. However, they found that there was good evidence that substantial reproduction occurred in parts of the lower Hudson in at least some years, where mean reported calcium concentrations were 23-24 mg/l, with a range of 12-38 mg/l.

Cohen and Weinstein (2001) also located unpublished records of zebra mussels in 13 inland lakes with less than 28 mg/l of calcium. Seven of the lakes are not connected to canals or to other, higher calcium waters that could serve as sources of veligers, and had reported mean calcium levels of 4-26 mg/l (Table 22). There were few calcium measurements (<4) in most of these lakes, so the reported means may not be representative. In lakes with few records of zebra mussels, establishment is uncertain, and where the records are of veligers only, misidentification or cross-contamination from other sampling sites is possible (Johnson, pers. comm. 2001).

Table 23 summarizes the evidence regarding zebra mussels' calcium requirements. It is clear they can reproduce and become established at concentrations above 28 mg/l, and there are a few reliable records indicating that populations have reproduced in waters with mean calcium concentrations in the 20-28 mg/l range, but there is little to suggest that they can do so at lower concentrations. A more precise assessment could be achieved with:

- experimental studies of zebra mussels' responses to low ambient calcium concentrations during reproductive and early larval development stages;
- further examination of zebra mussel records, particularly those based on collection of veligers at low-calcium sites;
- more extensive population sampling and physiological/histological examinations to determine whether zebra mussels reported from low calcium waters are in fact established and reproducing; and
- better data on the temporal/spatial range and variation in calcium concentrations in the apparently low calcium waters where zebra mussels have been reported.

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Tables and Figures

Table 1. Studies of the Potential Distribution of Zebra Mussels

Region Analyzed	Environmental Parameters Utilized	References
North America	mean annual air temperature, monthly mean air temperature	Strayer 1991
Ontario	pH, calcium	Neary & Leach 1992
Connecticut	calcium	Murray *et al.* 1993
Virginia	pH, calcium	Baker *et al.* 1993
Hudson River estuary	salinity	Strayer & Smith 1993
Wisconsin	pH, calcium, nitrate, phosphate	Koutnik & Padilla 1994
Mississippi River	monthly mean water temperatures	Armistead 1995
Rhode Island	pH, calcium	Tammi *et al.* 1995a
Rhode Island	calcium	Tammi *et al.* 1995b
North & South Carolina	pH, calcium, turbidity, *Corbicula* abundance	Duke Power 1995
North Carolina	temperature, salinity, pH, calcium, dissolved oxygen	Doll 1997
California	temperature, pH, calcium	Janik 1997
Manitoba	temperature, conductivity, pH, calcium, total hardness, dissolved oxygen, turbidity	Sorba & Williamson 1997
Florida	temperature, salinity, pH, calcium, dissolved oxygen, turbidity, sediment size	Hayward & Estevez 1997
California	temperature, salinity, pH, calcium, dissolved oxygen	Cohen & Weinstein 1998
United States	temperature, pH, alkalinity, dissolved oxygen	Ashby *et al.* 1998

Table 2. Zebra Mussel Distribution and Temperature in Europe (Strayer 1991)
Data refer to records of zebra mussels within 100 km of weather stations.

Parameter	Zebra Mussel Occurrence: Common (at > 40% of stations)	Uncommon (at ≤ 40% of stations)	Absent
Mean Annual Air Temperature	3°–12° C (n=71)	-1°–3° C (n=9) or 12°–18° C (n=28)	18°–19° C (n=2)
Highest Monthly Mean Air Temperature	15°–26° C (n=101)	13°–15° C (n=5)	27°–28° C (n=4)
Lowest Monthly Mean Air Temperature	-15°–6° C (n=97)	6°–9° C (n=13)	—
Number of Months with Mean Air Temperature ≥ 10° C	4–7 (n=85)	3 (n=7) or 8–12 (n=14)	—
Mean Annual Air Temperature (lake records)	6°–15° C (n=70)	3°–6° C (n=4)	—

Table 3. Criteria used in Potential Distribution Studies in Ontario (Neary & Leach 1992) and Rhode Island (Tammi *et al.* 1995a)

	— — — Distribution Potential — — —		
Parameter	**Unlikely**	**Possible**	**Probable**
Calcium	< 12 mg/l	12-20 mg/l	> 20 mg/l
	or	and	and
pH	< 7.4	≥ 7.4	≥ 7.4

Table 4. Criteria used in a Potential Distribution Study in Connecticut (Murray *et al.* 1993)

	— — — Distribution Potential — — —		
Parameter	**Unlikely**	**Possible**	**Probable**
Calcium	< 12 mg/l	12-20 mg/l	> 20 mg/l

Table 5. Zebra Mussel Environmental Requirements (Baker *et al.* 1993a)

Parameter	Adult Survival	Adult Growth (possible)	Adult Growth (optimal)	Larval Growth (possible)	Larval Growth (optimal)
Temperature	0-33° C	6-30(?)° C	?	12-24° C	17-18° C
Salinity	0-12 mg/l	0-0.6 mg/l	?	0-? mg/l	?
pH	7.0-?	7.5-?	?	7.4-9.4	8.4-8.5
Calcium	?	?	34.5-76 mg/l	≥ 12 mg/l	40-? mg/l

Table 6. Criteria used in a Potential Distribution Study in Rhode island (Tammi *et al.* 1995b)

	— — — — — Distribution Potential — — — — —				
Parameter	No Survival	Low Survival	Poor to Moderate Growth	Moderate to Good Growth	Very Good Growth
Calcium	≤ 6 mg/l	7-9 mg/l	10-24 mg/l	25-35 mg/l	> 35 mg/l

Table 7. Criteria used in a Potential Distribution Study in North Carolina (Doll 1997)

Study did not combine invidual factor rankings into an overall ranking.

	— — — Distribution Potential — — —		
Parameter	Unlikely	Maybe	Definite
Calcium	< 9 mg/l	9-15 mg/l	> 15 mg/l
pH	<6.8 or >9.5	6.8-7.4 or 8.7-9.5	7.4-8.7
Mean Summer Temperature	<15° or >32° C	31-32° C	15-31° C
Dissolved Oxygen	<4 mg/l	4-8 mg/l	>8 mg/l
Salinity	>10 mg/l	5-10 mg/l	<5 mg/l

Table 8. Criteria used in a Potential Distribution Study in Manitoba (Sorba & Williamson 1997)

	— — — Distribution Potential — — —			
Parameter	**Very Low**	**Low**	**Moderate**	**High**
Calcium	<9 mg/l	9-20 mg/l	20-25 mg/l	≥25 mg/l
Total Hardness	<25 mg/l	25-45 mg/l	45-90 mg/l	≥90 mg/l
pH	<6.5	6.5-7.2	7.2-7.5 or 8.7-9.0	7.5-8.7
Mean Summer Temperature	<8° or >30° C	9-15° or 28-30° C	16-18° or 25-28° C	18-25° C
Dissolved Oxygen	<4 mg/l	4-6 mg/l	6-8 mg/l	≥8 mg/l
Conductivity	<22 µS/cm	22-36 µS/cm	37-82 µS/cm	≥83 µS/cm
Secchi Disk Depth	<10 cm or >250 cm	10-20 cm or 200-250 cm	20-40 cm	40-200 cm

Table 9. Criteria used in a Potential Distribution Study in California (Cohen & Weinstein 1998)

	— — — Distribution Potential — — —		
Parameter	**Low-to-no**	**Moderate**	**High**
Calcium	<15 mg/l	15-25 mg/l	>25 mg/l
pH	<7.3 or >9.0	7.3-7.5 or 8.7-9.0	7.5-8.7
Mean Summer Temperature	–	0-15° C	16-31° C
Maximum Temperature	<10° or >31° C	10-31° C	10-31° C
Dissolved Oxygen	<4 mg/l	4-8 mg/l	>8 mg/l
Salinity	>10 mg/l	5-10 mg/l	<5 mg/l

Table 10. Criteria for Combining Individual Factor Rankings Used in a Potential Distribution Study in California (Cohen & Weinstein 1998)

Overall Ranking	Calcium	pH	Temperature	Dissolved Oxygen	Salinity
High	at least one factor ranked High and neither ranked Low-to-no		each factor ranked High or Moderate		
Moderate	both factors ranked Moderate		each factor ranked High or Moderate		
Low-to-no	at least one factor ranked Low-to-no				

Table 11. Lower Water Temperature Limits for Zebra Mussels as Indicated by Different Studies

Limit	Basis	Reference
-2° C	No survival below this value	Claudi & Mackie 1994
0° C	Does not survive freezing	McMahon 1996
0° C	Lower limit for adult survival, based on literature review	Baker *et al.* 1993a
0° C	Usual lower limit of distribution	Boelman et al. 1997
0° C	Lower limit for poor growth	Claudi & Mackie 1994
0° C	Index of 0 (perfectly unsuitable, or lethal) on the Habitat Suitability Index curve	Hayward & Estevez 1997
2-4° C	Lower limit for gametogenesis	Borcherding 1991
3° C	Lower limit of favorable conditions	Smirnova & Vinogradov 1990
6° C	Lower limit for occurrence in Europe	McMahon 1996
6° C	Lower limit for adult growth, based on literature review	Bij de Vaate 1989
9° C	Value dividing poor from moderate growth	Claudi & Mackie 1994
9° C	Mean summer value dividing "very low" from "low" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
10° C	Maximum annual value dividing "low-to-no" from "moderate" potential distribution in analysis in California	Cohen & Weinstein 1998
10° C	Lower limit for limited spawning in Great Lakes	Nichols 1996
10-12° C	Lower limit for spawning, based on literature review	McMahon 1996
10-12° C	Lower limit for adult growth in the Great Lakes	Baker *et al.* 1993a
11-12° C	Lower limit for adult growth in European lakes	Stanczykowska 1977
12° C	Lower limit for spawning and larval growth, based on literature review	Baker *et al.* 1993a
≈12° C	Lower limit for juvenile and adult growth, based on literature review	McMahon 1996
15° C	Mean summer value dividing "unlikely" from "definite" potential distribution in analysis in North Carolina	Doll 1997
16° C	Mean summer value dividing "low" from "moderate" potential distribution in analysis in Manitoba	Sorba & Williamson 1997

Table 12. Upper Temperature Limits for Zebra Mussels as Indicated by Different Studies

Temperatures are water temperatures unless otherwise indicated.

Limit	Basis	Reference
18° C	Absent within 100 km of weather stations with higher mean annual air temperatures (n= 2 of 110)	Strayer 1991
24° C	Zygote mortality in laboratory study	Sprung 1987
24° C	Upper limit for larval growth, based on literature review	Baker *et al.* 1993a
25° C	Usual upper limit of distribution	Boelman et al. 1997
26° C	Loss of sperm motility in laboratory study	Sprung 1987
26-30° C	Maximum temperature during spawning in Lake Erie	Haag & Garton 1992
26-32° C	Temperatures that can kill adults or larvae	McMahon & Tsou 1990
26-33° C	Upper limit for adult growth	Stanczykowska 1977
27° C	Absent within 100 km of weather stations with higher highest mean monthly air temperatures (n= 4 of 110)	Strayer 1991
28° C	Mean summer value dividing "low" from "moderate" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
≈30° C	Upper limit for juvenile and adult growth, based on literature review	McMahon 1996
30° C	Upper limit for adult growth, based on literature review	Baker *et al.* 1993a
30° C	Upper limit for poor growth	Claudi & Mackie 1994
30° C	Upper limit for regular feeding	Smirnova & Vinogradov 1990
30° C	Mean summer value dividing "very low" from "low" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
30-31° C	Mortality above ≈10% in different Volga River populations	Smirnova *et al.* 1990, based on Shkorbatov 1986
30-31° C	Abundant in southern US waters where temperatures often reach 30° C, but massive die-offs occur at 31° C	McMahon 1996
31° C	Upper limit for larvae and adults, based on literature review	McMahon 1996
31° C	Upper incipient lethal temperature with mean tolerated exposure of 52-292 hr depending on acclimatization	Armistead 1995

31° C	Maximum annual value dividing "low-to-no" from "moderate" potential distribution in analysis in California	Cohen & Weinstein 1998
31-33° C	Mortality above ≈50% in different Volga River populations	Smirnova *et al.* 1990, based on Shkorbatov 1986
32° C	Mean summer value dividing "unlikely" from "maybe" potential distribution in analysis in North Carolina	Doll 1997
32-33° C	Upper temperature limit	Smirnova & Vinogradov 1990
33° C	Upper limit for adult survival, based on literature review	Baker *et al.* 1993a
33-36° C	100% mortality in different Volga River populations	Smirnova *et al.* 1990, based on Shkorbatov 1986
39° C	Index of 0 (perfectly unsuitable, or lethal) on the Habitat Suitability Index curve	Hayward & Estevez 1997
40° C	No survival above this value	Claudi & Mackie 1994

Table 13. Upper Salinity Limit for Zebra Mussels as Indicated by Different Studies

Limit	Basis	Reference
0.4-2 ppt	Estimated upper limit in tidal estuaries	Strayer and Smith 1993
0.6 ppt	Upper limit of mean salinity where zebra mussels are present in estuaries in the Netherlands delta region	Wolff 1969
0.6 ppt	Upper limit for adult growth, based on literature review	Baker *et al.* 1993a
1 ppt	Upper limit for areas likely to support high densities of zebra mussels, based on literature review	Baker *et al.* 1993a
1-6 ppt	Incipient mortality from 2 week exposure in different Volga River populations	Smirnova *et al.* 1990, based on Antonov & Shkorbatov 1983
2 ppt	Maximum value where reproduction has been observed in tidal reaches of the Rhine River	Strayer and Smith 1993
2 ppt	Upper limit for sustaining large populations, based on literature review	Baker & Baker 1993
2 ppt	Value dividing "low-to-no" from "moderate" potential distribution in waters with fluctuating salinities in analysis in California	Cohen & Weinstein 1998
2.7 ppt	Upper limit for survival of acclimated adults at 15° C in laboratory	Barber 1992, cited by Baker *et al.* 1993a
3 ppt	Maximum salinity at sites in the Hudson River estuary with high densities (>1,000/m^2) of zebra mussels	Walton 1993, cited by Baker *et al.* 1993a
4 ppt	Upper limit where present in ponds in the Netherlands delta region	Wolff 1969
6 ppt	Maximum salinity at which zebra mussels have been reported in estuaries (Kiel Canal and Hudson River)	Strayer & Smith 1993; Baker *et al.* 1993a
6 ppt	Estimated upper limit in nontidal lagoons or other waters with relatively stable salinities	Strayer & Smith 1993
9 ppt	Maximum value where mussels occur in the Caspian Sea	Strayer & Smith 1993
6.5-9 ppt	Mortality above ≈10% from 2 week exposure in different Volga River populations	Smirnova *et al.* 1990, based on Antonov & Shkorbatov 1983

7.6 ppt	LC_{50} for 4 d exposure of unacclimated adults at 19° C in laboratory	Mackie & Kilgour 1992
8 ppt	85% survival of acclimated adults at 4° and 10° C in laboratory	Mackie & Kilgour 1992
10 ppt	Upper limit for long-term survival of acclimated mussels	Strayer & Smith 1993
10 ppt	Value dividing "unlikely" from "maybe" potential distribution in analysis in North Carolina	Doll 1997
10 ppt	Value dividing "low-to-no" from "moderate" potential distribution in waters with stable salinities in analysis in California	Cohen & Weinstein 1998
10-14 ppt	Estimated upper limit in sulfate-rich brackish lakes	Strayer & Smith 1993
12-14 ppt	Values where mussels dissappeared as salinities increased in the Aral Sea	Strayer & Smith 1993
12 ppt	Upper limit for adult survival, based on literature review	Baker *et al.* 1993a
15 ppt	Index of 0 (perfectly unsuitable, or lethal) on the Habitat Suitability Index curve	Hayward & Estevez 1997

Table 14. Lower pH Limit for Zebra Mussels as Indicated by Different Studies

Limit	Basis	Reference
6.5	Lower limit for adults based on literature review	McMahon 1996
6.5	Value dividing "very low" from "low" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
6.5	Index of 0 (perfectly unsuitable, or lethal) on the Habitat Suitability Index curve	Hayward & Estevez 1997
6.8	No survival below this value	Claudi & Mackie 1994
6.8	Value dividing "unlikely" from "maybe" potential distribution in analysis in North Carolina	Doll 1997
6.8-6.9	Lower limit below which there is net loss of calcium and sodium	Vinogradov *et al.* 1993
7.0	Lower limit for adult survival, based on literature review	Baker *et al.* 1993a
7.0	Lower limit for sustaining large populations, based on literature review	Baker & Baker 1993
7.2	Value dividing "low" from "moderate" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
7.3	Lower limit of occurrence in 76 lakes in Europe	Ramcharan *et al.* 1992
7.3	Value dividing "low-to-no" from "moderate" potential distribution in analysis in California	Cohen & Weinstein 1998
7.3-7.4	Lower limit for larvae based on literature review	McMahon 1996
7.4	Lower limit for veliger development in laboratory trials	Sprung 1993
7.4	Lower limit for larval growth, based on literature review	Baker *et al.* 1993a
7.4	Value dividing "unlikely" from "possible" potential distribution in analyses in Ontario and Rhode Island	Neary & Leach 1991, Tammi *et al.* 1995
7.5	Value dividing poor from moderate growth	Claudi & Mackie 1994
7.5	Lower limit for adult growth, based on literature review	Baker *et al.* 1993a

Table 15. Upper pH Limit for Zebra Mussels as Indicated by Different Studies

Limit	Basis	Reference
9.0	Value dividing "low" from "moderate" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
9.0	Value dividing "low-to-no" from "moderate" potential distribution in analysis in California	Cohen & Weinsten 1998
9.4	Upper limit for veliger development in laboratory trials	Sprung 1993
9.4	Upper limit for larval growth, based on literature review	Baker *et al.* 1993a
9.5	Value dividing "unlikely" from "maybe" potential distribution in analysis in North Carolina	Doll 1997
9.5	Index of 0 (perfectly unsuitable, or lethal) on the Habitat Suitability Index curve	Hayward & Estevez 1997

Table 16. Lower Calcium Limit for Zebra Mussels, as Reported by Different Studies

Limit	Basis	Reference
2 mg/l	Value apparently dividing "unlikely" from "possible" potential distribution in analysis in North & South Carolina	Duke Power 1995
5-6 mg/l	"No survival" range	Claudi & Mackie 1994
7 mg/l	Value dividing "no survival" from "low survival" in analysis in Rhode Island	Tammi *et al.* 1995b
8.5 mg/l		Hincks & Mackie 1997
9 mg/l	Value dividing "unlikely" from "maybe" potential distribution in analysis in North Carolina	Doll 1997
9 mg/l	Value dividing "very low" from "low" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
10 mg/l	Lower limit of distribution	Boelman *et al.* 1997
10 mg/l	Value dividing "low survival" from "poor to moderate growth" in analysis in Rhode Island	Tammi *et al.* 1995b
10-11 mg/l	"Poor growth" range	Claudi & Mackie 1994
10-12 mg/l	Minimum value for maintaining metabolic equilibrium in laboratory trials	Vinogradov *et al.* 1993
12 mg/l	Lower limit for larval growth, based on literature review	Baker *et al.* 1993a
12 mg/l	Lower limit for sustaining large populations, based on literature review	Baker & Baker 1993
12 mg/l	Value dividing "unlikely" from "possible" potential distribution in analyses in Ontario, Connecticut and Rhode Island	Neary & Leach 1991, Murray *et al.* 1993, Tammi *et al.* 1995a
12-15 mg/l	Lower limit for adults based on literature review	McMahon 1996
12-19 mg/l	Reported at these values in Lake Champlain, Richelieu River, St. Lawrence River and Duluth Harbor	Mellina and Rasmussen 1993; Cusson and Lafontaine 1997; Vermont Department of Environmental Conservation 1998; S. Nichols pers. comm. 1998
12-24 mg/l	Range between values producing <5% to >40% of the "normal" number of healthy	Sprung 1987

	larvae in 3-day exposure trials	
13-14 mg/l	Minimum value for maintaining metabolic equilibrium in laboratory trials	Vinogradov *et al.* 1987, cited in Vinogradov *et al.* 1993
15 mg/l	Lower limit for larvae based on literature review	McMahon 1996
15 mg/l	Value dividing "low-to-no" from "moderate" potential distribution in analysis in California	Cohen & Weinstein 1998
20 mg/l	Value dividing "low" from "moderate" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
20-25 mg/l	Reported to be abundant at these values in Lake Champlain, St. Lawrence River, Oneida Lake and the Hudson River	Mellina and Rasmussen 1993; Vermont Department of Environmental Conservation 1998
28.3 mg/l	Lower limit for occurrence in 76 lakes in Europe	Ramcharan *et al.* 1992
34.5 mg/l	Lower limit for large populations in 76 lakes in Europe	Ramcharan *et al.* 1992

Table 17. Minimum Dissolved Oxygen Concentrations Required for Zebra Mussels, as Indicated by Different Studies

Limit	Basis	Reference
1.5 mg/l	Index of 0 (perfectly unsuitable, or lethal) on the Habitat Suitability Index curve	Hayward & Estevez 1997
4 mg/l	Lethal lower limit for adults at 18° C	Sprung 1987; McMahon 1996
4 mg/l	Value dividing "unlikely" from "maybe" potential distribution in analysis in North Carolina	Doll 1997
4 mg/l	Value dividing "very low" from "low" potential distribution in analysis in Manitoba	Sorba & Williamson 1997
4 mg/l	Maximum annual value dividing "low-to-no" from "moderate" potential distribution in analysis in California	Cohen & Weinstein 1998
6 mg/l	Value dividing "low" from "moderate" potential distribution in analysis in Manitoba	Sorba & Williamson 1997

Table 18. Zebra Mussel Occurrence and River Width in Europe (Strayer 1991)

Stream width	Frequency of Occurrence	n
<3 m	0%	102
3–10 m	0%	59
10–30 m	10%	10
30–100 m	33%	6
> 100 m	83%	23

Table 19. Examples of Variation in Calcium Concentrations Within a Water Body

Water Body	Factor	Calcium Levels	Reference
Glen Lake, ON	Season	22-24 mg/l in winter 19-21 mg/l in spring/summer	Neary & Leach 1992
Wintergreen Lake, MI	Season	>50 mg/l at surface in winter ≈20 mg/l at surface in June near 0 mg/l at surface in Aug.	Wetzel 1975
Lawrence Lake, MI	Depth & Season	40 mg/l at surface in Mar. (just before ice melt) >70 mg/l at surface, and >85 mg/l at 12 m depth in Oct. & Dec.	Wetzel 1983
Blue Lake, WA	Depth	9 mg/l at surface 16 mg/l at 36 m depth	Edmondson 1963
Lower Goose Lake, WA	Depth	16 mg/l at surface 64 mg/l at 27 m depth	Edmondson 1963
Soap Lake, Grant Co., OR	Depth	16 mg/l at surface 16 mg/l at 17 m depth 8 mg/l at 18 m depth	Edmondson 1963
Soap Lake, Okanogan Co., OR	Depth	40 mg/l at surface 20 mg/l at 16 m depth	Edmondson 1963

Table 20. Reports of Zebra Mussel Populations in North American Waters with Low Calcium Concentrations

Location	Calcium Level	Reference
<u>Abundant</u>		
St. Lawrence River	16-38 mg/l	Mellina and Rasmussen 1994
Hudson River, NY	12-38 mg/l	Mellina and Rasmussen 1994; Strayer *et al.* 1996
Lake Champlain, VT	>18 mg/l	Vermont Department of Environmental Conservation 1998
<u>Present</u>		
Duluth Harbor, Lake Superior	13-23 mg/l	Balcer 1996; S. Nichols, pers. comm. 1998
Richelieu River	16-18 mg/l	Cusson & De Lafontaine 1997; De Lafontaine & Cusson 1997
Lake Champlain, VT	13-14 mg/l	Vermont Department of Environmental Conservation 1998

Table 21. Possible Sources of Reported Populations of Zebra Mussels in Low-calcium Waters in North America

Site of Population	Possible Source(s)	Comment
left bank of St. Lawrence River below Montrea	eastern Lake Ontario; St. Lawrence River above Montreal	Not present on the right bank of the St. Lawrence below Montreal, where calcium is 8-14 mg/l.
Hudson River below Troy	Mohawk River	Pattern of colonization suggests some reproduction in the lower Hudson, augmented by larvae from the Mohawk.
northern Lake Champlain & Richelieu River	southern Lake Champlain	The general flow of water from south to north through Lake Champlain and into the Richelieu River could carry larvae or drifitng juveniles; adults could travel attached to boat hulls.
Duluth Harbor in Lake Superior	lower Great Lakes	Zebra mussels could be regularly released in ballast water from the lower Great Lakes. Not present elsewher in Lake Superior, where calcium levels are lower.

Table 22. Zebra Mussels Reported in Inland, Isolated, Low-calcium Waters

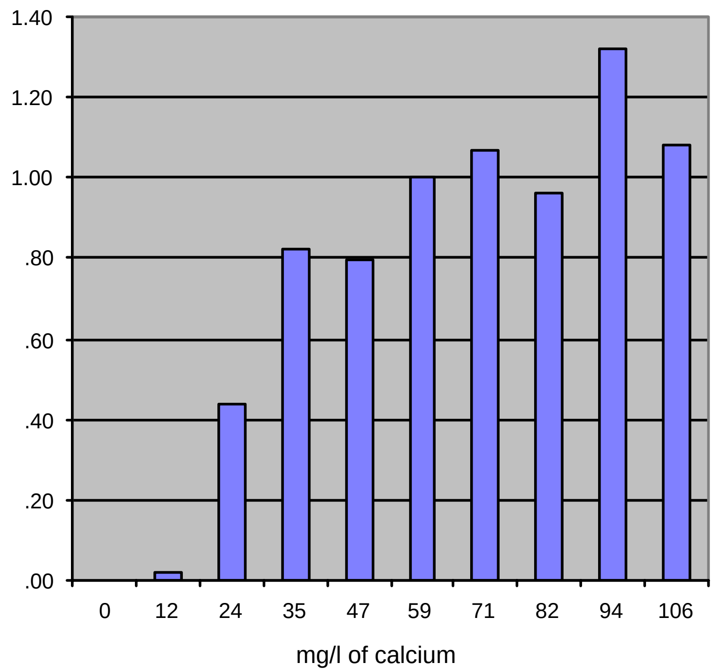
Site	Mean Calcium Level	n
Dogwood Lake, IN	26 mg/l	4
Houghton Lake, MI	20 mg/l	1
Lake St. Helen, MI	18 mg/l	1
Lake Bomoseen, VT	18 mg/l	2
Crotch Lake, ON	11 mg/l	?
Lake Muskoka, ON	6 mg/l	15
Lake Dunmore, VT	4 mg/l	4

Table 23. Summary of Evidence of Zebra Mussels' Calcium Threshold

Calcium Level	Evidence
>28 mg/l	Many abundant, reproducing populations are established at these calcium levels. In two studies of large numbers of European lakes, zebra mussels were only found in lakes with more than 25 or 28 mg/l of calcium.
20-28 mg/l	Experiments indicate good adult survival; and embryonic, larval and juvenile development and growth rates comparable to those in higher calcium waters. Zebra mussel adults have apparently been established in Duluth-Superior Harbor since 1998, where calcium was measured at 13-23 mg/l in 1994-95, and mussels kept in cages in the harbor since 1968 had normal gonad development. The population in the harbor may be in part supported by regular inputs of veligers or adults via ships from the lower Great Lakes. Large populations are present and reproduction has apparently occurred in the lower Hudson River where mean calcium concentrations are 23-25 mg/l, although calcium concentrations from 12-38 have been recorded and the concentrations at the sites and times where reproduction occurred are not known; and the large populations could be due in part to recruitment of larvae or juveniles from upstream. Zebra mussel veligers or adults have been reported from seven inland lakes with mean calcium levels of 20-27 mg/l; for at least a few of these the records are probably due to veligers drifting in from upstream or individuals introduced via boats.
15-20 mg/l	There is little experimental evidence or field data regarding threshold limits to zebra mussel reproduction or establishment within this calcium range. Zebra mussels were reported from two inland lakes with mean reported calcium of 18 mg/l based, respectively, on one and two measurements.
<15 mg/l	Some experiments found good adult survival down to 0 or 4 mg/l, while another reported no survival at 8 mg/l. Two studies reported loss of calcium or shell at ≤14 mg/l; and survival at low calcium levels may in part be at the cost of mobilizing calcium from shell or tissues. Weight loss in juveniles or adults was reported in waters up to 8 mg/l, and depressed growth rates in waters of 12-14 mg/l. One experiment found 50% success in fertilization and first cleavage at 4-8 mg/l, but other experiments found no release of sperm and poor or no larval production at concentrations up to 15 mg/l. Zebra mussels have been reported in the northeast arm of Lake Champlain at sites with 13-14 mg/l, and in three isolated, inland lakes with mean reported calcium of 4-11 mg/l, but it is not clear if these are established populations or if the reported calcium measurements reflect typical concentrations at these sites.

Figure 1. Larval Production at Different Calcium Levels

Larval production is the number of healthy larvae produced after 3 days, indexed to the number produced at a calciujm concentration of 59 mg/l. Calculated from graphs in Fig. 3 of Sprung (1987).



Appendix B

Volunteer Monitoring Packet

Zebra Mussel Monitoring Instructions

Placement of Sampler

Place sampler in low flow areas where there is frequent boat traffic, such as boat ramps and docks. Hide or disguise the sampler to prevent theft, vandalism, or disturbance. Tie off in a discrete location or use a plastic milk carton as a floation device.

The upper PVC tube should be about 1 meter (3 feet) below the surface. If the plexiglass plate is touching the bottom, then raise the sampler 1 to 2 feet or find a deeper location. If a deeper location cannot be found, then shorten the length of rope between the PVC tubes and the plexiglass plate. Record any modifications to the sampler in the "comments" section of the datasheet.

At time of placement, fill out all requested information on the datasheet. Please use a pencil. Under "Set Data", record the information when the sampler is placed in the water. Under "Retrieval Data", record the information when the sampler is removed from the water.

Sample Retrieval

Check the sampler monthly and year-round (or as long as the boat docks are in place and winter-time conditions allow access to the entrance roads).

- Visually inspect each component of the sampler (PVC tubes, mesh, and plexiglass plate) for juvenile mussels. *Immediately* report potential mussel sightings or if the PVC pipes or plexiglass plate feel "bumpy" to the touch.

If you suspect zebra mussels:

- Call the Zebra Mussel Watch staff at 1-888-840-8917.
- You may be instructed to:
    - Return the sampler to the water. Zebra Mussel Watch staff will retrieve it within 1 day.

    Or:

    - Detach the PVC tubes and plexiglass plate from the float and weight.
    - Remove the mesh from the PVC tubes. Place the mesh in a jar, along with a sample tag. Preserve the sample with isopropyl (rubbing) alcohol.
      <u>Note:</u> If it is not possible to preserve the mesh in alcohol, leave the mesh in the PVC tubes.
    - Place the PVC tubes and plexiglass plate in a ziplock bag, along with a sample tag. Leave the bag open and allow to air dry for 2-3 days or until contents are dry. Seal bag closed when dry.

Sample Pick-up

_____ Sample to be picked up by Zebra Mussel Watch staff.

_____ Mail sample to Zebra Mussel Watch staff in the provided envelope.

Other arrangements:

____

____

____

____

Other Activities

Conduct monthly inspections of your waterbody for living and dead zebra mussels. Look for live attached zebra mussels on boat docks, pilings, bouys, boats (propeller, hull, trim tabs, anchor), driftwood, tree snags, aquatic plants, and rocks. Look for zebra mussel shells on the shore (especially after water level drops), boat ramp areas, parking lots near boat ramps, etc.

Spread the word. Teach others how to prevent zebra mussels and other exotics from invading your lake or stream.

Contact Us for More Information

Zebra Mussel Watch Program
Coordinators: Tanya Veldhuizen
Cindy Messer

Hotline: 1-888-840-8917 (toll free)

E-mail: mussel@water.ca.gov

Address: California Department of Water Resources
Division of Environmental Services
3251 S Street
Sacramento, CA 95816
Attn: Zebra Mussel Watch Program

Zebra Mussel Monitoring Datasheet

Please Use Pencil

Location: ____

Lat/Long: N __ __ __ __ __ __ . __   W __ __ __ __ __ __ __ . __

Sample #: ________________________

Set Data

Recorded by: ____

Date: _____/_____/_____

Water Temperature: ____ ºF / ºC   **Water Depth:** _____ feet / meters

Substrate: mud / sand / rock / cement / unknown / other _________________________

Aquatic Vegetation: none / sparse / medium / thick

Type of Aquatic Vegetation: ____

Retrieval Data

Recorded by: ____

Date: _____/_____/_____

Water Temperature: ____ ºF / ºC   **Water Depth:** _____ feet / meters

Sample Condition:
______ good
______ rope tangled
______ disturbed/vandalized
_____ mesh out of tube
_____ missing/stolen
______ missing parts

Visual Inspection:
______ no mussels found
______ juvenile mussel/clam
______ feels bumpy
______ ZM Watch Staff contacted
______ sampler dried & mailed
______ sampler dried & picked up

Comments:____
____
____
____

Sample Received On: ________/______/______
Sample Analyzed By: ____________________________________ Date: ________/______/______

Zebra Mussel Watch Program

Sample Labels

Location:
Sample #:

Please use pencil to fill out labels.

Zebra Mussel Veliger Sample Year ______ Month ______ Location ______ Sample # ______	Zebra Mussel Veliger Sample Year ______ Month ______ Location ______ Sample # ______	Zebra Mussel Veliger Sample Year ______ Month ______ Location ______ Sample # ______
Zebra Mussel Veliger Sample Year ______ Month ______ Location ______ Sample # ______	Zebra Mussel Veliger Sample Year ______ Month ______ Location ______ Sample # ______	Zebra Mussel Veliger Sample Year ______ Month ______ Location ______ Sample # ______
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Appendix C

Zebra Mussel Information Packet

Zebra Mussel Watch Program

Volunteer Information and Reporting
Hotline: 1-888-840-8917
Fax: 916-227-7554
E-mail: mussel@water.ca.gov

Cindy Messer
Tanya Veldhuizen
Program Coordinators

CA Department of Water Resources
Division of Environmental Services
3251 S Street
Sacramento, CA 95816

NOT WANTED

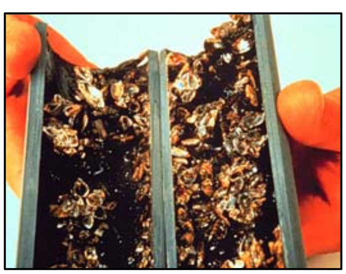
Zebra Mussel Outlaws

Threats to the West ~ Why Be Concerned?

Zebra mussels cause devastating impacts on municipal water systems, recreation and fisheries. Currently, they are widespread in Eastern USA and as far west as Oklahoma. We don't want these outlaws in California where they would rapidly reproduce and cause millions of dollars in damage to our water resources and recreation. We need your help to stop these mussels from entering our lakes, rivers and streams.

HOW COULD THESE OUTLAWS 'RIDE' HERE?

Attach to boat hulls and motors.



Cost millions of dollars each year to control in power plants and water delivery systems.

On infested recreational boats and commercial boat haulers from infested waters like the Mississippi River and Great Lakes.

HOW CAN WE ARREST THE SPREAD?

Learn how to identify zebra mussels (see sidebar).
Remove all aquatic plants and animals from boat, motor, trailer, and equipment.
Drain water from livewells, bilge, and motor.
Dispose of unwanted live minnows and worms in the trash.
Rinse boat and equipment with high pressure or hot water, especially if moored for more than a day, OR
Dry everything for at least 5 days.
Never launch watercraft with a suspected infestation.
Report sightings on watercraft or in a lake or river – note location, place mussel in a sealed container with rubbing (isopropyl) alcohol, and call the Zebra Mussel Watch Hotline, 1-888-840-8917.

VOLUNTEER FOR A POSSE

Early detection is key to preventing and mitigating impacts of zebra mussels. If you would like to help as a volunteer monitor to protect your lake or river, please contact:

Zebra Mussel Watch Program
1 (888) 840-8917 (toll free)
mussel@water.ca.gov

Found only in freshwater. Small barnacle-like clams with dark and light colored stripes.

Cover crayfish and clams, and outcompete native species for food and habitat.

CB DA

DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA

Program Implemented to Prevent the Establishment of the Invasive Zebra Mussel into California

By Tanya Veldhuizen and Cindy Messer, California Department of Water Resources, Sacramento, CA
mussel@water.ca.gov

Figure 1. Zebra mussels are usually less than 2 inches long. *Photo by USGS.*

The zebra mussel, *Dreissena polymorpha*, is a small, freshwater mussel usually less than 2 inches in length (Figure 1). Usually they have alternating light and dark brown stripes, but can also be solid light or dark brown (Figure 2). These mussels are only found in freshwater. Like the mussels found clinging to the rocks along the California coastline, zebra mussels attach onto hard surfaces (e.g. pipes, screens, rock, logs, boats, etcetera). No other freshwater mussel or clam in California can attach onto a hard surface. Zebra mussels form colonies made up of many individuals attached to a single object.

Zebra mussels are native to the Caspian Sea and Aral Sea region near Russia and the Ukraine. They were first discovered in North America in Lake St. Clair, a small water body connecting Lake Huron and Lake Erie, in June 1988. Within months of the discovery, large numbers of zebra mussels began to appear in Lake St. Clair and along the northern shoreline of western Lake Erie. The distribution of zebra mussels now covers most of the midwestern United States and is expanding into eastern states (Figure 3).

Figure 2. The zebra mussel has several color morphs — light brown, dark brown, and striped. *Photo by USGS.*

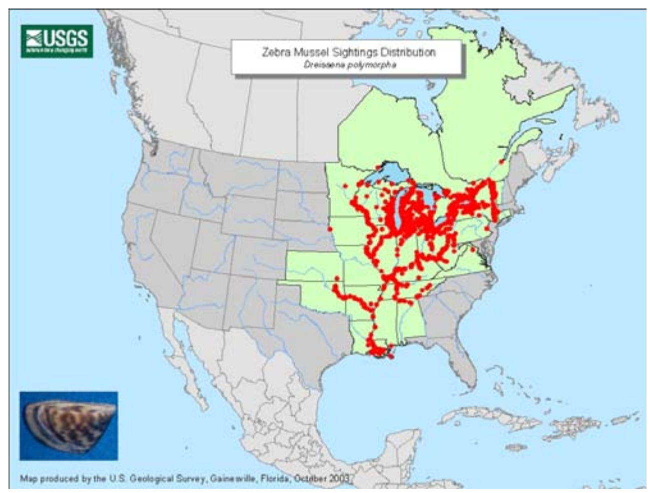


Figure 3. Distribution of the zebra mussel in the United States and Canada, October 2003. *Map by USGS.*

Initial introductions were most likely from foreign ballast water releases. Dispersal has mostly been due to the mussel's ability to attach to boats and barges that are then either navigated or trailered to other waterbodies. Under cool and humid conditions, zebra mussels can survive out of water for several days. At California border crossings, inspectors have discovered several live and dead zebra mussels attached to boat hulls or in boat engine compartments (Figure 4).

Zebra mussels have caused millions of dollars in damage to water intake structures and delivery systems, such as those used for power and municipal water treatment plants in the eastern United States from the Great Lakes into the Mississippi drainage (Figure 5). Based on this information, water and power facilities in California have a high potential of being adversely affected by zebra mussels.

Ecological impacts associated with the invasion of zebra mussels would probably be similar to those seen after the introduction of the Asian clam *(Potamocorbula amurensis)* in 1986, albeit more in the freshwater components of the San Francisco Bay-Delta system and watershed. Like the Asian clam, zebra mussels are filter feeders that remove planktonic organisms from the water column, essentially eliminating the basis of the aquatic food web. Studies have shown that zebra mussels have increased water clarity in Lake Erie up to six times what it was prior to their arrival. While increasing water clarity sounds like a good result, it is not. The increase in water clarity has resulted in an increase in the growth and expanse of aquatic plants, many of which are also unwanted introduced pests.

Figure 4. Inspectors at the agricultural inspection station in Truckee, CA, found zebra mussels attached between the hull and trim tabs of this boat. Instead of cleaning the boat before launching as instructed, the commercial hauler abandoned the boat in a marina parking lot in Stockton, CA. The parking lot flooded that winter, potentially inoculating the Sacramento-San Joaquin Delta with zebra mussels. *Photos by K. Webb, USFWS.*

The alteration of the aquatic food web and aquatic habitats in the Sacramento-San Joaquin Delta and upstream environment through the establishment of the zebra mussel could negatively affect key fish species, such as Chinook salmon, delta smelt, splittail, and striped bass.

In response to this threat the California Department of Water Resources (DWR), with funding from the California Bay-Delta Authority (CALFED), implemented a comprehensive program to protect our watershed and water supply from the invasive zebra mussel.

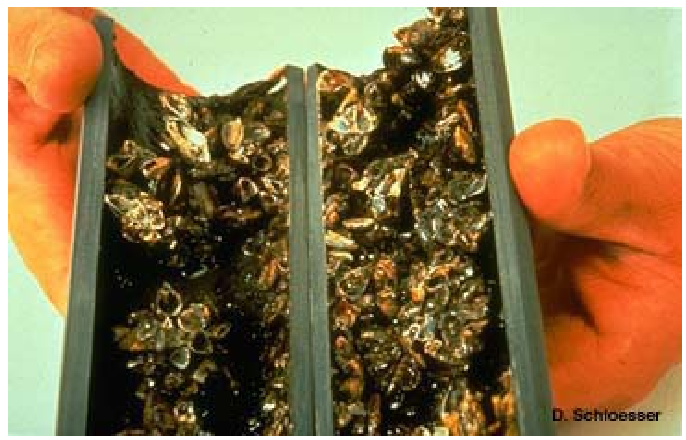


Figure 5. Cross-section of a pipe completely clogged by zebra mussels. *Photo by D. Schloesser, USGS.*

Zebra Mussel Watch Program

The "Zebra Mussel Detection and Outreach Program" is a multi-year project that began in 2001. The project entails a public outreach and education program, a risk assessment for California, an early detection monitoring program, and a rapid response plan. For outreach purposes this project is referred to as the "Zebra Mussel Watch" program.

The objectives of the public outreach and education program are to provide information materials to all interested parties on how to identify zebra mussels, how to prevent their introduction (e.g., how to properly clean boats), and what an individual should do upon finding a zebra mussel in California. This program focuses on eight specific counties (Sacramento, San Joaquin, Butte, Fresno, Merced, Glen, Colusa, and Tehama), but brochures and other information are circulated throughout California.

The risk assessment involves determining which waterbodies in California have a high risk of zebra mussel establishment. High risk areas have suitable zebra mussel habitat (e.g., substrate, pH, mineral availability), appropriate water temperatures for spawning, adequate food supplies, and high levels of boating activity.

Early detection monitoring is coordinated by DWR at high risk areas in the Bay-Delta system, as well as rivers and reservoirs in previously listed counties. Sampling primarily consists of suspending an artificial substrate for zebra mussels to attach onto and then checking this substrate for the presence of zebra mussels every month (Figure 6). The artificial substrate consists of a plexiglass plate and 2 PVC pipes filled with fabric mesh. These components are attached to a line of rope that is weighted at one end and can be suspended from a variety of structures located in the waterbody, including boat docks/slips, pipes, and piers. The artificial substrate monitoring is conducted by private citizens, marina staff, DWR staff, and staff from other agencies. During peak spawning months, DWR staff will sample for planktonic zebra mussel larvae. This more active form of sampling will only occur in areas deemed to be exceptionally high risk sites.

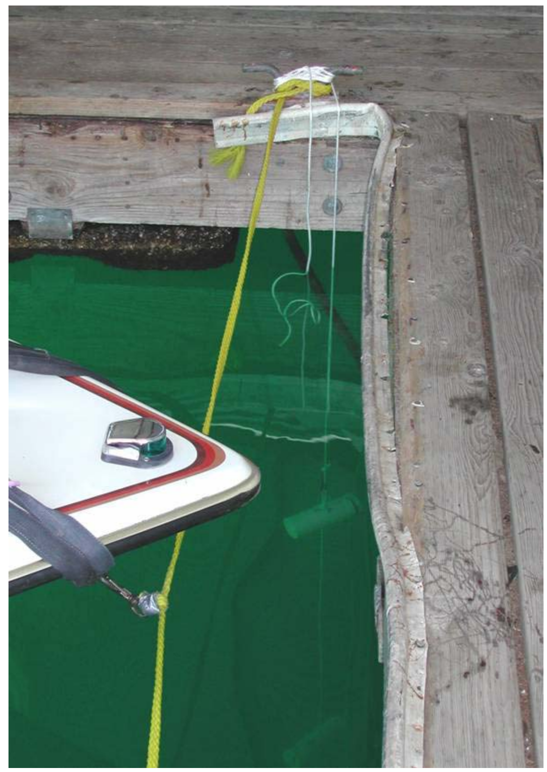


Figure 6. Zebra mussel sampling devices are composed of two PVC tubes stuffed with mesh and one plexiglass plate. Sample devices are placed near marina gas docks and boat ramps, locations where zebra mussels are most likely to be dislodged from boat hulls. *Photos by C. Messer, DWR.*

A centralized system is being established for reporting zebra mussel sightings. This system consists of a toll-free "zebra mussel hotline" and a website. Key information about zebra mussel sightings will be distributed via email, the internet, and phone calls to all necessary agencies, organizations, and facilities. A list of appropriate personnel from these agencies, organizations, and facilities is currently being compiled and will continually be updated as new parties express interest in being notified.

A rapid response plan is being developed to provide guidelines for zebra mussel sighting confirmation and appropriate eradication measures. This plan will provide a list of regulatory agencies to contact in the event of zebra mussel detection, identify the regulatory approvals necessary, identify the funds necessary for eradication of zebra mussels in California, and propose control and eradication strategies.

Protect your Watershed from Zebra Mussels, Become a Volunteer Monitor

By Tanya Veldhuizen and Cindy Messer, California Department of Water Resources, Sacramento, CA
mussel@water.ca.gov

We know it is just a matter of time before zebra mussels become established in California. Overland transport of recreational watercraft is the primary vector of zebra mussels. When the agricultural inspection stations began inspecting trailered boats entering California in October 1993, inspectors found zebra mussels on a boat within six weeks. Zebra mussels have been found on 24 boats between 1993 and April 2000. We feel this is a very high number considering that the inspections are not mandatory and the inspection stations are not open at all times. To make matters worse, currently 6 out of the 11 stations are closed because of California's budget crisis. The operating hours of the remaining 5 stations have been severely reduced and boat inspections are no longer being conducted. With this line of defense gone, we need to increase our public awareness efforts and become vigilant about monitoring for zebra mussels.

Why Monitor for Zebra Mussels?

Early Detection

The objective of field monitoring is to detect zebra mussels during the initial stage of establishment. In order to eradicate zebra mussels from a waterbody, we must implement control measures when the population is small and isolated. Early detection is the key to successful eradication. A rapid response plan will be in place and will contain guidelines and instructions for responding to a zebra mussel invasion.

Prevent Spread

Our ability to successfully eradicate or control an infestation of zebra mussels is more feasible and less costly if the population is isolated to a single lake as opposed to widespread in the watershed. Therefore, containing new zebra mussel populations is extremely important. In the event zebra mussels are discovered in a lake, the California Department of Fish and Game, along with other state and federal agencies, will take steps to prevent the mussel from spreading to other lakes and rivers. These steps may include boat cleaning at the infested lake, increasing public education and awareness efforts, and modifying the use of the infested lake.

Time to Prepare

Early detection provides water facility managers with an early warning system. They have some time to retrofit their facility to ensure uninterrupted water deliveries. Facility managers will need to change facility operating procedures to adapt to and minimize the impacts of zebra mussels. Such measures may include retrofitting intake valves with customized filters designed to screen out mussels, painting irritant coatings on surfaces to prevent mussels from settling, periodically flushing the system with high concentrations of chemicals (such as chlorine) or hot water to kill attached mussels, or periodically pressure washing all surfaces with hot water to kill and remove attached mussels. All of these measures are very costly and may require temporary facility shutdowns.

What You Can Do To Help

- ♦ Volunteer to monitor your lake, reservoir, or river. The time commitment is minimal (about 30 minutes per month), and the Zebra Mussel Watch program supplies the equipment.
- ♦ Inform others about how to prevent the spread of zebra mussels.
- ♦ Look for zebra mussels in your lake or reservoir by inspecting objects left in the water for long periods of time (e.g. boats, logs, aquatic vegetation, boat docks/ramps, bouys).
- ♦ Inspect out-of-state boats and trailers for the presence of zebra mussels.
- ♦ Clean and inspect your boat regularly and inform others to do the same.

How To Report Sightings

If you find zebra mussels, collect several specimens and record the precise location (e.g., waterbody, nearest landmark, GPS coordinates, etc), date, and your contact information. Preserve the specimens in ethanol, rubbing alcohol, a freezer, or allow to air dry. Immediately notify Zebra Mussel Watch staff by phone (1-888-840-8917) or email (mussel@water.ca.gov) for further instructions.

To Learn More

More information about zebra mussels and other introduced aquatic animals and plants can be found at the following websites:

www.100thmeridian.org (The 100th Meridian Initiative)

www.nsgo.seagrant.org (National Sea Grant Program)

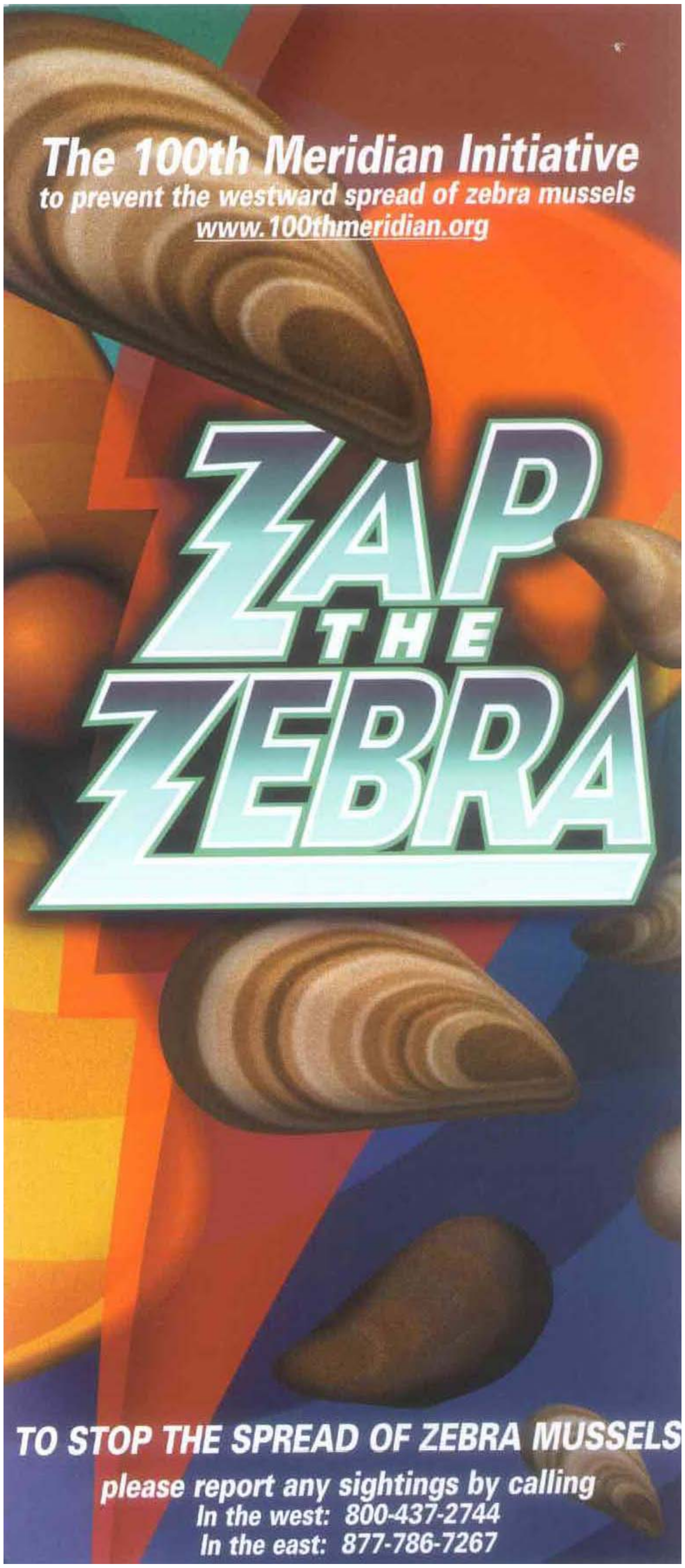
or by contacting:

Zebra Mussel Watch Program

Phone: 1-888-840-8917 (toll free)

Fax: (916) 227-7554

Email: mussel@water.ca.gov


The 100th Meridian Initiative
to prevent the westward spread of zebra mussels
www.100thmeridian.org
ZAP THE ZEBRA
TO STOP THE SPREAD OF ZEBRA MUSSELS
please report any sightings by calling
In the west: 800-437-2744
In the east: 877-786-7267

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Prevent the transport of nuisance species.
Clean all recreational equipment.

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When you leave a body of water:

- Remove any visible mud, plants, fish or animals before transporting equipment.
- Drain water from equipment (boat, motor, trailer, live wells) before transporting.
- Clean and dry anything that comes into contact with water (equipment, clothing, dogs, etc.).
- Never release plants, fish or animals into a body of water unless they came out of that body of water.

U.S. FISH & WILDLIFE SERVICE

NEWS RELEASE

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

600 Capitol Way North, Olympia, WA 98501-1091

May 25, 2004
Contact: Pam Meacham, 360-902-2741
Or Captain Mike Whorton, 509-456-3182

Zebra mussels discovered at Washington-Idaho border

SPOKANE - Zebra mussels, invasive species that could harm Washington fish and wildlife and damage hydroelectric dams and public water systems, were discovered this month on a large boat being trailered cross-country by commercial vehicle, the Washington Department of Fish and Wildlife (WDFW) reported today.

Despite the successful discovery at the Washington-Idaho border, WDFW officials are concerned that zebra mussels could be slipping in on smaller boats that are not required to stop at highway weigh stations.

Zebra mussels, fingernail-size freshwater mollusks native to the Black, Caspian and Aral Seas, were first introduced to the Great Lakes in 1986 in the ballast water of transoceanic ships. They can spread quickly, altering entire ecosystems of some waters by smothering native mussels and consuming food sources of other fish and wildlife.

The mussels have also cost industry, government and private citizens millions of dollars by clogging water intake pipes used for irrigation and municipal water supplies and damaging boat engines.

Zebra mussels are now found in at least 22 states and two Canadian provinces east of the continental divide. They spread by attaching to boats and other water-based recreational equipment.

On May 11, WDFW was alerted when a Washington State Patrol (WSP) officer at the Interstate 90 Port of Entry east of Spokane found live zebra mussels on the trim tabs of a 38-foot boat on its way from Tennessee to Washington's coast.

"Our nuisance species detection training paid off," said WDFW Regional Enforcement Captain Mike Whorton, who took the call from WSP's commercial vehicle inspector James J. Spencer.

With the help of Spokane Police Officer Brian L. Baldwin, Spencer detained the boat hauler until Whorton and WDFW officer Mike Sprecher arrived to collect information and make arrangements to send the boat to a decontamination site at a Bellingham marina.

The owner had attempted to clean the boat, Whorton said, but not thoroughly enough. Under federal and state laws, vessel owners and haulers are responsible for decontaminating against nuisance aquatic species, he explained, so enforcement action can be taken against them at interstate ports of entry.

Recently adopted Washington state law also now prohibits transport of any aquatic nuisance species on any size boats, trailers, fishing gear or bait wells, and allows state authorities to detain suspected carriers.

"Unfortunately, smaller boats don't have to stop at commercial ports like this one did, "Whorton said, "and we fear zebra mussels or other invasive plants and animals may be slipping by us."

Sometimes young zebra mussels are found in plants tangled on propellers or trailers, Whorton said. But often they can only be felt on the sides of boats, since they are too small to see. Adult zebra mussels might be seen attached in clusters to boats, but often hide in boat bilges, live wells, and motors.

Washington has been watching for zebra mussels for the past four years, said Pam Meacham, assistant coordinator for WDFW's aquatic invasive-species program. Several boats harboring the invasive species have been stopped and decontaminated before entering Washington waters, she said.

"So far, Washington is free of zebra mussels," Meacham said, "and we want to keep it that way. With thousands more recreationists heading our way in 2005 and 2006 to celebrate the two hundred year anniversary of the Lewis and Clark Expedition's travels in Washington, we need everyone's help. "

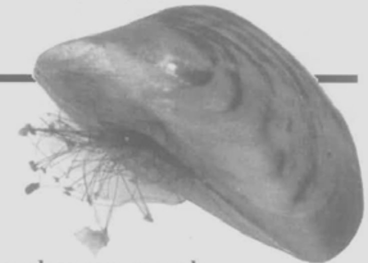
Boat owners can help by carefully inspecting and rigorously cleaning their vessels whenever leaving one water and heading for another, Meacham said, especially between states and provinces. Draining all water from boats and equipment, including bilges, live wells, bait buckets and coolers, is also critical.

For more information on zebra mussels, see Aquatic Nuisance Species on WDFW's website.

Sea Grant

Zebra mussels in North America

The invasion and its implications



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http://www-ohiosg.osc.edu/OhioSeagrant

Sea Grant is a program within the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce. Ohio Sea Grant is one of 29 state programs nationwide that work to improve the wise use and management of marine and Great Lakes resources for public benefit. Sea Grant uses university expertise in research, education, and technology transfer to help solve the problems and challenges of the oceans and the Great Lakes.

By Fred. L. Snyder, Maran Brainard Hilgendorf, and David W. Garton.

OHSU-FS-045
1990. Revised 1991, 1992, 1994, and 1997.

This publication is produced by the Ohio Sea Grant College Program (project A/ZM-1 under grant NA46RG0482).

Zebra mussels (*Dreissena polymorpha*) were first discovered in Lakes St. Clair and Erie in 1988. They quickly colonized much of the hard substrate found in waters deeper than 3 feet in western Lake Erie. As of July 1996, zebra mussels have been found in all of the Great Lakes and in waterways in 19 states and two provinces. Major river systems that now have zebra mussels include the St. Lawrence Seaway and the Hudson, Illinois, Mississippi, Ohio, Arkansas, and Tennessee Rivers.

Zebra mussels also have been reported in a growing list of inland lakes including Lake Champlain and lakes in Indiana, Michigan, Ohio, and Ontario.

In 1991, a second species of *Dreissena* was discovered in North America. Quagga mussels (*Dreissena bugensis*) have been found in the St. Lawrence Seaway, Lake Ontario, Lake Erie, and Saginaw Bay in Lake Huron. The percentage of the total *Dreissena* population composed of quagga mussels is increasing noticeably in some areas.

It is not clear when, how far, and into which waterways the zebra and quagga mussels will spread. The zebra mussel has spread faster and farther than expected. Its southward spread was thought to be limited in areas with average summer water temperatures above 81°F (27°C) but recent research shows that individual mussels adjust well to warmer temperatures. The northward spread might be limited by soils deficient in calcium or by summer water temperatures below 54°F (12°C).

Questions about zebra and quagga mussels abound, but finding answers is a difficult task. The following information answers some of the more commonly asked questions about zebra and quagga mussels.

The invasion

Dreissena polymorpha and *Dreissena bugensis* are native to an area in the Ukraine and Russia near the Black and Caspian Seas. Canals built during the late 1700s allowed the mussels to spread throughout eastern Europe. During the early 1800s, canals were built across the rest of Europe, which made bulk shipping much easier but also allowed rapid expansion of the zebra mussel's range. By the 1830s, the mussels had covered much of the continent and had invaded Britain.

The introduction of zebra mussels into the Great Lakes appears to have occurred in 1985 or 1986, when one or more transoceanic ships discharged ballast water into Lake St. Clair. The ballast, which is water ships carry to balance the vessel when they aren't fully loaded, may have contained zebra mussel larvae and possibly juveniles; or, adult mussels may have been carried in a sheltered, moist environment, such as a sediment-encrusted anchor or chain. The faster speed of today's ships provides exotic species a better chance of surviving the trip across the Atlantic. Being a temperate, freshwater species, the zebra mussels found the plankton-rich Lakes St. Clair and Erie to their liking.

Zebra and quagga mussels

The rapid spread and abundance of both mussels can be partly attributed to their reproductive cycles. A fully mature female mussel may produce up to one million eggs per season. Egg release starts when the water temperature warms to about 54°F (12°C) and continues until the water cools below 54°F. In Lake Erie, spawning may begin as early as May and end as late as October, but it peaks during July and August at water temperatures above 68°F (20°C).

Eggs are fertilized outside the mussel's body and within a few days develop into free-swimming microscopic larvae called veligers that soon develop miniature bivalve shells. Veligers swim and feed by using their hair-like cilia for 3 to 4 weeks, drifting with the currents. If they don't settle onto firm objects in that time, they die; the vast majority actually suffer this fate. It is estimated that only 1 to 3 percent survive this planktonic period of life. Those that find a hard surface quickly attach with sticky, secreted threads; they are then considered juveniles.

Mussels become adults when they reach sexual maturity, usually within a year. They grow rapidly, nearly an inch in their first year, adding another 1/2 to 1 inch their second year. European studies report mussels may live 4 to 6 years. Three years seems to be the maximum life span in Lake Erie, but there is insufficient data to know what to expect in other North American bodies of water.

Zebra mussels generate a tuft of fibers known as a byssus, or byssal threads, from a gland in the foot. The byssus protrudes through the two halves of the shell near the hinge. These threads attach to hard surfaces with an adhesive secretion that anchors the mussels in place. Small juveniles can actually shed their threads where they attach to the body, leaving the threads attached to the substrate. They then secrete new, buoyant threads that allow them to drift again with the currents and find a new surface.

Zebra mussels can colonize any surface that is not toxic — rock, metal, wood, vinyl, glass, rubber, fiberglass, paper, plants, or other mussels. Beds of mussels in some areas of Lake Erie now contain more than 30,000 — and sometimes up to 100,000 — mussels per square meter. Zebra mussels can colonize soft, muddy bottoms when hard objects deposited in or on the mud — such as pieces of native mussel shells or grains of sand— serve as a substrate (base). As a few mussels begin to grow, they in turn serve as substrate for additional colonization, forming what is known as a "druse." Individual zebra and quagga mussels can also live directly on a muddy or sandy bottom.

Zebra Mussels:

Questions and Answers for Inland Lake Managers

Patrice M. Charlebois,
Illinois-Indiana Sea Grant College Program

The zebra mussel invasion of North America has generated concern and anxiety among inland lake users and property owners about the potential impacts of zebra mussels on inland lakes. Despite the progress made in understanding the causes and consequences of the zebra mussel invasion, it is still impossible to predict exactly which lakes will be invaded or how they will be impacted. Inland water users armed with knowledge about the zebra mussel, however, can help prevent the spread and impacts of this exotic species.

What are zebra mussels?

Zebra mussels are small (< 4 cm/1.5 in), bivalve (shell composed of 2 halves) molluscs (relatives of clams). Their shells characteristically have alternating light and dark bands (like a zebra) but may be entirely light or dark. Two species of zebra mussels have invaded North America, *Dreissena polymorpha* and *Dreissena bugensis*. *Dreissena bugensis* is also referred to as the quagga mussel. Discovered after the zebra mussel, the quagga mussel gets its name from an extinct relative of the zebra.

Where did they come from? How did they get here?

Zebra mussels are native to drainages of the Black, Caspian, and Aral seas in Eastern Europe-Western Asia (Eurasia). They were most likely brought to North America as larvae in ballast water of ships that traveled from freshwater Eurasian ports inhabited by the mussels, across the Atlantic, and into the Great Lakes, where the ballast water and the zebra mussel larvae it contained were released.

How do they spread?

Zebra mussel larvae (called veligers) and adults can be spread by many mechanisms including water currents, anglers' bait buckets, and boaters' bilge and livewells. Adults can also be spread when they attach to boats and aquatic plants, which are then transported to other lakes. Aquatic plants are usually transported accidentally when they become entangled on the boat motor or the boat trailer's axle, license plate, lights, etc. Scientists currently believe that most inland lakes become infested by an introduction of adults rather than veligers.

How do zebra mussels reproduce?

Zebra mussels usually reach reproductive maturity by the end of their first year. Reproduction occurs through spawning when sperm and eggs are released into the water. Spawning peaks at water temperatures of about 20 °C (68 °F). A fertilized egg results in a free-swimming, planktonic larva called a veliger. This veliger remains suspended in the water column for 1 to 5 weeks, and then begins to sink and search for a stable surface (e.g., rocks, aquatic weeds, water intakes, boat hulls) on which to live, grow, and reproduce.

Why should I be concerned?

Because zebra mussels can interfere with recreational use of a lake and can substantially alter its ecosystem, anyone who lives or plays on an inland lake should be concerned about the possible impacts of zebra mussels. Exactly which impacts will occur, however, is difficult to predict. The population size and therefore the potential impacts depend on several characteristics of the lake (e.g., turbidity, chlorophyll a, amount of hard substrate) that can affect zebra mussel populations. There are several possible impacts that could result, however, based on experiences in the Great Lakes and in inland lakes already invaded by zebra mussels. These scenarios are based on the facts that:

1) zebra mussels can attach to almost any hard surface;

2) each mussel can filter up to 1 liter (1.06 quarts) of water per day; and

3) their shells are sharp.

• A knack for attachment

Zebra mussels attach to unprotected, submerged surfaces by producing adhesive structures called byssal threads. Boats, boat motors, water intake pipes, submersible pumps, docks, floats, rocks, native mussels, and aquatic plants are all susceptible to being colonized by zebra mussels. Impacts of zebra mussel attachment to these objects range from inconvenience, to expensive repairs, to death (of native mussels).

• Fanatic filterers

Zebra mussels feed by drawing water into their bodies and straining out most of the suspended microscopic plants, animals, and debris for food. This process can lead to increased water clarity and a depleted food

Appendix D

Early-Detection Monitoring Site and Volunteer Information

Data Reporting Mechanism: Datasheets (6 mos) = datasheets submitted every 6 months; Datasheet (monthly) = datasheets submitted monthly; Email/Verbal = volunteer contacted every 6 months for update.

Waterbody	Monitoring Site	Latitude	Longitude	Sample Number	Volunteer Name (Last, First)	Title	Organization	Contact Date	Start Date	Reporting Mechanism	Sampler Collection	Waterbody Coordinator	Current Status
Antelope Lake	DWR-ND Water Quality Monitoring Station	--	--	ANT-01	Coombe, Peter	Environmental Scientist	DWR Northern District	9/1/2003	4/1/2004	Datasheets (6 mos)	DWR to pick-up	N/A	No zebra mussels reported
Black Butte Reservoir	USACE Tower	394845.4	1222012	BLA-001	Pool, Lance	Resource Manager/Park Ranger	USACE	4/20/2004	5/8//2004	Datasheets (6 mos)	DWR to pick-up	N/A	No zebra mussels reported
Bucks Lake	Bucks Lakeshore Resort Marina	395248.7	1210951.1	BUC-01	Hopkins, Tina	Aquatic Biologist	USFS Plumas NF-Mt Hough Ranger District	8/12/2003	8/12/2003	Email/verbal report	Mail to DWR	N/A	Unknown
Butt Valley Reservoir	DWR-ND Water Quality Monitoring Station	--	--	BUT-01	Coombe, Peter	Environmental Scientist	DWR Northern District	9/1/2004	5/1/2005	Datasheets (6 mos)	DWR to pick-up	N/A	Unknown
Camanche Reservoir	Camanche North Shore Marina	381404.3	1205638.7	CAM-01	Cantwell, Chris	Marina Manager	Camanche Recreation Company	5/27/2004	5/27/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Camanche Reservoir	Camanche South Shore Marina	381256.5	1205550	CAM-02	Cantwell, Chris	Marina Manager	Camanche Recreation Company	5/27/2004	5/27/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Clear Lake	Braitos Buckingham Marina	390118	1224502.2	CLR-04	Braitos, Tony	Owner	Braitos Buckingham Marina	12/14/2004	12/14/2004	Email/verbal report	DWR to pick-up	N/A	Unknown
Clear Lake	City of Lakeport 3rd Street Marina	--	--	CLR-01	Harter, Scott	City Engineer	City of Lakeport	12/14/2004	pending	Email/verbal report	DWR to pick-up	N/A	Unknown
Clear Lake	City of Lakeport 5th Street Marina	--	--	CLR-02	Harter, Scott	City Engineer	City of Lakeport	12/14/2004	pending	Email/verbal report	DWR to pick-up	N/A	Unknown
Clear Lake	Holiday Harbor Marina	390719.9	1225029.6	CLR-03	Bartz, Joan	Owner	Holiday Harbor Marina	12/14/2004	pending	Email/verbal report	DWR to pick-up	N/A	Unknown
Collins Lake	Collins Lake Marina	392010	1211923.7	COL-01	Young, Bart	Manager	Private	8/18/2004	8/18/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Eagle Lake	DWR-ND Water Quality Monitoring Station	--	--	EAG-01	Coombe, Peter	Environmental Scientist	DWR Northern District	9/1/2003	4/1/2004	Datasheets (6 mos)	DWR to pick-up	N/A	Unknown
Englebright Reservoir	Narrows at USACE Boat House	391424	1211604.3	ENG-01	Sivertsen, Skip	US Army Corp of Engineers	USACE	8/19/2004	8/19/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Folsom Lake	Folsom Lake Marina	--	--	FOL-01	Ayres, Elizabeth	Natural Resource Specialist	USBR Folsom Dam Office	8/5/2004	pending	Datasheets (6 mos)	DWR to pick-up	Elizabeth Ayres	No zebra mussels reported

Waterbody	Monitoring Site	Latitude	Longitude	Sample Number	Volunteer Name (Last, First)	Title	Organization	Contact Date	Start Date	Reporting Mechanism	Sampler Collection	Waterbody Coordinator	Current Status
Frenchman Lake	DWR-ND Water Quality Monitoring Station	--	--	FRE-01	Coombe, Peter	Environmental Scientist	DWR Northern District	9/1/2003	4/1/2004	Datasheets (6 mos)	DWR to pick-up	N/A	Unknown
Lake Almanor	Plumas Pines Resort	401328.8	1211001.7	ALM-01	marina staff	staff	Plumas Pines Resort	8/13/2003	8/13/2003	Email/verbal report	Mail to DWR	Ken Roby	Unknown
Lake Berryessa	Lake Berryessa Marina Resort	383446.4	1221451.6	BER-02	Chuck and Sallie; Bill Wagoner	Manager	Lake Berryessa Marina Resort	6/2/2004	6/2/2004	Datasheets (6 mos)	DWR to pick-up	N/A	No zebra mussels reported
Lake Berryessa	Spanish Flat Resort	303128.1	1221249.4	BER-01	Renyer, Vince and Sharon	Manager	Spanish Flat Resort	6/2/2004	6/2/2004	Datasheets (6 mos)	DWR to pick-up	N/A	No zebra mussels reported
Lake Davis	unknown	--	--	DAV-01	Hopkins, Tina	Aquatic Biologist	USFS Plumas NF-Mt Hough Ranger District	8/12/2003	unknown	Email/verbal report	Mail to DWR	N/A	Unknown
Lake Don Pedro	Lake Don Pedro Marina at Fleming Meadows	374215.4	1202400	DON-01	Pool, Walt	Marina Manager	Lake Don Pedro Marina	7/1/2004	7/5/2004	Email/verbal report	DWR to pick-up	N/A	Unknown
Lake McClure	Barret Cove Park	373851.7	1201727.8	MCC-01	Miller, Dennis	Park Ranger	Merced Irrigation District	7/1/2004	7/5/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Lake McClure	McClure Point	373632.6	1201609.4	MCC-02	Miller, Dennis	Park Ranger	Merced Irrigation District	7/1/2004	7/5/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Lake Natoma	Brown's Ravine	--	--	NAT-01	Ayres, Elizabeth	Natural Resource Specialist	USBR Folsom Dam Office	8/5/2004	pending	Datasheets (6 mos)	DWR to pick-up	Elizabeth Ayres	No zebra mussels reported
Lake Oroville	Bidwell Marina	393205.5	1212708.4	ORO-01	See, Eric	Environmental Scientist	DWR Oroville Field Division	8/11/2003	8/11/2003	Email/verbal report	DWR to pick-up	N/A	Unknown
Little Grass Valley Reservoir	DWR-ND Water Quality Monitoring Station	394330.3	1210108.4	LGV-01	Coombe, Peter	Environmental Scientist	DWR Northern District	9/1/2003	4/1/2004	Datasheets (6 mos)	DWR to pick-up	N/A	Unknown
Millerton Lake	Millerton Lake Marina at Winchell Cove	365919.3	1194055.5	MIL-01	Hughes, Jim	Marina Manager	Millerton Lake Marina	6/8/2004	6/8/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
New Bullard's Bar Reservoir	Dark Day Boat Launch	--	--	BUL-02	Newell, Heather	Special Use Permit Admin./Public Info.	USFS Downieville Ranger Station	8/19/2004	pending	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported

Waterbody	Monitoring Site	Latitude	Longitude	Sample Number	Volunteer Name (Last, First)	Title	Organization	Contact Date	Start Date	Reporting Mechanism	Sampler Collection	Waterbody Coordinator	Current Status
New Bullard's Bar Reservoir	Emerald Cove Resort and Marina	--	--	BUL-01	Newell, Heather	Special Use Permit Admin./Public Info.	USFS Downieville Ranger Station	8/19/2004	8/19/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
New Hogan Lake	USACE Boat House	380851.6	1204841.7	HOG-01	Young, Kari	Park Ranger	USACE New Hogan Lake	5/28/2004	5/28/2004	Email/verbal report	DWR to pick-up	N/A	No zebra mussels reported
Pardee Reservoir	EBMUD Boat House	381650.5	1205203	PAR-01	Moranton, Marcel	Ranger Supervisor	EBMUD	5/27/2004	5/27/2004	Datasheets (6 mos)	DWR to pick-up	N/A	No zebra mussels reported
Sacramento-San Joaquin Delta	Bridgehead Marina	--	--	DEL-05	DWR-DES Staff	Environmental Scientist	DWR-DES	8/4/2003	8/4/2003	Datasheets (monthly)	DWR to pick-up	N/A	No zebra mussels reported
Sacramento-San Joaquin Delta	Eddos Harbor and RV Park	380300.4	1214200.8	DEL-04	DWR-DES Staff	Environmental Scientist	DWR-DES	12/15/2004	12/15/2004	Datasheets (monthly)	DWR to pick-up	N/A	No zebra mussels reported
Sacramento-San Joaquin Delta	Herman and Helens Marina and Resort	--	--	DEL-01	DWR-DES Staff	Environmental Scientist	DWR-DES	12/15/2004	12/15/2004	Datasheets (monthly)	DWR to pick-up	N/A	No zebra mussels reported
Sacramento-San Joaquin Delta	Holland Riverside Marina	375821.5	1213450.1	DEL-03	DWR-DES Staff	Environmental Scientist	DWR-DES	12/15/2004	12/15/2004	Datasheets (monthly)	DWR to pick-up	N/A	No zebra mussels reported
Sacramento-San Joaquin Delta	River Point Landing Marina and Resort	375839.3	1212240.9	DEL-02	DWR-DES Staff	Environmental Scientist	DWR-DES	12/15/2004	12/15/2004	Datasheets (monthly)	DWR to pick-up	N/A	No zebra mussels reported
Sacramento-San Joaquin Delta	Tracy Fish Collection Facility	--	--	CVP-01	Wu, Brandon	Biologist	USBR Tracy Fish Collection Facility	9/1/2004	9/8/2004	Datasheets (6 mos)	DWR to pick-up	N/A	No zebra mussels reported
Shasta Lake	Bridge Bay Resort	494519.2	1221926.5	SHA-02	Rollins, Karen and Samson, Teresa	Assistant Houseboat Manager	Bridge Bay Resort	8/13/2003	9/11/2003	Datasheets (monthly)	Mail to DWR	Joe Zustak	No zebra mussels reported
Shasta Lake	Digger Bay Resort	404338.2	1222332.9	SHA-03	Fahsholtz, Shelley and Mockridge, Larry	Marina Manager; Houseboat/Small Boat Manager	Digger Bay Marina	9/11/2003	9/11/2003	Datasheets (monthly)	Mail to DWR	Joe Zustak	No zebra mussels reported
Shasta Lake	Holiday Harbor Marina	404805.9	1221831.8	SHA-06	Kelly, Kevin	Operations Manager	Holiday Harbor	9/12/2003	9/12/2003	Email/verbal report	Mail to DWR	Joe Zustak	No zebra mussels reported
Shasta Lake	Jones Valley Resort	404420.1	1221325.1	SHA-01	Reha, Mike	General Manager	Jones Valley Resort/Shasta Lake Resort	8/14/2003	8/14/2003	Datasheets (6 mos)	Mail to DWR	Joe Zustak	No zebra mussels reported
Shasta Lake	Lakeview Resort	404845.5	1221736.4	SHA-04	Hammond, Rob	General Manager	Lakeview Resort	9/12/2003	9/12/2003	Email/verbal report	Mail to DWR	Joe Zustak	No zebra mussels reported

Waterbody	Monitoring Site	Latitude	Longitude	Sample Number	Volunteer Name (Last, First)	Title	Organization	Contact Date	Start Date	Reporting Mechanism	Sampler Collection	Waterbody Coordinator	Current Status
Shasta Lake	Sugar Loaf Resort	405113.6	1222344.4	SHA-05	Howe, Rich	General Manager	Sugarloaf Resort	9/12/2003	9/12/2003	Email/verbal report	Mail to DWR	Joe Zustak	No zebra mussels reported
Sly Creek Reservoir	DWR-ND Water Quality Monitoring Station	--	--	SLY-01	Coombe, Peter	Environmental Scientist	DWR Northern District	9/1/2003	4/1/2004	Datasheets (6 mos)	DWR to pick-up	N/A	Unknown
Trinity Lake	Cedar Stock Resort and Marina	405043.3	1224934.8	TRL-001	Christner, Deana	Assistant General Manager	Trinity Lake Resorts	4/22/2004	4/22/2004	Email/verbal report	Mail to DWR	N/A	No zebra mussels reported
Trinity Lake	Trinity Alps Marina	404857.6	1224554.9	TRL-003	Marlin, Darrel and Marilyn	Owner-Manager	Trinity Alps Marina	4/22/2004	4/22/2004	Email/verbal report	Mail to DWR	N/A	No zebra mussels reported
Trinity Lake	Trinity Center Marina	405819.7	1224122.6	TRL-002	Christner, Deana	Assistant General Manager	Trinity Lake Resorts	4/22/2004	4/22/2004	Email/verbal report	Mail to DWR	N/A	No zebra mussels reported
Whiskeytown Reservoir	Brandy Creek Marina	403716.5	1223421.3	WHI-003	Weatherbee, Russ	Wildlife Biologist	Whiskeytown National Recreation Area	4/21/2004	5/10/2004	Datasheets (6 mos)	Mail to DWR	Russ Weatherby	No zebra mussels reported
Whiskeytown Reservoir	Oak Bottom Marina	403900.3	1223508.2	WHI-002	Weatherbee, Russ	Wildlife Biologist	Whiskeytown National Recreation Area	4/21/2004	5/10/2004	Datasheets (6 mos)	Mail to DWR	Russ Weatherby	No zebra mussels reported
Whiskeytown Reservoir	Whiskey Creek Boat Launch	403857.2	1223322.1	WHI-001	Weatherbee, Russ	Wildlife Biologist	Whiskeytown National Recreation Area	4/21/2004	5/10/2004	Datasheets (6 mos)	Mail to DWR	Russ Weatherby	No zebra mussels reported

Appendix E

Waterbody and Resource Authority Contact Information

Waterbody	Resource Authority	Contact	Title	Address	City	State	Zip Code	Phone	Email
Antelope Lake	Dept. of Water Resources- Northern District	Coombe, Peter	Environmental Scientist	2440 Main Street	Red Bluff	CA	96080	(530) 529-7377	pcoombe@water.ca.gov
Black Butte Reservoir	US Army Corp of Engineers	Long, Brad	Supervisor	Black Butte Park Office County Road 200	Black Butte Park	CA	N/A	(530) 865-4781	brad.k.long@usace.army.mi/
Black Butte Reservoir	Orland Unit Water Users Assoc.	Massa, Rick	N/A	828 8th St.	Orland	CA	95963	(530) 865-4126	N/A
Black Butte Reservoir	US Bureau of Reclamation	Mike Huges	N/A	N/A	N/A	N/A	N/A	(530) 934-7066	
Bucks Lake	Plumas National Forest Ranger District	Hopkins, Tina	Aquatic Biologist	39696 HWY 70	Quincy	CA	95971	(530) 283-7689	thopkins@fs.fed.us
Bucks Lake	Pacific Gas and Electric	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CA Aqueduct - CVP	US Bureau of Reclamation	Wu, Brandon	Biologist - Tracy Fish Facility	N/A	N/A	N/A	N/A	N/A	N/A
Camanche Reservoir	Camanche Recreation Company	Cantwell, Chris	Marina Manager	2000 Camanche Road	Ione	CA	95640	(209) 763-5166	ccantwell@camancherecreation.com
Camanche Reservoir	EBMUD - Camanche Res. Office	Watkins, Paul	District Ranger	N/A	N/A	N/A	N/A	N/A	N/A
Clear Lake	City of Lakeport	Harter, Scott	City Engineer	225 Park Street	Lakeport	CA	95453	(707) 263-5614	sharter@cityoflakeport.com
Clear Lake	California State Parks & Recreation	Lynn, Bruce	Superintendent	5300 Soda Bay Rd.	Kelseyville	CA	95451	(707) 279-4293	N/A
Clear Lake	City of Capay- Yolo County Flood Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clear Lake	Clear Lake Public Works Dept.	Simkins, R.A. "Skip"	Clear Lake Lands Coordinator	255 N. Forbes Street	Lakeport	CA	95453	(707) 263-2341	skip_s@co.lake.ca.us
Collins Lake	Private	Young, Bart	Manager	PO Box 300/7530 Marysville Road	Oregon House	CA	95962	(800) 286-0576	info@collinslake.com
Eagle Lake	Dept. of Water Resources- Northern District	Coombe, Peter	Environmental Scientist	2440 Main Street	Red Bluff	CA	96080	(530) 529-7377	pcoombe@water.ca.gov
Englebright Reservoir	US Army Corp of Engineers	Rusey, Jill	District Office	N/A	N/A	N/A	N/A	(916) 557-5281	N/A
Englebright Reservoir	US Army Corp of Engineers	Sivertsen, Skip	Supervisor	PO Box 6	Smartville	CA	95977	(530) 432-6427	englebright-info@spk.usace.army.mil
Folsom Lake	US Bureau of Reclamation	Ayers, Elizabeth	Resource Ecologist	7794 Folsom Dam Rd	Folsom	CA	95630	(916) 989-7192	eayres@mp.usbr.gov
Folsom Lake	California State Parks & Recreation	Walters, Sally	District Resource Ecologist	N/A	N/A	N/A	N/A	N/A	N/A
Frenchman Lake	Dept. of Water Resources- Northern District	Coombe, Peter	Environmental Scientist	2440 Main Street	Red Bluff	CA	96080	(530) 529-7377	pcoombe@water.ca.gov
Lake Almanor	Lake Almanor Ranger Station - National Forest Service	McFarland, Melanie	Aquatic Biologist-Susanville	PO Box 767	Chester	CA	96020	(530) 258-5168	N/A
Lake Almanor	Lake Almanor Ranger Station - National Forest Service	Roby, Ken	Aquatic Biologist	PO Box 767	Chester	CA	96020	(530) 258-5168	N/A
Lake Almanor	Pacific Gas and Electric	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lake Berryessa	US Bureau of Reclamation	Peoples, Precious	Natural Resource Specialist	5520 Knoxville Road	Napa	CA	94558	(707) 966-2111	N/A
Lake Berryessa	Solano County	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lake Don Pedro	Lake Don Pedro Marina	Pool, Walt	Marina Manager	81 Bonds Flat Rd	La Grange	CA	95329	(209) 852-2369	N/A
Lake Don Pedro	Don Pedro Rec Agency	Russel, Carol	Director	31 Bonds Flat Rd	La Grange	CA	95329	(209) 852-2396	carussell@tid.org
Lake McClure	Merced Irrigation District	Latronica, Bill	Superintendent	9090 Lake McClure Rd	Snelling	CA	95369	(209) 378-2521	N/A

Waterbody	Resource Authority	Contact	Title	Address	City	State	Zip Code	Phone	Email
Lake McClure	Merced Irrigation District	Miller, Dennis	Park Ranger	9090 Lake McClure Rd	Snelling	CA	95369	(209) 378-2611	N/A
Lake Oroville	California State Parks & Recreation	Elliot, Woody	Resource Ecologist	400 Glen Drive	Oroville	CA	95966	(530) 538-2212	N/A
Lake Oroville	DWR-Oroville Field Division	Martin, Rosemary	Special Services	917 Kelly Ridge Road	Oroville	CA	95966	(530) 538-2219	N/A
Little Grass Valley	Dept. of Water Resources-Northern District	Coombe, Peter	Environmental Scientist	2440 Main Street	Red Bluff	CA	96080	(530) 529-7377	pcoombe@water.ca.gov
Little Grass Valley	OWID	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Little Grass Valley	National Forest Service	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Millerton Lake	California State Parks & Recreation	Harrison, Wayne	Senior Resource Ecologist	N/A	N/A	N/A	N/A	(209) 536-2914	N/A
Millerton Lake	Millerton Lake Marina	Hughes, Jim	Marina Manager	19305 Winchell Cove Road/PO Box 525	Friant	CA	93626	(559) 822-2264	N/A
Millerton Lake	California State Parks & Recreation	Vreeland, Karen	Office Assistant	PO Box 205/5290 Millerton Road	Friant	CA	93626	(559) 822-2332	kvree@parks.ca.gov
Millerton Lake	US Bureau of Reclamation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
New Bullards Bar Reservoir	Downieville Ranger District - National Forest Service	Frazer, Dave	Ranger	15924 Hwy. 49	Camptonville	CA	95922	(530) 288-0727	N/A
New Bullards Bar Reservoir	Downieville Ranger District - National Forest Service	Newell, Heather	Special Use Permit Admin./Public Info.	15924 Hwy. 49	Camptonville	CA	95922	(530) 288-3232	hnewell@fs.fed.us
New Bullards Bar Reservoir	Yuba County Water Agency	Onken, Steve	Manager	1409 D Street	Marysville	CA	95901	(530) 692-3400	N/A
New Hogan Lake	US Army Corp of Engineers	Burt, Donna	Interpretive Office	2713 Hogan Dam Road	Valley Springs	CA	95252	(209) 772-1343	donna.burt@usace.army.mil
New Hogan Lake	US Army Corp of Engineers	Johnson, Duane	Resource Manager	2713 Hogan Dam Road	Valley Springs	CA	95252	(209) 772-1343	duane.johnson@usace.army.mil
New Hogan Lake	US Army Corp of Engineers	Young, Kari	Resource Ranger	2713 Hogan Dam Road	Valley Springs	CA	95252	N/A	N/A
Pardee Reservoir	EBMUD Camanche Res. Office	Moranton, Marcel	Ranger Supervisor	4900 Stony Creek Road	Ione	CA	95640	(209) 772-8259	mmmoranto@ebmud.com
Pardee Reservoir	EBMUD Camanche Res. Office	Roberson, Harold	Supervisor	Bardee Cntre	Valley Springs	CA	95252	(209) 772-8368	hroberso@ebmud.com
Pardee Reservoir	EBMUD Camanche Res. Office	Watkins, Paul	District Ranger	4900 Stony Creek Road	Ione	CA	95640	(209) 772-8527	N/A
Sacramento - San Joaquin Delta	Dept. of Water Resources-Division of Env. Services	Veldhuizen, Tanya	Environmental Scientist	3251 S Street	Sacramento	CA	95816	(888) 840-3917	mussel@water.ca.gov
Sacramento - San Joaquin Delta	Dept. of Water Resources-Division of Env. Services	Messer, Cindy	Environmental Scientist	901 P Street	Sacramento	CA	94236	(916) 651-9687	mussel@water.ca.gov
Shasta Lake	USFS Shasta-Trinity	Adcock, Cheryl	Assistant Recreation Officer	14225 Holiday Road	Redding	CA	96003	(530) 275-1587	N/A
Shasta Lake	Shasta-Trinity NRA	Brown, Ramona	Manager of Visitor Center	14225 Holiday Road	Redding	CA	96003	(530) 275-1589	rbrown@fs.fed.us
Shasta Lake	US Bureau of Reclamation	Harral, Sheri	Public Affairs Specialist	16349 Shasta Dam BLVD	Shasta Lake	CA	96019-8400	(530) 275-1554	sharral@mp.usbr.gov
Shasta Lake	Shasta-Trinity National Forest Service	Zustak, Joe	Aquatic Biologist	14225 Holiday Road	Redding	CA	96003	(530) 242-5556	N/A
Sly Creek Reservoir	Dept. of Water Resources-Northern District	Coombe, Peter	Environmental Scientist	2440 Main Street	Red Bluff	CA	96080	(530) 529-7377	pcoombe@water.ca.gov
Sly Creek Reservoir	Oro-Wayondotte Irr. Dist.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Waterbody	Resource Authority	Contact	Title	Address	City	State	Zip Code	Phone	Email
Trinity Lake	Weaverville Ranger District	Cottini, Kristiy	District Ranger-USFS	14225 Holiday Road	Redding	CA	96003	(530) 275-1587	N/A
Trinity Lake	US Bureau of Reclamation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Trinity Lake	Weaverville Ranger District	Shaw, Ginger	Special Uses Team	PO Box 1190	Weaverville	CA	96093	(530) 623-2121	N/A
Whiskeytown Lake	US Bureau of Reclamation	De Staso, Jim	N/A	N/A	N/A	N/A	N/A	(530) 276-2046	jdestaso@mp.usbr.gov
Whiskeytown Lake	Whiskeytown NRA National Park Service	Gibson, Jennifer	Wildlife Biologist	PO Box 188	Whiskeytown	CA	96095	(530) 242-3445	N/A
Whiskeytown Lake	US Bureau of Reclamation	Hanson, Larry	N/A	N/A	N/A	N/A	N/A	(530) 225-2442	N/A
Whiskeytown Lake	Whiskeytown NRA National Park Service	Rasmussen, Brian	Interim Chief of Resource Management	Whiskeytown NRA, 14412 Kennedy Mem. Dr, PO Box 188	Whiskeytown	CA	96095	(530) 242-3445	N/A
Whiskeytown Lake	Whiskeytown NRA National Park Service	Weatherbee, Russ	Wildlife Biologist	PO Box 188	Whiskeytown	CA	96095	(530) 242-3445	N/A

Appendix F

Early-Detection Monitoring Data

Waterbody	Location	Latitude	Longitude	Station Code	Set Sample Date	Sample Device ID	Contact	Set Water Temp	Set Water Depth	Substrate	Aquatic Vegetation	Aquatic Veg Type	Retrieve Sample Date	Retrieve Water Temp	Retrieve Water Depth	Sample Condition	Visual Inspection	ActionTaken	Comments
Antelope Lake	DWR Northern District WQ			ANTELOPEL	4/1/2004	ANT-01	Coombe, Peter						4/30/05						SAMPLER SET04/04, NO DATASHEETS FOUND, RE-CHECKED 04/05
Antelope Lake	DWR Northern District WQ			ANTELOPEL	4/1/2005	ANT-02	Coombe, Peter						4/1/05						SAMPLER SET 04/04 - NO DATASHEETS FOUND - RE-CHECKED 04/05
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	4/20/2004	BLA-01	Long, Brad		1	Mud	sparse	SAV	5/8/04	68	1	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	5/8/2004	BLA-01	Long, Brad	68	1	Mud	sparse	SAV	6/6/04	71	1	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	6/6/2004	BLA-01	Long, Brad	71	1	Mud	sparse	SAV	7/6/04	82	1.5	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	7/6/2004	BLA-01	Long, Brad	82	1.5	Mud	none	None	8/7/04	82	1.5	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	8/7/2004	BLA-01	Long, Brad	82	1.5	Mud	none	None	9/6/04	78	1.5	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	9/6/2004	BLA-01	Long, Brad	78	1.5	Mud	none	None	10/16/04	70	1.5	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	10/16/2004	BLA-01	Long, Brad	70	1.5	Mud	none	None	11/16/04		1.5	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	11/16/2004	BLA-01	Long, Brad		1.5	Mud	none	None	12/16/04		1	MeshOut	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	12/16/2004	BLA-01	Long, Brad		1	Mud	none	None	1/16/04	50	1	Good	NoMussels	None	
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	1/16/2005	BLA-01	Long, Brad	50	1	Mud	none	None	2/18/05	52		Missing			
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	2/18/2005	BLA-01	Long, Brad	52		Mud	none	None	3/18/05	50		Missing			
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	3/18/2005	BLA-01	Long, Brad	50		Mud	none	None	4/15/05	58		Missing			
Black Butte Reservoir	USACE Tower	39 48 45.4	122 20 12.0	BLACK BR	4/15/2005	BLA-01	Long, Brad	58		Mud	none	None	5/18/05	66		Missing		ContactZMW	
Bucks Lake	Bucks Lakeshore Resort	39 52 48.7	121 09 51.1	BUCKSMARIN	8/12/2003	BUC-01	Hopkins, Tina			Sand	none	None							
CA Aqueduct	USBR Tracy Fish Facility			TRACY FF	9/8/2004	CVP-01	Wu, Brandon	24	1.45	Mud	none	None	10/12/04	19	1.07	Good	NoMussels	None	
CA Aqueduct	USBR Tracy Fish Facility			TRACY FF	10/12/2004	CVP-01	Wu, Brandon	19	1.07	Mud	sparse	SAV	11/8/04	14.1	1.27	Good	NoMussels	None	
CA Aqueduct	USBR Tracy Fish Facility			TRACY FF	11/8/2004	CVP-01	Wu, Brandon	14.1	1.27	Mud	thick	SAV	12/9/04	9.6	1.3	Good	NoMussels	None	
CA Aqueduct	USBR Tracy Fish Facility			TRACY FF	12/9/2004	CVP-01	Wu, Brandon	9.6	1.3	Mud	thick	SAV	1/7/05	9.1	2.38	Good	NoMussels	None	
CA Aqueduct	USBR Tracy Fish Facility			TRACY FF	1/7/2005	CVP-01	Wu, Brandon	9.1	2.38	Mud	medium	SAV	2/11/05	12.5	1.52	Good	NoMussels	None	
CA Aqueduct	USBR Tracy Fish Facility			TRACY FF	2/11/2005	CVP-01	Wu, Brandon	12.5	1.52	Mud	medium	SAV	3/8/05	15	1.98	Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	5/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	6/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	6/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	7/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	7/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	8/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	8/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	9/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	9/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	10/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	10/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	11/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	11/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	12/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	12/27/2004	CAM-01	Cantwell, Chris			Unknown	none	None	1/27/05			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	1/27/2005	CAM-01	Cantwell, Chris			Unknown	none	None	2/27/04			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	2/27/2005	CAM-01	Cantwell, Chris			Unknown	none	None	3/27/05			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	3/27/2005	CAM-01	Cantwell, Chris			Unknown	none		4/27/05			Good	NoMussels	None	
Camanche Reservoir	North Shore Recreation Area	38 14 04.3	120 56 38.7	CAMANCHENS	4/27/2005	CAM-01	Cantwell, Chris			Unknown	none	None	5/18/05			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	5/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	6/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	6/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	7/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	7/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	8/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	8/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	9/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	9/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	10/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	10/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	11/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	11/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	12/27/04			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	12/27/2004	CAM-02	Cantwell, Chris			Unknown	none	None	1/27/05			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	1/27/2005	CAM-02	Cantwell, Chris			Unknown	none	None	2/27/05			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	2/27/2005	CAM-02	Cantwell, Chris			Unknown	none	None	3/27/05			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	3/27/2005	CAM-02	Cantwell, Chris			Unknown	none	None	4/27/05			Good	NoMussels	None	
Camanche Reservoir	South Shore Recreation Area	38 12 56.5	120 55 50.0	CAMANCHESS	4/27/2005	CAM-02	Cantwell, Chris			Unknown	none	None	5/18/05			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	8/18/2004	COL-01	Young, Bart			Unknown	none	None	9/18/04			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	9/18/2004	COL-01	Young, Bart			Mud	none	None	10/18/04			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	10/18/2004	COL-01	Young, Bart			Unknown	none	None	11/18/04			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	11/18/2004	COL-01	Young, Bart			Unknown	none	None	12/18/04			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	12/18/2004	COL-01	Young, Bart			Unknown	none	None	1/18/05			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	1/18/2005	COL-01	Young, Bart			Unknown	none	None	2/18/05			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	2/18/2005	COL-01	Young, Bart			Unknown	none	None	3/18/05			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	3/18/2005	COL-01	Young, Bart			Unknown	none	None	4/18/05			Good	NoMussels	None	
Collins Lake	Collins Lake Marina	39 20 10.0	121 19 23.7	COLLINSMAR	4/18/2005	COL-01	Young, Bart			Unknown	none	None	5/18/05			Good	NoMussels	None	
Eagle Lake	DWR Northern District WQ			EAGLELAKE	4/1/2004	EAG-01	Coombe, Peter						4/30/05						SAMPLER SET 04/04, NO DATASHEETS, RE-CHECKED 04/05
Eagle Lake	DWR Northern District WQ			EAGLELAKE	4/2/2004	EAG-02	Coombe, Peter						4/29/05						SAMPLER SET 04/04, NO DATASHEETS, RE-CHECKED 04/05
Englebright Reservoir	Narrows@USACE boat house	39 14 24.0	121 16 04.3	ENGLENARR	8/19/2004	ENG-01	Sivertsen, Skip; Kathy			Unknown	none	None	9/19/04			Good	NoMussels	None	
Englebright Reservoir	Narrows@USACE boat house	39 14 24.0	121 16 04.3	ENGLENARR	9/18/2004	ENG-01	Sivertsen, Skip; Kathy			Unknown	none	None	10/19/04			Good	NoMussels	None	
Englebright Reservoir	Narrows@USACE boat house	39 14 24.0	121 16 04.3	ENGLENARR	10/19/2004	ENG-01	Sivertsen, Skip; Kathy			Unknown	none	None	11/19/04			Good	NoMussels	None	
Englebright Reservoir	Narrows@USACE boat house	39 14 24.0	121 16 04.3	ENGLENARR	11/19/2004	ENG-01	Sivertsen, Skip; Kathy			Unknown	none	None	12/19/04			Good	NoMussels	None	
Englebright Reservoir	Narrows@USACE boat house	39 14 24.0	121 16 04.3	ENGLENARR	12/19/2004	ENG-01	Sivertsen, Skip; Kathy			Unknown	none	None	1/19/05			Good	NoMussels	None	
Englebright Reservoir	Narrows@USACE boat house	39 14 24.0	121 16 04.3	ENGLENARR	1/19/2005	ENG-01	Sivertsen, Skip; Kathy			Unknown	none	None	2/19/05			Good	NoMussels	None	
Frenchman Lake	DWR Northern District WQ			FRENCHMANL	4/1/2004	FRE-01	Coombe, Peter						4/30/05						SAMPLER SET 04/04 - NO DATASHEETS - RECHECKED 04/05
Lake Almanor	Plumas Pines Resort	40 13 28.88	121 10 01.7	ALMANORPP	8/13/2003	ALM-01	Roby, Ken			Unknown	none	None							
Lake Berryessa	Lake Berryessa Marina Resort	38 34 46.4	122 14 51.6	BERRYMARIN	6/2/2004	BER-02	Wagoner, Bill			Mud	sparse	Algae	7/1/04			Good	NoMussels	None	
Lake Berryessa	Lake Berryessa Marina Resort	38 34 46.4	122 14 51.6	BERRYMARIN	8/12/2004	BER-02	Wagoner, Bill	76		Mud	none		9/11/04		10	Good	NoMussels	None	
Lake Berryessa	Lake Berryessa Marina Resort	38 34 46.4	122 14 51.6	BERRYMARIN	9/11/2004	BER-02	Wagoner, Bill		10	Mud	none		11/15/04		10	Good	NoMussels	None	
Lake Berryessa	Lake Berryessa Marina Resort	38 34 46.4	122 14 51.6	BERRYMARIN	1/12/2005	BER-02	Wagoner, Bill			Mud	sparse	Algae	3/17/05		12	Good	NoMussels	None	
Lake Berryessa	Lake Berryessa Marina Resort	38 34 46.4	122 14 51.6	BERRYMARIN	3/17/2005	BER-02	Wagoner, Bill			Mud	sparse	Algae				Missing		ContactZMW	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	6/2/2004	BER-01	Keen, Mike	72	40		sparse	Algae	7/2/04	74	40	Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	7/2/2004	BER-01	Keen, Mike	74			sparse	Algae	8/2/04	77	40	Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	8/2/2004	BER-01	Keen, Mike	77	40	Unknown	sparse	Algae	9/2/04	77	40	Good	NoMussels	None	

Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	9/2/2004	BER-01	Keen, Mike	74	40	Unknown	sparse	Algae	10/2/04	70	40	Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	10/2/2004	BER-01	Keen, Mike	65	40	Unknown	sparse	Algae	11/2/04	65	40	Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	11/2/2004	BER-01	Keen, Mike	55	40	Unknown	sparse	Algae	12/2/04	55	40	Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	12/2/2004	BER-01	Keen, Mike	55	40	Unknown	none	None	1/2/05	50	40	Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	1/2/2005	BER-01	Keen, Mike	52		Unknown	none	None	2/2/05	52		Good	NoMussels	None	
Lake Berryessa	Spanish Flat Resort	38 31 28.1	122 12 49.4	BERRYSPAN	2/2/2005	BER-01	Keen, Mike	52		Unknown	none	None	3/2/05	56	40	Good	NoMussels	None	
Lake Don Pedro	Fleming Meadows Marina	37 42 15.4	120 24 00.0	DONPEDFMM	7/5/2004	DON-01	Pool, Walt			Unknown	none	None	8/5/04			Good	NoMussels	None	
Lake McClure	Barret Cove Marina	37 38 51.7	120 17 27.8	MCCLUREBCM	7/5/2004	MCC-01	Latronica, Bill			Unknown	none	None	8/5/04			Good	NoMussels	None	
Lake McClure	Barret Cove Marina	37 38 51.7	120 17 27.8	MCCLUREBCM	8/5/2004	MCC-01	Latronica, Bill			Unknown	none	None	9/5/04			Good	NoMussels	None	
Lake McClure	Barret Cove Marina	37 38 51.7	120 17 27.8	MCCLUREBCM	9/5/2004	MCC-01	Latronica, Bill			Unknown	none	None	9/30/05			Missing			
Lake McClure	McClure Point	37 36 32.6	120 16 09.4	MCCLUREMP	7/5/2004	MCC-02	Latronica, Bill			Unknown	none	None	8/5/04			Good	NoMussels	None	
Lake McClure	McClure Point	37 36 32.6	120 16 09.4	MCCLUREMP	8/5/2004	MCC-02	Latronica, Bill			Unknown	none	None	9/5/04			Good	NoMussels	None	
Lake McClure	McClure Point	37 36 32.6	120 16 09.4	MCCLUREMP	9/5/2004	MCC-02	Latronica, Bill			Unknown	none	None	9/30/05			Missing			
Little Grass Valley Reservoir	DWR Northern District WQ	39 43 30.3	121 01 08.4	LGRASSVALL	4/1/2004	LGV-01	Coombe, Peter						4/30/05						SAMPLER SET 04/04, NO DATASHEETS, RECHECKED 04/05
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	6/8/2004	MIL-01	Hessey, Mack			Unknown	none	None	7/8/04			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	7/8/2004	MIL-01	Hessey, Mack			Unknown	none	None	8/4/04			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	8/4/2004	MIL-01	Hessey, Mack			Unknown	none	None	9/4/04			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	9/4/2004	MIL-01	Hessey, Mack			Unknown	none	None	10/4/04			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	10/8/2004	MIL-01	Hessey, Mack			Unknown	none	None	11/8/04			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	11/8/2004	MIL-01	Hessey, Mack			Unknown	none	None	12/8/04			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	12/8/2004	MIL-01	Hessey, Mack			Unknown	none	None	1/8/05			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	1/8/2005	MIL-01	Hessey, Mack			Unknown	none	None	2/8/05			Good	NoMussels	None	
Millerton Lake	Millerton Lake Marina	36 59 19.3	119 40 12.6	MILLERMLM	2/8/2005	MIL-01	Hessey, Mack			Unknown	none	None	3/14/05			Good	NoMussels	None	
New Hogan Lake	USACE Boat House	38 08 51.6	120 48 41.7	NEWHOGANL	5/28/2004	HOG-01	Young, Kari			Mud	thick	Algae	8/21/05			MeshOut	NoMussels	None	SAMPLER MUDDY AND LOTS OF ALGAE
Pardee Reservoir	EBMUD Boat House	38 16 50.5	120 52 03.0	PARDEEEBM	5/27/2004	PAR-01	Moranton, Marcel			Unknown	none	None	7/27/04			Good	NoMussels	None	
Pardee Reservoir	EBMUD Boat House	38 16 50.5	120 52 03.0	PARDEEEBM	7/27/2004	PAR-01	Moranton, Marcel			Unknown	none	None	9/27/04			Good	NoMussels	None	
Pardee Reservoir	EBMUD Boat House	38 16 50.5	120 52 03.0	PARDEEEBM	9/27/2004	PAR-01	Moranton, Marcel			Unknown	none	None	11/27/04			Good	NoMussels	None	
Pardee Reservoir	EBMUD Boat House	38 16 50.5	120 52 03.0	PARDEEEBM	11/27/2004	PAR-01	Moranton, Marcel			Unknown	none	None	1/27/05			Good	NoMussels	None	
Pardee Reservoir	EBMUD Boat House	38 16 50.5	120 52 03.0	PARDEEEBM	1/27/2005	PAR-01	Moranton, Marcel			Unknown	none	None	3/21/05			Good	NoMussels	None	
Sacramento-San Joaquin Delta	Bridgehead Marina			BRIDGEHEAD	12/4/2003	DEL-05	Messer, Cindy			Mud	medium	SAV	4/16/04			Good	NoMussels	None	
Sacramento-San Joaquin Delta	Bridgehead Marina			BRIDGEHEAD	8/4/2003	DEL-05	Messer, Cindy			Mud	medium	SAV	12/4/03			MeshOut	NoMussels	None	
Sacramento-San Joaquin Delta	Bridgehead Marina			BRIDGEHEAD	4/16/2004	DEL-05	Messer, Cindy			Mud	medium	SAV	8/15/04						
Sacramento-San Joaquin Delta	Bridgehead Marina			BRIDGEHEAD	8/15/2004	DEL-05	Messer, Cindy			Mud	medium	SAV	1/17/05			Good	NoMussels	None	
Sacramento-San Joaquin Delta	Bridgehead Marina			BRIDGEHEAD	1/17/2005	DEL-05	Messer, Cindy			Mud	medium	SAV	3/24/05			Good	NoMussels	None	
Sacramento-San Joaquin Delta	Eddos Harbor and RV Park	38 03 00.4	121 42 00.8	EDDOS	12/15/2004	DEL-04	Messer, Cindy			Mud	none	None							
Sacramento-San Joaquin Delta	Herman and Helen's Marina			HANDH	12/15/2004	DEL-01	Messer, Cindy			Mud	sparse	Algae	3/24/05			Good	NoMusssels	None	
Sacramento-San Joaquin Delta	Herman and Helen's Marina			HANDH	3/24/2005	DEL-01	Messer, Cindy			Mud	sparse	Algae							
Sacramento-San Joaquin Delta	River Point Landing Marina	37 58 39.3	121 22 40.9	RIVERPNT	12/15/2004	DEL-02	Messer, Cindy			Mud	medium	SAV	3/24/05			Good	NoMussels	None	
Sacramento-San Joaquin Delta	River Point Landing Marina	37 58 39.3	121 22 40.9	RIVERPNT	3/24/2005	DEL-02	Messer, Cindy			Mud	medium	SAV							
Sacramento-San Joaquin Delta	Holland Riverside Marina	37 58 21.5	121 34 50.1	HOLLANDRM	12/15/2004	DEL-03	Messer, Cindy			Mud	medium	SAV	3/24/05			Good	NoMussels	None	
Sacramento-San Joaquin Delta	Holland Riverside Marina	37 58 21.5	121 34 50.1	HOLLANDRM	3/24/2005	DEL-03	Messer, Cindy			Mud	medium	SAV							
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	9/11/2003	SHA-02	Rollins, Karen and Teresa Samson		100	Unknown	none	None	10/13/03		100	MeshOut	NoMussels	None	SNAILS PRESENT
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	10/13/2003	SHA-02	Rollins, Karen and Teresa Samson		100	Unknown	none	None	11/13/03		100	Good	NoMussels	None	
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	11/13/2003	SHA-02	Rollins, Karen and Teresa Samson		100	Unknown	none	None	12/11/03						
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	12/11/2003	SHA-02	Rollins, Karen and Teresa Samson	56	100	Unknown	none	None	1/14/04	24	100	Good	NoMussels	None	JELLY-LIKE EGGS GONE
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	1/14/2004	SHA-02	Rollins, Karen and Teresa Samson	54	100	Unknown	none	None	2/20/04	48	100	Good	NoMussels	None	
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	2/20/2004	SHA-02	Rollins, Karen and Teresa Samson	48	100	Unknown	none	None	3/16/04	48	100	Good	NoMussels	None	
Shasta Lake	Bridge Bay Resort	40 45 19.1	122 19 27.0	BRIDGEBAY	3/16/2004	SHA-02	Rollins, Karen and Teresa Samson	48	100	Unknown	none	None	4/13/04	60	100	Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	9/11/2003	SHA-03	Fahsholtz, Shelley		100	Unknown	none	None	10/15/03	70	100	Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	10/15/2003	SHA-03	Fahsholtz, Shelley	70	100	Unknown	none	None	12/31/03	55		Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	12/31/2003	SHA-03	Fahsholtz, Shelley	55		Unknown	none	None	1/30/04	45	100	MeshOut	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	1/30/2004	SHA-03	Fahsholtz, Shelley	45	100	Unknown	none	None	3/1/04		100	MeshOut	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	3/1/2004	SHA-03	Fahsholtz, Shelley		100	Unknown	none	None	4/1/04	50	100	MeshOut	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	4/1/2004	SHA-03	Fahsholtz, Shelley	50	100	Unknown	none	None	5/1/04						
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	5/1/2004	SHA-03	Fahsholtz, Shelley			Unknown	none	None	6/1/04			Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	6/1/2004	SHA-03	Fahsholtz, Shelley			Unknown	none	None	7/1/04			Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	7/1/2004	SHA-03	Fahsholtz, Shelley			Unknown	none	None	8/1/04			Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	8/1/2004	SHA-03	Fahsholtz, Shelley			Unknown	none	None	12/2/04			Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	12/2/2004	SHA-03	Fahsholtz, Shelley	52	100	Unknown	none	None	1/31/05	52	100	Tangled	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	1/31/2005	SHA-03	Fahsholtz, Shelley			Unknown	none	None	2/27/05			Good	NoMussels	None	
Shasta Lake	Digger Bay Resort	40 43 38.2	122 23 32.9	DIGGERBAY	2/27/2005	SHA-03	Fahsholtz, Shelley			Unknown	none	None	3/31/05			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	8/14/2003	sha 01	Reha, Mike	80	42	Unknown	none	None	9/14/03	79	30	Good	NoMussels	None	Heavy algae
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	9/14/2003	sha 01	Reha, Mike	79	30	Unknown	none	None	10/14/03	71	31	Good	NoMussels	None	Algae has turned to freshwater sponge w/tiny black seeds
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	10/15/2003	sha 01	Reha, Mike		39	Unknown	none	None	11/15/03	65	28	Good	NoMussels	None	freshwater sponge
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	11/15/2003	sha 01	Reha, Mike	65	28	Unknown	none	None	12/18/03	59	36	Good	NoMussels	None	Cleaned trap of algae and freshwater sponges
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	12/18/2003	SHA-01	Reha, Mike	59	36	Unknown	sparse	Algae	1/15/04	51	46	Good	NoMussels	None	ALGAE AND FRESHWATER SPONGES PRESENT
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	1/15/2004	SHA-01	Reha, Mike	51	46	Unknown	sparse	Algae	2/15/04	50	52	Good	NoMussels	None	ALGAE AND FRESHWATER SPONGES PRESENT
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	2/15/2004	SHA-01	Reha, Mike	50	52	Unknown	sparse	Algae	3/15/04	51	56	Good	NoMussels	None	FRESHWATER SPONGES PRESENT
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	3/15/2004	SHA-01	Reha, Mike	51	56	Unknown	none	None	4/15/04	60	59	Good	NoMussels	None	FRESHWATER SPONGES PRESENT
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	4/15/2004	SHA-01	Reha, Mike	62	59	Unknown	none	None	5/15/04	63	60	Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	5/15/2004	SHA-01	Reha, Mike	63	60	Unknown	none	None	6/15/04	69	58	Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	6/15/2004	SAH-01	Reha, Mike	69	58	Unknown	none	None	7/15/04	77	52	Good	NoMussels	None	CLEANED TRAP
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	7/15/2004	SHA-01	Reha, Mike			Unknown	none	None	8/15/04			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	8/15/2004	SHA-01	Reha, Mike			Unknown	none	None	9/15/04			Good	NoMussels	None	

Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	9/15/2004	SHA-01	Reha, Mike			Unknown	none	None	10/15/04			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	10/15/2004	SHA-01	Reha, Mike			Unknown	none	None	11/15/04			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	11/15/2004	SHA-01	Reha, Mike			Unknown	none	None	12/15/04			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	12/15/2004	SHA-01	Reha, Mike			Unknown	none	None	1/15/05			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	1/15/2005	SHA-01	Reha, Mike			Unknown	none	None	2/15/05			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	3/15/2005	SHA-01	Reha, Mike			Unknown	none	None	4/15/05			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	4/15/2005	SHA-01	Reha, Mike			Unknown	none	None	5/15/05			Good	NoMussels	None	
Shasta Lake	Jones Valley Resort	40 44 20.1	122 13 25.1	JONESVALLE	5/15/2005	SHA-01	Reha, Mike			Unknown	none	None	6/15/05			Good	NoMussels	None	
Shasta Lake	Sugarloaf Resort	40 51 13.6	122 23 44.4	SUGARLOAF	9/12/2003	SHA-05	Howe, Rich			Unknown	none	None	10/6/03			MeshOut	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	4/22/2004	TRL-03	Darrel			Unknown	none	None	5/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	5/22/2004	TRL-03	Darrel			Unknown	none	None	6/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	6/22/2004	TRL-03	Darrel			Unknown	none	None	7/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	7/22/2004	TRL-03	Darrel			Unknown	none	None	8/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	8/22/2004	TRL-03	Darrel			Unknown	none	None	9/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	9/22/2004	TRL-03	Darrel			Unknown	none	None	10/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	10/22/2004	TRL-03	Darrel			Unknown	none	None	11/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	11/22/2004	TRL-03	Darrel			Unknown	none	None	12/22/04			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	12/22/2004	TRL-03	Darrel			Unknown	none	None	1/22/05			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	1/22/2005	TRL-03	Darrel			Unknown	none	None	2/22/05			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	2/22/2005	TRL-03	Darrel			Unknown	none	None	3/22/05			Good	NoMussels	None	
Trinity Lake	Trinity Alps Marina	40 48 57.6	122 45 54.9	TRINITY AM	3/22/2005	TRL-03	Darrel			Unknown	none	None	4/22/05			Good	NoMussels	None	
Whiskeytown Lake	Brandy Creek Marina	40 37 16.5	122 34 21.3	WHISKEYBCM	5/10/2004	WHI-03	Weatherbee, Russ	14	6.5	Rock	none	None	6/24/04	14	6.5	MeshOut	NoMussels	None	
Whiskeytown Lake	Brandy Creek Marina	40 37 16.5	122 34 21.3	WHISKEYBCM	6/24/2004	WHI-03	Weatherbee, Russ	14	6.5	Rock	none	None	7/13/04		6.5	Good	NoMussels	None	
Whiskeytown Lake	Brandy Creek Marina	40 37 16.5	122 34 21.3	WHISKEYBCM	7/13/2004	WHI-03	Weatherbee, Russ		6.5	Rock	none	None	7/20/04	78	6.5	Good	NoMussels	None	
Whiskeytown Lake	Brandy Creek Marina	40 37 16.5	122 34 21.3	WHISKEYBCM	7/20/2004	WHI-03	Weatherbee, Russ	78	6.5	Rock	none	None	10/5/04	16.5	6.5	Good	NoMussels	None	
Whiskeytown Lake	Brandy Creek Marina	40 37 16.5	122 34 21.3	WHISKEYBCM	10/5/2004	WHI-03	Weatherbee, Russ	16.5	6.5	Rock	none	None	3/17/05			Missing		ContactZMW	
Whiskeytown Lake	Whiskey Creek Boat Launch	40 38 57.2	122 33 22.1	WHISKEYCBL	5/10/2004	WHI-01	Weatherbee, Russ	13	4	Cement	none	None	6/21/04	13	4	Good	NoMussels	None	
Whiskeytown Lake	Whiskey Creek Boat Launch	40 38 57.2	122 33 22.1	WHISKEYCBL	6/21/2004	WHI-01	Weatherbee, Russ	13	4	Cement	none	None	7/20/04	78	3.5	MeshOut	NoMussels	None	
Whiskeytown Lake	Whiskey Creek Boat Launch	40 38 57.2	122 33 22.1	WHISKEYCBL	7/20/2004	WHI-01	Weatherbee, Russ	78	3.5	Cement	none	None	9/2/04	16.5	3.5	Good	NoMussels	None	
Whiskeytown Lake	Whiskey Creek Boat Launch	40 38 57.2	122 33 22.1	WHISKEYCBL	9/2/2004	WHI-01	Weatherbee, Russ	16.5	3.5	Cement	none	None	10/5/04	16.5	3.5	Good	NoMussels	None	
Whiskeytown Lake	Whiskey Creek Boat Launch	40 38 57.2	122 33 22.1	WHISKEYCBL	10/5/2004	WHI-01	Weatherbee, Russ	16.5	3.5	Cement	none	None	2/11/05			Good	NoMussels	None	
Whiskeytown Lake	Whiskey Creek Boat Launch	40 38 57.2	122 33 22.1	WHISKEYCBL	2/11/2005	WHI-01	Weatherbee, Russ			Cement	none	None	7/20/05			Missing		ContactZMW	
Whiskeytown Lake	Oak Bottom Marina	40 39 00.3	122 35 08.2	WHISKEYOBM	5/10/2004	WHI-02	Weatherbee, Russ	11	10	Unknown	sparse	SAV	6/24/04	11	10	Good	NoMussels	None	
Whiskeytown Lake	Oak Bottom Marina	40 39 00.3	122 35 08.2	WHISKEYOBM	6/24/2004	WHI-02	Weatherbee, Russ	11	10	Unknown	sparse	SAV	7/13/04		10	Good	NoMussels	None	
Whiskeytown Lake	Oak Bottom Marina	40 39 00.3	122 35 08.2	WHISKEYOBM	7/13/2004	WHI-02	Weatherbee, Russ		10	Unknown	sparse	SAV	7/20/04	77	10	Good	NoMussels	None	Moved sampler to new location - public launch
Whiskeytown Lake	Oak Bottom Marina	40 39 00.3	122 35 08.2	WHISKEYOBM	7/20/2004	WHI-02	Weatherbee, Russ	77	10	Unknown	sparse	SAV	7/20/05			Good	NoMussels	None	
Whiskeytown Lake	Oak Bottom Marina	40 39 00.3	122 35 08.2	WHISKEYOBM	7/20/2005	WHI-02	Weatherbee, Russ			Unknown	sparse	SAV	8/22/05			Missing		ContactZMW	

Appendix G

Macroinvertebrate Data

1/1 43/

Sacramento-San Joaquin Delta Benthos Data Sheet

Department of Water Resources, Environmental Services Office

Lab Sample Number	Site	Bank	Grab Number	Sample Date	Sub Sample Size
~~55~~ DEL Ø3				05/ /05 (M M D D Y Y)	

Comments:

Sample Volume ___ mL:	% Vegetable Detritus: ___	% Peat: ___	% Hard Clay Particles: ___
	% Shell Fragment: ___	% Mica: ___	% Worm Tubes: ___
	% Sand: ___	% Gravel: ___	% Other: ___

	PHYLUM	FAMILY	GENUS	SPECIES	ORG.#	tally	COUNT
1.	ARTH	GAMM	GAMM	DAIB	4750	11 2+2	204
2.	ARTH	CORO	AMER	SPIN	4610	108+3	111
3.	ARTH	MUNN	UROM	SP A	4410	41	41
4.	MOLL	PHYS	PHYS	GYRI	6570		10
5.	MOLL	ANCY	FERR	CALI	6590	3??	41
6.	ANNE	NAID	SLAV	APPE	2270		50
7.	PLAT	PLAN	DUGE	TIGR	1010		21
8.	NEME	TETR	PROS	GRAE	1120		11
9.	ANNE	NAID	STYL	LACU	2290		16
10.	ANNE	SAEE	MANA	SPEC	3430	109	10
11.	ANNE	TUBI	BOTH	VEJO	2470		1
12.	ARTH	TANA	SINE	STAN	4270		1
13.	ANNE	NAID	CHAE	DIAP	2020		1
14.	ARTH	CHIR	PSEC	SP A	5990		6
15.	ARTH	CHIR	PARY	SP A	5510	1?	8
16.	ARTH	COEN	EMAL	SP A	5140	SP.N. (REF)	1
17.							
18.							
19.							
20.						/	
21.							
22.							
23.							
24.							
25.							

lumnid sopod –

Specimen Count: ______ x 4 = ______ + ______ = 447 / 504

Entered By: ______

QA/QC'd By: ______

August 2001

Sacramento-San Joaquin Delta Benthos Data Sheet

Department of Water Resources, Environmental Services Office

* APPROXIMATE

Lab Sample Number	Site	Bank	Grab Number	Sample Date	Sub Sample Size
E	BER		01	03/ /05 (MM DD YY)	

Comments: LAKE BERRYESSA ZEBRA MUSSEL MONITORING

Sample Volume mL: ____

% Vegetable Detritus: ____ % Peat: ____ % Hard Clay Particles: ____

% Shell Fragment: ____ % Mica: ____ % Worm Tubes: ____

% Sand: ____ % Gravel: ____ % Other: ____

	PHYLUM	FAMILY	GENUS	SPECIES	ORG.#	tally	COUNT
1.	CNID	HYDR	HYDR	SP			1720 →
2.	PLAT	PLAN	DUGE	TIGR			12
3.	NEME	TETR	PROS	GRAE			4
4.	NEMA	UNKN	NEMA	SP			1
5.	ANNE	NAID	NAIS	PARD			17
6.	MOLL	PHYS	PHYS	GYRI			45
7.	ARTH	GAEN	GAEN	SP			1
8.	ARTH	CHIR	PARA	SP			1
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							
21.							
22.							
23.							
24.							
25.							

Specimen Count: ______ x 4 = ______ + ______ = ______

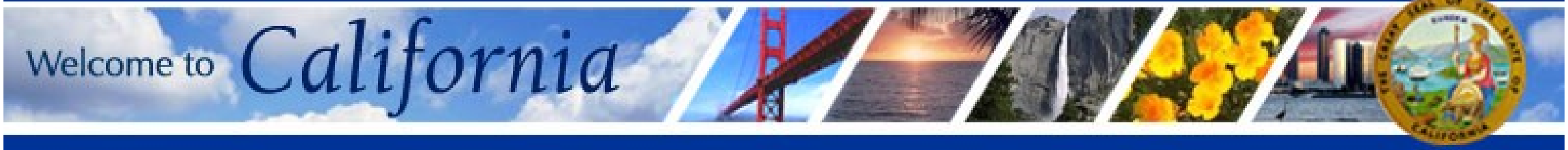
Entered By: ______

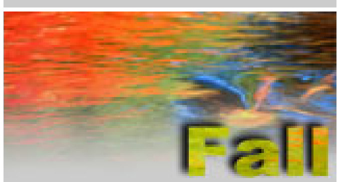
QA/QC'd By: ______

August 2003

Appendix H

Website for the California Zebra Mussel Watch Program





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Zebra Mussel Watch

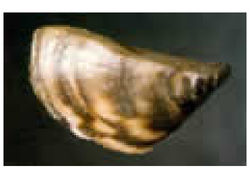
What is a Zebra Mussel?
The zebra mussel, Dreissena polymorpha, is a small, freshwater mussel usually...
more...

Program Overview
The California Department of Water Resources (DWR), on behalf of the CALFED Bay-Delta Program, is conducting a comprehensive project to protect...
more...

Early Detection Monitoring
Early detection monitoring is conducted at high risk rivers and reservoirs...
more...

How to Report Sightings
If you find zebra mussels...
more...

Distribution in California
Currently, there are no populations of zebra mussels in California.
more...



What can I do to help?
Volunteer to monitor your lake or reservoir. The time commitment is minimal....
more...

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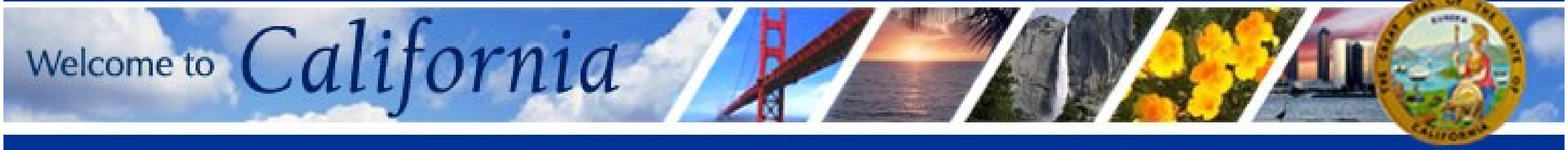

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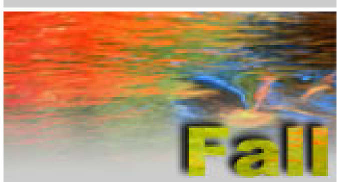

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Zebra Mussel - What is it?

What is a Zebra Mussel?

The zebra mussel, *Dreissena polymorpha*, is a small, freshwater mussel usually less than 2 inches in length. Usually they have alternating light and dark brown stripes, but can also be solid light or dark brown.

These mussels are only found in freshwater. Like the mussels found clinging to the rocks along the California coastline, zebra mussels attach onto hard surfaces (for example, pipes, screens, rock, logs, and boats). No other freshwater mussel or clam in California can firmly attach onto a hard surface. Zebra mussels form colonies made up of many individuals attaching onto an object and each other.

Where Did They Come From?

Zebra mussels are native to the Caspian Sea region in the former Soviet Union. They were first discovered in North America in Lake St. Clair, a small water body connecting Lake Huron and Lake Erie, in June 1988. Within months of the discovery, large numbers of zebra mussels began to appear in Lake St. Clair and along the northern shoreline of western Lake Erie. The distribution of zebra mussels now covers most of the midwestern United States and is expanding into eastern states.

Initial introductions were most likely from foreign ballast water releases. Dispersal has mostly been due to the mussel's ability to attach to boats and barges that are then either navigated or trailered to other waterbodies. Under cool and humid conditions, zebra mussels can survive out of water for several days. At California border crossings, inspectors have discovered several live and dead zebra mussels attached to boat hulls or in boat engine compartments.

Why are They Bad?

Zebra mussels have caused millions of dollars in damage to water intake structures and delivery systems, such as those used for power and municipal water treatment plants in the eastern United States from the Great Lakes into the Mississippi drainage. Based on this information, water and power facilities in California have a high potential of being adversely affected by zebra mussels.

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Zebra Mussel Staff

Zebra Mussel Information:

- Zebra Mussel Watch
- What is a Zebra Mussel?
- Program Overview
- Early Detection Monitoring
- How to Report Sightings
- Distribution in California
- What can I do?
- Outreach Materials

Related Links:

- Aquatic Ecology
- 100th Meridian Initiative
- US Army Corps of Engineers - Zebra Mussel Research Program
- US Geological Survey - Zebra Mussel Information

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Recreational boating can be affected by increased drag due to attached mussels. Small mussels can get into engine cooling systems causing overheating and damage. Increased hull and motor fouling will result in increased maintenance costs on houseboats and vessels moored for long periods of time. Navigational buoys have been sunk under the weight of attached zebra mussels. Fishing gear can be fouled if left in the water for long periods. Deterioration of dock pilings has increased when they are encrusted with zebra mussels. Continued attachment of zebra mussel can cause corrosion of steel and concrete affecting its structural integrity.

Ecological impacts associated with the invasion of zebra mussels would probably be similar to those seen after the introduction of the Asian clam, Potamocorbula amurensis, in 1986, albeit more in the freshwater components of the San Francisco Bay-Delta system and watershed. Like the Asian clam, zebra mussels are filter feeders and remove planktonic organisms, which are essentially the basis of the aquatic food web, from the water column. Studies have shown that zebra mussels have increased water clarity in Lake Erie up to six times what it was prior to their arrival. While increasing water clarity sounds like a good result, it is not. The increase in water clarity has resulted in an increase in the growth and expanse of aquatic plants, many of which are also unwanted introduced pests and navigational hazards. The alteration of the aquatic food web and aquatic habitats in the Sacramento-San Joaquin Delta and upstream environment through the establishment of the zebra mussel could negatively affect key fish species, such as Chinook salmon, delta smelt, splittail and striped bass.

How to Identify a Zebra Mussel

D - Shaped shell

Solid light brown, dark brown, or striped

Up to 1-1/2 inches in length

Firmly attaches onto objects with "byssal threads"

How they attach to objects:

Byssal Threads

Do Not Confuse Zebra Mussels with Asian Clams

Zebra mussels may be confused with the Asian clam, *Corbicula fluminea*, another introduced species commonly found in California waters. Both are relatively small in size, are similar in color, and live in freshwater. The Asian clam is common in most of California’s rivers and lakes. Dead shells are often found along the shoreline or in shallow water. This is the same clam that is used as fishing bait. To distinguish the Asian clam from the zebra mussel, refer to the following list of characteristics:

Zebra Mussel

1. **D-**shaped shell
2. Smooth or shallowly ridged shell
3. Solid light to dark brown or striped shell
4. Small, up to 1½ inches long
5. Attaches to hard surfaces with brown fibers
6. Brackish to fresh water

Asian Clam

1. **Fan-**shaped shell
2. Deep ridges on shell
3. Solid light to dark brown shell, may have a white patch near hinge
4. Small, up to 2 inches long
5. Burrows into sand or mud; never attaches to structures
6. Brackish to fresh water

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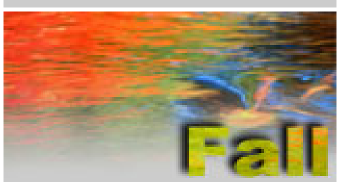

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DEPARTMENT OF WATER RESOURCES
ENVIRONMENTAL SERVICES

Zebra Mussel - Program Overview

Overview of California's Zebra Mussel Watch Program

The California Department of Water Resources (DWR), on behalf of the CALFED Bay-Delta Program, is conducting a comprehensive project to protect our watershed and water supply from the invasive zebra mussel.

The program is composed of several elements: a risk assessment, an early detection monitoring program "Early Detection Monitoring", a centralized reporting system "How to Report a Zebra Mussel Sighting", a rapid response plan, and public outreach and education"Outreach Materials".

The risk assessment involves determining which waterbodies in California have a high probability of zebra mussel establishment. High risk areas have suitable zebra mussel habitat (based on substrate type, pH, and mineral availability), appropriate water temperatures for spawning, adequate food supplies, and high levels of boating activity.

Early detection monitoring is conducted at high risk rivers and reservoirs in the Central Valley watershed. Sampling consists of suspending an artificial substrate (link to monitoring pictures) for zebra mussels to attach onto, and then checking this substrate for the presence of zebra mussels every month. The monitoring is conducted by private citizens, marina staff, DWR staff, and staff from other agencies.

A centralized system was created for reporting zebra mussel sightings. Sightings can be reported via a toll-free number or email:

Zebra Mussel Staff

Cindy Messer or Tanya Veldhuizen

Phone: 1-888-840-8917 (toll free)

Email: **mussel@water.ca.gov**

All reports go directly to staff at the Department of Water Resources in Sacramento, California. Notification of confirmed sightings are distributed by email to interested parties and made available on this website.

A rapid response plan is being developed to provide guidelines for zebra mussel sighting confirmation and appropriate eradication measures. This plan will provide a list of regulatory agencies to contact in the event of zebra mussel detection and propose control and eradication strategies.

The objectives of the public outreach and education program are to provide information materials to all interested parties on how to identify zebra mussels "What is a Zebra Mussel?", how to prevent their introduction (e.g., how to properly clean boats) "How to Inspect and Clean Boats and Trailers", and what to do if zebra mussels are found in California "How to report a sighting".

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DEPARTMENT OF WATER RESOURCES
ENVIRONMENTAL SERVICES

Zebra Mussel - Early Detection Monitoring

Early Detection Monitoring

Early detection monitoring is conducted at high risk rivers and reservoirs in the Central Valley watershed. Sampling primarily consists of suspending an artificial substrate for zebra mussels to attach onto and then checking this substrate for the presence of zebra mussels every month. The artificial substrate consists of a plexiglass plate and 2 PVC pipes filled with fabric mesh. These components are attached to a line of rope that is weighted at one end and can be suspended from a variety of structures located in the waterbody, including boat docks/slips, pipes, and piers. The artificial substrate monitoring is conducted by private citizens, marina staff, DWR staff, and staff from other agencies.

Why Monitor for Zebra Mussels?

Early Detection

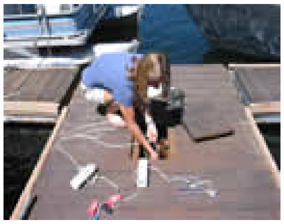
The objective of field monitoring is to detect zebra mussels during the initial stage of establishment. In order to eradicate zebra mussels from a waterbody, we need to begin control measures when the population is small and isolated. Early detection is the key to successful eradication. A rapid response plan will be in place and will contain guidelines and instructions for responding to a zebra mussel invasion.

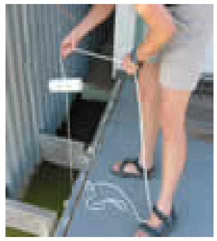
Prevent Spread

Our ability to successfully eradicate or control an infestation of zebra mussels is more feasible and less costly if the population is isolated to a single lake as opposed to widespread in the watershed. Therefore, containing new zebra mussel populations is extremely important. In the event zebra mussels are discovered in a lake, the California Department of Fish and Game, along with other state and federal agencies, will take steps to prevent the mussel from spreading to other lakes and rivers. These steps may include boat cleaning at the infested lake, increasing public education and awareness efforts, and perhaps modifying the use of the infested lake.

Time to Prepare

Early detection provides water facility managers with an early warning system. They have some time to retrofit the facility to ensure uninterrupted water deliveries. Facility managers will need to change facility operating procedures to adapt to and minimize the impacts of zebra mussels. Such measures may include retrofitting intake valves with customized filters designed to screen out mussels, painting irritant coatings on surfaces to prevent mussels from settling, periodically flushing the system with high concentrations of chemicals (such as chlorine) to kill attached mussels, or periodically pressure washing all surfaces with hot water to kill and remove attached mussels. All of these measures are very costly and may require temporary facility shutdowns.

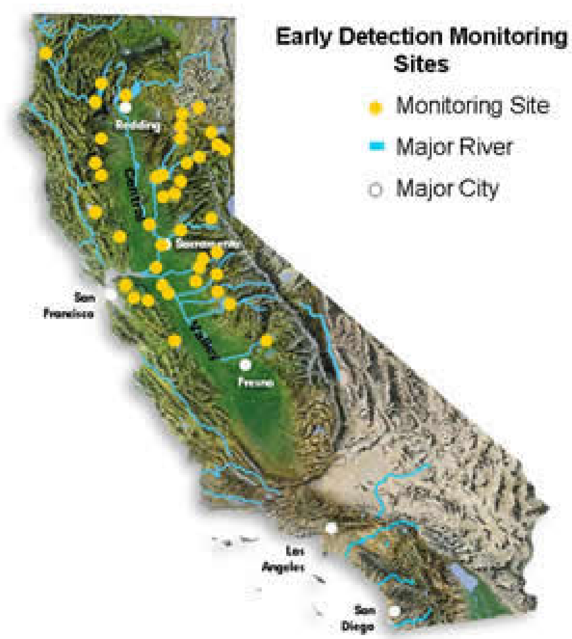




The sampler is composed of two PVC tubes (that have mesh inside) and a plexiglass plate. The sampler hangs vertically in the water column. The sampler is secured in a location with minimal human interference, such as in a private slip or an area with employee access only.

If possible, the sampler is placed near the boat launch and the fuel dock. Zebra mussels are most likely to be knocked off of boat hulls in these areas.

California Early Detection Monitoring Sites



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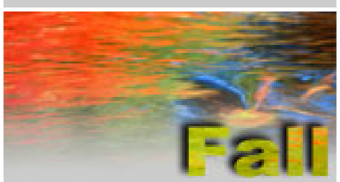

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DEPARTMENT OF WATER RESOURCES

ENVIRONMENTAL SERVICES

Zebra Mussel - Report Sightings

How to Report a Zebra Mussel Sighting

If You Find Zebra Mussels:

- Collect several specimens
- Record the precise location (for example, waterbody, nearest landmark, GPS coordinates, etc.)
- Record the date
- Preserve the specimens in ethanol, rubbing alcohol, a freezer, or allow to air dry
- Provide us with your contact information (name, phone number, etc.)

Immediately Notify our Zebra Mussel Staff :

Cindy Messer or Tanya Veldhuizen

Phone: 1-888-840-8917 (toll free)

Email: mussel@water.ca.gov

**Whatever you do,
please DO NOT throw Zebra Mussels
back in the water!**

crayfish covered with zebra mussels

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- Zebra Mussel Watch
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- US Geological Survey - Zebra Mussel Information

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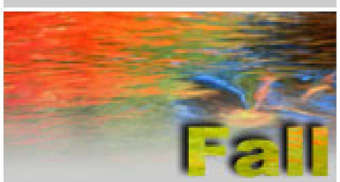
Fun Links for Kids...



Division of Environmental Services
Department of Water Resources

3251 S Street
Sacramento, Ca. 95816-7017

Mailing Address:
Post Office Box 942836
Sacramento, CA 94236-0001

General Information
(916) 227-7541

Zebra Mussel - California Distribution

Zebra Mussel Distribution in California

- Currently, there are no populations of zebra mussels in California.

Zebra Mussel Sightings in Nearby States

- May 11, 2004 – Interstate 90 Port of Entry east of Spokane at the Washington-Idaho border,; live zebra mussels found on the trim tabs of a 38-foot boat on its way from Tennessee to Washington’s coast.
- May 28, 2004 – Temple Bar on Lake Mead, AZ; adult zebra mussels found on the hull and live veligers were found in the generator intake filter of a 54-foot houseboat from a marina on the Ohio River in Kentucky.
- July 12, 2004 – Lake Mead; local marine repair shop found zebra mussels inside both of the outdrive motors of a recreational boat transported from Chicago, Illinois. Pictures available at http://www.100thmeridian.org/photos.asp.

click for larger image

DWR My CA Search

Contact

Zebra Mussel Staff

Zebra Mussel Information:

- Zebra Mussel Watch
- What is a Zebra Mussel?
- Program Overview
- Early Detection Monitoring
- How to Report Sightings
- Distribution in California
- What can I do?
- Outreach Materials

Related Links:

- Aquatic Ecology
- 100th Meridian Initiative
- US Army Corps of Engineers - Zebra Mussel Research Program
- US Geological Survey - Zebra Mussel Information

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[Weekly Activity Reports]

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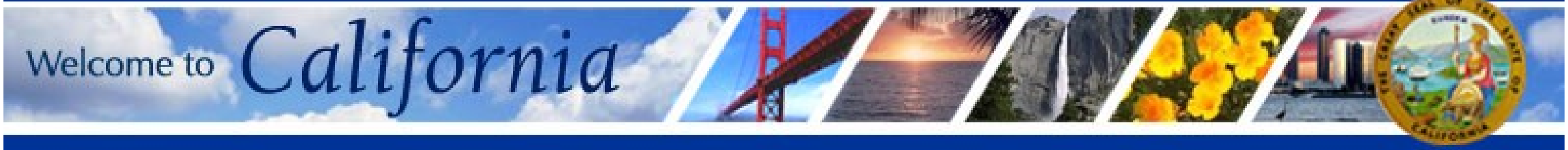

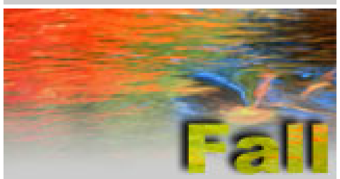

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Zebra Mussel - What Can I do to Help?

What You Can Do to Help:

- Volunteer to monitor your lake or reservoir. The time commitment is minimal (about 30 minutes per month), and the Zebra Mussel Watch program supplies the equipment.
- Inform others about how to prevent the spread of zebra mussels.
- Look for zebra mussels in your lake or reservoir by inspecting objects left in the water for long periods of time (for example, boats, logs, aquatic vegetation, boat docks/ramps, and buoys).
- Clean and inspect your boat regularly and inform others to do the same.
- Inspect out-of-state boats and trailers for the presence of zebra mussels.

To Become a Volunteer or Obtain more information about the program, Contact Zebra Mussel Staff:

Cindy Messer or Tanya Veldhuizen

Phone: 1-888-840-8917 (toll free)

Email: mussel@water.ca.gov

Help Stop the Spread:

Zebra mussels cause devastating impacts on municipal water systems, water recreation opportunities and businesses, and fisheries. Currently, they are widespread in eastern and midwestern states, and are as far west as Kansas and Oklahoma. We do not want zebra mussels in California where they would rapidly reproduce and cause millions of dollars in damage to our water resources and recreation. We need your help to stop these mussels from entering our lakes, rivers and streams.

Zebra mussels are transported from one waterbody to another in vessels. Microscopic larval mussels can "hitchhike" in water remaining in livewells, bilge tanks, engine cooling systems, and bait buckets. Juvenile and adults mussels can hitchhike attached to boat hulls, engine drive units, and boat trailers. Adult zebra mussels can survive for several days out of the water if in a moist, shaded area, and for over a week in wet areas such as bilges and livewells.

How to Inspect and Clean Boats and Trailers:

Learn how to identify zebra mussels.

Remove all aquatic plants and animals from boat, motor, trailer, and equipment.

Drain water from livewells, bilge, and motor.

Dispose of unwanted live minnows and worms in the trash.

Rinse boat and equipment with high pressure or hot water, especially if moored for more than a day, *OR*

Dry everything for at least 5 days.

Never launch watercraft with a suspected infestation.

Report sightings on watercraft or in lakes and rivers.

Where to Look for Zebra Mussels:

click for larger image

Early detection is key to preventing and mitigating impacts of zebra mussels

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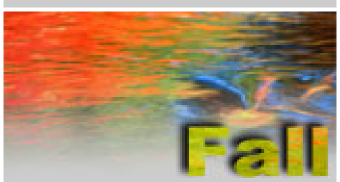

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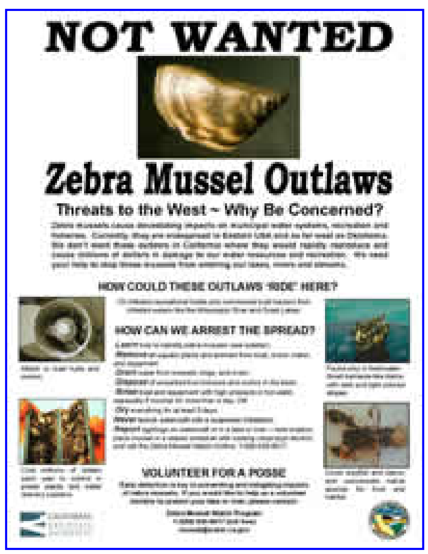
Zebra Mussel - Outreach Materials

Outreach Materials

Publications / Newsletters:

2004 Summer Newsletter - Zebra mussels found on vessels in Washington and Arizona...
more...

Materials Available for Public Use:



Not Wanted Poster (PDF: 1MB)

To Order Your Free Poster, Contact Zebra Mussel Staff:

Cindy Messer or Tanya Veldhuizen
Phone: 1-888-840-8917
Email: mussel@water.ca.gov

crafish covered with zebra mussels

Search
DWR My CA

Contact
Zebra Mussel Staff

Zebra Mussel Information:

- Zebra Mussel Watch
- What is a Zebra Mussel?
- Program Overview
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- Outreach Materials

Related Links:

- Aquatic Ecology
- 100th Meridian Initiative
- US Army Corps of Engineers - Zebra Mussel Research Program
- US Geological Survey - Zebra Mussel Information

Some documents may require Adobe Software for viewing.

Download Adobe Acrobat Reader - free.

Whatever You Do,
Please DO NOT Throw Zebra Mussels Back in the Water!

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Appendix I

List of Individuals and Organizations who Received Zebra Mussel Information and who Assisted with Information Dissemination

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Adcock, Cheryl	Assistant Recreation Officer	Shasta Lake Visitor Information Center	USFS Shasta-Trinity NRA	yes	yes
Alexander, Pete	Fisheries Biologist	Lake Del Valle	East Bay Regional Parks District	yes	no
Ayres, Elizabeth	Natural Resource Specialist	Folsom Lake/Lake Natoma	USBR Folsom Dam Office	yes	yes
Baldwin, Wen	Member	Lake Mead	Lake Mead Boat Owners Association	yes	no
Barkus, Kathy	Supervisor	Camanche Reservoir	Camanche Recreation Company - South Shore Marina	yes	no
Bartz, Joan	Owner	Clear Lake	Holiday Harbor Marina	yes	no
Beard, Denali	Assistant Resource Ecologist	Sacramento-San Joaquin Delta	CA State Parks, Gold Fields District	yes	no
Berman, Howard	Guide	San Luis Reservoir	DWR	yes	yes
Blakely, April		Lake Arrowhead	Lake Arrowhead Public Utilities	yes	yes
Boles, Jerry	Senior Environmental Scientist	Northern California	DWR Northern District Office	yes	no
Bowlin, David	Marina Manager	Sacramento-San Joaquin Delta	Holland Riverside Marina	yes	no
Braitos, Tony	Owner	Clear Lake	Braitos Buckingham Marina	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Bridges, Brent	Biologist	Sacramento-San Joaquin Delta	USBR Tracy Fish Collection Facility	yes	yes
Brown, Ramona	Manager	Shasta Lake Visitor Information Center	USFS Shasta-Trinity NRA	yes	yes
Burmingham, Mike	Manager	Lake McClure	Merced Irrigation District	yes	no
Burt, Donna	Interpretive Office	New Hogan Reservoir	USACE-New Hogan Lake	yes	yes
Cantwell, Chris	Marina Manager	Camanche Reservoir	Camanche Recreation Company	yes	no
Carlton, Joanne	Resource Ecologist	San Luis Reservoir	CA State Parks & Recreation-Four Rivers District	yes	yes
Chris	Marina Cashier	Lake Almanor	Plumas Pines Resort	yes	no
Christner, Deana	Assistant General Manager	Trinity Lake	Trinity Lake Resorts	yes	no
Chuck	Manager	Lake Berryessa	Lake Berryessa Marina Resort	yes	no
Cleary, Patty	Recreation Specialist	Calaveras Ranger District	USFS Stanislaus NF - Calaveras Ranger District	yes	no
Coombe, Peter	Environmental Scientist	Northern California	DWR Northern District	yes	no
Cottini, Kristy	District Ranger	Shasta Lake, Trinity Lake	USFS Shasta-Trinity NRA	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Cox, Dee	staff	San Luis Reservoir	CA State Parks & Recreation - Four Rivers District	yes	yes
DePrey, Paul	Chief of Resource Management	Whiskeytown Reservoir	Whiskeytown National Recreation Area	yes	yes
DeStaso, Jim		Northern California	USBR Mid-Pacific Region	yes	no
Doug	staff	Shasta Lake	Lakeview Resort	yes	no
Elliot, Woody	Resource Ecology	Lake Oroville	CA State Parks & Recreation	yes	no
Fahsholtz, Shelley	Marina Manager	Shasta Lake	Digger Bay Marina	yes	no
Frank & Nate	Owner & Supervisor/Marina Manager	Lake Oroville	Bidwell Canyon Marina	yes	no
Frazer, Dave	Assistant Resources Ecologist	New Bullards Bar Reservoir	USFS Downieville Ranger Station	yes	no
Fry, Donna	Instructor	not applicable	Trillium Lakelands DSB	yes	no
Garcia, Dave	Park Ranger	Lake Oroville	CA State Parks & Recreation-Oroville	yes	no
Gary	Harbor Master	Sacramento-San Joaquin Delta	Bridgehead Marina	yes	no
Gibson, Jennifer	Assistant Resource Ecologist	Whiskeytown Reservoir	Whiskeytown National Recreation Area	yes	no
Gray, Gary	Marina Manager	Lake Del Valle	Urban Parks Concessionaires, INC., Del Valle Park	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Grigsby, Mary Ellen		Trinity Lake	USFS Weaverville Ranger District	yes	yes
Grimes, Terry	Marina Manager	Sacramento-San Joaquin Delta	Herman and Helen's Marina and Resort	yes	no
Hammond, Rob	General Manager	Shasta Lake	Lakeview Resort	yes	no
Harral, Sheri	Public Affairs Specialist	Shasta Dam Visitors Center	USBR Mid-Pacific Reg	yes	yes
Harrison, Wayne	Senior Research Ecologist	Millerton Lake, San Luis Reservoir	CA State Parks & Recreation-Four Rivers District	yes	no
Harter, Scott	City Engineer	Clear Lake	City of Lakeport	yes	yes
Haskett, George	Resource Ranger	New Hogan Reservoir	USACE-New Hogan Lake	yes	no
Heaton, Patty	Owner	Sacramento-San Joaquin Delta	Eddos Harbor	yes	no
Heinesen, Lars	Owner	Sacramento-San Joaquin Delta	Holland Riverside Marina	yes	no
Henderson, Dewitt	Owner	Bucks Lake	Bucks Lake Marina	yes	no
Hess, Lloyd		Sacramento-San Joaquin Delta	USBR Tracy Fish Collection Facility	yes	no
Hommer, Ken	Marina Manager	Clear Lake	Konocti Harbor Resort	yes	no
Hopkins, Tina	Aquatic Biologist	Bucks Lake, Lake Davis, Frenchman Lake	USFS Plumas NF - Mt Hough Ranger Station	yes	no
Howe, Rich	General Manager	Shasta Lake	Sugarloaf Resort	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Hughes, Jim	Marina Manager	Millerton Lake	Millerton Lake Marina	yes	no
Johnson, Duane	Resource Manager	New Hogan Reservoir	USACE-New Hogan Lake	yes	no
Keen, Mike	Marina Manager	Lake Berryessa	Spanish Flat Resort	yes	no
Kelly, Kevin	Operations Manager	Shasta Lake	Holiday Harbor	yes	no
Kramer, Bobbi	General Manager	Lake McClure	Barrett Cove Park	yes	no
Latronica, Bill	Superindent	Lake McClure	Merced Irrigation District	yes	no
Leaman, Roberta	Harbor Master	Sacramento-San Joaquin Delta	Holland Riverside Marina	yes	no
Lemas, Jim	Water Plant & Sewer	San Luis Reservoir	CA State Parks & Recreation-Four Rivers District	yes	no
Long, Brad	Supervisor	Black Butte Reservoir	USACE	yes	no
Marlin, Darrel	Owner-Manager	Trinity Lake	Trinity Alps Marina	yes	no
Marlin, Marilyn	Owner-Manager	Trinity Lake	Trinity Alps Marina	yes	no
Marlin, Willy	Manager	Lake Del Valle	Del Valle Park Company	yes	no
Martin, Rosemary	Special Services	Lake Oroville - Kelly Ridge Visitors Center	DWR Oroville Field Division	yes	yes
McCleland, Eva	Guide	San Luis Reservoir	DWR	yes	yes
McFarland, Melanie	Aquatic Biologist	Susanville	USFS Lassen NF - Lake Almanor Ranger Station	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Miller, Dennis	Park Ranger	Lake McClure	Merced Irrigation District	yes	yes
Miller, Michelle	Supervisor	Lake Del Valle	East Bay Regional Parks District	yes	no
Mockridge, Larry	Houseboat/Small Boat Manager	Shasta Lake	Digger Bay Marina	yes	no
Moranton, Marcel	Ranger Supervisor	Pardee Reservoir	EBMUD	yes	no
Morgan, Jennifer	Interpretor	San Luis Reservoir	CA State Parks & Recreation- Four Rivers District	yes	yes
Munro, Dave	Owner/Operator	Englebright Reservoir	Skippers Cove Marina	yes	no
Newell, Heather	Special Use Permit Admin./Public Info.	New Bullards Bar Reservoir	USFS Downieville Ranger Station	yes	yes
Nixon, Val Meyer	Ranger	Clear Lake	CA St Parks and Rec - Clear Lake State Park	yes	no
Nowland, Jeff	General Manager	Lake Del Valle	Urban Parks Concessionaires, INC., Del Valle Park	yes	no
Oliver, Shawn	Natural Resource Planner	Folsom Lake/Lake Natoma	USBR Folsom Dam Office	yes	yes
Olivera, Al	Park Supervisor IV	Lake Del Valle	East Bay Regional Parks District	yes	no
Orland Unit Water Users' Association		Stonyford Reservoir, East Park Reservoir	Orland Unit Water Users' Association	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Pam	staff	Shasta Lake	Lakeview Resort	yes	no
Peckinpah, Marla	Special Uses Team	Trinity Lake	USFS Weaverville Ranger District	yes	yes
Peoples, Precious	Natural Resource Specialist	Lake Berryessa	USBR Lake Berryessa Field Office	yes	yes
Pool, Lance	Resource Manager/Park Ranger	Black Butte Reservoir	USACE	yes	no
Pool, Walt	Marina Manager	Lake Don Pedro	Lake Don Pedro Marina	yes	no
Reha, Mike	General Manager	Shasta Lake	Jones Valley Resort/ Shasta Lake Resort	yes	no
Renyer, Sharon	Manager	Lake Berryessa	Spanish Flat Resort	yes	no
Renyer, Vince	Manager	Lake Berryessa	Spanish Flat Resort	yes	no
Roberson, Harold	Water Treatment/Distribution Supervisor	Pardee Reservoir	EBMUD	yes	no
Roby, Ken	Aquatic Biologist	Lake Almanor	USFS Lassen NF - Lake Almanor Ranger Station	yes	yes
Rollins, Bob	General Manager	Shasta Lake	Bridge Bay Resort	yes	no
Rollins, Karen	Assistant Houseboat Manager	Shasta Lake	Bridge Bay Resort	yes	no
Rose, Ralph	Marina Manager	Pardee Reservoir	Lake Pardee Marina, Inc.	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Russel, Carol	Director	Lake Don Pedro	Don Pedro Recreation Agency	yes	no
Salles, Lori		Turtle Bay Exploration Park, Redding, CA	Turtle Bay Exploration Park	yes	yes
Sallie	Manager	Lake Berryessa	Lake Berryessa Marina Resort	yes	no
Saltel, Cindy	General Manager	Bucks Lake	Bucks Lakeshore Resort	yes	no
Samson, Teresa	staff	Shasta Lake	Bridge Bay Resort	yes	no
Scherf, Norm	Moorage Manager	Shasta Lake	Bridge Bay Marina	yes	yes
See, Eric	Environment al Scientist	Lake Oroville	DWR Oroville Field Division	yes	no
Shaw, Ginger	Special Uses Team	Trinity Lake	USFS Weaverville Ranger District	yes	yes
Simkins, Skip	Clear Lake Lands Coordinator	Clear Lake	Clear Lake Public Works	yes	yes
Sivertsen, Skip	US Army Corp of Engineers	Englebright Reservoir	USACE	yes	yes
Stephanie	staff	Trinity Lake	Trinity Lake Resort	yes	no
Vargas, Julio		not applicable	New England Aquarium	yes	no
Vreeland, Karen	Office Assistant	Millerton Lake	CA State Parks & Recreation-Four Rivers District	yes	yes

Name (Last, First)	Title	Waterbody/ Location	Organization	Information Recipient	Information Disseminator
Wagoner, Bill	staff	Lake Berryessa	Lake Berryessa Marina Resort	yes	no
Watkins, Paul	District Ranger	Camanche Reservoir	EBMUD	yes	no
Weatherbee, Russ	Wildlife Biologist	Whiskeytown Reservoir	Whiskeytown National Recreation Area	yes	no
Whitaker, Karen	Tourism Development Manager	California Welcome Center, Anderson, CA	Shasta Cascade Wonderland Association	yes	no
Wierman, Tracy	Director of Education	Turtle Bay Exploration Park, Redding, CA	Turtle Bay Exploration Park	yes	no
Williams, Larry	General Manager	Lake Oroville	Bidwell Marina and Boat Shop	yes	no
Williams, Richard	Marina Manager	Sacramento-San Joaquin Delta	River Point Landing	yes	no
Wu, Brandon	Biologist	Sacramento-San Joaquin Delta	USBR Tracy Fish Collection Facility	yes	no
Young, Bart	Manager	Collins Lake	Private	yes	no
Young, Kari	Park Ranger	New Hogan Reservoir	USACE-New Hogan Lake	yes	no
Zustak, Joe	Aquatic Biologist	Shasta Lake	USFS Shasta -Trinity NF, Shasta Lake Unit	yes	no

Appendix J

List of Individuals who Received Training for Zebra Mussel Early-Detection Monitoring and Conducted Monitoring

Name (Last, First)	Title	Waterbody/ Location	Organization	Received Training	Volunteer Monitor
Ayres, Elizabeth	Natural Resource Specialist	Folsom Lake/ Lake Natoma	USBR Folsom Dam Office	yes	yes
Bartz, Joan	Owner	Clear Lake	Holiday Harbor Marina	yes	yes
Beard, Denali	Assistant Resource Ecologist	Sacramento-San Joaquin Delta	CA State Parks, Gold Fields District	yes	yes
Boles, Jerry	Senior Environmental Scientist		DWR Northern District Office	yes	no
Bowlin, David	Marina Manager	Sacramento-San Joaquin Delta	Holland Riverside Marina	yes	yes
Braitos, Tony	Owner	Clear Lake	Braitos Buckingham Marina	yes	yes
Bridges, Brent	Biologist	Sacramento-San Joaquin Delta	USBR Tracy Fish Collection Facility	yes	no
Burt, Donna	Interpretive Office	New Hogan Reservoir	USACE New Hogan Lake	yes	no
Cantwell, Chris	Marina Manager	Camanche Reservoir	Camanche Recreation Company	yes	yes
Chris	Marina Cashier	Lake Almanor	Plumas Pines Resort	yes	no
Christner, Deana	Assistant General Manager	Trinity Lake	Trinity Lake Resorts	yes	yes
Chuck	Manager	Lake Berryessa	Lake Berryessa Marina Resort	yes	yes
Coombe, Peter	Environmental Scientist		DWR Northern District	yes	yes
DePrey, Paul	Chief of Resource Management	Whiskeytown Reservoir	Whiskeytown National Recreation Area	yes	no
Doug	staff	Shasta Lake	Lakeview Resort	yes	yes
Fahsholtz, Shelley	Marina Manager	Shasta Lake	Digger Bay Marina	yes	yes
Gibson, Jennifer	Assistant Resource Ecologist	Whiskeytown Reservoir	Whiskeytown National Recreation Area	yes	no
Grigsby, Mary Ellen		Trinity Lake	USFS Weaverville Ranger District	yes	no

Name (Last, First)	Title	Waterbody/ Location	Organization	Received Training	Volunteer Monitor
Hammond, Rob	General Manager	Shasta Lake	Lakeview Resort	yes	yes
Harter, Scott	City Engineer	Clear Lake	City of Lakeport	yes	yes
Hopkins, Tina	Aquatic Biologist	Bucks Lake, Lake Davis, Frenchman Lake	USFS Plumas NF, Mt Hough Ranger Station	yes	no
Howe, Rich	General Manager	Shasta Lake	Sugarloaf Resort	yes	yes
Hughes, Jim	Marina Manager	Millerton Lake	Millerton Lake Marina	yes	yes
Kelly, Kevin	Operations Manager	Shasta Lake	Holiday Harbor	yes	yes
Long, Brad	Supervisor	Black Butte Reservoir	USACE	yes	yes
Marlin, Darrel	Owner-Manager	Trinity Lake	Trinity Alps Marina	yes	yes
Marlin, Marilyn	Owner-Manager	Trinity Lake	Trinity Alps Marina	yes	yes
Miller, Dennis	Park Ranger	Lake McClure	Merced Irrigation District	yes	yes
Mockridge, Larry	Houseboat/Small Boat Manager	Shasta Lake	Digger Bay Marina	yes	yes
Moranton, Marcel	Ranger Supervisor	Pardee Reservoir	EBMUD	yes	yes
Newell, Heather	Special Use Permit Admin./Public Info.	New Bullards Bar Reservoir	USFS Downieville Ranger Station	yes	no
Oliver, Shawn	Natural Resource Planner	Folsom Lake/Lake Natoma	USBR Folsom Lake Dam Office	yes	no
Pam	staff	Shasta Lake	Lakeview Resort	yes	yes
Peckinpah, Marla	Special Uses Team	Trinity Lake	USFS Weaverville Ranger District	yes	no
Pool, Lance	Resource Manager/Park Ranger	Black Butte Reservoir	USACE	yes	yes
Pool, Walt	Marina Manager	Lake Don Pedro	Lake Don Pedro Marina	yes	yes
Reha, Mike	General Manager	Shasta Lake	Jones Valley Resort/Shasta Lake Resort	yes	yes
Renyer, Sharon	Manager	Lake Berryessa	Spanish Flat Resort	yes	yes

Name (Last, First)	Title	Waterbody/ Location	Organization	Received Training	Volunteer Monitor
Renyer, Vince	Manager	Lake Berryessa	Spanish Flat Resort	yes	yes
Roby, Ken	Aquatic Biologist	Lake Almanor	USFS Lassen NF, Lake Almanor Ranger Station	yes	no
Rollins, Karen	Assistant Houseboat Manager	Shasta Lake	Bridge Bay Resort	yes	yes
Rose, Ralph	Marina Manager	Pardee Reservoir	Lake Pardee Marina, Inc.	yes	no
Sallie	Manager	Lake Berryessa	Lake Berryessa Marina Resort	yes	yes
Samson, Teresa	staff	Shasta Lake	Bridge Bay Resort	yes	yes
See, Eric	Environmental Scientist	Lake Oroville	DWR Oroville Field Division	yes	yes
Shaw, Ginger	Special Uses Team	Trinity Lake	USFS Weaverville Ranger District	yes	no
Simkins, Skip	Clear Lake Lands Coordinator	Clear Lake	Clear Lake Public Works	yes	no
Sivertsen, Skip	US Army Corp of Engineers	Englebright Reservoir	USACE	yes	yes
Stephanie	staff	Trinity Lake	Trinity Lake Resort	yes	yes
Wagoner, Bill	staff	Lake Berryessa	Lake Berryessa Marina Resort	yes	yes
Weatherbee, Russ	Wildlife Biologist	Whiskeytown Reservoir	Whiskeytown National Recreation Area	yes	yes
Wu, Brandon	Biologist	Sacramento-San Joaquin Delta	USBR Tracy Fish Collection Facility	yes	yes
Young, Bart	Manager	Collins Lake	Private	yes	yes
Young, Kari	Park Ranger	New Hogan Reservoir	USACE New Hogan Lake	yes	yes
Zustak, Joe	Aquatic Biologist	Shasta Lake	USFS Shasta Trinity NF, Shasta Lake Unit	yes	no

Appendix K

Zebra Mussel Field Datasheets

Zebra Mussel Waterbody Information

Watershed Region____

Waterbody____

Type of Waterbody *Lake* *Reservoir* *River* *Delta* *Canal* *Aqueduct*

Activities *Boating* *Fishing* *DayUse* *Camping* *DrinkingWater* *Other* __________

Fishing Tournaments *None / Local / State / National*

Out of State Boaters *None / Few / Many* States ____________________

Camping Info # Sites ______ Months Open __________ Ranger Station Present Y / N

Ranger Station Info Contact____

Address____

Phone____

Kiosk Present Y / N How Many_____ Location(s)______________________

____

Interpretive Center Y / N Location__________________________________

Boat Ramp Y / N Location__________________________________

How Many________________ Fee Y / N Attendant / Self pay

Physical Structures & Authorities

	Ownership		Ownership
Dam	________________	*Hydroelect*	________________
Canal/Flume	________________	*Spillway*	________________
Land	________________	*Water*	________________
BoatLaunch	________________	*Marina*	________________
Campground	________________	*DayUseArea*	________________

Water Quality Data Temp Secchi DO EC Ca+ pH $H_2$0Velocity $CaCO_3$

Who Collects____

Where Available______________________________________

Corbicula Present Y / N / UNK

Native Clams Present Y / N / UNK Species ____________________________

Comments ____

____

Zebra Mussel Contact Information

Date __ __ / __ __ / __ __ **New / Add'l Info** **Photo #s** ________

Waterbody ______________________________ **WatershedRegion** ____________________

Location ____

Contact Description *BoatLaunch Marina Campground DayUse Dam Spillway Weir Hatchery Pier H_20QualityStation VisitorsCenter Concessionaire Gov'tAgency Other*

Way Point N ___ ___ ___ ___ ___ ___ . ___ W ___ ___ ___ ___ ___ ___ ___ . ___

Organization____

Area of Interest *Boating H_20Conveyance Fish Pollution Recreation Education Research Waterfowl Resident*

Available Resources *Money Boats Personnel Publications Kiosk DisplayArea PropertyAccess Website Meetings*

Site Authority? Y / N **Access Permission** *Granted NotifyInAdvance NotifyDayOf N/A*

Contact First ____________________ Last ____________________

Title________________________________

First ____________________ Last ____________________

Title________________________________

Address Line1______________________________________

Line2______________________________________

Street______________________________________

City________________________ State______ Zip__________

Phone (___ ___ ___) ___ ___ ___ - ___ ___ ___ ___ **Fax** (___ ___ ___) ___ ___ ___ - ___ ___ ___ ___

Email ____________________________ **Website** ____________________________

Role *VolunteerMonitor InfoDisseminator PropertyAccess SamplingSite InfoRecipient NoInterest*

Referred By Name ______________________ Org ______________________________

Materials Provided

	Zap the Zebra	Watch Cards	Wanted Poster	Clean Your Boat	Inland Managers	ZM in N.Amer	ZM in Calif	Info Packet	Volunteer Packet
Amt									
Date									

Comments ____

____

____

____

Zebra Mussel Site Information

Date __ __ / __ __ / __ __ **New / Add'l Info** **Photo #s** ________

Waterbody ______________________________ **Watershed Region** ______________________

Location ____

Site Description *BoatLaunch Marina Campground DayUse Dam Spillway Weir Hatchery Pier H_20QualityStation Other*

Way Point N __ __ __ __ __ __ . __ W __ __ __ __ __ __ __ . __

Sample #: _______________ **Landmark:** ____

Access Contact

Organization____

First ________________________ Last __________________________

Title____

Address Street____

City:____________________________ State:______ Zip__________

Phone (__ __ __) __ __ __ - __ __ __ __ **Fax** (__ __ __) __ __ __ - __ __ __ __ **Email** ________________________

Site Access Permission *Granted NotifyInAdvance NotifyDayOf N/A* *# of Days Required For Notification* _____

Volunteer Contact

Organization____

First ________________________ Last __________________________

Title____

Address Street____

City:____________________________ State:______ Zip__________

Phone (__ __ __) __ __ __ - __ __ __ __ **Fax** (__ __ __) __ __ __ - __ __ __ __ **Email** _______________________

Start Date __ __ / __ __ / __ __ **End Date** __ __ / __ __ / __ __

	Tubes	**Mesh**	**Plate**
Visual	________ - ________ start end	________ - ________ start end	________ - ________ start end
Air Dry	________ - ________ start end	________ - ________ start end	________ - ________ start end
Alcohol	________ - ________ start end	________ - ________ start end	________ - ________ start end

Retrieval *Mail / Pick-up / Other* ____

Retrieved by: ______________________________ **Retrieval Frequency**:____________________

Comments on Back

Appendix L

California Zebra Mussel Watch Program (CZMWP) staff information

Cindy Messer
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Division of Environmental Services
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Appendix M

California Zebra Mussel Action Team (CAZMAT)
Proposed Member Agencies/Organizations and Team Members

Federal Agencies

U.S. Fish and Wildlife Service (USFWS)
U.S. Bureau of Reclamation (USBR)
U.S. Army Corp of Engineers (USACE)
National Marine Fisheries Service (NMFS)
National Oceanic and Atmospheric Administration (NOAA)
U.S. Department of Food and Agriculture (USDA)

State Agencies

CA Department of Fish and Game (CDFG)
CA Department of Water Resources (DWR)
CA Environmental Protection Agency (CAL EPA)
CA State Lands Commission (SLC)
State Water Resources Control Board (SWRCB)
CA Department of Food and Agriculture (CDFA)
CA Department of Pesticide Regulation (CDPR)
CA Bay Delta Authority (CALFED) via

Regional and Local Agencies

Regional Water Quality Control Boards (various)
Water Agencies (various)
City and County agencies (various)

Special Interest Groups

Water treatment plants
Power generation plants
Water companies (Clear Lake)
Marina owners
Recreational boating/fishing organizations
Agricultural interests (e.g. irrigation issues)
Recreational water body related business owners (e.g. lodging, dining, retail)
Watershed groups

Private Citizens

Homeowners
Recreational enthusiasts

Appendix N

California Zebra Mussel Action Teams

Incident Coordinators
(TBD, but suggest CDFG be one agency involved at this level)

Incident Action Team members

1) **Susan Ellis**
Invasive Species Coordinator
California Department of Fish and Game
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2) **Cindy Messer**
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4) **Jeffrey J. Herod**
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5) **Dr. Rosser W. Garrison**
Associate Insect Biosystematist
Plan Pest Diagnostics
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Phone: (916) 262-1167
Fax: (916) 262-1190
Email: rgarrison@cdfa.ca.gov

Information Dissemination Team members

To Be Determined

Stakeholder Group members

Federal Representatives

1) **David Bergendorf**
Aquatic Nuisance Species Program Assistant
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US Fish and Wildlife
4001 N. Wilson Way
Stockton, CA 95205

2) **Lia McLaughlin**
Non-native Invasive Species Program
Watershed Coordinator
US Fish and Wildlife Service
4001 N Wilson Way
Stockton, CA 95205
Phone (209) 946-6400 x 337
Fax (209) 946-6355

State Agency Representatives

1) **Nate Dechoretz**
California Department of Food and Agriculture
1220 N Street, Room A-357
Sacramento CA 95814
Phone: (916) 654-0768
Fax: (916) 653-2403
Email: ndechore@cdfa.ca.gov

Local Agency Representatives

To Be Determined

Special Interest Groups

1) **100th Meridian Initiative**
(or appropriate individuals representing this organization)
www.100thmeridian.org

2) **Western Regional Panel**
Bettina Proctor
U.S. Fish and Wildlife Service - Region 6
P.O. Box 25486
Denver Federal Center
Denver, CO 80225
(303) 236-7862 x260
(303) 236-8163 FAX
answest@fws.gov

General Public & Media

To Be Determined

Appendix O

Description of CAZMAT Teams and Sub-groups

Main Group/Team	Subgroups/teams	Function	No. Core Members	Role
Incident Coordinators (IC) (incl. Assistant Incident Coordinator)		Lead group, coordinates/runs all large meetings, approves all rapid response activites via Incident Action Team, works directly with Stakeholder group, works directly with all agency management and government officials.	1 - 3 individuals from appropriate agencies	Initiate and implement rapid response actions
Incident Action Team (IAT)		Implements all rapid response activities, conducts all post-introduction, post-treatment acitivites		
	Technical Expertise	Zebra mussel expertise. Advise all groups on zebra mussel biology, monitoring,control/eradication methods. Conduct initial site inspection, confirm zm identification, coordinate/conduct monitoring, control/eradication methods.	3 individuals from academic, agency, private organizations.	Mussel biology, impacts, control
	Operations	Site expertise (including habitat type, structures present, recreation activities, businesses/homes present, resource ownership). Work with Technical Expertise and Logistics sub-teams and appropriate Stakeholder group members to conduct site survey,monitoring, post-introduction treatment.	1-2 individuals (depending on number, size, use of sites)	Site specific info, operations
	Health & Safety	Part of Operations Team - coordinates with various sub-teams during site survey, monitoring and post-introduction treatment activities. Addresses safety items/procures safety equipment.	1 individual w/ appropriate expertise.	Field safety
	Logistics	Determines, requests, receives and coordinates with appropriate Stakeholder sub-groups for resources, staff and supplies needed for site survey, monitoring, and post-introduction treatment activites. Works with Procurement &Facilities, Funding, Operations, Technical Expertise Teams to conduct these activies. Coordinates transportation and communication systems.	1-2 individuals (depending on number, size, use of sites)	Facilitation of monitoring, treatment activities. Organizing resources and staff
	Procurement & Facilities	Part of Logistics Team - orders all supplies needed, addresses lodging and per diem requests, completes rental agreements for equipment, assists with transportation and communication activites. Works with Funding sub-team on budget items.	1 individual w/ appropriate expertise.	Purchasing & securing resources
	Detection& Enforcement	Conducts boat inspections at water bodies or at CA border. Enforces boat cleaning at non-infested waterbodies, prevents launching of infested boats. Coordinates with Technical Expertise, Operations and Logistics Teams during site survey, monitoring and post-treatment activites.	1-2 ind/site Will vary depending on site affected, number of sites	Legal enforcement of detection, prevention activities
	Regulatory	For all rapid response-related activites; Secures required permits and licenses. Determines and coordinates required training. Determines and disseminates information regarding laws, regulations that must be heeded.	1-2 individuals w/ experience in this area. Help of various agency staff in permitting agencies.	Permits and regulations
	Funding	Determines necessary funding needed for all rapid response-related activites. Coordinates with appropriate Stakeholder Group members to acquire funding, establish contracts to receive/disburse funding, establishes necessary MOUs, develops and maintains incident budget for all activites.	1-2 individuals working closely w/ IC and Stake-holder group. Help from appropriate staff in funding agencies.	Securing funding, maintaining budget
Information Dissemination Team				
	Information Dissemination	Collects/disseminates information on all CAZMAT activites within CAZMAT, to media, to government officials. Prepares written reports and articles about CAZMAT activites. Presents information at conferences, meetings, workshops.	1-2 individuals	Experience working with media, government officials and law-makers, writing technical reports
	Public Outreach and Education	Conducts all public outreach/education activities. Prepares and distributes all educational literature. Coordinates with Information Dissemination Team to present information to the public/media during meetings. Presents information about CAZMAT as requested by agency, academic, public, and special interest groups Works with Detection & Enforcement Team to prevent spread of zebra mussels.	1-2 individuals	Experience working with general public, developing outreach materials
Stakeholders Group				
	Federal Agency Reps. State Agency Reps. Local Agency Reps. Special Interest Groups General Public and Media	Participate in CAZMAT as core group/team members. Provide funding, resources, staff for CAZMAT activites. Assist with permitting and licensing activites. Participate in CAZMAT meetings to discuss post-introduction monitoring and treatment options, agency/public concerns. Discuss information dissemination and reporting.	1 individual from appropriate agency/group to serve as core members. No limit on number of individuls to receive CAZMAT information and to attend public meetings.	Provide funding, staff, resources. Provide agency/public comments, opinions ideas.

Appendix P

Zebra Mussel Science Panel Members

Dr. Robert "Bob" McMahon
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The University of Texas at Arlington
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Expertise: zebra mussel biology

Dr. Sandra Nierzwicki-Bauer
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Professor, Biology
Rensselaer Polytechnic Institute
Bolton Landing, NY 12814
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Expertise: zebra mussel biology and experimental control

Dr. Rosser W. Garrison
Associate Insect Biosystematist
Plan Pest Diagnostics
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Phone: (916) 262-1167
Fax: (916) 262-1190
Email: rgarrison@cdfa.ca.gov

Expertise: agricultural pest control

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California Department of Fish and Game
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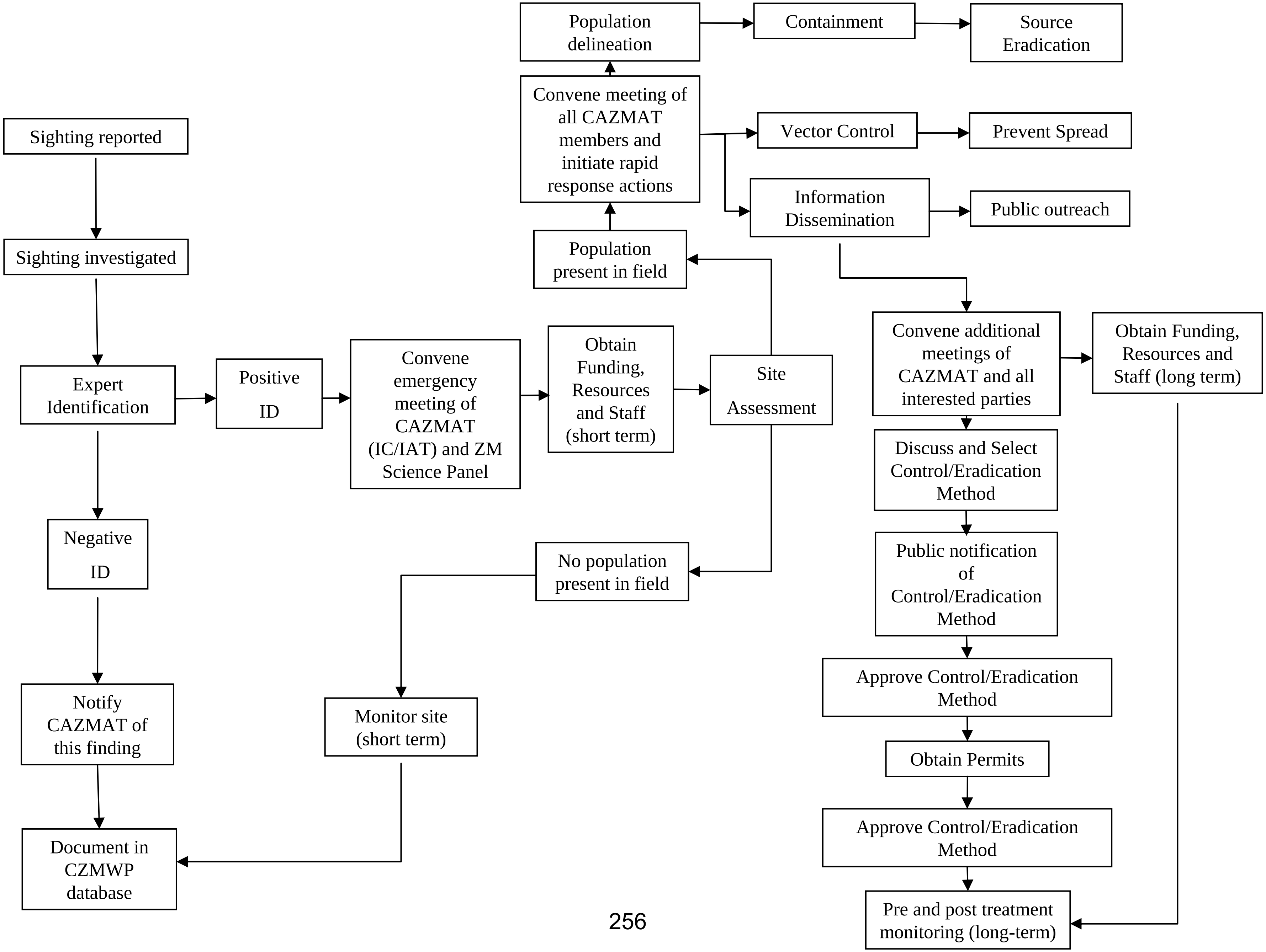
Phone: (916) 653-8983
Fax: (916) 653-8256
Email: sellis@dfg.ca.gov

Expertise: CA INS issues and regulations

Need additional members with the following expertise:
- Engineer, knowledge of SWP/CVP, CA water issues, water quality
- California freshwater mussels
- Control/eradication process (e.g. Northern pike experience)

Appendix Q.

Flow Chart of Zebra Mussel Rapid Response Plan


Sighting reported
Sighting investigated
Expert Identification
Positive ID
Convene emergency meeting of CAZMAT (IC/IAT) and ZM Science Panel
Obtain Funding, Resources and Staff (short term)
Site Assessment
Population present in field
Convene meeting of all CAZMAT members and initiate rapid response actions
Population delineation
Containment
Source Eradication
Vector Control
Prevent Spread
Information Dissemination
Public outreach
Convene additional meetings of CAZMAT and all interested parties
Obtain Funding, Resources and Staff (long term)
Discuss and Select Control/Eradication Method
Public notification of Control/Eradication Method
Approve Control/Eradication Method
Obtain Permits
Approve Control/Eradication Method
Pre and post treatment monitoring (long-term)
No population present in field
Monitor site (short term)
Negative ID
Notify CAZMAT of this finding
Document in CZMWP database

Appendix R

Summary of Zebra Mussel Eradication Options

Thermal Shock

Hot water treatment can kill zebra mussels. Temperatures of 37°C and above are lethal to zebra mussels. Depending upon acclimation temperature, zebra mussels will die in about 1 hour. At winter acclimation temperatures (5 to 10°C), temperatures of 33°C and above will kill zebra mussels within 13 hours. For further information, see Table 1 in McMahon et al. (1994).

Desiccation

Instantaneous mortality occurs at 36°C. Temperatures over 32°C are lethal within 5 hours. At temperature below 30°C, time to mortality is dependent upon relative humidity.

Temperature is positively related and humidity is negatively related to adult zebra mussel mortality. As humidity increases and temperature decreases, survivorship increases (Table 1). Aerial exposure of zebra mussels during summer months, when temperatures exceed 25°C, will result in 100% mortality in 2.1 days. During winter months, 100% mortality will take longer, depending upon the relatively humidity.

Desiccation is a viable option for eradicating zebra mussels from areas that can be dewatered for several days. Alternatively, desiccation can also act as a population control method in areas that can not be completely dewatered. For example, reservoir levels can be lowered (at least 30 vertical feet) to expose zebra mussel inhabiting shallow water. The majority of the zebra mussel population inhabits shallow water within 2 to 7 m below the surface, with moderate to low densities up to 50m. Colonization is dependent upon water temperature, oxygen content, and food availability. They tend to colonize above the thermocline.

Table 1. Number of days to 100% mortality of adult zebra mussels aerially exposed to different levels of relative humidity and air temperature. *Research conducted by Dr. RF McMahon and TA Ussery (in Payne, 1992, USACE Technical Note ZMR-2-10).*

	Days to 100 % Mortality at Air Temperature, °C		
Relative Humidity, %	**5**	**15**	**25**
95	26.6	11.7	5.2
50	16.9	7.5	3.3
5	10.8	4.8	2.1

Freezing

Adult zebra mussels die when aerially exposed to freezing temperatures for varying lengths of time. Populations can be controlled by winter-time dewatering and exposing zebra mussels to freezing air temperatures. Zebra mussels die in 2 days at 0°C and at minus 1.5°C, in 5 to 7 hours at minus 3°C, and in under 2 hours at minus 10°C. Duration to mortality is less for single mussels than for clustered mussels.

Research conducted by Dr. RF McMahon and TA Ussery (in Payne, 1992, USACE Technical Note ZMR-2-09).

Oxygen Starvation

Oxygen is removed from the water by cycling it through oxygen-starving pumps. The developer claims the equipment can cycle 200 million gallons of water. This technology was developed by Wilson J. Browning of Amark Corp, Norfolk County, VA. Another method of removing oxygen is to add oxygen scavenging chemicals, such as sodium-meta-bisulfite and hydrogen sulfide gas (USACE-ZMIS). Zebra mussels are able to tolerate oxygen deprivation for up to 2 weeks, provided ambient temperatures are low enough (USACE-ZMIS).

Benthic Mats

Researchers from the Rensselaer Polytechnic Institute in New York are investigating the use of benthic mats that would cover the sediment and zebra mussels, and smother the mussels. Research is planned to occur in Lake George, NY.

Predation

The relatively soft shells of zebra mussels and their exposure (on substrates as opposed to buried in sediment) make them vulnerable to predation. Possible predators of adult mussels are common carp, catfish, bullhead, sucker, sunfish, sturgeon, crayfish, and muskrats. A possible predator of veligers is the American shad. However, there is no evidence of predation control in the Great Lakes, Ohio River, and Poland. There is some evidence of population reduction in the Hudson River. Despite the lack of clear evidence of population control through predation, it is recommended that harvest of predatory species in infested waterbodies be stopped.

Chemical Treatment

The most susceptible life stages to chemical treatment are post-spawned mussels that are in a low energy state, and veligers and pediveligers that have undeveloped shells. There are 3 general categories of chemicals used to treat zebra mussel infestations: metallic salts, oxidizing biocides, and nonoxidizing biocides. Application rates and duration data for these compounds come from laboratory studies, power plants, and water treatment plants.

Metallic salts, electrolytically dissolved metallic ions, are effective on adult mussels because of the incomplete sealing of their shells. The required exposure time for most metallic ions ranges from 5 to about 48 hours.

Oxidizing chemicals have been used by the water treatment industry for disinfection since the late 1800s, and their effect on the environment is understood and documented (Claudi 1995). Zebra mussels can recognize oxidizing chemicals, such as chlorine, as a toxin. Oxidizing chemicals are very irritating. They work by oxidizing the gill lamellae and other parts, eventually causing death. In response to the irritation, zebra mussels expel the offending water and close their valves for several days. Periodically, they reopen their valves to “test” the water. Depending upon water temperature, respiration rate, and stored nutrient reserves, zebra mussels can remain closed and withstand exposure for many days before reopening their valves to resume respiration and feeding. Therefore, required exposure time for oxidizing biocides is usually 1 to 3 weeks.

Zebra mussels do not detect most non-oxidizing chemicals and continue to filter water. The chemical is drawn into the mussel’s body and attacks the cell walls. The cells lose the ability to maintain their chemical balance, and the mussel dies. Because the mussels continue to filter, exposing themselves to the chemical, treatment with non-oxidizing chemicals can be accomplished in hours as opposed to weeks.

The most commonly used non-oxidizing compounds are proprietary molluscicides (e.g. Clamtrol, Bulab, Bayluscide). They are applied at high concentrations, and, in most cases, the water must be detoxified after treatment. These compounds are usually deactivated by releasing a slurry of bentonite clay into the water. The cationic or surfactant active ingredients bind onto the clay, becoming inactive. The clay settles out of the water column and becomes part of the bed sediments. The compound is microbially degraded into nontoxic

products. These chemicals are less effective at lower water temperatures, so treatment is recommended during warmer months. The chemicals are usually administered with equipment supplied by the vendors.
Non-oxidizing chemicals were used to control the Asian clam in the southeastern US (Green 1995).

Table 2 contains a summary of various chemical treatment options, including treatment concentration, exposure duration, efficacy, affects on non-target species, environmental effects, and registration status. Additional information on most of these chemicals, such as formula, manufacturer, and application method, is available at http://www.wes.army.mil/el/zebra/zmis/idxlist.htm.

Bacterial Toxin

Experimental research is occurring on a toxin produced by *Pseudomonias fluorescens*, a soil bacterium. The toxin destroys the digestive gland of zebra mussels, but reportedly does not harm fish or native mussels. Currently, it is not economically feasible to produce large amounts of the biotoxin.

Appendix S

Eradication and Control Options for Various Zebra Mussel Waterbody Infestation Scenarios

Population Level / Waterbody	Isolated Population	Widespread Population
Pond, Isolated, non-draining	• Evaluate for natural control (e.g. winter freeze, summer desiccation) • Chemically treat area and buffer zone • quarantine, stop all recreational uses in infested area and buffer zone • mandatory cleaning of departing vessels and equipment	• chemically treat entire waterbody • stop water diversions, if any, and chemically treat diversion infrastructure • mandatory cleaning of all departing vessels and equipment • quarantine, stop all recreational uses
Pond, draining	• chemically treat released water or prevent water release • chemically treat area and buffer zone • monitor for spread within pond and downstream • quarantine, stop all recreational uses in infested area and buffer zone • mandatory cleaning of departing vessels and equipment	• minimize or prevent water release • chemically treat released water • chemically treat diversion infrastructure, if any • monitor for spread downstream • chemically treat entire waterbody • mandatory cleaning of all departing vessels and equipment • quarantine, stop all recreational uses
Small Reservoir	• minimize water releases • chemically treat released water • chemically treat area and buffer zone • monitor for spread within reservoir and downstream • quarantine, stop all recreational uses in infested area and buffer zone • mandatory cleaning of departing vessels and equipment	• evaluate need to reduce reservoir volume through water releases • chemically treat released water • chemically treat diversion infrastructure, if any • monitor for spread downstream • chemically treat entire waterbody • mandatory cleaning of all departing vessels and equipment • quarantine, stop all recreational uses
Large Reservoir	• reduce reservoir volume • chemically treat released water • chemically treat infested area and buffer zone • monitor for spread within reservoir and downstream • quarantine, stop all recreational uses in infested area and buffer zone • mandatory cleaning of departing vessels and equipment	• chemically treat released water • monitor for spread downstream • chemically treat diversion infrastructure, if any • evaluate potential for a water level drawdown to reduce the population • evaluate ability to chemically treat entire waterbody • prevent spread to upstream waterbodies and other watersheds • quarantine, stop all recreational uses • mandatory cleaning of all departing vessels and equipment

Population Level / Waterbody	Isolated Population	Widespread Population
River, Small Volume	• minimize or stop inflow and increase upstream water diversions to reduce stream volume and flow rate • install veliger settlement materials at downstream end of population • create pool conditions at downstream end of population to facilitate veliger settlement (e.g., installation of temporary weir) • treat with molluscicide • detoxify downstream of infested area • monitor for spread downstream • prevent spread to upstream waterbodies and other watersheds • quarantine, stop all recreational uses in infested area and buffer zone • installation of travel barrier and mandatory cleaning station for all vessels traveling upstream via waterway • mandatory cleaning of all departing vessels and equipment	• minimize or stop inflow and increase upstream water diversions to reduce stream volume and flow rate • treat with molluscicide • detoxify downstream of infested area • monitor for spread downstream • prevent spread to upstream waterbodies and other watersheds • quarantine, stop all recreational uses • installation of travel barrier and mandatory cleaning station for all vessels traveling upstream via waterway • mandatory cleaning of all departing vessels and equipment
River, Large Volume	• minimize inflow and increase upstream water diversions to reduce stream volume and flow rate • install veliger settlement materials at downstream end of population • create pool conditions at downstream end of population to facilitate veliger settlement (e.g., installation of temporary weir) • treat with molluscicide • detoxify downstream of infested area • monitor for spread downstream • prevent spread to upstream waterbodies and other watersheds • quarantine, stop all recreational uses in infested area and buffer zone • installation of travel barrier and mandatory cleaning station for all vessels traveling upstream via waterway • mandatory cleaning of all departing vessels and equipment	• prevent spread to upstream waterbodies and other watersheds • quarantine, stop all recreational uses • mandatory cleaning of all departing vessels and equipment • installation of travel barrier and mandatory cleaning station for all vessels traveling upstream via waterway • closure of unattended boat ramps, esp. in zebra mussel-free areas • mandatory inspection/cleaning of all vessels entering zebra mussel-free waterbodies • evaluate ability to chemically treat

Waterbody \ Population Level	Isolated Population	Widespread Population
Delta	• install veliger settlement materials at perimeter of population • divert upstream water to reduce river volume and flow rate (e.g. rock barrier) • create pool conditions at downstream end of population to facilitate veliger settlement (e.g., installation of temporary weir, tidal flow/rock barrier) • treat with molluscicide • detoxify downstream of infested area • monitor for spread • prevent spread to upstream waterbodies and other watersheds • quarantine, stop all recreational uses in infested area and buffer zone • installation of travel barrier and mandatory cleaning station for all vessels traveling upstream via waterway • mandatory cleaning of all departing vessels and equipment	• eradication doubtful • implement population level control measures (e.g. salt water intrusion during spawning season and veliger settlement) • prevent spread to upstream waterbodies, other watersheds, pumping plants, and aqueducts/diversion canals • mandatory cleaning of all departing vessels and equipment • closure of unattended boat ramps, esp. in zebra mussel-free areas • installation of travel barrier and mandatory cleaning station for all vessels traveling upstream via waterway • mandatory inspection/cleaning of all vessels entering zebra mussel-free waterbodies • establish regulations for ships traveling to/from Ports of Stockton, Sacramento, and Pittsburg • evaluate treatment/spread prevention at all points of diversion (e.g., Contra Costa PP, CVP, SWP, Barker Slough PP)
CVP/SWP Aqueduct	• if only one facility impacted, transfer all diversions to other facility • drain and air dry – 1 week high temps, 2 weeks cool temps, treat standing water with potassium ion or bromine OR isolate infested area and buffer zone with temporary barriers, chemically treat with potassium ion or bromine • treat removed water with potassium ion or bromine • monitor for downstream spread • mandatory cleaning of all vessels and equipment • quarantine, stop all recreational uses of aqueduct	• if only one aqueduct impacted, transfer all diversions to other facility; desiccate and chemically treat infested facility and aqueduct • If both facilities/aqueducts impacted: o treat water before transferring to San Luis Reservoir o chemically treat diverted water and diversion infrastructure (SCVWD and Metropolitan Water diversions) o mandatory cleaning of all vessels and equipment departing San Luis and Bethany reservoirs o quarantine, stop all recreational uses of reservoirs, forebay, and aqueducts o desiccate and chemically treat one facility and aqueduct at a time; continue diversions through other facility • retrofit facility(ies) to minimize impacts

Appendix T

Chemical Treatment Options

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
metallic salt		copper ions		5 ppm	24 hours		100% kill					O'Neill. 1996. p.46	
metallic salt		copper sulphate		300 mg/L @ 22.5 C	5 hours		55% kill		can corrode metal pipes			O'Neill. 1996. p.46	
metallic salt		copper sulphate		100 mg/L @ 22.5 C	5 hours		40% kill		can corrode metal pipes			O'Neill. 1996. p.46	
metallic salt		copper sulphate			48 hours		LC50= 2-2.5 mg/L @ 17C; 50% kill at this concentration					Waller et al. 1993	
metallic salt		copper sulphate and sodium hypochlorite		1 to 2 ppm	4 days		black striped mussel					Bax. 1999	Australia, coastal bay
metallic salt		mercury ions		5 ppm	24 hours		57% kill					O'Neill. 1996. p.46	
metallic salt		potassium chloride	KCl		48 hours		LC50 = 150 mg/L; 50% kill at this concentration	2 to 3 times more toxic to zm's than to fish				Waller et al. 1993	
metallic salt		potassium chloride	KCl	>100mg/L			intermediate toxicity;	more toxic to zm's than to rainbow trout and channel catfish					
metallic salt		potassium ion	KH2PO4	160 to 640 ppm	continuous		100% kill	kills native unionid clams at lower concentrations				O'Neill. 1996. p.46	
metallic salt		potassium ion	KCl	50 ppm	48 hours		100% adult kill	kills native unionid clams at lower concentrations					
metallic salt		potassium ion	KOH	>10 ppm			100% veliger kill	kills native unionid clams at lower concentrations				O'Neill. 1996. p.46	
metallic salt		silver ions		5 ppm	24 hours		72% kill					O'Neill. 1996. p.46	

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
nonoxidizing		dimethylbenzyl ammonium chloride and dodeclguanidine hydrochloride		1.95 ppm @ 11C	12 hours	bentonite clay	100% kill (after 48 hours post exposure)					Technical Note ZMR-2-14	
nonoxidizing		dimethylbenzyl ammonium chloride and dodeclguanidine hydrochloride		1.95 ppm @ 14C	14 hours	bentonite clay	100% kill (after 48 hours post exposure)					Technical Note ZMR-2-14	
nonoxidizing		dimethylbenzyl ammonium chloride and dodeclguanidine hydrochloride		1.95 ppm @ 20C	6 hours	bentonite clay	100% kill (after24 hours post exposure)					Technical Note ZMR-2-14	
nonoxidizing		dimethylbenzyl ammonium chloride and dodeclguanidine hydrochloride		1.95 ppm @ 20C	14 hours	bentonite clay	100% kill (after 48 hours post exposure)					Technical Note ZMR-2-14	
nonoxidizing; quaternary ammonium compound (polyquat)	Clamtrol CT-1			LC50 values: preveliger=48 microgram/L, veliger=95-179 microgram/L, plantigrade=8.8 mg/L, adult>13mg temperature @ 17C	24 hours	bentonite clay; strongly absorbed to sediment and rapidly degraded microbially to nontoxic products	LC50<1mg/L; fourth highest highest polyquat kill rate; very effective (even at <1mg/L); more effective on veligers than adults; plantigrades least sensitive	toxic to broadspectrum/ nontargets; more toxic to zm's than to rainbow trout and channel catfish; used as a lampricide; greater selectivity than Bayluscide	Virginia Dept Game and Inland Fisheries determined Clamtrol a viable chemical for quarry treatment	previously registered with EPA; have existing enviro data		Waller et al. 1993; Fisher et al. 1994	lampricide
oxidizing agent		bromine					best when pH<8.0	total residual bromine toxic to fish and daphnids @ >80 ppb; toxic to Asian clams @ 1350 ppb; generally toxic to nontargets @ 32 ppb	less enviro harmful than chlorine; component of some proprietary chemicals (e.g. Acti-Brom)			USACE-ZMIS; O'Neill. 1996. p.50	power plant

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
oxidizing agent		chloramine		1.2 ppm	24 hours		100% veliger kill					O'Neill. 1996. p.49	
oxidizing agent		chloramine		1.5 ppm	continuous flow through		90% veliger kill					O'Neill. 1996. p.49	
oxidizing agent		chlorine		usually administered to water systems as a gas or as hypochlorite salt (NaOCl)			zm's can detect Cl- in the water, so they stop filtering/close valves; need to treat for many days/weeks	toxic to all aquatic organisms; combines with organic compounds to form THMs and HAAs; highly regulated by EPA because of THMs, esp. if used in drinking water supply; EPA limited is 80 ppb in drinking water				USACE-ZMIS	
oxidizing agent		chlorine		2 ppm	continuous		90% adult kill					O'Neill. 1996. p.49	
oxidizing agent		chlorine		0.25 to 5 ppm	2.9 to 8.8 days at 14.3C 1.6 to 3.7 days at 25.8C		kills settling veligers, not adults					Green 1995	power plant
oxidizing agent		chlorine		0.3 ppm total residual chlorine	14 to 21 days		95% adult kill					O'Neill. 1996. p.49; USACE-ZMIS	
oxidizing agent		chlorine		0.5 ppm total residual chlorine	7 days		75% adult kill					O'Neill. 1996. p.49; USACE-ZMIS	
oxidizing agent		chlorine		applied @ 5.2-8.4 ppm to achieve free chlorine concentration of 0.5-1.0 ppm	21 days, continuous	sodium metabisulphate (NaHSO3); required 4.26-8.15 ppm @ outfall to reduce chlorine level to <0.01 ppm; applied 50% more to ensure compliance; applied dosage = 6.4-12.27 ppm						Command and Matthews. 1994.	
oxidizing agent		chlorine		10 ppm	2 days		100% mortality in 6 days (black striped mussel)						Australia, coastal bay

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
oxidizing agent		chlorine dioxide	ClO_2				not as toxic to adults as chlorine	forms chlorite ions, no THMs	must be prepared onsite			USACE-ZMIS	
oxidizing agent		chlorine dioxide	ClO_2	0.5 ppm	24 hours		100% veliger kill; not as toxic to adults as chlorine	forms chlorite ions, no THMs				O'Neill. 1996. p.49	
oxidizing agent		cyanuric acid		2,000 ppm	17 days		50% kill					O'Neill. 1996. p.49	
oxidizing agent		ozone		0.5 mg/L at 15C	10-11 days		100% adult kill	no THMs	outperforms chlorine, reaction time is 3000 times faster; dissipates rapidly in water; instability results in no residual at discharge point; effectiveness dependent upon temperature; unstable, explosive, must generate onsite; difficult to use in flowing systems; expensive equipment			USACE-ZMIS; O'Neill. 1996. p.49	
oxidizing agent		ozone		0.5 mg/L at 15-20C	5 hours		100% veliger and pediveliger kill	no THMs	outperforms chlorine; dissipates rapidly in water; instability results in no residual at discharge point; effectiveness dependent upon temperature; unstable, explosive, must generate onsite; difficult to use in flowing systems; expensive equipment			O'Neill. 1996. p.49	

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
oxidizing agent		ozone		1.5 ppm	continuous		prevents settlement	no THMs	outperforms chlorine; dissipates rapidly in water; instability results in no residual at discharge point; effectiveness dependent upon temperature; unstable, explosive, must generate onsite; difficult to use in flowing systems; expensive equipment			O'Neill. 1996. p.49	
oxidizing agent		potassium (Potash)					high zm kill rate	low non-target kill rate	impacts ability to breathe, asphyxiates mussels; Virginia Dept Game and Inland Fisheries determined Potash a viable chemical for quarry treatment				
oxidizing agent		potassium permanganate	$KMnO_4$	2.3 mg/L	16 hours at 21C								
oxidizing agent		potassium permanganate	$KMnO_4$	0.25 mg/L	continuous		prevents settlement	toxic to birds, aquatic invertebrates, and mammals; no THMs or HAAs	less effective than chlorine; turns water pink; used to correct taste and odor of treated water			USACE-ZMIS; Balog et al. 1995.	

Category	Brand Name	Chemical	Formula	Application Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
oxidizing agent		potassium permanganate	$KMnO_4$	apply at 2-3 ppm; produce aqueous concentration of 0.5 ppm	30 minutes		less than 100% mortality; not acutely toxic to veligers; requires long contact time; concentration varies with temperature	toxic to birds, aquatic invertebrates, and mammals; no THMs or HAAs	less effective than chlorine; turns water pink; used to correct taste and odor of treated water			USACE-ZMIS; Balog et al. 1995.	
oxidizing agent		potassium salts; example, potassium chloride		100 ppm			very toxic to zm's	toxic to nontargets				USACE-ZMIS	
oxidizing agent	ACTI-BROM 1338	soduim bromide and an oxyalkylate (aqueous solution)						toxic to fish and daphnia at less than 80 ppb; toxic to asian clams at about 1350 ppb			Nalco Chemical	USACE-ZMIS	
quaternary ammonium compound (polyquat)	Calgon H-130M	didecyl-dimethyl ammonium chloride		1 ppm	24 hours	5 ppm CA-35 bentonite clay per 1 part Calgon H-130M	100% kill (after 48 hours post exposure)		coagulates mucus layer on gills; inhibits oxygen transfer; adults can't detect toxin so keep filtering; not as effective @ temps below 12C because zm's do not actively feed and reproduce	previously registered with EPA	Calgon Corportation; has application and detoxification equipment; cost of chemical includes Calgon labor costs	Command and Matthews. 1994.	water intake system for industrial plant
quaternary ammonium compound (polyquat)	Clamtrol TM and niclosamide			clamtrol at 20 ppm; niclosamide at 1 ppm	"short-term"	bentonite clay	more effective on veligers than adults		short lived chemical; causes physio stress - interferes with ability to control water and salt balances, causes mussel to swell				

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
quaternary ammonium compound (polyquat)	Calgon H-130			LC50 values: preveliger=39 mg/L, veliger=89-175 mg/L, plantigrade=8.8 mg/L, adult=5.6-10mg temperature @ 17C	24 hours	5 ppm bentonite clay; strongly absorbed to sediment and rapidly degraded microbially to nontoxic products	LC50<1mg/L; fifth highest polyquat kill rate; more effective on veligers than adults; equal effectiveness on small (5-8mm) and large (20-25mm) adults	data available on detoxification effects on trout, fathead minnow, and daphnia	coagulates mucus layer on gills; inhibits oxygen transfer; adults can't detect toxin so keep filtering	previously registered with EPA	Calgon Corportation; has application and detoxification equipment	Waller et al. 1993; Fisher et al. 1994; Command and Matthews. 1994	
quaternary ammonium compound (polyquat)	Bulab 6002			4 to 8 ppmm		bentonite clay		toxic to nontargets at lower concentrations	does not readily degrade in water; highly absorptive to sediments and glassware			USACE-ZMIS	
quaternary ammonium compound (polyquat)	Salicylanide I (Sal I)			LC50 values: veliger=1.3-3.2 microgram/L, plantigrade=13.5 microgram/L, adult=55-65 microgram/L temperature @ 17C	24 hours		LC50<1mg/L; second highest polyquat kill rate; more effective on veligers than adults	3 to 4 times more toxic to fish than to zm's	structurally similar to Bayluscide, therefore degradation is probably similar			Waller et al. 1993; Fisher et al. 1994	
quaternary ammonium compound (polyquat)	Bayer 73			LC50 values: veliger=24-28 microgram/L, plantigrade=92 microgram/L, adult=50-56 microgram/L temperature @ 17C	24 hours		more effective on veligers than adults; plantigrades least sensitive					Fisher et al. 1994	

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
quaternary ammonium compound (polyquat)	TFM			LC50 values: preveliger=37 mg/L, veliger=2.3-2.5 mg/L, plantigrade=4.2 mg/L, adult=10-11 mg temperature @ 17C	24 hours	significantly degraded by photolysis in aquatic environment	LC50=1 to 150 mg/L; more effective on veligers than adults; TFM less effective on adults than Clamtrol CT-1, Bayer 73, Sal I, Calgon H-130, and Rotenone		significantly degraded by photolysis in aquatic environment; available in benthic release form			Waller et al. 1993; Fisher et al. 1994	larval lamprey
quaternary ammonium compound (polyquat)	Bayluscide					strongly absorbed to sediment and rapidly degraded	LC50<1mg/L; highest polyquat kill rate	more toxic to zm's than to rainbow trout and channel catfish	strongly absorbed to sediment and rapidly degraded; available as 5% granules for release @ sediment-water interface			Waller et al. 1993	
quaternary ammonium compound (polyquat)	Rotenone (Noxfish)			LC50 values: veliger=230-264 microgram/L, plantigrade=275 microgram/L, adult=155-161 microgram/L temperature @ 17C	24 hours		LC50<1mg/L; third highest polyquat kill rate; more effective on adults than veligers and plantigrades	3 to 4 times more toxic to fish than to zm's				Waller et al. 1993; Fisher et al. 1994	
	Evac												power plant
	Baythroid								insoluable in water at concentrations above 100mg/L; insuffiecent mortality at lower doses				
	Buckman Bulab 600203						insufficient mortality						

Category	Brand Name	Chemical	Formula	Concentration	Application Duration	Deactivator	Effectiveness	Nontarget Impacts	Comments	Approved?	Manufacturer	references	current use
	Buckman Bulab 6009						insufficient mortality						
	Calgon DMDACC						insufficient mortality						
	KML V2						insufficient mortality						
	KML V54						insufficient mortality						

Appendix U

In Situ Evaluation Method of Effective Applied Chemical Concentration and Determination of Death

Mortality Monitoring

- Suspend test cages containing attached live mussels into the water to be treated.
- Use at least 10 mussels per cage and multiple cages per waterbody.
- Monitor kill rate as chemical is administered.
- Able to increase chemical concentration based on kill success of mussels in test cages.
- Follow by extensive diver survey looking for live mussels.
- Monitor cages:
    - Conduct mortality count every 24 hours post-treatment application.
    - Transfer to recovery tank and recount in 48 hours.

Determination of “Dead” Mussel

- Valve gaping with no response of exposed mantle tissue to external stimuli.
- Failure of plantigrade mussel with gaping shells to respond to the touch of a probe.
- If shell is closed, then insert probe between the valves of the animal, look for ciliary beating and adductor muscle activity.